## EXPERIENCE SUMMARY

Mr. Kalapinski is an acoustical engineer with over thirteen years of professional consulting experience in transportation and stationary source impact assessments and design of noise mitigation. He has extensive experience with test instrumentation and measurement procedures, complex noise propagation modeling, applied noise and vibration research, and a through understanding of noise regulatory and permitting requirements applicable to a wide variety of projects in the industrial, energy, transportation, and real estate development. Mr. Kalapinski's principal focus over the past several years has been in the traditional and alternative energy sector including wind, solar, tidal, biomass, and both simple and combined cycle combustion power generation. Additional project related experience includes lateral transmission, pipeline, compressor station, and construction noise and vibration analyses as well as providing noise consulting services for several ongoing large scale projects under the National Environmental Policy Act. Mr. Kalapinski has over ten years professional experience in the study and evaluation of wind turbine acoustics with projects ranging from the siting of a single demonstration wind turbine unit to full scale utility wind energy conversion projects. Services provided to wind energy developers and communities include acoustic feasibility studies, tonality and low frequency noise analyses, screening level and detailed noise propagation modeling calculations, baseline sound surveys, and operational wind turbine generator equipment acoustic acceptance testing.

Mr. Kalapinski is also experienced in the design and deployment of underwater noise measurement systems and developing site specific underwater noise propagation algorithms for modeling sound attenuation through water bodies. Resultant data are routinely used in the assessment of compliance with regulatory limits and the determination of potential behavioral response of marine life for coastal development and offshore wind energy conversion projects. Underwater acoustics work has been completed in support of several coastal development and offshore wind energy conversion projects. Mr. Kalapinski has the ability to address noise related concerns in a clear concise manner through testing, analyses, reporting, public presentation, and expert witness testimony for which he has served before numerous state and local planning, environmental, energy facility siting, and health boards and in courts of law.

## EDUCATION

BS, Civil and Environmental Engineering, University of Massachusetts, 1994
Various Coursework, Environmental & Transportation Engineering, Northeastern University, 2001
Various Coursework, Environmental & Noise Control Engineering, Tufts University, 2001

## REGISTRATIONS/CERTIFICATIONS

Institute of Noise Control Engineering INCE Certified Full Member, Number 10244, Earned 3/1/99
Engineer in Training, MA, Number 16439, Earned 4/1/96

## TRAINING

Advanced Acoustic Modeling Techniques using Cadna A - 2007

## CORPORATION PROJECT EXPERIENCE

**Senior Sound and Vibration Consultant, 2007 - Present**
**Horizon Wind Energy LLC, Top Crop Wind Energy Conversion Project, IL**
Mr. Kalapinski served as the lead acoustic engineer for the Horizon Wind Energy Top Crop Wind Farm which is a proposed 600-megawatt wind energy facility in LaSalle, Grundy and Livingston Counties, Illinois. The objectives of the noise study were to: (1) establish potential Project noise sources (2) develop frequency (Hertz) dependant modeling algorithms and also standardized broadband dBA modeling representative of the range of future Project operational conditions and (3) determine the feasibility of the Project to operate in compliance with all applicable noise requirements as promulgated

by the Illinois Pollution Control Board. The results of the acoustic assessment demonstrated compliance at all existing residential receptor locations. The Project was also shown to be also in compliance with other well established environmental noise guidelines including the United States Environmental Protection Agency which can be used to assess or predict likely community reaction to environmental noise.

**Senior Sound and Vibration Consultant, 2008 - Present**
**AES Energy LLC, West Hill Wind Farm Project, NY**
Mr. Kalapinski served as the Senior Sound and Vibration Engineer for the proposed West Hill Wind Farm in Smithfield and Madison Counties, New York. A scope of work was prepared in response to a request by the client for an updated acoustic noise modeling of wind turbine noise propagation using methodology suitable for WEC projects located in complex terrain. The resulting analysis was subsequently used to successfully provide a demonstration of compliance with local noise bylaws pertaining to the operation of commercial wind energy conversion projects as well an assessment of the project in relation to New York State Environmental Quality Act noise guidelines. A letter report was submitted in support of permitting in layman's terms. Sound contours were presented graphically in color-coded broadband dBA isopleths projected onto scaled aerial photographs and USGS topographic mapping at a height of 1.52 meters above grade, the approximate height of the ears of a person standing.

**Senior Sound and Vibration Consultant, 2008 - Present**
**FPL Energy LLC, Noise Impact Assessment Helix Wind Resource Area Umatilla County, OR**
As the Lead Sound and Vibration Consultant, Mr. Kalapinski provided acoustic engineering services in support of the proposed expansion of the Helix Wind Resource Area located on the Vansycle Ridge in Umatilla County, Oregon. FPL Energy currently owns and operates the Stateline Wind Energy Project, which consists of 186 660 kV Vestas wind turbine generators. In 2005, FPLE was approved to construct an addition to the Stateline Wind Energy Project, called Stateline 3. The Stateline 3 Project was proposed to include 279 660 kV Vestas WTGs; however, this extension has not been built. In 2008, FPLE proposed to construct the Helix Wind Resource Area near the small town of Helix in Umatilla County, Oregon and retained Mr. Kalapinski to complete the revised acoustic analyses for several possible WTG layouts and to provide a document supporting regulatory compliance at all potentially impacted receptor locations. This Project is currently under review by the Oregon Energy Facility Siting Council. Mr. Kalapinski has been requested to provide further ongoing support and expert witness testimony in upcoming Energy Facility Siting Board hearings.

**Senior Sound and Vibration Consultant, 2008**
**Mid American Energy Company, Pomeroy Electrical Substation, IA**
Mr. Kalapinski was retained by Mid American Energy Company counsel to measure and analyze the sound levels at and within the immediate vicinity of the existing Pomeroy electrical substation facility, located in Pocahontas County, Iowa. Threats of possible legal action, due claims of excessive noise, and noise nuisance conditions as alleged by adjacent neighbor prompted local officials to request that a compliance analysis be completed by Mid American Energy. The comprehensive sound survey measured operational substation sound levels at several potential noise sensitive areas including points along the closest residential property line, the Project fence line and other publicly accessible areas. Measurement data was analyzed to determine the status of compliance of the Project to state and local limits, the project permitting conditions, as well accepted noise guidelines for potential noise effects on health and hearing loss, reasonableness of the community response, sleep disruption, tonality, and low frequency noise. Sound source measurements of transformers and fans were also compared to manufacturer specifications. Guidance was also provided to Mid American Energy for use in future substation equipment siting studies. Mr. Kalapinski has been contracted to provide ongoing permitting support in acoustics for up to eight future wind energy projects that are currently in permitting, design and construction, or in initial planning stages.

**Senior Sound and Vibration Engineer, 2005 (as subconsultant) - Present**
**Excelerate Energy LLC, Northeast Gateway Energy Bridge Project, MA**
Mr. Kalapinski was the acoustic lead for the Northeast Gateway Deepwater Port LNG import terminal proposed for an offshore location in Boston Harbor. This project involved the direct measurement and computer modeling of underwater sound propagation and attenuation in support of the assessment of the Project's potential for biological impacts on marine life. In support of this Project, an underwater computer noise propagation model was developed, implemented, and verified to provide highly accurate site-specific sound predictions. In addition, Mr. Kalapinski was responsible for drafting technical report sections pertaining to acoustics for the Environmental Impact Assessment, Incidental Harassment Authorization permit application, and Habitat Use Assessment. Currently responsible for oversight of the Cornell noise mitigation and monitoring plan, Mr. Kalapinski is also providing on-call underwater noise measurement services to collect data for use in regulatory compliance testing and for use by marine mammal spotters to accurately establish Marine Mammal Safety Zones.

**Senior Sound and Vibration Consultant, 2008 - Present**
**Babcock & Brown Wind LLC, Rock Run Wind Energy Project Noise Impact Assessment, PA.**
Babcock & Brown is proposing to construct and operate the Rock Run Wind Energy Project in Cambria County, Pennsylvania. Following an investigation of local, state, and federal applicable noise regulations, Mr. Kalapinski developed and executed a Scope of Work that was successfully used to demonstrate compliance with applicable guidelines and local noise bylaws pertaining to construction and operation on this wind energy conversion project. Wind turbine sound source data were obtained for each of the three candidate wind turbine generators. Sound propagation modeling was conducted using the Computer Aided Noise Abatement (CadnaA) version 3.7 incorporating proprietary noise modeling algorithms while adhering to ISO9613-2 standard requirements. The results of the analysis showed compliance with the Chest Township absolute limit within a reasonable margin of error at all existing residential receptor locations.

**Senior Sound and Vibration Consultant, 2008**
**Competitive Power Ventures, Keenan Wind Energy Project, OK**
Serving as the lead acoustic engineer, Mr. Kalapinski completed an acoustic modeling analysis and regulatory compliance determination for the proposed Keenan Wind Energy Project, located in Woodward County, Oklahoma. With a total nameplate capacity estimated at 152 MW, the proposed Project consists of 66 Siemens 2.3 MW wind turbine generators. No environmental noise regulations in the State of Oklahoma, county or local level directly applicable to this Project with either numerically defined broadband or frequency dependent decibel limits were identified in our review. Therefore, to provide a screening level acoustic evaluation to determine the potential for environmental noise impacts, Project noise impact criteria were developed employing the following well-established technical and regulatory guideline documents from the US EPA, the Bureau of Land Management, and Occupational Safety and Health Administration Safety Standards. Operational sound impacts were assessed ranging from wind turbine cut-in to maximum rotational conditions. The results of the analysis and technical report conclusively showed that the Project would not result in a noise nuisance condition, and the majority of people in nearby NSAs with sound levels shown to below criteria levels will regard Project operational sound as generally acceptable, as defined per the US EPA criteria. A screening level assessment was also conducted to review noise associated with on-site transformers, transmission lines, and construction and maintenance activities. This WEC project was successfully permitted and is currently under construction.

**Senior Sound and Vibration Consultant, 2008**
**TransCanada / North Baja Pipeline LLC, Yuma Lateral Pipeline Project, Mexico and United States**
North Baja Pipeline, LLC intends to construct the Yuma Lateral Natural Gas Pipeline Project, the entirety of the proposed natural gas pipeline consists of approximately 6.41 miles of 12-inch-diameter pipe within Mexico and the U.S. The proposed pipeline will extend from the Gasoducto Bajanorte Pipeline near Algodones, Mexico to the Yucca Power Plant in Yuma, Arizona. The 3.14-mile Mexican segment would connect with Sempra's Gasoducto Bajanorte pipeline south of Algodones, Mexico and extend to the international border. At the request of the Federal Energy Regulatory Commission, Mr. Kalapinski developed a noise control plan and mitigation strategy to address noise during project construction and horizontal directional drilling would require 24-hour operation. Several candidate noise control measures were identified including the use of temporary noise control barriers to mitigate impacts at residential receptors located close to the proposed pipeline lateral.

