NordFoU: External Influences on Spray Patterns (EPAS)

Report 16: Wind exposure on the test road at Bygholm

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ABSTRACT

The purpose of this study was to estimate how much time that is available for outdoor testing under acceptable wind conditions. It is generally assumed that maximum acceptable wind speed close to the road surface should not exceed 1.0 m/s during testing.

Two years of wind data from a local weather station is analyzed. During winter the salt spreading equipment is either in use or on stand-by. For testing purposes it was therefore decided to focus on wind data that was recorded during summer days from May through September.

The month with best chances of getting calm weather was August. It was found that August had 40% more time with calm weather compared with June.

One of the main obstacle to outdoor testing turned out to be the variation in time with calm weather during the day. In average the time suitable for testing was low during working hours with an average of only 7 minutes per hour from 8 in the morning to 16 in the afternoon. The use of a wind net to the south of the test road is estimated to nearly double the testing time available, but still this is at a very low level. The best time to be considered for testing was from midnight to 6 in the morning when the wind speed is not exceeding 1.0 m/s would occur more than 35 minutes per hour in average.

The other obstacle to outdoor testing was that winds parallel to the test road was recorded for 74% of the time. Techniques to reduce wind speed in these directions without disturbing the drive-through capability are not straight forward. Considerable gain in available testing time could be achieved if successful methods are developed.

The limit of maximum acceptable wind speed close to the road surface of 1.0 m/s may be questioned. Observations indicate the cross winds is more distorting for performance data of salt spreading equipment than parallel winds. More information is needed to make an informed decision on acceptable wind speeds and direction.

INTRODUCTION

Testing of salt spreaders is traditionally performed in the spreading hall at Bygholm. For future tests of salt spreaders it is a goal to establish a high speed testing procedure where the salt is spread at the same driving speed as on public roads. Such high speed tests are in principle possible at the test road at Bygholm. The main problem is to get performance data for the salt spreading equipment that is not distorted by wind.

Wind statistics was used to estimate which wind directions, which month and at which hours during the day outdoor testing is possible. In this report two years wind data from a local weather station is analyzed. During winter the salt spreading equipment is either in use or on stand-by. For testing purposes it was therefore decided to focus on wind recorded during summer days from May through September

For cross winds it is possible to use wind-breaking nets. This will reduce the wind velocities close to the road and thus increase periods suitable for testing. Special attention is given to southerly winds (SE to SW) in order to evaluate the advantage of placing a wind breaking net along the south side of the test road.

The purpose of this study is to provide information of how much time is available for outdoor testing under acceptable wind conditions. It is generally assumed that the maximum acceptable wind speed close to the road surface should not exceed 1.0 m/s (CEN/TC 337).

METHOD

The test road at Engineering Centre Bygholm is 800 m long and 10 m wide. It is oriented east-west. In these directions the surroundings are open land. To the south there is a belt with low grass and trees and buildings at a distance of about 50 m. To the north the terrain is characterized by a field with high grass and woodland at a distance of about 150 m.

A picture of the test road is shown in figure 1 with the spreading hall in the back ground and the local weather station to the right. The local weather station is placed half ways between the ends of the test road 2m to the south of the road side. Wind was measured with an ultrasonic sensor placed at a height of 4 m

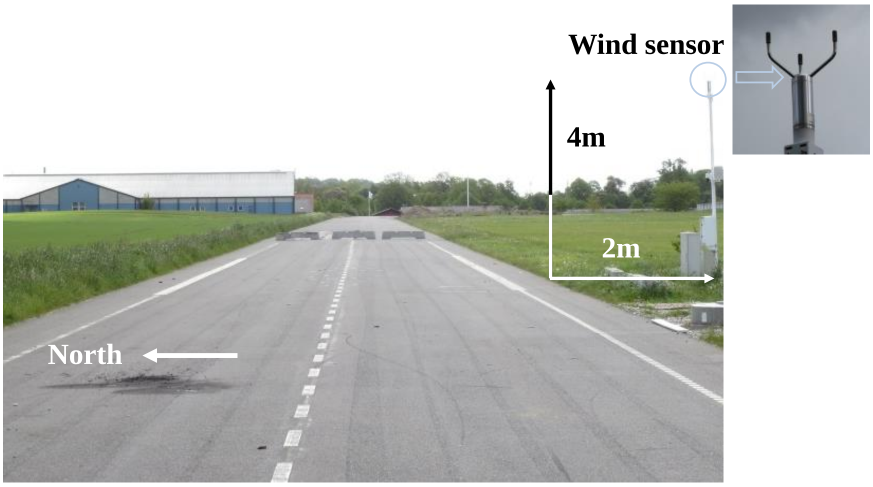

Figure 1. Photo of test road and weather station.

Data sorting

The local weather data for the two year period from April 2013 to April 2015 were kindly made available by Michel M. Eram from the Danish Road Directorate. The data contained a number of weather parameters such as wind speed, wind gust, wind direction, precipitation, air and road temperatures etc. It was decided to sort the data in order to focus only on data usable for outdoor testing of salt spreading equipment. Empty scans and scans without data for wind speed, direction and precipitation were sorted out.

During winter the salt spreading equipment is either in use or on stand-by. For testing purposes it was therefore decided to focus on wind recorded during summer days from May through September.

Basically, the weather station was programmed to scan and save information every 5 minutes. This would in principle make it possible to convert 12 scans to 1 hour. It turned out that the scanning period in some cases covered periods that did not start with a multiple of 5 minutes and these were therefore not included in the useful data.

