400 SACKVILLE DRIVE

WIND STUDY

2024

NOV 13, 2024

submitted by:

Fathom

fathom

400 SACKVILLE DRIVE
MICROCLIMATE STUDY

FIG 1. 400 SACKVILLE DRIVE Site context looking south west

The proposed 400 Sackville Drive Development includes a 8 and 10-storey infill removing a 2-storey (including roof) strip mall and parking lot on the existing site. The design includes a 2-storey parking podium underneath the 2 towers providing a central courtyard in the middle of the site that preserves views to the Sackville River. the buildings provide a 2-3m stepback at the 2nd and third-storey surrounding the tall midrise.

This wind and comfort assessment looks at impacts from the proposed development on the surrounding properties, at the street, neighbourhood to the south and in the centre of the courtyard.

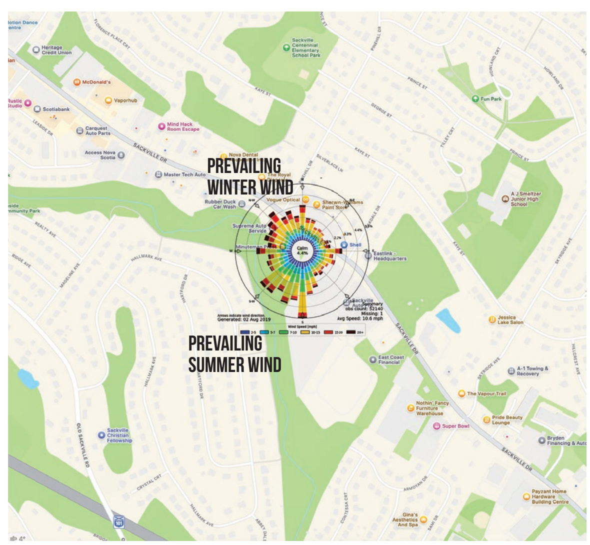


FIG 2. AERIAL PHOTO LOOKING NORTH-WEST
The figure shows the context of the proposed infill with the surrounding neighbourhood.

SHEARWATER, NS WIND DATA

This wind assessment analyzes the probable qualitative wind impacts on surrounding properties and public spaces as a result of the proposed development. Wind data was gathered from RCAF Shearwater, NS between 2007 and 2019 to understand the intensity, frequency, and direction of winds at the proposed site. The resulting diagrams (Fig. 3) shows the highest and most frequent wind speeds aggregated annually and then monthly using representative months for the 4 seasons. For this analysis we chose representative months in the middle of the season (Feb for winter, July for summer, April for spring and Oct for fall). In Halifax, the coastal conditions bring winds from many different directions throughout the year resulting in prevailing winds mostly from south and southwest in the summer and from the west to the north in the winter.

ANNUAL WIND AGGREGATED (FIG 3.1):

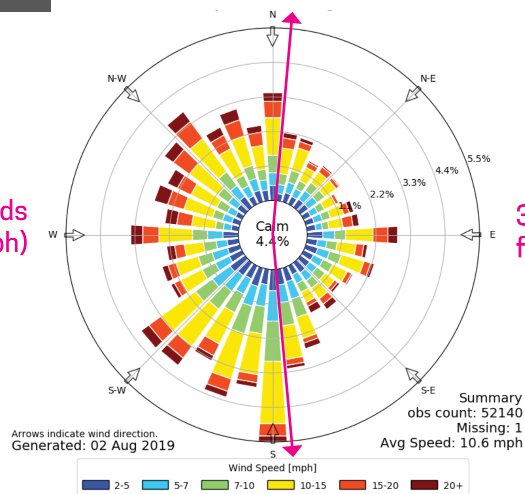
On an annual basis, winds are relatively infrequent (36% of all winds) between on the eastern semi-circle (the north and clockwise to the south semi-circle at about 10-170 degrees) and only 6% of winds from these easterly directions exceed 15 mph. In the annual western semi-circle (170-360 degrees) 59% of the wind comes from the western semi-circle north to the counterclockwise south quadrants (10.5% of winds from this direction exceed 15 mph). Over the year, the prevailing wind in Shearwater comes primarily from the south to west directions and secondly from the west to north directions. The annual average wind speed is 10.5 mph. Importantly, wind directions and wind speeds change significantly throughout the year. It is important to analyze the wind impacts in all four seasons.

FIG 3. SEASONAL WIND

Halifax Airport Wind Conditions 2007-2019

Fig 3.1 Annual

59% of the time (10.5% of winds from this direction exceed 15 mph)



36% of the time (only 6% of winds from this direction exceed 15 mph)

Fig 3.2 Winter (Feb)

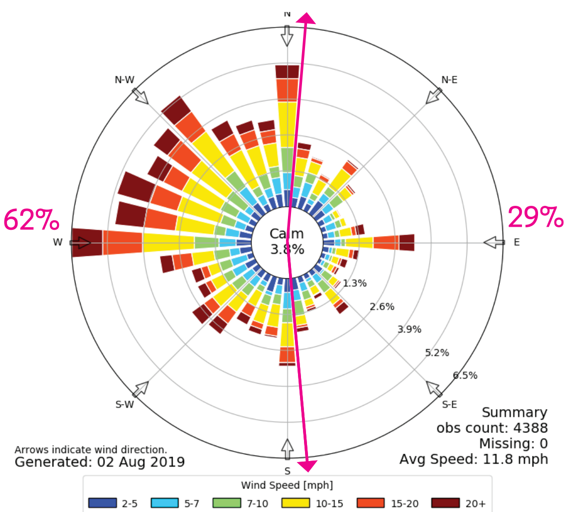


Fig 3.4 Summer (Jul)

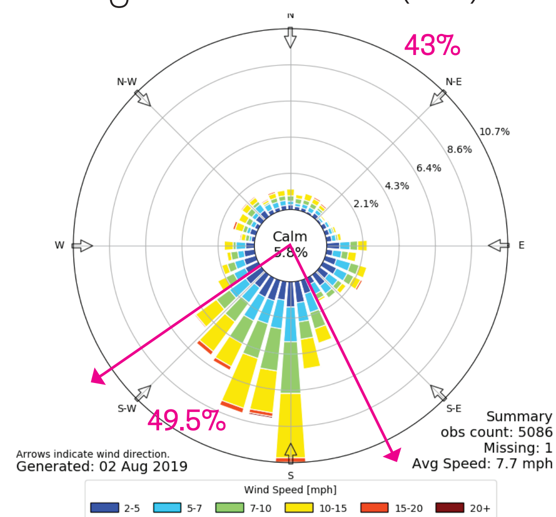


Fig 3.3 Spring (apr)

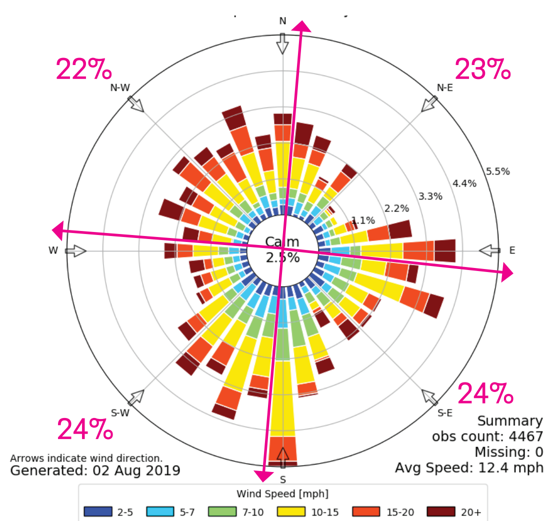
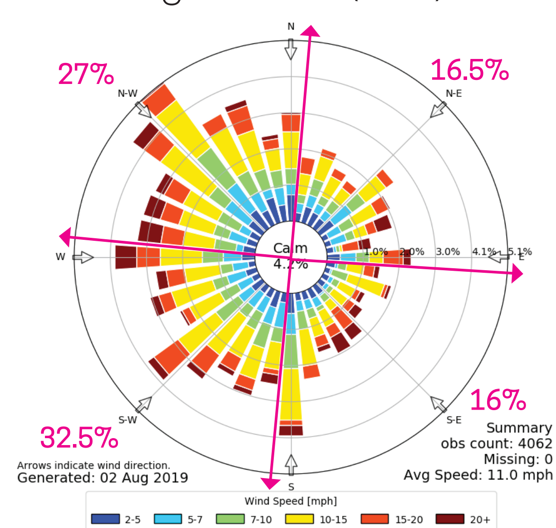


Fig 3.5 Fall (Oct)



WINTER WINDS (FIG 3.2 & FIG 4):

In the winter, prevailing winds come mainly from western directions (180-350 degrees) 62% of the time. The strongest winds come from the north-west. In the western directions 10% of the wind range between 15-20 mph. 8% of the wind in these same directions exceed 20 mph. Prevailing winds from the eastern directions (10-170 degrees) 29% of the time. These winds are less strong than from the west. 3.5% of eastern prevailing wind range between 15-20 mph. As well, only 3% of the eastern wind exceed 20 mph. The winter months are the least thermally comfortable in Halifax since this season sees the strongest prevailing winds out of the year. In the winter, winds greater than 20 MPH occurs more frequently than any other season.

SPRING WINDS (FIG 3.3 & FIG 5):

In the spring, the prevailing winds come from various directions relatively evenly distributed with 23% from the north-east quadrant, 24% from the south-east quadrant, 22% from the north-west quadrant and 24% from the south-west quadrant. The strongest winds come from both south-west and north-west quadrants with 15-20 mph winds occurring 7% of the time and exceeding 20 mph 4.5% of the tine. The strongest winds (>20 mph) come from the south in the spring. In the spring, like in the winter, 67% of the wind exceeds 10 mph making the spring a relatively windy season in Halifax. Unlike the winter months, winds that exceed 20 mph only occur 9.5% of the time (compared to 12% in the winter).