**Senior Sound and Vibration Consultant, 2008**
**Acciona Energy / Pacific Renewable Energy Generation, LLC. Lompoc Wind Energy Project, CA**
Mr. Kalapinski completed a quick response baseline sound survey in support of permitting for the Lompoc Wind Energy Project in Santa Barbara County, California. The purpose of this task was to document the acoustic environment as requisite to provide an objective regulatory compliance determination with the California Environmental Quality Act noise impact guidelines, the criteria is determined relative to the existing acoustic environment. During the monitoring program, baseline sound data was measured and data logged continuously in 1 and 10-minute intervals. The equivalent sound level ($L_{eq}$) was then analyzed and correlated with wind speed data using standard regression analysis methodology to determine background sound levels at integer wind speed operational conditions. These data were then used to accurately assess future project related incremental noise increases using applicant provided acoustic modeling results.

**Senior Sound and Vibration Consultant, 2008**
**Tennessee Gas Pipeline Company, Concord Expansion Project, NH**
Tennessee Gas Pipeline Company intends to construct and operate a new natural gas compressor station located in Hillsborough County, New Hampshire. In support of the environmental permitting process and Federal Energy Regulatory Commission reporting requirements, Mr. Kalapinski served as lead acoustical engineer for a screening level noise impact assessment to determine the feasibility of the Project of federal, state, and local noise requirements. This noise impact assessment consisted of the following five steps: (1) establishment of pre-development ambient sound levels in the vicinity of the Site; (2) identification of potential noise sources; (3) determination of noise source terms based on industry guidelines and from similar recently constructed projects; (4) conservative predictions of maximum sound levels at NSAs using the CadnaA sound propagation model that employs standard acoustic engineering calculation methods per ISO Standard 9613.2; and (5) the identification of candidate noise mitigation measures and design specifications that will ensure compliance with applicable regulatory criteria. Mr. Kalapinski also provided a facility conceptual noise control design to ensure compliance with all applicable federal, state, and local regulatory noise limits. Expert testimony was provided in support of project permitting.

**Senior Sound and Vibration Consultant, 2007 - Present**
**Atlantic Sea Island Group LLC, Safe Harbor Energy Deepwater Port, NY**
Mr. Kalapinski was the acoustic lead for the Safe Harbor Energy Deepwater Port Project proposed to be constructed in Federal Waters on the Outer Continental Shelf, approximately 13.5 miles south of the City of Long Beach, New York. A screening levels acoustic analyses of both in-air and underwater sound levels using source-path-receiver models were used in support of report documentation drafted for the Deepwater Port Application, Topic Report Eight on Air and Noise Quality. Ongoing work on this project includes site specific underwater noise propagation modeling for future construction and operations. The

analysis has been further expanded to include the evaluation of blast air overpressure noise waves created by explosives used in demolition, pile driving during construction and potential effect on marine mammals, as well as review of environmental noise at potential construction laydown construction to be located onshore.

**Senior Sound and Vibration Consultant, 2008 - Present**
**Pacific Corp / Idaho Power, Gateway West Transmission Line Project EIS, WY and ID**
The Gateway West Transmission Project will consist of eleven segments of high-voltage alternating current transmission lines that will run between proposed or expanded existing substations. These segments start in the east at the proposed Windstar Substation close to the Dave Johnston Power Plant near Glenrock, Wyoming, and continue west until reaching the proposed Hemingway Substation approximately 40 miles southwest of Boise, Idaho. Mr. Kalapinski was the lead acoustic engineer and performed review of applicable criteria and subsequent development of project noise significance criteria guidelines for both construction and operation. An acoustic screening level analysis was completed and results provided the noise report section detailing potential for adverse noise impacts and identification of candidate noise mitigation strategies.

**Senior Sound and Vibration Consultant, 2008 - Present**
**eSolar / Alta Vista SunTower, LLC, Alta Vista Solar Generating Station, CA**
Mr. Kalapinski provided the noise assessment and mitigation analysis in support of the Application for Certification to construct and operate the Alta Vista SunTower Solar Energy Project located northwest of Lancaster in the Mojave Dessert, in the County of Los Angeles, California. The project includes two solar concentrating thermal power plants, based on distributed power tower and heliostat mirror technology, in which heliostat (mirror) fields focus solar energy on power tower receivers near the center of each heliostat array integrated with solar thermal generating equipment, including steam turbine generator. The solar thermal equipment will utilize arrays of parabolic collectors that heat a working fluid that is then used to generate steam. In accordance with CEC power plant siting regulations, Mr. Kalapinski provided the acoustical section of the AFC addressing: (1) description of compliance with applicable laws, ordinances, regulations and standards, i.e. LORS. (2) characterization of the affected environment, (3) assessment of the potential for adverse Project impacts, (4) identification of candidate noise mitigation strategies, and (5) analysis of cumulative impacts.

**Senior Sound and Vibration Consultant, 2007 - 2008**
**Iowa Department of Environmental Protection, 23rd Street Bridge Project, IA**
The Iowa Department of Transportation and the Federal Highway Administration proposed roadway improvements along West 23rd Street and the replacement of the West 23rd Street Bridge following the recent successful completion of the Perry Creek Flood Control Project. As lead acoustic engineer, Mr. Kalapinski completed a roadway noise impact analysis in support of a streamlined Environmental Assessment (EA) effort. The noise analysis was conducted in accordance with the Iowa DoT noise guidelines, which are set forth in the document entitled Highway Traffic Noise Analysis and Abatement, Policy No. 500.7, April 21, 1997. Mr. Kalapinski calculated and compared existing and future peak-hour traffic noise exposure at noise sensitive areas located within the Project study area as defined as West 23rd Street extending from Myrtle Street to Geneva Street. In addition, an evaluation of candidate noise abatement measures for areas where exceedances of applicable noise abatement criteria (NAC) were identified was conducted and noise abatement measures were recommended where such measures were deemed to be feasible and reasonable in accordance with FHWA and Iowa DoT policy guidelines. As no impacted receptors were identified in this assessment that met the feasibility requirements, it was determined that a full mitigation analysis was not warranted and the EA deemed complete. A semi-qualitative assessment of roadway construction noise was also completed.

## PREVIOUS EXPERIENCE

**Senior Sound and Vibration Engineer, 1997 - 2007**
**Tech Environmental, Inc., Waltham, MA**

**Sound and Vibration Engineer, 1995 - 1997**
**KM Chng Environmental, Inc., Burlington, MA**

### RENEWABLE ENERGY

**Cape Wind Project Noise and Vibration Analyses, MA**
For the 420 MW offshore wind farm, Mr. Kalapinski served as the lead acoustic engineer responsible for the baseline sound level measurement program, acoustic modeling of in-air and underwater sound propagation. Underwater noise measurements were completed with a B&K hydrophone and data logger to document existing conditions as well as sound levels of offshore pile driving during construction of the metrological data tower. This acoustic data were used to provide real time data for NMFS marine mammal spotters and also used to develop sit specific sound attenuation decay rates for comparison and verification of the acoustic modeling. Acoustic modeling and a detailed impact assessment was drafted providing the results of the analysis and potential effects on coastal Cape Cod communities (in-air sound) and marine mammals (underwater sound). Several alternative sites throughout the Cape and South Shore were analyzed in support of the EIS.

**Halibut Point State Park Wind Turbine Demonstration Project, MA**
Mr. Kalapinski performed an environmental noise survey and acoustical analysis of a single wind turbine installed at the Halibut State Reservation in Rockport, Massachusetts. The study was prompted by complaints by local residences of a low frequency noise occurring during elevated wind events. Noise measurements were taken throughout the park under a variety of metrological conditions. Using the data collected, a noise modeling methodology incorporating the effects of wind velocity, topography, meteorological conditions, and the wind turbine's acoustical properties was used to characterize the noise levels for park visitors, and at nearby residential receptor locations. The wind turbine noise levels were compared to state and local noise regulations and candidate mitigation measures were evaluated. Due to the fact that DEM had conceded to community pressure prior to the release of the study, the final report included re-siting guidance as well as a recommended "buffer zone" setback distance between potential future turbine sites and any noise sensitive areas.

**Highland County Virginia Wind Turbine Power Generation Project, VA**
Mr. Kalapinski completed the environmental noise assessment for a wind turbine power generation project proposed for a site located in Highland County, Virginia. The Project consisted of twenty 2 MW wind turbine generators to be constructed in a rural area of Highland County Virginia. The results of the analysis clearly demonstrated that the Project would be able to operate in full compliance with the US EPA sound criteria at all noise sensitive locations. Mr. Kalapinski also provided support during the permitting hearings including expert witness testimony in a court of law and assistance in cross-examination of opposing witnesses.

**Massachusetts Technology Collaborative Renewable Energy Trust, MA**
Mr. Kalapinski was contracted as the sole approved acoustical consultant for the wind energy initiative for the MTC to provide ongoing acoustical engineering services for municipal wind turbine projects throughout the Commonwealth.

## TRADITIONAL ENERGY

**1500 MW Harford Power Project, MD.**
Mr. Kalapinski conducted a noise impact study for a 1,500 MW combined-cycle power project in Harford County, Maryland proposed by Conectiv. Baseline sound level monitoring and acoustic modeling were performed to calculate impacts at eight noise sensitive receptor locations. Several mitigation options were evaluated and compliance with the Maryland Department of the Environment (MDE) Noise Regulation was demonstrated. He assisted in the preparation of the Certificate of Public Convenience and Necessity (CPCN).

**510 MW ECAR Power Projects, Mid-Atlantic US**
Orion Energy was seeking to develop two gas-fired peaking power plants in the ECAR region in Henderson, Kentucky and Ceredo, West Virginia. Each plant was 510 MW and consisted of six GE 7EA turbines. Mr. Kalapinski's role in the project included and acoustical analysis that required the development of acceptable noise impact criteria for these regions that do not have state or local regulations with numerical decibel limits. A noise baseline monitoring and impact assessment was performed at both project locations. The final impact report included comparisons to EPA environmental noise guidelines and audibility thresholds. Mitigation measures were incorporated into the facility design to reduce off-site noise impacts.

