Acentech Report No. 359R

Acoustical Study of Proposed Beech Ridge Wind Farm Greenbrier County, WV

May 2006

James D. Barnes
Brian W. Donald
Joseph Horesco
Jonah Sacks

Submitted by:

Acentech Incorporated
33 Moulton Street
Cambridge, MA 02138

Prepared for:

Invenergy Wind LLC
3460 Olney-Laytonsville Road
Olney, MD 20832

Table of Contents

List of Figures and Tables

1. Introduction

Invenergy Wind LLC has proposed to design, construct, and operate a nominal 200 MW wind farm at a mountainous rural site in southeast West Virginia. In support of this project, Invenergy has requested that Acentech Incorporated perform an acoustical study of this project and provide information for review by the West Virginia Public Service Commission (WVPSC) during the site permitting process. To date, Acentech has reviewed the facility and site drawings, equipment information, and the revised noise study guidelines of the WVPSC that were provided to us by Invenergy; toured the project area; conducted sound measurements and observations of the existing ambient conditions at representative community locations; and estimated construction and operation sound levels for the facility. This report presents the ambient sound measurements and results of our acoustical study.

2. Description of Proposed Facility and Site

The proposed wind power project consists of up to 124 General Electric (GE) Model 1.5sle wind turbine generators (WTGs) and associated equipment, with each WTG to be mounted on individual 80-meter tall towers across 20 miles of ridgelines in Greenbrier County, WV. The associated equipment includes a 2 MVA transformer at each WTG tower, 34.5kV underground transmission lines for the electrical collection system, a 34.5/138kV substation with a 200 MVA main transformer and service building, and a 138kv overhead transmission line for connection to the power grid. Figure 1 displays the wind turbine lines (A through J) overlaid on a map of the region.

Each GE Series 1.5sle wind turbine incorporates a horizontal-axis propeller that drives a gearbox and generator mounted to the top of an 80-m (260-ft) high tower. A nacelle for weather protection and noise control encloses the gearbox and generator. The 77-m (250-ft) diameter rotor has three blades, which attach to a hub that contains active blade pitch control; this system provides for peak aerodynamic efficiency over a range of wind conditions. During routine operation, the rotational speed of the rotor will range from 10 to 20 revolutions per minute; and at wind speeds below 3.5 m/s (8 mph) and at wind speeds above 25 to 30 m/s (56 to 67 mph), it will not operate. The rated capacity of this unit is 1.5 MW at a wind speed of 12 m/s (27 mph). The WTGs include the following noise control treatments into its design: impact noise insulation of the gearbox and generator, reduced-noise gearbox, reduced-noise nacelle; vibration isolation mounts, and quieted-design rotor blades.

The wind farm is located on the mountain ridges to the north of Rt. 60 and I-64 and south of the Monongahela National Forest, and to the west of Rt. 219, and to the east of Big Clear Creek. Lightly traveled paved and unpaved roads cross this rural area, which is dotted with scattered homes and

seasonal hunting cabins, and with several small groups of homes and churches in settlements such as Duo, Leonard, Cordova, Friar's Hill, Trout, and Williamsburg. The substation will be constructed in the center of the wind farm with the overhead transmission line running to the northwest from the substation out to the external power grid.

3. Guidelines for Noise Studies

The WVPSC Guidelines for Noise Studies for Siting Certificates include:

- Preconstruction – identify land uses and existing ambient sound levels (Ldn) in communities within one mile of the facility.

- Construction – predict construction noise associated with blasting, earthmoving, pile driving, erection, traffic, and equipment installation at the nearest property boundary and within one mile and five miles from the facility. Identify noise sensitive areas within one mile and five miles of the facility. The noise sensitive areas include hospitals, schools, residences, cemeteries, parks, and churches. Describe construction equipment, procedure, and potential noise mitigation options.

- Operation – predict operation noise and identify land uses and type of structures (residential, commercial, or industrial) within one mile of the facility. Describe equipment and procedures to mitigate potential noise.

Information on the preconstruction ambient, construction, and operation sounds for the facility are presented in the following sections. Please refer to "Appendix A - Sound in Lay Terms" for a useful overview of sound and its measurement.

4. Preconstruction Ambient Sound Measurements

Figure 2 is a map of the project area with an overlay of the proposed turbine sites, land use classifications, the community sound measurement locations, and the measured day-night sound levels (Ldn). Table 1 describes the six monitoring locations selected for the ambient survey that Acentech conducted over a nominal one-week period in late September to early October 2005. The acoustic environment and nearby land uses were observed at these locations, and they were judged representative of those at the noise sensitive receptors, such as residences and churches, in the community bordering the project site.

The weather during the survey was seasonal and ranged from clear to cloudy skies with some rain early in the survey, calm to windy conditions, and temperatures from about 70ºF during the day down to about 50ºF at night. As Table 1 notes, most of the monitoring locations are near homes or small groups of homes and seasonal hunting cabins; and the locations range from 900 ft. (seasonal hunting cabins) to 3200 ft.* and 7800 ft. (year-round homes) from the nearest WTG location. The purpose of the survey was to characterize the existing land uses, sound sources, acoustic environment, and specifically, representative long-term Ldn values in the area. Figures 3 through 12 display photographs of the six locations where the A-weighted sound levels were monitored continuously during the survey. The field team also collected short-term measurements and observations during visits to each monitoring location. The observed sources typically included wind in trees, local traffic, birds, insects, aircraft, and a flowing creek. The results of these supplemental short-term measurements will be maintained in our project files. Table 2 lists the instruments that were employed for the ambient survey.

Figures 13 through 18 display the variations in sound levels that were measured at the six locations. To address the WVPSC Noise Guidelines for Noise Studies, the figures show the Leq sound level for each hour, and also, indicate the Ldn sound level for the nominal one-week period. As mentioned above, Appendix A provides an overview on sound and its measurement, and in particular, discusses the Leq and Ldn descriptors. Please note that Leq sound levels include both the steady background sounds (steady wind in trees or rushing stream) and the short-term intrusive sounds (e.g., bird chirps or local car passby). Of most significance, the data indicate that the long-term Ldn sound levels ranged from 49 dBA to 52 dBA, with an average value of 50 dBA and a standard deviation of 1.5 dBA across the six locations. Table 3 lists the long-term Ldn values measured at each location. The measured Ldn values, sound source types, and land uses are relatively uniform across the one-mile buffer area, and the study area contains no dominant existing sound sources that would generate sound contours, for example, a factory or a well-traveled Interstate highway. Therefore, the ambient sound level contours are flat within this area so that no individual contours are shown on Fig. 2, but instead, individual measured Ldn values are given.

* Homeowners in Little Beech Knob area (Location 2) to participate in project; otherwise, approximate distance to nearest WTG would be one mile.

5. Construction Noise Estimates and Mitigation Measures

Construction of the Beech Ridge Wind Farm is scheduled to start in Spring 2007 and continue to November 2007. Initial activities (Phase I) will include improvements and new construction of facility access roads; then clearing, excavation, foundation, and backfill work at the WTGs and the substation. Concrete for the project will be made at temporary on-site batch plants using trucked-in materials. Phase I activities will be followed by Phase II activities, which are comprised of erection of the WTG towers and installation of the WTGs; trenching and installation of the electrical collection system; and installation of substation equipment. Finally, prior to commercial operation, the individual equipment items and the entire facility will be tested and commissioned during Phase III.

A majority of the construction activities associated with the proposed project will be conducted during daylight hours. At times over the planned construction schedule, the construction activities will be audible to nearby residents. Any construction at the facility in the evening and nighttime is expected to be limited to relatively quiet activities and to be less noticeable than in the daytime.

The following mitigation measures will be employed during the construction phase of the project:

- Effective exhaust mufflers in proper working condition will be installed on all engine-powered construction equipment at the site. Mufflers found to be defective will be replaced promptly.

- Require contractors to comply with federal limits on truck noise.

- Construction contractors will be required to ensure that their employee and delivery vehicles are driven responsibly.

- Nighttime construction work that does occur will generally be limited to relatively quiet activities, such as welding and installing equipment, cabling, and instrumentation.

- Notify the community in advance of any blasting activity.

Construction sound that may be heard off-site will vary from hour-to-hour and day-to-day in accordance with the equipment in use and the operations being performed at the site. Since the construction activity at the site will be temporary, will occur mostly in the daytime hours, and will produce sounds that are already familiar to the community, its overall noise impact on the community beyond 1000 ft. of the nearest turbine is not expected to be significant. The community currently

experiences sound from timber operations, and has in the past and may in the future, experience sound from mining operations. In fact, mining is currently on-going in the region to the south and west of the project.

Typical on-site equipment used to construct the wind farm project will include trucks, cranes, dozers, excavators, trenchers, graders, and batch plants. Representative equivalent sound levels associated with these construction equipment during the workday are listed in Table 4. For example, with 2 trucks, 1 dozer, and 1 excavator operating at a WTG, the calculated equivalent sound level during the workday is 54 dBA at 1550 ft. (nearest property boundary and closest residence in Little Beech Knob* to WTG) and 41 dBA at 4000 ft. The reported sound levels are based on the results of extensive previous acoustical studies of engine-powered construction equipment. Figure 19 displays the contours of the estimated maximum Ldn sound levels over the entire study area for Construction Phase 1, which include the contributions of construction truck traffic, with comparisons to the measured preconstruction ambient Ldn values. These contours were developed with a commercial computer noise modeling program, Cadna/A. This program employs ray-tracing technology that accounts for various factors, including geometric spreading, atmospheric absorption, and wind conditions; for our modeling, we used wind rose data that were collected at the Beech Ridge site.