The effect of the sorting process is shown in table 1. The ideal number of scans for the two year period was 210.240 scans. This is set to 100% in the table. The total number of actual scans was 197.832, i.e. 94%. Sorting out empty and incomplete scans reduced the number of useful data to 82%. Only considering the summer months reduced it further to 33%. Sorting out scans not starting with a multiple of 5 minutes had no real effect on the number of useful recorded scans.

In average the number of useful, recorded scans was 34.963 per year.

Sorting criteria	Scans	%
Ideal (365 days, 24 hrs/day, 12 scans/hr, 2 years)	210.240	100%
Actual scans 2013 & 2014	197.832	94%
With velocity and irrigation data	173.350	82%
May - September	70.185	33%
Useful 5min scans only	69.925	33%
Average recorded 5 min scans per year	34.963	

Table 1. Effect of sorting on the amount of useful scans

Converting scans to hours

The average recorded number of useful scans is converted to hours by dividing number of scans with 12 scans per hour and dividing the result by the two years collection time. The accumulated recorded hours per year is shown in figure 2 as a function of maximum wind speed. The average recorded hours are shown in black. It is seen that recorded hours with calm weather were higher in 2014 than in 2013. The difference between the two years is not necessarily due to calmer weather, however, but is due a combination of calmer weather and a higher number of useful scans

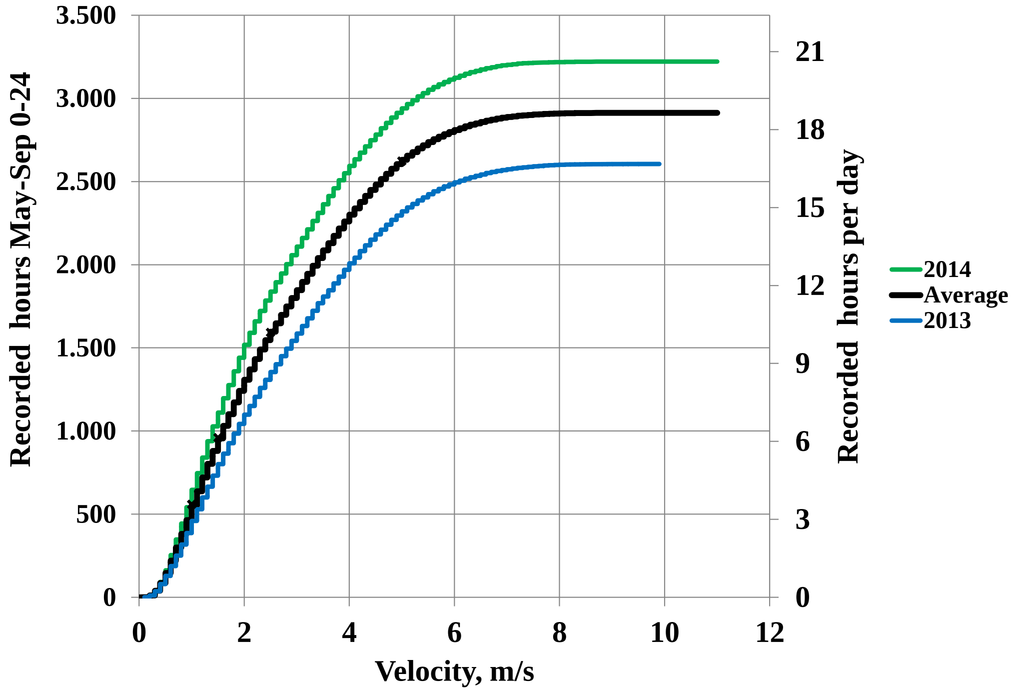

Figure 2. Recorded hours as a function of maximum velocities.

More detailed information is found in table 2. Compared with the average it is seen that there was a considerable difference between the numbers of useful scans for the two years. The number was only 89% of the average in 2013 compared to 111% in 2014. The difference between the two years is a little less, however, because the average wind speed which was slightly higher at 2.7 m/s in 2013 compared to 2.5 m/s in 2014.

Periods with precipitation are not suitable for testing of salt spreading equipment. In 2013 and 2014 precipitation was in average only recorded 2.4% of the time.

The number of useful recorded scans converted to hours results in an average of 2.914 recorded hours per year.

Data	Recorded scans/year			Recorded hours/year			%	Velocity	
	No precip	Precip	Sum	No precip	Precip	Sum		m/s	%
Recorded 2013	30.382	885	31.267	2.532	74	2.606	89%	2,7	104%
Recorded 2014	37.854	804	38.658	3.155	67	3.222	111%	2,5	97%
Average recorded per year	34.118	845	34.963	2.843	70	2.914	100%	2,6	100%
%	97,6%	2,4%	100%	97,6%	2,4%	100%			

Table 2. Recorded scans, hours and average speed

WIND ROSE

The average recorded hours from May through September with wind from different directions up to a given upper limit are found in the appendix table A1.

The duration of wind from different directions is visualized in the wind rose, figure 3. It is seen that winds from west (W) is the most frequent with more than 700 recorded hours per year. It is closely followed by winds from WNW with more than 500 hours per year. From the opposite direction winds from ESE occur 300 hours per year closely followed by E with 200 hours per year.

