MERTHYR TYDFIL
County Borough Council
Cyngor Bwrdeistref Sirol
MERTHYR TUDFUL

Detailed assessment for

Twynyrodyn Road

Merthyr Tydfil County Borough Council

In fulfillment of Part IV of the
Environment Act 1995
Local Air Quality Management

Date (16th November 2015)

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Executive Summary

Merthyr Tydfil County Borough Council carries out routine air quality monitoring and assessment. During the course of this monitoring an exceedance of the annual NO_2 objective was observed at Twynyrodyn Road. The purpose of this detailed assessment was to further investigate this exceedance.

Real time NO_2 monitoring and diffusion tubes were used to determine the short term, monthly and annual NO_2 concentrations. Meteorological data and traffic data were also investigated. Traffic is considered to be the predominant source of NO_2 on Twynyrodyn Road. Wind direction and speed, along with two buildings on either side of the road being close to the pavement are considered likely to cause NO_2 to accumulate around 55 Twynyrodyn Road.

Real time NO_2 concentrations were found to be highest when there was significant levels of traffic moving uphill. This is believed to be associated with the direction commuters and visitors to the town centre and Tesco are encouraged to leave, particularly as a consequence of recent changes to the road layout and parking arrangements in the town centre.

It is considered necessary to declare an AQMA from the Western End of Twynrodyn Road to 147 Gilfach Cynon. MTCBC will then produce an action plan, aiming to reduce NO_2 concentrations. As NO_2 is associated with traffic emissions solutions to reduce the speed, improve the flow and reduce the amount of traffic will be carried out.

Glossary

AADT	Annual Average Daily Traffic (vehicles per day)
AQMA	Air Quality Management Area
AQO	Air Quality Objective
AQ	Air Quality
AURN	Automatic Urban and Rural (air quality monitoring) Network
CO	Carbon monoxide
DA	Detailed Assessment
Defra	Department for Environment Food and Rural Affairs
DMRB	Design Manual for Roads and Bridges Screening Model
ECC	Electrochemical Cell
GIS	Geographical Information System
HDV	Heavy Duty Vehicles
IZS	Internal Zero Span
LA	Local Authority
LAQM	Local Air Quality Management
m/s	metres per second
$\mu g/m^3$	Micrograms of the pollutant per cubic metre of air
MTCBC	Merthyr Tydfil County Borough Council
NAEI	National Atmospheric Emissions Inventory
NAQS	National Air Quality Strategy
NO	Nitric oxide
NO_2	Nitrogen dioxide
NOx	Nitrogen oxides
PM_{10}	Particles with diameter less than 10µm
$PM_{2.5}$	Particles with diameter less than 2.5µm
QA/QC	Quality Assurance / Quality Control
R & A	Review and Assessment
SO_2	Sulphur dioxide
TEOM	Tapered Element Oscillating Microbalance
USA	Updating and Screening Assessment
VPD	Vehicles per day

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1. Introduction

1.1 Purpose of the study

The purpose of this assessment is to describe and assess the impact on air quality of the emissions from traffic on Twynyrodyn Road. The study seeks to provide MTCBC with a quantitative estimate of the air quality impact of the existing traffic in the context of current UK AQOs.

An area of Twynyrodyn Road has been found in recent routine assessments to have an exceedance of the annual AQO for NO_2. This exceedance was decreasing in line with improving air quality throughout the district, however recently there has been a marked increase in NO_2 levels following substantial changes to traffic flow, associated with changes to the road layout in Merthyr Tydfil town centre. It has now stabilised at a level above the AQO.

1.2 General approach taken

The approach taken to this study was to:

- Use diffusion tubes and a real time ECC monitor to obtain NO_2 concentrations for a 12 month period.
- Obtain 12 months of meteorological data from a local air quality station, located at Twynyrodyn Infants School.
- Use data from the Highways department of MTCBC to investigate vehicle use of Twynyrodyn Road.
- Compare data from the real time ECC monitor with the AURN data at Twynyrodyn Infants School, to identify inconsistencies.
- Compare data from the real time ECC monitor with meteorological data and traffic data, to identify any correlations.
- Modelling has not been undertaken at this stage.

2. Air quality

2.1 Air quality strategy and objectives

The latest National Air Quality Strategy (NAQS) published by Defra (2007) provides a framework for air quality improvements in the UK and contains national air quality standards and objectives established by the Government to protect human health. The objectives for nine pollutants (benzene, 1,3-butadiene, carbon monoxide, lead, nitrogen dioxide, sulphur dioxide, PM_{10} and $PM_{2.5}$ and ozone) have been prescribed within the Air Quality (Wales) Regulations 2010.

The Air Quality Standards (Wales) Regulations 2010 came into force on 16th May 2010. The Regulations bring together in one statutory instrument the Government's requirements to fulfil separate EU Daughter Directives through a single consolidated statutory instrument. The Objectives set out in the NAQS for the protection of human health are presented in Table 2.1. This table shows the objectives in units of microgrammes per cubic metre $\mu g/m^3$ (milligrammes per cubic metre, mg/m^3 for carbon monoxide) with the number of exceedances in each year that are permitted (where applicable).

Local Authorities are required to declare an Air Quality Management Area (AQMA) where it is likely that these objectives will not be achieved and, following its declaration, to prepare an Action Plan to set out proposed measures to be taken to achieve the air quality objectives. There are currently no AQMAs throughout Merthyr Tydfil County Borough, however the purpose of this report is to determine whether one is required in the Twynyrodyn Road area.

Table 2.1: Air Quality Objectives included in Regulations for the purpose of LAQM in Wales

Pollutant	Air Quality Objective		Date to be achieved by
	Concentration	Measured as	
Benzene	16.25 μg/m^3	Running annual mean	31.12.2003
	5.00 μg/m^3	Annual mean	31.12.2011
1,3-Butadiene	2.25 μg/m^3	Running annual mean	31.12.2003
Carbon monoxide	10 mg/m^3	Running 8-hour mean	31.12.2003
Lead	0.50 μg/m^3	Annual mean	31.12.2004
	0.25 μg/m^3	Annual mean	31.12.2008
Nitrogen dioxide	200 μg/m^3 not to be exceeded more than 18 times a year	1-hour mean	31.12.2005
	40 μg/m^3	Annual mean	31.12.2005
Ozone	100 μg/m^3 not to be exceeded more than 10 times a year	8 hour mean	31.12.2005
Particulate Matter (PM_{10}) (gravimetric)	50 μg/m^3, not to be exceeded more than 35 times a year	24-hour mean	31.12.2004
	40 μg/m^3	Annual mean	31.12.2004
Particulate Matter ($PM_{2.5}$) (gravimetric)	25 μg/m^3	Annual mean	01.01.2015
Sulphur dioxide	350 μg/m^3, not to be exceeded more than 24 times a year	1-hour mean	31.12.2004
	125 μg/m^3, not to be exceeded more than 3 times a year	24-hour mean	31.12.2004
	266 μg/m^3, not to be exceeded more than 35 times a year	15-minute mean	31.12.2005

2.2 Sensitive locations

The locations where objectives apply are defined in the AQS as locations outside buildings or other natural or man-made structures above or below ground where members of the public are regularly present and might reasonably be expected to be exposed over the relevant averaging period of the

objectives. Typically, these include residential properties, hospitals and schools for the longer averaging periods (i.e. annual mean) pollutant objectives and residential dwellings, shopping areas, etc. for short-term (i.e. 1-hour and 24 hour) pollutant objectives.

2.3 Road traffic emissions

Indications from existing air quality monitoring are that an area of Twynyrodyn Road is affected by elevated NO_2. Based on the location and absence of other combustion sources it is derived from road traffic. Road traffic can affect air quality. In particular nitric oxide (NO) is primarily derived from road traffic. It is rapidly oxidised to form NO_2. Additionally particulate matter is associated with road traffic.

Emissions to atmosphere affect air quality at a local level.

The subject of this study is the dispersion of NO_2 resulting from traffic on Twynyrodyn Road.

2.3.1 Oxides of nitrogen (NO_x)

As part of combustion using air as the source of oxygen, oxides of nitrogen are produced as a result of the reaction between the nitrogen present in the air. Oxides of nitrogen include nitric oxide (NO) and NO_2. Road transport is the main source of NO_x associated with the air quality issues. High levels of NO_x are associated with damage to lung function and enhancement of the response to allergens in sensitive individuals.

In addition, NO_x contributes to acidification and/or eutrophication of habitats. This affect does not necessarily impact on the local environment but can impact great distances from the source. N_2O has a contribution to global warming and hence climate change as it acts as a greenhouse gas and is 290 times more effective as a greenhouse gas than methane.

NO_x also contributes to ground level ozone via reactions with volatile organic compounds and sunlight.

2.3.2 Baseline information and background concentrations

Estimated background air pollution maps show pollutant concentrations for 1 km by 1 km grid squares (http://uk-air.defra.gov.uk/data/laqm-background-maps?year=2011). Data from 2011 has been used to predict pollutant concentrations from 2011 to 2030.

The centre of the relevant grid square (NGR 205500, 305500) within which Twynyrodyn Road, the proposed AQMA, lies has predicted background concentrations for 2014/2015 as shown in Table 2.2.

The detailed assessment is based on date running from April 2014 to March 2015 in order to synchronise diffusion tube data with 12 months of continuous NO_2 monitoring. Taking this into account this although both estimates are included, the lower figure has been selected, to represent a worst case scenario for the impact of local air quality.

Table 2.2: NO_2, NO_x and PM_{10} background concentrations

	Year			Estimated background representing worst case scenario (Predicted)
	2011 (Measured)	2014 (Predicted)	2015 (Predicted)	
NO_2 ($\mu g/m^3$)	12.56	11.83	11.59	11.59
NO_x ($\mu g/m^3$)	16.55	15.47	15.11	15.11
PM_{10} ($\mu g/m^3$)	14.11	13.61	13.47	13.47

2.4 Twynyrodyn Road

Merthyr Tydfil is the main town within Merthyr Tydfil County Borough. Twynyrodyn Road is a single carriage road connecting the town centre (Western end of the road) to the A4060 (Eastern end of the road), which then connects to the A465 Heads of the Valleys Road and the A470. Traffic flows in both directions along Twynyrodyn Road. It is known to become congested at various times throughout the day. It is a steep hill (in excess of 50m difference from the Western end to the Eastern end) with two-storey residential properties along the length of it. The significant proportion of the properties do not have a front garden area, their front doors opening directly onto the pavement. This results in a minor canyon effect.

There is a network of diffusion tubes throughout the county borough, however following a history of elevated NO_2 concentrations there are a significant number stationed along the length of the road (Figure 3.1), mainly at façade level. In particular they have been clustered immediately to the East and West of 55 Twynyrodyn Road, where an exceedance of the AQO was noted in the previous USA. The real time ECC monitor is also stationed at 55 Twynyrodyn Road.

At the roundabout at the Western end of the road, there is a 24-hour Tesco on Tramroadside. It is one of 2 large supermarkets supplying Merthyr Tydfil and the surrounding area. It has a 2-storey car park which is used by visitors to Tesco and to the town centre. Recently there have been changes to the road network around the town centre with the construction of a gyratory, and around Tramroadside constructing a one-way section (Figure 2.2). This has been anecdotally observed to have exacerbated the build-up of traffic along Twynyrodyn Road.

