U.S. DEPARTMENT OF ENERGY

PNNL- 20015

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

Offshore Wind Turbines

Estimated Noise from Offshore Wind Turbine, Monhegan Island, Maine

Environmental Effects of Offshore Wind Energy Development

P Aker
AM Jones
AE Copping

November 2010

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Richland, Washington 99352

Abstract

The development of offshore wind energy in the United States will be accelerated if floating wind platforms are successfully developed to harvest the largest and most consistent bands of wind over the oceans. DeepCwind, a consortium headed by the University of Maine will test the first U.S. offshore wind platforms in 2012. In advance of final siting and permitting of the test turbines off Monhegan Island, residents of the island off Maine require reassurance that the noise levels from the test turbines will not disturb them. Pacific Northwest National Laboratory, at the request of the University of Maine, and with the support of the U.S. Department of Energy Wind Program, modeled the acoustic output of the planned test turbines.

A commercial software package was used to model sound propagation over water due to three Northwind 100 wind turbines located three miles from the east coast of Monhegan Island, Maine. Sound pressure levels were calculated at a location approximating the island's central eastern shore region at a height of 1.5 m. Three types of modeling calculations were performed using worst-case conditions for sound to reach the island. In all cases the calculated noise reaching Monhegan Island is below nationally accepted noise standards. However, a breadth of calculations was made to ensure that local noise standards could be factored into the interpretation. The models used in the calculations do not address potential effects of wind turbulence or temperature inversions, which can influence the noise at the receiver location. Correction factors are suggested to account for wind turbulence and temperature, in order to make a conservative estimate of noise at Monhegan Island.

Contents

Tables

1.0 Introduction

Wind power is a major renewable energy source that has potential to contribute significantly to meeting energy needs around the world. Offshore wind energy is stronger and more reliable than land-based wind, with an estimated capacity of up to 4150 GW of power in the United States (Musial 2005; Schwartz et al. 2010). The United States is only beginning to capture this powerful resource with the approval of the nearshore Cape Wind Project in Massachusetts, which is slated to generate 468 MW (Waskes 2010). The European Union leads in offshore wind development with an installed capacity of 2,000 MW of energy. The U.S. Department of Energy (DOE) has recognized the potential for offshore wind power development and is supporting actions that will move towards offshore farms, with a particular emphasis on technologies that capture the stronger wind bands in deeper water. Based on the trajectory of land-based wind development and the examples of Cape Wind and other offshore wind farm applications, the industry and DOE recognize that siting and permitting of offshore wind farms are potentially the greatest uncertainty facing the industry. DOE has tasked Pacific Northwest National Laboratory to assist with understanding and evaluating risk from offshore wind development on the wildlife, the marine environment and perceptions of stakeholders and regulators that may confuse and slow development of the resource.

In 2009, the DOE Wind Program awarded funds to a consortium headed by the University of Maine (DeepCwind) to develop the nation's first offshore floating wind platforms. This project seeks to develop and deploy one to three floating platforms off the coast of Maine in the 2012 timeframe. Existing turbine technology will used to test the survivability and efficacy of wind generation at sea and in particular the physical dynamics of turbine operation on a platform that is not fixed rigidly in place. During FY10, DOE tasked PNNL to assist the University of Maine with high priority risks to siting and permitting the test turbines and platforms.

The DeepCwind consortium identified the need to determine the acoustic output of the test turbines as one of the key issues facing siting and permitting of the floating platforms off the coast of Monhegan Island in coastal Maine. At the request of the University of Maine, PNNL has carried out acoustic modeling using tools developed largely for the land-based wind industry.

2.0 Methodology

Since the configuration for deployment of the floating test platforms for DeepCwind has not been finalized, the acoustic modeling configuration represents a best guess at the time of the work. It has been decided by the University of Maine that one to three one-third scale Northwind 100 turbines will be deployed on the platforms. Published information from the turbine manufacturer was used as the acoustic source. The geometry of the floating platforms was set as a row of three platforms, spaced 100 m apart, three mi (4.83 km) east of Monhegan Island. Residents on Monhegan Island have expressed concern about the propagation of noise form the offshore turbines. This analysis focuses on providing the worst-case scenario for noise reaching the island from the turbines.

Sound propagation calculations have been performed using the WindPRO software package (EMD, Denmark). Three standard sound propagation models were used to perform the noise calculations: (a) the ISO 9613-2 general model, which is the standard used in the United States, and applies ot overland noise generation, (b) the Swedish EPA 6241 model for propagation over greater than 1 km of land, and (c) the Swedish EPA 6241 model for propagation over water. All models assume that the receiver is located directly downwind of the turbines, which represents a worst-case condition.

The downwind noise (an A-weighted sound pressure level in dBA units) from the three combined wind turbines was calculated at a point located 1.5 m above sea level on the central east side of Monhegan Island. The Northwind 100 turbine hub height and rotor diameter were 37 and 21 m, respectively, per vendor data. The 37 m hub height assumes the surface of the underwater support platform is at sea level. Since the 3 mi offshore range dominates the geometrical divergence effect, small variations in hub height are insignificant. However if the final configuration of the floating platforms changes the hub height of the rotor, there may be some change in the sound spectrum reaching shore.

The turbine noise specifications used in the calculations were obtained from the NREL NW 100 Noise Test Report 021003. The source sound power (dBA) versus wind speed and 1/3 octave source sound power levels (dBA) that were used in the calculations are shown in the Appendices. Noise has been calculated using 8 m/s wind speed and reported octave band data.

All calculations assumed that no obstructions were present between the wind turbines and the receiver, and include zero attenuation due to ground absorption in the source, mid and receiver regions. This means that the water surface is approximated as a perfectly flat, acoustically hard surface. The ISO 9613-2 calculations assume propagation through air at 10°C with 70% relative humidity and use absorption coefficient values defined by ISO 9613-1. This represents a worst-case scenario as atmospheric attenuation is minimal under these conditions. The Swedish models use a different set of A-weighted octave band absorption coefficients that are defined in the 6241 document, and appear to be independent of temperature and relative humidity.

For the purposes of this analysis, the air-sea interface was treated as a perfectly reflective surface, because the major transmission of sound from air to water takes place in lower frequencies than would be expected from wind turbines (Godin 2006; Godin 2007; Zhang 2002). Further studies of noise transmission from the test platforms are needed to determine whether there is sufficient low-frequency noise transmitted as vibration from the turbine tower to the surrounding water, as has been shown in monopole structures (Madsen et al. 2006).

3.0 Modeling Results

The results of the acoustic modeling are shown in the Appendices. Appendix A shows the model output for standard US models, using the ISO 9613 models, calculated at wind speeds of 8 m/s and variable wind speeds from 6 to 13 m/s, in 1 m/s steps. Appendix B shows the model output for the Swedish model 6241 for propagation over more than 1km of land. Appendix C shows the model output of the Swedish 6241 model for overwater propagation at 8 m/s and 13 m/s, respectively.

The most common noise standard for wind turbine applications limits the average sound pressure level at the point of interest to 40 dBA, assuming an average wind speed of 8 m/s. This wind speed and the octave band data shown in the Appendices were used to determine noise levels at the receiver site. The noise levels in Table 1 are calculated as output from the turbines and do not account for background ambient noise.

Table 1. Noise Calculated for 8 m/sec Wind Speed Using Turbine Octave Band Data

Propagation Model	Distance (km)	# Turbines	Sound Level at Receiver (dBA)	Appendix
ISO 9613-2	4.83	3	6.7	ISO_8_4830_Octave
Swedish 6241 Land (> 1 km)	4.83	3	6.1	SLAND_8_4830_Octave
Swedish 6241 Water	4.83	3	21.9	SWATER_8_4830_Octave

All three acoustic models predict noise levels at the receiver that are well below the 40 dBA standard threshold value. The noise standard is met even if an additional 4.8 dBA is added to account for wind turbulence. The noise levels predicted using the ISO 9613-2 and Swedish > 1 km over land models are in good agreement. The small difference between these models is due to the different atmospheric attenuation coefficients used by the models; attenuation is slightly more in the Swedish land model and less in the Swedish overwater model than in the U.S. model.

The noise level calculated using the Swedish overwater model is much larger than that calculated with the two land-based models. This is due to the manner in which the model treats the geometric divergence of the acoustic signal. While both land models assume spherical wave spreading throughout the entire region, the Swedish overwater model assumes spherical wave spreading for the first 200 m and then transitions to cylindrical spreading. For spherical wave spreading the sound pressure levels decrease 6 dB with every doubling in distance, while with cylindrical spreading there is a 3 dB reduction with every doubling in distance.

4.0 Noise as a Function of Wind Speed

Since turbine noise increases with wind speed, calculations of sound pressure levels as a function of wind speed were made in order to provide additional opportunities to address stakeholder concerns. Two calculations were performed using the ISO 9613-2 model and the Swedish overwater model.

The WindPRO ISO 9613-2 modeling software was used to calculate measured noise versus wind speed data, using the data shown in Table 2, to generate the values shown in Table 3. Following the ISO 9613-2 procedures, atmospheric attenuation values for the 500 Hz 1/3 octave band were used to support these calculations. The results indicate that at the highest wind speed of 13 m/s, the noise levels at the receiver are well below 40 dBA.

Table 2. Northwind 100 Source Sound Power Level versus Wind Speed[(a)]

Wind Speed (m/sec)	Source Sound Power Level (dBA)
6	89.6
7	91.8
8	93.8
9	95.1
10	97.2
11	98.0
12	99.5
13	100.7

(a) The NREL NW Noise Test Report 021003 provides sound pressure levels $L_{Aeq,c}$ at microphone one of their test set up, which is located at a 42 m slant distance, R, from the turbine hub. The NREL data were converted to represent sound power levels at the hub (LWA, ref) using the formula given in their report: LWA, ref = $L_{Aeq,c}$ - 6 + 10*LOG_{10}[4πR/1 m^2].

Table 3. Noise vs. Wind Speed for ISO 9613-2 Model and 500 Hz Atmospheric Attenuation. Data for these calculations can be found in Appendix B (ISO_Vary_4830_500Hz).

Distance (km)	Wind Speed (m/s)	# Turbines	Sound Level at Receiver (dBA)
4.83	6	3	3.5
4.83	7	3	5.7
4.83	8	3	7.7
4.83	9	3	9.0
4.83	10	3	11.1
4.83	11	3	11.9
4.83	12	3	13.4
4.83	13	3	14.6

The WindPRO Swedish overwater model software is not configured to determine variations in noise with wind speed, so a manual method was used to account for the increased noise level (Table 4). According to the National Renewable Energy Laboratory (NREL), noise levels of 100.7 dBA could be reached with the Northwind 100 turbine at a wind speed of 13 m/s. The noise reaching Monhegan Island was calculated using this maximum acoustic output level. As the model was not programmed with the measured source noise 1/3 octave band levels, atmospheric attenuation was calculated using the generic model adopted by the Swedish EPA 6241 document. The results of this calculation are shown in Table 5. The resulting noise at the Monhegan Island receiver is 30.6 dBA, well below 40 dBA threshold. The noise levels as a function of wind speed do not match up for the ISO and the Swedish overwater models due to differences in the model calculations, including the need to calculate the attenuation values for the Swedish model.

Table 4. NW100 Source Sound Power 1/3 Octave Band Levels

Band Center Frequency (Hz)	Sound Power Level (dBA)
20	Data not reported
25	Data not reported
31.5	Data not reported
40	60.7
50	66.3
63	65.9
80	68.9
100	73.1
125	72.7
160	75.6
200	76.9
250	77.8
315	79.8
400	81.1
500	82.9
630	85.5
800	86.0
1000	85.7
1250	84.6
1600	82.9
2000	81.2
2500	80.2
3150	78.6
4000	76.9
5000	73.2

Table 5. Noise at 13 m/s Wind Speed for Swedish Water Model and Generic Attenuation

Distance (km)	Wind Speed (m/sec)	# Turbines	Sound Level at Receiver (dBA)
4.83	13	3	30.6

5.0 References

Godin AO. 2007. "Transmission of Low-Frequency Sound through the Water-to-Air Interface." *Acoustical Physics* 2007, Vol. 53, No. 3, pp. 305–312

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Musial W. 2005. *Offshore Wind Energy Potential for the United States. National Renewable Energy Laboratory*. Wind Powering America-Annual State Summit, Evergreen Lake House, Evergreen Colorado, May 2005. Available at http://www.windpoweringamerica.gov/pdfs/workshops/2005_summit/musial.pdf.

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Waskes W. 2010. *Cape Wind Project*. Offshore Energy and Minerals Management, U.S. Department of the Interior. Available at http://www.mms.gov/offshore/RenewableEnergy/CapeWind.htm.

Zhang ZY. 2006. "Modeling of Sound Transmission from Air into Shallow and Deep Waters." *Phys. Rev. Lett*. 97, 164301. Conference Proceedings Acoustics 2002-Innovation in Acoustics and Vibration, November 13–15, 2002, Adelaide, Australia, pp. 234–243.

