IAQM Early Careers Network

IAQM Early Careers Network Meetup and Christmas Social

Air Quality's Next Top Model: Early Careers Air Quality Modelling Case Studies

Thursday 7th December 3pm - 5pm GMT | Hydrock, London

Marine Emission Dispersion Modelling
On the river Thames

Grace Staines, Port of London Authority

What we do at the Port of London Authority (PLA)

- Established in 1909, the PLA is responsible for the navigational safety of the river Thames.
- It is a trust port, so has no shareholders and operates for the benefit of customers and stakeholders now and in the future.
- The PLA owns and has jurisdiction over 95 miles of the tidal river from Southend to Teddington. Providing a range of services such as vessel traffic services, pilotage, licensing etc.

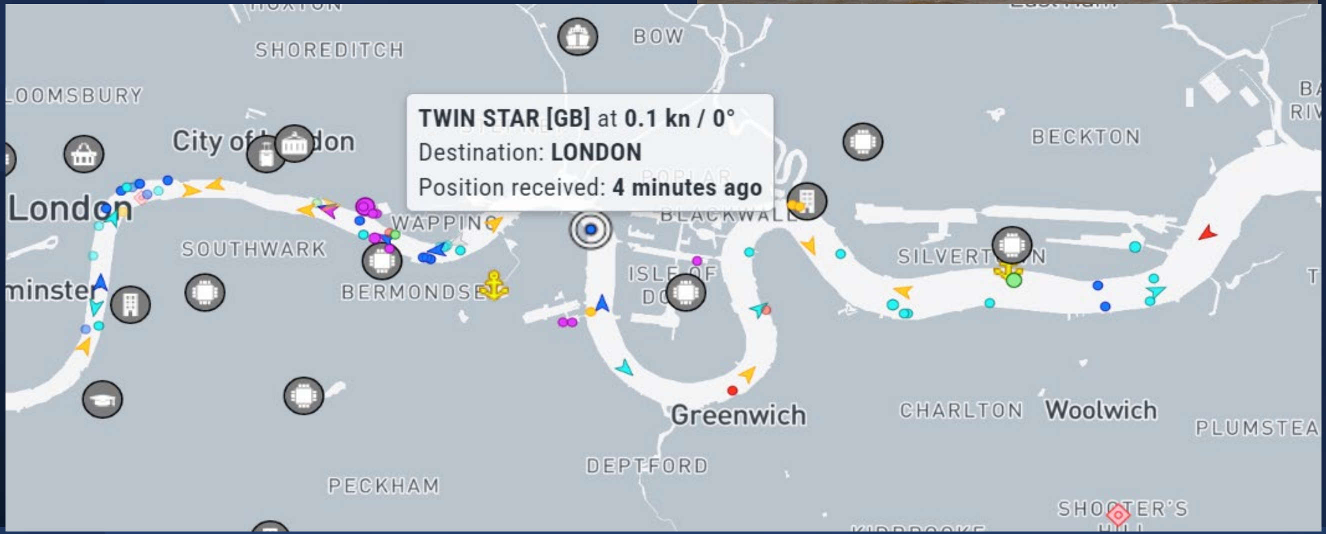
PORT OF LONDON AUTHORITY

River Emissions on the Thames

- As custodians of the tidal Thames, and considering the governments Net Zero ambitions, the PLA wanted to understand how river activity was contributing to poor air quality in and around its jurisdiction.

- In 2016, in collaboration with TfL, an emissions inventory was completed to gather this data. The methodology for this uses:
    - AIS (automatic identification system) data
    - Emissions factors
    - Port call information

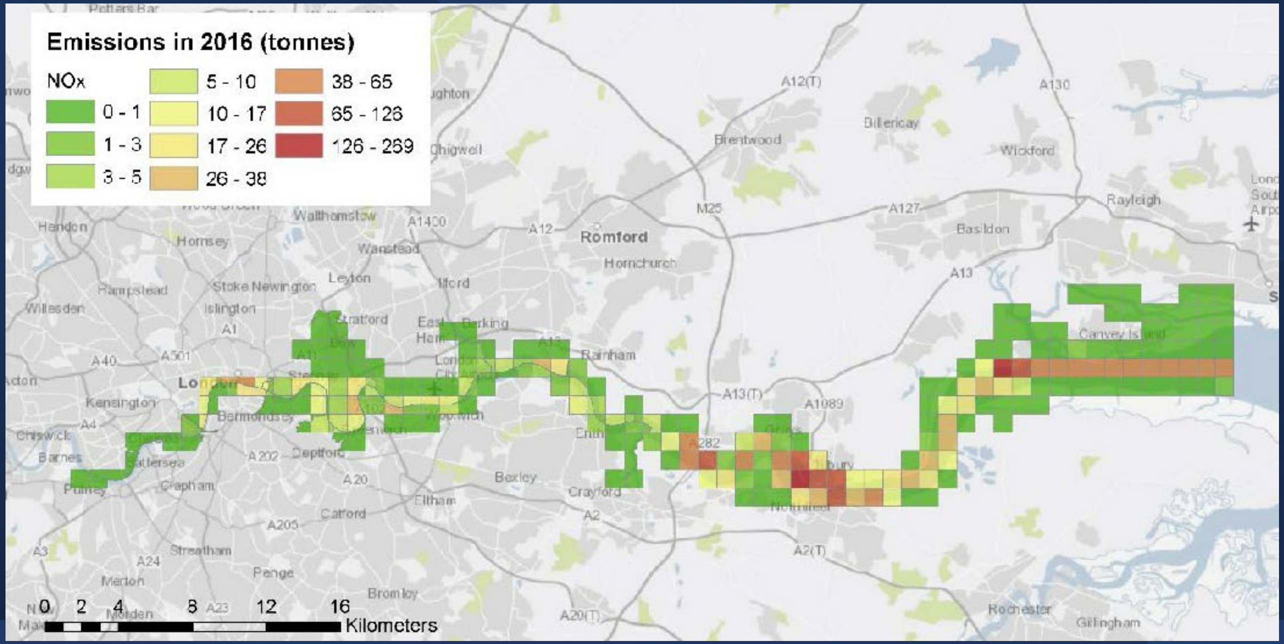
- Pollutants measured include:
    - Nitrogen oxides
    - Carbon dioxides
    - Particulate matter (PM10)
    - Sulphur oxides
    - Volatile Organic Compounds
    - Carbon Monoxide

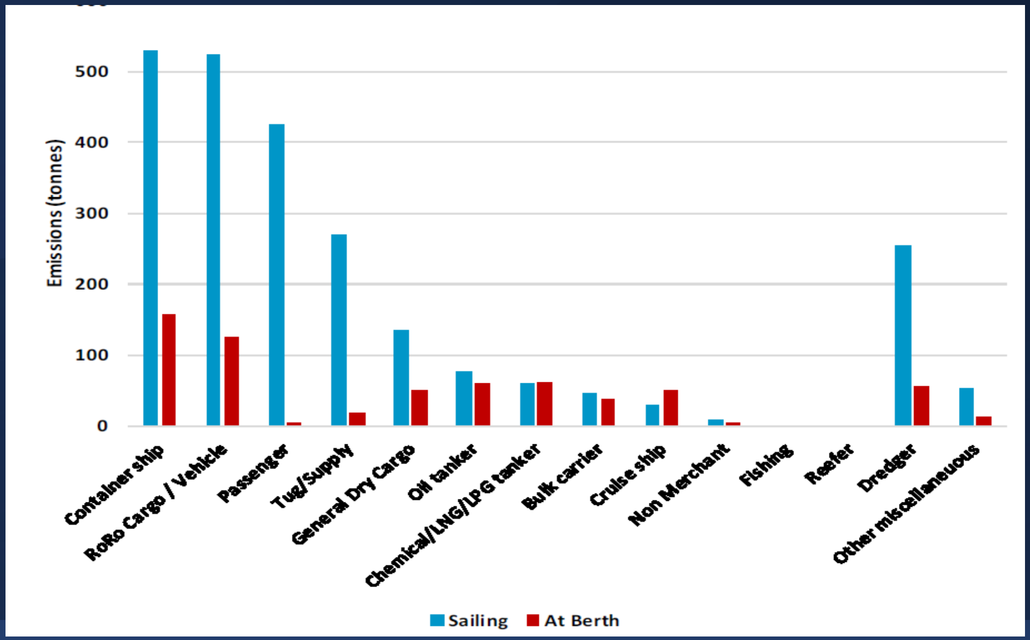


Emissions Inventory Outputs

Key Findings

- 66% of the total CO_2 emissions in 2016 are to the east of the M25.
- For oxides of nitrogen (NOx) the east of M25 area accounts for 71% of the total in 2016 and 75% for particulate matter, reflecting the higher sulphur fuels generally used by sea going vessels.
- Hotspots correlate to the locations of the large cargo handling ports.





Air Quality Mapped

- Data from the inventory results were translated into a map in the PLA's GIS system.
- This allowed us to filter by pollutant type and vessel type.
- The larger and darker the circles appear within the grid represent higher emissions.

Map shows data points for total pollutants and across all vessel types

Dispersion modelling of Emissions in the Greater London Authority (GLA)

- Focusing on the GLA boundary, dispersion modelling was undertaken based on the results of the inventory to contribute to the 2016 London Atmospheric Emissions Inventory (LAEI).

- Work was done by King's College London.

