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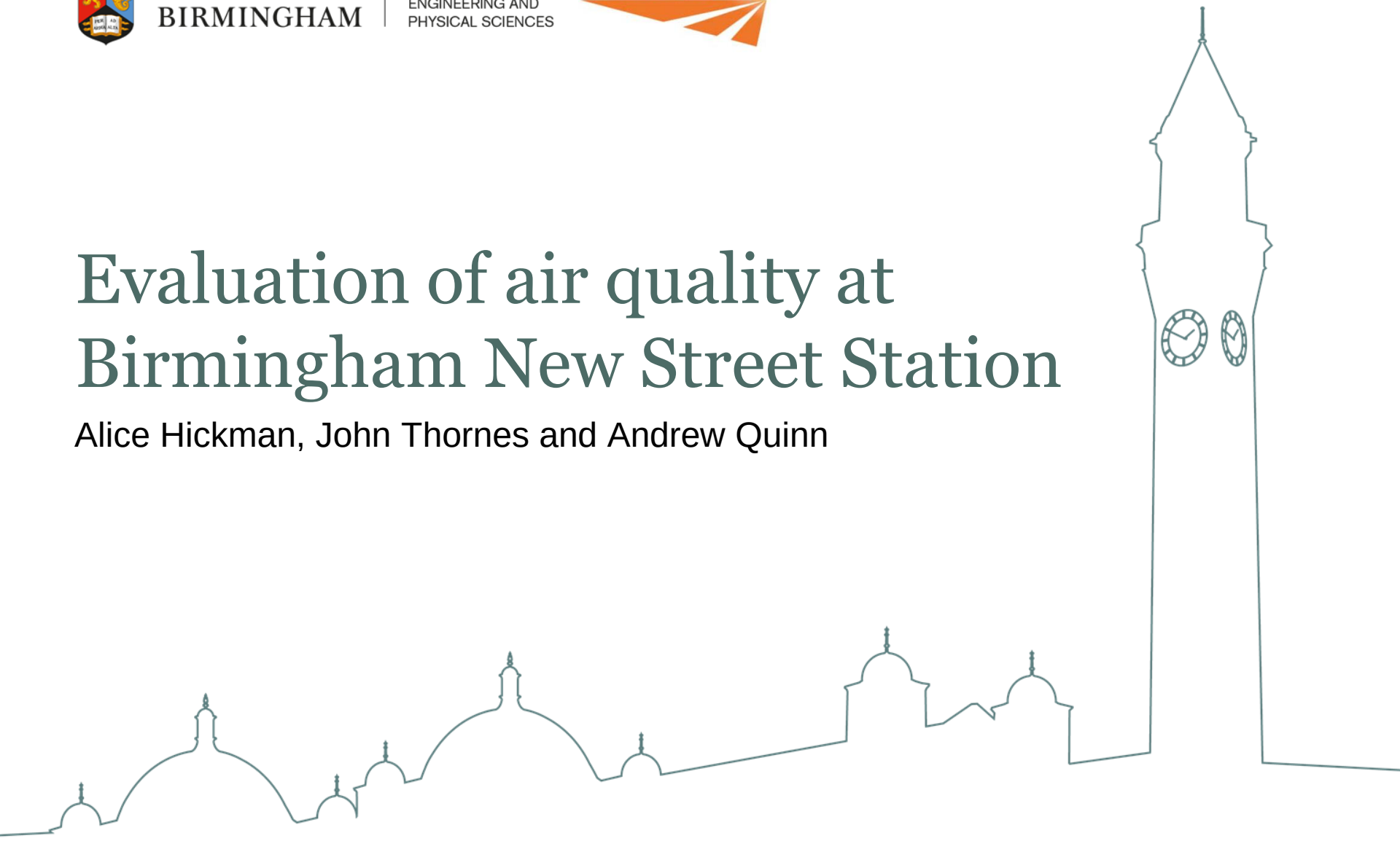
Evaluation of air quality at Birmingham New Street Station