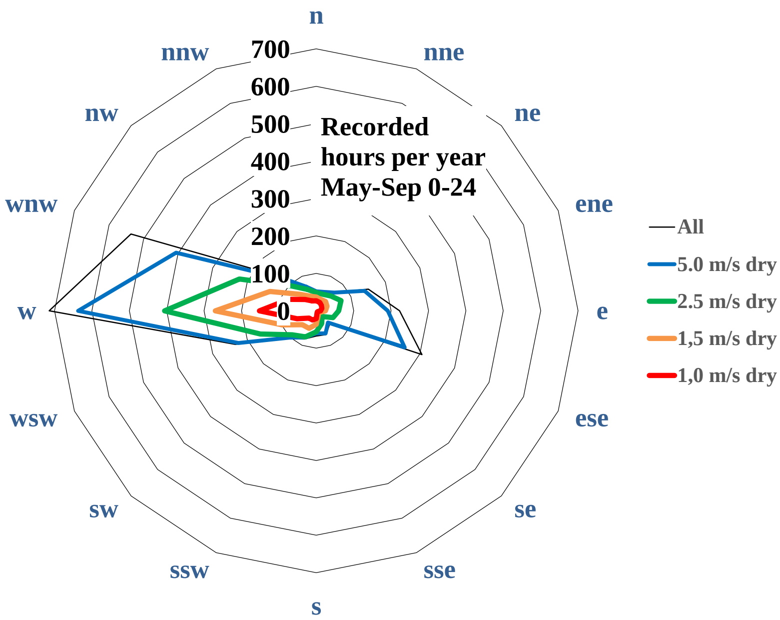

Figure 3. Recorded hours per year with wind from all directions

Crosswinds are in this study defined by winds from southerly (SW – SE) and northerly (NW – NE) directions. A wind breaking net perpendicular to the wind direction is a technique that may be suitable to reduce wind velocities close to the road surface and thus increase testing time with wind in these directions.

The wind rose for cross-winds is shown in figure 4. When evaluating the advantage of using a wind breaking net it is worthwhile to notice that wind perpendicular to the net will be less frequent than from other southerly directions. This may raise the question of whether a wind net parallel to the road is preferable or a net inclined more towards west is better.

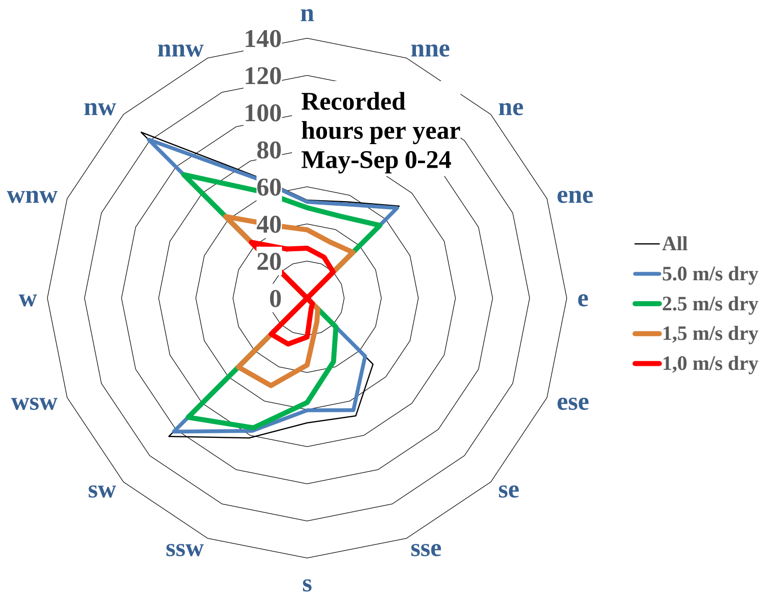

Figure 4 Recorded hours per year with cross-wind

A summary of recorded hours with wind from different directions is given in table 3.

Winds parallel to the test road is in this study defined by winds from west (WSW, W, and WNW) and from east (ENE, E, and ESE). According to the table the wind was from west 51% of the time and only half as often, 23%, in the opposite direction, i.e. 74% of the time parallel to the test road. Techniques to reduce wind velocities and thus increase testing time with wind in these directions may be difficult, but would be most welcome. Otherwise selecting periods with low natural wind velocities parallel to the road is the only option.

According to the table crosswinds from southerly directions occurred 13% of the time and the same in the opposite direction, i.e. in total 26% of the time.

Direction	Recorded hours per year no precipitation					All	Recorded hours per day no precipitation					All	All
	1,0 m/s	1,5 m/s	2.5 m/s	5.0 m/s	12 m/s	Precip	1,0 m/s	1,5 m/s	2.5 m/s	5.0 m/s	12 m/s	Precip	%
ene-ese	32	66	180	586	671	679	0,2	0,4	1,2	3,8	4,4	4,4	23%
wsw-wnw	288	503	790	1.268	1.451	1.485	1,9	3,3	5,2	8,3	9,5	9,7	51%
Parallel	320	569	970	1.854	2.122	2.164	2,1	3,7	6,3	12,1	13,9	14,1	74%
se-sw	85	161	282	349	352	373	0,6	1,1	1,8	2,3	2,3	2,4	13%
nw-ne	142	209	308	366	368	376	0,9	1,4	2,0	2,4	2,4	2,5	13%
Cross	227	370	590	714	721	749	1,5	2,4	3,9	4,7	4,7	4,9	26%
Sum	547	940	1.559	2.569	2.843	2.914	3,6	6,1	10,2	16,8	18,6	19,0	
% of all	19%	32%	54%	88%	98%	100%	19%	32%	54%	88%	98%	100%	
				May-September =	*153*	*days / year*							

Table 3. Overview of parallel winds and crosswinds.

RECORDED AND ADJUSTED HOURS

Due to missing or incomplete data the recorded data cannot be used to estimate the time suitable for testing. The recording period from May through September is 153 days. With 24 hours per day it should ideally yield 3.672 hours. Assuming that the wind speed distribution during the actual 2.914 recorded hours is representative for all hours, the recorded hours are multiplied by a factor of 3.672/2.914 = 1.260 to cover all hours. The result is shown in table 4.