**135 MW Chesapeake Peaking Station, VA**
Mr. Kalapinski completed a facility-wide noise mitigation analysis at an existing peaking station in Accomack County, Virginia, owned by Teco Energy. The mitigation analysis was conducted in response to violations for excessive noise, cited by the County Commissioners. A comprehensive noise and vibration monitoring program, using one-third octave bands, FFT, and sound intensity measurements, was conducted at all major onsite sources to document the acoustical fingerprint. Offsite measurements completed both indoor and outdoor of nearby residences were completed to identify the spectrum responsible for the complaints. Low frequency tonal sounds were identified and recommendations for mitigation were provided to the client. New stacks and silencers were designed and installed to reduce turbulence noise responsible for the low frequency rumble. Following the replacement of the stacks, follow-up testing demonstrated full compliance with the local noise criteria and noise complaints from local residences have since ceased.

**El Paso Corporation Gas Turbine Addition at Two Compressor Station Sites, MA**
Mr. Kalapinski completed a sound survey and predicted future off-site noise impacts for the Tennessee Gas Pipeline horsepower addition at two compressor stations located in Mendon and Agawam, Massachusetts. The analysis demonstrated that with the proposed noise control treatments, the predicted sound levels would be in full compliance with the broadband and pure tone requirements of the Massachusetts DEP's Noise Policy at all property line and residential receptor locations. A Best Available Noise Control Technology (BANCT) analysis was completed with various mitigation strategies outlined, and net benefit versus cost information as part of the analysis. A Federal Energy Regulatory Commission (FERC) Resource Report 9 for noise was also completed for both compressor stations.

**1800 MW Astoria Repowering Project, NY**
The existing Astoria Generating Station in New York City was being re-powered as a combined-cycle facility by Orion Energy using six Siemens/Westinghouse 501F turbines. Mr. Kalapinski prepared the noise study for the HYSDPS Article X application that includes comprehensive baseline sound level monitoring, acoustic modeling, impact sound isopleths, and cumulative impact modeling of the project with two other nearby combined-cycle projects that have been proposed.

**1650 MW Free State Electric Power Project, MD**
Mr. Kalapinski conducted a noise impact study for a 1650 MW combined-cycle power project in Charles County, Maryland being developed by Orion Energy. Baseline sound level monitoring and acoustic modeling were performed to calculate impacts at 16 sensitive receptor locations. Several mitigation options were evaluated and compliance with the Maryland Department of the Environment (MDE) Noise Regulation was demonstrated. He assisted in the preparation of the Certificate of Public Convenience and Necessity (CPCN).

**302 MW Bellingham Cogeneration Plant, MA**
The existing power plant in Bellingham, Massachusetts owned by Florida Power & Light was issued a notice of non-compliance by the Massachusetts DEP regarding noise. Mr. Kalapinski completed a comprehensive sound survey of the plant and identified tonal sound sources in two locations: the high pressure steam line split outside the turbine building, and the natural gas lines and valves next to the HRSG's. Mitigation for these sources was designed and documented in a report submitted to the DEP. Monitoring in the neighborhood was conducted to demonstrate compliance with the Town and DEP noise regulations. Mr. Kalapinski also provided assistance in meetings with DEP enforcement staff.

**620 MW Frederick Power Project, MD**
Mr. Kalapinski conducted a noise impact study for a 620 MW combined-cycle power project in Point of Rocks (Frederick County), Maryland being developed by Duke Energy North America. Both short and long-term sound level monitoring were completed at 12 noise sensitive receptor locations. Acoustic modeling was performed and detailed contour maps developed for several noise mitigation strategies and facility layouts. Compliance with the Maryland Department of the Environment (MDE) Noise Regulation was demonstrated. He also assisted in the preparation of the Certificate of Public Convenience and Necessity (CPCN).

## COMMERCIAL AND REAL ESTATE DEVELOPMENT

**Noise Analyses for C&D and Solid Waste Transfer, Disposal and Recovery Facilities, Northeast US**
Mr. Kalapinski has provided acoustical engineering services for transfer and disposal facilities throughout Massachusetts to support local zoning approvals. Projects typically include baseline monitoring, modeling of onsite sound sources, development of mitigation strategies, and post construction monitoring to demonstrate compliance with the regulatory limits. Projects include: Winchendon Sanitary Landfill, Winchendon; Mill Creek Solid Waste Transfer Station, Revere; Champion City Recovery Project, Brockton; and Cottage Street Landfill, Springfield.

**Acoustical Engineering Services for Over 50 Super Stop & Shop Supermarkets, Northeast US**
Mr. Kalapinski has provided acoustical engineering services for over 40 new and redeveloped Stop & Shop Supermarkets throughout New England, New York, and New Jersey. Serving as the principle field engineer, he has conducted sound level measurement programs, modeling of mechanical and roadway sound sources, and developed cost-effective noise mitigation strategies to ensure compliance with state and local noise criteria.

**Acoustical Support Services for Boston Developers filing PNF, PIR, EIR Documents, Boston, MA**
Mr. Kalapinski provided acoustic engineering services for over 25 real estate development projects in Boston, Massachusetts. Typical services included the documentation of baseline sound levels, analysis of future noise impacts from the project's mechanical equipment, comparison of results to the City of Boston and the Massachusetts DEP noise criteria, and the recommendation of noise mitigation, when necessary. For residential development projects, the existing peak hour noise was identified and compared to the US Dept. of Housing and Urban Development (HUD) design criteria for residential projects. Where exceedances were documented, acoustical design assistance was provided to bring interior ambient levels

to acceptable levels. Examples of projects includes: McAllen Building-Court Square Press; 251 Heath Street Residences; Albany Fellows; Joslin Diabetes Center; Portside at Pier 1; Mass College of Pharmacy; Dover Residences; Mt. Vernon Residences; 3 Dorchester Street; Highland Springs; 45 Province Street; 154 Berkeley Street; Pier 4; Brigham Circle; Saltonstall Building; Court Square; Parcel C; Dorchester Bay; CANA Parcels 1, 2 & 4; BioSquare; 99 Tremont Street; South End Place; Wilkes Passage; One Lincoln Street; Parcel P2; D Street Residences; Hotel Commonwealth Ave; 201 Essex Street; East First Street Residences.

**Acoustical Engineering Services for The Home Depot and Lowes Home Improvement Stores, Northeast US**
Mr. Kalapinski has provided expert acoustical engineering services for over 15 existing and proposed stores in Pennsylvania, Maine, Connecticut, New York, New Hampshire, Massachusetts, and Vermont. His role included baseline and compliance noise measurements, modeling of principle sound sources, and the development of candidate mitigation options including the use of barriers, low noise equipment, and silencers to ensure compliance with state and local noise criteria. Mr. Kalapinski also provided expert testimony in public hearings.

**Verizon Wireless Tower Sitings Acoustical Consulting, Northeast US**
Mr. Kalapinski was requested by Verizon to document operational sound levels of a prototype cellular station, and on a task order basis to project those sound levels at several proposed siting locations throughout Nee England. The potential noise sources were identified and were limited, in general, to the base structure which houses HVAC equipment that operates periodically to regulate interior temperatures, and an emergency generator which operates only during power outages and during short-term equipment reliability testing, as per the manufacturer's specifications. Eolian (or wind generated noise caused by turbulence with the tower structure) were also examined using accepted acoustical techniques of modeling noise emissions from turbulent gas flows. Mr. Kalapinski reviewed the equipment shelter and generator silencer design for each site to ensure that both normal operation of the shelter's HVAC equipment, and worst-case operation of all onsite support equipment, including an emergency generator, would be in compliance with applicable sound level criteria.

## CONSTRUCTION

**Boston Central Artery/Tunnel Project Consulting, MA**
Mr. Kalapinski completed noise predictions and quarterly control plans for the construction phase of over 15 CA/T work sections. This included developing construction noise mitigation to meet stringent daytime and nighttime noise criteria for commercial and residential property. In areas where structures were identified as historic and/or land use sensitive to construction noise and vibration, special consideration was provided. Existing noise and vibration levels were measured to define the existing or baseline conditions. Estimates of construction noise and vibration were developed based on equipment and activities to be performed. When predicted levels exceeded the applicable construction criteria established for this project, appropriate mitigation measures were recommended. In addition, contractor personnel were trained to perform construction noise measurements and construction equipment certification measurements.

**Massachusetts Water Resource Authority MetroWest Tunnel Project, MA**
Construction noise and vibration levels were predicted and evaluated against project specific noise criteria. Construction noise models assessing specific phases and durations of construction activities and scheduled equipment were developed to predict noise at nearby sensitive receptors. Blasting noise and vibration prediction were developed and compared to regulatory criteria. Candidate mitigation methods were evaluated where noise exceedances were predicted.

## MUNICIPAL SERVICES

**The City of Boston Environment Department Noise Compliance Monitoring, MA**
Mr. Kalapinski provided ongoing noise compliance monitoring for the City of Boston Environment Department. The purpose of this testing was to measure and document operational noise levels at locations that have been flagged due to complaints from Boston residences. The purpose of the monitoring was to determine whether the noise source under investigation was operating in compliance with the City of Boston Noise Control Regulations. Over the course of the contract, 25 noise surveys were completed, analyzed, and results reported to the City. Under the legal direction of The Environment Department, affidavits and cease and desist orders were prepared for owners/operators of the mechanical equipment that were exceeding the limits.

**Town of Dalton Noise Compliance Monitoring and Training, MA**
Mr. Kalapinski provided noise consulting services to the Board of Health (BoH) related to ongoing noise complaints due to operation of a gravel extraction operation located in Dalton, Massachusetts. Services included: (1) the development of a noise compliance monitoring plan using the procedures set forth in the recently approved Dalton Noise By-Law; (2) completion of compliance measurements at noise sensitive areas selected by the Board of Health; and (3) noise compliance training to BoH staff on noise meter operation and the interpretation of results. A written report describing the findings of the field survey included a comparison of the results to both the Dalton criteria and the Massachusetts Department of Environmental Protection (DEP) Noise Policy criteria and was presented by Mr. Kalapinski to the Town in a public hearing.

**Environmental Power Plant Reviews for Three Towns, MA**
Mr. Kalapinski provided noise impact reviews for the Boards of Selectmen in the Towns of North Smithfield, Rhode Island, and Dracut and Weymouth, Massachusetts regarding proposed combined-cycle turbine projects in those Towns. The projects are the 350 MW North Smithfield Energy Center (Indeck), the 750 MW Nickel Hill Energy Project (Constellation Power), and the 750 MW Fore River Station (Sithe Energies Group). Assistance was provided to the Towns as interveners in the Energy Facilities Siting Board process. A formal review of submitted noise documentation was completed and expert testimony was given in public hearings.