Appendix A

Model Outputs for ISO 9613

Project:

Monhegan Island Noise Calculation 3 miles

Description:

Noise (as sound pressure level) stemming from 3 Northwind 100 wind turbines, spaced 100 meters apart and located ~3 miles (4.8 km) off the eastern shore of Monhegan Island, Maine is determined for a receiver (denoted as human ear) located on the beach, 1.5 meters height above sea level. Atmospheric attenuation corresponds to 500 Hz octave band at a temperature of 10 C and 70% relative humidity (ISO standard)

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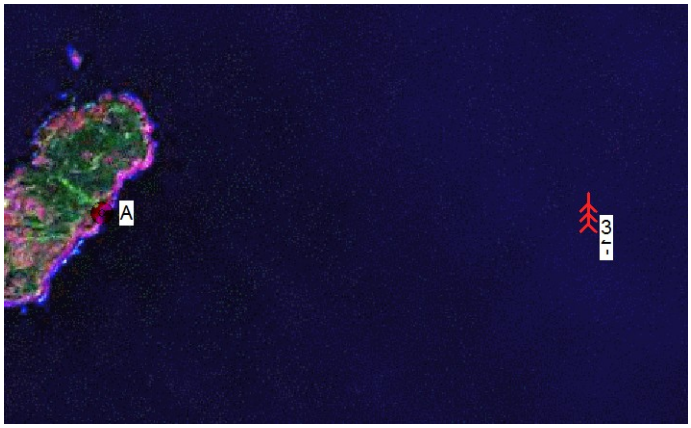
DECIBEL - Main Result

Calculation: Octave Calc ISO

Noise calculation model:
ISO 9613-2 General
Wind speed:
8.0 m/s
Ground attenuation:
None
Meteorological coefficient, C0:
0.0 dB
Type of demand in calculation:
1: WTG noise is compared to demand (DK, DE, SE, NL etc.)
Noise values in calculation:
All noise values are mean values (Lwa) (Normal)
Pure tones:
Pure and Impulse tone penalty are added to WTG source noise
Height above ground level, when no value in NSA object:
1.5 m Don't allow override of model height with height from NSA object
Deviation from "official" noise demands. Negative is more restrictive, positive is less restrictive.:
0.0 dB(A)



Scale 1:75,000

New WTG Noise sensitive area

WTGs

	UTM NAD27 Zone: 19				WTG type						Noise data						
	East	North	Z	Row data/Description	Valid	Manufact.	Type-generator	Power, rated	Rotor diameter	Hub height	Creator	Name	Wind speed	Hub height	LwA,ref	Pure tones	Octave data
	UTM NAD27 Zone: 19		[m]					[kW]	[m]	[m]			[m/s]	[m]	[dB(A)]		
1	480,086	4,845,413	0.0	-0.3°, 100.0 m	No	Northwind	NW100-100	100	21.0	37.0	USER	Octave data	8.0	37.0	94.1	0 dB	Yes
2	480,085	4,845,513	0.0		No	Northwind	NW100-100	100	21.0	37.0	USER	Octave data	8.0	37.0	94.1	0 dB	Yes
3	480,085	4,845,613	0.0		No	Northwind	NW100-100	100	21.0	37.0	USER	Octave data	8.0	37.0	94.1	0 dB	Yes

Calculation Results

Sound Level

Noise sensitive area		UTM NAD27 Zone: 19				Demands	Sound Level	Demands fulfilled ?
No.	Name	East	North	Z [m]	Imission height [m]	Noise [dB(A)]	From WTGs [dB(A)]	Noise
A	Ear	475,251	4,845,510	1.5	1.5	44.0	6.7	Yes

Distances (m)

WTG	A
1	4836
2	4834
3	4835

Project:
Monhegan Island Noise Calculation 3 miles

Description:
Noise (as sound pressure level) stemming from 3 Northwind 100 wind turbines, spaced 100 meters apart and located ~3 miles (4.8 km) off the eastern shore of Monhegan Island, Maine is determined for a receiver (denoted as human ear) located on the beach, 1.5 meters height above sea level. Atmospheric attenuation corresponds to 500 Hz octave band at a temperature of 10 C and 70% relative humidity (ISO standard)

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DECIBEL - Detailed results

Calculation: Octave Calc ISO**Noise calculation model:** ISO 9613-2 General 8.0 m/s

Assumptions

Calculated L(DW) = LWA,ref + K + Dc - (Adiv + Aatm + Agr + Abar + Amisc) - Cmet
(when calculated with ground attenuation, then Dc = Domega)

LWA,ref:	Sound pressure level at WTG
K:	Pure tone
Dc:	Directivity correction
Adiv:	the attenuation due to geometrical divergence
Aatm:	the attenuation due to atmospheric absorption
Agr:	the attenuation due to ground effect
Abar:	the attenuation due to a barrier
Amisc:	the attenuation due to miscellaneous other effects
Cmet:	Meteorological correction

Calculation Results

Noise sensitive area: A Ear

WTG **Wind speed: 8.0 m/s**

No.	Distance [m]	Sound distance [m]	Calculated [dB(A)]	LwA,ref [dB(A)]	Dc [dB]	Adiv [dB]	Aatm [dB]	Agr [dB]	Abar [dB]	Amisc [dB]	A [dB]	Cmet [dB]
1	4,836	4,836	**1.92**	94.1	3.00	84.69	10.54	0.00	0.00	0.00	95.23	0.00
2	4,834	4,834	**1.92**	94.1	3.00	84.69	10.54	0.00	0.00	0.00	95.23	0.00
3	4,835	4,835	**1.92**	94.1	3.00	84.69	10.54	0.00	0.00	0.00	95.23	0.00
Sum	6.69											

Project:

Monhegan Island Noise Calculation 3 miles

Description:

Noise (as sound pressure level) stemming from 3 Northwind 100 wind turbines, spaced 100 meters apart and located ~3 miles (4.8 km) off the eastern shore of Monhegan Island, Maine is determined for a receiver (denoted as human ear) located on the beach, 1.5 meters height above sea level. Atmospheric attenuation corresponds to 500 Hz octave band at a temperature of 10 C and 70% relative humidity (ISO standard)

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DECIBEL - Assumptions for noise calculation

Calculation: Octave Calc ISO**Noise calculation model:** ISO 9613-2 General 8.0 m/s

Noise calculation model:
ISO 9613-2 General
Wind speed:
8.0 m/s
Ground attenuation:
None
Meteorological coefficient, C0:
0.0 dB
Type of demand in calculation:
1: WTG noise is compared to demand (DK, DE, SE, NL etc.)
Noise values in calculation:
All noise values are mean values (Lwa) (Normal)
Pure tones:
Pure and Impulse tone penalty are added to WTG source noise
Height above ground level, when no value in NSA object:
1.5 m Don't allow override of model height with height from NSA object
Deviation from "official" noise demands. Negative is more restrictive, positive is less restrictive.:
0.0 dB(A)
Octave data required
Air absorption

63 [db/km]	125 [db/km]	250 [db/km]	500 [db/km]	1,000 [db/km]	2,000 [db/km]	4,000 [db/km]	8,000 [db/km]
0.1	0.4	1.0	1.9	3.7	9.7	32.8	117.0

WTG: Northwind NW100 60Hz 100 21.0 !O!
Noise: Octave data

Source	Source/Date	Creator	Edited
NREL 021003 Noise Test Report	11/9/2010	USER	11/9/2010 2:27 PM

					Octave data							
Status	Hub height [m]	Wind speed [m/s]	LwA,ref [dB(A)]	Pure tones	63 [dB]	125 [dB]	250 [dB]	500 [dB]	1000 [dB]	2000 [dB]	4000 [dB]	8000 [dB]
From Windcat	37.0	8.0	94.1	No	72.3	78.8	83.1	88.3	90.2	86.4	81.5	7.8

NSA: Ear-A
Predefined calculation standard: Open land
Imission height(a.g.l.): 1.5 m

Noise demand:

6.0 [m/s]	8.0 [m/s]
42.0 dB(A)	44.0 dB(A)

Distance demand: 0.0 m

Project:

Monhegan Island Noise Calculation 3 miles

Description:

Noise (as sound pressure level) stemming from 3 Northwind 100 wind turbines, spaced 100 meters apart and located ~3 miles (4.8 km) off the eastern shore of Monhegan Island, Maine is determined for a receiver (denoted as human ear) located on the beach, 1.5 meters height above sea level. Atmospheric attenuation corresponds to 500 Hz octave band at a temperature of 10 C and 70% relative humidity (ISO standard)

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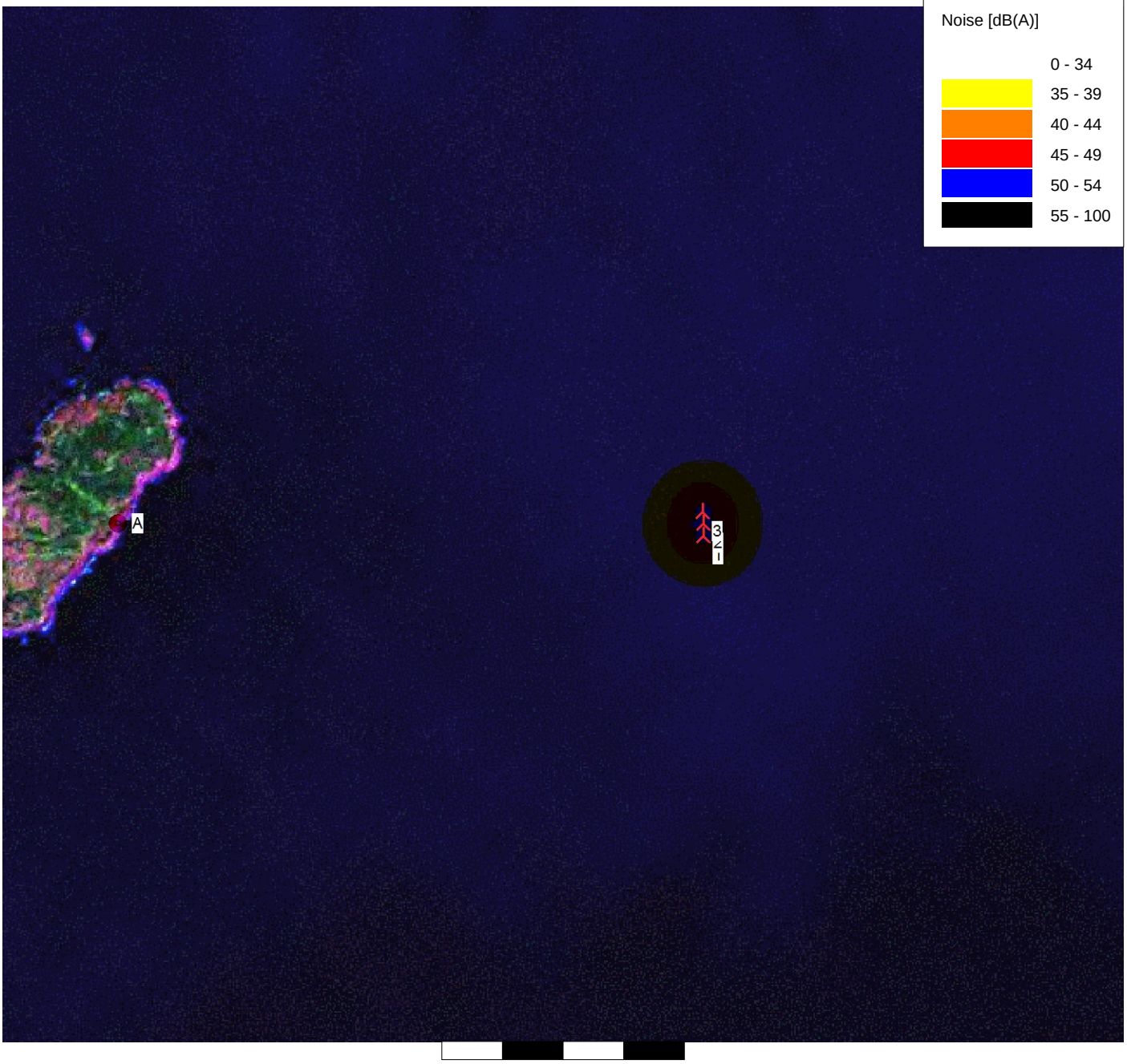
DECIBEL - Map 8.0 m/s

Calculation: Octave Calc ISO**Noise calculation model:** ISO 9613-2 General 8.0 m/s



Map: WindPRO map , Print scale 1:50,000, Map center UTM NAD 27 Zone: 19 East: 478,869 North: 4,845,518

Noise calculation model: ISO 9613-2 General. Wind speed: 8.0 m/s

New WTG Noise sensitive area

Height above sea level: 1.0 m

35.0 dB(A) 40.0 dB(A) 45.0 dB(A) 50.0 dB(A) 55.0 dB(A)

Project:

Monhegan Island Noise Calculation 3 miles

Description:

Noise (as sound pressure level) stemming from 3 Northwind 100 wind turbines, spaced 100 meters apart and located ~3 miles (4.8 km) off the eastern shore of Monhegan Island, Maine is determined for a receiver (denoted as human ear) located on the beach, 1.5 meters height above sea level. Atmospheric attenuation corresponds to 500 Hz octave band at a temperature of 10 C and 70% relative humidity (ISO standard)

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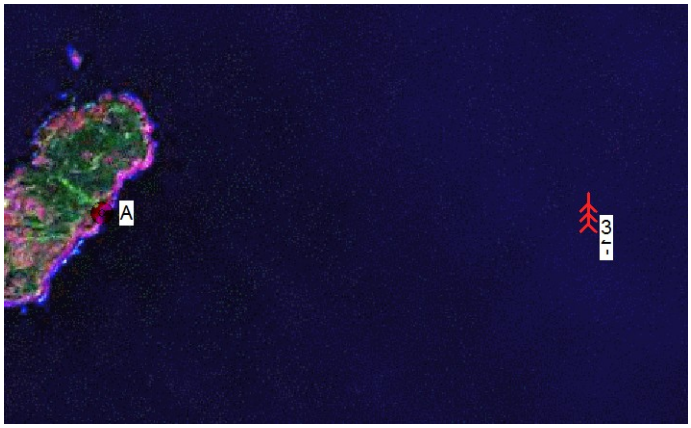
DECIBEL - Main Result