Data	Recorded hours/year			%
	No precip	Precip	Sum	
Average recorded per year	2.843	70	2.914	100%
Average adjusted per year	3.583	89	3.672	126%
Days May - September =			*153*	
Ideal hours per year (153 days, 24 hours/day) =			*3.672*	
Recorded hours per year =			*2.914*	
Average adjustment factor incl. precipitation =			*1,260*	

Table 4. Average adjusted scans and hours

The average adjusted hours for the two years with wind from different directions are found in the appendix table A2. A summary is given in table 5 below. It is seen that percentage distribution of hours is the same as for the recorded hours, but the number of hours is multiplied by the adjustment factor 1.260.

Direction	Adjusted hours per year no precipitation					All	Adjusted hours per day no precipitation					All	All
	1,0 m/s	1,5 m/s	2.5 m/s	5.0 m/s	12 m/s	12 m/s	1,0 m/s	1,5 m/s	2.5 m/s	5.0 m/s	12 m/s	12 m/s	%
ene-ese	41	84	226	739	846	855	0,3	0,5	1,5	4,8	5,5	6	23%
wsw-wnw	363	634	995	1.598	1.829	1.872	2,4	4,1	6,5	10,4	12,0	12	51%
Parallel	403	717	1.222	2.337	2.675	2.727	2,6	4,7	8,0	15,3	17,5	18	74%
se-sw	107	203	355	440	444	470	0,7	1,3	2,3	2,9	2,9	3	13%
nw-ne	179	263	388	461	464	474	1,2	1,7	2,5	3,0	3,0	3	13%
Cross	286	467	743	900	908	945	1,9	3,0	4,9	5,9	5,9	6	26%
Sum all	689	1.184	1.965	3.237	3.583	3.672	4,5	7,7	12,8	21,2	23,4	24	
% of all	19%	32%	54%	88%	98%	100%	19%	32%	54%	88%	98%	100%	
					May-September =		*153*	*days/year*					

Table 5. Adjusted hours for parallel wind and crosswind

For testing it is primarily the time available with low wind velocities that are of interest. The adjusted hours for wind velocities up to 5 m/s is shown in figure 5 for winds parallel to the test road and for crosswinds. It is seen that the time available for testing is highly dependent on the upper speed limit selected. From 1.0 to 2.5 m/s the increase in time is fairly linear, but at higher velocities the time with crosswind is increasing at a slower rate than parallel winds. This is of importance for the effect of a wind net that primarily will be applicable to reduce crosswind velocities.

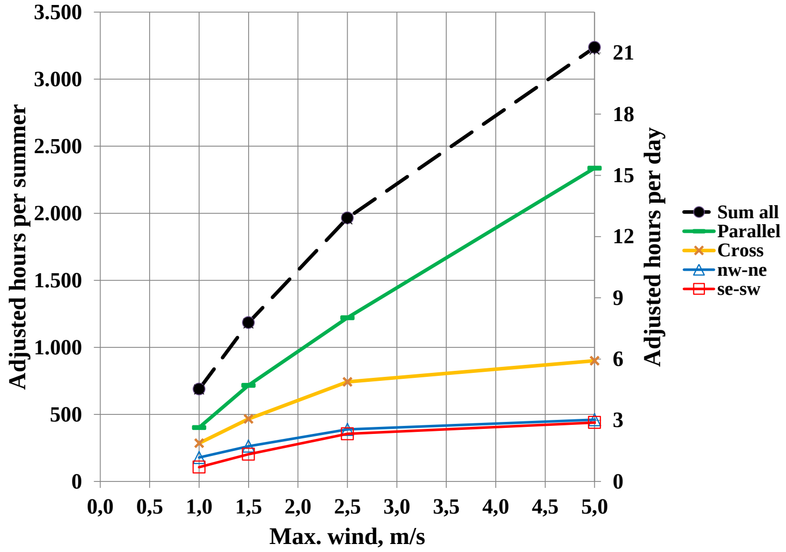

Figure 5 Adjusted hours for low wind velocities

MONTHLY VARIATIONS

The wind speed varies from month to month. The monthly variation in duration of recorded wind velocities from all directions is shown in table 6. It is seen that the number of all recorded hours for unknown reasons is falling from 673 hours in May to 494 hours in September. One explanation for this variation is the varying length of the month with 30 days in June and September and 30 days in the other months.

May-September 00:00-23:59	Recorded hours					Days	Hours	All	Adjust.	Adjusted hours per day				
	All directions no precipitation				All		per	%	factor	All directions no precipitation				All
	1,0 m/s	1.5 m/s	2.5 m/s	12 m/s			month			1,0 m/s	1.5 m/s	2.5 m/s	12 m/s	
May	129	215	369	652	673	31	744	90%	1,11	4,6	7,7	13,1	23,2	24,0
June	92	179	316	601	616	30	720	86%	1,17	3,6	7,0	12,3	23,4	24,0
July	120	202	322	604	615	31	744	83%	1,21	4,7	7,9	12,6	23,6	24,0
August	110	190	300	506	516	31	744	69%	1,44	5,1	8,8	13,9	23,5	24,0
September	95	154	253	480	494	30	720	69%	1,46	4,6	7,3	12,0	23,3	24,0
May-September	547	940	1.559	2.843	2.914	153	3.672	79%	1,260					
Hours per day	3,6	6,1	10,2	18,6	18,6					4,5	7,7	12,8	23,4	24,0
% of all hours	19%	32%	54%	98%	100%					19%	32%	53%	98%	100%

Table 6 Recorded and adjusted monthly hours for wind in all directions

The decline in recorded hours per month for different wind velocities is visible in figure 6.