Figure 2.1 a: Diffusion tube locations along Twynyrodyn Road

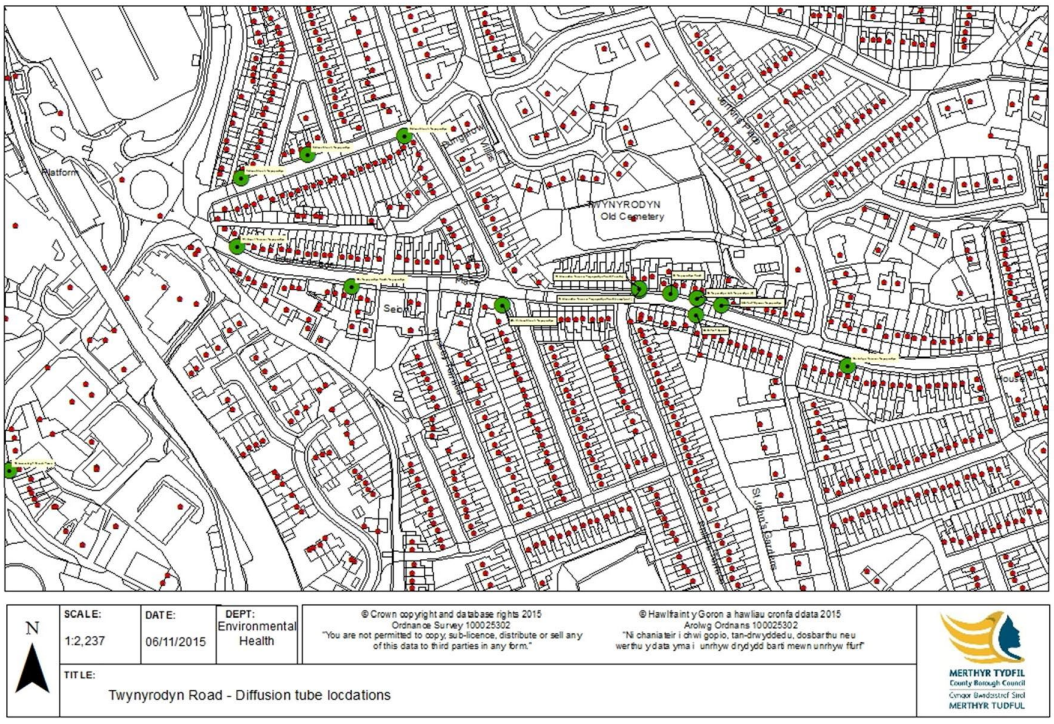


Figure 2.1 b: Diffusion tube locations along Twynyrodyn Road, Western section

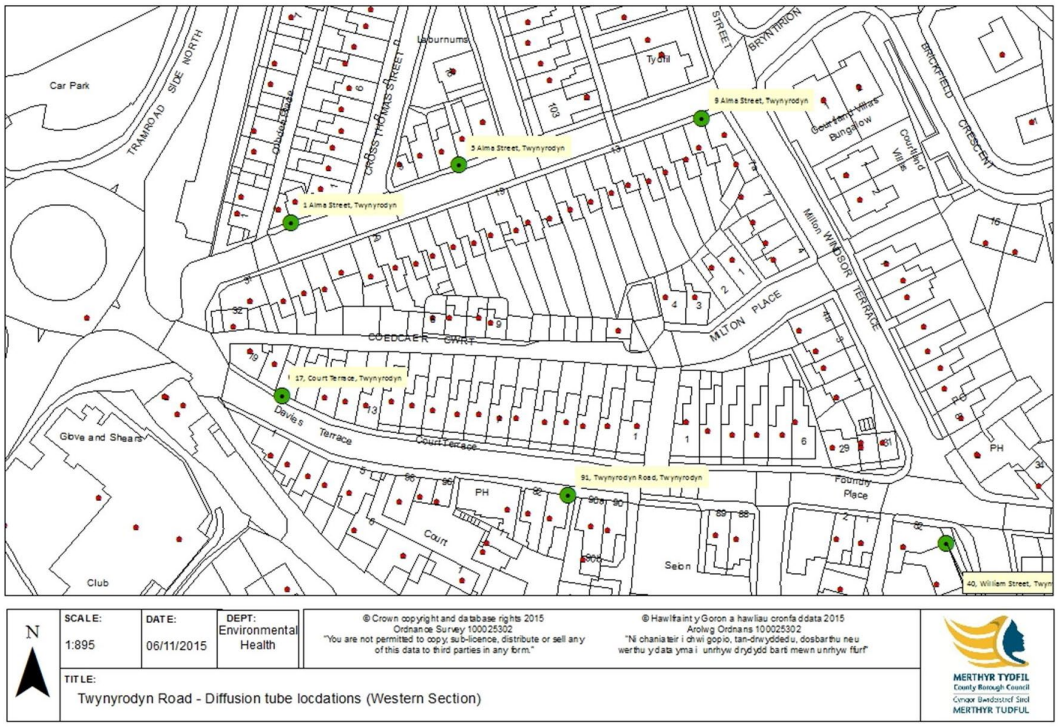


Figure 2.1 c: Diffusion tube locations along Twynyrodyn Road, Eastern section

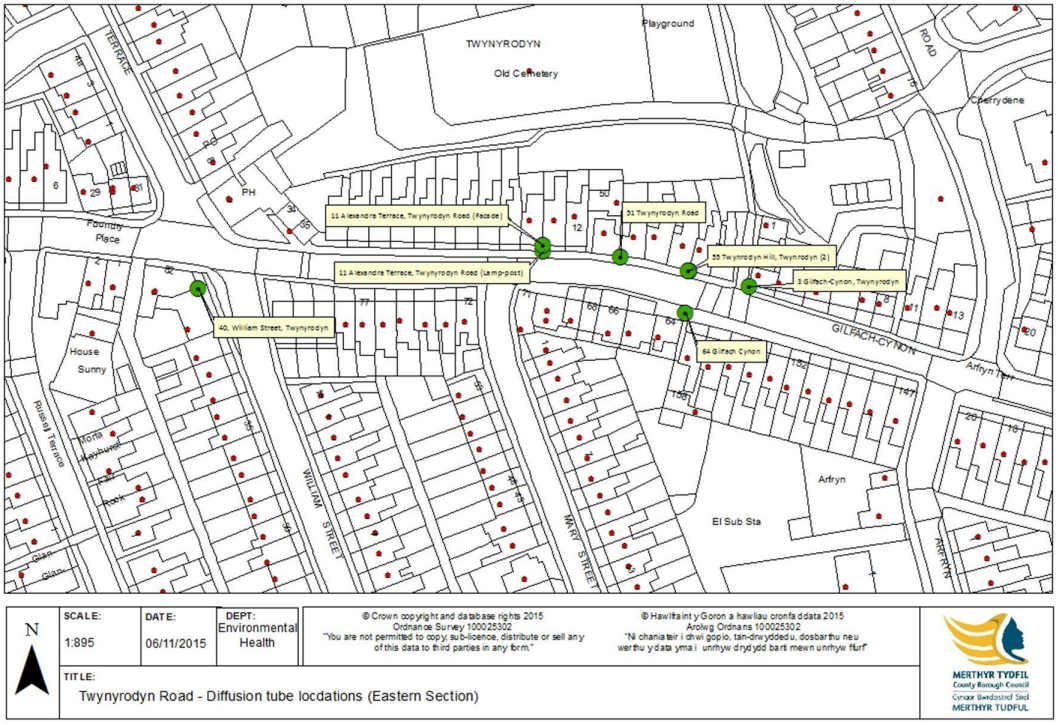
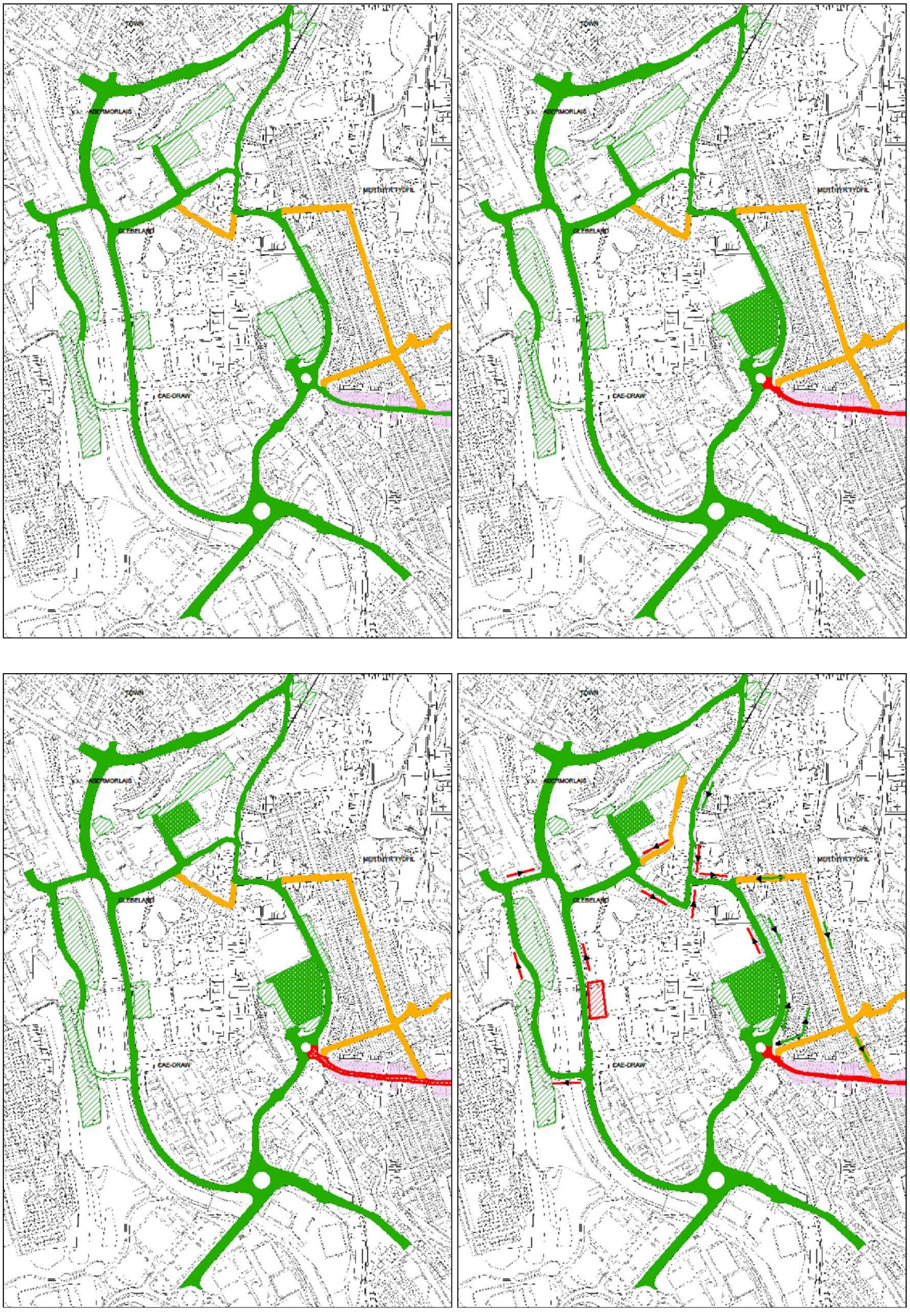


Figure 2.2: Merthyr Tydfil town centre key road network and car parking: a, b//c, d



Figures 2.2 a, b, c and d show stages in the development of the road network in the town centre in recent years. Roads shown in green are key routes between the town centre and outlying suburbs or the trunk road network (only relevant sections are highlighted). Amber roads are through routes of lesser significance. Twynyrodyn Road is highlighted in solid red when the nitrogen dioxide levels measured at the time are high and outlined in red when more marginal. If a road has no direction markers it is either two-way or considered insignificant. Green road direction markers show unchanged one-way roads and red markers show one-way roads where the road direction has changed.

Figure 2.2a (top left) reflects the situation prior to 2010 when nitrogen dioxide levels on Twynyrodyn Road were consistently below the objective level. Approximately one third of the supermarket car park is two-storey at this time.

Figure 2.2b reflects the situation after the car park of the supermarket at the western end of Twynyrodyn Road was upgraded in 2010 by extending the second level over most of the remaining open car park. This was suspected of being a significant factor when the diffusion tube results were found to have increased but the mechanism involved was unclear.

Figure 2.2c (bottom left) shows the situation around 2012. At this time traffic calming and road centre re-alignment works had been completed on Twynyrodyn Road and the Council's main, Castle Street, car park had been upgraded to provide an additional two levels. This had originally been an open car park.

Figure 2.2d (bottom right) shows the road network in 2014 after it had been substantially revised by the addition of a gyratory system to the west of the town centre and changes made to the road priorities in the town centre in connection with environmental improvements and pedestrianisation.

These alterations included closing off a road link north-east of the existing bus station (visible on plan as two large loops) and replacing it with a one-way network. This alteration is detailed in Figure 2.3 which shows the original two-way road link between Castle Street and the north-south road link to the east (High Street) cross-hatched in green. At this time the section of High Street connecting this to Church Street, as well as Church Street itself, can also be seen to be two-way.

Figure 2.3 Road Details 2010 and 2014 (Pre and Post Revision)

In 2010, traffic leaving the supermarket could reach the northern suburbs by using this road link. However, by 2014 this road link had been closed, requiring traffic leaving the supermarket to travel to the northern suburbs to use the traffic island at the western end of Twynyrodyn Road instead. From this point traffic could travel around the gyratory system but the most direct route to the north of the Borough and to the trunk road network is via Twynyrodyn Road itself.

During this period a change was made in the car parking tariffs for the council's town centre car parks to encourage the public's use of the new town centre by favouring long-stay parking against short-stay. The terms of use for the supermarket car park encourage short-stay visiting and it gives easy access to the town centre. This combination of factors is believed to have proportionally increased the use of the supermarket car park.

A relatively small, but probably significant, car park close to the main town centre shopping area, has also been closed to the public to enable construction of a new bus station nearby. This change permanently displaces vehicles to other, nearby, car parks.