Alice Hickman, John Thornes and Andrew Quinn



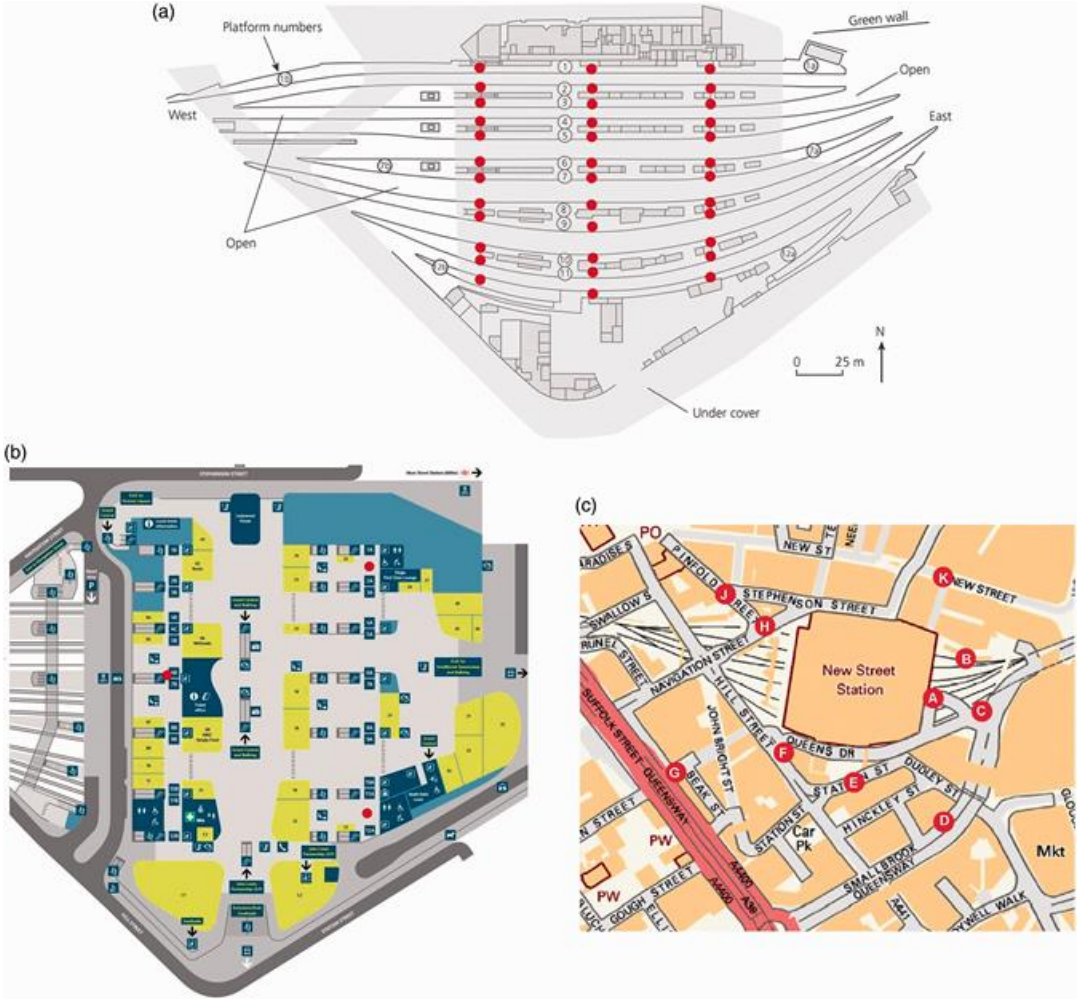
Introduction

- Birmingham New Street (BNS) is the busiest station outside London (entries & exits and interchanges).
- 12 platforms lie beneath concourse in a tunnel like environment.
- Approximately 45% of trains that serve BNS are diesel.
- University of Birmingham and Network Rail worked in collaboration and developed an extensive monitoring campaign to better understand the environment in and around the station.

Relevant Legislation

Pollutant	Workplace exposure limits		EU air quality standards	
	8 h (TWA)	15 min (TWA)	1 year	Short term
Nitrogen dioxide	955 µg/m^3 (SCOEL Guidance)	1910 µg/m^3	40 µg/m^3	200 µg/m^3 (1 h, not to be exceeded more than 18 times annually)
PM_{10}	n/a	n/a	40 µg/m^3	50 µg/m^3 (24 h, not to be exceeded more than 35 times annually)
$PM_{2.5}$	n/a	n/a	25 µg/m^3	n/a
Carbon dioxide	9150 mg/m^3	27 400 mg/m^3	n/a	n/a
Carbon monoxide	35 mg/m^3	232 mg/m^3	n/a	10 µg/m^3 (Maximum daily 8 h mean)
Oxides of Sulphur	n/a	n/a	n/a	350 µg/m^3 (1 h, not to be exceeded more than 24 times annually) 125 µg/m^3 (24 h, not to be exceeded more than 3 times annually)
PAHs	n/a	n/a	1 ng/m^3	n/a
Benzene	3.25 mg/m^3	n/a	5 µg/m^3	n/a