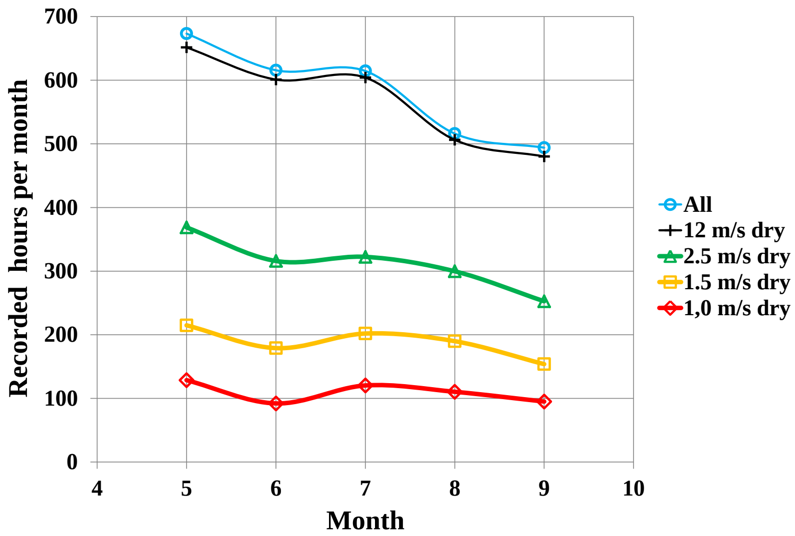

Figure 6 Monthly variations in recorded hours per month for wind in all directions

Because of this systematic decline in recorded hours during the period, separate adjustment factors are calculated to achieve the duration of all velocities equal to the number of hours in each month. Even if it is corrected for the length of each month it is seen in the table that the adjustment factor is still gradually increasing - from 1.11 in May to 1.46 in September.

The adjusted hours calculated in the table is visualized in figure 7.

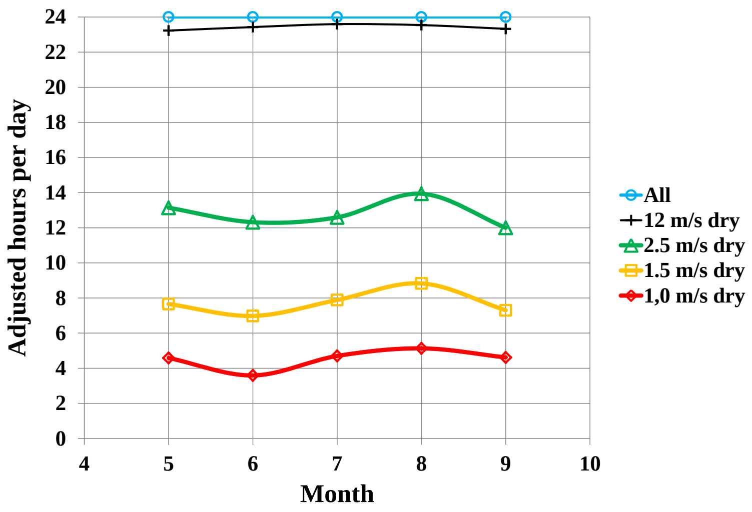

Figure 7 Monthly variations in adjusted hours per day for wind in all directions

The month with best chances of getting calm weather was August with 5.1 hours per day of no more than 1 m/s. The figure for July was 3.6 hours per day, i.e. 40% more time with calm weather in August compared with June. If wind velocities of no more than 1.5 m/s were acceptable the time suitable for testing would in average increase from 4.5 to 7.7 hours per day or an increase in available time of more than 70%.

DAILY VARIATIONS

The average wind speed varied considerably during the day. The daily variation in adjusted minutes per hour is shown in figure 8 with wind from all directions. The duration of calm weather is seen to be dramatically larger from midnight to morning than during the day.

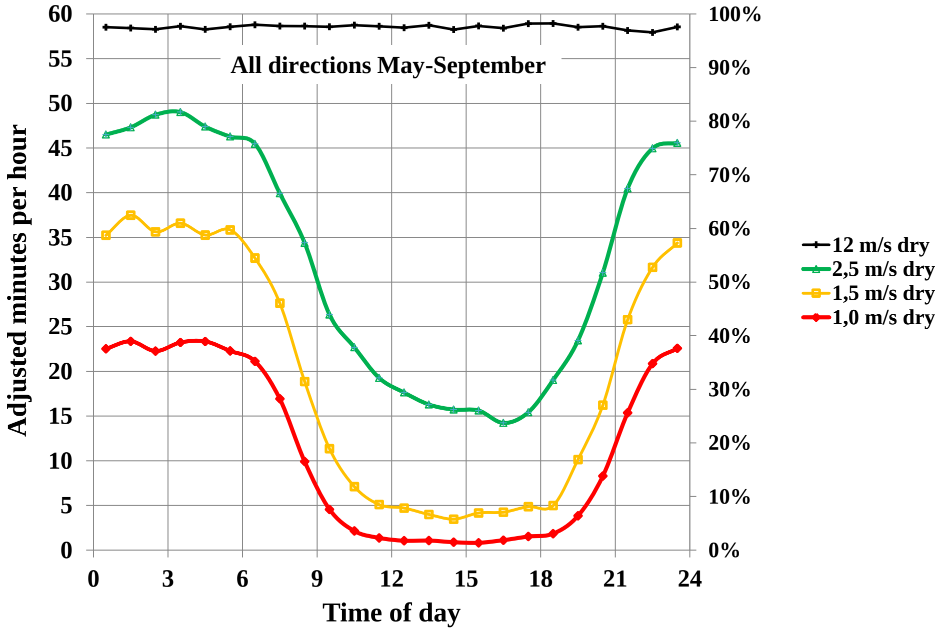

Figure 8 Adjusted minutes per day for wind in all directions

During day hours wind velocities not higher than 1 m/s was recorded about 1 minute per hour compared with over 20 minutes at night. Taking into account that velocities tend to be lower close to the road and the use of wind breaking net would increase available testing time.

