DNV KEMA ENERGY & SUSTAINABILITY

Wind Resource and Feasibility Assessment Report for the Lummi Reservation

CONFIDENTIAL

Prepared for:

Lummi Indian Business Council

2616 Kwina Road
Bellingham, WA 98226

DNV KEMA Report No.: CSRP0092-A
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Summary:

The overall goal of the Lummi Indian Reservation Wind Energy Development Feasibility Assessment Project (Project), funded through a grant from the U.S. Department of Energy (DOE), is to determine if and at what cost wind energy development can help achieve the tribal goal of energy self-sufficiency. To assist with making this determination, the governing body of Lummi Nation, the Lummi Indian Business Council (LIBC), retained DNV KEMA to assess the wind energy development feasibility on the Lummi Indian Reservation (the Reservation). The LIBC also contracted other consultants to assess the potential biological and noise impacts with installing wind turbines on the Reservation. This report summarizes the wind resource on the Reservation and presents the methodology, assumptions and final results of the wind energy development feasibility assessment.

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Indexing Terms	
Key Words	
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1 EXECUTIVE SUMMARY

The overall goal of the Lummi Indian Reservation Wind Energy Development Feasibility Assessment Project (Project), funded through a grant from the U.S. Department of Energy (DOE), is to determine if and at what cost wind energy development can help achieve the tribal goal of energy self-sufficiency. To assist with making this determination, the governing body of Lummi Nation, the Lummi Indian Business Council (LIBC), retained DNV KEMA to assess the wind energy development feasibility on the Lummi Indian Reservation (the Reservation). The LIBC also contracted other consultants to assess the potential biological and noise impacts with installing wind turbines on the Reservation.

Using data collected during a one-year wind measurement campaign, DNV KEMA has generated preliminary energy estimates and evaluated the economic feasibility of two project scenarios: 1) the installation and operation of a small, 5-megawatt (MW) "community" wind project and 2) the offset of electrical usage through 100-kilowatt (kW) of net-metering with a single 100-kW wind turbine. To evaluate these scenarios, DNV KEMA prepared a preliminary project pro forma for each scenario, incorporating items such as anticipated capital costs, O&M costs, estimated project performance, electricity pricing, finance structure, inflation rate, and other inputs.

The long-term adjusted, 80-m wind resource is estimated to range from 5.5 m/s to 6.5 m/s, with an annual estimated wind speed of 5.6 m/s at the Hillaire property, the proposed location of the 5-MW wind project scenario (referred to as Scenario 1 throughout this report). As documented in J.C. Brennan and Associates' *Wind Turbine Technical Noise Analysis*, attached as Appendix A to this report, two turbine models were evaluated for Scenario 1, with sound power levels ranging between 105 dBA and 108 dBA, resulting in respective sound levels of 42 dBA and 45 dBA at the nearest residence. With appropriate setback distances, noise impacts from either turbine could be mitigated in order to comply with the recommended 42 dBA noise level standard.

The *Site Screening Report for The Lummi Nation Wind Energy Development Feasibility Assessment Project,* prepared by Hamer Environmental L.P. (Hamer) and attached as Appendix B, identifies the potential biological resources on the Reservation which may require further study or present unique challenges to wind energy development. Based on the significant presence of Bald Eagle nests within the Reservation, the likelihood of occurrence of bald eagles is thought to be "Very High". As noted in Hamer's report, there are four species listed by the U.S. Fish and Wildlife Service as either endangered or threatened that are potentially within the Reservation boundaries. Of these species, only the Marble Murrelet is thought to have a "High" likelihood of occurring within the Reservation. The Lummi Flats and the Nooksack River Delta have been documented as foraging areas for raptors, thus given a "High" potential for biological impacts, as well as "High" potential impact to wetlands. Careful mitigation measures are recommended to ensure that wetlands are not impacted during wind project construction.

Using manufacturer-provided power curves, DNV KEMA has estimated that an approximate 5-MW wind project would be expected to produce on average P50 net energy of 11.3 to 13.4 GWh per year with corresponding P50 net capacity factors of 23.3% and 25.6%, respectively. The payback period is estimated to be greater than 20 years (the assumed life of the wind turbines), thereby resulting in a negative internal rate of return (IRR) and negative net present value (NPV).

A one 100-kW wind turbine located at the Se'eye'chen Youth Center (the LIBC facility with the highest wind resource), is estimated to have a long-term 37-m hub-height wind speed of 5.3 m/s and would be expected to generate an average P50 net energy of 150 MWh per year, with a corresponding P50 net capacity factor of 17.1%. The payback period is estimated to be 35 years (well beyond the assumed 20-year life of the wind turbine), thereby resulting in a negative IRR and NPV.

Under either scenario, a wind energy project would likely not be economically viable for the LIBC.

DNV KEMA's methodology, assumptions and analysis results are further described in the main body of this report. As requested by the LIBC, DNV KEMA has also provided a summary of typical "residential-scale" wind generation and high-level evaluation of a 5-kW net-metering scenario for residents on the Reservation, included as Appendix D.

2 BACKGROUND

The LIBC retained DNV KEMA to assess the wind energy development feasibility on the Reservation. DNV KEMA's scope of work includes an initial site survey and a one-year wind measurement campaign, followed by a preliminary energy assessment and economic evaluation.

As part of the wind resource assessment campaign, DNV KEMA conducted a site visit and initial survey of the Reservation to provide a preliminary estimate of the potential wind resource, identify possible barriers to wind energy development, prepare a conceptual turbine layout, and determine locations for on-site wind monitoring. The findings of this assessment can be found in the *Site Survey and Wind Monitoring Recommendations for the Lummi Nation* report dated November 12, 2010. In coordination with the Lummi Natural Resources Department (LNR), DNV KEMA installed two meteorological (met) towers and performed data collection and monthly data validation and reporting. Details regarding the met tower configuration and data summary can be found in *The Lummi Indian Reservation Wind Energy Development Feasibility Assessment Project Data Summary and Retrieval for January 2012* dated February 2012, and is included as Appendix C to this report.

In February 2012, DNV KEMA performed a preliminary assessment of the wind resource and potential energy generation at the met tower locations. Although the wind resource at the met tower locations was slightly higher than model predictions presented in the *Site Survey and Wind Monitoring Recommendations for the Lummi Nation* report, DNV KEMA informed the LIBC that the resulting net energy generation would be unlikely to yield the financial rate of returns sought by wind developers and investors. DNV KEMA suggested the LIBC consider a smaller-scale wind project under generation terms with Puget Sound Energy (PSE).

3 RESERVATION DESCRIPTION

The Reservation is located immediately west of Bellingham, Washington, and 20 miles south of the Canadian border in western Whatcom County. The Reservation encompasses 54.4 km^2 (21 sq mi) of land, including Sandy Point, the Lummi Flats, the Lummi Peninsula and uninhabited Portage Island, as shown in Figure 3-1, and summarized below.

- Sandy Point, while well exposed to the coastal winds, is densely populated leaving insufficient space for utility-scale wind turbines.
- The Lummi Flats, once the mouth of the Nooksack River, is a sparsely populated floodplain just a few feet above sea level and used primarily for agriculture.
- The Lummi Peninsula runs northeast to southwest separating Lummi Bay from Bellingham Bay. The peninsula contains a ridge that rises approximately 40 m (130 ft) above sea level and is densely forested. The majority of residences and facilities are located along the waterfront.
- Portage Island, according to the LNR, includes a large number of culturally sensitive sites and was not considered for wind turbine installation.

- In addition, the Reservation is surrounded by more than 7,000 acres of tidal land, which may be available for near-shore wind turbine installation; however, that was beyond the scope of DNV KEMA's assessment.

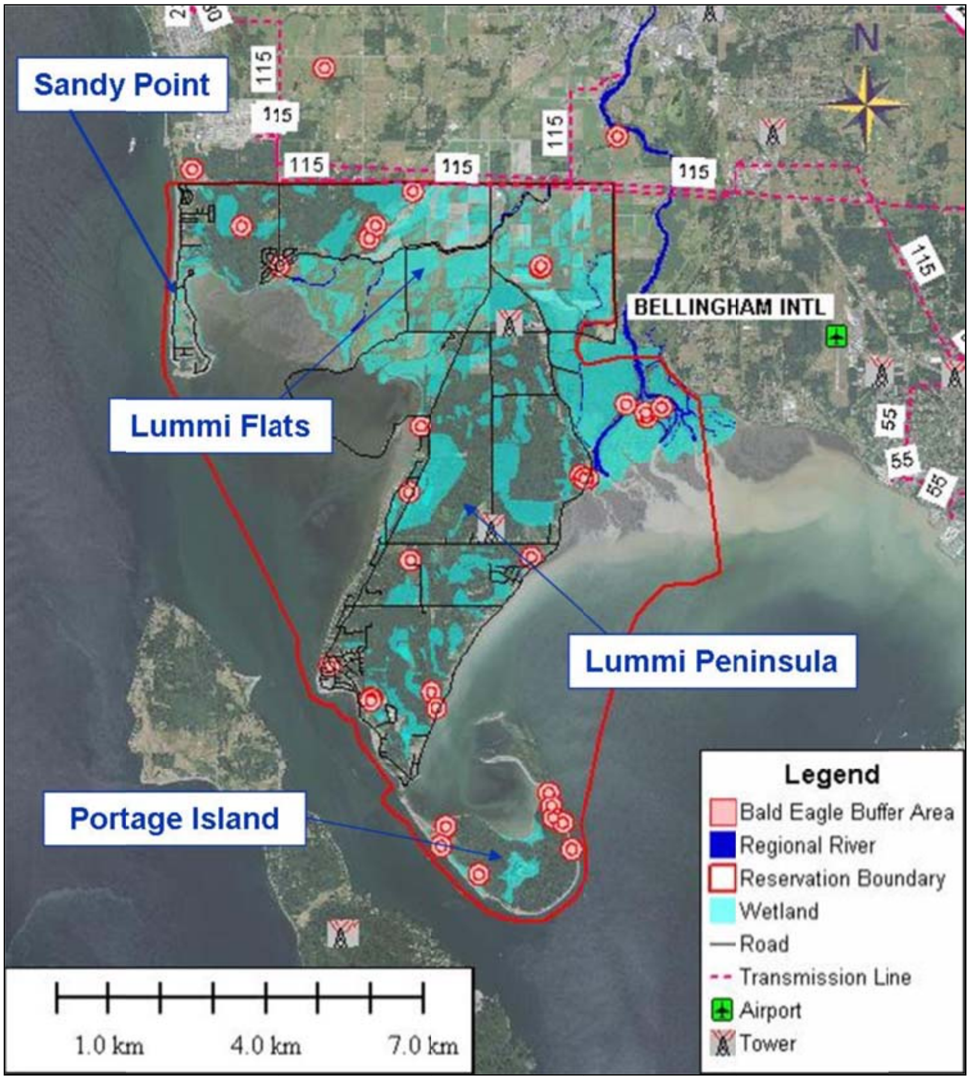


Figure 3-1. The Lummi Reservation Map

The LNR has provided the following GIS data layers, also shown in Figure 3-1: Reservation boundaries, rivers, wetlands designations, bald eagle nesting buffers, rivers and roads. DNV KEMA has also overlaid the location of regional transmission lines, the Bellingham International Airport, and communication towers.

4 REGIONAL ELECTRICAL MARKET

The electricity market in the northwest U.S. is managed through the Northwest Power Pool (NWPP), which encompasses Washington, Oregon, Idaho, Wyoming, Montana, Nevada, Utah, extreme northern California and the Canadian provinces of British Columbia and Alberta. The NWPP is a voluntary industry organization comprised of the major utilities and market participants in this area, such as Bonneville Power Administration (BPA), Puget Sound Energy (PSE), Portland General Electric, Avista Corporation, B.C. Hydro, PacifiCorp, Idaho Power Company, Seattle City Light, and the Alberta Electric System Operator[1].

Hydroelectric is the major source of electricity generation in the NWPP, followed by natural gas, coal, nuclear, wind and various non-hydroelectric renewable sources (such as geothermal, solar, and biomass). As a result of regional utilities' requirements to meet state renewable portfolio standards, renewable power (particularly wind) has been increasing its share of the market in this region. In general, NWPP has a surplus of electricity and sells the excess into the California and southwestern U.S. markets[2]. Sales from this surplus energy contribute to keeping the Northwest wholesale power rates, and subsequent electrical rates, low.

BPA is a federal agency part of the DOE that markets wholesale electricity and transmission to the Pacific Northwest's public and private utilities as well as some of the large industries. For instance, Whatcom County Public Utility District purchases their energy from BPA for distribution to their electric customers.

The LIBC's electrical utility provider, PSE, has been active in developing its own wind power and solar projects in recent years and provides power purchase terms for small-scale renewable generation projects as well as provisions for net-metering, further discussed in Section 5 that follows.

Wind turbines range in capacity from approximately 250 watts (W) – enough to power five 50 W light bulbs – to over 7 MW. On average, a one MW wind turbine can provide enough energy to power approximately 300 households in the U.S. Utility-scale turbines currently used for onshore applications typically range in capacity from approximately 1.5 MW to 2.5 MW with rotor diameters near 100 m, whereas residential-scale wind turbines typically range from 2 kW to 100 kW.

[1] Northwest Power Pool website, 2012. [Online]
Available at: http://www.nwpp.org/
[Accessed on August 16, 2012]

[2] Federal Energy Regulatory Commission, 2012. *Northwest Electric Market: Overview and Focal Points*, August 2012. [Online]
Available at: http://www.ferc.gov/market-oversight/mkt-electric/northwest/2012/08-2012-elec-nw-archive.pdf
[Accessed on August 16, 2012]

5 POTENTIAL WIND PROJECT SCENARIOS

DNV KEMA researched the terms and conditions for both directly selling energy produced by the wind turbine(s) through a small power production agreement and for offsetting energy consumption through net metering with PSE. This section outlines two project scenarios:

- Scenario 1: Small Power Production (5 MW)
- Scenario 2: Net Metering (100 kW)

5.1 Scenario 1: Small Power Production (5 MW)

5.1.1 General Rules and Provisions

For the small power production scenario (hereafter referred to as "Scenario 1"), PSE has provisions for up to 5 MW of small power production, as set forth in PSE Electric Tariff G Schedule 91 Cogeneration and Small Power Production[3]. Under this scenario, the LIBC would be required to enter into a Power Purchase Agreement (PPA) with PSE for the sale of the energy produced and for interconnection to PSE's electric distribution system. Energy sales rates can either be tied to market pricing (variable) or fixed pricing. For the purposes of this study, we are assuming a fixed price rate structure (dollars per MWh generated) to be paid monthly to LIBC by PSE. The rates (per MWh) published in the current Schedule 91 for agreements entered into between January 2, 2012, and December 31, 2012 follow:

2012	2013	2014	2015	2016
$56.12	$57.12	$58.96	$60.43	$61.94

2017	2018	2019	2020	2021
$63.49	$65.08	$66.70	$68.37	$70.08

2022	2023	2024	2025	2026
$71.83	$73.63	$75.47	$77.36	$79.29

The minimum term of the small power production PPA with PSE is five years. Under this tariff, LIBC would need to pay a monthly basic charge of approximately $100/month (for more than 350 kW) for interconnection to PSE's system. This charge would be in addition to the existing basic charge for electric service (typically around $8/month for residential or $50/month for commercial service).

[3] PSE, 2010. *Schedule 91 Cogeneration and Small Power Production* issued November 18, 2010. [Online] Available at: http://pse.com/aboutpse/Rates/Documents/elec_sch_091.pdf [Accessed on July 26, 2012]

Per discussion with PSE, projects above 100kW are handled on a case-by-case basis through PSE's Schedule 80 interconnection process[4]. A scoping meeting, system impact study, facilities study, and construction agreement are typically required through this process. Based on findings from the studies, system requirements (e.g., dedicated feeders, substation upgrades, etc.) are determined. The studies generally cost around $25,000. Costs for system upgrades are highly variable depending on what modifications are required and can generally range from $20,000 to $3,000,000. All costs (studies and upgrades) would be borne by the generator, LIBC.

5.1.2 Turbine Siting

Based on a typical 1.5 MW to 2.5 MW rating for utility-scale onshore wind turbines, two or three utility-scale turbines could be installed under PSE's provisions for small power production.

The LIBC identified the recently acquired 140-acre Hillaire property in the northeast corner of the Reservation as a desired location for siting a small wind turbine project. A comparison of the estimated wind resource of this property to the rest of the Reservation is provided in Section 6.5. DNV KEMA has performed a preliminary setback analysis for the property and identified three potential turbine locations, as shown in Figure 5-1.

[4] PSE, 2011. *Schedule 80 General Rules and Provisions* issued July 28, 2006. [Online] Available at: http://pse.com/aboutpse/Rates/Documents/elec_sch_080.pdf [Accessed on August 15, 2012]

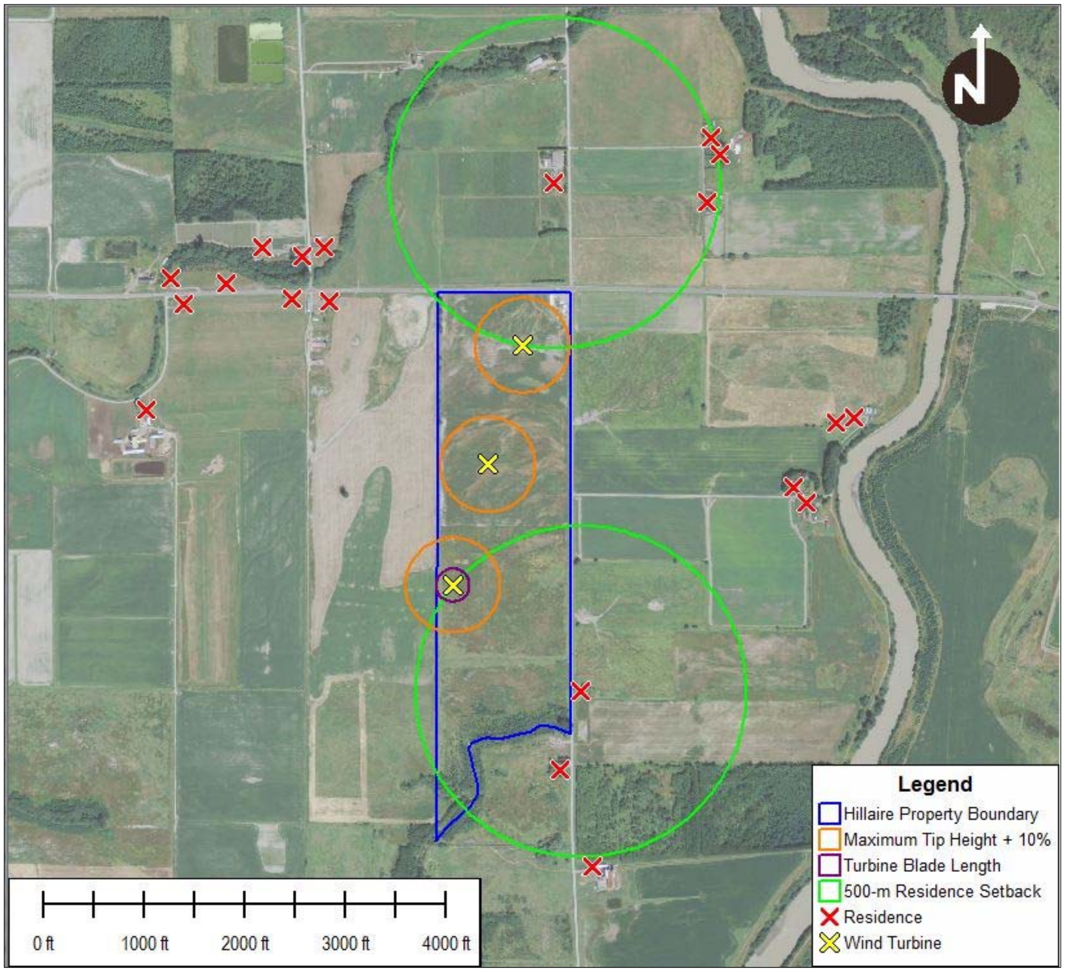


Figure 5-1. Scenario 1 Turbine Placement and Setback Analysis

The turbine placement, as shown in Figure 5-1, maintains a fall distance (maximum tip height) plus 10% from roads, approximate blade length from property lines, a 500-m setback from residences, and manufacturer recommended 3 x rotor diameter spacing between turbines. As documented in J.C. Brennan and Associates' *Wind Turbine Technical Noise Analysis*, attached as Appendix B, two turbine models were evaluated for Scenario 1, with sound power levels ranging between 105 dBA and 108 dBA. Using the CadnaA Noise Prediction Model, the generated noise levels associated with 105-dBA turbines are predicted to result in 42 dBA at the nearest residence (500-m setback), which complies with the recommended 42 dBA noise level standard. The generated noise levels associated with the 108 dBA turbines are predicted to result in 45 dBA at the same residences and would exceed the recommended standard. Increasing the setback distance would mitigate the noise impact associated with the higher sound-emitting turbines.

The Scenario 1 turbine locations are more than 3,000 feet from the nearest identified Bald Eagle nest, significantly further than the 330-ft and 660-ft buffers provided by LIBC and illustrated in

Figure 3-1. The *Site Screening Report for The Lummi Nation Wind Energy Development Feasibility Assessment Project*, prepared by Hamer Environmental L.P. (Hamer) and attached as Appendix C, identifies the potential biological resources on the Reservation which may require further study or present unique challenges to wind energy development. Avian surveys performed in 2010 identified 28 Bald Eagle nests within the Reservation, thus the likelihood of occurrence of bald eagles is thought to be "Very High". Although the Bald Eagle was removed from the Federal List of Endangered and Threatened Wildlife and Plants in 2007, they are still protected under both the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act. As noted in Hamer's report, there are four species listed by the United States Fish and Wildlife Service as either endangered or threatened that are potentially within the Reservation boundaries: Short-Tailed Albatross, Streaked Horned Lark, Northern Spotted Owl, and Marbled Murrelet. Of these species, only the Marble Murrelet is thought to have a "High" likelihood of occurring within the Reservation. Hamer's screening report further documents the likely presence of vertebrate and invertebrate species (including other avian species), as well as priority habitats and rare plants within or near the vicinity of the Reservation. Besides the previously noted likelihood of Marbled Murrelets and Bald Eagles within the Reservation, the Lummi Flats and the Nooksack River Delta have been documented as foraging areas for raptors, thus given a "High" potential for biological impacts. Due to the documented presence of numerous wetlands within the Reservation, Hamer has listed the potential biological impacts to wetlands be "High" and that careful mitigation measures can help ensure that wetlands are not impacted during construction.

As noted in the *Site Survey and Wind Monitoring Recommendations for the Lummi Nation Report,* construction of wind turbines within 5 miles of an active airport has increased potential for impacting navigable airspace or aviation communications. The Hillaire property is approximately 2.7 miles from the Bellingham International Airport. Due to this close proximity, DNV KEMA filed notices of proposed construction for the three turbine locations with the Federal Aviation Administration (FAA) on the LIBC's behalf. Following the initial aeronautical study, the FAA issued Notices of Presumed Hazard on June 15, 2012, indicating that wind turbines on the Hillaire property would exceed obstruction standards. Per the FAA, further study is necessary to make a final determination. Further study entails distribution to the public for comment. Results of this further study are not expected until late November.

5.2 Scenario 2: Net Metering (100 kW)

5.2.1 General Rules and Provisions

For the net metering scenario (hereafter referred to as "Scenario 2"), PSE allows for up to 100 kW of installed generation capacity as set forth in PSE Electric Tariff G Schedule 150 Net Metering Services for Customer-Generator Systems[5]. The LIBC would enter into an agreement for interconnection with PSE, whereby any energy produced by the turbine would be realized as

[5] PSE, 2011. *Schedule 150 Net Metering Services for Customer-Generator Systems* issued April 8, 2011. [Online] Available at: http://pse.com/aboutpse/Rates/Documents/elec_sch_150.pdf [Accessed on July 26, 2012]

a payment credit at retail rates. Credit can be "banked" over time, although on April 30th of each year, the credit resets to zero, no matter how much credit remains in the account. As such, it is beneficial to connect to a meter with sufficient load (i.e., load exceeding energy produced by the turbine). Alternatively, PSE allows for aggregation of multiple meters under the same account for a nominal fee (equal to the basic service charge per meter aggregated – typically around $8/month for residential or $50/month for commercial service); therefore, excess power generated through the meter at the turbine location could be attributed to other LIBC meters at other locations to ensure excess generation and associated credit are "consumed".

The LIBC provided DNV KEMA with their 2010 annual load and estimated costs for electrical service per facility. Considering all accounts for all facilities, LIBC estimated an average rate of $0.094 per kWh was spent in 2010.

In addition to net metering, a Renewable Energy Production Incentive Payment Program is offered through PSE Electric Tariff G, Schedule 151[6]. Under this program, $0.12 per kWh will be paid for electricity produced by wind, up to a maximum of $5,000 per year per entity. Note participation eligibility is subject to a ruling by the Washington Department of Revenue.

5.2.2 Turbine Siting

Under PSE's net-metering provisions, one 100-kW wind turbine or multiple smaller-rated turbines could be installed. For this analysis, DNV KEMA assumed one 100-kW wind turbine on a 37-m tower. A location for the 100-kW turbine was not identified for this analysis, rather net energy and economic modeling in the following sections are based on the potential range of annual 37-m wind speeds at LIBC load centers, so that the LIBC can balance competing land use demands with potential energy savings.

As noted in Section 5.2.1 above, to ensure all generation credit is consumed, a turbine could either be sited at a location with load exceeding generating capacity (e.g., Silver Reef Casino) or at lower load locations, where credit from excess energy produced could be realized through meter aggregation.

6 WIND RESOURCE

DNV KEMA collected, validated and summarized the raw data from two temporary met towers (Met 1001 and Met 1002) on a monthly basis. A summary of the annual wind resource for January 1, 2011, through January 31, 2012, can be found in *The Lummi Indian Reservation Wind Energy Development Feasibility Assessment Project Data Summary and Retrieval for January 2012,* attached as Appendix C to this report. The corresponding validated data set was utilized for this analysis. Wind speeds measured by anemometers at different heights were used to calculate the wind shear. The shear calculations were used to extrapolate wind speeds at the

[6] PSE, 2011. *Schedule 151 Renewable Energy Production Incentive Payment Program* issued April 8, 2011. [Online] Available at: http://pse.com/aboutpse/Rates/Documents/elec_sch_151.pdf [Accessed on July 26, 2012]

measurement heights to the 80-m and 37-m turbine hub-heights. DNV KEMA consulted nearby long-term reference stations to determine how well the on-site data represent the long-term average wind speeds and whether a long-term adjustment would be appropriate. The long-term hub-height wind speeds were normalized to one year (8,760 hours) so that annual wind speed frequency distributions could be created. Annual gross energy production was estimated using the annual wind speed frequency distribution and a generic turbine power curve. The net annual energy was then estimated based on the estimated gross annual energy and assumed technical losses.

6.1 Wind Shear

Wind speeds measured by anemometers at different heights were used to calculate the wind shear, which indicates how wind speed changes with height. DNV KEMA calculated wind shear[7] from anemometers on the same side of the tower with preference given to the south-oriented anemometers as they have the better exposure to the prevailing south-southeast winds. Due to the close proximity of trees to Met 1002, DNV KEMA incorporated a tree-adjustment into this measurement. The average shear value is 0.15 for Met 1001 and Met 1002. The monthly and diurnal wind shear pattern for Met 1001 provided in Figure 6-1 illustrates higher shear during the nighttime hours and lower shear during the daytime. The diurnal shear pattern for Met 1002 was less pronounced due to topographic variation. Shear was applied to upper-level wind speeds on a monthly and diurnal basis to estimate 80-m hub-height wind speeds.

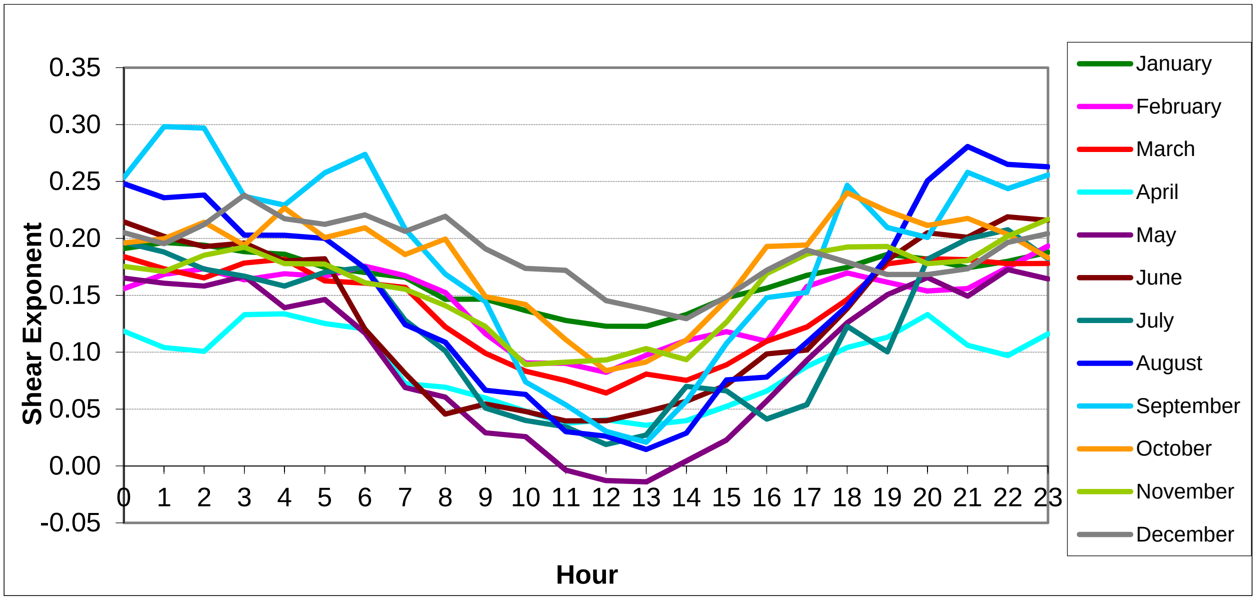


Figure 6-1. Monthly and Diurnal Wind Shear Pattern at Met 1001

[7] Wind shear describes the typical increase in wind speed at greater heights above the ground. The wind shear exponent (alpha or α) is one method of describing the extent to which wind speeds vary with increasing height above ground level. The equation that uses the exponent is $(V_1 / V_2) = (H_1 / H_2)^{\alpha}$, where V_1 and V_2 are wind speeds at heights H_1 and H_2, respectively (measured from the ground level), and α is the dimensionless wind shear exponent.

6.2 Long-Term Adjustment

Various long-term reference stations were consulted for correlation to on-site data for the purpose of adjusting on-site data to reflect the long-term average wind speed. The stations and the site are shown together in Figure 6-2. On-site data were correlated to regional long-term meteorological data from the Bellingham Automated Surface Observing System (ASOS) station at the International Airport, the Arlington Automated Weather Observing System (AWOS) station, the Burlington/Skagit AWOS station, the East Sound/Orcas AWOS station, the Friday Harbor ASOS station, and the Port Angeles ASOS station. After analyzing the reference data, DNV KEMA chose to make an aggregate long-term upward adjustment to each of the two on-site met towers on wind speed based on wind speed data from the Bellingham ASOS station. DNV KEMA made an upward adjustment of 1.1% at Met 1001 and 1.7% at Met 1002 based on the different on-site period of record and met tower exposure to the prevailing wind. The considerations and method for this adjustment are discussed below.

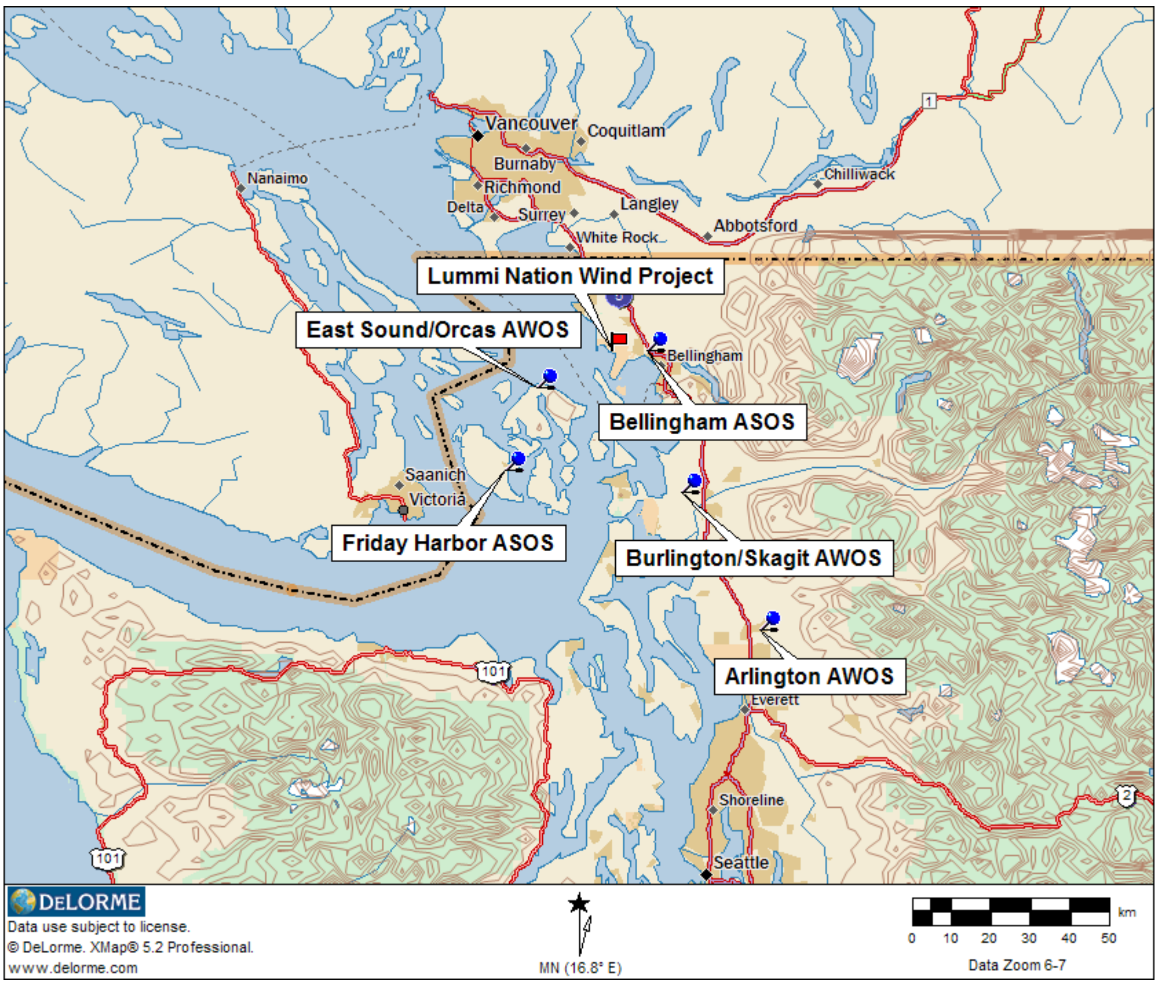


Figure 6-2. Location of the Lummi Reservation and Long-Term Reference Stations

The Bellingham ASOS station is located approximately 9 km (6 miles) east of the project. Data available since September 1, 1998, consist of 2-minute averages of wind speed and direction recorded hourly at 10 m. However, due to a change in sensor type from cup anemometer to sonic anemometer, only data after April 3, 2007 were used in the analysis.

Daily averages have a good correlation to on-site daily averages with an R-squared value of 0.83 at Met 0001 and 0.84 at Met 0002. The Bellingham ASOS data indicated the region's winds during the period of on-site record were 1.0 to 1.7% lower than the long-term average.

6.3 Long-Term Hub-Height Wind Speeds

Based on the estimated met tower wind speeds and the hourly monthly wind shear pattern at each met tower, DNV KEMA developed a wind speed frequency distribution representing the long-term, hub-height wind speed and wind direction at each met tower location. To generate frequency distributions, data from each tower over its entire period of record were binned by wind speed and direction. To normalize the data set to 8,760 hours, DNV KEMA developed a monthly record-length correction factor by counting the number of records with valid upper sensor wind speed and wind direction observations available in each month. The data were then categorized by wind direction sector (30° sectors centered on 0°, 30°, etc.) and wind speed bin (intervals of 0.5 m/s centered on 0.5 m/s, 1.0 m/s, etc.) to generate a frequency distribution showing the number of observations in each wind speed bin and for each wind direction sector.

The long-term 80-m hub-height frequency distribution at Met 1002 is shown in Figure 6-3. The frequency distribution at Met 1001 shows a similar pattern to that of Met 1002. Annual long-term hub-height wind speeds computed from the frequency distributions are presented in Table 6-1.

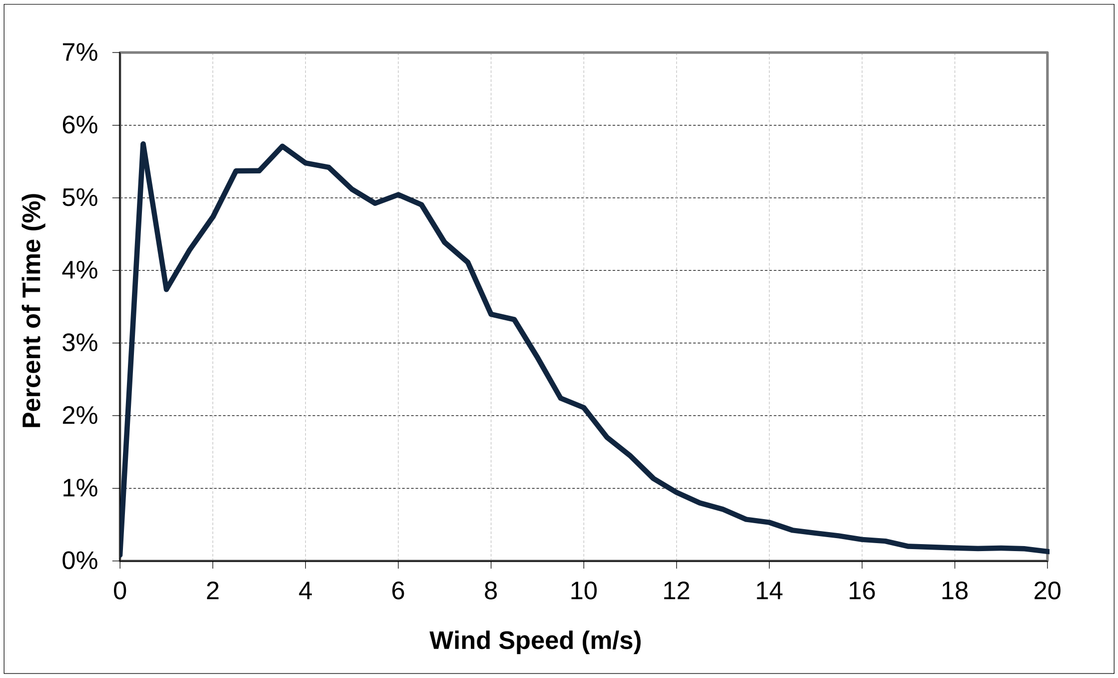


Figure 6-3. Long-Term 80-m Frequency Distribution for Met 1002

Table 6-1. Annual Average Long-Term 80-m Hub-Height Wind Speeds

Met Tower	Wind Speed (m/s)
1001	5.6
1002	5.8

6.4 Wind Rose

A wind rose depicts the frequency and energy content of wind by direction. An annualized wind rose estimated at 80 m for each met tower is presented in Figure 6-4 and Figure 6-5. The wind roses show a similar pattern, with significant energy-producing winds coming from the south-southeast.

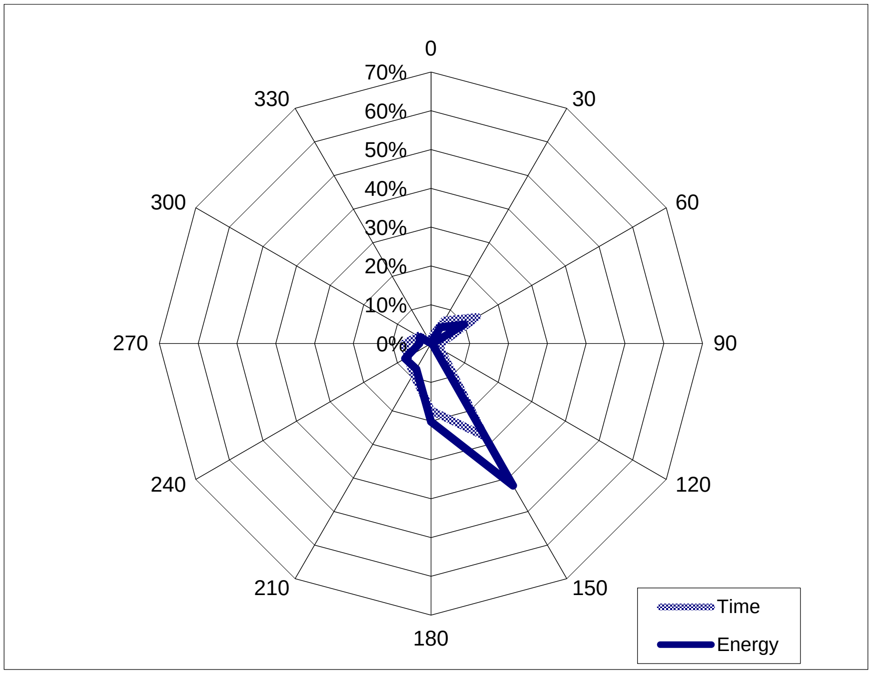


Figure 6-4. Met 1001 Annual Wind Rose at 80 m

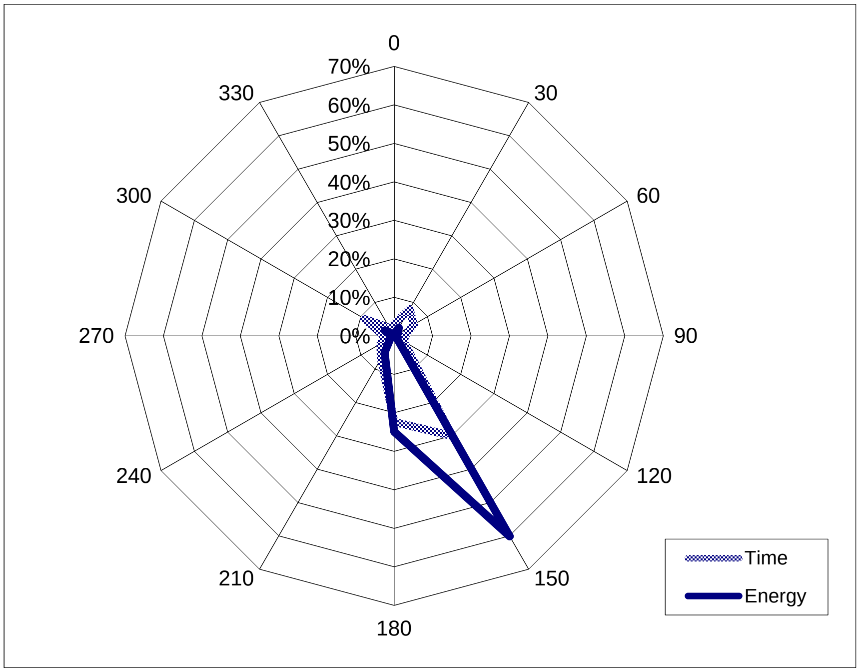


Figure 6-5. Met 1001 Annual Wind Rose at 80 m

6.5 Wind Map

Using the long-term annual wind speed frequency distributions from the met towers, DNV KEMA modeled the wind flow for the Reservation using the MS-Micro/3 software package. The results of the modeling were used to generate a wind flow map suitable for use in layout optimization and preliminary understanding of the Reservation's wind resource potential. A project wind map is shown in Figure 6-6 at an 80-m hub height.

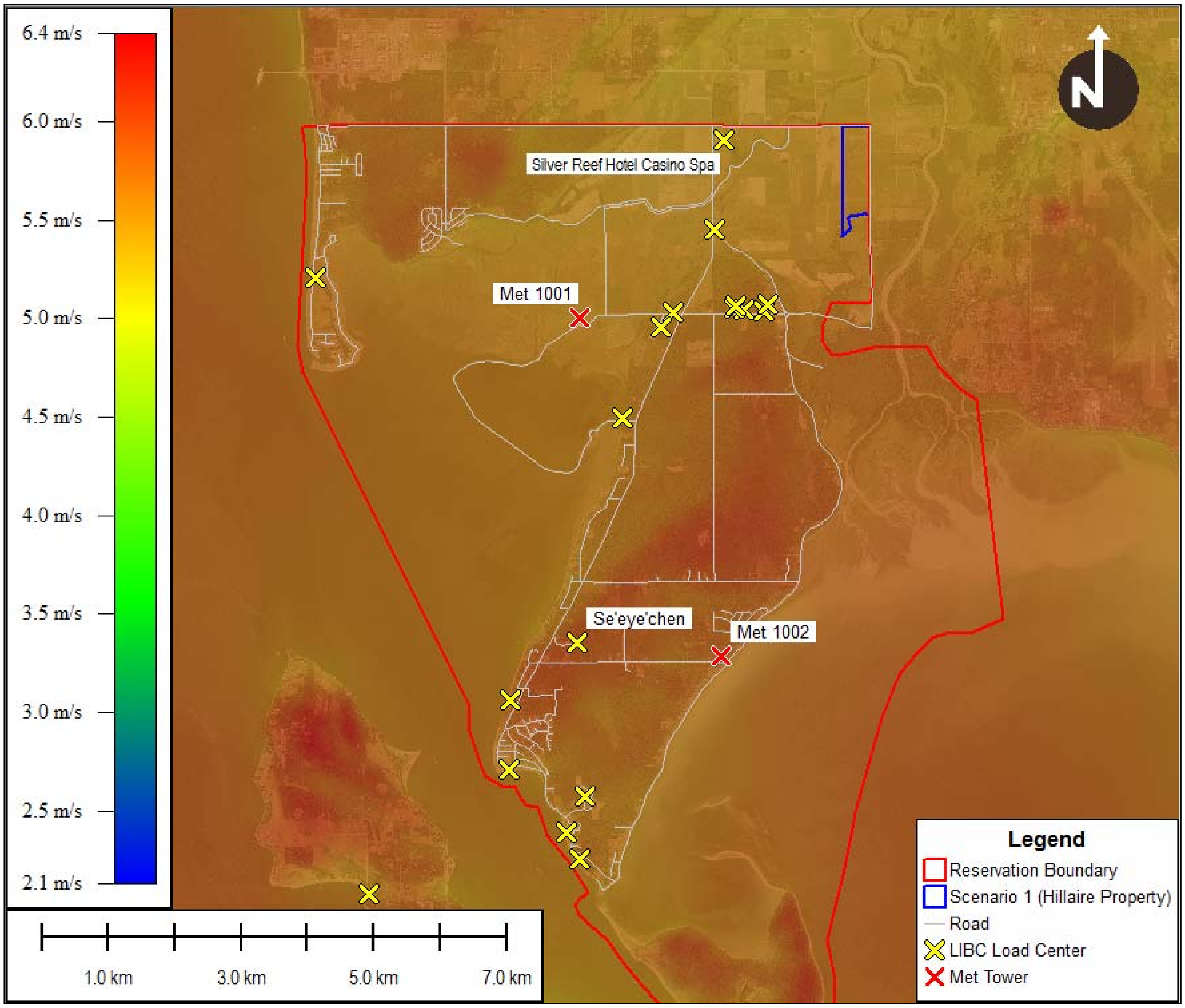


Figure 6-6. Reservation 80-m Wind Speed Map

As shown in Figure 6-6, the strongest wind resource, an annual wind speed of roughly 6.5 m/s at 80 meters, is estimated along the 40-m (130-ft) ridge on the Lummi Peninsula, whereas the lowest wind resource, approximately 5.5 m/s at 80 meters, is estimated on the leeward side of the ridge in the Lummi Flats. The Hillaire property, location of Scenario 1, has an annual estimated 80-m wind speed of 5.6 m/s.

7 ENERGY ASSESSMENT

DNV KEMA has estimated the potential energy production for Scenario 1 and 2. As described in previous sections, Scenario 1 evaluates three different top-tier utility-scale wind turbine make/models that have turbine nameplate capacities ranging from 1.5 to 2.5 MW (Turbine 1A, Turbine 1B, and Turbine 1C) on 80-m towers. Scenario 2 evaluates the use of a single 100 kW wind turbine (Turbine 2) on a 37-m tower.

This section presents DNV KEMA's method for estimating gross and net energy production, as well as energy loss assumptions. Gross energy estimates are based on the wind speed to wind turbine energy relationship alone; whereas, net energy estimates takes into account losses due to availability, wake effects, turbine performance, electrical, and environmental factors. As is consistent with industry convention, all production estimates presented are the best estimate result as a "P50", where there is a 50% chance that the actual production will be higher and a 50% chance that it will be lower. The net capacity factor of a wind project, referred to in this report, is the ratio of the actual output of the project over a period of time and the potential output had it operated at full nameplate capacity the entire time.

7.1 Scenario 1: Estimated Energy Production

In Scenario 1, DNV KEMA estimated individual turbine mean hub-height wind speeds based on the 80-m met tower wind speeds, the MS-Micro/3 software package wind flow model results, turbine distance from met towers, elevation and exposure, a roughness map based on aerial imagery, and DNV KEMA's judgment about wind flow across the terrain. The individual turbine gross energy was calculated based on the assigned turbine wind speeds and the wind speed to energy relationship derived from the met tower frequency distributions and the wind turbine power curves.

Project losses were estimated for each turbine type including availability, wake effects, turbine performance, electrical, and environmental. The losses are estimated based on DNV KEMA's current knowledge of the project and experiences with other wind projects. For example, the mechanical availability assumptions used are based on DNV KEMA's experiences monitoring performance of modern megawatt-scale wind turbines of similar design, but the availability at this particular site may be higher or lower for a variety of reasons.

Table 7-1 summarizes the loss assumption for each of the three turbine types considered in Scenario 1. It is important to note that project layouts for Turbines 1A and 1B contained a total of three wind turbines, while the project layout for Turbine 1C contains a total of two wind turbines.

Table 7-1. Long-Term P50 Project Losses

Losses	Long-Term P50 Losses, % of Energy		
	Turbine 1A Layout	**Turbine 1B Layout**	**Turbine 1C Layout**
Availability	10.5%		
Wake Effects	3.7%	3.7%	1.2%
Turbine Performance	1.2%		
Electrical	2.5%		
Environmental	1.9%		
Total	**18.5%**	**18.5%**	**16.4%**

Based on the wind resource assessment, estimated gross energy production, and estimated long-term P50 project losses, DNV KEMA estimated the long-term P50 net energy production for each turbine layout in Scenario 1. The results of this analysis are summarized in Table 7-2.

Table 7-2. Scenario 1 Estimated P50 Losses and Energy Production

Scenario 1 Wind Turbine	Number of Wind Turbines in Layout	Gross Energy Production (GWh/year)	Project Losses (%)	Net Energy Production (GWh/year)	Net Capacity Factor (%)
Turbine 1A	3	13.3	18.5%	10.8	25.0%
Turbine 1B	3	13.4	18.5%	10.9	25.6%
Turbine 1C	2	11.3	16.4%	9.4	23.3%

7.2 Scenario 2: Estimated Energy Savings

In Scenario 2, DNV KEMA identified the likely range of wind speeds at LIBC load centers based on the wind speed map presented in Figure 6-6, and estimated corresponding range of net energy generation. DNV KEMA determined the wind speeds at a 37-m hub height could range from 4.9 m/s at the Silver Reef Hotel Casino/Spa to 5.3 m/s at the Se'eye'chen Youth Center. Assuming standard losses for a one-turbine project (e.g., availability, electrical, and environmental), DNV KEMA estimates a range of P50 net energy production values from 125 to 150 MWh/year, corresponding to net capacity factors of 14.3% and 17.1%, respectively.

8 ECONOMIC ANALYSIS

DNV KEMA has assessed the financial viability of both small power production (Scenario 1) and net metering (Scenario 2) to help determine if purchase and operation of the turbine(s) results in a desirable financial outcome for the LIBC.

To evaluate these scenarios, DNV KEMA prepared a preliminary project pro forma (i.e., cash flow model) for each scenario, incorporating items such as anticipated capital costs, O&M costs, estimated project performance, electricity pricing, finance structure, inflation rate, and other inputs, as applicable. Based on the cost data available to DNV KEMA, the economic model was run.

A discussion of these inputs and the model results for each scenario are presented in the sections below.

8.1 Scenario 1: Economic Analysis for Small Power Production

For Scenario 1, DNV KEMA evaluated three different top-tier utility scale turbine makes/models all on 80-m towers and ranging in turbine nameplate capacity from approximately 1.5MW to 2.5MW. For confidentiality reasons, the turbine makes/models cannot be disclosed; therefore, the turbines are referred to as 1A, 1B, and 1C. Based on the nameplate capacity per turbine, either two or three turbines could be installed to comply with the maximum allowed total project capacity of 5MW (under PSE Schedule 91), as follows:

- Turbine 1A: 3 turbines
- Turbine 1B: 3 turbines
- Turbine 1C: 2 turbines

8.1.1 Capital Costs

For Scenario 1, DNV KEMA completed a capital cost evaluation for each turbine – Turbine 1A, Turbine 1B, and Turbine 1C. The evaluation was based on indicative price quotes provided by the respective turbine manufacturers and on DNV KEMA experience.

The primary cost components considered in the turbine capital cost evaluation included:

- Wind turbines (including towers, nacelles, hubs, blades, and other vendor-specific components)
- Transportation
- Transformers and switchgear
- Supervisory control and data acquisition (SCADA) system
- Power electronics, including low voltage ride through (LVRT), reactive power capability, and plant voltage/power factor controllers
- Technical support and commissioning
- Other (e.g., service lift, aviation lighting)

Note, not all of the above components were included in the base price quotes provided by each vendor, as certain options, systems, and configurations vary from turbine model to model. As such, in order to compare like items between the three vendors for each scenario, costs for certain items were estimated, based on either DNV KEMA experience or on quotes for similar components provided by another vendor.

Based on the above evaluation, the following turbine capital costs were estimated for the three turbines:

- Three 1A turbines: $8,871,000
- Three 1B turbines: $6,684,000
- Two 1C turbines: $7,049,000

In addition to turbine capital costs, DNV KEMA also estimated other capital costs for each turbine associated with:

- Development, Studies, and Engineering, including:
  - Systems impact and facilities study: $25,000
  - Other studies/monitoring: $75,000
  - Geotechnical investigation: $40,000
  - Design (foundation, electrical, civil/BOP): $100,000
- Construction / Balance-of-Plant (BOP), including:
  - Turbine assembly/erection: pricing discussed below
  - Foundations
  - Padmounts (for down-tower transformers)
  - Civil works (roads, site work, crane pads, etc.)
  - Collector system and electrical wiring
  - Substation upgrades and interconnection (see Section 5.1.1)
  - Construction management/oversight
  - Other
  - 10% construction contingency

DNV KEMA used a proprietary project cost database for estimating construction/BOP costs that has been developed and maintained by DNV KEMA over the past several years. This database contains both actual and estimated component cost data for numerous wind energy projects located throughout the Americas, including the United States, Canada, and Latin America. The cost data have been obtained from a combination of both public and proprietary sources (e.g., pro formas, supplier quotes, construction contractor bids, etc.) and is periodically updated as new wind energy project cost information becomes available.

DNV KEMA queried our database for 2010 to 2012 projects to determine average capital costs for construction/BOP for use in this analysis. Note, the majority of the project costs in our database are for large turbine installations, presumably realizing economies of scale pricing benefits from turbine suppliers/installers and BOP construction contractors. As such, for this 2-3 turbine analysis, a markup of 10% was used for certain construction costs (e.g., turbine assembly/erection, foundations, collector system). The resulting pricing follows:

- Three 1A turbines: $2,640,000
- Three 1B turbines: $2,620,000

- Two 1C turbines: $2,210,000

8.1.2 Operations and Maintenance Costs

DNV KEMA uses a proprietary in-house O&M cost model for estimating costs associated with operating and maintaining wind energy projects. This model considers typical costs associated with ongoing operations, including scheduled maintenance, unscheduled repairs, site management, and support personnel of a facility that comprises any number of conventional wind turbines. Data from a variety of wind power projects that represent different turbine types, turbine ages, and geographic locations have been used to develop the assumptions. The model includes a range of generic turbine sizes, with representative costs for parts and projected parts replacement rates, and default assumptions about staffing levels, labor rates, crane costs, etc. The model produces estimates of O&M costs based on averages of past performance of equipment that is not always representative of current or future wind turbines. Significant changes have occurred in wind turbine technology over the past decade, in both scale and configuration. The megawatt-scale, pitch-regulated, variable-speed turbines that are common today have a relatively short operating history. Many are still under warranty, so the reliability data for even this short time period are generally not available to the public. The component failures that do occur with newer machines often reflect a design that is not fully refined, and, therefore, may not be an accurate predictor of future reliability. The model does not reflect premature or serial failures, but rather uses failure rates that are appropriate for mature industrial equipment that has been field tested and proven.

For each turbine model assessed, DNV KEMA input the number of turbines, associated hub height (80-m), pitch control (hydraulic or electric, depending on model) and power conversion (full or partial, depending on model). For staffing, we assumed a single site manager and a senior technician dedicating 25% of their time annually for operating and maintaining the turbines. Using these inputs, the O&M model produced the following:

- Three 1A turbines:
    - Years 1-5, average: $41,300/turbine/year
    - Years 6-10, average: $48,000/turbine/year
    - Years 11-15, average: $57,000/turbine/year
    - Years 16-20, average: $56,500/turbine/year
- Three 1B turbines:
    - Years 1-5, average: $39,600/turbine/year
    - Years 6-10, average: $45,500/turbine/year
    - Years 11-15, average: $53,600/turbine/year
    - Years 16-20, average: $53,300/turbine/year
- Two 1C turbines:
    - Years 1-5, average: $52,800/turbine/year
    - Years 6-10, average: $58,500/turbine/year

- Years 11-15, average: $65,700/turbine/year
- Years 16-20, average: $73,200/turbine/year

These results were subsequently used in the financial analysis model, discussed below.

In addition to turbine O&M costs, DNV KEMA also estimated BOP O&M costs for years 1-20. These costs are based on data from our project cost database. BOP O&M items include transmission charges, O&M facilities (e.g., buildings, roads, fencing), communications, substation/ interconnect O&M, collection system O&M (overhead and below ground lines), electric usage, and others. A BOP O&M cost of $4,500 per MW per year was used for this analysis.

8.1.3 Other Inputs

In addition to the capital and O&M costs presented in Sections 8.1.1 and 8.1.2 above, the following inputs were used in the financial model for Scenario 1:

- 20-year operating life.
- Annual inflation of 2%.
- Nominal discount rate of 8.5%.
- Energy sales price per PSE Schedule 91 (see Section 5.1.1). For years beyond 2026, an annual escalation of 2.5% was applied, which is consistent with the annual rate increases through 2026 per Schedule 91.
- Monthly fee of $100 for interconnection to PSE's system.
- Construction completed and commercial operation in 2013.
- CAPEX funded from 40% cash/equity and 60% debt (loan).
- For debt portion:
    - 15-year loan term
    - Annual interest rate of **7%**

8.1.4 Financial Model Results

Energy production estimates (from Section 7) were combined with total project capital costs, operating costs, and the other specified inputs for each Scenario 1 turbine to develop the financial model. DNV KEMA used an in-house, Excel-based cash flow pro forma model to evaluate the project financial performance over the life of the project for the Scenario 1 turbines. The summary results for the small power production Scenario 1 are shown in Table 8-1 below.

Table 8-1. Financial Model Results: Small Power Production Scenario 1

	Turbine 1A	Turbine 1B	Turbine 1C
Turbine Rating[a]	1.5–2.5 MW	1.5–2.5 MW	1.5–2.5 MW
Number of Turbines	3	3	2
Total Installed Capacity	~5 MW	~5 MW	~5 MW
P50 Net Capacity Factor	23.7%	25.6%	23.3%
Total Plant Cost	$11,760,000	$9,750,000	$9,340,000
Amount Debt-Financed	60%	60%	60%
Total Project Cost Over 20 Years[b]	$21,741,000	$18,565,000	$17,472,000
Average Cost Per Year	$1,087,000	$928,000	$874,000
Energy Sales Revenue Over 20 Years	$16,885,000	$16,212,000	$14,140,000
Average Energy Sales Revenue Per Year	$844,000	$811,000	$707,000
Simple Payback Period	25.8 years	22.9 years	24.7 years
20-Year Internal Rate of Return (IRR)[c]	-6.1%	-3.3%	-5.1%
20-Year Net Present Value (NPV) of Project	-$4,694,000	-$3,316,000	-$3,554,000

a. Turbines evaluated range in capacity from approximately 1.5MW to 2.5MW. Due to confidentiality reasons, exact turbine rating cannot be disclosed.

b. Includes CAPEX (cash/equity portion plus financed portion) plus OPEX

c. Pre-tax, leveraged

8.2 Scenario 2: Economic Analysis for Net Metering

For Scenario 2, DNV KEMA evaluated the use of a single 100kW turbine on a 37-m tower with an energy production payment structure and estimated energy generation values as discussed in Sections 5.2 and 7.2, respectively. Similar to Scenario 1, for confidentiality reasons, the turbine make/model (and associated technical attributes and pricing) cannot be disclosed; therefore, this turbine is referred to as Turbine 2.

8.2.1 Capital Costs

For Scenario 2, a turn-key cost estimate of $550,000 was provided by the turbine supplier including turbine purchase ($365,000) and installation ($185,000). In addition to this amount, DNV KEMA included another $25,000 to cover further development/engineering costs plus a 10% construction contingency.

8.2.2 Operations and Maintenance Costs

For Scenario 2, a cost estimate of $2,000 per year was provided by the turbine supplier for provision of operations and maintenance (O&M) services for the single 100kW turbine. For financial modeling purposes, DNV KEMA used this pricing for years 1 through 10; however, we incrementally increased this amount by 10% for years 10 through 15 ($2,200) and another 10% for years 16 through 20 ($2,420) to account for aging equipment. In addition to turbine O&M

costs, DNV KEMA also estimated $200 per year for other O&M activities that may be needed, including maintaining roads, fencing, communications, and collection system components.

8.2.3 Other Inputs

In addition to the capital and O&M costs presented in Sections 8.2.2 and 8.2.2 above, the following inputs were used in the financial model for Scenario 2:

- 20-year operating life
- Annual inflation of 2%
- Nominal discount rate of 8.5%
- Energy offset price of $93.82 per MWh (per Section 5.2.1), escalated annually at rate of inflation
- Incentive payment of $12.00 per MWh (per Section 5.2.1), with a cap of $5,000 per year
- Construction completed and commercial operation in 2013
- CAPEX fully funded from cash (no debt financing)

8.2.4 Financial Model Results

Energy estimates (from Section 07.2) were combined with total project capital costs, operating costs, and the other specified inputs for Scenario 2 to develop the financial model. DNV KEMA used the same in-house, Excel-based cash flow pro forma model to evaluate the project financial performance over the life of the Scenario 2 100-kW turbine. The summary results for the net metering Scenario 2 are shown in Table 8-2below.

Table 8-2. Financial Model Results: Net Metering Scenario 2

Turbine Rating	100 kW
Number of Turbines	1
Total Installed Capacity	100 kW
P50 Net Capacity Factor	17.1%
Total Plant Cost	$594,000
Amount Financed	0
Total Project Cost Over 20 Years[a]	$669,000
Average Cost Per Year	$33,000
Energy Savings Over 20 Years	$384,000
Average Energy Savings Per Year	$19,000
Simple Payback Period	34.8 years
20-Year Internal Rate of Return (IRR) [b]	-5.3%
20-Year Net Present Value (NPV) of Project	-$355,000

a. Includes CAPEX (cash only) plus OPEX

b. Pre-tax, unleveraged

9 CONCLUSIONS

Based on the long-term adjusted 80-m hub-height wind resource, an approximate 5 MW wind project installed at the Hillaire property is expected to produce on average P50 net energy of 11.3 to 13.4 GWh per year. The corresponding P50 net capacity factors are 23.3% and 25.6%, respectively. The payback period is estimated to be greater than 20 years, (the assumed life of the wind turbines), thereby resulting in a negative internal rate of return (IRR) and negative net present value (NPV).

A 100-kW wind turbine located at the Se'eye'chen Youth Center (the LIBC facility with the highest wind resource) is expected to generate on average P50 net energy of 150 MWh per year, with a corresponding P50 net capacity factor of 17.1%. The payback period is estimated to be 35 years, (well beyond the assumed 20-year life of the wind turbine), thereby resulting in a negative IRR and NPV.

