APPENDIX F

BAT ACOUSTICAL STUDIES

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Bat Acoustical Studies for the Hermosa West Wind Resource Area Albany County, Wyoming

Final Report
July 2009 – November 2009

Prepared for:

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WEST, Inc.

July 9, 2010

EXECUTIVE SUMMARY

Western EcoSystems Technology, Inc. initiated surveys in July 2009 designed to assess bat use within the proposed Hermosa West Wind Resource Area, Albany County, Wyoming. Acoustic surveys for bats using Anabat[TM] SD1 ultrasonic detectors at 6 stations were conducted from July 15 to November 3, 2009, to estimate the seasonal and spatial use of the Hermosa West Wind Resource Area by bats. Two detectors were paired at a meteorological tower in grassland habitat, one placed near the ground and the other raised to approximately 45 meters. A third detector was moved among four temporary ground stations located in different habitats. Anabat units recorded 1,167 bat passes during 252 detector-nights. Averaging bat passes per detector-night across the four temporary stations, a mean of 14.11 bat passes per detector-night was recorded. The fixed raised station recorded an average of 2.05 bat passes per detector-night. The fixed ground station recorded 2.22 bat passes per detector-night and was the activity estimate used to assess risk, as it was the only location suitable for comparison with data from other wind-energy facilities that have recorded both bat activity and fatality rates.

Bat activity was greater at temporary stations than at fixed stations, likely due to habitat differences. Most bat passes were recorded at stations located near water, which may attract bats for foraging and drinking opportunities. Activity was moderate (relative to other sampling stations) within Ponderosa pine habitat, and was lowest within grassland and mountain mahogany habitats. Weekly bat activity was relatively steady between mid-July and mid-September, with most passes recorded in August. Recorded bat activity likely represents a combination of foraging activity by resident bats and commuting activity by bats migrating through the area. Bat activity was similar between the ground and raised detector at station HE1; however, species composition differed between detectors, with low-frequency species comprising the majority of bat passes at the raised station, likely due to their flight and echolocation characteristics.

Low-frequency bats (<30 kHz; e.g., big brown bat, hoary bat, silver-haired bat) comprised 48.2% of recorded bat passes, while 35.9% of passes were made by high-frequency bats (>40 kHz in frequency; e.g. *Myotis* species). The remaining passes were determined to be mid-frequency bat species (30-40 kHz; e.g. eastern red bat). Species identification was only possible for hoary and eastern red bats. Passes attributable to hoary bats comprised 8.1% of all passes. Hoary bats were recorded at all stations, and were most active between mid-July and late-September, suggesting this species was present in the Hermosa West Wind Resource Area during the summer season. September activity by hoary bats may also indicate passage of individuals migrating through the area. Eastern red bats comprised 2.0% of all passes, and most were recorded at the temporary station located in aspen riparian habitat. Eastern red bats were most active in late August and mid-September, suggesting fall migration through the area.

The mean number of bat passes per detector-night from the fixed ground station was compared to existing data from nine wind-energy facilities where both bat use and mortality levels have been measured as well as to publicly available bat activity levels recorded at facilities in Wyoming. The level of bat use documented at the Hermosa West Wind Resource Area was similar to the Foote Creek Rim Facility in Wyoming, where reported bat mortalities are low, and

was much lower than at facilities in the eastern US, where reported bat mortality is highest. Assuming a relationship between pre-construction bat activity and post-construction fatalities, bat mortality rates at the HWWRA are expected to be similar to the low rates reported at Foote Creek Rim, Wyoming.

Based on fatality rates at wind-energy facilities in the Rocky Mountain/western North American region, the bat activity observed at this project, and habitat of the project, it is expected that the potential risk to bats from turbine operations to be similar to rates observed at the Foote Creek Rim Facility in Wyoming, and not nearly as high as the rates observed at eastern ridgeline facilities. As more research is conducted at facilities in Wyoming, more information regarding the potential direct impacts of Wyoming wind-energy facilities to bats will be obtained.

STUDY PARTICIPANTS

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REPORT REFERENCE

K. Taylor, D. Solick, and K. Bay. 2010. Bat Acoustical Studies for the Hermosa Wind Resource Area, Albany County, Wyoming. Final Report: July 2009 – November 2009. Prepared for Shell WindEnergy, Inc., Houston, Texas. Prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming.

ACKNOWLEDGEMENTS

A number of individuals were instrumental in the completion of the bat acoustical surveys conducted at the proposed Hermosa Wind Resource Area. Clark McCreedy and Patricia Sweanor of the US Fish and Wildlife Service Ecological Field Office provided recommendations and review of the study design as did Scott Gamo and Mary Flanderka of the Wyoming Game and Fish Department. Shell WindEnergy provided funding for the field studies and access to the Hermosa Wind Resource Area. Jonathan Burke (project manager) and Helen Chun (health and safety advisor) of Shell were instrumental in administering information and coordination to WEST. All the landowners in the Hermosa Wind Resource Area deserve recognition for their support and cooperation in allowing safe, secure, and trouble-free property access.

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INTRODUCTION

Shell WindEnergy, LLC (Shell) is proposing to develop a wind-energy facility in Albany County, Wyoming. Shell requested that Western EcoSystems Technology, Inc. (WEST) develop and implement a standardized protocol for baseline studies of bat use in the Hermosa West Wind Resource Area (HWWRA) for the purpose of estimating the impacts of the wind-energy facility on bats, and to assist with siting turbines to minimize impacts to bats. The protocol for this baseline study is similar to protocols used at other wind-energy facilities in the United States. The protocol has been developed based on WEST's experience studying wildlife and wind turbines at wind-energy facilities throughout the US and included passive acoustic sampling using Anabat™ bat detectors to quantify bat use in the study area. Input from the Wyoming Game and Fish Department (WGFD) and US Fish and Wildlife Service (USFWS) were incorporated into the survey protocol. In addition, bat acoustical sampling is being conducted in 2010 at the request of the WGFD.

The following is a final report describing the results of acoustical bat surveys during the 2009 study season within the proposed HWWRA. In addition to site-specific data, this report presents existing information and results of bat monitoring studies conducted at other wind-energy facilities. Where possible, comparisons with regional and local studies were made.

STUDY AREA

The HWWRA, approximately 11,118 acres (17.4 square miles [mi^2]) in size, is located in southeastern Wyoming (Figure 1). The proposed wind resource area contains a variety of topographic features from generally flat/rolling areas to large drainage features and prominent rocky outcrops. Based on a vegetation/habitat mapping effort conducted within the HWWRA, grassland is the dominant landcover type (87.6%), followed by coniferous forest (6.0%), riparian (3.6%), and mountain mahogany (*Cerocarpus* spp., 1.2%). shrub-steppe and riparian/willow (*Salix* spp.) each cover less than 1% of the HWWRA (Table 1). The HWWRA is a mixture of private and state lands with the dominant land use being rangeland for grazing livestock.

METHODS

Bat Acoustic Surveys

The objective of the bat use surveys was to estimate the seasonal and spatial use of the HWWRA by bats. Bats were surveyed using Anabat™ SD1 bat detectors (Titley Scientific™, Australia). Bat detectors are a recommended method to index and compare habitat use by bats. The use of bat detectors for calculating an index to bat impacts is a primary bat risk assessment tool for baseline wind development surveys (Arnett 2007, Kunz et al. 2007a). Bat activity was surveyed using three detectors from July 15 to November 3, 2009, a period corresponding to likely fall bat migration at the HWWRA. Two detectors were paired at a meteorological tower in grassland habitat (station HE1) to compare bat activity at different heights; one was placed near the ground at a height of approximately 3.3 ft (1 m), and the other was mounted on the tower at a height of approximately 148 ft (45 m). A third detector was moved among four temporary locations between August 19 and November 3 to sample different habitats and increase spatial coverage within the HWWRA (Figure 1). Station HE5m was located in ponderosa pine (*Pinus ponderosa*) forest, station HE6m was located in willow/riparian habitat, station HE7m was located in aspen/riparian habitat, and station HE8m was located in mountain mahogany.

Anabat detectors record bat echolocation calls with a broadband microphone. The echolocation sounds are then translated into frequencies audible to humans by dividing the frequencies by a predetermined ratio. A division ratio of 16 was used for this study. Bat echolocation detectors also detect other ultrasonic sounds, such as those sounds made by insects, raindrops hitting vegetation, and other sources. A sensitivity level of six was used to reduce interference from these other sources of ultrasonic noise. Calls were recorded to a compact flash memory card with large storage capacity. The detection range of Anabat detectors depends on a number of factors (e.g., echolocation call characteristics, microphone sensitivity, habitat, the orientation of the bat, and atmospheric conditions; Limpens and McCracken 2004), but is generally less than 98 ft (30 m) due to atmospheric absorption on echolocation pulses (Fenton 1991). To ensure similar detection ranges among detectors, microphone sensitivities were calibrated using a BatChirp (Tony Messina, Las Vegas, Nevada) ultrasonic emitter as described in Larson and Hayes (2000). All units were programmed to turn on each night approximately one half-hour before sunset and turn off approximately one half-hour after sunrise.

Anabat detectors were placed inside plastic weather-tight containers with a hole cut in the side of the container for the microphone to extend through. Microphones were encased in PVC tubing with drain holes that curved skyward at 45 degrees outside the container to minimize the potential for water damage due to rain. Containers were raised off the ground to minimize echo interference and lift the unit above vegetation. Raised Anabat microphones were elevated on meteorological towers using a pulley system. Microphones were encased in a Bat-Hat weatherproof housing (EME Systems, Berkeley, California), and attached to a coaxial cable that transmitted ultrasonic sounds to an Anabat unit at the base of the tower. The Bat-Hat weatherproof housing was modified by replacing the Plexiglas reflector plate with a 45-degree angle PVC elbow, for better comparability with data collected by detectors on the ground.

Statistical Analysis

The units of bat activity were the number of bat passes (Hayes 1997). A pass was defined as a continuous series of two or more call notes produced by an individual bat with no pauses between call notes of more than one second (White and Gehrt 2001, Gannon et al. 2003). The number of bat passes was determined by downloading the data files to a computer and tallying the number of echolocation passes recorded. Total number of passes was corrected for effort by dividing by the number of detector-nights.

For each station, bat passes were sorted into three groups, based on their minimum frequency, that correspond roughly to species groups of interest. For example, most species of *Myotis* bats echolocate at frequencies above 40 kilohertz (kHz), whereas species such as the eastern red bat (*Lasiurus borealis*) typically have echolocation calls that fall between 30 and 40 kHz, and species such as big brown (*Eptesicus fuscus*), silver-haired (*Lasionycteris noctivagans*), and hoary bat (*Lasiurus cinereus*) have echolocation frequencies that fall at or below 25 kHz.

Therefore, passes were classified as high-frequency (HF; > 40 kHz), mid-frequency (MF; 30-40 kHz), or low-frequency (LF; < 30 kHz). To establish which species may have produced passes in each category, a list of species expected to occur in the HWWRA was compiled from range maps (Table 2; Harvey et al. 1999, BCI website). Data determined to be noise (produced by a source other than a bat) or call notes that did not meet the pre-specified criteria to be termed a pass were removed from the analysis.

Within these categories, an attempt was made to identify passes made by two *Lasiurus* species: hoary and eastern red bats. Passes that had a distinct U-shape and that exhibited variability in the minimum frequency across the call sequence were identified as belonging to the *Lasiurus* genus (C. Corben, pers comm.). Hoary and eastern red bats were distinguished based on minimum frequency; hoary bats typically produce calls with minimum frequencies between 18 and 24 kHz, whereas eastern red bats typically emit calls with minimum frequencies between 30 and 43 kHz (J. Szewczak, pers comm.). Only sequences containing three or more calls were used for species identification. These are conservative parameters; given the high intra-specific variability of *Lasiurus* calls and the number of call files that were too fragmented for proper identification, it is likely that more hoary and eastern red bat calls were recorded than were positively identified.

The total number of bat passes per detector-night was used as an index for bat use in the HWWRA. Bat pass data represented levels of bat activity rather than the numbers of individuals present because individuals could not be differentiated by their calls. To assess potential for bat mortality, the mean number of bat passes per detector-night (averaged across fixed ground-based monitoring stations) was compared to existing data from wind-energy facilities where both bat activity and mortality levels have been measured.

RESULTS

Bat Acoustic Surveys

Bat activity was monitored at six sampling locations on a total of 112 nights during the period July 15 to November 3, 2009. Anabat units were operable for 93.7% of the sampling period (Figure 2). Levels of wind and insect noise were relatively low throughout the study period (i.e., <1,500 noise files per detector-night; Figure 3). Anabat units recorded 1,167 bat passes on 252 detector-nights (Table 3). Averaging bat passes per detector-night across all stations, a mean of 10.12 ± 2.16 bat passes per detector-night was recorded. The pass rate for the fixed ground station was (mean ± SE) 2.22 ± 0.32 bat passes per detector-night, and for the fixed raised station the pass rate was 2.05 ± 0.27 bat passes per detector-night. The average pass rate for temporary ground stations was 14.11 ± 3.12.

Spatial Variation

Bat activity varied among Anabat ground stations (Figure 4), ranging between 2.22 and 25.80 passes per detector-night (Table 3). Activity was lowest in grassland and mountain mahogany habitats (stations HE1g, HE8m) and highest in riparian habitats (stations HE6m, HE7m). Differences in activity levels were likely due to differences in habitat rather than to timing of sampling effort, as temporary stations were sampled during periods of high and low bat activity (Figure 5). Comparing data at the paired station on just the nights that both ground and raised detectors were operating, pass rates were similar, although species composition differed (Figure 6).

Temporal Variation

Weekly bat activity at fixed stations was generally steady from the start of the study period on July 15 through September 8, with nearly half of all passes recorded between August 5 and September 1 (48.8%; Table 4, Figure 7). Activity declined through the end of September, and very few bats were detected in October (Figure 7). Temporary stations were excluded from temporal analyses because individual temporary stations were not sampled on a continuous basis throughout the study period. Temporal patterns between the ground and raised detector at station HE1 were similar (Figure 8), although the ground detector consistently recorded more bat passes on a nightly basis.

Species Composition

For all stations, passes by low-frequency bats (LF; 48.2% of all passes) outnumbered passes by high-frequency (HF; 35.9%) and mid-frequency bats (MF; 15.9%; Table 3). However, species composition varied considerably among stations (Figure 4). At paired station HE1, the raised station recorded mostly LF bat passes (94%; Table 3) relative to the ground station (Figure 5).

Among fixed stations, patterns of weekly activity differed among species groups (Figure 7). HF bats were most active early in the season, between July 15 and September 1 (96.3% of HF passes; Table 4), with no HF passes recorded after September 15 (Figure 7). MF species were most active between August 5 and September 1 (64% of MF passes; Table 4), with no MF passes recorded past September 29. Activity by LF bats was relatively high through September 22, with 41.0% of passes recorded between August 19 and September 8 (Table 4).

For all stations, passes attributable to hoary bats accounted for 8.1% of all bat passes, and 16.7% of all LF bat passes (Table 3). Hoary bats were detected at all Anabat stations (Figure 9), with most activity recorded at the raised grassland station (HE1h) and the temporary station located in riparian/willow habitat (HE6m). Among fixed stations, weekly hoary bat activity was relatively high and steady between July 15 and September 22 (96.9% of hoary bat passes; Table 5, Figure 10). Few hoary bats were recorded after September 22.

For all stations, passes attributable to eastern red bats accounted for 2.0% of all passes, and 12.4% of all MF passes (Table 3). Eastern red bats were recorded at raised station HE1h, and at temporary stations HE5m – HE7m (Figure 9), with most (73.9%; Table 3) recorded at station HE7m. Among fixed stations, eastern red bats were only detected in late August and mid-September (Figure 9; Table 5).

DISCUSSION

Potential Impacts

Assessing the potential impacts of wind-energy development to bats at the HWWRA is complicated because the proximate and ultimate causes of bat fatalities at turbines are poorly understood (Kunz et al. 2007b, Baerwald et al. 2008, Cryan and Barclay 2009), and because monitoring elusive, night-flying animals is inherently difficult (O'Shea et al. 2003). In addition, because installed capacity for wind-energy has increased rapidly in recent years, the availability of well-designed studies from existing projects lags development of proposed projects (Kunz et al. 2007b). To date, monitoring studies of wind-energy facilities suggest that:

a) bat mortality shows a potential relationship with bat use (Table 6);

b) the majority of fatalities occur during the post-breeding or fall migration season (roughly August and September);

c) migratory tree-roosting species (eastern red, hoary, and silver-haired bats) comprise almost 75% of reported bat fatalities, and;

d) the highest reported fatalities occur at wind-energy facilities located along forested ridge tops in the eastern and northeastern US. However, recent studies in agricultural regions of Iowa and Alberta, Canada, report relatively high fatalities as well (Table 6).

Based on these patterns, current guidance to estimate potential mortality levels at a proposed wind project involves evaluation of the on-site bat acoustic data in terms of activity levels, seasonal variation, and species composition (Kunz et al. 2007b), as well as comparison to regional patterns.

Overall Bat Activity

To date, few studies of wind-energy facilities have recorded both Anabat detections per night and bat mortality (Table 6). The addition of data sets from projects such as Hermosa will contribute to understanding of the relationship between bat activity near wind turbines and bat fatalities. To our knowledge, the Anabat detections per night data for the studies in Table 6 were collected from ground locations that were selected to sample areas representative of proposed turbine locations. Thus, this report relies on the mean bat activity for the one fixed ground-based detector to assess potential risk of bat fatality at the HWWRA relative to other publicly available studies with similar data.

Bat use recorded by the fixed ground detector within the HWWRA (2.22 ± 0.32 bat passes per detector-night) was similar to that observed at the Foote Creek Rim Facility in Wyoming, where recorded bat mortality was low, and was much lower than activity recorded at sites in West Virginia, Iowa, and Tennessee, where bat mortality rates were high (Table 6). Thus, assuming a relationship between pre-construction bat activity and post-construction fatalities, bat mortality rates at the HWWRA are expected to be similar to the low rates reported at Foote Creek Rim, Wyoming (Table 6).

Spatial Variation

The proposed wind-energy facility is not located near any large, known bat colonies likely to attract large numbers of bats. In general, bat activity was greater at temporary stations than at fixed stations, likely due to differences in habitat. The fixed ground station was located in grassland habitat, while temporary stations were located in habitats that might be attractive to bats, such as riparian/willow, riparian/aspen, or forested areas. Notably, the stations that recorded the most bat passes (HE6m and HE7m) were located in riparian habitat. Bat activity was moderate at the Ponderosa pine (station HE5m) location. Activity was lowest at the mountain mahogany location (HE8m). The ground and raised detectors at the paired station (HE1) recorded similar bat activity, suggesting that bats fly at a range of altitudes within the HWWRA.

Temporal Variation

Bat activity at fixed stations was relatively steady between mid-July and mid-September, with most passes recorded in August. Bat activity in July likely corresponds with the reproductive season, when pups are being weaned and foraging rates are high. Activity between August and mid-September is likely a combination of continued foraging activity by resident bats, as well as movement of migrating bats through the area. Few bats were recorded in October, indicating that most bats had left the area for winter hibernacula or warmer climates.

Fatality studies of bats at wind-energy facilities in the US have shown a peak in mortality in August and September and generally lower mortality earlier in the summer (Johnson 2005, Arnett et al. 2008). While the survey effort varies among the different studies, the studies that combine Anabat surveys and fatality surveys show a general association between the timing of increased bat call rates and timing of mortality, with both call rates and mortality peaking during the fall. Based on the available data, it is expected that bat mortality at the HWWRA will be highest between August and early-September.

Species Composition

Of the 11 species of bat likely to occur in the HWWRA, five are known fatalities at wind-energy facilities (Table 2). Acoustic bat surveys were able to classify bat calls to frequency groups that roughly correspond to groups of relative risk. Approximately 48% of passes were by low-frequency bats, suggesting greater relative abundance of species such as big brown, hoary and silver-haired bats. At raised stations, low-frequency passes outnumbered passes by other species groups, which most likely reflects different foraging behaviors among species. The behavioral characteristics of low-frequency bats may provide insight into why low-frequency bat passes outnumbered passes by other species groups. Generally, low-frequency species tend to forage at greater heights due to their wing morphology and echolocation call structure (Norberg and Rayner 1987).

Species composition varied over time at the fixed stations. High-frequency passes were most numerous from mid-July to late-August, and suggests these species leave the area once young are weaned and able to fly. Mid-frequency passes were most numerous in August, and may represent bats migrating through the project area. Low-frequency passes were numerous for the majority of the study period, with most passes recorded in August, and likely represent a combination of activity by resident and migrating individuals.

Hoary bats comprised 8.1% of all passes, were recorded at all stations, and were most active from mid-July to late-September. These results suggest this species likely resides in the HWWRA during the summer, although late-August to mid-September activity may also represent individuals migrating through the area. Hoary bat passes were most numerous at the station in riparian/willow habitat, and suggest this species may be attracted to this habitat for foraging, drinking, and possibly roosting opportunities. Hoary bats were also active at the raised station in grassland habitat, and indicate this species may be at greater risk for collision with turbine blades than lower-flying species.

Eastern red bats comprised 2.0% of all bat passes, and were mainly recorded at station HE7m, located in aspen riparian habitat. Eastern red bats were most active in late August and mid September at fixed stations, suggesting migration through the HWWRA, but the data are too few to draw meaningful conclusions about their timing.

Regional Studies

Publicly available bat fatality rate estimates corrected for searcher efficiency and carcass removal rates are available for 15 wind-energy facilities located throughout the Rocky Mountains and western North America, where annual bat fatality rates have ranged from 0.07 fatalities/MW/year at a wind-energy facility in California to 14.62 fatalities/MW/year at a facility in Alberta, and averaged 3.30 fatalities/MW/year (Table 6).

Bat activity from the ground based detector at the HWWRA (2.22± 0.32 bat passes/detector-night) was similar to the mean of 2.2 bat passes/detector-night recorded at the Foote Creek Rim wind-energy facility in 2000. The Foote Creek Rim facility is located approximately 60 miles (96.6 km) northwest of the HWWRA. Actual bat mortality at the Foote Creek Rim facility in 2000 (the only year for which bat activity estimates are available) was estimated at 1.05 bat fatalities/MW/year (Gruver 2002). The rate of 1.05 bat fatalities/MW/year measured at Foote Creek Rim is low compared to most other operational wind-energy facilities (Johnson 2005, Arnett et al. 2008). Based on similar activity levels, the proximity of the HWWRA to the Foote Creek Rim Facility, and the presence of similar habitats among the two areas, similar rates of bat mortality could be expected at the HWWRA. Bat activity at the HWWRA was within the range of bat activity levels recorded at several other wind resource areas in Wyoming, where they have ranged from 0.29 to 3.76 bat passes/detector night (Table 7). To date, however, the only bat mortality data for Wyoming are from the Foote Creek Rim wind-energy facility. As more research is conducted at facilities in the Wyoming, more information regarding the potential direct impacts of Wyoming wind-energy facilities to bats will be obtained.

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Table 1. Mapped vegetation/habitat types, coverage, and % composition within the Hermosa West Wind Resource Area.

Habitat	Acres	% Composition
Grassland	9,735.14	87.56
Coniferous Forest	661.33	5.95
Riparian	397.70	3.58
Mountain Mahogany	131.30	1.18
Shrub Steppe	106.46	0.96
Riparian/Willow	86.01	0.77
Total	**11,117.94**	**100.00**

Table 2 Bat species determined from range-maps (Harvey et al. 1999, BCI website) as likely to occur within the Hermosa West Wind Resource Area, sorted by call frequency.

Common Name	Scientific Name
High Frequency (HF; ≥ 40 kHz)	
western small-footed bat	*Myotis ciliolabrum*
long-legged bat[1]	*Myotis volans*
Mid Frequency (MF; 30-40 kHz)	
eastern red bat[1,2,3]	*Lasiurus borealis*
western long-eared bat	*Myotis evotis*
little brown bat[2]	*Myotis lucifugus*
Low Frequency (LF; < 30 kHz)	
pallid bat[3]	*Antrozous pallidus*
Townsend's big-eared bat	*Corynorhinus townsendii*
big brown bat[2]	*Eptesicus fuscus*
silver-haired bat[1,2]	*Lasionycteris noctivagans*
hoary bat[1,2]	*Lasiurus cinereus*
fringed bat	*Myotis thysanodes*

[1]long-distance migrant; [2]species known to have been found dead at wind-energy facilities; [3]species occurrence based upon a single source

Table 3. Results of acoustic bat surveys conducted at the Hermosa West Wind Resource Area, July 15 – November 3, 2009, separated by call frequency (HF = high frequency, MF = mid frequency, LF = low frequency).

Anabat Station	Type	Type	Habitat	# of HF Bat Passes	# of MF Bat Passes	# of LF Bat Passes	# of Eastern Red Bat Passes*	# of Hoary Bat Passes**	Total Bat Passes	Detector - Nights	Bat Passes/ Night
HE1g	Fixed	Ground	Grassland	82	38	104	0	9	224	101	2.22±0.34
HE1h	Fixed	Raised	Grassland	1	12	178	3	60	191	93	2.05±0.27
HE5m	Temporary	Ground	Ponderosa pine	52	17	23	1	2	92	13	7.08±2.03
HE6m	Temporary	Ground	Riparian/ willow	113	69	198	2	21	380	17	22.35±8.19
HE7m	Temporary	Ground	Riparian/ aspen	167	47	44	17	1	258	10	25.80±8.81
HE8m	Temporary	Ground	Mountain mahogany	4	2	16	0	1	22	18	1.22±0.46
Total Temporary Ground				**336**	**135**	**281**	**20**	**25**	**752**	**58**	**14.11±3.12**
Grand Total				**419**	**185**	**563**	**23**	**94**	**1,167**	**252**	**10.12±2.16**

*Passes by eastern red bats included in mid-frequency (MF) numbers; **Passes by hoary bats included in low-frequency (LF) numbers.

Table 4. Weekly bat activity and the contribution of each week (%) to total recorded activity for high-frequency (HF), mid-frequency (MF), low-frequency (LF) and all bats at fixed stations within the Hermosa West Wind Resource Area.

Week	HF Pass Rate	HF % Composition	MF Pass Rate	MF % Composition	LF Pass Rate	LF % Composition	All Bats Pass Rate	All Bats % Composition	Cumulative % Composition
07/15/09 to 07/21/09	1.29	16.9	0.14	3.7	1.86	8.2	3.29	9.6	9.6
07/22/09 to 07/28/09	1.83	24.1	0.33	8.5	1.17	5.2	3.33	9.8	19.4
07/29/09 to 08/04/09	0	0	0.14	3.7	1.71	7.6	1.86	5.4	24.8
08/05/09 to 08/11/09	1.57	20.6	0.64	16.5	2.21	9.8	4.43	13	37.8
08/12/09 to 08/18/09	1.07	14.1	0.5	12.8	1.29	5.7	2.86	8.4	46.2
08/19/09 to 08/25/09	0.79	10.3	0.79	20.1	2.93	12.9	4.5	13.2	59.3
08/26/09 to 09/01/09	0.79	10.3	0.57	14.6	3.5	15.5	4.86	14.2	73.6
09/02/09 to 09/08/09	0.21	2.8	0.07	1.8	2.86	12.6	3.14	9.2	82.8
09/09/09 to 09/15/09	0.07	0.9	0.5	12.8	1.64	7.3	2.21	6.5	89.2
09/16/09 to 09/22/09	0	0	0.07	1.8	2	8.8	2.07	6.1	95.3
09/23/09 to 09/29/09	0	0	0.14	3.7	1.14	5	1.29	3.8	99.1
09/30/09 to 10/06/09	0	0	0	0	0.15	0.7	0.15	0.4	99.5
10/07/09 to 10/13/09	0	0	0	0	0	0	0	0	99.5
10/14/09 to 10/20/09	0	0	0	0	0.17	0.7	0.17	0.5	100
10/21/09 to 10/27/09	0	0	0	0	0	0	0	0	100
10/28/09 to 11/03/09	0	0	0	0	0	0	0	0	100

Table 5. Weekly bat use and the contribution of each week (%) to total recorded activity for hoary bats and eastern red bats at fixed stations within the Hermosa West Wind Resource Area, from July 15 – November 3, 2009.

Week	Hoary Bat Pass Rate	Hoary Bat % Composition	Eastern Red Bat Use	Eastern Red Bat Composition	All Bats Use	All Bats % Composition	Cumulative % Composition
07/15/09 to 07/21/09	0	0	0.43	7.6	3.29	9.6	9.6
07/22/09 to 07/28/09	0	0	0.17	3	3.33	9.8	19.4
07/29/09 to 08/04/09	0	0	0.71	12.7	1.86	5.4	24.8
08/05/09 to 08/11/09	0	0	0.93	16.5	4.43	13	37.8
08/12/09 to 08/18/09	0	0	0.5	8.9	2.86	8.4	46.2
08/19/09 to 08/25/09	0	0	0.93	16.5	4.5	13.2	59.3
08/26/09 to 09/01/09	0.14	66.7	0.21	3.8	4.86	14.2	73.6
09/02/09 to 09/08/09	0	0	0.5	8.9	3.14	9.2	82.8
09/09/09 to 09/15/09	0.07	33.3	0.43	7.6	2.21	6.5	89.2
09/16/09 to 09/22/09	0	0	0.64	11.4	2.07	6.1	95.3
09/23/09 to 09/29/09	0	0	0	0	1.29	3.8	99.1
09/30/09 to 10/06/09	0	0	0.08	1.4	0.15	0.4	99.5
10/07/09 to 10/13/09	0	0	0	0	0	0	99.5
10/14/09 to 10/20/09	0	0	0.08	1.5	0.17	0.5	100
10/21/09 to 10/27/09	0	0	0	0	0	0	100
10/28/09 to 11/03/09	0	0	0	0	0	0	100

Table 6. Wind-energy facilities in North America with mortality data for bat species, grouped by geographic region. Bat activity rates are included where available. To date, no bat fatality estimates or studies from Southwestern or Southeastern wind-energy facilities have been made public.

Wind Energy Facility	Bat Use Estimate[A]	Mortality Estimate[B]	No. of Turbines	Total MW
Hermosa West, WY	2.22			
Rocky Mountains and Western				
Summerview, Alb. (2006)		14.62	39	70.2
Summerview, Alb. (2005/6)		10.27	39	70.2
Judith Gap, MT		8.93	90	135
Summerview, Alb. (2007)		8.23	39	70.2
Foote Creek Rim, WY (Phase I; 1999)		3.97	69	41.4
Foote Creek Rim, WY (Phase I; 2001/2002)		1.57	69	41.4
Foote Creek Rim, WY (Phase I; 2000)	2.2	1.05	69	41.4
Stateline, OR/WA (2003)		2.52	454	300
High Winds, CA (2004)		2.51	90	162
Nine Canyon, WA		2.47	37	48
Big Horn, WA		1.90	133	199.5
Combine Hills, OR		1.88	41	41
High Winds, CA (2005)		1.52	90	162
Stateline, OR/WA (2002)		1.20	454	300
Vansycle, OR		1.12	38	24.9
Klondike, OR		0.77	16	24
Hopkins Ridge, WA		0.63	83	150
Klondike II, OR		0.41	50	75
Wild Horse, WA		0.39	127	229
SMUD, CA		0.07		15
Midwest				
Blue Sky Green Field, WI	7.7[D]	24.57	88	145
Top of Iowa, IA (2004)	34.9[C]	10.27	89	80
Top of Iowa, IA (2003)	34.9[C]	7.16	89	80
Kewaunee County, WI		6.55	31	20
Buffalo Ridge, MN (Phases II & III; 2001)	2.2	4.03	281	210.75
Crescent Ridge, IL		3.27	33	49.5
Buffalo Ridge, MN (Phase III; 1999)		2.72	138	103.5
Buffalo Ridge, MN (Phase II; 1999)		2.59	143	107.25
Buffalo Ridge, MN (Phase II; 1998)		2.16	143	107.25
Buffalo Ridge, MN (Phases II & III; 2002)	1.9	1.73	281	210.75
NPPD Ainsworth, NE		1.16	36	59.4
Buffalo Ridge, MN (Phase I; 1999)		0.76	73	25
Southern Plains				
Oklahoma Wind Energy Center, OK		0.53	68	102
Buffalo Gap, TX		0.10	67	134

Table 6. Wind-energy facilities in North America with mortality data for bat species, grouped by geographic region. Bat activity rates are included where available. To date, no bat fatality estimates or studies from Southwestern or Southeastern wind-energy facilities have been made public.

Wind Energy Facility	Bat Use Estimate[A]	Mortality Estimate[B]	No. of Turbines	Total MW
Northeastern				
Buffalo Mountain, TN (2006)		39.70	18	29
Mountaineer, WV	38.3	31.69	44	66
Buffalo Mountain, TN (2000-2003)	23.7	31.54	3	2
Meyersdale, PA		18.00	20	30
Casselman, PA		15.66	23	34.5
Maple Ridge, NY (2006)		15.00	120	198
Noble Bliss, NY		14.66	67	100
Mount Storm, WV (2008)	35.2	12.11	82	164
Maple Ridge, NY (2007)		9.42	195	321.75
Noble Ellenburg, NY		5.45	54	80
Noble Clinton, NY		3.63	67	100.5
Mars Hill, ME (2007)		2.91	28	42

A=bat passes per detector night
B=number of bat fatalities/MW/year
C=averaged across phases and/or study years, and may not be directly related to mortality estimates
D=bat activity not measured concurrently with bat mortality studies
Data from the following sources:

Facility	Use Estimate	Mortality Estimate	Facility	Use Estimate	Mortality Estimate
Summerview, Alb. (06)		Baerwald 2008	Kewaunee County, WI		Howe et al. 2002
Summerview, Alb. (05/06)		Brown and Hamilton 2006	Buffalo Ridge, MN (Phase II& III; 01)		Johnson et al. 2004
Judith Gap, MT		TRC 2008	Crescent Ridge, IL		Kerlinger et al. 2007
Summerview, Alb. (07)		Baerwald 2008	Buffalo Ridge, MN (Phase III; 99)		Johnson et al. 2004
Foote Creek Rim, WY (Phase I; 99)		Young et al. 2003	Buffalo Ridge, MN (Phase II; 99)	Johnson et al. 2000	Johnson et al. 2004
Foote Creek Rim, WY (Phase I; 01/02)	Gruver 2002	Young et al. 2003	Buffalo Ridge, MN (Phase II; 98)	Johnson et al. 2000	Johnson et al. 2004
Foote Creek Rim, WY (Phase I; 00)	Gruver 2002	Young et al. 2003	Buffalo Ridge, MN (Phase II& III; 02)		Johnson et al. 2004
Stateline, OR/WA (03)		Erickson et al. 2004	NPPD Ainsworth, NE		Derby et al. 2007
High Winds, CA (04)		Kerlinger et al. 2006	Buffalo Ridge, MN (Phase I; 99)		Johnson et al. 2000
Nine Canyon, WA		Erickson et al. 2003	Oklahoma Wind Energy Center, OK		Piorkowski 2006
Big Horn, WA		Kronner et al. 2008	Buffalo Gap, TX		Tierney 2007
Combine Hills, OR		Young et al. 2006	Buffalo Mountain, TN (06)		Fiedler et al. 2007
High Winds, CA (05)		Kerlinger et al. 2006	Mountaineer, WV	Arnett (pers comm. 2005)	Kerns and Kerlinger 2004
Stateline, OR/WA (02)		Erickson et al. 2004	Buffalo Mountain, TN (00-03)	Fiedler 2004	Nicholson et al. 2005
Vansycle, OR		Erickson et al. 2000	Meyersdale, PA		Arnett et al. 2005
Klondike, OR		Johnson et al. 2003	Casselman, PA		Arnett et al. 2009
Hopkins Ridge, WA		Young et al. 2007	Maple Ridge, NY (06)		Jain et al. 2007
Klondike II, OR		NWC and WEST 2007	Noble Bliss, NY		Jain et al. 2009c
Wild Horse, WA		Erickson et al. 2008	Mount Storm, WV (08)	Young et al. 2009	Young et al. 2009
SMUD, CA		URS et al. 2005	Maple Ridge, NY (07)		Jain et al. 2008
Blue Sky Green Field, WI	Gruver 2008	Gruver et al. 2010	Noble Ellensburg, NY		Jain et al. 2009a
Top of Iowa, IA (04)	Jain 2005	Jain 2005	Noble Clinton, NY		Jain et al. 2009b
Top of Iowa, IA (03)	Jain 2005	Jain 2005	Mars Hill, ME (07)		Stantec 2008

Table 7. Bat activity indices for several wind resource areas in Wyoming.

Wind Resource Area	Location	Bat passes/ Detector night	Reference
Glenrock/Rolling Hills	Converse County	0.29	Johnson et al. 2008a
Campbell Hill	Converse County	2.03	Taylor et al. 2008
Seven Mile Hill	Carbon County	2.90	Johnson et al. 2008b
Dunlap Ranch	Carbon County	1.67	Johnson et al. 2009b
Simpson Ridge	Carbon County	1.79	Johnson et al. 2009c
High Plains	Carbon/Albany Counties	3.76	Johnson et al. 2009a
Foote Creek Rim	Carbon County	2.20	Gruver 2002
Hermosa West	Albany County	2.22	This study
Mean		**2.11**	

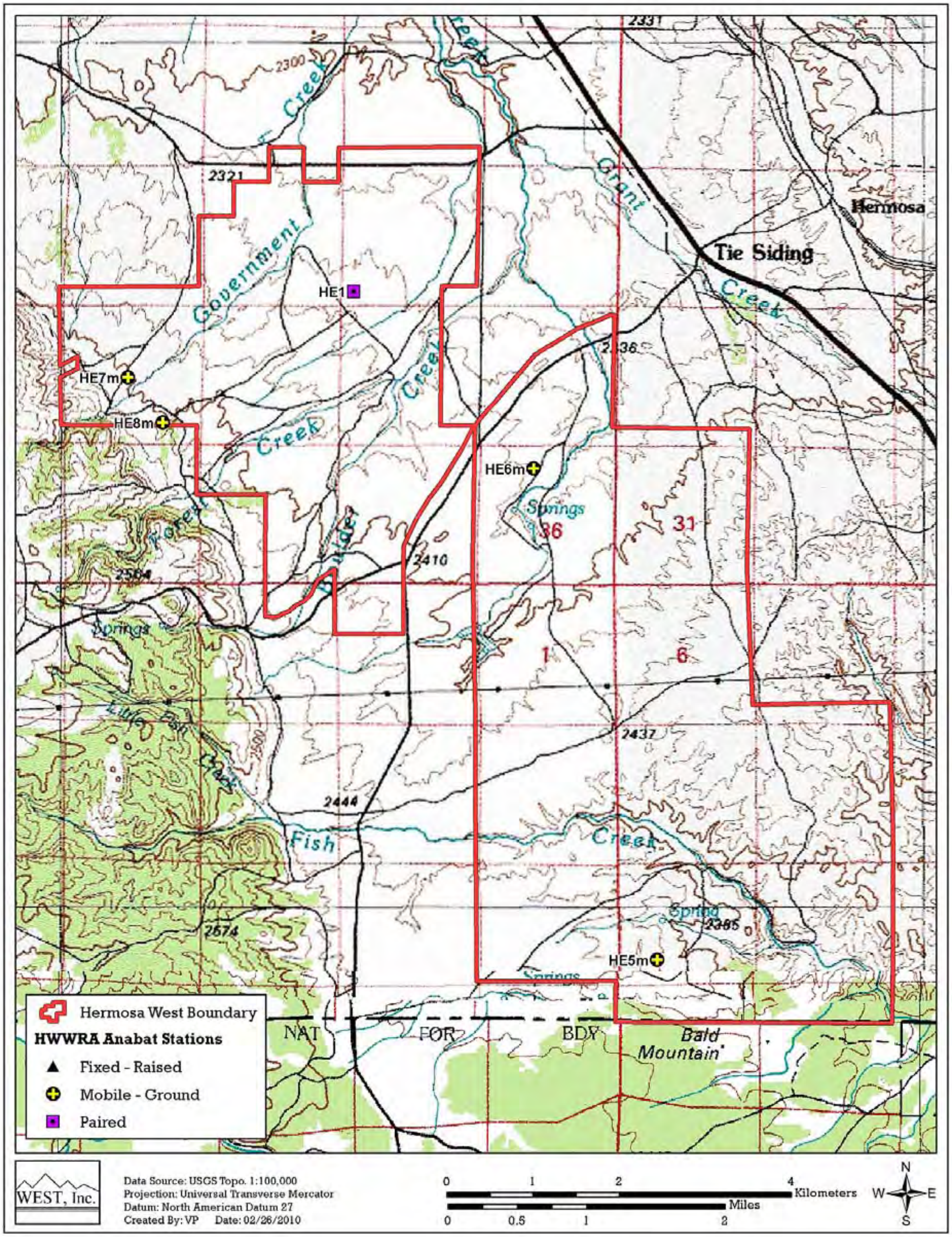

Figure 1. Study area map and Anabat sampling stations at the Hermosa West Wind Resource Area.