## WASTEWATER

**City of New Bedford/Wastewater Treatment Facility, MA**
Mr. Kalapinski was the project manager for an acoustic analysis of the New Bedford Wastewater treatment facility, an analysis that was prompted by local complaints of obtrusive noise originating from the facility. The goal of the study was to determine whether or not the facility was consistently operating within its permitted acoustic design goals. Long-term monitoring was proposed due to the fact that the complaints could not be linked to a specific operation or time period. An analysis of 18 days of measurements collected at four noise sensitive locations and one onsite monitoring station were analyzed for loudness, pure tone, and excessive low frequency spectra components. The study's conclusions, which were presented to the Town by Mr. Kalapinski in a special hearing, concluded that for over 99% of the time, sound from the facility could not be directly linked to community environmental sound levels, and at no time during our testing were the sound levels from facility operations (at any of the residential areas) above standard nuisance thresholds, including the nuisance thresholds that are actively enforced under the DEP Noise Policy.

**Town of Rockport/Water Treatment Facility, MA**
Mr. Kalapinski was project manager for a noise impact study for the Rockport Wastewater Aeration Blower Building. The goal of the study was to minimize future sound levels generated by the operation of

the aeration centrifugal blowers at the closest residential locations. The aeration was being added to reduce odors, and the MWRA did not want an odor problem that would be transferred into a noise problem. Multiple iterations of the building and blower design were completed in order to determine the best available noise control technologies for the project, as well the optimum building location and orientation, given the high-density residential area in which the building would be constructed. With the recommendations provided by Mr. Kalapinski, operation of the aeration centrifugal blowers was shown to be consistent with the measured existing nighttime ambient sound levels and in full compliance with the DEP Noise Policy.

## TRANSPORTATION

**Acoustical Consulting Services for State Highway and Transportation Departments, Northeast US**
Mr. Kalapinski has provided noise consulting services for several state Highway Departments and Transportation Authorities in support of EIR/EIS preparations. Services included noise and vibration monitoring, modeling roadway traffic using the FHWA Traffic Noise Model, rail movements using FTA's sound and vibration algorithms, mitigation development including barrier analysis and optimization, construction noise analysis, and he also provided expert witness testimony. Projects included: Mass Highway Department Salem Street Bridge; Manchester, NH Airport Access Road EIR/EIS; Maine DoT Route I-95/Stillwater Avenue Interchange Project; NH DoT Spaulding Turnpike; Massachusetts Bay Transportation Authority Attleboro to New Bedford/Fall River Commuter Rail Service; Massachusetts Bay Transit Authority Bradford Layover Facility EIR; Massachusetts Bay Transportation Authority Canton Viaduct Rehabilitation Project; Rhode Island Department of Transportation Freight Rail Improvement Project EIS; Massachusetts Bay Transportation Authority Orient Heights Rail Yard; Mass Highway Department Sagamore Rotary, and Mass Highway Department Route 44.

**Acoustical Engineering Services for Warehouse, Truck Terminal, and Refueling Facilities, Northeast US**
Mr. Kalapinski provided acoustical engineering services for over a dozen warehouse and truck terminal facilities throughout New England, in support of the state and local permitting process. Studies included baseline and compliance measurements, and the prediction of sound levels using standard acoustical modeling techniques including sound generated from HVAC units and air handling units, unloading activities at the loading dock and within the building, trash compactors, outdoor speakers and mobile sources namely truck travel on the site. Mitigation analyses were provided as necessary to comply with state and local noise criteria. The projects sites were: Poland Springs/Perrier (Seabrook, NH); Watkins Motor Lines (Windsor Locks, CT); DeMoulas Supermarkets (Tewksbury, MA); International Cargo Post II (Boston); General Mills (Haverhill, MA); Irving Oil Refueling Station (Eliot ME); Home Depot Distribution Warehouse (Shrewsbury, MA); Crystal Cold Storage (Medford, MA); Cirelli Foods (Middleborough, MA); Perkins Paper (Taunton, MA); Haffner Truck Stop (Amesbury, MA); and P&O Cold Logistics (Taunton, MA).

**Project Experience – Siting and Architectural Acoustic Services, Northeast US**
Mr. Kalapinski provided acoustical engineering support to several developers seeking assistance in the siting and construction of residential houses and condominiums in high noise areas. Services included long-term monitoring, and comparison of existing ambient sound levels to ANSI, HUD, EPA and FHWA criteria. When a proposed site did have elevated environmental sound levels that exceed the ideal residential criteria, Mr. Kalapinski worked with the developer to identify cost-effective construction methods and materials to bring interior sound levels down to acceptable levels. To reduce exterior sound levels, the FHWA TNM program was used to design an optimized berm and/or barrier location and height to maximize the developer's cost/benefit ratio. Projects include: Kasprazak Condominiums (Kennebunk, ME); Lancaster Union Properties (Lancaster, MA); Greendale Avenue Project (Needham, MA); Jenny's Way (Tewksbury, MA); Katz Development (Exeter, NH); and Hitchin' Post Greens (Westford, MA).

**Two Financial Center Environmental and Architectural Acoustic Design, MA**
Mr. Kalapinski provided environmental and architectural acoustic design services for Two Financial Center in Boston, MA. The environmental component of the project evaluated the potential noise impacts from the project's mechanical equipment on nearby sensitive receptors. The purpose of the noise analyses was to demonstrate compliance with the City of Boston and the Massachusetts Department of Environmental Protection noise regulations. During the mechanical design process, low noise equipment and appropriate noise control measures, including acoustical louvers and a rooftop penthouse, were implemented. The final design allowed the developers to demonstrate compliance with the City of Boston and DEP noise regulation at all nearby sensitive receptors.

The architectural acoustical design focused on providing a high-quality interior acoustic environment for executive office and presentation space. Mr. Kalapinski worked directly with the architects and project owner to identify potential problem areas and to provide mitigation methods to ensure compliance with the interior design goals. Mitigation methods employed included a floating floor for the penthouse emergency generator room, structurally isolated wall constructions and high noise transmission loss components in areas adjacent to potential noise sources, a thorough review of space adjacencies (functional proximity requirements and separation between noisy and quiet functions), and a review of the HVAC/air distribution equipment (an assessment the HVAC design to determine requirements for possible targets for additional noise reduction efforts).

**MILITARY AND DEPARTMENT OF DEFENSE**

**Massachusetts Military Reservation (MMR), MA.**
Mr. Kalapinski was part of a large team of consultants under the Cecil Group and was responsible for dealing with ongoing noise issues at the MMR. To demonstrate compliance with the Federal noise criteria, he quantified various noise generated from the activities by the Massachusetts Army National Guard, Mass. Air National Guard, Coast Guard, schools, and other tenants of the MMR. Air traffic (both helicopter and fixed wing aircraft) was modeled, as were onsite vehicular traffic and weapons training exercises.

**Noise Impact Study of Otis ANGB F-15 Operations on a Proposed Section 40B Housing Development in Sandwich, MA.**
Mr. Kalapinski was the field engineer in charge of developing and implementing a wide area, long-term noise monitoring program to document both residual sound levels and high energy sound levels occurring during F-15 operations at Otis Air National Guard Base on Cape Cod. The purpose of the measurements was to document the potential impacts on a proposed nearby Section 40B affordable housing subdivision.

## PUBLICATIONS & PRESENTATIONS

American Wind Energy Association. Mr. Kalapinski presented AWEA's 2nd Wind Power Project Siting Workshop, Siting Wind Power Projects in the Eastern US. The presentation provided technical guidance on wind turbine project permitting issues specific to the field of acoustics including baseline sound measurement, noise modeling and analyses, and criteria. Boston, Massachusetts, 2005.

## PROFESSIONAL AFFILIATIONS

Institute of Noise Control Engineering, Full Member, Number 10244
Acoustical Society of America, Associate Member, Number 10706732

## DISCIPLINE CODES

01 Acoustical Engineer, Y

## SKILL SET

| | | |
|---|---|---|
| Acoustics | Environmental Impact Statements | Sound and Vibration Measurements |
| Environmental Assessment | In-Air Noise Modeling | Noise Control Engineering |
| Underwater Noise Modeling | Permitting Strategy | Vibration Analysis |

## TECHNICAL EXPERTISE

Proficient in the following:

- Cadna A (comprehensive three-dimensional sound modeling software)
- Federal Highway Association's Traffic Noise Model (TNM) and Roadway Construction Noise Model (RCNM)
- Federal Transit Administration's Transit Noise and Vibration Impact Assessment Software
- Design and application of in-air and underwater noise and vibration measurement systems

Representative expert testimony before planning, health, and environmental boards and commissions and courts of law are as follows:

State of Vermont Department of Environmental Conservation. Provided expert witness testimony at DEC Act 250 hearings in support of a proposed rock quarry in Moretown, VT.

Monterey County Court, Highland County, Virginia. Provided a written deposition and expert witness testimony in the field of acoustics in support of the Highland New Wind Energy Project

Town of Ayer, MA Planning Board. Presented noise impact analysis of the proposed Guilford Rail Auto Unloading Facility.

Town of Dalton, MA Board of Health. Reported the results of noise compliance measurements. In addition, provided technical support to BoH staff in filing a cease and desist order on a gravel extraction operation for violations of the Town's noise bylaw.

Town of Winchester, MA Planning Board. Presented a sound study of potential noise from a proposed driving range expansion at a private golf course in Winchester.

City of Leominster, MA Planning Board. Provided expert witness testimony for noise and lighting for a proposed large shopping center on Route 117 near I-290 in Leominster, MA containing a Super Wal-Mart, Lowe's Home Improvement Store, and Kohl's.

Town of Windsor Locks, CT, Planning Board. Presented the results of a noise impact and mitigation analysis for a proposed Watkins Motor Trucking Lines Break-Bulk facility.

City of Merrimack, NH, Planning Board. Provided expert witness testimony for a proposed Home Depot store development.

City of West Roxbury, MA Planning Board. Presented the results of the acoustical study for a proposed Roche Brothers Supermarket.

City of New Bedford, MA Special Public Hearings. Presented the results of a noise measurement program completed to determine the state of compliance of the New Bedford Wastewater Treatment facility.

City of Weymouth, MA Public Hearings. Provide expert witness testimony for the acoustic engineering review of the Fore River Power Station.

