



# Lam Geotechnics Limited

Ground Investigation & Instrumentation Professionals

華益土力有限公司

Ref : G1938/CS/L248a/HyD  
Date : 21 January 2021

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88 Chung Hau Street,  
Ho Man Tin,  
Hong Kong  
Attn: Senior Engineer, Mr. WONG Yee Lok, Enoch

(By Post & Fax: 2714-5289)

Dear Enoch,

**Contract No. HY/2019/18**  
**Wanchai Development Phase II and Central-Wanchai Bypass**  
**Sampling, Field Measurement and Testing Works (Stage 4)**

**Investigation Report on Temporary Suspension of Operation of Tunnel Ventilation Fan Nos. MVB-TVF-012 and MVB-TVF-013 at Middle Ventilation Building (MVB) and Tunnel Ventilation Fan Nos. WVB-TVF-004 and 005 at West Ventilation Building (WVB) of Central Wanchai Bypass (CWB)**

We have reviewed the latest version of the captioned Investigation Report (the IR) dated 21 January 2021 and the responses to comments as per comments given by EPD up to 7 January 2021.

Based on the IR and the above responses to comments, we hereby certify the IR for your onwards submission to EPD as per the Event and Action Plan of the approved AQMP.

Please be reminded our certification does not absolve the EP holder/the project proponent/any person from any requirements or obligations under the Environmental Impact Assessment Ordinance (Cap. 499) or other laws in force in Hong Kong. In addition, please be reminded to ensure all relevant persons without missing the role of the Operator of CWB tunnel to carry out corresponding implementation to ensure normal operation of APS in accordance with the AQMP approved by EPD.

Yours faithfully,  
For and On Behalf of Lam Geotechnics Limited

Raymond Dai  
Environmental Team Leader

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21 January 2021

Highways Department  
Major Works Project Management Office  
Major Works Office (2)  
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88 Chung Hau Street, Ho Man Tin  
Kowloon, Hong Kong

By Post and Fax (2714 5289)

Attention: Mr. WONG Yee Lok, Enoch

Dear Mr. Wong,

**Re: Central – Wan Chai Bypass (CWB) including its Road Tunnel and Slip Roads (Environmental Permit: EP-482/2013/C)****Investigation Report on Temporary Suspension of Operation of Tunnel Ventilation Fan Nos. WVB-TVF-004, WVB-TVF-005, MVB-TVF-012 and MVB-TVF-013**

Reference is made to the captioned Final Investigation Report received through Project RSS's email and ET's certification letter (ref.: G1938/CS/L248a/HyD) received on 21 January 2021.

We write to verify the captioned final investigation report in accordance with the approved AQMP. By copy of this letter, HyD and relevant parties are reminded to follow ET's recommendations.

Thank you very much for your attention and please do not hesitate to contact the undersigned should you have any queries.

Yours sincerely,



David Yeung  
Independent Environmental Checker

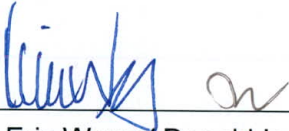
c.c.	AECOM	Attn: Mr. David Kwan	by fax: 3912 3010
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**Central – Wan Chai Bypass  
and Island Eastern Corridor Link**

**Investigation Report on Temporary  
Suspension of Operation of Tunnel  
Ventilation Fan Nos. WVB-TVF-004, WVB-  
TVF-005, MVB-TVF-012 and MVB-TVF-013  
(Final Report)**

Prepared by:   
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AECOM

Endorsed by:   
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## A. Introduction

Further to the incident of fan blades of tunnel ventilation fans (TVF) Nos. MVB-TVF-009 and MVB-TVF-010, Highways Department (HyD) engaged an independent specialist Dr. Lim to carry out investigation of the remaining 31 nos. of TVFs for the Central – Wan Chai Bypass (CWB) Tunnel. After inspection of the fan blades and review of gamma ray test results, where the possible causes may be related to the quality of the fan blade material, Dr. Lim recommended, for the sake of safety, to temporarily suspend the operation of Fan Nos. WVB-TVF-004 and WVB-TVF-005 and associated Air Purification System (APS) No. WVB-APS-001 located in West Ventilation Building (WVB), as well as Fan Nos. MVB-TVF-012 and MVB-TVF-013 and associated APS No. MVB-APS-004 located in Middle Ventilation Building (MVB), which took place on 14 and 16 July 2020 respectively. Please refer to Appendix 1 for schematic Diagram of Tunnel Ventilation System (TVS) and APSs.

Condition 2.9 of the Environmental Permit (EP) No. EP-482/2013/C sets out the requirements for the monitoring of the performance of APSs after the commencement of the operation of the CWB. An Air Quality Monitoring Plan (AQMP) as required in Condition 2.9 of EP No. EP-482/2013/A was approved by the Director of Environmental Protection on 17 January 2019 (See EPD website link: <https://www.epd.gov.hk/eia/register/english/permit/vep5112016/documents/aqmp/pdf/aqmp.pdf>). In the AQMP, there is a provision of Contingency Plan (Clause 3.2) which caters for emergency situations, such as an accidental breakdown of individual component causing malfunction of the TVF and APSs. The current situation has been handled in accordance with the procedures of the Contingency Plan. Please refer to the flowchart (in Appendix 2) which summarizes such procedures.

Regarding the incidents on 14 and 16 July 2020, HyD submits to the DEP this investigation report providing the chronology of events of temporary suspension of operation of Fan Nos. WVB-TVF-004, WVB-TVF-005, MVB-TVF-012 and MVB-TVF-013, comprehensive review on the reason of suspension of the fans operation, action plan / mitigation measures, proposal on monitoring and assessment of air quality impact at West Portal and Slip Road 1 (SR1) and in-tunnel air quality monitoring.

**B. Chronology of events of temporary suspension of operation of TVF Nos. WVB-TVF-004, WVB-TVF-005, MVB-TVF-012 and MVB-TVF-013**

**Parties Involved**

Highways Department (HyD)	The Permit Holder of EP-482/2013/C and the Employer of HyD Contract No. HY/2011/08
AECOM (Resident Site Staff (RSS), The Engineer)	The Consultant of HyD for the CWB project
Chun Wo Tunnel Management Ltd	The Management, Operation and maintenance contractor (MOm) – Operator of the CWB tunnel
LAM Geotechnics Ltd.	Environmental Team (ET) under Environmental Permit No. EP-482/2013/C
Ramboll Hong Kong Ltd.	Independent Environmental Checker (IEC) under Environmental Permit No. EP-482/2013/C
Leighton Joint Venture (LJV)	The Contractor for Contract No. HY/2011/08 which includes the APS and TVS
Zitron	The manufacturer and supplier for the TVFs and a Sub-contractor of LJV
Transport Department/Tunnels and Tsing Ma Section (TD/TTMS)	Management of CWB Tunnel
Electrical and Mechanical Services Department/Government Management Team (EMSD(GMT))	E & M Advisor to TD/TTMS
Ir Dr. Eric C. H. Lim (Dr. Lim)	Consultant, Safety, Accident, and Failure Experts Ltd., independent investigation specialist engaged by HyD

Dr. Zhi Ning (Prof. Ning)	Associate Professor, Division of Environment and Sustainability, Hong Kong University of Science and Technology, team leader for additional air quality monitoring
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## Chronology

<u>Date</u>	<u>Site Activities</u>	<u>Communications and Meeting Events</u>
10 July 2020 (Fri)	HyD specialist Dr. Lim performed gamma ray test on Fan Nos. WVB-TVF-004 and WVB-TVF-005 during the maintenance period from 1am to 6am.	
14 July 2020 (Tue)	HyD specialist Dr. Lim performed gamma ray test on Fan Nos. MVB-TVF-012 and MVB-TVF-013 during the maintenance period from 1am to 6am.	
14 July 2020 (Tue)		Following Dr. Lim's recommendation and the request by RSS, Fan Nos. WVB-TVF-004 and WVB-TVF-005 were manually switched off for further investigation. MOm notified EPD, HyD, TD, EMSD, ET, IEC and RSS regarding the temporary suspension of operation the TVFs by email at 11:39am.
16 July 2020 (Thu)		Following Dr. Lim's recommendation and the request by RSS, Fan Nos. MVB-TVF-012 and MVB-TVF-013 were manually switched off for further investigation. MOm notified EPD, HyD, TD, EMSD, ET, IEC and RSS regarding the temporary suspension of operation the TVFs by email at 11:14am.
16 July 2020 (Thu)		RSS furnished ET and IEC by email at 1:34pm with an update of temporary



		suspension of Fan Nos. WVB-TVF-004 and WVB-TVF-005.
16 July 2020 (Thu)		ET informed HyD and IEC noting the Change of Circumstances of Environmental Permit EP-482/2013/C Conditions 2.6(a) and (d) on the Operation of TVS in WVB of CWB Tunnel, as a result of the temporary suspension of Fan Nos. WVB-TVF-004 and WVB-TVF-005.
16 July 2020 (Thu)		IEC issued a letter to EPD notifying the Change of Circumstances for Condition 2.6(a) and (d) of Environmental Permit EP-482/2013/C, as a result of the temporary suspension of Fan Nos. WVB-TVF-004 and WVB-TVF-005.
17 July 2020 (Fri)		RSS furnished ET and IEC by email at 11:01am with an update of temporary suspension of Fan Nos. MVB-TVF-012 and MVB-TVF-013.
17 July 2020 (Fri)		ET informed HyD and IEC noting the Change of Circumstances of Environmental Permit EP-482/2013/C on the Operation of MVB and Zero Portal Emission at SR1 of CWB Tunnel, as a result of the temporary suspension of Fan Nos. MVB-TVF-012 and MVB-TVF-013.
17 July 2020 (Fri)		IEC issued a letter to EPD notifying the Change of Circumstances for Condition 2.6 of Environmental Permit EP-482/2013/C and the Recommendations of the

		Approved EIA Report on Zero Portal Emission, as a result of the temporary suspension of Fan Nos. MVB-TVF-012 and MVB-TVF-013.
20 July 2020 (Mon)		EPD, HyD, RSS, ET, IEC had a video conference to discuss about the temporary suspension of Fan Nos. WVB-TVF-004, WVB-TVF-005, MVB-TVF-012 and MVB-TVF-013, current status of APS/TVF at CWB, fan blade investigation/inspection results, potential air quality monitoring plan at West Portal and SR1, tentative resumption schedule for the ventilation fans, and air path review works in MVB.
22 July 2020 (Wed)	Dr. Lim performed X-ray test on the fan blades of Fan Nos. WVB-TVF-004 and WVB-TVF-005 and X-ray test results revealed that the condition of the fan blades was acceptable for operation without any repairing or replacement works.	
23 July 2020 (Thu)	LJV reinstalled the fan blades of Fan Nos. WVB-TVF-004 and WVB-TVF-005 and both TVFs and the associated APS No WVB-APS-001 resumed to normal operation at 2:09pm.	
24 July 2020 (Fri)		EPD, HyD, RSS, ET, IEC had a video conference to further discuss about the main causes of the problems, short term and longer terms measures to address the problems, air quality

		monitoring inside the tunnel and at nearby sensitive receivers, and remedial action/emergency response plan in case of exceedance of air quality requirements.
27 July 2020 (Mon)		Based on Dr. Lim's request by email at 6:18pm, it was suggested to suspend the operation of Fan Nos. WVB-TVF-004 and WVB-TVF-005 for further investigation.
28 July 2020 (Tue)		Following the request by RSS, Fan Nos. WVB-TVF-004 and WVB-TVF-005 were manually switched off at 9:00am for further investigation. MOm notified EPD, HyD, TD, EMSD, ET, IEC and RSS regarding the temporary suspension of operation the TVFs by email at 9:18am.
28 July 2020 (Tue)		ET notified IEC the status update regarding temporary suspension of Fan Nos. WVB-TVF-004 and WVB-TVF-005 by email at 1:05pm. IEC subsequently notified EPD the status update regarding temporary suspension of Fan Nos. WVB-TVF-004 and WVB-TVF-005 by email at 5:09pm.
30 August 2020 (Sun)	LJV completed the installation of the new impeller blade sets for Fan Nos. WVB-TVF-004 and WVB-TVF-005 and both TVFs and the associated APS No. WVB-APS-001 resumed operation at 4:30pm.	
11 September 2020 (Fri)	LJV completed the installation of spare fan blades and fan balancing	

	for Fan Nos. MVB-TVF-012 and MVB-TVF-013 and both TVFs and the associated APS No. MVB-APS-004 resumed operation at 8:33am.	
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## **C. Comprehensive review on the reason of temporary suspension of operation of TVFs**

### **i. Examination Methodologies**

After the incident of fan blades for Fan Nos. MVB-TVF-009 and MVB-TVF-010, HyD engaged an independent specialist Dr. Lim to carry out investigation of the condition of other TVFs at the three ventilation buildings of the CWB Tunnel. To facilitate investigation, gamma ray test, visual inspection and X-ray test had been used for the checking of the condition of fan blades. Investigations began with gamma ray test, of which required simpler set-up while providing a quick overview of the issue of the fan blades. After narrowing down the possible issues, visual inspection was conducted for the surface examination of fan blades, while X-ray test was further conducted for specific fan blades for more in-depth internal examination owing to its ability to provide sharper images.

### **ii. WVB-TVF-004 and WVB-TVF-005**

The checking on Fan Nos. WVB-TVF-004 and WVB-TVF-005 commenced on 10 July 2020. On 14 July 2020, based on the checking result, Dr. Lim suggested the temporary suspension of operation of Fan Nos. WVB-TVF-004 and WVB-TVF-005 for sake of safety and carrying out further checking by X-ray test to ensure the condition of the fan blades.