Noise calculation model:
ISO 9613-2 General
Wind speed:
6.0 m/s - 13.0 m/s, step 1.0 m/s
Ground attenuation:
None
Meteorological coefficient, C0:
0.0 dB
Type of demand in calculation:
1: WTG noise is compared to demand (DK, DE, SE, NL etc.)
Noise values in calculation:
All noise values are mean values (Lwa) (Normal)
Pure tones:
Pure and Impulse tone penalty are added to WTG source noise
Height above ground level, when no value in NSA object:
1.5 m Don't allow override of model height with height from NSA object
Deviation from "official" noise demands. Negative is more restrictive, positive is less restrictive.:
0.0 dB(A)



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New WTG Noise sensitive area

WTGs

	UTM NAD27 Zone: 19				WTG type						Noise data							
	East	North	Z	Row data/Description	Valid	Manufact.	Type-generator	Power, rated	Rotor diameter	Hub height	Creator	Name	First wind speed	LwaRef	Last wind speed	LwaRef	Pure tones	Octave data
	UTM NAD27 Zone: 19		[m]					[kW]	[m]	[m]			[m/s]	[dB(A)]	[m/s]	[dB(A)]		
1	480,086	4,845,413	0.0	-0.3°, 100.0 m	No	Northwind	NW100-100	100	21.0	37.0	USER	Wind Speed Data	6.0	89.6	13.0	100.7	0 dB	No
2	480,085	4,845,513	0.0		No	Northwind	NW100-100	100	21.0	37.0	USER	Wind Speed Data	6.0	89.6	13.0	100.7	0 dB	No
3	480,085	4,845,613	0.0		No	Northwind	NW100-100	100	21.0	37.0	USER	Wind Speed Data	6.0	89.6	13.0	100.7	0 dB	No

Calculation Results

Sound Level

Noise sensitive area		UTM NAD27 Zone: 19				Demands	Sound Level	Demands fulfilled ?
No.	Name	East	North	Z	Imission height	Max Noise	Max From WTGs	Noise
				[m]	[m]	[dB(A)]	[dB(A)]	
A	Ear	475,251	4,845,510	1.5	1.5	0.0	14.6	Yes

Distances (m)

WTG	A
1	4836
2	4834
3	4835

Project:

Monhegan Island Noise Calculation 3 miles

Description:

Noise (as sound pressure level) stemming from 3 Northwind 100 wind turbines, spaced 100 meters apart and located ~3 miles (4.8 km) off the eastern shore of Monhegan Island, Maine is determined for a receiver (denoted as human ear) located on the beach, 1.5 meters height above sea level. Atmospheric attenuation corresponds to 500 Hz octave band at a temperature of 10 C and 70% relative humidity (ISO standard)

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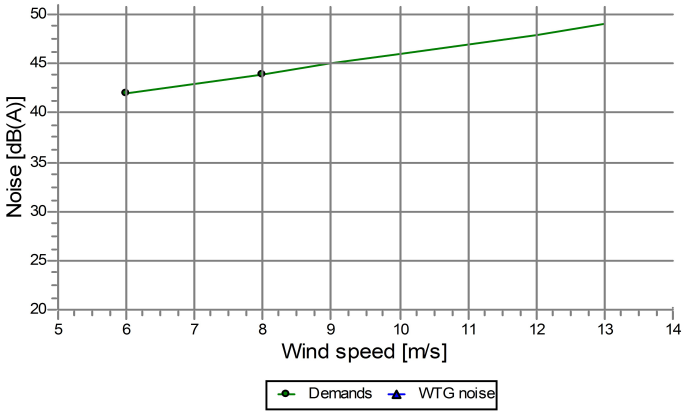
Calculated:
11/9/2010 2:04 PM/2.7.473

DECIBEL - Detailed results

Noise calculation model: ISO 9613-2 General

Ear (A)



Sound Level

Wind speed [m/s]	Demands [dB(A)]	WTG noise [dB(A)]	Demands fulfilled ?
6.0	42.0	3.5	Yes
7.0	43.0	5.7	Yes
8.0	44.0	7.7	Yes
9.0	45.0	9.0	Yes
10.0	46.0	11.1	Yes
11.0	47.0	11.9	Yes
12.0	48.0	13.4	Yes
13.0	49.0	14.6	Yes

Project:
Monhegan Island Noise Calculation 3 miles

Description:
Noise (as sound pressure level) stemming from 3 Northwind 100 wind turbines, spaced 100 meters apart and located ~3 miles (4.8 km) off the eastern shore of Monhegan Island, Maine is determined for a receiver (denoted as human ear) located on the beach, 1.5 meters height above sea level. Atmospheric attenuation corresponds to 500 Hz octave band at a temperature of 10 C and 70% relative humidity (ISO standard)

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Calculated:
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DECIBEL - Assumptions for noise calculation

Noise calculation model: ISO 9613-2 General

Noise calculation model:
ISO 9613-2 General
Wind speed:
6.0 m/s - 13.0 m/s, step 1.0 m/s
Ground attenuation:
None
Meteorological coefficient, C0:
0.0 dB
Type of demand in calculation:
1: WTG noise is compared to demand (DK, DE, SE, NL etc.)
Noise values in calculation:
All noise values are mean values (Lwa) (Normal)
Pure tones:
Pure and Impulse tone penalty are added to WTG source noise
Height above ground level, when no value in NSA object:
1.5 m Don't allow override of model height with height from NSA object
Deviation from "official" noise demands. Negative is more restrictive, positive is less restrictive.:
0.0 dB(A)
Octave data not required
Air absorption: 1.9 dB/km

WTG: Northwind NW100 60Hz 100 21.0 !O!
Noise: Wind Speed Data

Source	Source/Date	Creator	Edited
NREL report 021003 table 9 + 37.4 dB correct	11/8/2010	USER	11/8/2010 3:53 PM

Status	Hub height [m]	Wind speed [m/s]	LwA,ref [dB(A)]	Pure tones
From Windcat	37.0	6.0	89.6	No
From Windcat	37.0	7.0	91.8	No
From Windcat	37.0	8.0	93.8	No
From Windcat	37.0	9.0	95.1	No
From Windcat	37.0	10.0	97.2	No
From Windcat	37.0	11.0	98.0	No
From Windcat	37.0	12.0	99.5	No
From Windcat	37.0	13.0	100.7	No

NSA: Ear-A
Predefined calculation standard: Open land
Imission height(a.g.l.): 1.5 m

Noise demand:

6.0 [m/s]	8.0 [m/s]
42.0 dB(A)	44.0 dB(A)

Distance demand: 0.0 m

Project:

Monhegan Island Noise Calculation 3 miles

Description:

Noise (as sound pressure level) stemming from 3 Northwind 100 wind turbines, spaced 100 meters apart and located ~3 miles (4.8 km) off the eastern shore of Monhegan Island, Maine is determined for a receiver (denoted as human ear) located on the beach, 1.5 meters height above sea level. Atmospheric attenuation corresponds to 500 Hz octave band at a temperature of 10 C and 70% relative humidity (ISO standard)

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Calculated:
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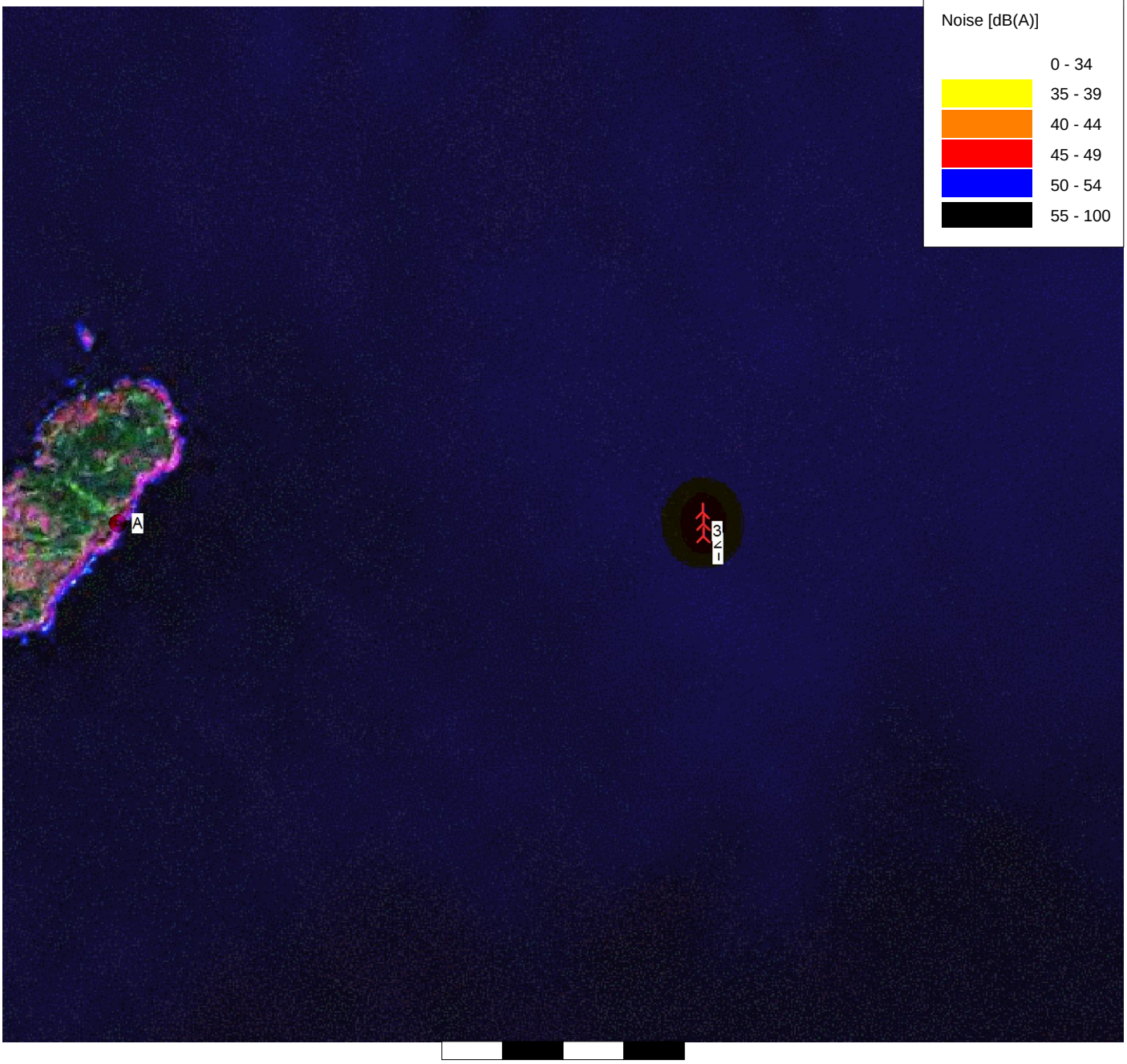
DECIBEL - Map 6.0 m/s

Noise calculation model: ISO 9613-2 General



Map: WindPRO map , Print scale 1:50,000, Map center UTM NAD 27 Zone: 19 East: 478,869 North: 4,845,518
Noise calculation model: ISO 9613-2 General. Wind speed: 6.0 m/s

New WTG Noise sensitive area

Height above sea level: 1.0 m

35.0 dB(A) 40.0 dB(A) 45.0 dB(A) 50.0 dB(A) 55.0 dB(A)

Project:

Monhegan Island Noise Calculation 3 miles

Description:

Noise (as sound pressure level) stemming from 3 Northwind 100 wind turbines, spaced 100 meters apart and located ~3 miles (4.8 km) off the eastern shore of Monhegan Island, Maine is determined for a receiver (denoted as human ear) located on the beach, 1.5 meters height above sea level. Atmospheric attenuation corresponds to 500 Hz octave band at a temperature of 10 C and 70% relative humidity (ISO standard)

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Calculated:
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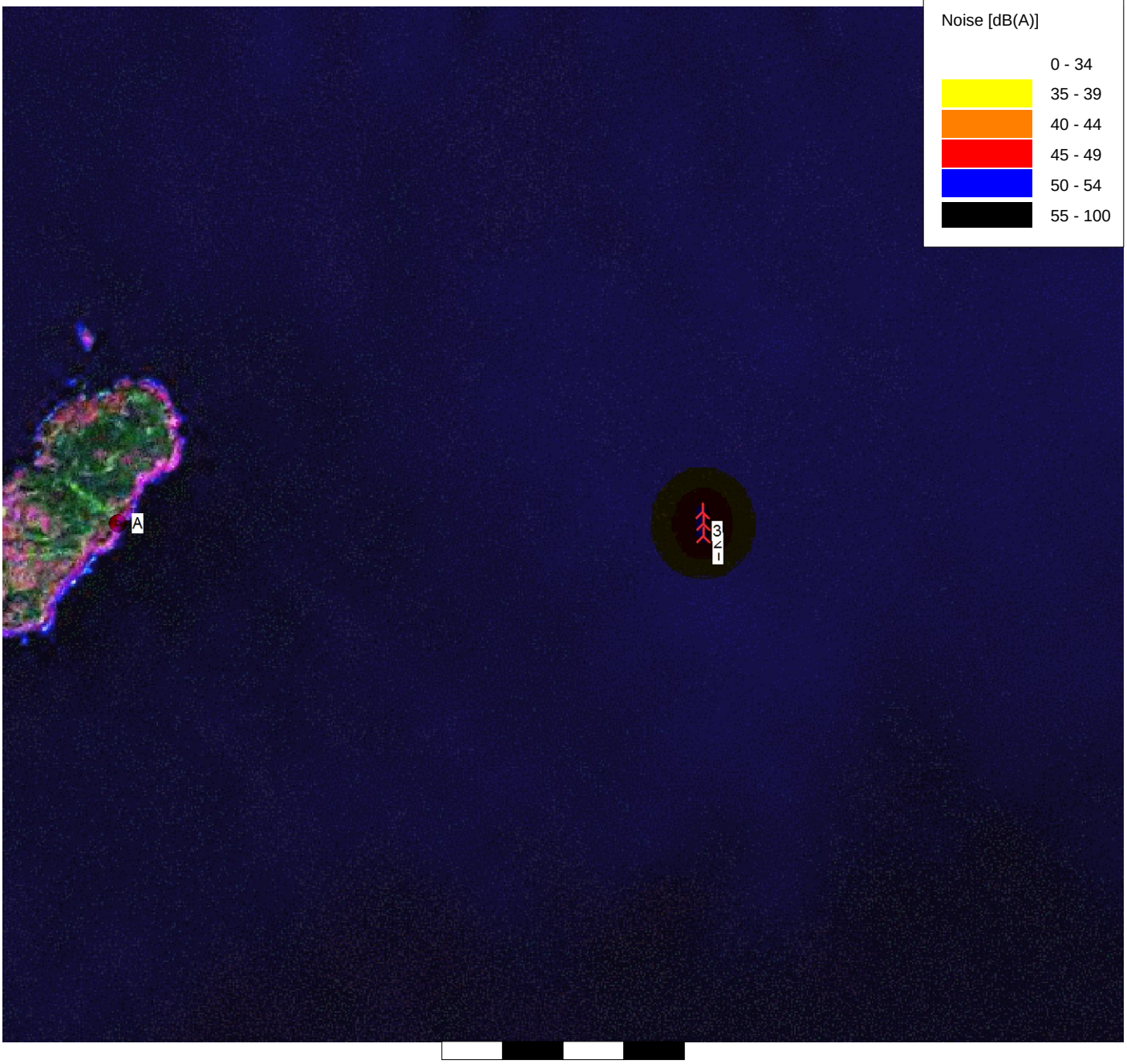
DECIBEL - Map 7.0 m/s

