Hong Kong Housing Authority

Proposed Public Housing Development at Tuen Mun Area 54 Sites 1 & 1A

Air Ventilation Assessment - Initial Study

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Executive Summary

Ove Arup and Partners Hong Kong Ltd (Arup) was appointed by Hong Kong Housing Authority (HKHA) to carry out an Air Ventilation Assessment (AVA) Initial Study for Proposed Public Housing Developments at Tuen Mun Area 54 Sites 1 & 1A (the Development).

The AVA Initial Study is conducted to investigate air ventilation performance of the Development, using Computational Fluid Dynamics (CFD) technique.

Site Wind Availability

The site wind availability data for the study is obtained from Planning Department's website [1], which was simulated using the meso-scale numerical model Regional Atmospheric Modelling System (RAMS) [2]. The location of the Development falls within the location grid (x:038, y:063) in the RAMS database.

Wind rose at 500m height is selected to investigate prevailing wind condition in the Initial Study, as the wind is unaffected by the urban roughness.

For annual condition, eight prevailing wind directions are considered in the Initial Study, which cover 78.3% of the total annual wind frequency. They are north-north-easterly (8.5%), north-easterly (10.8%) east-north-easterly (9.5%), easterly (12.4%), east-south-easterly (11.6%), south-easterly (8.8%), south-south-easterly (8.3%) and south-south-westerly (8.4%) winds.

For summer condition, seven prevailing wind directions are considered in the Initial Study, which cover 77.6% of the total summer wind frequency. They are easterly (5.5%), east-south-easterly (8.4%), south-easterly (7.8%), south-south-easterly (11.5%), southerly (13.6%), south-south-westerly (19.1%) and south-westerly (11.7%) winds.

Studied Scenarios

In this study, the potential individual ventilation impact of the proposed changes of the Development, as well as the potential cumulative ventilation impact of the proposed changes of the two developments (i.e. the Development and TM54-Sites3&4(E) Development) are investigated. Thus, there are three scenarios – namely Scenarios 1, 2 and 3 as shown below:

	Application for TM54-Sites1&1A Development	
Scenarios	TM54-Sites1&1A Development	TM54-Sites3&4(E) Development
1	Baseline Scheme	Baseline Scheme
2	Proposed Scheme	Baseline Scheme
3	Proposed Scheme	Proposed Scheme

[1] http://www.pland.gov.hk/pland_en/info_serv/site_wind/site_wind/index.html
[2] http://www.pland.gov.hk/pland_en/p_study/comp_s/InceptionReport_webpage_11-12/final_report.pdf

TM54-Sites1&1A Development

Baseline Scheme – consists of four domestic blocks with building height of 118mPD to 120mPD; with podiums of 2 stories at Block 1 and Block 2; a one-storey car park is located between Block 2 and Block 3; a 15m wide north-south running non-building area (NBA) is provided.

Proposed Scheme – consists of four domestic blocks with building height of 135mPD to 140mPD; with podiums of 2 stories at Block 1 and Block 2; a semi-sunken car park is located between Block 2 and Block 3.

TM54-Sites3&4(E) Development

Baseline Scheme – consists of five domestic blocks with building height of about 105mPD to 116mPD which is an OZP-conforming scheme with 15m wide north-south NBA provided.

Proposed Scheme – consists of five domestic blocks with building height of about 125mPD to 132mPD.

Test Point Location

Three types of test points are evenly placed along the site boundary and within the assessment area of the Development to determine the ventilation performance in the study.

Perimeter Test Points

Perimeter test points are the points positioned at the site boundary of the proposed development. In accordance with the Technical Circular for AVA, perimeter points are positioned at interval of about 15m alongside the site boundary. In total there are 40 perimeter test points in this study.

Overall Test Points

Overall test points are the points evenly positioned in the open area on the streets and places where pedestrian frequently access within the assessment area. In total there are 93 overall test points within the assessment area.

Special Test Points

Special test points are positioned at the major open space within the Development. In total there are 12 special test points for both Baseline Scheme and Proposed Scheme in this study.

Result and Discussion

The Wind Velocity Ratio (VR) as proposed by the Technical Circular was employed to assess the ventilation performances of the Development and surrounding environment. VR is defined as the ratio of the wind velocity at the pedestrian level (2m above ground) to the wind velocity at the top of the wind boundary layer. Higher VR implies better ventilation.

The Site spatial average velocity ratio (SVR) represents the average VR of all perimeter test points at the site boundary. The Local spatial average velocity ratio

(LVR) represents the average VR of all perimeter and overall test points. The SVR and LVR under annual and summer conditions were calculated respectively.

Annual Condition

Under annual condition, the values of SVR and LVR under Scenarios 2 and 3 are slightly higher than that under Scenario 1, indicating that the ventilation performance at the immediate area and local surrounding area would be slightly better under Scenarios 2 and 3.

Summer Condition

Under summer condition, the values of SVR and LVR are same under the three scenarios, indicating that the ventilation performance of the three scenarios at the immediate area and local surrounding would be generally similar.

Focus Area

Various Focus Areas with frequent pedestrian access and within major activity zones were defined.

Annual Condition

Under annual condition, the three analysed scenarios would achieve similar VR at most of the focus areas, indicating their ventilation performance is quite similar in general. Slightly higher VR would be observed at Village 3 and Major Open Spaces in TM54-Sites1&1A under Scenarios 2 and 3.

- At Village 3, Scenarios 2 and 3 would achieve slightly higher VR as compared with Scenario 1. It is mainly because of the stronger downwash effect induced by the Development under its Proposed Scheme.
- Meanwhile, under Proposed Scheme of the Development (i.e. Scenarios 2 and 3), the carpark is semi-sunken, which facilitates wind flow atop of the carpark. As a result, slightly higher VR would be observed at Major Open Spaces in TM54-Sites1&1A.

Summer Condition

Under summer condition, the three analysed scenarios would achieve similar VR at most of the focus areas, indicating their ventilation performance is quite similar in general. Slightly higher VR would be observed at Village 3 under Scenarios 2 and 3.

- At Village 3, Scenarios 2 and 3 would achieve slightly higher VR as compared with Scenario 1. It is mainly because of the stronger downwash effect induced by the Development under its Proposed Scheme.

Conclusion

Major findings of the study could be summarised as below:

Annual condition

- In general, Proposed Scheme of the Development (i.e. Scenarios 2 and 3) would results in slightly better ventilation environment.

Summer Condition

- In general, the three studied scenarios would results in similar ventilation environment.

1 Introduction

1.1 Project Background

Ove Arup and Partners Hong Kong Ltd (Arup) was appointed by Hong Kong Housing Authority (HKHA) to carry out an Air Ventilation Assessment (AVA) Initial Study for Proposed Public Housing Developments at Tuen Mun Area 54 Sites 1 & 1A (the Development).

The Development is zoned "Residential (Group A)" on the approved Tuen Mun Outline Zoning Plan No. S/TM/33, with a maximum domestic plot ratio of 5 or a maximum non-domestic plot ratio of 9.5, and a maximum building height of 120 mPD.

An "Applications for Permission under Section 16 of the Town Planning Ordinance" is being prepared for the Development, in order to obtain planning permission from the Town Planning Board for minor relaxation of the following development restrictions:

- Plot Ratio (domestic portion): from 5 to 6; and
- Maximum Building Height: from 120mPD to 140mPD.

The AVA Initial Study will be conducted to investigate air ventilation performance of the Development, using Computational Fluid Dynamics (CFD) technique.

1.2 Study Objectives

The objectives of the study are:

- To identify the site wind characteristics at the Development and the surrounding area;
- To evaluate the general ventilation pattern over the assessment area;
- To assess the ventilation performance at the focus areas;
- To identify problem areas and propose mitigation measures as appropriate; and
- To demonstrate good design features of the Development.

2 Site Characteristics

2.1 Site Location and the Surrounding Area

The Development is located in Tuen Mun district (Area 54), at the foot of a mountain area between Castle Peak and Yuen Tau Shan to its west. It is surrounded by low-rise developments such as Po Wah Garden to the northeast, and Siu On Garden, Ming Wong Garden, Po Wah Garden Phase 3, and Pui Lin Garden to the southeast.

Slightly away from the Development, there are a number of high-rise building clusters at east, south, and southwest directions, such as TM54-Site2 Development under construction, planned TM54-Site4A(S) Development, planned TM54-Sites3&4(E) Development, indicative TM54-Sites3&4(W) Development, planned TM54-Site5 Development, and Po Tin Estate. These high-rise building clusters would induce certain impact to the prevailing wind flow.

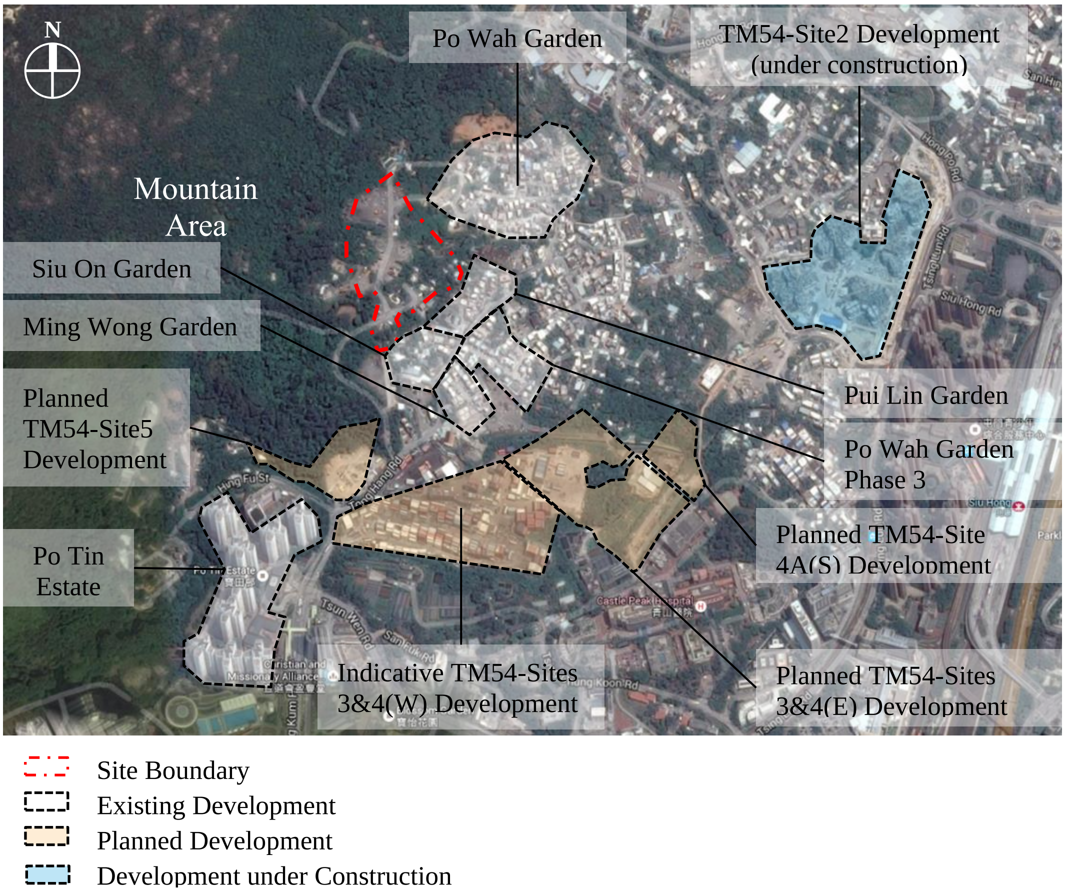
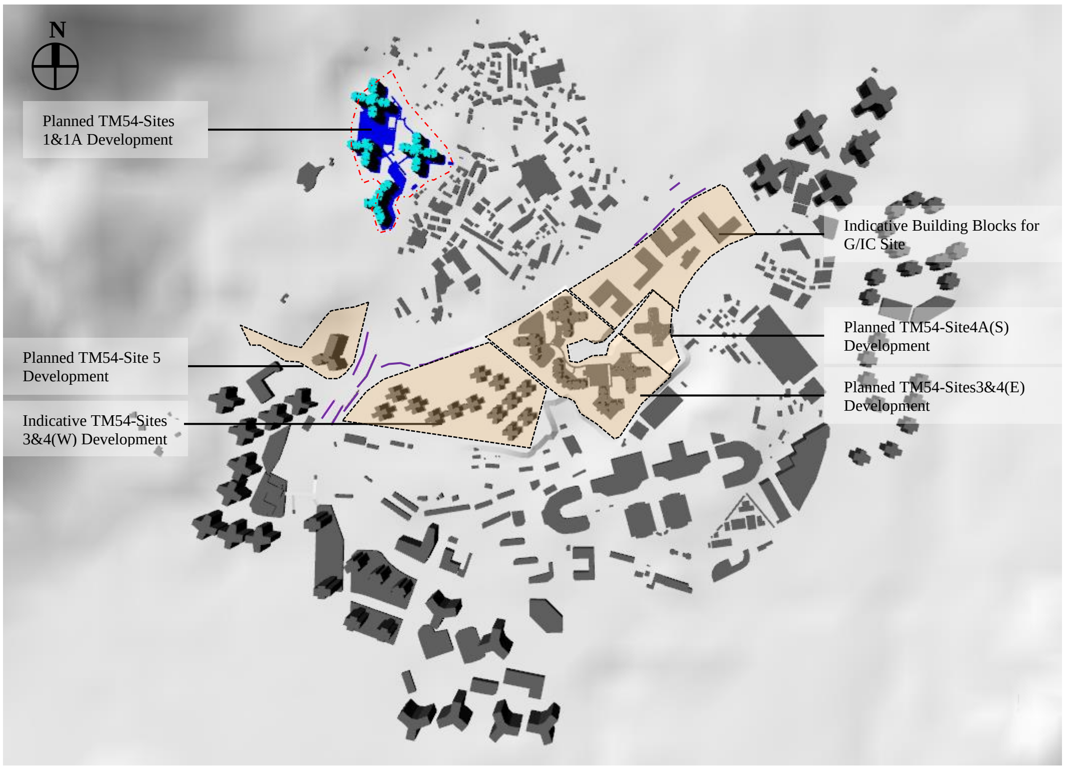


Figure 1 Site and the Surrounding Area of the Development

2.2 Planned Developments and Noise Barriers

Several planned developments and noise barriers are near the Development.

The CFD model for the AVA Initial Study is shown in Figure 2.



- Site Boundaries of the Development
- Site Boundaries of Planned Developments
- The Development
- Surrounding Developments
- Noise Barriers

Figure 2 CFD model for the AVA Initial Study

Planned TM54-Sites3&4(E) Development

In this study, the potential individual ventilation impact of the proposed changes of the Development, as well as the potential cumulative ventilation impact of the proposed changes of the two developments (i.e. the Development and TM54-Sites3&4(E) Development) are investigated.

Details of TM54-Sites3&4(E) can be found in *Air Ventilation Assessment - Initial Study* for 'Proposed Public Housing Development at Tuen Mun Area 54 Sites 3 & 4 (East)'.

Planned TM54-Site4A(S) Development

According to the approved Tuen Mun Outline Zoning Plan No. S/TM/33, this planned development is zoned "Residential (Group A) 24", with maximum domestic plot ratio of 5 or maximum non-domestic plot ratio of 9.5, and maximum building height of 120 mPD. This planned development consist of one 36-storey residential tower with maximum building height of 120mPD is included in the CFD model.

Planned TM54-Site5 Development

This planned development consist of one domestic block with building height of 120mPD, which is zoned “Residential (Group A) 25” on the approved Tuen Mun Outline Zoning Plan No. S/TM/33, with maximum domestic plot ratio of 5 and maximum non-domestic plot ratio of 0.4, and maximum building height of 120 mPD. This planned development is included in the CFD model.

Indicative Development for G/IC Site

There is a G/IC site near the project site. As there is currently no information on the exact development plan for the G/IC site, 4 indicative building blocks together with the existing Tuen Mun Area 54 Sewage Pumping Station are included in the CFD model.

Indicative TM54-Sites3&4(W) Development

According to the approved Tuen Mun Outline Zoning Plan No. S/TM/33, it is zoned “Residential (Group A)”, with maximum domestic plot ratio of 5 or maximum non-domestic plot ratio of 9.5, and maximum building height of 120 mPD. Since there is no planning status for this development, the indicative layout plan for this development is referenced to “Current Environmental Permit Held for Tuen Mun Area 54 Sewage Pumping Station (EP-381/2009)” published by the Environmental Protection Department (EPD) [3] with maximum building height of 120mPD is included in the CFD model.

Noise Barriers

“Formation, Roads and Drains in Area 54, Tuen Mun – Phase 1 & 2” in Tuen Mun Area 54 were proposed by Civil Engineering and Development Department (CEDD) [4]. As part of the works, a number of noise barriers will be constructed. These noise barriers are included in the CFD model.

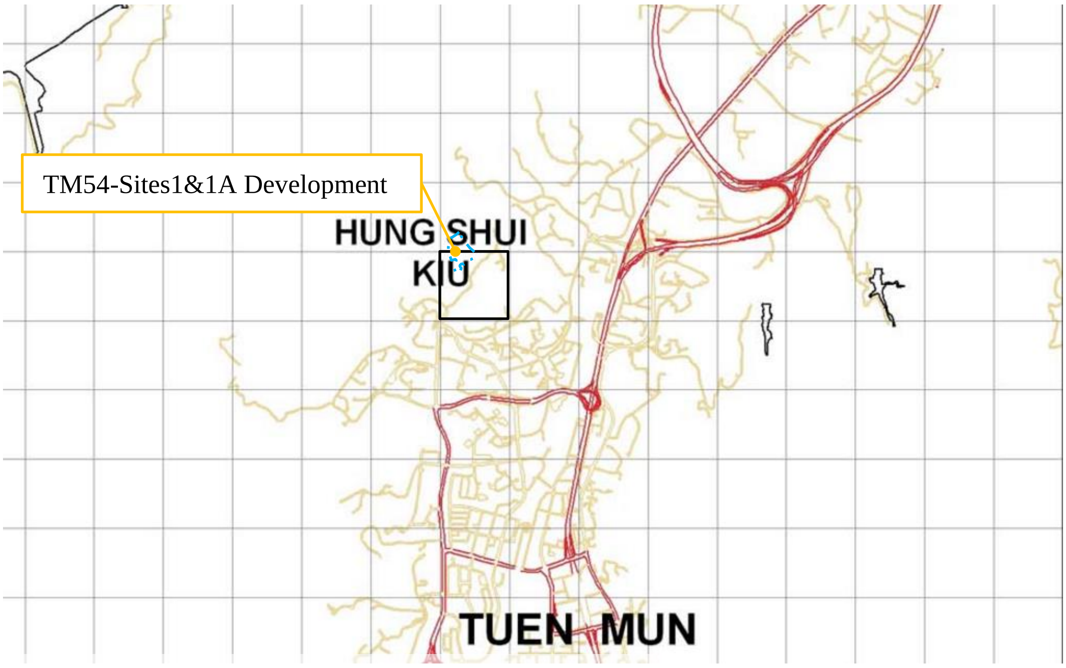
[3] http://www.epd.gov.hk/eia/english/alpha/aspd_503.html
[4] http://www.legco.gov.hk/yr14-15/english/fc/pwsc/papers/p15-10e.pdf

3 Site Wind Availability

This Initial Study follows the methodology for AVA as stipulated in "Technical Circular No. 1/06 – Air Ventilation Assessments" (the Technical Circular) and Annex A to the Technical Circular "Technical Guide for Air Ventilation Assessment for Developments in Hong Kong" (the Technical Guide) jointly issued by Housing, Planning and Lands Bureau and Environmental, Transport and Works Bureau on 19th July 2006 [5].

3.1 Site Wind Availability Data

The site wind availability data for the study is obtained from Planning Department's website [6], which was simulated using the meso-scale numerical model Regional Atmospheric Modelling System (RAMS) [7]. The location of the Development falls within the location grid (x:038, y:063) in the RAMS database as indicated in Figure 3. The wind rose for annual condition is presented in Figure 4. The wind rose for summer condition is presented in Figure 5.



Site Boundary of TM54-Sites1&1A Development

Figure 3 RAMS Grid and Location of the Developments

[5] https://www.devb.gov.hk/filemanager/en/content_679/hplb-etwb-tc-01-06.pdf
[6] http://www.pland.gov.hk/pland_en/info_serv/site_wind/site_wind/index.html
[7] http://www.pland.gov.hk/pland_en/p_study/comp_s/InceptionReport_webpage_11-12/final_report.pdf

Wind rose at 500m height is selected to investigate prevailing wind condition in the Initial Study, as the wind is unaffected by the urban roughness value.

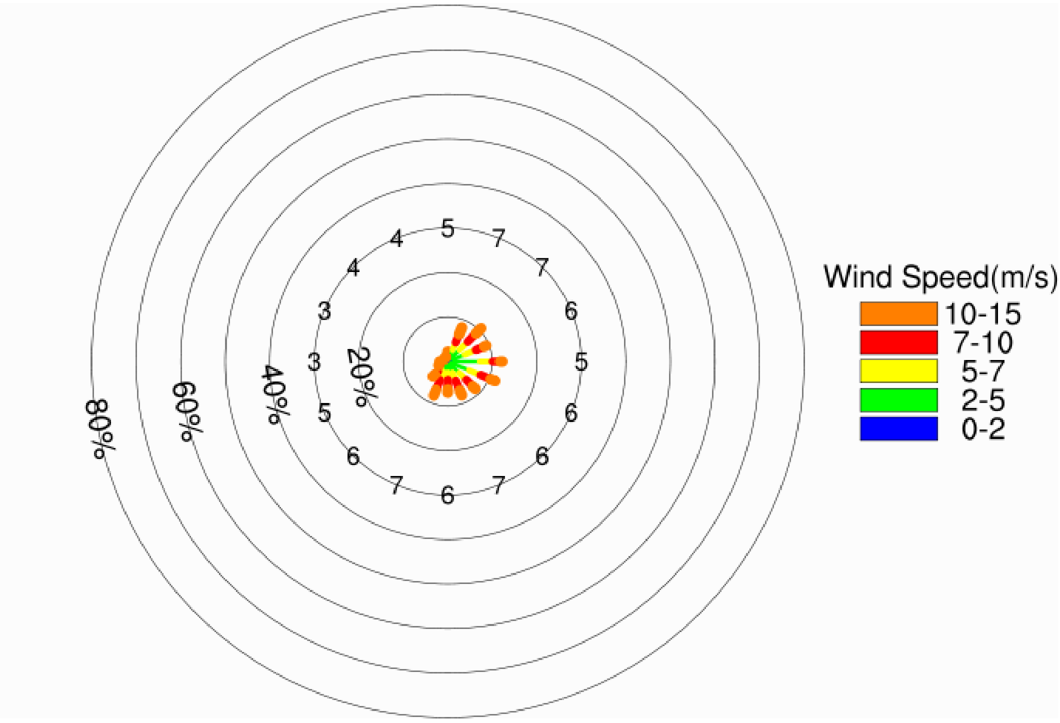


Figure 4 Wind Rose at 500mPD for Annual Condition (Grid x_ 038, y_ 063)

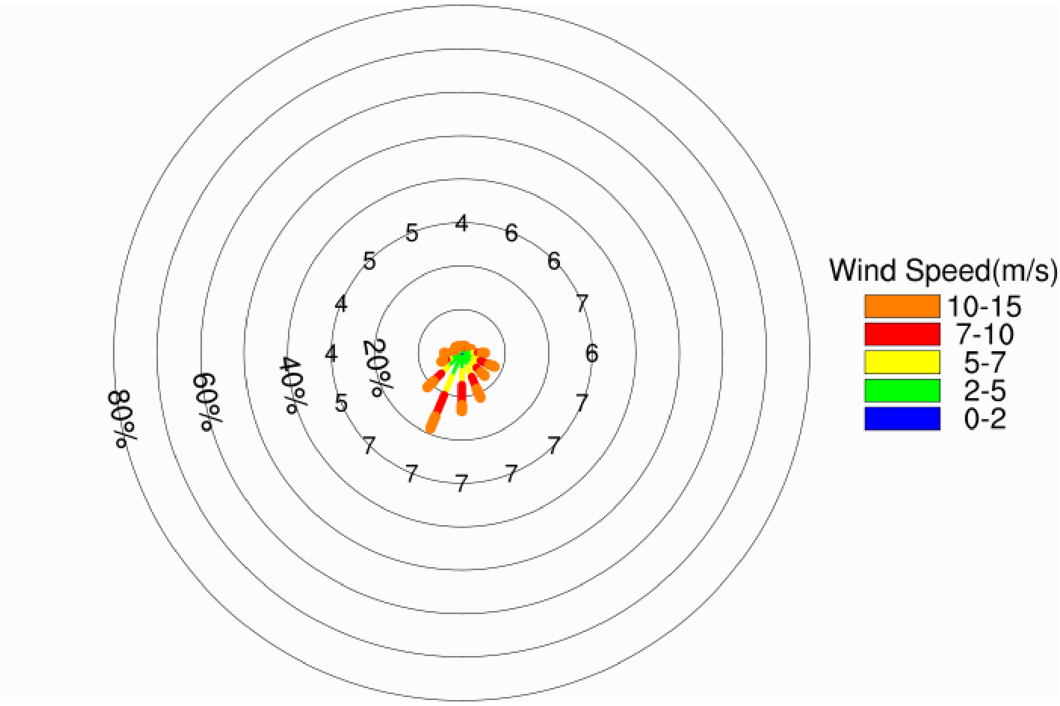


Figure 5 Wind Rose at 500mPD for Summer Condition (Grid x_ 038, y_ 063)

4 Methodology for Initial Study

4.1 Wind Directions

As mentioned in Section 3.1, the RAMS wind data of location grid (x:038, y:063) is adopted for the site wind availability in this study.

4.1.1 Annual Prevailing Wind

For annual condition, eight prevailing wind directions (highlighted in red colour in Table 1) are considered in the Initial Study, which cover 78.3% of the total annual wind frequency. They are north-north-easterly (8.5%), north-easterly (10.8%) east-north-easterly (9.5%), easterly (12.4%), east-south-easterly (11.6%), south-easterly (8.8%), south-south-easterly (8.3%) and south-south-westerly (8.4%) winds.

Table 1 Annual Wind Frequency of the Wind Directions

Wind Direction	N	NNE	NE	ENE	E	ESE	SE	SSE	
Frequency	2.3%	8.5%	10.8%	9.5%	12.4%	11.6%	8.8%	8.3%	
Wind Direction	S	SSW	SW	WSW	W	WNW	NW	NNW	**SUM**
Frequency	7.0%	8.4%	4.9%	2.3%	1.9%	1.0%	1.0%	1.2%	**78.3%**

** The wind directions in red are selected for the study for annual condition*

4.1.2 Summer Prevailing Wind

For summer condition, seven prevailing wind directions (highlighted in red colour in Table 2) are considered in the Initial Study, which cover 77.6% of the total summer wind frequency. They are easterly (5.5%), east-south-easterly (8.4%), south-easterly (7.8%), south-south-easterly (11.5%), southerly (13.6%), south-south-westerly (19.1%) and south-westerly (11.7%) winds.

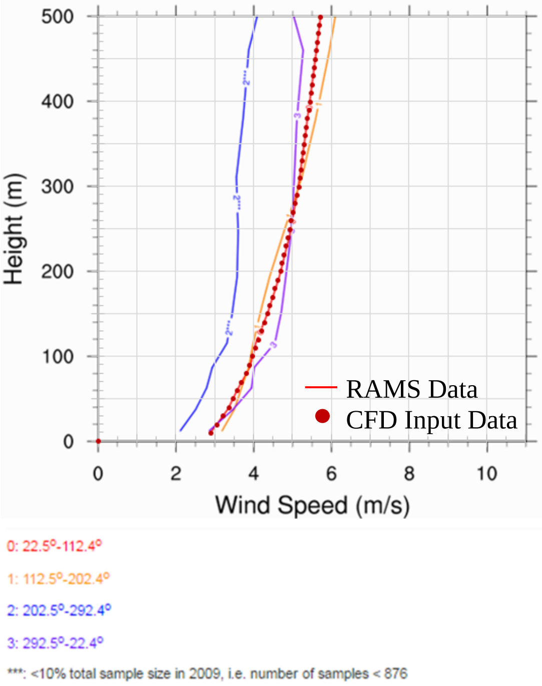
Table 2 Summer Wind Frequency of the Wind Directions

Wind Direction	N	NNE	NE	ENE	E	ESE	SE	SSE	
Frequency	1.6%	1.9%	1.6%	2.4%	5.5%	8.4%	7.8%	11.5%	
Wind Direction	S	SSW	SW	WSW	W	WNW	NW	NNW	**SUM**
Frequency	13.6%	19.1%	11.7%	5.1%	4.1%	1.8%	1.9%	1.7%	**77.6%**

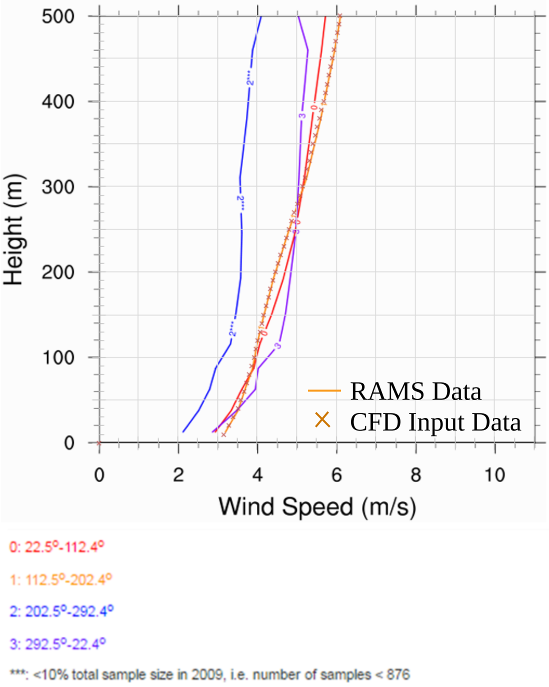
** The wind directions in red are selected for the study for summer condition*

4.2 Wind Profiles

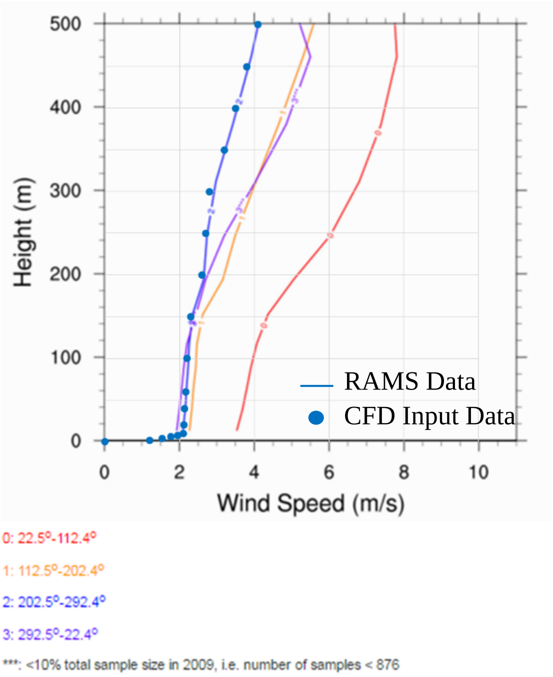
The wind profile calculated from RAMS is adopted in this AVA study. The profiles of wind speed from the PlanD RAMS database (x:038, y:063) are shown in Figure 6. RAMS wind profile data from 10 – 500m is extracted directly as it reflects the exact wind data. For the near ground wind speed from 0 to 10m, the power law equation is used to approximate near ground wind profile. For wind data above 500m height, the velocity is assumed the same as the data at 500m. These wind data will be the input parameters in the CFD simulation. And the wind profiles of the 16 wind directions, categorised into 4 sectors, the simulated wind profile under 4 sectors are presented in Figure 6.



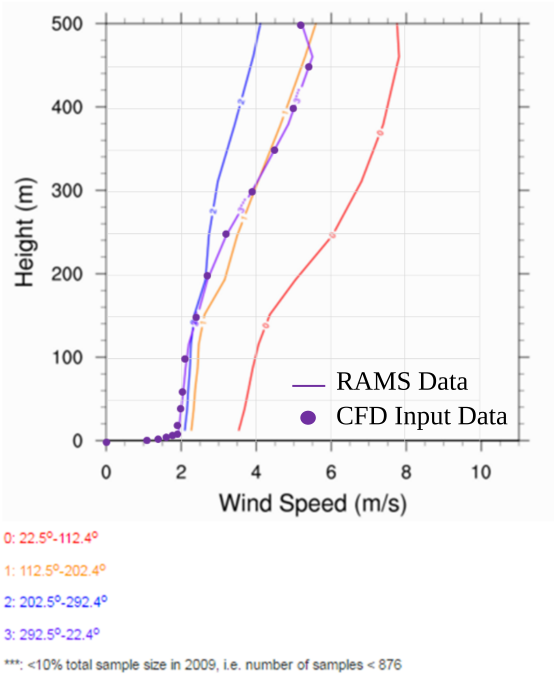
Simulated wind profile from 22.5° – 112.4°



Simulated wind profile from 112.5° – 202.4°



Simulated wind profile from 202.5° – 292.4°



Simulated wind profile from 292.5° – 22.4°

Figure 6 Wind Profile from RAMS at the Project Site (Grid x_ 038, y_ 063)

4.3 Technical Details of CFD Simulations

The Air Ventilation Assessment (AVA) methodology as stipulated in the Technical Circular and Technical Guide is used for this study. The following sections describe the details of the study methodology.

4.3.1 Project Assessment and Surrounding Areas

With reference to the Technical Guide, the Assessment Area would include the immediate surroundings of the development, up to 1H from the site boundary where H is the height of the tallest building of the development. The Surrounding Area would include the area up to 2H from the site boundary.

The tallest building of the Development has a building height of about 120m, so 1H and 2H would be 120m and 240m respectively. As TM54-Sites3&4(E) Development, with an H of about 125m, would also be included in the model, the Surrounding Area would also include the 2H (250m) area from the site boundary of TM54-Sites3&4(E) Development. The site boundary, Assessment Area, and Surrounding Area of the study are presented in Figure 7.

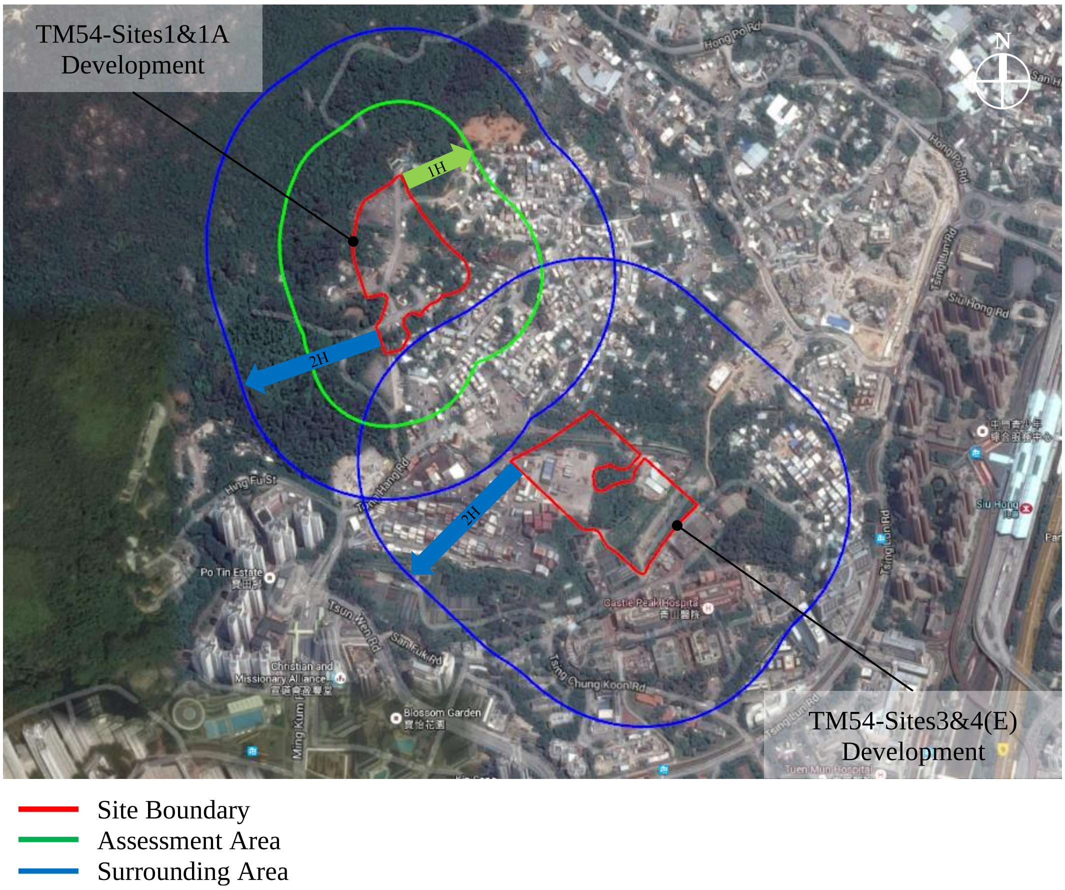


Figure 7 Site boundary, Assessment Area, and Surrounding Area (Image Source: Google Maps)

4.4 CFD Model

Following the Technical Circular for AVA, buildings within Surrounding Area shall be built in the CFD model. In addition, the model domain is built far beyond the Surrounding Area as required in the Technical Circular in order to eliminate the boundary effects. Therefore, the studied size of the CFD model for this Study is approximately 4300m (L) x 2800m (W) x 3000m (H). It is proposed one CFD model to contain both the TM54-Sites1&1A Development and TM54-Sites3&4(E) Development. The whole CFD domain covers both developments and their surrounding buildings within 2H region of the Developments.

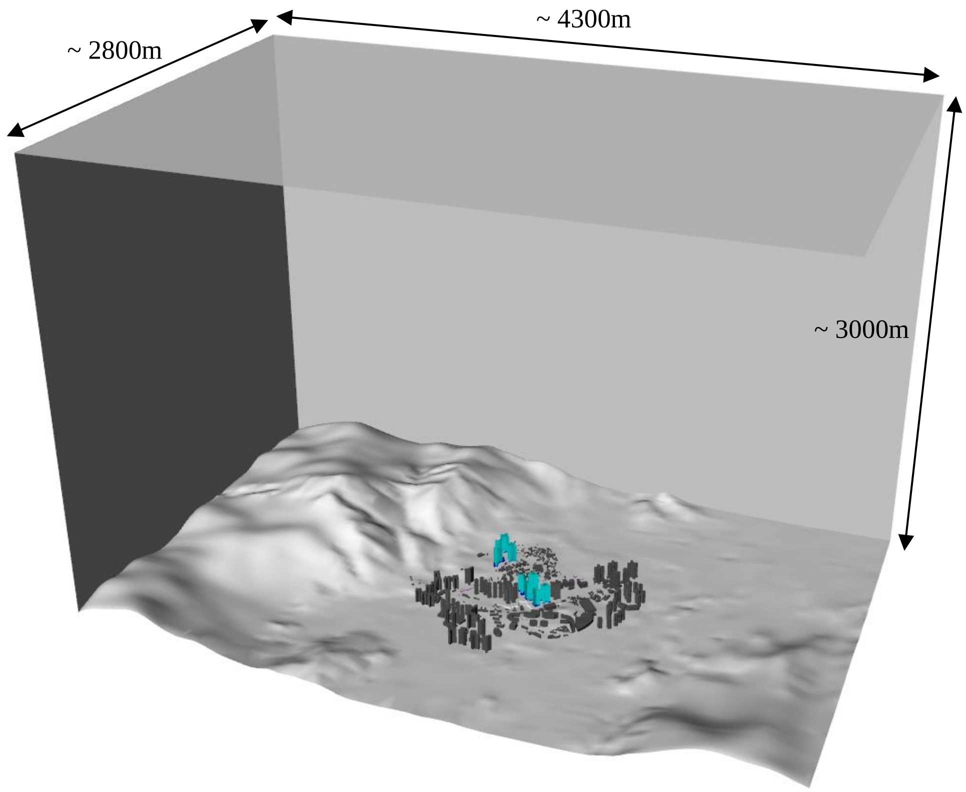


Figure 8 Domain of CFD model

4.5 Assessment Tool

The AVA Initial Study is conducted using Computational Fluid Dynamics (CFD) technique. Well recognised commercial CFD packages ANSYS ICEM-CFD and STAR-CCM+, which are widely used in the industry for AVA studies, will be used in this study. With the use of three-dimensional CFD simulation, the local airflow distribution can be modelled in detail.

4.5.1 Mesh Setup

Body-fitted unstructured grid technique is used to fit the geometry to reflect the complexity of the development geometry. A prism layer of 3m above ground (totalling 6 layers and each layer is 0.5m) is incorporated in the meshing so as to better capture the approaching wind. The expansion ratio is 1.3 while the maximum blockage ratio is 3%.

Finer grid system is applied to the most concerned area based on preliminary judgement, while coarse grid system is applied to the area of surrounding buildings for better computational performance while maintaining satisfactory result.

4.5.2 Turbulence Model

As highlighted in recent academic and industrial research literatures by CFD practitioners, the widely used standard k - ε turbulence model technique may not adequately model the effects of large scale turbulence around buildings and ignores the wind gusts leading to the relatively poor prediction in the recirculation regions around building. Therefore in this CFD simulation, realizable $k - \varepsilon$ turbulence modelling method is applied. This technique provides more accurate representation of the levels of turbulence that can be expected in an urban environment.

4.5.3 Calculation Method

The Segregated Flow model solves the flow equations in a segregated manner. The linkage between the momentum and continuity equations adopted the predictor-corrector approach. A collocated variable arrangement and a Rhie-and-Chow-type pressure-velocity coupling combined with a SIMPLE-type algorithm. A higher order differencing scheme is applied to discretize the governing equations. The convergence criterion is set to 1.0×10^{-4} on mass conservation. The calculation will repeat until the solution satisfies this convergence criterion.

The prevailing wind direction as mentioned in Section 4.1 is set to inlet boundary of the model with wind profile as detailed in Section 4.2. The downwind boundary is set to pressure with value of atmospheric pressure. The top and side boundaries are set to symmetry.

4.5.4 Summary

Based on previous sections, the key parameters of the CFD model are summarized in Table 3.

Table 3 Key Parameters of the CFD model

Parameter	Modelling Detail
Physical Model Scale	Real Scale model, 1:1 scale
Model details	Only include Topography, Building Blocks, Streets/Highways, no Landscape is included
Domain	4300m(L) x 2800m(W) x 3000m(H)
Assessment Area	1H from Site Boundary
Surrounding Area	2H from Site Boundary
Grid Expansion Ratio	The grid should satisfy the grid resolution requirement with maximum expansion ratio = 1.3
Prismatic layer	6 layer of prismatic layers and 0.5m each (i.e. total 3m above ground)
Inflow boundary Condition	Incoming wind profile as described in Section 3.1
Outflow boundary	Pressure boundary condition with dynamic pressure equal to zero
Wall boundary condition	Logarithmic law boundary
Solving algorithms	Rhie and Chow SIMPLE for momentum equation Hybrid model for all other equations
Blockage ratio	< 3%
Convergence criteria	Below 1.0×10^{-4}

4.6 AVA Indicator

The Wind Velocity Ratio (VR) as proposed by the Technical Circular is employed to assess the ventilation performances of the proposed development and surrounding environment. Higher VR implies better ventilation. The calculation of VR is given by the following formula:

$$VR = \frac{V_p}{V_\infty}$$

V_∞= the wind velocity at the top of the wind boundary layer (typically assumed to be around 500m above the centre of the site of concern, or at a height where wind is unaffected by the urban roughness below).

V_P= the wind velocity at the pedestrian level (2m above ground) after taking into account the effects of buildings.

The Average VR is defined as the weighted average VR with respect to the percentage of occurrence of all considered wind directions. This gives a general idea of the ventilation performance at the considered location on an annual basis.

4.6.1 Assessment Parameter

Site spatial average velocity ratio (SVR) and a Local spatial average velocity ratio (LVR) will be determined. The description of the assessment parameters are presented in Table 4.

Table 4 Assessment Parameter of the AVA Initial Study

Terminology	Description
Velocity Ratio (VR)	The velocity ratio (VR) represents the ratio of the air velocity at the measurement position to the value at the reference points.
Site spatial average velocity ratio (SVR)	The SVR represent the average VR of all perimeter test points at the site boundary which identified in the report.
Local spatial average velocity ratio (LVR)	The LVR represent the average VR of all points, i.e. perimeter and overall test points at the site boundary which identified in the report.

5 Studied Scenarios

In this study, the potential individual ventilation impact of the proposed changes of the Development, as well as the potential cumulative ventilation impact of the proposed changes of the two developments (i.e. the Development and TM54-Sites3&4(E) Development) are investigated. Thus, there are three scenarios – namely Scenarios 1, 2 and 3 as shown below:

	Application for TM54-Sites1&1A Development	
Scenarios	TM54-Sites1&1A Development	TM54-Sites3&4(E) Development
1	Baseline Scheme	Baseline Scheme
2	Proposed Scheme	Baseline Scheme
3	Proposed Scheme	Proposed Scheme

5.1 TM54-Sites1&1A Development

5.1.1 Baseline Scheme

Baseline Scheme is an indicative scheme which is formulated based on the existing development restrictions. The key development parameters of Baseline Scheme are presented in Table 5.

Table 5 Development Parameters of Baseline Scheme

Development Parameter	**Baseline Scheme**
Plot Ratio (domestic portion)	5
Maximum Building Height	120mPD

The scheme consists of four domestic blocks with building height of 118mPD to 120mPD. There are podiums of 2 stories at Block 1 and Block 2. A one-storey carpark is located between Block 2 and Block 3. The site ground level is approximately 21.5mPD to 25.4mPD.

A 15m wide north-south running NBA is provided in Baseline Scheme as indicated in Figure 9. There is no building structures (except part of canopy of Block 4 and cover for walkways) in the NBA.

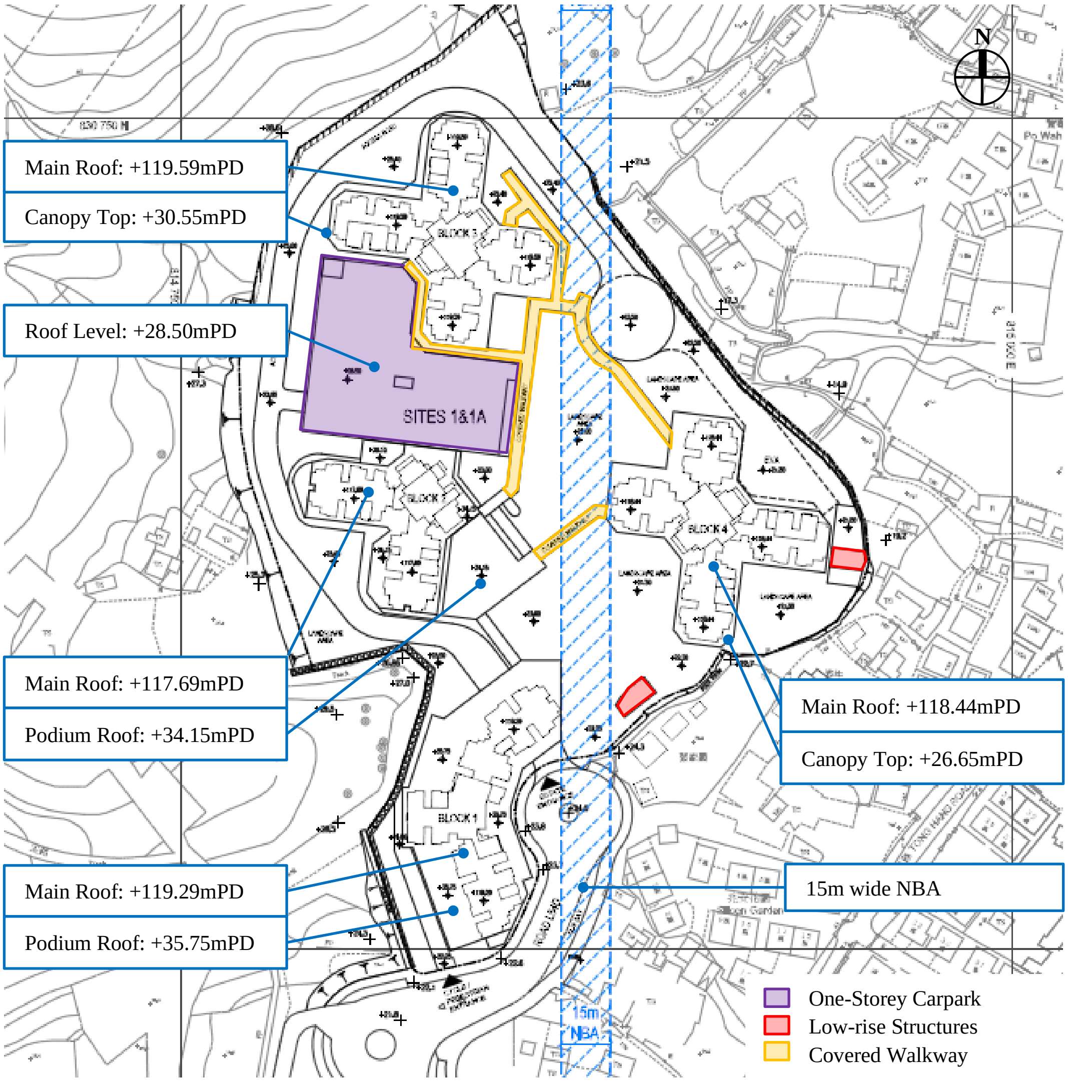
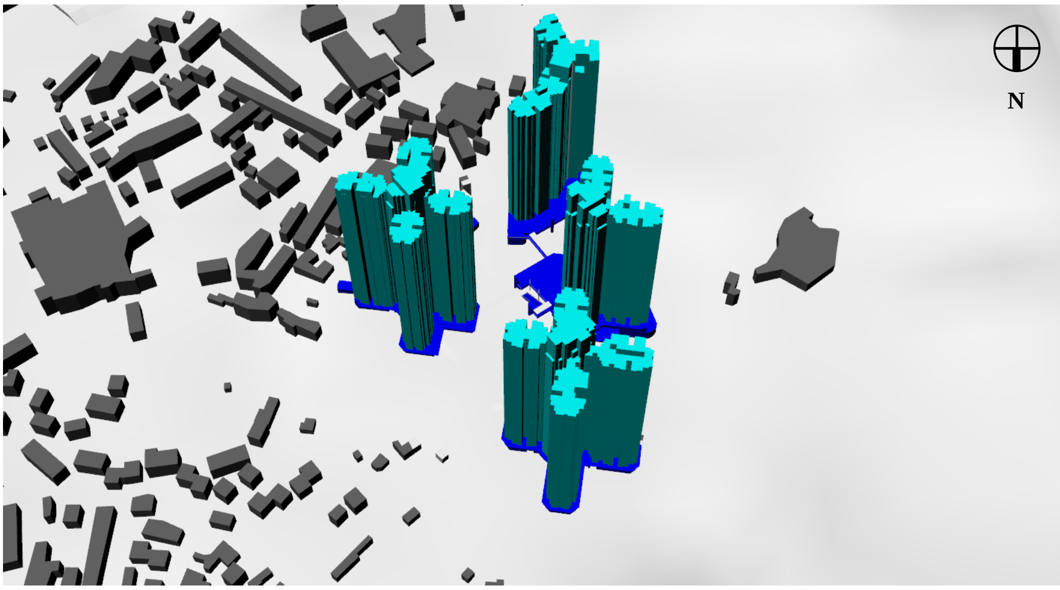


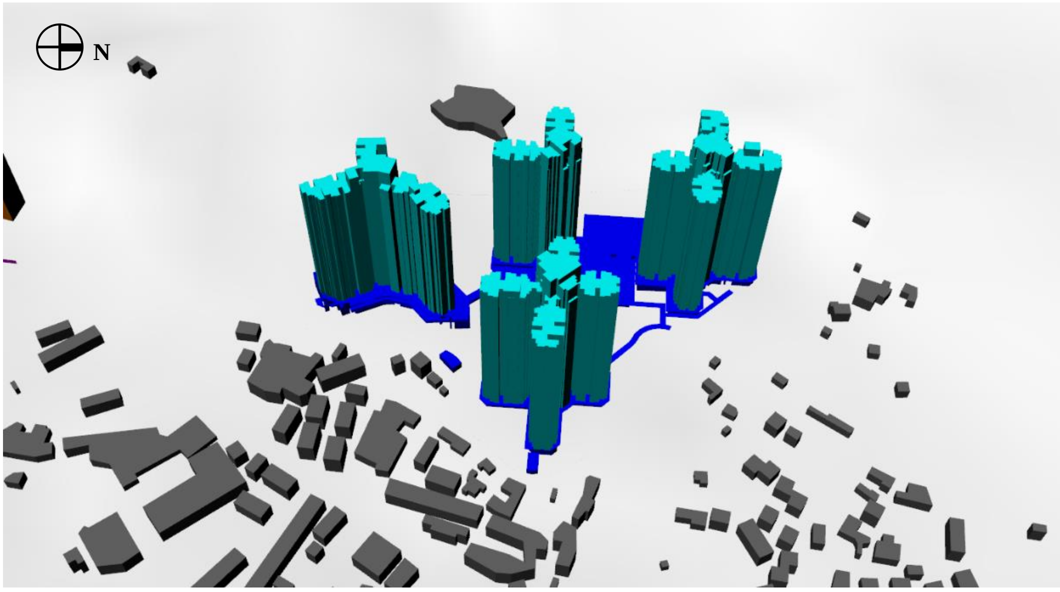
Figure 9 Baseline Scheme Master Layout Plan

By referring to the CAD drawings of the Baseline Scheme, the 3D model was constructed as shown in Figure 10 to Figure 13.



TM54-Sites 1&1A Development
Surrounding Developments

Figure 10 Northernly view of Baseline Scheme



TM54-Sites 1&1A Development
Surrounding Developments

Figure 11 Easternly view of Baseline Scheme

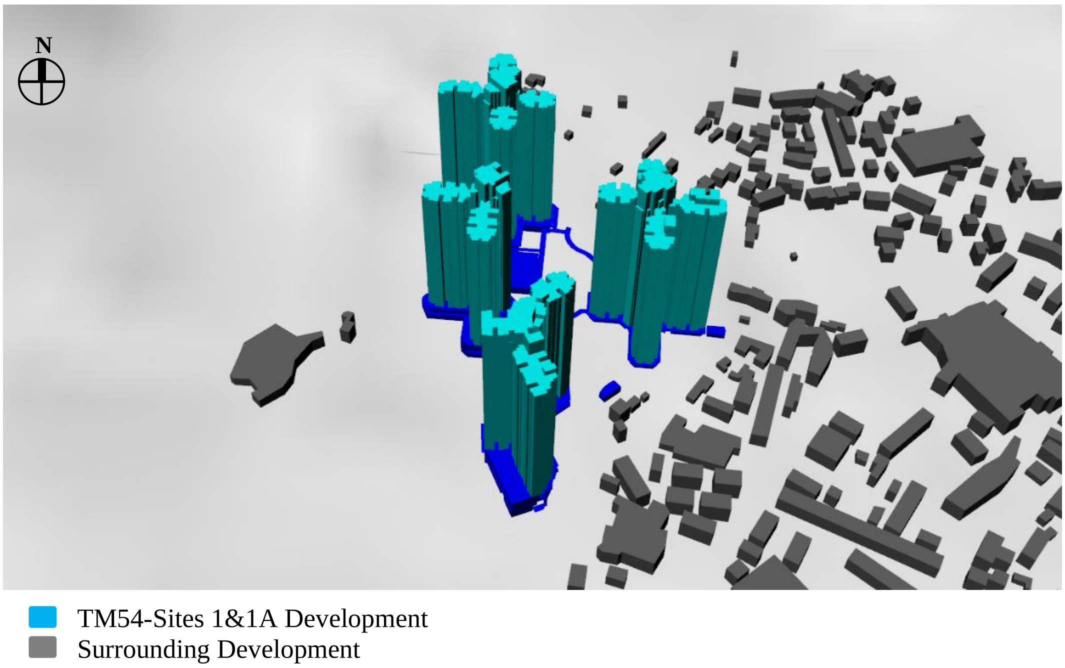


Figure 12 Southernly view of Baseline Scheme

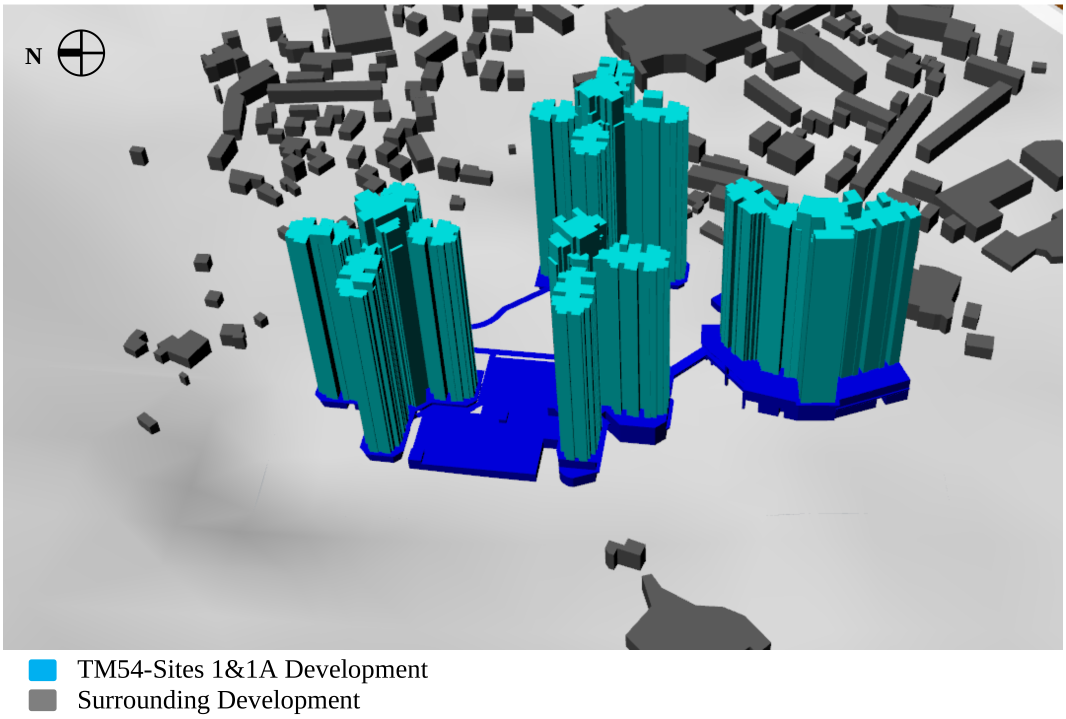


Figure 13 Westernly view of Baseline Scheme

5.1.2 Proposed Scheme

Proposed Scheme is the intended development scheme, with minor relaxation of certain development restrictions. The key development parameters of Proposed Scheme is presented in Table 6.

Table 6 Development Parameters of Proposed Scheme

Development Parameter	Proposed Scheme
Plot Ratio (domestic portion)	6
Maximum Building Height	140mPD

The scheme consists of four domestic blocks with building height of 135mPD to 140mPD. There are podiums of 2 stories at Block 1 and Block 2. A semi-sunken carpark is located between Block 2 and Block 3. The site ground level is approximately 21.5mPD to 25.4mPD.

A minimum 20m wide NNE-SSW running NBA at +36mPD and above is provided under Proposed Scheme as indicated in Figure 14. Meanwhile, Block 4 has a setback of approximately 4m when compared with Baseline Scheme.

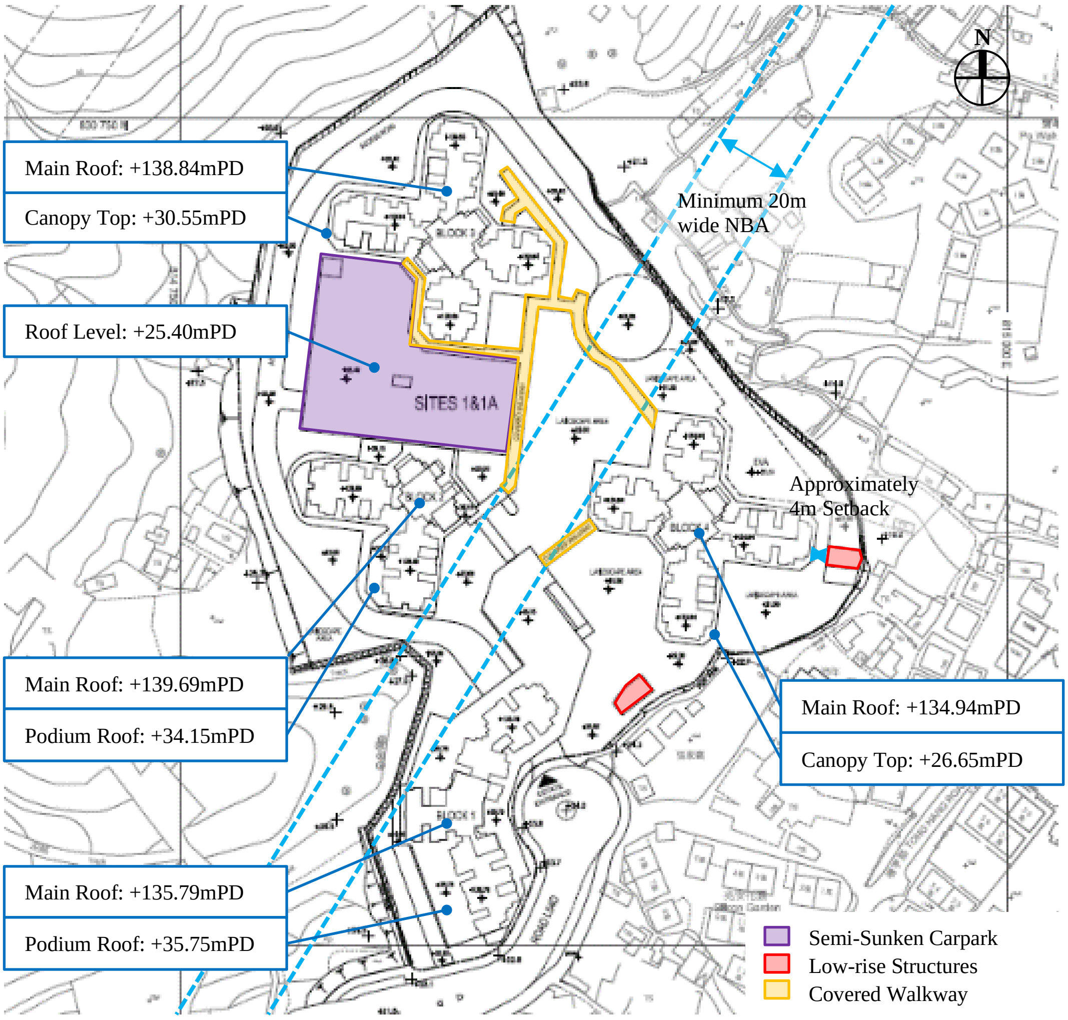
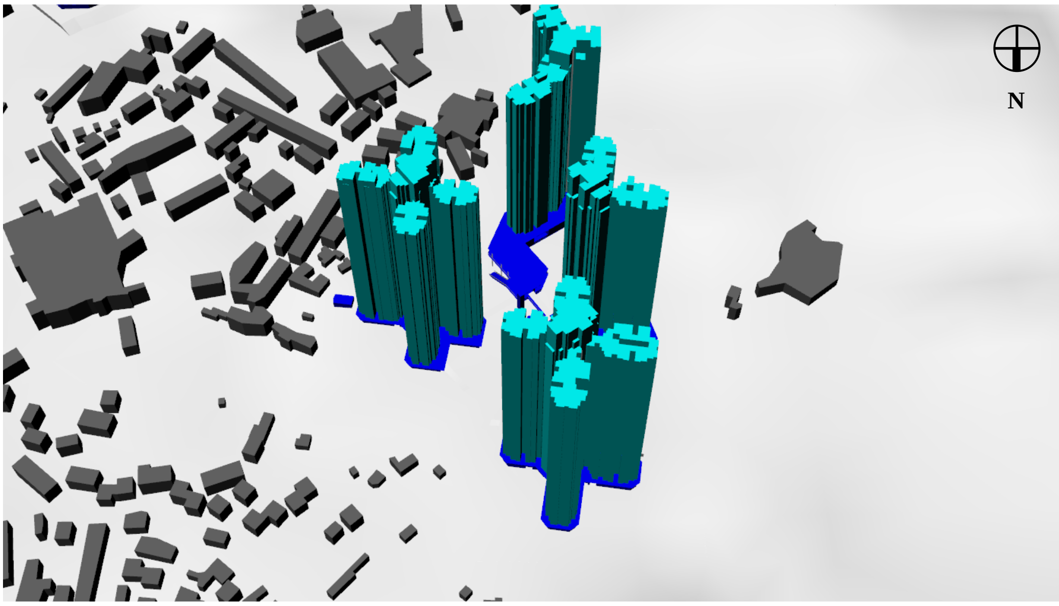


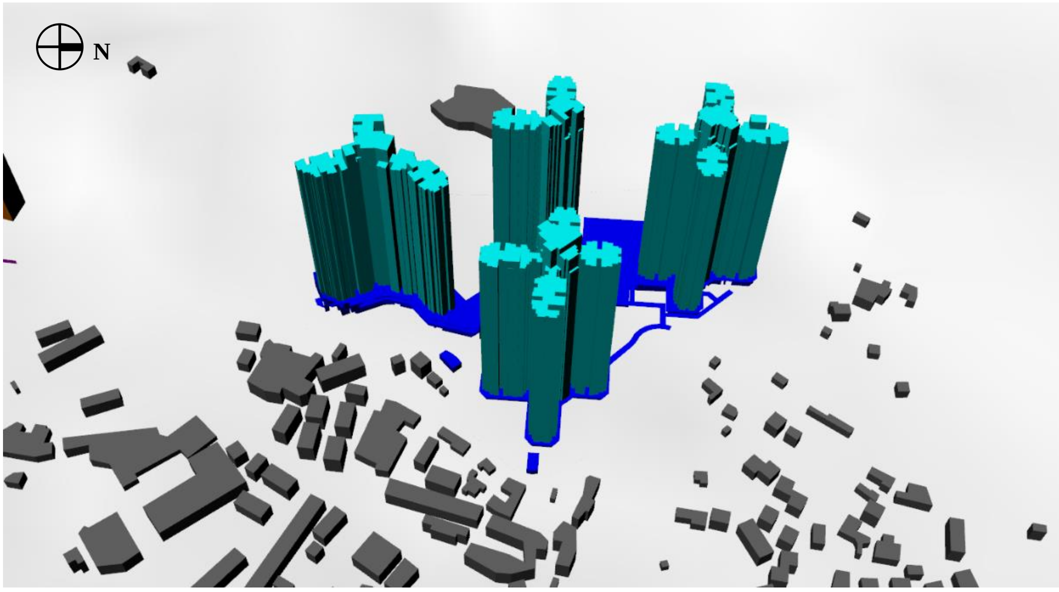
Figure 14 Proposed Scheme Master Layout Plan

By referring to the CAD drawings of the Proposed Scheme, the 3D model was constructed as shown in Figure 15 to Figure 18.



TM54-Sites 1&1A Development
Surrounding Development

Figure 15 Northernly view of Proposed Scheme



TM54-Sites 1&1A Development
Surrounding Development

Figure 16 Easternly view of Proposed Scheme

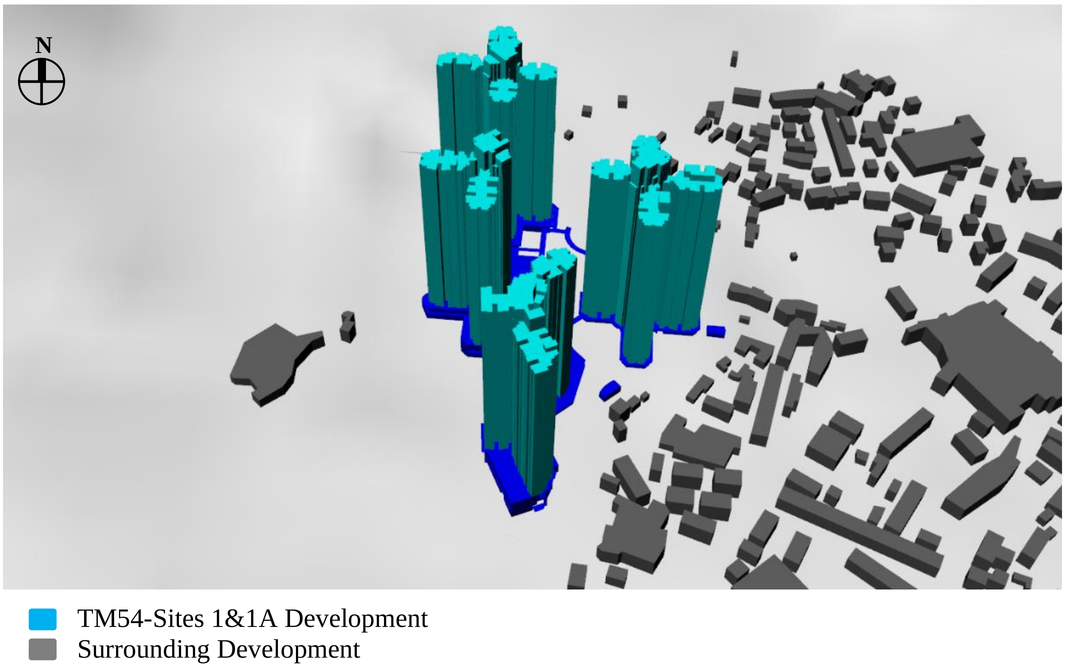


Figure 17 Southernly view of Proposed Scheme

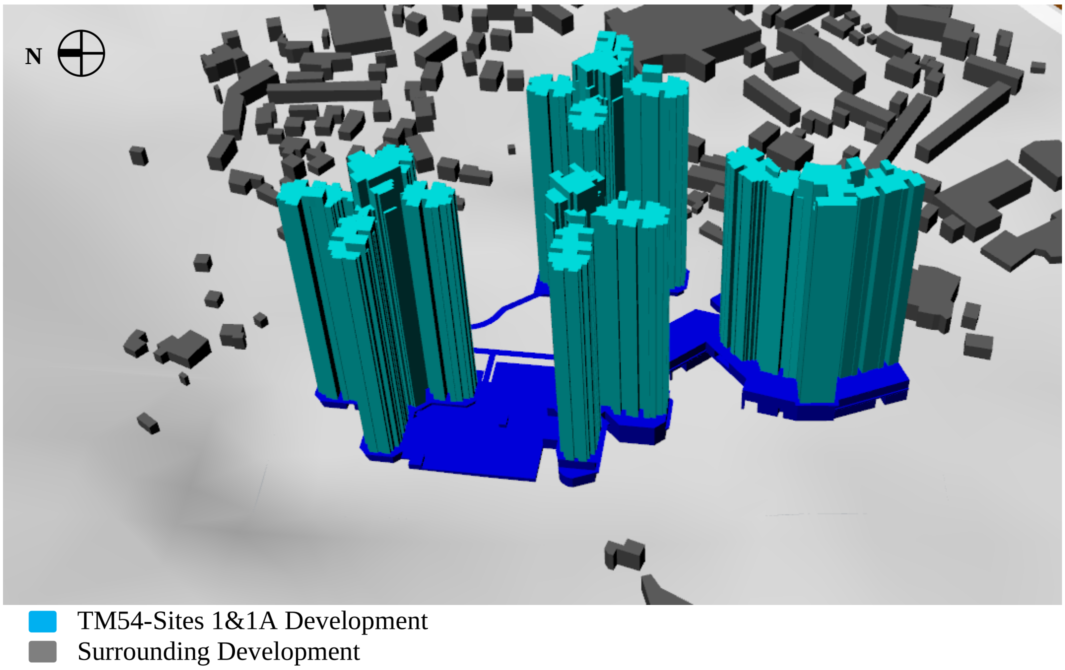


Figure 18 Westernly view of Proposed Scheme

5.2 TM54-Sites3&4(E) Development

An "Applications for Permission under Section 16 of the Town Planning Ordinance" is also being prepared for TM54-Sites3&4(E) Development, which is relatively close to TM54-Sites1&1A Development as shown in Figure 1. In order to evaluate the potential individual ventilation impact of the proposed changes of TM54-Sites1&1A Development, as well as the potential cumulative ventilation impact of the proposed changes of the two developments (i.e. TM54-Sites1&1A Development and TM54-Sites3&4(E) Development), the design schemes of TM54-Sites3&4(E) Development is also included in this AVA Initial Study.

5.2.1 Baseline Scheme

Baseline Scheme consists of five domestic blocks with building height of about 105mPD to 116mPD which is an OZP-conforming scheme with 15m wide north-south running non-building area (NBA) provided.

5.2.2 Proposed Scheme

Proposed Scheme consists of five domestic blocks with building height of about 125mPD to 132mPD.

Details of the design schemes for TM54-Sites3&4(E) Development can be found in *Air Ventilation Assessment - Initial Study* for 'Proposed Public Housing Development at Tuen Mun Area 54 Sites 3 & 4 (East)'.

5.3 Test Point Location

Test points are evenly placed along the site boundary and within the assessment area of the Development to determine the ventilation performance. There are three types of test points in the study:

Perimeter Test Points

Perimeter test points are the points positioned at the site boundary of the proposed development. In accordance with the Technical Circular for AVA, perimeter points are positioned at interval of about 15m alongside the site boundary. In total there are 40 perimeter test points (Red Points in Figure 19) in this study.

Overall Test Points

Overall test points are those points evenly positioned in the open area on the streets and places where pedestrian frequently access within the assessment area. In total there are 93 overall test points (**Black Points** in Figure 19) within the assessment area.

Special Test Points

Special test points are the points evenly positioned in the open area that pedestrians can access within the site boundary. In total, there are 12 special test points for both Baseline Scheme and Proposed Scheme in this study (Blue Points in Figure 20).

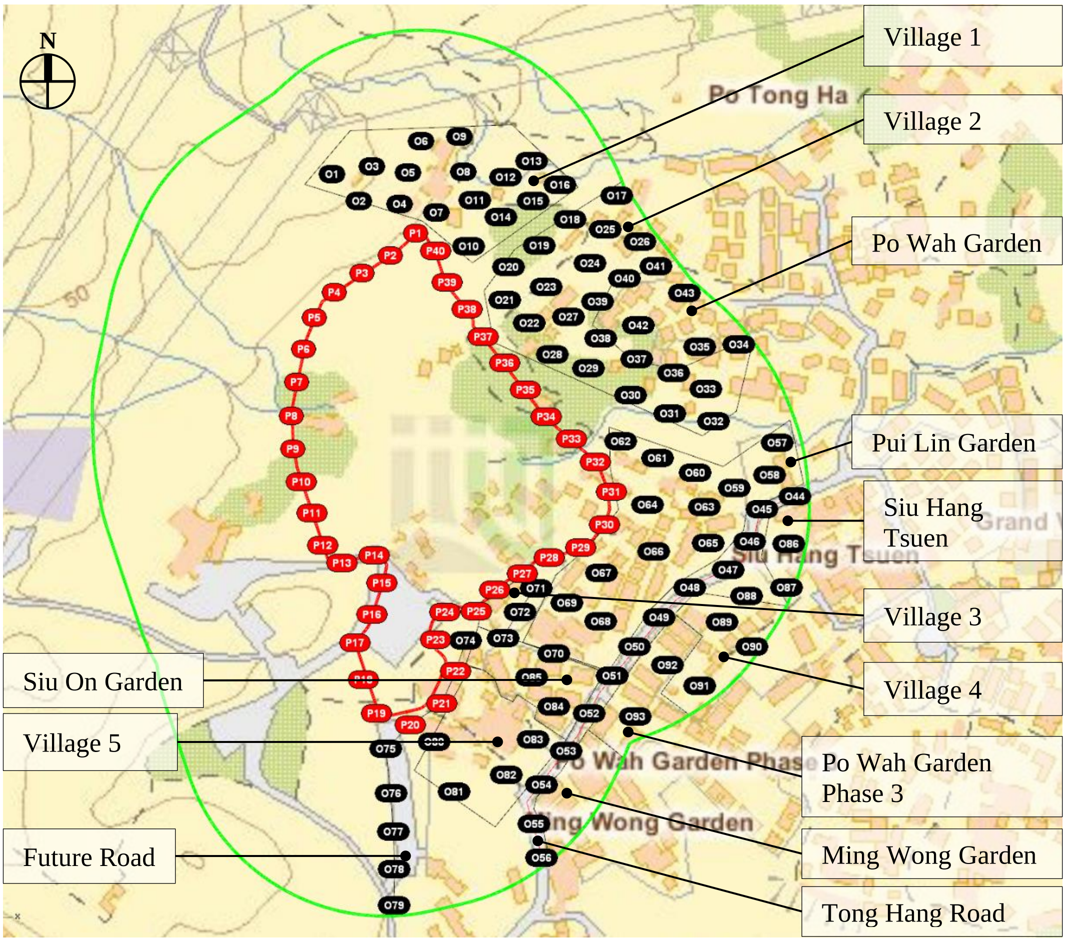


Figure 19 Perimeter and Overall Test Points and Focus Areas

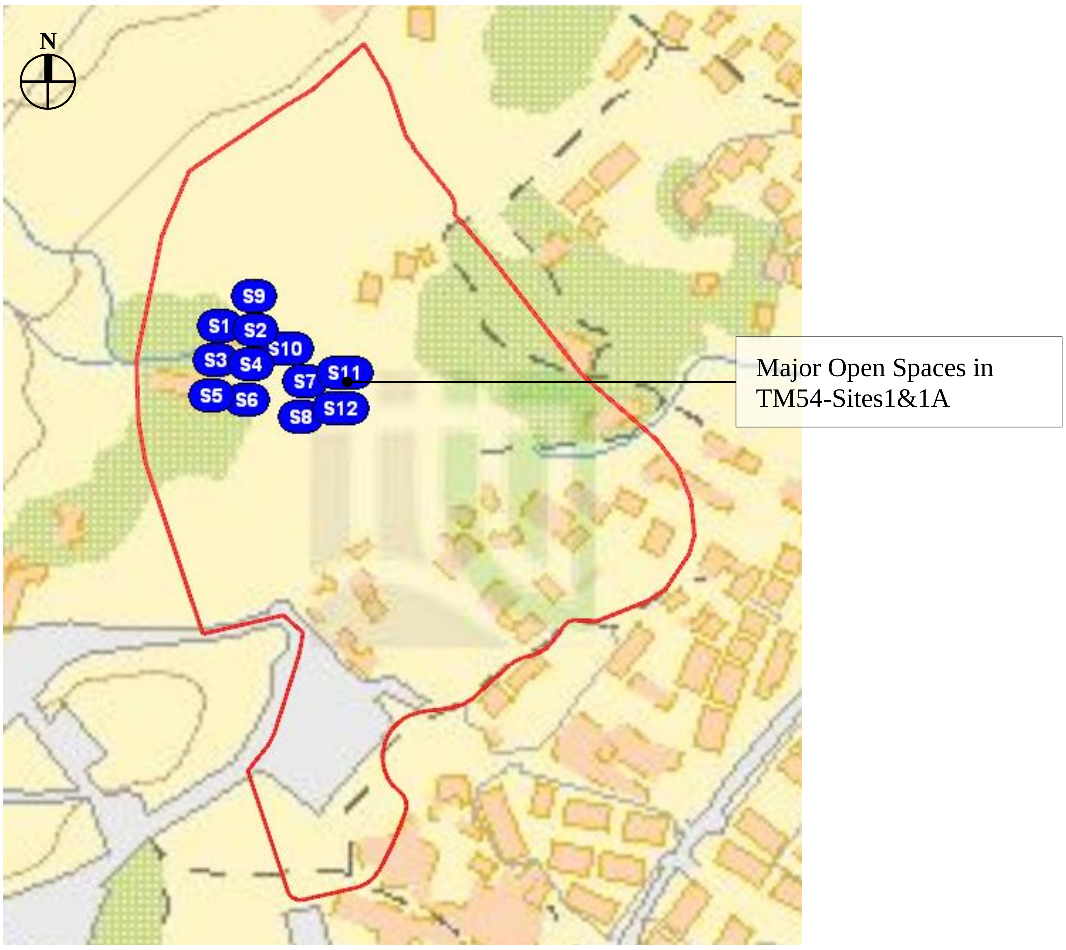


Figure 20 Special Test Points and Focus Area

6 Results and Discussion

The Wind Velocity Ratio (VR) as proposed by the Technical Circular was employed to assess the ventilation performances of the Development and surrounding environment. VR is defined as the ratio of the wind velocity at the pedestrian level (2m above ground) to the wind velocity at the top of the wind boundary layer. Higher VR implies better ventilation.

The Site spatial average velocity ratio (SVR) represents the average VR of all perimeter test points at the site boundary. The Local spatial average velocity ratio (LVR) represents the average VR of all perimeter and overall test points. The SVR and LVR under annual and summer conditions were calculated respectively.

6.1 Overall Ventilation Performance

6.1.1 Annual Condition

For the annual condition, eight wind directions were selected, accumulating to 78.3% occurrence frequency. The integrated effect of these winds indicates the annual overall ventilation performance. The major prevailing winds under annual wind condition come from north-eastern and south-eastern quarters. The VR contour plots under Scenarios 1 (S1), Scenario 2 (S2), and Scenario 3 (S3) are shown in Figure 21, Figure 22, and Figure 23 respectively. The VR contour plots show that:

- The overall ventilation performance among all three scenarios would be generally similar under annual condition. Slightly higher VR would be observed at Village 3 and Major Open Spaces in TM54-Sites1&1A under S2 & S3.

- Under S2 & S3, the domestic towers of the Development have higher building heights, and would induce a stronger downwash effect. Especially, Block 4 would downwash the incoming wind towards the area to the southeast of the development under S2 & S3 (Orange Ellipse in Figure 22 and Figure 23) when compared with S1 (Orange Ellipse in Figure 21). As a result, slightly higher VR would be observed at Village 3 under S2 & S3.

- Under S2 & S3 the carpark is semi-sunken, with roof level at +25.40mPD; while under Baseline Scheme the carpark is one-storey-high, with roof level at +28.50mPD. The lower carpark structure under Proposed Scheme would facilitate a more effective wind penetration towards the area to the west of the carpark. As a result, slightly higher VR would be observed at the area under S2 & S3 (Purple Ellipse in Figure 22 and Figure 23) when compared with S1 (Purple Ellipse in Figure 21).

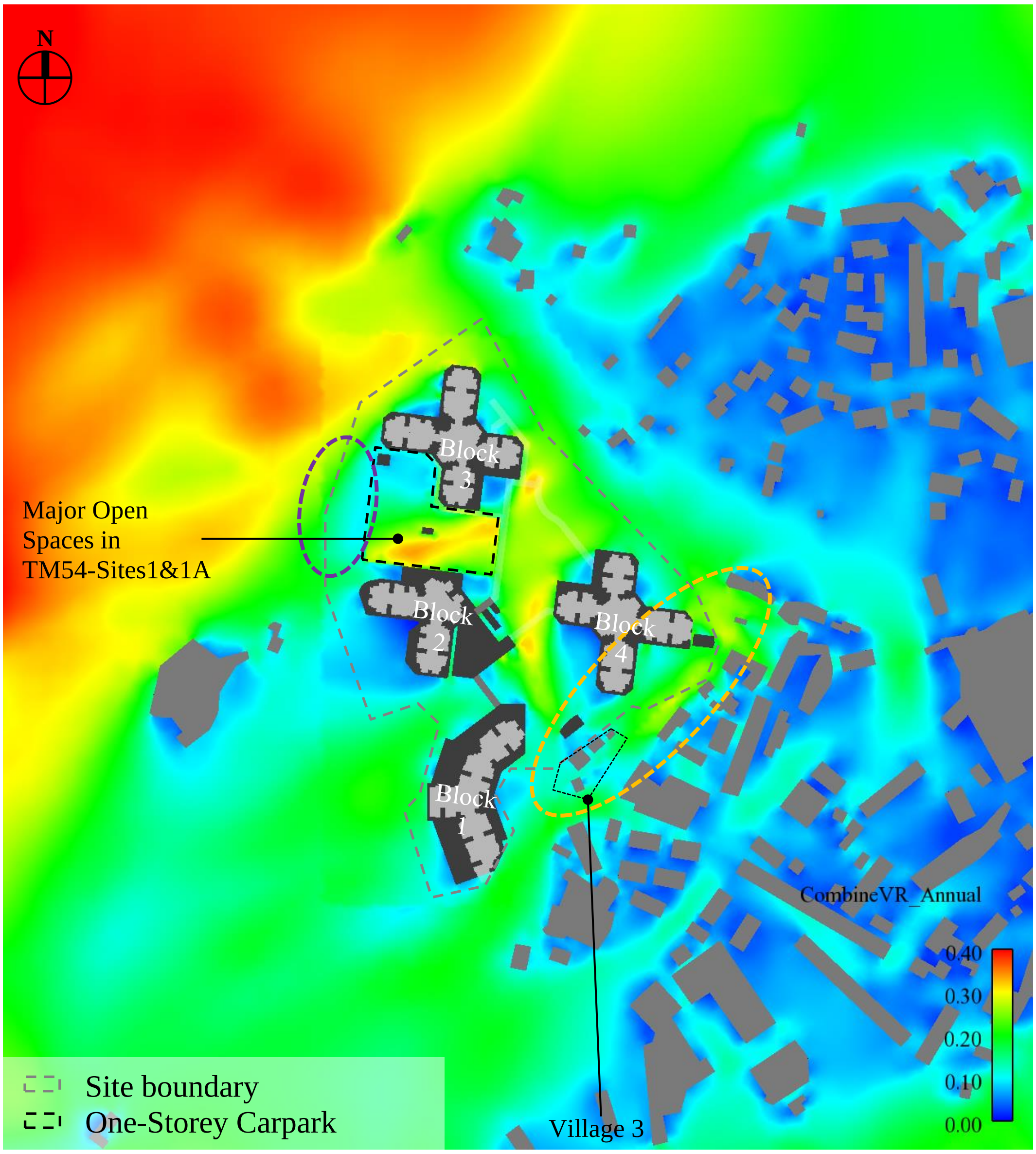


Figure 21 Average Annual VR Contour Plots for Baseline Scheme under Scenario 1

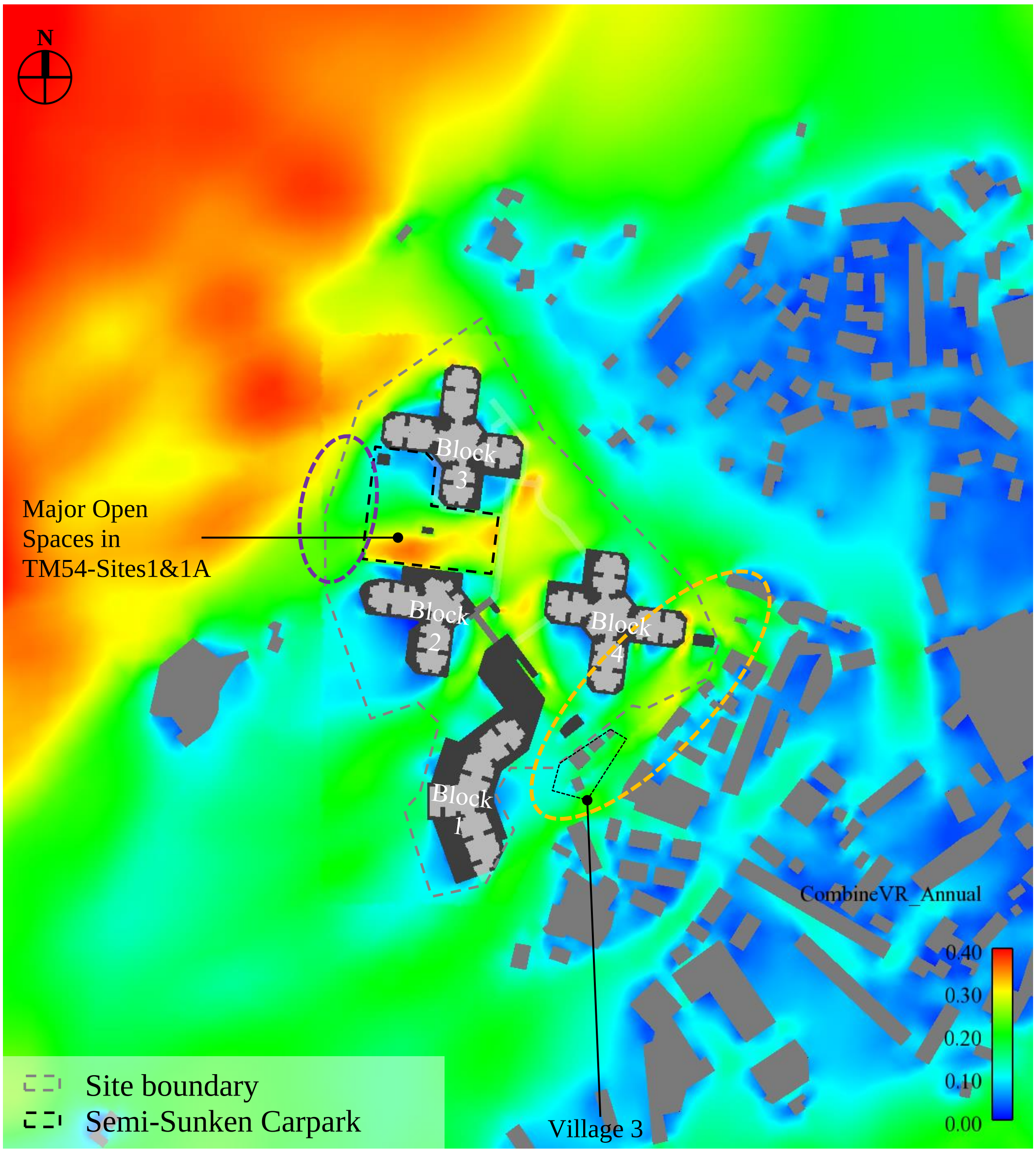


Figure 22 Average Annual VR Contour Plots for Proposed Scheme under Scenario 2

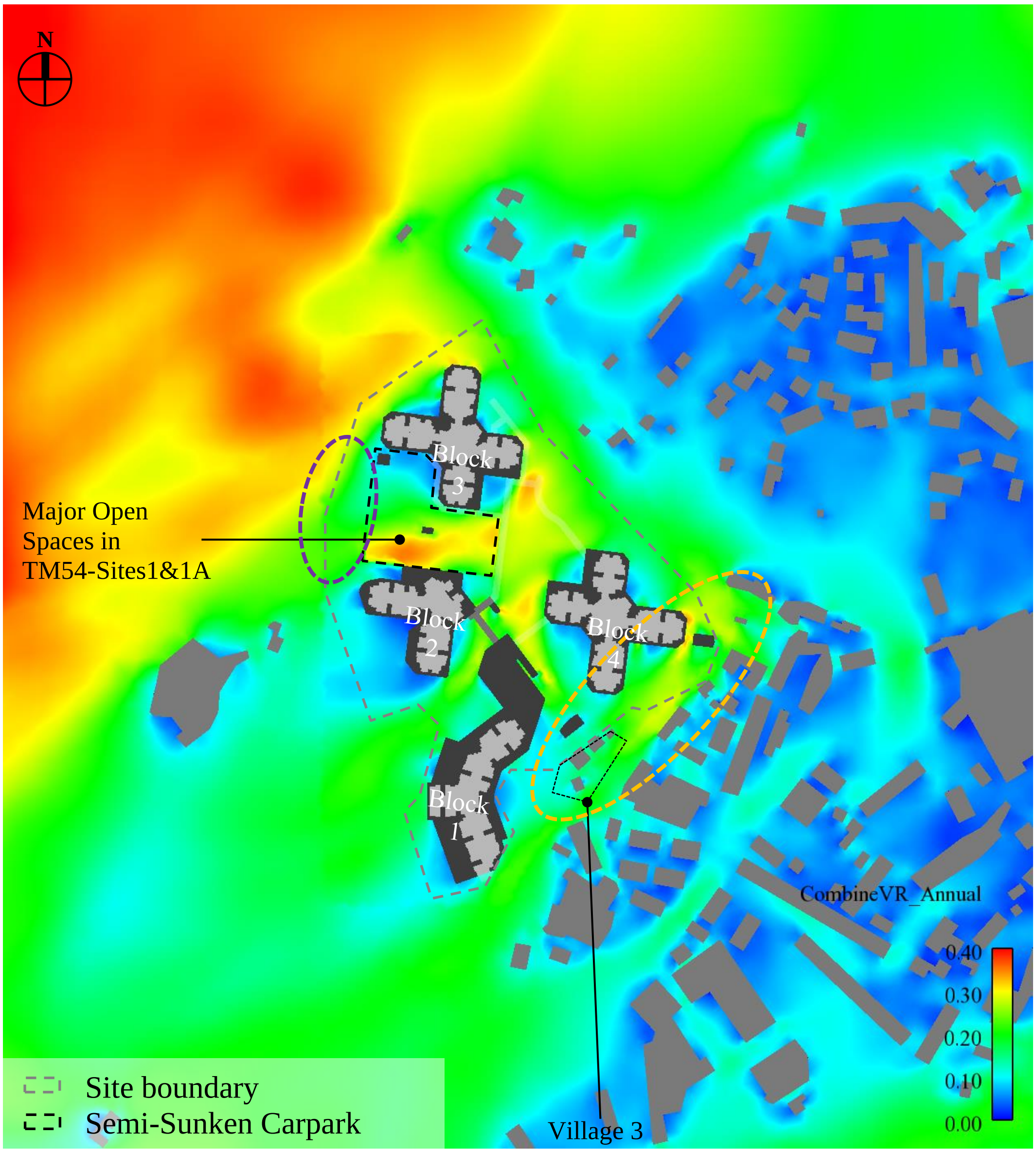


Figure 23 Average Annual VR Contour Plots for Proposed Scheme under Scenario 3

Table 7 Annual SVR and LVR for Scenarios 1, 2 and 3

	Scenario 1	Scenario 2	Scenario 3
SVR	0.18	0.19	0.19
LVR	0.13	0.14	0.14

Under annual condition, the values of SVR and LVR under S2 & S3 are slightly higher than that under S1, indicating that the ventilation performance at the immediate area and local surrounding area would be slightly better under S2 & S3.

6.1.2 Summer Condition

For the summer condition, seven wind directions were selected, accumulating to 77.6% occurrence of frequency. The integrated effect of these winds indicates the summer overall ventilation performance. The major prevailing winds under summer wind condition come from south-eastern and south-western quarters. The contour plots under summer condition (Figure 24, Figure 25, and Figure 26) show that:

- The overall ventilation performance among all three scenarios would be quite similar under summer condition. Slightly higher VR would be observed at Village under S2 & S3.
- Under S2 & S3, Block 4 would downwash the incoming wind towards the area to the east and southeast of the development under S2 & S3 (Orange Ellipse in Figure 25 and Figure 26) when compared with S1 (Orange Ellipse in Figure 24). As a result, slightly higher VR would be observed at Village 3 under S2 & S3.

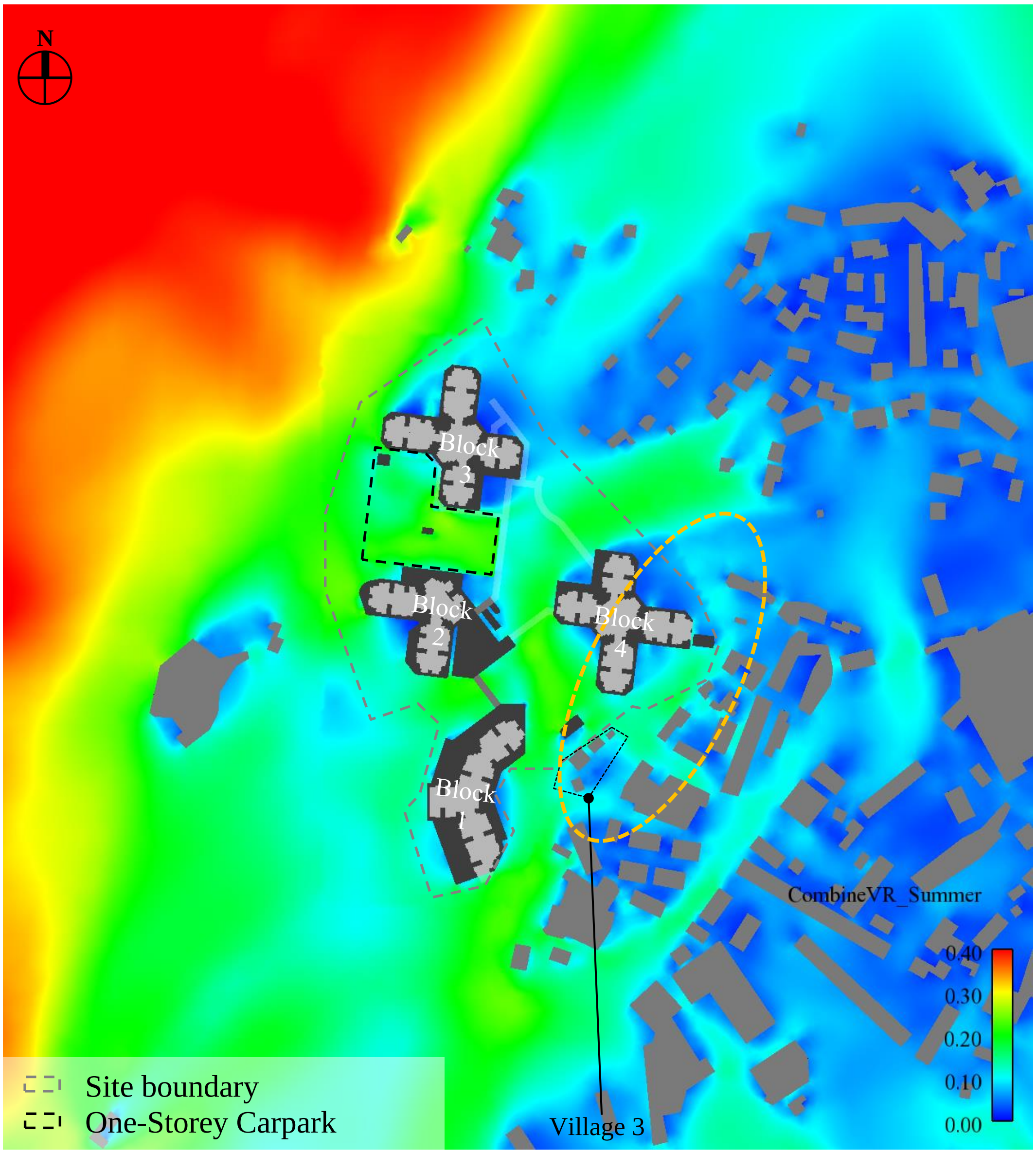


Figure 24 Average Summer VR Contour Plots for Baseline Scheme under Scenario 1

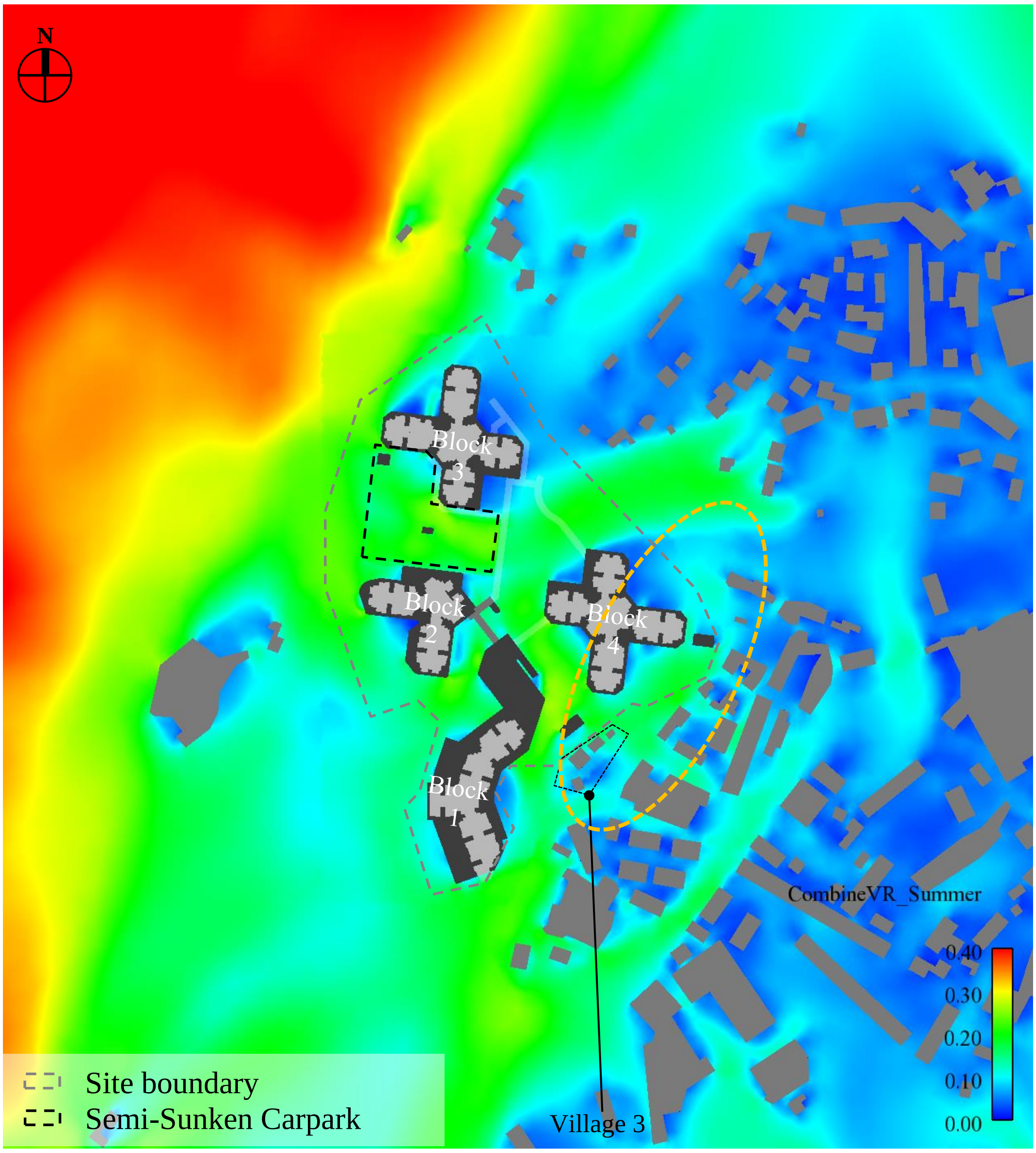


Figure 25 Average Summer VR Contour Plots for Proposed Scheme under Scenario 2

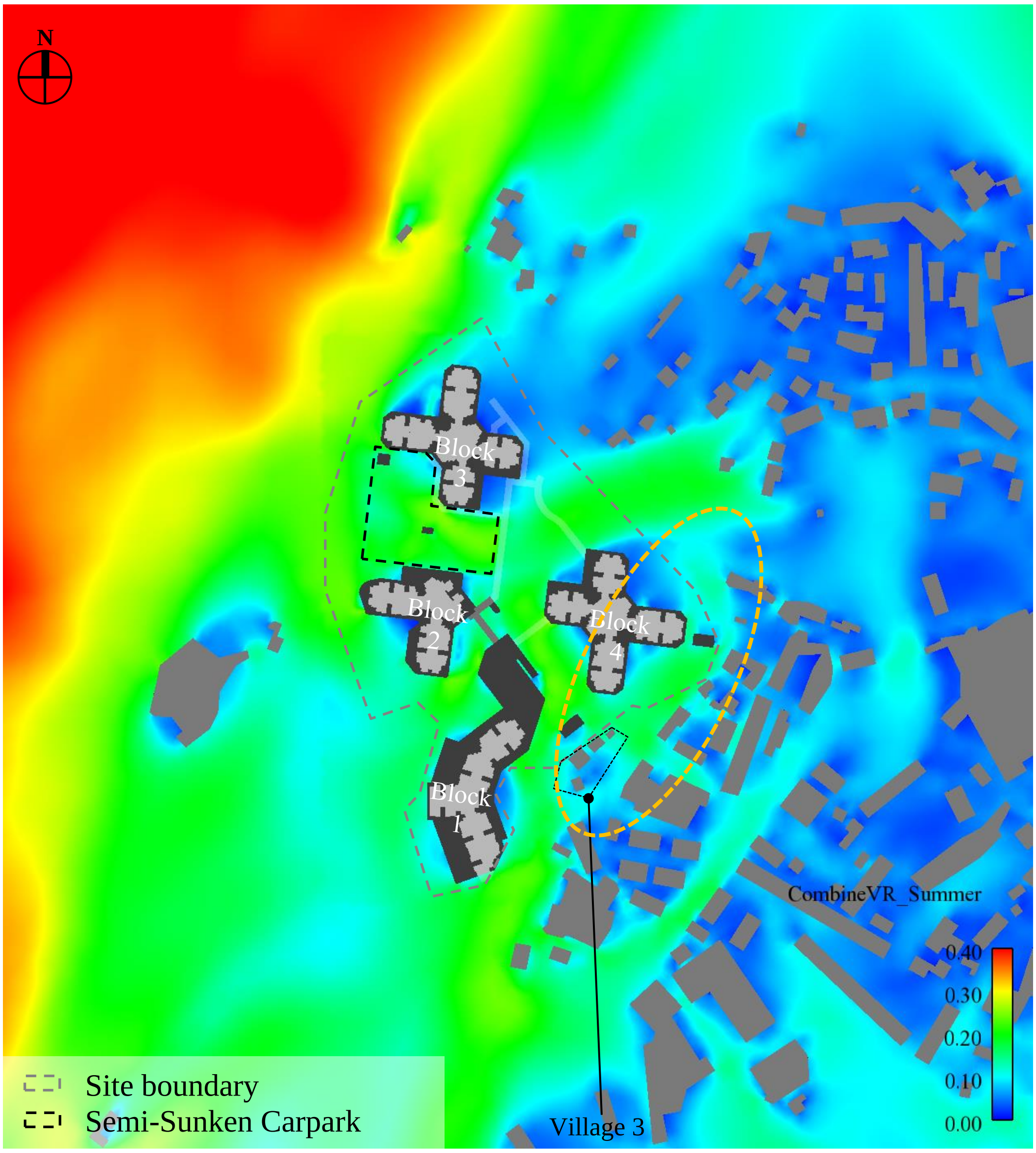


Figure 26 Average Summer VR Contour Plots for Proposed Scheme under Scenario 3

Table 8 Summer SVR and LVR for Scenarios 1, 2 and 3

	Scenario 1	Scenario 2	Scenario 3
SVR	0.15	0.15	0.15
LVR	0.12	0.12	0.12

Under summer condition, the values of SVR and LVR are same under the three scenarios, indicating that the ventilation performance of the three scenarios at the immediate area and local surrounding would be generally similar.