Diffusion Tube Locations



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Diffusion Tube Results

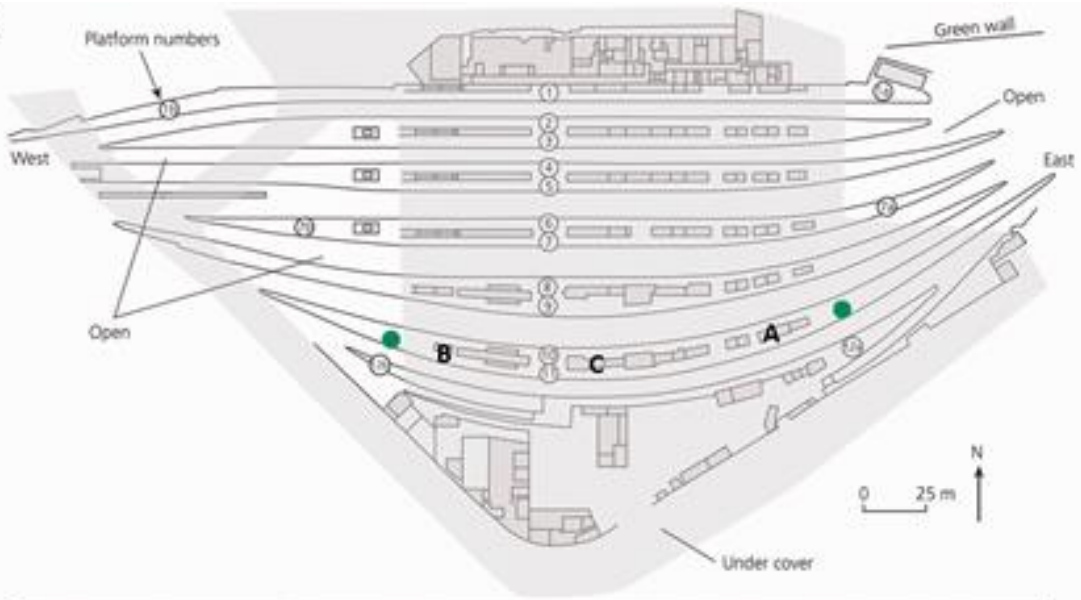
	West		Centre		East	
	Sample one	Sample two	Sample one	Sample two	Sample one	Sample two
Platform concentration						
Platform 1	276	285	440	464	250	384
Platform 2	318	318	437	508	287	412
Platform 3	278	244	411	504	284	392
Platform 4	325	271	344	427	238	361
Platform 5	271	236	341	405	210	399
Platform 6	236	234	297	368	178	298
Platform 7	204	197	364	375	205	302
Platform 8	251	240	355	412	262	331
Platform 9	280	264	428	452	323	449
Platform 10	298	280	420	501	297	389
Platform 11	232	214	398	500	287	332
Platform 12	361	360	380	427	252	353

	Sample one	Sample two
Lounge concentrations		
Red lounge	152	145
Blue lounge	295	354
Yellow lounge	310	353

	Sample one	Sample two
Area surrounding the station at locations A–K		
A	72	85
B	70	80
C	64	69
D	60	64
E	61	67
F	55	60
G	50	53
H	62	74
J	51	54
K	45	47

10-Week Monitoring Period

(a)



Monitoring Location	Pollutants Monitored	Meteorological Measurements
A & B	NO_x, PM, CO_2	Wind
C	NO_x, PM, CO_2, BC	n/a

(b)

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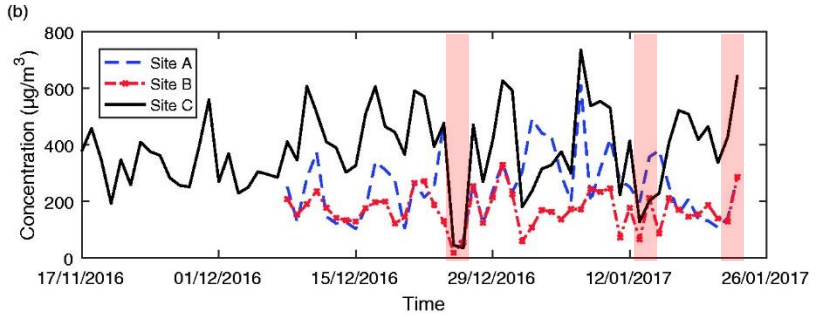
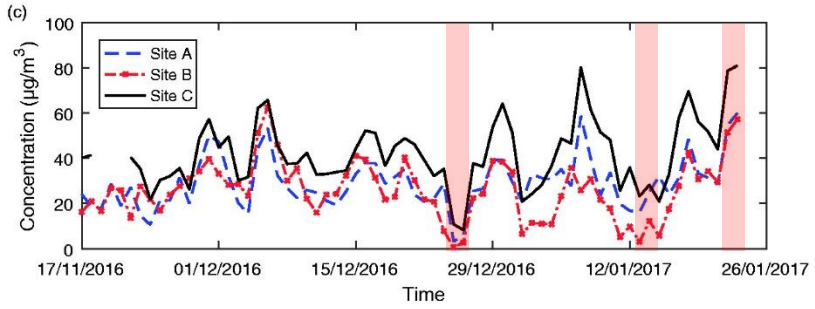
Monitoring Results

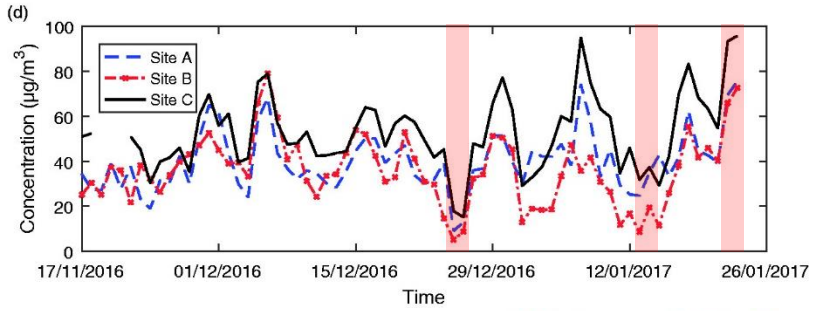
NO_2



$PM_{2.5}$



PM_{10}



NO_2

- **Average:** 307 μg/m^3
- **Max:** 560 μg/m^3 (30/11/16)
- **Min:** 30 μg/m^3 (25/12/16)