6. Station Sound Estimates and Mitigation Measures

The range of sound levels that will propagate from the wind turbine generators to various locations in the community around the site have been predicted. The project is addressing the facility sound with the purchase of the General Electric 1.5sle wind turbine generator, which incorporates the following noise control treatments into its design:

- Noise insulation of the gearbox and generator
- Reduced-noise gearbox
- Reduced-noise nacelle
- Vibration isolation mounts
- Quieted-design rotor blades

In addition, the project will specify and purchase high-efficiency, reduced-noise transformers. The estimated Ldn operating sound levels for the six community monitoring locations, and also,

* Homeowners in Little Beech Knob area (Location 2) to participate in project; otherwise, approximate distance to nearest WTG would be one mile.

Friars Hill, Trout, and Williamsburg, are listed in Table 5. Of added note, Figures 20 and 21 (without and with land use classifications, respectively) display the Ldn sound contours for the operating facility. The estimated Ldn values and contours for the operating phase were developed with the computer noise modeling program, Cadna/A. The estimated values at the community monitoring locations with year-round residences for the wind farm Ldn sound levels range from 17 dBA to 41 dBA*, which compare to the measured preconstruction ambient values of 49 dBA to 52 dBA. The facility sound estimates assume maximum sound output of all 124 wind turbine generators, which occurs under conditions of maximum rated wind speed (27 mph). Under conditions of reduced wind speeds, the background sound associated with wind in trees would be less; however, the WTG sound emissions would also be less.

The project sound levels are estimated on a time-weighted basis (Ldn) for outdoor locations; for indoor locations, these levels would be reduced by 12 dBA with the windows open and by 24 dBA or more with the windows closed. Although we judge that the wind farm may be heard at times in the community at distances of 4000 ft. from the project, our measurements and estimates indicate that the long-term Ldn sound levels of the wind farm will be significantly less than the existing ambient Ldn levels at that distance for both outdoor and indoor locations.

7. Noise Impact Assessment

As noted in Section 5, the majority of the construction activities associated with the project will be conducted during the daylight hours, and it will vary over time, depending on the equipment in use and the operations being performed at the site. The temporary noise associated with construction of the project will be similar to the noise produced during excavation, grading, and steel erection activities at many other mid-size building projects, and the current timber and mining activities in the region.

The project will be available to operate 24-hours per day and seven days per week. It is expected that routine operation will produce day-night sound levels in the community that are similar to or lower than the measured existing ambient day-night sound levels.

Community residents at 4000 ft. from the project may at times hear sounds associated with construction or operation of the project, but the overall impact is not expected to be significant at either outdoor or indoor locations.

* Homeowners in Little Beech Knob area (Location 2) to participate in project; otherwise, wind farm Ldn sound levels would range up to 39 dBA at year-round community residences in the vicinity of the project.

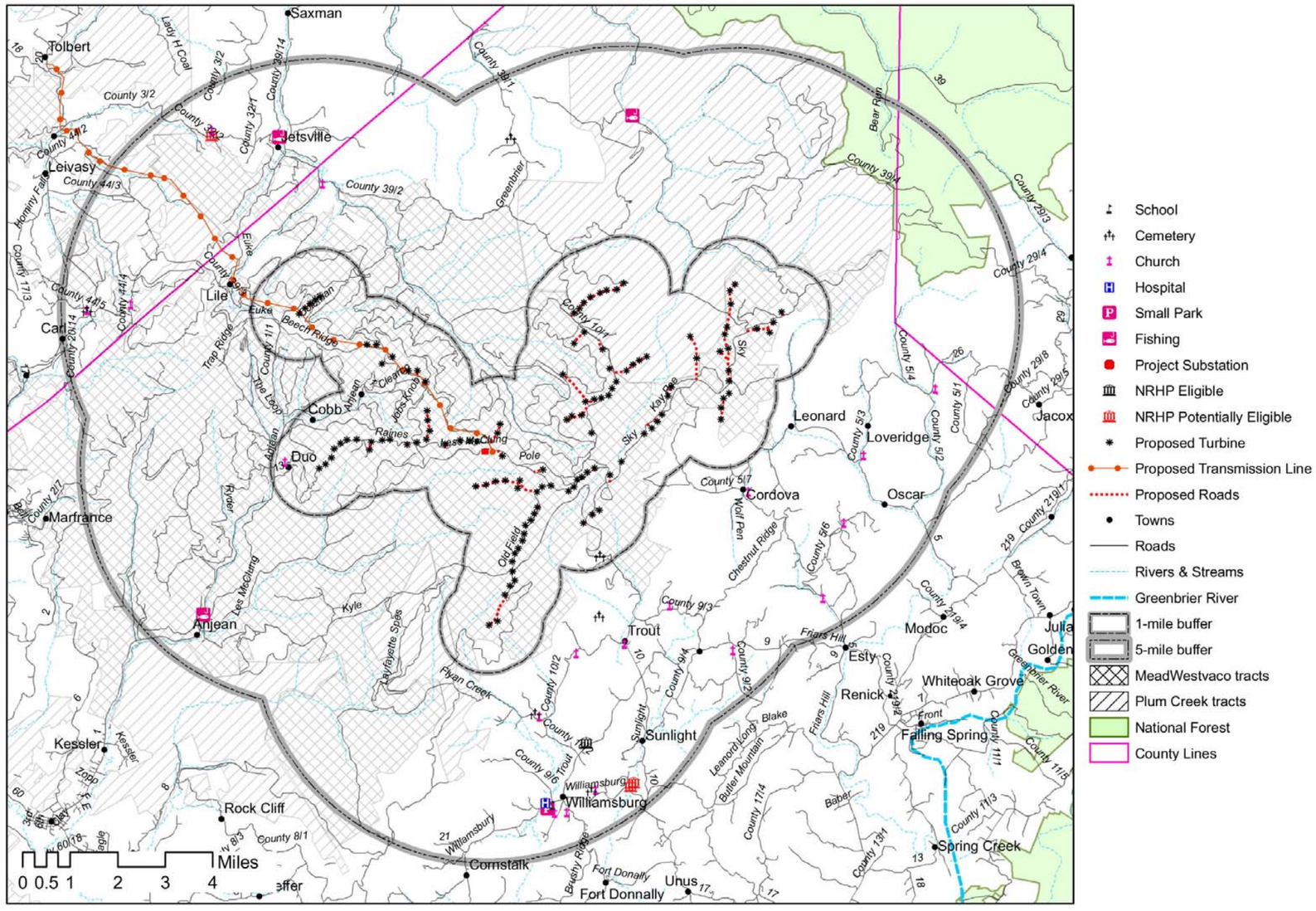
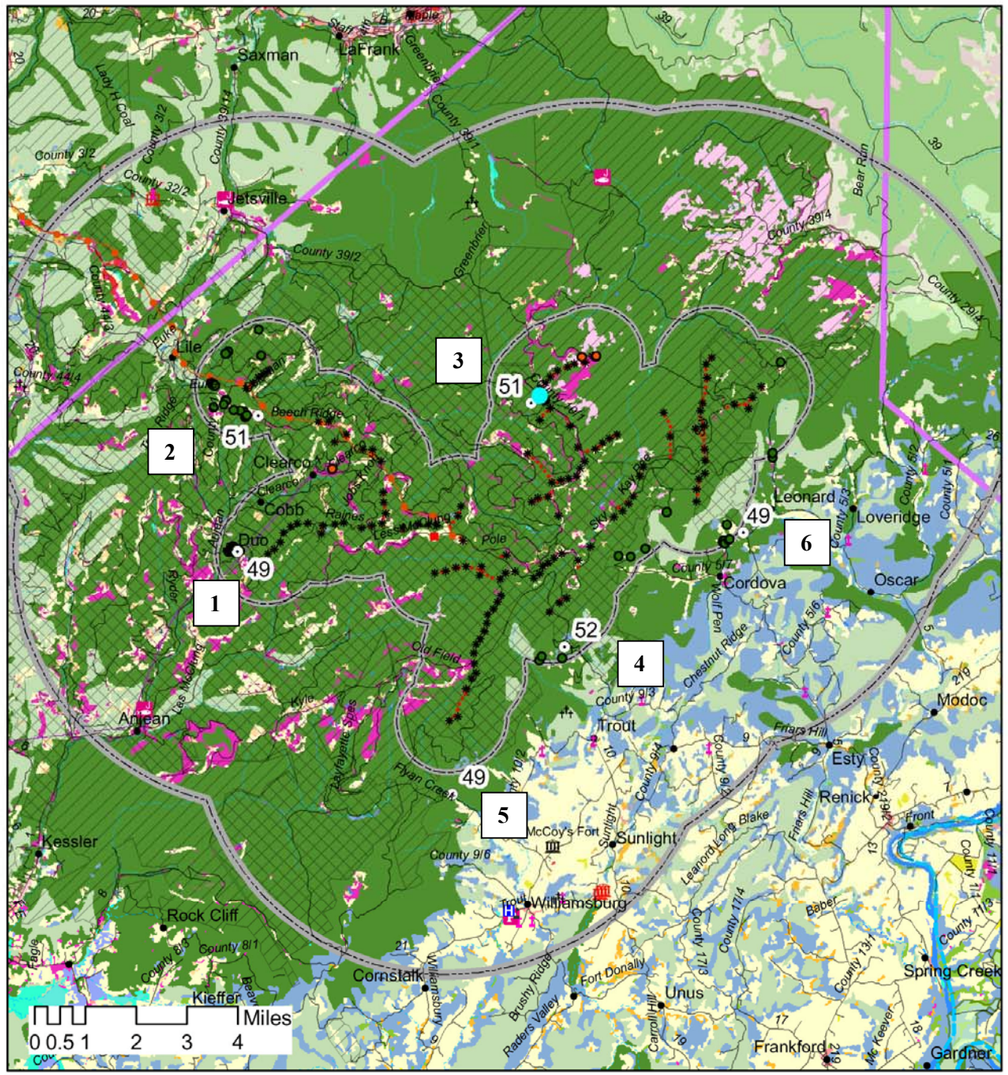


Figure 1. Area Map with Proposed Beech Wind Farm Showing Turbine Locations and One-Mile and Five-Mile Buffer Zones.