6.2 Directional Analysis

6.2.1 NNE Wind

NNE wind contributes approximately 8.5% of the annual wind rose. The VR contour plots under S1, S2, and S3 are shown in Figure 27, Figure 28, and Figure 29 respectively. In general, the overall ventilation environment is similar among the three scenarios. S2 & S3 would result slightly better ventilation performance at Village 3 and the area to the southwest of the Development.

The incoming wind would approach the Development with little obstruction, as the surrounding buildings at the upwind location are mainly low-rise village houses. The prevailing wind mainly enters the Development from the northeast site boundary, and mainly penetrate into the site through building separation between Block 3 and Block 4.

Under S1, the incoming wind would mainly flow along the N-S NBA and reach the southern site boundary (**Black Arrow** in Figure 27). Under S2 & S3, the incoming wind would be divided into two air streams. One stream would continue to flow through the building separation between Block 1 and Block 4 and reach the southern site boundary. Another air stream would penetrate into the NNE-SSW NBA (**Black Arrow** in Figure 28 and Figure 29), and flow towards the southwest side of the Development (Purple Ellipse in Figure 28 and Figure 29). As a result, slightly better VR would be observed at the area.

Under S2 & S3, Block 4 has a larger setback from the site boundary when compared with Baseline Scheme. This would increase the wind permeability at the area to the east of Block 4. Moreover, Block 4 is relatively higher and would induce a stronger downwash effect at the east of the Development (Blue Ellipse in Figure 28 and Figure 29). Together, these would allow more wind to flow towards Village 3.

Under S2 & S3 the carpark is semi-sunken, while under S1 the carpark is one-storey-high. The lower carpark structure under S2 & S3 would facilitate a more effective wind penetration towards the village houses at the west of Block 2 (**Black Ellipse** in Figure 28 and Figure 29). As a result, slightly higher VR would be observed at the area under S2 & S3.

Under S2 & S3, the larger building bulk would induce a slightly larger wind shadow at the southwest of Block 1 (Orange Ellipse in Figure 28 and Figure 29).

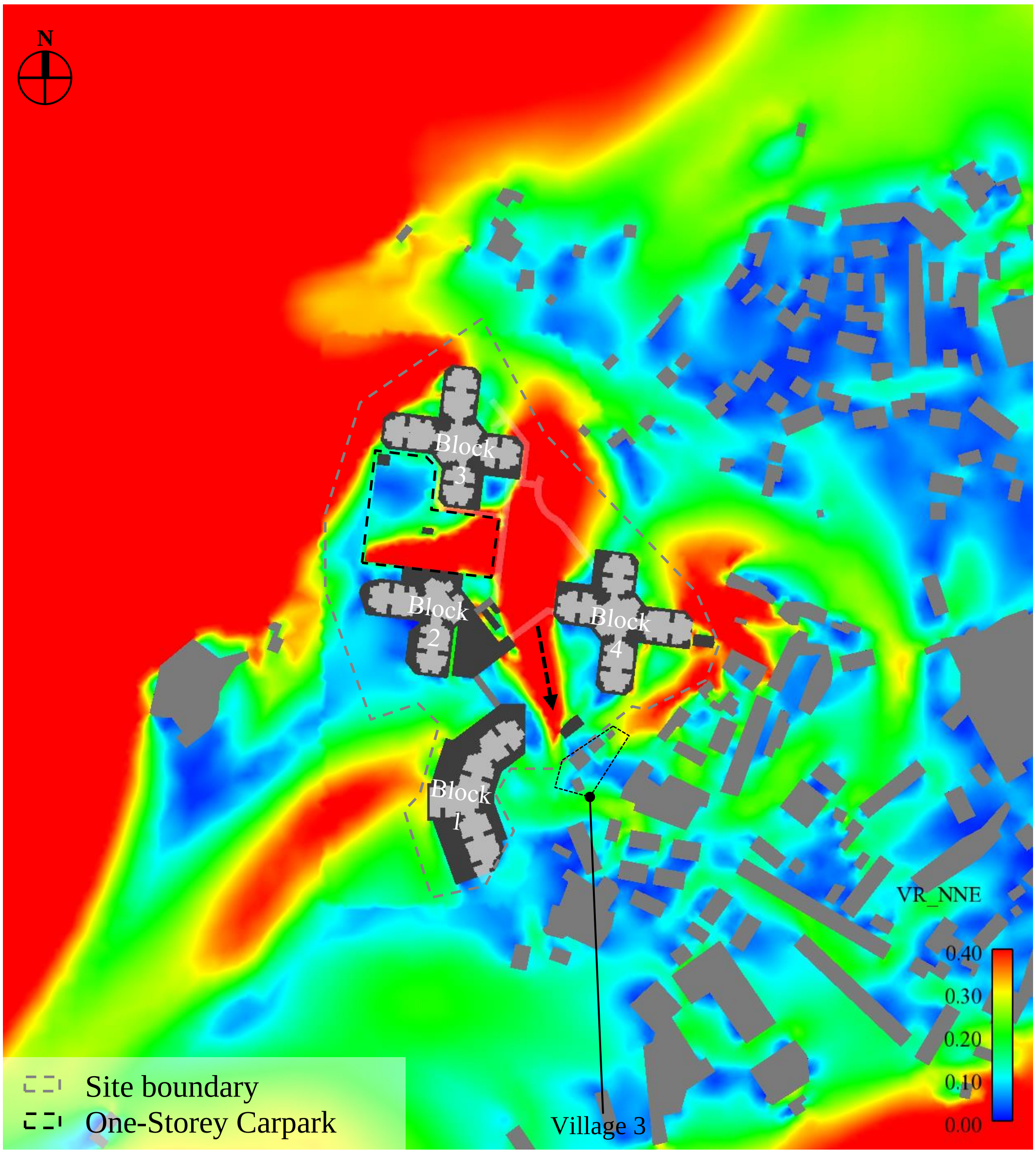


Figure 27 VR Contour Plot of NNE Direction for Baseline Scheme under Scenario 1

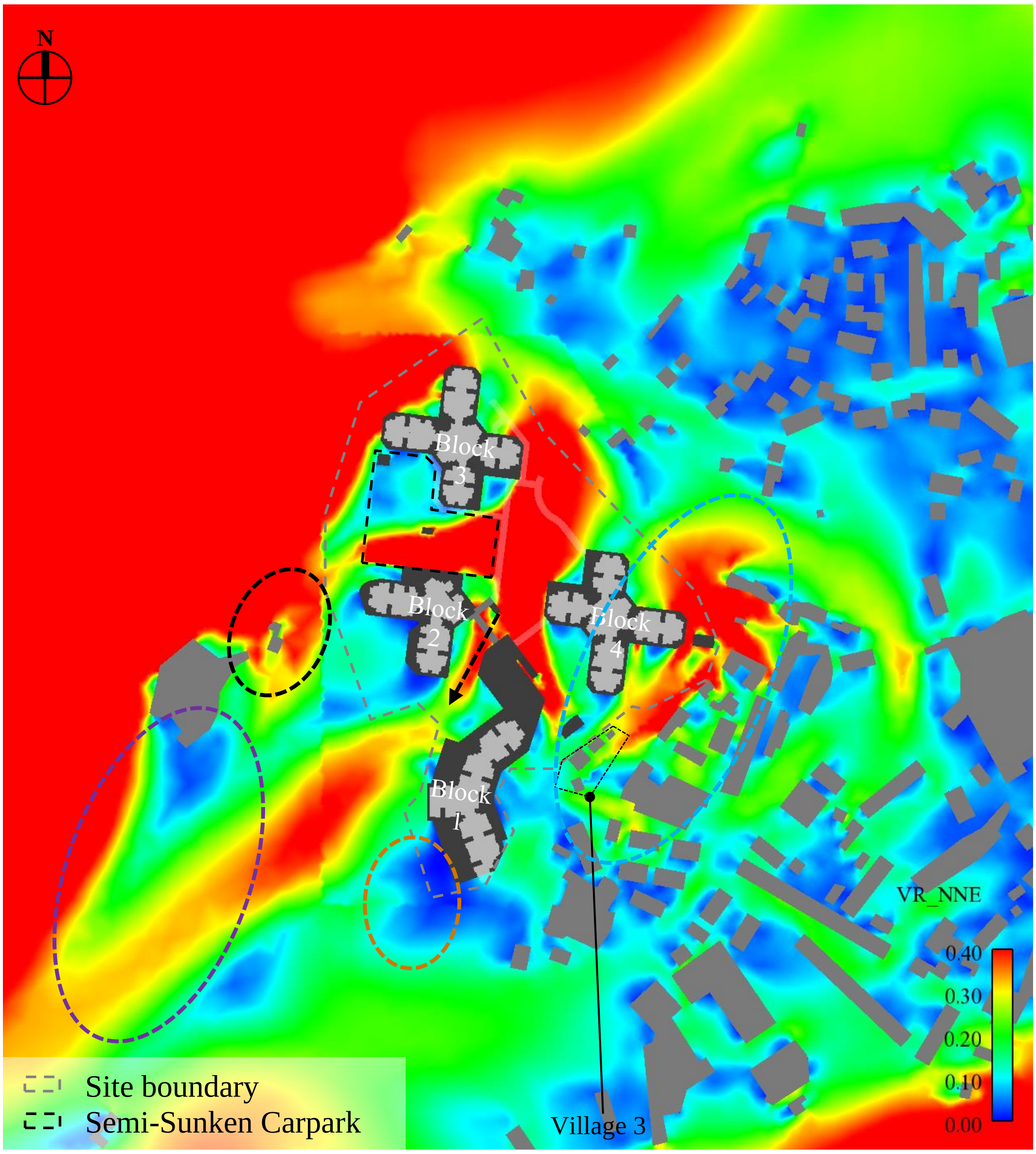


Figure 28 VR Contour Plot of NNE Direction for Proposed Scheme under Scenario 2

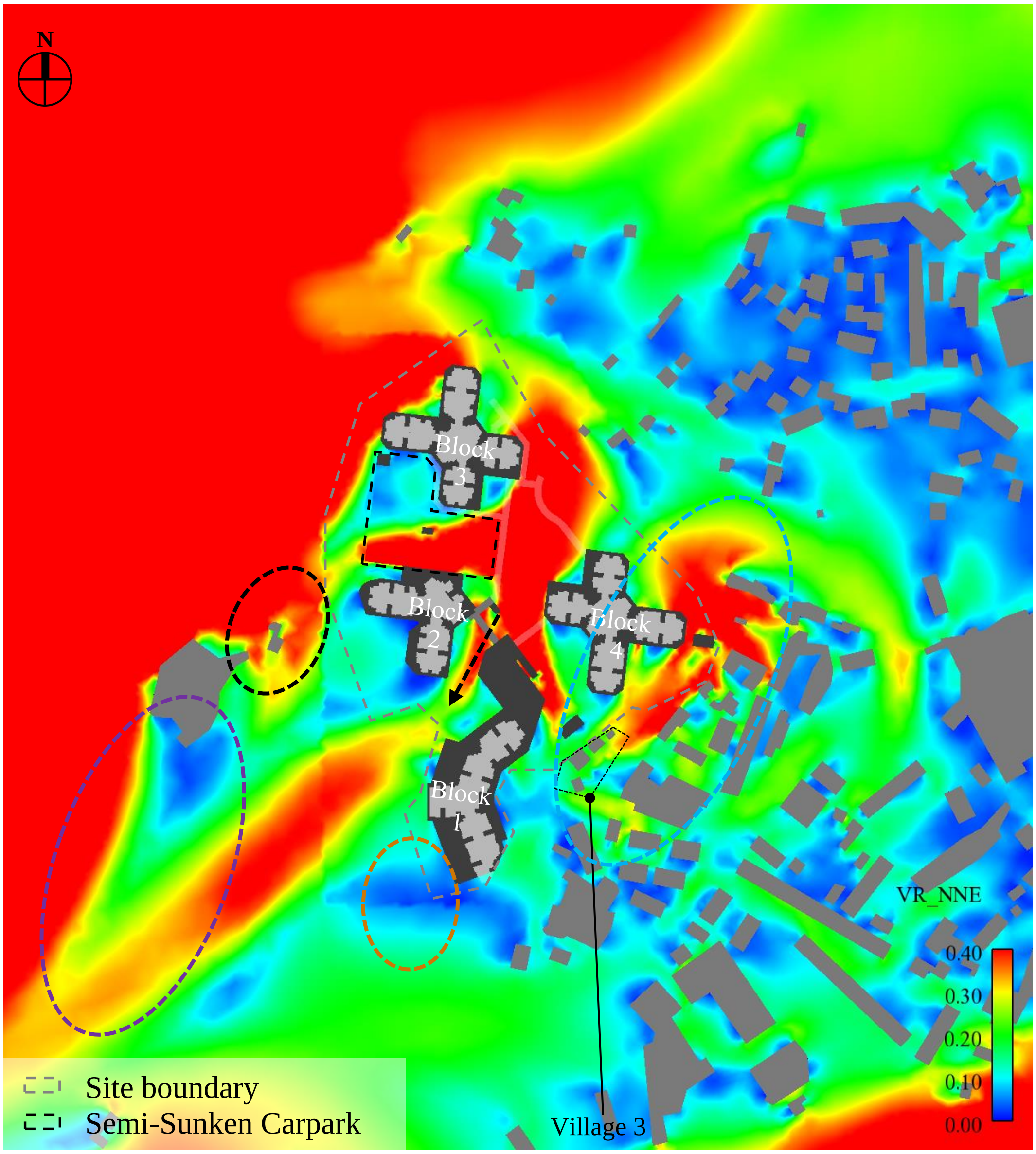


Figure 29 VR Contour Plot of NNE Direction for Proposed Scheme under Scenario 3

6.2.2 NE Wind

NE wind contributes approximately 10.8% of the annual wind rose. The VR contour plots under S1, S2, and S3 are shown in Figure 30, Figure 31, and Figure 32 respectively. In general, the overall ventilation environment is similar among the three scenarios. S2 & S3 would result better ventilation performance at Village 3, and slightly better ventilation performance at the area to the west of the Development.

The incoming wind would approach the Development with little obstruction, as the surrounding buildings at the upwind location are mainly low-rise village houses. The prevailing wind would mainly penetrate through the building separations of Block 3 and Block 4.

Similar to NNE wind, Block 4 of S2 & S3 have building setback and slightly taller building height. These features help to induce more wind towards Village 3 and the area to the east of the Development (Blue Ellipse in Figure 31 and Figure 32), and would enhance the ventilation performance at the area.

Also, the lower carpark structure under S2 & S3 would facilitate a more effective wind penetration towards the village houses at the west of Block 2 (Blue Arrow in Figure 31 and Figure 32). As a result, slightly higher VR would be observed at the area under S2 & S3.

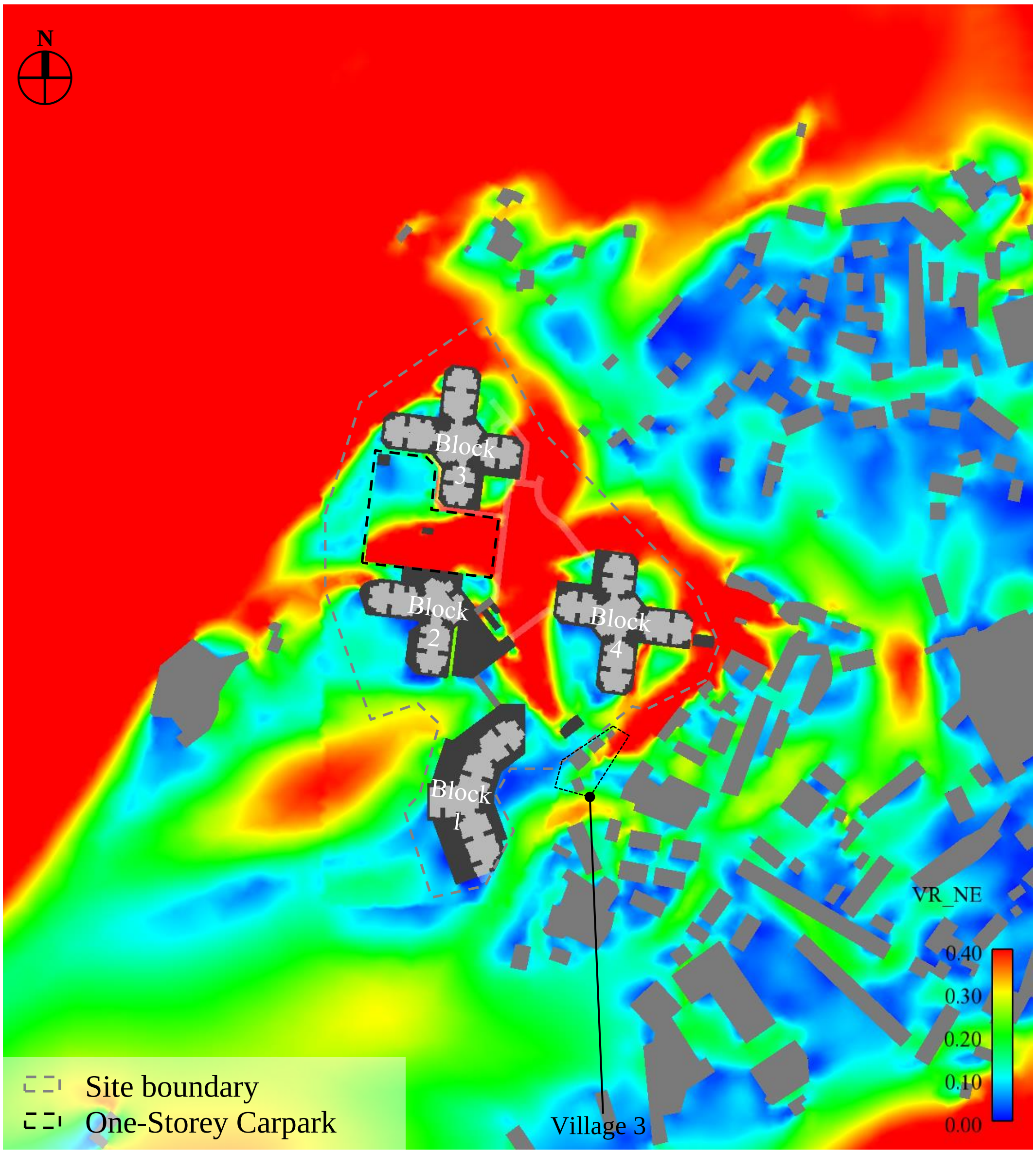


Figure 30 VR Contour Plot of NE Direction for Baseline Scheme under Scenario 1

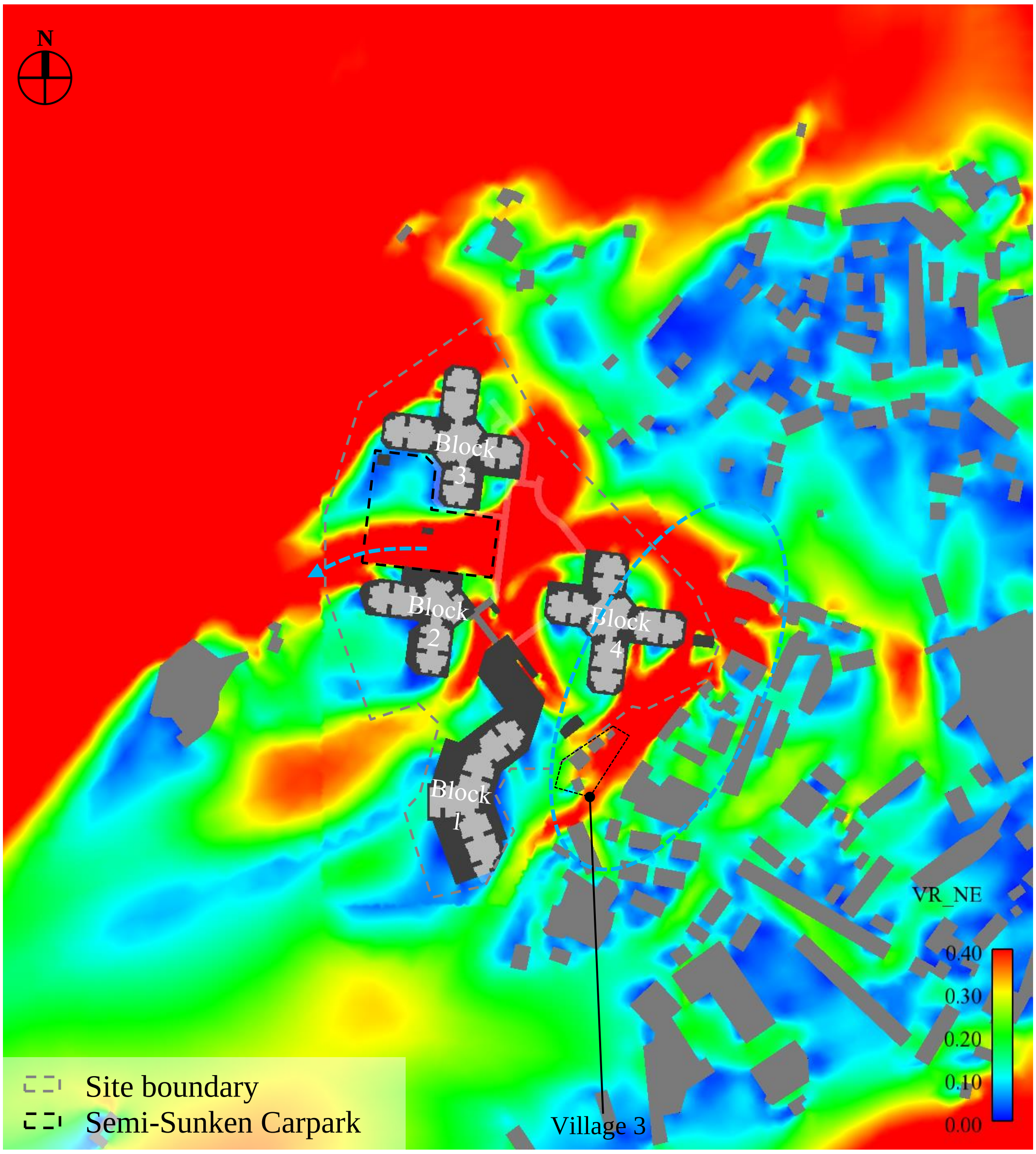


Figure 31 VR Contour Plot of NE Direction for Proposed Scheme under Scenario 2

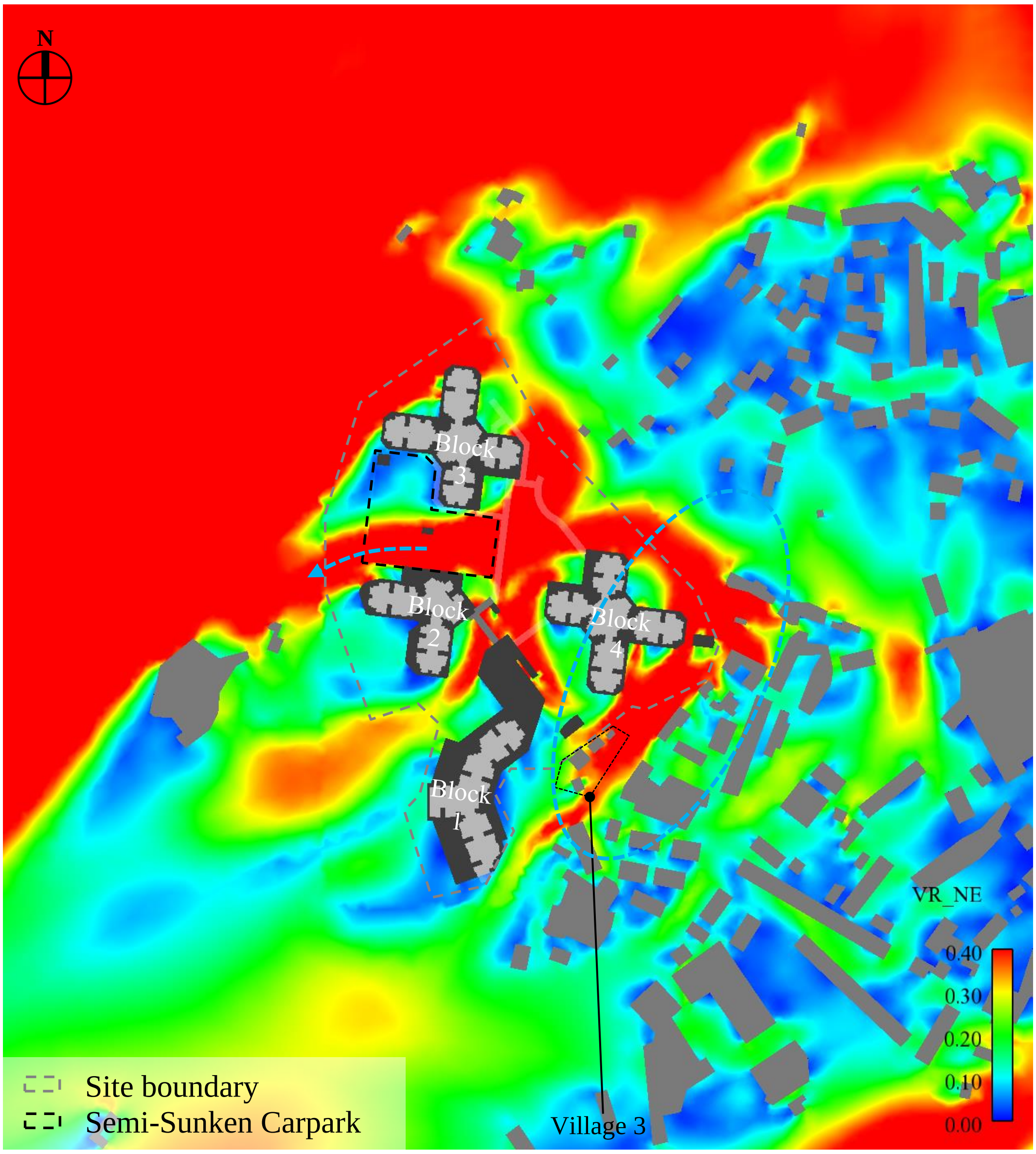


Figure 32 VR Contour Plot of NE Direction for Proposed Scheme under Scenario 3

6.2.3 ENE Wind

ENE wind contributes approximately 9.5% of the annual wind rose. The VR contour plots under S1, S2, and S3 are shown in Figure 33, Figure 34, and Figure 35 respectively. In general, the overall ventilation environment is similar among the three scenarios. S2 & S3 would result better ventilation performance at Village 3 and Major Open Spaces in TM54-Sites1&1A.

The incoming wind would approach the Development with little obstruction, as the surrounding buildings at the upwind location are mainly low-rise village houses. The prevailing wind would mainly penetrate through the building separations of Block 3 and Block 4.

Under S2 & S3, the prevailing wind would flow along the NNE-SSW NBA, through Block 1 and Block 2, and reach the southwest region of the Development. As a result, slightly higher VR would be observed at the area (Blue Ellipse in Figure 34 and Figure 35).

A portion of the prevailing wind would skim over the low-rise villages and reach Block 4 and Block 1. Due to the slightly taller building height of Block 4 and Block1 under S2 & S3, more high level wind would be downwashed towards Village 3 and portion of Future Road respectively (**Black Arrows** in Figure 34 and Figure 35). As a result, the ventilation performance would be slightly enhanced at the aforementioned areas.

Under S2 & S3, the lower carpark structure would facilitate a more effective wind penetration atop of the carpark and towards the leeward region. As a result, slightly higher VR would be observed at Major Open Spaces in TM54-Sites1&1A and the area to the west of the carpark under S2 & S3 (Purple Ellipse in Figure 34 and Figure 35) when compared with S1 (Purple Ellipse in Figure 33).

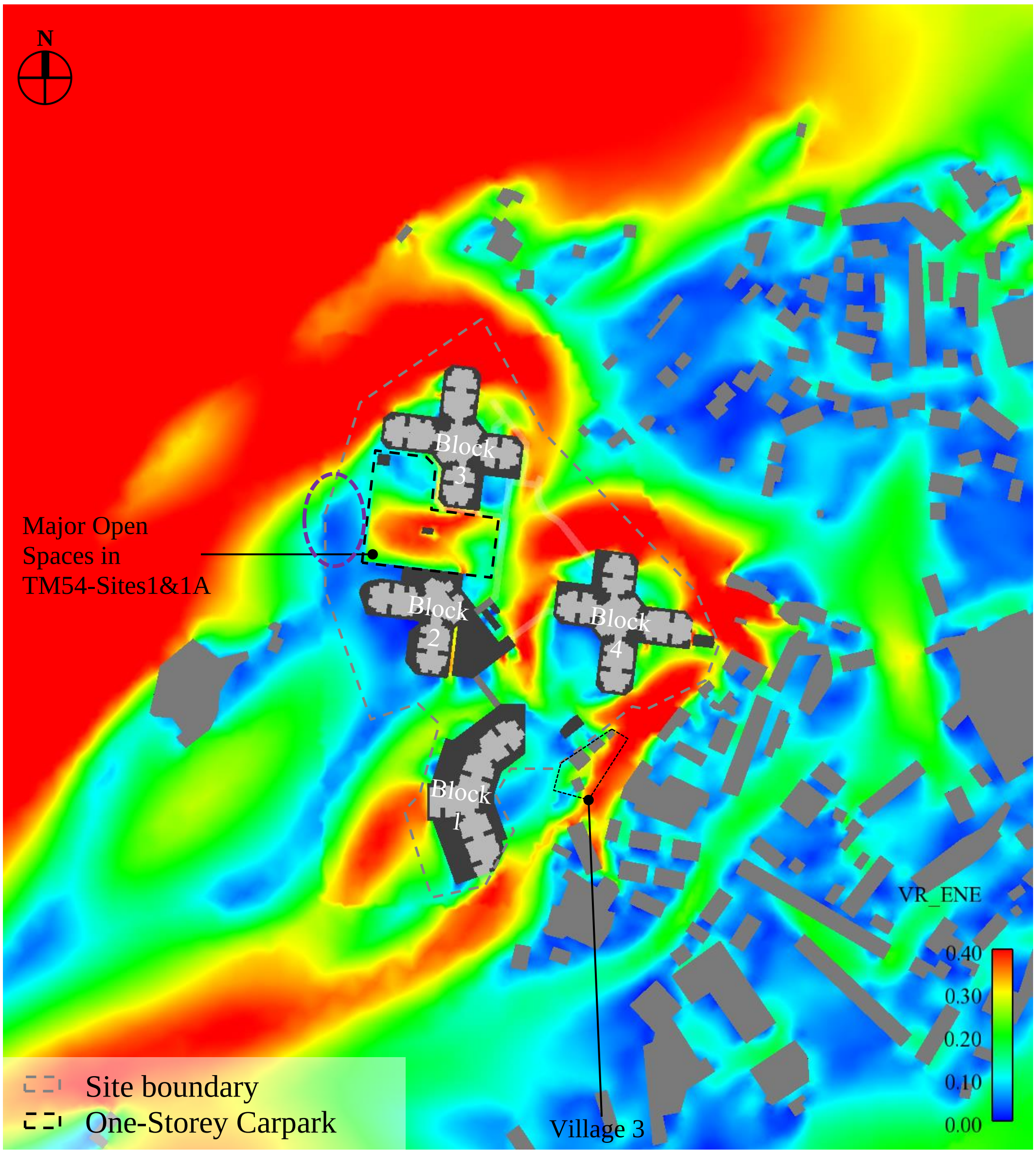


Figure 33 VR Contour Plot of ENE Direction for Baseline Scheme under Scenario 1

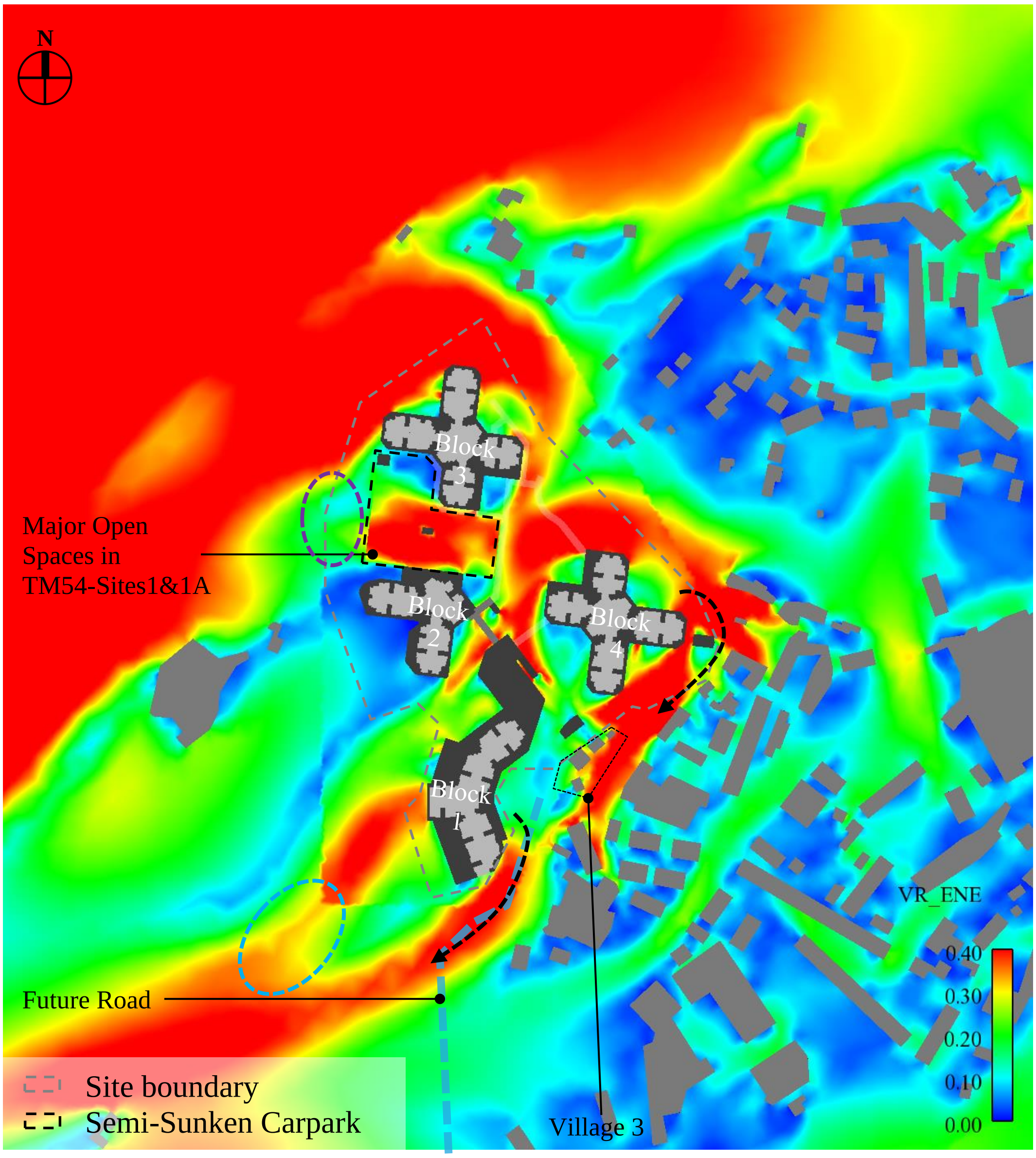


Figure 34 VR Contour Plot of ENE Direction for Proposed Scheme under Scenario 2

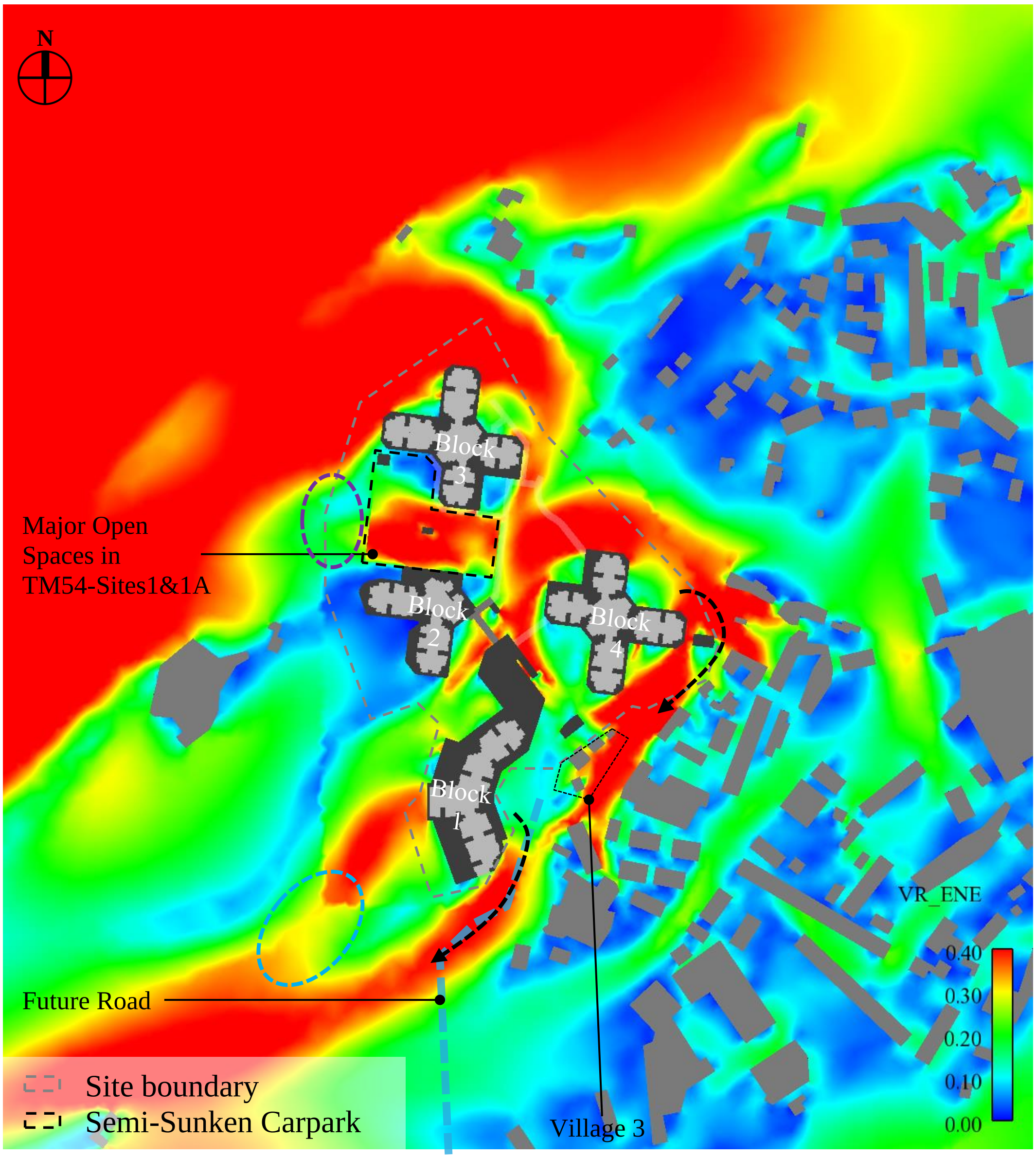


Figure 35 VR Contour Plot of ENE Direction for Proposed Scheme under Scenario 3

6.2.4 E Wind

E wind contributes approximately 12.4% of the annual wind rose and 5.5% of the summer wind rose. The VR contour plots under S1, S2, and S3 are shown in Figure 36, Figure 37, and Figure 38 respectively. In general, the overall ventilation environment is similar among the three scenarios. Slightly different ventilation patterns would be observed along the southeast site boundary. Meanwhile, S2 & S3 would result better ventilation performance at west of the site boundary.

Under S1, the N-S NBA would facilitate the wind flow through the Development towards the southern site bounrady (Purple Arrow in Figure 36). As a result, slightly higher VR would be observed at the northern portion of Future Road under S1.

Under S2 & S3, Block 4 has a larger setback from the site boundary, which allows more wind to flow through Village 3 and enhance the area (Orange Arrow in Figure 37 and Figure 38.

Meanwhile, the lower carpark structure under S2 & S3 would facilitate a more effective wind penetration towards the area to the west of the carpark (Blue Arrow in Figure 37 and Figure 38). As a result, higher VR would be observed at the west leeward area under S2 & S3.

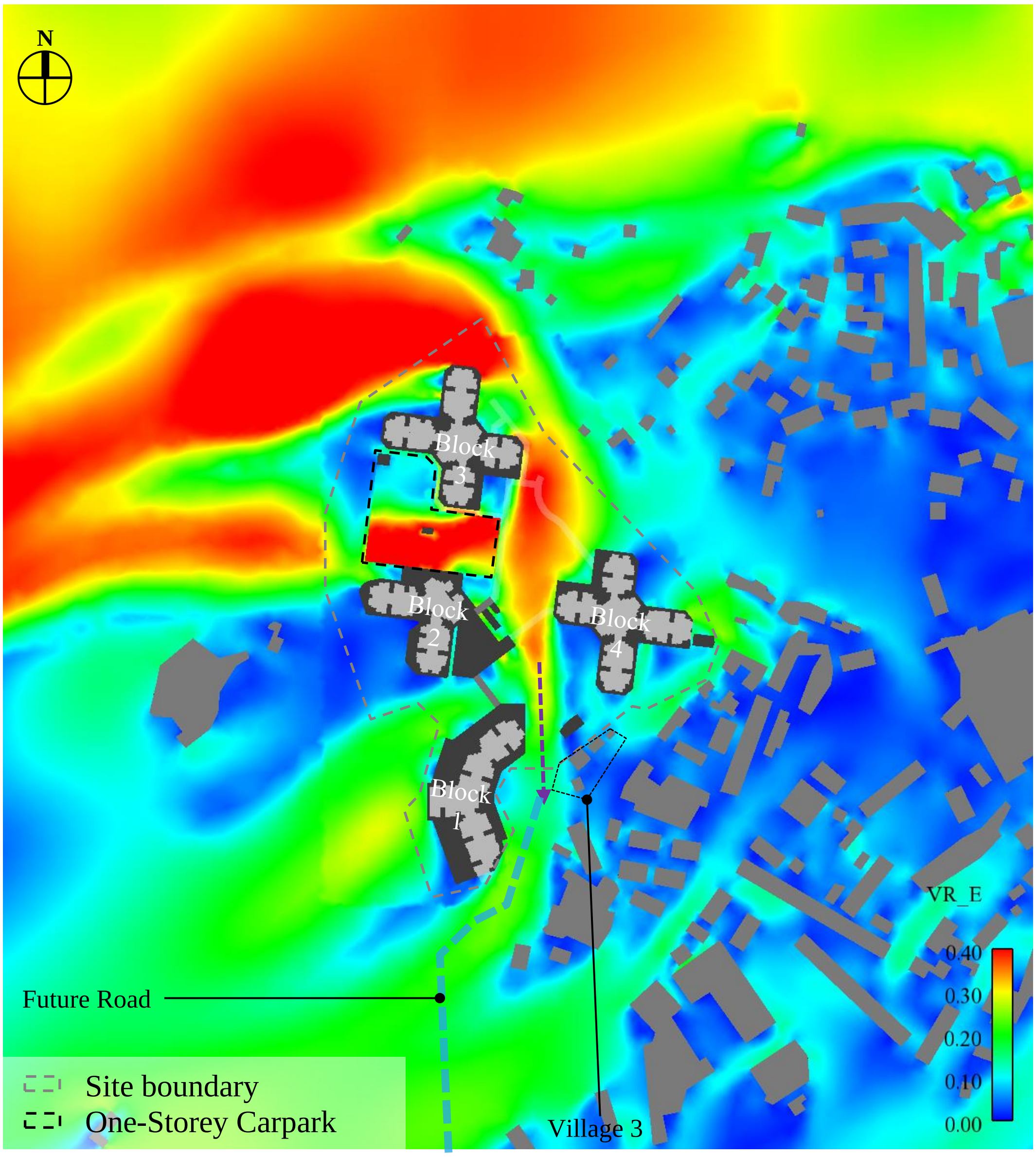


Figure 36 VR Contour Plot of E Direction for Baseline Scheme under Scenario 1

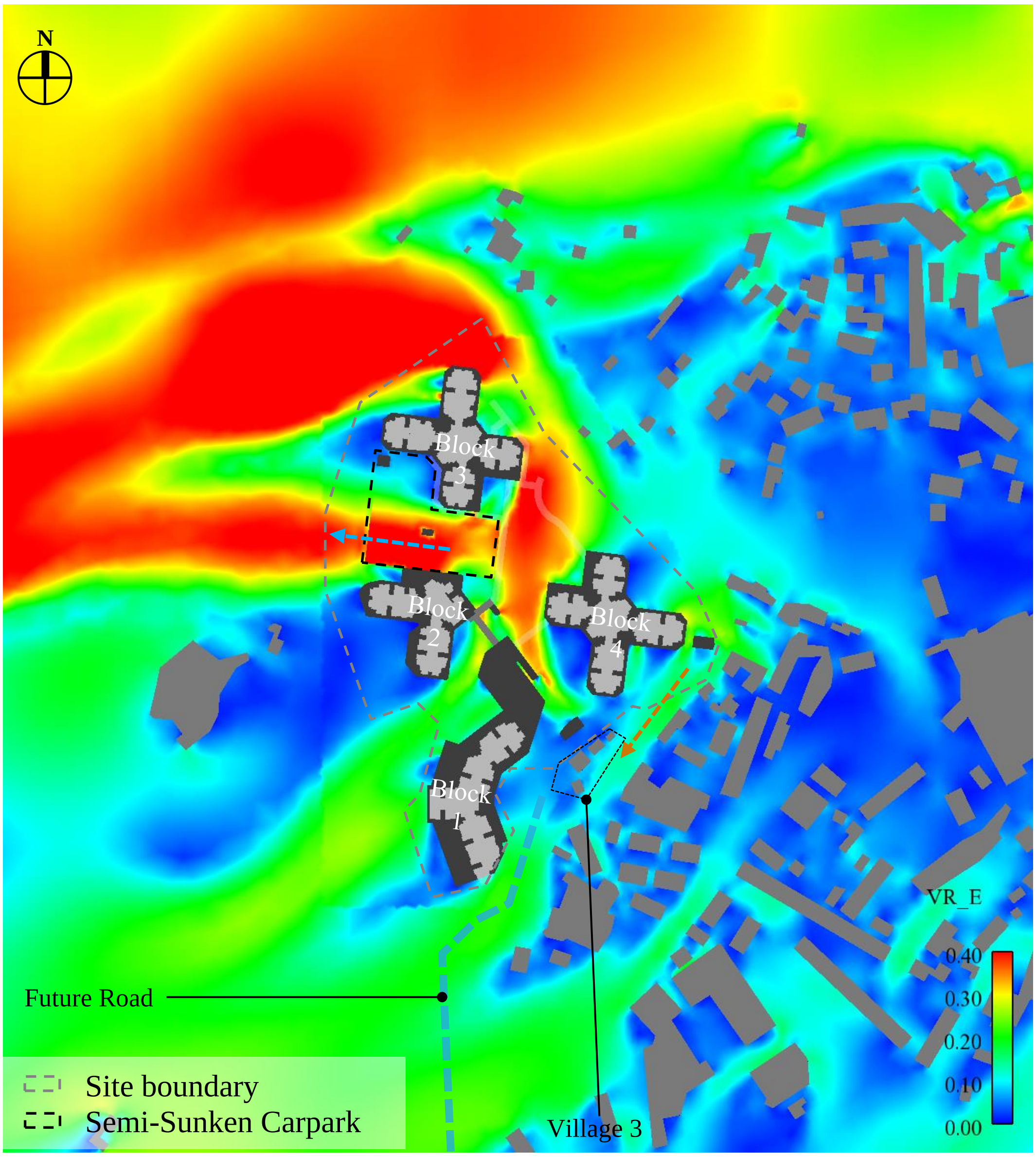


Figure 37 VR Contour Plot of E Direction for Proposed Scheme under Scenario 2

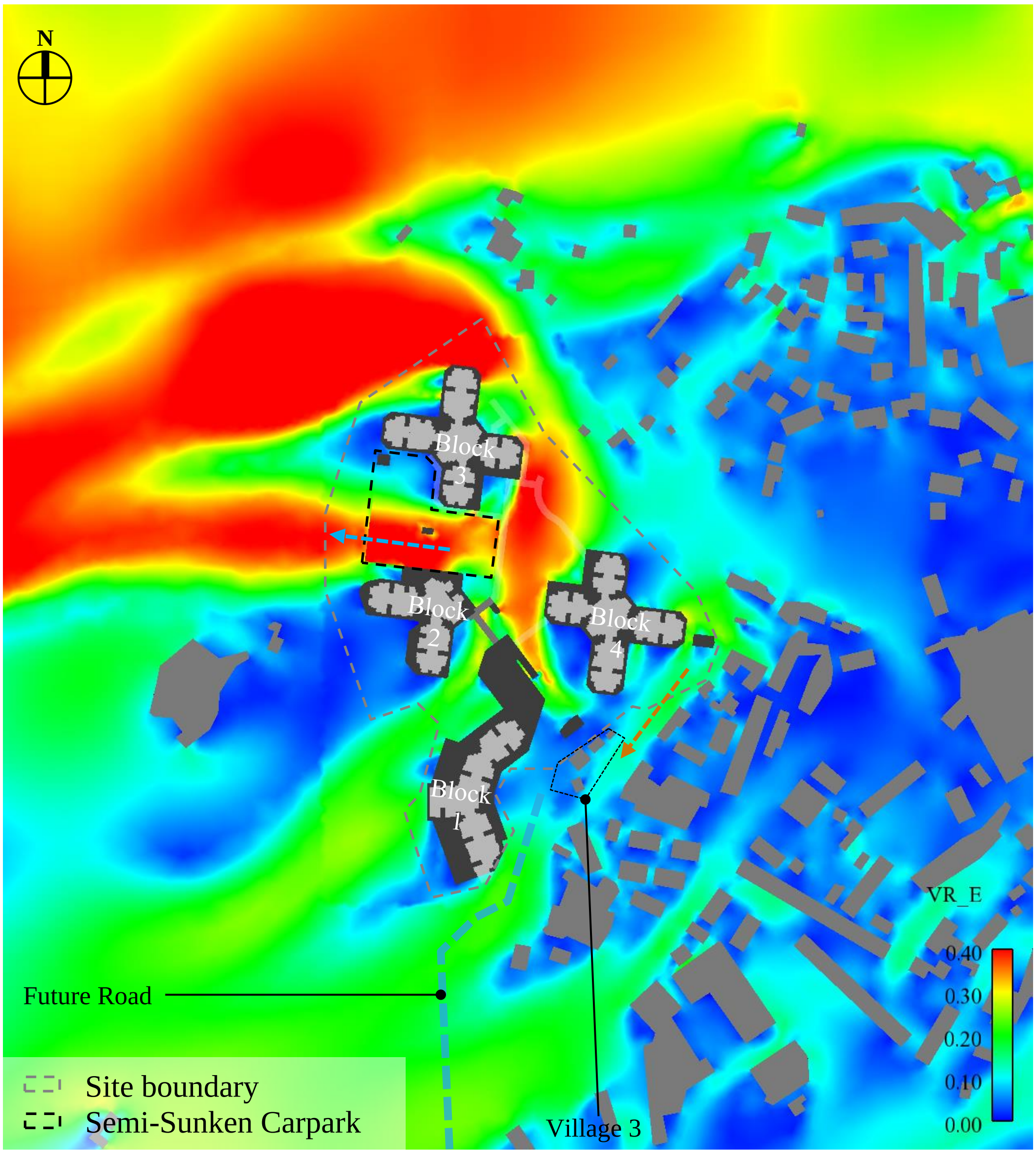


Figure 38 VR Contour Plot of E Direction for Proposed Scheme under Scenario 3

6.2.5 ESE Wind

ESE wind contributes approximately 11.6% of the annual wind rose and 8.4% of the summer wind rose. The VR contour plots under S1, S2, and S3 are shown in Figure 39, Figure 40, and Figure 41 respectively. In general, the overall ventilation environment is quite different among the three scenarios.

The prevailing wind would skim over the low-rise villages and reach the site from the southeast site boundary. Block 1 and Block 4 have slightly higher building height under S2, and would induce a slightly stronger downwash effect to the pedestrian level (**Black Arrows** in Figure 40). As a result, slightly better ventilation environment would be observed at Village 3, Village 5, Siu On Garden, and the north portion of Future Road. A portion of the downwashed wind from Block 4 would further travel towards Village 2 and Po Wah Garden.

The incoming wind could penetrate through the building separation between Block 1 and Block 4 into the Development. It would then be divided into two air streams, one stream travel towards Village 2, and the other stream would flow atop of the carpark between Block 2 and Block 3. Since the height of the semi-sunken carpark in S2 & S3 is lower when compared with S1, more wind would flow atop of the carpark and enhance the western region of the Development (Red Arrow in Figure 40 and Figure 41).

Since Block 3 has a slightly taller building height in S2 & S3, it would induce a stronger downwash effect. The downwashed stream would join the air stream between Block 1 and Block 4, and flow towards Village 2, enhancing the ventilation performance at the area (Orange Arrow in Figure 40 and Figure 41).

A portion of the incoming wind can reach Block 2 through the building separation between Block 1 and Block 4. As Block 2 has abutting podium edge facing the wind direction under S2 & S3, it allows most of the downwashed wind to flow towards the pedestrian level, and reach the villages at west of the Development (Purple Arrow in Figure 40 and Figure 41). On the other hand, the podium block of Block 2 in S1 would reduce the amount of the downwashed wind at pedestrian level. As a result, the ventilation performance would be slightly better under S2 & S3.

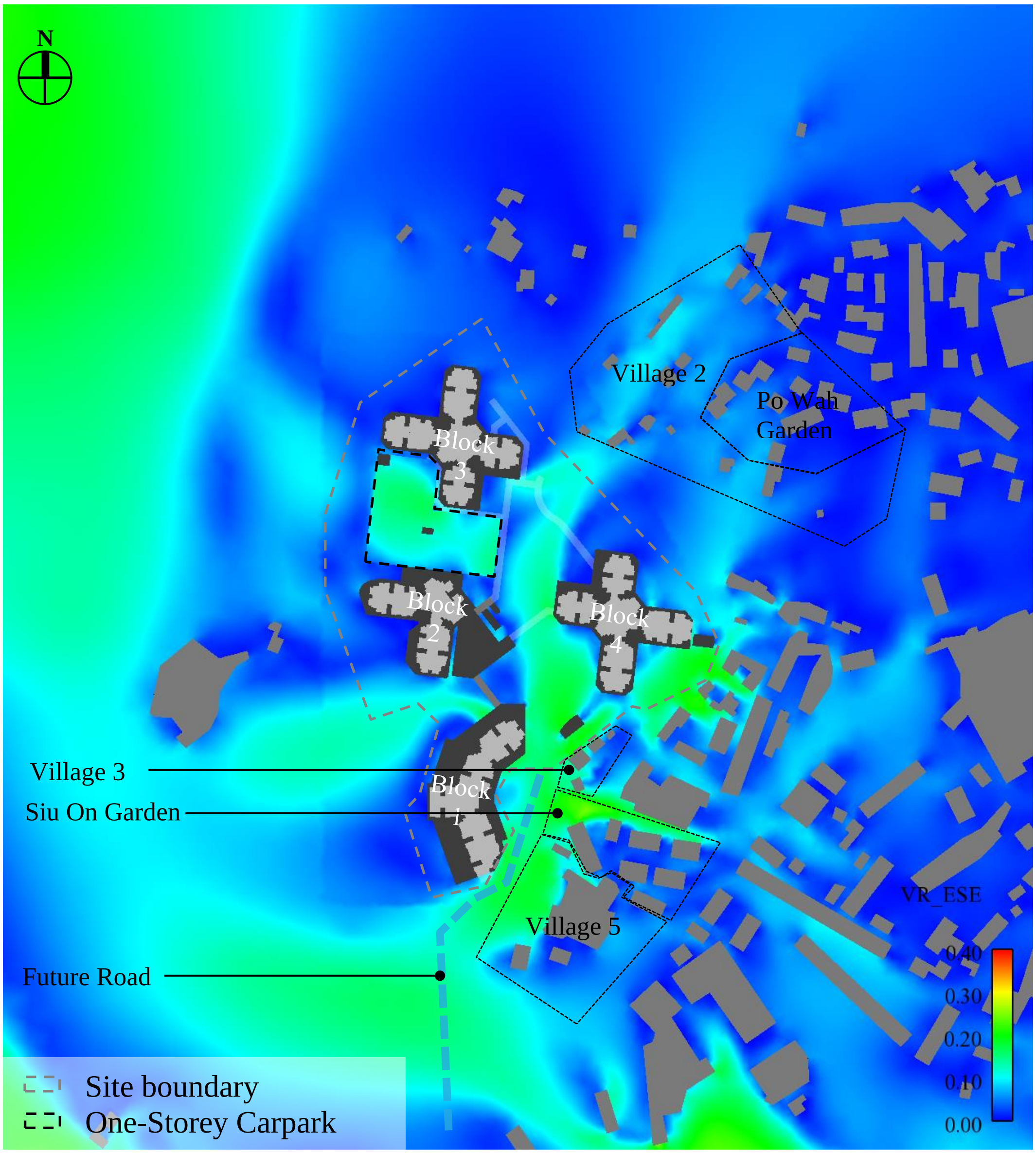


Figure 39 VR Contour Plot of ESE Direction for Baseline Scheme under Scenario 1

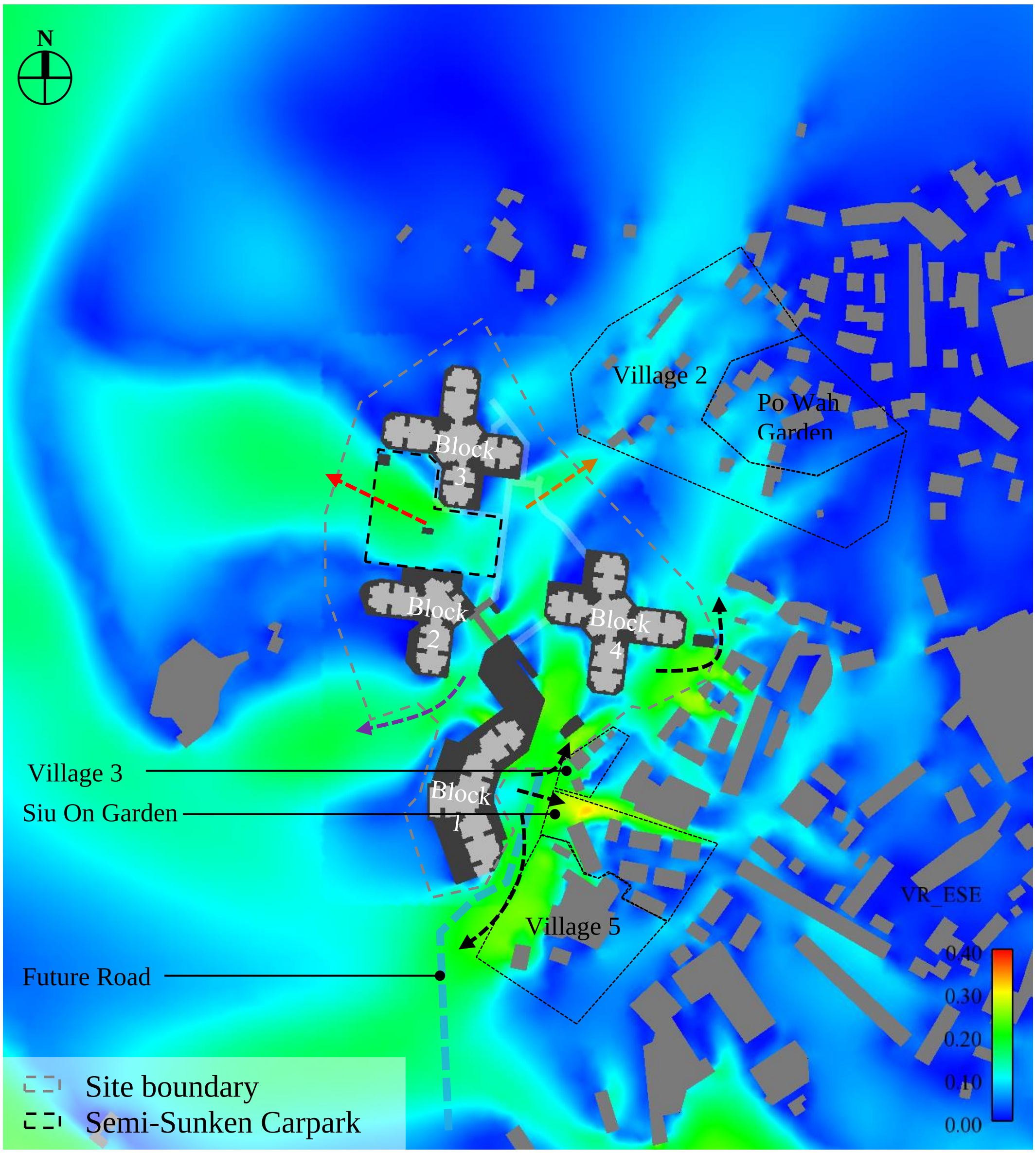


Figure 40 VR Contour Plot of ESE Direction for Proposed Scheme under Scenario 2

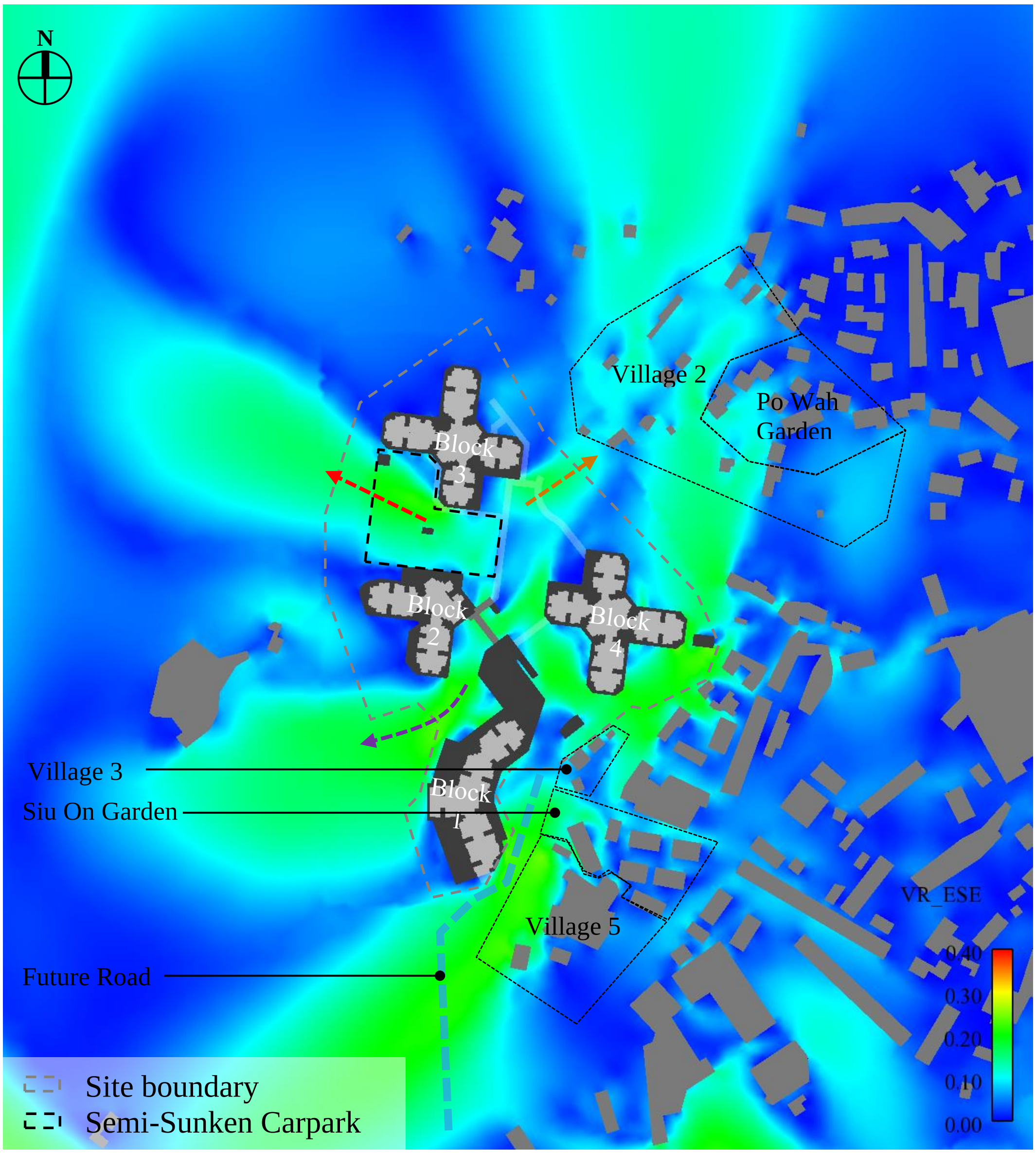


Figure 41 VR Contour Plot of ESE Direction for Proposed Scheme under Scenario 3

6.2.6 SE Wind

SE wind contributes approximately 8.8% of the annual wind rose and 7.8% of the summer wind rose. The VR contour plots under S1, S2, and S3 are shown in Figure 42, Figure 43, and Figure 44 respectively. In general, the overall ventilation environment is similar among the three scenarios. S1 would result better ventilation performance at Village 1, while S2 & S3 would result slightly better ventilation performance at the area to the west of the Development.

The prevailing wind would skim over the low-rise villages and reach the site from the southeast site boundary. It would then penetrate through the building separation between Blocks 1 & 2 and Blocks 3 & 4 towards the leeward region (Blue Arrow in Figure 42, Figure 43, and Figure 44). Meanwhile, another portion of the prevailing wind would flow along the west of the Development (**Black Arrow** in Figure 42, Figure 43, and Figure 44).

S2 & S3 has a higher building height and would induce a larger wind shadow when compared with S1. As a result, slightly lower VR would be observed at Village 1 under S2 & S3 when compared with S1.

The lower carpark structure under S2 & S3 would facilitate more wind flow towards the village houses at the west of the Development, and would enhance the ventilation performance at the area.

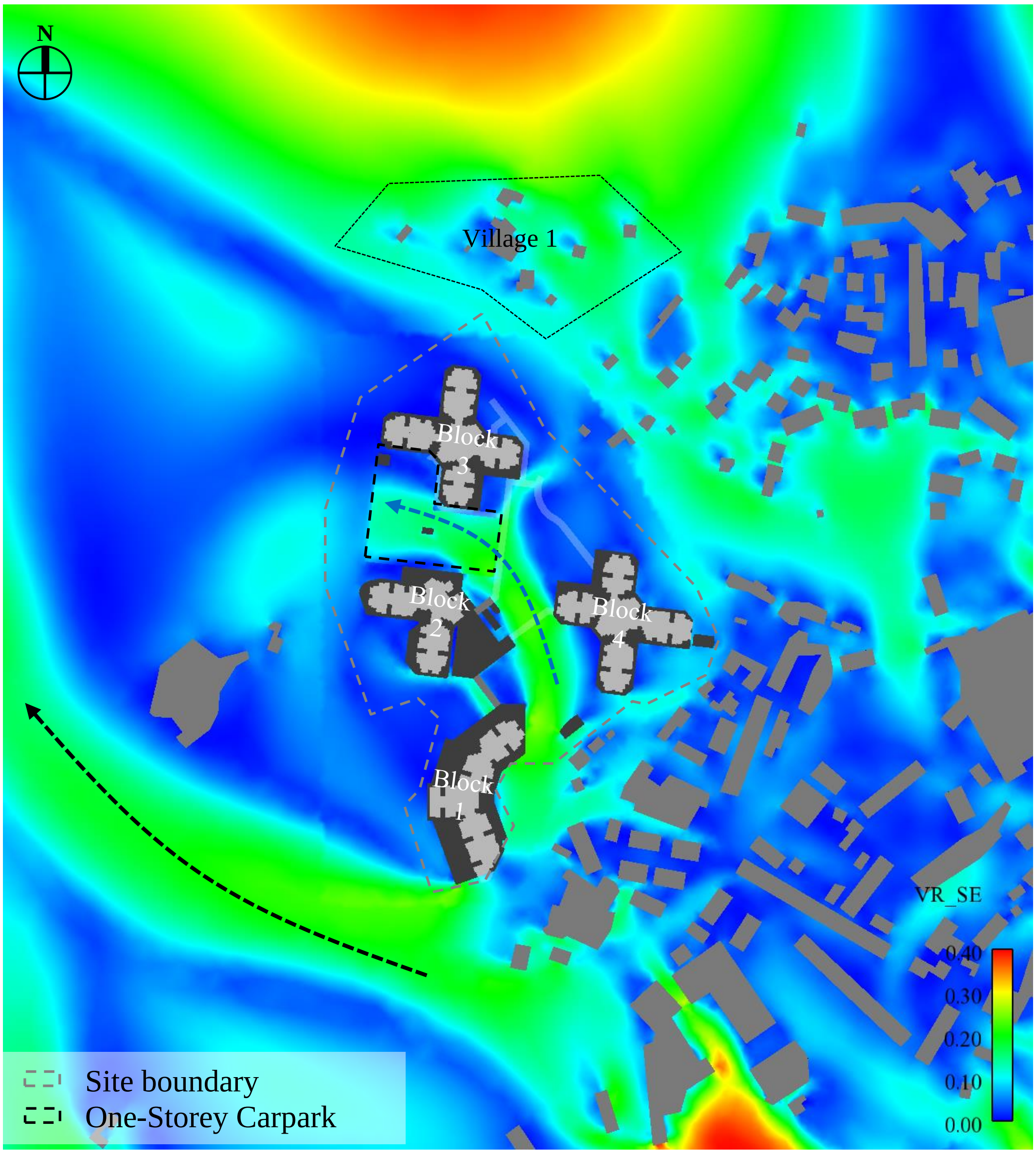


Figure 42 VR Contour Plot of SE Direction for Baseline Scheme under Scenario 1

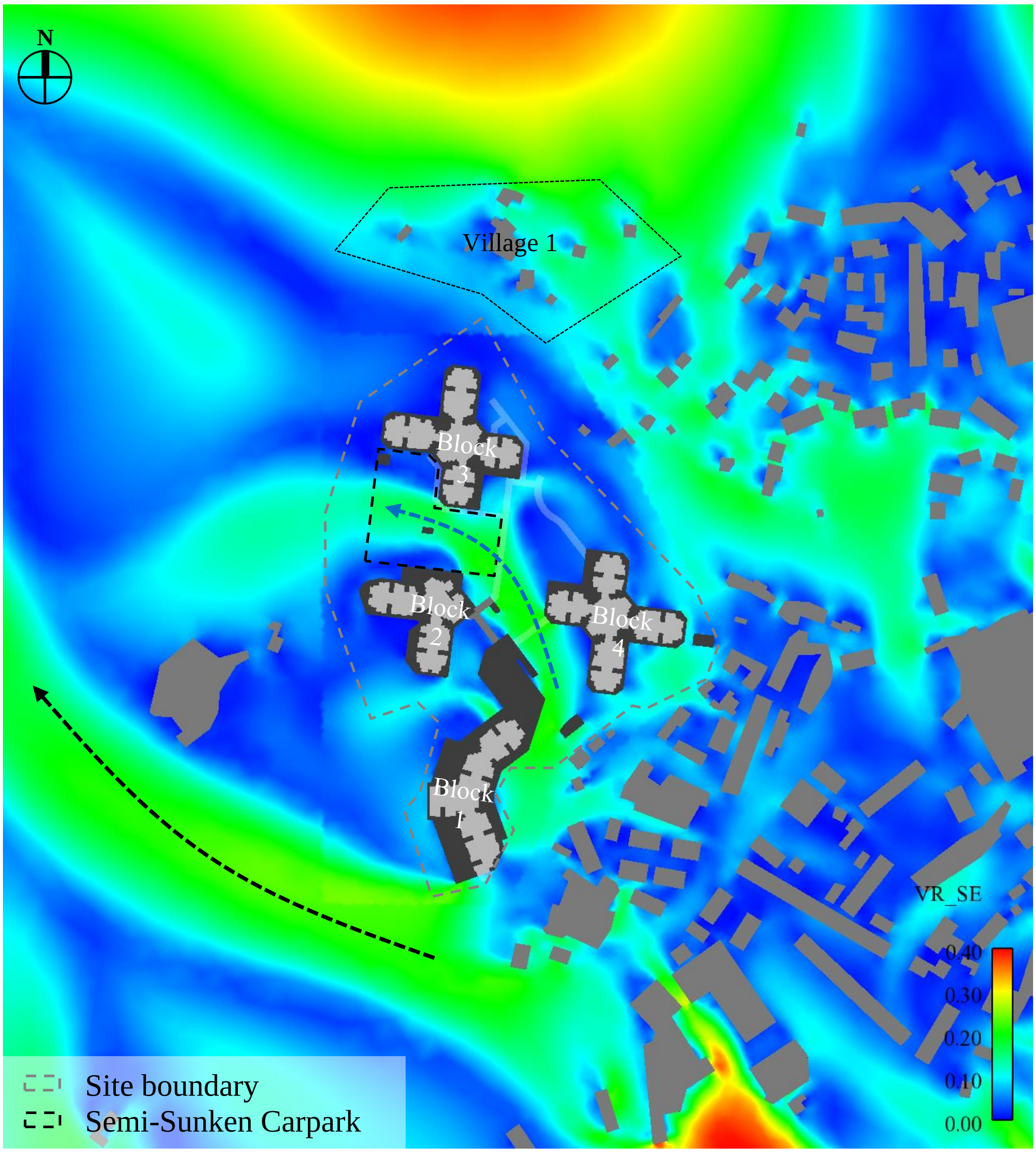


Figure 43 VR Contour Plot of SE Direction for Proposed Scheme under Scenario 2

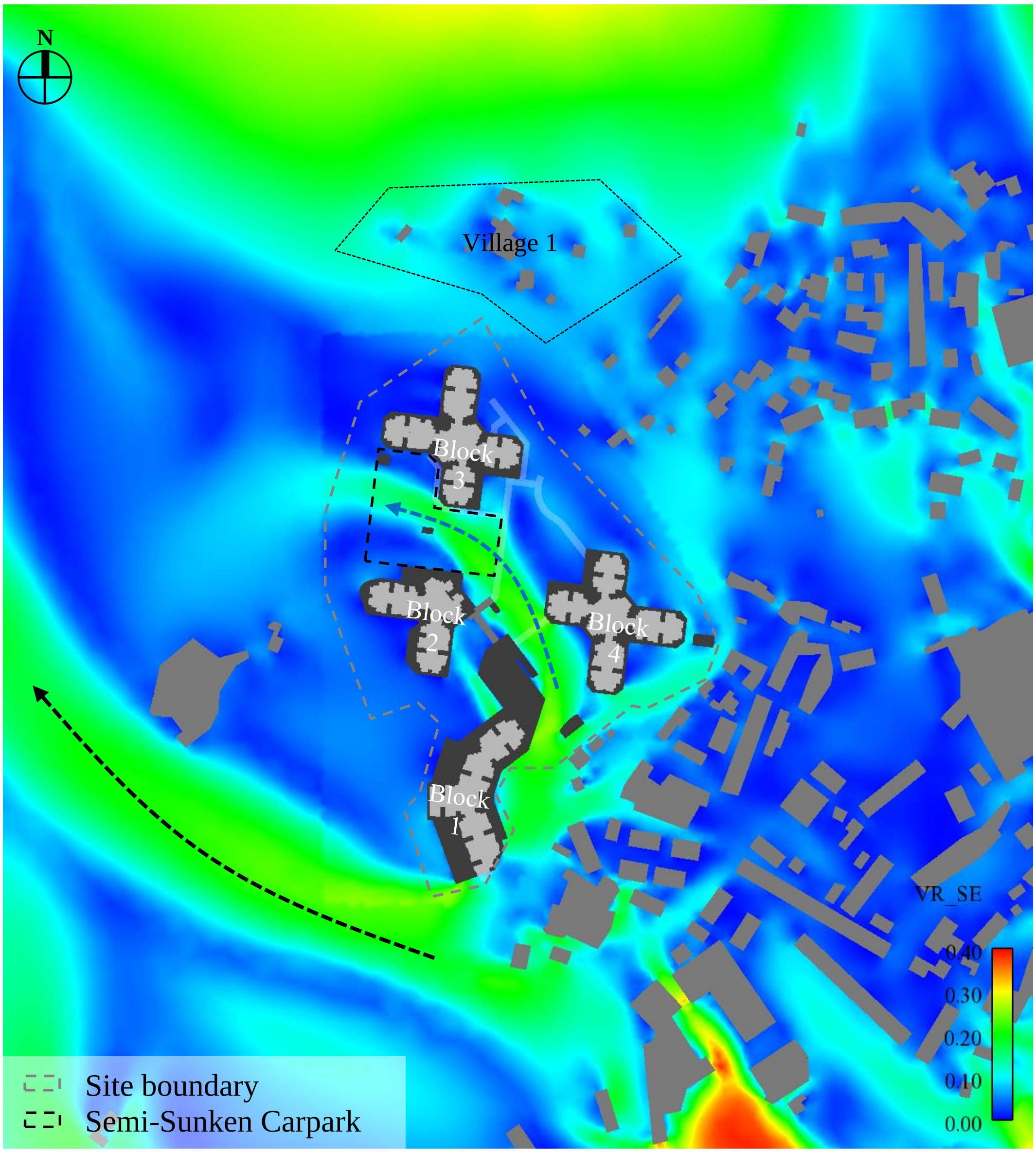


Figure 44 VR Contour Plot of SE Direction for Proposed Scheme under Scenario 3

6.2.7 SSE Wind

SSE wind contributes approximately 8.3% of the annual wind rose and 11.5% of the summer wind rose. The VR contour plots under S1, S2, and S3 are shown in Figure 45, Figure 46, and Figure 47 respectively. In general, the overall ventilation environment is similar among the three scenarios.

The prevailing wind would flow along the west of the Development (Blue Arrow in Figure 45, Figure 46, and Figure 47).

A portion of the prevailing wind would enter the Development from the building separation between Block 1 and Block 2 (Red Arrow in Figure 45, Figure 46, and Figure 47). The result show that more wind can flow along the building separation between Block 1 and Block 2 under S2 & S3, and further enhance the northeast side boundary and Village 2.

For all other areas, the ventilation performance is similar.

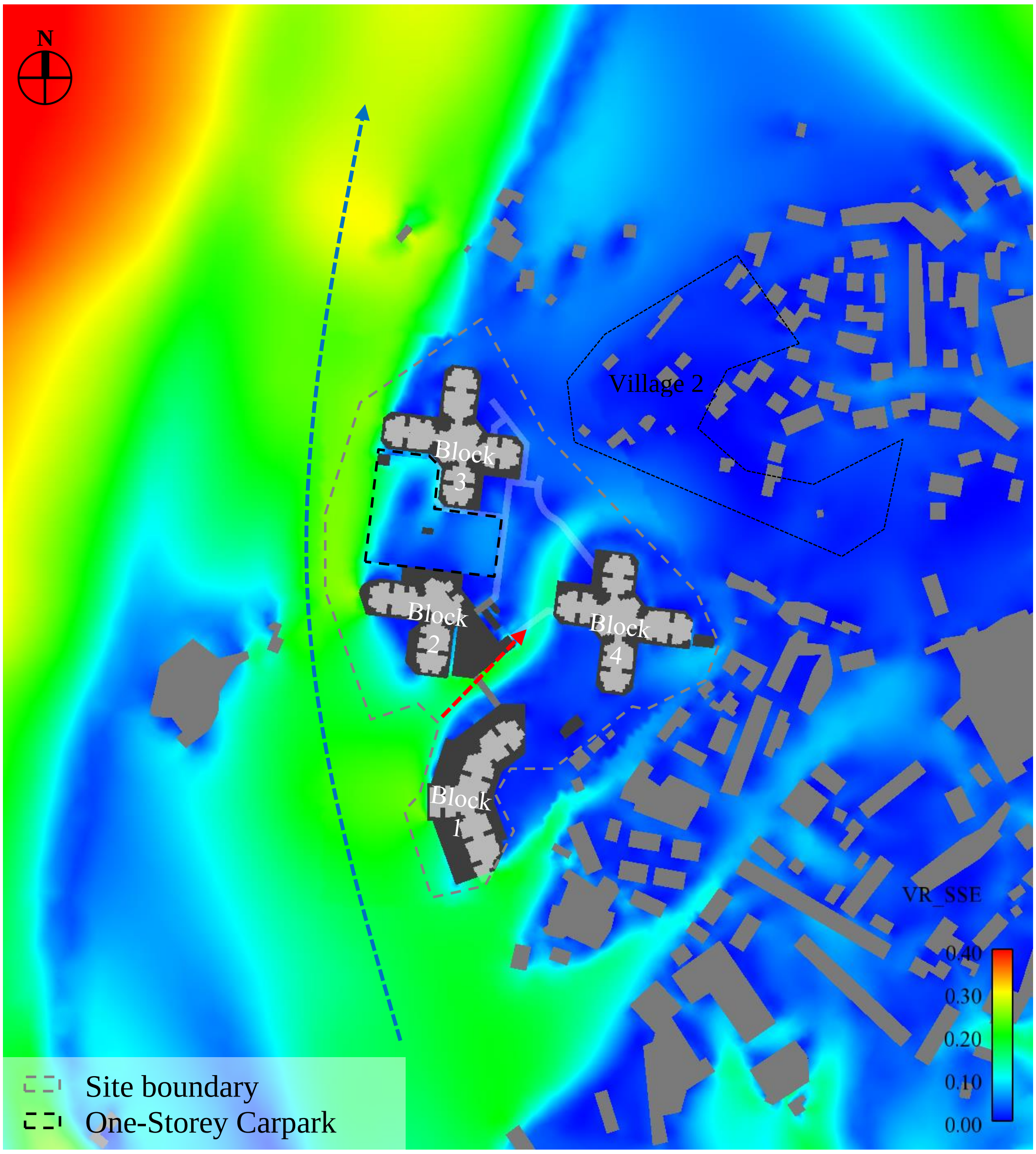


Figure 45 VR Contour Plot of SSE Direction for Baseline Scheme under Scenario 1

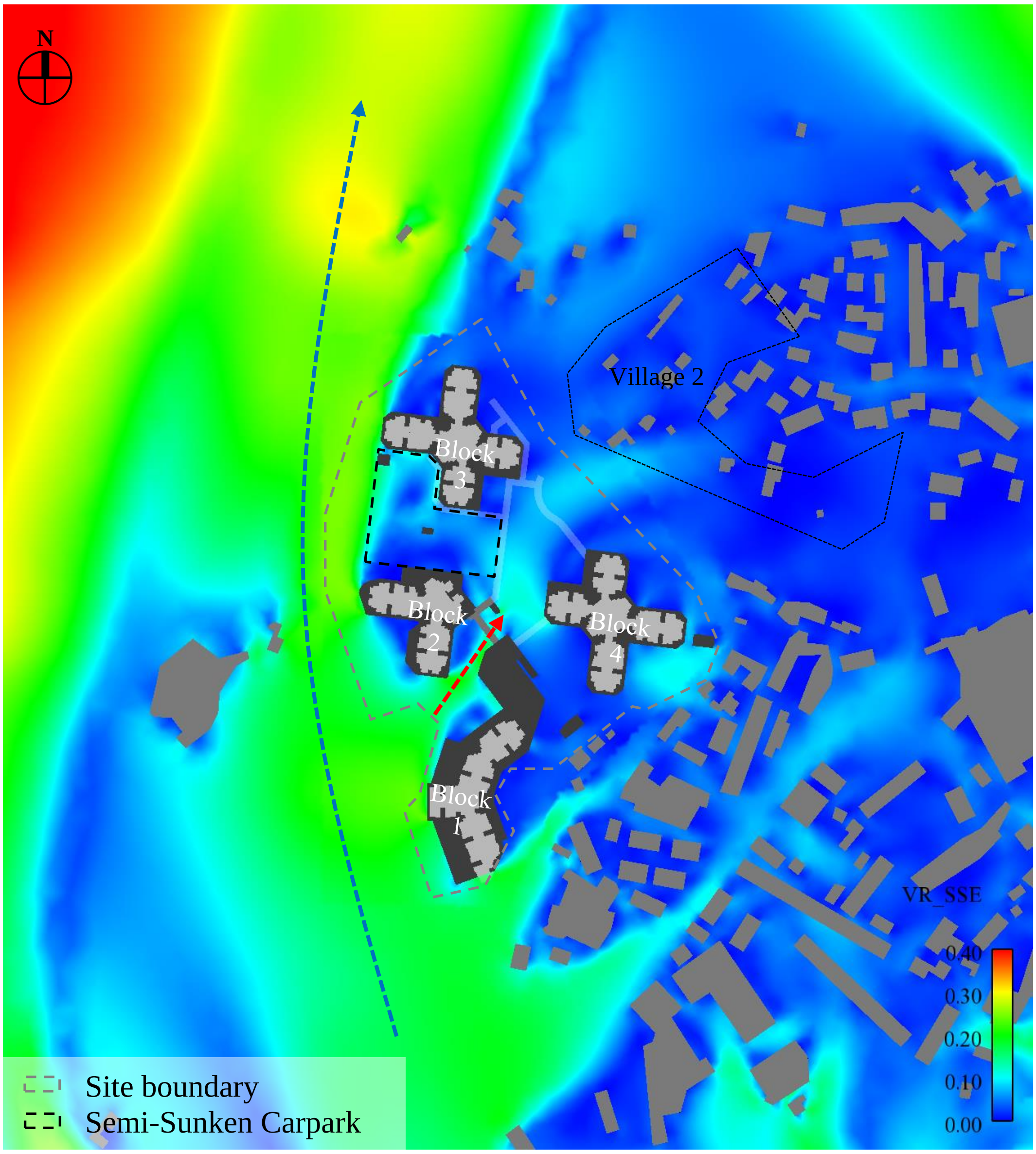


Figure 46 VR Contour Plot of SSE Direction for Proposed Scheme under Scenario 2

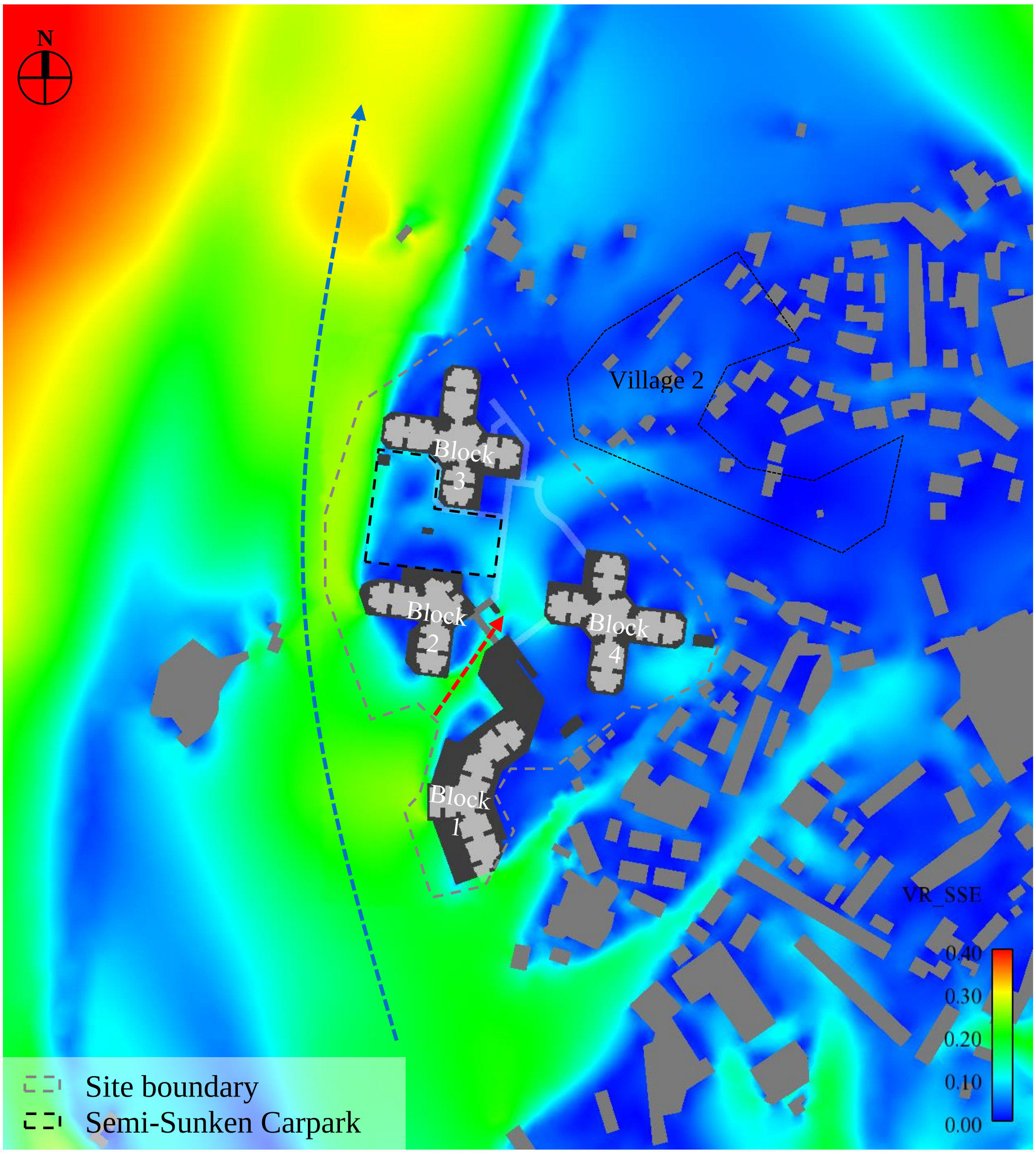


Figure 47 VR Contour Plot of SSE Direction for Proposed Scheme under Scenario 3

6.2.8 S Wind

S wind contributes approximately 13.6% of the summer wind rose. The VR contour plots under S1, S2, and S3 are shown in Figure 48, Figure 49, and Figure 50 respectively. In general, the overall ventilation environment is similar among the three scenarios.

Under S2 & S3, Block 4 has a higher building height and a building set back. This would induce a slightly stronger downwash effect (**Black Arrow** in Figure 49 and Figure 50) and increase the wind permeability at the east of the Development. . As a result, slightly higher VR would be observed at the area to the northeast of Block 4 under S2 & S3 (Red Circle in Figure 49 and Figure 50).

On the other hand, the larger building frontage under S2 & S3 would induce a slightly larger wake zone at the leeward region (Orange Ellipse in Figure 49 and Figure 50).

