Site Survey and Wind Monitoring Recommendations for the Lummi Nation

CONFIDENTIAL

Jeremy R. Freimund, P.H.
Water Resources Manager
Lummi Natural Resources Department

2616 Kwina Road
Bellingham, WA 98226

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For: Jeremy R. Freimund, P.H., Water Resources Manager Customer Name:, Lummi Indian Business Council Customer Address: 2616 Kwina Road, Bellingham, WA 98226			
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Summary:			
This report provides a summary of DNV's findings based on the site visit performed on October 7, 2010, at the Lummi Indian Reservation adjacent to Bellingham, Washington. In addition, we have included a conceptual turbine layout, discussion of potential fatal flaws, and our recommendation for the wind measurements campaign.			

Prepared by:	Hugh Turnbaugh, Project Analyst	Signature
Verified by:	Sarah Meyer, Senior Consultant	Signature
Approved by:	Chad Nancarrow, Group Leader Feasibility Services	Signature

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1 BACKGROUND

DNV understands that the overall goal of the Lummi Nation Indian Reservation Wind Energy Development Feasibility Assessment Project (Project) 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), has retained DNV to assess the wind energy development feasibility on the Lummi Nation Indian Reservation (the Reservation). DNV'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. LIBC has also contracted other consultants to assess the potential wildlife and noise impacts with installing wind turbines on the Reservation. This Project is being funded through a grant from the U.S. Department of Energy (DOE).

To develop a wind measurement campaign, DNV conducted a site visit and initial survey of the Reservation to indentify possible barriers to wind energy development, prepare a conceptual turbine layout, and determine locations for on-site wind monitoring. Prior to visiting the site, DNV reviewed publicly available wind data, aerial imagery, and geographic information system (GIS) data provided by the Lummi Natural Resources Department (LNR).

This report summarizes the results of our site survey and provides wind monitoring recommendations based on the site visit and an in-office review of the available information.

2 SITE 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 km² (21 sq mi) of land, including Sandy Point, the Lummi Flats, the Lummi Peninsula and uninhabited Portage Island, as shown in Figure 2-1, 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 approximate 50 m (164 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 should not be 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.

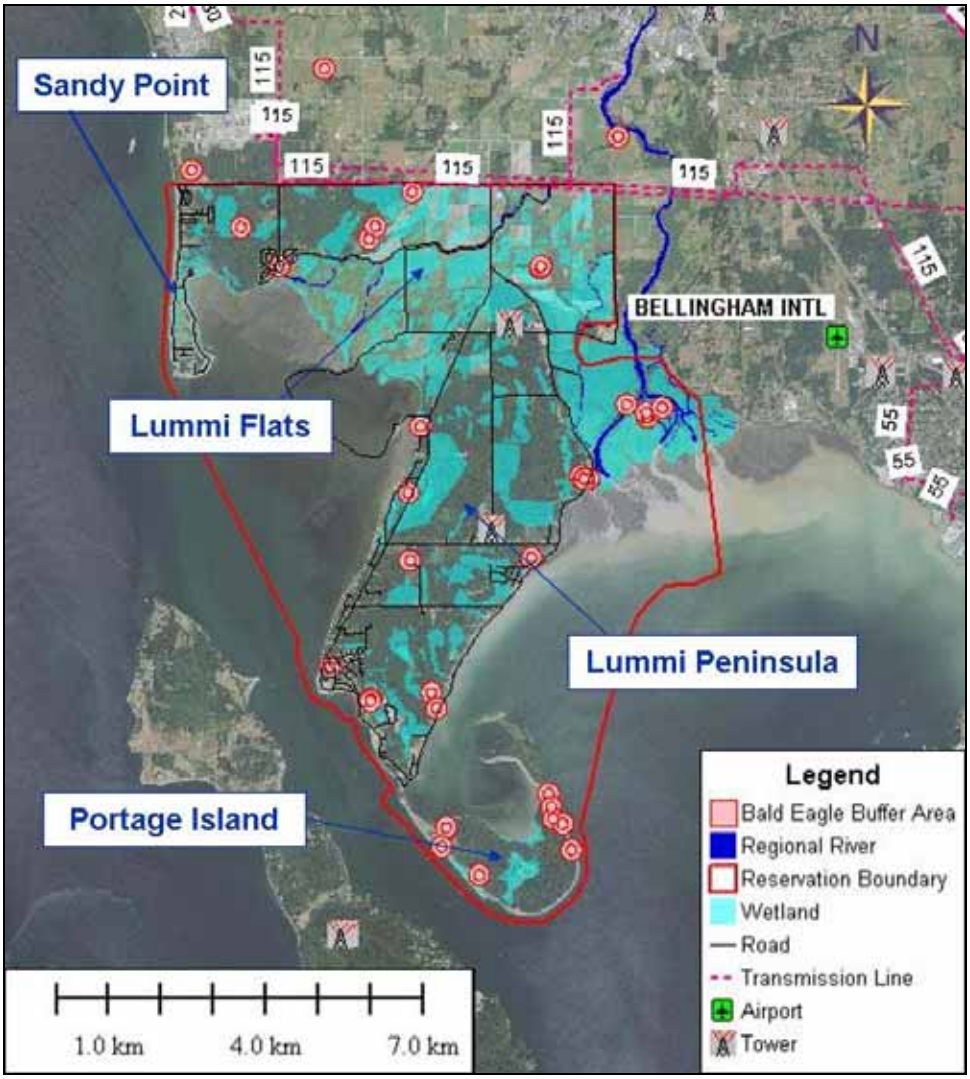


Figure 2-1. Site Map

The LNR has provided the following GIS data layers, as shown in Figure 2-1: Reservation boundaries, rivers, wetlands designations, bald eagle nesting buffers, rivers and roads. DNV has also overlaid the location of regional transmission lines, airports, and communication towers.