The traffic levels measured on Twynyrodyn Road in July 2015 show a distinct increase above those previously measured and, in addition, also show a clear imbalance in east and west-bound traffic with significantly larger numbers of vehicles leaving the town at the end of the day than travel to it at the start of the day. Road users entering the town by various routes appear to be funnelling through the traffic island at the western end of Twynyrodyn Road to leave; possibly after stopping at the supermarket for evening shopping.

3. Monitoring study

3.1 Scope and methodology

This assessment is focussed on NO_2, rather than a broader range of air pollutants. This is as there is a history of elevated NO_2 concentrations at diffusion tube locations along Twynyrodyn Road.

At Twynyrodyn School there is a TEOM, part of the AURN. This station has not detected any exceedances of the PM_{10} AQO. There are no fossil fuel power stations within Merthyr Tydfil therefore exceedances of the SO_2 AQO is considered unlikely. There are no petrol stations along Twynyrodyn Road therefore exceedances of the benzene AQO and the 1,3-butadiene AQO are considered unlikely. There are no relevant industries within the borough therefore exceedances of the lead AQO are considered unlikely. There are no reasons to suspect vehicle usage along Twynyrodyn Road would result in incomplete combustion therefore exceedances of the CO AQO are considered unlikely.

Air quality was monitored for a period of 12 months. This was from April 2014 to March 2015. This period was used as the detailed assessment intends to use both diffusion tube and real time data. The real time ECC monitor was installed in January 2014, and there was a brief period of stabilisation. Data of a suitable quality was obtained from April 2014 onwards. To allow comparison diffusion tube data from the network for the corresponding period has been used.

Diffusion tubes are clustered around 55 Twynyrodyn Road to delineate the area of exceedance. Diffusion tube data was bias adjusted. As it was from 2 calendar years, data from each month was bias adjusted and the mean obtained from the bias adjusted results. 2014 data was bias adjusted by 0.79, obtained from the National bias adjustment spreadsheets. A National bias adjustment factor was not available for 2015 data, so the data was adjusted by 0.85, the modal mean of bias adjustment factors from 2006 – 2014. This was considered to provide a reasonable approximation.

Real time data has been used to examine short term variations in order to indicate the cause(s) of the exceedance. 15 minute real time NOx readings have been screened for short term exceedances, and compared with traffic data and meteorological data.

3.2 Meteorological data

MTCBC does not operate a meteorological station but a major coal producer in the Borough maintains a meteorological facility at their AURN station at Twynyrodyn Infants School to assist in the tracking of particulates. Maintaining this AURN station was required as a planning condition for the development. The parameters recorded are temperature, humidity, rainfall, wind speed and wind direction. The company has made this data available for the purposes of the current air quality assessment.

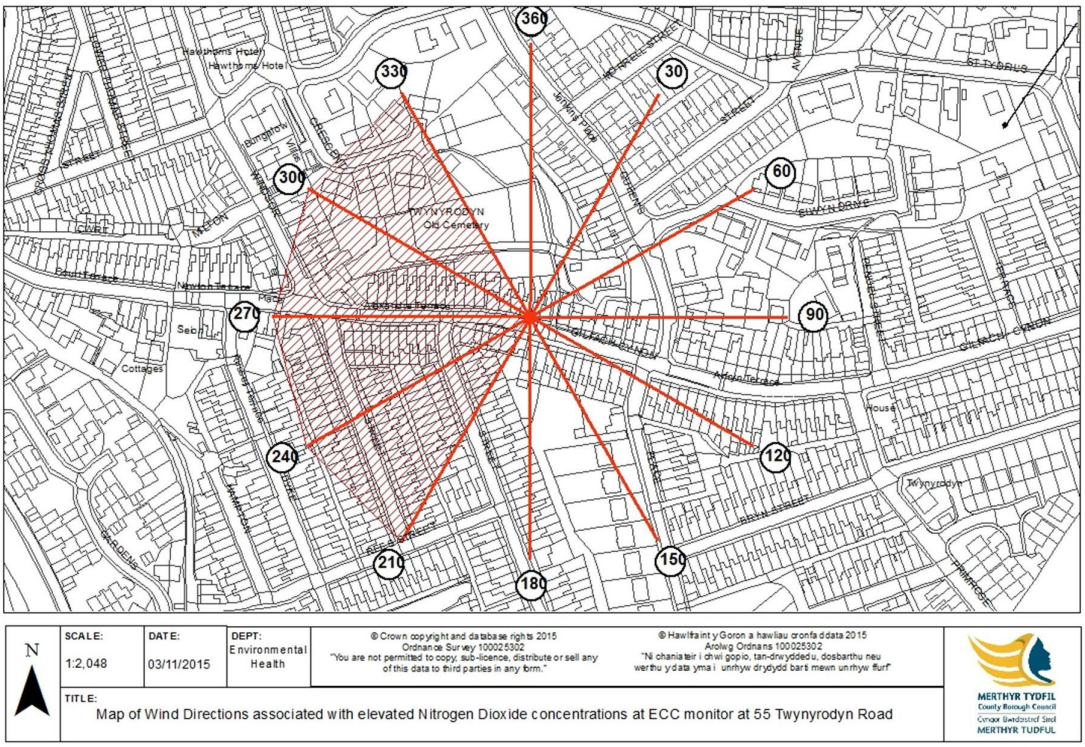
In addition, the ECC monitor located at 55 Twynyrodyn Road records temperature, relative humidity and atmospheric pressure.

A comparison has been made between temperature measured at the two locations and these have been found to be broadly comparable although there appears to be a local heat gain due to the ECC pod design and location.

Wind direction for the locality is generally South-Westerly and this was the case for the period studied.

Figure 3.1 shows an overview of correlating NO_2 levels against wind direction. NO_2 levels recorded were highest when the wind was blowing from the sectors highlighted i.e. South-Westerly to North-Westerly. A narrower wind direction band, centering on 105°, also provides a secondary contribution. This is shown in greater detail in Section 4.2.

Figure 3.1: Map of wind-rose directions primarily associated with elevated nitrogen dioxide at ECC monitor at 55 Twynyrodyn Road



A study was also made of the variance in nitrogen dioxide levels with wind speed. This indicates that the majority of high NO_2 concentrations occurred at low wind speeds; typically below 3m/s. The results of the study are shown in greater detail in Section 4.3 and Appendix 5.

3.3 Terrain and land use

As previously stated Twynyrodyn Road is a residential street. It has two-storey terraced housing on both sides with a significant proportion of these opening directly onto the pavement as they lack private front exterior space. The road is steep, with in excess of 50m increase in height from the Western end to the Eastern end of the road (Figure 3.2). In combination this appears to result in a minor canyon effect causing nitrogen dioxide emissions to concentrate as low wind-speeds move vehicle emissions along the line of the east-bound, uphill traffic.

Figure 3.2: Twynyrodyn Road aerial photograph with 5m contours

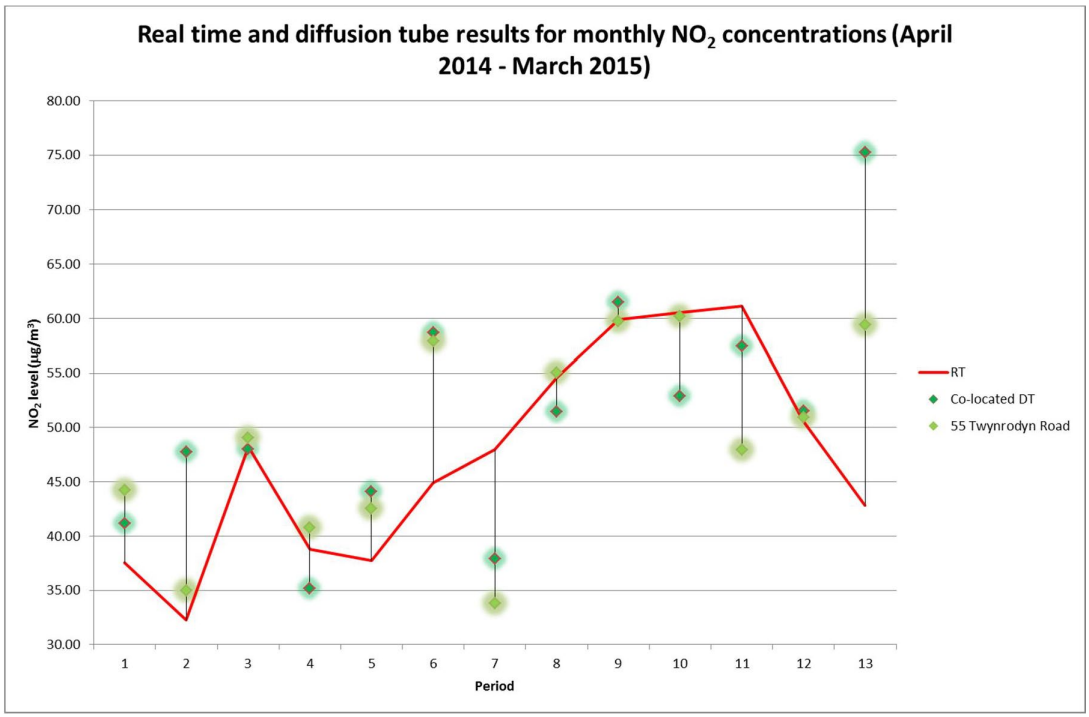
N	SCALE: 1:4,612	DATE: 06/11/2015	DEPT: Environmental Health	© Crown copyright and database rights 2015 Ordnance Survey 100025302 "You are not permitted to copy, sub-licence, distribute or sell any of this data to third parties in any form."	© Hawlfraint y Goron a hawliau cronfa ddata 2015 Arolwg Ordnans 100025302 "Ni chaniateir i chwi gopio, tan-drwyddedu, dosbarthu neu werthu ydata yma i unrhyw drydydd barti mewn unrhyw ffurf"	MERTHYR TYDFIL County Borough Council Cyngor Bwrdeistref Sirol MERTHYR TUDFUL
	TITLE: Twynrodyn Hill - 5m contours increasing in height above ground level from West to East					

4. Results

4.1 NO_2 real time monitoring

The ECC method used for real time monitoring is not as accurate as the chemiluminescent method but the results obtained were found to be broadly consistent with co-located diffusion tubes over the same exposure periods. Both methods indicated the annual mean AQO would be exceeded.

Figure 4.1: Comparison between real time and diffusion tube monitoring at 55 Twynrodyn Road



The shorter averaging time of the ECC monitor revealed nitrogen dioxide levels tended to be at their highest on weekday afternoons and early evenings with a shorter duration peak at around 08:00 hrs. Whilst this was attributed to the rush hour traffic further study provided additional detail on the mechanisms involved.

The NO_2 monitoring data was compared with data obtained both from the meteorological station at Twynyrodyn Infants School and from traffic counts on Twynyrodyn Road. These comparisons revealed the NO_2 concentrations to be influenced by the following factors;-

4.2 Wind direction and NO_2 concentrations

As stated in Section 3.2 when the wind direction ranged between South-Westerly and North-Westerly higher levels of nitrogen dioxide were detected.

This is of significance as the alignment of the road leading uphill to the area of likely exceedance corresponds with the prevailing wind direction, running West to East. This serves to carry emissions along the length of the road rather than dispersing them to either side. In addition it is believed the houses in the area of Alexandra Terrace may be concentrating the traffic emissions into the relatively narrower space in the region of 51 Twynyrodyn Road. (See figure 3.1).

Figures 4.2 and 4.3 show the distribution of wind-directions measured at Twynyrodyn Infants School against the NO_2 concentrations measured for the same time periods. The alignment of the peaks in Figure 3.3 shows generally high frequencies of elevated NO_2 readings associated with wind speeds in bands centered around 105° (easterly) and 265° (westerly). However these numbers do not reflect the actual concentrations recorded. When the numbers of readings for each wind direction are weighted according to the concentrations recorded the results, shown in Figure 3.4 more clearly show an association of NO_2 levels with the westerly wind direction. The traffic travelling westerly is closer to the monitor than vehicles travelling easterly. Westerly emissions will also be increased as these vehicles are travelling uphill. Additionally vehicle counts show that much larger numbers of vehicles travel westerly than easterly on this road.