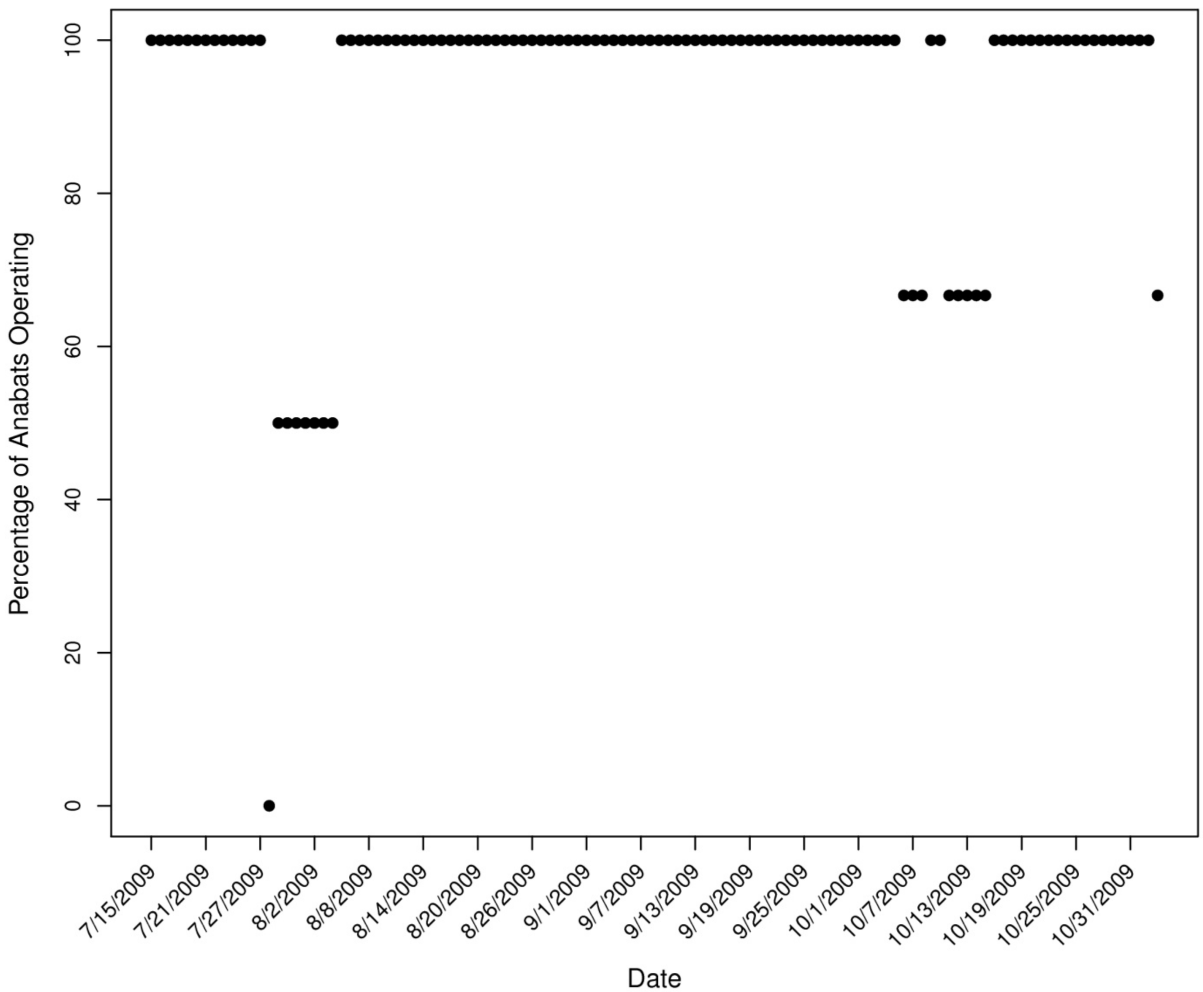

Figure 2. Percentage of Anabat detectors (n = 3) at the Hermosa West Wind Resource Area operating during each night of the study period July 15 – November 3, 2009. The detector used for temporary stations was in use at another project area between September 18 and October 4.

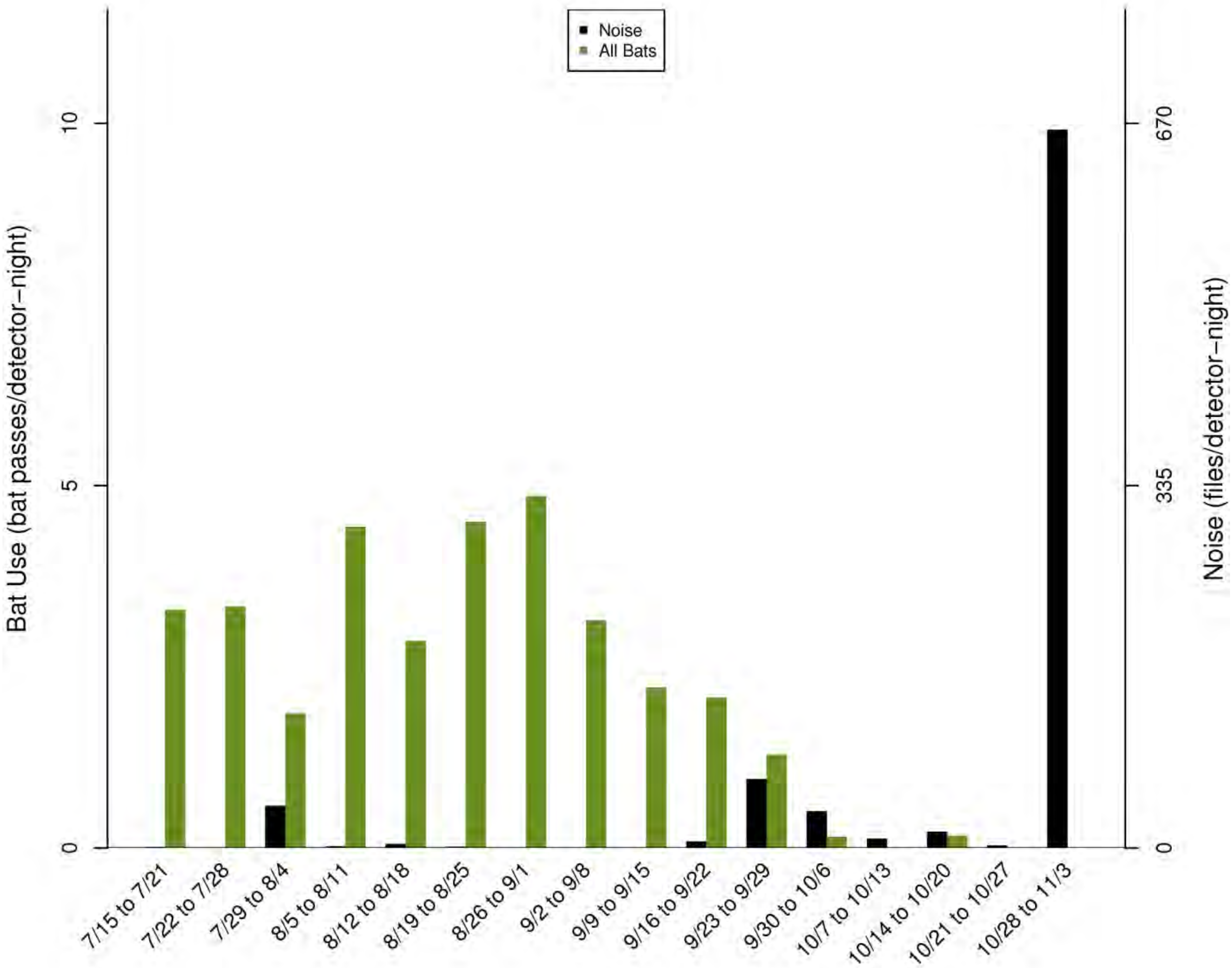

Figure 3. Bat use and noise files detected per detector-night for fixed stations at the Hermosa West Wind Resource Area for the study period July 15 – November 3, 2009, presented by week. Noise files are indicated on the second axis.

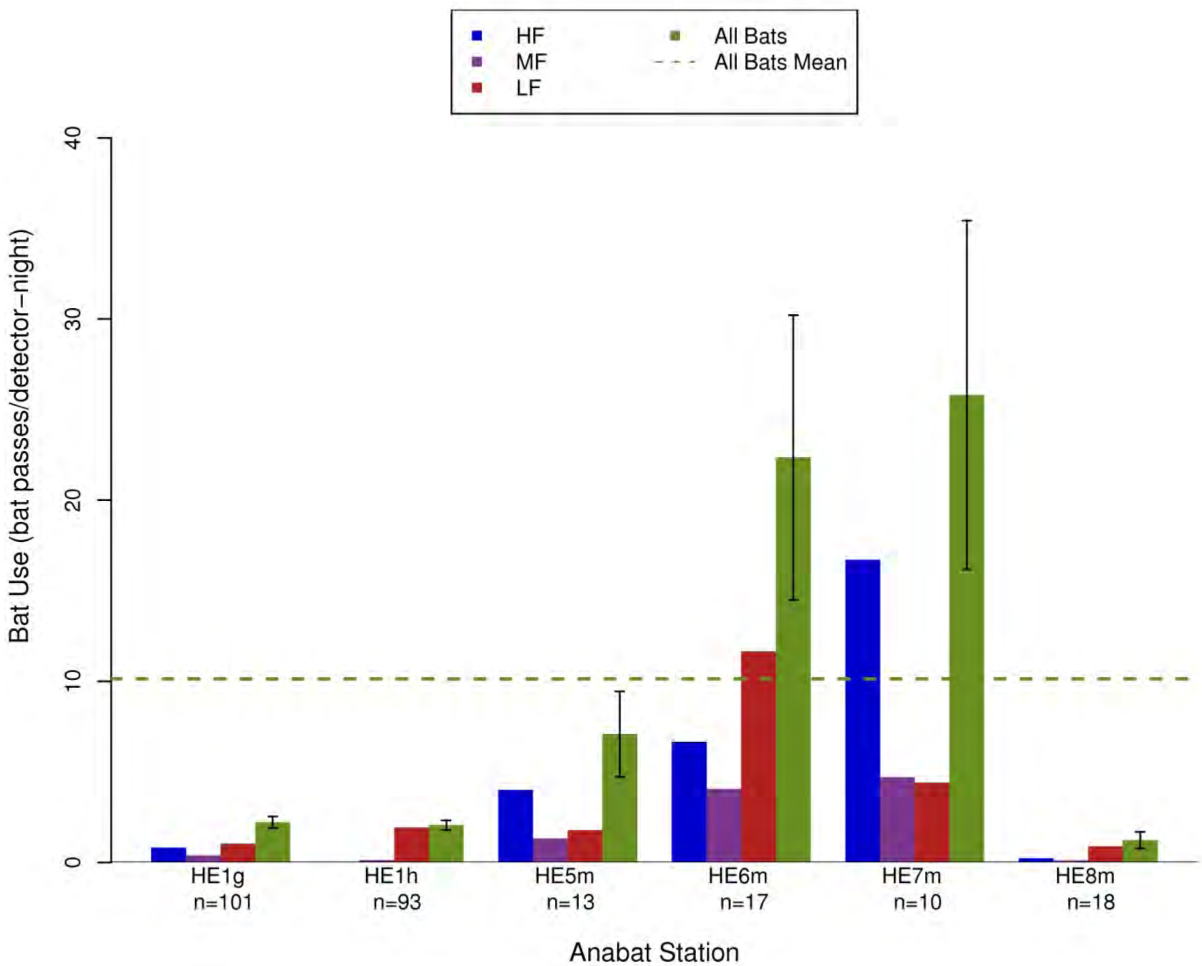

Figure 4. Number of bat passes per detector-night by Anabat station at the Hermosa West Wind Resource Area for the study period July 15 – November 3, 2009. For this study, stations HE1g and HE1h are paired ground and raised detectors. One detector was moved among temporary stations HE5m – HE8m. The bootstrapped standard errors are represented on the 'All Bats' columns.

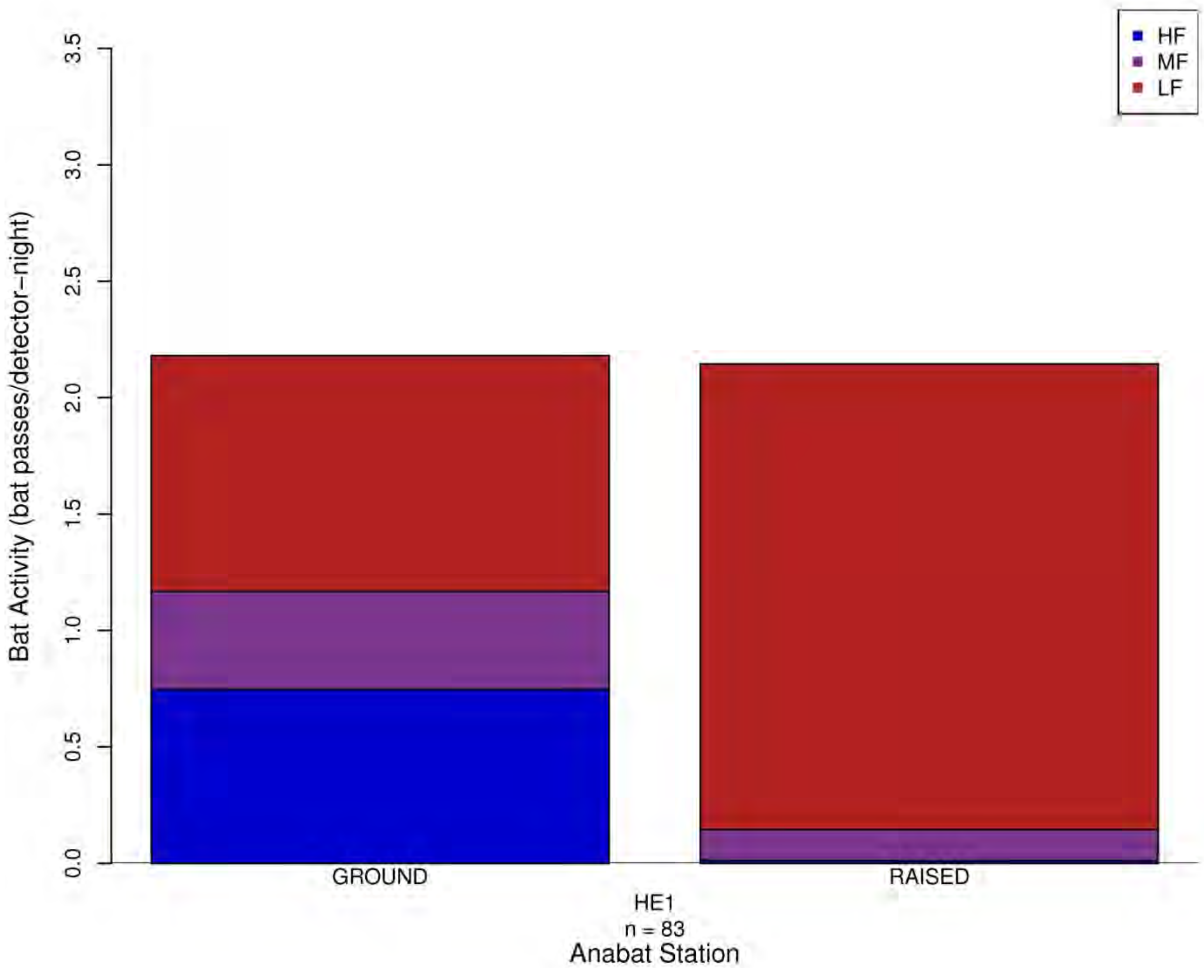

Figure 5. Number of high-frequency (HF), mid-frequency (MF), and low-frequency (LF) bat passes per detector-night recorded at the paired Anabat station with ground and raised detectors at the Hermosa West Wind Resource Area for the study period July 15 – November 3, 2009.

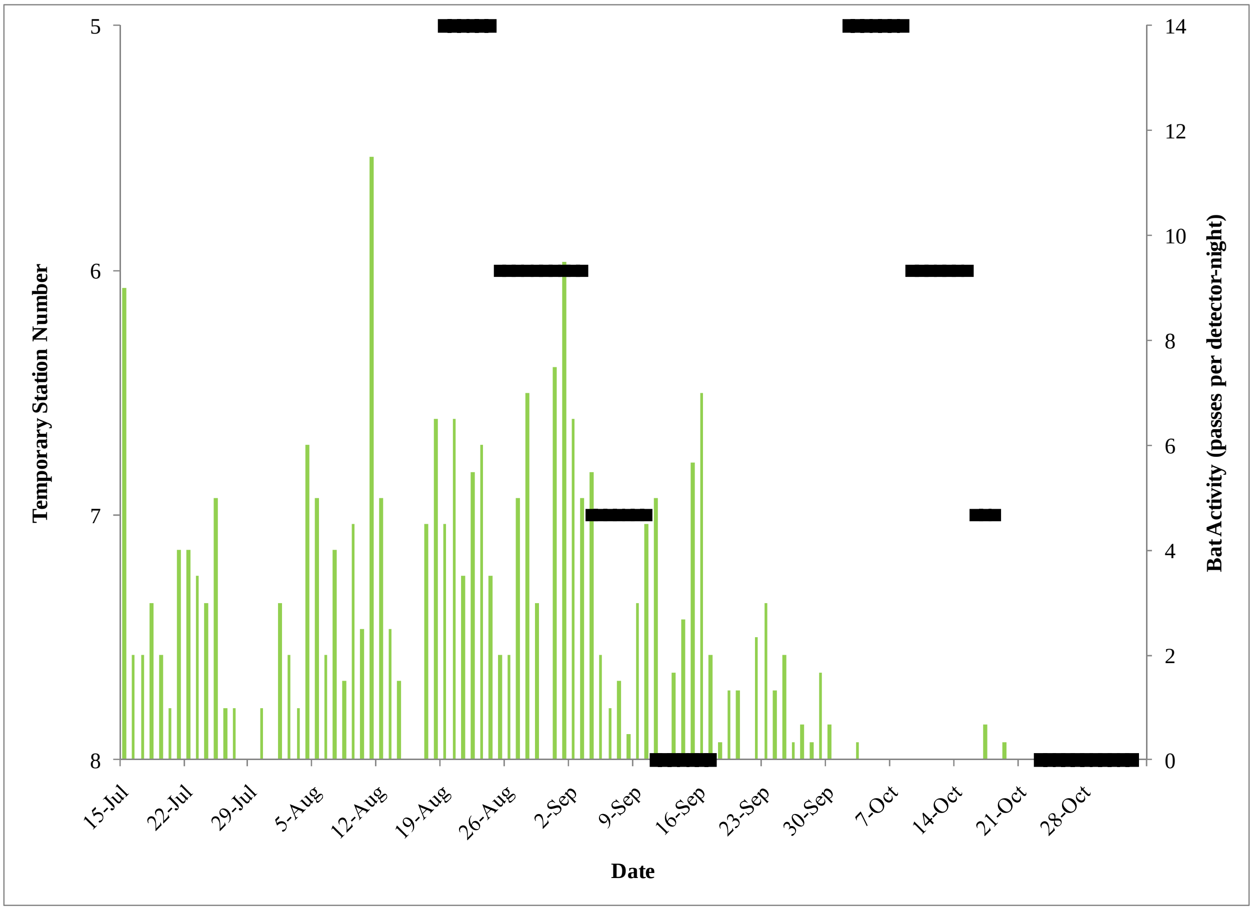

Figure 6. Nightly sampling effort in relation to bat activity for temporary Anabat stations at the Hermosa West Wind Resource Area for the study period July 15 – November 3, 2009. For example, the detector at station HE6m was operable between August 25 – September 2, and between September 9 – 14. Nightly bat activity is plotted on the second axis. The detector used at temporary stations was in use at another project area between September 18 and October 4.

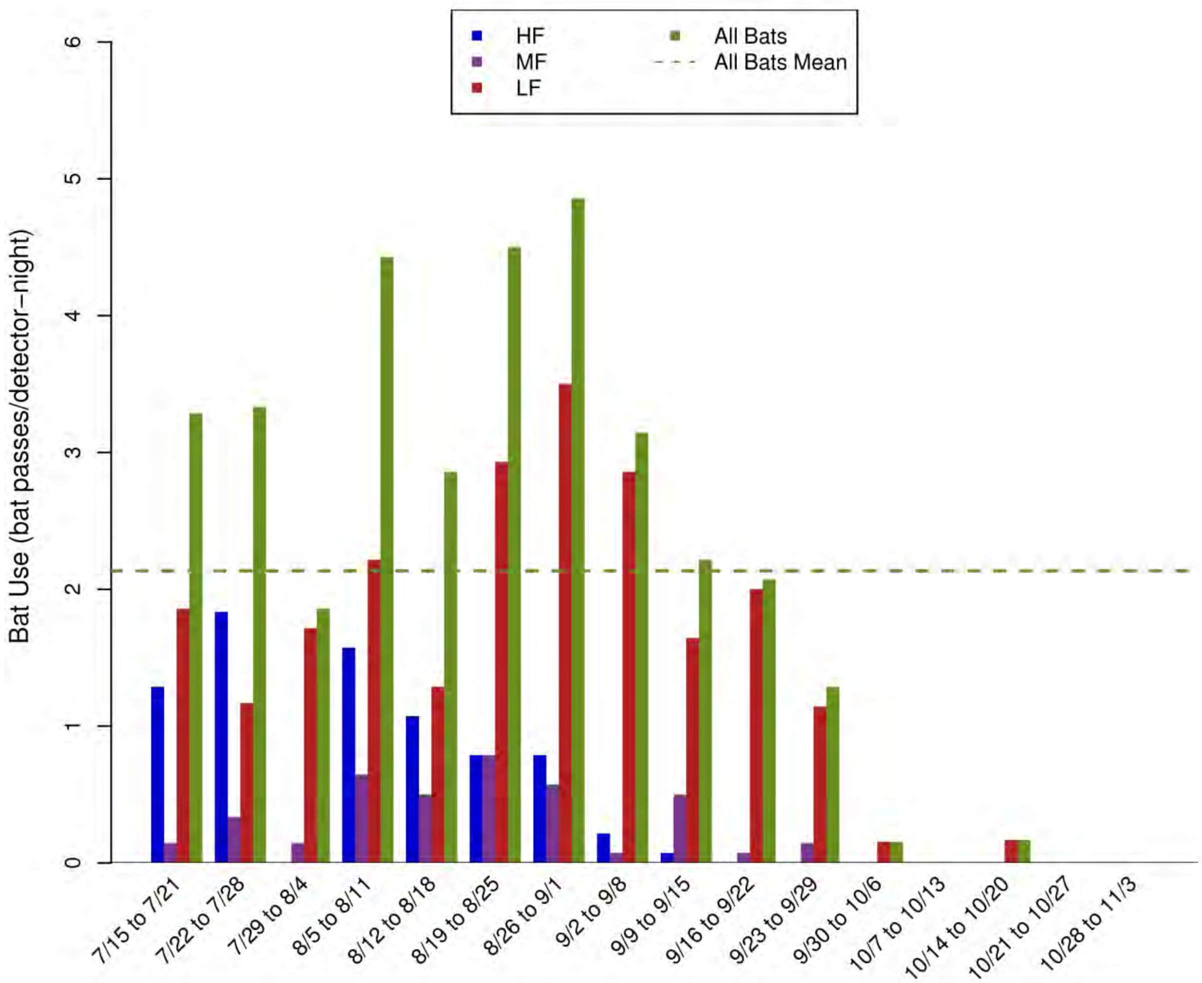

Figure 7. Weekly bat use by high-frequency (HF), mid-frequency (MF), and low-frequency (LF) bats at fixed stations at the Hermosa West Wind Resource Area for the study period July 15 – November 3, 2009.

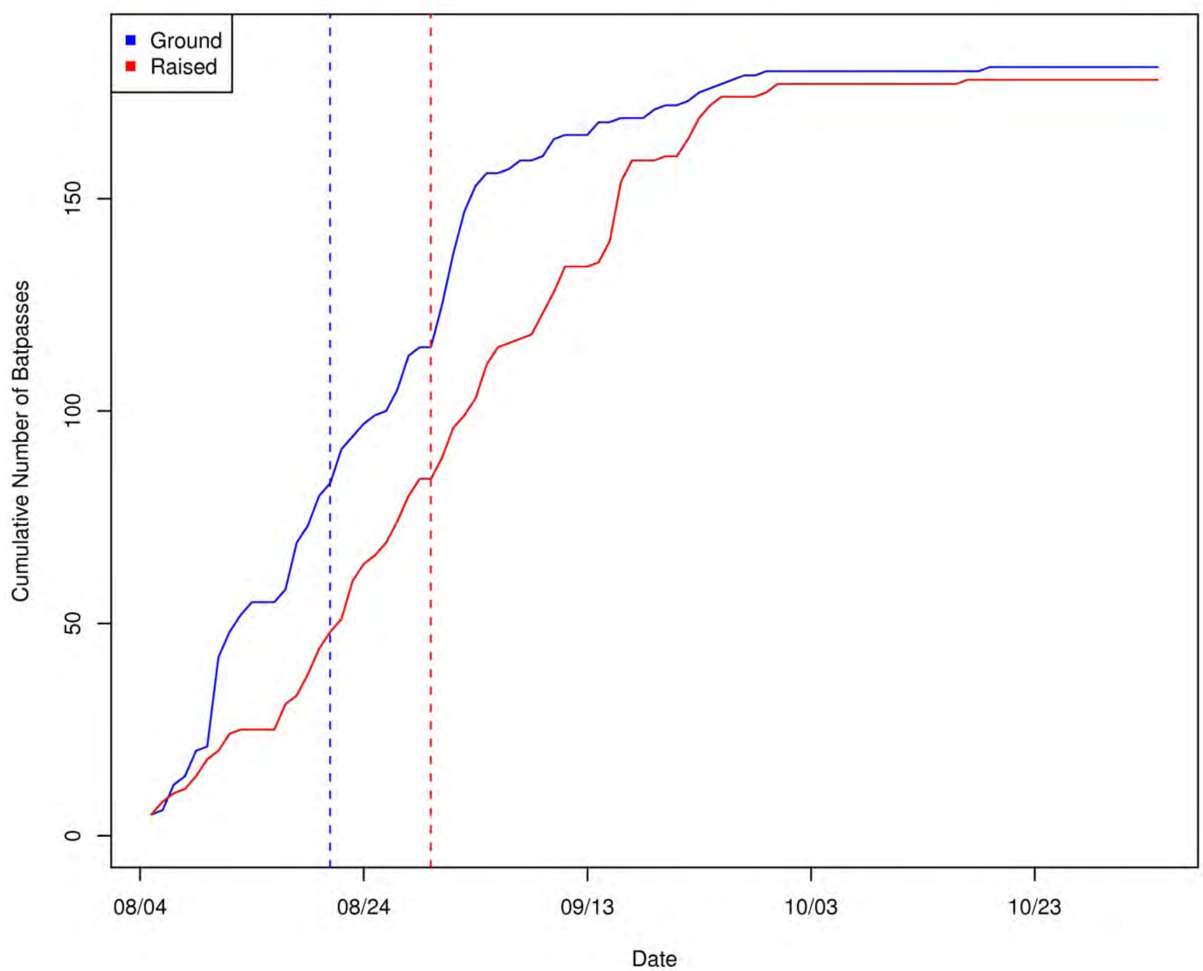

Figure 8. Empirical cumulative distribution of bat passes at ground and raised stations within the Hermosa West Wind Resource Area, July 15 – November 3, 2009. Dashed vertical lines indicate the point at which 50% of the calls occurred, an indication of the median date of bat activity.

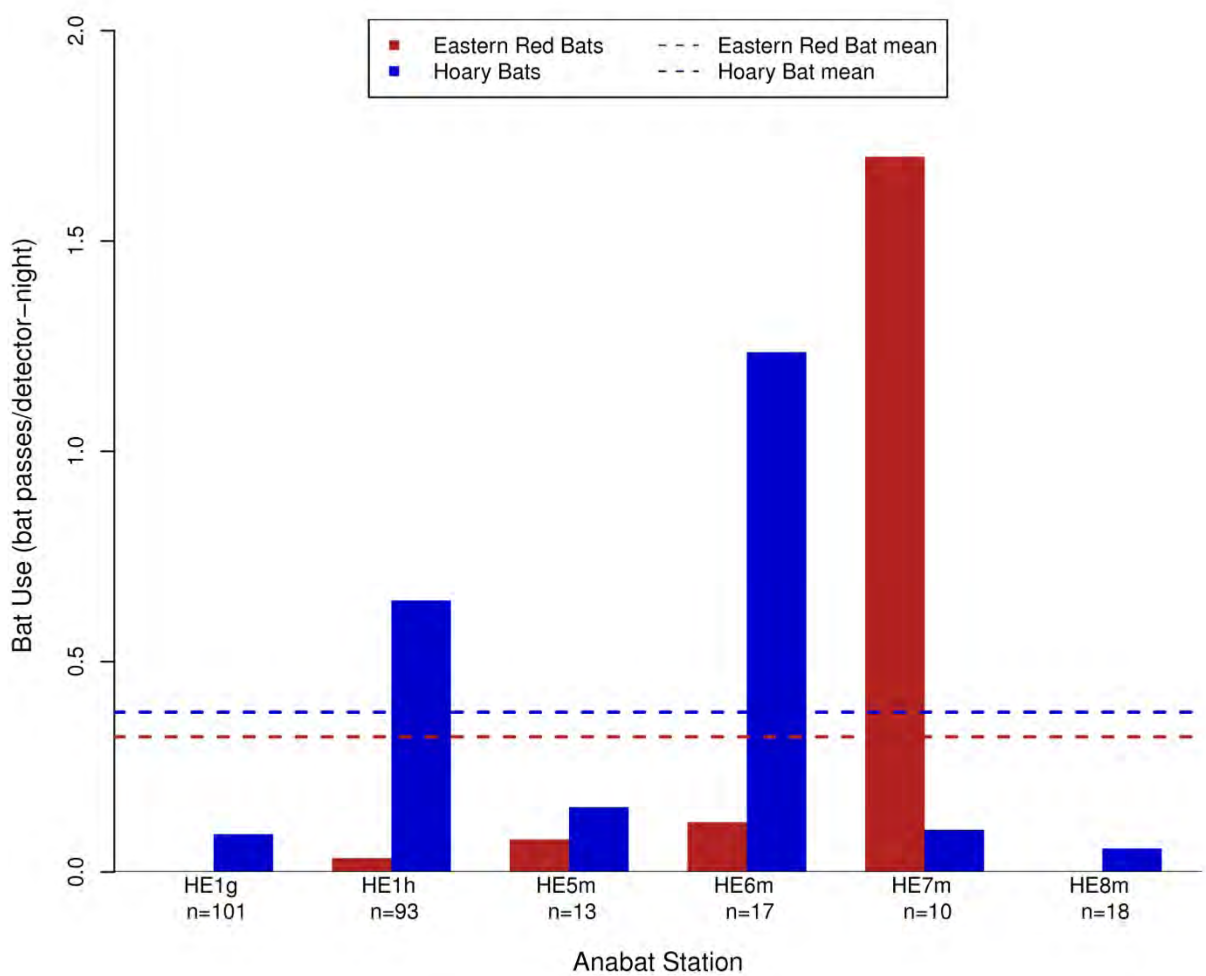

Figure 9. Number of passes per detector–night by hoary bats and eastern red bats recorded at Anabat stations within the Hermosa West Wind Resource Area, for the study period July 15 – November 3, 2009.

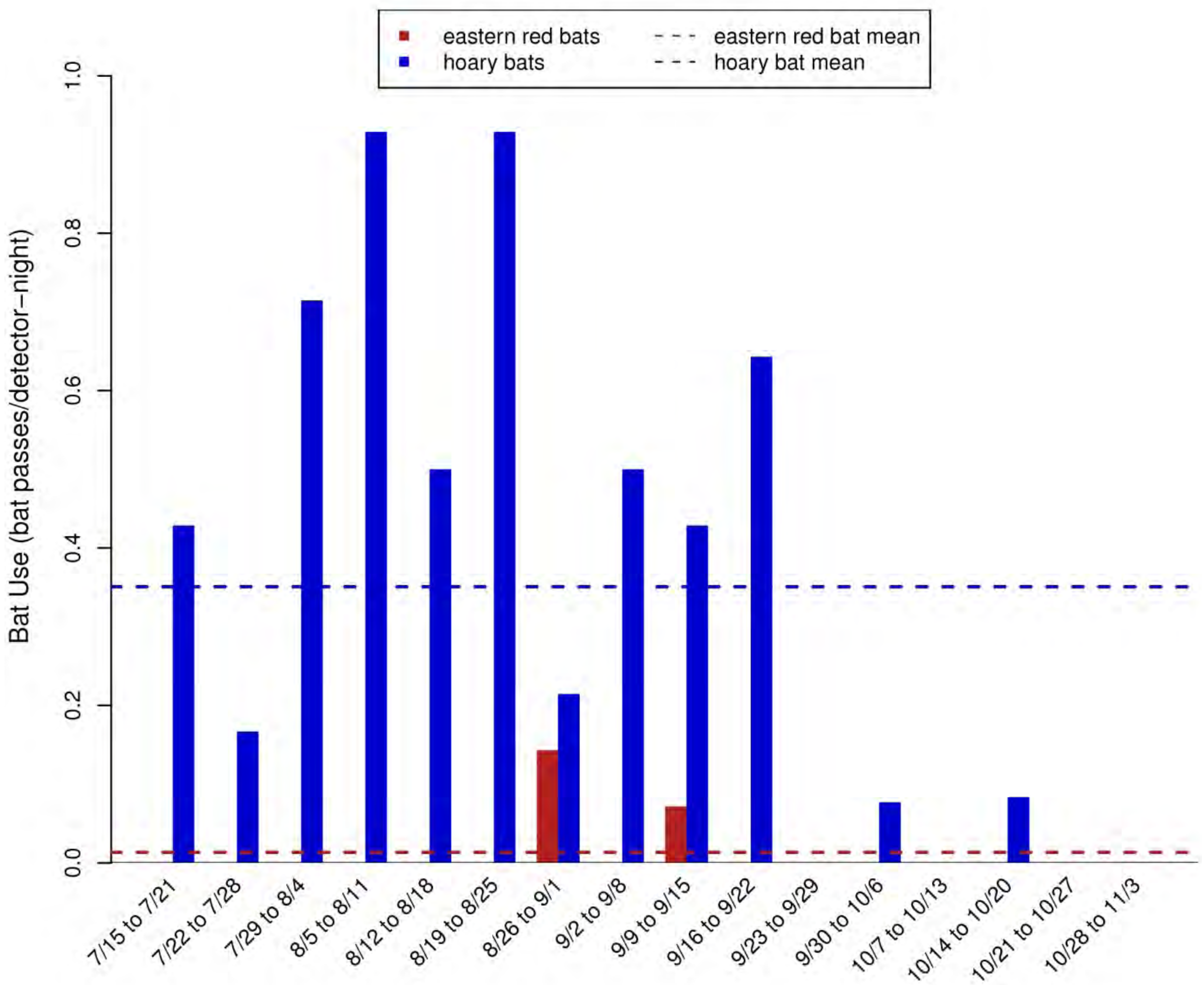

Figure 10. Weekly activity by hoary bats and eastern red bats at fixed stations within the Hermosa West Wind Resource Area for the study period July 15 – November 3, 2009.

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APPENDIX G

TRIBAL CONSULTATION LETTER

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Department of Energy
Western Area Power Administration
Rocky Mountain Customer Service Region
P.O. Box 3700
Loveland, CO 80539-3003

FEB 05 2010

Mr. Cedric Black Eagle, Chairman
Crow Nation
P.O. Box 159
Crow Agency, MT 59022

Dear Mr. Black Eagle:

The Western Area Power Administration (Western) invites your Tribe's involvement in the Hermosa West Wind Energy Project (Project) in southeastern Wyoming. The Project would consist of up to 200 wind turbines with a combined generating capacity of up to 300 megawatts. It would be located within an 11,125-acre site. Shell WindEnergy, Inc. (SWE) requested to interconnect the Project with Western's existing Craig-Ault 345-kilovolt (kV) Transmission Line in Albany County, Wyoming. Western will prepare an Environmental Impact Statement (EIS) to evaluate SWE's request. The EIS will evaluate the environmental impacts associated with the construction, operation and maintenance of the wind farm and a substation needed to interconnect with the transmission line. Enclosed is a map of the Project area with the proposed turbine corridors and access roads.

In addition to being the lead Federal agency in the environmental review, Western is the lead Federal agency for compliance with Section 106 of the National Historic Preservation Act (NHPA) and other cultural and historic resource protection requirements. The Project study area will be inventoried for cultural resources. Western invites the Tribe's participation in project review and consultation as Western fulfills its requirements under the NHPA. Western will coordinate with the Tribe for Cultural Resources issues on the Project. As the Project moves through the environmental review process, there may be modifications to turbine locations within the turbine corridors. The majority of land is privately-owned.

Western wants to ensure that important cultural and natural resources and places with traditional cultural significance for your Tribe within the Project area are considered and addressed in the EIS and NHPA consultations. We would appreciate receiving any information that you would be willing to share with us on any unique, special, ethnographic, or archaeological resources or areas in or near the proposed Project. If you are aware of any other Tribes, individuals, or tribally affiliated organizations that should be consulted regarding this Project, please let us know. A list of other Tribes and individuals receiving this letter is enclosed.

Gaining the Tribe's specific knowledge and perspective during development of the EIS is valuable to the overall success of the EIS. Western would like to facilitate discussion and information sharing with the Tribe. If the Tribe would like to be a cooperating agency in the EIS please let us know. Cooperating agencies participate in the preparation and review of the EIS and have jurisdiction by law over some aspect of the Project or have special expertise with respect to an environmental issue.

Preparation of the EIS will proceed over the next 12 months in a multi-step process that will include publication of the Draft EIS, the Final EIS, and Record of Decision (ROD) by Western, and other Federal cooperating agencies. The expected date of the ROD is March of 2011.

As part of the environmental review process, Western conducted two public scoping meetings in Cheyenne, WY and Laramie, WY. These meetings were on January 26 and January 27, 2010, respectively. Public hearings on the Draft EIS are anticipated in late fall or winter of 2010.

As Western progresses through the environmental review process, it will send the Tribe newsletters, public meeting notices and other information on the Project.