3 WIND RESOURCE POTENTIAL

As an initial step in the evaluation of the Reservation's development potential, DNV assessed the local wind resource using meso-scale wind maps. In February 2010, the DOE's Wind Powering America program announced the release of new wind resource maps developed through a collaborative project between the National Renewable Energy Laboratory (NREL) and AWS

Truewind, LLC. The publicly available 2.5 km high-resolution map for Washington State, which shows the predicted mean annual wind speeds at 80-m hub height, was obtained for this initial analysis and is provided in Appendix A. DNV also has a subscription to 3Tier's Prospecting Tool which provides access to a 5-km Firstlook data set. With this tool, DNV was able to obtain the predicted annual wind speed and direction for several locations throughout the Reservation.

According to the Washington high-resolution wind map, the Reservation is depicted as having an annual average wind speed of 5.0 to 5.5 m/s at 80 m. The 3Tier Prospecting Tool predicted annual average wind speeds of 4.9 to 5.3 m/s at 80 m, with the higher annual wind speeds over the peninsula. These wind speeds are lower than what is typically considered to be a viable wind resource for commercial-scale wind energy projects; however, with the right project financing structure, they could result in a plausible wind project for the Lummi Nation, ultimately helping to achieve the tribal goal of energy self-sufficiency. To make this determination, collection of on-site measurements at potential wind turbine locations is needed to more accurately assess the wind resource and to reduce uncertainty in the energy production estimate.

DNV also reviewed archived meteorological data from the Bellingham International Airport's weather station, located approximately 5 miles northeast of the Reservation, as an indication of wind direction. This station is maintained by the National Climatic Data Center and records hourly wind speed and direction data at a height of 10 m (33 ft) above ground level. The Bellingham International Airport recorded a south prevailing wind direction. The 3Tier Prospecting Tool indicates prevailing southwest winds in the Lummi Flats and prevailing southeast wind direction over the Lummi peninsula. However, LIBC personnel have indicated that the Lummi Flats also experience wind from the northeast during the winter months, which is consistent with the orientation of Fraser/Nooksack River Valley.

4 SITE EVALUATION

The site evaluation process is dynamic, factoring in a number of site-selection criteria including, but not limited to, exposure to the prevailing wind resource, terrain features and orientation, compatibility with existing or future land uses, proximity to electrical infrastructure, environmental and community acceptance factors, aviation and telecommunication factors, and appropriate turbine size and setback requirements.

4.1 Terrain Considerations

In general, wind dissipates as it moves from water to land. Water surfaces are relatively free of obstructions and have low surface roughness, presenting minimal barrier to wind flow. Thus, the strong winds funneling through the Strait of Georgia are expected to dissipate as they are redirected through the Lummi Flats. The 3Tier Prospecting Tool predicts a prevailing southeast wind over the Lummi Peninsula, thus the southwest to northeast orientation of the peninsula provides optimal turbine placement perpendicular to these winds.

4.2 Transmission Access

Transmission and substation information presented herein are based on data from Ventyx, an industry-leading supplier of energy information. Ventyx utilizes market data and high quality aerial imagery to accurately map existing and planned transmission lines, power plants, and substations. For this analysis, DNV has identified two 115 kV transmission lines running east to west, just north of the Reservation boundary (see Figure 2-1). The transmission line is operated by the Public Utility District No. 1 of Whatcom County and runs approximately 12 miles from the Bellingham substation to the BP Refinery. The second line is operated by Puget Sound Energy and runs approximately 5 miles from the Labounty substation near Bellingham to the Slater substation located on Slater Road (the Reservation north boundary), and then continues another 1.5 miles to the Terrell Substation at the Conoco Phillips Refinery.

Based on typical conductor size, DNV estimates the 115 kV transmission line's carrying capacity to be approximately 50-100 MW. A detailed transmission analysis would be needed to determine the actual capacity and availability for interconnection of new generation.

4.3 Community and Environmental Impacts

Primary impacts of a wind energy project on a community include noise from the wind turbine blades and generator, and the visual impact of the wind turbine on the landscape. Negative social impacts have the potential to inhibit or terminate wind project development, and the costs and time required for development may increase significantly.

When operating, wind turbines produce a "swishing" or "whooshing" sound as their rotating blades move through the air, as well as sounds from the mechanical parts such as the gearbox, generator, and cooling fans. As part of this Project, LIBC has contracted acoustic specialists, J.C. Brenan & Associates, to assess the noise impacts associated with wind turbine installation on the Reservation. DNV will incorporate the results of this study in our final report.

It is not uncommon for proposed wind projects to be met with public opposition due to concerns with the aesthetic impact on the landscape. Wind turbines located on the Lummi Flats would be visible from the residences throughout the flats, Sandy Point, and the western shore of the Lummi Peninsula, but the higher elevation and dense tree cover on the Lummi Peninsula would likely block the view of wind turbines located on the flats from Bellingham communities. Wind turbines sited on the top of the Lummi Peninsula, however, would likely be visible from Bellingham and other surrounding communities. Photo simulations of the potential wind turbines, as well as informational community meetings, can help to address any public concern about the visual impact on these areas.