$PM_{2.5}$

- **Average:** 32 μg/m^3
- **Max:** 66 μg/m^3 (23/01/17)
- **Min:** 5 μg/m^3 (25/12/16)

PM_{10}

- **Average:** 43 μg/m^3
- **Max:** 81 μg/m^3 (23/01/17)
- **Min:** 11 μg/m^3 (25/12/16)

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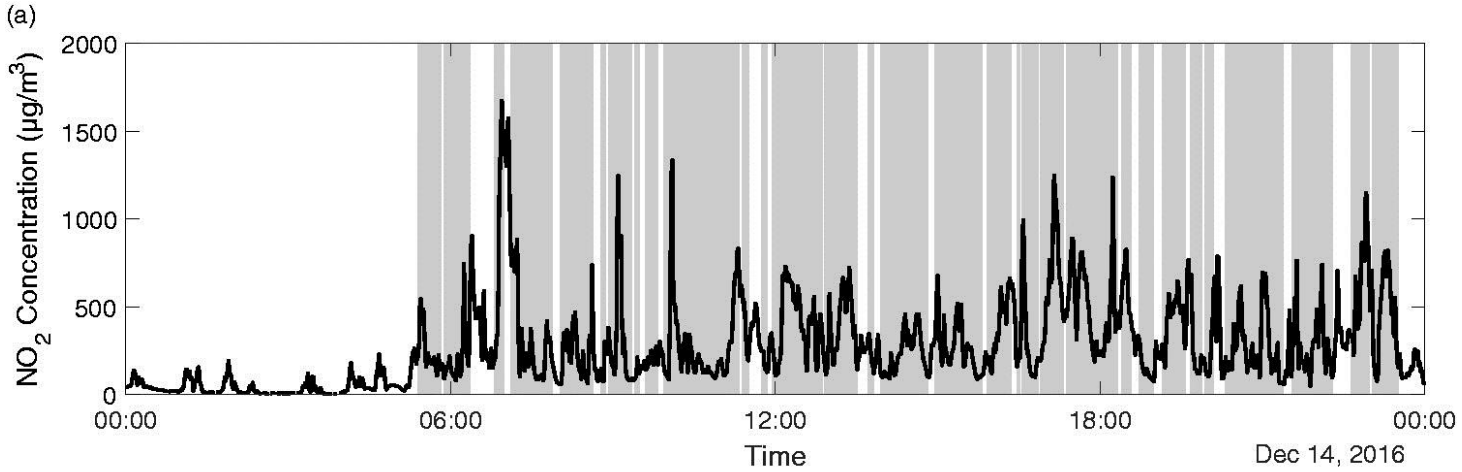
Train Analysis - Voyager



	Ratio of concentration when platforms occupied to average concentration
Platform 10, 220/221	1.24
Platform 10, 158/170	1.03
Platform 11, 220/221	1.33
Platform 11, 158/170	1.17
Platform 10, 220/221, Platform 11, 158/170	1.33
Platform 10, 158/170, Platform 11, 220/221	1.17
Platform 10, 220/221, Platform 11, 220/221	2.46
Platform 10, 158/170, Platform 11, 158/170	1.11