Noise calculation model: ISO 9613-2 General



Map: WindPRO map , Print scale 1:50,000, Map center UTM NAD 27 Zone: 19 East: 478,869 North: 4,845,518
Noise calculation model: ISO 9613-2 General. Wind speed: 7.0 m/s

New WTG Noise sensitive area

Height above sea level: 1.0 m

35.0 dB(A) 40.0 dB(A) 45.0 dB(A) 50.0 dB(A) 55.0 dB(A)

Project:
Monhegan Island Noise Calculation 3 miles

Description:
Noise (as sound pressure level) stemming from 3 Northwind 100 wind turbines, spaced 100 meters apart and located ~3 miles (4.8 km) off the eastern shore of Monhegan Island, Maine is determined for a receiver (denoted as human ear) located on the beach, 1.5 meters height above sea level. Atmospheric attenuation corresponds to 500 Hz octave band at a temperature of 10 C and 70% relative humidity (ISO standard)

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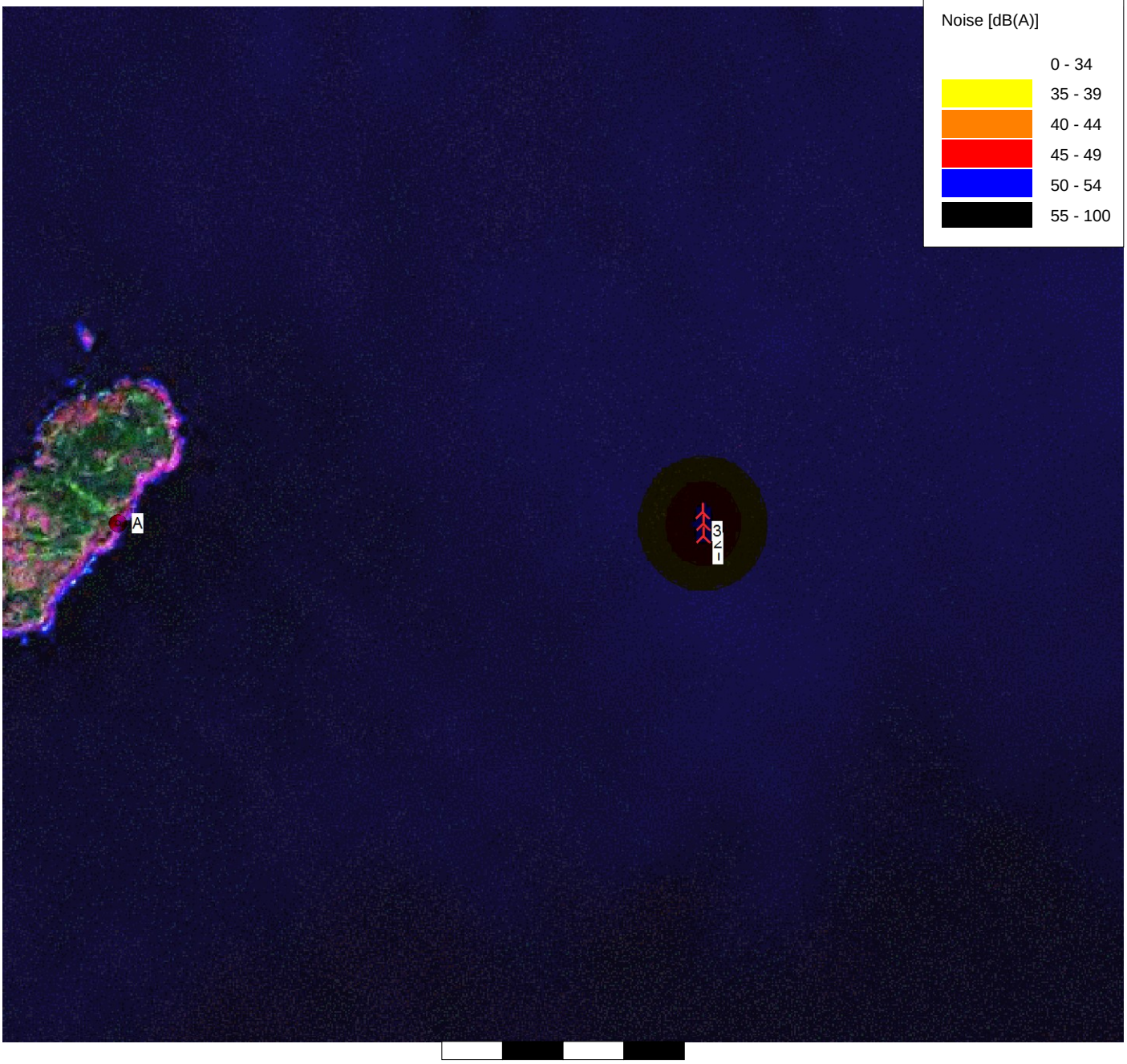
DECIBEL - Map 8.0 m/s

Noise calculation model: ISO 9613-2 General



Map: WindPRO map , Print scale 1:50,000, Map center UTM NAD 27 Zone: 19 East: 478,869 North: 4,845,518
Noise calculation model: ISO 9613-2 General. Wind speed: 8.0 m/s

New WTG Noise sensitive area

Height above sea level: 1.0 m

35.0 dB(A) 40.0 dB(A) 45.0 dB(A) 50.0 dB(A) 55.0 dB(A)

Project:

Monhegan Island Noise Calculation 3 miles

Description:

Noise (as sound pressure level) stemming from 3 Northwind 100 wind turbines, spaced 100 meters apart and located ~3 miles (4.8 km) off the eastern shore of Monhegan Island, Maine is determined for a receiver (denoted as human ear) located on the beach, 1.5 meters height above sea level. Atmospheric attenuation corresponds to 500 Hz octave band at a temperature of 10 C and 70% relative humidity (ISO standard)

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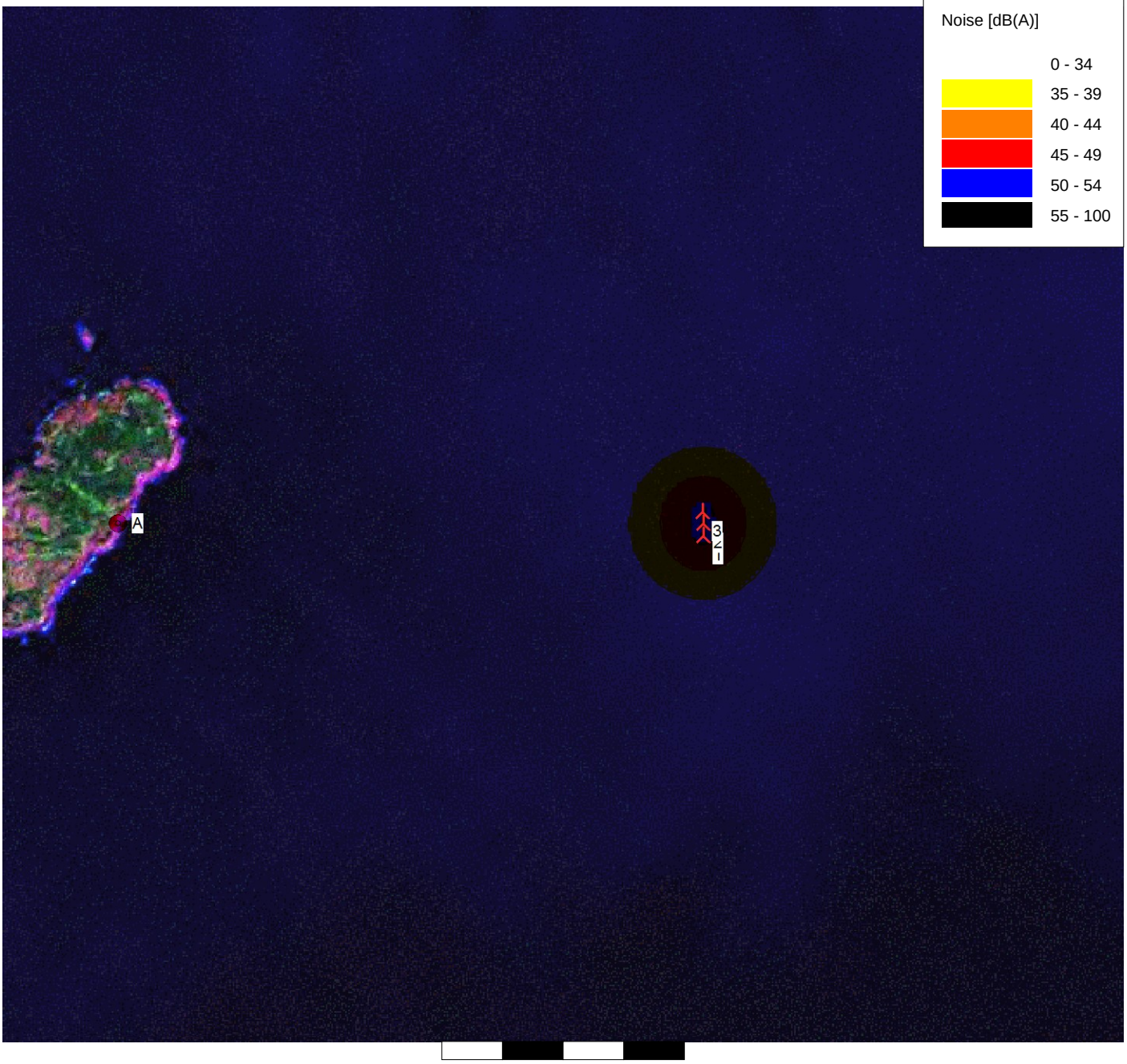
DECIBEL - Map 9.0 m/s

Noise calculation model: ISO 9613-2 General



Map: WindPRO map , Print scale 1:50,000, Map center UTM NAD 27 Zone: 19 East: 478,869 North: 4,845,518
Noise calculation model: ISO 9613-2 General. Wind speed: 9.0 m/s

New WTG Noise sensitive area

Height above sea level: 1.0 m

35.0 dB(A) 40.0 dB(A) 45.0 dB(A) 50.0 dB(A) 55.0 dB(A)

Project:

Monhegan Island Noise Calculation 3 miles

Description:

Noise (as sound pressure level) stemming from 3 Northwind 100 wind turbines, spaced 100 meters apart and located ~3 miles (4.8 km) off the eastern shore of Monhegan Island, Maine is determined for a receiver (denoted as human ear) located on the beach, 1.5 meters height above sea level. Atmospheric attenuation corresponds to 500 Hz octave band at a temperature of 10 C and 70% relative humidity (ISO standard)