- Methodology points for model:
  - Diurnal profile established
  - Stack height of vessel calculated
  - Grid size reduced to 20m x 20m

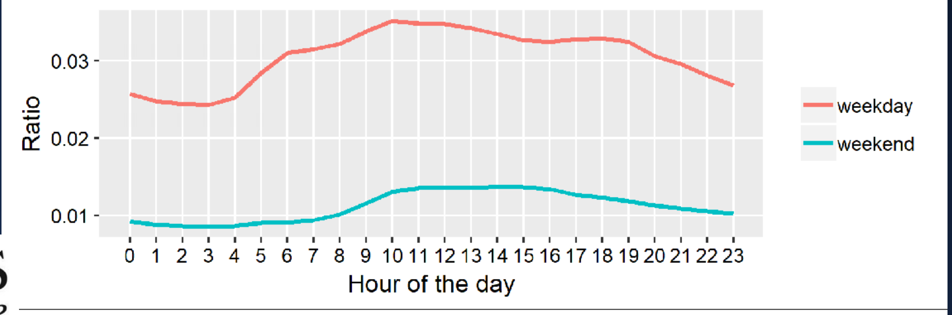


Figure 7: Diurnal profile of shipping applied to emissions (represented by the ratio of hourly ship activity to the total AIS GPS data)

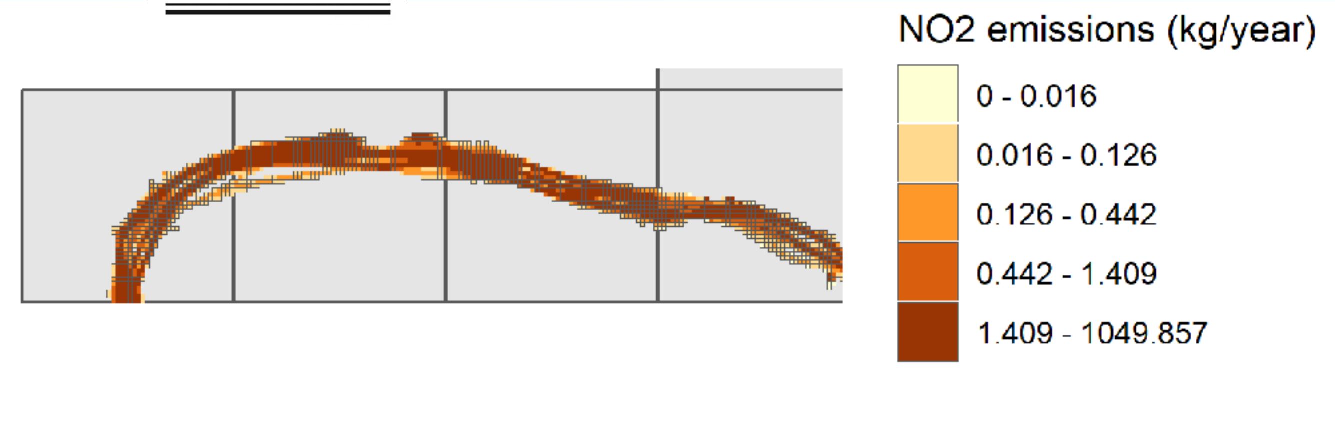


Figure 6: NO2 emissions for group 1 vessels in a 20m by 20m grid in central London

Dispersion Modelling Output for the GLA

Map of shipping contributions to total air quality were produced for NO_x, NO_2, PM_{10} and $PM_{2.5}$ at 20x20m resolution.

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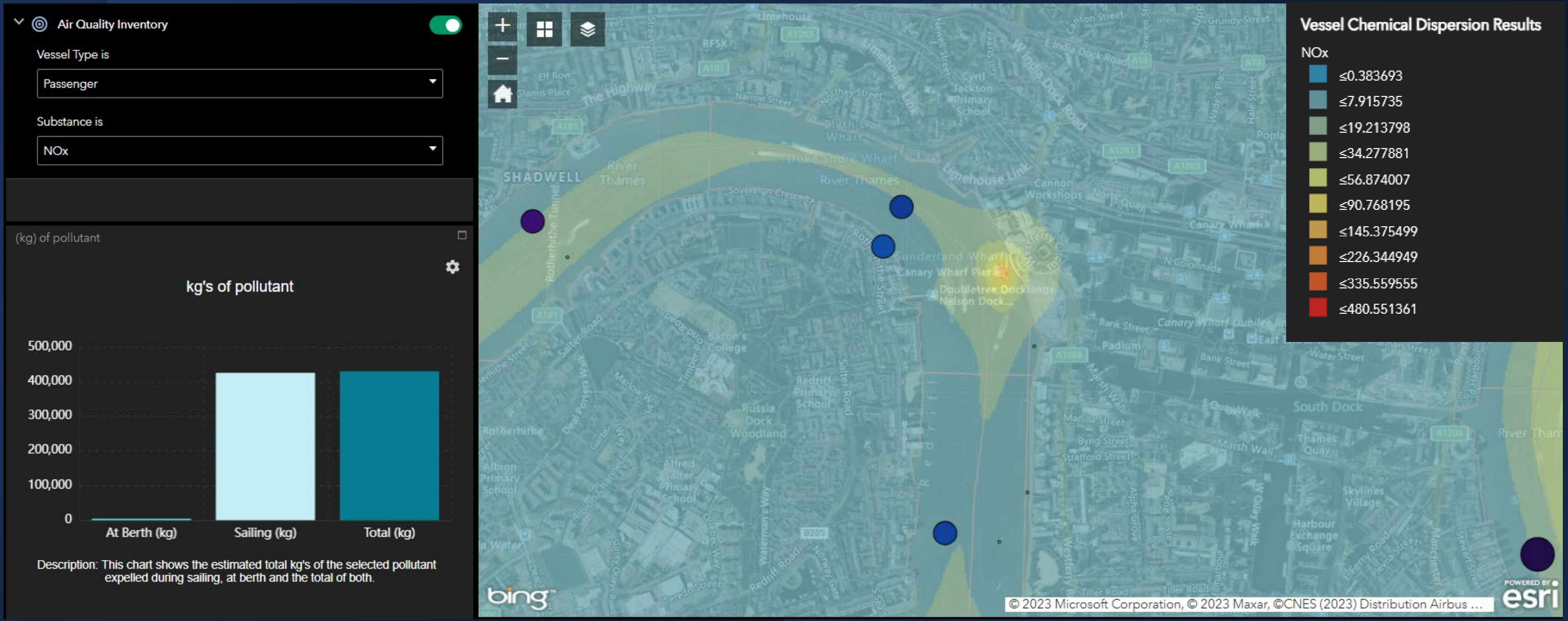
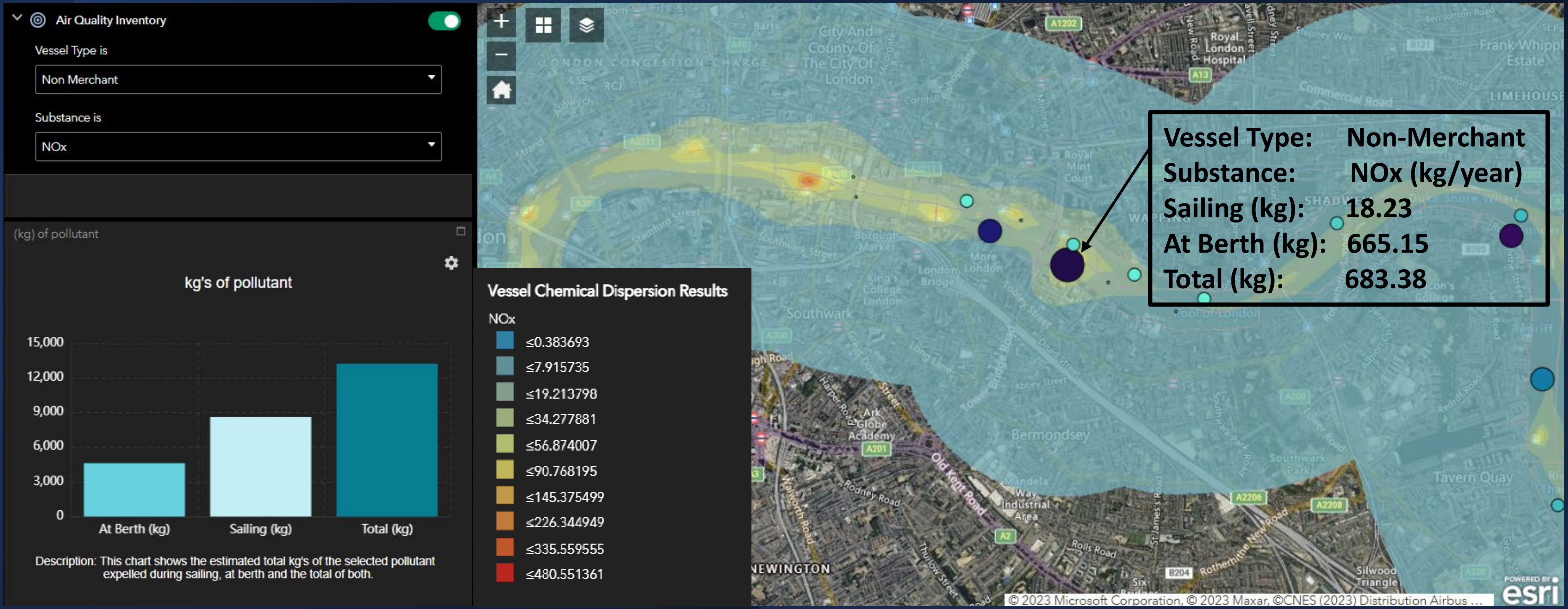
Dispersion Modelling Observations



Identifying the issues

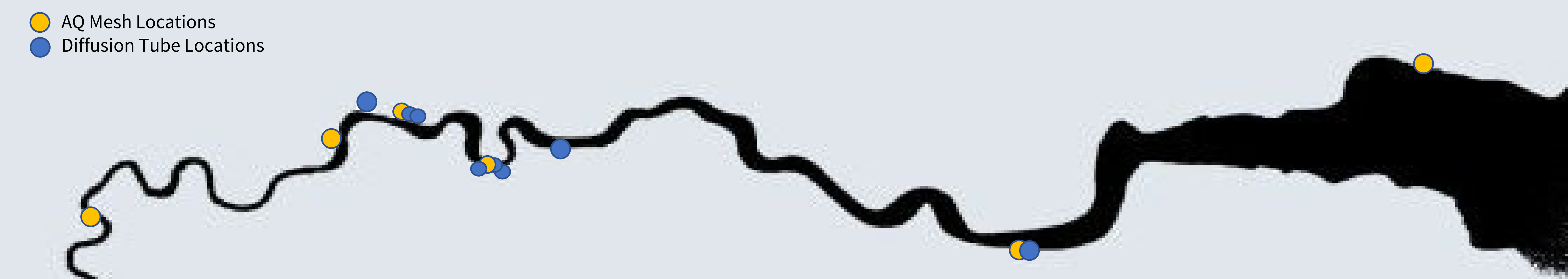


How has this information informed the PLA?

