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MISSOURI PUBLIC SERVICE COMMISSION

CASE NO. EA-2016-____

DIRECT TESTIMONY OF

WILLIAM H. BAILEY, Ph.D.

ON BEHALF OF

GRAIN BELT EXPRESS CLEAN LINE LLC

June 30, 2016

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I. QUALIFICATIONS

Q. Please state your name and business address.

A. My name is William H. Bailey, Ph.D. My business address is 17000 Science Drive, Suite 200, Bowie, MD 21705.

Q. What is your occupation and by whom are you employed?

A. I am a Principal Scientist in the Center for Occupational and Environmental Health Risk Assessment of Exponent, Inc. (Exponent). Exponent is a scientific research and engineering firm engaged in a broad spectrum of activities in science and technology.

Q. What is your educational background?

A. I earned a Ph.D. in neuropsychology from the City University of New York in 1975. I received two additional years of training in neurochemistry at The Rockefeller University in New York City under a fellowship from the National Institutes of Health. My education includes a BA from Dartmouth College received in 1966 and an MBA from the University of Chicago awarded in 1969.

Q. Please describe your professional background and experience.

A. I am a scientist and researcher focusing on environmental health sciences. My work involves reviewing, analyzing, and conducting health research. Much of my work over the past 30 years relates to the exposure and potential biological, environmental, and health effects associated with electrical facilities and devices, including electric utility facilities, electrified railroad lines, industrial equipment, appliances, and medical devices that produce electromagnetic fields across a wide range of frequencies. Since 1986, I have been a visiting research scientist at the Cornell University Weill Medical College. I also have been a visiting lecturer at Rutgers University, the University of Texas (San Antonio), and

the Harvard School of Public Health in the field of bioelectromagnetics. From 1983 through 1987, I was head of the Laboratory of Neuropharmacology and Environmental Toxicology at the New York State Institute for Basic Research. For the previous seven years, I was an Assistant Professor in Neurochemistry at The Rockefeller University. I am a member of The Rockefeller University Chapter of Sigma Xi, a national scientific honor society; the Health Physics Society; the International Committee on Electromagnetic Safety, Subcommittees 3 and 4 – Safety Levels with Respect to Human Exposure to Fields; the Bioelectromagnetics Society; the IEEE Engineering in Medicine and Biology Society; the Conseil International des Grands Réseaux Électriques (CIGRE); the American Association for the Advancement of Science; the New York Academy of Sciences; the Air & Waste Management Association; the Society for Risk Analysis; and the International Society of Exposure Analysis.

Q. Have you served as a reviewer and scientific advisor on health-related issues for state and federal agencies or scientific organizations?

A. Yes. I have reviewed research for the National Institutes of Health, the National Science Foundation, and other government agencies. Specifically regarding transmission lines, I served on a Scientific Advisory Panel convened by the Minnesota Environmental Quality Board to review the health and safety aspects of a high-voltage transmission line. In addition, I served as a consultant regarding transmission line health and safety issues for the Vermont Department of Public Service, the New York State Department of Environmental Conservation, and the staffs of the Maryland Public Service Commission and the Maryland Department of Natural Resources.

I have also worked with the National Institute of Occupational Safety and Health, the Oak Ridge National Laboratories, the U.S. Department of Energy, and the Federal Railroad Administration to review and evaluate health issues related to electric and magnetic fields ("EMF") from power lines and other sources. In addition, I assisted the U.S. EMF Research and Policy Information Dissemination ("RAPID") program to evaluate biological and exposure research as part of its overall risk assessment process.

Further, I worked with scientists from 10 countries to evaluate possible hazards from exposure to static electric and magnetic fields and extremely low frequency ("ELF") EMF for the International Agency for Research in Cancer ("IARC"), a division of the World Health Organization ("WHO"). I also was an invited participant in the workshop convened by the International Committee on Non-Ionizing Radiation Protection ("ICNIRP") to update guidelines for human exposures to alternating current ("AC") EMF. I have reviewed ICNIRP's draft guidelines for direct current ("DC") and AC magnetic fields as well. Most recently, I have served as an advisor to the U.S. Department of Energy, and several government agencies in Canada and the Netherlands, on topics relating to scientific research on EMF health and safety.

Q. Have you published or presented your research in bioelectromagnetics and other areas to the scientific community?

A. Yes. I have published or presented more than 90 scientific papers and reports on this and related subjects. These publications and presentations are listed in my curriculum vitae, attached as **Schedule WHB-1**.

II. PURPOSE OF TESTIMONY

Q. What is the purpose of your testimony?

A. I have been asked to assess the scientific issues related to potential health effects of electric and magnetic fields, as they relate to the proposed Grain Belt Express Project (the "Project").