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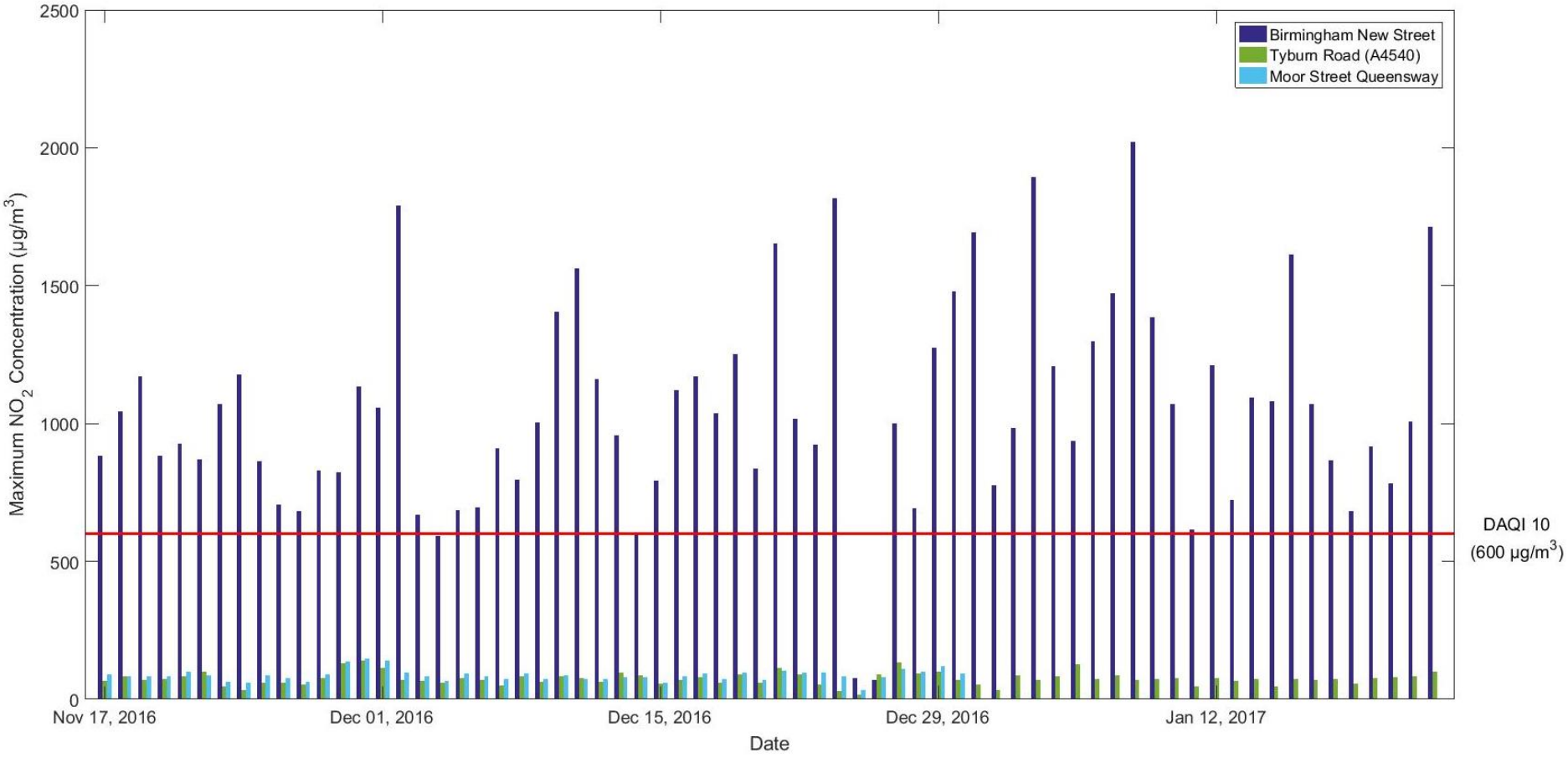
Daily Air Quality Index (DAQI)

- DAQI describes level of air pollution and informs the public in a similar way to the sun and pollen index.
- Index bands range from 1 to 10.

- Level determined by the highest concentration of five pollutants; NO_2, SO_2, O_3, $PM_{2.5}$ and PM_{10}.
- Each pollutant is assessed in a different way

DAQI: BNS vs A4540



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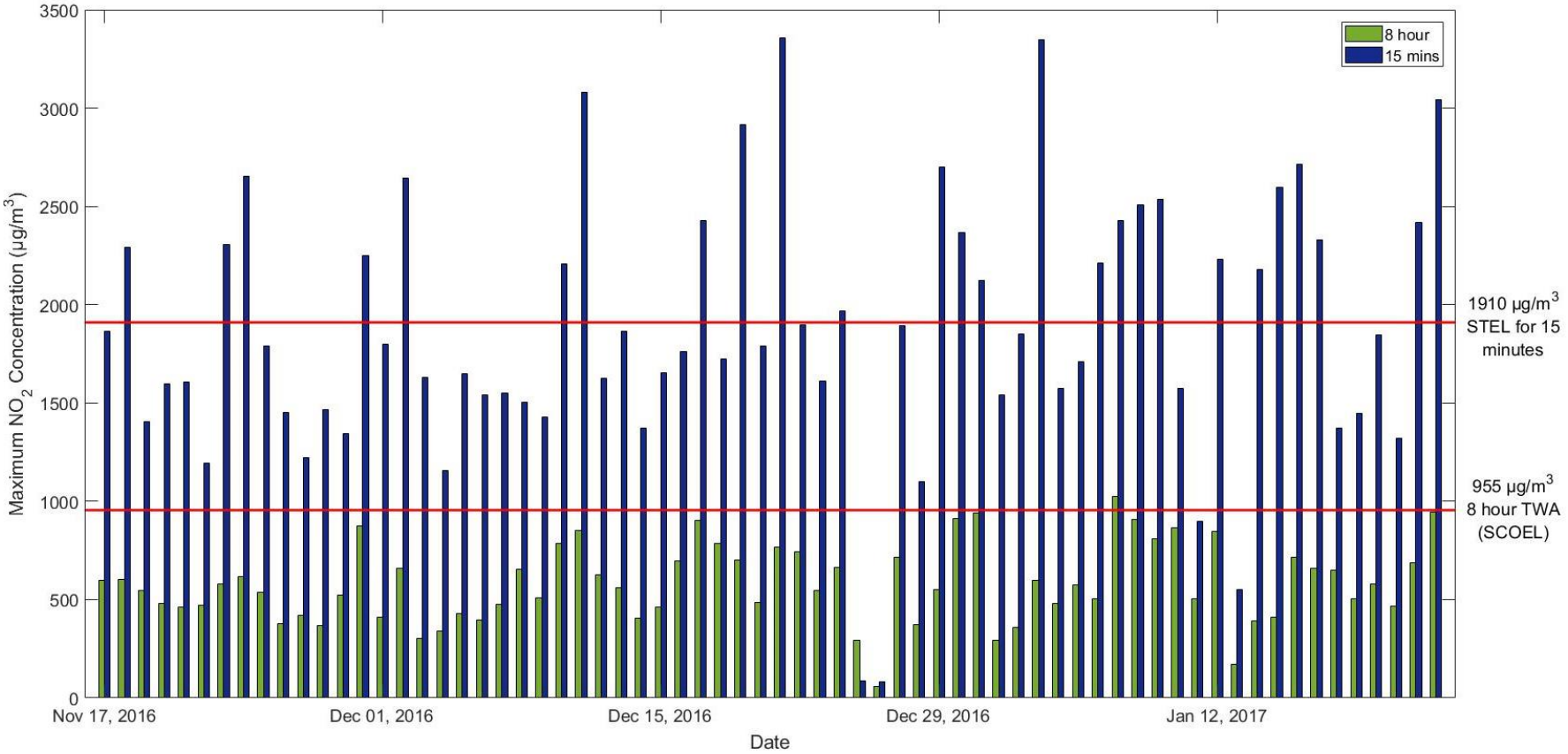
Occupational Limits