Under either scenario, a wind energy development project of the type described in this report would likely not be economically viable for the LIBC. For comparison, we note that economically feasible wind energy projects constructed in the United States typically have net capacity factors exceeding 30% and benefit from government incentives such as the Production Tax Credit (PTC) or Investment Tax Credit (ITC), which are set to expire on December 31, 2012.

In order to evaluate what it would require for a wind project on the Reservation to be financially desirable (i.e., positive NPV), DNV KEMA has modeled Scenario 1, assuming the use of Turbine 1B, with the following sensitivities:

A. Higher PPA pricing - a year 1 PPA price of $91.50 per MWh (escalated annually at 2.5%) would result in a positive 20-year NPV;
B. Lower CAPEX - lower capital costs by approximately $4,300,000 (44%) would result in a positive 20-year NPV;
C. Some combination of A and B; or
D. Renewable Energy Incentives - Assuming the PTC is extended (currently set to expire on December 31, 2012), accelerated depreciation is applied (per Modified Accelerated Cost Recovery System – MACRS), and if the LIBC could attract an investor with a tax appetite, the following scenarios could result in a positive NPV (after tax, leveraged):
    1. Increase PPA pricing to $69.60 (escalated annually at 2.5%);
    2. Reduce CAPEX by approximately $1,600,000 (while maintaining the current PSE PPA energy sales rate structure per Section 5.1.1); or
    3. Some combination of D1 and D2

Given the current power market conditions, it is unlikely that PPA prices will increase to Sensitivity A's rate of $91.50 per MWh in the near term. While a decline of turbine sales in 2012 due to PTC expiration may lower turbine costs (the trend of-late), the significant CAPEX reduction required for Sensitivity B is also unlikely.

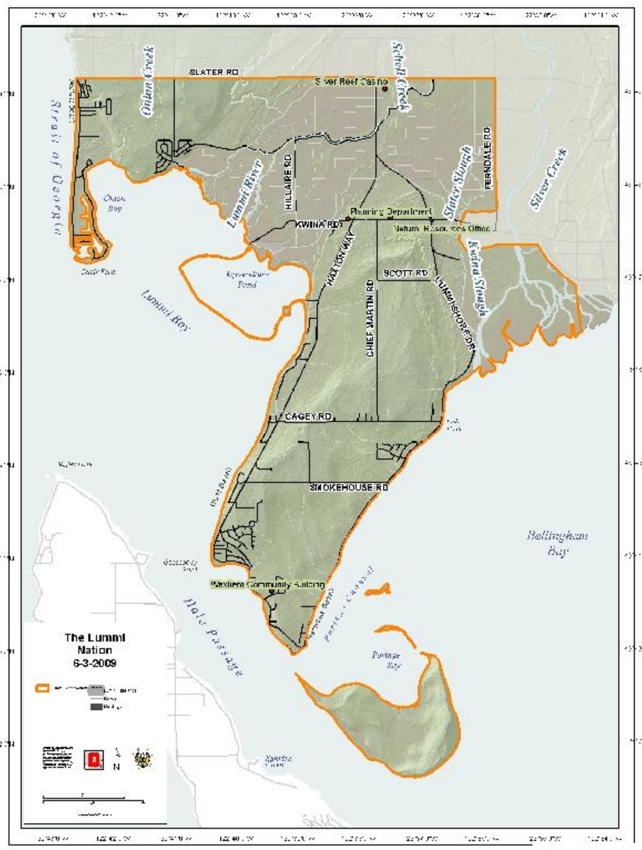
The Sensitivity D combination of PTC and MACRS with either increased PPA pricing or reduced CAPEX would likely be the most realistic. The D1 increased PPA pricing of $69.60 could potentially be achieved through energy sales to another off-taker (e.g., municipal coop or industry) or rate negotiation with PSE. The D2 CAPEX reduction of $1.6 million could potentially be realized through fund raising, grants, reduction in turbine pricing, or other means to reduce capital costs.

APPENDIX A

WIND TURBINE TECHNICAL NOISE ANALYSIS

j.c. brennan & associates
consultants in acoustics

Wind Turbine Technical Noise Analysis
Contract # 166-10
August 2012



Prepared for:

Lummi Nation
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Program Manager: Jeremy Freimund
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Bellingham, WA 98226

LUMMI NATION
TREATY OF 1855

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August 13, 2012

Mr. Jeremy Freimund
Lummi Indian Natural Resources Department
2616 Kwina Road
Bellingham, WA 98226

Subject: Submittal of the Wind Turbine Noise Analysis Results for the Lummi Nation Wind Turbine Feasibility Study

Dear Jeremy,

Attached you will find the Wind Turbine Technical Noise Analysis for the Lummi Nation Wind Turbine Feasibility Study. An original bound copy is being sent via mail.

Please feel free to contact me if you have questions.

Respectfully submitted,

j.c. brennan & associates, Inc.

Jim Brennan
President
Member: Institute of Noise Control Engineering

EXECUTIVE SUMMARY

The following provides the results of the analysis of noise impacts associated with the proposed wind turbine project for the Lummi Reservation Wind Turbine Feasibility Study. This analysis includes the results of the ambient noise survey and modeling calibration which was previously provided in a report dated August 2012. To quantify the existing ambient noise environment in the project vicinity, four (4) continuous hourly noise level monitoring sites were identified, and four (4) short-term noise level measurement sites were identified. Each of the sites, with the exception of one site, represents noise sensitive areas, such as residential and hotel land uses. One of the continuous hourly noise measurement sites (Site LT-2) was located at the Smokehouse Road meteorological tower to assist in establishing background noise to measured wind speed. The continuous hourly noise measurements were conducted for a period between six (6) and seven (7) days. In addition, infrasound measurements were conducted at each of the short-term noise measurement sites.

The results of the ambient noise survey indicate that overall background noise levels are low. The area can generally be characterized as a quiet noise environment, and consistent with a rural area. The noise measurement data will be used for a comparison to potential wind turbine noise levels which will be determined at a later date.

Infrasound noise, or very low frequency noise in the 1 Hz to 20 Hz range were also measured for short periods of time (approximately 10 to 15 minutes). The infrasound measurements indicated that some infrasound is currently present in the area, and is generally due to distant roadway traffic. The infrasound noise measurements were conducted in the early morning hours of April 20th, 2011. There were light winds during the measurement period, and therefore, existing infrasound noise levels were low. Generally, when winds range between 10 and 15 mph, measured infrasound levels can be expected to be significantly higher than those which were measured during the morning of April 20th.

To predict noise levels associated with the proposed three-turbine array of wind turbines, the CadnaA Noise Prediction Model was employed. This model is a state-of-the-art noise prediction model which accounts for multiple noise sources, sound power data for the noise source, noise source heights, topography ground type, and atmospheric conditions. A calibration of the CadnaA Noise Prediction Model was conducted based upon measured noise levels at the ambient noise monitoring sites while the existing tsunami warning system was activated. Noise level data provided by the tsunami manufacturer was used as direct inputs to the CadnaA Model for conducting the calibration of the model. The results indicated that the CadnaA Noise Prediction Model was accurate within 1.5 dBA at the noise monitoring locations used in the calibration process.

The results of the Wind Turbine Noise Impact Analysis

INTRODUCTION

The Lummi Nation Natural Resources Department has contracted with j.c. brennan & associates, Inc. to conduct an analysis of wind turbine noise impacts associated with the potential construction and operation of wind turbine arrays on the Lummi Nation Reservation. This document represents the final task for evaluating the wind turbine noise impacts.

BACKGROUND INFORMATION ON NOISE

Fundamentals of Acoustics

Acoustics is the science of sound. Sound may be thought of as mechanical energy of a vibrating object transmitted by pressure waves through a medium to human (or animal) ears. If the pressure variations occur frequently enough (at least 20 times per second), then they can be heard and are called sound. The number of pressure variations per second is called the frequency of sound, and is expressed as cycles per second or Hertz (Hz).

Noise is a subjective reaction to different types of sounds. Noise is typically defined as (airborne) sound that is loud, unpleasant, unexpected or undesired, and may therefore be classified as a more specific group of sounds. Perceptions of sound and noise are highly subjective from person to person.

Measuring sound directly in terms of pressure would require a very large and awkward range of numbers. To avoid this, the decibel scale was devised. The decibel scale uses the hearing threshold (20 micropascals), as a point of reference, defined as 0 dB. Other sound pressures are then compared to this reference pressure, and the logarithm is taken to keep the numbers in a practical range. The decibel scale allows a million-fold increase in pressure to be expressed as 120 dB, and changes in levels (dB) correspond closely to human perception of relative loudness.

The perceived loudness of sounds is dependent upon many factors, including sound pressure level and frequency content. However, within the usual range of environmental noise levels, perception of loudness is relatively predictable, and can be approximated by A-weighted sound levels.

There is a strong correlation between A-weighted sound levels (expressed as dBA) and the way the human ear perceives sound. For this reason, the A-weighted sound level has become the standard tool of environmental noise assessment. All noise levels reported in this section are in terms of A-weighted levels, but are expressed as dB, unless otherwise noted.

The decibel scale is logarithmic, not linear. In other words, two sound levels 10 dB apart differ in acoustic energy by a factor of 10. When the standard logarithmic decibel is A-weighted, an increase of 10 dBA is generally perceived as a doubling in loudness. For example, a 70 dBA sound is half as loud as an 80 dBA sound, and twice as loud as a 60 dBA sound.

Community noise is commonly described in terms of the ambient noise level, which is defined as the all-encompassing noise level associated with a given environment. A common statistical tool to measure the ambient noise level is the average, or equivalent, sound level (L_{eq}), which corresponds to a steady-state A-weighted sound level containing the same total energy as a time varying signal over a given time period (usually one hour). The L_{eq} is the foundation of the composite noise descriptor, L_{dn}, and shows very good correlation with community response to noise. The L(n) is the sound level exceeding a described percentile over a measurement period. For instance, an hourly L50 is the sound level exceeded 50% of the time during the one hour period.

The day/night average level (L_{dn}) is based upon the average noise level over a 24-hour day, with a +10 decibel weighing applied to noise occurring during nighttime (10:00 p.m. to 7:00 a.m.) hours. The nighttime penalty is based upon the assumption that people react to nighttime noise exposures as though they were twice as loud as daytime exposures. Because L_{dn} represents a 24-hour average, it tends to disguise short-term variations in the noise environment. Table 1 lists several examples of the noise levels associated with common noise sources. Appendix A provides a summary of acoustical terms used in this report.

Effects of Noise on People

The effects of noise on people can be placed in three categories:

- Subjective effects of annoyance, nuisance, and dissatisfaction
- Interference with activities such as speech, sleep, and learning
- Physiological effects such as hearing loss or sudden startling

Environmental noise typically produces effects in the first two categories. Workers in industrial plants can experience noise in the last category. There is no completely satisfactory way to measure the subjective effects of noise or the corresponding reactions of annoyance and dissatisfaction. A wide variation in individual thresholds of annoyance exists and different tolerances to noise tend to develop based on an individual's past experiences with noise.

Thus, an important way of predicting a human reaction to a new noise environment is the way it compares to the existing environment to which one has adapted: the so-called ambient noise level. In general, the more a new noise exceeds the previously existing ambient noise level, the less acceptable the new noise will be judged by those hearing it.

Table 1
Typical Maximum Noise Levels

Common Outdoor Activities	Noise Level (dBA)	Common Indoor Activities
	--110--	Rock Band
Jet Fly-over at 300 m (1,000 ft)	--100--	
Gas Lawn Mower at 1 m (3 ft)	--90--	
Diesel Truck at 15 m (50 ft), at 80 km/hr (50 mph)	--80--	Food Blender at 1 m (3 ft) Garbage Disposal at 1 m (3 ft)
Noisy Urban Area, Daytime Gas Lawn Mower, 30 m (100 ft)	--70--	Vacuum Cleaner at 3 m (10 ft)
Commercial Area Heavy Traffic at 90 m (300 ft)	--60--	Normal Speech at 1 m (3 ft)
Quiet Urban Daytime	--50--	Large Business Office Dishwasher in Next Room
Quiet Urban Nighttime	--40--	Theater, Large Conference Room (Background)
Quiet Suburban Nighttime	--30--	Library
Quiet Rural Nighttime	--20--	Bedroom at Night, Concert Hall (Background)
	--10--	Broadcast/Recording Studio
Lowest Threshold of Human Hearing	--0--	Lowest Threshold of Human Hearing

Source:Caltrans, Technical Noise Supplement, Traffic Noise Analysis Protocol. October 2009.

With regard to increases in A-weighted noise level, the following relationships occur:

- Except in carefully controlled laboratory experiments, a change of 1 dBA cannot be perceived;
- Outside of the laboratory, a 3 dBA change is considered a just-perceivable difference;
- A change in level of at least 5 dBA is required before any noticeable change in human response would be expected; and
- A 10 dBA change is subjectively heard as approximately a doubling in loudness, and can cause an adverse response.

Stationary point sources of noise – including stationary mobile sources such as idling vehicles – attenuate (lessen) at a rate of approximately 6 dB per doubling of distance from the source, depending on environmental conditions (i.e. atmospheric conditions and either vegetative or manufactured noise barriers, etc.). Widely distributed noises, such as a large industrial facility spread over many acres, or a street with moving vehicles, would typically attenuate at a lower rate.

Infrasound Noise Levels

Infrasound and low frequency sound are subjects of current controversy with regards to residents living in proximity to proposed wind turbine projects. As described earlier, infrasound is considered to be in the 1Hz to 20 Hz range. Low frequency sound is considered to be in the 10 Hz to 200 Hz range. The audibility of sound in the infrasound and low frequency sound ranges should be discussed. The human ear and a person's ability to hear sound at low frequencies becomes more difficult in these frequencies. The human ear's acuteness at hearing sound decreases as the frequencies decrease. Table 2 shows hearing threshold for sound in the infrasound and low frequency sound ranges for young healthy individuals.

Table 2
Hearing Thresholds in the Infrasound and Low Frequency Ranges

Frequency (Hz)	4	8	10	16	20	25	40	50	80	100	125	160	200
Sound Pressure (dB)	107	100	97	88	79	69	51	44	32	27	22	18	14

Source: Leventhall et al., 2003

Infrasound is generally always present in the environment. Infrasound can be associated with many sources including ambient air turbulence or wind, distant aircraft or roadway traffic, and wave action on a sea shore. The human respiratory, circulatory and digestive systems all emit internal infrasound. A person's heart beats at a frequency of 1 to 2 Hz. The most common source of infrasound is vehicular.

Based upon research from 2002 to 2006, conducted by the Renewable Energy Research Laboratory at the University of Massachusetts at Amherst, Department of Mechanical and Industrial Engineering, the following conclusions are provided:

"The primary human response to perceived infrasound is annoyance, with resulting secondary effects. Annoyance levels typically depend on other characteristics of infrasound, including intensity, and variations in time. Infrasound has three annoyance mechanisms:

- *A feeling of static pressure*
- *Periodic masking effects in the medium and higher frequencies*
- *Rattling of doors, windows, etc. from strong low frequency components*

Human effects vary by the intensity of the perceived infrasound, which can be grouped in these approximate ranges:

- *90 dB and below: No evidence of adverse effects*
- *115 dB: Fatigue, apathy, abdominal symptoms, hypertension in some humans*
- *120 dB: Approximate threshold of pain at 10 Hz*
- *120 – 130 dB and above: Exposure to 24 hours causes physiological damage"*

To place infrasound into perspective, when a child is swinging high on a swing, the pressure change on its ears, from top to bottom of the swing, is nearly 120 dB at a frequency of around 1 Hz."

"There is no reliable evidence that infrasound below the perception threshold produces physiological or psychological effects."

(*Source: Wind Turbine Acoustic Noise, A White Paper, Prepared by: Renewable Energy Research Laboratory Department of Mechanical and Industrial Engineering, University of Massachusetts at Amherst, June 2002 Amended January 2006*).

REGULATORY SETTING

U.S. Environmental Protection Agency

In response to the Federal Noise Control Act of 1972, the U.S. Environmental Protection Agency (EPA) has identified noise levels requisite to protect public health and welfare against hearing loss, annoyance and activity interference (EPA 1974). The EPA recommended criteria are shown in Table 3.

The document (EPA 1974) identifies a 24-hour exposure level of 70 A-weighted decibel (dBA) as the level of environmental noise which would prevent any measurable hearing loss over a lifetime. Likewise, levels of 55 dBA outdoors and 45 dBA indoors are identified as preventing activity interference and annoyance. These levels of noise are considered those which will permit spoken conversation and other activities such as sleeping, working and recreation, which are part of the daily human condition. The levels are not single event, or "peak" levels. Instead, they represent averages of acoustic energy over periods of time such as 8 or 24 hours, and over even longer periods of time (e.g., years).

Table 3
Summary of Noise Levels Identified as Requisite to Protect the Public Health and Welfare with an Adequate Margin of Safety

Effect	Level dBA[1]	Activity Area
Hearing Loss	70 L_{eq} (24-hour)	All areas
Outdoor Activity Interference and Annoyance	55 L_{dn}[2]	Outdoors in residential areas and farms and other outdoor areas where people spend widely varying amounts of time and other places in which quiet is a basis for use
	55 L_{eq} (24-hour)[3]	Outdoor areas where people spend limited amounts of time (e.g., school yards, playgrounds)
Indoor Activity Interference and Annoyance	45 L_{dn}[2]	Indoor residential areas
	45 L_{eq} (24-hour)[3]	Other indoor areas with human activities (e.g., school yards playgrounds)

Source: EPA 1974
[1] A-weighted decibel (dBA) is a measure on a logarithmic scale which indicates the squared ratio of sound pressure to a reference sound pressure.
A-weighted (A) refers to the specific frequency-dependent rating scale that is used to approximate human response.
[2] Day-Night Level (L_{dn}) is the energy-average of the A-weighted noise levels during a 24-hour period with 10 dBA added to the night (10 p.m. to 7 a.m.) hours.
[3] Equivalent Noise Level (L_{eq} is the energy mean (average) noise level. The instantaneous noise levels during a specific period of time (e.g., 24 hour) in dBA are converted to relative energy values. From the sum of the relative energy values, an average energy value is calculated, which is then converted back to dBA to determine the 24-hour L_{eq}.

Lummi Nation Noise Level Criteria

The Lummi Nation does not have noise level criteria which addresses project-related noise sources.

Recommended Noise Level Criteria

Much research is available regarding acceptable noise levels for wind energy projects. Based upon our review of various studies, j.c. brennan & associates, Inc. recommends that the proposed project generate noise levels consistent with those recommended by the Massachusetts Department of Environmental Protection (MEP) (Table 4). This recommended practice for nighttime sound levels was developed by a panel of independent experts commissioned by the Massachusetts DEP.

Table 4
Promising Practices for Nighttime Sound Pressure Levels by Land Use Type

Land Use	Sound Pressure Level, dB(A) Nighttime Limits
Industrial	70
Commercial	50
Villages, mixed usage	45
Sparsely populated areas, 8 m/s wind*	44
Sparsely populated areas, 6 m/s wind*	42
Residential areas, 8 m/s wind*	39
Residential areas, 6 m/s wind*	37

**measured at 10 m above ground, outside of residence or location of concern*

Based upon the Table 4 data, j.c. brennan & associates, Inc. recommends that the project generate noise levels of 42 dBA, or less, at the sparsely populated residential areas closest to the project site and 37 dBA for other residential areas.

PHYSICAL SETTING

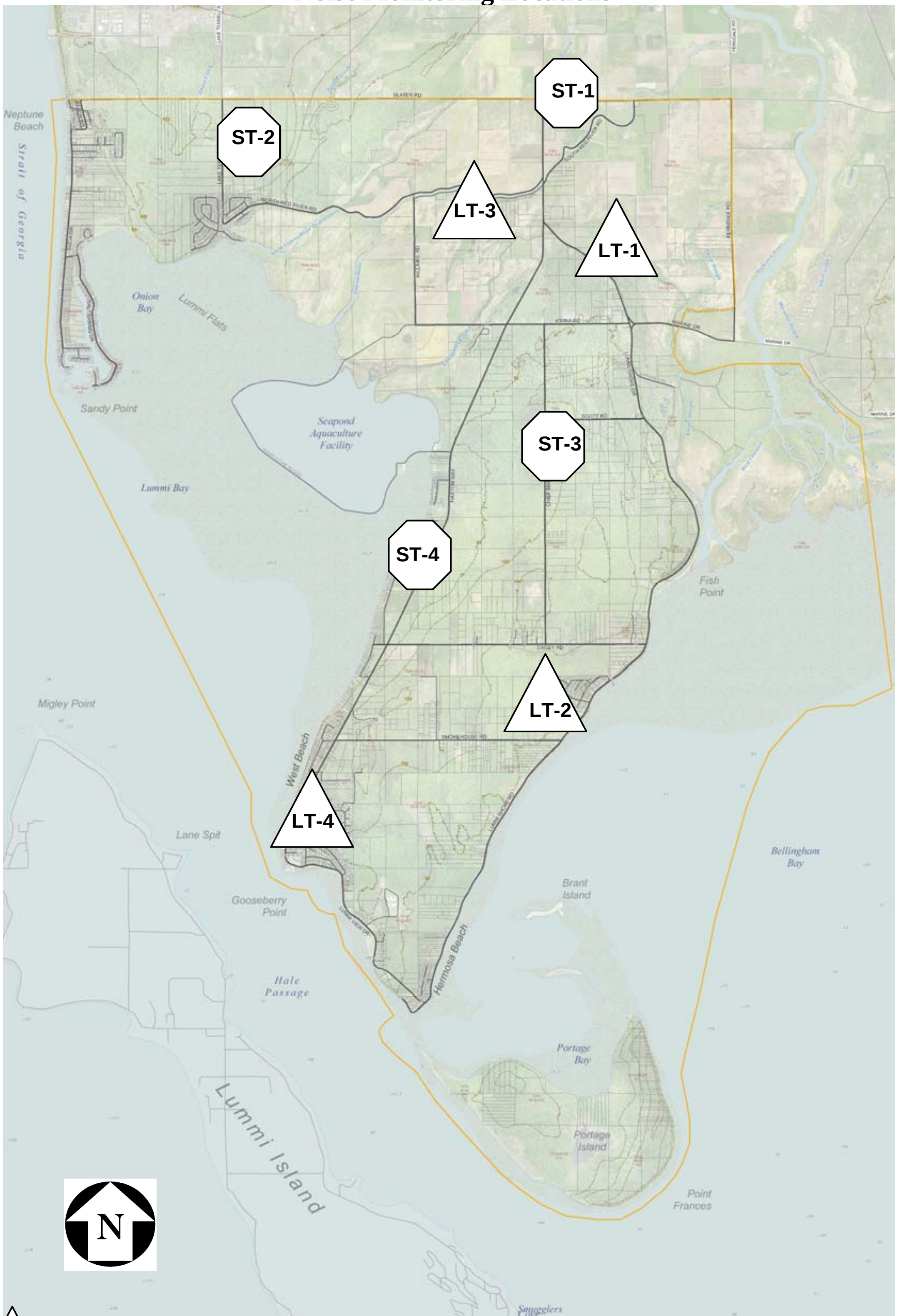
Existing Noise Environment in Project Vicinity

To quantify the existing ambient noise environment in the project vicinity, four (4) continuous hourly noise level monitoring sites were identified, and four (4) short-term noise level measurement sites were identified. Each of the sites, with the exception of one site, represents noise sensitive areas, such as residential and hotel land uses. One of the continuous hourly noise measurement sites (Site LT-2) was located at the Smokehouse Road meteorological tower to assist in establishing background noise to measured wind speed. The continuous hourly noise measurements were conducted for a period between six (6) and seven (7) days. In addition, infrasound measurements were conducted at each of the short-term noise measurement sites.

The continuous or long-term (LT) sound level meters were programmed to record the hourly maximum (Lmax), median (L_{50}), L_8, and average (L_{eq}) noise levels at each site during the survey. The maximum value, denoted L_{max}, represents the highest noise level measured. The average value, denoted L_{eq}, represents the energy average of all of the noise received by the sound level meter microphone during the monitoring interval periods. The median value, denoted L_{50}, represents the sound level exceeded 50 percent of the time during the monitoring period. The L_8 value represents the sound level exceeded 8 percent (5 minutes) of the time during the monitoring period. Figure 1 shows the locations of each of the noise monitoring sites.

Figure 1

Noise Monitoring Locations



LT-# Continuous Noise Monitoring Sites

ST-# Short-term Noise Monitoring Sites

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The noise level measurement survey results are provided in Table 5. Figures 2A through 2D shows the hourly ambient (L50) noise levels for each location over the noise monitoring period for each of the four continuous noise monitoring locations. See Appendix B for the complete continuous hourly noise measurement results.

Larson Davis Laboratories (LDL) Model 820 and Model 824 precision integrating sound level meters were used for the ambient noise level measurement survey. The meters were calibrated before and after use with an LDL Model CAL200 acoustical calibrator to ensure the accuracy of the measurements. Microphones were fitted with LDL windscreens to minimize the affects of wind across the diaphragm of the microphone. In addition, the continuous noise monitors were fitted with factory weather enclosures to ensure that moisture or condensation did not affect the microphone and preamplifier electronics. The equipment used meets all pertinent specifications of the American National Standards Institute for Type 1 sound level meters and 1/3 octave band filters (ANSI S1.4). All meters were set on A-weighting, slow response, and collected data in the dynamic range of 20 Hz to 20000 Hz.

Table 5
Summary of Ambient Noise Monitoring Results

Site	Date	Ldn, dBA	Daytime Hourly Average Noise Levels, dBA			Nighttime Hourly Average Noise Levels, dBA		
			Leq	L50	L08	Leq	L50	L08
LT-1	4/20/2011 – Wed.	50.7	47.8	42	50	43.3	35	43
	4/21/2011 – Thrs.	50.5	47.8	42	51	43.0	37	44
	4/22/2011 – Fri.	52.4	50.0	43	52	44.7	37	44
	4/23/2011 – Sat.	52.0	49.6	43	52	44.3	40	47
	4/24/2011 – Sun.	5.3.2	48.0	42	52	46.5	40	47
	4/25/2011 – Mon.	51.9	50.2	44	52	43.8	38	45
	4/26/2011 – Tue.	50.1	45.9	41	49	43.1	40	45
LT-2	4/20/2011 – Wed.	52.8	50.1	43	51	45.2	39	46
	4/21/2011 – Thrs.	53.5	48.2	44	52	46.9	38	49
	4/22/2011 – Fri.	54.7	48.3	44	51	48.3	45	51
	4/23/2011 – Sat.	51.6	48.4	43	51	44.3	39	48
	4/24/2011 – Sun.	55.6	50.0	47	54	49.1	44	51
	4/25/2011 – Mon.	57.8	58.4	55	61	46.5	42	49
	4/26/2011 – Tue.	55.5	50.0	46	53	48.9	45	51
LT-3	4/20/2011 – Wed.	51.9	49.7	41	49	44.2	40	45
	4/21/2011 – Thrs.	51.4	48.1	42	49	44.1	40	45
	4/22/2011 – Fri.	54.0	51.7	43	50	46.3	41	46
	4/23/2011 – Sat.	53.8	49.1	42	50	47.0	44	48
	4/24/2011 – Sun.	52.2	47.6	45	50	45.5	43	48
	4/25/2011 – Mon.	52.6	50.1	45	51	44.9	40	46
	4/26/2011 – Tue.	53.7	48.1	45	50	47.1	43	48
LT-4	4/28/2011 – Thrs.	50.9	45.5	43	48	44.3	42	47
	4/29/2011 – Fri.	47.2	45.6	42	49	39.0	33	40
	4/30/2011 – Sat.	45.8	44.6	41	46	37.3	32	38
	5/01/2011 – Sun.	46.4	41.3	38	45	38.5	33	40
	5/02/2011 – Mon.	48.3	39.8	39	43	40.2	34	41
	5/03/2011 – Tue.	47.9	47.1	42	50	39.0	36	41
ST-1	4/20/2011 – Thrs	---	---	---	---	60.8	---	---
ST-2	4/20/2011 – Thrs	---	---	---	---	51.6	---	---
ST-3	4/20/2011 – Thrs	---	---	---	---	37.3	---	---
ST-4	4/20/2011 – Thrs	---	---	---	---	45.2	---	---

Source: j.c. brennan & associates, Inc. 2011.

Figure 2A: Hourly Ambient Noise Levels - Site LT-1

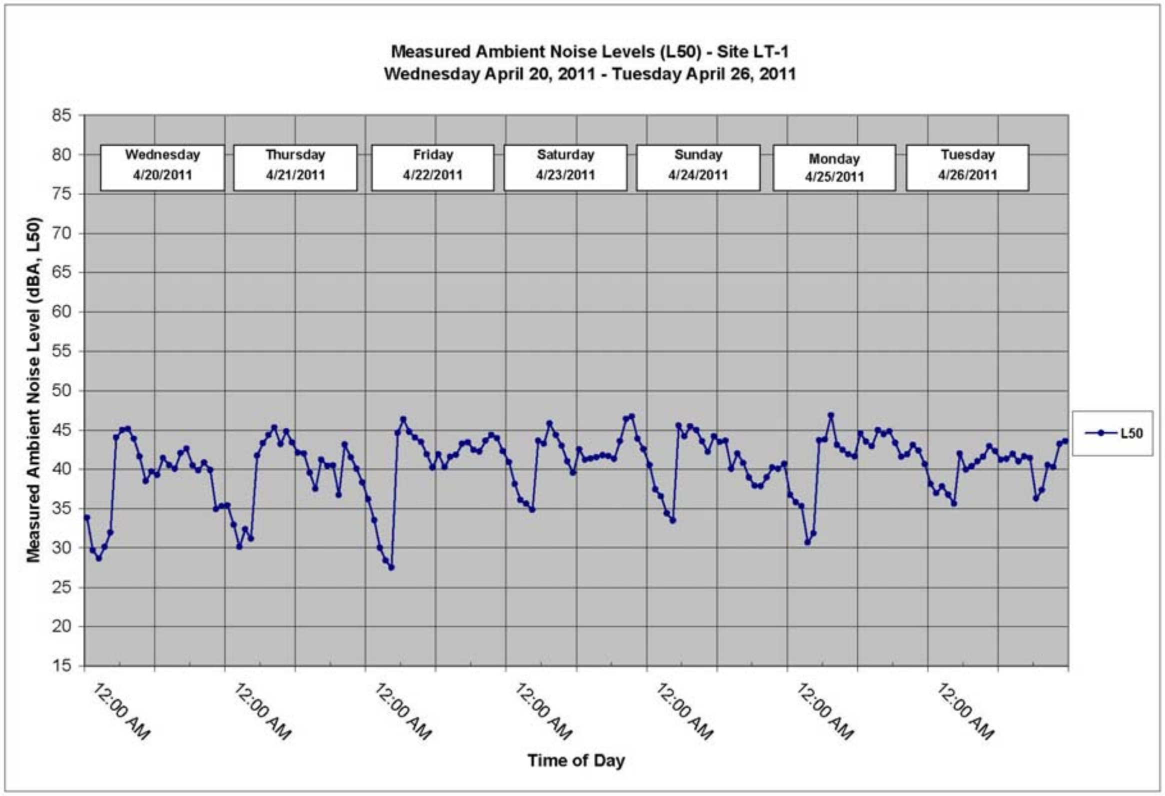


Figure 2B: Hourly Ambient Noise Levels - Site LT-2

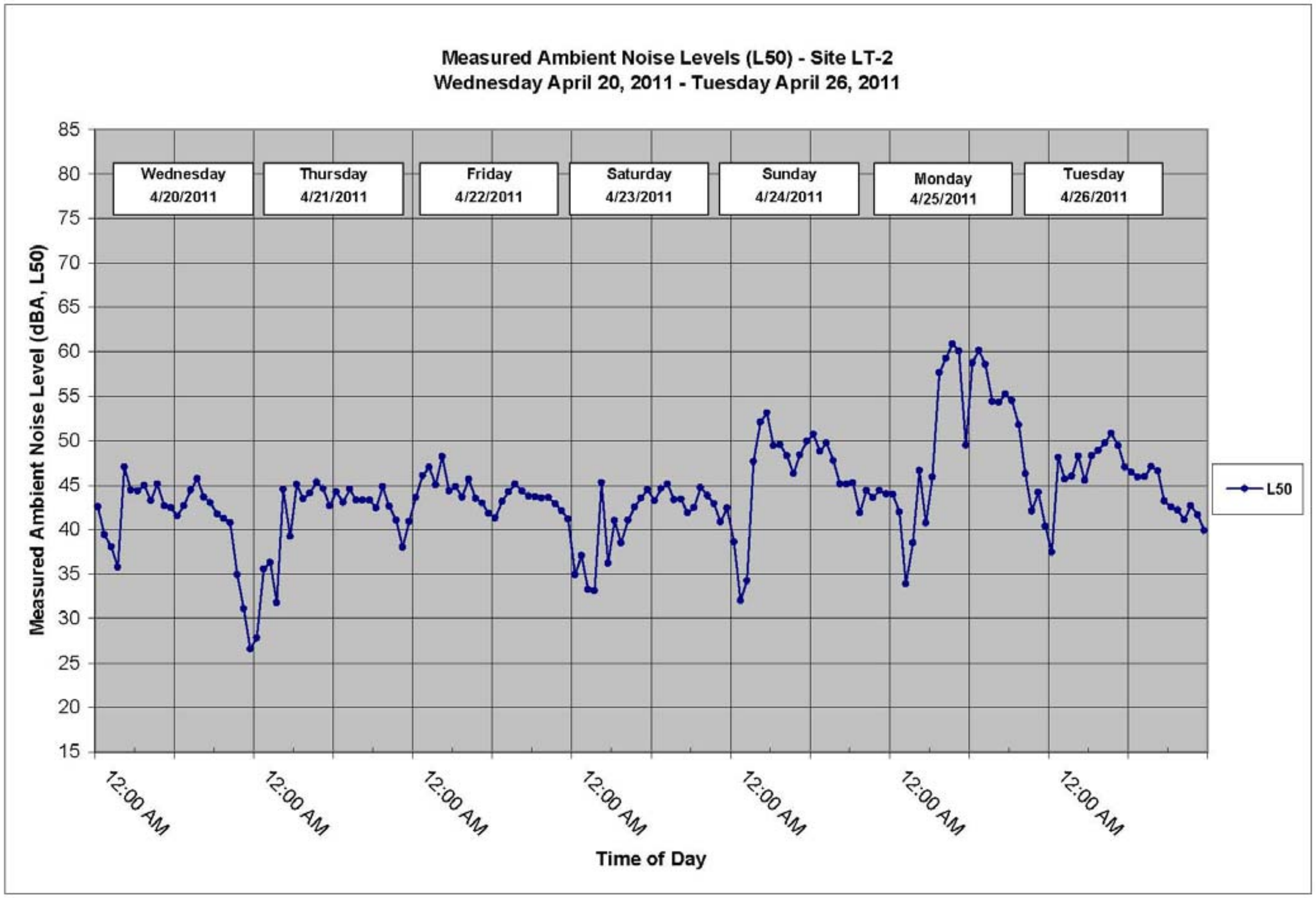


Figure 2C: Hourly Ambient Noise Levels - Site LT-3

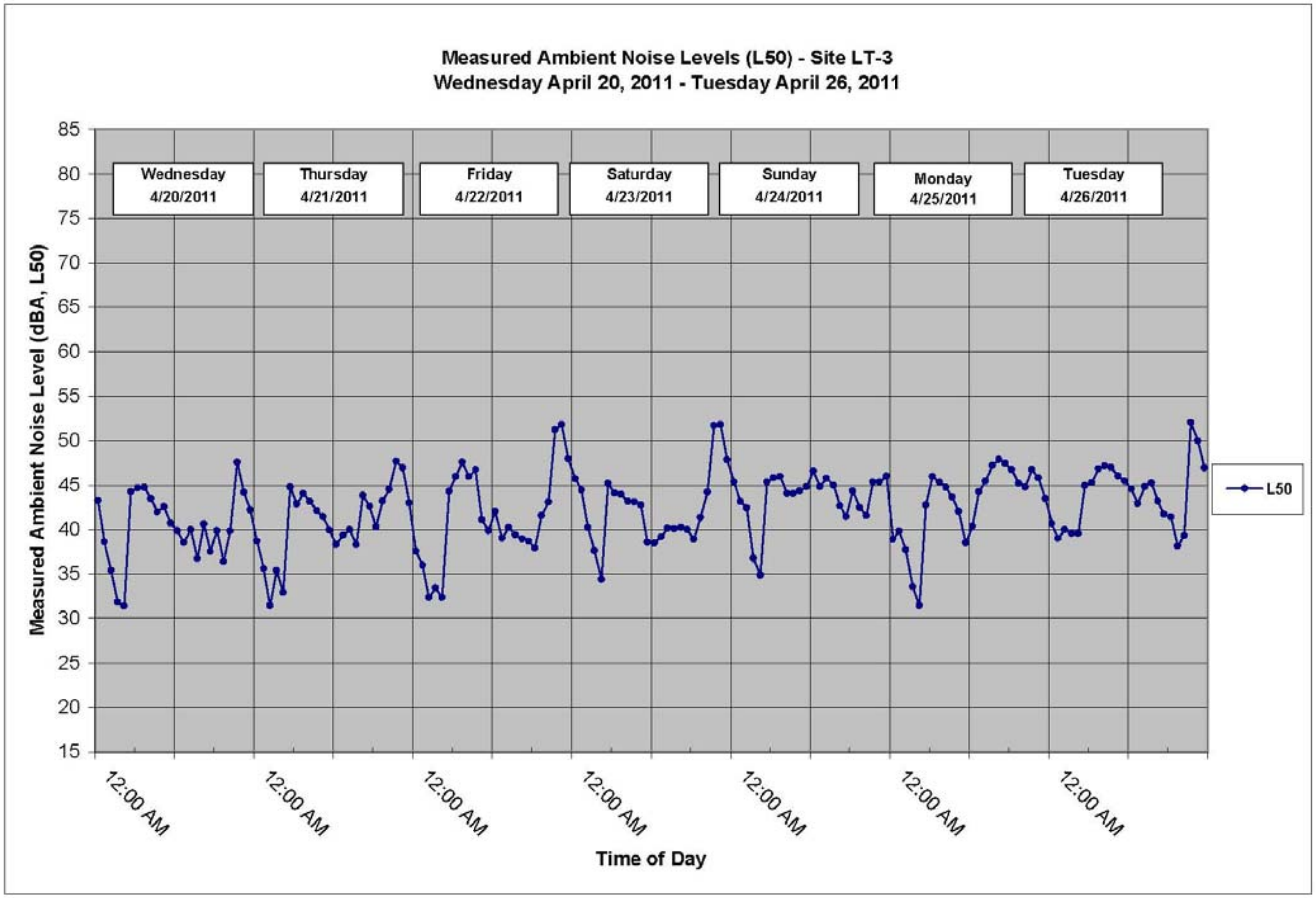
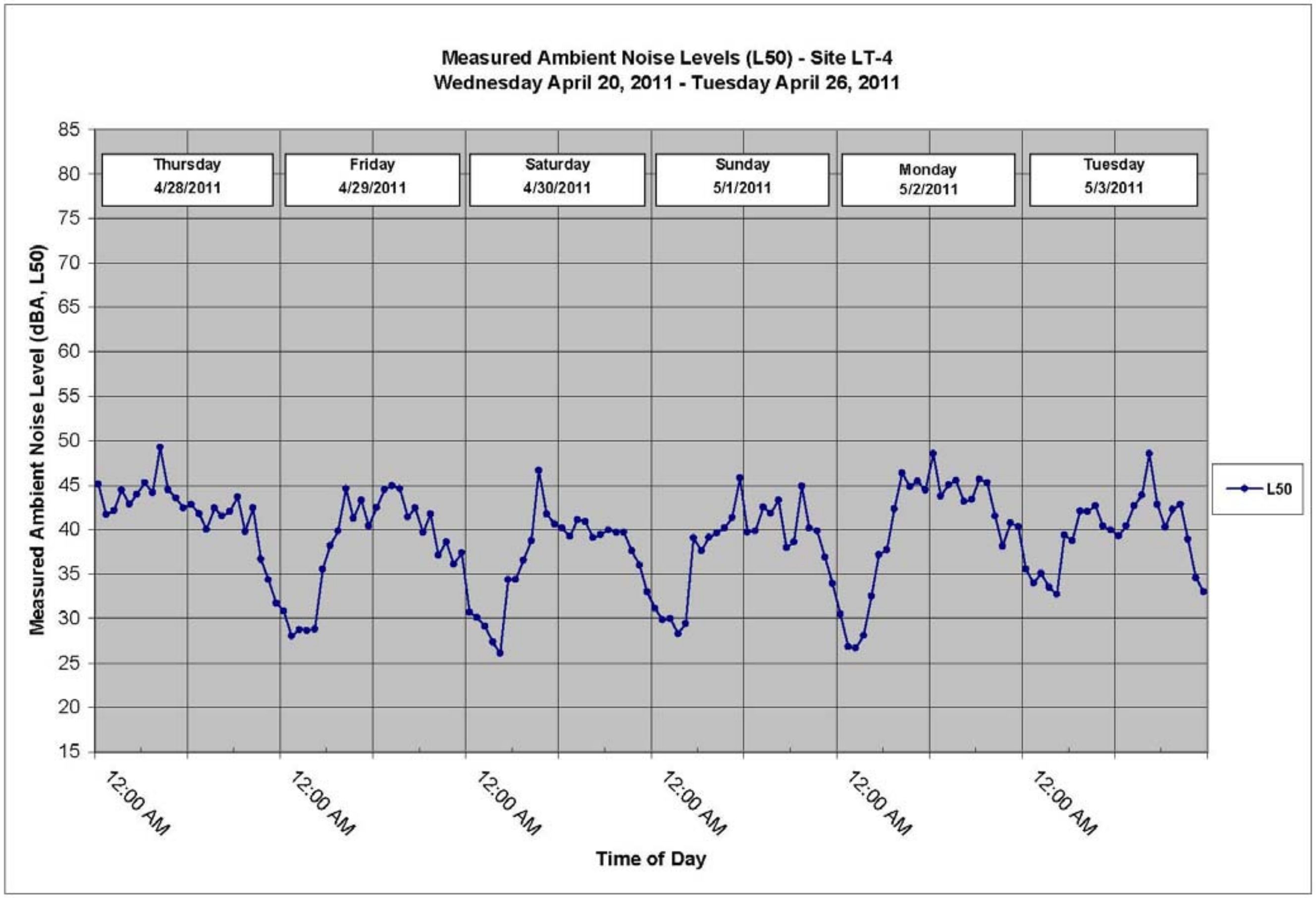


Figure 2D: Hourly Ambient Noise Levels - Site LT-4



Description of Ambient Noise Monitoring Locations

Below is a description of each of the ambient noise measurement sites:

Site LT-1: This was a long term continuous hourly noise measurement site which was monitored for seven consecutive days from April 20th through April 26th, 2011. The site was located approximately 200 feet east of Lummi Shore Drive, in the wetland restoration area of Smugglers Slough. The coordinates are 48°48'4.63"N, 122º37'10"W.

Site LT-2: This was a long term continuous hourly noise measurement site which was monitored for seven consecutive days from April 20th through April 26th, 2011. The site was located at the Smokehouse Road Meteorological Tower site. The coordinates are 48°44'50"N, 122°37'34"W.

Site LT-3: This was a long term continuous hourly noise measurement site which was monitored for seven consecutive days from April 20th through April 26th, 2011. The site was located Jefferson residence located west of Haxton Road. The coordinates are 48º48'7"N, 122º38'2"W.

Site LT-4: This was a long term continuous hourly noise measurement site which was monitored for seven consecutive days from April 28th through May 3rd, 2011. The site was located at the Gooseberry Point Fire Station. The coordinates are 48°44'11"N, 122°40'5"W.

Site ST-1: This was a short term noise measurement site which was monitored once during the nighttime period on April 20, 2011. The site was located in the parking lot of the Silver Reef Casino. This site was also used for collecting background infrasound noise levels which are discussed later in this report.

Site ST-2: This was a short term noise measurement site which was monitored once during the nighttime period on April 20, 2011. The site was located on Lake Terrell Road, south of Slater Road. This site was also used for collecting background infrasound noise levels which are discussed later in this report.

Site ST-3: This was a short term noise measurement site which was monitored once during the nighttime period on April 20, 2011. The site was located at the intersection of Chief Martin Road and Scott Road. This site was also used for collecting background infrasound noise levels which are discussed later in this report.

Site ST-4: This was a short term noise measurement site which was monitored once during the nighttime period on April 20, 2011. This site was located on Harden Road, west of Haxton Way. This site was also used for collecting background infrasound noise levels which are discussed later in this report.

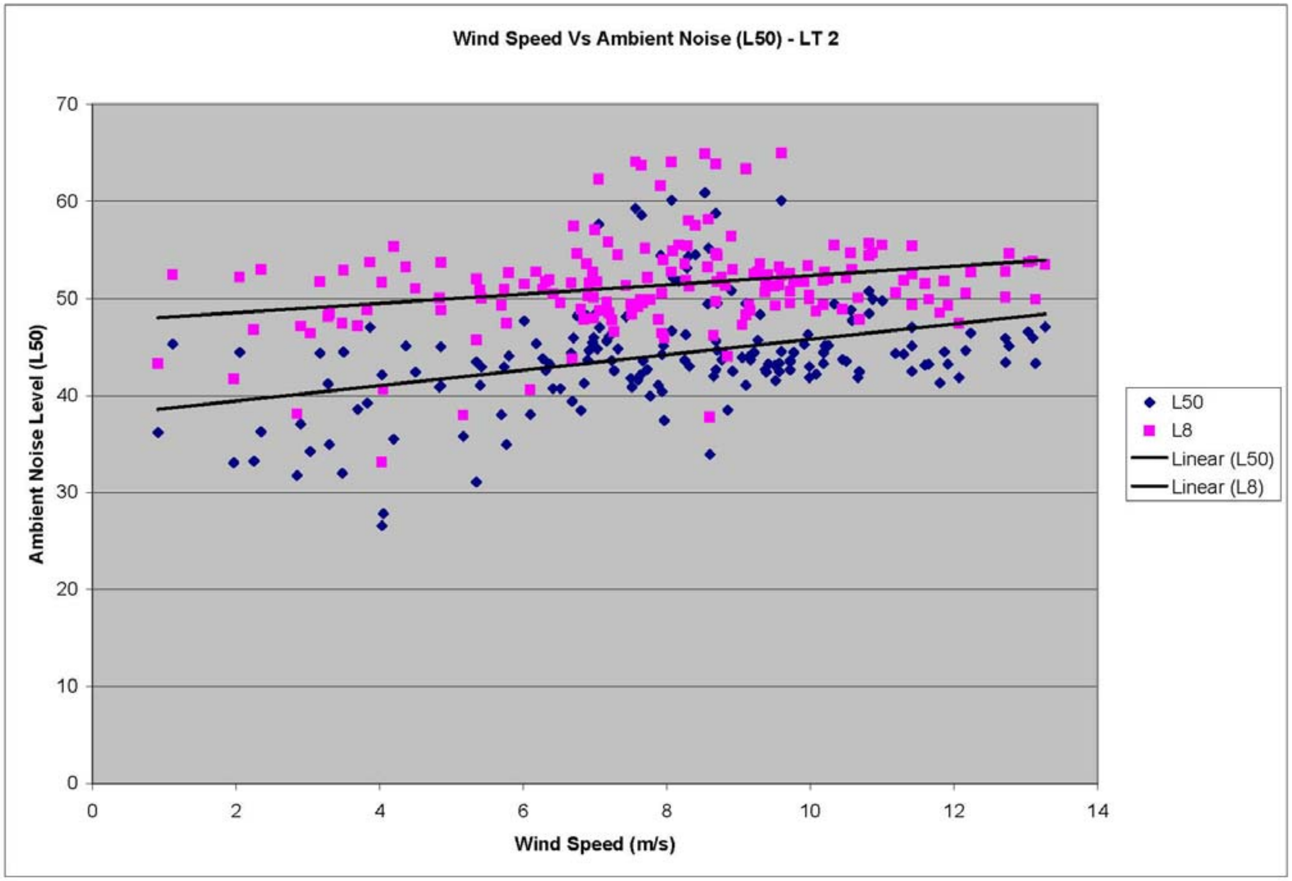
Table 4 shows the typical background noise levels during the daytime periods (7:00 a.m. – 10:00 p.m.) and nighttime periods (10:00 p.m. – 7:00 a.m.) at each of the continuous (LT) noise monitoring sites. In addition, Appendix B shows the complete results of the noise monitoring data for each day of monitoring. The maximum noise levels represent the maximum recorded noise levels for each hour. The hourly Leq values represent the energy average noise levels, which account for all measured sound, including periodic loud events. The L50 sound levels represent the mean sound level measured for the hour. The L50 discounts short-term periodic loud events. The L08 hourly noise levels discount all background noise, with the exception of the periodic loud events. Measured noise levels at the short-term noise measurement sites only included the average Leq noise levels.

Ambient Noise and Wind Speed

Another means of assessing the ambient noise environment is to prepare a scatter plot of measured ambient noise levels versus wind speeds. By adding a regression trendline to the collected data at Site LT-2 (the Smokehouse Meteorological Tower), it is possible to estimate the background noise levels as a function of wind speed. Wind data used for the regression analysis was collected at the Smokehouse meteorological tower. The results of the analysis are provided in Figure 3.

Figure 3 shows the wind speed data as compared to the noise measurement data collected at the meteorological tower (Site LT-2).

Figure 3: Ambient vs. Wind – Site LT-2



Measured Infrasound Noise Levels

j.c. brennan & associates, Inc. also conducted infrasound noise measurements at each of the short-term noise monitoring sites described above. The intent of conducting the infrasound noise measurements was to determine the background infrasound which is currently present in the environment.

Noise measurement equipment included an LDL Model 824 precision integrating sound level meter which was equipped with a G.R.A.S Type 40AN and Type 26AK pre-polarized low frequency microphone and preamplifier, respectively. The equipment meets all ANSI specifications for low frequency 1/3 octave band and narrow band noise measurements.

The results of the infrasound noise measurements are shown in Table 6. Based upon the measured background infrasound measurements, it is apparent that infrasound is already present in the background noise environment. Since winds were calm during the infrasound noise measurements, the existing measured infrasound levels are assumed to be due to distant roadway traffic. Based upon our experience conducting infrasound measurements during periods of wind between 10 and 15 mph, measured infrasound levels are in the 70 dB to 80 dB range.

Table 6
Measured Background Infrasound Noise Levels

Location	Date	Measured Levels Octave Band			
		1 Hz	2 Hz	5 Hz	10 Hz
ST-1 Silver Reef Casino	April 20, 2011	69.7 dB	64.3 dB	53.8 dB	52.9 dB
ST-2 Lake Terrell Road, south of Slater Road	April 20, 2011	73.8 dB	68.2 dB	53.9 dB	52.4 dB
ST-3 Intersection of Chief Martin Road and Scott Road	April 20, 2011	64.1 dB	58.7 dB	50.9 dB	49.7 dB
ST-4 Harden Road, west of Haxton Way	April 20, 2011	63.3 dB	57.6 dB	53.2 dB	46.9 dB
Source: j.c. brennan & associates, Inc. 2011.					

CALIBRATION OF CadnaA NOISE PREDICTION MODEL

Future analysis of wind turbine noise impacts will be provided in the future, when potential wind turbine types, configurations and turbine arrays have been determined. In order to predict noise levels at the nearest noise-sensitive receptors, j.c. brennan & associates, Inc. will utilize the CadnaA Noise Prediction Model, which is produced by DataKustik. The CadnaA model is able to predict overall noise levels for multiple noise sources, while also accounting for topography, air temperature, humidity, wind speed and wind direction. Inputs to the CadnaA model include ground topography and type, source locations, source heights, receiver locations, noise source sound power levels, and meteorological data.

As a means of calibrating the CadnaA Noise Prediction Model for future use, the model was used to predict noise levels associated with the existing Tsunami Warning System which is currently installed on the Lummi Reservation. Currently there are 3 warning towers located on the Lummi Reservation. The systems are manufactured by Federal Signal and include omni-directional speaker arrays, which produce a noise level of 125 dBC, at a distance of 100 feet. The systems are typically exercised on Friday's during the 12:00 p.m. hour. The alert notification is the "Westminster Chimes" signal.

As a means of collecting octave band noise levels associated with the Westminster Chimes signal, j.c. brennan & associates, Inc. conducted 1/3 octave band sound level measurements of the signal as produced on the Federal Signal website. This data was converted to sound power levels and used as direct inputs to the CadnaA Model. In addition, topographic base maps, and tower heights and locations which were provided by the Lummi Natural Resources Department were also used as direct inputs to the model. The CadnaA Noise Prediction Model was used to predict noise levels from the Tsumani Warning System at noise monitoring sites LT-1, LT-2 & LT-3 for the 12:00 p.m. hour on Friday April 22, 2011 when the warning signal was exercised.

> *Note: The warning system was supposed to be exercised on Friday April 29, 2011 when noise measurements were being conducted at monitoring site LT-4. However, based upon the measured noise levels collected at that site, it was apparent that the warning system was not exercised on that day.*

Table 7 shows the A-weighted sound power octave band levels which were input to the CadnaA Noise Prediction Model. Wind direction and wind speed were not entered into the model.

Table 7
Tsunami Warning System Octave Band Sound Power Levels, dBA

63.5 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
118	134	158	154	146	141	140	130
Source: General Electric & Siemens Power							

Predicted Tsunami Warning System Noise Levels

Figure 4 shows the predicted Tsunami Warning System maximum noise levels at each of the continuous noise measurement sites. Table 8 shows the predicted noise levels as compared to the measured noise levels at each of the sites.

As stated earlier, the warning system was supposed to be exercised on Friday April 29, 2011 when noise measurements were being conducted at monitoring site LT-4. However, based upon the measured noise levels collected at that site, it was apparent that the warning system was not exercised on that day. Therefore, Table 8 does not provide a correlation between the measured noise levels at site LT-4 and the warning system noise levels.

Table 8
Predicted vs Measured Tsunami Warning System Noise Levels

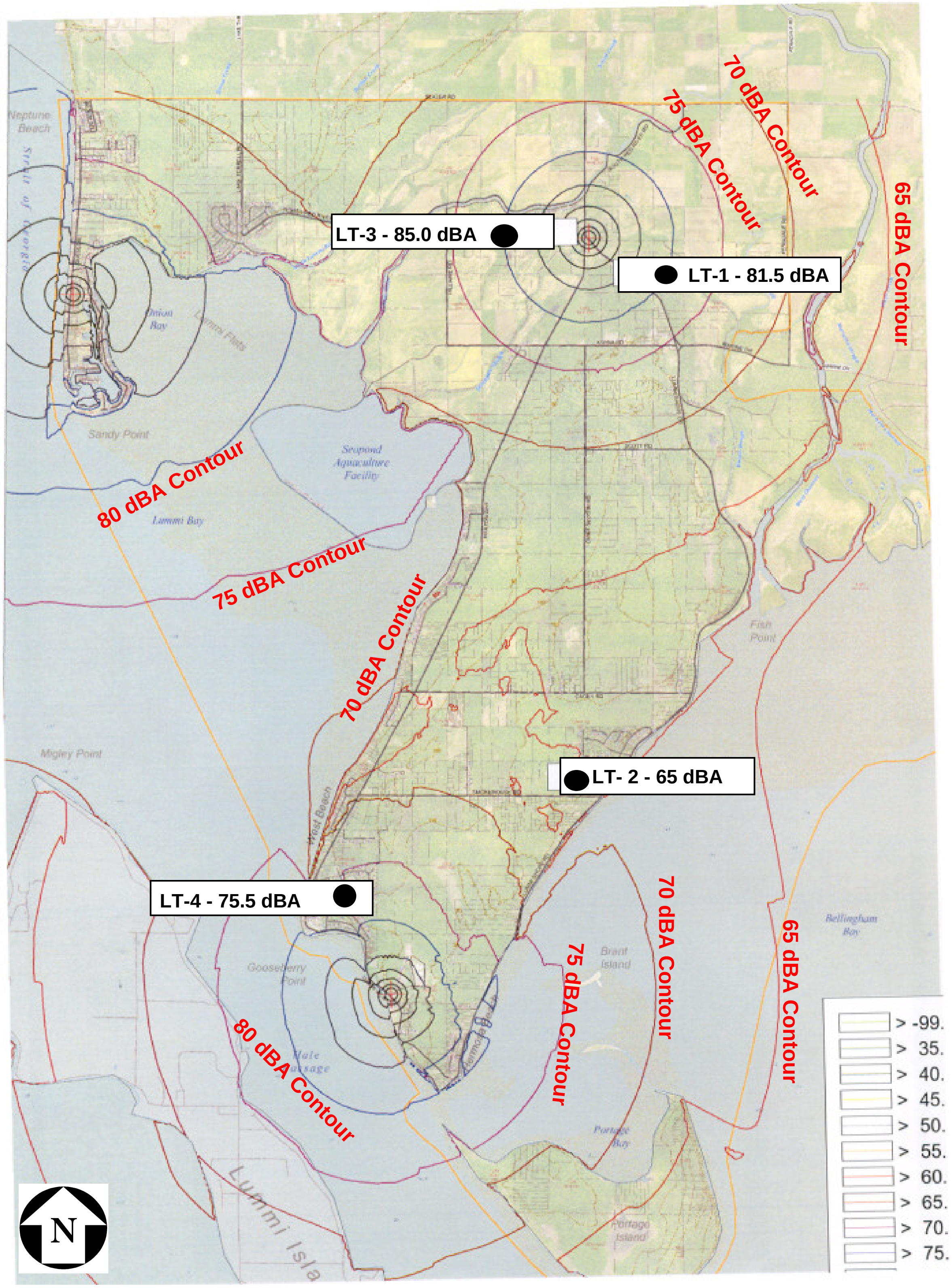
Location	Description	Measured (Lmax)	Predicted (Lmax)	Difference
LT-1	Lummi Shore Drive/Smugglers Slough	80.8 dBA	81.5 dBA	+0.7 dBA
LT-2	Smokehouse Road Meteorological Tower	64.5 dBA	65.0 dBA	+0.5 dBA
LT-3	Jefferson Residence West of Haxton Road	86.5 dBA	85.0 dBA	- 1.5 dBA
LT-4	Gooseberry Point Fire Station	NA	75.5 dBA	NA

Measured noise levels are during the 12:00 p.m. hour on Friday April 22, 2011
Predicted noise levels are based upon the CadnaA Noise Prediction Model and noise data provided by Federal Signal

Based upon the analysis, the CadnaA Noise Prediction Model predicted noise levels within 1.5 dBA of those which were measured at each of the continuous (LT) noise measurement sites.

Figure 4

Tsunami Warning System Predicted Noise Levels



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WIND TURBINE NOISE IMPACT ANALYSIS

In order to predict noise levels at the nearest noise-sensitive receptors, j.c. brennan & associates, Inc. once again utilized the CadnaA Noise Prediction Model. The CadnaA sound propagation model made by Datakustik GmbH was used to model sound levels from the proposed project. CadnaA uses ISO 9613 for calculating outdoor sound propagation. Inputs to the CadnaA model included ground topography and type, turbine locations, turbine heights, receiver locations, and turbine sound power levels. The model was run using ISO 9613 with non-spectral ground attenuation, as recommended by Kaliski.[1]

Sound power level data was provided by the turbine manufacturer's and represents the maximum sound output which would occur under wind speeds of 8 m/s. Noise level data for the turbines was based upon the International Standard IEC 61400-11 "Wind turbine generator systems - part 11: Acoustic noise measurement techniques." Two scenarios were modeled. The scenarios include Sound Power Levels of both 108 dBA and 105 dBA. Table 9 shows the sound power inputs for each of the scenarios.

Table 9
Wind Turbine Octave Band Sound Power Levels, dBA

63.5 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
105 dBA Turbine							
81.5	92.5	96.1	100.1	100.1	96.4	89.2	85.2
108 dBA Turbine							
84.5	95.4	99.1	103.1	103.1	99.4	92.2	88.2

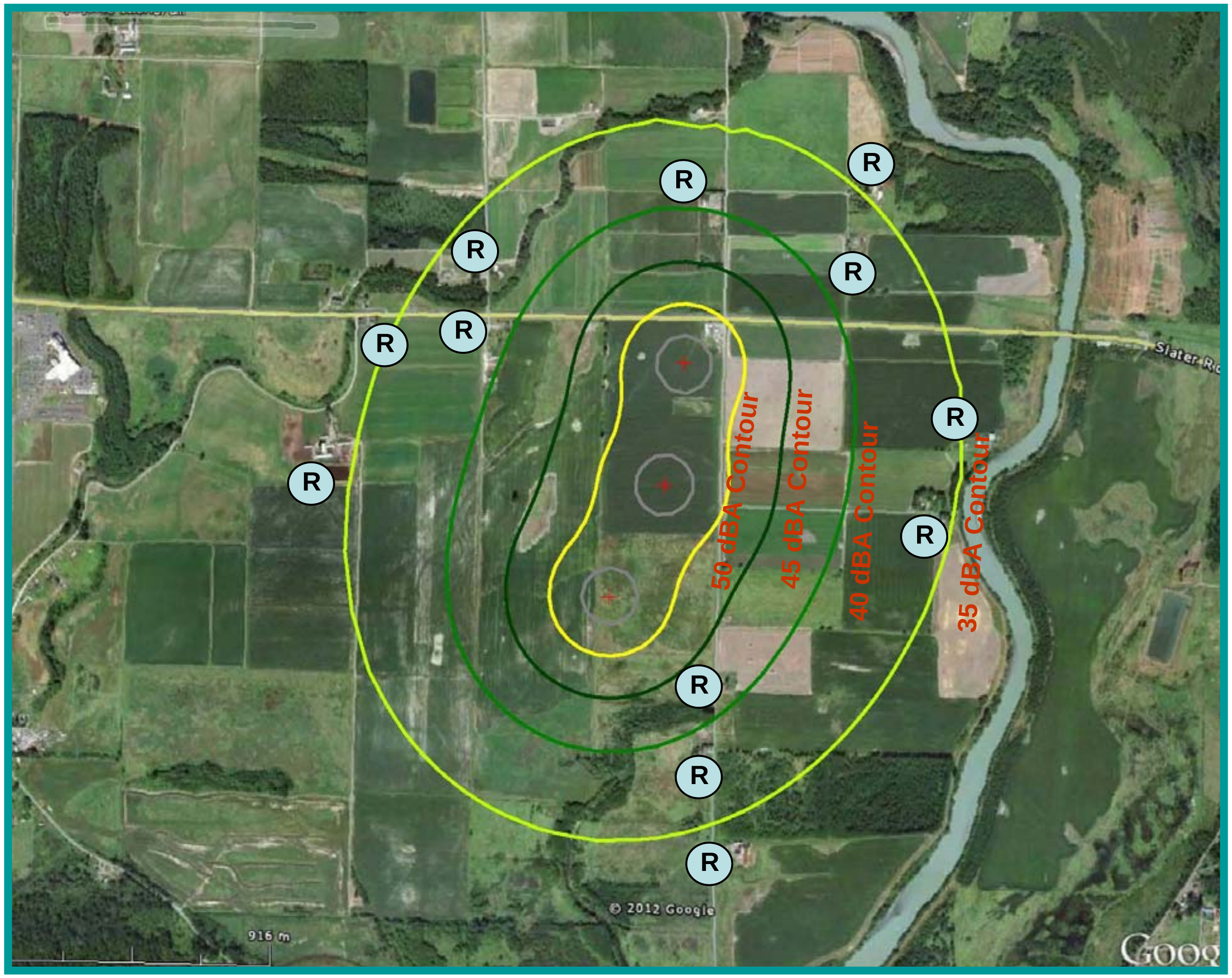
The results of the noise modeling process are shown on Figures 5 and 6. The noise contours associated with the 105 dBA turbines, as shown on Figure 5, indicate that the proposed project will generate noise level of 42 dBA at the nearest residence. The remaining residences will be exposed to turbine noise levels of less than 40 dBA. The noise contours associated with the 108 dBA turbines, as shown on Figure 6, indicate that the proposed project will generate noise level of 45 dBA at the nearest residence. The remaining residences will be exposed to turbine noise levels 43 dBA and 33 dBA.

