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Computational Fluid Dynamics (CFD) Applications at the School of Architecture, University of Hawaii: Internal CFD Simulation & Field Verification

Task 7

Prepared For
Hawaii Natural Energy Institute

Prepared By
Sustainable Design & Consulting LLC, UH Environmental Research and Design Laboratory, UH Sea Grant College Program & HNEI

April 2015

HNEI
Hawai‘i Natural Energy Institute
University of Hawai‘i at Mānoa

UNIVERSITY OF HAWAI‘I
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UA MAU KE EA O KA ‘ĀINA I KA PONO

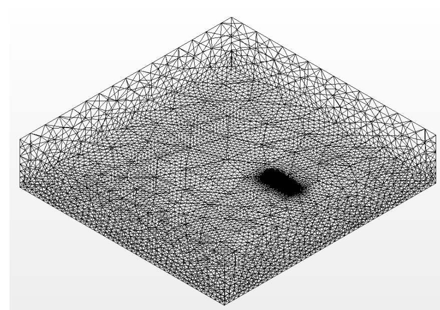
Project Phase 1- 7.B

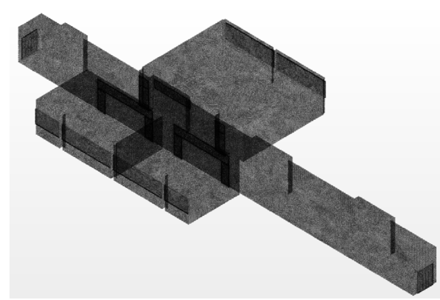
REPORT ON INTERNAL CFD SIMULATION & FIELD VERIFICATION FOR SELECTED AIR FLOW PATHWAYS THROUGH BUILDING

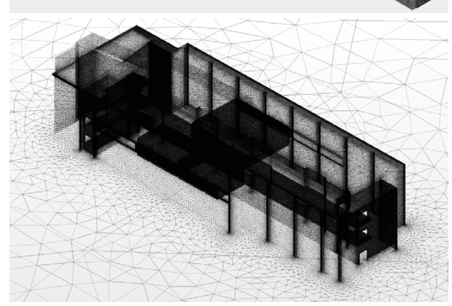
9.2

FINAL

April 1, 2015







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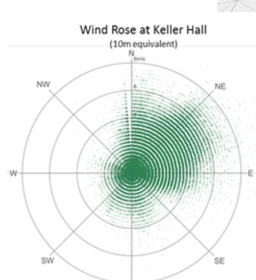

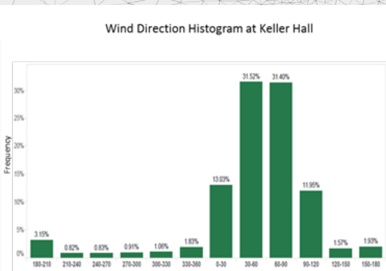

ERDL HNEI

Contract # N000-14-13-1-0463

Computational Fluid Dynamics (CFD) Applications at the School of Architecture, University of Hawaii

Project Phase 1 – 7.B

Develop Skill Set for Internal CFD Analysis and Validation at the Building

Project Deliverable No. 9.2

Report on Internal CFD Simulation & Field Verification for Selected Air Flow Pathways through building.

FINAL

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in support of

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The project work performed on the internal CFD simulation & field verification for air flow pathways through the selected building on the UHM, e.g. Keller Hall, was a significant team effort. The experiences gained will help the team to successfully conduct the subsequent phases of the CFD research project.

The documentation of the work performed and lessons learned will help incoming team members and expedite their learning curve in relevant research efforts.

The authors would like to thank the staff of the Environmental Design & Research Laboratory (ERDL) for their assistance in carrying out parts of this research study. The authors especially acknowledge the valuable contribution of postdoctoral fellow Aarthi Padmanabhan, D. Arch. The authors also acknowledge the dedicated work by research assistants Mike Poscablo, Christian Damo, Reed Shinsato and Steven Chen. Christian Damo has graduated in the meantime and we wish him all the best for his professional and personal future.

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SECTION 1: EXECUTIVE SUMMARY

The present report on Internal Computational Fluid Dynamics (CFD) is part of a CFD research program which is sponsored by the Hawaii Natural Energy Institute (HNEI). The research program endeavors to develop advanced building modeling skills at the Environmental Design and Research Laboratory (ERDL) of the School of Architecture, University of Hawaii at Manoa.

The present report, Project Deliverable 9.2, summarizes research work performed by the ERDL CFD research team to conduct the internal CFD investigation and validating measurements. The project work presented in this report used CFD workflow and data acquisition methodologies which were developed and benchmarked in conjunction with two previous parts of the same CFD research program. These previous parts were the development of an internal CFD workflow (Project Deliverable 7) and development of test methodologies (Project Deliverable 8).

The test site selected to conduct the internal CFD investigations and validation tests was a building on the University of Hawaii Mano campus, Keller Hall. The test site was a smaller portion of the Keller Hall building and consisted of three interconnected class rooms and one hallway on the third floor. The class rooms and the hallway are naturally ventilated. Their layout and configuration of the test site have basically remained unchanged from the original design of Keller Hall, while some portions of the building have been converted to air conditioned spaces. Keller Hall was also the test site for the external CFD investigation which was conducted earlier in 2014. The external CFD project work described theoretical predictions of external wind movement phenomena around Keller Hall and the external CFD results were validated with actual measurements. Keller Hall proved to be an excellent test site for the external as well as the internal CFD investigations.

The project work included the preparation of the test site inside Keller Hall, selecting five test scenarios, conducting extensive CFD investigations and measuring internal air movement in order to validate the theoretical CFD predictions.

A 3D-CAD model of Keller Hall building which was imported into the CFD software included a comprehensive depiction of the exterior of the Keller Hall building configuration as well as some internal spaces, including three interconnected class rooms and hallway on the third floor. The 3D-CAD model was created in Rhino3d. The 3D-CAD model was then exported to the CFD software Star-CCM^{+}, and the computation was created for the CFD simulations. A coupled domain approach was used for the CFD simulation. The coupled domain approach includes external as well as internal air volume as the computational domain. The coupled domain approach required more computational resources as the decoupled approach, but allows for a more reliable assessment of the air intake and outlet conditions of the internal spaces. While the focus of the CFD investigations was the determination of internal air movement through the interconnected and naturally ventilated classrooms and hallway, the area adjacent to Keller Hall was included in the coupled computational domain in order to model inlet conditions for the class rooms and hallway.

The investigations and results of the CFD investigations of this report are reported in three parts:

Part 1 - Generic air flow occurrences of internal test site: CFD investigations were comprised of five test scenarios. The test scenarios represented a combination of either open or closed internal openings between interconnected internal spaces of the test site. These openings were doorways, hallway sections and louvered wall sections. The flow patterns inside the test site were simulated and visualized with post processing methods, which were tested previously during the CFD research work. In addition to the airflow inside the test site the air flow patterns in opening between the spaces were determined. These descriptions of air flow doorways and hallway sections included the spatial distribution of air velocity inside the openings. The CFD simulations of all five test scenarios used the same wind approach directions (e.g. 45°) and normalized wind velocity (4 m/s). The results of Part 1 showed that the internal air flow characteristics could be depicted well.

Part 2 – Validation of CFD simulations for the five test scenarios: CFD investigations were conducted using wind velocity corresponding to wind conditions recorded during the measurements of internal air velocities at the test site. The methodology of using a control volume approach proved to facilitate the interpretation and validation of the CFD results. A control volume was defined that included the hallway with its control surfaces being doorways between the class rooms and the hallways, louvered sections between the hall ways and classrooms and two interfaces inside the hallway. CFD simulations results proved that the net inflow and outflow of the control volume was zero for all but one test scenario, where it was very close to zero. This showed that the CFD simulation could describe the air flow very well. Air velocities were measured at the control surfaces, e.g. inside the doorways of the three classrooms and one door of the hall way. Six hotwire anemometers were used for the measurement of the air velocities. The external wind conditions were measured over five months with a weather station installed on the roof of Keller Hall. The CFD calculations of airflow and actual air velocity measurements at the locations of selected control surfaces showed good comparison. This suggests that the CFRD could be validated with actual field measurements within expected ranges.

Part 3 – Development of a prediction method of probable air change rates: A methodology was developed by the research team using CFD simulations to determine air change rates for spaces and correlate these calculations with actual long term wind site specific conditions. The results of this methodology can be used to predict effectiveness of naturally ventilated spaces over a time period that includes different seasons. Air change rates are a predictor for the ventilation effectiveness of the internal spaces. The prediction method was applied to the ventilation performance of the larger classroom 302. The result of these correlations was a probability of exceedance of air change rates for the naturally ventilated space. The method to determine a probable exceedance of air change rates per hour (ACH) for a site specific wind record and building configuration is a promising design tool to optimize the performance of naturally ventilated buildings.

The overall results of the investigations presented in the report are considered significant contributions to the objective of developing skill sets of using advanced CFD simulations for natural ventilation at the Environmental Research and Design lab (ERDL). The CFD research team developed conclusions and recommendations for future CFD analyses of internal airflow.

One of the most significant conclusions was that the original design of the Keller Hall building and internal configuration of spaces that were used as the test site proved to be very effective to cause high air change rates and therefore ventilation by natural driving forces alone. This findings support the conclusion that, when designed right, natural ventilation can be a very energy effective method for buildings to provide the required air flow without mechanical assist ventilation.

CFD investigations such as demonstrated in this report can be used by building designers to verify natural ventilation performance of energy efficient buildings.

SECTION 2 – OBJECTIVES

The objectives of the project work carried out under project task "Task 7.b.4 Report on internal CFD simulation & field verification for selected air flow pathways through building" were as follows:

- Continue to further develop work skills at ERDL to perform CFD simulations of internal air movement and have an opportunity to validate theoretical CFD predictions with actually measured air flow phenomena in the controlled test environment of a naturally ventilated building.
- Utilize appropriate spaces in a naturally ventilated building on the University of Hawaii Manoa campus, the Keller Hall building, as a test site to carry out CFD simulation at the full scale prototype and validate the CFD results through measurements in the field.
- Determine a scope and approach for internal CFD simulation and validation that could be used to develop design tools for future internal air movement studies.
- Develop and test a methodology where the air movement in internal spaces can be predicted on a probability scale so that CFD simulations can be used as a powerful support for the design and optimization of naturally ventilated spaces to achieve high energy efficiency.
- Build on already previous CFD investigation of external wind movement and related physical properties around the Keller Hall building. Although the internal CFD simulation were a standalone study, the instrumentation and longer term weather data recordings installed during the external CFD studies at Keller could be re-used.

SECTION 3 – APPROACH

This section describes the approach taken in conducting the CFD simulations and validating the results through measurements in the field.

3.1 Selecting the Test Site

For the CFD simulations and validation of theoretical results, a test site was selected that offered several characteristics:

- Selecting large rooms and not small offices: Class rooms as preferred over offices as test site, since they contain a small amount of furniture and do not have any internal partitions.
- Ready access of the building and internal spaces: The investigation had to be carried out during times when the classrooms and the interconnecting causeways were not occupied. The classrooms 302, 313 and 314, on the third floor of the Keller Hall building, were readily accessible, thanks to the friendly cooperation with the facility department of the university, and the CFD team could control access for selected test periods within a reasonable scope.
- Natural ventilated spaces: The classrooms 302, 313 and 314, on the third floor of the Keller Hall building, were originally built as naturally ventilated space and they have never been converted to mechanically ventilated and cooled spaces.
- Controllable air flow through the interconnected spaces: The interconnected classrooms 302, 313 and 314 had controllable louvers that made it possible to control the internal air flow pathways.
- Use cross ventilated spaces to maximize the air low: The interconnected classrooms 302, 313 and 314, were exposed to cross ventilation, having the class room 302 on the North side of the building and class room 313 and 314 on the South side of the building. The orientation of Keller Hall with the longitudinal axis perpendicular, or close to perpendicular, to the predominant wind North East – South West approach wind direction resulted in favorable wind driven forces.
- Large intake and exhaust openings: Internal space that offered relatively large intake and exhaust opening in the wind ward and leeward side of the interconnected spaces (e.g. this could maximize driving forces and minimize air flow losses).
- Internal spaces with little internal flow obstructions: The CFD simulations and validation measurements for project deliverable 7.1 and 7.2 were carried out in an internal space with a large number of internal flow obstructions (e.g. cubicles) which created complicated internal air flow conditions. For the investigation of this report (e.g. deliverable 9.1 and 9.2) much less complicated internal space geometry was used.

3.2 CFD Analysis

The CFD analysis was based on the following main methodologies:

- Coupled domain selected: A coupled domain approach was selected for the CFD investigation. The entire building geometry of Keller was modeled in full scale with only selected internal spaces being connected to the external air volume. The rest of the Keller Hall building was modeled as an opaque building to lower the complexity of the simulation. No adjacent buildings of Keller Hall were included in the 3D-model and the domain extended a distance from the upwind and downwind building facades that were deemed sufficient to model air inlet and outlet conditions.

- Louvered intake openings: The intake and outlet of the selected classrooms were louvered windows without insect screens. For the tests, the louvers were brought into a horizontal position where they offered a minimum air flow resistance. For the CFD analysis it was opted that the louvers were not included as distinct geometries in the model in order to hold the computational gird at a manageable size. Inclusion of all louvers, along with the required resolution adjacent to the louvers, would have increased the required grid size significantly. The CFD team made the assumption that keeping the louver geometries out of the model would not result in a significant overall error. The CFD team, however, has concluded that the missing louvers could result in slightly higher airflow rates than calculated.

- Outside appurtenances of building envelope: The 3D-CAD geometry included all main appearances on the building envelope, such as larger vertical fins on the North and South side of the building. The CFD team assumed these larger vertical fins assisted in diverting the air flow into the internal spaces. Since the approach wind direction was primarily from the first quadrant (e.g. 0° to 90° from due North) the geometry of the North building façade had significant effects on the flow conditions near the wall and therefore on the airflow entering the building.

- Size of the domain grid (Meshing): As in previous investigation benchmarking with different mesh sizes were conducted to assess the convergence and computational performance of the simulations. Grid sensitivity was also part of this investigation.

- Post processing: For the CFD analysis two types of post processing methods were used. As used extensively in previous phases of the CFD research color counter maps and streamlines illustrations were used to obtain qualitative descriptions of the air flow patterns. For the present study quantitative assessments of air velocities and mass flow rates were used extensively.

- Control volume for quantitative analysis: The interconnecting class rooms were connected by an internal hall way. The hallway was defined as a control volume with the internal openings of the class rooms and hallway cross sections as the intake and exit mass flows of the control volume, therefore the control surfaces. These control surfaces allowed favorable locations for the determination of actual velocity and mass flow rates.

- Defining test scenarios: The CFD analysis was carried out for five test scenarios. The test scenarios differed in their combination of open internal doorways, internal louvers between the classrooms and the hall way as well as open external doors of the hall ways to the building exterior. The test scenarios were selected to allow CFD simulations which could be readily validated with the internal air flow measurements.
- CFD analysis process to determine the air velocity distribution in openings: The CFD analysis obtained a representative distribution of the air velocities across the representative internal openings, e.g. doorways between class room and internal hall way, where air velocities were measured. The air velocity distribution was determined with a sampling grid which defined a matrix in vertical and horizontal directions.
- CFD analysis to obtain average air velocities inside internal openings: The CFD analysis obtained average values of air velocities inside the representative openings by using a CFD software function where the average air velocity was determined based on all cells in the openings. This method of obtaining an average air velocity for the specific opening is different from the air flow velocity distributing based on the matrix approach to obtain the air velocity distribution inside the openings. Using cells instead of a matrix to evaluate average air velocities provided a much higher resolution of test points and therefore a better representation.
- CFD analysis to obtain overall mass flow rate: The CFD analysis obtained the resulting overall mass flow rate through the representative openings by using a specific CFD software function and apply it on the respective openings.
- CFD analysis to obtain percentage of exceedance: The CFD analysis obtained the expected number of air changes per hour (ACH) and created a correlation of ACH and external wind conditions. The results were a probability of exceedance of ACH for a space. This process would allow designers to develop a distinct prediction of the expected performance of naturally ventilated buildings.

3.3 Measurements in the Field

For the measurement of internal air velocities for validating the CFD simulation results the following methodologies were used:

- Parameter used for testing: Based on experiences in the development of the internal CFD workflow, e.g. studies pertaining to project deliverable 7.1 and 7.2, the measurement of air velocity was selected as the parameter for validating the CFD simulation results. Pressure differentials were not used to validate CFD simulations for internal air flow.
- Instruments used: For the measurements several hotwire anemometers were used. These instruments had already been used in previous field measurements.

- <u>Selecting locations to measure:</u> For the location of the air velocity measurements internal opening and internal air passageways with known cross sections were selected so that the mass flow rate could be readily verified. Due to practical considerations the anemometers were installed only in the internal doorways between the class rooms and the hall way as well as in the center of the hall way (e.g. only for one of the five test scenarios where all class room doors were closed and air could only flow in longitudinal direction of the hall way).

- <u>Placement of instrumentation:</u> The anemometers were installed in the center of the respective opening. It was anticipated that the openings could have a non-uniform vertical and horizontal air velocity distributions. With the available instrumentation it was not possible to measure the spatial velocity distribution, only spot measurements were possible. The measurement of only one air velocity in the opening was, however, deemed as reliable to obtain representative validation data.

- <u>Data acquisition:</u> Data acquisition was carried out with a data multiplexer in order to get good time dependent internal air velocity data for the deployed six anemometers.

- <u>External wind conditions:</u> The weather station which recorded the wind approach direction and wind speed on the roof of Keller Hall was synched with the internal air velocity measurements, in order to allow cross reference of internal air movement conditions to external wind conditions.

3.4 Validating the CFD Results

The CFD results were validated with measured internal air flow rates.

- <u>Validation methodology:</u> The methodology of validating CFD simulation results with measured air velocities was carried by comparing the average air velocity of the CFD simulation for the opening with the average of the measured air velocity in the opening taken over the time series of the measurements for the different scenarios.

- <u>Data filters:</u> The measured wind velocities records for the different test scenarios were filtered with regard to wind approach direction so that only those internal air velocity measurements were considered, which corresponded with the approach wind direction used in the CFD simulations.

- <u>Considering inertia of internal air mass:</u> The CFD team was aware that the inertia of the air mass inside the spaces affected the correlation of external wind approach with the internal air velocity measurements. With changing wind velocity the driving forces for internal air movement changed. The air inside the internal spaces has a certain inertia with which the internal air mass reacts to varying external driving forces (e.g. pressure differentials between windward and leeward building facades) and the internal air accelerates and decelerates according to the external conditions. The CFD team considered, however, that the sample frequency of the weather station of one data point per minute can account for the time that would be required for the internal air mass to react to differences in differential pressures and mean driving forces of the natural ventilation, without introducing significant errors.

3.5 Developing Building Design Support Tools based on CFD Work

The following methodology was used to develop design support tools for future ventilation assessment of internal spaces in buildings:

- Rationale: A major objective of the CFD study was to determine how the use of CFD investigation can be used in future design and optimization of buildings to use some form of natural ventilation. A very useful approach of estimating natural ventilated performance is using CFD investigation and correlating them with probability of external wind conditions.

- Use of air changes per hour: As a suitable approach to use the CFD process in assessing ventilation performance, the CFD team selected air change rates, expressed in air changes per hour (ACH), for spaces. ACH rates of internal spaces are determined by dividing the net mass flow rate of the space by the volume of the space. Since the air change rates are functions of the wind flow through the building, which in turn are affected by the external wind approach direction, the air change rate of a space can be correlated to the probability of wind approach.

SECTION 4 - METHODOLOGY

This section describes the methodology that was applied in this investigation.

4.1 Test Site, Instrumentation and Data analysis

This section describes the methodology of preparing the test site, defining the scenarios and carrying out the measurements and data analysis.

4.1.1 Description of the Test Site

The test site was the Keller Hall building, which is located on the University of Hawaii Manoa Campus. Figure 4.1.1.1 shows the location of Keller Hall building on the Manoa campus. The prevailing winds, e.g. trade winds, approach the building from the North-East. Figure 4.1.1.2 through 4.1.1.4 show the building from different viewpoints outside the building.

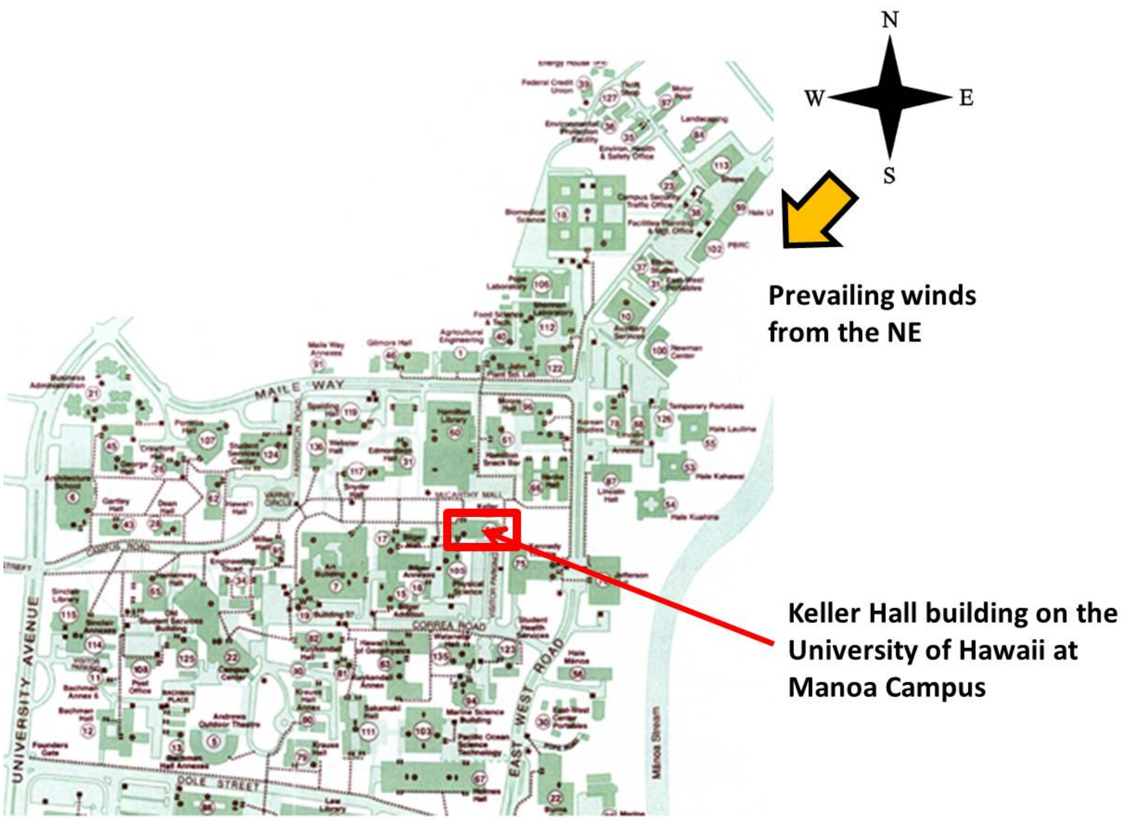
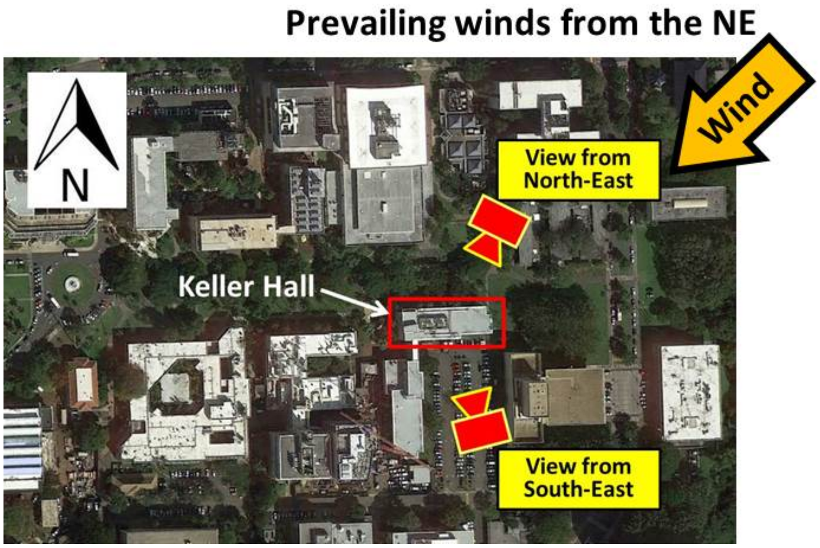
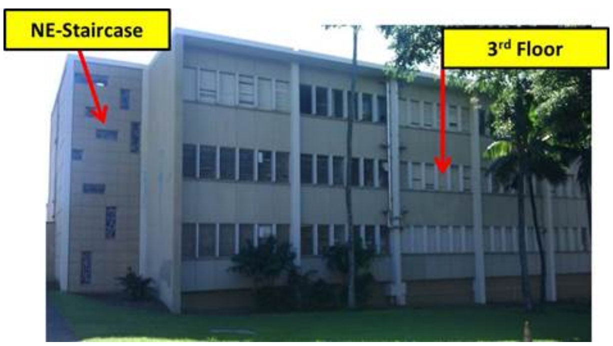


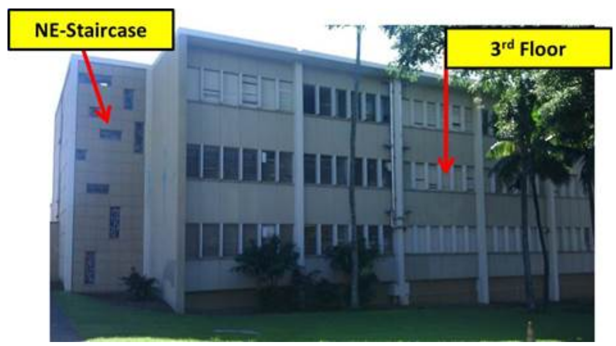
Figure 4.1.1.1: Location of test site on the University of Hawaii Manoa campus



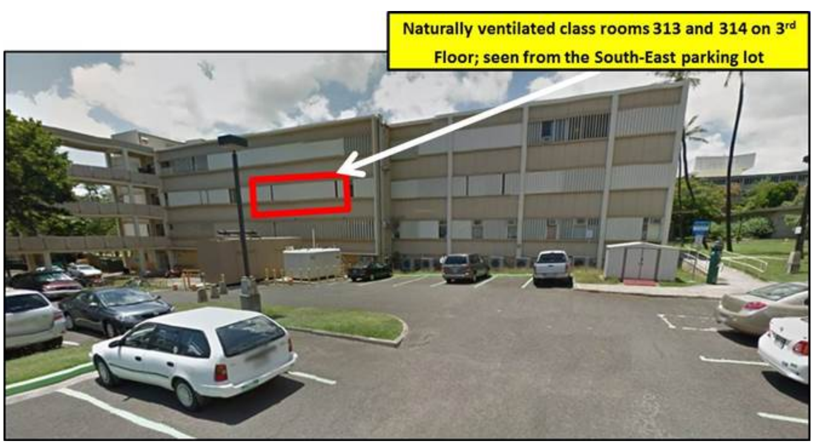
Definition of view point: The Keller Hall building is located South of the "Mall" of the Manoa campus. The Mall is a West-East wide vegetated strip with pedestrian walkways.
There is a large parking lot to the South of the Keller hall building.
Prevailing winds:
The prevailing wind comes from the Northeast



Keller Hall building – View from the North-East



Keller Hall building – View from the North-East



Keller Hall building – View from the South -East

Figure 4.1.1.2: Vicinity map and images of Keller Hall

The test site for the internal air flow investigation consisted of three interconnected classrooms and one internal hallway on the third floor of the Keller Hall building. Figure 4.1.1.3 shows the floor plan of the third floor and indicates the location of the three classrooms (e. g. the test site) on the third floor. Figure 4.1.1.3 indicates that classroom 302 is located on the North side of the building and classrooms 313 and 314 are located on the South side. All three class rooms and the internal hallway are naturally ventilated.

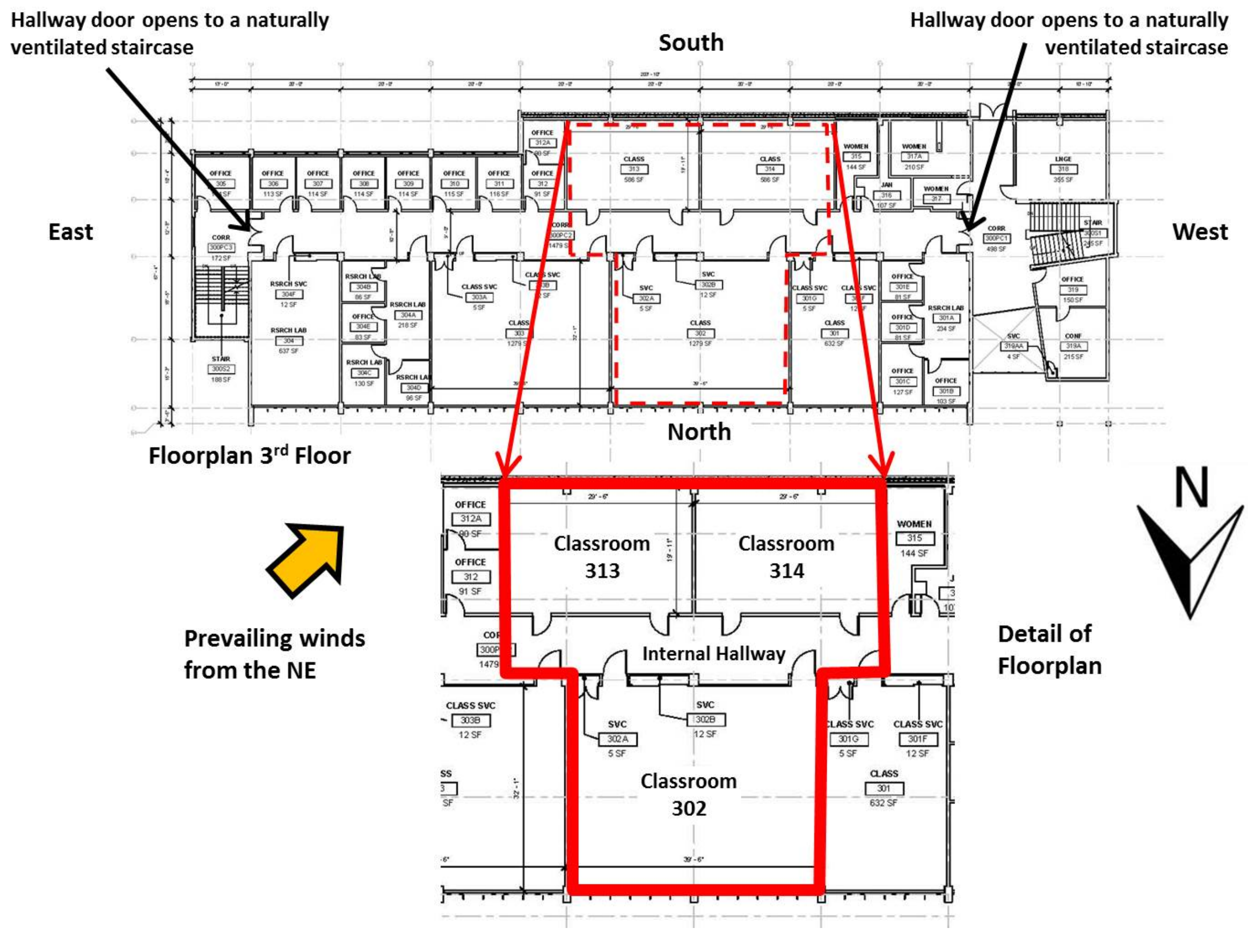


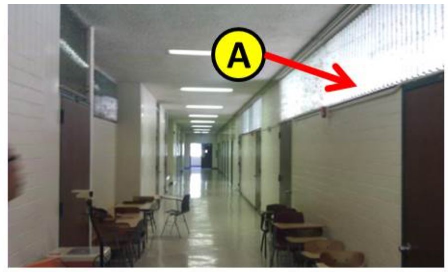
Figure 4.1.1.3: Floor plan of the 3rd floor of Keller Hall building and indication of the three classroom and interconnecting hallway which represent the test site

Figure 4.1.1.4 shows several images of the internal configuration of three classrooms and the interconnecting hall way.

Typical classroom outfitting

Internal louvered opening between hallway and classroom, seen from the classroom

(A) **Internal louvered openings between hallway and classrooms.**



Typical hallway configuration

Internal louvered opening between hallway and classroom, seen from the hallway

Internal louvered opening between hallway and classroom, seen from the classroom

External louvered window in classroom 302, facing North

Figure 4.1.1.4: Internal configuration of the classrooms and hall way which were the test site

4.1.2 Defining the Test Scenarios

The CFD team selected five test scenarios for which CFD simulations and validation measurements were carried out. The test scenarios were defined by different combinations of open and closed doorways and open or closed internal louvered connections between the classrooms and the hallway.

For the selection of test scenarios the internal doorways and louvered openings where identified with IDs. The IDs of the doorways and louvered openings described in Figure 4.1.2.1 and 4.1.2.2, Table 4.1.1.1. and 4.1.1.2 indicate what combination of open and closed doorways and louvered openings are used in the five different scenarios.

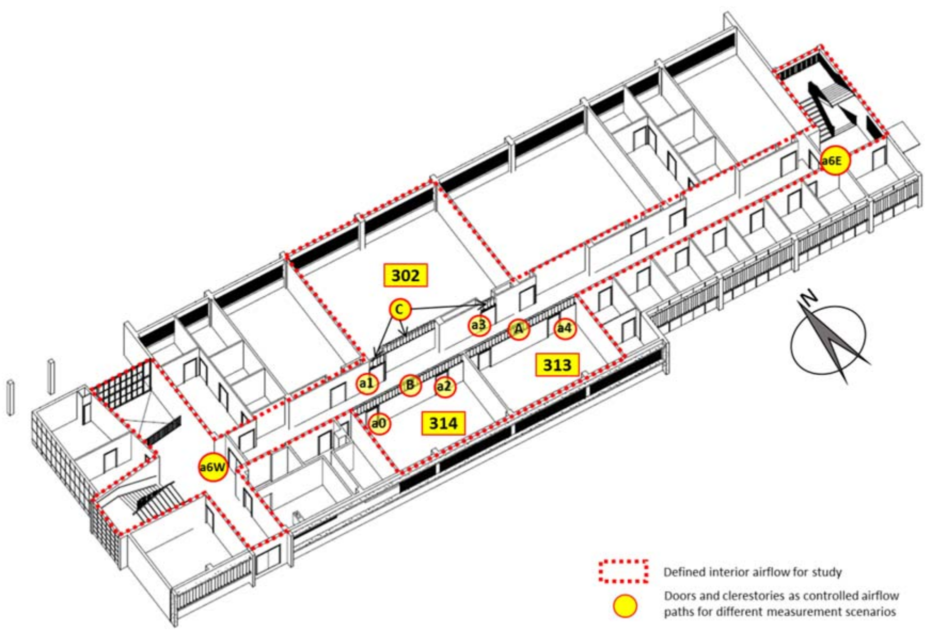


Figure 4.1.2.1: Definition and description of the IDs of internal doorways and louvered openings

The concept of control volume is important in the understanding of the test scenarios. The control volume will be discussed later in the report. At this point it is helpful to state that a section of the hallway acts as the control volume for which inflow and outflow is defined. Specifically, Figure 4.1.1.5 indicates the control volume by the light green shaded section of the hallway. The control volume is a mathematical abstraction which allows balancing of properties across its boundaries. In the control volume, under steady state conditions the change in mass inside the control volume is zero, which is evident since there is no storage of air inside the control volume. In our case the control volume is used to balance the net mass flow rate for the air moving from room 302 to the classrooms 313 and 314. The inlets and outlets of the control volume, e.g. the control surfaces, were the internal doorways and louvered wall sections. There were two additional control surfaces inside the hallway, which were defined as hallway cross-sections located at either side of the doors to the classrooms in longitudinal direction of the hallway.

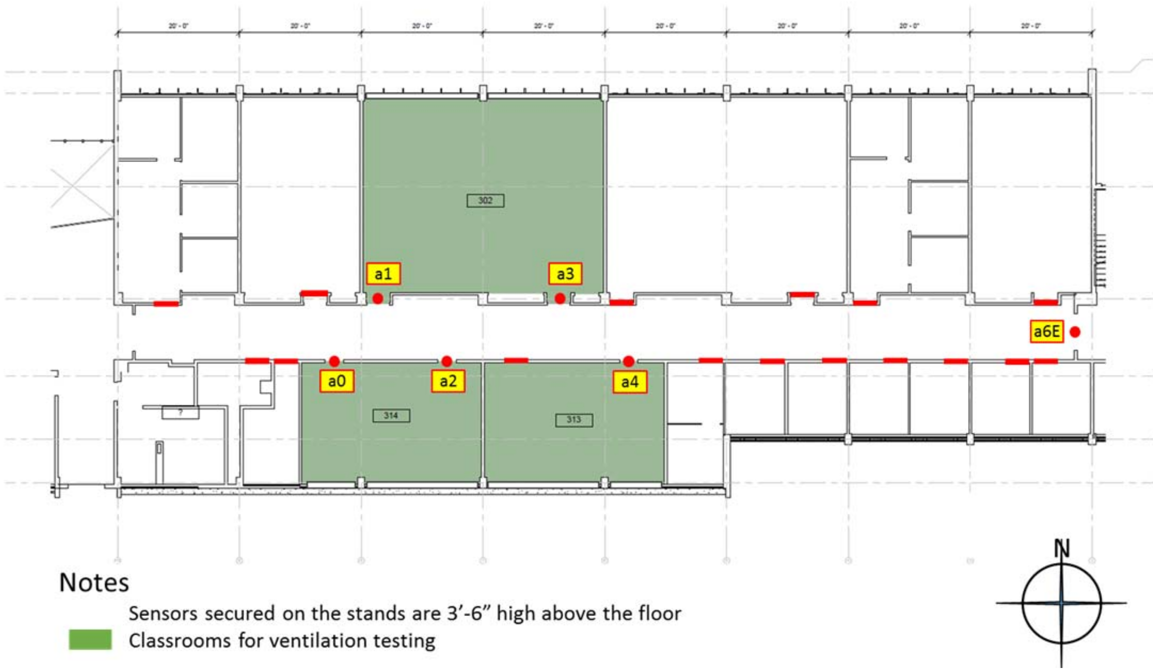


Figure 4.1.2.2: Definition and description of the IDs of internal doorways and louvered openings

Table 4.1.1.2: Description of the 5 test scenarios as the combination of open and closed internal openings

Label	Type	Room	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
a0	Door	314	closed	open	open	open	open
a1	Door	302	closed	open	closed	open	open
a2	Door	314	closed	open	open	open	open
a3	Door	302	closed	open	open	open	open
a4	Door	313	closed	open	open	open	open
a6E	Door	Hall way	open	closed	closed	open	open
a6W	Door	Hall way	open	closed	closed	open	open
A	Clerestory	313	closed	closed	closed	closed	open
B	Clerestory	314	closed	closed	closed	closed	open
C	Clerestory	302	closed	closed	closed	closed	open

Table 4.1.1.2: Description of the internal doorways and louvered openings used in establishing the five test scenarios

ID used for the openings	Type of opening	Location between		Description	size of the openings	
					width (ft)	height (ft)
A0	doorway	Room 314	Hallway	Doorway between Classroom 314 and hallway	3	7
A1	doorway	Room 302	Hallway	Doorway between Classroom 302 and hallway	3	7
A2	doorway	Room 314	Hallway	Doorway between Classroom 314 and hallway	3	7
A3	doorway	Room 302	Hallway	Doorway between Classroom 302 and hallway	3	7
A4	doorway	Room 313	Hallway	Doorway between Classroom 313 and hallway	3	7
A7E	hallway section	Hallway	Hallway	Virtual section inside the hallway on the Eastern side of the hallway	8	7
A7E	hallway section	Hallway	Hallway	Virtual section inside the hallway on the Southern side of the hallway	8	7
C1	louvered section	Room 302	Hallway	Louvered opening section above the doorway A1	3	2.5
C2	louvered section	Room 302	Hallway	Louvered opening section above the internal wall at 6 feet height	10	2.5
C3	louvered section	Room 302	Hallway	Louvered opening section above the doorway A3	3	2.5
A	louvered section	Room 313	Hallway	Louvered opening section above the internal wall at 6 feet height	8	2.5
B	louvered section	Room 314	Hallway	ouvered opening section above the internal wall at 6 feet height	8	2.5

4.1.3 Preparing the Site for Measurements of Test scenarios

This section describes and illustrates the preparation at the test site to carry out measurements of the air flow patterns between the interconnected class rooms and hallway. The following actions were required to prepare the test site:

- Bring the louver elements of the external louvered external windows into a horizontal position so that entrance and exit pressure losses are minimized.
- Apply lubrication to those louver elements which are corroded and otherwise hard to operate to a fully open position.
- Temporarily seal the internal louvered openings with a tarp to create a tight seal. In several sections of the internal louvered openings the louvers could not be completely closed, and the tarps assured sufficient closure.
- Make preparations that the third floor of Keller Hall was closed to general pedestrian traffic so that the doors between spaces and the hallway could be controlled and selectively closed and opened. The test dates were coordinated with facilities. On the days of tests signs were posted that air flow test were conducted. During the tests occupants of the third floor briefly opened and closed the hallway door to reach their offices. The occupants of offices on the third floor were asked to keep their doors closed.
- Instrumentation was deployed at the selected locations to measure air velocities.

Installing the temporary tarp to seal sections of the louvered openings; seen from classroom 302

Installing the temporary tarp to seal sections of the louvered openings; seen in the hallway (looking East)

Completed sealing of the louvered section; in Room 313

Completed sealing of the louvered section; in Room 314

Removing temporary cover on louvered sections; in Room 313

Removing temporary cover on louvered sections; in Room 314

Figure 4.1.3.1: Images of preparing the test site for measurements of internal air flow – sealing of the internal louvered sections

Preparing the hallway for measurements; note the extension cords were used for data acquisition

Preparing the hallway for measurements; the empty hallway during test runs

Preparing the hallway for measurements; note the extension cords were used for data acquisition

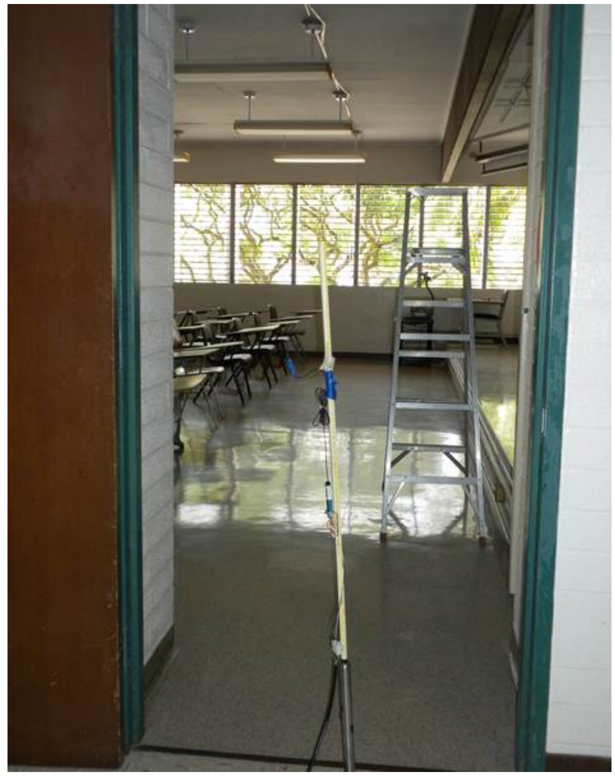
Preparing the hallway for measurements; note the anemometer stands were secures with red cones

Preparing the hallway for measurements; the East hallway door opening to the stairway

Preparing the hallway for measurements; the West hallway door opening; looking into the hallway

Figure 4.1.3.2: Images of preparing the test site for measurements of internal air flow – preparing the hallway for measurements

Deploying the anemometers at the test site; anemoters placement in doorway of room 313 (A4)



Deploying the anemometers at the test site; anemoters placement in doorway of room 302 (A3)

Deploying the anemometers at the test site; pleacement of all anemometers inside the hall way for measurements under scenario 1

Deploying the anemometers at the test site; data acquisition of anemometers with mutilexer; note the extension cords were used to supply the exciitation voltage as well as trasnmit the recorded data of the senors.

Figure 4.1.3.3: Deploying the anemoeters at the test site

4.1.4 Instrumentation

The present measurements used instrumentation and data acquisition protocols that were used and developed for previous investigations under the CFD research program.

<u>Weather Station on Keller Hall Roof:</u>

A weather station (Onset HOBO U30) was available to the research team to measure climatic conditions at the site over a period of five months. The measurements of internal air flow were conducted during this time. The weather station offered data acquisition of wind direction, instantaneous wind speed, and maximum wind gust. The sample rate was one data set per second. Figure 4.1.4.1 shows a picture of the Onset HOBO U30 instrument.

Figure 4.1.4.1: Onset HOBO U30 weather station (source Onset)

<u>Air velocity measurements:</u>

Six hotwire anemometers were used for the measurement of wind velocities at the test site. The type of hotwire anemometers used were the Degree Controls Accusense model F900-0-5-1-9-2 with the XS blade which has a range of 0 - 5 m/s air speed and an accuracy of 0.5 % of reading or 1% of full scale. Voltages from the sensors were measured by National Instruments USB-63341 data acquisition device (multi-plexer) using National Instruments Signal Express software on a laptop computer. Anemometers were mounted on a wire extending from a vertical stand at a height of 3 feet above the floor. The anemometers were wire connected to the USB-63341 data acquisition device by standard AC extension cords. The three poles of the AC extension cords were used for the excitation of anemometers and sensor signals recording. This innovative way providing excitation to the anemometers and connecting the sensor output to the multiplexer proved to be very effective. The relatively long extension cords were rugged and offered a good electric connection.

Data acquisition:

Voltage signals were recorded at 5-hz resolution by the National Instruments Signal Express software on a laptop computer. All anemometers were initially run for 15 minutes with the caps on to obtain a calibration. Data was acquired in a text format with a starting timestamp and frequency of collection (in this case 5 times per second). The Signal Express software did not record a timestamp for each reading. A Python script was written to present the data with timestamp information, averaged the 5-hz data to 1-second resolution with a trailing timestamp, scaled it (output of 0 - 4 V DC was scaled to 0 - 5 m/s less the calibration reading) and re-shaped for upload to a PostgreSQL database.

4.1.5 Correlating Air Velocity Data to the External Wind Condition

Wind condition measured outside the Keller Building affect the airflow characteristics of the naturally ventilated spaces. Since the CFD simulations used a distinct approach wind direction a data filter had to be applied that selectively considered only those internal air velocities that coincided with a specific wind direction range used in the CFD simulations.

The methodology of the data filter included the following steps:

- Data sets of the external wind direction and velocity recorded during the periods of the test, e.g. test scenarios, were obtained by the weather station on the Keller hall roof. A typical dataset is depicted in Figure 4.1.5.1.
- Only those measurements in the data sets of internal airflow which coincided with external wind direction falling into a selected range of main wind direction (for example main wind direction +/- 15°) were used in determining the average air velocity measured inside the building, e.g. at the test site. The resulting filtered wind data for a typical data filter is depicted in Figure 4.1.5.2. The data points in Figure 4.1.5.2 represent those wind data for which the corresponding internal air flow data was used to determine.

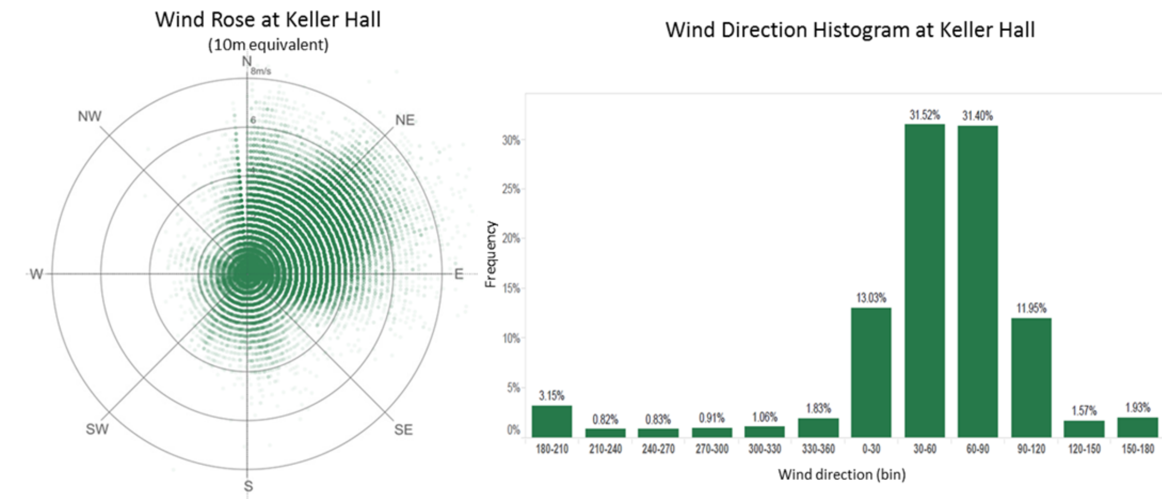


Figure 4.1.5.1: Sample wind observation for Keller Hall during predominate N/E winds.

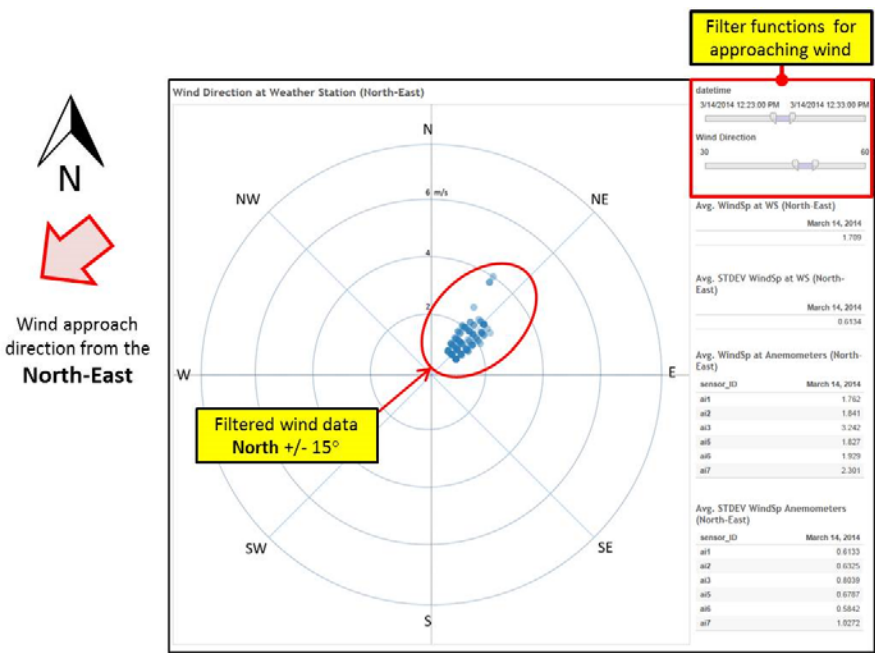


Figure 4.1.5.2:
Filtered wind data. The blue data points are the wind data which fall in the direction range of the apprpaching wind. Only those data for internal air velocity which correspondend to the filtered instantanous wind data were use to determine statistically representativeinternal air velocities.

4.2 Methodologies used in the CFD Simulations

This section presents the methodology used in preparing, running and post processing the CFD simulations.

4.2.1 Creating the 3D-CAD Model to be Used in CFD Meshing

The CAD model was developed using as-built plans of the Keller Hall buildings. Figure 4.2.1.1 shows the floor plan of the third floor of Keller Hall, with the color shaded area representing the test site, as well as the longitudinal section. Figure 4.2.1.2 shows the resulting 3D-CAD model of the Keller Hall building as an external rending. All major façade appurtenances were represented in the 3D-CAD model. Figure 4.2.1.3 illustrates all 3D-CAD objects (e.g. 3D-faces) which were used.

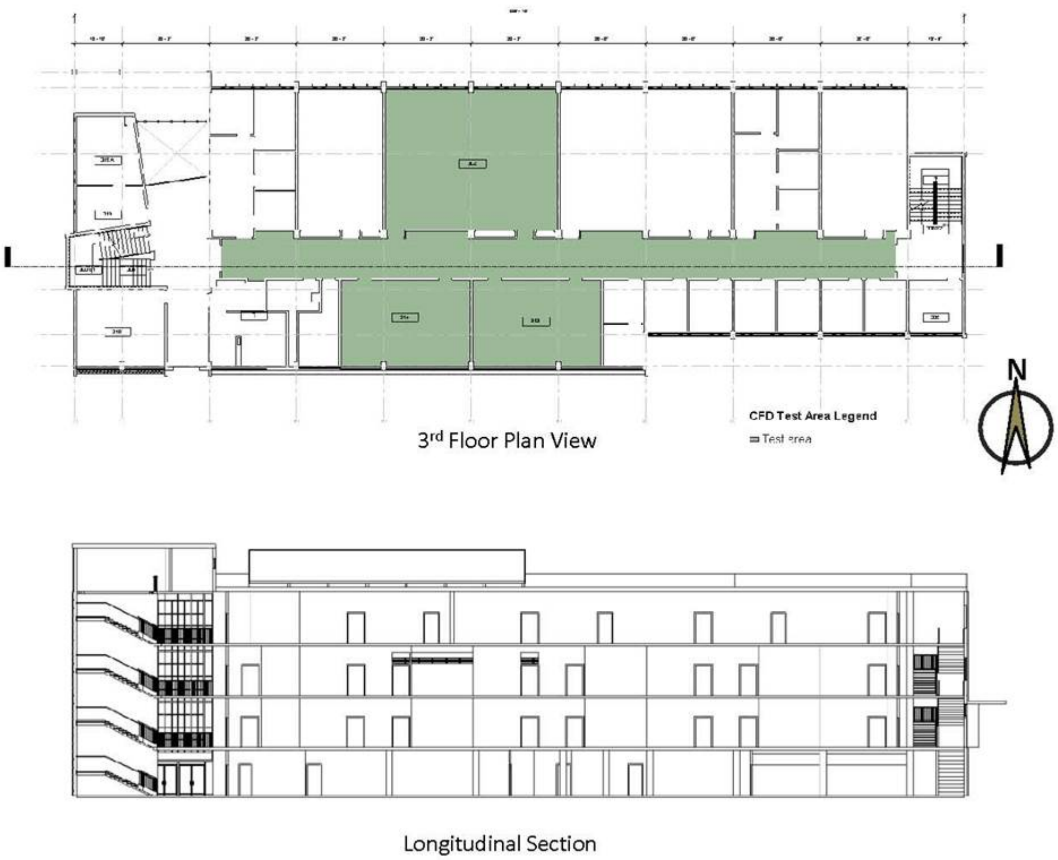
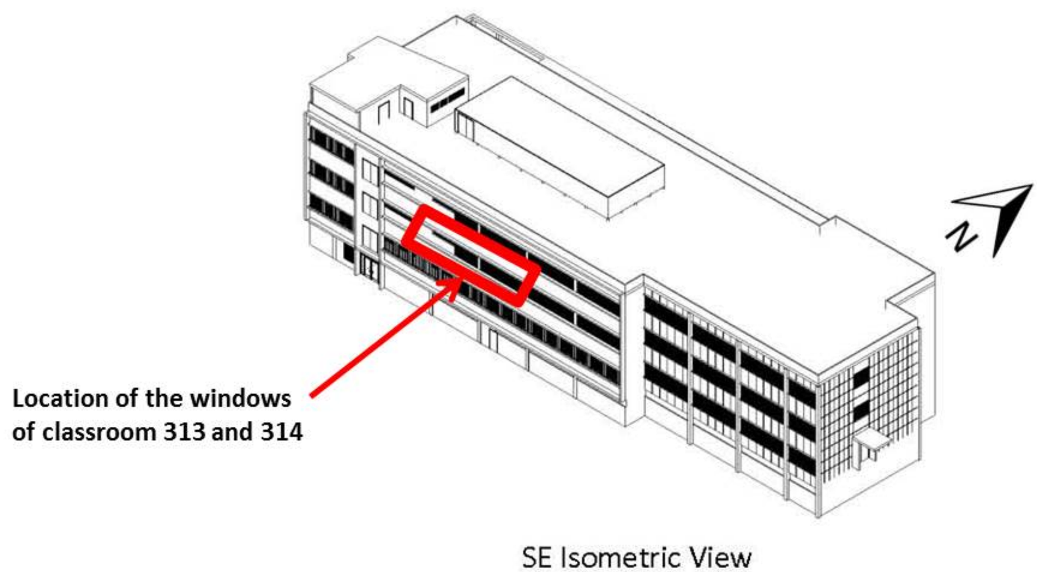


Figure 4.2.1.1: Keller Hall drawings which were used to develop the 3D-CAD model



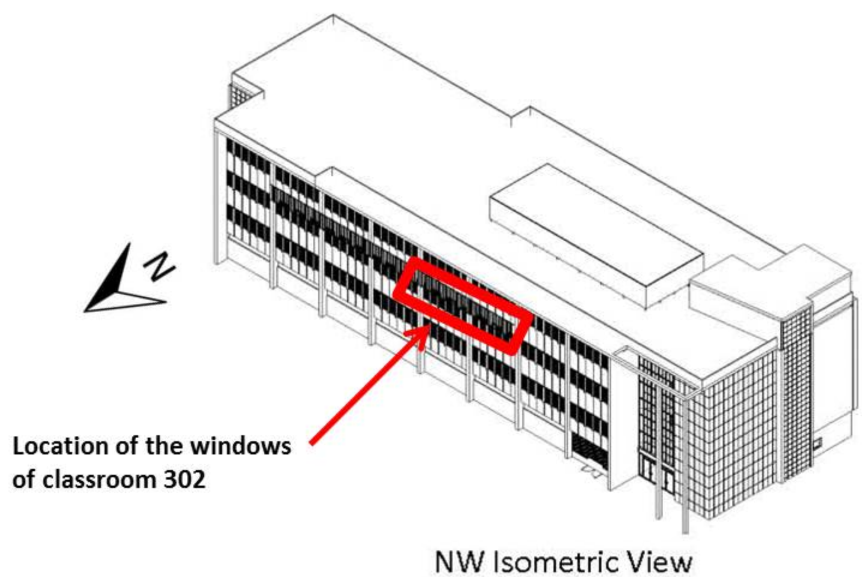
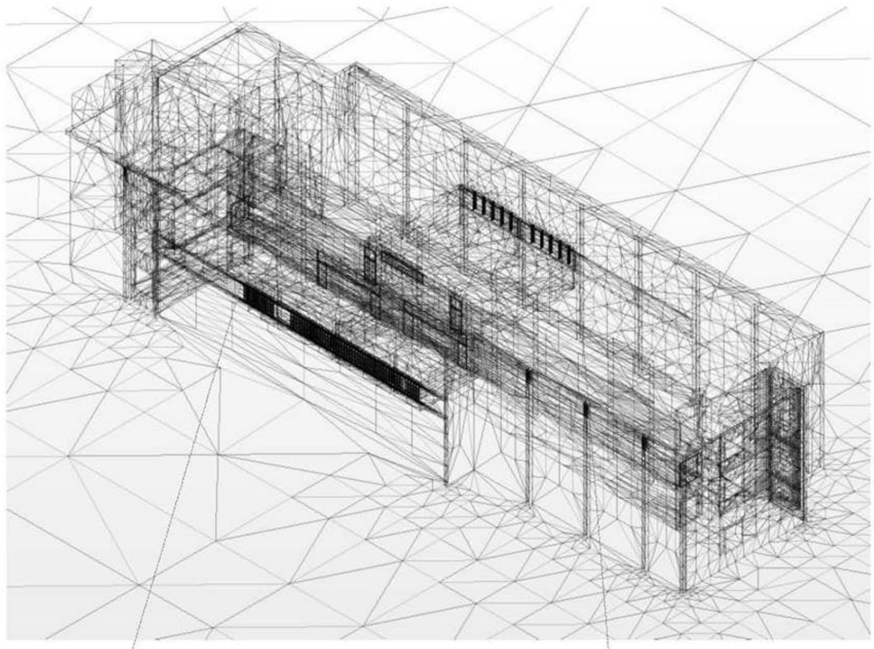
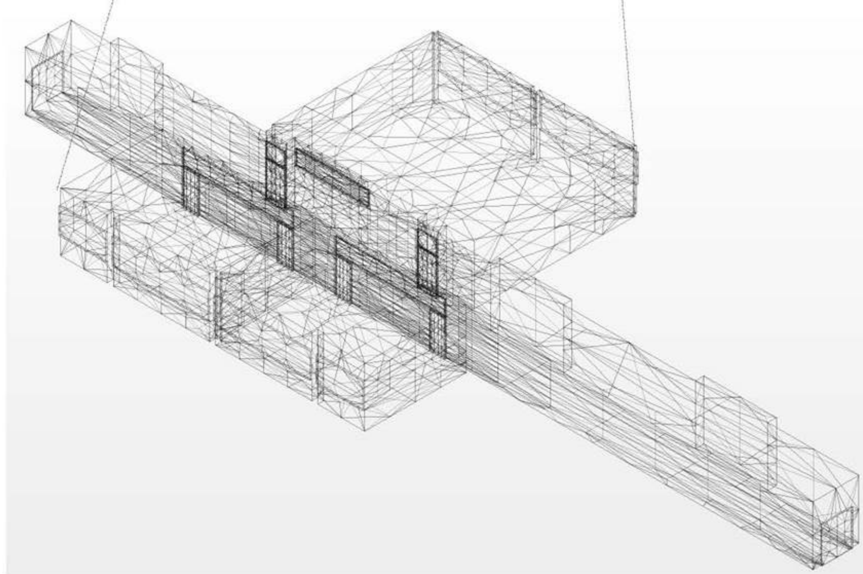


Figure 4.2.1.2: 3D-CAD model of Keller Hall building



CAD model close –up view of Keller Hall



CAD model close-up view of the area of interest

Figure 4.2.1.3: 3D-CAD geometry objects used to create the CFD mesh

4.2.2 Coupling of the Internal and External Computational Domains

The CFD study investigation of the air flows inside the test site (e.g. the interconnected classroom and hall ways) used the “coupled” computational domain approach. In the coupled domain approach internal and external air volume included in the same computational domain. In comparison the “decoupled” domain approach, which was used for the external CFD investigations of this research program, excludes interior building spaces from the computational domain. Coupled domains generally require more computational resources than decoupled approaches, but coupling has important benefits since computation resources can be deployed where they really matter, e.g. inside the building. Another benefit of the selected coupled domain approach is that the boundary condition, e.g. the external air inlet and outlet to the building, can be derived from actual flow simulations rather than inferred from external CFD simulations on an opaque building façade.

In order to reduce the demand on computational resources reduce the complexity of the computational domain, all adjacent buildings and foliage were excluded in the computational domain. The terrain at the site is varying but was assumed flat at the first floor level of the Keller Hall for the simplicity.

The vertical extension of the domain which is the distance starting from the highest point of the building to the top of the computational domain was 6H, where H is the height of the building. Approach wind directions were 15°NE, 45°NE and 75°NE. The lateral extension of the domain, which is considered the distance from building façades to either the north side or the east side of the computational domain, was set as 10H, resulting in the maximum blockage ratio of 1.7%. The extension of the computational domain in the direction of the outflow was modeled as 20H. The selection of the extent of the computational domain was consistent with Best Practice Guideline for the CFD Simulation of Flows in the Urban Environment (for more about Best Practice Guideline refer to the external CFD investigations of this research program). Figure 4.2.1.1 depicts the resulting extent of the computational domain.

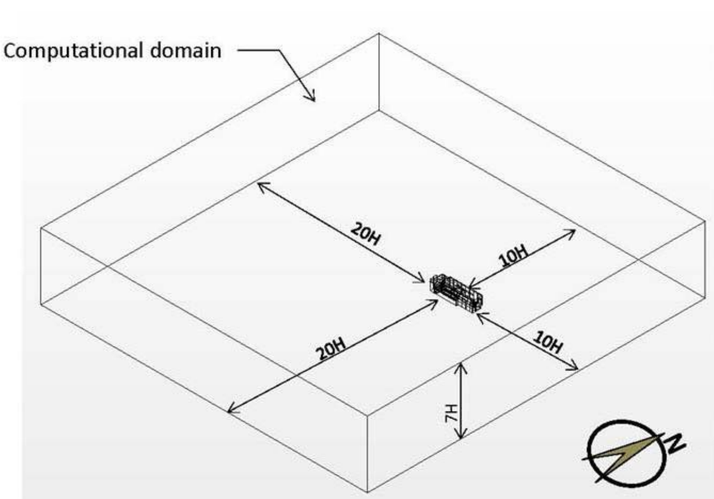


Figure 4.2.1.1: Extent of the computational domain used for the CFD investigations of the present study (H is the height of Heller Hall

4.2.3 Meshing

Creating the mesh: Meshing the CFD model involved surface and volume meshing procedures.

Surface meshing was carried out by using the surface Remesher function of the CFD software Star-CCM+ to improve the overall quality of the existing surfaces modeled in Rhino3d and imported into Star-CCM+. Surface Remesher allows optimizing the surface mesh for the subsequent volume meshing. The results of surface meshing of the entire computational domain and the area close to Keller Hall (the target building) are shown in Figures 4.2.3.1 and 4.2.3.3.

Volume meshing was carried out by using the trimmed cell mesher function of STAR-CCM+ to spatially discretize the computational domain into grids by trimming from the hexahedral mesh with minimal cell skewness. The presentations of volume meshing of the entire computational domain, of a close view of the target building and of the area of interest or control volume are shown in Figures 4.2.3.2 and 4.2.3.4.

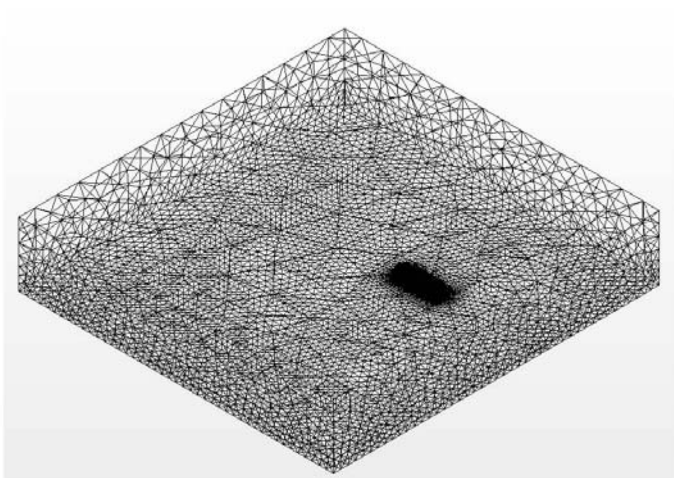


Figure 4.2.3.1: Surface mesh of the entire computational domain.

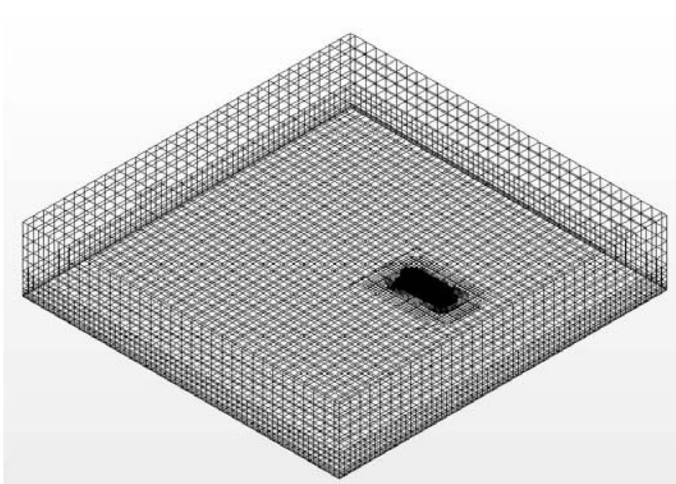
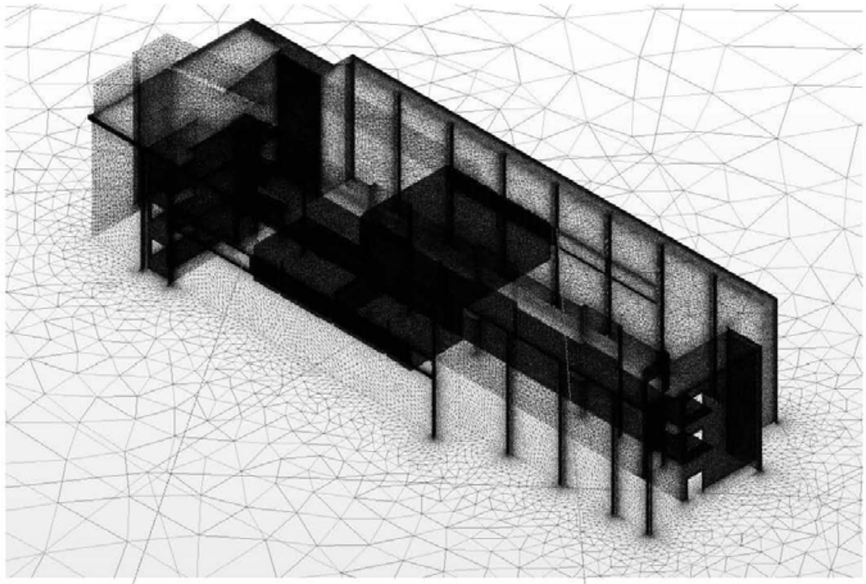
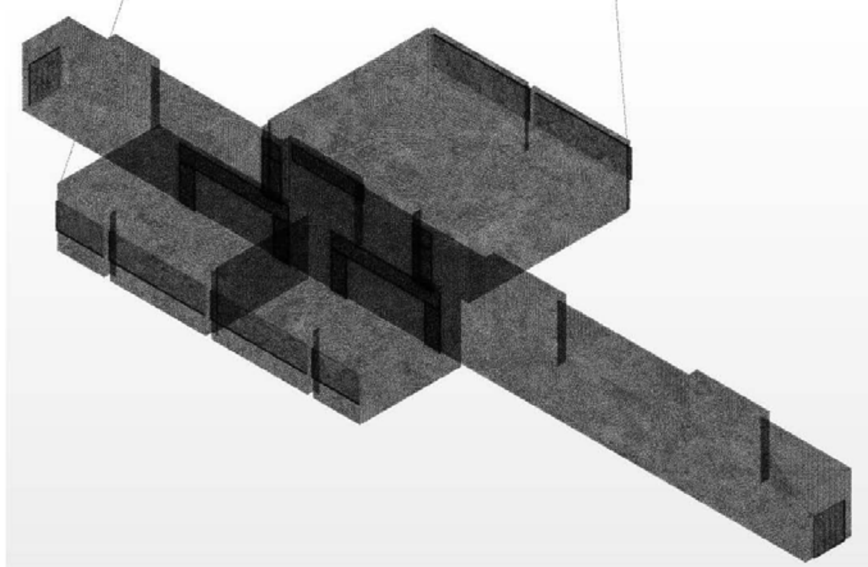


Figure 4.2.3.2: Volume mesh using the Trimmer mesh function of Star CCM+

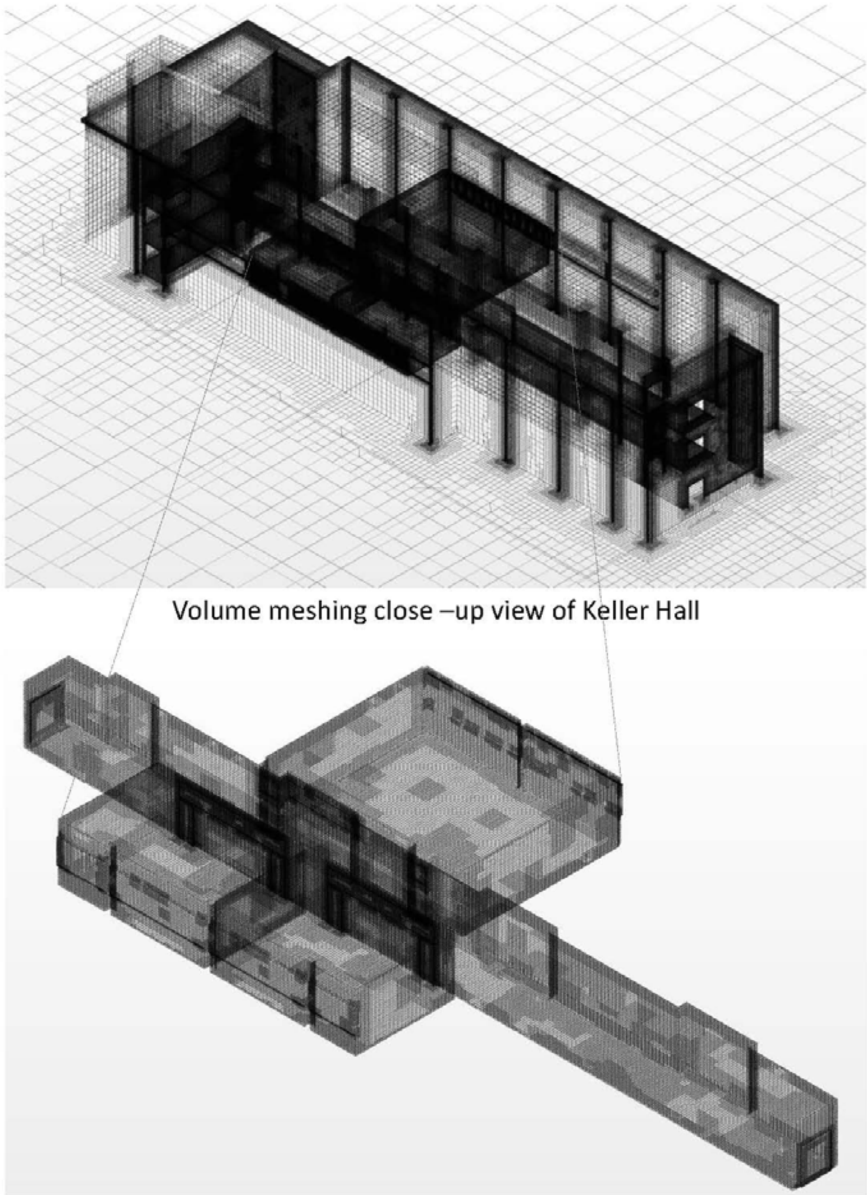


Surface meshing close –up view of Keller Hall



Surface meshing close-up view of the area of interest

Figure 4.2.3.3: Surface mesh for the area close to Keller Hall



Volume meshing close-up view of the area of interest

Figure 4.2.3.4: Volume mesh for the area close to Keller Hall

Analysis of quality of generated mesh:

Face validity cell checking: Cells with good face validity are those whose face normal vectors point outwards, e.g. away from the centroid. The criterion for good face validity is an area-weighted number of around 1. The face validity for the mesh used in this CFD investigation is shown in Figure 4.2.3.5.

Cell validity		# cells	%
	<=0.5	0	0.000%
0.5	0.6	0	0.000%
0.6	0.7	0	0.000%
0.7	0.8	0	0.000%
0.8	0.9	0	0.000%
0.9	0.95	0	0.000%
0.95	1	2	0.000%
1		13,035,317	100.000%
Total number of volume cells		13,035,319	

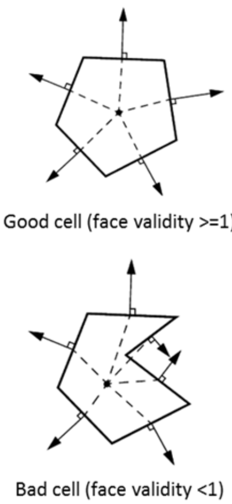


Figure 4.2.3.5: Face validity check for mesh - Good face validity is achieved

Volume change rate: Volume change rate (also sometimes referred to as aspect ratio) indicates the difference in sizes of adjacent cells; this means how large is the jump in volume from one cell to its adjacent cells. A good cell should have its volume change close to 1 while a small value refers to bad cells. The presence of a significant portion of bad cells can result in poor convergence performance. The volume change rates for the mesh used in this CFD investigation is shown in Figure 4.2.3.6.