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New Street Station Air Quality Update

Azhar Quaiyoom
Kevin Blacktop

20th March 2018

Introduction

Network Rail provided an overview of the research project to carry out a comprehensive assessment of air quality at Birmingham New Street station to Birmingham City Council on the 28th March 2017.

This update will explain actions undertaken by Network Rail following the work by the University of Birmingham post Jan 2017.

Initial Findings

- Report / Preliminary Analysis focuses upon NO2 and Particulate Matter based on EU Guidelines.
- Analysis acknowledges factors such as train idling and wind speeds create a variance in the results.
- Fume extract system / Impulse fans design assumes CO2 is a good indicator for other pollutants such as NO2 / NO (as in HSE HSG187), but report states no correlation between CO2 and NO2 / NO
- Clear correlation between spikes and train idling.

- UofB stated '*considerable week-by-week variation in pollutant levels and thus care must thus be taken in the interpretation of the results'.*

Legal overview - findings

- We have worked with our regulators Birmingham City Council, the Office of Rail and Road (ORR) and the Rail Safety and Standards Board and legal advisors to better understand the air quality requirements we are required to meet.
- We can confirm that the European Union (Air Quality Regulations 2010) and Department of Environment, Food and Rural Affairs limits do not apply within stations.
- However the Management of Health and Safety at Work Regulation 1999 and the Control of Substances Hazardous to Health Regulations (COSHH) 2002 are applicable.

Legal overview

The Management of Health and Safety at Work Regulation 1999 and the Control of Substances Hazardous to Health Regulations 2002 require us to reduce exposure as much as Network Rail has a duty (so far as reasonably practicable) to:-

- not expose those who are not in NR's employment (i.e. visitors, passengers and third parties) to risks to their health and safety.
- ensure the health, safety and welfare of its employees whilst at work.

Train Operations

- During a regular weekday there are currently **364 trains that have a dwell time of > 5 minutes** at New Street. These can be broken down as follows:

5-9 minutes	**179 trains**
10-14 minutes	82 trains
15+ minutes	103 trains

- TOC's have operational guidelines to turn off engines and prevent engine idling. The TOC's operating diesel trains at the station are:-
  - Virgin Trains
  - Cross Country
  - Arriva
  - WM trains (former London Midland)

Fume Extract System at New Street

- 98 jet fans across 12 platforms
- Fans are bi-directional depending upon wind direction
- Remove fumes towards end of platforms into open space
- Array of CO2 sensors that control 4 speeds of each fan over 2 zones

Fume Extract System Changes

- Diesel engine exhaust emissions are made up of a complex number of different gases and particulate elements and this has made practical air quality limits difficult to quantify.
- There are a number of conflicting values and monitoring standards applied for some elements individually, but the most convenient single measure is considered to be CO2 (example HSE HSG187), which is why the New Street Station Re-development Team adopted this as the trigger for the ventilation system.
- The work undertaken by the University of Birmingham highlighted that this may not be the case for Nitrogen Oxides.

Diesel Fume Extract Settings (Workplace Exposure Limits)

Carbon Dioxide (CO2)
- 5000ppm (8hour *TWA)
- 15000ppm (15min *TWA)

Carbon Monoxide (CO)
- 30ppm (8hour *TWA)
- 200ppm(15min *TWA)

Based upon: EH40-2005 Workplace Exposure Limits
*TWA = Time Weighted Average

Mode	Fan Speed	CO2 range (PPM)
Standby	0%	<1000
Low Pollution	25%	1000-2000
High Pollution	50%	2000-3500
Emergency Pollution	100%	>3500

1. HSE guidance (HSG 187) & EH:40 states the workplace exposure limit (WEL) is 5000PPM over an 8-hour time weighted average (TWA) with a 15 minute peak exposure of 15000PPM
2. CO2 range sits well within the HSE guidance and is targeted to reduce the emergency pollution mode operation and also target the fans to shutdown at low pollution times.