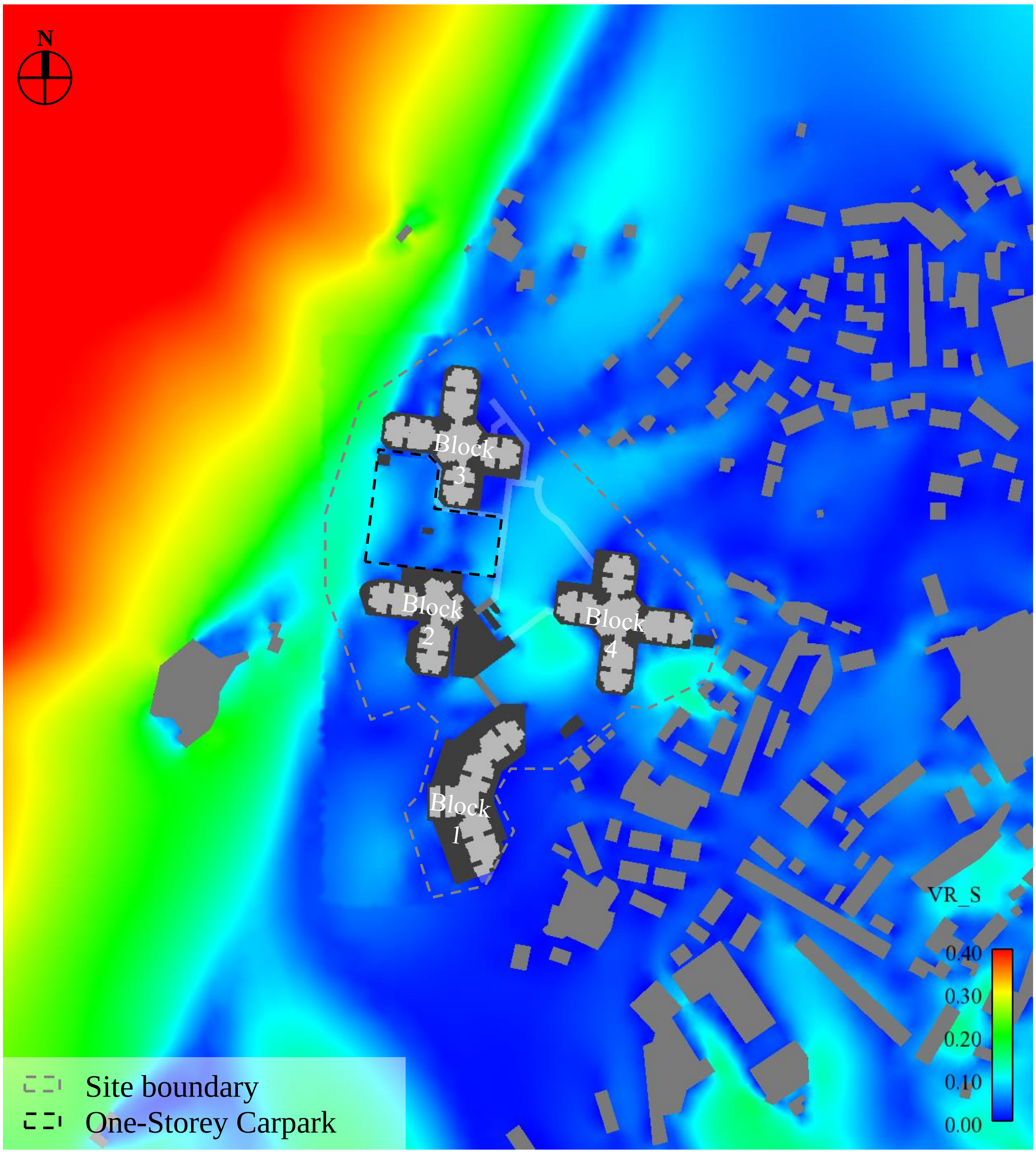


Figure 48 VR Contour Plot of S Direction for Baseline Scheme under Scenario 1

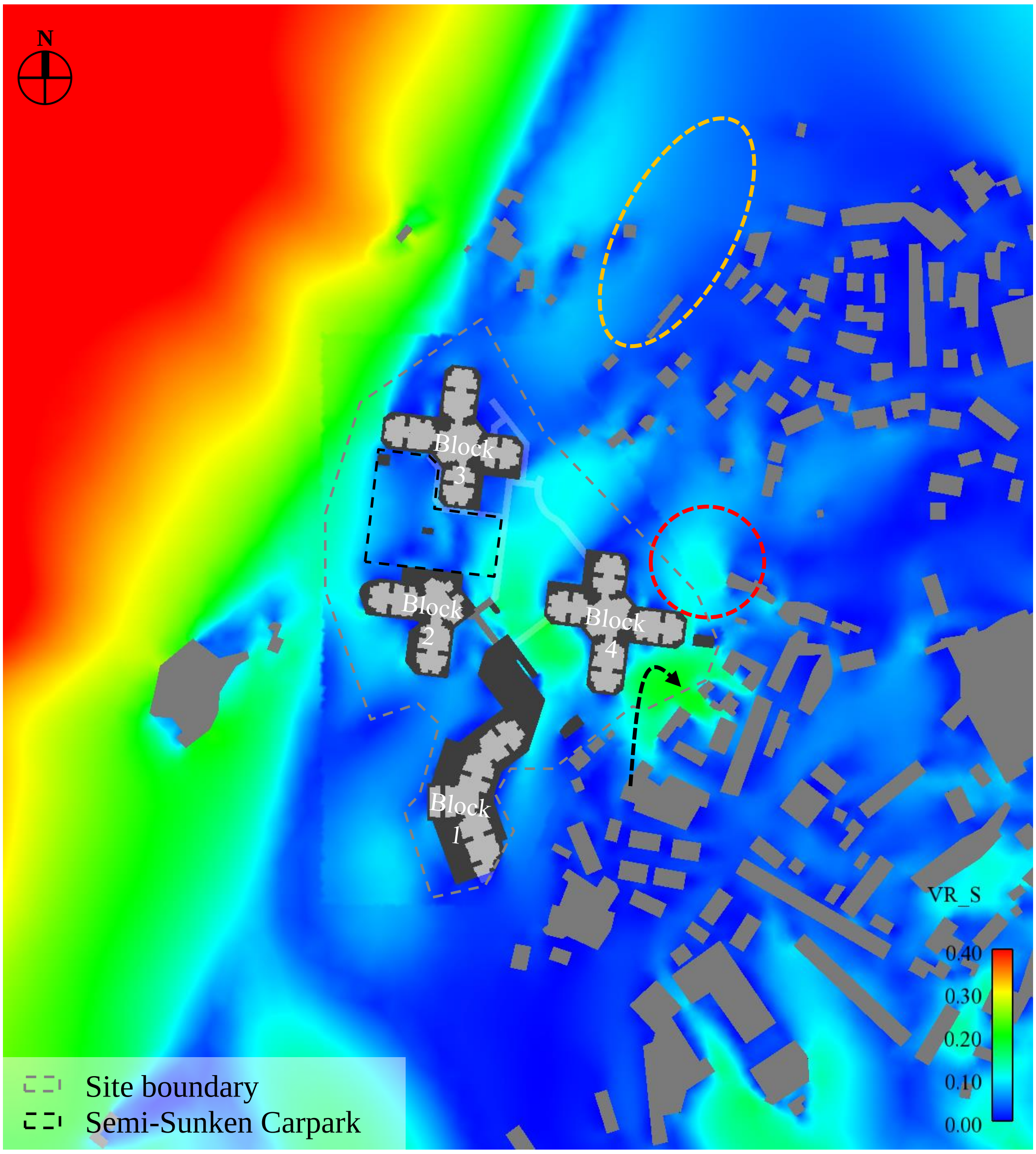


Figure 49 VR Contour Plot of S Direction for Proposed Scheme under Scenario 2

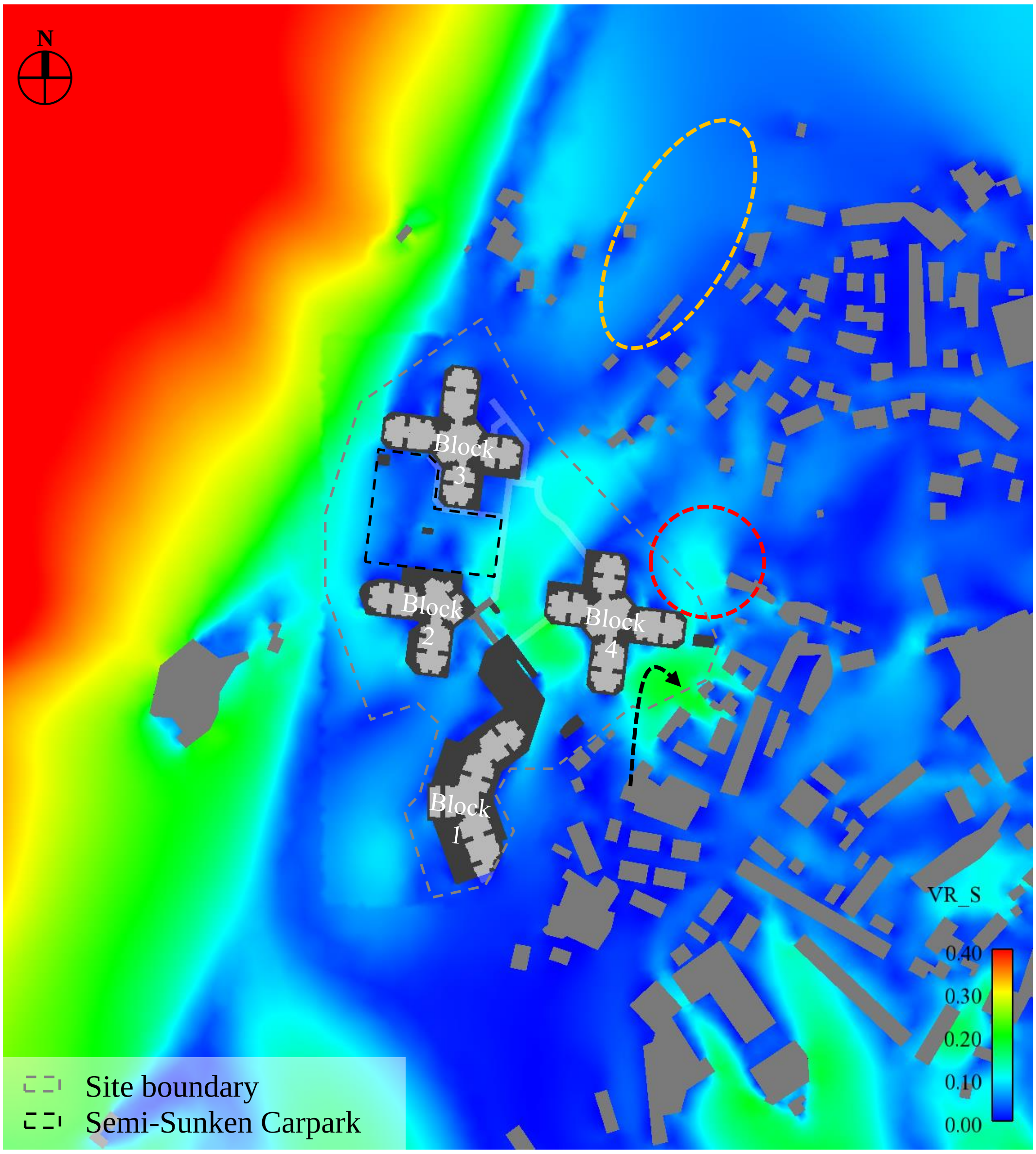


Figure 50 VR Contour Plot of S Direction for Proposed Scheme under Scenario 3

6.2.9 SSW Wind

SSW wind contributes approximately 8.4% of the annual wind rose and 19.1% of the summer wind rose. The VR contour plots under S1, S2, and S3 are shown in Figure 51, Figure 52, and Figure 53 respectively. In general, the overall ventilation environment is similar among the three scenarios.

The prevailing wind would flow through the building separation between Block 1 and Block 2 and enter the Development.

Under S2 & S3, Block 4 is setback when compared with Baseline Scheme. Slightly larger building facade area can capture the incoming wind from the building separation of Block 1 and Block 2. Thus, this feature facilitates the capture of more wind towards street level within the Development (Red Arrow in Figure 52 and Figure 53).

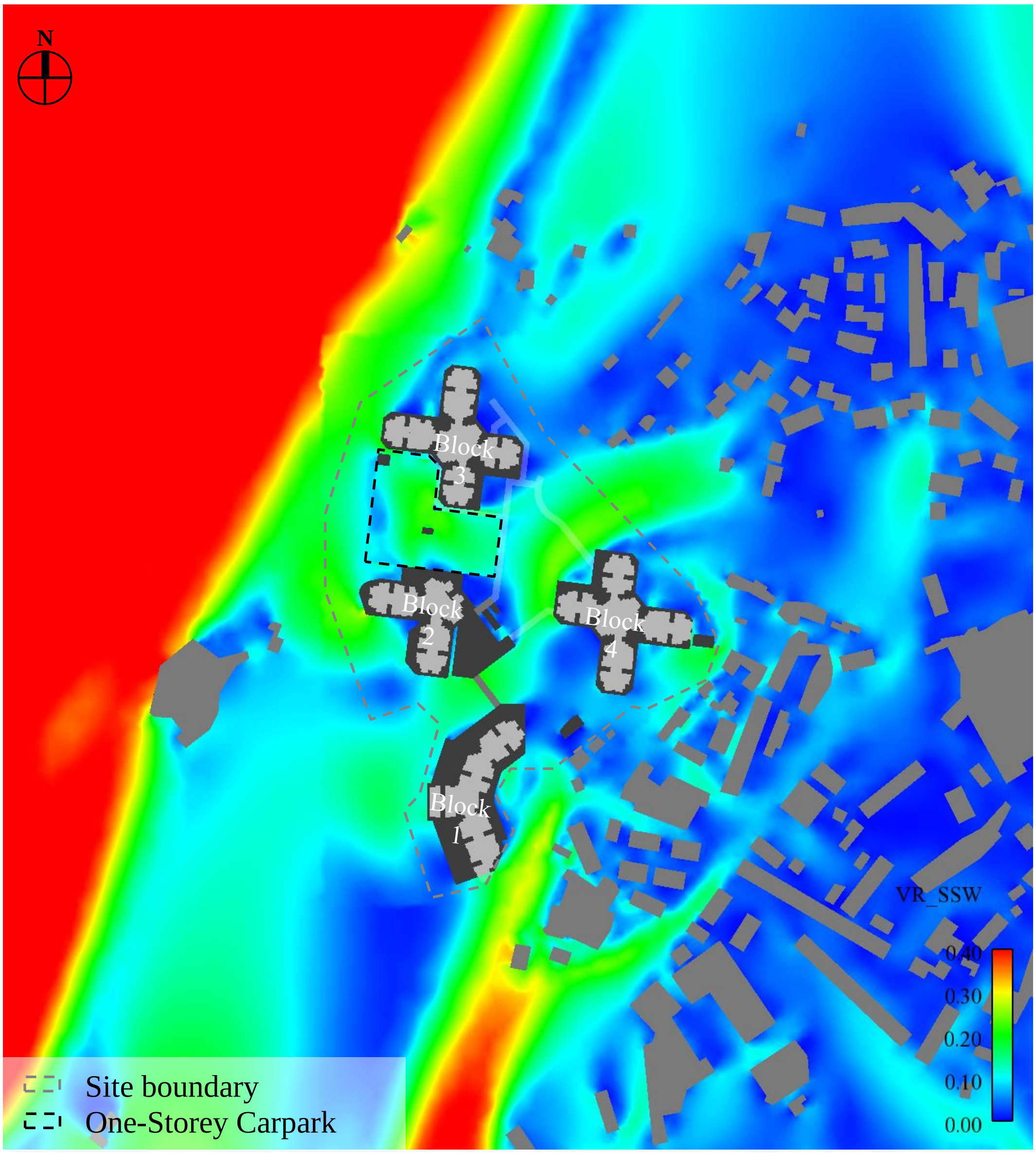


Figure 51 VR Contour Plot of SSW Direction for Baseline Scheme under Scenario 1

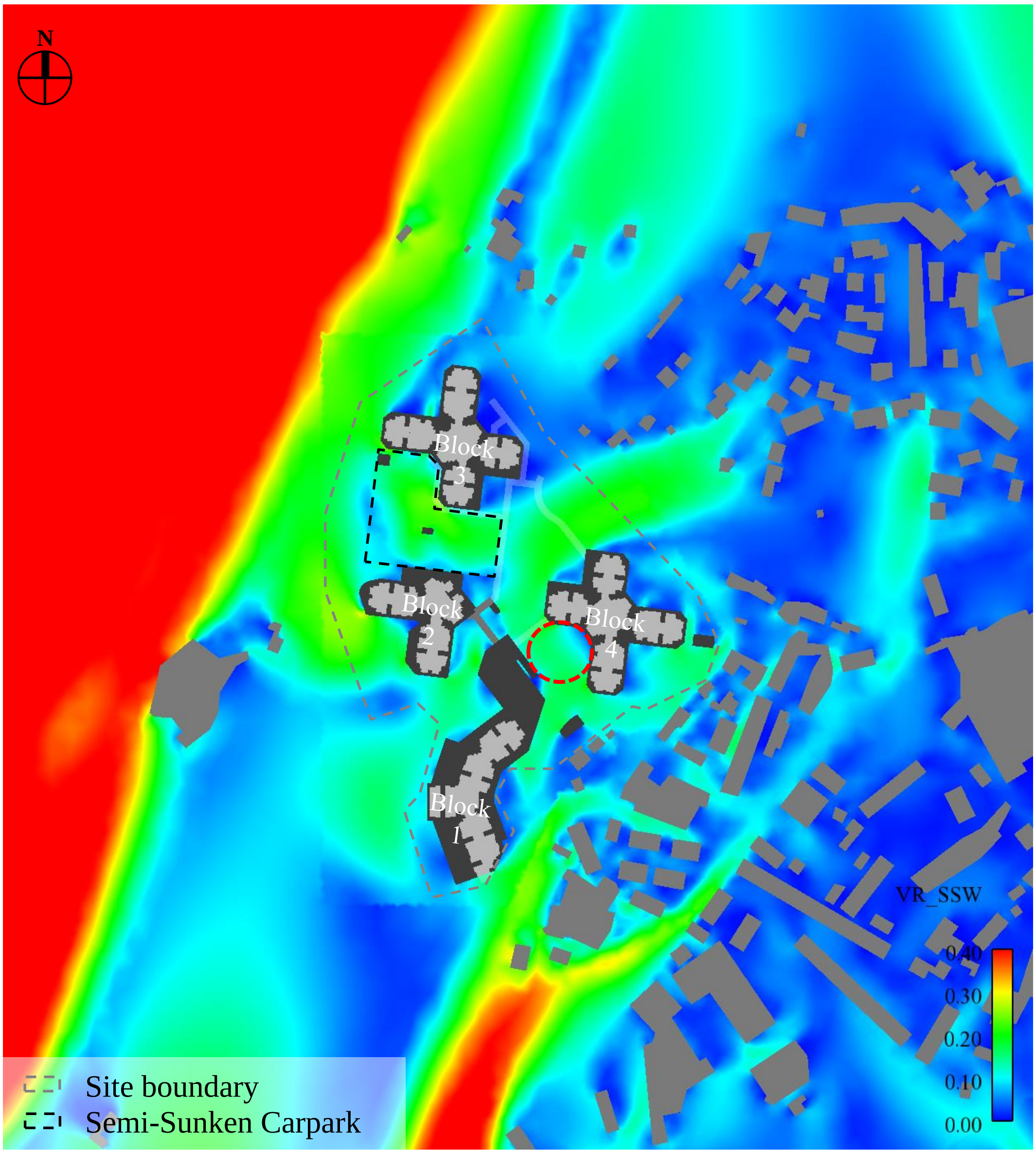


Figure 52 VR Contour Plot of SSW Direction for Proposed Scheme under Scenario 2

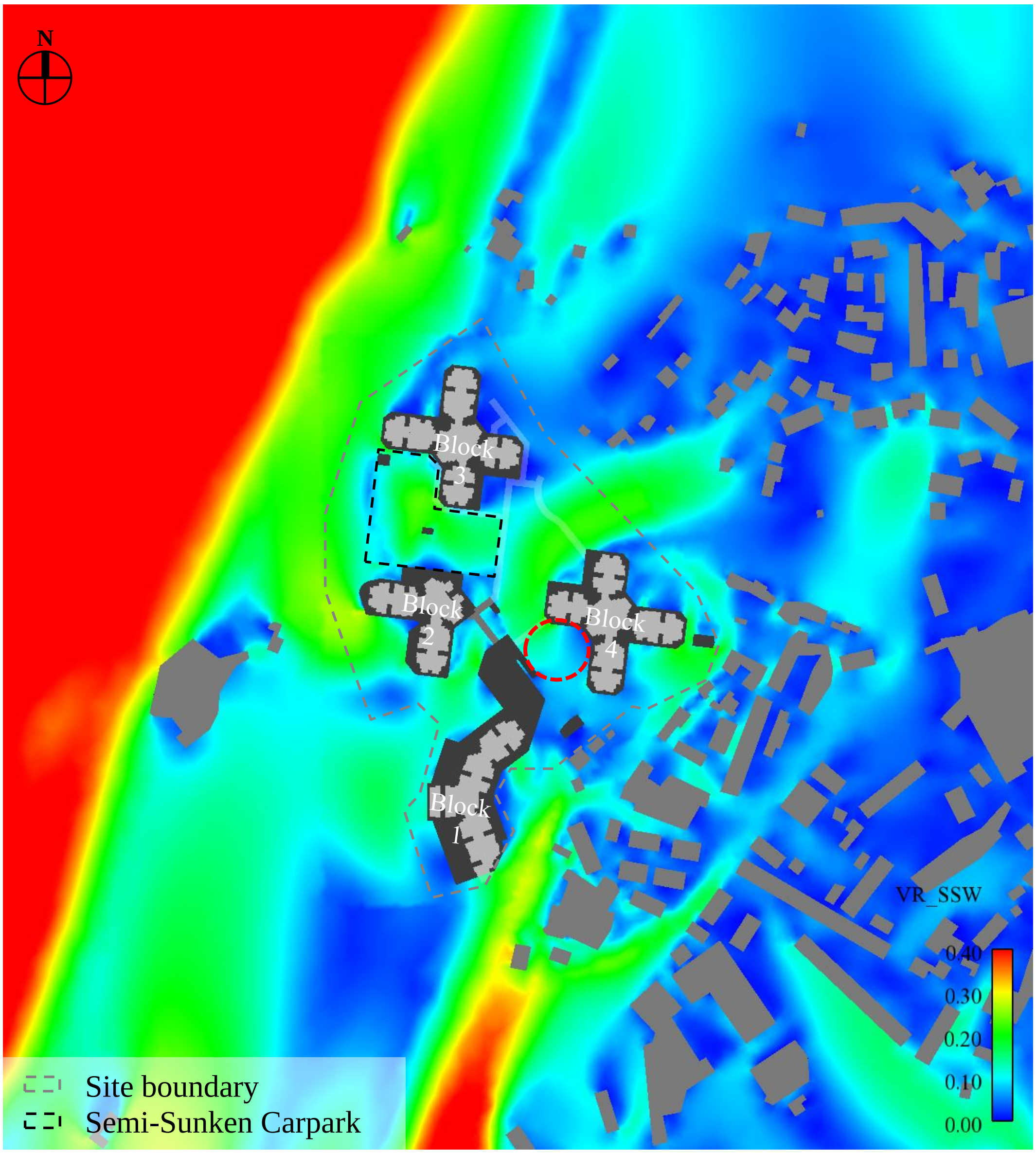


Figure 53 VR Contour Plot of SSW Direction for Proposed Scheme under Scenario 3

6.2.10 SW Wind

SW wind contributes approximately 11.7% of the summer wind rose. The VR contour plots under S1, S2, and S3 are shown in Figure 54, Figure 55, and Figure 56 respectively. In general, the overall ventilation environment is similar among the three scenarios.

The incoming wind would approach the Development from the southwest direction, and enter the Development through building separations between Block 1, Block 2, and Block 3.

Under S2 & S3, the lower carpark structure would enhance the wind permeability of the Development, and the incoming wind would be able to penetrate through the Development and flow towards the south portion of Village 2 more effectively. As a result, higher VR would be observed at the south portion of Village 2 under S2 & S3 (**Black Circle** in Figure 55 and Figure 56) when compared with S1 (**Black Circle** in Figure 54).

On the other hand, the Development has a higher building height under Proposed Scheme and would induce a slightly larger wind shadow. Slightly lower VR would be observed at the north portion of Village 2 under S2 & S3 (Orange Circle in Figure 55 and Figure 56) and the area to the east of the Development (**Black Ellipse** in Figure 55 and Figure 56) when compared with S1.

Meanwhile, Block 4 has a larger setback from the site boundary under Proposed Scheme. This would increase the wind permeability at the area to the east of Block 4. As a result, slightly higher VR would be observed at the area to the northeast of Block 4 under S2 & S3 (Red Circle in Figure 55 and Figure 56) when compared with S1 (Red Circle in Figure 54).

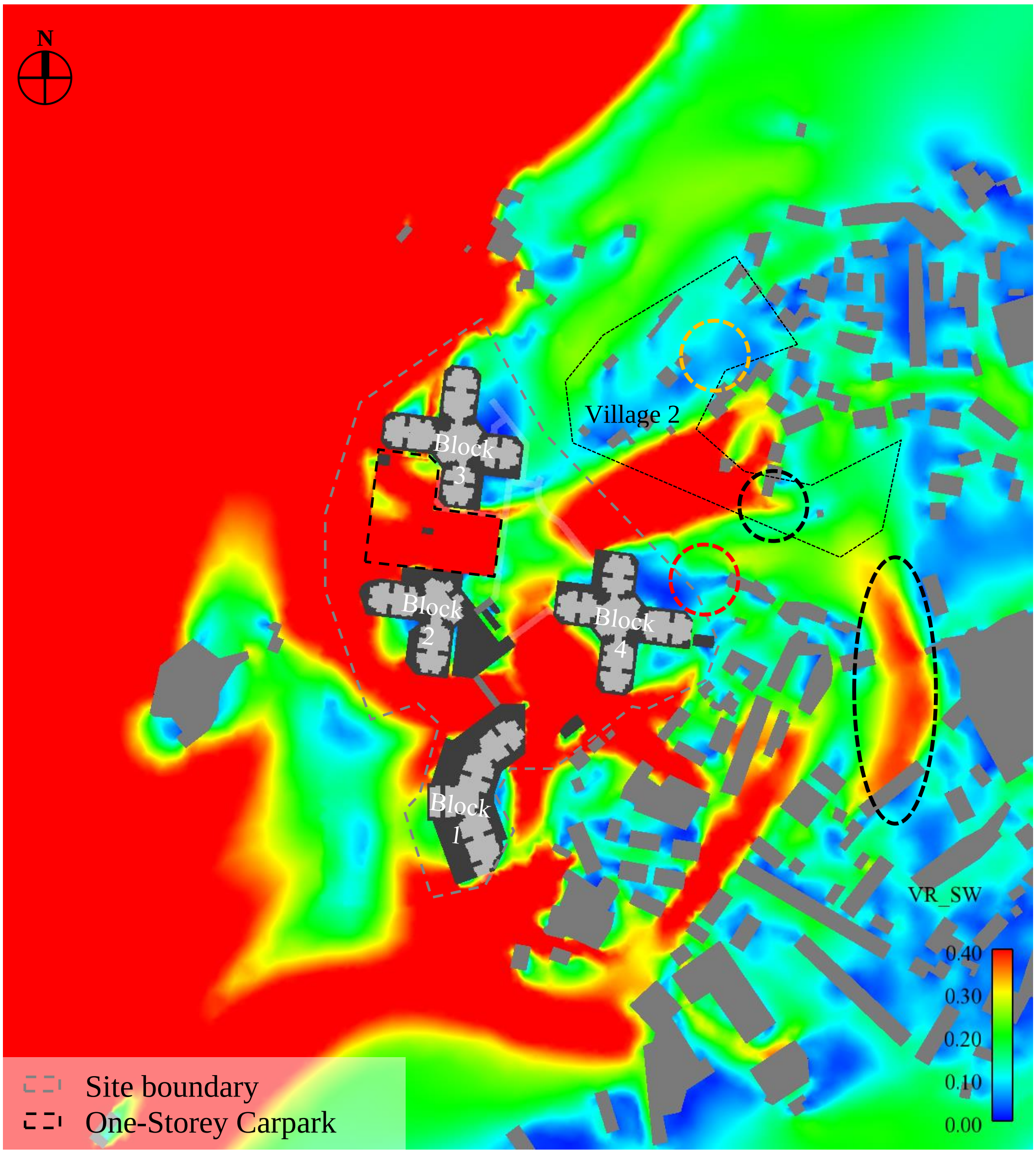


Figure 54 VR Contour Plot of SW Direction for Baseline Scheme under Scenario 1

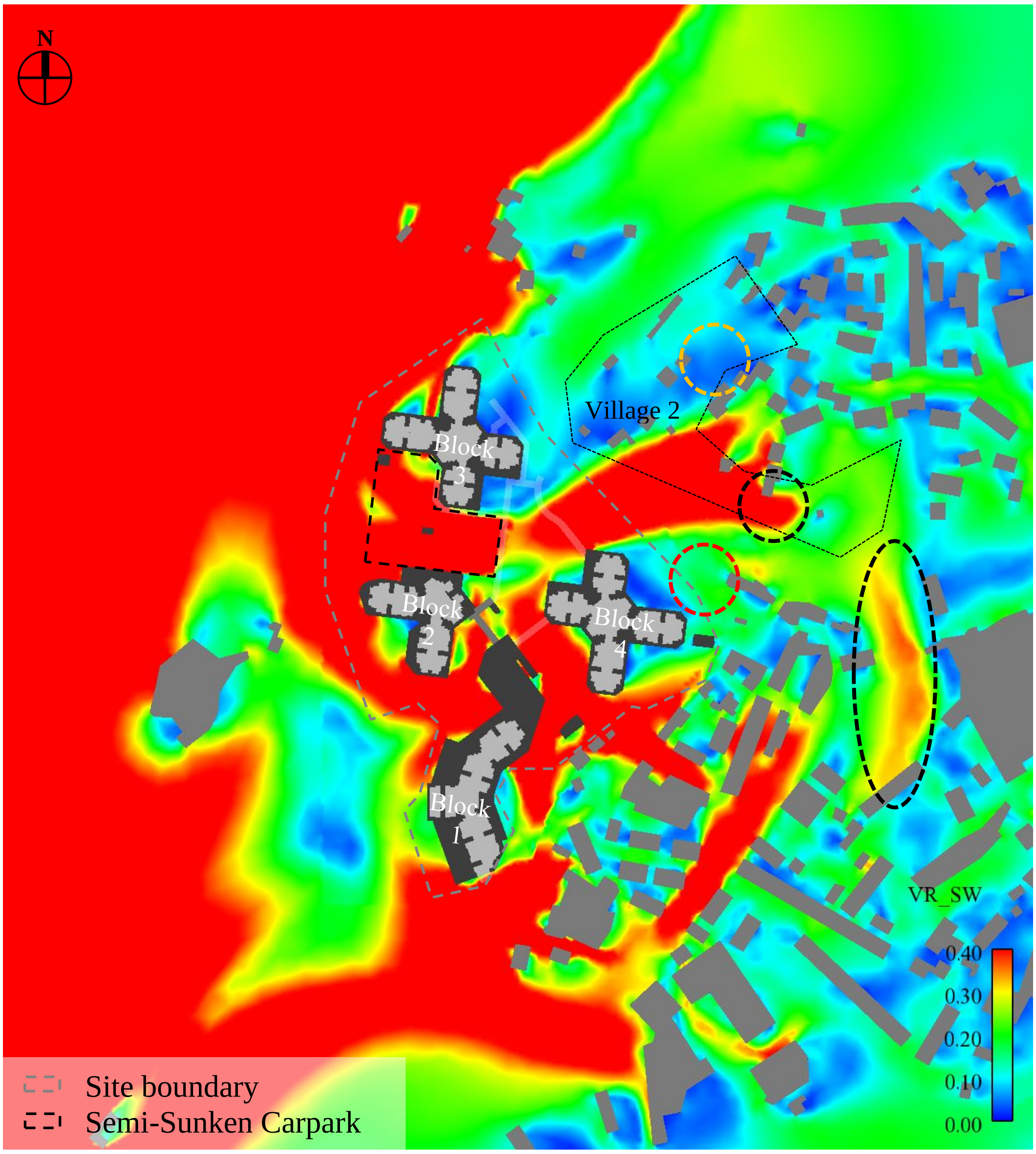


Figure 55 VR Contour Plot of SW Direction for Proposed Scheme under Scenario 2

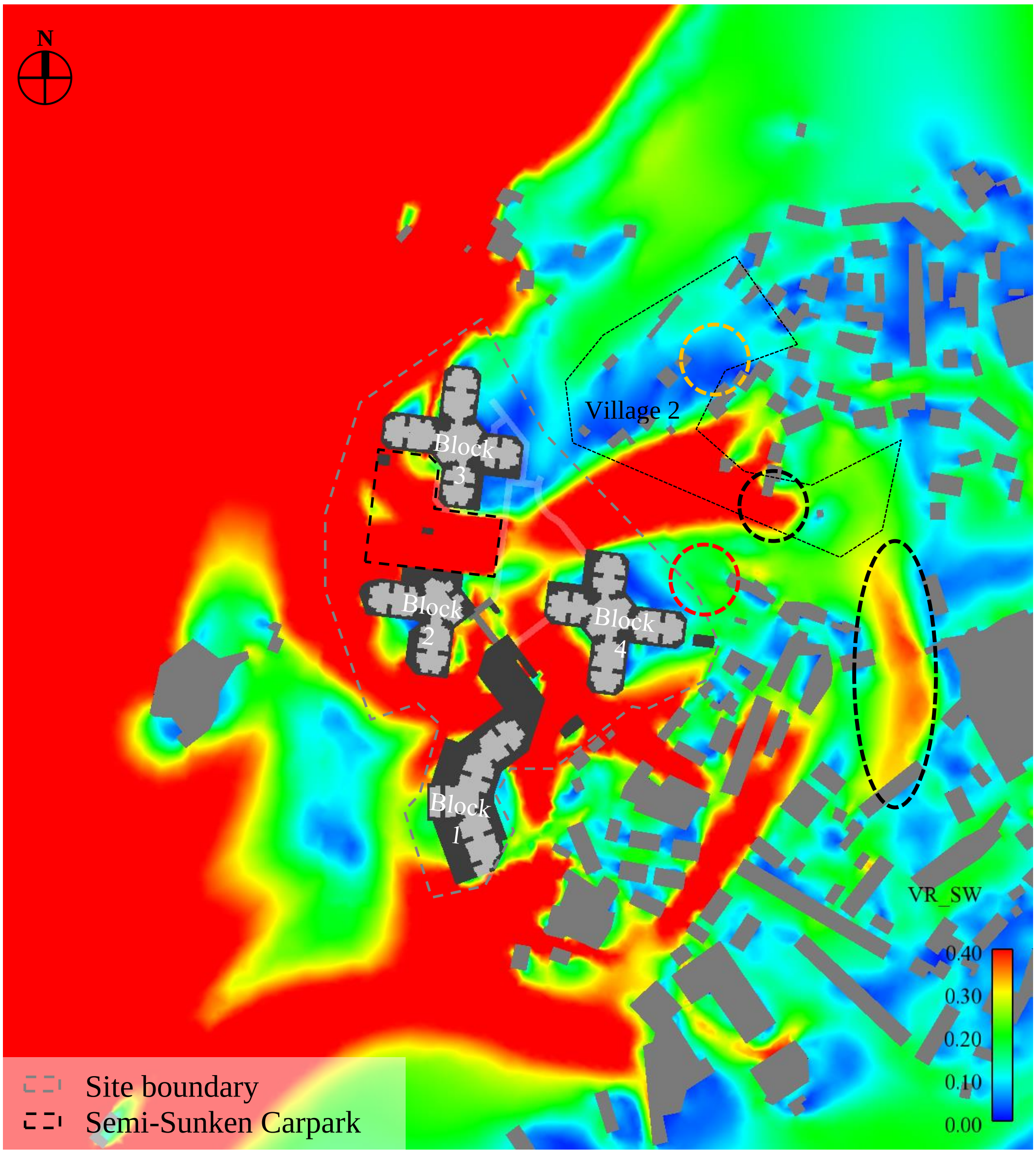


Figure 56 VR Contour Plot of SW Direction for Proposed Scheme under Scenario 3

6.3 Focus Area

Various Focus Areas with frequent pedestrian access and within major activity zones were defined, as shown in Figure 57.

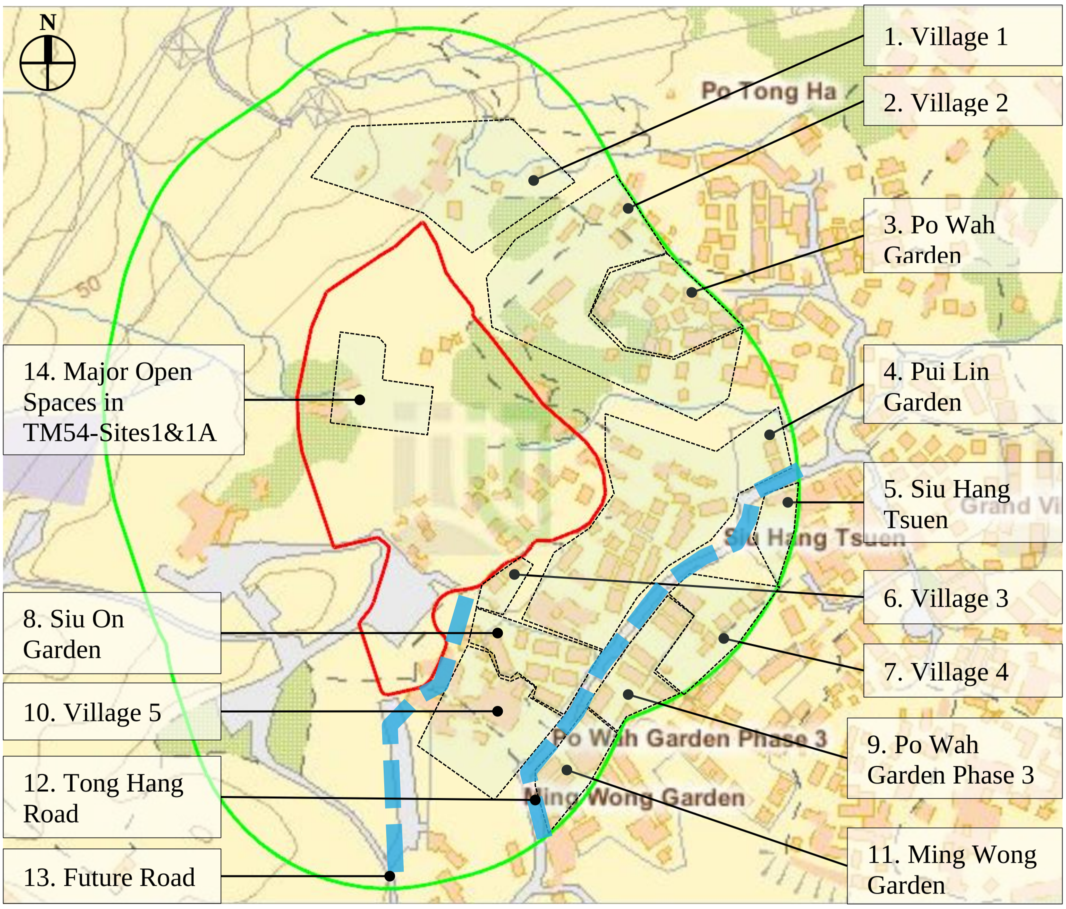


Figure 57 Location of Focus Areas

6.3.1 Annual Condition

Table 9 VR Results for Focus Areas under Annual Wind Condition

	Focus Areas	Test Points	Scenario 1	Scenario 2	Scenario 3
1	Village 1	O1 – O16	0.17	0.17	0.17
2	Village 2	O17 – O41	0.08	0.08	0.08
3	Po Wah Garden	O34 – O43	0.06	0.06	0.06
4	Pui Lin Garden	O57 – O73, O44 – O51	0.11	0.11	0.11
5	Siu Hang Tsuen	O44 – O46, O86, O87	0.11	0.11	0.11
6	Village 3	P25 – P27, O71 – O73	0.14	0.18	0.18
7	Village 4	O48, O87 – O91	0.09	0.09	0.09
8	Siu On Garden	O70, O73, O74, O84, O85, O51 – O53	0.12	0.12	0.12
9	Po Wah Garden Phase 3	O49 – O52, O92, O93	0.11	0.11	0.11
10	Village 5	P21, P22, O80 – O83	0.15	0.15	0.15
11	Ming Wong Garden	O53 – O56	0.09	0.09	0.09
12	Tong Hang Road	O44 – O56	0.11	0.11	0.11
13	Future Road	O74 – O79, P20 – P22	0.17	0.17	0.17
14	Major Open Spaces in TM54-Sites 1&1A	S1 – S12	0.22	0.24	0.24

Under annual condition, the three analysed scenarios would achieve similar VR at most of the focus areas, indicating their ventilation performance is quite similar in general. Slightly higher VR would be observed at Village 3 and Major Open Spaces in TM54-Sites 1&1A under Scenarios 2 and 3.

- At Village 3, Scenarios 2 and 3 would achieve slightly higher VR as compared with Scenario 1. It is mainly because of the stronger downwash effect induced by the Development under its Proposed Scheme.

- Meanwhile, under Proposed Scheme of the Development (i.e. Scenarios 2 and 3), the Carpark is semi-sunken, which facilitates wind flow atop of the carpark. As a result, slightly higher VR would be observed at Major Open Spaces in TM54-Sites 1&1A.

6.3.2 Summer Condition

Table 10 VR Results for Focus Areas under Summer Wind Condition

	Focus Areas	Test Points	Scenario 1	Scenario 2	Scenario 3
1	Village 1	O1 – O16	0.16	0.16	0.16
2	Village 2	O17 – O41	0.08	0.08	0.08
3	Po Wah Garden	O34 – O43	0.07	0.07	0.07
4	Pui Lin Garden	O57 – O73, O44 – O51	0.09	0.09	0.09
5	Siu Hang Tsuen	O44 – O46, O86, O87	0.08	0.08	0.08
6	Village 3	P25 – P27, O71 – O73	0.11	0.12	0.12
7	Village 4	O48, O87 – O91	0.07	0.07	0.07
8	Siu On Garden	O70, O73, O74, O84, O85, O51 – O53	0.11	0.11	0.11
9	Po Wah Garden Phase 3	O49 – O52, O92, O93	0.11	0.11	0.11
10	Village 5	P21, P22, O80 – O83	0.17	0.17	0.17
11	Ming Wong Garden	O53 – O56	0.12	0.12	0.12
12	Tong Hang Road	O44 – O56	0.11	0.11	0.11
13	Future Road	O74 – O79, P20 – P22	0.18	0.18	0.18
14	Major Open Spaces in TM54-Sites 1&1A	S1 – S12	0.19	0.19	0.19

Under summer condition, the three analysed scenarios would achieve similar VR at most of the focus areas, indicating their ventilation performance is quite similar in general. Slightly higher VR would be observed at Village 3 under Scenarios 2 and 3.

- At Village 3, Scenarios 2 and 3 would achieve slightly higher VR as compared with Scenario 1. It is mainly because of the stronger downwash effect induced by the Development under its Proposed Scheme.

7 Conclusion

Ove Arup and Partners Hong Kong Ltd (Arup) was appointed by Hong Kong Housing Authority (HKHA) to carry out an Air Ventilation Assessment Initial Study for Proposed Public Housing Development at Tuen Mun Area 54 Sites 1 & 1A (the Development).

A series of Computational Fluid Dynamics (CFD) simulations are performed based on the AVA methodology. Ten wind directions in total, which cover 78.3% and 77.6% of annual and summer wind condition of the area respectively, have been considered. The ventilation performance for the Development at the site boundary and within the assessment area was assessed under Scenarios 1, 2 and 3.

Major findings of the study could be summarised as below:

Annual condition

- Scenarios 2 and 3 achieved slightly higher SVR and LVR than Scenario 1, indicating that the ventilation performance at the immediate area and local surrounding area would be slightly better under Scenarios 2 and 3.
- Slightly higher VR would be observed at Village 3 and Major Open Spaces in TM54-Sites 1&1A under Scenarios 2 and 3.
- In general, Proposed Scheme of the Development (i.e. Scenarios 2 and 3) would results in slightly better ventilation environment.

Summer Condition

- The values of SVR and LVR are same under the three scenarios, indicating that the ventilation performance of the three scenarios at the immediate area and local surrounding would be generally similar.
- Slightly higher VR would be observed at Village 3 under Scenarios 2 and 3.
- In general, the three studied scenarios would results in similar ventilation environment.

Appendix A

Velocity Ratio Table of the Test Points

A1 Scenario 1

A1.1 Perimeter Test Points

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	Annual	Summer
Frequency	8.5%	10.8%	9.5%	12.4%	11.6%	8.8%	8.3%		8.4%		78.3%	
				5.5%	8.4%	7.8%	11.5%	13.6%	19.1%	11.7%		77.6%
P1	0.19	0.34	0.36	0.30	0.03	0.11	0.05	0.04	0.10	0.59	0.19	0.16
P2	0.28	0.45	0.46	0.40	0.04	0.08	0.10	0.09	0.14	0.62	0.25	0.20
P3	0.41	0.60	0.48	0.44	0.04	0.02	0.17	0.12	0.17	0.66	0.30	0.22
P4	0.46	0.63	0.43	0.38	0.04	0.03	0.24	0.18	0.20	0.67	0.30	0.25
P5	0.55	0.67	0.44	0.26	0.02	0.02	0.25	0.20	0.22	0.69	0.30	0.25
P6	0.62	0.63	0.41	0.06	0.07	0.01	0.24	0.17	0.19	0.59	0.27	0.22
P7	0.53	0.32	0.22	0.11	0.09	0.07	0.24	0.14	0.17	0.49	0.21	0.20
P8	0.32	0.11	0.04	0.24	0.06	0.09	0.25	0.13	0.18	0.49	0.16	0.21
P9	0.15	0.24	0.06	0.27	0.02	0.09	0.25	0.14	0.21	0.59	0.16	0.23
P10	0.17	0.15	0.06	0.05	0.06	0.06	0.23	0.12	0.23	0.64	0.12	0.23
P11	0.09	0.13	0.11	0.01	0.04	0.03	0.17	0.03	0.18	0.51	0.09	0.16
P12	0.09	0.17	0.11	0.04	0.08	0.02	0.17	0.04	0.06	0.38	0.09	0.12
P13	0.14	0.28	0.06	0.11	0.11	0.02	0.17	0.03	0.07	0.35	0.12	0.12
P14	0.13	0.25	0.13	0.13	0.11	0.02	0.15	0.03	0.11	0.60	0.13	0.17
P15	0.30	0.32	0.28	0.23	0.03	0.02	0.15	0.03	0.13	0.40	0.18	0.14
P16	0.28	0.22	0.19	0.14	0.03	0.01	0.20	0.02	0.12	0.39	0.14	0.14
P17	0.29	0.16	0.38	0.25	0.03	0.05	0.23	0.04	0.14	0.27	0.19	0.14
P18	0.21	0.08	0.30	0.19	0.02	0.05	0.19	0.04	0.08	0.28	0.14	0.12
P19	0.18	0.10	0.16	0.09	0.04	0.19	0.16	0.02	0.04	0.47	0.12	0.14
P20	0.10	0.06	0.23	0.05	0.11	0.21	0.14	0.02	0.08	0.62	0.12	0.18
P21	0.11	0.16	0.38	0.20	0.17	0.07	0.20	0.01	0.21	0.55	0.19	0.21
P22	0.10	0.20	0.20	0.19	0.15	0.15	0.04	0.01	0.10	0.32	0.15	0.12
P23	0.13	0.05	0.06	0.09	0.08	0.08	0.01	0.01	0.06	0.06	0.07	0.05
P24	0.16	0.05	0.15	0.11	0.15	0.19	0.02	0.01	0.14	0.48	0.12	0.15
P25	0.17	0.07	0.11	0.14	0.16	0.16	0.02	0.02	0.14	0.33	0.12	0.13
P26	0.07	0.10	0.13	0.03	0.19	0.10	0.01	0.02	0.03	0.41	0.09	0.11
P27	0.25	0.27	0.34	0.08	0.10	0.08	0.02	0.03	0.06	0.57	0.15	0.13
P28	0.33	0.37	0.45	0.12	0.15	0.11	0.02	0.08	0.08	0.43	0.21	0.14
P29	0.44	0.61	0.43	0.16	0.20	0.11	0.05	0.13	0.13	0.41	0.27	0.17
P30	0.42	0.47	0.32	0.16	0.19	0.08	0.07	0.10	0.17	0.10	0.24	0.12
P31	0.50	0.57	0.48	0.22	0.10	0.07	0.04	0.06	0.12	0.09	0.26	0.09
P32	0.41	0.48	0.41	0.14	0.09	0.11	0.04	0.07	0.13	0.06	0.23	0.09
P33	0.31	0.39	0.36	0.06	0.05	0.09	0.03	0.05	0.08	0.12	0.17	0.07
P34	0.16	0.40	0.42	0.11	0.03	0.05	0.05	0.03	0.13	0.52	0.17	0.14

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	Annual	Summer
Frequency	8.5%	10.8%	9.5%	12.4%	11.6%	8.8%	8.3%		8.4%		78.3%	
				5.5%	8.4%	7.8%	11.5%	13.6%	19.1%	11.7%		77.6%
P35	0.26	0.23	0.33	0.17	0.03	0.03	0.06	0.08	0.21	0.54	0.16	0.17
P36	0.37	0.30	0.13	0.22	0.11	0.03	0.04	0.08	0.12	0.14	0.17	0.10
P37	0.42	0.42	0.32	0.26	0.04	0.06	0.03	0.02	0.05	0.16	0.21	0.08
P38	0.34	0.36	0.38	0.25	0.04	0.05	0.03	0.05	0.07	0.17	0.20	0.08
P39	0.25	0.33	0.46	0.31	0.04	0.06	0.03	0.05	0.09	0.11	0.20	0.09
P40	0.16	0.28	0.37	0.27	0.03	0.11	0.03	0.03	0.07	0.34	0.17	0.11

A1.2 Overall Test Points

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	Annual	Summer
Frequency	8.5%	10.8%	9.5%	12.4%	11.6%	8.8%	8.3%		8.4%		78.3%	
				5.5%	8.4%	7.8%	11.5%	13.6%	19.1%	11.7%		77.6%
O1	0.45	0.55	0.50	0.23	0.05	0.12	0.29	0.32	0.47	0.81	0.32	0.37
O2	0.32	0.41	0.32	0.27	0.04	0.12	0.27	0.26	0.29	0.74	0.25	0.31
O3	0.28	0.34	0.32	0.17	0.04	0.14	0.18	0.18	0.21	0.49	0.21	0.21
O4	0.19	0.23	0.22	0.21	0.04	0.10	0.16	0.14	0.18	0.72	0.16	0.23
O5	0.23	0.31	0.18	0.08	0.03	0.08	0.18	0.17	0.18	0.71	0.15	0.22
O6	0.27	0.36	0.33	0.21	0.02	0.12	0.19	0.18	0.18	0.75	0.21	0.25
O7	0.10	0.19	0.17	0.12	0.02	0.09	0.04	0.04	0.07	0.45	0.10	0.12
O8	0.12	0.28	0.27	0.14	0.02	0.14	0.07	0.05	0.09	0.13	0.14	0.09
O9	0.25	0.35	0.33	0.25	0.01	0.23	0.05	0.03	0.05	0.18	0.19	0.10
O10	0.07	0.11	0.20	0.13	0.01	0.11	0.04	0.06	0.09	0.15	0.10	0.08
O11	0.09	0.11	0.09	0.14	0.02	0.16	0.06	0.07	0.12	0.09	0.10	0.09
O12	0.15	0.32	0.25	0.12	0.01	0.19	0.07	0.10	0.12	0.22	0.15	0.12
O13	0.19	0.38	0.32	0.18	0.03	0.12	0.07	0.10	0.12	0.24	0.18	0.12
O14	0.09	0.17	0.11	0.19	0.01	0.16	0.05	0.08	0.10	0.15	0.11	0.10
O15	0.09	0.17	0.16	0.18	0.03	0.14	0.04	0.06	0.09	0.14	0.12	0.09
O16	0.21	0.33	0.27	0.15	0.06	0.16	0.05	0.09	0.11	0.23	0.17	0.12
O17	0.16	0.09	0.08	0.11	0.07	0.11	0.03	0.05	0.05	0.12	0.09	0.07
O18	0.19	0.27	0.07	0.19	0.08	0.07	0.04	0.08	0.08	0.18	0.13	0.10
O19	0.14	0.24	0.07	0.12	0.06	0.11	0.04	0.08	0.08	0.21	0.11	0.10
O20	0.07	0.09	0.12	0.06	0.04	0.10	0.04	0.07	0.09	0.24	0.08	0.10
O21	0.19	0.14	0.20	0.07	0.05	0.12	0.03	0.04	0.04	0.17	0.10	0.07
O22	0.22	0.18	0.11	0.12	0.08	0.11	0.02	0.04	0.06	0.07	0.11	0.06
O23	0.10	0.12	0.07	0.07	0.10	0.12	0.01	0.04	0.03	0.12	0.08	0.06
O24	0.09	0.02	0.04	0.06	0.06	0.09	0.02	0.03	0.05	0.11	0.05	0.06
O25	0.10	0.04	0.03	0.04	0.07	0.15	0.02	0.04	0.05	0.12	0.06	0.06
O26	0.04	0.08	0.08	0.06	0.04	0.05	0.01	0.02	0.03	0.07	0.05	0.04
O27	0.15	0.11	0.06	0.08	0.05	0.13	0.01	0.04	0.03	0.09	0.08	0.05

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	Annual	Summer
Frequency	8.5%	10.8%	9.5%	12.4%	11.6%	8.8%	8.3%		8.4%		78.3%	
				5.5%	8.4%	7.8%	11.5%	13.6%	19.1%	11.7%		77.6%
O28	0.12	0.09	0.13	0.10	0.07	0.12	0.02	0.08	0.13	0.37	0.10	0.13
O29	0.14	0.09	0.08	0.10	0.06	0.17	0.02	0.05	0.16	0.57	0.10	0.17
O30	0.20	0.09	0.13	0.06	0.08	0.18	0.01	0.02	0.08	0.40	0.10	0.12
O31	0.19	0.18	0.15	0.07	0.04	0.14	0.02	0.03	0.03	0.14	0.10	0.06
O32	0.18	0.12	0.13	0.05	0.01	0.15	0.01	0.03	0.05	0.25	0.08	0.08
O33	0.14	0.10	0.07	0.04	0.02	0.16	0.02	0.04	0.03	0.17	0.07	0.06
O34	0.06	0.05	0.07	0.04	0.01	0.09	0.03	0.04	0.04	0.13	0.05	0.05
O35	0.11	0.07	0.09	0.04	0.01	0.14	0.03	0.04	0.03	0.22	0.06	0.07
O36	0.06	0.10	0.07	0.05	0.02	0.11	0.02	0.04	0.01	0.11	0.06	0.05
O37	0.07	0.10	0.08	0.06	0.08	0.12	0.01	0.01	0.05	0.37	0.07	0.10
O38	0.14	0.09	0.04	0.07	0.06	0.14	0.01	0.06	0.10	0.43	0.08	0.13
O39	0.04	0.10	0.04	0.10	0.07	0.12	0.01	0.03	0.04	0.09	0.07	0.06
O40	0.06	0.06	0.07	0.10	0.05	0.11	0.01	0.02	0.03	0.06	0.06	0.04
O41	0.04	0.06	0.09	0.07	0.03	0.05	0.02	0.02	0.03	0.10	0.05	0.04
O42	0.05	0.12	0.03	0.05	0.06	0.09	0.01	0.04	0.07	0.31	0.06	0.09
O43	0.04	0.09	0.10	0.05	0.02	0.09	0.02	0.02	0.02	0.08	0.05	0.04
O44	0.14	0.08	0.09	0.02	0.03	0.11	0.03	0.04	0.02	0.14	0.06	0.05
O45	0.25	0.35	0.28	0.07	0.08	0.16	0.03	0.06	0.09	0.41	0.16	0.13
O46	0.27	0.32	0.23	0.04	0.08	0.09	0.07	0.06	0.09	0.31	0.15	0.11
O47	0.17	0.19	0.12	0.02	0.08	0.04	0.08	0.05	0.06	0.22	0.09	0.08
O48	0.20	0.22	0.10	0.04	0.08	0.05	0.08	0.05	0.07	0.24	0.10	0.09
O49	0.23	0.28	0.18	0.06	0.07	0.06	0.07	0.03	0.06	0.39	0.13	0.11
O50	0.23	0.28	0.20	0.08	0.08	0.06	0.07	0.04	0.09	0.44	0.14	0.13
O51	0.08	0.14	0.17	0.09	0.05	0.04	0.06	0.03	0.06	0.47	0.09	0.11
O52	0.13	0.24	0.23	0.13	0.04	0.08	0.09	0.03	0.12	0.53	0.13	0.15
O53	0.06	0.16	0.21	0.16	0.05	0.07	0.10	0.04	0.16	0.37	0.12	0.14
O54	0.06	0.09	0.07	0.14	0.04	0.03	0.10	0.02	0.11	0.34	0.08	0.11
O55	0.10	0.13	0.05	0.09	0.06	0.11	0.05	0.03	0.08	0.44	0.09	0.12
O56	0.09	0.12	0.04	0.08	0.06	0.12	0.02	0.04	0.10	0.22	0.08	0.09
O57	0.05	0.09	0.14	0.02	0.03	0.06	0.01	0.03	0.05	0.07	0.06	0.04
O58	0.07	0.20	0.20	0.04	0.04	0.09	0.02	0.02	0.05	0.09	0.09	0.05
O59	0.26	0.25	0.23	0.08	0.01	0.09	0.02	0.01	0.09	0.31	0.13	0.09
O60	0.19	0.28	0.13	0.09	0.01	0.06	0.02	0.02	0.07	0.21	0.11	0.07
O61	0.11	0.14	0.04	0.10	0.04	0.07	0.01	0.04	0.05	0.20	0.07	0.07
O62	0.39	0.31	0.37	0.09	0.08	0.08	0.02	0.02	0.07	0.28	0.18	0.09
O63	0.06	0.07	0.06	0.03	0.05	0.07	0.02	0.03	0.06	0.12	0.05	0.05
O64	0.28	0.30	0.27	0.09	0.06	0.03	0.01	0.03	0.06	0.17	0.14	0.06
O65	0.08	0.08	0.05	0.01	0.07	0.04	0.04	0.03	0.07	0.18	0.06	0.07
O66	0.13	0.13	0.11	0.03	0.04	0.02	0.02	0.02	0.04	0.21	0.06	0.06

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	Annual	Summer
Frequency	8.5%	10.8%	9.5%	12.4%	11.6%	8.8%	8.3%		8.4%		78.3%	
				5.5%	8.4%	7.8%	11.5%	13.6%	19.1%	11.7%		77.6%
O67	0.10	0.07	0.07	0.02	0.12	0.03	0.02	0.08	0.04	0.21	0.06	0.08
O68	0.18	0.18	0.08	0.04	0.08	0.06	0.05	0.03	0.12	0.34	0.10	0.11
O69	0.15	0.20	0.07	0.04	0.09	0.05	0.01	0.04	0.05	0.51	0.08	0.12
O70	0.18	0.17	0.07	0.05	0.18	0.10	0.04	0.03	0.10	0.12	0.11	0.09
O71	0.25	0.50	0.46	0.10	0.04	0.08	0.06	0.04	0.06	0.53	0.19	0.13
O72	0.06	0.11	0.39	0.04	0.04	0.08	0.06	0.01	0.04	0.14	0.10	0.06
O73	0.22	0.33	0.34	0.06	0.24	0.14	0.09	0.03	0.11	0.15	0.19	0.11
O74	0.18	0.20	0.11	0.14	0.18	0.16	0.05	0.02	0.17	0.40	0.15	0.16
O75	0.14	0.17	0.37	0.17	0.12	0.19	0.19	0.02	0.05	0.51	0.17	0.17
O76	0.21	0.25	0.19	0.19	0.15	0.18	0.19	0.01	0.17	0.49	0.19	0.19
O77	0.19	0.25	0.15	0.18	0.15	0.06	0.19	0.01	0.29	0.28	0.18	0.18
O78	0.14	0.19	0.14	0.22	0.11	0.07	0.19	0.02	0.38	0.22	0.18	0.19
O79	0.16	0.18	0.09	0.22	0.04	0.09	0.17	0.04	0.42	0.17	0.17	0.19
O80	0.07	0.12	0.32	0.21	0.14	0.09	0.17	0.01	0.27	0.60	0.17	0.22
O81	0.17	0.17	0.14	0.10	0.09	0.19	0.17	0.01	0.31	0.48	0.16	0.21
O82	0.13	0.13	0.13	0.15	0.05	0.12	0.15	0.02	0.22	0.25	0.13	0.14
O83	0.08	0.10	0.04	0.08	0.07	0.13	0.06	0.02	0.06	0.23	0.08	0.09
O84	0.03	0.06	0.06	0.05	0.05	0.06	0.02	0.01	0.04	0.07	0.05	0.04
O85	0.14	0.21	0.10	0.05	0.04	0.02	0.02	0.01	0.05	0.18	0.08	0.05
O86	0.09	0.14	0.15	0.04	0.04	0.05	0.04	0.03	0.03	0.19	0.07	0.06
O87	0.09	0.22	0.19	0.03	0.04	0.05	0.06	0.04	0.03	0.13	0.09	0.05
O88	0.19	0.24	0.17	0.04	0.06	0.03	0.05	0.05	0.04	0.35	0.10	0.09
O89	0.20	0.24	0.17	0.05	0.05	0.03	0.03	0.04	0.04	0.30	0.10	0.08
O90	0.14	0.13	0.09	0.07	0.04	0.02	0.02	0.05	0.01	0.10	0.06	0.04
O91	0.05	0.06	0.06	0.05	0.07	0.04	0.07	0.05	0.05	0.12	0.06	0.06
O92	0.13	0.16	0.07	0.04	0.08	0.04	0.07	0.04	0.07	0.22	0.08	0.08
O93	0.14	0.09	0.05	0.11	0.06	0.02	0.05	0.02	0.04	0.11	0.07	0.05

A1.3 Special Test Points

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	Annual	Summer
Frequency	8.5%	10.8%	9.5%	12.4%	11.6%	8.8%	8.3%		8.4%		78.3%	
				5.5%	8.4%	7.8%	11.5%	13.6%	19.1%	11.7%		77.6%
S1	0.06	0.09	0.22	0.13	0.15	0.12	0.14	0.10	0.10	0.33	0.13	0.15
S2	0.05	0.10	0.16	0.09	0.16	0.13	0.02	0.06	0.19	0.44	0.11	0.16
S3	0.11	0.20	0.32	0.30	0.14	0.14	0.12	0.10	0.06	0.37	0.18	0.16
S4	0.14	0.30	0.37	0.31	0.14	0.15	0.04	0.05	0.18	0.44	0.21	0.18
S5	0.30	0.48	0.30	0.44	0.10	0.12	0.09	0.08	0.10	0.67	0.25	0.21
S6	0.47	0.66	0.36	0.47	0.12	0.12	0.04	0.03	0.16	0.75	0.31	0.22

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	Annual	Summer
Frequency	**8.5%**	**10.8%**	**9.5%**	**12.4%**	**11.6%**	**8.8%**	**8.3%**		**8.4%**		**78.3%**	
				5.5%	**8.4%**	**7.8%**	**11.5%**	**13.6%**	**19.1%**	**11.7%**		**77.6%**
S7	0.33	0.59	0.36	0.40	0.12	0.16	0.04	0.06	0.21	0.72	0.29	0.23
S8	0.60	0.62	0.31	0.39	0.09	0.07	0.02	0.05	0.11	0.75	0.28	0.20
S9	0.07	0.09	0.09	0.10	0.13	0.03	0.08	0.06	0.16	0.42	0.09	0.15
S10	0.16	0.21	0.30	0.17	0.16	0.15	0.08	0.05	0.22	0.66	0.18	0.22
S11	0.45	0.67	0.31	0.42	0.10	0.15	0.06	0.04	0.15	0.77	0.30	0.22
S12	0.56	0.55	0.21	0.34	0.11	0.19	0.05	0.05	0.16	0.74	0.28	0.22

A2 Scenario 2

A2.1 Perimeter Test Points

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	Annual	Summer
Frequency	8.5%	10.8%	9.5%	12.4%	11.6%	8.8%	8.3%		8.4%		78.3%	
				5.5%	8.4%	7.8%	11.5%	13.6%	19.1%	11.7%		77.6%
P1	0.20	0.35	0.41	0.31	0.02	0.07	0.04	0.04	0.10	0.62	0.19	0.16
P2	0.30	0.47	0.51	0.41	0.02	0.04	0.09	0.08	0.13	0.65	0.25	0.19
P3	0.42	0.62	0.51	0.45	0.03	0.03	0.12	0.10	0.16	0.69	0.30	0.22
P4	0.47	0.64	0.47	0.39	0.04	0.05	0.23	0.17	0.19	0.69	0.32	0.25
P5	0.56	0.68	0.46	0.28	0.05	0.04	0.24	0.19	0.21	0.70	0.32	0.26
P6	0.62	0.66	0.44	0.07	0.13	0.02	0.24	0.17	0.19	0.56	0.29	0.22
P7	0.57	0.43	0.25	0.19	0.15	0.11	0.24	0.14	0.17	0.50	0.26	0.22
P8	0.34	0.18	0.17	0.36	0.11	0.12	0.24	0.13	0.18	0.49	0.21	0.23
P9	0.29	0.45	0.13	0.29	0.04	0.08	0.24	0.12	0.22	0.59	0.22	0.23
P10	0.17	0.14	0.04	0.05	0.03	0.03	0.23	0.09	0.25	0.63	0.11	0.22
P11	0.14	0.16	0.09	0.02	0.06	0.03	0.17	0.07	0.23	0.48	0.11	0.18
P12	0.11	0.08	0.09	0.04	0.13	0.06	0.17	0.07	0.11	0.39	0.09	0.14
P13	0.12	0.23	0.06	0.07	0.15	0.10	0.17	0.03	0.05	0.37	0.12	0.13
P14	0.13	0.23	0.16	0.13	0.14	0.10	0.15	0.05	0.11	0.55	0.14	0.17
P15	0.29	0.27	0.28	0.16	0.12	0.03	0.16	0.06	0.13	0.38	0.18	0.15
P16	0.15	0.08	0.18	0.07	0.04	0.06	0.20	0.05	0.10	0.37	0.11	0.13
P17	0.18	0.10	0.37	0.20	0.04	0.07	0.23	0.05	0.13	0.26	0.16	0.14
P18	0.08	0.11	0.28	0.14	0.06	0.07	0.18	0.07	0.09	0.27	0.12	0.12
P19	0.03	0.06	0.18	0.06	0.09	0.18	0.16	0.04	0.08	0.47	0.10	0.15
P20	0.02	0.05	0.21	0.12	0.14	0.20	0.14	0.02	0.09	0.64	0.12	0.19
P21	0.13	0.20	0.42	0.19	0.20	0.07	0.19	0.02	0.18	0.59	0.20	0.21
P22	0.16	0.17	0.29	0.15	0.19	0.14	0.04	0.06	0.06	0.29	0.15	0.12
P23	0.04	0.03	0.11	0.04	0.10	0.07	0.01	0.03	0.05	0.11	0.06	0.06
P24	0.17	0.14	0.17	0.09	0.20	0.17	0.02	0.04	0.10	0.47	0.13	0.15
P25	0.09	0.17	0.10	0.05	0.20	0.16	0.03	0.05	0.06	0.44	0.11	0.14
P26	0.16	0.30	0.26	0.04	0.24	0.12	0.05	0.01	0.05	0.37	0.16	0.12
P27	0.29	0.42	0.36	0.05	0.15	0.09	0.02	0.08	0.11	0.55	0.19	0.16
P28	0.34	0.52	0.50	0.11	0.18	0.10	0.05	0.16	0.12	0.39	0.24	0.16
P29	0.45	0.56	0.39	0.16	0.25	0.13	0.09	0.19	0.14	0.39	0.27	0.19
P30	0.38	0.39	0.28	0.15	0.22	0.10	0.08	0.14	0.15	0.21	0.22	0.15
P31	0.47	0.57	0.46	0.21	0.14	0.06	0.05	0.07	0.08	0.15	0.26	0.10
P32	0.41	0.51	0.40	0.16	0.11	0.11	0.06	0.11	0.10	0.19	0.23	0.12
P33	0.33	0.42	0.33	0.08	0.08	0.10	0.04	0.08	0.08	0.12	0.18	0.08
P34	0.15	0.40	0.38	0.10	0.04	0.05	0.03	0.03	0.14	0.44	0.16	0.13
P35	0.26	0.20	0.32	0.16	0.03	0.03	0.06	0.08	0.20	0.63	0.16	0.19

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	Annual	Summer
Frequency	8.5%	10.8%	9.5%	12.4%	11.6%	8.8%	8.3%		8.4%		78.3%	
				5.5%	8.4%	7.8%	11.5%	13.6%	19.1%	11.7%		77.6%
P36	0.37	0.34	0.14	0.23	0.12	0.03	0.08	0.10	0.10	0.15	0.18	0.11
P37	0.41	0.41	0.30	0.27	0.05	0.02	0.04	0.04	0.05	0.10	0.20	0.07
P38	0.32	0.31	0.38	0.25	0.09	0.03	0.02	0.05	0.06	0.11	0.19	0.07
P39	0.26	0.30	0.45	0.31	0.06	0.02	0.03	0.05	0.08	0.10	0.20	0.08
P40	0.17	0.29	0.41	0.28	0.02	0.07	0.03	0.04	0.06	0.35	0.17	0.11

A2.2 Overall Test Points

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	Annual	Summer
Frequency	8.5%	10.8%	9.5%	12.4%	11.6%	8.8%	8.3%		8.4%		78.3%	
				5.5%	8.4%	7.8%	11.5%	13.6%	19.1%	11.7%		77.6%
O1	0.46	0.55	0.50	0.23	0.04	0.10	0.30	0.32	0.42	0.81	0.32	0.36
O2	0.33	0.42	0.33	0.29	0.03	0.09	0.27	0.26	0.26	0.79	0.25	0.30
O3	0.27	0.34	0.31	0.17	0.03	0.12	0.19	0.18	0.18	0.54	0.20	0.21
O4	0.19	0.25	0.26	0.23	0.03	0.08	0.15	0.14	0.18	0.77	0.17	0.23
O5	0.24	0.29	0.16	0.08	0.03	0.07	0.17	0.16	0.19	0.77	0.15	0.23
O6	0.27	0.36	0.32	0.21	0.02	0.12	0.17	0.16	0.19	0.82	0.21	0.25
O7	0.11	0.20	0.18	0.13	0.01	0.08	0.04	0.05	0.07	0.49	0.10	0.12
O8	0.10	0.28	0.26	0.13	0.02	0.13	0.08	0.08	0.09	0.13	0.14	0.09
O9	0.24	0.35	0.33	0.25	0.01	0.23	0.06	0.05	0.05	0.19	0.19	0.10
O10	0.08	0.11	0.26	0.11	0.03	0.09	0.05	0.06	0.09	0.11	0.10	0.08
O11	0.07	0.11	0.09	0.16	0.02	0.15	0.07	0.08	0.13	0.07	0.10	0.09
O12	0.13	0.31	0.21	0.12	0.02	0.18	0.07	0.08	0.15	0.14	0.15	0.11
O13	0.18	0.38	0.32	0.17	0.05	0.12	0.07	0.08	0.15	0.20	0.18	0.12
O14	0.09	0.17	0.12	0.19	0.03	0.15	0.06	0.07	0.12	0.08	0.12	0.09
O15	0.09	0.17	0.17	0.18	0.06	0.14	0.05	0.06	0.08	0.13	0.12	0.09
O16	0.20	0.33	0.25	0.15	0.09	0.16	0.06	0.06	0.13	0.20	0.17	0.12
O17	0.15	0.09	0.07	0.10	0.09	0.11	0.03	0.03	0.05	0.10	0.09	0.06
O18	0.17	0.26	0.07	0.17	0.09	0.07	0.04	0.04	0.09	0.17	0.12	0.09
O19	0.11	0.22	0.09	0.09	0.09	0.11	0.04	0.06	0.10	0.18	0.11	0.09
O20	0.08	0.09	0.17	0.04	0.07	0.09	0.05	0.07	0.11	0.19	0.09	0.09
O21	0.19	0.14	0.23	0.06	0.06	0.11	0.03	0.04	0.07	0.13	0.11	0.07
O22	0.21	0.18	0.10	0.11	0.10	0.11	0.05	0.07	0.06	0.05	0.12	0.07
O23	0.09	0.12	0.05	0.06	0.11	0.12	0.03	0.04	0.03	0.11	0.08	0.06
O24	0.08	0.02	0.02	0.05	0.07	0.09	0.03	0.03	0.04	0.10	0.05	0.05
O25	0.10	0.04	0.03	0.03	0.08	0.16	0.03	0.03	0.04	0.10	0.06	0.06
O26	0.04	0.08	0.06	0.06	0.06	0.05	0.02	0.02	0.03	0.04	0.05	0.04
O27	0.15	0.11	0.05	0.08	0.06	0.13	0.02	0.05	0.04	0.08	0.08	0.06
O28	0.11	0.09	0.12	0.10	0.08	0.12	0.06	0.08	0.13	0.42	0.10	0.15

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	Annual	Summer
Frequency	8.5%	10.8%	9.5%	12.4%	11.6%	8.8%	8.3%		8.4%		78.3%	
				5.5%	8.4%	7.8%	11.5%	13.6%	19.1%	11.7%		77.6%
O29	0.14	0.11	0.07	0.10	0.08	0.17	0.05	0.06	0.17	0.63	0.11	0.19
O30	0.21	0.07	0.09	0.07	0.11	0.19	0.02	0.07	0.08	0.58	0.10	0.16
O31	0.21	0.18	0.11	0.08	0.07	0.15	0.01	0.05	0.04	0.29	0.10	0.09
O32	0.18	0.15	0.12	0.05	0.02	0.16	0.02	0.02	0.04	0.22	0.09	0.07
O33	0.14	0.13	0.07	0.04	0.04	0.17	0.01	0.05	0.04	0.21	0.08	0.08
O34	0.06	0.06	0.07	0.04	0.03	0.10	0.03	0.06	0.04	0.14	0.05	0.06
O35	0.11	0.09	0.08	0.04	0.03	0.14	0.01	0.05	0.04	0.20	0.07	0.07
O36	0.05	0.11	0.07	0.05	0.05	0.12	0.01	0.06	0.02	0.12	0.06	0.06
O37	0.10	0.08	0.07	0.07	0.10	0.12	0.01	0.07	0.07	0.29	0.08	0.10
O38	0.15	0.09	0.04	0.07	0.08	0.14	0.03	0.04	0.12	0.38	0.09	0.13
O39	0.04	0.09	0.04	0.09	0.09	0.11	0.03	0.03	0.07	0.05	0.07	0.06
O40	0.07	0.06	0.06	0.09	0.06	0.11	0.02	0.02	0.03	0.05	0.06	0.04
O41	0.06	0.05	0.07	0.07	0.03	0.05	0.02	0.03	0.04	0.09	0.05	0.04
O42	0.05	0.13	0.02	0.05	0.08	0.09	0.02	0.04	0.09	0.27	0.07	0.09
O43	0.04	0.07	0.08	0.05	0.02	0.09	0.02	0.02	0.03	0.09	0.05	0.04
O44	0.13	0.09	0.09	0.03	0.03	0.11	0.02	0.04	0.02	0.12	0.06	0.05
O45	0.26	0.33	0.27	0.08	0.09	0.15	0.04	0.07	0.10	0.35	0.17	0.13
O46	0.25	0.31	0.22	0.05	0.08	0.09	0.08	0.06	0.09	0.28	0.14	0.11
O47	0.15	0.18	0.12	0.02	0.07	0.03	0.07	0.05	0.06	0.20	0.09	0.08
O48	0.20	0.20	0.10	0.03	0.09	0.05	0.08	0.05	0.08	0.22	0.10	0.09
O49	0.22	0.25	0.17	0.06	0.09	0.07	0.06	0.04	0.07	0.37	0.12	0.11
O50	0.22	0.25	0.20	0.08	0.09	0.07	0.07	0.04	0.09	0.44	0.13	0.13
O51	0.10	0.13	0.17	0.09	0.07	0.05	0.05	0.03	0.08	0.46	0.09	0.12
O52	0.17	0.24	0.23	0.13	0.06	0.06	0.08	0.03	0.14	0.54	0.14	0.16
O53	0.07	0.15	0.22	0.17	0.07	0.06	0.10	0.04	0.21	0.36	0.13	0.15
O54	0.07	0.08	0.08	0.15	0.05	0.03	0.09	0.02	0.14	0.31	0.09	0.12
O55	0.10	0.13	0.05	0.09	0.05	0.10	0.05	0.03	0.07	0.42	0.08	0.11
O56	0.08	0.12	0.04	0.08	0.06	0.11	0.02	0.03	0.09	0.34	0.08	0.10
O57	0.04	0.08	0.14	0.03	0.03	0.06	0.01	0.03	0.07	0.08	0.06	0.05
O58	0.10	0.18	0.19	0.06	0.06	0.09	0.03	0.04	0.06	0.11	0.10	0.06
O59	0.27	0.27	0.23	0.09	0.03	0.09	0.03	0.01	0.10	0.28	0.14	0.09
O60	0.21	0.28	0.16	0.10	0.02	0.07	0.01	0.03	0.03	0.21	0.11	0.06
O61	0.14	0.13	0.07	0.11	0.05	0.07	0.02	0.05	0.03	0.24	0.08	0.08
O62	0.38	0.34	0.33	0.10	0.12	0.08	0.01	0.05	0.04	0.25	0.18	0.09
O63	0.06	0.07	0.06	0.02	0.05	0.07	0.03	0.03	0.07	0.09	0.05	0.06
O64	0.26	0.30	0.27	0.08	0.07	0.04	0.02	0.04	0.05	0.11	0.14	0.06
O65	0.09	0.08	0.05	0.02	0.08	0.04	0.05	0.04	0.08	0.17	0.06	0.07
O66	0.13	0.13	0.10	0.03	0.03	0.02	0.03	0.03	0.05	0.25	0.06	0.07
O67	0.14	0.09	0.06	0.04	0.15	0.04	0.02	0.12	0.04	0.19	0.07	0.09

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	Annual	Summer
Frequency	8.5%	10.8%	9.5%	12.4%	11.6%	8.8%	8.3%		8.4%		78.3%	
				5.5%	8.4%	7.8%	11.5%	13.6%	19.1%	11.7%		77.6%
O68	0.19	0.16	0.09	0.05	0.10	0.07	0.05	0.04	0.11	0.36	0.10	0.12
O69	0.17	0.16	0.08	0.02	0.10	0.07	0.02	0.06	0.04	0.54	0.08	0.12
O70	0.20	0.13	0.09	0.05	0.22	0.10	0.05	0.02	0.13	0.16	0.12	0.11
O71	0.36	0.60	0.48	0.13	0.05	0.06	0.04	0.09	0.07	0.53	0.23	0.14
O72	0.11	0.41	0.41	0.12	0.05	0.07	0.05	0.02	0.04	0.15	0.16	0.06
O73	0.24	0.36	0.34	0.10	0.29	0.13	0.10	0.02	0.14	0.17	0.21	0.13
O74	0.08	0.18	0.11	0.09	0.21	0.15	0.04	0.06	0.09	0.48	0.12	0.15
O75	0.08	0.20	0.39	0.18	0.18	0.19	0.18	0.03	0.04	0.53	0.19	0.17
O76	0.20	0.25	0.21	0.16	0.17	0.20	0.19	0.02	0.11	0.51	0.19	0.18
O77	0.22	0.27	0.16	0.17	0.14	0.08	0.19	0.01	0.25	0.34	0.18	0.18
O78	0.16	0.21	0.15	0.21	0.13	0.04	0.18	0.02	0.38	0.25	0.18	0.19
O79	0.13	0.20	0.11	0.22	0.05	0.07	0.17	0.04	0.44	0.21	0.17	0.20
O80	0.06	0.11	0.34	0.19	0.24	0.09	0.17	0.02	0.22	0.61	0.18	0.22
O81	0.19	0.19	0.14	0.11	0.06	0.20	0.16	0.01	0.35	0.48	0.17	0.22
O82	0.16	0.15	0.14	0.14	0.06	0.12	0.14	0.02	0.29	0.25	0.14	0.16
O83	0.10	0.11	0.03	0.05	0.07	0.15	0.05	0.02	0.08	0.26	0.08	0.10
O84	0.04	0.07	0.06	0.05	0.04	0.05	0.03	0.01	0.05	0.07	0.05	0.04
O85	0.17	0.15	0.10	0.05	0.04	0.03	0.01	0.01	0.06	0.19	0.08	0.06
O86	0.09	0.13	0.15	0.04	0.04	0.05	0.04	0.03	0.03	0.16	0.07	0.06
O87	0.11	0.21	0.20	0.04	0.04	0.04	0.06	0.03	0.04	0.08	0.09	0.05
O88	0.19	0.24	0.17	0.03	0.06	0.03	0.05	0.05	0.05	0.31	0.10	0.09
O89	0.19	0.25	0.17	0.04	0.05	0.05	0.04	0.04	0.05	0.27	0.10	0.08
O90	0.15	0.12	0.10	0.05	0.04	0.02	0.02	0.05	0.02	0.12	0.07	0.04
O91	0.06	0.06	0.07	0.04	0.08	0.05	0.07	0.05	0.05	0.15	0.06	0.07
O92	0.14	0.15	0.07	0.04	0.08	0.04	0.07	0.04	0.07	0.16	0.08	0.07
O93	0.17	0.09	0.06	0.10	0.03	0.01	0.05	0.02	0.04	0.13	0.07	0.05

A2.3 Special Test Points

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	Annual	Summer
Frequency	8.5%	10.8%	9.5%	12.4%	11.6%	8.8%	8.3%		8.4%		78.3%	
				5.5%	8.4%	7.8%	11.5%	13.6%	19.1%	11.7%		77.6%
S1	0.06	0.08	0.24	0.19	0.19	0.14	0.11	0.07	0.13	0.42	0.15	0.17
S2	0.11	0.13	0.30	0.15	0.20	0.15	0.02	0.05	0.21	0.57	0.16	0.20
S3	0.10	0.27	0.35	0.34	0.17	0.15	0.10	0.07	0.09	0.34	0.21	0.16
S4	0.14	0.32	0.39	0.33	0.17	0.15	0.07	0.05	0.17	0.44	0.23	0.18
S5	0.44	0.60	0.43	0.46	0.13	0.09	0.07	0.07	0.09	0.61	0.30	0.19
S6	0.56	0.68	0.47	0.47	0.14	0.08	0.03	0.03	0.14	0.67	0.33	0.20
S7	0.43	0.52	0.39	0.35	0.14	0.16	0.05	0.08	0.20	0.64	0.29	0.22

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	Annual	Summer
Frequency	**8.5%**	**10.8%**	**9.5%**	**12.4%**	**11.6%**	**8.8%**	**8.3%**		**8.4%**		**78.3%**	
				5.5%	**8.4%**	**7.8%**	**11.5%**	**13.6%**	**19.1%**	**11.7%**		**77.6%**
S8	0.61	0.62	0.41	0.37	0.11	0.03	0.02	0.05	0.10	0.71	0.29	0.18
S9	0.11	0.10	0.09	0.09	0.14	0.03	0.07	0.04	0.18	0.40	0.10	0.15
S10	0.09	0.16	0.38	0.23	0.19	0.17	0.08	0.06	0.23	0.70	0.19	0.24
S11	0.47	0.55	0.37	0.32	0.11	0.15	0.06	0.06	0.18	0.74	0.28	0.23
S12	0.54	0.55	0.33	0.31	0.13	0.19	0.04	0.04	0.17	0.66	0.29	0.21

A3 Scenario 3

A3.1 Perimeter Test Points

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	Annual	Summer
Frequency	8.5%	10.8%	9.5%	12.4%	11.6%	8.8%	8.3%		8.4%		78.3%	
				5.5%	8.4%	7.8%	11.5%	13.6%	19.1%	11.7%		77.6%
P1	0.20	0.35	0.40	0.30	0.04	0.09	0.04	0.03	0.09	0.61	0.20	0.16
P2	0.30	0.47	0.50	0.40	0.04	0.08	0.09	0.06	0.12	0.64	0.26	0.19
P3	0.42	0.62	0.50	0.44	0.04	0.05	0.11	0.08	0.15	0.69	0.30	0.21
P4	0.47	0.64	0.46	0.39	0.04	0.02	0.24	0.14	0.18	0.69	0.31	0.24
P5	0.55	0.68	0.46	0.28	0.03	0.01	0.26	0.17	0.21	0.69	0.31	0.25
P6	0.61	0.65	0.44	0.07	0.14	0.03	0.26	0.15	0.20	0.56	0.29	0.22
P7	0.56	0.42	0.25	0.18	0.15	0.12	0.26	0.12	0.20	0.50	0.26	0.22
P8	0.33	0.18	0.16	0.35	0.10	0.05	0.26	0.11	0.20	0.49	0.21	0.22
P9	0.28	0.44	0.13	0.28	0.02	0.03	0.26	0.10	0.23	0.58	0.21	0.23
P10	0.16	0.14	0.03	0.05	0.08	0.05	0.24	0.09	0.26	0.62	0.12	0.22
P11	0.14	0.15	0.08	0.02	0.08	0.05	0.18	0.08	0.23	0.48	0.11	0.18
P12	0.11	0.08	0.08	0.04	0.09	0.05	0.17	0.07	0.09	0.39	0.09	0.14
P13	0.12	0.24	0.06	0.07	0.15	0.05	0.18	0.02	0.06	0.37	0.12	0.13
P14	0.12	0.23	0.15	0.13	0.15	0.04	0.16	0.05	0.10	0.54	0.14	0.17
P15	0.28	0.27	0.28	0.16	0.22	0.03	0.17	0.05	0.12	0.38	0.20	0.16
P16	0.15	0.09	0.18	0.07	0.18	0.03	0.21	0.05	0.11	0.37	0.13	0.15
P17	0.16	0.11	0.37	0.20	0.15	0.06	0.24	0.05	0.14	0.25	0.18	0.15
P18	0.11	0.11	0.29	0.13	0.09	0.06	0.19	0.05	0.09	0.27	0.13	0.13
P19	0.05	0.05	0.19	0.06	0.07	0.19	0.17	0.03	0.06	0.46	0.10	0.14
P20	0.02	0.05	0.20	0.12	0.11	0.21	0.14	0.02	0.08	0.61	0.12	0.18
P21	0.12	0.20	0.40	0.19	0.19	0.08	0.20	0.02	0.20	0.57	0.20	0.21
P22	0.14	0.18	0.26	0.15	0.21	0.17	0.04	0.04	0.10	0.29	0.16	0.13
P23	0.06	0.03	0.11	0.04	0.10	0.09	0.01	0.03	0.02	0.11	0.06	0.05
P24	0.19	0.13	0.17	0.09	0.11	0.18	0.02	0.04	0.15	0.49	0.13	0.16
P25	0.11	0.17	0.11	0.05	0.08	0.18	0.04	0.04	0.12	0.43	0.11	0.14
P26	0.18	0.30	0.24	0.03	0.13	0.15	0.05	0.01	0.02	0.36	0.14	0.10
P27	0.30	0.42	0.37	0.06	0.16	0.10	0.03	0.07	0.06	0.54	0.19	0.14
P28	0.35	0.53	0.48	0.11	0.20	0.13	0.04	0.15	0.08	0.40	0.24	0.15
P29	0.45	0.55	0.39	0.16	0.19	0.12	0.08	0.18	0.14	0.40	0.26	0.18
P30	0.38	0.38	0.28	0.15	0.19	0.12	0.08	0.14	0.17	0.20	0.22	0.15
P31	0.47	0.55	0.46	0.20	0.12	0.08	0.05	0.07	0.11	0.16	0.26	0.11
P32	0.41	0.50	0.40	0.15	0.17	0.10	0.05	0.11	0.13	0.20	0.24	0.13
P33	0.32	0.41	0.33	0.08	0.13	0.08	0.04	0.08	0.10	0.13	0.19	0.09
P34	0.16	0.40	0.38	0.10	0.09	0.05	0.04	0.03	0.14	0.45	0.17	0.13
P35	0.25	0.20	0.32	0.16	0.04	0.05	0.04	0.08	0.20	0.63	0.16	0.18

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	Annual	Summer
Frequency	8.5%	10.8%	9.5%	12.4%	11.6%	8.8%	8.3%		8.4%		78.3%	
				5.5%	8.4%	7.8%	11.5%	13.6%	19.1%	11.7%		77.6%
P36	0.37	0.33	0.14	0.23	0.12	0.05	0.09	0.10	0.09	0.15	0.18	0.11
P37	0.41	0.41	0.30	0.27	0.07	0.01	0.04	0.05	0.05	0.10	0.20	0.07
P38	0.32	0.31	0.37	0.25	0.06	0.02	0.03	0.03	0.06	0.08	0.18	0.06
P39	0.26	0.29	0.45	0.30	0.04	0.05	0.01	0.04	0.08	0.12	0.19	0.08
P40	0.17	0.29	0.40	0.27	0.04	0.08	0.03	0.03	0.07	0.36	0.18	0.11

A3.2 Overall Test Points

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	Annual	Summer
Frequency	8.5%	10.8%	9.5%	12.4%	11.6%	8.8%	8.3%		8.4%		78.3%	
				5.5%	8.4%	7.8%	11.5%	13.6%	19.1%	11.7%		77.6%
O1	0.46	0.55	0.51	0.24	0.06	0.12	0.32	0.33	0.33	0.82	0.32	0.34
O2	0.34	0.42	0.34	0.29	0.05	0.11	0.29	0.25	0.25	0.80	0.26	0.30
O3	0.28	0.34	0.32	0.18	0.06	0.12	0.20	0.18	0.18	0.54	0.21	0.22
O4	0.19	0.25	0.26	0.23	0.05	0.09	0.14	0.11	0.17	0.79	0.17	0.23
O5	0.24	0.29	0.17	0.08	0.05	0.07	0.17	0.13	0.17	0.78	0.15	0.23
O6	0.27	0.36	0.33	0.21	0.02	0.09	0.16	0.12	0.17	0.84	0.20	0.24
O7	0.11	0.20	0.18	0.13	0.03	0.07	0.04	0.05	0.07	0.50	0.11	0.13
O8	0.08	0.28	0.27	0.14	0.03	0.08	0.08	0.09	0.10	0.14	0.14	0.09
O9	0.24	0.35	0.33	0.26	0.05	0.14	0.07	0.07	0.06	0.22	0.19	0.11
O10	0.08	0.11	0.26	0.12	0.03	0.08	0.03	0.06	0.09	0.11	0.10	0.07
O11	0.06	0.11	0.09	0.16	0.04	0.09	0.06	0.08	0.13	0.06	0.09	0.09
O12	0.14	0.32	0.21	0.12	0.09	0.10	0.07	0.08	0.13	0.17	0.15	0.11
O13	0.19	0.38	0.32	0.17	0.10	0.08	0.07	0.07	0.12	0.22	0.18	0.12
O14	0.09	0.17	0.12	0.20	0.08	0.09	0.05	0.06	0.10	0.09	0.12	0.09
O15	0.09	0.18	0.17	0.19	0.12	0.09	0.04	0.06	0.08	0.15	0.13	0.09
O16	0.21	0.33	0.25	0.15	0.14	0.10	0.06	0.06	0.09	0.22	0.17	0.11
O17	0.15	0.09	0.07	0.10	0.09	0.08	0.02	0.03	0.04	0.14	0.08	0.07
O18	0.17	0.26	0.07	0.18	0.10	0.05	0.04	0.05	0.07	0.19	0.12	0.09
O19	0.11	0.23	0.09	0.10	0.12	0.07	0.02	0.06	0.06	0.18	0.11	0.08
O20	0.07	0.10	0.17	0.05	0.09	0.06	0.03	0.06	0.07	0.19	0.08	0.08
O21	0.19	0.14	0.23	0.06	0.10	0.08	0.04	0.04	0.04	0.11	0.11	0.06
O22	0.22	0.19	0.10	0.11	0.10	0.07	0.06	0.07	0.06	0.05	0.11	0.07
O23	0.10	0.12	0.05	0.07	0.12	0.07	0.04	0.04	0.03	0.09	0.08	0.06
O24	0.08	0.02	0.02	0.05	0.08	0.04	0.03	0.03	0.05	0.10	0.05	0.05
O25	0.10	0.05	0.03	0.03	0.09	0.09	0.03	0.03	0.05	0.12	0.06	0.06
O26	0.04	0.08	0.07	0.06	0.09	0.03	0.02	0.02	0.03	0.07	0.06	0.04
O27	0.15	0.11	0.06	0.08	0.09	0.07	0.05	0.05	0.03	0.07	0.08	0.06
O28	0.11	0.09	0.13	0.10	0.09	0.08	0.06	0.09	0.10	0.42	0.10	0.14

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	Annual	Summer
Frequency	8.5%	10.8%	9.5%	12.4%	11.6%	8.8%	8.3%		8.4%		78.3%	
				5.5%	8.4%	7.8%	11.5%	13.6%	19.1%	11.7%		77.6%
O29	0.14	0.11	0.07	0.11	0.15	0.10	0.05	0.05	0.15	0.64	0.11	0.18
O30	0.21	0.08	0.09	0.07	0.12	0.08	0.02	0.06	0.06	0.58	0.09	0.14
O31	0.20	0.18	0.11	0.07	0.04	0.05	0.01	0.05	0.02	0.27	0.09	0.07
O32	0.18	0.14	0.13	0.05	0.08	0.06	0.02	0.01	0.09	0.23	0.09	0.08
O33	0.14	0.12	0.07	0.04	0.08	0.08	0.01	0.04	0.07	0.22	0.08	0.08
O34	0.06	0.06	0.07	0.04	0.07	0.07	0.03	0.04	0.08	0.13	0.06	0.07
O35	0.11	0.08	0.09	0.04	0.06	0.09	0.02	0.05	0.05	0.23	0.07	0.08
O36	0.06	0.11	0.07	0.05	0.05	0.04	0.01	0.05	0.01	0.13	0.05	0.05
O37	0.10	0.09	0.08	0.07	0.13	0.07	0.01	0.07	0.06	0.31	0.08	0.10
O38	0.15	0.10	0.05	0.07	0.13	0.07	0.02	0.04	0.10	0.41	0.09	0.12
O39	0.04	0.09	0.04	0.10	0.12	0.07	0.04	0.04	0.06	0.04	0.07	0.06
O40	0.07	0.06	0.07	0.09	0.09	0.06	0.03	0.02	0.03	0.06	0.06	0.05
O41	0.06	0.05	0.08	0.07	0.05	0.02	0.02	0.03	0.03	0.12	0.05	0.05
O42	0.05	0.13	0.02	0.05	0.10	0.06	0.01	0.06	0.08	0.29	0.07	0.09
O43	0.03	0.07	0.09	0.05	0.04	0.07	0.02	0.03	0.02	0.10	0.05	0.04
O44	0.14	0.08	0.09	0.02	0.05	0.10	0.03	0.05	0.02	0.12	0.07	0.05
O45	0.27	0.36	0.29	0.08	0.08	0.07	0.05	0.09	0.09	0.39	0.16	0.12
O46	0.27	0.33	0.23	0.04	0.09	0.04	0.10	0.08	0.09	0.30	0.15	0.11
O47	0.16	0.19	0.12	0.02	0.06	0.04	0.10	0.06	0.07	0.21	0.09	0.09
O48	0.21	0.21	0.11	0.04	0.04	0.03	0.10	0.06	0.08	0.23	0.10	0.09
O49	0.23	0.27	0.18	0.06	0.05	0.02	0.09	0.04	0.06	0.38	0.12	0.10
O50	0.23	0.27	0.21	0.08	0.06	0.03	0.09	0.05	0.09	0.46	0.13	0.13
O51	0.10	0.14	0.18	0.10	0.08	0.04	0.08	0.03	0.07	0.48	0.10	0.13
O52	0.17	0.24	0.25	0.14	0.07	0.10	0.11	0.04	0.12	0.55	0.15	0.16
O53	0.07	0.16	0.23	0.17	0.08	0.08	0.12	0.05	0.17	0.36	0.14	0.15
O54	0.07	0.09	0.10	0.15	0.04	0.04	0.12	0.02	0.13	0.31	0.09	0.12
O55	0.10	0.12	0.05	0.09	0.01	0.11	0.07	0.03	0.07	0.42	0.08	0.12
O56	0.09	0.12	0.04	0.08	0.03	0.11	0.02	0.03	0.09	0.32	0.07	0.10
O57	0.04	0.09	0.14	0.02	0.03	0.04	0.02	0.05	0.04	0.07	0.05	0.04
O58	0.07	0.19	0.20	0.05	0.02	0.03	0.03	0.04	0.05	0.12	0.08	0.05
O59	0.28	0.27	0.23	0.08	0.03	0.03	0.03	0.01	0.10	0.29	0.13	0.09
O60	0.22	0.29	0.16	0.10	0.02	0.02	0.02	0.02	0.10	0.21	0.12	0.07
O61	0.15	0.15	0.07	0.11	0.04	0.05	0.02	0.05	0.05	0.24	0.08	0.08
O62	0.39	0.32	0.34	0.10	0.12	0.03	0.01	0.05	0.05	0.24	0.17	0.08
O63	0.06	0.07	0.06	0.02	0.07	0.04	0.04	0.04	0.07	0.10	0.05	0.06
O64	0.27	0.30	0.27	0.08	0.03	0.02	0.01	0.04	0.06	0.10	0.13	0.05
O65	0.09	0.08	0.05	0.01	0.08	0.02	0.06	0.05	0.08	0.18	0.06	0.08
O66	0.13	0.14	0.10	0.02	0.04	0.02	0.03	0.03	0.05	0.26	0.07	0.07
O67	0.15	0.09	0.07	0.04	0.11	0.02	0.02	0.12	0.04	0.20	0.07	0.08

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	Annual	Summer
Frequency	8.5%	10.8%	9.5%	12.4%	11.6%	8.8%	8.3%		8.4%		78.3%	
				5.5%	8.4%	7.8%	11.5%	13.6%	19.1%	11.7%		77.6%
O68	0.19	0.17	0.10	0.04	0.07	0.05	0.05	0.04	0.12	0.36	0.10	0.11
O69	0.18	0.17	0.08	0.03	0.08	0.04	0.01	0.05	0.04	0.55	0.08	0.12
O70	0.20	0.14	0.09	0.06	0.08	0.09	0.05	0.02	0.11	0.17	0.10	0.08
O71	0.38	0.61	0.51	0.13	0.16	0.08	0.05	0.08	0.08	0.55	0.26	0.16
O72	0.12	0.41	0.44	0.11	0.09	0.09	0.06	0.02	0.07	0.15	0.18	0.08
O73	0.26	0.37	0.37	0.09	0.09	0.16	0.11	0.02	0.13	0.17	0.20	0.11
O74	0.08	0.19	0.10	0.09	0.17	0.19	0.05	0.05	0.15	0.49	0.13	0.17
O75	0.12	0.20	0.39	0.18	0.17	0.19	0.19	0.03	0.04	0.53	0.19	0.17
O76	0.20	0.24	0.24	0.17	0.21	0.14	0.20	0.01	0.14	0.51	0.19	0.19
O77	0.22	0.26	0.15	0.18	0.18	0.05	0.20	0.01	0.27	0.33	0.19	0.18
O78	0.14	0.21	0.15	0.22	0.14	0.08	0.19	0.02	0.37	0.24	0.19	0.20
O79	0.16	0.19	0.09	0.23	0.10	0.08	0.18	0.05	0.43	0.20	0.18	0.21
O80	0.06	0.12	0.35	0.20	0.21	0.09	0.18	0.02	0.26	0.62	0.19	0.23
O81	0.19	0.19	0.13	0.11	0.07	0.20	0.18	0.01	0.31	0.48	0.17	0.21
O82	0.16	0.15	0.14	0.15	0.03	0.11	0.16	0.02	0.22	0.26	0.13	0.14
O83	0.10	0.11	0.03	0.06	0.06	0.15	0.04	0.02	0.06	0.26	0.08	0.09
O84	0.04	0.07	0.07	0.05	0.05	0.07	0.01	0.01	0.05	0.08	0.05	0.04
O85	0.17	0.15	0.11	0.05	0.04	0.02	0.02	0.01	0.05	0.20	0.08	0.06
O86	0.09	0.13	0.15	0.04	0.03	0.02	0.05	0.04	0.03	0.18	0.07	0.06
O87	0.10	0.21	0.21	0.03	0.02	0.02	0.07	0.04	0.03	0.09	0.09	0.04
O88	0.19	0.25	0.17	0.04	0.05	0.03	0.06	0.06	0.04	0.31	0.10	0.09
O89	0.20	0.25	0.17	0.05	0.06	0.01	0.06	0.06	0.05	0.27	0.11	0.08
O90	0.15	0.13	0.10	0.07	0.02	0.01	0.02	0.04	0.04	0.12	0.07	0.05
O91	0.06	0.06	0.07	0.05	0.04	0.05	0.08	0.06	0.06	0.15	0.06	0.07
O92	0.14	0.16	0.07	0.04	0.06	0.05	0.08	0.06	0.06	0.16	0.08	0.08
O93	0.16	0.10	0.06	0.11	0.07	0.02	0.04	0.03	0.04	0.12	0.08	0.06

A3.3 Special Test Points

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	Annual	Summer
Frequency	8.5%	10.8%	9.5%	12.4%	11.6%	8.8%	8.3%		8.4%		78.3%	
				5.5%	8.4%	7.8%	11.5%	13.6%	19.1%	11.7%		77.6%
S1	0.07	0.08	0.24	0.19	0.20	0.15	0.09	0.06	0.12	0.43	0.15	0.17
S2	0.11	0.13	0.30	0.15	0.21	0.17	0.03	0.03	0.22	0.58	0.17	0.20
S3	0.10	0.28	0.35	0.34	0.17	0.07	0.09	0.06	0.11	0.34	0.20	0.15
S4	0.15	0.33	0.39	0.34	0.17	0.08	0.07	0.04	0.20	0.45	0.23	0.18
S5	0.44	0.61	0.44	0.47	0.12	0.02	0.07	0.06	0.10	0.62	0.30	0.19
S6	0.56	0.69	0.48	0.47	0.13	0.02	0.04	0.02	0.18	0.68	0.33	0.20
S7	0.43	0.53	0.40	0.36	0.15	0.17	0.05	0.04	0.19	0.65	0.29	0.22

	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	Annual	Summer
Frequency	8.5%	10.8%	9.5%	12.4%	11.6%	8.8%	8.3%		8.4%		78.3%	
				5.5%	8.4%	7.8%	11.5%	13.6%	19.1%	11.7%		77.6%
S8	0.61	0.63	0.41	0.38	0.11	0.04	0.02	0.03	0.09	0.72	0.30	0.18
S9	0.11	0.10	0.09	0.09	0.14	0.05	0.05	0.03	0.17	0.41	0.10	0.14
S10	0.09	0.17	0.38	0.23	0.21	0.19	0.08	0.05	0.21	0.71	0.20	0.24
S11	0.48	0.56	0.37	0.33	0.11	0.16	0.07	0.07	0.16	0.75	0.28	0.23
S12	0.54	0.56	0.33	0.32	0.14	0.21	0.06	0.07	0.15	0.67	0.29	0.22