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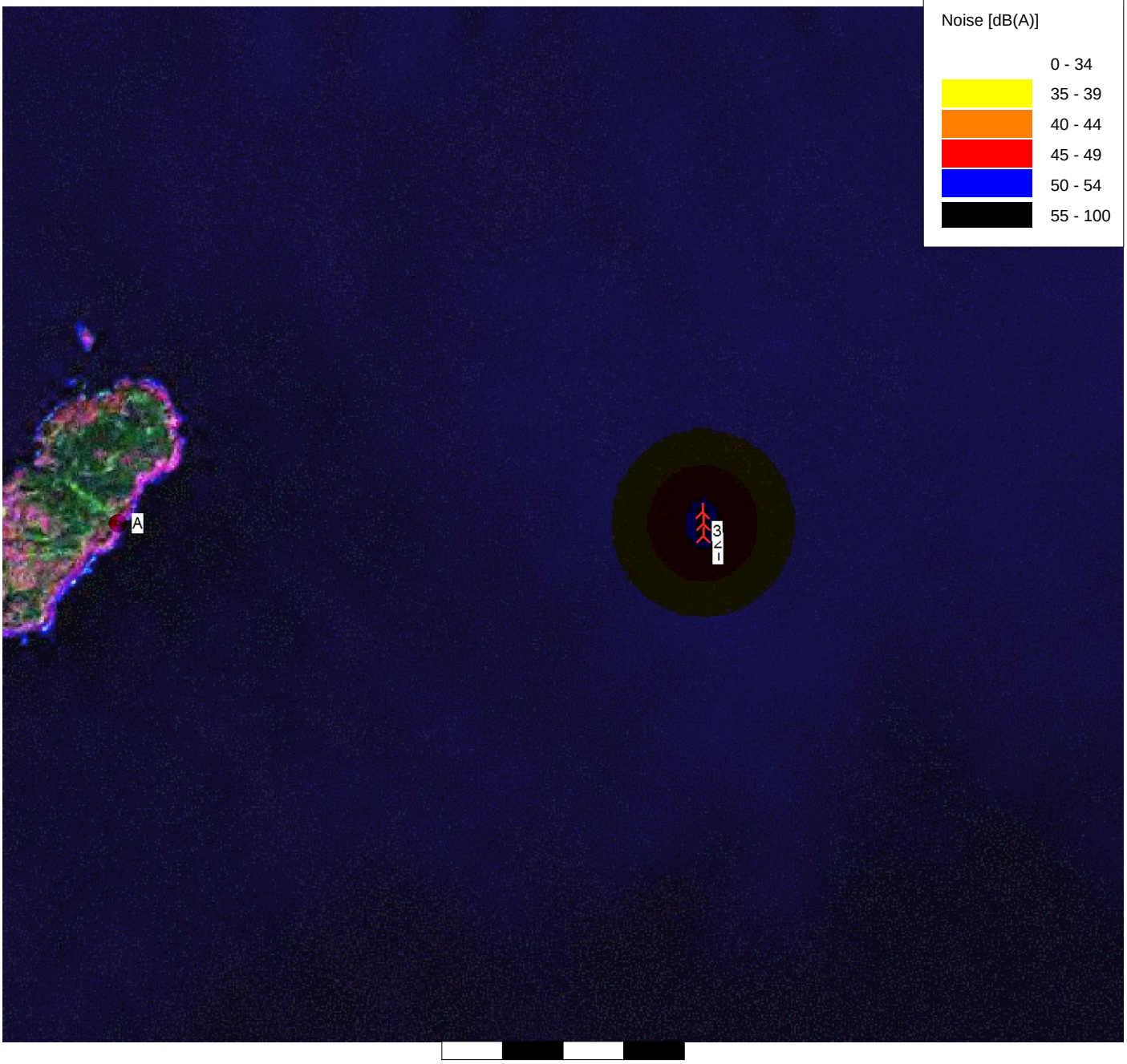
DECIBEL - Map 10.0 m/s

Noise calculation model: ISO 9613-2 General



Map: WindPRO map , Print scale 1:50,000, Map center UTM NAD 27 Zone: 19 East: 478,869 North: 4,845,518
Noise calculation model: ISO 9613-2 General. Wind speed: 10.0 m/s

New WTG Noise sensitive area

Height above sea level: 1.0 m

35.0 dB(A) 40.0 dB(A) 45.0 dB(A) 50.0 dB(A) 55.0 dB(A)

Project:
Monhegan Island Noise Calculation 3 miles

Description:
Noise (as sound pressure level) stemming from 3 Northwind 100 wind turbines, spaced 100 meters apart and located ~3 miles (4.8 km) off the eastern shore of Monhegan Island, Maine is determined for a receiver (denoted as human ear) located on the beach, 1.5 meters height above sea level. Atmospheric attenuation corresponds to 500 Hz octave band at a temperature of 10 C and 70% relative humidity (ISO standard)

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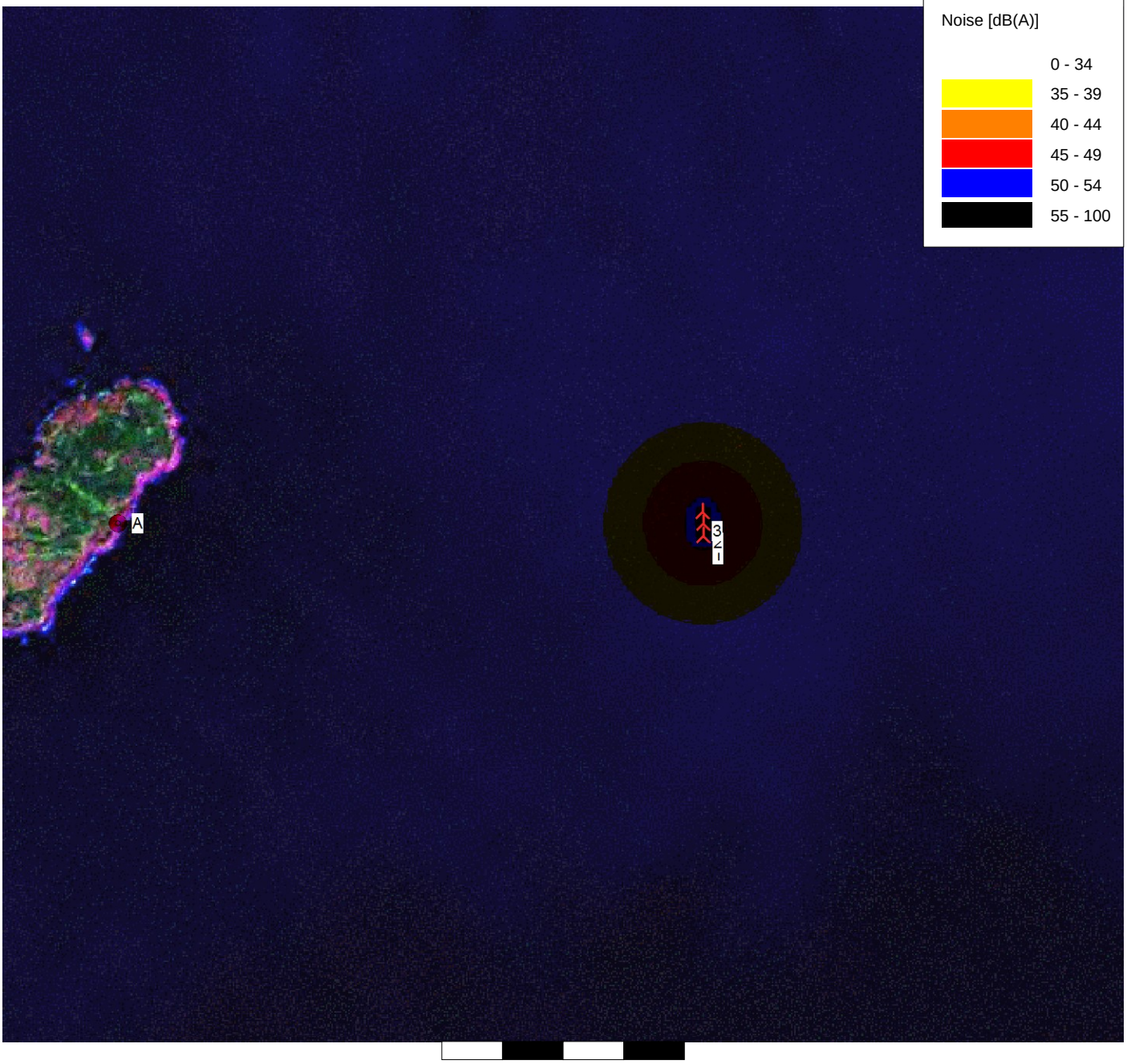
DECIBEL - Map 11.0 m/s

Noise calculation model: ISO 9613-2 General



Map: WindPRO map , Print scale 1:50,000, Map center UTM NAD 27 Zone: 19 East: 478,869 North: 4,845,518
Noise calculation model: ISO 9613-2 General. Wind speed: 11.0 m/s

New WTG Noise sensitive area

Height above sea level: 1.0 m

35.0 dB(A) 40.0 dB(A) 45.0 dB(A) 50.0 dB(A) 55.0 dB(A)

Project:

Monhegan Island Noise Calculation 3 miles

Description:

Noise (as sound pressure level) stemming from 3 Northwind 100 wind turbines, spaced 100 meters apart and located ~3 miles (4.8 km) off the eastern shore of Monhegan Island, Maine is determined for a receiver (denoted as human ear) located on the beach, 1.5 meters height above sea level. Atmospheric attenuation corresponds to 500 Hz octave band at a temperature of 10 C and 70% relative humidity (ISO standard)

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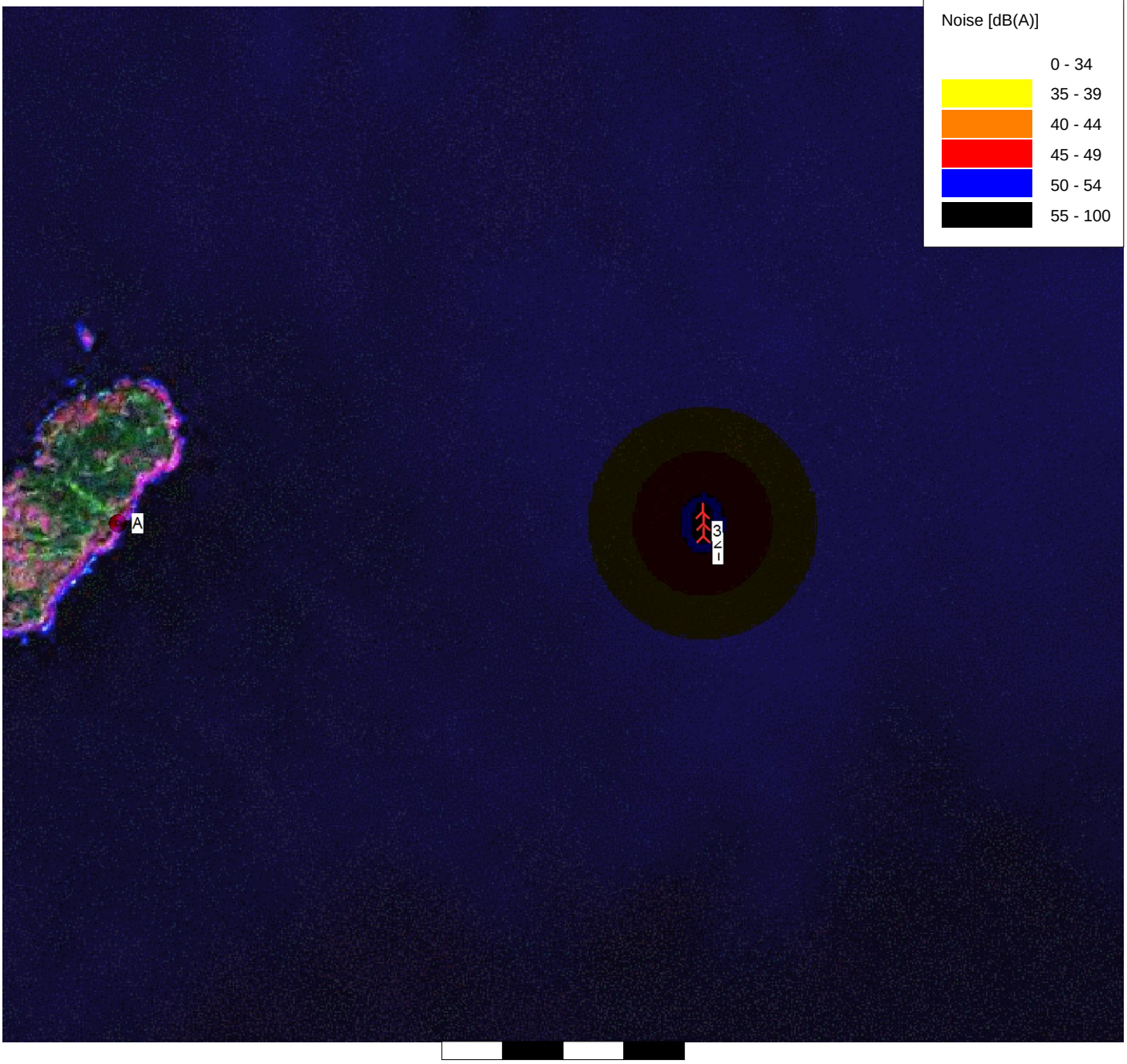
DECIBEL - Map 12.0 m/s

Noise calculation model: ISO 9613-2 General



Map: WindPRO map , Print scale 1:50,000, Map center UTM NAD 27 Zone: 19 East: 478,869 North: 4,845,518
Noise calculation model: ISO 9613-2 General. Wind speed: 12.0 m/s

New WTG Noise sensitive area

Height above sea level: 1.0 m

35.0 dB(A) 40.0 dB(A) 45.0 dB(A) 50.0 dB(A) 55.0 dB(A)

Project:

Monhegan Island Noise Calculation 3 miles

Description:

Noise (as sound pressure level) stemming from 3 Northwind 100 wind turbines, spaced 100 meters apart and located ~3 miles (4.8 km) off the eastern shore of Monhegan Island, Maine is determined for a receiver (denoted as human ear) located on the beach, 1.5 meters height above sea level. Atmospheric attenuation corresponds to 500 Hz octave band at a temperature of 10 C and 70% relative humidity (ISO standard)