## LANGUAGE SKILLS

Knowledge Level:

## PROFESSIONAL REFERENCES

## RELATED COMPANY INFORMATION

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# Lee-DeKalb Wind Energy Center
# Acoustic Assessment for DeKalb County, Illinois

**Prepared for:**

FPL Energy Illinois Wind, LLC

**March 19, 2009**

**Prepared by:**


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SGS

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Appendix A Illinois Noise Regulation
Appendix B Substation Acoustic Compliance Analysis

# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| A | extraneous attenuation factors |
| Applicant | FPL Energy Illinois Wind, LLC |
| CadnaA | Computer Aided Noise Abatement Program |
| D | directivity |
| DW | downwind |
| dB | decibel |
| dBA | A-weighted decibel |
| dBL | linear decibel |
| EPA | United States Environmental Protection Agency |
| ft | feet |
| Hz | Hertz |
| HPD | hearing protection devices |
| IEC | International Electrotechnical Commission |
| IPCB | Illinois Pollution Control Board |
| ISO | International Standard Organization |
| LBCS | Land-Based Classification Standards |
| $L_{dn}$ | day-night averaged sound level |
| $L_{eq}$ | equivalent sound level |
| LFN | low frequency noise |
| $L_{max}$ | maximum instantaneous sound level |
| $L_p$ | sound pressure level |
| $L_w$ | sound power level |
| m | meter |
| m/s | velocity in meters per second |
| MW | megawatt |
| NEMA | National Electrical Manufacturers Association |
| OSHA | Occupational Safety and Health Administration |
| PEL | permissible exposure limit |
| Project | Lee-DeKalb Wind Energy Center |
| PSA | Project Study Area |
| R | linear (slant) distance of Lp from source |
| Tetra Tech | Tetra Tech EC, Inc. |
| µPa | micropascal |
| USGS | United States Geological Survey |
| WEC | wind energy center |
| WTG | wind turbine generator |

# EXECUTIVE SUMMARY

An acoustic assessment has been completed for the proposed 151-turbine Lee-DeKalb Wind Energy Center (WEC) Project (Project) in Lee and DeKalb Counties, Illinois. The objectives of this study were to: (1) establish potential Project sound sources and site-specific sound propagation characteristics; (2) calculate worst case operational octave band frequency and broadband sound levels during a range of future Project operational conditions; and (3) determine the feasibility of the Project to operate in compliance with all applicable noise standards. Acoustic modeling results were compared to applicable environmental noise regulations adopted by the Illinois Pollution Control Board (IPCB).

Wind turbine sound source data were obtained from General Electric, the manufacturer of the GE XLE 1.5 MW wind turbine model. Sound propagation modeling was conducted using the Computer Aided Noise Abatement (CadnaA) software program (version 3.7.123) which is a comprehensive 3-dimensional acoustic program specifically developed for the power generation industry. CadnaA software was programmed to conform to the International Standard ISO 9613.2 "Attenuation of Sound During Propagation Outdoors." The industry standard CadnaA acoustic modeling software is widely used by sound engineers due to its adaptability to describe complex acoustic scenarios. It has been shown to be a highly effective acoustic modeling tool for wind energy development projects sited in Europe, Canada and the United States. Specific details pertaining to acoustic modeling methodology are given in Section 4.0 of this document.

The overall conclusions of the acoustic assessment are as follows:

As the proposed Project location exists in an agricultural rural environment, existing factors that may mask wind turbine operational sound include seasonal insects, farming activities including plowing and use of other mechanical equipment, and leaf and crop rustle sound during elevated wind conditions. The Project study area predominantly consists of farmland and the vegetation in the fields will serve to absorb some of the sound generated by the turbines. Audible sound from the Project will likely not be deemed excessive or unusually loud with sound levels below thresholds identified by the US EPA and the IPCB and will be consistent with sound generated at similar wind energy projects successfully sited throughout the State of Illinois and the United States employing similar noise criteria limits. The Project will generate sound levels that are within acceptable regulatory limits.

The results of the acoustic assessment demonstrate that the Project will operate in full compliance with the Illinois State noise regulations at all existing residential receptor locations. The Project will also comply with the environmental noise guidelines as developed by the United States Environmental Protection Agency (EPA).

# 1.0 INTRODUCTION

FPL Energy Illinois Wind, LLC (Applicant) proposes to construct an approximately 226.5-megawatt (MW) wind energy facility in Lee and DeKalb Counties, Illinois named the Lee-DeKalb Wind Energy Center (WEC) Project (Project). The portion of the Project to be constructed in DeKalb County consists of 133 turbines. This acoustic assessment is limited to addressing the sound levels resulting from Project operations in DeKalb County.

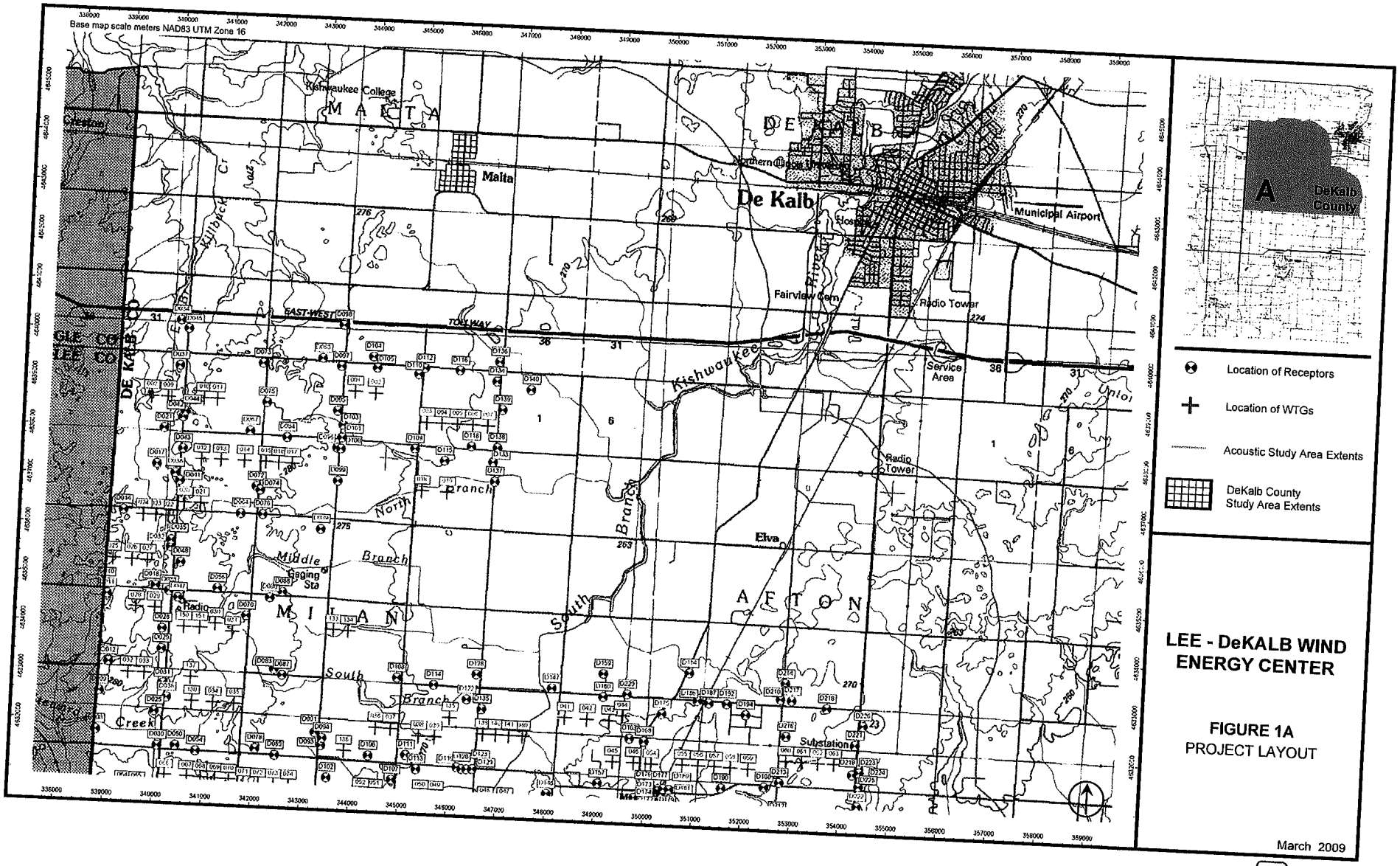
Each individual turbine is rated at 1.5 megawatts (MW) with a rotor diameter of 271 feet (82.5 meters) and an effective hub height of 262 feet (80 meters) above grade. In support of the environmental assessment for the Project, Tetra Tech EC, Inc. has completed an acoustic assessment, adhering to the Illinois Pollution Control Board (IPCB) noise limit regulations. Tetra Tech worked with the Applicant and evaluated several layout alternatives through an iterative acoustic process over an extended study period. This document presents the findings of that assessment, illustrating the predicted sound levels during Project operation and determining the feasibility of the Project to operate in compliance with applicable noise regulations and voluntary EPA guidelines.

## 1.1 Project Study Area

The Project Study Area (PSA) within DeKalb County consists of approximately 59,452 acres and is located southwest of the city of DeKalb, Illinois in north-central Illinois, approximately 75 miles west of Chicago. The predominantly flat PSA is located in a semi-rural setting with scattered residences surrounding Lee, Illinois, which is partially in DeKalb County. U.S. Route 30 runs north-south through the village of Lee, while U.S. Route 23 is located just south of Lee. A railroad also passes through the northwestern portion of the PSA, and the closest airport is located in the city of Rochelle, approximately 12 mile northwest of Lee. Interstate Highway I-88 also runs along the northern edge of the PSA.

Land use in the PSA primarily consists of corn and soybean agricultural fields. The turbine arrays are laid out in east-west rows to take advantage of the prevailing winds while taking into consideration available land and topography, in addition to minimizing interference with local farming operations. The topography of the PSA is characterized by flat terrain and minimal tree coverage. Consideration of PSA topography is important for both propagation and the degree to which the sound generated from the wind turbines is masked by wind. For instance, receptors located in valleys or depressed areas may be shielded from the wind and experience lower background sound levels, though at elevated wind turbine generator (WTG) hub heights the wind is strong enough to drive the rotor. The PSA topography information was imported into the acoustic model using the official United States Geological Survey (USGS) digital elevation dataset to accurately represent terrain in three dimensions.