Appendix B

Directional VR Contour Plots

B1 Scenario 1

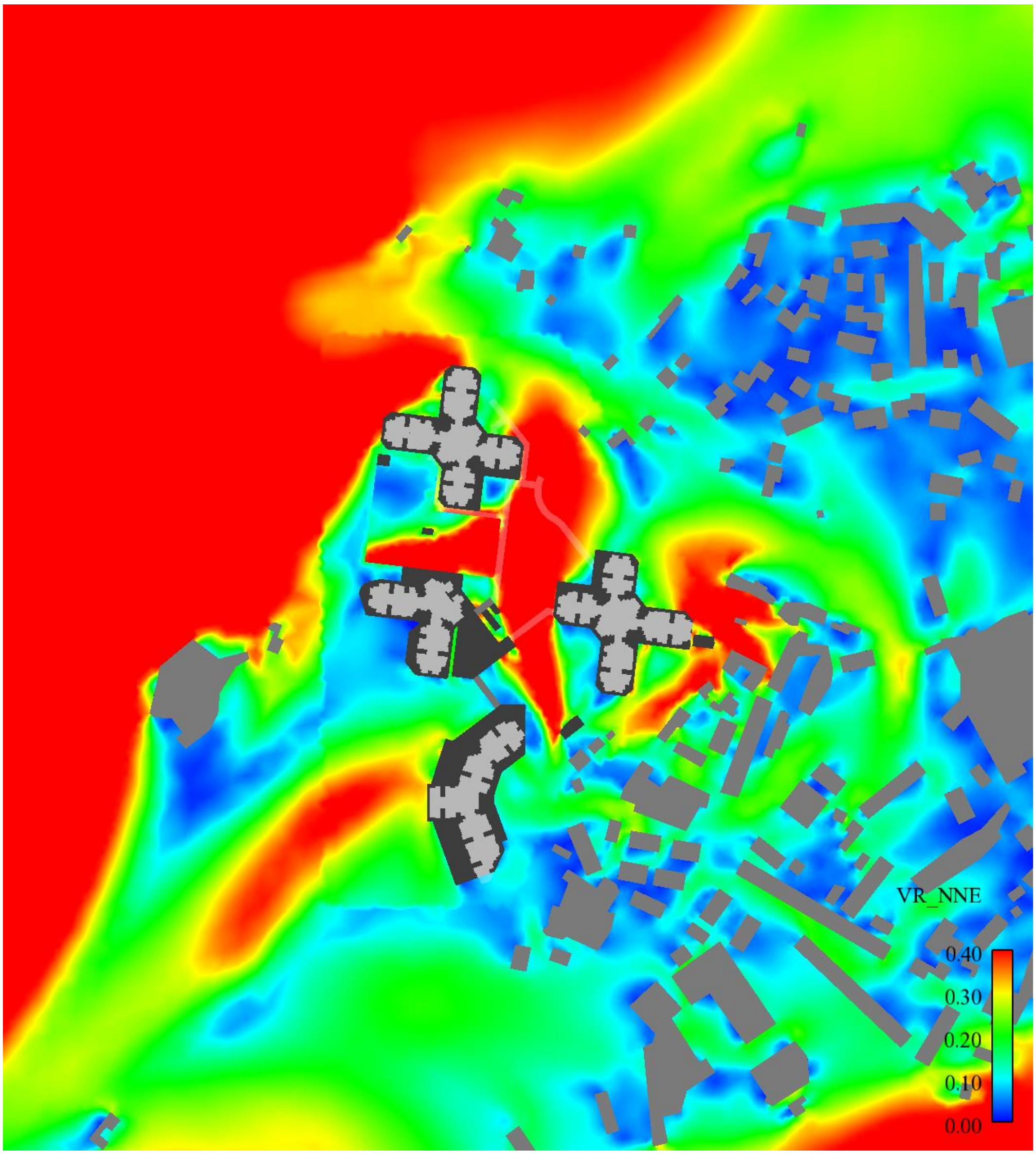


Figure B1 NNE Direction for Baseline Scheme under Scenario 1

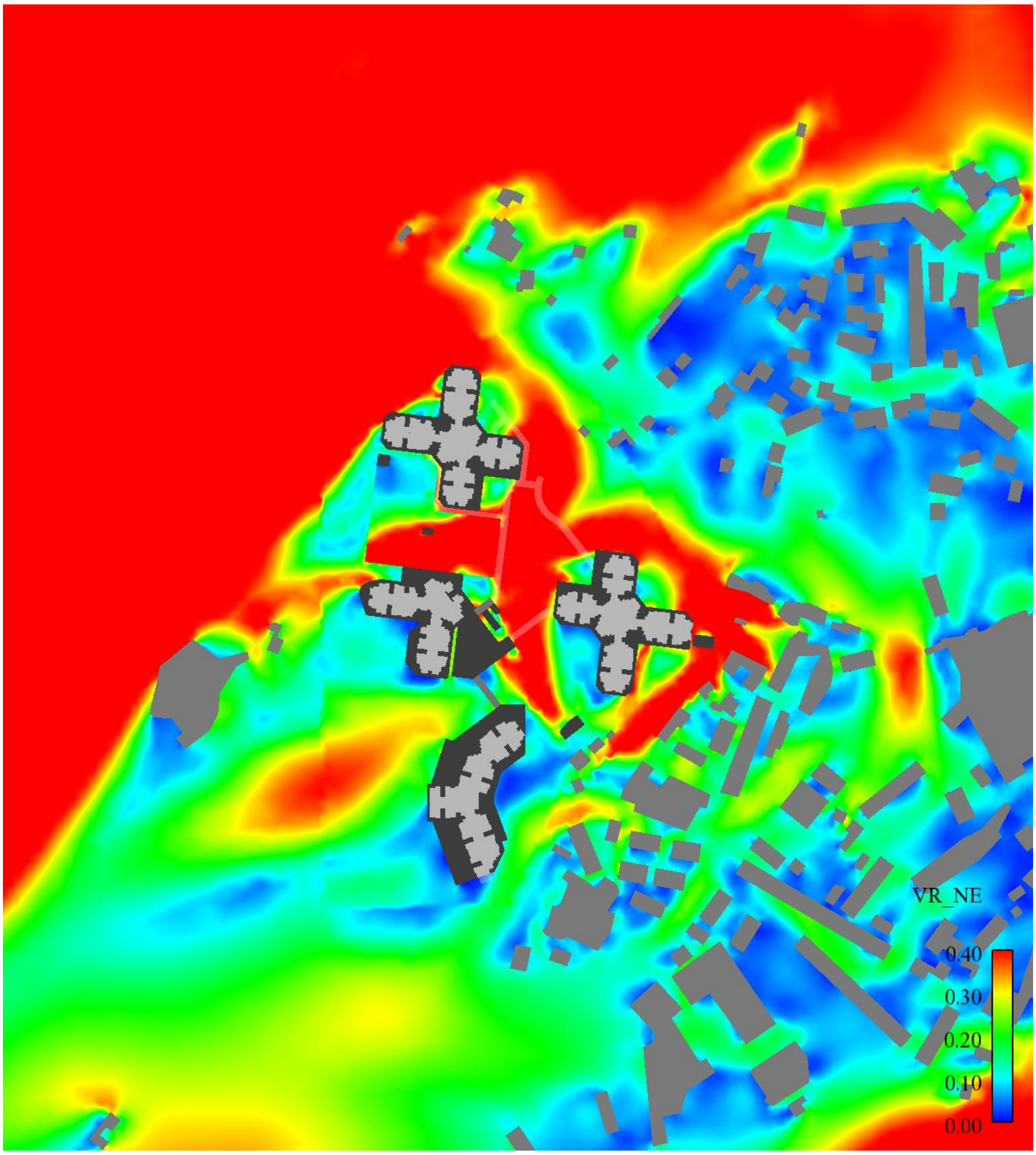


Figure B2 NE Direction for Baseline Scheme under Scenario 1

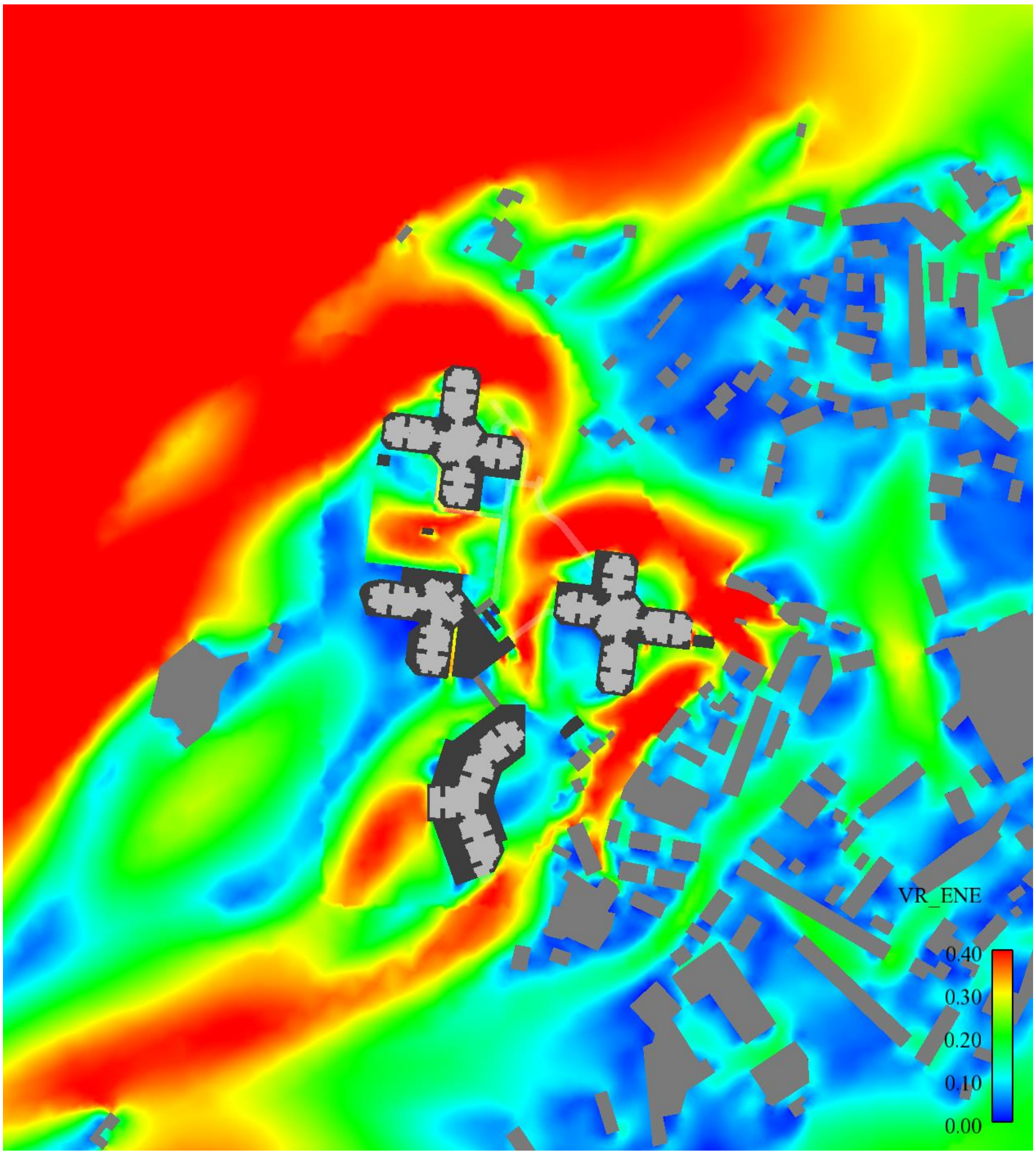


Figure B3 ENE Direction for Baseline Scheme under Scenario 1

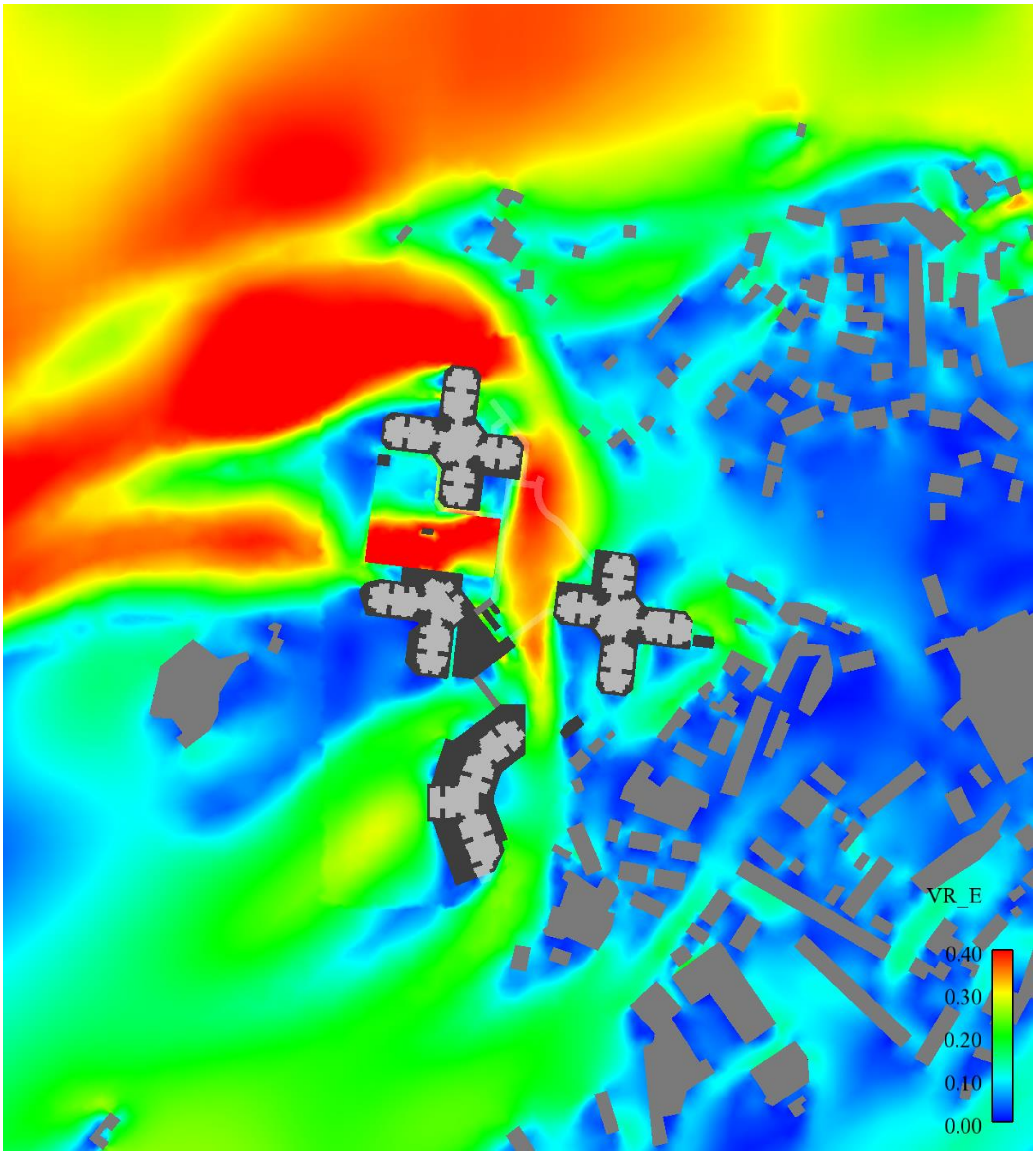


Figure B4 E Direction for Baseline Scheme under Scenario 1

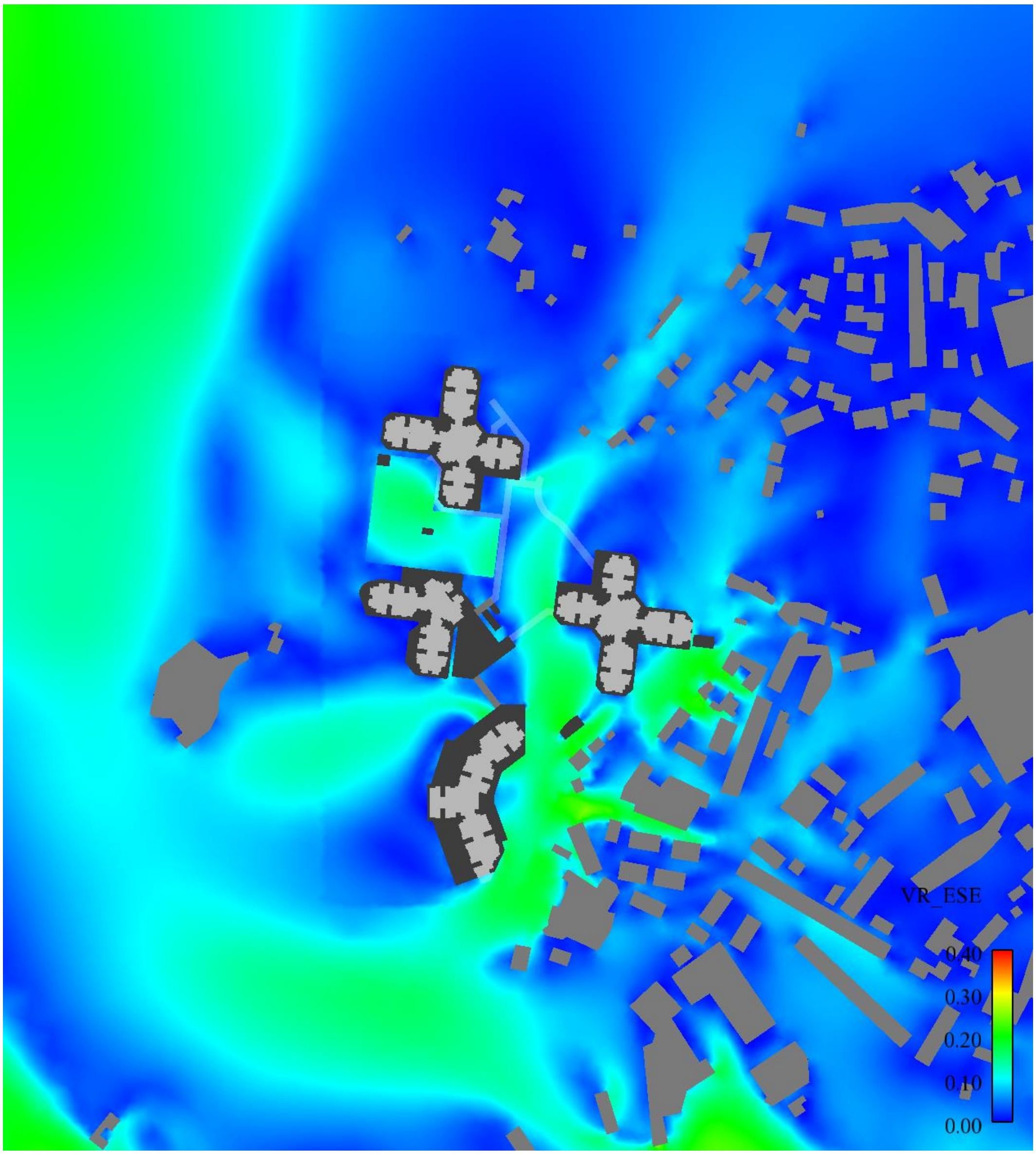


Figure B5 ESE Direction for Baseline Scheme under Scenario 1

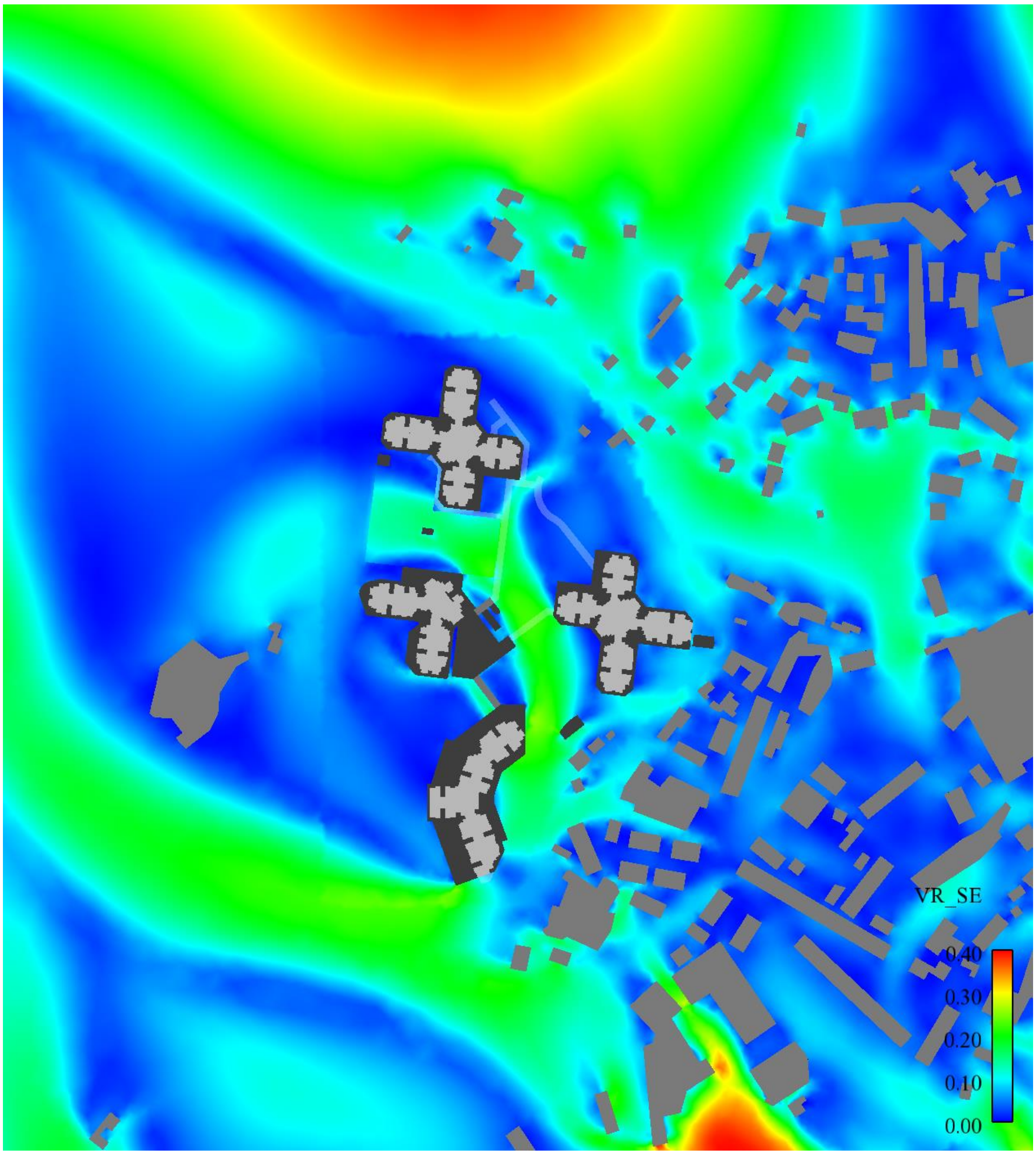


Figure B6 SE Direction for Baseline Scheme under Scenario 1

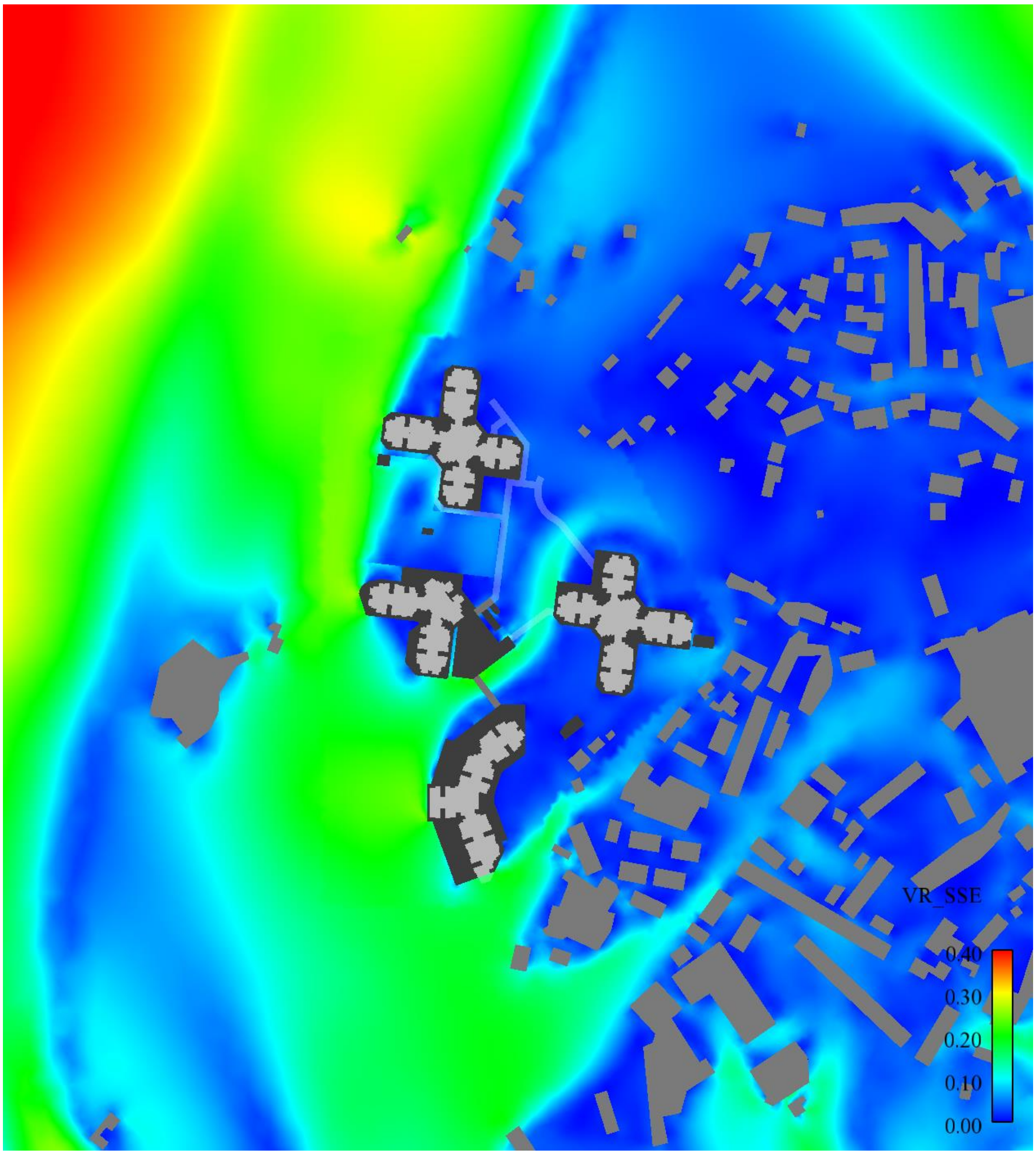


Figure B7 SSE Direction for Baseline Scheme under Scenario 1

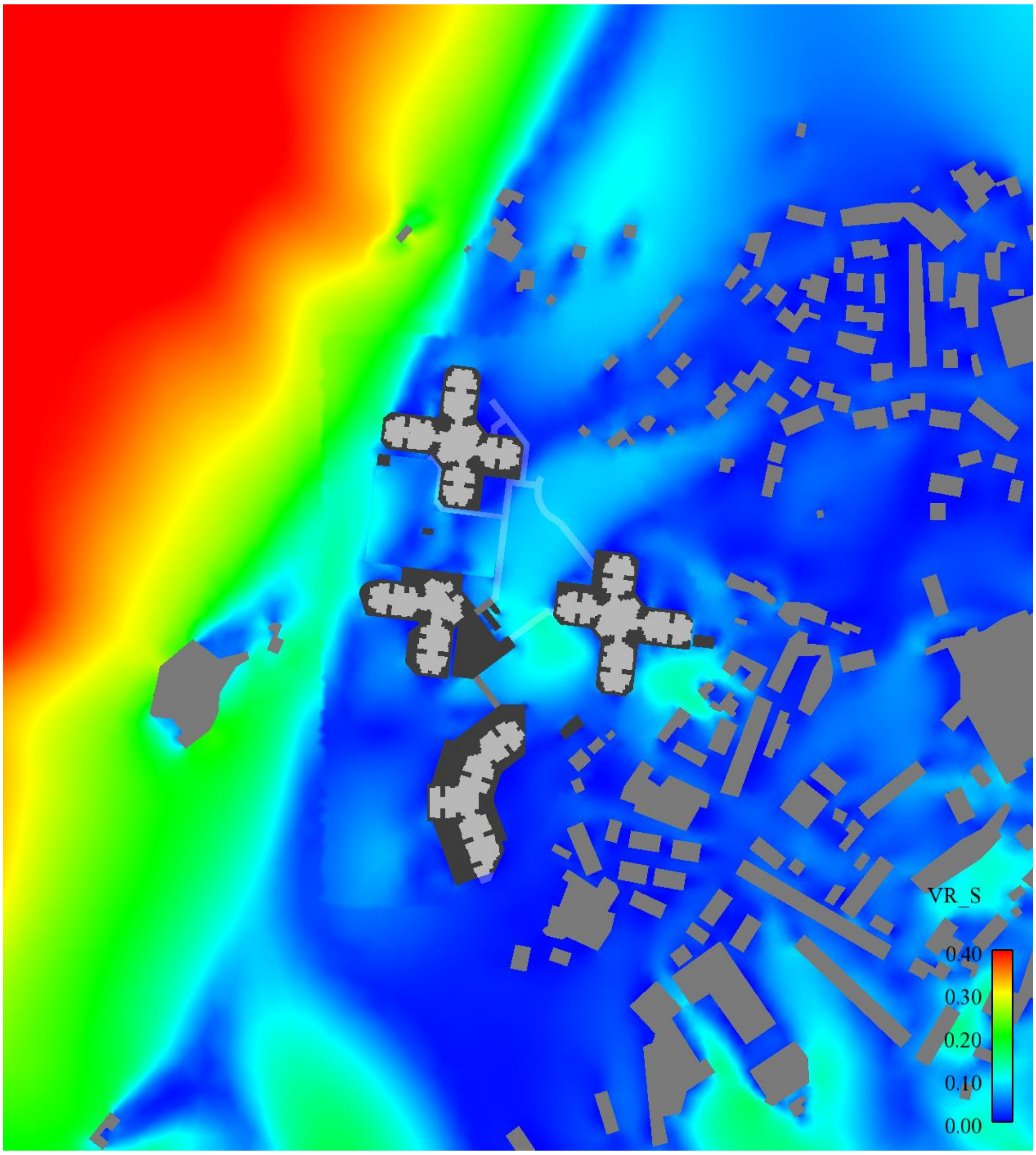


Figure B8 S Direction for Baseline Scheme under Scenario 1

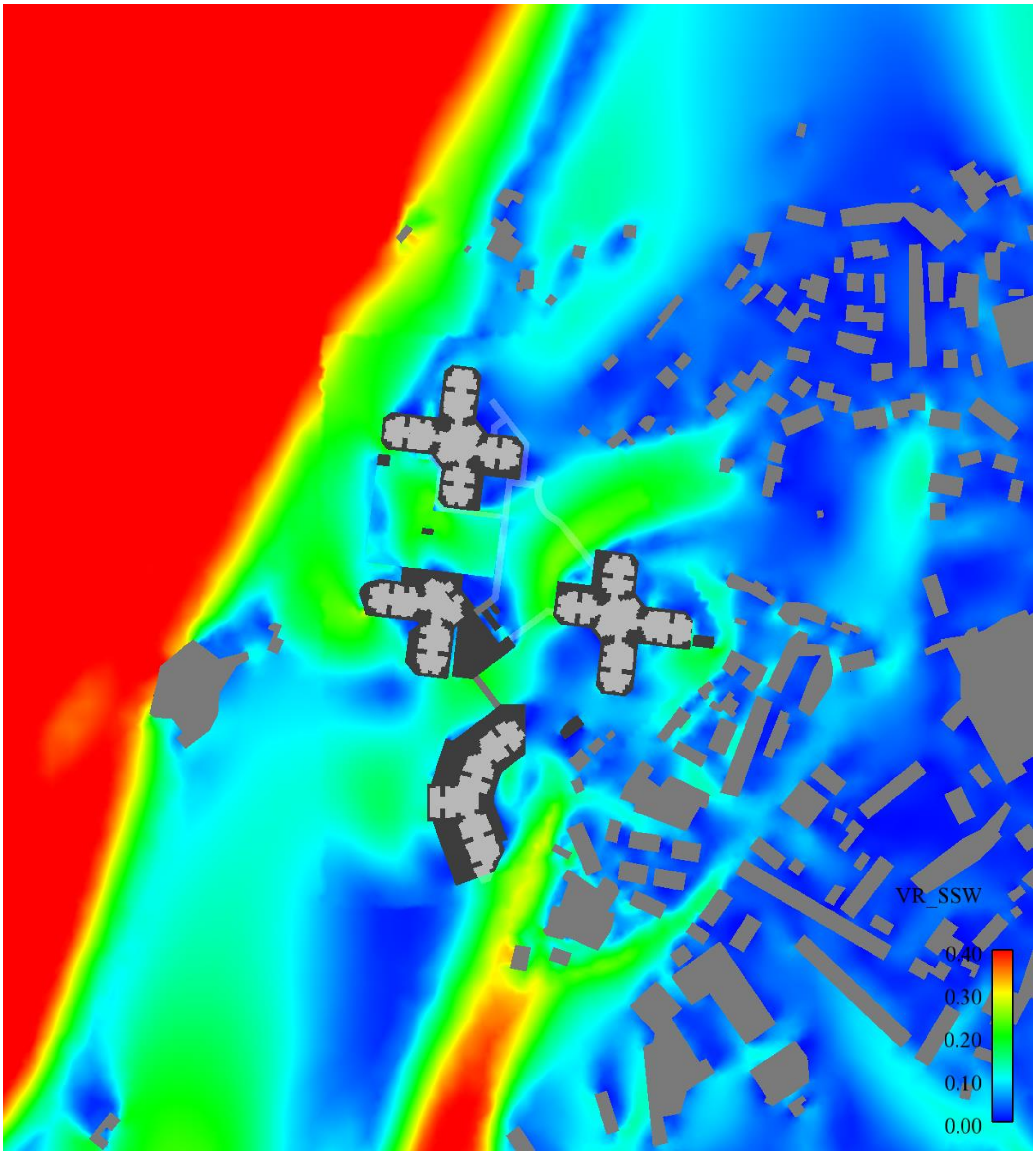


Figure B9 SSW Direction for Baseline Scheme under Scenario 1

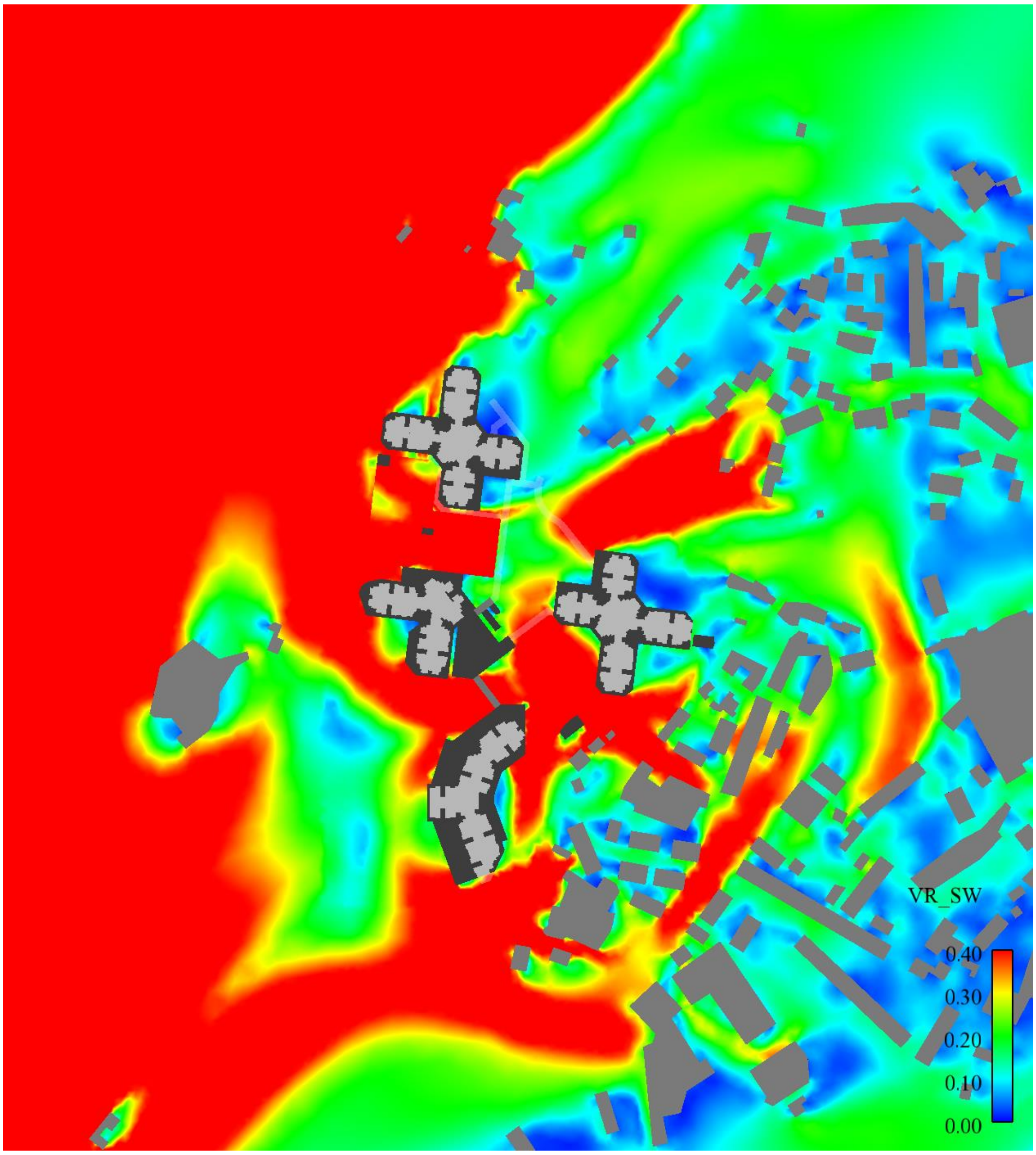


Figure B10 SW Direction for Baseline Scheme under Scenario 1

B2 Scenario 2

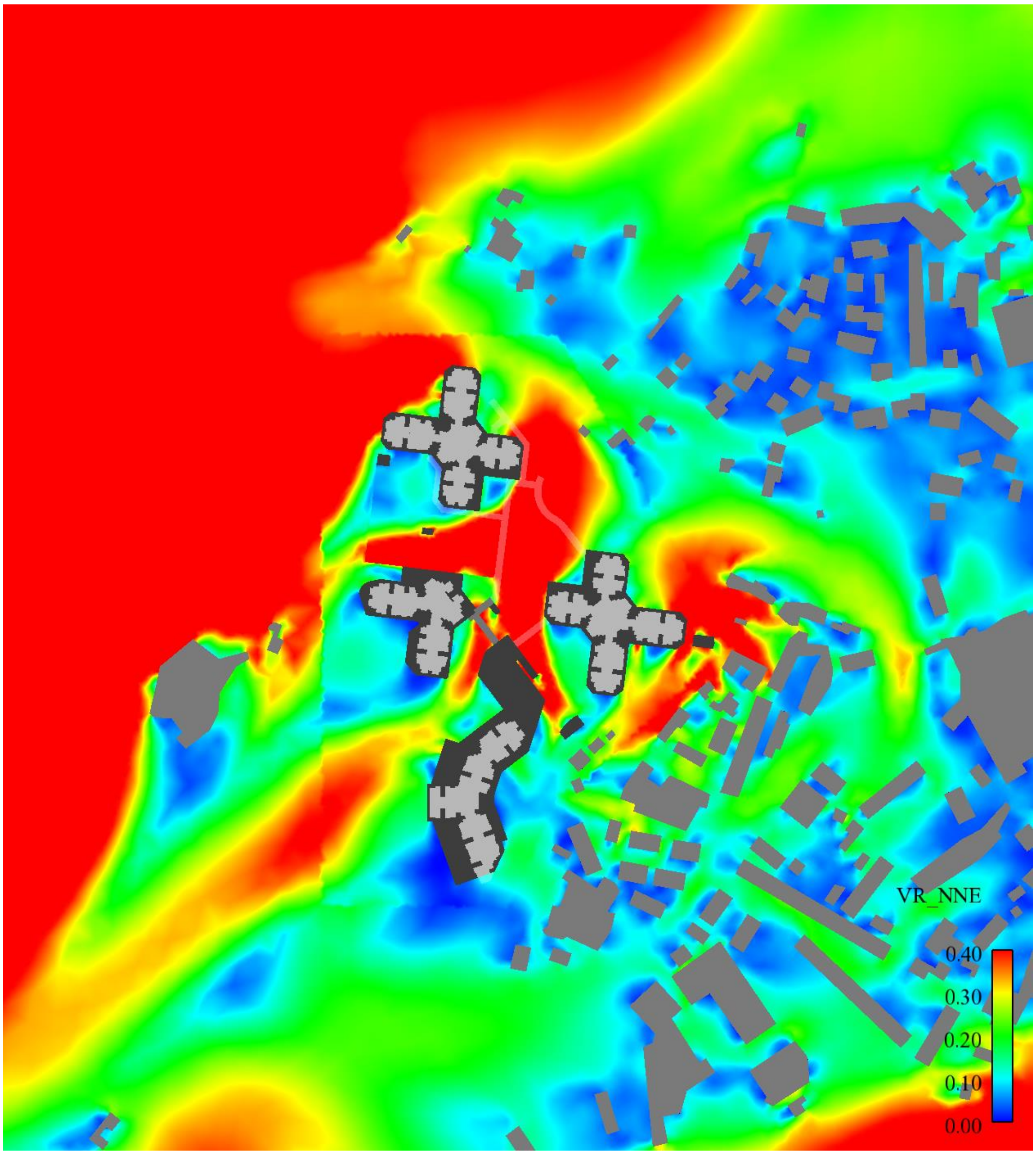


Figure B11 NNE Direction for Proposed Scheme under Scenario 2

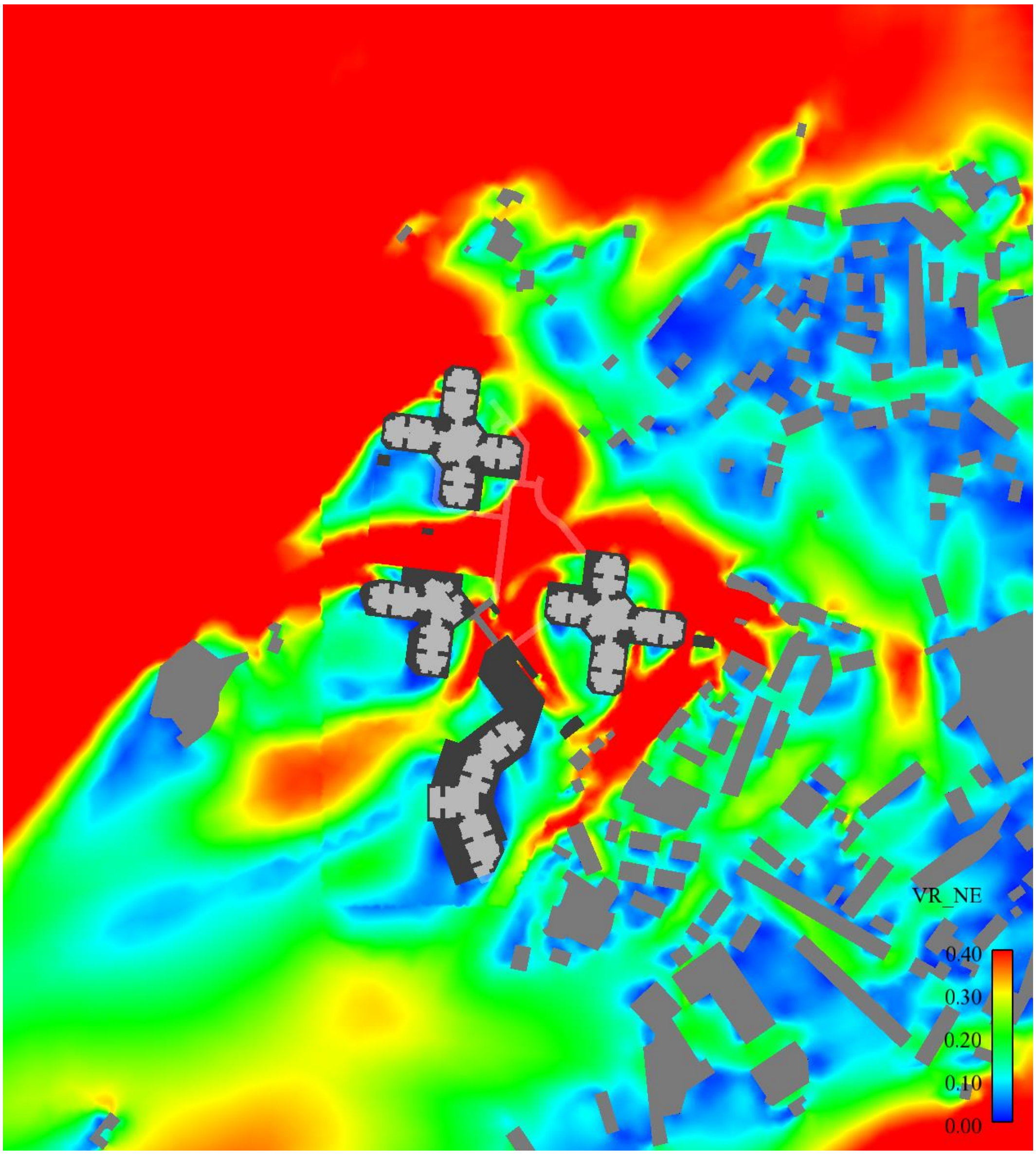


Figure B12 NE Direction for Proposed Scheme under Scenario 2

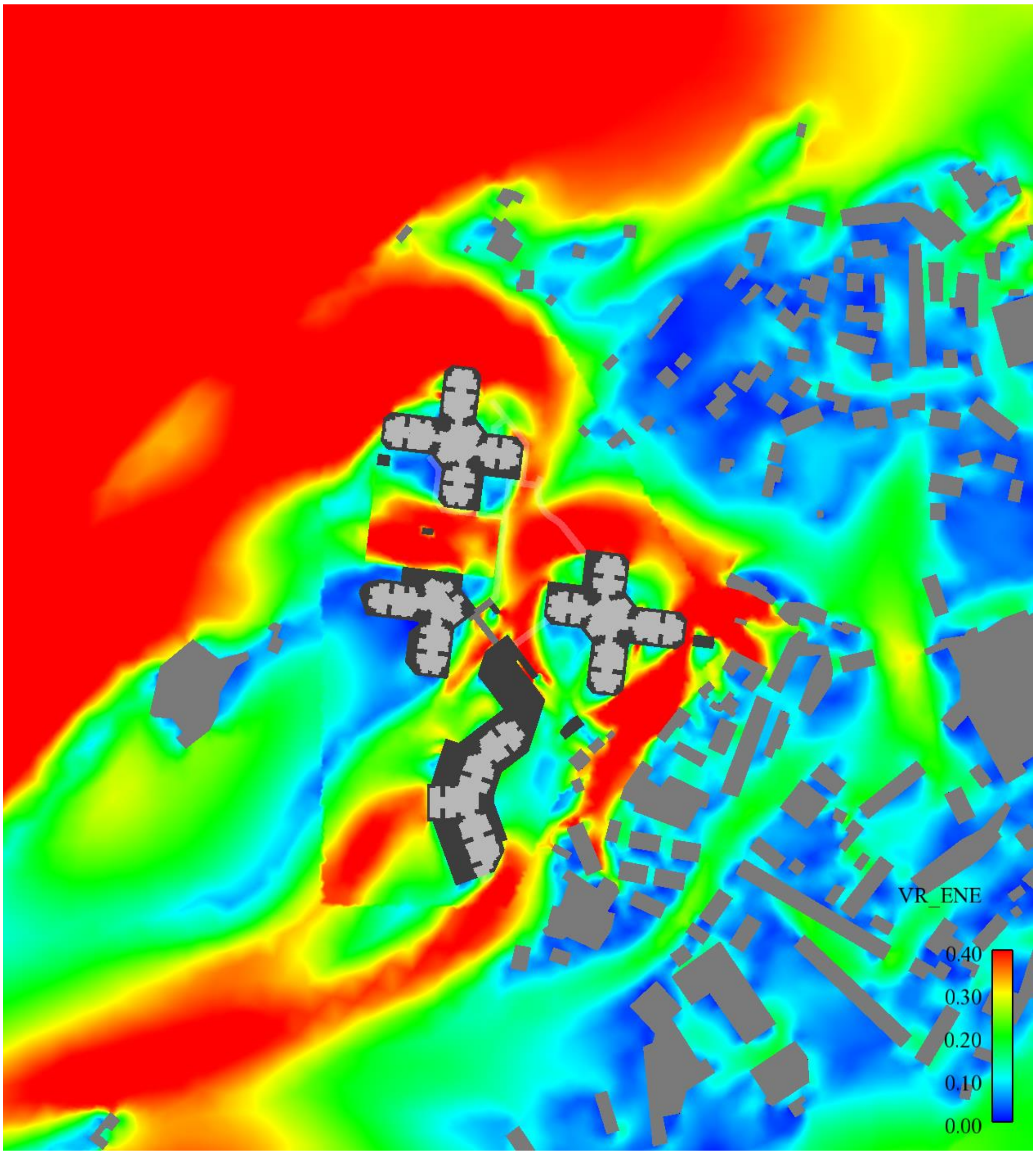


Figure B13 ENE Direction for Proposed Scheme under Scenario 2

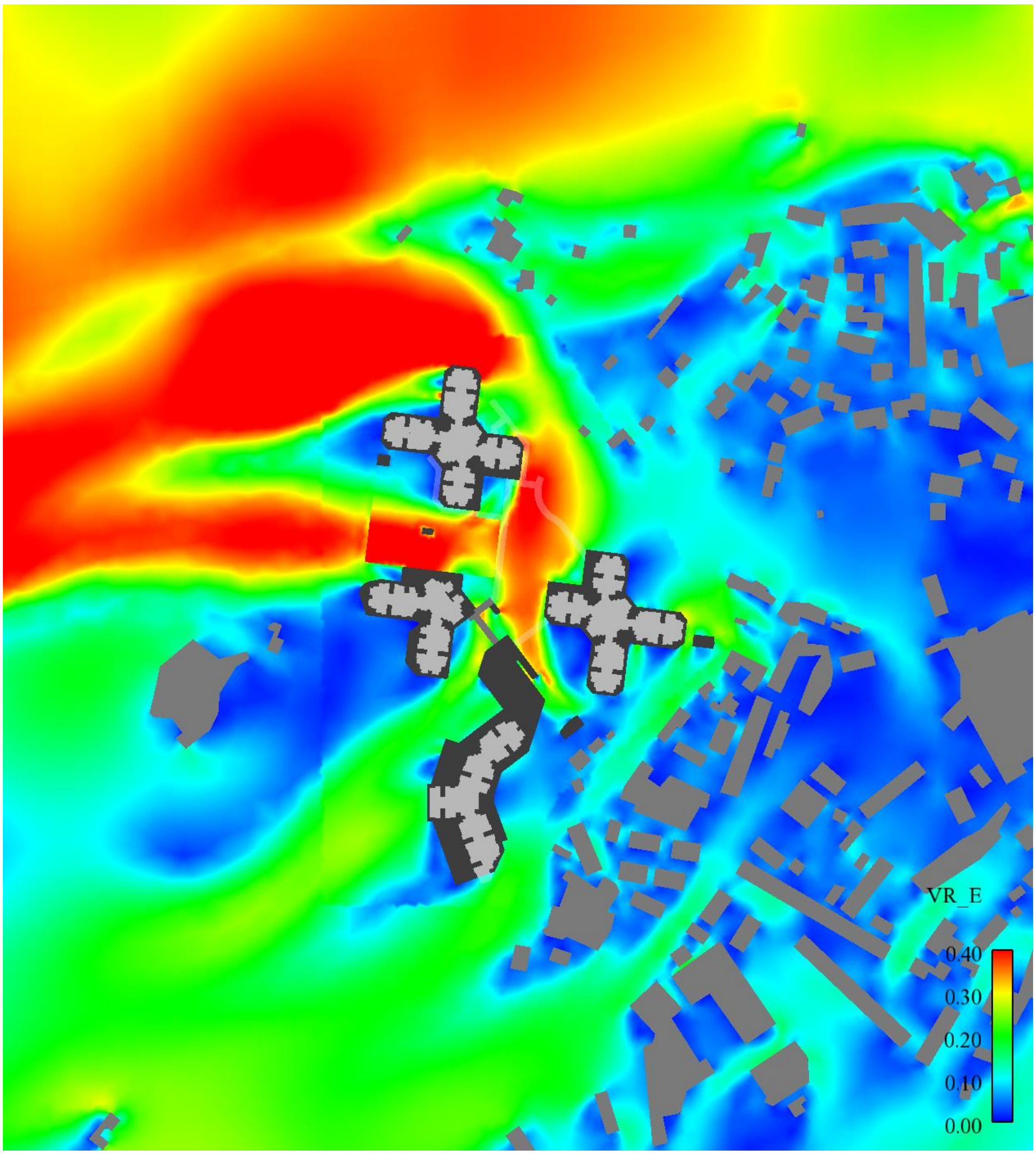


Figure B14 E Direction for Proposed Scheme under Scenario 2

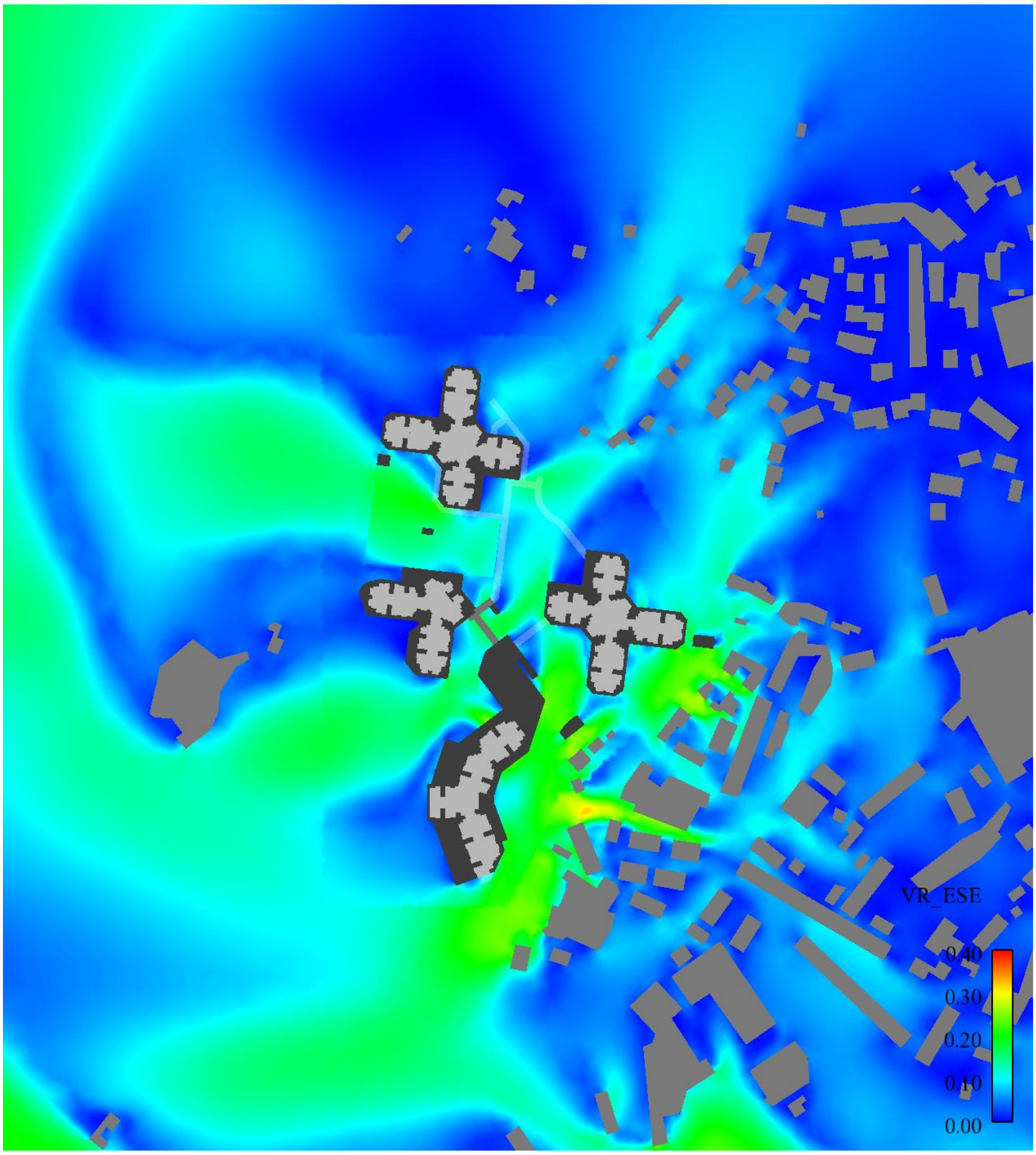


Figure B15 ESE Direction for Proposed Scheme under Scenario 2

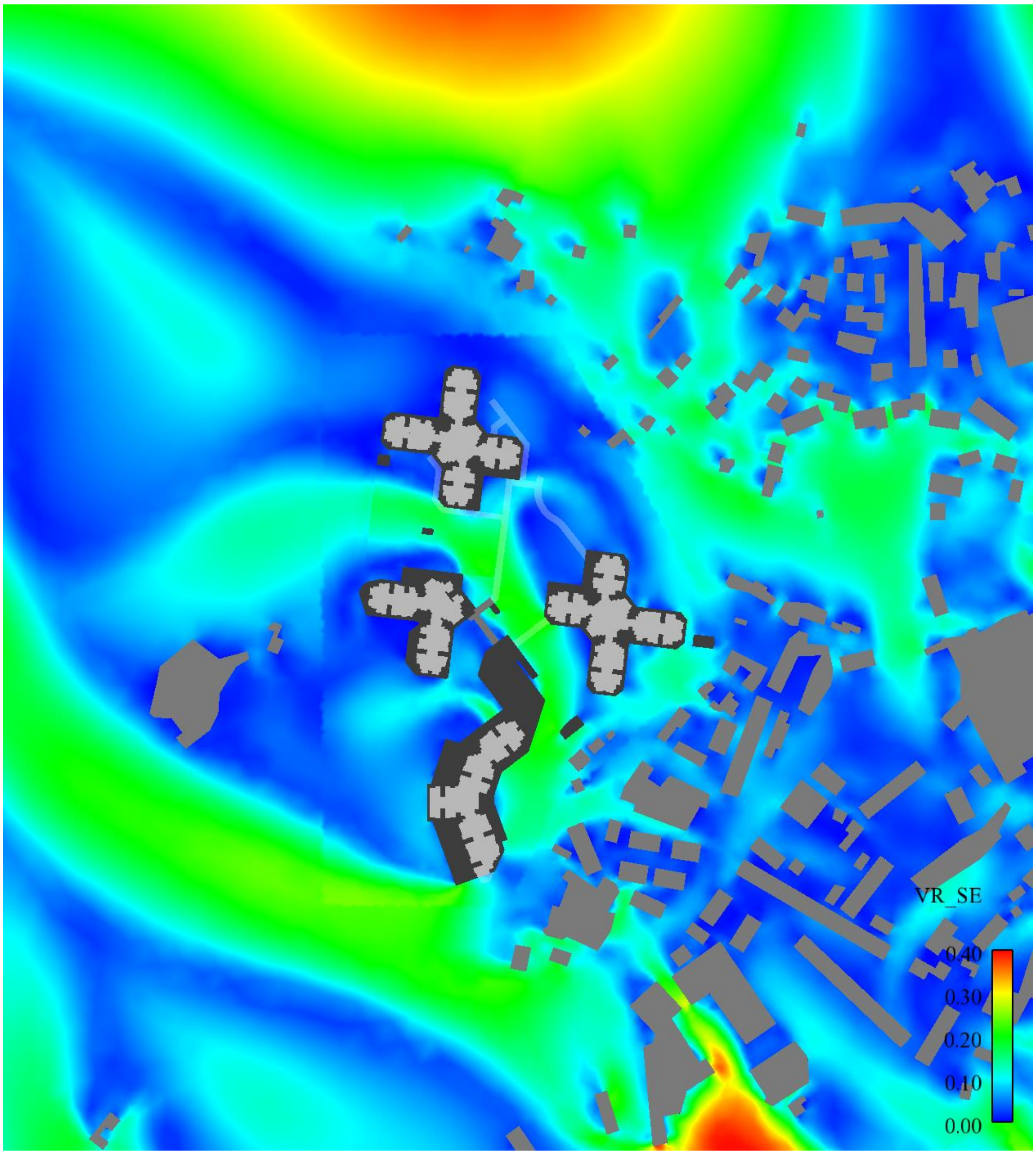


Figure B16 SE Direction for Proposed Scheme under Scenario 2

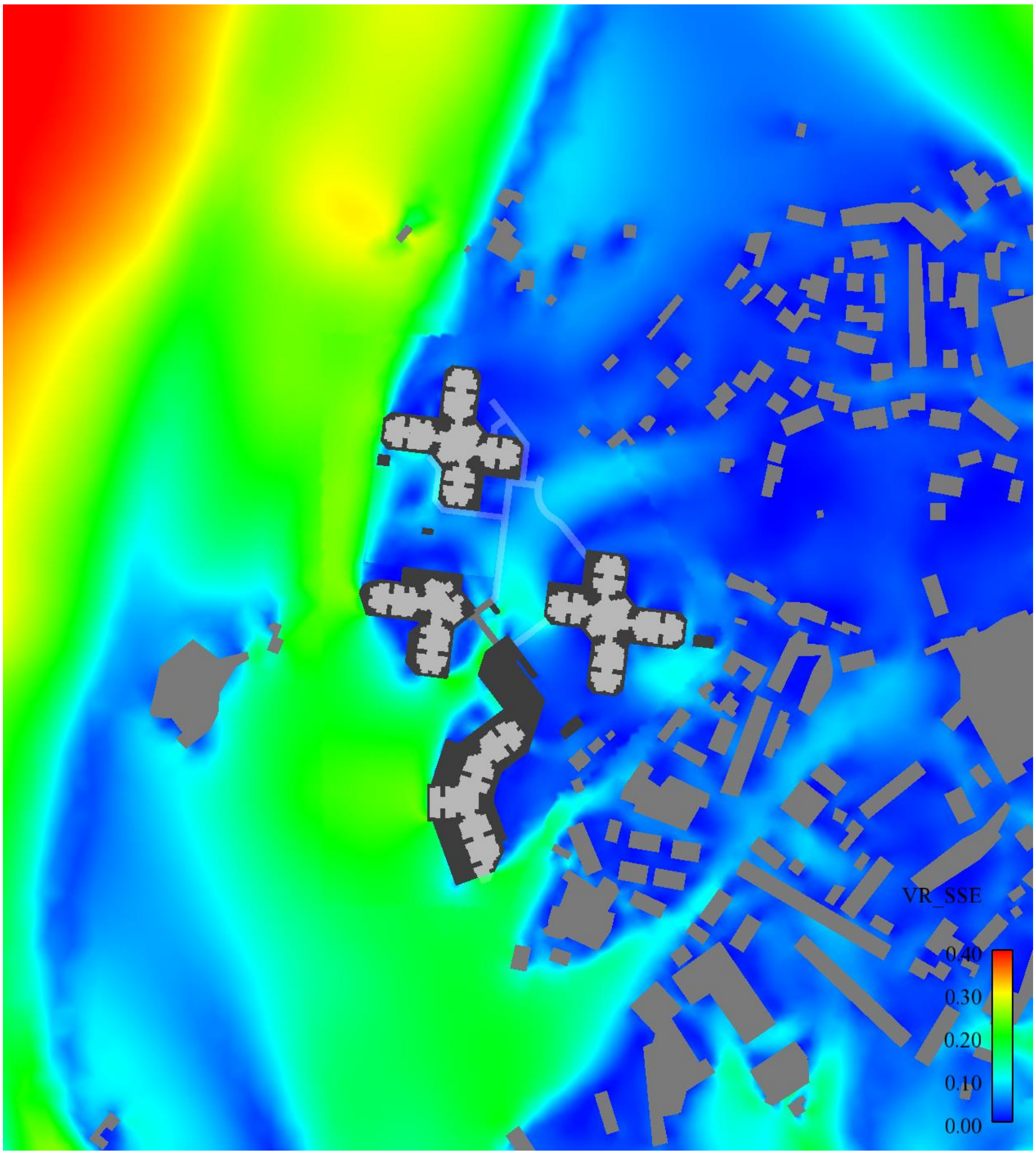


Figure B17 SSE Direction for Proposed Scheme under Scenario 2

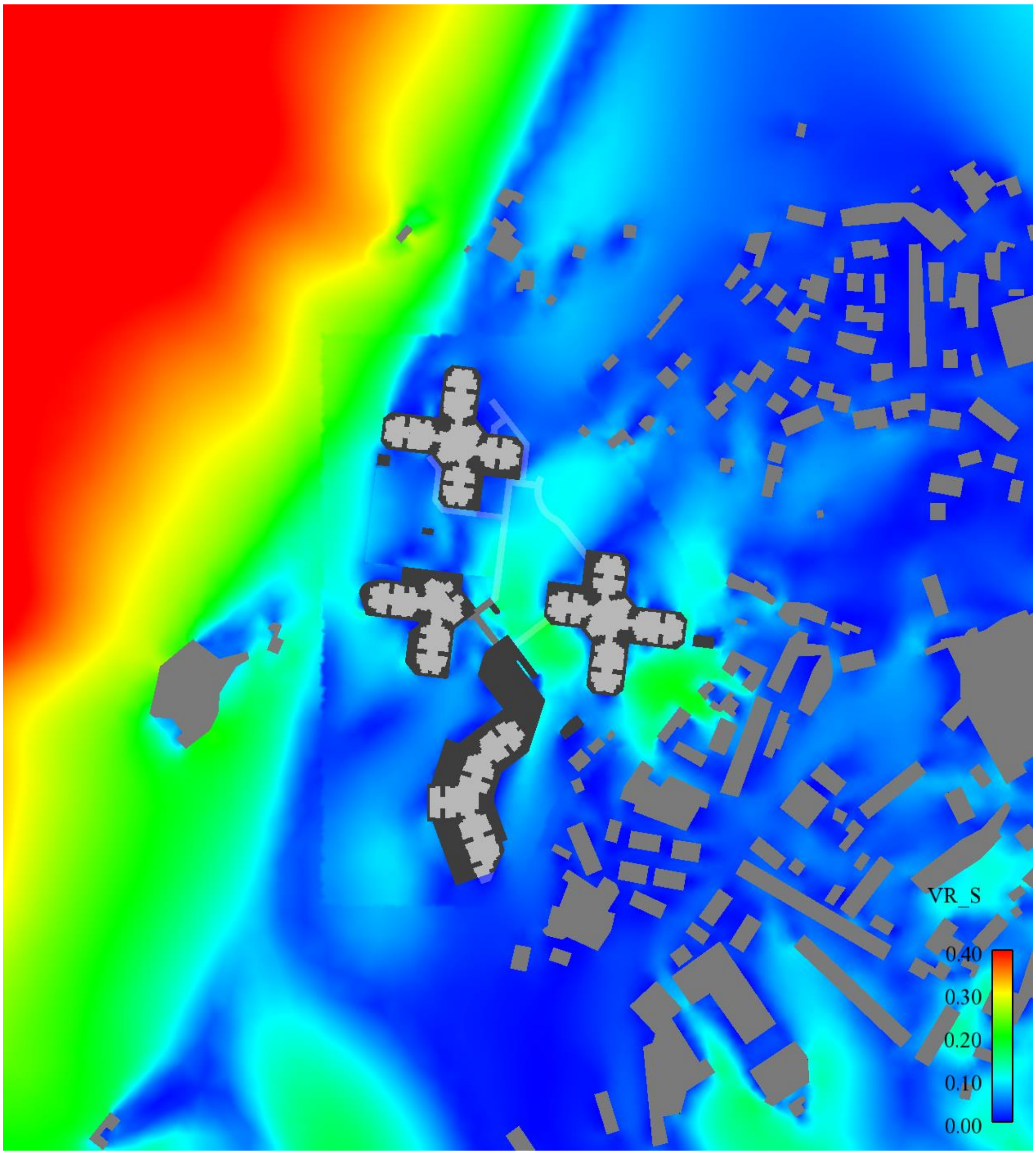


Figure B18 S Direction for Proposed Scheme under Scenario 2

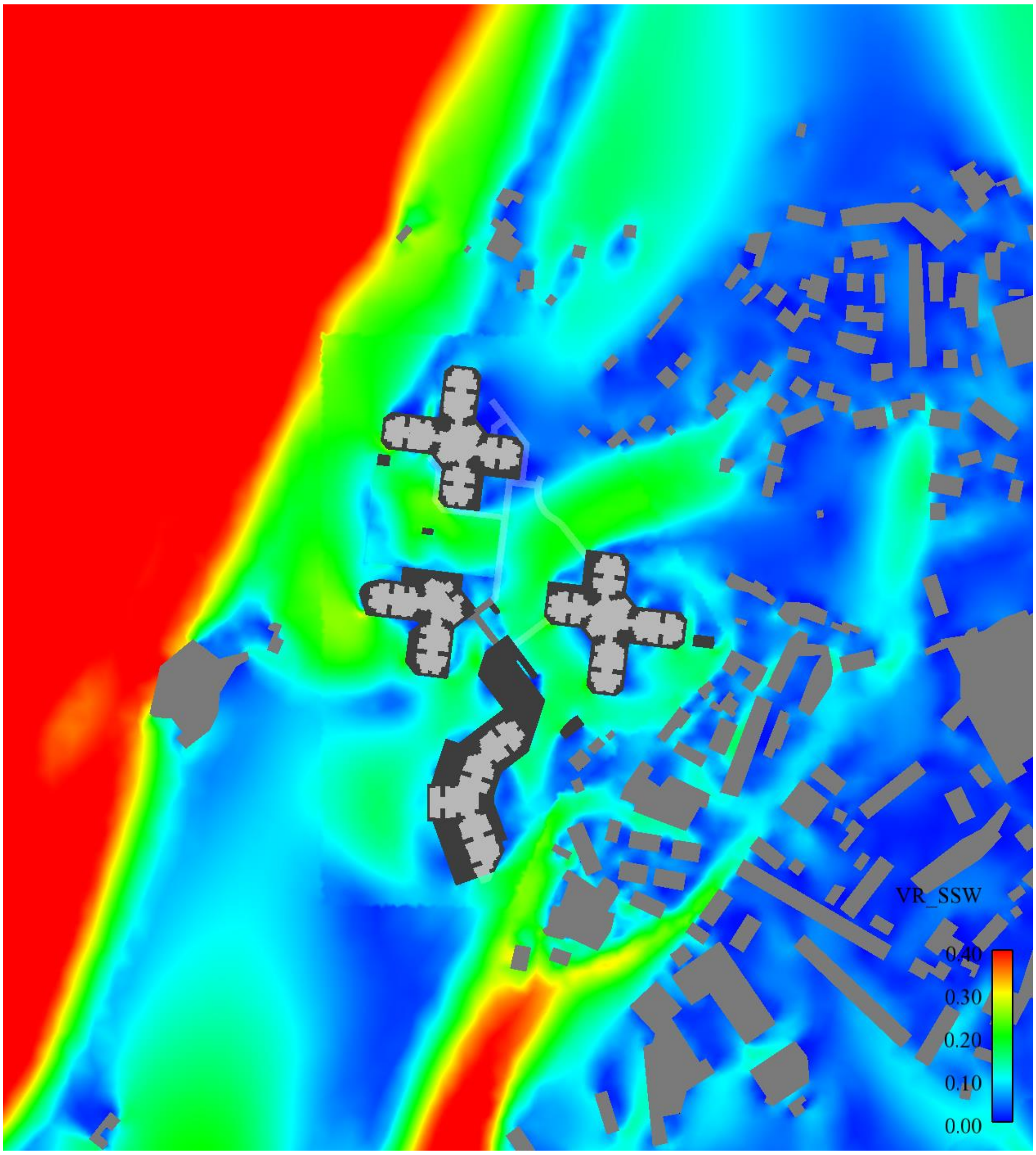


Figure B19 SSW Direction for Proposed Scheme under Scenario 2

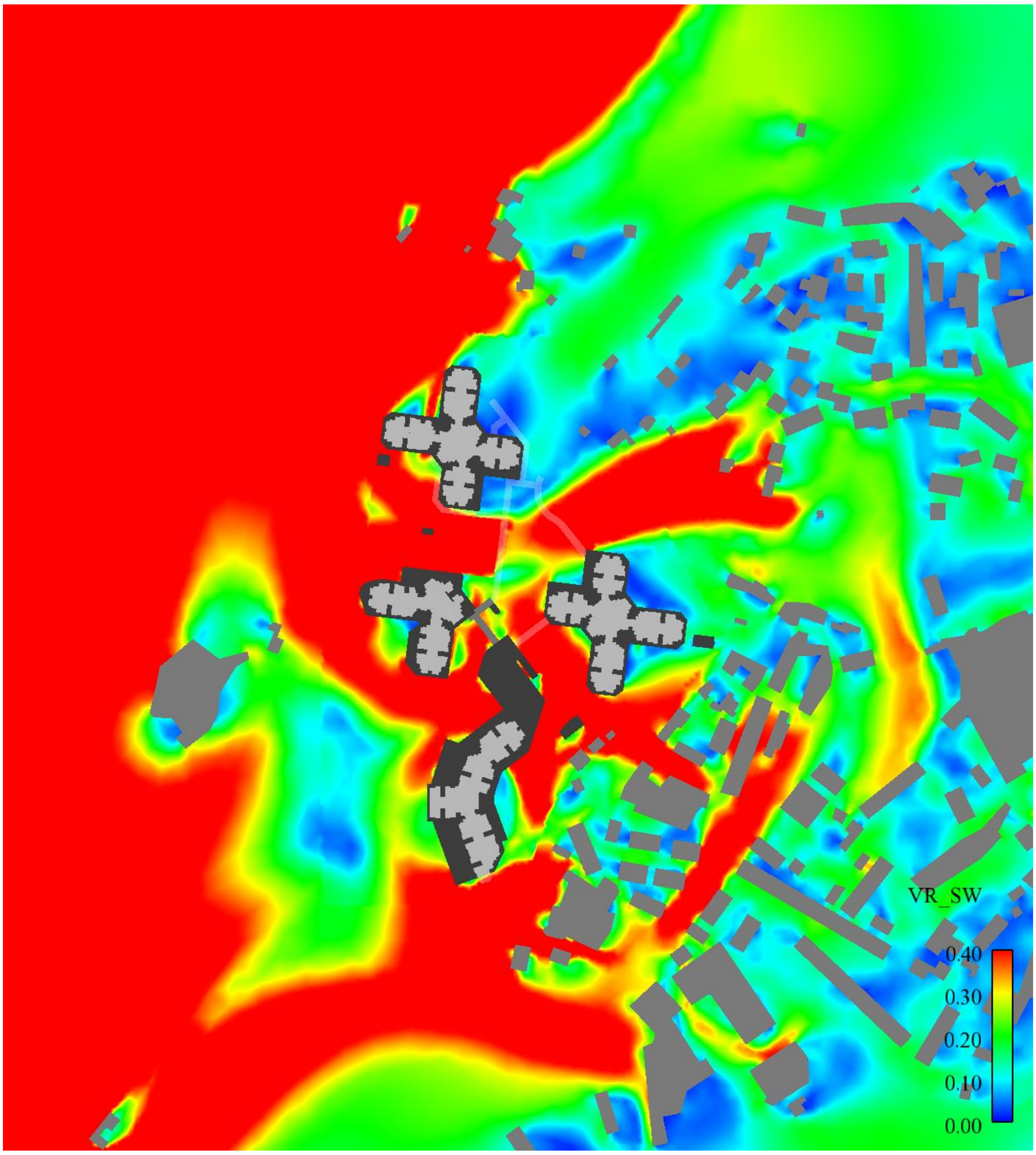


Figure B20 SW Direction for Proposed Scheme under Scenario 2

B3 Scenario 3

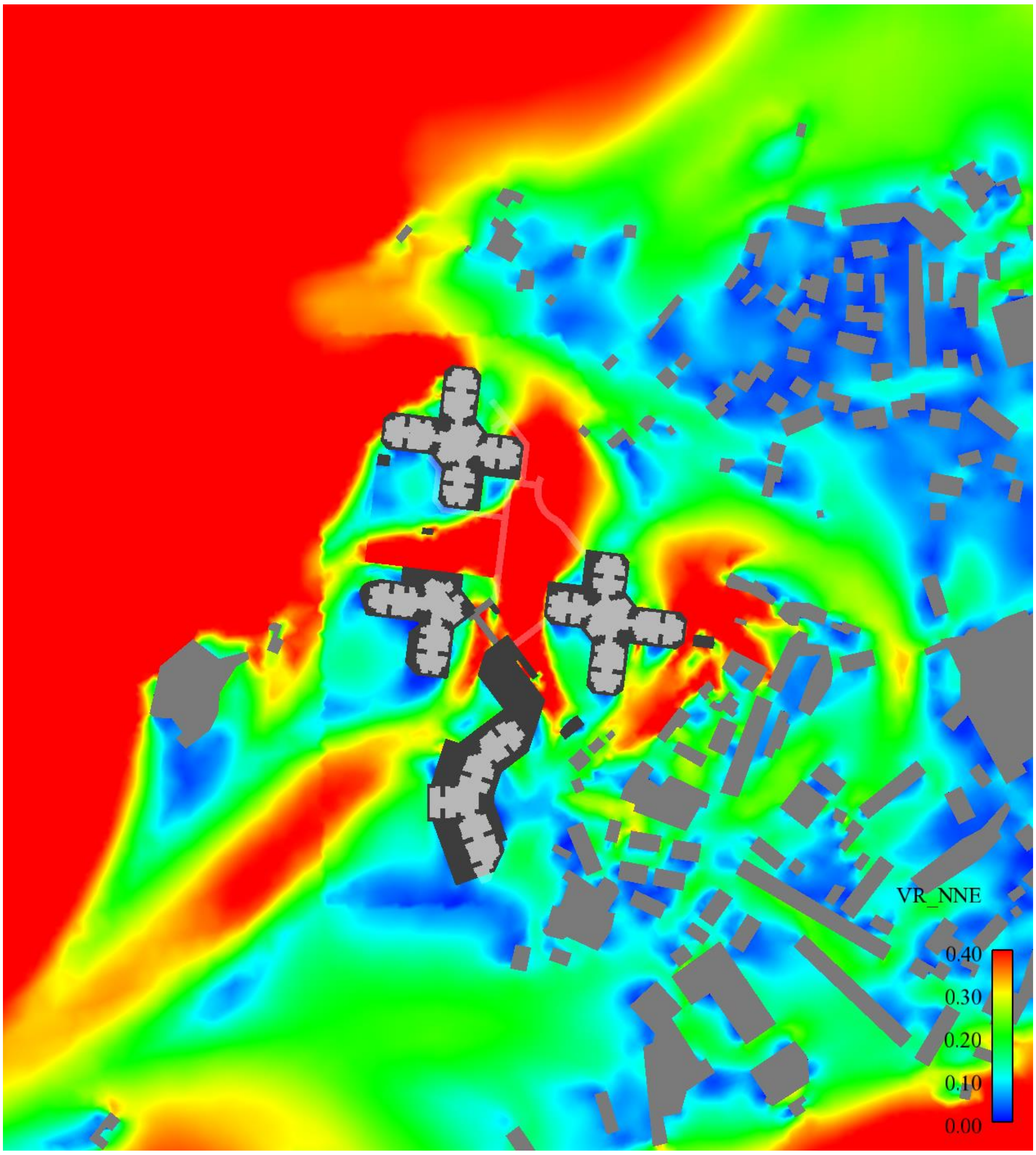


Figure B21 NNE Direction for Proposed Scheme under Scenario 3

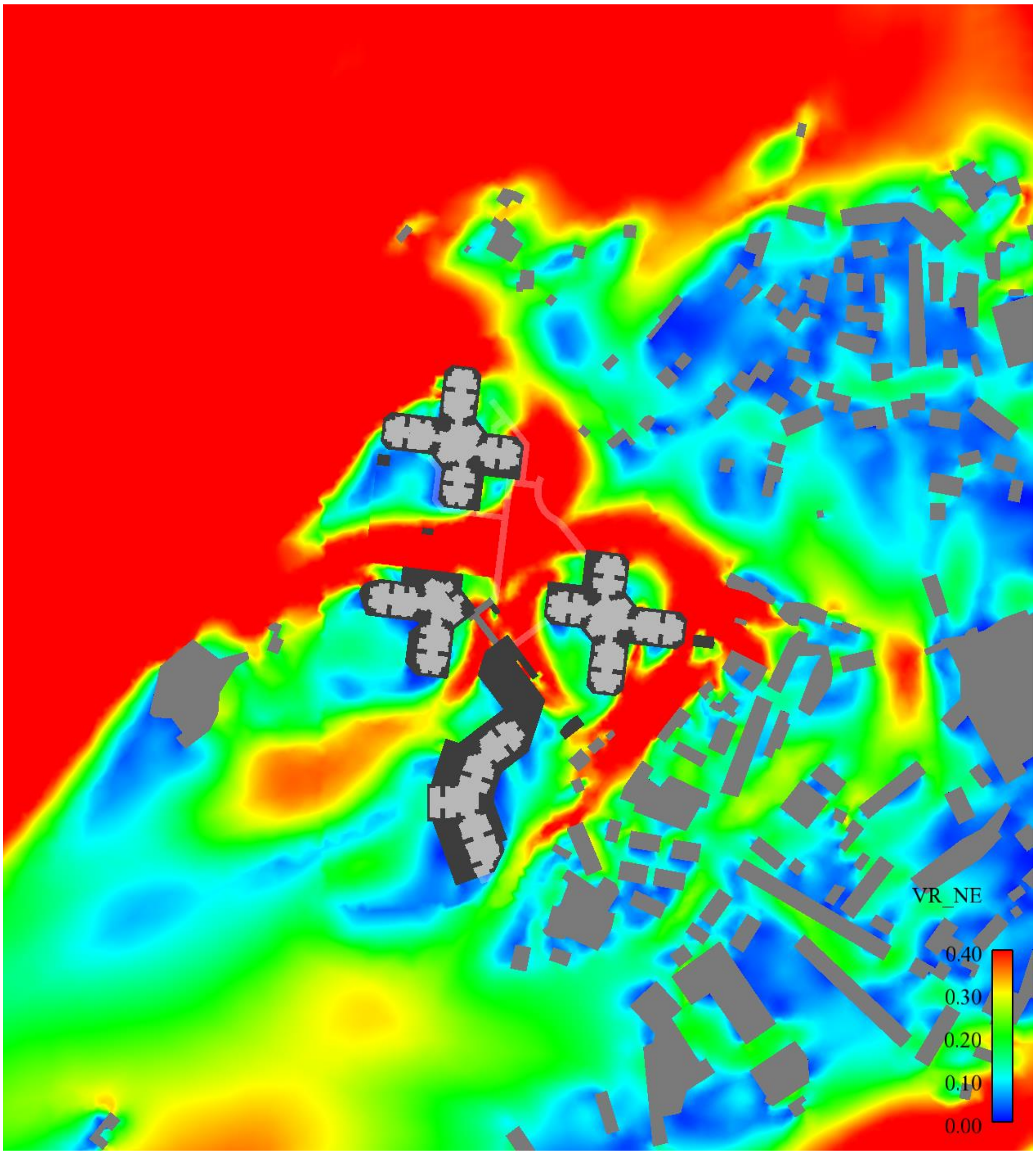


Figure B22 NE Direction for Proposed Scheme under Scenario 3

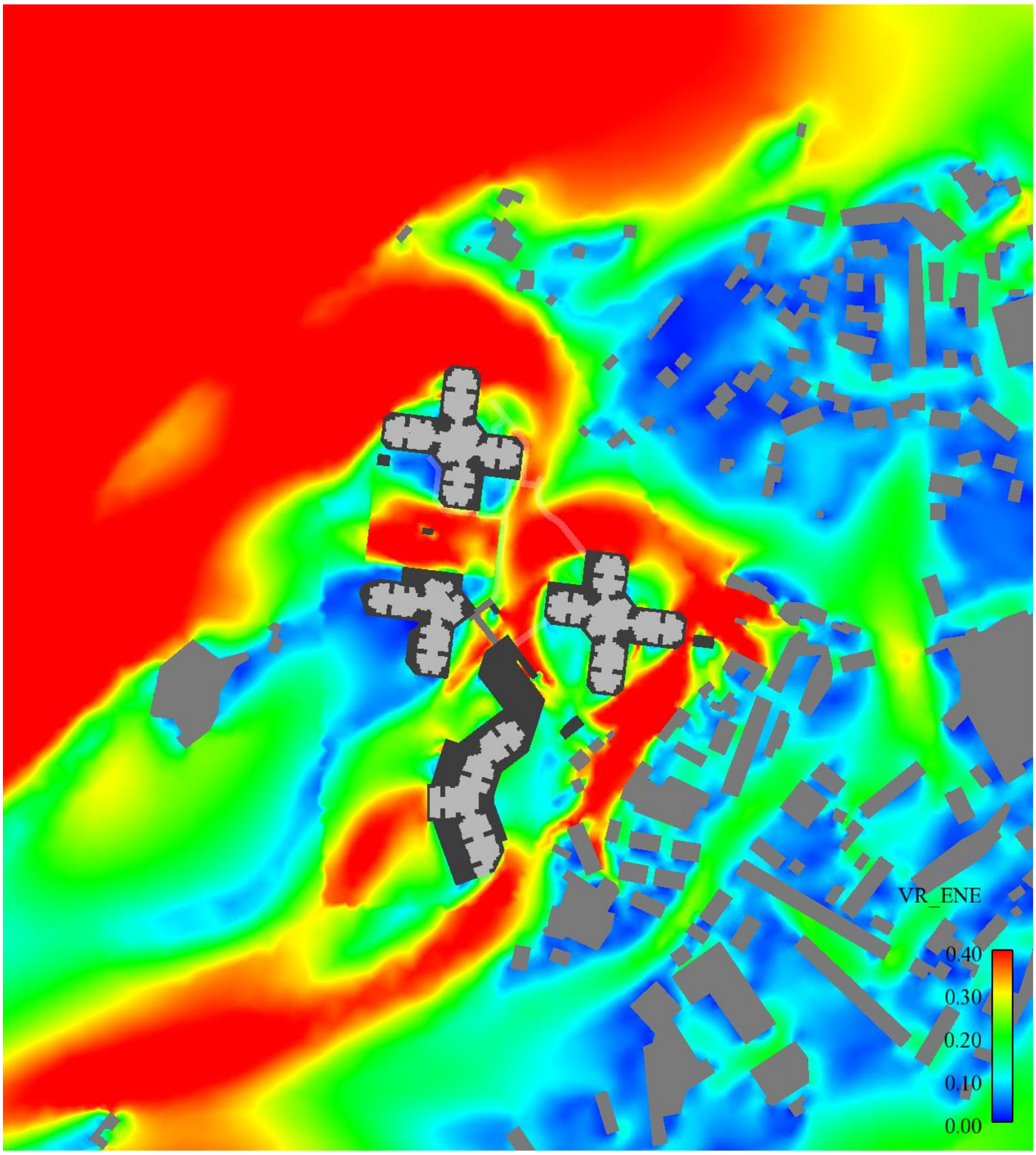


Figure B23 ENE Direction for Proposed Scheme under Scenario 3

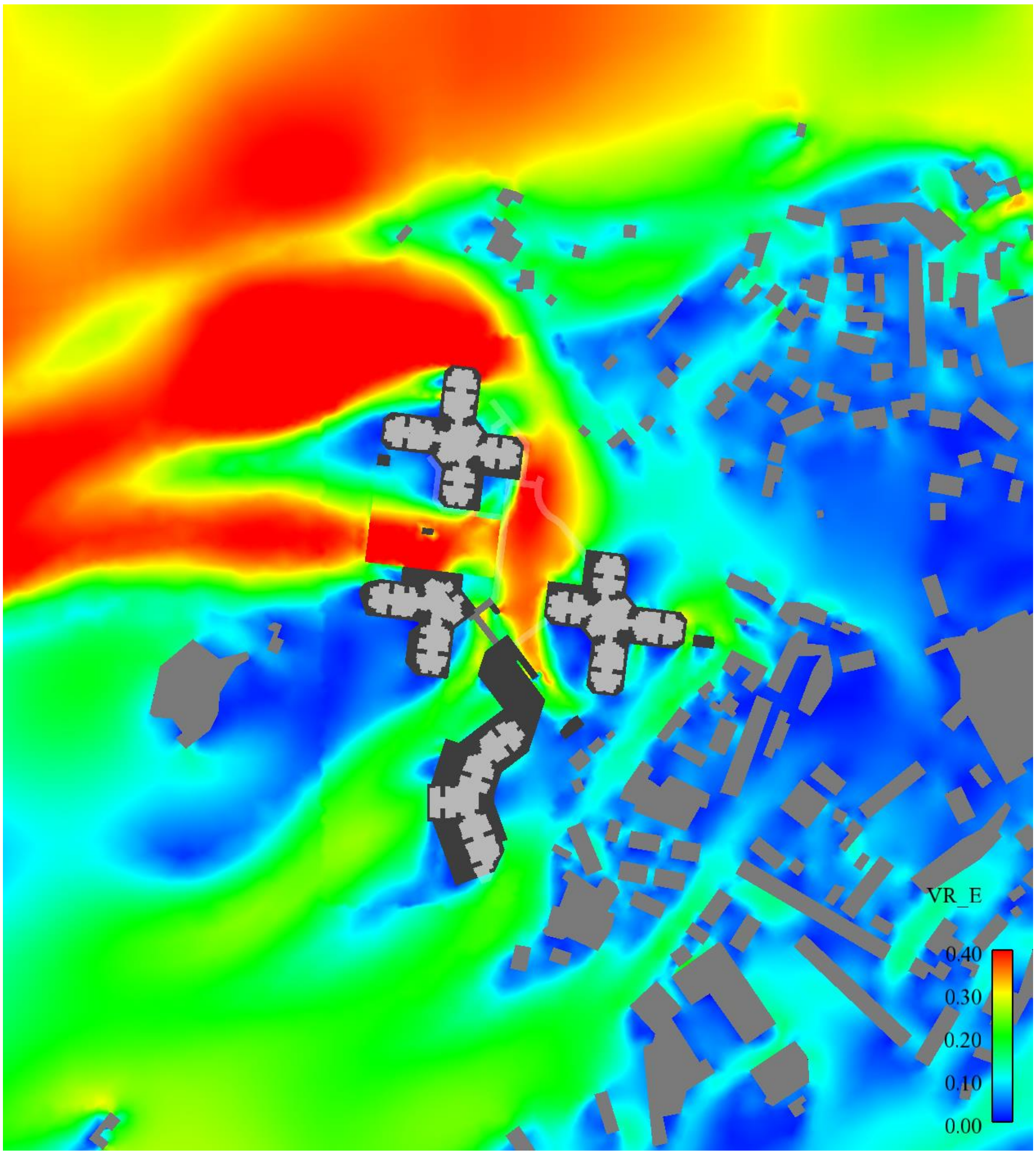


Figure B24 E Direction for Proposed Scheme under Scenario 3

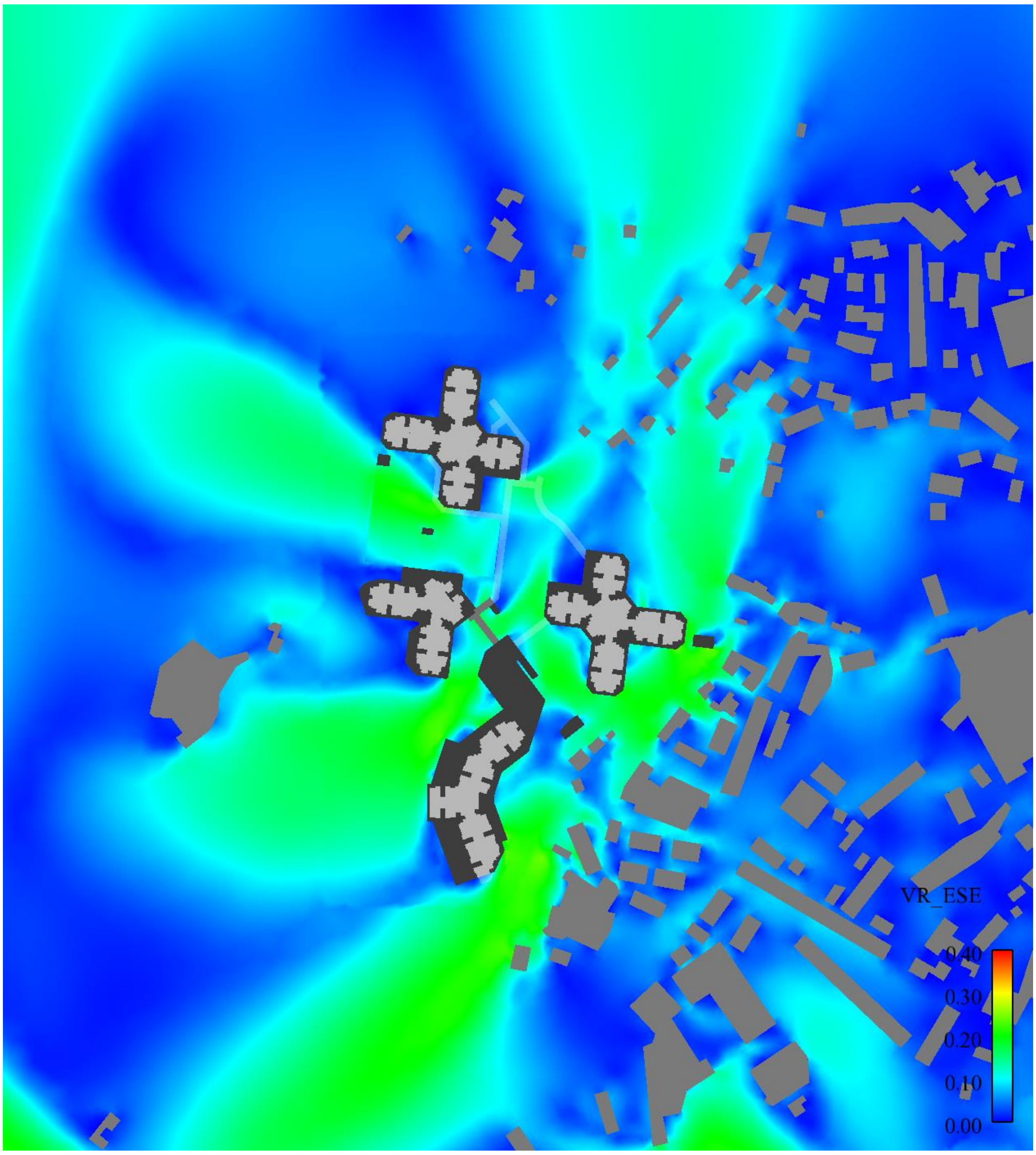


Figure B25 ESE Direction for Proposed Scheme under Scenario 3

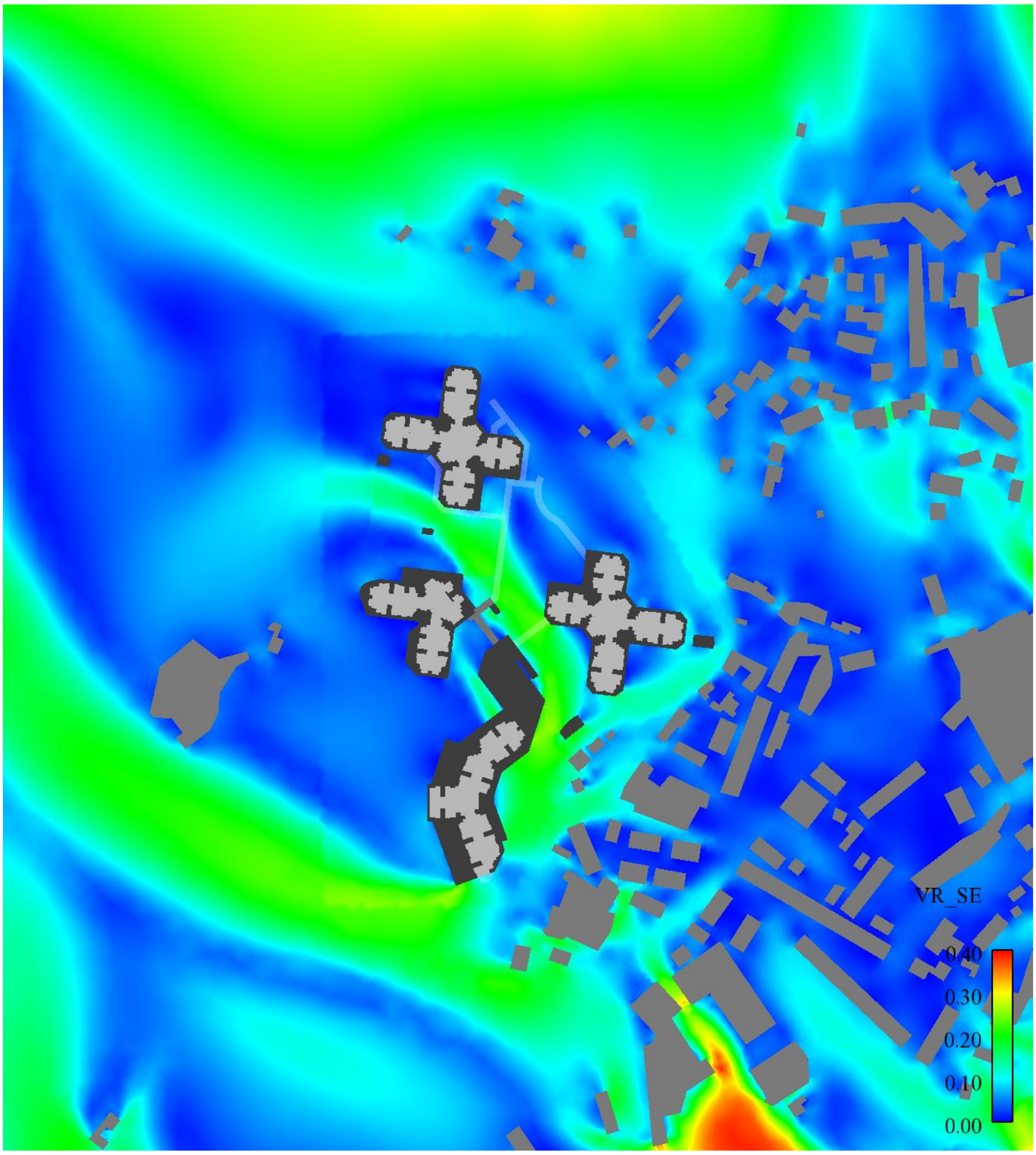


Figure B26 SE Direction for Proposed Scheme under Scenario 3

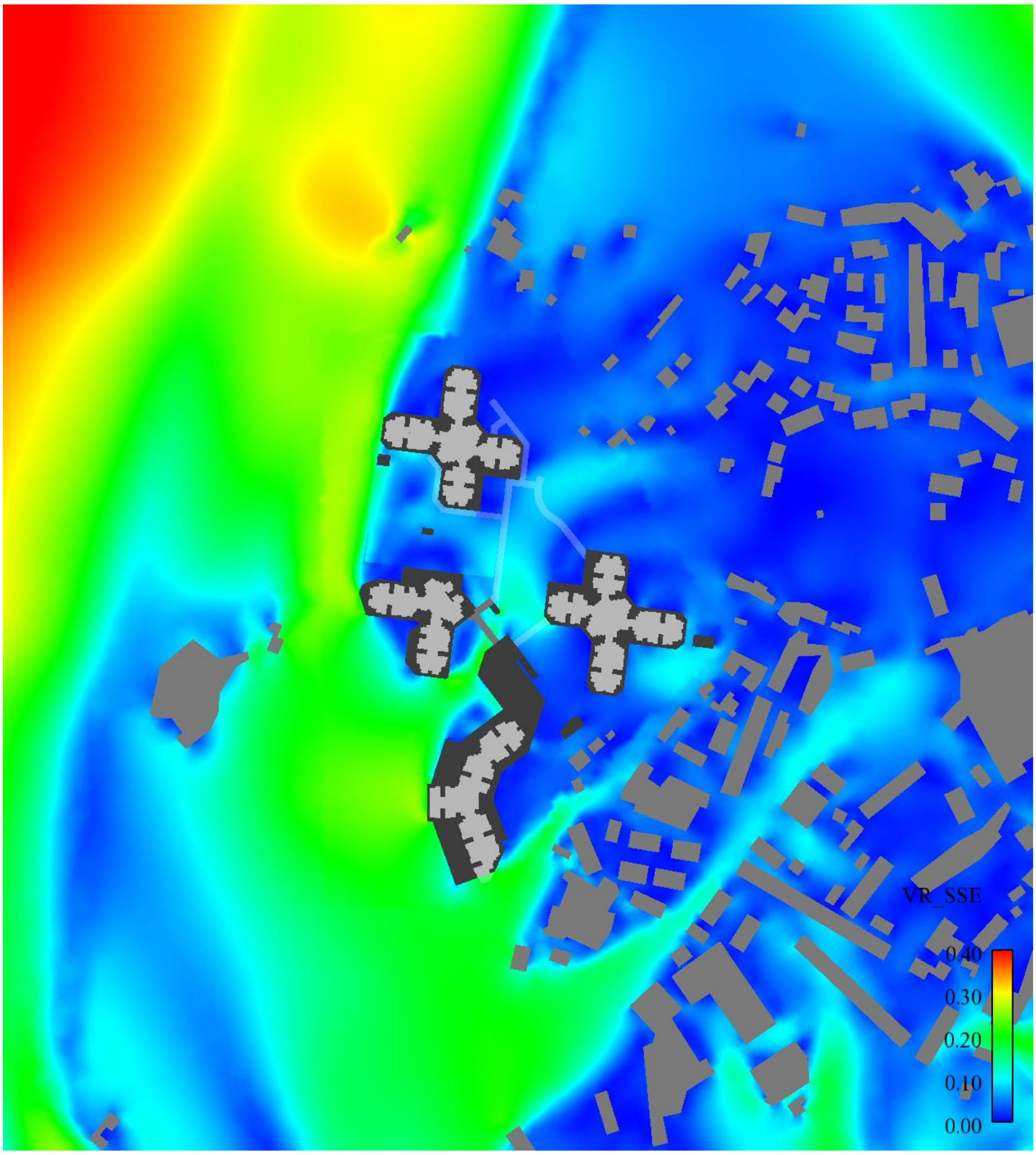


Figure B27 SSE Direction for Proposed Scheme under Scenario 3

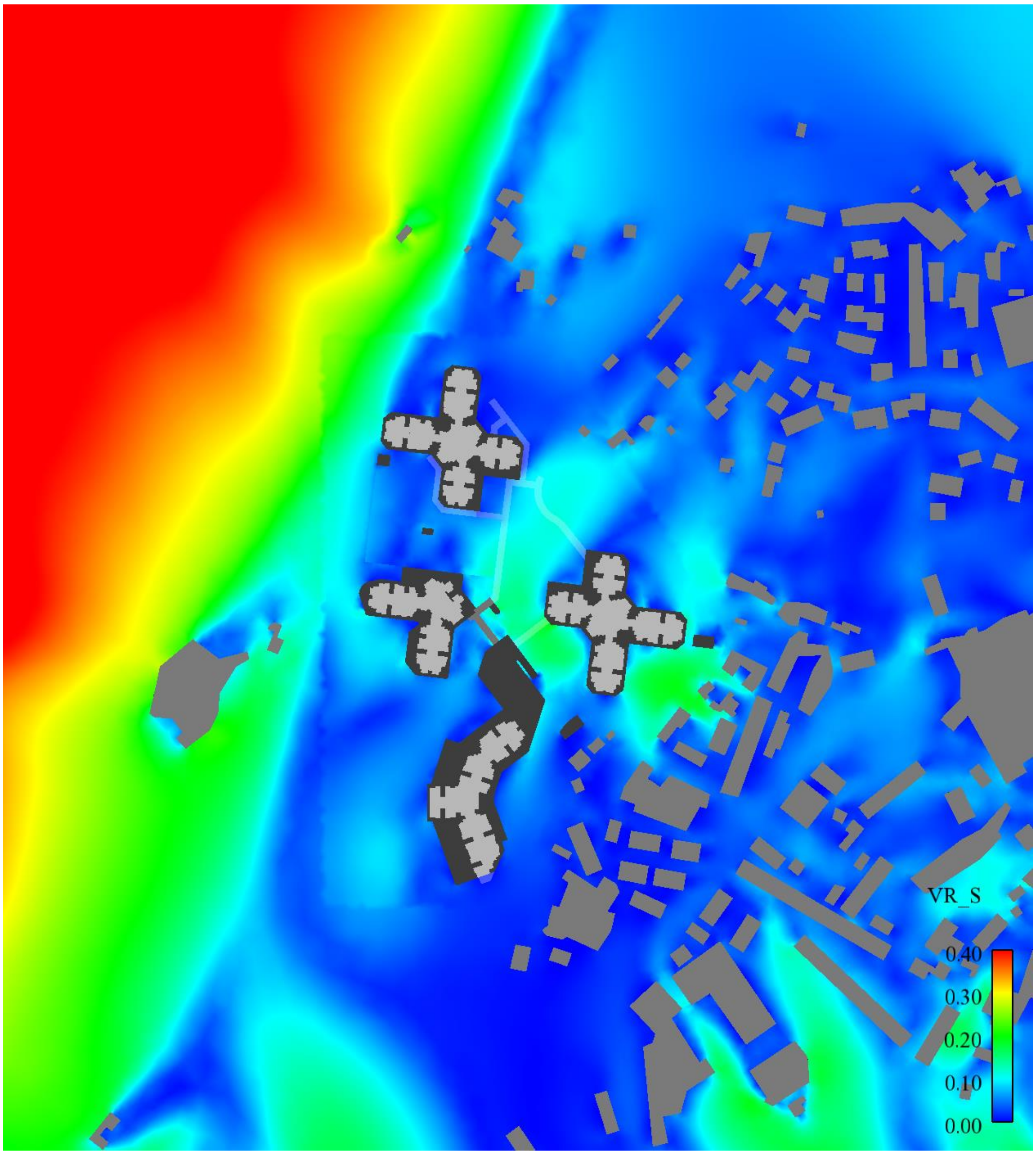


Figure B28 S Direction for Proposed Scheme under Scenario 3

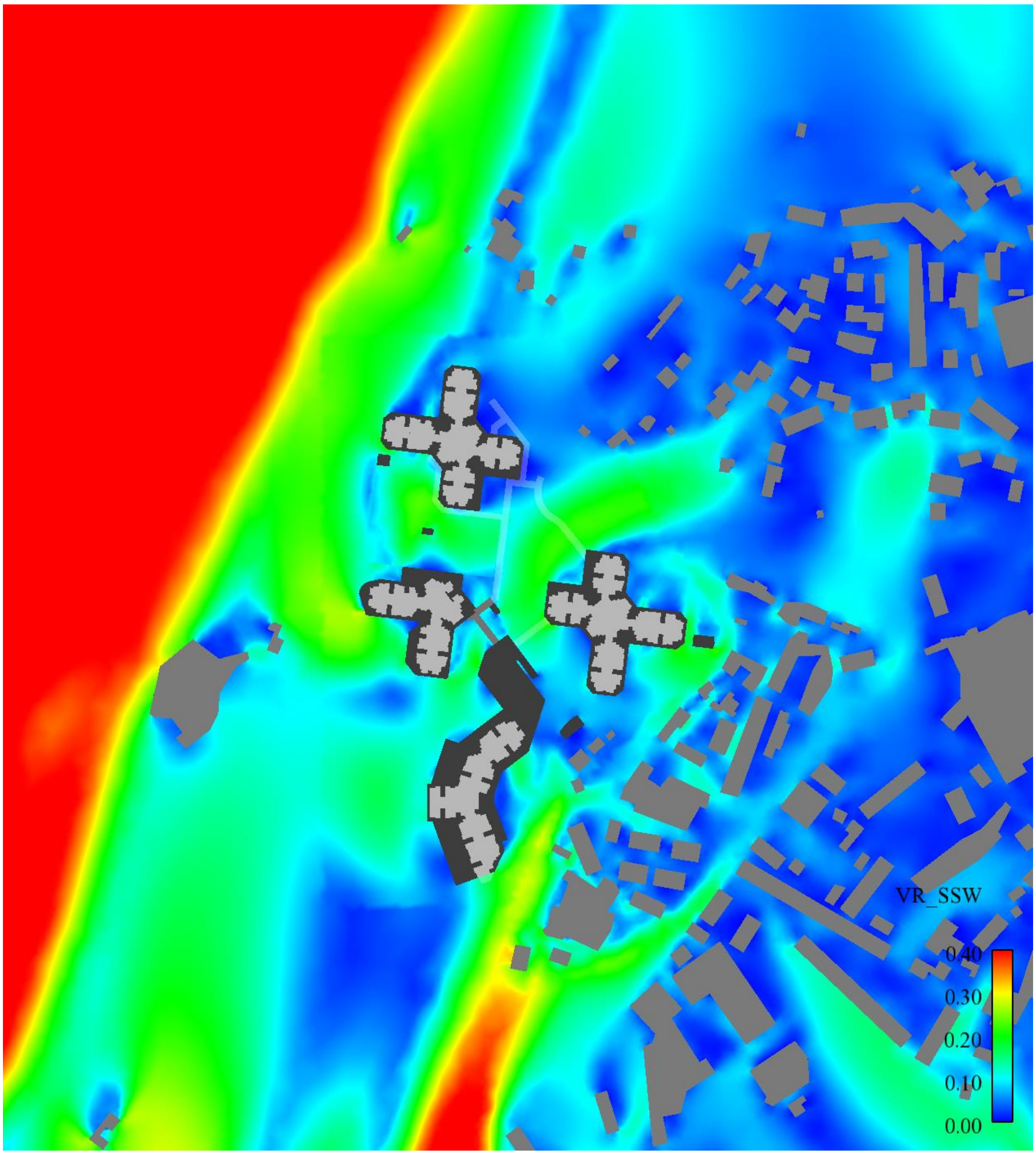


Figure B29 SSW Direction for Proposed Scheme under Scenario 3

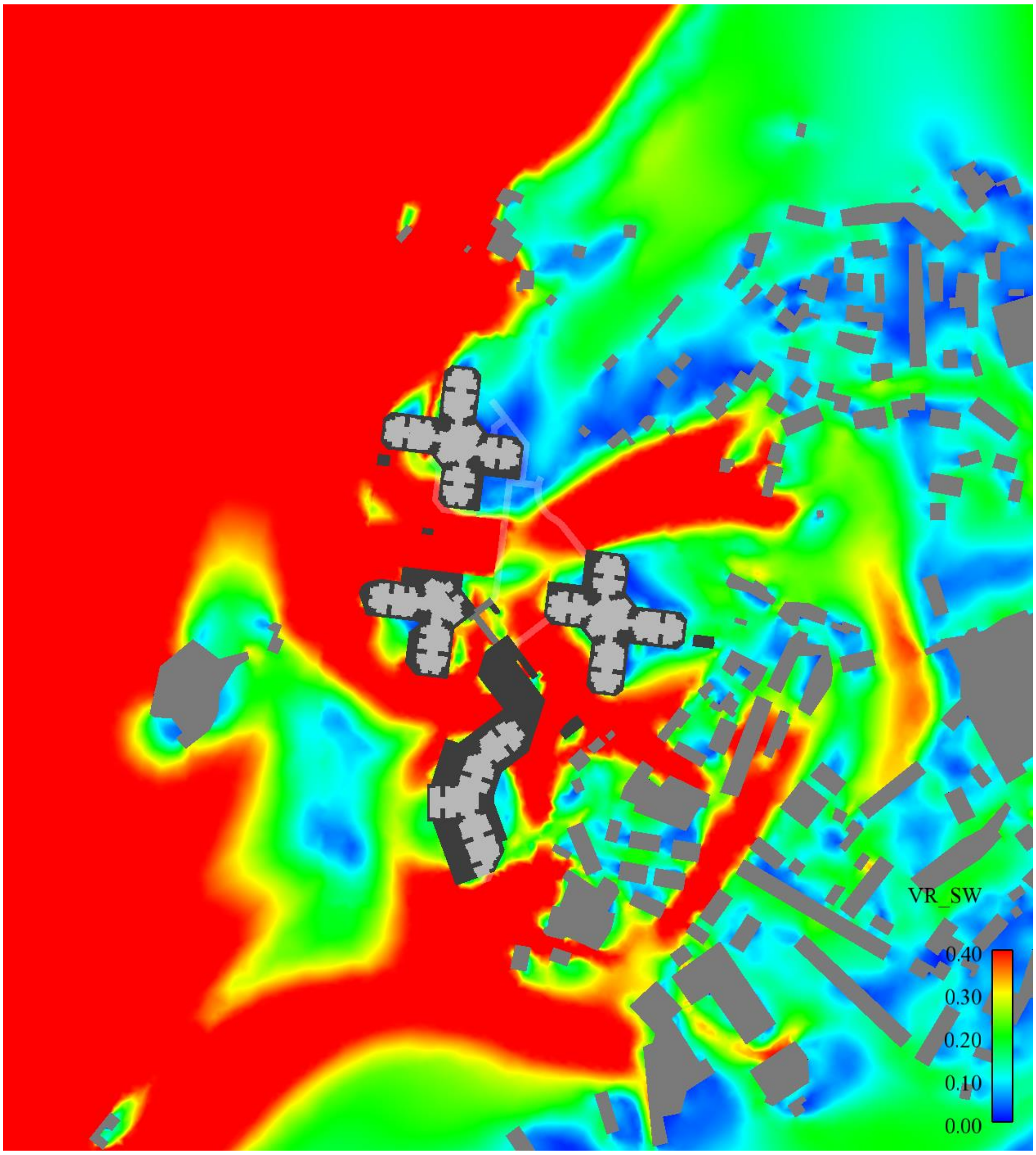


Figure B30 SW Direction for Proposed Scheme under Scenario 3

Appendix C

Directional VR Vector Plots

C1 Scenario 1

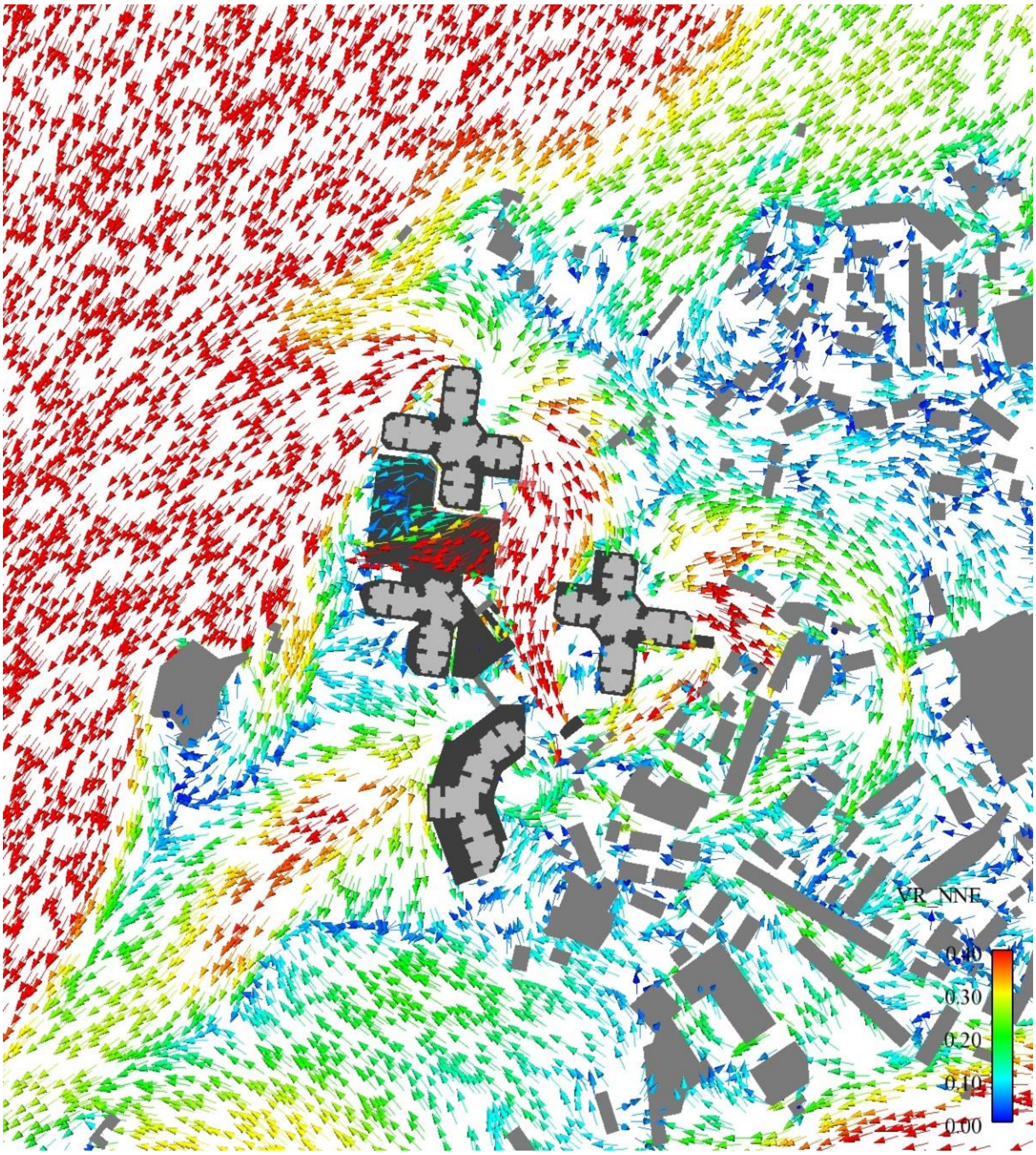


Figure C1 NNE Direction for Baseline Scheme under Scenario 1

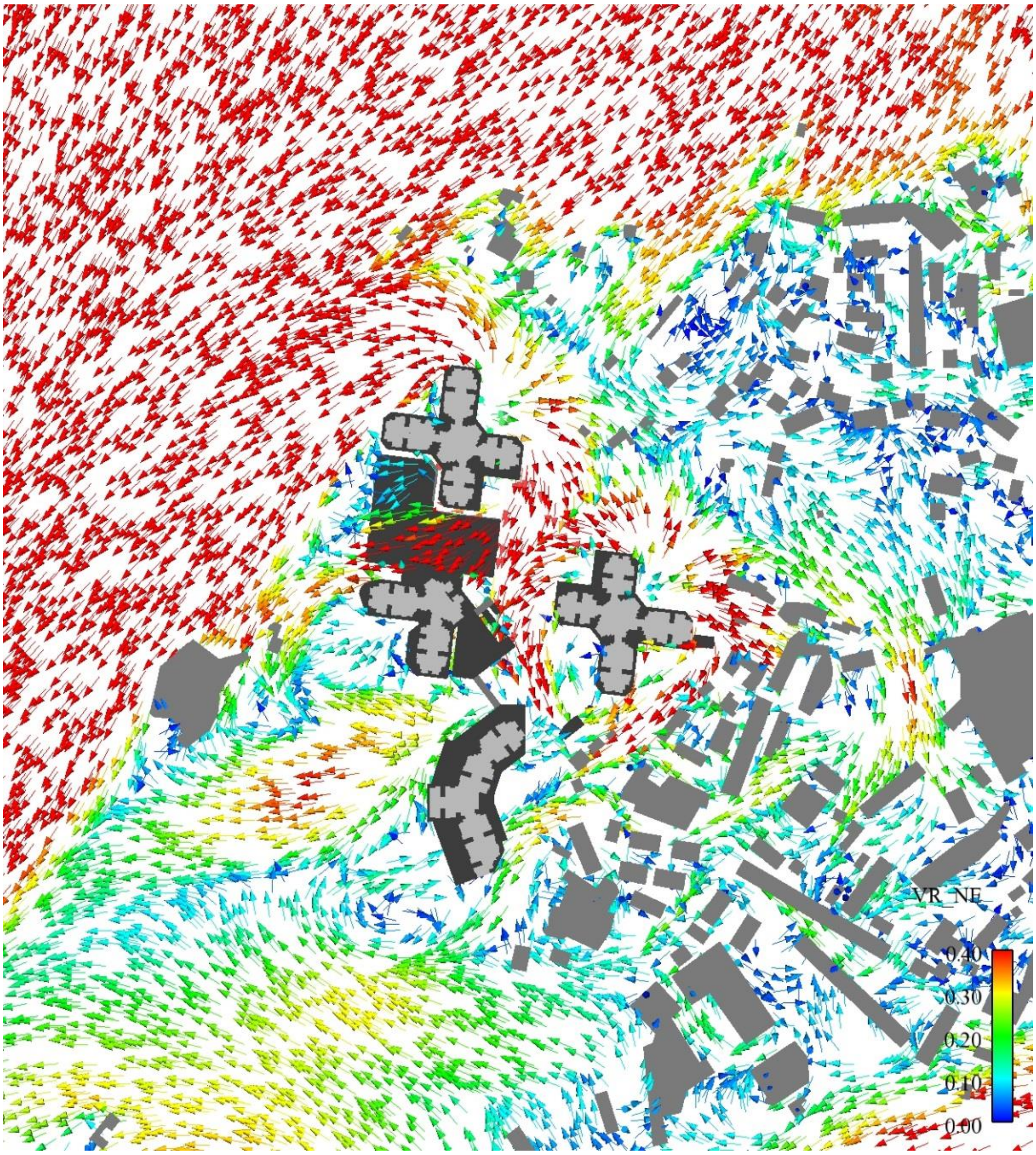


Figure C2 NE Direction for Baseline Scheme under Scenario 1

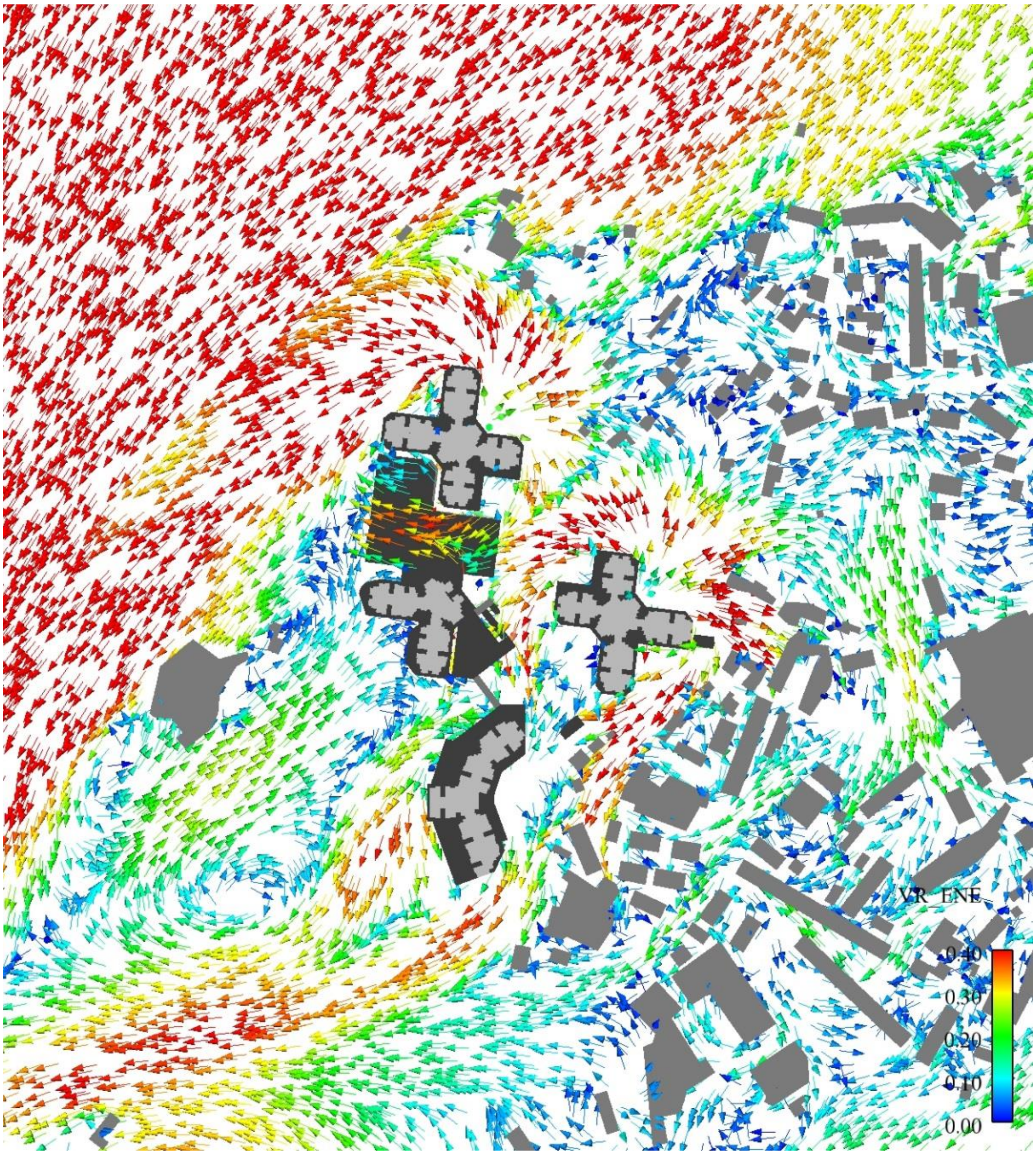


Figure C3 ENE Direction for Baseline Scheme under Scenario 1

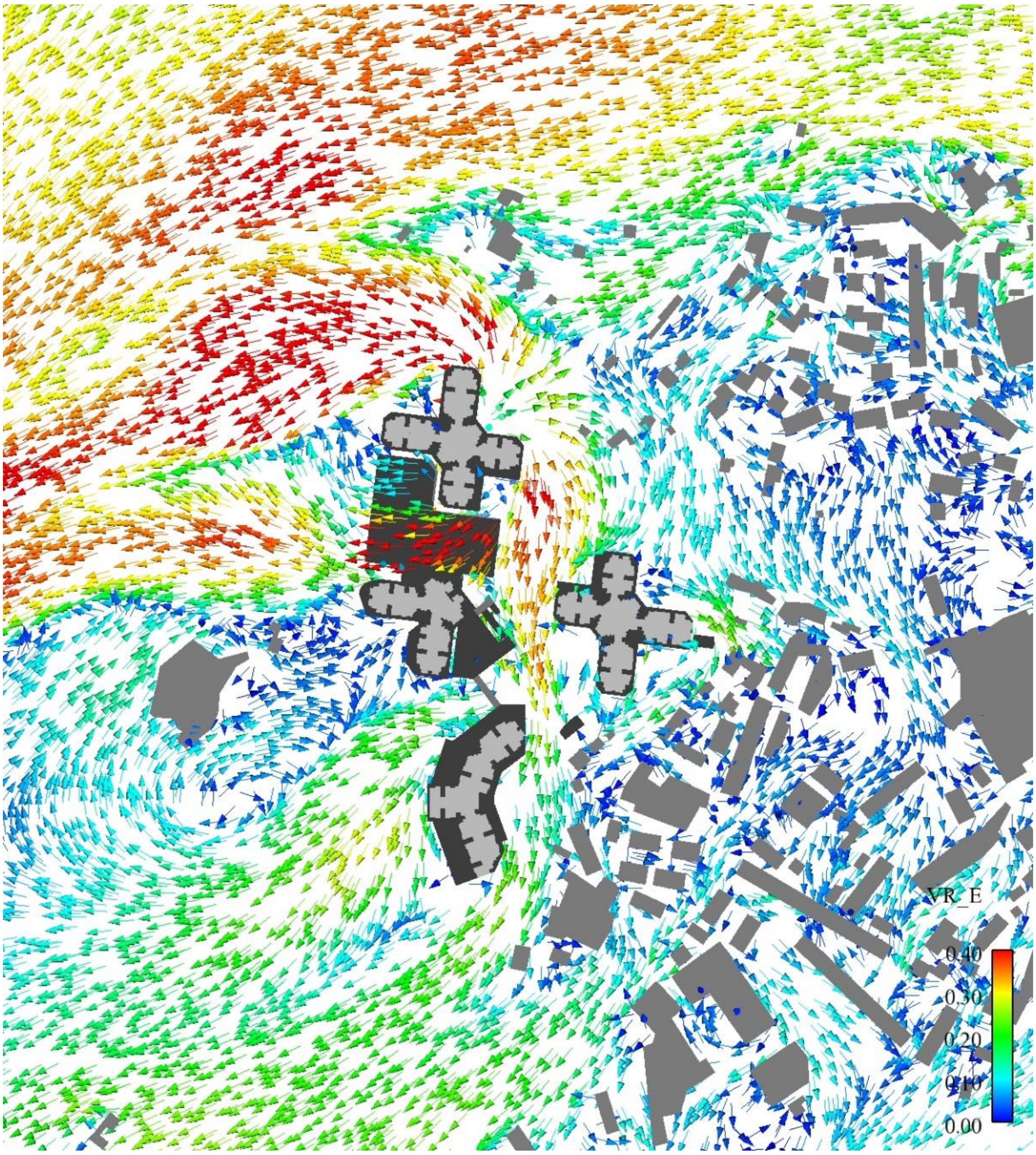


Figure C4 E Direction for Baseline Scheme under Scenario 1

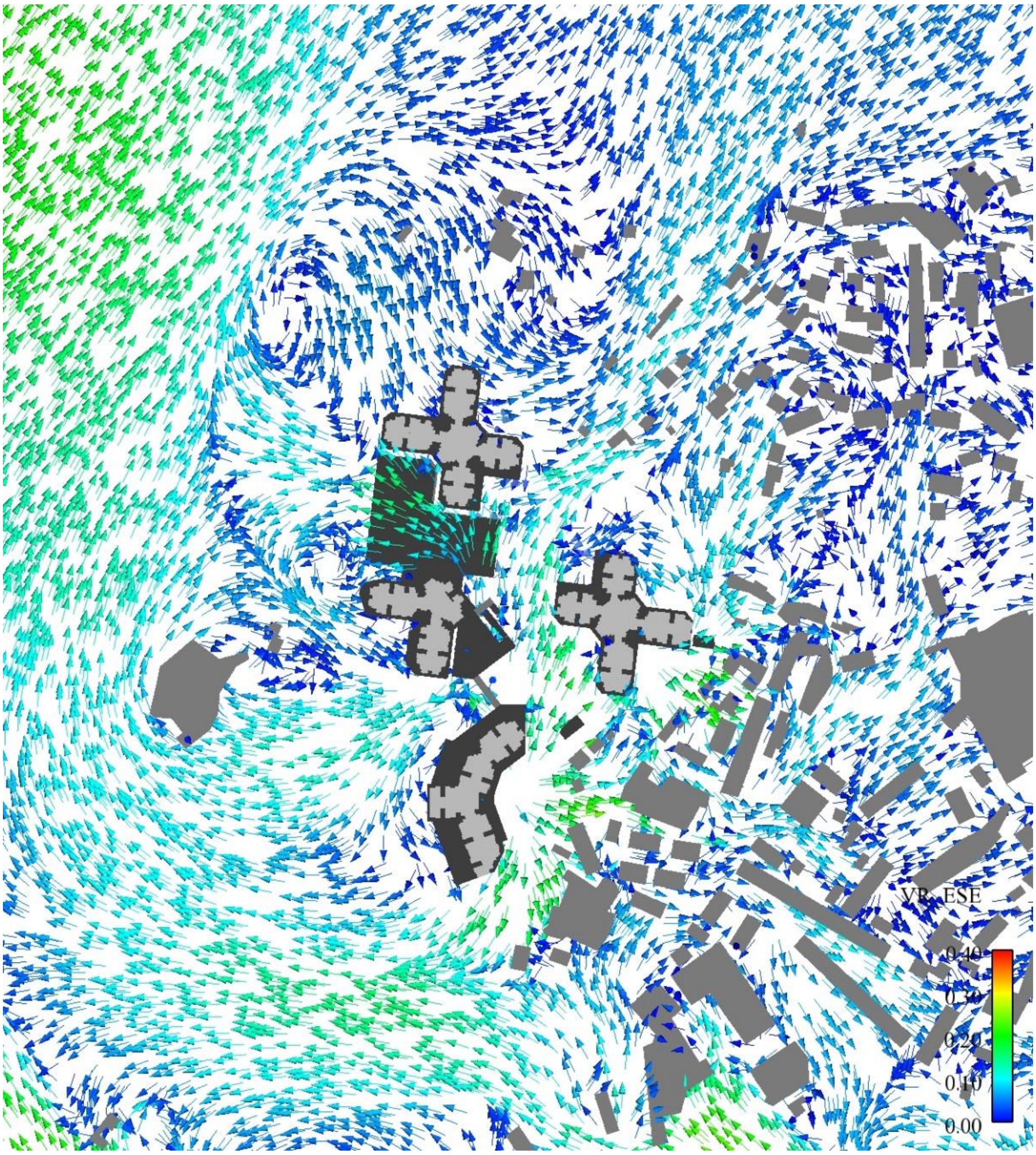


Figure C5 ESE Direction for Baseline Scheme under Scenario 1

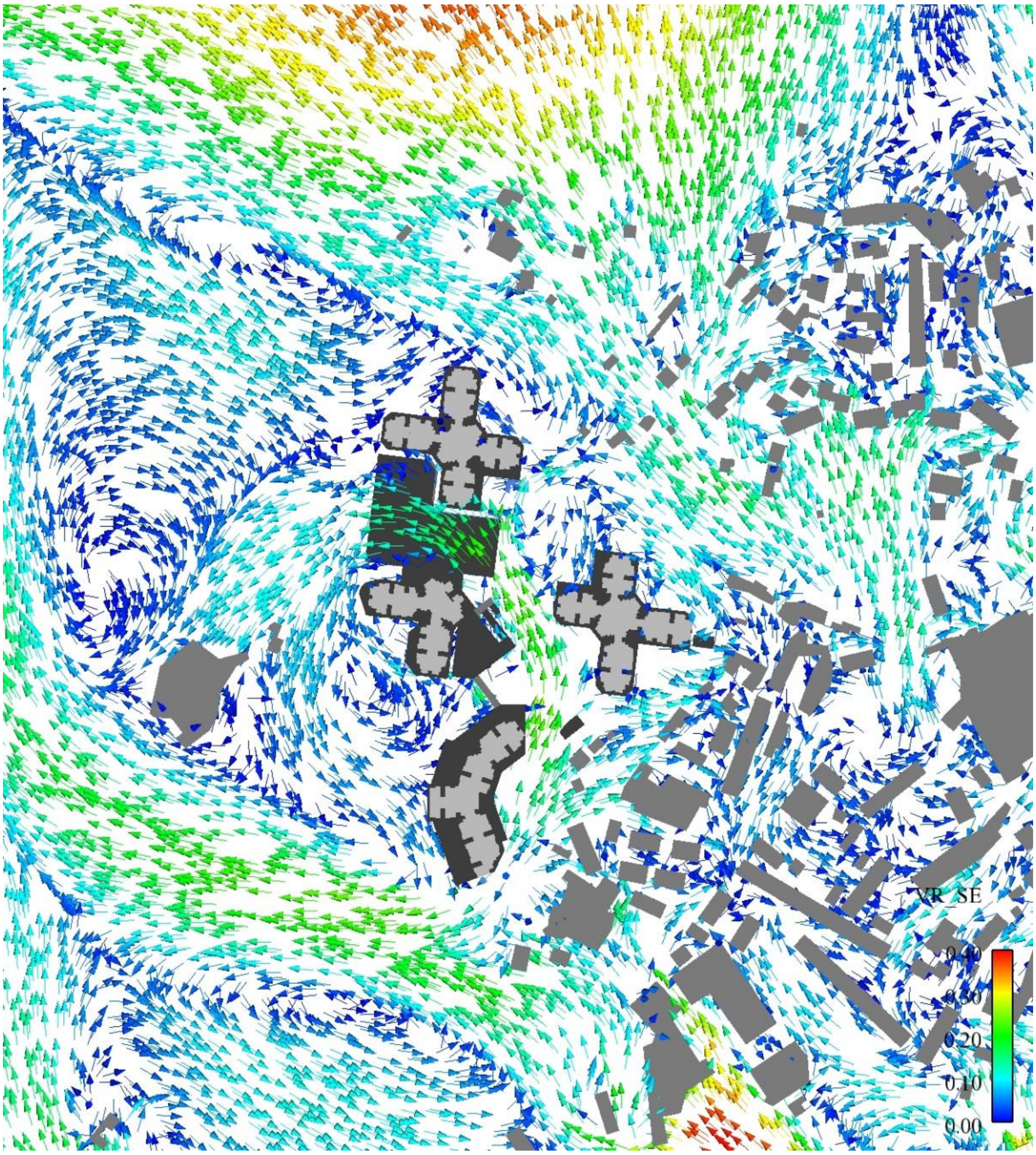


Figure C6 SE Direction for Baseline Scheme under Scenario 1

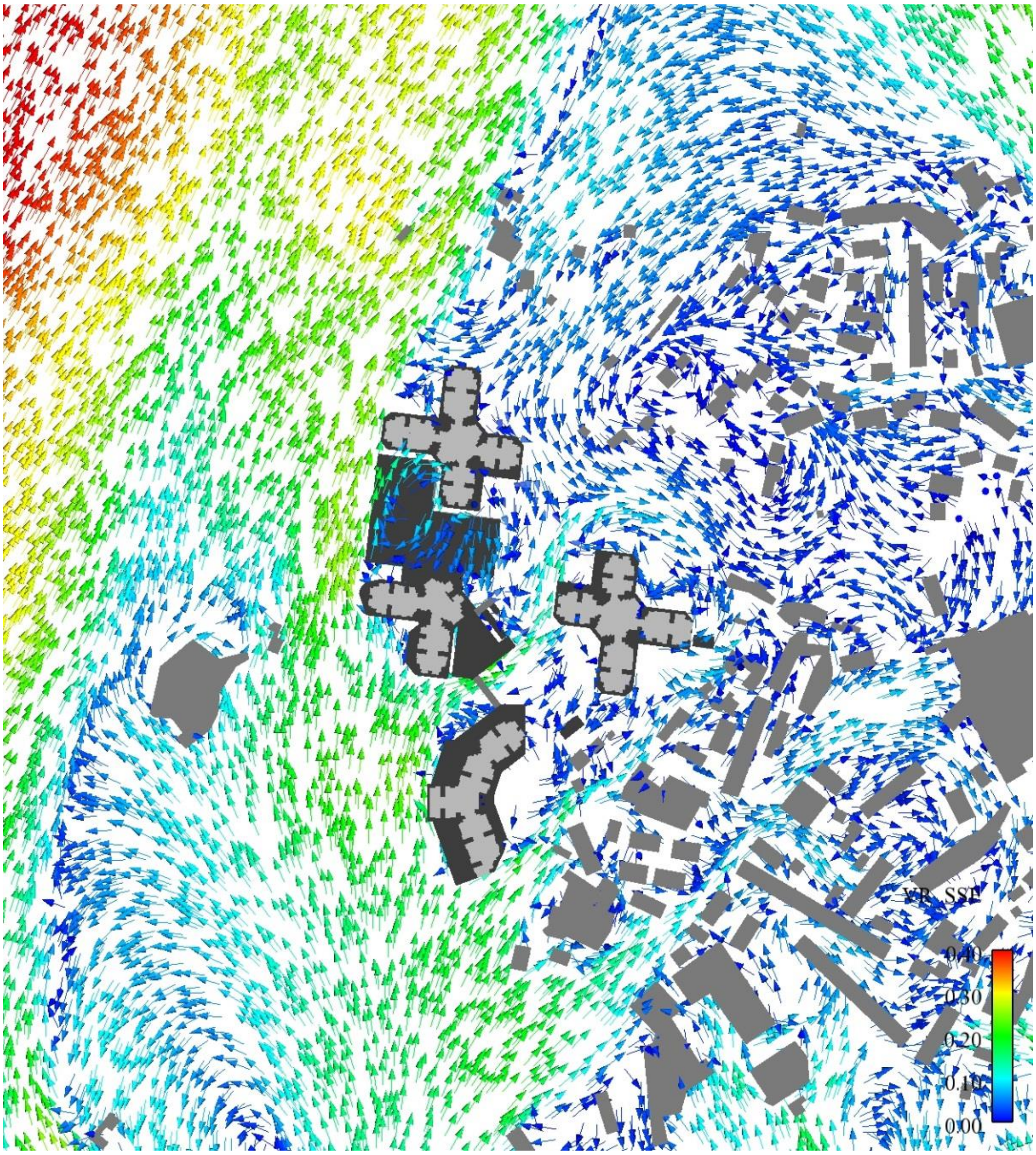


Figure C7 SSE Direction for Baseline Scheme under Scenario 1

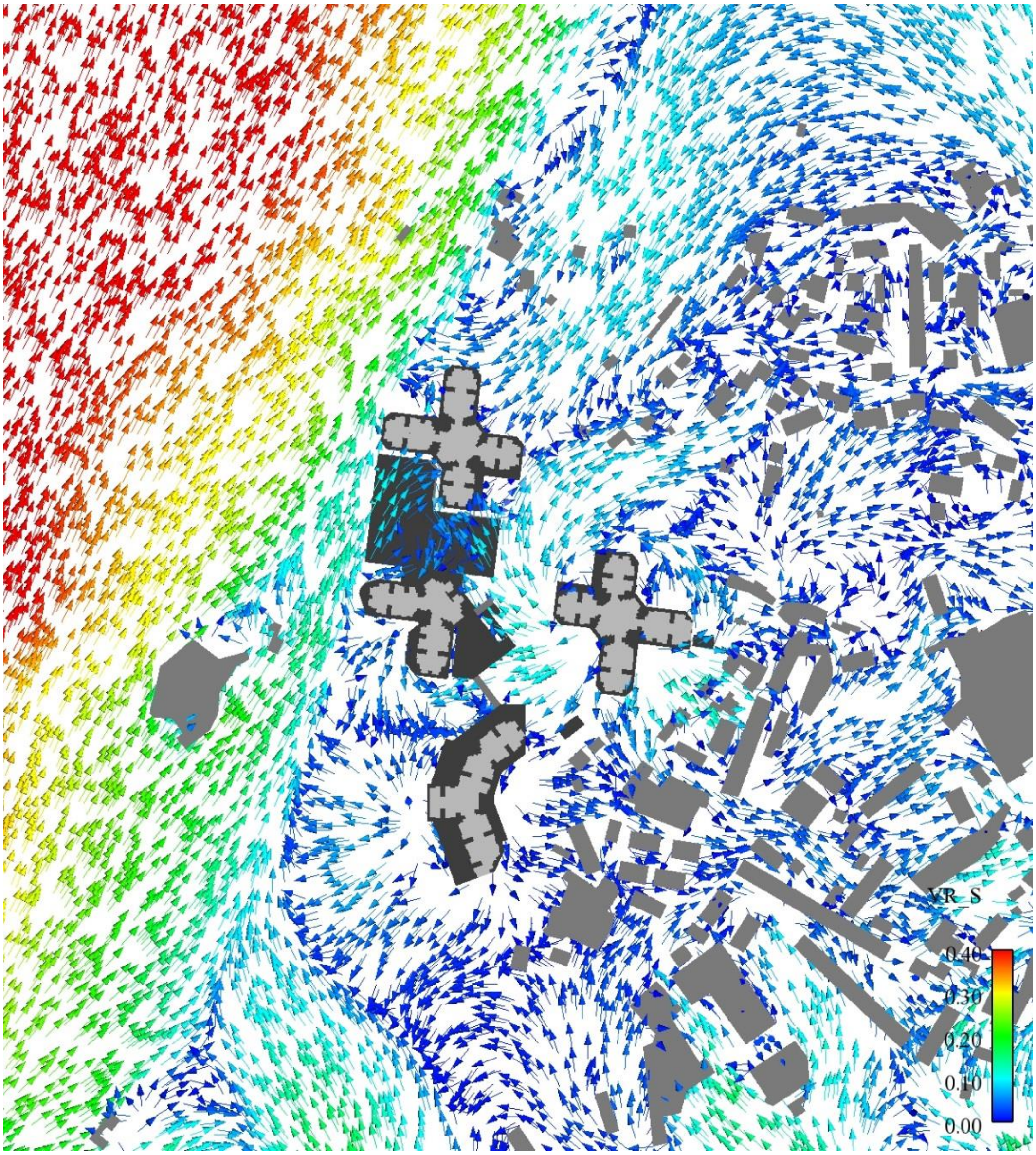


Figure C8 S Direction for Baseline Scheme under Scenario 1

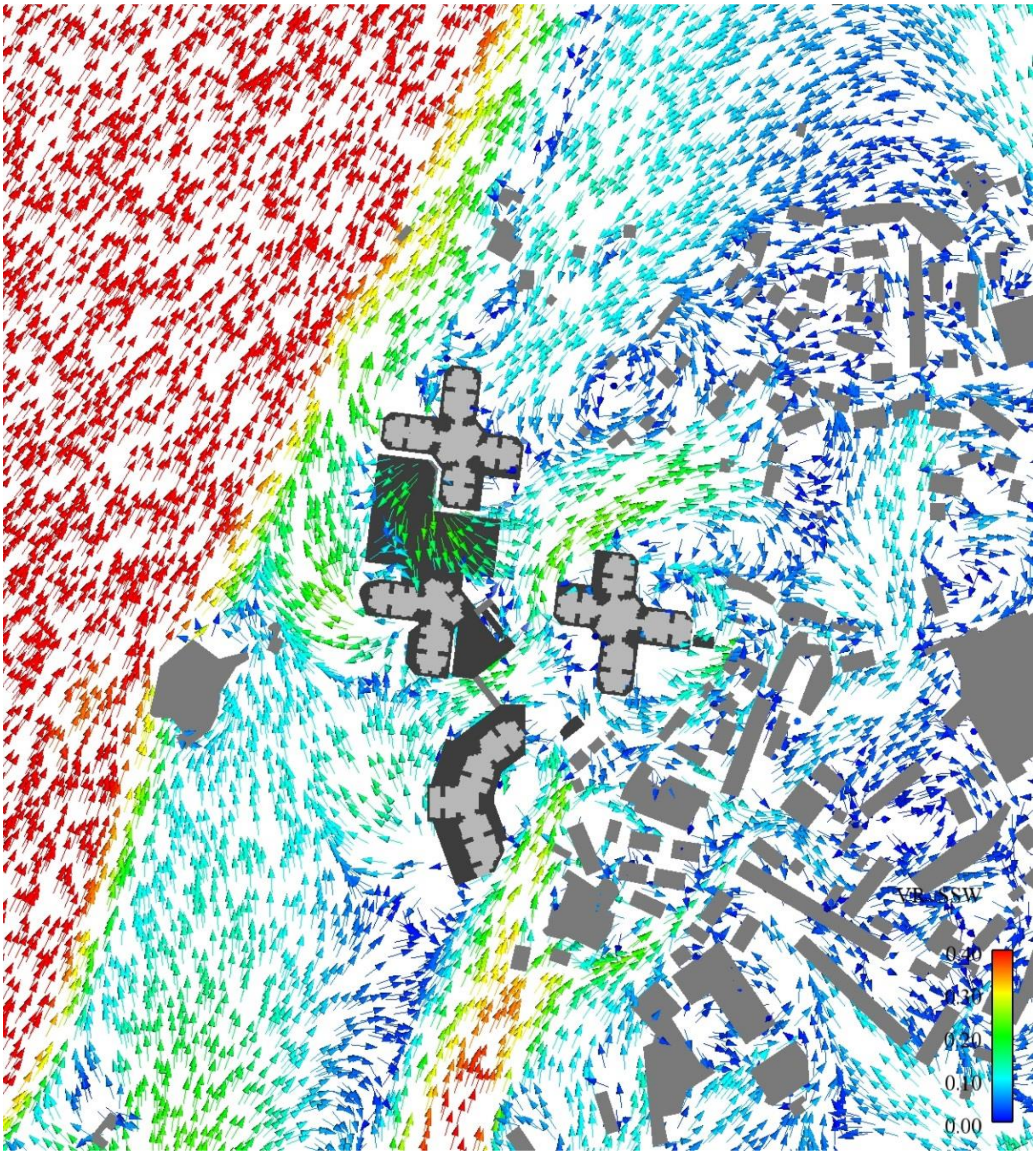


Figure C9 SSW Direction for Baseline Scheme under Scenario 1

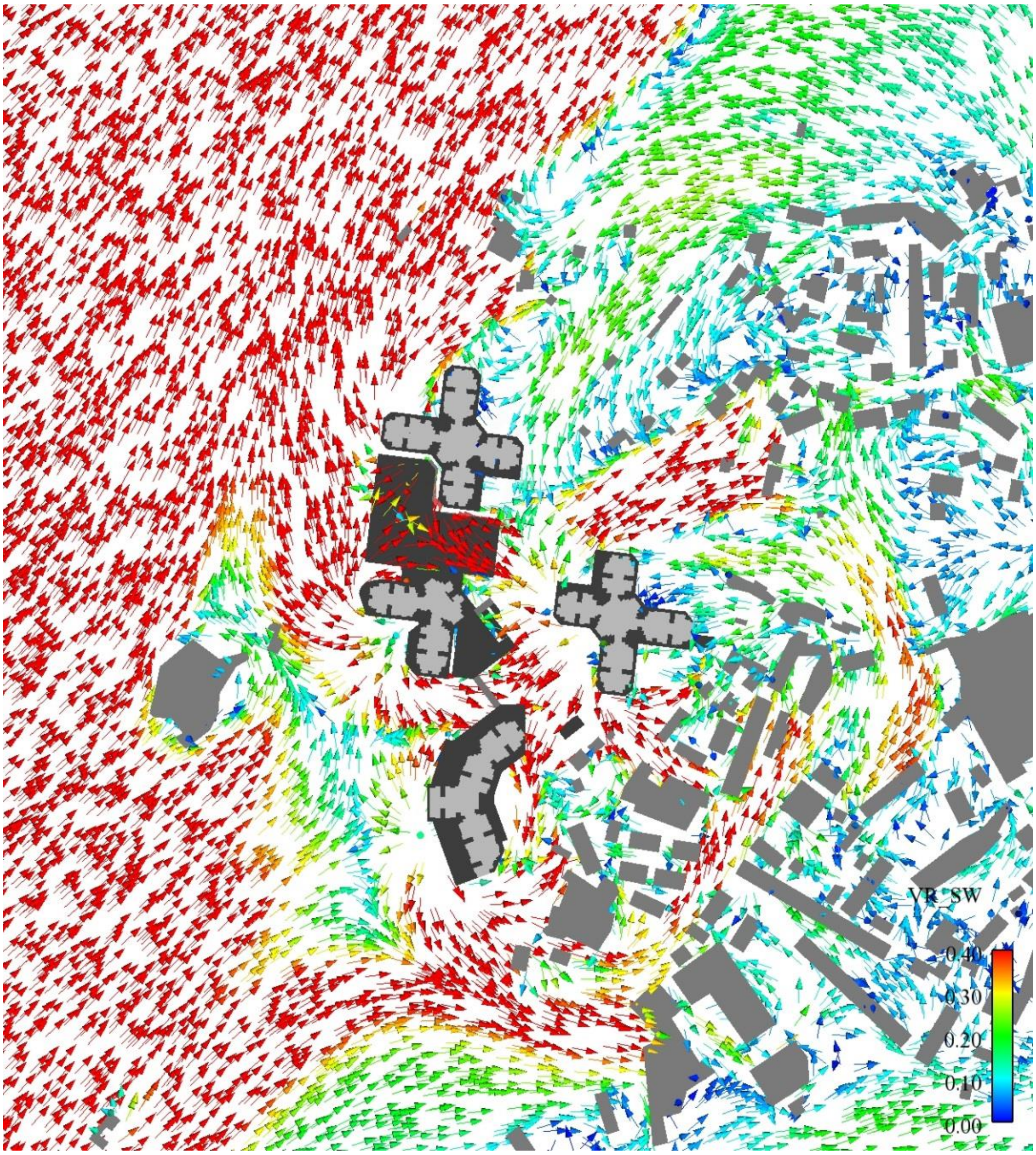


