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TITTEL

GANDSFJORDEN.
EXTREME MEAN WIND SPEEDS FOR 12 SECTORS.

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OPPDRAGSGIVER

NORWEGIAN CONTRACTORS

OPPDRAGSNR.

SAMMENDRAG

34 years with annual extremes from Stavanger airport, Sola, are the basis for the extreme value calculations. No wind data from Gandsfjorden exists. By a method of educated guess and a physical/ mathematical procedure wind extremes at three sites in Gandsfjorden are estimated for 12 sectors, for 100, 10 and 2 year return period.

The highest sector extreme value with 100 year return period is estimated to 29 m/s in the winter season and 24 m/s in the summer season. The all direction value is a little higher.

With the same evaluations as used above the wind profile at each site is given for heights up to 150 m.

UNDERSKRIFT

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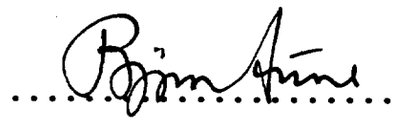
SAKSBEHANDLER



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1. INTRODUCTION

The background for this report is a request from Norwegian Contractors concerning environmental data in Gandsfjorden for the Heidrun field development project. As the requirements to analysis is increasing, there are need of more detailed information. Here we present estimates for the extreme wind conditions in sectors of 30 degrees all around the compass.

The extreme wind conditions in Gandsfjorden is performed earlier in 1977 and 1985 (1), for wider sectors. In the former reports the winter conditions are analysed. In this report we also present an analysis of the summer conditions. Furthermore we have now 34 years with annual extremes from Stavanger airport. Thus the uncertainties in the calculated extreme values at Sola are somewhat reduced due to the increasing data series.

Finally there are calculations of wind profiles for three positions in Gandsfjorden up to 150 m.

2. AREA DESCRIPTION

Gandsfjorden is situated 7-10 km east and northeast of the Sola Airport area. The fjord is extending about 10 km in the north-south direction with its outlet quite near the southern part of Stavanger city. See Figure 1.

West of the fjord there are relatively flat country with typhical heights below 40 m and a few small hills of 50-100 m. The landscape is partly covered with wood, groups of buildings and farm land. Forus and Sola airfields (11-12 m a.s.l.) are situated 3-8 km west of Gandsfjorden. A few kilometres further west there is open sea.

East of the fjord there are typhical heigts of 100-200 m and hill tops of 300 m.

3. DATA

The calculations are based on data from Stavanger Airport, Sola, September 1958 - August 1992.

Until June 87 measuring anemometer was Fuess 90z, then the weather station was equipped with an instrument of Vaisala type.

Concerning the two anemometers there are differences in the size and weight of the cups. The influence on the measured Fuess values is supposed to be small for the 10 minute means, perhaps a little too high in gusty wind (2).

The Vaisala 10 minute means are moving averages each third minute, the Fuess 10 minute means are consecutive 10 minute

averages. Thus the Vaisala values are a few percent higher than the Fuess values.

The two effects are partly excluding each other and thus we consider the data to be homogeneous. The last 5-6 years with data have under no circumstances any influence on the extreme value calculations.

4. EXTREME VALUE CALCULATIONS

Sola.

The calculations are based on the Fisher Tippett Type I extreme value distribution, also called the Gumbel distribution. In this report the parameters of the distribution are found by the method of maximum likelihood (see Gumbel (Kimball) (3) and Kite (4)). The calculations of extreme values independent of directions are based on 34 annual extremes. The extremes for the different sectors are based on data for the period 1958-89. The average of the 5 highest values in each sector (see Appendix B1) are divided by the corresponding all direction value to find the k-factor. The results are presented in Table 4.1 (winter) and Table 4.2 (summer). The k-factor and the all direction extremes for the different return periods (Tables 4.3-4.4) give the sector extremes.

Table 4.1.
The average of the 5 highest 10 minute mean values [m/s] from 8 sectors at Sola, period September-April 1958/59-1988/89 and the k-factor (see text) of each sector.

SECT.	N	NE	E	SE	S	SW	W	NW	ALL
AVG	23.5	12.8	17.9	20.8	20.6	19.1	22.5	25.4	25.9
k	0.90	0.49	0.69	0.80	0.79	0.74	0.87	0.98	1.00

Table 4.2.
The average of the 5 highest 10 minute mean values [m/s] from 8 sectors at Sola, period May-August 1959-1988 and the k-factor (see text) of each sector.