Q. What are the sources of electric and magnetic fields in the Project?

A. The Project consists of two distinct sources of electric and magnetic fields.

1. The largest source (a source of DC fields) is the proposed 780-mile, overhead, ±600-kilovolt ("kV") DC transmission line that connects a converter station in Dodge City, Kansas, to converter stations near Center, Missouri, and Sullivan, Indiana, at the Illinois/Indiana border.

2. The second source (a source of mainly AC fields) consists of the converter stations and associated AC interconnection facilities. The Kansas converter station will convert AC electricity generated by wind turbines and other facilities to DC electricity for transport over the DC transmission line. At the terminal converter stations in Missouri and at the Illinois/Indiana border, DC electricity will be converted back to AC electricity and transmitted to the AC grid.

Q. What portions of the Project described above are of interest to the Missouri Public Service Commission in this proceeding?

A. Of the total length of the Project, approximately 206 miles of the DC transmission line will operate in the State of Missouri. Additionally, the Project will include a DC/AC converter station proposed to be located in Ralls County that will interconnect to an existing 345-kV AC transmission line located on the same parcel of land as the converter station.

III. EXPOSURE TO ELECTRIC AND MAGNETIC FIELDS

Q. What are electric and magnetic fields?

A. Electric charges are contained in objects in our environment. When the numbers of positive and negative charges in an object are equal, the object is described as electrically neutral. When the object contains more of one charge or the other, the net charge gives rise to an electric field. Electricity is the presence and movement of electric charges. Consequently, electric and magnetic fields are properties of the space surrounding anything that generates, transmits, or uses electricity.

Magnetic fields are created by the movement of electric charges, or by the movement of electrons in certain materials such as permanent magnets. Electric fields occur when voltage is associated with these objects, while magnetic fields result from current flowing through these objects. Just as the heat from a radiator decreases as one moves farther away, the levels of both electric fields and magnetic fields decrease with distance from the source. Electric fields are blocked by conductive objects (such as trees, fences, and walls), including the human body, while magnetic fields are not.

Q. In what units are the intensities of electric and magnetic fields measured?

A. Electric fields are measured in units of volts per meter ("V/m") or kilovolts per meter ("kV/m"), where 1 kV/m is equal to 1,000 V/m. Magnetic fields in the United States are most commonly measured in units of gauss ("G") or milligauss ("mG"), where 1 G is equal to 1,000 mG.

Q. Are all electric and magnetic fields the same?

A. No. Both electric fields and magnetic fields are characterized by their frequency (i.e., the number of times [full cycles] the field direction changes each second). Frequency is measured in Hertz ("Hz"). A related characteristic is wavelength, which is inversely related to frequency—the lower the frequency, the longer the wavelength, and vice versa.

Frequency and wavelength of EMF greatly affect how these fields interact with physical materials and living cells or organisms. Thus, any potential effects of these fields, and the relevant scientific literature, need to be evaluated separately according to the frequency characteristics of the source. For example, the oscillating nature of AC magnetic fields causes weak currents and voltages to be induced in nearby conductive objects, as described by Faraday's law. Magnetic fields that do not oscillate (i.e., static [DC] magnetic fields) do not induce currents and voltages in conductive objects.

Q. What frequencies of electric and magnetic fields will be associated with the operation of the proposed Project?

A. The Project is designed to transport DC electricity. Thus, the dominant fields produced by the line are DC fields; DC fields are commonly referred to as static fields because they do not change direction and their characteristic frequency is at or about 0 Hz (i.e., they change direction at or about zero times per second).

The short interconnection lines between the Project's converter stations and the AC electric grid will be sources of AC EMF that oscillates at a dominant frequency of 60 Hz. These AC fields are everywhere in our communities because all transmission lines, electrical devices, appliances, related wiring, etc., connected to our AC electric power system produce EMF at this frequency. By way of clarification, the acronym EMF typically is used by scientific and engineering professionals to refer to AC electric and magnetic fields in the ELF range between 30 and 300 Hz. At times, the general public may refer to EMF when speaking of fields at other frequencies, such as the static geomagnetic field of the earth or the radiofrequency ("RF") fields produced by mobile phones. For that reason, the abbreviation ELF EMF is sometimes used to avoid this confusion when

referring to EMF from sources that principally derive from our AC electric utility system and the wiring and devices connected to it.

Q. We know that AC transmission lines and other sources are widespread across North America. Is the proposed DC transmission line at all unique?

A. No, it is not unique. There are many DC transmission lines and converter facilities now operating in the United States and Canada and more that are proposed or under construction.[1]

Q. What are other common sources and levels of static and AC electric and magnetic fields that people encounter in daily life?