If you would like to meet with Western to discuss the Project, have questions, or require additional information, please contact Mr. Steve Tromly at the address below:

Mr. Steve Tromly
Native American Liaison
Western Area Power Administration
P.O. Box 3700
Lakewood, CO 80539
720-962-7256
tromly@wapa.gov

Sincerely,

James Hartman
Environmental Manager

2 Enclosures

cc: (w/enclosures)

Mr. Marvin Keller, Regional Archaeologist
Bureau of Indian Affairs
Rocky Mountain Regional Office
316 North 26th Street
Billings, MT 59101

Bcc:

Gwen Brodsky, Tetra Tech EC, Inc. (w/enclosures)

Tetra Tech EC, Inc.
7350 East Progress Place, Suite 100
Greenwood Village, CO 80111

R. Rodgers, A7400, Lakewood, CO (w/enclosures)
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M.Wieringa, A7900, Lakewood, CO (w/enclosures)
J0400 (w/o enclosures)
J0440 (w/enclosures)

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Hermosa West Wind Energy Project Tribal Contacts
(2/3/2010)

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Mr. Hubert Two Leggings
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Crow Nation Cultural Committee
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Mr. Ivan Posey, Chairman
Shoshone Business Council
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Mr. Arlen Shoyo
Eastern Shoshone Tribal Historic Preservation Officer
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Mr. Harvey Spoonhunter, Chairman
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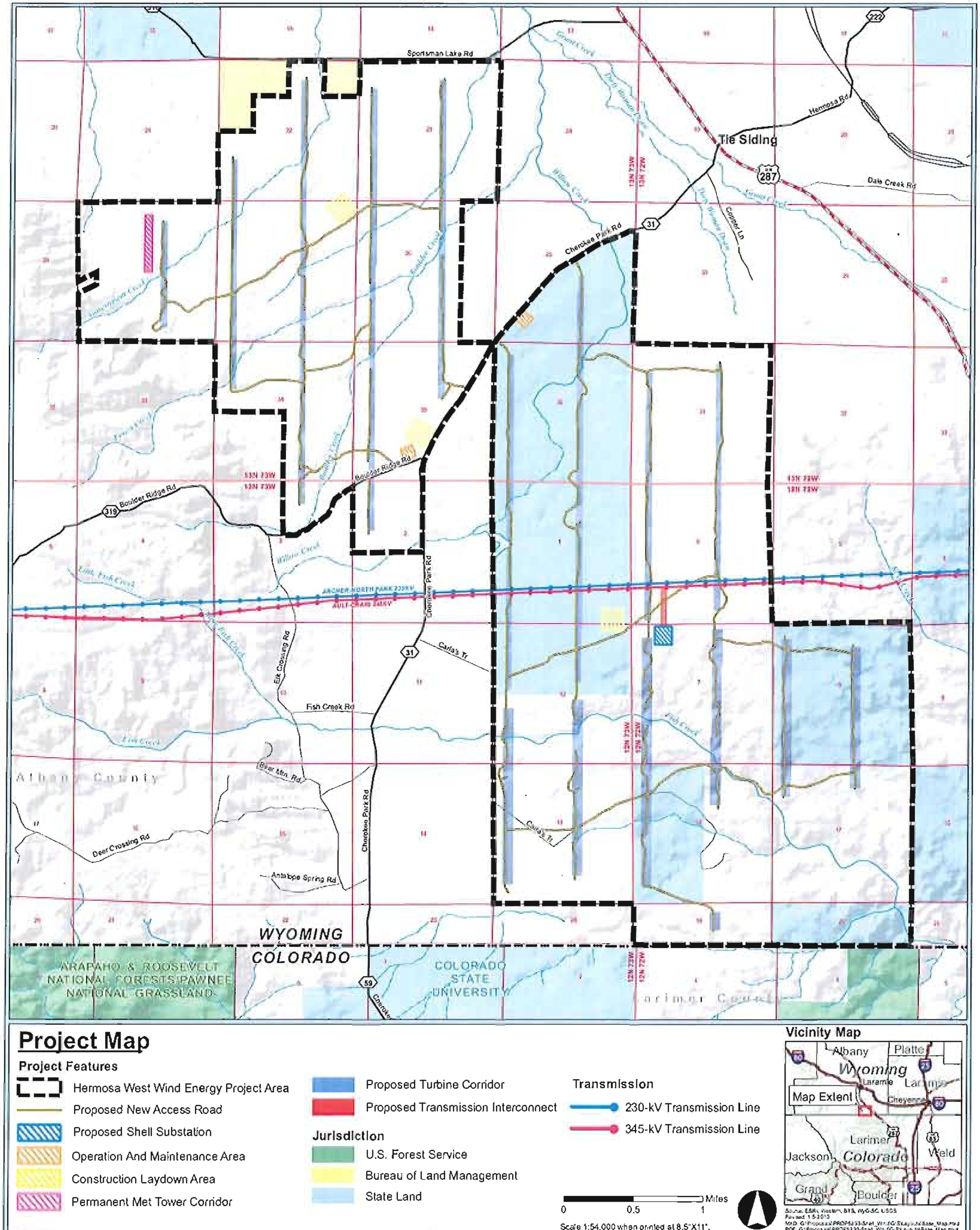
Northern Cheyenne Tribal Council
P.O. Box 128
Lame Deer, MT 59043

Mr. Linwood Tall Bull
Northern Cheyenne Tribal Historic and Preservation Officer
P.O. Box 128
Lame Deer, MT 59043



HERMOSA WEST WIND ENERGY PROJECT

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APPENDIX H

PALEONTOLOGIC RESOURCES ANALYSIS LETTER REPORT

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Erathem-Vanir Geological Consultants
3359 Summit Drive, Pocatello, ID 83201
Phone/Fax (208) 232-5212
Cell Phone (208) 244-1161
Email paleopoet@aol.com

14 May 2010

PALEONTOLOGIC RESOURCES ANALYSIS LETTER REPORT (EVG-2010-03)

Project: Shell Wind Energy, Inc. has applied to construct, operate and maintain the Hermosa West Wind Farm Project (Project) in southeast Albany County, Wyoming, near Tie Siding (Figure 1-1).

Location: The Project encompasses Section 31, T13N, R72W; Sections 22, 23,25, 26, 27, 28, 34, 35, and 36, T13N, R73W; Sections 6, 7, 8, 17, and 18, T12N, R72W and Sections 1, 2, 3, 12, and 13, T12N,, R73W (Figure 1-1, 1-2).

Summary of Work Conducted and Recommendations: A paleontological review was conducted for the Project by Erathem-Vanir Geological Consultants (EVG). The review included a geological map and literature review and fossil locality records search. The records search was conducted at the University of Wyoming. No existing fossil localities within the Project were revealed as a result of the records search. Based on the results of this map and literature review a spot inspection for fossils of any kind was recommended and conducted for geological outcrops mapped as the Pennsylvanian/Permian Fountain and Casper Formation within the Project.

No fossils of any kind were discovered during field inspection and although inspection was hindered by extensive snow cover, EVG determined that deep regolithic soil and thin loess deposits cover most of the exposures of the Casper Formation in the Project. As a result the Casper Formation is very poorly exposed in the Project. It also appears that none of the outcrops present in the Project contain limestone beds from which Casper Formation fossils have been previously recovered.

This review, as well as the nature of Wind Farm construction, indicates that it is very unlikely that any significant fossil resources will be encountered during development of the wind turbines, meteorological towers, substation, buildings, electrical connections, or access roads. As a result, no specific recommendations are made for fossil resources for the Project; however, if fossils of suspected scientific importance are discovered during construction a qualified paleontologist should be notified to evaluate the discovery.

Paleontological Principal Investigator (PI)/Field Investigator (FI): PI - Gustav F. Winterfeld, PhD, (EVG), Pocatello, ID. FI – Thomas M. Bown, PhD, EVG, Westminster, CO.

Project Description: The proposed Hermosa West Wind Farm Project would consist of a maximum of 200 wind turbines with a total generating capacity of up to 300 megawatts of electricity. The Project would also include a wind energy collection system, on-site operation and maintenance (O&M) building, underground collector lines, a transmission line and substation, associated access roads, and upgrades to facilities owned by the Western Area Power Administration.

The wind turbines would be arranged in roughly 11 collinear “strings”; each turbine string would be situated within an approximately 250 foot (ft) wide corridor, except for strings located in areas with steep topography, which would be located within an approximately 400 ft wide corridor in order to be safely constructed. This corridor design approach allows for turbines to be moved during the design phase within the corridor to avoid, when possible, wetlands, water bodies, cultural sites, and other environmentally sensitive areas, while the actual construction footprint will be much smaller. These corridors have been designed to incorporate landowner requirements and setbacks. Access roads and power collection lines will also be located within these corridors where feasible to minimize the Project’s overall footprint. For parts of the Project where it is not feasible to locate the access roads and power collection lines within the turbine string corridors, 250 ft wide corridors will be utilized in these areas. The precise locations of each turbine within the corridor would be based on the wind turbine model selected and other criteria such as optimal wind speed, geotechnical conditions, environmental considerations, and landowner requested setbacks.

Geologic Map Coverage: Ver Ploeg, A.J., Boyd, C.S. and Kirkaldie, A.L., 2000, Preliminary digital geologic map of the Laramie 30 minute x 60 minute Quadrangle, Albany and Laramie Counties, Wyoming: Wyoming State Geological Survey, Geologic Hazards Section Digital Map HSDM 00-1, scale 1:100000. Love, J. D. and A. Christiansen, 1985. Geologic Map of Wyoming. Scale 1:500,000 (Figure 1-3).

Work Conducted/Personnel: At the request of Environmental Resource Management (ERM), EVG’s Principal Scientist, Dr. Winterfeld conducted a study of the paleontology of the Project area. Dr. Gustav F. Winterfeld, is a registered Professional Geologist with 32 years field experience, and is considered to be an expert in the geology and paleontology of Wyoming. He has directed and performed literature and records reviews and conducted field geological and paleontological surveys for projects including coal mines, trona mines, pipelines, dam sites, flood control projects, gravel mining, housing developments, road construction, transmission lines, and well pads. He has analyzed environmental impacts to fossil resources and recommended and implemented mitigation and resource recovery programs for paleontological resources for clients including the federal, state and local government agencies, and private companies.

The preliminary study conducted by Dr. Winterfeld included literature and records reviews and searches, specifically:

- a geological review to identify the nature and ages of geological units within the Project area;

- a paleontological review to identify known and potential fossil-bearing rock units within the area;

- a paleontological locality search to identify known fossil localities which was conducted at the Department of Geology and Geophysics at The University of Wyoming, in Laramie by Dr. Michael Cassiliano;

- a review of the paleontological significance of known or potential fossils that occur within the area or the same geological units that occur nearby.

As a result of the study, Dr. Winterfeld has included recommendation for a spot inspection for fossils of any kind was recommended and conducted for geological outcrops mapped as the Pennsylvanian/Permian Fountain and Casper Formation within the Project.

Dr. Thomas M. Bown conducted a spot inspection of geological outcrops on April 27, 2010 and was accompanied by Ms. Kathryn Wanka with ERM, Houston, Texas. Dr. Bown is a paleontologist with over 40 years geological and paleontological experience and is considered an expert in the paleontology and geology of the western United States.

Paleontology Definitions and Significance:

Paleontology (*Gk paleos = ancient ology = study of*) is a biologic and geologic scientific discipline involving the study of fossil materials. Despite the tremendous volumes of sedimentary deposits preserved world-wide and the total number of organisms that must have lived, fossils (*Greek: to be dug up*) are rare and considered nonrenewable resources. Only a small percentage of all organisms that have ever lived have been preserved by fossilization. Even fewer are destined to be discovered, recovered, curated into museum collections and studied.

Paleontological resources or fossils include the body remains, traces, or imprints of plants or animals that has been preserved in the Earth's crust since some past geologic or prehistoric time. Generally in order to be considered fossil the remains must be older than Recent (10,000 years) in age. All fossils contain scientific information, but not all fossils are considered to have high scientific significance. Among paleontologists, fossils are generally considered to be scientifically significant if they are unique, unusual, or rare, diagnostically or stratigraphically important, or add to the existing body of knowledge in a specific area of the science. Government land agencies consider all vertebrate fossils to be scientifically significant. Invertebrate and plant fossils may be determined to be significant depending on the nature of the fossils on a case-by-case basis. Petrified wood is treated as a mineral material and may be collected or purchased under the Material Sales Act of 1947.

Fossils are of scientific interest as records of ancient life because of their rarity and the scientific information they contain. They provide information about the relationships of living organisms, their ancestry, and their former distribution. Progressive morphologic changes seen in fossil lineages provide critical information on the evolutionary process--the ways new species arise and organisms adapt or fail to adapt to changing environmental circumstances. Fossils also serve as important guides to the ages of the rocks in which they are contained and are useful in determining the temporal relationships of rock units from one area to another and the timing of geologic events. Time scales established by fossils provide relative chronologic frameworks for geologic studies of all kinds. Fossils can also provide clues to depositional environments of sedimentary rocks in which they are preserved, and they can be important indicators of ancient climates, and they help document climatic change, locally and globally.

Results of Geological Map and Literature Review: The Project is located near Tie Siding, Wyoming, just east of US Highway 287, about 15 miles south of Laramie. The southern boundary of the Project extends to the Wyoming/Colorado border.

The Project is included in the Rocky Mountain Foreland Structural Province, an area characterized by broad intermontane basins surrounded by massive reverse fault bounded uplifts with Precambrian rocks exposed in their cores. The Project overlies the southern end of the Laramie Range, which is composed chiefly of granite monandnocks that rise above a broad erosion surface and form extensive unwooded parks with surfaces generally at about 7,000 feet in elevation. Eastward-north eastward drainages from south to north that cross the area include, Fish Creek, Willow Creek, Boulder Creek, Forest Creek and Government Creek.

As mapped by Ver Ploeg and others (2000) and Love and Christiansen (1985), rocks of Precambrian, Pennsylvanian/Permian and sediments of Quaternary (Pleistocene and Holocene) occur in the Project area.

Precambrian Rocks

Granite (Ys on Figure 1-3) that comprises the bulk of the Laramie Range is part of the Sherman Batholith that was emplaced about 1.4 billion years ago. The Sherman Granite forms the core of the range and underlies most of the Project area at depth. It is exposed at the surface in the southeastern part of the Project, east of Cherokee Park Road. The Laramie Range is composed of lesser amounts of metasedimentary and metavolanic rocks including pelitic schist, marble, granite gneiss, layered amphobolite, and felsic gneiss (Xsv on Figure 1-3). These rocks are exposed in the northeastern part of the Project along Willow Creek, east of Cherokee Park Road.

The Precambrian rocks, including the Sherman Granite and metasedimentary and metavolcanic rocks forming the Laramie Range and exposed in the Project have no paleontological potential.

There is a profound nonconformity separating the Precambrian rocks forming the core of the Laramie Range from Pennsylvanian and Permian sedimentary rocks that overlie them. This unconformity represents a long period of erosion associated with the episodic uplift of the Ancestral Rocky Mountains (Maughan 1990), a complex of northwesterly uplifts of Late Paleozoic age. The Ancestral Rocky Mountains occur in approximately the same region as the much younger later Late Cretaceous-early Tertiary uplifts of the Laramide Orogeny, that formed most of the basins and ranges seen in Wyoming today, including uplifting the present day Laramie Range, but were oriented differently. As a result of this uplift of the Ancestral Rocky Mountains, all Paleozoic aged rocks older than Pennsylvanian age were eroded from the Project area.

Precambrian rocks forming the core of the Laramie Range are overlain in the Project by rocks of the Fountain Formation and overlying Casper formation (PPcf in Figure 1-3) of Pennsylvanian and Permian age.

Fountain Formation

The Fountain Formation in the Project consists wholly of arkosic (feldspar-rich) red sandstone. This sandstone originated from the feldspar-rich uplifted part of the Ancestral Rocky Mountains that shed sediments basinward that accumulated chiefly in large alluvial fans and braided streams proximal to the uplifts. The formation is not known to be fossiliferous in the Project. Fossils fusilinids attributed to the Fountain Formation (Mallory 1966), probably originated from limestone of the Casper Formation that interfinger with the Fountain Formation. However, in parts of Colorado, where the formation is exposed distal to the Ancestral Rocky Mountain highlands, the formation includes rock types other than arkose, (ie. limestones and shales) and is fossilferous. These rocks have produced trace fossils and fossils of invertebrates and plants, but these rock types are absent from the Project (Jennings 1980; Maples and Suttner 1990; Hasiotis and others 2002).

The Fountain Formation has a Probable Fossil Yield Classification of 2, which classifies it as a geologic unit that is not likely to contain vertebrate fossils or scientifically significant non-vertebrate fossils.

Casper Formation

The Casper Formation is mapped together with the Fountain Formation on the Wyoming State Geologic Map and the Laramie 30 x 60 geologic map. The two formations actually have a complex stratigraphic relationship. The lower parts of the Casper Formation interfingers with the Fountain Formation, whereas its upper parts overlie the formation unconformably. The Casper Formation consists of gray, tan and red thick-bedded sandstone underlain by interbedded sandstone and pink and gray limestone. These deposits accumulated laterally to sediments of the Fountain Formation in areas distal to the Ancestral Rockies during lower sea level and above the Fountain Formation during higher sea level. As a result sediments of the Casper Formation accumulated in variety of continental and marine environments. The lower parts of the formation accumulated chiefly in marine environments, whereas the upper part of the formation, including the sediments of the formation in the Project accumulated chiefly in eolian environments of an ancient erg (sand sea), The abundant and striking festoon cross bedded sandstone that characterize the formation south of Laramie document accumulation of sands in migrating sand dunes of that erg.

The Casper formation is known to be fossiliferous along the flanks of the Laramie range, but not specifically in the report area. In widely scattered localities throughout southeastern Wyoming, the Casper Formation has produced fossils of invertebrates, conodonts, and trace fossils at widely scattered localities.

Miller and Thomas (1936) reported on fusilinids, nautaloid cephalopods, and a trilobite from the formation along the flanks of the Laramie Range. Hensley (1956) noted the occurrence of marine invertebrate macrofossils along the west flank of the Laramie Range in Albany County, Wyoming, including more than 400 specimens representing 15 species of four phyla. Hoyt and Chronic (1962) noted the occurrence of fusilinids at a section of the formation at Granite Canyon on the east flank of the Laramie Range. Rare, but well preserved conodonts of Late Pennsylvanian and Early Permian age are known from the formation at the southern end of the Laramie Basin, where Heiman (1972) recovered fossils of 10 genera and 20 species from 10 limestone units interbedded with sandstones. Sando and Sandberg (1987) noted the occurrence of brachiopods, gastropods, ostracodes and crinoids debris, as well as abundant conodonts in the formation on Casper Mountain. In addition, Hanley and others (1971) described two trace fossils from the formation that demonstrated that the sands of the formation could not have been completely dry or completely wet during deposition.

The Casper Formation has Probable Fossil Yield Classification of 3, which classifies it as a geologic unit where fossil content varies in significance, abundance, and predictable occurrence. This ranking also includes sedimentary units of unknown fossil potential.

Quaternary Sediments (Pleistocene and Holocene) and Natural Animal Traps

Love and Christiansen (1985) mapped terrace debris of Quaternary age along the northwestern edges of the Project area at a scale of 1:500,000. Ver Ploeg and Boyd (2000) document in their mapping at a scale of 1:100000, the presence of older fan deposits (Qof) in broad areas along Government and Forest Creeks and both north and south of the Cherokee Park Road, In addition mapping of adjacent areas by Workman (2008) of the Eaton Reservoir Quadrangle and Braddock and others (1989) of the Diamond Peak Quadrangle, at a scale of 1:24000, document the presence of alluvium and colluvium of Holocene (Recent) age, as well as colluvium and pediment deposits of Pleistocene age.

Hager (1972) described the Chimney Rock natural animal trap in Larimer County, Colorado along Sand Creek about 15 miles to the west of the Project. The natural animal trap is a circular depression in the Casper Sandstone approximately 65 feet in diameter and 10 feet deep with an overhang of 4 to 25 feet. Four to 6 feet of fine sand in the depression contain a late Pleistocene to recent age fauna. The fossils from the trap include 33 vertebrate species, seven of which show boreal affinities and whose extant representatives presently inhabit higher altitudes and latitudes. Three extinct species are present, including *Martes nobilis*, *Panthera atrox*, and *Neogyps errans*. Dental variations in the lower first molar of *Vulpes vulpes* preserved in the paleofauna are thought to indicate a cold climate because of dental differences from the same species inhabiting temperate zones. Bone from the 48 inch level of the deposit yielded a radiometric date of about 11,980 years. The animal trap had formed and major sedimentation occurred by the late Wisconsin and as a result more recent faunas were added to and mixed into the deposit.

Holocene age deposits are by definition too young to contain fossils. Pleistocene deposits could be fossil bearing, because such deposits yield the remains of "Ice Age" vertebrates at widely scattered locations throughout Wyoming and Colorado. Such discoveries are however very rare. The paleontology potential of the Pleistocene deposits in the report area is thus thought to be low. In addition the likelihood of another natural animal trap is also considered low because the topography developed above the Casper Formation across the area is generally low. The area where the trap was found at Chimney Rock is relatively steep.

Results of Paleontology Locality Search: A locality search for the sections and townships underlying the Project was conducted by Dr. Michael Cassiliano, collections manager of the vertebrate fossils at the Department of Geology and Geophysics at The University of Wyoming. The museum's database recorded no fossil localities within the Project in its database.

Results of Geological Spot Inspection: During spot inspection, Dr. Bown reconnoitered the area south of Tie Siding and examined outcrops of the Pennsylvanian Casper Sandstone lying atop the Precambrian Sherman Granite. Exposures were of weathered granite conglomerate (grus) at the base of the Casper Formation.

No fossils of any kind were discovered during field inspection and although inspection was hindered by extensive snow cover (Figure 1-4). EVG determined that deep regolithic soil and thin loess deposits cover most of the exposures of the Casper Formation in the Project. As a result the Casper Formation is very poorly exposed in the Project. It also appears that none of the outcrops present in the Project contain limestone beds from which Casper Formation fossils have been previously recovered.

The results of the spot inspection, as well as the nature of wind farm construction, indicate that it is very unlikely that any significant fossil resources will be compromised by development of the Project components.

Recommendations for Fossil Resources: No specific recommendations are made for fossil resources for the Project; however, if fossils of suspected scientific importance are discovered during construction a qualified paleontologist should be notified to evaluate the discovery.

Sincerely,

Gustav F. Winterfeld Ph.D. 14 May 2010

Gustav F. Winterfeld, Ph.D. Date
Principal Scientist

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EBSCOR Reference Search
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Google Scholar Search
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  Other Search Terms: Tensleep Formation, Fossils Fountain Formation, Fossils Casper Formation, Trace Fossils Wyoming, Natural Animal Traps

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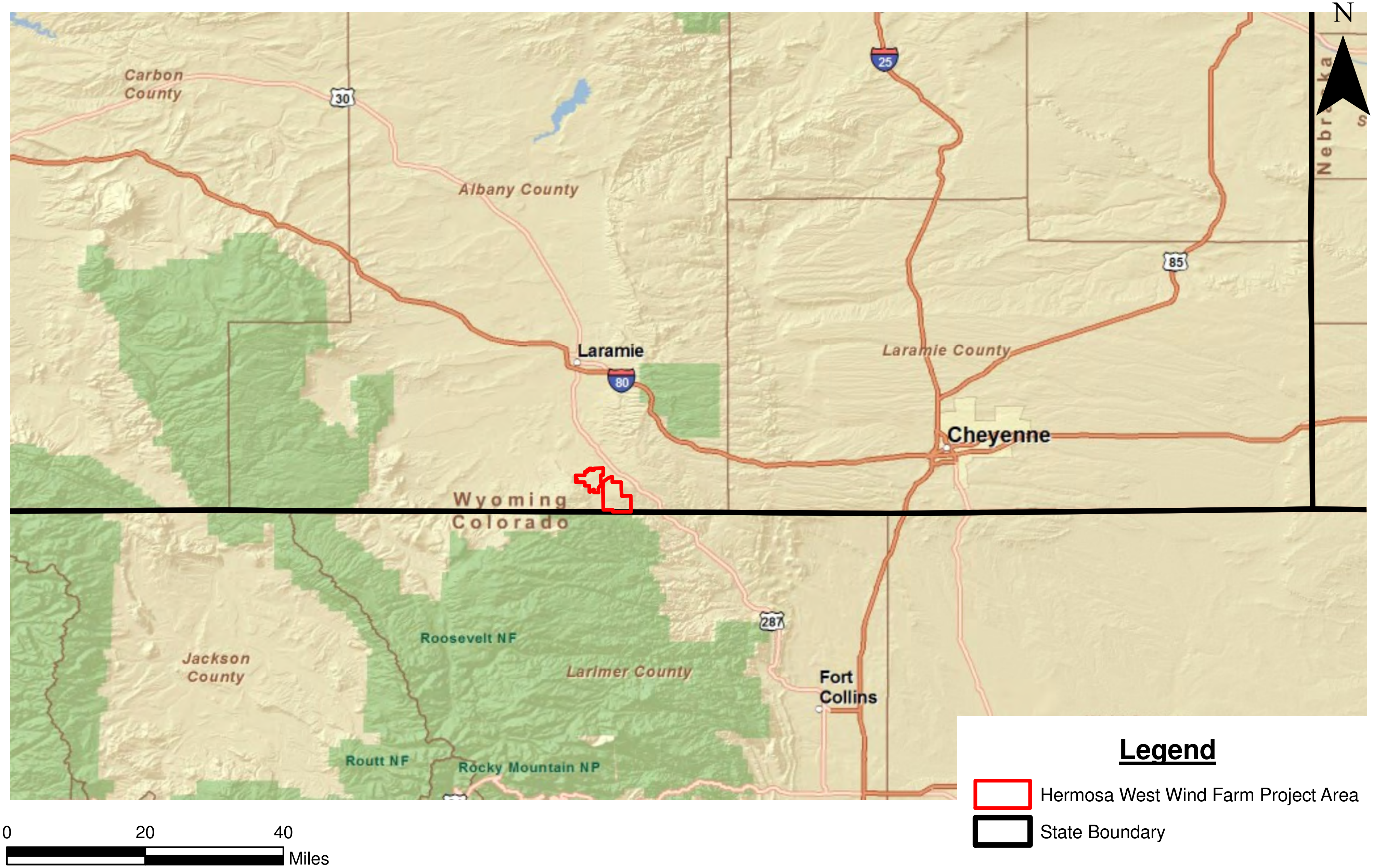

Environmental Resources Management

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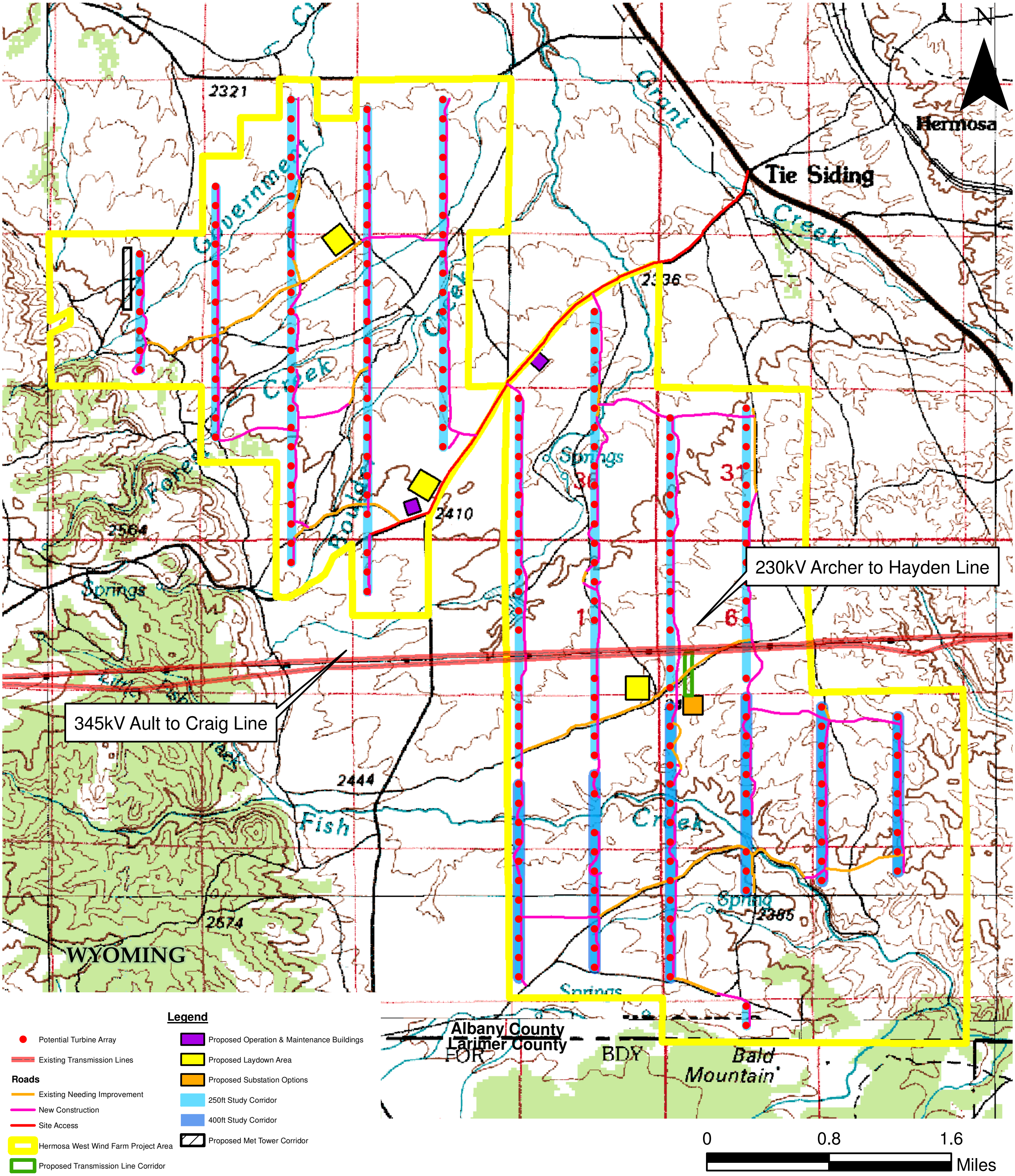
FIGURE 1-1
VICINITY MAP
Hermosa West Wind Farm Project
Albany County, Wyoming

ERM



Environmental Resources Management

DESIGN: K Wanka	DRAWN: S King	CHKD.: A Smith
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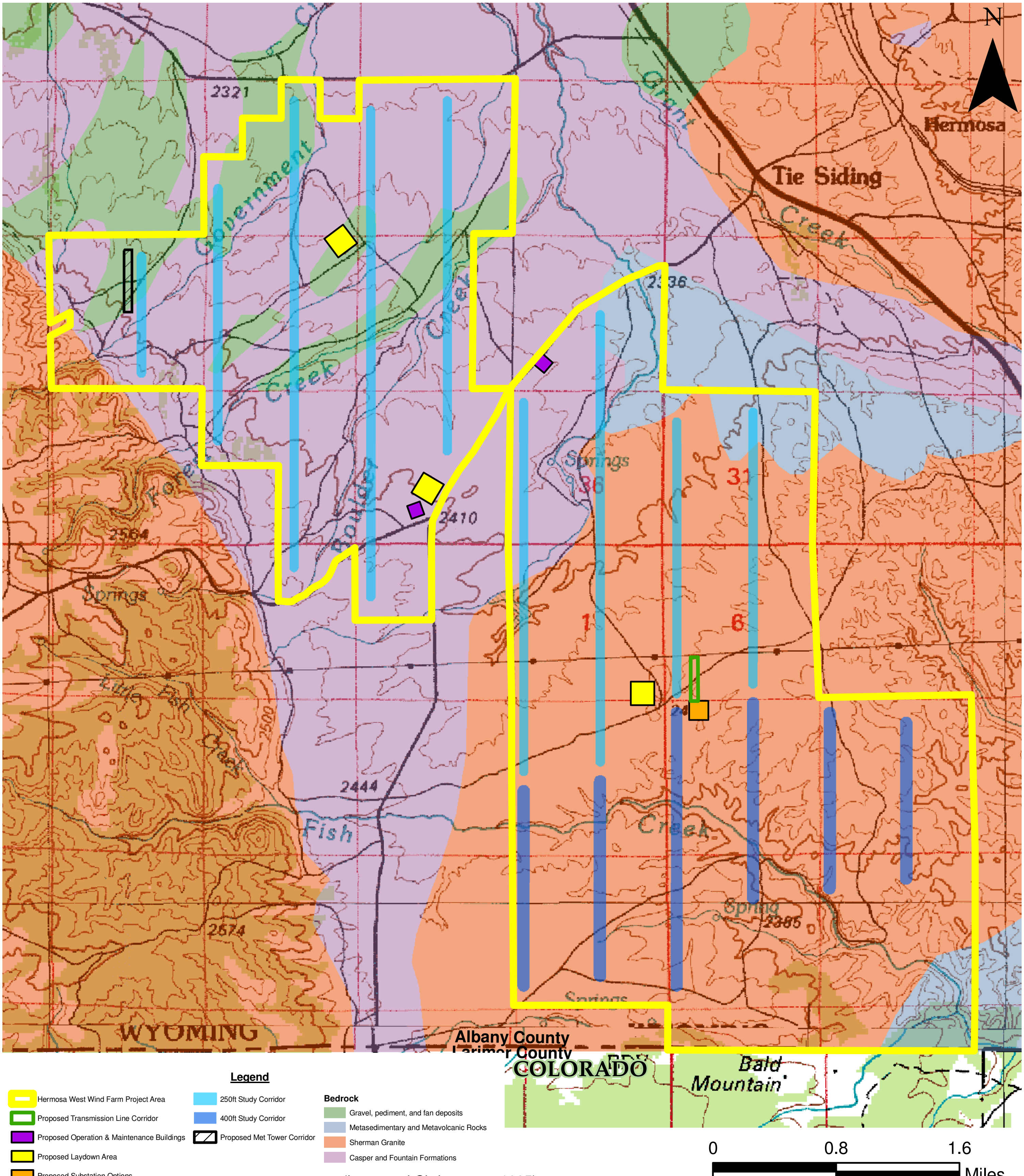
FIGURE 1-2
SITE PLAN
Hermosa West Wind Farm Project
Albany County, Wyoming

ERM



Legend

- Hermosa West Wind Farm Project Area
- Proposed Transmission Line Corridor
- Proposed Operation & Maintenance Buildings
- Proposed Laydown Area
- Proposed Substation Options
- 250ft Study Corridor
- 400ft Study Corridor
- Proposed Met Tower Corridor

Bedrock

- Gravel, pediment, and fan deposits
- Metasedimentary and Metavolcanic Rocks
- Sherman Granite
- Casper and Fountain Formations

(Lowe and Christansen, 1985)

Environmental Resources Management

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FIGURE 1-3
BEDROCK GEOLOGY
Hermosa West Wind Farm Project
Albany County, Wyoming

ERM

View to southwest of regolithic soil (foreground) and sandstone of Casper Formation (middle distance) from NAD83, UTM Zone 13T 0454684mE, 04548775mN.

View to south of regolithic soil and weathered sandstones of Casper Formation from UTM (NAD83) Zone 13T 0454684mE, 04548775mN.

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FIGURE 1-4
SITE PHOTOGRAPHS
Hermosa West Wind Farm Project
Albany County, Wyoming

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APPENDIX I

NOISE ASSESSMENT

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NOISE ASSESSMENT, UPDATED, MARCH 15, 2012

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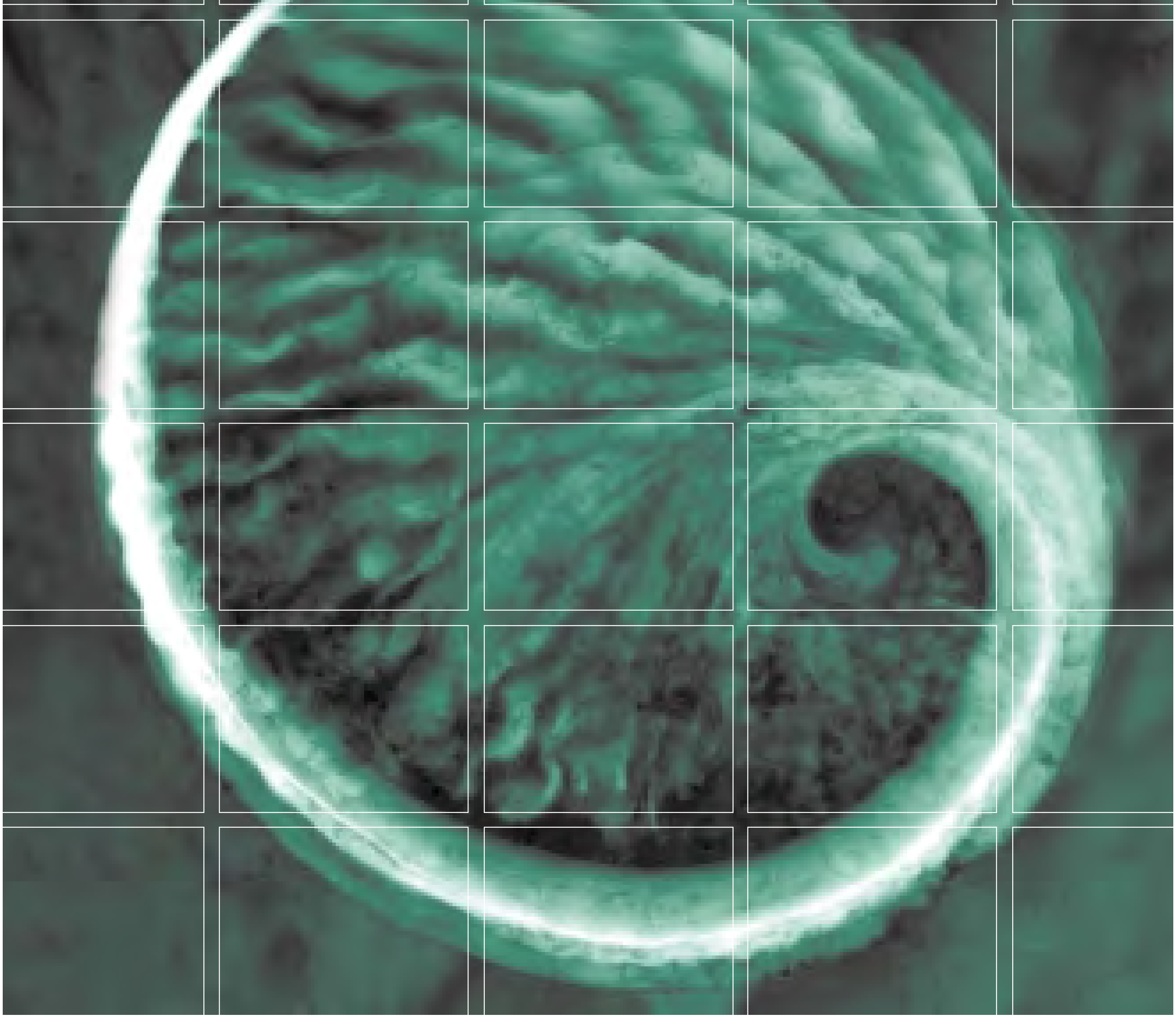

Hermosa West Wind Farm: *Updated Noise Assessment*

Shell WindEnergy
Albany County, Wyoming

March 15, 2012

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Shell WindEnergy

Hermosa West Wind Farm:
Updated Noise Assessment

March 15, 2012

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Albany County, Wyoming

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1.0 INTRODUCTION

1.1 BACKGROUND

This report is an update to the ERM *Hermosa West Wind Farm Project Noise Assessment* that was initiated in 2010. Data in this report will be used to estimate the noise impacts of three selected turbine models and layouts on the closest noise sensitive properties. It concluded that there were no significant operational wind turbine noise impacts when assessed against the Albany County noise criteria of 55 dB(A) at any point along the common property lines and at the closest representative noise sensitive properties.

This noise assessment has taken into account additional data collected since the initial study, including newly measured baseline noise data at representative noise sensitive properties associated with the project.