Figure 4.2:

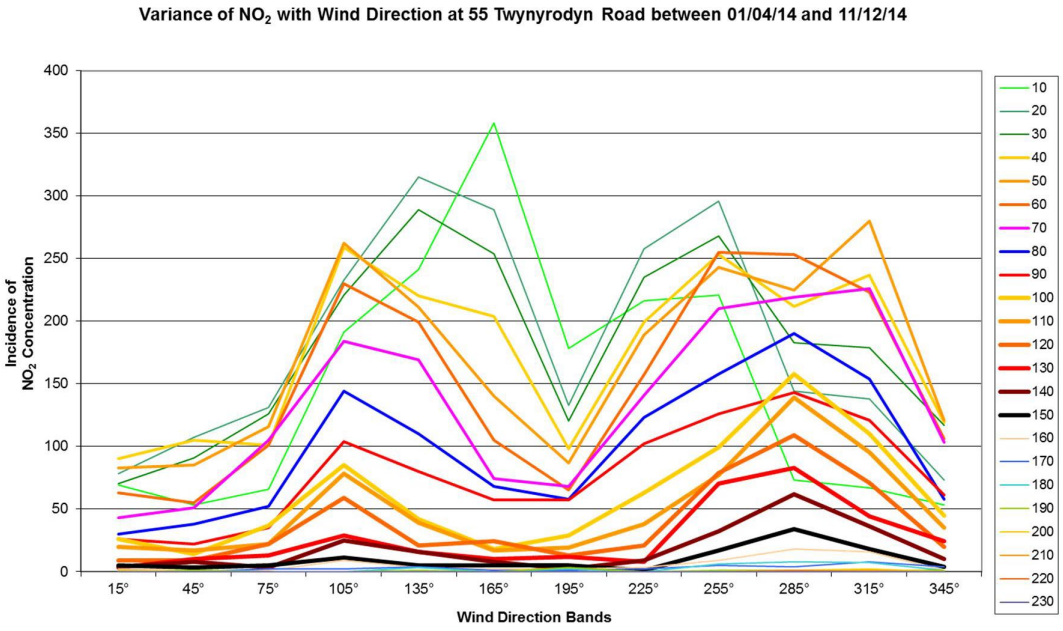
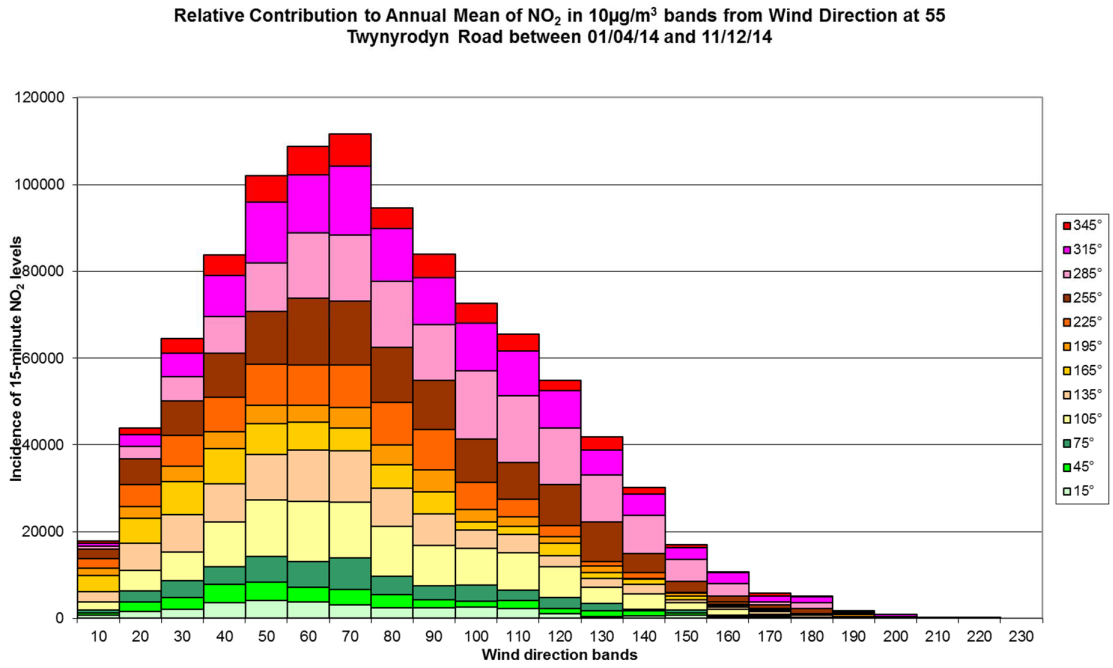


Figure 4.3:



4.3 Wind speed and NO_2 concentrations

Figures 4.4 and 4.5 provide the results of a similar study of wind speed against measured NO_2 levels.

These show a strong association between higher NO_2 levels and lower wind speeds with the highest concentrations occurring in calm conditions or light winds.

This has significance as road improvement works should avoid lowering wind speed e.g. the planting of nitrogen fixing plants may be counterproductive if they reduce air flow through the road corridor.

Figure 4.4:

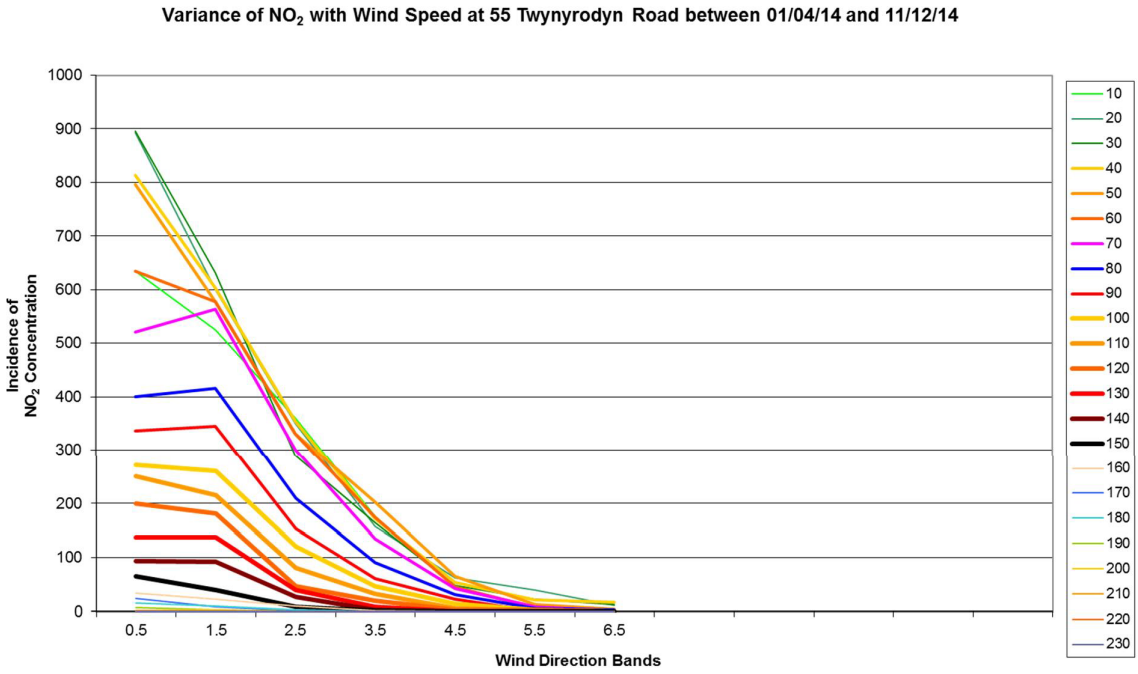
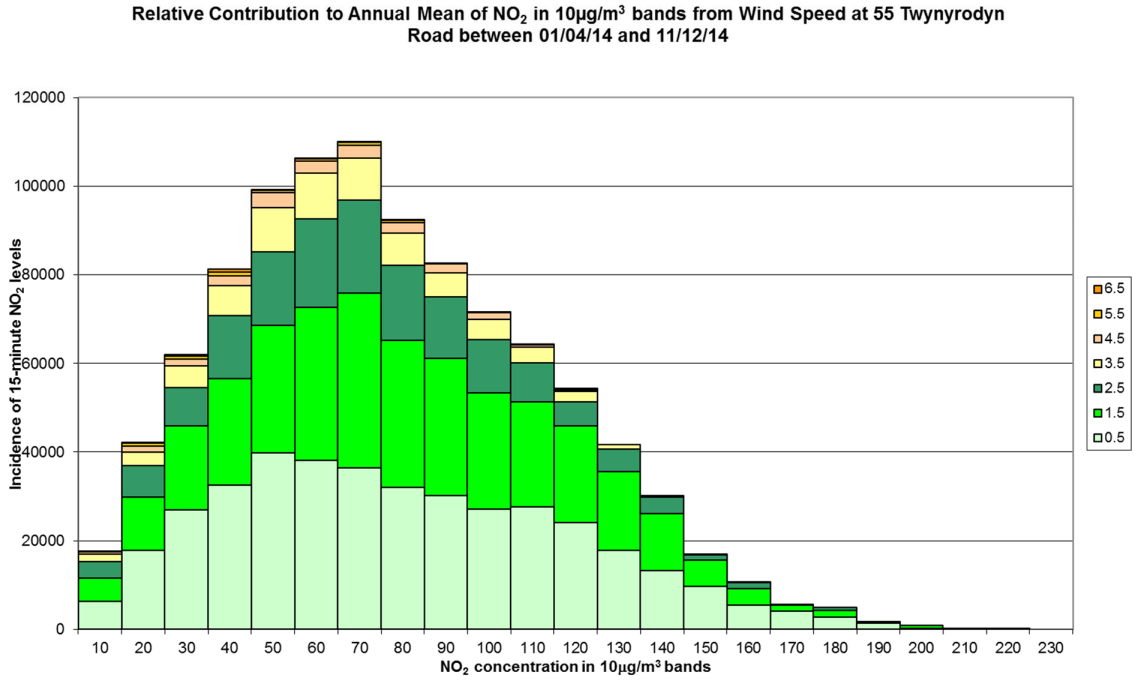


Figure 4.5:



4.4 Traffic flow and NO_2 concentrations

Comparison of hourly nitrogen dioxide averages against hourly uphill traffic flows under typical conditions revealed elevated concentrations at the same time of day as peaks in uphill traffic i.e. at around 16:00hrs. At the same time of day downhill traffic flow was relatively light.

In contrast, the hourly peak in downhill traffic occurring at around 08:00hrs was relatively brief and the association with higher NO_2 concentrations was much less obvious. Figure 4.6 shows this data for the period 09/07/15 to 19/07/15.

A traffic assessment had previously been carried out for the period 25/06/15 to 05/07/15 but during the course of the exercise it became apparent that traffic control had been installed on Twynyrodyn Road by local builder. The traffic flow in this period was therefore atypical and necessitated a further traffic assessment. However, by co-incidence, the traffic control involved coning off the uphill carriageway from approximately the middle of Alexandra Terrace up to 51 Twynyrodyn Hill and installing traffic lights. This was analogous to the traffic control measures being considered as part of the draft action plan and this period was therefore also studied to give an insight into the likely effects of installing the traffic management. The results of the traffic study for the period 25/06/15 to 05/07/15 are shown in Figure 4.7.

These results show that although the general pattern of traffic flow was similar in both periods a clear reduction in both nitrogen dioxide levels and traffic flow occurred when the traffic control was active.