Another potential community impact is shadow flicker that can be generated by the turbine's rotating blades during certain ambient lighting conditions. The shadow of the rotating blades can cause an annoyance until the sun changes position in the sky. It is likely that the resulting setback recommendations from the noise impact assessment will also mitigate the impacts of shadow

flicker. Additional shadow flicker modelling can be performed during project permitting to determine the possible shadow flicker impact.

As part of the Project, LIBC has contracted Hamer Environmental to study the potential impacts to wildlife associated with wind turbine installation on the Reservation. DNV will incorporate the results of the wildlife study in our final report. Other potential environmental impacts, such as cultural and archaeological, transportation, storm water, wetlands, floodplain, environmental justice, are outside this scope of this feasibility assessment and would need to be addressed as part of the National Environmental Policy Act (NEPA) and the tribal permitting process, as necessary.

4.4 Aviation and Radar Conflicts

Due to FAA air space regulations, construction of a wind project within 5 miles of an active runway has increased potential for impacting navigable airspace or aviation communications. As shown in Figure 2-1, the Reservation boundary is less than two miles from the Bellingham International Airport. Due to this close proximity, FAA height restrictions may apply depending on the distance, orientation, and elevation difference between the runway surface and the turbine location(s). DNV recommends consulting an aviation specialist to conduct a building constraints study.

FAA rules also prevent a structure the size of a typical utility-scale wind turbine from being erected within at least 1 km (0.62 mi) of a VHF Omni-directional Radio Range (VOR) station.[1] In DNV's experience, these FAA-operated radio navigation systems have proven to be a fatal flaw when in close proximity to a proposed wind development site. Due to the omni-directional nature of the signals transmitted by these navigation aids, tall structures, such as the turbine towers, in the vicinity of the VOR may interfere with signal transmittal. Since the nearest VOR facility is more than 15 km from the site, DNV does not anticipate that these facilities will impact turbine development on the Reservation.

The FAA online Long-Range Radar Tool provides a preliminary estimate of the effect of a wind power project on Air Defense and Homeland Security radar. Per this tool, the Lummi Reservation is flagged as "green," which is defined as no anticipated impact to Air Defense and Homeland Security radars (see Appendix B).

The FAA online NEXRAD (Next Generation Weather Service Radars) tool provides a preliminary estimate of the effect of a wind power project on weather radar. Per this tool, the Lummi Reservation is also flagged as "green," which is defined as minimal to no impact on weather surveillance radar operations (see Appendix B). However, the NEXRAD Program administrators advise notification of wind farm construction to the National Telecommunications and Information Administration (NTIA).

[1] Aviation Systems Inc. "Airspace Obstruction and Electromagnetic Interference Considerations for Wind Power Projects." January 2007. Massachusetts Technology Collaborative. <http://www.mtpc.org/renewableenergy/Community_Wind/FAA/AirspaceJan2007.pdf>

4.5 Telecommunications Conflicts

Wind turbines, like all tall structures, can create interference or degradation of certain communication signals if they are located in the line-of-sight of any communications equipment such as microwave, radio, or satellite dishes. Based on the Federal Communications Commission (FCC) antenna structure registration (ASR) database, there is one registered communication station within the Reservation and a number of stations located nearby (see Figure 2-1). Analysis of communications line-of-sight is beyond the scope of this review. Further analysis may be required, which would take into account the proposed turbine dimensions, turbine location, and transmittal paths of various types of communication signals in the area.

5 MET TOWER LOCATION SELECTION

To aid in the wind monitoring location selection, the LNR provided a GIS screening of potentially suitable areas for 60-m meteorological (met) towers. This screening criterion excluded bald eagle nesting areas, parcels designated as fee land or other unsuitable ownership, and setbacks from roads and rivers. Flagged wetlands were identified as potentially suitable, but not ideal for met tower placement. The results of this screening analysis are attached as Appendix C.

On October 7, 2010, representatives from DNV met with the LNR staff to survey potential met tower locations. Prior to the site visit, DNV identified several potential met tower locations (based on aerial imagery and screening analysis) for subsequent on-site investigation. The locations are situated in the Lummi Flats and on the Lummi Peninsula. The LNR also made arrangements to meet with a private landowner to evaluate his property in the Lummi Flats as a possible tower site. A map of the potential monitoring selected locations is provided in Figure 5-1, and summary of the site visit findings and DNV recommendations are provide below.