In general, noise from wind turbines increases with the wind speed up to the 'rated power' when the noise then remains constant or reduces at higher wind speeds. Background noise, noise experienced at a property in the absence of wind turbine noise, tends to increase with wind speed at a rate greater than that of wind turbines, the effect of which can be to mask wind farm noise.

Currently the only standards for addressing noise for this project are those established by Albany County Wind Energy Siting Regulations which require a standard of 55 dB(A) along the common property lines. The purpose of baseline noise data presented in this report is to understand the existing environment of the area and to compare turbine noise levels to measured ambient noise levels in addition to the assessment against the Albany County criteria.

1.2 SCOPE OF ASSESSMENT

This noise assessment provides a refined noise prediction model taking account of pre-existing background noise levels to assess wind turbine generator (WTG) noise at the closest representative noise sensitive properties and at the project site boundary.

As set out in the March 2010 assessment, the project shall consist of a maximum of 200 wind turbines with a total generating capacity of up to 300 megawatts (MW) of electricity. Although the precise layout and turbine type have yet to be selected, the following three options have been considered:

- 224 GE 1.5MW wind turbines (normal operation), hub height 80m and total capacity of 336MW;
- 147 Siemens SWT 2.3MW wind turbines (normal operation), hub height 80m and total capacity of 338 MW; and
- 113 Vestas V90 3MW wind turbines (mode 0), hub height 80m and total capacity of 339MW.

The Project area is within Albany County, Wyoming; approximately 18 miles south east of the City of Laramie; with the town of Tie Siding located to the north-northeast of the Project area. There are a number of isolated properties in and around the Project area; nine of which have been selected as representative of the closest noise affected properties.

The reactions of individuals to the windfarm will be very context specific, and will result from a complex mixture of site and receptor specific factors. This study has followed the guidance proposed for Albany County which has been adopted to indicate a level which provides an objective means of assessing the effects on resources and the surrounding community.

1.2.1 Glossary of Terms

The terms 'sound' and 'noise' tend to be used interchangeably, but noise can be defined as unwanted sound. Sound is a normal and desirable part of life. However, when noise is imposed on people it can lead to disturbance, annoyance and other undesirable effects.

Noise is measured and quantified using decibels (dB), and examples of noise levels are shown in Table 1-1.

TABLE 1-1: Examples of Noise Levels on a Decibel Scale

Noise Level, dB(A)	Typical noise source / example
0	"Threshold of hearing" – lowest sound an average person can hear
20	Standard required in a broadcasting or recording studio – just audible
30	Library or soft whisper at 5 feet – this is very quiet
40	Bedroom or living room
50	Conversational speech at 3 feet
60	Busy general office or air conditioning unit at 20 feet
70	Traffic on freeway at 50 feet
80	Pneumatic drill at 50 feet
90	Heavy truck at 50 feet
140	"Threshold of Pain" – maximum tolerable noise level such as very close to a jet engine or similar
The dB(A) scale is a particular way of measuring the different frequencies in sound, designed to match how the human ear perceives sound, called the 'A'-weighting.	

The decibel scale is logarithmic, which means that noise levels do not add up or change according to simple linear arithmetic. For example, adding two equal noise sources results in a doubling of sound *energy*, which gives a combined noise level that is 3 dB higher than the individual levels. For example, adding 60 dB and 60 dB equals 63 dB.

However, even though the *energy* levels have doubled, the ear *perceives* only a slight increase in loudness instead of a doubling because human hearing responds to changes in noise logarithmically. This means that a relatively large change in sound *energy* is needed before it is *perceived* to be louder or quieter. For example, it is generally accepted that:

- an increase or decrease of 1 dB cannot usually be heard in everyday conditions (although possible in 'laboratory' conditions);
- an increase or decrease of 3 dB is generally accepted as the smallest change that is noticeable in ordinary conditions;
- an increase or decrease of 5 dB is a clearly perceptible change in noise; and
- an increase or decrease of 10 dB is perceived to be a doubling (or halving) of perceived loudness.

Sound can be distinguished by its content, and Hertz (Hz) is the unit used to describe the tonality or the frequency content of sound. The lowest frequency that can be identified as sound by a person with good hearing is approximately 20Hz. Frequencies below this (infrasound) can be detected, but are perceived as a feeling in the body as opposed to an actual sound. At the other end of the scale, the highest frequency that can he heard may be up to 20,000Hz (20KHz), but this depends on factors such as age, health and previous exposure to noise and an upper range between 16 and 18 KHz might be more representative. Sound below 20Hz is referred to as 'infrasound', and sound between 10Hz and 200Hz is often described as 'low frequency noise' (LFN), although there is not a commonly held definition for these terms. Noise from wind turbines are in the mid-frequencies of 200Hz to 1kHz.

Human hearing can detect sounds throughout this range, but it does not ascribe the same importance or 'weight' to sound in each frequency. For example, if a person was listening to a tone at 1KHz at a fixed level, then a tone at 30Hz would have to be approximately 50dB higher for it to be judged equally as loud, although this varies depending on the reference loudness. To account for our sensitivity to sound over different frequencies, environmental noise sources are often described as 'A'-weighted decibels, denoted as dB (A). This A-weighting is an internationally agreed standard that reflects the frequency sensitivity of the ear.

Since noise also often varies over time, statistical parameters (or metrics) are used to measure, and describe noise. Two common noise metrics used for environmental noise measurement are the LAeq and LA90.

The $L_{Aeq, T}$ metric is called the 'continuous equivalent sound level'. It represents a varying noise level by calculating the constant sound level that would have the same sound energy content over the measurement period. The letter 'A' denotes that 'A'-weighting has been used and the 'eq' indicates that an equivalent level has been calculated. So '$L_{Aeq,T}$' is the A-weighted continuous sound level, measured over period 'T'. L_{Aeq} is a logarithmic average noise level over a period (instead of an arithmetic average) which gives a high weighting to high noise levels even if they are relatively short lived or infrequent events.

The $L_{A90,T}$ metric is a percentile noise level in dB(A). This represents the noise level exceeded for 90% of the time period (T) being considered. Note that it is higher than the minimum noise level but may be regarded as the typical noise level during 'quiet periods' and is often used to describe the background or underlying noise level.

Noise can also be referred to in terms of their 'power' level or as a 'pressure' level. A Sound Power Level (L_W) is a measure of the total power radiated by a source. The Lw of a source is a fundamental property of the source and is independent of the surrounding environment. Wind turbine manufacturers will often quote the noise levels from their turbines in terms of Lw.

The Sound Pressure Level (L_p) on the other hand is the level of sound pressure (in terms of movements in air pressure) and is the received sound experienced by a person and can be measured directly with a sound level meter. This differs from L_W in that it can be affected by environmental factors such as the presence of other sounds, meteorological conditions, ground conditions and barriers. The Lw is therefore useful in calculating the Lp at a desired location. Where Lp levels are quoted they must be given at a defined distance or location relative to the source, otherwise it is meaningless.

Noise at any particular location can also be affected by a number of factors, the most significant being:

- how loud the source is;
- how far away the source is from the receiver;
- what type of ground is between the source and the receiver, for example concrete, grass, water, sand etc;
- how the ground topography varies between the source and the receiver (is it flat, hilly, mountainous) as blocking the line of sight to a noise source will generally reduce the level of noise; and
- any other obstacles that block the line of sight between the source to receiver e.g. buildings or walls.

2.0 NOISE CRITERIA

2.1 APPLICABLE NOISE CRITERIA FOR WIND TURBINE NOISE

The Albany County Standard for noise is as follows.

Noise associated with wind energy operation shall not exceed fifty-five (55) dB(A) as measured at a point along the common property lines between a non-participating property and a participating property.

a. *This level may be exceeded during short-term events such as utility outages, severe weather events, and construction and maintenance operations.*
b. *This standard shall not apply along any portion of the common property line where the participating property abuts state or federal property.*
c. *Noise levels may exceed the fifty-five (55) dB(A) limit along common property lines if written permission, as recorded with the Albany County Clerk, is granted by the affected adjacent non-participating property owners.*

In order to provide a robust assessment ERM has predicted noise levels at the common property lines and at the closest representative noise sensitive properties.

2.2 REVIEW OF WIND TURBINE NOISE CRITERIA

The New York State Department of Environmental Conservation publication 'Assessing and Mitigating Noise Impacts' (February, 2001) suggests noise impacts should be assessed on the basis of:

- magnitude of change in noise (comparing the wind turbine noise against 'background' noise); and
- a fixed noise guidance level, which depending on the context is generally in the range of 55 dB to 65 dB.

However, noise from wind turbine generators (WTGs) is unusual in that noise will increase with wind speed and the rotational speed of the rotor blades. Background noise (i.e. the noise that exists without the WTG) will also increase with wind speed in most areas, unless the noise is dominated by a fixed noise source such as a noisy factory. The greatest difference between turbine noise and background noise is therefore likely to occur when wind speeds are low. However, for some sheltered locations, the background noise (from wind) may remain low even when wind speeds are high, meaning such locations will be less likely to experience 'masking' from background wind noise.

2.3 HERMOSA WEST WIND TURBINE NOISE OPERATIONAL NOISE CRITERIA

This assessment has adopted WTG operational noise criteria based on the Albany County Standard where the absolute operational noise criteria level is LA90, 10-min 55 dB. However, consideration has also been made between measured background noise and wind turbine noise in order to put this standard and the predicted noise levels into context.

2.4 CONSTRUCTION NOISE

The following significance criteria were developed by the Western Area Power Administration for use in determining whether construction noise impacts from the proposed Project may be significant.

A significant impact on noise may result if any of the following were to occur from construction or operation of the proposed Project:

- *Exceeding local, state or Federal noise regulations or guidelines at sensitive receptors, such as residences, hospitals, or schools.*
- *Exposure of persons to or generation of excessive ground borne vibration or ground borne noise levels where they live, work or participate in recreational activities.*

No contractor has been selected and no new information has been made available on the construction methodology or likely program of works, therefore, no noise modelling of construction noise levels at the closest noise sensitive receivers has been undertaken, and the results of the previous assessment for this site have been used to assess construction noise.

Section 5.2 discusses construction noise impacts further.

3.0 BASELINE NOISE & METEOROLOGICAL DATA

3.1 NOISE

Baseline noise measurements were undertaken at eight locations between November 17 to 25, 2010 and June 2 to 15, 2011. The measurements recorded the L_{Aeq} and L_{A90} parameters in consecutive 10-minute increments, this sample period was selected to correspond with the wind speed data recorded at Shell's Met tower located on site. Location 3, north of Fish Creek Road and west of Elk Crossing Road did not yield any results due to equipment failure.

The survey was undertaken using Quest Technologies Sound Pro Model DL (Type 1) Sound Level Meters (SLMs). These were deployed in a secure environmental enclosure with independent power supplies and environmental microphones. No rainfall was recorded during the assessment period.

The SLMs were generally placed on relatively flat areas which mainly consisted of hill grassland ranch areas and located away from reflective surfaces and roads by at least 15 – 30 meters (50 to 100 feet) and away from any trees and streams.

A description of each noise measurement location (including distance to the closest wind turbine for the three layouts) is given in Table 3-1 and illustrated in Figures 1, 2 and 3. A summary of measured existing L_{Aeq} noise levels is provided in Section 3.2.2.

TABLE 3-1: Summary of Noise Measurement Locations

Location	Coordinates (Easting, Northing)	Elevation (m)	Distance to Closest Turbine (m) & Turbine ID (GE 1.5Mw Layout)	Distance to Closest Turbine (m) & Turbine ID (Siemens 2.3 Mw Layout)	Distance to Closest Turbine (m) & Turbine ID (Vestas 3 Mw Layout)	Comments
Location 1	451528.26 E; 4544766.27 N	2439	352 (T187)	445 (T123)	583 (T36)	Located on Elk Crossing Road to the north of Colorado Road 319. The area was rolling hills with pine trees, shrubs and grassland. The SLM was placed 3 m (10 ft) from a wire fence and 31 m (100 ft) from the nearest trees and shrubs
Location 2	451697.87 E; 4543436.73 N	2481	917 (T44)	928 (T30)	983 (T78)	Located on Colorado Road 319 which is bounded by Cherokee Park Road to the East and Elk Crossing Road to the west. The area was flat rolling hills grassland. The SLM was placed approximately 6m (20 ft) from the road. There was an ephemeral creek approximately 12m (40 ft) west of the road. Water was not observed at the time of the site visits. No structures were noted. A small tree was located about 3 to 4.5m (10 to 15 ft) away from the SLM
Location 6	457486.73 E; 4539629.14 N	2410	609 (T8)	613 (T1)	603 (T60)	Located at the eastern portion of Cara's Trail. The area can be described as flat rolling hills pasture ranch grassland. The SLM was placed in an open area approximately 90 m (400 ft) from the nearest trees and about 37m (120 ft) away from the road. This property is within the Project area boundary
Location 7	462015.47 E; 4540233.57 N	2295	3055 (T11)	3048 (T8)	3048 (T61)	Located on Home Rock Road. The area consisted of rolling hills grassland. The SLM was placed away approximately 15m (50 ft) away from bushes or other reflective surfaces and 25m (80 ft) to the south of the road
Location 8	460632.74 E; 4541437.64 N	2334	1667 (T24)	1681 (T16)	1667 (T69)	Located to the north of location 6 (eastern portion of Cara's Trail), on Home Rock Road. The area consisted of a hilly, rocky area used as a pasture. The SLM was placed approximately 15m (50 ft) south of Home Rock Road and was at least 90m (300 ft) away from a shed
Location 9	459563.78 E; 4545591.21 N	2435	202 (T73)	2205 (T49)	2243 (T91)	Located next to the meteorological tower north of Pumpkin Vine Road. The area was a large hill consisting of grassland and the SLM placed in proximity to the site meteorological tower

Location	Coordinates (Easting, Northing)	Elevation (m)	Distance to Closest Turbine (m) & Turbine ID (GE 1.5Mw Layout)	Distance to Closest Turbine (m) & Turbine ID (Siemens 2.3 Mw Layout)	Distance to Closest Turbine (m) & Turbine ID (Vestas 3 Mw Layout)	Comments
Location 10	454899.86 E; 4550408.25 N	2403	1991 (T117)	2133 (T76)	2207 (T113)	Located off to Sportsman Lake Road and northwest of Tie Siding. The area was flat, slightly rolling grassland. No trees or signs of wildlife were observed until the last site visit where horses were seen. The SLM was placed 3m (10 ft) onto the property beyond a wire fence. There was an ephemeral creek approximately 27m (90 ft) to the east of the location but did not contain any water at the time of the site visit
Location 15	450131.39 E; 4546241.77 N	2437	859 (T89)	455 (T136)	278 (T44)	Location at the end of Sportsman Lake Road and west of location 1. The area was flat rolling hills grassland approximately 400m (120 ft) north of foothills. The SLM was placed approximately 15m (50 ft) to the north of wire fence and 6m (20 ft) from a small wooden structure. No trees or signs of wildlife were noted in the area

1. Location 3 has been excluded as no valid noise measurement data was collected

3.2 *EXISTING AMBIENT L_{AEQ} NOISE LEVELS*

Baseline measurements identify that existing ambient noise levels ($L_{Aeq,\ 10\ minute}$) were measured to be as low as 25 dB, but at times is much higher depending on the measurement location and time of day. These 'short-term' values are affected by near and distant sources that may be detected by the SLM during each sample period and would typically include a range of ambient sources (e.g. wind blown vegetation, fauna noise). In many cases the ambient noise levels may be higher than those predicted for the wind turbines.

It is more relevant to review the 'average' noise level for each location based on the overall data set. At Location 6 the measured ambient L_{Aeq} noise levels are significantly elevated in comparison to all other locations and are not considered representative of ambient noise levels in the area, this data is determined to be invalid for the purposes of this assessment, and has not been used. Possible causes could be equipment malfunction or extraneous local noise sources that are not typical of the area. Excluding this data will provide a higher level of precision and will limit the potential to over state the noise impacts.

Based on all valid measured noise levels the overall ambient $L_{Aeq,\ 24hr}$ noise level averaged over all measurements is 49 dB. A summary of the measured $L_{Aeq,\ 24hr}$ noise levels (the logarithmic average of all valid samples during all 24 hour periods) for each location is summarised in Table 3-2 below:

TABLE 3-2: Summary of Measured Ambient L_{Aeq} Noise Levels

Location	**Summary LAeq Ambient Noise Level**
Location 1	47
Location 2	50
Location 6	86 (not used in assessment)
Location 7	45
Location 8	46
Location 9	48
Location 10	53
Location 15	48

It is noted that the measured noise levels at locations 1, 2, 7, 8, 9, 10 and 15 are below the Albany County Standard, and therefore it is likely that there is little justification for adopting a higher assessment criterion.

4.0 CALCULATION PROCEDURES

Wind turbine noise at each location has been calculated in accordance with the procedures set out in International Standard ISO 9613 (1). In undertaking predictions of noise levels from wind farms, the ISO 9613 calculation procedures take the following factors into account:

- the decrease in noise with distance;
- the absorption of noise in air;
- the attenuation of noise over acoustically 'soft' ground;
- screening of the turbines by topography and other obstacles; and
- meteorological conditions.

In predicting operational noise from the Project area, air absorption and distance attenuation were accounted for using the method described in ISO 9613. No acoustic screening of the turbines is expected. No attenuation from ground absorption has been assumed in the model to present a conservative assumption.

The noise emissions of each turbine have been reported in independent tests undertaken in accordance with IEC 61400-11(2) and used as the basis of the operational noise assessments. Results have been reported as A-weighted octave band sound power levels for a wind speed of 10 m/s (22 mph), corrected to a height of 10 meters (33 feet) in Table 4-1, and as the A-weighted sound power level at wind speeds of 3 to 12 m/s in Table 4-2.

This is based on the following operating modes:

- GE 1.5MW operating at normal operation as opposed to noise restricted operation;
- Siemens SWT 2.3MW operating at normal operation as opposed to noise restricted operation; and
- Vestas V90 3MW operating in mode 0, with the highest noise emission levels.

TABLE 4-1: Assumed Octave Band Sound Power Level Spectral Shape (dB) for Wind Turbines

Frequency Hz	63	125	250	500	1000	2000	4000	8000
Vestas V90	93.5	96.9	102.0	104.0	104.0	99.7	93.7	80.7
Siemens SWT	86.3	95.3	102.0	102.6	99.0	95.0	90.2	85.4
GE 1.5	85.1	94.0	97.2	98.6	97.9	94.5	87.3	78.1

It should be noted that the values in Table 4-1 are based on the available spectral data for the candidate turbines, and enable the effect of the frequency content of wind turbines to be taken into account when predicting the noise propagation, which is frequency related. These spectra have been adjusted as part of the

(1) ISO 9613-2 '*Acoustics - Attenuation of Sound During Propagation Outdoors. Part 2: General Method of Calculation*'. ISO, 1996.
(2) IEC 61400-11 "Wind turbine generator systems - Part 11: Acoustic noise measurement techniques", IEC, 2002.

prediction methodology so that absolute sound power levels on which the predictions at receptors are as show in Table 4-2 which is derived from data from wind turbine manufacturers.

TABLE 4-2: Wind Turbine Sound Power Levels (dB) for the Wind Turbines (hub height 80m/262 feet, corrected to 10m/33 feet) at Increasing Wind Speeds

Wind Speed (m/s) at 10m / 33 feet (mph in brackets)	Sound Power Level (L_{WA}) for Vestas V90, dB	Sound Power Level (L_{WA}) for Siemens SWT, dB	Sound Power Level (L_{WA}) for GE 1.5, dB (1)
3 (7)	-	-	98.0
4 (9)	97.0	-	98.0
5 (11)	105.0	-	101.1
6 (13)	105.8	105.0	105.0
7 (16)	108.2	107.0	106.0
8 (18)	109.3	107.0	106.0
9 (20)	109.4	107.0	106.0
10 (22)	106.7	107.0	-
11 (25)	105.9	-	-
12 (27)	105.7	-	-

This includes a +2 dB uncertainty correction reported in the test report for this turbine.
Full data between 3 – 12m/s for the Siemens SWT and GE wind turbines were not made available in the independent test reports.

The calculation of wind turbine noise above approximately 12 m/s is not usually required as wind affected background noise above this speed tends to dominate and typically wind turbines do not operate at this speed. It can be seen from Table 5-1 that the sound power values do not increase above 10 m/s.

5.0 RESULTS

The overall noise level contribution from each of the turbines was predicted at the property boundary and closest residential locations identified in Table 3-2 in accordance with ISO 9613.

A summary of the predicted noise levels for the closest noise sensitive receivers for the GE 1.5MW, Siemens SWT 2.3MW and Vestas V90 3MW turbine layouts are presented in Tables 5-1, 5-2 and 5-3 respectively. Wind speeds evaluated for each of the turbines were based on recommended levels provided by the manufacturer. Since we are using a fixed criterion in this case, the important thing to recognize is that the highest noise output from the windfarm has been considered. The three sets of data all include the wind speeds of 8 and 9 m/s and which suggests that the noise from the wind turbines tends to flatten out or reduce above these speeds. Therefore, although the highest wind speed is not the same in all cases it is reasonable to say that those speeds that are presented cover the highest likely noise levels from wind farm based on typical characteristics. It is important to note that average wind speeds for the area are approximately 10 m/s. Appendix A, Appendix B and Appendix C provide figures plotting the predicted wind turbine noise over wind speed at the sensitive receiver locations and the Albany County noise criteria (55 dB).

Predicted noise levels at selected boundary locations (illustrated on Figure 4) are summarised in Table 5-4 below and visually presented as Appendix D with the Albany County noise criteria.

TABLE 5-1: Predicted Wind Turbine Noise from the GE 1.5 MW (Normal Operation) at the Closest Noise Sensitive Receivers

Location	Predicted Wind Turbine Noise by Wind Speed, m/s (& mph in brackets), LA90, dB						
	3 (8)	4 (9)	5 (11)	6 (13)	7 (16)	8 (18)	9 (20)
Location 1	42	42	45	49	50	50	50
Location 2	37	37	40	44	45	45	45
Location 6	40	40	43	47	48	48	48
Location 7	27	27	30	34	35	35	35
Location 8	33	33	36	40	41	41	41
Location 9	31	31	34	38	39	39	39
Location 10	30	30	33	37	38	38	38
Location 15	37	37	40	44	45	45	45

1. Exceedances of the Albany County Noise Criteria of 55 dB are highlighted in bold.

TABLE 5-2: Predicted Wind Turbine Noise from the Siemens SWT 2.3 MW (Normal Operation) at the Closest Noise Sensitive Receivers

Location	Predicted Wind Turbine Noise by Wind Speed, m/s (& mph in brackets), LA90, dB				
	6 (13)	7 (16)	8 (18)	9 (20)	10 (22)
Location 1	46	48	48	48	48
Location 2	42	44	44	44	44
Location 6	46	48	48	48	48
Location 7	33	35	35	35	35
Location 8	38	40	40	40	40
Location 9	37	39	39	39	39
Location 10	36	38	38	38	38
Location 15	45	47	47	47	47

1. Exceedances of the Albany County Noise Criteria of 55 dB are highlighted in bold.

TABLE 5-3: Predicted Wind Turbine Noise from the Vestas V90 3 MW (Mode 0) at the Closest Noise Sensitive Receivers

Location	Predicted Wind Turbine Noise by Wind Speed, m/s (& mph in brackets), LA90, dB								
	4 (9)	5 (11)	6 (13)	7 (16)	8 (18)	9 (20)	10 (22)	11 (25)	12 (27)
Location 1	36	41	45	47	48	48	45	45	44
Location 2	32	37	41	43	44	44	41	41	40
Location 6	37	42	46	48	49	49	47	46	46
Location 7	23	28	32	34	35	35	33	32	32
Location 8	28	33	37	40	41	41	38	37	37
Location 9	27	32	35	38	39	39	36	35	35
Location 10	26	31	34	37	38	38	35	35	34
Location 15	39	44	48	50	51	51	49	48	48

1. Exceedances of the Albany County Noise Criteria of 55 dB are highlighted in bold.

*Predicted wind speeds evaluated are based on recommended levels provided by the manufacturer.

**Average winds speeds for the project area are 10 m/s.

TABLE 5-4: Predicted Noise Levels at Boundary Locations as Identified on Figure 4

Location on *Figure 4*	Location Coordinates			GE 1.5MW	Siemens 2.3MW	Vestas 3MW
	Easting (m)	Northing (m)	Elevation (m)	LA90	LA90	LA90
A	454819	4539096	2445	48	47	47
B	456433	4539076	2429	48	52	54
C	456452	4538626	2441	44	46	47
D	458387	4538618	2384	40	42	43
E	459610	4542331	2385	43	44	45
F	458513	4542313	2449	48	48	50
G	458017	4542304	2460	50	50	52
H	457955	4544019	2458	47	48	49
I	457985	4545496	2427	44	46	45
J	456924	4545512	2387	47	49	50
K	454805	4541037	2420	52	54	54
L	453169	4543165	2432	48	47	47
M	454779	4543514	2400	52	53	54
N	452367	4543320	2447	46	47	47
O	452365	4544094	2437	51	53	53
P	451567	4544739	2443	48	48	48
Q	449996	4545667	2474	42	44	45
R	449974	4547144	2392	41	45	50
S	451595	4547962	2349	47	49	51
T	452581	4548763	2321	49	49	49
U	454854	4548769	2313	43	44	45
W	461284	4543708	2255	35	36	36

1. Exceedances of the Albany County Noise Criteria of 55 dB are highlighted in bold.

5.1 SUMMARY OF OPERATIONAL NOISE ASSESSMENT

In all cases, the predicted WTG L_{A90} noise levels presented in Table 5-1, are below the Albany County noise criteria of 55 dB. Wind turbine noise levels over a range of wind speeds are also below the Albany County standard.

The Albany County noise guidance applied in this assessment applies to noise from wind turbines and not from the cumulative noise of the baseline noise and the wind turbines. However, in general even the combined noise levels (from baseline and wind turbine noise) do not exceed the 55 dB guidance level except at Location 6 where the baseline noise is already close to the 55 dB limit or above it at wind speeds of 11 and 12 m/s. At these wind speeds it is the high baseline noise (and not the wind turbine noise) that primarily leads to the total noise marginally above the 55 dB limit. The resulting total levels are 56 and 58 dB L_{A90} at 11 and 12 m/s wind speed for the Vestas V90 layout. The change in the baseline as a result of the windfarm is less than 0.5 dB(A), which is a very small change which is not considered significant. Put into context, a noise change of 3 dB(A) is normally considered to be the smallest that would be noticeable under normal listening conditions (ie not in a laboratory). Noise from the other turbine options does not show total levels above 55 dB.

WTG noise at the boundary locations identified in Table 5-4 and illustrated on Figure 4 are also in compliance with Albany County noise criteria of 55 dB.

Predicted WTG L_{A90} noise levels for the majority of receivers and scenarios are typically below the overall existing overall ambient $L_{Aeq,\,24hr}$ noise level of 49 dB which represents the general existing ambient noise environment of the project area although the noise from the wind farm will be above the L_{A90} background noise levels at some wind speeds.

5.2 CONSTRUCTION NOISE

No new information has been made available on the construction methodology that shall be used during the construction of the Project. As such, the findings of the ERM *Hermosa West Wind Farm Project Noise Assessment* dated March 2, 2010 are valid. The findings reported within this assessment with respect to construction noise are reproduced below:

The Proposed Action includes construction/decommissioning related noises, as well as operation of a substation. Construction equipment associated with Projects such as this one typically generate noise levels ranging from approximately 75 to 90 dB(A) at 50 feet, depending on the equipment being used (U.S. Department of Transportation 2006: United States Department of Transportation. August 2006. FHWA Highway Construction Noise Handbook). Construction of the Proposed Action would cause temporary increases in ambient noise levels in the immediate vicinity of the construction sites. On-site construction noise would occur mainly from heavy-duty construction equipment (e.g., trucks, backhoes, excavators, loaders, and cranes). As a result, construction-generated noise would be considered a less-than-significant short-term impact.

The Wyoming Department of Transportation (WYDOT) completed noise studies along State Highway 287 as part of an Environmental Assessment (EA) for the expansion of State Highway 287 which was completed in 2009. Prior to the expansion of State Highway 287, WYDOT determined that the existing noise conditions at Tie Siding were between 54.8 and 63.3 dB(A) and these were attributed to wind effects and not traffic noise emanating from State Highway 287. Based on noise modeling, the post highway expansion noise conditions at Tie Siding were estimated to be between 56.7 and 70.0 dB(A). The EA determined that the expansion would only have a minor noise impact to one receptor (a single family home) and no mitigation measures were required. Additionally, the EA determined that noise impacts from construction activities would be temporary and minimal.

5.3 SUBSTATION NOISE

Similarly, no further information on the location of the substations has been made available, and again, the findings of the ERM *Hermosa West Wind Farm*

Project Noise Assessment dated March 2, 2010 are valid, and are reproduced below:

Substations typically produce between 60 and 70 L_{A90}, dB during operations. The proposed substation location is over 3,000 feet from the participating owner's property line. Noise dissipates at approximately 6 dB(A) per doubling of distance based on a point source (and not taking account of additional mitigation from air and ground absorption which will be quite significant at distances greater than approximately 300 feet), and impacts would be considered less than significant.

5.4 WIND TURBINE NOISE & ALLEGED HEALTH EFFECTS

Although wind turbines are generally considered to be quiet, concerns have been expressed about low frequency noise and infrasound from wind turbine cause adverse health effects.

There are number of papers, and scientific studies available on this topic with conflicting viewpoints. Given the volume of literature, rather than repeating the studies here, the following links provide a critique of research by qualified professionals in the United States, Canada and in Australia. They also give an overview of the fundamental aspects of acoustics with respect to wind turbine noise and discuss topics such as low frequency noise and infrasound which are often quoted as a topic of concern.

- Colby et. al, *Wind Turbine Sound and Health Effects. An Expert Panel Review*. Prepared for the American Wind Energy Association and Canadian Wind Energy Association (December 2009). http://www.awea.org/_cs_upload/learnabout/publications/5728_1.pdf
- Chief Medical Officer of Health (Ontario) Report. *The Potential Health Impact of Wind Turbines* (May 2010). http://www.health.gov.on.ca/en/public/publications/ministry_reports/wind_turbine/wind_turbine.pdf
- Australian Government National Health and Medical Research Council. *Wind Turbines and Health. A Rapid Review of the Evidence*. July 2010. http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/new0048_evidence_review_wind_turbines_and_health.pdf

The latter report includes a review of the December 2009 and May 2010 reports and concludes:

"This review of the available evidence, including journal articles, surveys, literature reviews and government reports, supports the statement that: *There are no direct pathological effects from wind farms and that any potential impact on humans can be minimised by following existing planning guidelines.*"

In addition, the UK National Health Service (NHS) have produced two articles presenting the finding of a peer review on reports on wind turbine noise and health effects.

The first is a review of the work of Dr Nina Pierpont, the author of *Wind Turbine Syndrome: A report on a natural experiment*:
(http://www.windturbinesyndrome.com)

Dr Pierpont has made well publicised claims of links between wind turbine noise and health effects. The second article provides a review of the December 2009 study by Colby *et. al*.

Links to these articles can be found here:

- NHS *Are wind farms a health risk?* (August 3, 2009). http://www.nhs.uk/news/2009/08august/Pages/Arewindfarmsahealthrisk.aspx
- NHS *Wind turbine sound 'needs research'* (January 28, 2010). http://www.nhs.uk/news/2010/01January/Pages/Wind-turbine-sound-and-health.aspx

On the Pierpont study, the NHS review commented:

No firm conclusions can be drawn from this study as the design was weak and included only 38 people. Participants were asked about their symptoms before they were exposed to wind turbines to provide a control for their symptoms after exposure. This was not a sufficient control as many of the participants were reportedly already convinced that wind turbines caused their symptoms and were actively trying to move out of their homes or had already moved. Further study is needed.

On the Colby Study the review commented:

This research is unlikely to resolve the controversy over the potential health effects from wind turbines. This is mainly because the research on which the review was based is not sufficient to prove or disprove that there are health effects. The review itself also had some methodological shortcomings, and the reviewing group did not include an epidemiologist, usually a given for assessing potential environmental health hazards. Further research on this issue is needed. Ideally this would involve comparing people exposed to wind turbine noise with well-matched control subjects who have not had that exposure. These studies should also carefully evaluate the psychological harms of noise exposure.

5.5 VIBRATION

5.5.1 Construction

The closest sensitive properties are greater than 200m from the nearest wind turbines (refer Table 3-1); beyond 100 m construction vibration is unlikely to be perceptible. Therefore, significant disturbance is not expected given the separation distance between the construction site and the nearest properties. Ground-borne vibration from construction is not likely to result in significant effects.

5.5.2 *Operation*

A comprehensive study of vibration measurements in the vicinity of a modern wind farm undertaken in 1997 [3] found that vibration levels 100 m from the nearest turbine were a factor of 10 less than those recommended for human exposure in sensitive buildings, such as hospitals or laboratories housing precision measurement instruments. Ground-borne vibration from wind turbines is not likely to result in significant effects.

(3) ETSU W/13/00392/REP 'Low frequency noise and vibrations measurement at a modern wind far'. Department of Trade and Industry, 1997.

6.0 CONCLUSION

This report presents the findings of the ERM *Hermosa West Wind Farm Project Noise Assessment* that was complete in July 2011. This noise assessment has taken into account data collected used to measure baseline noise levels at representative noise sensitive properties associated with the Project.

Operational WTG noise levels from three different turbine layouts have been predicted at representative noise sensitive receivers around the site (identified on Figures 1, 2 and 3); and at selected boundary locations (Figure 4). The turbine options considered in this assessment consisted the following:

- 224 GE 1.5MW wind turbines (normal operation), hub height 80m and total capacity of 336MW;
- 147 Siemens SWT 2.3MW wind turbines (normal operation), hub height 80m and total capacity of 338 MW; and
- 113 Vestas V90 3MW wind turbines (mode 0), hub height 80m and total capacity of 339MW.

It is noted that although several options with larger MW output were evaluated as part of this study the total power generation capacity of the wind farm will not exceed 300 MW in any operational scenario. The larger volume of MW output was used to provide a broader range of field data and to allow for adjustments in the locations of turbines.

Operational noise levels have been assessed against the Albany County Standard noise criteria of $L_{A90,\ 10\text{-min}}$ 55 dB and data from this study indicate that predicted noise levels will be in compliance with this standard.

In all cases, WTG noise is below the Albany County criteria at the closest noise sensitive receivers and at the project site boundary and no significant operational noise impacts from wind turbine noise are predicted on this basis [(4)].

Although no new information has been made available on the likely construction method and program, or on substation locations; no significant noise impacts from these sources are expected.

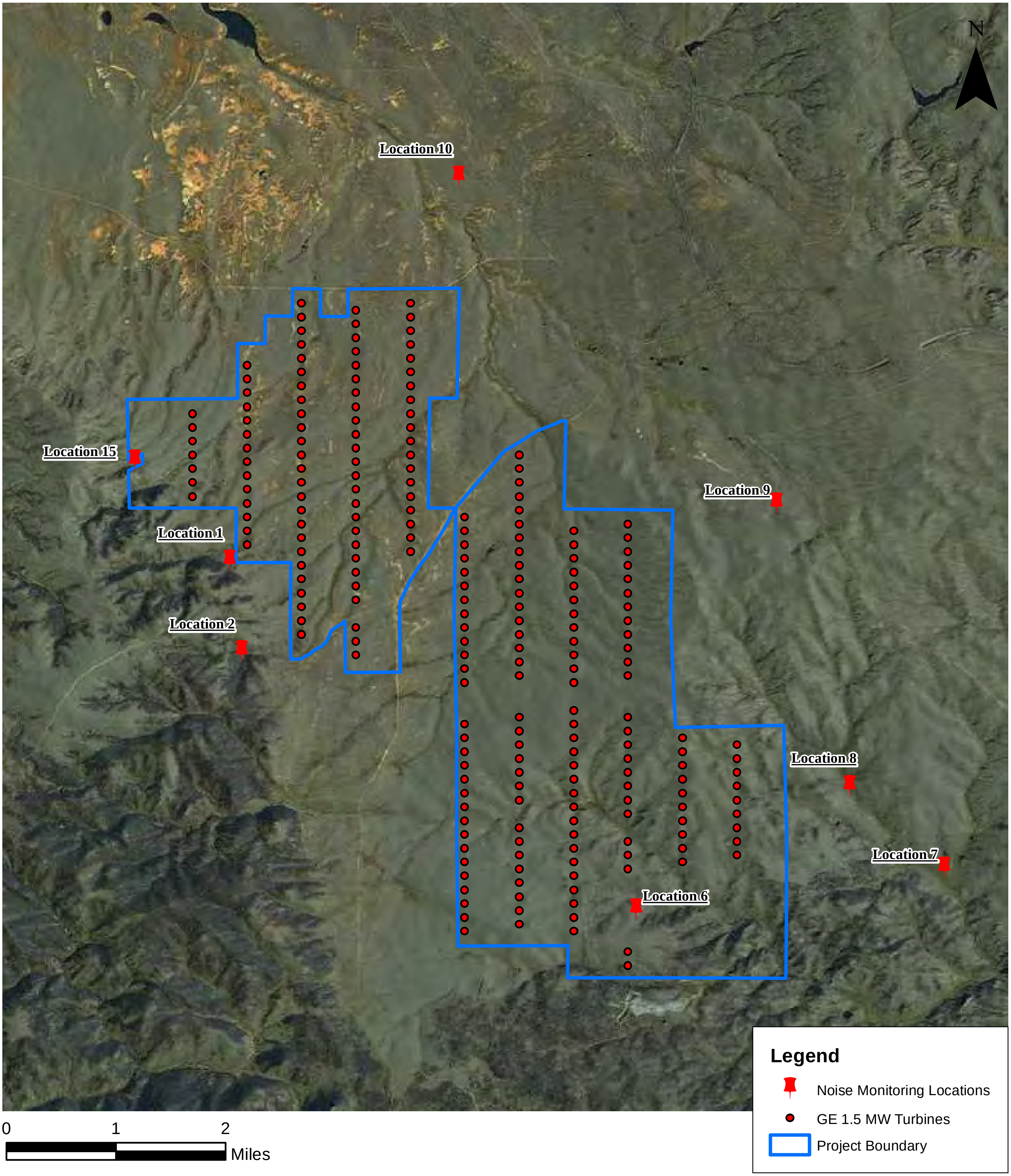
Determining the likelihood of health effects is outside the scope of this report, however a number of links to key research papers has been made available in *Section 5.4*. No vibration impacts are expected.

(4) It is noted that a dose response relationship is not available for wind farm noise and annoyance, and this assessment cannot therefore consider the likelihood of individuals being annoyed by the noise from the wind farm.