Volume Change		# cells	%
	<= 1e-6	0	0.000%
1e-6	1e-5	0	0.000%
1e-5	1e-4	2	0.000%
1e-4	1e-3	9	0.000%
1e-3	1e-2	2454	0.019%
1e-2	1e-1	100384	0.770%
1e-1	1.0	12,932,470	99.211%
Total number of volume cells		13,035,319	

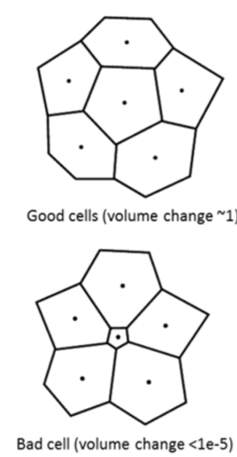


Figure 4.2.3.6: Volume change rate check for mesh - Good Volume change rate is achieved

Prism boundary layers: In order to reduce the grid resolution at the near wall regions, wall-function treatment was used. The distance from the centroid of the first prism layer to wall Cp has had to be larger than the equivalent grain roughness height (r). Three prism layers were selected to describe effects surface roughness in CFD model. The heights of each prism layers were set as is indicated in Table 4.2.3.1.

Table 4.2.3.1: Prism layer parameters

	Equipvalent grain roughness height r (r=36 x z_0)	Minimum height of centroid near-wall cell Cp (Cp > r)	The height of each prism layer (three layer total)
Upstream and downstream regions	0.9	1.080	3.650
			2.808
			2.160
Central region close to target building	0.18	0.360	1.217
			0.936
			0.720
Transition between ground and building surfaces	0.03	0.063	0.212
			0.163
			0.125

Grid refinement:

Grid refinement was applied during meshing in order to increase the resolution in regions of interest, such as close to the external air inflow and outflow as well as in and adjacent to the control volume inside the building. The surface control function of the CFD software was used to customize the size of the surface meshes of certain objects, thus controlling the sizes of certain volume cell sizes at locations of interest. For example, cell sizes differed at maximum with cells as large as 8.2m for far field regions and minimum with cells as small as 0.02m for the regions close to fins of north facing and south facing windows. Volumetric control feature from Star-CCM+ was used to locally customize sizes of the prism layers which vary as the terrain roughness is changing from upstream/downstream regions to the central region close to the target building and the transition region between ground and building surfaces. (see Figure 4.2.3.7.).

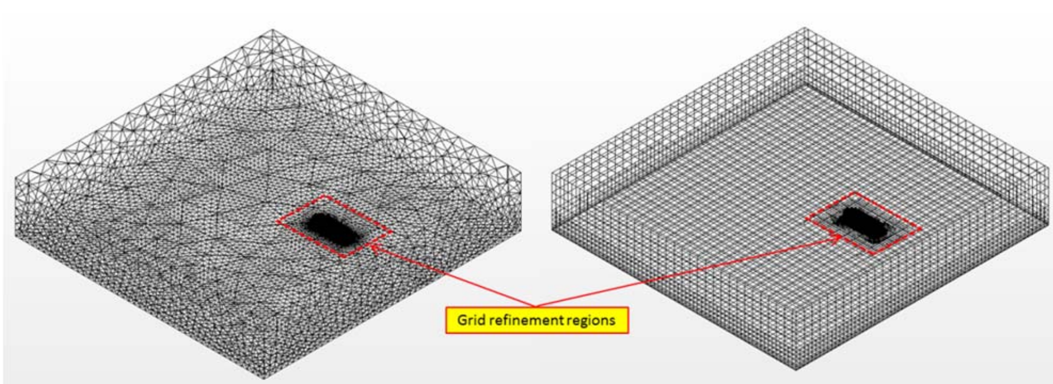


Figure 4.2.3.7: Grid refinement

4.2.4 Grid Sensitivity Analysis

Three types of grids with different resolutions were used in meshing (refer to Table 4.2.4.1).

Grid resolution		Coarse	Fine	Finest
Smallest cell size	{m}	0.025	0.02	0.015
Largest cell size	{m}	12.5	10	7.5
Number of cells	#	9,506,654	13,035,319	19,024,134

Table 4.2.4.1.: Three grid resolutions used in the CFD analysis, e.g. coarse, fine and finest resolution.

A grid sensitivity analysis was carried out using a Grid Convergence Index (GCI) following a procedure proposed by Roache (1994). This procedure basically assesses the uncertainty of grid convergence on the basis of GCI. The Roache grid sensitivity analysis procedure was applied to the three grid resolutions and for all five test scenarios, used in the CFD simulation. As a representative parameter for the analysis the location of the anemometer A0 was used for the fine and coarse grid (e.g. refer to Table 4.2.4.1), where local wind velocities were extracted by means of a from grid presentation type probe. Using parameters values proposed by Roache and applying it to the present CFD present the relative error ϵ and GCI for the fine and coarse grids were calculated and the results are given in Table 4.2.4.2. Applying normalization to $\epsilon = 1\%$ results in the CGI values for the fine and coarse grid which are given in Table 4.2.4.3.

	Coarse		Fine	
	ϵ	*GCI*	ϵ	*GCI*
Scenario 1	1.9%	15.8%	3.5%	19.5%
Scenario 2	1.2%	9.8%	1.6%	8.9%
Scenario 3	0.3%	2.6%	0.9%	4.7%
Scenario 4	4.4%	35.3%	1.3%	6.9%
Scenario 5	3.1%	25.5%	5.1%	27.3%

Table 4.2.4.2.: The relative error and Grid Convergence Index (GCI) of coarse and fine grids applied on the solutions of wind velocities of anemometer A0.

	Coarse grid GCI	Fine grid GCI
Scenario 1	8.3%	5.5%
Scenario 2	8.2%	5.4%
Scenario 3	8.3%	5.4%
Scenario 4	8.0%	5.3%
Scenario 5	8.3%	5.3%

Table 4.2.4.3.: The Grid Convergence Index (GCI) of coarse solutions and fine grid solutions, normalized to ϵ=1%

The CGI values computed for the coarse and fine girds, presented in Table 4.2.4.3, were well in the range of favorable GCI values given by Roache. Therefore, both coarse grid and fine grid resolutions used in the CFD investigations were sufficient to assure grid-independence solutions. The finest grid, e.g. about 19 million cells, was only tested once and required intensive computational resources, e.g. very long simulation times. The CFD team decided that only the fine grid resolution would be used for entire the analysis.

4.2.5 Boundary Conditions

Boundary conditions included atmosphere boundary layers (logarithmic profile wind for velocity inlet, constant pressure outlet), the ground surface and the building's surfaces.

The atmosphere boundary layer: the inlet boundary condition was approximated by approaching wind with a logarithmic wind velocity profile for wind coming from three directions, e.g. 15°NE, 45°NE and 75°NE. The logarithmic wind profile was assigned to the north and the east side of the computational domain. The wind velocity U_z (m/s) was assumed to vary with the elevation *z* (m) based on log-law formula as follows:

$$U(z) = \frac{U^*_{ABL}}{k} ln\left(\frac{z - z_{ground} + z_0}{z_0}\right)$$

$$k(z) = \frac{U^{*2}_{ABL}}{\sqrt{C_\mu}}$$

$$\varepsilon(z) = \frac{U^{*3}_{ABL}}{k(z + z_0)}$$

Where *k* is the Karman constant (=0.42), z_0 is the roughness parameter and U^*_{ABL} is the atmospheric boundary layer friction velocity can be calculated as:

$$U^*_{ABL} = \frac{kU_r}{\ln((z_r + z_0)\,/z_0)}$$

Therefore,

$$U(z) = U_r ln\left(\frac{z - z_{ground} \ + z_0}{z}\right)/\ln\left(\frac{z_r + z_0}{z}\right)$$

Where *z* is the height, z_{ground} is the ground elevation, z_o is the aerodynamic roughness length selected from Table 4.2.5.1, U_r is the reference velocity at the reference height z_r. U_r is the 10m equivalent mean velocity obtained at the Keller Hall weather station.

Table 4.2.5.1: Aerodynamic roughness length z_o based on the terrain classification

Class	*Short terrain description*	z_0 *(m)*
1	Open sea, fetch at least 5 km	0.000 2
2	Mud flats, snow; no vegetation, no obstacles	0.005
3	Open flat terrain; grass, few isolated obstacles	0.03
4	Low crops; occasional large obstacles, $x/H > 20$	0.10
5	High crops; scattered obstacles, $15 < x/H < 20$	0.25
6	Parkland, bushes; numerous obstacles, $x/H \approx 10$	0.5
7	Regular large obstacle coverage (suburb, forest)	1.0
8	City centre with high- and low-rise buildings	≥2

Note: Here *x* is a typical upwind obstacle distance and *H* is the height of the corresponding major obstacles. For more detailed and updated terrain class descriptions see Davenport and others (2000) (see also Part II, Chapter 11, Table 11.2).

Terrain roughness: Since the CFD investigation focused on internal airflow, the complexity of the external environment was reduced by applying terrain roughness to accommodate the influence of the adjacent large structures and nearby foliage on the internal airflow. The terrain roughness was specified by assessing the terrain roughness of the site conditions based on terrain classification shown in Table 4.2.5.1. The aerodynamic roughness length z_o was used as input for log-law wind profile as well as to determine the size of the first prism layer of the ground surface in wall-treatment for near-wall flow region. Considering an open field condition, the aerodynamic roughness length z_o was selected as 0.03. The size of the first prism layer of the ground surface was determined by using equivalent sand-grain roughness height r in the STAR-CCM- CFD code using the following formula as follow:

$$r = \frac{Ez_o}{C} \approx 36z_o$$

Where E is 9.0 and C is 0.253 as wall function coefficients (STAR-CCM+ Manual V.902). In order to create a smooth transition between the upstream and downstream region of the building, two additional regions called "central region close to building" and "transition region between ground and building" were created in order to reduce the size of the first prism layer when their locations are getting close to the building. (see Figure 4.2.5.1)

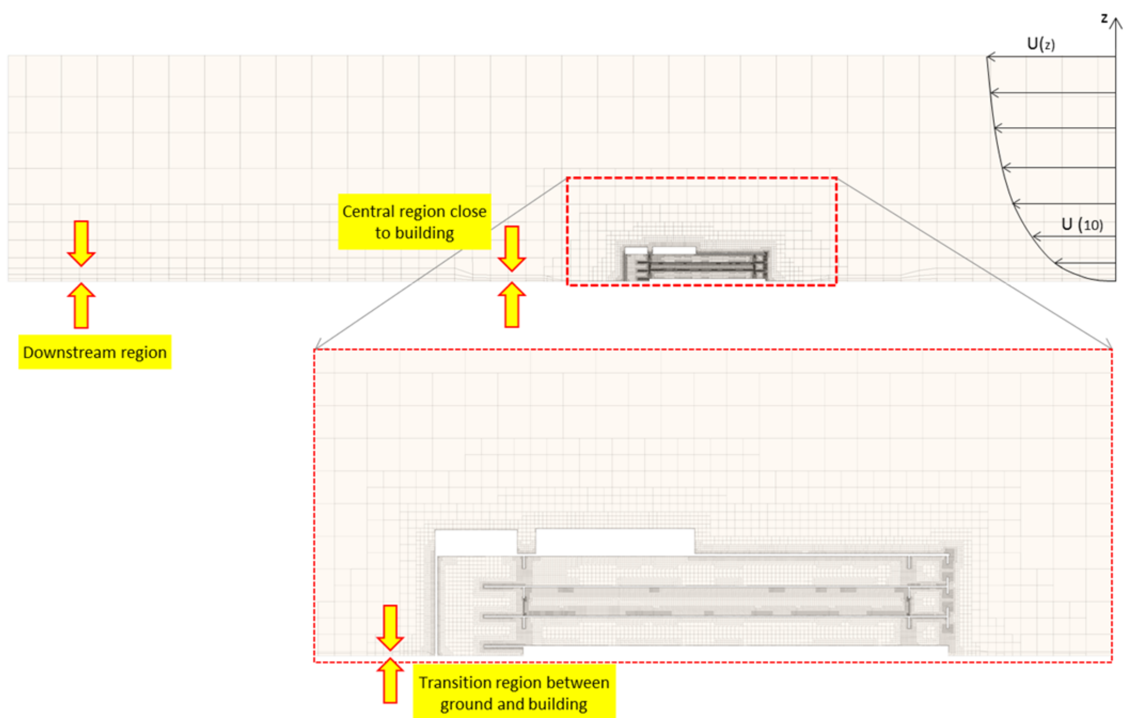


Figure 4.2.5.1: Two additional regions added to create a smooth transition for the first prism layer when its location getting close to the building.

Wall treatment: Wall treatment in referred to as the approach to model near-wall viscous-affected region by using wall-functions to obtain the boundary conditions for the near-wall region, thus to reduce near-wall mesh resolution. Two-layer high y+ wall treatment was selected for the CFD simulation to utilize the smooth blending when solving turbulent dissipation rate ε between the near-wall layer and the far field region (see STAR-CCM+ Manual V.902).

4.2.6 Solver Setting

Reynolds-Average Navier-Stokes (RANS) turbulence modeling approach: Based on the previous literature review and development of internal workflow (e.g. Project Deliverables 6 and 7.2) the RANS turbulence modeling approach was chosen. The RANS approach considers the mean flow and the effects of turbulence on mean flow properties. RANS turbulence modeling approach requires only modest computational resources and therefore this approach represents the overwhelming percentage of engineering CFD applications.

Turbulence model: The Realizable two layer k-epsilon (k-ε) was chosen for the CFD investigation. This model is derived from the conventional k-ε model which is a two-equation model in which transport equations are solved for the turbulent kinetic energy (k) and its dissipation rate (ε). The Realizable k-ε model contains a transport equation for the turbulence dissipation rate e and substituting the constant $C\mu$ in the standard model utilizes the two-layer approach to explicitly model turbulence in the far field and viscous sublayer. The values of near-wall layers are blended smoothly with the values computed from solving the transport equation far locations distant from the wall. The equation for the turbulent kinetic energy is solved in the entire flow.

Segregated flow model: Segregated flow model was chosen for the solver settings for the study. Segregated flow model is suitable in constant-density flows (e.g. incompressible or mildly compressible flows).

Under-relaxation factors: Under-relaxation factors (for velocity, pressure, k-e turbulence and k-e turbulent viscosity) were used to improve convergence of the solution by governing the extent to which the newly computed solutions are affected by previous solution during the iterative process. The following under-relaxation factors were used: for velocity (0.7), for pressure (0.3), for k-e turbulence (0.8) and for k-e turbulent viscosity (1.0).

Numerical discretization scheme: Second-order upwind scheme was selected.

Convergence criteria and monitoring: Several convergence criteria were used in the CFD simulations. One of the convergence criteria used the residuals computed during iterative process to determine the errors in solutions of particular variables such as continuity, momentum, kinetic turbulence energy (e), turbulence dissipation rate (k). These residual RMS errors were set to $10e^{-4}$ and $10e^{-5}$. Other convergence criteria used the monitors at any location of interest in the computational domain to assure a good and steady solution has been achieved. Figures 4.2.6.1 and 4.2.6.2 show convergence performance selected as residuals and parameter monitors, respectively.

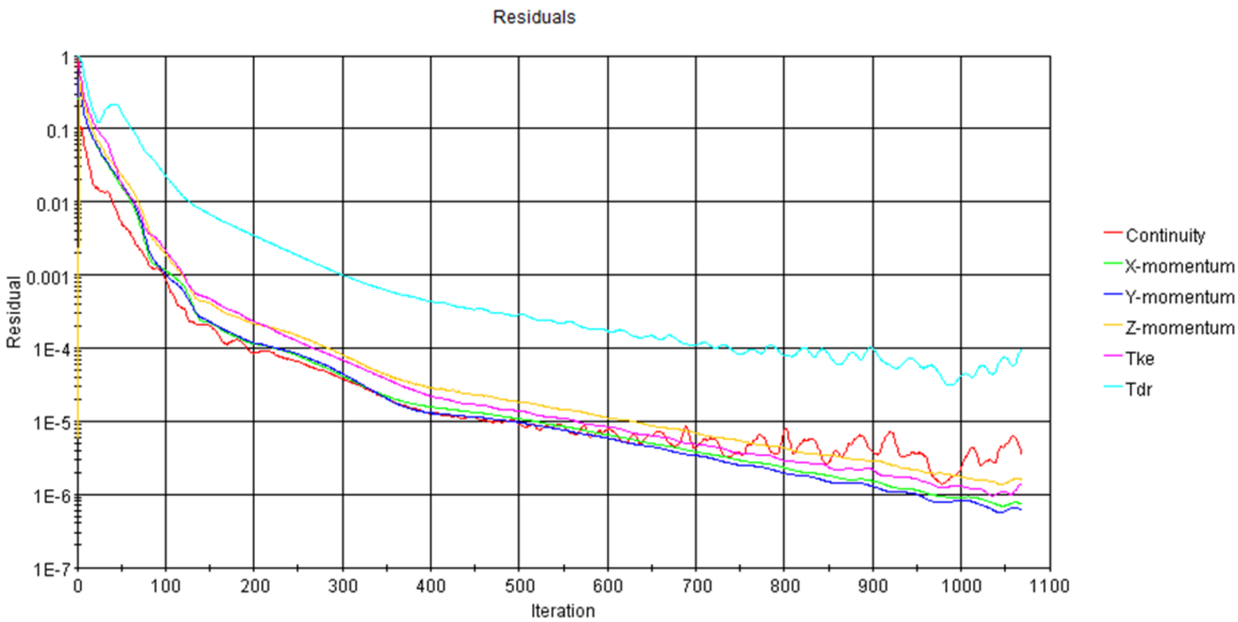


Figure 4.2.6.1: Residuals plot show residuals reached below 1e^{-4}

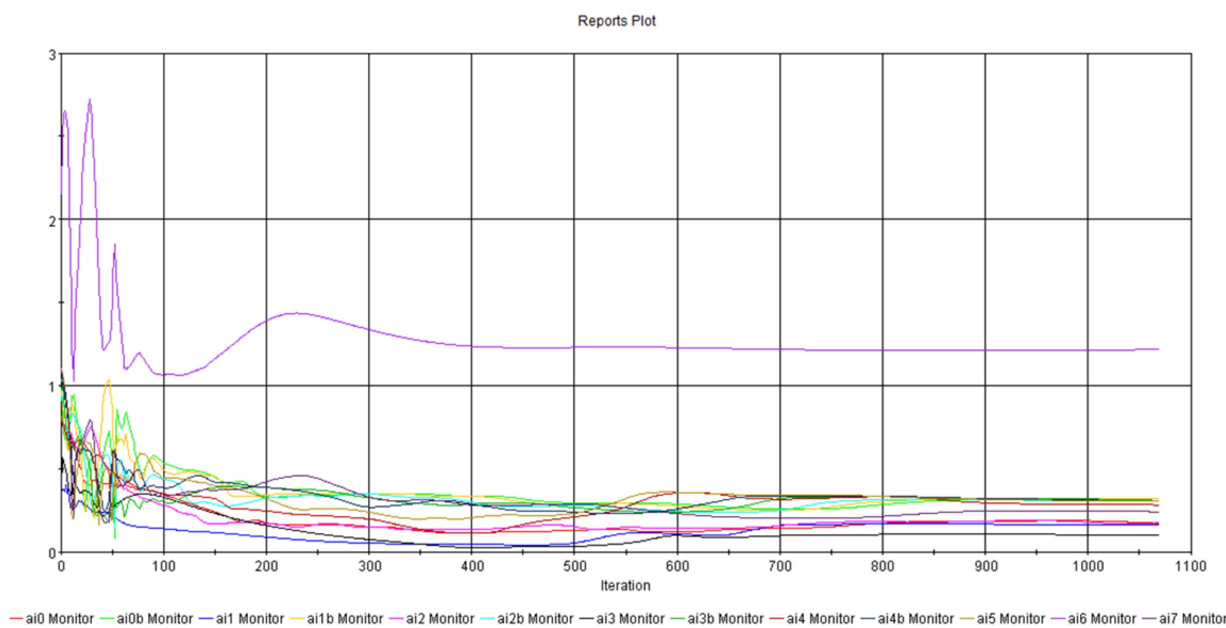


Figure 4.2.6.2: Plot monitors of local velocities to asses convergence - velocities indicate convergence at locations of the anemometers

4.2.7 Categories of CFD Simulations

The methodologies of running the CFD simulations can be grouped in three categories of CFD investigations, each with a specific objective. The three groups of CFD simulations carried out are described as follows.

Group 1 CFD runs: The objective was to conduct CFD runs to determine the flow characteristics under the five test scenarios using qualitative post processing.

Group 2 CFD runs: The objective was to conduct CFD runs to determine predictions of air velocities and allow comparison of CFD air velocity predictions with actual measurement. .

Group 3 CFD runs: The objective was to conduct CFD runs to develop a work methodology of predicting anticipated air changes rates for internal spaces based on site specific historical wind records.

Methodology of Group 1 CFD runs: The methodology of running the CFD simulations to obtain characteristics of internal air flow in the three class rooms and the adjoining hallway included the following main steps:

- Create the CFD boundary conditions that corresponded with the combination of closed and open internal doorways and louvered sections.
- Based on the recorded wind condition, determine the predominant wind direction. It was determined that a wind approach from North-East (e.g. 45°) was the representative wind direction.
- Select a representative wind approach velocity and run the five test scenarios to determine the air flow characteristics.
- Observe convergence of the solution using two types of data monitors. Decide on the quality of the convergence and terminate the simulation run when good convergence could be detected.

Methodology of Group 2 CFD runs: The methodology of running the CFD simulations to obtain the representative air velocities at the locations of actual measurements, which were used in comparing the theoretical CFD with the actually measures air velocities, included the following main steps:

- Create CFD boundary conditions that corresponded with the combination of closed and open internal doorways and louvered sections used in the five scenarios.
- Select the predominant wind direction for the CFD simulations. It was determined that a wind approach from North-East (e.g. 45°) was the representative wind direction.
- Analyze the wind velocity record of the weather station for the time periods when the air velocity measurements of the five test scenarios were conducted, to obtain the representative average wind

velocity for the test scenarios. Use the representative wind velocity in CFD simulations to obtain theoretical internal air flow condition so that the actual test measurements could be compared. It should be noted that all five test scenarios had different wind velocities.

Methodology of Group 3 CFD runs: The methodology of running CFD simulations to determine the probability of exceedance of air changes used the following additional steps:

- Analyze a longer wind direction record to determine the frequency distribution of wind directions.
- Determine three representative ranges of wind directions, e.g. three ranges of wind direction which have the highest frequency relative to the entire wind direction record.
- For the three ranges of wind directions multiple air speed were used in CFD simulation and the resulting air changes based on the CFD mass flow rates through these class rooms were determined.
- Establish a correlation function of air change rates versus approach wind velocities. For each range of wind directions one correlation function could be determined.

4.2.8 Qualitative Post Processing

The CFD results of the five test scenarios provided a qualitative determination of the air flow conditions inside the interconnected class rooms and internal hallways.

The methodology for qualitative post processing followed procedures that had been established during the development of internal CFD workflow (see Project Deliverable No. 8). Color contour mapping and streamline visualization were used to depict flow patterns of the five test scenarios.

4.2.9 Quantitative Post Processing

The following quantitative post processing methods were used to determine specific data from the CFD results:

Presentation grid: The spatial distribution of air passing through the seven internal openings was measured by means of a “presentation grid”. This methodology included defining a matrix of virtual “probes” in the computational domain at the places of interest. The results of these presentation grids were air velocity values calculated as the coordinate of the presentation gird points. The presentation gird was used in conjunction with the Group 1 CFD runs.

Average air velocity inside the openings: The average air velocities in the selected openings where air velocities were measures was determined for the surface representing the opening in the computational grid. A specific CFD software function was employed to get a magnitude (scalar) of the air velocity. This theoretical air velocity was then compared with the measured air velocities at the same location conjunction with the Group 2 CFD runs.

Overall mass flow rate: The overall mass flow rate, which means the mass (or converted volume) of air flowing in and out of the control volume, was determined by an internal CFD software function. The mass flow rates through the control surfaces were used in conjunction with the Group 3 CFD runs.

4.2.10 Control Volume

The internal hallway was defined as a control volume for air flow, with the internal doorways, hallway section and louvered wall sections representing the inlets and outlets, e.g. the control surfaces. The control volume is used to verify the conservation of mass assumption in the CFD analysis of the three interconnected classrooms and hall way under steady state conditions. The steady state assumption is consistent with the type of CFD analysis carried out for this study. Figure 4.2.10.1 illustrates balancing the control volume under steady state conditions. Under steady state the net mass flow rate, e.g. sum of all mass flow into (positive) and out (negative) of the control volume has to be zero since no air is stored in the control volume.

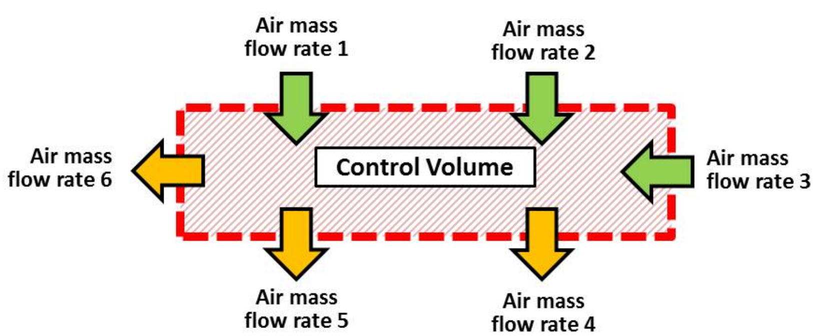


Figure 4.2.10.1: Mass flow balancing of a control volume

4.2.11 Definition of Air Changes

The term Air Changes per Hour (ACH) is used as an approximation of how often air is exchanged per hour by air passing through the space. Our assumption of ACH considers a uniform or perfectly mixture of the air. Actual mixing conditions may differ from this assumption, but for quantification of the air flow effectiveness our study defines ACH as follows:

ACH = Volumetric hourly flow rate of air / Volume of the space [1/hour]

As an example assume for an internal space:

volumetric flow rate	=	120	m^3/min
volume of space	=	360	m^3

The number of air changes per hour (ACH) is calculated as follows:

$$\mathbf{20}\quad \frac{1}{\text{hour}} = \frac{120\ \cancel{m^2}\quad 60\ \cancel{\text{min}}}{\cancel{\text{min}}\quad 1\quad \text{hour}\quad 360\ \cancel{m^2}}$$

In our example the volumetric flow rate would be the inflow, or the outflow, since considering steady state control volume conditions, inflow and outflow must be identical.

In establishing the volume of the space it must be kept in mind that actually only the volume of the air in the space should be considered. Any volumes of objects in the room would need to be subtracted from the volume. The term “volumetric permeability” describes this volume reduction and provides a value between 0 and 1, which defines the air volume reduction of objects in a space. A volumetric permeability of 1 would indicate that there is not volume reduction. The present study considers a slightly reduction though rounding of the internal space dimensions.

4.2.12 Defining the Probability of ACH Rates Based on Measured Wind Conditions

A very effective design application of CFD analysis of naturally ventilated spaces is the prediction of a probability of exceedance of ACH rates based on the site specific wind record, e.g. wind direction and velocity. The present study developed a work methodology that can provide the designer of naturally ventilated buildings with important information about effectiveness of natural ventilation. The methodology is ab attempt to establish such a work procedure and uses some simplifications to serve as proof of concept. The development of the methodology included the following steps:

- Obtain a wind record for the site. The wind record should be long enough so that different seasonal condition can be considered. For the present the wind record at the site was only four month long.
- Determine the frequency distribution of wind direction and determine what sectors of the wind rose should be considered as representative. For the present study the CFD team selected the sector from 0° to 90° as representative (see Figure 4.2.9.1).

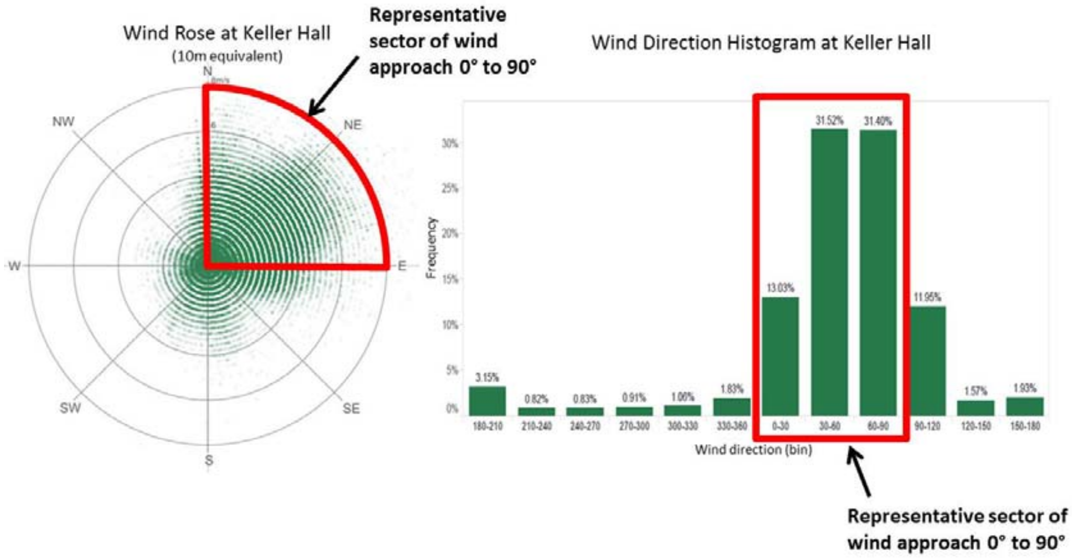


Figure 4.2.12.1: Wind rose data and frequency density distribution of wind direction measured over four month at Keller Hall

- Divide the selected wind rose sector from 0° to 90° further into three sub-sectors with an angle range 30° each, as suggested in Figure 4.2.9.2. The representative wind approach direction for the sub-sectors is the angle bisection; for example the first sub-sector from 0° to 30° has the representative wind approach direction of 15° the second sub-section uses 45°.

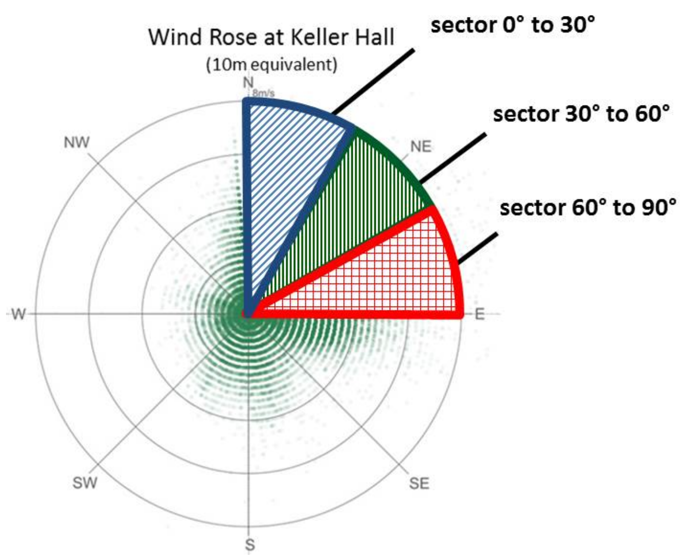


Figure 4.2.12.2: Definition of three sub-sectors in the representative first quarter of the wind rose.

- For each of the 30°-sub-sectors determine the frequency distribution of wind velocity. Figure 4.2.12.3 indicates the frequency density distribution of wind velocities for the sub-sector 30° to 60° .

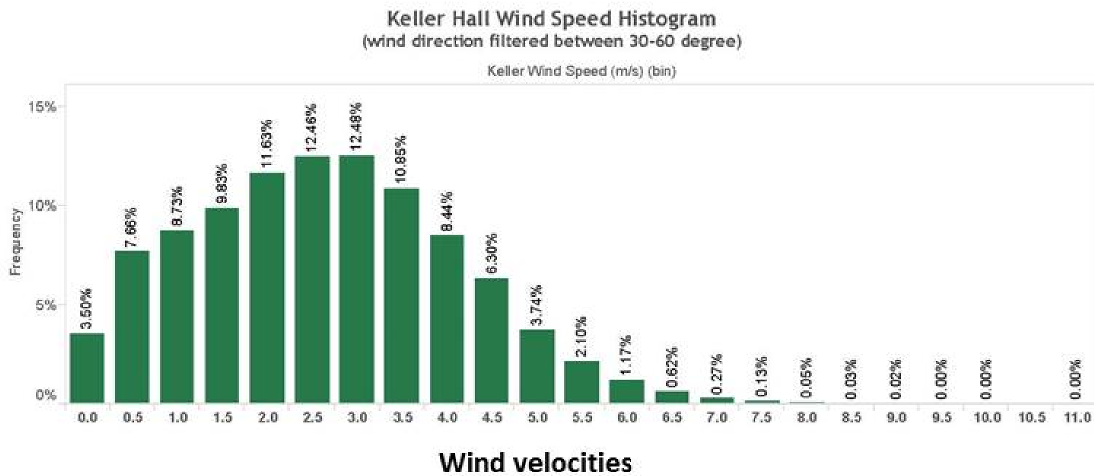


Figure 4.2.12.3: Sample frequency density distribution of wind velocities - sub-sector 30° to 60° .

- Run CFD simulations for each sub-sector for a range of wind velocities with the wind approach velocity being the angle bisector.
- For the different wind velocities the resulting air changes per hour rate (ACH) is determined for a range of wind approach velocities. A linear regression is obtained to define the relationship function of ACH versus approach wind approach.
- The frequency density distribution of the wind velocities for each sub-sector is used to determine the frequency of exceedance versus ACH for each sub section. Curve fitting is used to determine the relationship function of percentage of exceedance of ACH for the specific sub-sector.
- The relationship functions of percentage of exceedance of ACH of all three sub-sectors are used to compose the overall relationship function of percentage of exceedance of ACH for the first quarter of the wind rose, which was defined as the representative part of the total wind rose of the site. Weights are applied to the three sub-sectors in accordance to their contribution overall frequency distribution of wind velocities.

SECTION 5: RESULTS AND DISCUSSION

This section presents and discusses results of the present CFD investigation and the validation measurements. The results are presented and discussed in three parts, in accordance to the three CFD groups defined in Section 4.2.4 .

5.1 CFD Group 1 - Flow Characteristics of the Five Test Scenarios

The CFD simulation of CFD Group 1 investigated the internal airflow inside the three interconnected class rooms and hallway and provided a qualitative description of the flow patterns for the five test scenarios.

5.1.1 Wind Characteristics Considered

The weather station on Keller Hall had recorded the wind direction over duration of 5 months, from April to September 2014. Data for wind direction and velocities for the entire duration of 5 months is depicted Figure 5.1.1.1. The wind record suggests that the main wind approach direction is within the first quarter, e.g. from 0° to 90°.

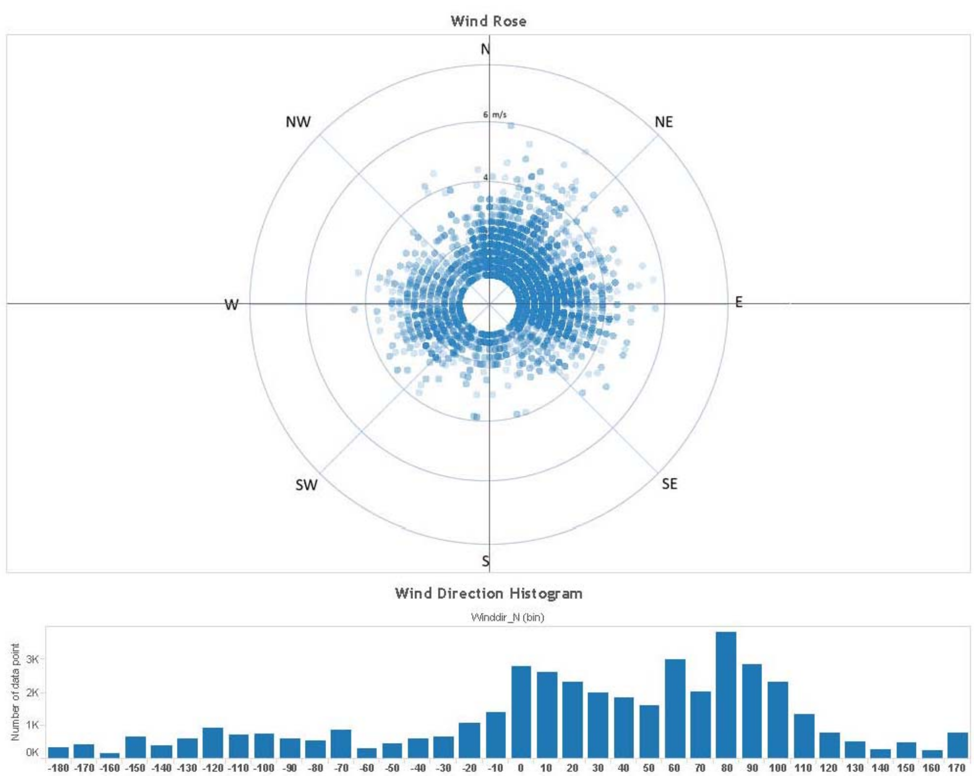


Figure 5.1.1.1: Wind direction and velocities recorded at Keller Hall from April to September 2014

Figure 5.1.1.2 shows the wind record that was obtained during the three days of measurements (June 2014) when the measurements of air velocities for this study were obtained. A comparison of the wind records shown in Figures 5.1.1.1 (record over 5 months) and 5.1.1.2 (wind record for this investigation) suggest that the representative wind direction during the measurements for this investigation was around 45°. This data resulted in the selection of 45° as the wind approach direction for the CFD simulation for CFD group 1. Furthermore, based on the wind data a wind approach velocity of 4.0 m/sec was selected for the CFD simulations.

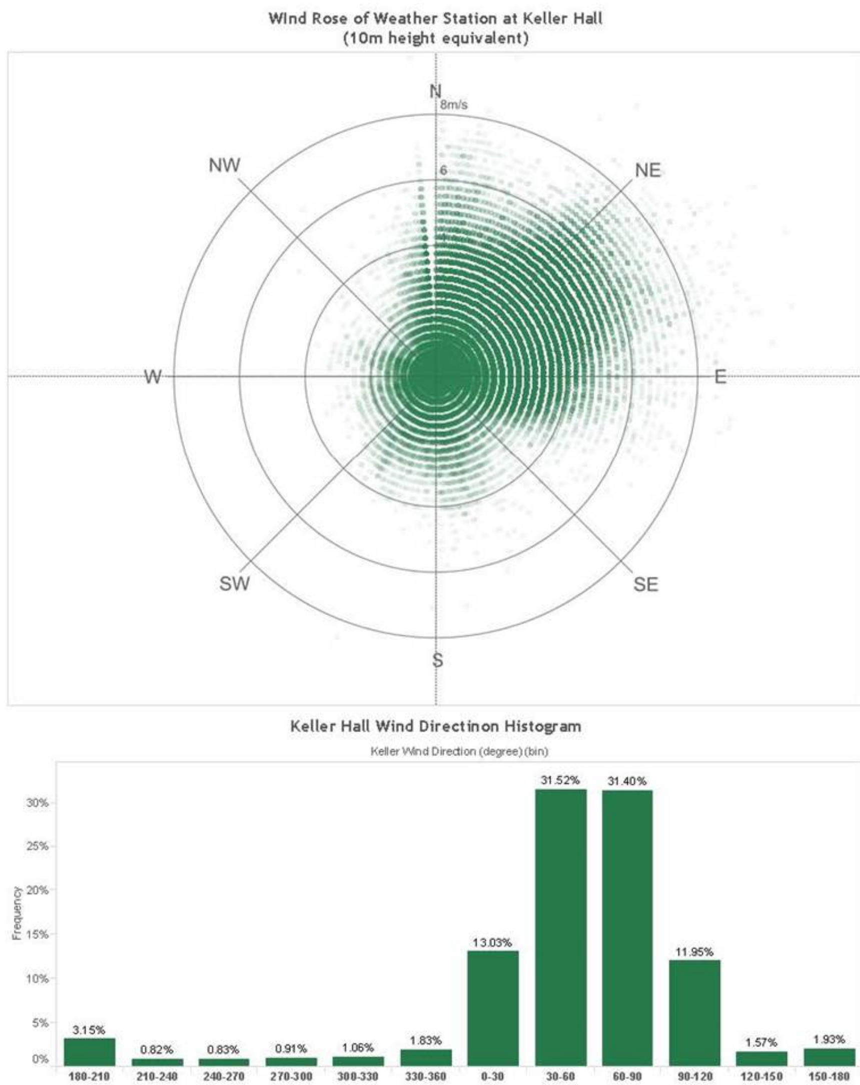


Figure 5.1.1.2: Wind direction and velocities recorded at Keller Hall during the measurements for this investigation

5.1.2 Visualization of Air Flow Patterns for Five test Scenarios

The results of the CFD simulations provided description of the wind flow patterns through the three class rooms and the hallway. The air flow patterns were visualized with air velocity contour maps and streamline images using several horizontal and vertical slices. The annotated Figures 5.1.2.1 through 5.1.2.8 show the air flow visualizations of Test Scenario 3. The visualization of air flow patterns for all five test scenarios is presented in **APPENDIX A**.

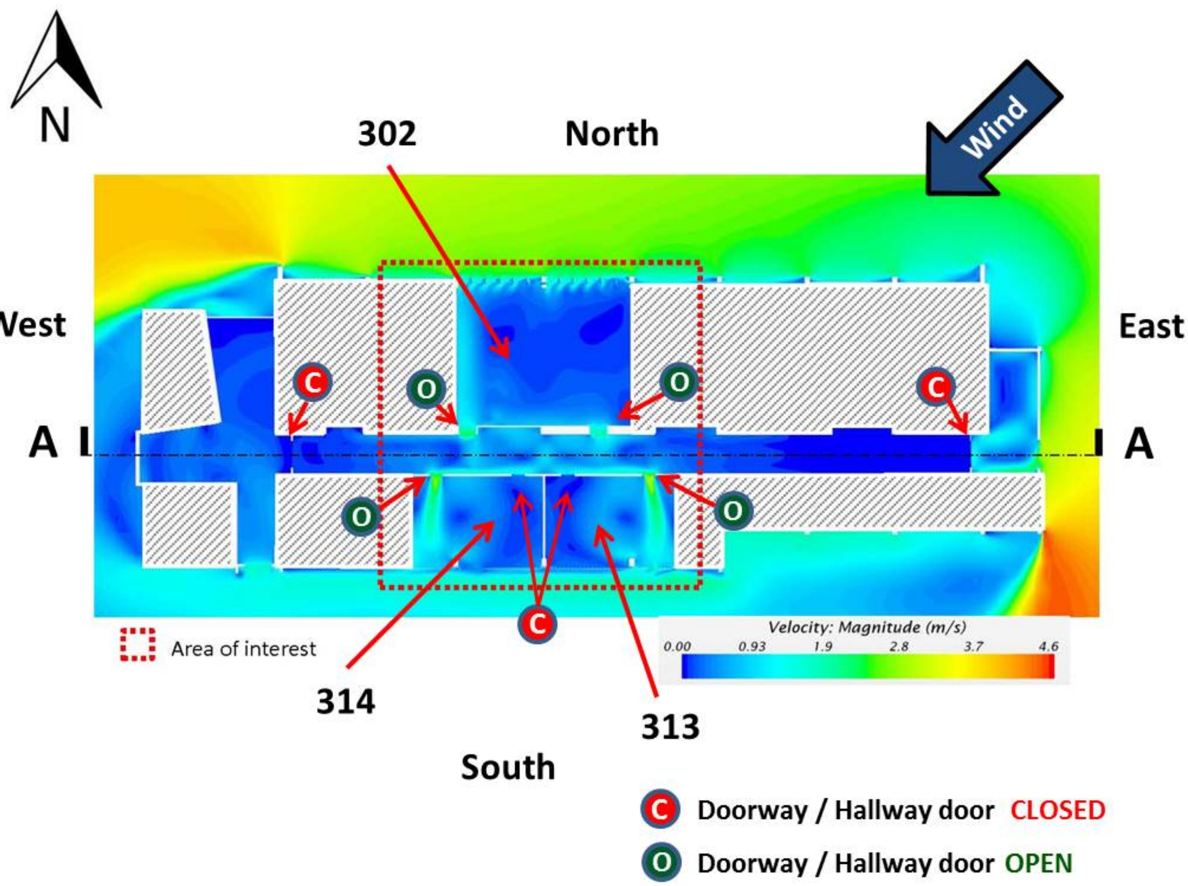


Figure 5.1.2 .1: Visualization of Scenario 3 – Velocity Contour Map on the Horizontal Plane

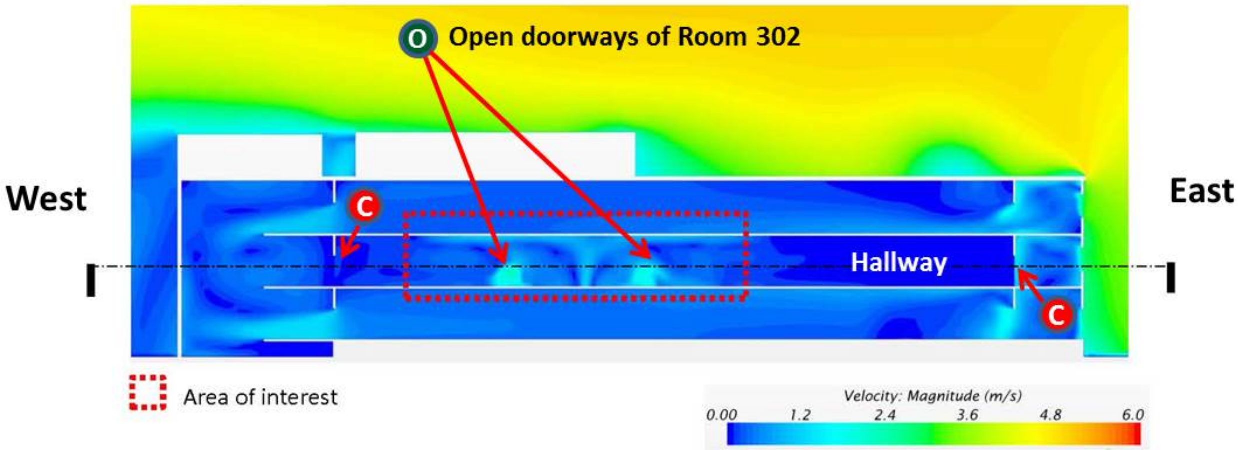


Figure 5.1.2 .2: Visualization of Scenario 3 – Velocity Contour Map on the vertical Plane – Refer to Section A-A in Figure 5.1.2.1

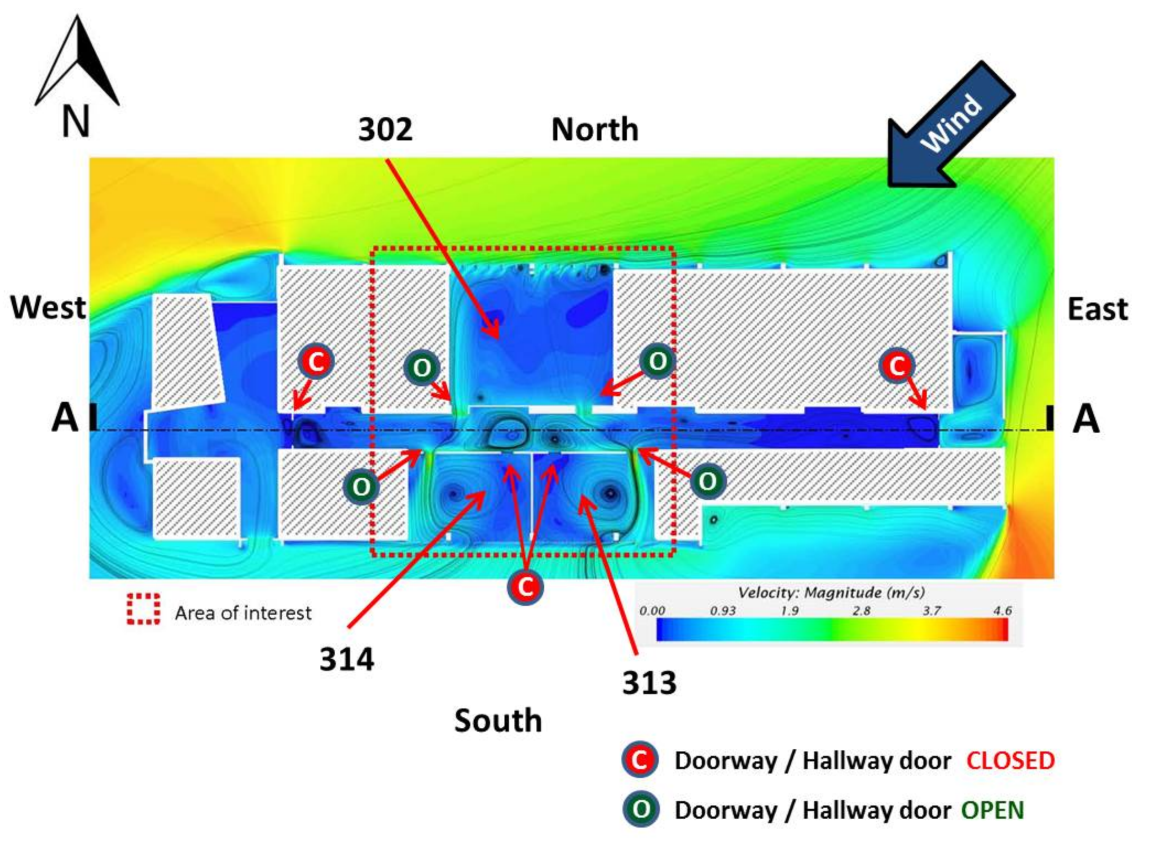


Figure 5.1.2 .3: Visualization of Scenario 3 – Streamline overlaid on Velocity Contour Map on the Horizontal Plane

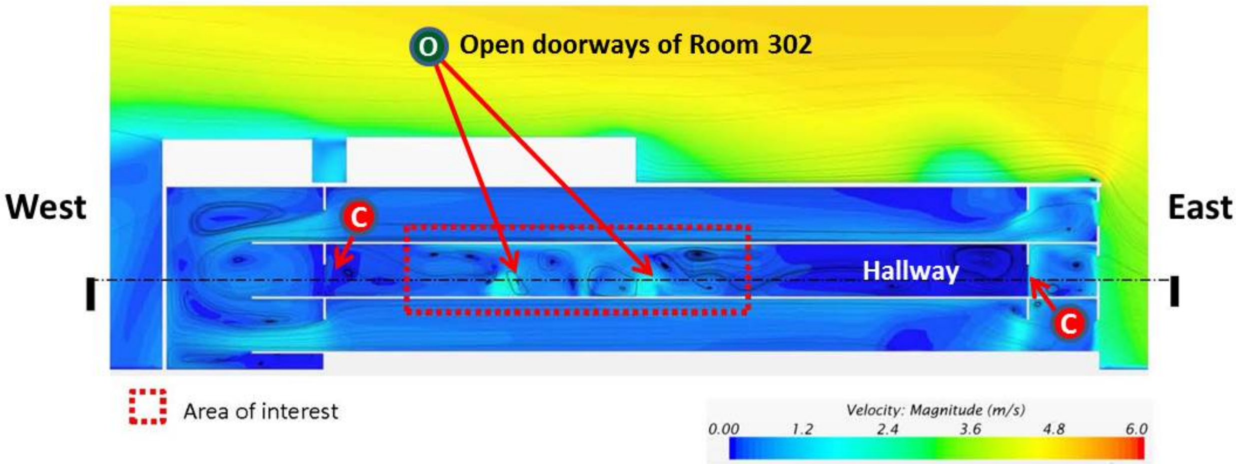


Figure 5.1.2 .4: Visualization of Scenario 3 – Streamline overlaid on Velocity Contour Map on the Longitudinal Section Plane– Refer to Section A-A in Figure 5.1.2.3

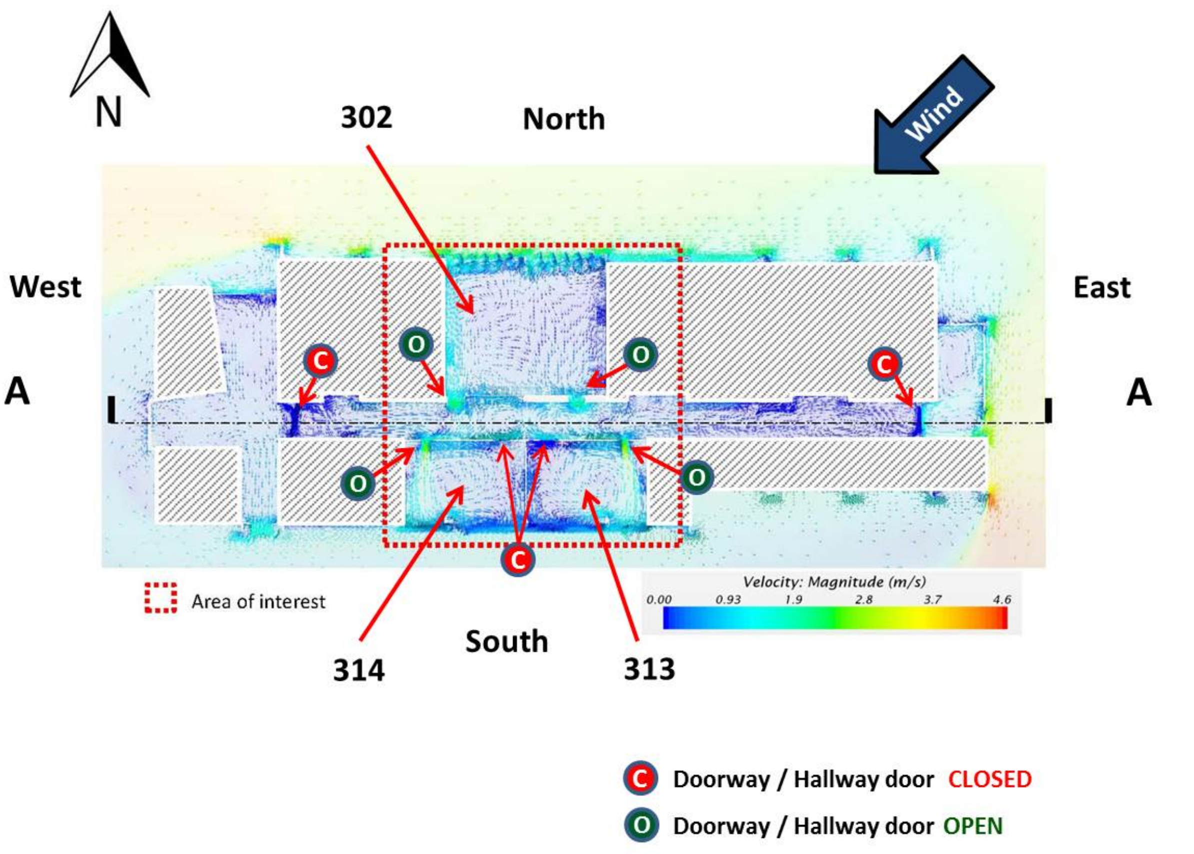


Figure 5.1.2 .5: Visualization of Scenario 3- Velocity Vector Map on the Horizontal Plane

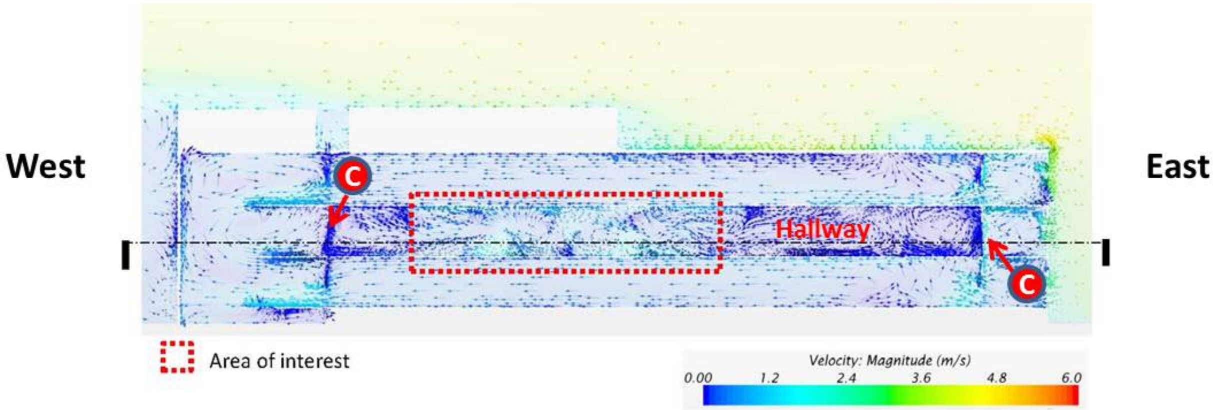


Figure 5.1.2 .6: Visualization of Scenario 3 – Velocity Vector Map on the Longitudinal Section Plane– Refer to Section A-A in Figure 5.1.2.5

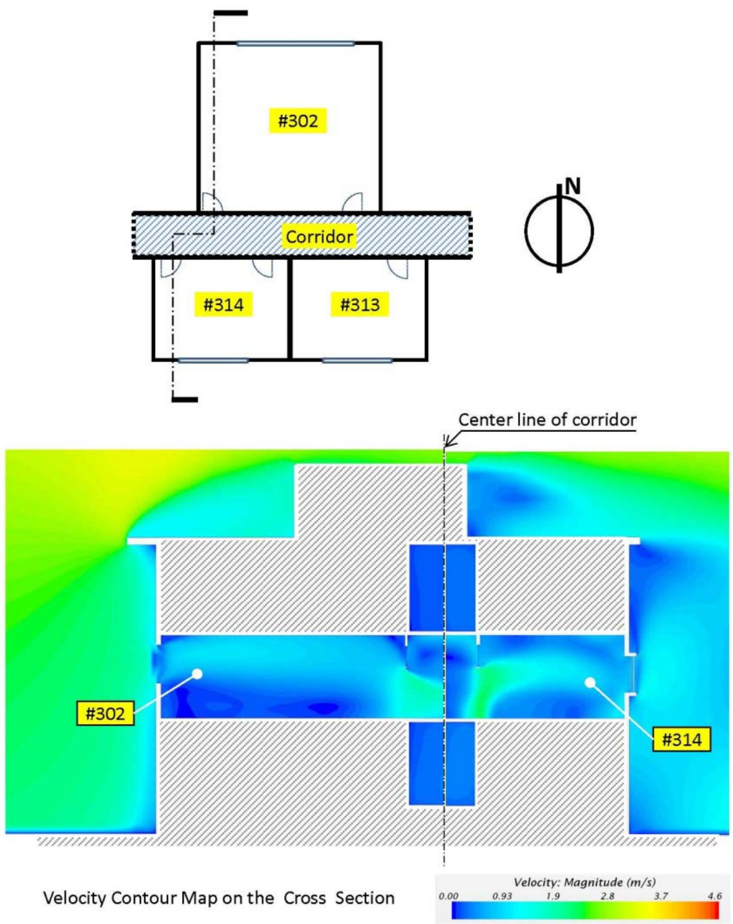


Figure 5.1.2 .7: Visualization of Scenario 3 – Velocity Contour Map on the Cross Section

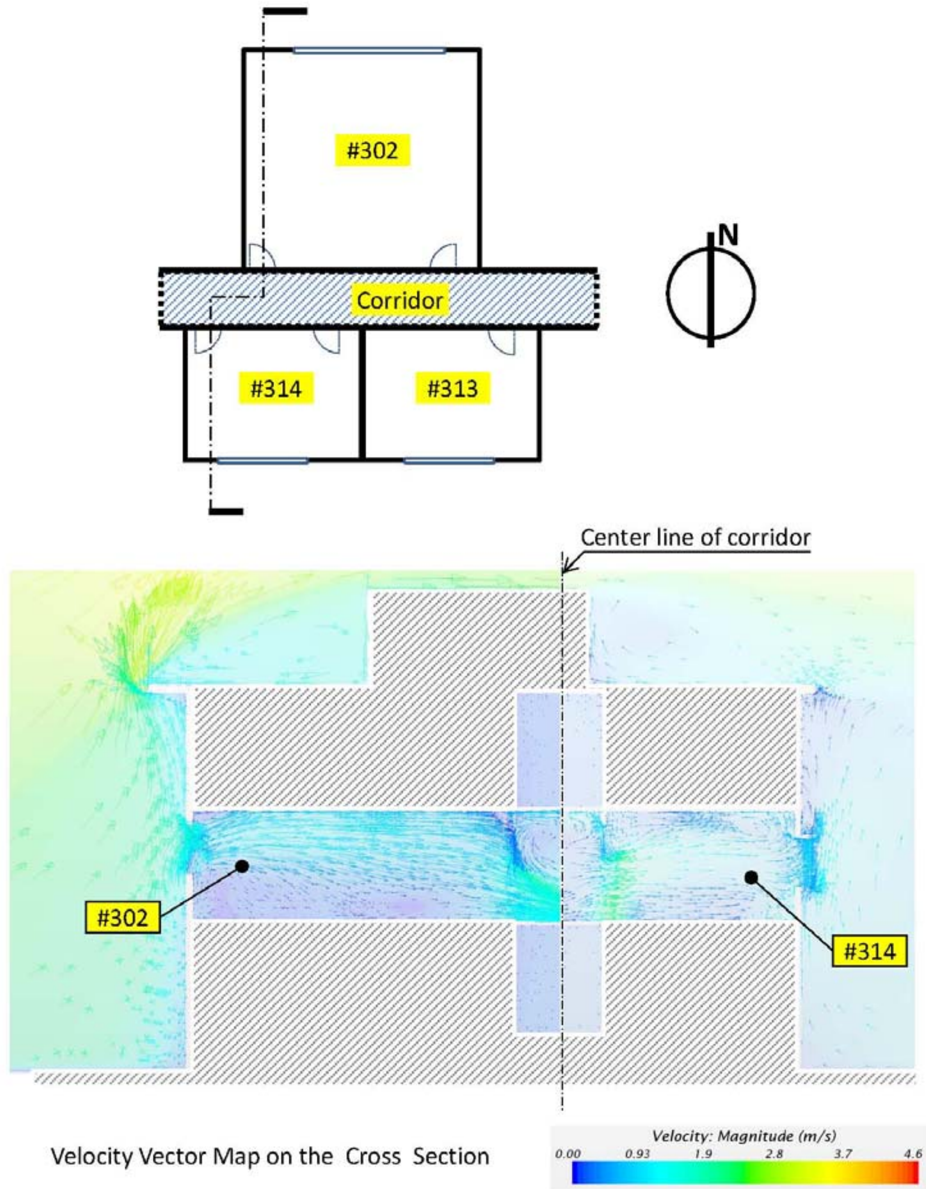


Figure 5.1.2 .8: Visualization of Scenario 3 – Velocity Vector Map on the Cross Section

5.1.3 Air Flow Distribution through Internal Doorways and Hallway Sections

The air flow through internal doorways was considered not to be uniform. The CFD investigation produced a series of flow visualizations with the help of a "presentation grid". A presentation grid is a virtual probe in matrix form that is deployed at specified locations in the computational domain. The velocity vectors at the nodes of the presentation grid matrix were extracted from the CFD data base for all doorways and hallway sections at which location actual measurements with anemometers were conducted. Figures 5.1.3.1 through 5.1.3.3 illustrate magnitudes of air velocity distribution in typical doorways and hallway sections, which were connect to the control volume. More flow visualization cases are presented in **APPENDIX B**.

As an example, Figure 5.2.3.1 shows the horizontal and vertical velocity distribution in the opening A0 (doorway to classroom 314) of Scenario 3. The red and blue bars indicate flow out from and into the control volume, respectively. For opening A0 the air flow is to the South, out of the control volume and into the class room 314. Figure 5.1.3.2 shows the horizontal and vertical velocity distribution in the opening A1 (doorway to classroom 302) of Scenario 3. For opening A1 the air flow is to the South into the control volume and out from the class room 302. Figure 5.1.3.3 shows the shows the horizontal and vertical velocity distribution in the opening A7E, the cross section in the hallway. For opening A7E the air flow is to the West, into the control volume.

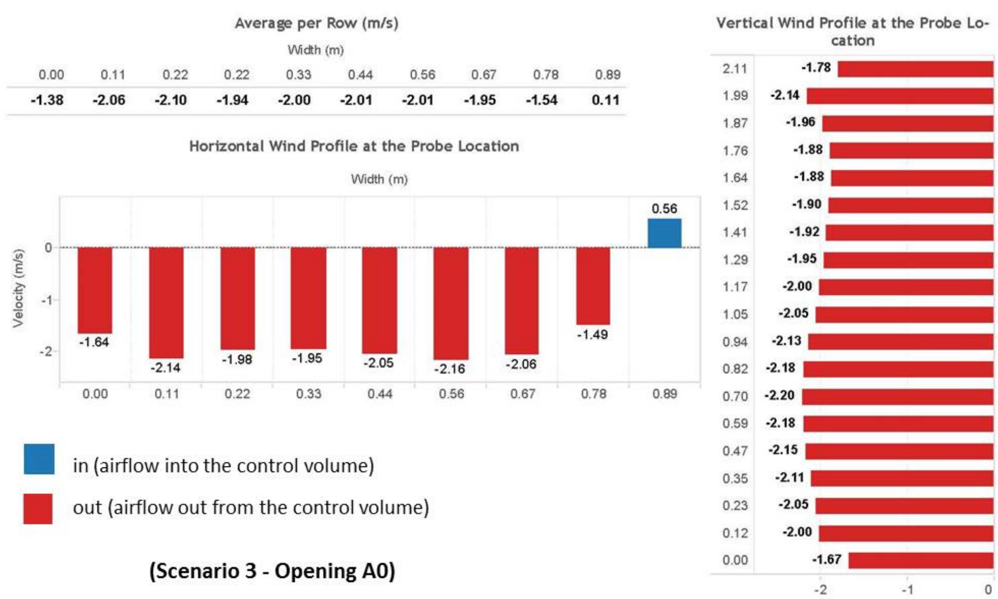
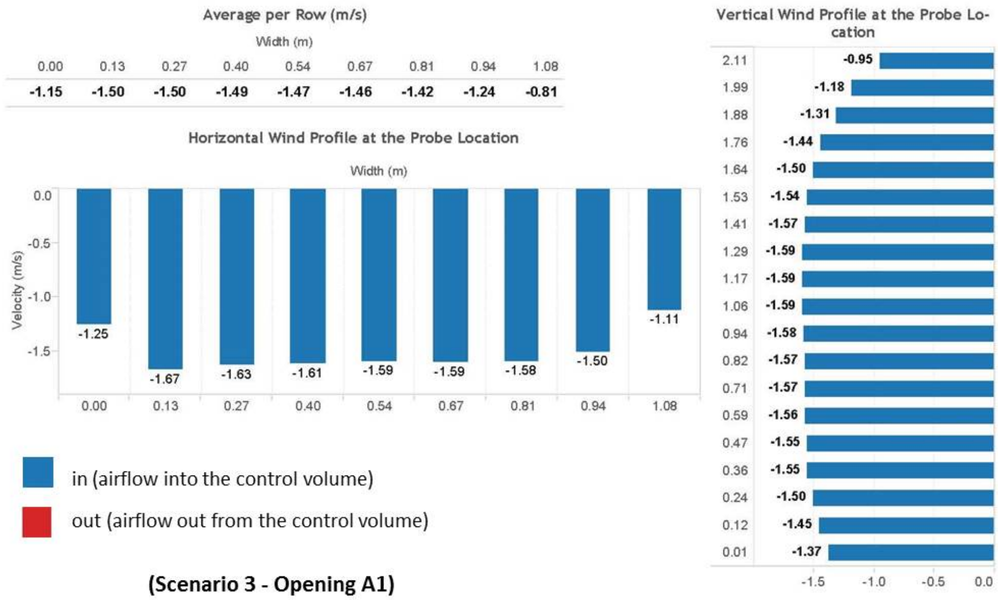
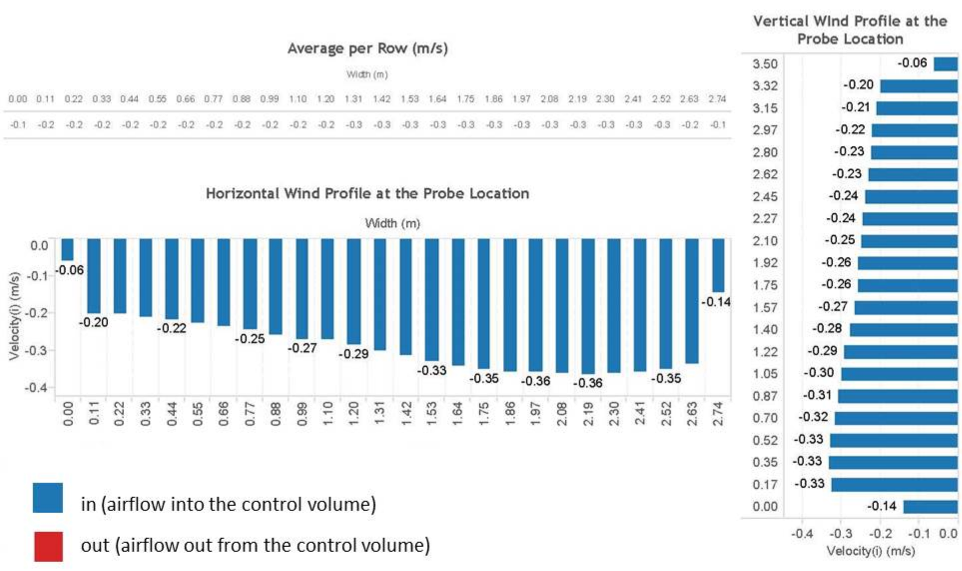


Figure 5.2.3.1: Internal air flow through openings – example Scenario 3 – opening A0 – doorway 314



(Scenario 3 - Opening A1)

Figure 5.2.3.2: Internal air flow through openings – example Scenario 3 – opening A1 doorway 302



(Scenario 1 - Opening A7E)

Figure 5.2.3.3: Internal air flow through openings – example Scenario 1 – opening A7E hallway section

5.1.4 Discussion of Results

The visualization presented in Section 5.1 provides a good description of the internal air flow patterns. The visualizations can provide the designer with qualitative assessment of the internal air flow and how the internal airflow can be affected by internal openings. The type of post processing, color contour maps, streamline maps and presentation grids offer intuitive tools to determine internal flow patterns.

5.2 CFD Group 2 – Validation Test of CFD Results

This section presents the results of the validation of CFD simulation. In order to validate the air velocities calculated with the CFD simulations for the five test scenarios, measurements of air velocities were conducted with hot wire anemometers at six control surfaces, e.g. at locations of doorways and hallway sections bordering the control volume. Test scenario 1 is an exception since the anemometers were placed in the center of the hall way since test scenario 1 the doorways to the class rooms remained closed and air flow was restricted along the axis of the hallway.

5.2.1 Determining the Wind Velocities for the CFD analysis

The CFD simulations for all five test scenarios used the same approach wind direction of 45° but with varying wind velocities. The wind velocities for the CFD simulations of CFD Group 2 was determined by analyzing the wind record collected during the test measurements and determining the specific wind approach for individual test scenarios. During each test scenario the wind velocities were measured by the weather station and one specific representative wind velocity for each five test scenario was defined.

Figures 5.2.1.1 and 5.2.1.2 show the method to determine the representative wind approach velocity for the five test scenarios. The figures show the wind roses for each test scenario with an indication of the wind directions for each test scenario. While the predominant wind direction varied throughout the measurements for the test scenarios, the CFD simulations used a constant 45° wind approach direction for all test scenarios; only the wind velocities varied for the test scenarios.