Then, Dr. Lim performed X-ray test on the fan blades of Fan Nos. WVB-TVF-004 and WVB-TVF-005 on 22 July 2020. X-ray test results revealed that the condition of the fan blades was acceptable for operation without any repairing or replacement works. As such, the blades of Fan Nos. WVB-TVF-004 and WVB-TVF-005 were re-installed back to the TVFs and both TVFs resumed to operation on 23 July 2020.

On 27 July 2020, Dr. Lim recommended to re-suspend the operation of the two fans for more detailed study of the X-ray test. Fan Nos. WVB-TVF-004 and WVB-TVF-005 were re-suspended of operation in the morning of 28 July 2020. The operation of fan Nos. WVB-TVF-004 and WVB-TVF-005 was resumed on 30 August 2020.

### **iii. MVB-TVF-012 and MVB-TVF-013**

For Fan Nos. MVB-TVF-012 and MVB-TVF-013, upon the completion of gamma ray test on 14 July 2020, Dr. Lim advised that further examinations of the fan blades were necessary.

Firstly, Dr. Lim performed visual inspection on the TVFs on 16 July 2020 and advised that holes and surface pores were found on blade surfaces, while holes were found on the transition areas of at least 2 blades of Fan No. MVB-TVF-012 and 1 blade of Fan No. MVB-TVF-013. Very light stress marks were also observed on Fan No. MVB-TVF-012. For safety reason, Dr. Lim suggested the temporary suspension of operation of both TVFs on 16 July 2020.

Then, Dr. Lim performed X-ray test on selected fan blades, i.e. MVB-TVF-012 Blade 15 and MVB-TVF-013 Blade 13, on 21 July 2020. X-ray test results revealed that both blades exhibited signs of pores on surface, with significant amount of pores found at transition zone of MVB-TVF-012 Blade 15. Surface pores were also found on the mounting plates of MVB-TVF-013 Blade 13. Signs of stress marks over the transition zones and signs of coalescence of internal pores were found on both blades. From the observations, Dr. Lim considered that the operation of both TVFs should be further suspended for safety reason.

The investigation works by gamma ray test, visual inspection and X-ray test for these two fans were completed. Based on Dr. Lim's advice, the fan blade for these two fans should be replaced. The operation of fan Nos. MVB-TVF-012 and MVB-TVF-013 was resumed on 11 September 2020.

## **D. Action plan / mitigation measures**

### **i. Independent investigation by HyD specialist**

Further to the incident of fan blades of Fan Nos. MVB-TVF-009 and MVB-TVF-010, HyD engaged Dr. Lim to carry out investigation of the condition of all the remaining TVFs for the CWB Tunnel.

### **ii. Resumption of operation of Fan Nos. WVB-TVF-004 and 005**

Upon re-examination of X-ray films produced by Zitron and the examination results that Dr. Lim produced, Dr. Lim recommended to re-suspend the operation of Fan Nos. WVB-TVF-004 and WVB-TVF-005. As such, the downtime of Fan Nos. WVB-TVF-004 and WVB-TVF-005 would be prolonged.

To resume the operation of Fan Nos. WVB-TVF-004 and WVB-TVF-005 and associated APS No. WVB-APS-001, new impeller blade sets were ordered by LJV from Zitron for replacement. The replacement works of the new impeller blade sets was completed, thus the operation of the TVFs and APS resumed, on 30 August 2020.

### iii. Resumption of operation of Fan Nos. MVB-TVF-012 and 013

Upon the results of X-ray test on 21 July 2020, Dr. Lim recommended to replace the fan blades with questionable quality for Fan Nos. MVB-TVF-012 and MVB-TVF-013. As such, the downtime of Fan Nos. MVB-TVF-012 and MVB-TVF-013 would be prolonged.

After reviewed by LJV, LJV advised that the option of extracting tunnel air for SR1 and in tunnel in parallel through APS Nos. MVB-APS-003 and MVB-APS-004 by using TVF No. MVB-TVF-011 would cause the fan running close to stall region and it was not recommended to pursue this option.

To resume the operation of Fan Nos. MVB-TVF-012, MVB-TVF-013 and associated APS No. MVB-APS-004, it was proposed to use the spare fan blades for replacement. The replacement works of the spare fan blades were completed by qualified technician appointed by Zitron on 11 September 2020, thus the operation of the TVFs and APS resumed on the same day.

## E. Proposal on monitoring of air quality impact

### i. Background for additional air quality monitoring

The status of the affected APS is as below:

<u>APS No.</u>	<u>Time of Suspension</u>	<u>Time of Resumption</u>
WVB-APS-001	14 July 2020 11:22am	23 July 2020 2:00pm
	28 July 2020 9:00am	30 August 2020 4:30pm
MVB-APS-004	16 July 2020 11:14am	11 September 2020 8:33am

The downtime of Fan Nos. MVB-TVF-012 and MVB-TVF-013 and associated APS No. MVB-APS-004 would be prolonged and zero portal emission at SR1 would be affected. In this connection, an additional air quality monitoring at SR1 Portal would be required.

Due to the re-suspension of Fan Nos. WVB-TVF-004 and WVB-TVF-005, the downtime of these two fans and their associated APS No. WVB-APS-001 would be prolonged. In this connection, an additional air quality monitoring at West Portal and the air sensitive receiver (ASR) on eastern side of 3/F podium of IFC, respectively, would be required.

## ii. Additional air quality monitoring plan

HyD immediately engaged Prof. Ning of HKUST and his team (Monitoring Team) to temporarily install air monitoring stations at West Portal and SR1 Portal to closely monitor the air quality ( $\text{NO}_x$  and  $\text{PM}_{10}$ ) in the surrounding areas. The monitoring work consists of the following tasks:

### a. Task 1 – Provision and calibration of mini air stations

The Monitoring Team would use Mini Air Station (MAS) Model MAS-AF300, which had a strong track record in documented data quality performance and local project experience including the demonstration measurement studies conducted in various government projects, for the additional air quality monitoring. The Mini Air Station Model MAS-AF300 could be both mounted on walls and portable deployment for flexible arrangement of the air quality measurements.  $\text{PM}_{10}$ ,  $\text{NO}$  and  $\text{NO}_2$  would be monitored with the highest time resolution at 1-minute to capture the impact of traffic density on emission pollutants inside the tunnel. The wind speed and wind direction were also measured concurrently by MAS-AF300 system.

To facilitate the fast monitoring status checking and data verification, the air stations would provide wireless data transmission capabilities via 4G network with cloud-based data platform for data storage and visualization and SD card for raw data storage.

The high-performance sensor system MAS-AF300 employed dual sensor principle to track gas measurement baseline and eliminate interference impact from temperature and humidity. The pre-installation calibration followed standard reference analyzer calibration process with zero and multiple point span check for the sensor response linearity and sensitivity. The  $\text{PM}_{10}$  measurement was based on the forward light scattering photometer with linear response to the PM mass concentration. The multiple calibrations were conducted in factor manufacturer facility and the operational calibration procedure was conducted with the side by side local collocation to the HKEPD AQMS prior to the sensor deployment for calibration.

The routine data quality control and assurance was conducted on weekly basis with two tier operation with consideration of difficulties in field operation inside the tunnel and desired minimum interruption of the operation time.

Tier 1 – Remote data quality check and quality assurance:

The air quality monitor operation status including flow rate, raw output range, internal signal voltage, temperature and humidity



control point, was checked on weekly basis to ensure the operation status falling into manufacturer's guideline and the project team's scientific judgment.

Tier 2 – On-site data quality check and quality control:

In case the sensor output from the air quality meter is observed out of range during routine Tier 1 process, ad-hoc maintenance request would be raised by the project team for immediate site visit the soonest possible. Manual zero and span check would be conducted for the air quality monitor. Collocation with transfer standard would also be conducted if deemed necessary by the project team.

b. Task 2 – Measurements and maintenance of air monitoring equipment

A monitoring station were be installed at the SR1 Portal (Site A), West Portal (Site B) and ASR on the eastern side of 3/F podium of IFC (Site C). Please see the Appendix 3 for the layout plan.

The measurement parameters for the individual sites are listed below:

<u>Site</u>	<u>Description</u>	<u>Measurement parameters</u>
Site A	SR1 Portal	NO, NO <sub>2</sub> and PM <sub>10</sub> , wind speed* and wind direction*
Site B	West Portal	NO, NO <sub>2</sub> and PM <sub>10</sub>
Site C	ASR on eastern side of 3/F podium of IFC	NO, NO <sub>2</sub> and PM <sub>10</sub>

\*Wind speed and wind direction collected at Site A would serve to evaluate the air quality monitoring results in case high pollution levels are recorded. It might not warrant other assessment purposes with constraints of installation site and obstacles of nearby structure.

Site A was located close to ASR A34 (Hong Kong Convention and Exhibition Centre extension) in the EIA. It was considered that the data from the air monitoring station at the SR1 Portal could represent the air quality at A34, and at the same time it could be used for monitoring the status of air quality impact with respect to portal emission. Please note that SR1 Portal representation of ASR A34 is case specific and only limited to the impact of air quality with respect to exit from SR1 Portal. In this connection, the monitoring results would be checked against the Hong Kong Air Quality Objectives (AQO) in addition to the in-tunnel air quality standard.

During the monitoring period, the Prof. Ning's Monitoring Team conducted data calibration and validation with quality control and assurance measures following the supplier's instruction and scientific judgment. Works included:

- Multi point standard gas calibration for MAS-AF300 in laboratory;
- Side by side comparison with reference analyzer or transfer standard;
- Air quality measurements; and
- Data quality control and assurance for routine check and validation.

All the QA/QC activities conducted for the measurement exercise were recorded.

c. Task 3 – Data analysis and interpretation

The multiple point air quality monitoring data inside and outside of the tunnel were analyzed in terms of diurnal variations, spatial distributions and pattern of peak occurrence. The wind direction and wind speed would be used as supplementary information to support the data analysis. The data collected at Sites A and B were compared with the relevant pollution concentration limit provided by Practice Note on Control of Air Pollution in Vehicle Tunnels as below:

<u>Pollutant</u>	<u>Averaging time</u>	<u>Concentration limit (<math>\mu\text{g}/\text{m}^3</math>)</u>
Nitrogen dioxide	5-minute	1,800

Apart from the above, data collected from Sites A and C would also refer to AQO as below:

<u>Pollutant</u>	<u>Averaging time</u>	<u>Concentration limit (<math>\mu\text{g}/\text{m}^3</math>)</u>	<u>Number of exceedances allowed per year</u>
Nitrogen dioxide	1-hour	200	18

Respirable suspended particulates (PM <sub>10</sub> )	24-hour	100	9
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Three routine exercise tasks were done in the monitoring period:

- 1) The raw data analysis and quality assurance were conducted internally by the Monitoring Team on daily basis. In addition, comparison would be made between data of MAS and that of EPD's AQMS. Specifically, data obtained from Site B MAS would be compared to data obtained from EPD's roadside AQMS, data obtained from Site C MAS would be compared to data obtained from EPD's ambient AQMS, while data obtained from Site A MAS would be compared to data obtained from both of EPD's roadside and ambient AQMS. In case abnormality of air monitoring conditions is observed, Prof. Ning's Monitoring Team would contact the RSS team for immediate corrective actions.
- 2) Formatted data summary and interpretation report were submitted to HyD twice a week on Tuesdays and Fridays (Monday and Friday in the first week). The report summarized the data from period between the report intervals with further analysis.
- 3) A weekly report summarizing the two reports during the week was submitted to EPD.

A set of preliminary monitoring results taken from 24 July to 13 September 2020 (Site B), 27 July to 24 September 2020 (Site A) and 30 July to 13 September 2020 (Site C), together with data analysis and interpretation, are enclosed in Appendix 4.

In summary,

- 5-minute NO<sub>2</sub> concentrations inside the CWB Tunnel (Site A and B) were below the 5-min concentration limit as required in the Practice Note on Control of Air Pollution in Vehicle Tunnels.
- NO<sub>2</sub> concentration measured at Site A and C was within the HKAQO 1-hour NO<sub>2</sub> concentration limit since the start of air quality monitoring except for four exceedances observed on 2 and 3 September 2020 at Site A and three exceedances on 2 September 2020 at Site C due to recent high pollution episode all across Hong Kong. These NO<sub>2</sub> exceedances were not resulted from the fan

temporary suspension. Moreover, Site A and C had NO<sub>2</sub> levels comparable to general ambient AQMS in Central Western and Eastern.

- PM<sub>10</sub> concentration measured at Site A and C was within the HKAQO 24-hour PM<sub>10</sub> concentration limit since the start of air quality monitoring.

## F. In-tunnel air quality monitoring and action plan to fulfill the limit stipulated in EPD's Practice Note

### i. In-tunnel air quality monitoring

In-tunnel air quality near SR1 Portal was closely monitored until the resumption of TVF/APS operation in MVB.

The in-tunnel air quality results are as below:

<u>Pollutant</u>	<u>Averaging time</u>	<u>Maximum limit as stated in the Practice Note<sup>#</sup></u>	<u>Near SR1 (Eastbound) from 16 to 24 September 2020</u>
CO	5-min	<100ppm	39.1816ppm to 52.8838ppm
NO <sub>2</sub>	5-min	<1ppm	0.0028ppm to 0.1222ppm
Visibility	5-min	<0.005 m <sup>-1</sup>	0.00m <sup>-1</sup> to 0.0031m <sup>-1</sup>

In-tunnel air quality near West Portal was closely monitored until the resumption of TVF/APS operation in WVB.