The villages of Shabbona and Waterman, located in DeKalb County lie within close proximity of the Project. Shabbona, which consists of an approximate 0.7 square mile area, had a population of 929 according to the U.S. 2000 Census Bureau, whereas Waterman consists of an approximate 1.0 square mile area with a U.S. 2000 Census recorded population of 1,224. Figures 1A and 1B present the PSA, the locations of the proposed Project WTGs, and discrete residential receptor locations that were included in the acoustic assessment. Due to the extended acoustic study area, all figures in this report have been subdivided into two sections, A and B, to more effectively present data visually.

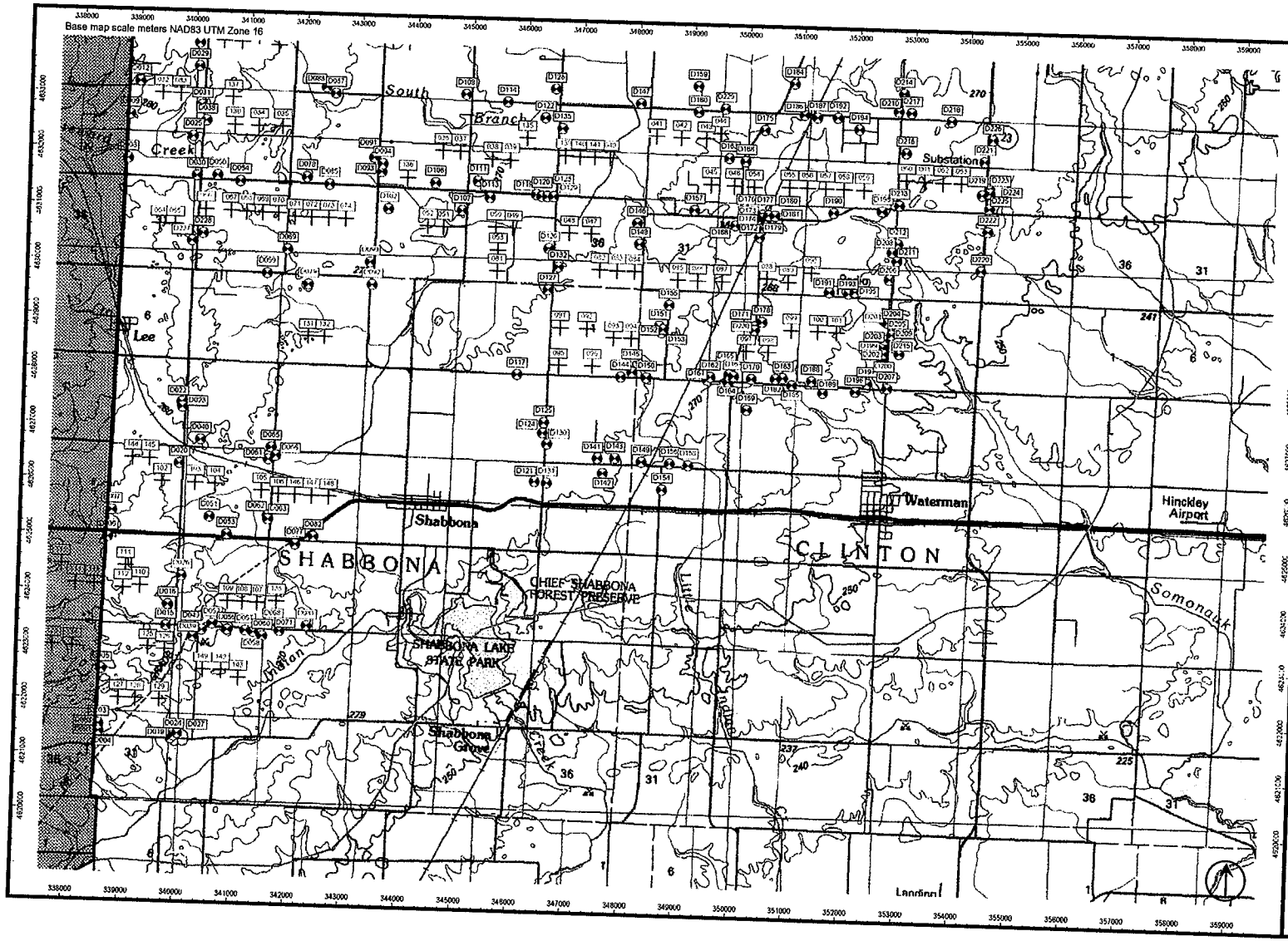


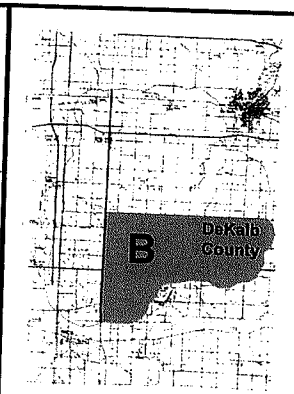

**LEE - DeKALB WIND ENERGY CENTER**

**FIGURE 1A**
PROJECT LAYOUT

March 2009

TETRA TECH




Location of Receptors

Location of WTGs

Acoustic Study Area Extents

DeKalb County Study Area Extents

**LEE - DeKALB WIND ENERGY CENTER**

**FIGURE 1B**
PROJECT LAYOUT

March 2009

TETRA TECH

## 2.0 ACOUSTIC TERMINOLOGY & DEFINITIONS

All sounds originate with a source whether it is a human voice, motor vehicles on a roadway, or crickets chirping in a field. Every source has a sound power level ($L_w$), which is an inherent property of the sound source that is independent of external factors. By definition, the sound power is the rate at which acoustical energy is radiated from a sound source and it is expressed in terms of Watts. The sound energy travels from the source to a person's ears as sound waves, which are rapid oscillatory compressional changes in air. In other words, sound travels as fluctuations of air pressure above and below the atmospheric pressure. The sound pressure ($L_P$) is the amount of variation in air pressure fluctuation a source creates. At a given distance, the sound pressure level can be measured using a microphone or calculated based on knowledge of the source sound power level. In this acoustic assessment, sound pressure levels also include the effects of propagation and attenuation that occur along the path between the source and receiver. Sound power level cannot be measured directly, but is determined through measurements of sound intensity or sound pressure near the source.

Sound pressure can be expressed in units of microPascals (μPa). When characterizing silence versus loud sounds, the difference in sound pressure is a factor of 1,000,000:1 or more. Discussing sound pressure levels using large numbers such as these is very unpractical; therefore, an alternative scale was adopted. The logarithmic decibel scale was adopted to accommodate the huge dynamics of sound intensities to which the human ear is subjected and the standard unit of sound is the decibel (dB). By definition, the decibel corresponds to ten times the base-10 logarithm of the ratio of two powers. For example, 10 $\log_{10}(P_1/P_2)$ quantifies the difference between two powers $P_1$ and $P_2$. , and a 10-dB difference means that $P_1$ is 10 times higher than $P_2$.

A reference level is necessary to determine absolute levels in dB. For sound power, the logarithm is taken of the ratio of the actual sound power to the reference sound power of 1 picowatt. This value is then multiplied by 10 to calculate the decibel value. For sound pressure, the equation is similar by taking 20 times (to compensate for the use of quadratic units) the logarithm of the ratio of two sound pressures ($p_1$ and $p_2$).

$$10\log\left(\frac{P_1}{P_2}\right) = 10\log_{10}\left(\frac{p_1^2}{p_2^2}\right) = 20\log_{10}\left(\frac{p_1}{p_2}\right)$$

For every level using decibel terms, there must be a well-defined reference quantity. Though sound power and sound pressure use different references, the decibel principle is identical. When the sound pressure or sound power equals its respective reference quantity, the decibel level will be equal to zero. For example, in environmental acoustics, the reference sound pressure level is 20 μPa, the approximate threshold of human perception to sound at a frequency of 1000 Hz. Therefore, a sound pressure level of 20 μPa would be equal to its reference quantity and result in a decibel value equal to zero. Table 1 illustrates how a tenfold increase of the sound pressure will result in increases in 20 dB steps.

**Table 1 Logarithmic Definition for Sound Pressure Levels (Linear form, non squared units)**

| Relation of Value to Reference | Exponential Form of Ratio | Level Form 20*Exponent | Corresponding Sound Pressure (µPa) |
|---|---|---|---|
| 1 | $10^0$ | 0 | 20 (Reference) |
| 10 | $10^1$ | 20 | 200 |
| 100 | $10^2$ | 40 | 2,000 |
| 200 | $10^3$ | 46 | 4,000 |
| 1,000 | $10^4$ | 60 | 20,000 |
| 10,000 | $10^5$ | 80 | 200,000 |
| 100,000 | $10^6$ | 100 | 2,000,000 |
| 1,000,000 | $10^7$ | 120 | 20,000,000 |

An inherent property of the logarithmic decibel scale is that it is not possible to directly add or subtract physical quantities when expressed in decibel form since the addition of logarithmic values correspond to multiplication of the original quantity. For example, if a sound of 50 dB is added to another sound of 50 dB, the total is a 3-decibel increase (or 53 dB), not an arithmetic doubling to 100 dB.

Sound is typically composed of acoustic energy across a wide range of frequencies, referred to as the frequency spectra; however, the human ear does not interpret the sound level from each frequency as equally loud. The A-weighting filter attenuates low and high frequency energy similar to the way people hear sound. This weighting is most commonly used for the evaluation of environmental sound levels and is the most widely accepted descriptor for community noise assessments. Sound levels that are A-weighted to reflect human response are presented as dBA in this report.

Scientific research demonstrates the following general relationships between sound level and human perception:

- 1 dBA is the practically achievable limit of the accuracy of noise measurement systems and corresponds to an approximate 10% variation in sound pressure. A 1 dBA increase or decrease is a non-perceptible change in sound.
- 3 dBA increase or decrease is a doubling (or halving) of acoustic energy, and it corresponds to the threshold of perceptibility of change in a laboratory environment. In practice, the average person is not able to distinguish a 3 dBA difference in environmental sound outdoors.
- 5 dBA increase or decrease is described as a perceptible change in sound level and is a discernable change in an outdoor environment.
- 10 dBA increase or decrease is a tenfold increase or decrease in acoustic energy but is perceived as a doubling or halving in sound (i.e., the average person will judge a 10 dBA change in sound level to be twice or half as loud).