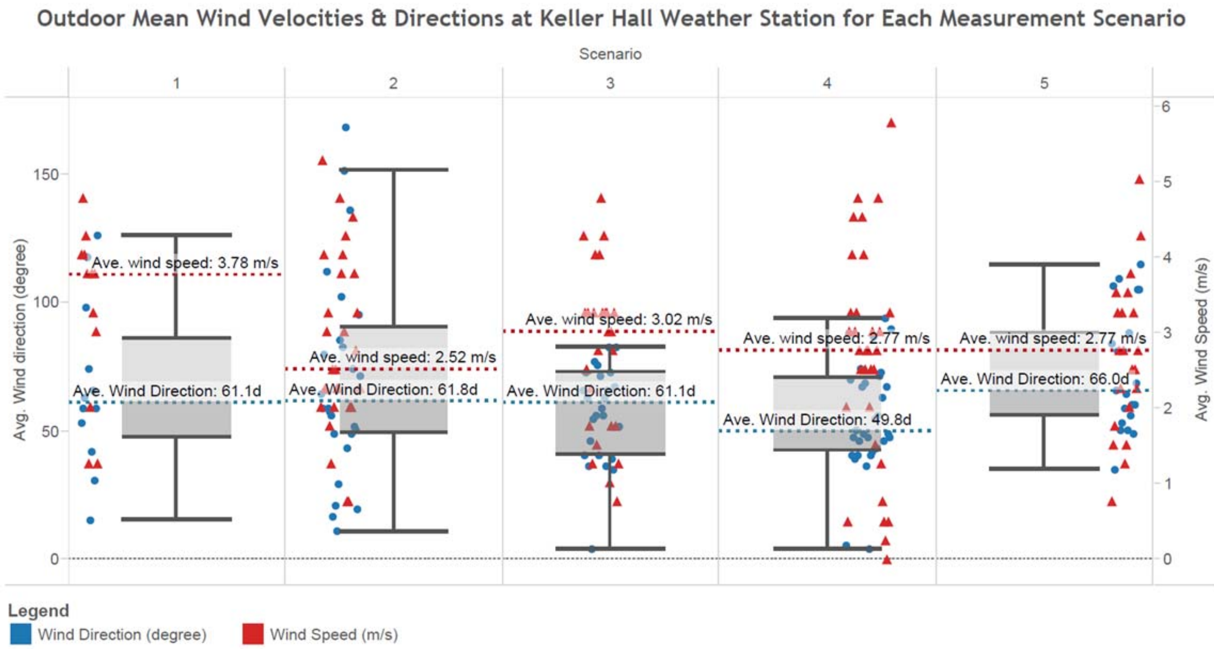


Figure 5.2.1.1: 10m equivalent height wind speed and wind direction at the Keller Hall weather station obtained at the same time as the indoor air velocity measurement for all test scenarios 1 through 5

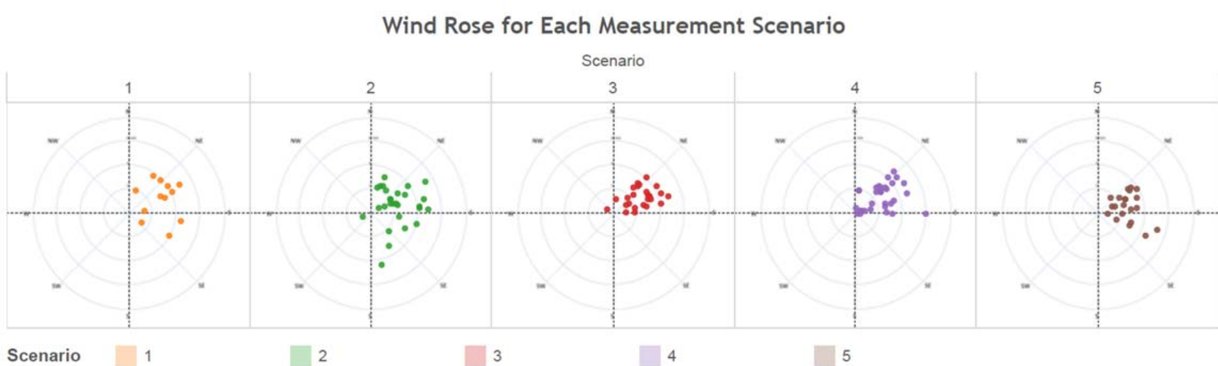
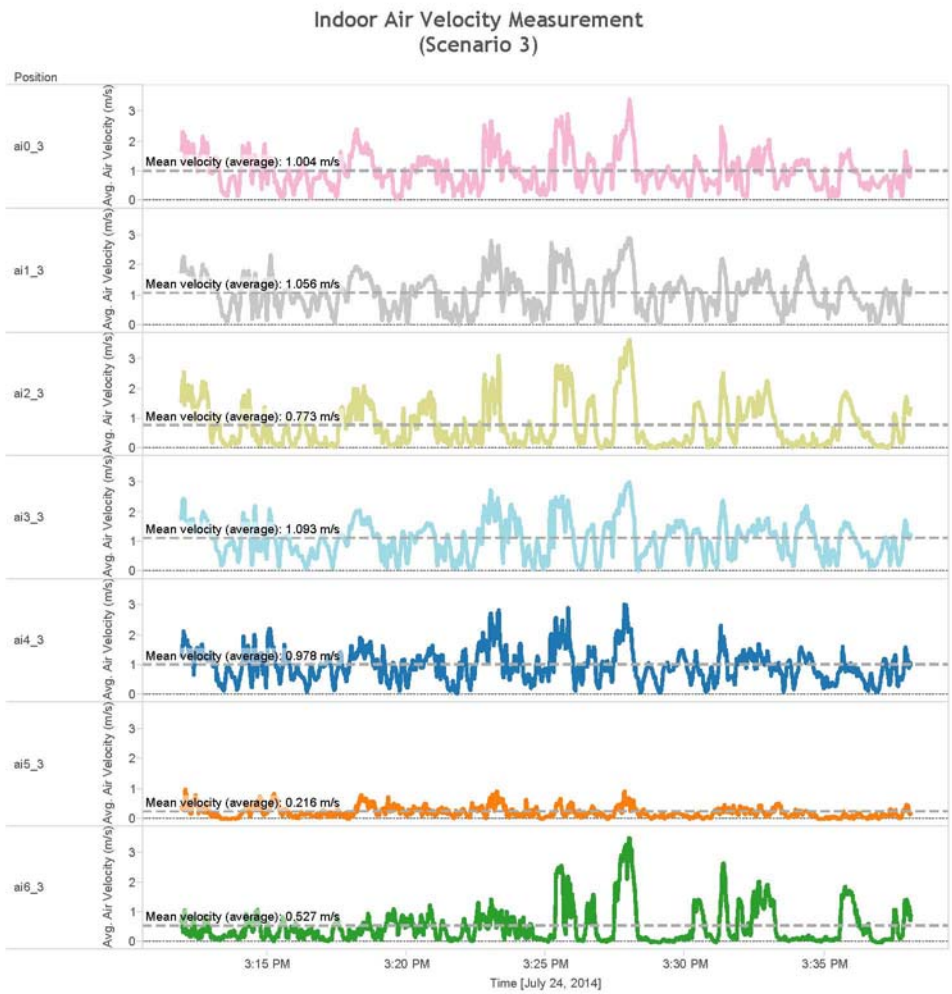


Figure 5.2.1.1: Wind direction at the Keller Hall weather station obtained at the same time as the indoor air velocity measurement for all test scenarios 1 through 5

5.2.2 Measurements of the Internal Air Flow Velocities

Measurements of internal air velocities were carried out with seven hot wire anemometers for all five test scenarios at the locations A0 through A6. As a sample data set Figure 5.2.2.1 shows the recorded data sets for the anemometers for test scenario 3. All data sets measured are presented in **Appendix C.**



Position: ai0_3, ai1_3, ai2_3, ai3_3, ai4_3, ai5_3, ai6_3

Scenario: ☐ 1, ☐ 2, ☑ 3, ☐ 4, ☐ 5

Indoor Air Velocity Measurement (Scenario 3)
(Mean)

Position	July 24, 2014
ai0_3	1.004
ai1_3	1.056
ai2_3	0.773
ai3_3	1.093
ai4_3	0.978
ai5_3	0.216
ai6_3	0.527

Indoor Air Velocity Measurement (Scenario 3)
(Stdev)

Position	July 24, 2014
ai0_3	0.583
ai1_3	0.607
ai2_3	0.752
ai3_3	0.611
ai4_3	0.529
ai5_3	0.178
ai6_3	0.616

Figure 5.2.2.1: Internal air velocities recorded for seven anemometers – Sample data set of test Scenario 3

Table 5.2.2.1 summarizes the air velocity measurements for the test scenarios 1 through 5. During the measurement of test scenario 1, the doors to the classrooms were closed and the anemometers A0 through A5 were placed on the center line of the hall way at the height of the doors. Therefore, for test scenario 1, the anemometers were all measuring air velocities along the centerline of the hallway.

For the time records of the air velocity measurements, average values were determined for every anemometer and for every test scenario.

It should be noted that the type of anemometer used for the tests were hot wire anemometers, which correlate the air movement past the sensor with a cooling effect that is then translated into an air velocity. These anemometers are therefore not directional anemometers.

Measurement							
Scenario		a0	a1	a2	a3	a4	a6
		{m/s}	{m/s}	{m/s}	{m/s}	{m/s}	{m/s}
1 note**	Mean	0.29	0.26	0.24	0.30	#N/A	0.83
	Stdev	0.24	0.22	0.19	0.26	#N/A	0.58
2	Mean	0.86	1.22	0.88	1.10	1.08	#N/A
	Stdev	1.06	1.33	0.90	1.44	1.23	#N/A
3	Mean	1.00	1.06	#N/A	1.09	0.98	#N/A
	Stdev	0.58	0.61	#N/A	0.61	0.53	#N/A
4	Mean	0.63	1.05	0.58	0.99	0.85	0.29
	Stdev	0.57	0.73	0.42	0.67	0.61	0.24
5	Mean	0.52	0.94	0.45	1.01	0.79	1.03
	Stdev	0.37	0.57	0.28	0.61	0.57	0.82
** Note	For Test Scenario 1 the anemometers a0, a1, a2, a3, a4, were installed along the axis of the hallway (offset 4'-6" away from its original locations) not at the doorways of the class						

Table 5.2.2.1: Results of the air velocity measurements for test scenarios 1 through 5

5.2.3 CFD Simulations of Air Velocities for Validation

CFD simulations were carried out for each test scenario using the specific wind approach velocity (refer to Table 5.2.3.1, column Uref) while using the same wind approach direction of 45°. A small CFD presentation grid was used to determine the calculated virtual velocities at locations in the computational grid, which corresponded with the locations of the anemometers during the test measurements. The results of the CFD simulations are presented in the Table 5.2.3.

Simulation							
Scenario	Uref	a0	a1	a2	a3	a4	a6
	{m/s}	{m/s}	{m/s}	{m/s}	{m/s}	{m/s}	{m/s}
1	3.78	0.32	0.32	0.31	0.31	0.30	0.63
2	2.52	0.86	1.22	0.88	1.10	1.08	#N/A
3	3.02	1.35	1.23	#N/A	1.06	1.46	#N/A
4	2.77	0.85	1.39	0.95	1.23	1.14	0.32
5	2.77	0.13	1.57	0.46	0.87	0.54	0.46

Table 5.2.3.1: Results of the CFD simulations for validation for all five test scenarios.

For the data points in Table 5.2.3.1 which are labeled with N/A, no measurements were conducted at that location. As noted earlier, the highlighted test scenario 1 indicates that that the locations of the "virtual" anemometers are in the center of the hallway and not inside the doorways or hallway doors.

5.2.4 Mass Flow Verification for Control Volume

The results of the CFD analysis conducted for the validation of measured air velocities were verified by applying the principle of mass conservation of the control volume. For air flow conditions in the control volume under steady state the net sum of inflow and outflow must be zero.

For each of the five tests scenarios the mass flow in and out of the control volume was determined. Determining the mass flow rate for the control surfaces was done with a specific software function. Figure 5.2.4.1 depicts the methodology of determining the mass flow rate for the control surfaces using Scenario 3 as an example. The mass flow balance for all five tests scenarios is presented in **APPENDIX D.** Table 5.2.4.1 presents the results of the mass balance for the five test scenarios.

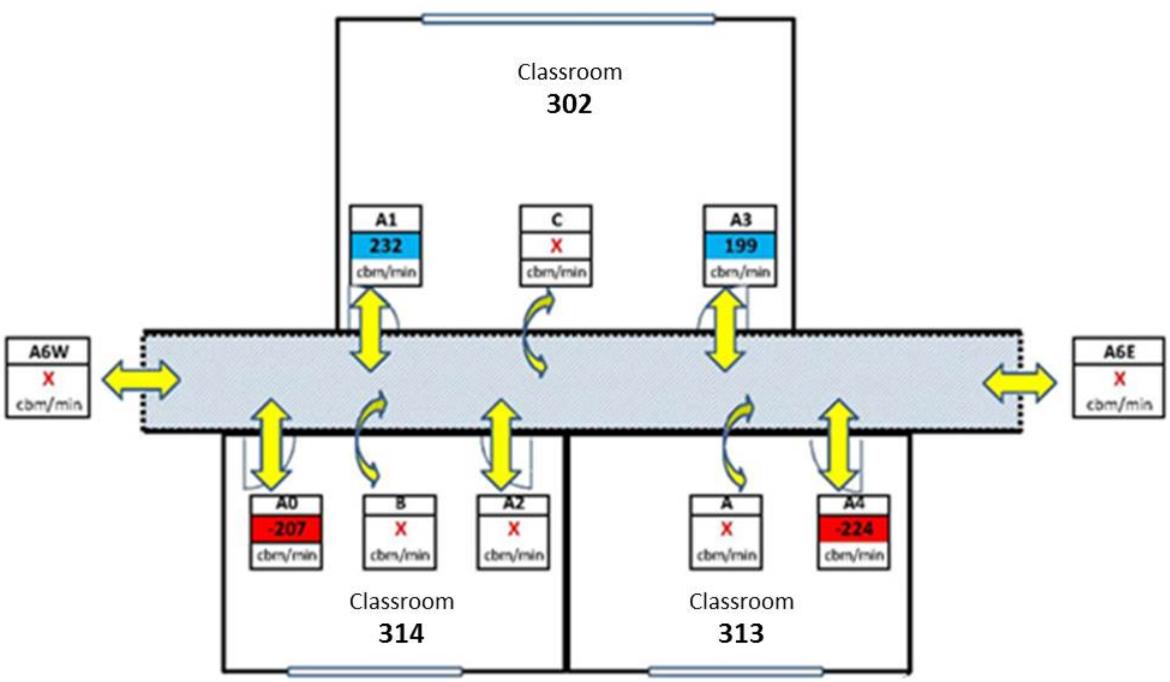


Figure 5.2.4.1: Verification of mass flows conditions for control volume for all test scenarios 1 through 5 – Definition of control surfaces

Table 5.2.4.1: Verification of mass flows conditions for control volume for all test scenarios 1 through 5

	Mass flow rates of control surfaces [m^3/min]					
Control surface ID	**Test scenario 1**	**Test scenario 2**	**Test scenario 3**	**Test scenario 4**	**Test scenario 5**	**Descripion of control surface (see Fig. 5.2.4.1)**
A0		-157	-207	-142	-24	Doorway room 314
A1		270	232	283	320	Doorway room 302
A2		-159		-158	-73	Doorway room 314
A3		243	199	249	174	Doorway room 302
A4		-197	-224	-189	-91	Doorway room 313
A6E	147			107	95	Hallway section
A6W	-147			-149	-198	Hallway section
A					-357	Louvers room 313
B					-446	Louvers room 314
C					600	Louvers room 302
sums >>	0	0	0	1	0	

Mass balance of the control volume:

Inflow	147	513	431	639	1189
Outflow	-147	-513	-431	-638	-1189
Residual	**0**	**0**	**0**	**1**	**0**
Error	0.0%	0.0%	0.0%	0.2%	0.0%

Legend for color coding

(blue)	Inflow into control volume shown with Positive value
(red)	Outflow out of control volumeshown with negative value
(yellow)	Control surface was closed

The results of the mass balance indicate residual errors which are either 0 or very close to zero. This suggests that the CFD simulations provided good theoretical predictions of the internal air flow conditions.

5.2.5 Comparison between CFD Calculated and Measured Air Velocities

The results of the CFD simulations and the corresponding measurements are compared in Table 5.2.4.1 and Figures 5.2.5.1 through 5.2.5.5.

Simulation							
Scenario	Uref {m/s}	a0 {m/s}	a1 {m/s}	a2 {m/s}	a3 {m/s}	a4 {m/s}	a6 {m/s}
1	3.78	0.32	0.32	0.31	0.31	0.30	0.63
2	2.52	0.86	1.22	0.88	1.10	1.08	#N/A
3	3.02	1.35	1.23	#N/A	1.06	1.46	#N/A
4	2.77	0.85	1.39	0.95	1.23	1.14	0.32
5	2.77	0.13	1.57	0.46	0.87	0.54	0.46

Measurement							
Scenario		a0 {m/s}	a1 {m/s}	a2 {m/s}	a3 {m/s}	a4 {m/s}	a6 {m/s}
1 note**	Mean	0.29	0.26	0.24	0.30	#N/A	0.83
	Stdev	*0.24*	*0.22*	*0.19*	*0.26*	*#N/A*	*0.58*
2	Mean	0.86	1.22	0.88	1.10	1.08	#N/A
	Stdev	*1.06*	*1.33*	*0.90*	*1.44*	*1.23*	*#N/A*
3	Mean	1.00	1.06	#N/A	1.09	0.98	#N/A
	Stdev	*0.58*	*0.61*	*#N/A*	*0.61*	*0.53*	*#N/A*
4	Mean	0.63	1.05	0.58	0.99	0.85	0.29
	Stdev	*0.57*	*0.73*	*0.42*	*0.67*	*0.61*	*0.24*
5	Mean	0.52	0.94	0.45	1.01	0.79	1.03
	Stdev	*0.37*	*0.57*	*0.28*	*0.61*	*0.57*	*0.82*

** Note: For Test Scenario 1 the anemometers a0, a1, a2, a3, a4, were installed along the axis of the hallway (offset 4'-6" away from its original locations) not at the doorways of the class

Table 5.2.5.1: Comparison between the CFD simulations and measurements for all five test scenarios.

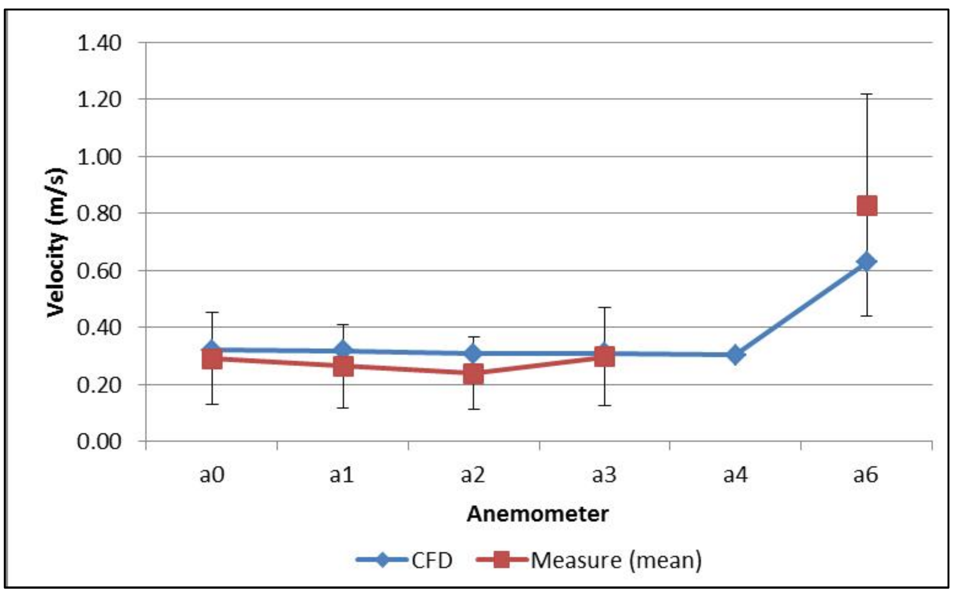


Figure 5.2.5.1: Comparison between the CFD simulations and measurements for test scenario 1.

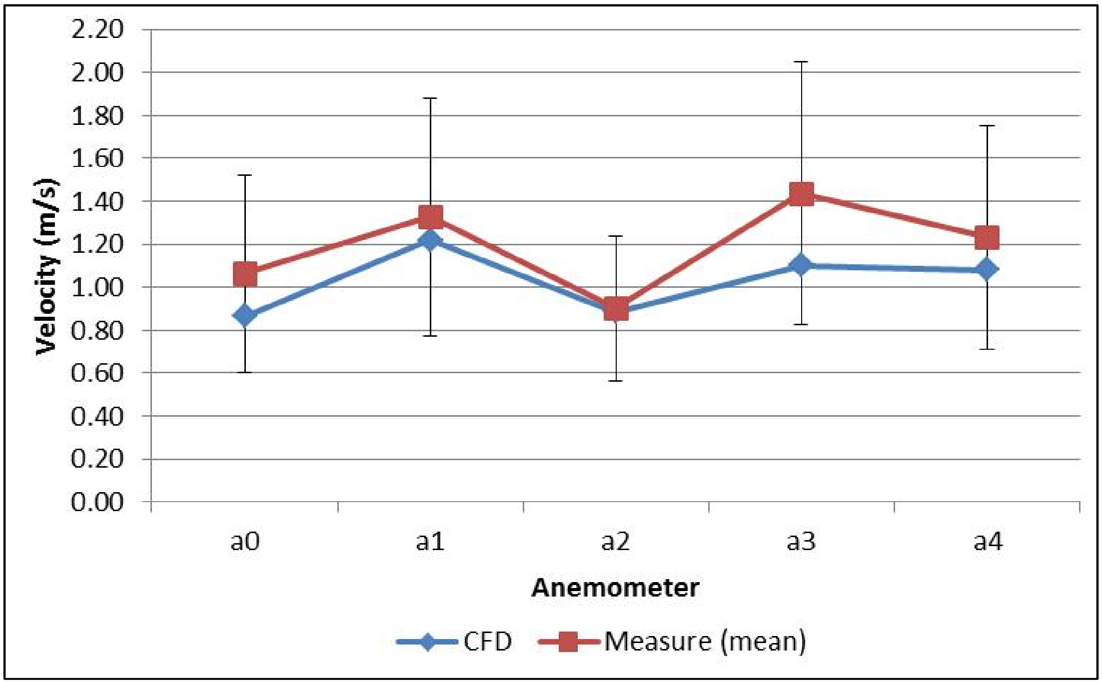


Figure 5.2.5.2: Comparison between the CFD simulations and measurements for test scenario 2.

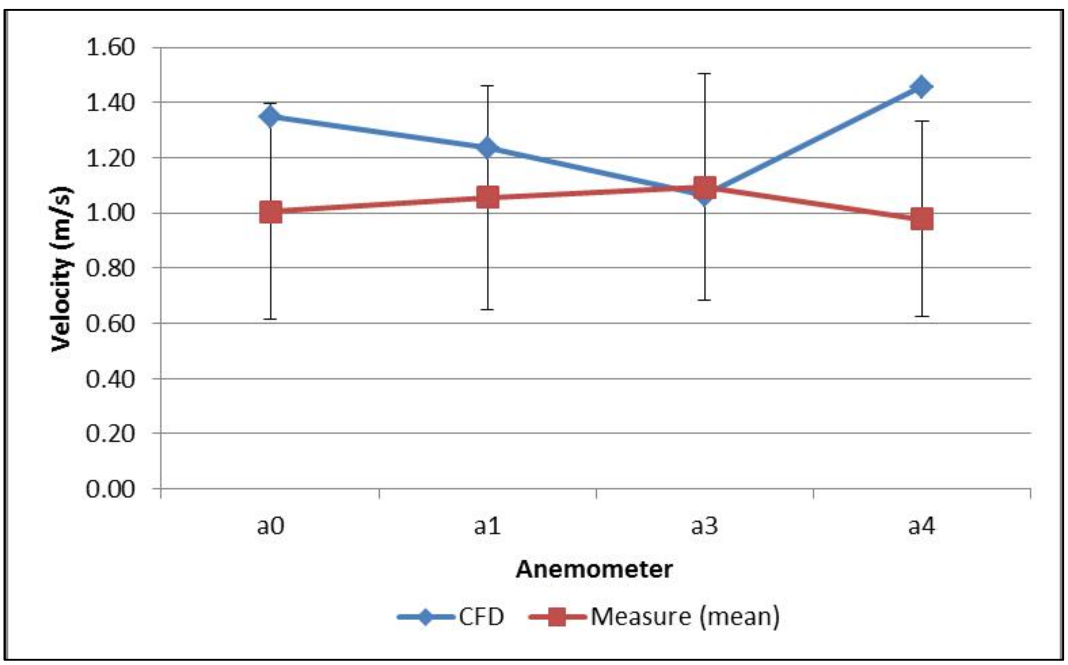


Figure 5.2.5.3: Comparison between the CFD simulations and measurements for test scenario 3

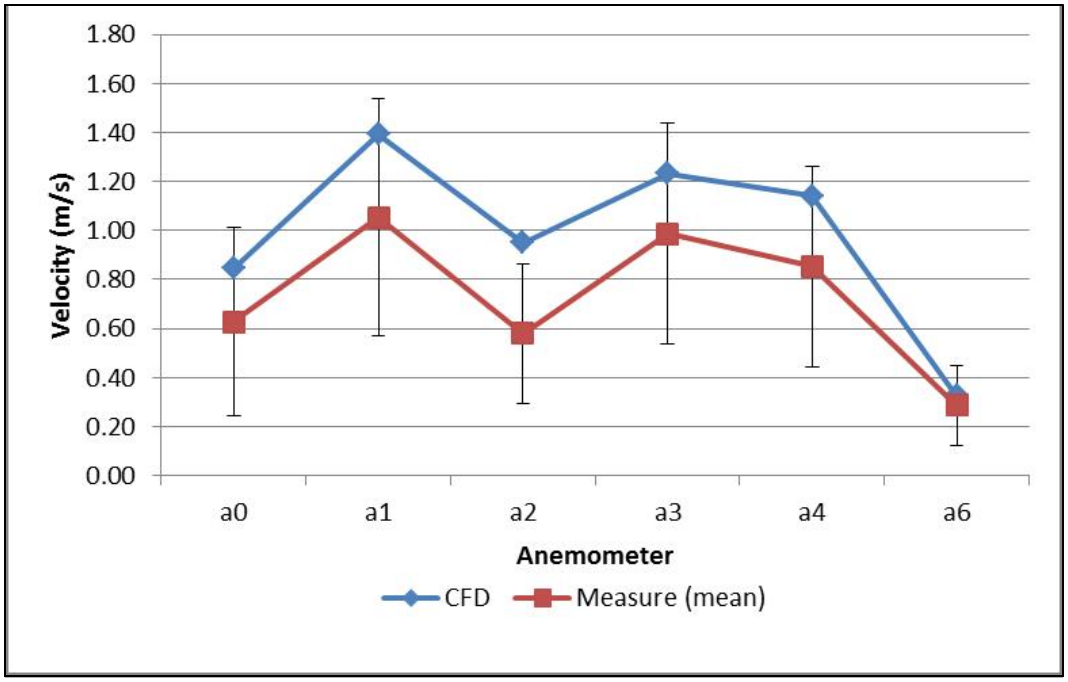


Figure 5.2.5.4: Comparison between the CFD simulations and measurements for test scenario 4

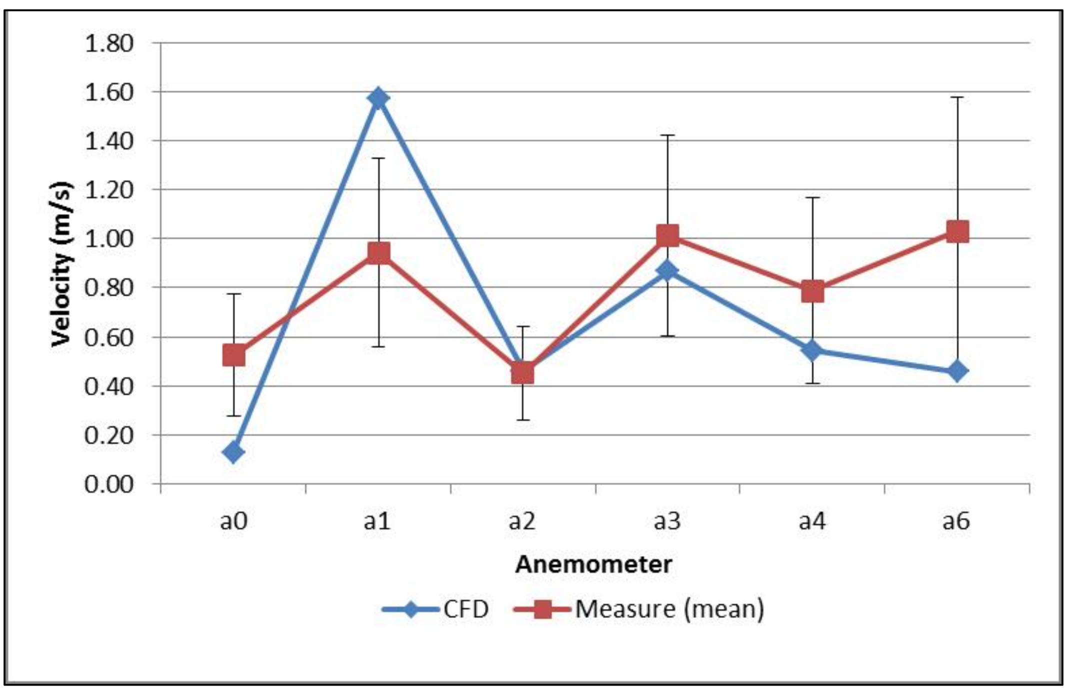


Figure 5.2.5.5: Comparison between the CFD simulations and measurements for test scenario 5

5.2.6 Discussion

The results of the CFD simulations and the measurements for the air velocities and the "virtual" and actual anemometers compare reasonably well. Differences between the two types of values, e.g. the theoretical CFD results and the actual measurements, can be anticipated. The observed differences are within the range of what could be expected. Overall, the validation of CFD results with actual measurements can be regarded as successful. The fact that relatively high air velocities were simulated and observed in the doorways and hallway sections give confidence that results depict actual conditions of air flow at the test site.

5.3 Procedure of Deriving Probable Air Changes Rates

This section presents the results of the procedure which was developed by the CFD team to derive probable air change rates for interior space. The procedure is demonstrated for classroom 302 only.

5.3.1 Determining the Frequency Distribution of Wind Direction for Analysis

The frequency distribution for the wind direction of the total wind record measured at the test site is depicted in Figure 5.3.1.1. The first quadrant (e.g. wind direction 0° to90°) of the wind rose of the wind record contains the bulk of the wind direction observations.

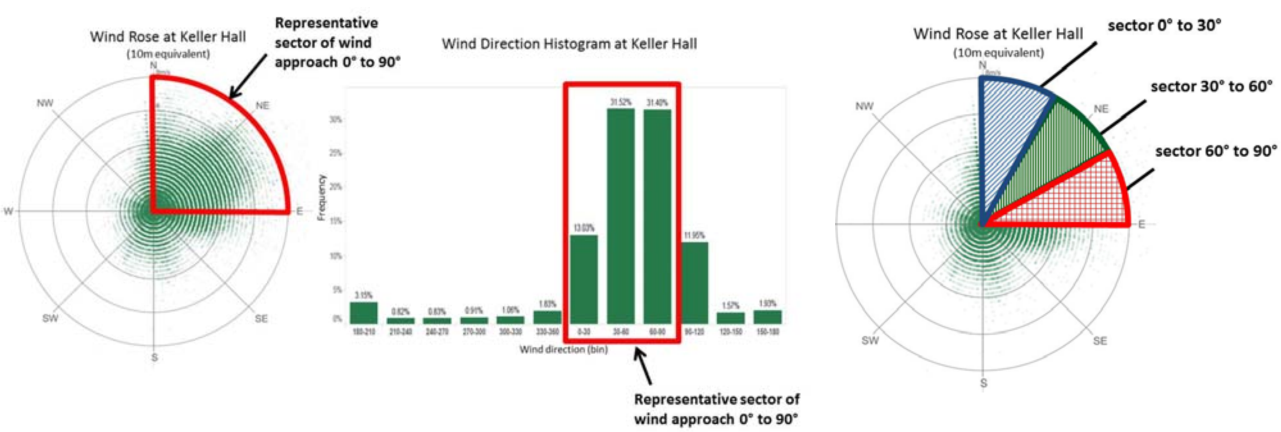


Figure 5.3.1.1: Selected wind direction sample group and three sub-sector for analysis

From the data presented in Figure 5.3.1.1 the contribution, or frequency and therefore weight, of the three sectors in quadrant 1 of the wind rose can be calculated.

Table 5.3.1.1: Frequency of wind direction in total wind rose - determining weight of subsector

No.	Wind approach direction degrees		degrees	Sector name	Frequency (total wind rose)	Frequency (only quandrant 1)
1	0	to	30	Subsector 1	13%	17%
2	30	to	60	Subsector 2	32%	42%
3	60	to	90	Subsector 3	31%	41%
				sum >>	**76%**	**100%**

The frequency for the sub-sectors presented in Table 5.3.1.1 represents the weights with which the anticipated air changes per hour (ACH) were considered for the overall probability distribution of ACH.

5.3.2 Frequency of Wind Velocities for Sub-Sectors

For the sub-sectors 1 through 3 of quadrant 1, the frequency of wind velocities was determined. Wind velocity observations were assigned to ranges and their frequency relative to all wind velocity readings in the sectors were determined by the probability density function depicted in Figure 5.3.2.1. The resulting the frequency distribution for wind velocity ranges is shown in Table 5.3.2.1. The values for frequency distribution were used in determining the contribution of the resulting air changes (ACH) for the sector and the wind velocity range.

Table 5.3.2.1: Frequency of wind direction in total wind rose - determining weight of subsector

Wind velocity range in m/s			representative wind velocity m/s	Frequency of observations in sector (from Figure 5.3.2.1) for sector 0 to 30 degress	for sector 30 to 60 degress	for sector 60 to 90 degress
0	to	0.5	<1	10%	4%	4%
0.5	to	1.5	1	29%	16%	23%
1.5	to	2.5	2	20%	21%	30%
2.5	to	3.5	3	20%	25%	23%
3.5	to	4.5	4	13%	19%	13%
4.5	to	5.5	5	5%	10%	5%
5.5	to	6.5	6	2%	3%	2%
			>6	1%	1%	1%

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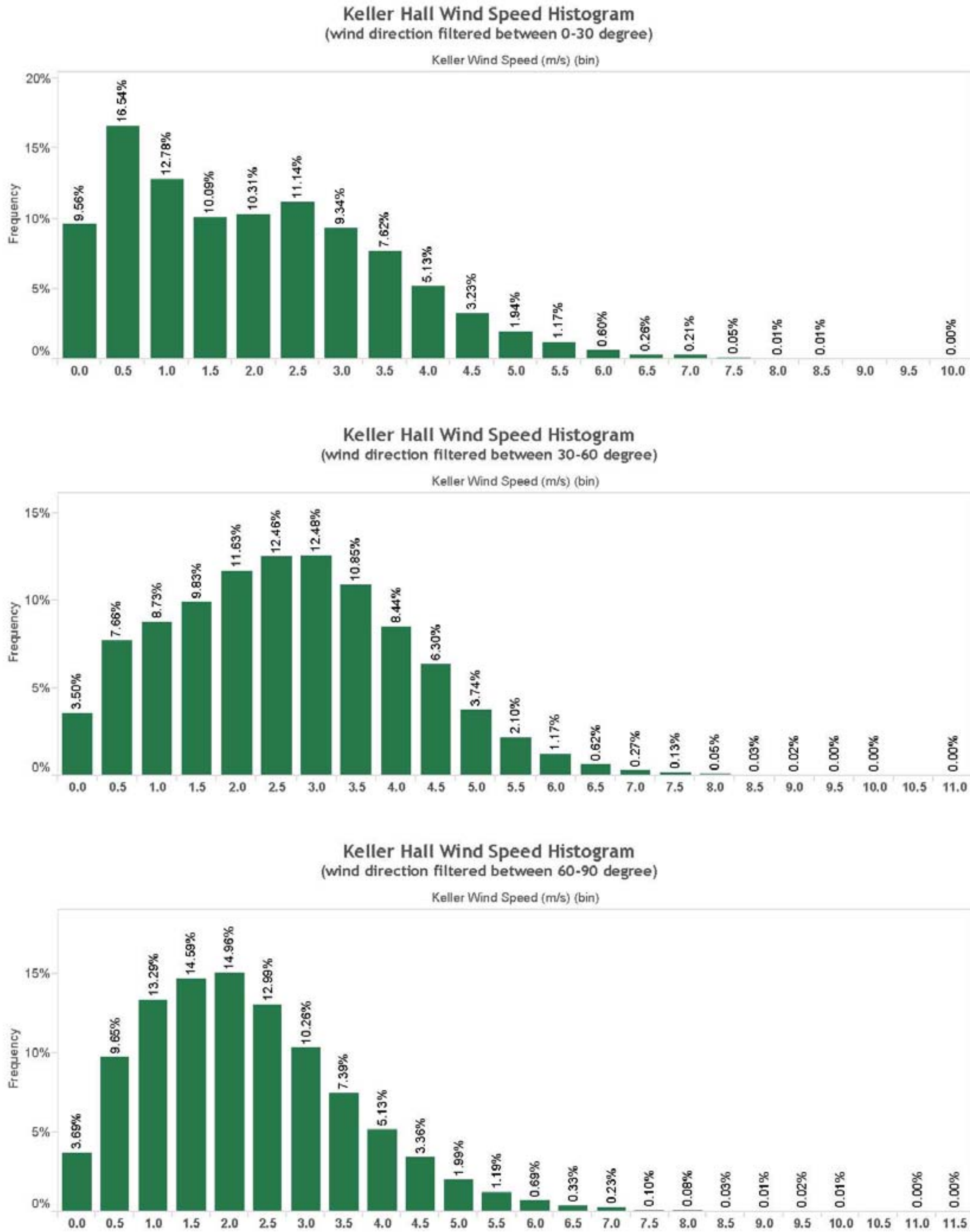


Figure 5.3.2.1: Frequency occurrence of wind direction for sectors 1 (0 to 30), sector 2 (30 to 60) and sector 3 (60 to 90)

5.3.3 Calculating the Air Changes for Room 302 for the three Sectors in Quadrant 1

For each of the three sub-sectors of quadrant 1 (of the wind rose), a number of CFD simulations were carried out with the specific wind approach for the sector and a selected wind velocity. Starting with sector 2 (e.g. winds approach direction 30° to 60°) CFD simulations were carried out for wind velocities 1 through 4 m/s and a wind approach direction of 45°.

For each of the four CFD simulations using wind velocities 1 through 4 m/s of sector 2, the air change rates (ACH) were determined by the air flow rate through room divided by the specific volume of room 302. The resulting air change rates derived by the CFD simulations are depicted in Figure 5.3.3.1. The regression analysis derived good linear functionality between the external wind velocity and the resulting air change rate (R^2 = 0.998).

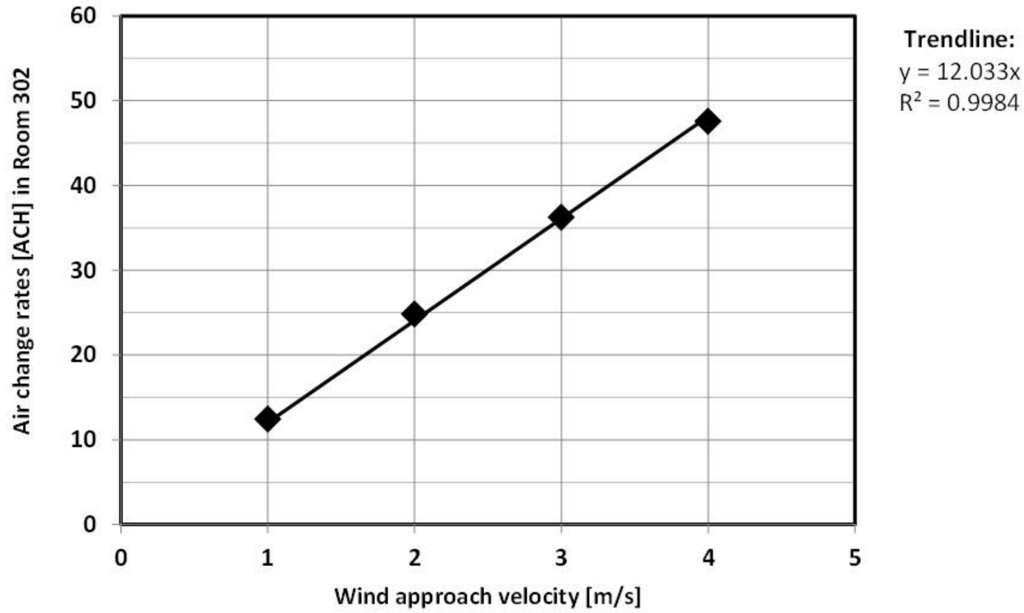


Figure 5.3.3.1: ACH rates derived by CFD simulations for sector 2 (e.g. 30° to 60°)

Based on the good ACH to wind velocity correlation of the four CFD simulations derived for sector 2 (e.g. wind velocities 1 through 4 m/s), it was decided that linear functionalities could also be expected for the sectors 1 and 3. Therefore one simulation each was conducted for sectors 1 and 3, using 2.5 m/s and 15° for sector 1 and 2.5 m/s and 75° for sector 3. From the results, the linear curve functions as y_1= 17.8*x_1 and y_3= 17.8*x_3 for sector 1 and 2 were determined, respectively. The resulting ACH for all sectors 1 through 3 are depicted in Figure 5.3.3.2.

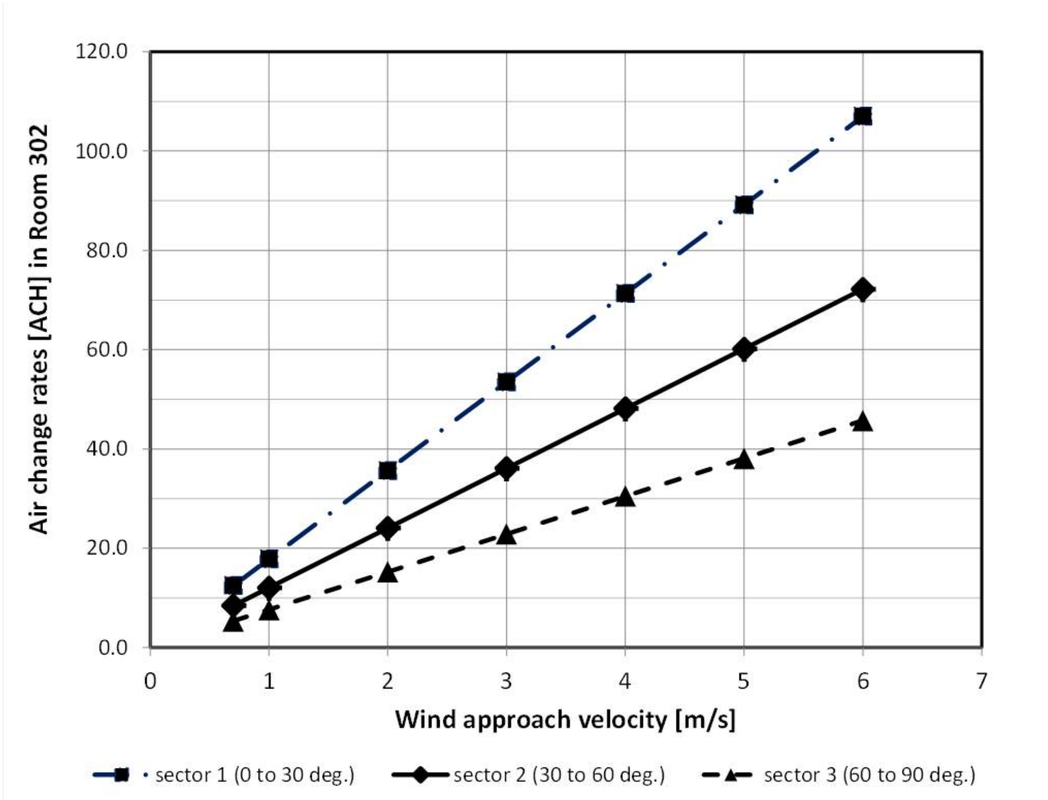


Figure 5.3.3.2: ACH rates derived by CFD simulations for sector 2 (e.g. 30° to 60°)

The ACH rates for the wind directions were applied to the frequency of occurrence for sectors 1 through 3 (as depicted in Figure 5.3.2.1) to derive the probability of exceedance of ACH based on the wind records. Figure 5.3.3.3 shows the probability of exceedance for each sector 1 through 3. Applying the normalized weight of sectors 1 through 3 (See frequency for quadrant 1 in Table 5.3.1.1) gave the probability of exceedance of ACH for the wind directions 0° to 90°, e.g. the quadrant 1. The resulting probability of exceedance of ACH for quadrant 1 is given in Figure 5.3.3.4.

The number of wind direction observations for quadrant 1 represented 76% of the total wind direction record for Keller Hall. Therefore quadrant 1 represents a reliable indicator of the anticipated probability of exceedance of ACH for the test site.

Figure 5.3.3.4 represents a powerful design tools for naturally ventilated spaces based on advanced CFD simulations and actual wind observations at the site.

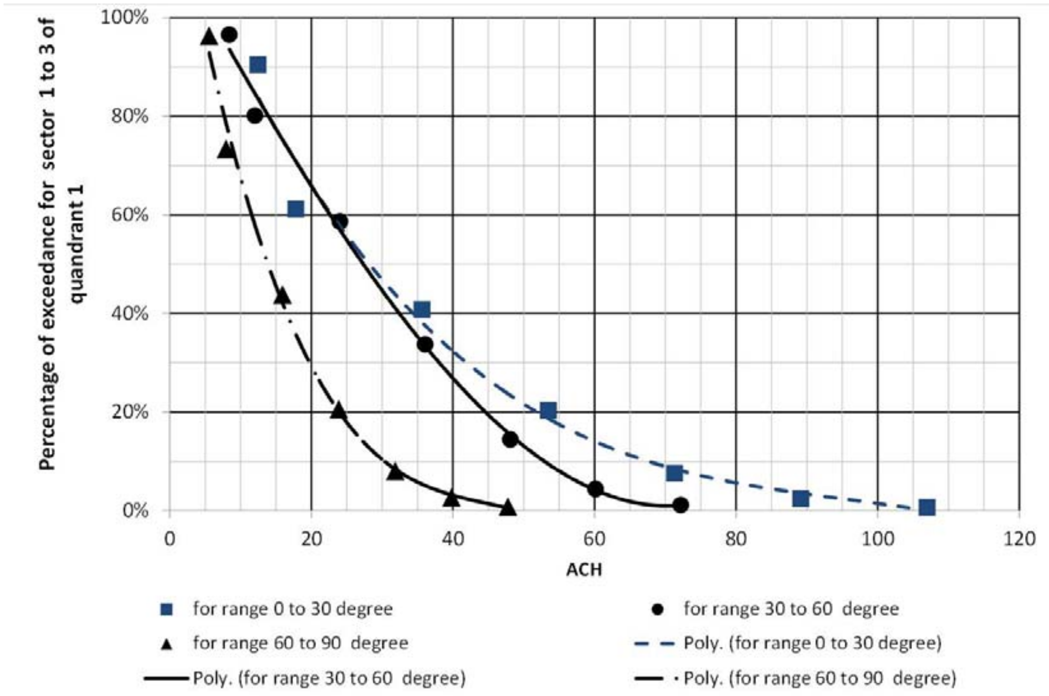


Figure 5.3.3.3: Probability of exceedance of ACH for sectors 1 to 3of quadrant 1

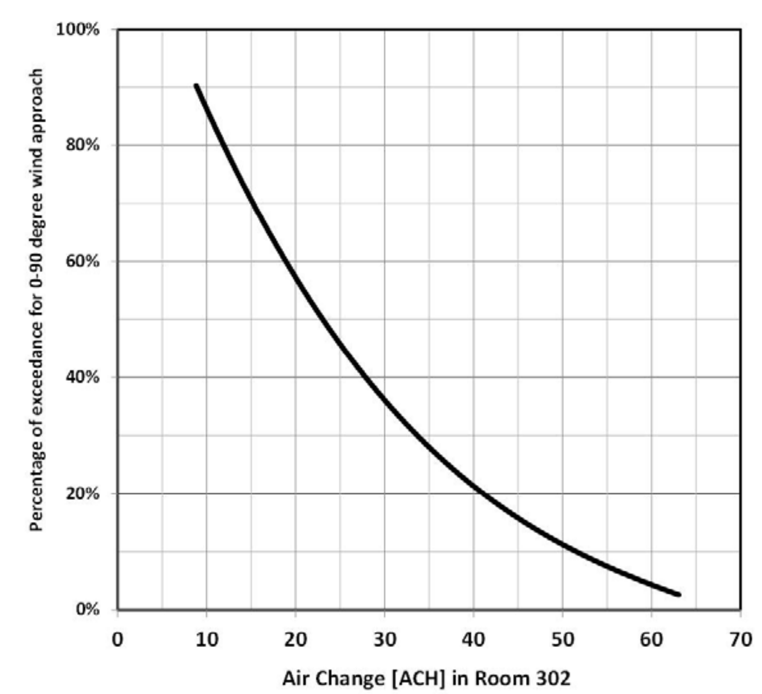


Figure 5.3.3.4: Probability of exceedance of ACH for quadrant 1

SECTION 6 - CONCLUSIONS AND RECOMMENDATIONS

This section summarizes conclusions and recommendations of the internal CFD investigation that is presented in this report.

Overall Comments and Recommendations

- The internal CFD investigations presented in this report make a significant contribution to demonstrate applications of advanced CFD in building performance modeling.
- The predicted CFD simulation values for internal air velocities compared well with actual measurements, therefore increasing the reliability of the theoretical CFD predictions.
- The internal CFD procedure and workflows described in this report provide a good basis for further CFD related work at ERDL and the School of Architecture.
- The objective of developing advanced building performance modeling skills for students and professionals at ERDL has been met.
- The research work has proved that natural ventilation can supply very effective ventilation performance for buildings that are properly located and designed.
- The CFD simulation and analysis procedures demonstrated in this report of offer significant support functions in designing and optimizing building that use forms of natural ventilation.

Selecting the Test Site

- The Keller Hall building proved to be a good selection as a test site to conduct the internal CFD investigation and validation through actual measurements. The Keller Hall building had already been the test site for external CFD investigation and therefore a long-term wind data record was available from a weather station installed on the roof of Keller Hall.
- The selection of three classrooms and an internal interconnecting hallway on the third floor on the Keller Hall building proved to be a good site to carry out the different categories of the CFD investigation. The spaces investigated were originally designed as naturally ventilated spaces and were never modified by installing mechanical ventilation.
- The configuration of the external windows, internal louvered wall sections and the doorways provided ample air passage through cross ventilation through the building.
- The class rooms contained very little furniture and no internal partitions of other flow obstructions which would yield a complicated internal air flow filed.
- The test site could be readily prepared and modified for the test. Future studies could use the same test site and include additional parameters into the CFD model to enhance the solution. More

precise (e.g. 3D-capable) anemometers and external wind measurements at a higher frequency could be used for further studies.

Depicting air flow patterns inside buildings:

- The method of visualization of air flow patterns inside internal spaces, used in this report, followed the same approach that was developed during the development of an internal CFD workflow, an earlier phase of the work on the research program (Refer to Project Deliverable 7.2). The type of air flow visualization provided an effective qualitative description of the internal air flow patterns.
- The "presentation grid" approach used in the report provided a good description of the spatial distribution of air velocities in internal openings. If needed for specific design functions, the spatial distribution of air velocities in openings could provide valuable tools for the design and optimization of internal airflow.
- The depiction of internal air flow can assist the designer of naturally ventilated buildings to decide on a favorable room layout by creating preferred pathways of air flow inside the internal spaces, which can move significant air volumes, and areas of low airflow which occupants might prefer as work places.

Validation of CFD results through actual measurements

- Using air velocities as the descriptor of internal air flow patterns gave good results. Air velocities not only validate the overall air flow patterns, e.g. qualitative description, but measured air flows also provide important quantitative information about intensity of the air flow inside the spaces.
- Placing the anemometers inside openings between spaces proved to be successful since relative high air velocities were present in these openings and the measured air velocities could be used to determine the air change rate for the spaces. The air velocities measured at the locations were well above the threshold velocity of anemometers instrument, which means above velocities when reliable air velocity readings can be made with the type of instruments.
- The type of anemometer used in the validation tests was a hot wire anemometer which does not provide directional air velocity values, but only provides non-directional air velocity past the sensor tip. Validation of internal air flow predicted by CFD can be challenging if the actual air velocity has significant components in all directions. A directional (or 3D) anemometer can provide more reliable measurements, but the test team did not have ready access to a number of these more expensive and sensitive 3D-anemometers. The data collected with the hot wire anemometers, however, was deemed to be a reliable indicator for validation of CFD generated air flow information.
- Placing the anemometers into doorways and hallway sections introduced the anemometer into a somewhat directional air stream where the air velocity vector had the largest directional component normal to the surface to the opening. This mitigated the fact that the hot wire anemometers did not have a directional air flow reading capability.

- The data correlation of external wind conditions with the weather station on the Keller Hall roof and the recorded internal air flow conditions provided important information about coupling between external wind induced driving forces and the resulting internal air movement. Based on the available instrumentation for this research effort, the weather station data and the internal air velocities had to be measured with two independently operating data acquisition systems. The weather station recording and the internal air flow measurements used different data frequencies. In comparison to one second interval data of indoor measurement, the measurement of outdoor wind was done at a one minute interval. Careful synchronization of the two independent data sets was required to generate reliable data groups for data filtering. In future investigations, it would be helpful to use only one data acquisition system for the external wind condition and internal air movements with comparable data recording frequencies.
- In order to achieve comparable wind conditions for the different test scenarios, the average data recording length was about 20 minutes per test scenario. This shorter duration proved successful in respect to mitigating the effect of changing wind conditions between measurements of different test scenarios. In the future the recording length should be a bit longer, for example, 30 minutes.
- The recorded values for air velocities inside the selected openings, e.g. doorways compared reasonably well with the air velocities calculated with CFD at these locations inside the computational domain.

CFD approach used in the simulations

- The CFD investigations utilized many CFD solver settings that were identified as favorable in the previous project work about developing an internal CFD process. This included 3D-CAD integration into the CFD software framework, meshing approach, turbulence model, to name the most important elements of the CFD workflow. Using these previously identified solver settings resulted in good convergent performance of the solutions and verification of calculated air flow.
- A grid sensitivity analysis proved that from the three grid resolutions, e.g. coarse, fine, and finest, the coarse and fine grid performed well. The finest grid was used only on a few occasions to compare convergence performance. It was found that the required additional computational resources were considerable and did not result in a significantly better solution that the coarse and fine grid. Consequently, the fine grid was used for most of the CFD simulation runs.
- The CFD team decided not to include the louvers of the external windows and of the internal louvered wall sections between the classrooms and the internal hall way in the CFD model. Generally speaking, including the louvers would provide a reliable indication of the pressure losses at these external and internal building openings. Modeling louvers as geometric objects, however, requires significant numbers of volume cells and therefore a very high demand on computational resources - resources which were not readily available to the CFD team. An alternative method of quantifying pressure losses through louvers would be to assign a gross pressure loss to the interface surface of the louvered openings. Reliable references of experimental pressure losses caused by the type of

louvers used in Keller Hall could not be found in the literature. Weighing the arguments for and against including louvers in the CFD model, it was decided not to include louvers since the pressure losses of the entirely opened louvered windows would assert only minor pressure losses at the inlets and outlets of the class rooms.

- Overall the CFD team experienced few difficulties in carrying out the different simulations. What was new for the CFD research team was the extensive use of data filtering, statistical analysis and correlating the CFD generated internal air movement to short-term and long-term wind records at the site. After trial and error efforts the CFD team succeeded in carrying out all analysis work.

Mathematical and statistical concepts used in the research work

- The use of a control volume as a mathematical abstraction of the test site was an effective approach, not only to carry out the data analysis but also to configure the test site and conduct the test measurements. The benefits of using the control volume approach included the following features:
  - Selecting the internal hallway as the control volume made it possible to define the doorway, louvered internal wall sections and hallway sections as control surfaces, where air velocity measurements were carried out for validation.
  - The combination of open and closed control surfaces which could readily modeled in CFD but also realized at the test site provided a good rationale for the selection of the five test scenarios.
  - The mass balance of the control volume served as verification of the CFD simulations. The mass balance resulted in zero net in- and outflow. Therefore conservation of mass was proven for the solutions.
  - The resulting mass flow rate through the control surfaces of the control volume was used to assess the overall air change rates in the class rooms.
- Extensive use was made of data filtering in order to correlate relevant theoretical CFD results and actual measurements in the field. The process of statistical analysis proved to be effective and resulted in data correlations that could be used in the different parts of the study in order to derive important conclusions.

Probabilistic Approach to Anticipated Ventilation Performance

- A procedure to provide probable exceedance rates of air changes per hour (ACH) for the site was developed during the studies and benchmarked using one class room and one test scenario. The procedure included the calculation of ACH as a function of wind approach directions from three different sectors of the site-specific wind rose and varying wind velocities. These ACH results were then correlated with the long-term wind record at the test site. The resulting procedure provides an expression of anticipated exceedance of ACH for the length of the wind record, and therefore the ventilation effectiveness.

- The procedure developed offers a means to assess the ventilation performance of internal spaces on the basis of site specific wind condition statistics.
- This procedure, if more developed, can be an effective tool for the designer to assess the natural ventilation effectiveness of buildings. The development of the procedure highlights integrated CFD applications as a powerful tool in the design or optimization of buildings that employ some form of natural ventilation.

REFERENCES

Previous research reports and notes elaborated under this research program, and literature cited in these previous reports, have been used in this report without giving reference.

One new reference which has not been provided in previous reports is listed below:

P. J. Roache (1994) "Perspective: A Method for Uniform Reporting of Grid Refinement Studies", Journal of Fluids Engineering, Vol. 116, p.405-513

ACRONYMS

3D	Three Dimensional
3D-Cad	Three Dimensional Computer Aided Design
ABL	Atmospheric Boundary Layer
CFD	Computational Fluid Dynamics
ERDL	Environmental Research and Design Laboratory
HNEI	Hawaii Natural Energy Institute
HVAC	Heating, Ventilating, and Air Conditioning
ID	Identification Index of Descriptor
LES	Large Eddy Simulation
Room 301	Room 301 of the Sinclair Library, University of Hawaii Manoa campus
V	Velocity
WS	Weather Station

Unit:

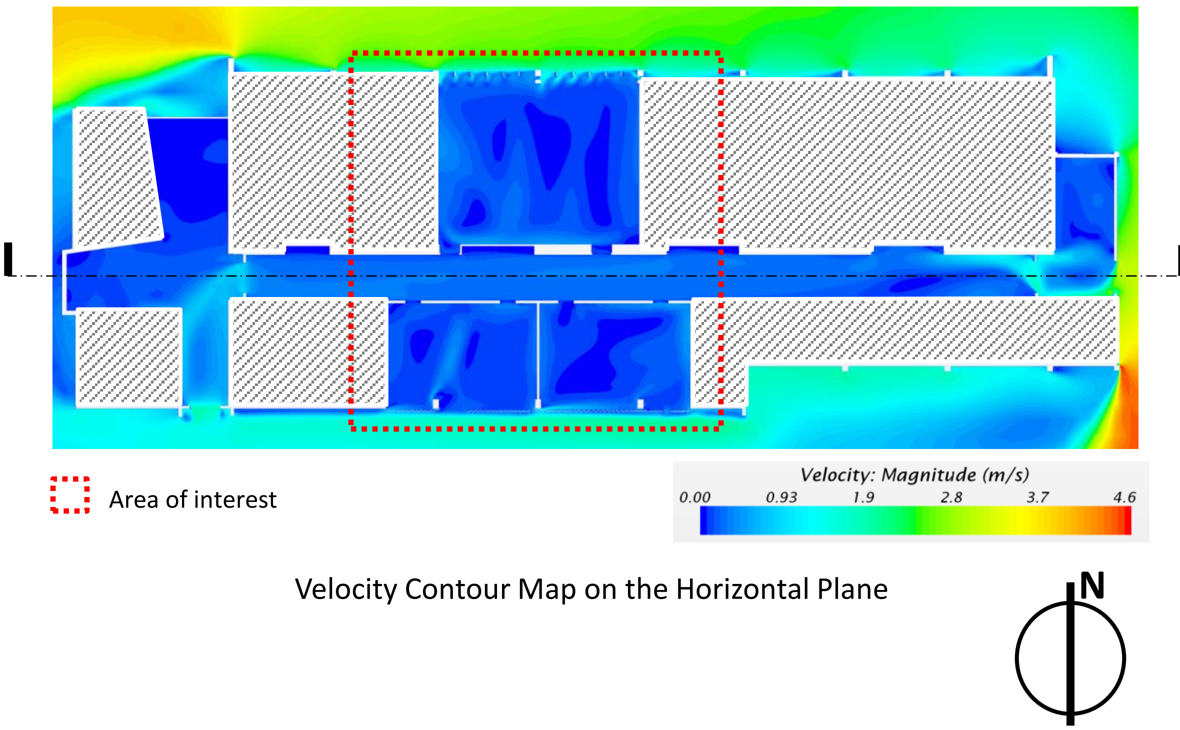
DC	Direct Current
Ft.	Foot or feet
Hz	Hertz
M	Meter
M/s	Meter per second
Mph	Miles per Hour
Pa	Pascal
sqft	Square Feet

APPENDIX A

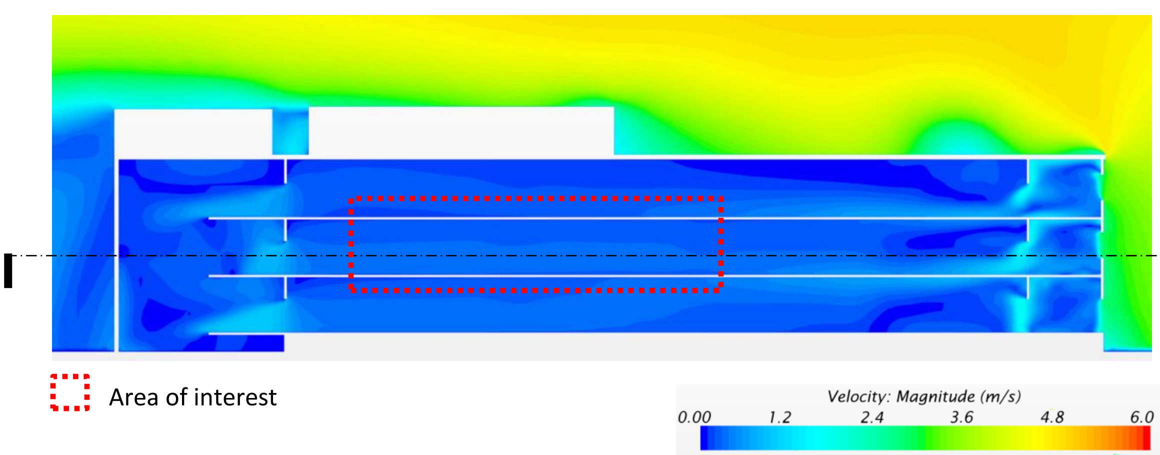
VISUALIZATIONS OF INTERNAL AIR FLOW PATTERNS FOR THE TEST SITE FOR FIVE TEST SCENARIOS

SCENARIO 1

CFD Visualization Analysis



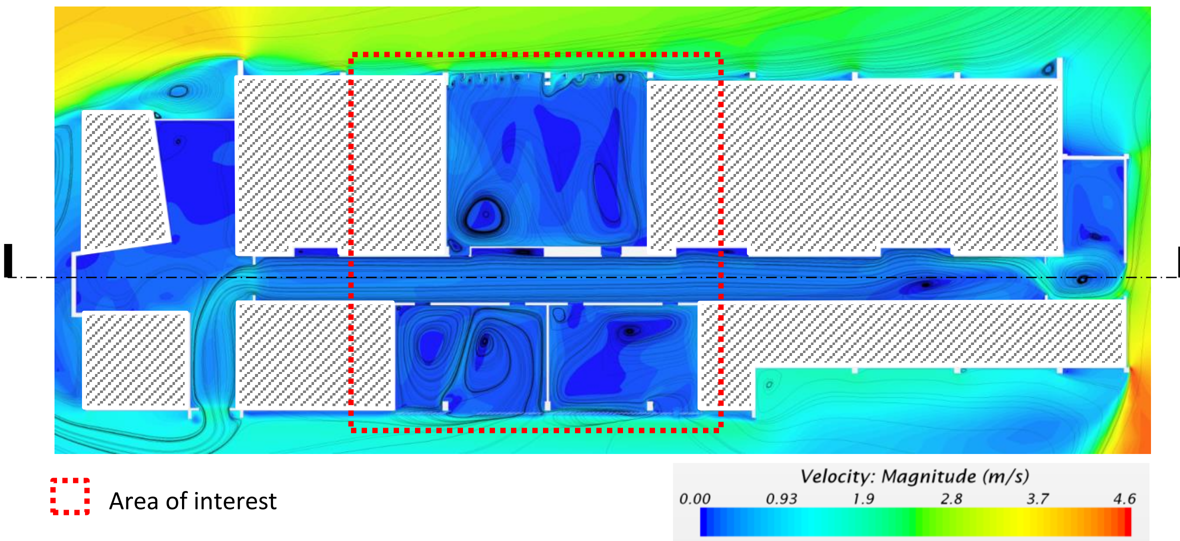
Velocity Contour Map on the Horizontal Plane



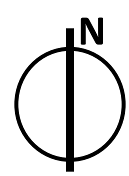
Velocity Contour Map on the Longitudinal Section Plane

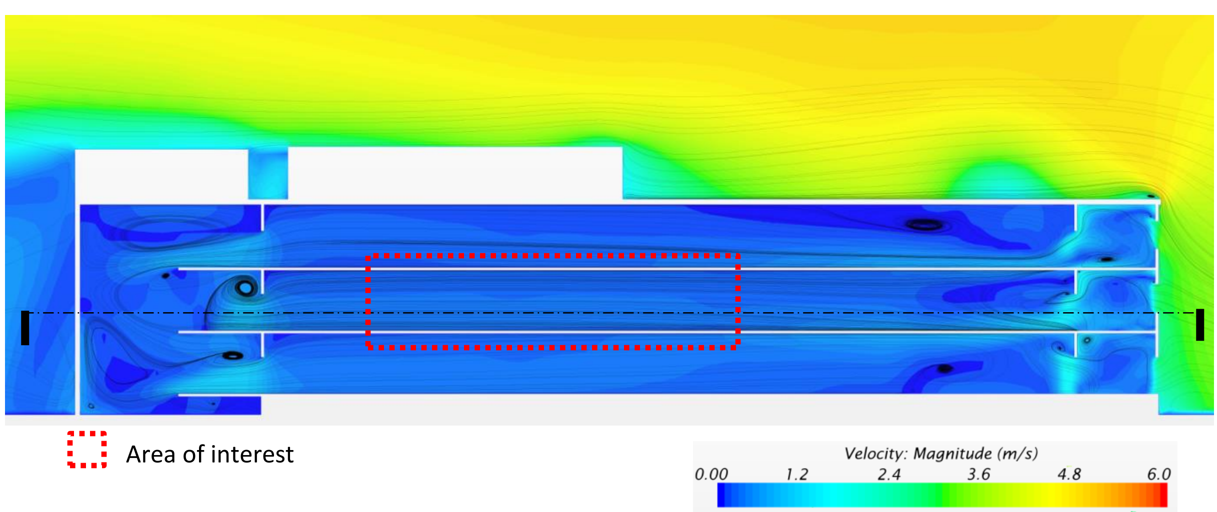
SCENARIO 1

CFD Visualization Analysis



Streamline overlaid on Velocity Contour Map on the Horizontal Plane

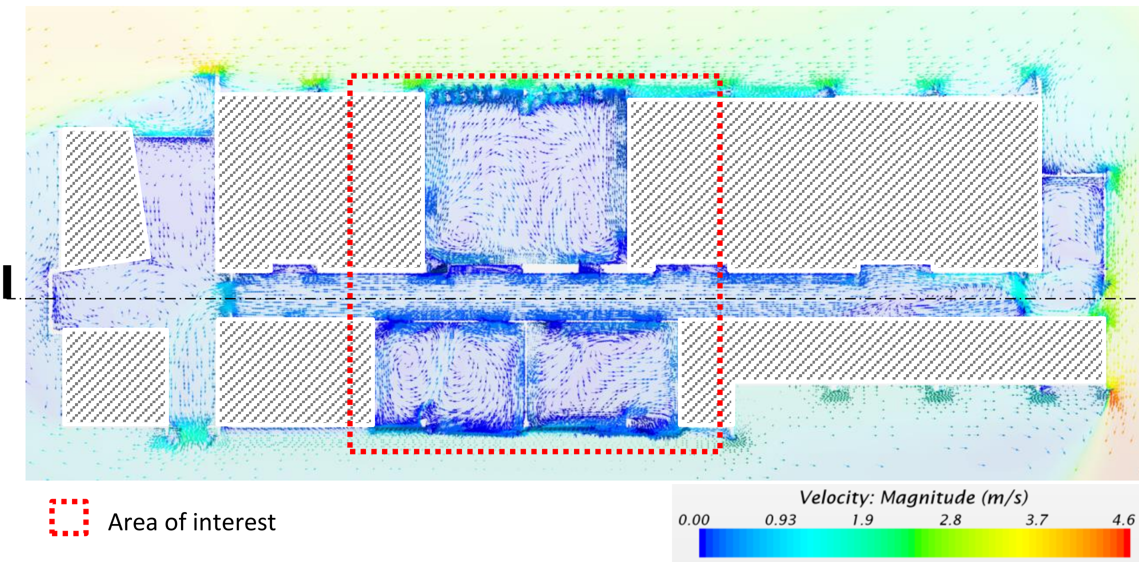




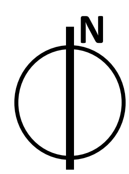
Streamline overlaid on Velocity Contour Map on the Longitudinal Section Plane

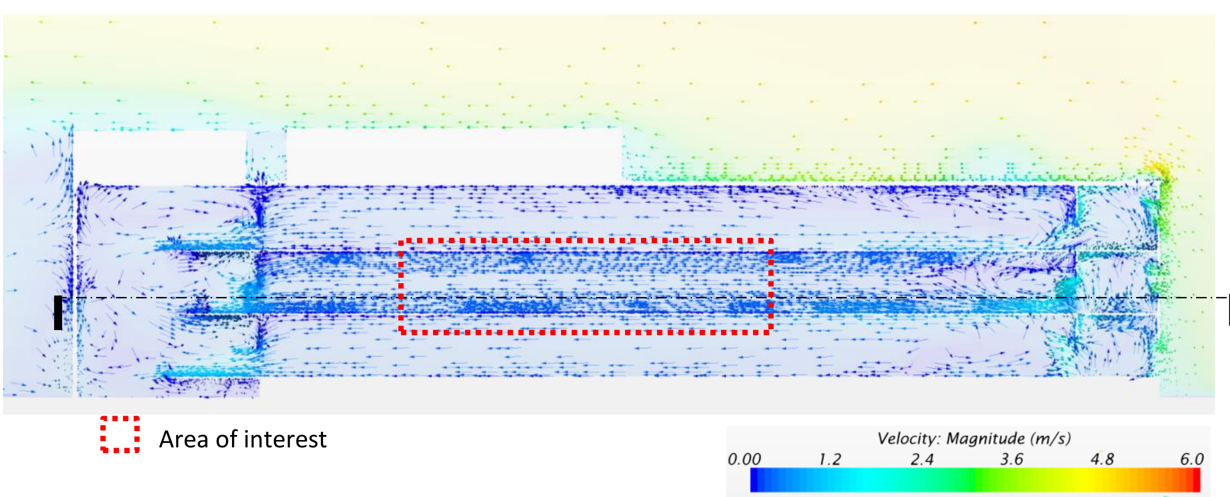
SCENARIO 1

CFD Visualization Analysis



Velocity Contour Map on the Horizontal Plane

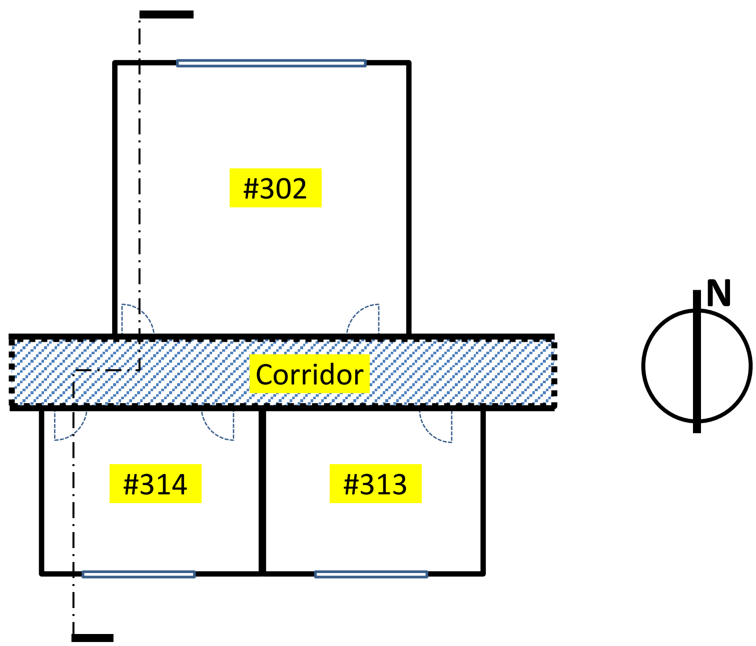


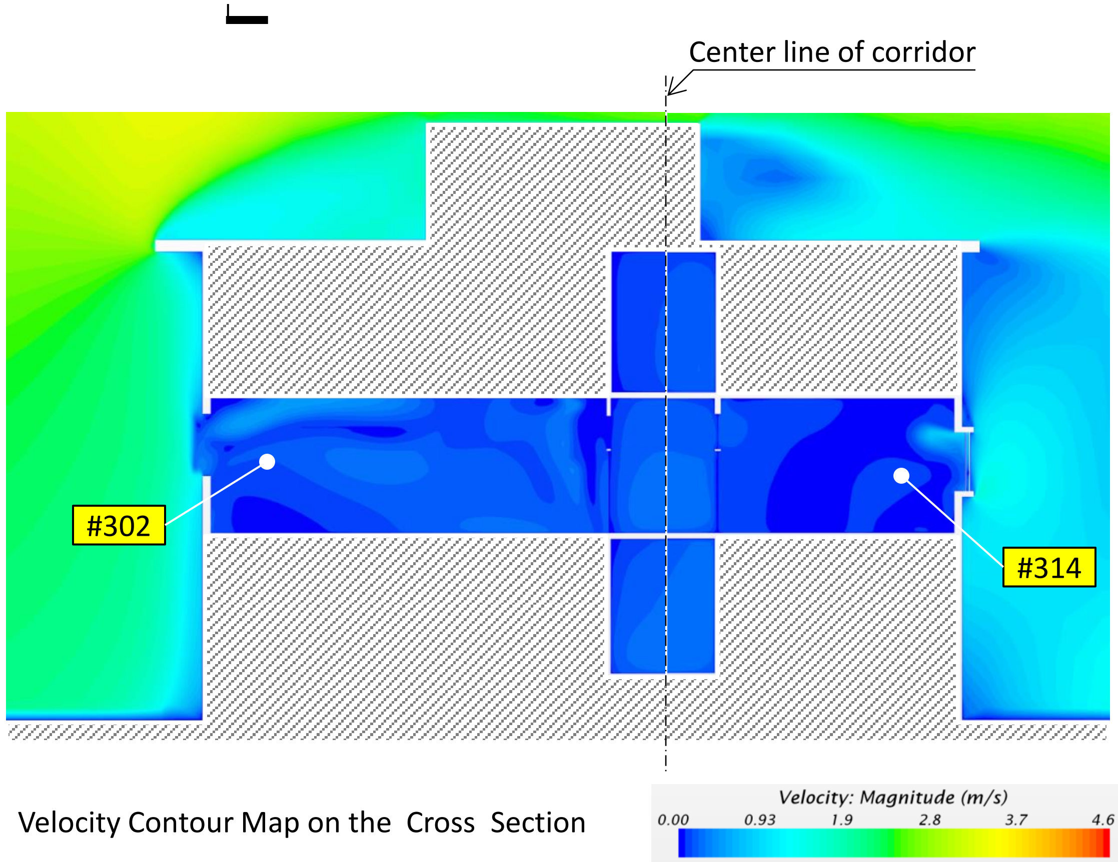


Velocity Vector Map on the Longitudinal Section Plane

SCENARIO 1

CFD Visualization Analysis

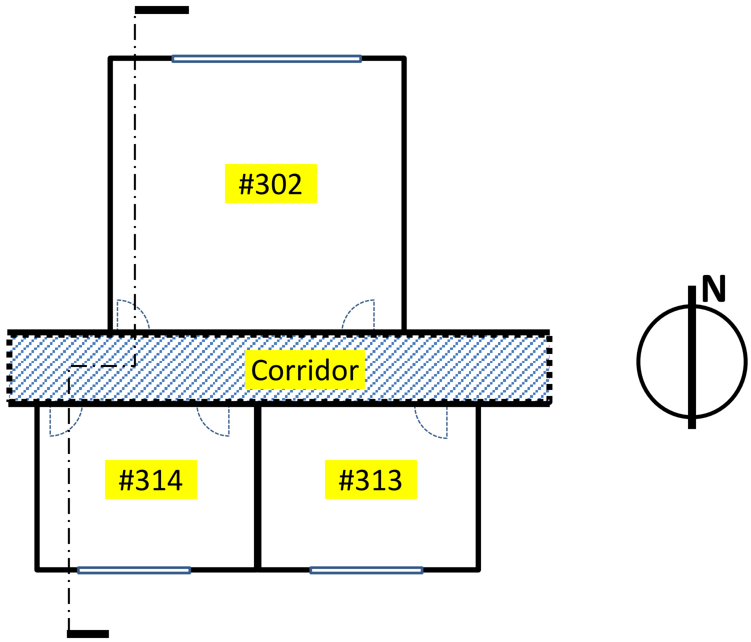


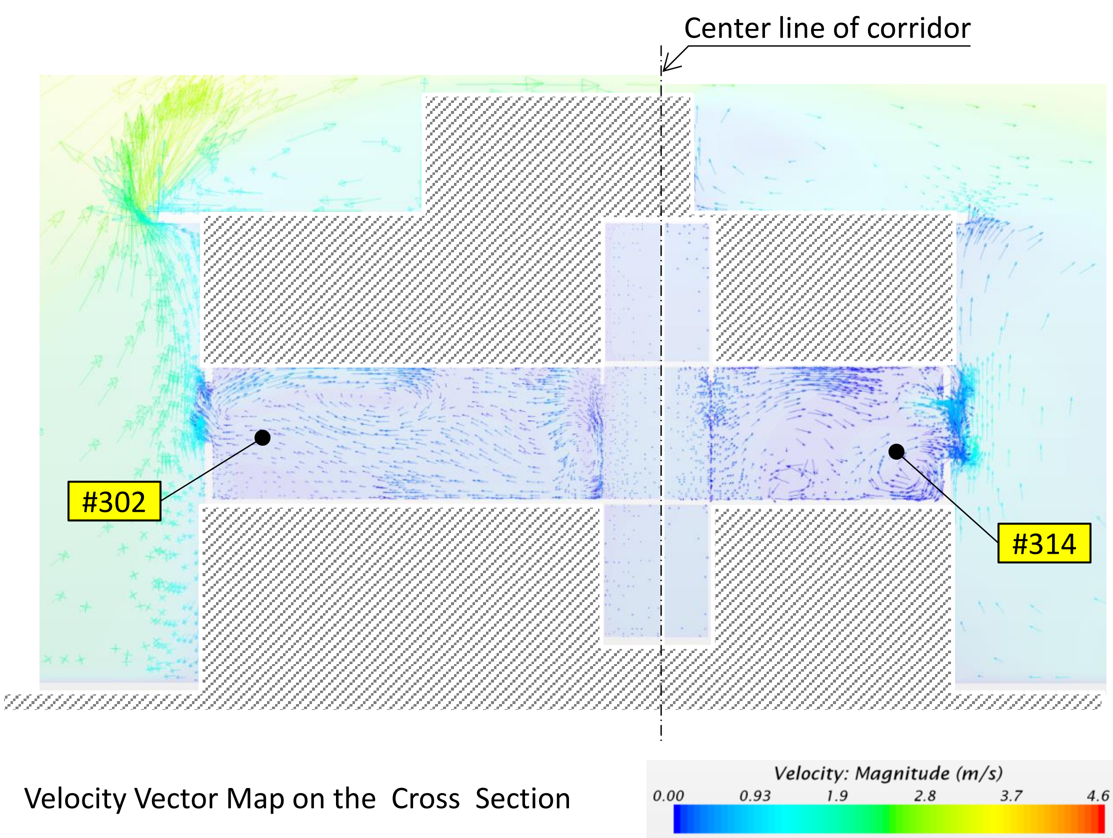


Velocity Contour Map on the Cross Section

SCENARIO 1

CFD Visualization Analysis

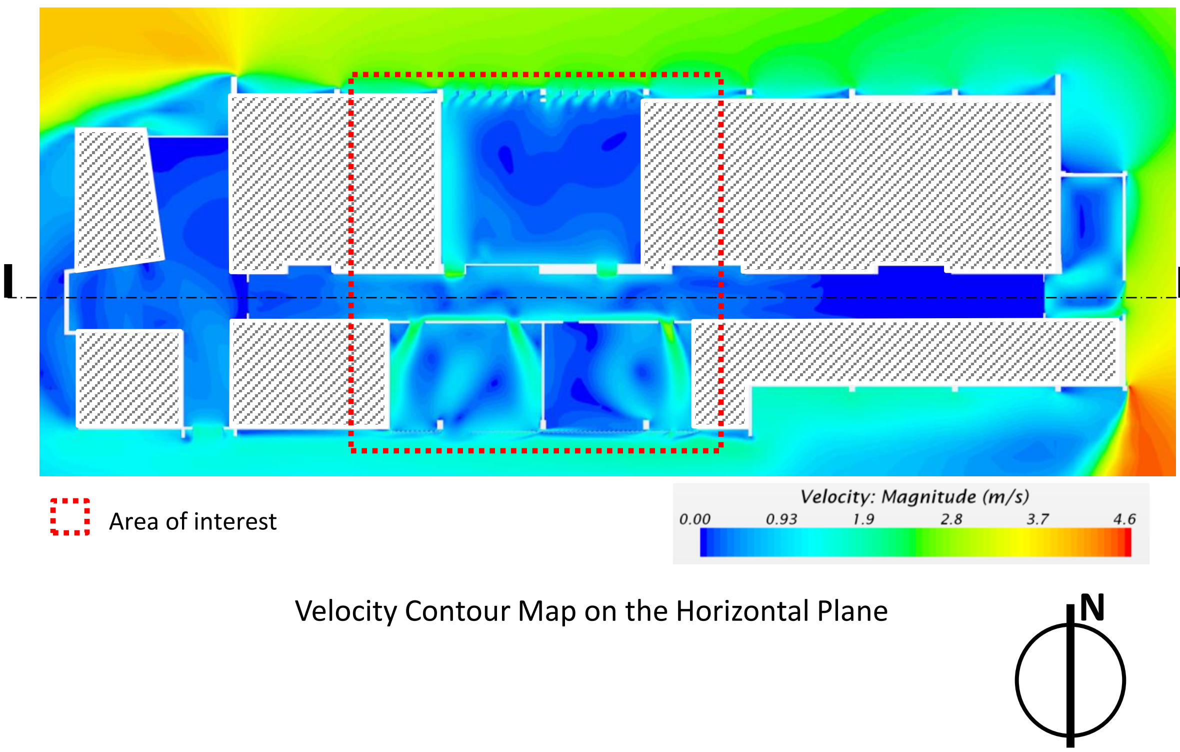




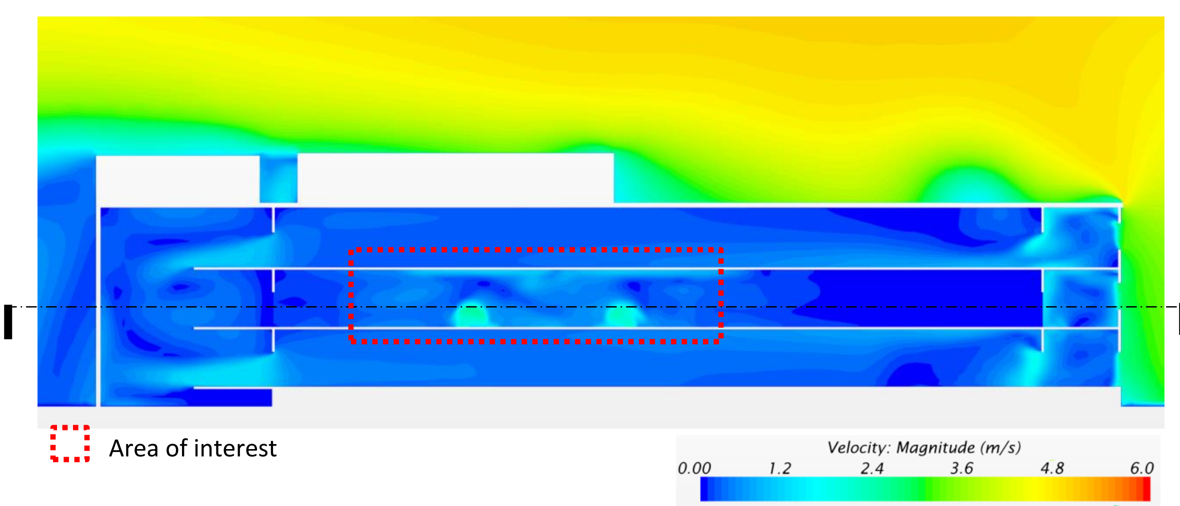
Velocity Vector Map on the Cross Section