Figure C10 SW Direction for Baseline Scheme under Scenario 1

C2 Scenario 2

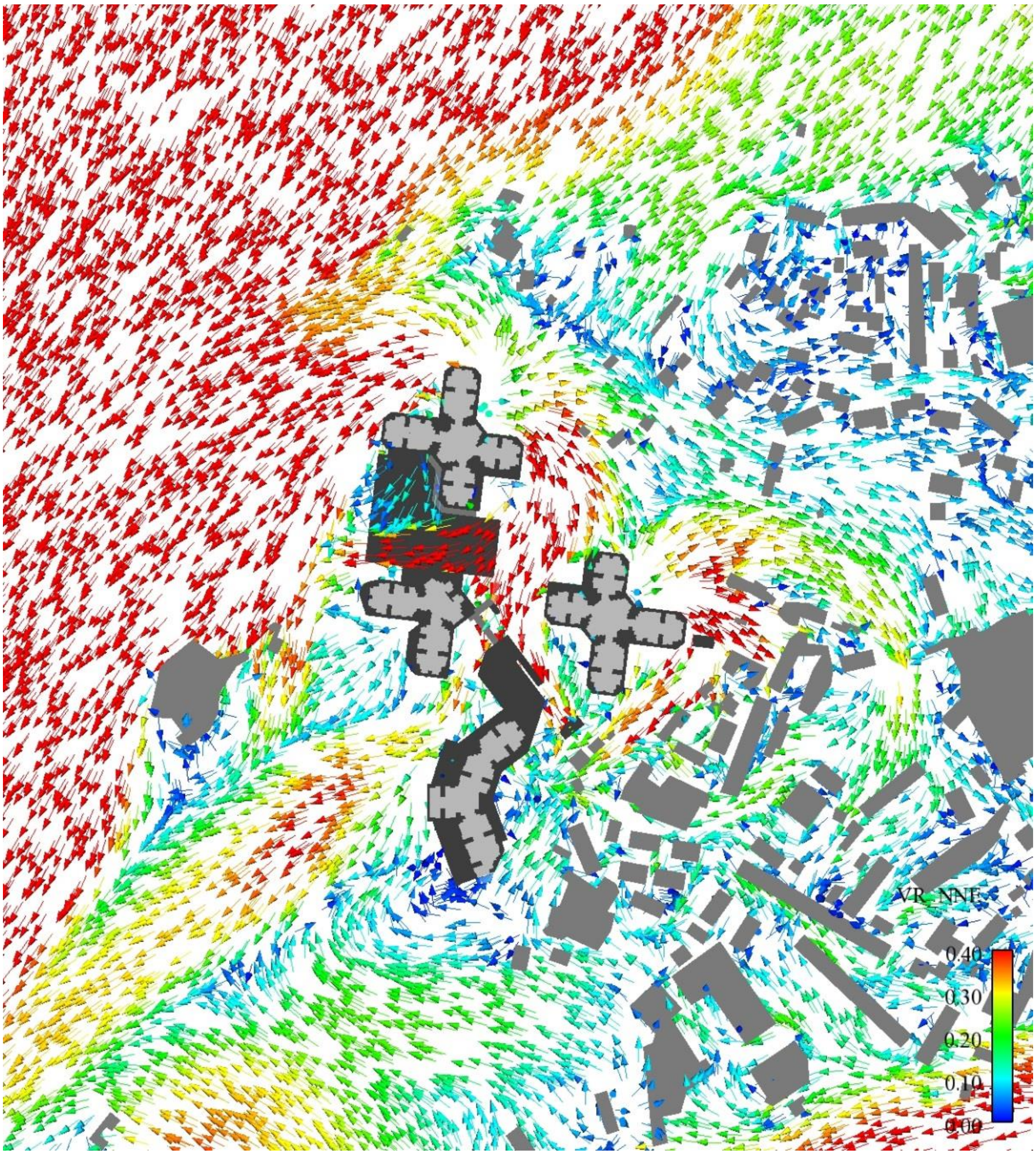


Figure C11 NNE Direction for Proposed Scheme under Scenario 2

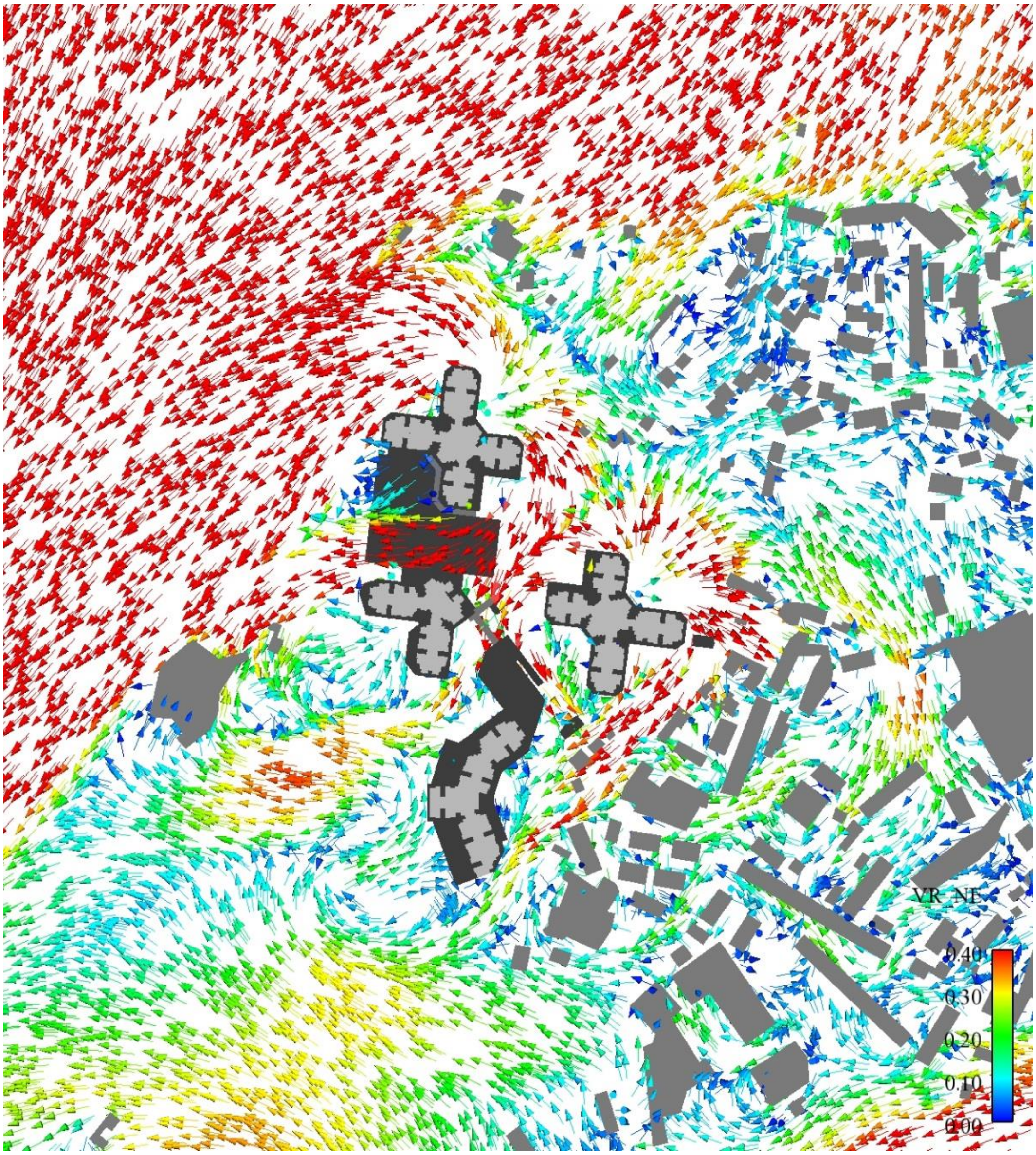


Figure C12 NE Direction for Proposed Scheme under Scenario 2

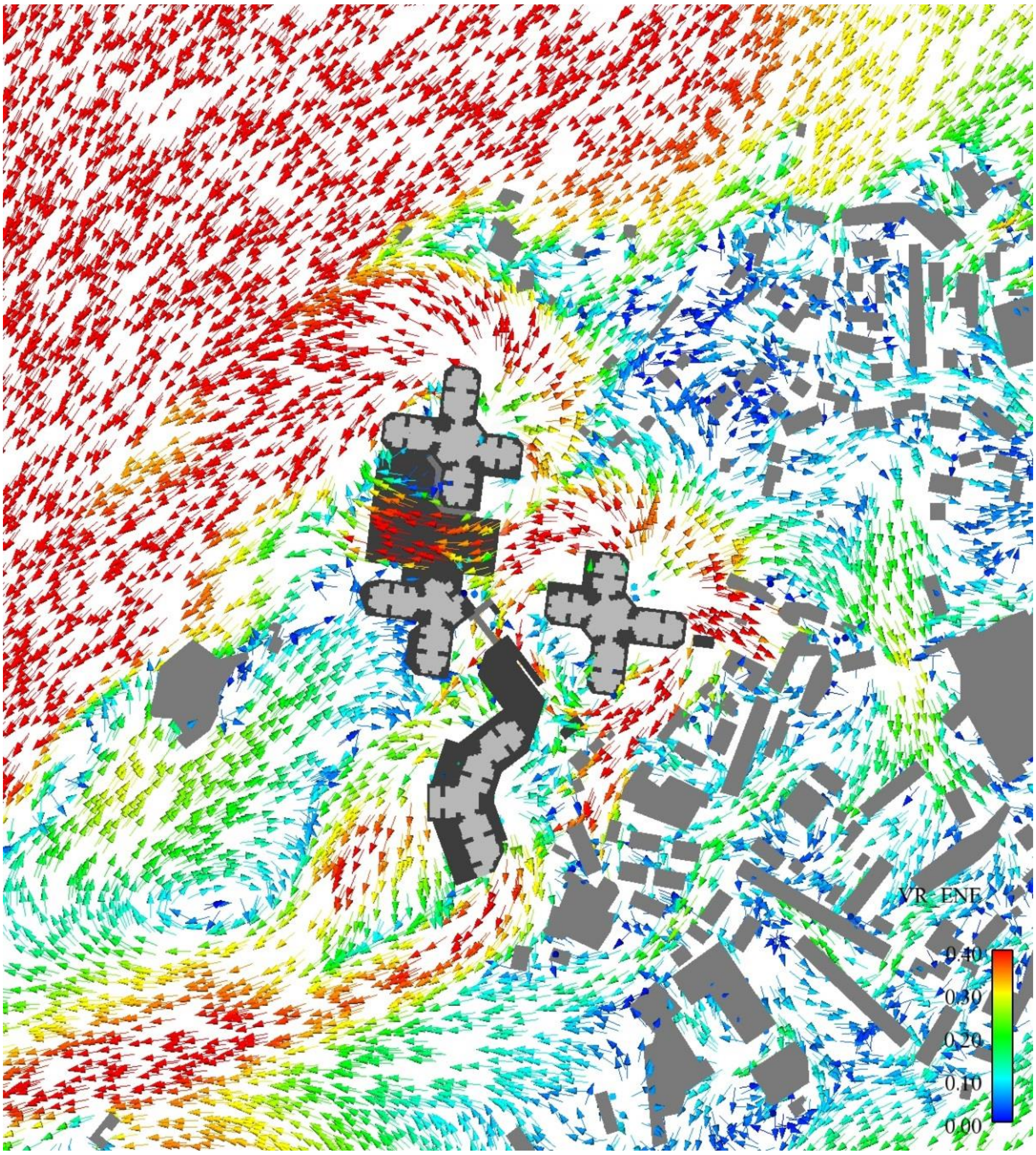


Figure C13 ENE Direction for Proposed Scheme under Scenario 2

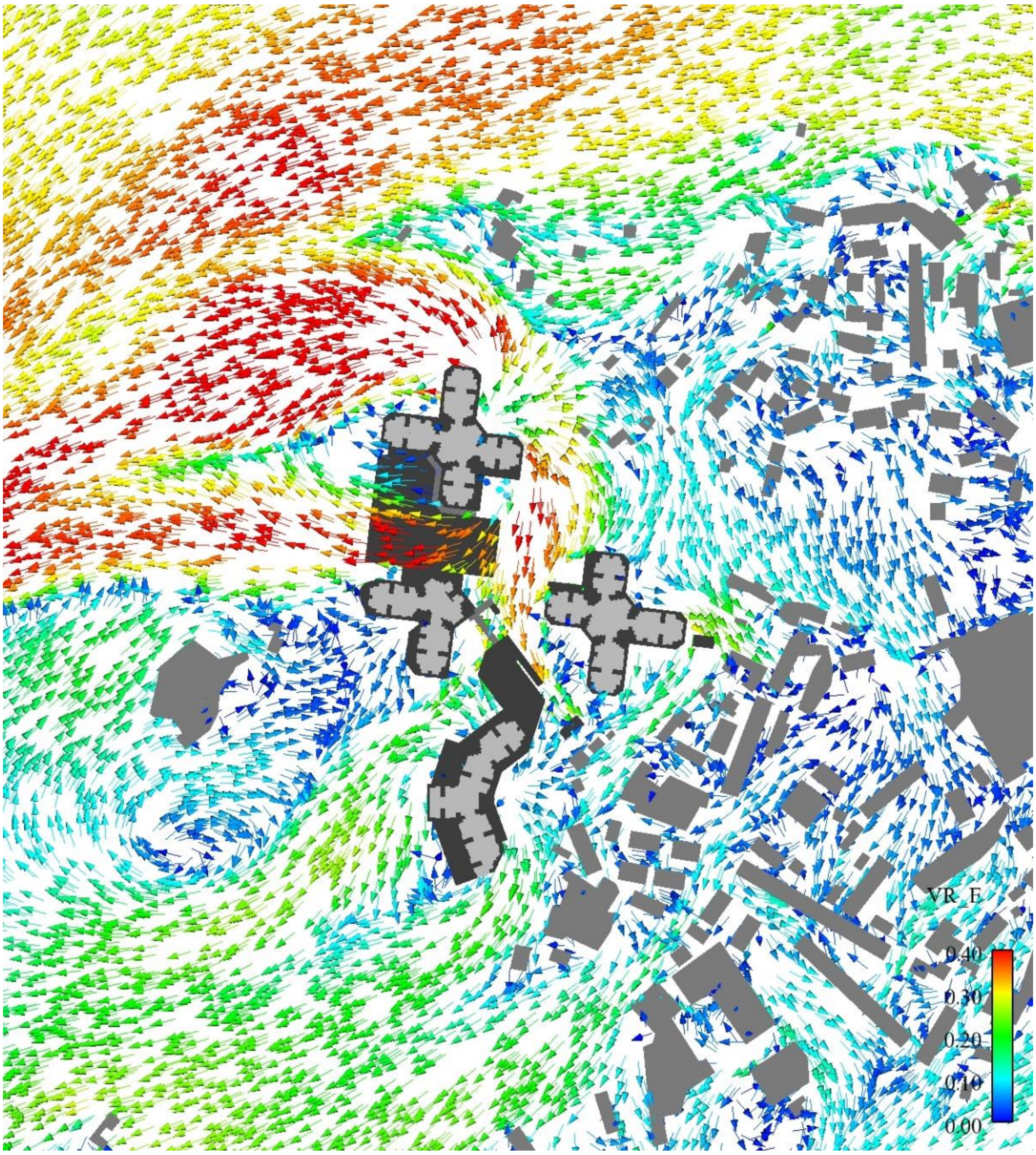


Figure C14 E Direction for Proposed Scheme under Scenario 2

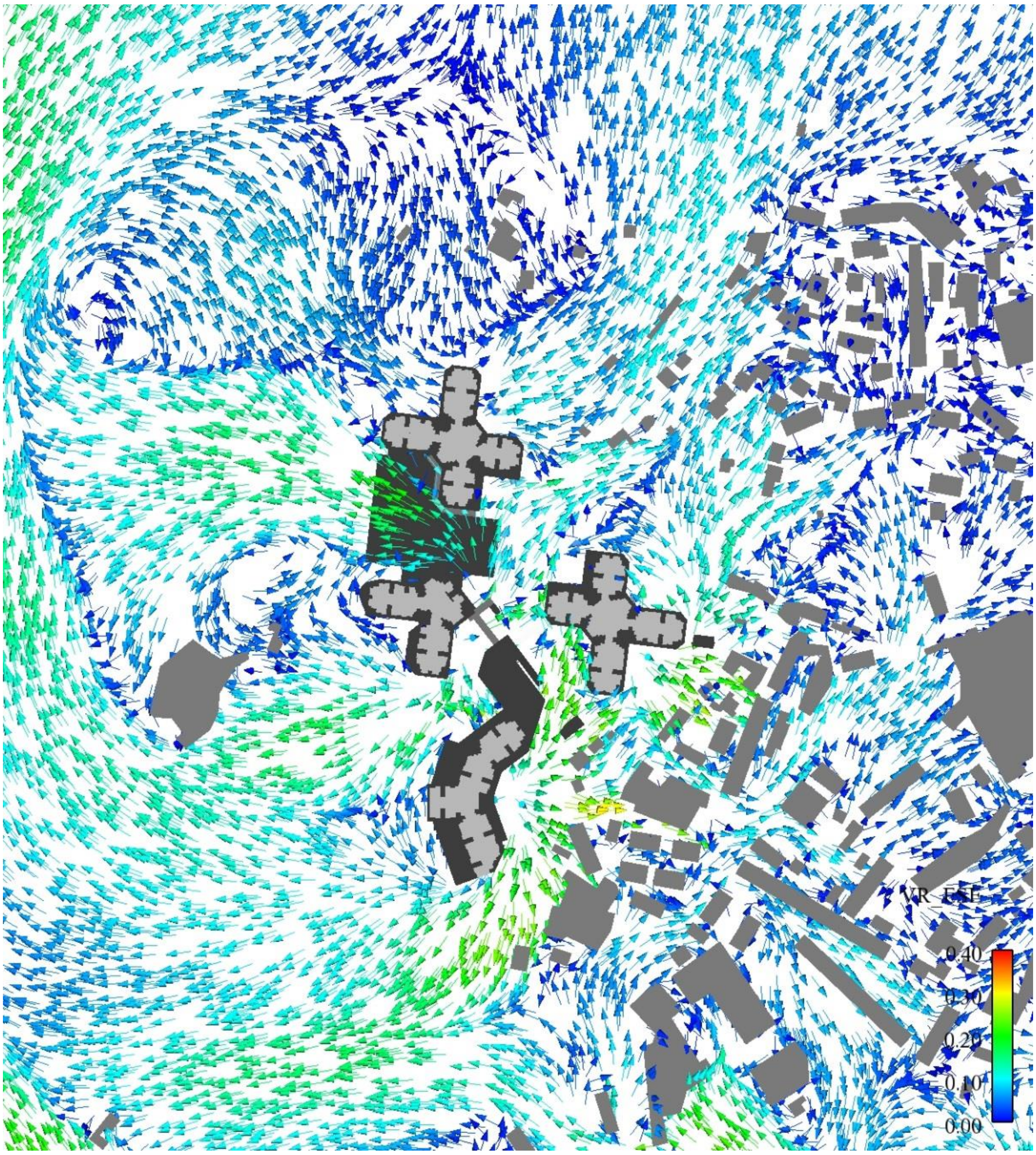


Figure C15 ESE Direction for Proposed Scheme under Scenario 2

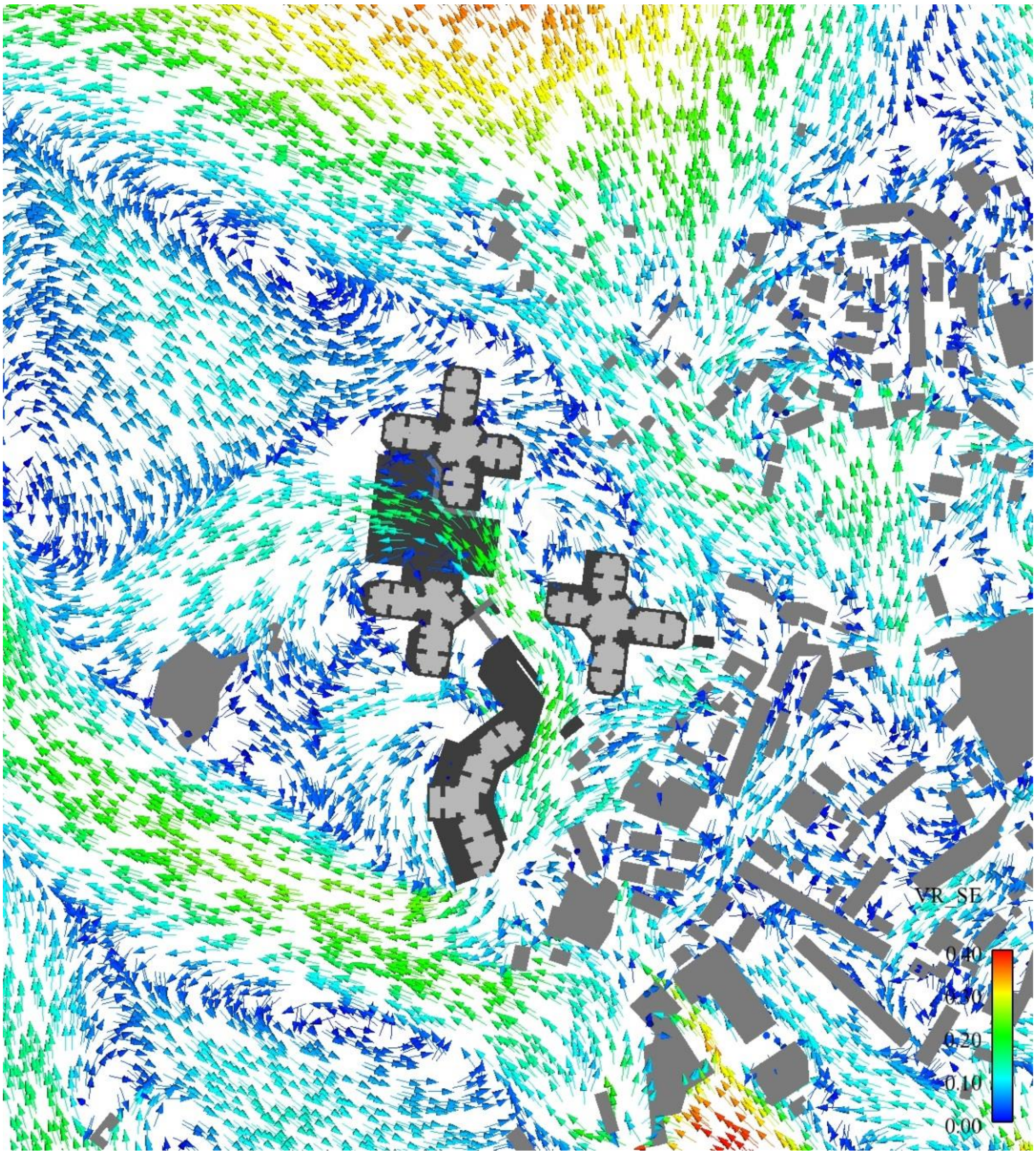


Figure C16 SE Direction for Proposed Scheme under Scenario 2

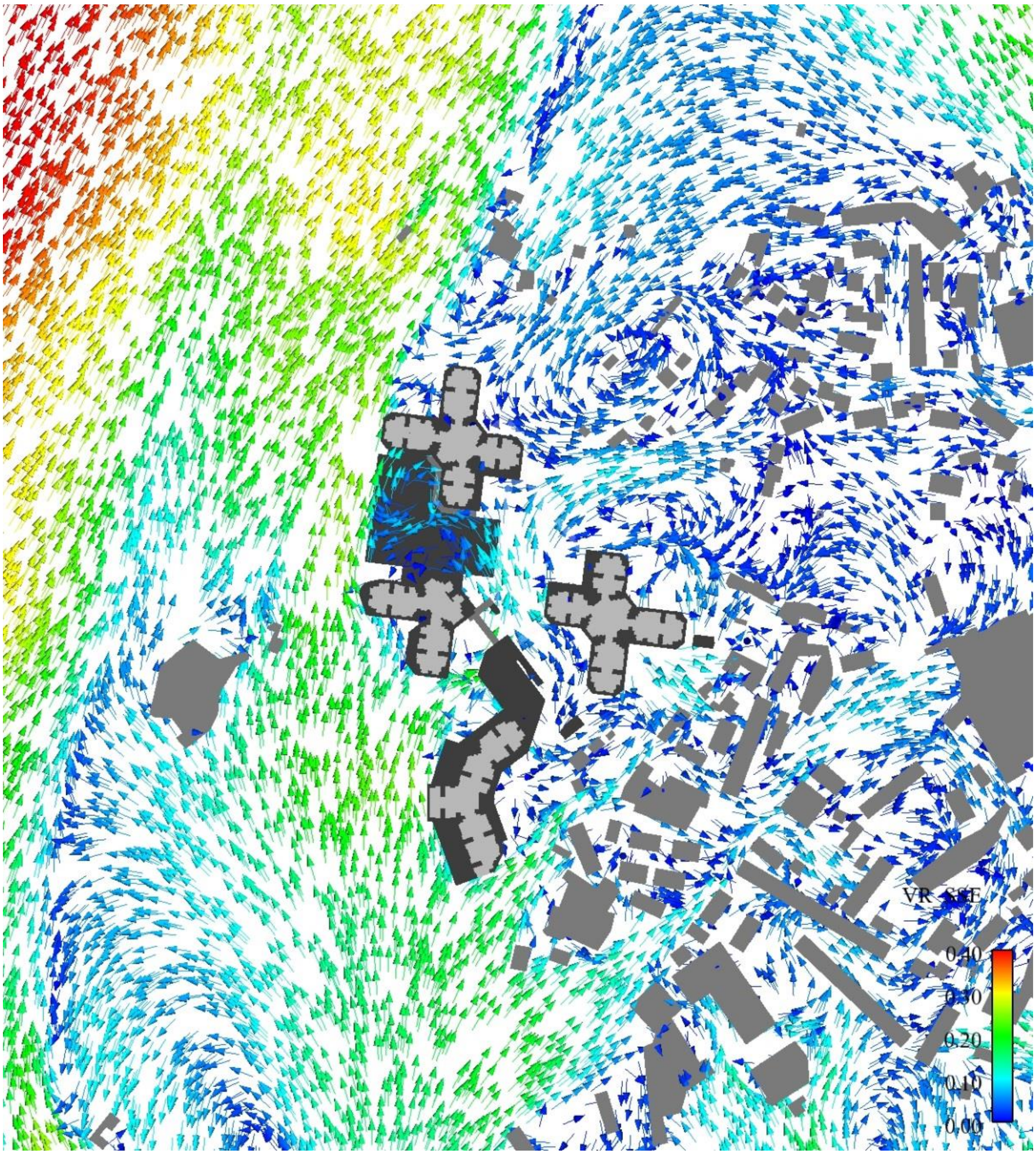


Figure C17 SSE Direction for Proposed Scheme under Scenario 2

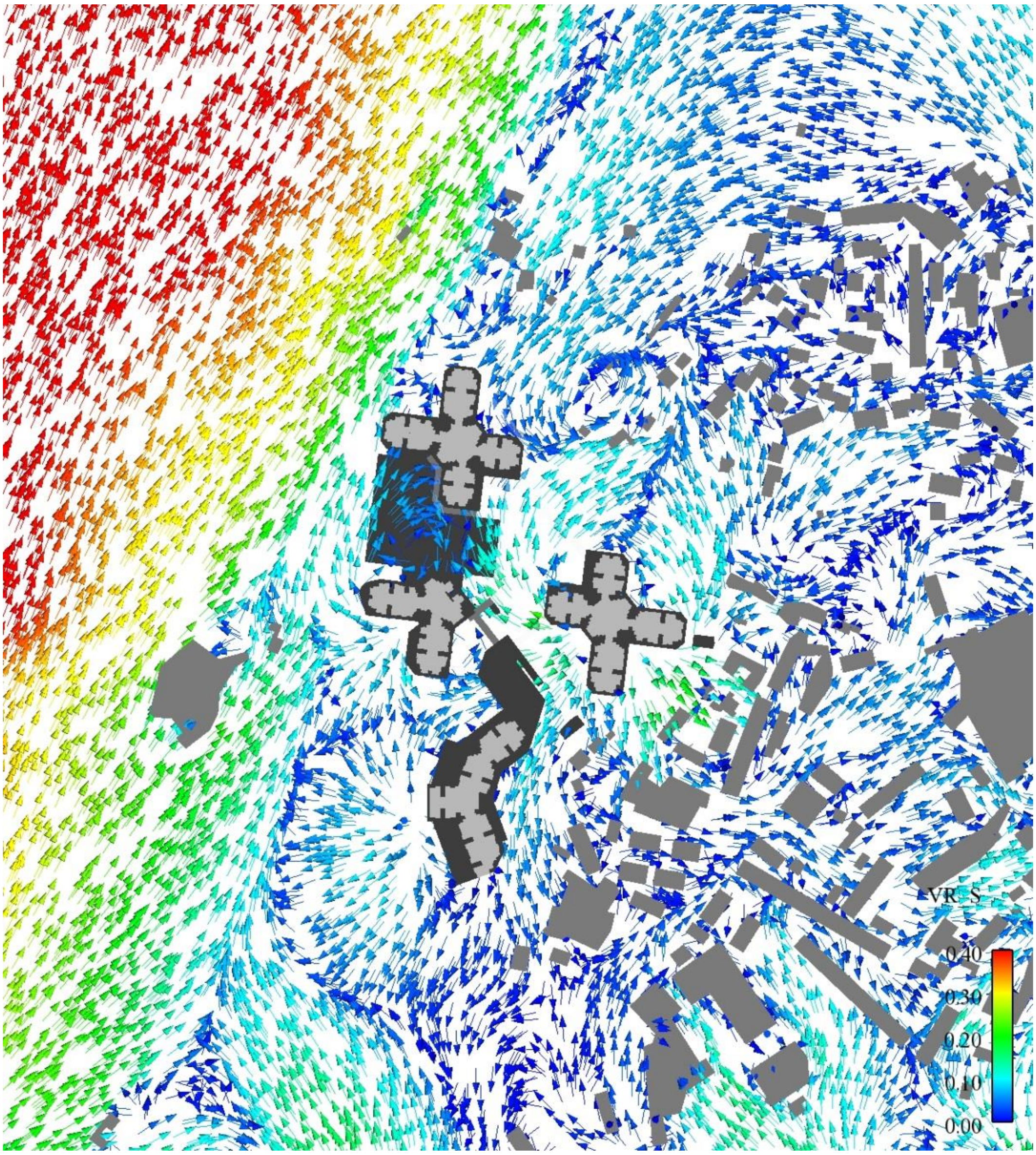


Figure C18 S Direction for Proposed Scheme under Scenario 2

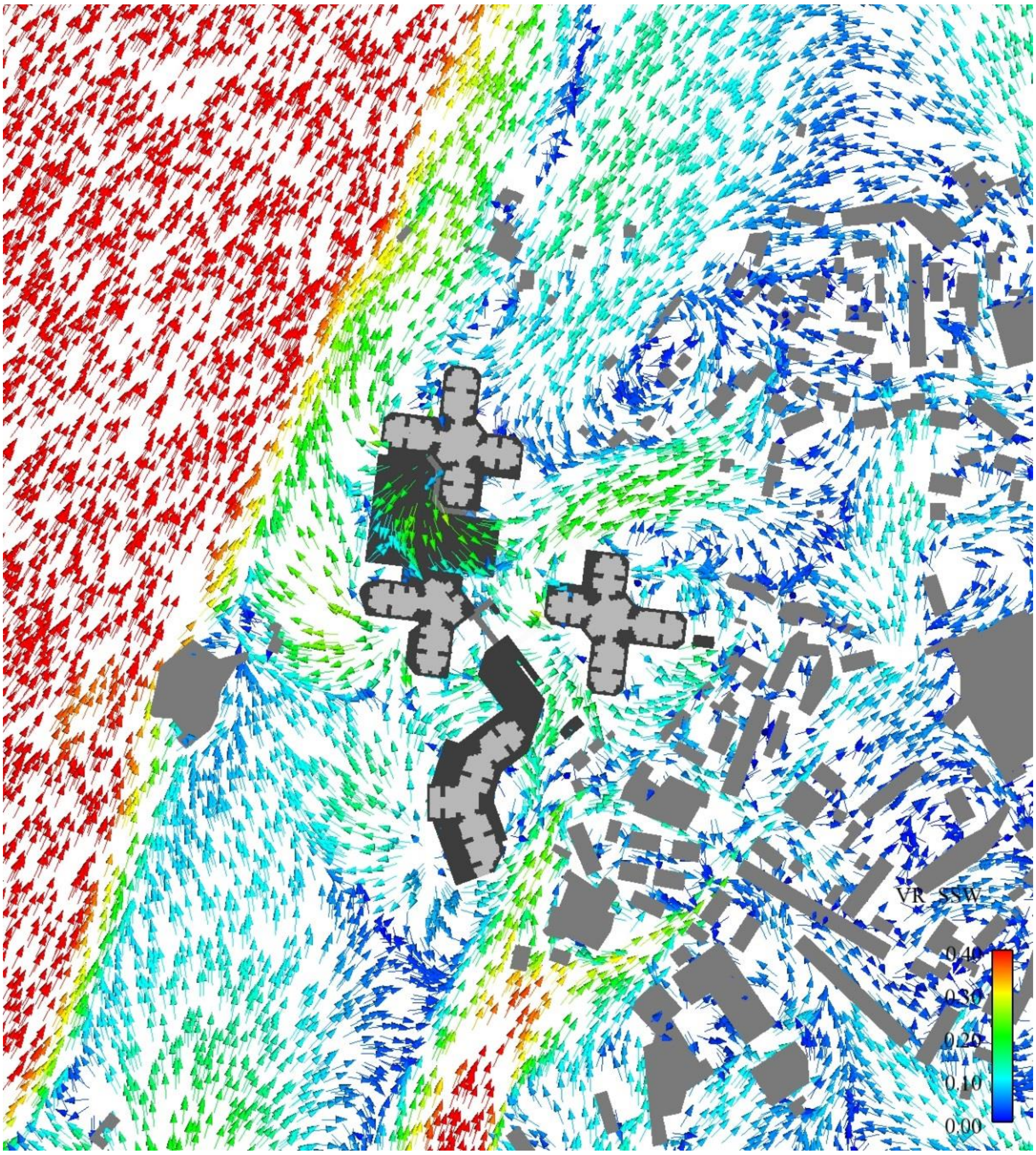


Figure C19 SSW Direction for Proposed Scheme under Scenario 2

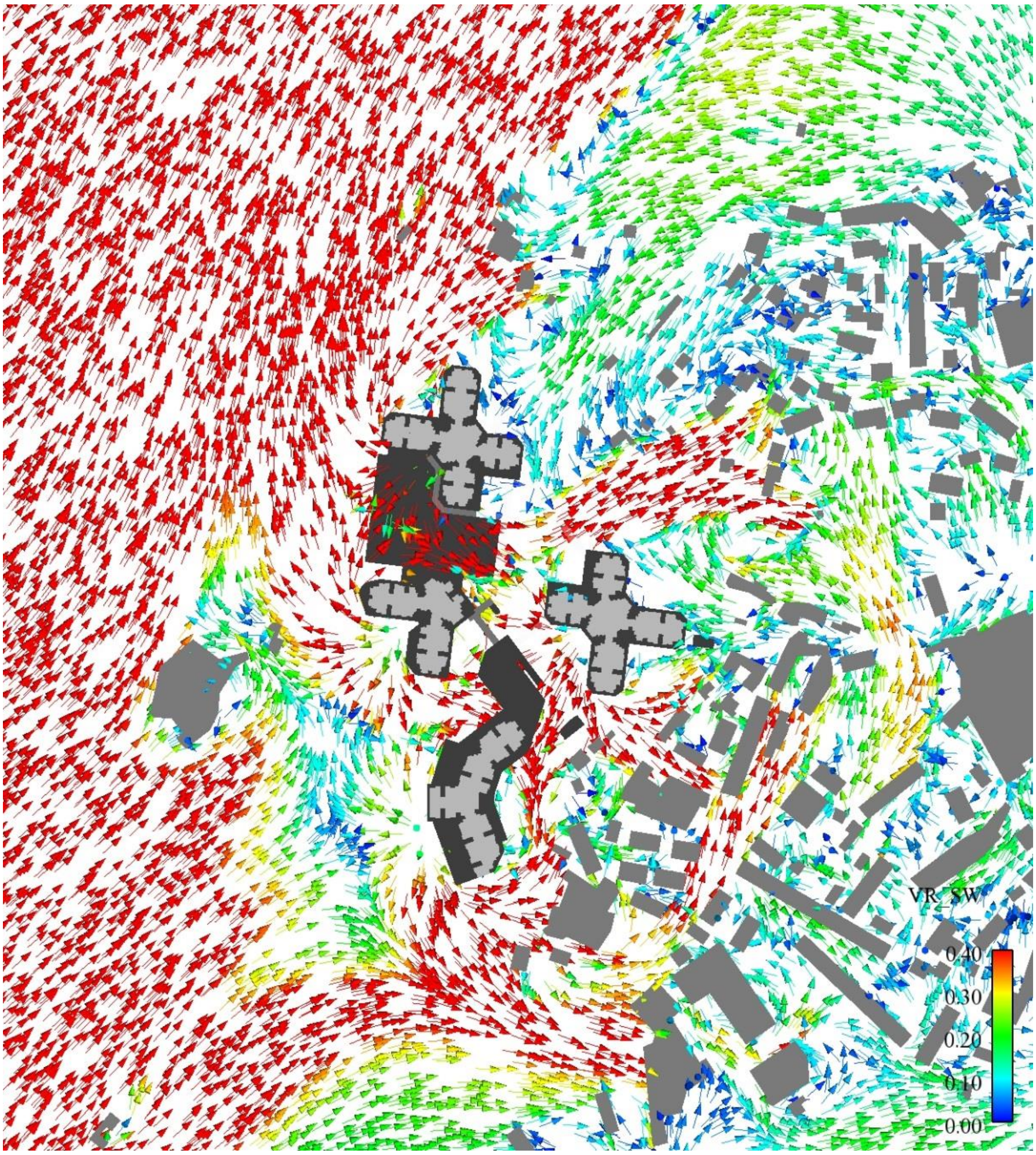


Figure C20 SW Direction for Proposed Scheme under Scenario 2

C3 Scenario 3

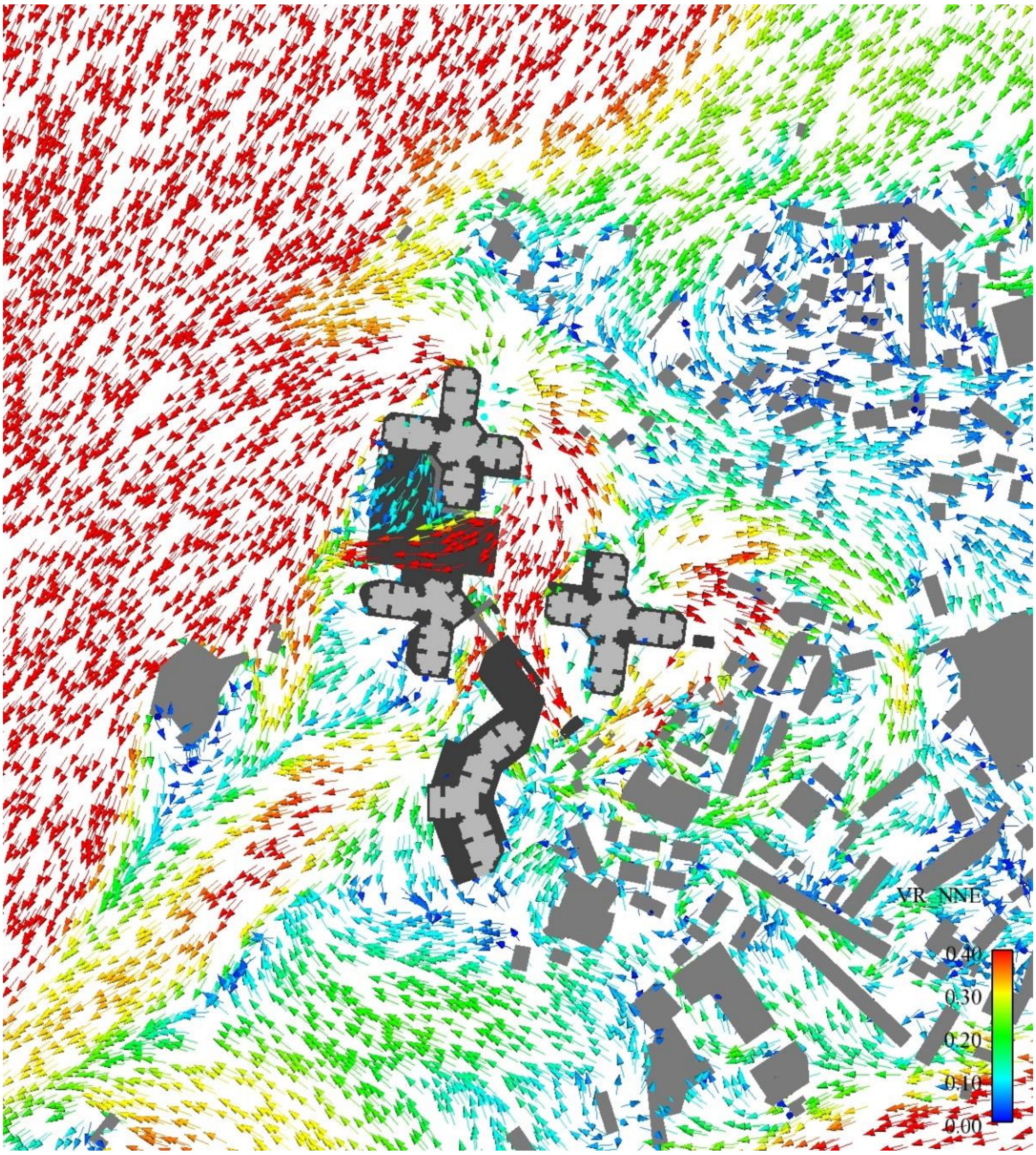


Figure C21 NNE Direction for Proposed Scheme under Scenario 3

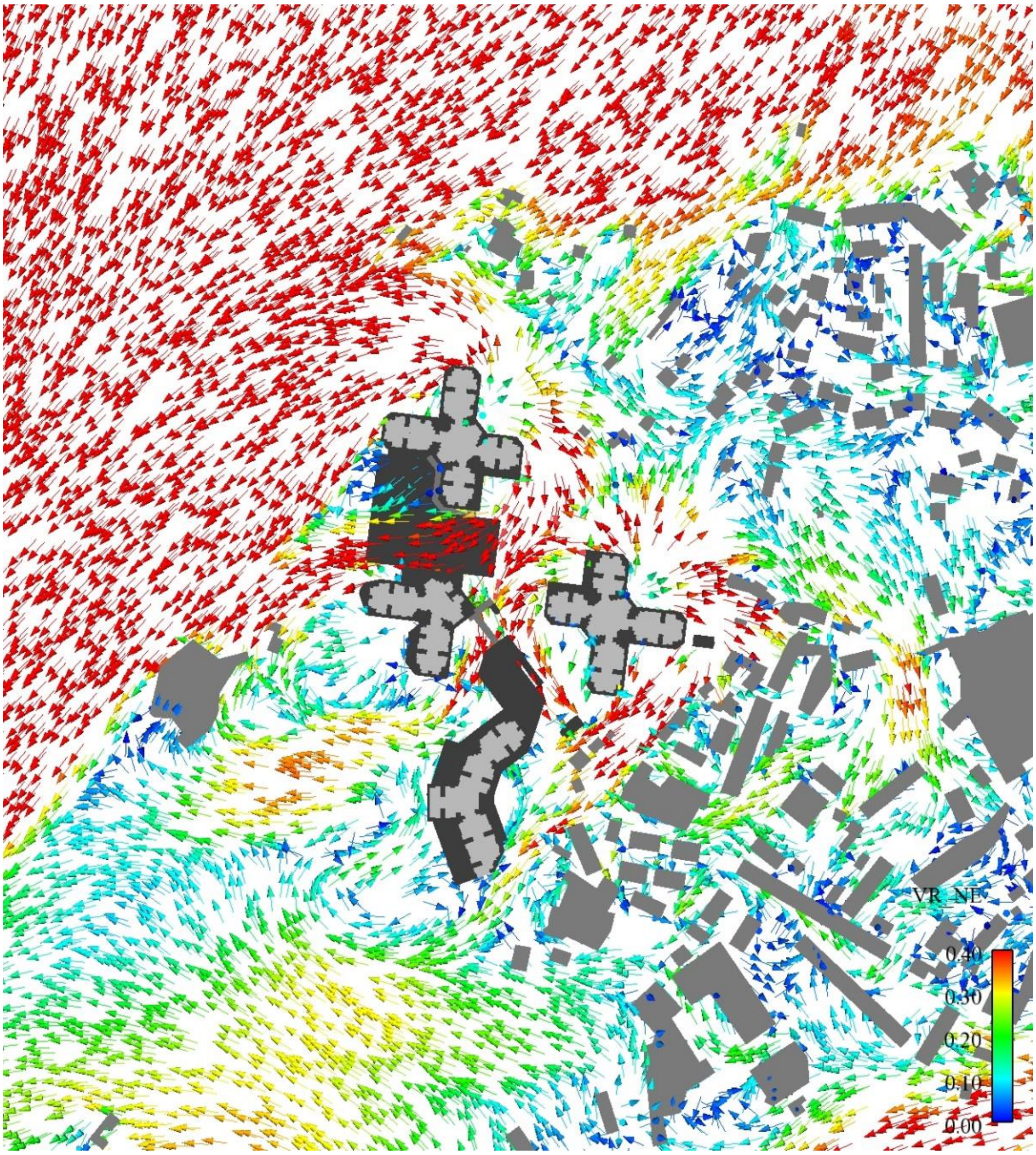


Figure C22 NE Direction for Proposed Scheme under Scenario 3

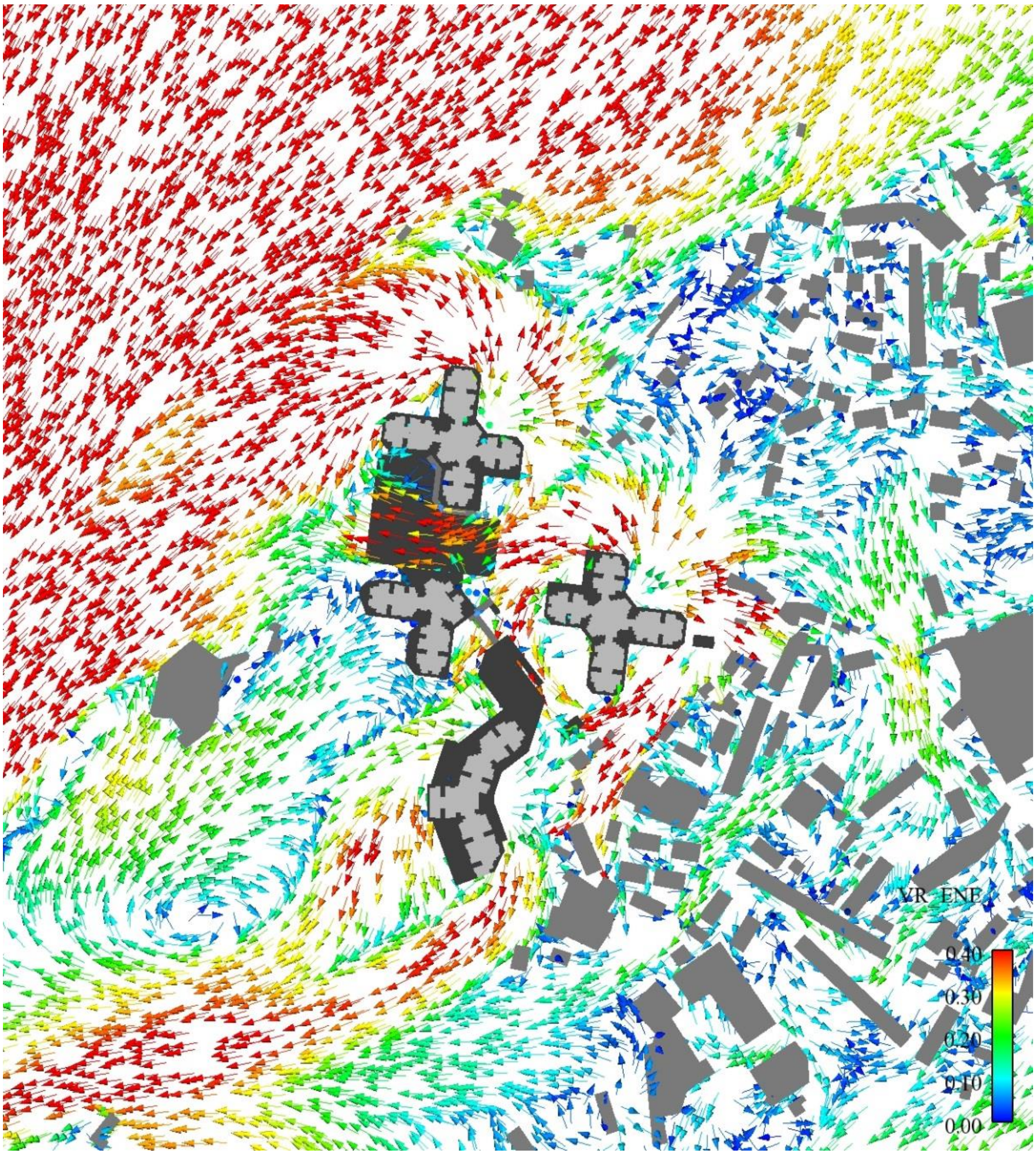


Figure C23 ENE Direction for Proposed Scheme under Scenario 3

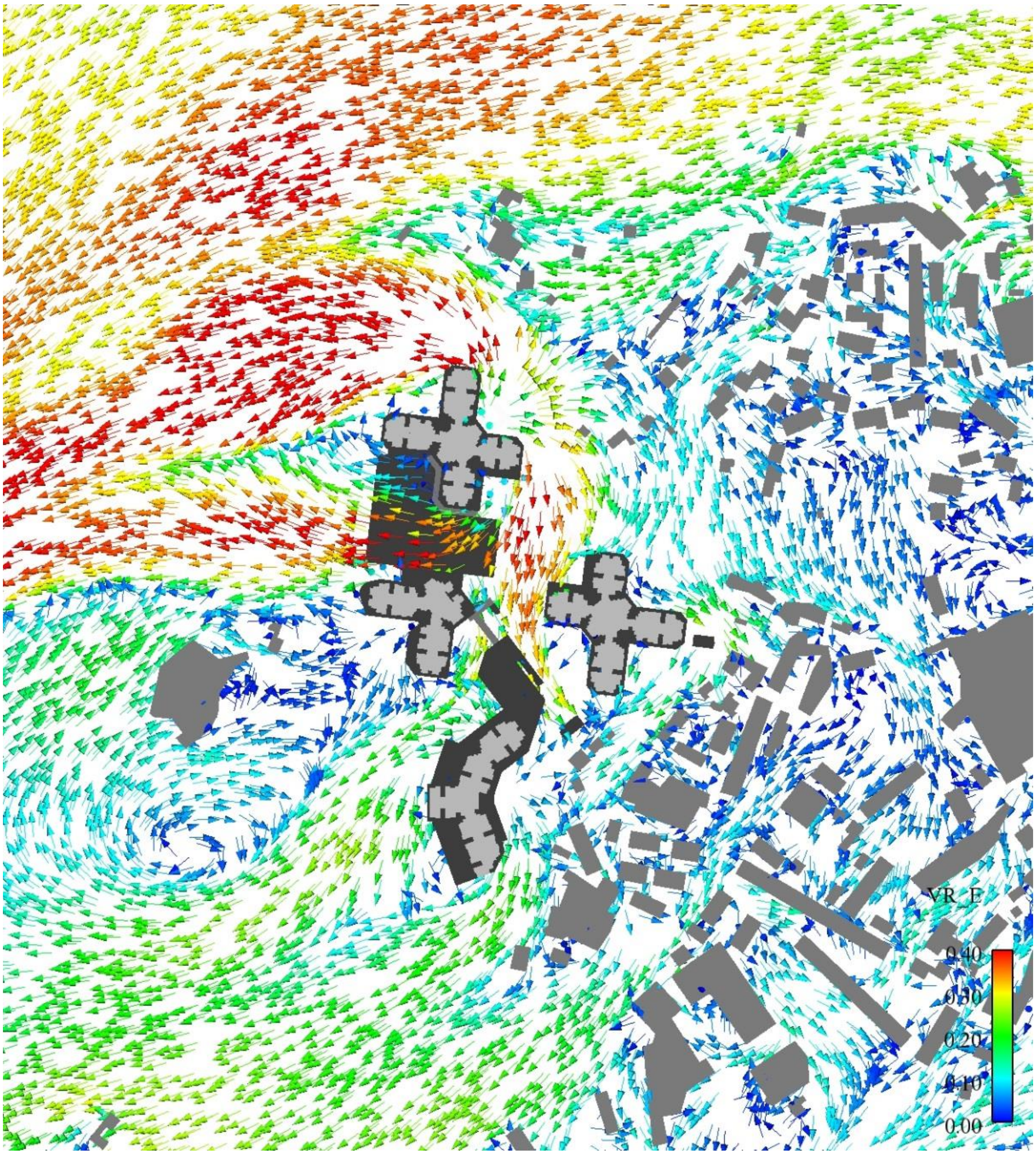


Figure C24 E Direction for Proposed Scheme under Scenario 3

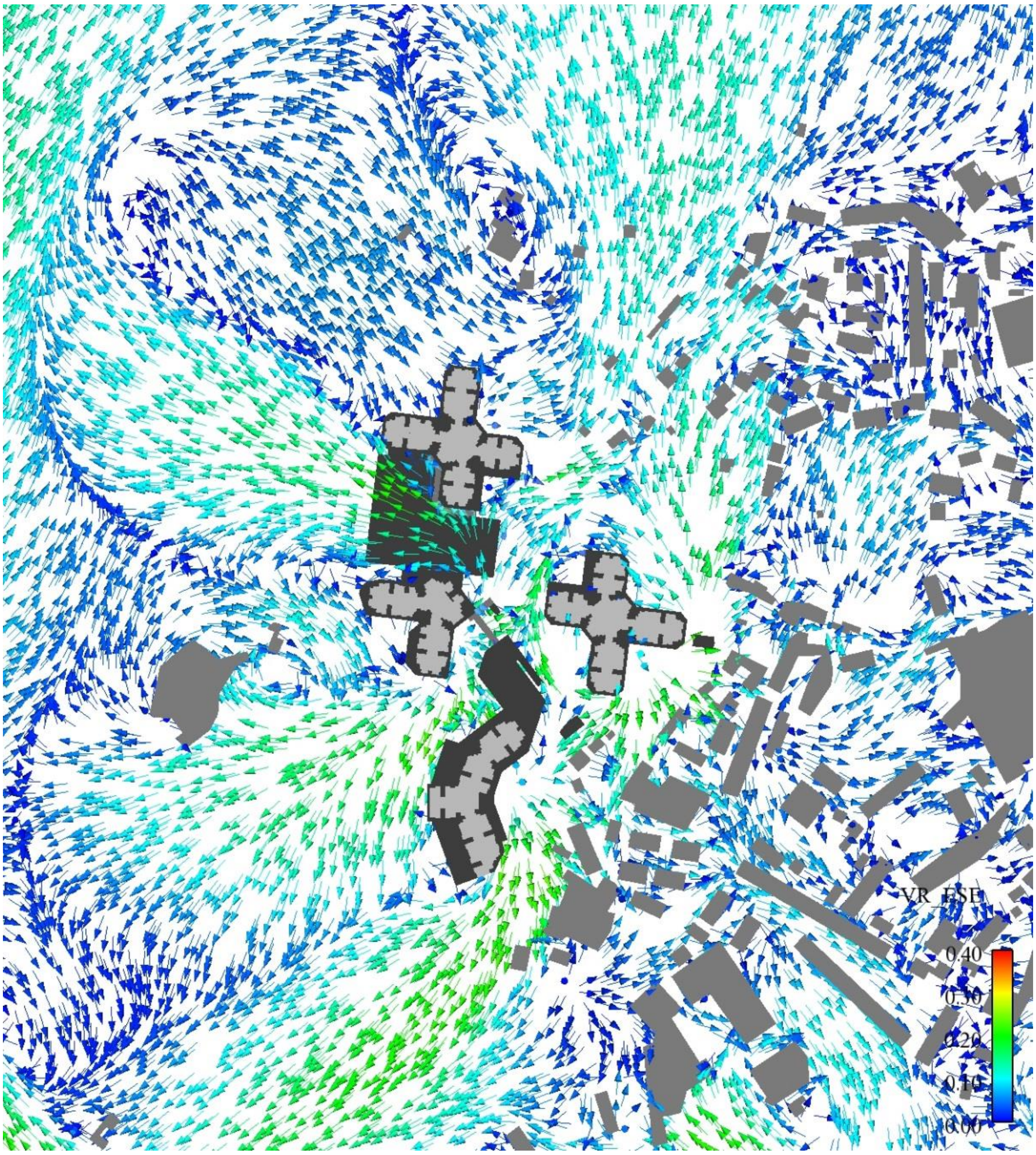


Figure C25 ESE Direction for Proposed Scheme under Scenario 3

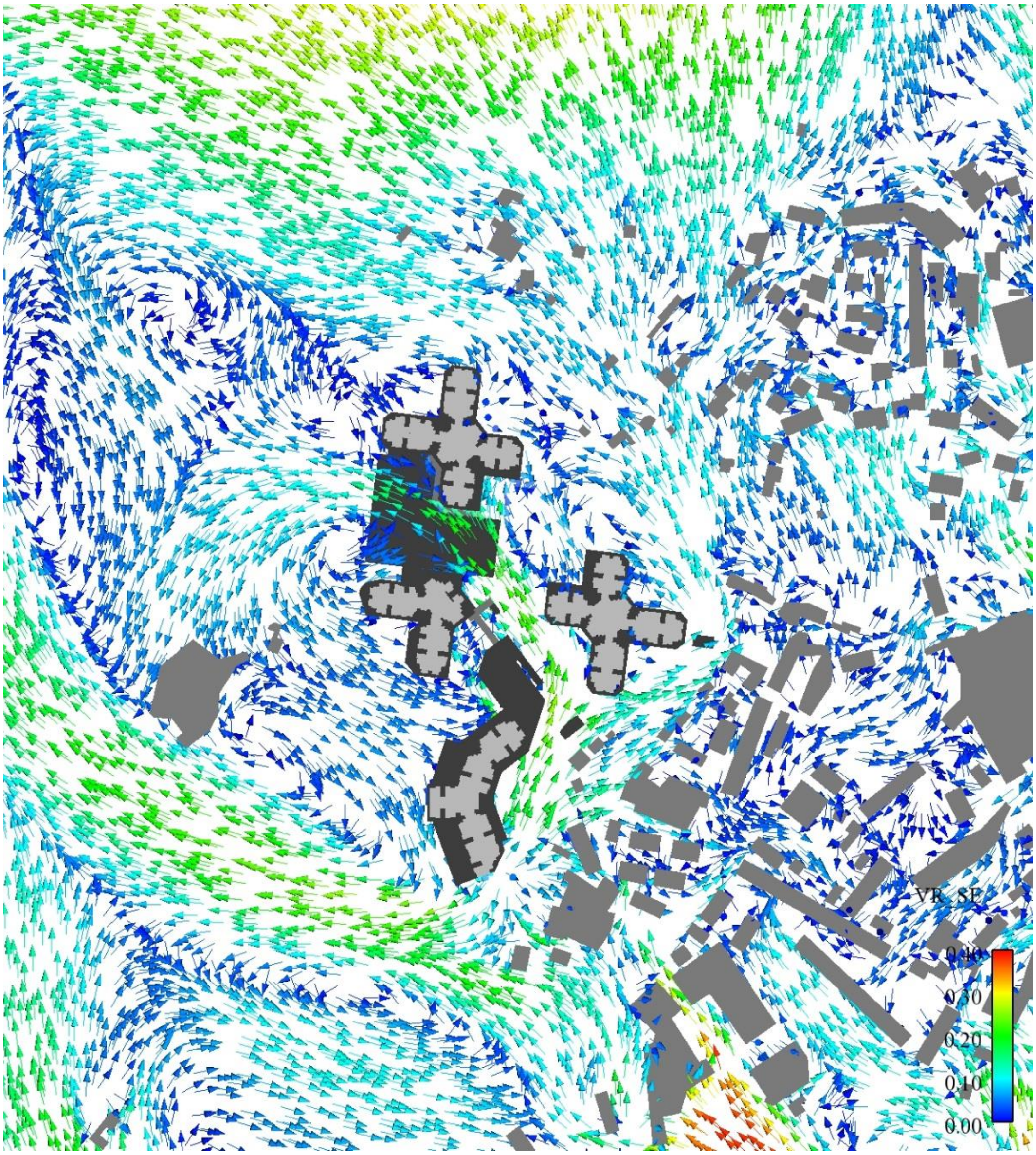


Figure C26 SE Direction for Proposed Scheme under Scenario 3

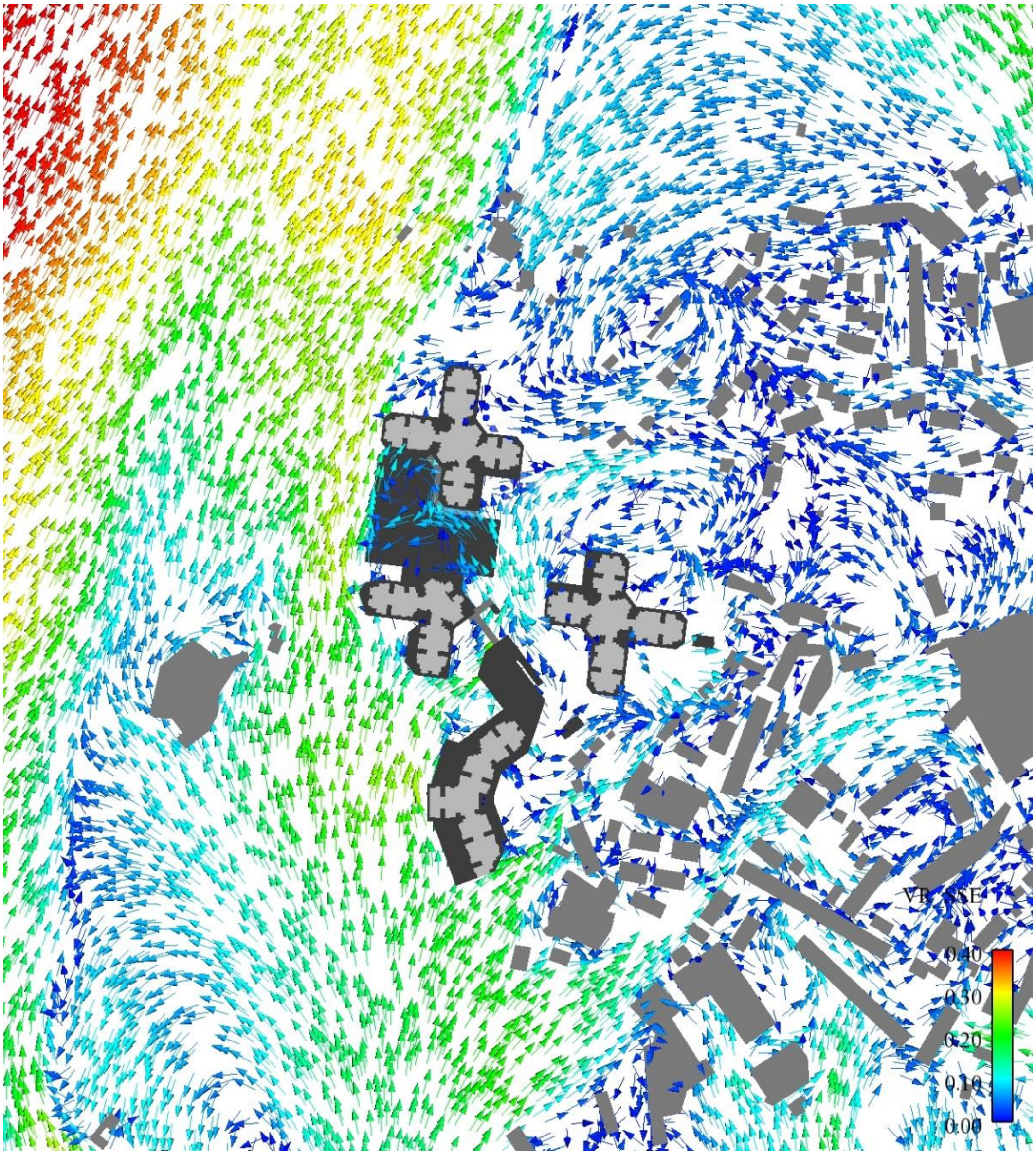


Figure C27 SSE Direction for Proposed Scheme under Scenario 3

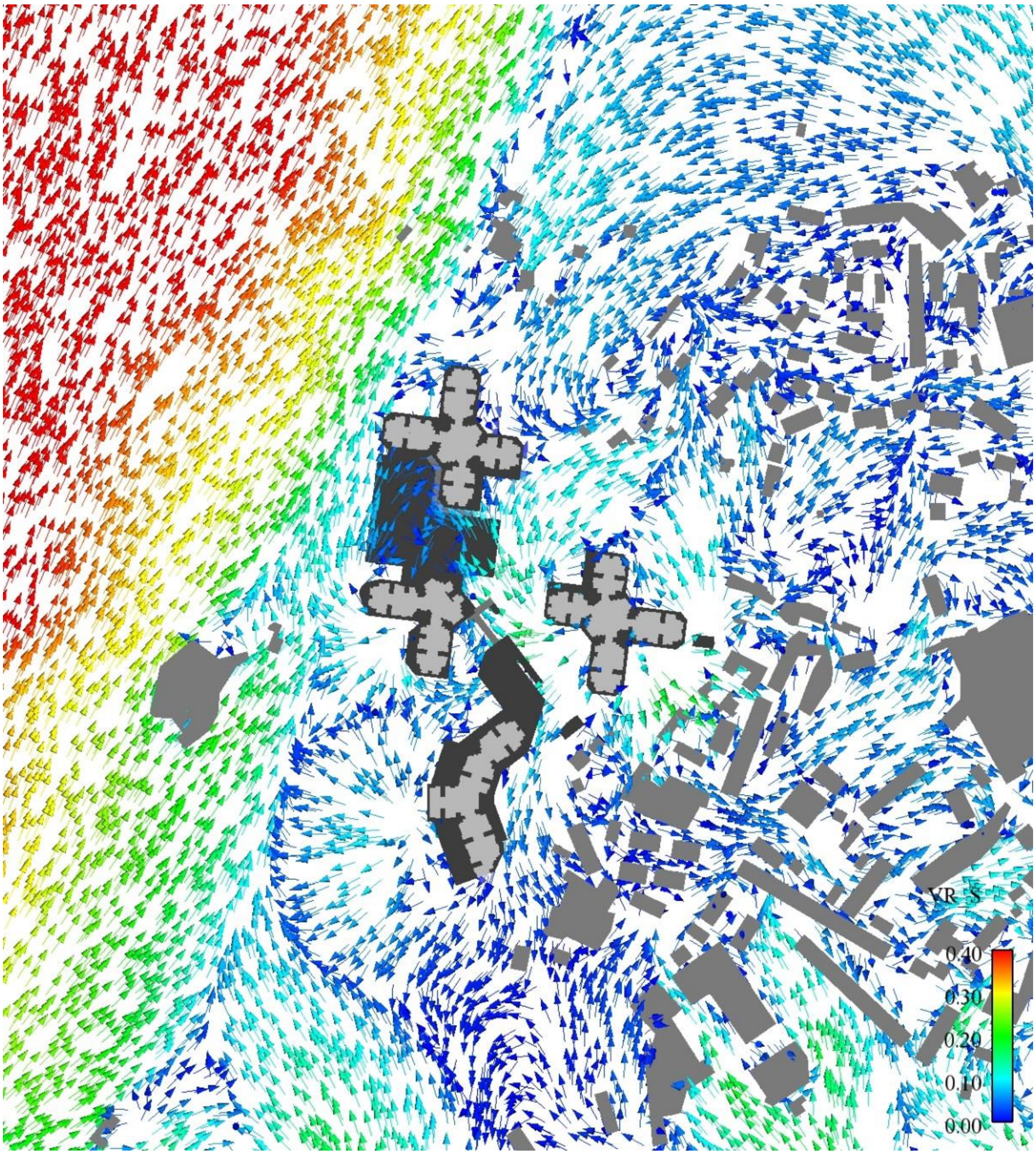


Figure C28 S Direction for Proposed Scheme under Scenario 3

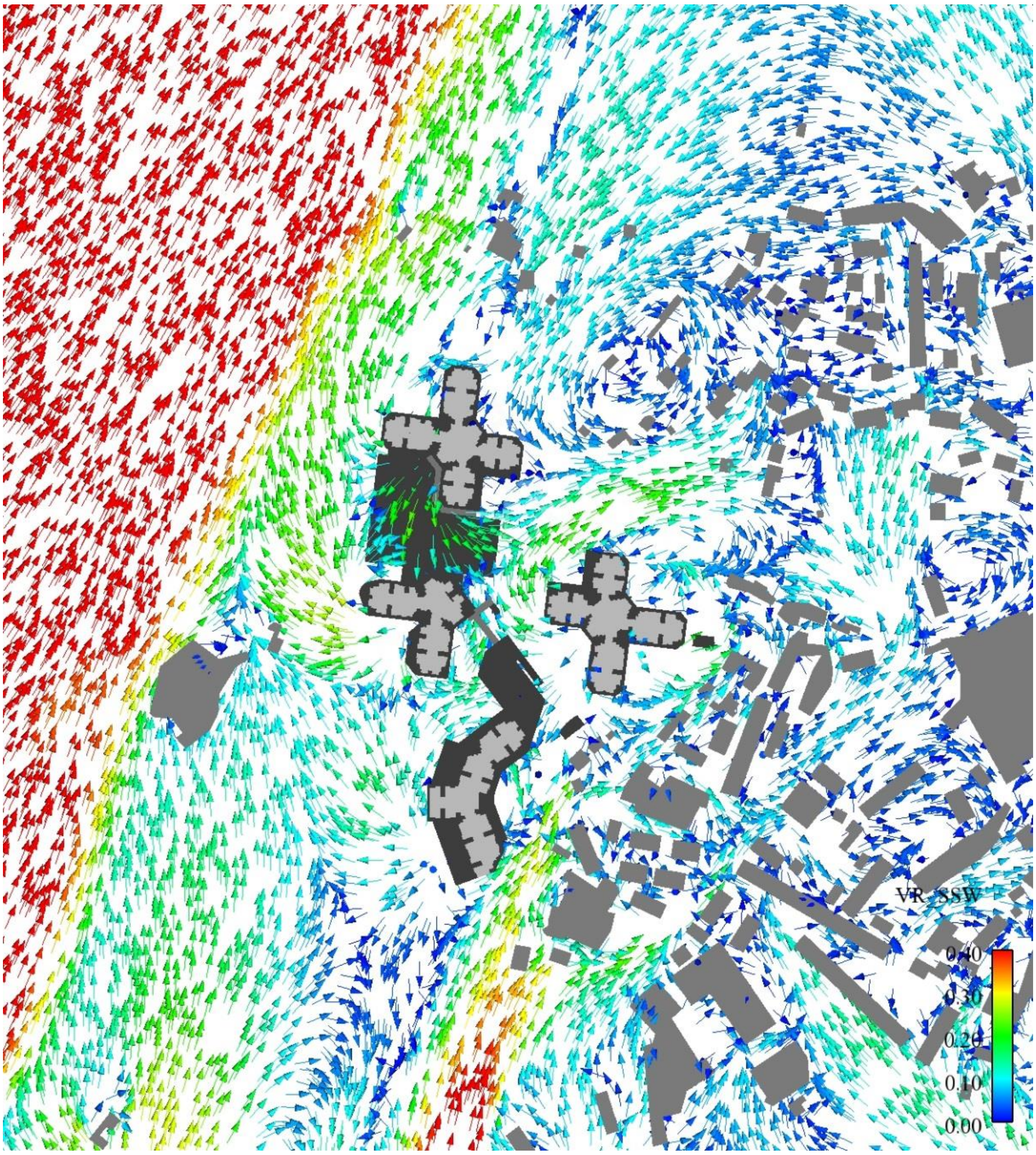


Figure C29 SSW Direction for Proposed Scheme under Scenario 3

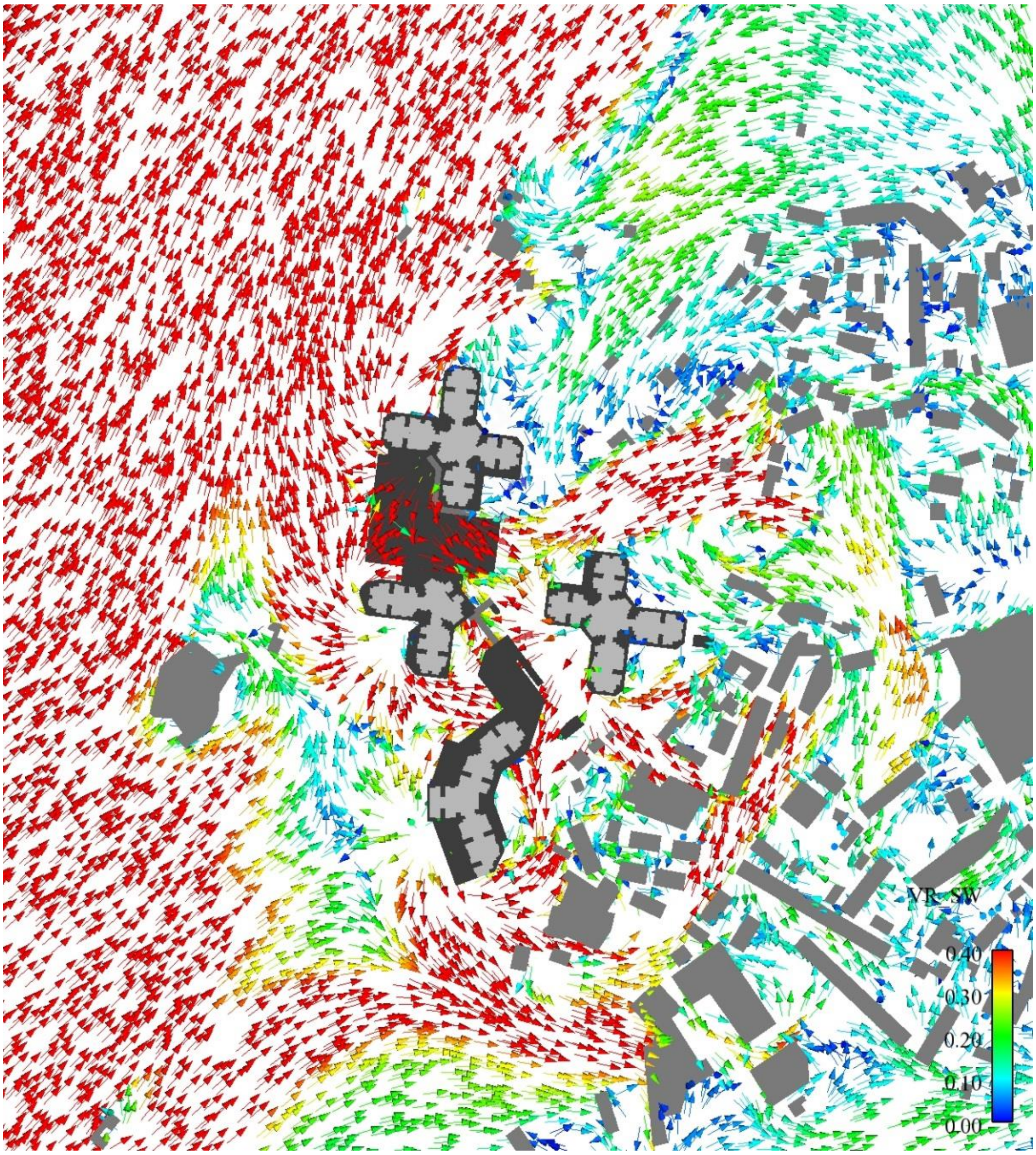


Figure C30 SW Direction for Proposed Scheme under Scenario 3

Appendix D

Cumulative Impact of TM54-Sites1&1A Development and TM54-Sites3&4(E) Development

Cumulative Impact of TM54-Sites1&1A Development and TM54-Sites3&4(E) Development

Introduction

This Appendix presents the potential cumulative ventilation impact of the proposed changes of the two developments.

The studied scenarios are shown below:

	Application for TM54-Sites1&1A Development	
Scenarios	TM54-Sites1&1A Development	TM54-Sites3&4(E) Development
1	Baseline Scheme	Baseline Scheme
2	Proposed Scheme	Baseline Scheme
3	Proposed Scheme	Proposed Scheme

Overall Ventilation Performance under Annual Condition

Table 1 Annual SVR and LVR for TM54-Sites1&1A Development

	Scenario 1	Scenario 2	Scenario 3
SVR	0.18	0.19	0.19
LVR	0.13	0.14	0.14

Table 2 VR Results for Focus Areas under Annual Wind Condition

	Focus Areas	Test Points	Scenario 1	Scenario 2	Scenario 3
1	Village 1	O1 – O16	0.17	0.17	0.17
2	Village 2	O17 – O41	0.08	0.08	0.08
3	Po Wah Garden	O34 – O43	0.06	0.06	0.06
4	Pui Lin Garden	O57 – O73, O44 – O51	0.11	0.11	0.11
5	Siu Hang Tsuen	O44 – O46, O86, O87	0.11	0.11	0.11
6	Village 3	P25 – P27, O71 – O73	0.14	0.18	0.18
7	Village 4	O48, O87 – O91	0.09	0.09	0.09
8	Siu On Garden	O70, O73, O74, O84, O85, O51 – O53	0.12	0.12	0.12
9	Po Wah Garden Phase 3	O49 – O52, O92, O93	0.11	0.11	0.11
10	Village 5	P21, P22, O80 – O83	0.15	0.15	0.15

Focus Areas		Test Points	Scenario 1	Scenario 2	Scenario 3
11	Ming Wong Garden	O53 – O56	0.09	0.09	0.09
12	Tong Hang Road	O44 – O56	0.11	0.11	0.11
13	Future Road	O74 – O79, P20 – P22	0.17	0.17	0.17
14	Major Open Spaces in TM54-Sites 1&1A	S1 – S12	0.22	0.24	0.24

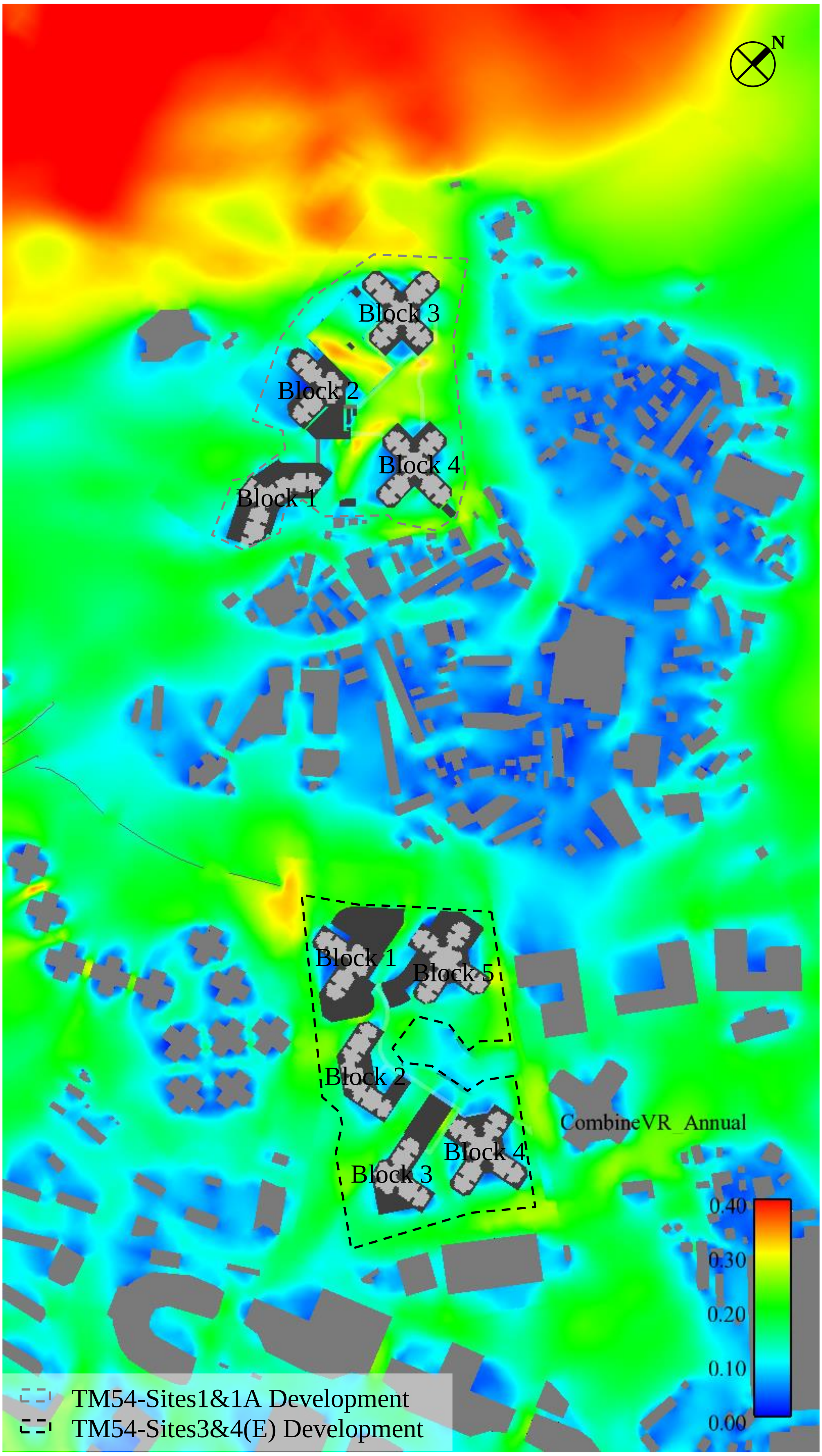


Figure 1 Average Annual VR Contour Plot for Both Developments under Scenario 1

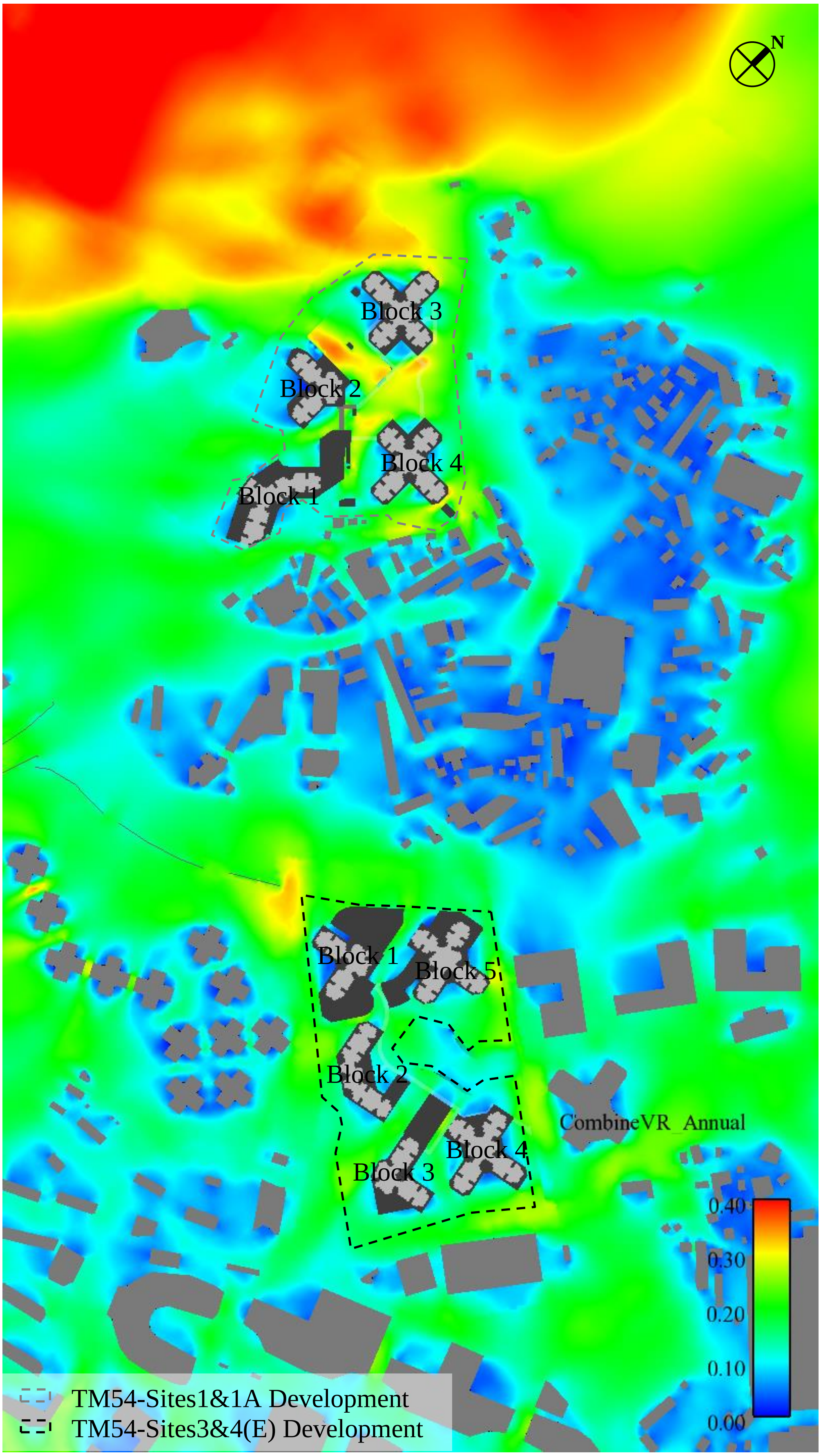


Figure 2 Average Annual VR Contour Plot for Both Developments under Scenario 2

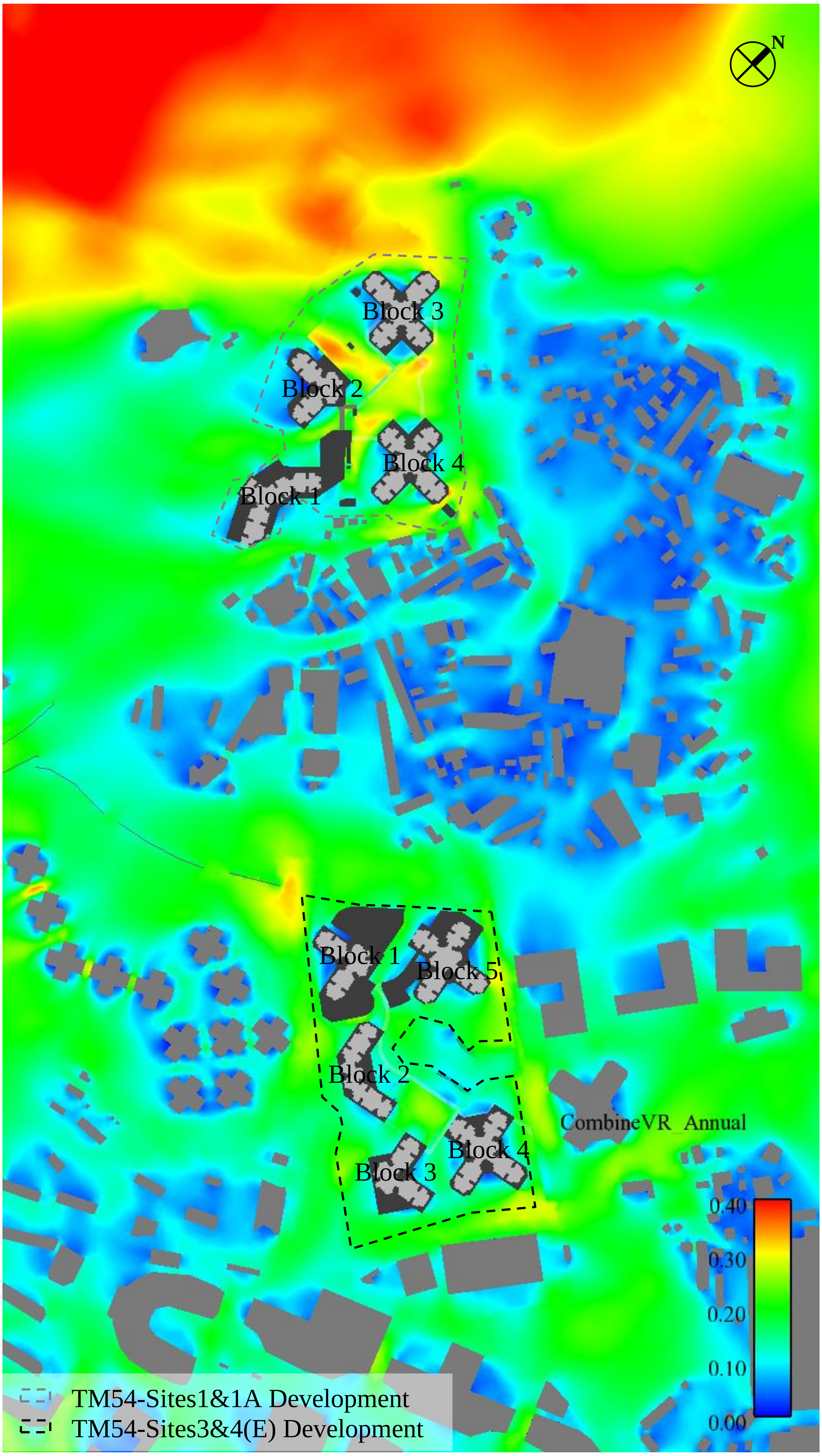


Figure 3 Average Annual VR Contour Plot for Both Developments under Scenario 3

Under annual condition, the values of SVR and LVR are same between S2 and S3. S2 and S3 have slightly higher SVR and LVR than S1.