River-side Monitoring
- River-side monitoring has now been in situ since 2019
- Inventory results were one factor used to identify the locations for monitoring

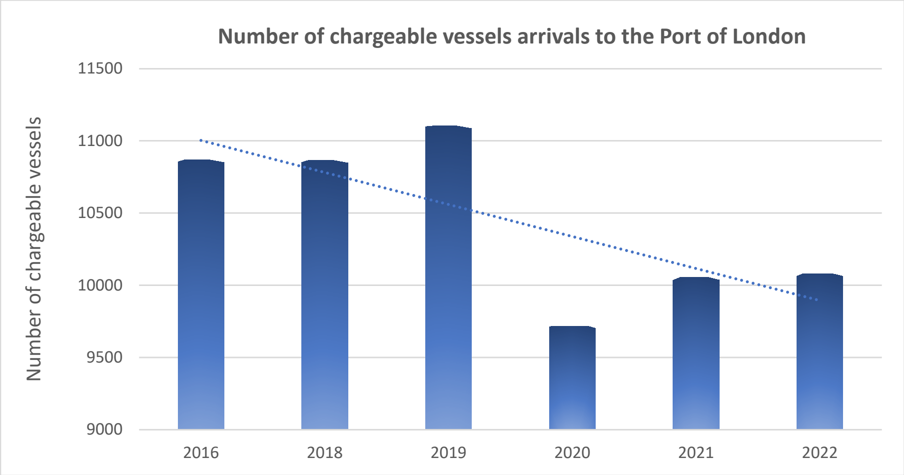
Targeted Action
- The PLA published Air Quality Strategies that outline actions to combat air pollution from operators on the Thames.

Public Perception
- Results of the dispersion modelling have often been used to re-assure residents



How is modelling going to be used in the future in the PLA?

- With 2016 as our baseline, we can carry out further modelling to see how the relative impact of river emissions are changing due to factors such as:
  - Tightening legislation on road vehicles
  - Low emission zones and other levies
  - Increased light freight on the river
  - Vessel fleet transitions to alternative fuels
    - Electrification
    - Hydrogen
    - Methanol
    - Ammonia



Thanks for Listening

Grace Staines AMIEnvSci, Technical Advisor (Air Quality),
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Email: grace.staines@pla.co.uk

Scan for PLA Website

Scan for Thames Vision

Assessing How Would an “Extreme” Wildfire at Hamsterley Forest Affect Regional Air Quality

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Alex Forest
Graduate Air Quality Consultant

ENGINEERING | ENERGY | SUSTAINABILITY

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Key Goals for the Study

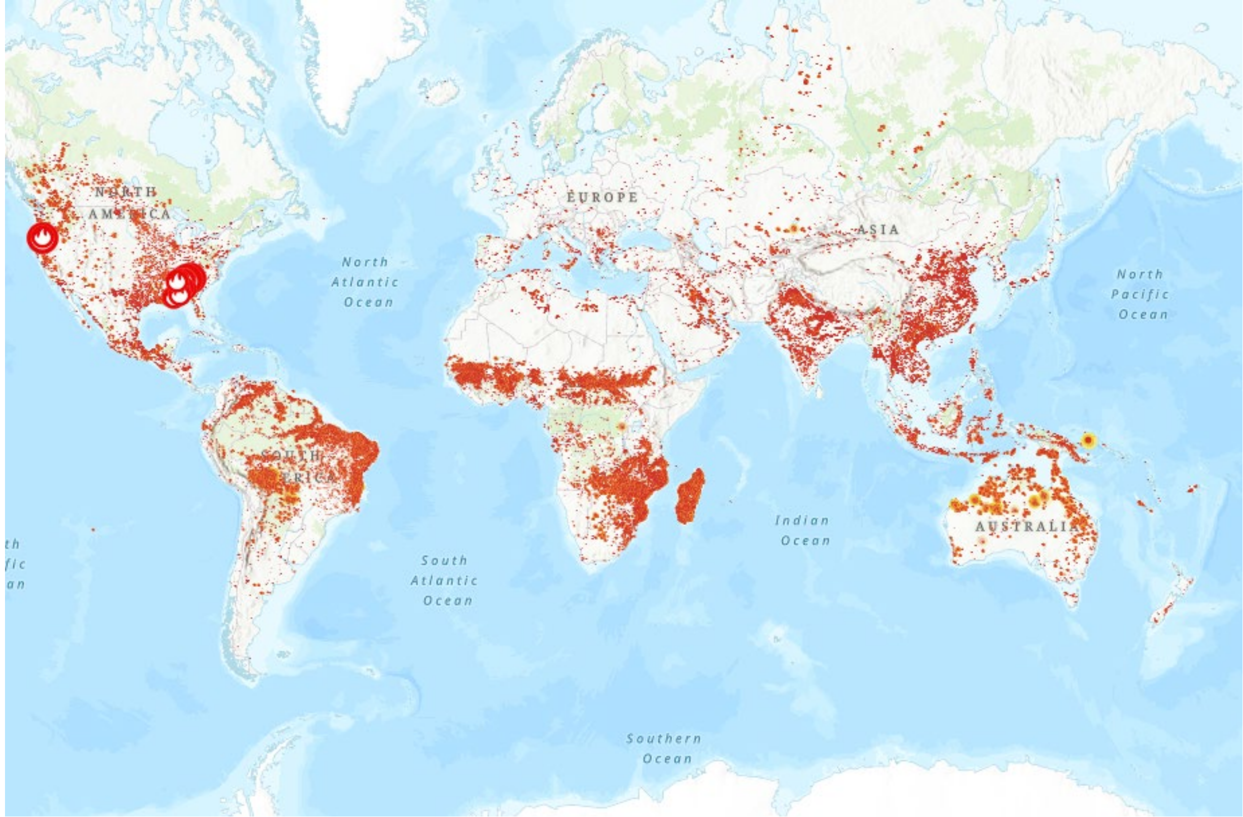
1. Calculate the Energy Mass Balance (EMB) of the assessable fuel in Hamsterley Forest consider different types of fuels present and their associated combustion characteristics and properties.

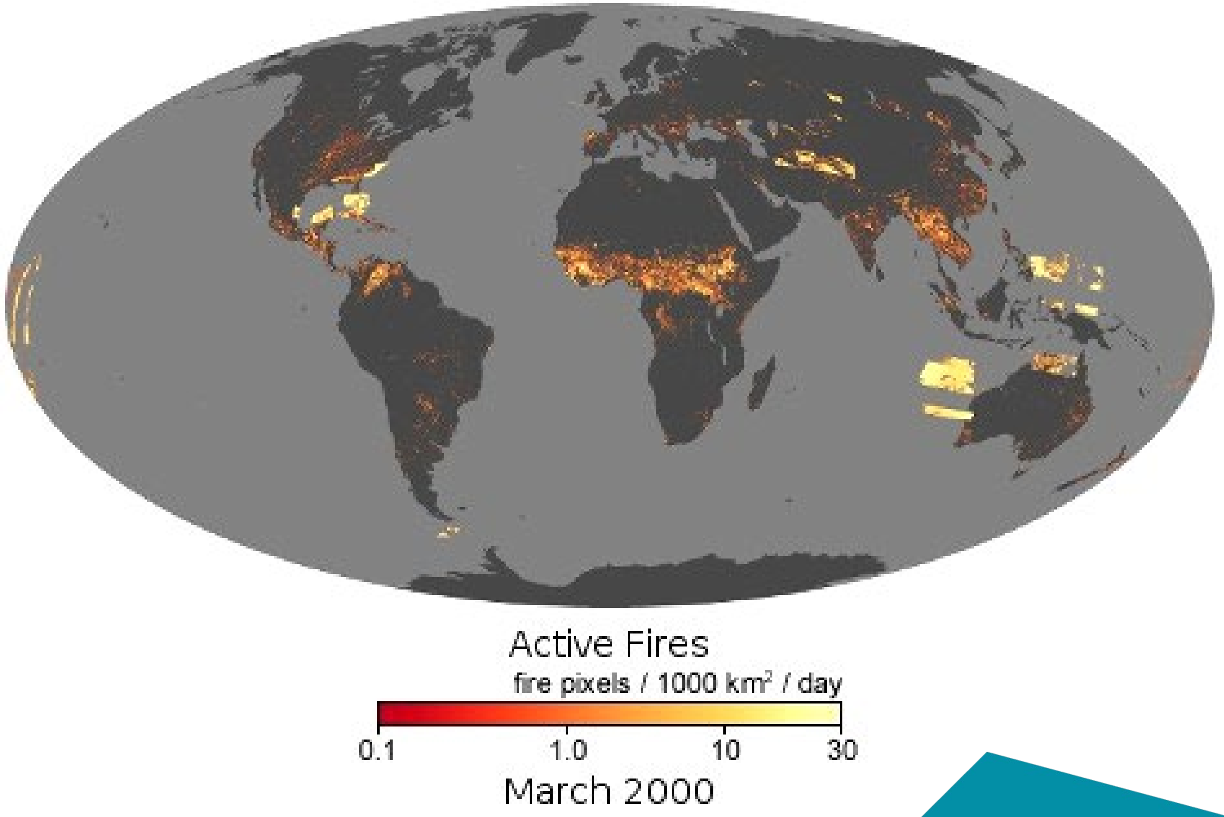
2. Utilise AERMOD's Plume Dispersion Modelling software. Predict the spread of fumes generated by the fire using gaussian plume models under different meteorological scenarios.

3. Analyse and assess the impacts of the plume dispersion on local air quality (focusing on human health). Explore the potential strategies needed to mitigate and minimise the adverse effects on the environment and human health.