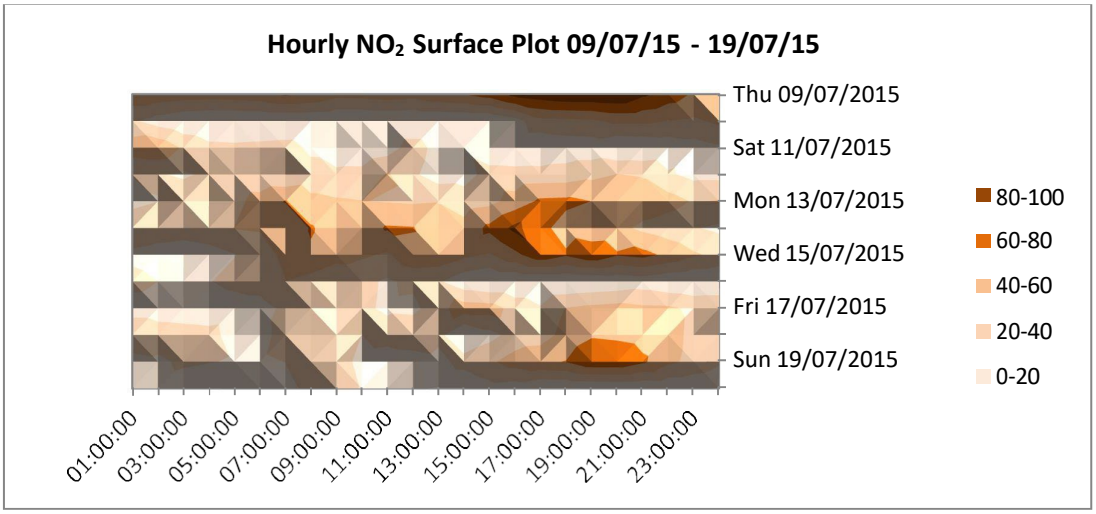
Twynyrodyn Road is used by commuters, travelling downhill in the morning and uphill in the late afternoon/evening. There is a brief peak of downhill traffic in the morning and a more sustained peak in the late afternoon/evening for uphill traffic. This suggests traffic travels into the town centre by alternative routes but leaves via Twynyrodyn Road at the end of the working day. There are a numbers of factors which are believed to have amplified the traffic conditions which existed prior to 2008, and caused subsequent exceedances. These factors include:

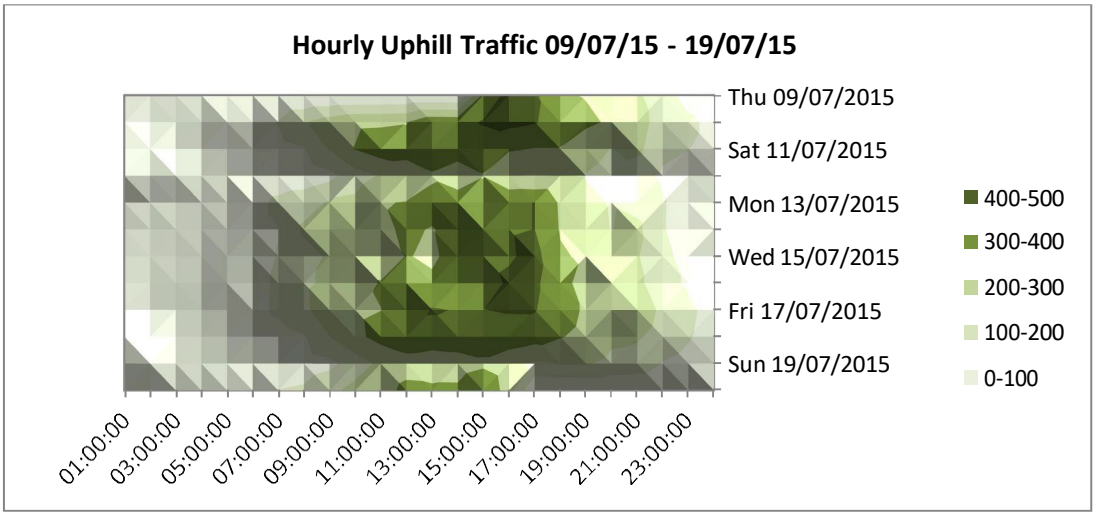
- Enlargement of Tesco supermarket and associated parking;
- Changes to the layout of entrances and exits to parking at Tesco encouraging a progressive increase in traffic onto Twynyrodyn Road;
- Alteration of Town Centre layout, particularly in 2013, specifically the introduction of areas of one-way traffic, leading traffic towards the traffic island outside Tesco at the Western end of Twynyrodyn Road;

- During the period the alternate road layout was being constructed the parking tariffs for the town centre were altered to encourage longer stays to revitalise the town centre economy. This has encouraged people seeking short stay parking to park at Tesco.

There has been an increase in the numbers of road users on Twynrodyn Road. It is suspected an increasing proportion of road users go to Tesco carpark (this carpark serves the town centre shops as well as Tesco) at the end of the working day then leave the town centre via Twynyrodyn Road. The changes to the access and road network do not encourage traffic leaving by other routes. This was to some extent moderated by traffic calming undertaken prior to the alterations of the town centre layout. During this period there was a brief reduction in the annual mean NO_2 concentration, however the improvement was not maintained when the traffic layout was altered.

Figure 4.6: Comparison of hourly NO_2 concentrations with vehicle numbers on the uphill (West to East) and downhill (East to West) carriageway – typical conditions





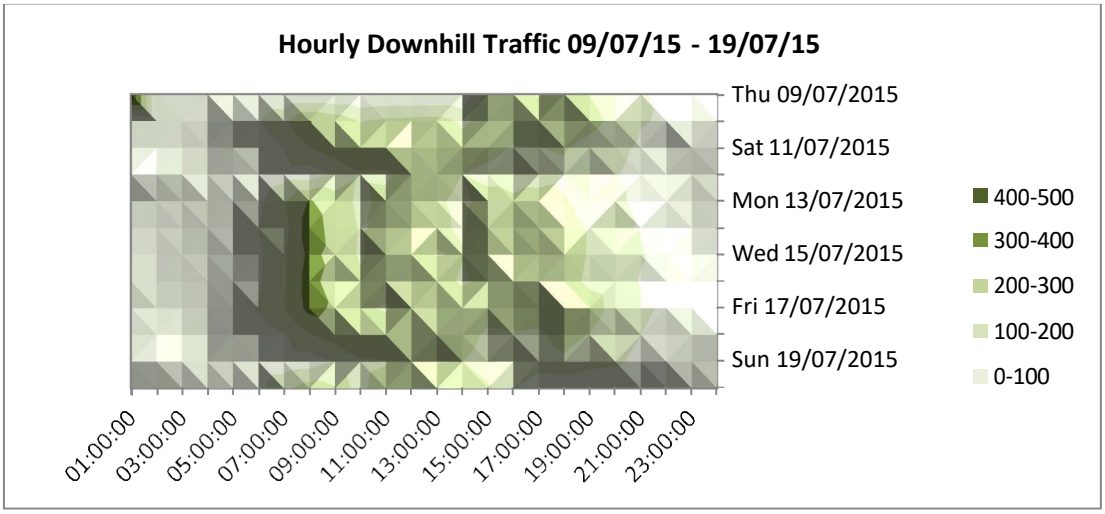
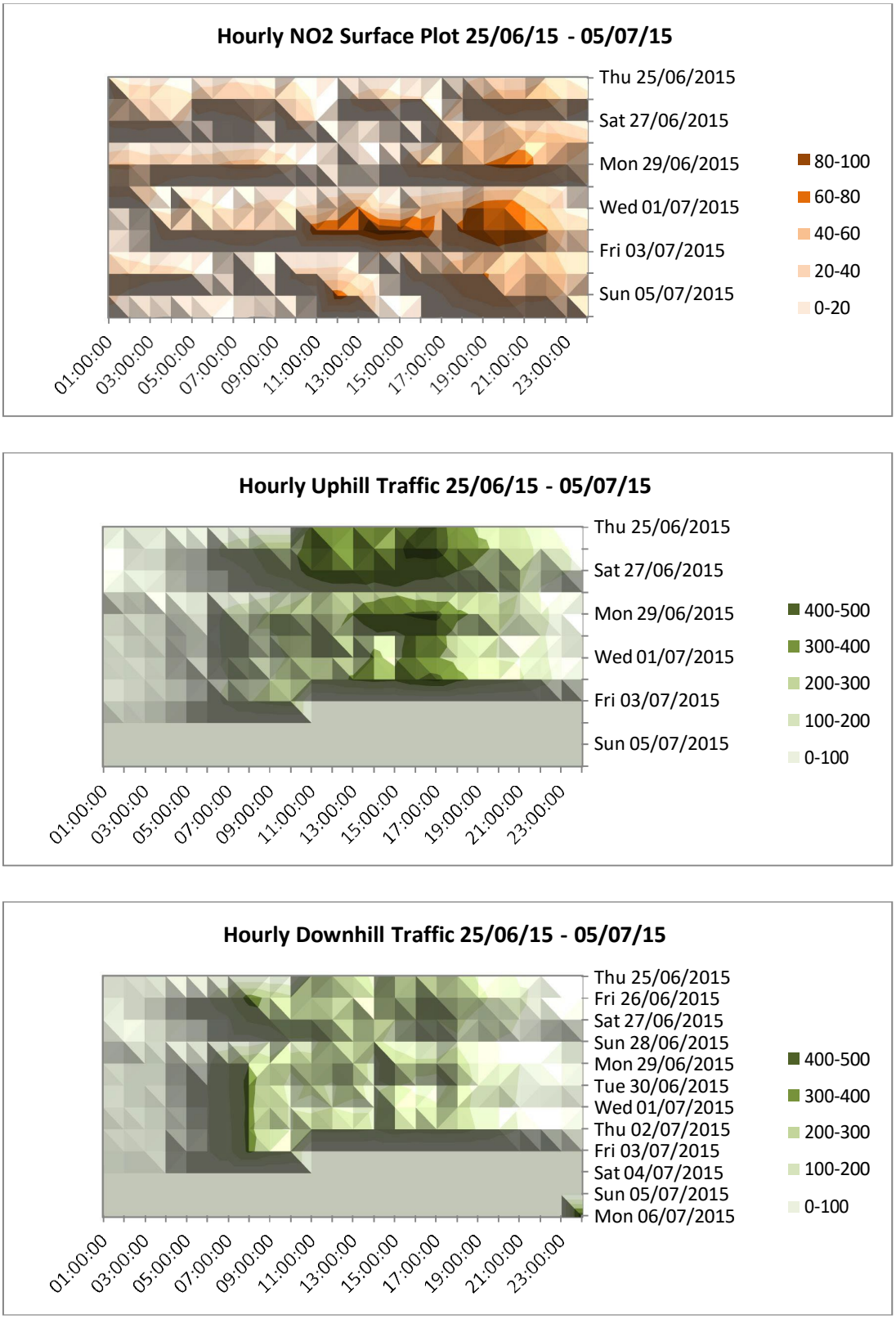


Figure 4.7: Comparison of hourly NO_2 concentrations with vehicle numbers on the uphill (West to East) and downhill (East to West) carriageway – atypical conditions



4.5 NO_2 diffusion tube data

The tubes within the district can be grouped into 4 categories: “Area of likely exceedance” for tubes between Alexandra Terrace and 64 Gilfach Cynon; “Other Twynyrodyn Road” for tubes located along Twynyrodyn Road West of Alexandra Terrace or East of 64 Gilfach Cynon; “Other roads” for tubes located on other roads within MTCBC; and “Background” for background sites within MTCBC. As shown by Table 4.1 the AQO was exceeded at 4 of 6 sites within the area of likely exceedance. The AQO was not exceeded at any other sites. It is worth noting background concentrations were in line with Defra predictions in Table 2.2.

Figure 4.8 shows NO_2 concentrations throughout the year, April 2014 to March 2015. There are no sites with results in excess of 60$\mu g/m^3$ NO_2. This indicates it is unlikely the hourly objective is exceeded, which has been supported by the real time monitoring. Sites clustered around 55 Twynyrodyn Road, the area of likely exceedance, have NO_2 concentrations in excess of 40$\mu g/m^3$ from September 2014 to March 2015, resulting in an annual exceedance of the AQO in this area. Other sites along Twynyrodyn Road have elevated NO_2 compared to other roads, however the readings are at no time in excess of 40$\mu g/m^3$.

Table 4.1: Annual mean NO_2 concentrations at sites throughout Merthyr Tydfil County Borough

