Project report

Suurhiekka wind farm

Calculation of noise from wind turbines

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Suurhiekka wind farm

Calculation of noise from wind turbines

Client: WPD Finland Oy

Tapiolan Keskustorni
FIN-02100 Espoo
Finland
Tel:

Commission: Calculation for three layouts of sound immission from the planned Suurhiekka wind farm with the calculation model Nord 2000.

Summary: Calculations of the sound immission from the planned wind farm Suurhiekka are performed with the Nordic prediction model Nord 2000. Nord 2000 gives a result with greater accuracy than the model developed by the Swedish Naturvårdsverket and Boverket which can be used for planning purposes. The result is presented as noise maps and is within the swedish guding value 40 dB(A).

Responsible:	**QA responsible:**
Paul Appelqvist	Martin Almgren

Contents

1. Calculation of sound from Surrhiekka Wind Farm

1.1. Background

On commission by WPD Finland Oy calculations of the sound immission from Suurhiekka wind farm, Finland, are performed. These calculations are executed with the Nordic prediction model Nord 2000, Delta, av 1719/01, 2002, according to assumptions in the Swedish guidelines regarding wind turbine noise. As software SoundPlan 6.4 is used.

Nord 2000 is a calculation modell developed in a joint project between the Nordic countries. Nord 2000 considers the influence of wind, temperature, ground absorbtion and screening. It is also possible to choose different wind speed and temperature gradients. Nord 2000 is suitable for calculations over hilly terrain as it takes varying topography in to account. It also takes in to consideration the acoustic characteristics of water and hence is appropriate for calculation of sound propagating over water.

Calculations are performed for three layouts of the wind farm according to data delivered in e-mail by the client. The layouts are described briefly below and are presented graphically in the noise maps, see chapter 1.3.

Layout - 120 REpower 5 MW:. 120 wind turbines of model REpower 5 MW with a sound emission óf L_w=107 dBA and hub height 100 m. Frequency spectra of the sound emission is presented in table 1.

Layout - 80 REpower 5 MW:. 80 wind turbines of model REpower 5 MW with a sound emission of L_w=107 dBA ánd hub height 100 m. Frequency spectra of the sound emission is presented in table 1.

Layout - 95 SWT 5 MW:. 95 wind turbines of model Siemens 3.6 MW with a sound emission of L_w=107 dBA ánd hub height 100 m. Frequency spectra of the sound emission is presented in table 1.

1.2. Input

- For calculations in Nord 2000 air humidity RH 70 %, temperature 15° C and air pressure 1013 mbar are assumed.

- The geografic model in SoundPlan is build out of digital maps containing ground heights, delivered by the client. The calculation height is 2 m above sea surface.

- Roughness length z0 is assigned as 0.055 according to the defintion in ”Ljud från vindkraftverk, Naturvårdsverkets rapport 6241”. Areas of water are in Nord 2000 defined through the effective flow resistance, which for water is class G, hard area.

- The sound emission has been given in 1/3 octave band spectrum for all wind turbines and is presented in tabel 1. These data are taken from our database. Nord 2000 considers both low and high frequencies and their influence on the propagation of sound.

Tabel 1. 1/3-octave band spectrum of the emission sound level

1/3-octave band frequencies	REpower 5 MW L_W=107 dB(A)	Siemens 3.6 MW L_W=107 dB(A
25Hz	66	66,45946
31Hz	70,6	69,55946
40Hz	76,1	74,65945
50Hz	79,1	79,25946
63Hz	82,5	82,75946
80Hz	85,8	86,25946
100Hz	89,2	89,55946
125Hz	92,8	91,95946
160Hz	95,6	93,45946
200Hz	95,5	94,35946
250Hz	97,9	97,05946
315Hz	98,8	96,65945
400Hz	97	95,25946
500Hz	97,5	95,35946
630Hz	95,2	94,15945
800Hz	94,2	95,55946
1kHz	93,4	94,65945
1.25kHz	93	96,15945
1.6kHz	92,7	95,05946

2kHz	91,5	93,95946
2.5kHz	89,9	93,75946
3.15kHz	86,8	92,15945
4kHz	82,4	90,75946
5kHz	77,8	87,75946
6.3kHz	73,9	85,85946
8kHz	70,5	82,75946
10kHz		80,75946

1.3. Result

The result is presented as noise maps as shown in figure 1. Detailed maps are presented in appendix A01-A06. In appendix A01-A03 the result is shown as color fields in steps of 5-dB and in appendix A04-A06 as ISO-lines in steps of i 5-dB.