Global Significance

Quick background





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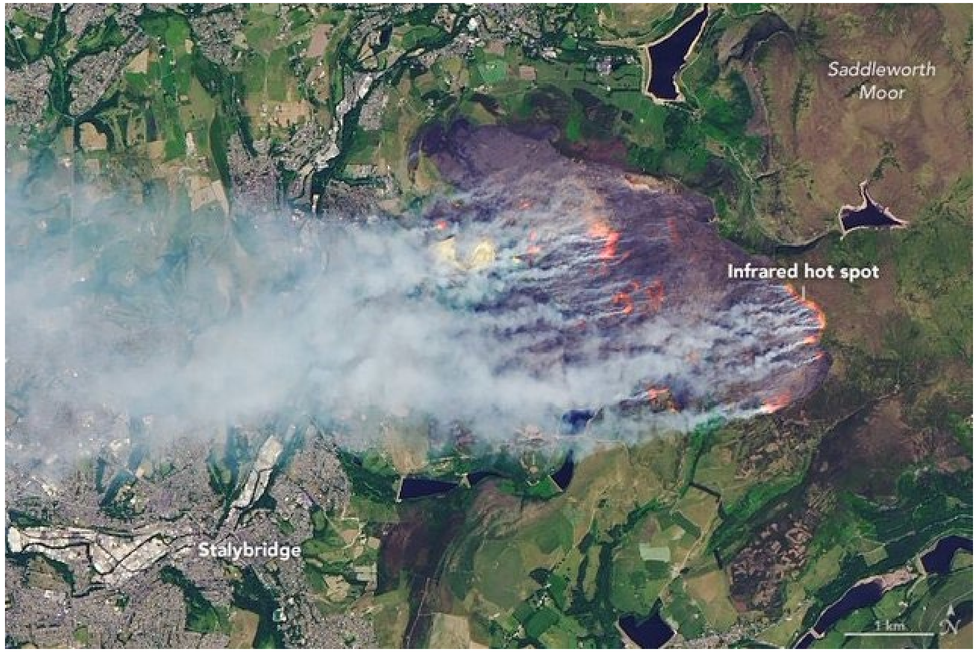
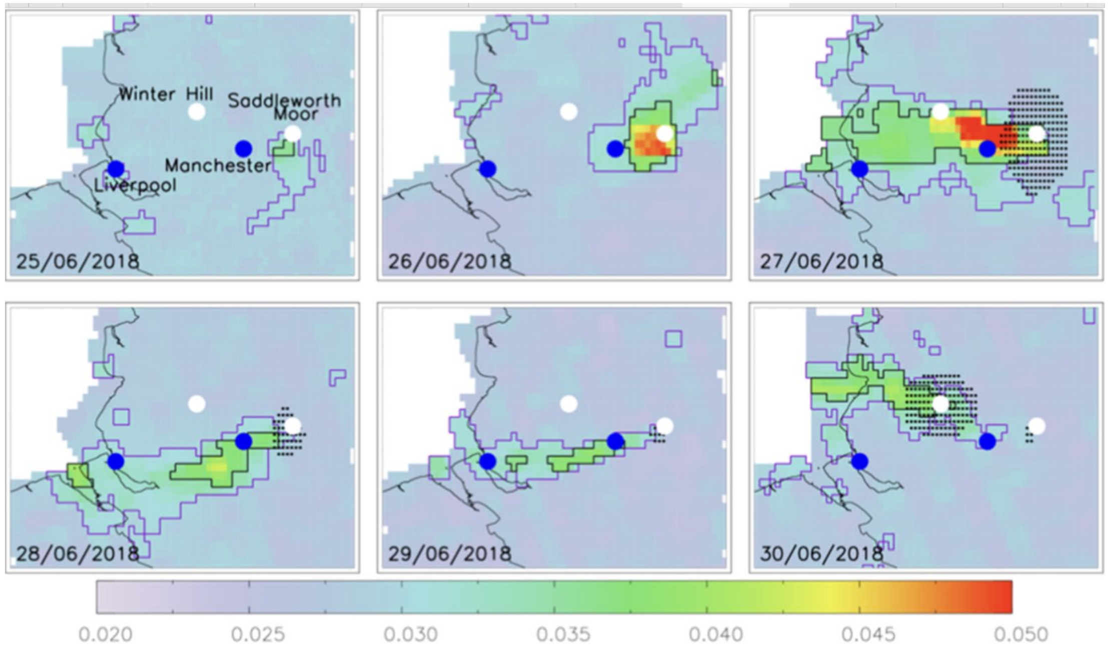




UK Wildfires

Saddleworth Moor Wildfire

- In June 2018 Saddleworth Moor in the northwest of England became one of the largest wildfires on recent record. The fire lasted approximately three weeks.
- Over the course of the burn, surface satellite observations and research flight platform measurements were taken, used to quantify substantial enhancements through emitted trace gases.
- Special focus on measuring PM2.5 was taken as this has deep respiratory penetration in humans making it a major concern.
- Published in Graham et al., 2020

Why is this a problem?

Climate Change

- In the UK, climate change heightens wildfire risks as rising temperatures contribute to drier conditions. Prolonged heatwaves increase the likelihood of vegetation drying out, elevating the potential for ignition. Altered precipitation patterns may result in drier vegetation, while changing wind patterns can facilitate the spread of wildfires.
- These factors collectively intensify the frequency and severity of wildfires, posing threats to ecosystems, wildlife, and communities. Mitigating climate change through emissions reduction is crucial to address these risks and enhance resilience against the escalating threat of wildfires in the UK.

IMAGE CREDIT: BBC News

Why Hamsterley?

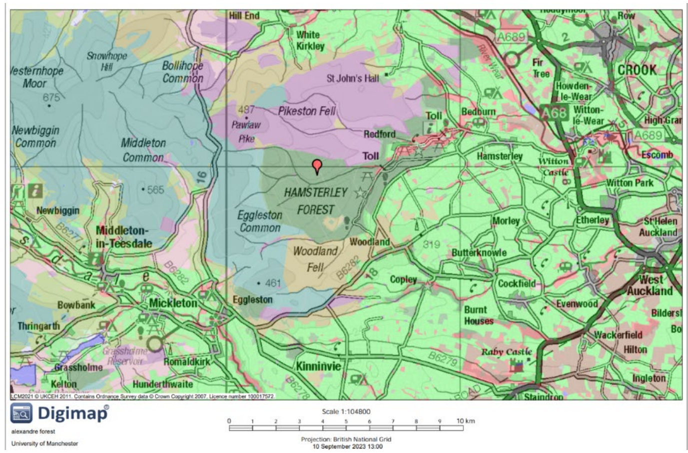
Location

- Hamsterley Forest is located forest in County Durham and owned and managed by Forestry England. It is the largest forest in County Durham and covers more than 5,000 hectares.

- The forest has a rich diversity of mature woodland, with Scots Pines that are aged around 70 years, but it does have a variety of younger plantation, plus great trees possibly planted in the 19th century by the Surtees family.

- Being located between Weardale and Teesdale, and lying close to the Pennines, the whole area opens up endless possibilities for visitors to explore the great outdoors of Durham.

- The forest has become more commercial over the past 5 years and Forestry England is assessing future projects to further develop the area and provide up to 100 sensitive cabins and associated amenities.