Notes

Measured Ldn sound levels, sound sources, and land uses were relatively uniform within the one-mile buffer zone, resulting in a flat ambient sound contour for the area.

Number of residential structures within 1-mile buffer at Little Beech Knob – 10; Leonard-Cordova – 10; south of B-turbines – 4; Duo – 29; and hunting camp – 15.

- Measurement Locations
- Residential Structures*
- Seasonal Homes/Hunting Cabins
- School
- Cemetery
- Church
- Hospital
- Small Park
- Fishing
- Project Substation
- NRHP Eligible
- NRHP Potentially Eligible
- Proposed Turbine
- Proposed Transmission Line
- Proposed Roads
- Towns
- Roads
- Rivers & Streams
- Greenbrier River
- 1-mile buffer
- 5-mile buffer
- MeadWestvaco tracts
- Plum Creek tracts
- County Lines
- Major powerlines
- Major highways
- Populated area - mixed land cover
- Low intensity urban
- Moderate intensity urban
- Intensive urban
- Planted grassland
- Conifer plantation
- Row crop agriculture
- Pasture/grassland
- Shrubland
- Woodland
- Floodplain forest
- Cove hardwood forest
- Diverse/mesophytic hardwood forest
- Hardwood/conifer forest
- Oak dominant forest
- Mountain hardwood forest
- Mountain hardwood/conifer forest
- Mountain conifer forest
- Surface water
- Forested wetland
- Shrub wetland
- Herbaceous wetland
- Barren land - mining, construction
- National Forest

** Includes barns, garages, trailers, etc.*

Figure 2. Area Map with Community Sound Monitoring Locations 1 through 6 and Average Measured Existing Ambient Day-Night Sound Levels (Ldn) during September - October 2005 Sound Survey.

Figure 3. View of Location 1 (Town of Duo).

Figure 4. View of Church near Location 1 (Town of Duo).

Figure 5. View of Location 2 (Little Beech Knob).

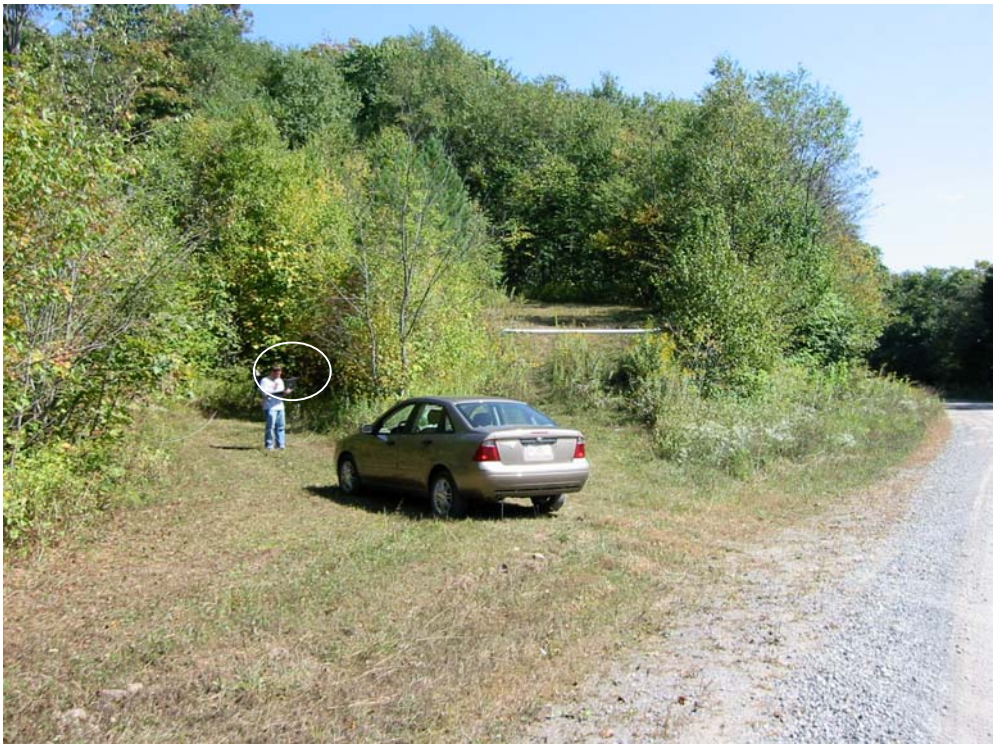


Figure 6. Close-in View of Location 2 (Little Beech Knob).

Figure 7. View of Location 3 (Hunting Cabins).

Figure 8. View of Cabin near Location 3 (Hunting Cabins).

Figure 9. View of Location 4 (Home South of B Turbine Line).

Figure 10. View of Location 5 (Flynn's Creek).

Figure 11. View of Location 6 (Leonard/Cordova).

Figure 12. View of Road near Location 6 (Leonard/Cordova).
(short-term measurement taken at road without traffic; long-term monitoring performed away from road)

Figure 13. Hourly Leq A-Weighted Existing Ambient Sound Levels Measured at Location 1 (Town of Duo) during 27 September – 5 October 2005.

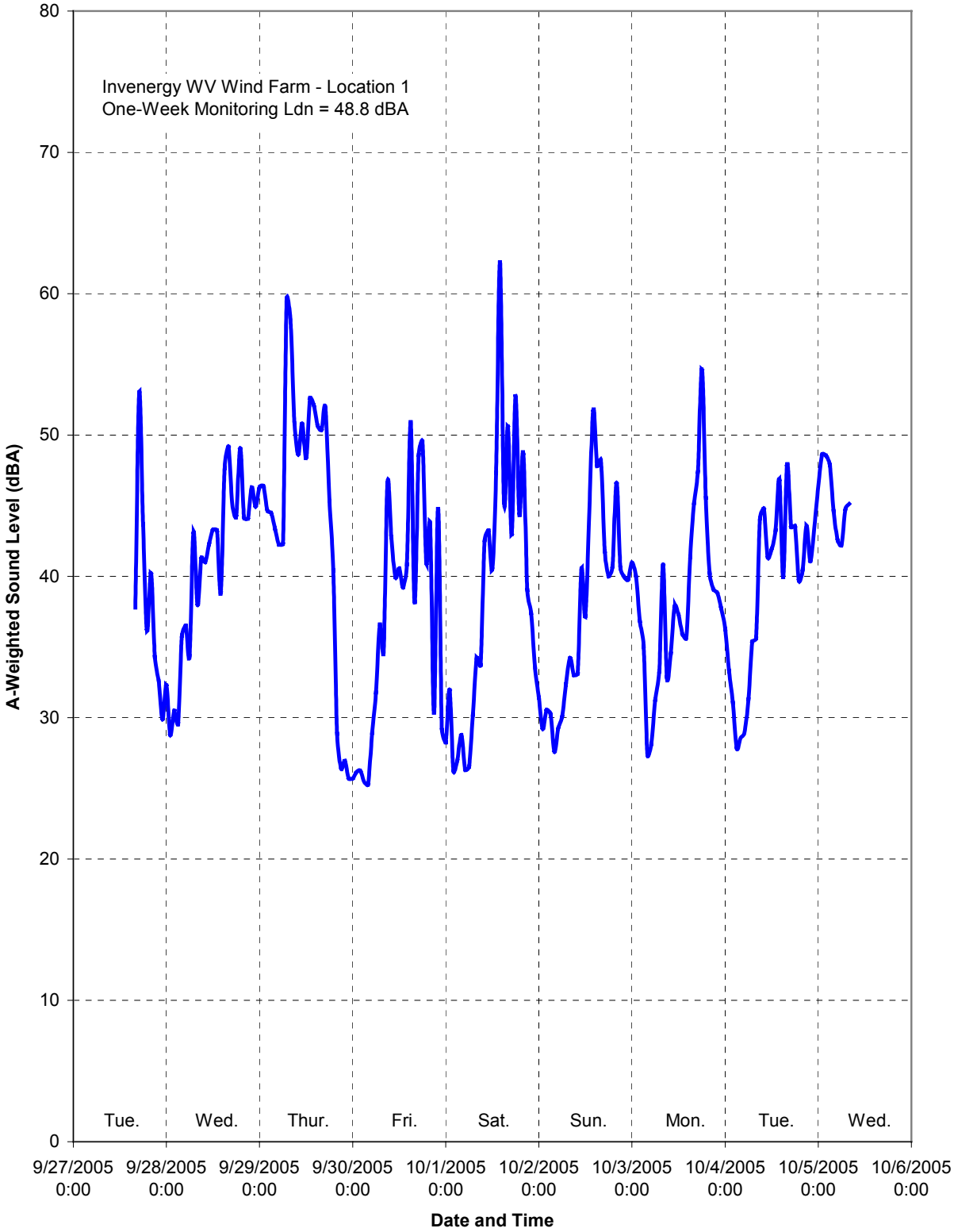


Figure 14. Hourly Leq A-Weighted Existing Ambient Sound Levels Measured at Location 2 (Little Beech Knob) during 27 September – 5 October 2005.