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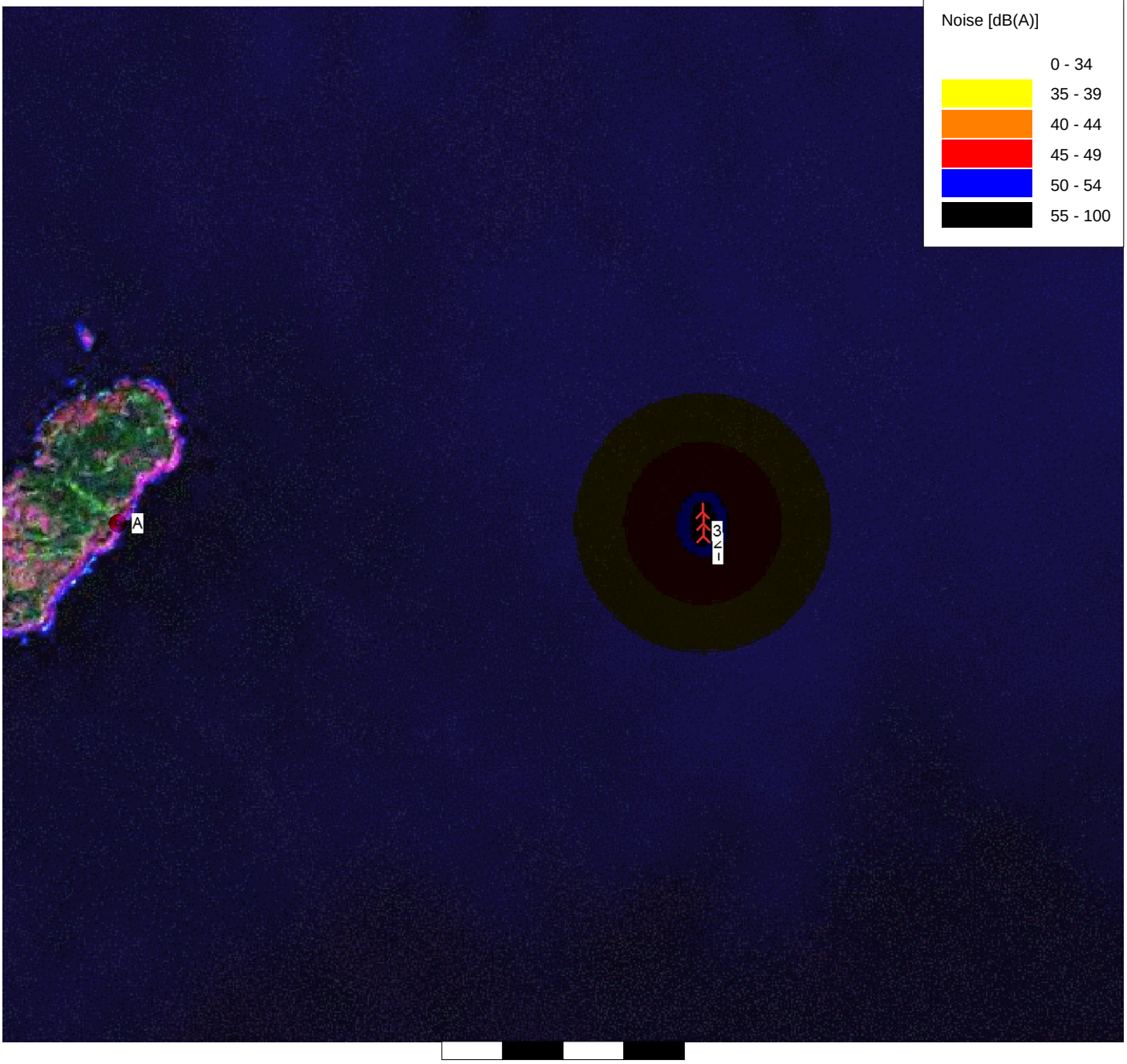
DECIBEL - Map 13.0 m/s

Noise calculation model: ISO 9613-2 General



Map: WindPRO map , Print scale 1:50,000, Map center UTM NAD 27 Zone: 19 East: 478,869 North: 4,845,518
Noise calculation model: ISO 9613-2 General. Wind speed: 13.0 m/s

New WTG Noise sensitive area

Height above sea level: 1.0 m

35.0 dB(A) 40.0 dB(A) 45.0 dB(A) 50.0 dB(A) 55.0 dB(A)

Appendix B

Model Outputs for Swedish Model 6241 for Propagation Over 1 km

Project:
Monhegan Island Noise Calculation 3 miles

Description:
Noise (as sound pressure level) stemming from 3 Northwind 100 wind turbines, spaced 100 meters apart and located ~3 miles (4.8 km) off the eastern shore of Monhegan Island, Maine is determined for a receiver (denoted as human ear) located on the beach, 1.5 meters height above sea level. Atmospheric attenuation corresponds to 500 Hz octave band at a temperature of 10 C and 70% relative humidity (ISO standard)

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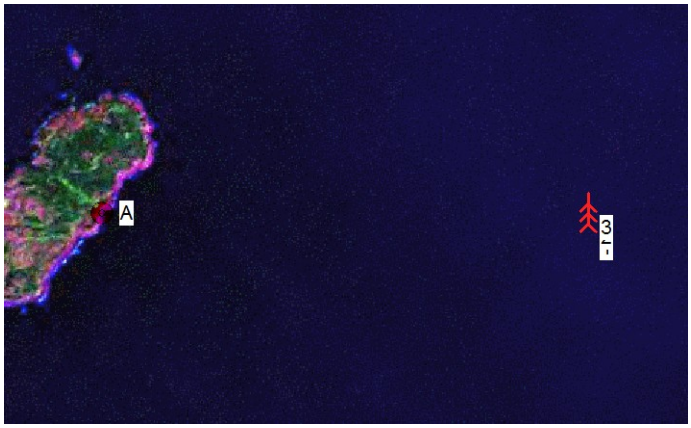
DECIBEL - Main Result

Calculation: Swede land Octave

SWEDISH RULES FOR NOISE CALCULATION.

The calculation is based on the "Ljud från landbaserade vindkraftverk", 2001 (ISBN 91-620-6249-2)

Roughness class: 0.0
Roughness length: 0.000
K: 1.0 dB/(m/s)



Scale 1:75,000

New WTG Noise sensitive area

WTGs

	UTM NAD27 Zone: 19				WTG type						Noise data						
	East	North	Z	Row data/Description	Valid	Manufact.	Type-generator	Power, rated	Rotor diameter	Hub height	Creator	Name	Wind speed	Hub height	LwA,ref	Pure tones	Octave data
	UTM NAD27 Zone: 19		[m]					[kW]	[m]	[m]			[m/s]	[m]	[dB(A)]		
1	480,086	4,845,413	0.0	-0.3°, 100.0 m	No	Northwind	NW100-100	100	21.0	37.0	USER	Octave data	8.0	37.0	94.1	No	Yes
2	480,085	4,845,513	0.0		No	Northwind	NW100-100	100	21.0	37.0	USER	Octave data	8.0	37.0	94.1	No	Yes
3	480,085	4,845,613	0.0		No	Northwind	NW100-100	100	21.0	37.0	USER	Octave data	8.0	37.0	94.1	No	Yes

Calculation Results

Sound Level

Noise sensitive area		UTM NAD27 Zone: 19				Demands	Sound Level	Demands fulfilled ?
No.	Name	East	North	Z [m]	Imission height [m]	Noise [dB(A)]	From WTGs [dB(A)]	Noise
A	Ear	475,251	4,845,510	1.5	1.5	44.0	6.1	Yes

Distances (m)

WTG	A
1	4836
2	4834
3	4835

Project:
Monhegan Island Noise Calculation 3 miles

Description:
Noise (as sound pressure level) stemming from 3 Northwind 100 wind turbines, spaced 100 meters apart and located ~3 miles (4.8 km) off the eastern shore of Monhegan Island, Maine is determined for a receiver (denoted as human ear) located on the beach, 1.5 meters height above sea level. Atmospheric attenuation corresponds to 500 Hz octave band at a temperature of 10 C and 70% relative humidity (ISO standard)

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Calculated:
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DECIBEL - Detailed results

Calculation: Swede land Octave**Noise calculation model:** Swedish, Jan 2002, Land 8.0 m/s

Assumptions

Calculated L(DW) = LWA,ref + K + Dc - (Adiv + Aatm + Agr + Abar + Amisc) - Cmet
(when calculated with ground attenuation, then Dc = Domega)

LWA,ref:	Sound pressure level at WTG
K:	Pure tone
Dc:	Directivity correction
Adiv:	the attenuation due to geometrical divergence
Aatm:	the attenuation due to atmospheric absorption
Agr:	the attenuation due to ground effect
Abar:	the attenuation due to a barrier
Amisc:	the attenuation due to miscellaneous other effects
Cmet:	Meteorological correction

Calculation Results

Noise sensitive area: A Ear

WTG **Wind speed: 8.0 m/s**

No.	Distance [m]	Sound distance [m]	Calculated [dB(A)]	LwA,ref [dB(A)]	Dc [dB]	Adiv [dB]	Aatm [dB]	Agr [dB]	Abar [dB]	Amisc [dB]	A [dB]	Cmet [dB]
1	4,836	4,836	**1.29**	94.1	0.00	0.00	-	0.00	0.00	0.00	-	0.00
2	4,834	4,834	**1.29**	94.1	0.00	0.00	-	0.00	0.00	0.00	-	0.00
3	4,835	4,835	**1.29**	94.1	0.00	0.00	-	0.00	0.00	0.00	-	0.00
Sum	6.06											

- Data undefined due to calculation with octave data

Project:
Monhegan Island Noise Calculation 3 miles

Description:
Noise (as sound pressure level) stemming from 3 Northwind 100 wind turbines, spaced 100 meters apart and located ~3 miles (4.8 km) off the eastern shore of Monhegan Island, Maine is determined for a receiver (denoted as human ear) located on the beach, 1.5 meters height above sea level. Atmospheric attenuation corresponds to 500 Hz octave band at a temperature of 10 C and 70% relative humidity (ISO standard)

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DECIBEL - Assumptions for noise calculation

Calculation: Swede land Octave**Noise calculation model:** Swedish, Jan 2002, Land 8.0 m/s

Noise calculation model:
Swedish, Jan 2002, Land
Wind speed:
8.0 m/s
Ground attenuation:
None
Meteorological coefficient, C0:
0.0 dB
Type of demand in calculation:
1: WTG noise is compared to demand (DK, DE, SE, NL etc.)
Noise values in calculation:
All noise values are mean values (Lwa) (Normal)
Rough. Class %d:
0.0 m/s
Pure tones:
Pure tone penalty are added to demand: 5.0 dB(A)
Height above ground level, when no value in NSA object:
1.5 m Don't allow override of model height with height from NSA object
Deviation from "official" noise demands. Negative is more restrictive, positive is less restrictive.:
0.0 dB(A)
Octave data required
Air absorption

63 [db/km]	125 [db/km]	250 [db/km]	500 [db/km]	1,000 [db/km]	2,000 [db/km]	4,000 [db/km]	8,000 [db/km]
0.1	0.3	0.6	1.4	3.2	7.9	22.0	50.0

WTG: Northwind NW100 60Hz 100 21.0 !O!
Noise: Octave data

Source	Source/Date	Creator	Edited
NREL 021003 Noise Test Report	11/9/2010	USER	11/9/2010 2:27 PM

Status	Hub height [m]	Wind speed [m/s]	LwA,ref [dB(A)]	Pure tones	Octave data 63 [dB]	125 [dB]	250 [dB]	500 [dB]	1000 [dB]	2000 [dB]	4000 [dB]	8000 [dB]
From Windcat	37.0	8.0	94.1	No	72.3	78.8	83.1	88.3	90.2	86.4	81.5	7.8

NSA: Ear-A
Predefined calculation standard: Open land
Imission height(a.g.l.): 1.5 m

Noise demand:

6.0 [m/s]	8.0 [m/s]
42.0 dB(A)	44.0 dB(A)

Distance demand: 0.0 m

Project:

Monhegan Island Noise Calculation 3 miles

Description:

Noise (as sound pressure level) stemming from 3 Northwind 100 wind turbines, spaced 100 meters apart and located ~3 miles (4.8 km) off the eastern shore of Monhegan Island, Maine is determined for a receiver (denoted as human ear) located on the beach, 1.5 meters height above sea level. Atmospheric attenuation corresponds to 500 Hz octave band at a temperature of 10 C and 70% relative humidity (ISO standard)

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Calculated:

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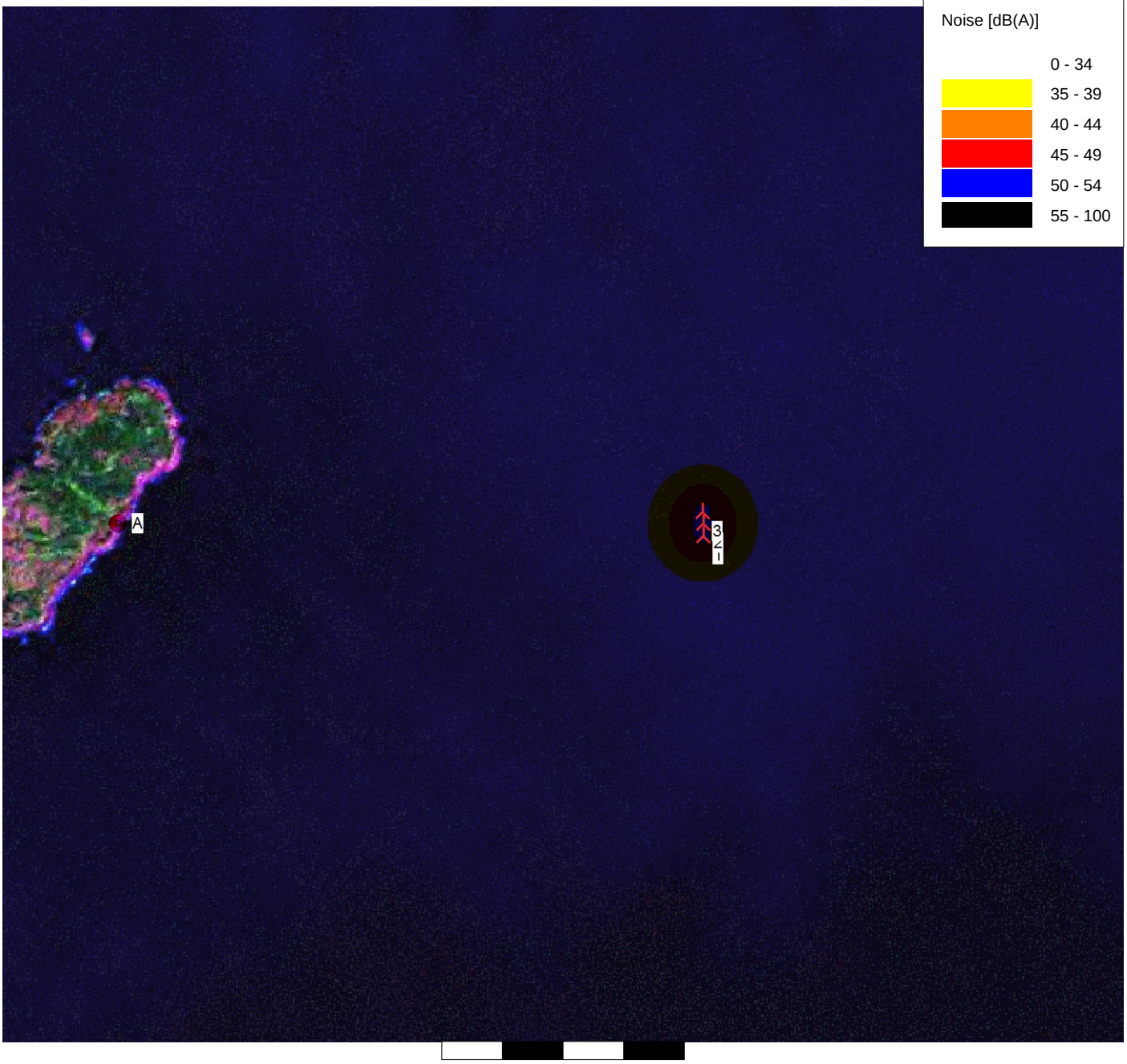
DECIBEL - Map 8.0 m/s