The in-tunnel air quality results are as below:

<u>Pollutant</u>	<u>Averaging time</u>	<u>Maximum limit as stated in the Practice Note<sup>#</sup></u>	<u>Near West Portal (Westbound) from 14 to 13 September 2020</u>
------------------	-----------------------	---	--

CO	5-min	<100ppm	5.6101ppm to 36.8221ppm
NO <sub>2</sub>	5-min	<1ppm	0.0023ppm to 0.5062ppm
Visibility	5-min	<0.005 m <sup>-1</sup>	0.00m <sup>-1</sup> to 0.0007m <sup>-1</sup>

# Practice Note on Control of Air Pollution in Vehicle Tunnels issued by Air Services Group of Environmental Protection Department in November 1995.

Relevant in-tunnel air quality monitoring data were provided to ET and IEC for vetting until the resumption of the concerned TVF and APS.

It was observed from air quality records that the in-tunnel air quality was well below the maximum limits as stated in the Practice Note. Data collected from in-tunnel air quality monitoring sensors (NO<sub>2</sub>) near West Portal and SR1 Portal was supplemented to those from MAS for the study of air quality impacts. Please refer to the graphical representation in Appendix 5.

For the comparison of in-tunnel air quality (CO, NO<sub>2</sub> and Visibility) near West Portal and SR1 Portal one week before and one week after the temporary suspension incidents, please refer to the graphical representation in Appendix 6.

## ii. Action plan in case of exceedance of in-tunnel air quality

The current in-tunnel air quality has been well below limits in EPD's Practice Note on the Control of Air Pollution in Vehicle Tunnels. If the in-tunnel air quality deteriorates to 80% of the limit in EPD's Practice Note, in-tunnel ventilation system would be turned on automatically until the in-tunnel air quality is improved to be lower than 40% of the limit in EPD's Practice Note on the Control of Air Pollution in Vehicle Tunnels.

The in-tunnel air monitoring was conducted continuously to give a 5-min average value. The ventilation fan (Fan No. MVB-TVF-007 for CH1480 – CH2885) would be activated automatically when the in-tunnel air quality reach the action level (80% of the limits) to improve the air quality in Eastbound. In case of exceedance of the in-tunnel air quality standard, the ventilation level would go up automatically (Fan

No. MVB-TVF-008 for CH1480 – CH2885) until the air quality data is below the pre-set value.

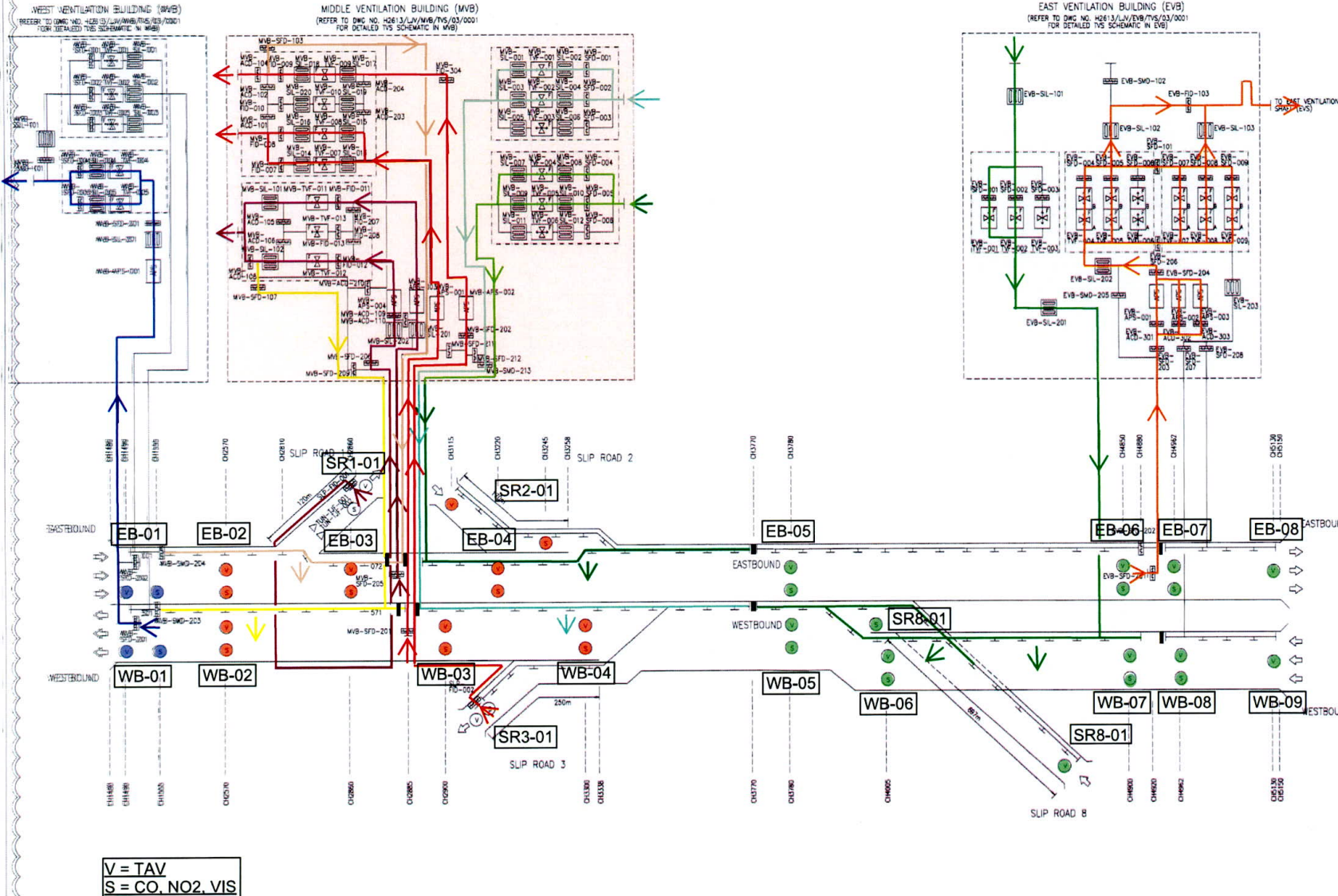
However, in the event of the extreme breakdown incident of the associated Fan Nos. MVB-TVF-007 and MVB-TVF-008 occurred in the future which might cause the action plan stated in the above paragraph not able to be implemented and the unexpected CWB-related exceedance of the in-tunnel air quality standard, the contingency plan stated in the AQMP would be implemented, the option of noticing/alerting the tunnel users of the situation would be considered subject to the discussion with all relevant parties.

### **iii. Action plan in case of exceedance of air quality at the ASR**

Fan Nos. WVB-TVF-004, WVB-TVF-005, MVB-TVF-012 and MVB-TVF-013 and their respective associated APS Nos. WVB-APS-001 and MVB-APS-004 resumed normal operation on 30 August 2020 and 11 September 2020, respectively. The additional air quality monitoring continued for two more weeks and ended on 13 August and 25 September 2020, respectively. So far, no CWB-related exceedance of air quality at the ASR was recorded during these periods of temporary suspension.

In the event of exceedance of HKAQO 1-hour average concentration of NO<sub>2</sub> at Sites A or C, detailed investigation and analysis of air monitoring data, including comparison with EPD's general and roadside air quality monitoring stations if considered appropriate, would be carried out as soon as possible to determine whether the exceedance is CWB-related or not. Real time air quality monitoring data on EPD's website would be obtained for comparison and record, if considered necessary, once the corresponding data is available on EPD's website. If it is CWB-related, the contingency plan at AQMP would be followed.

# Normal Operation (Uni-Directional)



- NOTES:**
- FOR LEGEND, GENERAL NOTES AND ABBREVIATIONS, REFER TO DRAWING NO. H2613/LJW/SW/TVS/01/0001
  - THE TUN-SL-001 TO 004 WILL BE INSTALLED IN FRONT AND BEHIND THE TUN-TF-001 AND TUN-TF-002 RESPECTIVELY.

- LEGEND:**
- BI-DIRECTIONAL TWO STAGE TUNNEL VENTILATION FAN (TVF)
  - UNI-DIRECTIONAL SINGLE STAGE TUNNEL VENTILATION FAN (TVF)
  - BI-DIRECTIONAL SINGLE STAGE TUNNEL VENTILATION FAN (TVF)
  - OHVD Separation Wall

E	REVISED AS PER COMMENT	EC	MAR18
D	REVISED AS PER COMMENT	BC	JAN15
C	REVISED AS PER COMMENT	BC	DEC14
B	REVISED AS PER COMMENT	BC	NOV14
A	REVISED AS PER COMMENT	BC	OCT14
-	FOR APPROVAL	BC	JUL14
REV	DATE	BY	CHK
DATE	DATE	DATE	DATE

Highways Department 路政署  
Major Works Project Management Office

**CENTRAL - WAN CHAI BYPASS AND IEC LINK**  
CENTRAL - WAN CHAI BYPASS  
TUNNEL BUILDING, SYSTEMS AND FITTINGS,  
AND WORKS ASSOCIATED WITH TUNNEL COMMISSIONING

CONSULTANT ENGINEER  
**AECOM**  
AECOM Asia Co. Ltd.

CONTRACTOR  
**LEIGHTON JOINT VENTURE**

DRAWING TITLE  
**TVS OVERALL TVS SCHEMATIC**

DRG NO. 圖號	H2613/LJW/SW/TVS/03/0001	E
DESIGN BY 設計	EC	APPROVED BY 核准
DRAWN BY 繪圖	DeC	DATE 日期
SCALE 比例	N.T.S.	WORKING DRAWING 施工圖
UNITS 單位	METRES	© COPYRIGHT RESERVED 版權所有

**Appendix 2**

Procedure Flowchart of AQMP Contingency Plan

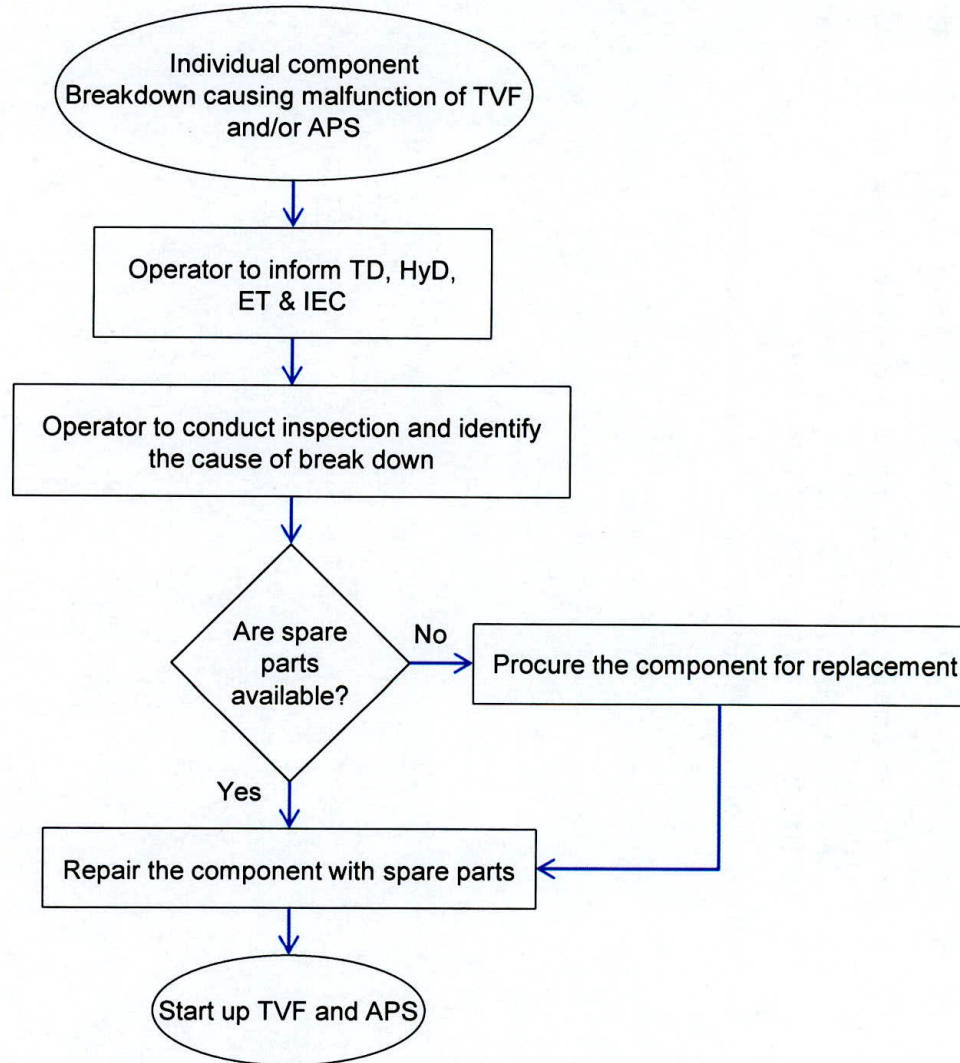


When there is an accidental breakdown of individual component causing malfunction of TVFs and/or APS, the Operator will follow the procedures below to start up TVFs and APS as soon as practicable.

1. Operator to inform TD, HyD, ET and IEC;
2. Operator to conduct inspection and identify the root cause of the breakdown;
3. Operator to check if there is any spare part available for repair;
4. If there are spare parts available, Operator to repair the broke down component with spare parts;
5. If there is no spare part available, Operator to procure the broke down component for replacement;
6. Operator to start up the APS according to the APS Operational Procedures after finishing repair/replace the broke down component.