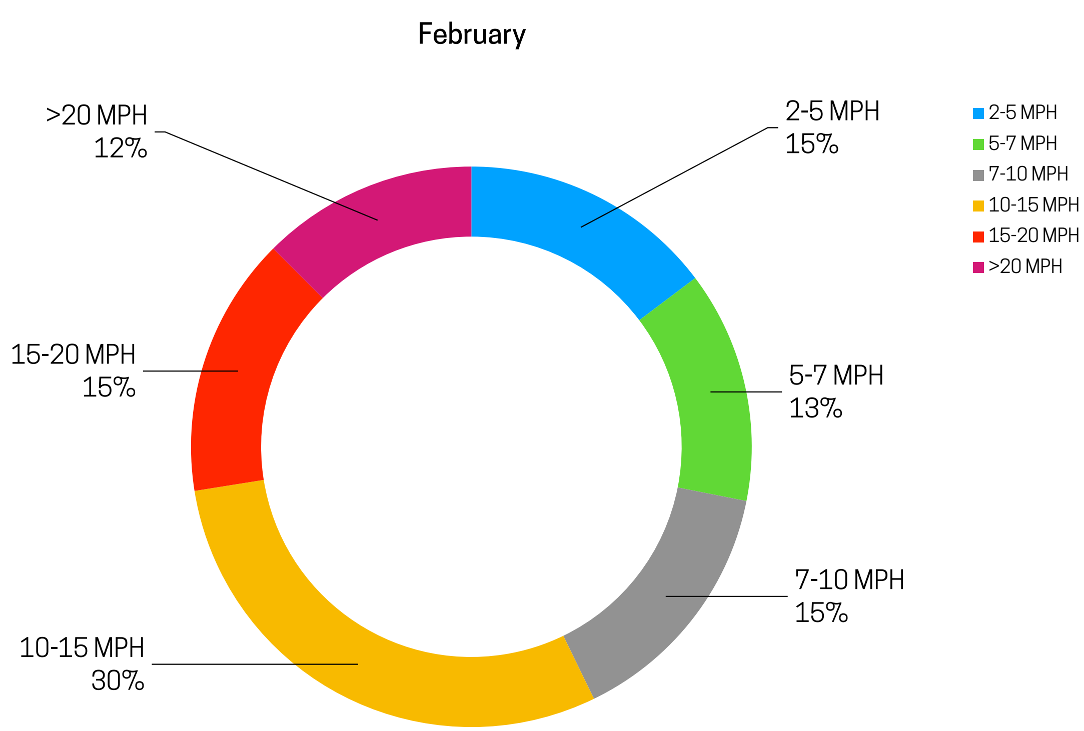


FIG 4. WINTER WIND DISTRIBUTION
Shearwater Airport Wind Conditions 2007-2019

April

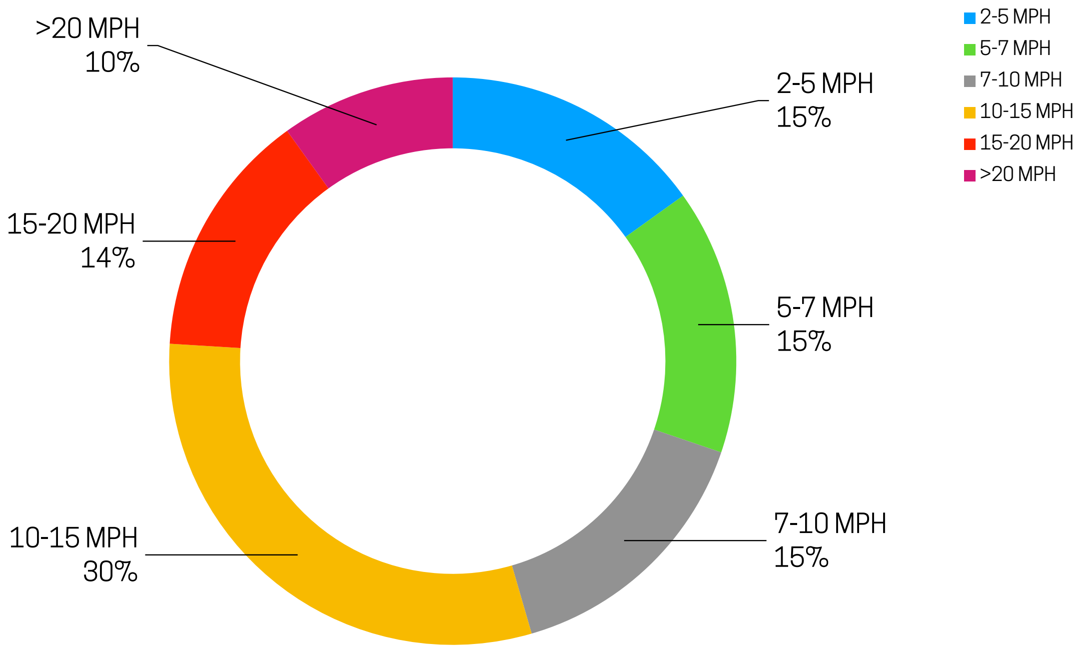


FIG 5. SPRING WIND DISTRIBUTION
Shearwater Airport Wind Conditions 2007-2019

SUMMER WINDS (FIG 3.4 & FIG 6):

In the summer, wind speeds are by far the lowest compared to the other 3 seasons and the winds originate primarily from the south quadrant 49.5% of the time. In the summer, wind speeds between 15-20 mph occur only 3% of the time and exceed >20 mph only 0.5% of the time (see Fig 6). Wind speeds less than 10 mph occur 69% of the time. Wind from the other 3 quadrants only occur 43% of the time and with fairly low wind speeds.

Generally speaking summer wind speeds are low in Halifax and come from the south and south-west directions.

FALL WINDS (FIG 3.5 & FIG7):

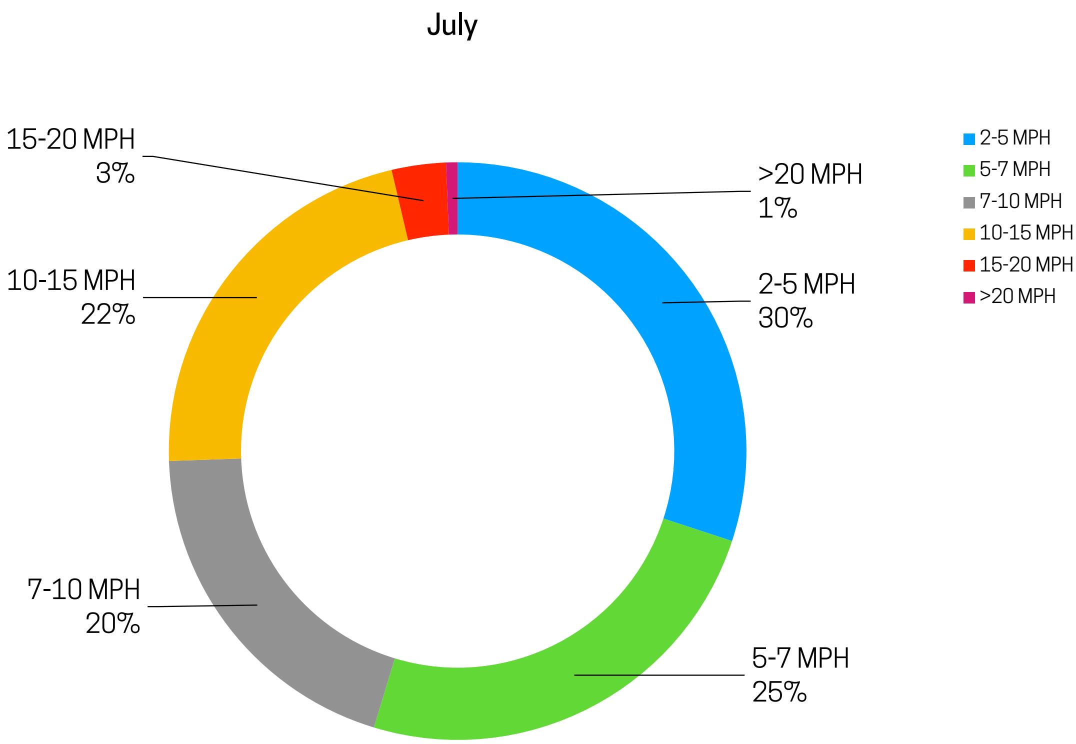
In the fall, the prevailing wind comes from south-western quadrant about 32.5% of the time; the north-west quadrant has wind 27% of the time; the north-east has wind 16.5% of the time and wind coming from the south-west occurs 16% of the time. The strongest winds come from the south-west. 80% of the winds speeds are less than 15 mph in the fall making Halifax a very comfortable location compared to other Canadian cities. Only 5% of all wind exceeds 20 mph and 10.5% of the wind is between 15-20 mph making the fall the second least windy season following the summer.

COMFA MODEL (BROWN AND GILLESPIE, 1995)

Dr. Robert Brown of the University of Guelph developed the COMFA model to model human thermal comfort as a result of a number of variables including wind speed. Comfort is a function of wind speed, temperature, metabolic activity level, insulation and permeability value of clothing, relative humidity and solar/terrestrial radiation. A person can be comfortable in windy conditions if they are active,

FIG 6. JULY WIND DISTRIBUTION

Shearwater Airport Wind Conditions 2007-2019



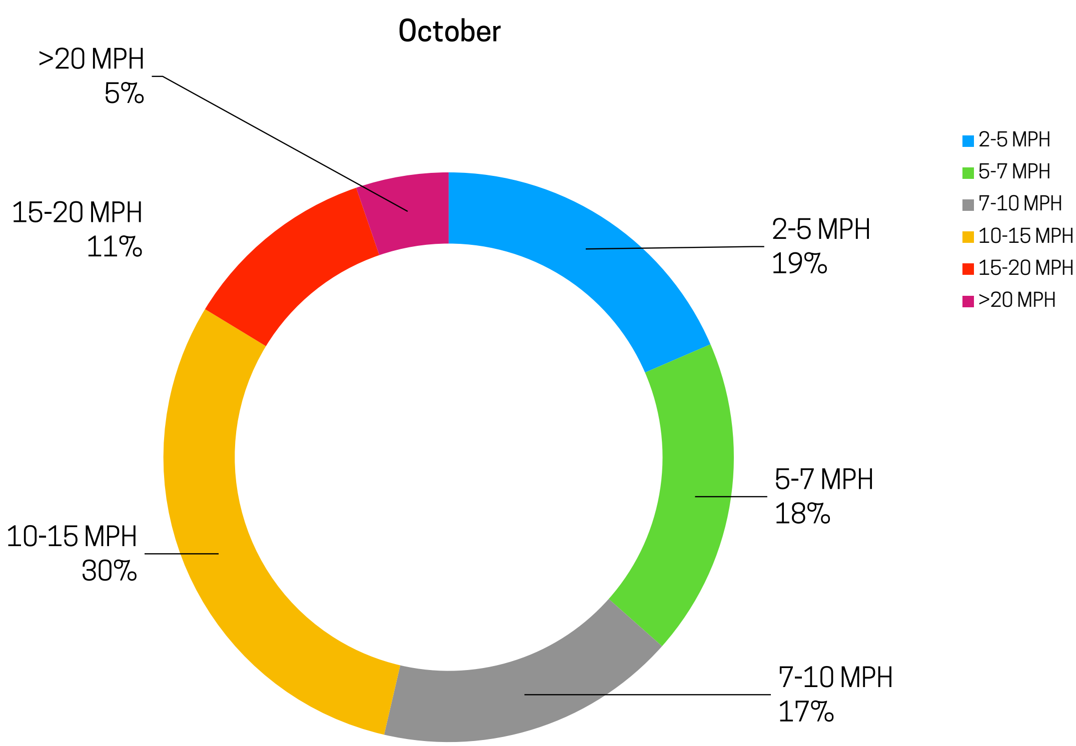


FIG 7. OCTOBER WIND DISTRIBUTION

Shearwater Airport Wind Conditions 2007-2019 adequately dressed, in the sun and with high relative humidity.