SCENARIO 2

CFD Visualization Analysis



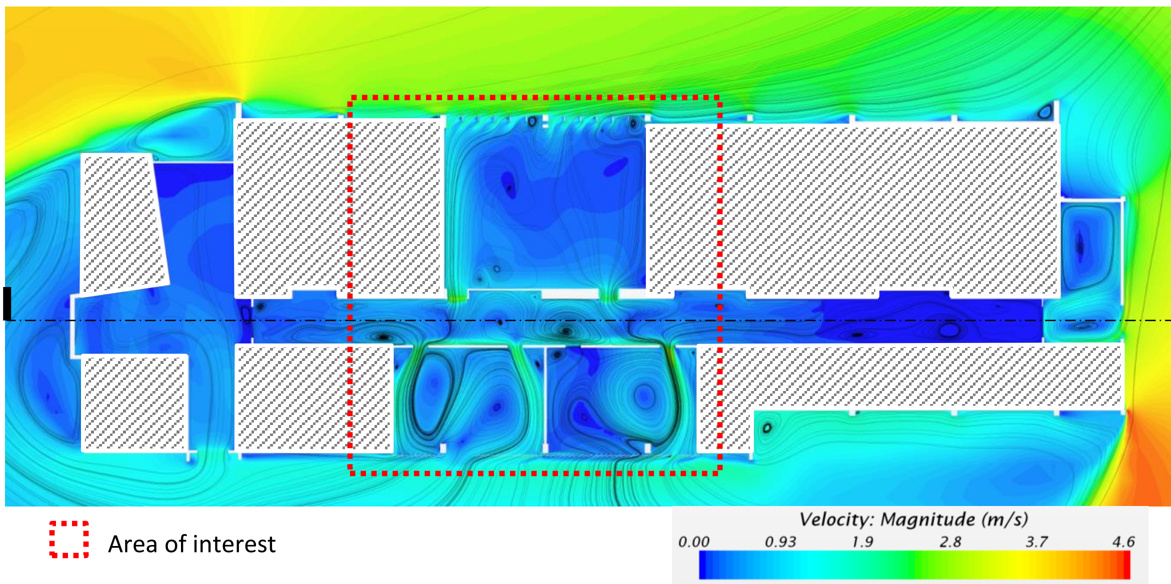
Velocity Contour Map on the Horizontal Plane



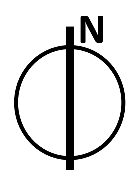
Velocity Contour Map on the Longitudinal Section Plane

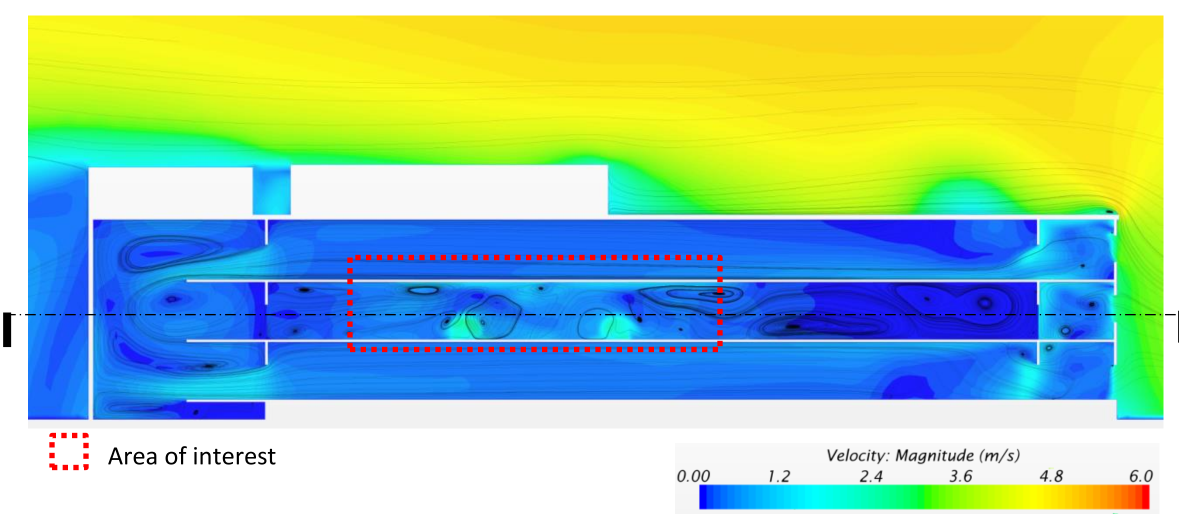
SCENARIO 2

CFD Visualization Analysis



Streamline overlaid on Velocity Contour Map on the Horizontal Plane

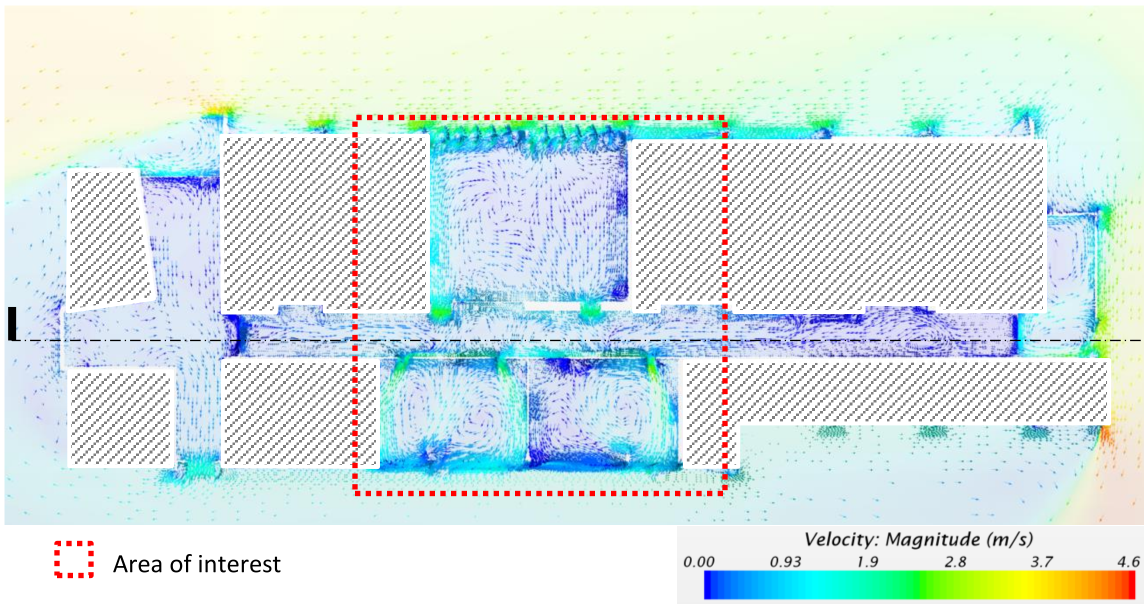




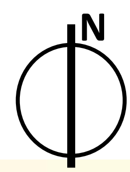
Streamline overlaid on Velocity Contour Map on the Longitudinal Section Plane

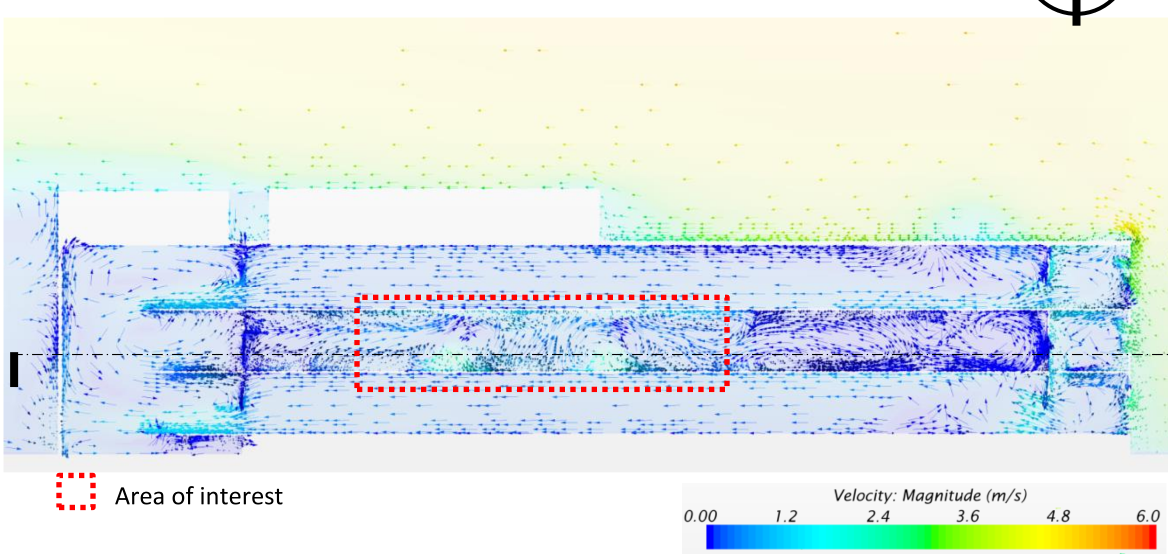
SCENARIO 2

CFD Visualization Analysis



Velocity Contour Map on the Horizontal Plane

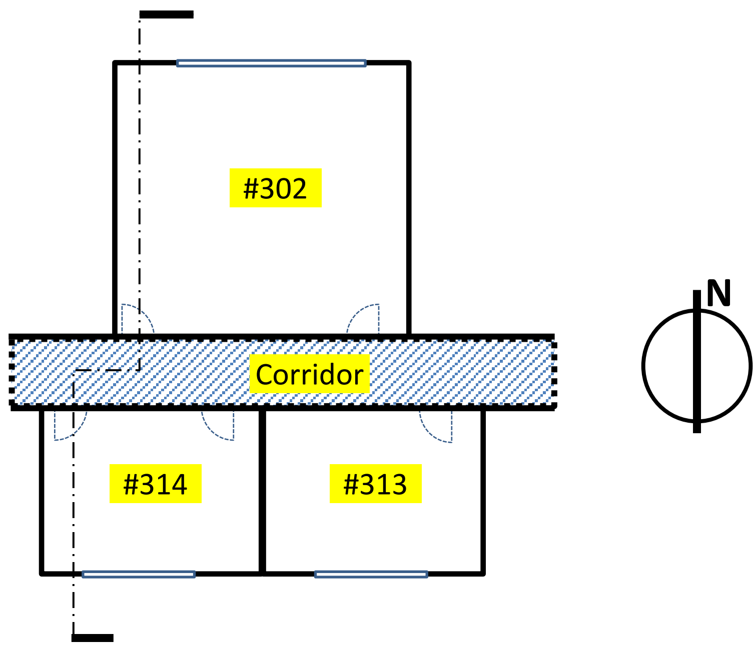


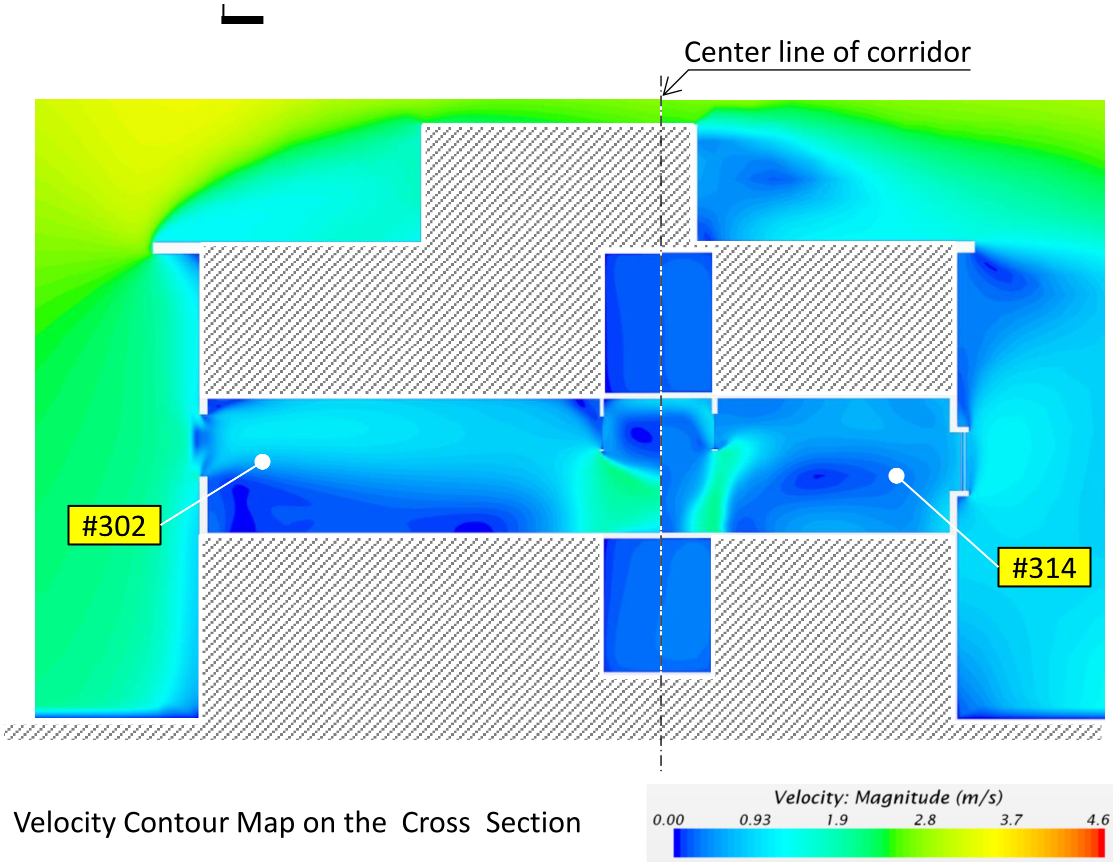


Velocity Vector Map on the Longitudinal Section Plane

SCENARIO 2

CFD Visualization Analysis

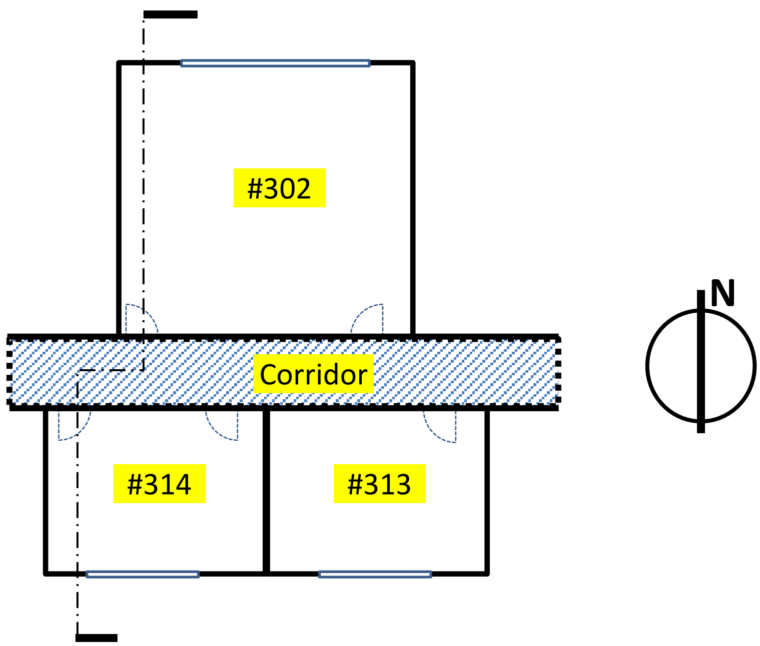


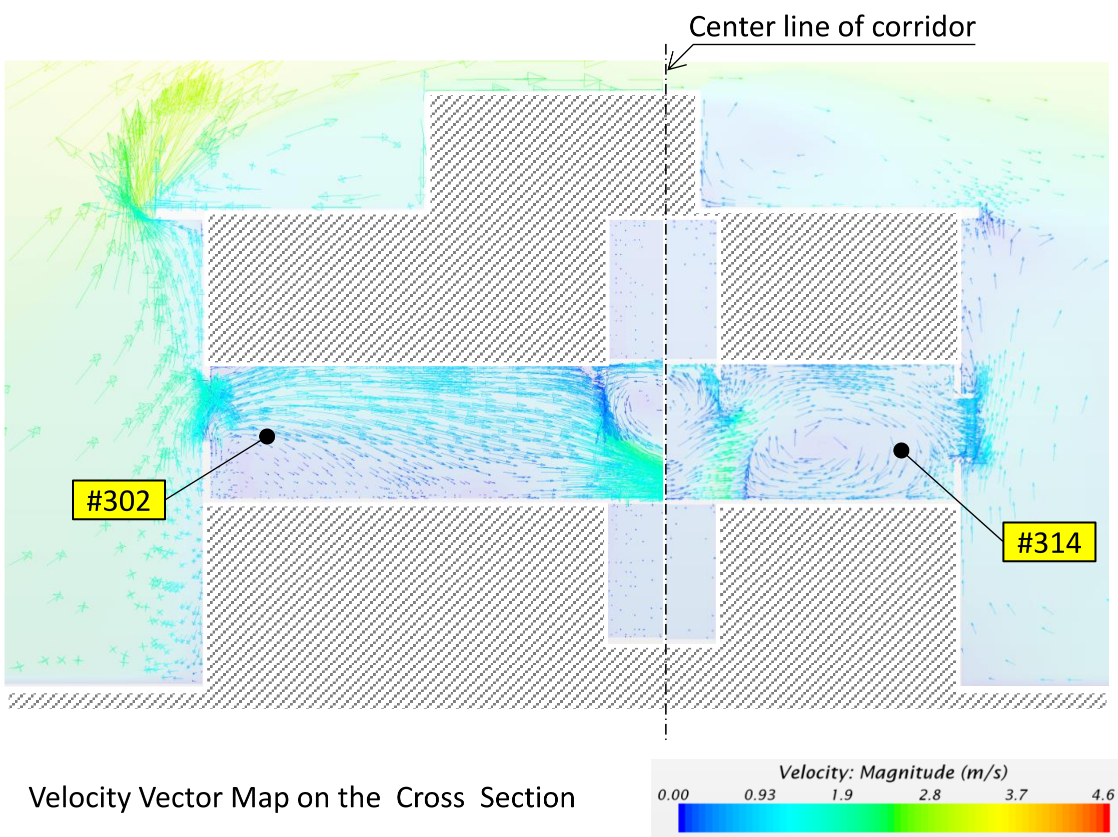


Velocity Contour Map on the Cross Section

SCENARIO 2

CFD Visualization Analysis

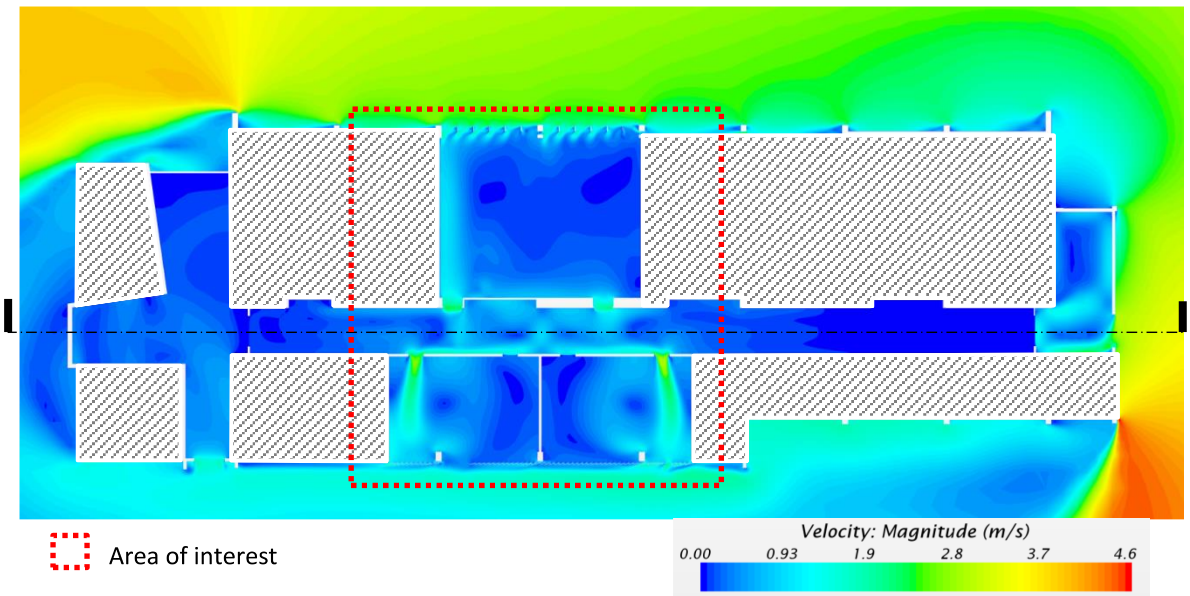




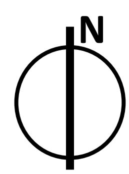
Velocity Vector Map on the Cross Section

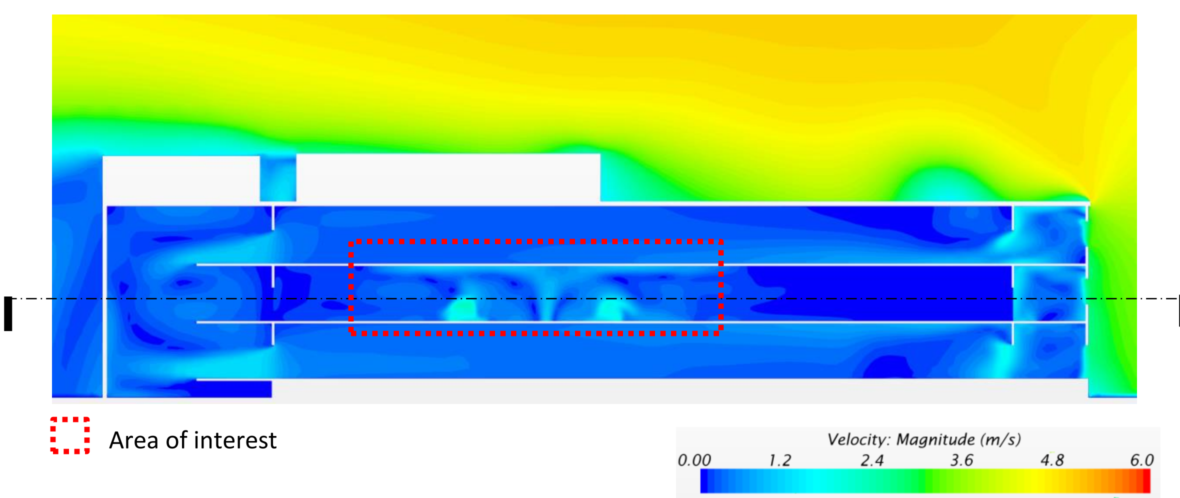
SCENARIO 3

CFD Visualization Analysis



Velocity Contour Map on the Horizontal Plane

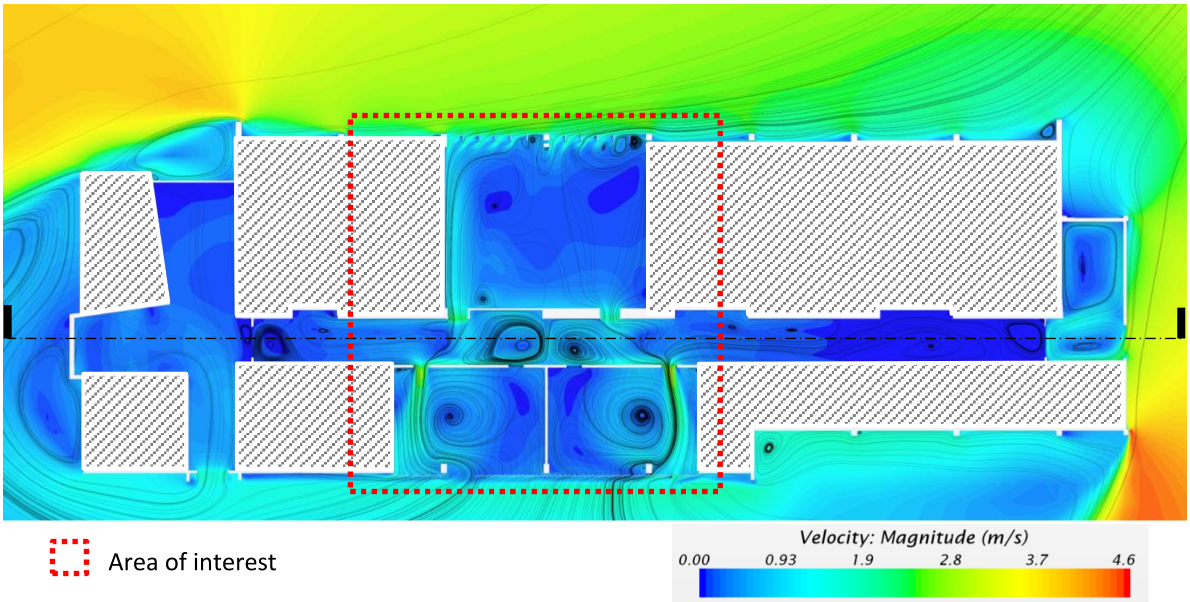




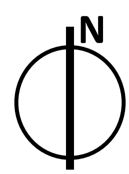
Velocity Contour Map on the Longitudinal Section Plane

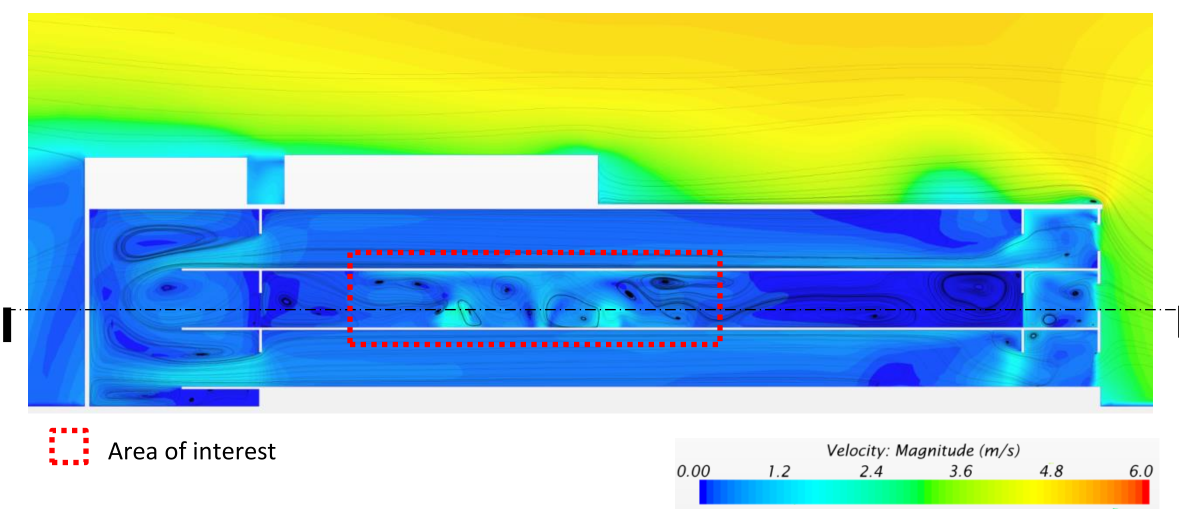
SCENARIO 3

CFD Visualization Analysis



Streamline overlaid on Velocity Contour Map on the Horizontal Plane

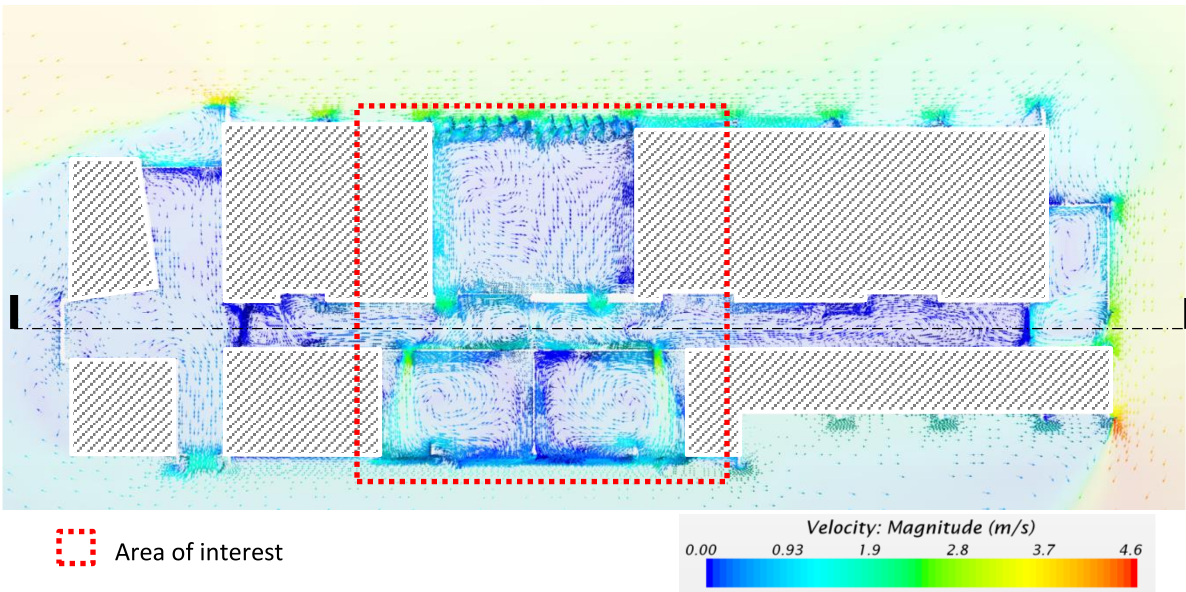




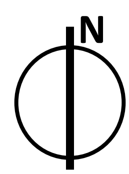
Streamline overlaid on Velocity Contour Map on the Longitudinal Section Plane

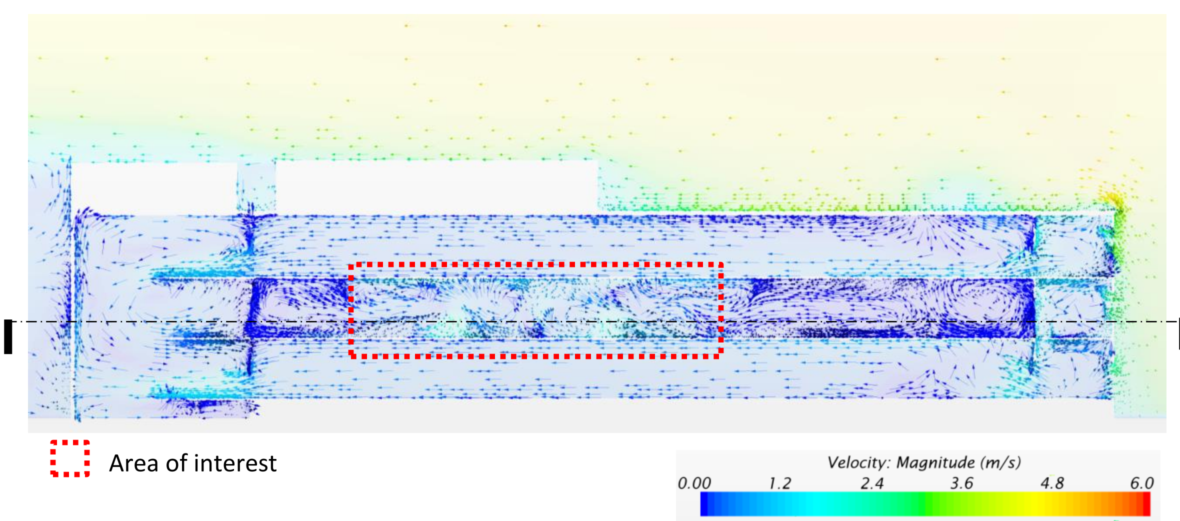
SCENARIO 3

CFD Visualization Analysis



Velocity Contour Map on the Horizontal Plane

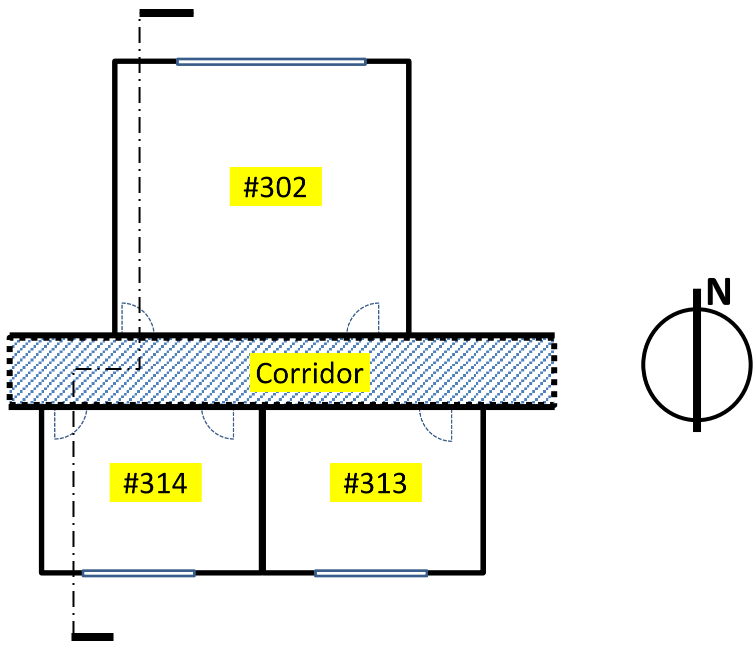


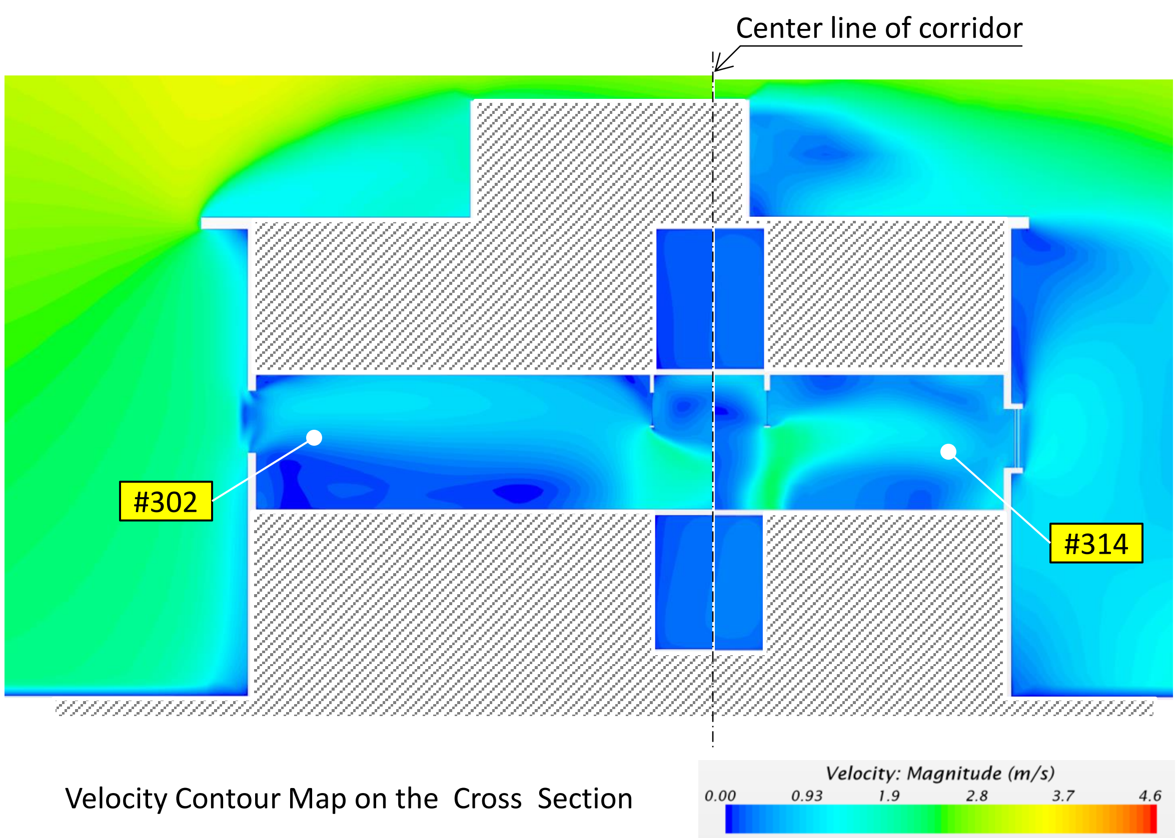


Velocity Vector Map on the Longitudinal Section Plane

SCENARIO 3

CFD Visualization Analysis

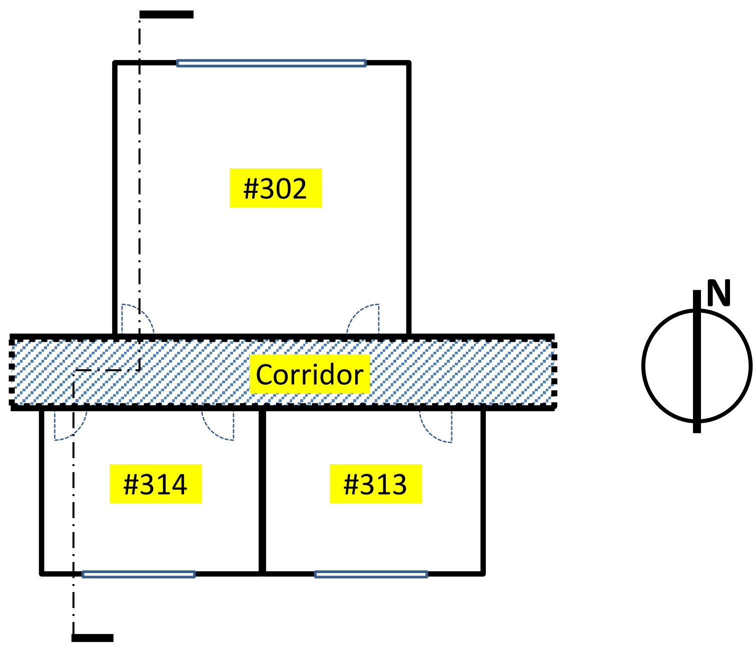


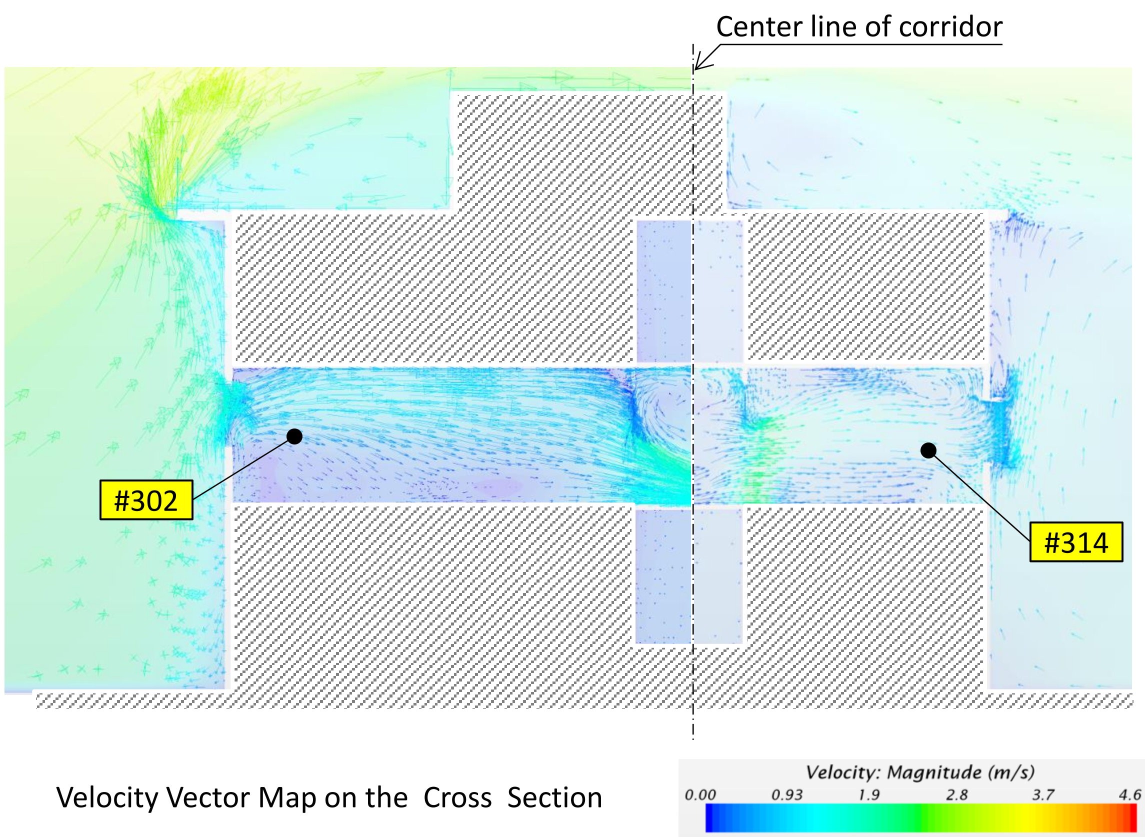


Velocity Contour Map on the Cross Section

SCENARIO 3

CFD Visualization Analysis

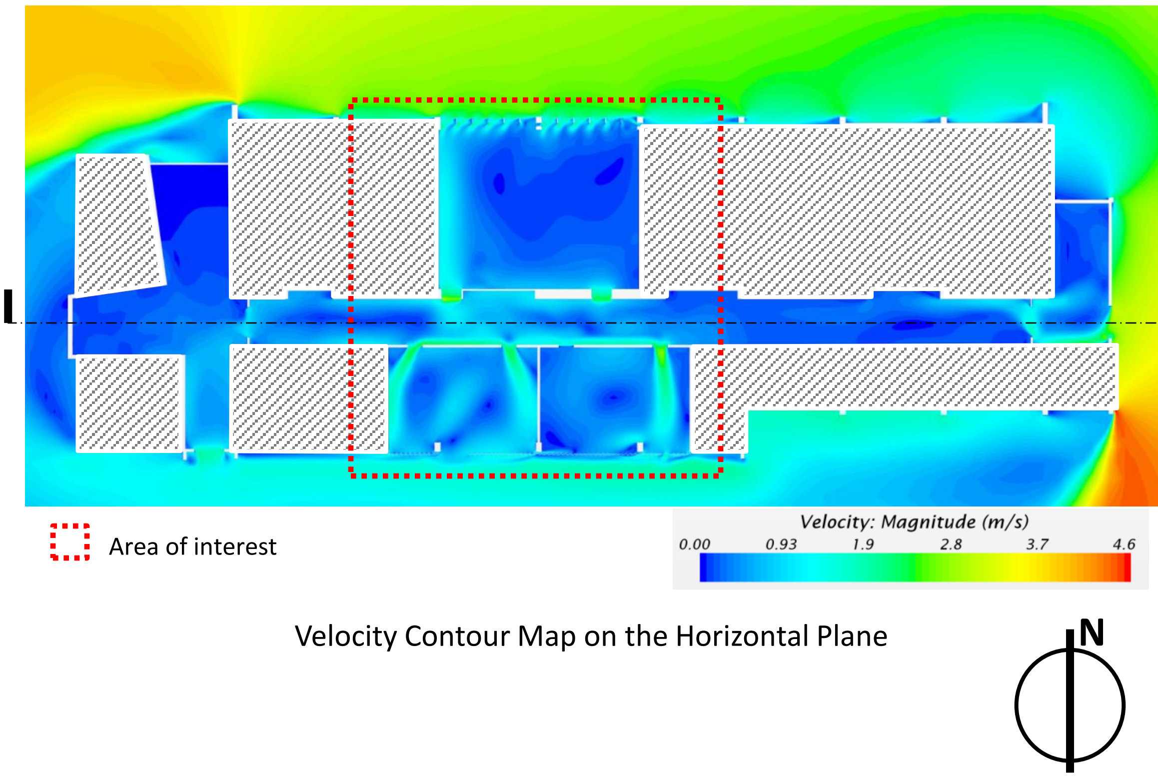




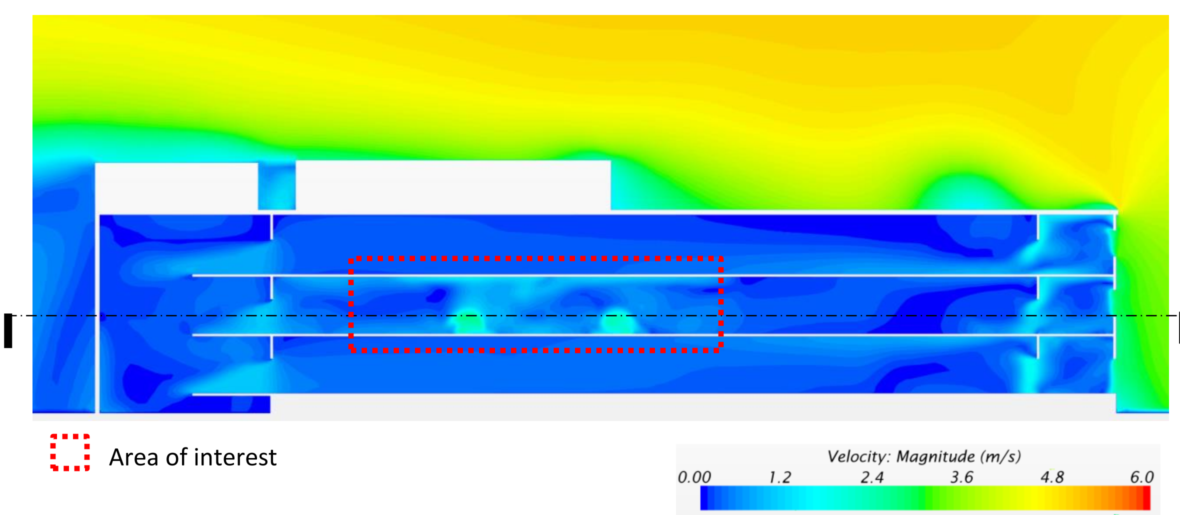
Velocity Vector Map on the Cross Section

SCENARIO 4

CFD Visualization Analysis



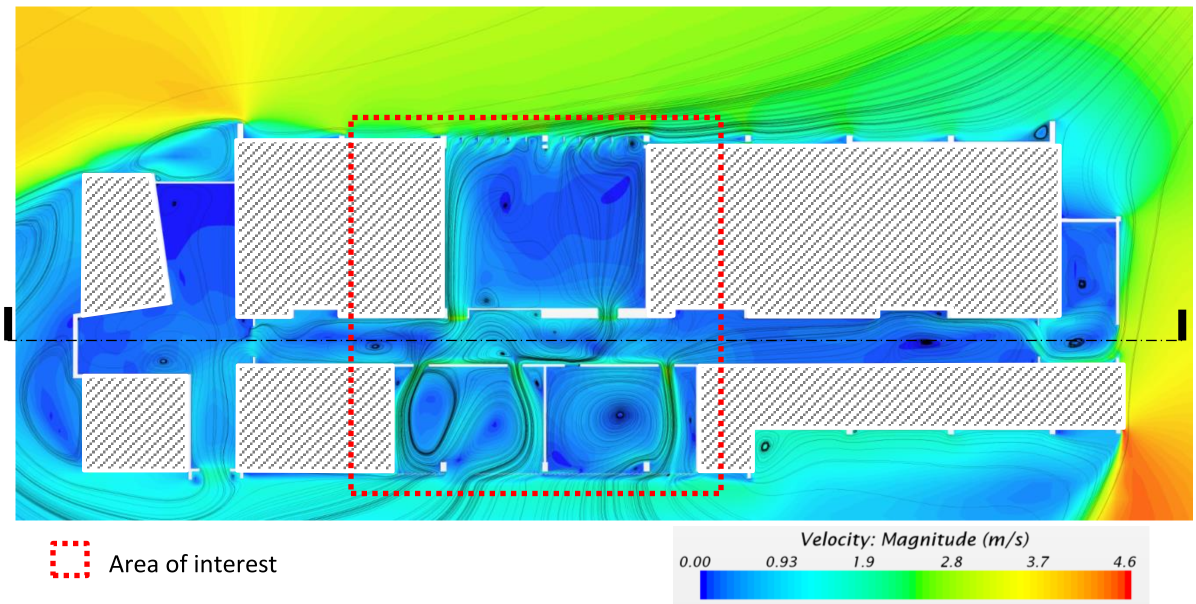
Velocity Contour Map on the Horizontal Plane



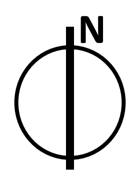
Velocity Contour Map on the Longitudinal Section Plane

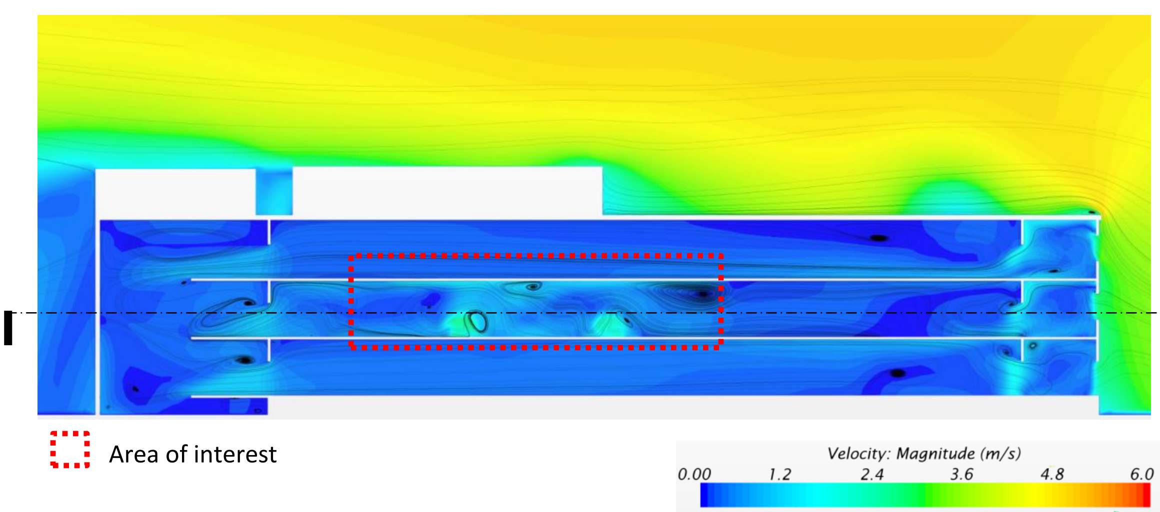
SCENARIO 4

CFD Visualization Analysis



Streamline overlaid on Velocity Contour Map on the Horizontal Plane

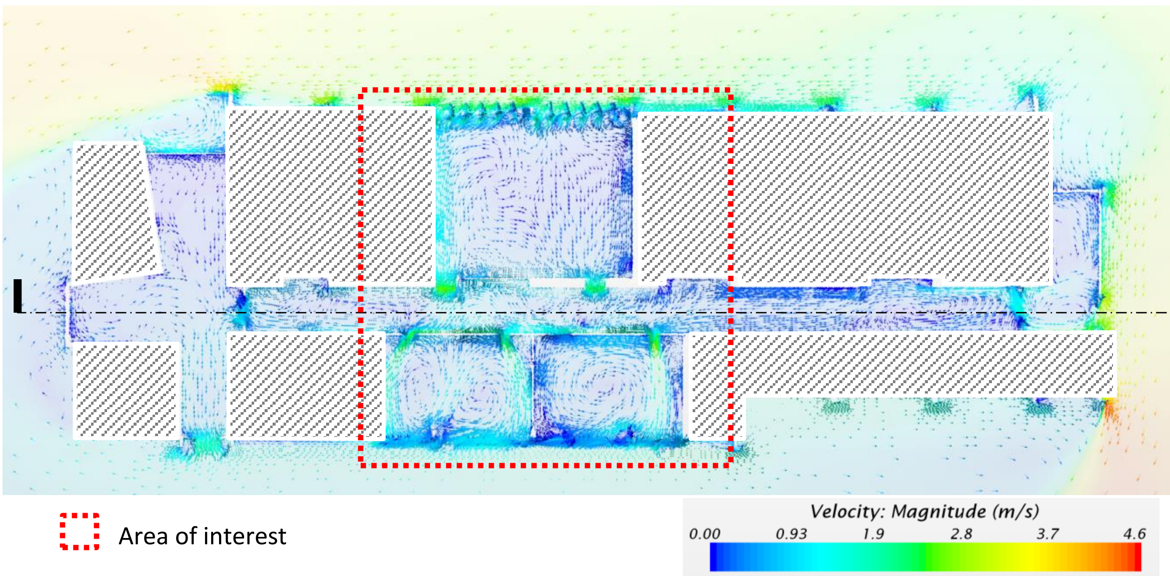




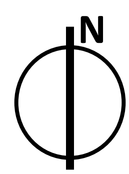
Streamline overlaid on Velocity Contour Map on the Longitudinal Section Plane

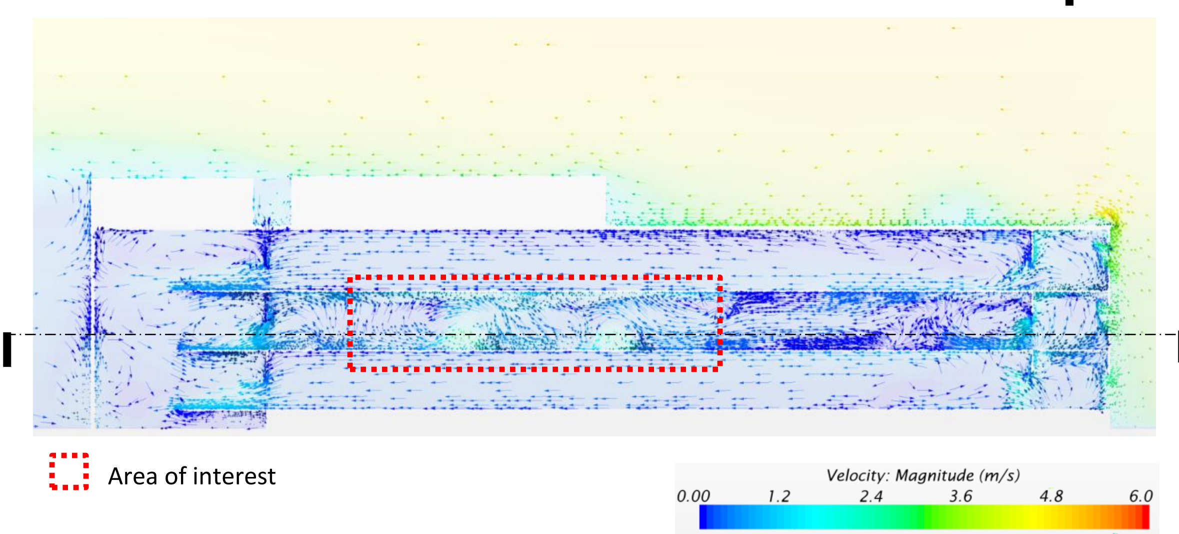
SCENARIO 4

CFD Visualization Analysis



Velocity Contour Map on the Horizontal Plane

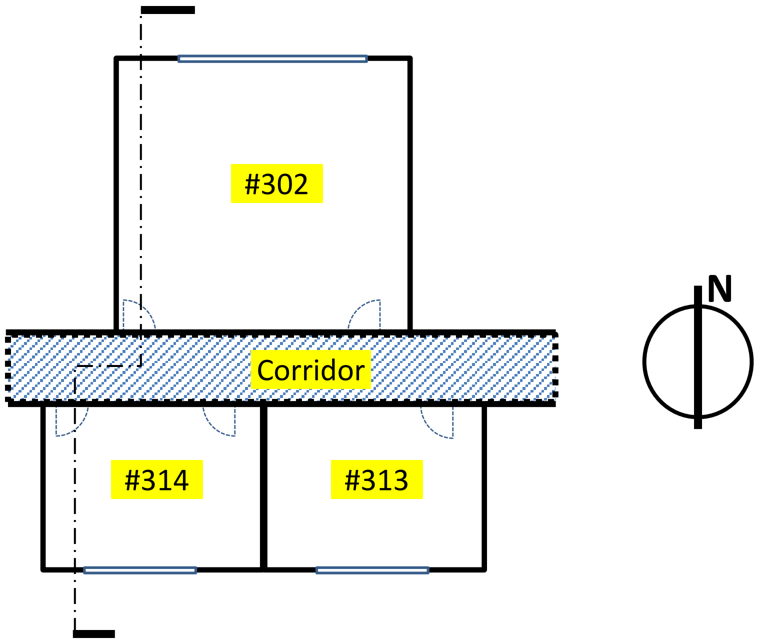


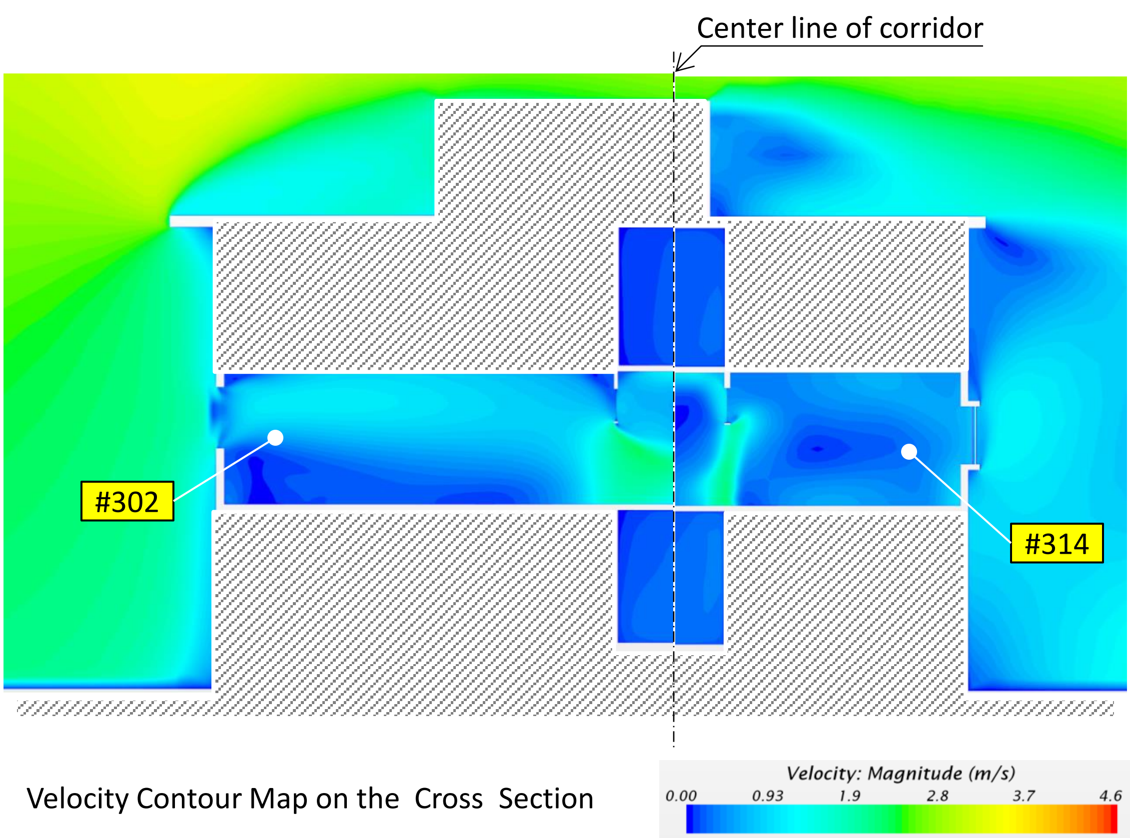


Velocity Vector Map on the Longitudinal Section Plane

SCENARIO 4

CFD Visualization Analysis

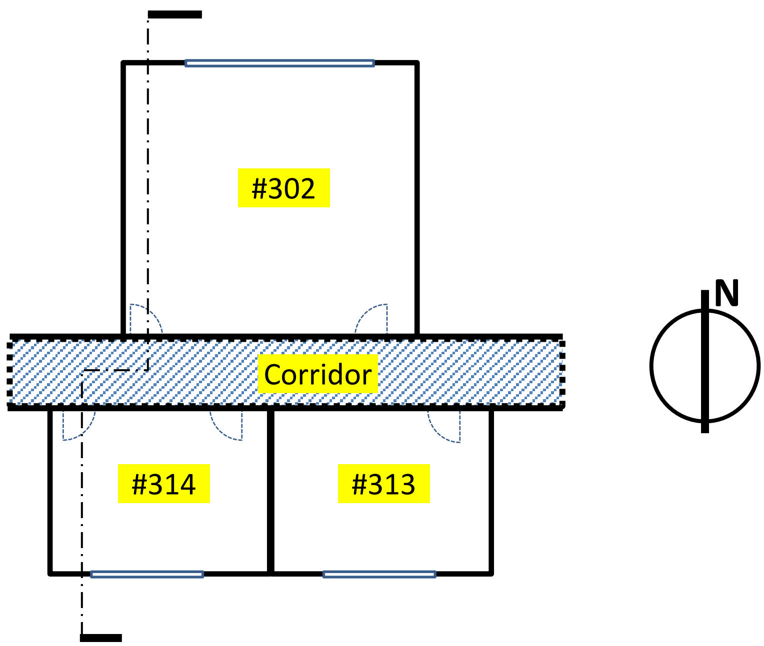


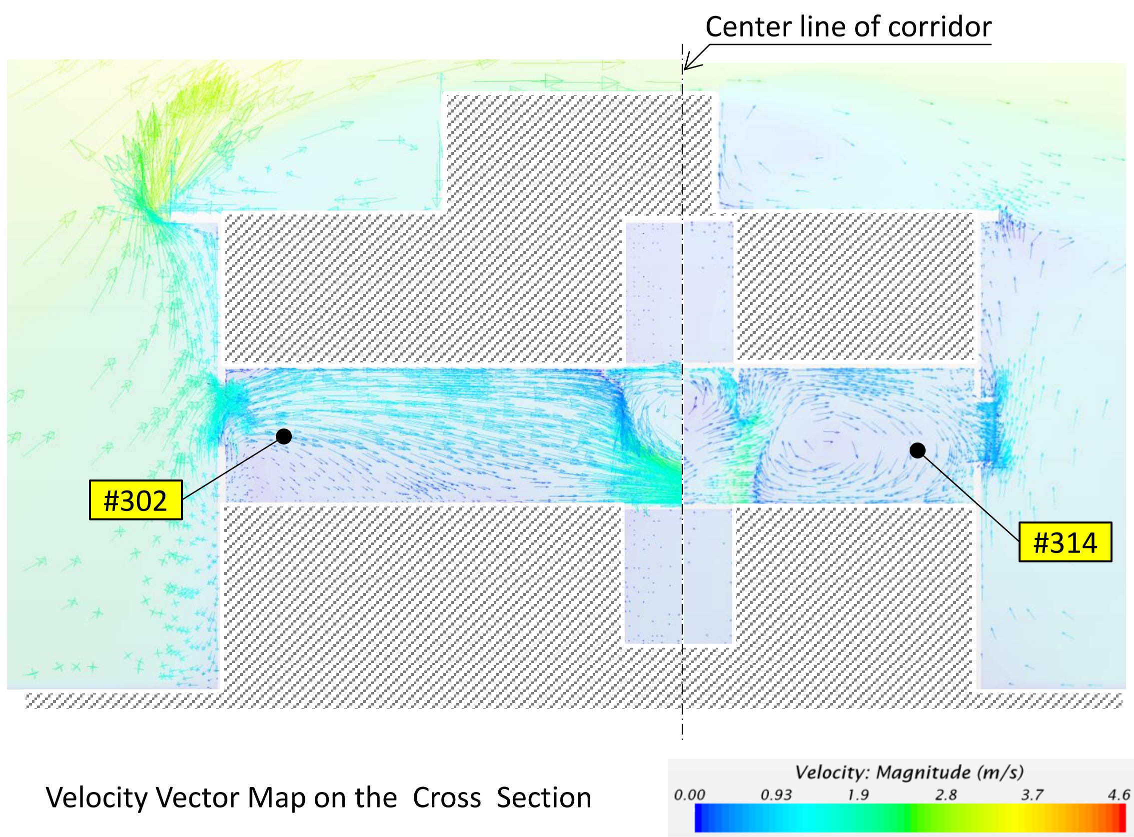


Velocity Contour Map on the Cross Section

SCENARIO 4

CFD Visualization Analysis

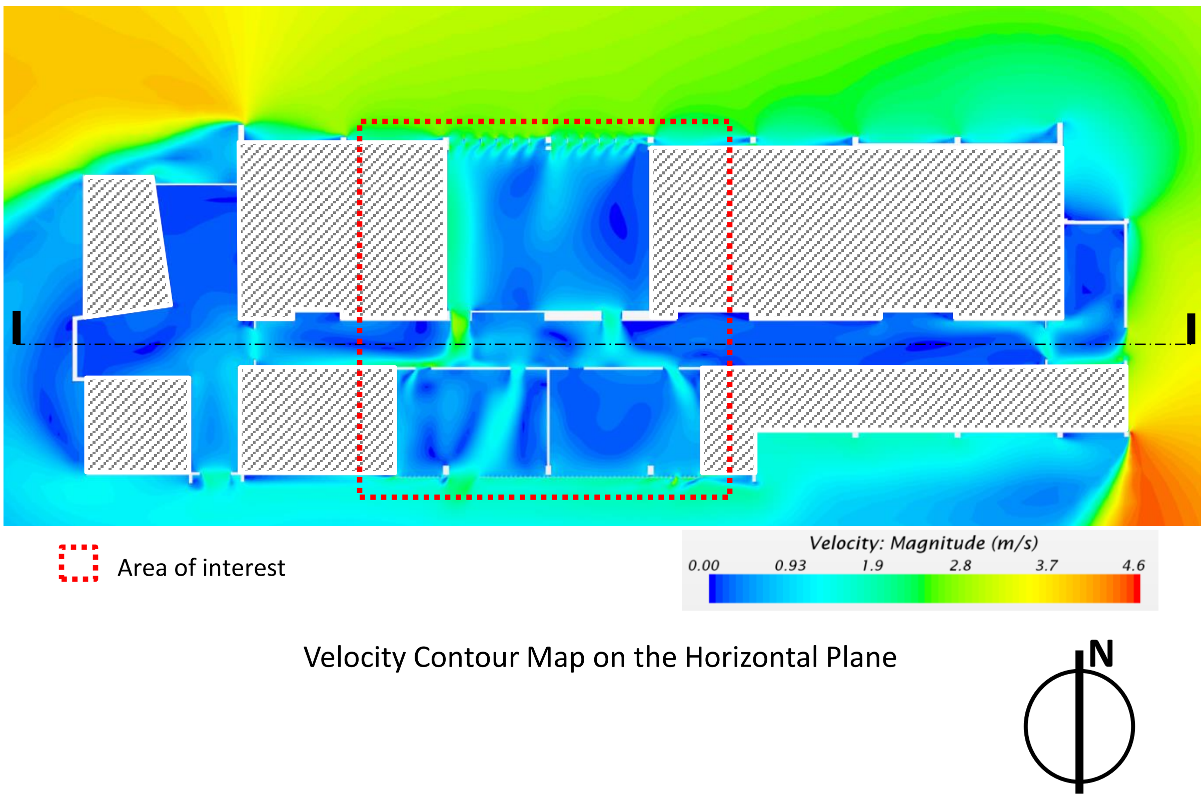




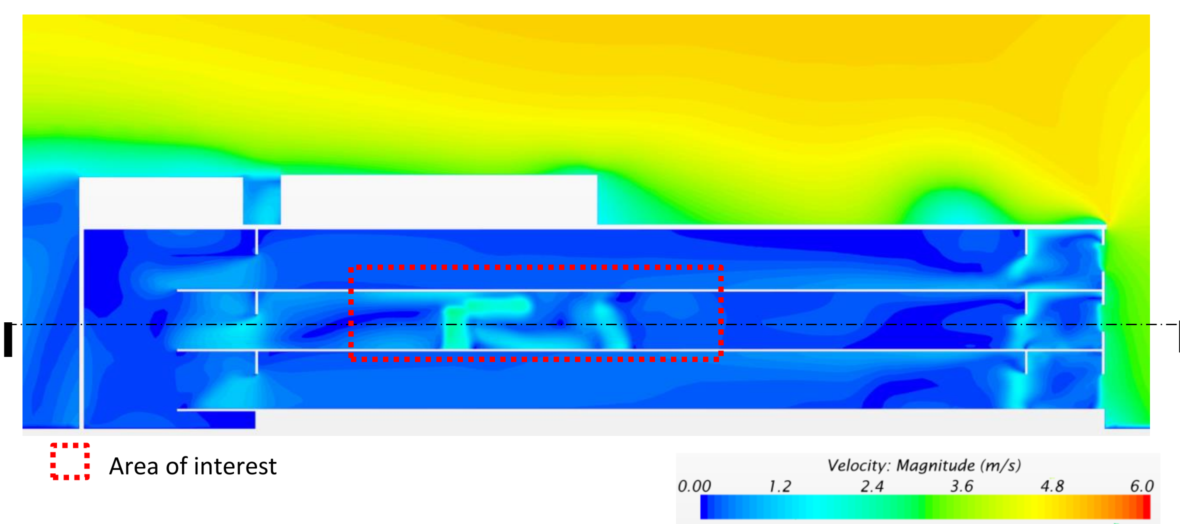
Velocity Vector Map on the Cross Section