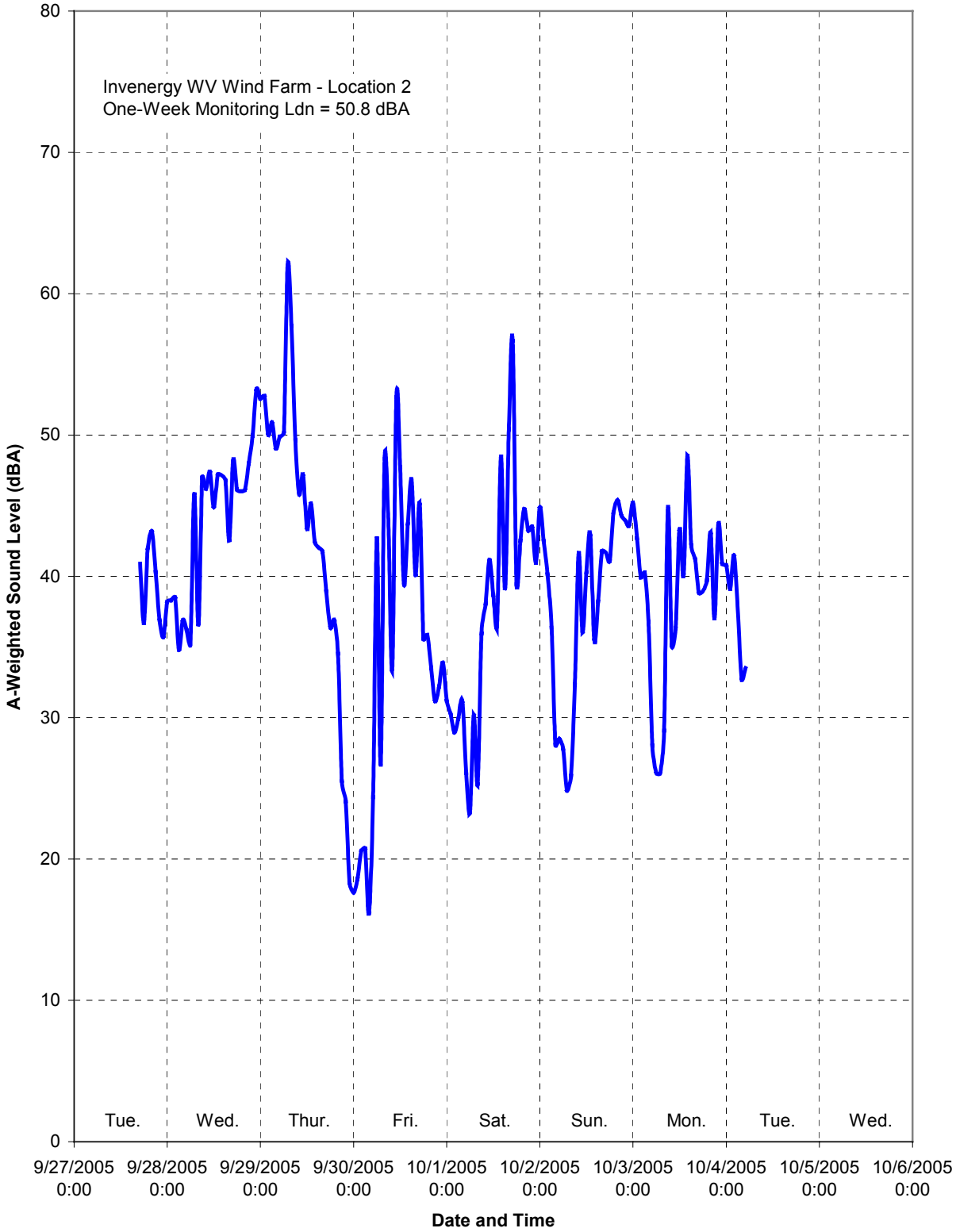


Figure 15. Hourly Leq A-Weighted Existing Ambient Sound Levels Measured at Location 3 (Hunting Cabins) during 27 September – 5 October 2005.

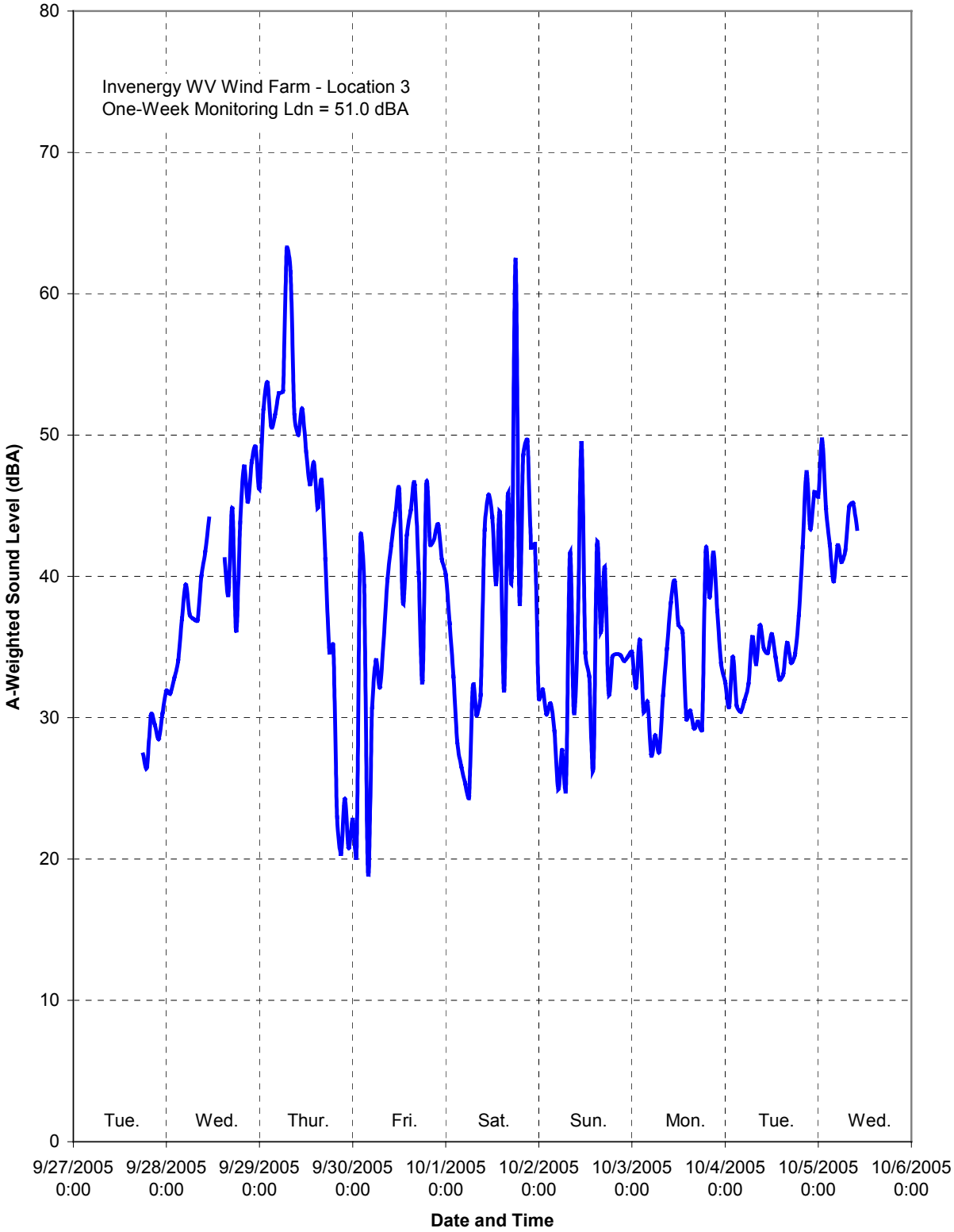


Figure 16. Hourly Leq A-Weighted Existing Ambient Sound Levels Measured at Location 4 (Home South of B-Turbine Line) during 27 September – 5 October 2005.