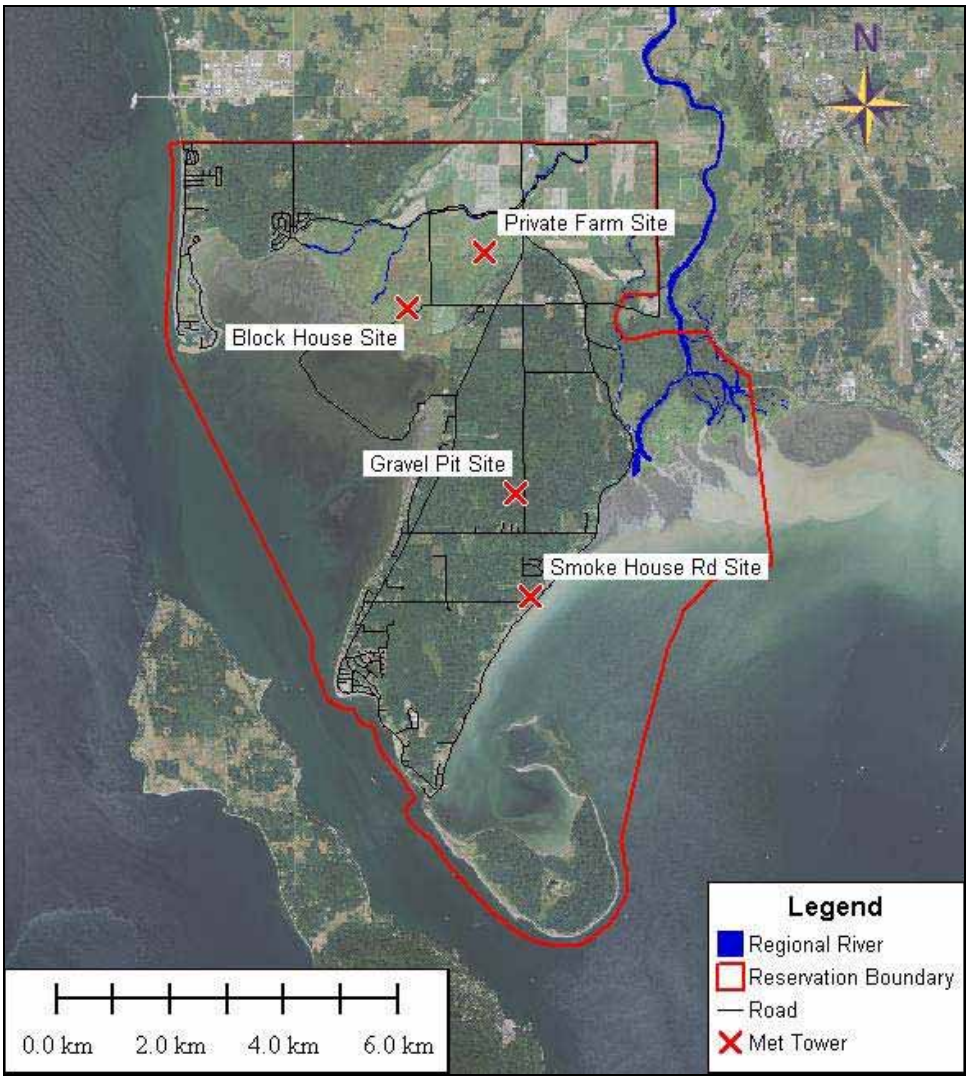


Figure 5-1. Potential Met Tower Locations

5.1 Block House Site – Recommended Met Tower Location

The Block House Site is located in the Lummi Flats near corner of Chief Kwina Road and Hillaire Road. This location, previously home to a naval communications tower and associated block house, is well exposed to the expected southwest winds and can easily accommodate a 60-m met tower. The surrounding grass and brush ranges in height from less than one to approximately five meters (< 3 feet to 25 feet). As shown by the photo in Figure 5-2, a large area has already been cleared which is desirable for tower installation. Some additional clearing may be required, however, to accommodate the outer anchors. According to LNR staff, there is a concern for vandalism at the site, therefore fencing or other security measures are recommended.

Figure 5-2. Recommended Met Tower Location (View Southwest)

5.2 Private Farm Site – Alternate Wind Monitoring Location

As proposed by the LNR staff, DNV evaluated a private landowner's farm in the Lummi Flats for tower installation. While the location near the center of the Lummi Flats may provide representative wind resource data, the site itself provides installation challenges. According to the landowner, the Lummi River floods annually, with standing water of one to two meters deep. In addition, the pasture area (shown in Figure 5-3) proposed by the landowner is too small to accommodate the full 60-m met tower anchor footprint. This location could possibly accommodate a met tower with a reduced footprint or a future sonic detection and ranging (sodar) measurement unit; however, mitigation measures for potential flooding would need to be implemented.

Figure 5-3. Alternate Wind Monitoring Location (View Southeast)

5.3 Gravel Pit Site – Potential Met Tower Location

As previously described, the Lummi Peninsula is heavily wooded, therefore finding a clearing large enough to accommodate a 60-m met tower is challenging. DNV identified several cleared areas form the aerial imagery provided by the LNR. The Gravel Pit Site, located off of Chief Martin Road and close to Cagey Road, was identified as a desirable location based on its central location and representative elevation. The LNR staff has indicated that the landowner has been accommodating to the LNR requests in the past and would likely agree to a met tower installation at this site. However, the site provides several installation challenges due to the current mining activities. The mining operations have created significant pits and sharp deviations in surface elevation, as well as refuse and waste piles. A photo of the Gravel Pit Site is shown in Figure 5-4. DNV recommends that the installation subcontractor visit the site to evaluate anchor placement and determine if grading and debris removal would be necessary. Until then, DNV recommends that this site be considered an alternate wind monitoring site.

Figure 5-4. Potential Met Tower Location (View East)

5.4 Smokehouse Road Site – Alternate Met Tower Location

Based on DNV's recommendation for wind measurement on the Lummi Peninsula, the LNR staff identified a clearing on the east side of the peninsula as a potential wind monitoring location. The site near Smokehouse and Lummi Shore Drive that was previously used as a construction staging area, now appears to consist of graded, compacted dirt. There is sufficient space at this location to accommodate a 60-m met tower; however, DNV recommends that the installation subcontractor visit the site to evaluate anchoring into potentially disturbed soil. A photo of the site is provided in Figure 5-5 and shows the view southeast towards Bellingham Bay and the prevailing southeast wind direction.