The emergency flowchart for individual component breakdown is attached below.

# Component Breakdown



### **Appendix 3**

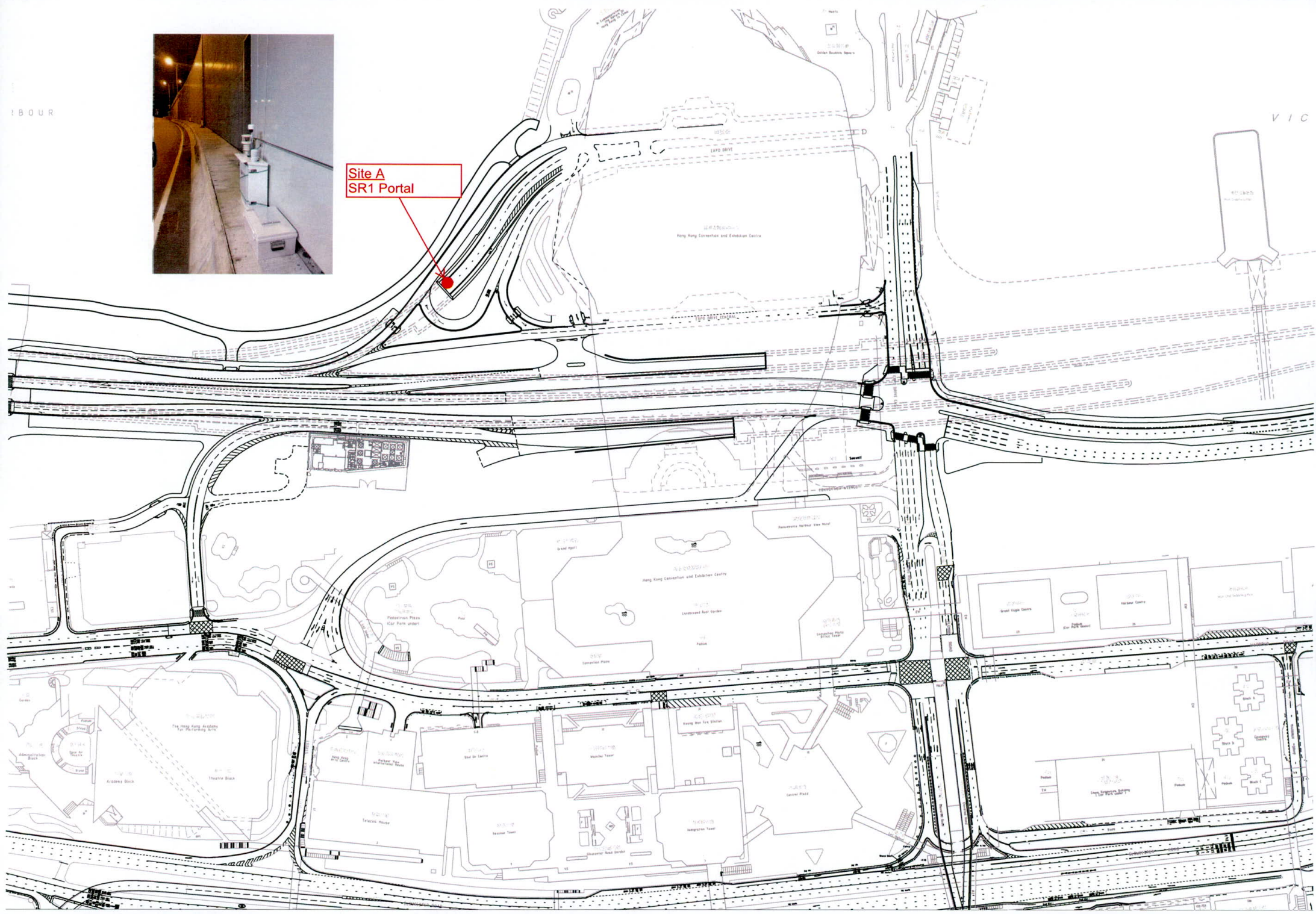
Layout plan of Additional Air Quality Monitoring Stations

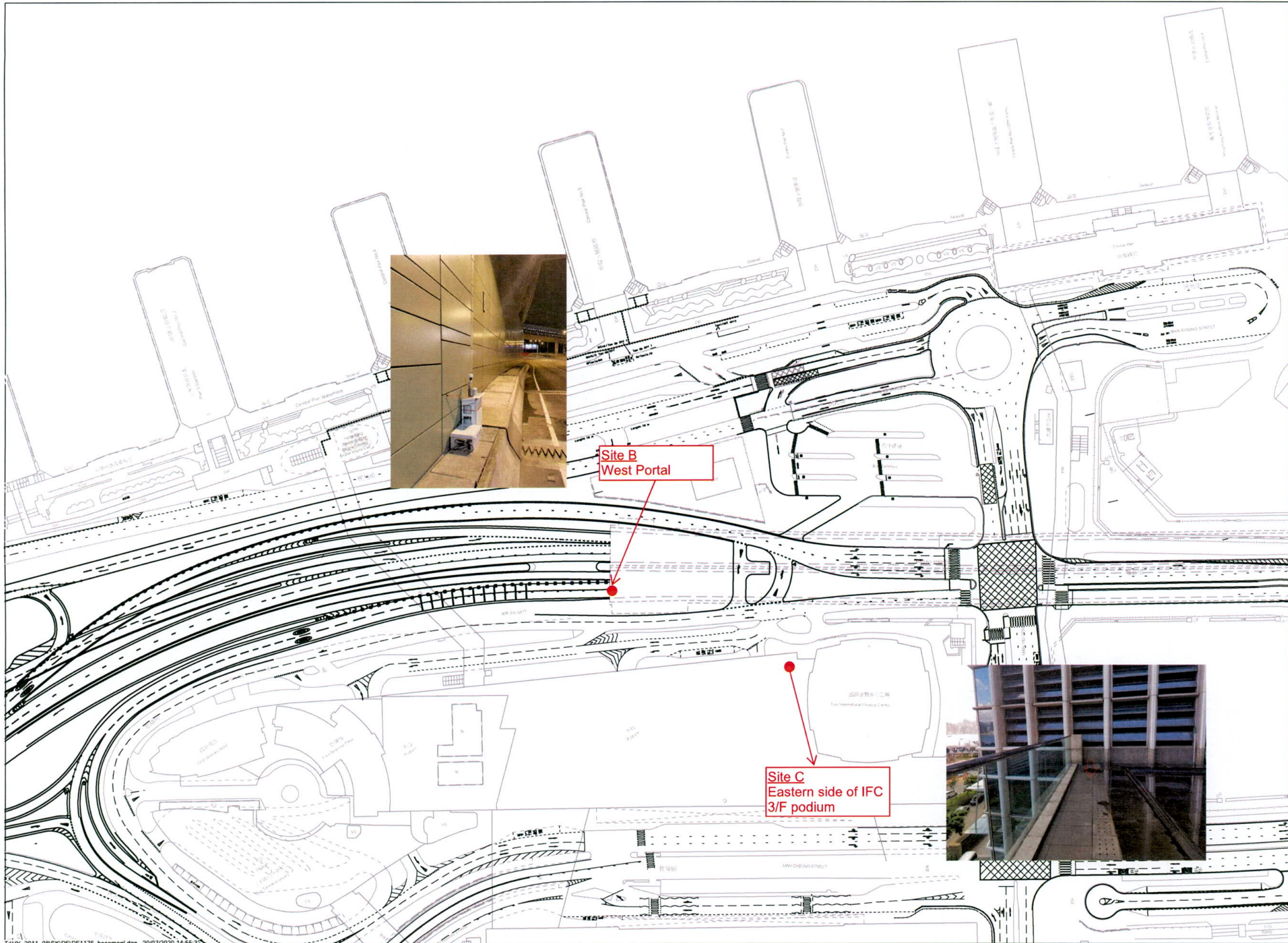


Site A  
SR1 Portal

BOUR

VIC





## **Appendix 4**

Preliminary Monitoring Results, Data Analysis and Interpretation



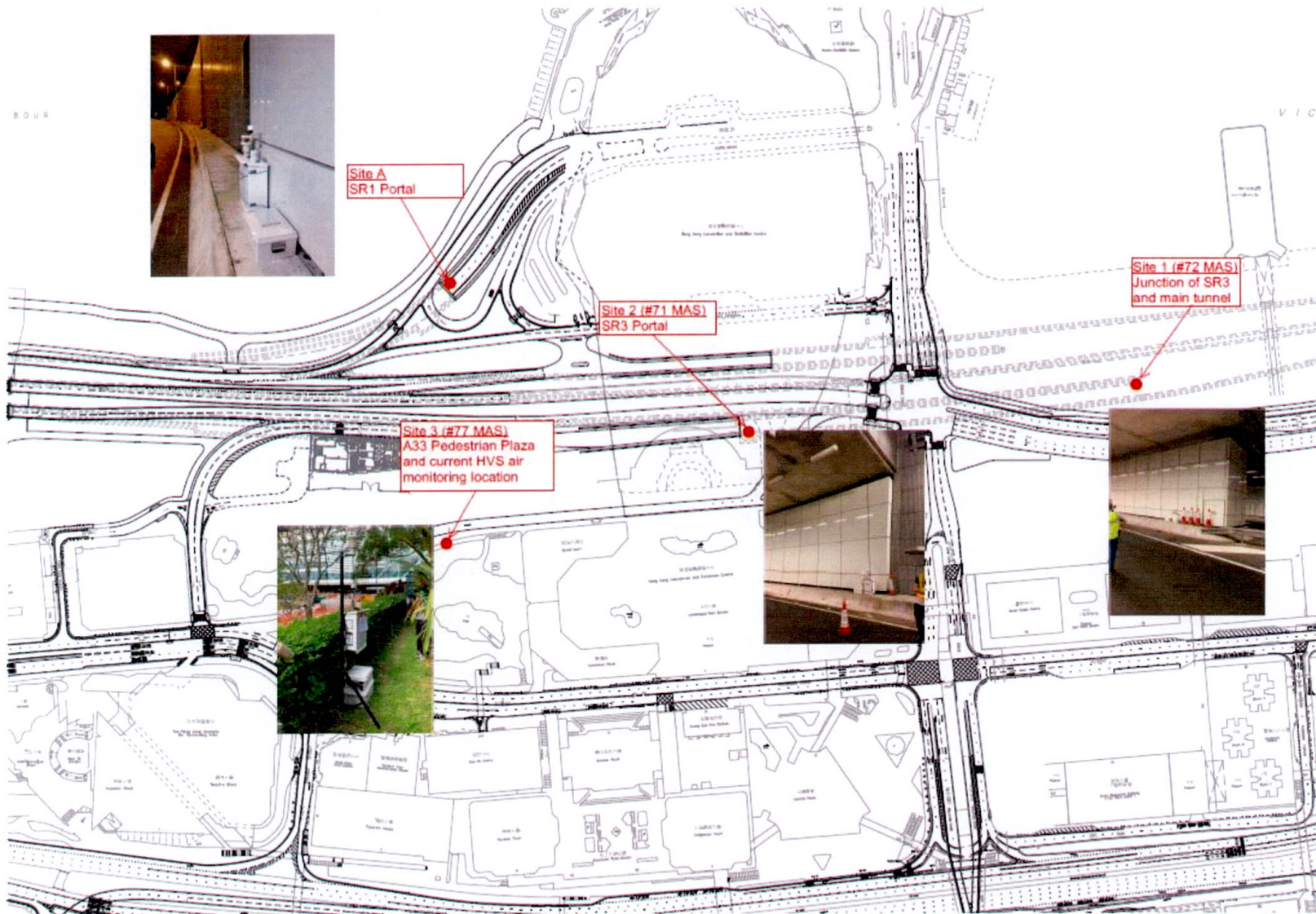
# **Central-Wan Chai Bypass Monitoring West Portal and Slip Road 1 Data Report**