Human thermal comfort is more pronounced during low-activity situations like sitting than during high-activity situations like running. The model is explained in the paper by Brown and LeBlanc (2003). Mr. LeBlanc was also the co-author with Dr. Brown in the 2008 ed. “Landscape Architectural Graphic Standards”, Microclimate chapter. This model is the basis for the theoretical assessment of human thermal comfort changes as a result of the building explained below.

PEDESTRIAN COMFORT:

Pedestrian comfort and safety is an important consideration in the design of new developments in downtowns. Building height and massing can have considerable impacts on human thermal comfort at the street-level impacting the livability and walkability of neighbourhoods, snow loading on adjacent roofs and environmental conditions in neighbourhoods.

The Beaufort scale is an empirical measure that relates wind speed to observed conditions on land and sea. The attached Beaufort scale (Figure 7) is a general summary of how wind affects people and different activities, and distinguishes at what points wind speeds can become uncomfortable or dangerous. Wind speed is only one variable of human thermal comfort as described below.

The wind values are represented later in this report using a computational fluid dynamics (CFD) model to assess wind comfort conditions as a result of this new addition.

Figure 7. Beaufort Scale

	2-5 mph	1-2 m/s	calm	Direction shown by smoke drift but not by wind vanes
	5-7 mph	2-3 m/s	light breeze	Wind felt on face; leaves rustle; wind vane moved by wind
	7-10 mph	3-4 m/s	gentle breeze	Leaves and small twigs in constant motion; light flags extended
	10-15 mph	4-7 m/s	moderate breeze	Raises dust and loose paper; small branches moved.
	15-20 mph	7-9 m/s	fresh breeze	Small trees in leaf begin to sway; crested wavelets form on inland waters.
	+20 mph	> 10 m/s	strong breeze	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty.

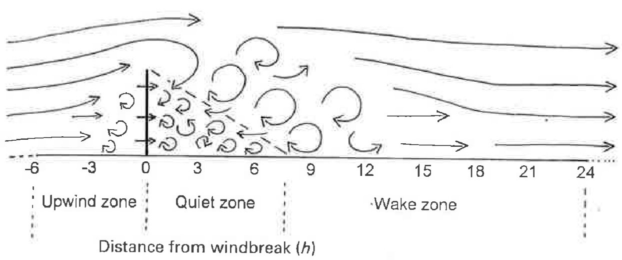
URBAN WINDBREAK IMPACTS

Urban neighbourhoods with tall buildings are generally windier and more gusty than neighbourhoods with shorter buildings because the larger surface area of the tall buildings intercepts wind from higher altitudes (moving at faster speeds), funnelling it downward towards the street or accelerating it between buildings. Buildings which increase the surface area in the direction of the wind are more prone to increasing wind speeds at the street. Buildings which are oriented in the direction of the wind create less surface area and consequently have less wind impacts at the street.

Generally speaking, buildings will slow down wind speeds in the immediate upwind zone and in the downwind zone for a distance of up to 6-8 times the height of the building.

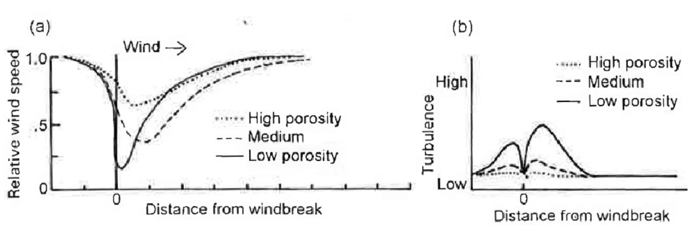
The wake zone for zero porosity structures like buildings can extend 8-30 times the height of a structure creating eddies and more intense turbulence. A 10-storey building (30m) can generate more turbulent wind speeds between 0.25 - 1km on the downwind side (see Fig. 8). This zone can be characterized as being slightly more gusty winds with interspersed quiet periods.

Of course buildings are 3 dimensional structures so while wind speeds can be reduced in the upwind and quiet zones, it does so at the expense of accelerating wind around the sides of the structure and between other tall buildings.



Zones with altered airflow caused by a windbreak. Vertical dimension is magnified for illustration. Vertical line indicates windbreak; *h* = height of windbreak. Large eddies = strong turbulence. Uninterrupted airflow in the open is to the left of the upwind zone, and to the right of the wake zone. Widths of zones are approximate. Based on several sources.

Windbreak Diagram



Effect of windbreak porosity on streamline and turbulent airflows. (a) Streamline airflow based on treebelts of different foliage densities; wind measurements at 1.4 m height. From Heisler & DeWalle (1988) with permission of Elsevier Science Publishers. (b) Generalized expected turbulence pattern based on Robinette (1972), Rosenberg *et al.* (1983), Heisler & DeWalle (1988), McNaughton (1988).

Porosity Diagram

Figure 8. Windbreak Diagram and Porosity Diagram

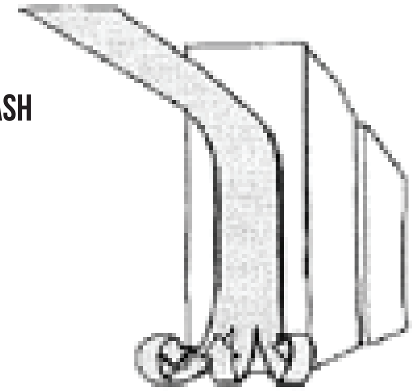
WIND IMPACTS FROM TALL BUILDINGS

There are a number of observed aerodynamic impacts from a new tall building in an urban setting including:

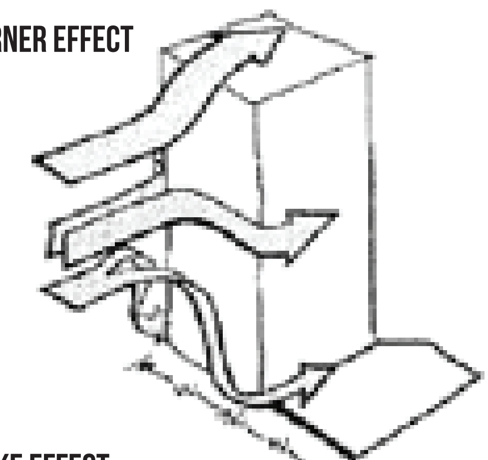
1. **Downwash**: Wind speed increases with the surface area of the building (i.e. height and width) so when a tower is exposed to wind, the pressure differential between the top and the bottom of tower forces the high pressure at the top down the windward face increasing pedestrian wind speeds. The taller the exposed face is, the higher the wind speed will be at the base. Wind speeds increase with altitude in cities so the tower funnels the higher wind velocities to the base of the building. Stepback at the base of towers direct the downdraft on to the raised podium of the building reducing the impacts at the street. Te proposed building has been designed with a stepback at the street to will receive the bulk of this downwash.
2. **The corner effect:** at the windward corners of buildings there can be unexpected increases in wind speeds as wind forces around the windward corners from high pressure on the windward face to low pressure on the lee side. Some of the ways to decrease this impact is to create pyramidal height steps which increases the surface area of the edges. This has been designed into the proposed tower.
3. **The Wake Effect:** Wake is generally caused by both the downwash and corner effect. The greatest impact area occurs within an area of direct proportion to the tower height and width on the lee side of the wind. Impacts are minimized by creating a stepback base on the building.

Building Groups: The effects that occur individually around buildings cannot be applied directly to groups of buildings. The cumulative effect of many clustered tall buildings, like in this situation, can create a wide range of different wind scenarios that must be modelled as a group to understand the cumulative impacts.

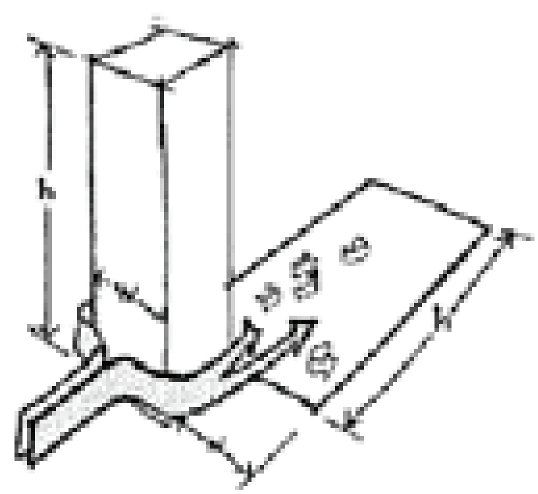
DOWNWASH



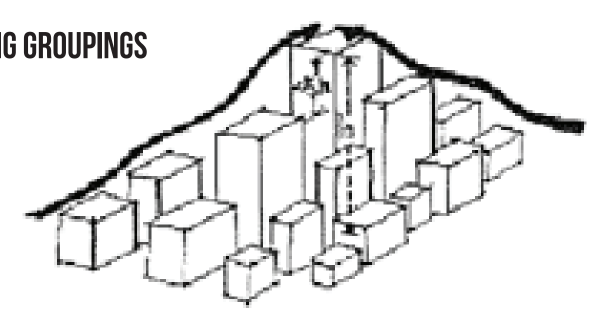
THE CORNER EFFECT



THE WAKE EFFECT



BUILDING GROUPINGS



BLDG A Roof
ALUMINUM GLAZING SYSTEM, TYP.
CERAMIC, TYP.
BALCONY, TYP.
METAL PANEL, TYP.
MASONRY, TYP.
COMMERCIAL
BUILDING A ENTRANCE
OUTDOOR AMENITY
INDOOR AMENITY
Level 1
97' - 0"
29.04 m
Fathom
fathomstudio.ca
40 King Street, Dartmouth, NS, B2Y 2R4
Consultants
Client
Red Leaf Developments
Key Plan
True North
Project North
SCALE: N.T.S
Seal
Revisions
No. Description Date
1 Issued for DA 03-May-2023
2 Reissued for DA 12-Dec-2023
3 Reissued for DA 31-Oct-2024
Project
Sackville Drive DA
400 Sackville Drive
Drawing Name
Building A Elevations
Scale
3/32" = 1'-0"
Project Number
22-115

BLDG A Roof
ALUMINUM GLAZING SYSTEM, TYP.
CERAMIC, TYP.
METAL PANEL, TYP.
OUTDOOR AMENITY
MASONRY, TYP.
BALCONY, TYP.
Level 1
P2 PARKING ENTRANCE
P1 GARBAGE ENTRANCE
P1 PARKING ENTRANCE
Fathom
fathomstudio.ca
40 King Street, Dartmouth, NS, B2Y 2R4
Consultants
Client
Red Leaf Developments
Key Plan
True North
Project North
SCALE: N.T.S
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Sackville Drive DA
400 Sackville Drive
Drawing Name
Building A Elevations
Scale
3/32" =
Project Number
22-115

WIND & SNOW IMPACTS FROM DEVELOPMENT

To simulate the impacts of different wind conditions and directions on the building, Fathom employed a CFD simulation (Computational Fluid Dynamics) to model the wind impacts at different times of the year. The CFD was constructed using Autodesk Forma which is a platform commonly used for wind and fluid simulations. CFD simulations are now being widely used for the prediction and assessment of pedestrian wind comfort environments and high-rise building aerodynamics. There are various types of wind analysis that can be carried out using CFD and they provide a high predictive qualitative assessment but more detailed quantitative assessments still employ wind tunnels to measure more accurate wind speeds. Wind tunnels require the construction of scaled physical models and are still time consuming and expensive.