SECT.	N	NE	E	SE	S	SW	W	NW	ALL
AVG	16.1	9.8	14.3	15.9	17.0	15.5	15.6	16.5	17.6
k	0.91	0.56	0.81	0.91	0.96	0.88	0.89	0.94	1.00

As described above the extreme values are calculated from the Type I distribution for different return periods. The lowest return period coming out from the analysis is a 2 year value. See Table 4.3 (winter) and Table 4.4 (summer). Then there is a a probability of 50% that the corresponding wind speed value will

be exceeded an arbitrary year.

The standard error of estimate is 0.5, 0.9 and 1.6 m/s respectively for the 2, 10 and 100 year return period winter values and 0.3, 0.6 and 1.0 m/s for the summer values.

Table 4.3.
10 minute mean wind speed [m/s] for different return periods for 8 sectors and all directions at Sola, period September-April 1959-1988.

RET. PER.	N	NE	E	SE	S	SW	W	NW	ALL
2	19	10	15	17	17	16	18	21	21.1
10	23	12	18	20	20	19	22	25	25.5
100	28	15	21	25	24	23	27	30	30.9

Table 4.4.
10 minute mean wind speed [m/s] for different return periods for 8 sectors and all directions at Sola, period May-August 1959-1988.

RET. PER.	N	NE	E	SE	S	SW	W	NW	ALL
2	14	9	12	14	15	13	14	14	15.3
10	16	10	15	16	17	16	16	17	18.0
100	19	12	17	19	20	19	19	20	21.3

At Sola the winter extremes are most likely to occur in the northwest sector and the summer extremes in the south and the northwest sector.

Gandsfjorden.

Roughly the Gandsfjord area is well represented by the Sola data. However, due to different exposure, differences between the two areas occur, as well as differences between the three sites in Gandsfjorden.

We think that using a method of educated guess combined with a physical/mathematical procedure should give us wind estimates for the three sites, where the inaccuracies are reduced compared with using the Sola data directly. However, with no wind measurments at the actual sites the quality of the estimates is rather poor.

The extreme values for Gandsfjorden have to be based on three kinds of estimations: 1) change of the wind field from Sola to Gandsfjorden in southwest, southeast and easterly sector (10% increase, site 1 and 2), due to the topography east of the fjord, 2) change of the wind field in northerly sector due to an inland weakening of the wind field (5% decrease, all sites) and

3) ground (or sea) roughness parametres in the 12 30-degrees sectors (from estimations of gust factor values, see Appendix B2).

The method of the extreme value calculations for Gandsfjorden is presented in Appendix A.

In the light of longer record series from Sola, and a more reasoned and detailed argumentation, it is reason to believe that the given data set has a somewhat better quality than the earlier given estimates (1). However, the uncertainties in the results are comparable with the differences between the results from the two reports.

5. WIND PROFILE

The wind profile is calculated according to the wind profile law:

$$\frac{v(z)}{v(10)} = \left(\frac{z}{10}\right)^n$$

where n depends on the ground friction. At open sea and stormy weather n is about 0.11. In a fjord area and over relatively flat country n is 0.15-0.20 and over rough topograpy n is greater than 0.20.

For the three locations in Gandsfjorden the n-values for each sector are calculated in Appendix B2. The results are presented in Chapter 6.2.

6. RESULTS / CONCLUSION

6.1. Extreme wind conditions in Gandsfjorden, 10 m above sea level.

In Appendix B2 we have calculated the winter and summer extremes in 30 degrees sectors in Gandsfjorden. The results are presented in Table 6.1 and 6.2.

Table 6.1.
Estimates of extreme 10 minutes mean wind speed [m/s] in Gandsfjorden for different return periods and sectors, September-April.

SECTOR GANDS-FJORD	POS 1			POS 2			POS 3		
	2	10	100	2	10	100	2	10	100
345-015	19	23	28	19	23	28	14	18	21
015-045	12	15	18	11	13	15	10	12	14
045-075	12	14	17	10	13	15	13	15	18
075-105	14	17	21	13	15	19	16	18	21
105-135	15	18	22	14	17	21	19	21	25
135-165	15	19	23	15	18	21	20	22	27
165-195	20	24	29	20	24	29	18	22	27
195-225	18	22	27	18	22	27	16	18	21
225-255	16	20	24	15	19	23	14	17	21
255-285	17	20	25	17	20	25	16	19	23
285-315	19	22	27	19	22	27	17	21	26
315-345	19	23	28	19	23	28	17	20	25

The table shows that the highest extreme will be expected from the sector 165-195° and 315-015° for positions 1 and 2, and from 135-195° and 285-315° for position 3 in the winter time. In the summer time the highest extremes are likely to come from a southerly or southeasterly direction: 165-225° (position 1 and 2) and 105-195° (position 3). See Table 6.2.