Calculation: Swede land Octave**Noise calculation model:** Swedish, Jan 2002, Land 8.0 m/s



Map: WindPRO map , Print scale 1:50,000, Map center UTM NAD 27 Zone: 19 East: 478,869 North: 4,845,518

Noise calculation model: Swedish, Jan 2002, Land. Wind speed: 8.0 m/s

New WTG Noise sensitive area

Height above sea level: 1.0 m

35.0 dB(A) 40.0 dB(A) 45.0 dB(A) 50.0 dB(A) 55.0 dB(A)

Appendix C

Model Outputs for Swedish Model 6241 for Overwater Propagation

Project:
Monhegan Island Noise Calculation 3 miles

Description:
Noise (as sound pressure level) stemming from 3 Northwind 100 wind turbines, spaced 100 meters apart and located ~3 miles (4.8 km) off the eastern shore of Monhegan Island, Maine is determined for a receiver (denoted as human ear) located on the beach, 1.5 meters height above sea level. Atmospheric attenuation corresponds to 500 Hz octave band at a temperature of 10 C and 70% relative humidity (ISO standard)

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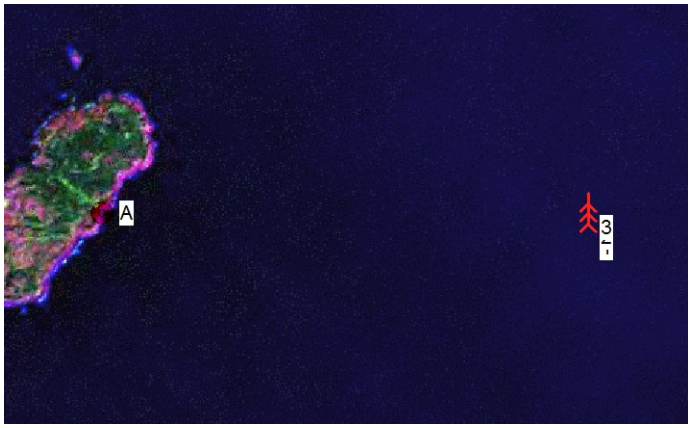
DECIBEL - Main Result

Calculation: Swede Water Octave

SWEDISH RULES FOR NOISE CALCULATION.

The calculation is based on the "Ljud från havsbaserade vindkraftverk", 2001 (ISBN 91-620-6249-2).

K: 1.0 dB/(m/s)



Scale 1:75,000

New WTG Noise sensitive area

WTGs

	UTM NAD27 Zone: 19				WTG type						Noise data						
	East	North	Z	Row data/Description	Valid	Manufact.	Type-generator	Power, rated	Rotor diameter	Hub height	Creator	Name	Wind speed	Hub height	LwA,ref	Pure tones	Octave data
	UTM NAD27 Zone: 19		[m]					[kW]	[m]	[m]			[m/s]	[m]	[dB(A)]		
1	480,086	4,845,413	0.0	-0.3°, 100.0 m	No	Northwind	NW100-100	100	21.0	37.0	USER	Octave data	8.0	37.0	94.1	No	Yes
2	480,085	4,845,513	0.0		No	Northwind	NW100-100	100	21.0	37.0	USER	Octave data	8.0	37.0	94.1	No	Yes
3	480,085	4,845,613	0.0		No	Northwind	NW100-100	100	21.0	37.0	USER	Octave data	8.0	37.0	94.1	No	Yes

Calculation Results

Sound Level

Noise sensitive area		UTM NAD27 Zone: 19				Demands	Sound Level	Demands fulfilled ?
No.	Name	East	North	Z [m]	Imission height [m]	Noise [dB(A)]	From WTGs [dB(A)]	Noise
A	Ear	475,251	4,845,510	1.5	1.5	44.0	21.9	Yes

Distances (m)

WTG	A
1	4836
2	4834
3	4835

Project:
Monhegan Island Noise Calculation 3 miles

Description:
Noise (as sound pressure level) stemming from 3 Northwind 100 wind turbines, spaced 100 meters apart and located ~3 miles (4.8 km) off the eastern shore of Monhegan Island, Maine is determined for a receiver (denoted as human ear) located on the beach, 1.5 meters height above sea level. Atmospheric attenuation corresponds to 500 Hz octave band at a temperature of 10 C and 70% relative humidity (ISO standard)

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DECIBEL - Detailed results

Calculation: Swede Water Octave **Noise calculation model:** Swedish, Jan 2002, Water 8.0 m/s

Assumptions

Calculated L(DW) = LWA,ref + K + Dc - (Adiv + Aatm + Agr + Abar + Amisc) - Cmet
(when calculated with ground attenuation, then Dc = Domega)

LWA,ref:	Sound pressure level at WTG
K:	Pure tone
Dc:	Directivity correction
Adiv:	the attenuation due to geometrical divergence
Aatm:	the attenuation due to atmospheric absorption
Agr:	the attenuation due to ground effect
Abar:	the attenuation due to a barrier
Amisc:	the attenuation due to miscellaneous other effects
Cmet:	Meteorological correction

Calculation Results

Noise sensitive area: A Ear

WTG **Wind speed: 8.0 m/s**

No.	Distance [m]	Sound distance [m]	Calculated [dB(A)]	LwA,ref [dB(A)]	Dc [dB]	Adiv [dB]	Aatm [dB]	Agr [dB]	Abar [dB]	Amisc [dB]	A [dB]	Cmet [dB]
1	4,836	4,836	**17.12**	94.1	0.00	0.00	-	0.00	0.00	0.00	-	0.00
2	4,834	4,834	**17.13**	94.1	0.00	0.00	-	0.00	0.00	0.00	-	0.00
3	4,835	4,835	**17.12**	94.1	0.00	0.00	-	0.00	0.00	0.00	-	0.00

Sum 21.89

- Data undefined due to calculation with octave data

Project:
Monhegan Island Noise Calculation 3 miles

Description:
Noise (as sound pressure level) stemming from 3 Northwind 100 wind turbines, spaced 100 meters apart and located ~3 miles (4.8 km) off the eastern shore of Monhegan Island, Maine is determined for a receiver (denoted as human ear) located on the beach, 1.5 meters height above sea level. Atmospheric attenuation corresponds to 500 Hz octave band at a temperature of 10 C and 70% relative humidity (ISO standard)

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DECIBEL - Assumptions for noise calculation

Calculation: Swede Water Octave **Noise calculation model:** Swedish, Jan 2002, Water 8.0 m/s

Noise calculation model:
Swedish, Jan 2002, Water
Wind speed:
8.0 m/s
Ground attenuation:
None
Meteorological coefficient, C0:
0.0 dB
Type of demand in calculation:
1: WTG noise is compared to demand (DK, DE, SE, NL etc.)
Noise values in calculation:
All noise values are mean values (Lwa) (Normal)
Pure tones:
Pure tone penalty are added to demand: 5.0 dB(A)
Height above ground level, when no value in NSA object:
1.5 m Don't allow override of model height with height from NSA object
Deviation from "official" noise demands. Negative is more restrictive, positive is less restrictive.:
0.0 dB(A)
Octave data required
Air absorption

63 [db/km]	125 [db/km]	250 [db/km]	500 [db/km]	1,000 [db/km]	2,000 [db/km]	4,000 [db/km]	8,000 [db/km]
0.1	0.3	0.6	1.4	3.2	7.9	22.0	50.0

WTG: Northwind NW100 60Hz 100 21.0 !O!
Noise: Octave data

Source	Source/Date	Creator	Edited
NREL 021003 Noise Test Report	11/9/2010	USER	11/9/2010 2:27 PM

					Octave data							
Status	Hub height [m]	Wind speed [m/s]	LwA,ref [dB(A)]	Pure tones	63 [dB]	125 [dB]	250 [dB]	500 [dB]	1000 [dB]	2000 [dB]	4000 [dB]	8000 [dB]
From Windcat	37.0	8.0	94.1	No	72.3	78.8	83.1	88.3	90.2	86.4	81.5	7.8

NSA: Ear-A
Predefined calculation standard: Open land
Imission height(a.g.l.): 1.5 m

Noise demand:

6.0 [m/s]	8.0 [m/s]
42.0 dB(A)	44.0 dB(A)

Distance demand: 0.0 m

Project:
Monhegan Island Noise Calculation 3 miles

Description:
Noise (as sound pressure level) stemming from 3 Northwind 100 wind turbines, spaced 100 meters apart and located ~3 miles (4.8 km) off the eastern shore of Monhegan Island, Maine is determined for a receiver (denoted as human ear) located on the beach, 1.5 meters height above sea level. Atmospheric attenuation corresponds to 500 Hz octave band at a temperature of 10 C and 70% relative humidity (ISO standard)

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Calculated:
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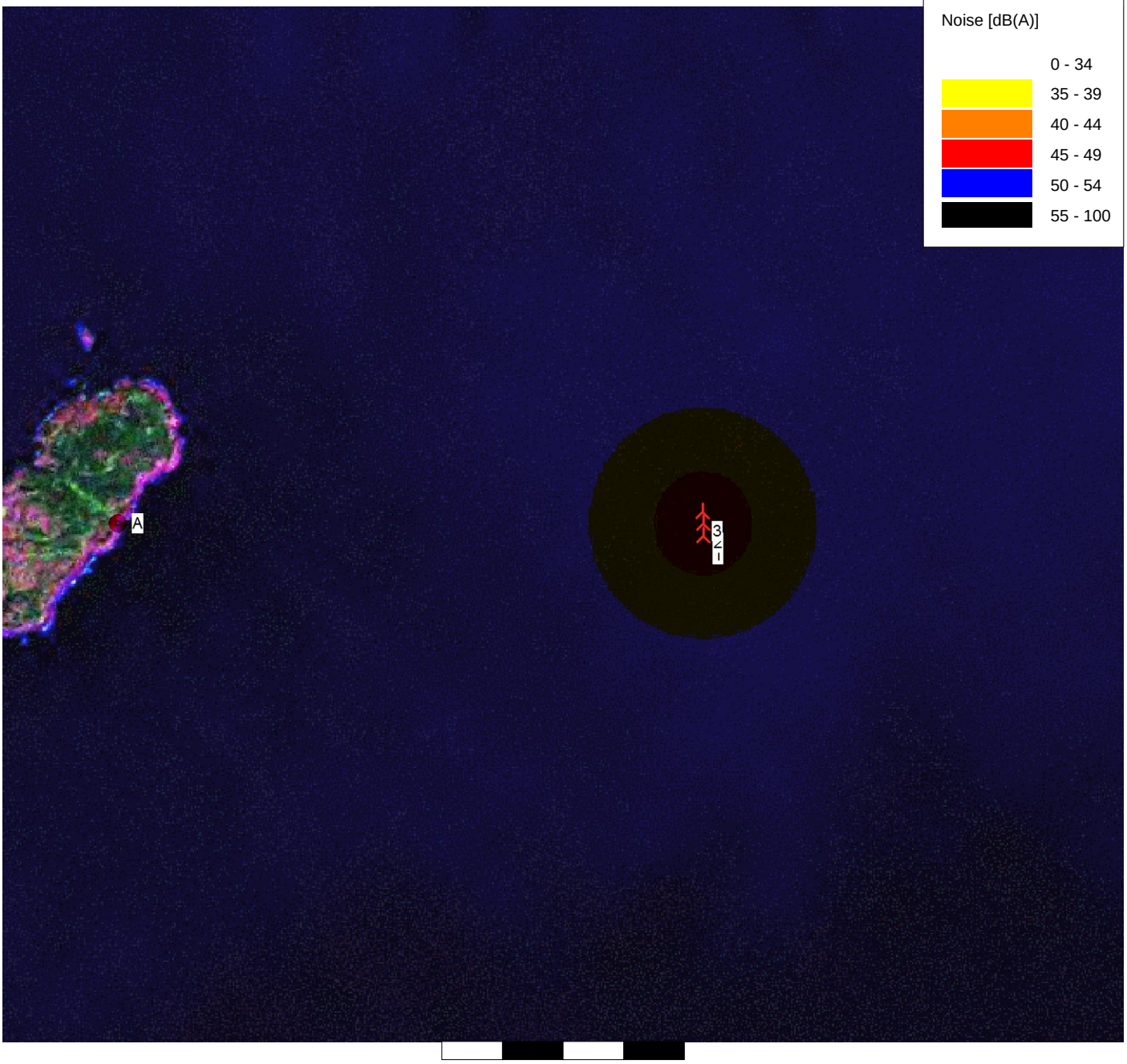
DECIBEL - Map 8.0 m/s