Results from CFD wind simulation are considered to be a reliable sources of quantitative and qualitative data and are frequently used to make important design decisions. For this wind assessment a CFD model was employed using the latest September 2024 model of the of the building (simplified to reduce modelling complexity) and the digital building and terrain data from the city.

The wind direction and wind speed data was used from the data acquired at the Shearwater airport and described in the earlier section of this report. To keep the model simple (CFD are notoriously complicated simulations), trees were not modeled and building details like decks and windows were not included. The CFD simulations were run at 6' (2m) off the ground to simulate street conditions. The wind speeds were sensitivity tested in the model using 10 m/s starting wind speeds and there was very little variation in the simulation.

WIND IMPACTS: NORTH WIND (FIG 12)

In the wind frequency analysis, winds from the north fare relatively infrequent but sometimes occur in the winter and spring. North originating winds are very infrequent in the summer and fall. During the winter and spring, northerly wind speeds from 15-20 mph occur only 2% of the time, and exceed 20 mph only 1% of the time. The CFD simulation was set at 10 m/s for wind speed (purple to pink) and the cyan and blue colours represent areas where the wind speeds will be reduced. Areas in pink are areas where wind speeds will be accelerated around buildings.

When the winds come from the north, it flows around the sideyards of both buildings concentrating flows in the inner courtyard. The stepbacks direct downdraft winds down the midrise to the stepback rooftop on the 3rd or 4th floors. There are very little impacts on the sidewalks and streets and there are little to no impacts on the surrounding neighbourhoods to the south. The podium open space will need to be sheltered with trees to rediuce windspeeds from cold winter winds.

The light blue areas are the wind shadows created by the building where wind speeds are rapidly reduced to 0 mph due to the sheltering of the buildings. These are areas where snow drifting could potentially accumulate. The drofting will occur in the Sackville Greenway but should not impact the properties on the south side of the Sackville River.

FIGURE 12. URBAN WINDBREAKS

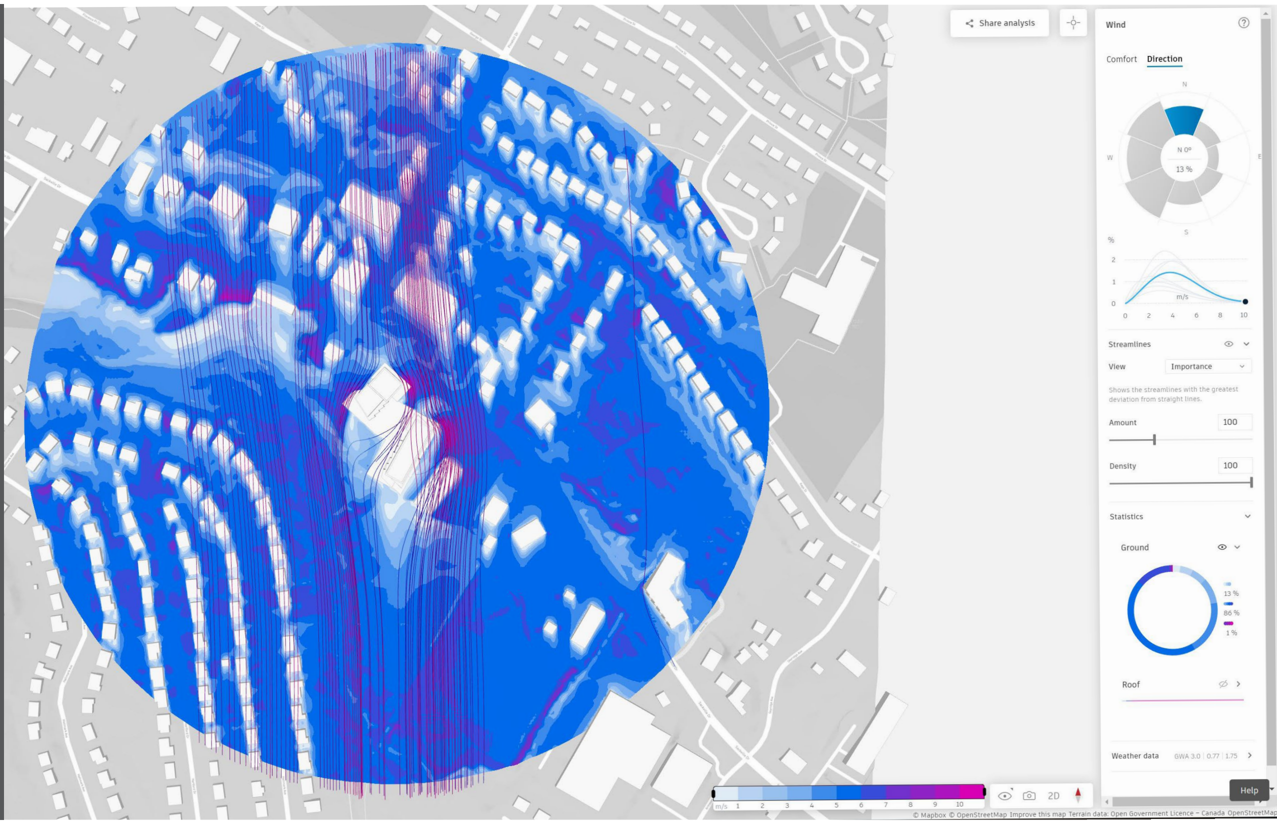


FIG 12. NORTH WIND

North Winds occur mainly from the fall to spring. When they occur, they have moderate wind speeds

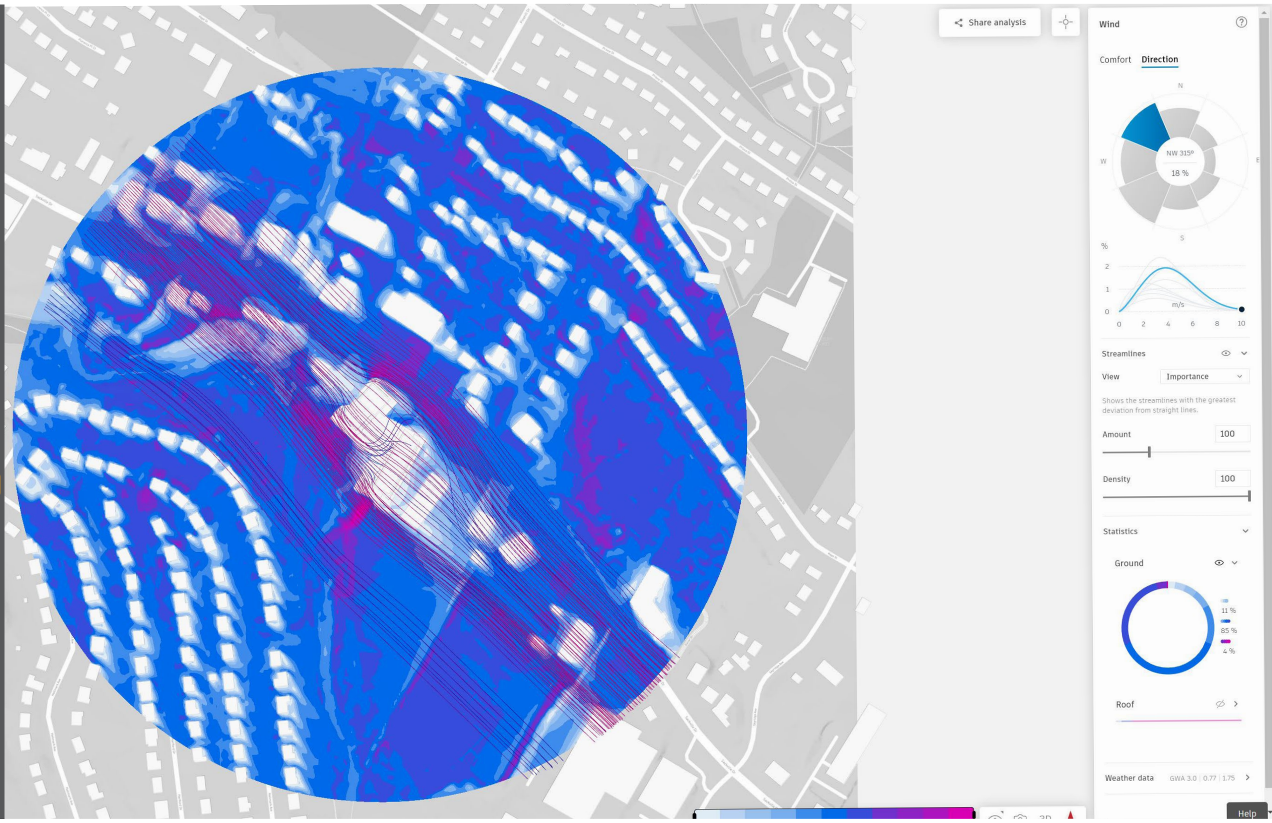
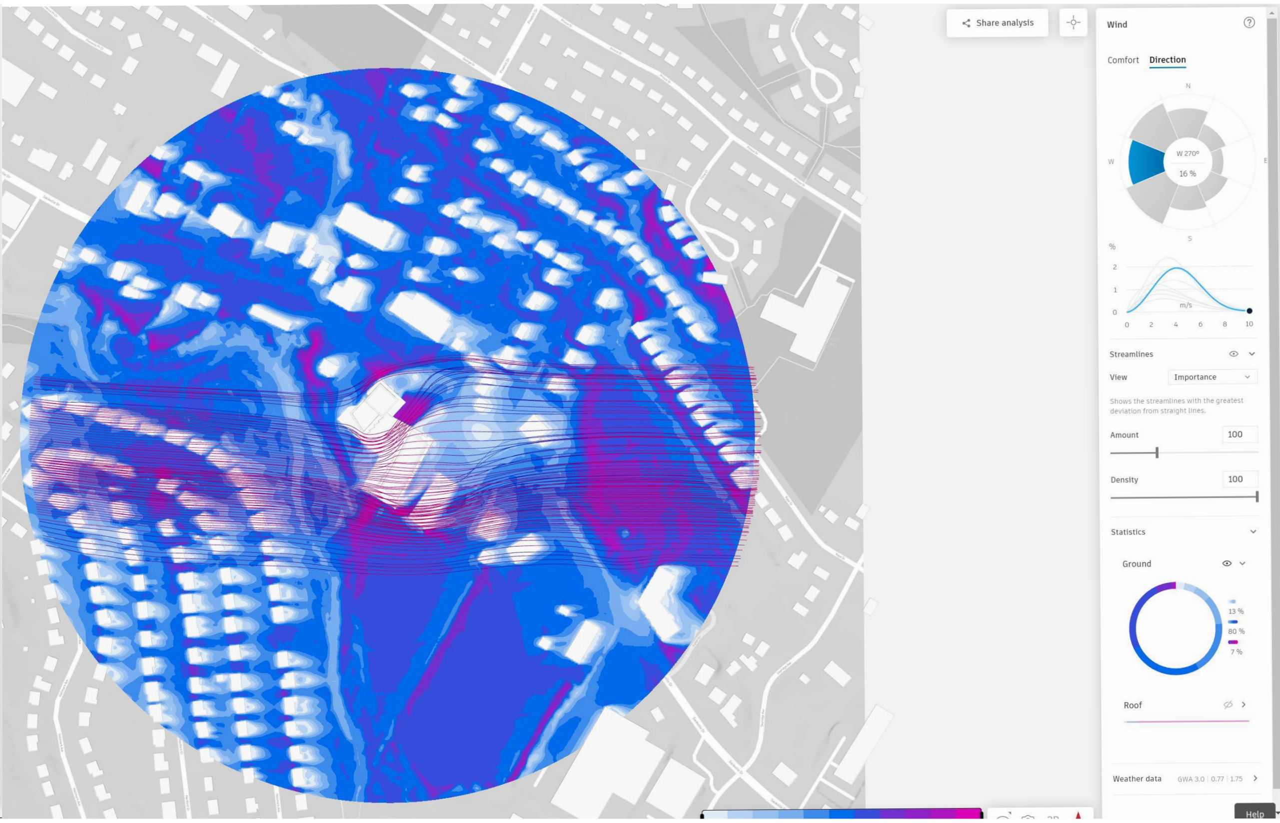