According to Strøm & Brøchner (2015) the wind speed varied linearly from 57% at height 0.05 m to 69% at height 0.5 m compared with the wind speed measured by the weather station, figure 9. During the measurement the wind direction was constant from west with short bursts from west-southwest or west-northwest. The wind profiles in other directions are presumably different, and additional measurements are needed to cover winds from other directions than westerly.

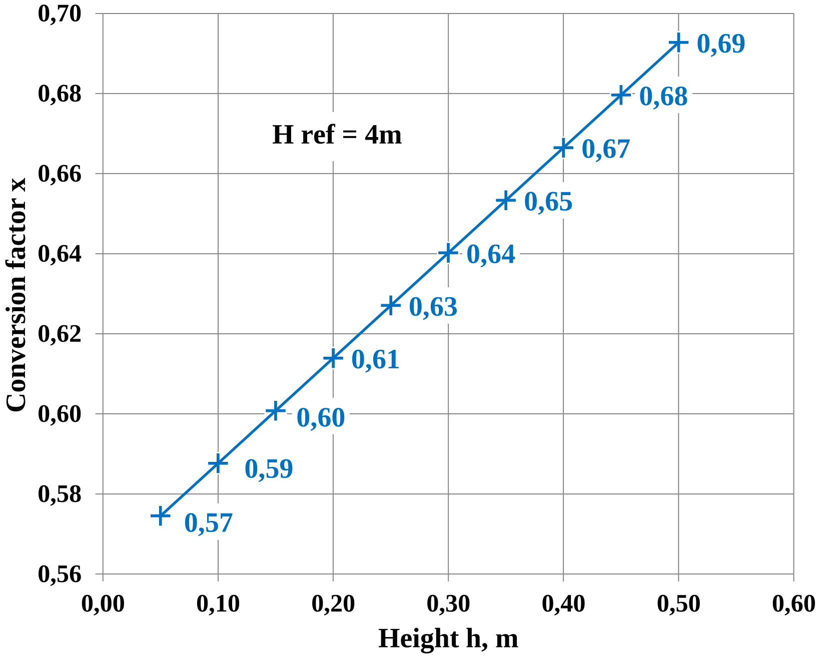

Figure 9. Wind speed near test road relative to wind 4 m above

In this report it is assumed that a speed of 1.5 m/s measured at height 4 m is equivalent to a speed of 1.0 m/s near the road. This is a conversion factor of 0.66 that for lack of more information is used for wind from all directions.

The effect of a wind breaking net on air speed has been studied with a 50cm high and 100cm wide wind net on the wind table at Bygholm (Strøm, Brøchner & Filimon, 2015). The result is shown in figure 10. The speed at a reference point placed at a height of 20 cm at a distance of 50 cm from the wind table front edge is set at 100% with no net on the table. Placing the net 100 cm from the front edge the speed in the reference point fell to 85%. Downstream of the net the air speed was reduced to 40% of the no-net reference speed close to the net and decreased further downstream.

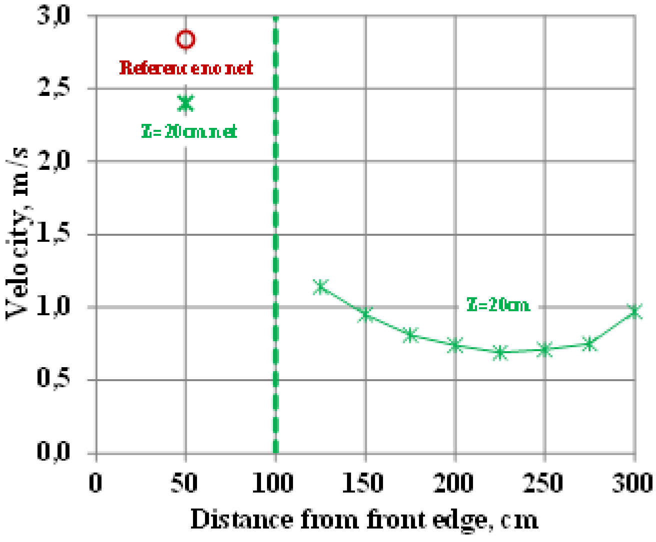

Figure 10. Effect of wind net on air speed

Assuming that a wind breaking net would reduce the wind speed by at least 40% at the test road a wind speed of 2.5 m/s measured at height 4 m is equivalent to a speed of 1.0 m/s near the road. By doing so the effect of the wind profile is not included leaving some safety margin for winds not being due perpendicular to the net.

The duration of wind velocities up to 2.5 m/s for southerly directions and 1.5 m/s for other directions is shown in the appendix table A3. The result is summarized in figure 11.