Calculation: Swede Water Octave **Noise calculation model:** Swedish, Jan 2002, Water 8.0 m/s



Map: WindPRO map , Print scale 1:50,000, Map center UTM NAD 27 Zone: 19 East: 478,869 North: 4,845,518
Noise calculation model: Swedish, Jan 2002, Water. Wind speed: 8.0 m/s

New WTG Noise sensitive area

Height above sea level: 1.0 m

35.0 dB(A) 40.0 dB(A) 45.0 dB(A) 50.0 dB(A) 55.0 dB(A)

Project:
Monhegan Island Noise Calculation 3 miles

Description:
Noise (as sound pressure level) stemming from 3 Northwind 100 wind turbines, spaced 100 meters apart and located ~3 miles (4.8 km) off the eastern shore of Monhegan Island, Maine is determined for a receiver (denoted as human ear) located on the beach, 1.5 meters height above sea level. Atmospheric attenuation corresponds to 500 Hz octave band at a temperature of 10 C and 70% relative humidity (ISO standard)

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Calculated:
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DECIBEL - Main Result

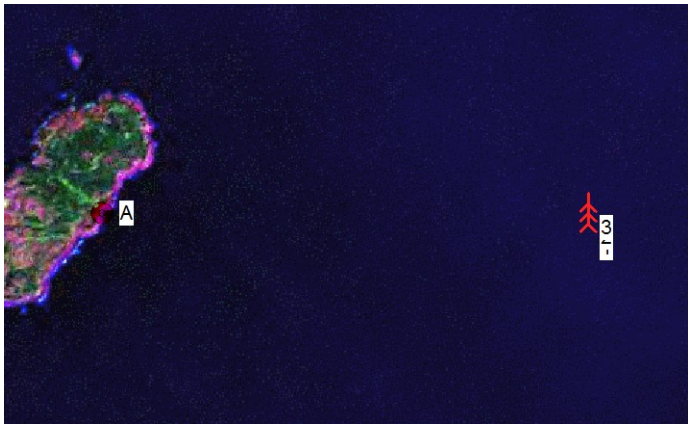
Calculation: Swede water for 13 m/sec forced

SWEDISH RULES FOR NOISE CALCULATION.

The calculation is based on the "Ljud från havsbaserade vindkraftverk", 2001 (ISBN 91-620-6249-2).

K: 1.0 dB/(m/s)

NOTICE
Octave data for one or more WTGs are missing. Generic values are used.



Scale 1:75,000

New WTG Noise sensitive area

WTGs

	UTM NAD27 Zone: 19				WTG type						Noise data						
	East	North	Z	Row data/Description	Valid	Manufact.	Type-generator	Power, rated	Rotor diameter	Hub height	Creator	Name	Wind speed	Hub height	LwA,ref	Pure tones	Octave data
	UTM NAD27 Zone: 19		[m]					[kW]	[m]	[m]			[m/s]	[m]	[dB(A)]		
1	480,086	4,845,413	0.0	-0.3°, 100.0 m	No	Northwind	NW100-100	100	21.0	37.0	USER	Wind speed data	8.0	37.0	100.7	No	Generic *)
2	480,085	4,845,513	0.0		No	Northwind	NW100-100	100	21.0	37.0	USER	Wind speed data	8.0	37.0	100.7	No	Generic *)
3	480,085	4,845,613	0.0		No	Northwind	NW100-100	100	21.0	37.0	USER	Wind speed data	8.0	37.0	100.7	No	Generic *)

***)Notice: One or more noise data for this WTG is generic or input by user**

Calculation Results

Sound Level

Noise sensitive area		UTM NAD27 Zone: 19				Demands	Sound Level	Demands fulfilled ?
No.	Name	East	North	Z	Imission height	Noise	From WTGs	Noise
				[m]	[m]	[dB(A)]	[dB(A)]	
A	Ear	475,251	4,845,510	1.5	1.5	44.0	30.6	Yes

Distances (m)

WTG	A
1	4836
2	4834
3	4835

Project:
Monhegan Island Noise Calculation 3 miles

Description:
Noise (as sound pressure level) stemming from 3 Northwind 100 wind turbines, spaced 100 meters apart and located ~3 miles (4.8 km) off the eastern shore of Monhegan Island, Maine is determined for a receiver (denoted as human ear) located on the beach, 1.5 meters height above sea level. Atmospheric attenuation corresponds to 500 Hz octave band at a temperature of 10 C and 70% relative humidity (ISO standard)

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Calculated:
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DECIBEL - Detailed results

Calculation: Swede water for 13 m/sec forced**Noise calculation model:** Swedish, Jan 2002, Water 8.0 m/s

Assumptions

Calculated L(DW) = LWA,ref + K + Dc - (Adiv + Aatm + Agr + Abar + Amisc) - Cmet
(when calculated with ground attenuation, then Dc = Domega)

LWA,ref:	Sound pressure level at WTG
K:	Pure tone
Dc:	Directivity correction
Adiv:	the attenuation due to geometrical divergence
Aatm:	the attenuation due to atmospheric absorption
Agr:	the attenuation due to ground effect
Abar:	the attenuation due to a barrier
Amisc:	the attenuation due to miscellaneous other effects
Cmet:	Meteorological correction

Calculation Results

Noise sensitive area: A Ear

WTG **Wind speed: 8.0 m/s**

No.	Distance [m]	Sound distance [m]	Calculated [dB(A)]	LwA,ref [dB(A)]	Dc [dB]	Adiv [dB]	Aatm [dB]	Agr [dB]	Abar [dB]	Amisc [dB]	A [dB]	Cmet [dB]
1	4,836	4,836	**25.78**	100.7	0.00	0.00	-	0.00	0.00	0.00	-	0.00
2	4,834	4,834	**25.78**	100.7	0.00	0.00	-	0.00	0.00	0.00	-	0.00
3	4,835	4,835	**25.78**	100.7	0.00	0.00	-	0.00	0.00	0.00	-	0.00

Sum 30.55

- Data undefined due to calculation with octave data

Project:
Monhegan Island Noise Calculation 3 miles

Description:
Noise (as sound pressure level) stemming from 3 Northwind 100 wind turbines, spaced 100 meters apart and located ~3 miles (4.8 km) off the eastern shore of Monhegan Island, Maine is determined for a receiver (denoted as human ear) located on the beach, 1.5 meters height above sea level. Atmospheric attenuation corresponds to 500 Hz octave band at a temperature of 10 C and 70% relative humidity (ISO standard)

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Calculated:
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DECIBEL - Assumptions for noise calculation

Calculation: Swede water for 13 m/sec forced**Noise calculation model:** Swedish, Jan 2002, Water 8.0 m/s

Noise calculation model:
Swedish, Jan 2002, Water
Wind speed:
8.0 m/s
Ground attenuation:
None
Meteorological coefficient, C0:
0.0 dB
Type of demand in calculation:
1: WTG noise is compared to demand (DK, DE, SE, NL etc.)
Noise values in calculation:
All noise values are mean values (Lwa) (Normal)
Pure tones:
Pure tone penalty are added to demand: 5.0 dB(A)
Height above ground level, when no value in NSA object:
1.5 m Don't allow override of model height with height from NSA object
Deviation from "official" noise demands. Negative is more restrictive, positive is less restrictive.:
0.0 dB(A)
Octave data required
Air absorption

63 [db/km]	125 [db/km]	250 [db/km]	500 [db/km]	1,000 [db/km]	2,000 [db/km]	4,000 [db/km]	8,000 [db/km]
0.1	0.3	0.6	1.4	3.2	7.9	22.0	50.0

WTG: Northwind NW100 60Hz 100 21.0 !O!
Noise: Wind speed data

Source	Source/Date	Creator	Edited
NREL 021003	11/9/2010	USER	11/10/2010 11:31 AM

						Octave data							
Status	Hub height [m]	Wind speed [m/s]	LwA,ref [dB(A)]	Pure tones		63 [dB]	125 [dB]	250 [dB]	500 [dB]	1000 [dB]	2000 [dB]	4000 [dB]	8000 [dB]
From Windcat	37.0	8.0	100.7	No	Generic data	82.3	89.3	92.7	95.3	95.1	92.2	87.4	77.9

NSA: Ear-A
Predefined calculation standard: Open land
Imission height(a.g.l.): 1.5 m

Noise demand:

6.0 [m/s]	8.0 [m/s]
42.0 dB(A)	44.0 dB(A)

Distance demand: 0.0 m

Project:
Monhegan Island Noise Calculation 3 miles

Description:
Noise (as sound pressure level) stemming from 3 Northwind 100 wind turbines, spaced 100 meters apart and located ~3 miles (4.8 km) off the eastern shore of Monhegan Island, Maine is determined for a receiver (denoted as human ear) located on the beach, 1.5 meters height above sea level. Atmospheric attenuation corresponds to 500 Hz octave band at a temperature of 10 C and 70% relative humidity (ISO standard)

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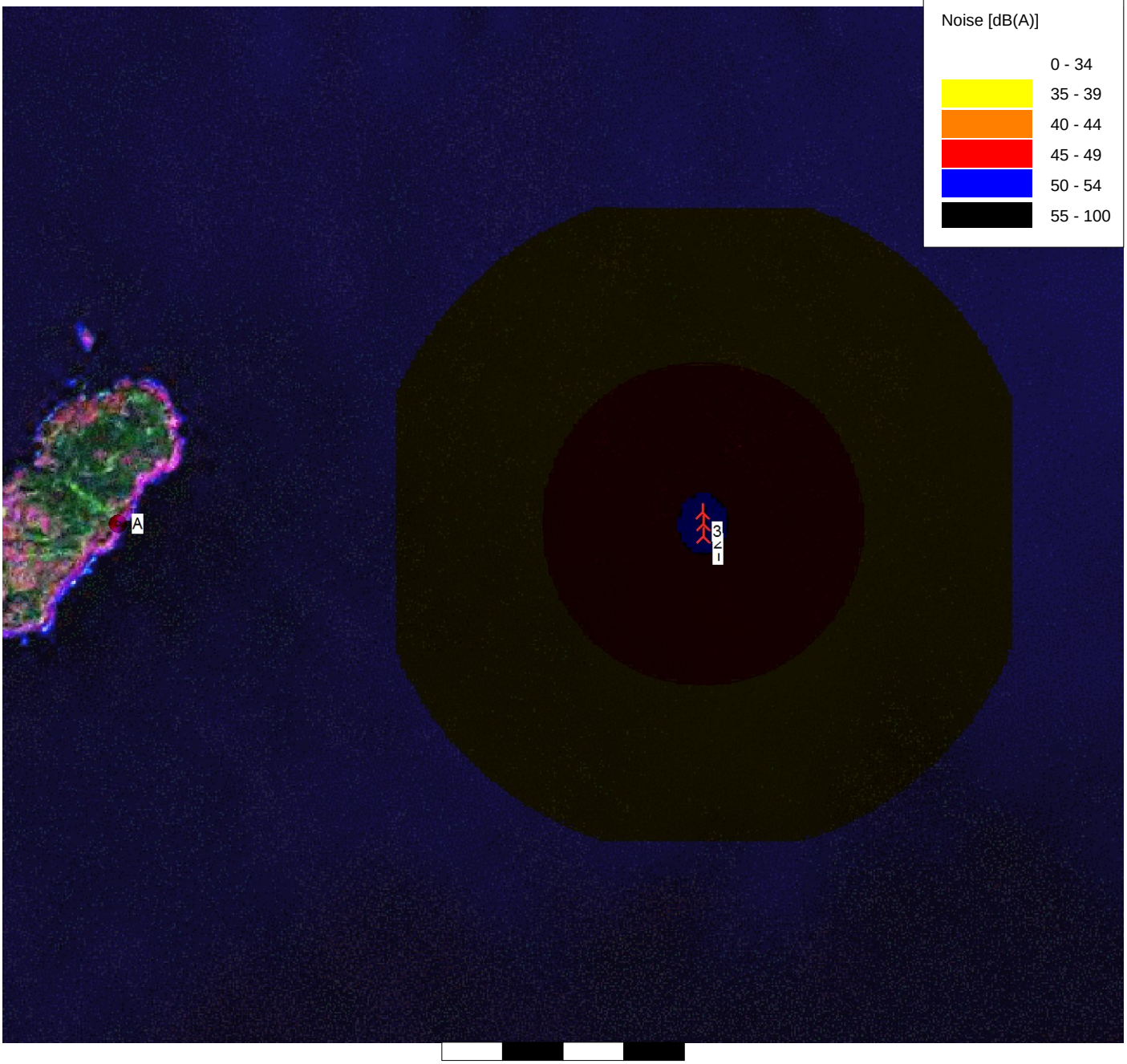
DECIBEL - Map 8.0 m/s

Calculation: Swede water for 13 m/sec forced**Noise calculation model:** Swedish, Jan 2002, Water 8.0 m/s



Map: WindPRO map , Print scale 1:50,000, Map center UTM NAD 27 Zone: 19 East: 478,869 North: 4,845,518
Noise calculation model: Swedish, Jan 2002, Water. Wind speed: 8.0 m/s

New WTG Noise sensitive area

Height above sea level: 1.0 m

35.0 dB(A) 40.0 dB(A) 45.0 dB(A) 50.0 dB(A) 55.0 dB(A)

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