Figures

March 15, 2012
Project No. 0116974

Environmental Resources Management
15810 Park Ten Place, Suite 300
Houston, Texas 77084-5140
(281) 600-1000



Environmental Resources Management

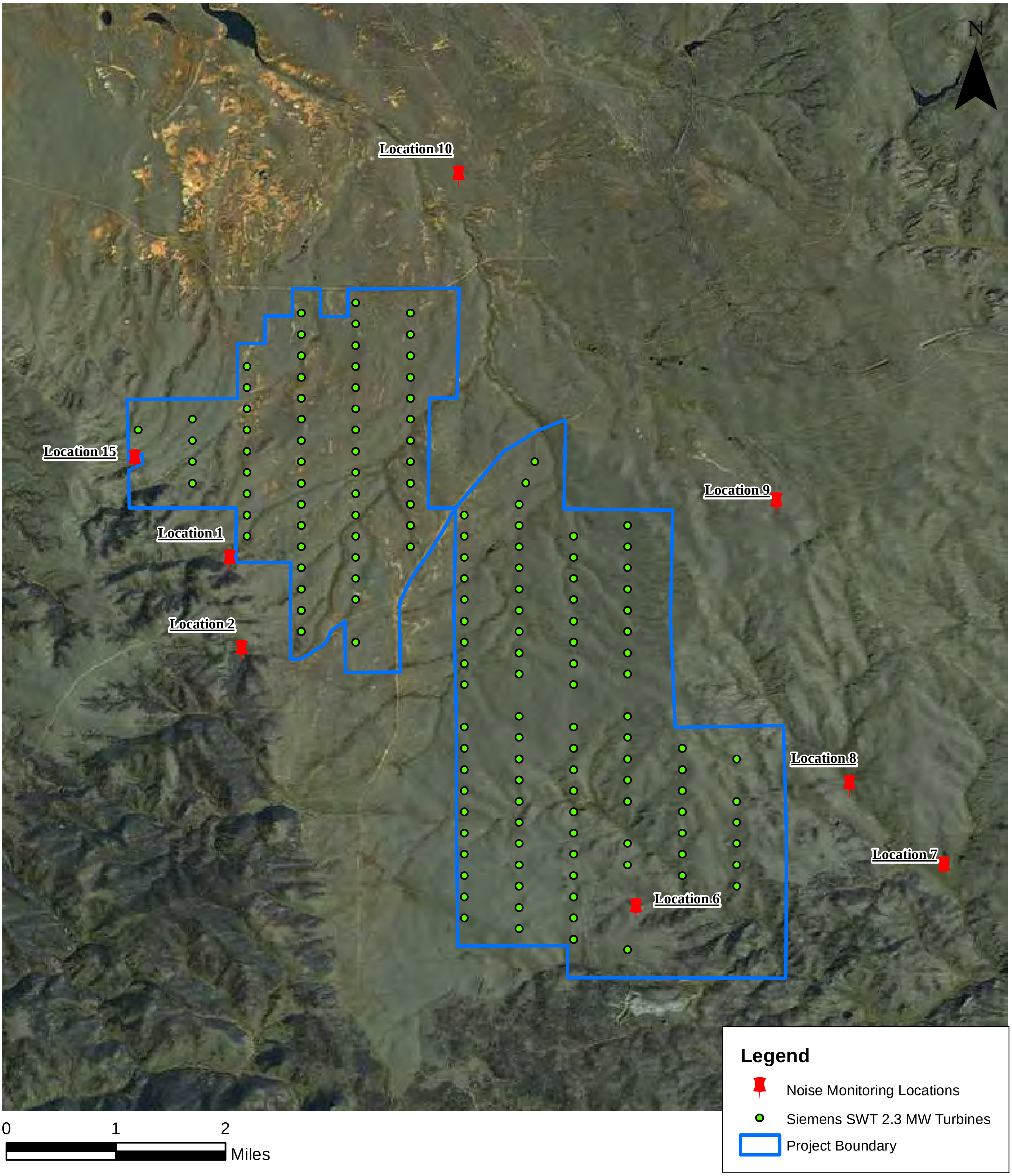
DESIGN: S King	DRAWN: PKrishnan	CHKD.: P Maddock
DATE: 11/21/2011	SCALE: AS SHOWN	REVISION: 1

File: K:\GIS\Shell\Hermosa\projects\noise\noise_mont_locs_fig1.mxd

FIGURE 1
Location of Noise Sensitive Properties, Project Area and Layout for GE1.5 MW Turbines

Hermosa West Wind Farm Project
Albany County, Wyoming

ERM



Environmental Resources Management

DESIGN: S King	DRAWN: PKrishnan	CHKD.: P Maddock
DATE: 11/21/2011	SCALE: AS SHOWN	REVISION: 1

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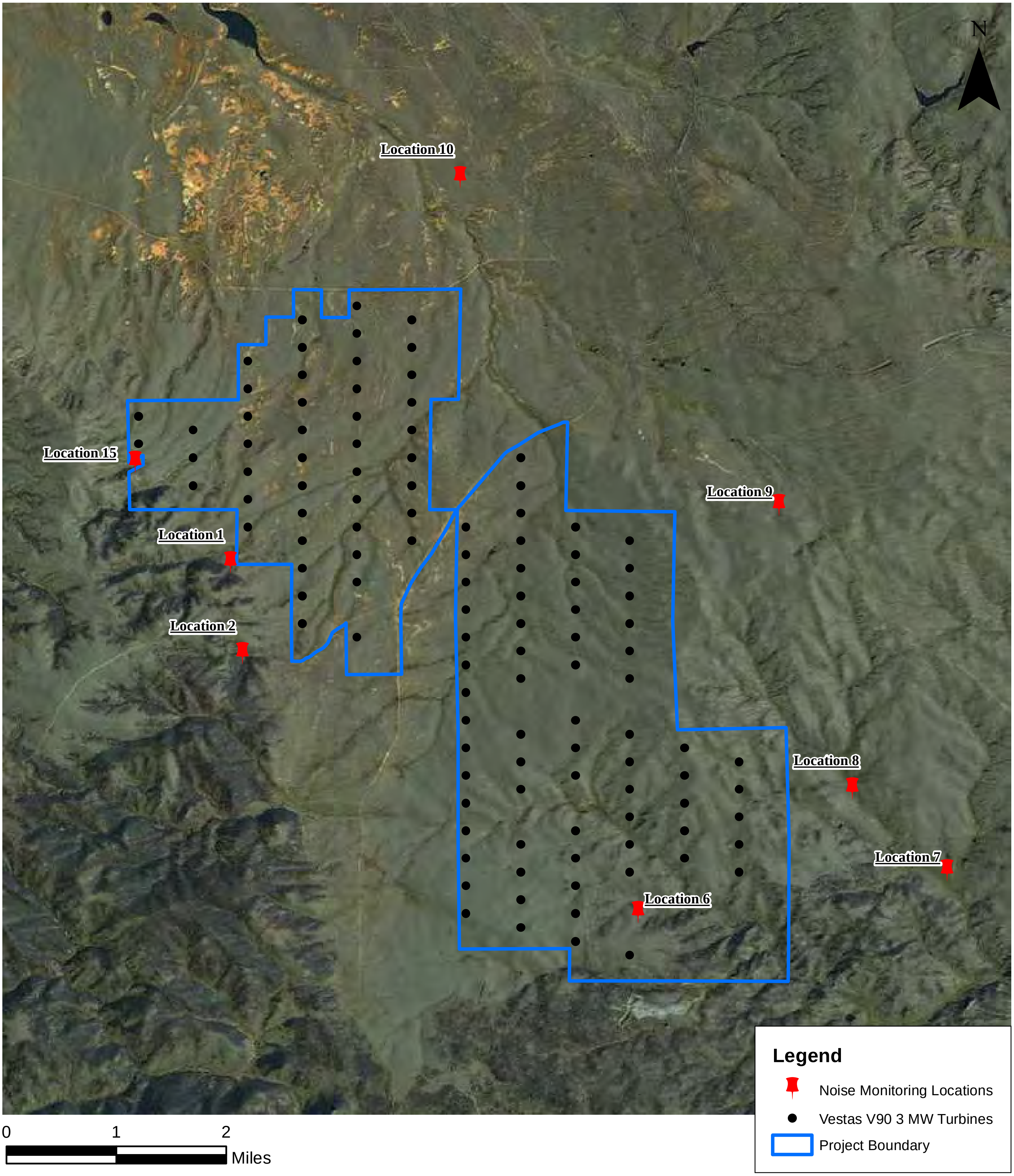
FIGURE 2
Location of Noise Sensitive Properties, Project Area and Layout for Siemens SWT 2.3 MW Turbines

Hermosa West Wind Farm Project
Albany County, Wyoming

ERM



Environmental Resources Management

DESIGN: S King	DRAWN: PKrishnan	CHKD.: P Maddock
DATE: 11/21/2011	SCALE: AS SHOWN	REVISION: 1

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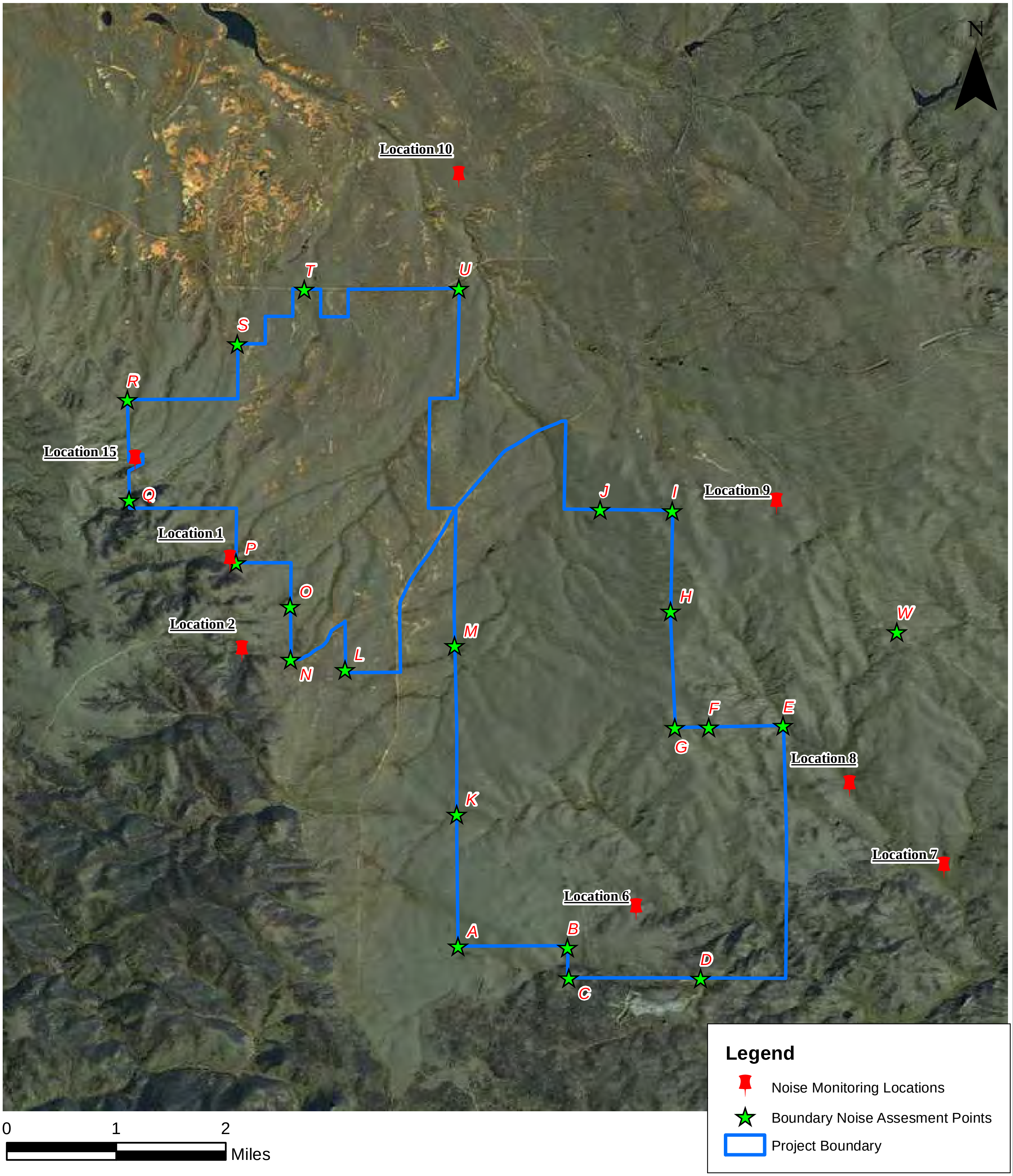
FIGURE 3
Location of Noise Sensitive Properties, Project Area and Layout for Vestas V90 3 MW Turbines

Hermosa West Wind Farm Project
Albany County, Wyoming

ERM



Environmental Resources Management

DESIGN: S King	DRAWN: PKrishnan	CHKD.: P Maddock
DATE: 11/21/2011	SCALE: AS SHOWN	REVISION: 1

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FIGURE 4
Location of Noise Sensitive Properties, Project Area and Representative Boundary Noise Assessment Points

Hermosa West Wind Farm Project
Albany County, Wyoming

ERM

GE 1.5Mw Results

Appendix A

March 15, 2012
Project No. 0116974

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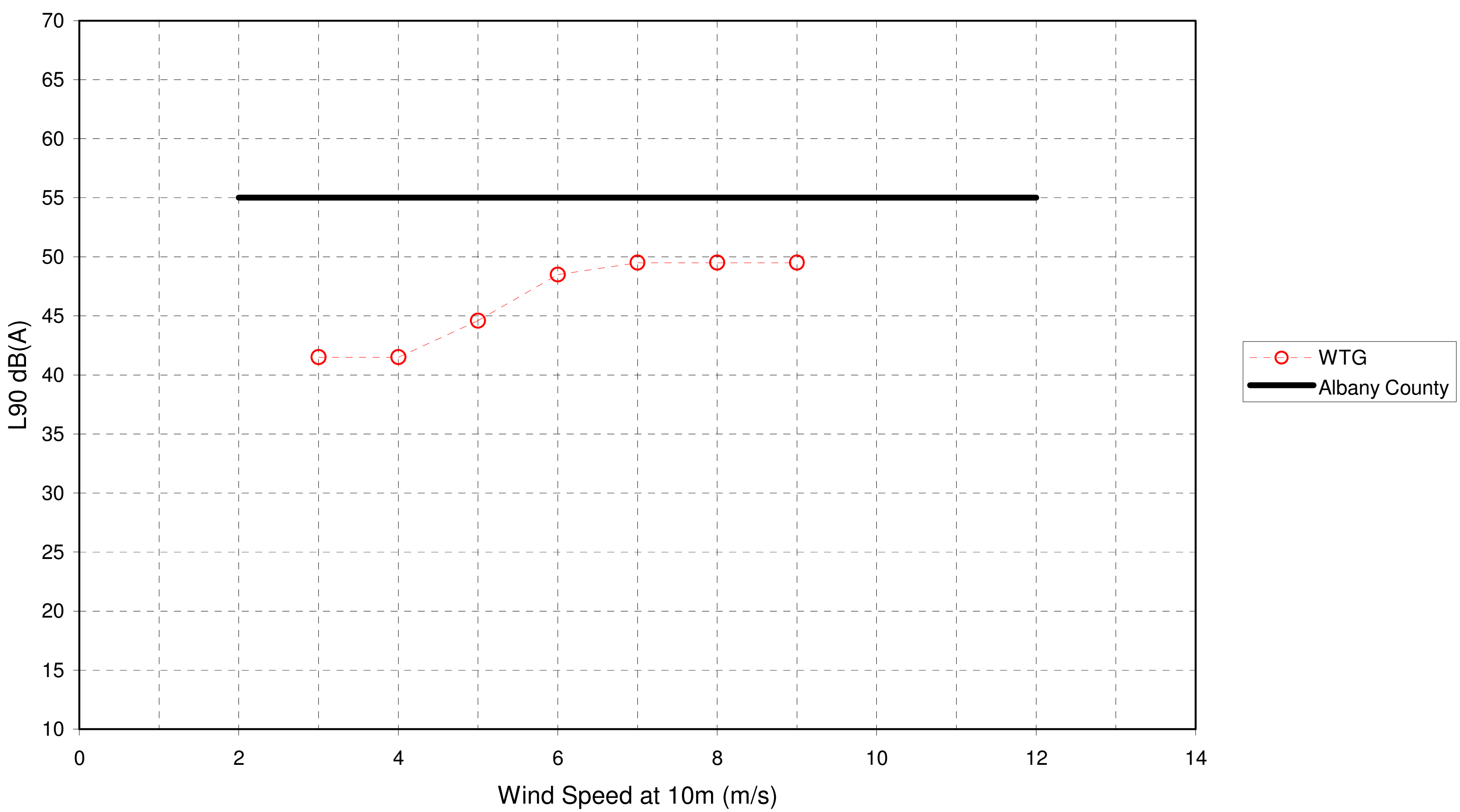
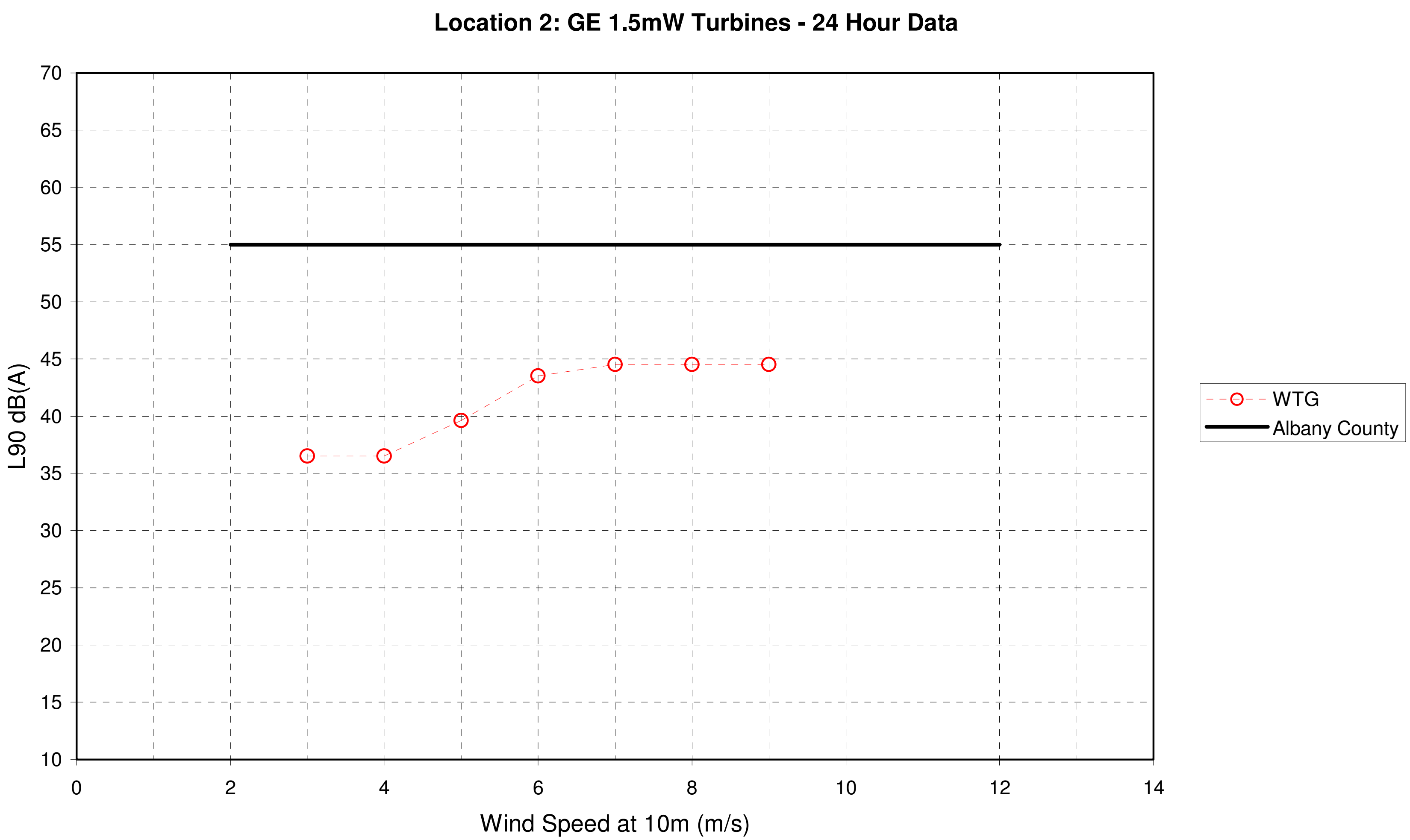
Houston, Texas 77084-5140
(281) 600-1000

Location 1: GE 1.5mW Turbines - 24 Hour Data




Location 2: GE 1.5mW Turbines - 24 Hour Data
L90 dB(A)
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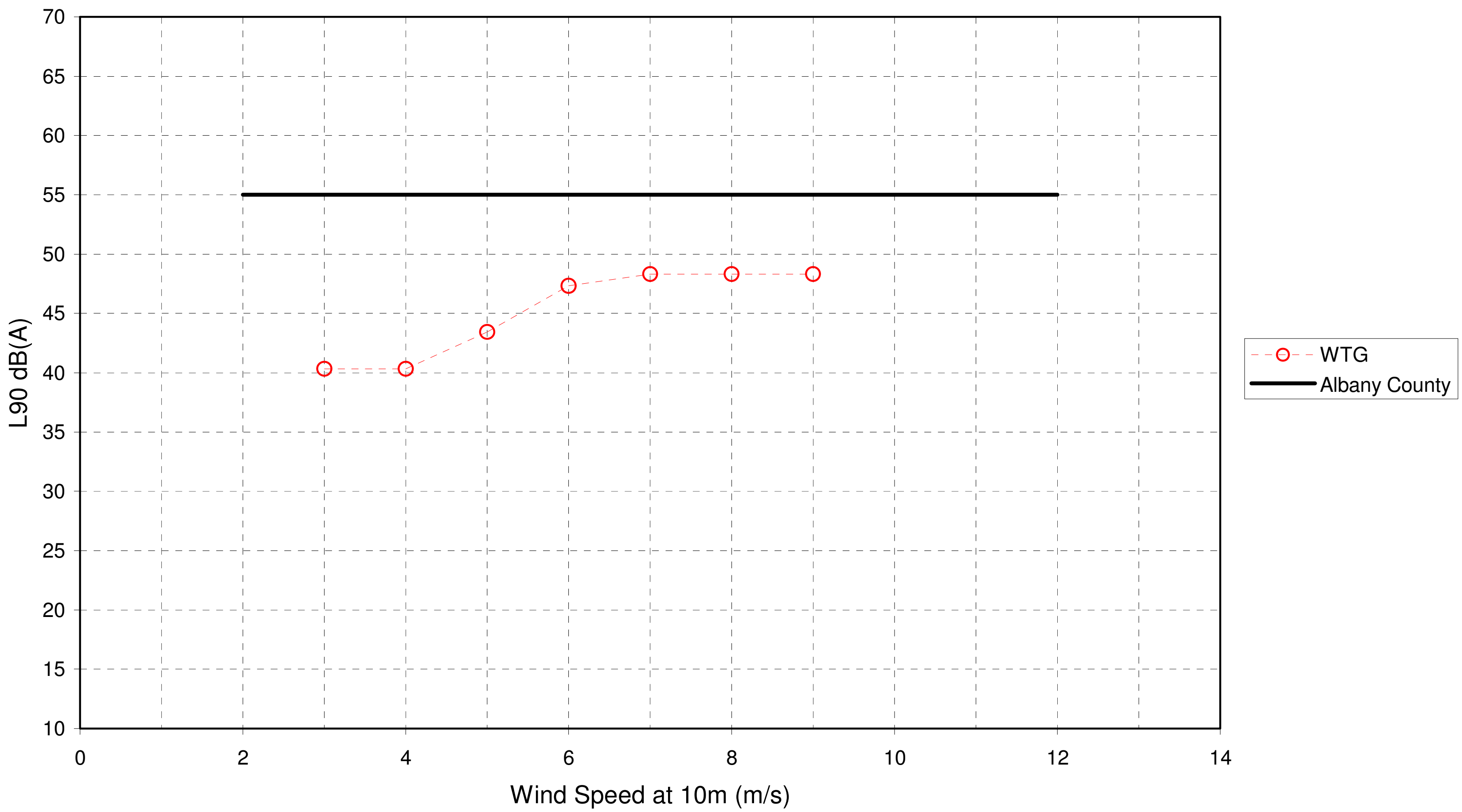
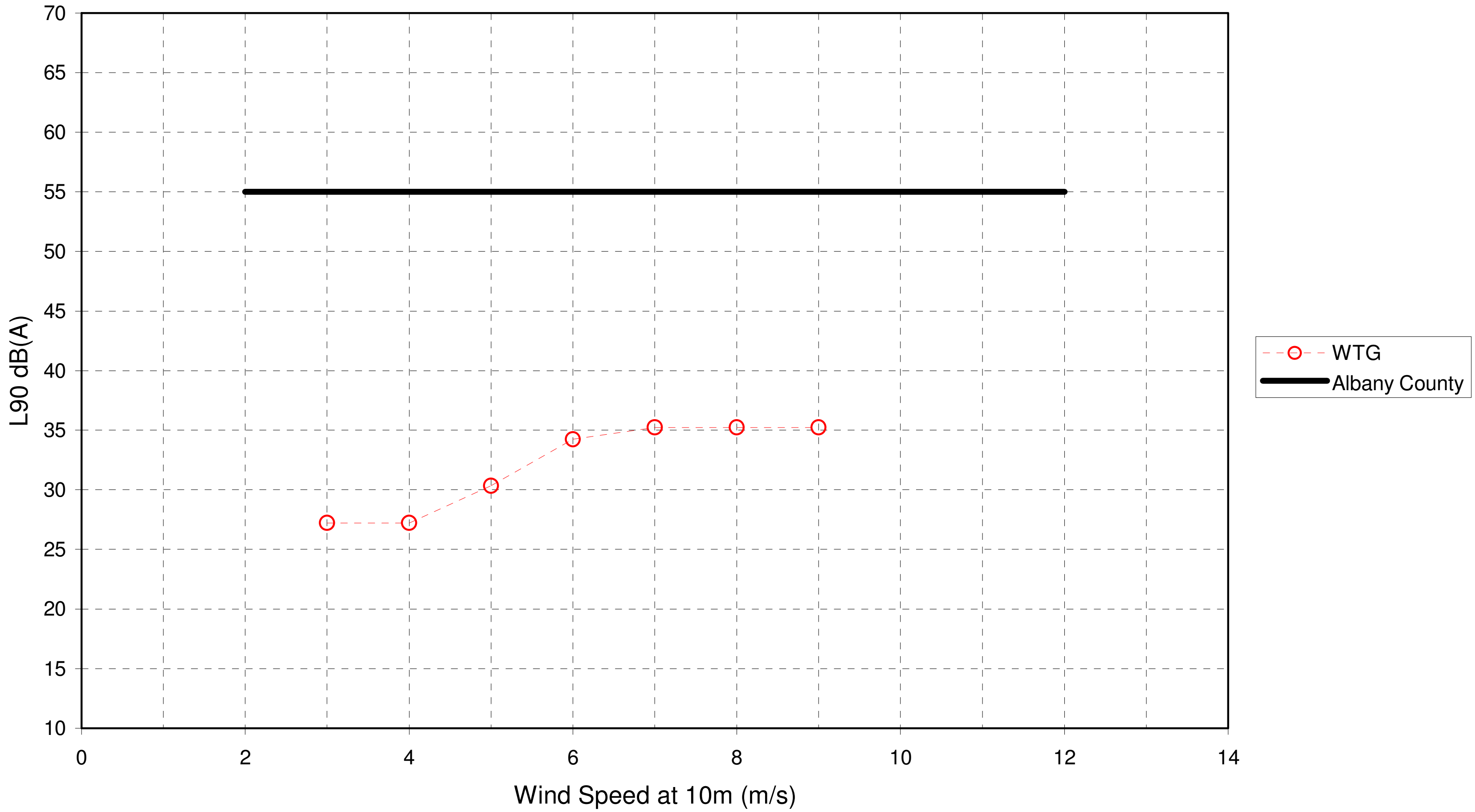
Wind Speed at 10m (m/s)
WTG
Albany County

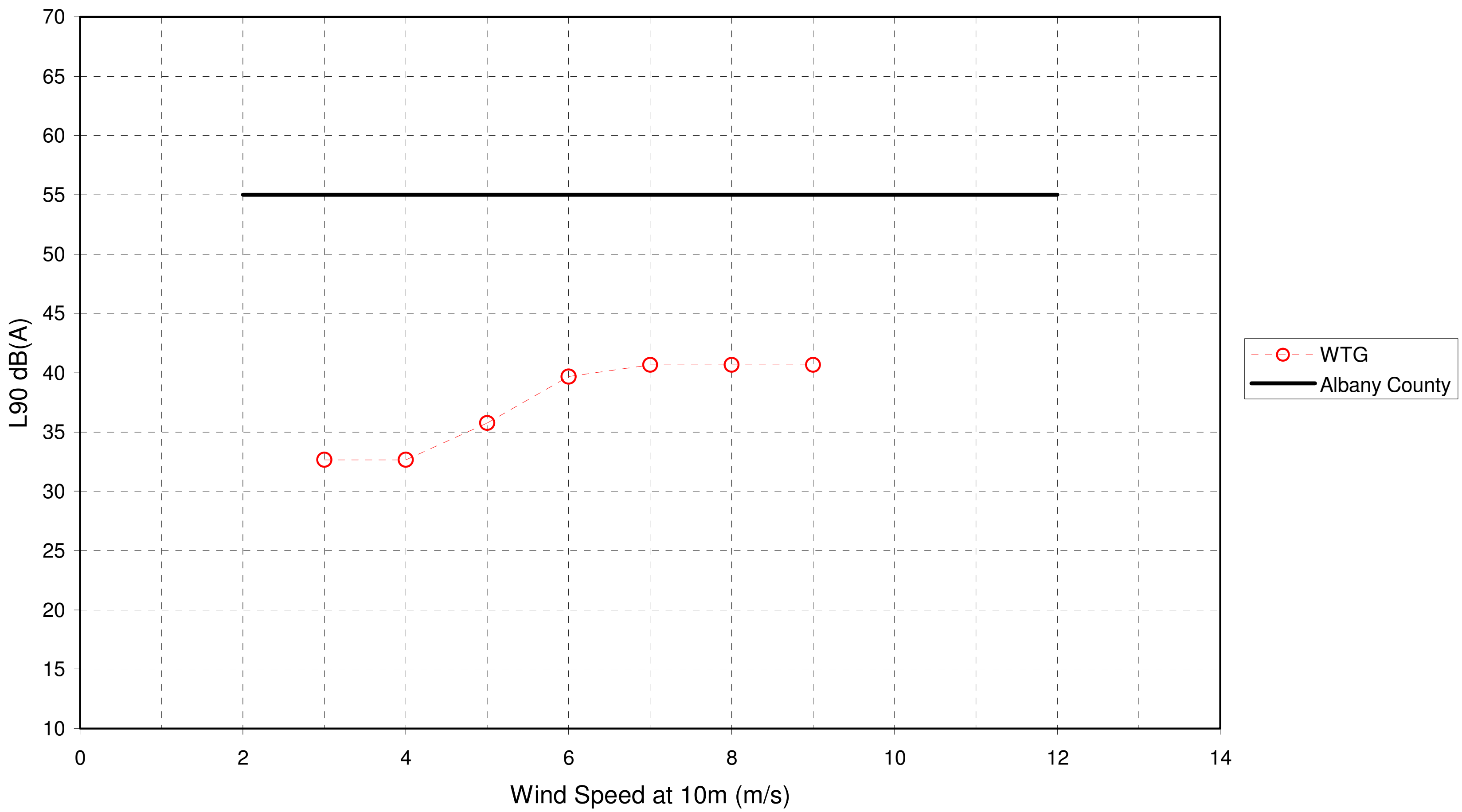
Location 6: GE 1.5mW Turbines - 24 Hour Data



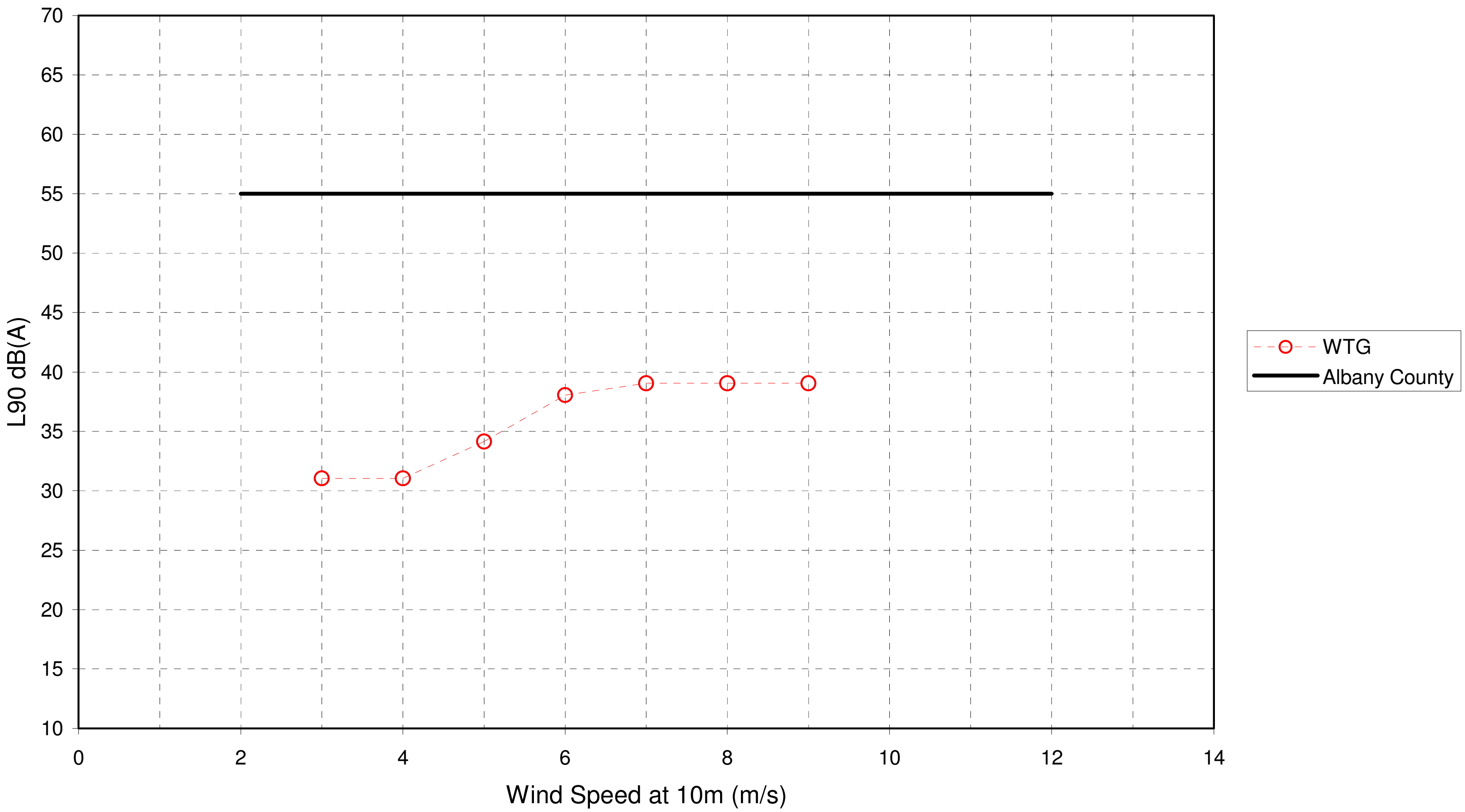
Location 7: GE 1.5mW Turbines - Night-Time Data (2300 - 0700)

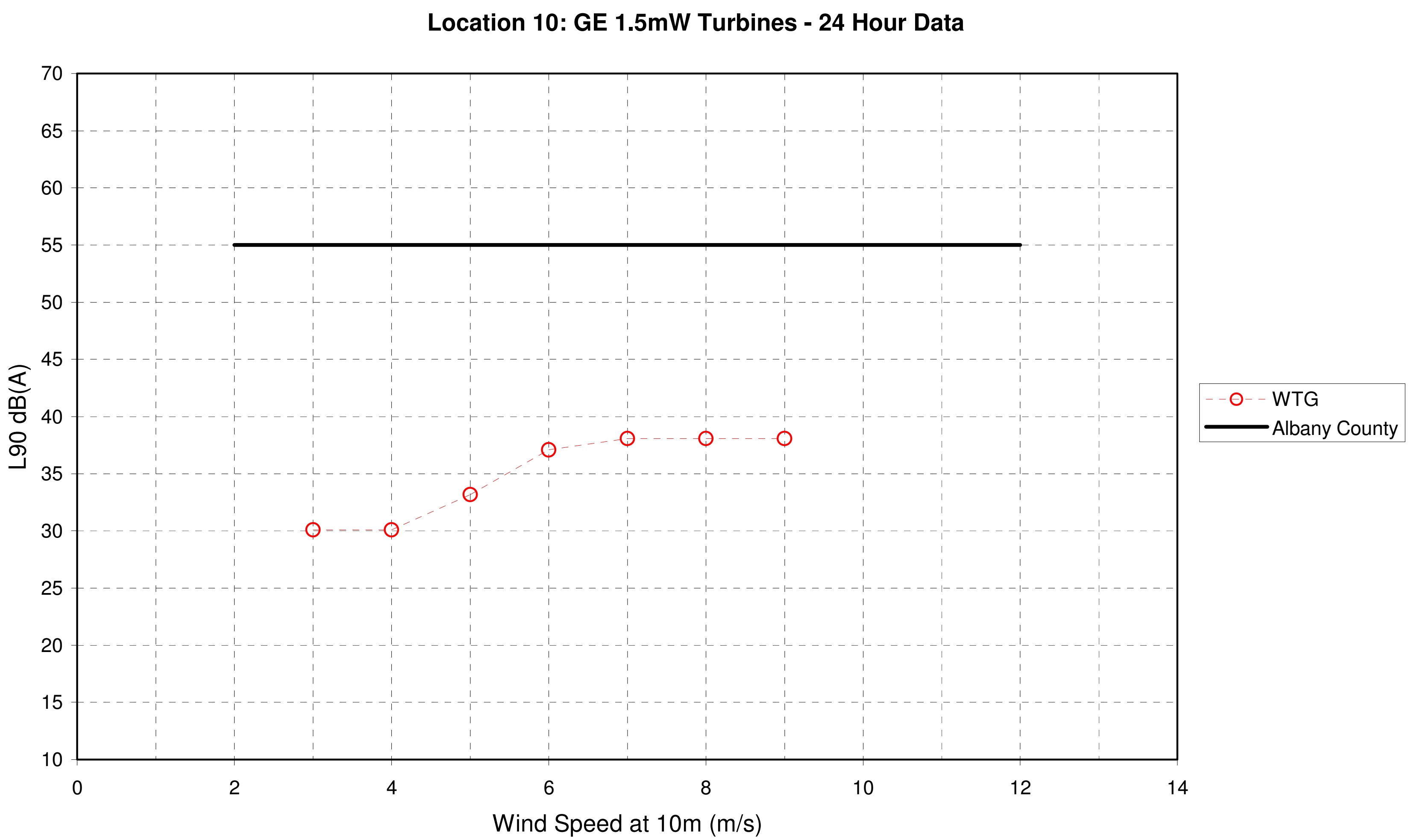


Location 8: GE 1.5mW Turbines - 24 Hour Data



Location 9: GE 1.5mW Turbines - 24 Hour Data





Location 10: GE 1.5mW Turbines - 24 Hour Data
L90 dB(A)
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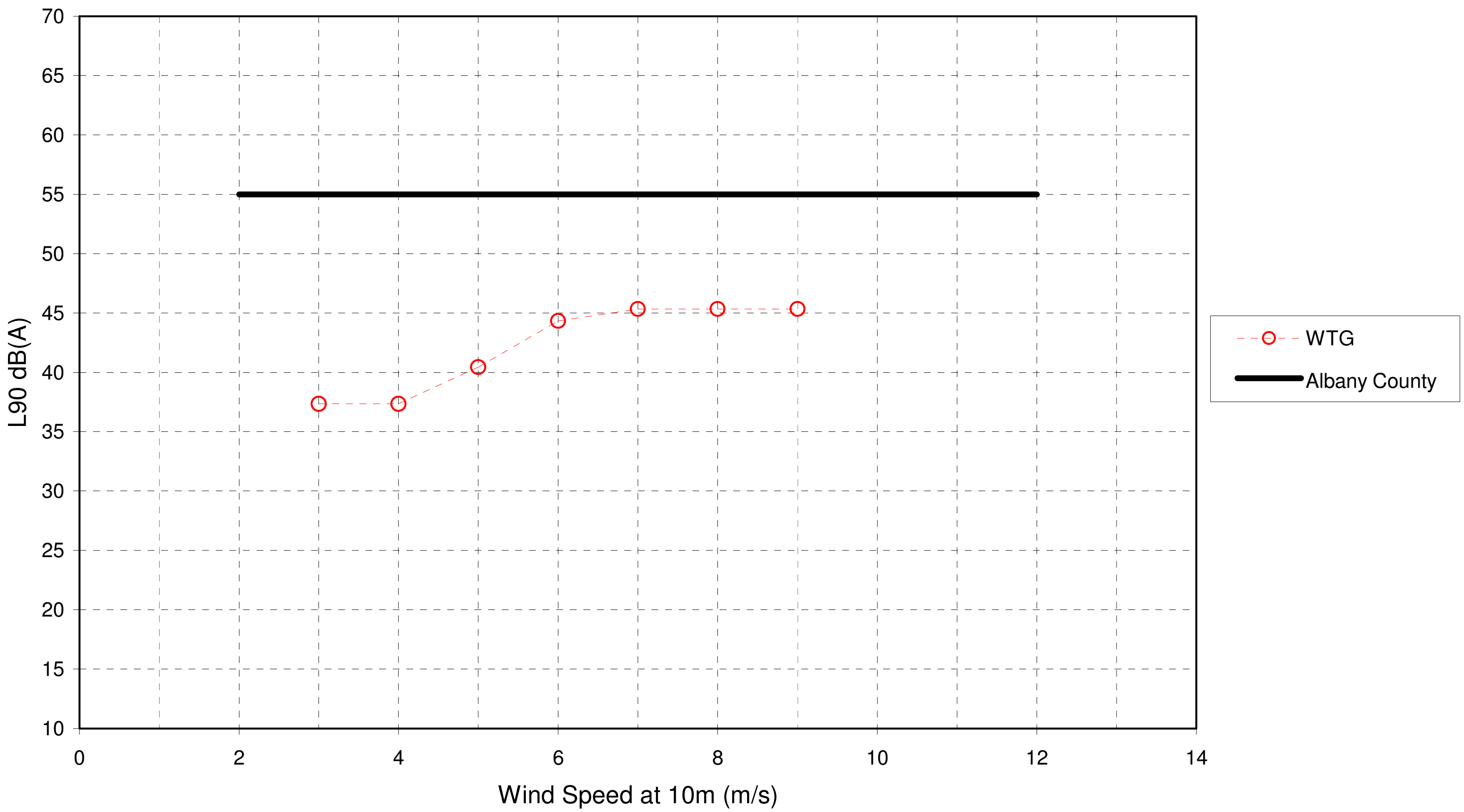
Wind Speed at 10m (m/s)
WTG
Albany County