Table 6.2.
Estimates of extreme 10 minutes mean wind speed [m/s] in Gandsfjorden for different return periods and sectors, May-August.

SECTOR GANDS-FJORD	POS 1			POS 2			POS 3		
	2	10	100	2	10	100	2	10	100
345-015	14	16	19	14	16	19	11	12	15
015-045	10	12	14	9	10	12	8	9	11
045-075	10	11	13	8	10	12	11	13	15
075-105	12	14	17	11	13	15	14	16	19
105-135	12	14	17	12	14	16	16	18	22
135-165	13	15	18	12	14	17	16	19	23
165-195	17	20	24	17	20	24	16	19	22
195-225	16	19	22	16	19	22	14	16	19
225-255	14	17	20	13	16	19	12	15	17
255-285	13	15	18	13	15	18	12	14	16
285-315	13	15	18	13	15	18	12	14	17
315-345	13	16	18	13	16	18	12	14	16

As for Sola the all direction extreme value with 100 year return period for Gandsfjorden is 1-2 m/s higher than the highest sector extreme. In winter time this is 30-31 m/s for sites 1 and 2, 28-29 m/s for site 3. In summer time the all direction extreme is 25 m/s for site 1 and 2, 24 m/s for site 3.

6.2. Wind profile in Gandsfjorden.

From the wind profile law we have calculated v(z)/v(10) coefficients for different z-values at the three positions (Appendix B2). The results are presented in Table 6.3. To find the extreme wind value in given height level for actual return period and given season, use the coefficients from this table together with the wind extremes/actual return period in Table 6.1 and 6.2.

An example with a return period of 100 years and the 150 m level shows extremes of 44-45 m/s for the winter time and 35-36 m/s for the summer time (see Table B.15).

Table 6.3.
The wind profiles in Gandsfjorden as a ratio between the wind speeds in the heights z and 10 m, z=50, 100 and 150 m.

SECTOR GANDSFJORD	POS 1			POS 2		
	50	100	150	50	100	150
345-015	1.27	1.40	1.49	1.27	1.40	1.49
015-045	1.27	1.40	1.49	1.33	1.50	1.61
045-075	1.35	1.54	1.66	1.40	1.61	1.75
075-105	1.40	1.61	1.75	1.43	1.67	1.83
105-135	1.41	1.64	1.79	1.43	1.67	1.83
135-165	1.40	1.61	1.75	1.41	1.64	1.79
165-195	1.27	1.40	1.49	1.27	1.40	1.49
195-225	1.30	1.45	1.55	1.30	1.45	1.55
225-255	1.30	1.45	1.55	1.33	1.50	1.61
255-285	1.35	1.54	1.66	1.35	1.54	1.66
285-315	1.35	1.54	1.66	1.35	1.54	1.66
315-345	1.33	1.50	1.61	1.33	1.50	1.61

SECTOR GANDSFJORD	POS 3		
	50	100	150
345-015	1.38	1.58	1.71
015-045	1.35	1.54	1.66
045-075	1.30	1.45	1.55
075-105	1.35	1.54	1.66
105-135	1.33	1.50	1.61
135-165	1.30	1.45	1.55
165-195	1.30	1.45	1.55
195-225	1.35	1.54	1.66
225-255	1.35	1.54	1.66
255-285	1.38	1.58	1.71
285-315	1.38	1.58	1.71
315-345	1.38	1.58	1.71

More details, i.e. steps of 25 m, in the interval 25-150 m, are presented in Table B.14.

6.3. Conclusion.

The extreme values for Sola are updated for a period of 34 years, and 8 sector extremes are given.

The detailed description of the extreme wind conditions in Gandsfjorden depends on the quality of the estimations of the wind gust factor for the three sites in the fjord and the estimations of topographical effects on the wind field. With no wind measurements from actual sites, uncertainties in the results will necessarily arise. The magnitude of these are comparable with the differences between the extreme values in this report and DNMI-report (1). The uncertainties of the gust factors also leads to uncertainties for the wind profiles.

With these reservations in mind the presented results give a reasonable description of the differences between the 12 sectors.

7. WAVE CONDITIONS

DNMI's "FJORD-SEA" wave model gives best results for open water. It takes no notice of the topography of the land areas. With the uncertainties of the wind values in mind and the limitations of the model, we will not recommend to run the model with wind across the fjord.