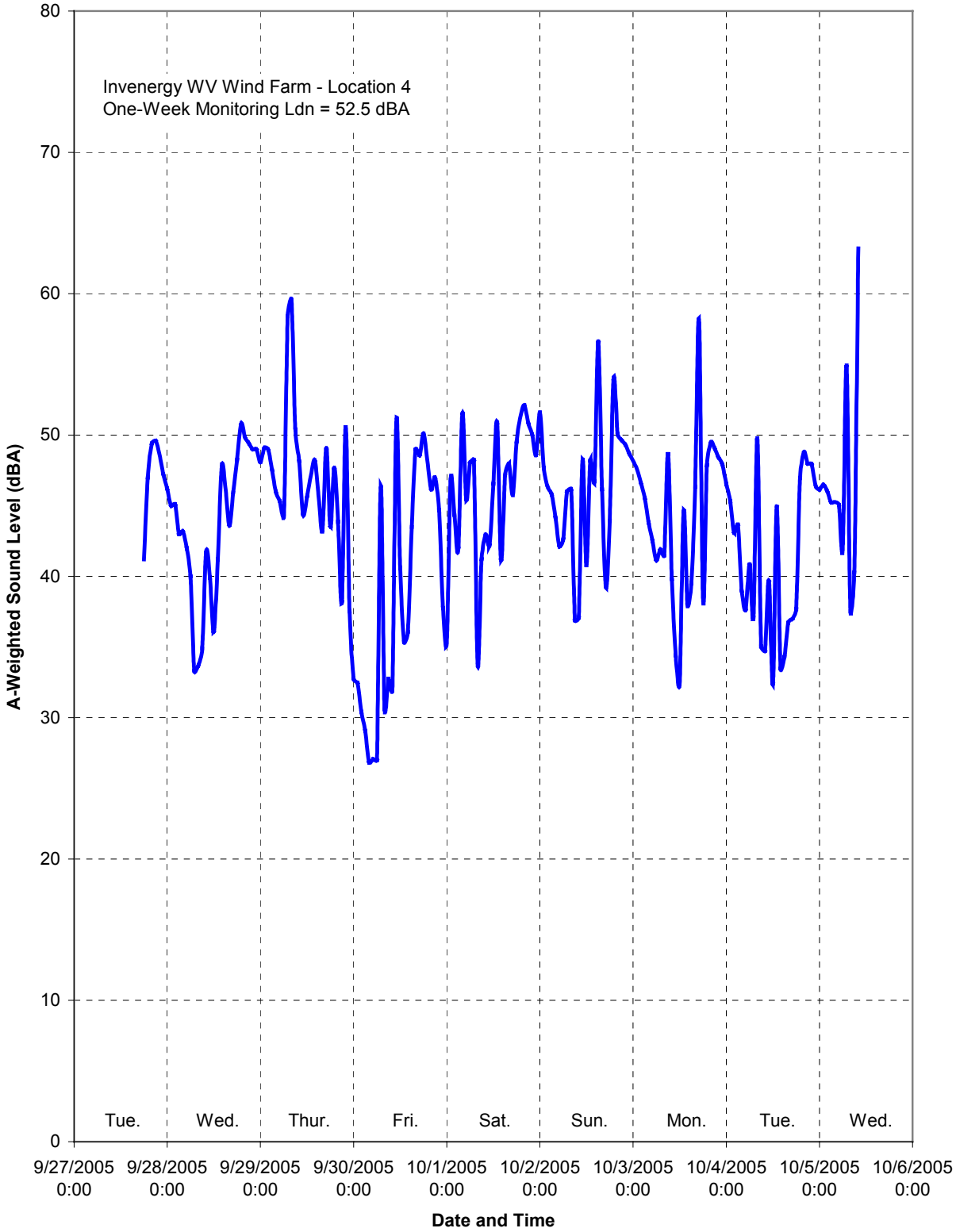


Figure 17. Hourly Leq A-Weighted Existing Ambient Sound Levels Measured at Location 5 (Flynn's Creek) during 27 September – 5 October 2005.