FIG 13. NORTH-WEST WIND

North-west winds occur mainly from the fall to spring and are more frequently than north winds. When they do, they have some of the highest wind speeds



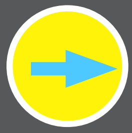


FIG 14. WEST WIND

western winds occur mainly during to fall to spring and can be strong in the winter and fall.

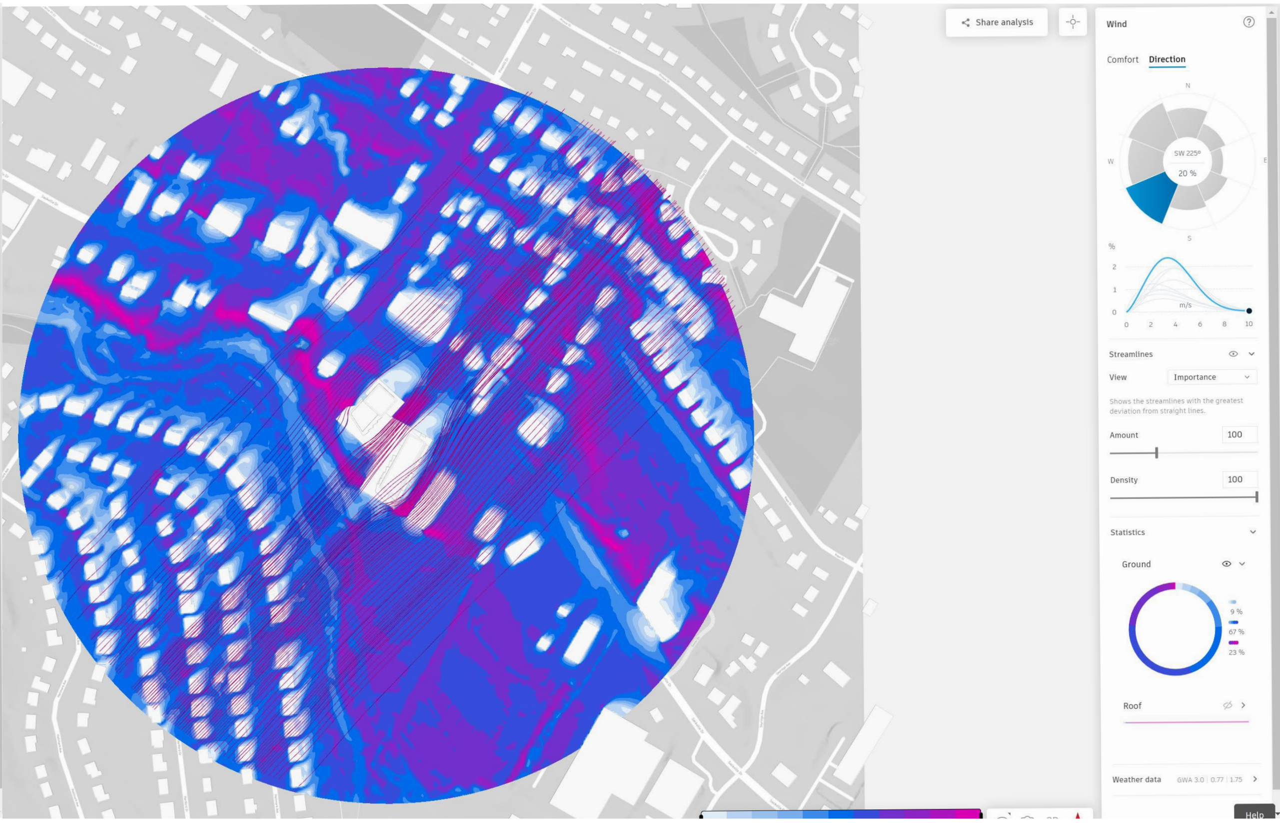


FIG 15. SOUTH-WEST WIND

South-west winds occur throughout the year can be the strong in the spring and fall.

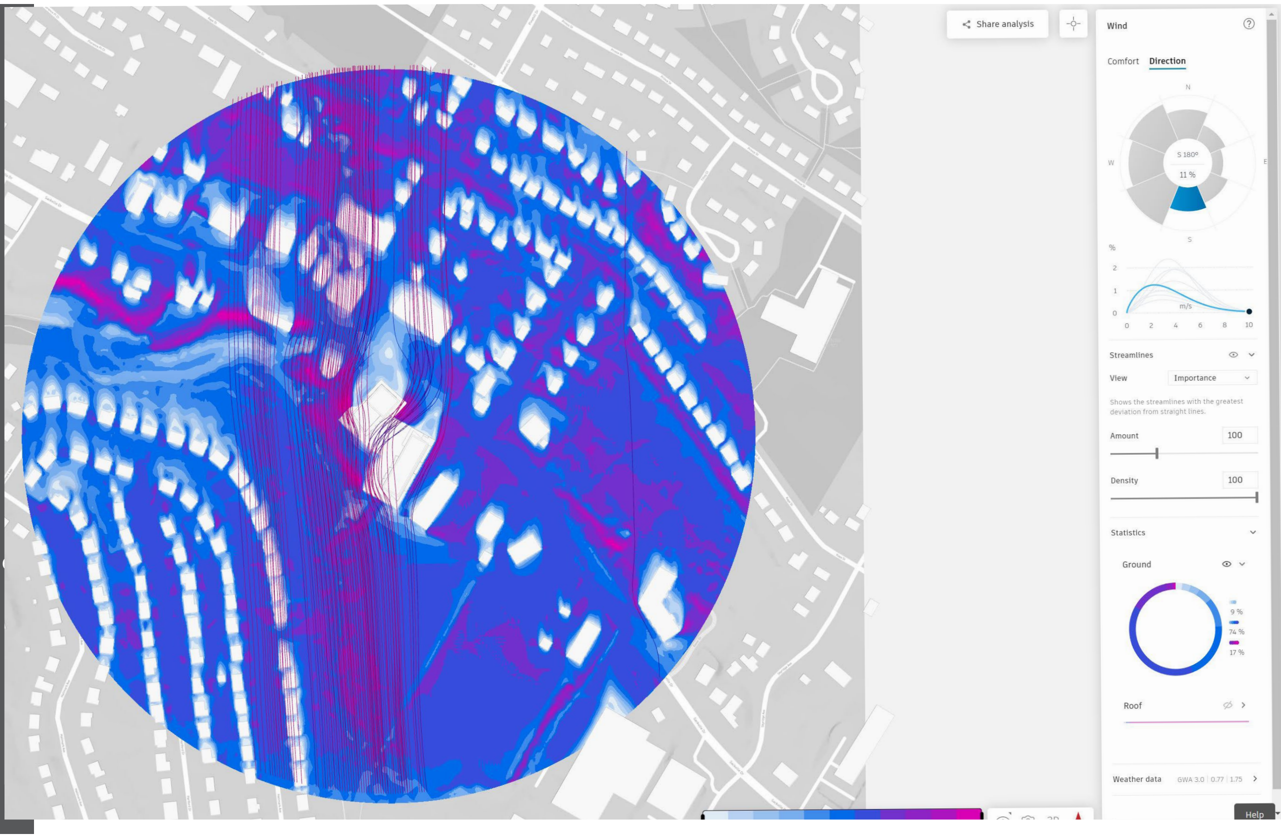


FIG 16. SOUTH WIND

South winds occur mostly in th summer.

WIND IMPACTS: NORTH-WEST WIND (FIG 13)

Prevailing winds coming form the north-west occur from the fall through until the spring and are more frequent than winds coming from the north. The strongest winds occur in the winter from this direction. Based on an annual average, wind ranging 15-20 mph will occur 2.5% of the time and reach >20 mph 1.5% of the time. The CFD simulation was set at 10 m/s for wind speed (purple to pink) and the cyan and blue colours represent areas where the wind speeds will be reduced. Areas in pink are areas where wind speeds will be accelerated around buildings.