A. **Static Fields.** Static electric fields are natural phenomena that arise from various sources. The most common sources of static electric fields are distant storm fronts (10-20 kV/m), storm clouds over a lake (40 kV/m), static electricity (i.e., charge separation) such as that which occurs after walking across a carpet (up to 100 kV/m), and the surface charge on the body from static cling (up to 500 kV/m).

Static magnetic fields are also natural phenomena produced by the flow of electric currents. The earth produces an ever-present background geomagnetic field that originates from the electrical currents in the earth's molten core and crustal sources. The geomagnetic field varies with latitude. For instance, it is highest at the magnetic poles and lowest at the equator (~700 and ~300 mG, respectively). Slight variations in the geomagnetic field may also occur over time at any given geographic location. In 2016, at Jefferson City, Missouri, the magnetic field is about 523 mG.

[1] See http://www.cleanlineenergy.com/technology/hvdc/history, for example.

Man-made DC magnetic fields result from a number of sources including battery-operated appliances (3,000-10,000 mG), electrified railways (<10,000 mG), and magnetic-resonance imaging machines (15-30 million mG).

AC ELF fields. Magnetic fields at ELF frequencies in homes in the United States average about 1 mG, when not near a particular source. In the immediate vicinity of electrical household appliances and power tools, ELF magnetic-field levels rise to several hundred mG or more. ELF electric fields are typically below 20 V/m in households in the United States and derive mostly from indoor sources since buildings shield AC electric fields from outside sources (as well as DC electric fields).

Q. What aspects of a transmission line produce static or ELF fields during operation?

A. The voltage applied to the conductors is the source of the electric field. The current flow on the conductors is the source of the magnetic field.

Q. Can environmental factors, such as wind, affect the type or magnitude of fields around the lines?

A. The *type* of electric and magnetic fields whether it is AC or DC, depends upon the operation and design of the line and not environmental conditions, including wind speed. Where transmission lines, such as those associated with this Project, carry a significant amount of electricity generated by wind generators, the current flow on the transmission lines will vary with the amount of electricity (power) produced by the changing wind speed at the turbine generators. This will cause the magnitude (i.e., the level) of the magnetic field near the line to vary with wind speed because the magnetic-field level varies directly with current flow.

The static magnetic field from the DC line and the ELF magnetic field from the short AC interconnections from the Grain Belt Express Project can be expected to be similar to the values projected by the U.S. Department of Energy for the DC transmission line and short 345-kV connections in its evaluation of the ± 600 kV 3,500 megawatt Plains & Eastern Clean Line Transmission Project (DOE, 2015).

The magnitude of the electric field from the AC lines is fixed by the voltage prescribed in the design of the lines and will not vary appreciably because the voltage on the line is controlled within strict limits. While the voltage on the DC line is also fixed and controlled, the intensity of the static electric field from the DC line may increase, such as in foul weather conditions due to rain droplets on the conductors and then wind could shift the peak value of the static electric field a few meters downwind. The presence of conductive materials in an electric field such as fences, trees, shrubbery, and buildings, however, can effectively shield the area around them from the electric field. The values of the static and AC electric fields expected during operation of the Grain Belt Express project also will be similar to those projected for the operation of the Plains & Eastern DC and 345-kV AC lines that were evaluated by the U.S. Department of Energy (DOE, 2015).

IV. WEIGHT-OF-EVIDENCE SCIENTIFIC APPROACH

Q. Could you please explain the method you have used to review and evaluate the scientific literature to assess potential effects of the Project on health and safety?

A. We have relied upon the generally accepted method for health risk evaluation (i.e., the evaluation of the scientific literature for evidence for or against a potential causal association between an environmental exposure and health outcomes), known as the

weight-of-evidence approach. This is a standard, general scientific method and is employed by regulatory, scientific, and health agencies worldwide.

Q. Please describe the weight-of-evidence approach.

A. The weight-of-evidence approach includes the systematic identification and review of the relevant literature for a specific exposure and potentially related health outcome. The reviewed scientific literature includes epidemiologic studies of humans observed in their natural environments, laboratory studies of animals (*in vivo* studies), and laboratory studies of cells and tissues (*in vitro* studies). These types of studies provide complementary information regarding potential biological and health effects of the exposure in question. Each of the identified studies in these scientific areas is then individually evaluated for their overall quality. The scientific quality of each study determines how much weight the individual study receives in the overall evaluation. High quality studies are given greater weight, while lower quality studies contribute less, and poor quality studies are sometimes given no weight at all.