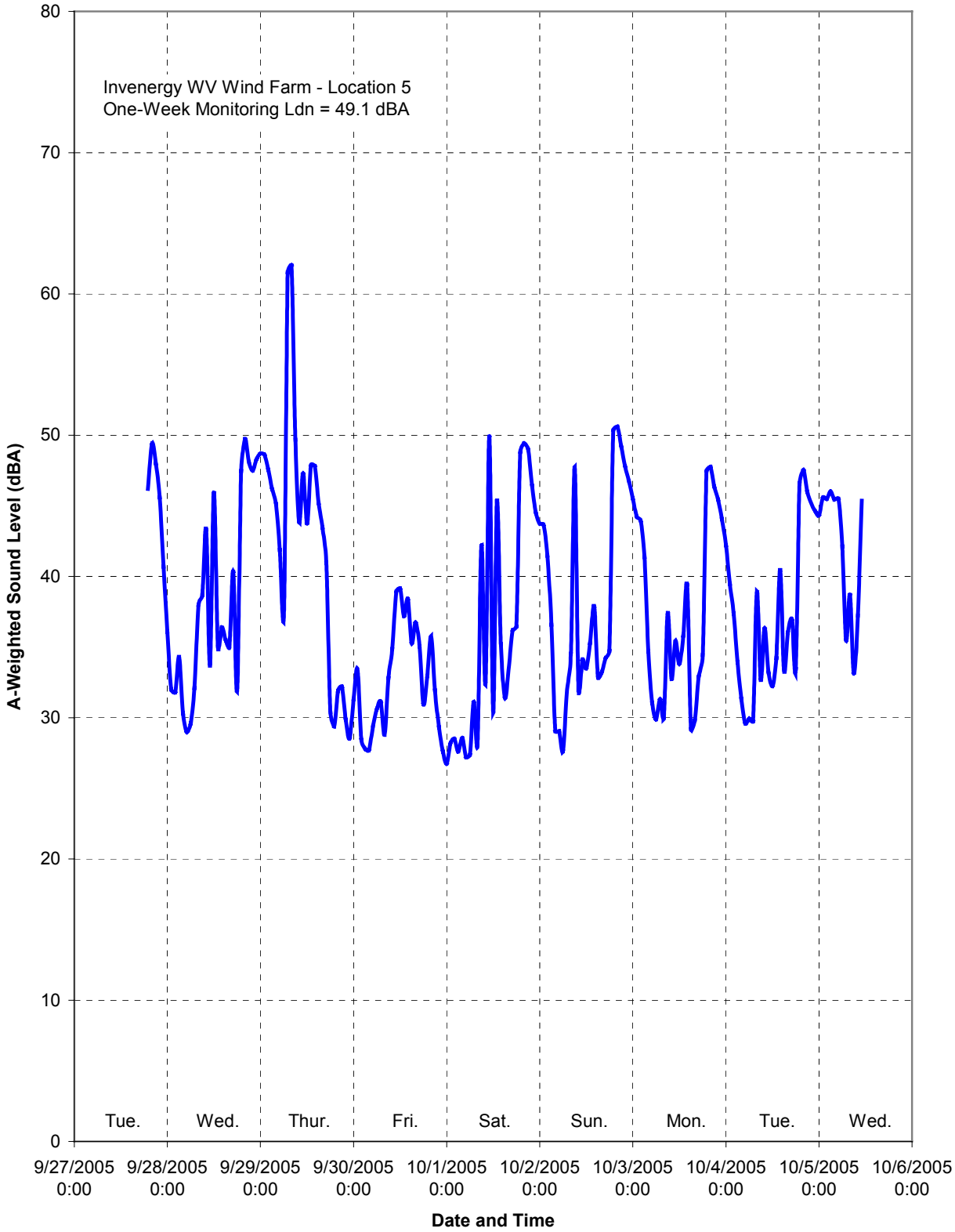
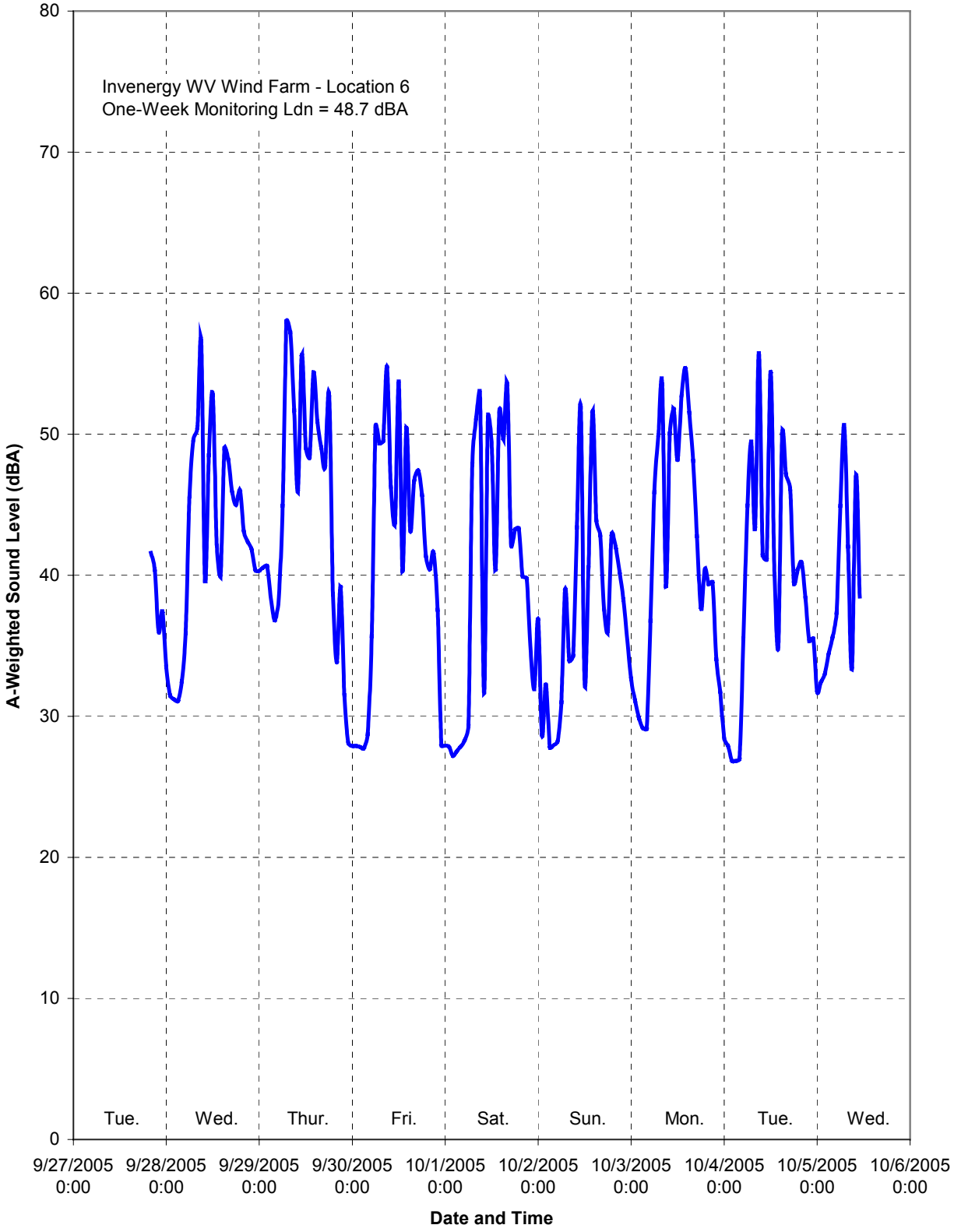
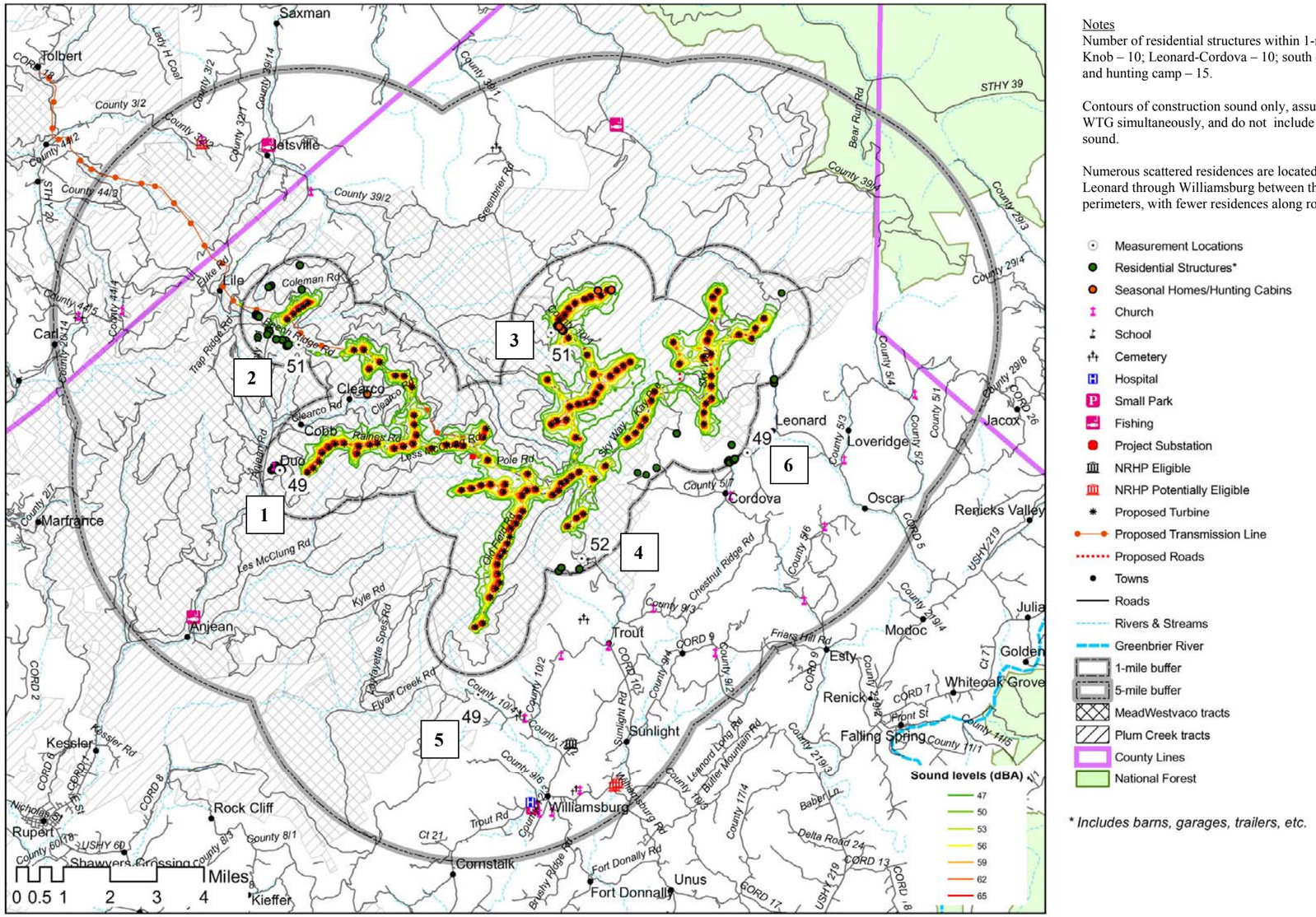


Figure 18. Hourly Leq A-Weighted Existing Ambient Sound Levels Measured at Location 6 (Leonard/Cordova) during 27 September – 5 October 2005.





Notes
Number of residential structures within 1-mile buffer at Little Beech Knob – 10; Leonard-Cordova – 10; south of B-turbines – 4; Duo – 29; and hunting camp – 15.

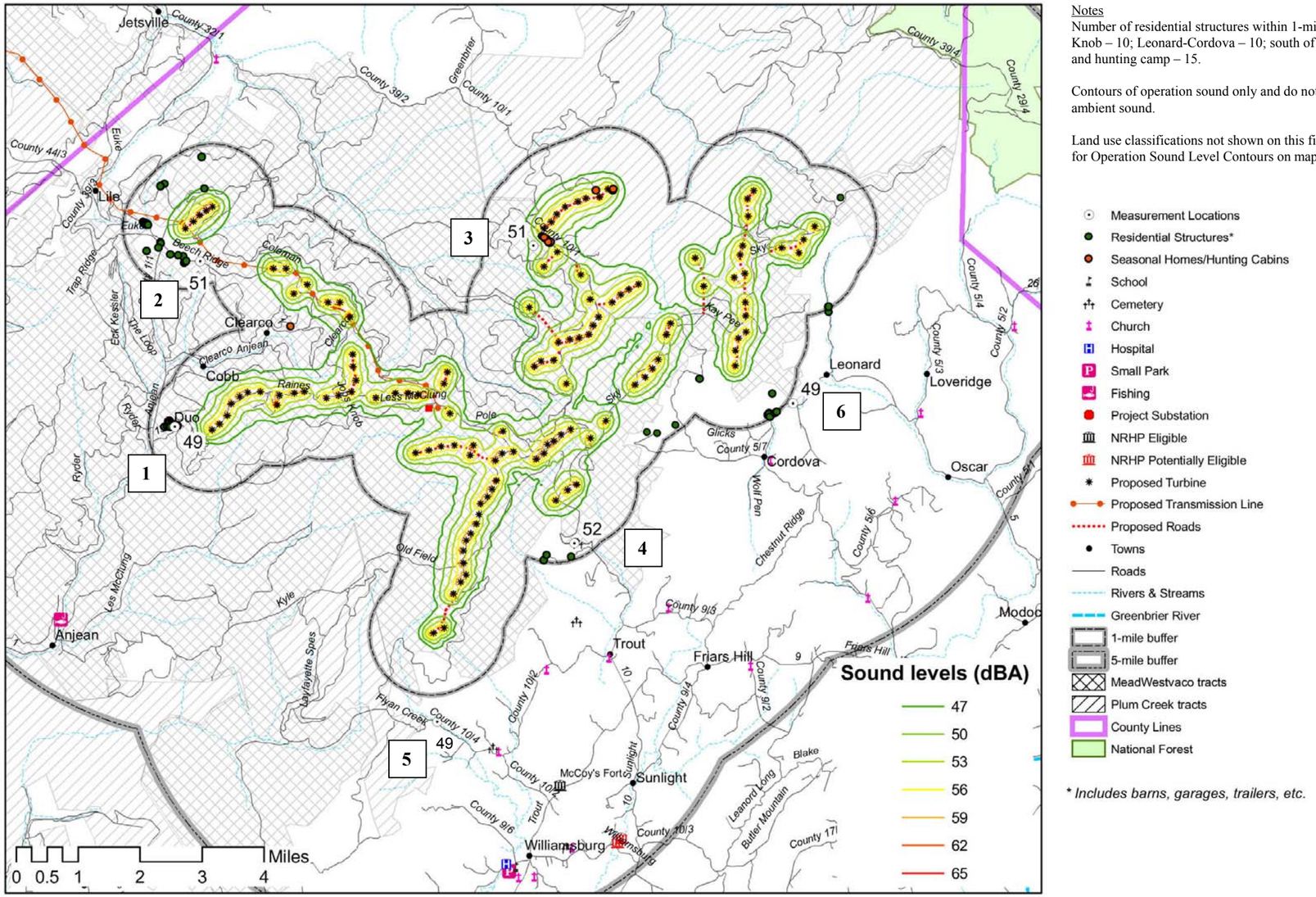
Contours of construction sound only, assuming construction at each WTG simultaneously, and do not include contribution of ambient sound.