Winds speeds will be somewhat reduced on the east sides of the buildings and the courtyard will be well protected. There could be some windier impacts along Sackville Drive sidewalk when wind comes from the prevailing north-west direction but much of this impct will be reduced with the stepbacks imposed on the building. There could be some increased winds on the neighbouring industrial lot to the east compared to today.

The simulation suggests that based on light blue areas of wind shadow, snow will accumulate in the courtyard and east side of the new building. There will also be drifting snow in the courtyard for winds from this direction.

WIND IMPACTS: WEST WIND (FIG 14)

Western prevailing winds occur from the fall to spring and rarely during the summer. Based on a yearly average, 2% of the time wind range 20 mph from the west and occurs 1% of the time exceeding 20 mph. The strongest prevailing winds occur during the winter.

The CFD simulation was set at 10 m/s for wind speed (purple to pink) and the cyan and blue colours represent areas where the wind speeds will be reduced. Areas in pink are areas where wind speeds will be accelerated around buildings. In all directions surrounding the building winds will not be increased at the surrounding street levels as a result of the new infill. One area of Sackville Drive to the east of the intersection will see slightly windier conditions

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There could be additional snow drifting near the entry of the building at Sackville Drive and some drifting at the parking garage exit near Sackville Drive.

WIND IMPACTS: SOUTH-WEST WIND (FIG 15)

South-west winds are frequent throughout the year and the strongest winds occur mostly in the spring and fall. Based on a yearly average, winds ranging 15-20 mph occur 1.5% of the time and reach >20 mph 1% of the time. The CFD simulation was set at 20 mph for wind speed (Yellow-orange) and the green, cyan and blue colours represent areas where the wind speeds will be reduced. Areas in orange and red are areas where wind speeds will be accelerated around buildings.

Wind coming from south-west will have little to no impacts on the surrounding streets and will actually improve conditions as compared with the open parking lot by the Waverley today (south-west winds funnel between the Thompson Building and the Waverley Inn most when they come from the southwest direction). The rearyard podium will experience some down-draft conditions when winds come from the south-west.

WIND IMPACTS: SOUTH WIND (FIG 16)

Prevailing winds coming from the south occur year-round and are felt the most in the spring and fall. In the summer months these winds are usually only felt from the south. Based on a yearly average wind reaching 15-20 mph occur 1.5% a year and reach 20 >mph 0.5% a year. The CFD simulation was set at 10 m/s for wind speed (purple to pink) and the cyan and blue colours represent areas where the wind speeds will be reduced. Areas in pink are areas where wind speeds will be accelerated around buildings.

The simulation indicates that the there could be some slight impacts to the residences on the north side of Sackville Drive as a result of the new buildings and the sloping nature of this side of the road. This wind will also cause the windiest conditions in the inner courtyard , however, since south originating winds don't occur frequently in the winter in Halifax, (0.5%) of the time, there will not be frequent impacts from this direction.

The wind shadow shows potential snow drifting in cyan colours and wind from this direction could leave some drifting on Sackville Drive just north of the buildings. The impacts will be substantially reduced from the building stepbacks

WIND IMPACTS: OTHER DIRECTIONS

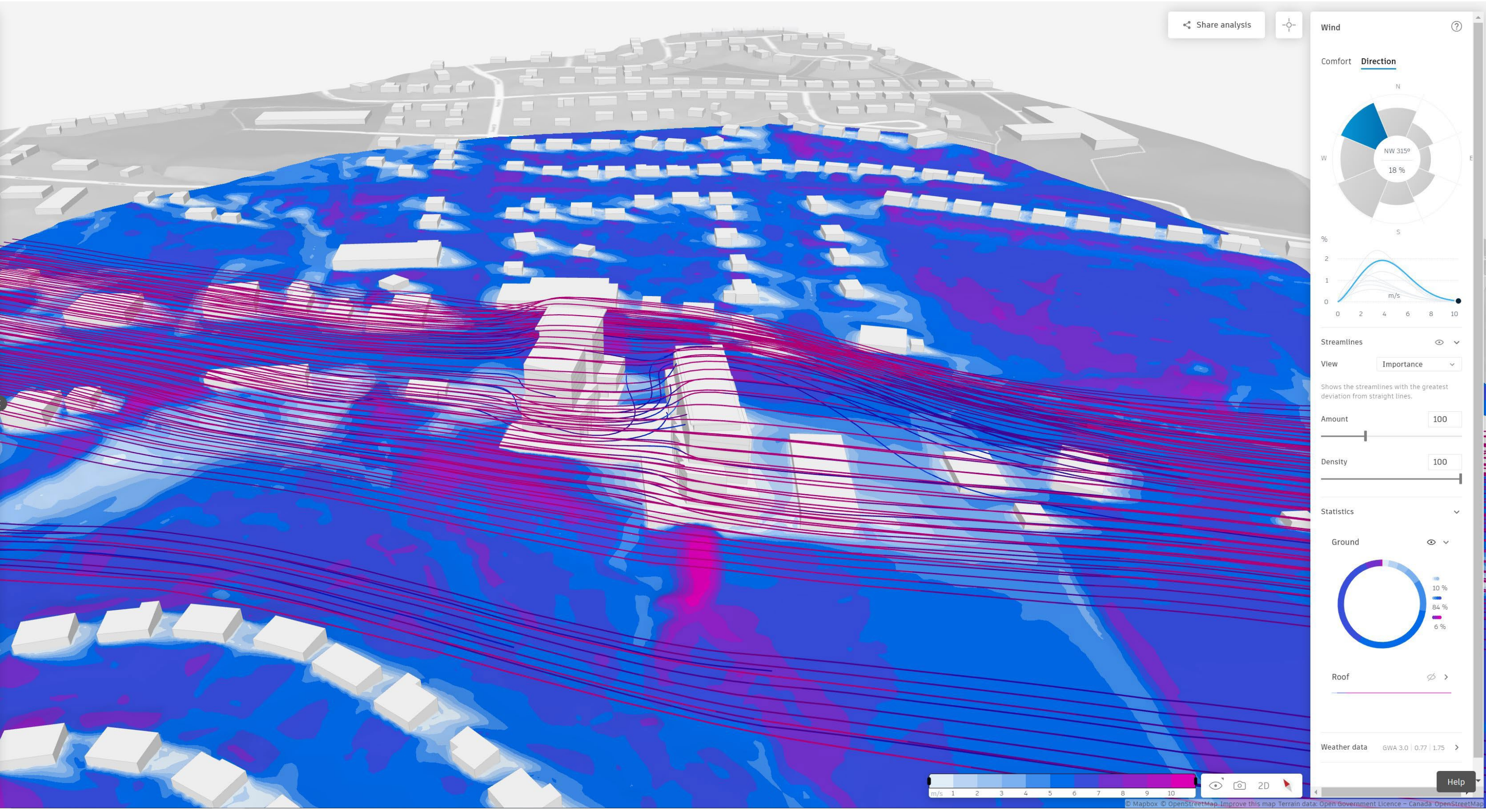
Similarly to the directions presented above, winds from other directions (10-170 degrees) are infrequent enough that they will have very little impact as a result of the new development. Strong storms that come from the north-east (nor-easters) and from the east are usually very windy storms and the streets would already be very windy for storms from these directions.

HUMAN THERMAL COMFORT

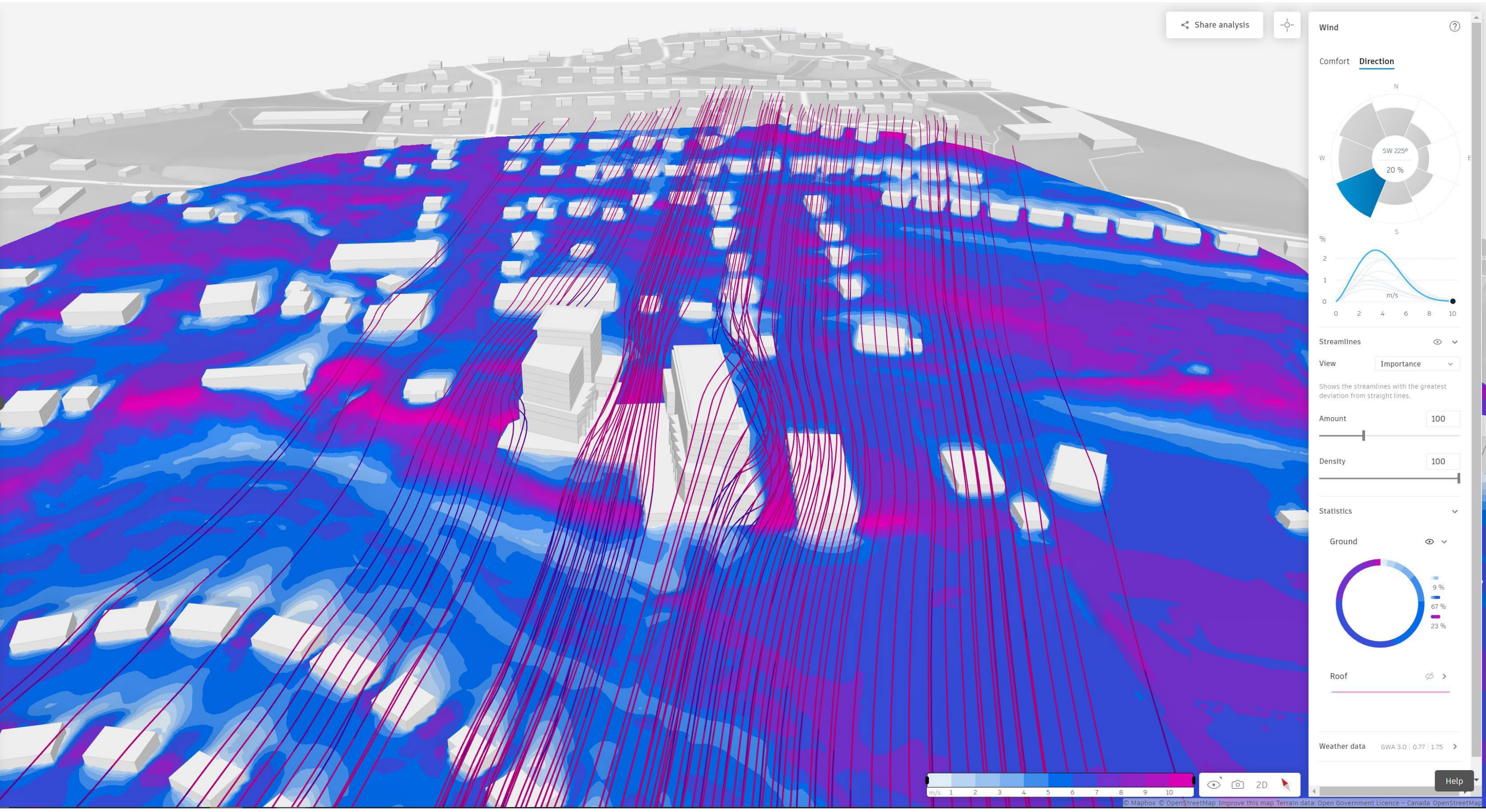
Human comfort in an outdoor space is dependant on a number of variables including wind speed, activity level (sitting, walking, running), long-wave radiation (sunlight emitted from the sun), temperature, shortwave radiation (heat emitted from surrounding buildings and site features), clothing level (partially to fully clothed), and relative humidity. The combination of variables can be very complex on any site leading to a wide range of human thermal comfort outcomes. But many cities have developed criteria of comfort based on wind alone to determine relative comfort levels in different wind conditions.