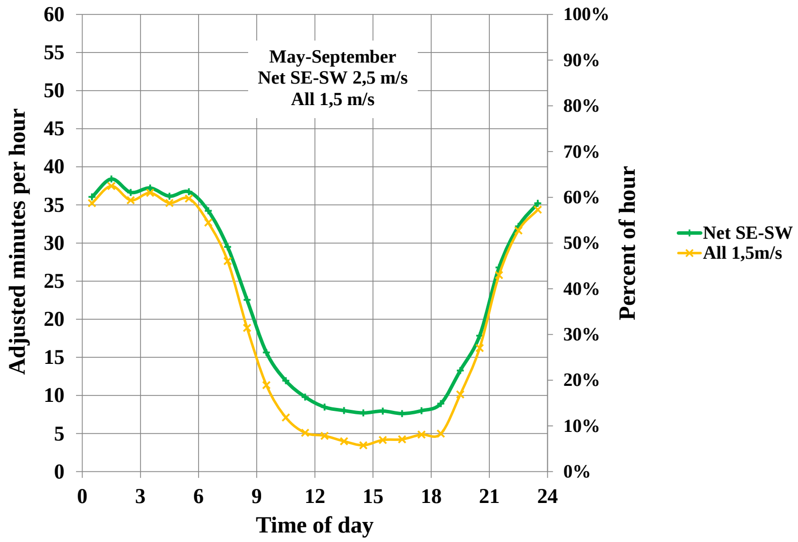

Figure 11 Adjusted minutes per day with and without net on south side

The time usable for testing increases on this basis to about 5 minutes per hour during day and slightly more than 35 minutes per hour at night.

The effect of a wind breaking net on the southern side of the test road is more effective during day nearly doubling the available testing time. At night the effect is small.

A summary of the effect of a wind breaking net to the south of the test road is given in table 7. The day is divided in four periods: all day 00-24, calm period 00-06, windy period 11-19 and working hours 08-16

Without wind breaking net testing was possible for 19 minutes per hour in average for all day nearly doubling to 36 minutes per hour during the calm night hours. During working hours testing could be performed for 7 minutes per hour increasing to 12 minutes per hour with net on the south side of the test road. The positive effect of the net is thus seen during the windy period including the working hours

Wind conditions	Time of day	Hours	Adjusted minutes per hour			Effect %	
			All no net 1,5 m/s	Net SE-SW	All no net 2,5 m/s	Net SE-SW	All no net 2,5 m/s
All day	00-24	24	19	22	32	113%	165%
Calm hours	00-06	6	36	37	48	102%	132%
Windy hours	11-19	8	5	10	19	184%	366%
Work hours	08-16	8	7	12	21	157%	286%
	%		100%	157%	286%		

Table 7. Adjusted minutes per day with and without net on south side

A wind speed of 2.5 m/s measured at 4 meters height would be equivalent to 1.65 m/s close to the road. If acceptable limit for testing was increased to this level testing time would nearly triple to 21 minutes per hour during the working hours.

DISCUSSION

The actual frequencies of wind speed and direction vary from year to year. In this study only recorded wind data for two consecutive years is analyzed. The recorded hours with calm weather were 11% higher in 2014 and 11% lower than average in 2013. The difference between the two years is not necessarily due to calmer weather, but due a combination of calmer weather and a higher number of useful scans. It is an indication, however, of difference between years, and the difficulties in predicting how much time is available for outdoor testing under acceptable wind conditions from year to year.

The speed data used was for winds at the height of 4 meters, where the sensor for the local weather station is positioned. For testing of salt spreading equipment the speed close to the road is more relevant. In this study a wind profile was used that was determined for wind from west with short bursts from west-southwest or west-northwest. The wind profiles in other directions are presumably different, but additional measurements are needed to cover wind from other directions than westerly.

The limit of maximum acceptable wind speed close to the road surface of 1.0 m/s may be questioned. Observations indicate the cross winds is more distorting for performance data of salt spreading equipment than parallel winds. More information is needed to make an informed decision on acceptable wind speeds and direction.

When evaluating the advantage of using a wind breaking net it is worthwhile to notice noticing that wind perpendicular to the net will be less frequent than from other southerly directions. This may raise the question of whether a wind net parallel to the road is preferable or a net inclined more towards west is better.

CONCLUSIONS

Winds parallel to the test road is in this study defined by winds from west (WSW, W, and WNW) and from east (ENE, E, and ESE). In average for 2013 and 2014 the wind was from west 51% of the time and only half as often, 23%, in the opposite direction, i.e. 74% of the time parallel to the test road. Crosswinds from southerly directions occurred 13% of the time and the same in the opposite direction, i.e. in total 26% of the time.

The month with best chances of getting calm weather was August with 5.1 hours per day of no more than 1 m/s. For July it was 3.6 hours per day, i.e. 40% more time with calm weather in August compared to June. If wind velocities of no more than 1.5 m/s were acceptable the time suitable for testing would in average increase from 4.5 to 7.7 hours per day or an increase in available time of more than 70%.

In this report it is assumed that a speed of 1.5 m/s measured at height 4 m is equivalent to a speed of 1.0 m/s near the road. This corresponds to a conversion factor of 0.66 that for lack of more information is used for wind from all directions. The time usable for testing thus increases to about 5 minutes per hour during day and slightly more than 35 minutes per hour at night.

A model experiment with wind net showed that downstream of the net the air speed was less than 40% of the free wind speed. This indicates that a wind speed of 2.5 m/s measured at height 4 m is equivalent to a speed of 1.0 m/s near the road.

With wind velocities up to 2.5 m/s for southerly directions and 1.5 m/s for other directions the time usable for testing is 19 minutes per hour in average for the 24 hour day but 36 minutes per hour during the calm night hours from midnight to 06 in the morning. During an 8 hour working day testing could be performed for 7 minutes per hour increasing to 12 minutes per hour with net on the south side of the test road. The positive effect of the net is thus seen during the day hours.

If acceptable limit for testing was increased from 1.0 m/s to 1.65 m/s the testing time would nearly triple from 7 to 21 minutes per hour during the working hours without use of wind breaking net.