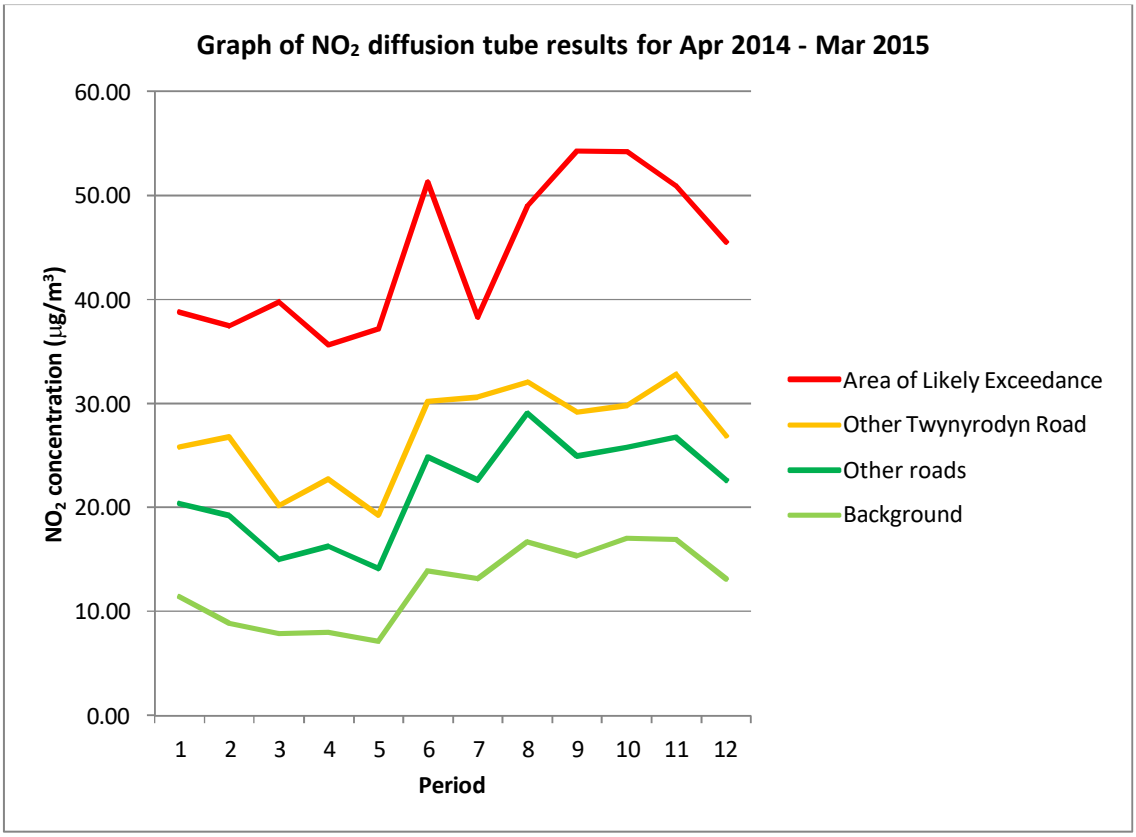
Site ID	Location	Site Type	Description	Triplicate or Co-located Tube	Data Capture (Number of Months from April 2014 to March 2015)	Annual Mean Concentration ($\mu g/m^3$) (Bias adjusted)
29	55 Twynyrodyn Road	Roadside	1 - Area of likely exceedance	Y	12 (of 12)	**48.1**
29H	51 Twynyrodyn Road	Roadside	1 - Area of likely exceedance	N	12 (of 12)	**47.5**
29I	3 Gilfach Cynon	Roadside	1 - Area of likely exceedance	N	12 (of 12)	37.5
29J	55 Twynyrodyn (co-located tube)	Roadside	1 - Area of likely exceedance	Y	12 (of 12)	**49.0**
38	11 Alexandra Terrace, lamppost	Roadside	1 - Area of likely exceedance	Y	12 (of 12)	**46.1**
39	11 Alexandra Terrace, façade	Kerbside	1 - Area of likely exceedance	N	12 (of 12)	38.0

Site ID	Location	Site Type	Description	Triplicate or Co-located Tube	Data Capture (Number of Months from April 2014 to March 2015)	Annual Mean Concentration (µg/m^3) (Bias adjusted)
29E	40 William Street	Roadside	2 - Other Twynyrodyn Road	N	11 (of 12)	22.8
29A	91 Twynyrodyn Road	Roadside	2 - Other Twynyrodyn Road	N	10 (of 12)	29.1
29B	15 Arfryn Terrace	Roadside	2 - Other Twynyrodyn Road	N	11 (of 12)	33.6
29D	17 Court Terrace	Roadside	2 - Other Twynyrodyn Road	N	12 (of 12)	31.5
29F	Mardy Street, Mount View	Roadside	2 - Other Twynyrodyn Road	N	11 (of 12)	22.9
29G	64 Gilfach Cynon	Roadside	2 - Other Twynyrodyn Road	N	12 (of 12)	23.2

Site ID	Location	Site Type	Description	Triplicate or Co-located Tube	Data Capture (Number of Months from April 2014 to March 2015)	Annual Mean Concentration (µg/m^3) (Bias adjusted)
1	Imperial Hotel	Roadside	3 - Other roads	N	9 (of 12)	24.2
2	Civic Centre	Urban background	3 - Other roads	N	11 (of 12)	16.8
15	Victoria Street	Urban centre	3 - Other roads	N	9 (of 12)	26.0
25	Upper Dowlais	Roadside	3 - Other roads	N	12 (of 12)	26.0
36	15 Lower High Street	Roadside	3 - Other roads	N	12 (of 12)	28.3
42	5 Alma Street	Roadside	3 - Other roads	N	12 (of 12)	16.9

Site ID	Location	Site Type	Description	Triplicate or Co-located Tube	Data Capture (Number of Months from April 2014 to March 2015)	Annual Mean Concentration (µg/m^3) (Bias adjusted)
43	9 Alma Street	Roadside	3 - Other roads	N	12 (of 12)	18.1
44	1 Alma Street	Roadside	3 - Other roads	N	12 (of 12)	20.1
3	Twynyrodyn Infants School	Suburban	4 - Background	N	10 (of 12)	12.3
16	Six Bells Estate	Suburban	4 - Background	N	12 (of 12)	11.9
30	Quakers Yard	Suburban	4 - Background	N	12 (of 12)	13.2
31	4 Erw Las	Suburban	4 - Background	N	12 (of 12)	12.0

Figure 4.8: Monthly NO_2 concentrations April 2014 – March 2015 for the 4 categories of site



Diffusion tube data for the twelve month period was grouped into four categories to establish whether there were any local effects in the area of likely exceedance independent of the seasonal variations for the period (shown by in the background group). The sites follow a generally similar pattern which is to be expected as the background levels for the area are reflected in all groups. The pattern of results for the area of likely exceedance are very much more marked. This is possibly due to the higher NO_2 levels generated on the road being subject to the same dispersion conditions as the rest of the Borough. The levels in the area of likely exceedance are significantly higher than those for the other sites in Twynyrodyn Road. This indicates the existence of a local factor either increasing NO_2 emissions or lowering NO_2 dispersion, or a combination thereof, in the area of likely exceedance.

5. Outcome of detailed assessment

The monitoring report has identified a breach of the annual NO_2 Air Quality Objective where receptors are likely to be exposed for a period of time appropriate to the averaging period. In this instance residents are likely to be exposed to elevated NO_2 concentrations throughout the course of a year.

On this basis it is considered necessary to declare an AQMA.

5.1 Area and population affected

It is proposed to designate an AQMA from the roundabout at the Western end of Twynyrodyn Road to junction with Queens Road and Arfryn Place East of 64 Gilfach Cynon (Figure 5.1). The area of likely exceedance falls within this area, and is considered to incorporate 1-12 Alexandra Terrace, 51-56 Twynyrodyn Road, 3-13 Gilfach Cynon (North side of Twynyrodyn Road) and 64-81 Twynyrodyn Road, and 147-157 Gilfach Cynon (South side of Twynyrodyn Road). At this stage MTCBC has chosen to designate an AQMA extending beyond the area of likely exceedance. This is as it will enable road improvement works throughout the length of the road to be monitored to determine whether the exceedance has been addressed or shifted to another section of road. MTCBC will consider whether the AQMA should be removed or reviewed at a later stage.

5.2 Estimated population size within proposed AQMA

Within their Detailed Assessments, local authorities are required to estimate the number of people exposed to pollutant concentrations above the objectives, and the maximum pollutant concentration (measured or modelled) at a relevant receptor location. This information is required to help Defra and the devolved administrations quantify the health benefits of improving air quality within the LAQM regime. DEFRA acknowledge that it is not feasible to take into account subtleties such as transient exposure (e.g. at schools) or exposure at different heights within these assessments, and authorities should assume that the residential population is representative of exposure within the exceedance area. Total relevant exposure has been estimated within the Twynyrodyn Road using Merthyr Tydfil County Borough Council's Geographic Information System (GIS) and average household size for Merthyr Tydfil as identified by the 2011 census. The information is shown in Table 5.1 below.

Figure 5.1: Proposed AQMA

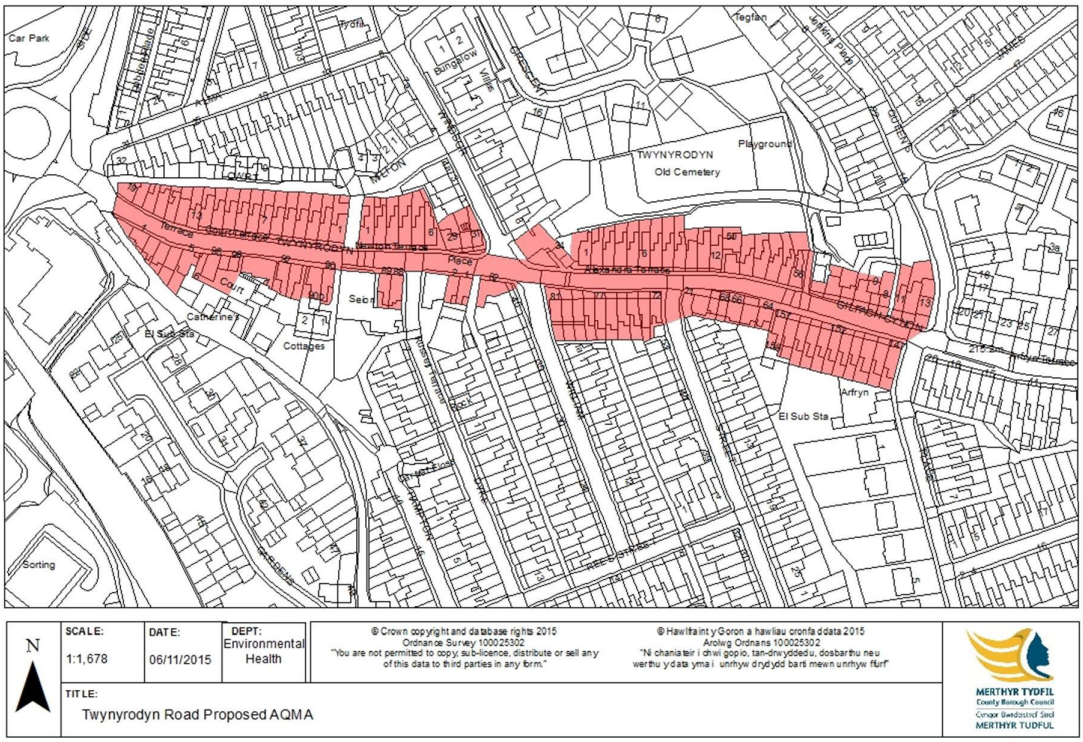


Table 5.1: **Estimated number of residential properties located within predicted** area of exceedance

Area	Residential properties	Equivalent population (No. Properties x 2.3)
Predicted possible area of exceedance	113	260

6. Recommendations

The following recommendations are made based on this Detailed Assessment report:

- Undertake formal consultation on the detailed assessment.
- Declare an AQMA in the vicinity of Twynyrodyn Road incorporating the aforementioned addresses.
- Continue to work with the Highways Department, developing an Action Plan to improve traffic flow in the area, reducing vehicle-related NO_2 exceedances.
- Assess changes through continued monitoring and further assessment.

References

- Defra, 2009, Local Air Quality Management Technical Guidance LAQM.TG(09)
- Defra, 2007, The Air Quality Strategy for England, Scotland, Wales and Northern Ireland (Volume 1)
- MTCBC, 2014, 2014 Air Quality Progress Report
- National Assembly for Wales, 2010, Air Quality Standard (Wales) Regulations 2010
- Welsh Assembly Government, 2009, Local Air Quality Management Local air quality management policy guidance for Wales

Appendices

Appendix 1: NO_2 diffusion tube data (Unadjusted)

MTCBC	Site No.	Name	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1	WAQF 001	Imperial Hotel	22	27.1	20.4		18.3			42.3	33.4	36.4	37.1	30.7
2	WAQF 002	Civic Centre	22.3	22.3	19.3	18.2	16.5	24.1	24.9		25.6	10.5	25.1	20.4
3	WAQF 003	Twynyrodyn Infants School	14.5	12.7	11.4	10.3	9.4	22	18.7		17.3	17.7	15.7	17.6
15	WAQF 015	Victoria St taxi rank		20.1	19.2			26.8	27.9	39.6	44	43.7	38.5	28.4
16	WAQF 016	Six Bells Estate	13.4	7.7	9	7.8	7.4	15.2	14.1	19.2	20.8	23.6	22.5	15.9
25	WAQF 025	Dowlais Upper	31.7	36.4	23	27.2	25.7	43.2	31.6	40.4	34.5	34.2	29.5	29.8
29	WAQF 029	55 Twynyrodyn Road	56	44.3	62.1	51.6	53.8	73.3	42.8	69.7	75.6	70.8	56.4	59.9
30	WAQF 030	Quakers Yard	15.3	13.1	10.3	11.8	9.8	16.2	16.5	23.6	22.7	20.7	21.8	14.7
31	WAQF 031	Erw Las	14.6	11.5	9.3	10.7	9.8	16.8	17.2	20.6	17	18	19.7	13.6
36	36	15 Lower High Street	36.7	36.9	28.7	28.7	26.6	43.9	36.7	45.3	29.1	36.9	37.6	33.6
38	38	11 Alexandra Terrace - lamppost	43.7	49.1	59.3	40.7	47.8	67.8	54.6	59.6	70.4	66.9	67.4	58.8
39	39	11 Alexandra Terrace -	39.5	46.8	37.3	39.2	31.8	50.1	42.7	55.7	70.7	56.3	47.5	47.3

		façade												
42	42	5 Alma Street	21.1	16.6	14	15.3	14.1	23.9	22.9	30.9	27	23.2	20.9	21.3
43	43	9 Alma Street	22.2	15.7	13.5	14.1	14.5	25.2	27.5	25.7	27.5	28	30.5	24.7
44	44	1 Alma Street	24.8	19.1	13.5	20	9.5	32.7	28.9	33.2	31.5	29.3	32.5	23.9
29A	29A	91 Twynyrodyn Road	39	35.1	28.7	34	31.9	41.9	36.1		42.5	41.3	31.6	
29B	29B	15 Arfryn Terrace	42.3	43.7	33.6	34.5	31.3		55.2	44.9	44.6	39.3	50.3	38.6
29D	29D	17 Court Terrace	36.4	50.3	24.4	30.4	28.7	46.7	41.9	50.4	35.9	38	47.4	37.9
29E	29E	40 William St	27.2	22		26.6	19.2	29	31.8	30.8	35.1	30.5	31.1	28
29F	29F	Mount View Mardy St	28.8	29.9	20.1	20.2	16.2		32.6	38.1	31.8	27.6	40	25.7
29G	29G	64 Gilfach Cynon	22	22.6	20.9	27	19	35.5	34.7	38.8	31.7	33.5	31	28.2
29H	29H	51 Twynyrodyn Road	57.8	42.9	48.9	54.9	53.3	66.3	62.9	68.6	60.6	70	63	57.6
29I	29I	3 Gilfach Cynon	45.2	40.9	33.5	39.7	39.6	57.2	39.9	53.5	56.8	56.5	57.4	37
29J	29J	Colocated site, 55 Twynyrodyn Road	52.1	60.4	60.8	44.5	55.8	74.3	48	65.1	77.8	62.2	67.6	60.6