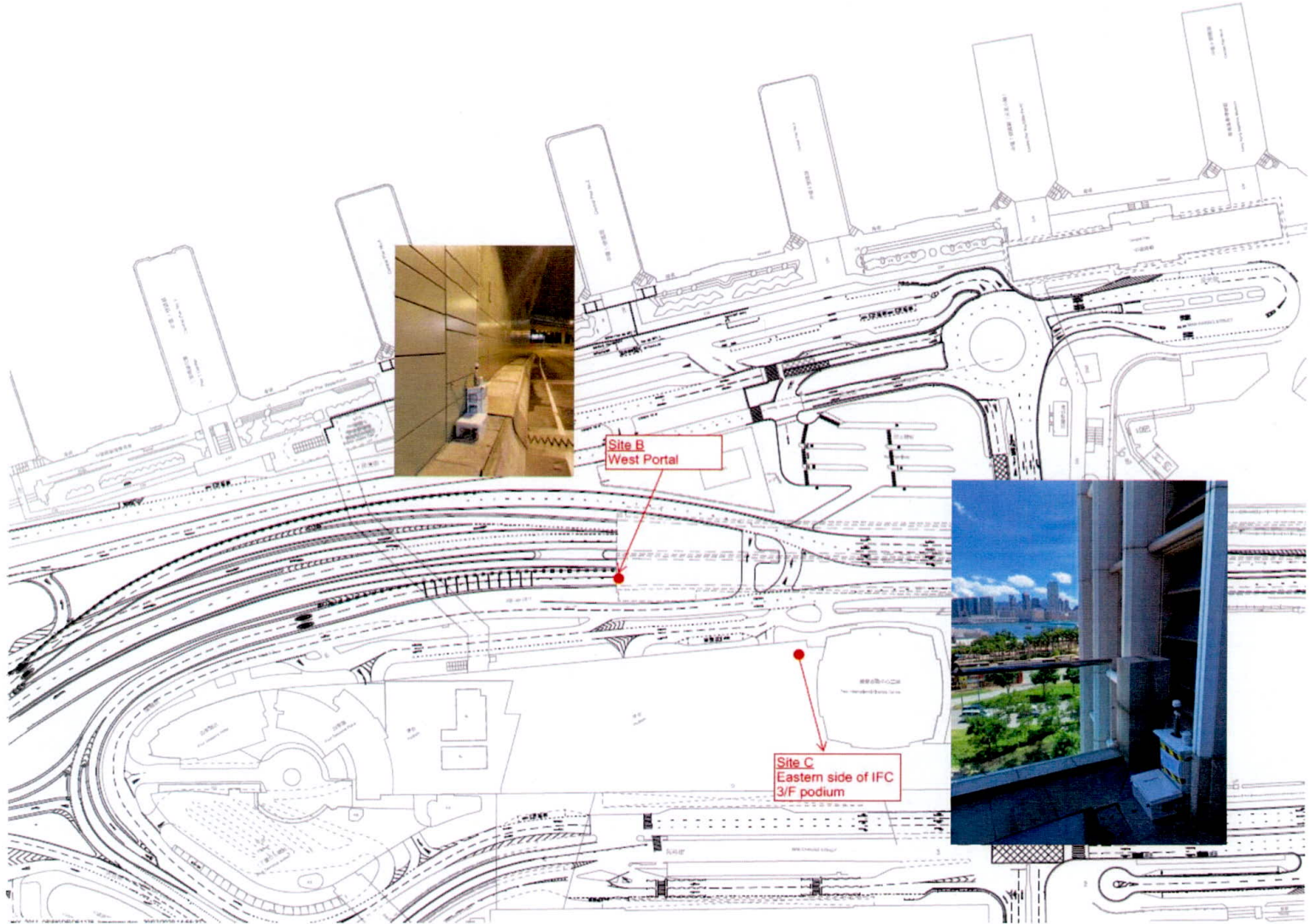
- Update 1. 2020 JULY 27, 13:00 PM
- Update 2. 2020 JULY 31, 15:00 PM
- Update 3. 2020 AUGUST 04, 14:00 PM
- Update 4. 2020 AUGUST 07, 13:00 PM
- Update 5. 2020 AUGUST 11, 13:00 PM
- Update 6. 2020 AUGUST 14, 14:00 PM
- Update 7. 2020 AUGUST 18, 13:00 PM
- Update 8. 2020 AUGUST 21, 13:00 PM
- Update 9. 2020 AUGUST 25, 13:00 PM
- Update 10. 2020 AUGUST 28, 13:00 PM
- Update 11. 2020 SEPTEMBER 01, 14:00 PM
- Update 12. 2020 SEPTEMBER 04, 13:00 PM
- Update 13. 2020 SEPTEMBER 08, 14:00 PM
- Update 14. 2020 SEPTEMBER 11, 13:00 PM
- Update 15. 2020 SEPTEMBER 15, 13:00 PM
- Update 16. 2020 SEPTEMBER 18, 13:00 PM
- Update 17. 2020 SEPTEMBER 22, 13:00 PM
- Update 18. 2020 SEPTEMBER 25, 14:00 PM



# **MINI AIR STATION INSTALLATION AND SETUP**







## Monitoring parameters and schedule

Site	Description	Measurement parameters
Site A	SR1 Portal	NO, NO <sub>2</sub> and PM <sub>10</sub> , wind speed* and wind direction*
Site B	West Portal	NO, NO <sub>2</sub> and PM <sub>10</sub> ** , wind speed*# and wind direction*#
Site C	ASR on the eastern side of 3/F podium of the IFC	NO, NO <sub>2</sub> and PM <sub>10</sub> , wind speed*# and wind direction*#

\*Wind speed and wind direction collected at Site A serve to evaluate the air quality monitoring results in case high pollution levels are recorded. It may not warrant other assessment purposes with constraints of installation site and obstacles of nearby structure.

\*\* Data collection for PM<sub>10</sub> at Site B from 24 - 29 July 2020, and from 6 August 2020 onwards.

# Date collection for wind speed and wind direction at Site C from 6 August 2020 onwards.

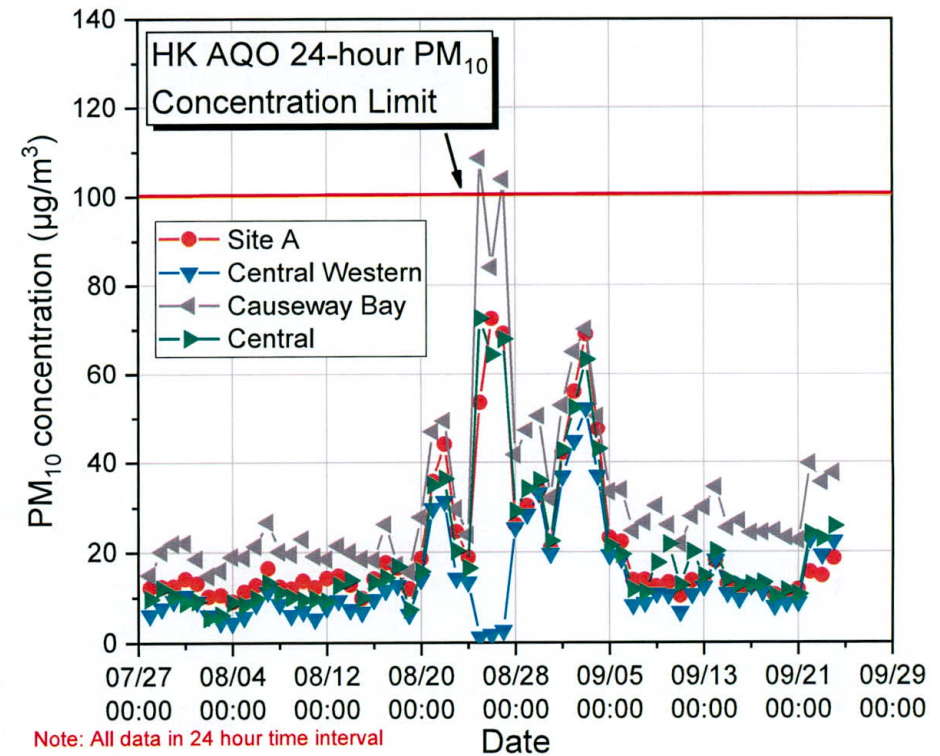
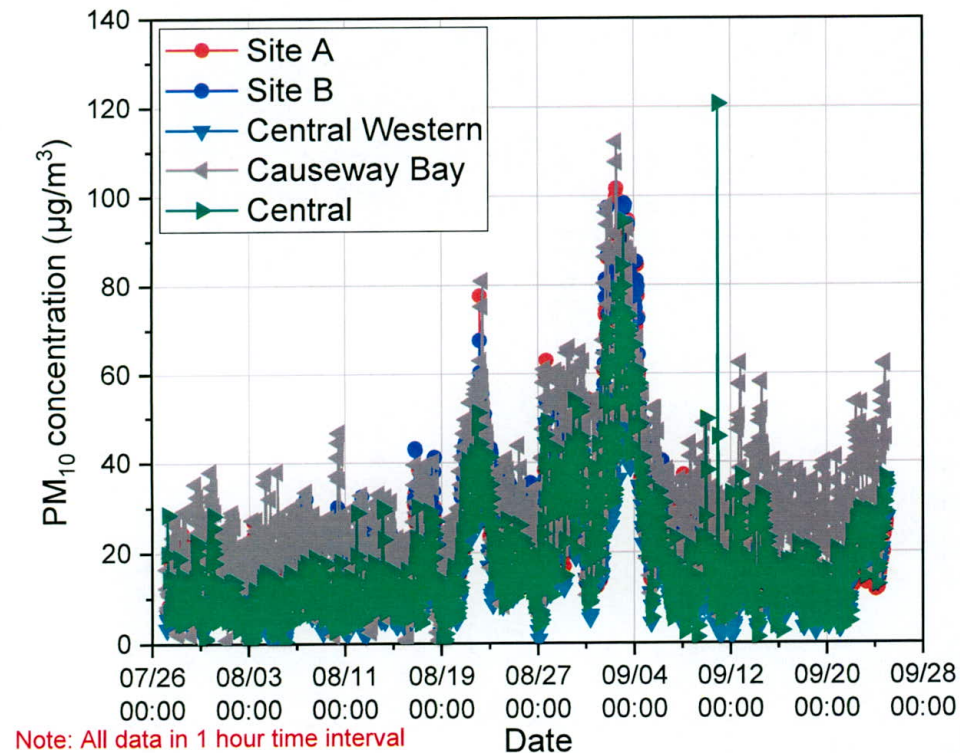
Site visit and installation of MAS at Site B	24/07/2020 01:00-03:00
Site visit and installation of MAS at Site A	27/07/2020 01:00-03:00
Site visit and installation of MAS at Site C	30/07/2020 10:00-18:00
Commencement of air quality monitoring	24/07/2020 for Site B, 27/07/2020 for Site A, 30/07/2020 for Site C



# **AIR QUALITY MONITORING**

# Site A SR1 Portal and Site B West Portal

- **Site A:** 2020/07/27 02:00 - 2020/09/24 23:59
- **Site B (PM<sub>10</sub>):** 2020/08/06 02:00 - 2020/09/13 23:59

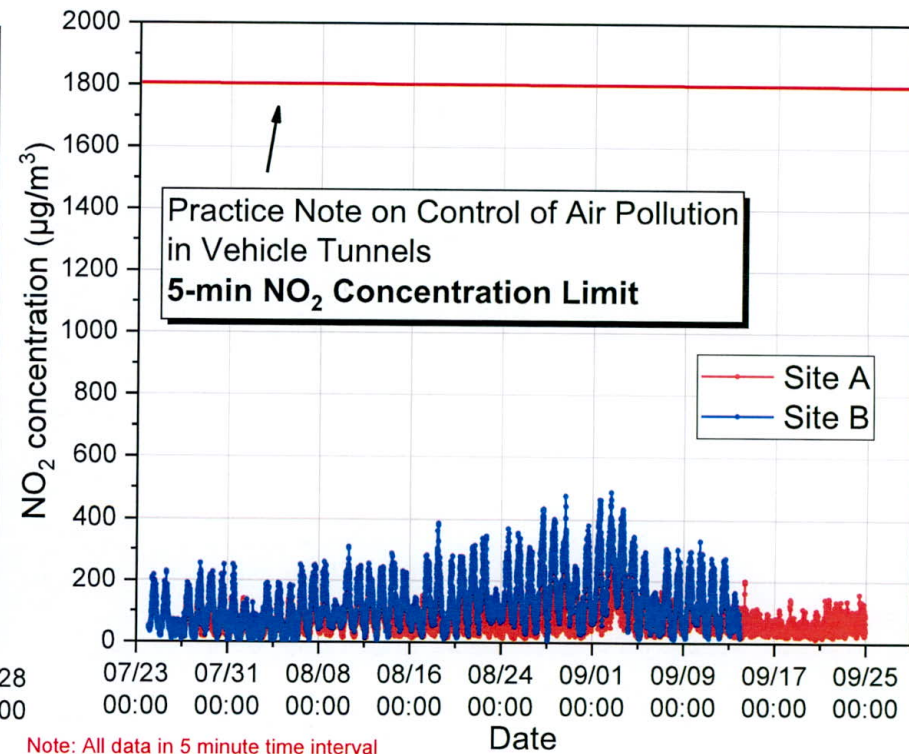
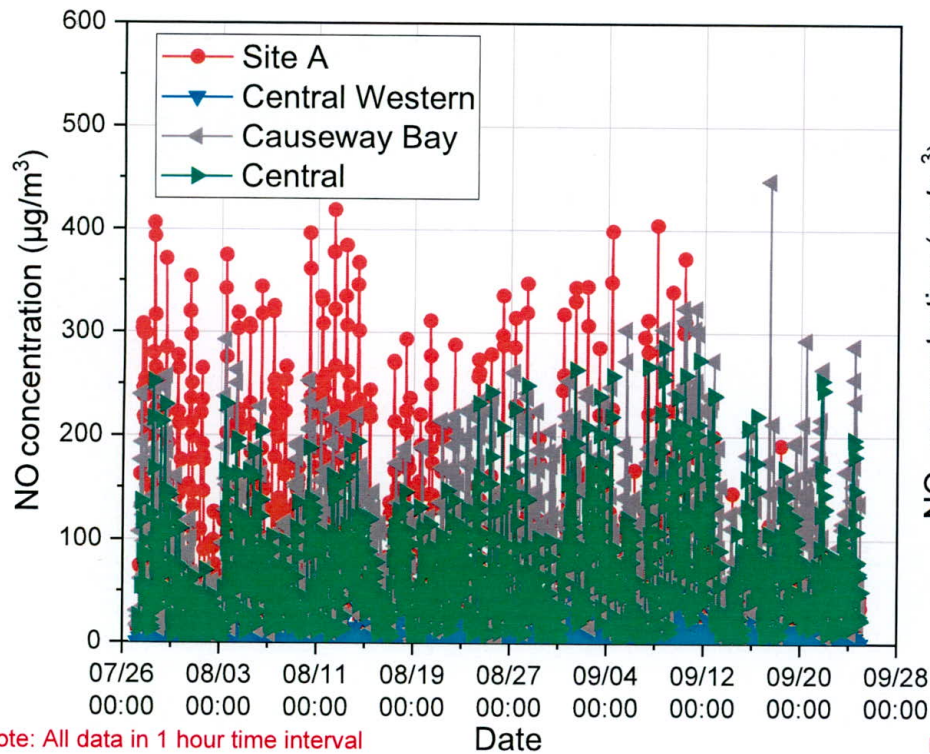