Location 15: GE 1.5mW Turbines - 24 Hour Data



Siemens 2.3Mw Results

Appendix B

March 15, 2012
Project No. 0116974

Environmental Resources Management
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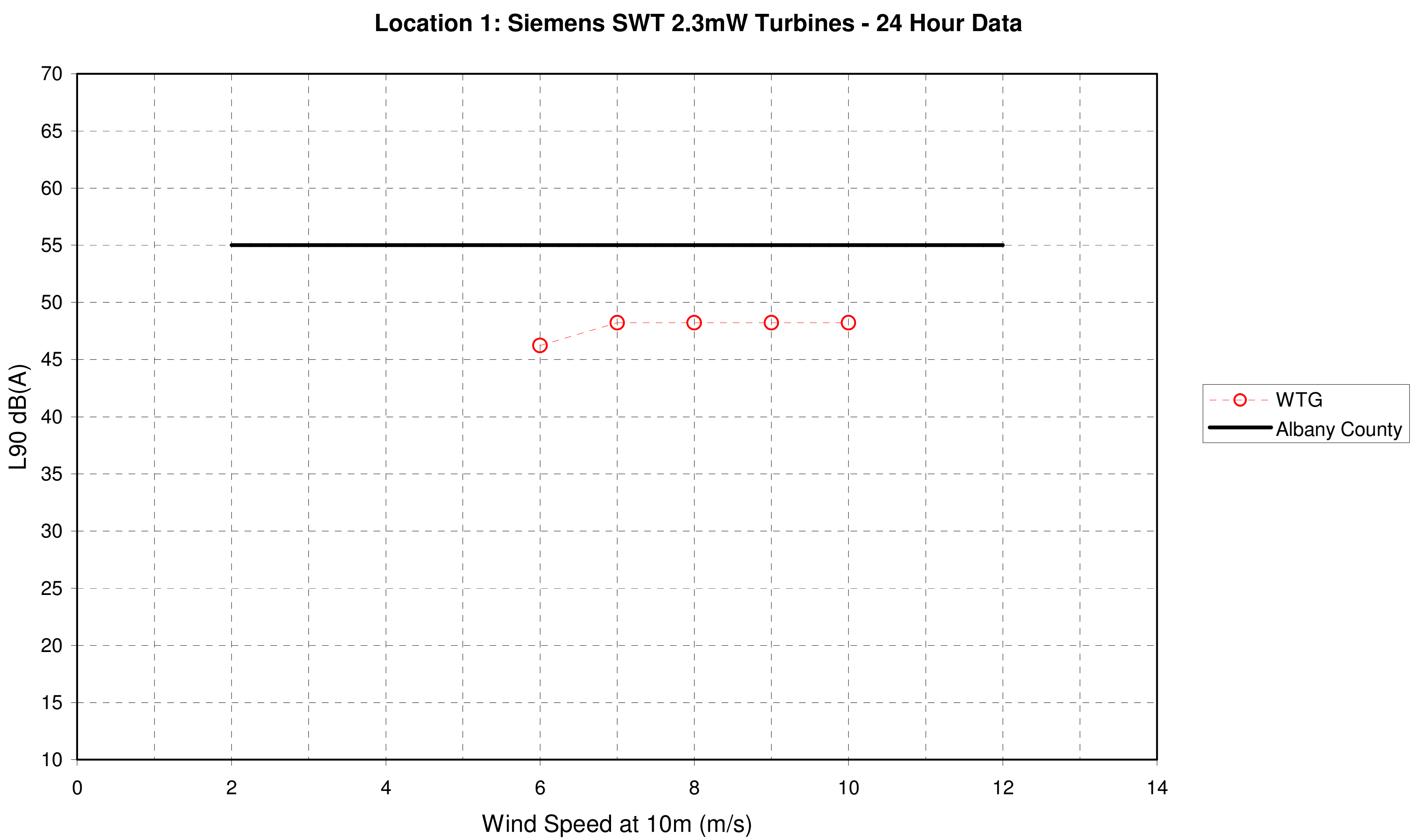
Location 1: Siemens SWT 2.3mW Turbines - 24 Hour Data
L90 dB(A)
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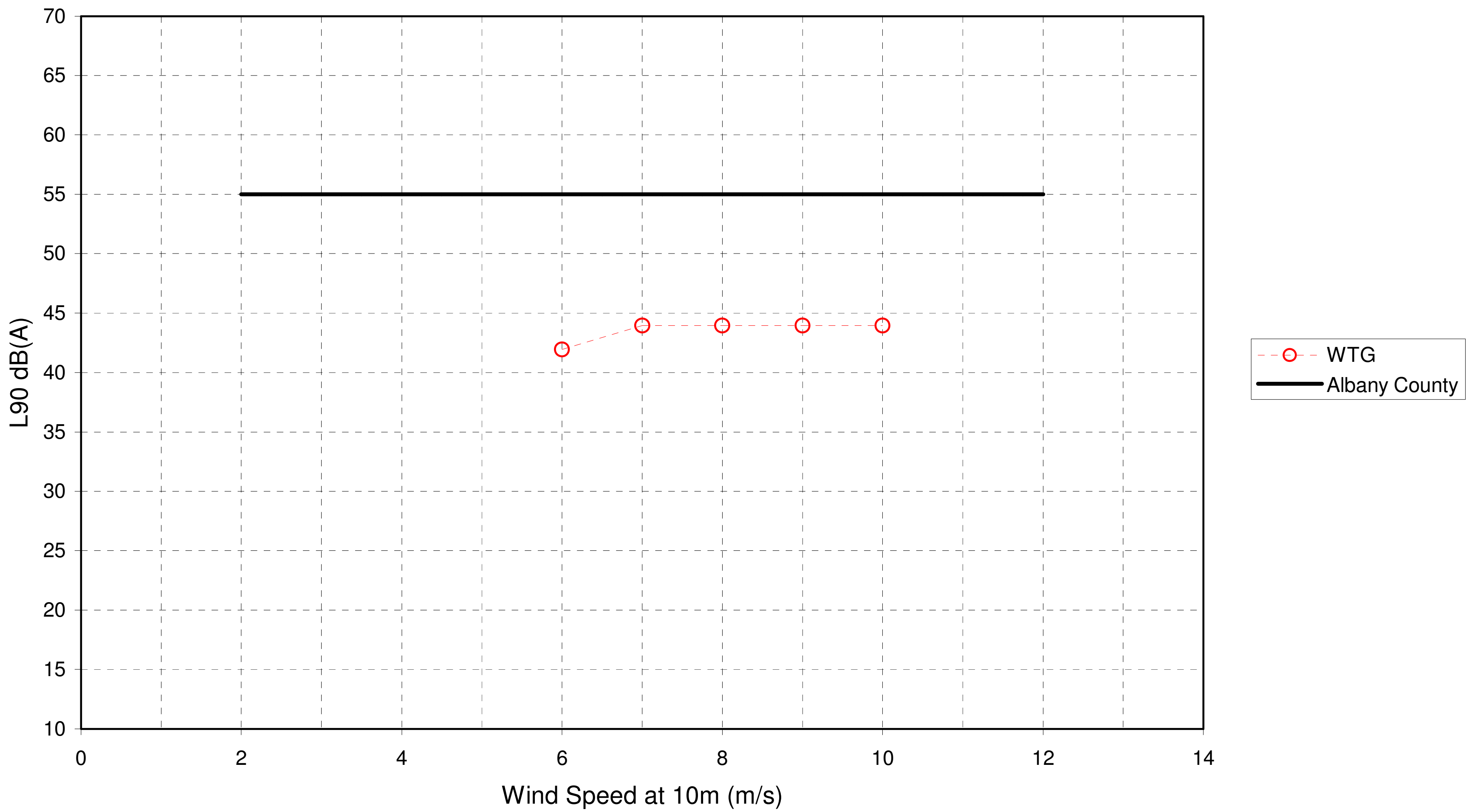
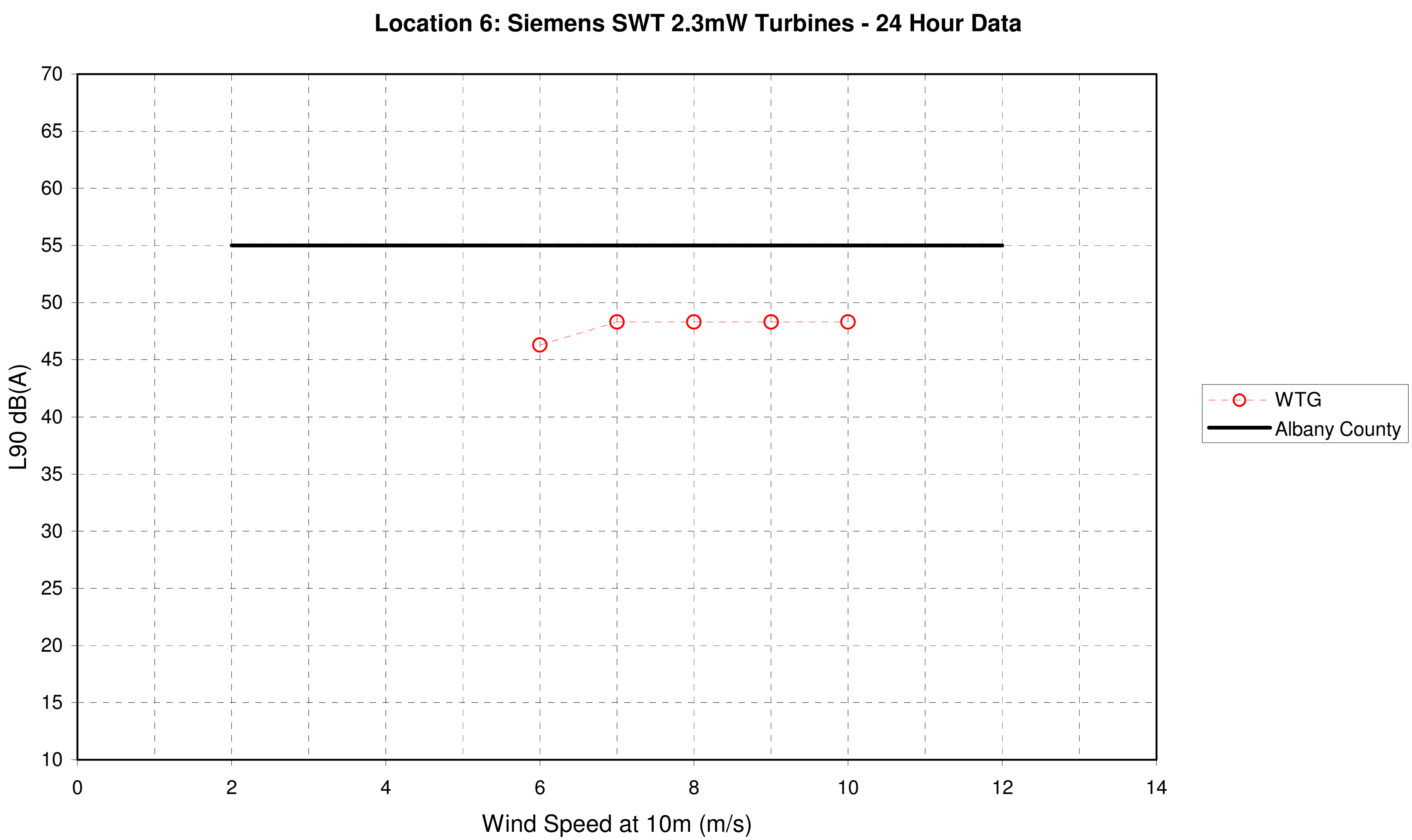
Wind Speed at 10m (m/s)
WTG
Albany County

Location 2: Siemens SWT 2.3mW Turbines - 24 Hour Data





Location 6: Siemens SWT 2.3mW Turbines - 24 Hour Data
L90 dB(A)
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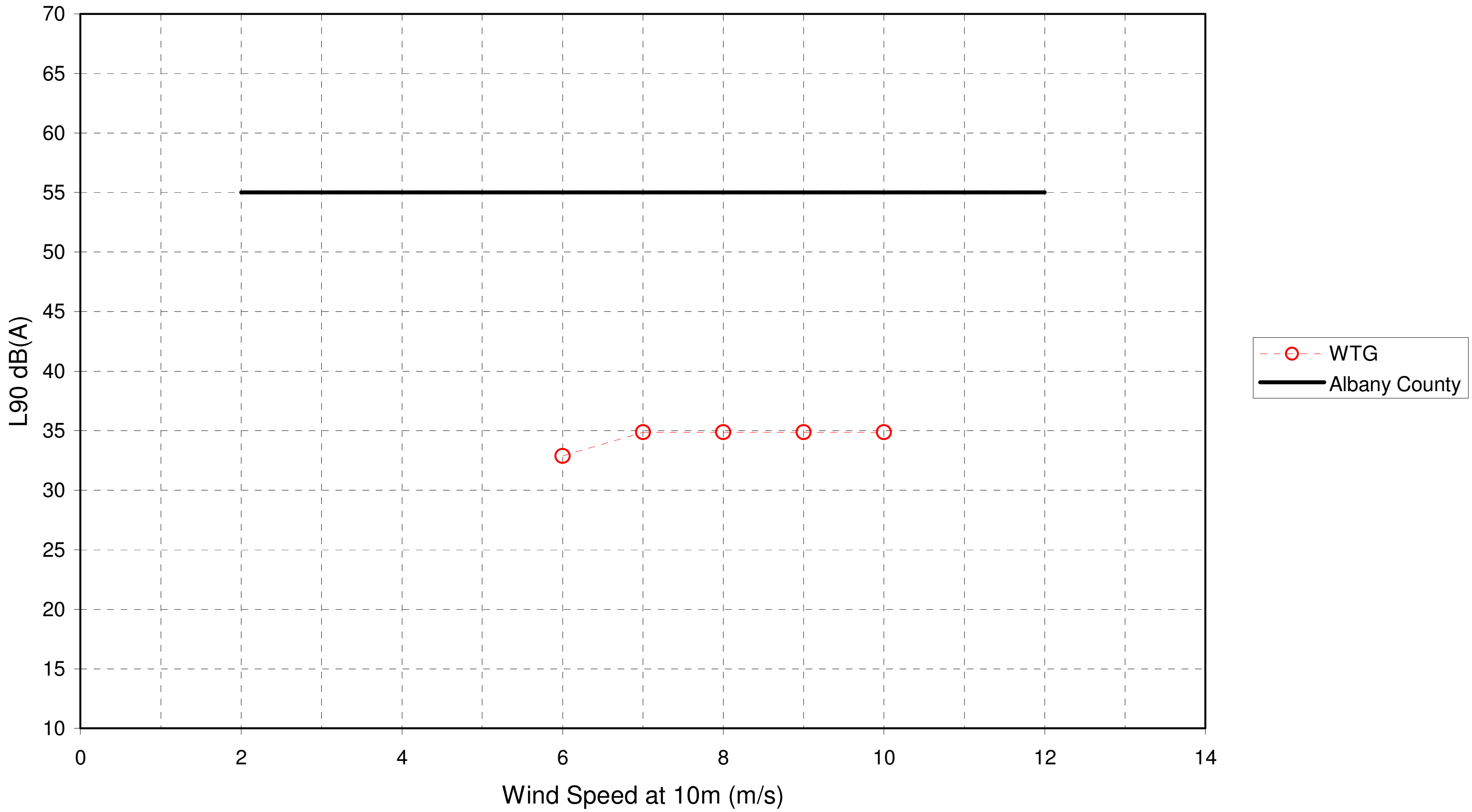
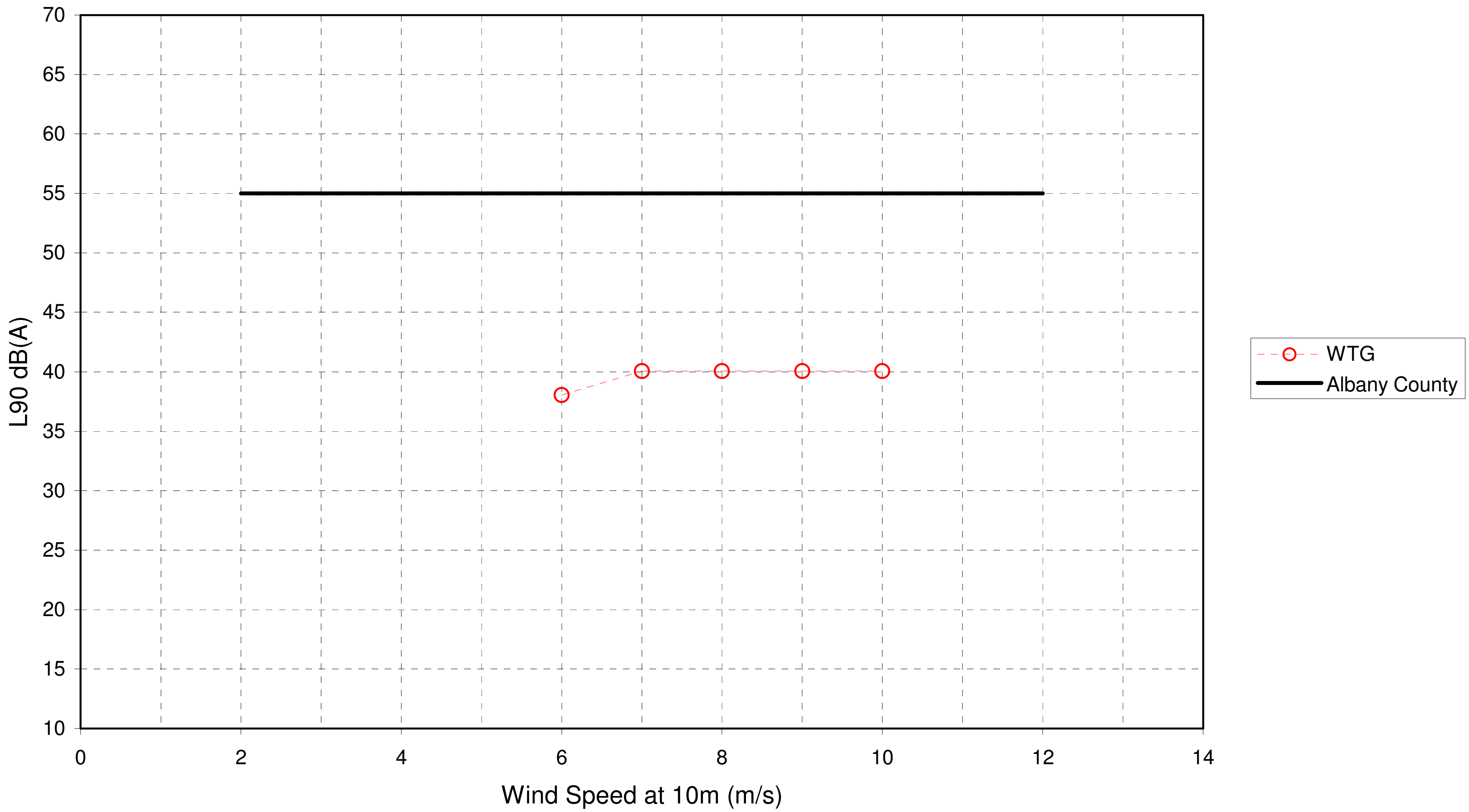
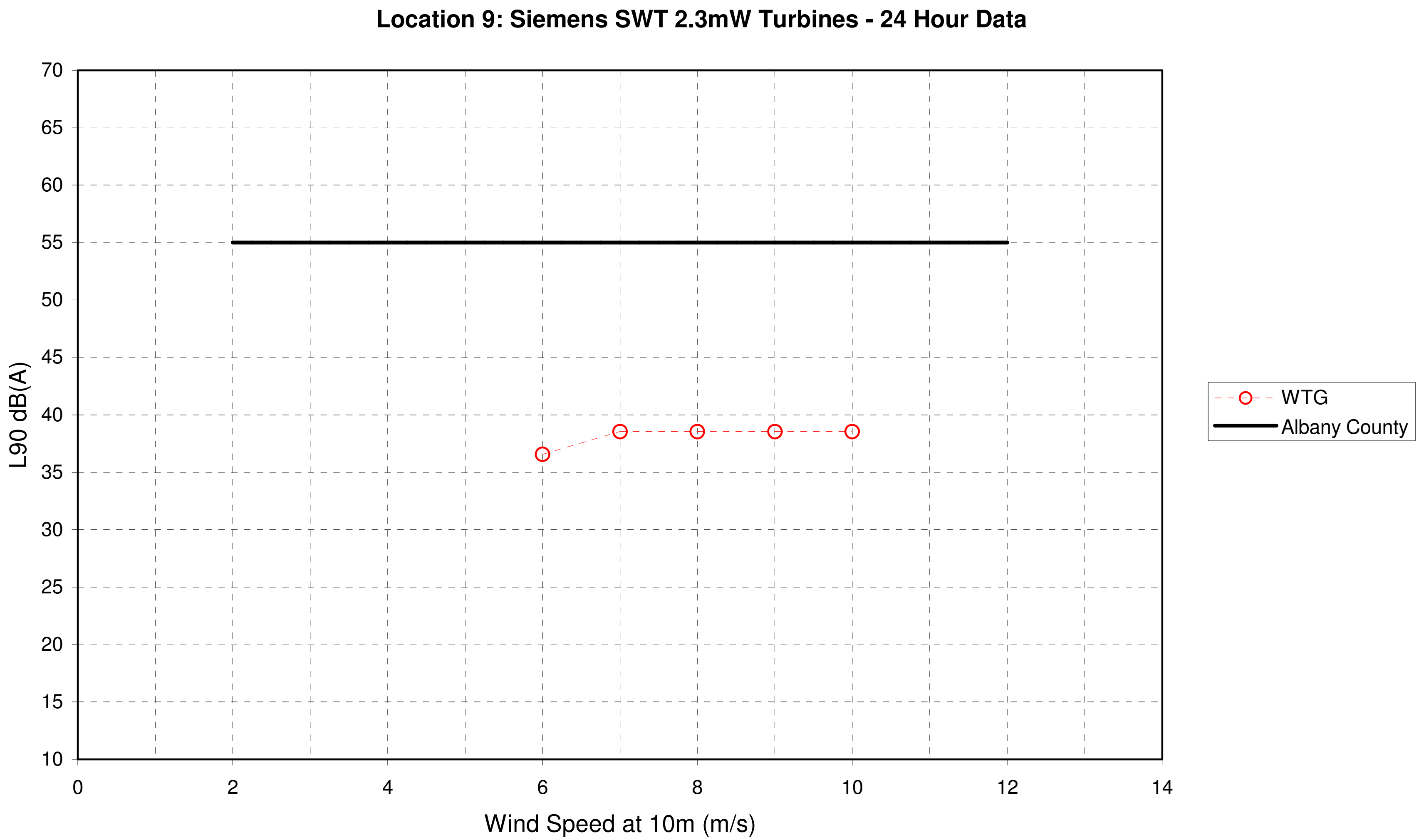
Wind Speed at 10m (m/s)
WTG
Albany County

Location 7: Siemens SWT 2.3mW Turbines - 24 Hour Data



Location 8: Siemens SWT 2.3mW Turbines - 24 Hour Data




Location 9: Siemens SWT 2.3mW Turbines - 24 Hour Data
L90 dB(A)
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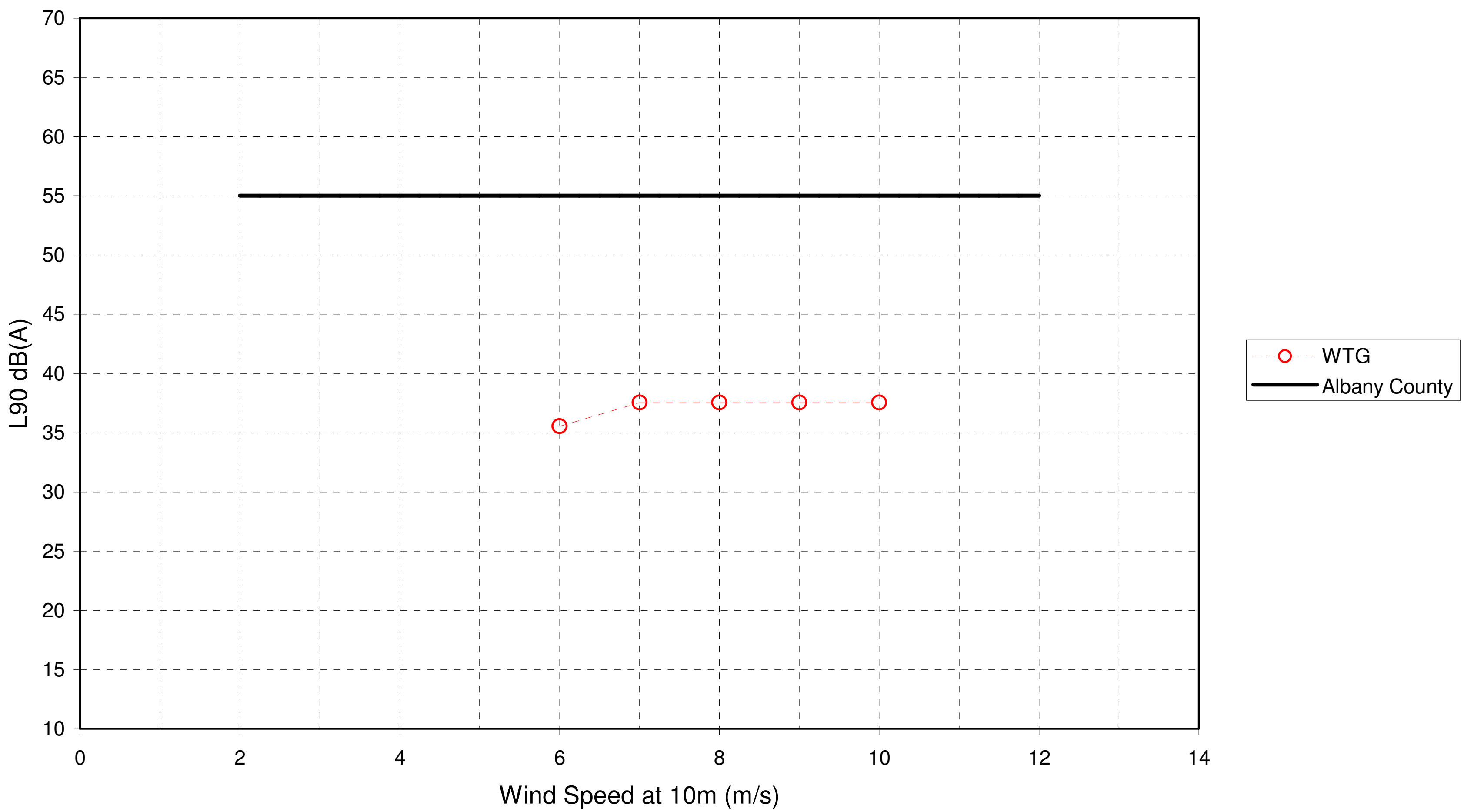
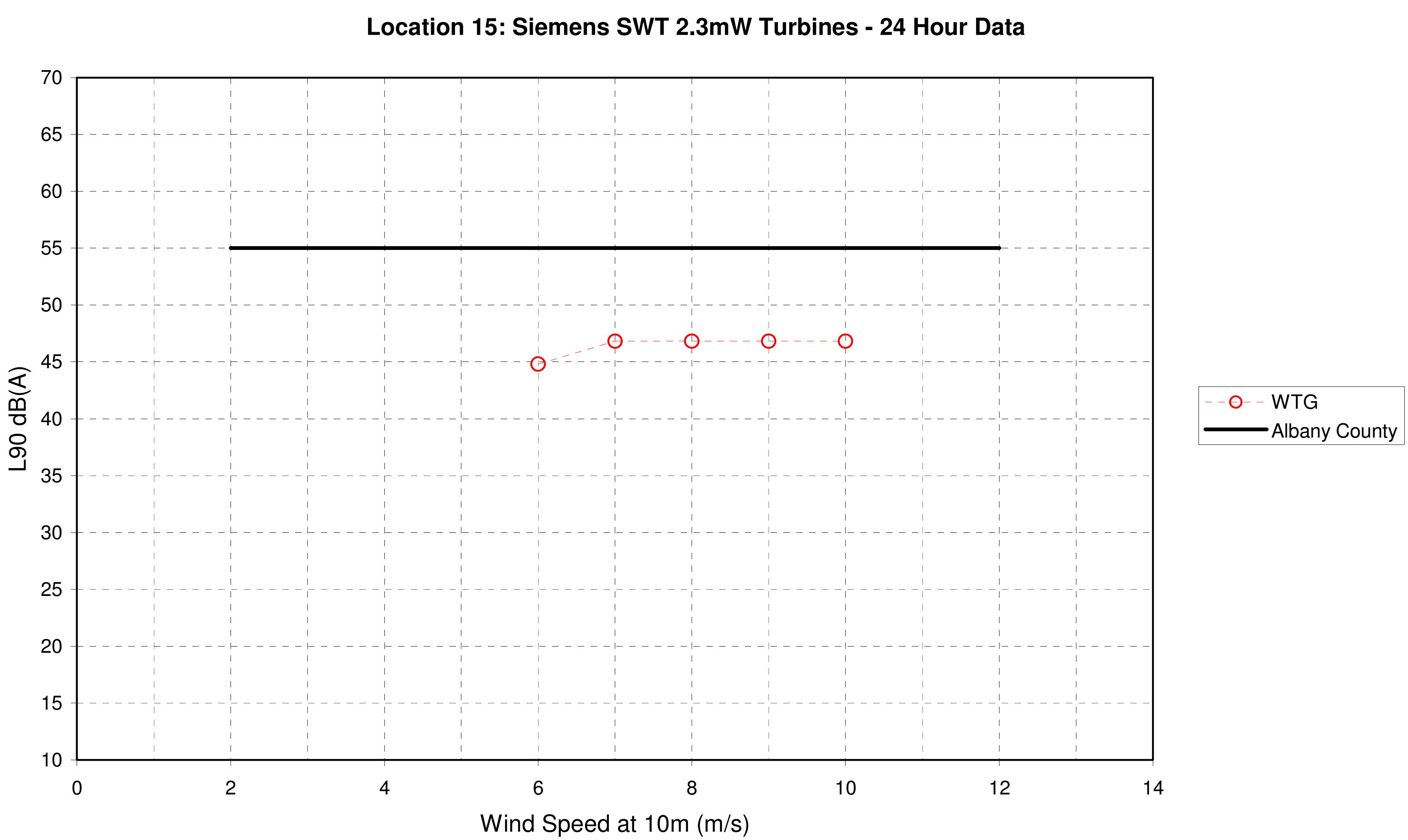
Wind Speed at 10m (m/s)
WTG
Albany County

Location 10: Siemens SWT 2.3mW Turbines - 24 Hour Data




Location 15: Siemens SWT 2.3mW Turbines - 24 Hour Data
L90 dB(A)
Wind Speed at 10m (m/s)
WTG
Albany County
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Vestas V90 3Mw Results

Appendix C

March 15, 2012
Project No. 0116974

Environmental Resources Management
15810 Park Ten Place, Suite 300
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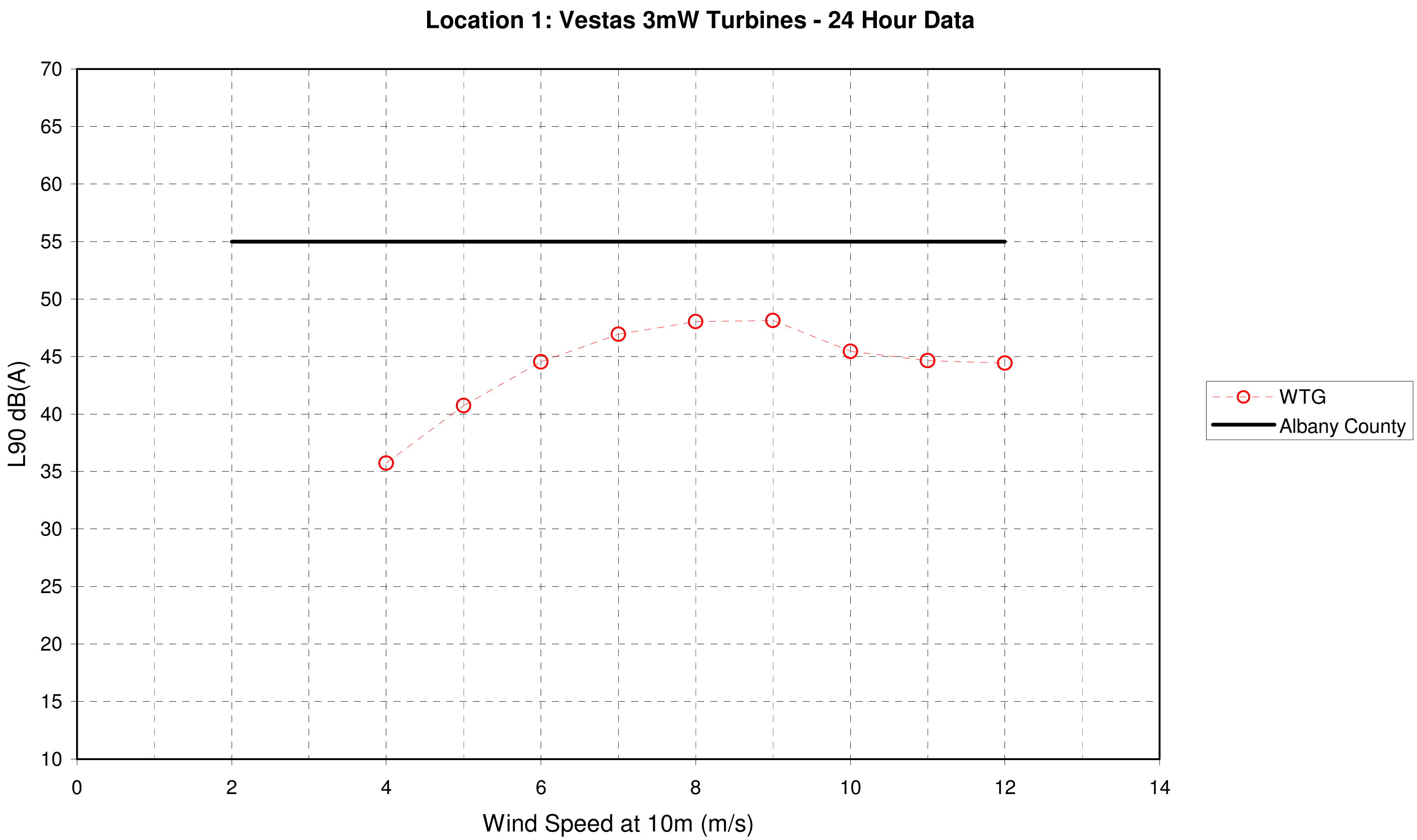
(281) 600-1000



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L90 dB(A)
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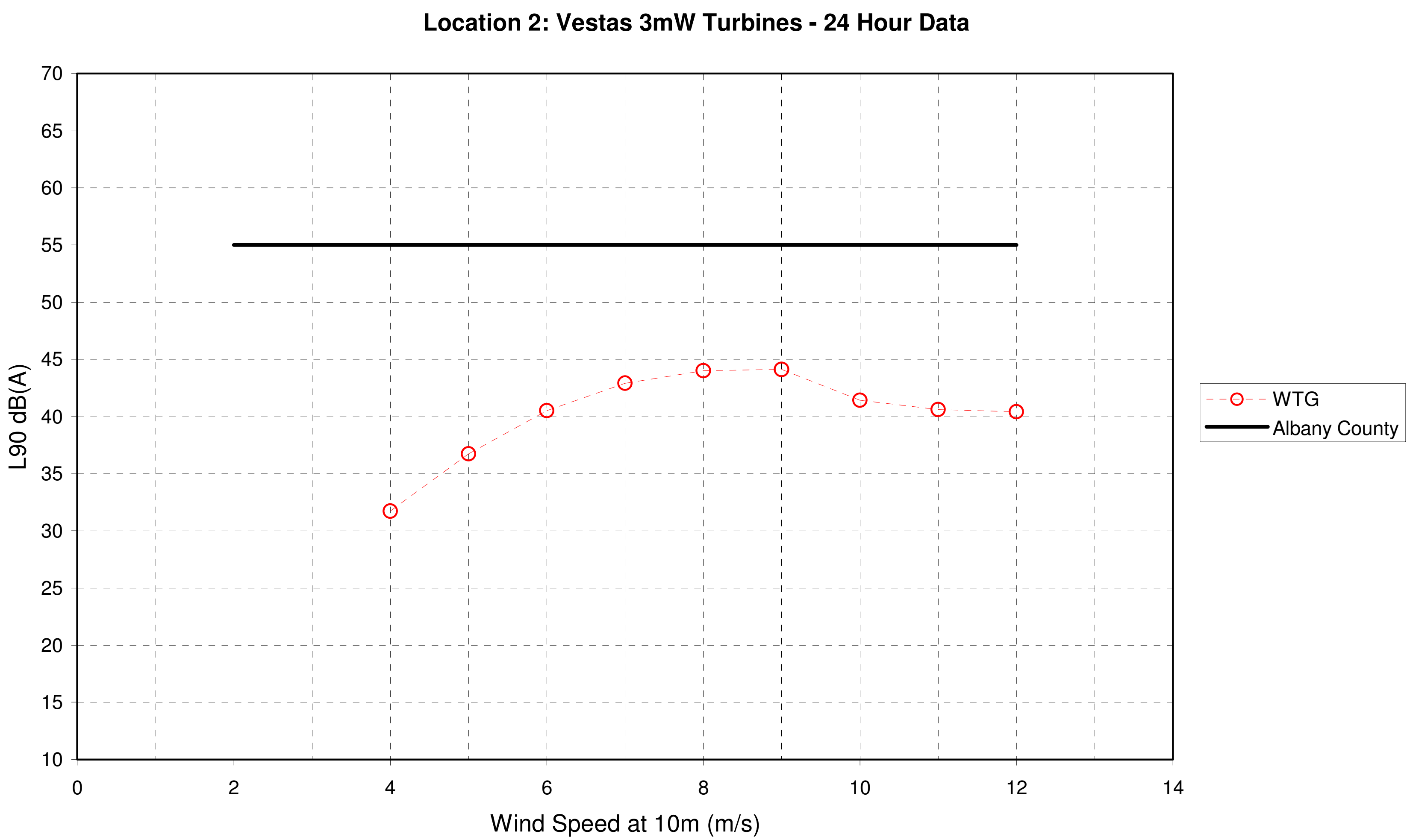
Wind Speed at 10m (m/s)
WTG
Albany County