Figure 5-5. Alternate Met Tower Location (View Southeast)

6 CONCEPTUAL TURBINE LAYOUT

Based on the met tower suitability screening performed by the LNR and the expected southwest and southeast wind directions, DNV prepared the conceptual turbine layout shown in Figure 6-1. This layout is very preliminary and provided only to illustrate the representativeness of the proposed met tower locations. Land designated by LNR as not suitable for met towers are assumed to be unsuitable for turbine placement and areas designated as wetlands were generally avoided; however, not possible for all locations in the Lummi Flats. As the wind direction of the site is yet to be determined, an intra-row turbine spacing (i.e., distance between turbines in the

same row) of 5 x 100-m rotor diameter was assumed, along with 10 x rotor diameter intra-row spacing (i.e., distance between rows). Revisions to this layout will be made in the final report based on the on-site wind data, the noise and wildlife impact studies, and a more detailed setback analysis.

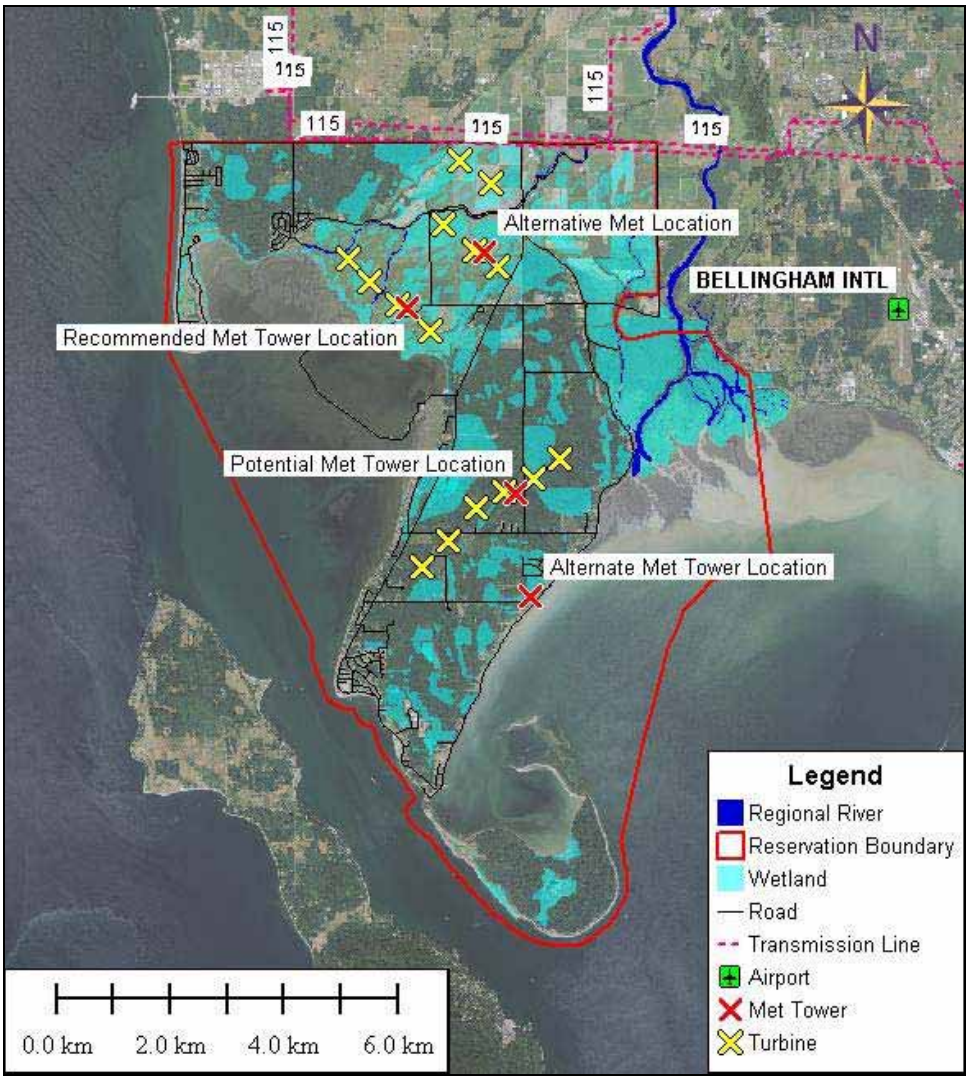


Figure 6-1. Conceptual Turbine Layout

7 CONCLUSIONS AND WIND MONITORING RECOMMENDATIONS

Based on the available meso-scale wind maps, the Lummi Reservation is believed to have a potentially developable wind resource. There is also potential access to nearby transmission lines; however, a detailed transmission analysis impact study would be necessary to determine the available capacity.

DNV has performed an initial survey of potential barriers to wind project development on the Reservation. Wind turbines would be unlikely to impact military or weather radar; however, the close proximity to the Bellingham International Airport will require additional study for both wind turbine and met tower installation. The potential noise and wildlife impacts will be further addressed in the final feasibility report once on-site assessments are performed.

DNV recommends on-site wind monitoring on both the Lummi Flats and the Lummi Peninsula in order to characterize the potentially different wind resources. A summary of DNV's recommendations for the potential met tower locations is provided in Table 7-1 below.