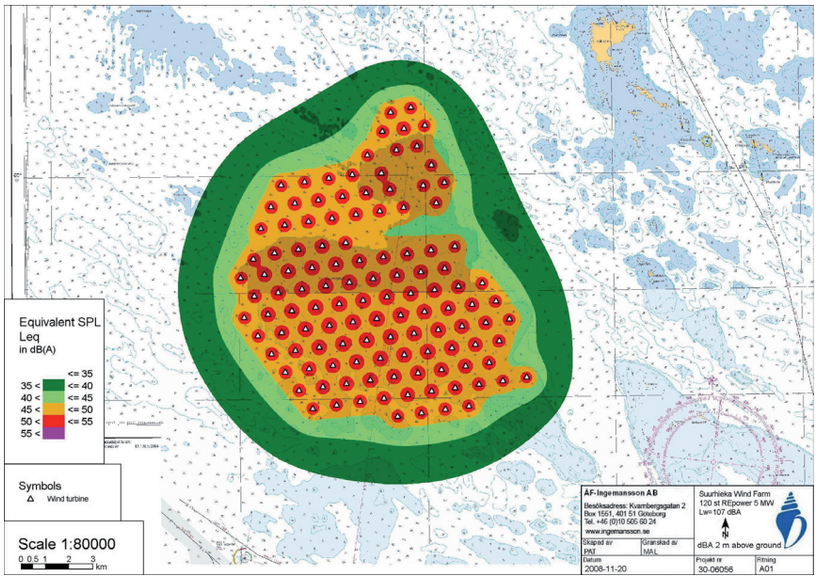


Figure 1. Noise map showing one layout of the wind farm.

2. Comments to the result

2.1.1. Sound propagating over water

In the calculations the Nordic prediction model Nord 2000 has been used in stead of the calculation model recommended by Naturvådsverket and Boverket in Sweden. This choice is commented below.

Naturvårdsverket, Boverket and Energimyndigheten in Sweden assigns in report rapport 6241 ”Ljud från vindkraftverk” från december 2001, that sound immission from wind turbines shall be calculated with a specfic calculation model regarding sound propagating over water. This model is based on the presensce of so called ”low level jets” (Lisa Johansson “Sound propagation around off-shore wind turbines.

Long-range parabolic equation calculations for Baltic Sea conditions" KTH, meddelande nr 192, Stockholm 2003.)

The model for offshore wind farms as given by Naturvårdsverket has not been verified sufficiently. In the report is stated that: "For offshore wind farms a preliminary prediction model is used which primarly is intended for long distances" and further: "There are no theoretically correct calculations models that are validated against measurements for more than a couple of hundred meters. Because of the absence of such models the immission level is calculated in the following way (the model is based on a few sets of measurements series from Sweden, Denmark and Holland). This calculation model gives an upper value of the sound immission"

In Naturvårdsverkets external referral on wind turbine noise from 2006, the direction to the calculation model is removed.

The presumption of the model is according to the report: "There are times although with seldom occurance, when the wind speed is low or very low at ground level and at the same time the wind speed at hub height is several times higher. This more predominant wind speed gradient could also be amplified by presence of low level jets, which are wind maximums in the lowest hundred meters.

At the Royal Institue of Technology a researce program is conducted with measurements on the propagation of sound over sea in Kalmarsund. Wind speed and temperature gradients have been measured at the same time. The measurements were performed between june 2005 and june 2006 at downwind conditions. The measurements shows that the transition between spherical and cylindrical propagation occur at 700 m instead of the previously assumed 200 m (Mats Åbom och Mathieu Boué, "Long-range sound propagation over the sea with application to wind turbine noise", Proceedings Wind Turbine Noise 2007, Lyon). This indicates that the extreme situation, which is the basis for the offshore model provided by Naturvårdsverket, seldom occurs.

Calculations based on Nord 2000, downwind conditions at 8 m/s, hard surface (water) shows good agrement with the land based model according to Naturvårdsverket. That model on the other hand shows good agreement with calculations models used in other countries for example ISO 9613-2 which is used in many countries for offshore wind farms.