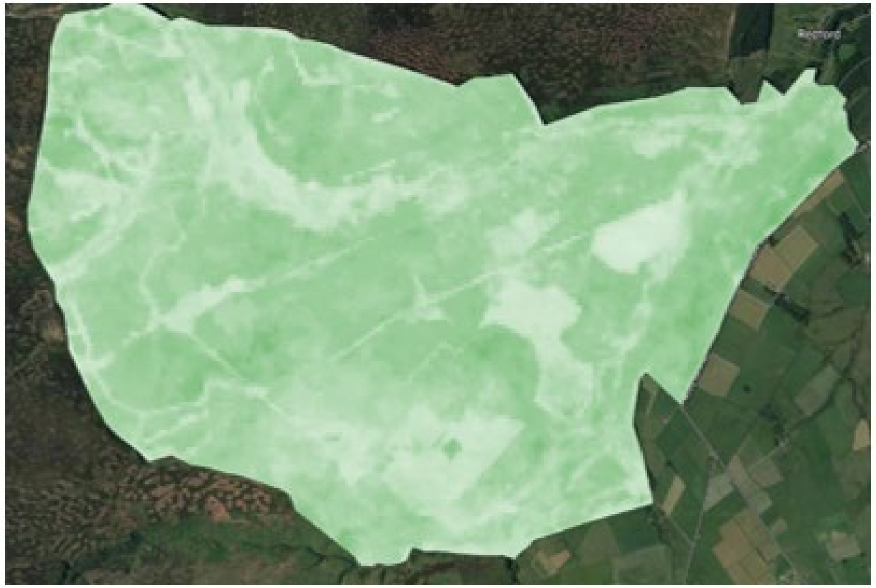


Forest Health

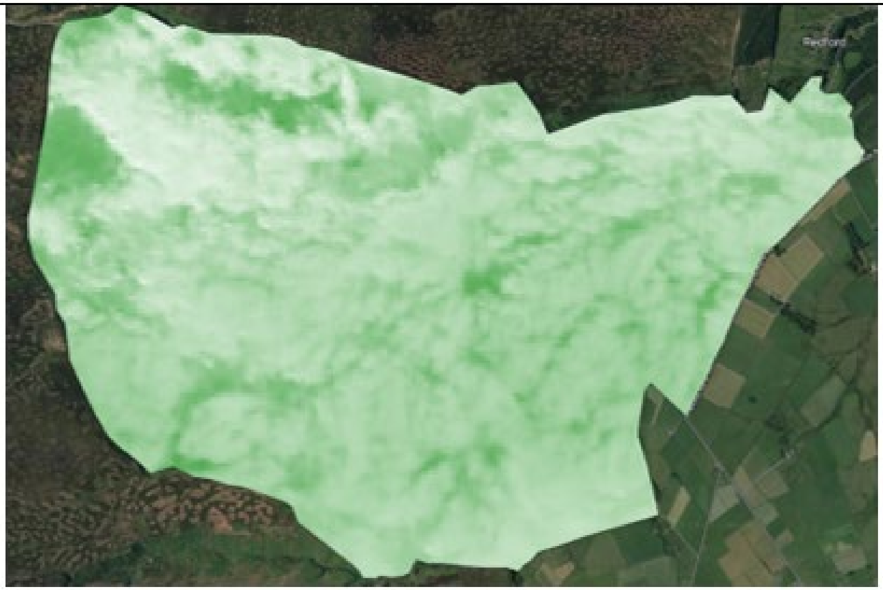
MODIS | Landsat Series

Created using Google Earth Engine

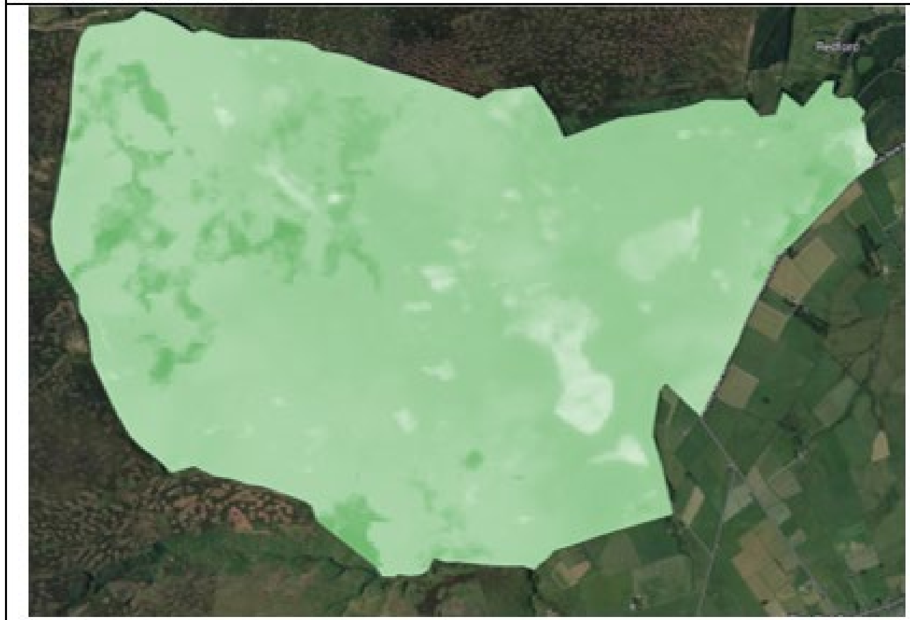
- Uses Red Wavelengths
- Near-Infrared (NIR)
- NDVI and EVI data



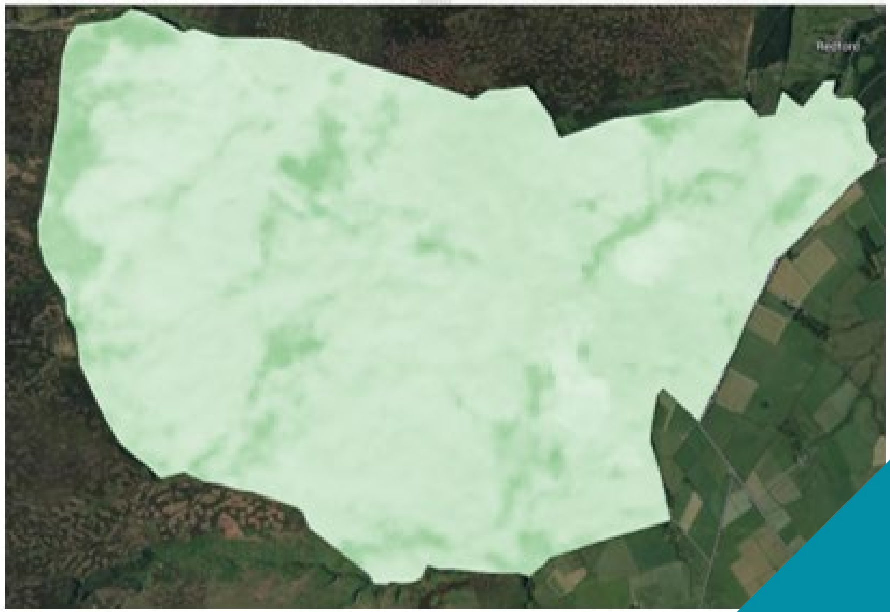
Annual 2019



July 2019



August 2019



September 2019

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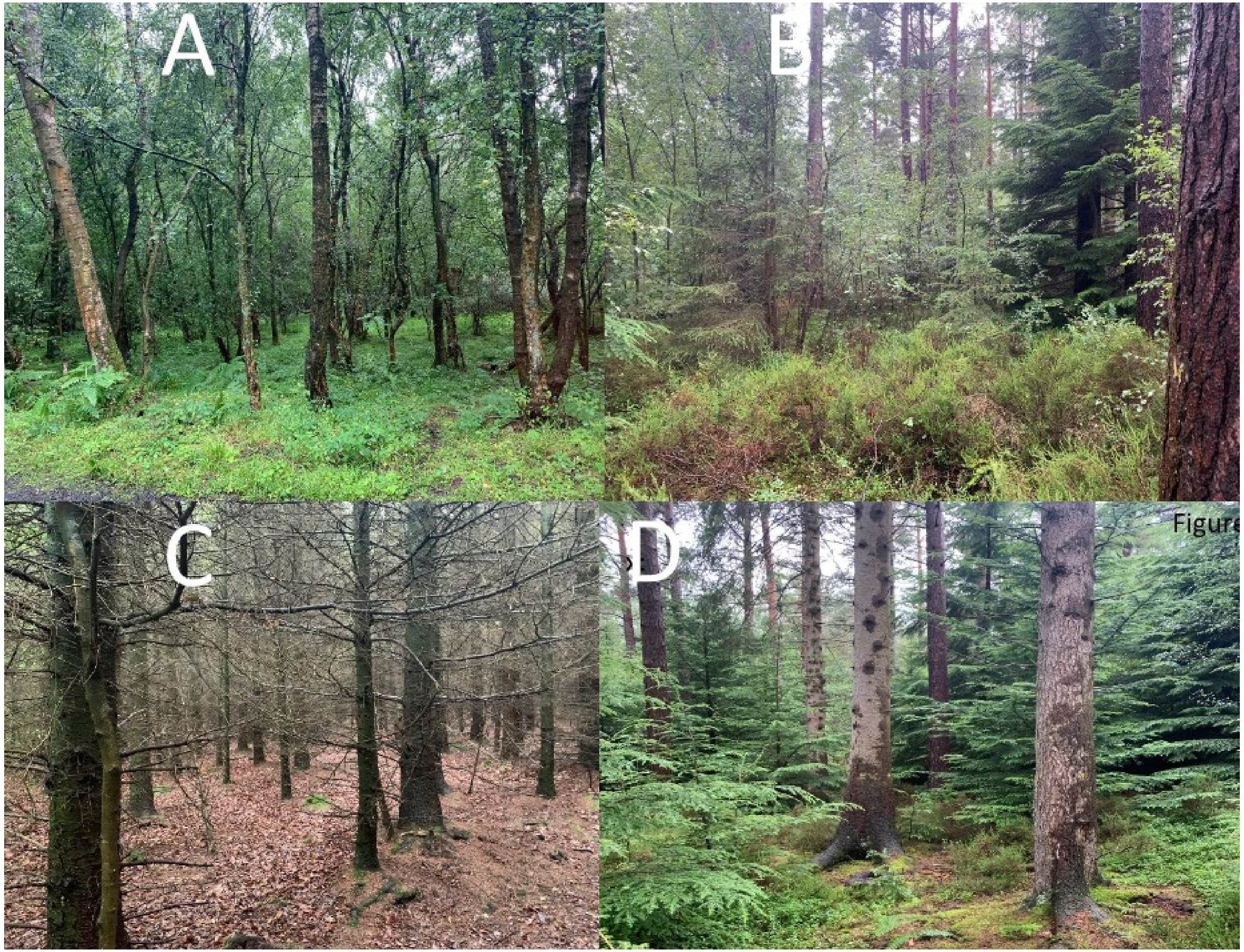

Field Research

- Using "a" and "b" as constants specific to the calorific values of individual tree species, tree allometry can be used to validate the AGB value using the DBH (easiest measured value) measurements from the forest plot.
- 'a', the "allometric coefficient" and it represents a scaling factor that adjusts the magnitude of the biomass estimates.
- 'b' represents the "allometric exponent" and it determines the rate at which biomass changes as DBH changes.
- AGB = a x (DBH)b (Chave et al., 2014)

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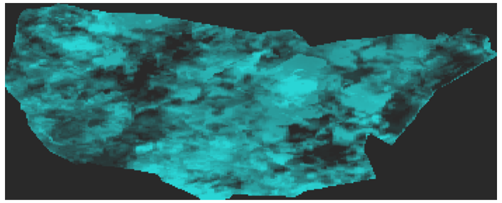
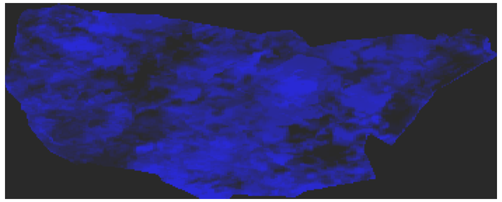
Calculated Biomass