Location 2: Vestas 3mW Turbines - 24 Hour Data
L90 dB(A)
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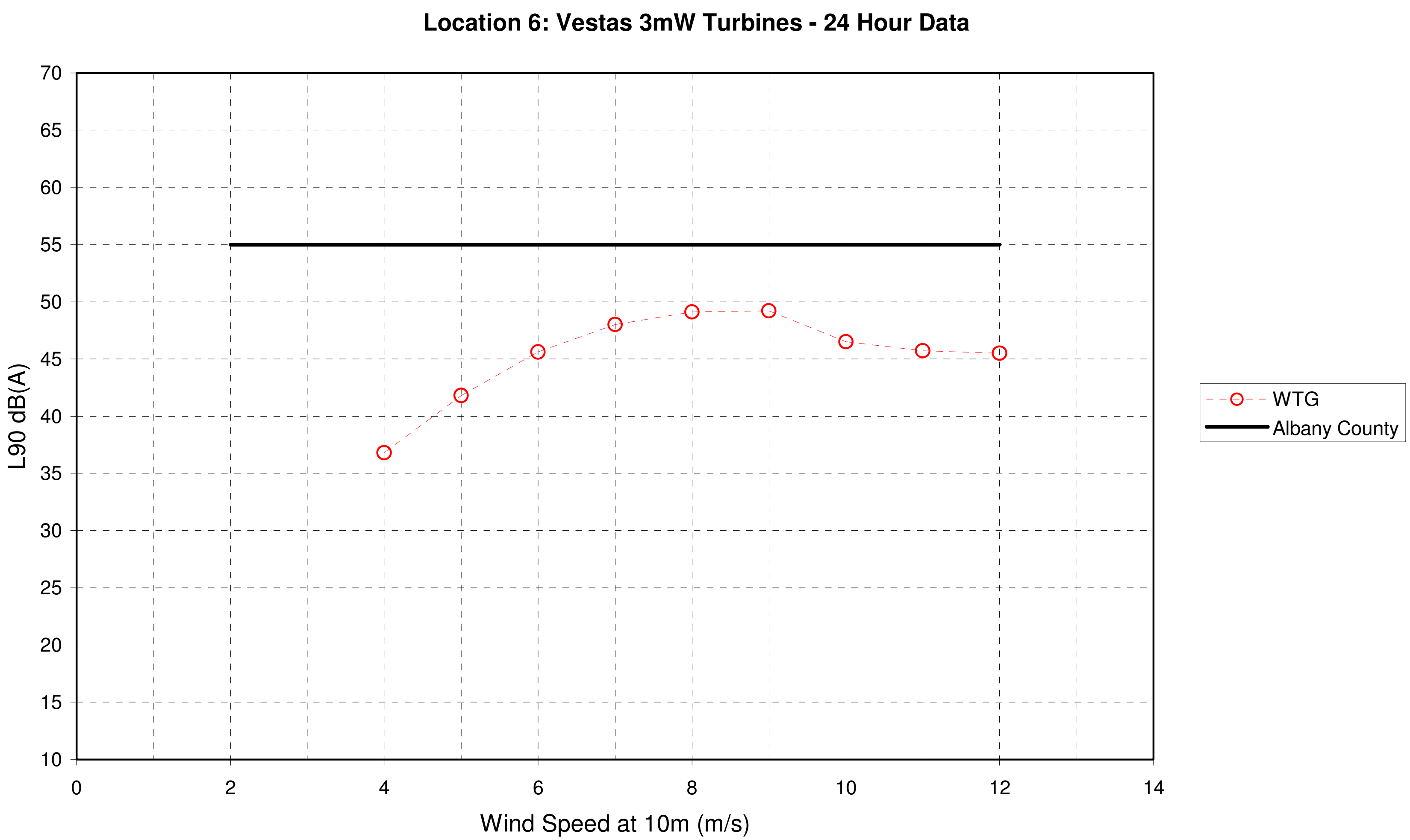
Wind Speed at 10m (m/s)
WTG
Albany County


Location 6: Vestas 3mW Turbines - 24 Hour Data
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L90 dB(A)
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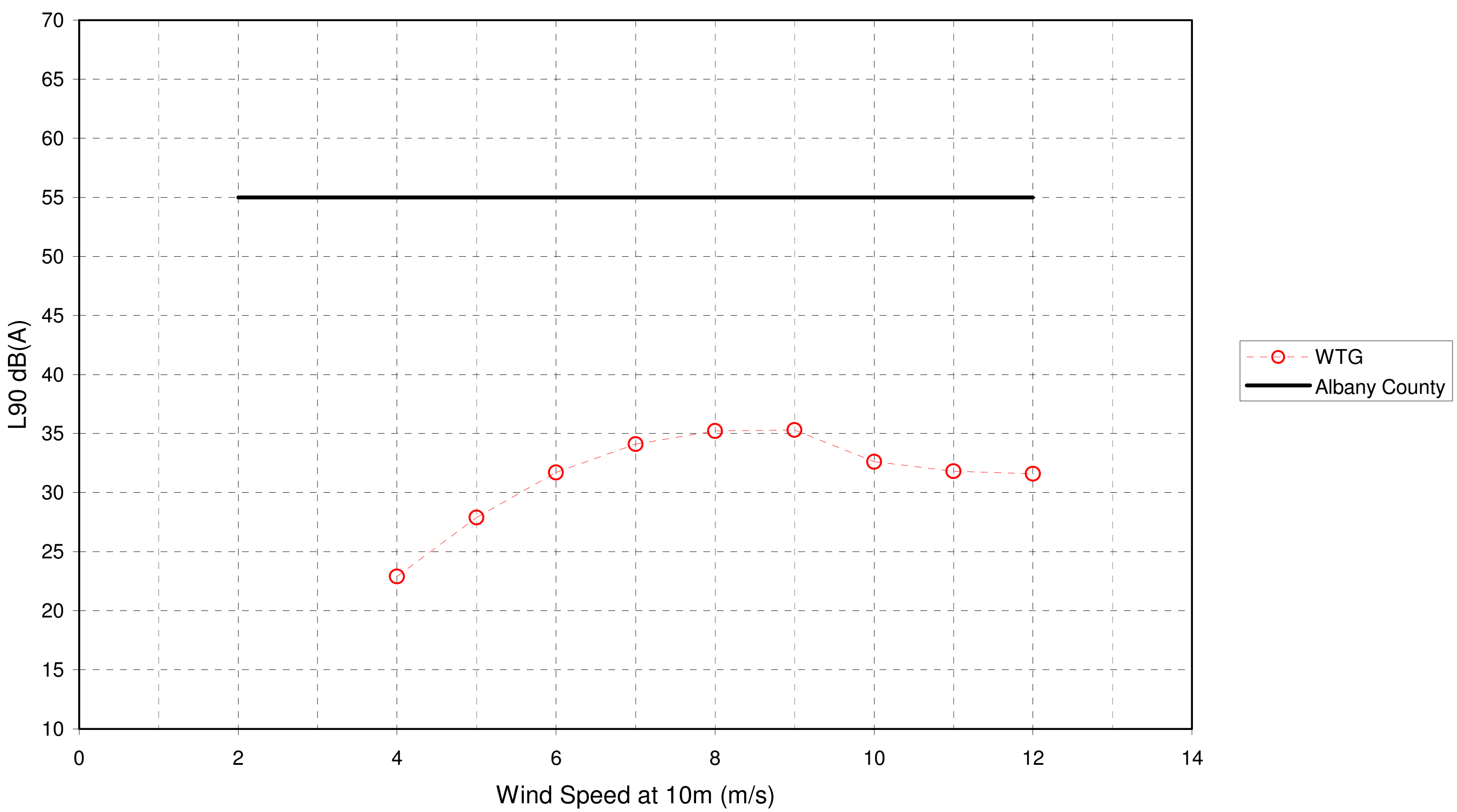
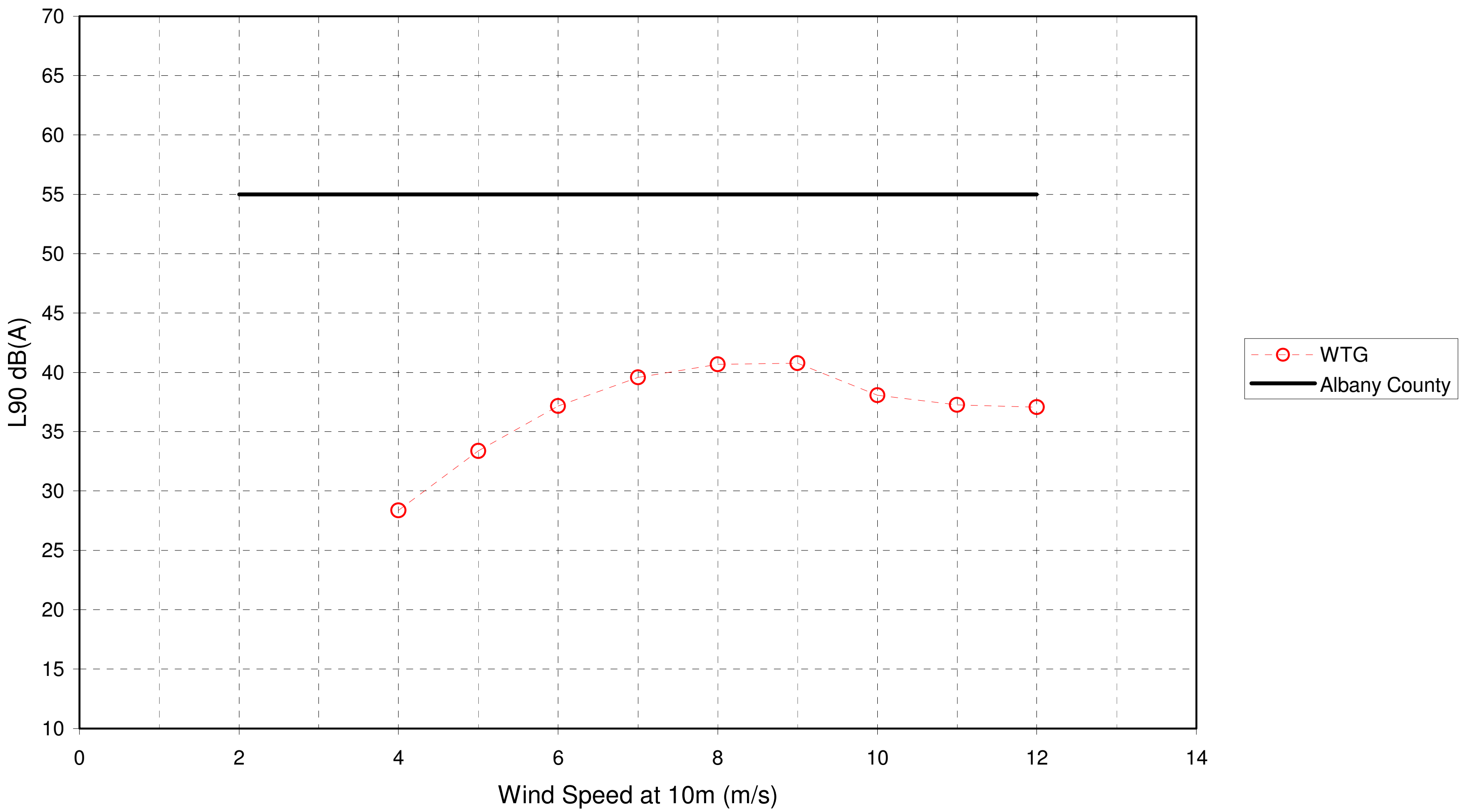
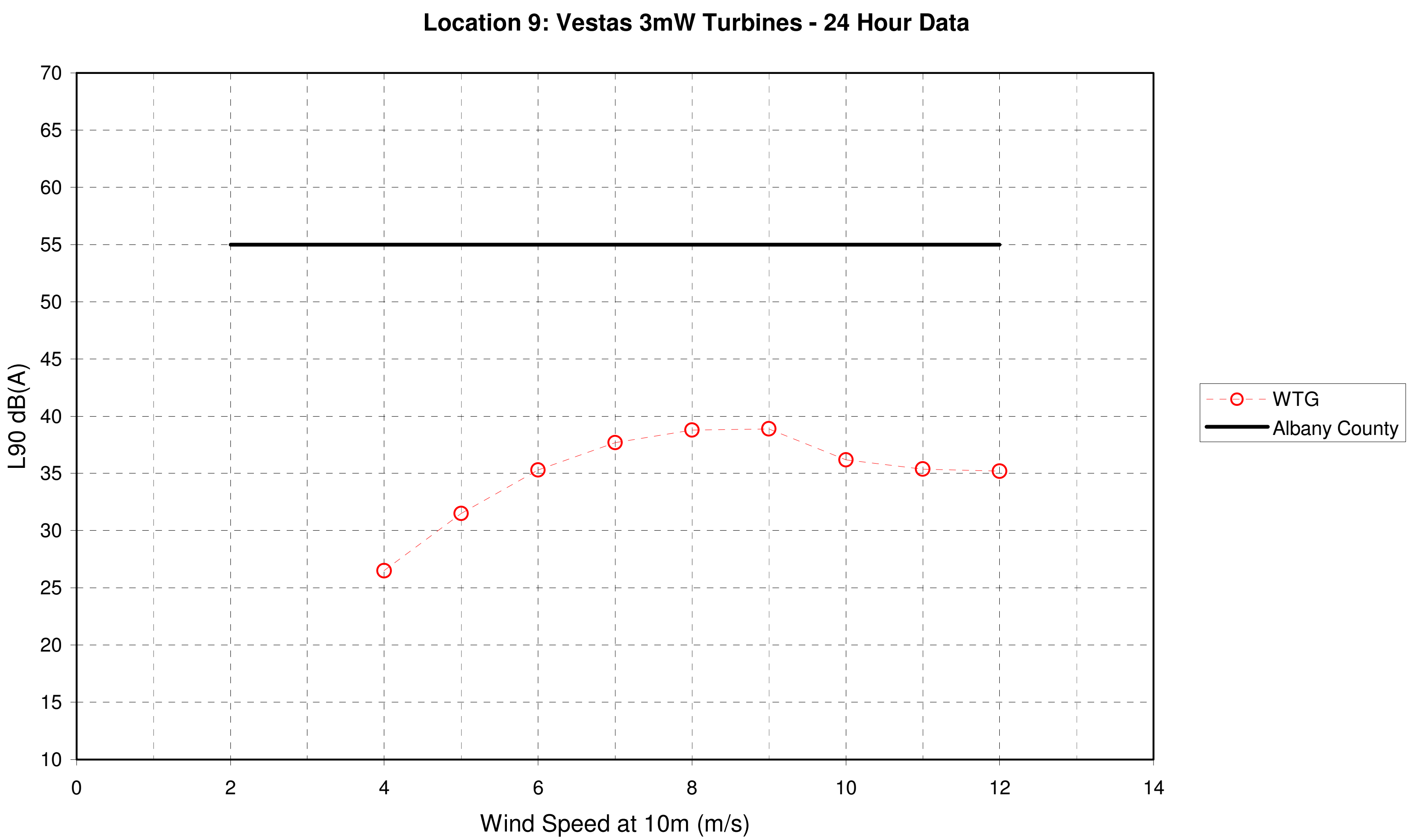
Wind Speed at 10m (m/s)
WTG
Albany County

Location 7: Vestas 3mW Turbines - 24 Hour Data



Location 8: Vestas 3mW Turbines - 24 Hour Data




Location 9: Vestas 3mW Turbines - 24 Hour Data
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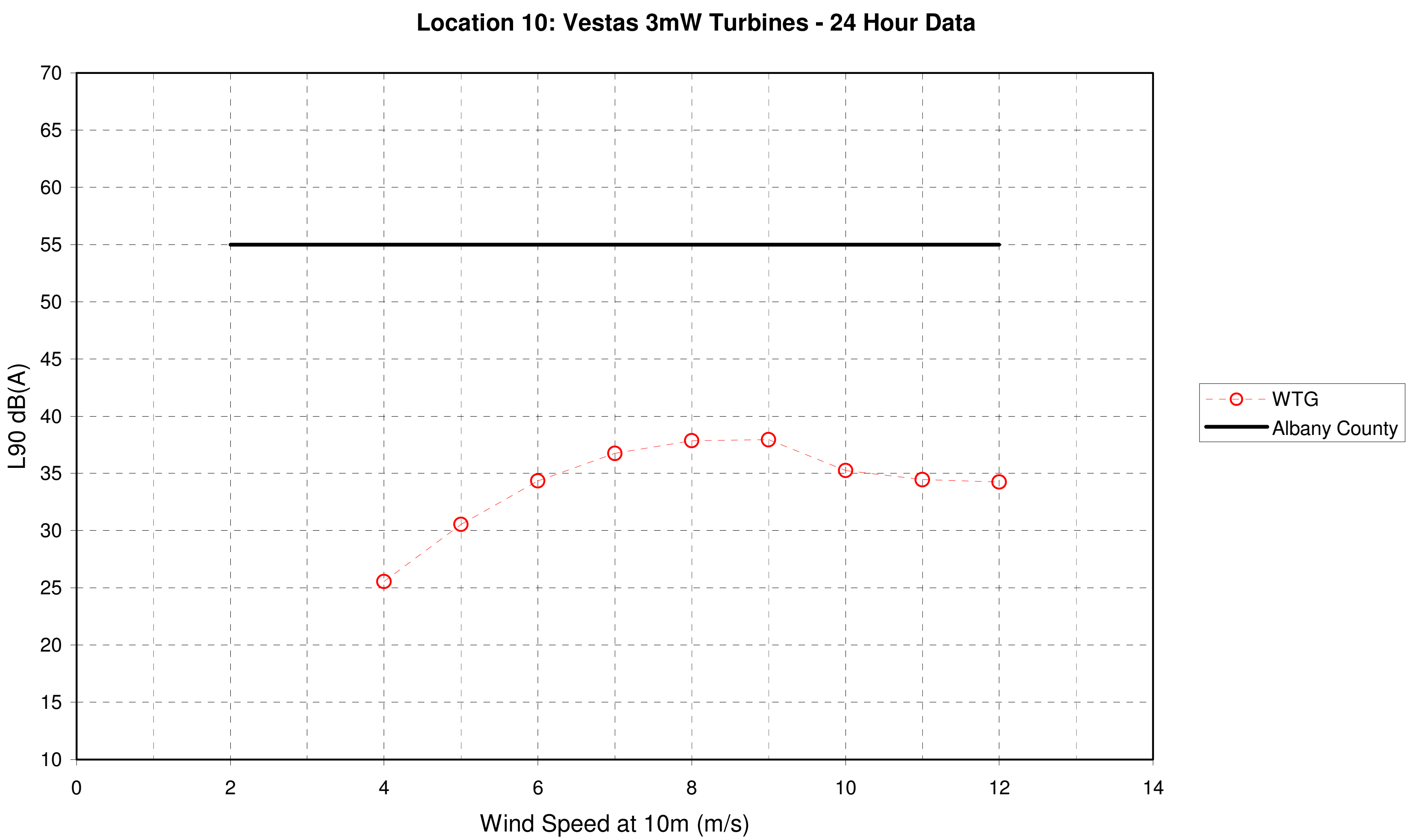
Wind Speed at 10m (m/s)
WTG
Albany County


Location 10: Vestas 3mW Turbines - 24 Hour Data
L90 dB(A)
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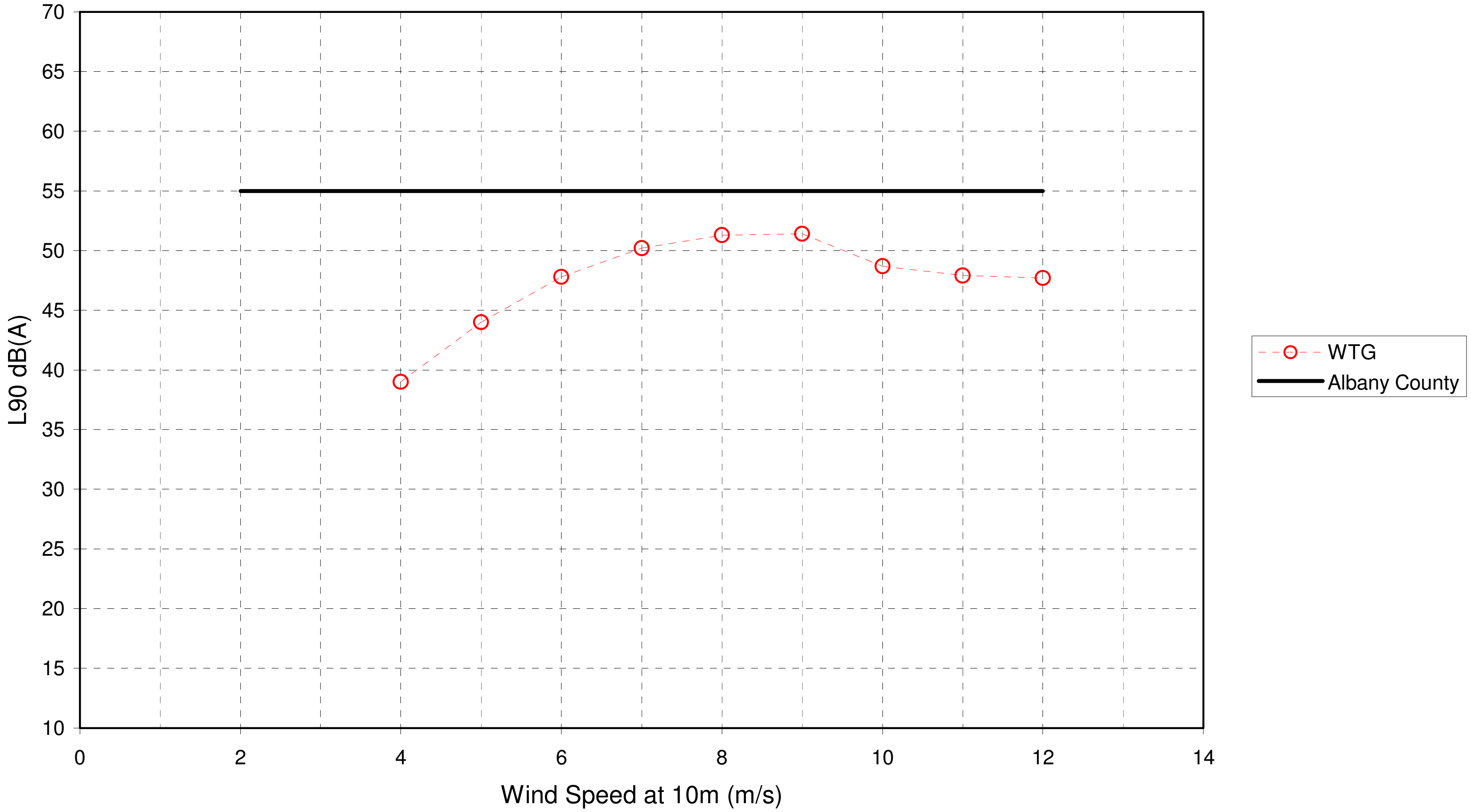
Wind Speed at 10m (m/s)
WTG
Albany County

Location 15: Vestas 3mW Turbines - 24 Hour Data



Predicted Noise Levels at Boundary Locations

Appendix D

March 15, 2012
Project No. 0116974

Environmental Resources Management
15810 Park Ten Place, Suite 300
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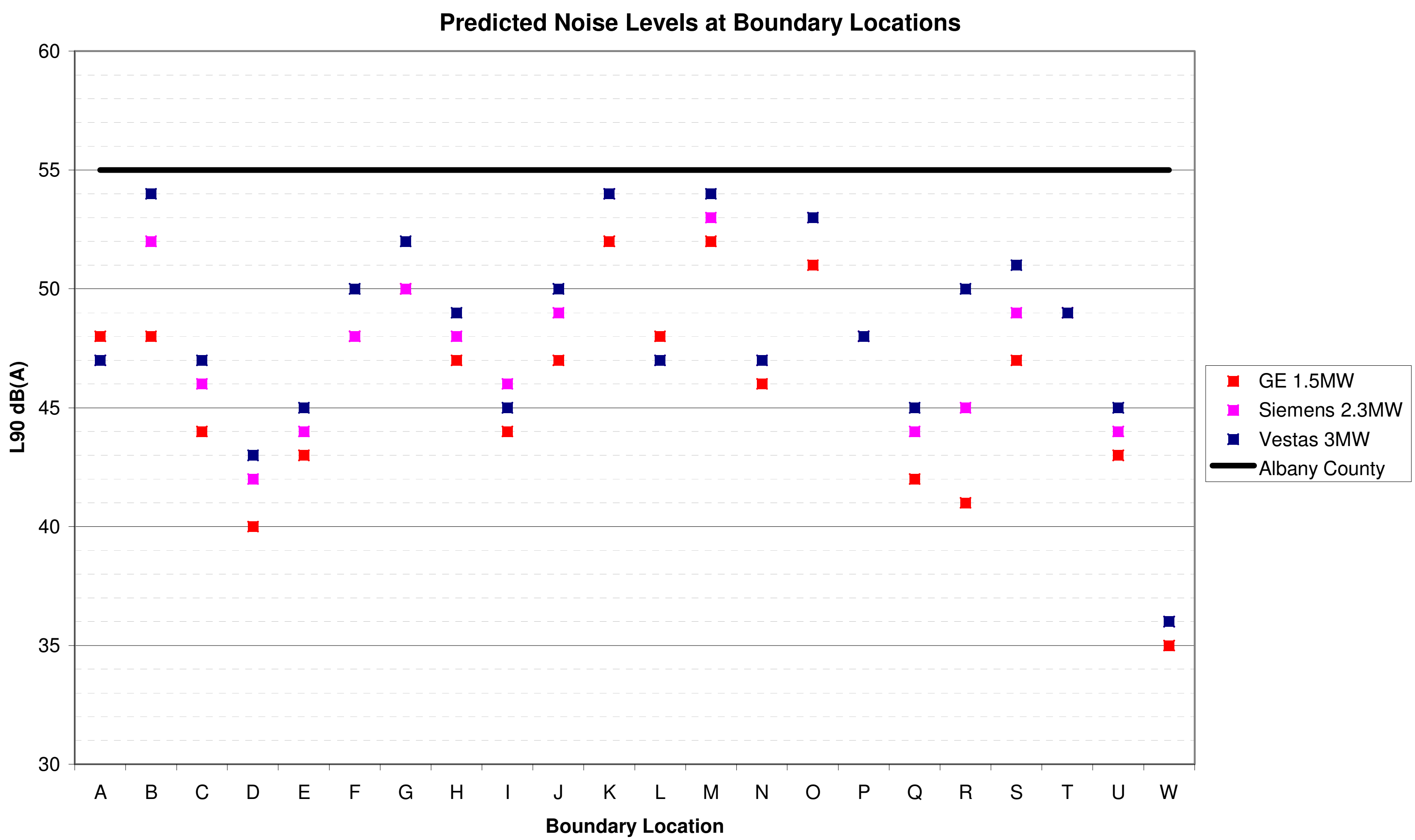
Predicted Noise Levels at Boundary Locations
60
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L90 dB(A)
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Boundary Location
GE 1.5MW
Siemens 2.3MW
Vestas 3MW
Albany County

NOISE ASSESSMENT, JUNE 4, 2010

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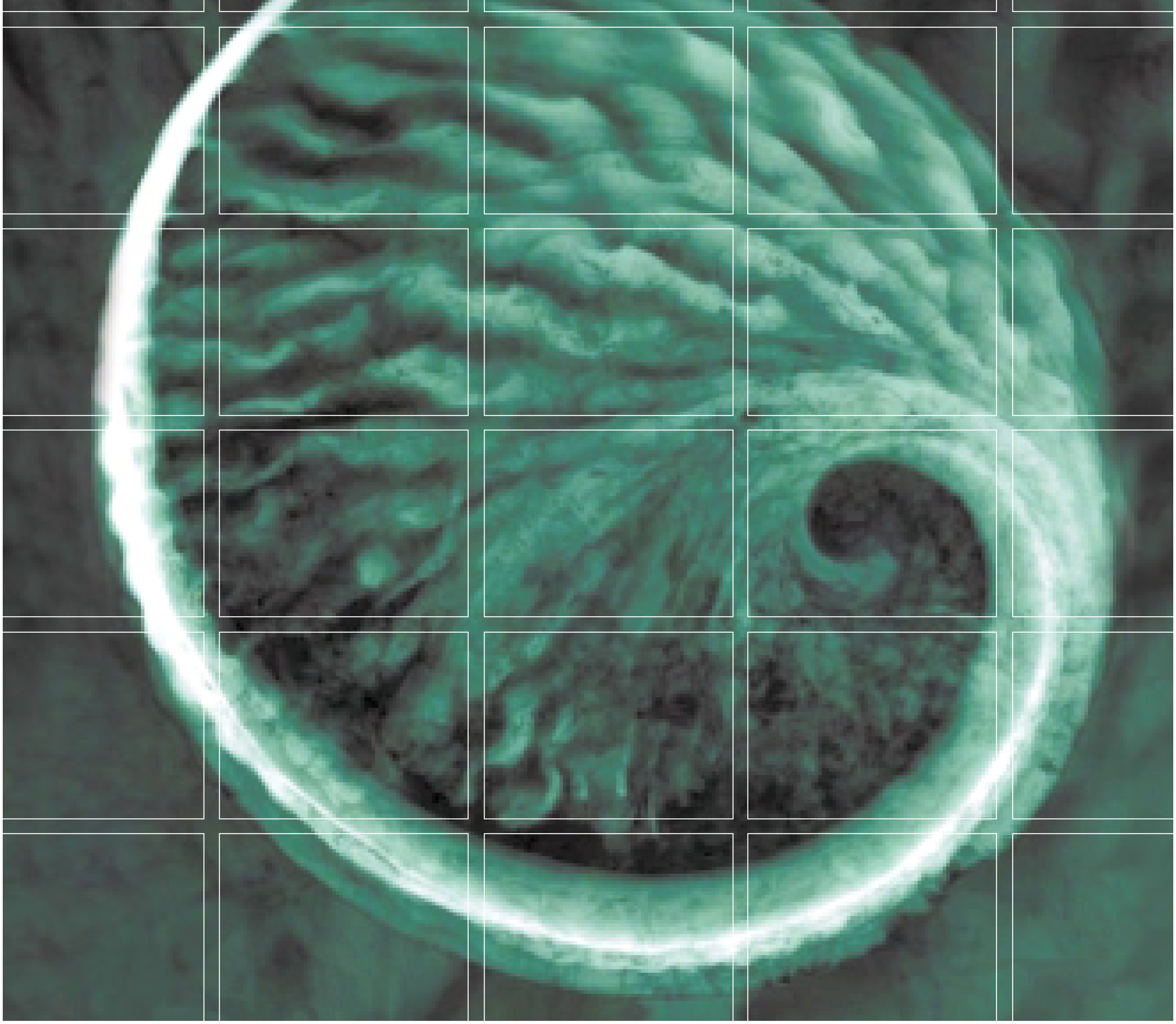

Noise Assessment

Shell WindEnergy
Hermosa West Wind Farm Project, Albany County, Wyoming

June 4, 2010

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Noise Assessment:
Hermosa West Wind Farm Project

June 4, 2010

Project No. 0111210
Albany County, Wyoming

Alicia C. Smith, R.E.M.

Partner-in-Charge

Chris Zeisloft

Project Manager

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Texas Registered Engineering Firm F-2393

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1.0 HERMOSA WEST WIND FARM NOISE ASSESSMENT

1.1 INTRODUCTION

Shell WindEnergy, Inc. (SWE) proposes to construct, operate and maintain the Hermosa West Wind Farm Project (the Project) in southeast Albany County, Wyoming near Tie Siding (Figure 1-1, Site Vicinity Map). Western Area Power Authority (Western) is evaluating under the National Environmental Policy Act (NEPA) the interconnection of the Project, which consists of transmission system upgrades and construction of a new substation (Proposed Action). The Project would consist of a maximum of 200 wind turbines with a total generating capacity of up to 300 megawatts (MW) of electricity. The wind turbines would be arranged in roughly collinear "strings"; each turbine string would be situated within an approximately 250 foot (ft) or 400ft wide corridor, depending on topography. The Project would interconnect with a Western-operated transmission line traversing the Project area.

The Project would also include a wind energy collection system, on-site operation and maintenance (O&M) building, underground collector lines, an Applicant-built transmission line and substation, associated access roads, and off-site upgrades to facilities owned by Western.

At the request of SWE, Environmental Resources Management (ERM) has prepared this Noise Assessment for the Project. The Noise Assessment is intended to provide information on estimated noise impacts of the three selected turbine models on sensitive noise receptors located near the Project area. Noise prediction (screening) calculations have been undertaken at the closest noise sensitive properties to the three proposed scheme layout and wind turbine options. The following options have been considered:

- 147 Siemens SWT 2.3MW wind turbines (normal operation), hub height 80m and total capacity of 338 MW;
- 224 GE 1.5MW wind turbines (normal operation), hub height 80m and total capacity of 336MW; and
- 113 Vestas V90 3MW wind turbines (mode 0), hub height 80m and total capacity of 339MW.

The layouts of each turbine option (and closest noise sensitive properties) are illustrated in Figures 1-2, 1-3 and 1-4.

1.2 PROJECT SETTING

The Project area is located within Albany County, Wyoming. The City of Laramie is located approximately 18 miles northwest of the Project area, while the town of Tie Siding, Wyoming is located to the north-northeast of the Project area. One residence is located within the Project area, while the area surrounding the Project area is sparsely populated with a majority of these homes being located directly west of the Project area along a ridge line. The elevation of the Project area is 7,100 to 7,900 ft and it is characterized by nearly level floodplains and low terraces. According to the National Renewable Energy the average wind speed at 30m within the Project Area is approximately 17 miles per hour (mph). The Project area is located approximately three to four miles west of State Highway 287. This is a highly utilized highway which was widened near the Project in 2009 from two to four lanes. There is also a railroad located approximately two miles to the northeast.

1.2.1 *Baseline Information*

Sources of noise within the Project area include trucks and automobiles, aircraft, railroad, power lines, firearms, animal communications, and wind.

Six noise sensitive properties around the Project participating property boundary have been considered for the screening calculations and are listed in Table 1-1 below.

TABLE 1-1: Closest Noise Sensitive Properties to the Project

Property	Coordinates	Distance to closest turbine (Vestas V90 layout), feet	Distance to closest turbine (Siemens SWT layout), feet	Distance to closest turbine, (GE 1.5 layout), feet
The Buttes	452226, 4558120	36,410	36,320	36,150
Home 4 – Fish Creek	451630, 4543490	3,360	3,210	3,180
Home 3 – Fish Creek	451963, 4543962	2,055	2,045	2,050
Home 2 – Fish Creek	452353, 4541414	8,090	7,610	7,265
Tie Siding	457259, 4547829	6,995	7,190	6,945
Home 1 – Tie Siding	457517, 4546720	5,435	4,790	4,715
Landowner	450567, 4546067	1,500	1,475	1,400
Home 5	450112, 4546288	780	1,350	2,875

Measurements of the prevailing monthly wind speed, direction and wind shear exponent are listed in Table 1-2 below.

TABLE 1-2: Site Wind Measurements

Measurement Period	Mean Wind Speed (m/s) at 57 m height	Mean Wind Shear (57m / 32m)	Prevailing Wind Direction
January 2008	13.21	0.15	West
February 2008	12.81	0.12	West
March 2008	11.28	0.10	West
April 2008	9.98	0.10	West
May 2008	9.06	0.09	North West
June 2008	8.34	0.09	West
July 2008	6.01	0.09	South South East
August 2008	6.60	0.15	South East
September 2008	6.41	0.09	South South East
October 2008	7.43	0.12	West North West
November 2008	14.13	0.17	West
December 2008	13.31	0.16	West

The predominant wind direction, based on 2008 measurements is westerly (7 months out of 12), blowing away from the town of Tie Siding. This could also increase ambient noise levels in the area from the highway.

Wind shear is discussed in Section 3-3 below.

1.2.2 *Acoustics and Glossary of Terms*

The terms 'sound' and 'noise' tend to be used interchangeably, but noise can be defined as unwanted sound. Sound is a normal and desirable part of life. However, when noise is imposed on people it can lead to disturbance, annoyance and other undesirable effects.

Noise is measured and quantified using decibels (dB), and examples of noise levels are shown in Table 1-3.

TABLE 1-3: Examples of Noise Levels on a Decibel Scale

Noise Level, dB(A)	Typical noise source / example
0	"Threshold of hearing" – lowest sound an average person can hear
20	Standard required in a broadcasting or recording studio – just audible
30	Library or soft whisper at 5 feet – this is very quiet
40	Bedroom or living room
50	Conversational speech at 3 feet
60	Busy general office or air conditioning unit at 20 feet
70	Traffic on freeway at 50 feet
80	Pneumatic drill at 50 feet
90	Heavy truck at 50 feet
140	"Threshold of Pain" – maximum tolerable noise level such as very close to a jet engine or similar

The dB(A) scale is a particular way of measuring the different frequencies in sound, designed to match how the human ear perceives sound, called the 'A'-weighting.

The decibel scale is logarithmic, which means that noise levels do not add up or change according to simple linear arithmetic. For example, adding two equal noise sources results in a doubling of sound *energy*, which gives a combined noise level that is 3dB higher than the individual levels.
So, 60 dB + 60 dB = 63 dB (not 120 dB).

However, even though the *energy* levels have doubled, the ear *perceives* only a slight increase in loudness instead of a doubling because human hearing responds to changes in noise logarithmically. This means that a relatively large change in sound *energy* is needed before it is *perceived* to be louder or quieter. For example, it is generally accepted that:

- an increase or decrease of 1dB cannot usually be heard in everyday conditions (although possible in 'laboratory' conditions);
- an increase or decrease of 3dB is generally accepted as the smallest change that is noticeable in ordinary conditions;
- an increase or decrease of 5dB is a clearly perceptible change in noise; and
- an increase or decrease of 10dB is perceived to be a doubling (or halving) of perceived loudness.

To place this into context, to change a noise level by around 3dB there would need to be a doubling or halving of the noise energy; and a change of 10dB would need a ten-fold change in noise energy.

Sound can be distinguished by its content, and Hertz (Hz) is the unit used to describe the tonality or frequency content of sound. The lowest frequency that can be identified as sound by a person with good hearing is 20Hz. Frequencies below this (infrasound) can be detected, but are perceived as a feeling in the body as opposed to an actual sound. At the other end of the scale, the highest frequency that can he heard may be up to 20,000Hz, but this depends on factors such as age, health and previous exposure to noise and an upper range between 16 and 18 kilo hertz (KHz) might be more representative. Sound below 20Hz is referred to as 'infrasound', and sound between 10Hz and 200Hz is often described as 'low frequency noise' (LFN), although there is no a commonly held definition for these terms. Although our hearing can detect sounds throughout this range, it does not ascribe the same importance or weight to sound in each frequency.