To sum up our assessment is that Naturvårdsverkets model for offshore wind farms is based on a rare meteorological situation. Our recommendation is that calculations should be performed with hard surface (water) and wind speed corresponding to 8 m/s at 10 m height should. In our calculations we call these case constant wind speed at 10 m height. The calculation model used is the Nordic prediction model Nord 2000.

2.1.2. Masking of wind turbine noise

Sound from wind turbines has broadbanded characteristics and many similarities with natural background sounds as wind induced sound in vegetation and sound from breaking waves. The consequence of this is that under the right circumstances sound from wind turbines is masked by natural background sound. In several countries for example England and Austrailia this masking effect is considered in the guidelines regarding wind turbine noise. The main principle in these guidelines is

that when the background sound has a high sound level a higher level of wind turbine sound is allowed. In Sweden the masking effect is proposed in Naturvårdsverkets external referral on wind turbine noise from 2006. Here a higher guiding value of up to 5 dBA is allowed if the condition of masking from natural background sources can be proved.

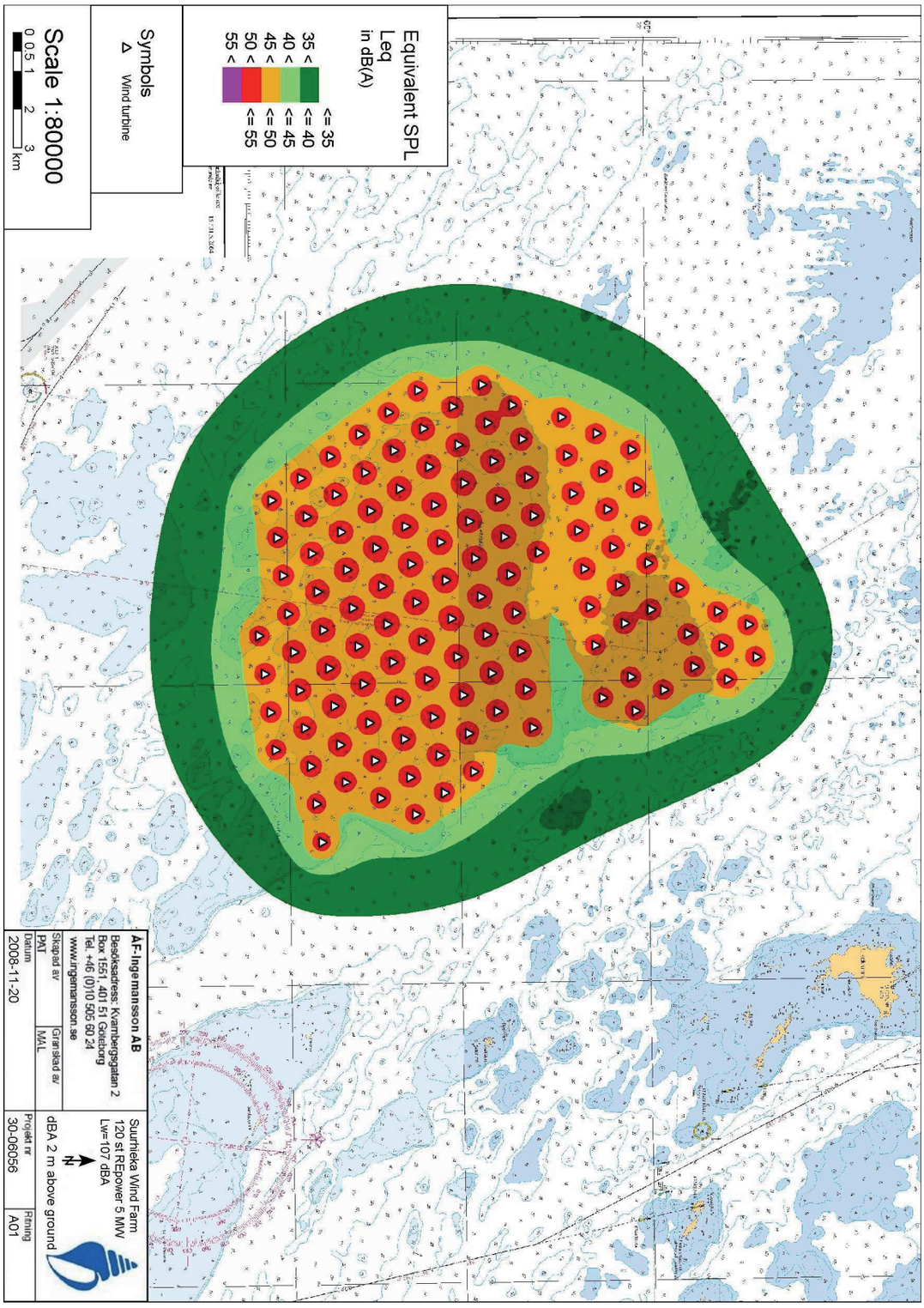
An extensive study on the masking effect from sea waves has been performed which shows good masking potential on wind turbine sound (P.Appelqvist, ”Maskering av vindkraftljud vis naturligt bakgrundsljud – särskillt havsbrus.”, KTH, TRITA-AVE 2006:100). The result has also been presented on several conferences among them Wind Turbine Noise 2007 i Lyon (P. Appelqvist, M. Almgren, K. Bolin, M. Åbom, ” Masking of wind turbine noise by sea waves”, Proceedings Wind Turbine Noise 2007, Lyon).