REFERENCES

CEN/TC 337 2010: Winter maintenance equipment – Spreading machines (gritting machines) – Part 2: Requirements for distribution and their test. *CEN/TS 15597-2:2010 rev 2014 Berlin.*

Strøm & Brøchner 2015: NordFoU: External Influences on Spray Patterns (EPAS) Report 15: Local wind profile for the test road at Bygholm

Strøm, Brøchner & Filimon 2015: NordFoU: External Influences on Spray Patterns (EPAS) Report 14: Local wind profile for the test road at Bygholm

APPENDIX

May-Sep	1,0 m/s	1,5 m/s	2.5 m/s	5.0 m/s	12 m/s	All
00:00-23:59	Recorded hours per year no precipitation					Precip
n	27	37	49	52	52	53
nne	24	33	48	55	55	56
ne	20	35	55	69	69	70
ene	16	31	72	139	148	151
e	11	24	60	191	221	223
ese	5	11	48	256	303	306
se	4	8	22	44	47	50
sse	6	14	37	65	65	69
s	21	36	56	60	60	67
ssw	27	51	76	77	77	82
sw	27	52	91	102	102	105
wsw	56	98	162	225	228	234
w	152	270	406	637	698	714
wnw	80	134	222	406	525	537
nw	43	62	94	121	124	126
nnw	29	42	62	70	70	71
Sum recorded hours/year	547	940	1.559	2.569	2.843	2.914
Recorded hours per day	3,6	6,1	10,2	16,8	18,6	19,0
% of sum recorded (=< 12 m/s)	19%	32%	54%	88%	98%	100%
May-September =	*153*	*days / year*				

Table A1. Recorded hours per year for all wind directions as an average of 2013 and 2014

NordFoU

May-Sep	1,0 m/s	1,5 m/s	2.5 m/s	5.0 m/s	12 m/s	All
00:00-23:59	Adjusted hours per year no precipitation					Precip
n	34	46	61	65	65	67
nne	30	41	60	69	69	71
ne	25	44	70	87	87	88
ene	20	39	90	176	186	190
e	14	31	75	241	278	281
ese	6	14	61	322	382	385
se	5	10	28	56	60	63
sse	7	17	47	82	82	87
s	26	45	71	76	76	85
ssw	34	64	95	98	98	103
sw	35	66	114	128	128	133
wsw	70	124	204	284	288	295
w	192	340	511	803	880	900
wnw	101	169	280	512	662	676
nw	54	78	119	152	156	159
nnw	36	53	78	88	88	89
Sum adjusted hours/year	689	1.184	1.965	3.237	3.583	3.672
Sum adjusted hours per day	4,5	7,7	12,8	21,2	23,4	24,0
% of all (=< 15 m/s)	19%	32%	54%	88%	98%	100%
Average adjustment factor incl. precipitation =				*1,260*		

Table A2. Adjusted hours per year for all wind directions as an average of 2013 and 2014

Time	Recorded minutes per hour					Adjustment	Adjusted minutes per hour					
	1,5 m/s			2,5 m/s	1,5+2,5 m/s	factor	1,5 m/s			2,5 m/s	1,5+2,5 m/s	2,5 m/s
	all	SE-SW	all-(SE-SW)	SE-SW	Net (SE-SW)		all	SE-SW	All-(SE-SW)	SE-SW	Net (SE-SW)	all
00:00-00:59	29	4	25	4	29	1,23	35	4	31	5	36	46
01:00-01:59	28	4	24	4	28	1,35	37	5	33	6	38	47
02:00-02:59	28	4	24	5	29	1,26	36	5	31	6	37	49
03:00-03:59	29	4	26	4	30	1,25	37	5	32	5	37	49
04:00-04:59	26	3	23	4	26	1,38	35	4	31	5	36	47
05:00-05:59	29	4	25	5	30	1,23	36	5	31	6	37	46
06:00-06:59	27	4	23	5	28	1,23	33	5	28	7	34	45
07:00-07:59	21	4	17	5	22	1,33	28	5	23	7	29	40
08:00-08:59	15	3	12	6	18	1,22	19	4	15	7	23	34
09:00-09:59	9	3	7	6	13	1,23	11	3	8	8	16	26
10:00-10:59	5	2	4	5	9	1,32	7	2	5	7	12	23
11:00-11:59	4	1	3	5	8	1,20	5	2	3	6	10	19
12:00-12:59	4	1	3	4	7	1,23	5	1	3	5	8	18
13:00-13:59	3	1	2	4	6	1,33	4	1	3	5	8	16
14:00-14:59	3	1	2	4	6	1,20	3	1	3	5	8	16
15:00-15:59	3	1	2	4	7	1,22	4	1	3	5	8	16
16:00-16:59	3	1	2	4	6	1,33	4	1	3	5	8	14
17:00-17:59	4	1	3	4	7	1,22	5	2	3	5	8	15
18:00-18:59	4	1	3	5	7	1,23	5	2	3	6	9	19
19:00-19:59	8	3	5	5	10	1,33	10	4	6	7	13	23
20:00-20:59	13	4	9	5	15	1,23	16	5	11	6	18	31
21:00-21:59	21	4	18	4	22	1,21	26	4	21	5	27	40
22:00-22:59	24	3	21	3	24	1,34	32	4	28	5	32	45
23:00-23:59	28	3	24	4	29	1,23	34	4	30	5	35	46
Sum 0-24	369	63	305	111	416	1,260	467	80	387	139	527	773
	100%				113%		100%				113%	165%

Table A3. Minutes per hour with and without net along south side