[1] Kaliski, Kenneth. *Propagation Modeling Parameters for Wind Power Projects*. Sound & Vibration. December 2008. Online: http://www.rsginc.com/assets/Kens-EEA-Reports/0812kali-web-ready.pdf

Figure 5

Wind Turbine Noise Contours

Assuming Turbines with 105 dBA Sound Power Levels



N

R **Location of Residences**

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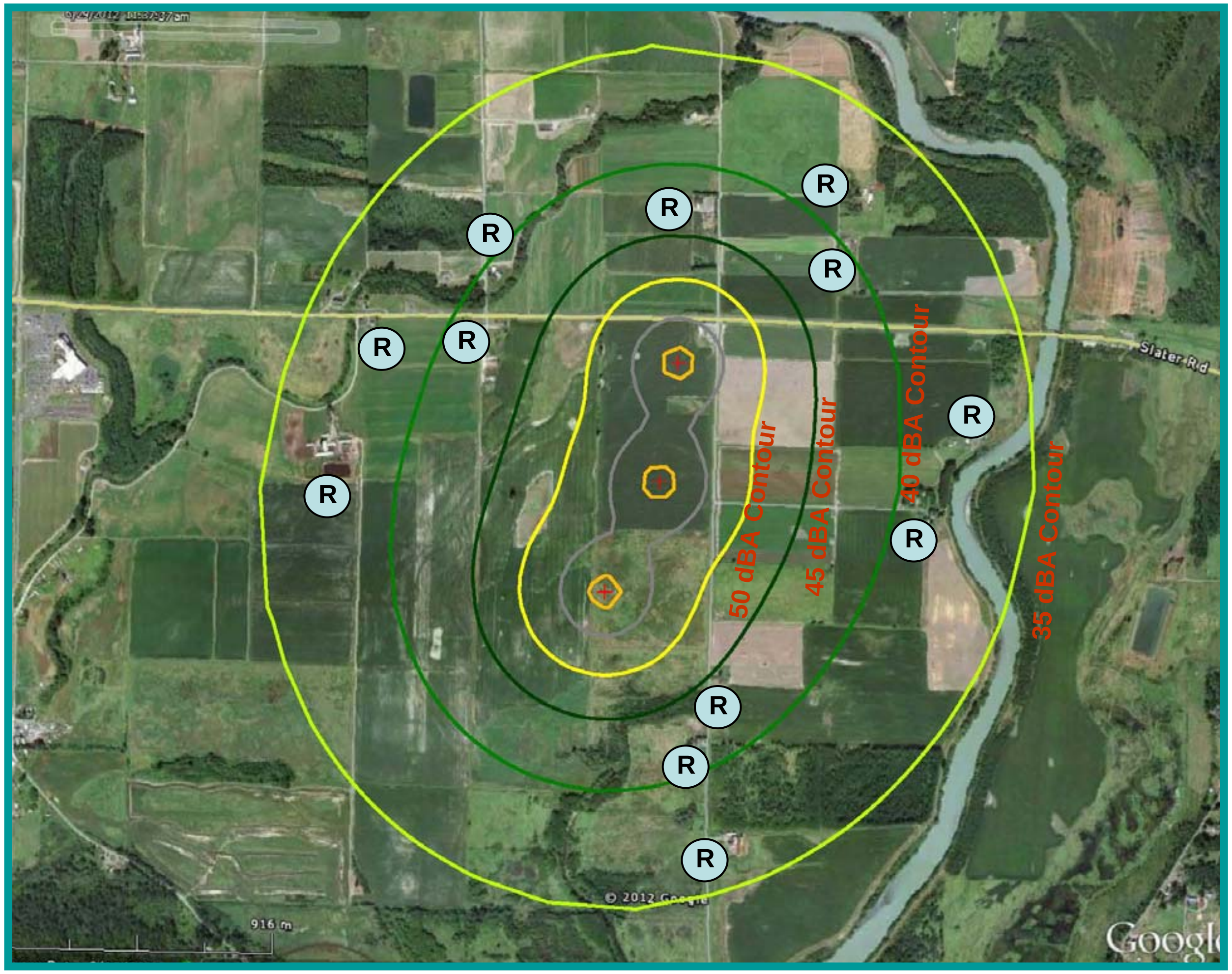
Figure 6

Wind Turbine Noise Contours

Assuming Turbines with 108 dBA Sound Power Levels



N

R **Location of Residences**

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CONCLUSIONS

1. Ambient noise levels in the vicinity of the Lummi Reservation are generally consistent with those associated with a rural environment. Hourly average (Leq) noise levels generally range between the low 40 dBA to the high 40 dBA;

2. Two types of turbines are being evaluated for the wind turbine site. The sound power levels for each of the turbine types range between 105 dBA and 108 dBA;

3. Predicted noise levels associated with the turbines are generally consistent with the existing background noise levels;

4. The predicted noise levels associated with the 105 dBA turbines are predicted to comply with the recommended 42 dBA noise level standard. The predicted noise levels associated with the 108 dBA turbines are predicted to exceed the recommended 42 dBA noise level standard at one residence.

Appendix A

Acoustical Terminology

Acoustics	The science of sound.
Ambient Noise	The distinctive acoustical characteristics of a given space consisting of all noise sources audible at that location. In many cases, the term ambient is used to describe an existing or pre-project condition such as the setting in an environmental noise study.
Attenuation	The reduction of an acoustic signal.
A-Weighting	A frequency-response adjustment of a sound level meter that conditions the output signal to approximate human response.
Decibel or dB	Fundamental unit of sound, A Bell is defined as the logarithm of the ratio of the sound pressure squared over the reference pressure squared. A Decibel is one-tenth of a Bell.
CNEL	Community Noise Equivalent Level. Defined as the 24-hour average noise level with noise occurring during evening hours (7 - 10 p.m.) weighted by a factor of three and nighttime hours weighted by a factor of 10 prior to averaging.
Frequency	The measure of the rapidity of alterations of a periodic signal, expressed in cycles per second or hertz.
Ldn	Day/Night Average Sound Level. Similar to CNEL but with no evening weighting.
Leq	Equivalent or energy-averaged sound level.
Lmax	The highest root-mean-square (RMS) sound level measured over a given period of time.
L(n)	The sound level exceeded a described percentile over a measurement period. For instance, an hourly L50 is the sound level exceeded 50% of the time during the one hour period.
Loudness	A subjective term for the sensation of the magnitude of sound.
Noise	Unwanted sound.
Peak Noise	The level corresponding to the highest (not RMS) sound pressure measured over a given period of time. This term is often confused with the "Maximum" level, which is the highest RMS level.
RT_{60}	The time it takes reverberant sound to decay by 60 dB once the source has been removed.
Sabin	The unit of sound absorption. One square foot of material absorbing 100% of incident sound has an absorption of 1 sabin.
Threshold of Hearing	The lowest sound that can be perceived by the human auditory system, generally considered to be 0 dB for persons with perfect hearing.
Threshold of Pain	Approximately 120 dB above the threshold of hearing.
Impulsive	Sound of short duration, usually less than one second, with an abrupt onset and rapid decay.
Simple Tone	Any sound which can be judged as audible as a single pitch or set of single pitches.

Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-1
Wednesday, April 20, 2011

Hour	Leq	Lmax	L50	L8
0:00	38.2	55.34	33.86	39.94
1:00	36.76	55.44	29.68	38.05
2:00	35.59	53.19	28.65	37.48
3:00	35.09	55.8	30.13	36.02
4:00	34.06	50.42	31.94	36.84
5:00	49.23	66.52	44.02	52.06
6:00	47.9	63.37	44.96	51.72
7:00	47.48	61.37	45.12	50.81
8:00	49.23	68.78	43.87	51.93
9:00	48.52	67.68	41.64	50.98
10:00	43.64	64.11	38.48	47.12
11:00	46.04	70.59	39.69	49.85
12:00	50.11	72.81	39.27	50.41
13:00	46.34	63.37	41.44	51.13
14:00	43.87	56.9	40.52	48.17
15:00	51.31	75.3	40.06	50.48
16:00	45.87	61.04	42.05	50.3
17:00	50.5	72.52	42.61	51.27
18:00	46.12	61.74	40.5	50.94
19:00	43.73	55.46	39.87	48.5
20:00	44.36	59.77	40.86	48.86
21:00	49.32	71.73	39.91	49.59
22:00	41.34	61.69	34.93	44.68
23:00	40.42	63.55	35.31	43.82

	Statistical Summary					
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	51.3	43.6	47.8	49.2	34.1	43.3
Lmax (Maximum)	75.3	55.5	65.5	66.5	50.4	58.4
L50 (Median)	45.1	38.5	41.1	45.0	28.7	34.8
L8	51.9	47.1	50.0	52.1	36.0	42.3

Computed Ldn, dB	50.7
% Daytime Energy	83%
% Nighttime Energy	17%

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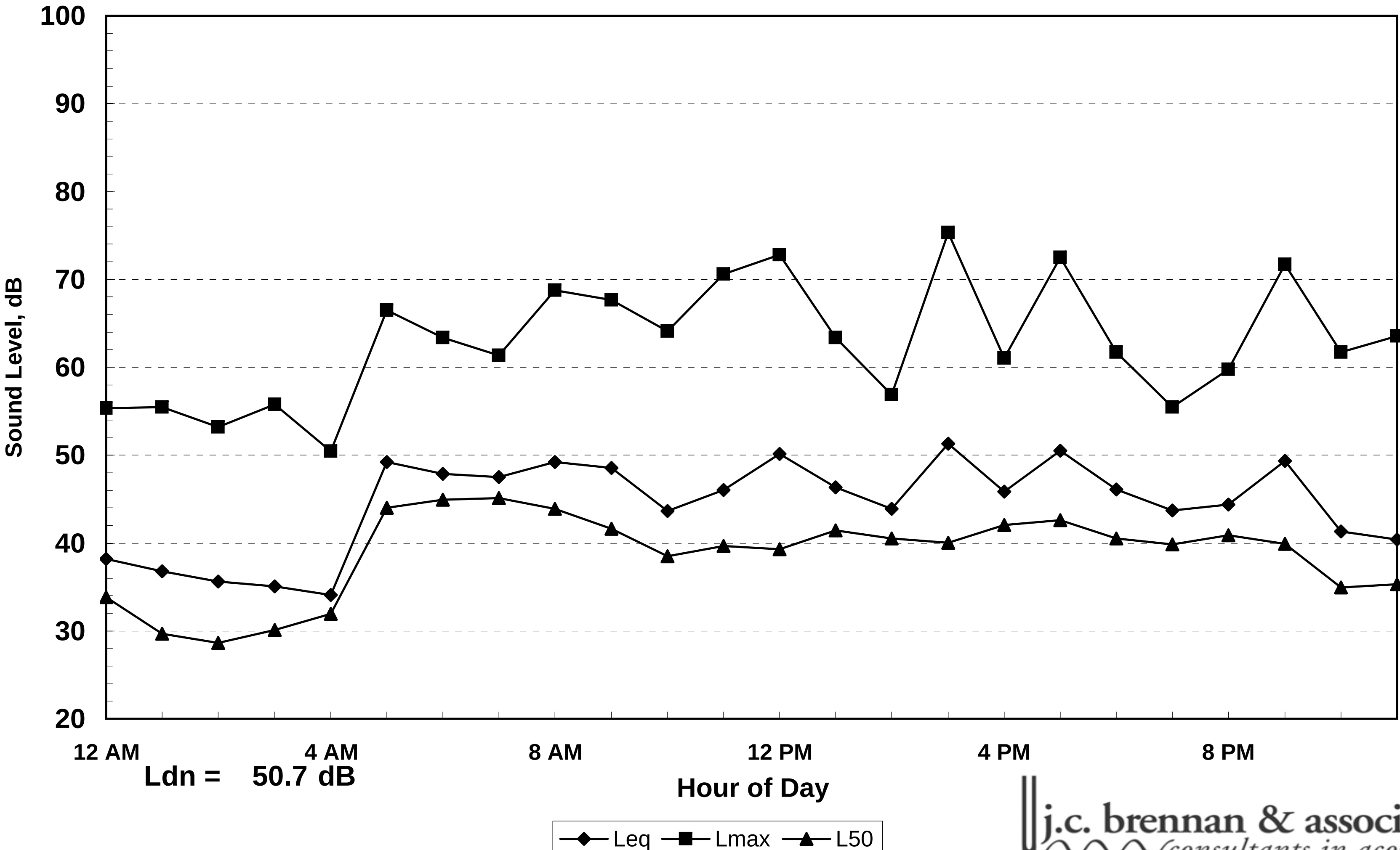
Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-1
Wednesday, April 20, 2011



Ldn = 50.7 dB

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Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-1
Thursday, April 21, 2011

Hour	Leq	Lmax	L50	L8
0:00	39.97	58.52	35.42	42.81
1:00	37.24	51.76	32.94	41.37
2:00	32.57	48.11	30.1	34.32
3:00	35.24	48.61	32.38	38.83
4:00	34.06	50.85	31.18	36.27
5:00	46.62	61.23	41.76	51.62
6:00	48.43	69.1	43.29	52.86
7:00	47.61	69.98	44.34	51.04
8:00	51.56	80.98	45.29	52.97
9:00	47.24	66.87	43.18	51.72
10:00	50.5	73.14	44.8	51.84
11:00	47.85	67.91	43.41	51.39
12:00	48.52	69.96	42.09	50.4
13:00	47.17	66.84	42.02	50.68
14:00	50.38	77.58	39.55	49.56
15:00	43.1	57.61	37.52	48.45
16:00	46.23	66.17	41.21	50.02
17:00	46.29	63.8	40.42	50.66
18:00	46.36	65.6	40.5	50.16
19:00	43.57	61.46	36.69	48.73
20:00	46.34	62.91	43.14	50.73
21:00	45.04	60.05	41.52	49.66
22:00	43.83	56.51	40.05	48.84
23:00	42.62	55.01	38.31	47.97

	Statistical Summary					
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	51.6	43.1	47.8	48.4	32.6	43.0
Lmax (Maximum)	81.0	57.6	67.4	69.1	48.1	55.5
L50 (Median)	45.3	36.7	41.7	43.3	30.1	36.2
L8	53.0	48.5	50.5	52.9	34.3	43.9

Computed Ldn, dB	50.5
% Daytime Energy	83%
% Nighttime Energy	17%

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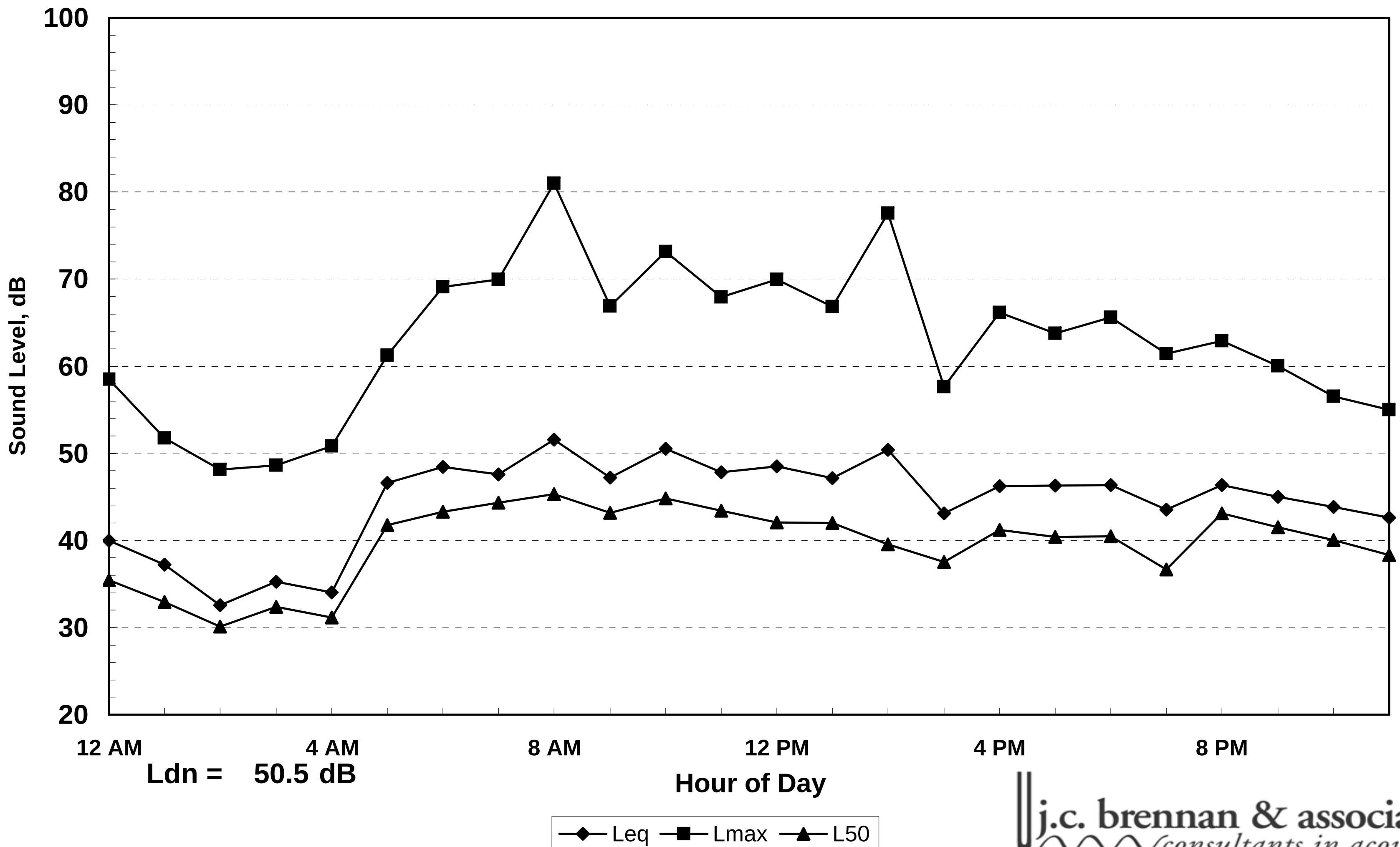
Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-1
Thursday, April 21, 2011



Ldn = 50.5 dB

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Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-1
Friday, April 22, 2011

Hour	Leq	Lmax	L50	L8
0:00	39.4	54.51	36.17	42.49
1:00	36.09	51.13	33.5	38.8
2:00	35.94	51.87	30.03	39.61
3:00	33.27	50.49	28.37	35.31
4:00	30.82	50.99	27.52	31.52
5:00	47.27	60.48	44.63	51.93
6:00	50.64	68.82	46.32	54.64
7:00	48.64	66.94	44.77	51.42
8:00	49.45	70.35	44.05	53.09
9:00	47.4	63.55	43.44	51.57
10:00	46.24	64.95	41.91	50.95
11:00	46.08	63.39	40.24	50.52
12:00	53.39	80.77	41.91	50.91
13:00	44.66	63.16	40.28	48.48
14:00	55.13	81.07	41.6	51.24
15:00	53.98	80.35	41.84	50.49
16:00	50.63	71.8	43.26	51.78
17:00	48.42	66.9	43.43	51.87
18:00	46.64	60.94	42.48	50.98
19:00	45.87	61.03	42.27	50.26
20:00	47.3	62.71	43.6	51.87
21:00	46.94	56.79	44.37	51.19
22:00	46.94	59.55	43.92	51.25
23:00	44.52	56.28	42.32	48.32

	Statistical Summary					
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	55.1	44.7	50.0	50.6	30.8	44.7
Lmax (Maximum)	81.1	56.8	67.6	68.8	50.5	56.0
L50 (Median)	44.8	40.2	42.6	46.3	27.5	37.0
L8	53.1	48.5	51.1	54.6	31.5	43.8

Computed Ldn, dB	52.4
% Daytime Energy	85%
% Nighttime Energy	15%

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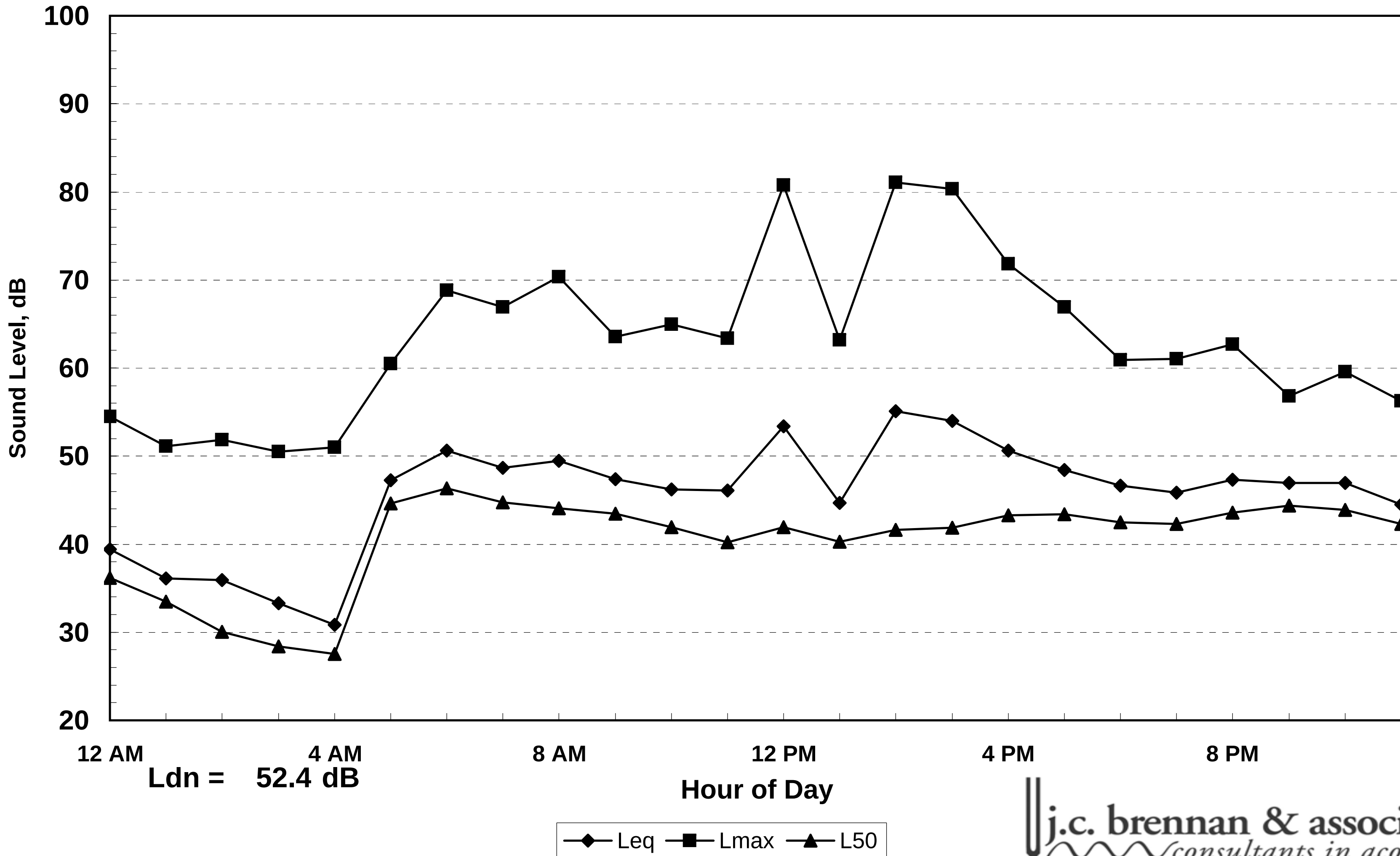
Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-1
Friday, April 22, 2011



Ldn = 52.4 dB

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Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-1
Saturday, April 23, 2011

Hour	Leq	Lmax	L50	L8
0:00	43.66	65.83	40.91	46.43
1:00	42.45	56.33	38.11	47.18
2:00	41.54	60.43	36.09	44.6
3:00	41.59	58.65	35.59	46.45
4:00	38.57	59.9	34.85	38.59
5:00	46.05	56.88	43.63	50.34
6:00	47.75	63.87	43.23	51.2
7:00	51.63	72.5	45.79	55.72
8:00	50.25	66.69	44.34	54.22
9:00	51.05	67.32	42.99	55.46
10:00	48.16	70.41	40.99	51.33
11:00	53.73	78.3	39.56	51.37
12:00	51.19	72.1	42.5	52.2
13:00	47.31	68.23	41.23	49.77
14:00	45.57	59.66	41.37	50.51
15:00	51.23	73.95	41.53	50.23
16:00	48.42	69.02	41.77	50.89
17:00	47.68	69.37	41.69	50.07
18:00	44.62	58.58	41.34	49.02
19:00	47.17	63.19	43.58	51.05
20:00	48.73	66.38	46.39	52.53
21:00	47.71	56.84	46.7	50.72
22:00	45.55	60.57	43.88	48.8
23:00	44.73	56.92	42.58	48.05

	Statistical Summary					
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	53.7	44.6	49.6	47.8	38.6	44.3
Lmax (Maximum)	78.3	56.8	67.5	65.8	56.3	59.9
L50 (Median)	46.7	39.6	42.8	43.9	34.9	39.9
L8	55.7	49.0	51.7	51.2	38.6	46.8

Computed Ldn, dB	52.0
% Daytime Energy	85%
% Nighttime Energy	15%

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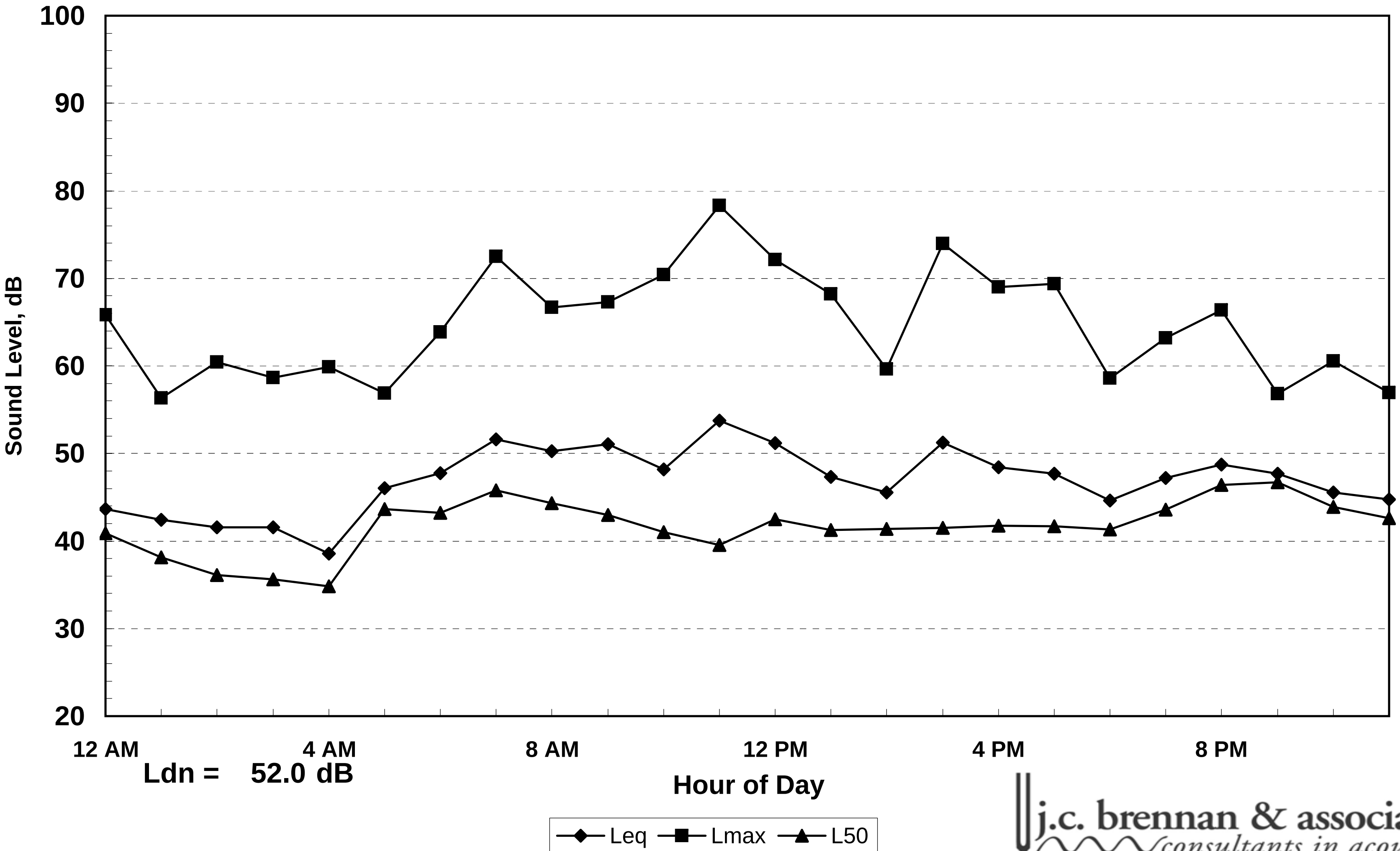
Appendix B

Lummi Wind Study

24hr Continuous Noise Monitoring - Site LT-1

Saturday, April 23, 2011



Ldn = 52.0 dB

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Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-1
Sunday, April 24, 2011

Hour	Leq	Lmax	L50	L8
0:00	43.04	56.9	40.55	46.62
1:00	40.48	60.11	37.44	41.21
2:00	39.66	56.96	36.56	41.97
3:00	37.31	54.19	34.43	38.83
4:00	37.06	53.8	33.46	40.12
5:00	52.31	65.8	45.54	57.21
6:00	51.27	66.74	44.21	56.08
7:00	52.01	70.02	45.45	57.19
8:00	51.02	65.83	44.98	55.48
9:00	49.52	67.26	43.56	53.24
10:00	48.66	67.54	42.21	52.92
11:00	49.61	69.71	44.17	53.29
12:00	48.04	63.15	43.45	52.39
13:00	46.36	60.42	43.63	50.73
14:00	44.73	62.44	40.07	49.68
15:00	48.66	66.81	42	52.68
16:00	45.92	64.3	40.79	50.8
17:00	46.12	65.02	38.95	50.52
18:00	44.76	64.73	37.93	49.24
19:00	44.04	59.03	37.88	49.16
20:00	44.98	59.94	38.96	49.9
21:00	45.1	65.68	40.2	47.09
22:00	44.42	65.03	40.08	47.35
23:00	42.69	58.52	40.69	46.08

	Statistical Summary					
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	52.0	44.0	48.0	52.3	37.1	46.5
Lmax (Maximum)	70.0	59.0	64.8	66.7	53.8	59.8
L50 (Median)	45.5	37.9	41.6	45.5	33.5	39.2
L8	57.2	47.1	51.6	57.2	38.8	46.2

Computed Ldn, dB	53.2
% Daytime Energy	70%
% Nighttime Energy	30%

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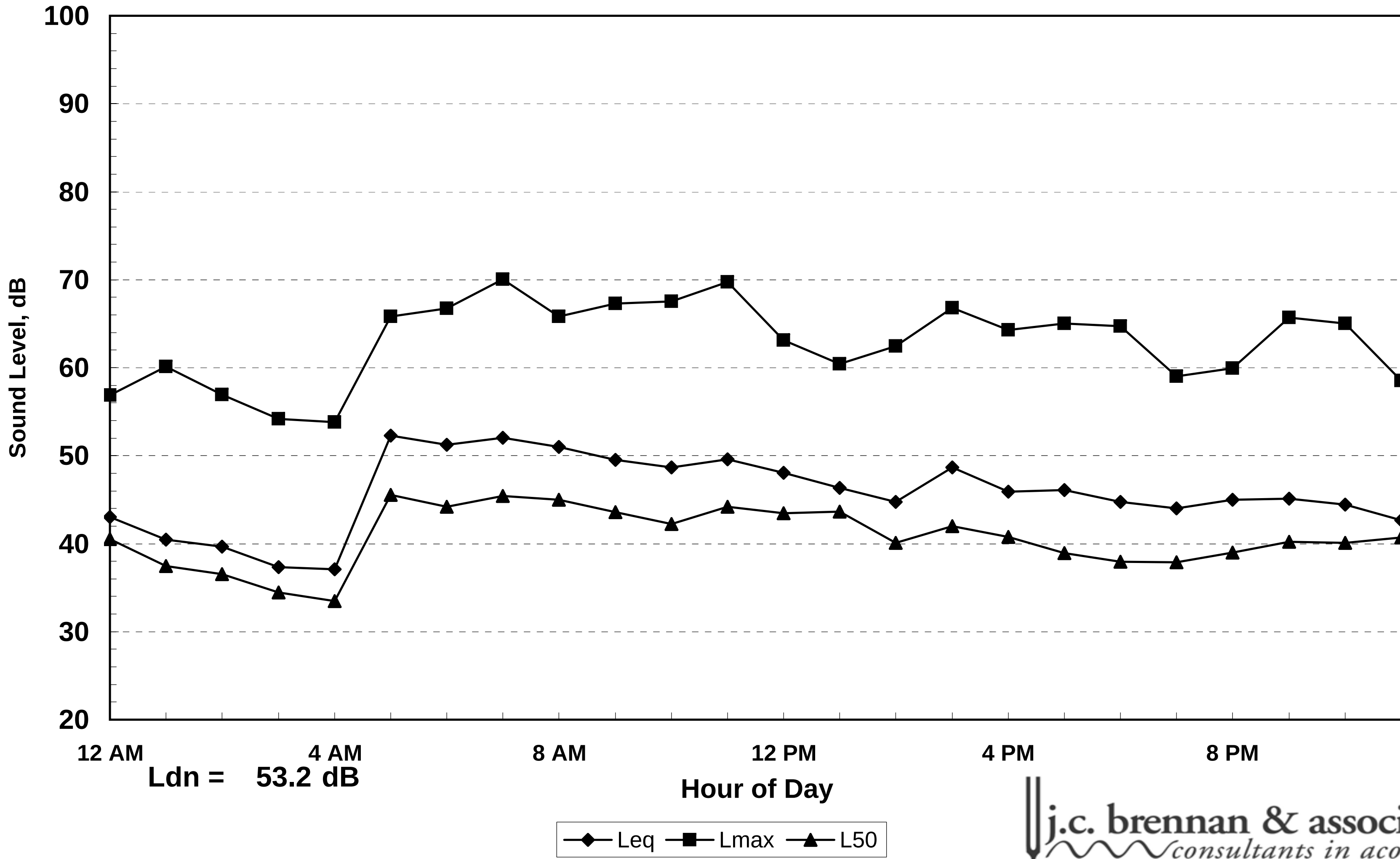
Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-1
Sunday, April 24, 2011



Ldn = 53.2 dB

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Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-1
Monday, April 25, 2011

Hour	Leq	Lmax	L50	L8
0:00	39.68	62.62	36.75	42.55
1:00	39.32	54.61	35.83	43.07
2:00	38.59	51.35	35.28	42.8
3:00	35.57	56.97	30.69	37.41
4:00	35.34	55.22	31.87	37.3
5:00	47.92	61.33	43.68	52.5
6:00	48.49	65.08	43.79	51.95
7:00	53.54	76.94	46.86	55.37
8:00	49.52	70.05	43.11	51.23
9:00	53.98	77.94	42.46	50.4
10:00	53.55	78.95	41.91	50.73
11:00	44.73	57.48	41.61	48.96
12:00	47.03	57.04	44.56	51.48
13:00	46.98	57.91	43.51	51.81
14:00	46.49	62.92	42.96	50.55
15:00	47.66	63.91	44.99	51.25
16:00	47.27	60.77	44.44	51.59
17:00	47.34	60.52	44.84	51.37
18:00	47.15	70.64	43.37	50.73
19:00	44.63	57.01	41.59	49.23
20:00	48.2	72.5	41.87	49.91
21:00	54.59	75.35	43.08	52.64
22:00	45.04	56.19	42.36	49.32
23:00	42.59	56.17	40.63	45.75

	Statistical Summary					
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	54.6	44.6	50.2	48.5	35.3	43.8
Lmax (Maximum)	79.0	57.0	66.7	65.1	51.4	57.7
L50 (Median)	46.9	41.6	43.4	43.8	30.7	37.9
L8	55.4	49.0	51.2	52.5	37.3	44.7

Computed Ldn, dB	51.9
% Daytime Energy	88%
% Nighttime Energy	12%

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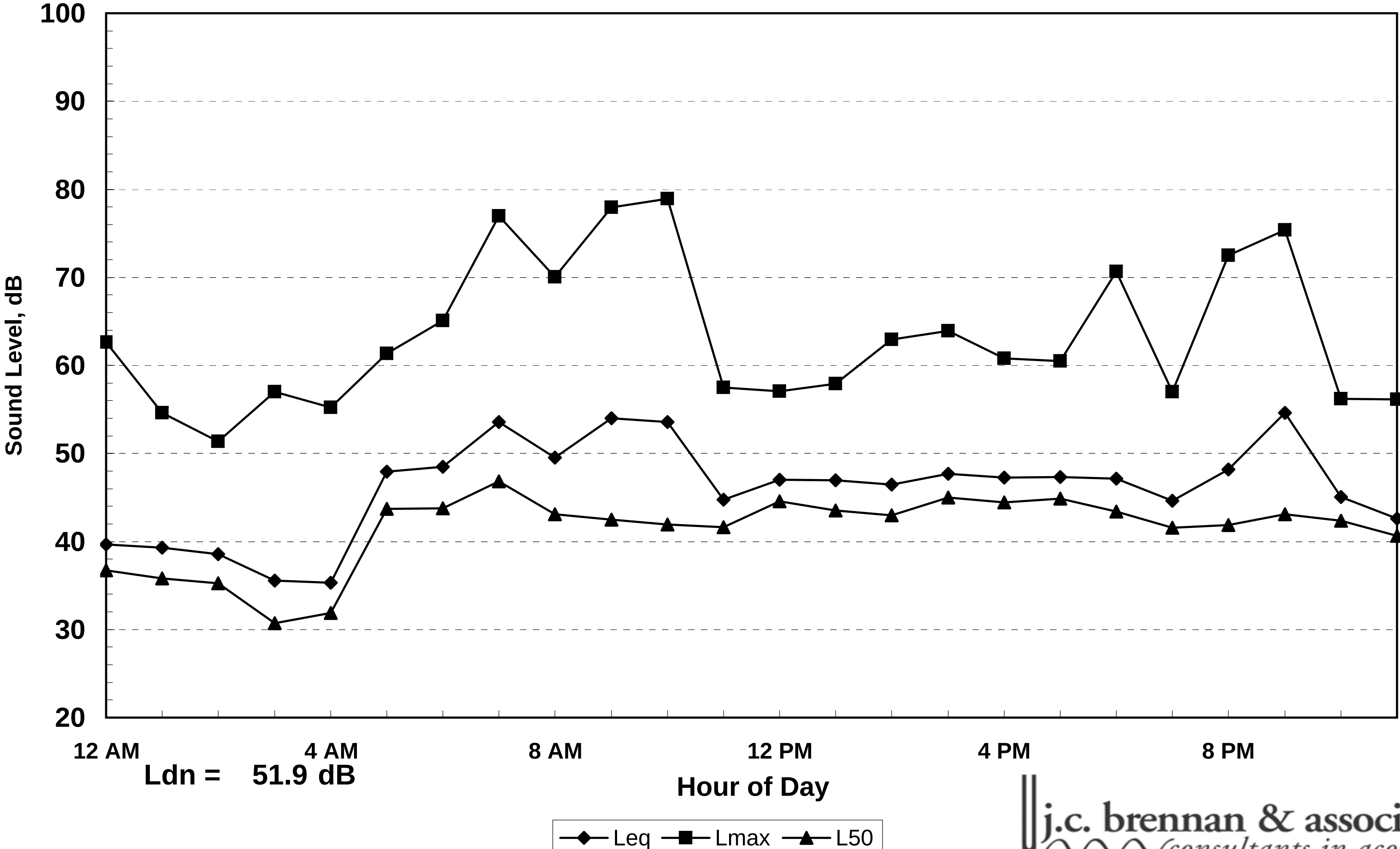
Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-1
Monday, April 25, 2011



Ldn = 51.9 dB

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Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-1
Tuesday, April 26, 2011

Hour	Leq	Lmax	L50	L8
0:00	41.85	55.91	38.13	46.06
1:00	38.68	56.27	36.95	40.88
2:00	39.15	55.02	37.79	40.71
3:00	38.57	56.41	36.76	40.25
4:00	38.08	55.03	35.6	39.05
5:00	45.49	58.78	41.98	50.05
6:00	46.1	63.9	39.94	49.98
7:00	43.99	61.28	40.37	48.22
8:00	47.7	71.05	40.99	49.88
9:00	47.25	65.56	41.58	50.34
10:00	45.23	56.61	42.94	49.31
11:00	47.34	66.25	42.3	50.19
12:00	44.73	64.71	41.23	48.32
13:00	45.78	66.55	41.29	48.87
14:00	45.22	62.55	41.93	48.68
15:00	46.63	69.45	41.02	48.42
16:00	46.43	67.48	41.63	49.77
17:00	45.45	62.23	41.44	49.87
18:00	42.73	56.94	36.29	48.11
19:00	42.27	56.37	37.34	47.55
20:00	48.57	82.08	40.54	49.62
21:00	43.7	56.31	40.29	48.16
22:00	44.85	58.16	43.19	48.02
23:00	45.34	57.76	43.55	48.77

	Statistical Summary					
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	48.6	42.3	45.9	46.1	38.1	43.1
Lmax (Maximum)	82.1	56.3	64.4	63.9	55.0	57.5
L50 (Median)	42.9	36.3	40.7	43.6	35.6	39.3
L8	50.3	47.6	49.0	50.1	39.1	44.9

Computed Ldn, dB	50.1
% Daytime Energy	76%
% Nighttime Energy	24%

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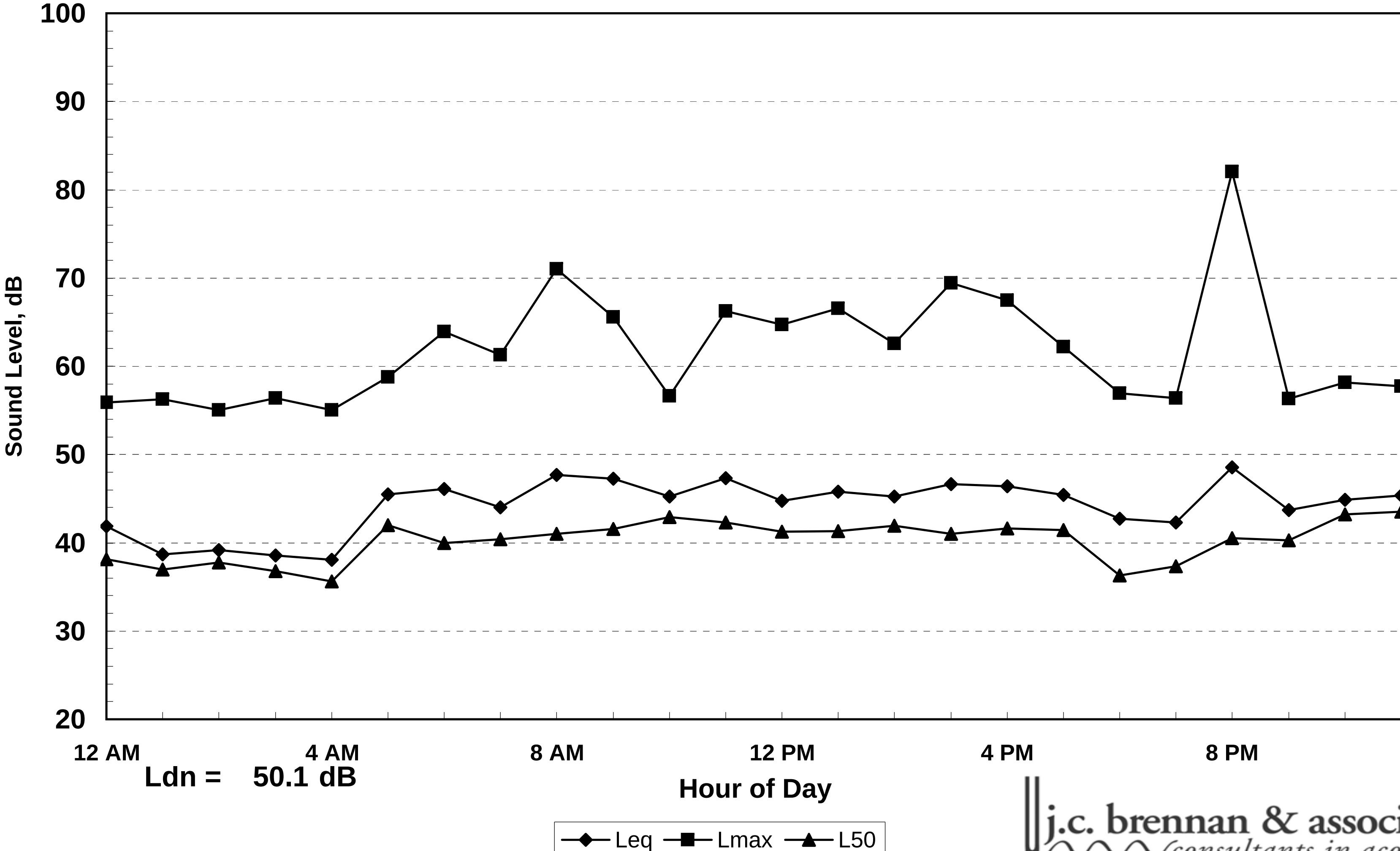
Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-1
Tuesday, April 26, 2011



Ldn = 50.1 dB

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Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-2
Wednesday, April 20, 2011

Hour	Leq	Lmax	L50	L8
0:00	43.74	55.78	42.57	46.6
1:00	42.49	66.78	39.41	43.8
2:00	38.88	55.76	38.05	40.6
3:00	37.44	54.98	35.78	37.98
4:00	49.32	58.6	47.01	53.75
5:00	47.93	61.55	44.44	52.19
6:00	49.18	69.42	44.35	51.73
7:00	54.12	75.07	45	53.72
8:00	47.98	64.91	43.26	51.97
9:00	55.05	81.14	45.13	53.97
10:00	47.84	68.38	42.65	50.63
11:00	52.2	71.21	42.48	53.23
12:00	48.79	70.09	41.51	49.25
13:00	47.61	67.6	42.68	50.72
14:00	48.34	65.95	44.44	51.72
15:00	49.88	70.17	45.72	52.72
16:00	48.89	76	43.69	52.18
17:00	48.39	70.05	43.05	51.21
18:00	46.7	68.02	41.76	49.43
19:00	44.81	66.48	41.26	47.85
20:00	51.05	74.23	40.74	49.58
21:00	43.72	63.96	34.93	47.44
22:00	40.89	56.05	31.09	45.77
23:00	31.84	48.9	26.58	33.13

	Statistical Summary					
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	55.1	43.7	50.1	49.3	31.8	45.2
Lmax (Maximum)	81.1	64.0	70.2	69.4	48.9	58.6
L50 (Median)	45.7	34.9	42.6	47.0	26.6	38.8
L8	54.0	47.4	51.0	53.8	33.1	45.1

Computed Ldn, dB	52.8
% Daytime Energy	84%
% Nighttime Energy	16%

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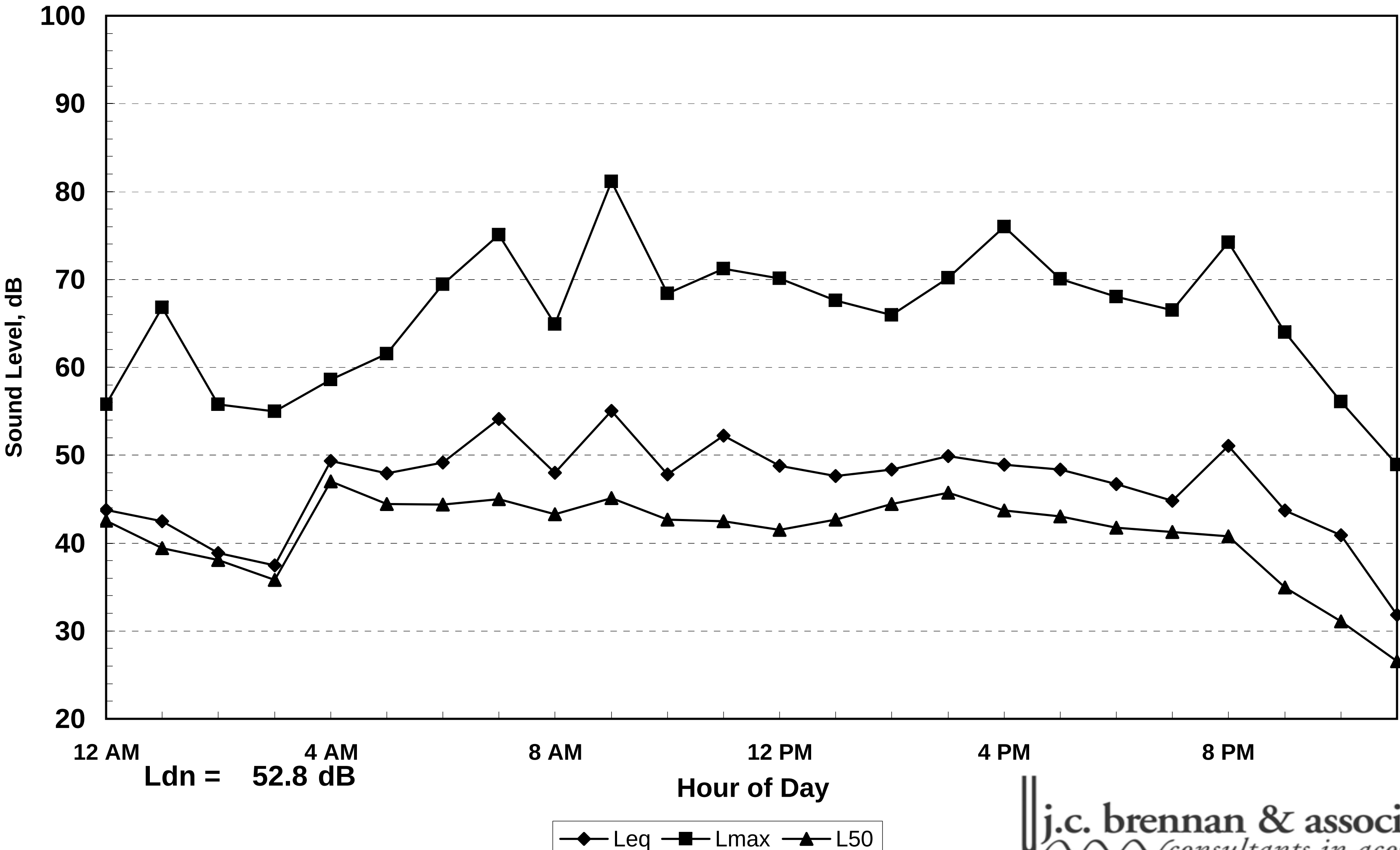
Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-2
Wednesday, April 20, 2011



Ldn = 52.8 dB

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Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-2
Thursday, April 21, 2011

Hour	Leq	Lmax	L50	L8
0:00	36.77	56.73	27.83	40.7
1:00	49.33	65.62	35.54	55.29
2:00	46.93	66.23	36.29	52.98
3:00	36.74	55.19	31.77	38.11
4:00	49.86	68.68	44.49	52.94
5:00	45.02	64.18	39.24	48.79
6:00	50.35	68.89	45.08	53.22
7:00	47.23	62.5	43.46	52.01
8:00	48.33	69.8	44.08	52.65
9:00	50.34	70.22	45.34	52.78
10:00	48.81	71.15	44.61	51.59
11:00	47.88	64.28	42.69	52.14
12:00	51.03	75.85	44.24	51.31
13:00	48.51	73.38	43.06	51.26
14:00	48.51	66.33	44.56	52.35
15:00	48.14	62.77	43.29	52.44
16:00	48.07	68.18	43.31	51.36
17:00	46.05	62.27	43.3	49.32
18:00	46.47	58.76	42.41	51.35
19:00	47.32	60.17	44.83	51.72
20:00	47.1	62.16	42.63	51.74
21:00	46.28	59.64	41.05	50.89
22:00	44.39	59.5	38.01	49.28
23:00	45.1	64.39	40.89	48.33

	Statistical Summary					
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	51.0	46.1	48.2	50.4	36.7	46.9
Lmax (Maximum)	75.9	58.8	65.8	68.9	55.2	63.3
L50 (Median)	45.3	41.1	43.5	45.1	27.8	37.7
L8	52.8	49.3	51.7	55.3	38.1	48.8

Computed Ldn, dB	53.5
% Daytime Energy	69%
% Nighttime Energy	31%

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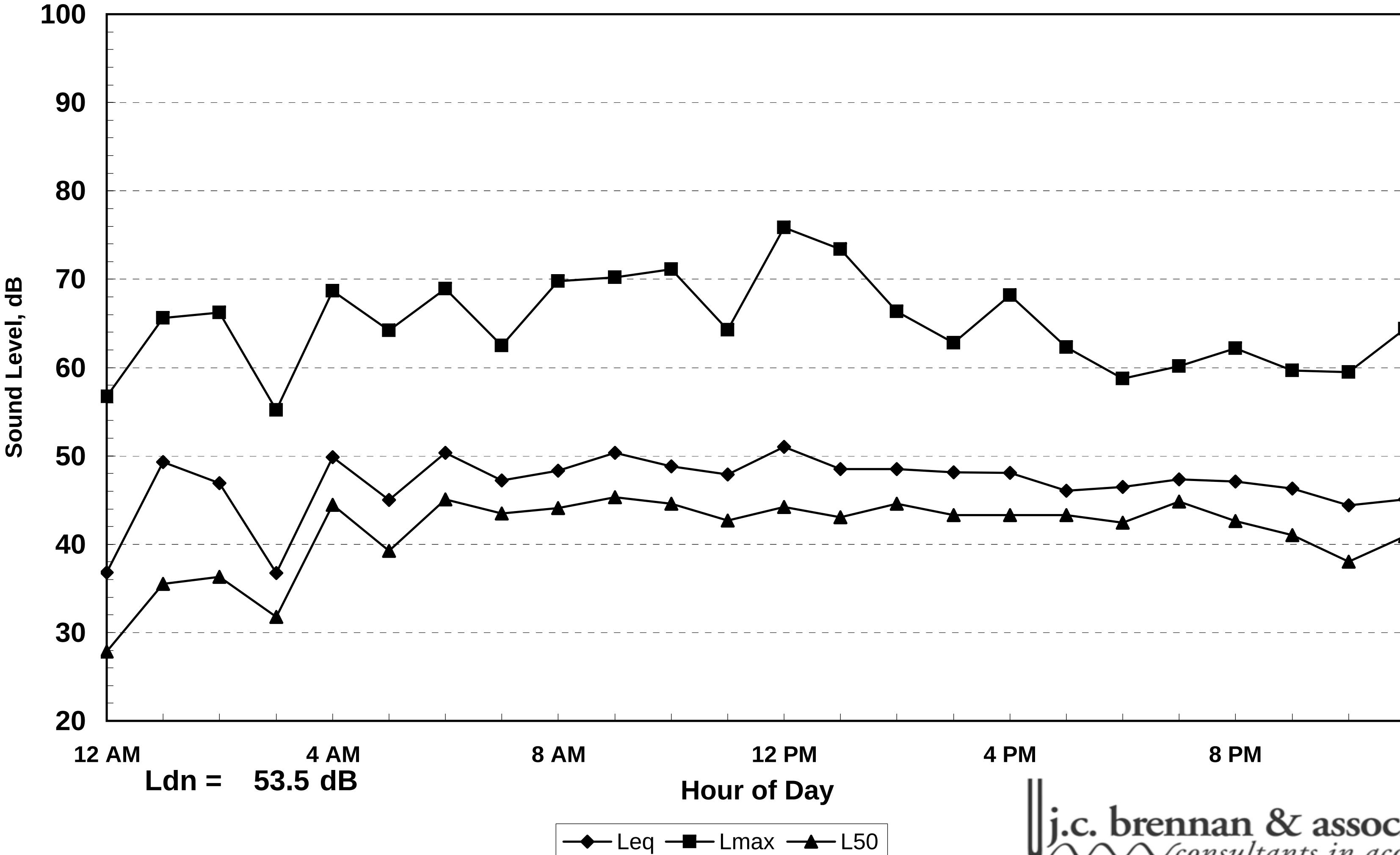
Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-2
Thursday, April 21, 2011



Ldn = 53.5 dB

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Appendix B

Lummi Wind Study

24hr Continuous Noise Monitoring - Site LT-2

Friday, April 22, 2011

Hour	Leq	Lmax	L50	L8
0:00	44.93	56.9	43.62	47.78
1:00	46.69	56.78	46.08	48.5
2:00	47.34	59.54	47.01	48.76
3:00	45.91	56.04	45.03	47.96
4:00	50.82	64.77	48.21	54.62
5:00	47.89	63.13	44.33	51.57
6:00	52.22	69.54	44.81	54.47
7:00	49.14	69.05	43.66	53.58
8:00	50.72	66.94	45.64	54.58
9:00	48.3	66.75	43.52	52.55
10:00	47.27	64.78	42.97	49.99
11:00	48.61	72.24	41.84	50.09
12:00	46.02	64.5	41.29	48.53
13:00	50.63	72.47	43.15	51.55
14:00	50.25	70.72	44.27	51.88
15:00	49.72	70.69	45.12	52.5
16:00	46.88	60.87	44.35	50.58
17:00	45.63	59.52	43.75	48.91
18:00	47.62	68.16	43.7	48.75
19:00	45.54	58.62	43.58	49.51
20:00	46.12	59.6	43.63	50.22
21:00	45.61	56.72	42.92	50.03
22:00	48.25	65.38	42.13	51.67
23:00	44.03	57.18	41.19	48.16

	Statistical Summary					
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	50.7	45.5	48.3	52.2	44.0	48.3
Lmax (Maximum)	72.5	56.7	65.4	69.5	56.0	61.0
L50 (Median)	45.6	41.3	43.6	48.2	41.2	44.7
L8	54.6	48.5	50.9	54.6	47.8	50.4

Computed Ldn, dB	54.7
% Daytime Energy	62%
% Nighttime Energy	38%

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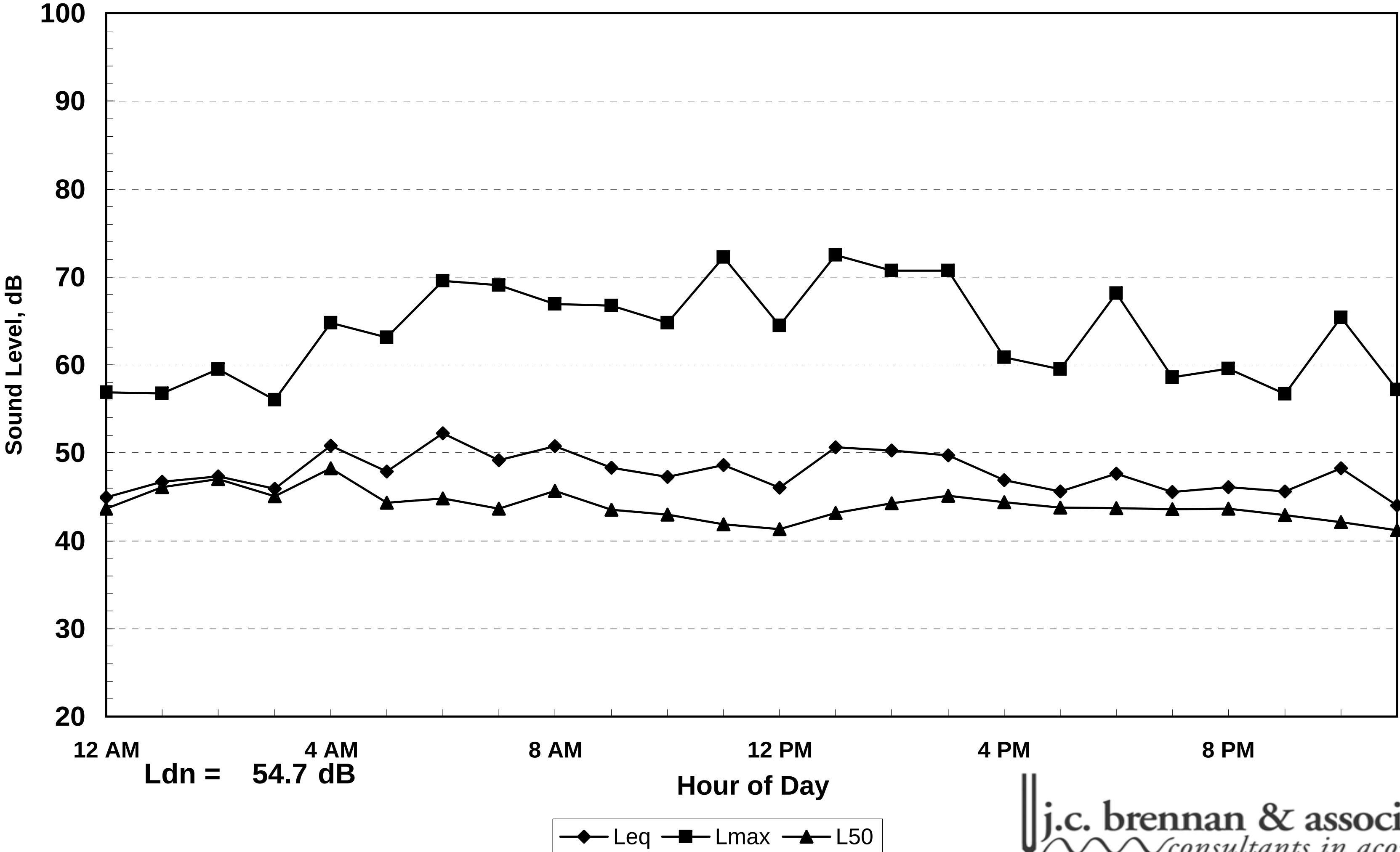
Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-2
Friday, April 22, 2011



Ldn = 54.7 dB

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Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-2
Saturday, April 23, 2011

Hour	Leq	Lmax	L50	L8
0:00	43.47	59.41	34.94	48.44
1:00	42.09	55.39	37.06	47.14
2:00	41.74	58.24	33.28	46.78
3:00	38.76	56.23	33.09	41.73
4:00	47.79	58.58	45.29	52.44
5:00	39.74	55.94	36.19	43.26
6:00	45.35	63.7	41.01	48.82
7:00	46.03	70.59	38.49	48.9
8:00	44.2	62.6	41.05	47.89
9:00	50.75	72.4	42.51	52.97
10:00	49.88	72.37	43.56	52.14
11:00	49.14	67.5	44.5	51.82
12:00	45.9	60.21	43.23	49.95
13:00	47.12	60.89	44.62	50.55
14:00	54.4	77.08	45.11	54.63
15:00	46.16	59.74	43.33	49.95
16:00	46.32	61.33	43.4	50.12
17:00	44.32	59.97	41.88	47.45
18:00	44.53	58.38	42.45	47.86
19:00	49.16	77.15	44.69	51.72
20:00	46.51	57.45	43.85	50.96
21:00	46.48	60.69	42.93	50.97
22:00	45.28	61.02	40.85	50.02
23:00	46.2	58.59	42.4	51.08

	Statistical Summary					
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	54.4	44.2	48.4	47.8	38.8	44.3
Lmax (Maximum)	77.2	57.5	65.2	63.7	55.4	58.6
L50 (Median)	45.1	38.5	43.0	45.3	33.1	38.2
L8	54.6	47.5	50.5	52.4	41.7	47.7

Computed Ldn, dB	51.6
% Daytime Energy	81%
% Nighttime Energy	19%

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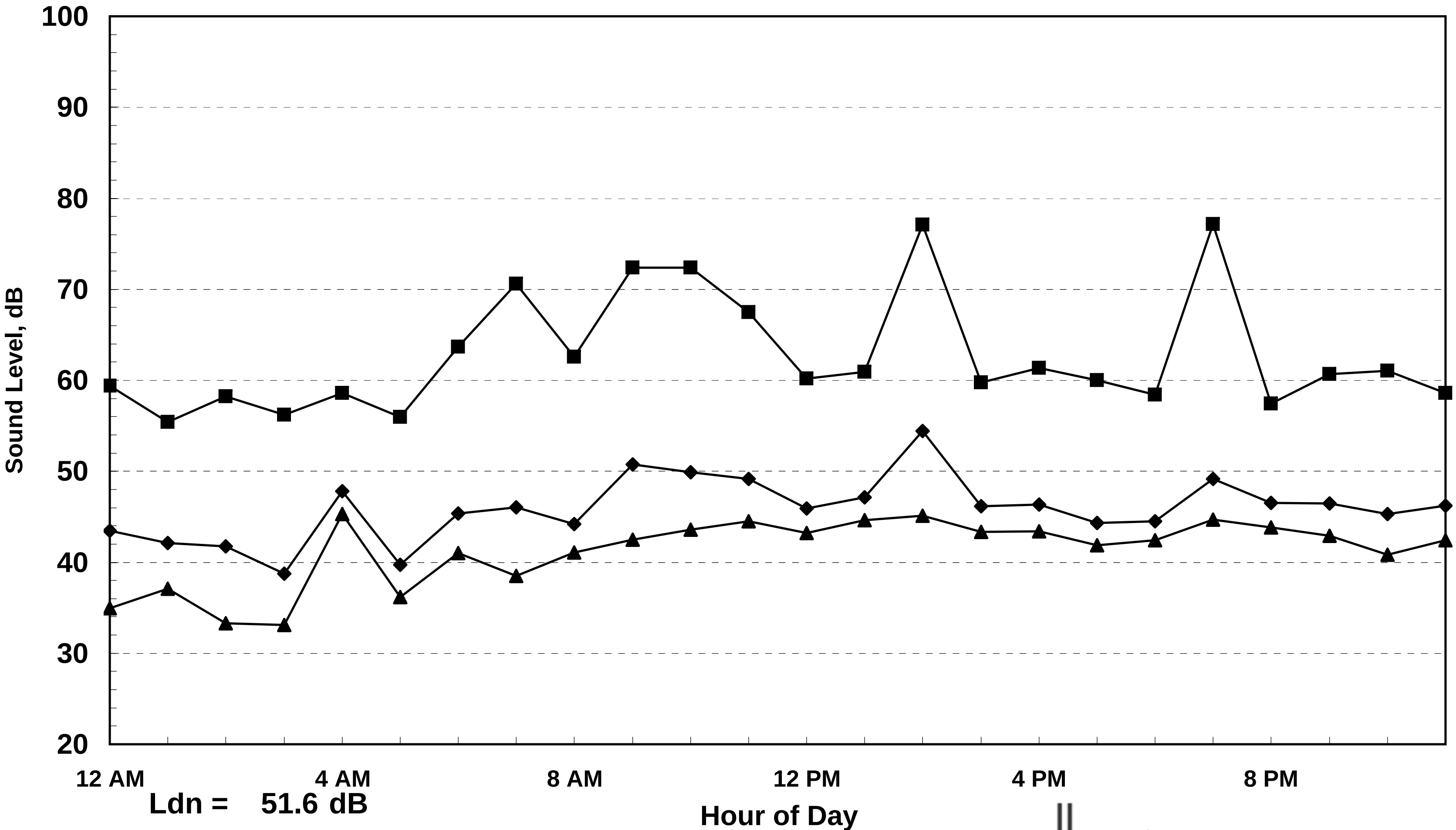
Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-2
Saturday, April 23, 2011