Our conclusion is that for the planned Suurhiekka wind farm the conditions regarding masking from sea waves are good.

3. Conclusion

Our assesment is that for Suurhiekka wind farm the prediction model Nord 2000 gives a more reliable result than the prescribed modell by Naturvårdsverket. The calculations are presented as noise maps and are suitable for the process of permits. All layouts are within Naturvådsverkets guiding value 40 dB(A)

4. Appendix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km
ÅF-Ingemansson AB
Besöksadress: Kvarnbergsgatan 2
Box 1551, 401 51 Göteborg
Tel. +46 (0)10 505 60 24
www.ingemansson.se
Skapad av
PAT
Granskad av
MAL
Datum
2008-11-20
Surhieka Wind Farm
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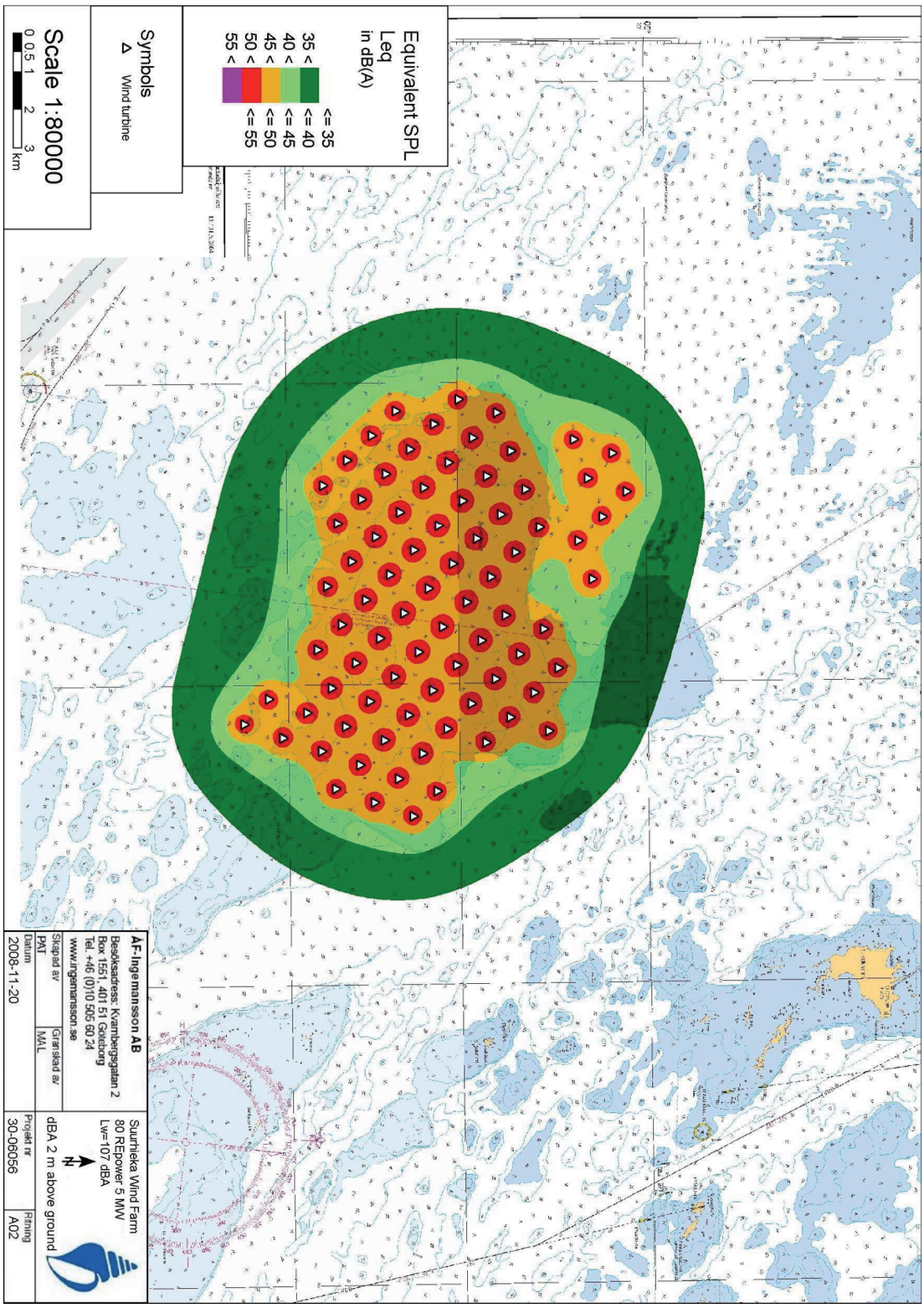
Lw=107 dBA
dBA 2 m above ground
Projekt nr
30-06056
Ritning
A01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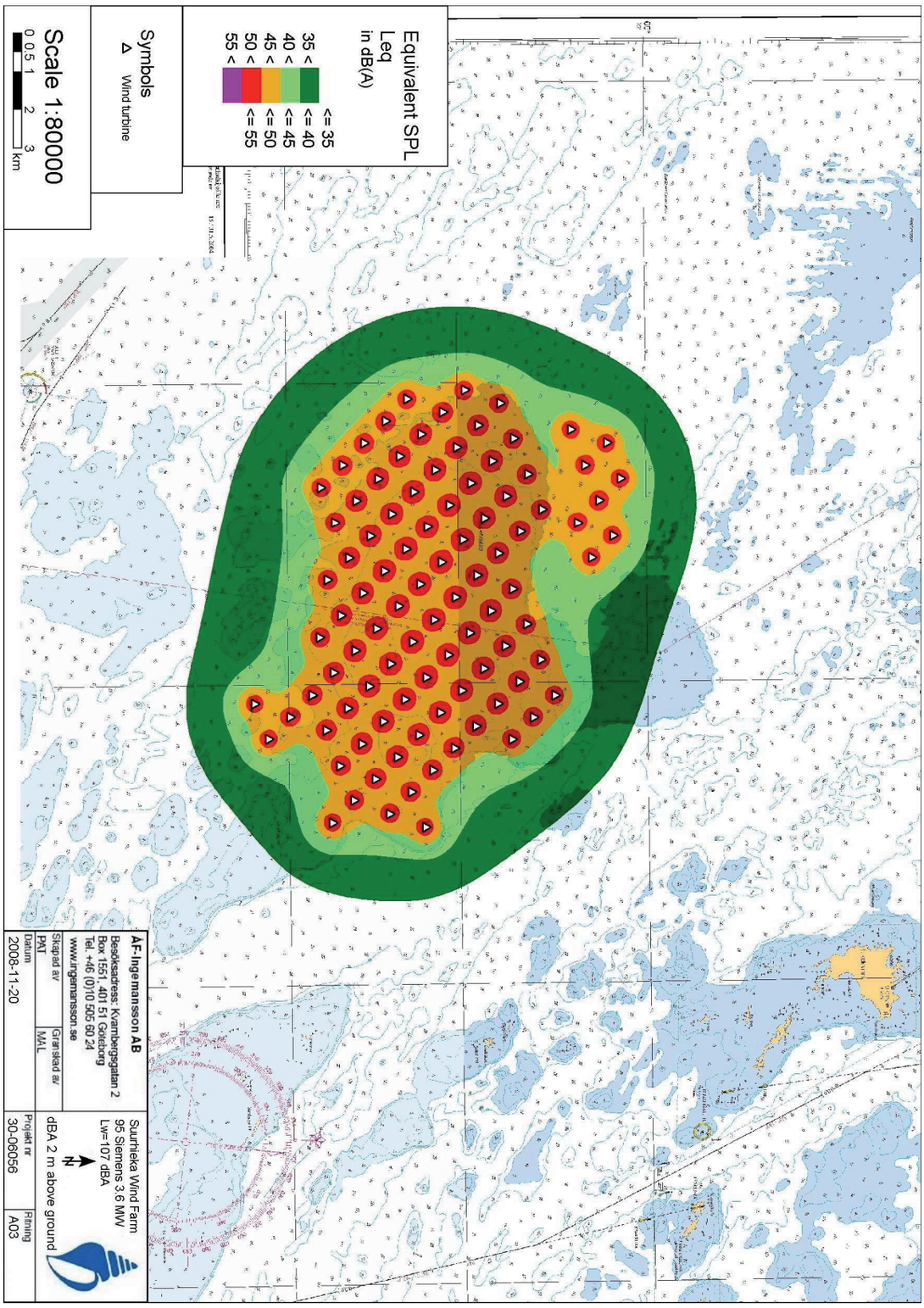