SCENARIO 5

CFD Visualization Analysis



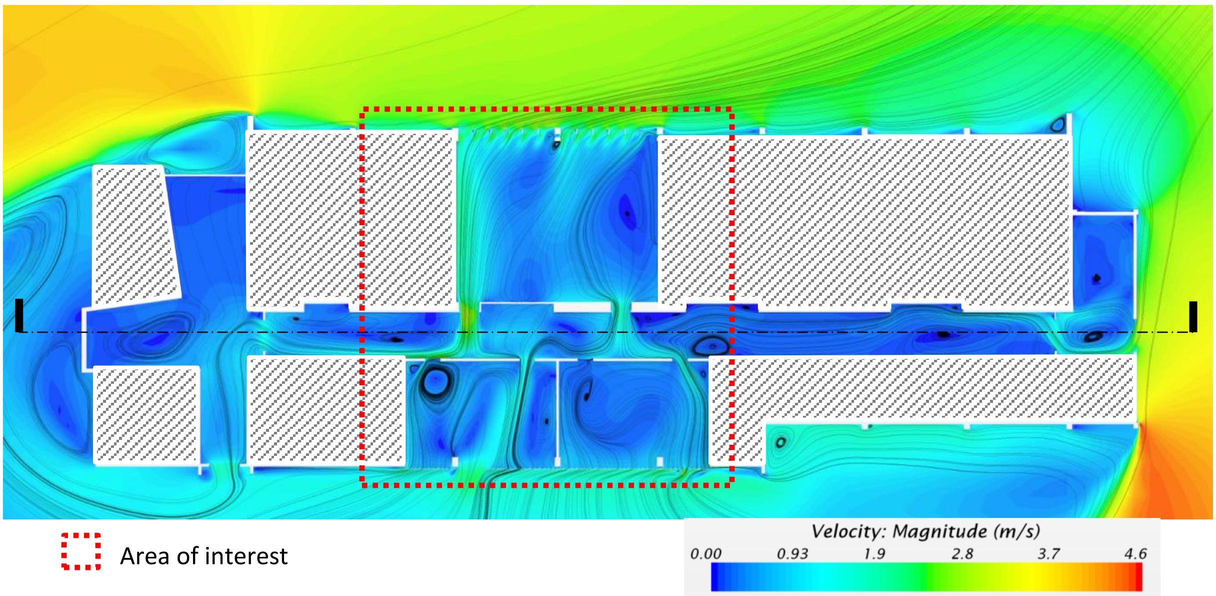
Velocity Contour Map on the Horizontal Plane



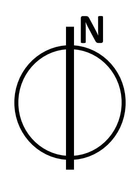
Velocity Contour Map on the Longitudinal Section Plane

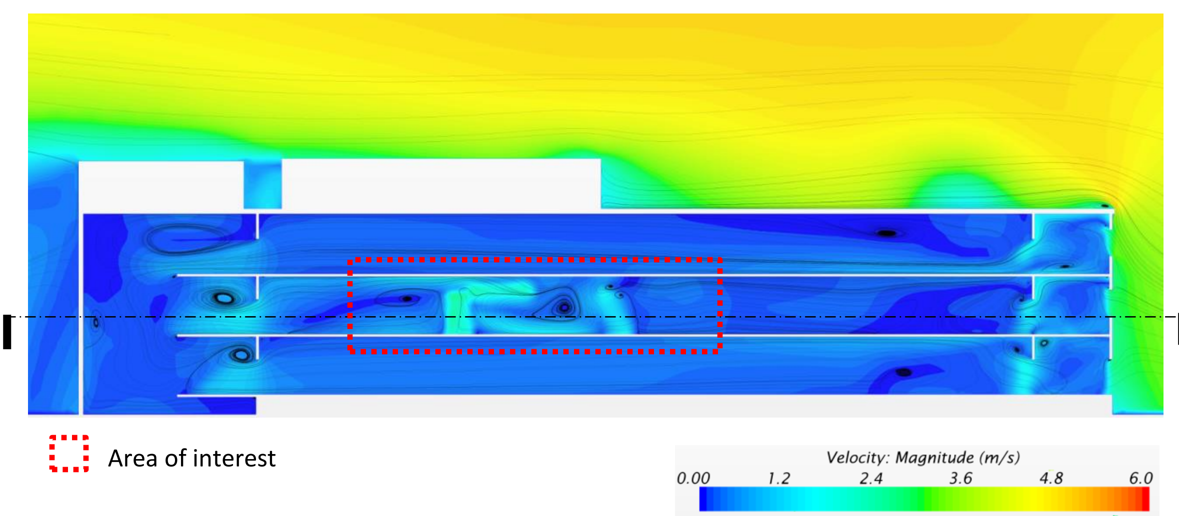
SCENARIO 5

CFD Visualization Analysis



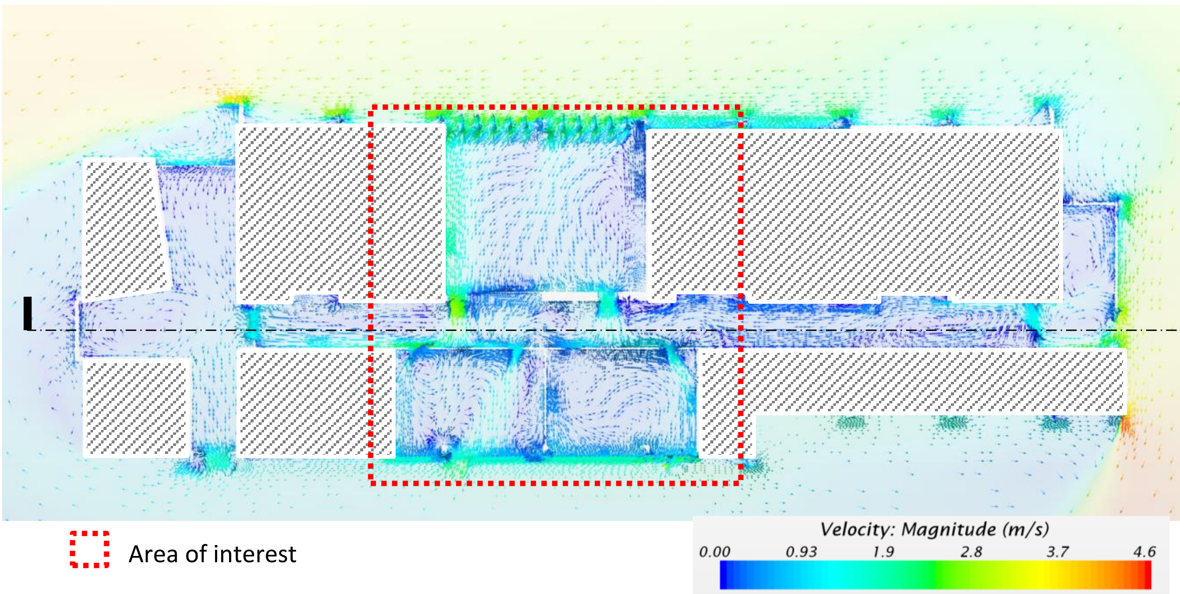
Streamline overlaid on Velocity Contour Map on the Horizontal Plane



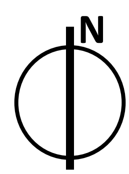


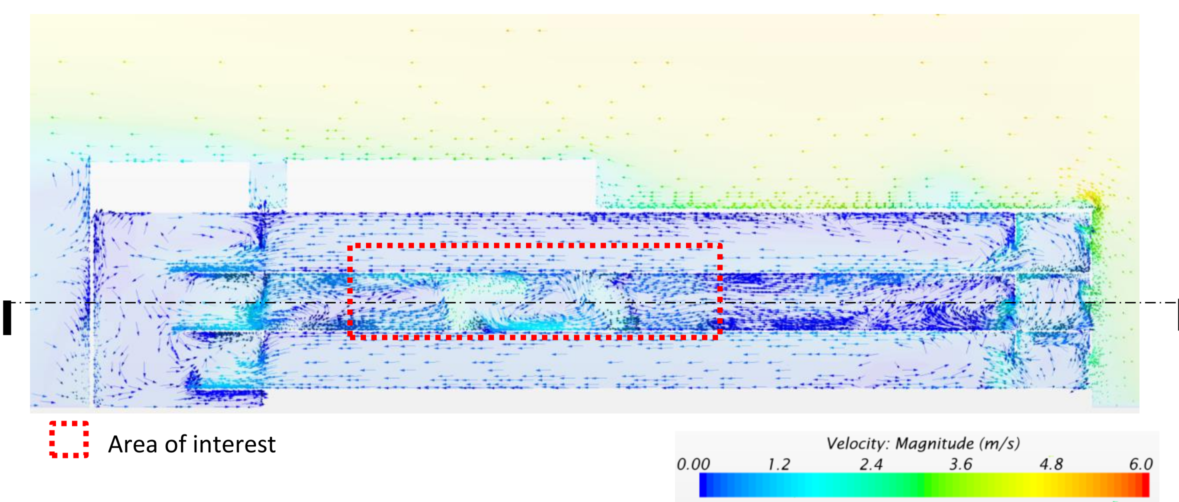
Streamline overlaid on Velocity Contour Map on the Longitudinal Section Plane

SCENARIO 5
CFD Visualization Analysis



Velocity Contour Map on the Horizontal Plane

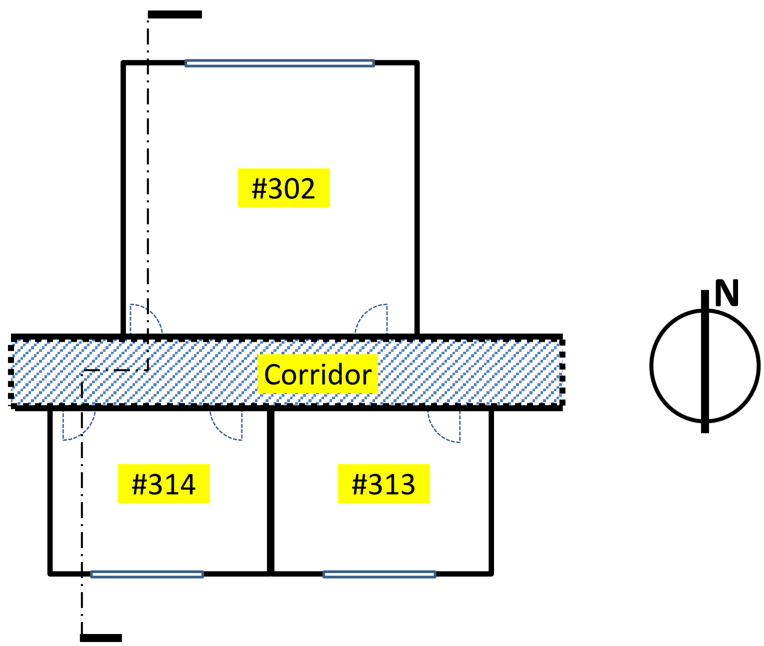


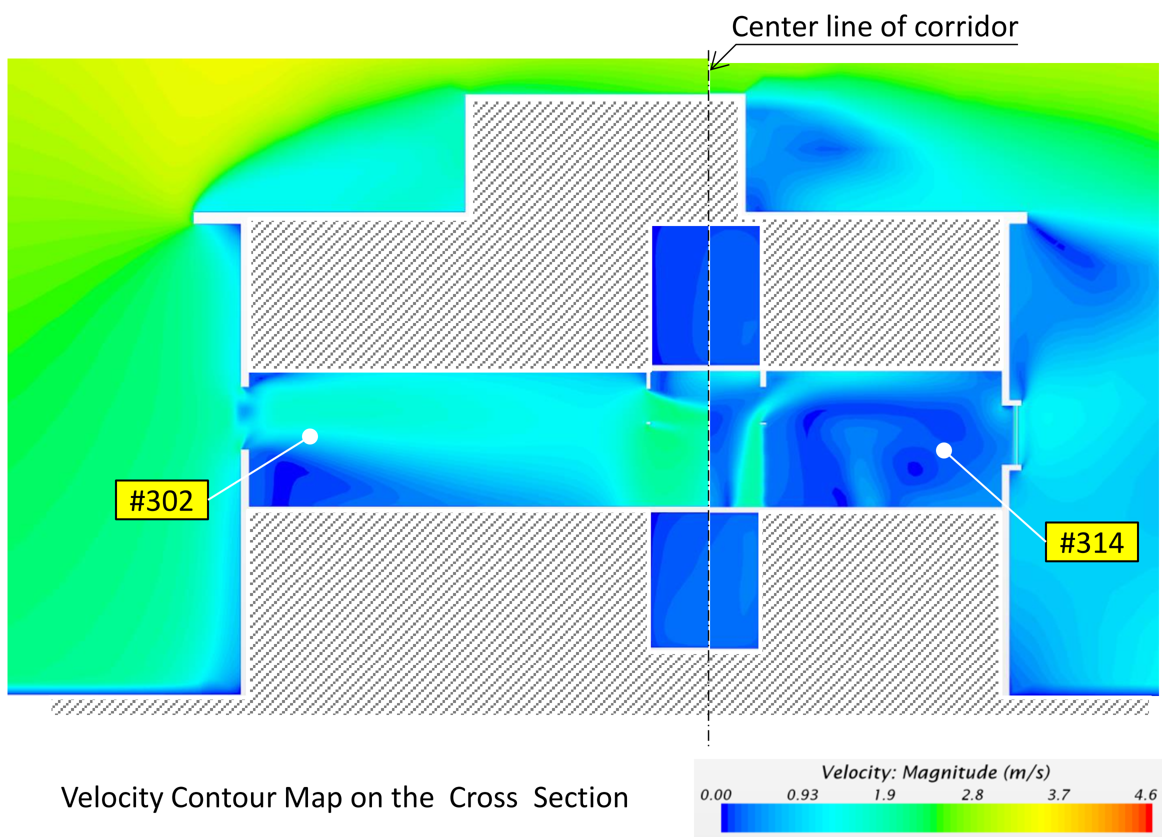


Velocity Vector Map on the Longitudinal Section Plane

SCENARIO 5

CFD Visualization Analysis

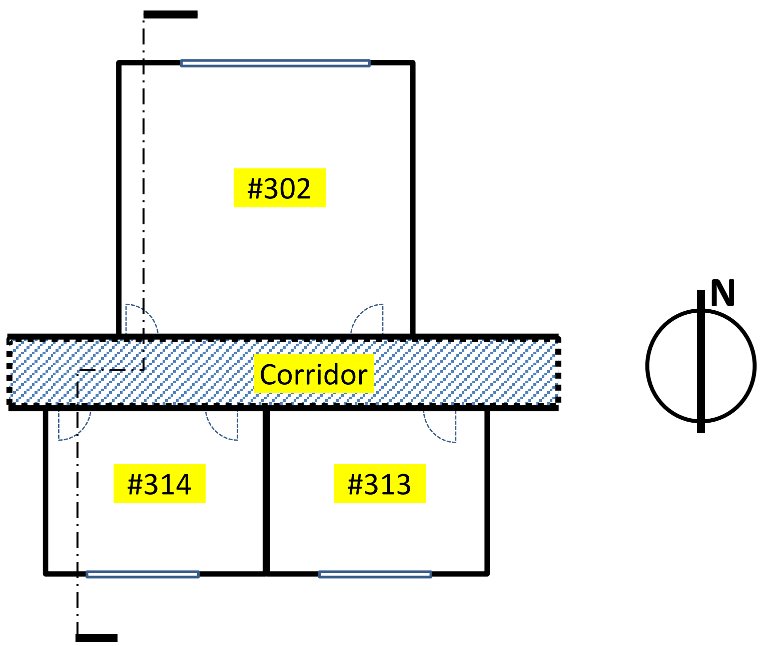


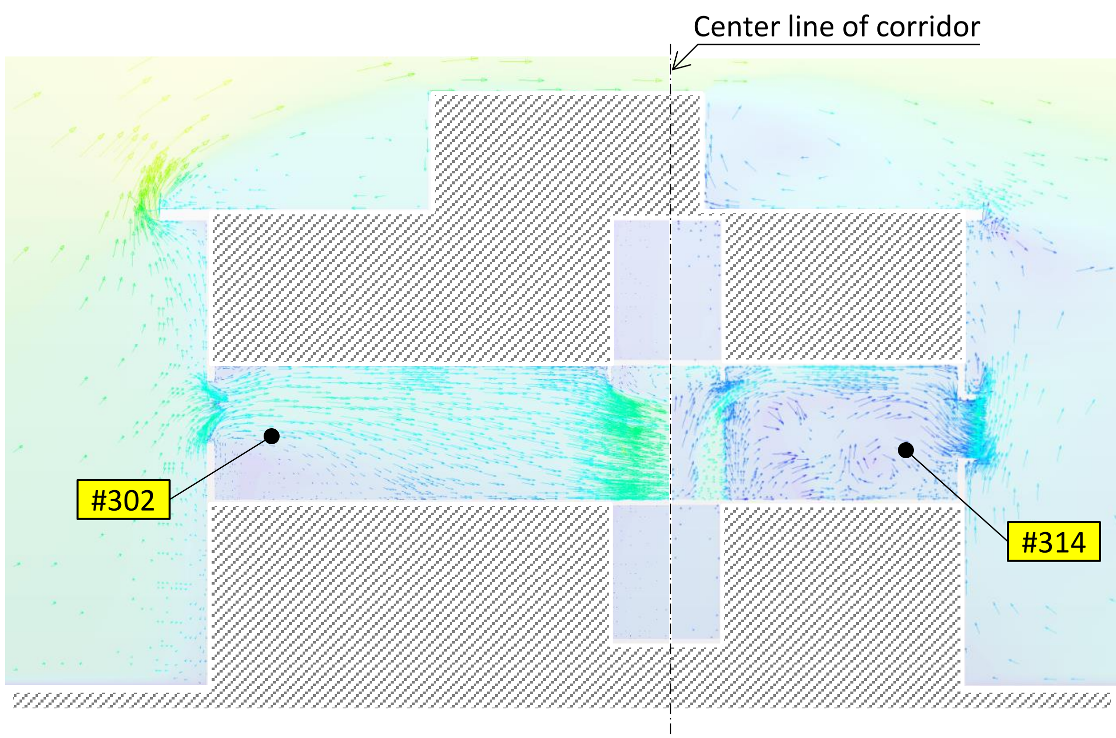


Velocity Contour Map on the Cross Section

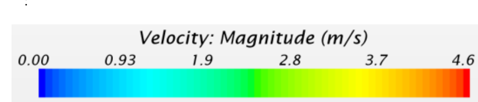
SCENARIO 5

CFD Visualization Analysis





Velocity Vector Map on the Cross Section



APPENDIX B

VISUALIZATIONS OF INTERNAL AIR FLOW PATTERNS FOR SELCTED CONTROL SURFACES FOR FIVE TEST SCENARIOS

SIMULATION DATA ANALYSIS
(Scenario 1 - Opening A7E)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height ..																										
3.50	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0
3.32	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1
3.15	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1
2.97	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1
2.80	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1
2.62	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1
2.45	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1
2.27	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.1
2.10	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.1
1.92	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.1
1.75	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.1
1.57	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.1
1.40	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.1
1.22	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.1
1.05	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.3	-0.1
0.87	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.3	-0.1
0.70	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.3	-0.1
0.52	0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.3	-0.1
0.35	0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.3	-0.1
0.17	0.0	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.4	-0.4	-0.4	-0.4	-0.5	-0.5	-0.4	-0.4	-0.4	-0.4	-0.3	-0.3	-0.1
0.00	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	0.0

0.00 0.50 1.00 1.50 2.00 2.50

Width (m)

Average per Column (m/s)

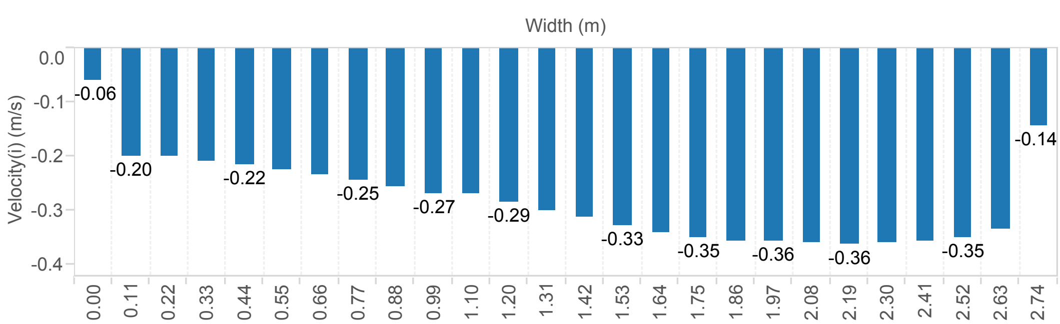
Height (m)	
3.50	-0.05
3.32	-0.18
3.15	-0.19
2.97	-0.20
2.80	-0.21
2.62	-0.21
2.45	-0.22
2.27	-0.23
2.10	-0.24
1.92	-0.24
1.75	-0.25
1.57	-0.26
1.40	-0.27
1.22	-0.27
1.05	-0.28
0.87	-0.29
0.70	-0.29
0.52	-0.29
0.35	-0.29
0.17	-0.28
0.00	-0.11

Average per Row (m/s)

Width (m)

0.00	0.11	0.22	0.33	0.44	0.55	0.66	0.77	0.88	0.99	1.10	1.20	1.31	1.42	1.53	1.64	1.75	1.86	1.97	2.08	2.19	2.30	2.41	2.52	2.63	2.74
-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2	-0.1

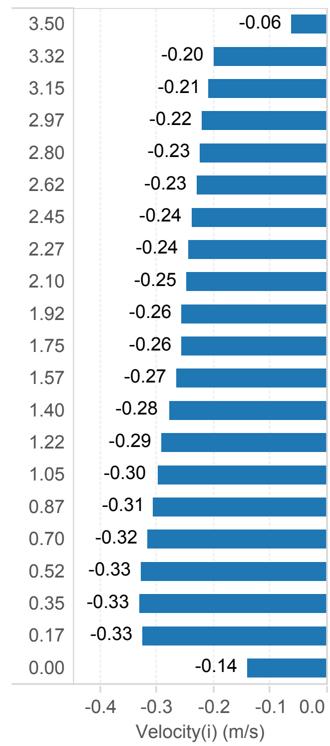
Horizontal Wind Profile at the Probe Location



Width (m) *All*

Height (m) *1.05*

Vertical WInd Profile at the Probe Location



Width (m) *1.31*

Height (m) *All*

Average Volume Flow Rate Across the Opening

133.095 cm/min

Mean Velocity Across the Opening

-0.2316

in (airflow into control volume)

SIMULATION DATA ANALYSIS
(Scenario 1 - Opening A7W)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height ..																										
3.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.32	0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	0.0
3.15	0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	0.0
2.97	0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	0.0
2.80	-0.1	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	0.0
2.62	-0.1	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	0.0
2.45	-0.1	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	0.0
2.27	-0.1	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1
2.10	-0.1	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1
1.92	-0.1	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1
1.75	-0.1	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1
1.57	-0.1	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1
1.40	-0.1	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.1
1.22	-0.1	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.1
1.05	-0.1	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.1
0.87	-0.1	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.1
0.70	-0.1	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.1
0.52	-0.1	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.1
0.35	-0.1	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.1
0.17	-0.1	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.1	0.0
0.00	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0

0.00 0.50 1.00 1.50 2.00 2.50

Width (m)

Average per Column (m/s)

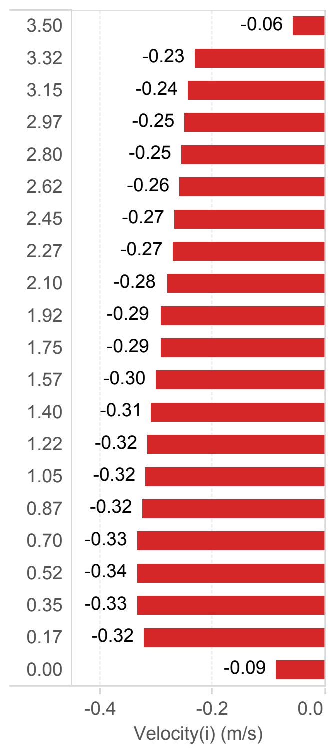
Height (m)	
3.50	-0.04
3.32	-0.18
3.15	-0.20
2.97	-0.21
2.80	-0.22
2.62	-0.22
2.45	-0.23
2.27	-0.24
2.10	-0.25
1.92	-0.25
1.75	-0.25
1.57	-0.26
1.40	-0.27
1.22	-0.27
1.05	-0.28
0.87	-0.28
0.70	-0.29
0.52	-0.29
0.35	-0.28
0.17	-0.26
0.00	-0.07

Average per Row (m/s)

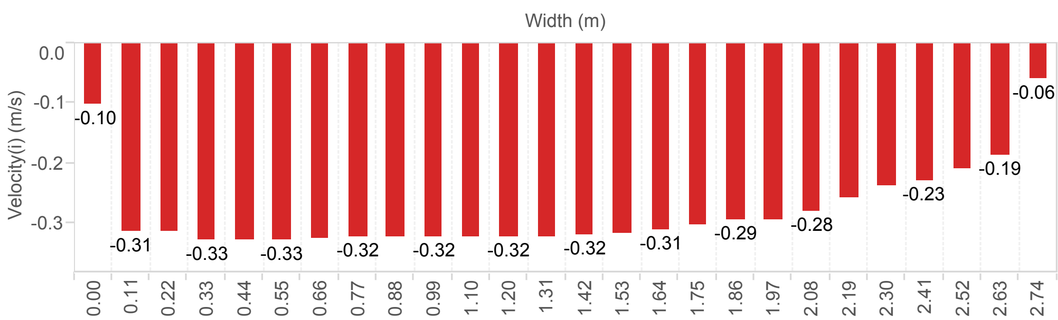
Width (m)

0.00	0.11	0.22	0.33	0.44	0.55	0.66	0.77	0.88	0.99	1.10	1.20	1.31	1.42	1.53	1.64	1.75	1.86	1.97	2.08	2.19	2.30	2.41	2.52	2.63	2.74
-0.1	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	0.0

Vertical WInd Profile at the Probe Location



Horizontal Wind Profile at the Probe Location



Width (m)	All	Height (m)	1.05

Average Volume Flow Rate Across the Opening

132.618 cm/min

Mean Velocity Across the Opening

-0.2308

out (airflow out from control volume)

Width (m)	1.31
Height (m)	All

SIMULATION DATA ANALYSIS
(Scenario 2 - Opening A0)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height (m)									
2.11	-1.50	-1.38	-1.31	-1.33	-1.37	-1.45	-1.52	-1.70	-1.48
1.99	-1.51	-1.78	-1.61	-1.51	-1.52	-1.57	-1.58	-1.46	0.16
1.87	-1.40	-1.73	-1.53	-1.47	-1.53	-1.62	-1.60	-1.40	0.37
1.76	-1.44	-1.70	-1.50	-1.49	-1.58	-1.64	-1.59	-1.37	0.41
1.64	-1.45	-1.65	-1.49	-1.52	-1.61	-1.64	-1.56	-1.15	0.37
1.52	-1.47	-1.62	-1.48	-1.55	-1.65	-1.66	-1.54	-1.00	0.46
1.41	-1.45	-1.59	-1.50	-1.60	-1.69	-1.66	-1.54	-0.90	0.47
1.29	-1.42	-1.55	-1.54	-1.66	-1.72	-1.66	-1.53	-1.12	0.47
1.17	-1.36	-1.54	-1.61	-1.71	-1.73	-1.64	-1.48	-0.95	0.24
1.05	-1.35	-1.55	-1.66	-1.76	-1.73	-1.61	-1.44	-0.63	0.50
0.94	-1.34	-1.61	-1.73	-1.78	-1.71	-1.58	-1.42	-0.91	0.50
0.82	-1.37	-1.66	-1.78	-1.77	-1.68	-1.53	-1.36	-0.83	0.20
0.70	-1.41	-1.70	-1.79	-1.75	-1.65	-1.49	-1.28	-0.41	0.45
0.59	-1.45	-1.72	-1.78	-1.73	-1.62	-1.47	-1.28	-0.40	0.48
0.47	-1.48	-1.70	-1.75	-1.70	-1.59	-1.45	-1.30	-0.86	0.25
0.35	-1.51	-1.69	-1.72	-1.66	-1.55	-1.40	-1.20	-0.37	0.44
0.23	-1.53	-1.65	-1.67	-1.61	-1.49	-1.33	-1.07	-0.20	0.37
0.12	-1.52	-1.62	-1.62	-1.55	-1.45	-1.29	-1.03	-0.12	0.23
0.00	-1.23	-1.42	-1.43	-1.32	-1.20	-1.25	-1.19	-1.05	-0.10

0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90

Width (m)

Average per Column (m/s)

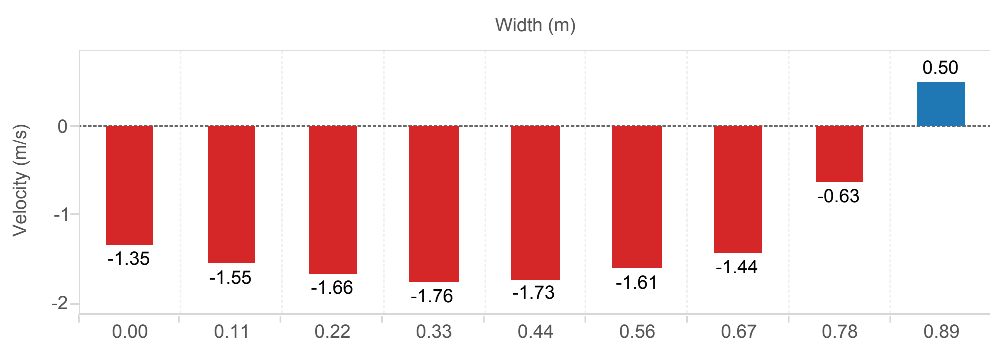
Height (m)	
2.11	**-1.45**
1.99	**-1.37**
1.87	**-1.32**
1.76	**-1.32**
1.64	**-1.30**
1.52	**-1.28**
1.41	**-1.27**
1.29	**-1.30**
1.17	**-1.31**
1.05	**-1.25**
0.94	**-1.29**
0.82	**-1.31**
0.70	**-1.23**
0.59	**-1.22**
0.47	**-1.29**
0.35	**-1.18**
0.23	**-1.13**
0.12	**-1.11**
0.00	**-1.13**

Average per Row (m/s)

Width (m)

0.00	0.11	0.22	0.22	0.33	0.44	0.56	0.67	0.78	0.89
-1.43	**-1.62**	**-1.70**	**-1.52**	**-1.60**	**-1.58**	**-1.52**	**-1.39**	**-0.89**	**0.25**

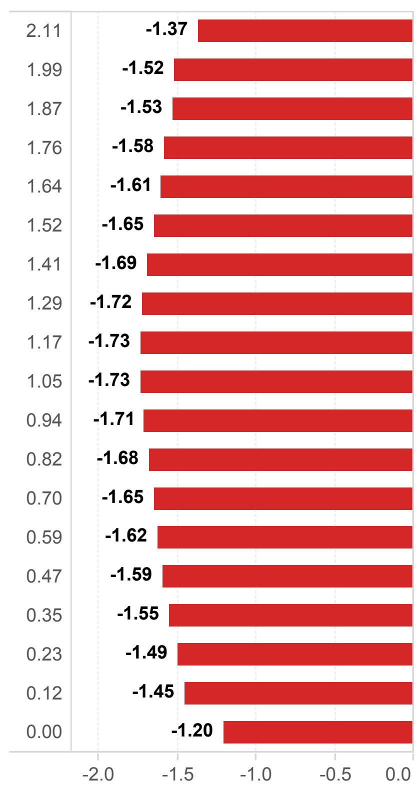
Horizontal Wind Profile at the Probe Location



Width (m)
All

Height (m)
1.05

Vertical Wind Profile at the Probe Location



Width (m) *0.44*

Height (m) *All*

Average Volume Flow Rate Across the Opening

142.531 cm/min

Mean Velocity Across the Opening

-1.266 m/s

in (airflow into the .. out (airflow out fro..

SIMULATION DATA ANALYSIS
(Scenario 2 - Opening A1)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height (m)									
2.11	-0.70	-1.13	-1.15	-1.10	-1.04	-0.96	-0.89	-0.79	-0.66
1.99	-1.02	-1.45	-1.42	-1.37	-1.31	-1.23	-1.15	-1.04	-0.89
1.88	-1.23	-1.63	-1.58	-1.53	-1.47	-1.39	-1.31	-1.20	-1.03
1.76	-1.44	-1.81	-1.73	-1.68	-1.62	-1.54	-1.47	-1.37	-1.17
1.64	-1.66	-1.90	-1.82	-1.76	-1.70	-1.61	-1.55	-1.45	-1.22
1.53	-1.74	-1.97	-1.88	-1.82	-1.77	-1.69	-1.63	-1.54	-1.25
1.41	-1.64	-2.02	-1.93	-1.87	-1.82	-1.75	-1.71	-1.61	-1.27
1.29	-1.63	-2.04	-1.95	-1.90	-1.85	-1.81	-1.78	-1.68	-1.33
1.17	-1.58	-2.05	-1.95	-1.91	-1.87	-1.85	-1.82	-1.73	-1.33
1.06	-1.50	-2.03	-1.95	-1.91	-1.87	-1.87	-1.85	-1.76	-1.32
0.94	-1.37	-1.99	-1.93	-1.90	-1.88	-1.89	-1.88	-1.79	-1.31
0.82	-1.21	-1.91	-1.90	-1.89	-1.87	-1.91	-1.91	-1.82	-1.30
0.71	-1.36	-1.85	-1.87	-1.86	-1.87	-1.90	-1.92	-1.82	-1.16
0.59	-1.41	-1.81	-1.84	-1.84	-1.85	-1.91	-1.95	-1.87	-1.20
0.47	-1.50	-1.78	-1.81	-1.81	-1.82	-1.90	-1.95	-1.86	-1.05
0.36	-1.45	-1.76	-1.80	-1.79	-1.81	-1.86	-1.88	-1.64	-0.63
0.24	-1.45	-1.73	-1.76	-1.75	-1.75	-1.77	-1.69	-1.07	-0.18
0.12	-1.43	-1.72	-1.74	-1.72	-1.72	-1.72	-1.57	-0.81	-0.11
0.01	-1.16	-1.69	-1.68	-1.66	-1.67	-1.71	-1.54	0.00	0.33

0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00 1.10

Width (m)

Average per Column (m/s)

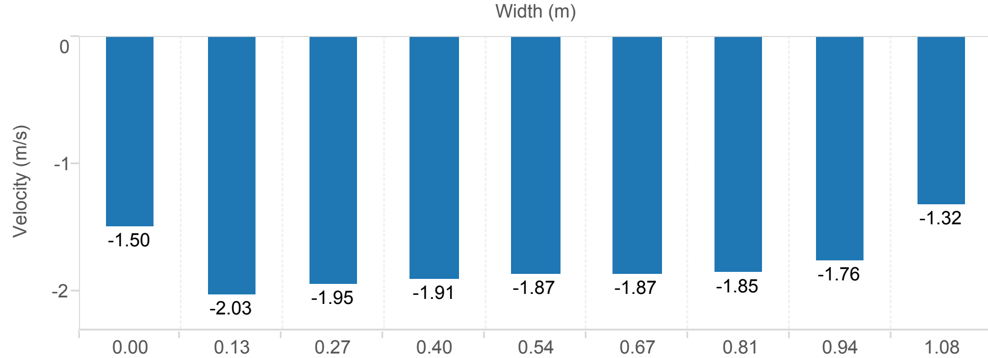
Height (m)	
2.11	**-0.94**
1.99	**-1.21**
1.88	**-1.38**
1.76	**-1.54**
1.64	**-1.63**
1.53	**-1.70**
1.41	**-1.74**
1.29	**-1.77**
1.17	**-1.79**
1.06	**-1.78**
0.94	**-1.77**
0.82	**-1.75**
0.71	**-1.73**
0.59	**-1.74**
0.47	**-1.72**
0.36	**-1.62**
0.24	**-1.46**
0.12	**-1.39**
0.01	**-1.20**

Average per Row (m/s)

Width (m)

0.00	0.13	0.27	0.40	0.54	0.67	0.81	0.94	1.08
-1.39	**-1.80**	**-1.77**	**-1.74**	**-1.71**	**-1.70**	**-1.65**	**-1.41**	**-0.95**

Horizontal Wind Profile at the Probe Location



Width (m) *All* ***Height (m)*** *1.06*

Average Volume Flow Rate Across the Opening

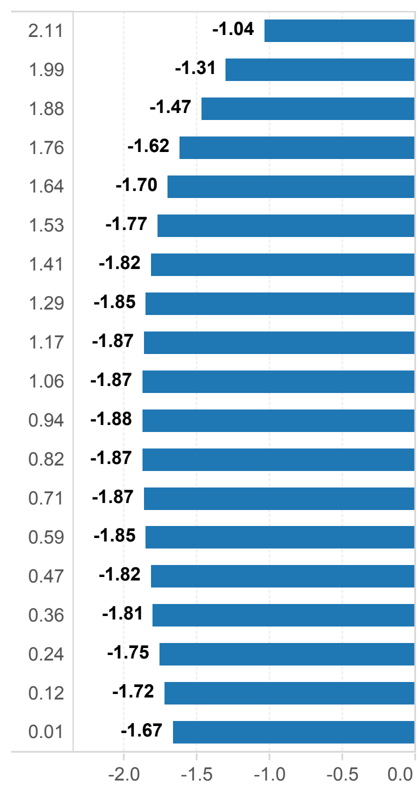
213.530 cm/min

Mean Velocity Across the Opening

-1.572 m/s

in (airflow into the controll volume) out (airflow out from the control volume)

Vertical Wind Profile at the Probe Location



Width (m) *0.54*

Height (m) *All*

SIMULATION DATA ANALYSIS
(Scenario 2 - Opening A2)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height (m) \ Width (m)	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
2.12	-0.03	-1.80	-1.64	-1.46	-1.32	-1.26	-1.40	-1.74	-1.40	
2.00	0.46	-1.64	-1.68	-1.61	-1.53	-1.53	-1.65	-1.82	-1.41	
1.88	0.45	-1.56	-1.65	-1.62	-1.56	-1.57	-1.63	-1.72	-1.27	
1.76	0.12	-1.53	-1.62	-1.62	-1.59	-1.59	-1.63	-1.67	-1.25	
1.64	0.37	-1.45	-1.60	-1.61	-1.60	-1.59	-1.62	-1.65	-1.27	
1.52	0.40	-1.33	-1.57	-1.61	-1.60	-1.60	-1.62	-1.63	-1.25	
1.41	0.27	-1.27	-1.54	-1.60	-1.60	-1.60	-1.62	-1.60	-1.26	
1.29	0.38	-1.15	-1.51	-1.60	-1.61	-1.61	-1.62	-1.60	-1.25	
1.17	0.35	-0.90	-1.47	-1.59	-1.62	-1.62	-1.62	-1.60	-1.23	
1.05	0.39	-0.70	-1.44	-1.58	-1.62	-1.62	-1.63	-1.61	-1.23	
0.93	0.35	-0.89	-1.44	-1.60	-1.63	-1.64	-1.63	-1.60	-1.23	
0.81	0.36	-0.66	-1.42	-1.60	-1.64	-1.64	-1.64	-1.60	-1.28	
0.70	0.34	-0.80	-1.41	-1.60	-1.65	-1.65	-1.64	-1.62	-1.28	
0.58	0.33	-0.63	-1.37	-1.60	-1.66	-1.67	-1.65	-1.62	-1.28	
0.46	0.35	-0.56	-1.34	-1.61	-1.68	-1.67	-1.65	-1.64	-1.29	
0.34	0.32	-0.35	-1.27	-1.60	-1.69	-1.68	-1.65	-1.65	-1.29	
0.22	0.30	-0.24	-1.21	-1.60	-1.70	-1.68	-1.63	-1.66	-1.34	
0.10	0.27	-0.58	-1.31	-1.61	-1.71	-1.68	-1.60	-1.66	-1.31	

Average per Column (m/s)

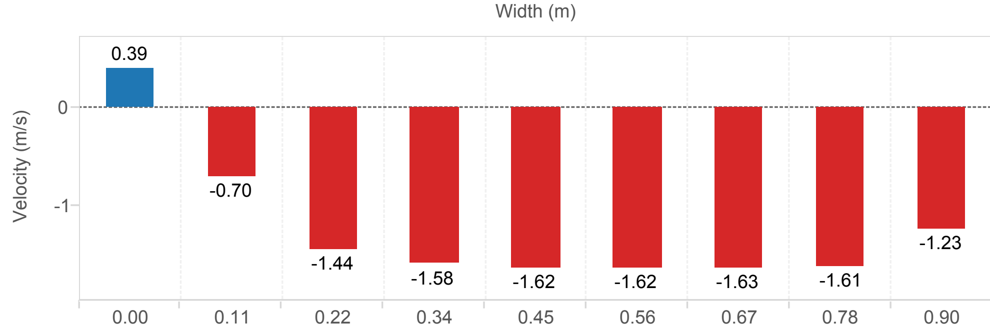
Height (m)	
2.12	**-1.34**
2.00	**-1.38**
1.88	**-1.35**
1.76	**-1.38**
1.64	**-1.34**
1.52	**-1.31**
1.41	**-1.32**
1.29	**-1.29**
1.17	**-1.26**
1.05	**-1.23**
0.93	**-1.26**
0.81	**-1.24**
0.70	**-1.26**
0.58	**-1.24**
0.46	**-1.23**
0.34	**-1.21**
0.22	**-1.20**
0.10	**-1.24**

Average per Row (m/s)

Width (m)

0.00	0.11	0.22	0.34	0.45	0.56	0.67	0.78	0.90
0.32	**-1.00**	**-1.47**	**-1.59**	**-1.61**	**-1.61**	**-1.62**	**-1.65**	**-1.29**

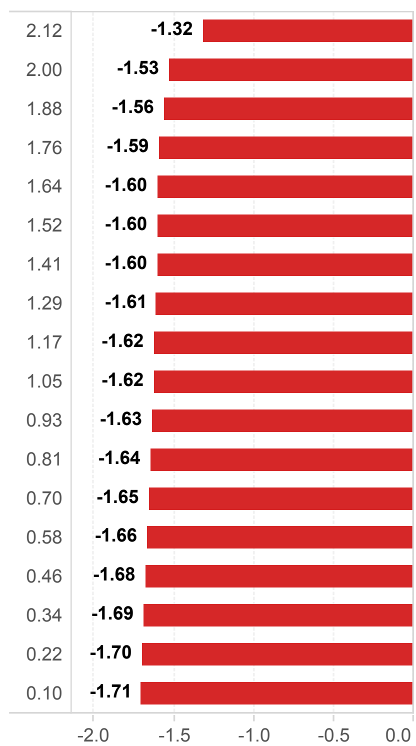
Horizontal Wind Profile at the Probe Location



Width (m)
All

Height (m)
1.05

Vertical Wind Profile at the Probe Location



Width (m) *0.45*

Height (m) *All*

Average Volume Flow Rate Across the Opening

138.381 cm/min

Mean Velocity Across the Opening

-1.280 m/s

in (airflow into the .. out (airflow out fro..

SIMULATION DATA ANALYSIS
(Scenario 2 - Opening A3)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height (m)									
2.11	0.03	-0.98	-1.07	-0.97	-0.86	-0.86	-0.91	-0.72	-0.16
1.99	-0.22	-1.21	-1.28	-1.18	-1.10	-1.11	-1.16	-1.01	-0.38
1.88	-0.38	-1.34	-1.40	-1.31	-1.25	-1.27	-1.31	-1.20	-0.52
1.76	-0.54	-1.46	-1.52	-1.44	-1.40	-1.39	-1.47	-1.38	-0.65
1.64	-0.63	-1.55	-1.56	-1.49	-1.48	-1.50	-1.55	-1.47	-0.71
1.52	-0.70	-1.61	-1.63	-1.57	-1.56	-1.59	-1.64	-1.55	-0.70
1.41	-0.73	-1.65	-1.70	-1.63	-1.63	-1.66	-1.70	-1.58	-0.62
1.29	-0.74	-1.69	-1.75	-1.70	-1.68	-1.72	-1.75	-1.61	-0.53
1.17	-0.72	-1.73	-1.79	-1.75	-1.73	-1.75	-1.77	-1.56	-0.43
1.06	-0.69	-1.77	-1.83	-1.79	-1.77	-1.78	-1.76	-1.48	-0.36
0.94	-0.66	-1.79	-1.86	-1.82	-1.78	-1.79	-1.77	-1.43	-0.29
0.82	-0.59	-1.82	-1.89	-1.86	-1.81	-1.82	-1.79	-1.48	-0.27
0.70	-0.51	-1.87	-1.90	-1.86	-1.84	-1.84	-1.82	-1.54	-0.78
0.59	-0.39	-1.85	-1.92	-1.87	-1.85	-1.86	-1.84	-1.67	-1.15
0.47	-0.19	-1.79	-1.90	-1.86	-1.83	-1.85	-1.84	-1.70	-1.28
0.35	-0.04	-1.54	-1.82	-1.84	-1.82	-1.81	-1.81	-1.70	-1.34
0.24	0.01	-1.05	-1.68	-1.75	-1.75	-1.75	-1.75	-1.68	-1.38
0.12	-0.01	-0.83	-1.57	-1.69	-1.69	-1.69	-1.70	-1.67	-1.38
0.00	0.36	-0.42	-1.50	-1.53	-1.47	-1.45	-1.47	-1.48	-1.27

0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00 1.10

Width (m)

Average per Column (m/s)

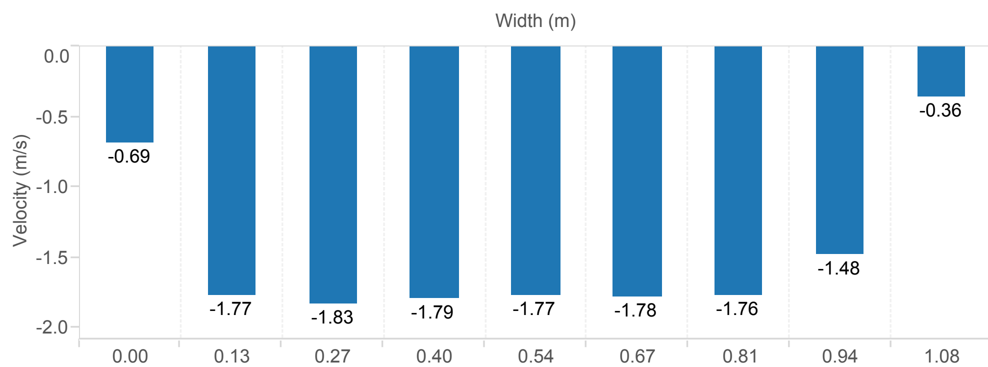
Height (m)	
2.11	**-0.72**
1.99	**-0.96**
1.88	**-1.11**
1.76	**-1.25**
1.64	**-1.33**
1.52	**-1.40**
1.41	**-1.43**
1.29	**-1.46**
1.17	**-1.47**
1.06	**-1.47**
0.94	**-1.47**
0.82	**-1.48**
0.70	**-1.55**
0.59	**-1.60**
0.47	**-1.58**
0.35	**-1.52**
0.24	**-1.42**
0.12	**-1.36**
0.00	**-1.14**

Average per Row (m/s)

Width (m)

0.00	0.13	0.27	0.40	0.54	0.67	0.81	0.94	1.08
-0.39	**-1.47**	**-1.66**	**-1.63**	**-1.59**	**-1.61**	**-1.62**	**-1.47**	**-0.75**

Horizontal Wind Profile at the Probe Location



Width (m) *All*

Height (m) *1.06*

Average Volume Flow Rate Across the Opening

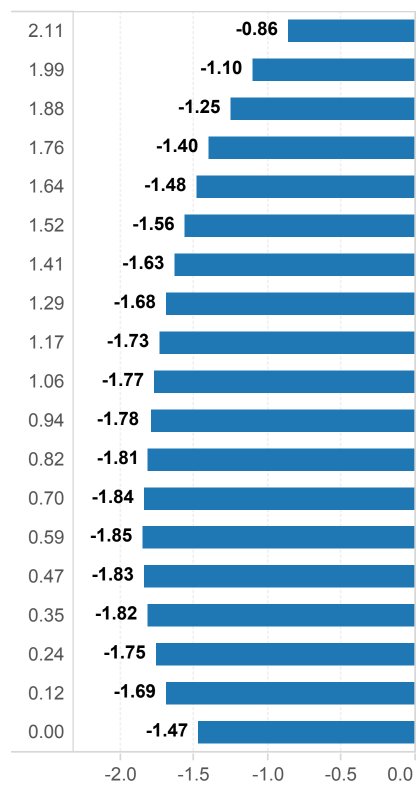
184.280 cm/min

Mean Velocity Across the Opening

-1.354 m/s

■ in (airflow into the control volume) ■ out (airflow out from the control volume)

Vertical Wind Profile at the Probe Location



Width (m) *0.54*

Height (m) *All*

SIMULATION DATA ANALYSIS
(Scenario 2 - Opening A4)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height (m) \ Width (m)	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
2.12	0.59	-1.92	-1.67	-1.53	-1.43	-1.35	-1.07	-0.69	-0.16	
2.00	0.69	-1.97	-2.03	-2.02	-2.04	-2.09	-2.23	-2.29	-1.96	
1.88	0.65	-1.86	-1.98	-1.99	-1.98	-1.96	-1.98	-2.20	-0.75	
1.77	0.62	-1.78	-1.95	-1.98	-1.96	-1.93	-1.93	-2.21	-0.39	
1.65	0.60	-1.72	-1.94	-1.98	-1.96	-1.94	-1.93	-2.21	-0.67	
1.53	0.60	-1.62	-1.92	-1.97	-1.96	-1.95	-1.94	-2.19	-1.03	
1.41	0.58	-1.52	-1.91	-1.96	-1.96	-1.96	-1.95	-2.17	-1.32	
1.30	0.57	-1.41	-1.90	-1.96	-1.97	-1.96	-1.96	-2.15	-1.54	
1.18	0.56	-1.33	-1.88	-1.96	-1.97	-1.96	-1.97	-2.13	-1.60	
1.06	0.55	-1.22	-1.86	-1.96	-1.97	-1.97	-1.97	-2.12	-1.64	
0.94	0.56	-1.11	-1.84	-1.96	-1.97	-1.97	-1.97	-2.10	-1.67	
0.82	0.50	-1.06	-1.82	-1.96	-1.97	-1.97	-1.97	-2.07	-1.80	
0.71	0.49	-0.99	-1.80	-1.96	-1.97	-1.97	-1.96	-2.07	-1.81	
0.59	0.49	-0.92	-1.78	-1.96	-1.97	-1.96	-1.96	-2.05	-1.80	
0.47	0.49	-0.84	-1.77	-1.96	-1.96	-1.95	-1.95	-2.06	-1.83	
0.35	0.47	-0.78	-1.76	-1.97	-1.96	-1.94	-1.93	-2.04	-1.81	
0.24	0.46	-0.73	-1.75	-1.98	-1.95	-1.92	-1.92	-2.03	-1.96	
0.12	0.52	-0.66	-1.81	-1.99	-1.93	-1.89	-1.89	-2.03	-1.84	
0.00	0.51	-1.32	-1.89	-1.99	-1.92	-1.88	-1.87	-2.03	-1.76	

Width (m)

Average per Column (m/s)

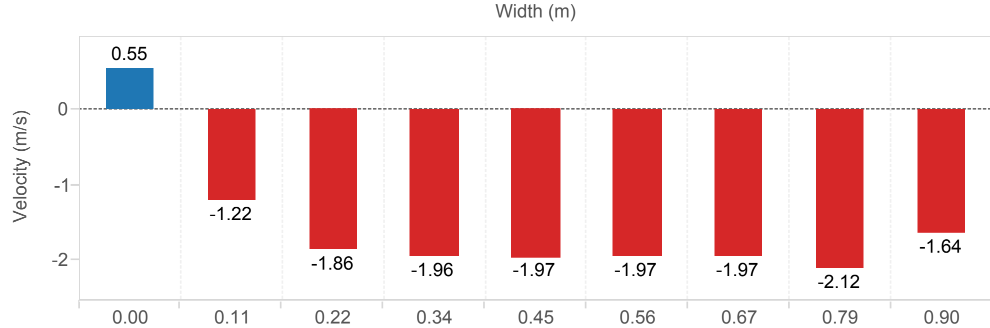
Height (m)	
2.12	**-1.02**
2.00	**-1.77**
1.88	**-1.56**
1.77	**-1.50**
1.65	**-1.53**
1.53	**-1.55**
1.41	**-1.58**
1.30	**-1.59**
1.18	**-1.58**
1.06	**-1.57**
0.94	**-1.56**
0.82	**-1.57**
0.71	**-1.56**
0.59	**-1.54**
0.47	**-1.54**
0.35	**-1.52**
0.24	**-1.53**
0.12	**-1.50**
0.00	**-1.57**

Average per Row (m/s)

Width (m)

0.00	0.11	0.22	0.34	0.45	0.56	0.67	0.79	0.90
0.55	**-1.30**	**-1.86**	**-1.95**	**-1.94**	**-1.92**	**-1.91**	**-2.04**	**-1.44**

Horizontal Wind Profile at the Probe Location



Width (m)
All

Height (m)
1.06

Average Volume Flow Rate Across the Opening

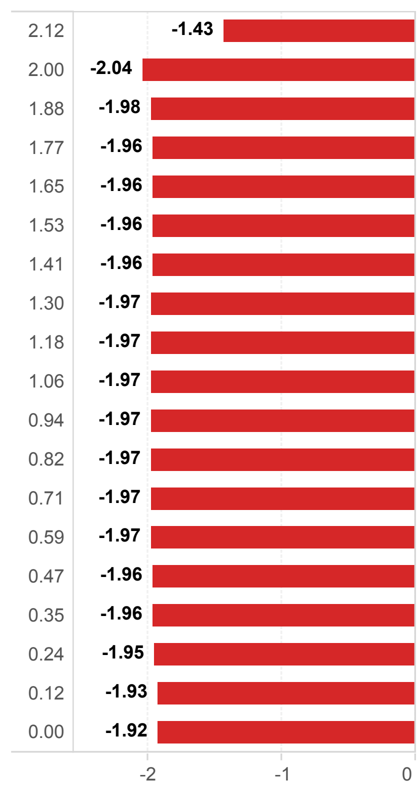
175.360 cm/min

Mean Velocity Across the Opening

-1.535 m/s

in (airflow into the .. out (airflow out fro..

Vertical Wind Profile at the Probe Location



Width (m) *0.45*

Height (m) *All*

SIMULATION DATA ANALYSIS
(Scenario 2 - Opening A7E)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height ..																										
3.50	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.2	0.1
3.32	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.2
3.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.2
2.97	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.3	0.2
2.80	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.3	0.2
2.62	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.2
2.45	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.2	0.2	0.2
2.27	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.2	0.2	0.2
2.10	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	0.0	0.0	0.0	0.1	0.2	0.2	0.2	0.2	0.2
1.92	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.2
1.75	0.0	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.1
1.57	0.0	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
1.40	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
1.22	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
1.05	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
0.87	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0
0.70	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0
0.52	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0
0.35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0
0.17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0
0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1

0.00 0.50 1.00 1.50 2.00 2.50

Width (m)

Average per Column (m/s)

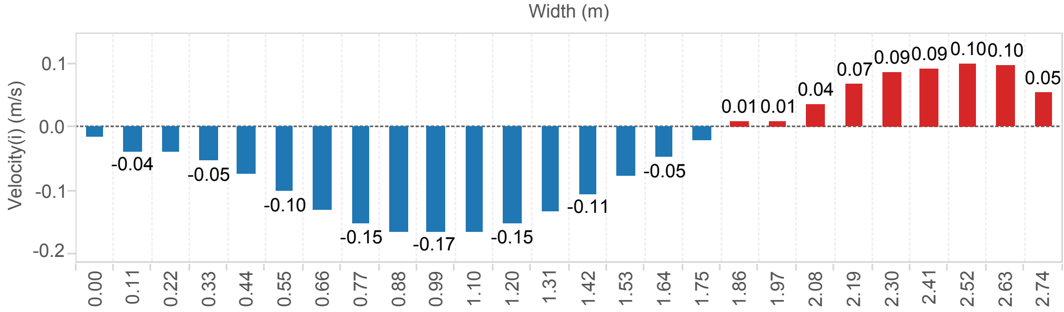
Height (m)	
3.50	0.10
3.32	0.18
3.15	0.15
2.97	0.08
2.80	0.03
2.62	0.00
2.45	-0.04
2.27	-0.05
2.10	-0.07
1.92	-0.07
1.75	-0.08
1.57	-0.07
1.40	-0.07
1.22	-0.05
1.05	-0.04
0.87	-0.03
0.70	0.00
0.52	0.01
0.35	0.01
0.17	0.01
0.00	0.02

Average per Row (m/s)

Width (m)

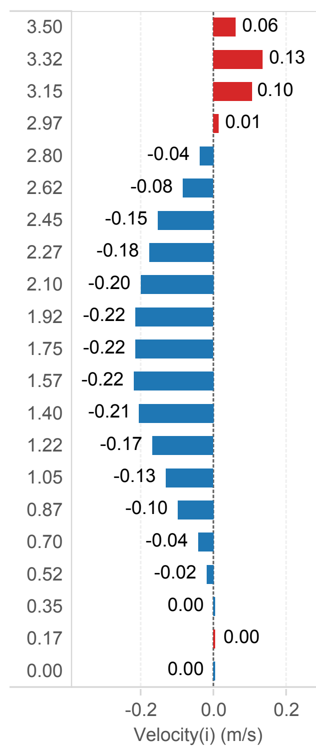
0.00	0.11	0.22	0.33	0.44	0.55	0.66	0.77	0.88	0.99	1.10	1.20	1.31	1.42	1.53	1.64	1.75	1.86	1.97	2.08	2.19	2.30	2.41	2.52	2.63	2.74
0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.1

Horizontal Wind Profile at the Probe Location



Width (m) *All* ***Height (m)*** *1.05*

Vertical WInd Profile at the Probe Location



Average Volume Flow Rate Across the Opening

0.618 cm/min

Mean Velocity Across the Opening

0.001075

Width (m) *1.31*

Height (m) *All*

in (airflow into control volume) out (airflow out from control volume)

SIMULATION DATA ANALYSIS
(Scenario 2 - Opening A7W)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height ..																										
3.50	-0.5	-0.7	-0.7	-0.7	-0.7	-0.7	-0.7	-0.6	-0.6	-0.5	-0.5	-0.5	-0.5	-0.4	-0.4	-0.4	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2
3.32	-0.6	-0.6	-0.6	-0.5	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.3	-0.3
3.15	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.4	-0.4	-0.3	-0.3
2.97	0.0	-0.1	-0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	-0.1	-0.2	-0.3	-0.3	-0.3	-0.3	-0.2
2.80	-0.1	-0.1	-0.1	0.0	0.0	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.0	-0.1	-0.2	-0.2	-0.3	-0.3	-0.2
2.62	-0.1	-0.1	-0.1	0.0	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.1	0.1	0.1	0.0	-0.1	-0.2	-0.3	-0.3	-0.2
2.45	-0.2	-0.2	-0.2	-0.1	0.1	0.1	0.2	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.2	0.2	0.2	0.1	0.0	-0.1	-0.2	-0.2	-0.2
2.27	-0.2	-0.2	-0.2	-0.1	0.1	0.2	0.2	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.2	0.1	0.0	-0.1	-0.2	-0.2	-0.2
2.10	-0.3	-0.2	-0.2	-0.1	0.1	0.2	0.3	0.3	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.3	0.3	0.2	0.1	0.0	-0.1	-0.1	-0.2	-0.1
1.92	-0.3	-0.3	-0.3	-0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.3	0.3	0.2	0.1	0.0	-0.1	-0.1	-0.2	-0.1
1.75	-0.4	-0.3	-0.3	-0.1	0.0	0.2	0.2	0.3	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.3	0.3	0.2	0.1	0.0	0.0	-0.1	-0.1	-0.1
1.57	-0.5	-0.4	-0.4	-0.1	0.0	0.1	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.5	0.5	0.4	0.3	0.3	0.3	0.2	0.1	0.0	0.0	-0.1	-0.1	-0.1
1.40	-0.6	-0.4	-0.4	-0.2	0.0	0.1	0.2	0.2	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.2	0.2	0.2	0.1	0.0	0.0	-0.1	-0.1	-0.1
1.22	-0.7	-0.5	-0.5	-0.2	0.0	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.0	0.0	-0.1	-0.1	-0.1
1.05	-0.8	-0.6	-0.6	-0.2	0.0	0.0	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0	-0.1	-0.1	0.0
0.87	-0.9	-0.6	-0.6	-0.3	-0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	-0.1	-0.1	0.0
0.70	-1.0	-0.8	-0.6	-0.2	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0
0.52	-1.1	-0.9	-0.6	-0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0
0.35	-1.2	-0.9	-0.6	-0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.17	-1.3	-1.0	-0.7	-0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.00	-1.2	-1.0	-0.8	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

0.00 0.50 1.00 1.50 2.00 2.50

Width (m)

Average per Column (m/s)

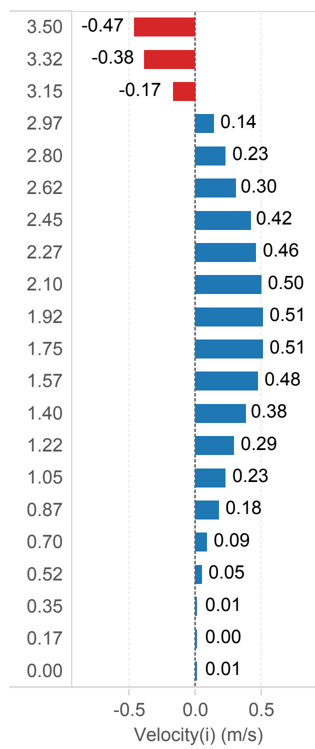
Height (m)	
3.50	-0.45
3.32	-0.41
3.15	-0.20
2.97	-0.03
2.80	0.03
2.62	0.08
2.45	0.14
2.27	0.16
2.10	0.18
1.92	0.18
1.75	0.17
1.57	0.14
1.40	0.10
1.22	0.04
1.05	0.00
0.87	-0.03
0.70	-0.08
0.52	-0.10
0.35	-0.12
0.17	-0.12
0.00	-0.10

Average per Row (m/s)

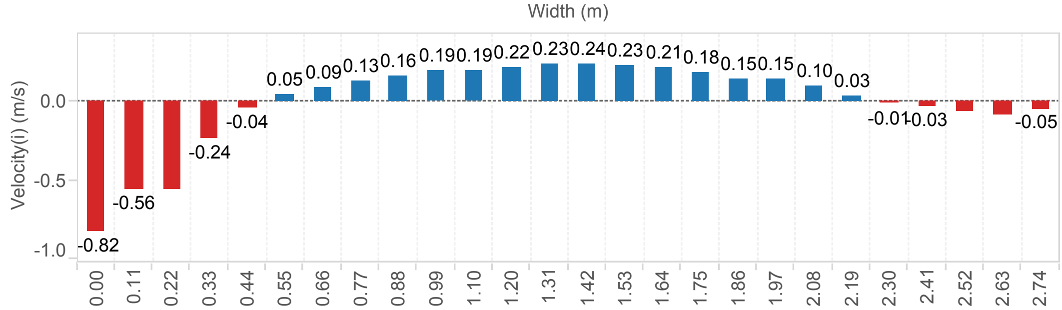
Width (m)

0.00	0.11	0.22	0.33	0.44	0.55	0.66	0.77	0.88	0.99	1.10	1.20	1.31	1.42	1.53	1.64	1.75	1.86	1.97	2.08	2.19	2.30	2.41	2.52	2.63	2.74
-0.6	-0.5	-0.4	-0.2	-0.1	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0	-0.1	-0.1	-0.1	-0.2	-0.1

Vertical WInd Profile at the Probe Location



Horizontal Wind Profile at the Probe Location



Width (m) *All* ***Height (m)*** *1.05*

Average Volume Flow Rate Across the Opening

12.150 cm/min

Mean Velocity Across the Opening

-0.02114

in (airflow into control volume) out (airflow out from control volume)

Width (m) *1.31*

Height (m) *All*

SIMULATION DATA ANALYSIS
(Scenario 3 - Opening A0)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height (m)									
2.11	-1.45	-1.17	-1.45	-1.67	-1.78	-1.82	-1.86	-2.08	-1.87
1.99	-1.81	-2.16	-2.19	-2.21	-2.14	-2.08	-2.08	-2.07	-0.69
1.87	-0.60	-2.09	-1.98	-1.95	-1.96	-2.03	-2.08	-2.07	-0.19
1.76	-0.17	-2.11	-1.93	-1.85	-1.88	-2.00	-2.06	-2.06	-0.05
1.64	-0.14	-2.12	-1.96	-1.86	-1.88	-1.98	-2.06	-1.99	0.01
1.52	-0.59	-2.14	-1.97	-1.87	-1.90	-2.01	-2.06	-1.92	0.53
1.41	-1.17	-2.17	-1.97	-1.88	-1.92	-2.03	-2.07	-1.81	0.57
1.29	-1.43	-2.17	-1.97	-1.89	-1.95	-2.07	-2.09	-1.85	0.55
1.17	-1.50	-2.16	-1.97	-1.90	-2.00	-2.13	-2.09	-1.82	-0.11
1.05	-1.64	-2.14	-1.98	-1.95	-2.05	-2.16	-2.06	-1.49	0.56
0.94	-1.75	-2.13	-1.99	-2.02	-2.13	-2.16	-2.03	-1.51	0.63
0.82	-1.81	-2.09	-2.02	-2.11	-2.18	-2.13	-1.98	-1.59	-0.04
0.70	-1.77	-2.08	-2.07	-2.18	-2.20	-2.09	-1.89	-1.01	0.54
0.59	-1.75	-2.09	-2.12	-2.21	-2.18	-2.06	-1.87	-0.95	0.55
0.47	-1.76	-2.09	-2.16	-2.21	-2.15	-2.03	-1.87	-1.48	0.10
0.35	-1.77	-2.11	-2.18	-2.19	-2.11	-1.98	-1.80	-0.89	0.56
0.23	-1.80	-2.11	-2.18	-2.13	-2.05	-1.92	-1.72	-0.64	0.45
0.12	-1.80	-2.12	-2.15	-2.08	-2.00	-1.87	-1.69	-0.52	0.25
0.00	-1.48	-1.95	-1.98	-1.86	-1.67	-1.74	-1.66	-1.50	-0.31

0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90

Width (m)

Average per Column (m/s)

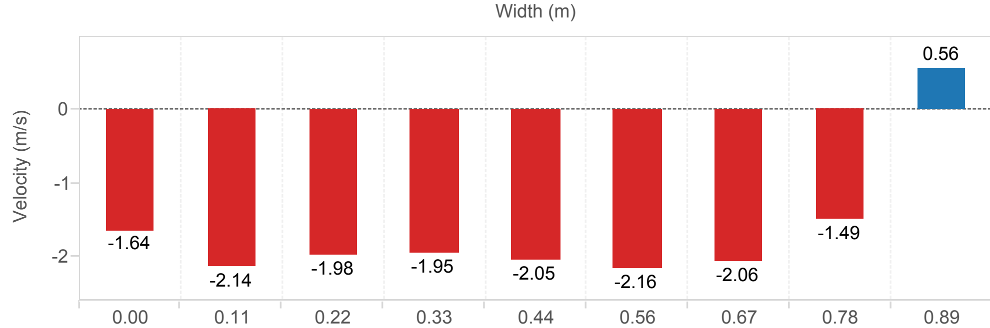
Height (m)	
2.11	**-1.68**
1.99	**-1.94**
1.87	**-1.66**
1.76	**-1.57**
1.64	**-1.55**
1.52	**-1.55**
1.41	**-1.61**
1.29	**-1.65**
1.17	**-1.74**
1.05	**-1.66**
0.94	**-1.68**
0.82	**-1.77**
0.70	**-1.64**
0.59	**-1.63**
0.47	**-1.74**
0.35	**-1.61**
0.23	**-1.57**
0.12	**-1.55**
0.00	**-1.57**

Average per Row (m/s)

Width (m)

0.00	0.11	0.22	0.22	0.33	0.44	0.56	0.67	0.78	0.89
-1.38	**-2.06**	**-2.10**	**-1.94**	**-2.00**	**-2.01**	**-2.01**	**-1.95**	**-1.54**	**0.11**

Horizontal Wind Profile at the Probe Location



Width (m)
All

Height (m)
1.05

Average Volume Flow Rate Across the Opening

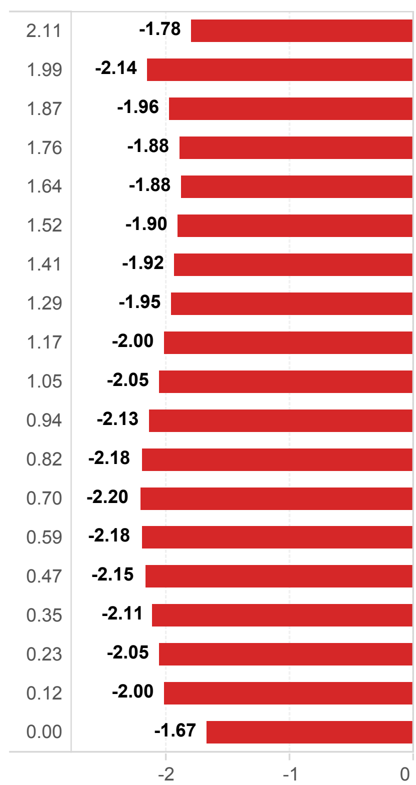
185.867 cm/min

Mean Velocity Across the Opening

-1.651 m/s

in (airflow into the .. out (airflow out fro..