Computations of waves with wind along the fjord will not give significant differences compared with the results given in (1). We therefore recommend those values.

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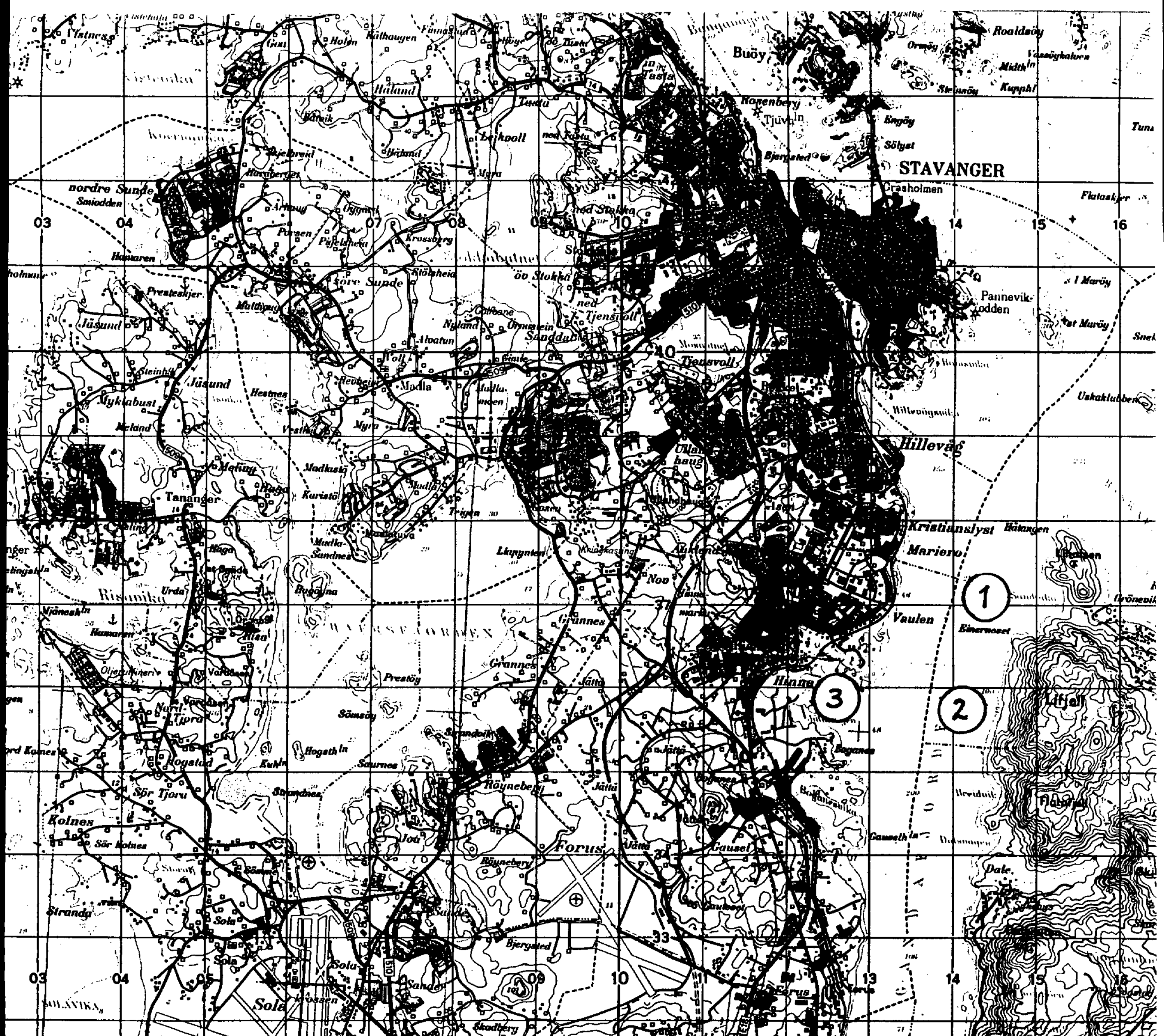

Figur 1.
Map of Gandsfjorden and Stavanger airport, Sola.