Stage	PPM CO2	Fan Speed (%)
1	0	25
2	1000	50
3	2250	100

Fan/Sensor settings during January 2018 assessment

Short term Action plan - complete

Action / Intervention

- Completion of UoB Air Quality report & Study √
- Further emission tests carried out post University of Birmingham Study √
- intervention of Impulse Fan system (25% over ride and adjust CO2 threshold) √
- Status review of current & historic maintenance √
- Performance Review of existing fume extract system √

Ongoing Action Plan

Action / Intervention
TOC Focus Group - Train idling / stopping positions
Further adjustment of CO2 thresholds for fan speed
Staff Occupational Health Tests and screening
Comparison of SOCOTEC test results V's B'ham University
DfT / ORR / RSSB / BCC EHO Meetings and updates for guidance

Long term plan (Week > 6 months)

Action / Intervention

TOC Behaviour Change Programme for Drivers to turn off engines and overcome technical challenges

Engine / emission improvement (Auto Shutdown System / Stop/Start/ Selective Catalytic Reduction (SCR))

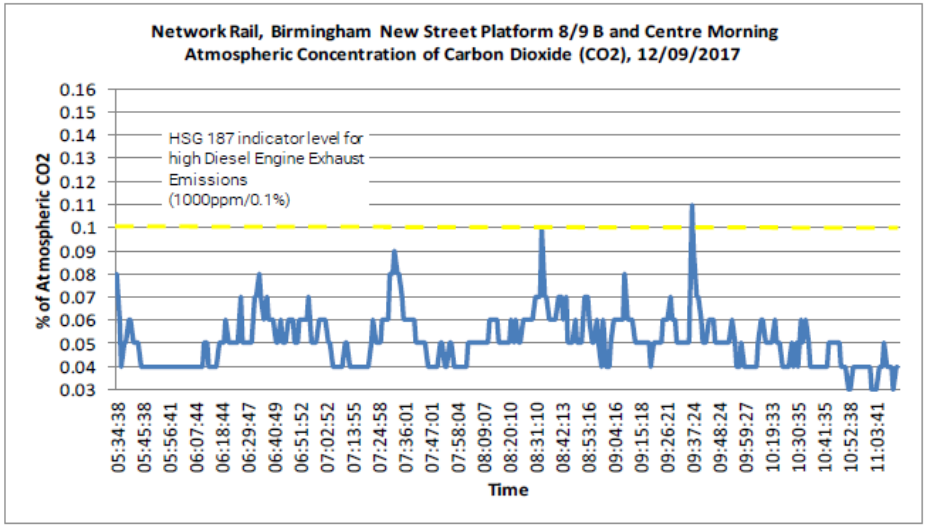
Performance optimisation for impulse / jet fans fume extract system:

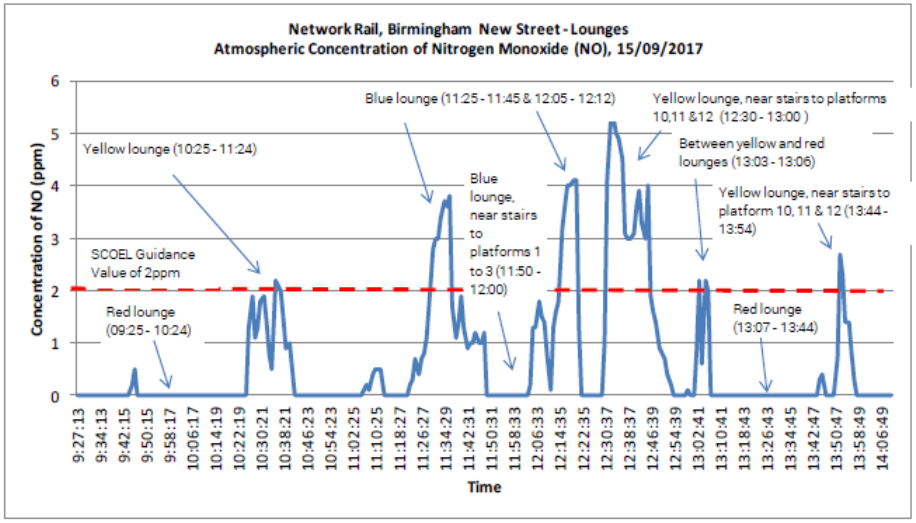
- BMS integration
- NOx Sensors
- Real time monitoring of NOx and CO2
- Real time performance monitoring of each jet fan