Vertical Wind Profile at the Probe Location



Width (m) *0.44*

Height (m) *All*

SIMULATION DATA ANALYSIS
(Scenario 3 - Opening A1)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height (m)									
2.11	-0.59	-0.97	-1.04	-1.00	-0.95	-0.88	-0.81	-0.72	-0.60
1.99	-0.86	-1.26	-1.27	-1.23	-1.18	-1.11	-1.04	-0.94	-0.80
1.88	-1.04	-1.42	-1.41	-1.36	-1.31	-1.24	-1.17	-1.07	-0.92
1.76	-1.23	-1.56	-1.52	-1.48	-1.44	-1.37	-1.30	-1.21	-1.04
1.64	-1.42	-1.63	-1.58	-1.54	-1.50	-1.42	-1.36	-1.27	-1.07
1.53	-1.47	-1.68	-1.63	-1.58	-1.54	-1.48	-1.43	-1.35	-1.10
1.41	-1.39	-1.71	-1.65	-1.61	-1.57	-1.52	-1.48	-1.40	-1.10
1.29	-1.38	-1.72	-1.66	-1.62	-1.59	-1.56	-1.53	-1.46	-1.14
1.17	-1.34	-1.70	-1.65	-1.62	-1.59	-1.58	-1.56	-1.49	-1.13
1.06	-1.25	-1.67	-1.63	-1.61	-1.59	-1.59	-1.58	-1.50	-1.11
0.94	-1.04	-1.58	-1.59	-1.59	-1.58	-1.60	-1.60	-1.52	-1.09
0.82	-0.86	-1.49	-1.56	-1.57	-1.57	-1.61	-1.62	-1.54	-1.07
0.71	-0.99	-1.46	-1.53	-1.55	-1.57	-1.61	-1.61	-1.52	-0.94
0.59	-1.13	-1.46	-1.52	-1.54	-1.56	-1.62	-1.63	-1.54	-0.97
0.47	-1.24	-1.46	-1.51	-1.53	-1.55	-1.61	-1.61	-1.52	-0.86
0.36	-1.21	-1.45	-1.51	-1.53	-1.55	-1.57	-1.56	-1.39	-0.55
0.24	-1.22	-1.43	-1.48	-1.49	-1.50	-1.50	-1.44	-1.04	-0.17
0.12	-1.21	-1.42	-1.45	-1.44	-1.45	-1.44	-1.33	-0.77	-0.05
0.01	-1.00	-1.39	-1.40	-1.38	-1.37	-1.37	-1.29	-0.28	0.28

0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00 1.10

Width (m)

Average per Column (m/s)

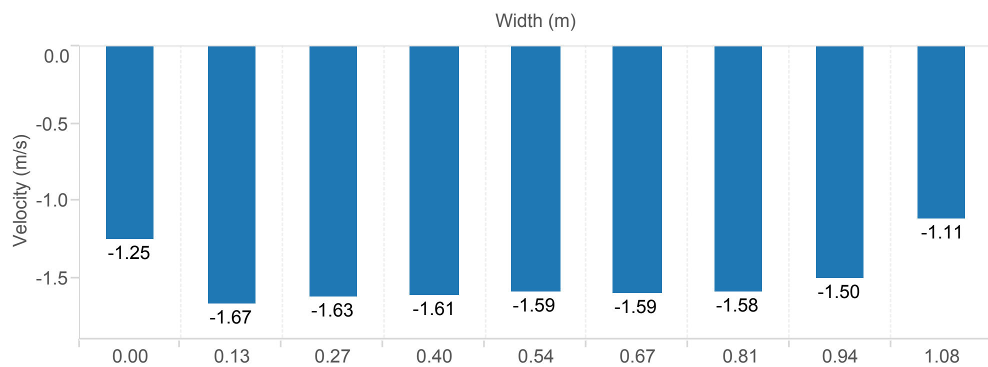
Height (m)	
2.11	**-0.84**
1.99	**-1.08**
1.88	**-1.22**
1.76	**-1.35**
1.64	**-1.42**
1.53	**-1.47**
1.41	**-1.49**
1.29	**-1.52**
1.17	**-1.52**
1.06	**-1.50**
0.94	**-1.47**
0.82	**-1.43**
0.71	**-1.42**
0.59	**-1.44**
0.47	**-1.43**
0.36	**-1.37**
0.24	**-1.25**
0.12	**-1.17**
0.01	**-1.02**

Average per Row (m/s)

Width (m)

0.00	0.13	0.27	0.40	0.54	0.67	0.81	0.94	1.08
-1.15	**-1.50**	**-1.50**	**-1.49**	**-1.47**	**-1.46**	**-1.42**	**-1.24**	**-0.81**

Horizontal Wind Profile at the Probe Location



Width (m) *All*

Height (m) *1.06*

Average Volume Flow Rate Across the Opening

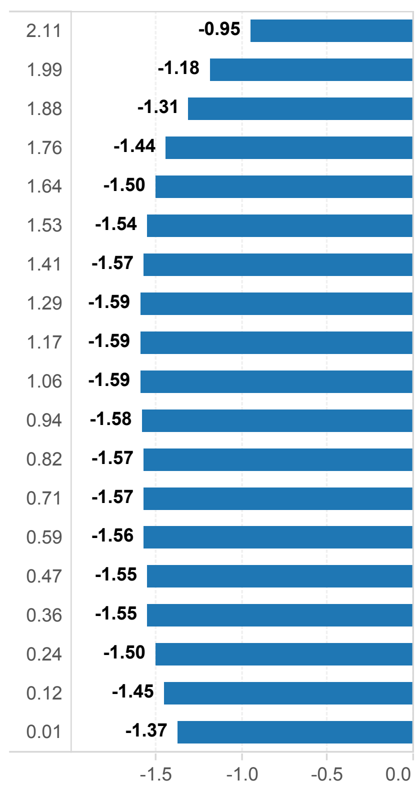
181.741 cm/min

Mean Velocity Across the Opening

-1.338 m/s

in (airflow into the control volume) out (airflow out from the control volume)

Vertical Wind Profile at the Probe Location



Width (m) *0.54*

Height (m) *All*

SIMULATION DATA ANALYSIS
(Scenario 3 - Opening A3)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height (m)									
2.11	0.06	-0.80	-0.92	-0.86	-0.75	-0.72	-0.73	-0.57	-0.18
1.99	-0.13	-0.99	-1.09	-1.04	-0.95	-0.93	-0.93	-0.82	-0.38
1.88	-0.25	-1.10	-1.19	-1.14	-1.07	-1.05	-1.06	-0.98	-0.51
1.76	-0.37	-1.19	-1.27	-1.23	-1.18	-1.15	-1.20	-1.15	-0.64
1.64	-0.44	-1.26	-1.31	-1.26	-1.24	-1.24	-1.27	-1.25	-0.72
1.52	-0.48	-1.31	-1.35	-1.31	-1.29	-1.31	-1.35	-1.35	-0.75
1.41	-0.50	-1.33	-1.40	-1.35	-1.34	-1.36	-1.40	-1.39	-0.68
1.29	-0.51	-1.36	-1.43	-1.40	-1.38	-1.40	-1.45	-1.38	-0.55
1.17	-0.51	-1.39	-1.46	-1.43	-1.41	-1.43	-1.46	-1.32	-0.38
1.06	-0.50	-1.42	-1.49	-1.46	-1.44	-1.45	-1.45	-1.23	-0.30
0.94	-0.48	-1.43	-1.50	-1.48	-1.45	-1.46	-1.44	-1.16	-0.24
0.82	-0.45	-1.46	-1.53	-1.51	-1.48	-1.48	-1.45	-1.16	-0.21
0.70	-0.40	-1.49	-1.53	-1.51	-1.49	-1.50	-1.48	-1.22	-0.57
0.59	-0.32	-1.47	-1.54	-1.52	-1.50	-1.52	-1.50	-1.34	-0.95
0.47	-0.19	-1.42	-1.52	-1.50	-1.49	-1.51	-1.50	-1.37	-1.05
0.35	-0.07	-1.21	-1.45	-1.48	-1.47	-1.47	-1.46	-1.35	-1.09
0.24	-0.01	-0.81	-1.32	-1.40	-1.41	-1.41	-1.40	-1.33	-1.11
0.12	0.00	-0.63	-1.22	-1.33	-1.35	-1.35	-1.36	-1.31	-1.11
0.00	0.31	-0.38	-1.17	-1.21	-1.16	-1.15	-1.17	-1.16	-0.98

0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00 1.10

Width (m)

Average per Column (m/s)

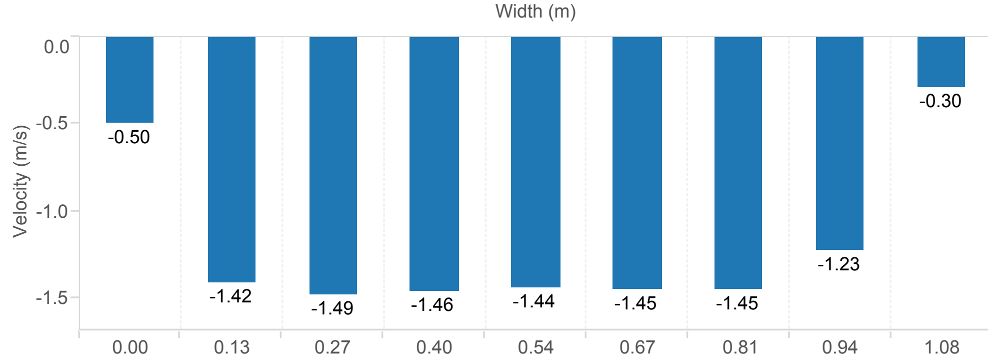
Height (m)	
2.11	**-0.61**
1.99	**-0.81**
1.88	**-0.93**
1.76	**-1.04**
1.64	**-1.11**
1.52	**-1.17**
1.41	**-1.20**
1.29	**-1.21**
1.17	**-1.20**
1.06	**-1.19**
0.94	**-1.19**
0.82	**-1.19**
0.70	**-1.24**
0.59	**-1.30**
0.47	**-1.28**
0.35	**-1.23**
0.24	**-1.13**
0.12	**-1.07**
0.00	**-0.90**

Average per Row (m/s)

Width (m)

0.00	0.13	0.27	0.40	0.54	0.67	0.81	0.94	1.08
-0.28	**-1.18**	**-1.35**	**-1.34**	**-1.31**	**-1.31**	**-1.32**	**-1.20**	**-0.65**

Horizontal Wind Profile at the Probe Location



Width (m) *All*

Height (m) *1.06*

Average Volume Flow Rate Across the Opening

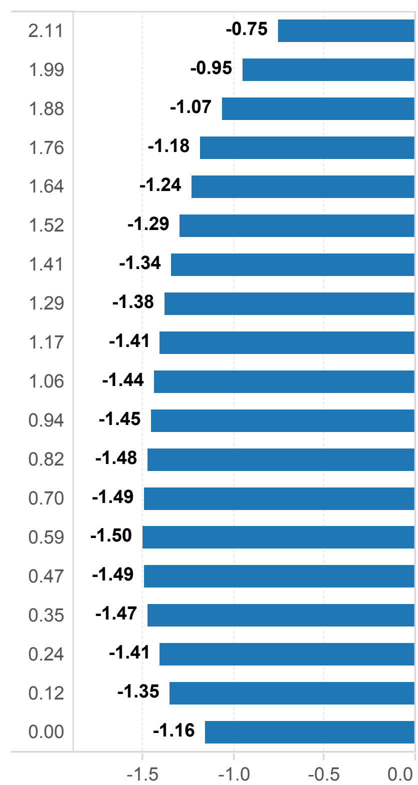
150.320 cm/min

Mean Velocity Across the Opening

-1.104 m/s

■ in (airflow into the control volume) ■ out (airflow out from the control volume)

Vertical Wind Profile at the Probe Location



Width (m) *0.54*

Height (m) *All*

SIMULATION DATA ANALYSIS
(Scenario 3 - Opening A4)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height (m) \ Width (m)	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
2.12	0.69	-1.88	-1.63	-1.47	-1.27	-1.06	-0.65	-0.36	0.21	
2.00	0.72	-2.32	-2.34	-2.33	-2.38	-2.46	-2.52	-2.46	-2.17	
1.88	0.75	-2.23	-2.27	-2.26	-2.23	-2.19	-2.22	-2.35	-0.88	
1.77	0.69	-2.17	-2.24	-2.23	-2.18	-2.10	-2.18	-2.41	-0.11	
1.65	0.67	-2.10	-2.22	-2.21	-2.18	-2.14	-2.21	-2.45	-0.27	
1.53	0.67	-2.01	-2.20	-2.19	-2.18	-2.18	-2.22	-2.50	-0.70	
1.41	0.65	-1.90	-2.19	-2.18	-2.18	-2.19	-2.23	-2.52	-1.17	
1.30	0.65	-1.78	-2.17	-2.18	-2.18	-2.19	-2.24	-2.50	-1.57	
1.18	0.64	-1.70	-2.15	-2.17	-2.18	-2.19	-2.25	-2.48	-1.69	
1.06	0.62	-1.59	-2.13	-2.17	-2.18	-2.19	-2.25	-2.45	-1.79	
0.94	0.62	-1.50	-2.10	-2.16	-2.17	-2.18	-2.25	-2.43	-1.86	
0.82	0.55	-1.45	-2.08	-2.15	-2.16	-2.18	-2.25	-2.39	-2.03	
0.71	0.54	-1.40	-2.07	-2.15	-2.16	-2.17	-2.24	-2.40	-2.05	
0.59	0.54	-1.35	-2.06	-2.14	-2.15	-2.16	-2.23	-2.37	-2.05	
0.47	0.54	-1.30	-2.05	-2.14	-2.14	-2.15	-2.22	-2.39	-2.09	
0.35	0.51	-1.26	-2.06	-2.14	-2.13	-2.14	-2.20	-2.38	-2.10	
0.24	0.50	-1.23	-2.07	-2.14	-2.12	-2.13	-2.20	-2.38	-2.22	
0.12	0.57	-1.22	-2.12	-2.13	-2.10	-2.11	-2.19	-2.37	-2.17	
0.00	0.64	-1.69	-2.16	-2.12	-2.09	-2.12	-2.17	-2.37	-2.02	

Width (m)

Average per Column (m/s)

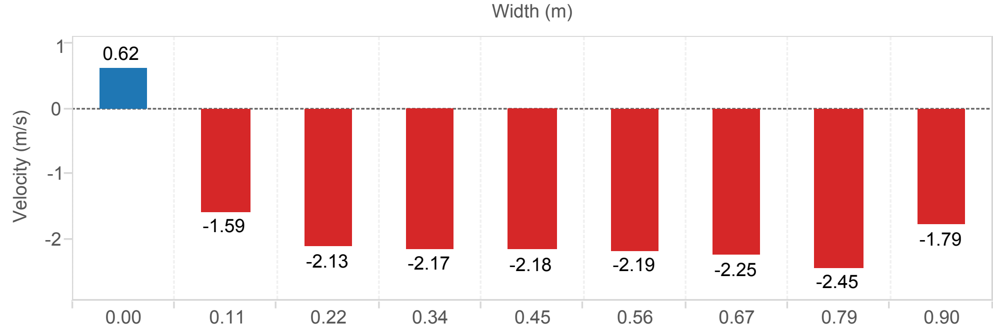
Height (m)	
2.12	**-0.82**
2.00	**-2.03**
1.88	**-1.76**
1.77	**-1.66**
1.65	**-1.68**
1.53	**-1.72**
1.41	**-1.77**
1.30	**-1.80**
1.18	**-1.80**
1.06	**-1.79**
0.94	**-1.78**
0.82	**-1.79**
0.71	**-1.79**
0.59	**-1.77**
0.47	**-1.77**
0.35	**-1.77**
0.24	**-1.78**
0.12	**-1.76**
0.00	**-1.79**

Average per Row (m/s)

Width (m)

0.00	0.11	0.22	0.34	0.45	0.56	0.67	0.79	0.90
0.62	**-1.69**	**-2.12**	**-2.14**	**-2.12**	**-2.12**	**-2.15**	**-2.31**	**-1.51**

Horizontal Wind Profile at the Probe Location



Width (m)
All

Height (m)
1.06

Average Volume Flow Rate Across the Opening

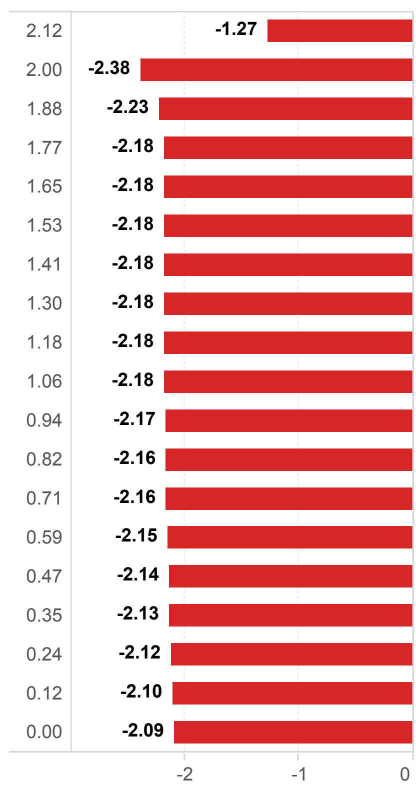
197.470 cm/min

Mean Velocity Across the Opening

-1.728 m/s

in (airflow into the .. out (airflow out fro..

Vertical Wind Profile at the Probe Location



Width (m) *0.45*

Height (m) *All*

SIMULATION DATA ANALYSIS
(Scenario 3 - Opening A7E)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height ..																										
3.50	0.1	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.1
3.32	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.2
3.15	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.2
2.97	0.0	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.2
2.80	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2
2.62	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2
2.45	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.2	0.2	0.2
2.27	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.2	0.1
2.10	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
1.92	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
1.75	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
1.57	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
1.40	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
1.22	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
1.05	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
0.87	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.70	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.52	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0

0.00 0.50 1.00 1.50 2.00 2.50

Width (m)

Average per Column (m/s)

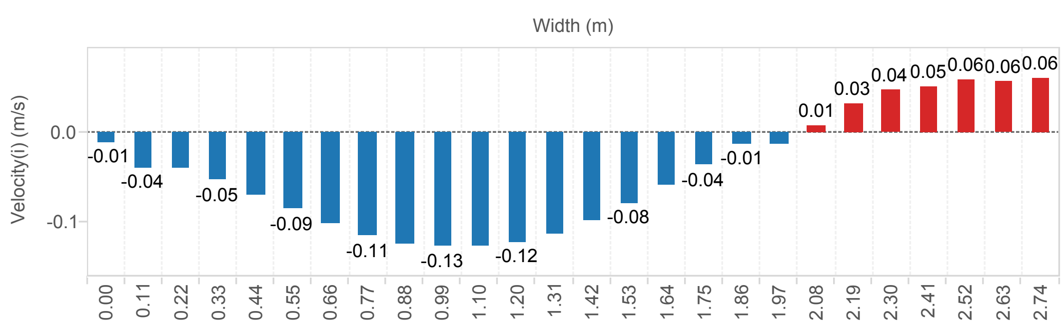
Height (m)	
3.50	0.14
3.32	0.21
3.15	0.16
2.97	0.08
2.80	0.03
2.62	0.00
2.45	-0.04
2.27	-0.05
2.10	-0.06
1.92	-0.07
1.75	-0.07
1.57	-0.06
1.40	-0.06
1.22	-0.05
1.05	-0.04
0.87	-0.03
0.70	-0.02
0.52	-0.01
0.35	0.00
0.17	0.00
0.00	0.01

Average per Row (m/s)

Width (m)

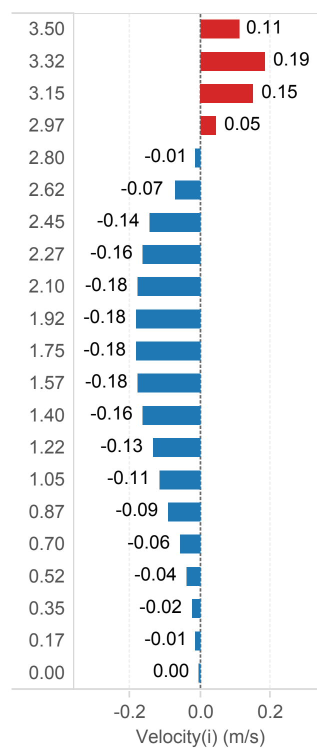
0.00	0.11	0.22	0.33	0.44	0.55	0.66	0.77	0.88	0.99	1.10	1.20	1.31	1.42	1.53	1.64	1.75	1.86	1.97	2.08	2.19	2.30	2.41	2.52	2.63	2.74
0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Horizontal Wind Profile at the Probe Location



Width (m) *All* ***Height (m)*** *1.05*

Vertical WInd Profile at the Probe Location



Average Volume Flow Rate Across the Opening

1.701 cm/min

Mean Velocity Across the Opening

0.002960

Width (m) *1.31*

Height (m) *All*

in (airflow into control volume)   out (airflow out from control volume)

SIMULATION DATA ANALYSIS
(Scenario 3 - Opening A7W)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height ..																										
3.50	-0.5	-0.7	-0.8	-0.8	-0.8	-0.7	-0.7	-0.7	-0.6	-0.6	-0.6	-0.6	-0.5	-0.5	-0.5	-0.5	-0.4	-0.4	-0.4	-0.4	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3
3.32	-0.6	-0.8	-0.8	-0.7	-0.7	-0.7	-0.7	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.4
3.15	-0.3	-0.3	-0.3	-0.3	-0.3	-0.4	-0.4	-0.4	-0.4	-0.5	-0.5	-0.5	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.5	-0.5	-0.5	-0.4
2.97	0.1	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.4	-0.4	-0.4	-0.5	-0.4
2.80	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.3	-0.4	-0.4	-0.4	-0.4
2.62	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.2	-0.3	-0.3	-0.4	-0.4	-0.3
2.45	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.1	0.1	0.0	0.0	-0.1	-0.1	-0.2	-0.3	-0.3	-0.4	-0.3
2.27	0.1	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.1	0.0	0.0	0.0	-0.1	-0.2	-0.2	-0.3	-0.3	-0.3
2.10	0.1	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.1	0.1	0.0	-0.1	-0.1	-0.2	-0.3	-0.3	-0.2
1.92	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.2	0.2	0.1	0.1	0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.2
1.75	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.2	0.2	0.1	0.1	0.0	0.0	-0.1	-0.2	-0.2	-0.2	-0.2
1.57	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.1	0.1	0.0	0.0	-0.1	-0.1	-0.2	-0.2	-0.1
1.40	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0	-0.1	-0.1	-0.2	-0.2	-0.1
1.22	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0	-0.1	-0.1	-0.1	-0.2	-0.1
1.05	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1
0.87	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1
0.70	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1
0.52	0.1	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	0.0
0.35	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	0.0
0.17	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0
0.00	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

0.00 0.50 1.00 1.50 2.00 2.50

Width (m)

Average per Column (m/s)

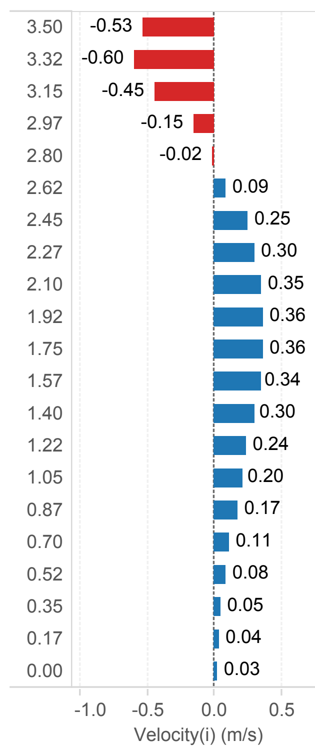
Height (m)	
3.50	-0.52
3.32	-0.60
3.15	-0.42
2.97	-0.18
2.80	-0.07
2.62	0.00
2.45	0.08
2.27	0.11
2.10	0.15
1.92	0.16
1.75	0.17
1.57	0.17
1.40	0.15
1.22	0.13
1.05	0.11
0.87	0.10
0.70	0.07
0.52	0.06
0.35	0.04
0.17	0.04
0.00	0.03

Average per Row (m/s)

Width (m)

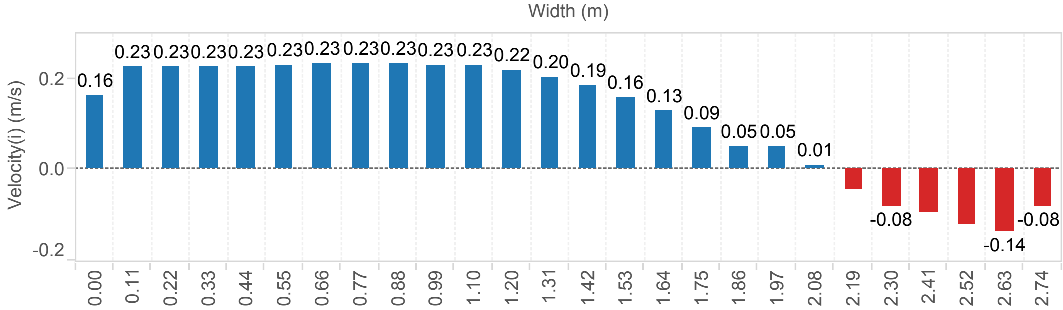
0.00	0.11	0.22	0.33	0.44	0.55	0.66	0.77	0.88	0.99	1.10	1.20	1.31	1.42	1.53	1.64	1.75	1.86	1.97	2.08	2.19	2.30	2.41	2.52	2.63	2.74
0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.3	-0.2

Vertical WInd Profile at the Probe Location



Horizontal Wind Profile at the Probe Location

Width (m)



Width (m) *All*

Height (m) *1.05*

Average Volume Flow Rate Across the Opening

6.478 cm/min

Mean Velocity Across the Opening

-0.01127

Width (m) *1.31*

Height (m) *All*

in (airflow into controll volume)

out (airflow out from control volume)

SIMULATION DATA ANALYSIS
(Scenario 3a - Opening A0)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height (m)									
2.11	-0.38	-0.34	-0.41	-0.45	-0.47	-0.47	-0.48	-0.48	-0.40
1.99	-0.47	-0.57	-0.58	-0.57	-0.56	-0.54	-0.53	-0.49	-0.26
1.87	-0.39	-0.56	-0.56	-0.53	-0.54	-0.55	-0.53	-0.48	-0.14
1.76	-0.09	-0.52	-0.50	-0.48	-0.52	-0.55	-0.54	-0.48	-0.12
1.64	0.00	-0.54	-0.48	-0.46	-0.51	-0.54	-0.53	-0.47	-0.15
1.52	-0.02	-0.54	-0.49	-0.46	-0.52	-0.55	-0.53	-0.46	-0.01
1.41	-0.12	-0.54	-0.49	-0.47	-0.53	-0.55	-0.53	-0.45	0.04
1.29	-0.13	-0.55	-0.49	-0.49	-0.54	-0.56	-0.53	-0.45	0.02
1.17	-0.17	-0.56	-0.50	-0.49	-0.55	-0.56	-0.52	-0.43	-0.09
1.05	-0.25	-0.56	-0.49	-0.51	-0.55	-0.56	-0.52	-0.40	0.08
0.94	-0.37	-0.55	-0.50	-0.53	-0.57	-0.55	-0.51	-0.39	0.07
0.82	-0.48	-0.54	-0.50	-0.55	-0.57	-0.55	-0.49	-0.36	-0.02
0.70	-0.47	-0.54	-0.52	-0.57	-0.58	-0.54	-0.47	-0.28	0.16
0.59	-0.47	-0.54	-0.53	-0.58	-0.58	-0.53	-0.47	-0.28	0.16
0.47	-0.48	-0.54	-0.55	-0.59	-0.57	-0.52	-0.46	-0.33	0.03
0.35	-0.48	-0.54	-0.56	-0.59	-0.57	-0.51	-0.45	-0.25	0.16
0.23	-0.50	-0.54	-0.56	-0.59	-0.56	-0.50	-0.43	-0.20	0.13
0.12	-0.50	-0.54	-0.56	-0.58	-0.55	-0.50	-0.43	-0.19	0.07
0.00	-0.36	-0.49	-0.50	-0.48	-0.43	-0.49	-0.44	-0.36	-0.03

0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90

Width (m)

Average per Column (m/s)

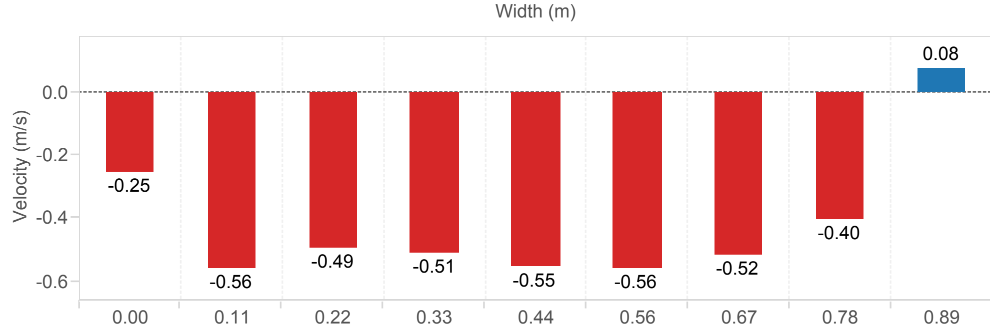
Height (m)	
2.11	**-0.43**
1.99	**-0.51**
1.87	**-0.48**
1.76	**-0.42**
1.64	**-0.41**
1.52	**-0.40**
1.41	**-0.41**
1.29	**-0.41**
1.17	**-0.43**
1.05	**-0.42**
0.94	**-0.43**
0.82	**-0.45**
0.70	**-0.42**
0.59	**-0.42**
0.47	**-0.45**
0.35	**-0.42**
0.23	**-0.42**
0.12	**-0.42**
0.00	**-0.40**

Average per Row (m/s)

Width (m)

0.00	0.11	0.22	0.22	0.33	0.44	0.56	0.67	0.78	0.89
-0.32	**-0.53**	**-0.53**	**-0.50**	**-0.52**	**-0.54**	**-0.53**	**-0.49**	**-0.38**	**-0.02**

Horizontal Wind Profile at the Probe Location



Width (m)
All

Height (m)
1.05

Average Volume Flow Rate Across the Opening

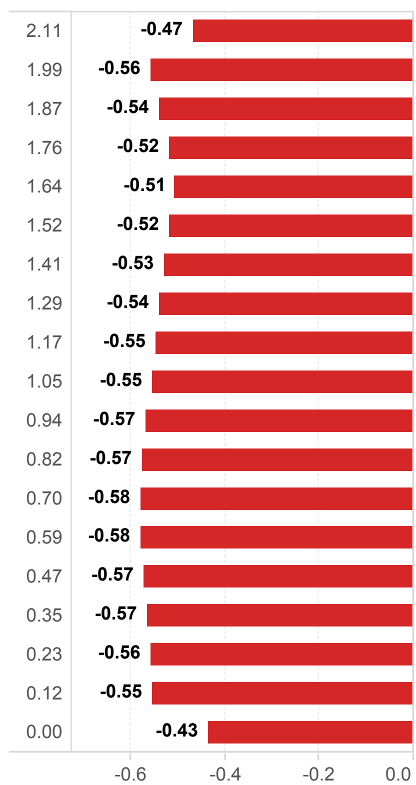
48.246 cm/min

Mean Velocity Across the Opening

-0.429 m/s

in (airflow into the control volume) out (airflow out from the control volume)

Vertical Wind Profile at the Probe Location



Width (m) *0.44*

Height (m) *All*

SIMULATION DATA ANALYSIS
(Scenario 3a - Opening A1)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height (m)									
2.11	-0.12	-0.20	-0.25	-0.25	-0.24	-0.23	-0.22	-0.19	-0.12
1.99	-0.19	-0.28	-0.31	-0.31	-0.30	-0.29	-0.28	-0.24	-0.16
1.88	-0.23	-0.32	-0.34	-0.34	-0.33	-0.33	-0.31	-0.28	-0.19
1.76	-0.29	-0.37	-0.38	-0.37	-0.37	-0.36	-0.35	-0.31	-0.22
1.64	-0.34	-0.40	-0.39	-0.39	-0.38	-0.38	-0.36	-0.32	-0.22
1.53	-0.37	-0.42	-0.41	-0.41	-0.40	-0.39	-0.38	-0.34	-0.22
1.41	-0.36	-0.44	-0.43	-0.42	-0.41	-0.41	-0.39	-0.35	-0.22
1.29	-0.37	-0.45	-0.43	-0.43	-0.42	-0.42	-0.41	-0.37	-0.23
1.17	-0.36	-0.45	-0.44	-0.43	-0.42	-0.43	-0.42	-0.38	-0.23
1.06	-0.34	-0.45	-0.44	-0.43	-0.42	-0.43	-0.42	-0.39	-0.22
0.94	-0.32	-0.45	-0.43	-0.42	-0.42	-0.43	-0.43	-0.39	-0.21
0.82	-0.31	-0.43	-0.42	-0.42	-0.42	-0.43	-0.43	-0.40	-0.20
0.71	-0.34	-0.42	-0.41	-0.41	-0.41	-0.43	-0.43	-0.39	-0.16
0.59	-0.33	-0.41	-0.41	-0.40	-0.41	-0.43	-0.43	-0.40	-0.17
0.47	-0.33	-0.40	-0.40	-0.40	-0.40	-0.42	-0.42	-0.39	-0.14
0.36	-0.33	-0.39	-0.40	-0.40	-0.40	-0.42	-0.41	-0.37	-0.09
0.24	-0.34	-0.39	-0.39	-0.39	-0.39	-0.40	-0.40	-0.34	-0.03
0.12	-0.34	-0.38	-0.38	-0.38	-0.38	-0.39	-0.39	-0.32	0.01
0.01	-0.27	-0.37	-0.37	-0.37	-0.37	-0.38	-0.40	-0.33	0.07

0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00 1.10

Width (m)

Average per Column (m/s)

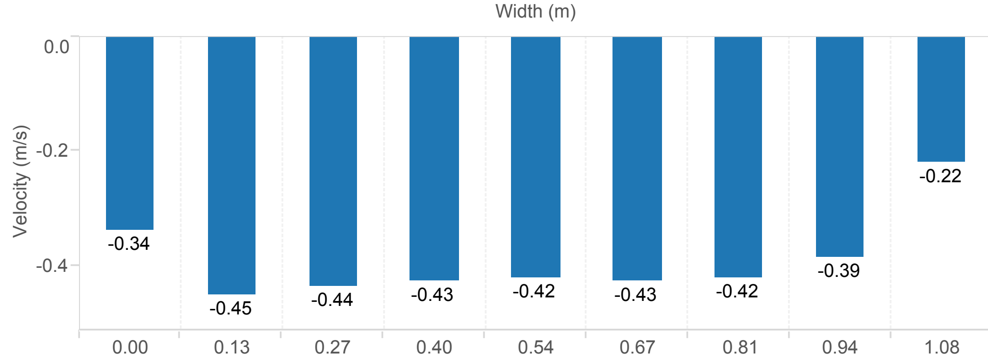
Height (m)	
2.11	**-0.20**
1.99	**-0.26**
1.88	**-0.30**
1.76	**-0.33**
1.64	**-0.35**
1.53	**-0.37**
1.41	**-0.38**
1.29	**-0.39**
1.17	**-0.39**
1.06	**-0.39**
0.94	**-0.39**
0.82	**-0.38**
0.71	**-0.38**
0.59	**-0.38**
0.47	**-0.37**
0.36	**-0.36**
0.24	**-0.34**
0.12	**-0.33**
0.01	**-0.31**

Average per Row (m/s)

Width (m)

0.00	0.13	0.27	0.40	0.54	0.67	0.81	0.94	1.08
-0.31	**-0.39**	**-0.39**	**-0.39**	**-0.39**	**-0.39**	**-0.38**	**-0.34**	**-0.15**

Horizontal Wind Profile at the Probe Location



Width (m) *All* ***Height (m)*** *1.06*

Average Volume Flow Rate Across the Opening

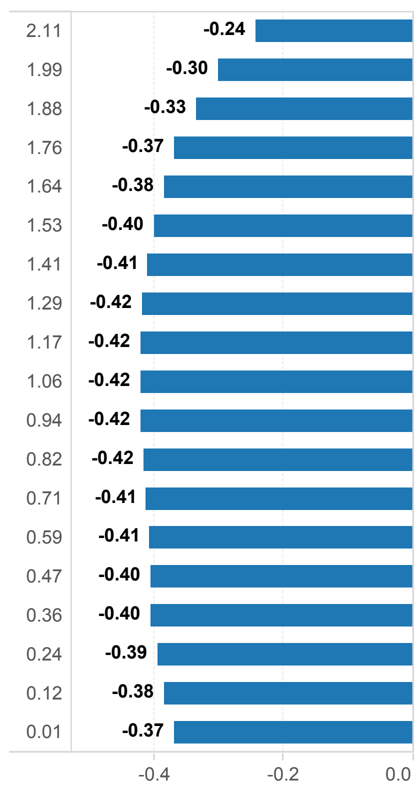
47.286 cm/min

Mean Velocity Across the Opening

-0.348 m/s

in (airflow into the controll volume) out (airflow out from the control volume)

Vertical Wind Profile at the Probe Location



Width (m) *0.54*

Height (m) *All*

SIMULATION DATA ANALYSIS
(Scenario 3a - Opening A3)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height (m)									
2.11	0.00	-0.23	-0.26	-0.23	-0.21	-0.20	-0.17	-0.11	-0.07
1.99	-0.05	-0.29	-0.30	-0.28	-0.26	-0.25	-0.23	-0.17	-0.11
1.88	-0.08	-0.31	-0.32	-0.30	-0.29	-0.28	-0.27	-0.22	-0.13
1.76	-0.10	-0.34	-0.34	-0.32	-0.31	-0.30	-0.31	-0.27	-0.15
1.64	-0.12	-0.35	-0.35	-0.33	-0.32	-0.33	-0.34	-0.29	-0.13
1.52	-0.12	-0.37	-0.36	-0.34	-0.34	-0.35	-0.36	-0.32	-0.11
1.41	-0.12	-0.37	-0.38	-0.36	-0.35	-0.37	-0.38	-0.31	-0.09
1.29	-0.11	-0.38	-0.39	-0.37	-0.37	-0.38	-0.39	-0.31	-0.08
1.17	-0.10	-0.39	-0.40	-0.38	-0.38	-0.39	-0.39	-0.30	-0.07
1.06	-0.08	-0.40	-0.41	-0.40	-0.39	-0.39	-0.40	-0.32	-0.09
0.94	-0.06	-0.41	-0.42	-0.40	-0.39	-0.40	-0.40	-0.35	-0.17
0.82	-0.04	-0.42	-0.42	-0.41	-0.40	-0.40	-0.41	-0.37	-0.23
0.70	-0.01	-0.42	-0.42	-0.41	-0.40	-0.40	-0.40	-0.36	-0.26
0.59	0.00	-0.40	-0.42	-0.41	-0.40	-0.40	-0.40	-0.37	-0.28
0.47	0.00	-0.33	-0.41	-0.40	-0.39	-0.40	-0.40	-0.37	-0.30
0.35	0.01	-0.23	-0.39	-0.39	-0.39	-0.39	-0.38	-0.36	-0.31
0.24	0.01	-0.16	-0.36	-0.38	-0.37	-0.37	-0.37	-0.35	-0.31
0.12	0.02	-0.13	-0.34	-0.37	-0.36	-0.36	-0.35	-0.34	-0.31
0.00	0.06	-0.18	-0.31	-0.31	-0.27	-0.25	-0.24	-0.23	-0.19

0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00 1.10

Width (m)

Average per Column (m/s)

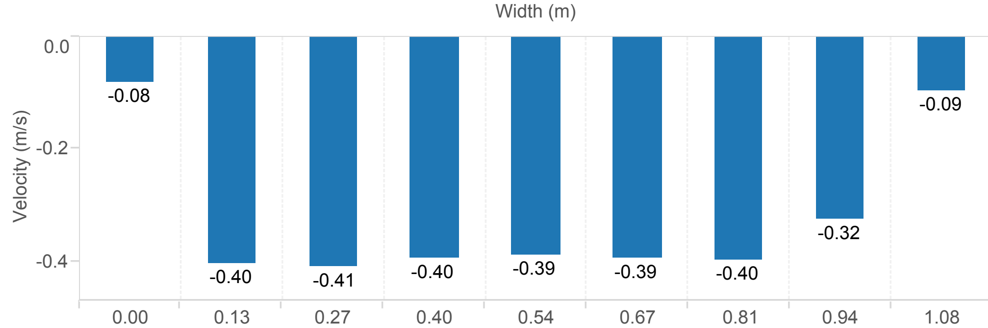
Height (m)	
2.11	**-0.17**
1.99	**-0.22**
1.88	**-0.24**
1.76	**-0.27**
1.64	**-0.28**
1.52	**-0.30**
1.41	**-0.30**
1.29	**-0.31**
1.17	**-0.31**
1.06	**-0.32**
0.94	**-0.33**
0.82	**-0.34**
0.70	**-0.34**
0.59	**-0.34**
0.47	**-0.33**
0.35	**-0.31**
0.24	**-0.30**
0.12	**-0.28**
0.00	**-0.21**

Average per Row (m/s)

Width (m)

0.00	0.13	0.27	0.40	0.54	0.67	0.81	0.94	1.08
-0.05	**-0.32**	**-0.37**	**-0.36**	**-0.35**	**-0.35**	**-0.35**	**-0.30**	**-0.18**

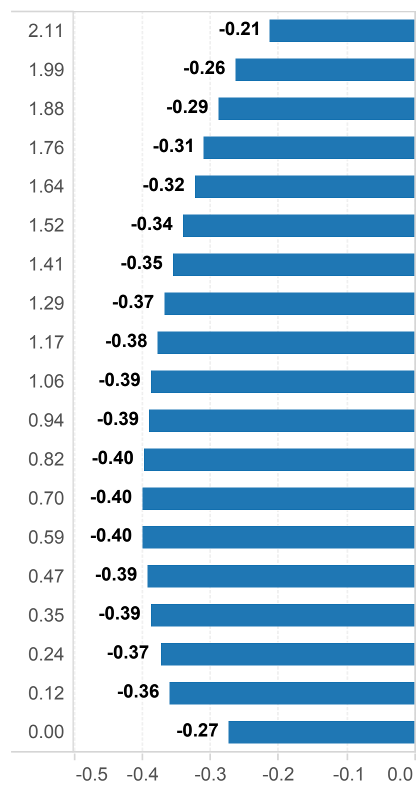
Horizontal Wind Profile at the Probe Location



Width (m)
All

Height (m)
1.06

Vertical Wind Profile at the Probe Location



Width (m) *0.54*

Height (m) *All*

Average Volume Flow Rate Across the Opening

39.545 cm/min

Mean Velocity Across the Opening

-0.291 m/s

in (airflow into the controll volume) out (airflow out from the controll volume)

SIMULATION DATA ANALYSIS
(Scenario 3a - Opening A4)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height (m)									
2.12	0.15	-0.43	-0.39	-0.34	-0.27	-0.22	-0.15	-0.11	0.01
2.00	0.13	-0.59	-0.61	-0.62	-0.63	-0.65	-0.68	-0.68	-0.58
1.88	0.19	-0.56	-0.59	-0.60	-0.60	-0.60	-0.63	-0.66	-0.48
1.77	0.17	-0.54	-0.58	-0.59	-0.58	-0.56	-0.58	-0.60	-0.10
1.65	0.16	-0.53	-0.58	-0.59	-0.57	-0.55	-0.55	-0.61	0.03
1.53	0.17	-0.51	-0.57	-0.58	-0.57	-0.55	-0.56	-0.62	-0.02
1.41	0.16	-0.50	-0.56	-0.58	-0.57	-0.56	-0.56	-0.62	-0.05
1.30	0.17	-0.48	-0.56	-0.58	-0.57	-0.56	-0.56	-0.62	-0.10
1.18	0.16	-0.46	-0.55	-0.57	-0.57	-0.57	-0.56	-0.63	-0.12
1.06	0.16	-0.44	-0.55	-0.57	-0.57	-0.57	-0.57	-0.64	-0.16
0.94	0.15	-0.43	-0.54	-0.57	-0.57	-0.57	-0.57	-0.64	-0.23
0.82	0.13	-0.42	-0.54	-0.57	-0.57	-0.57	-0.58	-0.64	-0.37
0.71	0.13	-0.41	-0.54	-0.57	-0.57	-0.57	-0.58	-0.64	-0.41
0.59	0.12	-0.40	-0.54	-0.57	-0.57	-0.56	-0.58	-0.64	-0.45
0.47	0.13	-0.39	-0.54	-0.57	-0.56	-0.56	-0.58	-0.65	-0.49
0.35	0.12	-0.39	-0.54	-0.57	-0.56	-0.56	-0.58	-0.65	-0.50
0.24	0.12	-0.38	-0.55	-0.57	-0.56	-0.55	-0.58	-0.65	-0.59
0.12	0.14	-0.40	-0.56	-0.57	-0.55	-0.55	-0.58	-0.65	-0.53
0.00	0.16	-0.48	-0.58	-0.57	-0.55	-0.55	-0.58	-0.64	-0.49

0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90

Width (m)

Average per Column (m/s)

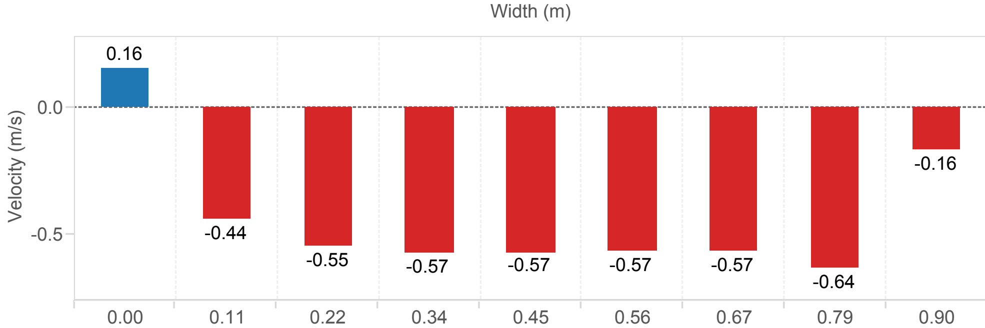
Height (m)	
2.12	**-0.19**
2.00	**-0.54**
1.88	**-0.50**
1.77	**-0.44**
1.65	**-0.42**
1.53	**-0.42**
1.41	**-0.43**
1.30	**-0.43**
1.18	**-0.43**
1.06	**-0.43**
0.94	**-0.44**
0.82	**-0.46**
0.71	**-0.46**
0.59	**-0.46**
0.47	**-0.47**
0.35	**-0.47**
0.24	**-0.48**
0.12	**-0.47**
0.00	**-0.48**

Average per Row (m/s)

Width (m)

0.00	0.11	0.22	0.34	0.45	0.56	0.67	0.79	0.90
0.15	**-0.46**	**-0.55**	**-0.57**	**-0.56**	**-0.55**	**-0.56**	**-0.61**	**-0.30**

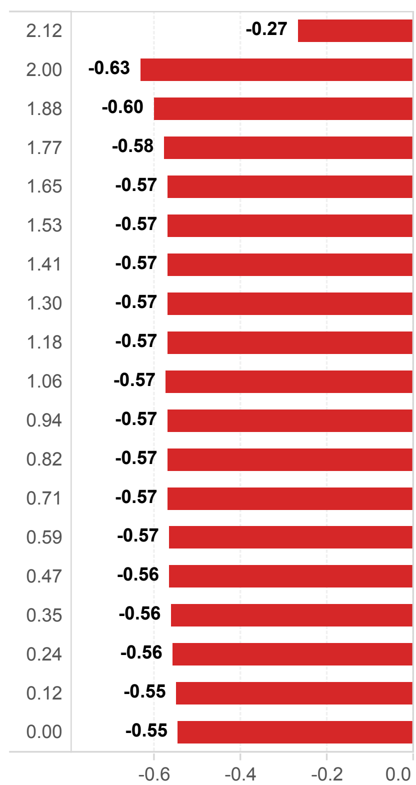
Horizontal Wind Profile at the Probe Location



Width (m)
All

Height (m)
1.06

Vertical Wind Profile at the Probe Location



Width (m) *0.45*

Height (m) *All*

Average Volume Flow Rate Across the Opening

50.756 cm/min

Mean Velocity Across the Opening

-0.444 m/s

in (airflow into the controll volume)   out (airflow out from the control volume)

SIMULATION DATA ANALYSIS
(Scenario 3a - Opening A7E)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height .. \ Width (m)	0.00	0.11	0.22	0.33	0.44	0.55	0.66	0.77	0.88	0.99	1.10	1.20	1.31	1.42	1.53	1.64	1.75	1.86	1.97	2.08	2.19	2.30	2.41	2.52	2.63	2.74
3.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.32	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
3.15	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
2.97	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
2.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.62	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.92	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.57	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.87	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.52	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Width (m): 0.00 0.50 1.00 1.50 2.00 2.50

Average per Column (m/s)

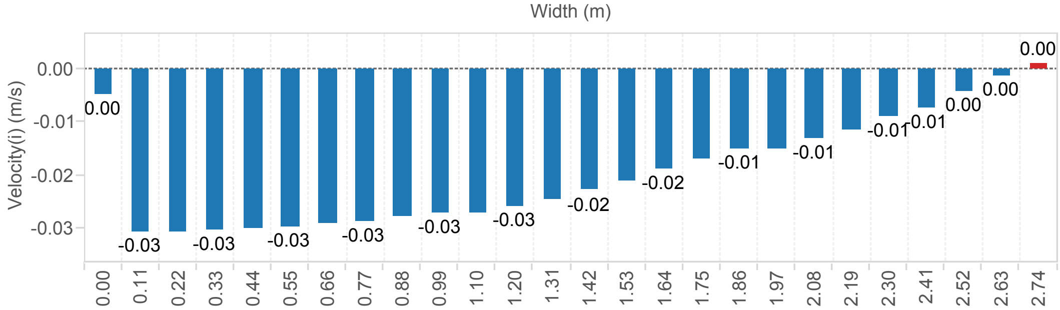
Height (m)	
3.50	0.02
3.32	0.07
3.15	0.05
2.97	0.03
2.80	0.02
2.62	0.01
2.45	0.00
2.27	0.00
2.10	-0.01
1.92	-0.01
1.75	-0.01
1.57	-0.02
1.40	-0.02
1.22	-0.02
1.05	-0.02
0.87	-0.02
0.70	-0.02
0.52	-0.02
0.35	-0.02
0.17	-0.02
0.00	0.00

Average per Row (m/s)

Width (m)

0.00	0.11	0.22	0.33	0.44	0.55	0.66	0.77	0.88	0.99	1.10	1.20	1.31	1.42	1.53	1.64	1.75	1.86	1.97	2.08	2.19	2.30	2.41	2.52	2.63	2.74
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

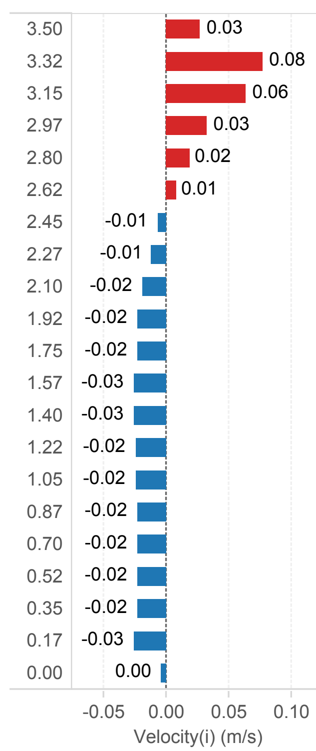
Horizontal Wind Profile at the Probe Location



Width (m) *All*

Height (m) *1.05*

Vertical WInd Profile at the Probe Location



Average Volume Flow Rate Across the Opening

0.075 cm/min

Mean Velocity Across the Opening

-0.0001306

Width (m) *1.31*

Height (m) *All*

in (airflow into control volume)   out (airflow out from control volume)

SIMULATION DATA ANALYSIS
(Scenario 3a - Opening A7W)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height ..																										
3.50	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.32	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0
3.15	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0
2.97	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0
2.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0
2.62	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	0.0
2.45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	0.0
2.27	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0
2.10	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0
1.92	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0
1.75	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.57	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.22	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.05	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.87	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.70	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.52	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.35	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.17	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

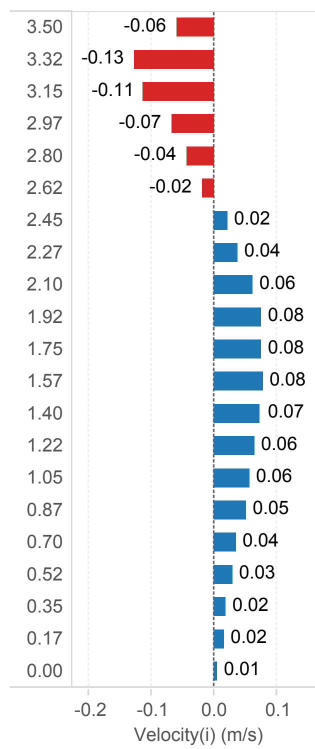
0.00 0.50 1.00 1.50 2.00 2.50

Width (m)

Average per Column (m/s)

Height (m)	
3.50	-0.05
3.32	-0.12
3.15	-0.10
2.97	-0.07
2.80	-0.05
2.62	-0.03
2.45	0.01
2.27	0.02
2.10	0.03
1.92	0.04
1.75	0.04
1.57	0.04
1.40	0.04
1.22	0.04
1.05	0.04
0.87	0.03
0.70	0.03
0.52	0.02
0.35	0.02
0.17	0.02
0.00	0.01

Vertical WInd Profile at the Probe Location

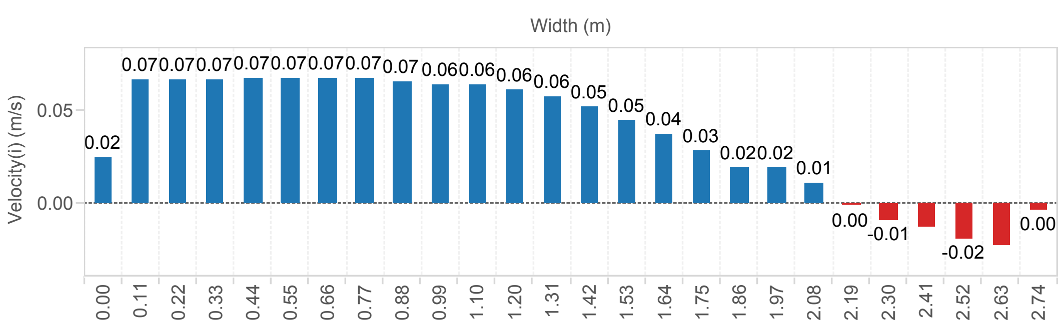


Average per Row (m/s)

Width (m)

0.00	0.11	0.22	0.33	0.44	0.55	0.66	0.77	0.88	0.99	1.10	1.20	1.31	1.42	1.53	1.64	1.75	1.86	1.97	2.08	2.19	2.30	2.41	2.52	2.63	2.74
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Horizontal Wind Profile at the Probe Location



Width (m) *All*

Height (m) *1.05*

Average Volume Flow Rate Across the Opening

0.006 cm/min

Mean Velocity Across the Opening

-0.000009824

Width (m) *1.31*

Height (m) *All*

in (airflow into controll volume)

out (airflow out from control volume)

SIMULATION DATA ANALYSIS
(Scenario 3b - Opening A0)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height (m)									
2.11	-0.70	-0.56	-0.71	-0.84	-0.91	-0.94	-0.96	-1.07	-0.94
1.99	-0.93	-1.09	-1.11	-1.14	-1.11	-1.09	-1.09	-1.07	-0.33
1.87	-0.40	-1.05	-1.01	-1.01	-1.02	-1.05	-1.09	-1.07	-0.04
1.76	-0.05	-1.07	-0.97	-0.94	-0.96	-1.03	-1.08	-1.08	-0.01
1.64	-0.05	-1.08	-1.00	-0.95	-0.95	-1.03	-1.08	-1.05	-0.04
1.52	-0.14	-1.09	-1.02	-0.97	-0.97	-1.04	-1.08	-1.03	0.26
1.41	-0.39	-1.11	-1.02	-0.97	-0.99	-1.06	-1.09	-0.98	0.30
1.29	-0.60	-1.13	-1.03	-0.98	-1.01	-1.08	-1.10	-0.99	0.28
1.17	-0.73	-1.13	-1.02	-0.98	-1.03	-1.10	-1.10	-0.95	-0.03
1.05	-0.82	-1.12	-1.02	-1.01	-1.05	-1.12	-1.08	-0.78	0.33
0.94	-0.94	-1.10	-1.03	-1.04	-1.10	-1.12	-1.06	-0.79	0.32
0.82	-1.01	-1.09	-1.04	-1.08	-1.13	-1.11	-1.03	-0.81	0.02
0.70	-0.97	-1.08	-1.06	-1.12	-1.14	-1.09	-0.98	-0.53	0.28
0.59	-0.96	-1.08	-1.08	-1.14	-1.14	-1.07	-0.97	-0.50	0.29
0.47	-0.95	-1.08	-1.11	-1.15	-1.13	-1.06	-0.96	-0.75	0.07
0.35	-0.96	-1.08	-1.12	-1.15	-1.11	-1.03	-0.92	-0.48	0.30
0.23	-0.98	-1.08	-1.13	-1.13	-1.08	-0.99	-0.88	-0.37	0.24
0.12	-0.98	-1.08	-1.13	-1.11	-1.06	-0.97	-0.87	-0.34	0.14
0.00	-0.76	-0.98	-1.03	-0.98	-0.86	-0.94	-0.86	-0.76	-0.17

0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90

Width (m)

Average per Column (m/s)

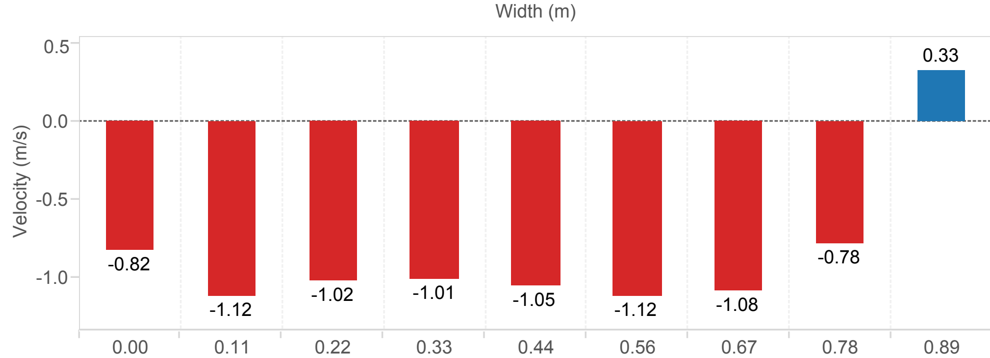
Height (m)	
2.11	**-0.85**
1.99	**-1.00**
1.87	**-0.86**
1.76	**-0.80**
1.64	**-0.80**
1.52	**-0.79**
1.41	**-0.81**
1.29	**-0.85**
1.17	**-0.90**
1.05	**-0.85**
0.94	**-0.87**
0.82	**-0.92**
0.70	**-0.86**
0.59	**-0.85**
0.47	**-0.90**
0.35	**-0.84**
0.23	**-0.82**
0.12	**-0.82**
0.00	**-0.82**

Average per Row (m/s)

Width (m)

0.00	0.11	0.22	0.22	0.33	0.44	0.56	0.67	0.78	0.89
-0.70	**-1.06**	**-1.08**	**-0.99**	**-1.04**	**-1.04**	**-1.05**	**-1.01**	**-0.81**	**0.07**

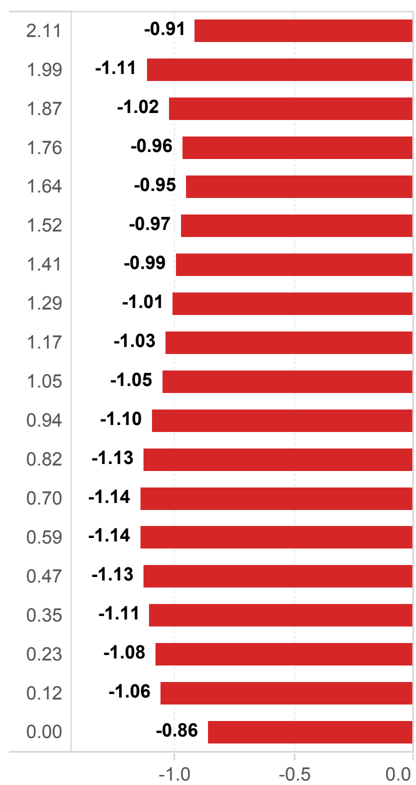
Horizontal Wind Profile at the Probe Location



Width (m) *All*

Height (m) *1.05*

Vertical Wind Profile at the Probe Location



Width (m) *0.44*

Height (m) *All*

Average Volume Flow Rate Across the Opening

96.034 cm/min

Mean Velocity Across the Opening

-0.853 m/s

in (airflow into the controll volume) out (airflow out from the control volume)

SIMULATION DATA ANALYSIS
(Scenario 3b - Opening A1)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height (m)									
2.11	-0.28	-0.46	-0.53	-0.52	-0.50	-0.47	-0.43	-0.39	-0.32
1.99	-0.41	-0.63	-0.66	-0.64	-0.62	-0.58	-0.55	-0.50	-0.42
1.88	-0.51	-0.72	-0.73	-0.71	-0.69	-0.65	-0.62	-0.57	-0.49
1.76	-0.62	-0.80	-0.79	-0.77	-0.75	-0.72	-0.69	-0.64	-0.55
1.64	-0.73	-0.85	-0.82	-0.80	-0.78	-0.75	-0.72	-0.68	-0.56
1.53	-0.76	-0.88	-0.85	-0.83	-0.81	-0.78	-0.76	-0.72	-0.57
1.41	-0.72	-0.90	-0.87	-0.84	-0.83	-0.80	-0.79	-0.75	-0.57
1.29	-0.71	-0.90	-0.87	-0.85	-0.83	-0.82	-0.81	-0.78	-0.60
1.17	-0.68	-0.90	-0.87	-0.85	-0.84	-0.84	-0.83	-0.79	-0.59
1.06	-0.62	-0.89	-0.86	-0.85	-0.84	-0.84	-0.84	-0.80	-0.58
0.94	-0.54	-0.86	-0.85	-0.84	-0.84	-0.85	-0.85	-0.81	-0.57
0.82	-0.47	-0.81	-0.83	-0.83	-0.83	-0.85	-0.86	-0.82	-0.55
0.71	-0.56	-0.79	-0.81	-0.82	-0.83	-0.85	-0.86	-0.80	-0.48
0.59	-0.62	-0.78	-0.80	-0.81	-0.82	-0.85	-0.86	-0.81	-0.48
0.47	-0.64	-0.77	-0.79	-0.79	-0.80	-0.83	-0.84	-0.78	-0.37
0.36	-0.63	-0.75	-0.79	-0.79	-0.79	-0.80	-0.79	-0.63	-0.18
0.24	-0.63	-0.74	-0.77	-0.76	-0.76	-0.77	-0.74	-0.43	-0.06
0.12	-0.63	-0.73	-0.75	-0.75	-0.75	-0.76	-0.73	-0.32	-0.03
0.01	-0.54	-0.72	-0.74	-0.73	-0.73	-0.77	-0.73	-0.16	0.14

0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00 1.10

Width (m)

Average per Column (m/s)

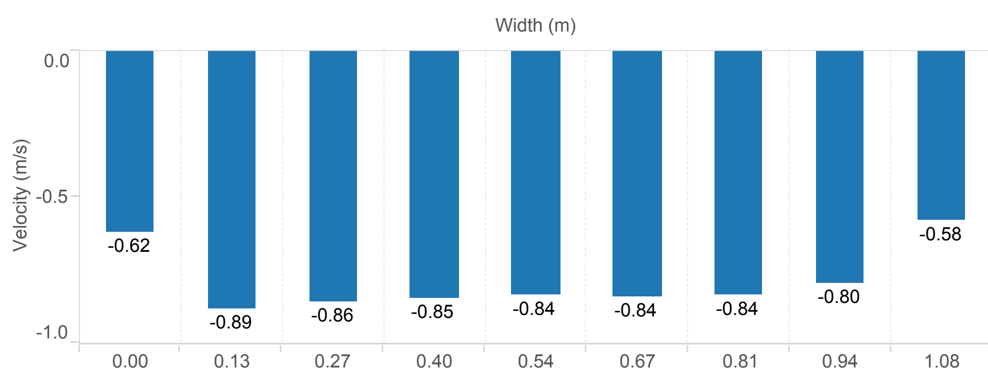
Height (m)	
2.11	**-0.43**
1.99	**-0.56**
1.88	**-0.63**
1.76	**-0.70**
1.64	**-0.74**
1.53	**-0.77**
1.41	**-0.78**
1.29	**-0.80**
1.17	**-0.80**
1.06	**-0.79**
0.94	**-0.78**
0.82	**-0.76**
0.71	**-0.76**
0.59	**-0.76**
0.47	**-0.73**
0.36	**-0.68**
0.24	**-0.63**
0.12	**-0.60**
0.01	**-0.55**

Average per Row (m/s)

Width (m)

0.00	0.13	0.27	0.40	0.54	0.67	0.81	0.94	1.08
-0.59	**-0.78**	**-0.79**	**-0.78**	**-0.77**	**-0.77**	**-0.75**	**-0.64**	**-0.41**

Horizontal Wind Profile at the Probe Location



Width (m) *All* ***Height (m)*** *1.06*

Average Volume Flow Rate Across the Opening

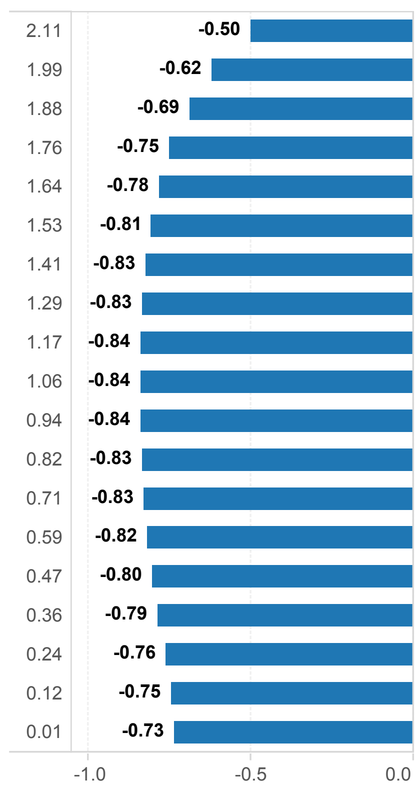
94.898 cm/min

Mean Velocity Across the Opening

-0.699 m/s

in (airflow into the control volume) out (airflow out from the control volume)

Vertical Wind Profile at the Probe Location



Width (m) *0.54*

Height (m) *All*

SIMULATION DATA ANALYSIS
(Scenario 3b - Opening A3)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height (m)									
2.11	-0.02	-0.42	-0.47	-0.42	-0.38	-0.38	-0.38	-0.27	-0.12
1.99	-0.11	-0.53	-0.56	-0.51	-0.49	-0.50	-0.50	-0.40	-0.20
1.88	-0.17	-0.58	-0.61	-0.56	-0.55	-0.56	-0.57	-0.49	-0.24
1.76	-0.22	-0.63	-0.66	-0.61	-0.61	-0.60	-0.64	-0.58	-0.28
1.64	-0.25	-0.67	-0.67	-0.64	-0.63	-0.65	-0.68	-0.62	-0.28
1.52	-0.27	-0.70	-0.70	-0.67	-0.66	-0.69	-0.72	-0.67	-0.26
1.41	-0.27	-0.71	-0.73	-0.69	-0.69	-0.72	-0.75	-0.66	-0.23
1.29	-0.27	-0.73	-0.75	-0.72	-0.72	-0.74	-0.77	-0.65	-0.19
1.17	-0.26	-0.75	-0.77	-0.75	-0.74	-0.76	-0.77	-0.61	-0.16
1.06	-0.24	-0.76	-0.79	-0.77	-0.76	-0.77	-0.77	-0.60	-0.14
0.94	-0.22	-0.77	-0.80	-0.78	-0.76	-0.78	-0.78	-0.64	-0.19
0.82	-0.19	-0.78	-0.81	-0.80	-0.78	-0.79	-0.79	-0.69	-0.39
0.70	-0.15	-0.80	-0.81	-0.80	-0.79	-0.79	-0.80	-0.70	-0.48
0.59	-0.11	-0.78	-0.82	-0.80	-0.79	-0.80	-0.80	-0.73	-0.53
0.47	-0.06	-0.73	-0.80	-0.79	-0.78	-0.79	-0.79	-0.72	-0.57
0.35	-0.02	-0.58	-0.76	-0.78	-0.77	-0.77	-0.76	-0.71	-0.59
0.24	0.00	-0.40	-0.71	-0.75	-0.74	-0.73	-0.73	-0.69	-0.59
0.12	0.03	-0.32	-0.68	-0.72	-0.71	-0.70	-0.70	-0.67	-0.59
0.00	0.14	-0.35	-0.62	-0.62	-0.57	-0.55	-0.54	-0.50	-0.34

0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00 1.10

Width (m)

Average per Column (m/s)

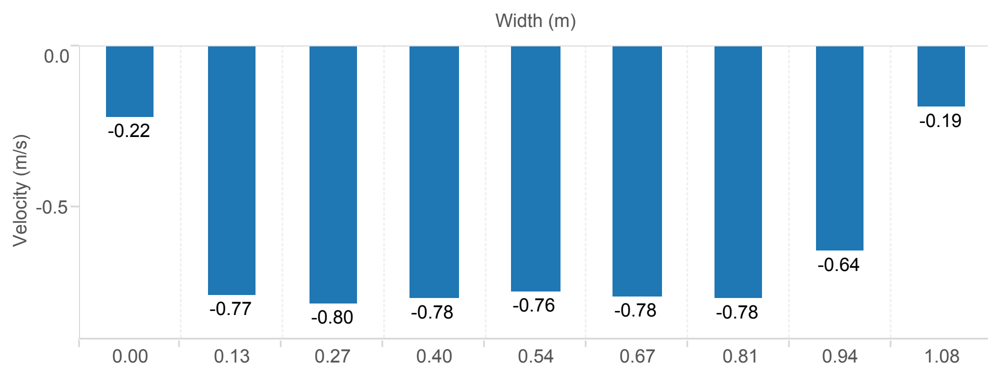
Height (m)	
2.11	**-0.32**
1.99	**-0.42**
1.88	**-0.48**
1.76	**-0.54**
1.64	**-0.57**
1.52	**-0.59**
1.41	**-0.61**
1.29	**-0.62**
1.17	**-0.62**
1.06	**-0.62**
0.94	**-0.64**
0.82	**-0.67**
0.70	**-0.68**
0.59	**-0.68**
0.47	**-0.67**
0.35	**-0.64**
0.24	**-0.59**
0.12	**-0.56**
0.00	**-0.44**

Average per Row (m/s)

Width (m)

0.00	0.13	0.27	0.40	0.54	0.67	0.81	0.94	1.08
-0.14	**-0.63**	**-0.71**	**-0.69**	**-0.68**	**-0.69**	**-0.70**	**-0.61**	**-0.34**

Horizontal Wind Profile at the Probe Location



Width (m) *All* ***Height (m)*** *0.94*

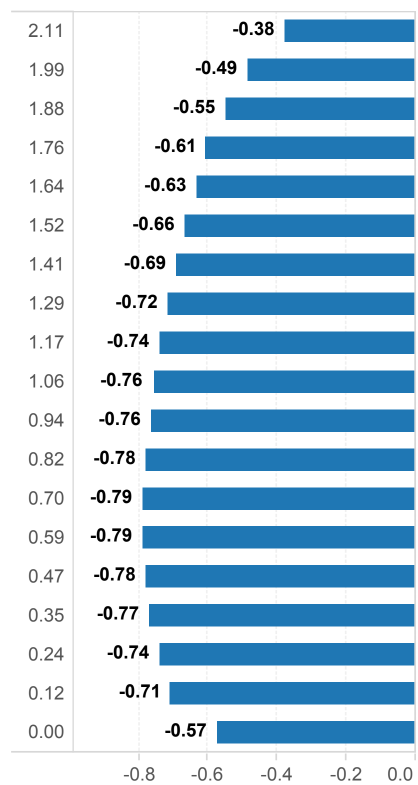
Average Volume Flow Rate Across the Opening

78.440 cm/min

Mean Velocity Across the Opening

-0.576 m/s

Vertical Wind Profile at the Probe Location



Width (m) *0.54*

Height (m) *All*

in (airflow into the control volume) out (airflow out from the control volume)

SIMULATION DATA ANALYSIS
(Scenario 3b - Opening A4)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height (m)									
2.12	0.35	-0.94	-0.81	-0.70	-0.57	-0.45	-0.26	-0.16	0.22
2.00	0.31	-1.20	-1.23	-1.24	-1.27	-1.31	-1.32	-1.29	-1.11
1.88	0.41	-1.14	-1.20	-1.20	-1.18	-1.17	-1.19	-1.23	-0.66
1.77	0.37	-1.10	-1.17	-1.18	-1.14	-1.10	-1.12	-1.24	-0.02
1.65	0.36	-1.06	-1.16	-1.16	-1.13	-1.11	-1.14	-1.26	-0.11
1.53	0.34	-1.02	-1.15	-1.15	-1.14	-1.13	-1.14	-1.29	-0.23
1.41	0.31	-0.97	-1.13	-1.15	-1.14	-1.14	-1.14	-1.30	-0.42
1.30	0.29	-0.91	-1.12	-1.14	-1.14	-1.14	-1.15	-1.30	-0.58
1.18	0.28	-0.87	-1.11	-1.14	-1.14	-1.14	-1.16	-1.30	-0.65
1.06	0.27	-0.82	-1.09	-1.14	-1.14	-1.14	-1.16	-1.30	-0.76
0.94	0.26	-0.79	-1.08	-1.13	-1.14	-1.14	-1.17	-1.29	-0.86
0.82	0.24	-0.77	-1.07	-1.13	-1.13	-1.14	-1.17	-1.27	-0.98
0.71	0.23	-0.75	-1.07	-1.13	-1.13	-1.14	-1.17	-1.28	-1.01
0.59	0.23	-0.74	-1.06	-1.13	-1.13	-1.13	-1.17	-1.27	-1.01
0.47	0.24	-0.73	-1.07	-1.13	-1.13	-1.13	-1.16	-1.29	-1.05
0.35	0.22	-0.73	-1.08	-1.13	-1.12	-1.12	-1.16	-1.29	-1.07
0.24	0.21	-0.72	-1.09	-1.14	-1.12	-1.12	-1.16	-1.29	-1.23
0.12	0.27	-0.76	-1.12	-1.13	-1.11	-1.11	-1.16	-1.29	-1.09
0.00	0.36	-0.94	-1.16	-1.13	-1.11	-1.12	-1.16	-1.29	-1.03

0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90

Width (m)

Average per Column (m/s)

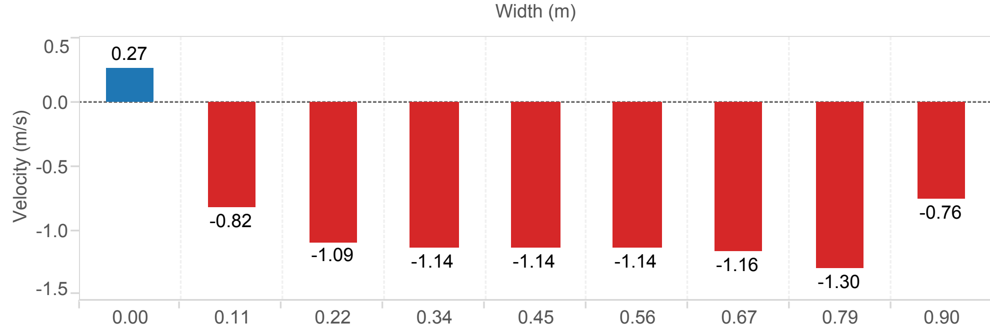
Height (m)	
2.12	**-0.37**
2.00	**-1.07**
1.88	**-0.95**
1.77	**-0.85**
1.65	**-0.86**
1.53	**-0.88**
1.41	**-0.90**
1.30	**-0.91**
1.18	**-0.91**
1.06	**-0.92**
0.94	**-0.93**
0.82	**-0.94**
0.71	**-0.94**
0.59	**-0.94**
0.47	**-0.94**
0.35	**-0.94**
0.24	**-0.96**
0.12	**-0.95**
0.00	**-0.95**

Average per Row (m/s)

Width (m)

0.00	0.11	0.22	0.34	0.45	0.56	0.67	0.79	0.90
0.29	**-0.89**	**-1.10**	**-1.13**	**-1.11**	**-1.10**	**-1.12**	**-1.22**	**-0.72**

Horizontal Wind Profile at the Probe Location



Width (m)
All

Height (m)
1.06

Average Volume Flow Rate Across the Opening

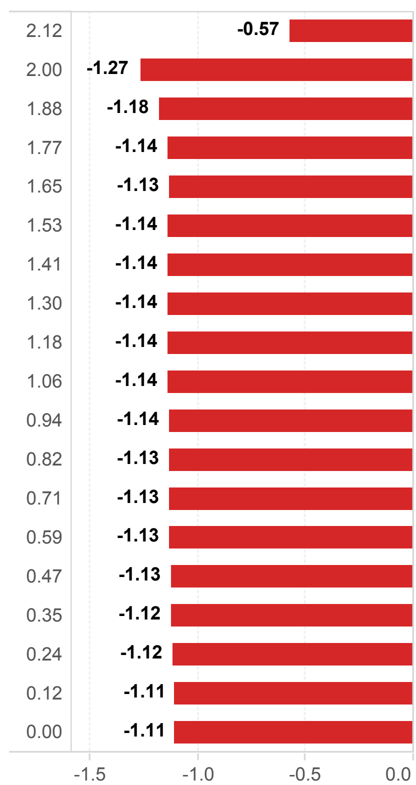
102.895 cm/min

Mean Velocity Across the Opening

-0.900 m/s

in (airflow into the control volume) out (airflow out from the control volume)

Vertical Wind Profile at the Probe Location



Width (m) *0.45*

Height (m) *All*

SIMULATION DATA ANALYSIS
(Scenario 3b - Opening A7E)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height ..																										
3.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.32	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0
3.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2.97	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
2.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
2.62	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
2.45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
2.27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0
1.92	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0
1.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
1.57	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.87	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.52	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

0.00 0.50 1.00 1.50 2.00 2.50

Width (m)

Average per Column (m/s)

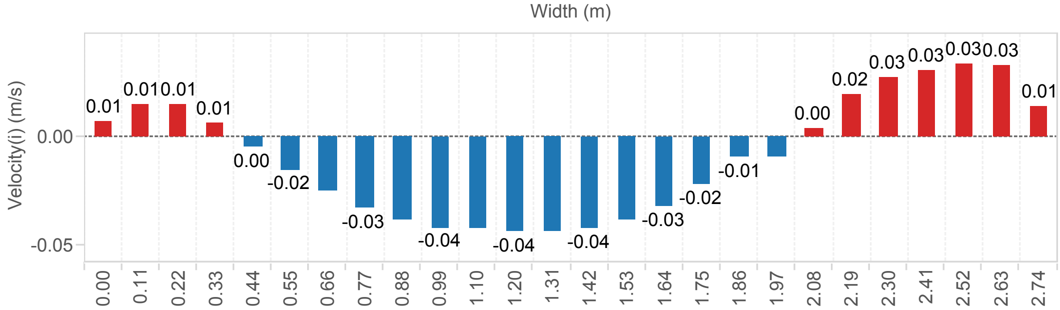
Height (m)	
3.50	0.02
3.32	0.05
3.15	0.03
2.97	0.02
2.80	0.01
2.62	0.00
2.45	-0.01
2.27	-0.02
2.10	-0.02
1.92	-0.03
1.75	-0.03
1.57	-0.02
1.40	-0.02
1.22	-0.01
1.05	-0.01
0.87	0.00
0.70	0.00
0.52	0.01
0.35	0.01
0.17	0.01
0.00	0.01

Average per Row (m/s)

Width (m)

0.00	0.11	0.22	0.33	0.44	0.55	0.66	0.77	0.88	0.99	1.10	1.20	1.31	1.42	1.53	1.64	1.75	1.86	1.97	2.08	2.19	2.30	2.41	2.52	2.63	2.74
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0

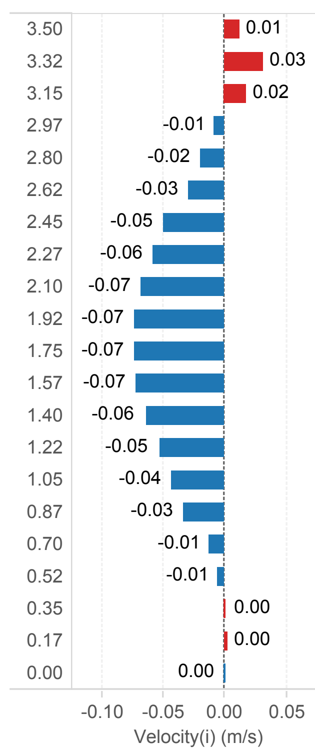
Horizontal Wind Profile at the Probe Location



Width (m) *All*

Height (m) *1.05*

Vertical WInd Profile at the Probe Location



Average Volume Flow Rate Across the Opening

0.105 cm/min

Mean Velocity Across the Opening

-0.0001832

in (airflow into control volume)

out (airflow out from control volume)

Width (m) *1.31*

Height (m) *All*

SIMULATION DATA ANALYSIS
(Scenario 3b - Opening A7W)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height ..																										
3.50	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
3.32	-0.2	-0.4	-0.4	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2
3.15	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2
2.97	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1
2.80	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.1
2.62	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.1
2.45	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.1
2.27	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.2	-0.1
2.10	0.0	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1
1.92	0.0	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1
1.75	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1
1.57	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1
1.40	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1
1.22	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	0.0
1.05	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0
0.87	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0
0.70	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0
0.52	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0
0.35	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0
0.17	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