Ldn = 51.6 dB

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Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-2
Sunday, April 24, 2011

Hour	Leq	Lmax	L50	L8
0:00	42.75	56.7	38.57	47.19
1:00	41.61	57.93	31.99	47.45
2:00	41.6	57.65	34.25	46.42
3:00	48.07	59.39	47.67	51.49
4:00	52.35	60.08	52.1	54.91
5:00	53.33	59.52	53.12	55.4
6:00	50.86	66.8	49.43	53.24
7:00	51.44	65.12	49.53	54.38
8:00	50.22	68.01	48.34	53.62
9:00	49.37	64.51	46.27	53.38
10:00	50.62	64.07	48.44	54.42
11:00	51.84	69.28	49.95	54.69
12:00	52.53	68.42	50.75	55.67
13:00	51.07	65.53	48.8	54.67
14:00	52.19	67.12	49.75	55.49
15:00	49.4	61.97	47.75	53.04
16:00	49.68	68.96	45.15	52.77
17:00	48.09	64.8	45.15	52.05
18:00	47.79	66.14	45.28	51.72
19:00	45.76	58.36	41.87	50.37
20:00	47.37	58.58	44.38	51.86
21:00	45.58	57.05	43.61	49.5
22:00	48.37	64.8	44.42	52.53
23:00	45.76	61.04	44	49.39

	Statistical Summary					
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	52.5	45.6	50.0	53.3	41.6	49.1
Lmax (Maximum)	69.3	57.1	64.5	66.8	56.7	60.4
L50 (Median)	50.8	41.9	47.0	53.1	32.0	44.0
L8	55.7	49.5	53.2	55.4	46.4	50.9

Computed Ldn, dB	55.6
% Daytime Energy	67%
% Nighttime Energy	33%

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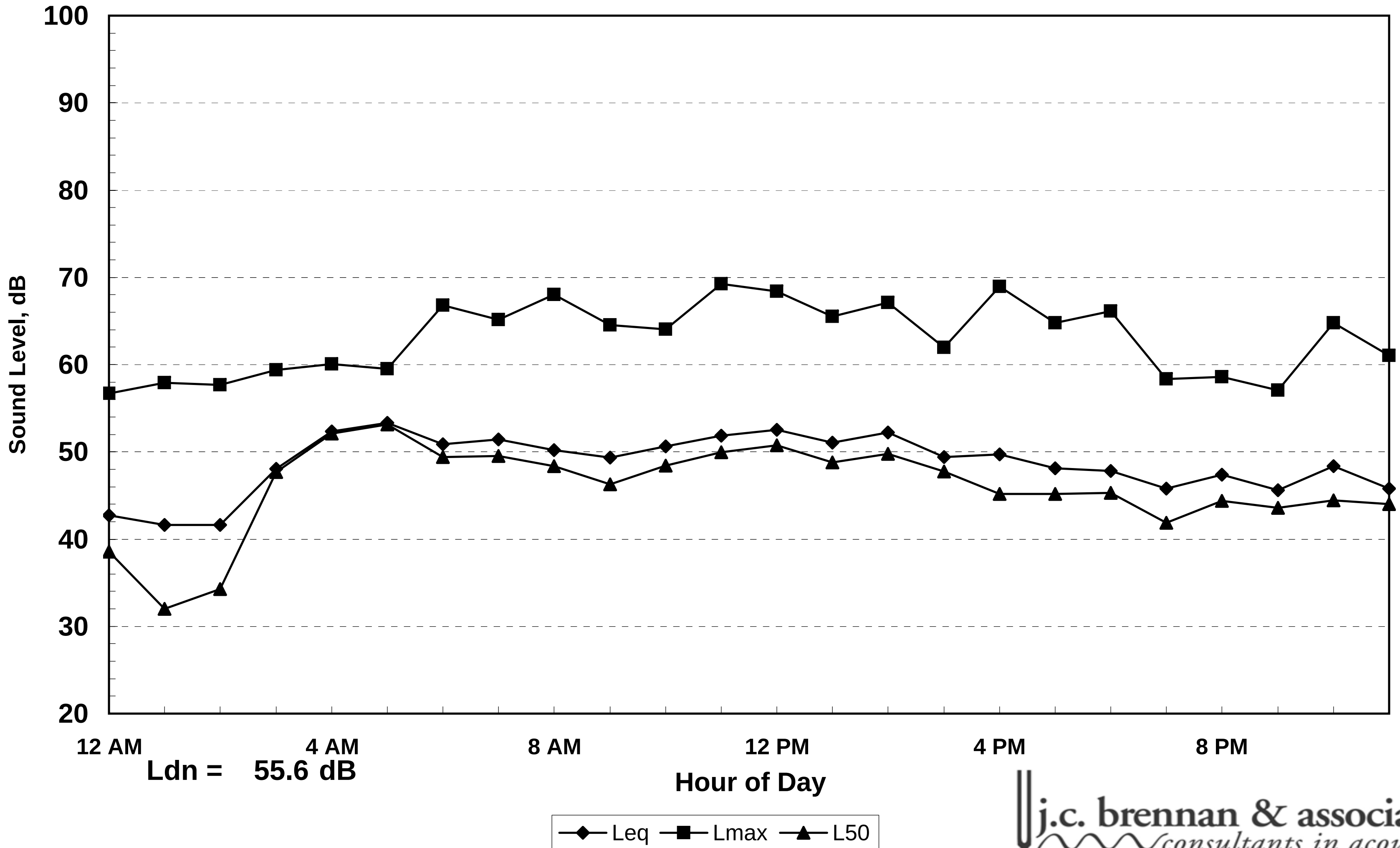
Appendix B

Lummi Wind Study

24hr Continuous Noise Monitoring - Site LT-2

Sunday, April 24, 2011



Ldn = 55.6 dB

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Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-2
Monday, April 25, 2011

Hour	Leq	Lmax	L50	L8
0:00	44.74	54.9	43.94	47.27
1:00	43.05	57.9	42.01	46.16
2:00	35.96	54.01	33.91	37.75
3:00	40.62	53.63	38.51	44
4:00	48.39	57.75	46.67	52.76
5:00	46.33	64.99	40.72	50.47
6:00	52.2	65.97	45.94	57.42
7:00	58.87	69.19	57.65	62.31
8:00	60.35	70.76	59.28	64.1
9:00	61.76	71.69	60.9	64.89
10:00	61.19	71.87	60.08	64.96
11:00	57.72	70.9	49.48	63.33
12:00	59.9	70.3	58.75	63.85
13:00	60.62	74.01	60.15	64.05
14:00	59.96	78.47	58.59	63.69
15:00	57.14	69.45	54.39	61.57
16:00	56.3	77.05	54.3	58.03
17:00	55.77	65.43	55.21	58.14
18:00	55.17	65.79	54.5	57.51
19:00	53	68.41	51.78	55.46
20:00	48.21	62.74	46.28	51.87
21:00	46	62.08	42.12	49.94
22:00	46.32	58.82	44.19	50.53
23:00	42.6	55.39	40.39	46.4

	Statistical Summary					
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	61.8	46.0	58.4	52.2	36.0	46.5
Lmax (Maximum)	78.5	62.1	69.9	66.0	53.6	58.2
L50 (Median)	60.9	42.1	54.9	46.7	33.9	41.8
L8	65.0	49.9	60.2	57.4	37.8	48.1

Computed Ldn, dB	57.8
% Daytime Energy	96%
% Nighttime Energy	4%

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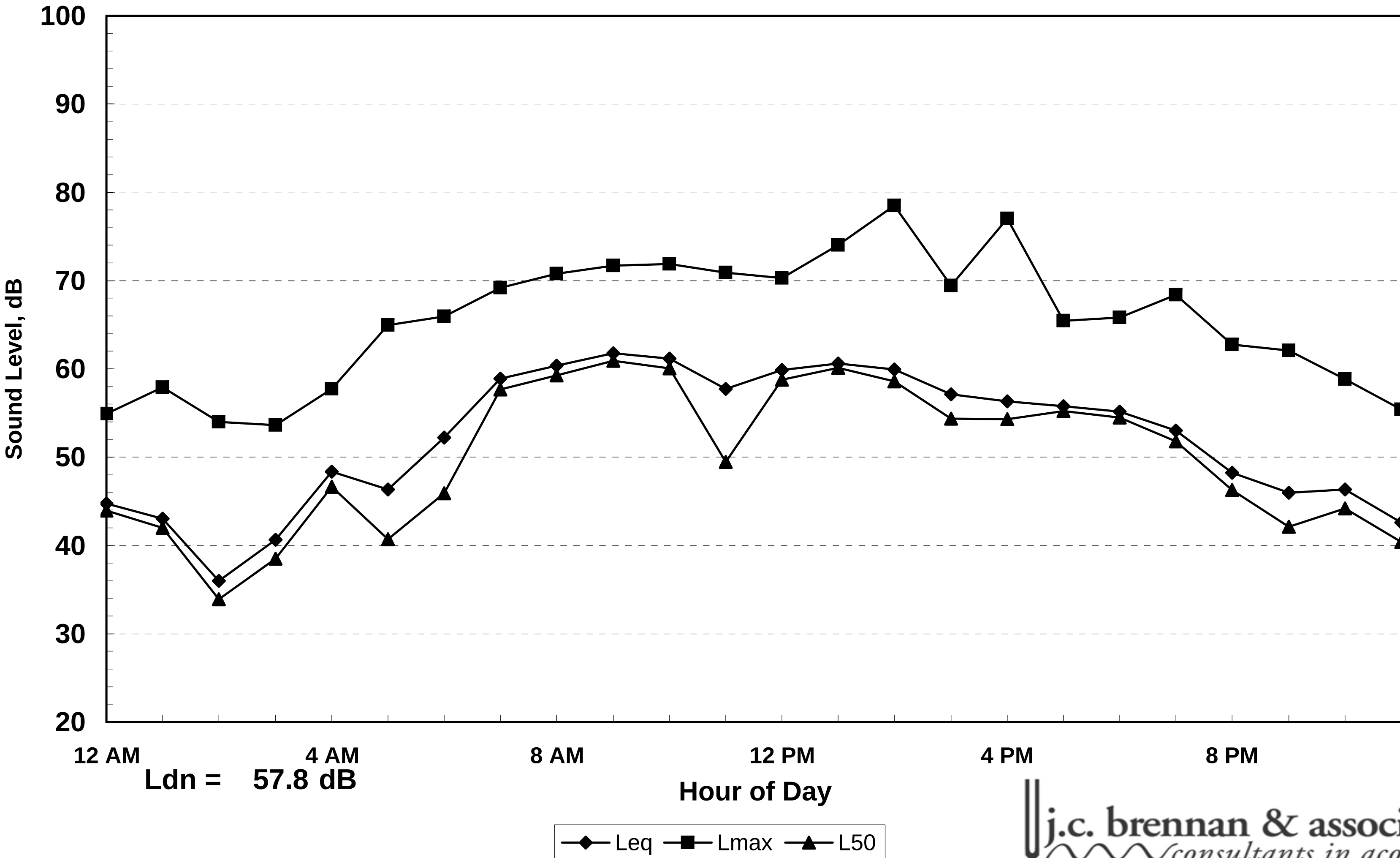
Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-2
Monday, April 25, 2011



Ldn = 57.8 dB

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Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-2
Tuesday, April 26, 2011

Hour	Leq	Lmax	L50	L8
0:00	42.2	61.33	37.44	45.95
1:00	48.72	60.69	48.12	51.3
2:00	46.97	59.2	45.64	49.6
3:00	47.76	63.58	46	50.12
4:00	50.25	64.44	48.26	53.56
5:00	49.62	72.94	45.49	52.72
6:00	53.54	70.19	48.33	57.06
7:00	51.94	67.72	48.92	55.83
8:00	51.77	65.14	49.72	55.14
9:00	52.75	68.94	50.85	56.38
10:00	52.21	70.83	49.44	55.44
11:00	52.8	70.39	47.04	55.38
12:00	48.8	62.3	46.43	52.72
13:00	48.96	70.6	45.9	52.8
14:00	49.88	65.3	45.95	53.87
15:00	49.98	64.16	47.08	53.53
16:00	50.39	68.42	46.58	53.74
17:00	45.25	56.85	43.22	49.26
18:00	46.3	62.37	42.53	49.32
19:00	45.19	63.8	42.19	48.72
20:00	43.98	56.99	41.08	48.29
21:00	45.88	62.83	42.67	49.7
22:00	45.68	64.03	41.62	49.13
23:00	45.48	62.89	39.91	49.87

	Statistical Summary					
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	52.8	44.0	50.0	53.5	42.2	48.9
Lmax (Maximum)	70.8	56.9	65.1	72.9	59.2	64.4
L50 (Median)	50.9	41.1	46.0	48.3	37.4	44.5
L8	56.4	48.3	52.7	57.1	46.0	51.0

Computed Ldn, dB	55.5
% Daytime Energy	68%
% Nighttime Energy	32%

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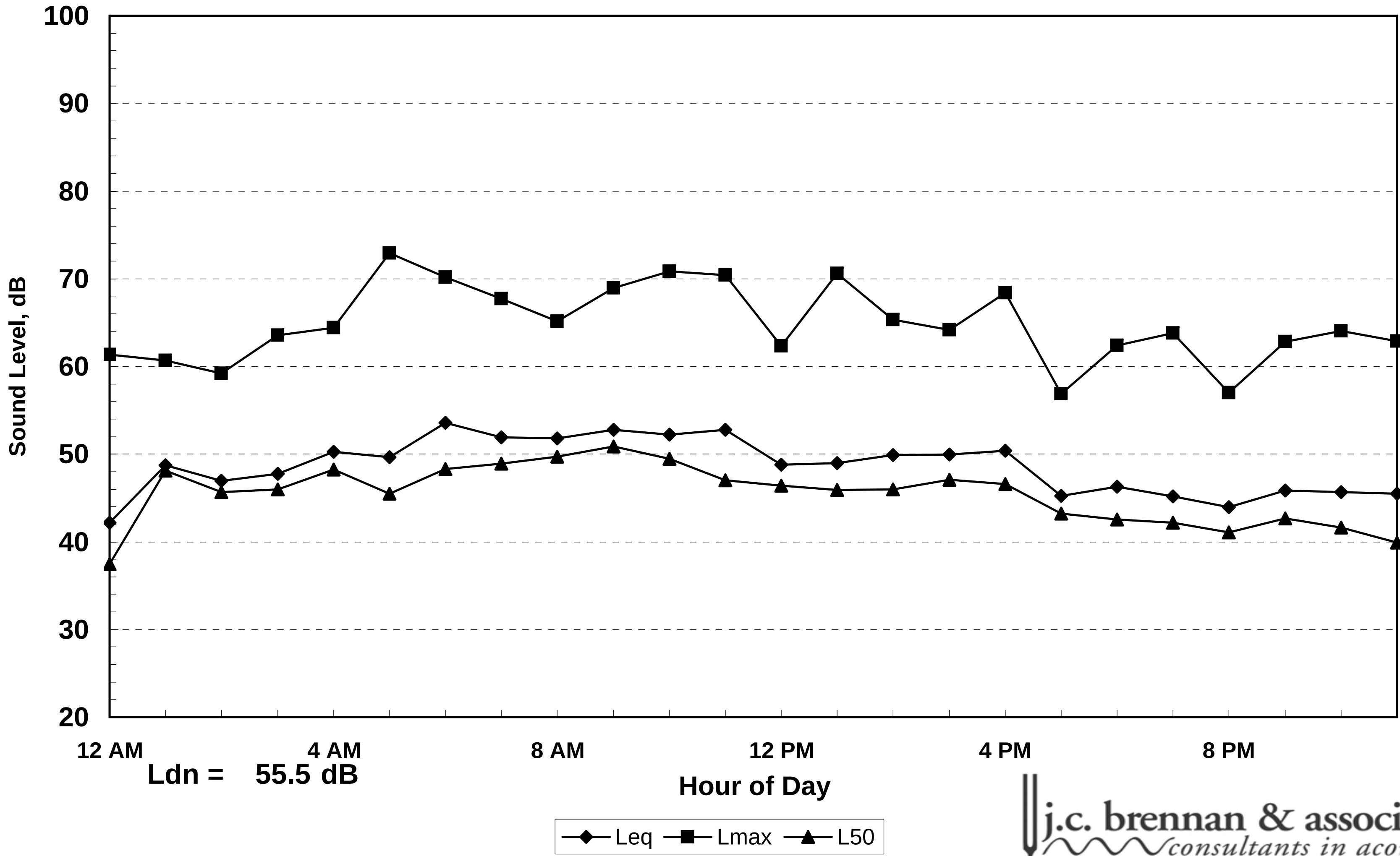
Appendix B

Lummi Wind Study

24hr Continuous Noise Monitoring - Site LT-2

Tuesday, April 26, 2011



Ldn = 55.5 dB

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Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-3
Wednesday, April 20, 2011

Hour	Leq	Lmax	L50	L8
0:00	43.76	51.37	43.26	46.29
1:00	39.72	51.23	38.59	42.66
2:00	37.27	51.46	35.38	40.04
3:00	34.35	47.58	31.85	38.12
4:00	33.45	45.94	31.37	36.87
5:00	46.35	58.42	44.25	49.61
6:00	50.02	74.79	44.65	52.94
7:00	47.57	61.78	44.72	51.16
8:00	51.85	78.58	43.44	49.72
9:00	47.44	68.21	41.97	49.6
10:00	46.47	58.99	42.57	51.23
11:00	51.23	79.29	40.76	51.47
12:00	56.48	86.34	39.9	51.11
13:00	46.67	65.3	38.54	49.94
14:00	46.87	74.93	40.01	49.92
15:00	45.44	68.14	36.72	42.95
16:00	46.6	72.29	40.63	49.64
17:00	49.34	71.23	37.48	45.2
18:00	45	63.66	39.9	49.34
19:00	39.54	55.89	36.41	41.96
20:00	45.8	67.65	39.87	46.19
21:00	52.19	76.05	47.57	51.3
22:00	44.48	58.13	44.19	46.26
23:00	42.86	55.35	42.19	45.45

	Statistical Summary					
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	56.5	39.5	49.7	50.0	33.5	44.2
Lmax (Maximum)	86.3	55.9	69.9	74.8	45.9	54.9
L50 (Median)	47.6	36.4	40.7	44.7	31.4	39.5
L8	51.5	42.0	48.7	52.9	36.9	44.2

Computed Ldn, dB	51.9
% Daytime Energy	86%
% Nighttime Energy	14%

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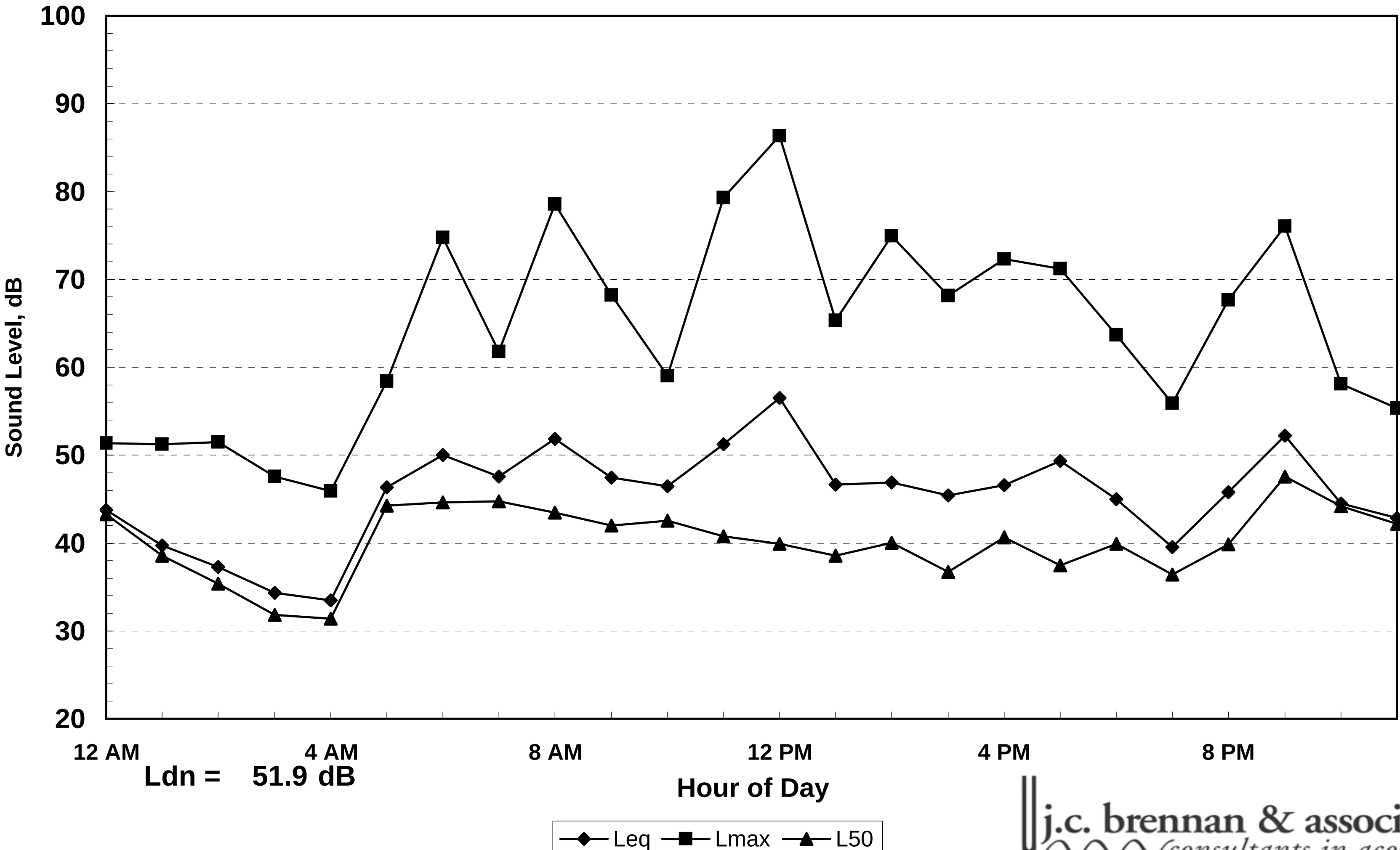
Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-3
Wednesday, April 20, 2011



Ldn = 51.9 dB

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Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-3
Thursday, April 21, 2011

Hour	Leq	Lmax	L50	L8
0:00	39.57	47.69	38.72	42.48
1:00	37.06	45.79	35.59	40.43
2:00	34.51	55.16	31.42	36.48
3:00	38.76	56.16	35.4	41.36
4:00	35.86	49.04	32.92	39.69
5:00	47.37	58.6	44.76	51.19
6:00	48.51	72.79	42.87	50.75
7:00	49.04	75.67	44.04	49.27
8:00	48.76	70.07	43.13	50.87
9:00	46.09	61.58	42.15	47.44
10:00	46.37	71.38	41.49	47.04
11:00	43.02	61.79	39.96	45.63
12:00	46.23	69.29	38.26	44.97
13:00	43.62	61.32	39.4	46.68
14:00	53.39	77.66	40.01	53.05
15:00	46.72	70.72	38.29	51.22
16:00	52.99	75.65	43.83	48.22
17:00	44.47	59.62	42.62	47.08
18:00	42.57	60.13	40.32	45.14
19:00	44.54	62.12	43.19	47.17
20:00	47.12	67.34	44.51	48.4
21:00	47.9	52.05	47.72	49.64
22:00	47.44	61.69	46.97	49.28
23:00	43.81	56.42	43	45.82

	Statistical Summary					
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	53.4	42.6	48.1	48.5	34.5	44.1
Lmax (Maximum)	77.7	52.1	66.4	72.8	45.8	55.9
L50 (Median)	47.7	38.3	41.9	47.0	31.4	39.1
L8	53.1	45.0	48.1	51.2	36.5	44.2

Computed Ldn, dB	51.4
% Daytime Energy	81%
% Nighttime Energy	19%

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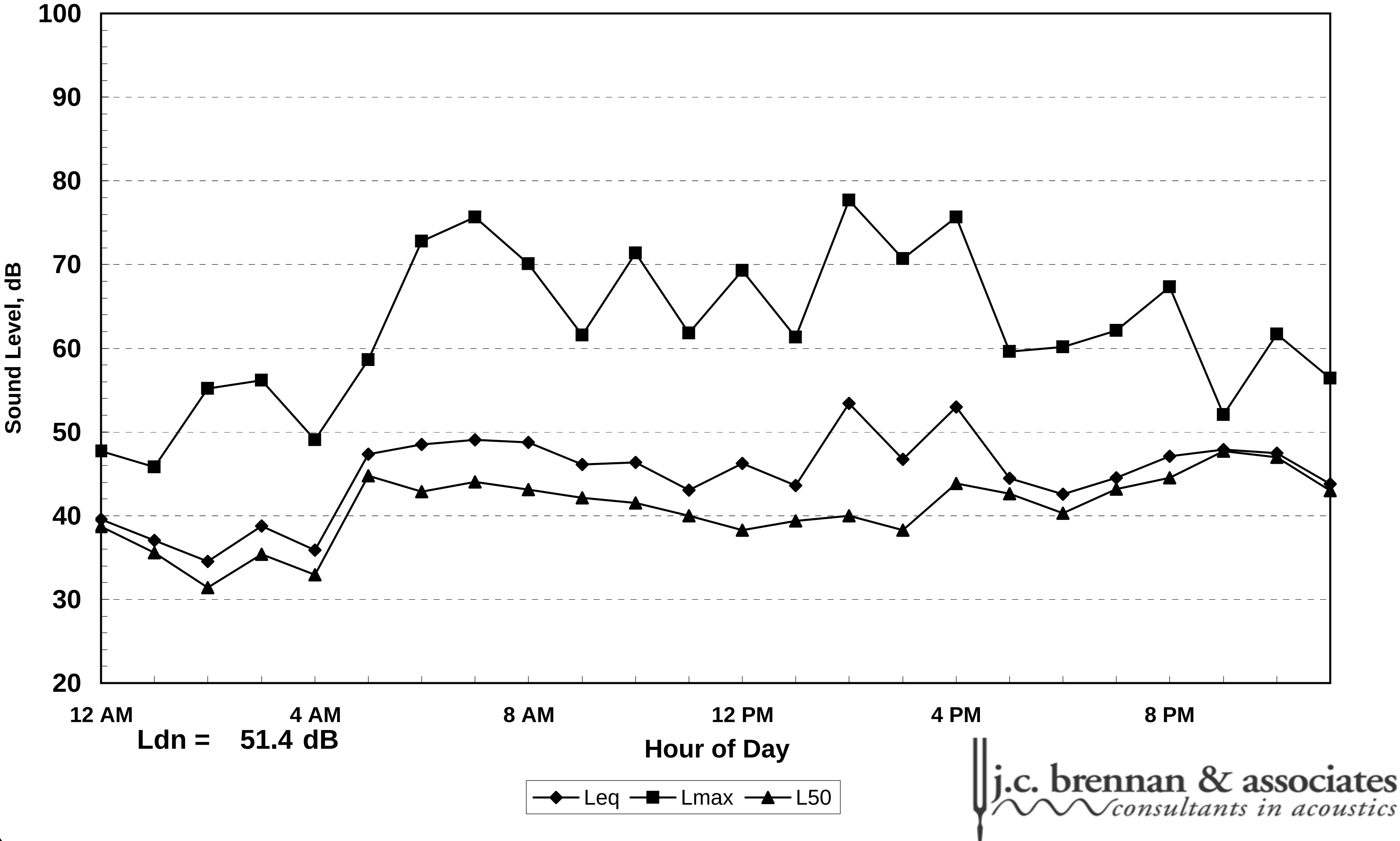
Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-3
Thursday, April 21, 2011



Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-3
Friday, April 22, 2011

Hour	Leq	Lmax	L50	L8
0:00	38.81	50.05	37.54	41.98
1:00	37.12	45.06	36	40.16
2:00	35.13	45.31	32.35	39.2
3:00	35.64	47.06	33.46	39.23
4:00	34.85	46.82	32.35	38.51
5:00	47.14	58.29	44.28	51.3
6:00	49.2	63.39	45.95	53.26
7:00	50.07	67.76	47.58	53.22
8:00	49.78	67.27	45.99	53.48
9:00	49.39	65.51	46.76	53.05
10:00	48.27	70.54	41.11	49.46
11:00	49.21	70.82	39.92	50.86
12:00	59.35	86.51	42.05	51.17
13:00	45.13	62.58	39.02	48.51
14:00	51.39	76.11	40.27	50.43
15:00	49.66	74.04	39.42	47.37
16:00	46.04	69.52	38.95	47.37
17:00	42.94	65.36	38.72	44.2
18:00	54.22	76.09	37.92	46.37
19:00	52.27	75.2	41.58	48.54
20:00	45.12	57	43.11	48.85
21:00	51.28	66.72	51.19	52.87
22:00	52.12	56.28	51.76	53.97
23:00	48.01	52.87	47.98	49.85

	Statistical Summary					
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	59.4	42.9	51.7	52.1	34.9	46.3
Lmax (Maximum)	86.5	57.0	70.1	63.4	45.1	51.7
L50 (Median)	51.2	37.9	42.2	51.8	32.4	40.2
L8	53.5	44.2	49.7	54.0	38.5	45.3

Computed Ldn, dB	54.0
% Daytime Energy	85%
% Nighttime Energy	15%

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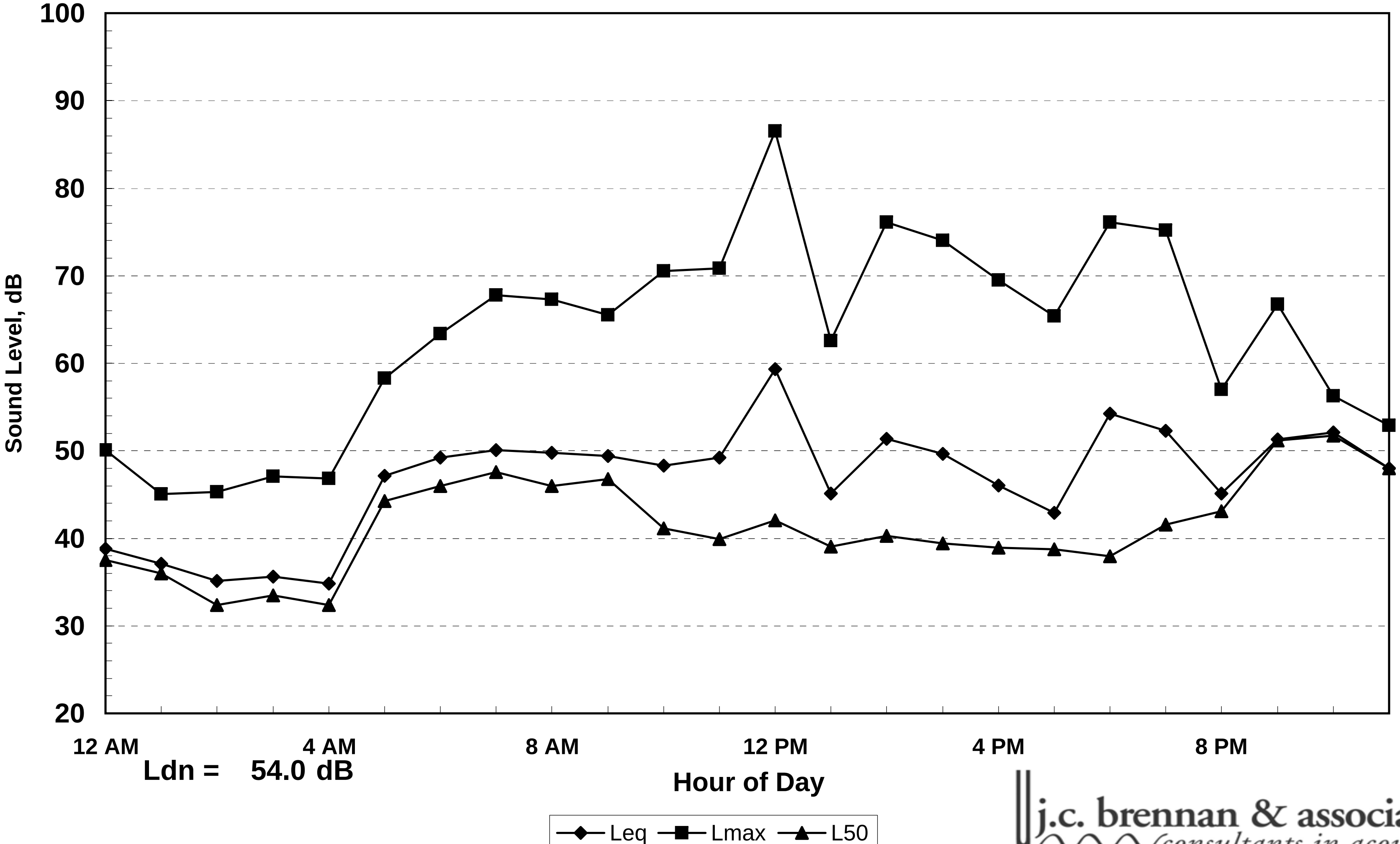
Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-3
Friday, April 22, 2011



Ldn = 54.0 dB

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Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-3
Saturday, April 23, 2011

Hour	Leq	Lmax	L50	L8
0:00	46.62	60.34	45.69	48.9
1:00	45.06	50.9	44.44	47.81
2:00	40.9	60.51	40.29	42.97
3:00	38.9	48.36	37.59	41.94
4:00	35.55	46.47	34.43	38.38
5:00	47.22	62.97	45.2	50.26
6:00	48.47	63.85	44.08	53.12
7:00	47.52	61.67	43.93	51.6
8:00	47.83	60.65	43.14	52.51
9:00	49	66.64	43.12	53.24
10:00	48.39	65.41	42.76	52.78
11:00	54.97	82.83	38.54	51.9
12:00	52.15	76.31	38.44	47.37
13:00	46.15	67.09	39.17	48.21
14:00	46.37	67.37	40.14	48.76
15:00	46.93	70.08	40.09	47.29
16:00	46.46	63.72	40.25	49.12
17:00	44.13	65.03	40.01	46.42
18:00	43.83	66.53	38.91	43.7
19:00	47.3	66.59	41.37	48.68
20:00	46.13	65.72	44.19	48.24
21:00	51.71	55.05	51.66	53.39
22:00	52	56.43	51.79	53.5
23:00	48.52	55.23	47.84	50.83

	Statistical Summary					
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	55.0	43.8	49.1	52.0	35.6	47.0
Lmax (Maximum)	82.8	55.1	66.7	63.9	46.5	56.1
L50 (Median)	51.7	38.4	41.7	51.8	34.4	43.5
L8	53.4	43.7	49.5	53.5	38.4	47.5

Computed Ldn, dB	53.8
% Daytime Energy	73%
% Nighttime Energy	27%

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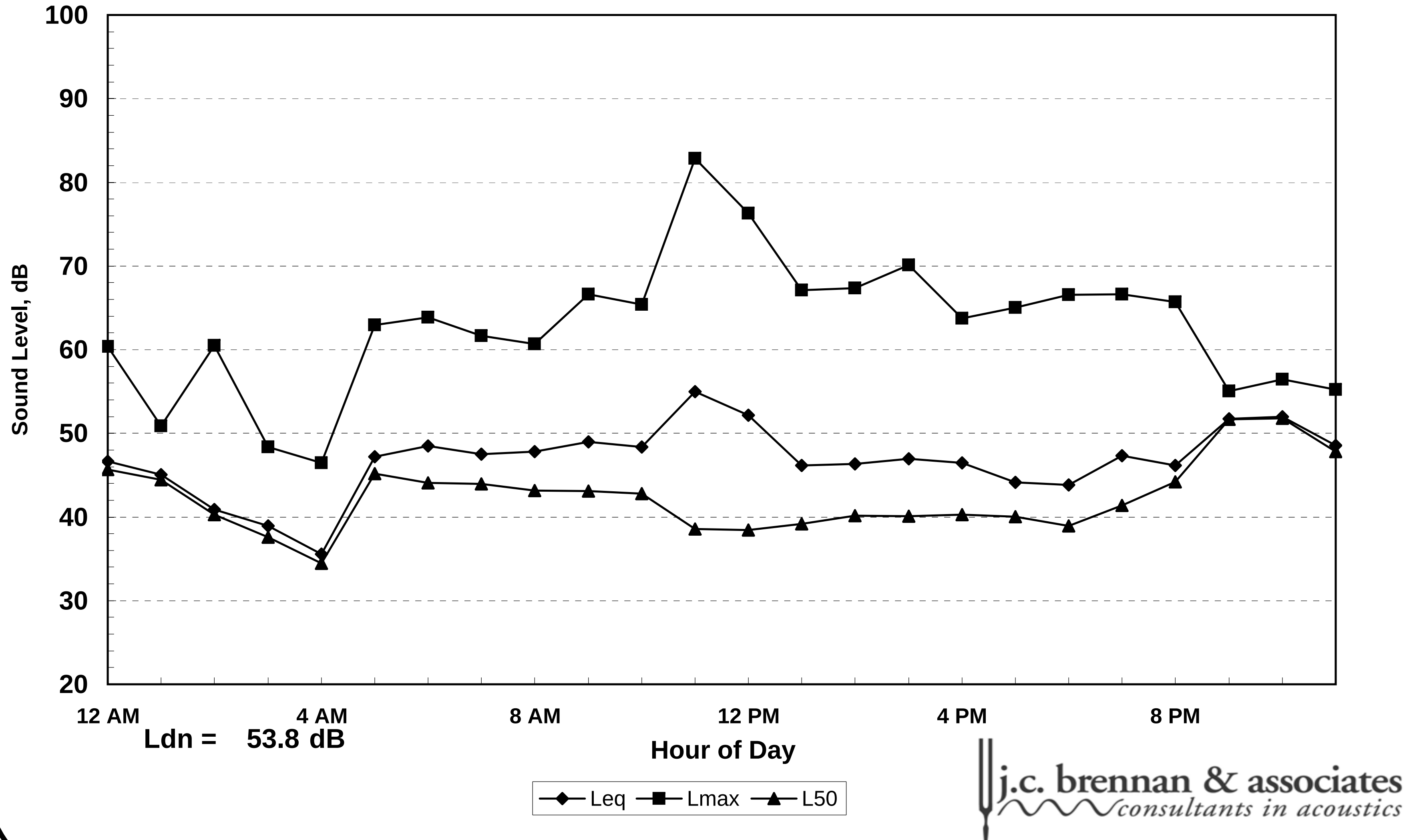
Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-3
Saturday, April 23, 2011



Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-3
Sunday, April 24, 2011

Hour	Leq	Lmax	L50	L8
0:00	45.71	51.37	45.33	47.72
1:00	43.57	50.07	43.14	45.65
2:00	43.14	52.86	42.42	46
3:00	37.78	48.29	36.77	40.22
4:00	37.35	51.65	34.87	41.06
5:00	47.83	59.86	45.32	51.65
6:00	48.27	58.26	45.84	52.34
7:00	47.94	59.72	45.97	51.55
8:00	48.74	67.28	44.02	50.95
9:00	45.69	56.74	44.06	48.71
10:00	47.97	70.08	44.34	49.87
11:00	47.15	64.12	44.84	49.86
12:00	51.48	73.69	46.62	52.93
13:00	46.34	62.98	44.8	48.64
14:00	47.42	64.62	45.78	49.63
15:00	49.14	67.82	45	50.26
16:00	45.26	61.52	42.66	48.41
17:00	46.37	69.11	41.45	46.83
18:00	46.71	67.33	44.34	47.75
19:00	44.12	63.7	42.47	46.43
20:00	45.25	67	41.58	46.31
21:00	48.47	68.12	45.32	48.83
22:00	46.65	58.59	45.32	49.62
23:00	46.97	54.21	46.05	49.85

	Statistical Summary					
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	51.5	44.1	47.6	48.3	37.4	45.5
Lmax (Maximum)	73.7	56.7	65.6	59.9	48.3	53.9
L50 (Median)	46.6	41.5	44.2	46.1	34.9	42.8
L8	52.9	46.3	49.1	52.3	40.2	47.1

Computed Ldn, dB	52.2
% Daytime Energy	73%
% Nighttime Energy	27%

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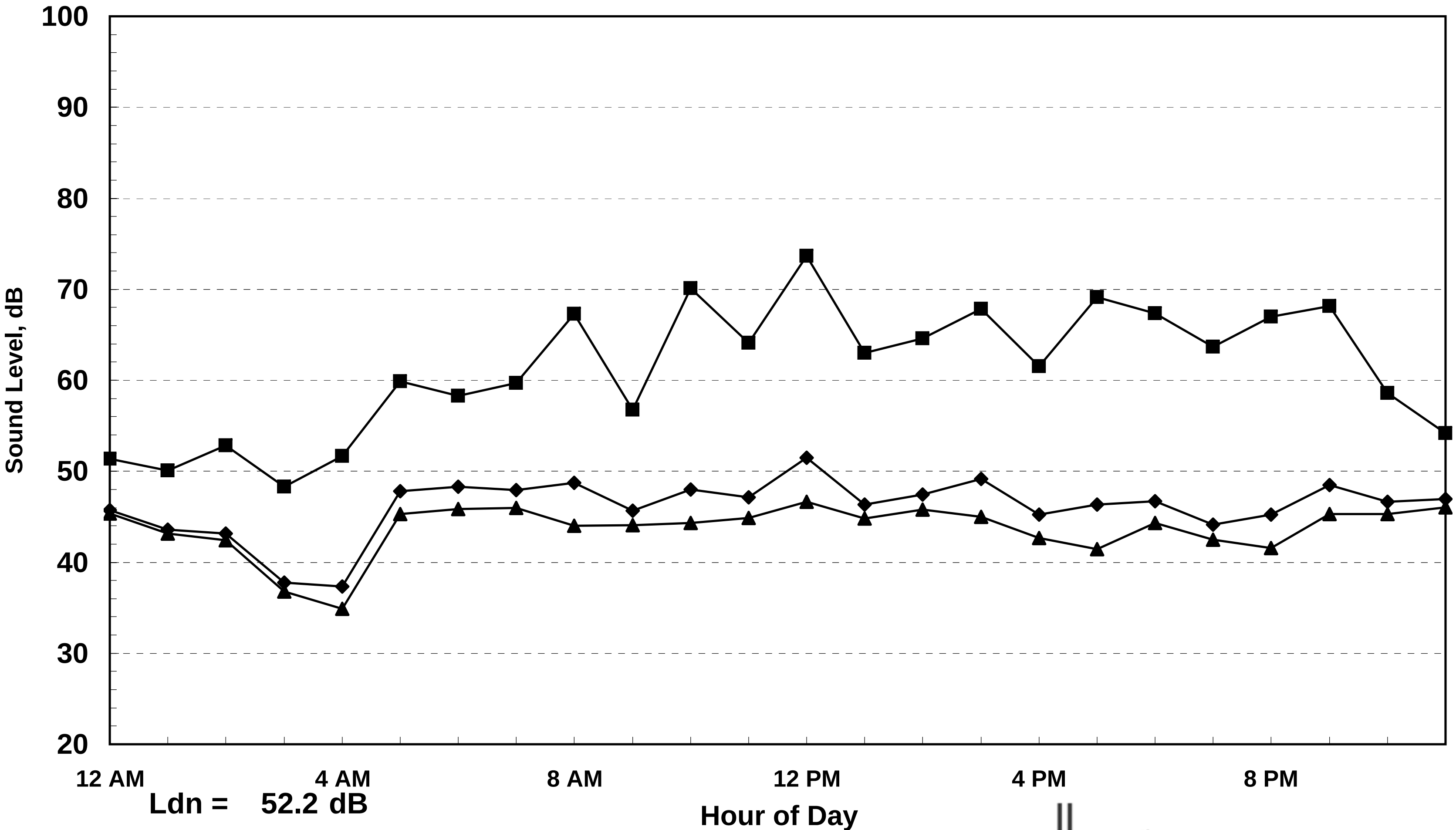
Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-3
Sunday, April 24, 2011



Ldn = 52.2 dB

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Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-3
Monday, April 25, 2011

Hour	Leq	Lmax	L50	L8
0:00	39.54	47.95	38.9	41.97
1:00	44.47	58.32	39.84	47.27
2:00	39.25	51.69	37.71	42.3
3:00	35.64	52.8	33.55	38.85
4:00	34.51	54.93	31.44	37.44
5:00	48.15	71.67	42.79	52.15
6:00	49.44	66.27	45.99	53.62
7:00	51.11	75.77	45.36	53.73
8:00	50.69	70.54	44.69	53.53
9:00	52.83	74.18	43.67	53.32
10:00	50.47	74.46	42.07	52.53
11:00	43.9	62.91	38.47	47.94
12:00	45.65	65.74	40.36	48.01
13:00	47.44	65.36	44.24	49.67
14:00	47.25	61.64	45.44	49.76
15:00	48.09	57.42	47.23	50.68
16:00	48.97	60.65	47.89	51.29
17:00	48.12	60.38	47.5	50.33
18:00	48.08	66	46.76	49.85
19:00	46.74	63.97	45.18	48.92
20:00	46.69	65.22	44.77	48.58
21:00	56.44	77.43	46.76	52.72
22:00	46.85	65.25	45.84	48.86
23:00	44.13	52.85	43.46	46.41

	Statistical Summary					
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	56.4	43.9	50.1	49.4	34.5	44.9
Lmax (Maximum)	77.4	57.4	66.8	71.7	48.0	58.0
L50 (Median)	47.9	38.5	44.7	46.0	31.4	39.9
L8	53.7	47.9	50.7	53.6	37.4	45.4

Computed Ldn, dB	52.6
% Daytime Energy	85%
% Nighttime Energy	15%

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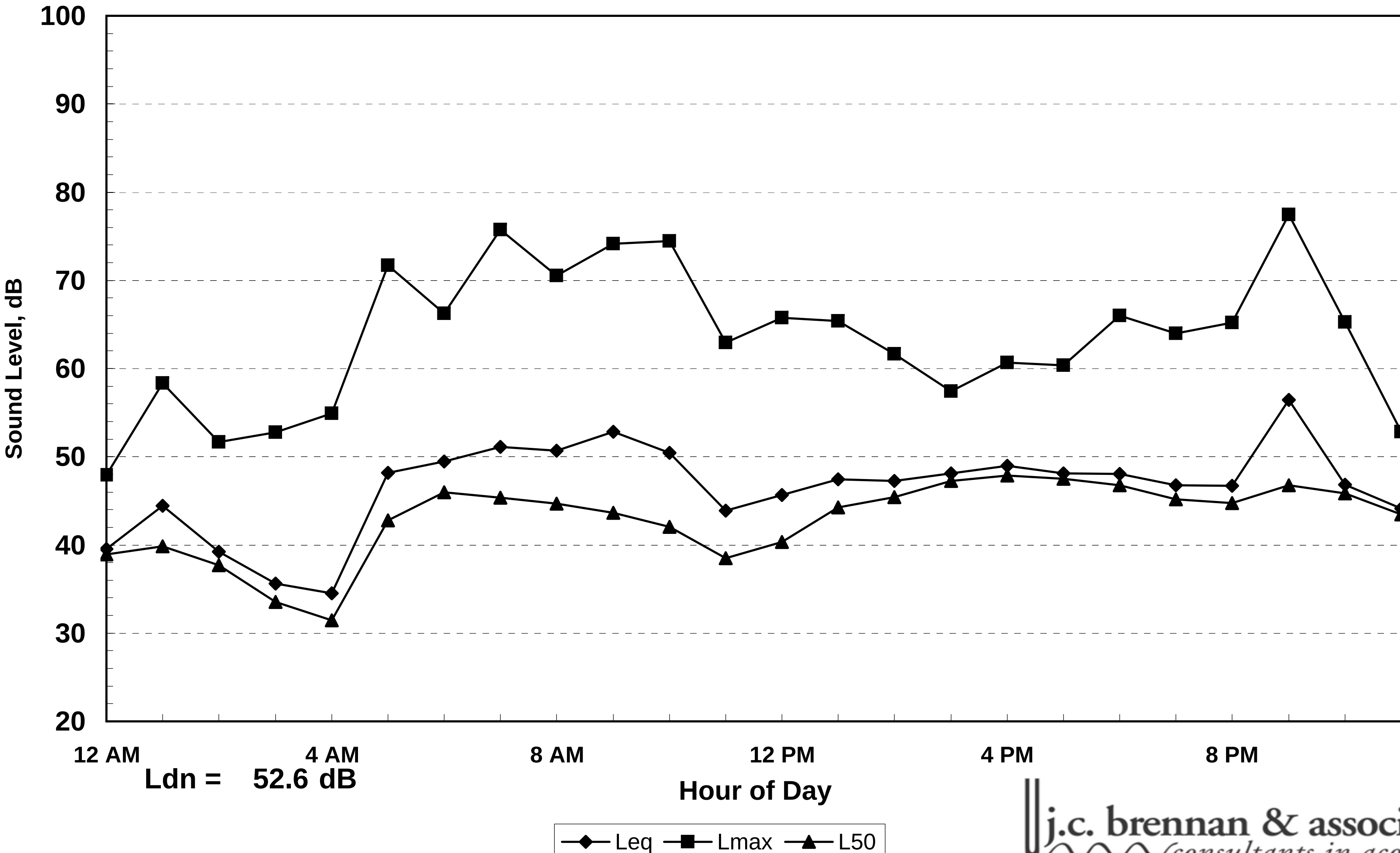
Appendix B

Lummi Wind Study

24hr Continuous Noise Monitoring - Site LT-3

Monday, April 25, 2011



Ldn = 52.6 dB

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Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-3
Tuesday, April 26, 2011

Hour	Leq	Lmax	L50	L8
0:00	42.73	59.22	40.69	44.52
1:00	40.54	56.72	39.03	43.62
2:00	41.15	53.48	40.01	43.66
3:00	40.69	51.49	39.59	43.19
4:00	40.8	51.74	39.58	43.58
5:00	49.9	64.97	44.93	53.47
6:00	51.01	71.6	45.27	54.08
7:00	48.6	62.37	46.84	51.68
8:00	49.37	67.65	47.15	51.61
9:00	50.76	77.19	47.03	51.4
10:00	48.02	63.58	46.05	50.79
11:00	47.76	64.97	45.45	50.27
12:00	47.14	59.62	44.54	50.58
13:00	47.22	72.08	42.94	49.74
14:00	49.06	79.07	44.81	48.62
15:00	46.55	57.98	45.22	49.59
16:00	47.9	67.6	43.19	48.8
17:00	44.04	60.86	41.74	46.32
18:00	42.93	59.94	41.4	45.7
19:00	40.79	59.98	38.12	43.07
20:00	47.62	80.49	39.34	49.05
21:00	52	57.69	52.02	53.68
22:00	50.92	69.4	50.01	52.56
23:00	47.02	57.2	46.95	48.98

	Statistical Summary					
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	52.0	40.8	48.1	51.0	40.5	47.1
Lmax (Maximum)	80.5	57.7	66.1	71.6	51.5	59.5
L50 (Median)	52.0	38.1	44.4	50.0	39.0	42.9
L8	53.7	43.1	49.4	54.1	43.2	47.5

Computed Ldn, dB	53.7
% Daytime Energy	68%
% Nighttime Energy	32%

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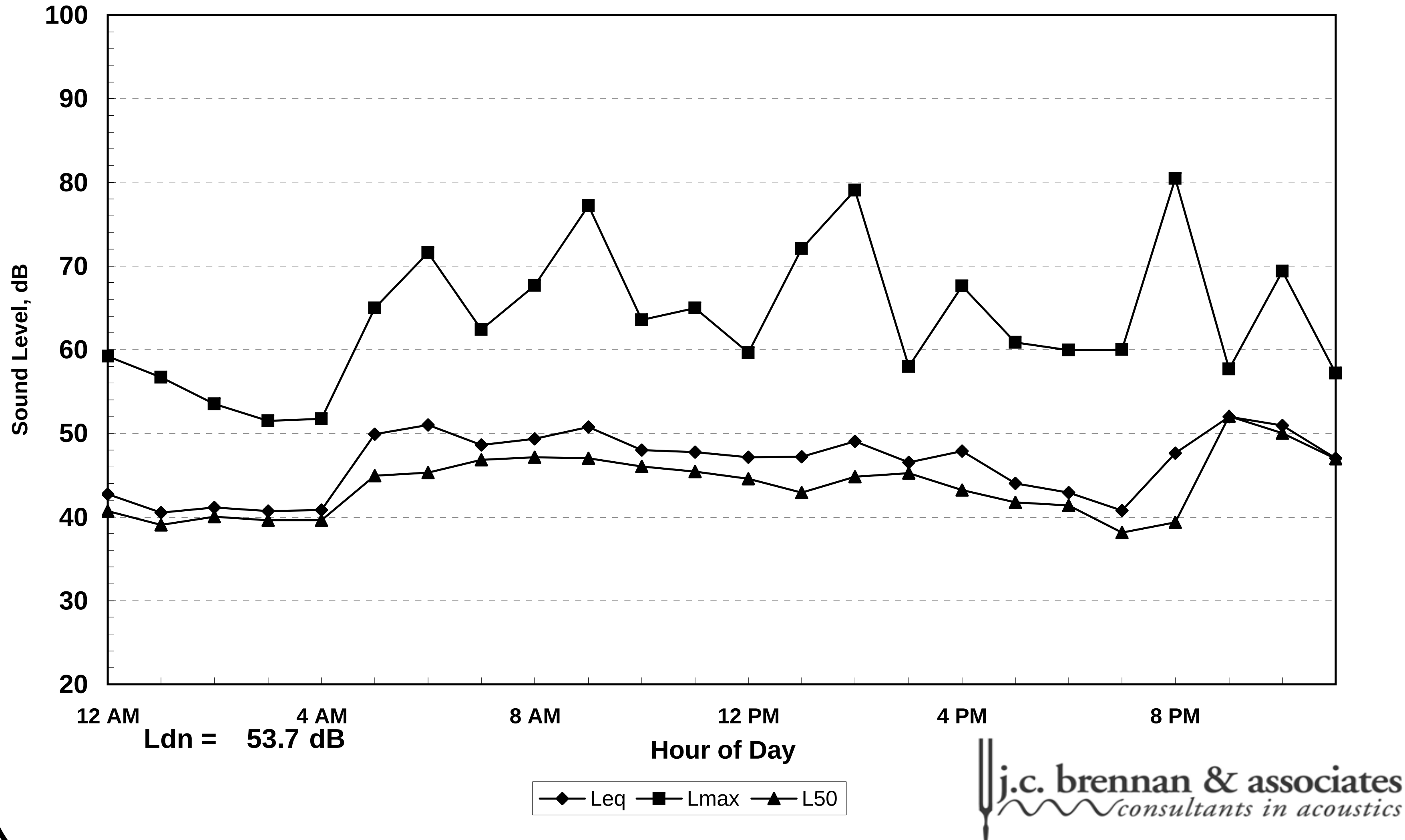
Appendix B

Lummi Wind Study

24hr Continuous Noise Monitoring - Site LT-3

Tuesday, April 26, 2011



Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-4
Thursday, April 28, 2011

Hour	Leq	Lmax	L50	L8
0:00	46.52	54.64	45.15	49.55
1:00	43.03	57.51	41.68	45.64
2:00	42.96	54.39	42.15	45.72
3:00	44.76	52.01	44.48	47.73
4:00	43.43	52.52	42.89	45.28
5:00	45.85	53.39	43.92	50.02
6:00	46.71	55.89	45.29	50.11
7:00	45.65	59.39	44.15	48.47
8:00	49.76	61.28	49.29	52.03
9:00	45.83	57.93	44.51	48.19
10:00	44.87	57.33	43.58	47.4
11:00	45.01	56.86	42.42	49.11
12:00	45.46	55.17	42.83	49.29
13:00	44.9	61.41	41.78	47.05
14:00	42.01	56.43	40	45.02
15:00	44.64	60.97	42.42	46.88
16:00	44.08	58.23	41.52	46.94
17:00	45.17	56.83	42.07	49.48
18:00	48.97	76.15	43.65	49.78
19:00	42.57	57.4	39.79	46.11
20:00	43.5	58.83	42.42	46.54
21:00	39.57	56.28	36.68	42.42
22:00	42.61	66.09	34.38	44.18
23:00	36.39	52.83	31.74	40

	Statistical Summary					
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	49.8	39.6	45.5	46.7	36.4	44.3
Lmax (Maximum)	76.2	55.2	59.4	66.1	52.0	55.5
L50 (Median)	49.3	36.7	42.5	45.3	31.7	41.3
L8	52.0	42.4	47.6	50.1	40.0	46.5

Computed Ldn, dB	50.9
% Daytime Energy	68%
% Nighttime Energy	32%

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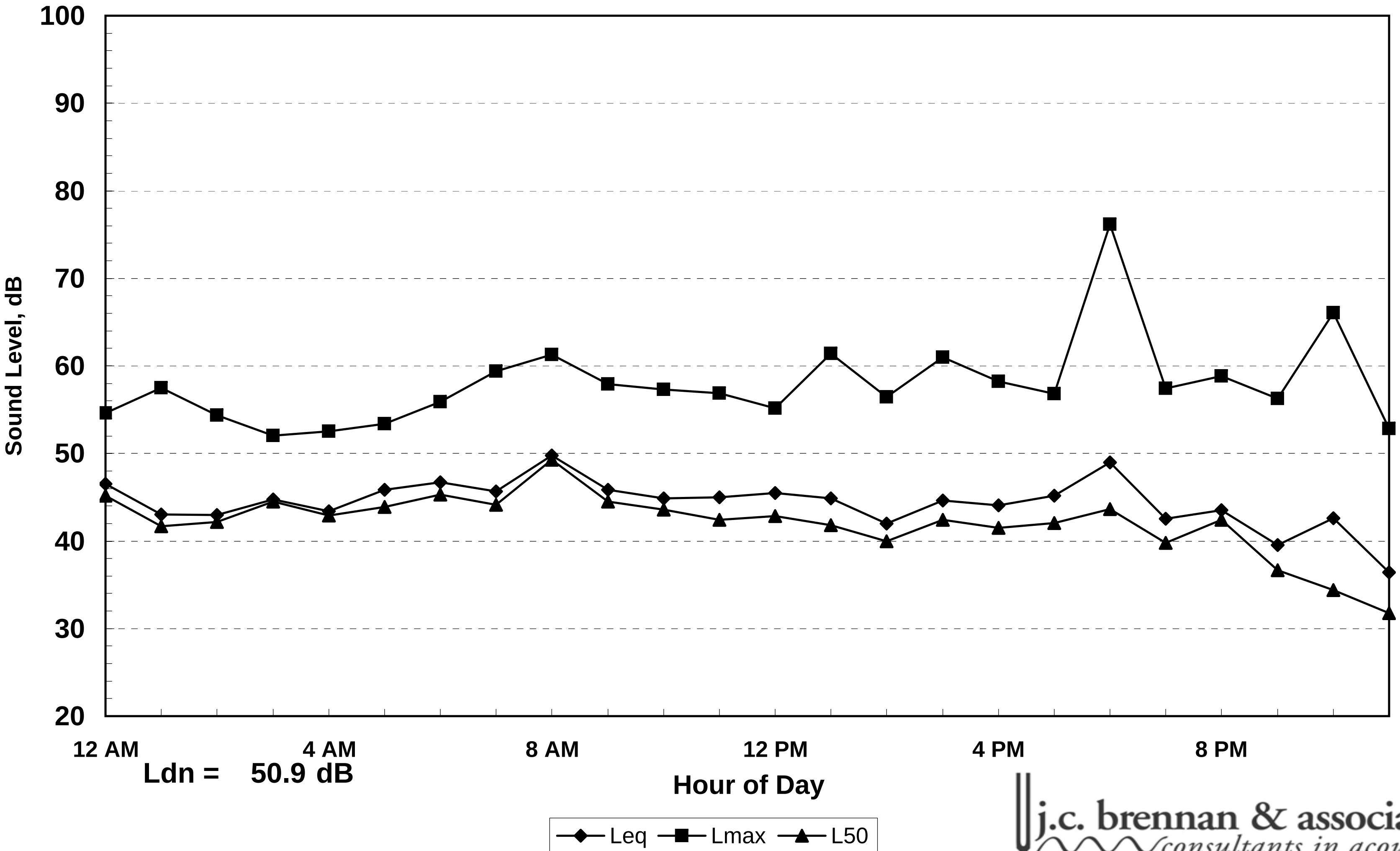
Appendix B

Lummi Wind Study

24hr Continuous Noise Monitoring - Site LT-4

Thursday, April 28, 2011



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Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-4
Friday, April 29, 2011

Hour	Leq	Lmax	L50	L8
0:00	36.22	54.68	30.84	39.97
1:00	32.33	47.4	28.04	34.92
2:00	32.15	46.15	28.74	34.6
3:00	31.89	53.02	28.63	34.03
4:00	31.13	48.01	28.79	32.58
5:00	42.76	55.01	35.55	49.19
6:00	41.43	58.28	38.18	44.04
7:00	45.55	67.79	39.84	46.13
8:00	47.5	62.44	44.59	50.51
9:00	43.39	56.1	41.28	46.51
10:00	47.89	67.86	43.3	51.17
11:00	43.26	59.31	40.44	46.14
12:00	45.68	59.91	42.48	49.7
13:00	47.33	63.94	44.49	48.78
14:00	46.43	59.73	44.92	49.32
15:00	47.18	61.79	44.6	50.25
16:00	45.17	62.22	41.4	47.98
17:00	43.85	58.54	42.4	46.69
18:00	44.61	61.79	39.69	47.06
19:00	46.31	65.58	41.74	49.64
20:00	39.92	52.26	37.12	43.35
21:00	43.04	54.83	38.59	48.53
22:00	38.81	53.31	36.06	42.38
23:00	43.26	55.26	37.4	48.57

	Statistical Summary					
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	47.9	39.9	45.6	43.3	31.1	39.0
Lmax (Maximum)	67.9	52.3	60.9	58.3	46.2	52.3
L50 (Median)	44.9	37.1	41.8	38.2	28.0	32.5
L8	51.2	43.4	48.1	49.2	32.6	40.0