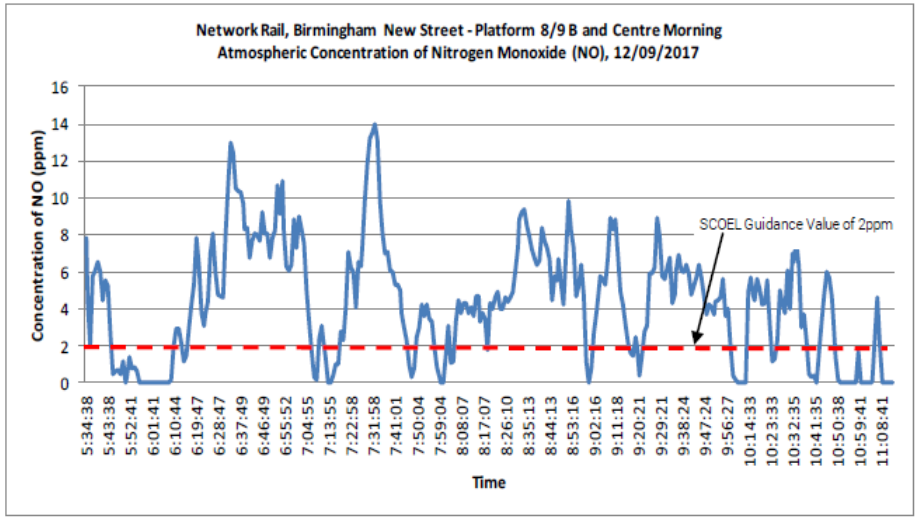
Regular PPM for Impulse fans system

Post UofB Monitoring – September 2017

- Diesel emissions are not considered as a whole, but some elements are legislated individually.
- NOx guidance limits based upon SCOEC (Scientific Committee on Occupational Exposure Limits) June 14'
- There is a correlation with spikes in NOx and train idling.
- Low NO2 Lounge levels but some spikes in NO2 above 2ppm for short periods







Post UoB Monitoring – Oct & Nov 2017

- Oct individual monitors showed ave. CO, CO2 and NOx below WEL Guidance limits
- Nov results show reduction in peak NO compare to Sept 17 results
- Overall compliance to WEL COSHH 2002 regs.

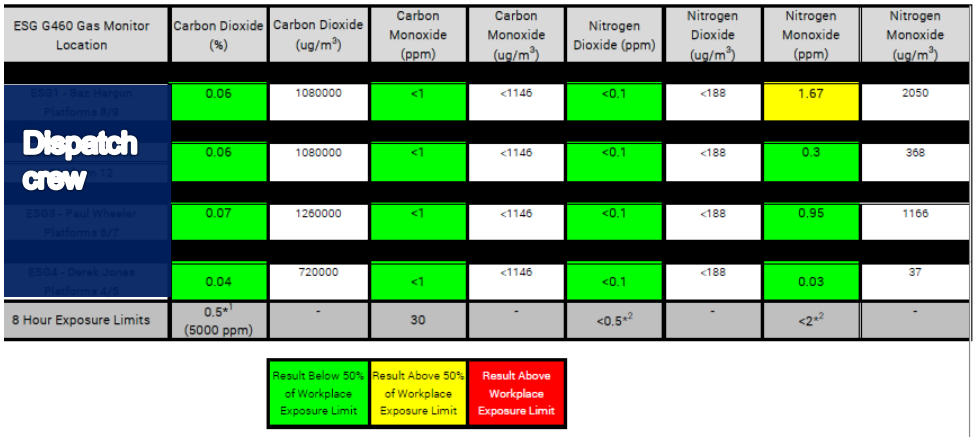
Table 2 – Workplace Exposure Limits (WELs)

Substance	Workplace Exposure Limit LTEL (8h TWA)		STEL (15 min TWA)		Notes
	ppm	$mg.m^{-3}$	ppm	$mg.m^{-3}$	
Carbon monoxide	30	-	200	-	EH40
Nitrogen monoxide	2	-	-	-	SCOEL, see below
Nitrogen dioxide	0.5	-	-	-	SCOEL, see below
Carbon dioxide	5000	-	15000	-	
Elemental Carbon	-	0.1	-	-	See 5.3.10

TWA – Time weighted average *LTEL – Long term exposure limit*
ppm – parts per million *STEL – Short term exposure limit*

Comparison over Sept & Nov fixed monitoring (average over the day)

Platform	Date	Time of Day	CO_2 (%)	NO (PPM)
8/9A	12/09/2017	5:00 - 12:00	0.05	2.1
	07/11/2017		0.07	2.08
8/9B	12/09/2017	5:00 - 12:00	0.05	4.3
	07/11/2017		0.04	2.08
10/11A	14/09/2017	5:00 - 12:00	0.05	3.5
	07/01/2017		0.05	2.06
10/11A	14/09/2017	12:00 - 00:00	0.05	1.4
	08/11/2017		0.08	2.9
4/5A	14/09/2017	19:00 -00:00	0.05	3
	08/11/2017		0.04	2.08



Individual monitoring outputs – 25th Oct 2017

Conclusion

The monitoring undertaken by the University of Birmingham and Network Rail at New Street Station is one of the most comprehensive air quality projects carried out in the UK rail industry.

The information obtained from this work will help Network Rail optimise and improve the systems in place at New Street and enable discussion with train operators to be based on measured evidence.

There are multiple factors creating ‘spikes’ in diesel emissions – multi faceted approach is required with support from train operators and other stakeholders.

Thank you.

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