## Site A :

- **24-h average PM<sub>10</sub> concentration is below the 24-hour PM<sub>10</sub> concentration limit in HKAQO.**

# Site A SR1 Portal and Site B West Portal

- **Site A:** 2020/07/27 02:00 - 2020/09/24 23:59
- **Site B:** 2020/07/27 02:00 - 2020/09/13 23:59

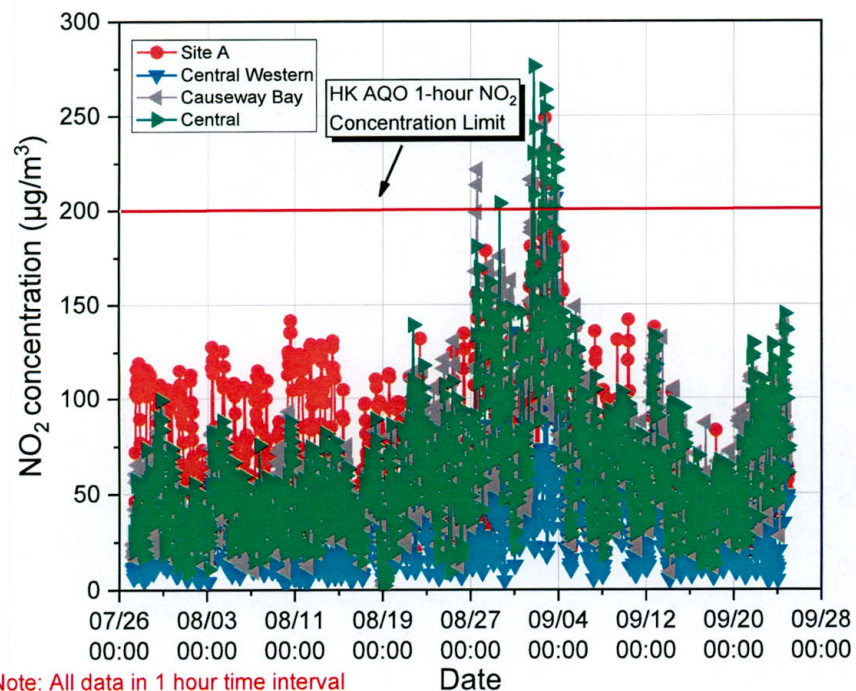


## Site A and B:

- **5-min average NO<sub>2</sub> concentration is below the 5-min concentration limit in the Practice Note on Control of Air Pollution in Vehicle Tunnels.**

# Site A SR1 Portal and Site B West Portal

- Site A: 2020/07/27 02:00 - 2020/09/24 23:59



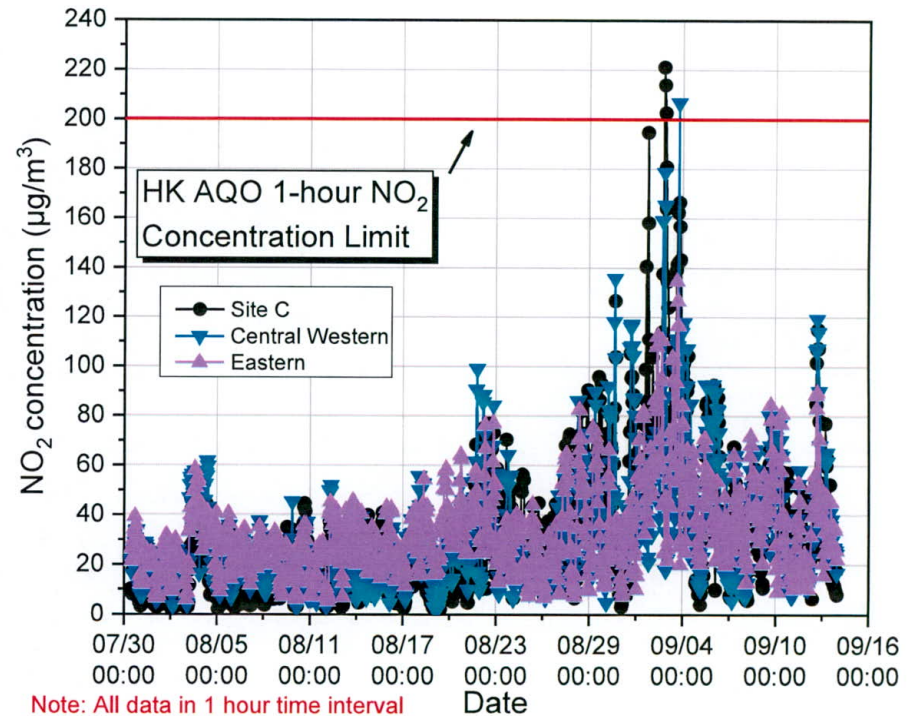
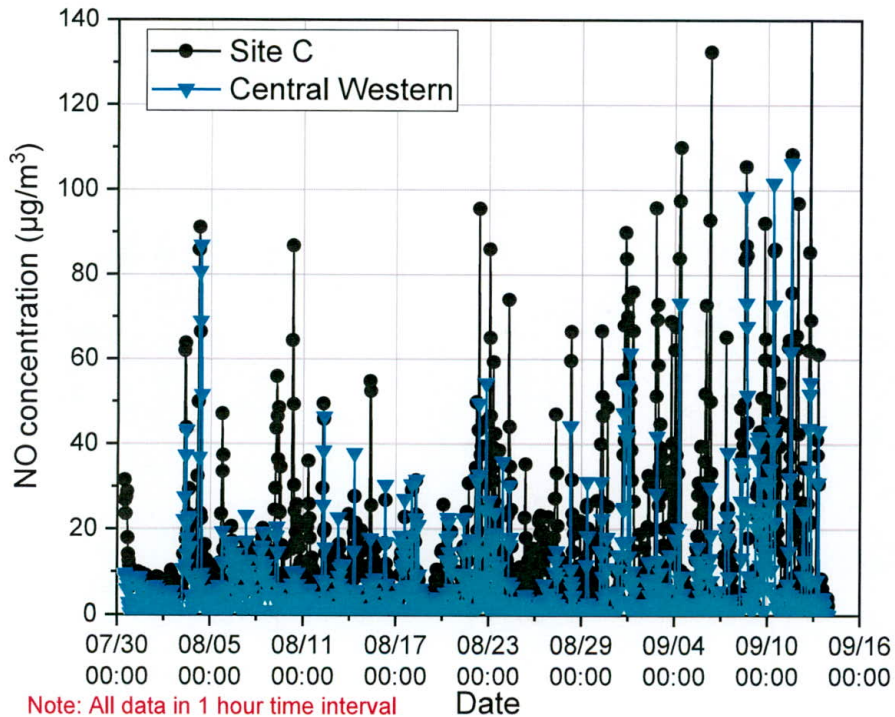
## Site A:

- Most of hourly NO<sub>2</sub> concentration is below the 1-hour NO<sub>2</sub> concentration limit in HKAQO. Four exceedances were observed due to the recent high pollution episode all across Hong Kong.

No. of NO <sub>2</sub> exceedances	Date	Time	Concentration (µg/m <sup>3</sup> )
1	2020/09/02	19:00	248.7
2	2020/09/02	20:00	213.5
3	2020/09/02	21:00	200.8
4	2020/09/03	16:00	231.6

# Site C ASR

■ Site C: 2020/07/30 11:00 - 2020/09/13 23:59



## Site C:

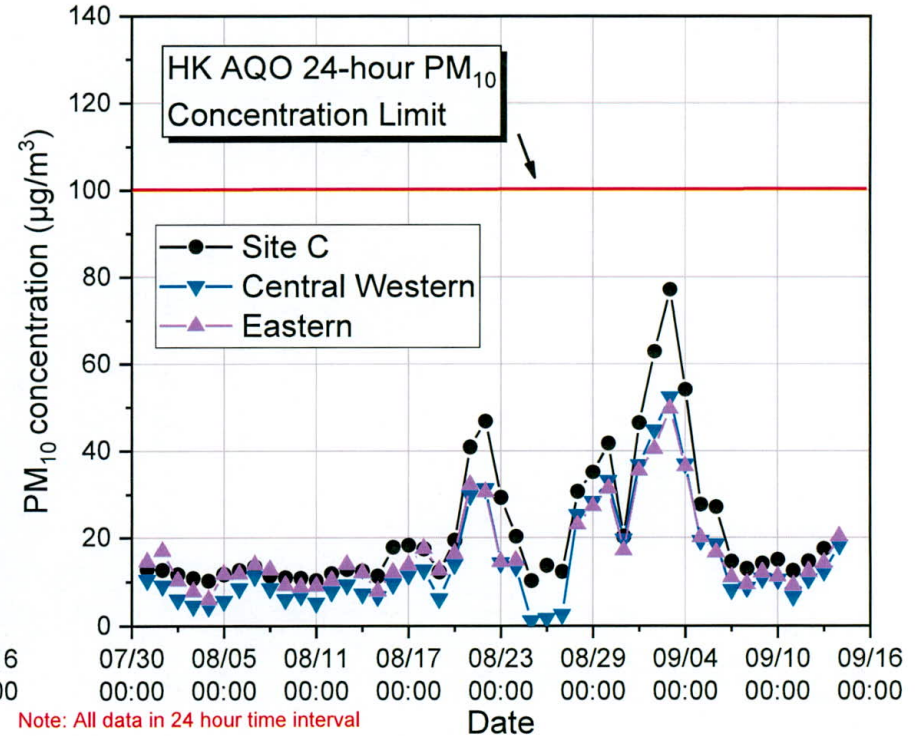
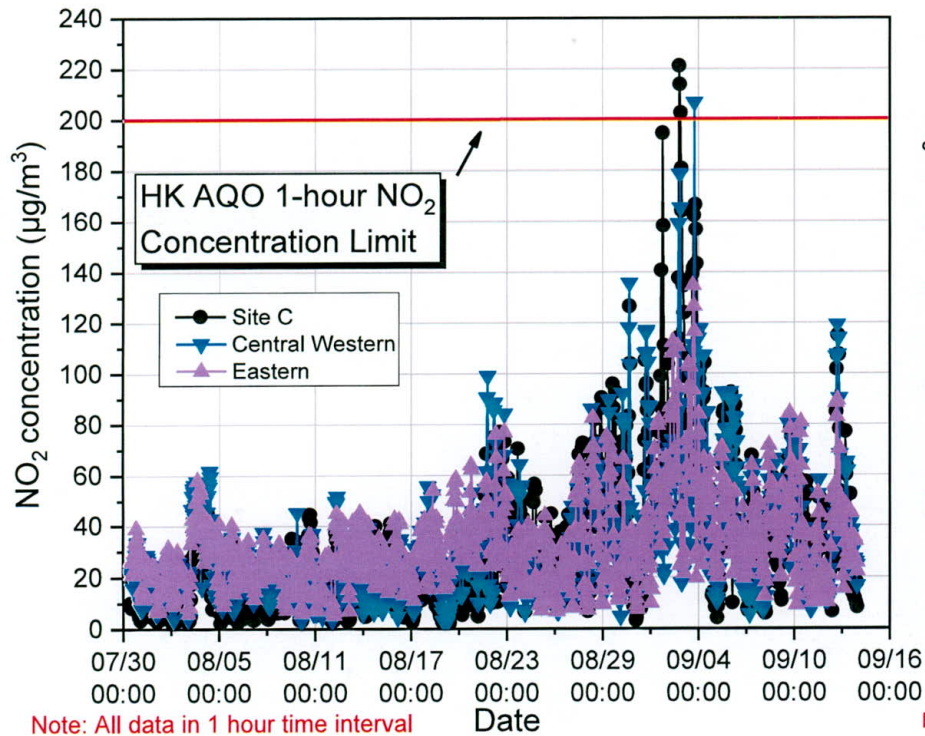
- Most of hourly  $\text{NO}_2$  concentration is below the 1-hour  $\text{NO}_2$  concentration limit in HKAQO. Three exceedances were observed due to the recent high pollution episode all across Hong Kong.