Q. Has the weight-of-evidence approach been applied by authoritative expert panels to the evaluation of <u>static electric and magnetic field</u> health research?

A. Yes. Multidisciplinary expert panels—on behalf of a number of national and international health and scientific agencies—have reviewed the available scientific literature regarding potential health effects of static electric and magnetic fields using this approach. These include, for example, IARC in 2002, WHO in 2006, the United Kingdom's Health Protection Agency in 2008, International Commission on Nonionizing Radiation Protection ("ICNIRP") in 2009, and the European Commission's Scientific Committee on Emerging and Newly Identified Health Risk ("SCENIHR") in 2015. None of these

agencies found reliable evidence of biologically harmful effects resulting from static magnetic fields below exposure levels of several tens of thousands gauss. These levels are several thousand-fold higher than the maximum static magnetic fields associated with the operation of the proposed DC line, which are comparable in magnitude to the geomagnetic field of the earth. Regarding electric fields, the only effects identified were direct perception and potential microshocks similar to those encountered when touching a door knob after walking across a rug during the winter, and none of these agencies reported that these static electric-field effects are harmful.

Q. Has the weight-of-evidence approach also been applied to the evaluation of <u>ELF EMF</u> by authoritative expert panels and what are the overall conclusions of these panels?

A. Yes. Multidisciplinary expert panels on behalf of national and international health and scientific agencies also have reviewed the available scientific literature on potential health effects of ELF EMF using the weight-of-evidence approach. These evaluations include those conducted by the National Institute of Environmental Health Sciences (1999), IARC (2002), WHO (2007), ICNIRP (2010), and SCENIHR (2015). While these reviews acknowledged the limited epidemiologic evidence with respect to a statistical association between long-term exposure to ELF magnetic fields and childhood leukemia, they also concluded that experimental evidence does not support a cause-and-effect relationship with any cancer. No adverse health effects were identified in association with exposure to ELF electric fields. On its website, the WHO currently states that *"[b]ased on a recent in-depth review of the scientific literature, the WHO concluded that current evidence does not confirm the existence of any health consequences from exposure to low level electromagnetic fields."* The WHO website also states that *"[w]ith more and more*

research data available, it has become increasingly unlikely that exposure to electromagnetic fields constitutes a serious health hazard."[2]

V. EVALUATION OF POTENTIAL HEALTH EFFECTS OF STATIC AND ELF FIELDS

Q. Please provide more detail on the evaluations of health research on electric and magnetic fields. What types of studies of potential health effects of electric- and magnetic-field exposure have been evaluated by health and scientific agencies?

A. These agencies have evaluated human epidemiologic studies and laboratory studies of humans and animals. The evaluations considered potential associations of cancer and non-cancer outcomes with residential and occupational exposures among adults and children.

Q. What is the main finding of these evaluations?

A. These agencies confirm that the potential adverse effects of exposure to these fields relate to stimulation of brain and nerves at very high levels of exposure. To protect against such direct effects, exposure guidelines for static magnetic fields and ELF EMF have been set by ICNIRP and the IEEE's International Committee on Electromagnetic Safety ("ICES"). The exposure limits established by these organizations, and by the U.S. Food and Drug Administration, are shown in Table 1. The WHO recommended the implementation of the ICNIRP and ICES guidelines as a protection against known acute effects involving stimulation of the nervous system.

[2] http://www.who.int/peh-emf/about/WhatisEMF/en/index1.html

Table 1. Recommended reference levels for public exposure to electric and magnetic fields

Exposure	Organization (Year)	Reference Level
Static magnetic field	U.S. Food and Drug Administration (2003)	80,000 G > age 1 month
	U.S. Food and Drug Administration (2003)	40,000 G < age 1 month
	ICNIRP (2009)	4,000 G
ELF magnetic field	ICES (2002)	9.04 G
	ICNIRP (2010)	2 G
ELF electric field	ICES (2002) ICNIRP (2010)	5 kV/m (10 kV/m on the right-of-way) 4.3 kV/m

Health-based guidelines for exposure to static electric fields have not been proposed by these agencies.