LAWSON WIND CRITERIA.

Lawson criteria, are a series of comfort criteria categories that quantify the worst wind conditions that most passers-by will consider acceptable. Levels of pedestrian comfort strongly depend on individual activity when they are sitting, standing, walking or running. Someone sitting is uncomfortable in lower wind speeds than someone running



Share analysis
Wind
Comfort
Direction
N
W
E
S
NW 315°
18 %
%
m/s
Streamlines
View
Importance
Shows the streamlines with the greatest deviation from straight lines.
Amount
100
Density
100
Statistics
Ground
10 %
84 %
6 %
Roof
Weather data
GWA 3.0 | 0.77 | 1.75
Help
2D



Share analysis
Wind
Comfort
Direction
N
W
E
S
SW 225°
20 %
%
m/s
Streamlines
View
Importance
Shows the streamlines with the greatest deviation from straight lines.
Amount
100
Density
100
Statistics
Ground
9 %
67 %
23 %
Roof
Weather data
GWA 3.0 | 0.77 | 1.75
Help
2D

or jogging. The comfort level also depends on the amount of time that the person experiences the windy conditions. Generally, the Lawson model assumes that the wind speeds are exceeded less than 5% of the time (3 minutes per hour). The Lawson criteria can be divided into a range of activity criteria comfort levels depending on wind speed.

In our wind simulations, wind speeds which do not exceed 4 m/s (blue to purple in our wind plots) are generally comfortable for sitting. Once the color changes to purple (6m/s) the areas are comfortable for standing but a little uncomfortable for sitting. Once the colour reaches purple/ pink in our plots (>8 m/s), the area is comfortable for strolling but a little uncomfortable for sitting or standing. Once wind speeds reach pink in our plots (10 m/s), the areas are comfortable for brisk walking. If the 10 m/s wind speed is sustained for more than 3-5 minutes it could start to get uncomfortable even brisk walking. At wind speeds over 15 m/s for more than a minute (red in our plots), it is unsafe for elderly frail people. Wind speeds are very unlikely to exceed 20 m/s for more than a minute, but when it is, it is unsafe and uncomfortable for many people.

A	4 m/s	< 5%	Sitting
B	6 m/s	< 5%	Standing
C	8 m/s	< 5%	Strolling
D	10 m/s	< 5%	Business Walking
E	10 m/s	> 5%	Uncomfortable
S	15 m/s	> 0.023%	Unsafe frail
S	20 m/s	> 0.023%	Unsafe all

CONCLUSIONS

The proposed 10-storey and 8-storey development will have very little impacts on the surrounding residential neighbourhoods and on driving or walking conditions along Sackville Drive. The courtyard will in some cases be very windy when winds come from the north and southwest but impacts could be reduced with strategic plantings. There will be some stronger winds within 200-300 m of the new buildings but most of this will not impact surrounding residential properties. The industrial land to the west of the site will be very infrequently impacted, while the industrial lands to the east could see windier conditions than exist today.

There could be some additional drifting of snow on Sackville Drive when the winds come from the south and southwest.

The architects have done a good job at adding vertical and horizontal articulation to reduce the wind sheer, downdrafts, wake effects and corner effects that typify buildings of this scale.

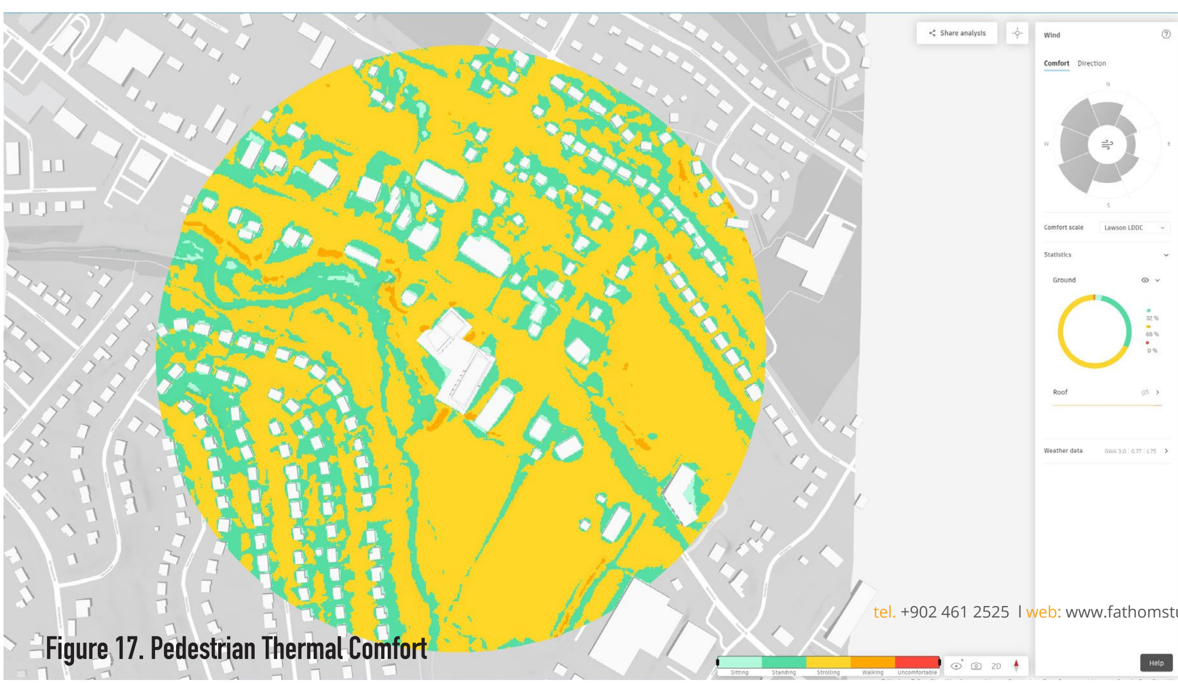


Figure 17. Pedestrian Thermal Comfort

APPENDIX

Shearwater All Year Windrose

	2-5 MPH	5-7 MPH	7-10 MPH	10-15 MPH	15-20 MPH	>20 MPH	Direction Total
0	0.57	0.416	0.436	0.975	0.446	0.298	3.141
10	0.33	0.295	0.323	0.674	0.27	0.166	2.058
20	0.382	0.311	0.326	0.609	0.225	0.113	1.966
30	0.396	0.281	0.277	0.475	0.15	0.055	1.634
40	0.417	0.315	0.252	0.383	0.119	0.064	1.550
50	0.399	0.328	0.233	0.351	0.118	0.061	1.490
60	0.417	0.275	0.228	0.358	0.122	0.054	1.454
70	0.4	0.269	0.222	0.39	0.168	0.134	1.583
80	0.385	0.242	0.245	0.497	0.246	0.189	1.804
90	0.573	0.402	0.381	0.843	0.39	0.315	2.904
100	0.437	0.336	0.323	0.596	0.289	0.174	2.155
110	0.452	0.348	0.292	0.549	0.228	0.168	2.037
120	0.515	0.352	0.264	0.416	0.159	0.138	1.844
130	0.441	0.316	0.248	0.352	0.126	0.107	1.590
140	0.461	0.319	0.269	0.364	0.13	0.117	1.660
150	0.488	0.375	0.292	0.376	0.118	0.114	1.763
160	0.609	0.564	0.474	0.578	0.153	0.107	2.485
170	0.631	0.601	0.588	0.75	0.15	0.094	2.814
180	0.914	0.903	0.813	1.182	0.243	0.138	4.193
190	0.695	0.696	0.66	0.989	0.22	0.12	3.380
200	0.822	0.767	0.733	1.092	0.286	0.17	3.870
210	0.803	0.736	0.675	1.04	0.345	0.215	3.814
220	0.77	0.751	0.736	1.196	0.378	0.241	4.072
230	0.721	0.828	0.747	1.119	0.32	0.186	3.921
240	0.651	0.66	0.588	0.812	0.226	0.114	3.051
250	0.525	0.571	0.561	0.786	0.247	0.139	2.829
260	0.433	0.43	0.469	0.774	0.285	0.187	2.578
270	0.546	0.502	0.500	0.995	0.421	0.285	3.249
280	0.367	0.336	0.399	0.837	0.403	0.308	2.650
290	0.433	0.420	0.428	0.967	0.477	0.334	3.059
300	0.487	0.464	0.433	0.946	0.448	0.312	3.090
310	0.564	0.516	0.476	0.966	0.464	0.253	3.239
320	0.644	0.589	0.550	1.083	0.471	0.273	3.610
330	0.616	0.487	0.425	0.889	0.381	0.238	3.036
340	0.549	0.411	0.405	0.874	0.405	0.274	2.918
350	0.450	0.352	0.332	0.750	0.381	0.263	2.528
Total	**19.293**	**16.764**	**15.603**	**26.833**	**10.008**	**6.518**	