For example, if a person was listening to a tone at 1KHz at a fixed level, then a tone at 30Hz would have to be 50dB higher for it to be judged equally as loud, although this varies depending on the reference loudness. To account for our sensitivity to sound over different frequencies, environmental noise sources are often described as 'A'-weighted decibels, denoted as dB(A). This A-weighting is an internationally agreed standard that reflects the frequency sensitivity of the ear.

Since noise also often varies over time, statistical parameters (or metrics) are used to measure, and describe noise. Two common noise metrics used for environmental noise measurement are the L_{Aeq} and L_{A90}.

The $L_{Aeq, T}$ metric is called the 'continuous equivalent sound level'. It represents a varying noise level by calculating the constant sound level that would have the same sound energy content over the measurement period. The letter 'A' denotes that 'A'-weighting has been used and the 'eq' indicates that an equivalent level has been calculated. So '$L_{Aeq,T}$' is the A-weighted continuous sound level, measured over period 'T'. L_{Aeq} is a logarithmic average noise level over a period (instead of an arithmetic average) which gives a high weighting to high noise levels even if they are relatively short lived or infrequent events.

The $L_{A90, T}$ metric is a percentile noise level in dB(A). This represents the value exceeded for 90% of the time period (T) being considered. Note that it is higher than the minimum noise level but may be regarded as the typical noise level during 'quiet periods'.

1.3 NOISE PREDICTION MODEL

Wind Turbine Generated (WTG) noise predictions were carried out under down wind propagation conditions. The predictions were performed using the calculation methodology set out in ISO 9613[1] *Acoustics - Attenuation of Sound During Propagation Outdoors. Part 2: General Method of Calculation*. The sound power levels used as a basis of the assessment are also measured under down wind conditions.

In undertaking predictions of noise levels from wind farms the following factors can be considered:

- the decrease in noise with distance;
- the absorption of noise in air;
- the attenuation of noise over acoustically 'soft' ground;
- screening of the turbines by topography and other obstacles; and
- meteorological conditions.

The calculation inputs (wind turbine sound sources in sound power level octave bands) were entered into the model as X, Y and Z coordinates (representing northing, easting, and elevation). Additionally included in the calculation is the hub height of each type of turbine. Once these are fixed, noise levels from all turbines were calculated at each property (input as X, Y, and Z) and the combined turbine noise level reported for at 10 meters (33 feet). This method allows for verifying consistency with the noise source data that is always presented at a derived 10 meter height.

In predicting operational noise from the Project area, air absorption and distance attenuation were accounted for using the method described in ISO 9613 assuming 10°C and 70% humidity. No acoustic screening of the turbines is expected. In this approach, no corrections have been applied for ground roughness or for intervening barriers (for example topography) to provide for a reasonable worst-case assessment. Additionally, no attenuation from ground absorption has been assumed in the model to present a conservative assumption. Spectral data in the form of octave band sound power levels for each type of turbine was taken into account, and then added to provide the LAeq and LA90 noise levels

1 ISO 9613-2 'Acoustics - Attenuation of Sound During Propagation Outdoors. Part 2: General Method of Calculation'. ISO, 1996.

2.0 NOISE PREDICTIONS

2.1 WIND TURBINE NOISE SOURCE TERMS

Three types of wind turbines and layouts have been considered as discussed in Section 1.1 above.

Noise emissions of each turbine have been reported in independent tests undertaken in accordance with IEC 61400-11[(2)] and used as the basis of the operational noise assessments.

Results have been reported as A-weighted octave band sound power levels for a wind speed of 10 m/s (22 mph), corrected to a height of 10 meters (33 feet) in Table 2-1, and as the A-weighted sound power level at wind speeds of 4 to 10 m/s in Table 2-2.

This is based on the following operating modes:

- Vestas V90 operating in mode 0, with the highest noise emission levels;
- Siemens SWT operating at normal operation as opposed to noise restricted operation; and
- GE 1.5 operating at normal operation as opposed to noise restricted operation.

Table 2-1 presents the octave band sound power levels, which are an inherent property of the turbine. This is the data that is ultimately used to predict the LAeq and LA90. Table 2-2 presents the octave band broadband levels at varying wind speed and used to predict wind turbine noise at different wind speeds. These are the figures provided by the manufacturer and a 0.1 dB difference is not significant.

TABLE 2-1: Octave Band Sound Power Levels (dB) for the Vestas V90 3 MW, Siemens SWT 2.3MW and GE 1.5MW Wind Turbines (hub height 80m/262 feet, corrected to 10m/33 feet) in Accordance with IEC 61400-11

Frequency Hz	63	125	250	500	1000	2000	4000	8000	dB(A)
Vestas V90	93.5	96.9	102.0	104.0	104.0	99.7	93.7	80.7	109.3
Siemens SWT	86.3	95.3	102.0	102.6	99.0	95.0	90.2	85.4	107.0
GE 1.5	85.1	94.0	97.2	98.6	97.9	94.5	87.3	78.1	104.0

TABLE 2-2: Wind Turbine Noise Levels (dB) for the Vestas V90 3MW, Siemens SWT 2.3MW and GE 1.3 MW Turbines (hub height 80m/262 feet, corrected to 10m/33 feet) at Increasing Wind Speeds

Wind Speed (m/s) at 10m (mph in brackets)	Sound Power Level (L_{WA}) for Vestas V90, dB	Sound Power Level (L_{WA}) for Siemens SWT, dB	Sound Power Level (L_{WA}) for GE 1.5, dB [(1)]
4 (9)	97.0	-	98.0
5 (11)	105.0	-	101.1
6 (13)	105.8	105.0	105.0
7 (16)	108.2	107.0	106.0

(2) IEC 61400-11 "Wind turbine generator systems - Part 11: Acoustic noise measurement techniques", IEC, 2002.

Wind Speed (m/s) at 10m (mph in brackets)	Sound Power Level (L_{WA}) for Vestas V90, dB	Sound Power Level (L_{WA}) for Siemens SWT, dB	Sound Power Level (L_{WA}) for GE 1.5, dB (1)
8 (18)	109.3	107.0	-
9 (20)	109.4	107.0	-
10 (22)	106.7	107.0	-
11 (25)	105.9	-	-
12 (27)	105.7	-	-

(1) This includes a +2 dB uncertainty correction reported in the test report for this turbine

The location and elevations of the turbines layouts used in this analysis are illustrated in Figures 1-2, 1-3, and 1-4. The results of the assessment are presented in Table 2-3, Table 2-4 and, Table 2-5 below. All results presented in the report assume cumulative noise from all turbines for each layout and turbine combination at the identified properties. Refer to Section 1.2.2 for definition of acoustic terminology.

The "average" LAeq shown in the third column in Tables 2-3 to 2-5 is calculated from the data given in Table 2-1 for each turbine type. The predicted LAeq noise levels, over a range of wind speed, are derived from the data presented in Table 2-2. Tables 2-3 through 2-5 present the overall noise levels predicted for each noise receptor based on the turbine type and layout. The variation in noise levels in Tables 2-3 through 2-5 are different because of two factors:

- the layout given for each turbine type (GE 1.5 based on 224 turbines; Siemens 2.3 based on 147 turbines and Vestas V90 3.0 based on 113 turbines); and
- the source noise levels of each turbine (Tables 2-1 and 2-2).

Predicted noise levels show that the GE 1.5MW turbine will have the lowest noise levels, followed by the Siemens 2.3MW turbine and the Vestas V90 3MW turbine. However, all turbine types / configurations meet the 55 dB Albany County Standard. Based on these data, SWE would not be confined to one particular turbine type of the three evaluated and can use whichever of the three turbine types (and layouts) that best meet their needs.

TABLE 2-3: Predicted WTG Noise from the Vestas V90 3 MW (mode 0) at the Closest Noise Sensitive Properties

Noise Receptor	Predicted WTG Noise		Distance to Closest Turbine (feet)	Closest Turbine	Predicted WTG Noise by wind speed (m/s) (and mph in brackets)								
	L_{A90}, dB	L_{Aeq}, dB			4 (9)	5 (11)	6 (13)	7 (16)	8 (18)	9 (20)	10 (22)	11 (25)	12 (27)
The Buttes	23	25	36,410	T55	32	15	19	21	23	23	20	19	19
Home 4 – Fish Creek	44	46	3,360	T79	32	37	40	43	44	44	41	41	40
Home 3 – Fish Creek	48	50	2,055	T79	35	40	44	47	48	48	45	44	44
Home 2 – Fish Creek	40	42	8,090	T79	28	33	37	39	40	40	38	37	37
Tie Siding	40	42	6,995	T102	27	32	36	39	40	40	37	36	36
Home 1 – Tie Siding	42	44	5,435	T91	30	35	39	41	42	42	39	39	38
Landowner	51	53	1,500	T95	38	43	47	49	51	51	48	47	47
Home 5	52	54	780	T44	40	45	49	51	52	52	50	49	49

TABLE 2-4: Predicted WTG Noise from the Siemens SWT 2.3MW (normal operation) at the Closest Noise Sensitive Properties

Noise Receptor	Predicted WTG Noise		Distance to Closest Turbine (m)	Closest Turbine	Predicted WTG Noise by wind speed (m/s) (and mph in brackets)				
	L_{A90}, dB	L_{Aeq}, dB			6 (13)	7 (16)	8 (18)	9 (20)	10 (22)
The Buttes	21	23	36,320	T147	19	21	21	21	21
Home 4 – Fish Creek	44	46	3,210	T30	42	44	44	44	44
Home 3 – Fish Creek	47	49	2,045	T33	45	47	47	47	47
Home 2 – Fish Creek	40	42	7,610	T30	38	40	40	40	40
Tie Siding	39	41	7,190	T60	37	39	39	39	39
Home 1 – Tie Siding	42	44	4,790	T49	40	42	42	42	42
Landowner	49	51	1,475	T57	47	49	49	49	49
Home 5	47	49	1,350	T146	45	47	47	47	47

TABLE 2-5: Predicted WTG Noise from the GE 1.5MW (normal operation) at the Closest Noise Sensitive Properties

Noise Receptor	Predicted WTG Noise		Distance to Closest Turbine (m)	Closest Turbine	Predicted WTG Noise by wind speed (m/s) (and mph in brackets)				
	L_{A90}, dB	L_{Aeq}, dB			6 (13)	7 (16)	8 (18)	9 (20)	10 (22)
The Buttes	20	22	36,150	T116	15	15	18	22	23
Home 4 – Fish Creek	42	44	3,180	T44	36	36	40	43	44
Home 3 – Fish Creek	46	48	2,050	T47	40	40	43	47	48
Home 2 – Fish Creek	39	41	7,265	T164	33	33	36	40	41
Tie Siding	38	40	6,945	T92	32	32	35	39	40
Home 1 – Tie Siding	38	40	4,715	T73	32	32	35	39	40
Landowner	48	50	1,400	T85	42	42	45	49	50
Home 5	43	45	2,875	T89	37	37	40	44	45

3.0 NOISE FROM WIND TURBINES, LOW FREQUENCY NOISE, INFRASOUND AND HEALTH EFFECTS

3.1 INTRODUCTION

Although wind turbines are generally considered to be quiet, concerns have been expressed about low frequency noise and infrasound causing health effects and distress to neighbors. There have been many notable studies published on these topics, some with conflicting viewpoints.

In December 2009, an expert panel was assembled by the American Wind Energy Association (AWEA) and Canadian Wind Energy Association (CanWEA) to 'provide an authoritative reference document for legislators, regulators, and anyone who wants to make sense of the conflicting information about wind turbine sound'[(3)].

To avoid bias and conflict of interest, the expert panel selected consisted of independent experts in acoustics, audiology, medicine, and public health with a remit to address health concerns associated with wind turbine noise. The findings of the AWEA and CanWEA report are discussed here, however for the interested reader the full report can be found at:

http://www.awea.org/newsroom/releases/12-15-09-sound_panel_release.html

3.2 SOURCES OF NOISE

Wind turbine noise originates from mechanical sound (the gearbox and control mechanisms) and aerodynamic sound (produced by the rotation of the turbine blade through the air).

Aerodynamic noise is the dominant source and will be present over all frequencies, including the infrasound range (i.e. below 20Hz), but is generally within the mid frequency range (approximately 500Hz to 1KHz).

Noise within this range will rise and fall as the turbine blade rotates and this change or 'modulation' is described as 'amplitude modulation' which can be perceived by a listener as a fluctuation in sound occurring approximately every second. It has been suggested that under certain conditions such as wind shear (see below), this fluctuation can be heard some distance away, and because it is a noise that frequently changes, it is more noticeable for the listener.

3.3 WEATHER EFFECTS AND WIND SHEAR

Meteorological factors can affect the propagation of sound from wind turbines. For example, warm air at ground level would cause noise from the turbine to curve upwards which would reduce noise levels; whilst warm air during temperature inversions may cause noise from the turbine to curve downwards,

(3) 'Wind Turbine Sound and Health Effects. An Expert Panel Review'. AWEA and CanWEA, December 2009

resulting in increased noise levels. Wind direction can also affect the level of turbine noise at a property (i.e. blowing towards or away from the property).

Wind shear is a measure of how much wind speed increases with height. Under certain circumstances such as very stable atmospheric conditions, which may occur at night, wind speed at the turbine hub height may be substantially increased over that which is expected. This means that masking of wind turbine noise at a property by the wind does not always occur. For example, the wind at turbine height may be sufficient to power the turbine (and generate noise), yet the wind speed at a property may be negligible and no masking of wind turbine noise will take place leading to higher source noise levels.

There is general agreement that wind turbine noise assessments are undertaken at a reference height of 10m (33 feet) based on the fact that the method(4) used by wind turbine manufacturers to measure noise levels from wind turbines (in turn used to calculated wind turbine noise at properties) are also corrected to a reference height of 10 meters. For the purpose of the modeling described herein, a wind shear correction is applied in converting the hub height noise level to this reference height. Site specific wind shear correction takes into account the different time periods in the day which may vary significantly between early morning, evening and night (data was available from meteorological data collected at the site). A mathematical correction for wind shear is applied to account for this.

Noise models err on the side of caution and present a reasonable worst-case noise assessment, calculating noise downwind and applying a ground roughness factor to account for wind shear effects.

Wind shear measurements reported in Table 1-2 are typical of smooth, level, grass covered terrain. The results of this indicate that the predicted noise levels will not be significantly affected by wind shear; although such weather conditions *could* occur from time to time.

3.4 *INFRASOUND, LOW FREQUENCY NOISE AND ANNOYANCE*

The infrasound from wind turbines is at a level of 50 to 70dB, sometimes higher, but well below the audible threshold of hearing which ranges between 79dB at 20Hz and 107dB at 4Hz. Infrasound from natural sources such as the wind also surrounds us and is also below the threshold of audibility.

Some people attribute health effects to wind turbine noise exposure. When amplitude modulation occurs, this can provoke complaint and may be labeled as 'low frequency noise' or 'infrasound' by some, although this 'swishing' noise is in fact in the 500Hz to 1KHz range. It is this fluctuating noise (i.e. amplitude modulation) which only occurs under certain conditions that cause most

(4) IEC 61400-11 'Wind Turbine Generator Systems Part 11: Acoustic Noise Measurement Techniques'.

complaints due to the more disturbing nature of a fluctuating noise compared to a non-fluctuating noise such as free-flowing traffic.

The AWEA and CanWEA report refers to a UK study (5) that concluded that out of 130 wind farms, only 4 had a problem with amplitude modulation, and 3 of these had been resolved. Furthermore, this amplitude modulation when observed beneath a turbine does not always occur at greater separation distances.

Comprehensive research (6) on low frequency noise has been repeatedly shown by measurements of wind turbine noise undertaken in the USA, UK, Denmark and Germany over the past decade that the levels of infrasonic noise and vibration radiated from modern, wind turbines are at a very low level; so low that they lie below the threshold of perception, even for those people who are particularly sensitive to such noise, and even on an actual wind turbine site.

Claims of health effects from wind turbines are addressed within the AWEA and CanWEA report, in particular, the claim of 'wind turbine syndrome' promoted by Pierpont (7) based on the following assertions:

- low levels of airborne infrasound from wind turbines (1 – 2Hz) affect the vestibular system (this is the system that governs our balance and sense of orientation); and
- low levels of airborne infrasound from wind turbines at the 4 – 8Hz range enter the lungs and vibrate the diaphragm which in turn transmits vibration through other organs in the body.

Pierpont claims this combined effect causes a range of symptoms termed wind turbine syndrome.

The AWEA and CanWEA report, in response to these assertions states:

There is no credible scientific evidence that low levels of wind turbine sound at 1 to 2Hz will directly affect the vestibular system. In fact, it is likely that the sound will be lost in the natural infrasonic background sound of the body. The second hypothesis is equally unsupported with appropriate scientific investigations. The body is a noisy system at low frequencies. In addition to the beating heart at a frequency of 1 to 2Hz, the body emits sounds from blood circulation, bowels, stomach, muscle contraction, and other internal sources. Body sounds can be detected externally to the body by the stethoscope.

(5) 'Research into Aerodynamic Modulation of Wind Turbine Noise' (2007). www.berr.gov.uk/files/file40570.pdf
(6) "A Review of Published Research on Low Frequency Noise and its Effects" Report for DEFRA by Dr Geoff Leventhall Assisted by Dr Peter Pelmear and Dr Stephen Benton. May 2003
(7) Pierpont, N 2009, pre publication draft 'Wind Turbine Syndrome: a report on a natural experiment'. http://www.windturbinesyndrome.com

The report goes on to say:

"Wind turbine syndrome" is not a recognized medical diagnosis, is essentially reflective symptoms associated with noise annoyance and is an unnecessary and confusing addition to the vocabulary on noise. This syndrome is not a recognized diagnosis in the medical community. There are no unique symptoms or combinations of symptoms that would lead to a specific pattern of this hypothesized disorder. The collective symptoms in some people exposed to wind turbines are more likely associated with annoyance to low sound levels.

Furthermore, the evidence presented by Pierpont to support the hypothesis of wind turbine syndrome is based a single case series from a group of self-nominated individuals and from a single investigator. This has limited credibility in terms of scientific peer review.

In summary, following a review of available literature, the Expert Panel assembled by the AWEA and CanWEA concluded the following.

1. Sound from wind turbines does not pose a risk of hearing loss or any other adverse health effect in humans.
2. Sub-audible, low frequency sound and infrasound from wind turbines do not present a risk to human health.
3. Some people may be annoyed at the presence of sound from wind turbines, but annoyance is not a pathological entity.
4. A major cause of concern about wind turbine sound is its fluctuating nature. Some may find this sound annoying, a reaction that depends on personal characteristics as opposed to the intensity of the sound level.

3.5 VIBRATION

A comprehensive study of vibration measurements in the vicinity of a modern wind farm undertaken in 1997 (8) found that vibration levels 100 m from the nearest turbine were a factor of 10 less than those recommended for human exposure in sensitive buildings, such as hospitals or laboratories housing precision measurement instruments.

(8) ETSU W/13/00392/REP 'Low frequency noise and vibrations measurement at a modern wind far'. Department of Trade and Industry, 1997.

4.0 RESULTS

The Proposed Action includes construction/decommissioning related noises, as well as operation of a substation. Construction equipment associated with Projects such as this one typically generate noise levels ranging from approximately 75 to 90 dB(A) at 50 feet, depending on the equipment being used (U.S. Department of Transportation 2006: United States Department of Transportation. August 2006. FHWA Highway Construction Noise Handbook). Construction of the Proposed Action would cause temporary increases in ambient noise levels in the immediate vicinity of the construction sites. On-site construction noise would occur mainly from heavy-duty construction equipment (e.g., trucks, backhoes, excavators, loaders, and cranes). As a result, construction-generated noise would be considered a less-than-significant short-term impact.

The Wyoming Department of Transportation (WYDOT) completed noise studies along State Highway 287 as part of an Environmental Assessment (EA) for the expansion of State Highway 287 which was completed in 2009[9]. Prior to the expansion of State Highway 287, WYDOT determined that the existing noise conditions at Tie Siding were between 54.8 and 63.3 dB(A) and these were attributed to wind effects and not traffic noise emanating from State Highway 287. Based on noise modeling, the post highway expansion noise conditions at Tie Siding were estimated to be between 56.7 and 70.0 dB(A). The EA determined that the expansion would only have a minor noise impact to one receptor (a single family home) and no mitigation measures were required. Additionally, the EA determined that noise impacts from construction activities would be temporary and minimal.

Substations typically produce between 60 and 70 L_{A90}, dB during operations. The proposed substation location is over 3,000 feet from the participating owner's property line. Noise dissipates at approximately 6 dB(A) per doubling of distance based on a point source (and not taking account of additional mitigation from air and ground absorption which will be quite significant at distances greater than approximately 300 feet), and impacts would be considered less than significant.

In addition to the impacts discussed above, the Project would include wind turbine generated noise. The Albany County standard for noise is as follows.

Noise associated with wind energy operation shall not exceed fifty-five (55) dB(A) as measured at any point along the common property lines between a non-participating property and a participating property.

a. This level may be exceeded during short-term events such as utility outages, severe weather events, and construction or maintenance operations.

[9] WYDOT. 2007. WYDOT Project No. 0N23-02 (045, 048, 049, 050, 051) US 287, Laramie, Wyoming to the Colorado State Line. U.S. Department of Transportation Federal Highway Administration and WYDOT. 2007.

b. This standard shall not apply along any portion of the common property line where the participating property abuts state or federal property.

c. Noise levels may exceed the fifty-five (55) dB(A) limit along common property lines if written permission, as recorded with the Albany County Clerk, is granted by the affected adjacent non-participating property owners.

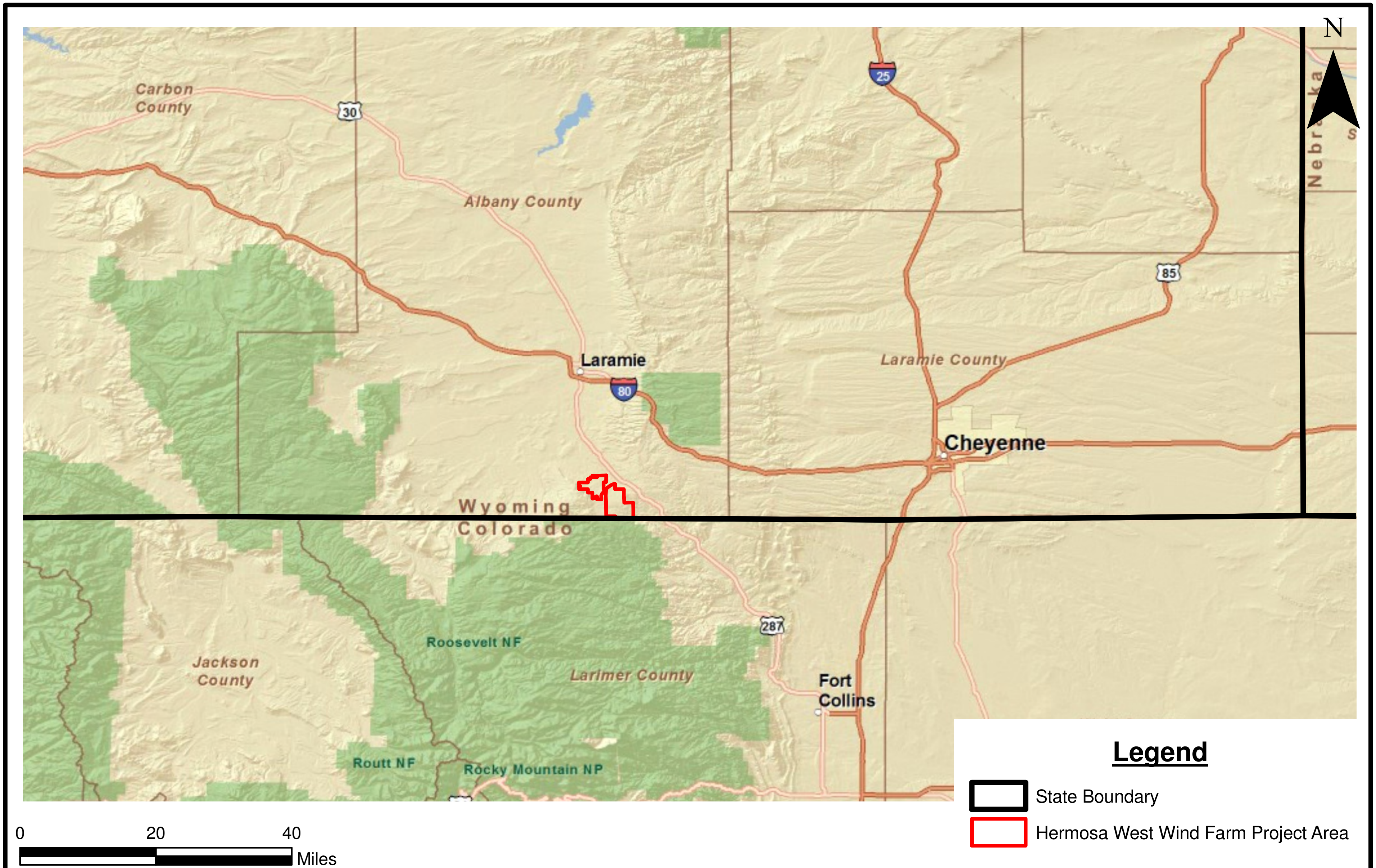
Based on the assessment performed, noise levels would not be expected to exceed fifty-five (55) dB(A) as measured at any point along the common property lines between a non-participating property and a participating property. During high wind events in excess of 10 m/s wind generated noise is likely to be masked from wind noise.

Other factors such as the existing ambient noise levels (especially from the nearby highway) and wind direction will also affect the perception of wind turbine noise at local properties.

Figures

June 4, 2010
Project No. 0111210

Environmental Resources Management Southwest, Inc.
15810 Park Ten Place, Suite 300
Houston, Texas 77084-5140
(281) 600-1000



Environmental Resources Management

DESIGN:	E Johnson	DRAWN:	S King	CHKD.:	A Smith
DATE:	10/02/2009	SCALE:	AS SHOWN	REVISION:	0
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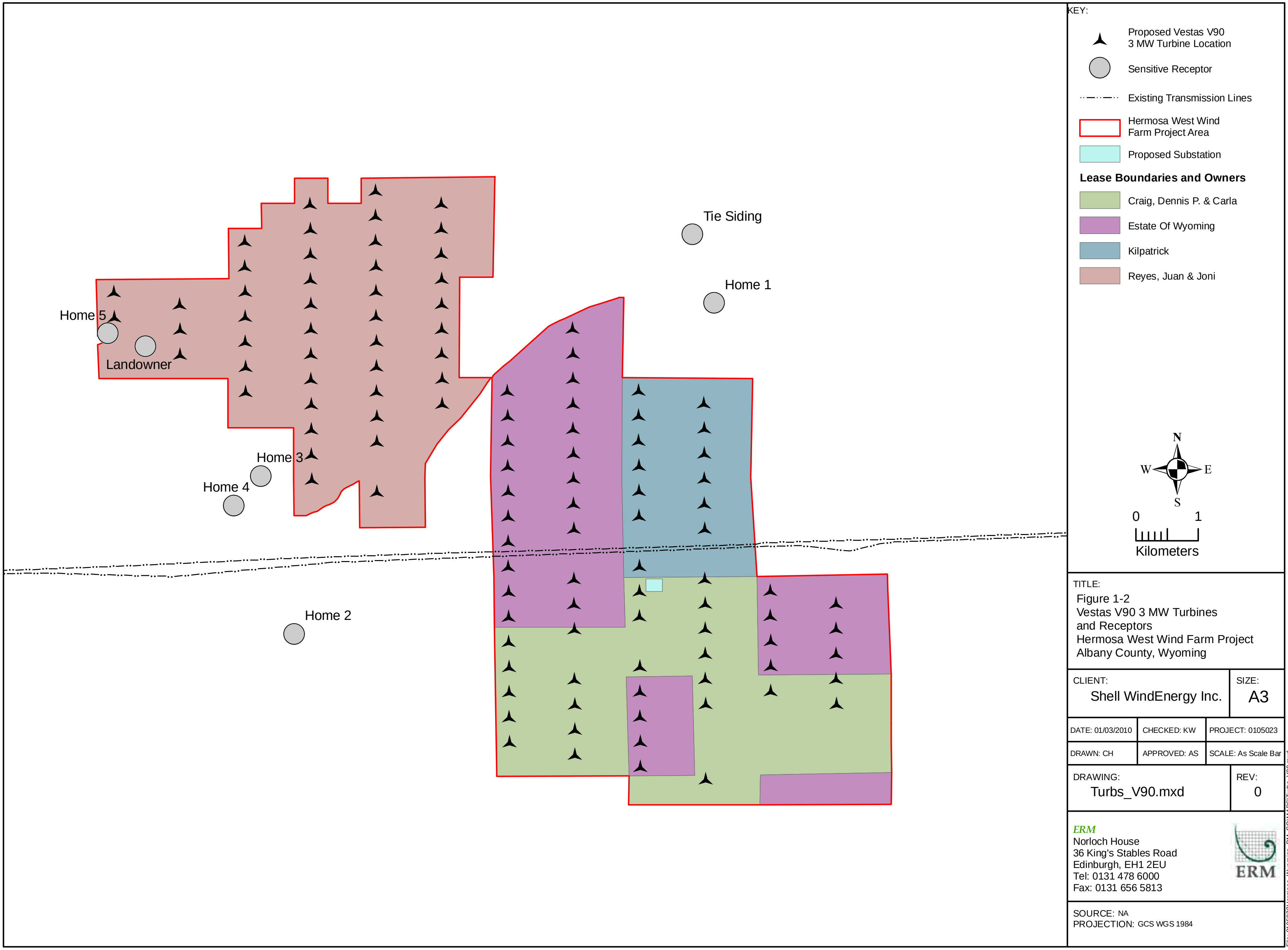
FIGURE 1-1
VICINITY MAP
Shell Wind Energy
Hermosa West Wind Farm Project

ERM



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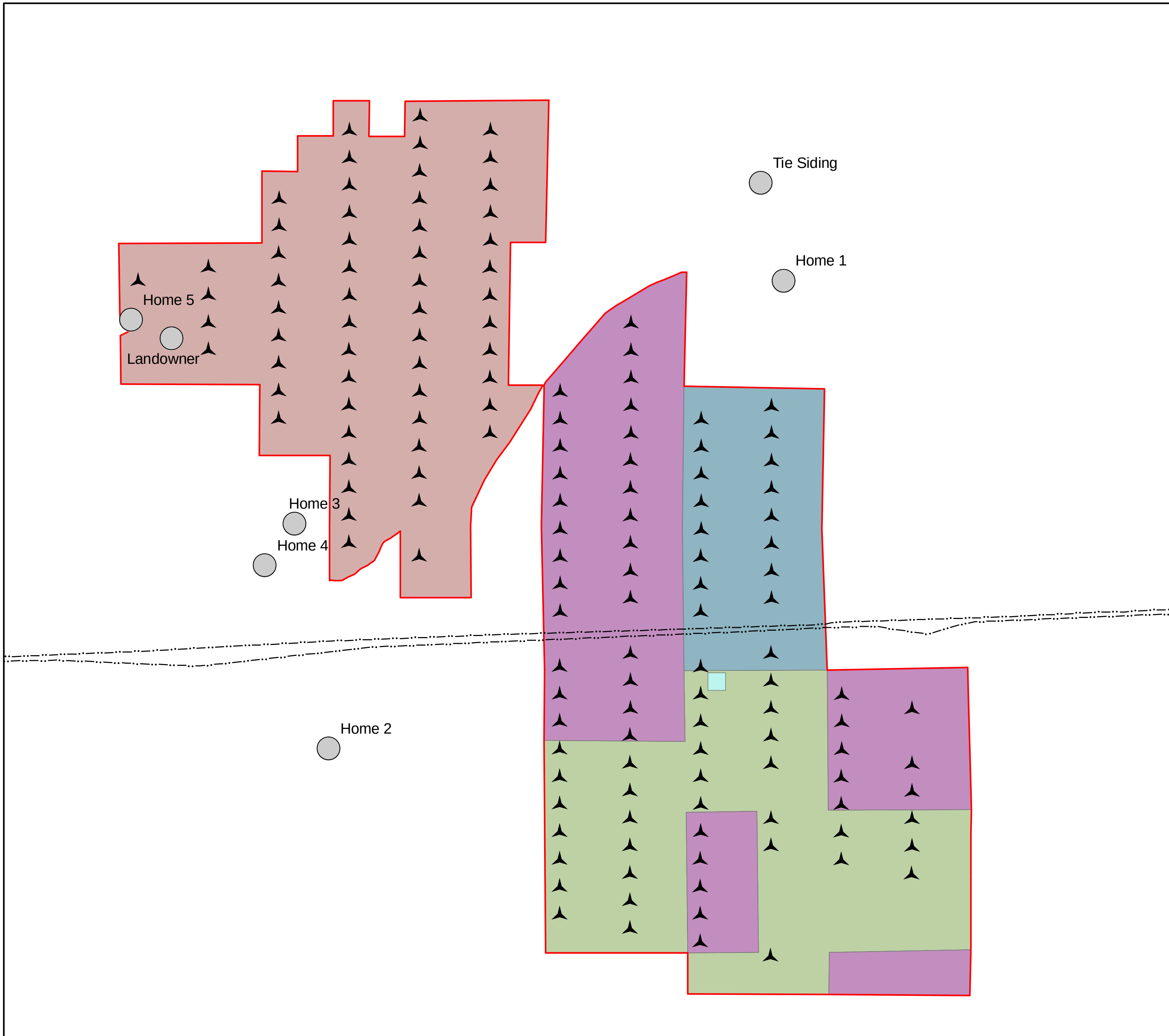
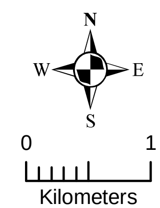


KEY:

- Proposed Siemens SWT 2.3 MW Turbine Location
- Sensitive Receptor
- Existing Transmission Lines
- Hermosa West Wind Farm Project Area
- Proposed Substation

Lease Boundaries and Owners

- Craig, Dennis P. & Carla
- Estate Of Wyoming
- Kilpatrick
- Reyes, Juan & Joni



TITLE:
Figure 1-3
Siemens SWT 2.3 MW Turbines and Receptors
Hermosa West Wind Farm Project
Albany County, Wyoming

CLIENT: Shell WindEnergy Inc.	SIZE: A3

DATE: 29/12/2009	CHECKED: KW	PROJECT: 0105023
DRAWN: CH	APPROVED: AS	SCALE: As Scale Bar

DRAWING: Turbs_SWT.mxd	REV: 0

ERM
Norloch House
36 King's Stables Road
Edinburgh, EH1 2EU
Tel: 0131 478 6000
Fax: 0131 656 5813

SOURCE: NA
PROJECTION: WGS 1984 UTM Zone 13N

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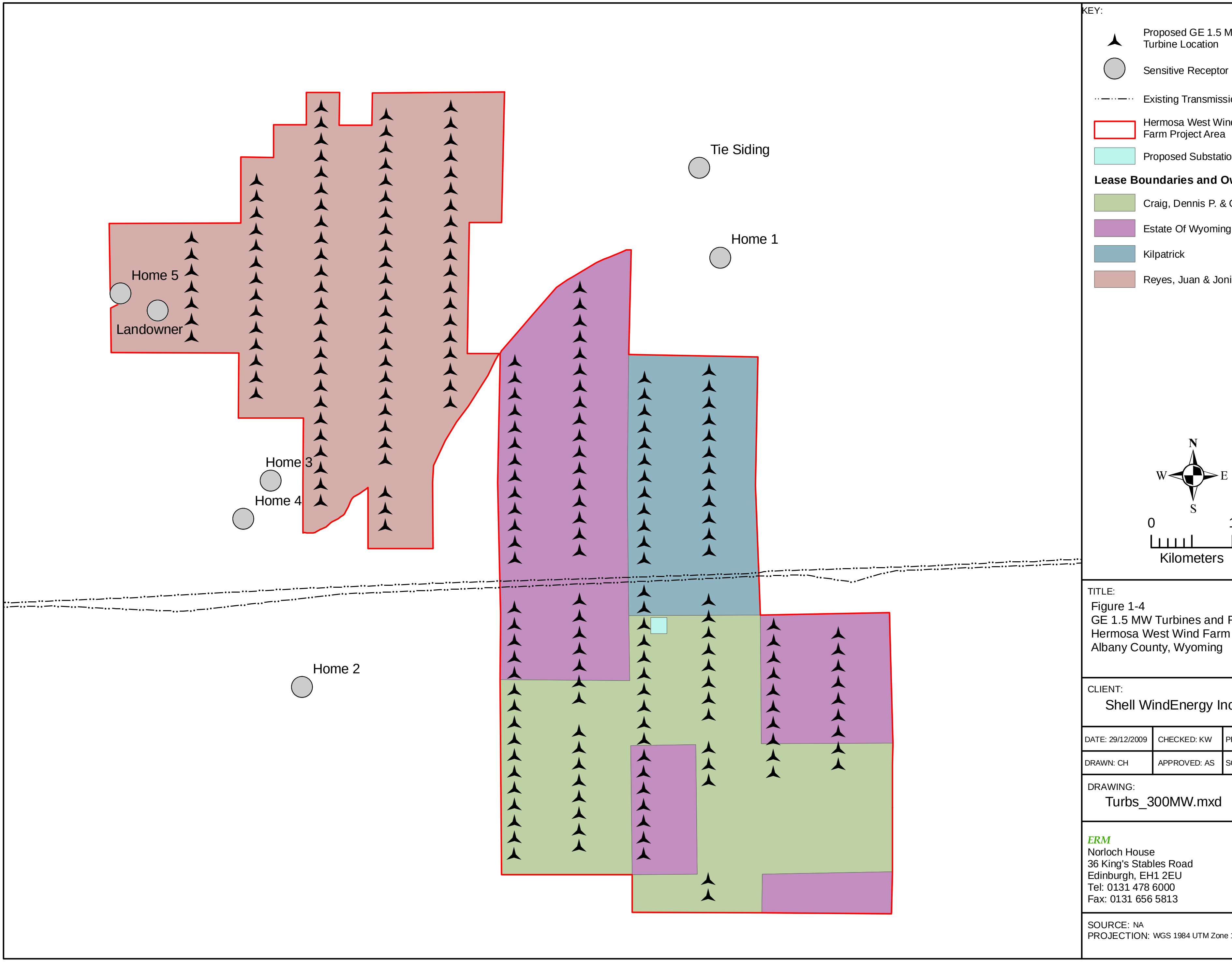
g:\2010\0111210\14661H(figs).pdf



KEY:

- Proposed GE 1.5 MW Turbine Location
- Sensitive Receptor
- Existing Transmission Lines
- Hermosa West Wind Farm Project Area
- Proposed Substation

Lease Boundaries and Owners

- Craig, Dennis P. & Carla
- Estate Of Wyoming
- Kilpatrick
- Reyes, Juan & Joni

TITLE:
Figure 1-4
GE 1.5 MW Turbines and Receptors
Hermosa West Wind Farm Project
Albany County, Wyoming

CLIENT: Shell WindEnergy Inc.		SIZE: A3
DATE: 29/12/2009	CHECKED: KW	PROJECT: 0105023
DRAWN: CH	APPROVED: AS	SCALE: As Scale Bar
DRAWING: Turbs_300MW.mxd		REV: 0

ERM
Norloch House
36 King's Stables Road
Edinburgh, EH1 2EU
Tel: 0131 478 6000
Fax: 0131 656 5813

SOURCE: NA
PROJECTION: WGS 1984 UTM Zone 13N

File: 0105023Hermosa_Wyoming_PM_CO\MAPS\Turbs_300MW.mxd

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