Sound levels can be measured, modeled and presented in various formats. The most common sound metric used in community sound surveys is the equivalent sound level ($L_{eq}$). The $L_{eq}$ value is the energy averaged sound level and is defined as the steady, continuous sound level, over a specified time, which has the same acoustic energy as the actual varying sound levels over the same time. Community sound levels are also often described in terms of the day-night averaged sound level ($L_{dn}$). The $L_{dn}$ is a 24-hour, A-weighted average sound level that uses the same energy-averaged equivalence concept as with the $L_{eq}$, but has a nighttime addition (penalty) of 10 dB on levels that occur during the hours of 10:00 p.m. and

7:00 a.m. The nighttime penalty accounts for the increased annoyance that comes with elevated sound levels at night.

Studies have shown that additional annoyance occurs during the nighttime since background sound levels are typically at their minimum, and many people are sound sensitive while trying to sleep. For sound sources that operate continuously over a 24-hour period, a 55 $L_{dn}$ is equivalent to both a 24 and one-hour $L_{eq}$ of 48.6 dBA. The $L_{eq}$ and $L_{dn}$ have been shown to provide both an effective and uniform method for comparing time varying sound levels that typically occur and have been used routinely in community acoustic assessments for wind energy projects.

The $L_{max}$ is the maximum instantaneous sound level as measured during a specified time period. It can also be used to quantify the maximum instantaneous sound pressure level generated by a piece of equipment or an activity that normally varies with time or the maximum allowable sound pressure level as set by regulatory agencies or the manufacturer.

The $L_{eq}$, $L_{dn}$ and $L_{max}$ metrics are broadband, i.e., they include sounds at all audible frequencies. In addition to broadband, sound level data typically include an analysis of the various frequency components of the sound spectrum to determine tonal characteristics. The unit of frequency is Hertz (Hz), measuring the cycles per second of the sound pressure waves, and typically the frequency analysis examines eleven octave (or 1/3 octave) bands from 16 Hz (low) to 16,000 Hz (high).

Estimates of various indoor and outdoor sound levels and acoustic environments (as would likely occur under calm to light wind conditions) are presented in Table 2. Table 3 presents additional reference information on terminology used in wind energy environmental noise assessments.

**Table 2 Various Indoor and Outdoor Sound Pressure Levels**

| Outdoor Sound Levels | Sound Pressure (μPa) | | Sound Level (dBA) | Indoor Sound Levels |
|---|---|---|---|---|
| | 6,324,555 | - | 110 | Rock Band at 5 m (16 ft) |
| Jet Over-Flight at 1000 ft. (300 m) | | - | 105 | |
| | 2,000,000 | - | 100 | Inside New York Subway Train |
| Gas Lawn Mower at 1 m (3 ft) | | - | 95 | |
| | 632,456 | - | 90 | Food Blender at 1 m (3 ft) |
| Diesel Truck at 15 m (50 ft) | | - | 85 | |
| Noisy Urban Area—Daytime | 200,000 | - | 80 | Garbage Disposal at 1 m (3 ft) |
| | | - | 75 | Shouting at 1 m (3 ft) |
| Gas Lawn Mower at 30 m | 63,246 | - | 70 | Vacuum Cleaner at 3 m (3 ft) |
| Suburban Commercial Area | | - | 65 | Normal Speech at 1 m (3 ft) |
| Air Conditioning Unit at 20 feet | 20,000 | - | 60 | |
| Light Auto Traffic at 100 feet | | - | 55 | Quiet Conversation at 1m (3 ft) |
| Quiet Urban Area—Nighttime | 6,325 | - | 50 | |
| Suburban Area—Daytime | | - | 45 | |
| Quiet Rural Area—Daytime | 2,000 | - | 40 | Empty Theater or Library |
| Suburban Area—Nighttime | | - | 35 | |
| Quiet Rural Area—Nighttime | 632 | - | 30 | Quiet Bedroom at Night |
| | | - | 25 | Empty Concert Hall |
| Rustling Leaves | 200 | - | 20 | Average Whisper |
| | | - | 15 | Broadcast and Recording Studios |
| | 63 | - | 10 | |
| | | - | 5 | Human Breathing |
| Reference Pressure Level | 20 | - | 0 | Threshold of Hearing |

Notes: μPa - Micropascals describe sound pressure levels (force/area).
dBA - A-weighted decibels describe sound pressure on a logarithmic scale with respect to 20 μPa.
SOURCE: Data compiled in part by Tetra Tech from multiple technical and engineering resources and also from direct acoustic field measurement experience. Data should be used for general informational purposes only.

**Table 3 Acoustic Terms and Definitions**

| Term | Definition |
|---|---|
| Noise | Noise and sound are physically the same. Noise is typically defined as unwanted sound based on level, character, frequency or pitch, time of day, and sensitivity and perception of the listener. |
| Sound Pressure Level ($L_P$) | Pressure fluctuations in a medium (air in this case). Sound pressure is measured in decibels referenced to 20 micronewtons per square meter (or microPascals), the approximate threshold of human perception to sound at 1000 Hz. |
| Sound Power Level ($L_W$) | The total acoustic power of a noise source measured in decibels referenced to $10^{-12}$ watts. Sound power is independent of the environment The wind turbine noise specification is provided by the manufacturer in these terms since sound power is independent of environment. |
| A-Weighted Decibel (dBA) | Environmental sound is typically composed of acoustic energy across all frequencies (Hz). To compensate for the auditory frequency response of the human ear, an A-weighting filter is commonly used for describing environmental sound levels. Sound levels that are A-weighted are presented as dBA in this report. |
| Unweighted Decibels (dBL) | Unweighted sound levels are referred to as linear, or dBL. Linear decibels are used to determine a sound's tonality and to engineer solutions to reduce or control noise as techniques are different for low and high frequency noise. |
| Acoustic Modulation | Technical term describing the variation of sound pressure caused by aerodynamic noise as the blade passes through the air and interaction with turbulence effects created by the tower structure, i.e. blade swish. |
| Propagation/Attenuation | The decrease in amplitude of an acoustic signal due to geometric spreading losses with increased distance from the source. Other factors that can effect attenuation include air absorption, terrain effects, ground absorption, diffraction around objects and topographical features, trees, and meteorological conditions including wind velocity, temperature, humidity and non-homogenous atmospheric conditions. |
| Octave Bands | The audible range of humans spans from 20 to 20,000 Hertz and is typically divided into center frequencies (Hz) ranging from 31 to 8,000 Hz. |
| Masking | Interference in the perception of one sound by the presence of another sound. At elevated wind speeds, wind generated noise and leaf rustle will mask WTG sound levels which remain relatively constant. |
| Broadband | Containing sound energy at all frequencies across the entire audible spectra. |
| Low Frequency Noise (LFN) | The frequency range of 20 to 200 Hz is typically defined as low frequency noise. At sufficiently high levels, LFN can cause vibrations in structures and physiological effects in humans. Low frequency noise is generally associated with older wind turbines with downwind rotor configurations. For comparative purposes, the lowest note on a full range piano is approximately 32 Hz and middle C is 261 Hz. |
| Directivity | Directivity accounts for the variation in sound intensity with orientation relative to the noise source. The Directivity correction is given as DI. |
| Wavelength | The distance between peaks of a propagating wave with a well defined frequency. It is related to the frequency through the following equation $\lambda=c/f$ where c is the sound speed and f is the frequency in Hz. It has the dimensions of length. |

Notes: Compiled by TtEC from multiple technical and engineering sources

# 3.0 NOISE REGULATIONS AND GUIDELINES

The DeKalb zoning ordinance refers to the Illinois Pollution Control Board (IPCB) rules and regulations with respect to acceptable environmental noise levels. The IPCB regulations describe a comprehensive approach to the measurement and assessment of commercial and industrial noise, and thus are relevant to the development and operation of wind energy projects. The EPA has published noise guidance criteria in their landmark 1974 report on the effects of environmental noise. These guidelines were implemented as voluntary Project design goals to further assist in the identification of the potential for adverse impacts within the acoustic study area.

With exception to the United States Occupational Health and Safety Administration's (OSHA) regulations that describe health and safety limits for noise exposure, there are no other overarching State or Federal noise regulations or requirements specific to this Project or wind energy facilities in the State of Illinois. The IPCB regulatory limits are the controlling noise criteria for the Project.

These regulatory and guideline limits are absolute and independent of the existing acoustic environment; therefore, a baseline noise survey was not required for this Project to provide a regulatory compliance determination.

## 3.1 Illinois Pollution Control Board (IPCB) Noise Regulations

The Environmental Regulations for the State of Illinois, IPCB standard *Part 901: Sound Emission Standards and Limitations for Property Line Sources* identify frequency dependent linear decibel limits for noise sensitive land uses such as a residential/accommodations area. The IPCB employs a land use classification system for the purposes of applying octave band center frequency decibel sound limits for source receiver designations per the State Land-Based Classification Standards (LBCS). The proposed Project site and surrounding areas are classified as Class C land by the LBCS and is zoned as an Agricultural District under the DeKalb County Use Districts. The area will remain a Class C land as the WEC project is considered an Alternative Energy Source. The IPCB classifies land use of a residential or accommodation function, in addition to other potentially noise sensitive functions such as recreational parks and educational services, as Class A use.

Part 900, General Provisions, of the IPCB regulations, defines noise pollution as "the emission of sound that unreasonably interferes with the enjoyment of life or with any lawful business or activity". In the IPCB Opinion R72-2 in the Matter of Noise Pollution Control Regulations further stipulates (with emphasis) "so as to violate any regulation or standard adopted by the Board under this Act". Part 900, General Provisions, of the IPCB regulations, defines a property-line noise-source as any equipment, facility or combination thereof, which operates within any classification of land as specified by the LBCS in Section 901.101. The regulation explicitly states that during daytime hours no person shall cause or allow the emission of sound from any property-line noise-source located on Class A, B, or C land to any receiving Class A land, which exceeds the allowable linear octave band sound pressure levels presented in Table 4. The IPCB does not regulate sound emitted from Class C land to Class C land or to otherwise unclassified land.

Section 901.102 of the regulation provides noise limits for daytime (07:00-22:00) and nighttime (22:00-07:00) hours for sound emitted to Class A land from noise sources on Class C land. For purposes or our assessment, Class A use on Class C Land has been defined as the residential structure. When the daytime Class C land octave band sound pressure level limits provided in Table 4 are summed

logarithmically and A-weighting is applied, the resulting allowable broadband sound pressure level limit to receiving Class A land is approximately 60 dBA daytime.