Shearwater April Windrose

Direction	Calm 2	2-5 MPH	5-7 MPH	7-10 MPH	10-15 MPH	15-20 MPH	>20 MPH	Direction Total
0	3.78	0.417	0.302	0.439	1.314	0.83	0.789	4.091
10		0.272	0.283	0.454	0.901	0.536	0.517	2.963
20		0.328	0.32	0.417	0.972	0.57	0.264	2.871
30		0.357	0.246	0.302	0.663	0.249	0.101	1.918
40		0.406	0.376	0.354	0.555	0.197	0.104	1.992
50		0.35	0.346	0.328	0.395	0.175	0.208	1.802
60		0.476	0.32	0.279	0.529	0.272	0.093	1.969
70		0.357	0.298	0.283	0.704	0.436	0.275	2.353
80		0.38	0.335	0.29	0.83	0.447	0.458	2.740
90		0.64	0.622	0.476	1.407	0.808	0.607	4.560
100		0.439	0.406	0.413	0.946	0.666	0.398	3.268
110		0.413	0.465	0.32	0.793	0.558	0.391	2.940
120		0.529	0.409	0.309	0.514	0.29	0.261	2.312
130		0.469	0.365	0.391	0.395	0.182	0.127	1.929
140		0.424	0.346	0.32	0.436	0.149	0.138	1.813
150		0.443	0.357	0.346	0.476	0.097	0.127	1.846
160		0.495	0.543	0.532	0.942	0.168	0.108	2.788
170		0.454	0.532	0.685	1.091	0.227	0.074	3.063
180		0.558	0.718	0.696	1.4	0.391	0.194	3.957
190		0.439	0.532	0.614	1.053	0.253	0.156	3.047
200		0.525	0.607	0.603	1.161	0.342	0.153	3.391
210		0.413	0.584	0.648	0.912	0.331	0.201	3.089
220		0.376	0.655		0.994	0.339	0.16	2.524
230		0.398	0.558	0.432	0.811	0.316	0.115	2.630
240		0.395	0.354	0.421	0.614	0.275	0.104	2.163
250		0.35	0.391	0.402	0.625	0.235	0.078	2.081
260		0.298	0.342	0.328	0.629	0.29	0.145	2.032
270		0.287	0.361	0.402	0.826	0.283	0.279	2.438
280		0.242	0.231	0.324	0.637	0.354	0.383	2.171
290		0.328	0.313	0.313	0.752	0.428	0.309	2.443
300		0.339	0.346	0.324	0.785	0.369	0.246	2.409
310		0.395	0.361	0.316	0.774	0.421	0.186	2.453
320		0.402	0.38	0.376	0.975	0.398	0.197	2.728
330		0.398	0.35	0.249	0.819	0.484	0.298	2.598
340		0.387	0.302	0.354	0.946	0.622	0.614	3.225
350		0.342	0.294	0.361	0.737	0.573	0.696	3.003
Total		**14.521**	**14.55**	**14.101**	**29.313**	**13.561**	**9.554**	

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Shearwater July Windrose

Direction	Calm 2	2-5 MPH	5-7 MPH	7-10 MPH	10-15 MPH	15-20 MPH	>20 MPH	Direction Total
0	7.09	0.4	0.224	0.244	0.397	0.068	0.034	1.367
10		0.227	0.18	0.187	0.271	0.014	0.003	0.882
20		0.258	0.193	0.146	0.197	0.034	0.01	0.838
30		0.248	0.197	0.122	0.149	0.034	0.007	0.757
40		0.332	0.136	0.061	0.105	0.02	0.003	0.657
50		0.309	0.126	0.061	0.105	0.007	0	0.608
60		0.292	0.122	0.081	0.115	0.024	0	0.634
70		0.38	0.136	0.132	0.234	0.034	0.007	0.923
80		0.37	0.237	0.261	0.441	0.153	0.027	1.489
90		0.695	0.499	0.499	0.828	0.156	0.017	2.694
100		0.567	0.522	0.383	0.522	0.092	0.017	2.103
110		0.695	0.522	0.329	0.353	0.047	0	1.946
120		0.811	0.546	0.319	0.275	0.075	0.003	2.029
130		0.723	0.553	0.278	0.234	0.027	0.01	1.825
140		0.858	0.577	0.383	0.217	0.037	0.007	2.079
150		0.899	0.638	0.414	0.329	0.041	0.007	2.328
160		1.208	1.214	0.919	0.617	0.027	0.02	4.005
170		1.35	1.099	1.153	1.011	0.037	0.027	4.677
180		1.998	1.832	1.781	1.594	0.109	0.014	7.328
190		1.54	1.499	1.323	1.448	0.126	0.027	5.963
200		1.747	1.666	1.282	1.56	0.173	0.041	6.469
210		1.737	1.56	1.15	1.16	0.149	0.044	5.800
220		1.577	1.35	1.347	1.781	0.204	0.02	6.279
230		1.306	1.482	1.119	1.174	0.115	0.027	5.223
240		1.167	1.038	0.716	0.797	0.112	0.01	3.840
250		0.845	0.767	0.699	0.6	0.085	0.003	2.999
260		0.607	0.475	0.458	0.444	0.068	0.014	2.066
270		0.824	0.512	0.407	0.387	0.078	0.020	2.228
280		0.407	0.275	0.248	0.258	0.078	0.017	1.283
290		0.475	0.421	0.271	0.417	0.088	0.014	1.686
300		0.597	0.380	0.261	0.444	0.085	0.003	1.770
310		0.550	0.499	0.329	0.370	0.071	0.027	1.846
320		0.668	0.546	0.336	0.434	0.085	0.034	2.103
330		0.512	0.360	0.234	0.370	0.095	0.031	1.602
340		0.424	0.282	0.244	0.353	0.088	0.027	1.418
350		0.309	0.227	0.193	0.332	0.081	0.024	1.166
Total		**27.912**	**22.892**	**18.37**	**20.323**	**2.817**	**0.596**	

Shearwater October Windrose

Direction	Calm 2	2-5 MPH	5-7 MPH	7-10 MPH	10-15 MPH	15-20 MPH	>20 MPH
0	3.97	0.716	0.471	0.467	0.957	0.471	0.23
10		0.383	0.329	0.337	0.743	0.31	0.142
20		0.417	0.352	0.41	0.7	0.207	0.077
30		0.444	0.364	0.341	0.639	0.195	0.034
40		0.471	0.314	0.283	0.471	0.188	0.031
50		0.406	0.44	0.241	0.444	0.199	0.019
60		0.364	0.279	0.291	0.413	0.222	0.05
70		0.322	0.283	0.168	0.367	0.195	0.13
80		0.279	0.149	0.199	0.44	0.218	0.138
90		0.387	0.302	0.329	0.628	0.352	0.214
100		0.337	0.188	0.222	0.467	0.23	0.119
110		0.241	0.195	0.302	0.563	0.138	0.149
120		0.356	0.218	0.203	0.57	0.18	0.153
130		0.36	0.233	0.195	0.348	0.13	0.13
140		0.268	0.195	0.191	0.337	0.222	0.184
150		0.306	0.306	0.199	0.455	0.23	0.149
160		0.352	0.379	0.249	0.574	0.299	0.096
170		0.322	0.406	0.341	0.666	0.268	0.092
180		0.509	0.448	0.521	0.976	0.26	0.195
190		0.44	0.486	0.387	0.846	0.318	0.138
200		0.697	0.697	0.586	0.865	0.291	0.203
210		0.712	0.735	0.589	1.033	0.398	0.115
220		0.628	0.827	0.831	1.321	0.482	0.165
230		0.578	0.819	0.934	1.466	0.387	0.157
240		0.582	0.773	0.712	1.056	0.222	0.046
250		0.521	0.792	0.746	1.217	0.36	0.145
260		0.433	0.566	0.639	1.03	0.302	0.096
270		0.566	0.708	0.888	1.378	0.41	0.191
280		0.478	0.455	0.704	0.961	0.371	0.218
290		0.547	0.681	0.524	1.033	0.433	0.233
300		0.727	0.681	0.555	1.03	0.356	0.188
310		0.7	0.743	0.609	1.045	0.333	0.145
320		0.934	0.899	0.796	1.148	0.444	0.1
330		0.785	0.658	0.555	1.06	0.402	0.149
340		0.723	0.513	0.486	0.961	0.352	0.211
350		0.486	0.429	0.379	0.662	0.23	0.214
Total		**17.777**	**17.313**	**16.409**	**28.87**	**10.605**	**5.046**

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Shearwater February Windrose

Direction	Calm 2	2-5 MPH	5-7 MPH	7-10 MPH	10-15 MPH	15-20 MPH	>20 MPH	Direction Total
0	3.6	0.675	0.525	0.592	1.397	0.703	0.639	4.531
10		0.379	0.316	0.434	0.888	0.3	0.178	2.495
20		0.367	0.304	0.359	0.825	0.292	0.189	2.336
30		0.359	0.213	0.296	0.742	0.284	0.122	2.016
40		0.422	0.296	0.312	0.56	0.193	0.067	1.850
50		0.403	0.308	0.335	0.47	0.154	0.13	1.800
60		0.375	0.328	0.292	0.58	0.126	0.028	1.729
70		0.276	0.296	0.292	0.355	0.111	0.107	1.437
80		0.249	0.154		0.41	0.174	0.367	1.354
90		0.387	0.245	0.201	0.691	0.521	0.766	2.811
100		0.253	0.166	0.189	0.509	0.371	0.296	1.784
110		0.245	0.197	0.15	0.355	0.193	0.272	1.412
120		0.32	0.166	0.154	0.343	0.193	0.114	1.290
130		0.253	0.174	0.201	0.339	0.095	0.111	1.173
140		0.233	0.249	0.233	0.462	0.142	0.17	1.489
150		0.268	0.217	0.213	0.288	0.118	0.111	1.215
160		0.249	0.324	0.205	0.335	0.122	0.075	1.310
170		0.347	0.296	0.316	0.359	0.083	0.107	1.508
180		0.517	0.521	0.403	0.75	0.292	0.118	2.601
190		0.328	0.359	0.304	0.734	0.237	0.087	2.049
200		0.426	0.292	0.407	0.734	0.32	0.189	2.368
210		0.351	0.407	0.371	0.864	0.485	0.45	2.928
220		0.43	0.422	0.474	0.813	0.485	0.553	3.177
230		0.434	0.533	0.639	1.05	0.438	0.462	3.556
240		0.387	0.418	0.375	0.691	0.312	0.229	2.412
250		0.312	0.387	0.478	0.77	0.347	0.209	2.503
260		0.339	0.316	0.497		0.355	0.288	1.795
270		0.399	0.434	0.584	1.125	0.801	0.659	4.002
280		0.308	0.312	0.505	1.16	0.774	0.679	3.738
290		0.32	0.367	0.604	1.539	0.852	0.789	4.471
300		0.426	0.489	0.631	1.488	0.821	0.655	4.510
310		0.553	0.454	0.738	1.563	0.939	0.58	4.827
320		0.734	0.777	0.789	1.717	0.845	0.608	5.470
330		0.659	0.545	0.521	1.263	0.647	.	3.635
340		0.58	0.497	0.458	1.168	0.655	0.45	3.808
350		0.458	0.446	0.45	0.943	0.537	0.58	3.414
Total		**14.021**	**12.75**	**14.002**	**28.28**	**14.317**	**11.434**	