0.00 0.50 1.00 1.50 2.00 2.50

Width (m)

Average per Column (m/s)

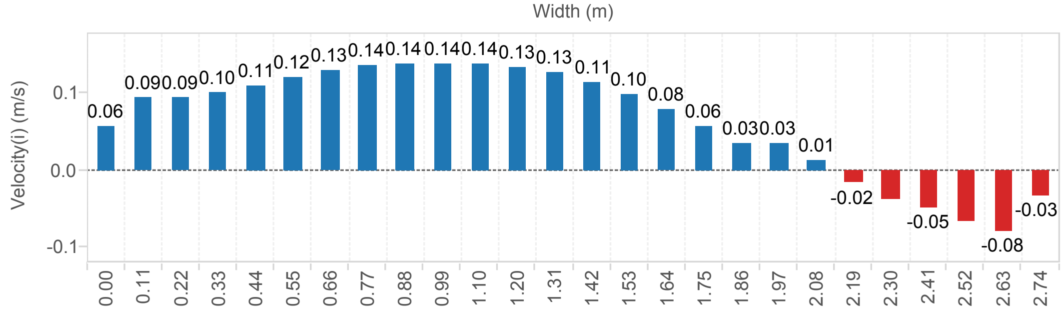
Height (m)	
3.50	-0.19
3.32	-0.28
3.15	-0.20
2.97	-0.09
2.80	-0.04
2.62	-0.01
2.45	0.03
2.27	0.05
2.10	0.07
1.92	0.08
1.75	0.09
1.57	0.09
1.40	0.09
1.22	0.07
1.05	0.06
0.87	0.05
0.70	0.03
0.52	0.02
0.35	0.01
0.17	0.00
0.00	0.01

Average per Row (m/s)

Width (m)

0.00	0.11	0.22	0.33	0.44	0.55	0.66	0.77	0.88	0.99	1.10	1.20	1.31	1.42	1.53	1.64	1.75	1.86	1.97	2.08	2.19	2.30	2.41	2.52	2.63	2.74
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1

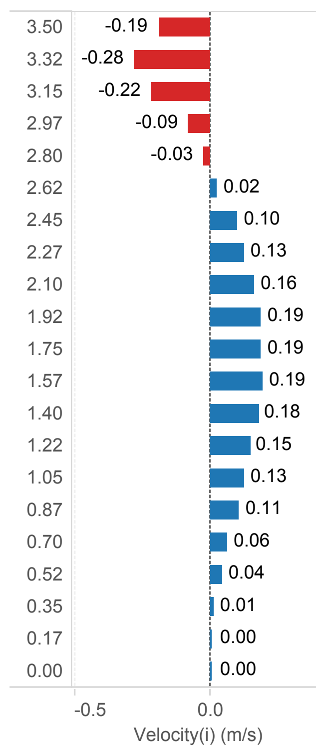
Horizontal Wind Profile at the Probe Location



Width (m) *All*

Height (m) *1.05*

Vertical WInd Profile at the Probe Location



Average Volume Flow Rate Across the Opening

1.471 cm/min

Mean Velocity Across the Opening

-0.002560

in (airflow into controll volume)   out (airflow out from control volume)

Width (m) *1.31*

Height (m) *All*

SIMULATION DATA ANALYSIS
(Scenario 3c - Opening A0)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height (m)									
2.11	-1.08	-0.90	-1.10	-1.26	-1.36	-1.39	-1.42	-1.59	-1.43
1.99	-1.38	-1.64	-1.66	-1.69	-1.65	-1.60	-1.60	-1.59	-0.50
1.87	-0.48	-1.59	-1.51	-1.50	-1.51	-1.55	-1.59	-1.59	-0.15
1.76	-0.11	-1.61	-1.47	-1.41	-1.43	-1.52	-1.58	-1.58	-0.06
1.64	-0.09	-1.62	-1.50	-1.42	-1.43	-1.52	-1.58	-1.54	-0.02
1.52	-0.38	-1.64	-1.51	-1.44	-1.45	-1.54	-1.58	-1.49	0.40
1.41	-0.74	-1.66	-1.52	-1.45	-1.47	-1.55	-1.59	-1.41	0.43
1.29	-1.04	-1.66	-1.52	-1.45	-1.49	-1.58	-1.61	-1.44	0.41
1.17	-1.15	-1.66	-1.52	-1.46	-1.52	-1.62	-1.61	-1.41	-0.08
1.05	-1.28	-1.65	-1.53	-1.50	-1.56	-1.65	-1.59	-1.16	0.42
0.94	-1.37	-1.64	-1.54	-1.55	-1.62	-1.66	-1.56	-1.16	0.48
0.82	-1.41	-1.62	-1.56	-1.61	-1.67	-1.64	-1.52	-1.23	-0.03
0.70	-1.38	-1.61	-1.59	-1.67	-1.68	-1.60	-1.45	-0.78	0.42
0.59	-1.37	-1.61	-1.62	-1.69	-1.67	-1.58	-1.43	-0.72	0.42
0.47	-1.37	-1.61	-1.65	-1.68	-1.64	-1.54	-1.42	-1.12	0.09
0.35	-1.38	-1.62	-1.66	-1.65	-1.59	-1.50	-1.36	-0.66	0.42
0.23	-1.41	-1.63	-1.65	-1.60	-1.54	-1.44	-1.29	-0.46	0.33
0.12	-1.42	-1.63	-1.62	-1.55	-1.50	-1.41	-1.27	-0.37	0.19
0.00	-1.11	-1.50	-1.47	-1.38	-1.25	-1.32	-1.27	-1.13	-0.19

0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90

Width (m)

Average per Column (m/s)

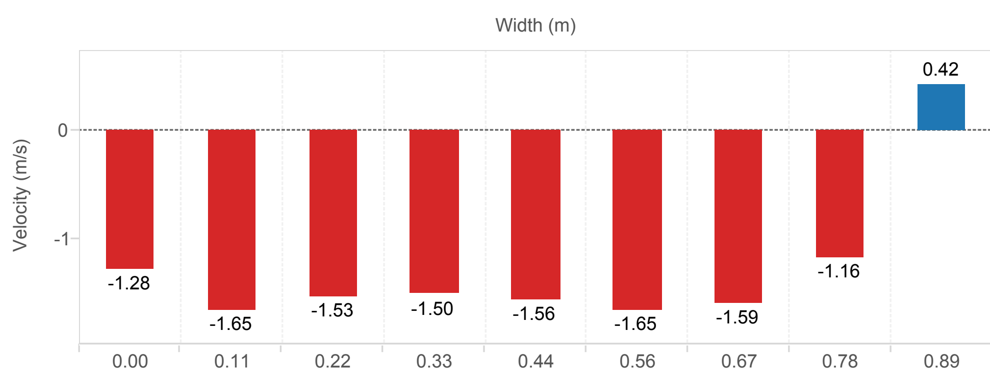
Height (m)	
2.11	**-1.28**
1.99	**-1.48**
1.87	**-1.27**
1.76	**-1.20**
1.64	**-1.19**
1.52	**-1.18**
1.41	**-1.22**
1.29	**-1.26**
1.17	**-1.34**
1.05	**-1.28**
0.94	**-1.29**
0.82	**-1.36**
0.70	**-1.26**
0.59	**-1.25**
0.47	**-1.33**
0.35	**-1.22**
0.23	**-1.19**
0.12	**-1.17**
0.00	**-1.18**

Average per Row (m/s)

Width (m)

0.00	0.11	0.22	0.22	0.33	0.44	0.56	0.67	0.78	0.89
-1.05	**-1.58**	**-1.60**	**-1.48**	**-1.52**	**-1.53**	**-1.54**	**-1.49**	**-1.18**	**0.08**

Horizontal Wind Profile at the Probe Location



Width (m) *All* ***Height (m)*** *1.05*

Average Volume Flow Rate Across the Opening

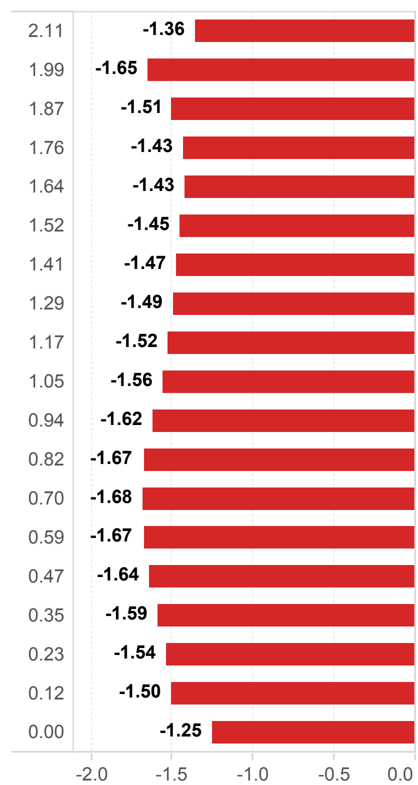
141.934 cm/min

Mean Velocity Across the Opening

-1.261 m/s

in (airflow into the controll volume) out (airflow out from the controll volume)

Vertical Wind Profile at the Probe Location



Width (m) *0.44*

Height (m) *All*

SIMULATION DATA ANALYSIS
(Scenario 3c - Opening A1)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height (m)									
2.11	-0.44	-0.73	-0.79	-0.76	-0.72	-0.67	-0.62	-0.55	-0.46
1.99	-0.64	-0.96	-0.97	-0.94	-0.90	-0.84	-0.79	-0.72	-0.61
1.88	-0.78	-1.08	-1.07	-1.04	-1.00	-0.95	-0.89	-0.82	-0.70
1.76	-0.93	-1.19	-1.16	-1.13	-1.09	-1.04	-1.00	-0.93	-0.80
1.64	-1.08	-1.25	-1.21	-1.17	-1.14	-1.09	-1.04	-0.98	-0.82
1.53	-1.12	-1.29	-1.24	-1.21	-1.18	-1.13	-1.09	-1.04	-0.85
1.41	-1.06	-1.31	-1.26	-1.23	-1.20	-1.16	-1.13	-1.08	-0.86
1.29	-1.04	-1.31	-1.26	-1.24	-1.21	-1.19	-1.17	-1.12	-0.90
1.17	-0.98	-1.28	-1.25	-1.23	-1.21	-1.21	-1.19	-1.14	-0.89
1.06	-0.86	-1.24	-1.23	-1.22	-1.21	-1.21	-1.20	-1.15	-0.89
0.94	-0.67	-1.16	-1.21	-1.21	-1.20	-1.22	-1.22	-1.16	-0.88
0.82	-0.62	-1.10	-1.19	-1.21	-1.21	-1.23	-1.23	-1.17	-0.87
0.71	-0.79	-1.11	-1.17	-1.19	-1.21	-1.23	-1.23	-1.16	-0.79
0.59	-0.91	-1.12	-1.17	-1.20	-1.22	-1.25	-1.25	-1.19	-0.81
0.47	-0.95	-1.12	-1.17	-1.19	-1.22	-1.25	-1.25	-1.18	-0.74
0.36	-0.93	-1.10	-1.17	-1.19	-1.21	-1.22	-1.21	-1.09	-0.57
0.24	-0.93	-1.08	-1.13	-1.13	-1.14	-1.13	-1.04	-0.74	-0.26
0.12	-0.92	-1.07	-1.09	-1.07	-1.06	-1.01	-0.86	-0.45	-0.11
0.01	-0.78	-1.04	-1.05	-1.01	-0.99	-0.95	-0.77	-0.01	0.23

0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00 1.10

Width (m)

Average per Column (m/s)

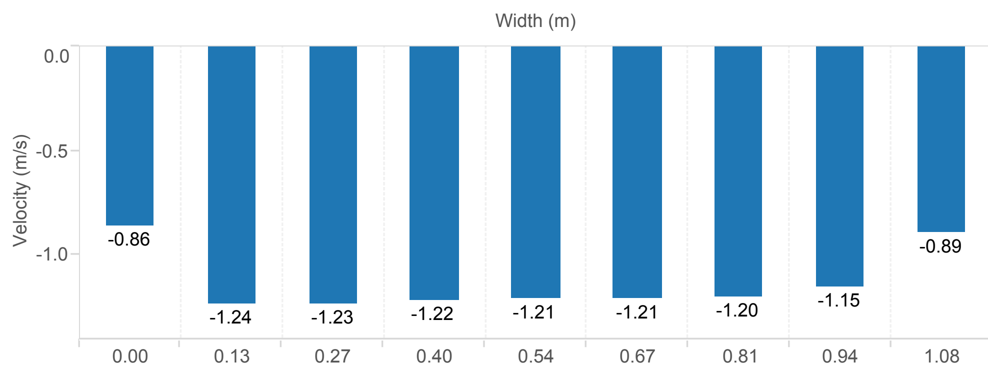
Height (m)	
2.11	**-0.64**
1.99	**-0.82**
1.88	**-0.93**
1.76	**-1.03**
1.64	**-1.09**
1.53	**-1.13**
1.41	**-1.14**
1.29	**-1.16**
1.17	**-1.15**
1.06	**-1.13**
0.94	**-1.10**
0.82	**-1.09**
0.71	**-1.10**
0.59	**-1.12**
0.47	**-1.12**
0.36	**-1.08**
0.24	**-0.95**
0.12	**-0.85**
0.01	**-0.71**

Average per Row (m/s)

Width (m)

0.00	0.13	0.27	0.40	0.54	0.67	0.81	0.94	1.08
-0.86	**-1.13**	**-1.15**	**-1.14**	**-1.12**	**-1.10**	**-1.06**	**-0.93**	**-0.66**

Horizontal Wind Profile at the Probe Location



Width (m) *All* ***Height (m)*** *1.06*

Average Volume Flow Rate Across the Opening

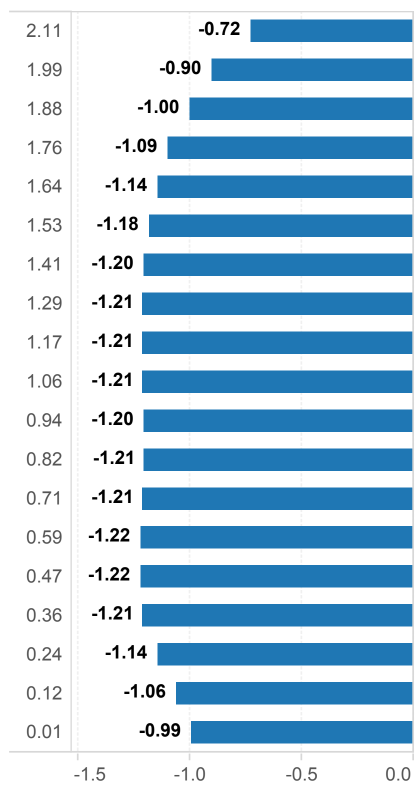
138.272 cm/min

Mean Velocity Across the Opening

-1.018 m/s

in (airflow into the control volume) out (airflow out from the control volume)

Vertical Wind Profile at the Probe Location



Width (m) *0.54*

Height (m) *All*

SIMULATION DATA ANALYSIS
(Scenario 3c - Opening A3)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height (m)									
2.11	0.00	-0.62	-0.70	-0.64	-0.56	-0.55	-0.56	-0.40	-0.15
1.99	-0.14	-0.77	-0.84	-0.78	-0.72	-0.71	-0.72	-0.60	-0.29
1.88	-0.23	-0.85	-0.91	-0.86	-0.81	-0.81	-0.82	-0.73	-0.38
1.76	-0.31	-0.92	-0.97	-0.93	-0.90	-0.88	-0.92	-0.87	-0.46
1.64	-0.36	-0.97	-1.00	-0.95	-0.94	-0.95	-0.98	-0.92	-0.49
1.52	-0.39	-1.01	-1.03	-0.99	-0.98	-1.00	-1.04	-0.97	-0.46
1.41	-0.40	-1.03	-1.07	-1.03	-1.02	-1.05	-1.08	-0.98	-0.40
1.29	-0.40	-1.05	-1.10	-1.07	-1.05	-1.08	-1.11	-0.98	-0.33
1.17	-0.39	-1.08	-1.12	-1.10	-1.08	-1.10	-1.11	-0.91	-0.25
1.06	-0.37	-1.10	-1.14	-1.12	-1.11	-1.12	-1.11	-0.85	-0.19
0.94	-0.35	-1.11	-1.16	-1.14	-1.12	-1.13	-1.12	-0.88	-0.19
0.82	-0.31	-1.13	-1.18	-1.16	-1.14	-1.15	-1.14	-0.98	-0.52
0.70	-0.26	-1.16	-1.18	-1.16	-1.15	-1.16	-1.16	-1.02	-0.70
0.59	-0.18	-1.14	-1.19	-1.16	-1.15	-1.17	-1.17	-1.07	-0.79
0.47	-0.08	-1.08	-1.17	-1.15	-1.14	-1.15	-1.15	-1.06	-0.83
0.35	-0.01	-0.86	-1.11	-1.13	-1.12	-1.12	-1.11	-1.03	-0.86
0.24	0.01	-0.55	-1.02	-1.08	-1.07	-1.07	-1.06	-1.00	-0.86
0.12	0.01	-0.44	-0.95	-1.03	-1.03	-1.02	-1.02	-0.99	-0.86
0.00	0.22	-0.30	-0.90	-0.92	-0.86	-0.84	-0.83	-0.79	-0.68

0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00 1.10

Width (m)

Average per Column (m/s)

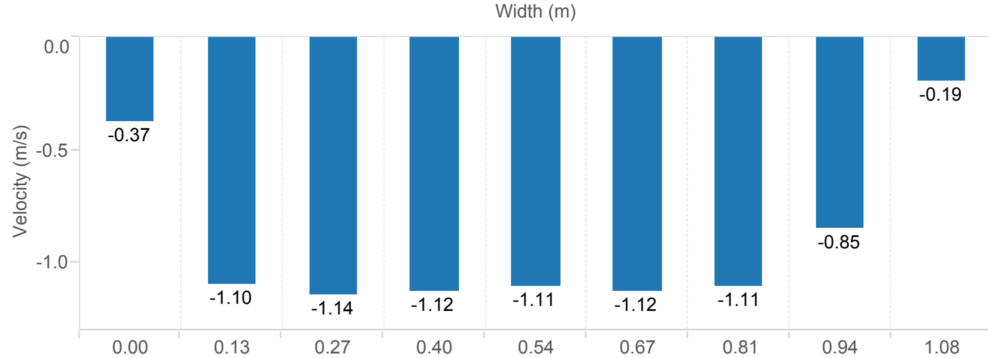
Height (m)	
2.11	**-0.47**
1.99	**-0.62**
1.88	**-0.71**
1.76	**-0.80**
1.64	**-0.84**
1.52	**-0.88**
1.41	**-0.89**
1.29	**-0.91**
1.17	**-0.90**
1.06	**-0.90**
0.94	**-0.91**
0.82	**-0.97**
0.70	**-0.99**
0.59	**-1.00**
0.47	**-0.98**
0.35	**-0.93**
0.24	**-0.86**
0.12	**-0.81**
0.00	**-0.66**

Average per Row (m/s)

Width (m)

0.00	0.13	0.27	0.40	0.54	0.67	0.81	0.94	1.08
-0.21	**-0.90**	**-1.04**	**-1.02**	**-1.00**	**-1.00**	**-1.01**	**-0.90**	**-0.51**

Horizontal Wind Profile at the Probe Location



Width (m) All

Height (m) 1.06

Average Volume Flow Rate Across the Opening

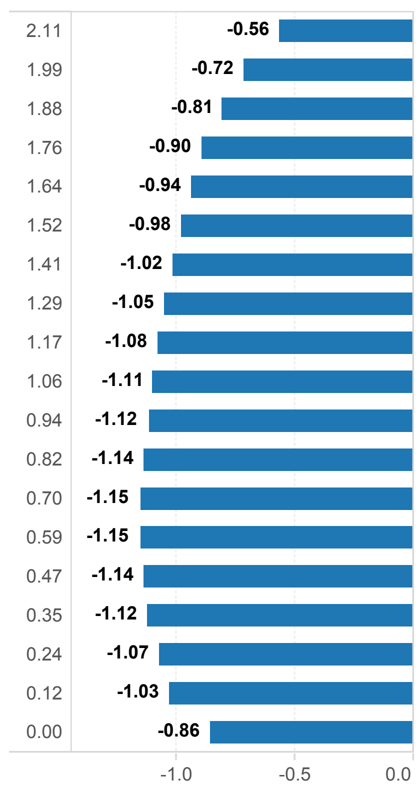
114.803 cm/min

Mean Velocity Across the Opening

-0.843 m/s

in (airflow into the control volume) out (airflow out from the controll volume)

Vertical Wind Profile at the Probe Location



Width (m) 0.54

Height (m) All

SIMULATION DATA ANALYSIS
(Scenario 3c - Opening A0)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height (m)									
2.12	0.51	-1.42	-1.23	-1.10	-0.95	-0.80	-0.49	-0.28	0.12
2.00	0.55	-1.76	-1.79	-1.79	-1.83	-1.90	-1.94	-1.90	-1.67
1.88	0.57	-1.68	-1.73	-1.73	-1.71	-1.69	-1.73	-1.83	-0.79
1.77	0.53	-1.62	-1.70	-1.70	-1.67	-1.62	-1.68	-1.88	-0.14
1.65	0.51	-1.57	-1.69	-1.68	-1.66	-1.65	-1.70	-1.91	-0.33
1.53	0.50	-1.49	-1.67	-1.67	-1.66	-1.66	-1.69	-1.93	-0.67
1.41	0.48	-1.41	-1.66	-1.66	-1.66	-1.66	-1.70	-1.92	-0.97
1.30	0.48	-1.33	-1.64	-1.66	-1.66	-1.66	-1.70	-1.90	-1.19
1.18	0.46	-1.27	-1.63	-1.65	-1.66	-1.66	-1.71	-1.89	-1.25
1.06	0.45	-1.19	-1.61	-1.65	-1.65	-1.66	-1.71	-1.87	-1.31
0.94	0.43	-1.13	-1.60	-1.64	-1.65	-1.66	-1.71	-1.86	-1.36
0.82	0.40	-1.10	-1.58	-1.64	-1.64	-1.65	-1.71	-1.83	-1.50
0.71	0.40	-1.07	-1.58	-1.64	-1.64	-1.65	-1.70	-1.83	-1.53
0.59	0.39	-1.04	-1.57	-1.63	-1.64	-1.64	-1.70	-1.82	-1.54
0.47	0.40	-1.01	-1.57	-1.63	-1.63	-1.64	-1.69	-1.83	-1.58
0.35	0.37	-0.99	-1.57	-1.63	-1.62	-1.63	-1.68	-1.83	-1.58
0.24	0.37	-0.97	-1.58	-1.63	-1.62	-1.62	-1.67	-1.82	-1.70
0.12	0.43	-0.97	-1.61	-1.63	-1.60	-1.61	-1.67	-1.82	-1.63
0.00	0.50	-1.30	-1.66	-1.62	-1.60	-1.62	-1.65	-1.82	-1.52

0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90

Width (m)

Average per Column (m/s)

Height (m)	
2.12	**-0.63**
2.00	**-1.56**
1.88	**-1.37**
1.77	**-1.28**
1.65	**-1.30**
1.53	**-1.33**
1.41	**-1.35**
1.30	**-1.36**
1.18	**-1.36**
1.06	**-1.36**
0.94	**-1.35**
0.82	**-1.36**
0.71	**-1.36**
0.59	**-1.35**
0.47	**-1.35**
0.35	**-1.35**
0.24	**-1.36**
0.12	**-1.35**
0.00	**-1.36**

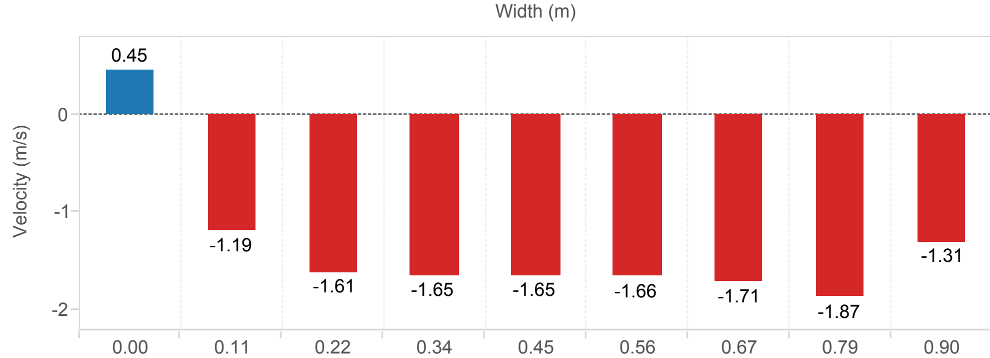
Average per Row (m/s)

Width (m)

0.00	0.11	0.22	0.34	0.45	0.56	0.67	0.79	0.90
0.46	**-1.28**	**-1.61**	**-1.63**	**-1.62**	**-1.62**	**-1.64**	**-1.78**	**-1.17**

Horizontal Wind Profile at the Probe Location

Width (m)



Width (m) *All*

Height (m) *1.06*

Average Volume Flow Rate Across the Opening

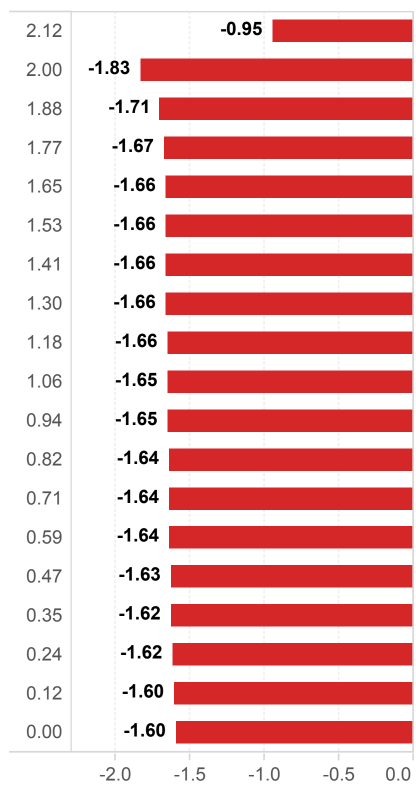
150.886 cm/min

Mean Velocity Across the Opening

-1.320 m/s

in (airflow into the control volume) out (airflow out from the control volume)

Vertical Wind Profile at the Probe Location



Width (m) *0.45*

Height (m) *All*

SIMULATION DATA ANALYSIS
(Scenario 3c - Opening A7E)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height ..																										
3.50	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
3.32	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.1
3.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.1
2.97	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.1
2.80	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.1
2.62	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.2	0.1
2.45	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.1
2.27	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
2.10	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1
1.92	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1
1.75	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1
1.57	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
1.40	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
1.22	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
1.05	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0
0.87	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0
0.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0
0.52	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0

0.00 0.50 1.00 1.50 2.00 2.50

Width (m)

Average per Column (m/s)

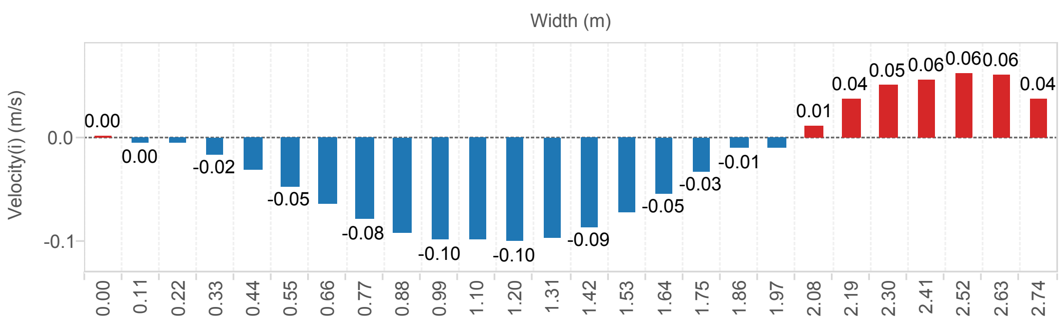
Height (m)	
3.50	0.07
3.32	0.11
3.15	0.08
2.97	0.04
2.80	0.02
2.62	0.00
2.45	-0.02
2.27	-0.03
2.10	-0.04
1.92	-0.05
1.75	-0.05
1.57	-0.05
1.40	-0.04
1.22	-0.03
1.05	-0.03
0.87	-0.02
0.70	0.00
0.52	0.01
0.35	0.01
0.17	0.01
0.00	0.01

Average per Row (m/s)

Width (m)

0.00	0.11	0.22	0.33	0.44	0.55	0.66	0.77	0.88	0.99	1.10	1.20	1.31	1.42	1.53	1.64	1.75	1.86	1.97	2.08	2.19	2.30	2.41	2.52	2.63	2.74
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1

Horizontal Wind Profile at the Probe Location



Width (m) *All*

Height (m) *1.05*

Average Volume Flow Rate Across the Opening

0.585 cm/min

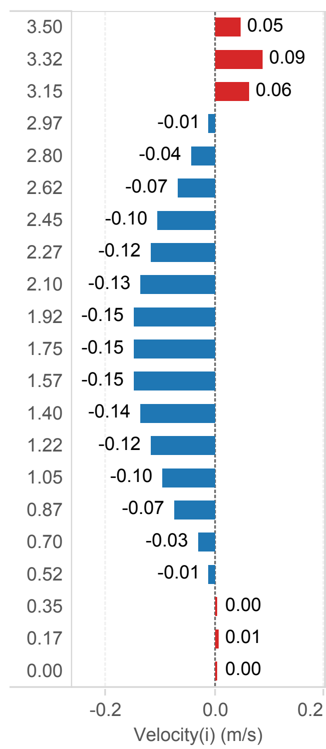
Mean Velocity Across the Opening

0.001019

in (airflow into control volume)

out (airflow out from control volume)

Vertical WInd Profile at the Probe Location



Width (m) *1.31*

Height (m) *All*

SIMULATION DATA ANALYSIS
(Scenario 3c - Opening A7W)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height ..																										
3.50	-0.4	-0.5	-0.6	-0.6	-0.5	-0.5	-0.5	-0.5	-0.4	-0.4	-0.4	-0.4	-0.4	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2
3.32	-0.4	-0.6	-0.6	-0.6	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.3
3.15	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.4	-0.3
2.97	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3
2.80	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.2
2.62	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3	-0.2
2.45	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.2
2.27	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.0	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2
2.10	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0	-0.1	-0.1	-0.2	-0.2	-0.1
1.92	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.1	0.1	0.1	0.0	0.0	-0.1	-0.1	-0.2	-0.2	-0.1
1.75	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.1	0.1	0.1	0.0	0.0	-0.1	-0.1	-0.2	-0.2	-0.1
1.57	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1
1.40	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1
1.22	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1
1.05	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1
0.87	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	0.0
0.70	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	0.0
0.52	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	0.0
0.35	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	0.0
0.17	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.00	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

0.00 0.50 1.00 1.50 2.00 2.50

Width (m)

Average per Column (m/s)

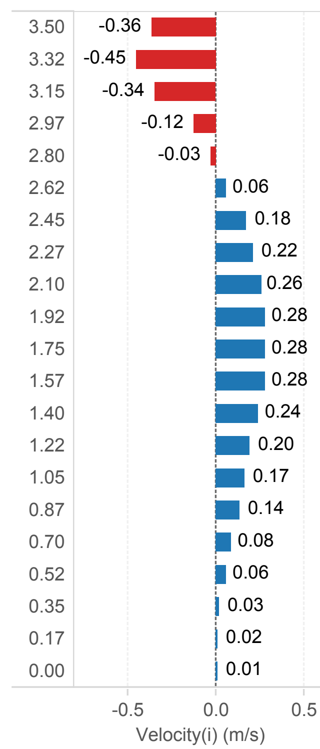
Height (m)	
3.50	-0.36
3.32	-0.45
3.15	-0.31
2.97	-0.14
2.80	-0.06
2.62	-0.01
2.45	0.06
2.27	0.08
2.10	0.12
1.92	0.13
1.75	0.13
1.57	0.13
1.40	0.12
1.22	0.10
1.05	0.09
0.87	0.08
0.70	0.05
0.52	0.04
0.35	0.02
0.17	0.02
0.00	0.01

Average per Row (m/s)

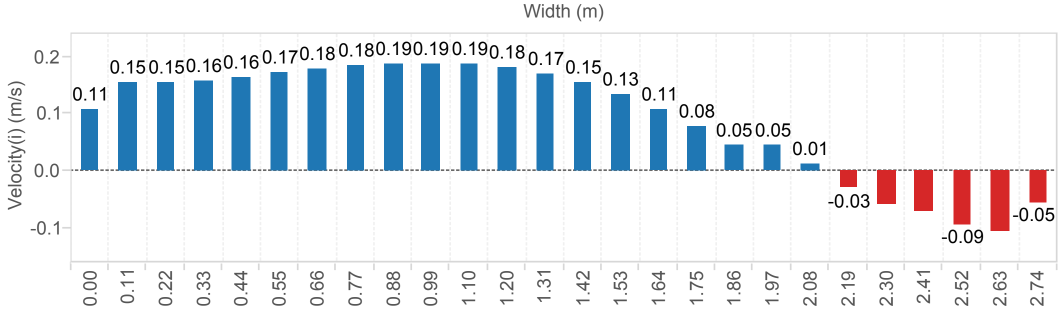
Width (m)

0.00	0.11	0.22	0.33	0.44	0.55	0.66	0.77	0.88	0.99	1.10	1.20	1.31	1.42	1.53	1.64	1.75	1.86	1.97	2.08	2.19	2.30	2.41	2.52	2.63	2.74
0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.1

Vertical WInd Profile at the Probe Location



Horizontal Wind Profile at the Probe Location



Width (m) *All*

Height (m) *1.05*

Average Volume Flow Rate Across the Opening

3.843 cm/min

Mean Velocity Across the Opening

-0.006687

in (airflow into control volume)

out (airflow out from control volume)

Width (m) *1.31*

Height (m) *All*

SIMULATION DATA ANALYSIS
(Scenario 4 - Opening A0)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height (m)	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
2.11	-1.30	-1.22	-1.21	-1.25	-1.29	-1.37	-1.46	-1.63	-1.34	
1.99	-1.35	-1.43	-1.36	-1.36	-1.41	-1.45	-1.42	-1.10	0.35	
1.87	-1.34	-1.43	-1.37	-1.40	-1.46	-1.52	-1.44	-0.95	0.37	
1.76	-1.34	-1.42	-1.37	-1.43	-1.52	-1.54	-1.42	-0.97	0.44	
1.64	-1.31	-1.40	-1.37	-1.46	-1.56	-1.53	-1.39	-0.70	0.36	
1.52	-1.28	-1.38	-1.38	-1.50	-1.61	-1.56	-1.38	-0.59	0.44	
1.41	-1.25	-1.37	-1.41	-1.57	-1.65	-1.58	-1.40	-0.57	0.47	
1.29	-1.22	-1.37	-1.47	-1.65	-1.68	-1.58	-1.42	-0.91	0.50	
1.17	-1.20	-1.41	-1.56	-1.69	-1.68	-1.56	-1.37	-0.74	0.30	
1.05	-1.21	-1.45	-1.63	-1.73	-1.67	-1.53	-1.33	-0.45	0.50	
0.94	-1.24	-1.54	-1.69	-1.71	-1.63	-1.49	-1.33	-0.75	0.52	
0.82	-1.29	-1.58	-1.70	-1.68	-1.58	-1.42	-1.24	-0.68	0.24	
0.70	-1.32	-1.59	-1.67	-1.63	-1.53	-1.36	-1.12	-0.26	0.43	
0.59	-1.32	-1.59	-1.65	-1.61	-1.49	-1.34	-1.12	-0.21	0.46	
0.47	-1.33	-1.57	-1.63	-1.57	-1.46	-1.32	-1.17	-0.72	0.26	
0.35	-1.34	-1.55	-1.60	-1.55	-1.43	-1.27	-1.03	-0.20	0.42	
0.23	-1.35	-1.51	-1.55	-1.50	-1.38	-1.20	-0.90	-0.10	0.36	
0.12	-1.35	-1.48	-1.50	-1.45	-1.35	-1.17	-0.86	-0.04	0.23	
0.00	-1.05	-1.28	-1.31	-1.24	-1.14	-1.17	-1.08	-0.85	0.35	

Width (m)

Average per Column (m/s)

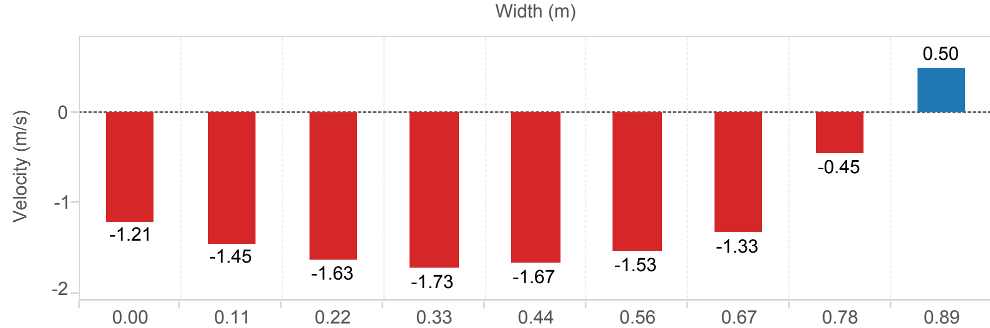
Height (m)	
2.11	**-1.34**
1.99	**-1.17**
1.87	**-1.17**
1.76	**-1.17**
1.64	**-1.15**
1.52	**-1.14**
1.41	**-1.15**
1.29	**-1.20**
1.17	**-1.21**
1.05	**-1.17**
0.94	**-1.21**
0.82	**-1.21**
0.70	**-1.12**
0.59	**-1.10**
0.47	**-1.17**
0.35	**-1.06**
0.23	**-1.02**
0.12	**-1.00**
0.00	**-0.97**

Average per Row (m/s)

Width (m)

0.00	0.11	0.22	0.22	0.33	0.44	0.56	0.67	0.78	0.89
-1.28	**-1.45**	**-1.59**	**-1.41**	**-1.52**	**-1.50**	**-1.42**	**-1.26**	**-0.65**	**0.30**

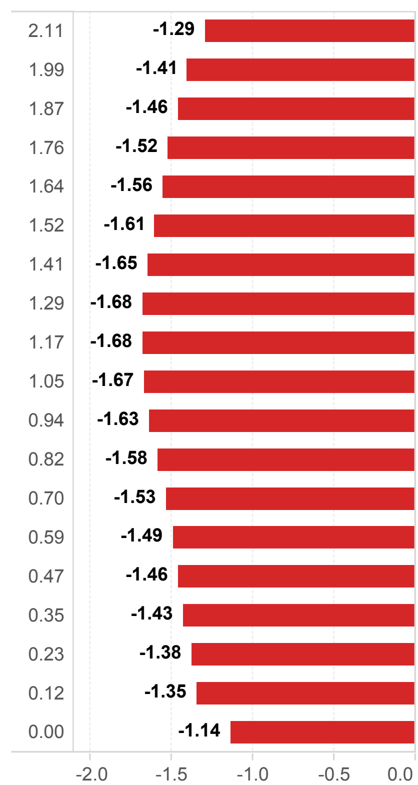
Horizontal Wind Profile at the Probe Location



Width (m)
All

Height (m)
1.05

Vertical Wind Profile at the Probe Location



Width (m) *0.44*

Height (m) *All*

Average Volume Flow Rate Across the Opening

128.729 cm/min

Mean Velocity Across the Opening

-1.143 m/s

in (airflow into the .. out (airflow out fro..

SIMULATION DATA ANALYSIS
(Scenario 4 - Opening A2)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height (m) \ Width (m)	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
2.12	-0.25	-1.82	-1.59	-1.41	-1.32	-1.35	-1.56	-1.91	-1.11	
2.00	0.39	-1.68	-1.63	-1.54	-1.51	-1.56	-1.72	-1.96	-0.80	
1.88	0.43	-1.62	-1.61	-1.57	-1.52	-1.56	-1.63	-1.85	-0.41	
1.76	0.15	-1.57	-1.58	-1.56	-1.54	-1.55	-1.61	-1.77	-0.50	
1.64	0.36	-1.51	-1.56	-1.55	-1.54	-1.55	-1.60	-1.73	-0.69	
1.52	0.37	-1.40	-1.55	-1.54	-1.54	-1.55	-1.59	-1.70	-0.84	
1.41	0.28	-1.33	-1.53	-1.54	-1.54	-1.56	-1.59	-1.66	-0.95	
1.29	0.38	-1.24	-1.52	-1.54	-1.55	-1.56	-1.59	-1.65	-0.99	
1.17	0.35	-1.00	-1.50	-1.55	-1.56	-1.57	-1.60	-1.64	-0.97	
1.05	0.41	-0.86	-1.49	-1.55	-1.56	-1.57	-1.61	-1.65	-0.98	
0.93	0.35	-1.04	-1.51	-1.58	-1.57	-1.59	-1.62	-1.65	-0.99	
0.81	0.38	-0.93	-1.51	-1.59	-1.58	-1.58	-1.62	-1.65	-1.13	
0.70	0.37	-1.02	-1.52	-1.61	-1.59	-1.59	-1.63	-1.68	-1.10	
0.58	0.36	-0.82	-1.51	-1.63	-1.60	-1.59	-1.64	-1.69	-1.09	
0.46	0.36	-0.85	-1.50	-1.66	-1.62	-1.58	-1.64	-1.71	-1.10	
0.34	0.33	-0.54	-1.46	-1.66	-1.62	-1.57	-1.63	-1.74	-1.04	
0.22	0.30	-0.42	-1.43	-1.69	-1.63	-1.55	-1.62	-1.76	-1.01	
0.10	0.27	-0.75	-1.49	-1.70	-1.64	-1.50	-1.58	-1.80	-0.68	

Width (m)

Average per Column (m/s)

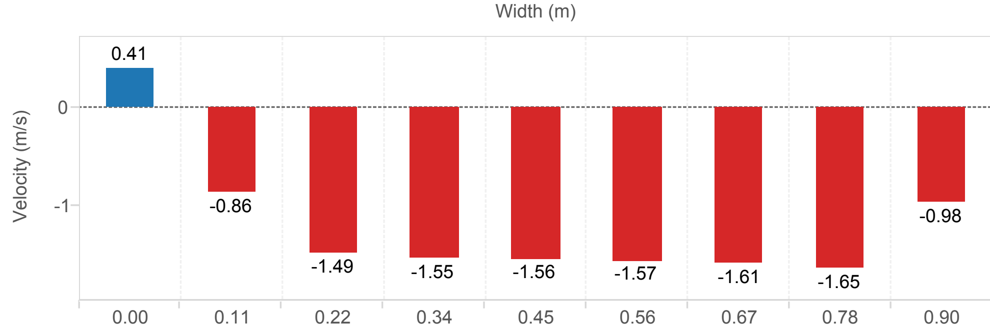
Height (m)	
2.12	**-1.37**
2.00	**-1.33**
1.88	**-1.26**
1.76	**-1.28**
1.64	**-1.26**
1.52	**-1.26**
1.41	**-1.27**
1.29	**-1.25**
1.17	**-1.23**
1.05	**-1.21**
0.93	**-1.24**
0.81	**-1.25**
0.70	**-1.26**
0.58	**-1.25**
0.46	**-1.26**
0.34	**-1.22**
0.22	**-1.20**
0.10	**-1.21**

Average per Row (m/s)

Width (m)

0.00	0.11	0.22	0.34	0.45	0.56	0.67	0.78	0.90
0.31	**-1.13**	**-1.53**	**-1.58**	**-1.56**	**-1.55**	**-1.62**	**-1.73**	**-0.91**

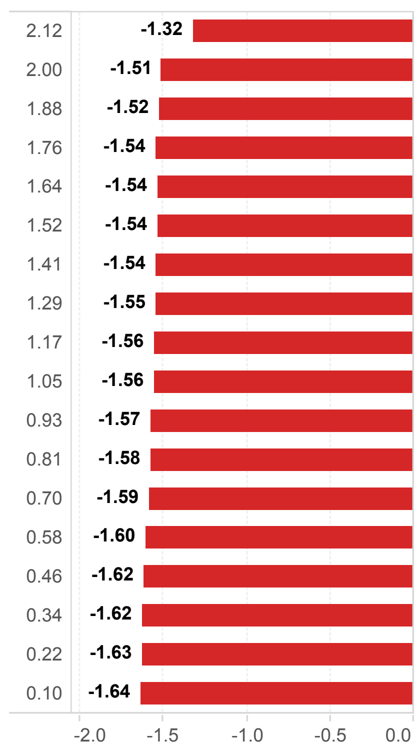
Horizontal Wind Profile at the Probe Location



Width (m)
All

Height (m)
1.05

Vertical Wind Profile at the Probe Location



Width (m) *0.45*

Height (m) *All*

Average Volume Flow Rate Across the Opening

135.777 cm/min

Mean Velocity Across the Opening

-1.256 m/s

in (airflow into the .. | out (airflow out fro..

SIMULATION DATA ANALYSIS
(Scenario 4 - Opening A4)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height (m) \ Width (m)	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
2.12	0.51	-1.89	-1.63	-1.50	-1.39	-1.23	-0.84	-0.43	0.36	
2.00	0.53	-1.98	-1.97	-1.98	-2.02	-2.10	-2.24	-2.21	-1.78	
1.88	0.73	-1.90	-1.94	-1.97	-1.97	-1.96	-2.02	-2.12	-1.02	
1.77	0.67	-1.86	-1.91	-1.95	-1.94	-1.88	-1.90	-2.12	0.21	
1.65	0.65	-1.83	-1.90	-1.94	-1.92	-1.87	-1.88	-2.11	0.06	
1.53	0.64	-1.81	-1.89	-1.93	-1.91	-1.87	-1.87	-2.10	-0.02	
1.41	0.60	-1.78	-1.89	-1.92	-1.91	-1.87	-1.86	-2.10	-0.01	
1.30	0.56	-1.73	-1.89	-1.92	-1.91	-1.88	-1.85	-2.10	-0.02	
1.18	0.52	-1.70	-1.90	-1.92	-1.91	-1.88	-1.84	-2.10	0.03	
1.06	0.49	-1.63	-1.91	-1.92	-1.91	-1.88	-1.83	-2.10	0.13	
0.94	0.48	-1.57	-1.93	-1.92	-1.91	-1.88	-1.83	-2.10	0.13	
0.82	0.46	-1.53	-1.95	-1.93	-1.91	-1.88	-1.82	-2.08	-0.21	
0.71	0.46	-1.48	-1.96	-1.93	-1.90	-1.87	-1.82	-2.09	-0.23	
0.59	0.44	-1.41	-1.98	-1.94	-1.89	-1.87	-1.81	-2.08	-0.11	
0.47	0.45	-1.34	-2.00	-1.95	-1.88	-1.85	-1.81	-2.10	-0.15	
0.35	0.40	-1.28	-2.02	-1.97	-1.86	-1.83	-1.80	-2.11	0.09	
0.24	0.43	-1.24	-2.05	-1.97	-1.84	-1.81	-1.80	-2.08	-1.03	
0.12	0.54	-1.22	-2.09	-1.97	-1.81	-1.78	-1.81	-2.12	0.12	
0.00	0.67	-1.60	-2.13	-1.97	-1.78	-1.78	-1.86	-2.13	-0.74	

Width (m)

Average per Column (m/s)

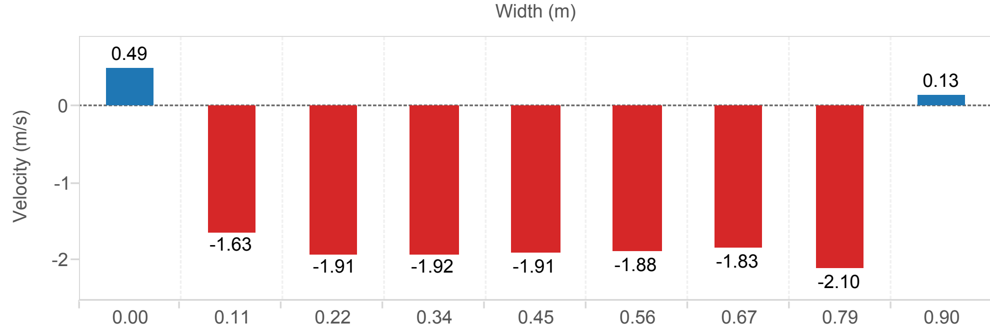
Height (m)	
2.12	**-0.89**
2.00	**-1.75**
1.88	**-1.57**
1.77	**-1.41**
1.65	**-1.42**
1.53	**-1.42**
1.41	**-1.42**
1.30	**-1.42**
1.18	**-1.41**
1.06	**-1.40**
0.94	**-1.39**
0.82	**-1.43**
0.71	**-1.42**
0.59	**-1.41**
0.47	**-1.40**
0.35	**-1.38**
0.24	**-1.49**
0.12	**-1.35**
0.00	**-1.48**

Average per Row (m/s)

Width (m)

0.00	0.11	0.22	0.34	0.45	0.56	0.67	0.79	0.90
0.54	**-1.62**	**-1.94**	**-1.92**	**-1.87**	**-1.84**	**-1.82**	**-2.02**	**-0.22**

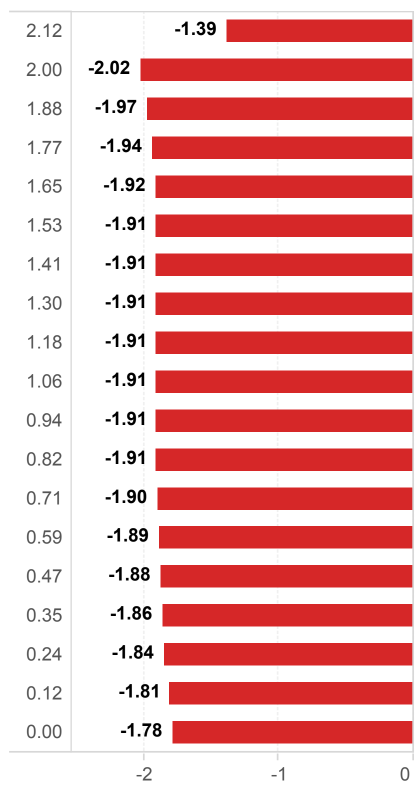
Horizontal Wind Profile at the Probe Location



Width (m)
All

Height (m)
1.06

Vertical Wind Profile at the Probe Location



Width (m) *0.45*

Height (m) *All*

Average Volume Flow Rate Across the Opening

161.432 cm/min

Mean Velocity Across the Opening

-1.413 m/s

in (airflow into the control volume) out (airflow out from the controll volume)

SIMULATION DATA ANALYSIS
(Scenario 4 - Opening A7E)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height ..																										
3.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.15	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.97	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.80	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0
2.62	-0.1	-0.1	-0.1	-0.1	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0
2.45	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
2.27	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
2.10	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1
1.92	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1
1.75	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2
1.57	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.2
1.40	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2
1.22	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2
1.05	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2
0.87	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2
0.70	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.1
0.52	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.1
0.35	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.1
0.17	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.1
0.00	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0

0.00 0.50 1.00 1.50 2.00 2.50

Width (m)

Average per Column (m/s)

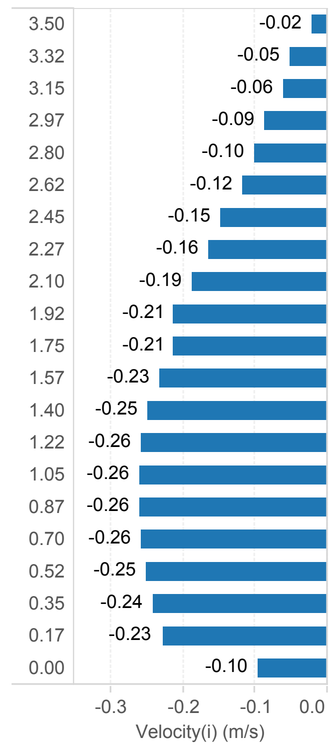
Height (m)	
3.50	-0.02
3.32	-0.03
3.15	-0.04
2.97	-0.07
2.80	-0.09
2.62	-0.10
2.45	-0.13
2.27	-0.15
2.10	-0.18
1.92	-0.20
1.75	-0.21
1.57	-0.23
1.40	-0.24
1.22	-0.26
1.05	-0.26
0.87	-0.26
0.70	-0.26
0.52	-0.26
0.35	-0.25
0.17	-0.24
0.00	-0.10

Average per Row (m/s)

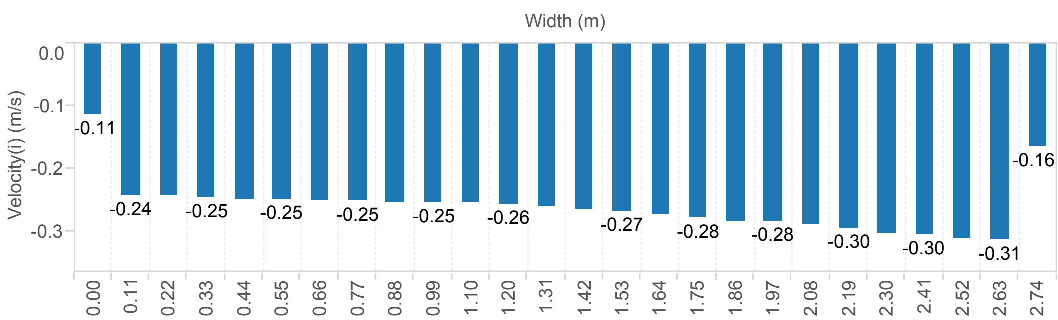
Width (m)

0.00	0.11	0.22	0.33	0.44	0.55	0.66	0.77	0.88	0.99	1.10	1.20	1.31	1.42	1.53	1.64	1.75	1.86	1.97	2.08	2.19	2.30	2.41	2.52	2.63	2.74
-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1

Vertical WInd Profile at the Probe Location



Horizontal Wind Profile at the Probe Location



Width (m) *All*

Height (m) *1.05*

Average Volume Flow Rate Across the Opening

97.964 cm/min

Mean Velocity Across the Opening

-0.1705

in (airflow into control volume)

out (airflow out from control volume)

Width (m) *1.31*

Height (m) *All*

SIMULATION DATA ANALYSIS
(Scenario 4 - Opening A7W)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height ..																										
3.50	-0.7	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.8	-0.8	-0.7	-0.7	-0.7	-0.6	-0.6	-0.6	-0.5	-0.5	-0.4	-0.4	-0.4	-0.3	-0.2	-0.3	-0.3	-0.3	-0.3
3.32	-0.8	-0.8	-0.8	-0.7	-0.6	-0.7	-0.7	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.4
3.15	-0.4	-0.3	-0.3	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.5	-0.5	-0.5	-0.4
2.97	-0.1	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.3	-0.3	-0.4	-0.4	-0.4	-0.5	-0.4
2.80	-0.2	-0.3	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.2	-0.3	-0.3	-0.4	-0.4	-0.4
2.62	-0.2	-0.3	-0.3	-0.2	-0.2	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.2	-0.2	-0.3	-0.4	-0.4	-0.3
2.45	-0.3	-0.3	-0.3	-0.3	-0.2	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	-0.1	-0.2	-0.2	-0.3	-0.4	-0.3
2.27	-0.3	-0.4	-0.4	-0.3	-0.2	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	-0.1	-0.1	-0.2	-0.3	-0.4	-0.3
2.10	-0.5	-0.5	-0.5	-0.3	-0.2	-0.2	-0.1	-0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	-0.1	-0.2	-0.3	-0.3	-0.2
1.92	-0.5	-0.5	-0.5	-0.4	-0.3	-0.2	-0.1	-0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	-0.1	-0.2	-0.3	-0.3	-0.2
1.75	-0.6	-0.6	-0.6	-0.4	-0.3	-0.2	-0.1	-0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	-0.1	-0.2	-0.3	-0.3	-0.2
1.57	-0.7	-0.7	-0.7	-0.5	-0.3	-0.2	-0.2	-0.1	-0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	-0.1	-0.1	-0.2	-0.3	-0.3	-0.2
1.40	-0.8	-0.7	-0.7	-0.5	-0.4	-0.2	-0.2	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	-0.1	-0.1	-0.2	-0.3	-0.3	-0.2
1.22	-1.0	-0.9	-0.9	-0.6	-0.4	-0.3	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.2	-0.2	-0.2	-0.3	-0.2
1.05	-1.1	-1.0	-1.0	-0.7	-0.4	-0.3	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.3	-0.1
0.87	-1.2	-1.0	-1.0	-0.7	-0.5	-0.3	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.3	-0.1
0.70	-1.3	-1.2	-1.1	-0.7	-0.4	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.1
0.52	-1.4	-1.3	-1.1	-0.7	-0.5	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.2
0.35	-1.5	-1.4	-1.2	-0.8	-0.5	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2
0.17	-1.5	-1.4	-1.2	-0.8	-0.4	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.4	-0.2
0.00	-1.4	-1.3	-1.1	-0.6	-0.2	-0.2	-0.2	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2

0.00 0.50 1.00 1.50 2.00 2.50

Width (m)

Average per Column (m/s)

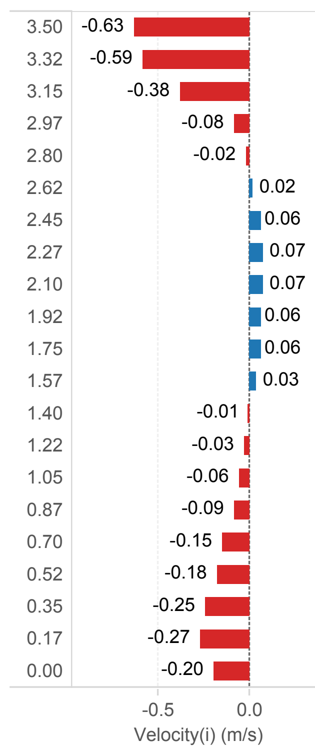
Height (m)	
3.50	-0.60
3.32	-0.59
3.15	-0.37
2.97	-0.19
2.80	-0.15
2.62	-0.13
2.45	-0.10
2.27	-0.10
2.10	-0.11
1.92	-0.11
1.75	-0.13
1.57	-0.16
1.40	-0.19
1.22	-0.24
1.05	-0.27
0.87	-0.29
0.70	-0.34
0.52	-0.37
0.35	-0.41
0.17	-0.45
0.00	-0.36

Average per Row (m/s)

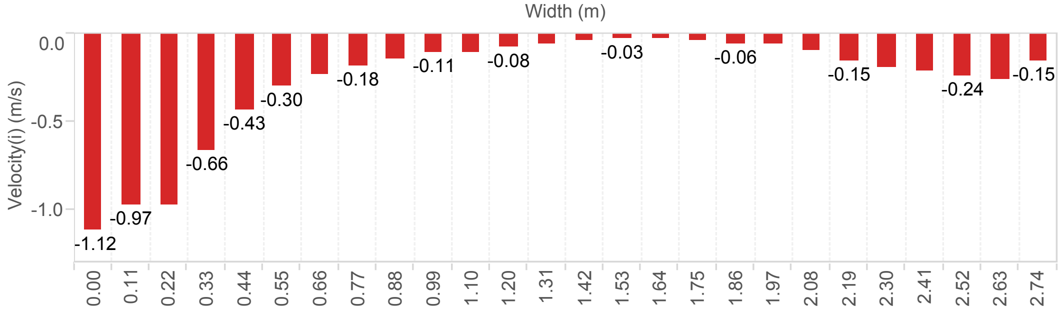
Width (m)

0.00	0.11	0.22	0.33	0.44	0.55	0.66	0.77	0.88	0.99	1.10	1.20	1.31	1.42	1.53	1.64	1.75	1.86	1.97	2.08	2.19	2.30	2.41	2.52	2.63	2.74
-0.8	-0.8	-0.7	-0.5	-0.4	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3

Vertical WInd Profile at the Probe Location



Horizontal Wind Profile at the Probe Location



Width (m) *All* ***Height (m)*** *1.05*

Average Volume Flow Rate Across the Opening

154.956 cm/min

Mean Velocity Across the Opening

-0.2696

in (airflow into control volume) out (airflow out from control volume)

Width (m) *1.31*

Height (m) *All*

SIMULATION DATA ANALYSIS
(Scenario 5 - Opening A)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

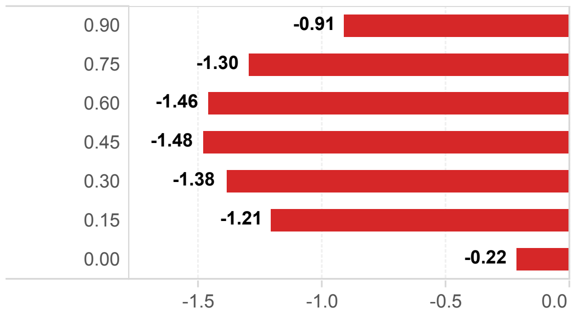
Heig..																																											
0.90	-0.6	-0.7	-0.8	-0.8	-0.8	-0.8	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-1.0	-1.0	-0.9	-0.9	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-1.0	-0.9	-0.9	-0.8	-0.7	-0.8	-0.9	-0.3
0.75	-0.7	-0.9	-0.9	-0.9	-1.0	-1.0	-1.0	-1.1	-1.1	-1.2	-1.2	-1.2	-1.3	-1.3	-1.3	-1.3	-1.3	-1.3	-1.2	-1.2	-1.2	-1.2	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-0.3
0.60	-0.8	-0.9	-0.9	-1.0	-1.0	-1.0	-1.1	-1.1	-1.2	-1.2	-1.3	-1.3	-1.4	-1.4	-1.5	-1.5	-1.5	-1.4	-1.4	-1.3	-1.3	-1.3	-1.2	-1.2	-1.2	-1.2	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-0.6
0.45	-0.8	-0.9	-0.9	-0.9	-0.9	-1.0	-1.0	-1.0	-1.1	-1.2	-1.2	-1.3	-1.4	-1.4	-1.5	-1.5	-1.5	-1.5	-1.4	-1.4	-1.3	-1.3	-1.2	-1.2	-1.2	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.0	-1.0	-1.0	-1.0	-1.0	-1.1	-1.1	-1.1	-1.1	-0.7
0.30	-0.8	-0.9	-0.9	-0.9	-0.8	-0.9	-0.9	-0.9	-1.0	-1.0	-1.1	-1.2	-1.3	-1.3	-1.4	-1.4	-1.4	-1.4	-1.3	-1.3	-1.2	-1.2	-1.1	-1.1	-1.1	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.1	-1.1	-0.9
0.15	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.9	-0.9	-1.0	-1.1	-1.2	-1.2	-1.2	-1.2	-1.2	-1.1	-1.1	-1.0	-1.0	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.8	-0.8	-0.9	-0.9	-0.9	-0.9	-0.9	-1.0	-1.0	-1.0	-1.1	-0.9
0.00	-0.7	-0.5	-0.3	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	-0.1	-0.2	-0.4	-0.6	-0.7	-0.8	-0.8	-0.6

0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50

Average per Column (m/s)

Height (m)	
0.90	**-0.84**
0.75	**-1.11**
0.60	**-1.15**
0.45	**-1.14**
0.30	**-1.06**
0.15	**-0.94**
0.00	**-0.16**

Vertical Wind Profile at the Probe Location



Width (m) *2.18*

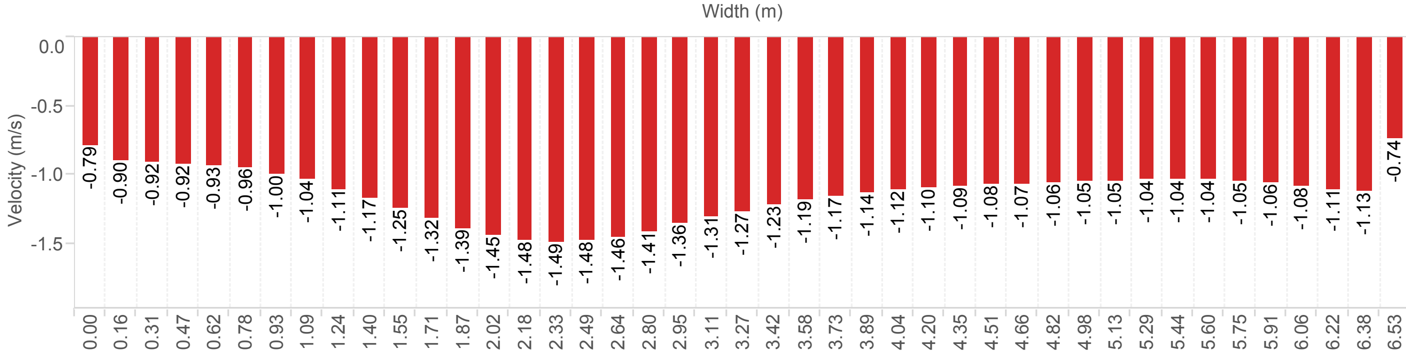
Height (m) *All*

Average per Row (m/s)

Width (m)

0.00	0.16	0.31	0.47	0.62	0.78	0.93	1.09	1.24	1.40	1.55	1.71	1.87	2.02	2.18	2.33	2.49	2.64	2.80	2.95	3.11	3.27	3.42	3.58	3.73	3.89	4.04	4.20	4.35	4.51	4.66	4.82	4.98	5.13	5.29	5.44	5.60	5.75	5.91	6.06	6.22	6.38	6.53
##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##

Horizontal Wind Profile at the Probe Location



Width (m) *All*

Height (m) *0.45*

Average Volume Flow Rate Across the Opening

320.275 cm/min

Mean Velocity Across the Opening

-0.914 m/s

in (airflow into the control volume)   out (airflow out from the controll volume)

SIMULATION DATA ANALYSIS
(Scenario 5 - Opening A0)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height (m)									
2.11	-0.44	-0.49	-0.48	-0.44	-0.41	-0.38	-0.35	-0.11	0.10
1.99	-0.52	-0.42	-0.33	-0.21	-0.15	-0.07	-0.01	0.07	0.25
1.87	-0.58	-0.44	-0.33	-0.20	-0.12	-0.04	0.01	0.09	0.24
1.76	-0.61	-0.46	-0.34	-0.22	-0.15	-0.09	-0.02	0.09	0.27
1.64	-0.62	-0.46	-0.34	-0.21	-0.14	-0.08	-0.03	0.05	0.27
1.52	-0.60	-0.47	-0.35	-0.21	-0.13	-0.05	0.01	0.10	0.28
1.41	-0.59	-0.48	-0.37	-0.23	-0.15	-0.06	0.01	0.11	0.29
1.29	-0.58	-0.49	-0.40	-0.28	-0.20	-0.11	-0.03	0.10	0.29
1.17	-0.58	-0.50	-0.41	-0.30	-0.22	-0.16	-0.10	0.02	0.30
1.05	-0.59	-0.51	-0.42	-0.29	-0.21	-0.12	-0.05	0.07	0.29
0.94	-0.58	-0.51	-0.43	-0.31	-0.22	-0.14	-0.06	0.09	0.31
0.82	-0.57	-0.51	-0.43	-0.32	-0.24	-0.17	-0.11	0.02	0.28
0.70	-0.58	-0.51	-0.43	-0.30	-0.21	-0.12	-0.04	0.10	0.27
0.59	-0.58	-0.52	-0.44	-0.31	-0.22	-0.12	-0.03	0.11	0.28
0.47	-0.57	-0.51	-0.44	-0.33	-0.25	-0.18	-0.12	0.02	0.28
0.35	-0.58	-0.51	-0.43	-0.30	-0.21	-0.14	-0.06	0.08	0.27
0.23	-0.58	-0.51	-0.41	-0.26	-0.15	-0.08	-0.01	0.10	0.24
0.12	-0.56	-0.51	-0.41	-0.26	-0.15	-0.06	0.01	0.11	0.15
0.00	-0.35	-0.44	-0.45	-0.40	-0.36	-0.37	-0.35	-0.34	0.29

0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90

Width (m)

Average per Column (m/s)

Height (m)	
2.11	**-0.33**
1.99	**-0.15**
1.87	**-0.15**
1.76	**-0.17**
1.64	**-0.17**
1.52	**-0.16**
1.41	**-0.16**
1.29	**-0.19**
1.17	**-0.22**
1.05	**-0.20**
0.94	**-0.20**
0.82	**-0.23**
0.70	**-0.20**
0.59	**-0.20**
0.47	**-0.23**
0.35	**-0.21**
0.23	**-0.18**
0.12	**-0.19**
0.00	**-0.31**

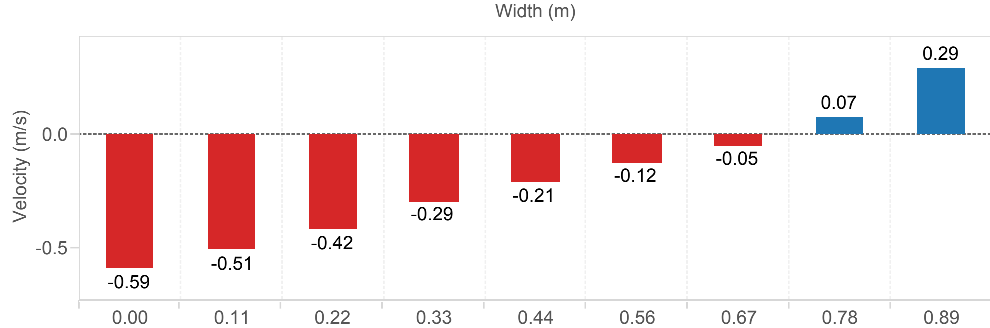
Average per Row (m/s)

Width (m)

0.00	0.11	0.22	0.22	0.33	0.44	0.56	0.67	0.78	0.89
-0.56	**-0.49**	**-0.43**	**-0.38**	**-0.28**	**-0.20**	**-0.13**	**-0.07**	**0.05**	**0.26**

Horizontal Wind Profile at the Probe Location

Width (m)



Width (m)
All

Height (m)
1.05

Average Volume Flow Rate Across the Opening

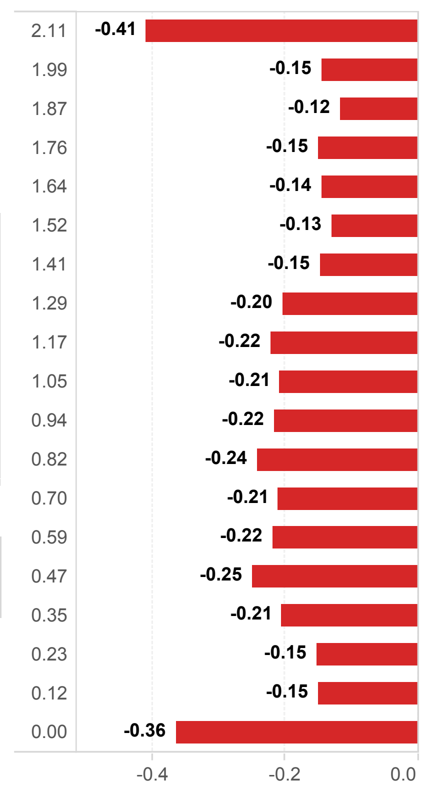
22.970 cm/min

Mean Velocity Across the Opening

-0.204 m/s

in (airflow into the controll volume) out (airflow out from the control volume)

Vertical Wind Profile at the Probe Location



Width (m) *0.44*

Height (m) *All*

SIMULATION DATA ANALYSIS
(Scenario 5 - Opening A2)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height (m)									
2.12	-1.11	-1.32	-1.35	-1.37	-1.34	-1.25	-1.04	-0.75	0.08
2.00	-1.06	-1.39	-1.42	-1.43	-1.40	-1.34	-1.22	-1.08	-0.72
1.88	-0.84	-1.19	-1.25	-1.26	-1.23	-1.17	-1.07	-0.97	-0.65
1.76	-0.66	-1.02	-1.10	-1.12	-1.10	-1.02	-0.94	-0.84	-0.54
1.64	-0.60	-0.90	-0.99	-1.02	-0.98	-0.93	-0.85	-0.76	-0.51
1.52	-0.43	-0.76	-0.86	-0.90	-0.87	-0.84	-0.76	-0.68	-0.50
1.41	-0.25	-0.65	-0.74	-0.79	-0.78	-0.77	-0.70	-0.62	-0.50
1.29	-0.13	-0.57	-0.65	-0.70	-0.70	-0.70	-0.66	-0.60	-0.51
1.17	0.21	-0.51	-0.58	-0.62	-0.64	-0.65	-0.63	-0.58	-0.52
1.05	0.29	-0.33	-0.56	-0.58	-0.60	-0.61	-0.61	-0.58	-0.54
0.93	0.26	-0.04	-0.42	-0.56	-0.56	-0.58	-0.58	-0.56	-0.55
0.81	0.23	-0.01	-0.26	-0.59	-0.57	-0.57	-0.57	-0.54	-0.54
0.70	0.21	0.02	-0.17	-0.48	-0.63	-0.63	-0.59	-0.55	-0.53
0.58	0.20	0.02	-0.15	-0.40	-0.60	-0.68	-0.68	-0.59	-0.53
0.46	0.20	0.08	-0.05	-0.31	-0.53	-0.68	-0.73	-0.66	-0.55
0.34	0.19	0.07	-0.05	-0.27	-0.47	-0.66	-0.76	-0.72	-0.59
0.22	0.20	0.10	0.01	-0.18	-0.42	-0.65	-0.79	-0.76	-0.64
0.10	0.16	0.00	-0.12	-0.30	-0.51	-0.66	-0.79	-0.77	-0.66

0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90

Width (m)

Average per Column (m/s)

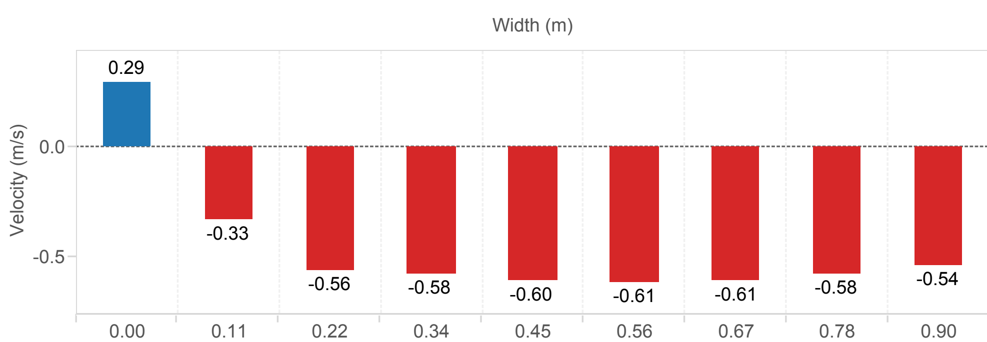
Height (m)	
2.12	**-1.05**
2.00	**-1.23**
1.88	**-1.07**
1.76	**-0.93**
1.64	**-0.84**
1.52	**-0.73**
1.41	**-0.64**
1.29	**-0.58**
1.17	**-0.50**
1.05	**-0.46**
0.93	**-0.40**
0.81	**-0.38**
0.70	**-0.37**
0.58	**-0.38**
0.46	**-0.36**
0.34	**-0.36**
0.22	**-0.35**
0.10	**-0.41**

Average per Row (m/s)

Width (m)

0.00	0.11	0.22	0.34	0.45	0.56	0.67	0.78	0.90
-0.16	**-0.47**	**-0.59**	**-0.72**	**-0.77**	**-0.80**	**-0.78**	**-0.70**	**-0.53**

Horizontal Wind Profile at the Probe Location



Width (m)
All

Height (m)
1.05

Average Volume Flow Rate Across the Opening

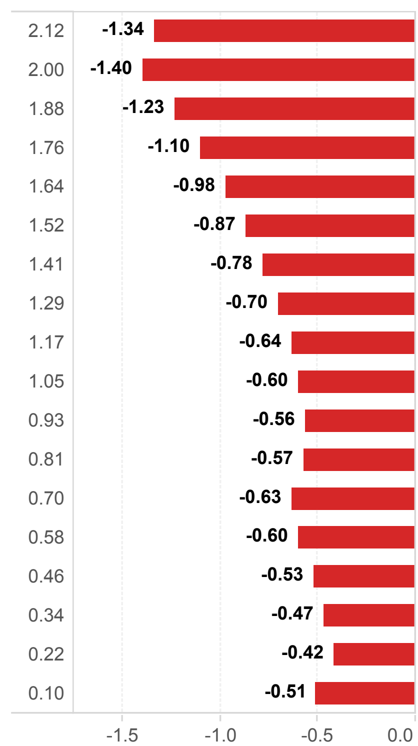
66.314 cm/min

Mean Velocity Across the Opening

-0.613 m/s

■ in (airflow into the control volume) ■ out (airflow out from the control volume)