S2 and S3 would achieve similar VR at all the focus areas. S2 and S3 would have slightly higher VR at Village 3 and Major Open Spaces in TM54-Sites 1&1A when compared with S1.

The ventilation performance between S2 and S3 is generally similar. No significant cumulative ventilation impact could be observed under annual condition.

S3 would have slightly better ventilation performance at areas near the site boundary of TM54-Sites3&4(E) Development. This is mainly because of the design changes between Proposed Scheme and Baseline Scheme of TM54-Sites3&4(E) Development.

Overall Ventilation Performance under Summer Condition

Table 3 Summer SVR and LVR for TM54-Sites1&1A Development

	Scenario 1	Scenario 2	Scenario 3
SVR	0.15	0.15	0.15
LVR	0.12	0.12	0.12

Table 4 VR Results for Focus Areas under Summer Wind Condition

Focus Areas		Test Points	Scenario 1	Scenario 2	Scenario 3
1	Village 1	O1 – O16	0.16	0.16	0.16
2	Village 2	O17 – O41	0.08	0.08	0.08
3	Po Wah Garden	O34 – O43	0.07	0.07	0.07
4	Pui Lin Garden	O57 – O73, O44 – O51	0.09	0.09	0.09
5	Siu Hang Tsuen	O44 – O46, O86, O87	0.08	0.08	0.08
6	Village 3	P25 – P27, O71 – O73	0.11	0.12	0.12
7	Village 4	O48, O87 – O91	0.07	0.07	0.07
8	Siu On Garden	O70, O73, O74, O84, O85, O51 – O53	0.11	0.11	0.11
9	Po Wah Garden Phase 3	O49 – O52, O92, O93	0.11	0.11	0.11
10	Village 5	P21, P22, O80 – O83	0.17	0.17	0.17
11	Ming Wong Garden	O53 – O56	0.12	0.12	0.12
12	Tong Hang Road	O44 – O56	0.11	0.11	0.11
13	Future Road	O74 – O79, P20 – P22	0.18	0.18	0.18
14	Major Open Spaces in TM54-Sites 1&1A	S1 – S12	0.19	0.19	0.19

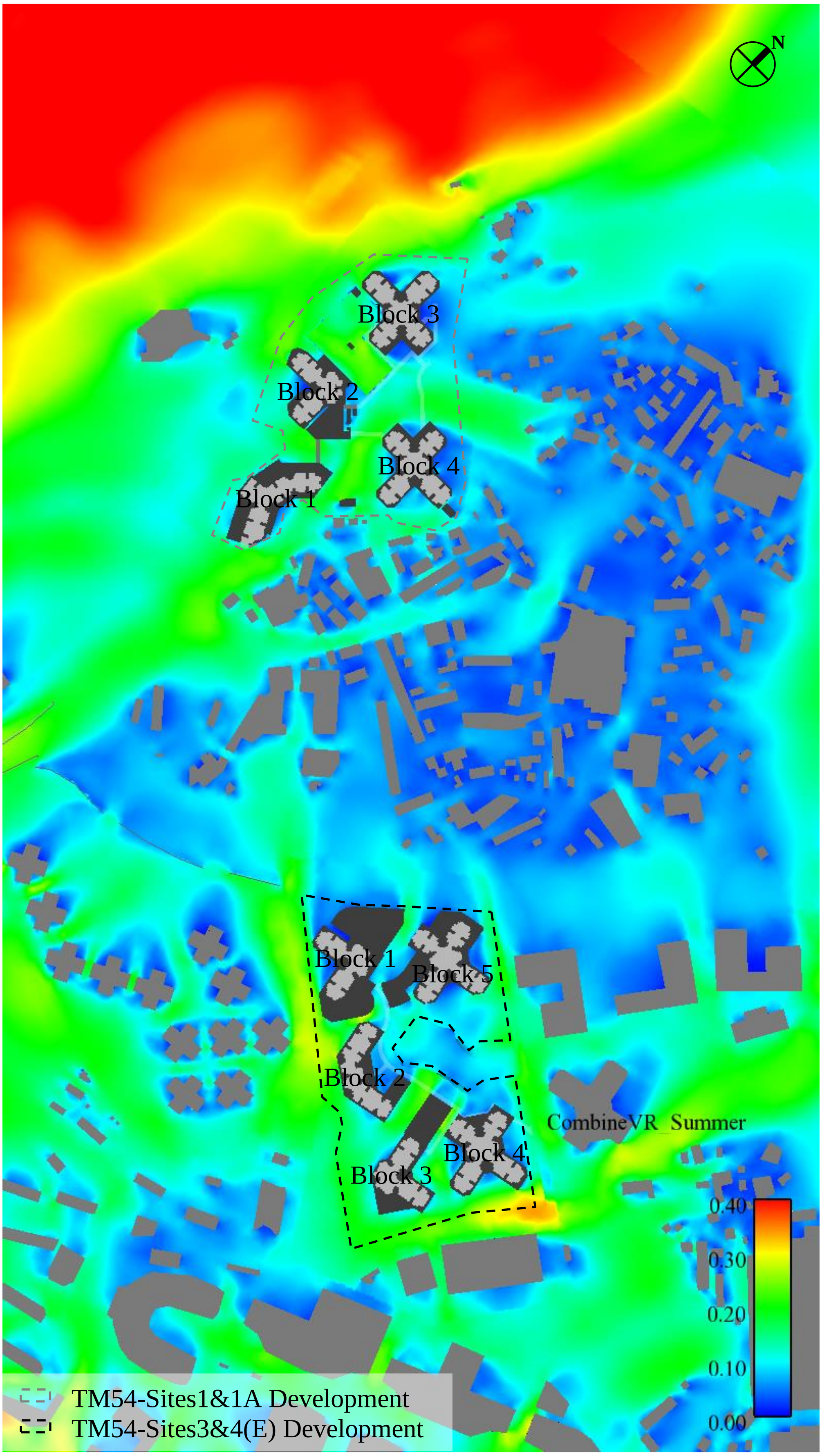


Figure 4 Average Summer VR Contour Plot for Both Developments under Scenario 1

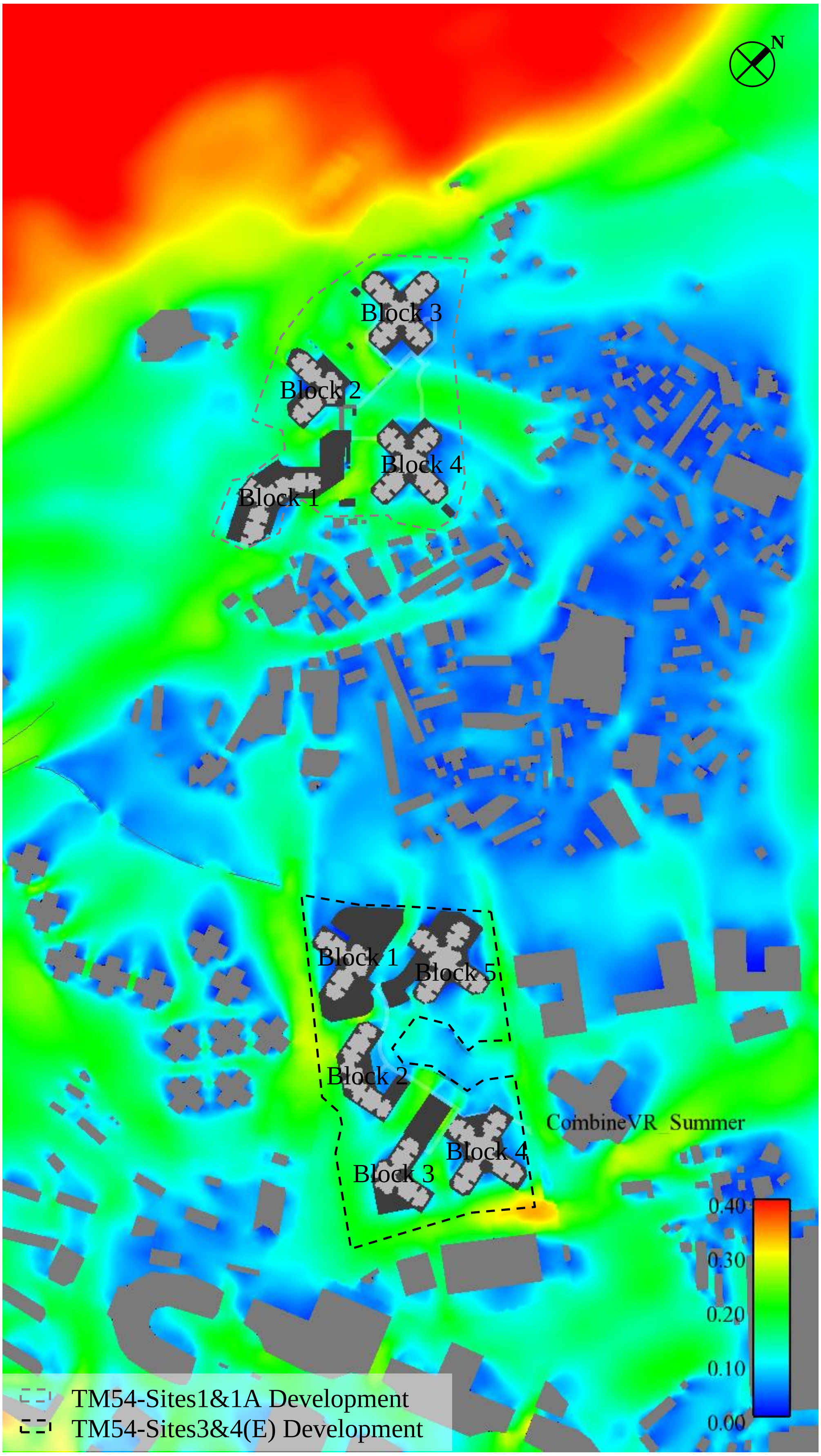


Figure 5 Average Summer VR Contour Plot for Both Developments under Scenario 2

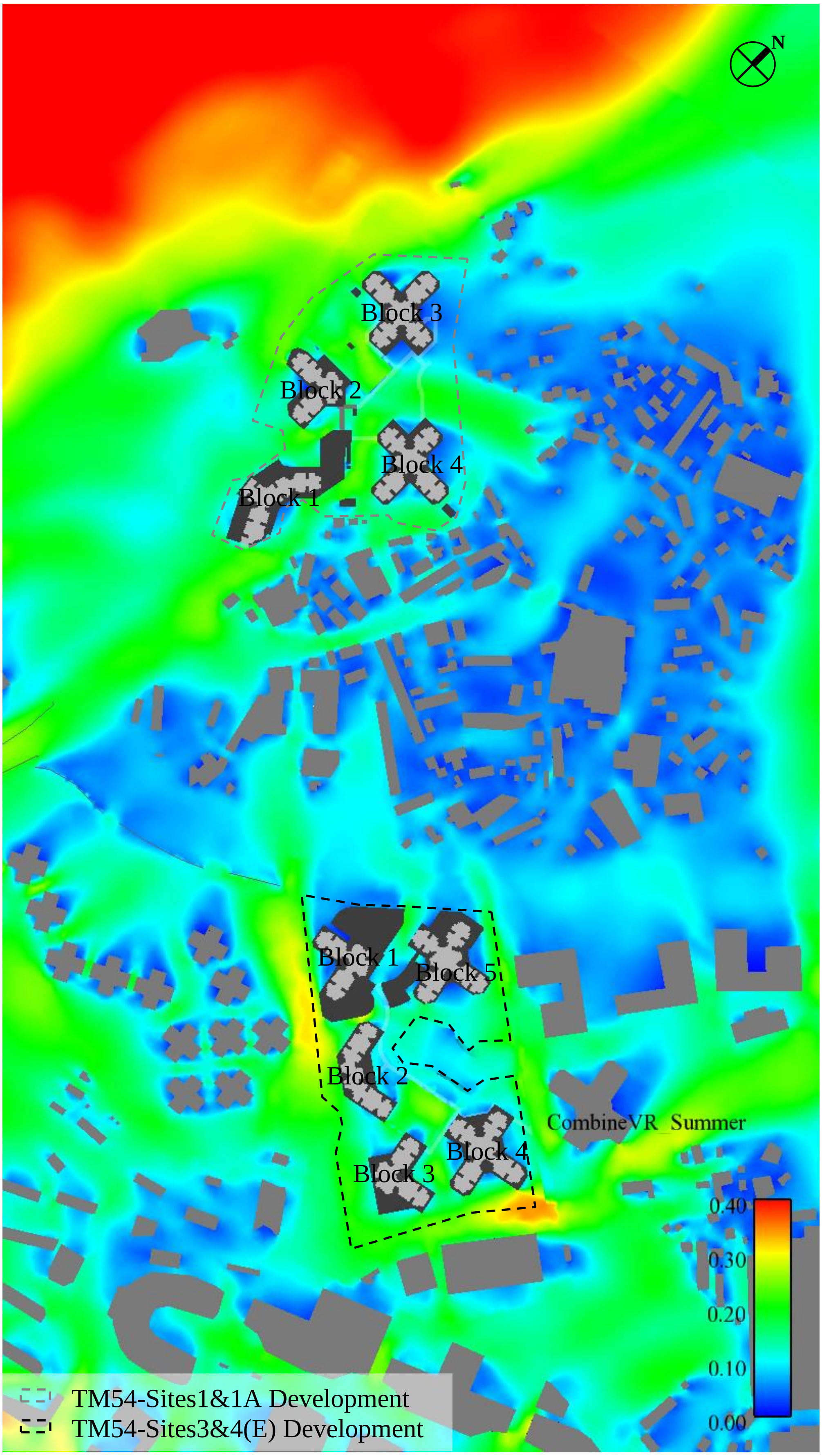


Figure 6 Average Summer VR Contour Plot for Both Developments under Scenario 3

Under summer condition, the values of SVR and LVR are same under the three scenarios.

S2 and S3 would achieve similar VR at all the focus areas. S2 and S3 would have slightly higher VR at Village 3 when compared with S1.

The ventilation performance between S2 and S3 is generally similar. No significant cumulative ventilation impact could be observed under summer condition.

S3 would have slightly better ventilation performance at areas near the site boundary of TM54-Sites3&4(E) Development. This is mainly because of the design changes between Proposed Scheme and Baseline Scheme of TM54-Sites3&4(E) Development.

Directional Analysis

The ventilation performance between S2 and S3 is generally similar under all the wind directions, except ESE and SE winds. Thus, no significant cumulative ventilation impact could be observed.

Under ESE and SE winds, different ventilation environment could be observed between S2 and S3, suggesting that there would be cumulative ventilation impact resulted under these two wind conditions. The observations are presented below.

ESE Wind

Under S3, TM54-Sites3&4(E) Development has a higher building height when compared with S1 & S2, which provide a larger building frontage area to divert a larger amount of the high level incoming wind towards Block 4 of TM54-Sites1&1(A) Development (**Black Arrow** in Figure 9).

Moreover, Under S3, Block 4 of TM54-Sites1&1(A) Development would further downwash more incoming wind towards the east of TM54-Sites1&1(A) Development (Red Arrow in Figure 9). As a result, higher VR would be observed at Village 2 and Po Wah Garden.

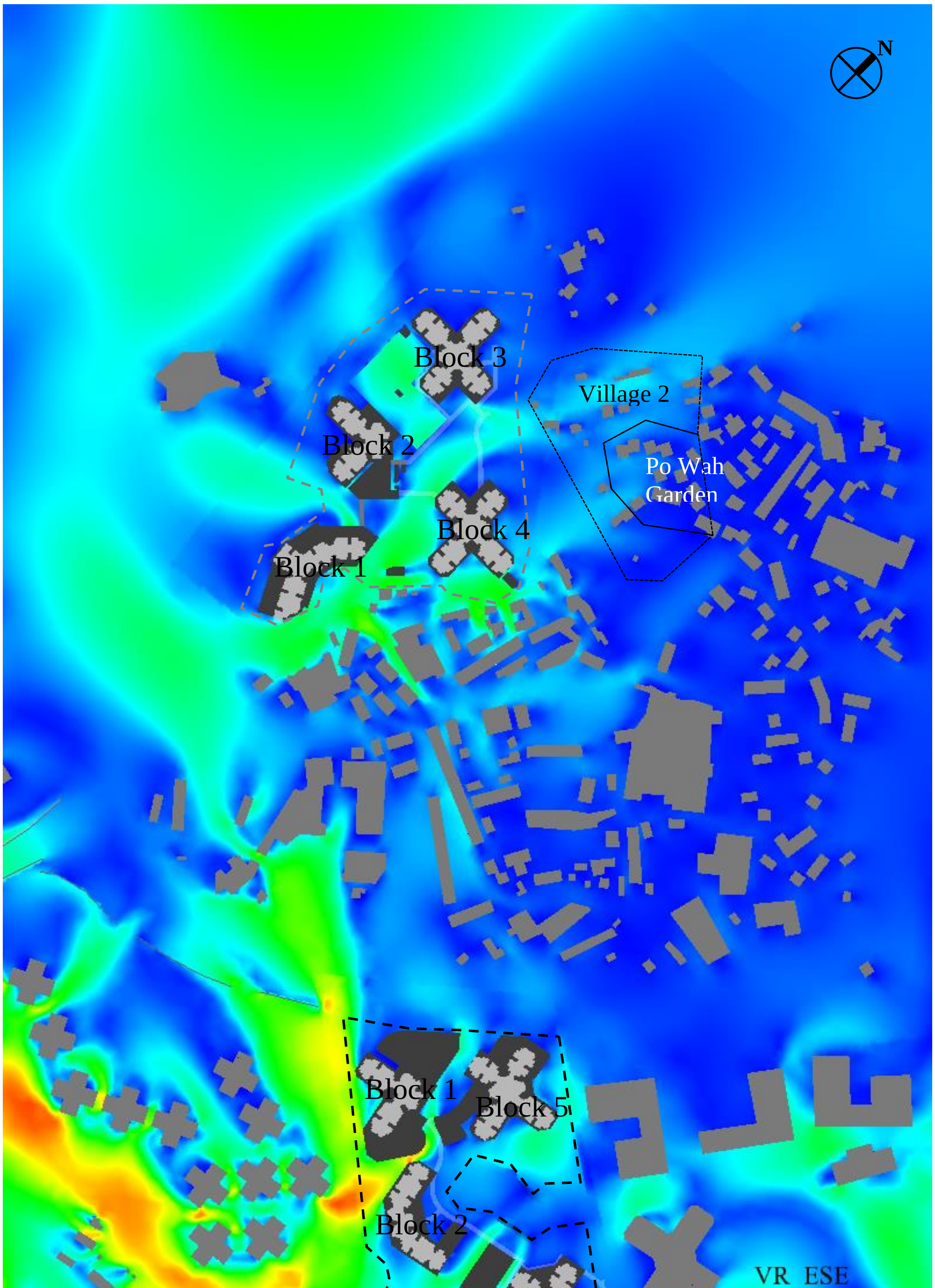


Figure 7 VR Contour Plot of ESE Diretion for Both Developments under Scenario 1

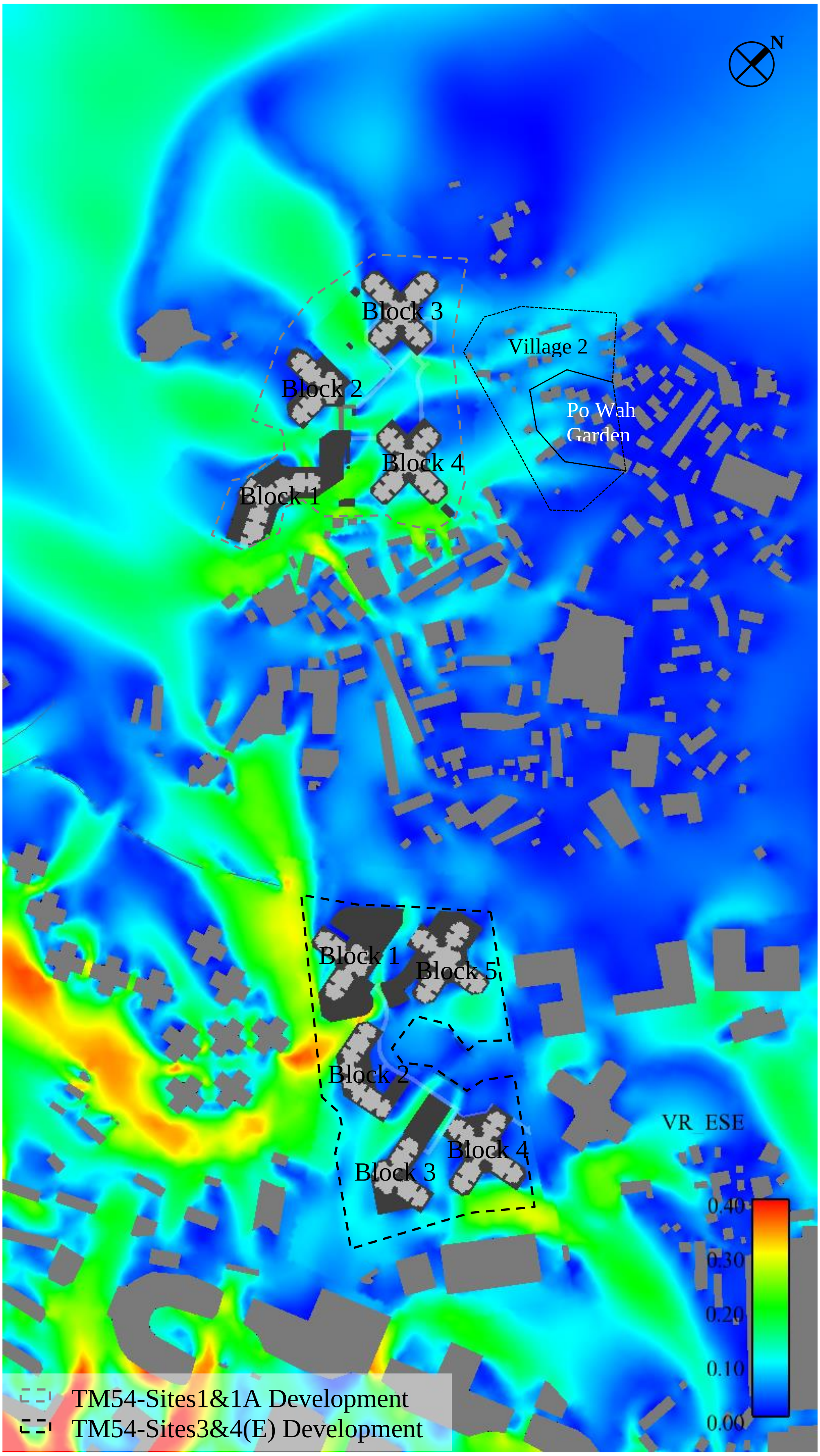


Figure 8 VR Contour Plot of ESE Diretion for Both Developments under Scenario 2

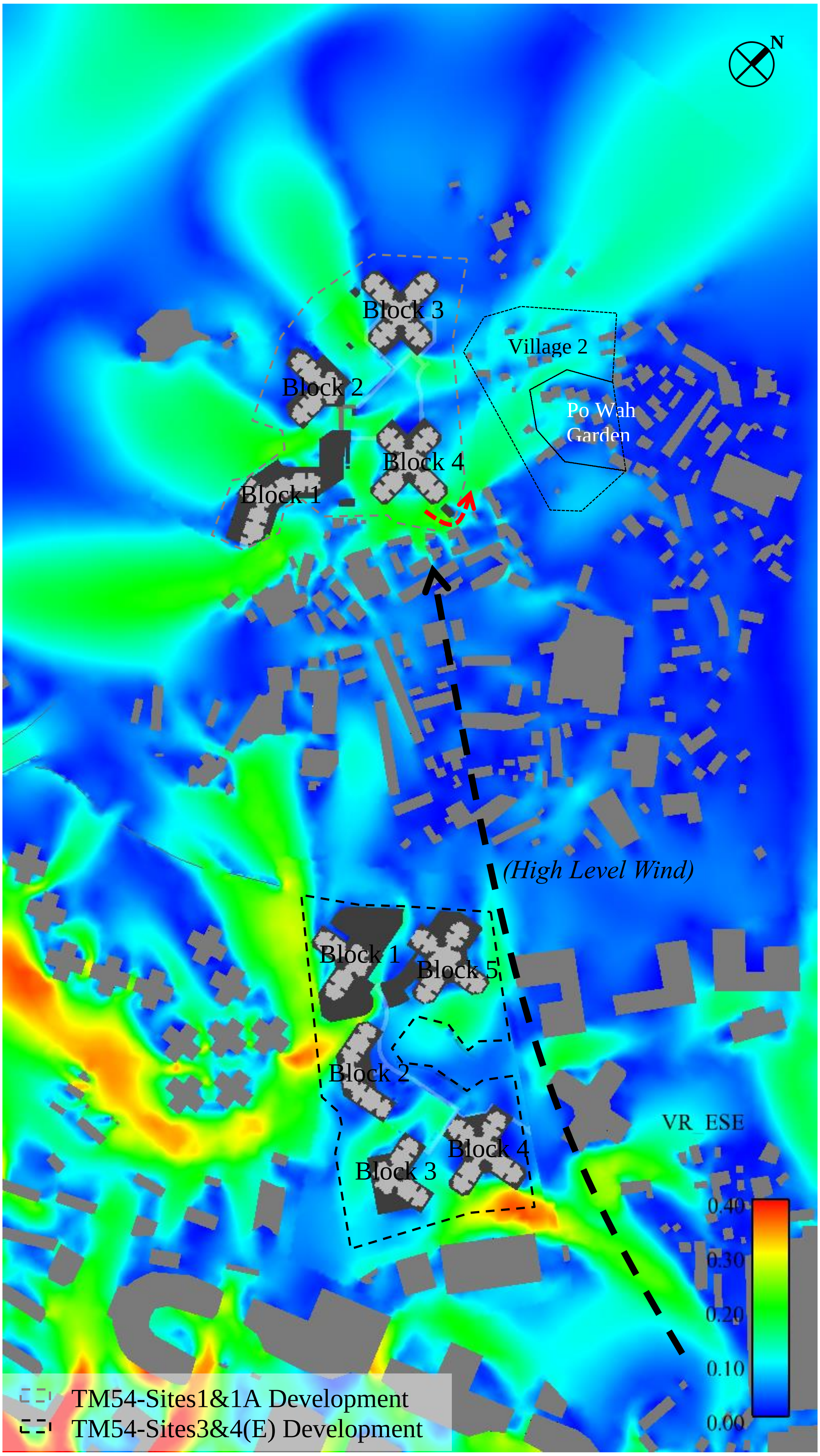


Figure 9 VR Contour Plot of ESE Diretion for Both Developments under Scenario 3

SE Wind

Under S3, TM54-Sites3&4(E) Development at the upwind location is higher when compared with S1 & S2. It would inevitably induce a larger wind shadow at the area to the east of TM54-Sites1&1(A) Development. Lower VR would be observed at Village 2, Po Wah Garden, and north of Pui Lin Garden under S3.