APPENDIX A. METHOD OF CALCULATING EXTREME WIND IN GANDSFJORDEN AND WIND PROFILES BASED ON SOLA DATA

On the basis of gust factor values, k_g (maximum gust divided by 10 minute mean), the roughness parameter, z_0, can be calculated from:

$$k_g = 1 + \frac{2.55}{\ln(\frac{z}{z_0})} \qquad \textbf{(A.1)}$$

(The equation is developed from Panofsky and Dutton (4)). At the 10 m level z_0 can be written:

$$z_0 = \frac{10}{e^{\frac{2.55}{k_g - 1}}} \qquad \textbf{(A.2)}$$

Sola is a reference station for the different locations in Gandsfjorden. The k_g values from Sola are known. Then the $z_{0,ref}$ of Sola is known in 8 sectors. The 30-degrees values can be interpolated. See Appendix B1. The proportion between the velocity in Gandsfjorden $u(10)_{z0}$ and the velocity at Sola $u(10)_{z0,ref}$, on the condition that the wind field is unchanged from Sola to Gandsfjorden, can be developed from the equation:

$$u(z) = 0.285 \cdot v_G \cdot (\frac{v_G}{f \cdot z_0})^{-0.065} \cdot \ln(\frac{z}{z_0}) \qquad \textbf{(A.3)}$$

(Davenport (5)). For the 10 m level we have:

$$\frac{u(10)_{z_0}}{u(10)_{z_{0,ref}}} = (\frac{z_0}{z_{0,ref}})^{0.065} \cdot \frac{\ln(\frac{10}{z_0})}{\ln(\frac{10}{z_{0,ref}})} \qquad \textbf{(A.4)}$$

The proportion is calculated for each 30-degrees sector and applied on the adjusted sector extremes from Sola, adjustments to secure the condition mentioned above. See also Chapter 4.

From the z_0 values of Gandsfjorden the exponent, n, in the wind power law (Chapter 5) can be calculated from:

$$n = 0.26 \cdot z_0^{0.14} \qquad \textbf{(A.5)}$$

The equation is developed by a method of curve fitting to table data of z_0 and n.

APPENDIX B. EXTREME WINDS IN SECTORS

B1. Sola.

Table B.1.
The 5 highest 10 minute mean wind speeds (knots) at Sola for different return periods and sectors, September - April 1958/59-1988/89. v5 is the average value.
k is the ratio between the sector value and the all direction value.

	N	NE	E	SE	S	SW	W	NW	ALL
1	53	27	40	41	41	42	47	57	57
2	45	27	38	41	41	38	46	48	53
3	44	25	33	41	40	38	44	48	48
4	43	23	32	40	39	34	42	48	48
5	43	22	31	39	39	34	40	46	46
v5 (kts)	45.6	24.8	34.8	40.4	40.0	37.2	43.8	49.4	50.4
v5 [m/s]	23.5	12.8	17.9	20.8	20.6	19.1	22.5	25.4	25.9
k	0.90	0.49	0.69	0.80	0.79	0.74	0.87	0.98	1.00

Table B.2.
The 5 highest 10 minute mean wind speeds (knots) at Sola for different return periods and sectors, May - August 1959-1988. v5 is the average value.
k is the ratio between the sector value and the all direction value.

	N	NE	E	SE	S	SW	W	NW	ALL
1	34	25	33	33	36	36	33	35	36
2	33	18	30	32	33	32	31	33	35
3	31	18	26	30	33	30	30	31	34
4	30	17	26	30	32	27	29	31	33
5	28	17	24	30	31	26	29	30	33
v5 (kts)	31.2	19.0	27.8	31.0	33.0	30.2	30.4	32.0	34.2
v5 [m/s]	16.1	9.8	14.3	15.9	17.0	15.5	15.6	16.5	17.6
k	0.91	0.56	0.81	0.91	0.96	0.88	0.89	0.94	1.00

Table B.3.
The 5 highest gust wind speeds (knots) at Sola for different return periods and sectors, September - April 1958/59-1988/89. v5 is the average value.
k is the ratio between the sector value and the all direction value.

	N	NE	E	SE	S	SW	W	NW	ALL
1	82	51	61	68	63	60	77	77	82
2	66	42	59	62	63	58	68	72	77
3	64	42	53	59	60	57	63	71	72
4	61	41	53	59	59	56	63	67	71
5	60	37	51	59	58	55	62	65	68
v5 (kts)	66.6	42.6	55.4	61.4	60.6	57.2	66.6	70.4	74.0
v5 [m/s]	34.3	21.9	28.5	31.6	31.2	29.4	34.3	36.2	38.1
k	0.90	0.58	0.75	0.83	0.82	0.77	0.90	0.95	1.00

Table B.4.
The 5 highest gust wind speeds (knots) at Sola for different return periods and sectors, May - August 1959-1988. v5 is the average value.
k is the ratio between the sector value and the all direction value.