Vertical Wind Profile at the Probe Location



Width (m) *0.45*

Height (m) *All*

SIMULATION DATA ANALYSIS
(Scenario 5 - Opening A4)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height (m)	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
2.12	0.23	-1.06	-1.00	-0.96	-0.95	-0.94	-0.93	-0.92	-0.90	
2.00	0.36	-0.70	-0.86	-0.90	-0.92	-0.93	-0.93	-0.91	-0.85	
1.88	0.29	-0.59	-0.83	-0.90	-0.93	-0.95	-0.96	-0.94	-0.86	
1.77	0.27	-0.50	-0.82	-0.90	-0.95	-0.97	-0.98	-0.95	-0.86	
1.65	0.27	-0.44	-0.81	-0.90	-0.95	-0.97	-0.98	-0.96	-0.87	
1.53	0.26	-0.39	-0.79	-0.90	-0.95	-0.97	-0.99	-0.96	-0.87	
1.41	0.26	-0.35	-0.77	-0.90	-0.96	-0.98	-1.00	-0.97	-0.88	
1.30	0.27	-0.32	-0.76	-0.90	-0.96	-0.98	-1.00	-0.97	-0.88	
1.18	0.27	-0.30	-0.75	-0.90	-0.96	-0.99	-1.01	-0.97	-0.88	
1.06	0.28	-0.26	-0.73	-0.90	-0.97	-0.99	-1.01	-0.98	-0.89	
0.94	0.28	-0.25	-0.72	-0.89	-0.97	-1.00	-1.02	-0.98	-0.89	
0.82	0.27	-0.24	-0.71	-0.89	-0.98	-1.01	-1.03	-0.97	-0.89	
0.71	0.27	-0.23	-0.70	-0.89	-0.99	-1.02	-1.03	-0.98	-0.89	
0.59	0.28	-0.21	-0.69	-0.90	-1.00	-1.03	-1.04	-0.98	-0.89	
0.47	0.28	-0.20	-0.69	-0.91	-1.01	-1.04	-1.05	-1.00	-0.89	
0.35	0.27	-0.18	-0.68	-0.91	-1.03	-1.06	-1.06	-1.00	-0.88	
0.24	0.27	-0.16	-0.67	-0.92	-1.04	-1.07	-1.06	-1.00	-0.87	
0.12	0.29	-0.17	-0.69	-0.94	-1.05	-1.08	-1.06	-0.99	-0.86	
0.00	0.24	-0.37	-0.75	-0.94	-1.06	-1.09	-1.06	-0.97	-0.83	

Width (m)

Average per Column (m/s)

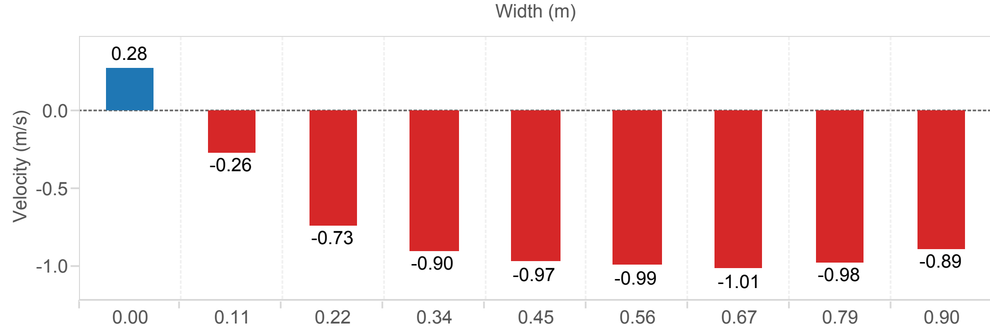
Height (m)	
2.12	**-0.83**
2.00	**-0.74**
1.88	**-0.74**
1.77	**-0.74**
1.65	**-0.73**
1.53	**-0.73**
1.41	**-0.73**
1.30	**-0.72**
1.18	**-0.72**
1.06	**-0.72**
0.94	**-0.72**
0.82	**-0.72**
0.71	**-0.72**
0.59	**-0.72**
0.47	**-0.72**
0.35	**-0.72**
0.24	**-0.73**
0.12	**-0.73**
0.00	**-0.76**

Average per Row (m/s)

Width (m)

0.00	0.11	0.22	0.34	0.45	0.56	0.67	0.79	0.90
0.28	**-0.36**	**-0.76**	**-0.91**	**-0.98**	**-1.00**	**-1.01**	**-0.97**	**-0.88**

Horizontal Wind Profile at the Probe Location



Width (m)
All

Height (m)
1.06

Vertical Wind Profile at the Probe Location

Width (m) *0.45*

Height (m) *All*

Average Volume Flow Rate Across the Opening

83.752 cm/min

Mean Velocity Across the Opening

-0.733 m/s

in (airflow into the control volume)   out (airflow out from the control volume)

SIMULATION DATA ANALYSIS
(Scenario 5 - Opening A7E)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height ..																										
3.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
3.32	0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
3.15	0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
2.97	0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1
2.80	0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1
2.62	0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1
2.45	0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1
2.27	0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1
2.10	0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1
1.92	0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1
1.75	0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1
1.57	0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1
1.40	0.0	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1
1.22	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1
1.05	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.1
0.87	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.1
0.70	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.1
0.52	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.1
0.35	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.1
0.17	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.1
0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1

0.00 0.50 1.00 1.50 2.00 2.50

Width (m)

Average per Column (m/s)

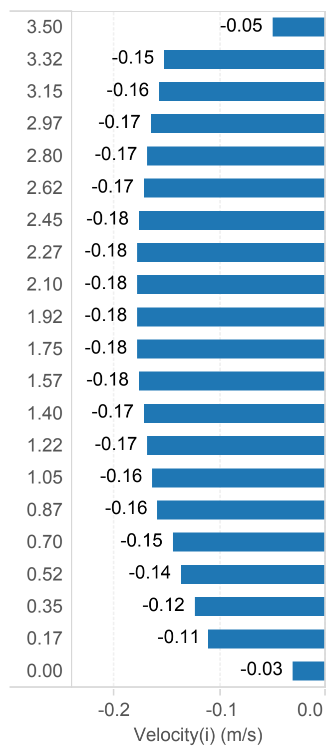
Height (m)	
3.50	-0.05
3.32	-0.15
3.15	-0.15
2.97	-0.16
2.80	-0.16
2.62	-0.17
2.45	-0.17
2.27	-0.17
2.10	-0.17
1.92	-0.18
1.75	-0.18
1.57	-0.18
1.40	-0.18
1.22	-0.17
1.05	-0.17
0.87	-0.17
0.70	-0.16
0.52	-0.15
0.35	-0.14
0.17	-0.11
0.00	-0.03

Average per Row (m/s)

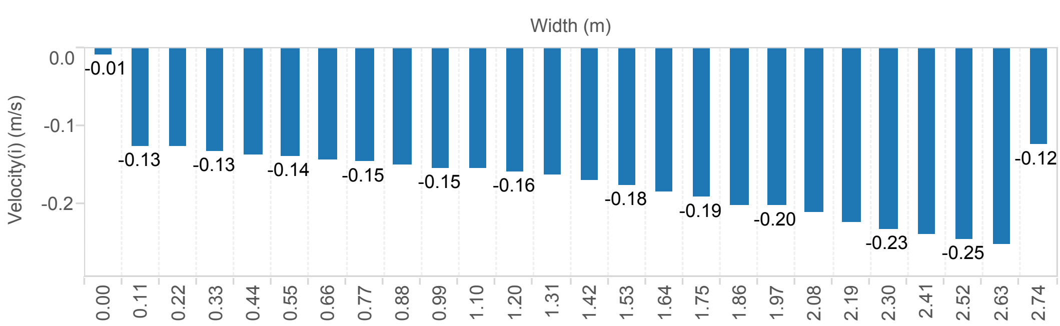
Width (m)

0.00	0.11	0.22	0.33	0.44	0.55	0.66	0.77	0.88	0.99	1.10	1.20	1.31	1.42	1.53	1.64	1.75	1.86	1.97	2.08	2.19	2.30	2.41	2.52	2.63	2.74
0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1

Vertical WInd Profile at the Probe Location



Horizontal Wind Profile at the Probe Location



Width (m) *All*

Height (m) *1.05*

Average Volume Flow Rate Across the Opening

86.093 cm/min

Mean Velocity Across the Opening

-0.1498

Width (m) *1.31*

Height (m) *All*

in (airflow into control volume)

out (airflow out from control volume)

SIMULATION DATA ANALYSIS
(Scenario 5 - Opening A7W)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height ..																										
3.50	-0.7	-0.8	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.8	-0.8	-0.8	-0.8	-0.8	-0.7	-0.7	-0.7	-0.6	-0.6	-0.6	-0.6	-0.5	-0.5	-0.4	-0.3	0.0	0.0
3.32	-0.4	-0.8	-0.8	-0.9	-0.9	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.8	-0.7	-0.5	-0.3	-0.2
3.15	-0.6	-0.8	-0.7	-0.7	-0.7	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.7	-0.6	-0.5	-0.3	-0.2
2.97	-0.9	-1.0	-0.9	-0.7	-0.6	-0.6	-0.6	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.5	-0.4	-0.3	-0.1
2.80	-1.2	-1.2	-1.1	-0.8	-0.6	-0.5	-0.5	-0.5	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.4	-0.3	-0.3	-0.1
2.62	-1.4	-1.4	-1.2	-0.9	-0.6	-0.5	-0.4	-0.4	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.3	-0.3	-0.1
2.45	-1.5	-1.6	-1.6	-1.2	-0.8	-0.6	-0.4	-0.3	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.1
2.27	-1.5	-1.7	-1.7	-1.3	-0.9	-0.6	-0.4	-0.3	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	0.0
2.10	-1.6	-1.8	-1.8	-1.4	-1.0	-0.6	-0.4	-0.3	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	0.0
1.92	-1.6	-1.9	-1.9	-1.5	-1.0	-0.7	-0.4	-0.3	-0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	-0.1	-0.1	-0.1	0.0
1.75	-1.6	-1.9	-1.9	-1.6	-1.1	-0.7	-0.5	-0.3	-0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
1.57	-1.6	-2.0	-2.0	-1.7	-1.2	-0.8	-0.5	-0.3	-0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1
1.40	-1.7	-2.0	-2.0	-1.7	-1.3	-0.9	-0.5	-0.3	-0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
1.22	-1.7	-2.1	-2.1	-1.8	-1.4	-0.9	-0.5	-0.2	0.0	0.2	0.2	0.3	0.3	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.1
1.05	-1.7	-2.1	-2.1	-1.9	-1.4	-0.9	-0.5	-0.2	0.0	0.2	0.2	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2
0.87	-1.7	-2.1	-2.1	-1.9	-1.4	-0.9	-0.5	-0.2	0.1	0.2	0.2	0.4	0.4	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.2
0.70	-1.7	-2.2	-2.1	-1.9	-1.4	-0.8	-0.5	-0.1	0.2	0.3	0.3	0.5	0.5	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.3	0.2
0.52	-1.7	-2.2	-2.2	-1.9	-1.4	-0.9	-0.5	-0.1	0.2	0.4	0.4	0.5	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.3
0.35	-1.7	-2.2	-2.2	-2.0	-1.5	-0.9	-0.5	0.0	0.3	0.5	0.5	0.6	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.4
0.17	-1.6	-2.2	-2.2	-2.2	-1.8	-1.0	-0.5	0.1	0.4	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.4
0.00	-1.5	-1.8	-1.8	-1.7	-1.6	-1.0	-0.4	0.1	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4

0.00 0.50 1.00 1.50 2.00 2.50

Width (m)

Average per Column (m/s)

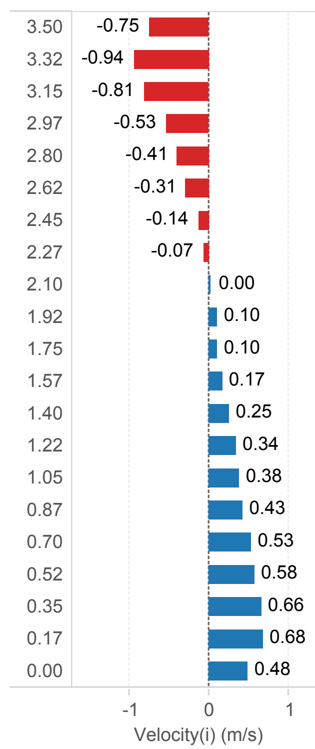
Height (m)	
3.50	-0.65
3.32	-0.82
3.15	-0.72
2.97	-0.59
2.80	-0.54
2.62	-0.50
2.45	-0.44
2.27	-0.41
2.10	-0.37
1.92	-0.34
1.75	-0.33
1.57	-0.30
1.40	-0.27
1.22	-0.24
1.05	-0.21
0.87	-0.18
0.70	-0.12
0.52	-0.09
0.35	-0.04
0.17	-0.02
0.00	-0.04

Average per Row (m/s)

Width (m)

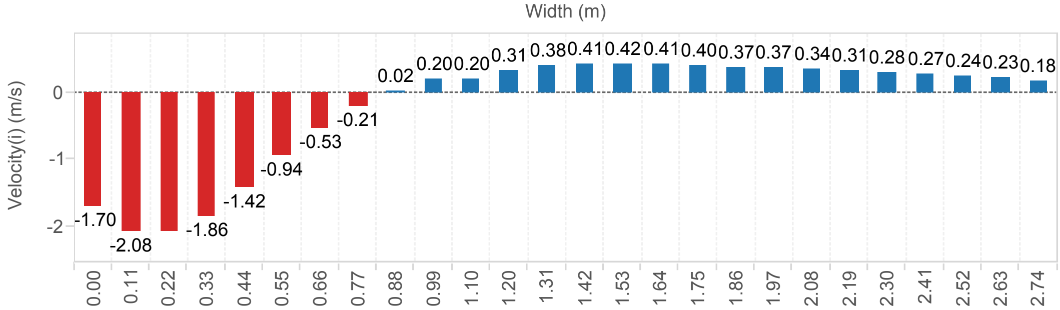
0.00	0.11	0.22	0.33	0.44	0.55	0.66	0.77	0.88	0.99	1.10	1.20	1.31	1.42	1.53	1.64	1.75	1.86	1.97	2.08	2.19	2.30	2.41	2.52	2.63	2.74
-1.4	-1.7	-1.7	-1.5	-1.1	-0.8	-0.5	-0.3	-0.2	-0.1	-0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1

Vertical WInd Profile at the Probe Location



Horizontal Wind Profile at the Probe Location

Width (m)



Width (m) All	Height (m) 1.05

Width (m) 1.31

Height (m) All

Average Volume Flow Rate Across the Opening

197.531 cm/min

Mean Velocity Across the Opening

-0.3437

in (airflow into control volume)   out (airflow out from control volume)

SIMULATION DATA ANALYSIS
(Scenario 5 - Opening B)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

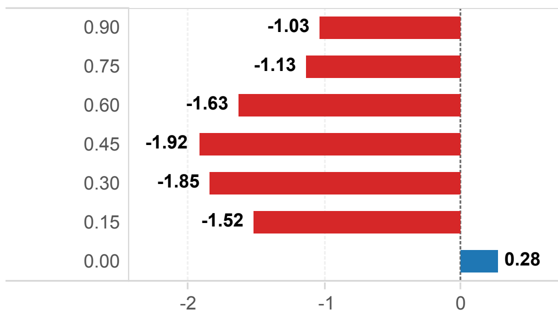
Heig..																																				
0.90	0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.4	-0.5	-0.6	-0.8	-1.0	-1.2	-1.4	-1.5	-1.4	-1.4	-1.3	-1.2	-1.2	-1.2	-1.1	-1.1	-1.1	-1.1	-1.0	-1.0	-1.1	-1.1	-1.1	-1.2	-1.1	-1.1
0.75	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.4	-0.4	-0.5	-0.7	-0.8	-1.0	-1.1	-1.3	-1.6	-1.8	-1.9	-1.9	-1.8	-1.7	-1.7	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.7	-1.7	-1.7	-1.7	-1.5
0.60	-0.2	-0.2	-0.3	-0.3	-0.3	-0.4	-0.4	-0.5	-0.6	-0.7	-0.9	-1.1	-1.4	-1.6	-1.6	-1.6	-1.6	-1.7	-1.9	-2.0	-2.0	-1.9	-1.9	-1.8	-1.8	-1.7	-1.7	-1.7	-1.7	-1.7	-1.8	-1.8	-1.8	-1.8	-1.8	-1.6
0.45	-0.3	-0.4	-0.4	-0.5	-0.6	-0.6	-0.7	-0.8	-1.0	-1.1	-1.4	-1.6	-1.8	-1.9	-1.9	-1.9	-1.9	-1.8	-1.7	-1.9	-1.9	-1.9	-1.9	-1.9	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.9	-1.8	-1.7
0.30	-0.5	-0.4	-0.5	-0.5	-0.6	-0.7	-0.8	-1.0	-1.2	-1.4	-1.6	-1.8	-1.8	-1.8	-1.8	-1.9	-2.0	-2.0	-1.7	-1.7	-1.7	-1.8	-1.8	-1.8	-1.8	-1.8	-1.7	-1.7	-1.7	-1.7	-1.8	-1.8	-1.8	-1.8	-1.8	-1.6
0.15	-0.8	-0.4	-0.3	-0.3	-0.3	-0.4	-0.5	-0.7	-0.8	-1.0	-1.2	-1.5	-1.5	-1.5	-1.5	-1.6	-1.7	-1.9	-1.8	-1.6	-1.6	-1.6	-1.6	-1.7	-1.7	-1.6	-1.6	-1.6	-1.6	-1.7	-1.7	-1.7	-1.8	-1.8	-1.7	-1.5
0.00	-0.7	-0.1	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.2	0.2	0.2	0.3	0.3	0.2	-0.3	0.2	0.0	-0.4	-0.6	-0.8	-0.9	-1.0	-1.0	-1.0	-1.1	-1.1	-1.2	-1.3	-1.5	-1.6	-1.6	-1.6	-1.4

0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50

Average per Column (m/s)

Height (m)	
0.90	**-0.83**
0.75	**-1.14**
0.60	**-1.33**
0.45	**-1.48**
0.30	**-1.50**
0.15	**-1.33**
0.00	**-0.45**

Vertical Wind Profile at the Probe Location



Width (m) *2.55*

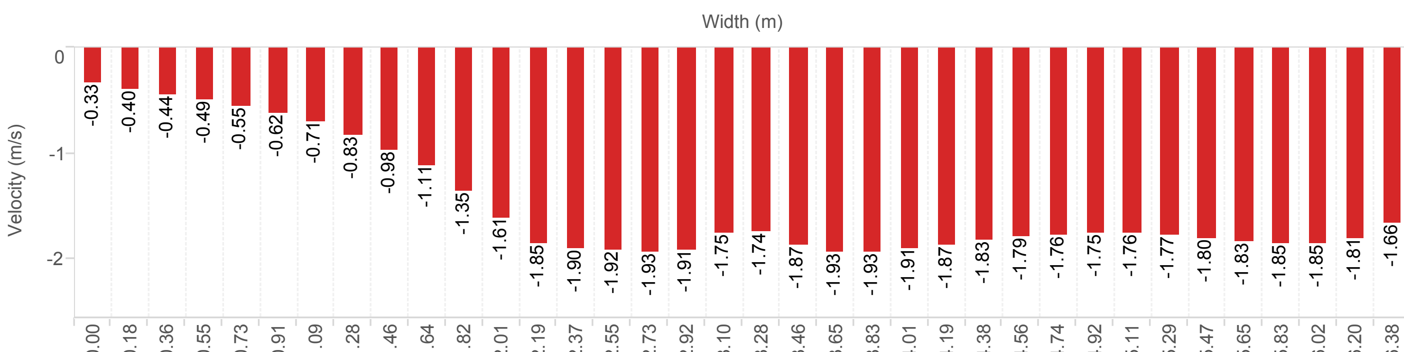
Height (m) *All*

Average per Row (m/s)

Width (m)

0.00	0.18	0.36	0.55	0.73	0.91	1.09	1.28	1.46	1.64	1.82	2.01	2.19	2.37	2.55	2.73	2.92	3.10	3.28	3.46	3.65	3.83	4.01	4.19	4.38	4.56	4.74	4.92	5.11	5.29	5.47	5.65	5.83	6.02	6.20	6.38
-0.4	-0.2	-0.2	-0.3	-0.3	-0.3	-0.4	-0.5	-0.6	-0.7	-0.8	-1.0	-1.1	-1.2	-1.3	-1.3	-1.4	-1.6	-1.5	-1.5	-1.5	-1.5	-1.6	-1.6	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5	-1.6	-1.6	-1.7	-1.7	-1.6	-1.5

Horizontal Wind Profile at the Probe Location



Width (m) *All*

Height (m) *0.45*

Average Volume Flow Rate Across the Opening

393.143 cm/min

Mean Velocity Across the Opening

-1.152 m/s

in (airflow into the control volume)

out (airflow out from the controll volume)

SIMULATION DATA ANALYSIS
(Scenario 5 - Opening C1)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height (m)									
0.84	-0.28	0.06	0.19	0.18	0.03	0.34	0.42	0.39	-0.05
0.70	-1.72	-2.39	-2.27	-2.18	-2.13	-2.09	-2.05	-2.09	-1.67
0.56	-1.64	-2.42	-2.31	-2.20	-2.14	-2.10	-2.11	-2.20	-1.58
0.42	-1.76	-2.45	-2.37	-2.27	-2.21	-2.17	-2.17	-2.22	-2.02
0.28	-1.50	-2.49	-2.41	-2.30	-2.25	-2.21	-2.19	-2.24	-1.92
0.14	-1.45	-2.51	-2.46	-2.34	-2.28	-2.23	-2.21	-2.24	-1.94
0.00	-1.55	-2.55	-2.54	-2.43	-2.37	-2.32	-2.29	-2.26	-1.98

0.00 0.20 0.40 0.60 0.80 1.00

Width (m)

Average per Column (m/s)

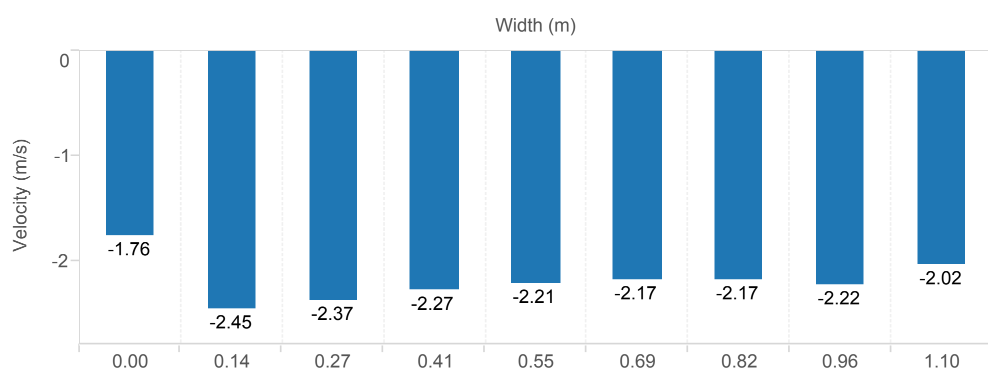
Height (m)	
0.84	**0.14**
0.70	**-2.07**
0.56	**-2.08**
0.42	**-2.18**
0.28	**-2.17**
0.14	**-2.19**
0.00	**-2.26**

Average per Row (m/s)

Width (m)

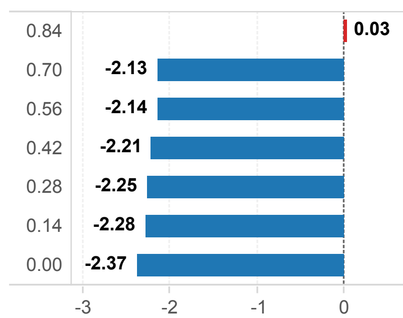
0.00	0.14	0.27	0.41	0.55	0.69	0.82	0.96	1.10
-1.41	**-2.11**	**-2.02**	**-1.93**	**-1.91**	**-1.83**	**-1.80**	**-1.84**	**-1.59**

Horizontal Wind Profile at the Probe Location



Width (m) *All* ***Height (m)*** *0.42*

Vertical Wind Profile at the Probe Location



Average Volume Flow Rate Across the Opening

101.546 cm/min

Mean Velocity Across the Opening

-1.827 m/s

Width (m) *0.55*

Height (m) *All*

in (airflow into the control volume) out (airflow out from the control volume)

SIMULATION DATA ANALYSIS
(Scenario 5 - Opening C2)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

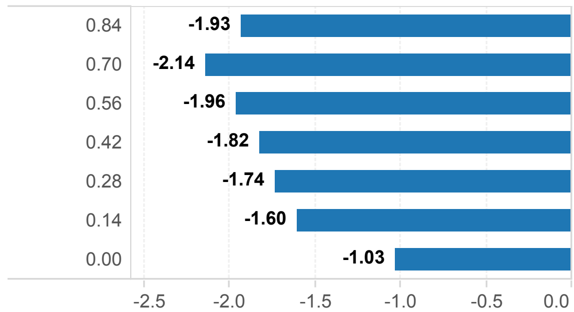
Height (m)																									
0.84	-1.2	-1.5	-1.3	-1.7	-1.7	-1.7	-1.4	-1.4	-1.5	-1.9	-1.9	-1.9	-1.9	-2.0	-2.0	-2.0	-2.0	-2.0	-1.4	-1.4	-1.4	-1.4	-1.4	-0.9	0.7
0.70	-1.9	-2.1	-2.0	-2.0	-1.9	-2.0	-2.0	-2.0	-2.0	-2.1	-2.1	-2.1	-2.1	-2.2	-2.2	-2.2	-2.2	-2.2	-2.2	-2.2	-2.2	-2.2	-2.1	-2.2	-0.2
0.56	-1.9	-2.0	-1.9	-1.9	-1.8	-1.8	-1.8	-1.9	-1.9	-1.9	-1.9	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.1	-0.2
0.42	-1.9	-2.0	-1.9	-1.8	-1.8	-1.7	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.9	-1.9	-1.9	-1.9	-1.9	-1.9	-1.9	-2.0	-1.2
0.28	-1.9	-2.0	-1.9	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.7	-1.7	-1.7	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.9	-1.9	-1.2
0.14	-1.8	-2.1	-2.0	-1.9	-1.9	-1.8	-1.8	-1.7	-1.7	-1.7	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.7	-1.7	-1.7	-1.8	-1.8	-1.2
0.00	-1.6	-1.5	-1.4	-1.5	-1.5	-1.4	-1.4	-1.4	-1.1	-1.1	-1.1	-1.1	-1.0	-1.2	-1.3	-1.3	-1.3	-1.2	-1.2	-1.3	-1.4	-1.5	-1.4	-1.5	-0.8

0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50

Average per Column (m/s)

Height (m)	
0.84	**-1.53**
0.70	**-2.02**
0.56	**-1.88**
0.42	**-1.83**
0.28	**-1.78**
0.14	**-1.70**
0.00	**-1.31**

Vertical Wind Profile at the Probe Location



Width (m) *2.15*

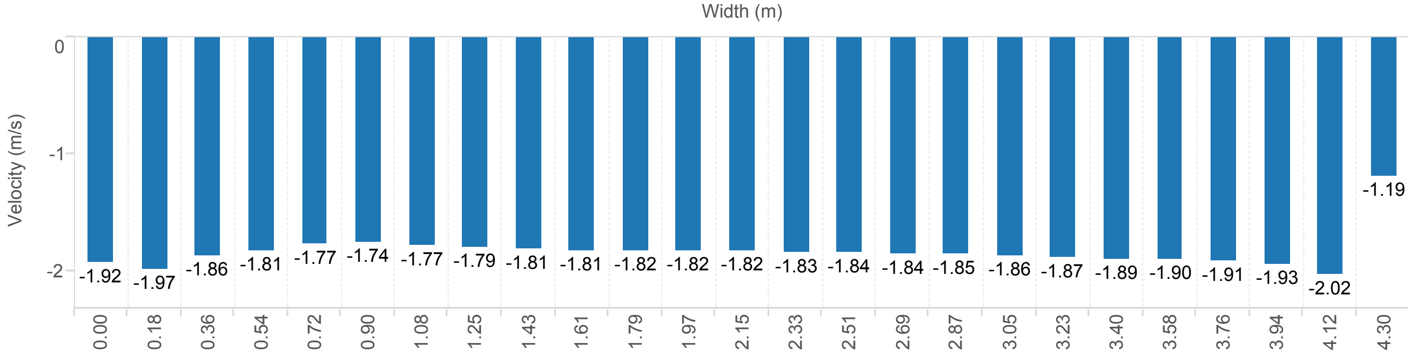
Height (m) *All*

Average per Row (m/s)

Width (m)

0.00	0.18	0.36	0.54	0.72	0.90	1.08	1.25	1.43	1.61	1.79	1.97	2.15	2.33	2.51	2.69	2.87	3.05	3.23	3.40	3.58	3.76	3.94	4.12	4.30
-1.8	**-1.9**	**-1.8**	**-1.8**	**-1.7**	**-1.7**	**-1.7**	**-1.7**	**-1.7**	**-1.8**	**-1.8**	**-1.8**	**-1.7**	**-1.8**	**-1.8**	**-1.8**	**-1.8**	**-1.8**	**-1.7**	**-1.8**	**-1.8**	**-1.8**	**-1.8**	**-1.8**	**-0.6**

Horizontal Wind Profile at the Probe Location



Width (m) *All*

Height (m) *0.42*

Average Volume Flow Rate Across the Opening

375.414 cm/min

Mean Velocity Across the Opening

-1.721 m/s

in (airflow into the control volume)

out (airflow out from the control volume)

SIMULATION DATA ANALYSIS
(Scenario 5 - Opening C3)

Wind Velocity Perpendicular to Opening Distribution over Opening Area (m/s)

Height (m)									
0.85	-0.47	-0.59	-0.66	-0.76	-0.30	-0.20	-0.22	0.10	-0.05
0.71	-0.76	-1.45	-1.68	-1.47	-1.41	-1.37	-1.35	-1.11	-0.80
0.57	-0.35	-1.28	-1.73	-1.67	-1.57	-1.50	-1.46	-1.22	-0.78
0.42	-0.14	-1.14	-1.68	-1.67	-1.61	-1.53	-1.44	-1.24	-0.71
0.28	-0.22	-1.15	-1.64	-1.65	-1.61	-1.52	-1.44	-1.15	-0.74
0.14	-0.37	-1.19	-1.60	-1.64	-1.61	-1.54	-1.43	-1.10	-0.77
0.00	-0.54	-1.28	-1.65	-1.69	-1.65	-1.55	-1.41	-1.02	-0.80

0.00 0.20 0.40 0.60 0.80 1.00

Width (m)

Average per Column (m/s)

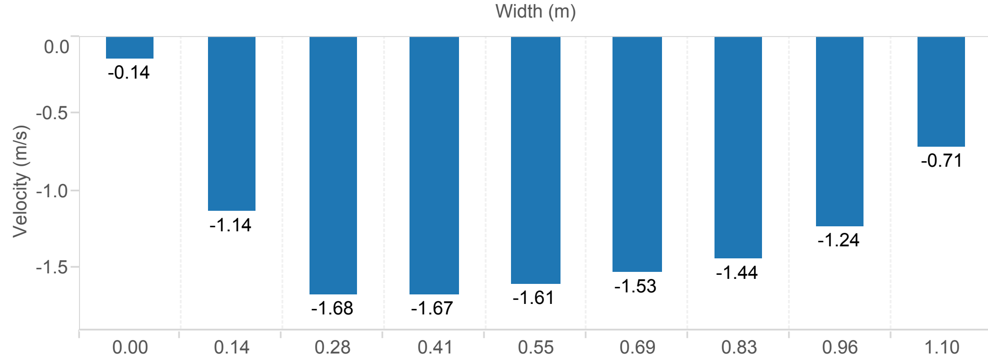
Height (m)	
0.85	**-0.35**
0.71	**-1.27**
0.57	**-1.28**
0.42	**-1.24**
0.28	**-1.23**
0.14	**-1.25**
0.00	**-1.29**

Average per Row (m/s)

Width (m)

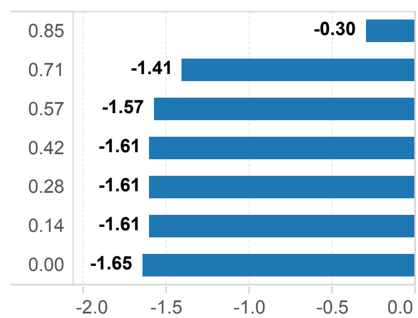
0.00	0.14	0.28	0.41	0.55	0.69	0.83	0.96	1.10
-0.41	**-1.15**	**-1.52**	**-1.51**	**-1.39**	**-1.31**	**-1.25**	**-0.96**	**-0.67**

Horizontal Wind Profile at the Probe Location



Width (m) *All* | *Height (m)* *0.42*

Vertical Wind Profile at the Probe Location



Average Volume Flow Rate Across the Opening

63.374 cm/min

Mean Velocity Across the Opening

-1.131 m/s

Width (m) *0.55*

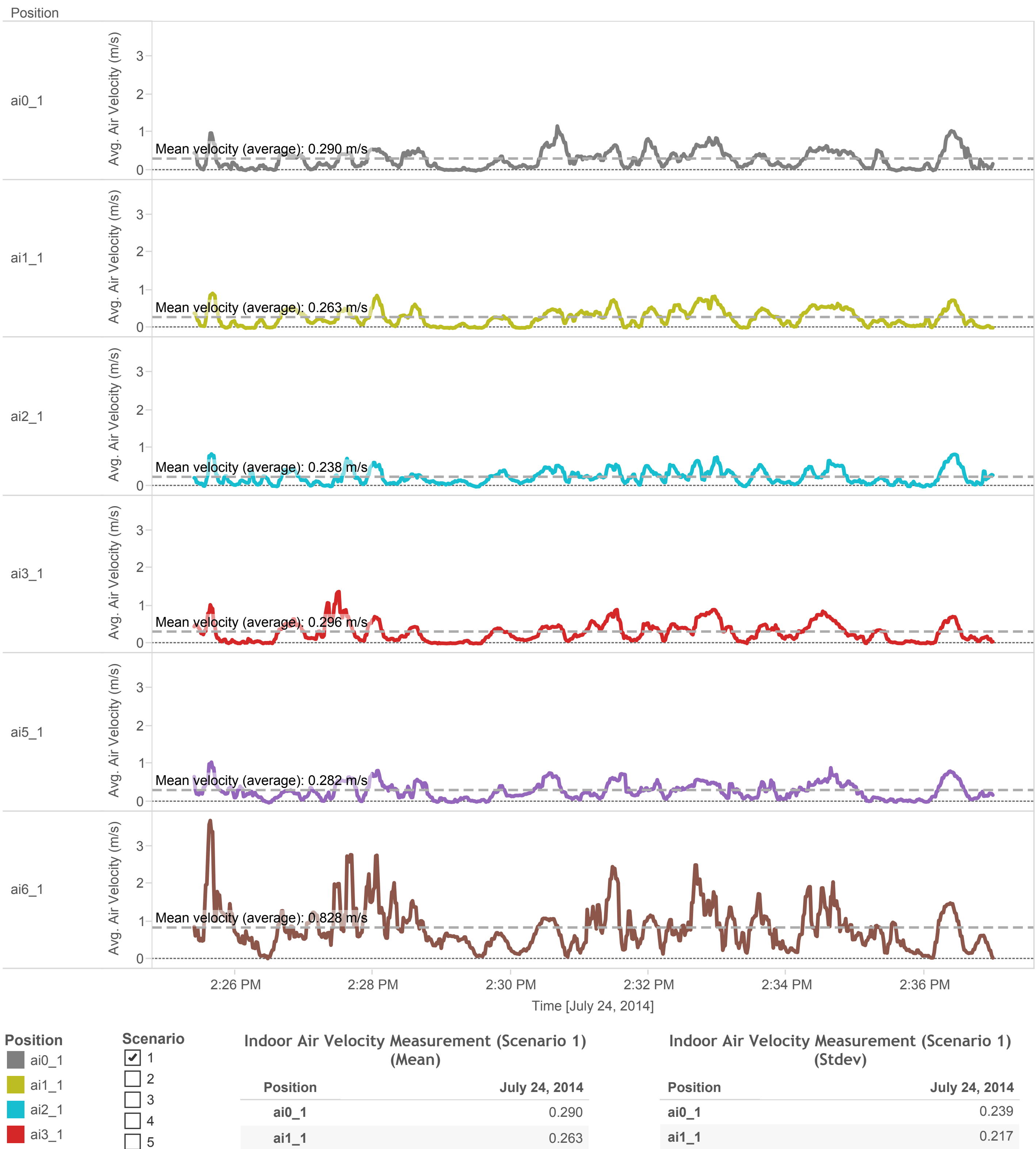
Height (m) *All*

in (airflow into the control volume) out (airflow out from the controll volume)

APPENDIX C

RESULTS OF AIR FLOW MEASUREMENT FOR SELCTED CONTROL SURFACES FOR FIVE TEST SCENARIOS

Indoor Air Velocity Measurement
(Scenario 1)



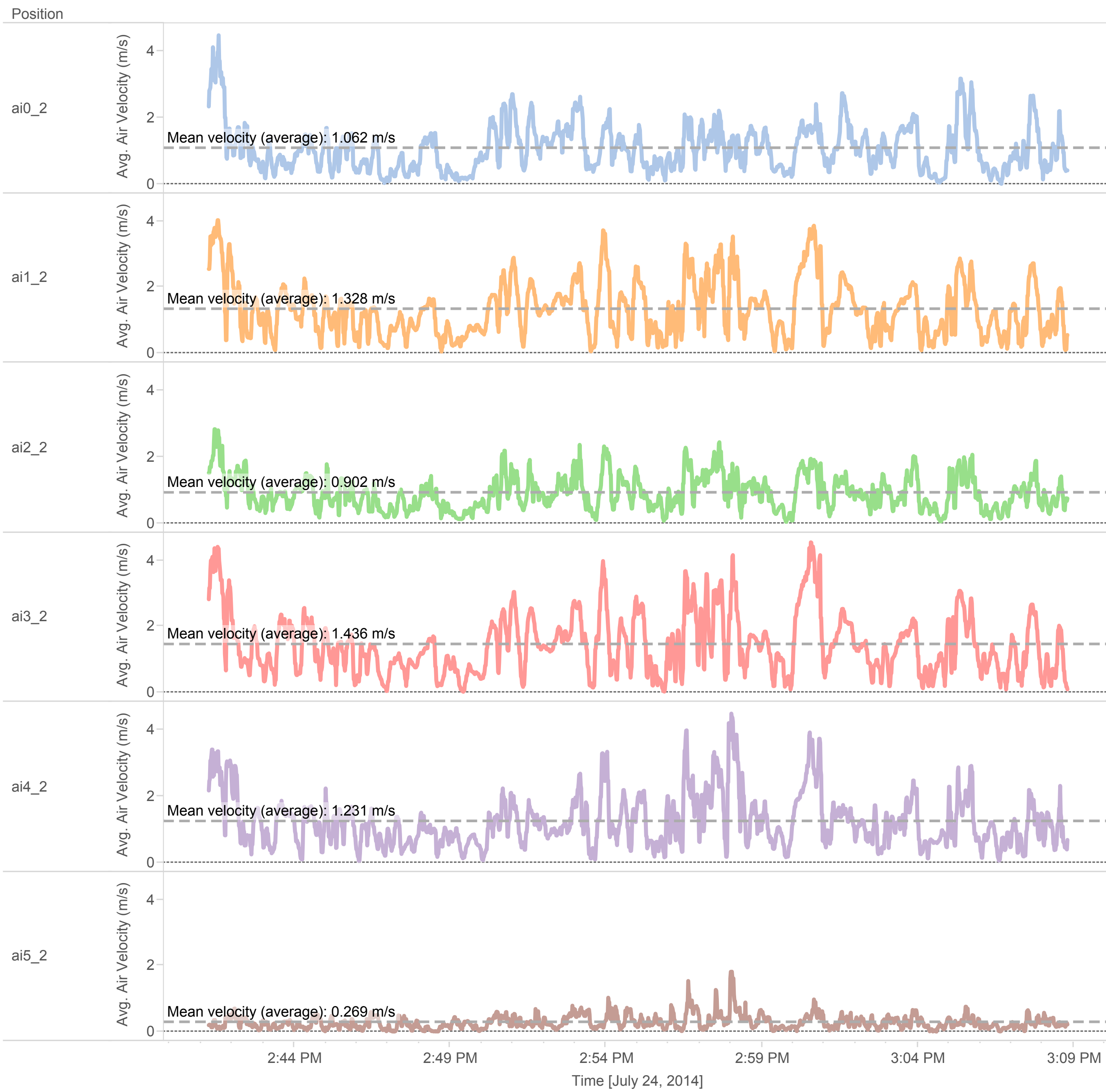
Indoor Air Velocity Measurement (Scenario 1) (Mean)

Position	July 24, 2014
ai0_1	0.290
ai1_1	0.263
ai2_1	0.238
ai3_1	0.296
ai5_1	0.282
ai6_1	0.828

Indoor Air Velocity Measurement (Scenario 1) (Stdev)

Position	July 24, 2014
ai0_1	0.239
ai1_1	0.217
ai2_1	0.190
ai3_1	0.256
ai5_1	0.214
ai6_1	0.580

Indoor Air Velocity Measurement (Scenario 2)



Position

- ai0_2
- ai1_2
- ai2_2
- ai3_2
- ai4_2
- ai5_2

Scenario

- ☐ 1
- ☑ 2
- ☐ 3
- ☐ 4
- ☐ 5

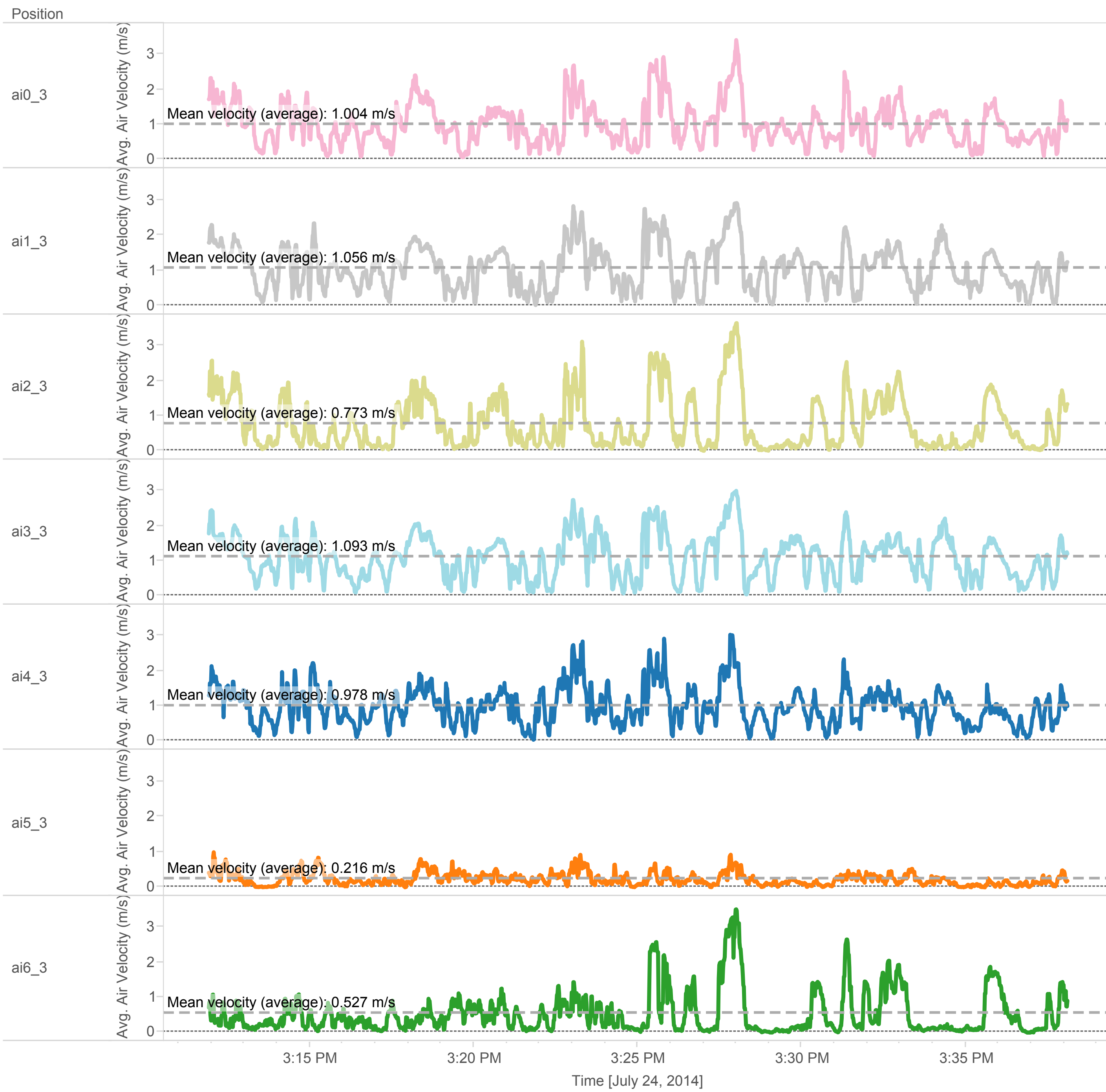
Indoor Air Velocity Measurement (Scenario 2) (Mean)

Position	July 24, 2014
ai0_2	1.062
ai1_2	1.328
ai2_2	0.902
ai3_2	1.436
ai4_2	1.231
ai5_2	0.269

Indoor Air Velocity Measurement (Scenario 2) (Stdev)

Position	July 24, 2014
ai0_2	0.690
ai1_2	0.826
ai2_2	0.505
ai3_2	0.913
ai4_2	0.776
ai5_2	0.212

Indoor Air Velocity Measurement
(Scenario 3)



Position
- ai0_3
- ai1_3
- ai2_3
- ai3_3
- ai4_3
- ai5_3
- ai6_3

Scenario
- ☐ 1
- ☐ 2
- ☑ 3
- ☐ 4
- ☐ 5

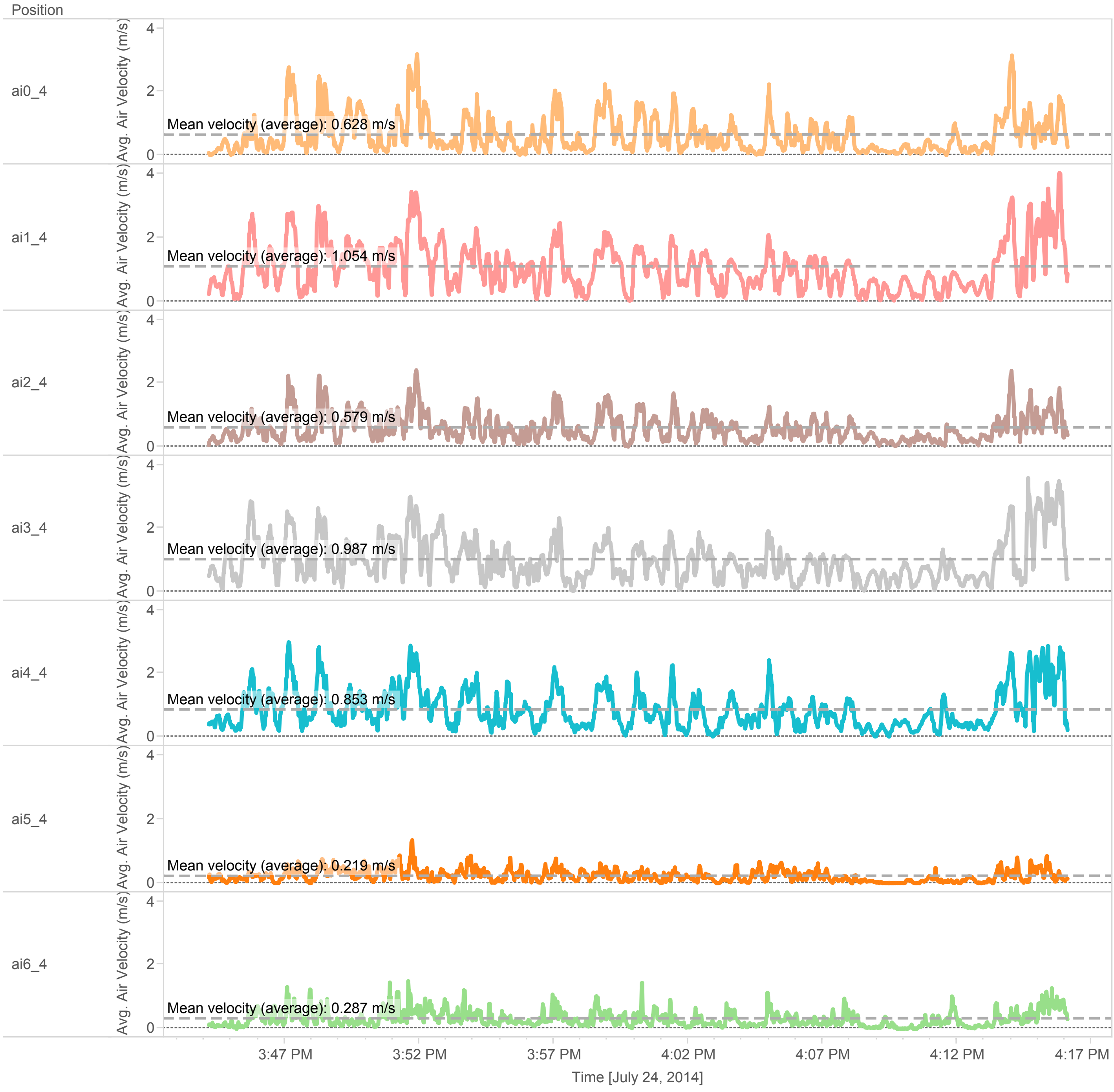
Indoor Air Velocity Measurement (Scenario 3) (Mean)

Position	July 24, 2014
ai0_3	1.004
ai1_3	1.056
ai2_3	0.773
ai3_3	1.093
ai4_3	0.978
ai5_3	0.216
ai6_3	0.527

Indoor Air Velocity Measurement (Scenario 3) (Stdev)

Position	July 24, 2014
ai0_3	0.583
ai1_3	0.607
ai2_3	0.752
ai3_3	0.611
ai4_3	0.529
ai5_3	0.178
ai6_3	0.616

Indoor Air Velocity Measurement
(Scenario 4)



Position
- ai0_4
- ai1_4
- ai2_4
- ai3_4
- ai4_4
- ai5_4
- ai6_4

Scenario
- ☐ 1
- ☐ 2
- ☐ 3
- ☑ 4
- ☐ 5

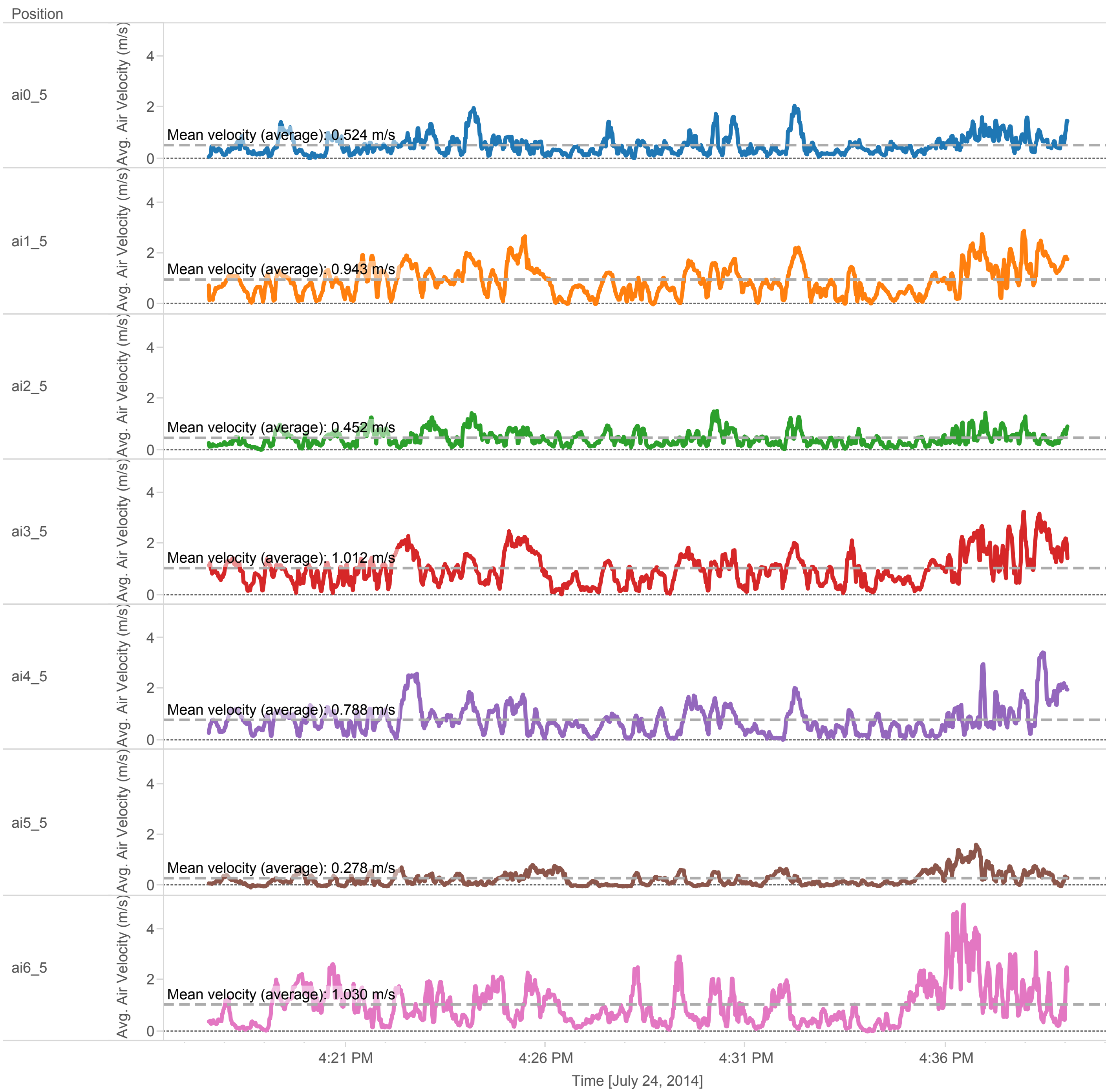
Indoor Air Velocity Measurement (Scenario 4) (Mean)

Position	July 24, 2014
ai0_4	0.628
ai1_4	1.054
ai2_4	0.579
ai3_4	0.987
ai4_4	0.853
ai5_4	0.219
ai6_4	0.287

Indoor Air Velocity Measurement (Scenario 4) (Stdev)

Position	July 24, 2014
ai0_4	0.574
ai1_4	0.726
ai2_4	0.424
ai3_4	0.669
ai4_4	0.610
ai5_4	0.183
ai6_4	0.245

Indoor Air Velocity Measurement
(Scenario 5)



Position
- ai0_5
- ai1_5
- ai2_5
- ai3_5
- ai4_5
- ai5_5
- ai6_5

Scenario
- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☑ 5

Indoor Air Velocity Measurement (Scenario 5) (Mean)

Position	July 24, 2014
ai0_5	0.524
ai1_5	0.943
ai2_5	0.452
ai3_5	1.012
ai4_5	0.788
ai5_5	0.278
ai6_5	1.030

Indoor Air Velocity Measurement (Scenario 5) (Stdev)

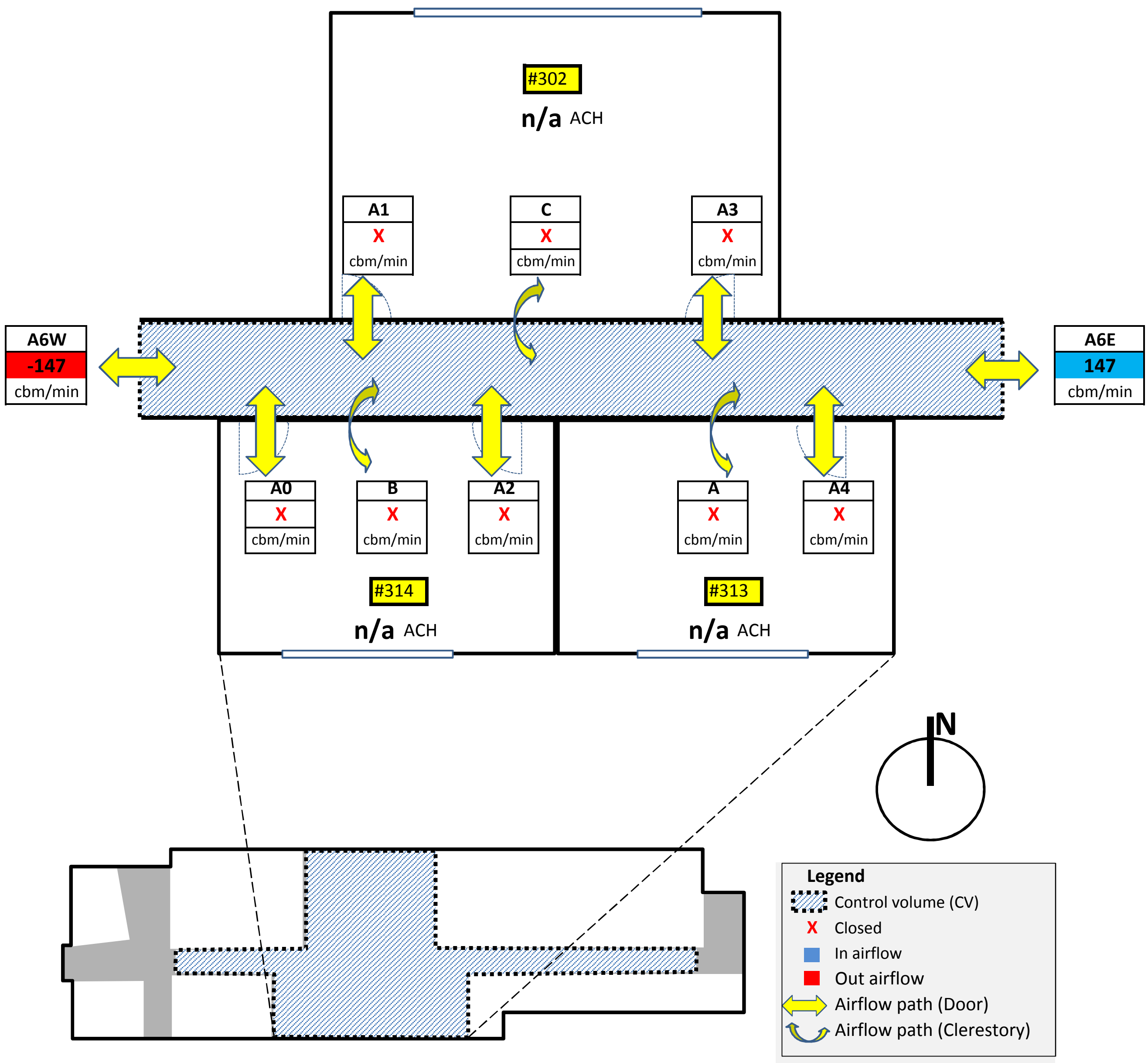
Position	July 24, 2014
ai0_5	0.372
ai1_5	0.574
ai2_5	0.285
ai3_5	0.610
ai4_5	0.568
ai5_5	0.269
ai6_5	0.819

APPENDIX D

MASS BALANCE FOR AIR FLOW IN CONTROL VOLUME

AIRFLOW DIAGRAM THROUGH THE CONTROL VOLUME & ROOMS' AIR CHANGE RATES PER SCENARIO

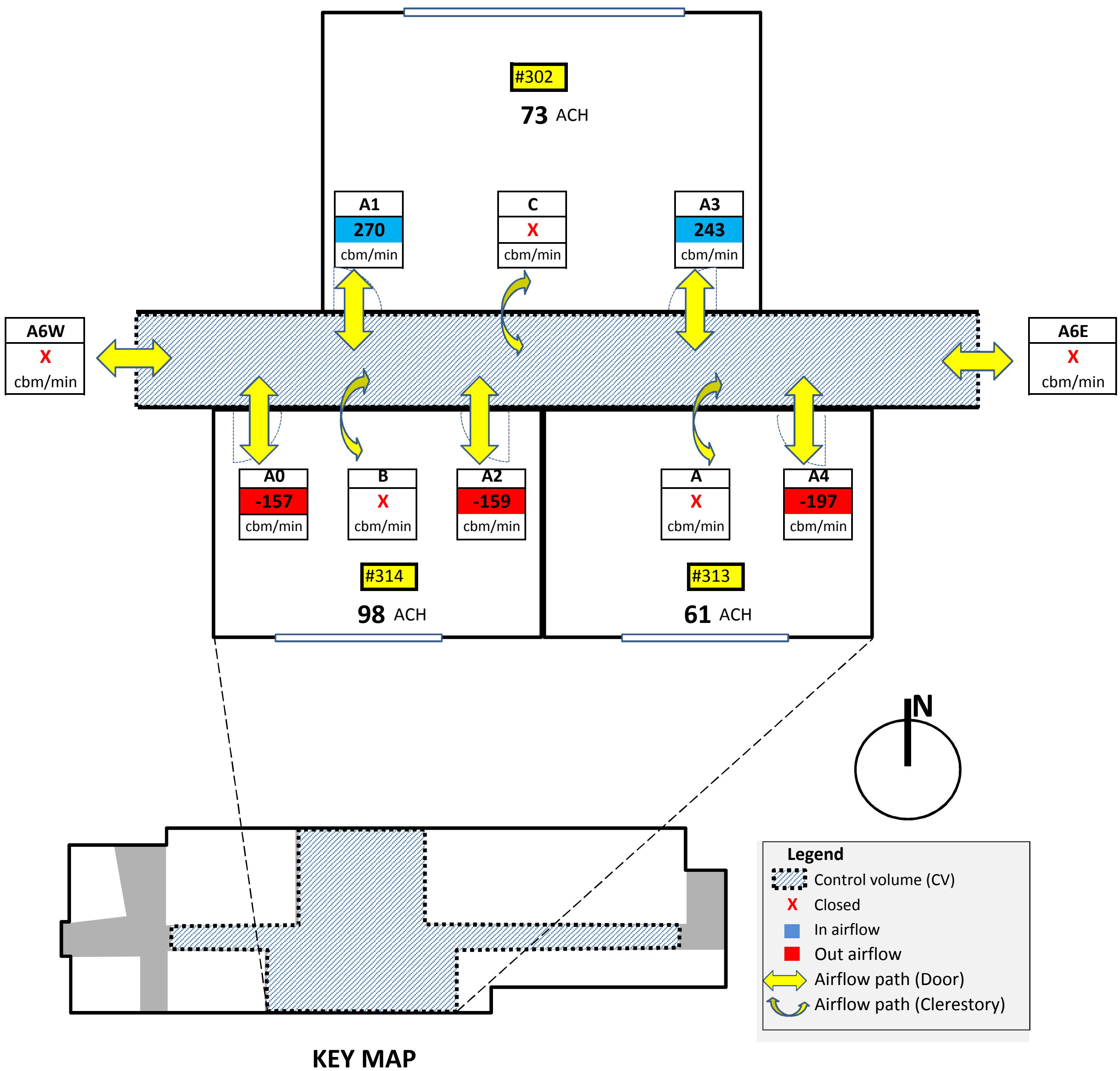
Scenario 1



KEY MAP

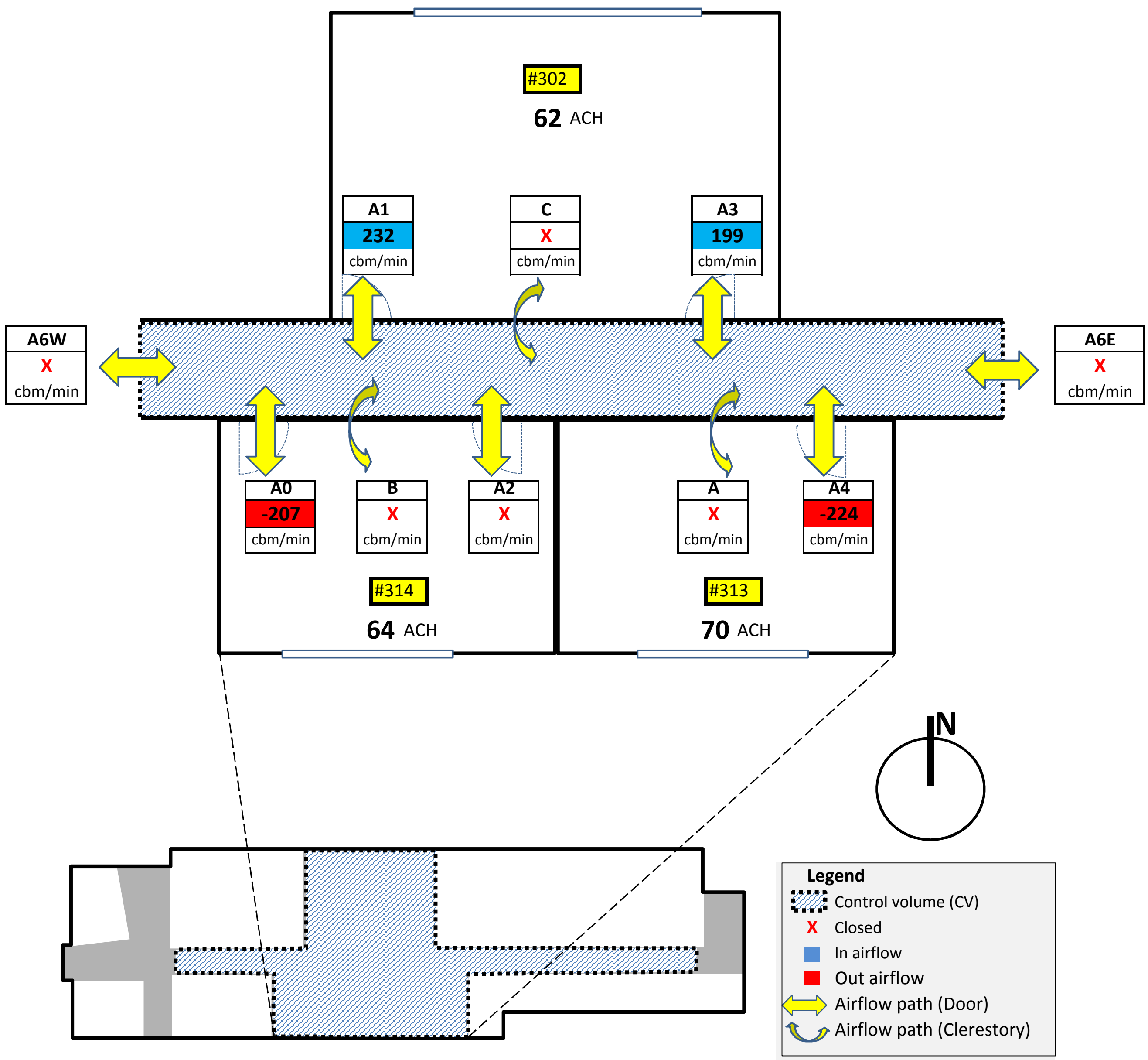
AIRFLOW DIAGRAM THROUGH THE CONTROL VOLUME & ROOMS' AIR CHANGE RATES PER SCENARIO

Scenario 2



AIRFLOW DIAGRAM THROUGH THE CONTROL VOLUME & ROOMS' AIR CHANGE RATES PER SCENARIO

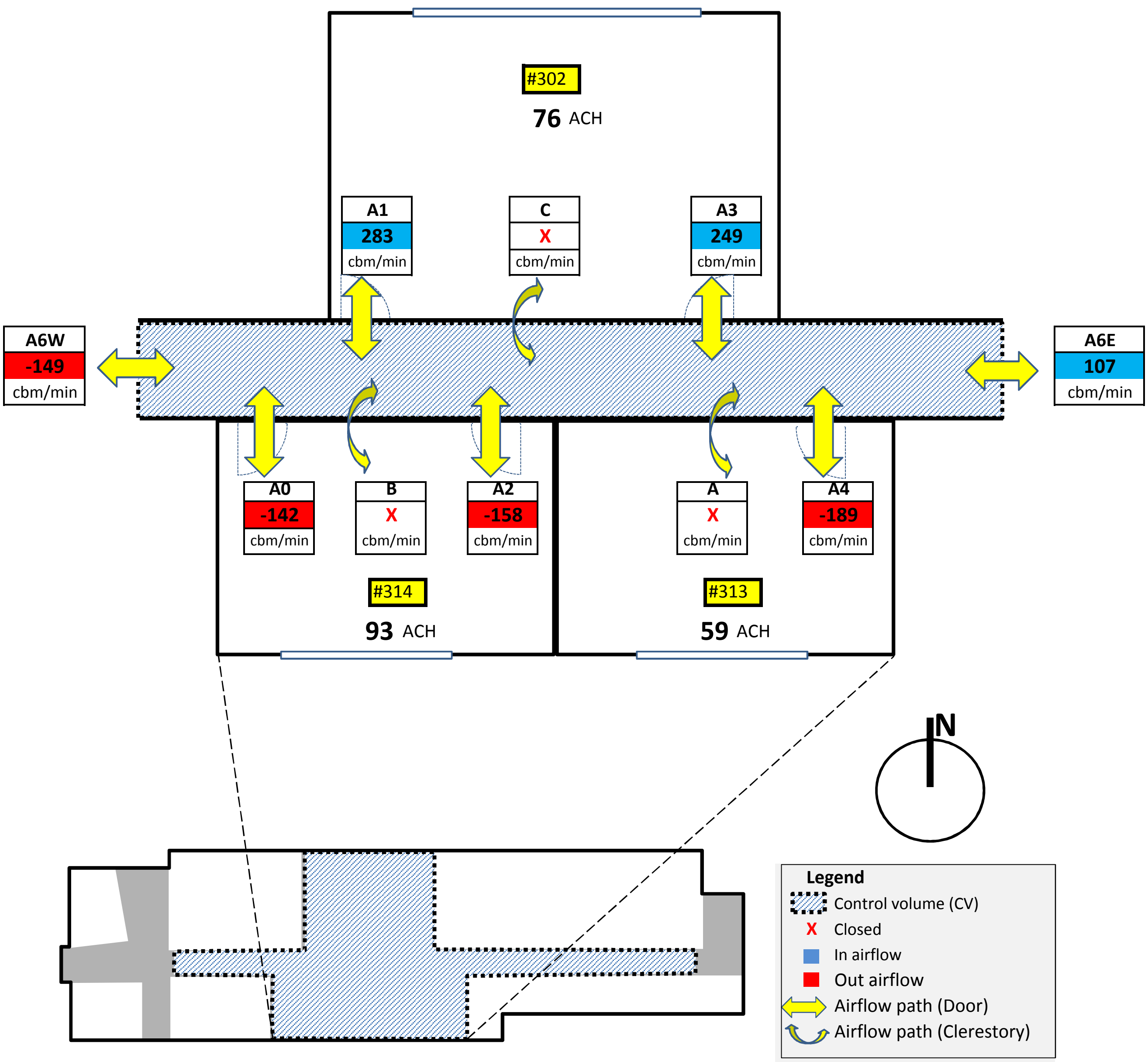
Scenario 3



KEY MAP

AIRFLOW DIAGRAM THROUGH THE CONTROL VOLUME & ROOMS' AIR CHANGE RATES PER SCENARIO

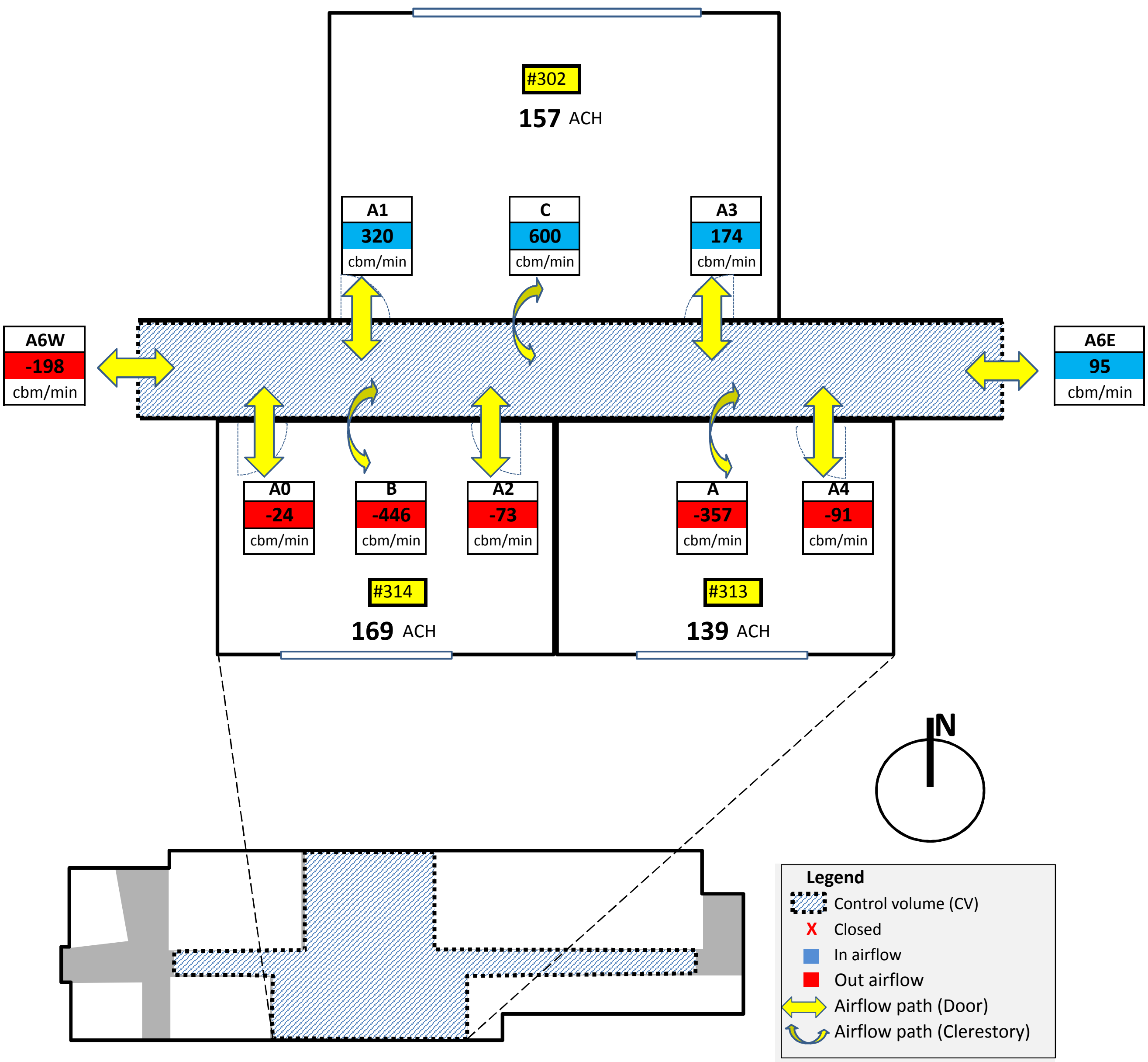
Scenario 4



KEY MAP

AIRFLOW DIAGRAM THROUGH THE CONTROL VOLUME & ROOMS' AIR CHANGE RATES PER SCENARIO

Scenario 5



KEY MAP