Q. Would the transmission lines proposed as part of the Project be able to meet these reference levels?

A. Yes. The static magnetic field contributed by the DC line to the background geomagnetic field at full-power rating will be a very, very small fraction of these levels. As for the AC EMF reference levels, these would be met at the edges of the right-of-way ("ROW") . In addition, The EMF levels from equipment in converter stations and substations are quite low at the boundaries of such sites because the fields diminish rapidly with distance from the equipment within the large confines of the sites. Thus, fields at the boundaries of these Project sites arise from the DC line and the AC interconnection lines that connect to converter stations and substations rather than the equipment within the stations. In addition, on the ROW and beyond, the expected electric and magnetic field levels from the AC interconnector would be far below exposures that would cause the actual

exposure limits of these standards for the general public to be exceeded (Kavet et al., 2012)

Q. Does compliance with these guidelines limit the possibility of shocks under the lines?

A. Yes. The reference levels for AC electric fields have been set to "*limit indirect effects [i.e., shocks] of contact with electrical conductors in the field*" (Matthes, 1998, p. 438). The severity of such shocks, if they occur at all, would be similar to a harmless shock delivered to the hand from a door knob after walking across a carpeted floor. At the low electric-field levels under the AC lines, such microshocks would not be harmful. For the DC line, microshocks and perception of the field would be even less likely to occur. Harmful shocks would be precluded by adherence to design standards given in the IEEE's National Electrical Safety Code (2012), which applies to all transmission lines.

Q. Have health and scientific agencies evaluated research on the possibility that exposure to static or ELF electric and magnetic fields might cause cancer?

A. Yes. Many national and international agencies have reviewed research on this topic over the past 40 years. One of the most influential reviews of research on static and ELF fields was performed by a Working Group of scientists for the IARC, an affiliate of the WHO in 2002.

Q. Can you briefly explain the IARC classification process for rating the potential carcinogenicity of exposures?

A. The IARC classification of carcinogenicity is based on weight-of-evidence evaluation of two main streams of evidence: epidemiologic studies in humans and *in vivo* laboratory animal studies. A third component—*in vitro* laboratory studies—also may be used to provide supplementary information on the mechanism of the potential carcinogenesis. The

overall evidence from human and animal studies is then separately categorized into one of four categories: (1) sufficient, (2) limited, (3) inadequate evidence of carcinogenicity, or (4) evidence suggesting lack of carcinogenicity. Based on a combination of the two streams of evidence, the exposure is then classified into one of five mutually exclusive categories: Group 1 (carcinogenic to humans); Group 2A (probably carcinogenic to humans); Group 2B (possibly carcinogenic to humans); Group 3 (not classifiable as to its carcinogenicity to humans); and Group 4 (probably not carcinogenic to humans). The Group 1 classification typically requires sufficient evidence from studies of humans, and the Group 2A classification is used when there is limited evidence from studies of humans and sufficient evidence from laboratory animal studies. The Group 2B classification is used when there is limited evidence from studies of humans and less than sufficient evidence from laboratory animal studies. Group 3 is used when the evidence of carcinogenicity is inadequate in studies of humans and inadequate or limited in studies of laboratory animals. Finally, Group 4 is used when there is evidence suggesting lack of carcinogenicity in studies of humans and of laboratory animals. This classification system is summarized in Table 2.

Table 2. IARC criteria for classifying exposure as to the strength of the evidence for carcinogenicity

Group	Criteria
Group 1 *Carcinogenic to humans*	• Sufficient evidence of carcinogenicity in studies of humans
Group 2A *Probably carcinogenic to humans*	• Limited evidence of carcinogenicity in studies of humans and • Sufficient evidence of carcinogenicity in studies of laboratory animals
Group 2B *Possibly carcinogenic to humans*	• Limited evidence of carcinogenicity in studies of humans and • Less than sufficient evidence of carcinogenicity in studies of laboratory animals

Group 3 *Not classifiable as to its carcinogenicity to humans*	• Inadequate evidence of carcinogenicity in studies of humans and • Inadequate or limited evidence of carcinogenicity in studies of laboratory animals
Group 4 *Probably not carcinogenic to humans*	• Evidence suggesting lack of carcinogenicity in studies of humans • Evidence suggesting lack of carcinogenicity in studies of laboratory animals

Q. How were static and ELF fields classified by IARC?

A. We have to distinguish between the evaluation of static fields and ELF fields. For static fields, which have primary relevance for DC transmission lines, both static electric fields and static magnetic fields were classified into Group 3 (i.e., not classifiable as to its carcinogenicity to humans). These classifications were based on inadequate evidence for carcinogenicity in studies of humans and the lack of data relevant to carcinogenicity in laboratory animal studies.

ELF electric fields were similarly categorized into Group 3 based on inadequate evidence and lack of carcinogenicity data studies of humans and laboratory animals, respectively. Only ELF magnetic fields were classified into Group 2B, based on limited evidence of carcinogenicity in studies of humans and inadequate evidence in laboratory animal studies.