Appendix 2: Monthly NO_2 data for real time ECC and Diffusion tubes

			Period Means		
Period	**From**	**To**	**RT**	**Co-located DT**	**55 Twynrodyn Road**
1	01/04/14	24/04/14	37.54	41.16	44.24
2	24/04/14	15/05/14	32.27	47.72	35.00
3	15/05/14	10/06/14	48.22	48.03	49.06
4	10/06/14	02/07/14	38.79	35.16	40.76
5	02/07/14	30/07/14	37.72	44.08	42.50
6	30/07/14	04/09/14	44.89	58.70	57.91
7	04/09/14	01/10/14	47.97	37.92	33.81
8	01/10/14	29/10/14	54.61	51.43	55.06
9	29/10/14	04/12/14	59.90	61.46	59.72
10	04/12/14	08/01/15	60.52	52.87	60.18
11	08/01/15	03/02/15	61.14	57.46	47.94
12	03/02/15	04/03/15	50.60	51.51	50.92
13	04/03/15	07/04/15	42.84	75.23	59.42

Appendix 3

Appendix 3a: Traffic Data Period 1

Traffic Flow Up	Thu 25/06/2015	Fri 26/06/2015	Sat 27/06/2015	Sun 28/06/2015	Mon 29/06/2015	Tue 30/06/2015	Wed 01/07/2015	Thu 02/07/2015	Fri 03/07/2015
01:00:00		21	40	53	14	13	11	10	18
02:00:00		10	28	31	10	5	7	7	9
03:00:00		18	16	24	6	9	2	5	7
04:00:00		8	6	5	13	8	6	10	16
05:00:00		31	19	6	37	39	41	27	32
06:00:00		51	36	13	43	62	51	63	58
07:00:00		137	58	33	127	124	121	99	122
08:00:00		186	108	40	158	191	159	151	193
09:00:00		276	225	66	219	191	171	196	235
10:00:00		277	249	135	252	216	210	210	258
11:00:00	310	321	351	193	259	238	222	243	
12:00:00	317	392	378	249	291	298	241	258	
13:00:00	310	329	371	251	303	248	248	313	
14:00:00	323	388	345	263	351	284	311	338	
15:00:00	351	378	362	280	391	273	285	322	
16:00:00	391	434	352	234	415	329	329	395	
17:00:00	437	446	347	197	428	336	306	431	
18:00:00	359	361	304	203	321	258	265	328	
19:00:00	282	319	281	200	281	216	230	275	
20:00:00	271	284	237	191	207	198	195	243	
21:00:00	216	232	236	199	197	158	187	215	
22:00:00	137	181	138	87	129	113	123	140	
23:00:00	71	117	115	44	55	54	54	65	
00:00:00	16	62	81	30	26	42	37	39	

Traffic Flow Down	Thu 25/06/2015	Fri 26/06/2015	Sat 27/06/2015	Sun 28/06/2015	Mon 29/06/2015	Tue 30/06/2015	Wed 01/07/2015	Thu 02/07/2015	Fri 03/07/2015
01:00:00		10	27	27	6	6	13	4	3
02:00:00		9	18	28	2	5	6	3	6
03:00:00		12	6	11	7	8	2	4	9
04:00:00		16	4	6	10	5	6	7	2
05:00:00		46	23	9	45	38	31	36	50
06:00:00		95	36	22	81	101	92	94	89
07:00:00		181	86	49	190	195	186	171	171
08:00:00		345	219	45	296	334	323	331	321
09:00:00		273	245	96	245	224	221	204	246
10:00:00		223	246	192	207	189	197	197	219
11:00:00	217	239	250	189	210	206	192	221	
12:00:00	257	244	258	222	223	196	200	232	
13:00:00	237	236	215	217	241	215	190	227	
14:00:00	186	207	229	224	179	184	191	197	
15:00:00	242	252	202	165	256	205	250	253	
16:00:00	245	232	202	134	216	188	218	232	
17:00:00	247	270	201	141	217	181	205	249	
18:00:00	272	258	219	189	236	218	232	244	
19:00:00	186	224	175	124	170	186	177	193	
20:00:00	146	172	138	94	126	133	113	137	
21:00:00	88	112	96	74	100	96	91	96	
22:00:00	83	77	74	42	63	65	56	66	
23:00:00	33	58	69	22	23	35	25	41	
00:00:00	9	37	42	14	13	19	14	18	

Total Traffic Flow	Thu 25/06/2015	Fri 26/06/2015	Sat 27/06/2015	Sun 28/06/2015	Mon 29/06/2015				Fri 03/07/2015
01:00:00	0	31	67	80	20	19	24	14	21
02:00:00	0	19	46	59	12	10	13	10	15
03:00:00	0	30	22	35	13	17	4	9	16
04:00:00	0	24	10	11	23	13	12	17	18
05:00:00	0	77	42	15	82	77	72	63	82
06:00:00	0	146	72	35	124	163	143	157	147
07:00:00	0	318	144	82	317	319	307	270	293
08:00:00	0	531	327	85	454	525	482	482	514
09:00:00	0	549	470	162	464	415	392	400	481
10:00:00	0	500	495	327	459	405	407	407	477
11:00:00	527	560	601	382	469	444	414	464	0
12:00:00	574	636	636	471	514	494	441	490	0
13:00:00	547	565	586	468	544	463	438	540	0
14:00:00	509	595	574	487	530	468	502	535	0
15:00:00	593	630	564	445	647	478	535	575	0
16:00:00	636	666	554	368	631	517	547	627	0
17:00:00	684	716	548	338	645	517	511	680	0
18:00:00	631	619	523	392	557	476	497	572	0
19:00:00	468	543	456	324	451	402	407	468	0
20:00:00	417	456	375	285	333	331	308	380	0
21:00:00	304	344	332	273	297	254	278	311	0
22:00:00	220	258	212	129	192	178	179	206	0
23:00:00	104	175	184	66	78	89	79	106	0
00:00:00	25	99	123	44	39	61	51	57	0

The days shaded dark green are those where traffic control was in place.

Appendix 3b: Traffic Data Period 2

Traffic Flow Up	Thu 09/07/2015	Fri 10/07/2015	Sat 11/07/2015	Sun 12/07/2015	Mon 13/07/2015	Tue 14/07/2015	Wed 15/07/2015	Thu 16/07/2015	Fri 17/07/2015	Sat 18/07/2015	Sun 19/07/2015	Mon 20/07/2015
01:00:00		17	36	71	16	7	10	17	20	52	47	14
02:00:00		9	33	35	6	3	7	7	6	31	64	10
03:00:00		10	14	30	3	7	6	9	6	11	19	5
04:00:00		14	10	14	8	9	11	12	10	13	11	11
05:00:00		40	22	14	20	30	37	40	29	18	13	29
06:00:00		49	39	12	58	59	54	53	60	38	16	50
07:00:00		105	68	29	127	97	105	121	121	54	26	103
08:00:00		191	92	34	162	215	166	190	188	91	49	115
09:00:00		246	207	70	210	218	212	212	238	198	75	174
10:00:00		284	304	159	219	245	246	240	283	276	150	232
11:00:00		287	351	208	296	286	235	308	299	332	223	256
12:00:00		295	341	241	303	311	304	327	328	372	256	329
13:00:00		373	369	287	329	296	288	313	407	368	233	324
14:00:00		368	346	248	348	326	330	320	396	373	247	322
15:00:00	321	408	349	295	338	389	364	328	399	369	278	400
16:00:00	436	428	311	204	391	391	387	423	405	370	223	246
17:00:00	417	408	296	194	401	401	433	418	406	344	184	0
18:00:00	312	348	296	203	287	293	311	336	338	305	203	0
19:00:00	294	321	237	196	221	232	285	259	288	276	209	0
20:00:00	253	285	197	164	194	198	246	278	280	221	176	0
21:00:00	216	247	225	135	167	224	207	227	267	213	160	0
22:00:00	142	149	124	85	110	108	129	130	176	156	95	0
23:00:00	58	121	102	49	41	41	59	88	117	109	67	0
00:00:00	36	71	70	31	25	33	17	37	69	56	23	

Traffic Flow Down	Thu 09/07/2015	Fri 10/07/2015	Sat 11/07/2015	Sun 12/07/2015	Mon 13/07/2015	Tue 14/07/2015	Wed 15/07/2015	Thu 16/07/2015	Fri 17/07/2015	Sat 18/07/2015	Sun 19/07/2015	Mon 20/07/2015
01:00:00	499	6	16	49	8	6	8	13	9	20	40	6
02:00:00		9	17	27	4	0	1	4	7	22	36	3
03:00:00		10	9	18	2	1	6	5	7	10	19	1
04:00:00		7	8	4	8	13	8	10	8	4	7	9
05:00:00		47	27	13	28	27	31	37	37	34	15	31
06:00:00		91	26	18	72	102	83	82	108	43	25	74
07:00:00		180	104	55	186	163	185	184	197	90	38	176
08:00:00		304	195	43	309	351	325	345	331	190	51	246
09:00:00		261	256	115	251	262	272	239	285	244	105	210
10:00:00		193	285	189	178	191	187	220	215	254	189	194
11:00:00		220	279	183	226	219	255	246	189	268	197	217
12:00:00		229	253	243	233	229	261	239	258	246	234	215
13:00:00		238	238	231	210	211	197	245	253	275	197	236
14:00:00		184	237	199	182	192	205	185	274	241	202	220
15:00:00	238	234	235	173	233	262	242	227	235	184	155	212
16:00:00	247	230	195	121	233	222	219	251	219	195	119	116
17:00:00	189	256	199	171	229	230	233	259	230	190	167	
18:00:00	273	226	206	186	206	231	252	237	268	223	189	
19:00:00	198	232	169	126	165	192	191	179	249	196	136	
20:00:00	136	176	126	106	124	112	160	151	164	124	119	
21:00:00	114	108	83	68	70	95	108	93	112	100	69	
22:00:00	70	87	49	47	52	43	60	66	91	71	61	
23:00:00	39	55	53	29	19	17	24	39	52	53	31	
00:00:00	14	48	36	16	14	13	14	19	29	40	17	

Total Traffic Flow	Thu 09/07/2015	Fri 10/07/2015	Sat 11/07/2015	Sun 12/07/2015	Mon 13/07/2015	Tue 14/07/2015	Wed 15/07/2015	Thu 16/07/2015	Fri 17/07/2015	Sat 18/07/2015	Sun 19/07/2015	Mon 20/07/2015
01:00:00	499	23	52	120	24	13	18	30	29	72	87	20
02:00:00	0	18	50	62	10	3	8	11	13	53	100	13
03:00:00	0	20	23	48	5	8	12	14	13	21	38	6
04:00:00	0	21	18	18	16	22	19	22	18	17	18	20
05:00:00	0	87	49	27	48	57	68	77	66	52	28	60
06:00:00	0	140	65	30	130	161	137	135	168	81	41	124
07:00:00	0	285	172	84	313	260	290	305	318	144	64	279
08:00:00	0	495	287	77	471	566	491	535	519	281	100	361
09:00:00	0	507	463	185	461	480	484	451	523	442	180	384
10:00:00	0	477	589	348	397	436	433	460	498	530	339	426
11:00:00	0	507	630	391	522	505	490	554	488	600	420	473
12:00:00	0	524	594	484	536	540	565	566	586	618	490	544
13:00:00	0	611	607	518	539	507	485	558	660	643	430	560
14:00:00	0	552	583	447	530	518	535	505	670	614	449	542