	N	NE	E	SE	S	SW	W	NW	ALL
1	48	37	50	48	53	50	48	52	53
2	44	28	44	48	49	48	45	48	52
3	43	26	43	45	49	42	44	47	50
4	42	24	38	43	48	40	44	46	50
5	42	22	36	43	48	39	41	44	49
v5 (kts)	43.8	27.4	42.2	45.4	49.4	43.8	44.4	47.4	50.8
v5 [m/s]	22.5	14.1	21.7	23.4	25.4	22.5	22.8	24.4	26.1
k	0.86	0.54	0.83	0.89	0.97	0.86	0.87	0.93	1.00

Table B.5.
Gust factor, vg, as the ratio between v5(gust) and v5(mean) from the Tables B.3 and B.1(winter), B.4 and B.2 (summer).

	N	NE	E	SE	S	SW	W	NW	ALL
vg(win)	1.46	1.72	1.59	1.52	1.52	1.54	1.52	1.43	1.47
vg(sum)	1.40	1.44	1.52	1.46	1.50	1.45	1.46	1.48	1.49
vg(avg)	1.43	1.58	1.55	1.49	1.51	1.49	1.49	1.45	1.48

Table B.6.
Extreme 10 minuts mean wind speed [m/s] at Sola for different return periods and sectors, September-April 1958/59-1991/92.

	N	NE	E	SE	S	SW	W	NW	ALL
k	0.90	0.49	0.69	0.80	0.79	0.74	0.87	0.98	
2	19	10	15	17	17	16	18	21	21.1
10	23	13	18	20	20	19	22	25	25.5
100	28	15	21	25	25	23	27	30	30.9

Table B.7.
Extreme 10 minuts mean wind speed [m/s] at Sola for different return periods and sectors, May-August 1959-1992.

	N	NE	E	SE	S	SW	W	NW	ALL
	0.91	0.56	0.81	0.91	0.96	0.88	0.89	0.94	
2	14	9	12	14	15	14	14	14	15.3
10	16	10	15	16	17	16	16	17	18.0
100	19	12	17	19	21	19	19	20	21.3

B1. Gandsfjorden.

Table B.8.
Estimated gust factor, kg, calculated roughness parameter, z0, and exponent , n, in the wind profile law for Gandsfjorden

		kg			z0			n		
		Pos 1	Pos 2	Pos 3	Pos 1	Pos 2	Pos 3	Pos 1	Pos 2	Pos 3
345-015	N	1.40	1.40	1.60	0.02	0.02	0.14	0.15	0.15	0.20
015-045	NE	1.40	1.50	1.55	0.02	0.06	0.10	0.15	0.18	0.19
045-075	NE	1.55	1.65	1.45	0.10	0.20	0.03	0.19	0.21	0.16
075-105	E	1.65	1.75	1.55	0.20	0.33	0.10	0.21	0.22	0.19
105-135	SE	1.70	1.75	1.50	0.26	0.33	0.06	0.22	0.22	0.18
135-165	SE	1.65	1.70	1.45	0.20	0.26	0.03	0.21	0.22	0.16
165-195	S	1.40	1.40	1.45	0.02	0.02	0.03	0.15	0.15	0.16
195-225	SW	1.45	1.45	1.55	0.03	0.03	0.10	0.16	0.16	0.19
225-255	SW	1.45	1.50	1.55	0.03	0.06	0.10	0.16	0.18	0.19
255-285	W	1.55	1.55	1.60	0.10	0.10	0.14	0.19	0.19	0.20
285-315	NW	1.55	1.55	1.60	0.10	0.10	0.14	0.19	0.19	0.20
315-345	NW	1.50	1.50	1.60	0.06	0.06	0.14	0.18	0.18	0.20

Table B.9.
Gust factor at Sola interpolated for 30-degrees sectors, corresponding roughness factor, z0, and calculated ratio k=G/S between same wind field for Gandsfjorden and Sola when z0 is known at both places.

		Sola		k=G/S		
		kg	z0	Pos 1	Pos 2	Pos 3
345-015	N	1.43	0.03	1.04	1.04	0.80
015-045	NE	1.51	0.07	1.17	1.01	0.95
045-075	NE	1.57	0.11	1.03	0.91	1.17
075-105	E	1.55	0.10	0.89	0.79	1.00
105-135	SE	1.52	0.07	0.81	0.76	1.03
135-165	SE	1.50	0.06	0.83	0.79	1.07
165-195	S	1.51	0.07	1.17	1.17	1.09
195-225	SW	1.50	0.06	1.07	1.07	0.94
225-255	SW	1.49	0.05	1.06	0.99	0.92
255-285	W	1.49	0.05	0.92	0.92	0.87
285-315	NW	1.47	0.04	0.90	0.90	0.85
315-345	NW	1.44	0.03	0.92	0.92	0.81

Table B.10.
Winter extremes [m/s] at Sola interpolated from Table B.6 for 30-degrees sectors (left) and adjusted for comparing with position 1 and 2 in Gandsfjorden (right).