Q. What was the basis for the 2B classification?

A. The 2B classification (possibly carcinogenic to humans) of ELF magnetic fields was based on limited evidence of carcinogenicity in studies of humans and inadequate evidence of carcinogenicity in studies of laboratory animals. A statistical association observed in some of the epidemiologic studies of residential exposure to ELF magnetic fields and occurrence of childhood leukemia was considered as "limited evidence." For all other cancer

outcomes among children and adults, in association with both residential and occupational exposure, the epidemiologic evidence was considered inadequate.

Q. Does that mean that ELF magnetic fields cause cancer?

A. No. The existence of any adverse health effect has not been confirmed by the available scientific evidence below scientifically established exposure guidelines. The classification of "limited evidence" for a statistical association between ELF magnetic field exposure and childhood leukemia in epidemiologic studies by IARC derives from IARC's determination that chance, bias, or confounding cannot be excluded as an explanation for the observed association. The overall absence of evidence in the literature for potential carcinogenicity in laboratory animals, including studies in which lifetime exposure of rodents to very high magnetic fields did not result in an increase in cancer development, also does not support a cause-and-effect association. In addition, no generally accepted biophysical mechanism exists that could explain a carcinogenic effect of ELF magnetic fields at environmental levels.

Q. Has the assessment of research regarding cancer changed since the IARC review in 2002?

A. No. The conclusions of subsequent reviews by international scientific and health agencies have been consistent with those of IARC. In addition to cancer, the scientific evidence related to other non-cancer health outcomes also has been reviewed by these agencies (e.g., WHO in 2007, and SCENIHR in 2009 and 2015). As the WHO states on its website, referring to both cancer and non-cancer outcomes, the *"current evidence does not confirm the existence of any health consequences from exposure to low level electromagnetic fields."*

Q. Do some scientists advocate alternative views?

A. Yes. Some scientists advocate alternative views of the research that are not consistent with the conclusions of any of the authoritative reviews mentioned earlier. One of the most frequently referenced documents that advocates alternative views and conclusions is known as the BioInitiative report. It is important to note upfront that these alternative views are not based on weight-of-evidence evaluations of the scientific evidence, which is, as mentioned above, the generally accepted scientific method for risk assessment.

Q. What is the BioInitiative report and who authored it?

A. The BioInitiative report was authored by the BioInitiative Working Group, which is a self-selected volunteer group of scientists and EMF activists. The BioInitiative Working Group did not represent or act on behalf of any recognized or authoritative scientific, health, or regulatory agency. In their own view, the BioInitiative report provides an overview of the scientific literature on potential health effects of ELF and RF EMF. The BioInitiative report concludes that current exposure guidelines are inadequate and calls for up to a several thousand-fold reduction in ELF and RF EMF exposure limits. The BioInitiative report was completed in 2007 and then updated in 2012. Both versions were posted on the internet and were not peer-reviewed. The BioInitiative report did not employ the weight-of-evidence approach, and mostly and selectively references studies that suggest some biological or health effects without consideration given to study quality. It heavily relied on *in vitro* studies, which are considered only as secondary supplementary sources of information by, for example, IARC and WHO. At the same time, it almost entirely lacks a thorough review of *in vivo* laboratory animal studies of carcinogenicity. The BioInitiative

report contains sections authored by individual contributors, and provides conclusions of the individual authors rather than consensus opinions.

Q. Does the BioInitiative report discuss potential effects of static electric and magnetic fields associated with DC lines?

A. No. Although, among the many hundreds of references, the BioInitiative report cites a handful of *in vitro* studies related to static electric and magnetic fields, it does not specifically deal with potential effects of static fields; thus, it is not directly pertinent to the assessment of potential health effects of static fields such as those produced by transmission lines carrying DC electricity.

Q. Is the BioInitiative report consistent with reviews and conclusions of authoritative health and scientific agencies?

A. No. The conclusions of the BioInitiative report are wholly inconsistent with the conclusions of authoritative health risk assessments conducted by national and international governmental, health, and scientific agencies, such as the WHO, IARC, ICNIRP, and the NIEHS. None of these agencies concluded that environmental exposures to static, ELF, or RF fields at levels below current scientifically established guidelines pose any risk to human health. The BioInitiative report has been widely criticized in the scientific community, for example, by the Health Council of the Netherlands (HCN, 2008) and the Australian Centre for Radiofrequency Bioeffects Research (ACRBR, 2008), for not following generally accepted scientific methods, such as the well-established weight-of-evidence assessment, when reviewing the scientific literature on EMF and health. The criticisms include selective reporting of positive studies in support of a specific conclusion, lack of consideration of study quality, and the heavy reliance on *in vitro* studies of tissues

and cells, as opposed to *in vivo* laboratory animal studies and epidemiologic research. These flaws explain why their conclusions are largely inconsistent with the conclusions of other national and international expert risk assessment panels and the large body of scientific literature. In other words, the conclusions expressed in the BioInitiative report are based on individual opinions of the authors of the individual chapters, without appropriate scientific peer review, and do not represent a consensus opinion.