Table 7-1. Recommendations for Potential Met Tower Locations

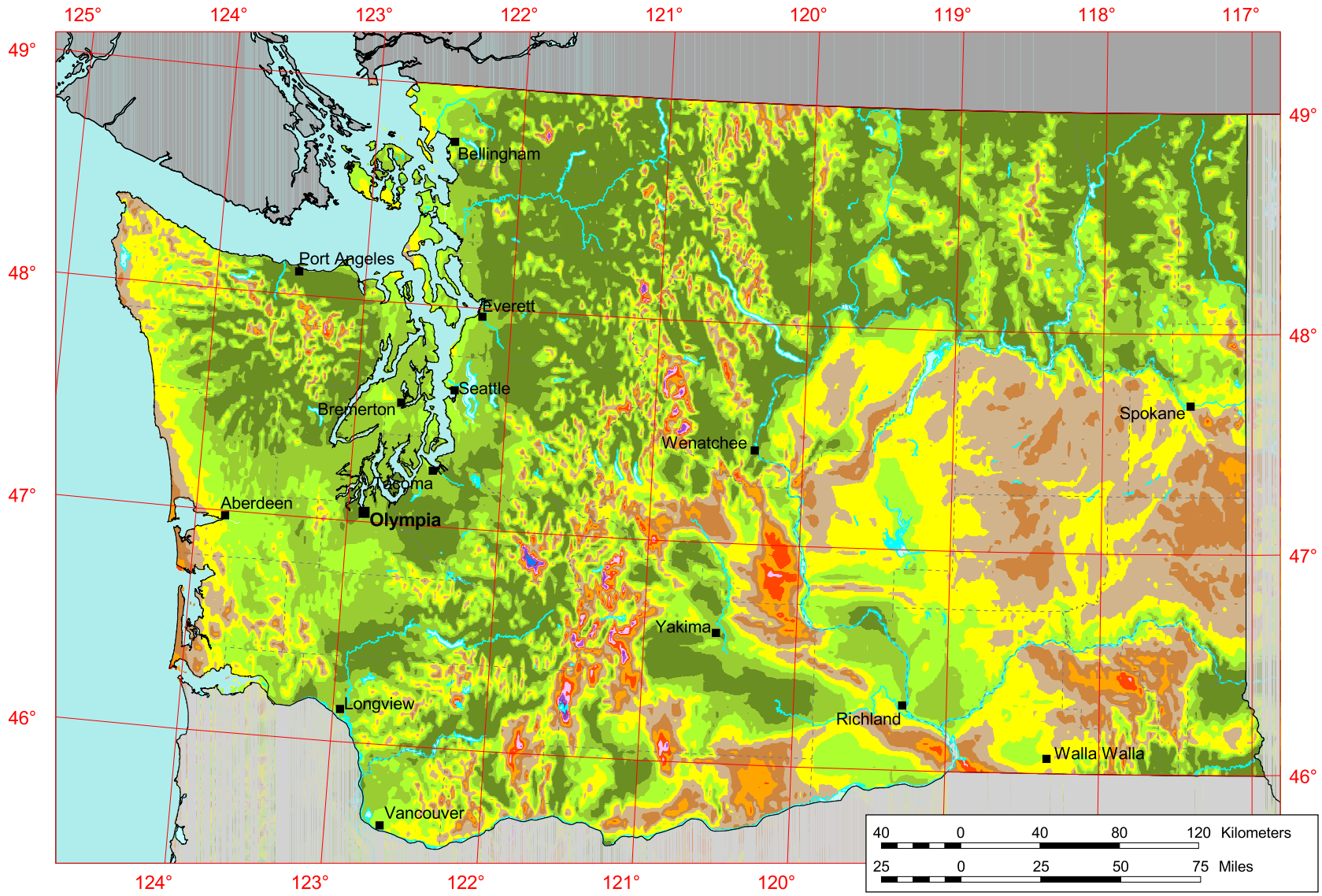
Location	Latitude	Longitude	Elev (ft)	Recommendation
Block House Site	48° 47' 36.01" N	122° 39' 18.64" W	11	Recommended Met Tower Location
Private Farm Site	48° 48' 7.62" N	122° 38' 11.99" W	8	Alternate Wind Monitoring Location
Gravel Pit Site	48° 45' 49.96" N	122° 37' 46.32" W	164	Potential Met Tower Location
Smokehouse Rd Site	48° 44' 51.09" N	122° 37' 34.78" W	49	Alternate Met Tower Location

Datum - WGS84

In the event that only one met tower be available for this Project, DNV recommends the tower be installed at the Block House Site on the Lummi Flats. The Lummi Flats is believed to have the higher wind development potential because it is closer to transmission, farther from the airport, and potentially has more area to accommodate a greater number of turbines (i.e., increased installed capacity). DNV recommends that the second tower be installed at the Gravel Pit Site, contingent on the installation subcontractor's evaluation. Should installation at the Gravel Pit Site not be possible, DNV recommends that the second tower be installed at the Smokehouse Rd Site.

APPENDIX A
WASHINGTON 80-M WIND SPEED MAP

Washington - Annual Average Wind Speed at 80 m



Wind Speed m/s

> 10.0
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
< 4.0

Source: Wind resource estimates developed by AWS Truewind, LLC for windNavigator®. Web: http://navigator.awstruewind.com | www.awstruewind.com. Spatial resolution of wind resource data: 2.5 km. Projection: UTM Zone 11 WGS84.