		2	10	100	2	10	100	years
345-015	N	19	23	28	18.1	21.9	26.6	
015-045	NE	10	13	15	10.4	12.5	15.2	
045-075	NE	10	13	15	11.4	13.8	16.7	
075-105	E	15	18	21	16.0	19.4	23.5	
105-135	SE	17	20	25	18.6	22.5	27.2	
135-165	SE	17	20	25	18.6	22.5	27.2	
165-195	S	17	20	25	16.7	20.2	24.5	
195-225	SW	16	19	23	17.1	20.7	25.1	
225-255	SW	16	19	23	15.6	18.8	22.8	
255-285	W	18	22	27	18.3	22.2	26.9	
285-315	NW	21	25	30	20.7	25.0	30.3	
315-345	NW	21	25	30	20.7	25.0	30.3	

Table B.11.
Summer extremes [m/s] at Sola interpolated from Table B.7 for 30-degrees sectors (left) and adjusted for comparing with position 1 and 2 in Gandsfjorden (right).

		2	10	100	2	10	100	years
345-015	N	14	16	19	13.3	15.6	18.5	
015-045	NE	9	10	12	8.5	10.0	11.8	
045-075	NE	9	10	12	9.4	11.0	13.0	
075-105	E	12	15	17	13.7	16.1	19.0	
105-135	SE	14	16	19	15.3	17.9	21.2	
135-165	SE	14	16	19	15.3	17.9	21.2	
165-195	S	15	17	21	14.8	17.4	20.6	
195-225	SW	14	16	19	14.9	17.5	20.7	
225-255	SW	14	16	19	13.5	15.9	18.8	
255-285	W	14	16	19	13.6	16.0	18.9	
285-315	NW	14	17	20	14.3	16.8	19.9	
315-345	NW	14	17	20	14.3	16.8	19.9	

Table B.12.
Estimates of extreme 10 minutes mean wind speed [m/s] in Gandsfjorden for different return periods and sectors, September-April.

	POS 1			POS 2			POS 3			
	2	10	100	2	10	100	2	10	100	years
345-015	19	23	28	19	23	28	14	18	21	
015-045	12	15	18	11	13	15	10	12	14	
045-075	12	14	17	10	13	15	13	15	18	
075-105	14	17	21	13	15	19	16	18	21	
105-135	15	18	22	14	17	21	19	21	25	
135-165	15	19	23	15	18	21	20	22	27	
165-195	20	24	29	20	24	29	18	22	27	
195-225	18	22	27	18	22	27	16	18	21	
225-255	16	20	24	15	19	23	14	17	21	
255-285	17	20	25	17	20	25	16	19	23	
285-315	19	22	27	19	22	27	17	21	26	
315-345	19	23	28	19	23	28	17	20	25	

Table B.13
Estimates of extreme 10 minutes mean wind speed [m/s] in Gandsfjorden for different return periods and sectors, May-August.

	POS 1			POS 2			POS 3			
	2	10	100	2	10	100	2	10	100	years
345-015	12	16	19	14	16	19	11	12	15	
015-045	10	12	14	9	10	12	8	9	11	
045-075	10	11	13	8	10	12	11	13	15	
075-105	12	14	17	11	13	15	14	16	19	
105-135	12	14	17	12	14	16	16	18	22	
135-165	13	15	18	12	14	17	16	19	23	
165-195	17	20	24	17	20	24	16	19	22	
195-225	16	19	22	16	19	22	14	16	19	
225-255	14	17	20	13	16	19	12	15	17	
255-285	13	15	18	13	15	18	12	14	16	
285-315	13	15	18	13	15	18	12	14	17	
315-345	13	16	18	13	16	18	12	14	16	

Table B.14.
Wind profile, v(z)/v(10), for different sectors in Gandsfjorden.