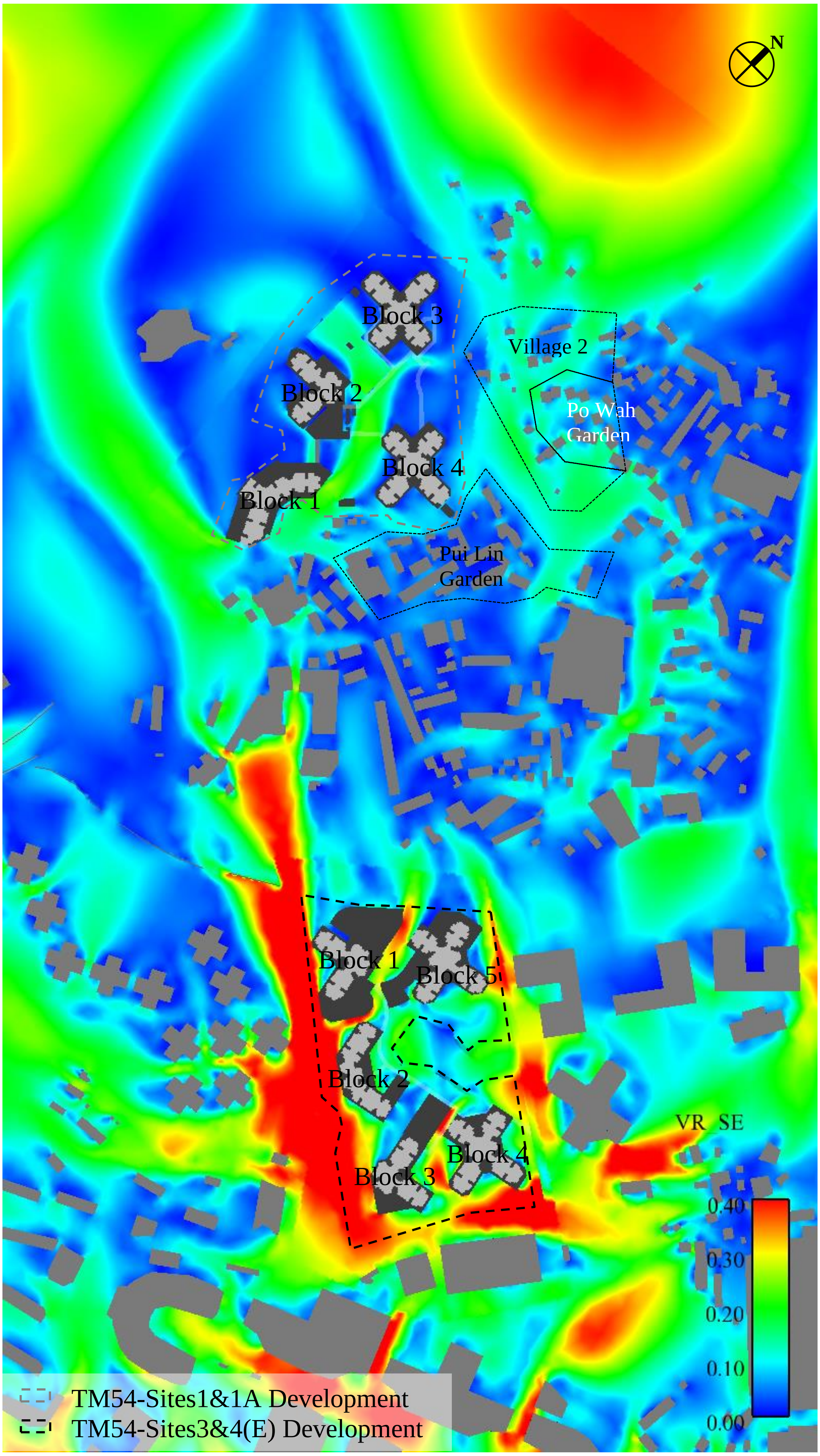


Figure 10 VR Contour Plot of SE Diretion for Both Developments under Scenario 1

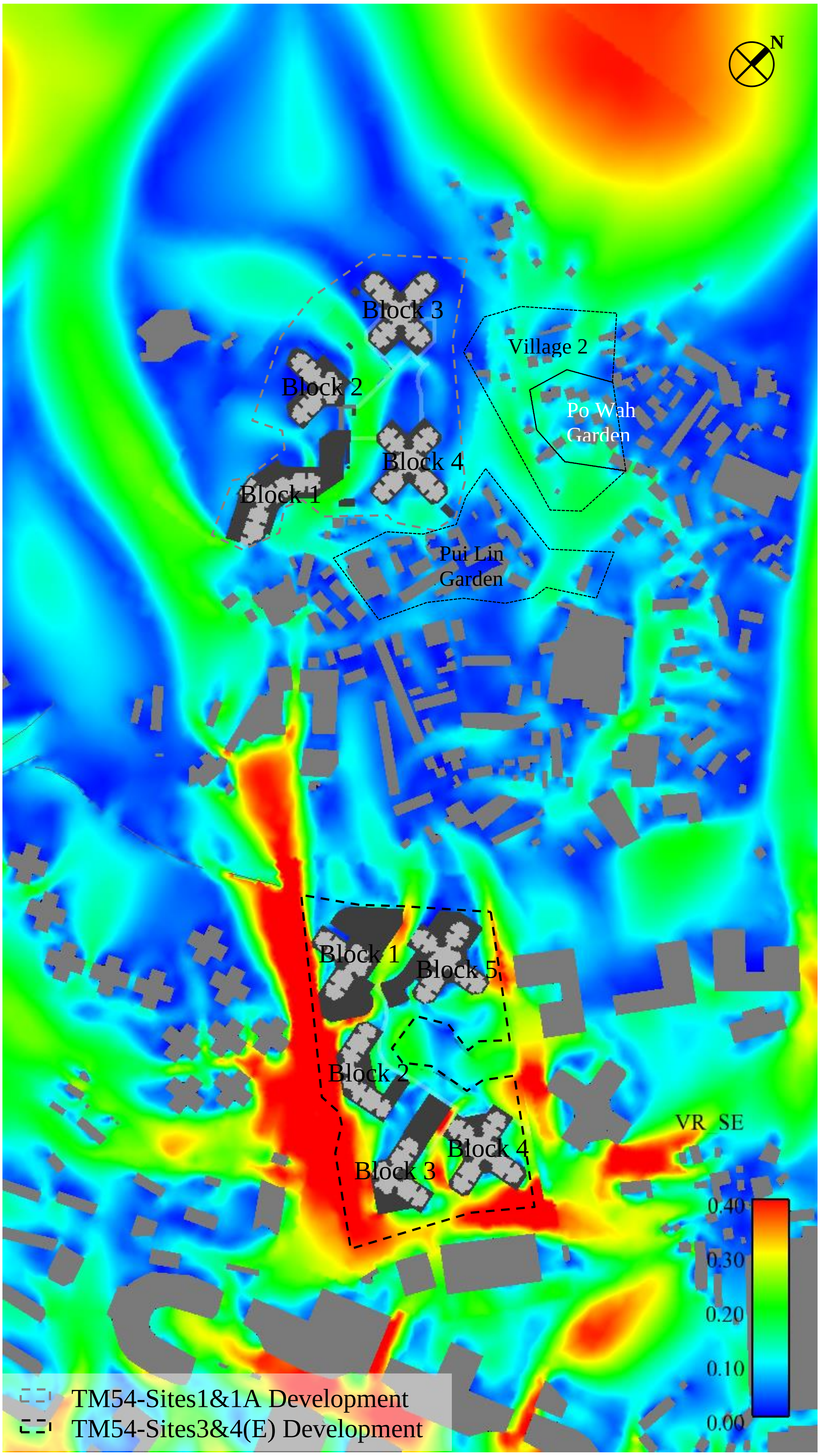


Figure 11 VR Contour Plot of SE Diretion for Both Developments under Scenario 2

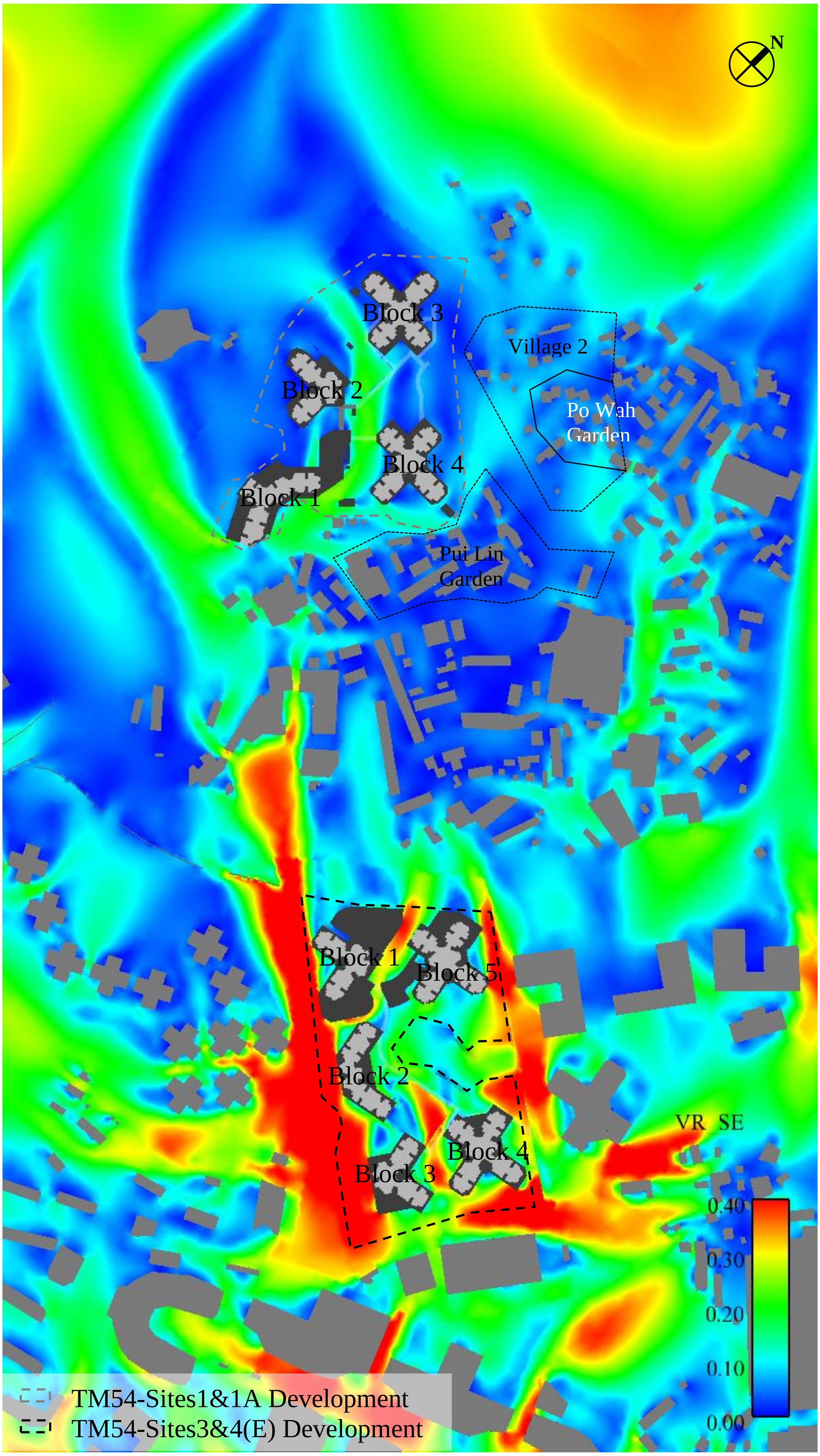


Figure 12 VR Contour Plot of SE Diretion for Both Developments under Scenario 3

Appendix E

VR Contour Plots of TM54-Sites1&1A Development and TM54-Sites3&4(E) Development

E1 Scenario 1

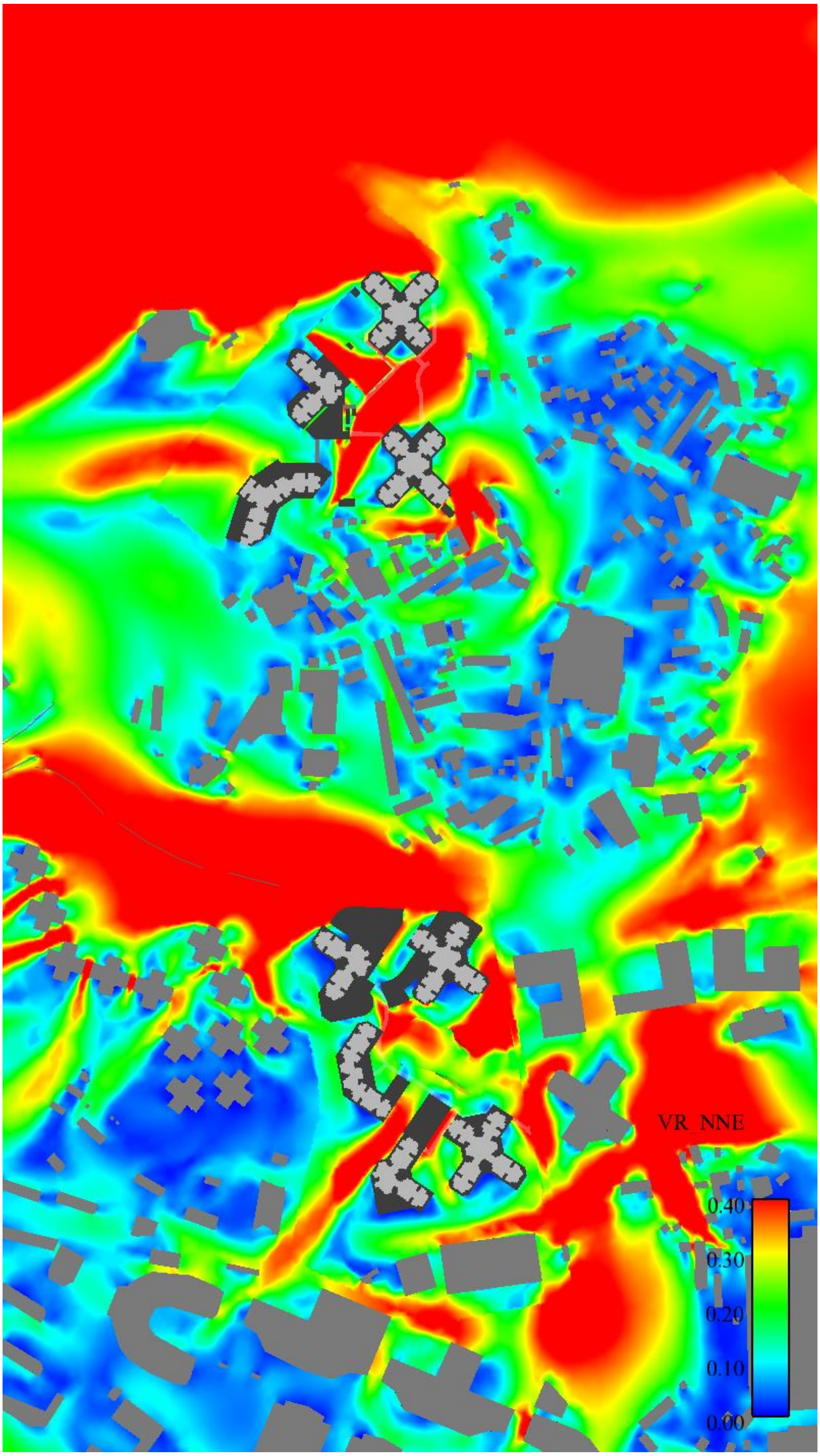


Figure E1 NNE Direction for Both Developments under Scenario 1

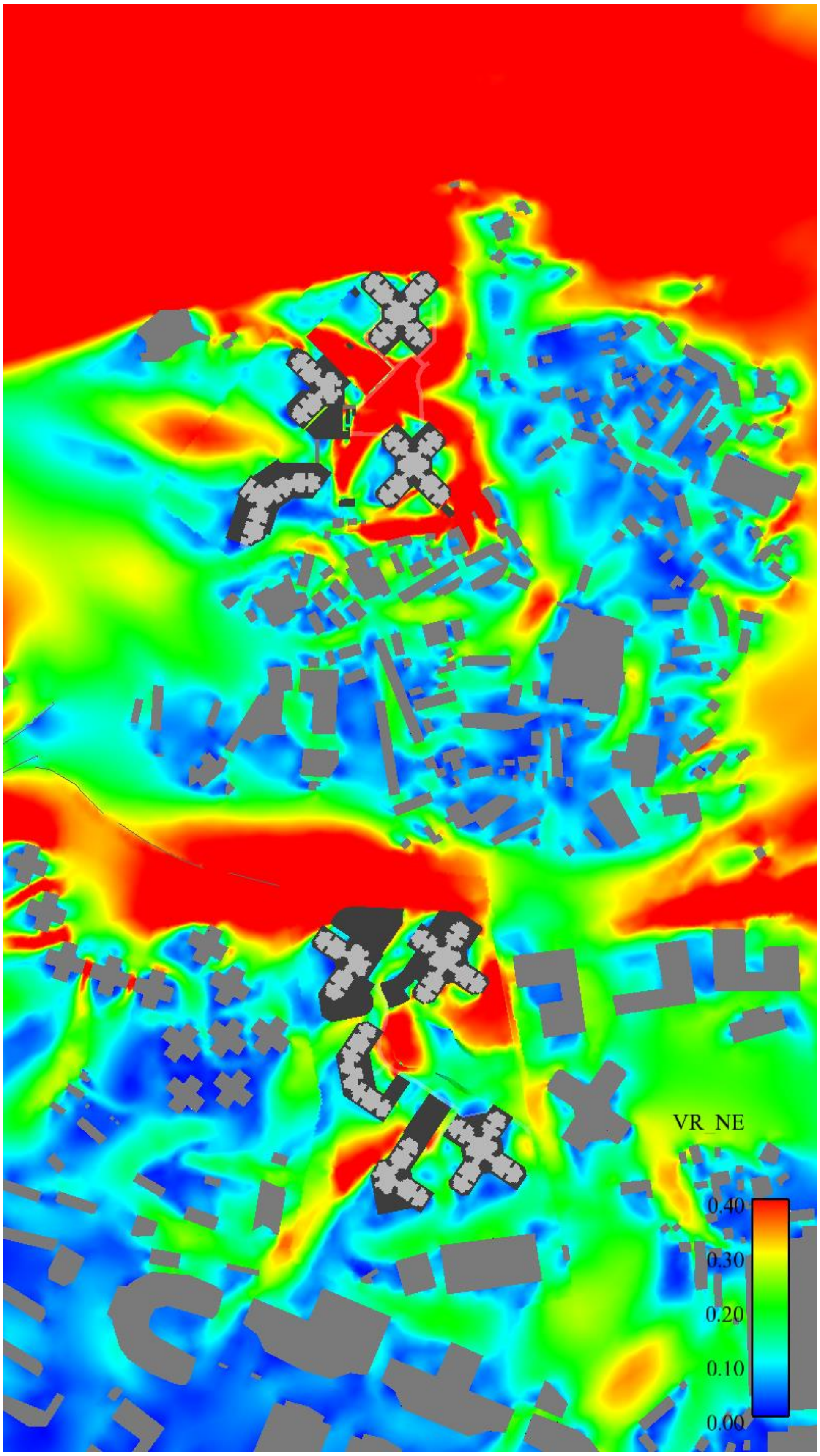


Figure E2 NE Direction for Both Developments under Scenario 1

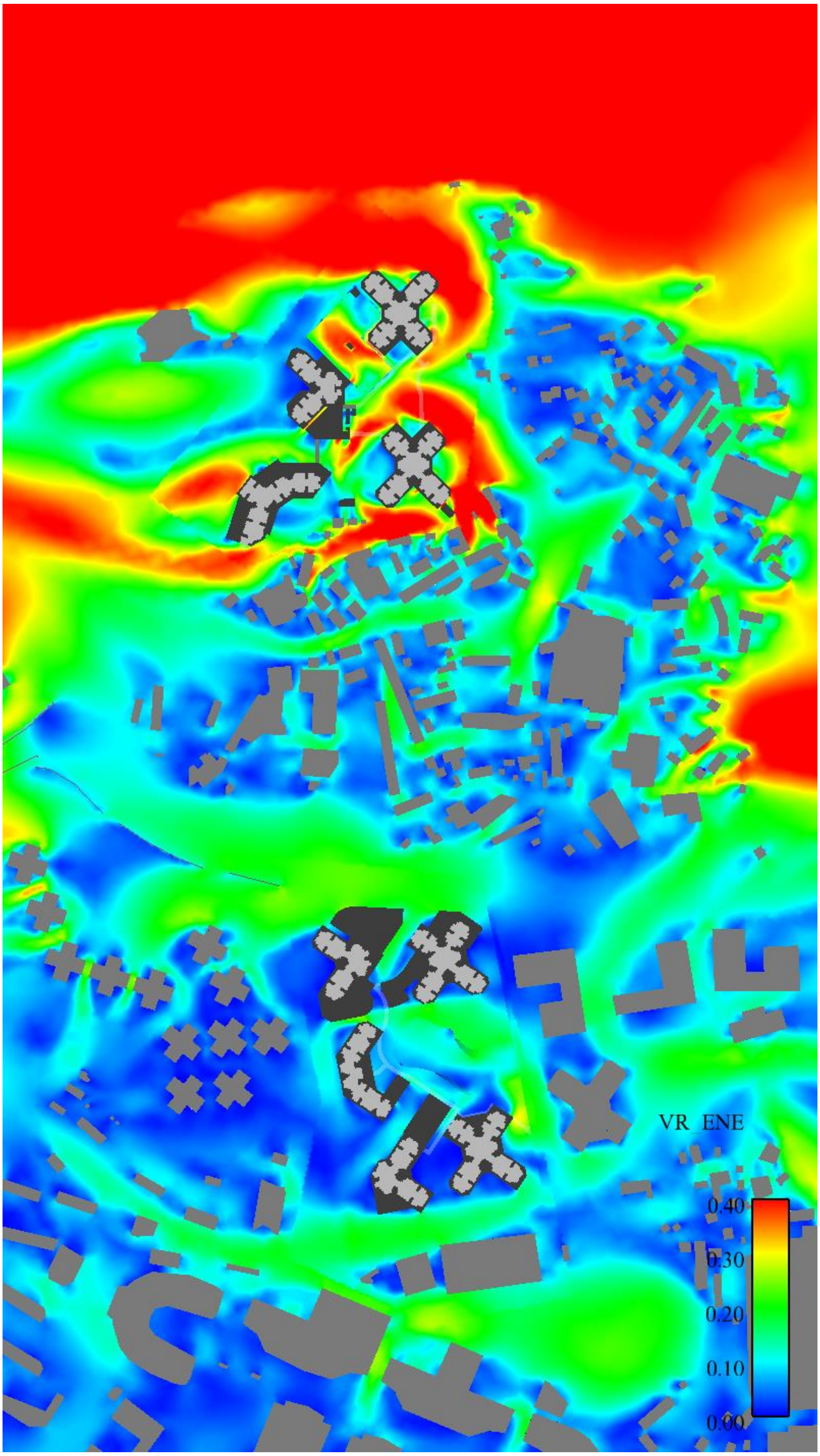


Figure E3 ENE Direction for Both Developments under Scenario 1

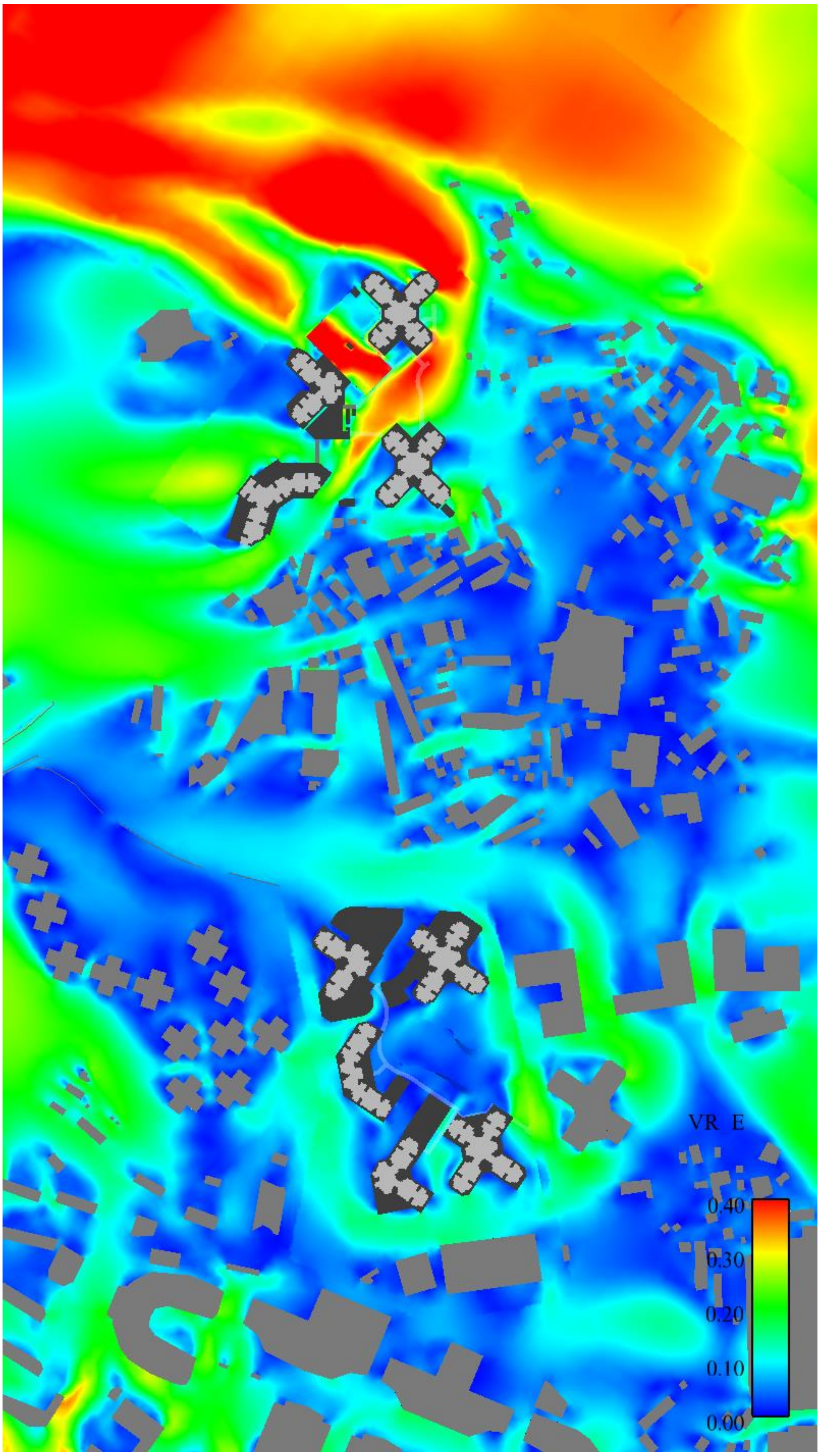


Figure E4 E Direction for Both Developments under Scenario 1

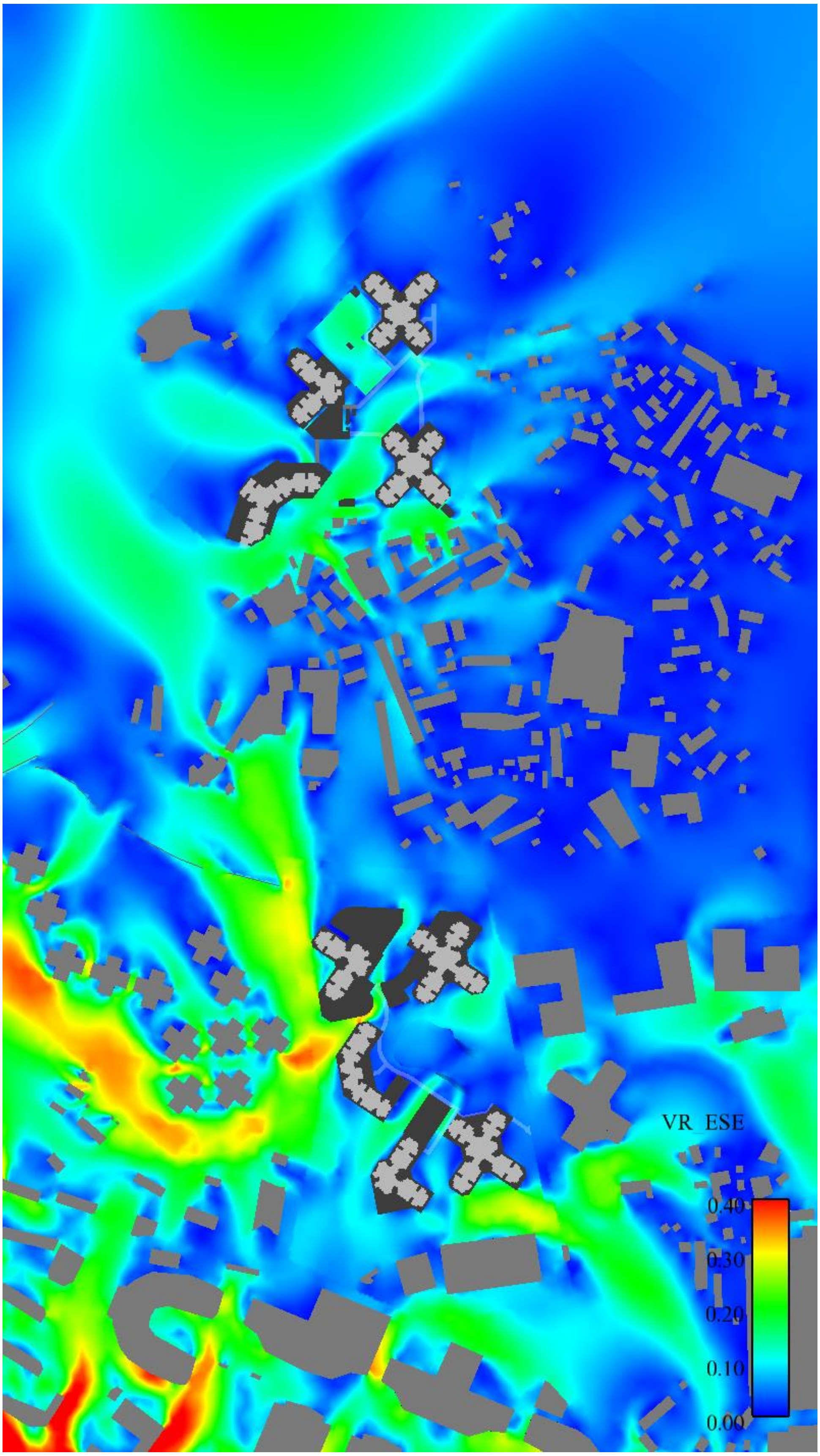


Figure E5 ESE Direction for Both Developments under Scenario 1

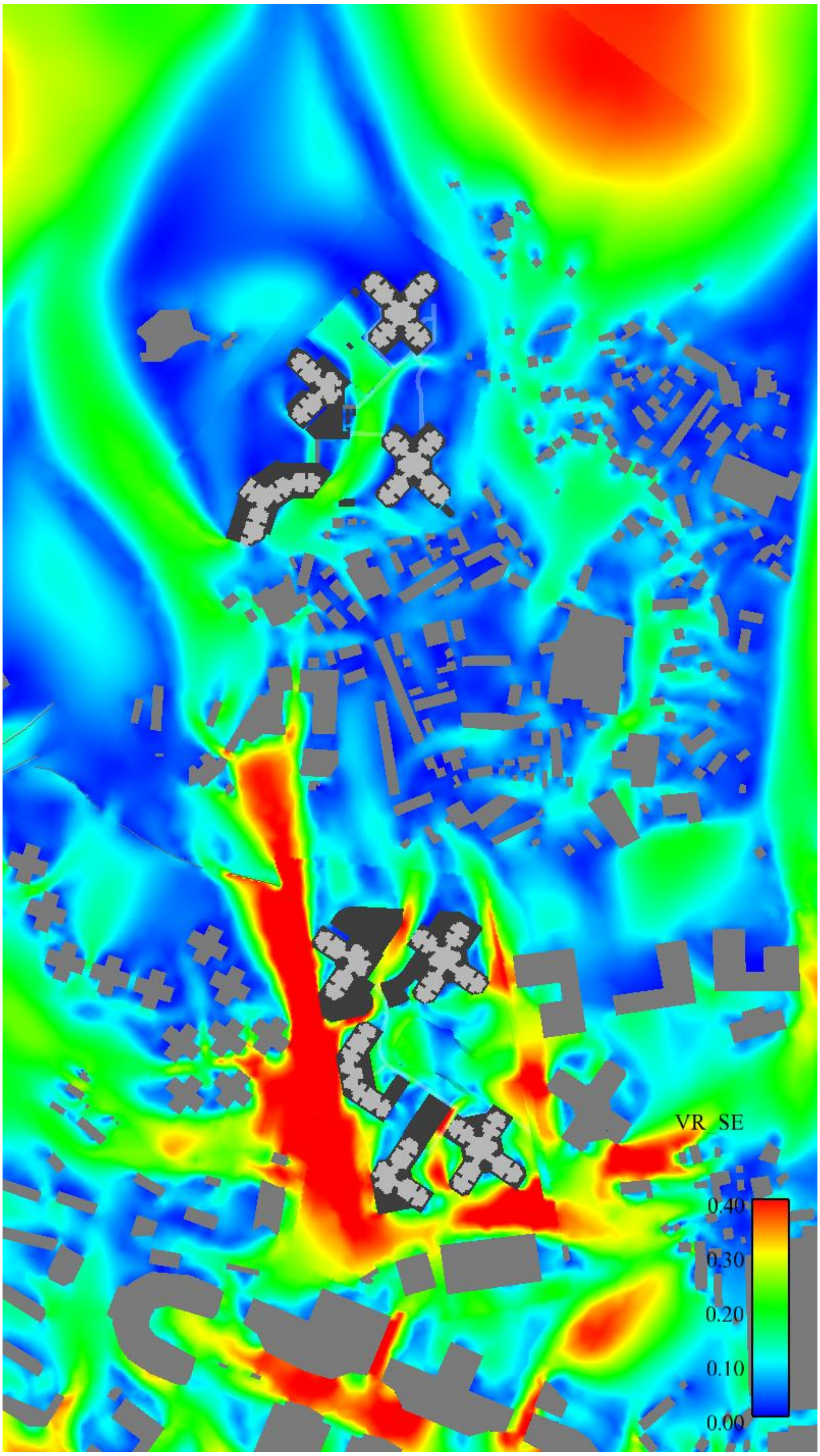


Figure E6 SE Direction for Both Developments under Scenario 1

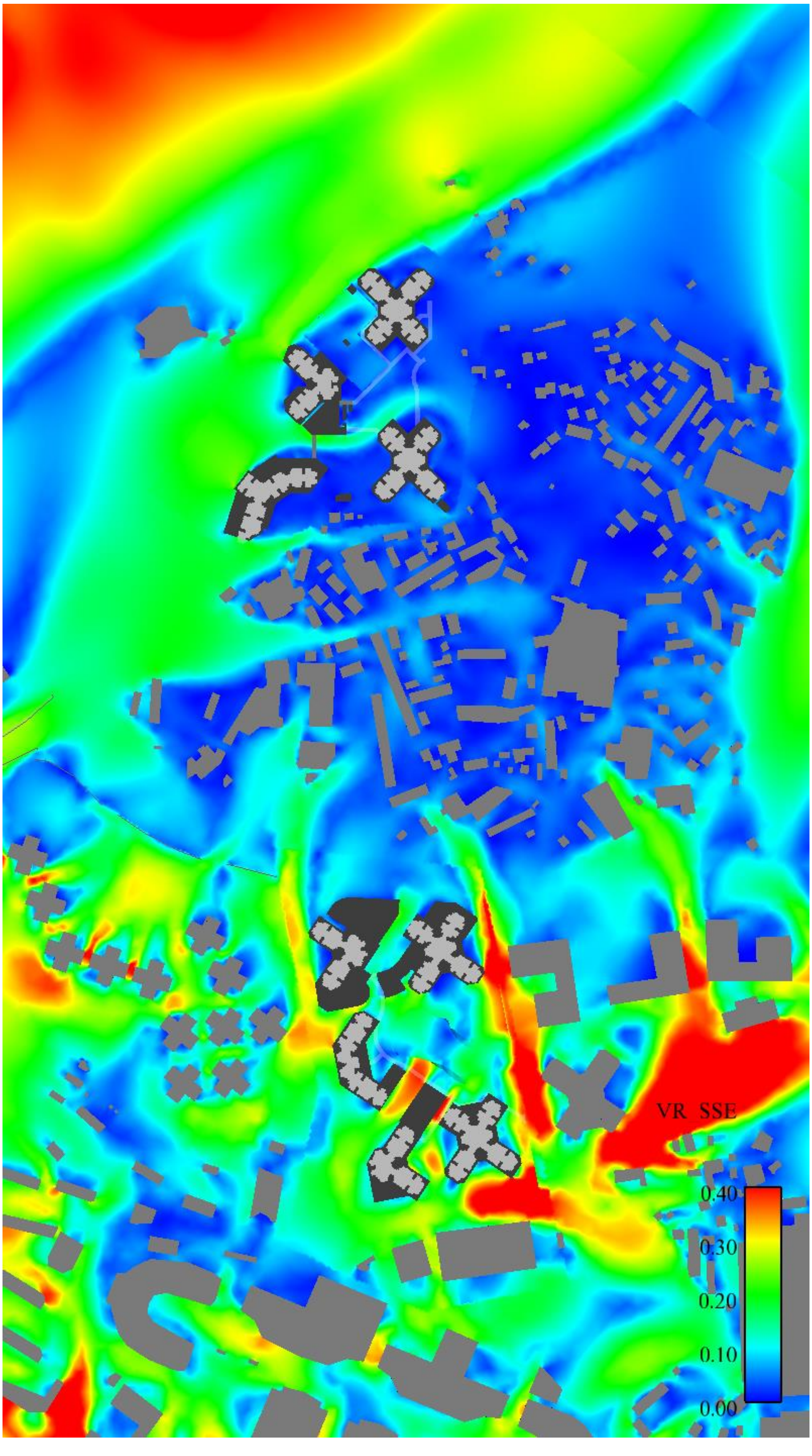


Figure E7 SSE Direction for Both Developments under Scenario 1

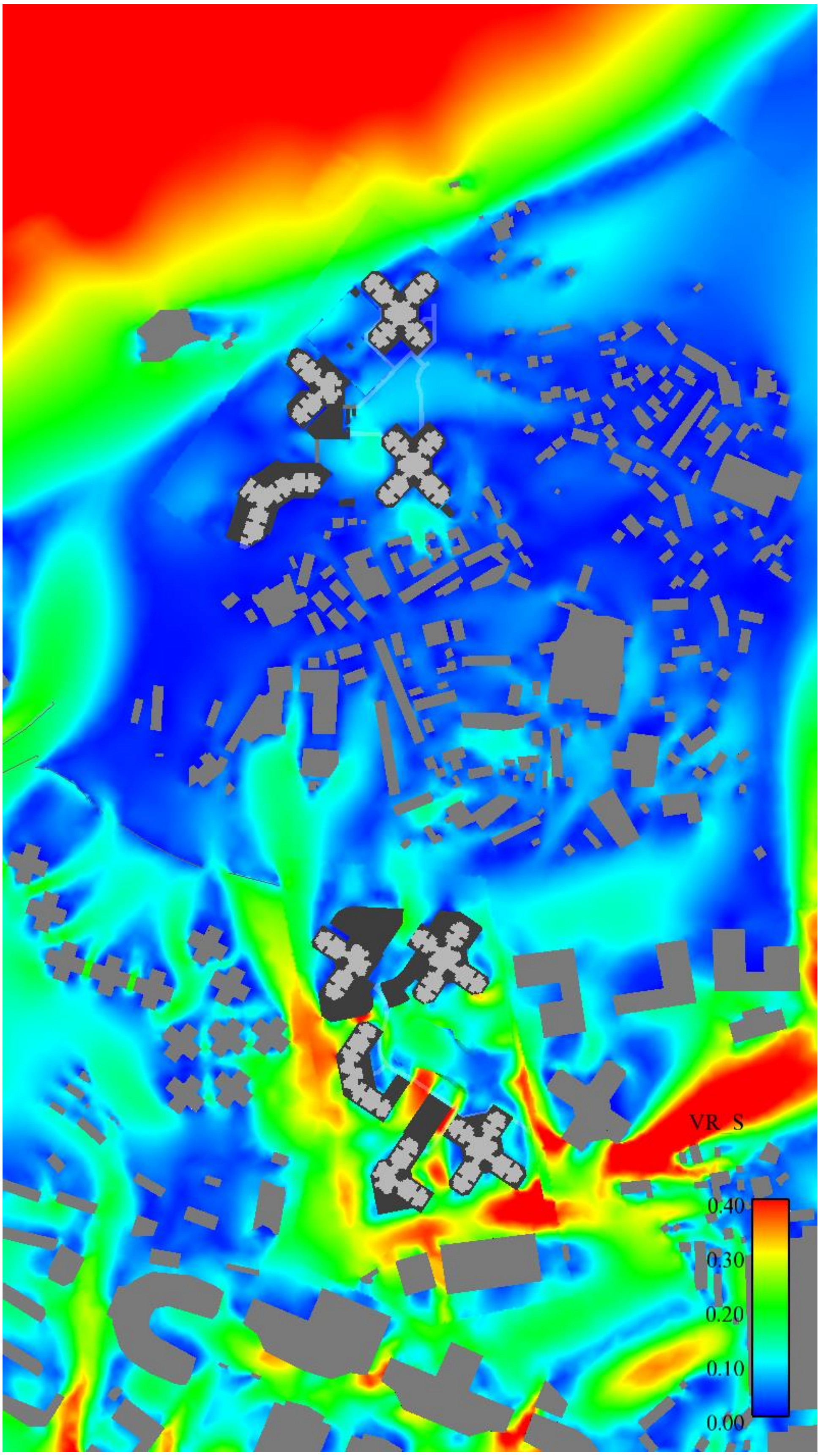


Figure E8 S Direction for Both Developments under Scenario 1

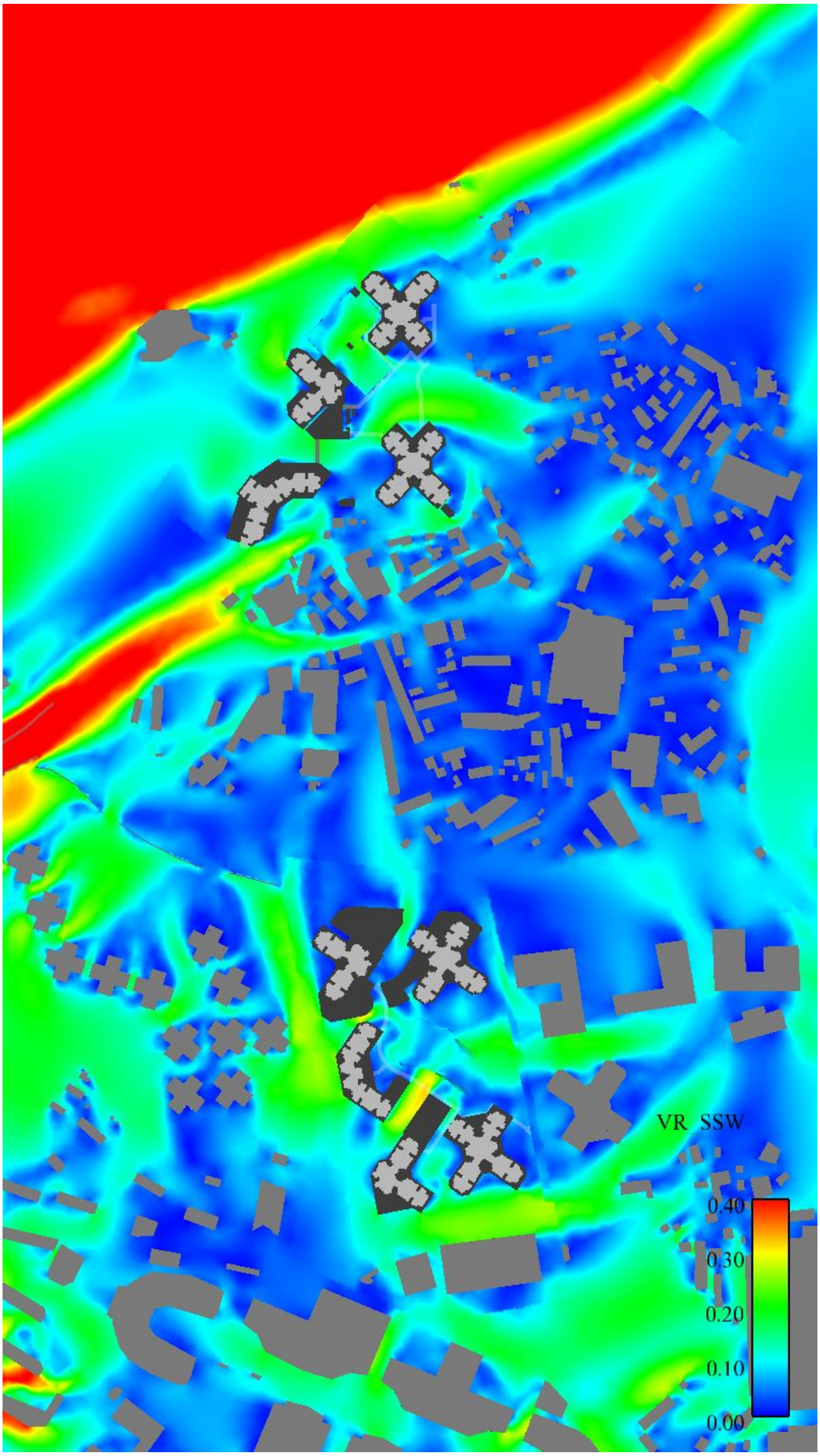


Figure E9 SSW Direction for Both Developments under Scenario 1

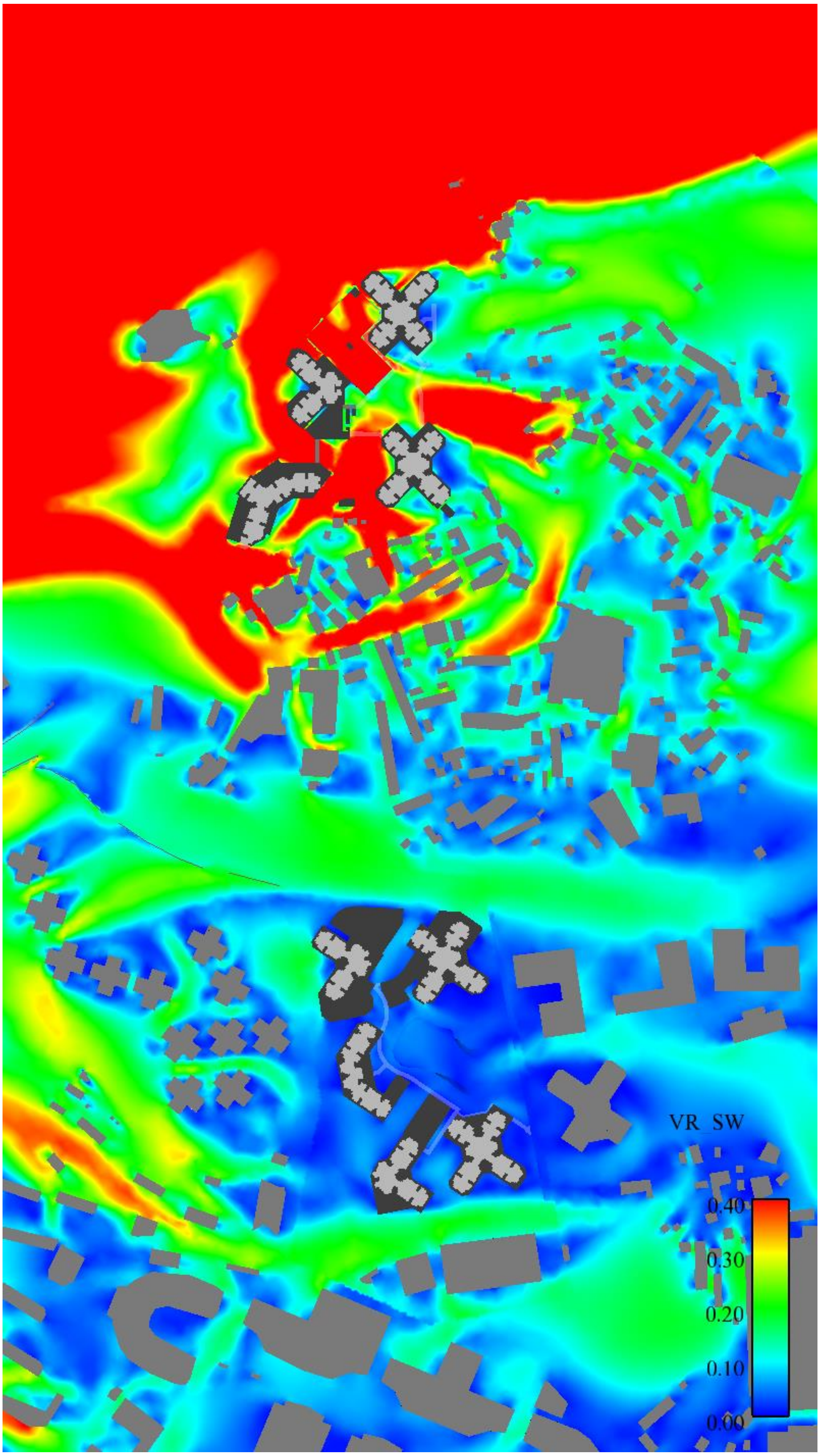


Figure E10 SW Direction for Both Developments under Scenario 1

E2 Scenario 2

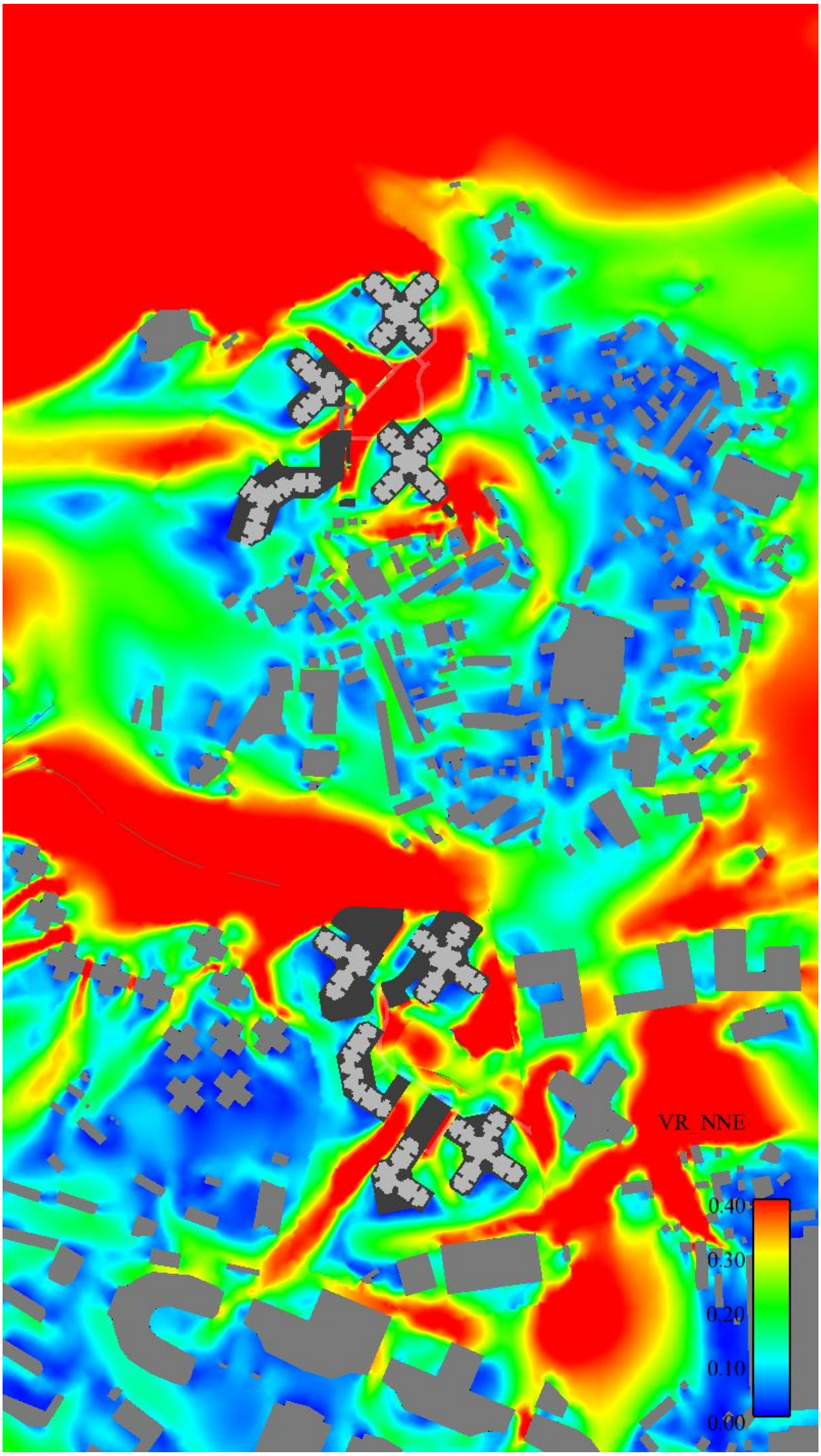


Figure E11 NNE Direction for Both Developments under Scenario 2

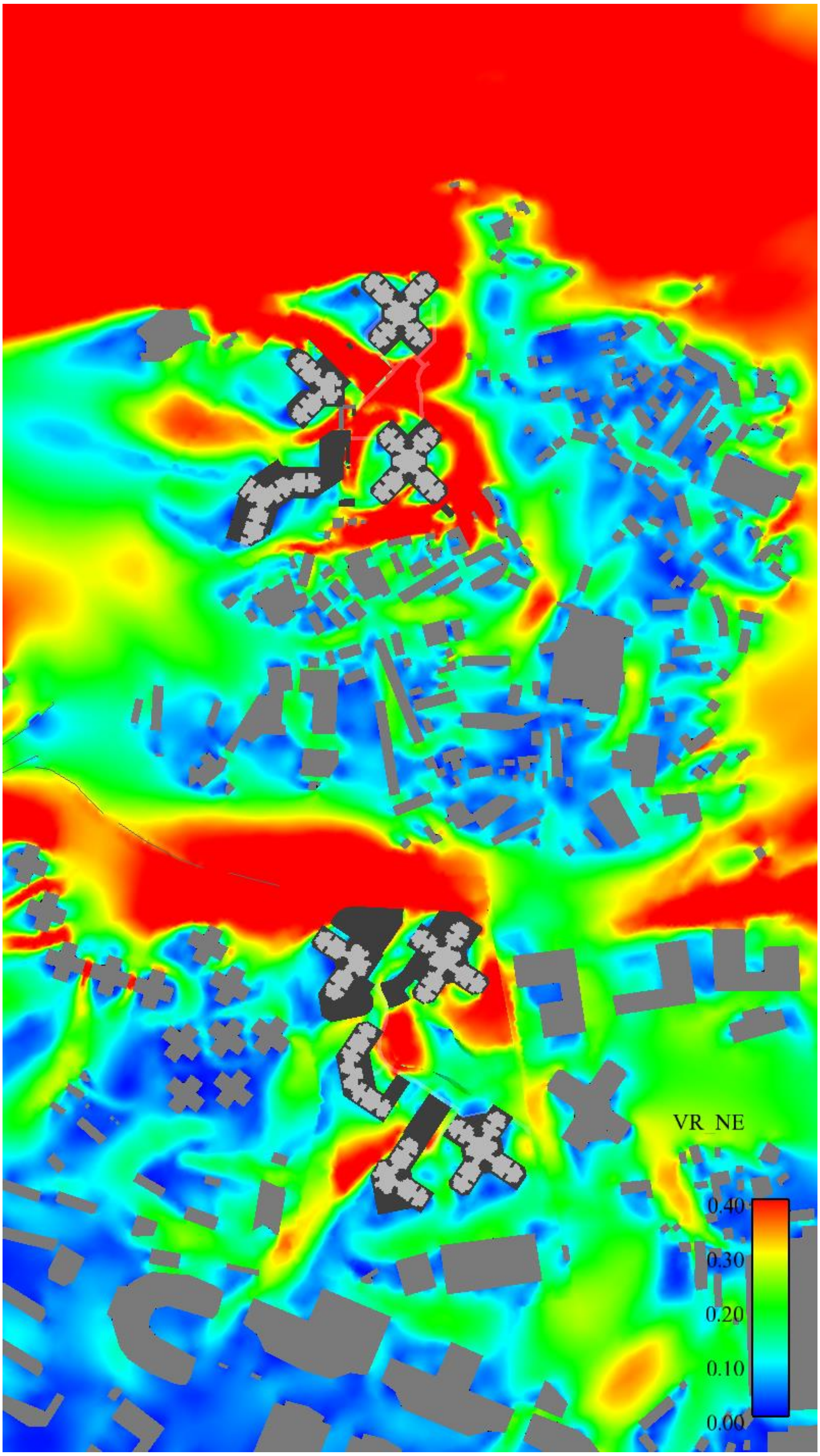


Figure E12 NE Direction for Both Developments under Scenario 2

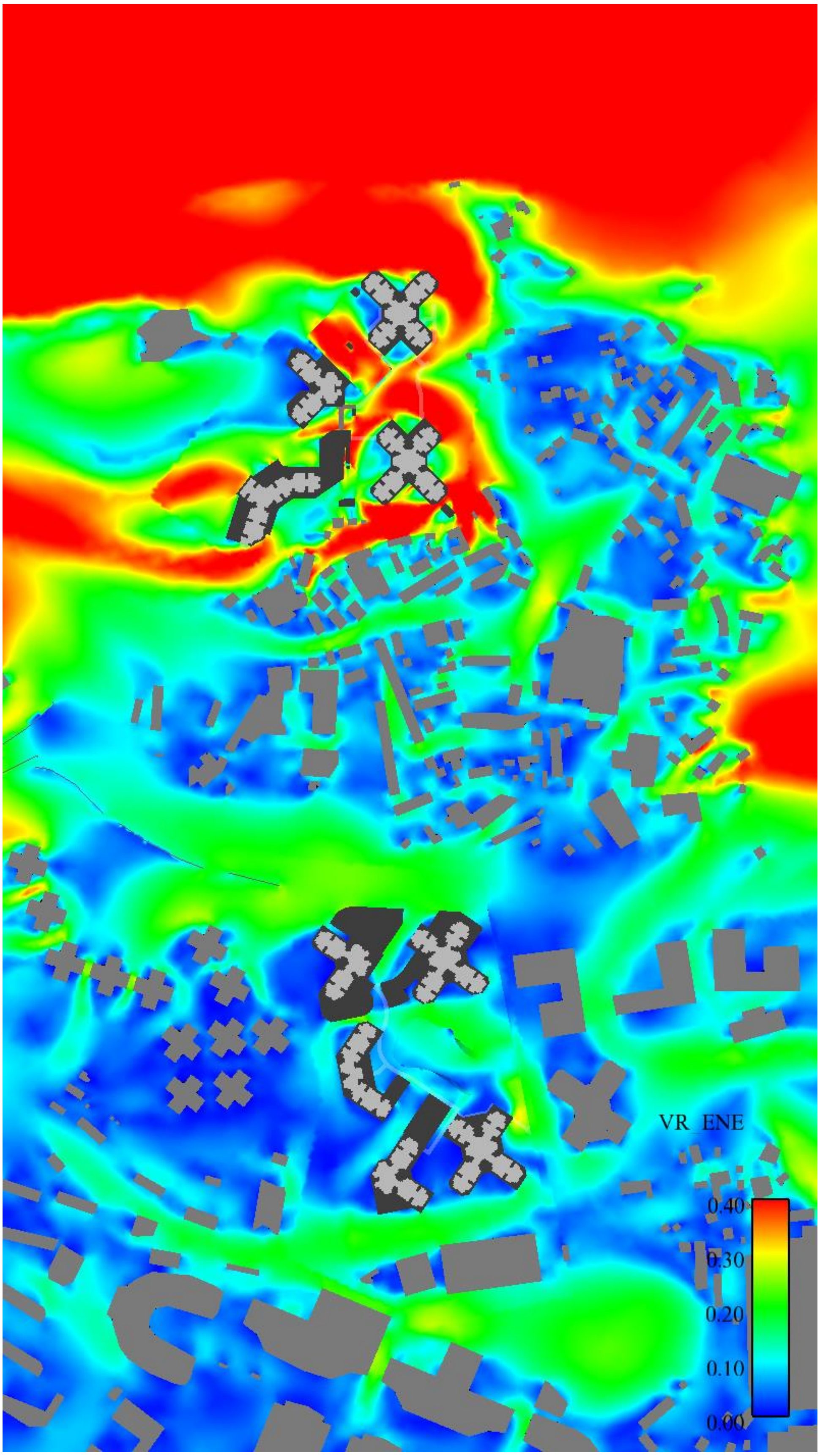


Figure E13 ENE Direction for Both Developments under Scenario 2

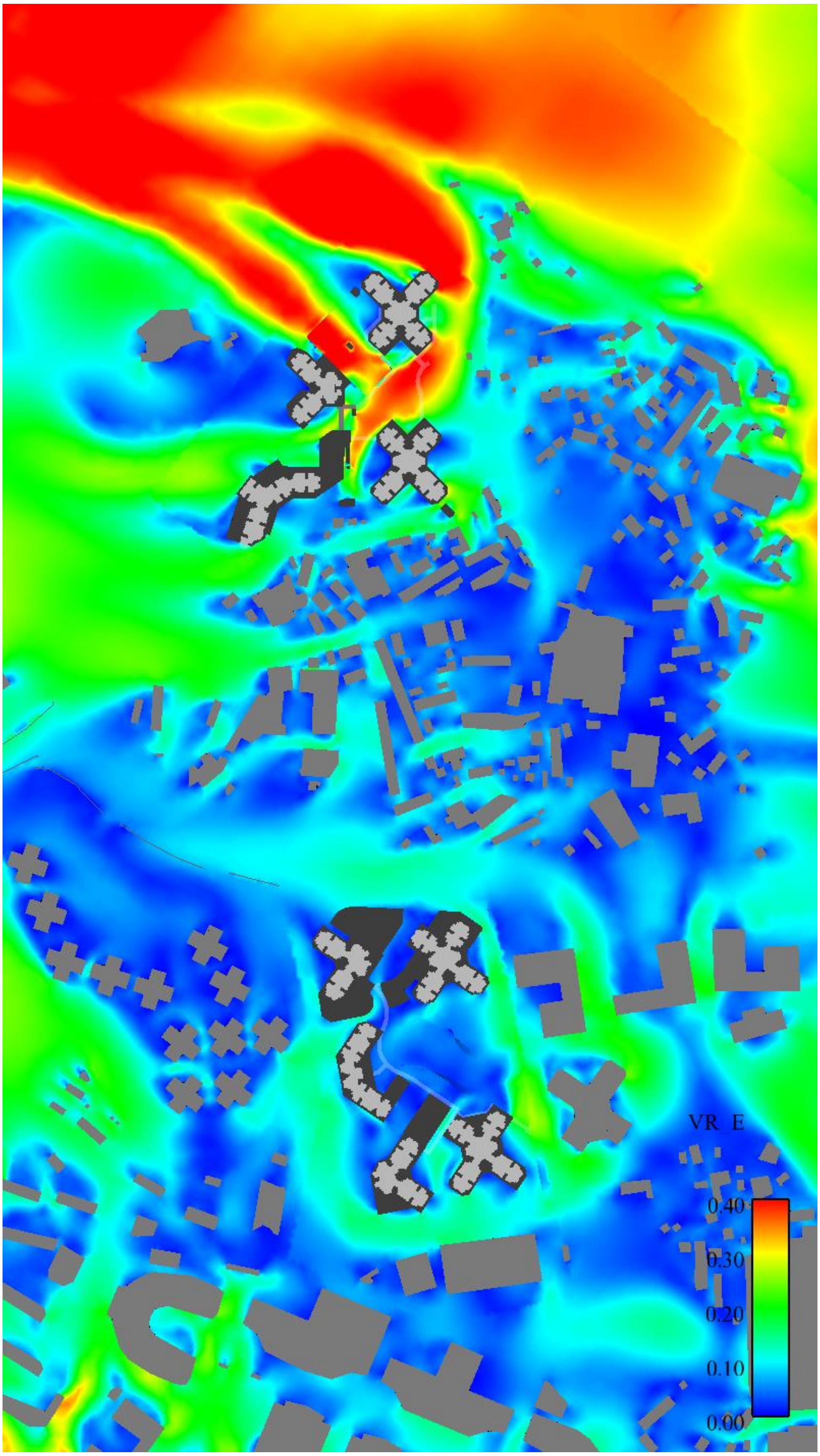


Figure E14 E Direction for Both Developments under Scenario 2

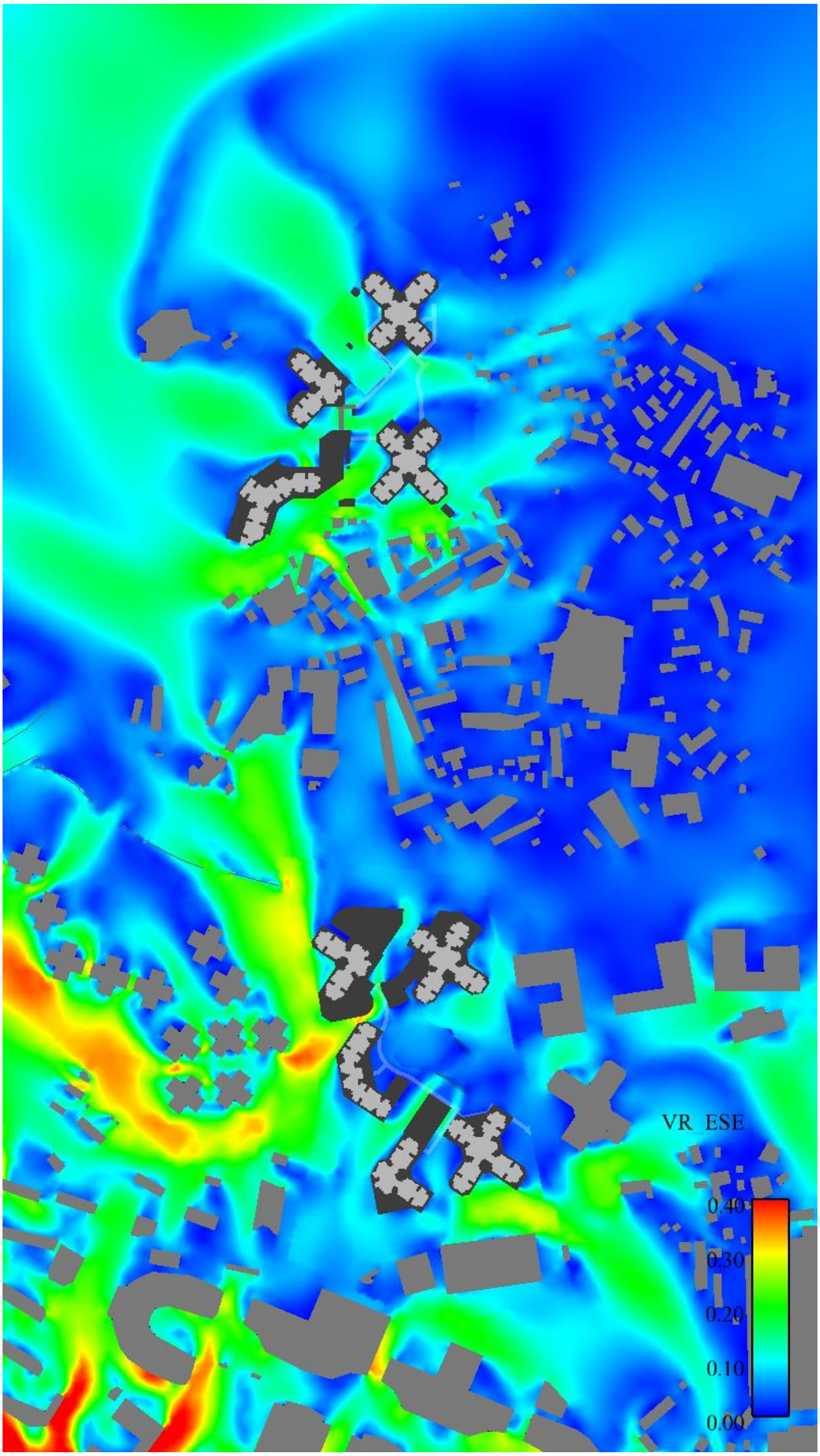


Figure E15 ESE Direction for Both Developments under Scenario 2

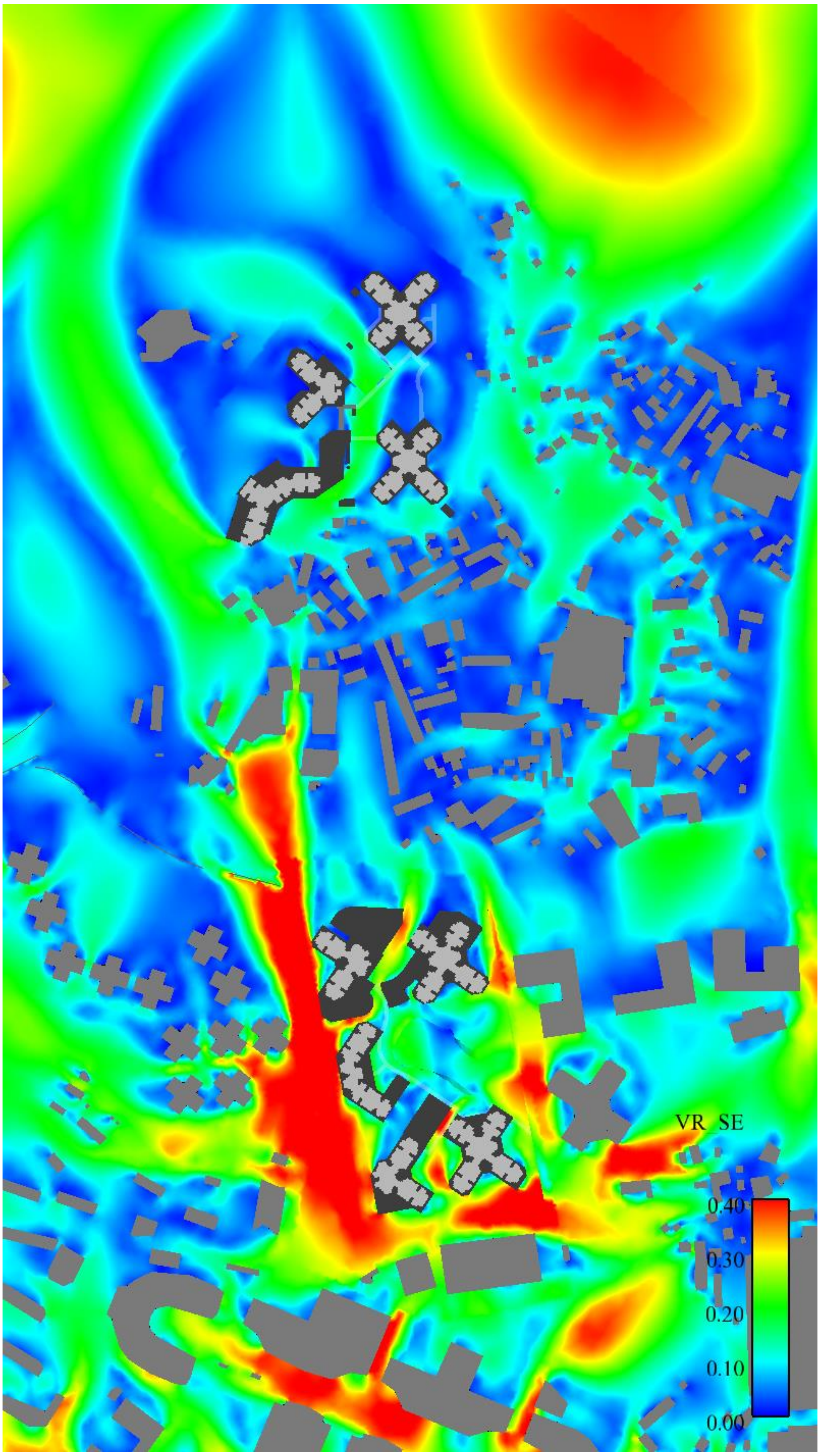


Figure E16 SE Direction for Both Developments under Scenario 2

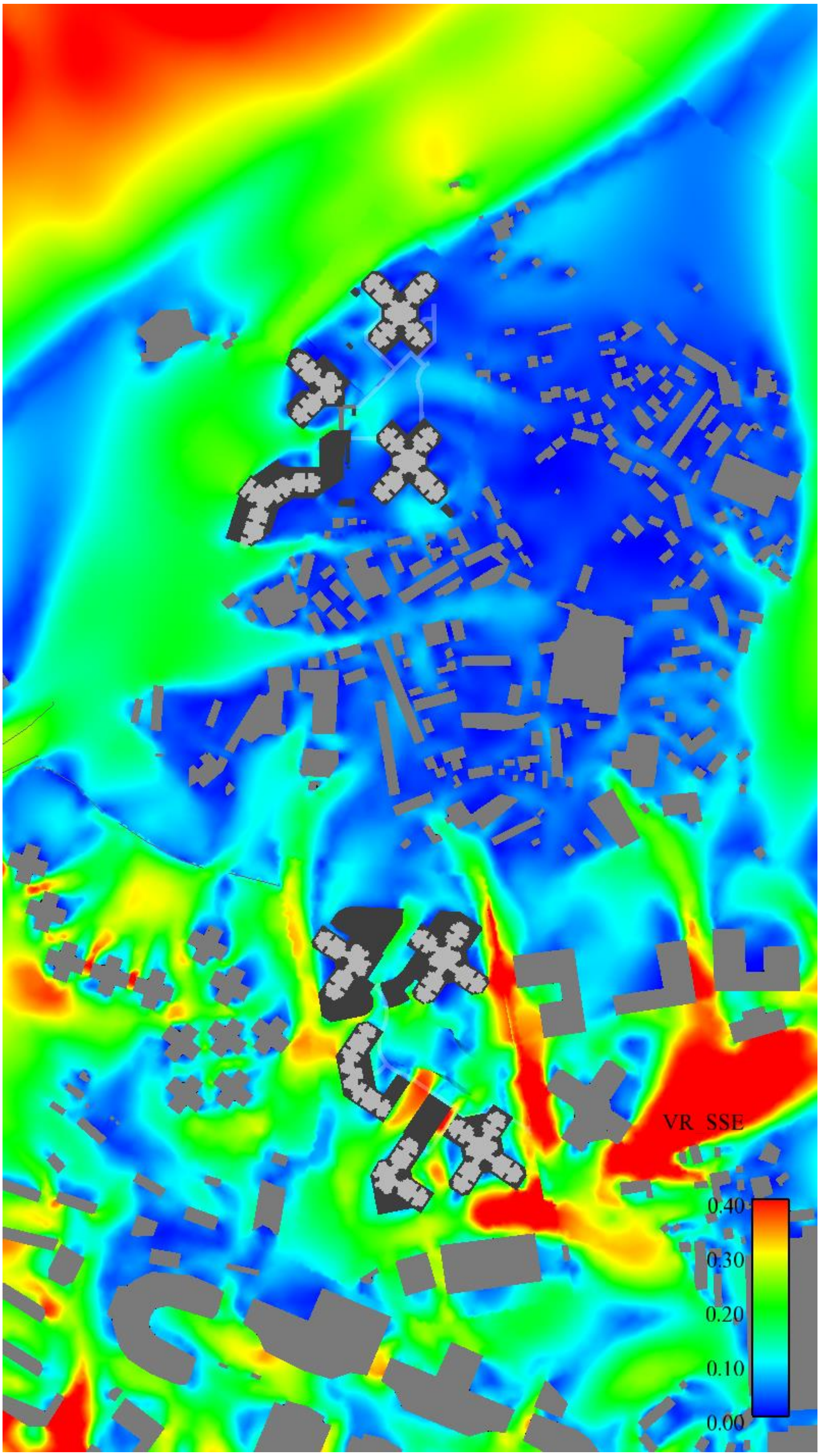


Figure E17 SSE Direction for Both Developments under Scenario 2

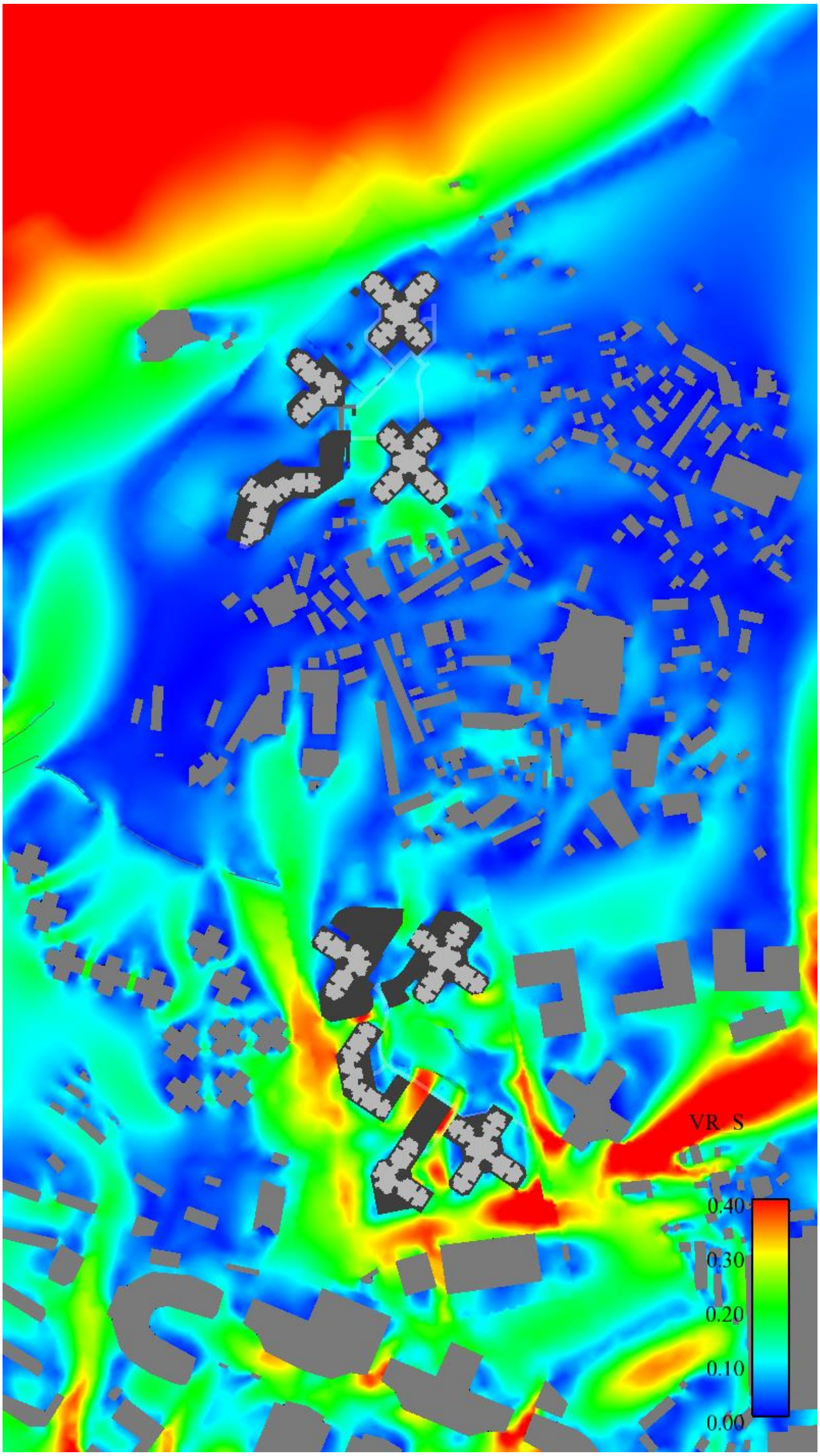


Figure E18 S Direction for Both Developments under Scenario 2

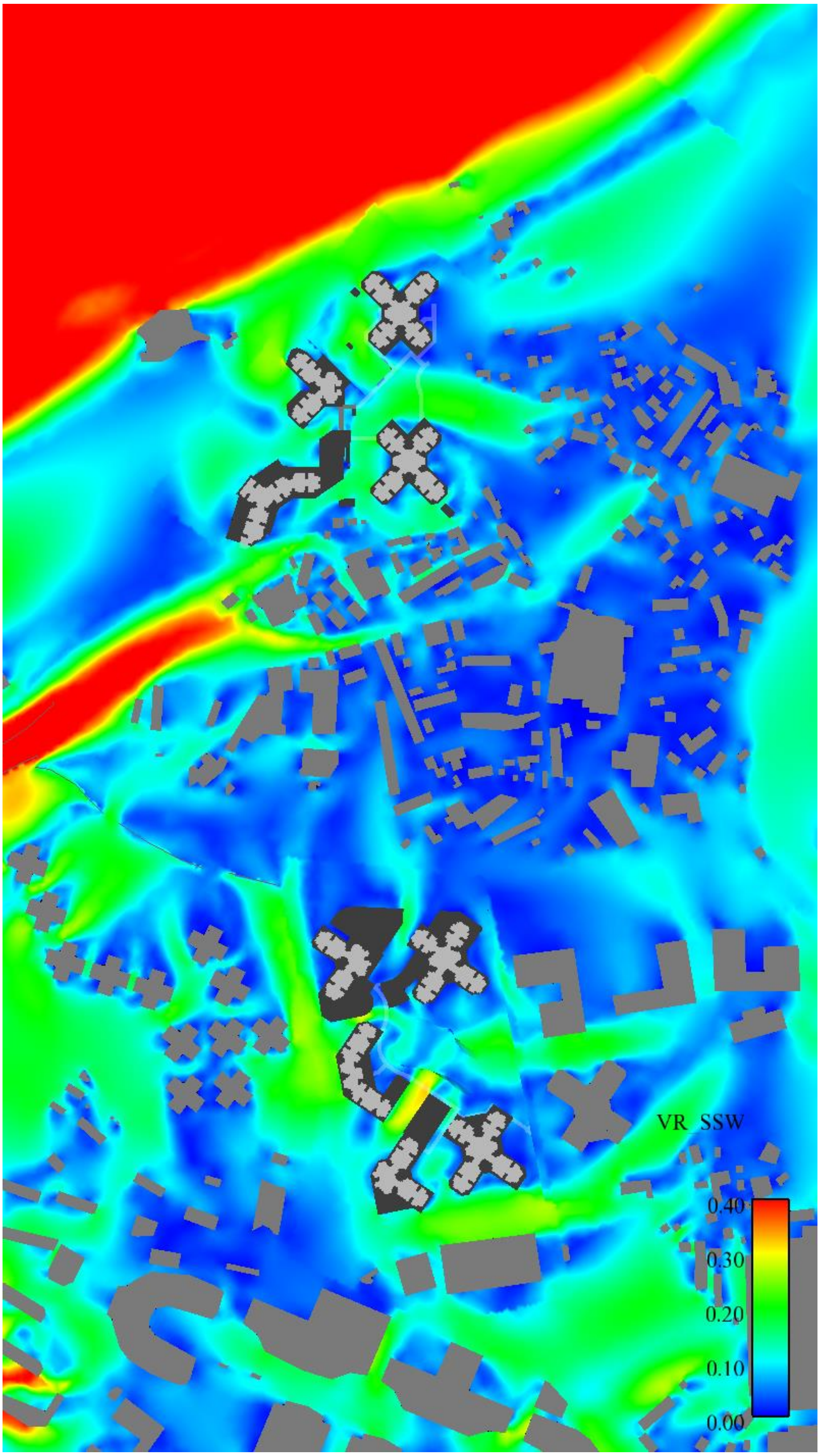


Figure E19 SSW Direction for Both Developments under Scenario 2

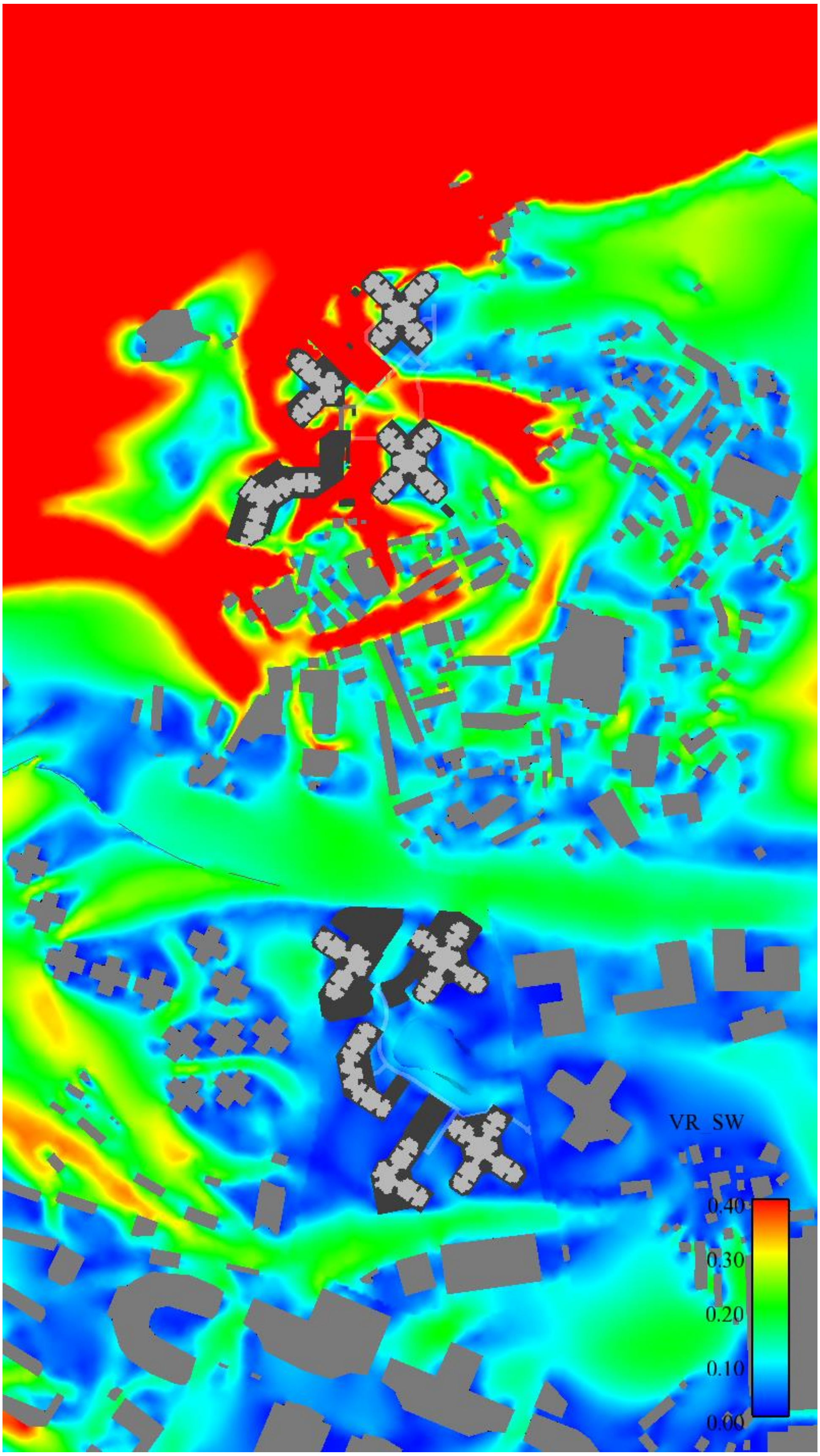


Figure E20 SW Direction for Both Developments under Scenario 2

E3 Scenario 3

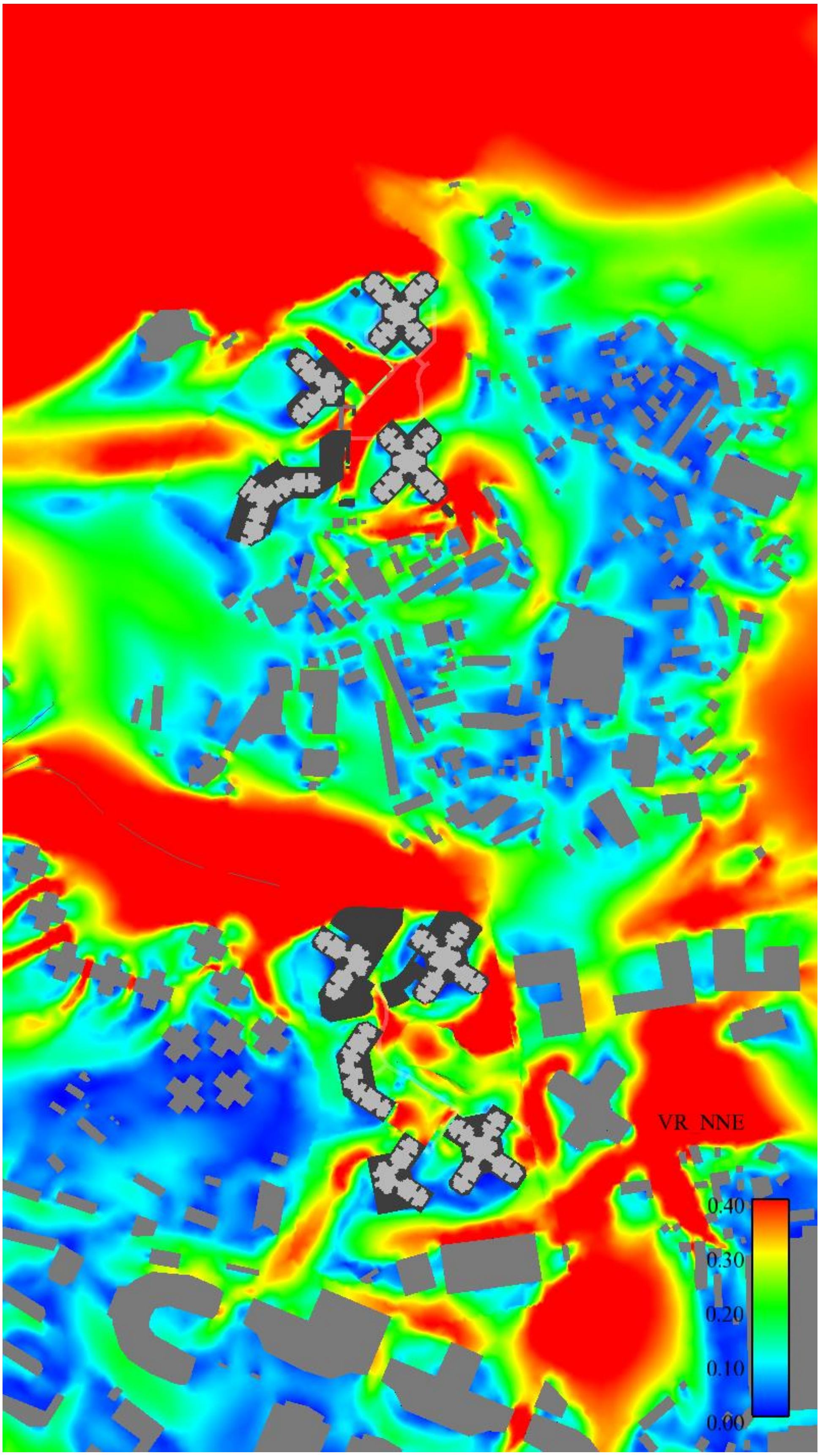


Figure E21 NNE Direction for Both Developments under Scenario 3

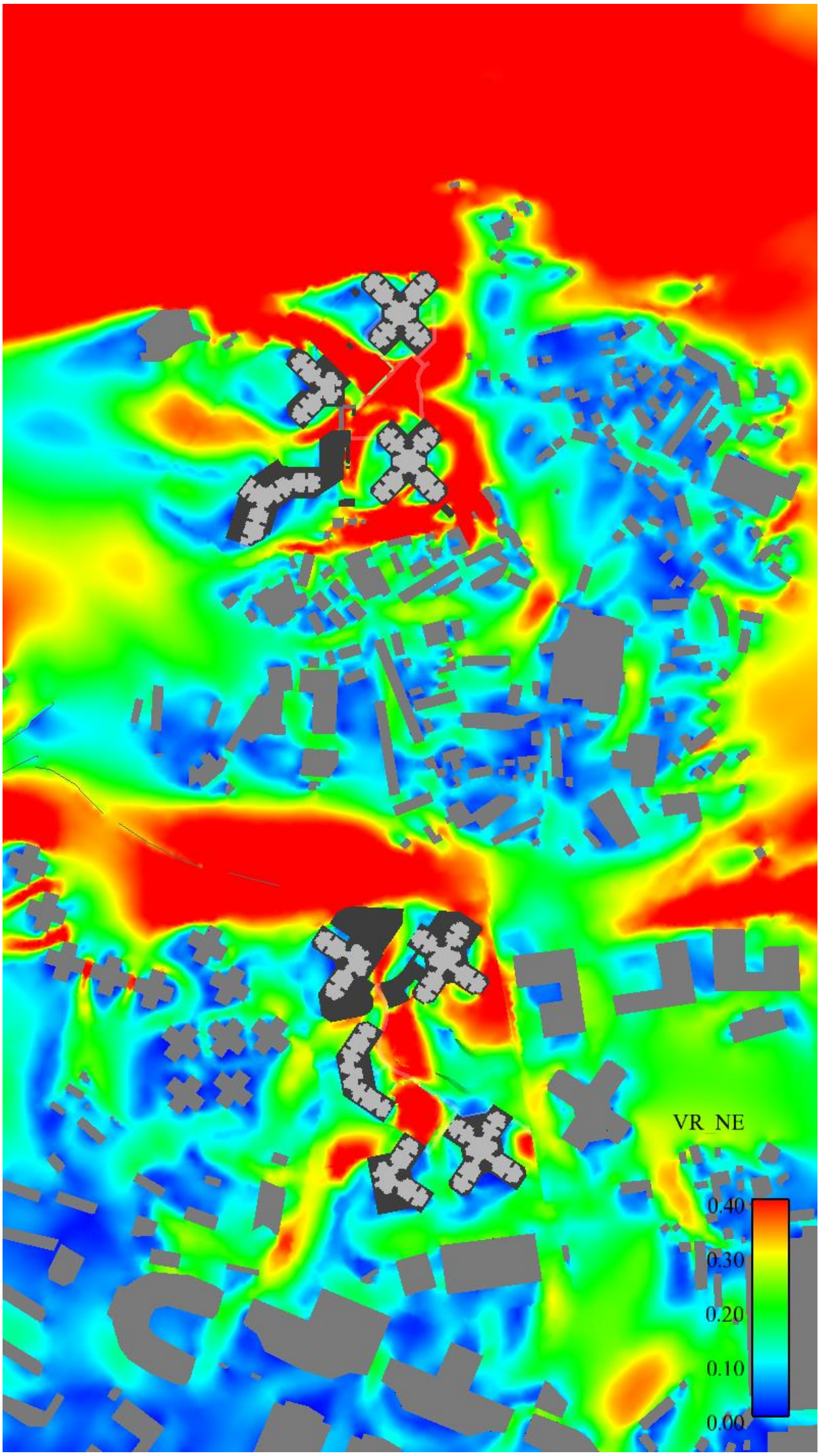


Figure E22 NE Direction for Both Developments under Scenario 3

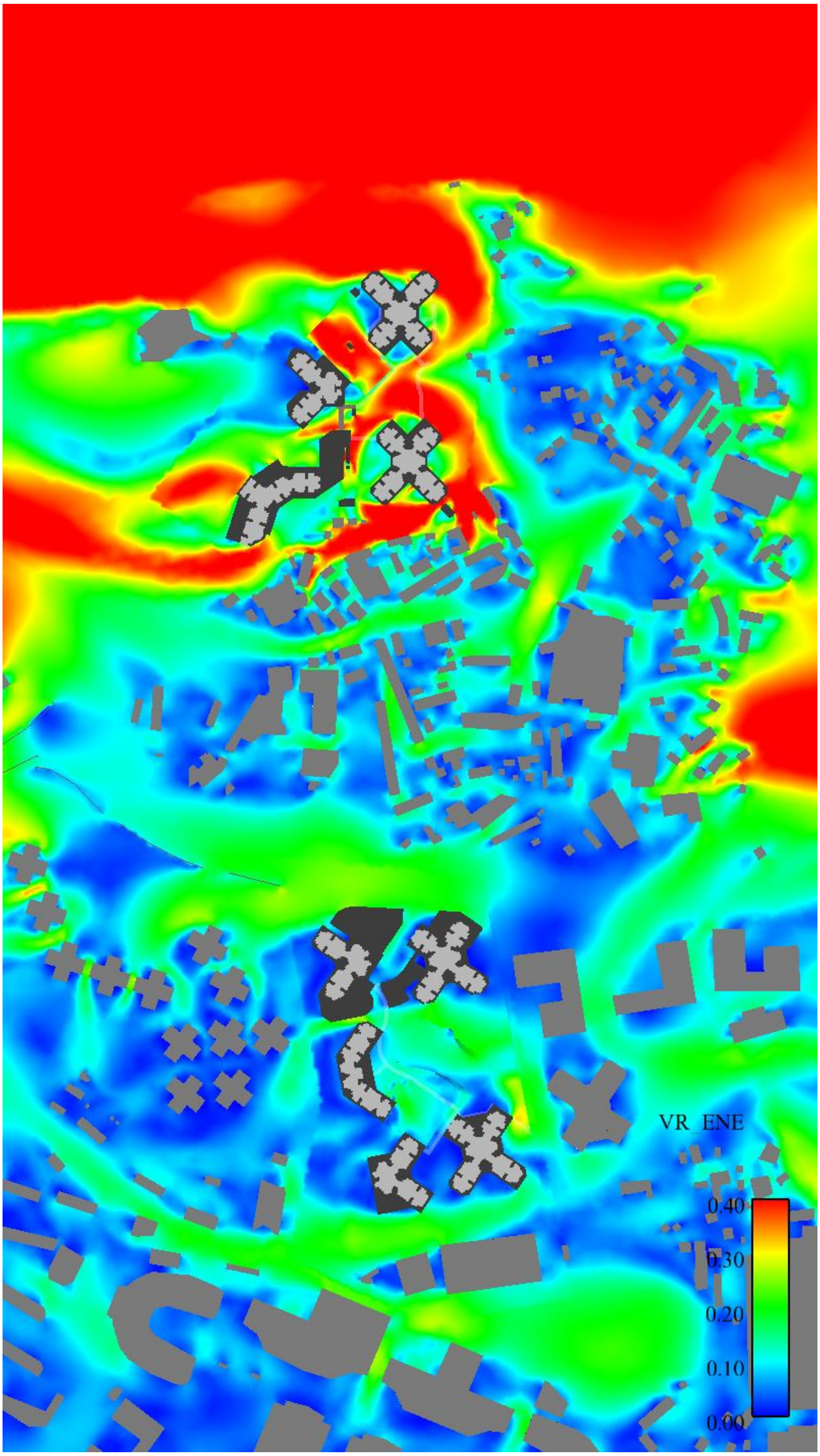


Figure E23 ENE Direction for Both Developments under Scenario 3

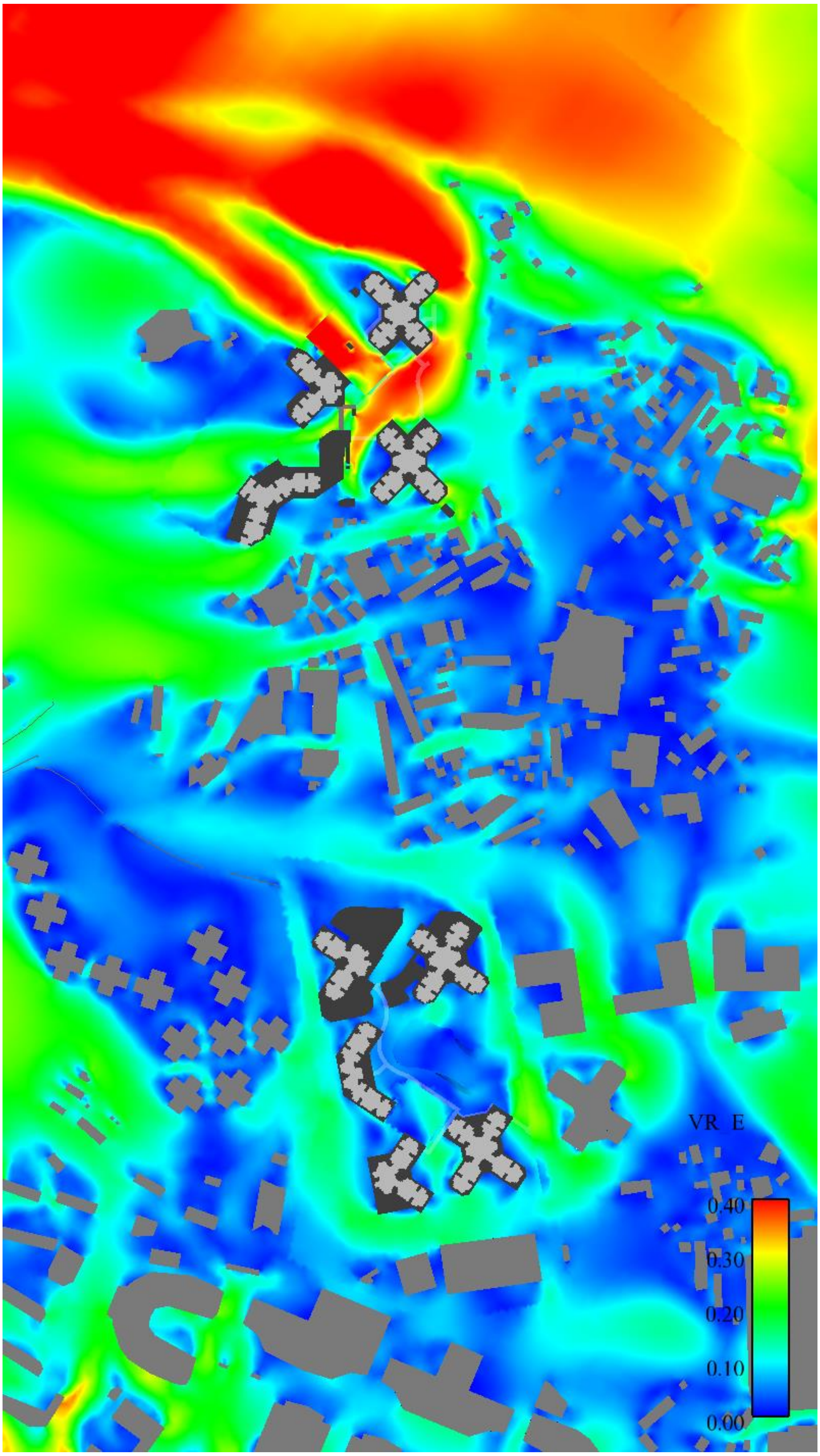


Figure E24 E Direction for Both Developments under Scenario 3

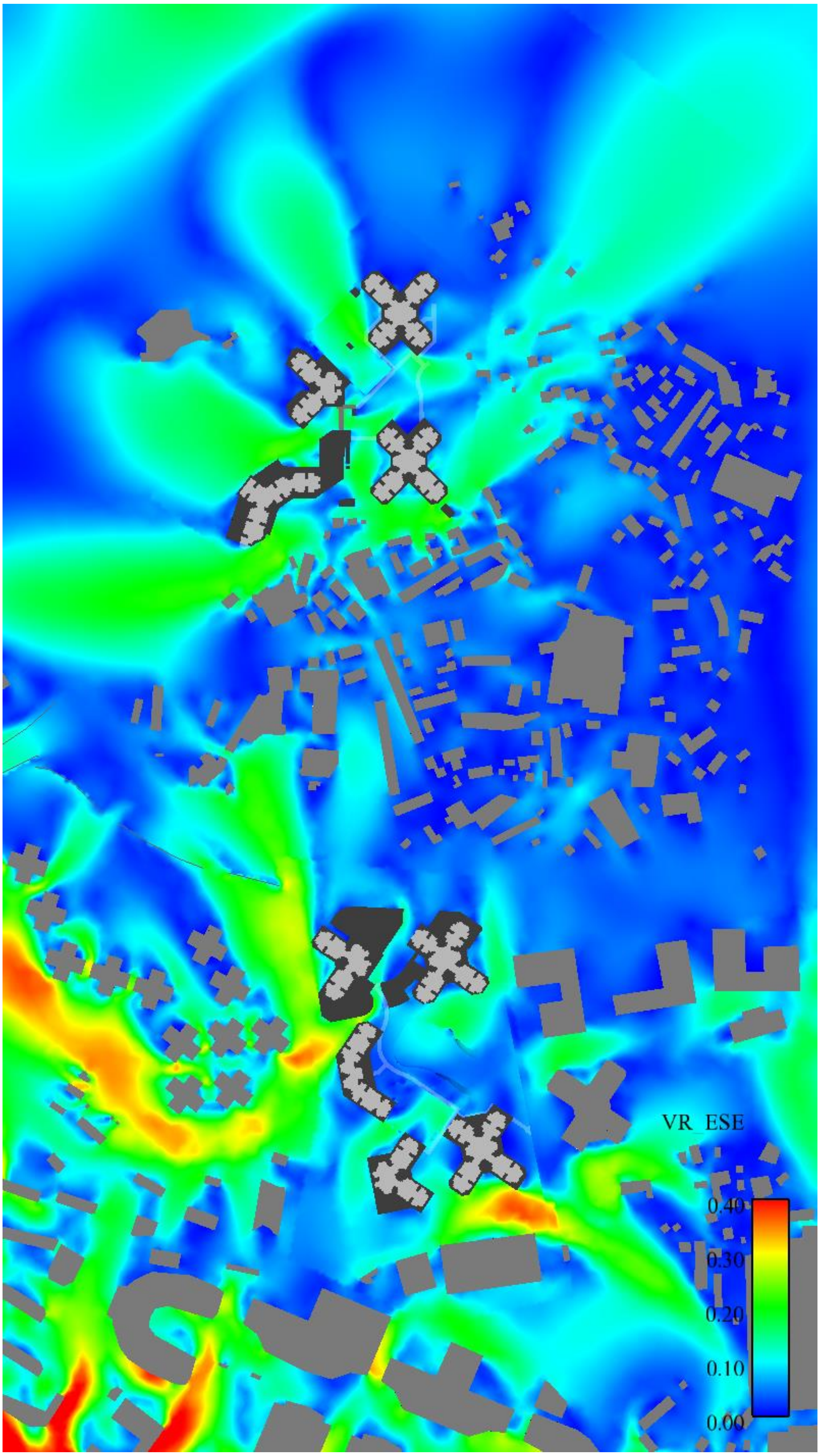


Figure E25 ESE Direction for Both Developments under Scenario 3

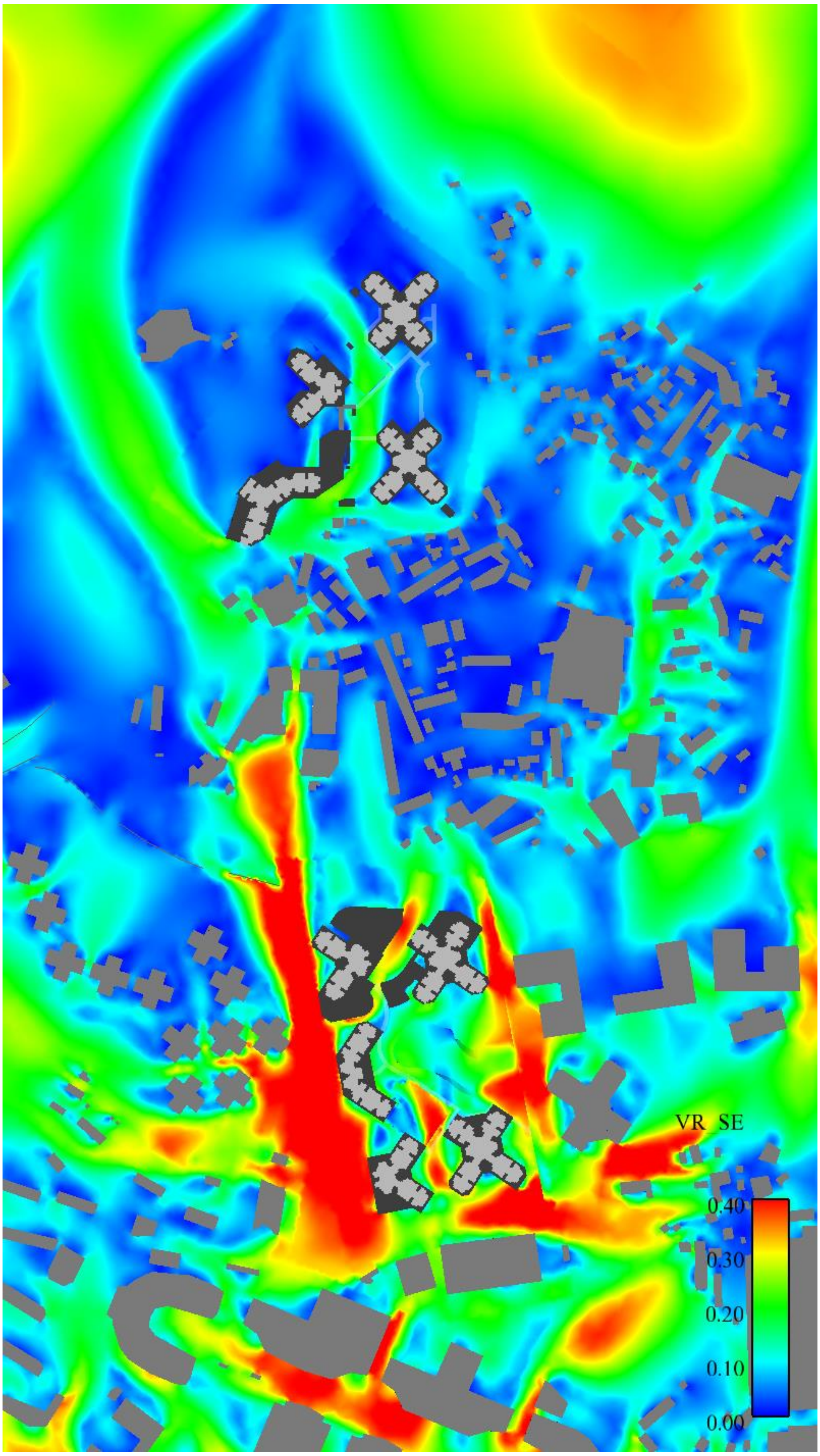


Figure E26 SE Direction for Both Developments under Scenario 3

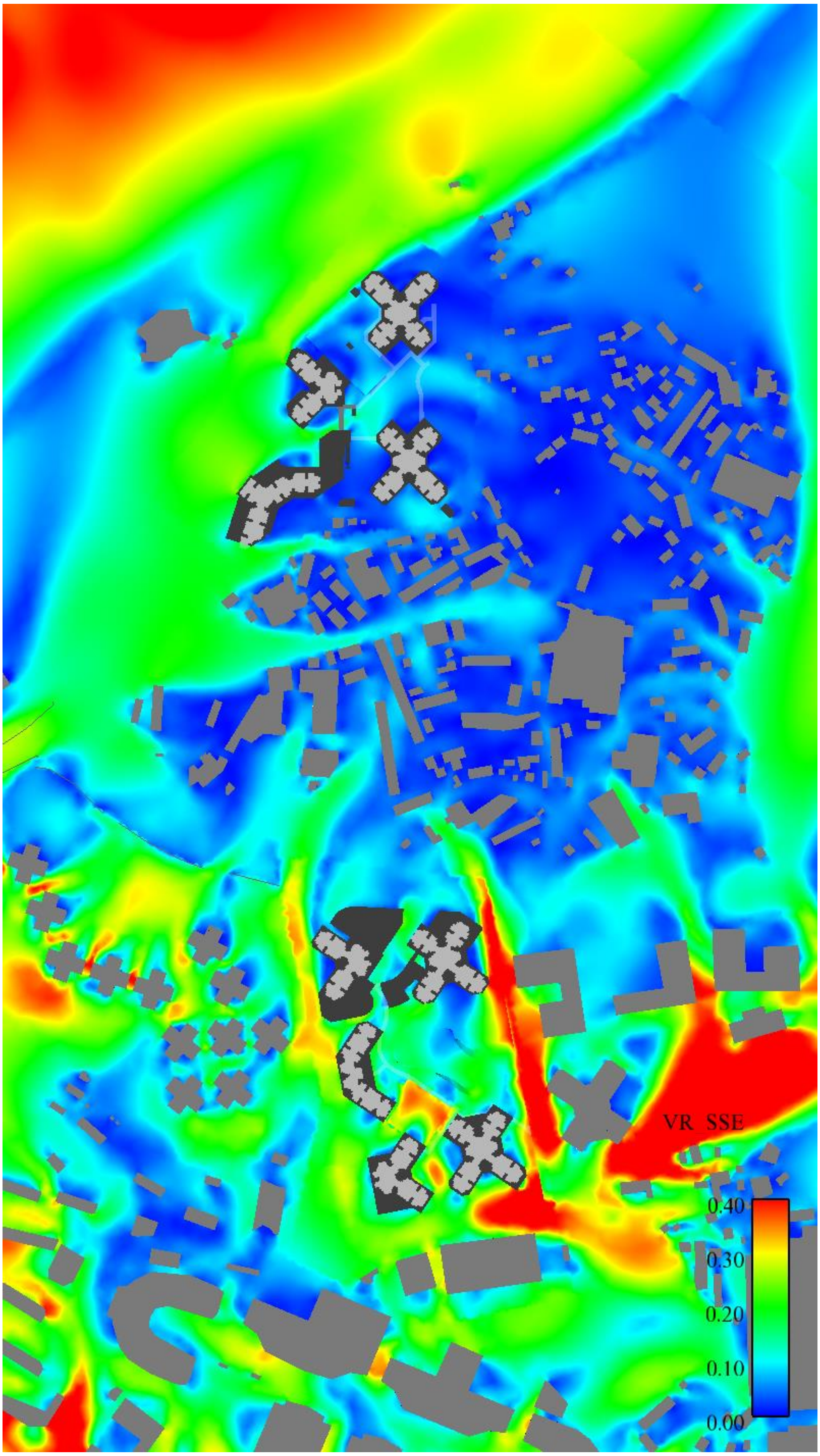


Figure E27 SSE Direction for Both Developments under Scenario 3

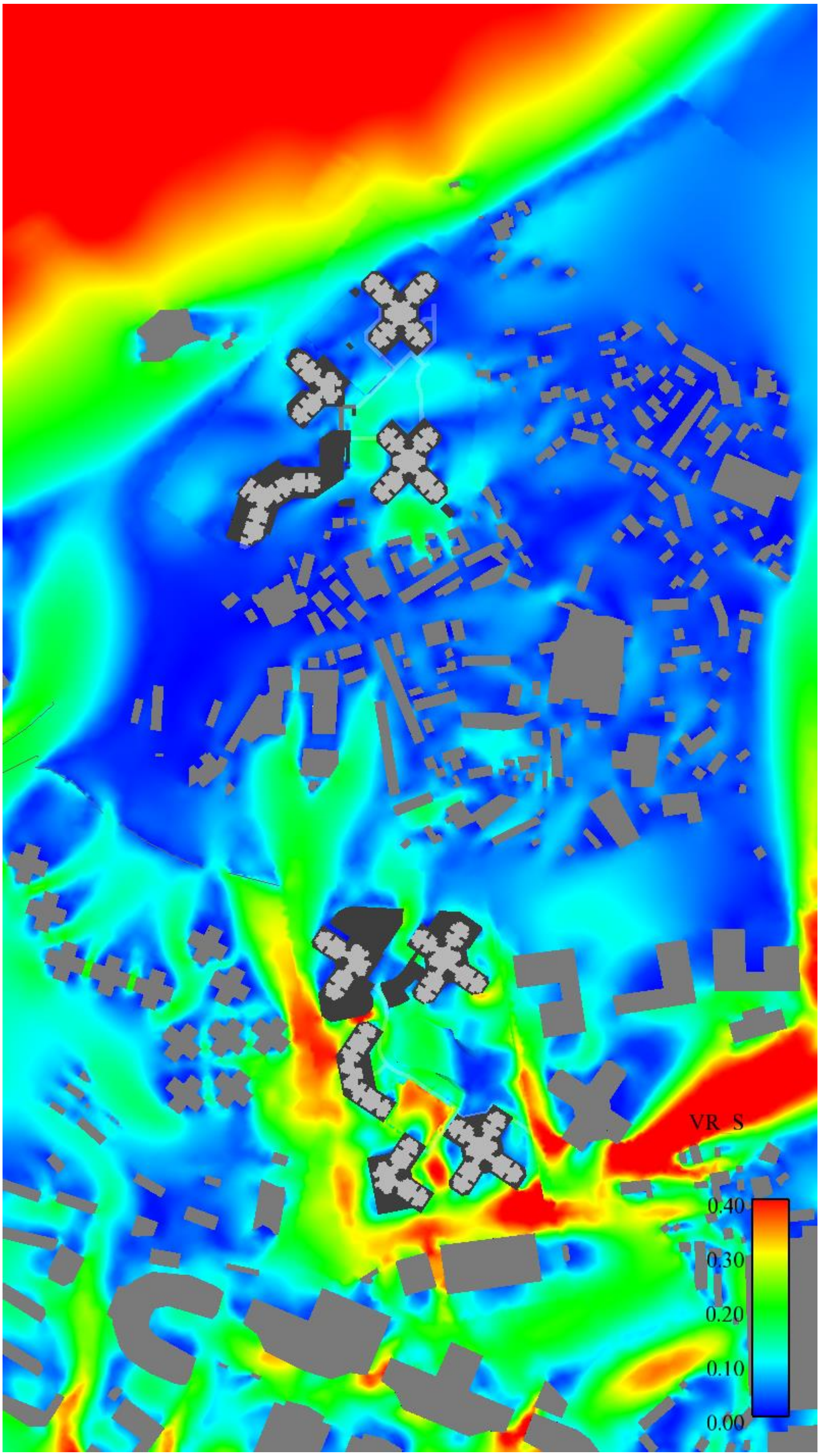


Figure E28 S Direction for Both Developments under Scenario 3

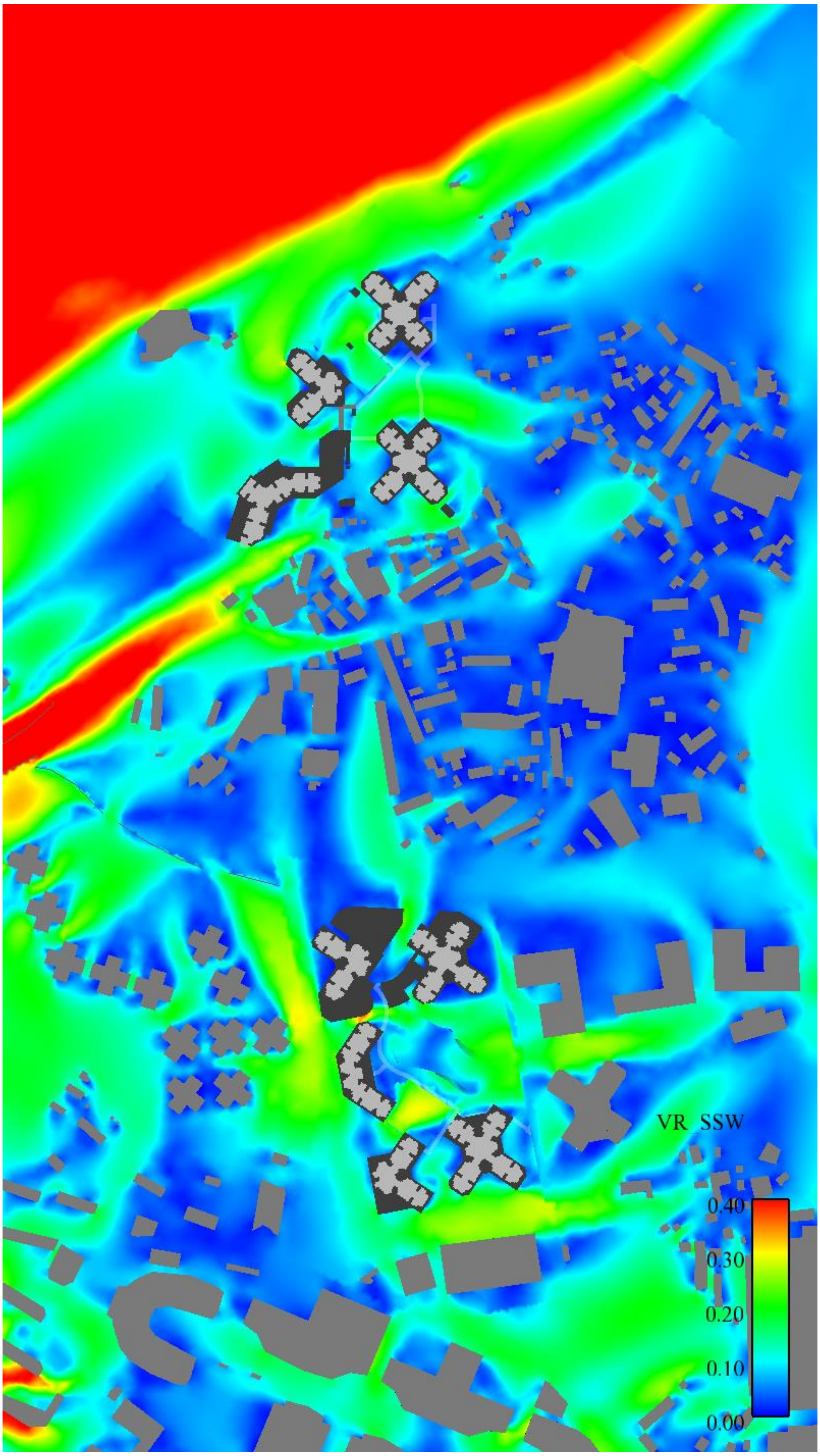