Computed Ldn, dB	47.2
% Daytime Energy	88%
% Nighttime Energy	12%

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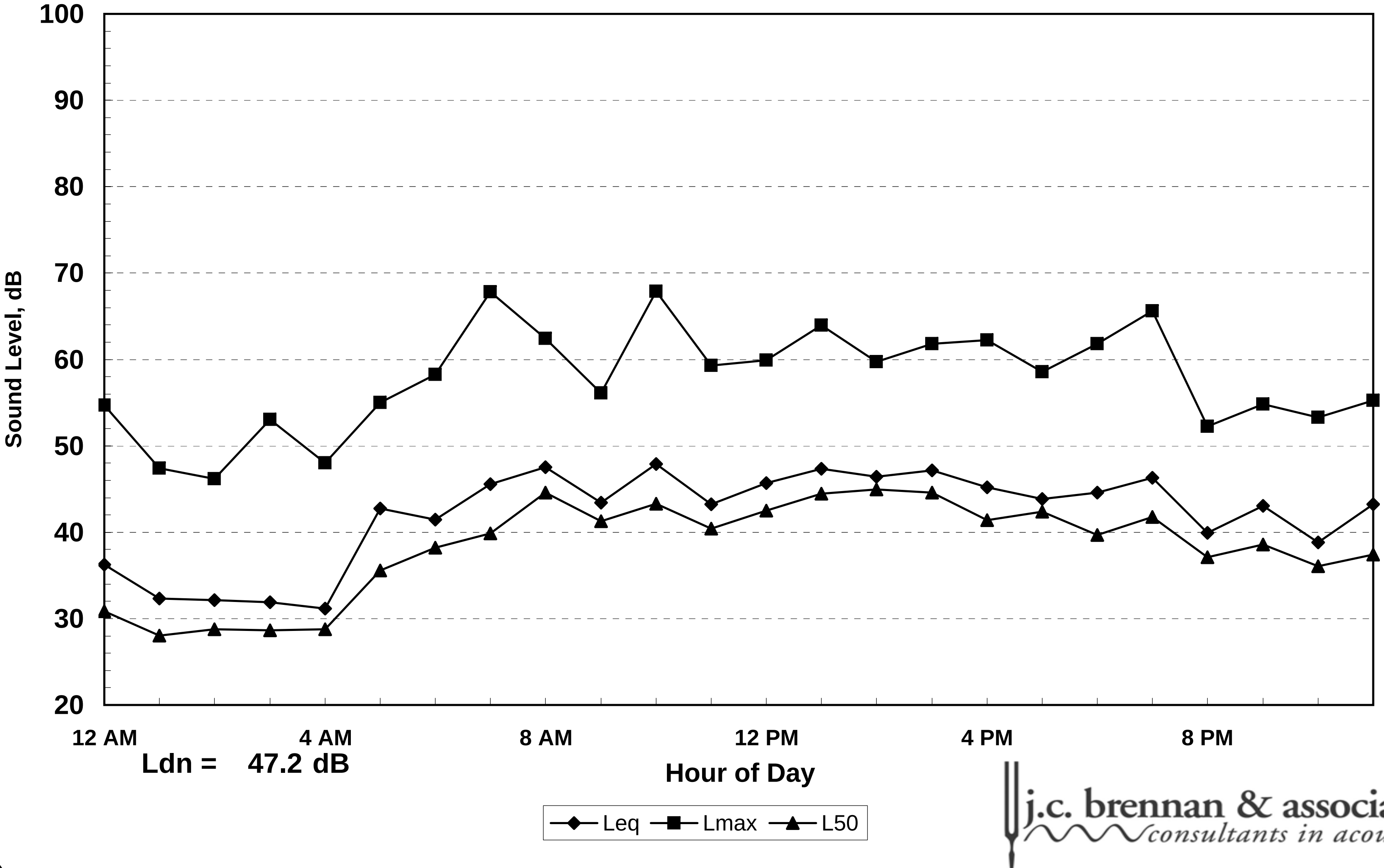
Appendix B

Lummi Wind Study

24hr Continuous Noise Monitoring - Site LT-4

Friday, April 29, 2011



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Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-4
Saturday, April 30, 2011

Hour	Leq	Lmax	L50	L8
0:00	36.08	49.74	30.67	40.36
1:00	34.2	53.72	30.13	36.05
2:00	31.55	49.45	29.1	33.61
3:00	30.04	46.58	27.36	31.55
4:00	29.01	54.08	26.08	29.99
5:00	36.6	47.34	34.34	40.26
6:00	37.97	53.22	34.34	42.11
7:00	40.04	52.48	36.55	44.24
8:00	42.06	55.23	38.76	45.41
9:00	47.61	62.12	46.66	50.24
10:00	43.99	56.76	41.73	48.2
11:00	42.59	58.92	40.65	45.1
12:00	43.1	61.61	40.18	46.28
13:00	42.73	62.4	39.22	45.57
14:00	45.83	66.4	41.09	47.61
15:00	42.66	59.18	40.9	45.03
16:00	45.59	69.36	39.04	44.64
17:00	43.08	58.89	39.44	46.09
18:00	44.94	57.7	39.96	49.21
19:00	41.39	56.2	39.7	44.11
20:00	45.25	73.65	39.7	44.54
21:00	48.47	78.18	37.61	43.86
22:00	43.57	76.29	35.96	42.85
23:00	37.29	58.12	33.01	40.23

	Statistical Summary					
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	48.5	40.0	44.6	43.6	29.0	37.3
Lmax (Maximum)	78.2	52.5	61.9	76.3	46.6	54.3
L50 (Median)	46.7	36.6	40.1	36.0	26.1	31.2
L8	50.2	43.9	46.0	42.9	30.0	37.4

Computed Ldn, dB	45.8
% Daytime Energy	90%
% Nighttime Energy	10%

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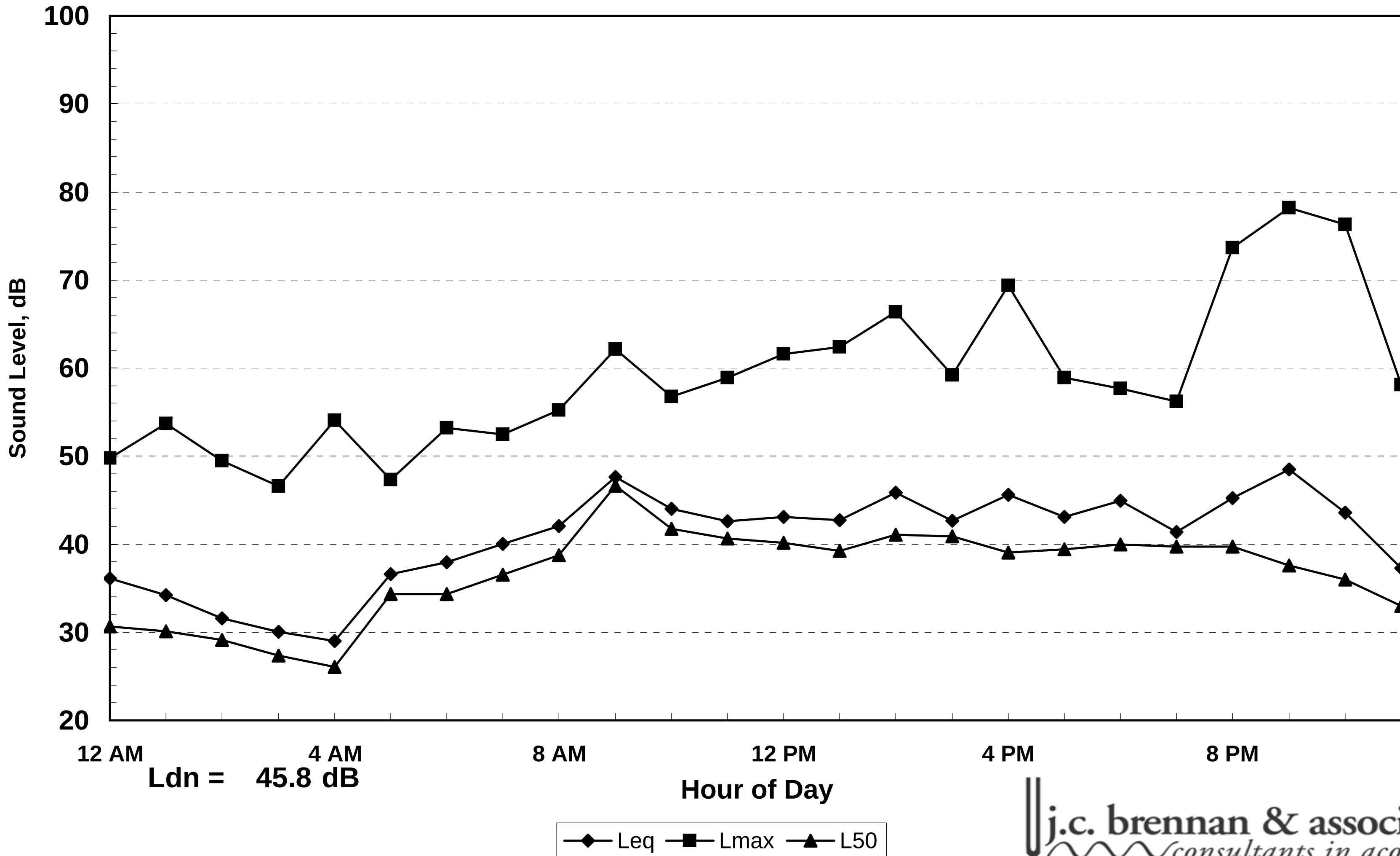
Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-4
Saturday, April 30, 2011



Ldn = 45.8 dB

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Appendix B

Lummi Wind Study

24hr Continuous Noise Monitoring - Site LT-4

Sunday, May 01, 2011

Hour	Leq	Lmax	L50	L8
0:00	34.98	51.15	31.17	38.33
1:00	33.15	53.84	29.88	35.96
2:00	32.6	49.57	29.97	34.21
3:00	29.33	43.69	28.27	30.93
4:00	30.92	44.05	29.44	32.45
5:00	43.17	55.79	39.08	48.52
6:00	39.89	51.92	37.61	43.36
7:00	41.33	56.81	39.14	44.16
8:00	43.93	58.82	39.66	48.65
9:00	45.19	66.35	40.18	47.24
10:00	44.99	57	41.35	49.31
11:00	47.24	65.26	45.8	49.56
12:00	42.76	60.36	39.72	45.24
13:00	42.8	60.57	39.86	45.71
14:00	44.13	58.39	42.5	46.56
15:00	44.57	61.18	41.83	46.27
16:00	46.69	61.93	43.29	49.67
17:00	41.55	59.04	37.99	44.21
18:00	42.24	63.97	38.6	44.44
19:00	45.92	62.99	44.87	48.93
20:00	43.96	57.31	40.19	48.5
21:00	43.98	61.9	39.86	48.3
22:00	42.78	55.2	36.89	48.32
23:00	37.6	60.52	33.96	39.85

Statistical Summary

	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	47.2	41.3	44.4	43.2	29.3	38.5
Lmax (Maximum)	66.4	56.8	60.8	60.5	43.7	51.7
L50 (Median)	45.8	38.0	41.0	39.1	28.3	32.9
L8	49.7	44.2	47.1	48.5	30.9	39.1

Computed Ldn, dB	46.4
% Daytime Energy	87%
% Nighttime Energy	13%

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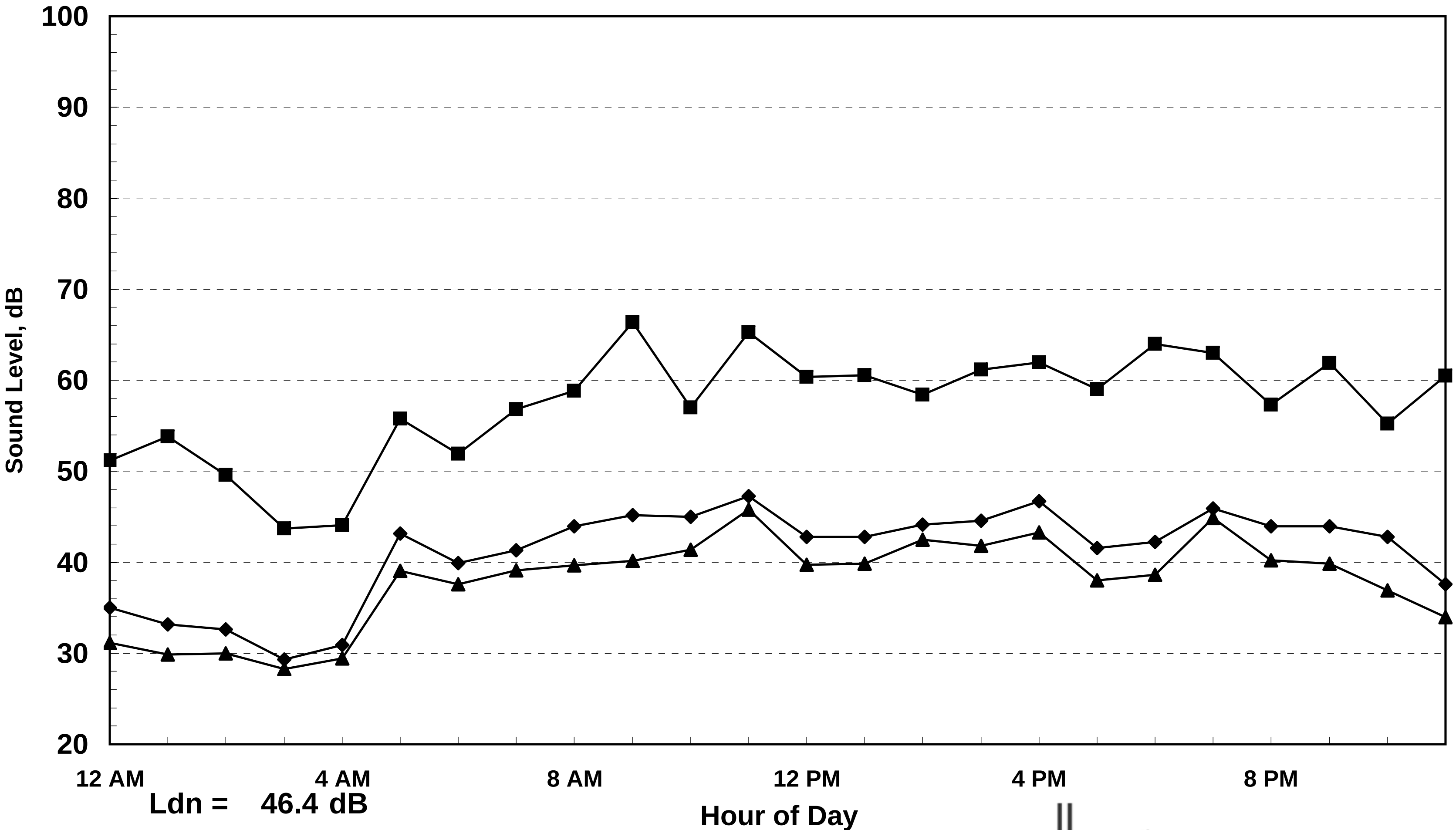
Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-4
Sunday, May 01, 2011



Ldn = 46.4 dB

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Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-4
Monday, May 02, 2011

Hour	Leq	Lmax	L50	L8
0:00	34.52	51.77	30.49	37.15
1:00	29.04	45.15	26.81	31.21
2:00	28.65	43.65	26.68	31.19
3:00	32.27	49.02	28.09	32.78
4:00	44.18	56.27	32.55	48
5:00	42.34	51.28	37.17	47.89
6:00	41.29	54.53	37.68	44.88
7:00	44.51	60.79	42.33	47.29
8:00	48.1	60.15	46.33	51.22
9:00	45.79	56.91	44.82	48.68
10:00	47.72	61.91	45.46	50.71
11:00	46.05	61.16	44.47	48.4
12:00	49.9	65.79	48.53	51.85
13:00	45.91	64.03	43.79	47.9
14:00	47.53	66.79	45.01	50.21
15:00	47.34	59.42	45.51	50.12
16:00	46.32	64.17	43.14	47.76
17:00	45.32	61.18	43.4	48.86
18:00	46.76	59.74	45.65	49.57
19:00	47.22	56.33	45.27	50.34
20:00	43.24	56.07	41.52	45.89
21:00	39.81	53.89	38.14	42.96
22:00	41.66	52.63	40.72	44.36
23:00	42.25	60.86	40.34	44.62

	Statistical Summary					
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	49.9	39.8	46.6	44.2	28.7	40.2
Lmax (Maximum)	66.8	53.9	60.6	60.9	43.7	51.7
L50 (Median)	48.5	38.1	44.2	40.7	26.7	33.4
L8	51.9	43.0	48.8	48.0	31.2	40.2

Computed Ldn, dB	48.3
% Daytime Energy	88%
% Nighttime Energy	12%

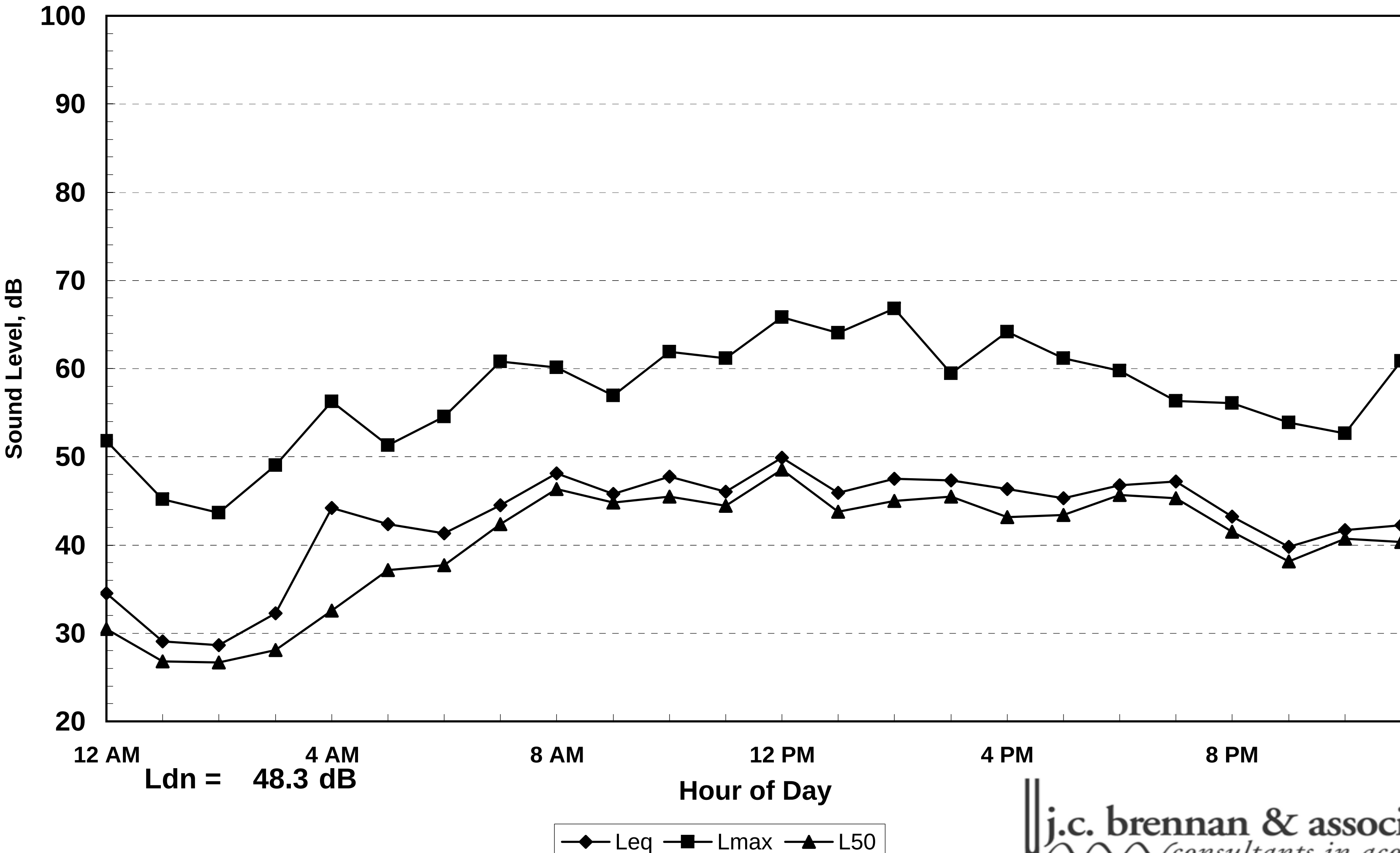
j.c. brennan & associates
consultants in acoustics

Appendix B

Lummi Wind Study

24hr Continuous Noise Monitoring - Site LT-4

Monday, May 02, 2011



Ldn = 48.3 dB

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Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-4
Tuesday, May 03, 2011

Hour	Leq	Lmax	L50	L8
0:00	38.13	52.23	35.54	39.89
1:00	35.15	52.68	34.01	36.94
2:00	36.5	46.98	35.11	39.51
3:00	34.53	47.35	33.52	36.72
4:00	34.01	45.97	32.73	35.83
5:00	44.13	54.97	39.38	49.26
6:00	41.69	56.33	38.77	44.81
7:00	44.66	59.96	42.11	47.86
8:00	46.08	60.76	42.06	49.94
9:00	47.08	63.01	42.65	49.79
10:00	44.51	61.39	40.4	48.06
11:00	44.86	63.84	39.96	46.32
12:00	45.67	64.76	39.3	47.35
13:00	44.38	65.62	40.43	46.57
14:00	47.06	63.14	42.68	50.1
15:00	47.73	66.86	43.86	49.8
16:00	49.34	65.85	48.54	51.58
17:00	44.52	56.18	42.82	47.84
18:00	42.19	59.19	40.29	45.01
19:00	46.04	62.23	42.24	49.38
20:00	49.5	61.57	42.84	55.28
21:00	51.67	70.11	38.9	56.83
22:00	37.72	53.07	34.58	40.96
23:00	36.61	52.64	33.02	38.86

	Statistical Summary					
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	51.7	42.2	47.1	44.1	34.0	39.0
Lmax (Maximum)	70.1	56.2	63.0	56.3	46.0	51.4
L50 (Median)	48.5	38.9	41.9	39.4	32.7	35.2
L8	56.8	45.0	49.4	49.3	35.8	40.3

Computed Ldn, dB	47.9
% Daytime Energy	91%
% Nighttime Energy	9%

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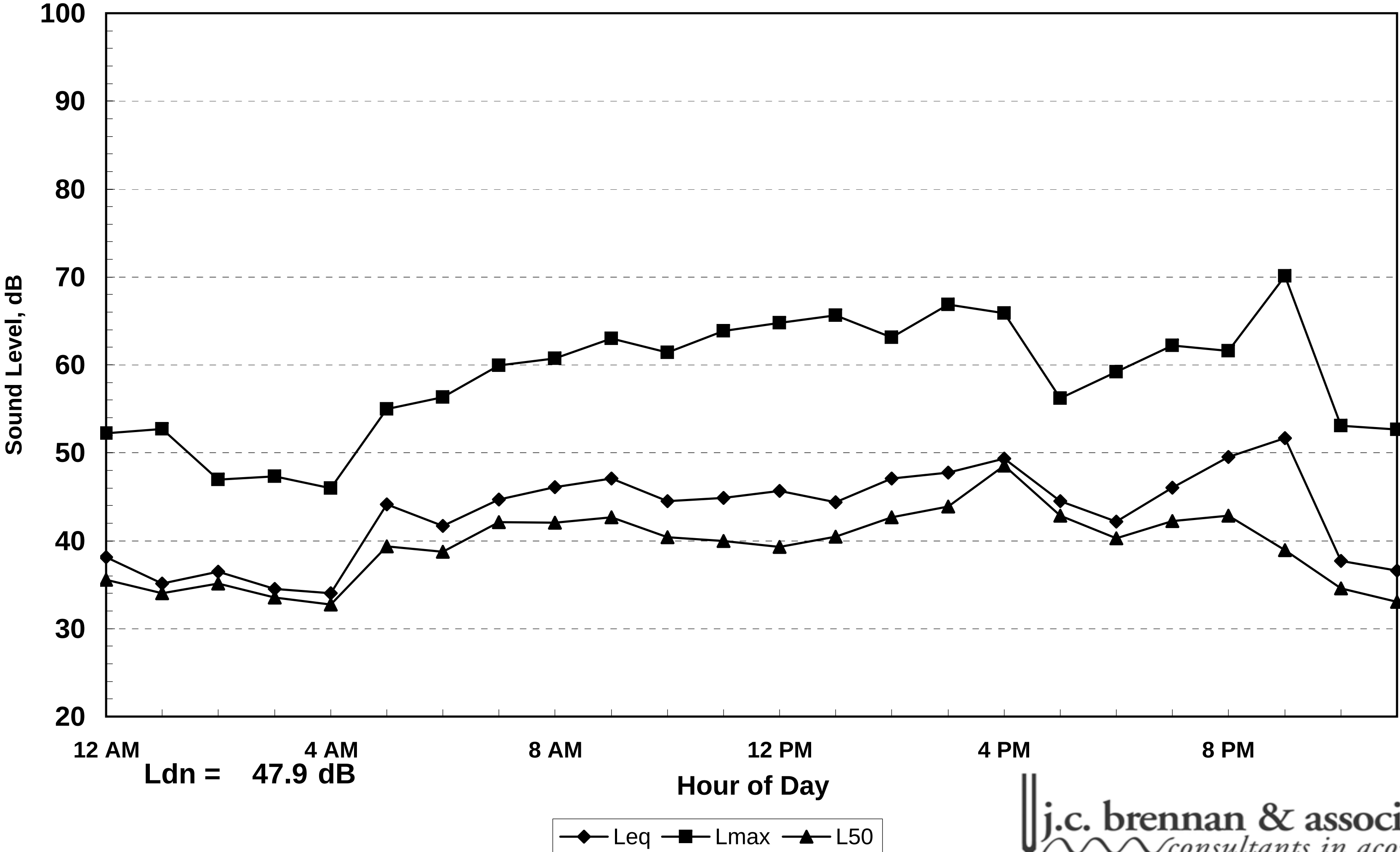
consultants in acoustics

Appendix B
Lummi Wind Study
24hr Continuous Noise Monitoring - Site LT-4
Tuesday, May 03, 2011



Ldn = 47.9 dB

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consultants in acoustics

APPENDIX B

SITE SCREENING REPORT FOR LUMMI NATION WIND ENERGY DEVELOPMENT

SITE SCREENING REPORT FOR THE

LUMMI NATION WIND ENERGY DEVELOPMENT FEASIBILITY ASSESSMENT PROJECT

LUMMI INDIAN RESERVATION, WASHINGTON

Photo: Lummi Natural Resources 2008

PREPARED FOR:

Lummi Nation Natural Resources
2616 Kwina Road
Bellingham, WA 98226

PREPARED BY:

Hamer Environmental L.P.,
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Mount Vernon, WA, 98273
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August 10, 2012

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ACRONYMS AND DEFINITIONS

BBS:	Breeding Bird Survey
BGEPA:	Bald and Golden Eagle Protection Act
CBC:	Christmas Bird Count
ESA:	Endangered Species Act
LNR:	Lummi Natural Resources
NWI:	National Wetland Inventory
USFWS:	U.S. Fish and Wildlife Service
WDNR:	Washington Department of Natural Resources
WDFW:	Washington Department of Fish and Wildlife
WNHP:	Washington Natural Heritage Program

Status Definitions:

Note that the Lummi Indian Reservation is a federal reserve and only federal or tribal laws apply to wildlife management on the Reservation. However, since wildlife do not respect jurisdictional boundaries, species that the adjacent State of Washington has listed for protection are also considered as part of this screening evaluation. In addition, it is noted that although the Lummi Indian Reservation is located adjacent to Whatcom County, many of the available databases that identify candidate, proposed, sensitive, threatened, or endangered and critical habitat report this information based on Washington State counties.

Endangered Species Act: The Endangered Species Act (ESA) prohibits unauthorized "take" of listed species. Take is defined within the ESA as "to harm, harass, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct." Habitat modification that actually injures or kills a listed species through impairment of essential behavior is considered a take.

Bald and Golden Eagle Protection Act: Although the Bald Eagle has been de-listed from the endangered species list, it is still legally protected under the Bald and Golden Eagle Protection Act (BGEPA). The Bald and Golden Eagle Protection Act prohibits anyone, without a permit issued by the Secretary of the Interior, from "taking" bald eagles, including their parts, nests, or eggs. Take" is defined in the Act as pursuing, shooting, shooting at, poisoning, wounding, killing, capturing, trapping, collecting, molesting, or disturbing. "Disturbing" is defined in the Act as "To agitate, or bother a bald eagle to the degree that interferes with or interrupts normal breeding, feeding, or sheltering habits causing injury, death, or nest abandonment. Violating the Act can result in a fine of

$100,000 ($200,000 for organizations) imprisonment for one year, or both, for a first offense. Penalties increase substantially for additional offenses, and a second violation is considered a felony.

Migratory Bird Treaty Act: Although the Bald Eagle has been de-listed from the endangered species list, it is still legally protected under the Migratory Bird Treaty Act. This act prohibits the taking of any migratory bird or any part, nest, or egg, except as permitted by regulation. "Take" is defined in the Act as pursuing, hunting, shooting, wounding, killing, trapping, capturing, possessing or collecting.

Federal or State Candidate Species: "Candidate" means any wildlife species that is being reviewed for possible listing as Endangered or Threatened. A species will be considered for designation as a Candidate species if sufficient evidence suggests that its status may meet the listing criteria defined for endangered or threatened species. Under the federal system, a species is listed under one of two categories, threatened or endangered, depending on its status and the degree of threat it faces. Under the State of Washington system, a species is listed under one of three categories: sensitive, threatened, or endangered.

State Sensitive Species: "Sensitive" means any wildlife species native to the state of Washington that is vulnerable or declining and is likely to become endangered or threatened in a significant portion of its range within the state without cooperative management or removal of threats. The federal system does not utilize a "sensitive" species category – species are either listed as endangered or threatened.

Federal or State Threatened Species: "Threatened" means any wildlife species native to the area that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range without cooperative management or removal of threats.

Federal or State Endangered Species: "Endangered" means any wildlife species native to an area that is in danger of extinction throughout all or a significant portion of its range.

INTRODUCTION

As part of a Lummi Nation wind energy development feasibility assessment, the Lummi Natural Resources Department retained Hamer Environmental L.P. to evaluate the potential occurrence of rare plants, wildlife, and habitats of concern within a potential wind energy development project site on the Lummi Indian Reservation, Washington (Figure 1). The purpose of this screening report is to identify potential biological resources within and adjacent to the possible wind project area which may require further study or present challenges to any wind energy development plans. When exploring proposed wind power developments, knowledge of the presence and locations of wildlife and other biological resources within and surrounding the project area assists the wind industry to identify and avoid potential ecological problems at an early stage in the development process. The objective of this review is not to try and assess potential impacts of the possible wind power project, but to alert project proponents to potential conflicts with biological resources of concern that may be present within or near the proposed project boundaries. This analysis was primarily a "desktop" exploration of available wildlife, botanical, and ecological data for the Lummi Reservation, a bat utilization study at the two anemometer locations, a limited Marbled Murrelet utilization study using radar, and brief site visits to help field-verify results of the database reviews. The area evaluated in this report includes the area within the possible Lummi Wind Energy Project boundaries, which encompasses the entire Lummi Indian Reservation (feasibility assessment area) (Figure 1).

Hamer Environmental L.P. also gathered data within a larger geographic area for the bald eagle (*Haliaeetus leucocephalus*). The Proposed Eagle Conservation Plan Guidance (USFWS 2011a) draft recommendations for the size of avoidance zones for bald eagle nests have been based on documented distances between nests and territory boundaries. Garrett et al. (1993) found that bald eagle territories typically extend at least 2 miles from the nests. For evaluating siting options and for assessing disturbance effects of wind facilities on eagles breeding in neighboring territories, the USFWS (2011a) draft guidance states that it is necessary to determine the locations of occupied nests of Bald (and Golden Eagles [*Aquila chrysaetos*]) within the project footprint and within 10 miles of the perimeter of the footprint.

This report and analyses included summarizing information on the following topics:

- Candidate, Proposed, Threatened, or Endangered Federal and State Species of Conservation Concern:
    - Identify potential occurrence of federal and state listed or protected species through existing literature, U.S. Fish and Wildlife Service (USFWS) databases, Washington Department of Fish and Wildlife (WDFW) and Washington Natural Heritage Program (WNHP) databases, and other sources,
    - Evaluate the suitability of habitat at the possible wind development project site for protected species through a site visit.
- Raptors:
    - Determine raptor species likely to occur in the potential project area and near vicinity,

- Identify areas of potentially high nesting density, potential nest locations, and areas of high prey density,
- Determine potential migratory pathways.

- Migrating Birds:
  - Determine potential migratory pathways of passerines, waterfowl, and shorebirds.
- Bats:
  - Determine species likely to occur in the potential project area and near vicinity,
  - Determine the proximity to potential feeding sites and hibernacula.
- Wetlands and Rare Plants:
  - Determine the potential for wetlands and rare plants to occur within the potential project area and near vicinity from the Lummi Nation Wetland Inventory (2009), National Wetland Inventory (NWI), and WNHP records and site visit.
- Unique Habitats:
  - Determine the potential for unique habitats to occur within the possible project area and near vicinity, and the uniqueness of the possible wind project development site relative to the surrounding area.

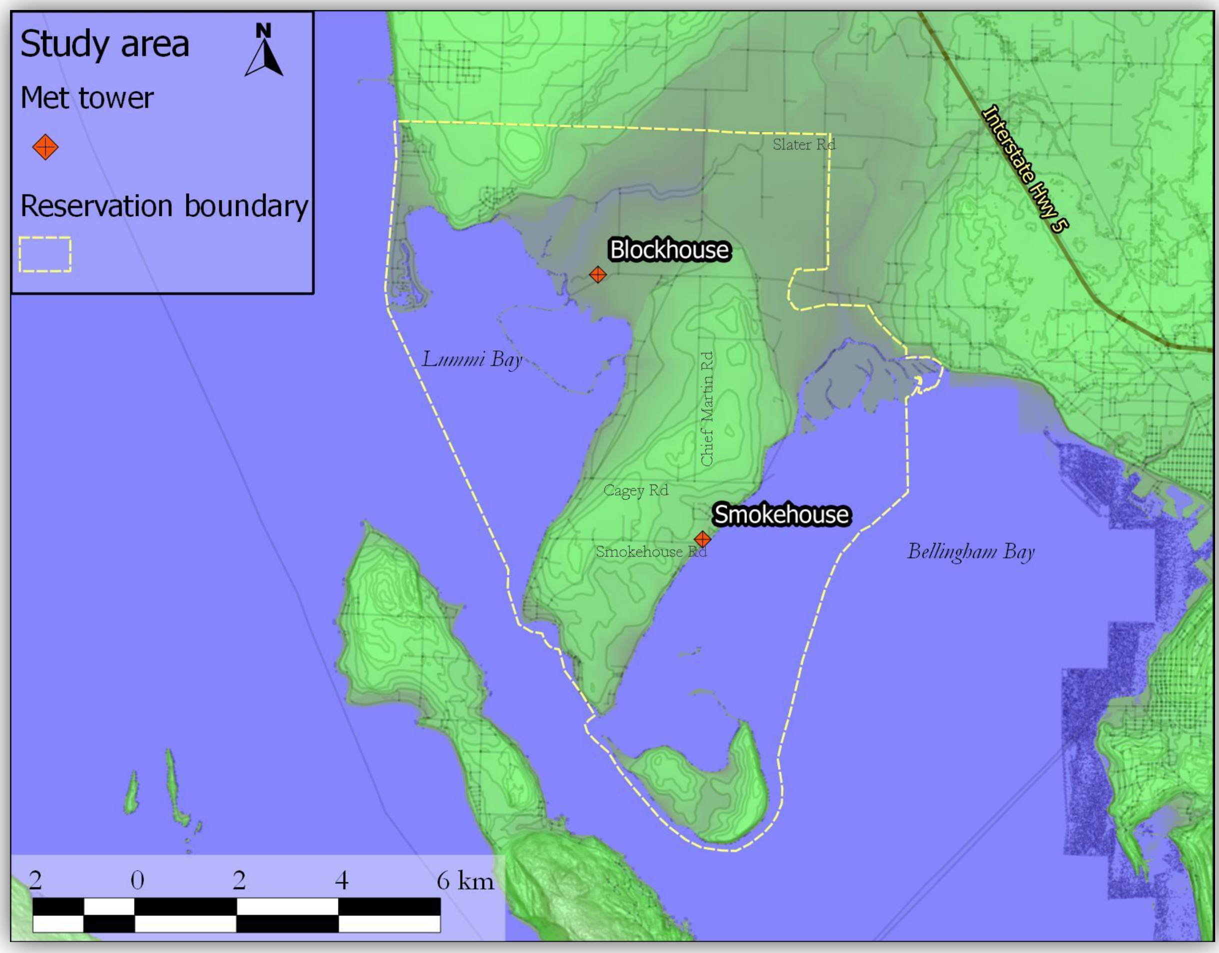

Figure 1. Reservation boundaries and two anemometer locations (Blockhouse and Smokehouse) on the Lummi Indian Reservation, Washington.

METHODS

Hamer Environmental L.P. conducted a "desktop" review of available wildlife, botanical, and ecological data. In addition, Hamer Environmental L.P. conducted one site visit to help field-verify results of the database reviews. Several sources of data were used for the desktop review, including data obtained from the USFWS, WDFW, and the WNHP; agency websites describing the potential local distribution of species with status under the federal or state Endangered Species Acts (ESA), including Washington State's Sensitive Species list; federal and state candidate species listings; and other additional important preliminary considerations (e.g., Bald and Golden Eagle Protection Act [BGEPA]). For any species included in the preliminary lists, Hamer Environmental L.P. investigated local occurrence records using on-line and print sources (see below) and then summarized the potential likelihood of these species being in the possible project area.

Previously, several biological studies were conducted or commissioned by staff of the Lummi Natural Resources Department (LWRD 2000, LNR 2008, LNR 2010a, LNR 2010b, Eissinger and Drummond 1994), which included a Reservation-wide wetland inventory, a forest inventory, an intertidal inventory, assessment of fisheries and wildlife, wetland delineations, and others. To determine a comprehensive list of avian species documented in the vicinity of the feasibility assessment area, Hamer Environmental L.P. consulted several additional sources. Numerous online and print data sources were searched including materials such as Kunz (2003) and Wahl et al. (2005). Hamer Environmental L.P. also used the Audubon Christmas Bird Count (CBC) data (available years: 1979-2010) from the Bellingham (WABG) count circle. The CBC data covers a 24 km (15 mi) diameter survey area and includes winter bird observations throughout the Lummi Indian Reservation. In its current format, the national Audubon database of CBC records does not allow the acquisition of data at a finer scale than the entire count circle.

Hamer Environmental L.P. chose the closest publicly available eBird reporting site, Lummi Flats, which includes one of the anemometer sites (Blockhouse) and vicinity and is approximately 5 km (3 mi) from the other anemometer site (Smokehouse). All of these sources were complied into a master list of birds for the site and cross checked with ESA-status species from USFWS (Endangered, Threatened and Candidate) and WDFW (Endangered, Threatened, Sensitive, and Candidate) listed species of concern. These lists primarily included the USFWS's most recent "Birds of Conservation Concern" (USFWS 2008), which included the agency's priority species at multiple scales (National, USFWS Region 1, and Bird Conservation Region 5), and the WDFW "State Monitored" list. Hamer Environmental L.P. also reviewed the recent draft USFWS Wind Energy Guidelines (2011b) and the proposed draft Guidance for Eagle Conservation Plans (2011a).

Study Area

The potential Lummi Wind Energy Development Project site is located 9.7 km (6 mi) west of Bellingham on the Lummi Indian Reservation, Washington (Figure 1). Reservation lands are bounded to the west by Georgia Strait and to the east by Bellingham Bay. The Nooksack River drains into Bellingham Bay, and the river delta comprises the eastern most extent of the Lummi Indian Reservation. The Nooksack River is an important waterway for fisheries, with all six species of salmon, wild trout, and steelhead present. The Lummi River and associated flood plain separates the Lummi Peninsula and the northwestern upland area of the Reservation. Prior to 1860, the Nooksack River discharged into Lummi Bay by way of the channel presently used by the Lummi River (WSDC 1960, Deardorff 1992). In 1860 a log jam blocked the Nooksack River and diverted it to a small stream that flowed into Bellingham Bay (WSDC 1960). Since that year, due to the increased commercial value of the river that resulted from its proximity to sawmills along Bellingham Bay, considerable effort has been expended to keep the Nooksack River discharging into Bellingham Bay (Deardorff 1992). The stream remaining in the Nooksack River's old channel has been called the Lummi or Red River (WSDC 1960). In the 1920s, a reclamation project was initiated to both construct a dike to keep back the sea along the shore of Lummi Bay, and to construct a levee along the west side of the Nooksack River (Deardorff 1992). This project, which was started in 1926 and completed in 1934, initially resulted in the near complete separation of the Lummi River from the Nooksack River. However, when salt water intrusion onto the newly reclaimed farm lands and damage to the dam at the head of the Lummi River occurred during flooding, the dam was replaced with a dam and spillway structure (Deardorff 1992). This spillway structure was also damaged over the years during high flow conditions and was most recently replaced by a culvert structure that allows flow into the Lummi River only during high flow conditions. Levees were also constructed along the Lummi River to prevent salt water intrusion onto adjacent farmlands. Currently, the Lummi River consists of a narrow, diked channel which allows for farming of surrounding lands. The Lummi Indian Reservation consists of approximately 4,856 ha (12,500 ac) of uplands and 2,833 ha (7,000 ac) of tideland habitats (Grindell, 2009). Upland habitats consist primarily of deciduous forested lands as well as those cleared and converted to agriculture (LNR 2010b). Deciduous forested lands are dominated by red alder (*Alnus rubra*) intermixed with patches of bigleaf maple (*Acer macrophyllum*), cottonwood (*Populus trichocarpa*) and western hemlock (*Tsuga heterophylla*) ((LNR 2010b, Eissinger and Drummond 1994). Lands cleared for agricultural use are typically found in the lowland flats area of the reservation. Crops grown on the lowland flats include seed potato, silage corn, hay, carrots, peas and wheat, with fallow lands also an important part of the rotational agriculture.

The entire Lummi Reservation is under consideration for the wind energy development although wind resource maps produced by the National Renewable Energy Laboratory (NREL) indicate that some areas of the Reservation have higher wind energy development potential than other areas.. Two meteorological (met) towers (Smokehouse and Blockhouse) were installed at two sites representative of the higher wind energy potential areas on the Reservation as mapped by NREL to determine the wind resources at each site. The Smokehouse site is located on cleared land at the junction of Smokehouse Road and Lummi Shore Road (Figure 1). The Smokehouse site is 13 m (43 ft) in elevation and is surrounded by deciduous forest with a few scattered private residences nearby, with Bellingham Bay 150 m (492 ft) to the East. The Blockhouse site is located off of Kwina Road 1.4 km (0.9 mi) west of the Kwina Road and Haxton Way junction on land previously cleared for agricultural use (Figure 1). The immediate area and vicinity within the lower floodplain of the Lummi River is generally referred to as "Lummi Flats", and in addition to agricultural and fallow fields in various stages of succession, contains hedgerows, scattered trees, and the riparian area along the river (Eissinger and Drummond 1994, Kuntz 2003). The Blockhouse site is 2 m (7ft) in elevation and is surrounded by active agricultural lands, with small emergent wetlands throughout. The Blockhouse site location and adjacent areas have been set aside by the Lummi Nation for use as a wetland and habitat mitigation bank or habitat restoration projects (LIBC 2009).

Project Description

The overall goal of the Lummi Indian Reservation Wind Energy Development Feasibility Assessment project is to conduct an assessment that will provide the information needed for the Lummi Indian Business Council (LIBC) to make a knowledge-based determination if a wind generation project on the Reservation provides enough economic, environmental, cultural, and social benefits to justify the cost of the development. The overall goal of the Lummi Indian Reservation Wind Energy Development Feasibility Assessment Project is to determine if and at what cost wind energy development on the Reservation can help achieve the tribal goal of energy self-sufficiency. The primary questions that will be addressed in this renewable energy assessment project are the following:

1. Is there enough wind on the Reservation to justify further pursuit of developing wind generation capabilities on the Reservation?
2. What are likely wildlife impacts associated with installing one or more wind turbines on the Reservation and what are practicable mitigation measures if there are unavoidable impacts?
3. What are the likely noise impacts associated with installing one or more wind turbines on the Reservation and what are practicable mitigation measures if there are unavoidable impacts?

Other specific impacts (e.g., cultural and archeological, transportation, storm water, wetlands, floodplain, and geotechnical) of a wind generation development project will need to be formally addressed as part of the National Environmental Policy Act (NEPA) and tribal permitting process if a determination is made that a project is feasible and desirable.

RESULTS AND DISCUSSION

Federal and State Species of Conservation Concern

There are four species listed by the USFWS as either endangered or threatened that are potentially within the possible wind energy development project site: Short-Tailed Albatross, Streaked Horned Lark, Northern Spotted Owl, and Marbled Murrelet. As summarized below, the likelihood of the first three of these species occurring within the potential project area is “Very Low”; the likelihood of Marbled Murrelets is “High”.

Short-Tailed Albatross (*Phoebastria albatrus*) [Federally Endangered, State Candidate]

The Short-Tailed Albatross is a federally listed endangered species whose breeding distribution is restricted to a few islands off Japan, and is very rarely found off the coast of Washington. Only two records within 60 km of Grays Harbor were noted since 1993 (Wahl et al. 2005). Prior to this, occurrence records for this species in Washington dated back to 1896 (Wahl et al. 2005). Generally increasing numbers on the breeding grounds has led to increasing, though still very rare, sightings off the coast of Alaska, California, and Oregon. Due to lack of sightings at inland sites, this species has a “Very Low” likelihood of occurrence in the potential project area.

Streaked Horned Lark (*Eremophila alpestris strigata*) [Federally Threatened, State Endangered]

The Streaked Horned Lark is a federally listed threatened species. This subspecies is apparently extirpated in the area (Pearson and Altman 2005, Wahl et al. 2005), with the last reported sightings occurring in 1981 (CBC data). Overall there is a “Very Low” likelihood of this species occurrence in the potential project area or vicinity.

Northern Spotted Owl (*Strix occidentalis*) [Federally Threatened, State Endangered]

The Northern Spotted Owl is a federally listed threatened species. Northern Spotted Owls have been in decline throughout much of their range due to past decreases in high-quality mature forest habitat and other factors (USFWS 2004). They nest primarily in old-growth conifer forests, but hunt and forage in a variety of forest types. Old-growth forest stands of 3 ha (7.5 ac) or greater are mapped by WDFW as they are considered a priority habitat (WDFW 2008). No old-growth forest stands have been delineated by WDFW within the potential project area or near vicinity. The potential project area is within the historic species distribution according to Wahl et al. (2005). No Northern Spotted Owl detection records or known occupied habitat was found within the Reservation area (WDFW 2011a). The likelihood of presence of Northern Spotted Owl within the vicinity of the project was categorized as “very low”, as there appears to be little potential for either Northern Spotted Owl or suitable habitat within the vicinity of the project.

Marbled Murrelet (*Brachyramphus marmoratus*) [Federally Threatened, State Threatened]

The Marbled Murrelet is a federally listed threatened species. Although the WDFW did not note this species in its records search for the area, there are consistent reports during winter of foraging birds from observers along the Lummi Reservation shore (WDFW 2011a, Kunz 2003, LNR 2010). In addition, many wintering Marbled Murrelets are documented in the Puget Sound/Strait of Juan de Fuca inland waters, where a recent effort estimated the wintering population at 4,699 birds (95% confidence interval = 3,132 – 6,201 birds; i.e., "Zone 1", Lance et al. 2009). There is a possibility that Marbled Murrelet will utilize the project area, as this species nests inland and often transits between inland nests and marine water foraging areas over land and/or along river corridors. In addition, murrelets are known to visit occupied stands in the winter. The status of populations of Marbled Murrelets upriver from the Lummi Flats is unknown, but occupied and presence sites have been documented inland in the upper Skagit River Valley, upper Nooksack River Valley, and on State Lands in the North Cascades (T. Hamer, personal observations, unpublished reports). Since there is a distinct possibility of summer and winter overland flights through the potential project area to access marine foraging areas, there is a high probability of occurrence in the potential project vicinity.

Yellow-Billed Cuckoo (*Coccyzus americanus*) [Federal and State Candidate]

The Yellow-Billed Cuckoo is a federal and state candidate species for listing. The Yellow-Billed Cuckoo has not regularly bred in Washington since the 1930s, however one of the very few areas of regular occurrence since the 1930s was from Whatcom County (Wahl et al. 2005). Since the species is apparently extirpated in the area, there is a very low likelihood of occurrence of the species within the project area.

Two species protected under the federal and/or state Endangered Species Acts have been documented by the Lummi Natural Resources Department and WDFW within the project vicinity: the Bald Eagle and Peregrine Falcon (Figures 2, 3). Both of these species were de-listed under the federal Endangered Species Act

Bald Eagle (*Haliaeetus leucocephalus*) [State Sensitive, in recovery status at the federal level]

The Bald Eagle was removed from the Federal List of Endangered and Threatened Wildlife and Plants on June 28, 2007. There is more information on Bald Eagle use of the Lummi Reservation than most other wildlife species. This is likely due to a combination the eagle's high detectability, the relatively large number of eagles on the Reservation, history as an endangered species, and cultural importance to the Lummi Nation as well as more generally within the larger US population (LNR 2010). Avian surveys conducted over the course of a year at 12 sites distributed along the shoreline of Lummi Nation lands found Bald Eagles were most commonly observed at Lummi Bay (near Blockhouse site), Portage Bay and adjacent to Lummi Shore Road (near Smokehouse site), and were most common during the spring and summer months at the majority of sites surveyed (LNR 2010). During the nesting/breeding season (generally January through July), Bald Eagle nesting density appears to be fairly high in the vicinity of the two met tower sites (Figure 2). In all, 28 Bald Eagle nests have recently been identified within the Lummi Indian Reservation with a status of active as of the last survey (LNR 2010). The WDFW records for the area indicate presence of 17 active Bald Eagle nests (WDFW 2011a, Figure 2). While sites with greater concentrations of breeding eagles have been documented (i.e., at a locality in Alaska, the minimum defended territory size was 0.5 km^2, or one breeding pair/0.8 km of shoreline), the nesting density on the Lummi Indian Reservation appears to be high as compared to historically noted averages in Washington (2.5 km [1.5 mi] average territory radius) and elsewhere across the range of the species (see Buehler 2000, Rodrick and Milner 1991, and references therein). Given the density of Bald Eagles during the nesting season as well as non-breeding seasons, the likelihood of occurrence of bald eagles within the potential project site is thought to be "Very High".

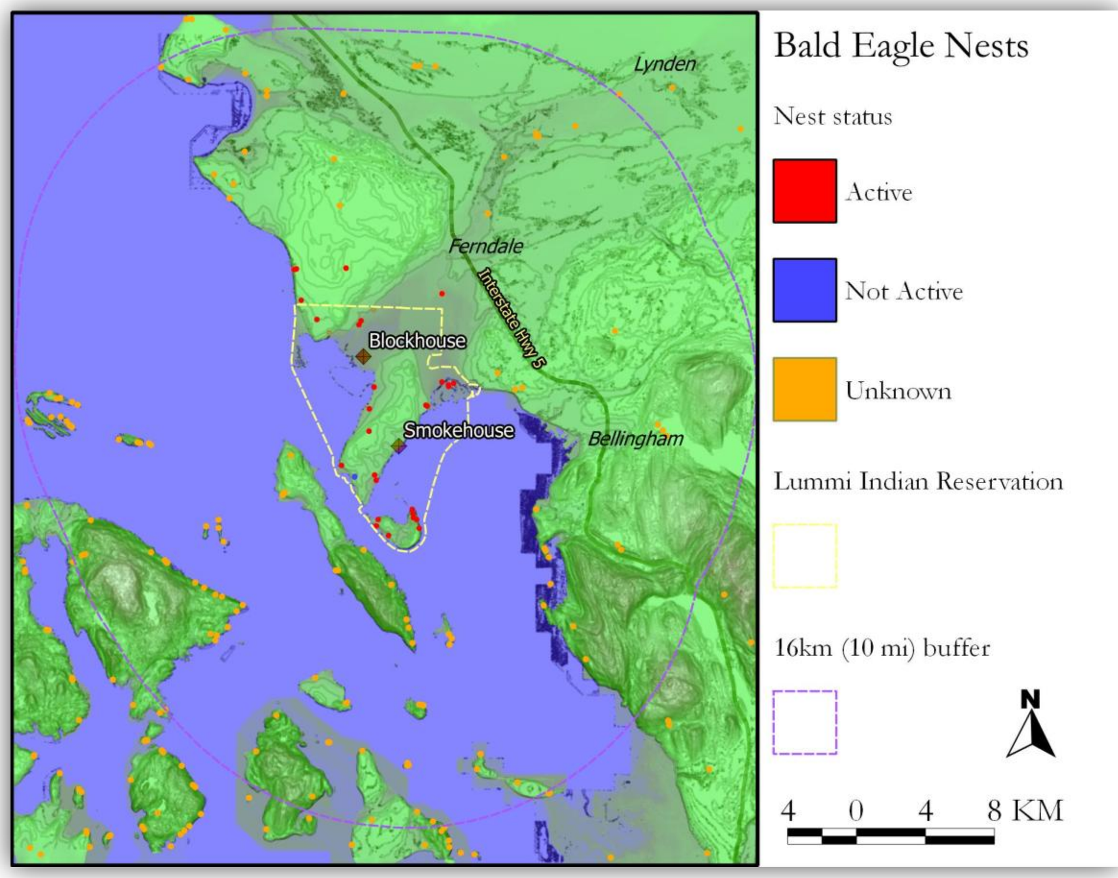

Figure 2. Bald Eagle nests (with 122 m [400 ft] buffers) identified within 3.2 km (2 mi) and 16 km (10 mi) of the Lummi Indian Reservation, Washington. Note: data outside the Lummi Indian Reservation were supplied by Washington DNR, who does not release the status (i.e. active, inactive) of the nests.

Peregrine Falcon (*Falco peregrinus*) [State Sensitive, in recovery status at the federal level]

The Peregrine Falcon was removed from the Federal List of Endangered and Threatened Wildlife and Plants on 25 August 1999. There are Peregrine Falcon nest sites known to occur in the San Juan Islands, and the species is regularly detected during the winter months in the vicinity of Lummi Bay (Hayes and Buchanan 2002 and references therein, Wahl et al. 2005). The open, lowland areas of the Lummi Flats and lower Nooksack River are classified by the WDFW as Peregrine Falcon use areas (Figure 3). Due to nearby nest locations and regular use of the area for foraging birds during all seasons of the year, it was determined that use may be "Very High" for Peregrine Falcons in the project vicinity.

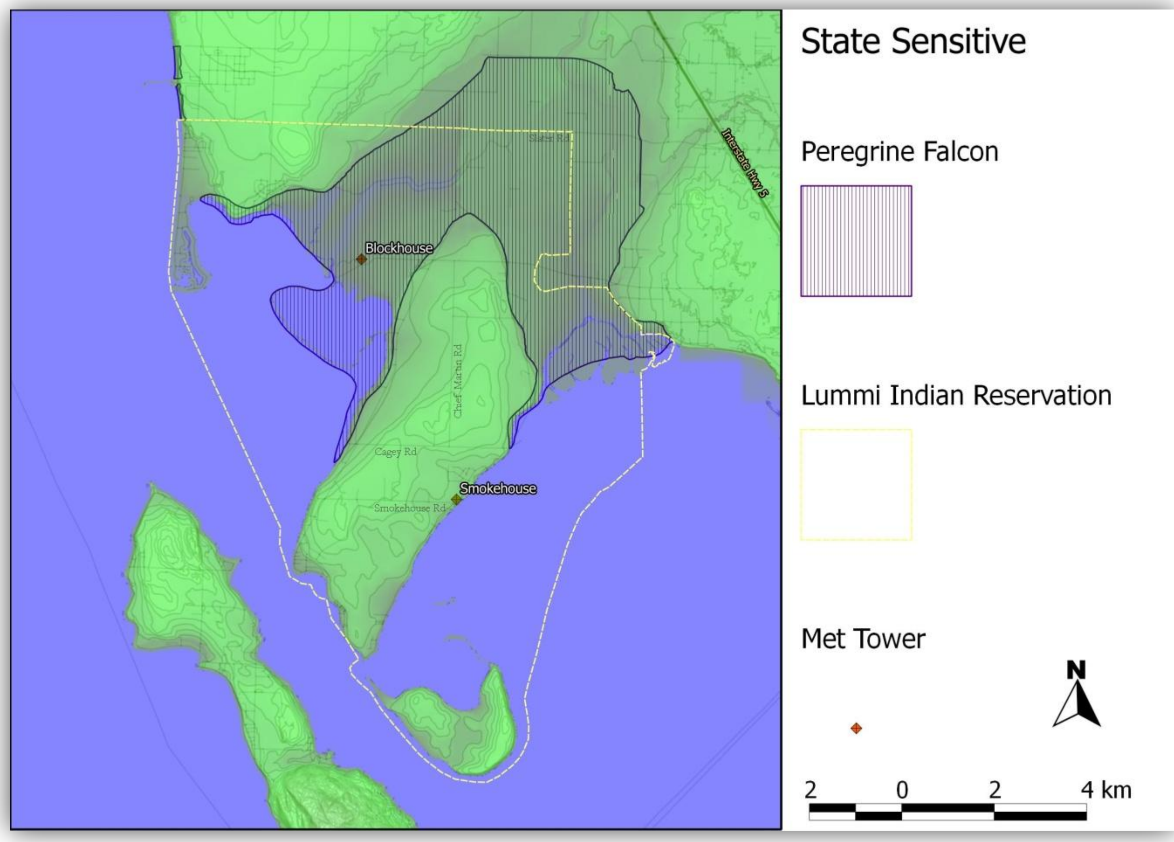

Figure 3. Peregrine Falcon use areas identified by WDFW within the vicinity of the Lummi Indian Reservation, Washington.

Common Loon (*Gavia immer*) [State Sensitive]

Though it can be found nesting at a few secluded lake sites in western Washington, the Common Loon is mainly a wintering species throughout coastal and inland marine waters and major rivers (Wahl et al. 2005). This species mainly uses the inland marine waters near the project area in winter, and was listed as "common" on Lummi lands by Eissinger and Drummond (1994). The species is known to fly overland, yet near the coast, during migratory periods (Wahl et al. 2005, Evers et al. 2010). It therefore has a "Moderate" likelihood of occurrence in the project area, though it is not expected to be commonly detected flying over land in the project area.

Western Grebe (*Aechmophorus occidentalis*) [State Candidate]

The Western Grebe flies mostly over water while transiting between salt water and inland freshwater sites therefore regular flights through the project area are not anticipated. However, the Western Grebe is common and regularly recorded in the vicinity (on both CBC and eBird reports), including some non-breeders during the summer (Wahl et al. 2005), so the likelihood of presence in the project area is likely "Low".

Clark's Grebe (*Aechmophorus clarkii*) [State Candidate]

The likelihood of Clark's Grebe presence in the project area is likely "Low" based on low local abundance and small numbers of individuals, though it is possible this species could transit inland toward breeding sites on the east side of the Cascades (Wahl et al. 2005).

Brandt's Cormorant (*Phalacrocorax penicillatus*) [State Candidate]

Brandt's Cormorant regularly occurs in marine waters surrounding the potential project area (Essinger and Drummond 1994). Individual birds may very rarely transit through the project area. For example, if traveling between marine waters of Lummi and Bellingham Bays, the birds would likely transit over water, but overland flights are also possible. Since the Brandt's Cormorant is generally a saltwater-obligate species and very few inland records exist, it likely has a "Low" likelihood of occurrence for this species in the project area (Wallace et al. 1998, Wahl et al. 2005).

Northern Goshawk (*Accipiter gentilis*) [State Candidate, USFWS regional concern species].

The Northern Goshawk occurs regularly in the area, albeit in small numbers. For example, one individual is regularly reported on the local CBC (8 different years), and has been noted as "uncommon" (as opposed to rare) on Lummi lands (Eissinger and Drummond 1994). Therefore, low numbers would likely transit through the project area when moving between denser forest patches typically utilized by the species, or during migration. Though there may be some semi-suitable forested habitat near the Smokehouse met tower site (especially for migrant stop overs), there is a "Low" likelihood of use in the project vicinity given the lack of suitable habitat in the area and apparent low abundance. The Smokehouse site and vicinity may be utilized more by this species than the Blockhouse site and vicinity, due to higher amounts of forest habitat in the area.

Golden Eagle (*Aquila chrysaetos*) [State Candidate]

The Golden Eagle has been documented on the Lummi Indian Reservation several times during Christmas Bird Counts (1976-78, 1999, 2007), and was listed as "uncommon" (and not "rare") by Eissinger and Drummond (1994). The species is known to breed and winter in rain-shadow areas of the San Juan Islands and to nest in clear-cut, open forest areas on the west-side of the Cascades, though it is primarily associated with east-side, open or montane habitats in Washington state. Given the generally low abundance in western Washington, and intermittent reports in the vicinity of the Lummi Indian Reservation, this species has a "Low" likelihood of occurrence in the project area or vicinity.

Common Murre (*Uria aalge*) [State Candidate]

Records on the CBC and eBird reports confirm that the Common Murre uses the project area in winter (Wahl et al. 2005). Because Common Murre forage in marine waters only, there is a "Low" likelihood the species will use the actual project area.

Vaux's Swift (*Chaetura vauxi*) and Pileated Woodpecker (*Dryocopus pileatus*) [Both State Candidate]

Both the Vaux's Swift and Pileated Woodpecker are fairly common in western Washington forests, with habitat requirements that include older snags and trees, yet they regularly forage in (Pileated

Woodpecker) or above (Vaux's Swift) younger- and open-forest conditions. Though one of the met tower sites (Blockhouse) is relatively more open and with fewer trees, both of these species are common enough in mixed-age stands and the vicinity, there is a "High" likelihood of occurrence for these two species in the project area and vicinity.

Black-backed Woodpecker (*Picoides arcticus*) [State Candidate]

There are no records for the Black-backed Woodpecker on the Lummi Indian Reservation and vicinity, only on the far eastern side of Whatcom County, in montane forests. Therefore, there is a "Very Low" likelihood of occurring in the project area.

Purple Martin (*Progne subis*) [State Candidate]

In Washington, the Purple Martin is mostly found in association with locations where humans maintain nest boxes, although they may still nest in forests that contain snags with cavities (Wahl 2005). Due to lack of local records, but possibility of nesting within forested conditions or in nest boxes, the likelihood of occurrence in the project area and vicinity is likely "Low".

White-breasted Nuthatch (*Sitta carolinensis aculeata*) [State Candidate]

Though once reported regularly in the Puget Sound trough wherever oak-prairie savannahs were found, today the "Slender-billed" subspecies of White-breasted Nuthatch is extirpated from most of its original range. The last records for the species in the vicinity of the project appear to be from the 1983 CBC. Consequently, there is a "Very Low" likelihood of occurrence in the project area.

Table 1. Avian species that may occur in the project area, and their state and federal protection status, Whatcom County, Washington.

Common Name	Scientific Name	Listed Status[1]	Likely to be in Project Area[2]	Found in Local Records Search?
Short-tailed Albatross	*Phoebastria albatrus*	FE, SC	VL	N
Streaked Horned Lark	*Eremophila alpestris strigata*	FC, SE	VL	Y*
Northern Spotted Owl	*Strix occidentalis*	FT, SE	VL	N
Marbled Murrelet	*Brachyramphus marmoratus*	FT, ST	H	Y
Yellow-billed Cuckoo	*Coccyzus americanus*	FC, SC	VL	N
Bald Eagle	*Haliaeetus leucocephalus*	SS	VH	Y
Peregrine Falcon	*Falco peregrines*	SS	VH	Y
Common Loon	*Gavia immer*	SS	M	Y
Western Grebe	*Aechmophorus occidentalis*	SC	L	Y
Clark's Grebe	*Aechmophorus clarkia*	SC	L	Y
Brandt's Cormorant	*Phalacrocorax penicillatus*	SC	L	Y
Northern Goshawk	*Accipiter gentilis*	SC	L	Y
Golden Eagle	*Aquila chrysaetos*	SC	L	Y
Common Murre	*Uria aalge*	SC	L	Y
American White Pelican	*Pelecanus erythrorhynchos*	SE	VL	Y
Vaux's Swift	*Chaetura vauxi*	SC	H	Y
Pileated Woodpecker	*Dryocopus pileatus*	SC	H	Y
Black-backed Woodpecker	*Picoides arcticus*	SC	VL	N
Purple Martin	*Progne subis*	SC	L	N
White-breasted Nuthatch	*Sitta carolinensis*	SC	VL	Y*
Sandhill Crane	*Grus Canadensis*	SE	L	Y

[1]Washington State Status: ST- threatened, SE- endangered, SS- sensitive, SC- candidate; Federal Status: FT- threatened, FE- endangered, FC- candidate;
[2]Codes include likelihood that spp will breed in project area or vicinity, or transit through during daily or seasonal movements: Very High, High, Moderate, Low, Very Low.
*These species are likely extirpated. Streaked Horned Lark was last documented in the area in 1981 and the White-breasted Nuthatch was last documented in 1983.

Table 2 below includes both listed vertebrate and invertebrate species (other than birds) with known records within the Lummi Indian Reservation, and other species described as occurring in Whatcom County by the USFWS and/or WDFW.

Table 2. Vertebrate and invertebrate species that may or have occurred within the potential Lummi wind energy development project site or vicinity, Whatcom County, Washington, with state and/or federal status (USFWS 2011c, WDFW 2011a, b).