Numerous scattered residences are located in the general area from Leonard through Williamsburg between the one-mile and five-mile perimeters, with fewer residences along roads in the other areas.

- Measurement Locations
- Residential Structures*
- Seasonal Homes/Hunting Cabins
- Church
- School
- Cemetery
- Hospital
- Small Park
- Fishing
- Project Substation
- NRHP Eligible
- NRHP Potentially Eligible
- Proposed Turbine
- Proposed Transmission Line
- Proposed Roads
- Towns
- Roads
- Rivers & Streams
- Greenbrier River
- 1-mile buffer
- 5-mile buffer
- MeadWestvaco tracts
- Plum Creek tracts
- County Lines
- National Forest

* *Includes barns, garages, trailers, etc.*

Figure 19. Area Map of Proposed Beech Ridge Wind Farm with Estimated Construction Sound Level Contours Compared to Average Measured Existing Ambient Ldn Sound Levels at Locations 1 to 6.



Notes
Number of residential structures within 1-mile buffer at Little Beech Knob – 10; Leonard-Cordova – 10; south of B-turbines – 4; Duo – 29; and hunting camp – 15.

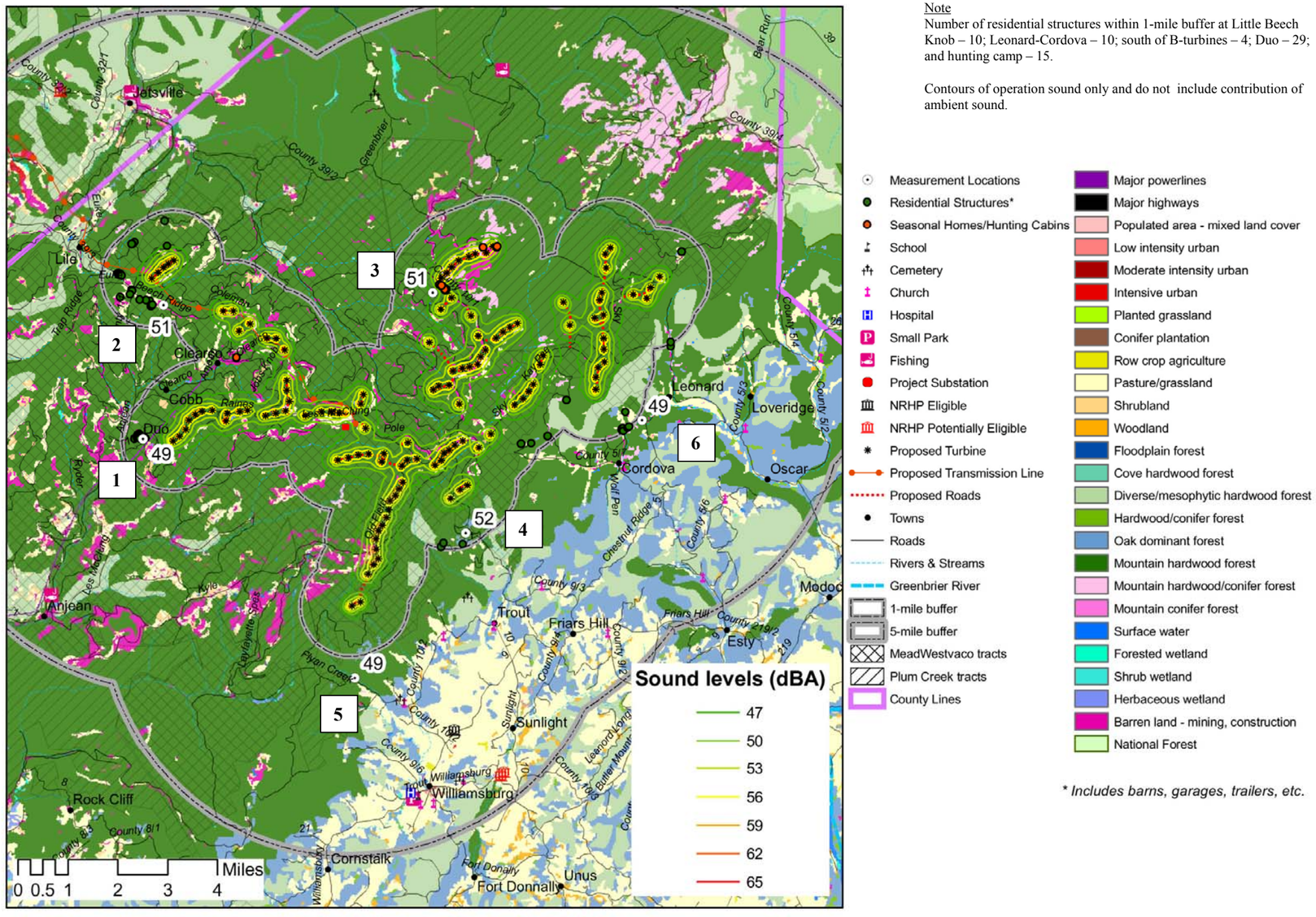
Contours of operation sound only and do not include contribution of ambient sound.

Land use classifications not shown on this figure for clarity; see Figure 21 for Operation Sound Level Contours on map with land use classifications.

- Measurement Locations
- Residential Structures*
- Seasonal Homes/Hunting Cabins
- School
- Cemetery
- Church
- Hospital
- Small Park
- Fishing
- Project Substation
- NRHP Eligible
- NRHP Potentially Eligible
- Proposed Turbine
- Proposed Transmission Line
- Proposed Roads
- Towns
- Roads
- Rivers & Streams
- Greenbrier River
- 1-mile buffer
- 5-mile buffer
- MeadWestvaco tracts
- Plum Creek tracts
- County Lines
- National Forest

* *Includes barns, garages, trailers, etc.*

Figure 20. Area Map of Proposed Beech Ridge Wind Farm with Estimated Operation Sound Level Contours Compared to Average Measured Existing Ambient Ldn Sound Levels at Locations 1 to 6.



Note
Number of residential structures within 1-mile buffer at Little Beech Knob – 10; Leonard-Cordova – 10; south of B-turbines – 4; Duo – 29; and hunting camp – 15.

Contours of operation sound only and do not include contribution of ambient sound.

- Measurement Locations
- Residential Structures*
- Seasonal Homes/Hunting Cabins
- School
- Cemetery
- Church
- Hospital
- Small Park
- Fishing
- Project Substation
- NRHP Eligible
- NRHP Potentially Eligible
- Proposed Turbine
- Proposed Transmission Line
- Proposed Roads
- Towns
- Roads
- Rivers & Streams
- Greenbrier River
- 1-mile buffer
- 5-mile buffer
- MeadWestvaco tracts
- Plum Creek tracts
- County Lines
- Major powerlines
- Major highways
- Populated area - mixed land cover
- Low intensity urban
- Moderate intensity urban
- Intensive urban
- Planted grassland
- Conifer plantation
- Row crop agriculture
- Pasture/grassland
- Shrubland
- Woodland
- Floodplain forest
- Cove hardwood forest
- Diverse/mesophytic hardwood forest
- Hardwood/conifer forest
- Oak dominant forest
- Mountain hardwood forest
- Mountain hardwood/conifer forest
- Mountain conifer forest
- Surface water
- Forested wetland
- Shrub wetland
- Herbaceous wetland
- Barren land - mining, construction
- National Forest

** Includes barns, garages, trailers, etc.*

Figure 21. Area Map of Proposed Beech Ridge Wind Farm with Estimated Operation Sound Level Contours Compared to Average Measured Existing Ambient Ldn Sound Levels at Locations 1 to 6. Includes Land Use Classifications.

Table 1.
Description of Monitoring Locations for Preconstruction Ambient Sound Survey.

Location	Description	Approx. Dist. (ft.) to Nearest WTG
1 – Town of Duo	hamlet with several homes and small church	3600
2 – Little Beech Knob*	few rural homes	3200
3 – Hunting Cabins	group of seasonal hunting cabins	900
4 – Home South of B-Turbine Line	rural home	4100
5 – Flynn's Creek	scattered rural homes, farms, and church	7800
6 – Leonard/Cordova	road between two small settlements	6000

* Homeowners in this area to participate in project; otherwise, approximate distance to nearest WTG would be one mile.

Table 2.
Type of Acoustic Instrumentation Used for Ambient Sound Survey during 27 September - 5 October 2005.