Figure E29 SSW Direction for Both Developments under Scenario 3

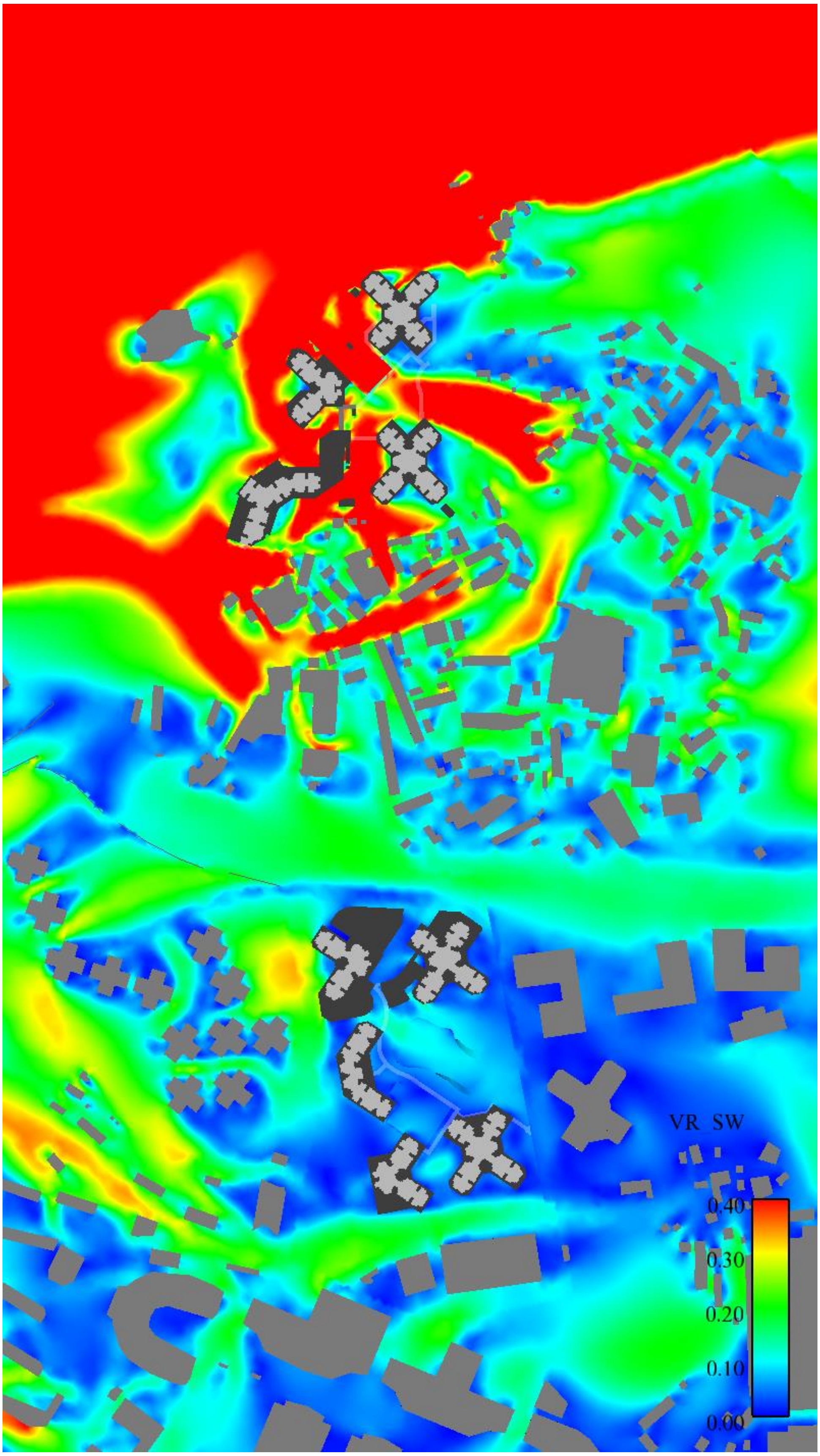


Figure E30 SW Direction for Both Developments under Scenario 3

Appendix F

VR Vector Plots of TM54-Sites1&1A Development and TM54-Sites3&4(E) Development

F1 Scenario 1

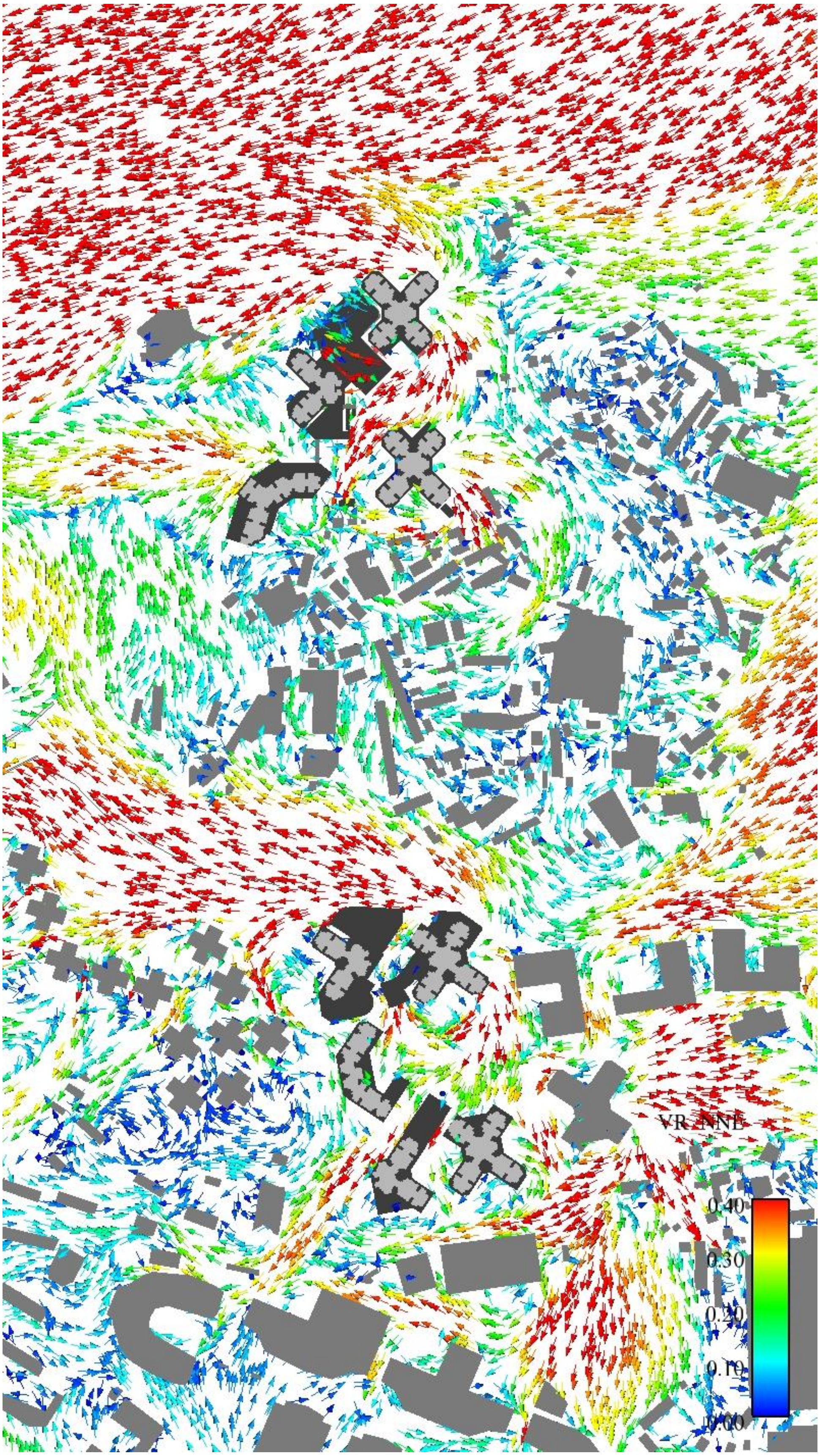


Figure F1 NNE Direction for Both Developments under Scenario 1

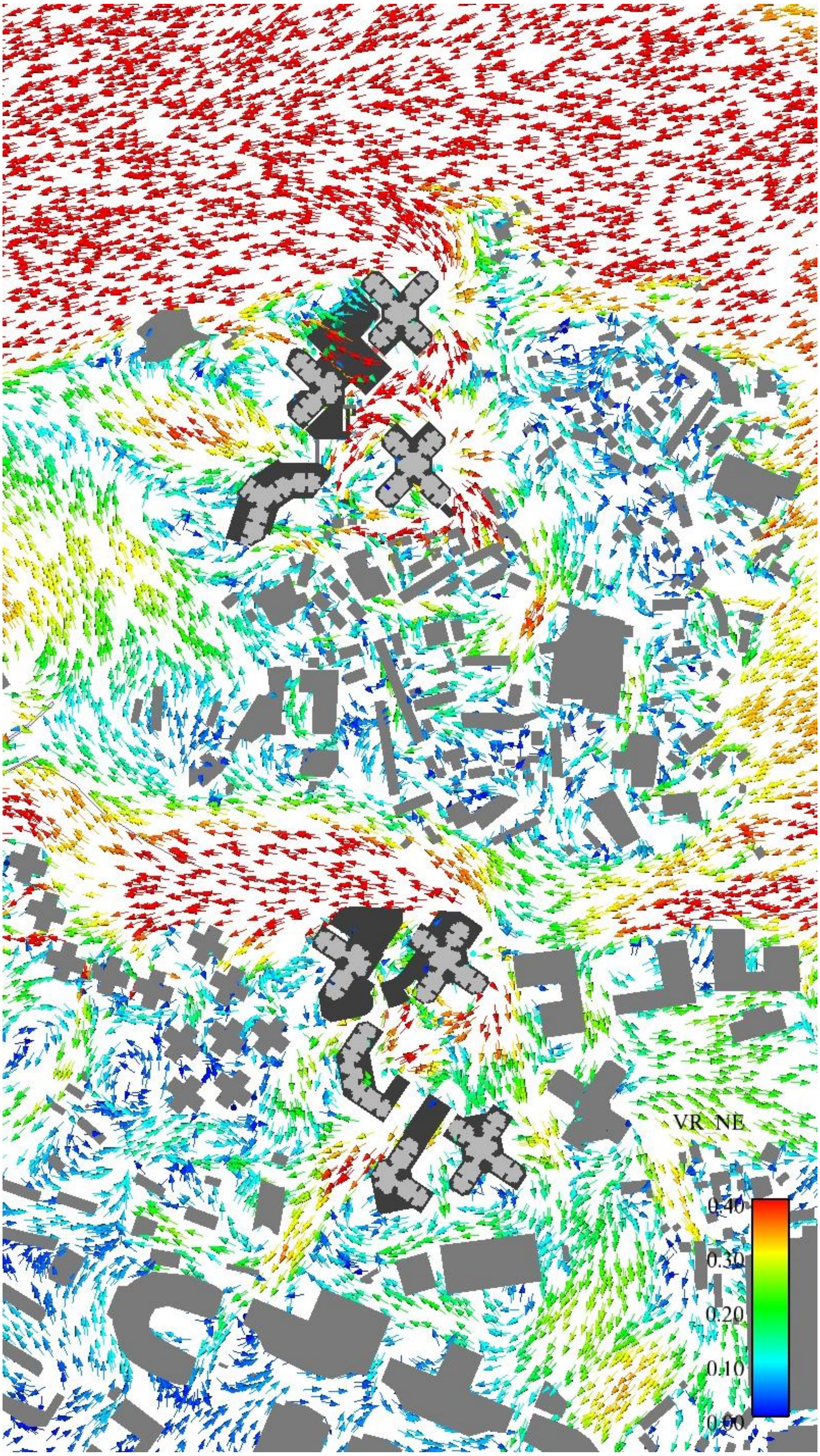


Figure F2 NE Direction for Both Developments under Scenario 1

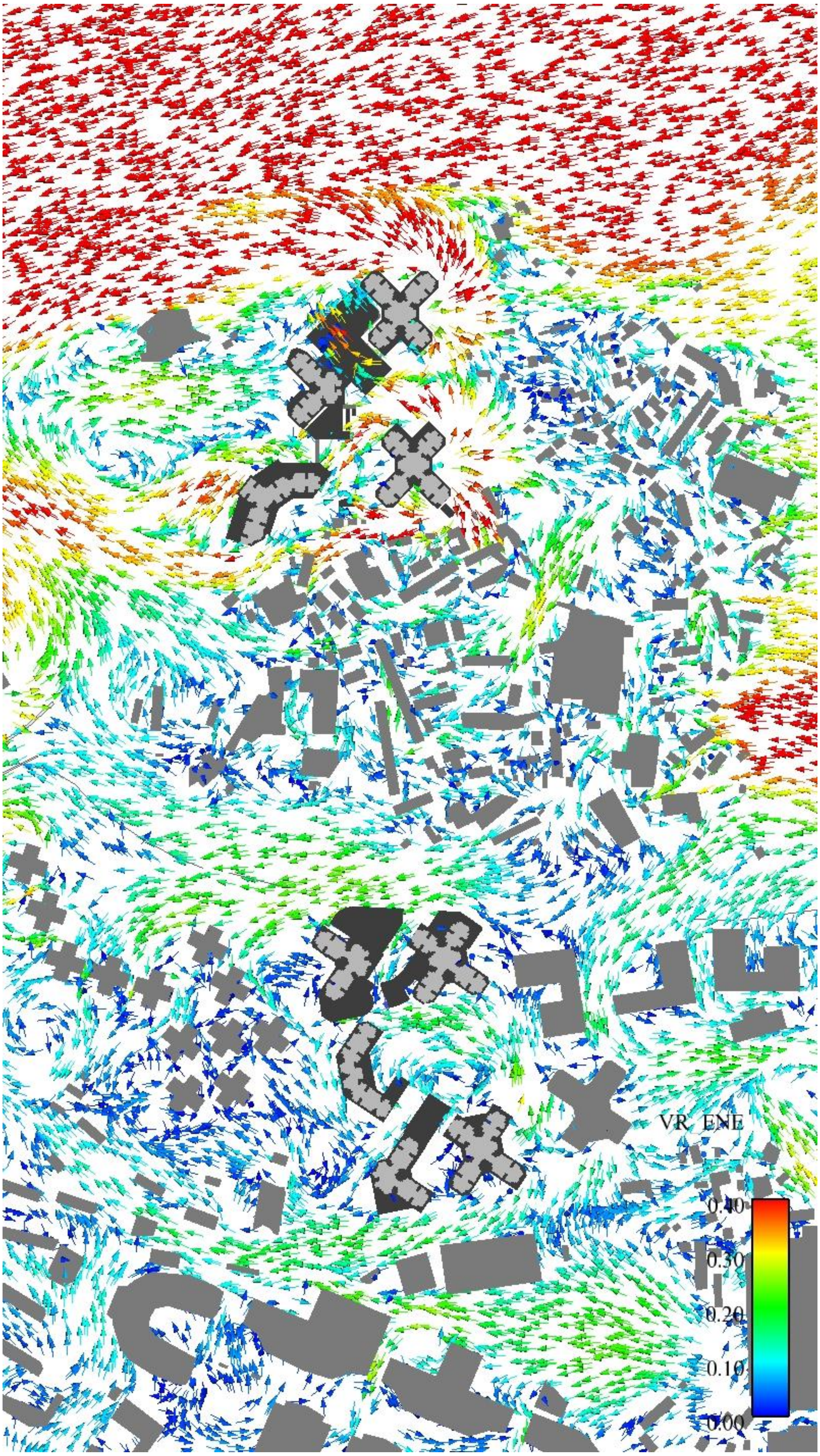


Figure F3 ENE Direction for Both Developments under Scenario 1

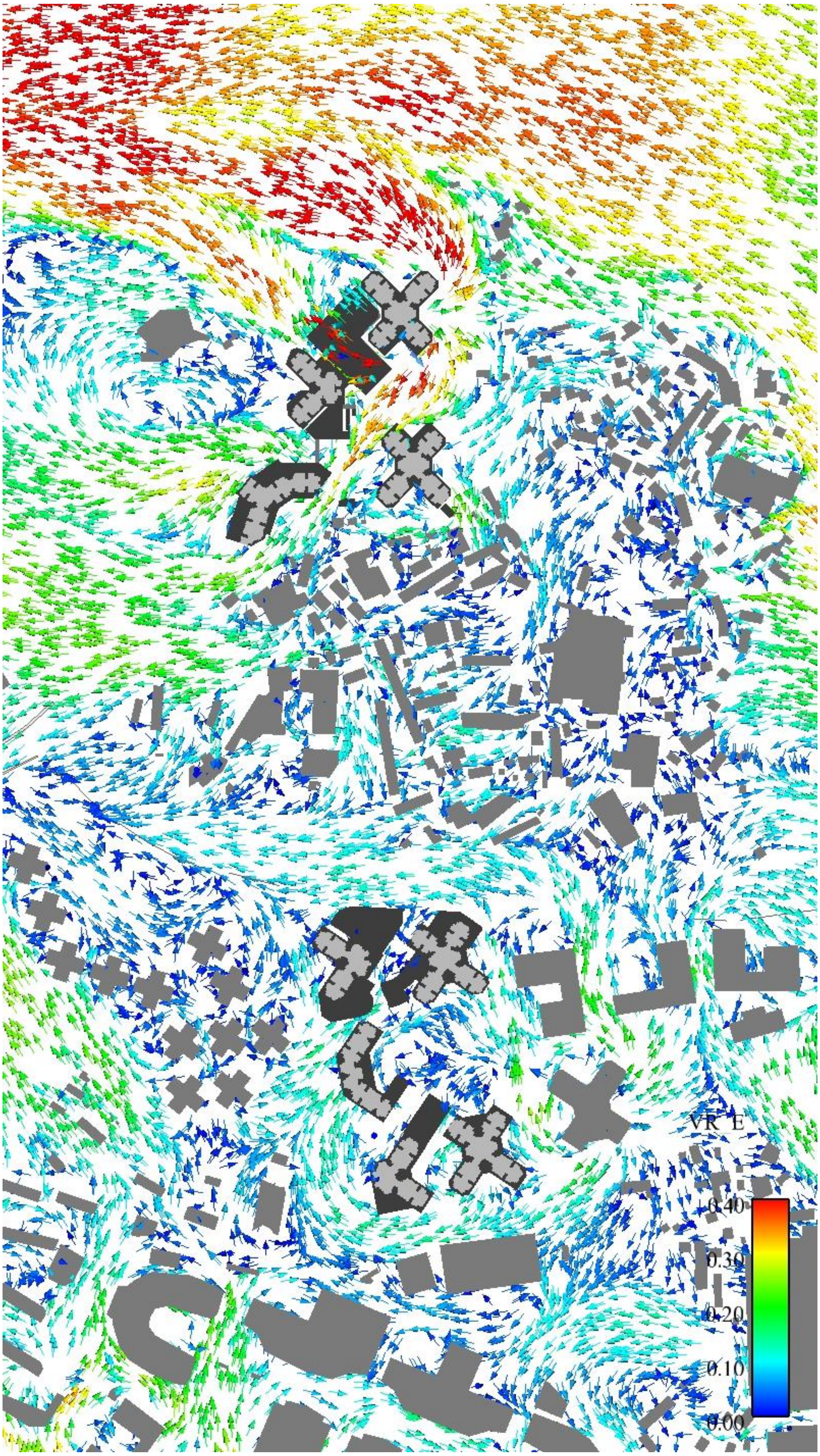


Figure F4 E Direction for Both Developments under Scenario 1

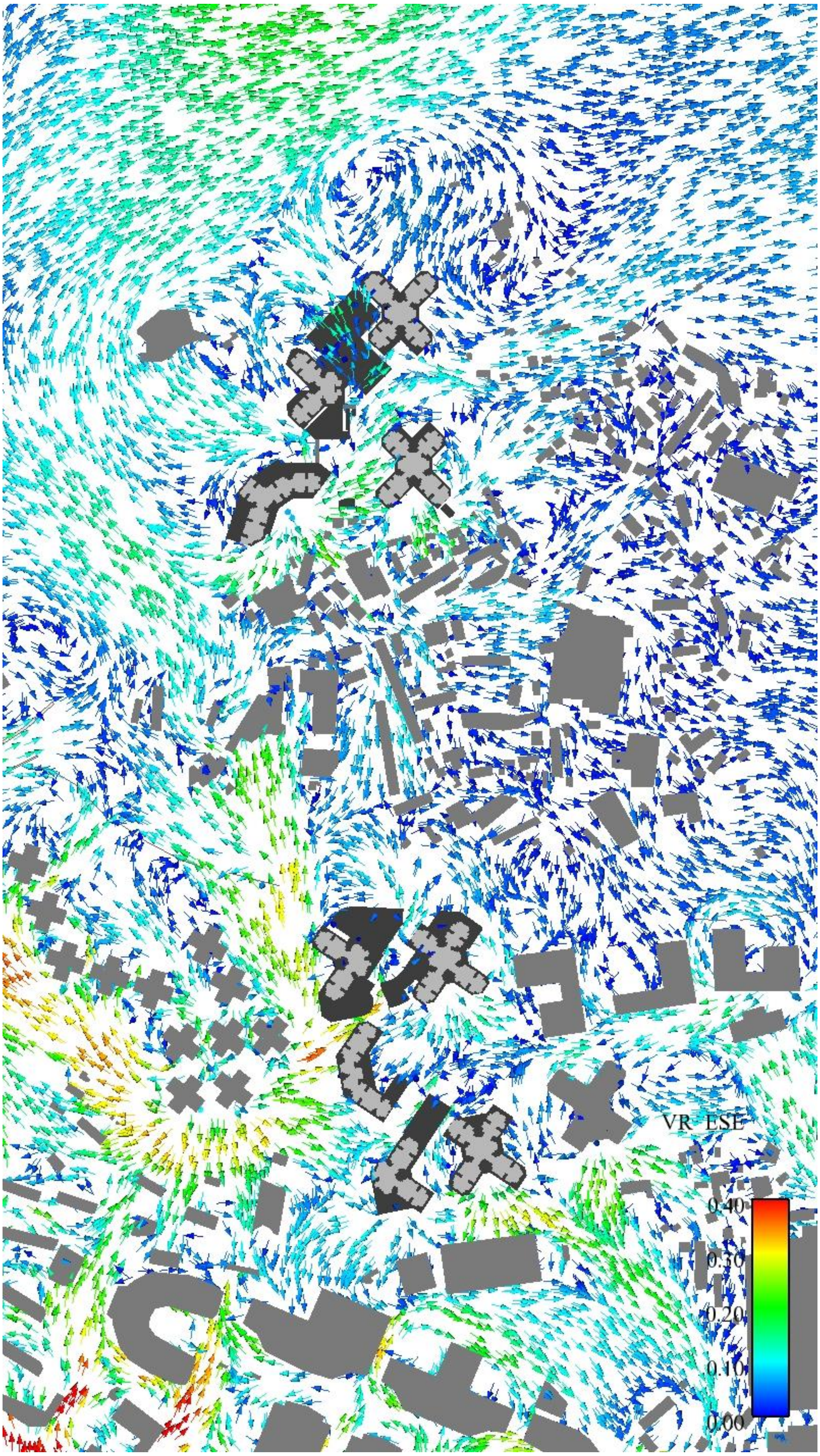


Figure F5 ESE Direction for Both Developments under Scenario 1

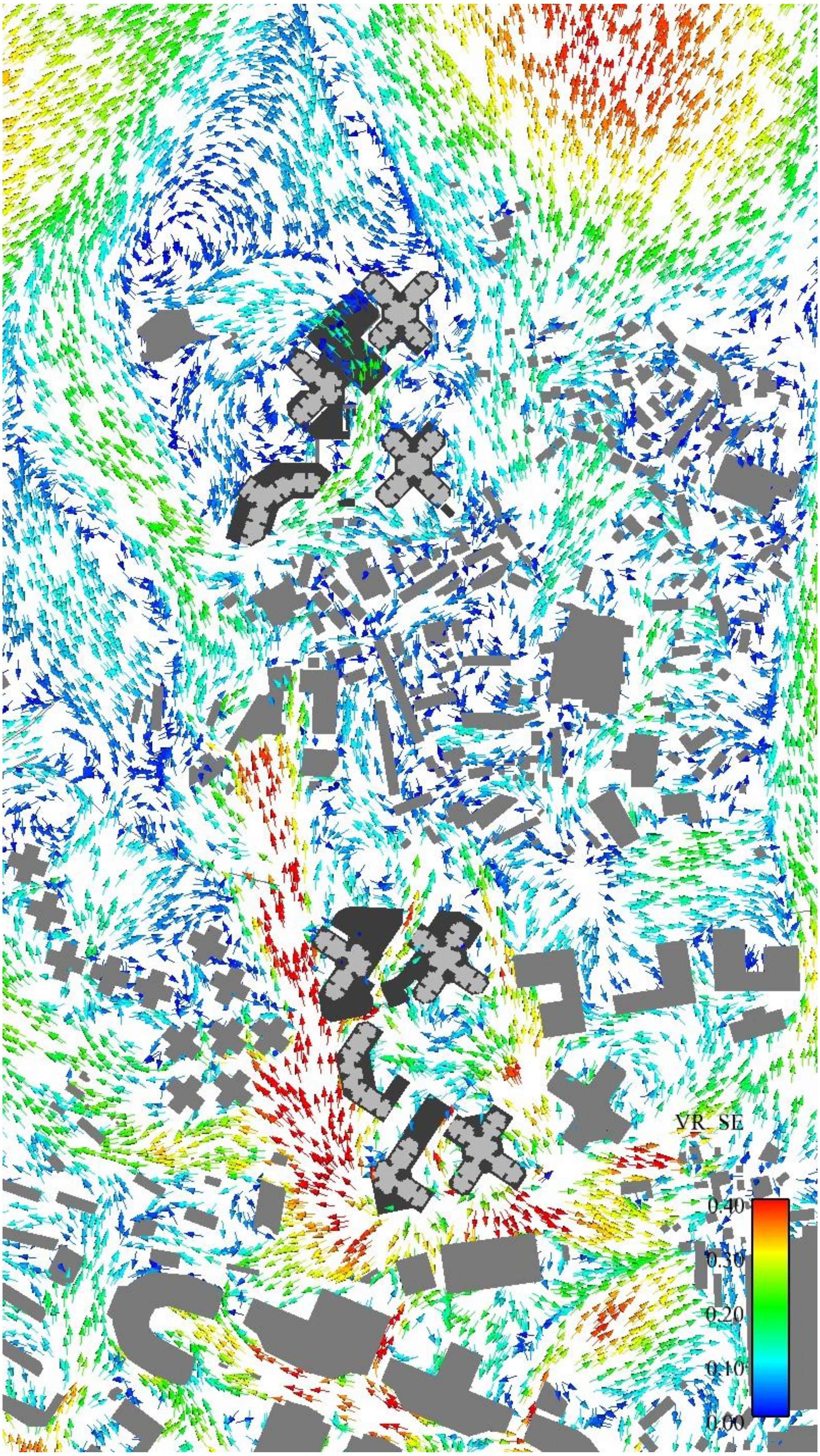


Figure F6 SE Direction for Both Developments under Scenario 1

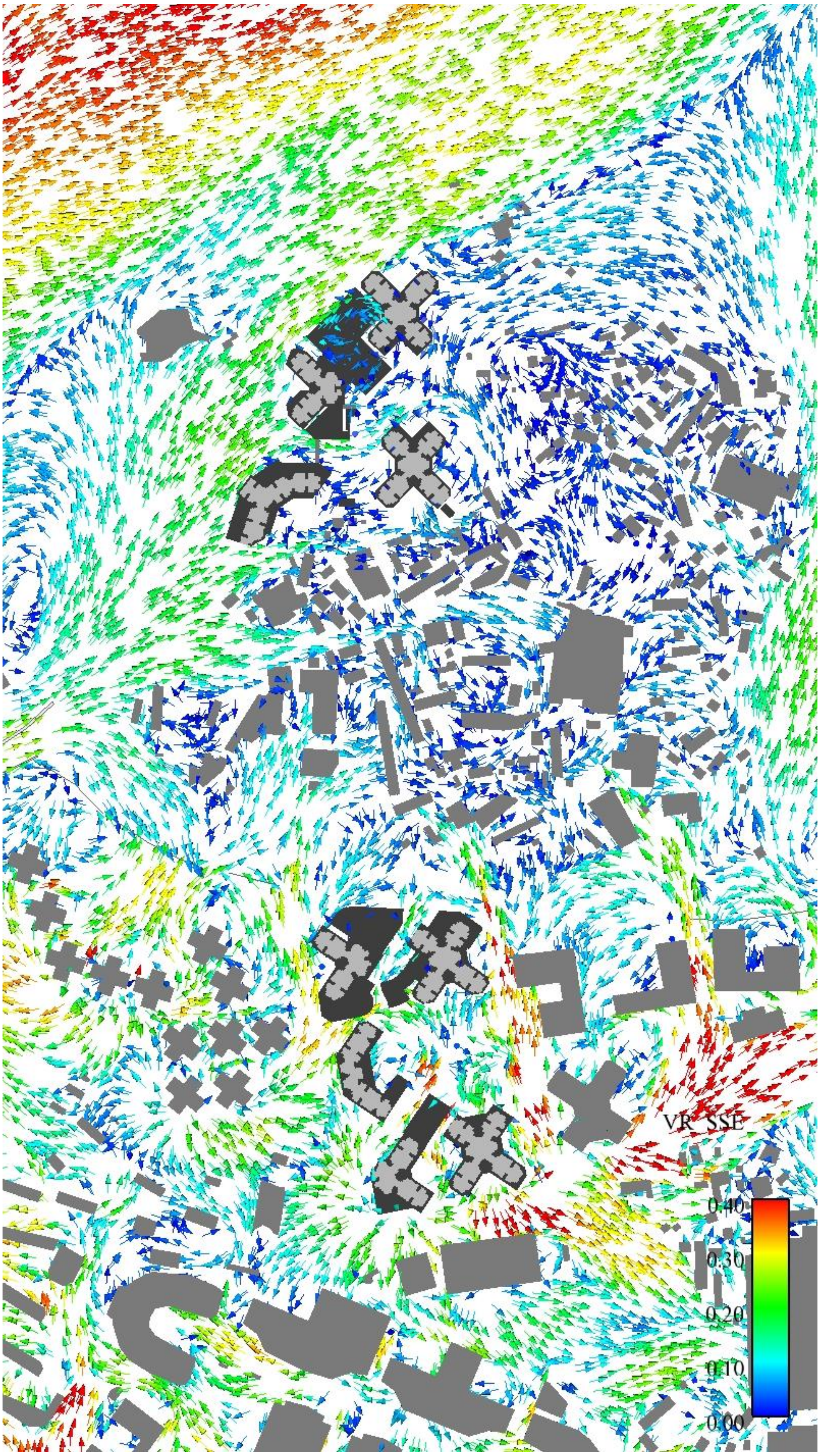


Figure F7 SSE Direction for Both Developments under Scenario 1

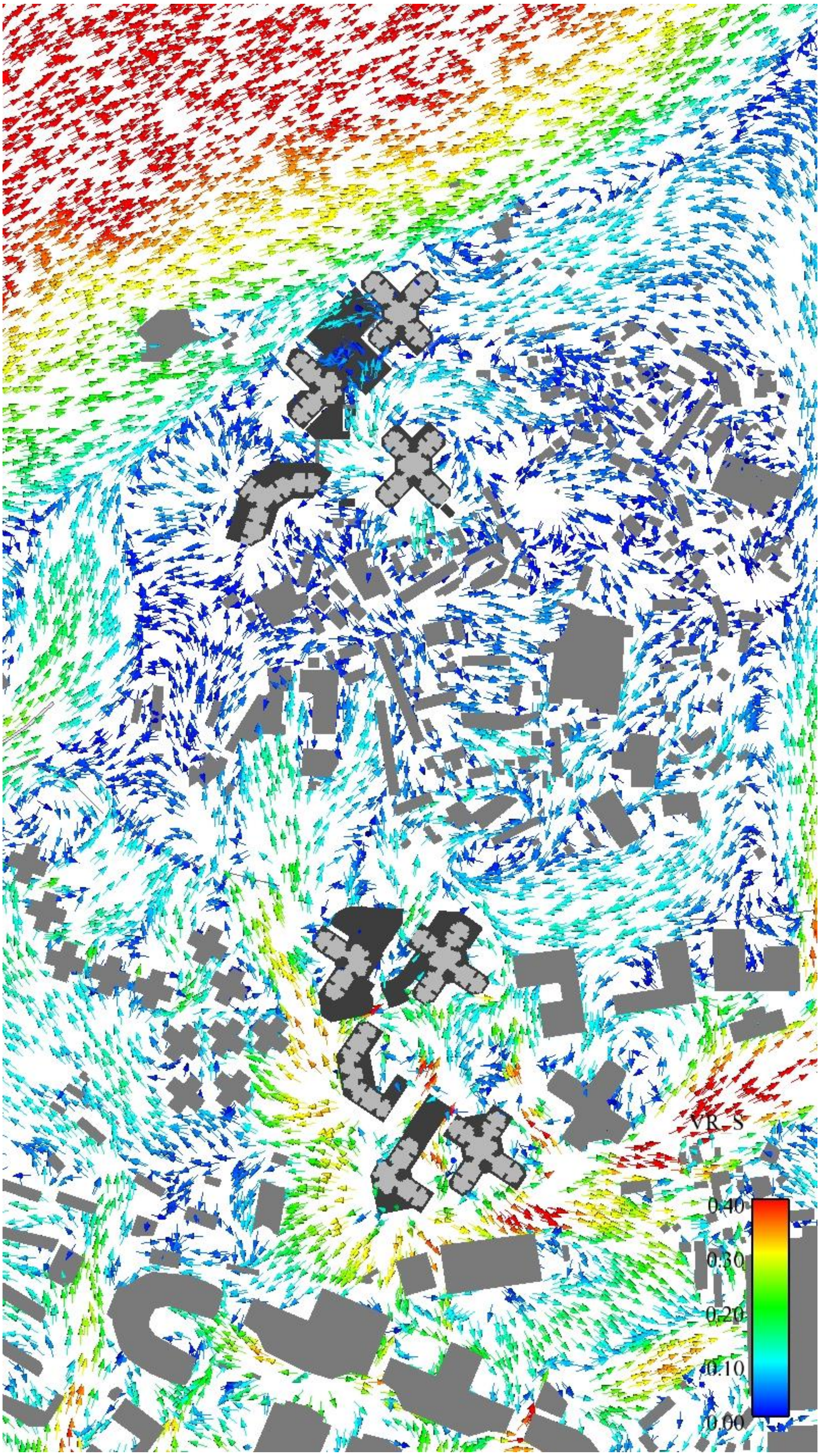


Figure F8 S Direction for Both Developments under Scenario 1

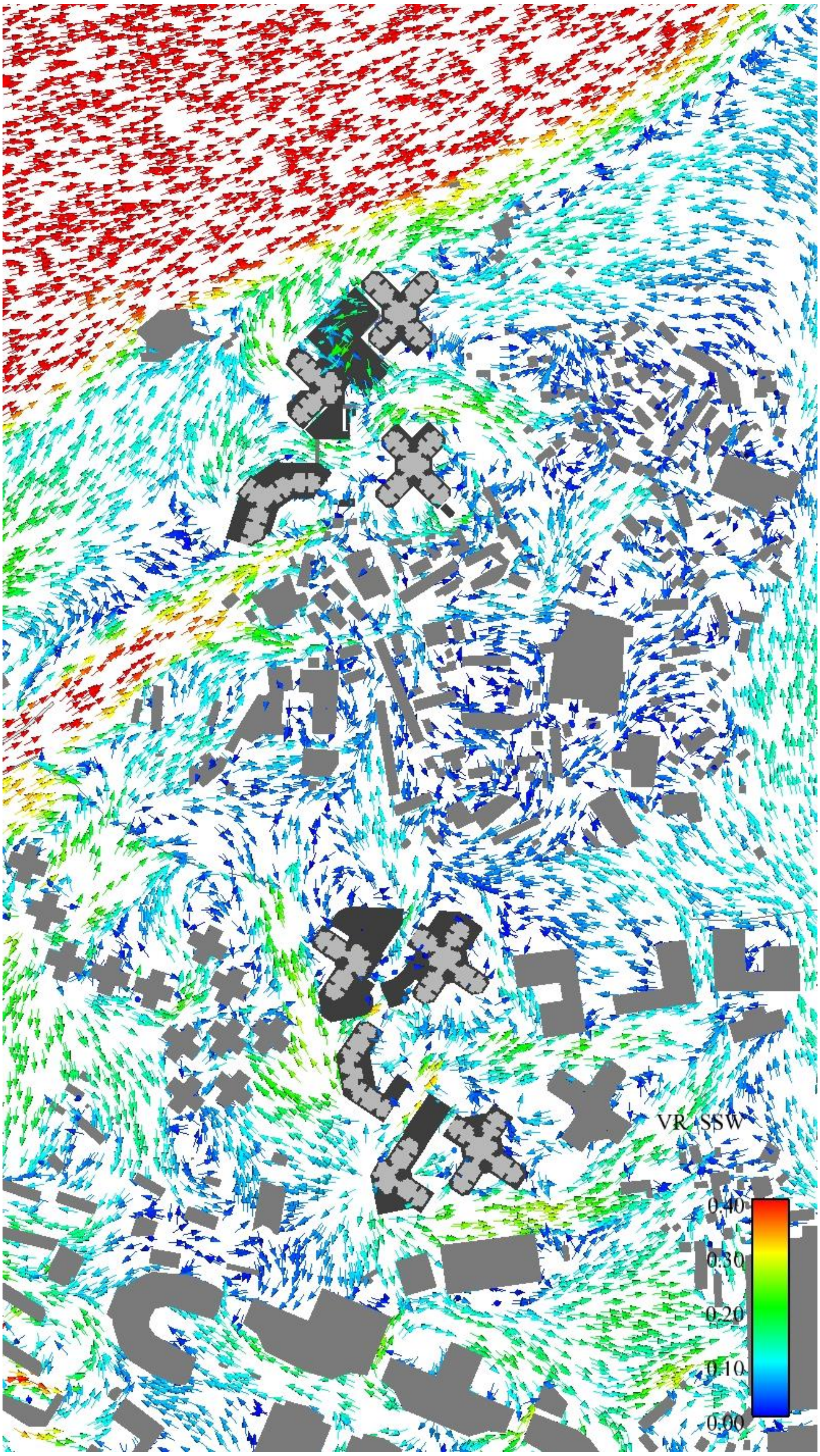


Figure F9 SSW Direction for Both Developments under Scenario 1

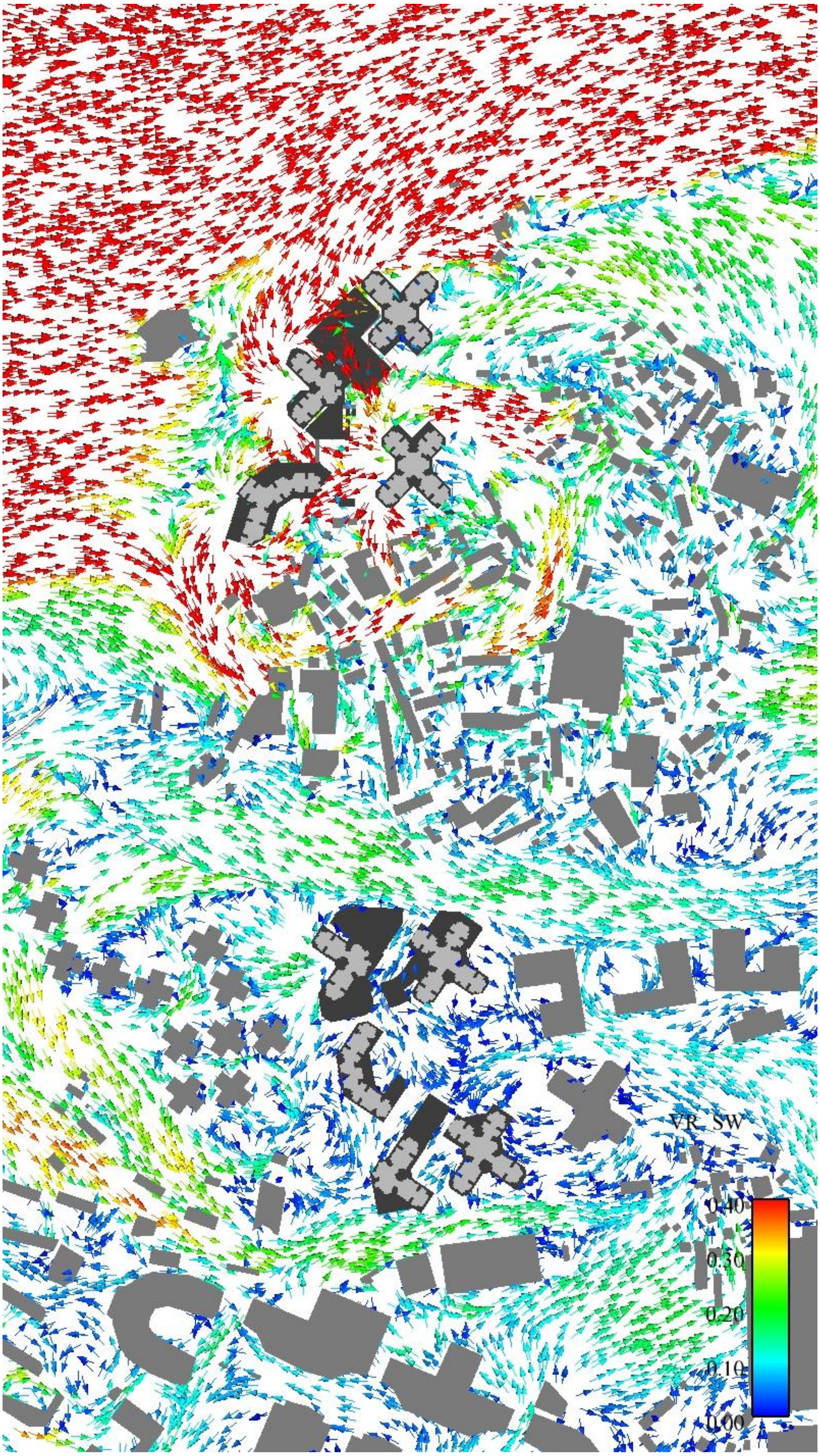


Figure F10 SW Direction for Both Developments under Scenario 1

F2 Scenario 2

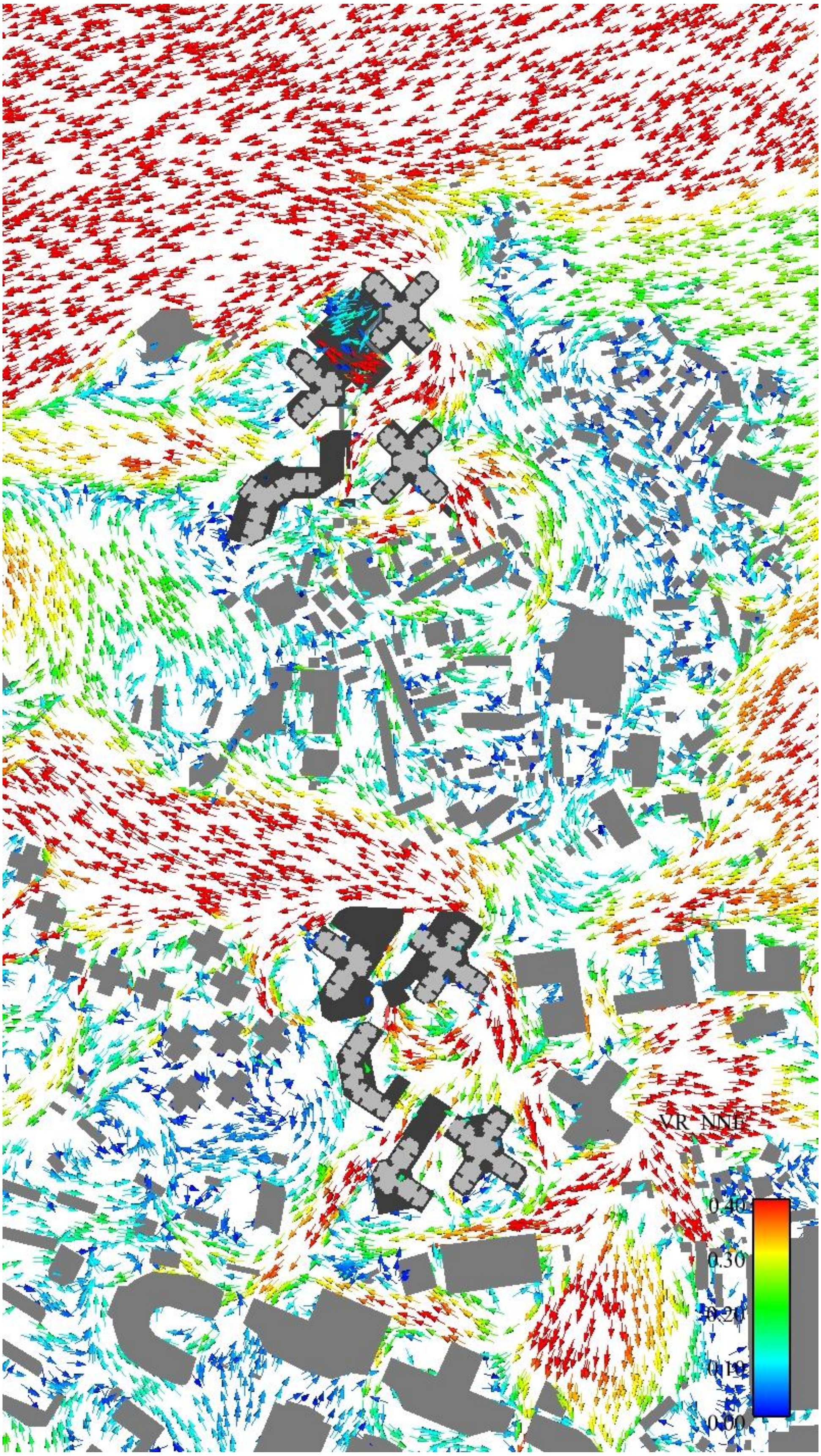


Figure F11 NNE Direction for Both Developments under Scenario 2

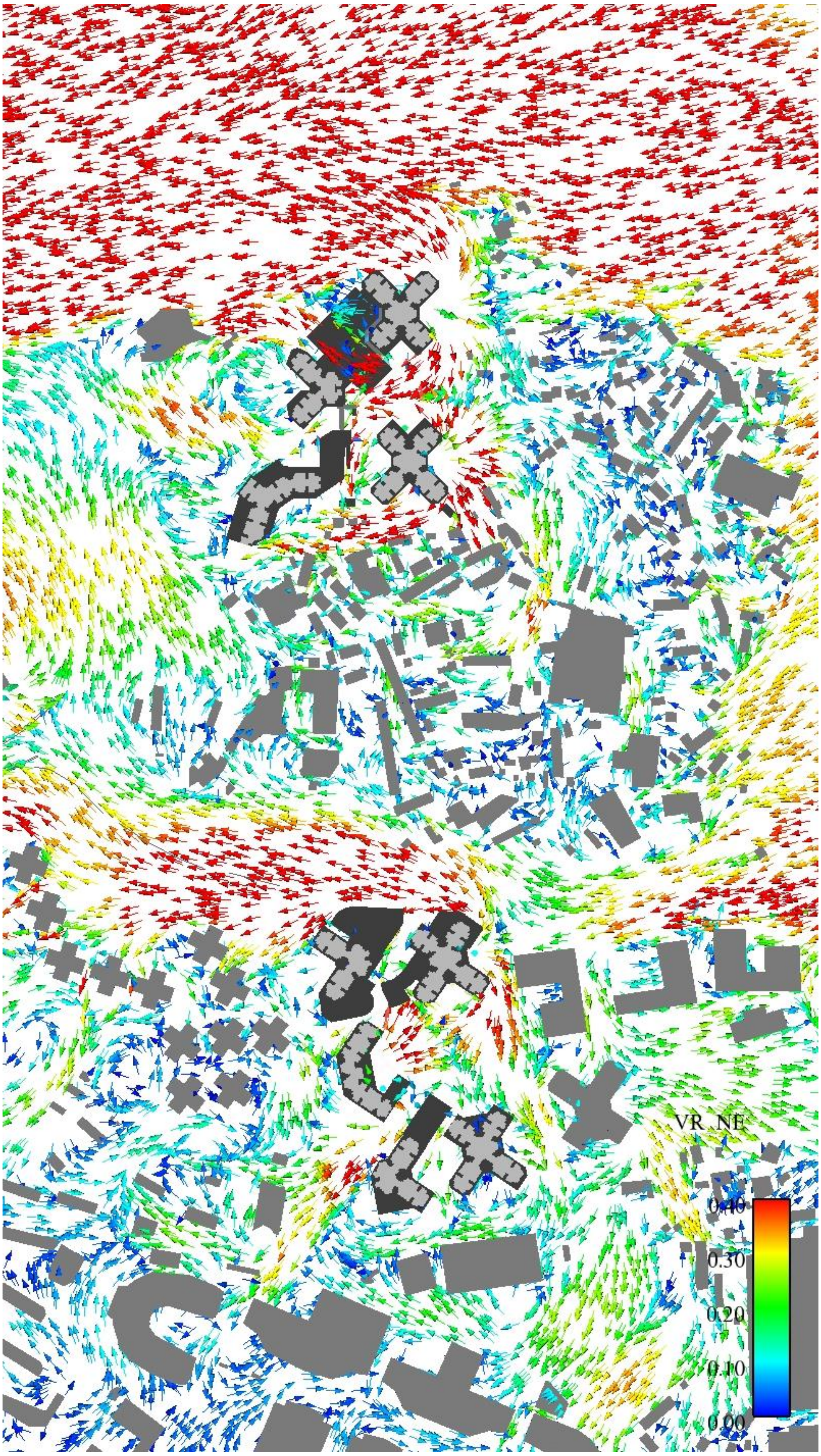


Figure F12 NE Direction for Both Developments under Scenario 2

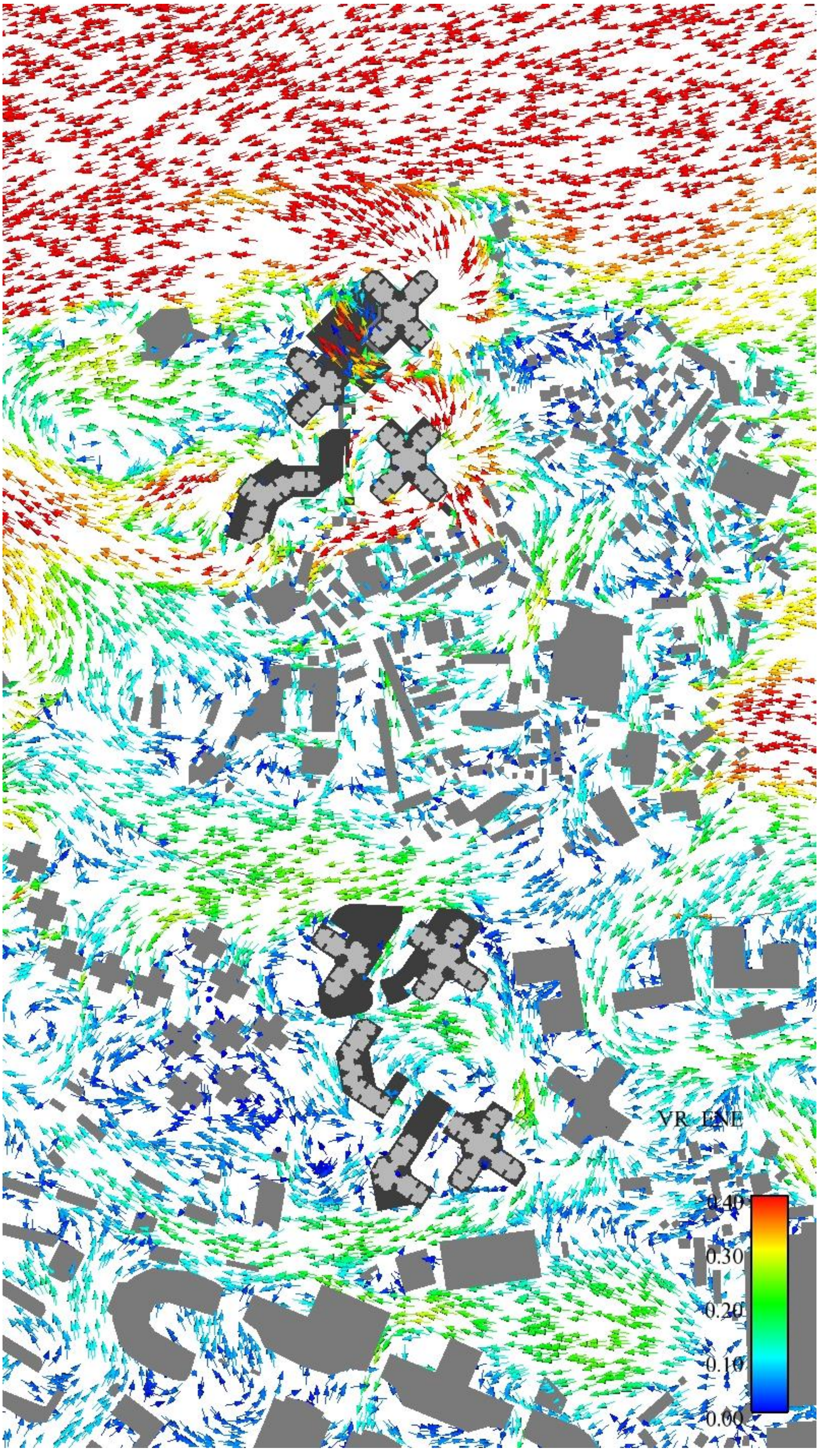


Figure F13 ENE Direction for Both Developments under Scenario 2

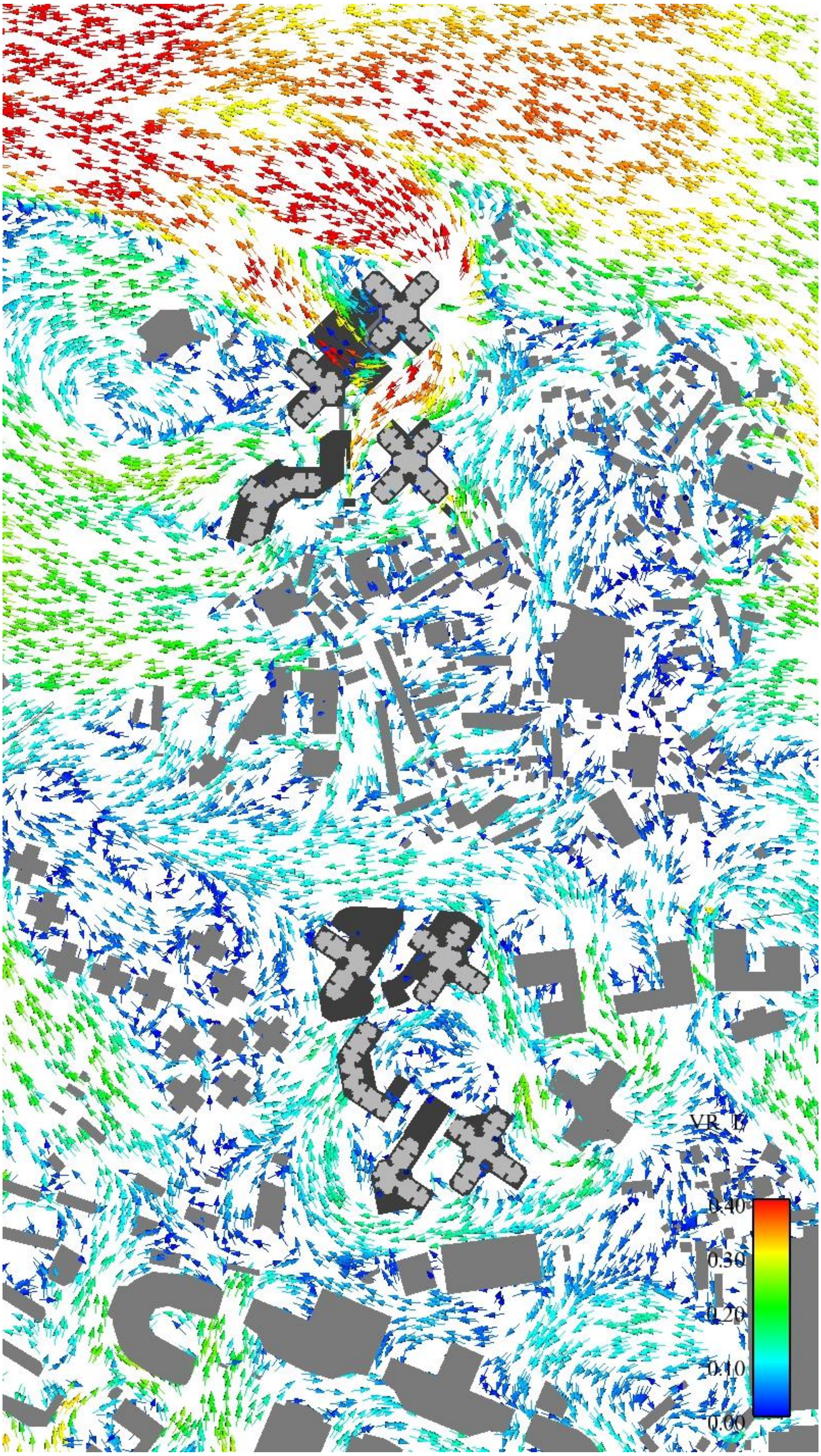


Figure F14 E Direction for Both Developments under Scenario 2

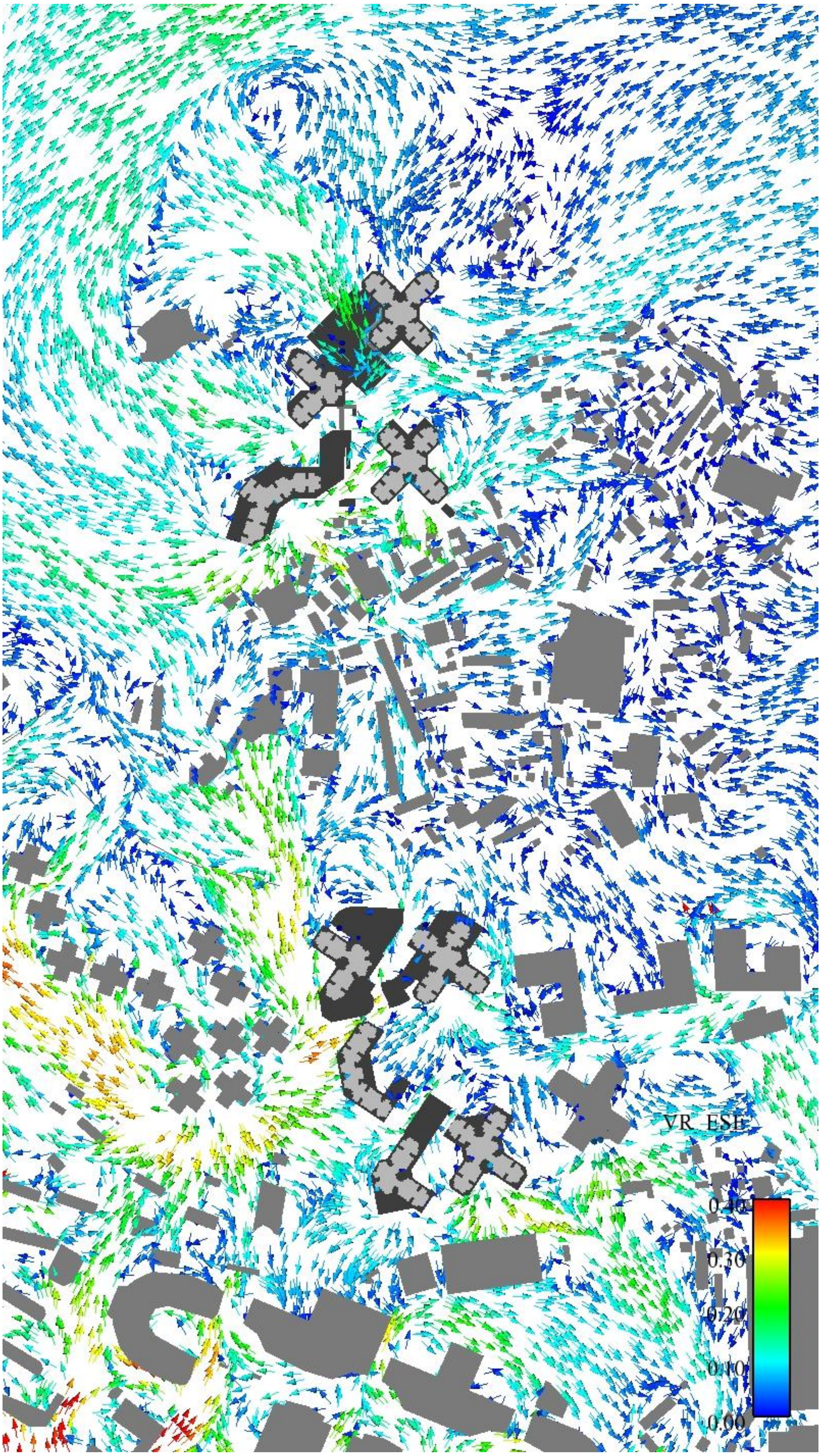


Figure F15 ESE Direction for Both Developments under Scenario 2

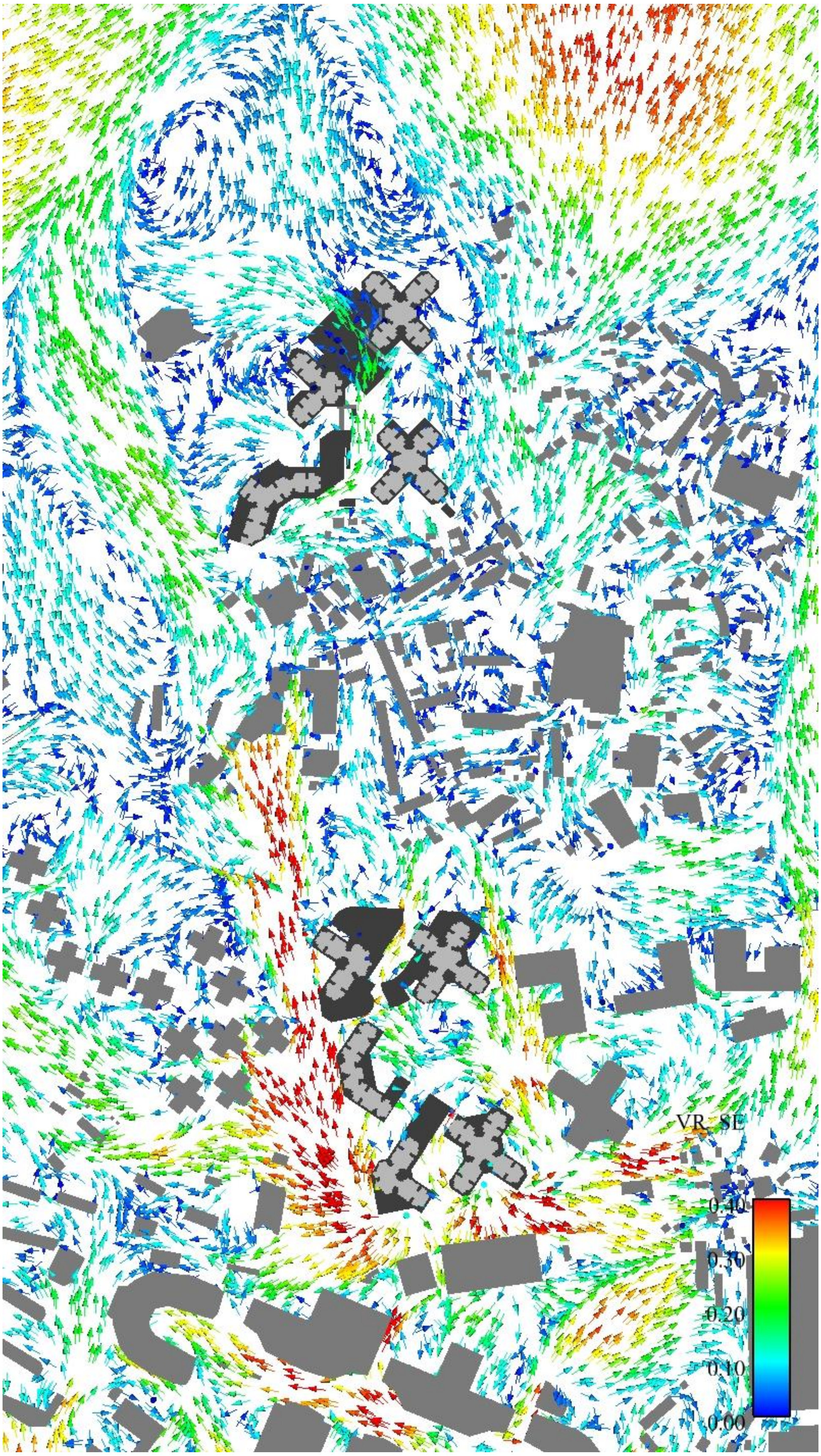


Figure F16 SE Direction for Both Developments under Scenario 2

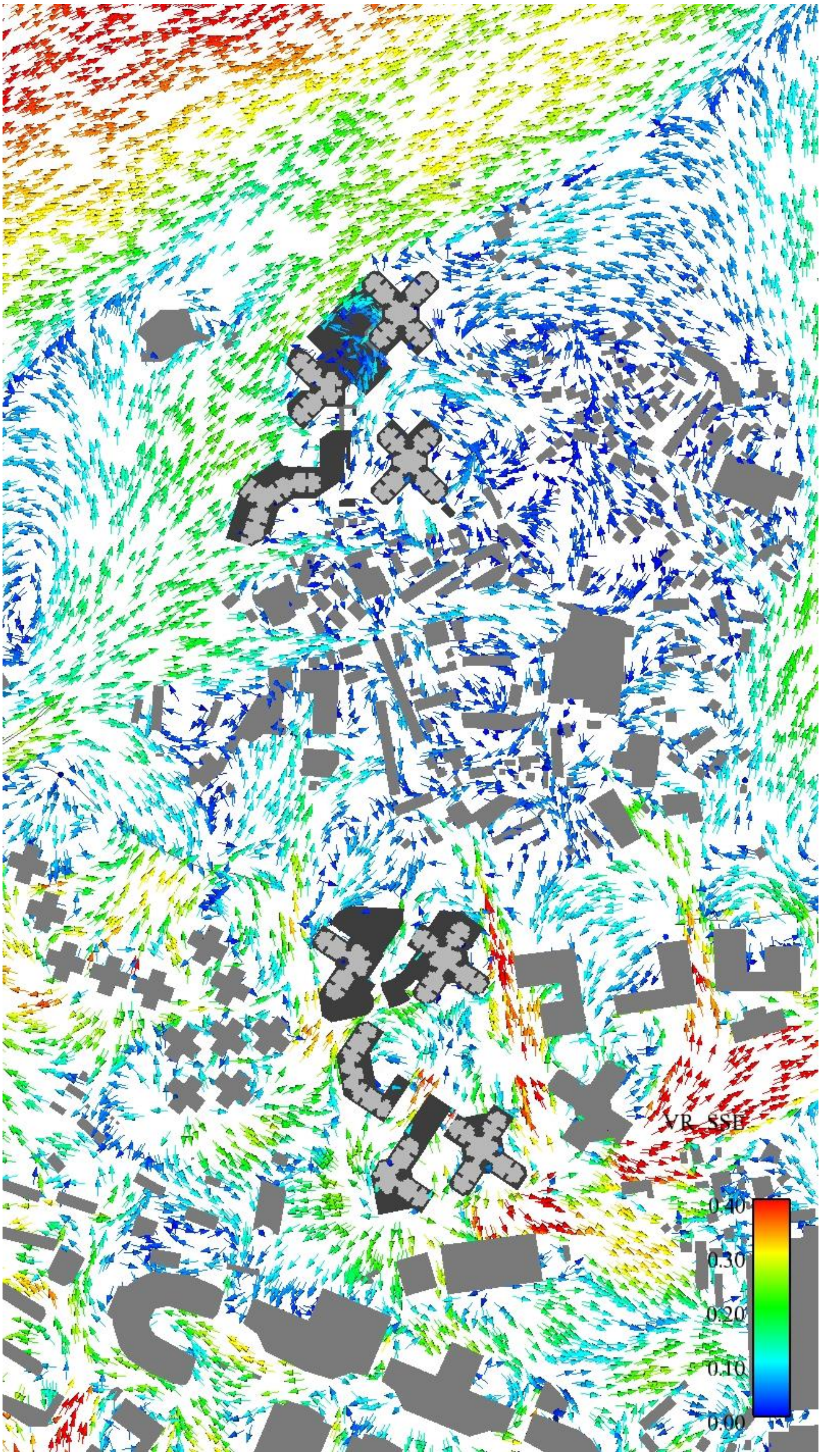


Figure F17 SSE Direction for Both Developments under Scenario 2

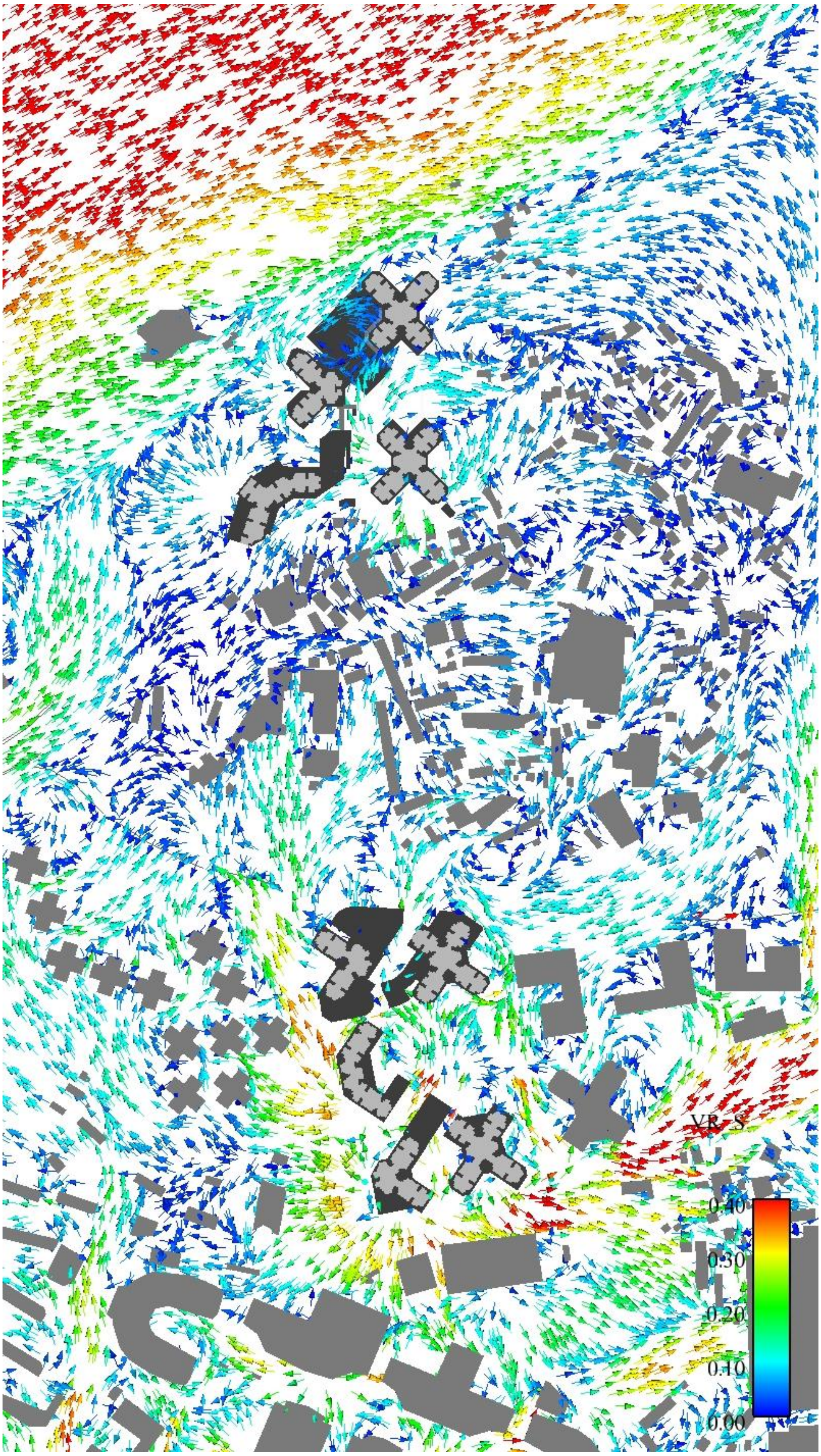


Figure F18 S Direction for Both Developments under Scenario 2

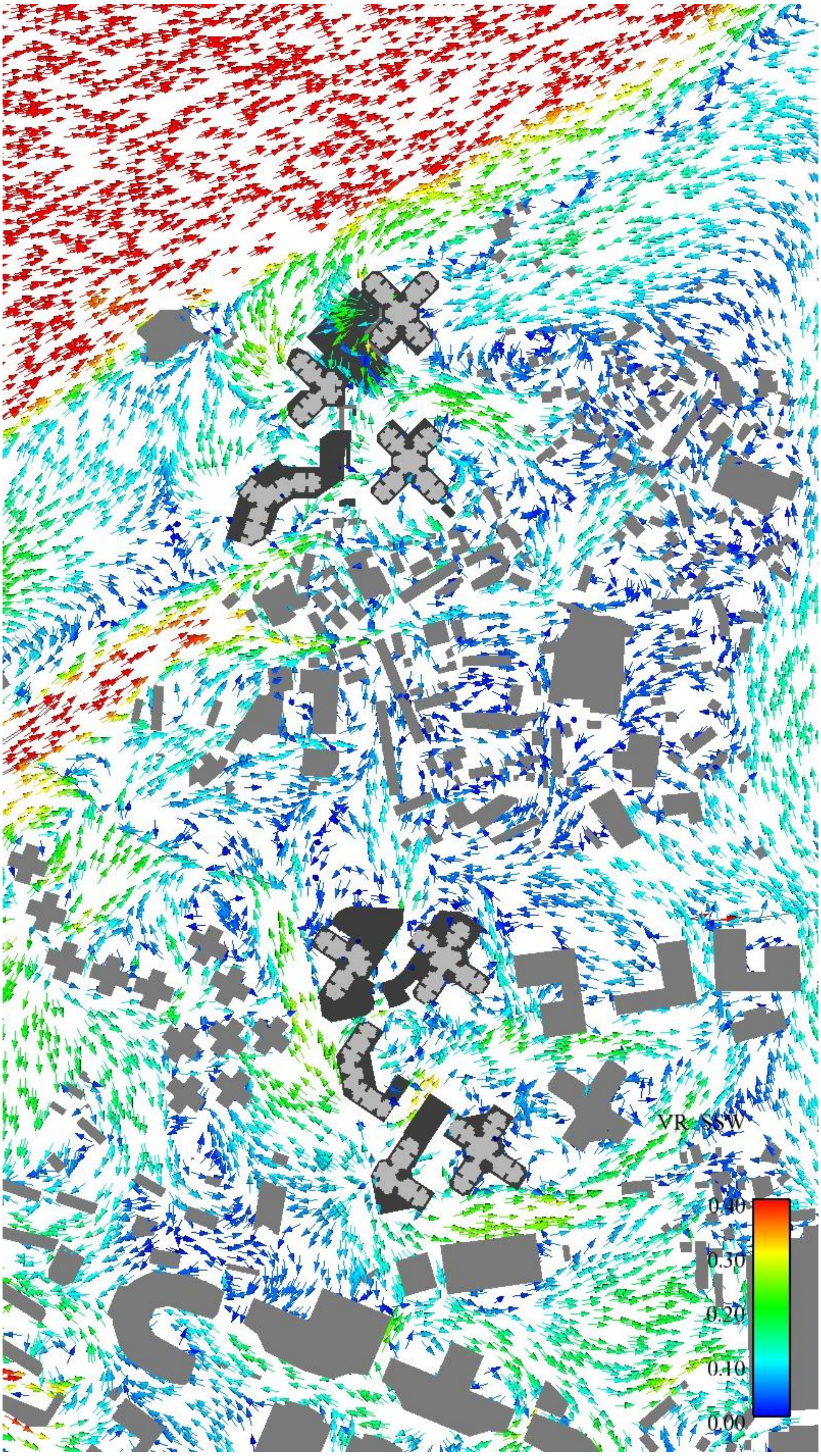


Figure F19 SSW Direction for Both Developments under Scenario 2

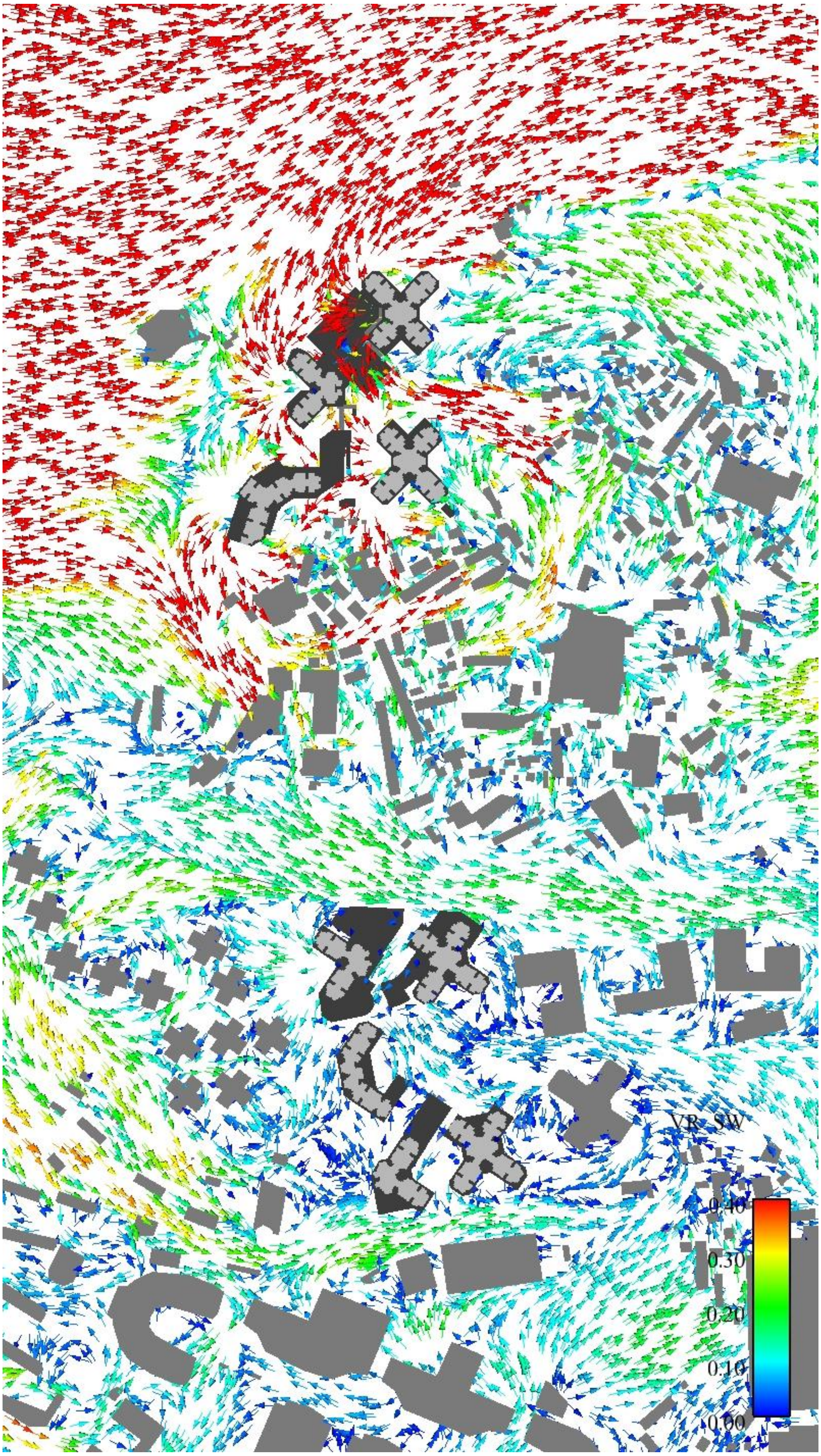


Figure F20 SW Direction for Both Developments under Scenario 2

F3 Scenario 3

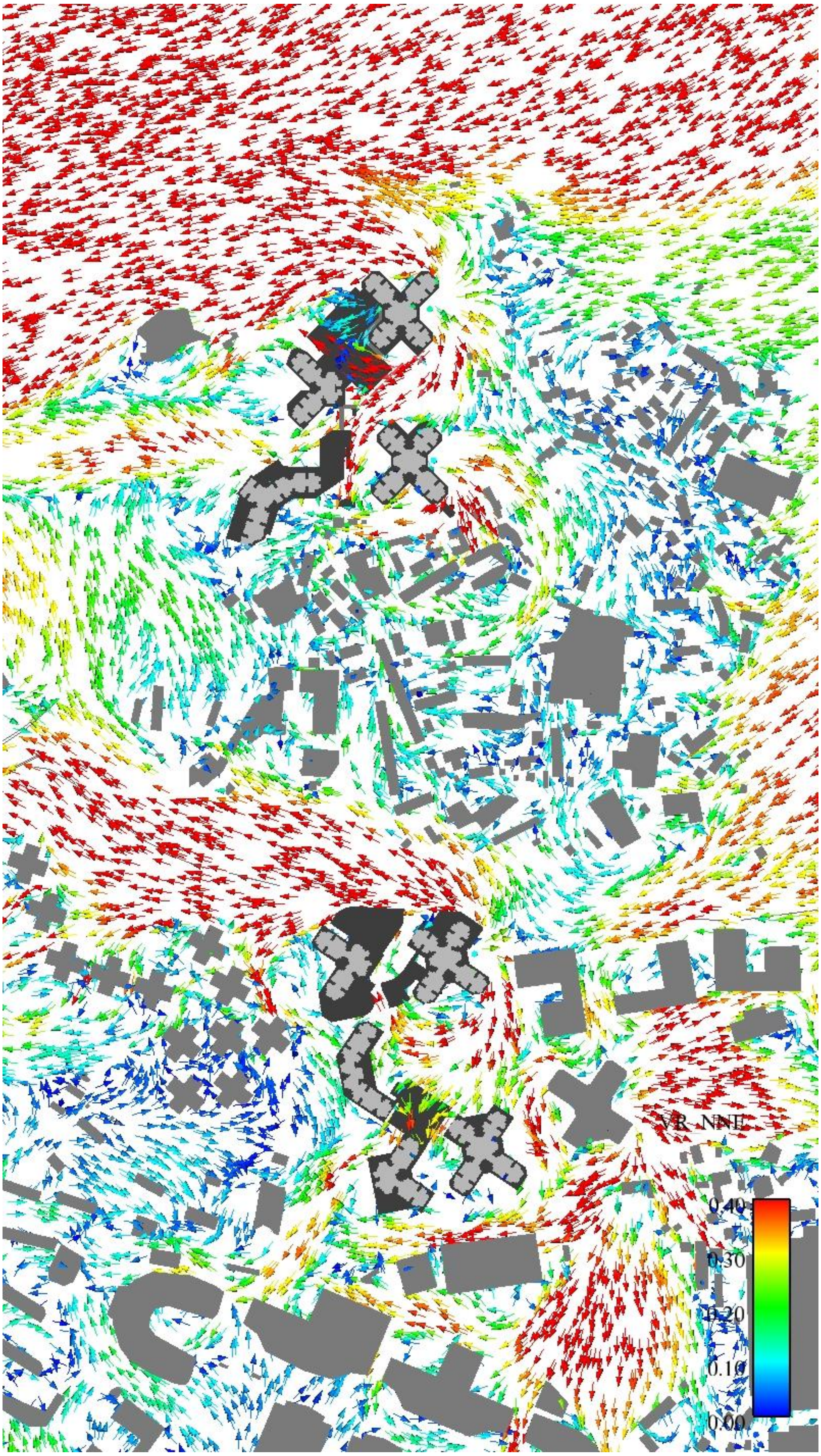


Figure F21 NNE Direction for Both Developments under Scenario 3

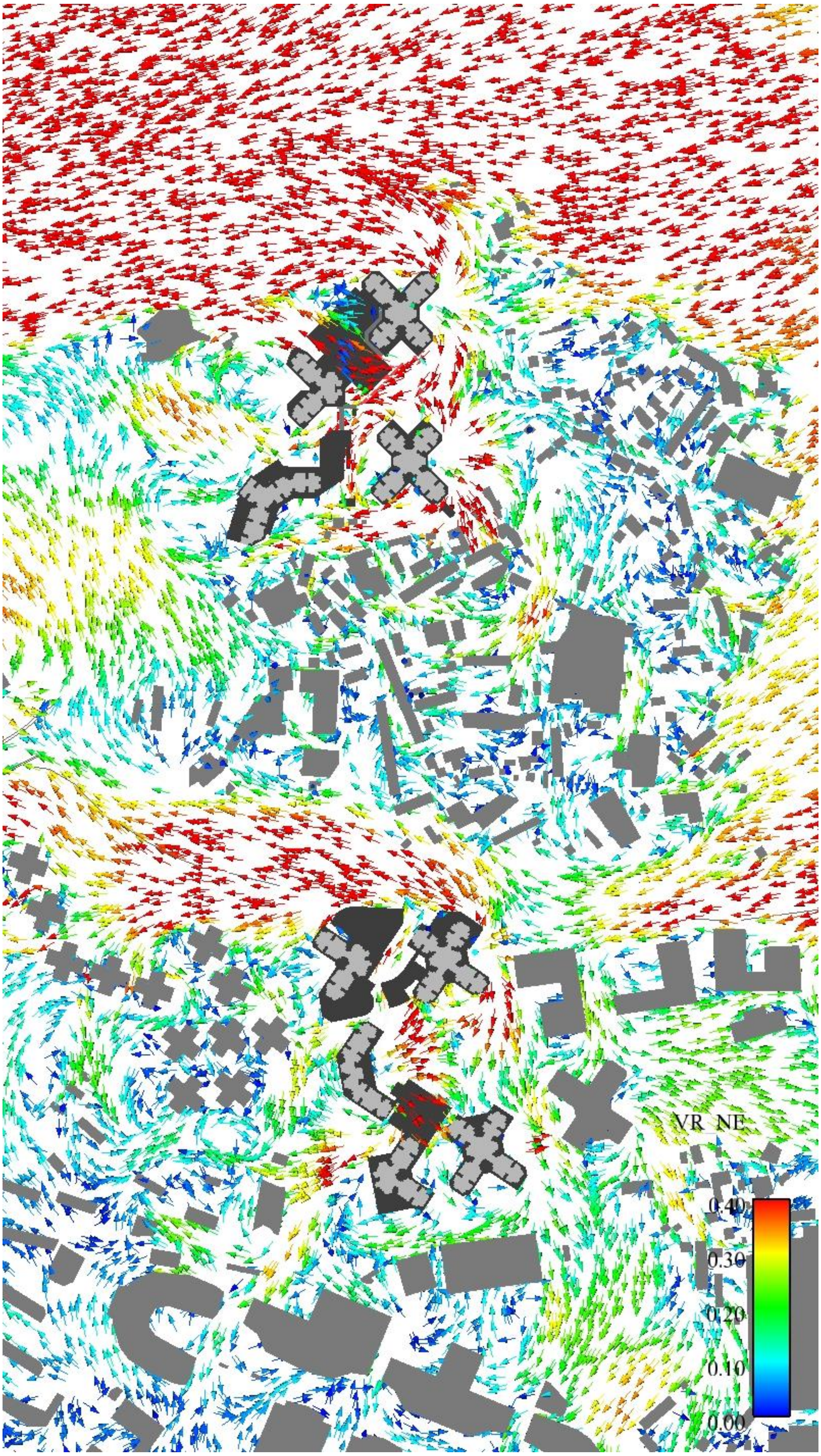


Figure F22 NE Direction for Both Developments under Scenario 3

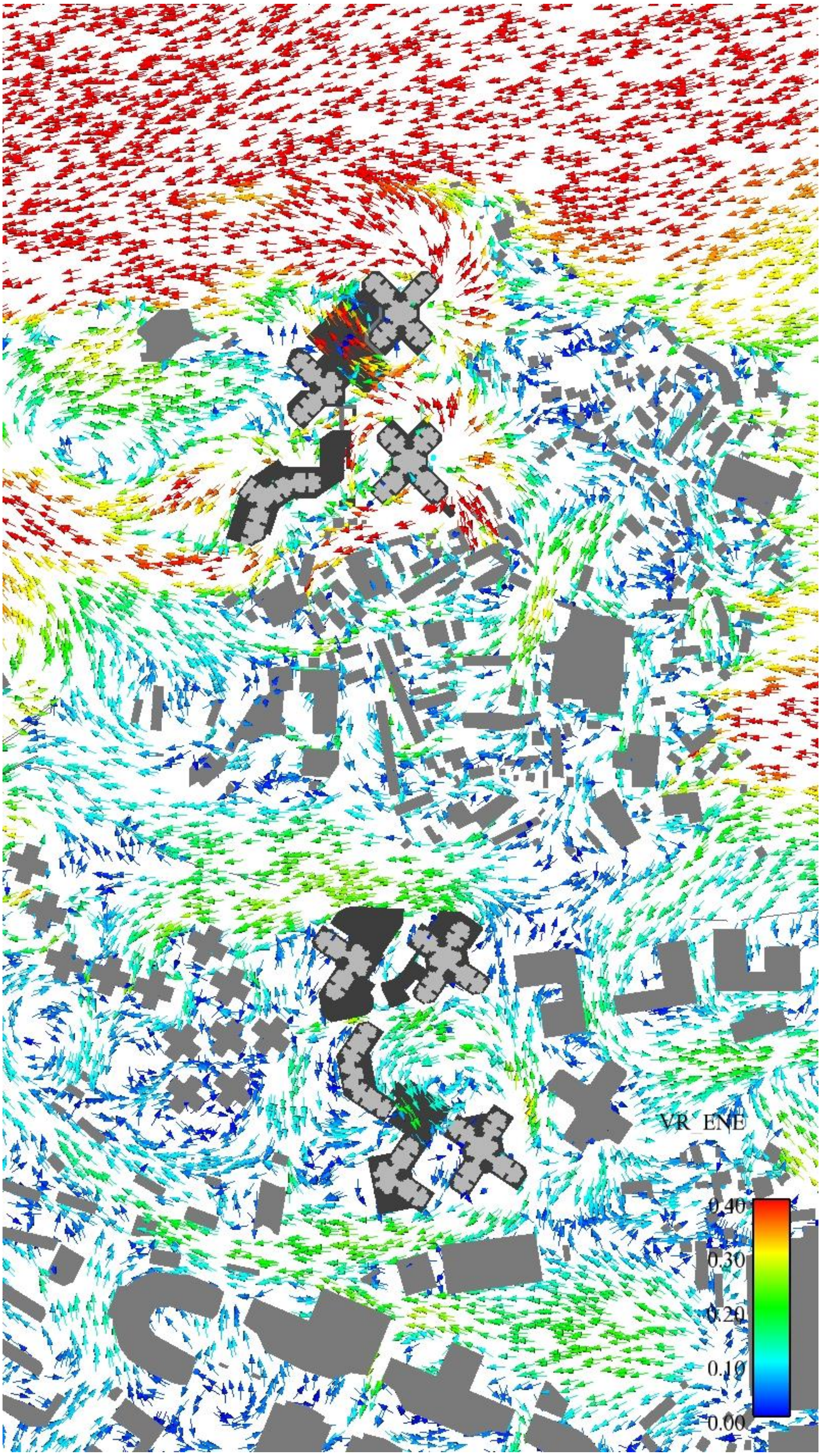


Figure F23 ENE Direction for Both Developments under Scenario 3

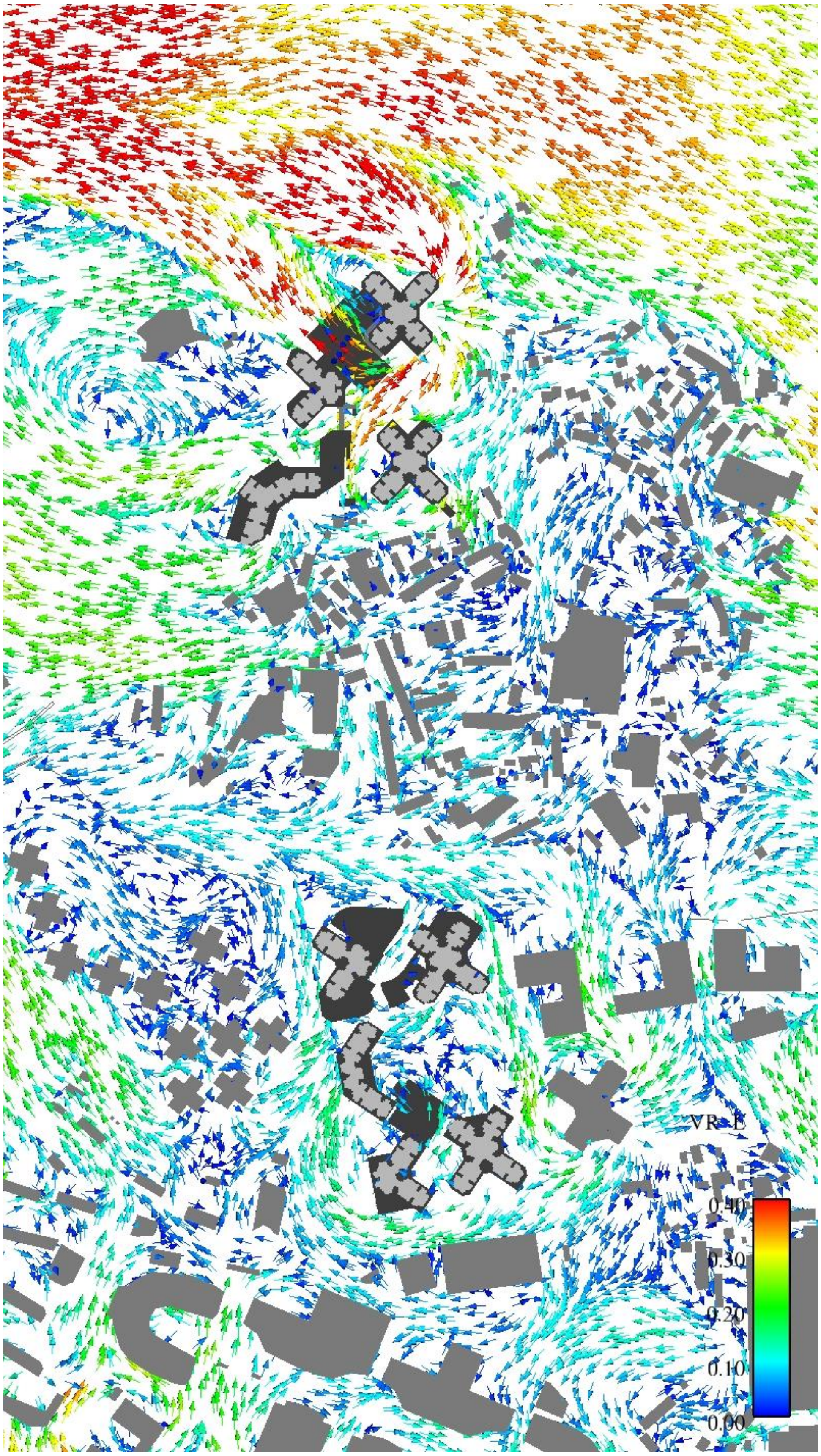


Figure F24 E Direction for Both Developments under Scenario 3

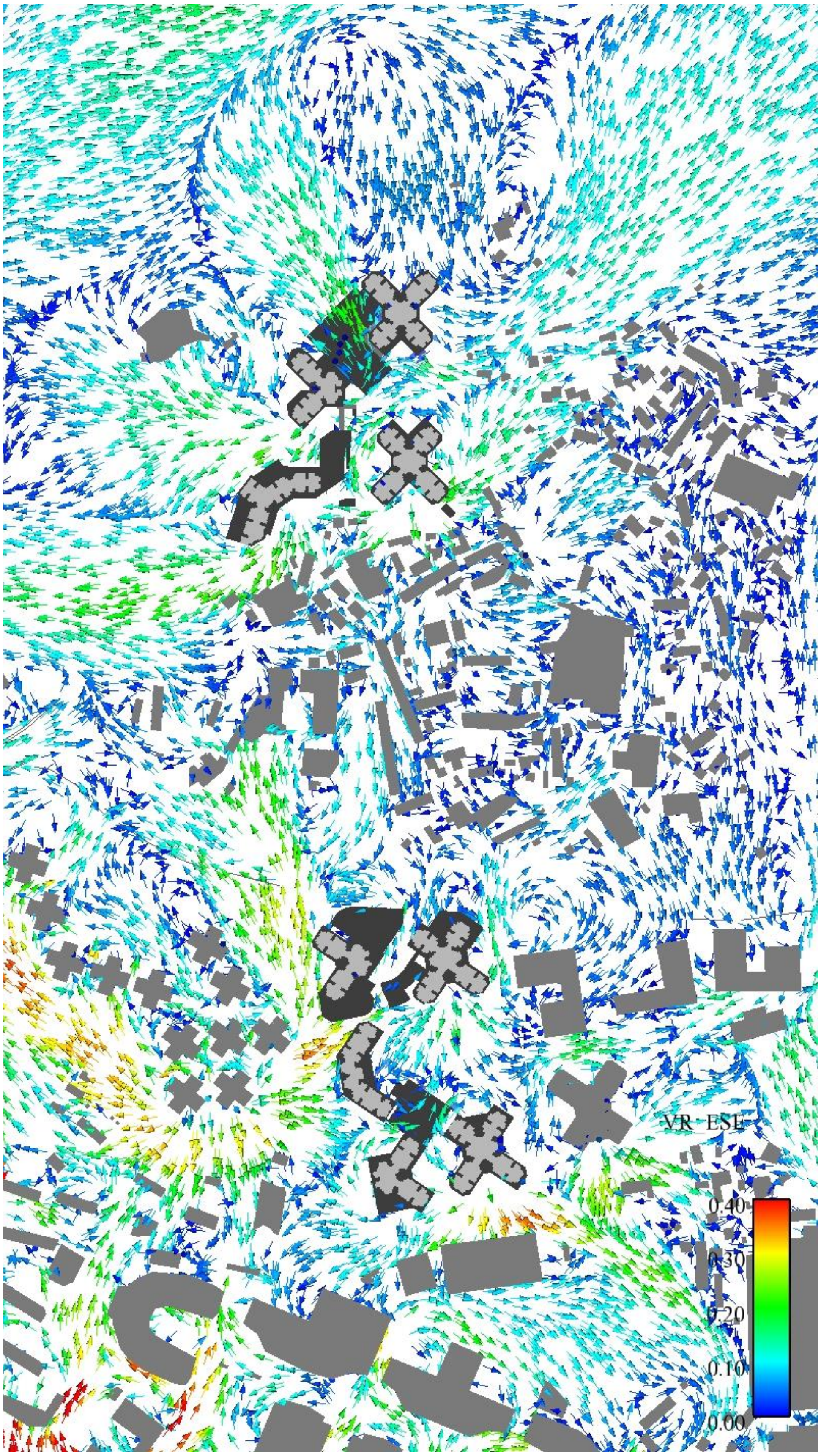


Figure F25 ESE Direction for Both Developments under Scenario 3

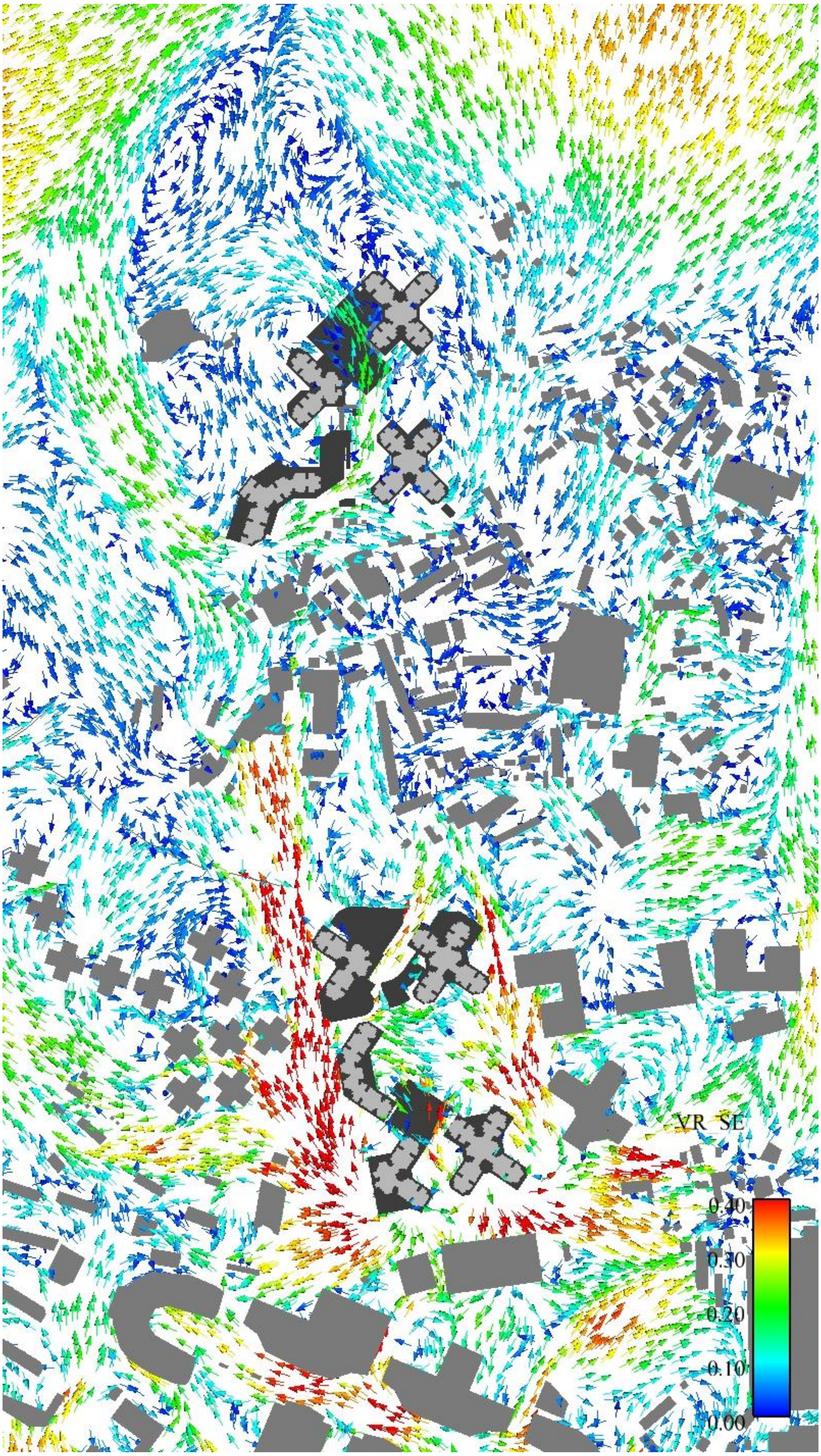


Figure F26 SE Direction for Both Developments under Scenario 3

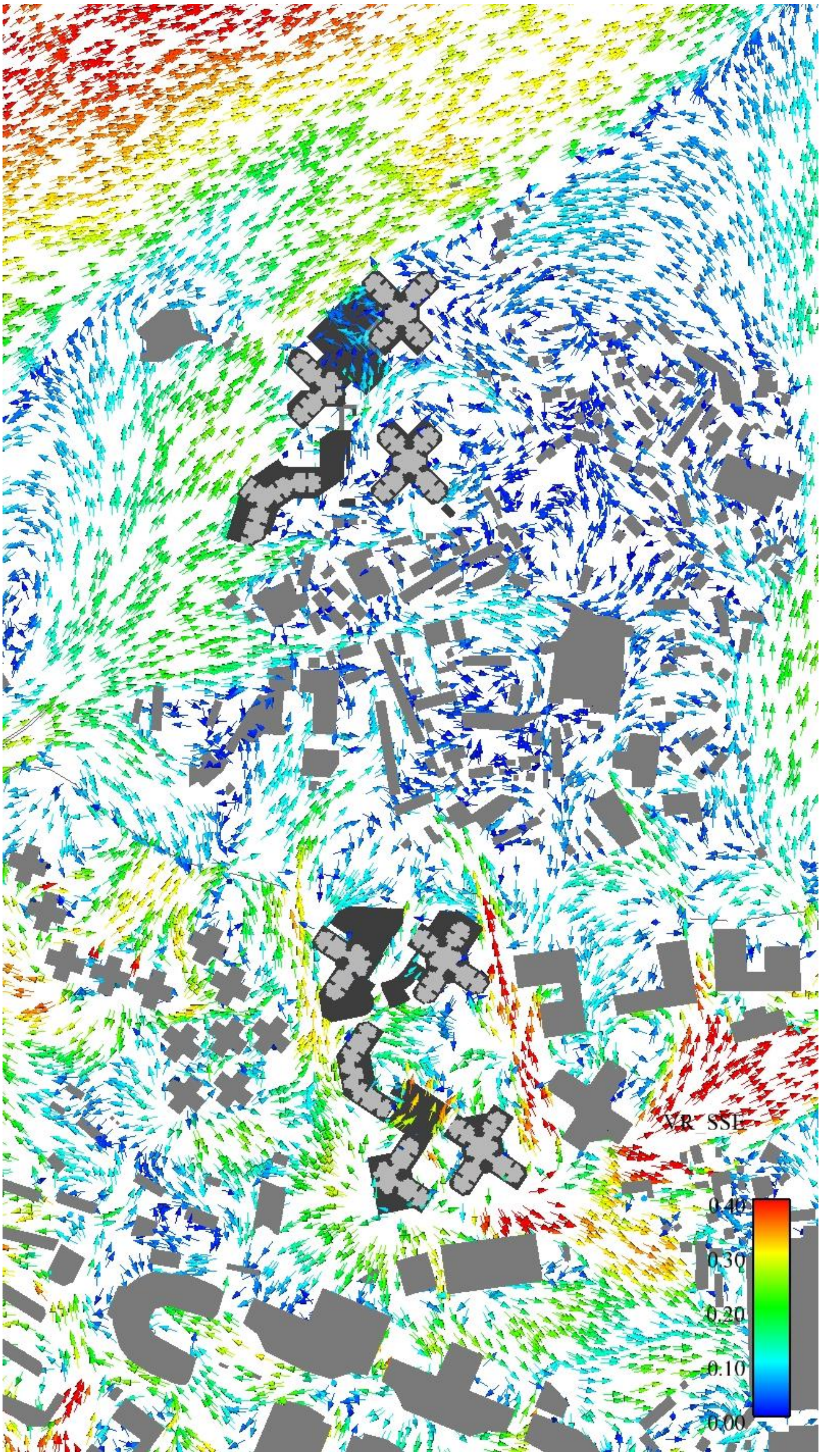


Figure F27 SSE Direction for Both Developments under Scenario 3

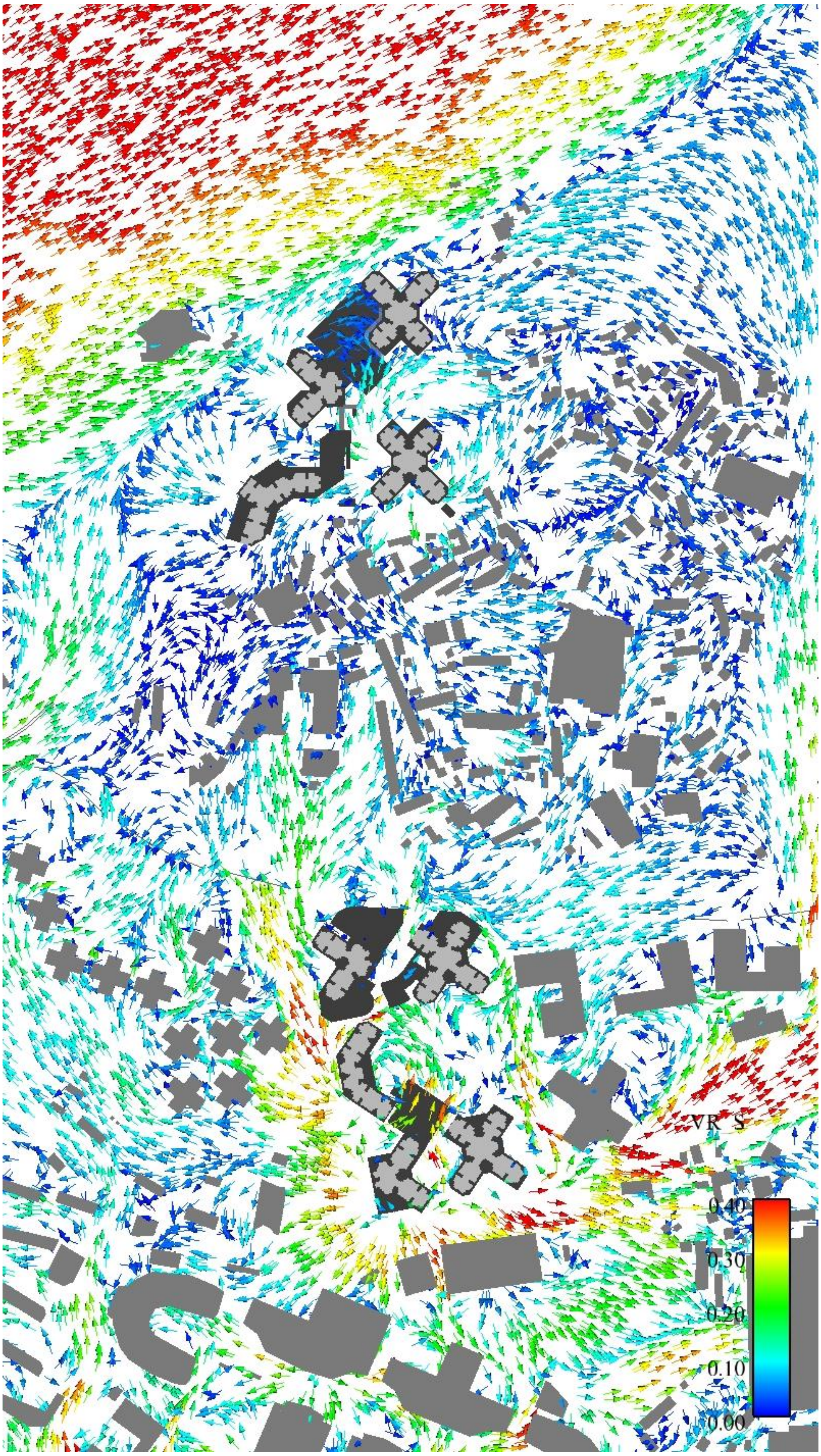


Figure F28 S Direction for Both Developments under Scenario 3

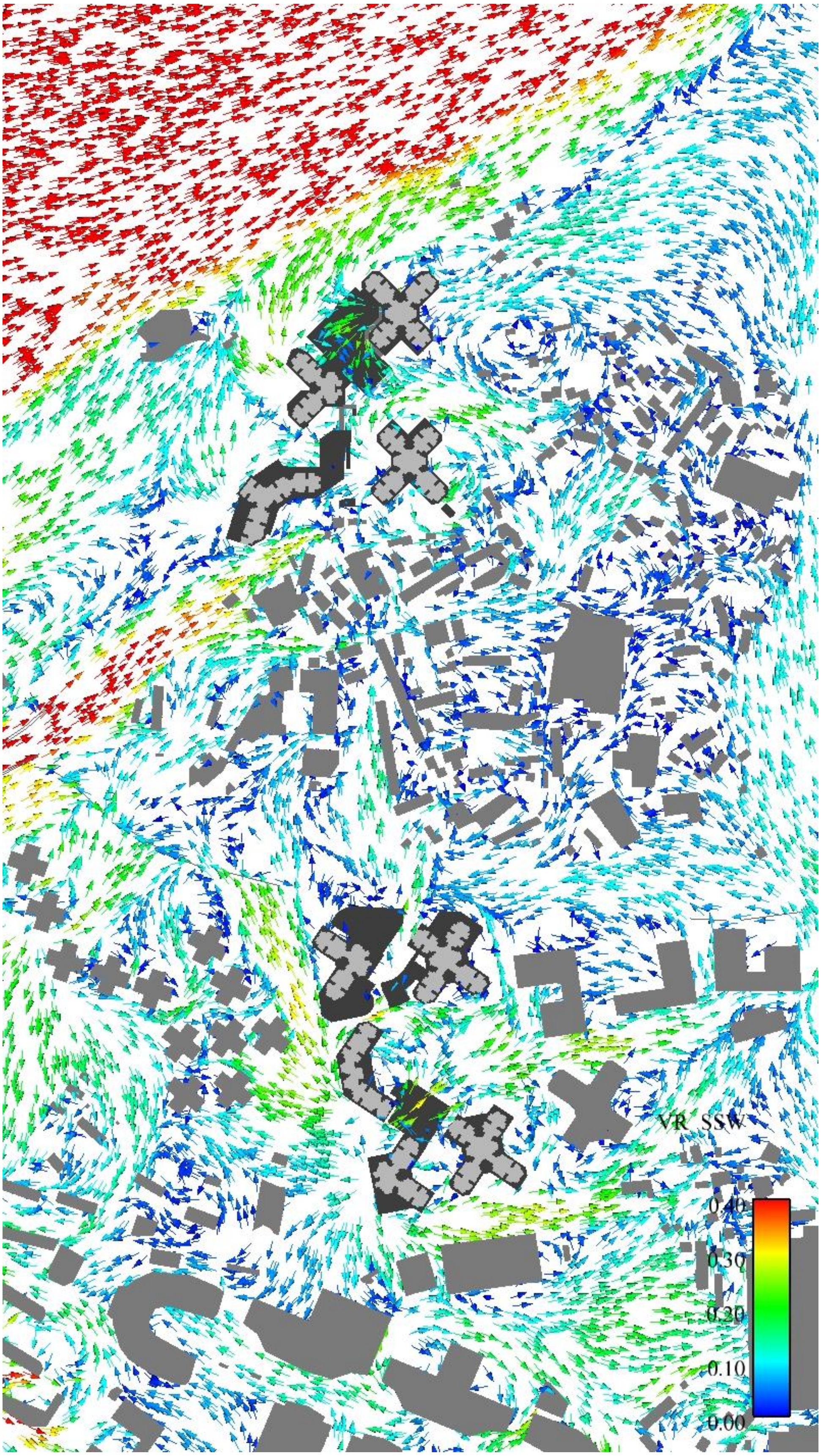


Figure F29 SSW Direction for Both Developments under Scenario 3

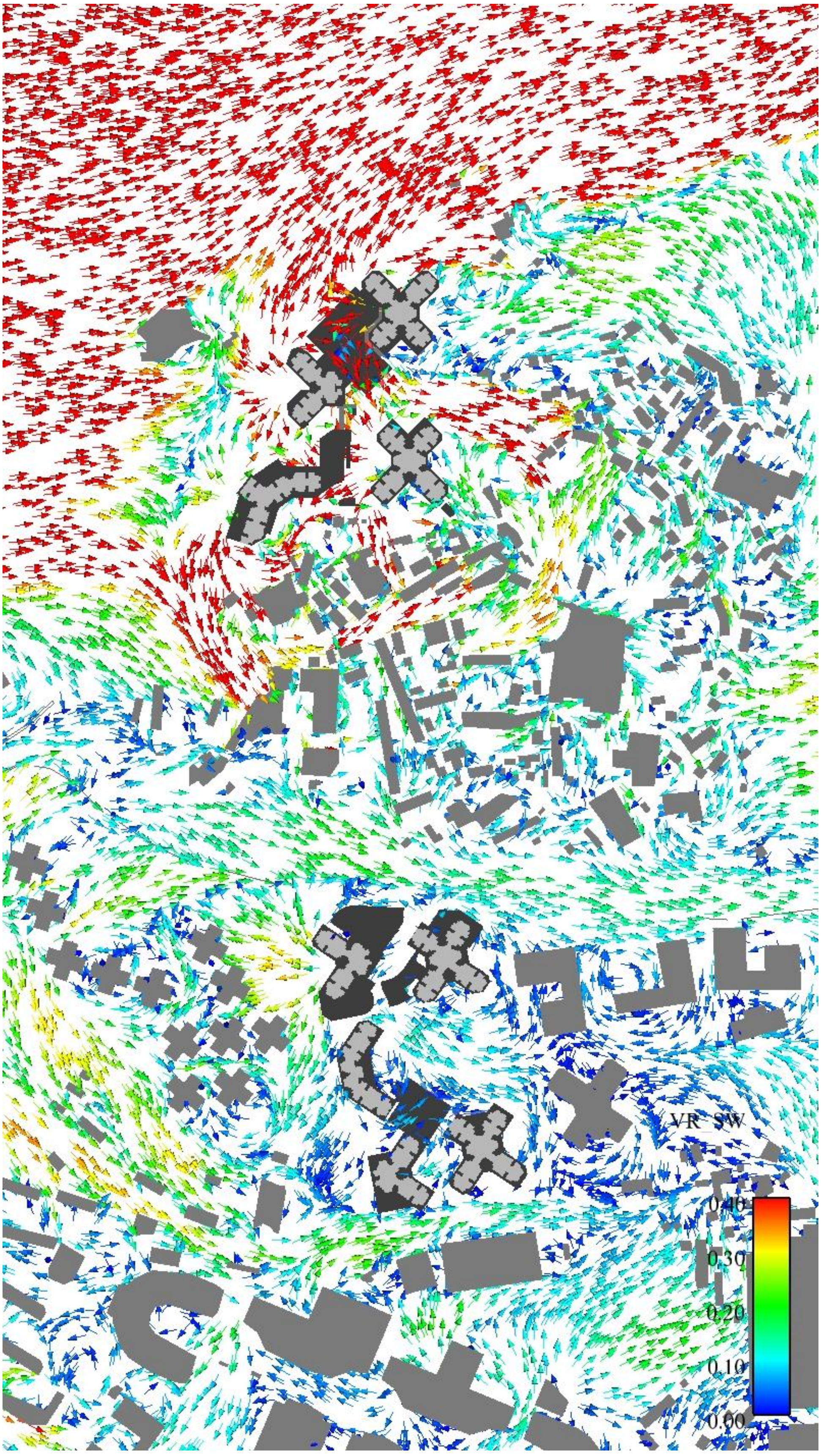


Figure F30 SW Direction for Both Developments under Scenario 3