Pos 1	z=	10	25	50	75	100	125	150 m
345-015		1.00	1.14	1.27	1.34	1.40	1.45	1.49
015-045		1.00	1.14	1.27	1.34	1.40	1.45	1.49
045-075		1.00	1.19	1.35	1.46	1.54	1.61	1.66
075-105		1.00	1.21	1.40	1.52	1.61	1.69	1.75
105-135		1.00	1.22	1.41	1.54	1.64	1.72	1.79
135-165		1.00	1.21	1.40	1.52	1.61	1.69	1.75
165-195		1.00	1.14	1.27	1.34	1.40	1.45	1.49
195-225		1.00	1.16	1.30	1.39	1.45	1.51	1.55
225-255		1.00	1.16	1.30	1.39	1.45	1.51	1.55
255-285		1.00	1.19	1.35	1.46	1.54	1.61	1.66
285-315		1.00	1.19	1.35	1.46	1.54	1.61	1.66
315-345		1.00	1.17	1.33	1.42	1.50	1.56	1.61

Pos 2	z=	10	25	50	75	100	125	150 m
345-015		1.00	1.14	1.27	1.34	1.40	1.45	1.49
015-045		1.00	1.17	1.33	1.42	1.50	1.56	1.61
045-075		1.00	1.21	1.40	1.52	1.61	1.69	1.75
075-105		1.00	1.23	1.43	1.57	1.67	1.76	1.83
105-135		1.00	1.23	1.43	1.57	1.67	1.76	1.83
135-165		1.00	1.22	1.41	1.54	1.64	1.72	1.79
165-195		1.00	1.14	1.27	1.34	1.40	1.45	1.49
195-225		1.00	1.16	1.30	1.39	1.45	1.51	1.55
225-255		1.00	1.17	1.33	1.42	1.50	1.56	1.61
255-285		1.00	1.19	1.35	1.46	1.54	1.61	1.66
285-315		1.00	1.19	1.35	1.46	1.54	1.61	1.66
315-345		1.00	1.17	1.33	1.42	1.50	1.56	1.61

Pos 3	z=	10	25	50	75	100	125	150 m
345-015		1.00	1.20	1.38	1.49	1.58	1.65	1.71
015-045		1.00	1.19	1.35	1.46	1.54	1.61	1.66
045-075		1.00	1.16	1.30	1.39	1.45	1.51	1.55
075-105		1.00	1.19	1.35	1.46	1.54	1.61	1.66
105-135		1.00	1.17	1.33	1.42	1.50	1.56	1.61
135-165		1.00	1.16	1.30	1.39	1.45	1.51	1.55
165-195		1.00	1.16	1.30	1.39	1.45	1.51	1.55
195-225		1.00	1.19	1.35	1.46	1.54	1.61	1.66
225-255		1.00	1.19	1.35	1.46	1.54	1.61	1.66
255-285		1.00	1.20	1.38	1.49	1.58	1.65	1.71
285-315		1.00	1.20	1.38	1.49	1.58	1.65	1.71
315-345		1.00	1.20	1.38	1.49	1.58	1.65	1.71

Table B.15.
Winter extremes and summer extremes [m/s] for 100 year return period at 50, 100 and 150 m level.

50 m	winter			summer		
	POS 1	POS 2	POS 3	POS 1	POS 2	POS 3
345-015	35	35	29	24	24	20
015-045	22	20	20	17	16	15
045-075	23	21	23	18	17	20
075-105	29	27	29	24	22	26
105-135	31	30	34	24	23	29
135-165	32	30	34	25	24	30
165-195	36	36	35	30	30	29
195-225	35	35	29	29	29	26
225-255	31	30	29	26	25	24
255-285	34	34	32	24	24	23
285-315	37	37	35	24	24	23
315-345	37	37	34	24	24	22

100 m	winter			summer		
	POS 1	POS 2	POS 3	POS 1	POS 2	POS 3
345-015	39	39	33	27	27	23
015-045	25	23	22	19	18	17
045-075	26	24	26	21	19	22
075-105	34	31	33	27	25	29
105-135	36	35	38	28	27	33
135-165	36	35	39	28	27	33
165-195	40	40	39	34	34	32
195-225	39	39	33	32	32	30
225-255	35	34	32	29	28	27
255-285	38	38	37	27	27	26
285-315	42	42	40	28	28	27
315-345	42	42	39	28	28	25

150 m	winter			summer		
	POS 1	POS 2	POS 3	POS 1	POS 2	POS 3
345-015	41	41	36	29	29	25
015-045	26	25	24	21	19	19
045-075	29	27	28	22	21	24
075-105	36	34	35	30	28	32
105-135	39	38	41	31	30	35
135-165	40	38	41	31	30	35
165-195	43	43	41	36	36	35
195-225	42	42	36	34	34	32
225-255	37	36	35	31	30	29
255-285	41	41	40	29	29	28
285-315	45	45	44	30	30	29
315-345	45	45	42	30	30	28