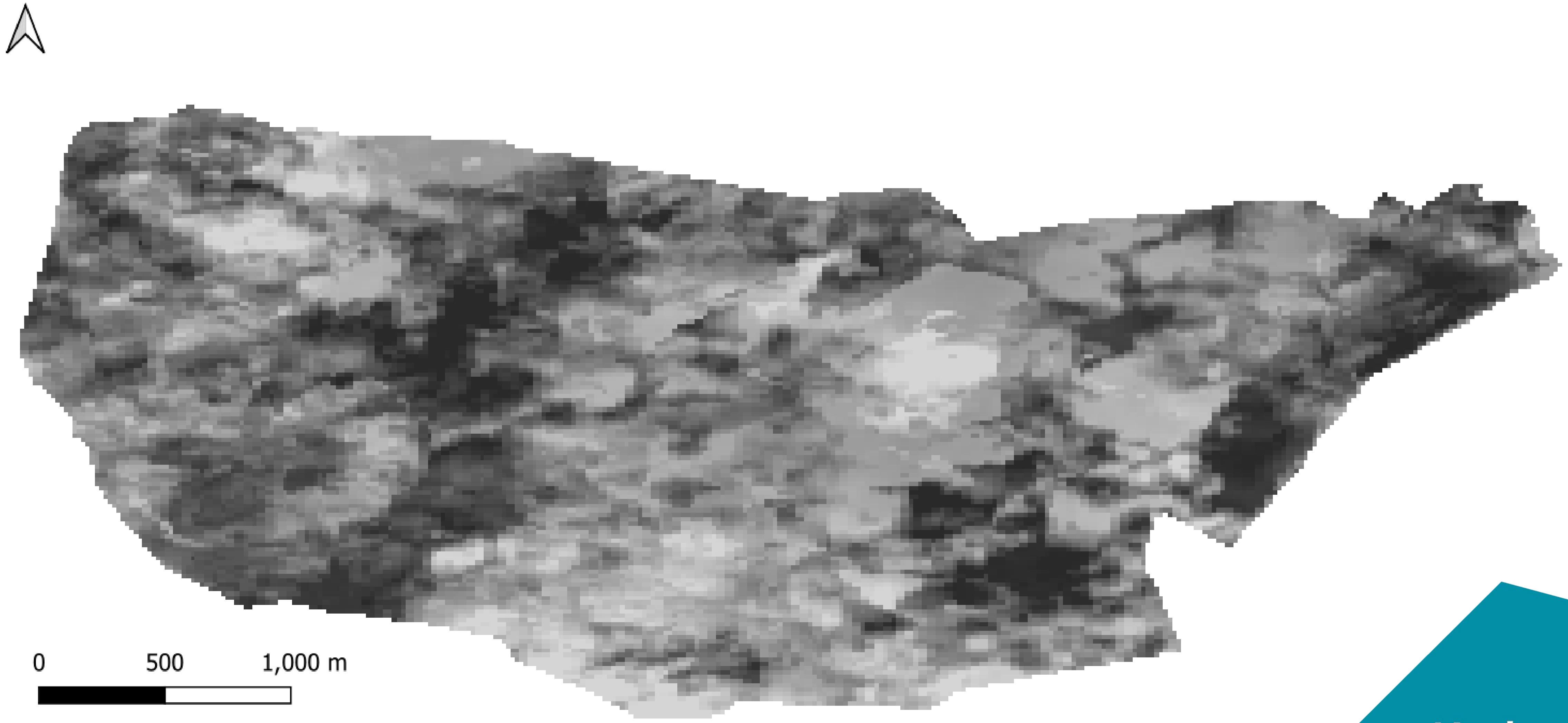
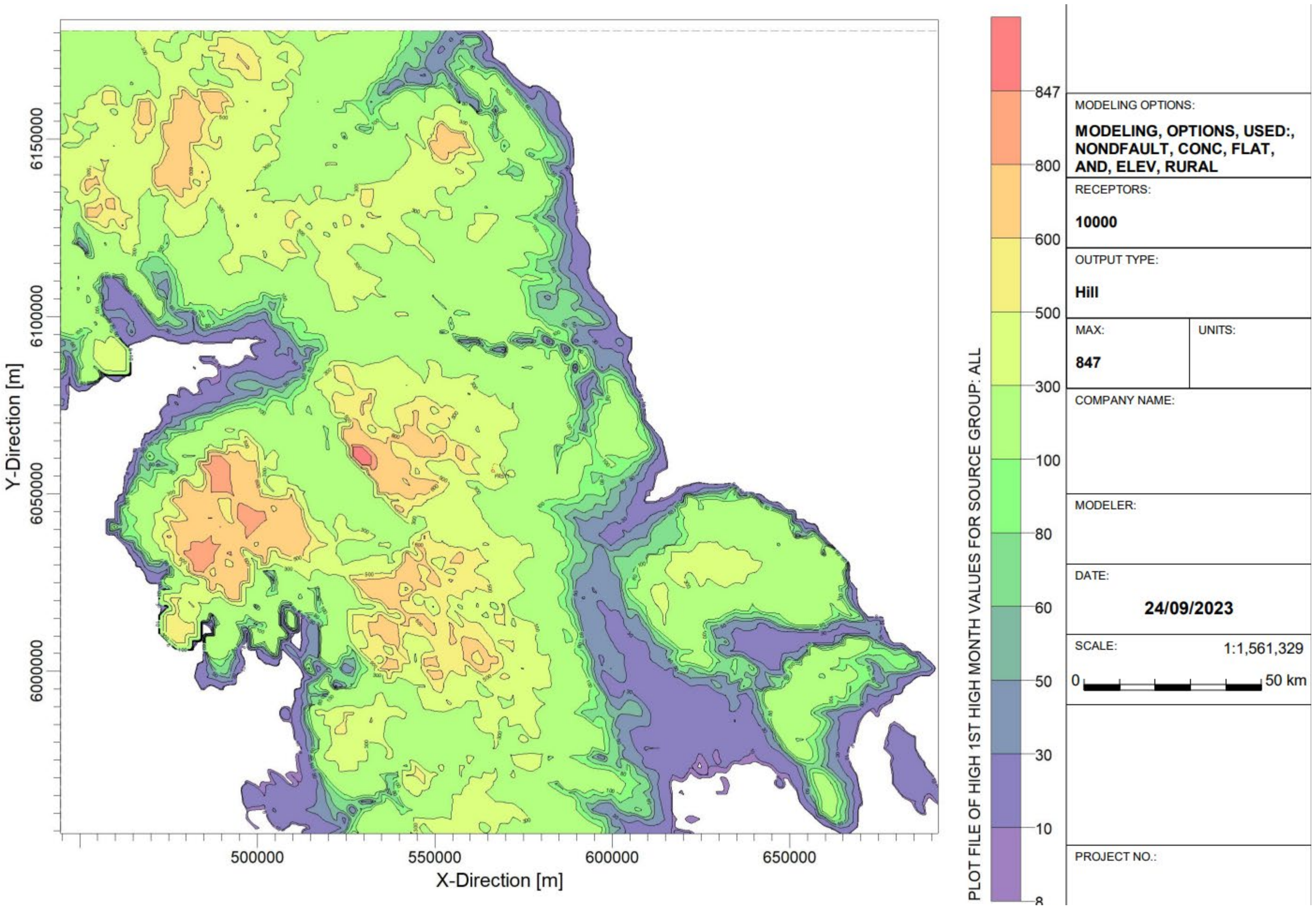


IMAGE CREDIT:

Terrain Modelling Using DEMs



- AERMAP, which is part of the AERMOD modelling system, is responsible for processing terrain data, including digital elevation models (DEMs).
- AERMAP has a built-in capability to handle the terrain data required for AERMOD dispersion modelling. It can process elevation data from various sources, including user-provided elevation files and the U.S. Geological Survey's (USGS) National Elevation Dataset (NED).

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Accessible Fuel

- Using these values, we can calculate the energy contained in each component of the biomass. For example, the total energy in the oak component of the biomass would be:

- (20 MJ/kg) x (0.3) x (4,960,462 kg) = 29.7 MJ / 3e12

Tree Specie	Calorific Value (MJ/Kg)
English Oak (Quercus robur)	20.0
Scots Pine (Pinus sylvestris)	19.5
Silver Birch (Betula pendula)	20.5
European Beech (Fagus sylvatica)	21.5
Ash (Fraxinus excelsior)	20.5
Sitka Spruce (Picea sitchensis)	19.5
Rowan (Sorbus aucuparia)	20.0

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Theoretical Dispersion Modelling Using AERMOD