Q. Should persons with cardiac pacemakers not come close to high-voltage DC transmission lines?

A. Because static fields do not induce any appreciable voltages or currents within the body that might be sensed by pacemakers, they do not have the same potential to affect cardiac pacemakers as do strong AC electric-field sources. For example, the ANSI/AAMI/ ISO 14117:2012 standard for electromagnetic compatibility for active implantable medical devices published by the American National Standards Institute and the Association for the Advancement of Medical Instrumentation in 2012 specifies that implanted medical devices "*shall not be affected by static magnetic fields of flux density of up to 1 mT (millitesla)"* (e.g., 1 millitesla = 10,000 mG) [Section 4.6.1, p. 39]. This level is about 10-fold higher than the level that could be experienced near the proposed DC line.

Q. Does the short AC interconnection between the converter station and the electrical grid pose a serious risk to persons with pacemakers?

A. The risk is vanishingly small even within the ROW. Sensing of electrical impulses of the heart is the key to normal functioning of implanted cardiac devices, such as pacemakers or implanted cardioverter defibrillators. Sensing of electric signals from other sources

may, in principle, result in electromagnetic interference. Power lines, however, are not typical sources of such interference. A recent search (April 2016 of the Manufacturer and User Facility Device Experience database maintained by the U.S. Food and Drug Administration has not identified episodes of electromagnetic interference with implanted cardiac devices due to electric or magnetic fields from either AC or DC power lines.

Modern implanted medical devices incorporate various technological safeguards (e.g., shielding by titanium casing, the presence of bipolar leads, and electrical filtering) to minimize the potential for interference (Dyrda and Khairy, 2008). A procedure developed by the European Committee for Electrotechnical Standardization to assess the potential risk to workers with an active implantable medical device provides guidelines for reference levels that are sufficient to ensure compliance (CENELEC 50527-1:2010). The recommended reference level for ELF electric-field exposure is 5.0 kV/m and ELF magnetic-field exposure is 100 microtesla (μT) (i.e., 1,000 mG) for the general public (European Union, 1999). These exposure levels will not be exceeded outside the ROW by any likely configuration of the short AC interconnections.

VI. TRANSMISSION LINES AND CATTLE

Q. Will exposure to a DC transmission line have any adverse effects on cattle health and productivity?

A. The presence of overhead power lines through agricultural land sometimes has raised concerns about the potential effects of electric and magnetic fields from the lines on the health of livestock grazing and being reared in close proximity to them.

In response to the concerns of farmers near the ±400-kV CPA/UPA DC transmission line in Minnesota, researchers examined possible effects of the electrical

environment of this DC transmission line on dairy cattle. Martin et al. (1983) at the University of Minnesota used the records of the Dairy Herd Improvement Association to study the health and productivity of about 24,000 cows (approximately 500 dairy herds) from farms located near the transmission line. They examined 6 years of veterinary records that spanned a period from 3 years before the line was energized in 1979 to 3 years after energization. The herds were grouped according to distance of the farm from the transmission line, with the closest herds less than 0.25 miles from the line and the farthest between 6 and 10 miles away. Endpoints selected for study included milk production per cow, herd average of milk production, milk fat content, and measures of reproductive efficiency. The health and productivity of the herds was found to be the same before and after energization and also was found to be unrelated to distance of the herds from the transmission line.

Investigators at Oregon State University compared the health and productivity of 200 cow-calf pairs randomly assigned to pens directly under the ±500 kV DC Pacific Intertie transmission line or 615 meters away from it. The exposure and control groups were evaluated for breeding activity, conception rate, calving, calving interval, body mass of calves at birth, body mass at weaning, or mortality over a 3-year period. No differences between the animals in the exposed and control pens were noted for any of these categories (Angell et al., 1990).

The investigators also monitored the activities of the exposed and control cattle at 15-minute intervals during a 24-hour period each month (Ganskopp et al., 1991). The distribution of cattle along feed troughs in the exposed and control pens was similar and unrelated to measures of the static electric field and there were no major differences in

the time spent in various behaviors. Although small differences in the distribution of cattle within the pens were noted, the investigators reported that the differences were not correlated with fluctuations in the static electric field or audible noise levels.

Overall, the available scientific literature does not provide evidence that static fields associated with DC transmission lines adversely affect cattle living under and around these lines.