No. of $\text{NO}_2$ exceedances	Date	Time	Concentration ( $\mu\text{g}/\text{m}^3$ )
1	2020/09/02	19:00	221.1
2	2020/09/02	20:00	213.9
3	2020/09/02	21:00	202.7



# Site C ASR

## Site C: 2020/07/30 11:00 - 2020/09/13 23:59

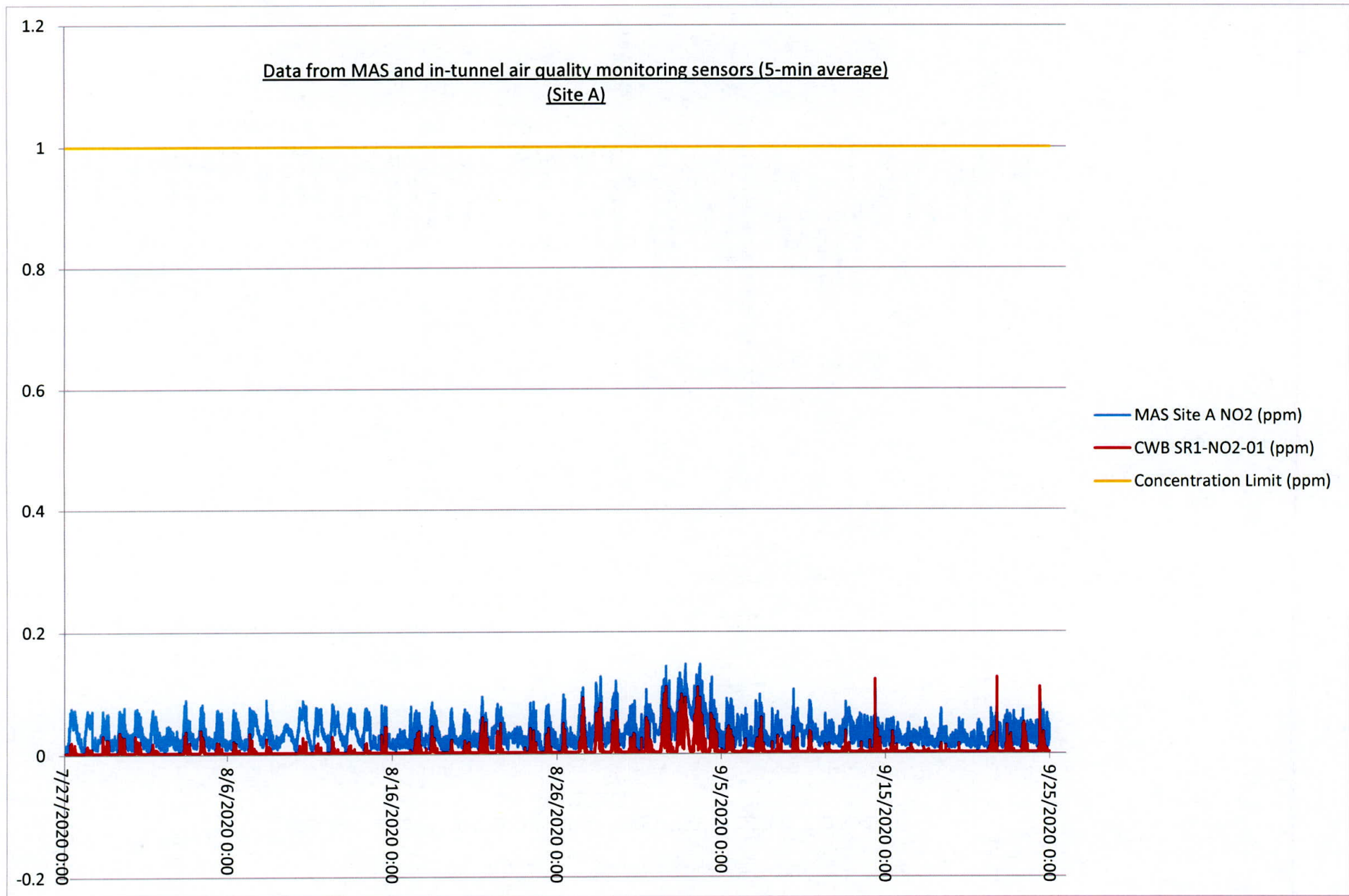


### Site C:

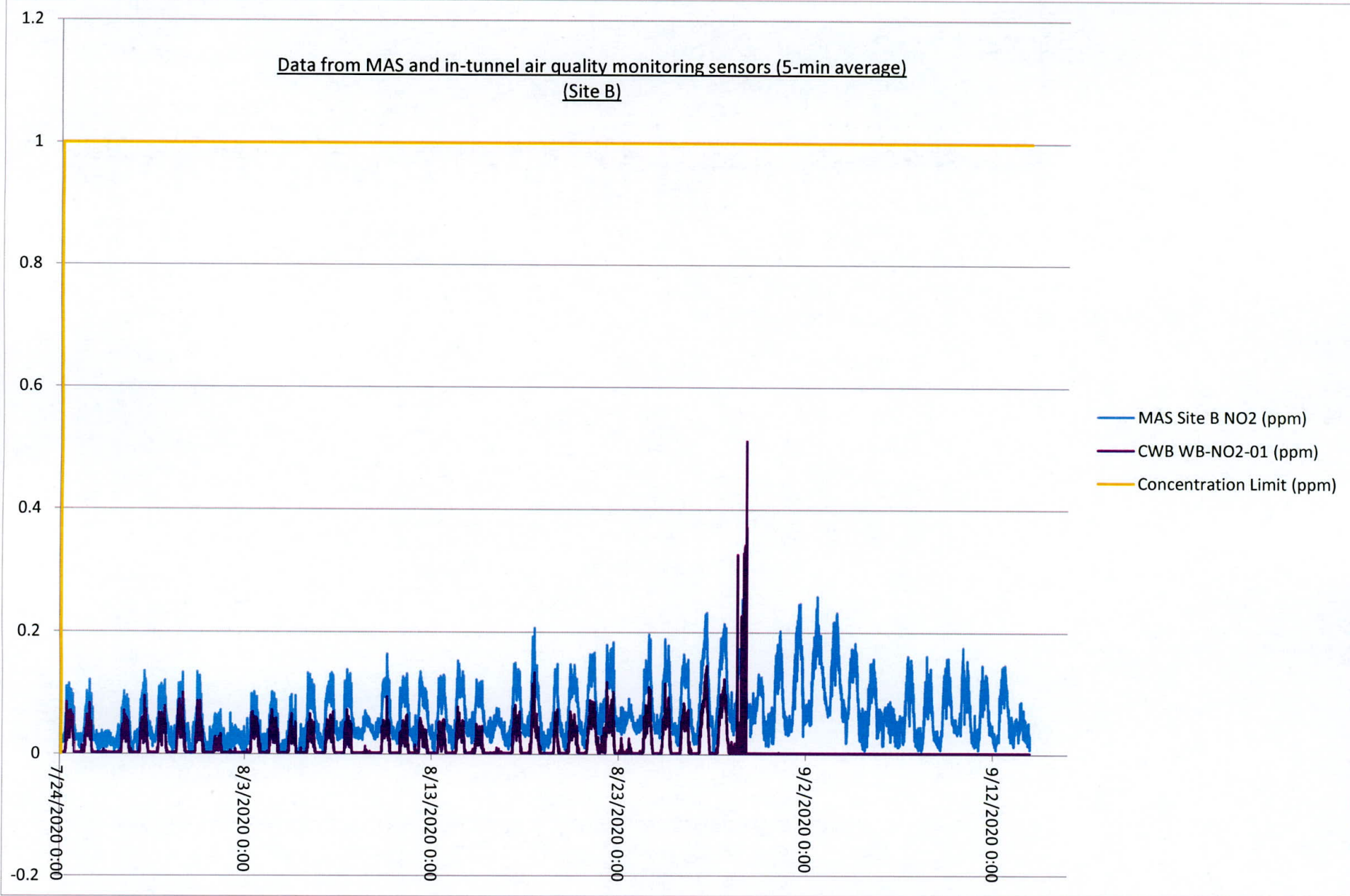
- 24-h average  $PM_{10}$  concentration is below the 24-hour  $PM_{10}$  concentration limit in HKAQO.

## **Appendix 5**

In-tunnel Air Quality Data (NO<sub>2</sub>) and MAS Air Quality Data



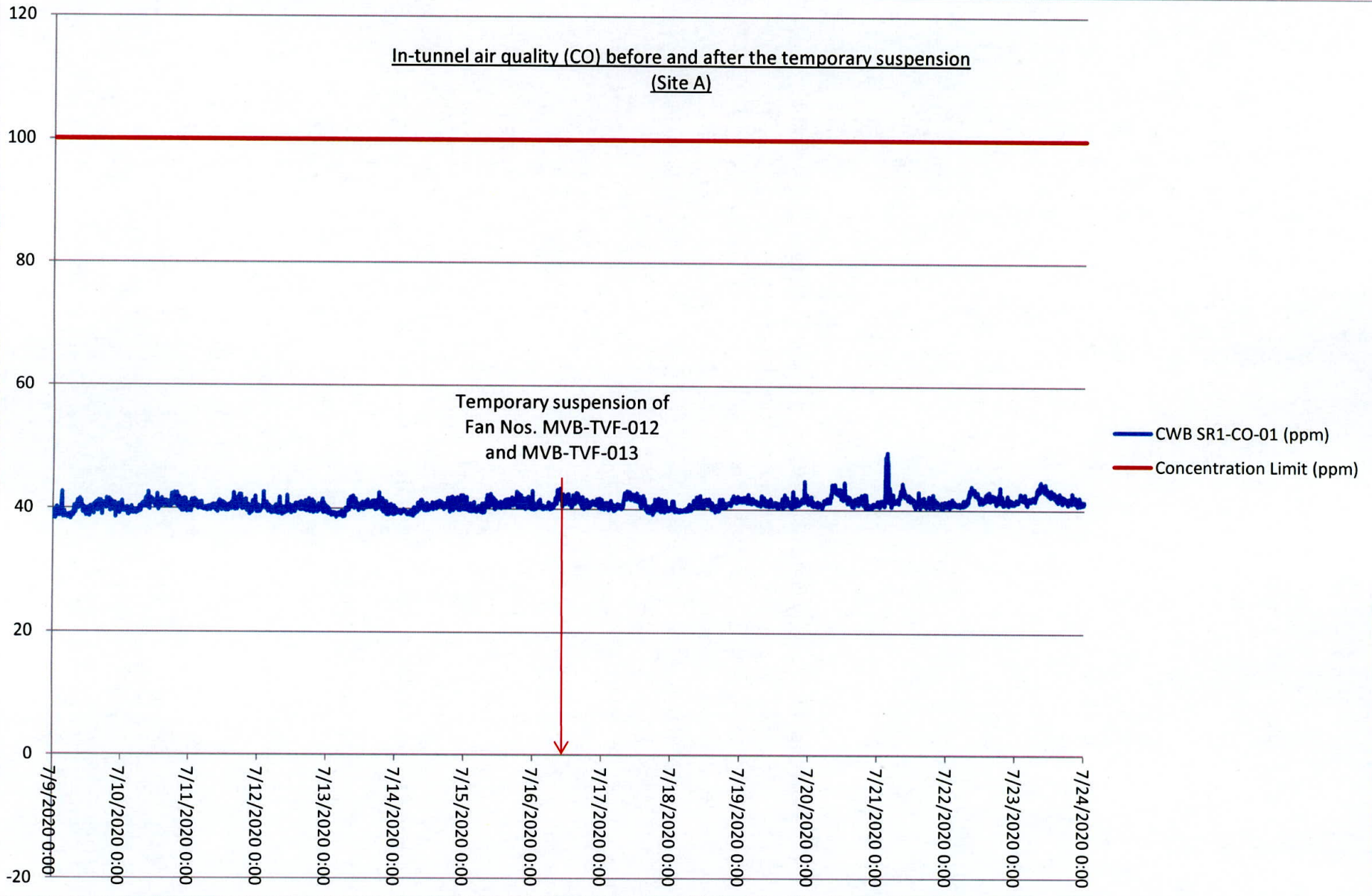
Data from MAS and in-tunnel air quality monitoring sensors (5-min average)  
(Site B)

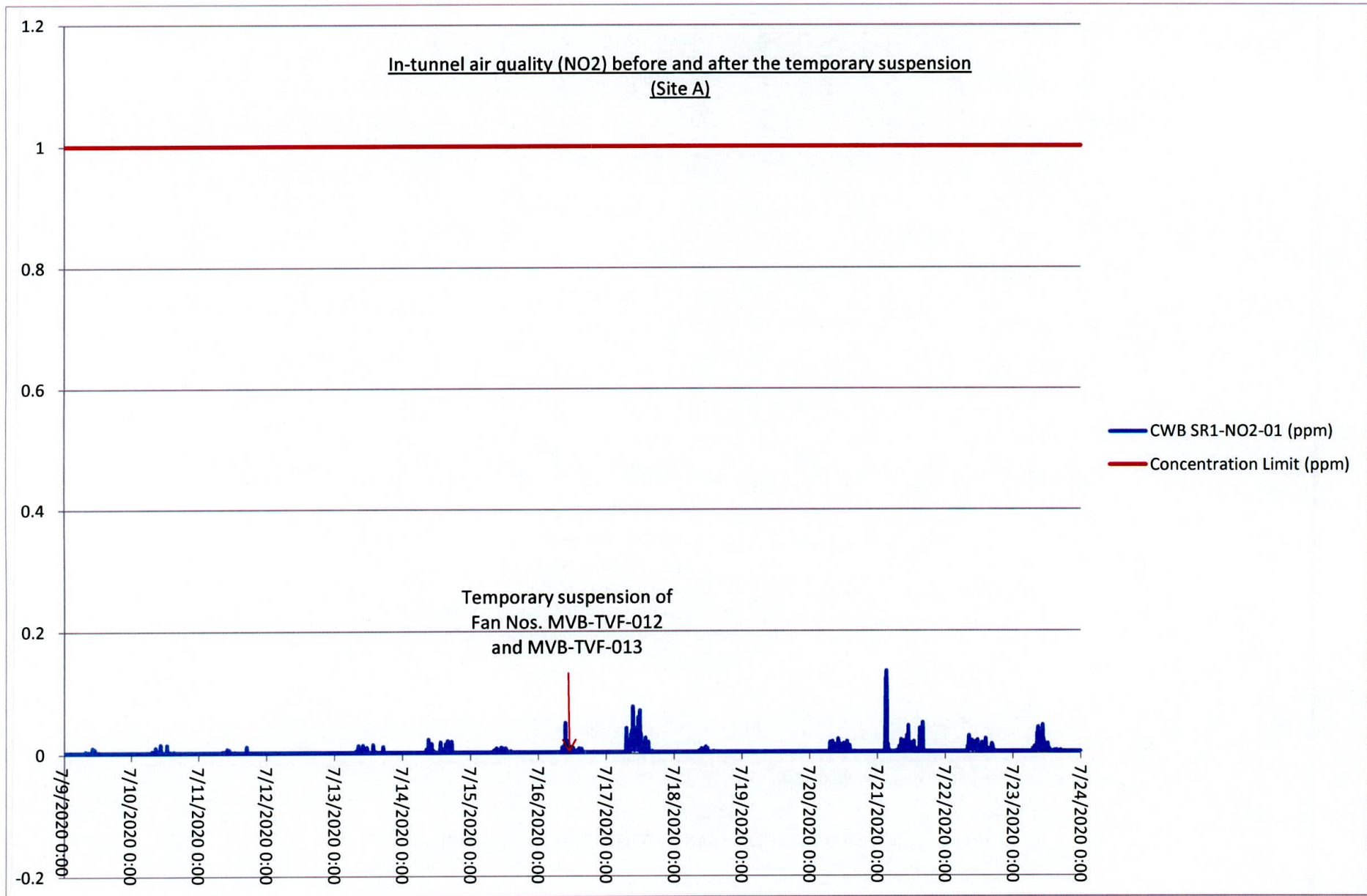


- MAS Site B NO2 (ppm)
- CWB WB-NO2-01 (ppm)
- Concentration Limit (ppm)