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dBA 2 m above ground
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30-06056
Ritning
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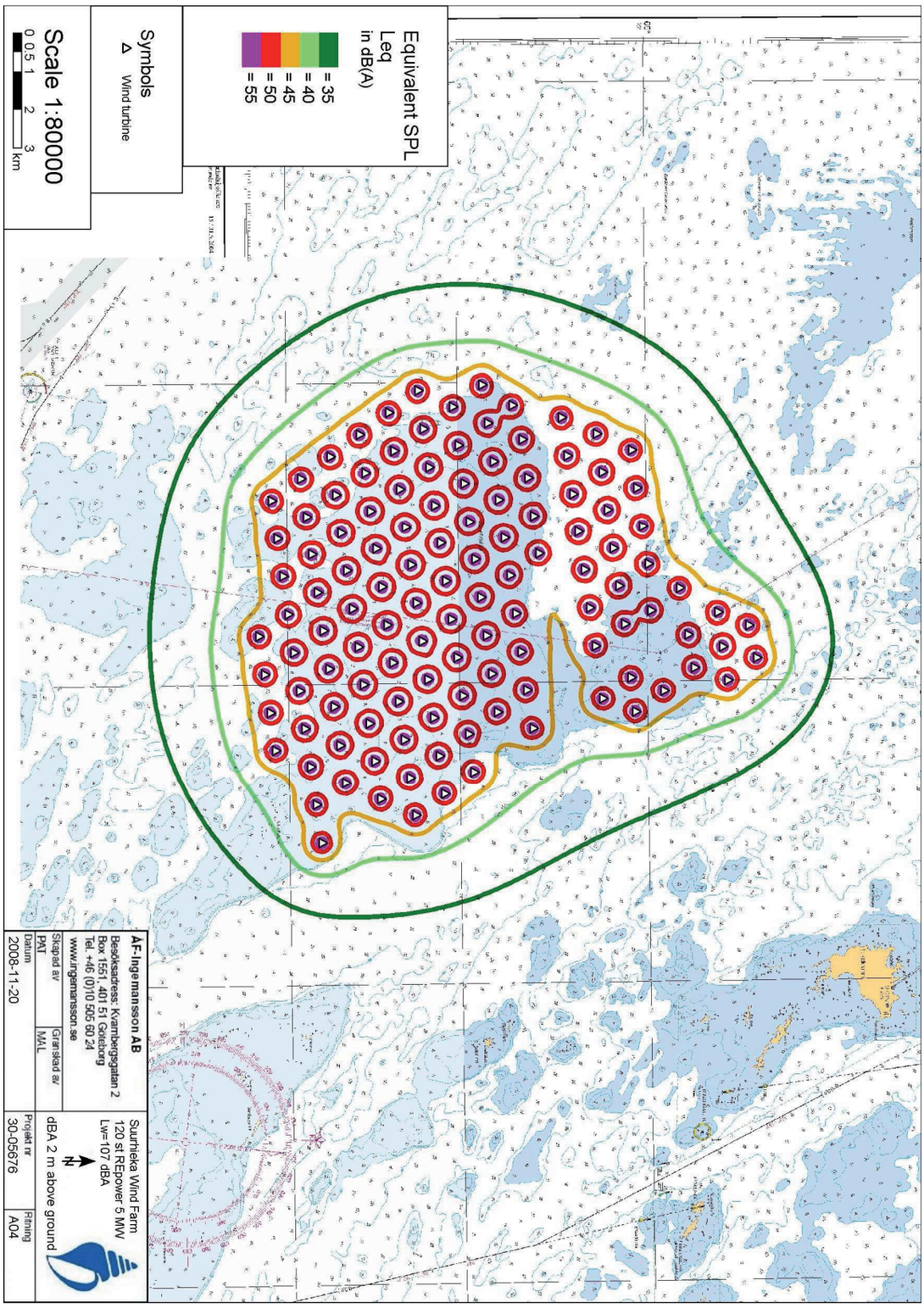
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dBA 2 m above ground