Instrument Type	Manufacturer	Model
Continuous Sound Level Monitors	Rion	NL-31 & NL-32
Preamplifiers	Rion	NH-21
1/2" Microphones	Rion	UC-53A
Calibrator	Bruel & Kjaer	4231
Precision Sound Level Meter and Octave Band Analyzer	Rion	NA-27
Preamplifier	Rion	NH-20
1/2" Microphone	Rion	UC-53A
Calibrator	Norsonic	1251

Table 3.
Summary of Monitoring Locations and Ldn Sound Levels (dBA) Measured during Ambient Sound Survey (27 September - 5 October 2005).

Location	GPS Reading			Dist. to Nearest WTG (ft.)	Ambient Ldn*
	N	W	Elev. (ft.)		
1 – Town of Duo	38° 04.361'	80° 35.889'	3444	3600	49
2 – Little Beech Knob**	38° 06.611'	80° 35.343'	3990	3200	51
3 – Hunting Cabins	38° 06.911'	80° 29.196'	3875	900	51
4 – Home South of B-Turbine Line	38° 02.608'	80° 28.715'	3170	4100	52
5 – Flynn's Creek	38° 00.098'	80° 31.169'	2439	7800	49
6 – Leonard/Cordova	38° 04.562'	80° 24.818'	2470	6000	49

* Ldn measured over 186 hours at Locations 1 and 3 – 6; and measured over 157 hours at Location 2.

** Homeowners in this area to participate in project; otherwise, approximate distance to nearest WTG would be one mile.

Note that across the six locations, measured average Ldn of 50 dBA with a standard deviation of 1.6 dBA.

Table 4.
Estimated Equivalent Sound Levels (Leq*) of Representative Construction Equipment at Various Distances.

Equipment	Construction Sound Levels (dBA)			
	1550 ft. †	4000 ft.	1 mile	5 miles
Phase I – Preparation & Foundation				
Blasting	60**	47**	43**	14**
Pile Driving	59**	46**	42**	13**
Dozer	49	36	32	3
Excavator	50	37	33	4
Trencher	50	37	33	4
Grader	48	35	31	2
Roller	45	32	28	<0
Trucks	44	31	27	<0
Batch Plant	41	28	24	<0
Phase II – Erection & Installation				
Trucks	44	31	27	<0
Crane	50	37	33	4
Phase III – Test & Commission				
Trucks	44	31	27	<0

* Estimated Leq sound levels over a 10-hour daytime shift. 24-hr Ldn would be 4 dBA less than each Leq.

† Estimated sound levels at nearest property boundary and year-round community residence (closest residence in Little Beech Knob to WTG). Homeowners in this area to participate in project; otherwise, approximate distance to nearest WTG would be one mile. Estimated sound levels for a group of temporary residences closer to a WTG (Location 3 – seasonal hunting cabins) would be 6 dBA greater than these levels.

** Estimated values for blasting and pile driving are maximum (Lmax) sound levels, not Leq.

Reference: ESEERCO Power Plant Construction Noise Guide, BBN Report No. 3321, May 1977.

Table 5.
Comparison of Average Measured Ldn Sound Levels during Ambient Sound Survey with Estimated Ldn Sound Levels for WTG Facility (dBA).

Location*	Dist. to Nearest WTG (ft.)	Average Measured Ambient Ldn	Estimated Facility Operation - Ldn
1 – Town of Duo	3600	49	39
2 – Little Beech Knob**	3200	51	41
3 – Hunting Cabins	900	51	52
4 – Home South of B-Turbine Line	4100	52	35
5 – Flynn's Creek	7800	49	28
6 – Leonard/Cordova	6000	49	34
Trout	15,000	--	30
Friars Hill	22,000	--	25
Williamsburg	21,000	--	17

* Comparisons provided for the actual sound monitoring locations; in some areas, residences are located closer to wind turbines.

** Homeowners in this area to participate in project; otherwise, approximate distance to nearest WTG would be one mile.

Appendix A

Sound in Lay Terms

Sounds we hear come from small pressure oscillations, or sound waves, that travel through the air and actuate our hearing mechanism. These airborne pressure oscillations cause the eardrum and small bones of the middle ear to vibrate. These vibrations are transmitted to the fluid-filled cochlea of the inner ear's sensory organ. Sensory hair cells then transduce these vibrations into nerve impulses that are transmitted to the brain where they are perceived and interpreted.

Noise is often defined as unwanted sound and the degree of disturbance or annoyance of an intruding noise depends on various factors including the magnitude and nature of the intruding noise, the magnitude of the background or ambient sound present without the intruding noise, and the nature of the activity of people in the area where the noise is heard. For example, people relaxing at home generally prefer a quiet environment, while factory employees may be accustomed to relatively high noise levels when at work.

The magnitude, or loudness, of sound waves (pressure oscillations) is described quantitatively by the terms sound pressure level, sound level, or simply noise level. The magnitude of a sound is measured in decibels, abbreviated dB. Decibels are used to quantify sound pressure levels just as degrees are used to quantify temperature and inches are used to quantify distance. The faintest sound level that can be heard by a young healthy ear is about 0 dB, a moderate sound level is about 50 dB, and a loud sound level is about 100 dB. Various common outdoor sound levels are listed below.

130 dBA	Loud siren at 100 feet
95 dBA	Pile Driver at 100 feet
80 dBA	Truck at 100 feet
65 dBA	Lawn mower at 100 feet
60 dBA	Average speech
55 dBA	Automobile 30 mph at 100 feet
50 dBA	Quiet urban daytime
35 dBA	Quiet suburban nighttime
25 dBA	Quiet rural nighttime

Sound energy spreads as it travels away from its source causing the sound level to diminish. Other factors that reduce sound levels include absorption in the atmosphere, diffraction and refraction in the atmosphere, and terrain.

The frequency of a sound is analogous to its tonal quality or pitch. The unit for frequency is hertz, abbreviated Hz (formerly cycles per second or cps). Thus, if a sound wave oscillates 500 times per second, its frequency is 500 Hz. The fundamental frequency of Middle C on a piano keyboard, for example, is 262 Hz. However, most sounds include a composite of many frequencies and are characterized as broad band or random. The normal frequency range of human hearing extends from a low frequency of about 20 to 50 Hz (a rumbling sound) up to a high frequency of about 10,000 to 15,000 Hz (a hissing sound) or even higher for some people. People have different hearing sensitivity to different frequencies and generally hear best in the mid-frequency region that is common to human speech, about 500 to 4000 Hz.

Appendix A Con't.

Sound level meters are usually equipped with electronic filters or weighting circuits, such as specified in standards ANSI S1.4 or IEC 651, for the purpose of simulating the frequency response characteristics of the human ear. The A-weighting filter included with essentially all sound level meters is most commonly employed for this purpose because the measured sound level data correlate well with subjective response to sounds. Sound levels measured using the A-weighting network are designated by dBA.

The background or ambient acoustic environment in most communities varies from place to place and varies with time at any given location due to the composite of many nearby and distant sound sources. The ambient environment includes high sound level single-events such as the passby of an airplane or nearby car, the barking of a dog, thunder, or a siren. The ambient acoustic environment also includes relatively steady residual or background sounds caused by sources such as distant traffic and ventilation equipment. The quantity of the single-event sounds and the amplitude of the background sounds are usually least during the late night hours from about midnight to 5:00 am. Indeed, the ambient sound level at a location is related to the amount of human activity in its vicinity. The amplitude statistics of this rather complex acoustic environment are considered to be non-Gaussian (because of the presence of the lower-level residual background sounds) and non-stationary (because of diurnal and seasonal variations).

At any location, a complete physical description of the ambient acoustic environment might include its sound level at various frequencies, as a function of time. As a first step towards simplifying this multi-dimensional description, it has become common practice to eliminate the frequency variable by measuring the A-weighted sound level (dBA), as observed on a standard sound level meter. The A-weighting filter emphasizes the mid-frequency components of sounds to approximate the frequency response of the human ear. A-weighted sound levels correlate well with our perception of most sounds.

To evaluate impacts and report time-varying ambient sound levels it is common practice, using the A-weighted scale, to measure the equivalent sound level and the day-night sound level. The equivalent sound level (Leq) is the level of a steady-state sound that has the same (equivalent) energy as the time-varying sound of interest, taken over a specified time period. Thus, the equivalent sound level is a single-valued level that expresses the time-averaged total energy of the entire ambient sound energy. It includes both the high-level single event sounds and the relatively steady background sounds. The day-night sound level (Ldn) is simply the average equivalent sound for 24-hours after 10 dBA has been added to the nighttime sound levels from 10pm to 7am. Adding 10 dBA to the nighttime sound levels accounts for people's expectations that nighttime be a quiet period. Both the equivalent sound level and the day-night sound levels have been selected by the U.S. Environmental Protection Agency (USEPA) as the best descriptors to use for the purpose of identifying and evaluating levels of environmental noise. EPA has identified an Ldn level of 55 dBA as protective of the health and welfare of humans. In addition, the Federal Energy Regulatory Commission (FERC) employs an Ldn level of 55 dBA as its criterion during review of proposed projects.

As part of the application process, the West Virginia Public Service Commission (WVPSC) Guidelines for Noise Studies for Siting Certificates require a project to submit preconstruction ambient Ldn data and facility operation Ldn estimates for review in addition to information on construction noise.