Theoretical Dispersion Modelling Using AERMOD

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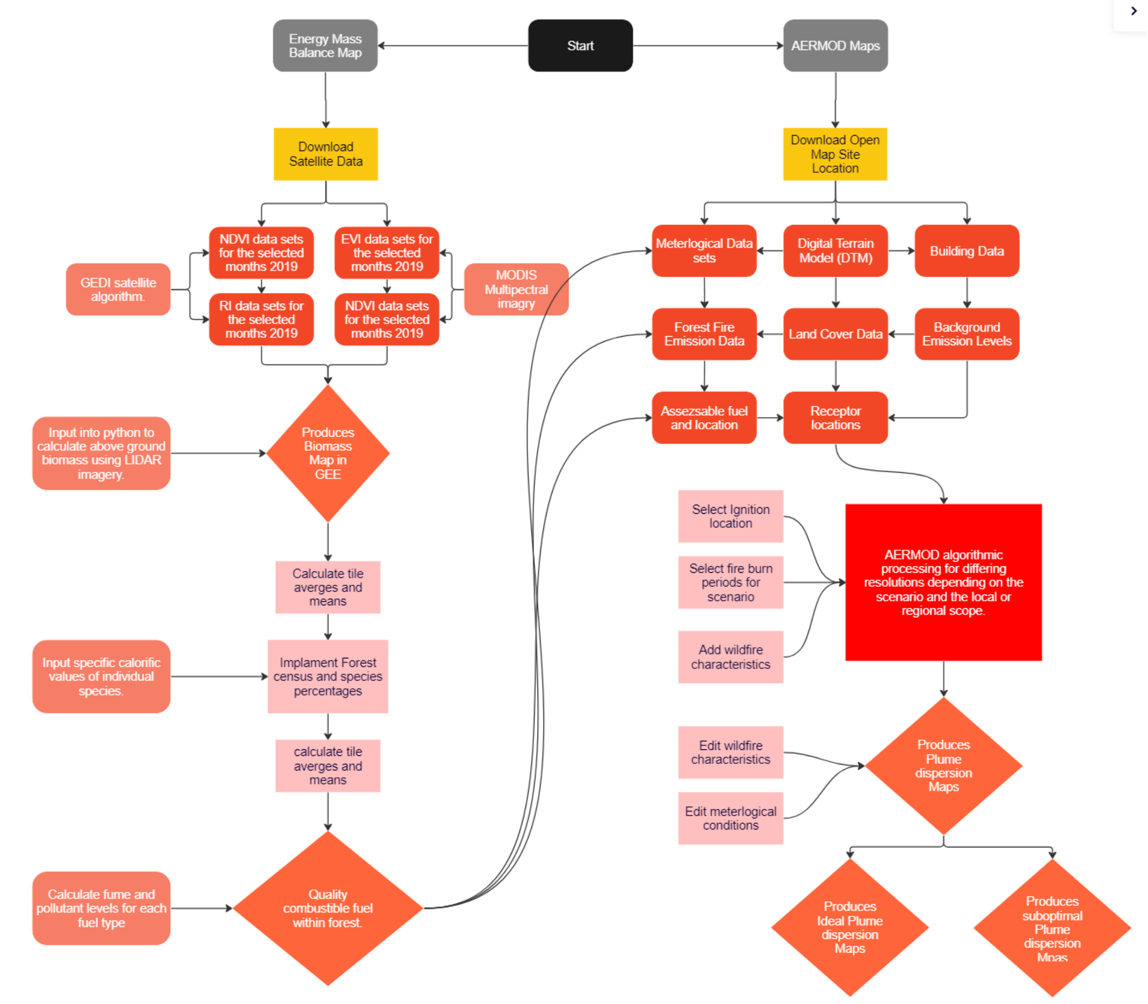
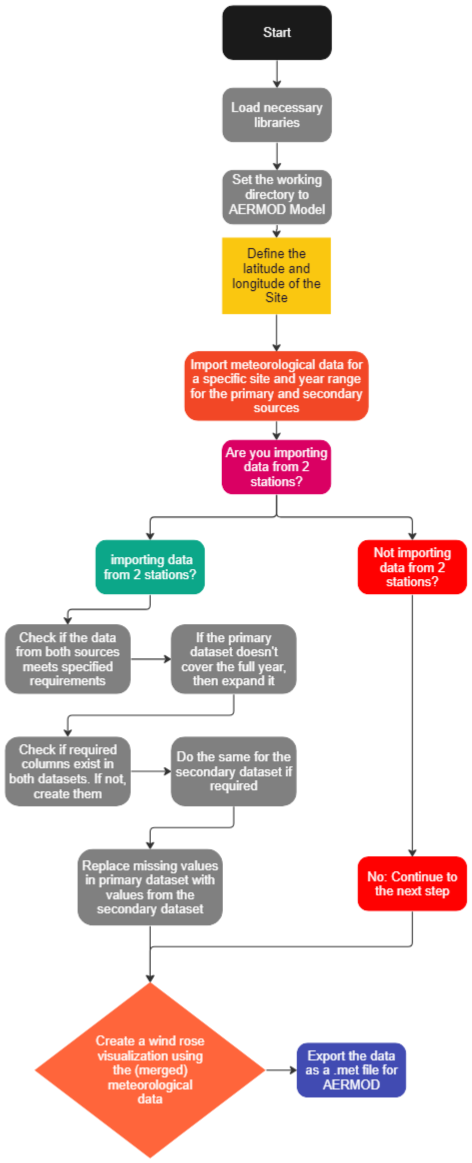
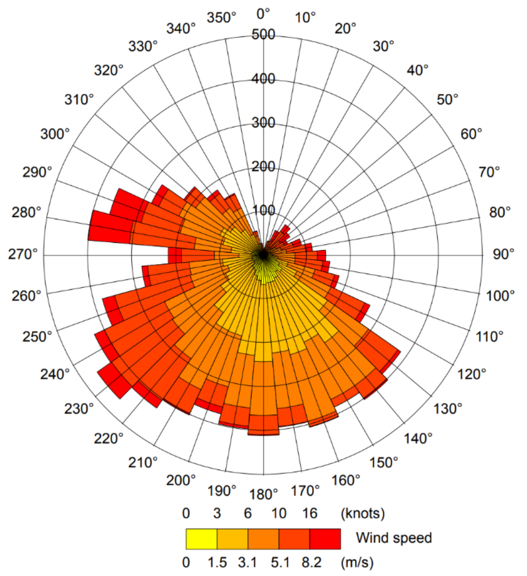
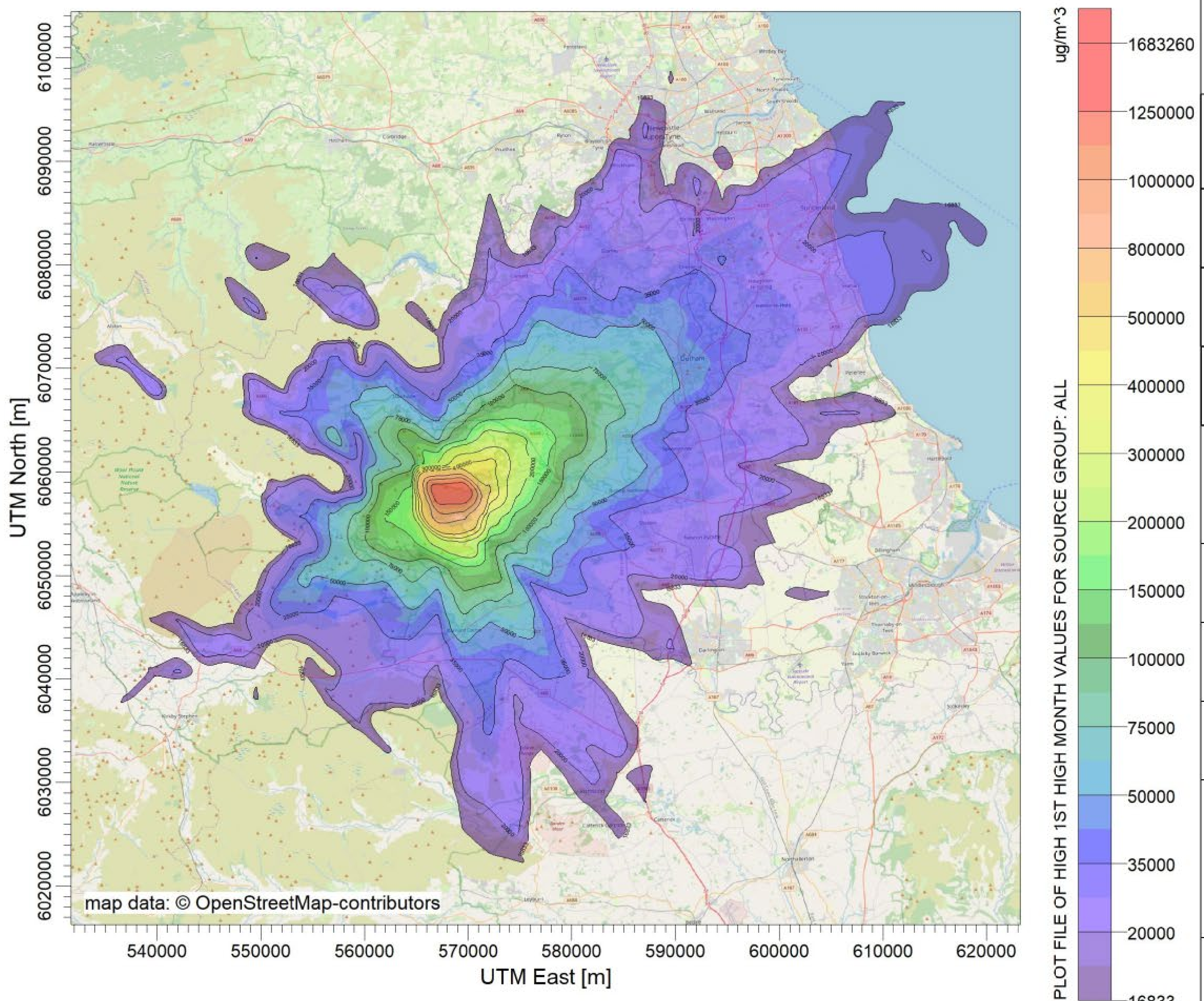
Compiling Data







Results



MODELING OPTIONS:

MODELING, OPTIONS, USED:, REGDFAULT, CONC, ELEV, RURAL

RECEPTORS:

10000

OUTPUT TYPE:

Concentration

MAX:	UNITS:
1683260.24842	**ug/m^3**

COMPANY NAME:

MODELER:

DATE:

24/09/2023

SCALE: 1:600,298

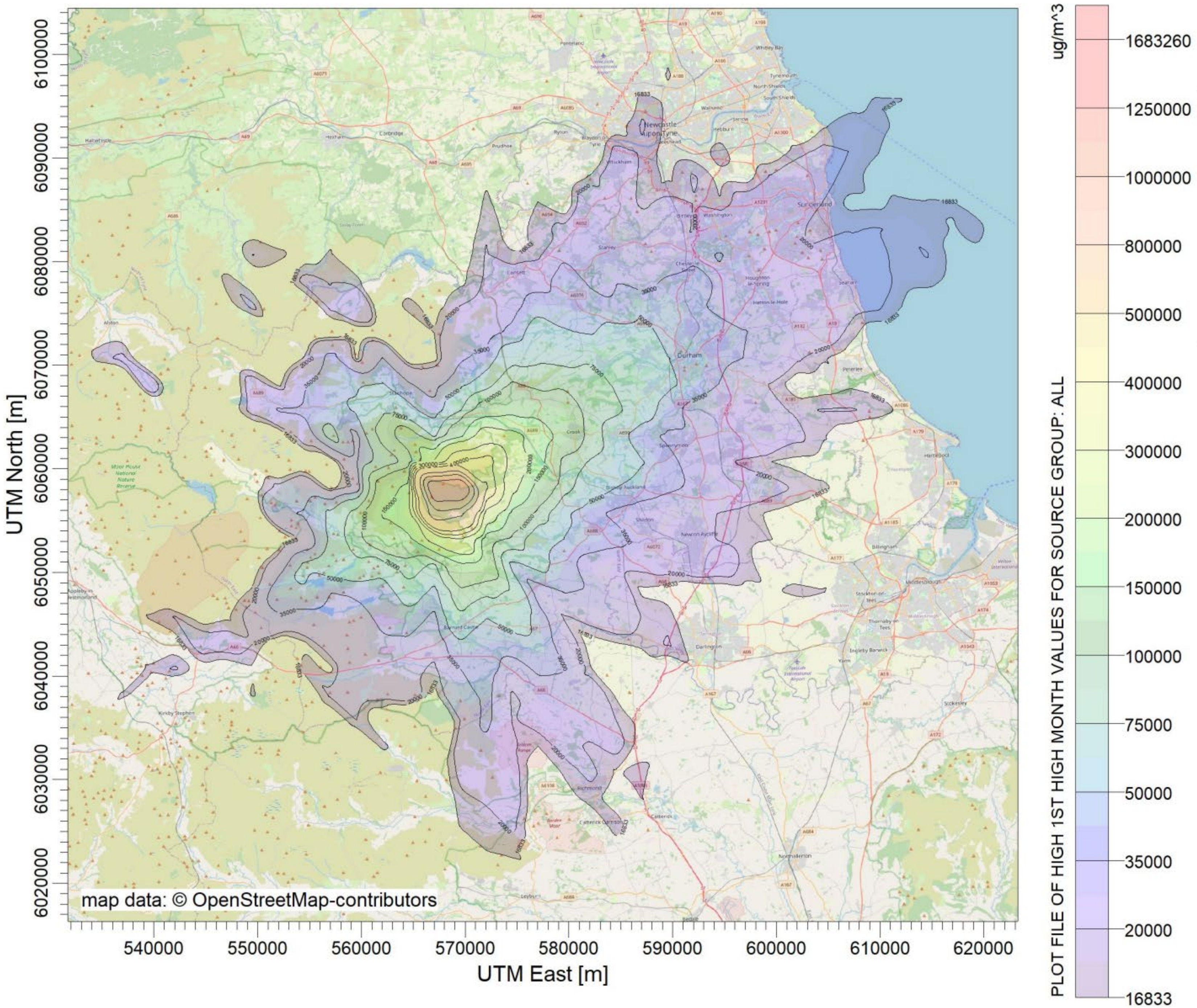
0 10 km

PROJECT NO.:

NO_2

Main 1-hour NO_2 Concentration Map

Wildfire based pollutants when breathed in have immediate and severe health consequences even in short term inhalation periods. Long term exposures of NO2. are associated with multiple health effects, predominately raspatory and cardiovascular problems (Simons & Wood, 2003)



NO_2

- Inhalation can lead to reportorial irritation tightening the chest and causing coughing which has far more dramatic effects on the local populus suffering from asthma and or smoking damage. Acute exposure increases of 10 µg/m^3 can decrease lung function in asthmatics by up to 2% (McConnell et al., 2002).