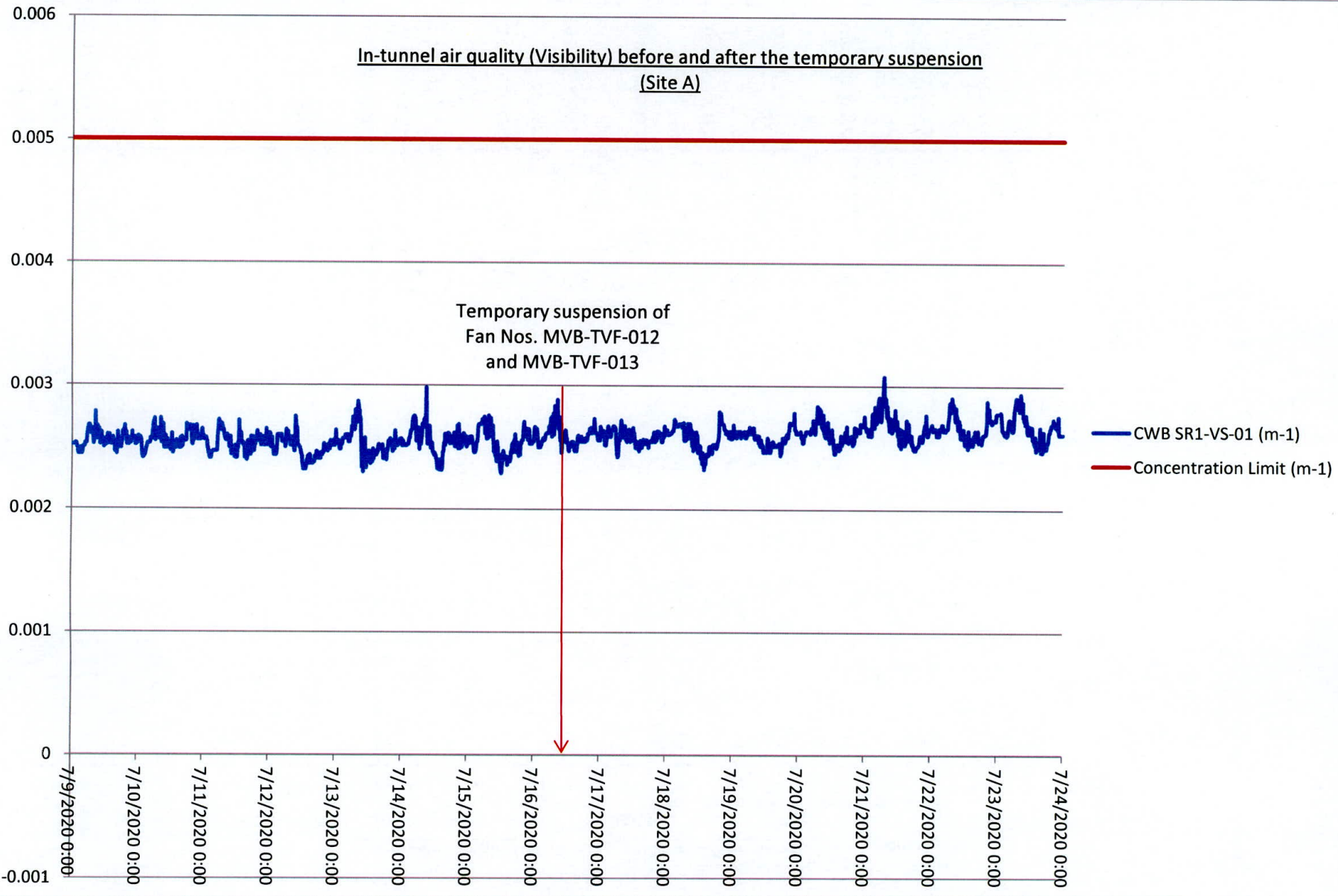
## **Appendix 6**

In-tunnel Air Quality Data (CO, NO<sub>2</sub> and Visibility) Before and After the  
Temporary Suspension Incidents

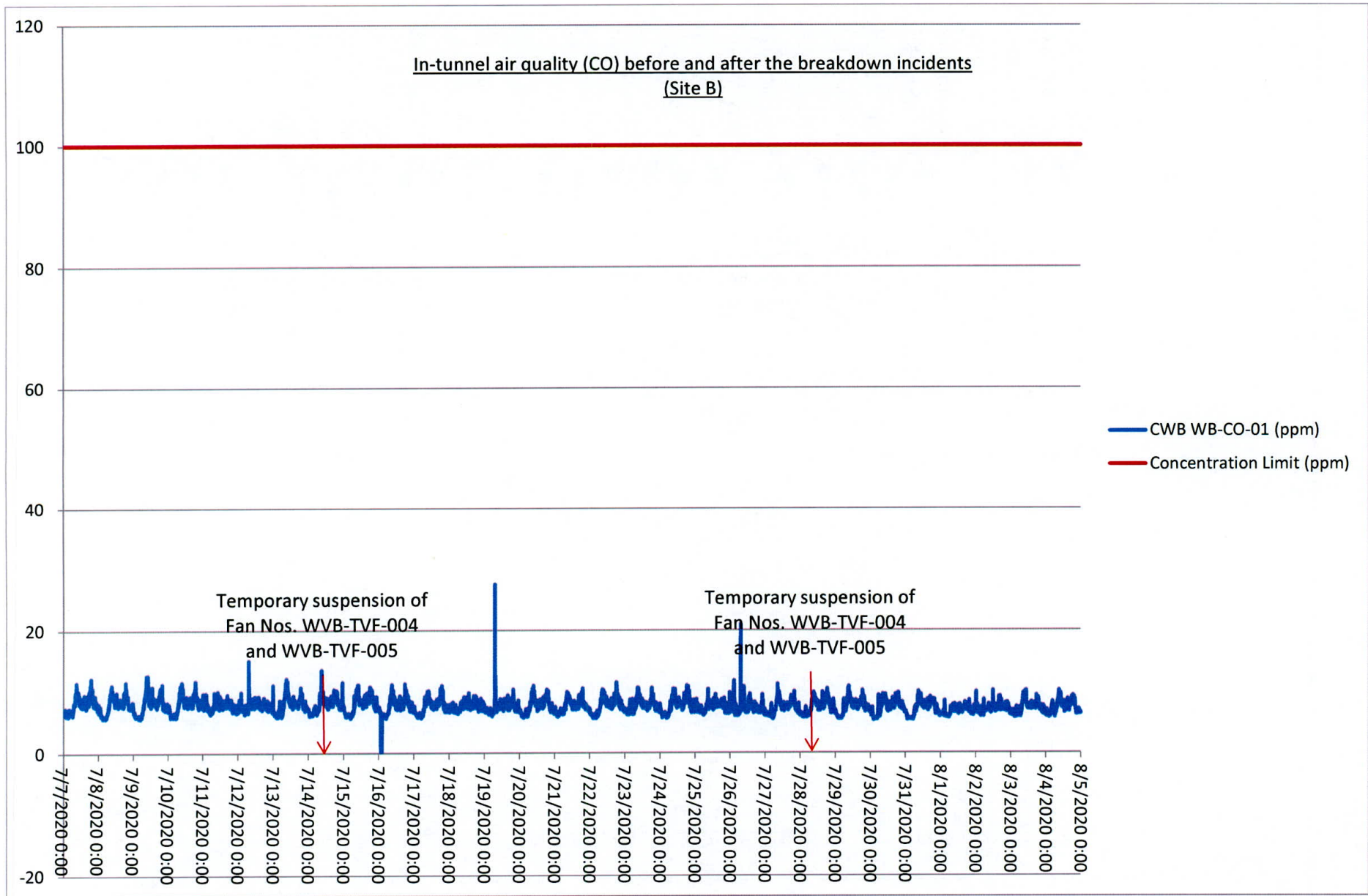




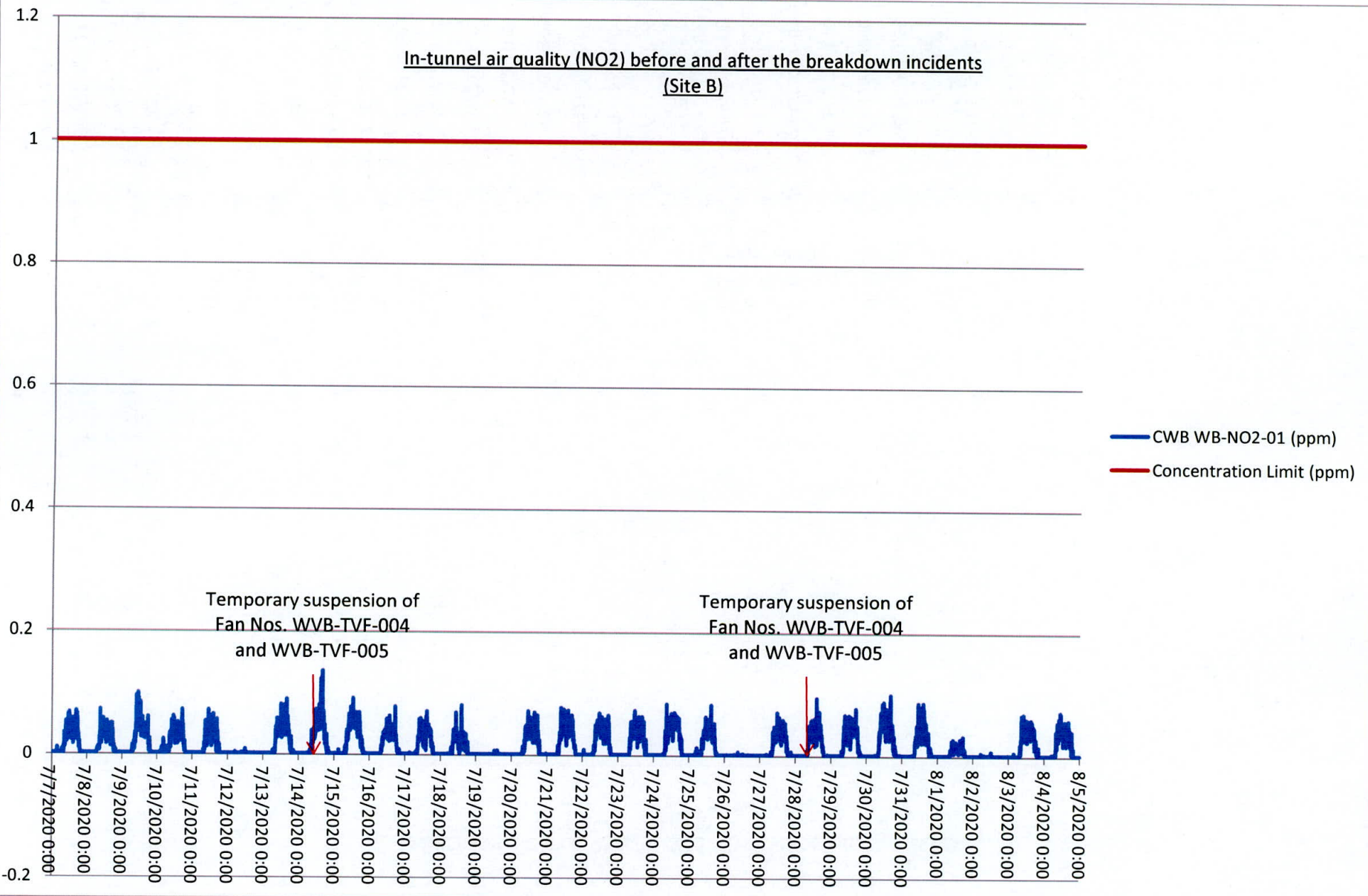
In-tunnel air quality (Visibility) before and after the temporary suspension  
(Site A)







In-tunnel air quality (NO2) before and after the breakdown incidents  
(Site B)



In-tunnel air quality (Visibility) before and after the breakdown incidents  
(Site B)