Appendix 4: Diffusion tube data (adjusted) grouped by location

	WAQF 001	WAQF 002	WAQF 003	WAQF 015	WAQF 016	WAQF 025	WAQF 029	WAQF 030	WAQF 031	36	38	39	42	43	44	29A	29B	29D	29E	29F	29G	29H	29I	29J	Area of Likely Exceedance	Other Twynyrodyn Road	Other roads	Background
Apr-14	17.4	17.6	11.5		10.6	25	44.2	12.1	11.5	29	34.5	31.2	16.7	17.5	19.6	30.8	33.4	28.8	21.5	22.8	17.4	45.7	35.7	41.20	38.75	25.78	20.40	11.43
May-14	21.4	17.6	10	15.9	6.1	28.8	35	10.3	9.1	29.2	38.8	37	13.1	12.4	15.1	27.7	34.5	39.7	17.4	23.6	17.9	33.9	32.3	47.70	37.45	26.80	19.19	8.88
Jun-14	16.1	15.2	9	15.2	7.1	18.2	49.1	8.1	7.3	22.7	46.8	29.5	11.1	10.7	10.7	22.7	26.5	19.3		15.9	16.5	38.6	26.5	48.00	39.75	20.18	14.99	7.88
Jul-14		14.4	8.1		6.2	21.5	40.8	9.3	8.5	22.7	32.2	31	12.1	11.1	15.8	26.9	27.3	24	21	16	21.3	43.4	31.4	35.20	35.67	22.75	16.27	8.03
Aug-14	14.5	13	7.4		5.8	20.3	42.5	7.7	7.7	21	37.8	25.1	11.1	11.5	7.5	25.2	24.7	22.7	15.2	12.8	15	42.1	31.3	44.10	37.15	19.27	14.13	7.15
Sep-14		19	17.4	21.2	12	34.1	57.9	12.8	13.3	34.7	53.6	39.6	18.9	19.9	25.8	33.1		36.9	22.9		28	52.4	45.2	58.70	51.23	30.23	24.80	13.88
Oct-14		19.7	14.8	22	11.1	25	33.8	13	13.6	29	43.1	33.7	18.1	21.7	22.8	28.5	43.6	33.1	25.1	25.8	27.4	49.7	31.5	37.90	38.28	30.58	22.61	13.13
Nov-14	33.4			31.3	15.2	31.9	55.1	18.6	16.3	35.8	47.1	44	24.4	20.3	26.2		35.5	39.8	24.3	30.1	30.7	54.2	42.3	51.40	49.02	32.08	29.04	16.70
Dec-14	26.4	20.2	13.7	34.8	16.4	27.3	59.7	17.9	13.4	23	55.6	55.9	21.3	21.7	24.9	33.6	35.2	28.4	27.7	25.1	25	47.9	44.9	61.50	54.25	29.17	24.95	15.35
Jan-15	30.9	8.9	15	37.1	20.1	29.1	60.2	17.6	15.3	31.4	56.9	47.9	19.7	23.8	24.9	35.1	33.4	32.3	25.9	23.5	28.5	59.5	48	52.90	54.23	29.78	25.73	17.00
Feb-15	31.5	21.3	13.3	32.7	19.1	25.1	47.9	18.5	16.7	32	57.3	40.4	17.8	25.9	27.6	26.9	42.8	40.3	26.4	34	26.4	53.6	48.8	57.50	50.92	32.80	26.74	16.90
Mar-15	26.1	17.3	15	24.1	13.5	25.3	50.9	12.5	11.6	28.6	50	40.2	18.1	21	20.3		32.8	32.2	23.8	21.8	24	49	31.5	51.50	45.52	26.92	22.60	13.15

Appendix 5: Real time 15 minute NO2 concentration bands with wind direction

Incidence of 15-minute Nitrogen Dioxide levels with Wind Direction between 01/04/14 and 11/12/14

Nitrogen Dioxide (µg/m3)	Wind Direction (±15°)											
	15°	45°	75°	105°	135°	165°	195°	225°	255°	285°	315°	345°
10	69	53	66	191	241	358	178	216	221	73	67	53
20	78	107	131	233	315	289	133	258	296	144	138	73
30	70	91	126	221	289	254	120	235	268	183	179	117
40	90	105	101	259	220	204	98	199	253	212	237	119
50	83	85	116	262	211	140	87	189	243	225	280	121
60	63	55	101	230	199	105	65	157	255	253	223	106
70	43	51	105	184	169	74	68	141	210	219	226	103
80	30	38	52	144	110	68	58	123	158	190	154	58
90	26	22	35	104	80	57	57	102	126	143	121	61
100	26	14	37	85	42	18	29	63	99	158	110	45
110	20	17	22	78	39	17	19	38	77	139	95	35
120	9	9	22	59	21	24	13	21	79	109	71	20
130	3	10	13	29	16	10	12	8	70	83	44	24
140	4	8	3	25	16	8	2	9	32	62	36	10
150	5	3	5	11	5	5	5	1	17	34	18	4
160	2	1	1	9	3	2	2	3	9	18	16	1
170	1	0	2	2	4	1	1	2	5	4	8	4
180	0	1	0	0	3	0	2	0	6	8	7	1
190	0	1	0	0	1	0	3	0	1	1	1	1
200	1	0	0	0	0	0	0	0	0	1	2	0
210	0	0	0	0	0	0	0	0	0	0	1	0
220	0	0	0	0	0	0	0	0	0	1	0	0
230	0	0	0	0	0	0	0	0	0	0	0	0
240	0	0	0	0	0	0	0	0	0	0	0	0
250	0	0	0	0	0	0	0	0	0	0	0	0
260	0	0	0	0	0	0	0	0	0	0	0	0
270	0	0	0	0	0	0	0	0	0	0	0	0
280	0	0	0	0	0	0	0	0	0	0	0	0
290	0	0	0	0	0	0	0	0	0	0	0	0
300	0	0	0	0	0	0	0	0	0	0	0	0

Relative Contribution to Annual Mean	Wind Direction (±15°)											
	15°	45°	75°	105°	135°	165°	195°	225°	255°	285°	315°	345°
10	690	530	660	1910	2410	3580	1780	2160	2210	730	670	530
20	1560	2140	2620	4660	6300	5780	2660	5160	5920	2880	2760	1460
30	2100	2730	3780	6630	8670	7620	3600	7050	8040	5490	5370	3510
40	3600	4200	4040	10360	8800	8160	3920	7960	10120	8480	9480	4760
50	4150	4250	5800	13100	10550	7000	4350	9450	12150	11250	14000	6050
60	3780	3300	6060	13800	11940	6300	3900	9420	15300	15180	13380	6360
70	3010	3570	7350	12880	11830	5180	4760	9870	14700	15330	15820	7210
80	2400	3040	4160	11520	8800	5440	4640	9840	12640	15200	12320	4640
90	2340	1980	3150	9360	7200	5130	5130	9180	11340	12870	10890	5490
100	2600	1400	3700	8500	4200	1800	2900	6300	9900	15800	11000	4500
110	2200	1870	2420	8580	4290	1870	2090	4180	8470	15290	10450	3850
120	1080	1080	2640	7080	2520	2880	1560	2520	9480	13080	8520	2400
130	390	1300	1690	3770	2080	1300	1560	1040	9100	10790	5720	3120
140	560	1120	420	3500	2240	1120	280	1260	4480	8680	5040	1400
150	750	450	750	1650	750	750	750	150	2550	5100	2700	600
160	320	160	160	1440	480	320	320	480	1440	2880	2560	160
170	170	0	340	340	680	170	170	340	850	680	1360	680
180	0	180	0	0	540	0	360	0	1080	1440	1260	180
190	0	190	0	0	190	0	570	0	190	190	190	190
200	200	0	0	0	0	0	0	0	0	200	400	0
210	0	0	0	0	0	0	0	0	0	0	210	0
220	0	0	0	0	0	0	0	0	0	220	0	0
230	0	0	0	0	0	0	0	0	0	0	0	0
240	0	0	0	0	0	0	0	0	0	0	0	0
250	0	0	0	0	0	0	0	0	0	0	0	0
260	0	0	0	0	0	0	0	0	0	0	0	0
270	0	0	0	0	0	0	0	0	0	0	0	0
280	0	0	0	0	0	0	0	0	0	0	0	0
290	0	0	0	0	0	0	0	0	0	0	0	0
300	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 6

Incidence of 15-minute Nitrogen Dioxide levels with Wind Speed between 01/04/14 and 11/12/14

Nitrogen Dioxide (µg/m3)	Wind Speed Band (±0.5m/s)								
	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5
10	701	593	375	176	46	2	1	0	0
20	1014	711	377	161	62	39	11	2	0
30	1079	726	325	171	49	23	12	1	0
40	1025	733	420	188	62	21	16	1	0
50	966	734	392	248	103	18	4	2	1
60	772	735	401	208	67	9	2	2	1
70	635	684	350	157	54	13	1	2	2
80	515	511	232	102	42	6	3	1	0
90	413	423	184	80	30	1	1	0	0
100	337	302	145	57	18	4	0	0	0
110	294	245	97	36	6	3	0	0	0
120	250	198	51	22	3	2	0	0	0
130	166	145	41	8	0	0	0	0	0
140	111	97	29	2	0	0	0	0	0
150	77	41	8	1	0	0	0	0	0
160	43	24	9	1	0	0	0	0	0
170	30	8	1	0	0	0	0	0	0
180	19	9	3	0	0	0	0	0	0
190	12	2	0	0	0	0	0	0	0
200	3	4	0	0	0	0	0	0	0
210	0	1	0	0	0	0	0	0	0
220	1	1	0	0	0	0	0	0	0
230	0	0	0	0	0	0	0	0	0
240	0	0	0	0	0	0	0	0	0
250	0	0	0	0	0	0	0	0	0
260	0	0	0	0	0	0	0	0	0
270	0	0	0	0	0	0	0	0	0
280	0	0	0	0	0	0	0	0	0
290	0	0	0	0	0	0	0	0	0
300	0	0	0	0	0	0	0	0	0

Relative Contribution to Annual Mean	Wind Speed Band (±0.5m/s)											
	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5			
10	7010	5930	3750	1760	460	20	10	0	0	0	0	0
20	20280	14220	7540	3220	1240	780	220	40	0	0	0	0
30	32370	21780	9750	5130	1470	690	360	30	0	0	0	0
40	41000	29320	16800	7520	2480	840	640	40	0	0	0	0
50	48300	36700	19600	12400	5150	900	200	100	50	0	0	0
60	46320	44100	24060	12480	4020	540	120	120	60	0	0	0
70	44450	47880	24500	10990	3780	910	70	140	140	0	0	0
80	41200	40880	18560	8160	3360	480	240	80	0	0	0	0
90	37170	38070	16560	7200	2700	90	90	0	0	0	0	0
100	33700	30200	14500	5700	1800	400	0	0	0	0	0	0
110	32340	26950	10670	3960	660	330	0	0	0	0	0	0
120	30000	23760	6120	2640	360	240	0	0	0	0	0	0
130	21580	18850	5330	1040	0	0	0	0	0	0	0	0
140	15540	13580	4060	280	0	0	0	0	0	0	0	0
150	11550	6150	1200	150	0	0	0	0	0	0	0	0
160	6880	3840	1440	160	0	0	0	0	0	0	0	0
170	5100	1360	170	0	0	0	0	0	0	0	0	0
180	3420	1620	540	0	0	0	0	0	0	0	0	0
190	2280	380	0	0	0	0	0	0	0	0	0	0
200	600	800	0	0	0	0	0	0	0	0	0	0
210	0	210	0	0	0	0	0	0	0	0	0	0
220	220	220	0	0	0	0	0	0	0	0	0	0
230	0	0	0	0	0	0	0	0	0	0	0	0
240	0	0	0	0	0	0	0	0	0	0	0	0
250	0	0	0	0	0	0	0	0	0	0	0	0
260	0	0	0	0	0	0	0	0	0	0	0	0
270	0	0	0	0	0	0	0	0	0	0	0	0
280	0	0	0	0	0	0	0	0	0	0	0	0
290	0	0	0	0	0	0	0	0	0	0	0	0
300	0	0	0	0	0	0	0	0	0	0	0	0