AWS Truewind

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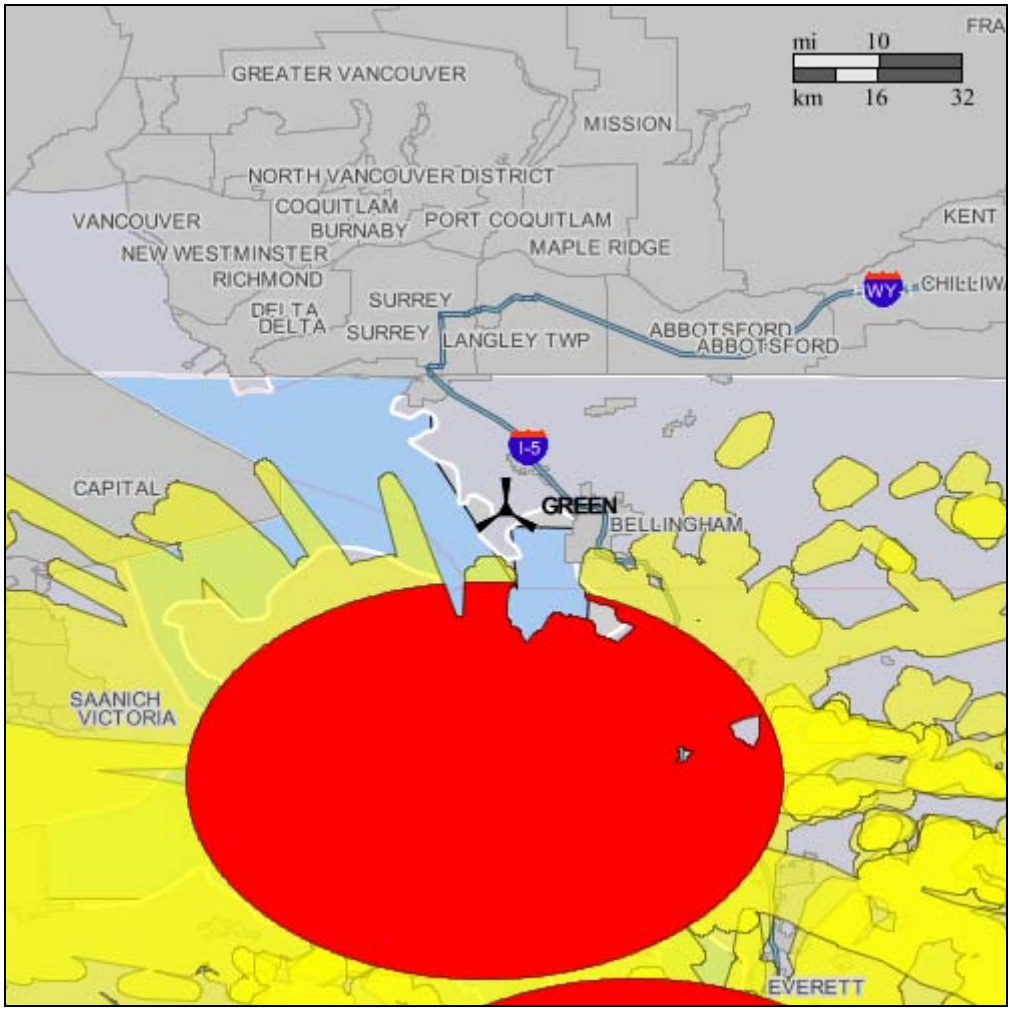
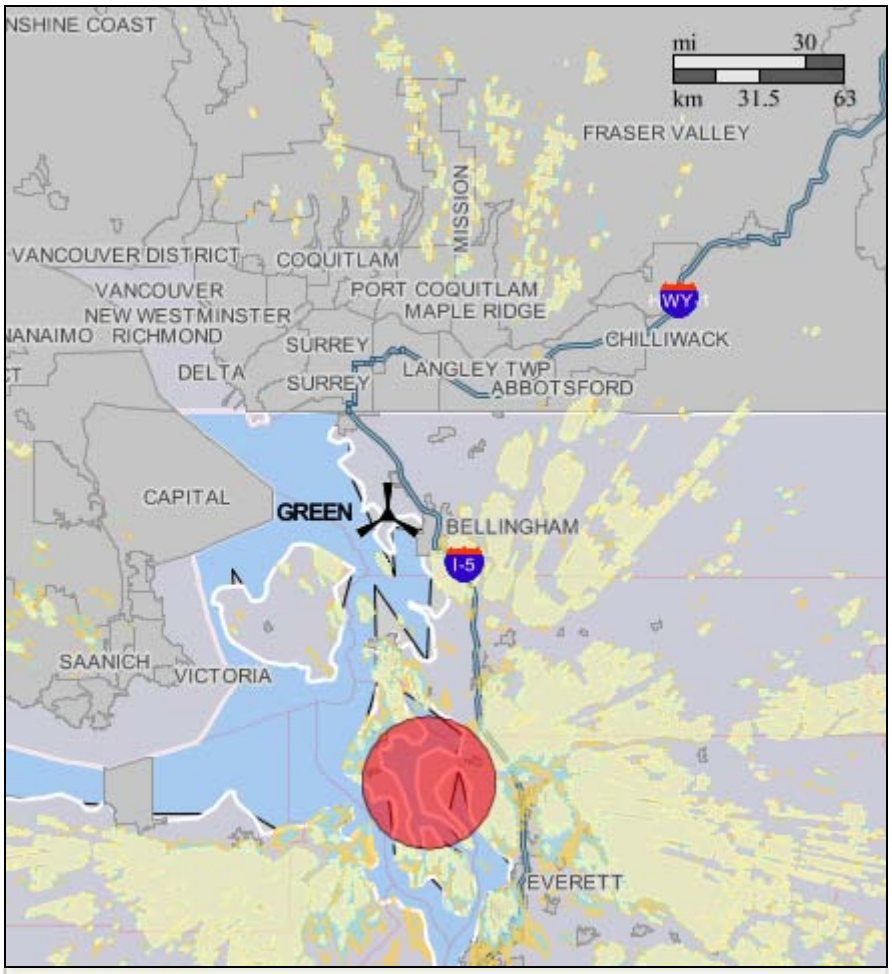
APPENDIX B
DOD PRELIMINARY SCREENING TOOL RESULTS