Species/Habitats	Scientific Name	Listed Status*	Potential and Known Occurrence
Gray wolf	*Canis lupus*	SE, FE	Highly adaptable to habitat as long as there is a food source. Most commonly found in forested areas with flat, open spaces. Highly unlikely within the project area or vicinity.
Bull trout	*Salvelinus confluentus*	SC, FT	USFWS describes bull trout as occurring in Whatcom County. Critical habitat units identified for bull trout include the Nooksack River and all nearshore areas surrounding the Lummi Reservation, which are part of the Puget Sound Unit (USFWS 2010).
North American wolverine	*Gulo gulo luscus*	SC, FC	Rough terrain and deep, persistent snow. Dens in snow-covered boulder talus in subalpine basins. Highly unlikely within the project area or vicinity.
Columbia spotted frog	*Rana luteiventris*	SC	Highly aquatic, usually associated with streams, lakes, ponds and marshes. During wet weather may be found in uplands or streamside animal burrows. Breeds in shallow water. Moderate chance of being within the project area or vicinity.
Western toad	*Bufo boreas*	SC	Can be found in various upland habitats around ponds, lakes, reservoirs, and slow-moving rivers and streams. Likely present.
Keen's myotis	*Myotis keenii*	SC	Summer roosts under bark and occasionally man-made structures. Forages over trees and ponds. Moderate chance of being within the project area or vicinity.
Townsend's big-eared bat	*Corynorhinus townsendii*	SC	Roosts in caves, mines, man-made structures, and occasionally in trees. Forages in a variety of habitats, including riparian zones and open water. Moderate chance of presence within the project area or vicinity.
Cascade red fox	*Vulpes vulpes cascadensis*	SC	Open to semi-open habitats including woodlands and suburban areas. Breeds in winter with dens created under logs, stumps, or by utilizing other animal dens. The Cascade subspecies is short-tailed with small teeth and yellow fur. Moderate chance of presence within the project area or vicinity
Johnson's hairstreak butterfly	*Speyeria zerene hyppolita*	SC	Habitat is old –growth conifer forest with western hemlock or firs present. The caterpillar is parasitic and is often linked to mistletoe (*Arceuthobium campylopodum*) infestations which attack some conifer species, notably western hemlock. Highly unlikely within the project area or vicinity.

*Washington State Status: ST- threatened, SE- endangered, SS- sensitive, SC- candidate; Federal Status: FT- threatened, FE- endangered, FC- candidate

State Monitored Species and Priority Habitats

The WDFW also monitors species with no conservation status that are viewed as priorities for management and preservation (Table 3, Figure 4). Although these species do not have state or federal protection status, they are prioritized because they represent:

- Vulnerable Aggregations: Species or groups of animals susceptible to population decline based on their nature to gather together. These include seabird concentrations, heron rookeries, fish spawning areas and others;
- Species of Recreational, Commercial and/or Tribal Ceremonial and Subsistence Importance: This includes native and non-native fish and wildlife species of recreational, commercial, and tribal importance which are vulnerable to decline based on their biological or ecological traits (WDFW 2008). These include Roosevelt elk, Wild Turkey, and others.

Although not formally protected with a regulatory status, Washington State considers management of these species a priority in order to prevent the need for listing under the ESA or other actions (Table 3, Figure 4). At the federal level, the 1988 amendment to the Fish and Wildlife Conservation Act mandates the USFWS to "identify species, subspecies, and populations of all migratory nongame birds that, without additional conservation actions, are likely to become candidates for listing under the Endangered Species Act of 1973" (USFWS 2008). The State monitored species and Priority habitats listings represent this type of action being taken at the state jurisdictional level.

Table 3. State monitored animal species and priority habitat species that may occur within the Potential Lummi Wind Energy Development Project site or vicinity, Whatcom County, Washington.

Species/Habitats	Scientific Name	Status*
Long-eared Myotis	*Myotis evotis*	SM
Long-legged Myotis	*Myotis volans*	SM
Great Blue Heron	*Ardea Herodias*	SM
Horned Grebe	*Podiceps auritus*	SM
Red-necked Grebe	*Podiceps grisegena*	SM
Great Egret	*Ardea alba*	SM
Green Heron	*Butorides virescens*	SM
Black-crowned Night-heron	*Nycticorax nycticorax*	SM
Turkey Vulture	*Cathartes aura*	SM
Osprey	*Pandion haliaetus*	SM
Swainson's Hawk	*Buteo swainsoni*	SM
Gyrfalcon	*Falco rusticolus*	SM
Prairie Falcon	*Falco mexicanus*	SM
Black Oystercatcher	*Haematopus bachmani*	SM
Caspian Tern	*Hydroprogne caspia*	SM
Arctic Tern	*Sterna paradisaea*	SM
Snowy Owl	*Bubo scandiacus*	SM
Black Swift	*Cypseloides niger*	SM
Western Bluebird	*Sialia Mexicana*	SM
Roosevelt Elk	*Cervus elaphus roosevelti*	PHS
Great Blue Heron Rookeries	NA	PHS
Cavity Nesting Ducks	NA	PHS
Waterfowl Concentrations	NA	PHS
Biodiversity Areas & Corridors	NA	PHS
Herbaceous Balds	NA	PHS
Old-growth/Mature Forest	NA	PHS
Oregon White Oak Woodlands	NA	PHS
Riparian	NA	PHS
Freshwater Wetlands & Fresh Deepwater	NA	PHS
Open Coast Nearshore	NA	PHS
Puget Sound Nearshore	NA	PHS
Instream	NA	PHS
Caves	NA	PHS
Cliffs	NA	PHS
Snags and Logs	NA	PHS
Talus	NA	PHS

*Washington State Status: SM-monitored, PHS: Priority Habitat Species

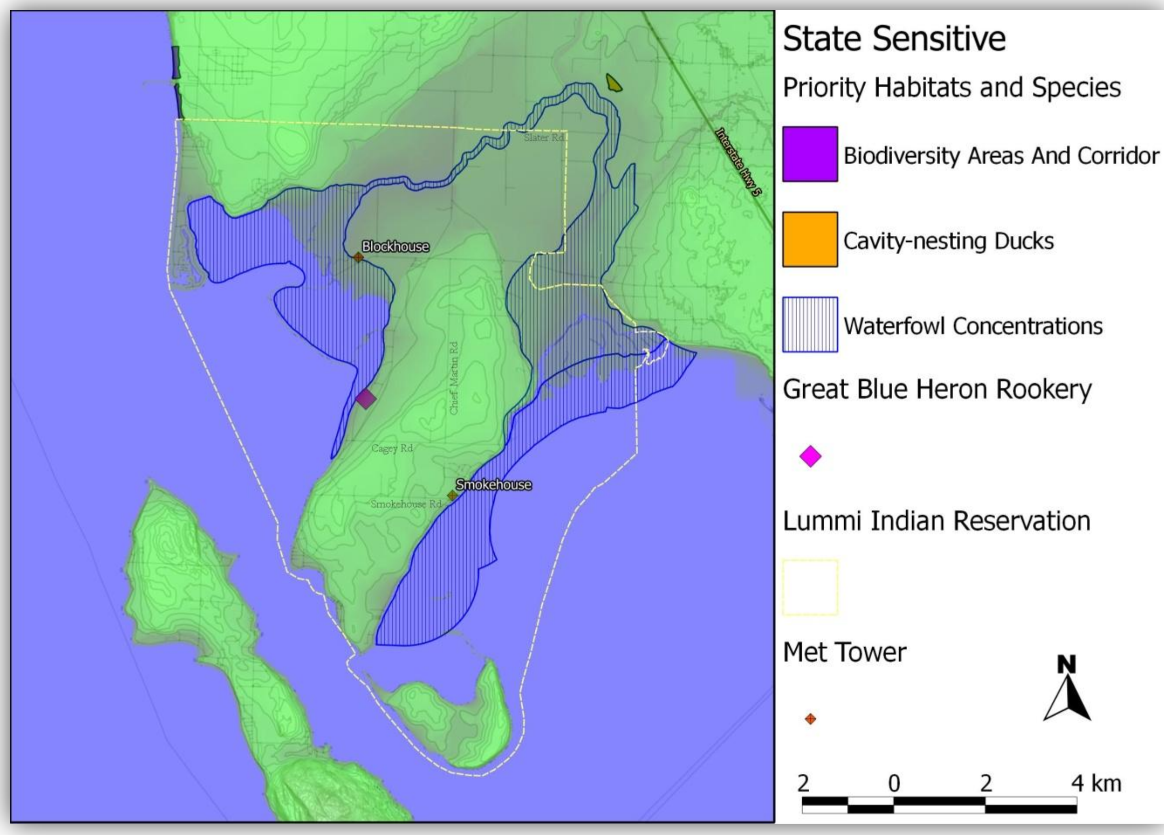

Figure 4. Priority habitat species monitored by WDFW (no protection status) and identified within the potential project vicinity (or just outside of the project vicinity for Biodiversity areas and Cavity-nesting ducks) of the Potential Lummi Wind Energy Development Project Site, Whatcom County, Washington.

Raptor Migration

Little is known about the migration pathways of birds of prey in western Washington. The majority of raptor migration flight paths are typically at higher altitude areas and further inland toward the Cascade Mountains than the Potential Lummi Reservation Wind Energy Development Project site and vicinity. However, during spring a large number of north migrating raptors have been documented at Cape Flattery (data from 1990-1997) on the northwest tip of the Olympic Peninsula (158 km west-southwest of the potential project site) (Clark and Clark 1998). These data indicate that some raptors may migrate further to the west along the Pacific coastline. Large-scale geographic and topographic features (presence of hills and mountain ranges) likely strongly influence the migration pathways of raptors due to the lift they provide to soaring birds of prey. The extent to which migrating birds of prey pass along the coast of the Lummi Indian Reservation or stop over in the vicinity of the project area is unknown but some use by migrants is likely, particularly near the Blockhouse site where a high diversity of raptor species are regularly encountered (Eissinger and Drummond 1994, Kunz 2003). Due to a lack of local raptor migration data or other information applicable to an assessment of turbine risk to migrating raptors, we designate the potential impact of the potential wind energy development project on migrating raptors from "Low to High" to reflect our uncertainty.

Other Raptors

In addition to Bald Eagle, Golden Eagle, Peregrine Falcon, and Northern Goshawk, 11 other diurnal raptor species have been documented on the Lummi Indian Reservation, including: Osprey (*Pandion haliaetus*), Northern Harrier (*Circus cyaneus*), Sharp-shinned Hawk (*Accipiter striatus*), Cooper's Hawk (*Accipiter cooperii*), Swainson's Hawk (*Buteo swainsoni*), Red-tailed Hawk (*Buteo jamaicensis*), Rough-legged Hawk (*Buteo lagopus*), American Kestrel (*Falco sparverius*), Merlin (*Falco columbarius*), Gyrfalcon (*Falco rusticolus*) and Prairie Falcon (*Falco mexicanus*). In particular, the Lummi Flats area in the vicinity of the Blockhouse site is well known for providing a mix of habitats and prey base which results in a high diversity of raptors. On the Lummi Flats, 15 diurnal and seven nocturnal raptors have been documented by various sources (Eissinger and Drummond 1994, Kunz 2003, LNR 2010).

It is likely that several raptor species would be residents (present during breeding season and other times of year) in nearby forests of the potential project vicinity, including Northern Harrier, Cooper's Hawk, Sharp-shinned Hawk, Red-tailed Hawk, American Kestrel, and Merlin. Ospreys are likely to occur regularly in the summer and/or during fall or spring migrations in the vicinity of the project area. Northern Goshawks occasionally fly through the area and a few individuals regularly over-winter in the project vicinity. Similarly, Prairie Falcons are known to occasionally migrate through and winter-over, though this species is more rarely reported on CBC's in this area. During winter, Rough-legged Hawks and Gyrfalcons are known to utilize the project vicinity; the former species was described as "common", the latter "rare", by Eissenger and Drummond (1994). Turkey vultures (*Cathartes aura*) are perhaps the most commonly observed soaring bird in the northwest, and could be found in the vicinity of the project area from March-October.

Short-eared owl (*Asio flammeus)* (a USFWS national and regional concern species) are regularly seen in the Lummi Flats area (Blockhouse met tower site vicinity), and Snowy Owl (*Bubo scandiacus*) are easily seen during irregular "irruption years" (Kunz 2003). Our local records search also found the following owl species documented in the area: Barn Owl (*Tyto alba*), Western Screech-Owl (*Megascops kennicottii*), Great Horned Owl (*Bubo virginianus*), Northern Pygmy-Owl (*Glaucidium gnoma*), Barred Owl (*Strix varia*), Long-eared Owl (*Asio otus*), and Northern Saw-whet Owl (*Aegolius acadicus*).

Migrating Passerines, Waterfowl, and Shorebirds

Although no information was found which quantifies migration rates near the potential project site or surrounding landscape, passerines, waterfowl, and shorebirds are regularly encountered during migration periods in the vicinity of the potential project (Eissenger and Drummond 1994, Kunz 2003, LNR 2008, 2010). This indicates a potential migratory route along the shoreline of the Puget Sound. Many songbird and raptor species migrating through the region could be more concentrated near the outer coastline along the Olympic Peninsula to the west (180 km [112 mi]) of the potential

Lummi Reservation Wind Energy Development Project site, but no data are available to confirm this. Migration studies along the Pacific coast of North America tend to be focused on shorebirds or single species and have not collected data on flight altitudes. Studies of nocturnal migration at several wind energy developments throughout North America (Oregon, Wyoming, California) suggest the mortality appears low compared to the passage rate of birds flying through the area (Erickson et al. 2002). Most birds (>90%) fly significantly higher than turbine heights (Erickson et al. 2002). Avian migration studies in other regions also indicate that the great majority of nocturnal migrants fly at heights well-above wind turbine height (e.g., Bruderer and Liechti. 1998, Liechti and Schmaljohann 2007, Dokter et al. 2010). However, even when numbers of fatalities at a wind park are low, the largest proportion of fatalities is often suspected to be passerine migrants (e.g., Johnson et al. 2002). In a year-long, multiple-methods (including radar) avian study in the North Sea, Huppop et al. (2006) found that one third of all birds migrating over an island in the North Sea were within 100 m of the ground, and that passerines were at the greatest risk of collision. However, most studies in other areas of the US and Europe indicate that a vast majority of birds tend to migrate at higher altitudes than turbine heights. Due to lack of local migration data and inconsistent reports elsewhere we give a range of likely impacts, from "Low to High", to reflect this uncertainty.

Other Avian Considerations

Species richness and abundance of all bird types is greatest on the Lummi Indian Reservation during the winter season (Kunz 2003, LNR 2010). This indicates that any consistent and ample survey effort should be spent during winter, rather than the breeding season as is often typical for many pre-construction wildlife studies at proposed wind energy developments. Additionally, at least one Great Blue Heron rookery is in the area, off of Robertson Road (3.2 km [2.0 mi] south of the Blockhouse met tower site, and 2.6 km [1.6 mi] west-northwest of the Smokehouse met tower site) and which contained a minimum of 160 active nests in 2009 (LNR 2010, Figure 5). Another rookery near Neptune Beach (3.6 km [2.2 mi] north of the Blockhouse site, 8.6 km [5.3 mi] northwest of the Smokehouse site) was active until 2003, though follow up surveys there have not re-located the colony (LNR 2010).

Salmon Bearing Streams

Aquatic resources data were provided by WDFW for the feasibility assessment area and near vicinity. Based on their data, only a few streams are present within the potential project area, all outside of where turbine pads are presumed to be planned. Fish species documented or presumed to be present within or immediately adjacent to the feasibility assessment area include: Coho salmon (*Oncorhynchus kisutch)*, coast resident red throat (*Oncorhynchus clarki clarki)*, Chinook salmon (*Oncorhynchus tshawytscha* [Federally Threatened, State Candidate]), Chum salmon (*Oncorhynchus keta* [Federally Threatened, State Candidate]), pink salmon (*Oncorhynchus gorbuscha*), steelhead trout (*Oncorhynchus mykiss* [Federally Threatened, State Candidate]), and bull trout (*Salvelinus confluentus* [Federally Threatened, State Candidate]) (Figure 5). These species are found along the Nooksack River, Lummi River and Jordan Creek. Spring Chinook salmon runs are considered "Critical" by the

WDFW in the North, Middle and South Forks of the Nooksack River and Silver Creek (WDFW 2011a). Fall Chum salmon are considered healthy in the region. Health of winter and summer steelhead, Coho salmon, cutthroat trout, fall Chinook and bull trout runs are unknown in this area.

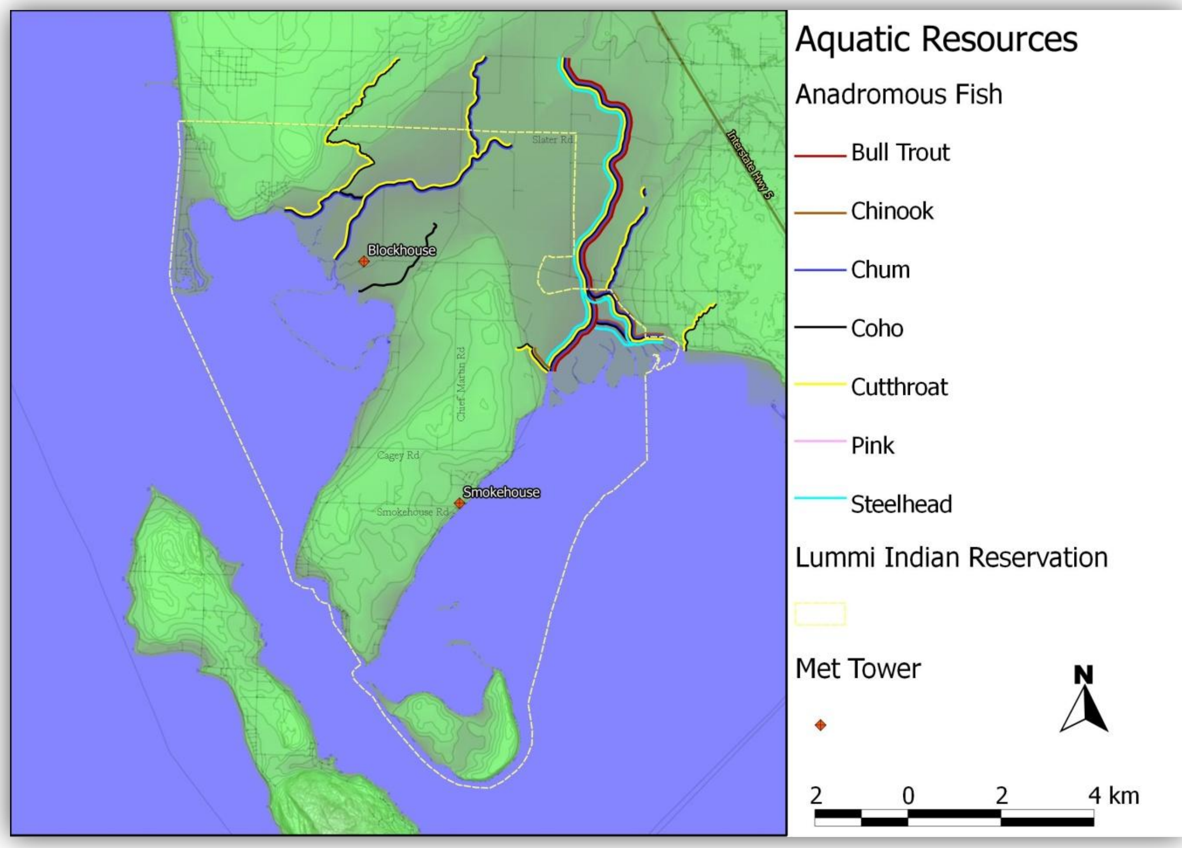

Figure 5. Documented, presumed, and potential salmon and trout bearing streams in the vicinity of the Lummi Indian Reservation, Washington.

Bats

Although all of the bat species listed in Table 4 could be found in the vicinity of the potential project site, it is unlikely that all would be simultaneously present within the area at a given time. Species that roost and rear young in the area would be present in the project area from early summer to early fall. In contrast, species that use the area as a migratory pathway would likely only be present during short periods in late spring and early to mid-fall. Those bat species hibernating in buildings or crevices would only be present during the winter months. In addition, the Smokehouse and Blockhouse met tower sites both represent distinct habitat types, and thus the species composition is likely different between the two sites. In the eastern United States, wooded ridge-tops, such as the area surrounding the Smokehouse met tower site, have been documented as having higher levels of activity from migratory tree-roosting bats (e.g. Hoary bat and Silver-haired bat) during migration and mating (Kunz et al. 2007). These same species also use forested habitats for roosting during the summer months. Big brown bats have also been documented preferentially foraging in forested areas during the summer months (Christophersen and Kunz 2003). At many wind energy facilities, these three species comprise the majority of the fatalities (Arnett et al 2008, Kunz et al. 2007, Kerlinger et al. 2006). The Blockhouse met tower site, in contrast, represents habitat in a lowland floodplain with minimal woody vegetation. While such sites are unlikely to attract bats for roosting or mating, such areas can be attractive to some species for foraging, particularly if the open water serves as a breeding ground for large numbers of insects. Studies in North Cascades National Park have documented *Myotis* spp. preferentially using riparian forest and shrub areas for foraging during the summer months (Christophersen and Kunz 2003). While *Myotis* spp. generally represent a small proportion of the bats killed at wind energy developments, there are exceptions throughout North America. Finally, a communal roost of Towsend's big-eared bats has been documented approximately 10 to 12 km (6 to 7.5 mi) from the Smokehouse met tower site (WDFW 2011a). While the Townsend's big eared bats have been documented using trees and snags as roosts, they most often congregate in buildings and caves (WDFW 2005). Should such structures be present within the selected project area, WDFW recommends that these structures be assessed during spring, summer, and fall prior to construction. It is important to note that the majority of bat fatalities at wind energy developments generally do not occur during the summer months, but more often during spring and fall months during migration (Arnett et al 2008, Kunz et al. 2007). The majority of the North American bat migratory routes are still unknown, and thus careful study of bat activity within a feasibility assessment area during the migratory period is crucial to the siting process. To fully assess bat use and species composition within the feasibility assessment area, the Lummi Natural Resources Department contracted Hamer Environmental, L.P. to conduct a baseline study of bat activity in the area. Acoustic surveys were conducted using Anabat SD1 data-logging, ultrasonic bat detectors affixed at 5 m and 50 m above ground level on two meteorological towers (met towers) within the feasibility assessment area (Stumpf and Hamer 2012, See Appendix 1). Seasonal use of the feasibility assessment area by resident and migratory bat populations was monitored from 19 April 2011 until 14 November 2011. The surveys recorded 3,875 identifiable bat calls over the course of 834 detector nights. The majority of the calls (58%) were made by the California Myotis/Yuma Myotis species group (Myotis californicus and/or Myotis yumanensis). The remaining detections consisted of calls from big brown bat/silver-haired bat species group (34%), little brown bat/long-legged Myotis species group (4.6%), Hoary bats (2.5%), and the long-eared Myotis/fringed Myotis species group (1.1%). Activity peaked in both early May and mid- to late September, likely indicating spring and fall migratory activity.

Table 4. Bats that may occur in the vicinity of the potential Lummi Wind Energy Development Project site, Whatcom County, Washington.

Species	Scientific Name	Status*
Townsend's western big-eared bat	*Corynorhinus townsendii townsendii*	SC
Keen's myotis	*Myotis keenii*	SC
Long-eared myotis	*Myotis evotis*	SM
Long-legged myotis	*Myotis volans*	SM
Silver-haired bat	*Lasionycteris noctivagans*	N/A
Yuma myotis bat	*Myotis yumanensis*	N/A
Big brown bat	*Eptesicus fuscus*	N/A
Hoary bat	*Lasiurus cinereus*	N/A
Fringed *Myotis*	*Myotis thysanodes*	N/A
Little brown bat	*Myotis lucifugus*	N/A
California bat	*Myotis californicus*	N/A

*Washington State Status: SC- Candidate, SM- Monitored.

Rare Plants and Wetlands

Rare plants have not been documented by the Washington Natural Heritage Program (WNHP) within the potential project area (WNHP 2010). However, the absence of records does not mean that rare plants do not exist in the project area, rather that rare plant inventory surveys have likely not been conducted. Bristly sedge (*Carex comosa*) and Canadian St. John's wort (*Hypericum majus*) were documented on nearby Lummi Island. Rare plant species that may potentially occur within the potential Lummi Wind Energy Development Project area or near vicinity were taken from the WNHP rare species list for Whatcom County (Table 5).

Table 5. Washington State listed botanical species with potential to occur in the project area.

Species Name	Scientific Name	WA Status*	Habitat Description
Bristly sedge	*Carex comosa*	S	Marshes, lake shores, wet meadows, Id. May- July
Large-awn sedge	*Carex macrochaeta*	T	Coastal, seepage areas, wet meadows, along streams, Id. mid-May- July
Long-styled sedge	*Carex stylosa*	S	Coastal, shallow marshes, streambanks, Id. June- September
Tall bugbane	*Cimicifuga elata var. elata*	S	Margins of forests, along north or east slopes, Id. late May - early August
Spotted Joe-pye weed	*Eutrochium maculatum var. bruneri*	X	Occurs in swamps and other moist, open places from sea level to high plains, Id. July - September
Black lily	*Fritillaria camschatcensis*	S	Near lakes, streams, salt marshes, bogs, wetlands, Id. May- July
Canadian St. John's wort	*Hypericum majus*	S	Associated with riparian habitats, along ponds, lakes, etc., ID. July- September
Water lobelia	*Lobelia dortmanna*	T	Aquatic, found in lake and pond margins, Id. June- August
Bog clubmoss	*Lycopodiella inundata*	S	Low elevations, wetland margins, Slough sedge, oceanspray, and cattail associated, Id. year-round
Pygmy water-lily	*Nymphaea tetragona*	X	Aquatic, found in ponds, swamps, lakes, Id. June- August
Soft-leaved willow	*Salix sessilifolia*	S	Lowland areas, intertidal zone with other Salix species, Id. May- June
Water awlwort	*Subularia aquatica var. americana*	R	Margins of freshwater lakes, streams, Id. June- August

*Washington State Status: T – threatened, S – sensitive, X – possibly extinct or extirpated from WA, R – of potential concern but needs more fieldwork to assign status.

The Lummi Indian Reservation is located on low elevation, coastal lands with many wetland habitats present throughout (Figure 6). Within the vicinity of the Smokehouse met tower site are numerous (20+) palustrine forested wetlands, located to the north, south and west. Two palustrine scrub/shrub wetlands are located at the southern end of the Lummi Reservation, over 2.4 km (1.5 mi) from the Smokehouse met tower site. In addition, 1 riverine scrub/shrub wetland and 1 palustrine emergent wetland are located north of the Smokehouse met tower site, while 3 palustrine emergent wetlands are located to the northwest.

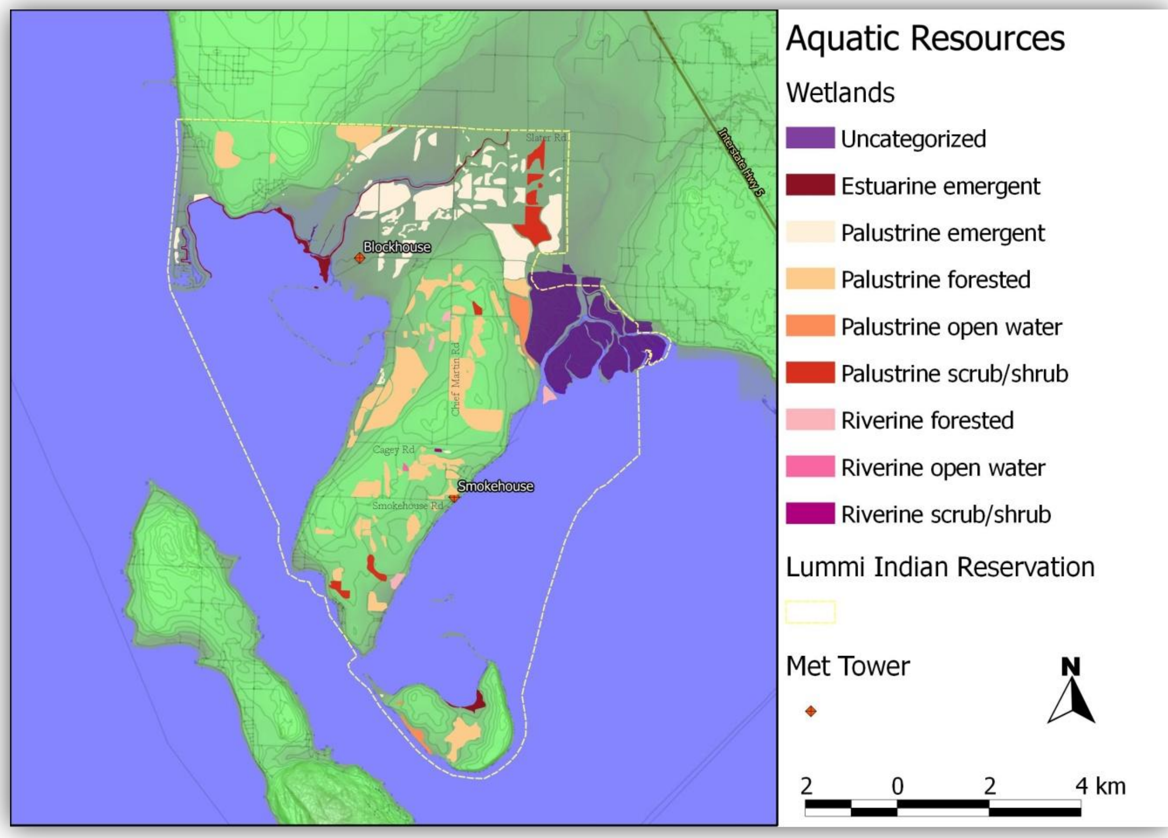

Figure 6. Wetlands of Lummi Indian Reservation from National Wetlands Inventory and Lummi Wetland Delineations, Lummi Indian Reservation, Washington.

Numerous (25+) palustrine emergent wetlands are located within 3.2 km (2 mi) of the Blockhouse met tower site, most to the north, east and east by southeast (Figure 6). Two palustrine scrub-shrub wetlands are near the Blockhouse met tower site, one to the north and one to the southeast. Palustrine forested wetlands are also found in the vicinity of the Blockhouse site, to the north and southeast. The Lummi River, categorized as estuarine emergent, runs to the northwest of the Blockhouse met tower site. The Lummi government maintains a diked pond for aquaculture purposes 0.5 km (0.3 mi) south of the Blockhouse met tower site, categorized as an intertidal emergent wetland. Siting of wind turbine pads, access roads and equipment staging areas should be carefully planned to avoid impacts to these wetland areas.

Unique Habitats

The Lummi Indian Reservation lands consist primarily of two main habitat types, deciduous forest and cleared/or agricultural lands. The two met tower sites, Blockhouse and Smokehouse, were located within relatively different habitats found on the Lummi Reservation. The Blockhouse met tower site is located on land cleared for agriculture and is surrounded by active agricultural lands and emergent wetlands in an area that is generally known as the "Lummi Flats". While the Smokehouse met tower site is located on cleared land, it is surrounded on three sides by deciduous forest. Relative to land cover found on the Lummi Indian Reservation, neither of these met tower sites is located within unique habitats.

SUMMARY TABLE

Summary of potential biological impacts from the potential wind development project on the Lummi Indian Reservation:

VH = Very High, H = High, M = Medium, L = Low, and U = Unknown

Issue	VH	H	M	L	U	Potential Biological Impacts
Marbled Murrelet		X				No Marbled Murrelet occupied sites were documented by WDFW within the vicinity of the feasibility assessment area. However, a radar study conducted in 2011 by Hamer Environmental detected Marbled Murrelets transiting from coastal fishing grounds to inland nest sites through the area (Appendix 2). The three-day ornithological radar study conducted during July 2011, during peak activity time, documented the presence of murrelets transiting through the Lummi Indian Reservation and near vicinity but indicated low utilization.
Raptor nest sites	X					At least 28 Bald Eagle nests were documented recently on the Lummi Indian Reservation. Though no other nesting raptors were documented, it is likely that additional breeding species are present. A raptor nest study should be conducted to determine presence and activity status of nests in the vicinity of the project if the project development advances.
Raptor flights through project area		X				Regular flights of Bald Eagles, Peregrine Falcons, and occasional flights of other raptors are anticipated.
Raptor prey areas		X				Bald Eagle foraging was documented along most shoreline areas of the Lummi Indian Reservation, and Peregrine Falcon are common (especially in winter) throughout low-lying areas of Lummi Flats and the Nooksack River Delta. Several other raptor species were regularly documented foraging near the Blockhouse met tower site (Lummi Flats) and are likely throughout the project area. These species include Red-tailed Hawk, Cooper's and Sharp-shinned Hawk and occasionally Northern Goshawk, Merlin, American Kestrel, Gyrfalcon, Rough-legged Hawk and others.
Raptor migratory pathways					X	The majority of raptor migration flight paths are typically in higher elevation areas in the Cascade Mountains. However, large numbers of spring raptors have been documented migrating north along the Pacific Coast near Cape Flattery (158 km [98 mi] west-southwest). Due to a lack of local

Issue	VH	H	M	L	U	Potential Biological Impacts
						raptor migration data or other information applicable to an assessment of risk, the proportion of migrating raptors potentially passing through the project area is Unknown.
Avian migratory pathways					X	Some avian migration through the area is possible, since the potential project area is within 3 km (2 mi) or less of the Lummi Bay shoreline. In addition, passerines, shorebirds and waterfowl are regularly documented in the area during periods of migration. However, concentrated shorebird and passerine migration could occur along the Pacific Coast to the west of the assessment area. Due to a lack of local avian migration data, the potential impact to migrants is currently unknown.
Townsend's big-eared bat				X		Short-distance fall migrants (approx. late Aug. to Oct.). Habitat includes existing structures, snags and riparian areas. A Townsend's big-eared bat communal roost site was documented 10-12 km (6-7.5 mi) east of the assessment area, but it is unknown if bats would transit through the assessment area. An acoustic bat study was conducted from April to October 2011 to determine species presence in the feasibility assessment area (See Appendix 1). No calls that could be definitively attributed to Townsend's big-eared bats were recorded during the study.
***Myotis* spp. (bats)**					X	Fall migrants (approx. late Aug. to Oct.). Habitat includes riparian areas and snags. While there is a high likelihood of presence in the project vicinity, *Myotis* spp. represent a small proportion of the bats killed at wind energy developments. However, there are localized exceptions, and for this reason impacts to *Myotis* spp. remain Unknown. An acoustic bat study was conducted April to October 2011 to determine species present in the project vicinity (Appendix 1). A variety of *Myotis* spp. were detected. Activity levels observed at both sites were lower than those observed at many wind resource areas for which pre-construction (activity) and post-construction (mortality) surveys have been completed. However, accurate prediction of bat mortality at the potential wind resource development site is problematic given the dearth of data from west of the Cascade mountains from which to draw inference.
Wetlands		X				National Wetland Inventory, Washington Natural Heritage Program and Lummi Wetland Studies have

Issue	VH	H	M	L	U	Potential Biological Impacts
						determined presence of numerous wetlands within the project area, particularly near the Blockhouse met tower site but none along the potential turbine pads or access roads. Careful construction planning can help ensure no wetlands are impacted by temporary roads, or equipment staging.
Rare plants			X			No rare plant species or plant communities were documented in or near the project area. However, many rare plants listed for Whatcom County occur in or near wetlands and therefore have a moderate likelihood of occurrence within the vicinity of the project.
Unique habitats				X		The two met tower sites (Blockhouse and Smokehouse) consist of differing habitats. The Blockhouse site is located within the Lummi Flats consisting of agricultural and fallow lands and emergent wetlands. The Smokehouse site is located on cleared land, but is surrounded by mid-seral mixed conifer-deciduous forest on three sides. Both of these sites represent habitats common throughout the Lummi Indian Reservation.

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APPENDIX 1. ACOUSTIC BAT STUDIES FOR THE LUMMI INDIAN RESERVATION WIND ENERGY FEASIBILITY ASSESSMENT PROJECT

ACOUSTIC BAT STUDIES FOR THE LUMMI INDIAN RESERVATION WIND ENERGY FEASIBILITY ASSESSMENT PROJECT

FINAL REPORT

Lummi Indian Reservation, Whatcom County, Washington

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EXECUTIVE SUMMARY

In 2011, Hamer Environmental conducted studies to assess the potential impacts on resident and migratory bat communities of a potential wind energy development project on the Lummi Indian Reservation, Washington. Acoustic surveys were conducted using Anabat SD1 data-logging, ultrasonic bat detectors affixed at 5 m and 50 m above ground level on two meteorological towers (met towers) within the potential project area. Seasonal use of the potential project area by resident and migratory bat populations was monitored from 19 April 2011 until 14 November 2011. The surveys recorded 3,875 identifiable bat calls over the course of 834 detector nights.

The majority of the calls (58%) were made by the California *Myotis*/Yuma *Myotis* species group (*Myotis californicus* and/or *Myotis yumanensis*). The remaining detections consisted of calls from big brown bat/silver-haired bat species group (34%), little brown bat/long-legged *Myotis* species group (4.6%), Hoary bats (2.5%), and the long-eared *Myotis*/fringed *Myotis* species group (1.1%). Activity peaked in both early May and mid- to late September, likely indicating spring and fall migratory activity.

Activity levels observed at both sites were lower than those observed at many wind resource areas for which pre-construction (activity) and post-construction (mortality) surveys have been completed. Siting turbines in the Lummi Flats area (near the Blockhouse met tower site) would likely reduce risk to bats as this site showed markedly lower activity rates throughout the study relative to the Smokehouse met tower site. However, accurate prediction of bat mortality at the potential wind resource development site is problematic given the dearth of data from west of the Cascade mountains from which to draw inference. It is therefore recommended that mortality monitoring using pre-established protocols and recommendations take place if the project is developed and becomes operational.

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INTRODUCTION

Wind energy is able to generate electricity without the negative ecological impacts associated with other forms of power generation (e.g., pollution and carbon emission). However, in recent years direct impacts to bat populations have been reported as a result of wind turbine operation. Though the precise behavioral or ecological causes are still unknown, at some sites, large numbers of bat fatalities have been reported at operational wind energy facilities throughout North America (Johnson et al 2003, Fielder 2004, Johnson 2005, Arnett et al. 2008). Similar to the bird fatalities reported at the same sites, many of the fatalities come as a result of direct impact with turbine blades. However, it has recently come to light that many of the fatalities come as result of rapid vascular decompression as the bats fly though the low pressure wave in the wake of the moving turbine and show no signs of physical contact with the turbine blades (Baerwald et al 2008). While fatalities appear to happen year-round, they tend to peak in late summer, indicating that individuals may be at the greatest risk during migration (Arnett et al. 2008). As a result of the extent of the ecological impact coupled with the lack of information regarding its root cause, state and federal agencies in the United States often recommend that wind energy project developers conduct studies to assess the risk of proposed developments to bat populations.

There are ten bat species known to occur on or near the Lummi Indian Reservation:

- Townsend's big-eared bat (*Corynorhinus townsendii townsendii*)
- Silver-haired bat (*Lasionycteris noctivagans*)*
- Big brown bat (*Eptesicus fuscus*)
- Hoary bat (*Lasiurus cinereus*)*
- Long-eared *Myotis* (*Myotis evotis*)
- Fringed *Myotis* (*Myotis thysanodes*)
- Long-legged *Myotis* (*Myotis volans*)
- Yuma *Myotis* (*Myotis yumanensis*)
- California *Myotis* (*Myotis californicus*)
- Keen's Myotis (*Myotis keenii*)

* species known to be migratory.

To determine bat species composition, use, and activity levels at a potential wind-energy facility on the Lummi Indian Reservation, Washington, the Lummi Nation Natural Resources Department contracted Hamer Environmental, L.P. to conduct a baseline study of bat activity in the project area. Data collected for this study will be used to make siting and mitigation recommendations in order to reduce or eliminate the effects of a potential wind-energy facility on resident and migratory bat populations.

Results of acoustic bat surveys conducted during the 2011 survey season are described in this report. The objectives of this report are to:

- Describe and quantify patterns of bat use within the potential wind-resource area.
- Relate the findings of this study with those of other studies at wind-energy developments where both pre- and post-construction bat activity and mortality studies have been conducted to predict as best as possible post-construction risk of mortality at the potential wind-power development site(s) on the Lummi Indian Reservation.
- Use these predictions in the context of relevant literature to make recommendations for any post-construction studies and/or mitigation measures.

STUDY AREA

The potential wind energy development area is located on the Lummi Indian Reservation, approximately 9.7km (6 mi) north of the town of Bellingham, Washington (Figure 1). The exact location of the wind development within the reservation is currently unknown. Two meteorological towers (met towers) were installed during early 2011, denoted as Smokehouse and Blockhouse in Figure 1. The topography in the vicinity of the potential project is relatively flat, accented with low, rolling terrain. The Smokehouse met tower site is located on the Lummi peninsula near the intersection of Smokehouse Road and Lummi Shore Road. It is situated within an upland deciduous forest consisting primarily of red alder (*Alnus rubra*) intermixed with patches of bigleaf maple (*Acer macrophyllum*), cottonwood (*Populus trichocarpa*) and western hemlock (*Tsuga heterophylla*). The Blockhouse met tower site is located in open and mostly treeless riparian floodplain habitat commonly called "Lummi Flats" near the intersection of Kwina Road and Hillaire Road.

METHODS

The protocol used for this study was adapted from those used for pre-construction monitoring of bat activity across the United States and Canada (e.g., Reynolds 2006, Arnett et. al. 2006, Arnett et. al. 2008). Data logging, zero-crossing period meter bat detectors (Anabat SD1, Titley Electronics, East Brisbane, Australia) were mounted at 5m and 50m above ground level at the two different meteorological towers within the potential project area (Figure 1). Zero-crossing detectors consist of a sound-activated, high frequency microphone whose output is fed though a circuit that generates a data point every time the waveform recorded by the microphone passes the zero point (i.e., changes from positive to negative, or vice versa). The result is a highly compressed frequency spectrogram that can be easily stored (due to its compressed size) and read. Detectors were calibrated to have a minimum sampling distance of approximately 20 meters (m), though actual sampling distance varies based on echolocation call characteristics of individual bat species and atmospheric conditions such as wind and precipitation. Detectors were powered by 12V, 7 Amp hour batteries, which were recharged daily by a photovoltaic cell fitted to the outside of the unit. Detectors are sound activated, and were set to record all detections taking place between 19:00 and 06:30 from 16 April 2011 to 14 November 2011. A division ratio of 8 was used for all calls recorded for this study to make call identification more reliable. The division ratio setting on the Anabat units further compresses the signal produced by the detector by recording only the Nth crossing of the zero point. Calls were recorded to a 4 GB compact flash memory card. To minimize data loss that might occur as a result of machine failures (due to electrical storms, disk corruption, etc.), data were retrieved from the units every two weeks and stored off-site for later analysis.

Bat calls, defined as a continuous series of two or more, clearly identifiable call notes produced by an individual with no pauses of longer than one second, were used as the unit measure of activity for this study. Calls were individually examined using the Analook software package (Titley Electronics, East Brisbane, Australia). Each call was identified to the lowest taxonomic group possible, using keys developed by Ober (2006), Weller (2006), and Keinath (unpublished data), as well as reference calls in combination with a species list compiled from GIS range maps (England 2003). Species that do not produce calls that can be reliably discriminated were lumped into functional groups. For example, big brown bats (*Eptesicus fuscus*) and silver-haired bats (*Lasionycteris noctivagans*) both produce calls with minimum frequencies of ~25KHz that are variable in shape, leading to a great deal of overlap in observed call signatures. The number of calls recorded per detector per night was used as an index of activity to make relative comparisons among time periods and towers. It is important to note that acoustic surveys cannot differentiate individuals within a species, and thus direct population estimates are not possible from these data. After call identification, Python (Python Software Foundation 2011) and the software program R (R Development Core Team 2011) were used for data processing, summaries, and analyses.

To predict the potential for bat mortality at the site, the mean number of calls recorded per station per night was compared to studies already conducted at existing wind facilities where both pre-construction activity and post-construction mortality surveys have been completed. To date, five studies have examined both pre-construction activity and post-construction mortality at the same wind energy development (Young et al 2003, Johnson et al. 2004, Jain Fielder 2004, 2005, E.B. Arnett, Bat Conservation International, unpublished data).

RESULTS

Bat activity was monitored at two locations using four detectors. At each location, one detector was placed 5 m above ground surface and another 50 m above ground surface and call activity recorded from 16 April 2011 to 14 November 2011 (212 days). Disk corruption for 14 days from 12 June to 26 June at the Blockhouse site's 50 m detector lessened the expected number of detector nights from 848 (4 detectors * 212 days) to 834. In addition, the same detector suffered an intermittent short in the microphone cable during the first two weeks of June. While this did not render the unit completely non-functional, it did result in a great deal of extra noise being recorded, and may have masked some bat calls. In total, 93,049 acoustic detections (files) were recorded, downloaded, and analyzed. Of these, 89,174 (95.8%) were noise (wind, rain, insect noise, electronic interference, etc.) and 3,875 (4.2%) were identifiable bat call files. Of the 3,875 files that could be positively identified as bat calls, 2,554 (65.9%) were detected at the lower (5 m) detectors and 1,321 (34.1%) were detected at the higher (50 m) detectors. A significantly higher proportion of the calls were recorded at the Smokehouse site (77.2% vs. 22.8% at Blockhouse; $X^2 = 322.17$, DF = 1, $p<0.01$).

Six species or species complexes were detected within the potential wind resource area. Fifty eight percent of the recorded call activity was produced by the California *Myotis*/Yuma *Myotis* species group (*Myotis californicus* and/or *Myotis yumanensis*). As summarized in Table 1, the remaining detections consisted of calls from big brown bat/silver-haired bat species group (34%), little brown bat/long-legged *Myotis* species group (4.6%), Hoary bats (2.5%), and the long-eared *Myotis*/fringed *Myotis* species group (1.1%). No calls that could be definitively attributed to Townsend's big-eared bats or Keen's *Myotis* were recorded. Over the duration of the study (32 weeks), a mean of 4.65 bat calls were recorded per detector per night.

Table 1. Total number of detections of each bat species or species complex detected at each meteorological tower from 16 April 2011 to 14 November 2011 within the potential wind energy development area on the Lummi Indian Reservation, Washington. Percentage in parentheses is the percent of detections of each species group at that met tower location.

Met Tower Site	Big brown bat/Silver-haired bat	Little brown bat/Long-legged *Myotis*	Hoary bat	Long-eared bat/Fringed *Myotis*	California *Myotis*/Yuma *Myotis*
Smokehouse	1085 (83%)	87 (49%)	80 (82%)	17 (40%)	1723 (76%)
Blockhouse	219 (17%)	90 (51%)	18 (18%)	26 (60%)	530 (24%)
Total	**1304**	**177**	**98**	**43**	**2253**

Bat activity at the potential wind resource area was highest for all species groups during the 18th and 38th weeks of the calendar year (1 May to 7 May and 18 Sept to 24 Sept), though not all species peaked in activity during the same week (see Figure 2 through Figure 5). The big brown/silver-haired bat group peaked in activity during the 36th week (4 Sept to 10 Sept) with a mean of 8.3 calls/detector/night recorded. Hoary bats peaked in activity the following week (11 Sept to 17 Sept), with a mean 3.4 calls/detector/night recorded. Both of these species/groups were more often recorded at the higher (50 m) detectors than at the lower (5 m) detectors, particularly during the peak of their activity (Figure 3). Conversely, all of the *Myotis* species/groups were more often recorded at the lower detectors, than at the higher detectors (Figure 4 and Figure 5). All species/groups of *Myotis* with measurable levels of activity throughout the season peaked in activity during the 18th and 38th weeks (1 May to 7 May and 18 Sept to 24 Sept) of the year (Figure 4 and Figure 5).

DISCUSSION

Predictions of bat mortality at wind energy developments based on pre-construction activity are currently complicated by the dearth of studies including both pre- and post-construction data from which to draw correlative inferences. This is further exacerbated by some of the challenges associated with post-construction mortality assessment and a lack of standardized use of correction for searcher efficiency and carcass removal (Kuntz et al. 2007). Though geographically disparate, the limited number of studies currently available suggests a rough correlation between pre-construction activity and post-construction mortality. In Iowa, Jain (2005) found pre-construction activity of 34.9 bats/detector/night to correspond to approximately 10 bats killed/MW/year post-construction. The Mountaineer, West Virginia development estimated 38 bats killed/turbine/year after recording an average of 38.2 calls/detector/night (E.B. Arnett, Bat Conservation International, unpublished data). Similarly, projects in Minnesota and Wyoming with pre-construction activity levels of 2.1 and 2.2 calls/detector/night reported an estimated 2.37 and 2.23 bats killed/MW/year, respectively (Johnson et al. 2004, Young et al 2003) (Figure 7).

To date, many studies of post-construction bat mortality at wind energy sites have been conducted at wind energy developments across the United States and Canada. As with studies of pre-construction activity, temporal peaks in mortality tend to coincide with migration, leading researchers to conclude that migrating bats are at the highest risk for mortality (Johnson 2005, Kunz et al. 2007). In particular, migrating, tree-roosting bats, including silver-haired bats, hoary bats, and eastern red bats, tend to make up the highest proportion of bats killed at wind energy developments (Johnson 2005).

The higher rates of activity observed at the Smokehouse site station relative to the Blockhouse site may be a result of forested environment surrounding the met tower location, which likely provides not only roosting habitat, but cover from predators and possibly an increased diversity of insect prey. It also likely attracts the larger, obligate tree-roosting species such as Hoary bats and silver-haired bats (Table 1). These species are known to migrate and forage and commute at higher altitudes than smaller *Myotis* species which tend to forage closer to the ground (Figure 3 through Figure 5). This flying behavior puts these larger, migratory species at greater risk for collision with wind turbines, and in most studies they are the most abundant species found in carcass searches below operational turbines (Arnett et al. 2008). In the eastern United States, wind developments on forested ridges have also shown higher number of bat fatalities (Arnett et al. 2008).

Given the magnitude of the difference in activity rates between the two sites, it is likely that siting turbines nearer to the Blockhouse site or similarly open, grassy habitat would reduce the potential impacts of the potential wind development to bats. Detectors recorded a site-wide mean 4.65 calls/detector/night, peaking during mid-to-late-August at 15.86 calls/detector/night. The mean number of calls recorded per detector per night during this study was more similar to rates recorded at sites in Minnesota and Wyoming (Johnson et al. 2004, Young et al 2003), where mortality rates were lower than those recorded in eastern deciduous forests (e.g., Jain 2005).

The patterns of activity shown by hoary bats and the California *Myotis*/Yuma *Myotis* species group indicate that these species are likely migrating through the area in spring and fall. Hoary bats were only detected in the late summer and early fall, indicating that they may be passing through the area at this time. Given this information, it is possible that this potential wind development could pose a risk to migrating bat populations during the peaks of migration in early May and mid September. However, as outlined above, the correlation between pre-construction activity and post-construction mortality is still somewhat vague. In addition, there is currently no empirical information on activity-mortality relationships for this region. Due to the relatively lower mean number of calls recorded per detector, the mortality per megawatt can reasonably be expected to be lower than in the eastern and Midwestern United States where before-and-after construction studies have taken place (Erickson et al. 2002, Arnett et al. 2008). It is recommended that mortality monitoring using protocols and recommendations outlined by Arnett et al. (2008) take place if a wind energy development project on the Lummi Indian Reservation becomes operational. If it is determined that substantive mortality occurs as a result of the development, mitigation via curtailment of power generation when wind speed are less than 5.1 m/sec has been shown to substantially reduce mortality, particularly during migration (approximately 15 August – 30 August), when both bat activity and mortality are at their peak (Arnett et al. 2009, Weller 2009).

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FIGURES

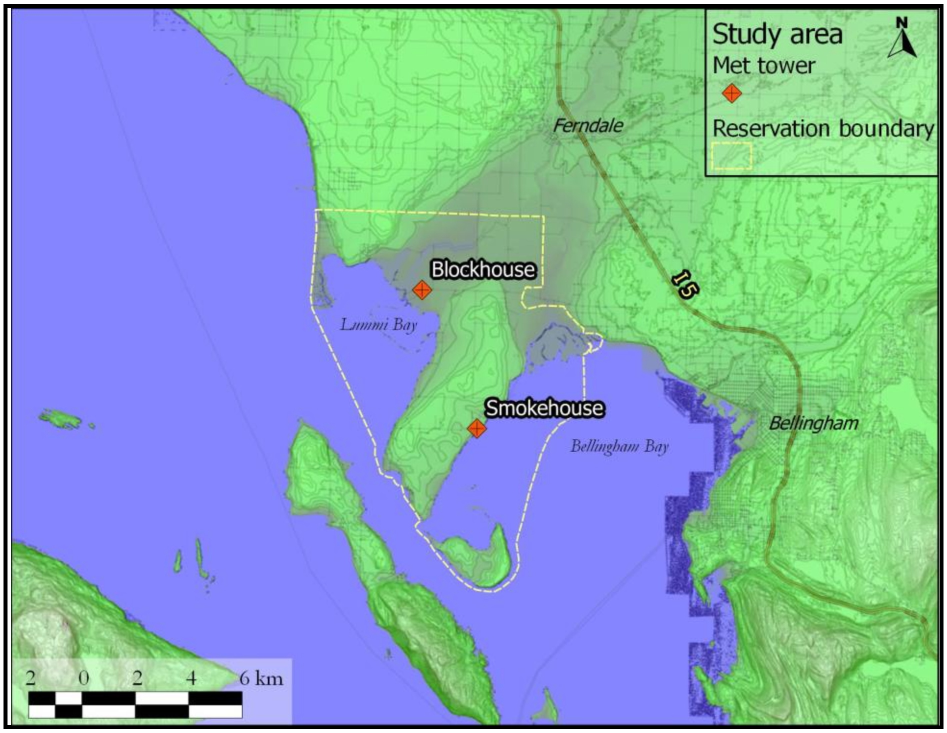

Figure 1. Lummi Indian Reservation and surrounding area. The locations of the two meteorological towers sampled for bat activity are shown.

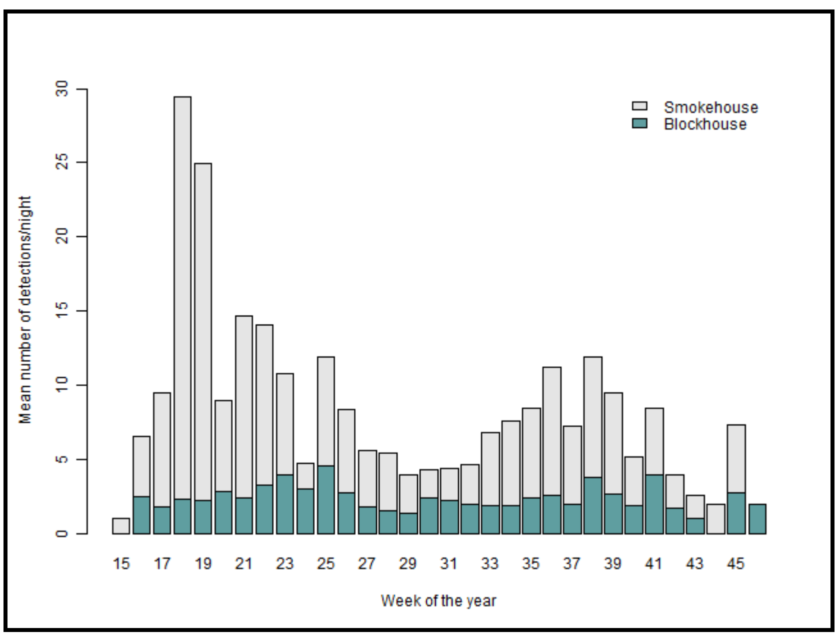

Figure 2. Mean number of calls recorded per detector per night from 16 April 2011 to 14 November 2011 at the Potential Wind Resource Area, Lummi Indian Reservation, Washington.

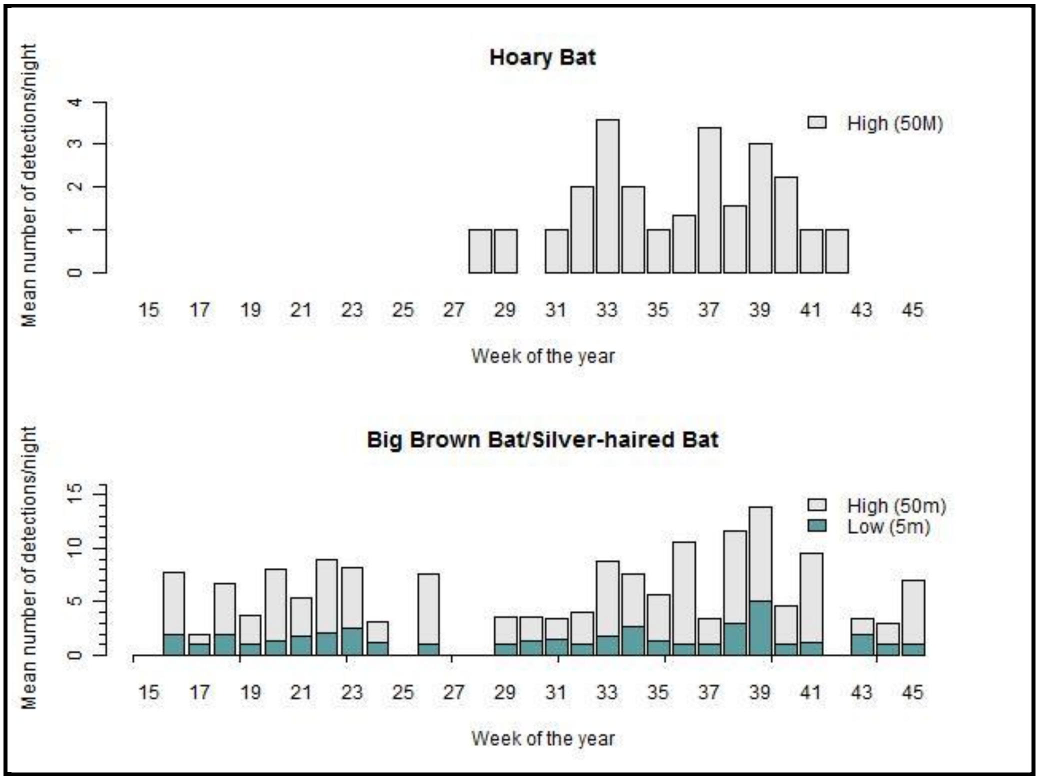

Figure 3. Mean number of calls recorded per detector per night for hoary bats (*Lasiurus cinereus*, above) and the big brown bat/silver-haired bat group (*Eptesicus fuscus*/*Lasionycterus noctivagans*, below) at the potential wind development project area on the Lummi Indian Reservation, Washington from 16 April 2011 to 14 November 2011. Results are summarized by week and height of detector above the ground.

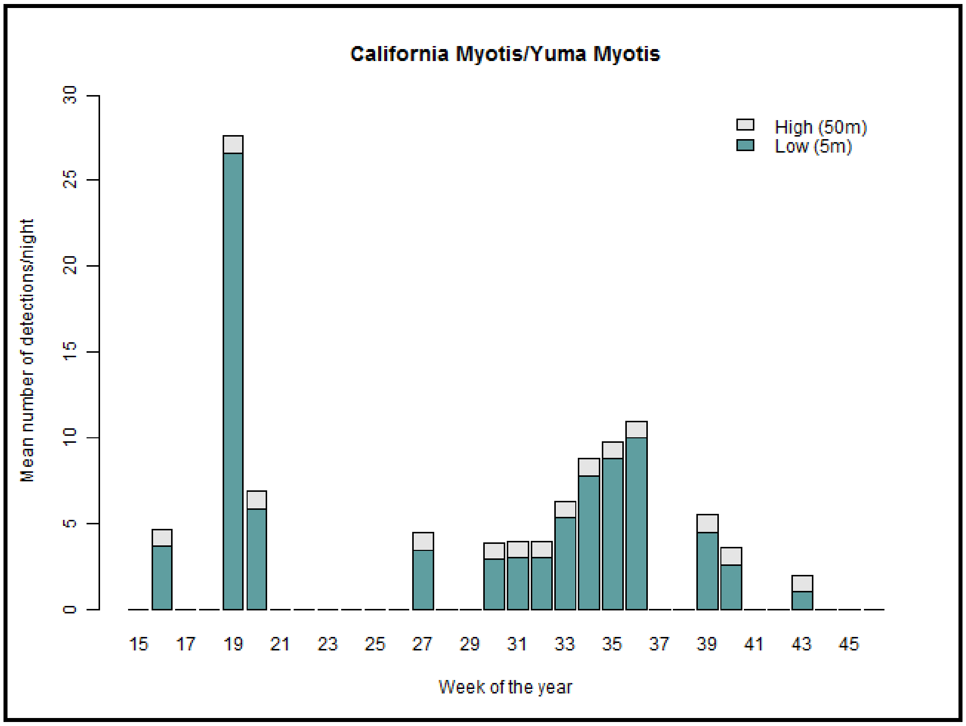

Figure 4. Mean number of calls produced by California or Yuma Myotis recorded per detector per night at the potential Lummi Indian Reservation, Washington Wind Energy Development Site from 16 April 2011 to 14 November 2011. Results are summarized by week and height of detector above the ground.

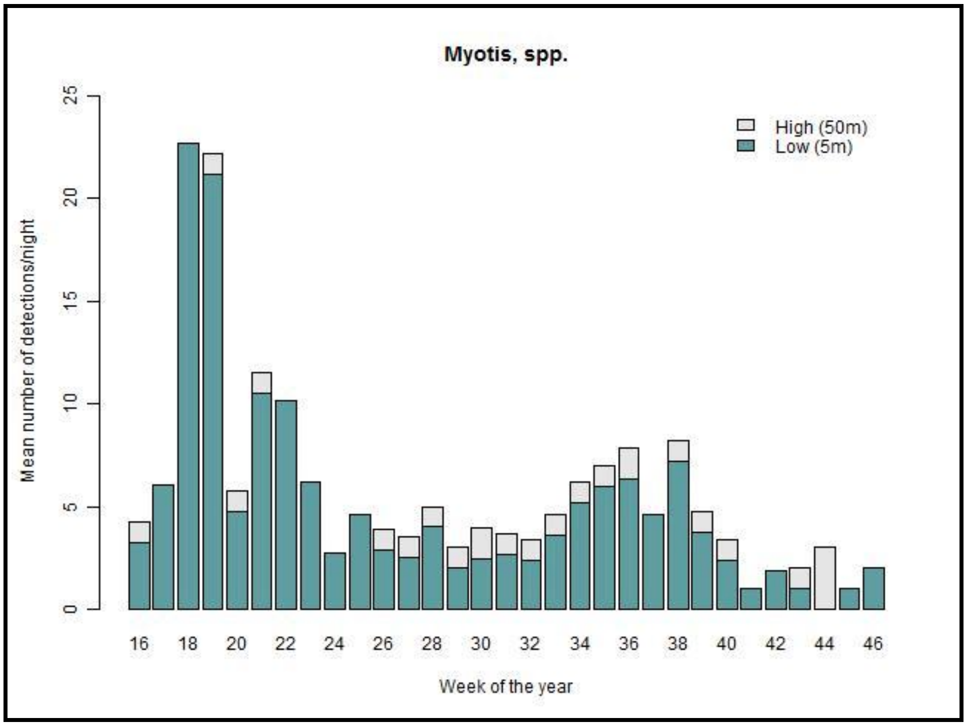

Figure 5. Mean number of calls recorded by any *Myotis* species per detector per night at the potential Lummi Indian Reservation, Washington Wind Energy Development Site from 16 April 2011 to 14 November 2011. Results are summarized by week and height of detector above the ground.