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Ritning
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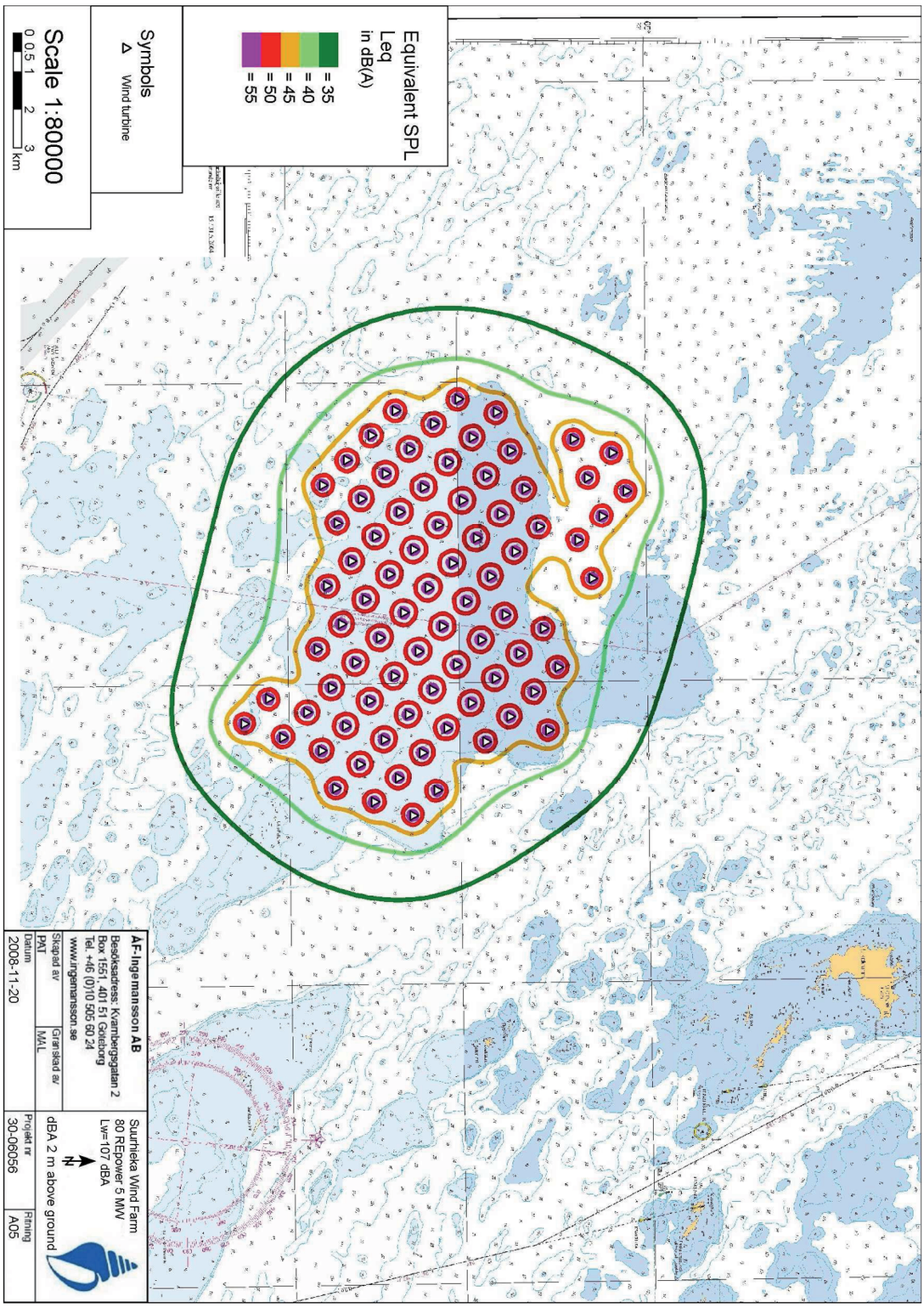
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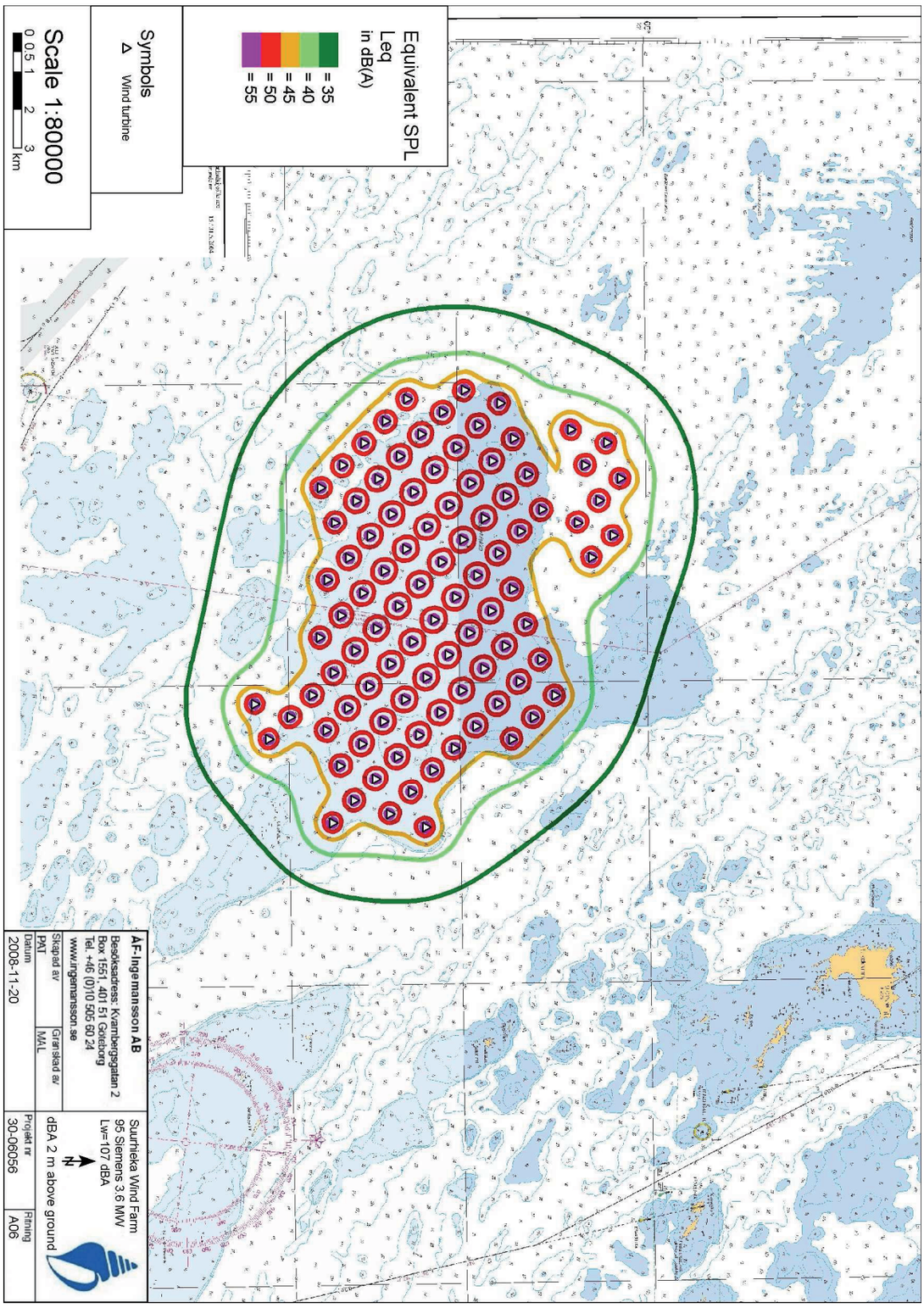
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