DOD Long-Range Radar Preliminary Screening Results



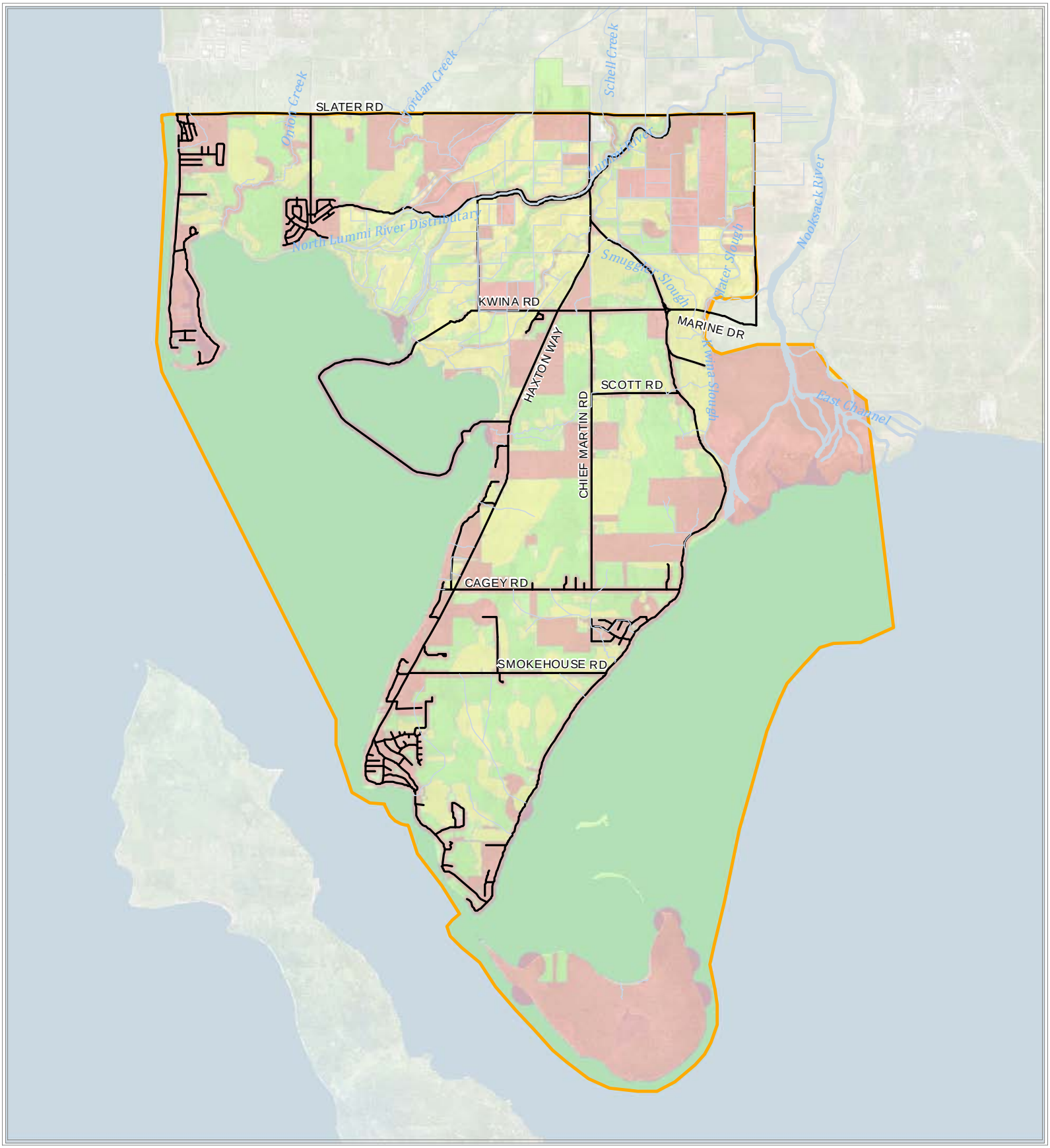
NEXRAD Preliminary Screening Results



Map Legend:

- **Green:** Minimal to no impact to Weather Surveillance Radar-1988 Doppler (WSR-88D) weather radar operations. National Telecommunications & Information Administration (NTIA) notification advised.
- **Yellow:** RLOS Coverage At or Below 130m AGL. Impact likely to WSR-88D weather radar operations. Turbines likely in radar line of sight. Impact study required. NTIA notification advised.
- **Blue:** RLOS Coverage At or Below 160m AGL. Impact likely to WSR-88D weather radar operations. Turbines likely in radar line of sight. Impact study required. NTIA notification advised.
- **Gold:** RLOS Coverage At or Below 200m AGL. Impact likely to WSR-88D weather radar operations. Turbines likely in radar line of sight. Impact study required. NTIA notification advised.
- **Red:** Impact highly likely to WSR-88D weather radar operations and wind turbine electronics. Turbines likely in radar line of sight. Aeronautical study required. NTIA notification strongly advised.

APPENDIX C
LNR MET TOWER SUITABILITY ANALYSIS



Met Tower / Turbine Placement Area

(10/06/2010)

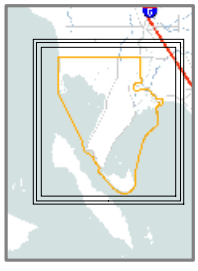
Met Tower Site Suitability

- Suitable and Ideal
- Suitable (Not Ideal)
- No Tower Placement
- Lummi Reservation Boundary

0 1 2
Miles

N

Cartography: Gerry Gabrisch geraldg@lummi-nsn.gov
Datum, Projection, Coordinate System: NAD83 UTM 10 N



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