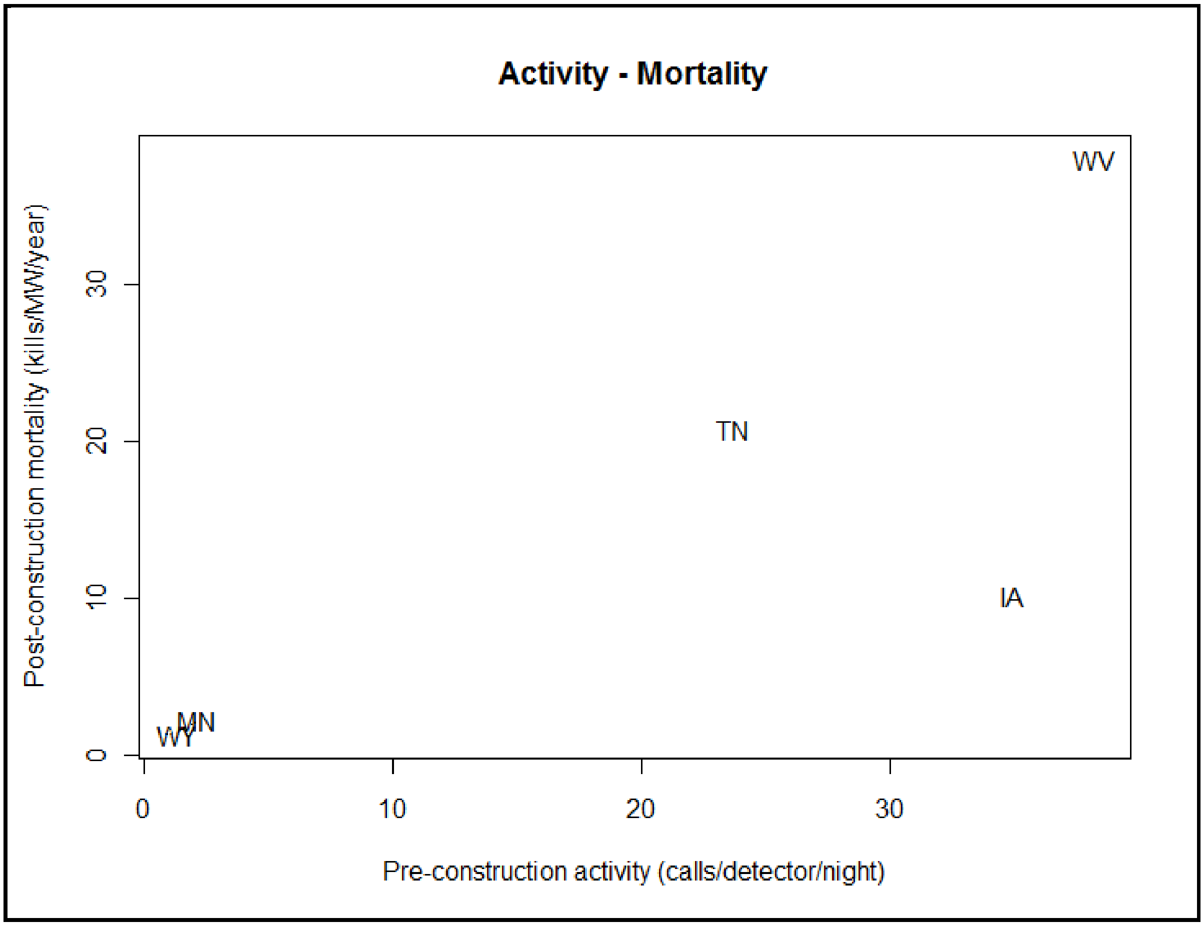

Figure 6. An illustration of the positive correlation between pre-construction activity and post-construction bat mortality recorded at existing wind power developments where pre-construction activity surveys were conducted. Data points are labeled with the state in which the study took place. References: Johnson et al. 2004 (MN), Young et al 2003 (WY), Jain 2005 (IA), Fielder 2004 (TN), E.B. Arnett, Bat Conservation International, unpublished data (WV).

Appendix 2. Marbled Murrelet Studies for the Lummi Indian Reservation Wind Energy Feasibility Assessment Project.

Final Report

Use of Radar to Determine Passage Rates of Marbled Murrelets for the Lummi Indian Reservation Wind Energy Feasibility Assessment Project, Whatcom County, Washington

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Executive Summary

- We conducted radar and ground surveys for the Marbled Murrelet to determine the likelihood of the presence of Marbled Murrelets (*Brachyramphus marmoratus*) within the Lummi Indian reservation in Whatcom County, Washington, and, if present, to document the passage rate of murrelet-type targets detected, timing of activity, flight paths, flight speeds, and flight behavior.

- Because of the difficulties involved with direct visual observations of Marbled Murrelets, radar was used to detect murrelets within the project area and monitor the inland flight activity. Radar is able to detect silent murrelet-type targets that are likely to be nesting, detect murrelet-type targets passing over a landscape out to a 1.5 km radius (more than 40 times the area of a typical ground observer), and detect murrelet-type targets through darkness and fog. Radar is considered to be an excellent and unique tool for determining murrelet presence on a landscape scale

- Surveillance (horizontal) radar was used during the 2012 breeding season at one survey site. Radar surveys were completed during the morning activity period beginning 105 minutes before official sunrise and ending 75 minutes after sunrise for a total of 3 hours of sampling each day. Ground surveys conducted by an outside observer also started 105 minutes before sunrise and continued to 75 minutes after sunrise for a total of 3 hours of survey time.

- Murrelet-type targets detected on radar were distinguished from other avian species by the target size, flight speed, flight direction, and time of day.

- Three murrelet radar surveys were conducted on the Lummi Reservation on the mornings of 6, 7 and 8 July 2012. A total of 12 murrelet-type targets were recorded on radar over the 3 survey mornings. Murrelet-type targets were recorded with surveillance radar on 3 of 3 survey mornings. In comparison to radar studies conducted in other regions, our breeding season detection rates at the Lummi Reservation were relatively low (4.0 murrelet-type targets/3km/survey morning). Of the 12 murrelet-type targets detected over the three years, 10 were defined as flying inbound and 2 were flying outbound. Due to low passage rates, our outside observers were not able to confirm any of the murrelet-type radar detections passing over the Lummi Reservation.

- Of the 12 radar targets recorded, 11 (91.6 percent) were recorded before sunrise while the earliest target was recorded 105 minutes before sunrise. The latest target was recorded at 0630. The average timing of target movement was 57 minutes before sunrise.

- The average flight speed of the murrelet-type targets recorded by surveillance radar was 45.9 mph (S.E. = 2.2, n = 12) while the minimum flight speed was 40.8 mph and the maximum was 60.1 mph

- A high proportion (83.3%) of murrelet-type targets flew toward the east (landward) (Mean =53.7 ± 72.25 (SD) (Figure 2). In terms of flight behavior, all birds were recorded flying in a straight flight direction.

- In summary, the pre-dawn flight activity, fast flight speeds, straight directional flight patterns, and consistent landward flight activity from day to day indicate that it is likely the majority of these radar targets were Marbled Murrelets. However, none of these targets were identified to species by the outside observer.

TABLE OF CONTENTS

INTRODUCTION

Hamer Environmental L.P. was contracted to determine the likelihood of the presence of Marbled Murrelets (*Brachyramphus marmoratus*) within the Lummi Indian Reservation as part of a wind energy feasibility assessment in Whatcom County, Washington, and, if present, to document the number of murrelet-type targets detected and their flight behavior. The Marbled Murrelet was listed as threatened by the U.S. Fish and Wildlife Service in 1992 (USFWS 1997).

The objectives of this monitoring program were to:

1) Use radar technology to determine the presence or absence of murrelets within the Lummi Indian Reservation.
2) Document the passage rates, flight patterns, and timing of activity of any murrelet-type targets that were detected.

BACKGROUND

The murrelet is a medium sized Pacific seabird that nests in forests with old growth characteristics in the Pacific Northwest some distance from the coast (Carter and Sealy 1987, Hamer et al. 1994, Grenier and Nelson 1995). Collecting biological information on this seabird at inland sites is extremely difficult because of poor visibility conditions for ground observers. Challenges for direct observation include, low light levels during dawn and dusk activity periods, limited viewing capability in closed canopy forests, as well as the species' small size, rapid flight speed, cryptic plumage, and secretive behavior. The rare visual observations are short in duration and offer only limited glimpses of much longer flight paths and behaviors (Hamer et al. 1995).

An inland survey protocol for the murrelet was first developed in 1990 (Paton et al. 1990, Evans et al. 2003). With this protocol, murrelets could be detected by both auditory and visual observations. However, in regions that receive little use by murrelets, they may be extremely difficult to detect using this protocol. It is suspected that murrelets may not vocalize very often in regions where only solitary murrelets are flying inland because vocalizations are often initiated only when other murrelets are present. Since 85-90 percent of murrelets are detected by hearing their vocalizations (Hamer and Cummins 1990), silent murrelets are extremely difficult to detect. Data collected by Ralph et al. (1994) suggests that observers generally see murrelets only within 100 m (328 ft) or hear murrelets within 200 m (656 ft). Observers can detect murrelets at greater distances, but many are missed at these distances and classifying behavior is more difficult. Therefore, ground observation is often an inefficient method to determine the presence of murrelets within a larger area that may be utilized by only a few individuals.

Evidence from radar studies indicate breeding murrelets may be flying inland before ground protocol surveys begin, or during the early survey period when low ambient light levels preclude detection by the surveyors (Cooper and Blaha 2002, Burger 1997). Radar studies on the Olympic Peninsula, Vancouver Island, and in the North Cascades found an initial peak of silent murrelets 45 to 60 minutes before sunrise when low light levels preclude detection by standard surveys (Cooper and Blaha 2002, Burger 1997). We believe it is likely that the early influx of silent murrelets consists primarily of breeders. These murrelets are very difficult to detect using standard ground protocol surveys.

Because of the difficulties involved with direct visual observations of murrelets, another method was needed to detect murrelets within a watershed and monitor the inland flight activity. Several types of radar have been effective tools in ornithological research for more than four decades (Eastwood 1967). Marine radar is the easiest and least expensive to operate, and has additional benefits such as high resolution, small minimal sampling range, high availability, and high portability (Cooper et al. 1991, Hamer et al. 1995). The U.S. Fish and Wildlife Service and the Pacific Seabird Group support the use of radar (Evans et al. 2003). For these reasons, radar is an excellent and unique tool for determining murrelet presence on a landscape scale.

The primary advantage of radar surveys over standard direct observation surveys is the radar's ability to detect murrelet-type targets regardless of light levels and to detect murrelet-type targets over a greater portion of the landscape. Radar is able to detect silent murrelets that are likely to be nesting, detect murrelets passing over a landscape out to a 1.5 km radius (more than 40 times the area of a typical ground observer), and detect murrelets through darkness and fog (Hamer et al. 1995). It can provide information on flight speed, flight direction and behavior, where individual murrelet-type targets are headed, and determine which areas are likely being used by the murrelet-type targets. Therefore, it is a more efficient tool for determining murrelet presence across a landscape than the ground-survey approach described by the Pacific Seabird Group survey Protocol.

STUDY AREA

The radar survey location was located within the Lummi Indian Reservation in Whatcom County, Washington (UTM Coordinate: 10U 0527034, 5404606) (Figure 1). The survey station was located adjacent to Kwina Road approximately ¼ mile west of the Lummi Natural Resource Offices. The radar can detect murrelet size targets out to a radius of 1,500 meters (Cooper et al. 2006).

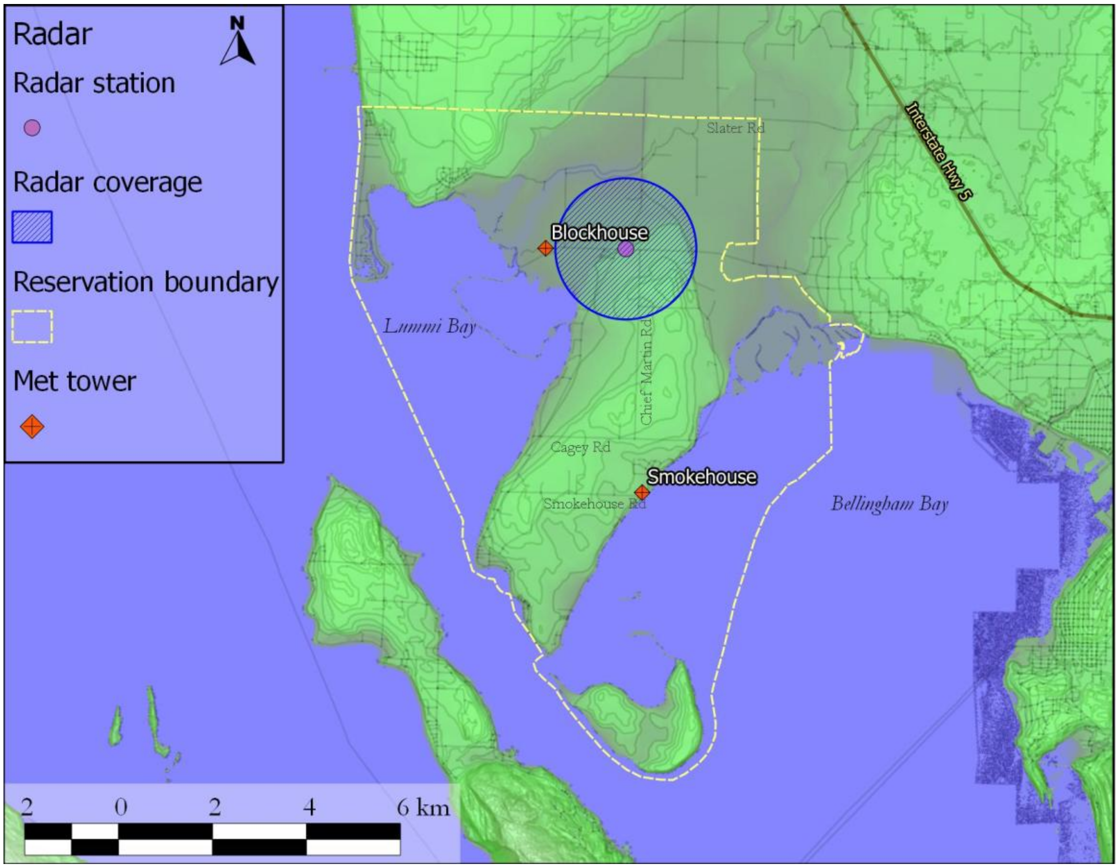

Figure 1. Location of the radar survey station and 1.5 km radius radar survey coverage.

METHODS

Two methods were used to detect and track murrelets as they crossed the Lummi reservation. These methods consisted of: 1) using radars in surveillance mode and; 2) the use of an outside observer.

Radar tracking in horizontal mode was performed using a high-frequency marine radar (Furuno Model FR-1510 Mark 3, Furuno Electric Company, Nishinomiya, Japan) transmitting at 9,410 MHz (i.e. X-band) with 2 m long slotted wave guide array antennae with a peak power output of 12 kW. The radar beam had a vertical span of 25° and a horizontal beam width of 2°. The radar was operated at a range of 1.5 km. The unit was powered by 2000 kW Honda quiet generator positioned within 5 m of the radar lab. The radar was mounted on 4WD pick-up trucks.

Radar surveys began 105 minutes before official sunrise and ended 75 minutes after sunrise for a total of 3 hours of sampling each day. This survey period was designed to cover the morning daily peak activity period of murrelets. Ground surveys using an outside observer also started and ended at the same time as the radar surveys. Sunset and sunrise times to calculate survey start and end times were obtained from the Bellingham, Washington NOAA Sunrise/Sunset tables (2011). We conducted radar surveys during the murrelet breeding seasons of 2012.

For each radar detection of a murrelet-type target identified in horizontal mode, we gathered the following information: time, radar species identification, outside observer's species identification, flight behavior, flight direction, flight speed, furthest distance detected from the radar unit, and flock size.

The second survey method consisted of an observer conducting ground surveys outside the radar unit using the Pacific Seabird Group (PSG) Marbled Murrelet Inland Survey Protocol (Evans et al. 2003). This protocol uses ground observers to record all audio detections or visual sightings of murrelets. Murrelets are known to vocalize as they travel along river corridors or across the landscape. The ground observer was stationed approximately 200 meters from the radar unit. The radar technician was in radio contact with the ground observer to communicate the distance, direction, and flight path of any murrelet-type targets detected on the radars. The ground observer attempted to identify these murrelet-type targets and confirm murrelet presence or absence in the study area. Night vision goggles were used by the outside observer during the dark portions of the 3 hours survey period.

Weather

Although ornithological radar is perfectly suitable to use in heavy fog, clutter forms on the screen during periods of rain/snow making the detection of murrelet-type targets difficult, or in the case of heavy rain/snow, impossible. This is not to say that birds cannot be detected through all types of rain clutter. During periods of lighter rain, rain clutter on the screen is often somewhat transparent, and echoes of birds can often be tracked and measured through the clutter. We could not collect horizontal radar data during periods of heavy rain because the electronic filtering required to remove the echoes of the precipitation from the display screen also removed bird targets.

The calculation of the mean passage rate (murrelet-type targets detected/survey morning) of murrelet-type targets is affected by two variables, the total number of murrelet-type targets detected (numerator) and the total number of mornings sampled (denominator). It is possible that passage rates could be underestimated if portions of the survey period where murrelet-type targets could not be detected due to rain clutter on the radar monitor were inadvertently counted as acceptable survey time, thus increasing the value of the denominator (total survey time) and decreasing the estimated mean passage rate. As a result, we recorded the number of minutes of each survey morning where ≥35 percent of the radar monitor contained clutter due to rain or heavy mist (where fog starts turning into rain droplets). During these portions of the survey period the radar could be compromised by rain to the point where we could no longer reliably detect murrelet-type targets. Therefore, any compromised survey minutes were excluded from mean passage rate calculations.

Species Identification

Murrelet-type targets detected on radar were distinguished from other avian species by the target size, flight speed, flight direction, and time of day. At inland sites, Hamer et al. (1995) found the only other common inland species of similar size and flight speed to the murrelet was the Band-tailed Pigeon (*Columba fasciata*), which overlapped at the lower end of murrelet flight speed. Although less common, other birds at inland sites can also have similar body size and flight speeds to murrelets. These species can include smaller bodied local waterfowl (mallards, mergansers), terns, migrating shorebirds, and sometimes raptors.

Only murrelet-type targets flying ≥67.7 km/hr (40.8 mph) were recorded as murrelets to minimize the number of non-murrelet targets recorded. Although the original recommendation in the protocol is to use ≥64.4 km/hr (40 mph) as a speed threshold (Evans et al. 2003), we can only accurately record the distance between echoes on the radar screen to the nearest millimeter. Therefore, the type of radar monitor used and the survey scale plays a role in determining the final speed threshold that can be accurately applied. In general, the faster the flight speed the more likely the target could be a murrelet. In addition, murrelets will typically show a somewhat higher mean flight speed for outbound versus inbound flights (Burger 1997). This discrepancy results from the murrelets losing altitude after visiting nest sites in the nearby hills and mountains as they descend back to sea level. Murrelets heading inland to nest sites usually have to gain some altitude to fly over nearby ridges and hills and this slows their flight speed.

Direct flight paths along drainages and east-west flight directions on their way to and from marine waters can also help distinguish the murrelet from other species. Therefore, we defined a murrelet-type target as inbound if it was headed between 0 and 179 degrees and outbound if the target had a flight bearing between 180 and 359 degrees. In addition to speed and flight direction, the murrelet's compact body and relatively large muscle mass make comparatively large, round, echo sizes on the radar monitor. These criteria, when considered together, assist in the identification of murrelet-type targets using radar and in the final assessment of whether a site has a likelihood of murrelets present. Radar targets showing roughly inbound-outbound flight patterns, high flight speeds, occurring before sunrise, and arriving in pulses of inbound and outbound detections have a much higher likelihood of being murrelets than other similar radar targets.

RESULTS

Weather Conditions

Three murrelet radar surveys were conducted on the Lummi Reservation on the mornings of 6, 7 and 8 July 2012. No surveys were affected by rain or heavy fog. Wind speeds varied from 0-7 mph during the three mornings and wind directions varied from south to southwest. Cloud cover varied from 0 to 100%. Visibility was >5000 m on each survey morning. The height of the cloud cover ceiling was always >1,000 m. Air temperatures varied from 45 -60° F.

Survey Effort

Three murrelet radar surveys were conducted from a single radar station on the Lummi Reservation on the mornings of 6, 7 and 8 July 2012. Three hours of surveys were conducted each morning beginning 105 minutes before official sunrise and ending 75 minutes after sunrise. Survey started approximately 0330 and ended at 0630. An outside observer was present at all three of these surveys. The percent of the 1.5 km radar survey area consisting of ground clutter was only 5.0 percent, low enough not to affect our ability to detect marbled murrelet-type targets.

Counts and Passage Rates

All passage rates are reported as radar targets per 3 km (diameter) of radar survey coverage per day. Murrelet-type radar targets were detected by surveillance radar on all three survey mornings. Radar detected 12 murrelet-type targets over the 3 survey mornings for an average detection rate of 4.0 detections per survey morning per 3 km of radar survey coverage. On average, this was 1.33 detections/hour/3 km of radar survey coverage. Three radar detections were recorded on 6 July, four on 7 July, and five detections on 8 July (Table 1). None of these detections were able to be confirmed by the outside observer.

Table 1. Data for each Marbled Murrelet-type radar target detected on the Lummi Reservation, July 2012.

Date	Detection Time	Distance to Target (m)	Flight Direction°	Inbound/Outbound	Flight Speed (mph)
7/6/11	3:36:00	600.00	95.00	In	54.37
7/6/11	4:07:00	496.00	240.00	Out	40.80
7/6/11	4:23:00	729.00	30.00	In	54.37
7/7/11	3:45:00	1071.00	145.00	In	40.80
7/7/11	3:46:00	1237.00	170.00	In	40.80
7/7/11	3:46:00	1142.00	70.00	In	54.37
7/7/11	6:15:00	583.00	300.00	Out	40.80
7/8/11	4:15:00	1217.00	25.00	In	40.80
7/8/11	4:15:00	1025.00	26.00	In	40.80
7/8/11	4:22:00	1392.00	40.00	In	40.80
7/8/11	4:29:00	1250.00	32.00	In	61.16
7/8/11	4:40:00	429.00	62.00	In	40.80

Timing of Activity

Of the 12 radar targets recorded, 11 (91.6 percent) were recorded before sunrise while the earliest target was recorded 105 minutes before sunrise (Figure 2) (Table 1). The latest target was recorded at 0630. The average timing of target movement was 57 minutes before sunrise.

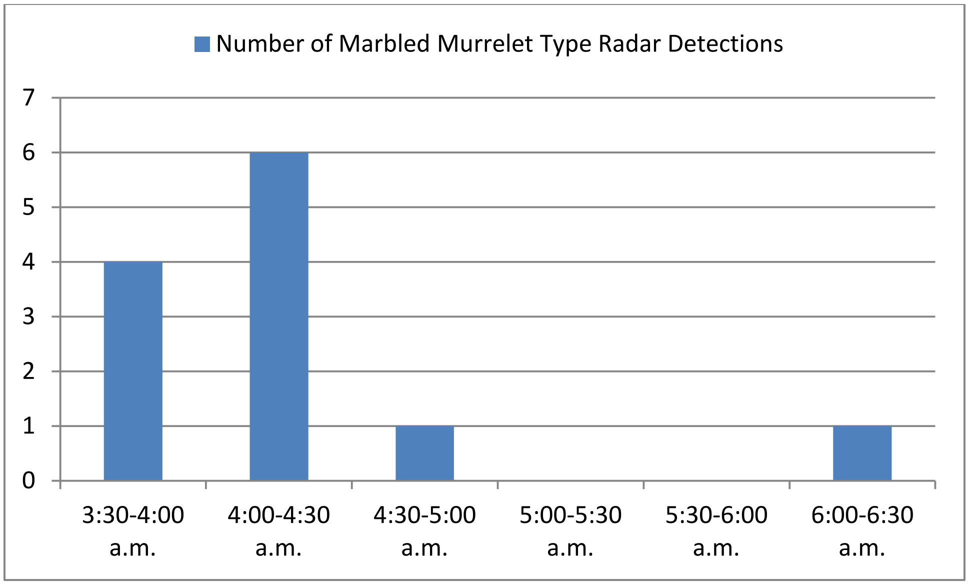

Figure 2. Number of Marbled Murrelet-type targets detected in 30 minute intervals during the three mornings of sampling on the Lummi Reservation, July 2012.

Flight Speed

The average flight speed of the murrelet-type targets recorded by surveillance radar was 45.9 mph (S.E. = 2.2, n = 12) while the minimum flight speed was 40.8 mph and the maximum was 60.1 mph (Table 1).

Flight Direction

Murrelet-type targets were defined as inbound if their flight direction was between 0 and 179 degrees. Murrelet-type targets were defined as outbound when their flight paths were between 180 and 259 degrees. A high proportion (83.3%) of murrelet-type targets flew toward the east (landward) (Mean =53.7 ± 72.25 (SD) (Figure 2). In terms of flight behavior, all birds were recorded flying in a straight flight direction. No circling birds were detected.

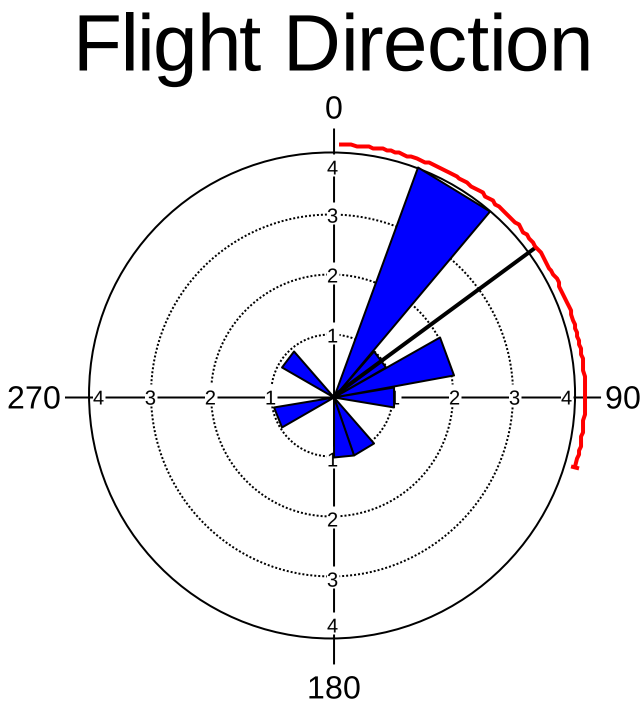

Figure 2. Flight directions of Marbled Murrelet-type targets detected on the Lummi Reservation, July 2012. The mean flight vector and circular standard deviation (red) are also shown.

DISCUSSION

Passage Rates

In comparison to radar studies conducted in other regions, our breeding season detection rate on the Lummi Reservation was relatively low (4.0 murrelet-type targets/3km/survey morning). However, none of these detections were able to be confirmed by the outside observer as the birds were often many hundreds of meters away from the location of the outside observer and the radar. The mean distance of murrelet-type targets from the radar was 930 meters. Radar data on murrelets collected from 10 watersheds on the Olympic Peninsula Washington in 2000 had maximum counts of inbound murrelet-type targets ranging from 28-193 detections per morning and mean counts that ranged from 25.3-160 detections per morning (Raphael et al. 2002). Data from five independent radar studies which surveyed 108 watersheds in British Columbia had mean annual maximum counts that varied from 7-1,005 murrelet-type targets per morning (Burger 2002). Of these 108 sites, 91.7 percent had ≥20 detections per survey morning (mean annual maximum count). These studies only counted landward (inbound) murrelet-type targets (murrelet-type targets flying in a westerly direction), while our study counted all murrelet-type targets regardless of flight direction (in-bound or out-bound). However, all of these radar studies were conducted in regions with much greater amounts of suitable habitat available on the landscape for nesting murrelets compared to this region, and thus were encountering and measuring larger populations.

Timing of Activity and Flight Speed

The peak of inbound flights has been reported as occurring 35-60 minutes before sunrise (Burger 1997), 35-45 minutes before sunrise (Cooper and Blaha 2002), and 20 to 75 minutes before sunrise (Cooper et al. 2001). Although there is some variation in the reported timing of inbound murrelet-type targets, there is general consensus that the number of flights measured with marine radar peaks between ½ and 1 hour before sunrise. At the Lummi Reservation we found that inbound flights peaked one hour before sunrise, with 91.6% of the targets detected before sunrise. However, the study detected few murrelet-type targets flying seaward (outbound). It could be that seaward birds are taking different flight routes when returning from their nest sites or that the number of days sampled at this site was too low. Flight speeds of murrelet-type targets recorded in this study are within the same ranges recorded by other studies.

Flight Direction

Most murrelet-type targets detected in this study were flying landward toward the northeast. This flight direction generally follows the Nooksack River Corridor which heads north and then northeast as it flows out of the North Cascade Mountains.

Summary

In summary, the pre-dawn flight activity, fast flight speeds, straight directional flight patterns, and consistent landward flight activity from day to day indicate that it is likely the majority of these targets were Marbled Murrelets. However, none of these radar targets were identified to species by the outside observer. Additional sampling would be needed to confirm the species for a sample of radar targets. In addition, data on the flight heights of these birds was not collected so that an assessment of collision risk of transiting birds to any man-made structures in this area is not possible at this time.

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APPENDIX C

THE LUMMI INDIAN RESERVATION WIND ENERGY DEVELOPMENT FEASIBILITY ASSESSMENT PROJECT DATA SUMMARY AND RETRIEVAL FOR JANUARY 2012

Wind Resource Data Summary

The Lummi Indian Reservation Wind Energy Development Feasibility Assessment Project

Data Summary and Transmittal for January 2012

Prepared for:

Lummi Nation Business Council
2616 Kwina Road
Bellingham, Washington 98226

February 2012

DNV Renewables (USA) Inc.
1809 7th Avenue, Suite 900, Seattle, WA 98101
Phone: (206) 387-4200 Fax: (206) 387-4201
www.dnv.com/windenergy

BACKGROUND

The Lummi Nation Business Council in Bellingham, Washington, contracted with DNV Renewables (USA) Inc. (DNV) to collect, quality control (QC), validate, summarize, and transmit data for one 60-m and one 50-m meteorological tower located on the Lummi Indian Reservation outside of Bellingham, Washington. The 60-m XHD tower, provided by NRG Systems, is identified as Site 1001. The second tower, an NRG 50-m Standard, is identified as Site 1002. Wear Construction Inc., LLC of Snohomish, Washington, installed the 60-m tower on December 30, 2010, and the 50-m tower on February 4, 2011, under contract with DNV.

Location Summary

Site Number	Tower Type	Installation Date	Tower Coordinates (WGS 84)		Elevation
			Latitude	Longitude	
1001	**NRG 60-m XHD**	December 30, 2010	N 48°47.613'	W 122°39.307'	2 m (7 ft)
1002	**NRG 50-m Standard**	February 4, 2011	N 48°44.862'	W 122°37.533'	10 m (33 ft)

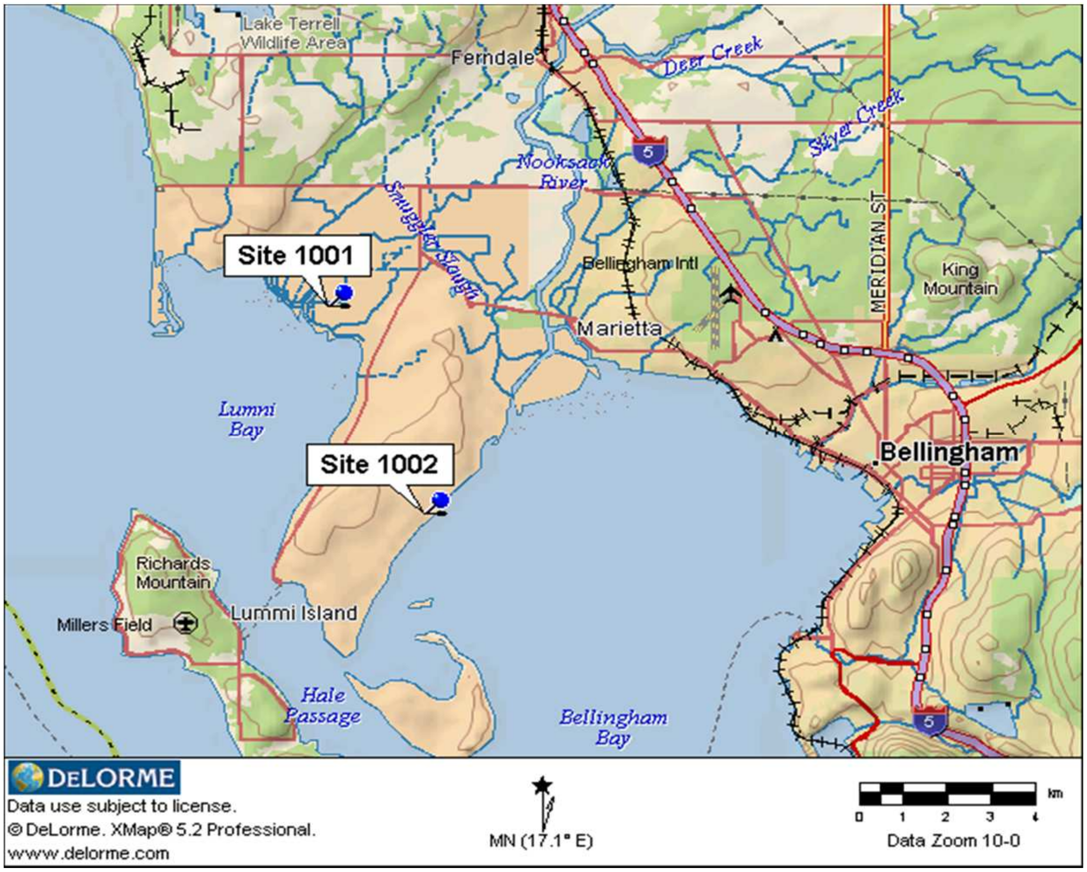
Sensor Summary
Site 1001

	Quantity	Nominal Sensor Height (m)	Actual Sensor Height (m)	Sensor Orientation (°)*	Boom Length (m)
NRG #40C Anem.	2	60	58	180, 270	2.4
NRG #40C Anem.	1	50	50	180	2.4
NRG #40C Anem.	2	40	40	180, 270	2.4
NRG #40C Anem.	1	25	25	180	2.4
NRG #200P Vanes	2	50, 45	52, 47.5	0, 0	2.4
NRG #110S Temp.	1	3	3		

Site 1002

	Quantity	Nominal Sensor Height (m)	Actual Sensor Height (m)	Sensor Orientation (°)*	Boom Length (m)
NRG #40C Anem.	2	50	48.5	185, 101	1.1
NRG #40C Anem.	2	35	35	197, 105	1.1
NRG #40C Anem.	2	25	26.5	197, 101	1.1
NRG #200P Vanes	2	40, 30	42, 30	5, 5	1.5
NRG #110S Temp.	1	3	3		

*** An orientation of 180° means the sensor is due south of the tower.**



Location of Lummi Indian Reservation Wind Monitoring Stations

OBJECTIVE AND DESCRIPTION

The monthly data summary is not a detailed analysis intended for use in making long-term energy estimates. The monthly activities provide a general validation and summarization of the 10-minute data, presented in a cumulative format. This includes elimination of data associated with tower shadow, icing, intermittent sensors, and failed sensors. The data summary does not include the detailed analysis of the data that is needed to address relatively small tower and boom effects, small sensor discrepancies, and other anomalies that may occur. While the validated data provided in the monthly processing provide a building block for evaluating a site's wind resource, they are not being delivered as a final wind resource assessment.

The information provided in this monthly data summary is based on the validated data but does not include detailed analysis and should be considered preliminary. For example, invalid data have not been replaced, and no consideration has been given to the long-term representativeness of the data that have been collected and reported in this summary. Additional analysis is required to establish a representative long-term data set.

Data Recovery - Site 1001

	Hours	Hours Lost				Recovery Rate	
	In Period	60 m	50 m	40 m	25 m	All Heights	Upper Level
January 2011	744	0	18	0	18	98.8%	100.0%
February	672	0	10	0	10	99.3%	100.0%
March	744	0	16	0	16	98.9%	100.0%
April	720	11	33	11	33	97.0%	98.5%
May	744	0	8	0	8	99.5%	100.0%
June	720	0	4	0	4	99.7%	100.0%
July	744	0	9	0	9	99.4%	100.0%
August	744	0	5	0	5	99.7%	100.0%
September	720	0	17	0	17	98.8%	100.0%
October	744	0	43	0	43	97.1%	100.0%
November	720	0	27	0	27	98.1%	100.0%
December	744	0	60	8	59	95.7%	100.0%
January 2012	744	0	18	0	18	98.8%	100.0%
Overall	**9,504**	**11**	**267**	**19**	**266**	**98.5%**	**99.9%**

Data Recovery - Site 1002

	Hours	Hours Lost			Recovery Rate	
	In Period	50 m	35 m	25 m	All Heights	Upper Level
February 2011	600	90	90	90	84.0%	85.1%
March	744	0	0	0	98.5%	100.0%
April	720	0	0	0	95.5%	100.0%
May	744	0	0	0	95.0%	100.0%
June	720	0	0	0	96.3%	100.0%
July	744	0	0	0	97.5%	100.0%
August	744	0	0	0	96.0%	100.0%
September	720	0	0	0	100.0%	100.0%
October	744	0	0	0	100.0%	100.0%
November	720	0	0	4	99.8%	100.0%
December	744	9	9	9	98.8%	98.8%
January 2012	744	2	14	2	99.2%	99.8%
Overall	**8,688**	**101**	**113**	**104**	**98.8%**	**98.8%**

O&M Summary

	Site 1001 NRG 60-m XHD Installed December 30, 2010	Site 1002 NRG 50-m Standard Installed February 4, 2011
January 2011	Tower installed 12/30/2010.	
February	No Issues.	Tower installed 2/4/2011.
March	No Issues.	Sensor orientations updated in data validation and met sheet.
April	Incomplete data transmittal on 4/17.	No Issues.
May	No Issues.	No Issues.
June	No Issues.	No Issues.
July	No Issues.	No Issues.
August	No Issues.	No Issues.
September	No Issues.	No Issues.
October	No Issues.	No Issues.
November	No Issues.	No Issues.
December	No Issues.	No Issues.
January 2012	No Issues.	No Issues.

Green shading indicates greater than 70% data recovery at 60 m.

Cause of Hours Lost (Upper Level)

	Site 1001				Site 1002			
	Missing	Malfunction	Icing	Tower	Missing	Malfunction	Icing	Tower
January 2011	0	0	0	0	N/A	N/A	N/A	N/A
February	0	0	0	0	90	0	0	0
March	0	0	0	0	0	0	0	0
April	11	0	0	0	0	0	0	0
May	0	0	0	0	0	0	0	0
June	0	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0	0
August	0	0	0	0	0	0	0	0
September	0	0	0	0	0	0	0	0
October	0	0	0	0	0	0	0	0
November	0	0	0	0	0	0	0	0
December	0	0	0	0	0	0	9	0
January 2012	0	0	0	0	0	0	2	0
Overall	**11**	**0**	**0**	**0**	**90**	**0**	**11**	**0**

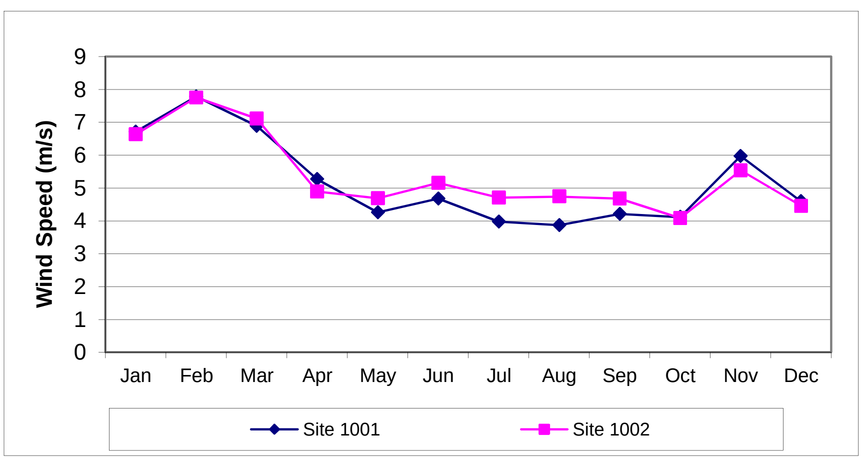
Monthly Average Wind Speeds (m/s)

	Site 1001			
	60 m	**50 m**	**40 m**	**25 m**
January 2011	6.2	6.0	5.7	5.3
February	8.0	7.8	7.5	7.0
March	7.0	6.9	6.6	6.2
April	5.2	5.3	4.9	4.7
May	4.3	4.3	4.0	3.8
June	4.8	4.7	4.5	4.3
July	4.1	4.0	3.8	3.6
August	4.0	3.9	3.7	3.5
September	4.3	4.2	3.9	3.6
October	4.1	4.1	3.7	3.5
November	6.0	6.0	5.5	5.1
December	4.6	4.6	4.2	4.0
January 2012	7.5	7.4	6.9	6.5
Average [1]	**5.3**	**5.2**	**4.9**	**4.6**

[1] The Weighted Average is an annual average calculated by averaging duplicate calendar months.

	Site 1002		
	50 m	**35 m**	**25 m**
February 2011	7.8	7.2	6.6
March	7.1	6.7	6.3
April	4.9	4.7	4.3
May	4.7	4.5	4.2
June	5.2	4.9	4.7
July	4.7	4.5	4.2
August	4.7	4.5	4.2
September	4.7	4.2	3.9
October	4.1	3.7	3.3
November	5.5	5.2	4.5
December	4.5	4.1	3.6
January 2012	6.6	6.1	5.5
Average [1]	**5.4**	**5.0**	**4.6**

[1] Average values are from February 4, 2011 through the current month.



Monthly Average Wind Speed (50 m)

Maximum Wind Speed Gust (m/s)

	Site 1001			
	60 m	50 m	40 m	25 m
January 2011	24.1	23.7	24.1	22.5
February	26.4	26.0	26.0	26.4
March	28.3	28.3	28.3	27.5
April	22.2	22.5	21.8	19.9
May	13.4	13.0	14.1	12.6
June	14.9	14.5	15.3	14.5
July	16.4	16.0	16.0	14.9
August	17.2	15.7	16.4	14.9
September	22.5	21.8	22.9	22.5
October	22.2	21.4	20.2	18.0
November	32.1	31.0	30.6	27.9
December	28.7	27.9	28.3	26.7
January 2012	28.3	27.1	27.5	25.6
Period of Record [1]	**32.1**	**31.0**	**30.6**	**27.9**

[1] Period of Record is the maximum wind speed from January 1, 2011, through the current month.

	Site 1002		
	50 m	35 m	25 m
February 2011	24.5	23.3	22.8
March	32.1	32.1	30.9
April	24.4	24.4	23.3
May	15.3	14.5	14.5
June	14.5	14.9	14.1
July	17.9	17.6	17.2
August	16.4	16.1	14.9
September	28.3	28.7	27.1
October	20.2	19.9	18.7
November	29.8	29.8	28.3
December	30.6	30.2	31.3
January 2012	30.9	29.4	28.7
Period of Record [1]	**32.1**	**32.1**	**31.3**

[1] Period of Record is the maximum wind speed from February 4, 2011, through the current month.

Site 1001

Diurnal Wind Speed Trend (60 m)

	Hour																								
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**AVG**
January 2011	6.0	6.1	6.0	6.1	5.9	6.2	6.3	6.2	6.6	6.5	6.5	6.5	6.3	6.3	6.6	6.3	6.3	5.9	5.7	6.0	5.8	6.0	6.0	6.1	6.2
February	7.5	7.6	7.7	7.7	7.8	7.9	7.9	8.3	8.4	8.2	8.1	8.0	8.0	7.9	8.2	8.3	8.3	7.8	7.9	7.9	8.1	8.0	8.0	7.6	8.0
March	7.5	7.6	7.8	7.6	7.5	7.7	7.7	7.7	7.7	7.8	7.5	7.1	7.1	6.7	6.4	6.3	6.2	6.1	6.2	6.5	6.2	6.5	6.8	7.1	7.0
April	4.4	4.6	4.8	5.4	5.3	5.4	5.4	5.2	5.5	6.0	6.1	6.2	6.0	5.8	5.8	5.4	4.9	4.9	4.9	4.8	4.8	4.8	4.6	4.4	5.2
May	4.1	4.1	4.1	4.1	4.1	4.0	4.0	4.1	4.4	4.4	4.6	4.8	4.8	5.1	4.9	4.7	4.7	4.5	4.3	3.9	4.2	4.0	4.1	4.1	4.3
June	5.0	4.7	4.5	4.6	4.6	4.6	4.5	4.5	4.6	4.8	5.1	5.4	5.4	5.2	5.1	5.2	5.0	5.0	4.9	4.8	4.7	4.4	4.5	4.5	4.8
July	3.8	3.7	3.6	4.0	3.8	4.0	3.9	4.2	4.1	4.4	4.5	4.7	4.8	4.7	4.6	4.7	4.5	4.2	4.0	4.0	3.5	3.5	3.6	3.7	4.1
August	4.0	3.9	4.0	3.9	4.0	4.2	3.8	3.8	3.7	3.9	4.4	4.5	4.7	4.6	4.6	4.4	4.5	4.3	4.0	3.3	3.4	3.6	3.7	3.9	4.0
September	3.9	3.8	4.1	4.4	4.0	4.1	4.1	4.3	4.1	4.4	5.1	5.3	5.4	5.4	5.0	5.0	4.6	4.2	4.4	3.5	3.4	3.3	3.6	3.5	4.3
October	3.5	3.8	3.8	3.8	3.9	4.1	3.6	4.0	4.2	4.2	4.4	4.6	4.8	4.6	4.7	4.4	4.2	3.9	4.1	4.4	4.1	3.8	4.1	4.0	4.1
November	6.2	6.1	5.9	5.7	6.1	5.9	5.8	5.7	5.8	6.1	5.9	5.8	5.8	5.8	5.8	6.0	6.2	5.9	5.6	6.1	6.6	6.4	6.5	6.2	6.0
December	4.7	4.6	4.9	4.9	4.6	5.0	4.9	4.6	4.8	4.9	4.7	4.5	4.3	4.0	4.0	4.1	4.2	4.5	4.4	4.5	4.8	5.4	4.9	5.2	4.6
January 2012	6.9	6.9	7.5	7.5	7.9	8.1	8.2	8.3	8.1	7.9	7.8	7.8	7.5	7.5	7.5	7.6	7.5	7.3	6.8	7.0	6.8	6.7	7.2	6.9	7.5
Average [1]	**5.1**	**5.1**	**5.2**	**5.2**	**5.2**	**5.3**	**5.2**	**5.3**	**5.4**	**5.5**	**5.6**	**5.7**	**5.7**	**5.5**	**5.5**	**5.5**	**5.4**	**5.2**	**5.1**	**5.0**	**5.0**	**5.0**	**5.1**	**5.1**	**5.3**

[1] The Weighted Average is an annual average calculated by averaging duplicate calendar months.

Diurnal Wind Speed Trend (50 m)

	Hour																								
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**AVG**
January 2011	5.7	5.9	5.9	6.0	5.6	5.9	6.1	6.1	6.4	6.3	6.3	6.4	6.3	6.2	6.6	6.4	6.4	6.0	5.8	5.8	5.6	5.8	5.8	5.9	6.0
February	7.2	7.3	7.5	7.4	7.5	7.7	7.6	8.0	8.2	8.0	8.0	7.8	7.9	8.0	8.2	8.1	8.1	7.6	7.9	7.8	8.1	7.8	7.7	7.3	7.8
March	7.5	7.5	7.5	7.3	7.2	7.5	7.5	7.5	7.5	7.6	7.4	7.0	7.0	6.5	6.3	6.2	6.1	5.9	6.2	6.5	6.0	6.3	6.6	6.9	6.9
April	4.5	4.8	4.9	5.3	5.2	5.3	5.3	5.2	5.6	6.0	6.0	6.2	6.0	5.8	5.8	5.4	5.0	4.9	4.9	4.8	4.9	5.0	4.8	4.5	5.3
May	3.9	3.9	4.0	4.0	4.1	3.9	3.9	4.0	4.4	4.4	4.6	4.8	4.8	5.1	4.9	4.7	4.7	4.4	4.2	3.8	4.1	3.9	3.9	4.1	4.3
June	4.8	4.5	4.4	4.4	4.4	4.4	4.4	4.4	4.5	4.7	5.1	5.4	5.3	5.1	5.0	5.2	4.9	4.9	4.7	4.6	4.5	4.2	4.2	4.3	4.7
July	3.6	3.5	3.4	3.8	3.7	3.8	3.8	4.1	4.0	4.4	4.4	4.6	4.7	4.6	4.5	4.6	4.5	4.2	3.9	3.9	3.4	3.2	3.3	3.5	4.0
August	3.6	3.6	3.7	3.6	3.7	4.0	3.6	3.6	3.7	3.9	4.3	4.5	4.7	4.6	4.6	4.4	4.4	4.3	3.8	3.1	3.1	3.3	3.3	3.5	3.9
September	3.7	3.6	3.9	4.2	4.0	4.1	4.1	4.4	4.1	4.4	5.1	5.3	5.4	5.4	5.0	4.9	4.6	4.1	4.3	3.5	3.3	3.1	3.4	3.3	4.2
October	3.5	3.8	3.9	3.9	3.8	4.1	3.6	4.0	4.2	4.3	4.4	4.6	4.7	4.6	4.7	4.4	4.1	3.9	4.0	4.4	4.1	3.8	4.0	4.0	4.1
November	6.1	6.0	5.7	5.7	5.9	5.8	5.8	5.5	5.6	6.0	5.9	5.9	5.8	5.7	5.8	6.2	6.6	6.1	5.7	6.2	6.6	6.2	6.3	6.0	6.0
December	4.7	4.6	4.9	4.8	4.6	5.0	4.7	4.4	4.8	4.7	4.5	4.4	4.3	4.0	4.0	4.3	4.5	4.5	4.4	4.8	4.7	5.2	4.7	4.9	4.6
January 2012	6.8	6.7	7.3	7.3	7.8	7.9	7.9	8.0	7.8	7.7	7.7	7.7	7.4	7.5	7.6	7.7	7.8	7.4	6.8	7.0	6.8	6.6	7.0	6.7	7.4
Average [1]	**4.9**	**4.9**	**5.0**	**5.1**	**5.1**	**5.2**	**5.1**	**5.2**	**5.3**	**5.4**	**5.6**	**5.6**	**5.6**	**5.5**	**5.5**	**5.5**	**5.4**	**5.1**	**5.0**	**5.0**	**4.9**	**4.8**	**4.9**	**4.9**	**5.2**

[1] The Weighted Average is an annual average calculated by averaging duplicate calendar months.

Diurnal Wind Speed Trend (40 m)

	Hour																								
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**AVG**
January 2011	5.5	5.7	5.5	5.6	5.4	5.7	5.9	5.8	6.1	6.0	6.1	6.2	6.0	6.0	6.2	6.0	5.9	5.5	5.3	5.6	5.3	5.5	5.5	5.6	5.7
February	7.0	7.0	7.2	7.2	7.2	7.3	7.3	7.7	7.9	7.8	7.8	7.6	7.6	7.5	7.7	7.9	7.9	7.2	7.3	7.4	7.5	7.5	7.4	7.1	7.5
March	6.9	7.1	7.3	7.0	6.9	7.2	7.1	7.2	7.2	7.4	7.2	6.8	6.8	6.4	6.1	6.0	6.0	5.7	5.8	6.0	5.7	6.0	6.3	6.6	6.6
April	4.1	4.2	4.5	4.9	4.9	5.0	5.0	4.9	5.3	5.8	5.9	6.0	5.8	5.7	5.7	5.2	4.8	4.7	4.6	4.4	4.4	4.4	4.2	3.9	4.9
May	3.5	3.5	3.6	3.6	3.6	3.5	3.6	3.8	4.2	4.3	4.5	4.7	4.7	5.0	4.8	4.6	4.5	4.3	4.0	3.6	3.8	3.5	3.5	3.7	4.0
June	4.5	4.1	4.0	4.1	4.1	4.1	4.1	4.2	4.4	4.6	5.0	5.3	5.2	5.0	4.9	5.0	4.8	4.7	4.6	4.4	4.3	3.9	4.0	4.0	4.5
July	3.2	3.1	3.1	3.4	3.3	3.5	3.5	3.8	3.9	4.2	4.4	4.6	4.7	4.6	4.4	4.6	4.4	4.1	3.8	3.7	3.1	2.9	3.1	3.1	3.8
August	3.4	3.3	3.5	3.4	3.6	3.8	3.5	3.5	3.6	3.9	4.3	4.5	4.7	4.6	4.5	4.4	4.4	4.2	3.8	3.0	2.8	3.0	3.0	3.2	3.7
September	3.4	3.3	3.6	3.8	3.5	3.7	3.5	3.8	3.8	4.2	5.0	5.1	5.3	5.3	4.9	4.8	4.5	4.0	3.9	3.2	2.9	2.7	3.0	3.0	3.9
October	3.1	3.4	3.4	3.5	3.4	3.5	3.1	3.5	3.6	3.7	4.1	4.3	4.6	4.4	4.4	4.0	3.9	3.4	3.5	3.7	3.6	3.3	3.4	3.4	3.7
November	5.7	5.6	5.3	5.1	5.4	5.3	5.1	5.0	5.2	5.6	5.5	5.4	5.4	5.4	5.5	5.6	5.7	5.4	5.0	5.5	6.0	5.7	5.8	5.6	5.5
December	4.4	4.3	4.5	4.5	4.1	4.5	4.3	4.1	4.4	4.4	4.3	4.1	4.0	3.7	3.7	3.8	3.8	4.0	3.9	4.2	4.5	4.9	4.4	4.7	4.2
January 2012	6.2	6.2	6.8	6.8	7.4	7.5	7.6	7.7	7.5	7.4	7.3	7.3	7.1	7.0	7.0	7.1	7.0	6.7	6.3	6.4	6.3	6.2	6.6	6.2	6.9
Average [1]	**4.6**	**4.6**	**4.7**	**4.7**	**4.7**	**4.8**	**4.7**	**4.9**	**5.0**	**5.2**	**5.4**	**5.4**	**5.4**	**5.3**	**5.3**	**5.2**	**5.1**	**4.8**	**4.7**	**4.6**	**4.5**	**4.5**	**4.5**	**4.5**	**4.9**

[1] The Weighted Average is an annual average calculated by averaging duplicate calendar months.

Diurnal Wind Speed Trend (25 m)

	Hour																								
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**AVG**
January 2011	5.0	5.1	5.1	5.2	4.9	5.2	5.5	5.4	5.6	5.6	5.7	5.8	5.8	5.7	6.0	5.8	5.7	5.3	5.1	5.1	4.9	5.1	5.0	5.0	5.3
February	6.4	6.4	6.6	6.6	6.6	6.9	6.7	7.1	7.3	7.3	7.4	7.2	7.3	7.4	7.5	7.4	7.4	6.8	7.0	6.9	7.2	6.9	6.8	6.4	7.0
March	6.6	6.7	6.7	6.5	6.4	6.6	6.7	6.7	6.8	7.0	6.9	6.6	6.5	6.1	5.8	5.7	5.6	5.4	5.5	5.7	5.2	5.6	5.8	6.1	6.2
April	3.9	4.1	4.3	4.6	4.7	4.7	4.6	4.7	5.2	5.5	5.6	5.8	5.6	5.4	5.5	5.0	4.6	4.5	4.4	4.1	4.1	4.2	4.1	3.8	4.7
May	3.1	3.2	3.3	3.4	3.4	3.2	3.4	3.7	4.1	4.1	4.3	4.6	4.6	4.9	4.7	4.5	4.3	4.0	3.7	3.3	3.5	3.2	3.2	3.4	3.8
June	4.2	3.9	3.9	3.8	3.8	3.8	4.0	4.1	4.4	4.5	4.9	5.2	5.1	4.9	4.8	4.9	4.6	4.6	4.3	4.1	4.0	3.6	3.7	3.7	4.3
July	2.9	2.9	2.8	3.1	3.1	3.2	3.3	3.7	3.7	4.1	4.2	4.4	4.5	4.4	4.3	4.4	4.2	3.9	3.6	3.4	2.9	2.6	2.7	2.8	3.5
August	2.8	2.8	3.0	3.1	3.3	3.6	3.2	3.3	3.5	3.8	4.1	4.4	4.5	4.5	4.4	4.2	4.1	3.9	3.6	2.8	2.4	2.6	2.6	2.8	3.5
September	3.2	3.0	3.2	3.4	3.3	3.3	3.2	3.7	3.7	4.0	4.7	5.0	5.1	5.0	4.6	4.4	4.1	3.6	3.6	2.9	2.5	2.4	2.6	2.8	3.6
October	3.0	3.2	3.3	3.2	3.2	3.3	3.0	3.3	3.6	3.8	4.0	4.2	4.3	4.2	4.2	3.8	3.5	3.1	3.2	3.6	3.4	3.1	3.2	3.3	3.5
November	5.2	5.1	4.7	4.8	5.0	4.9	4.9	4.7	4.8	5.3	5.3	5.3	5.3	5.2	5.2	5.5	5.8	5.3	4.8	5.3	5.6	5.3	5.3	5.1	5.1
December	4.2	4.1	4.2	4.1	3.9	4.2	3.8	3.6	4.0	4.0	4.0	3.9	3.9	3.6	3.6	3.8	3.8	3.7	3.7	4.1	4.1	4.5	4.1	4.4	4.0
January 2012	5.7	5.7	6.3	6.3	6.9	6.9	7.1	7.2	6.9	6.9	6.9	7.0	6.8	6.9	6.9	6.9	6.9	6.5	6.0	6.2	6.0	5.8	6.0	5.7	6.5
Average [1]	**4.2**	**4.2**	**4.3**	**4.4**	**4.4**	**4.5**	**4.4**	**4.6**	**4.8**	**5.0**	**5.1**	**5.2**	**5.3**	**5.2**	**5.1**	**5.0**	**4.9**	**4.6**	**4.4**	**4.3**	**4.2**	**4.1**	**4.1**	**4.2**	**4.6**

[1] The Weighted Average is an annual average calculated by averaging duplicate calendar months.

Site 1002
Diurnal Wind Speed Trend (50 m)

	Hour																								
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**AVG**
February 2011	6.4	6.5	7.0	6.6	6.8	7.1	7.0	7.3	7.3	7.3	7.5	7.4	7.7	8.1	8.6	8.5	8.2	7.8	7.4	7.1	7.3	7.5	7.5	6.7	7.4
March	7.2	8.1	7.7	7.6	7.5	7.6	7.8	7.4	7.7	7.7	7.4	7.2	7.5	6.9	6.3	6.3	6.2	6.1	6.6	6.6	6.4	6.6	7.0	7.2	7.1
April	4.5	4.6	4.5	5.1	5.2	5.1	5.0	4.6	5.0	5.5	5.7	5.6	5.6	5.3	5.4	5.2	4.7	4.7	4.2	4.2	4.4	4.4	4.4	4.3	4.9
May	5.1	4.9	5.0	4.8	4.8	5.0	4.7	4.9	4.9	4.4	4.5	5.0	4.9	4.9	5.0	4.9	4.5	4.3	4.3	4.2	4.1	4.3	4.6	4.5	4.7
June	5.4	5.6	5.4	5.5	5.3	5.5	5.4	5.2	5.3	5.3	5.0	5.3	5.2	5.0	4.8	5.0	4.9	5.0	5.1	5.0	5.0	4.8	5.0	5.0	5.2
July	4.9	4.8	5.0	5.0	4.8	4.9	4.9	5.1	4.9	4.8	4.6	4.8	5.0	4.7	4.7	4.6	4.5	4.3	4.1	4.3	4.4	4.2	4.5	5.0	4.7
August	5.0	5.3	5.3	5.1	5.4	5.2	5.2	5.0	4.8	4.7	4.7	4.6	4.9	4.8	4.7	4.2	4.2	4.1	4.4	4.1	4.1	4.3	4.6	5.0	4.7
September	4.1	4.2	4.6	4.6	4.5	4.5	4.5	4.5	4.7	5.1	5.5	5.7	5.7	5.8	5.2	5.1	4.9	5.0	4.7	4.4	3.5	3.7	4.0	3.9	4.7
October	3.5	3.7	3.4	3.4	3.3	3.2	3.2	3.7	4.3	4.6	4.9	4.7	4.8	4.7	4.8	4.6	4.6	4.6	4.6	4.3	4.1	3.9	3.6	3.6	4.1
November	4.9	4.5	4.8	4.7	5.5	5.0	5.4	5.3	5.3	5.1	5.5	5.9	5.8	5.9	6.0	5.8	6.3	6.2	6.0	6.1	6.1	5.7	5.3	5.4	5.5
December	4.9	4.3	4.2	4.2	4.3	4.4	4.5	4.7	4.6	4.7	4.9	4.9	4.3	3.7	3.7	3.7	4.1	4.3	4.3	4.1	4.6	4.9	4.8	4.8	4.4
January 2012	6.1	6.2	6.2	6.4	6.6	6.9	7.3	7.4	7.2	7.0	6.5	6.4	6.8	7.2	7.3	7.2	7.0	6.6	6.2	5.7	6.1	5.9	6.1	6.5	6.6
Average [1]	**5.2**	**5.2**	**5.2**	**5.3**	**5.3**	**5.4**	**5.4**	**5.4**	**5.5**	**5.5**	**5.6**	**5.6**	**5.7**	**5.6**	**5.6**	**5.4**	**5.4**	**5.2**	**5.2**	**5.0**	**5.0**	**5.0**	**5.1**	**5.2**	**5.3**

[1] Average values are from February 4, 2011 through the current month.

Diurnal Wind Speed Trend (35 m)

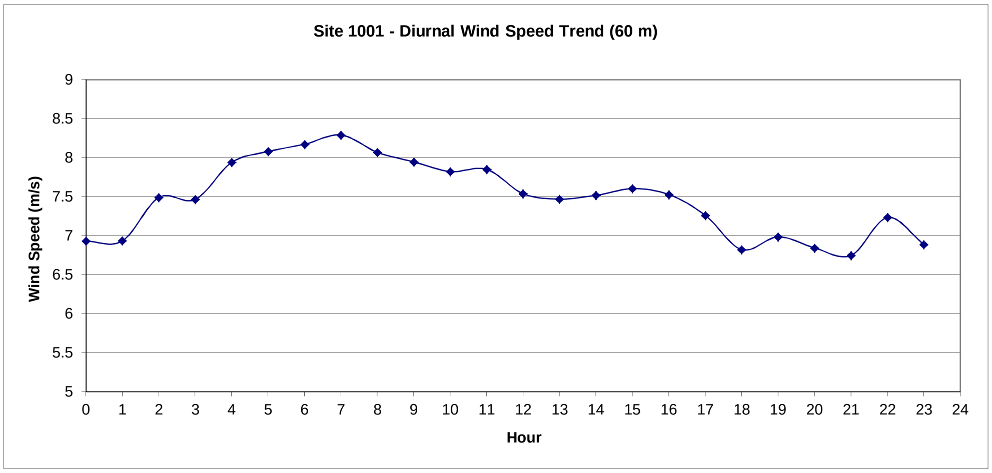
	Hour																								
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**AVG**
February 2011	6.3	6.3	7.0	6.6	6.8	7.1	7.0	7.1	7.1	7.1	7.4	7.3	7.7	7.8	8.3	8.2	8.0	7.6	7.2	6.7	6.9	7.1	7.1	6.6	7.2
March	6.8	7.6	7.2	7.2	7.0	7.1	7.4	7.0	7.3	7.4	7.1	6.9	7.2	6.6	6.0	6.0	5.8	5.7	6.3	6.1	5.9	6.2	6.6	6.7	6.7
April	4.4	4.4	4.3	4.8	4.9	4.8	4.7	4.4	4.9	5.4	5.6	5.5	5.4	5.2	5.2	5.0	4.5	4.5	4.0	4.0	4.1	4.2	4.1	4.1	4.7
May	4.9	4.8	4.8	4.7	4.6	4.9	4.6	4.9	4.8	4.4	4.5	4.9	4.8	4.8	4.8	4.7	4.4	4.1	4.0	3.8	3.7	4.0	4.4	4.3	4.5
June	5.1	5.3	5.1	5.3	5.0	5.2	5.2	5.1	5.1	5.2	4.8	5.1	5.0	4.8	4.6	4.8	4.7	4.7	4.7	4.6	4.6	4.4	4.8	4.7	4.9
July	4.6	4.6	4.8	4.8	4.6	4.7	4.8	5.0	4.8	4.7	4.5	4.6	4.9	4.5	4.6	4.5	4.3	4.0	3.7	3.9	4.0	3.8	4.1	4.6	4.5
August	4.7	5.0	5.0	4.8	5.1	4.9	5.0	4.8	4.6	4.6	4.5	4.5	4.7	4.7	4.5	4.1	3.9	3.7	3.9	3.7	3.8	3.8	4.2	4.7	4.5
September	3.6	3.7	4.1	4.2	4.1	4.1	4.1	4.2	4.5	4.8	5.2	5.3	5.3	5.4	4.8	4.6	4.4	4.4	4.1	4.0	2.9	3.3	3.5	3.4	4.2
October	3.1	3.2	3.0	3.1	3.0	2.9	2.8	3.3	4.0	4.4	4.6	4.5	4.5	4.4	4.4	4.3	4.2	4.1	4.0	3.8	3.6	3.4	3.2	3.1	3.7
November	4.5	4.2	4.3	4.4	5.1	4.7	5.0	4.9	5.0	4.9	5.3	5.8	5.6	5.7	5.8	5.5	5.9	5.8	5.6	5.7	5.6	5.2	4.8	4.9	5.2
December	4.5	3.9	3.9	3.8	3.9	4.0	4.1	4.3	4.2	4.5	4.7	4.7	4.0	3.5	3.4	3.5	3.7	4.0	3.9	3.8	4.1	4.4	4.4	4.5	4.1
January 2012	5.7	5.8	5.7	5.8	6.0	6.3	6.7	6.8	6.6	6.4	6.2	6.0	6.4	6.8	6.9	6.8	6.5	6.0	5.7	5.2	5.6	5.3	5.7	6.1	6.1
Average [1]	**4.9**	**4.9**	**4.9**	**4.9**	**5.0**	**5.1**	**5.1**	**5.1**	**5.3**	**5.3**	**5.4**	**5.4**	**5.5**	**5.3**	**5.3**	**5.1**	**5.0**	**4.9**	**4.8**	**4.6**	**4.6**	**4.6**	**4.7**	**4.8**	**5.0**

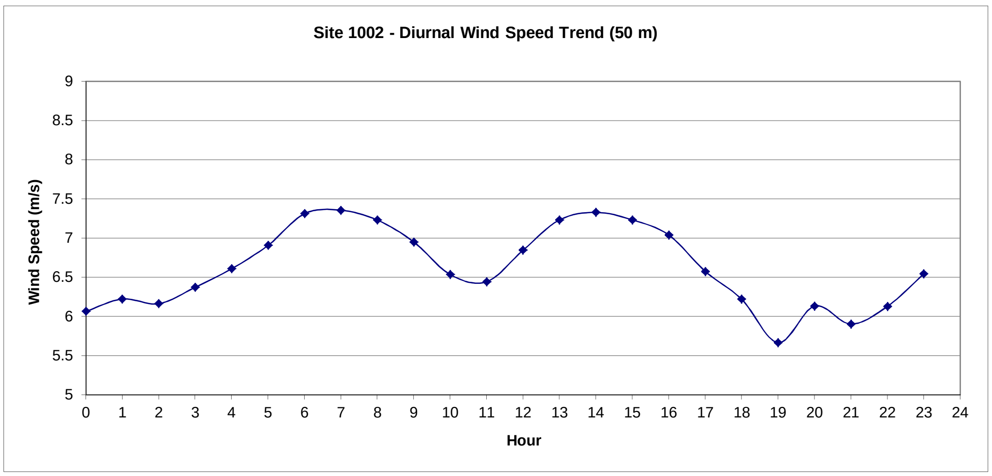
[1] Average values are from February 4, 2011 through the current month.