**Table 4 Illinois Pollution Control Board Allowable Daytime Octave Band Sound Pressure Level Limits According to Emitting Land Use Area**

| Octave Band Center Frequency (Hz) | Allowable Daytime Octave Band Sound Pressure Levels (dBL) of Sound Emitted to any Receiving Class A Land from | | |
|---|---|---|---|
| | Class C Land | Class B Land | Class A Land |
| 31.5 | 75 | 72 | 72 |
| 63 | 74 | 71 | 71 |
| 125 | 69 | 65 | 65 |
| 250 | 64 | 57 | 57 |
| 500 | 58 | 51 | 51 |
| 1000 | 52 | 45 | 45 |
| 2000 | 47 | 39 | 39 |
| 4000 | 43 | 34 | 34 |
| 8000 | 40 | 32 | 32 |

Source: Sec 901.102 of the Illinois State Noise Regulation

To account for lower background noise levels and increased sensitivity to environmental noise, nighttime sound pressure level limits are lower than those set for daytime hours. The nighttime limits are provided in Table 5. When summed and A-weighted, the allowable nighttime Class C land octave band sound pressure level limits are equivalent to an overall broadband sound pressure level to receiving Class A use of approximately 50 dBA. Assessing compliance of a broadband source on a frequency dependent basis is a conservative approach and is required under IPCB Regulations.

**Table 5 Illinois Pollution Control Board Allowable Nighttime Octave Band Sound Pressure Level Limits According to Emitting Land Use Area**

| Octave Band Center Frequency (Hz) | Allowable Nighttime Octave Band Sound Pressure Levels (dBL) of Sound Emitted to any Receiving Class A Land from | | |
|---|---|---|---|
| | Class C Land | Class B Land | Class A Land |
| 31.5 | 69 | 63 | 63 |
| 63 | 67 | 61 | 61 |
| 125 | 62 | 55 | 55 |
| 250 | 54 | 47 | 47 |
| 500 | 47 | 40 | 40 |
| 1000 | 41 | 35 | 35 |
| 2000 | 36 | 30 | 30 |
| 4000 | 32 | 25 | 25 |
| 8000 | 32 | 25 | 25 |

Source: Sec 901.102 of the Illinois State Noise Regulation

For the purpose of this assessment, all of the Lee-DeKalb WEC Project area is assumed as Class C land. Therefore, the first columns of the daytime and nighttime allowable octave band sound pressure level data in Tables 4 and 5 (in bold) apply as a basis of regulatory compliance for predicted sound levels at all existing residential receptor locations. For projects such at the Lee-DeKalb WEC Project that may operate during daytime or nighttime, the more stringent nighttime limits are the controlling factor. The limits presented in Tables 4 and 5 are based on $L_{eq}$ averaging, as defined in 35 Ill. Adm. Code 900-101, using a reference time of one hour. For time-varying sources, conservatively assessing compliance under the worst case operational condition ($L_{max}$) will ensure compliance during all other possible future operational conditions.

The Illinois noise regulations also include a prohibition of a tonal condition. A tonal condition is defined as sound spectra in which any 1/3 linear octave band sound pressure level exceeds the arithmetic average of the two adjacent 1/3 octave bands by the following amounts:

- 5 dB for such one-third octave band with a center frequency from 500 Hz to 10,000 Hz, inclusive.
- 8 dB for such one-third octave band with a center frequency from 160 Hz to 400 Hz, inclusive.
- 15 dB for such one-third octave band with a center frequency from 25 Hz to 125 Hz, inclusive.

Per IPCB, the tonal provision does not apply to prominent discrete tones having a one-third octave band sound pressure level that are 10 dB or greater below the allowable octave band sound pressure level limit for the octave band which contains the one-third octave band.

## 3.2 Environmental Protection Agency Environmental Noise Guidelines

While the EPA has no regulations governing environmental noise, the EPA has conducted extensive studies to identify the effects of certain sound levels on public health and welfare. In 1974, the EPA published a landmark noise document entitled, "Information on Levels of Environmental Noise Requisite to Protect the Public Health and Welfare with an Adequate Margin of Safety". It is important because it remains the authoritative published study that includes a large database of community reaction to noise. The EPA "Levels Document" identifies sound levels "requisite to protect the public health and welfare with an adequate margin of safety" (U.S. EPA 1974). The EPA sound level guidelines do not provide an absolute measure of noise impact, but rather a consensus on potential community interference and likelihood of annoyance. For outdoors in residential areas and other places in which quiet is a basis for use, the recommended EPA guideline is an $L_{dn}$ of 55 dBA (equivalent to a $L_{eq}$ (1-hour) of 48.6 dBA assuming continuous 24-hour operation). The EPA document also suggests a $L_{eq}$ of 70 dBA (24-hour) limit to avoid adverse effects on public health and safety at publicly accessible property lines or extents of work areas where extended public exposure is possible. These criteria were not developed because they are practical, but because they represent criteria that are very protective of both human health and welfare. EPA criteria limits are summarized in Table 6.

**Table 6 Summary of EPA Cause and Effect Noise Levels**

| Location | Level | Effect |
|---|---|---|
| All public accessible areas with prolonged exposure | 70 dBA $L_{eq(24)}$ | Safety / hearing loss concerns |
| Outdoor at residential structure and other areas where a large amount of time is spent | 55 dBA $L_{dn}$ | |
| Outdoor areas where limited amounts of time are spent, i.e., park areas, school yards, golf courses, etc. | 55 dBA $L_{eq(24)}$ | Protection against annoyance and activity interference |
| Indoor residential | 45 dBA $L_{dn}$ | |
| Indoor non-residential | 55 dBA $L_{eq(24)}$ | |

The EPA document states that the levels identified are low enough to be protective with an adequate margin of safety. From page 4 of the EPA document, "These levels are not to be construed as standards, as they do not take into account cost or feasibility." It should also be noted that in any environment, a portion of the general population may be annoyed (and complain) due to the presence of any level of recurring audible sound, regardless of the actual or perceived loudness. On a broadband basis, the EPA guideline level is 1.4 dBA lower (48.6 dBA) than the nighttime IPCB limit for Class C land emitting sound to any receiving Class A land of 50 dBA when discrete frequencies are summed individually. The IPCB 50 dBA maximum total sound power output could only occur if the sound pressure was at the maximum permissible level for each of the regulated frequency bands. Because of the nature of the sound power output of the GE wind turbine systems; this will not occur under operating conditions

## 3.3 Occupational Safety and Health Administration Noise Safety Standards

The Federal Government has long recognized the potential hazards caused by noise on industrial and construction projects. OSHA's current noise standard for the construction industry stems from the occupational noise standard originally published in 1969 by the Bureau of Labor Standards under the authority of the Construction Safety Act (40 U.S.C. 333). OSHA adopted the construction noise standard in 1971 (36 FR 7340, 4/27/ 71) and later recodified it as 29 CFR 1926.52. Another section of the construction standard (29 CFR 1926.101) contains a provision requiring employers to provide hearing protection devices when needed. Both sections 1926.52 and 1926.101 apply to employers engaged in construction where high noise levels are possible.

**Table 7 OSHA Permissible Daily Noise Exposure Limits**

| Duration of Exposure Per Day (Hours) | Sound Level (dBA) |
|---|---|
| 8 | 90 |
| 6 | 92 |
| 4 | 95 |
| 3 | 97 |
| 2 | 100 |
| 1 ½ | 102 |
| 1 | 105 |
| ½ | 110 |
| ¼ or less | 115 |

Paragraph (a) of section 1926.52 requires protection against the effects of noise exposure when 8-hour time-weighted average sound levels exceed a permissible exposure limit (PEL) of 90 dBA, measured on the A-scale of a sound level meter set at slow response. The exposure level is raised 5 dB for every halving of exposure duration as shown in Table 7. Furthermore, exposure to impulsive or impact noise should not exceed a 140 dB peak sound pressure level.

Paragraph 29 CFR 1926.52(b) states that when employees are subjected to noise doses exceeding those shown in Table 7, feasible administrative or engineering controls will be identified and implemented to lower employee noise exposure. If controls fail to reduce sound to the PEL, personal protective

equipment must be provided and used to reduce noise exposure. In compliance with OSHA, Project contractors will be required to readily provide construction workers with OSHA approved hearing protection devices (HPD) and to identify high noise areas and activities where hearing protection will be required. Operational sound generated from the Project will not approach OSHA noise exposure limits even in very close proximity to individual WTG locations.

## 3.4 Summary of Acoustic Criteria

A summary of the pertinent acoustic criteria used to assess sound levels at existing sensitive areas during Project operation is provided below:

- EPA 70 dBA $L_{eq}$ (24) at publicly accessible Project property lines or extents of work areas where extended public exposure is possible;
- EPA 55 dBA $L_{eq}$ (24) in outdoor areas where limited time is spent;
- 55 dBA $L_{dn}$ (24) outdoors at all residential receptor locations where extended periods of time are spent outdoors, residential structures and areas in close proximity to the residential structure. i.e. yards. Wind turbines operate intermittently depending on wind conditions at hub height. Assuming the wind turbine is operating as a continuous steady state sound and is the dominant contributor of environmental sound level at the receiver location, the $L_{dn}$ is approximately 6.4 dB above the measured $L_{eq}$. Consequently, an $L_{dn}$ of 55 dBA corresponds to a maximum instantaneous $L_{eq}$ of 48.6 dBA;
- IPCB nighttime octave band frequency dBL dependent limits for Class C land emitting sound to present Class A use located within the designated Class C land (Table 5); and
- OSHA regulatory limits for worker and public safety exposure to high noise levels.

State and community noise standards are one important aspect of affording adequate protection of human health and of quality of life. Noise criteria identified cannot be used to infer audibility thresholds; however, compliance with IPCB standards and EPA guidelines would likely result in reduced probability of annoyance and noise complaints. Inaudibility under all operating conditions is an unrealistic expectation, and one that is not required under any other industrial, commercial, or agricultural activity in the State of Illinois. These EPA noise guidelines are considered unenforceable internal design guidelines. OSHA safety and IPCB environmental noise regulatory limits are mandatory requirements at all times. Regulations and guidelines presented are absolute and are assessed for Project generated noise only. They are independent of existing acoustic environment; therefore, no baseline sound survey is required to assess conformity.

# 4.0 ACOUSTIC MODELING METHODOLOGY

## 4.1 Wind Turbine Sound Characteristics

There are two principal sound sources from an operating wind turbine generator (WTG): mechanical and aerodynamic sound. Mechanical sound is generated at the gearbox, generator, and cooling fan and is radiated from the surfaces of the nacelle and machinery enclosure and by openings in the nacelle casing. Aside from upset conditions that may create mechanical noise, the dominant noise generating components of utility scale WTGs are aerodynamic.