Q. Will exposure to an AC transmission line have any adverse effects on cattle health and productivity?

A. Potential effects of AC ELF EMF on cattle also have been extensively investigated. The most comprehensive series of experimental studies were conducted by scientists at McGill University in Québec, Canada (e.g., Rodriguez et al., 2002, 2003, 2004; Burchard et al., 2003, 2004, 2007). The studies were conducted in a controlled laboratory setting. Cows were exposed to magnetic fields up to 300 mG or electric fields up to 10kV/m, or both. The studies assessed the potential effect of electric fields and magnetic fields, separately and in combination, on dairy cattle's milk production, fertility, and hormone levels. While some of the studies showed differences in milk fat content and dry matter intake, these differences were not consistently observed in the series of experiments and none of these differences were outside of normal variations. Various measures of fertility and a variety of hormone levels (including progesterone, melatonin, cortisol, and thyroid hormones) also were not affected by ELF EMF exposure. Some subgroup analyses showed minor changes, but according to the authors' conclusions, these were small, within the range of normal for dairy cattle, and unlikely to represent adverse health effects. As the authors concluded in one of their most recent studies, *"[t]he absence of*

abnormal clinical signs and the absolute magnitude of the significant changes detected during MF [magnetic field] exposure, make it plausible to preclude any major animal health hazard" (Burchard et al., 2007, p. 471.)

VII. CONCLUSION

Q. Based on your own review and evaluation of the research literature on exposure to electric and magnetic fields at static or ELF frequencies, would the levels of static electric and magnetic fields and ELF EMF associated with the proposed Project, which would be similar to Clean Line's Plains & Eastern project, pose any known risk to human health?

Q. My conclusion, made to a reasonable degree of scientific certainty, is no. The WHO and other scientific and health agencies have thoroughly considered this issue and have concluded that, on balance, the scientific weight of evidence does not support the conclusion that static and ELF fields cause any long-term adverse health effects. Recent research does not provide evidence to alter this overall conclusion. The conclusions of the WHO and other agencies apply to all sources of these fields in our environment, including power distribution lines, transmission lines, and electrical appliances. In addition, electric- and magnetic-field levels at and beyond the edges of the ROW would be well below international standards, which are protective of public health.

Q. Does it conclude your testimony?

A. Yes.

VIII. ACRONYMS AND ABBREVIATIONS

μT	Microtesla
AC	Alternating current
ANSI	American National Standard Institute
AAMI	Association for the Advancement of Medical Instrumentation
ACRBR	Australian Centre for Radiofrequency Bioeffects Research
DC	Direct current
ELF	Extremely low frequency
EMF	Electric and magnetic fields
G	Gauss
Hz	Hertz
IARC	International Agency for Research on Cancer
ICES	International Committee on Electromagnetic Safety
ICNIRP	International Commission on Non-Ionizing Radiation Protection
kV	Kilovolt
kV/m	Kilovolts per meter
mG	Milligauss
NIEHS	National Institute of Environmental Health Sciences
RF	Radiofrequency
ROW	Right of way
SCENIHR	Scientific Committee on Emerging and Newly Identified Health Risks
The Project	The Grain Belt Express Project
WHO	World Health Organization

1	V/m	Volts per meter

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BEFORE THE PUBLIC SERVICE COMMISSION
OF THE STATE OF MISSOURI

In the Matter of the Application of Grain Belt Express Clean Line LLC for a Certificate of Convenience and Necessity Authorizing it to Construct, Own, Control, Manage, Operate and Maintain a High Voltage, Direct Current Transmission Line and an Associated Converter Station Providing an Interconnection on the Maywood-Montgomery 345 kV Transmission Line	)))))))	Case No. EA-2016-_____

AFFIDAVIT OF WILLIAM H. BAILEY

STATE OF MD)
) **ss**
COUNTY OF Talbot)

William H. Bailey, being first duly sworn on his oath, states:

1. My name is William H. Bailey. I am a Principal Scientist in the Center for Occupational and Environmental Health Risk Assessment of Exponent, Inc.

2. Attached hereto and made a part hereof for all purposes is my Direct Testimony on behalf of Grain Belt Express Clean Line LLC consisting of 29 pages, having been prepared in written form for introduction into evidence in the above-captioned docket.

3. I have knowledge of the matters set forth therein. I hereby swear and affirm that my answers contained in the attached testimony to the questions therein propounded, including any attachments thereto, are true and accurate to the best of my knowledge, information and belief.

William H. Bailey

Subscribed and sworn before me this 29 day of June, ~~2016~~.

Notary Public

My commission expires: LAURA E. PRICE
NOTARY PUBLIC STATE OF MARYLAND
My Commission Expires September 5, 2018

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