Diurnal Wind Speed Trend (25 m)

	Hour																								
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**AVG**
February 2011	5.3	5.4	5.9	5.6	5.8	6.0	5.9	6.1	6.2	6.3	6.5	6.5	6.9	7.1	7.6	7.5	7.2	6.7	6.2	6.0	6.1	6.3	6.2	5.6	6.3
March	6.3	7.1	6.8	6.7	6.5	6.6	6.9	6.5	6.9	7.0	6.7	6.5	6.9	6.3	5.7	5.7	5.5	5.3	5.8	5.6	5.5	5.7	6.1	6.2	6.3
April	4.0	4.0	3.9	4.3	4.5	4.3	4.3	4.1	4.6	5.1	5.3	5.2	5.1	4.9	4.9	4.6	4.2	4.1	3.5	3.5	3.6	3.7	3.7	3.7	4.3
May	4.5	4.4	4.5	4.3	4.3	4.5	4.3	4.6	4.6	4.2	4.3	4.6	4.5	4.5	4.5	4.4	4.1	3.8	3.6	3.3	3.2	3.5	3.9	3.9	4.2
June	4.8	5.1	4.9	5.1	4.8	5.1	5.1	4.9	5.0	5.0	4.6	4.9	4.8	4.5	4.4	4.5	4.5	4.4	4.4	4.3	4.3	4.2	4.5	4.5	4.7
July	4.3	4.3	4.6	4.6	4.4	4.5	4.6	4.8	4.7	4.5	4.4	4.5	4.7	4.3	4.4	4.2	4.1	3.7	3.4	3.6	3.7	3.5	3.8	4.3	4.2
August	4.5	4.7	4.8	4.6	4.8	4.7	4.8	4.7	4.5	4.4	4.4	4.4	4.6	4.5	4.3	3.9	3.7	3.5	3.5	3.3	3.4	3.5	3.9	4.5	4.2
September	3.4	3.5	3.8	3.9	3.8	3.7	3.8	3.9	4.3	4.6	4.9	5.1	5.0	5.1	4.4	4.3	4.0	4.0	3.7	3.6	2.6	3.0	3.2	3.1	3.9
October	2.7	2.7	2.5	2.6	2.6	2.5	2.4	2.9	3.6	4.1	4.3	4.2	4.2	4.0	4.1	4.0	3.8	3.6	3.4	3.2	3.0	3.0	2.7	2.7	3.3
November	3.8	3.4	3.6	3.7	4.5	4.0	4.3	4.2	4.4	4.4	4.8	5.2	5.2	5.2	5.3	4.9	5.3	5.1	5.0	5.0	4.9	4.4	3.9	4.1	4.5
December	3.9	3.3	3.3	3.3	3.3	3.4	3.6	3.7	3.7	4.0	4.3	4.2	3.6	3.0	2.9	3.0	3.2	3.4	3.3	3.3	3.5	3.7	3.7	3.9	3.5
January 2012	5.0	5.2	5.1	5.3	5.4	5.7	6.1	6.2	6.1	5.9	5.6	5.5	5.9	6.3	6.3	6.2	5.9	5.3	5.0	4.6	4.9	4.6	4.9	5.4	5.5
Average [1]	**4.4**	**4.4**	**4.5**	**4.5**	**4.6**	**4.6**	**4.7**	**4.7**	**4.9**	**5.0**	**5.0**	**5.1**	**5.1**	**5.0**	**4.9**	**4.8**	**4.6**	**4.4**	**4.2**	**4.1**	**4.1**	**4.1**	**4.2**	**4.3**	**4.6**

[1] Average values are from February 4, 2011 through the current month.


Site 1001 - Diurnal Wind Speed Trend (60 m)
Wind Speed (m/s)
9
8.5
8
7.5
7
6.5
6
5.5
5
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour


Site 1002 - Diurnal Wind Speed Trend (50 m)
Wind Speed (m/s)
9
8.5
8
7.5
7
6.5
6
5.5
5
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour

1001 Frequency Distribution (60 m)

Wind Speed Bin (m/s) [1]	Feb '11 Frequency (hours)	Mar '11 Frequency (hours)	Apr '11 Frequency (hours)	May '11 Frequency (hours)	Jun '11 Frequency (hours)	Jul '11 Frequency (hours)	Aug '11 Frequency (hours)	Sept '11 Frequency (hours)	Oct '11 Frequency (hours)	Nov '11 Frequency (hours)	Dec '11 Frequency (hours)	Jan '12 Frequency (hours)	Annual Frequency (hours)
0.5	4	14	25	21	20	21	27	36	54	23	41	6	292
1.0	6	10	18	18	17	25	24	36	36	17	32	5	242
1.5	10	12	21	30	26	36	37	44	45	27	46	8	341
2.0	17	14	29	38	31	57	58	66	57	36	59	12	474
2.5	23	19	40	57	42	76	66	65	69	35	64	23	579
3.0	23	24	48	70	45	89	83	61	67	40	59	21	630
3.5	30	29	50	78	49	71	77	57	58	48	60	33	638
4.0	30	37	52	71	59	57	71	57	57	54	58	35	638
4.5	34	34	52	67	58	58	52	49	54	46	48	37	588
5.0	35	35	55	63	63	47	44	44	45	42	44	42	559
5.5	29	43	48	58	62	43	50	31	32	47	29	46	519
6.0	28	46	37	41	61	36	35	29	29	37	27	36	442
6.5	29	45	40	38	55	34	37	27	23	31	17	41	417
7.0	31	42	39	28	37	27	28	23	18	25	18	36	352
7.5	28	42	29	21	29	25	19	16	14	23	23	37	306
8.0	29	42	24	16	26	16	14	14	14	19	19	37	269
8.5	27	40	21	15	18	9	5	10	13	17	14	38	228
9.0	23	36	16	8	14	8	4	7	15	14	14	38	196
9.5	19	33	15	4	4	5	4	6	10	19	10	35	163
10.0	21	28	13	2	2	3	5	5	8	12	8	30	137
10.5	19	26	10	0	1	2	2	6	7	13	9	29	124
11.0	19	20	7	0	1	1	1	7	5	12	8	21	101
11.5	20	16	5	0	0	0	0	5	5	15	6	16	87
12.0	21	16	3	0	0	0	1	5	3	12	7	12	79
12.5	16	10	3	0	0	0	0	4	2	8	5	13	60
13.0	15	8	3	0	0	0	0	4	2	8	4	7	50
13.5	11	6	1	0	0	0	0	3	0	8	2	8	40
14.0	13	4	2	0	0	0	0	3	1	7	3	9	42
14.5	11	3	1	0	0	0	0	2	1	6	3	6	33
15.0	11	3	1	0	0	0	0	1	0	5	2	6	29
15.5	9	3	0	0	0	0	0	0	0	4	1	4	21
16.0	6	2	0	0	0	0	0	0	0	3	1	4	17
16.5	7	2	0	0	0	0	0	0	0	2	1	2	14
17.0	5	2	0	0	0	0	0	0	0	2	1	2	11
17.5	3	0	0	0	0	0	0	0	0	1	1	1	6
18.0	3	0	0	0	0	0	0	0	0	0	1	2	7
18.5	3	0	0	0	0	0	0	0	0	1	0	3	7
19.0	2	0	0	0	0	0	0	0	0	1	0	2	5
19.5	1	0	0	0	0	0	0	0	0	1	0	1	4
20.0	1	0	0	0	0	0	0	0	0	0	0	1	2
20.5	1	0	0	0	0	0	0	0	0	1	0	1	2
21.0	0	0	0	0	0	0	0	0	0	0	0	0	1
21.5	0	0	0	0	0	0	0	0	0	0	0	0	0
22.0	0	0	0	0	0	0	0	0	0	0	0	0	0
22.5	0	0	0	0	0	0	0	0	0	0	0	0	0
23.0	0	0	0	0	0	0	0	0	0	0	0	0	0
23.5	0	0	0	0	0	0	0	0	0	0	0	0	0
24.0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Time	672	744	709	744	720	744	744	720	744	720	744	744	8749

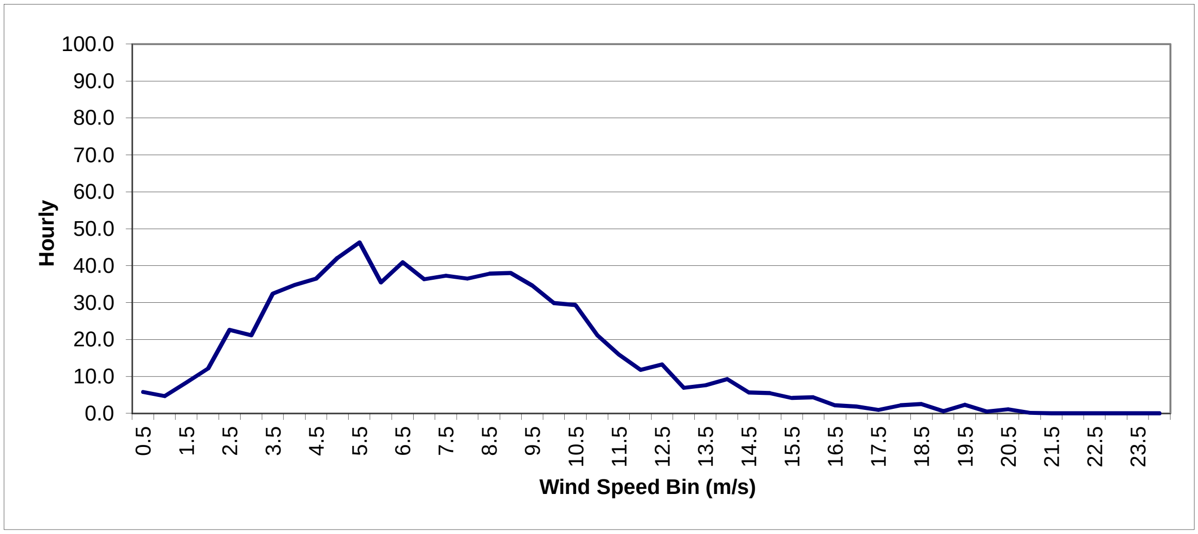
[1] The wind speeds listed are the centers of the wind speed bins.

1002 Frequency Distribution (50 m)

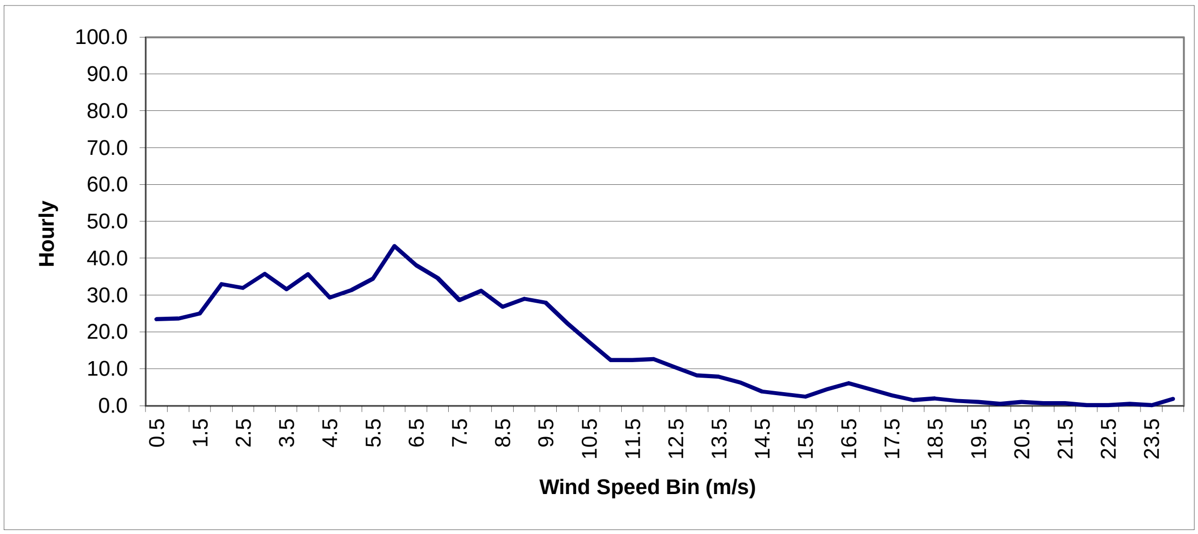
Wind Speed Bin (m/s) [1]	Feb '11 Frequency (hours)	Mar '11 Frequency (hours)	Apr '11 Frequency (hours)	May '11 Frequency (hours)	Jun '11 Frequency (hours)	Jul '11 Frequency (hours)	Aug '11 Frequency (hours)	Sept '11 Frequency (hours)	Oct '11 Frequency (hours)	Nov '11 Frequency (hours)	Dec '11 Frequency (hours)	Jan '12 Frequency (hours)	Annual Frequency (hours)
0.5	12	27	52	43	31	40	31	66	88	69	83	24	565
1.0	20	22	32	26	25	28	30	46	45	38	55	24	391
1.5	18	23	36	32	33	38	37	48	52	40	53	25	433
2.0	19	19	40	35	36	45	50	43	58	40	58	33	476
2.5	21	29	50	39	37	41	54	46	59	39	56	32	502
3.0	23	29	47	49	39	49	47	49	53	45	55	36	520
3.5	31	30	57	50	34	58	54	44	53	49	50	32	541
4.0	28	30	47	54	35	54	48	38	40	41	43	36	493
4.5	30	32	48	52	33	51	52	37	42	35	38	29	480
5.0	28	31	36	62	41	45	45	37	41	31	30	31	458
5.5	22	35	36	55	42	46	41	33	29	28	25	35	426
6.0	20	36	40	51	53	43	36	37	26	30	22	43	434
6.5	23	34	32	45	65	28	36	32	23	28	19	38	403
7.0	17	38	24	36	57	32	40	27	21	21	16	35	363
7.5	15	31	17	29	52	32	34	21	17	20	16	29	311
8.0	16	29	16	22	31	36	28	15	13	16	18	31	272
8.5	20	25	15	19	21	26	24	17	16	12	13	27	234
9.0	20	27	14	17	15	18	19	12	15	10	13	29	209
9.5	20	29	12	13	16	11	12	14	12	9	9	28	185
10.0	19	24	12	6	13	9	9	8	11	7	11	22	150
10.5	20	20	10	5	8	4	6	7	7	8	9	17	120
11.0	15	20	5	5	5	3	6	6	7	7	8	12	100
11.5	17	19	5	1	1	3	4	6	4	9	6	12	85
12.0	15	14	4	0	0	2	1	5	4	8	6	13	72
12.5	16	16	7	0	0	2	1	3	3	10	5	10	72
13.0	14	12	7	0	0	1	0	4	2	6	4	8	57
13.5	14	8	5	0	0	1	0	2	1	7	3	8	49
14.0	9	11	4	0	0	0	0	2	1	7	2	6	41
14.5	12	9	3	0	0	0	0	2	1	8	3	4	41
15.0	7	6	2	0	0	0	0	2	1	7	3	3	31
15.5	5	7	1	0	0	0	0	2	1	5	1	3	23
16.0	4	6	1	0	0	0	0	2	2	4	3	5	27
16.5	4	5	1	0	0	0	0	3	0	4	2	6	24
17.0	3	3	0	0	0	0	0	1	0	2	2	5	17
17.5	1	3	0	0	0	0	0	1	0	5	1	3	14
18.0	2	2	0	0	0	0	0	1	0	3	2	2	11
18.5	1	2	1	0	0	0	0	1	0	2	1	2	10
19.0	1	2	0	0	0	0	0	1	0	3	1	1	9
19.5	1	1	0	0	0	0	0	1	0	1	0	1	4
20.0	1	1	0	0	0	0	0	0	0	2	1	1	4
20.5	1	1	0	0	0	0	0	0	0	0	0	1	4
21.0	1	0	0	0	0	0	0	0	0	2	1	1	4
21.5	0	0	0	0	0	0	0	0	0	1	0	1	2
22.0	0	0	0	0	0	0	0	0	0	1	0	1	1
22.5	0	0	0	0	0	0	0	0	0	0	0	0	1
23.0	0	0	0	0	0	0	0	0	0	1	0	0	1
23.5	0	0	0	0	0	0	0	0	0	1	0	0	1
24.0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Time	583	744	720	744	720	744	744	720	744	720	744	742	8669

[1] The wind speeds listed are the centers of the wind speed bins.

Frequency Distributions



Site 1001 Monthly Frequency Distribution (60 m)



Site 1002 Monthly Frequency Distribution (50 m)

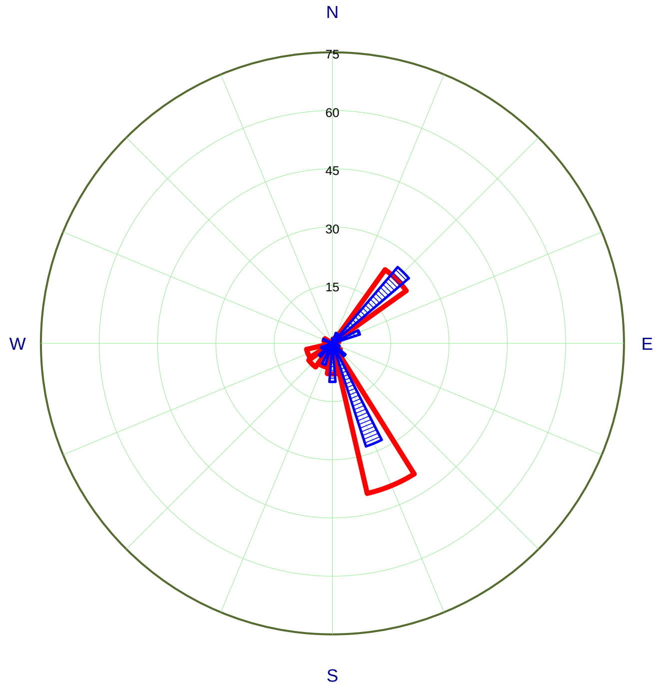
Temperature Ranges (℃)

	Site 1001		
	Average	Minimum	Maximum
January 2011	4.8	-5.2	13.2
February	3.7	-8.0	11.8
March	7.5	-2.1	16.7
April	7.7	-0.1	16.2
May	11.1	2.2	19.0
June	14.5	6.1	22.9
July	16.0	5.3	24.4
August	16.3	5.9	27.1
September	14.8	2.3	26.5
October	9.7	-0.7	18.6
November	5.4	-5.6	15.1
December	3.9	-4.5	11.8
January 2012	3.8	-11.9	14.1
Period of Record [1]	**9.6**	**-11.9**	**27.1**

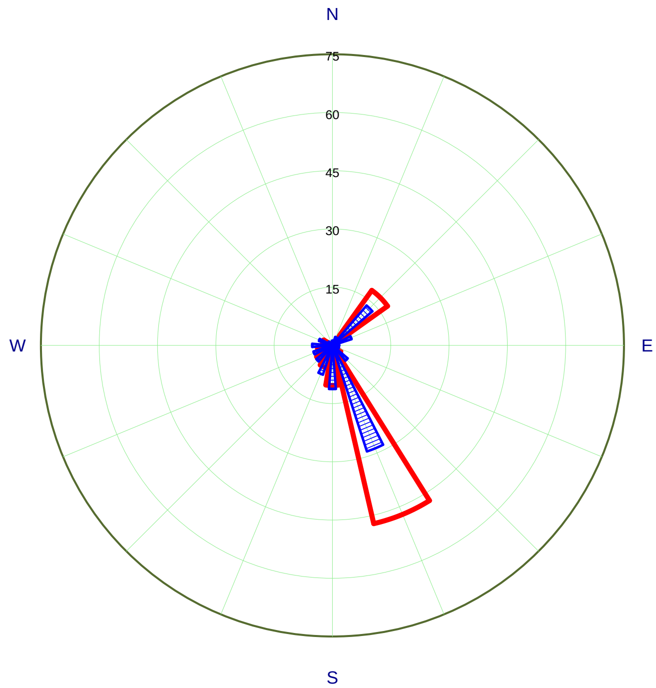
[1] Period of Record is a weighted annual average calculated by averaging duplicate calendar months. Minimum and maximum values are from January 1, 2011 through the current month.

	Site 1002		
	Average	Minimum	Maximum
February 2011	2.8	-8.7	10.3
March	7.0	-1.5	16.2
April	7.1	0.4	13.4
May	10.8	3.3	19.0
June	14.0	6.9	22.5
July	15.7	7.5	24.4
August	16.4	9.0	24.4
September	15.1	4.4	24.7
October	9.8	1.9	17.4
November	5.4	-5.1	16.8
December	4.1	-3.5	11.5
January 2012	3.6	-11.4	12.8
Period of Record [1]	**9.3**	**-11.4**	**24.7**

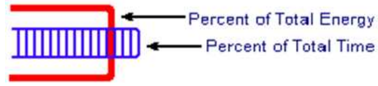
[1] Period of Record values are from February 4, 2011 through the current month.

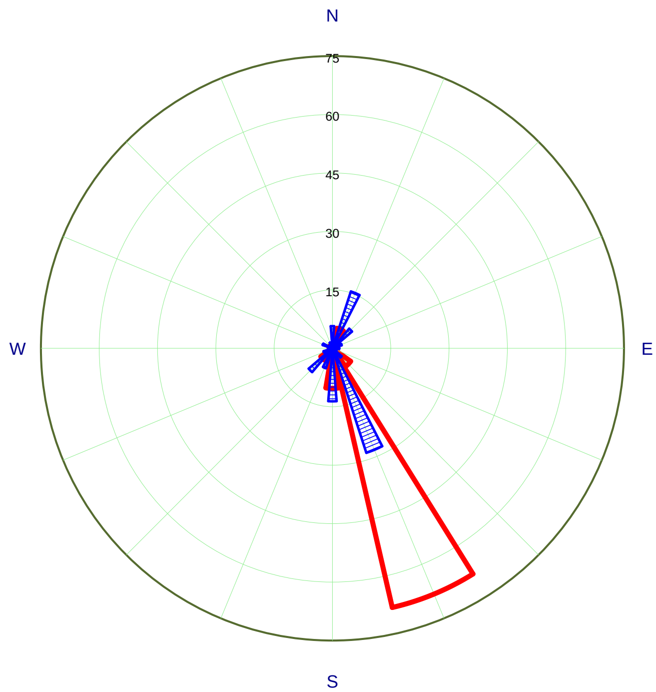


Monthly Wind Rose - Site 1001 (60 m)

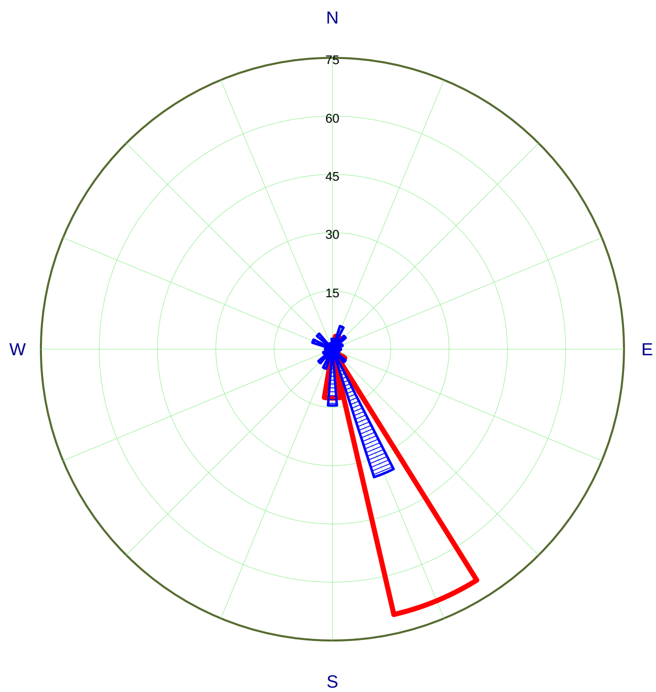


Annual Wind Rose - Site 1001 (60 m)

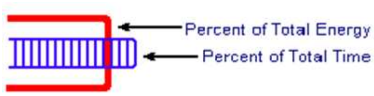




Monthly Wind Rose - Site 1002 (50 m)



Cumulative Wind Rose - Site 1002 (50 m)



Wind Shear Exponent

	Site 1001	
	40-60 m	**25-50 m**
January 2011	0.19	0.17
February	0.16	0.15
March	0.17	0.15
April	0.13	0.12
May	0.15	0.13
June	0.17	0.12
July	0.16	0.13
August	0.15	0.13
September	0.18	0.17
October	0.22	0.19
November	0.21	0.20
December	0.22	0.20
January 2012	0.20	0.17
Average [1]	**0.18**	**0.16**

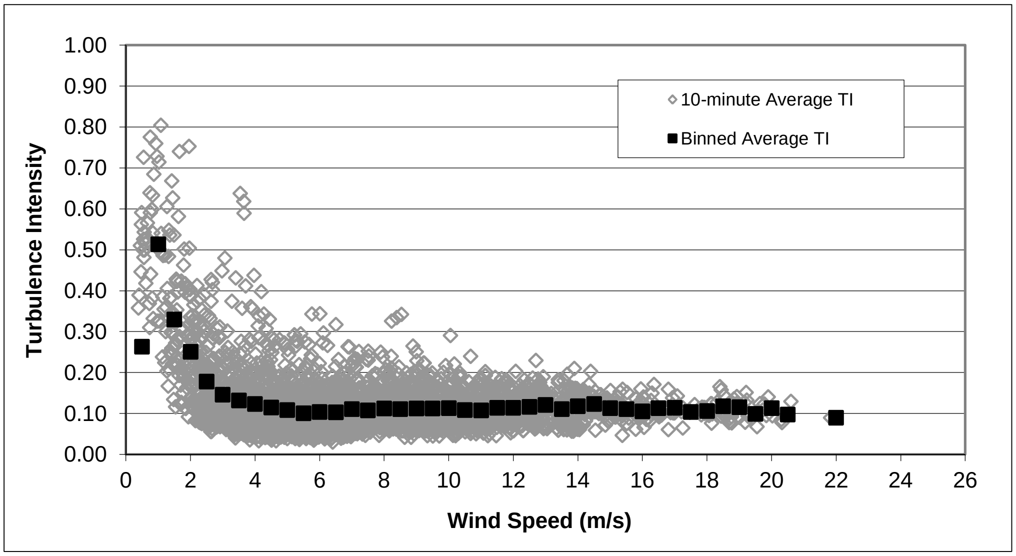
[1] The Weighted Average is an annual average calculated by averaging duplicate calendar months.

N/A indicates less than 200 hours of wind speed recovery at both monitoring heights.

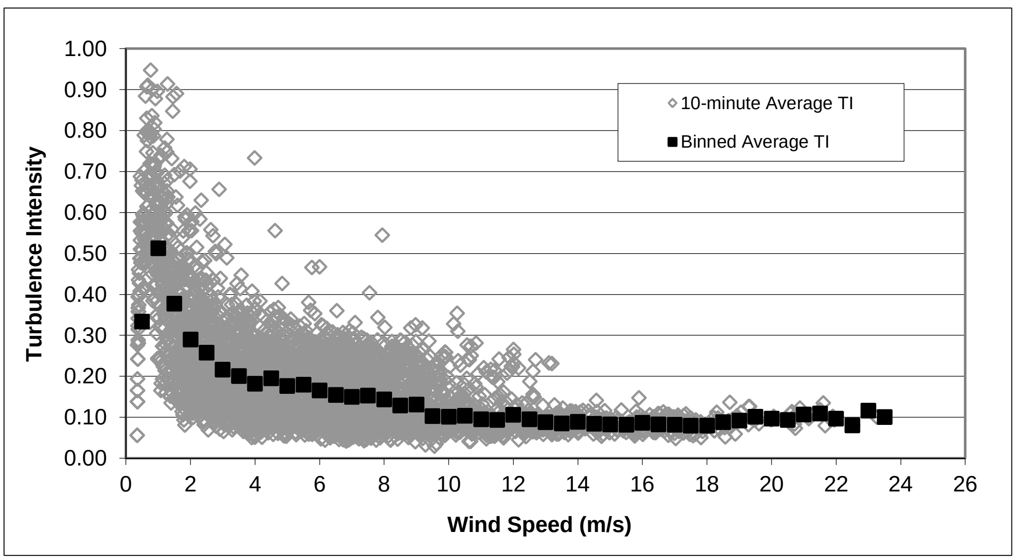
	Site 1002
	25-50 m
February 2011	0.25
March	0.18
April	0.15
May	0.12
June	0.12
July	0.13
August	0.13
September	0.21
October	0.21
November	0.22
December	0.21
January 2012	0.27
Average [1]	**0.18**

[1] Average values are from February 4, 2011 through the current month.

N/A indicates less than 200 hours of wind speed recovery at both monitoring heights.



Turbulence Intensity by Wind Speed - Site 1001 (60 m)



Turbulence Intensity by Wind Speed - Site 1002 (50 m)

PRELIMINARY DATA QUALITY CHECKING AND VALIDATION

Data are considered invalid if they do not appear to represent the actual wind conditions at the site. Typical causes of invalid data include tower wake influences, sensor icing, and equipment damage due to lightning, electrostatic discharge, failed components, or vandalism. The data validation process used to generate this report is generally automated and DNV is continuing to implement further automation. However, some manual review is required to assure the quality of the validated data. The data processing and validation are completed on 10-minute average data unless only hourly averages are available. The following provides a description of the data processing and validation activities completed prior to generating the data summaries.

Quality Checking

Data are quality checked on a weekly basis to verify normal operation of the logger and sensors. This process identifies failed sensors or other malfunctions that require immediate corrective action to maximize data recovery rates. During freezing conditions, this may require a determination as to whether a sensor has failed or is operating abnormally due to icing.

Validation

On a monthly basis, the 10-minute data are compiled into a monthly data set and data are validated to identify and remove data affected by tower wake influences, icing, intermittent operation, and other anomalies.

Tower Wake Influence - Wind speeds collected from an anemometer directly downwind of the tower are shadowed by the tower and consequently invalid. These invalid winds are removed from the data set. For example, an anemometer mounted to the south of the tower will record invalid wind speed data when the winds are from the north. The orientation of the anemometers is reported on the met tower commissioning sheets and can be verified by comparing two sensors on the tower that are oriented in different directions. For NRG tubular towers, the significant tower wake influence is approximately 50°. The exclusion sector may be wider for lattice towers which have a wider tower face than the tubular towers.

Icing - During freezing conditions, sensor icing can result in a significant amount of invalid data. The initial screening used to flag suspect data identifies periods where the standard deviation of the direction data is zero (direction is constant) and temperatures are 35°F or lower. This is used as the primary criteria because vanes are typically affected by icing several hours before an anemometer at the same height is affected. These flagged data are reviewed to determine if the sensors are being affected by icing or if the winds are just low. Typically, upper level sensors are affected before the lower level sensors because the temperatures are colder at the upper levels than at the lower. Upper level anemometers recording wind speeds lower than the lower level anemometers is another indicator of icing.

Intermittent Operation - When a sensor is operating intermittently, all data from the sensor are considered suspect and are removed from the validated data set. An anemometer that has failed will record the sensor offset. Vane failures are identified when the sensors on the same tower do not agree. These invalid values are all removed from the validated data set.

Other Issues - While the above process identifies the majority of invalid data, DNV also plots time series of wind speed, wind direction, and temperature for the month. This process provides another verification that all significant anomalies have been removed.

Most Representative Data Set

From the validated data, DNV generates a data set for each height at which data are available that are most representative of the wind speeds at that height. The factor considered in developing this data set is wind direction. When two sensors are installed at the same height, the valid wind speed data from the sensor that is least influenced by the tower is used. For example, where anemometers are oriented to the west and south, when the wind direction is between 45° and 225°, the winds from the south anemometer are selected, when the wind direction is between 225° and 360° or 0° to 45°, the winds from the west anemometer are selected. These criteria are applied to each 10-minute record. While all valid data are saved, this most representative data set is used to develop the data summary.

DATA SUMMARY

A data summary is generated from the most representative data set. The information included in the summary is described below.

Data Recovery, O&M Summary, and Reason for Hours Lost - The data recovery rates are provided for valid wind speed data collected at all heights. The “Hours Lost” column indicates the number of hourly data points that were missing or removed during the data validation process for each monitoring height. The “Recovery Rate” represents the remaining data expressed as a percentage of total sensor hours in the period. A summary of O&M events is provided as well as a table that indicates the reason for missing or invalid data.

Monthly Average Wind Speed and Maximum Wind Speed Gust - The average monthly wind speeds are summarized and include data for the entire period of record. When a period of record (POR) is longer than 12 months, the weighted average calculation weights the additional months of data to estimate an annual average. For example, if a POR begins November 1 and ends 14 months later at the end of December, the two Novembers would be averaged, and the two Decembers would be averaged, and these two averages would be included with the remaining ten monthly averages, resulting in a weighted annual average wind speed. A graphical illustration of the individual monthly wind speeds (weighted when there are more than 12 months of data) is also provided. The maximum 2-second wind speeds are summarized on a monthly basis.

Temperature Ranges - A summary of the monthly average, minimum, and maximum temperature data is provided for the period of record.

Monthly and Cumulative Wind Roses - Wind rose graphs are provided on a monthly and cumulative basis. The cumulative wind rose is based on all data collected to date, or the most recent 12 months if more than a year of data has been collected. The graphs consist of two bars in each of the 16 wind direction sectors that represent the percent of total time and the percent of total wind energy. The calculated wind energy in the wind rose is based on a cube of the wind speed. Total wind energy from a project will be somewhat different. The winds above rated wind speed of a wind turbine have a non-cubic relationship to the energy. However, the wind roses provide a clear indication of the direction of the energy-producing winds.

Wind Shear Exponent - Monthly wind shear exponent values are summarized for the period of record. The wind shear exponent represents the degree to which wind speed increases with height. The wind shear exponent is only calculated from sensors with the same orientation and when the wind speed is higher than 4 m/s (operable winds). Calculation of the wind shear exponent is based on the following equation:

$$\left(\frac{H_1}{H_2}\right)^{\alpha} = \left(\frac{V_1}{V_2}\right)$$

where H_1 and H_2 are measurement heights, V_1 and V_2 are wind speeds, and α is the wind shear.

Turbulence Intensity - Turbulence intensity (TI) is a relative indicator of turbulence and not an absolute value. The average turbulence intensity at the upper monitoring level is summarized. The TI values are calculated by dividing the 10-minute standard deviation of the wind speed by the 10-minute average wind speed. The plot illustrates the average TI for all wind speeds as well as the average TI for each wind speed bin.

APPENDIX D

SMALL WIND TURBINES AND EXAMPLE 5-KW ECONOMIC ASSESSMENT

Small wind turbines can be used to generate clean electric power on-site for homes, farms, and small businesses and can contribute to financial savings on electricity bills and potentially generate income if excess energy is produced to supply to the grid. A minimum property size of one acre would be needed, ideally with space for clearance of tall trees and surrounding buildings. The rating for small wind turbines typically range from less than 1 kW up to 100 kW.

Turbines for residential use are typically sized to meet a specific household demand which typically ranges from 2 kW to 10 kW. The size of wind turbines is defined based on the rotor diameter (the diameter of the swept area of the blades making up the rotor) and the tower height. The below table provides typical small wind turbine ratings, size and costs.

Typical Small Wind Turbine Ratings and Sizes[8]

Power Rating	**1 kW**	**5 kW**	**10 kW**	**20 kW**	**50 kW**
Rotor Diameter	2.5 m	6.4 m	8 m	12.4 m	15 m
Tower Height	19 m	24 m	24 m	24 m	30 m
Assumed Total	$7,000	$25,000	$48,000	$92,000	$225,000
Cost Range	Expect +/- 20% for "average" installations				
Cost Assumptions	Turn-key cost per turbine - installed and operational				

The cost for small wind turbines is primarily dependent on the system size and rating, ranging from approximately $5,000 to more than $200,000. Numerous federal, state, and local incentive systems, including rebates and tax credit programs, are available to help encourage investment in small wind turbines by reducing the upfront costs. Additionally, many states and utilities offer net metering programs through which excess power generated from a small wind turbine can be fed back to the grid resulting in a credit that is applied against electricity that is purchased from the utility.

Additional information and resources regarding small wind turbines can be found at the following websites:

American Wind Energy Association Small Wind FAQ Fact Sheet:
http://awea.org/learnabout/publications/factsheets/upload/Small-Wind-FAQ-Factsheet-_-Updated-May-2011.pdf

[8] Energy Matters LLC, http://www.wind-estimate.org/
[Accessed on August 29, 2012]

Energy Matters LLC: http://www.wind-estimate.org/

Tools

Numerous tools are available on the internet to help homeowners and small businesses assess the potential feasibility of a small wind turbine for their home or business. Energy Matters LLC (http://www.wind-estimate.org/) has a useful tool to help size a turbine system and evaluate the projected financial performance of a small wind turbine. The following section presents an example assessment using this tool. A printout of the full model inputs, results, and assumptions is also included as a supplement to this appendix.

Example Assessment

The following sections provide some supporting information for the inputs used in the example assessment as well as interpretation of the results.

Inputs

The inputs for this assessment were developed to represent a typical small wind turbine system for a residence on the Reservation.

- **Wind Turbine Size:** A 5-kW turbine was selected based on a typical household load.
- **Installed Price:** $24,500 was assumed which represents the mid-point of the $19,600-$29,400 range for a 5-kW turbine as listed on the tool website.
- **Average Annual Wind Speed at 50 m:** The average 50-m wind speed for the Reservation (12.5 mph or 5.6 m/s) was assumed. The tool automatically extrapolates the 50-m wind speed to the hub height of the chosen turbine (24-m for a 5 kW turbine).
- **Electrical Rate:** $0.10/kWh was assumed based on information found on Puget Sound Energy's (PSE) website[9]. According to PSE's Electrical Rates for Residential Customers, a 1,000 kWh/month results in approximately a $100 bill, representing a $0.10/kWh rate.
- **Monthly Electrical Usage:** 1,030 kWh – This is based on the U.S. Electrical Information Administration's 2010 average residential electrical usage for Washington State[10].
- **Utility Annual Inflation Rate:** A 2.5% inflation rate was used to represent a typical inflation rate.
- **Utility Savings Method:** PSE offers a net metering program, so the Net Metering option was selected. According to the website tool, tiered rates and time-of-use metering are

[9] Puget Sound Energy. *Electricity Rates for Residential Customers*, May 2010 [Online]
Available at: http://pse.com/aboutpse/Rates/Documents/summ_elec_1215_res_2010_05_01.pdf
[Accessed on August 29, 2012]

[10] U.S. Electrical Information Administration. *Average Monthly Residential Electricity Consumption, Prices, and Bills by State*, December 6, 2011 [Online]
Available at: http://www.eia.gov/tools/faqs/faq.cfm?id=97&t=3
[Accessed on August 29, 2012]

applicable. These programs can result in higher savings if the energy generated by the wind turbine offsets energy from the grid during higher priced periods or keeps the total usage at a lower price tier.

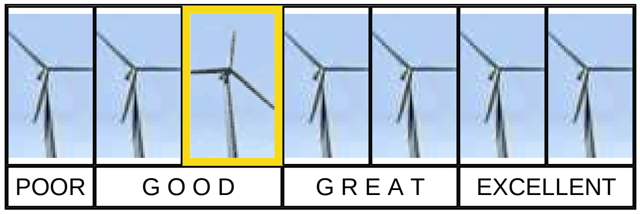
- **Calculate Financial Ratios with Utility Savings As:** Pre-Tax Dollars (Gross Income) - This is the default option. A post-tax calculation option is also available.
- **Federal ITC Based Upon:** Gross Cost – The Federal Investment Tax Credit is available for small wind turbines installed through end of 2016. This credit is calculated as 30% of gross installation cost.
- **Federal Income Tax Rate:** The 25% tax bracket was assumed.
- **Loan Parameters:** A loan size of 50% (after the 30% ITC is applied), an interest rate of 7%, and loan term (15 years) are representative of a typical loan scenario.

Model Results

The results are provided in the printout included as a supplement to this appendix. The result of this example scenario shows a 12-year payback period ("break even"), which represents the amount of time to "repay" an investment, and is calculated as the time required to achieve a positive cumulative cash flow. It is important to note that the 12-year payback does not account for the time-value of money. Based on the Wind-Estimator's discount rate of 5%, this example scenario has a negative NPV. Other scenarios may yield a positive result depending on the financial inputs. The results of the model for a given wind resource and turbine size are particularly sensitive to the electrical rate, inflation rate, tax bracket, incentive programs, and loan parameters.

Your Wind Turbine Estimate

YOUR WIND RATING ?



The wind rating of your area is **Good** for a wind energy system. (3.92 m/s or 8.8 mph annual average).
Now we'll do some estimating for you:

This is the average annual Wind from our wind database of monthly wind speeds. However, for turbine output estimates we have used the average annual wind value **as entered by you: 12.5 mph (5.59 m/s)**

You may want to change some of the information to better match your situation.

Customize Your Assumptions

Wind Turbine Size: 5 kW

Number of Wind Turbines: 1

Price Installed: $24500 per Turbine

Ave. Annual Wind Speed: 12.5 mph (at 164 ft or 50 m: About Wind Gradients) (enter 0 to reset to default)

Weibull Shape Factor: 2.00 Even Distribution of Wind See note below

1 x 5-kW wind turbines can supply about **55% of your electricity**, on average.

Electric Rate: $ 0.1 /kWh More

Monthly Electric Usage: 1,030 kWh/Month More

Utility Annual Inflation Rate: 2.5 %

Utility Savings Method: Net Metering (common) help

Calculate Financial Ratios with Utility Savings As: Pre-Tax Dollars (Gross Income)

Federal ITC Based Upon: Gross Cost help

Federal Income Tax Rate: 25% help

State Income Tax Rate: 0.0 % (Low: 0.00% - High: 0.00%) help

Loan Modeling: Borrow 50 % of $17,150 estimated cost
at 7 % interest (apr) re-paid over 15 years

» Update My Assumptions

If you agree **this is a smart investment**, we encourage you to work with a Professional to help you install your very own system.

Click on the More buttons to learn about our assumptions and other important information used to generate your estimate. Also, please review the Notes below.

Help us improve. We rely on feedback from our users to help keep our service accurate and useful:
» Send us your Feedback

Your Wind Energy Estimate by the Numbers

Building Type:	Residential	
State & County:	WA - Whatcom	
Utility:	Puget Sound Energy Inc	
Utility Type:	Investor-Owned Utility	
Your Average Monthly Electricity Bill: (Assumed rate x average monthly useage)	$ 103 / Month	
Tiered Rates Apply:	Yes - See Notes, below!	
Time-of-Use Metering Offered:	Yes - See Notes, below!	
Net-Metering Available:	Yes - See Notes, below!	More

ESTIMATED SYSTEM SIZE

The system size best for your situation will vary based upon product, building, geographic and other variables. We encourage you to work with a Solar Pro who can better estimate the system size best for your situation.

Wind Rating:	12.5 mph (5.59 m/s) (as entered by you)	More
Wind Turbine(s):	**1 x 5-kW**	
Equivalent Annual Production:	6,782 kWh electricity	

ESTIMATED SYSTEM COST

This is only an estimate based upon many assumptions. Installation costs can vary considerably. We encourage you to work with a Solar Pro who can provide you with a more detailed cost estimate. We estimate a wind energy system, as shown above, will cost between $19,600 and $29,400. This estimate assumes the mid-point of this cost range.

Assumed Installation Gross Cost: "Gross Cost" is the cost before any rebates, incentives, tax credits, etc. are applied. See the Cost Notes, below!	**$24,500**	More

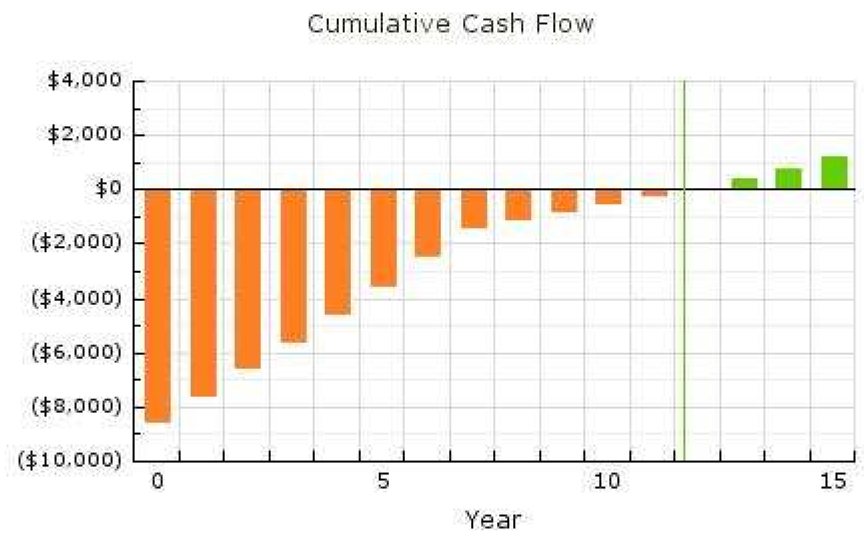
assuming $24500 per turbine

FINANCIAL INCENTIVES

Financial incentives shown are totals across all years. So, if an incentive spans multiple years then the value shown is the total of all years. For details, please refer to the table below "Cash Flow by Year and Cumulative Across Years"

Federal Tax Credit (30% of Gross Cost at Installation) » link	$ 7,350
WA R.E. Production Incentive ($ 0.12/kWh thru June 2020) » link	$ 5,695
ESTIMATED NET COST:	**$ 11,455** More
ESTIMATED NET COST AT INSTALLATION:	**$ 17,150** More
Cash & Loan Amounts:	$ 8,575 Cash $ 8,575 Borrowed
Loan Monthly Payment (7% apr, 15 years):	$ 77

CASH FLOW



Cash Flow Breakeven is where the chart crosses the $0 point - this is when your investment has paid itself back in cash.

The chart above is a summary of the net cash flow you can expect over time. Net Cash Flow is the total cash after all costs (out-flows of cash) are reduced by financial incentives, annual utility savings and tax effects (in-flows of cash).

Average values are used together with your assumed income tax rate (25%). Any property appreciation has not been included, as this is generally not a cash flow (it's an investment). The loan modeled, if any, is included. Because individual tax situations vary, we have not included Federal income tax liabilities that may result from having received non-federal incentives, if any (e.g. state rebate programs) as they are usually not taxed as earned income.

SAVINGS & BENEFITS

First-year Utility Savings:

Your utility offers Tiered rates and/or TOU metering. Therefore, the electricity savings you realize may exceed the annual electricity needs of your building. See the Notes, below, about why you may want to choose a smaller system. **$680 to $1,305** More

Average Monthly Utility Savings: *over 15-year expected life of system*	**$69 to $133**	More
Average Annual Utility Savings: *over 15-year expected life of system*	**$833 to $1,599**	More
15-year Utility Savings:	**$12,495 to $23,986**	More
Levelized Cost of your Wind Energy: $11,455 cost / 101,733 kWh electricity replaced by wind	**$0.11 per kWh**	More

Utility savings shown above do not take income tax effects into account (they use "Post-Tax" dollars). The financial ratios shown below are based upon the cash flow values shown in the Cash Flow table, below, which include income tax effects, as noted.

Appreciation (Increase) in Property Value:	**$10,197 to $19,574**	More
Return on Investment (ROI):	**15% - 164%**	More
Internal Rate of Return (IRR):	**2.3% - 19%**	More
Net Present Value (NPV):	**$-1,176 - $7,979**	More
Profitability Index:	**0.9 - 1.5**	More
Greenhouse Gas (CO2) Saved: *over 15-year system life*	**84 tons** **168,000 auto miles**	More

Cash Flow by Year and Cumulative Across Years

This cash flow table includes tax effects applied to utility savings and loan interest payments (if any). You have elected (above) to show utility savings in **Pre-Tax (Gross Income) dollars** ("pre-tax" or what you earned). Therefore for every dollar saved on utility bills, the pre-tax savings will be higher: Pre-tax Utility Savings = ($'s saved on utility bill) / (1 - Income Tax Rate). You may also earn compounding interest tax free (not shown). Because individual tax situations vary, we have not included Federal income tax liabilities that may result from having received non-federal incentives, if any (e.g. state rebate programs) as they are usually not taxed as earned income. Any income from your system (e.g. performance-based incentives and "SREC's") may be taxed as income (also not shown).

Year of Operation:	at Install	1	2	3	4	5
Gross Cost	($24,500)					
Federal Tax Credit (30% of Gross Cost at Installation)	$7,350	$0	$0	$0	$0	$0
WA R.E. Production Incentive ($ 0.12/kWh thru June 2020)	$0	$814	$814	$814	$814	$813
Utility Savings	$0	$929	$952	$976	$1,000	$1,026
Loan Proceeds (Payments)	$8,575	($924)	($924)	($924)	($924)	($924)
Tax savings from Interest Payments		$147	$141	$135	$128	$120
ANNUAL CASH FLOW	$-8,575	$966	$984	$1,001	$1,018	$1,035
Cumulative Cash Flow	$-8,575	$-7,609	$-6,625	$-5,624	$-4,606	$-3,571

Year of Operation:	6	7	8	9	10	11
Gross Cost						
Federal Tax Credit (30% of Gross Cost at Installation)	$0	$0	$0	$0	$0	$0
WA R.E. Production Incentive ($ 0.12/kWh thru June 2020)	$813	$813	$0	$0	$0	$0
Utility Savings	$1,051	$1,077	$1,104	$1,132	$1,160	$1,189

Loan Proceeds (Payments)	($924)	($924)	($924)	($924)	($924)	($924)
Tax savings from Interest Payments	$113	$104	$95	$85	$74	$63
ANNUAL CASH FLOW	$1,053	$1,070	$275	$293	$311	$328
Cumulative Cash Flow	$-2,518	$-1,448	$-1,173	$-880	$-569	$-241

Year of Operation:	12	13	14	15
Gross Cost				
Federal Tax Credit (30% of Gross Cost at Installation)	$0	$0	$0	$0
WA R.E. Production Incentive ($ 0.12/kWh thru June 2020)	$0	$0	$0	$0
Utility Savings	$1,219	$1,249	$1,281	$1,313
Loan Proceeds (Payments)	($924)	($924)	($924)	($924)
Tax savings from Interest Payments	$51	$38	$24	$9
ANNUAL CASH FLOW	$346	$363	$381	$398
Cumulative Cash Flow	$105 **Breakeven**	$468	$849	$1,247

FAQ's: Frequently Asked Questions for WA:

- Is solar equipment exempt from sales tax in Washington State?
- Where can I find more information about Washington Renewable energy programs and incentives?

Tip: Measure the wind characteristics at your location.

If you are thinking of installing a wind turbine, you might want to monitor the wind speed at your location, first. There are several weather stations and wind speed meters (anemometer) available that can provide this information to you at a reasonable price. And, you'll probably have some fun doing it.

The one pictured to the right is about $100 at Amazon.com: La Crosse Technology WS-1612AL-IT Professional Weather Station, White

Notes & Assumptions: Wind Turbine Systems

* HOW TO REDUCE THE SYSTEM SIZE NEEDED & INCREASE SAVINGS

The estimate provided above assumes "base" electric rates apply. Other taxes and surcharges may be applied to your utility bill. We suggest you review a recent utility bill and change the "Assumed Electric Rate", above, as needed to better match your situation.

You may have other metered-rate options with your utility. Options such as Tiered billing rates, Time-Of-Use (TOU) metering, and Net-Metering, if available, can help reduce the system size you need to provide a "net-zero" energy bill. Sometimes people also reduce the size of their wind energy system to accommodate planned improvements in their building's energy efficiency, or to match a budget and/or the available space for installing a wind energy system.

Energy Efficiency: Improving your building's energy efficiency will reduce the system size you need to attain a "net-zero" energy bill.

Tiered Rates: Often people are paying a "Tiered" rate for their electricity. This is a higher rate (higher than the "Base" rate) for electricity charged when a home or building uses more that a "Base" amount allocated for the building. Installing a wind energy system will reduce your electrical demand from the utility. This can result in a lower utility rate because you stay within the "Base" rate level. In this case, the more expensive "Tiered" rate electricity is eliminated, reducing your average electricity rate.

TOU Metering: Many utilities offer Time-of-Use (TOU) meters. This allows the price of electricity to vary by time of day (called "Peak" or "Off-Peak" periods) and by season (usually "Winter" versus "Summer" rates). If TOU metering is offered by your utility, a wind energy system may result in additional savings. This is because peak (more expensive electricity) rates often occur during the daytime. This is usually when a wind energy system is producing the most output, thus reducing your demand for peak-rate electricity from the utility.

Most utilities do charge for the purchase and installation of a time-of-use meter (normally a few hundred dollars). We have assumed the cost for this is part of the "Estimated Installation cost" shown above.

Net-Metering: With Net-Metering, surplus electricity generated by your renewable energy system will be credited back to your utility account. So if your wind energy system makes more electricity than you are using, the "meter spins backwards". You are not actually "selling" electricity, since in most states the utility will not reimburse you for excess electricity. But, if your utility offers "Net-Metering" you may be able to get credit for electricity provided back to the grid during peak periods. Combined with TOU metering, Net-Metering can result in multiplied savings since your electricity account may be gaining electricity credits during the time of peak utility rates -- Think of a hot, sunny summer day with thermal winds blowing -- your wind energy system is producing power, spinning your electric meter backwards, and supplying the grid with electricity to run other people's air conditioners -- in this case, you're "spinning back" cost at peak rates! That's the potential savings power of Net-metering, combined with TOU rates.

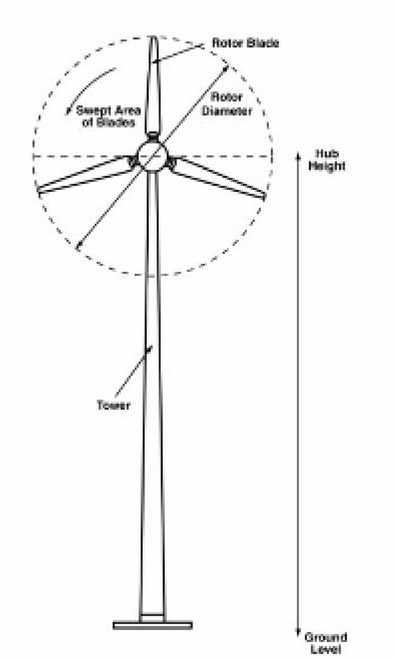
Wind Power "Fixes" Energy Costs: The cost of wind is free. Utility rates, on the other hand, tend to rise steadily in cost. So, the value of your savings from a wind energy system are likely to increase as time goes on. If you are on a fixed income (e.g. nearing or in retirement) this may be of particular interest to you.

THE COST TO GO WITH THE WIND

This is only an estimate based upon many assumptions and limited data entered by you: Installation costs can vary considerably. The cost to purchase and install a complete grid-tied wind energy system on a residential home is typically as defined in the table, below. This does not include the cost of options you may select, such as battery backup power storage, or the costs of building preparation work, power line trenching, etc. Costs can also be higher if you add other features or have special installation needs (such as a steep or rough terrain or difficult access) or you choose to use special tower systems. Other factors may also affect price, including, but not limited to, your location, the building condition, type and location, its wiring, and warrantees offered.

Turbine Specifications	400 watt	1 kW	5 kW	10 kW	20 kW	50 kW
Typical Power Rating	400 watts	1 kW	5 kW	10 kW	20 kW	50 kW

Swept Area	1.2 m^2	4.9 m^2	32 m^2	50 m^2	121 m^2	177 m^2
Rotor Diameter	1.2 m	2.5 m	6.4 m	8.0 m	12.4 m	15 m
Tower Height	14 m	19 m	24 m	24 m	24 m	30 m
COST ASSUMPTIONS	"turn-key" cost per Turbine (installed & operational)					
Assumed Total	$2,400	$5,000	$24,500	$48,000	$92,000	$225,000
Cost range:	expect +/- 20% for "normal" installations					



Energy production from a wind energy system is a function of several factors, including the following. Our assumptions are:

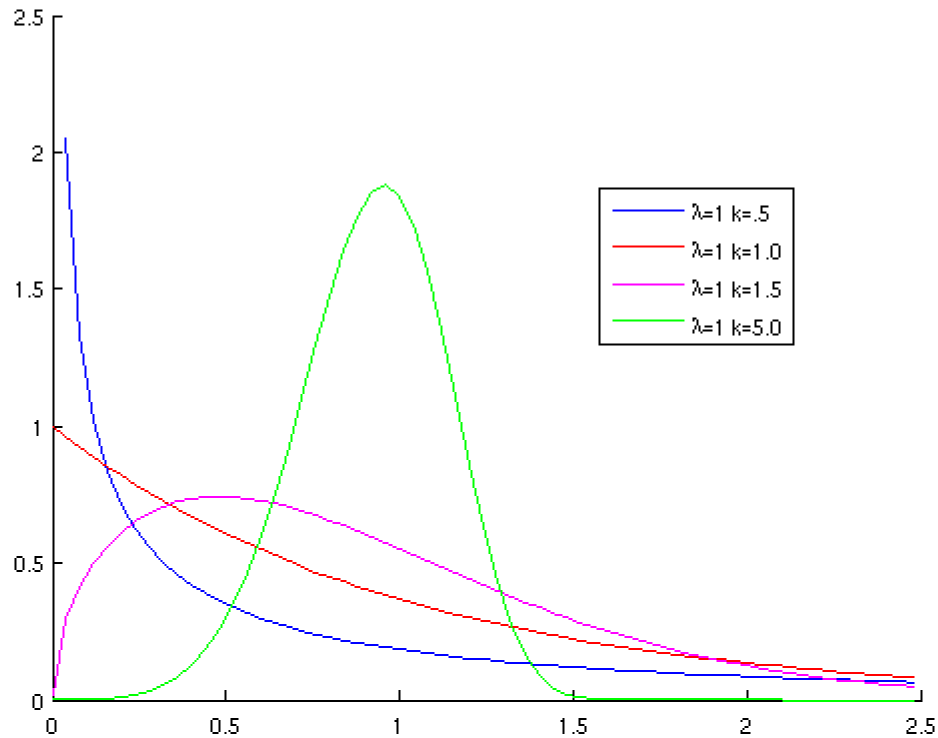
Factor	Assumption
Wind resources	Average monthly wind velocity as per NASA Surface meteorology data measured at 50 meters and adjusted for tower height using the "seventh power" rule. This means for the Rayleigh distribution (see below) the wind power density at 50 meters is twice that at 10 meters. In other words, the higher the turbine is mounted, the more wind power that is available.
Turbine Energy Curve	As per manufacturer`s published specifications. Common turbines in each power class were chosen for pulling this data.
System configuration	Grid-tied, Non-battery
Availablility	98%
Air foil soiling/icing, wiring & other power losses	12% (88% delivered)
Total Energy Delivered	98% x 88% = 86%
Installation Costs	Common installation costs for all locations. Obviously, real installations vary in complexity and accessibility, resulting in higher installation costs in, say, rugged or remote locations.

Wind Resource Data

For wind turbine calculations we utilize a wind rating based upon the average monthly wind speed (m/s) near your location (nearest latitude and longitude derived from your postal code or zip code). Our data reference source is the NASA Surface meteorology data from the Atmospheric Data Center. This data is based upon satellite-derived data over a 22-year period. The data is compiled for each degree of latitude and longitude (each degree represents about 69 ground miles).

Weibull Shape Factor

We use the Weibull distribution to estimate the energy recovered by a wind turbine using a shape factor (λ). We default to a shape factor of 2. The higher the value of shape factor (from 1 to 3) the higher the median wind speed - i.e. locations with lots of low wind speeds as well as some very strong winds would have a value of shape of below 2, locations with fairly consistent wind speeds around the median would have a shape value of 3. Typical Weibull distributions are shown below. On this graph, one (1) represents the average and the graph shows how wind speed is expected to vary in probability around that average.



OTHER ASSUMPTIONS

This summary is based upon many assumptions and the limited data you entered. An actual site assessment by a qualified wind energy system retailer or contractor will be needed to determine the actual costs and benefits of installing a wind energy system.

HELPFUL PDF's & Links

Natural Resources Canada's: **RETScreen Renewable Energy Calculators**

Wind Industry: **Windustry.org wind project calculator**

A Free Public Service of the Solar & Wind Communities since 2000

Contractor verification assisted by **» ContractorCheck.com**

Pre-screened, Customer-recommended Solar Pros
See: **» How it Works**

Your privacy is important. We will not release or disclose your personal information to others without your permission. Privacy Policy

WIND-ESTIMATE.ORG is a free, public service. We believe the efficient use of energy and renewable energy systems makes for comfortable living and a more secure future. So we want to help you reduce your energy demands, increase your energy efficiency and help you utilize more energy from renewable energy systems and sources -- like solar electric (PV - photovoltaics), solar space (air), water & pool heating, wind turbines, biomass furnaces and ground-source heat pumps. Our mission is to serve as a convenient, user-friendly means for home and small commercial building owners to make preliminary evaluations of renewable and solar energy options for their location, run financial analysis and help find and verify the experience, quality and business status of certified solar contractors, and other professionals who can design, install and service renewable and solar energy and energy efficient power systems. (See How It Works). As a business verification service, we maintain the largest directory of current local solar installer and solar contractor profiles including extensive customer reviews and ratings of these professionals. Profiles are not limited to solar energy professionals, but include many other renewable energy, design, engineering and support professional services. We also serve as a consolidator of national and region-specific solar and energy efficiency programs, and utility information about renewable energy, solar energy and energy efficient measures. Our software tools and content include: Online solar estimator (solar calculator, analysis) to help you determine the costs and benefits of a renewable or solar energy system for your particular location and building needs, including financial analysis tools. We also provide a trusted means by which you, as a consumer, can review and access solar panel installers, solar contractors, solar pros and other solar, renewable energy and energy efficiency professional services. And we offer answers to frequently asked questions about renewable and solar power, links and resources to current information about solar power, solar energy, renewable energy, energy bill savings, energy efficiency data, solar incentives, tax credits, rebates and other programs and helpful information so you can learn about solar energy, help us promote renewable and solar power adoption and, hopefully, install a solar system for your home, building, company or community and/or improve your energy efficiency and use. **Site Map**

A solar-powered site and service of Energy Matters LLC.

Det Norske Veritas:

Det Norske Veritas (DNV) is a leading, independent provider of services for managing risk with a global presence and a network of 300 offices in 100 different countries. DNV's objective is to safeguard life, property and the environment.

DNV assists its customers in managing risk by providing three categories of service: classification, certification and consultancy. Since establishment as an independent foundation in 1864, DNV has become an internationally recognized provider of technical and managerial consultancy services and one of the world's leading classification societies. This means continuously developing new approaches to health, safety, quality and environmental management, so businesses can run smoothly in a world full of surprises.

Global impact for a safe and sustainable future