- Chronic Respiratory Diseases develop rapidly as a result of exposure to deteriorated air quality. For every annual increase of 10 µg/m^3, an 15% increase in asthma symptom days in children is expected (Gauderman et al., 2004).

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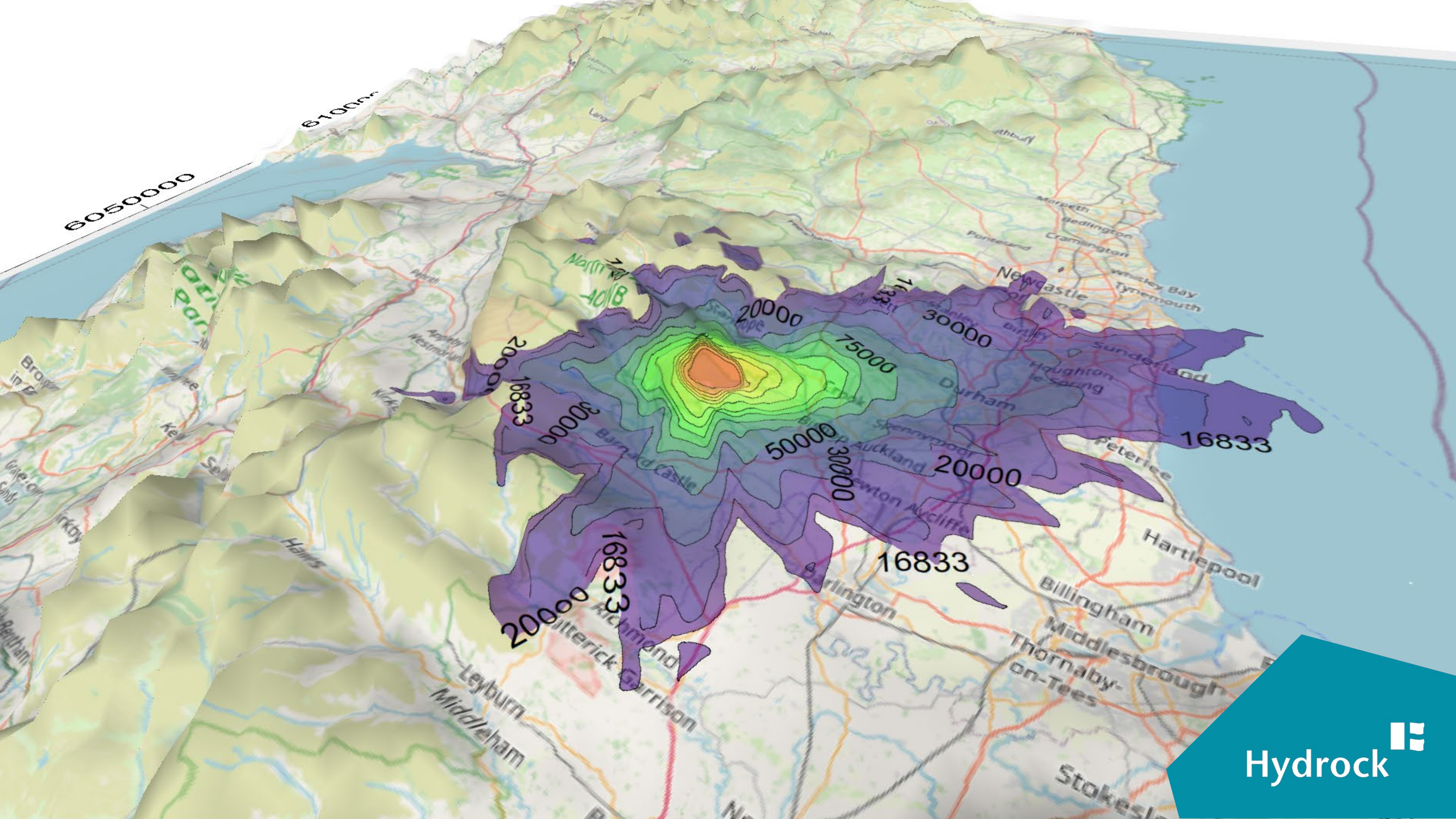
6050000
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75000
50000
30000
16833
20000
16833
20000
16833
30000
20000
16833
Newcastle
Tynemouth
Sunderland
Houghton-le-Spring
Durham
Spennymoor
Bishop Auckland
Peterlee
Newton Aycliffe
Barnard Castle
Stanhope
Hartlepool
Darlington
Billingham
Middlesbrough
Thornaby-on-Tees
Richmond
Catterick Garrison
Leyburn
Middleham
Hawes
Morpeth
Bedlington
Cramlington
Ponteland
Appleby-in-Westmorland
Whitley Bay

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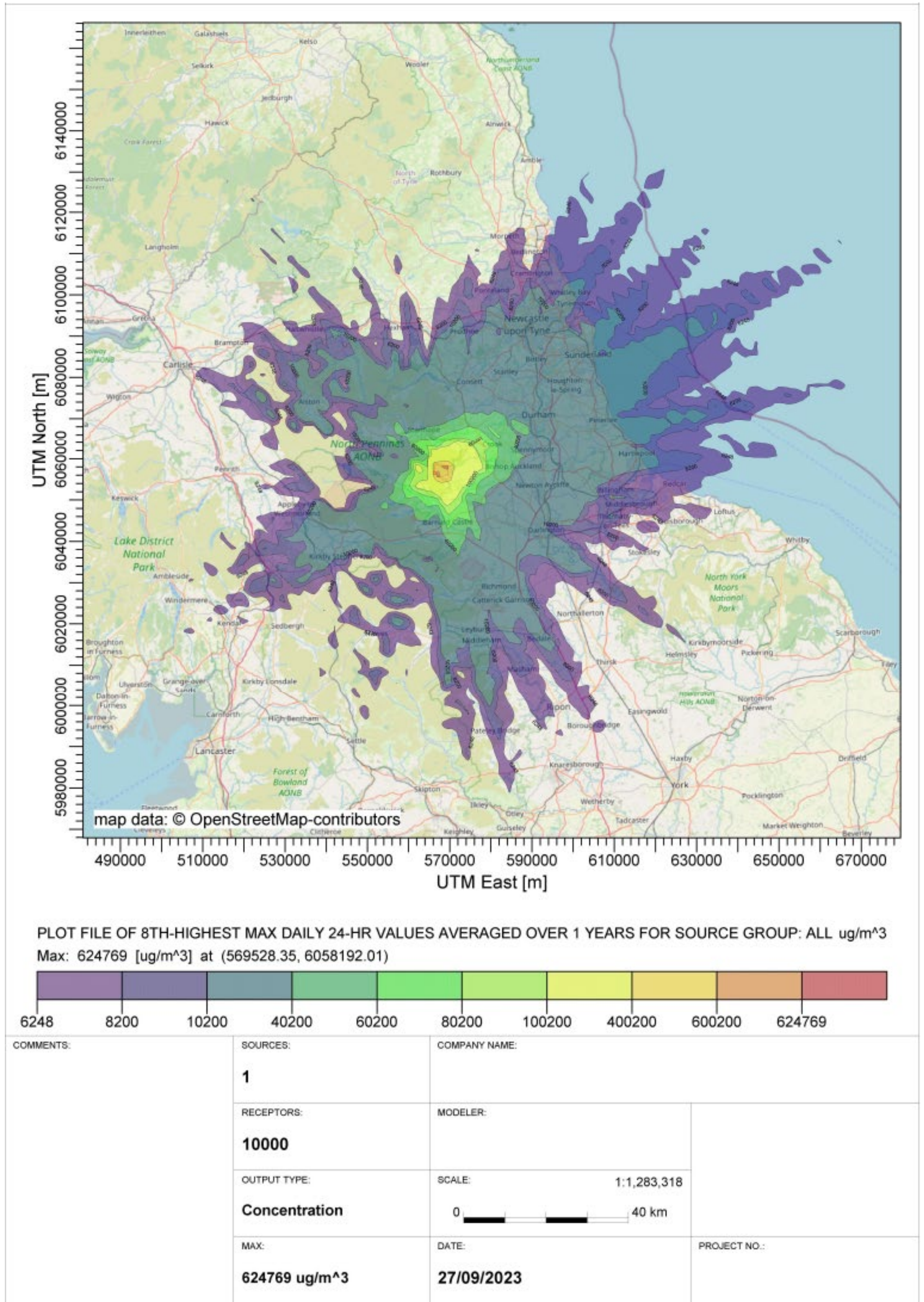

Main PM2.5 1-Hour Concentration

- PM2.5 and SO2 maps are presented in Figure 13 and Figure 14. As topographical layering is incompatible within a model larger than 5km long, it had to be removed. This causes a larger, unrealistic, spread with lower reliability and higher uncertainty. Spread southwest was impacted by the steeper terrain which has not occur due to this in these figures. The maps both suggest a direct correlation with NO2. However, these pollutants molecularly heavier (SO2 and NO2 are 64 and 56 grams per mole respectively) and drop off much faster than nitrogen. Their fore receptors further away are at lower risk than those in proximity to the fire leaning that there is likely an inverse exponential correlation between the two.

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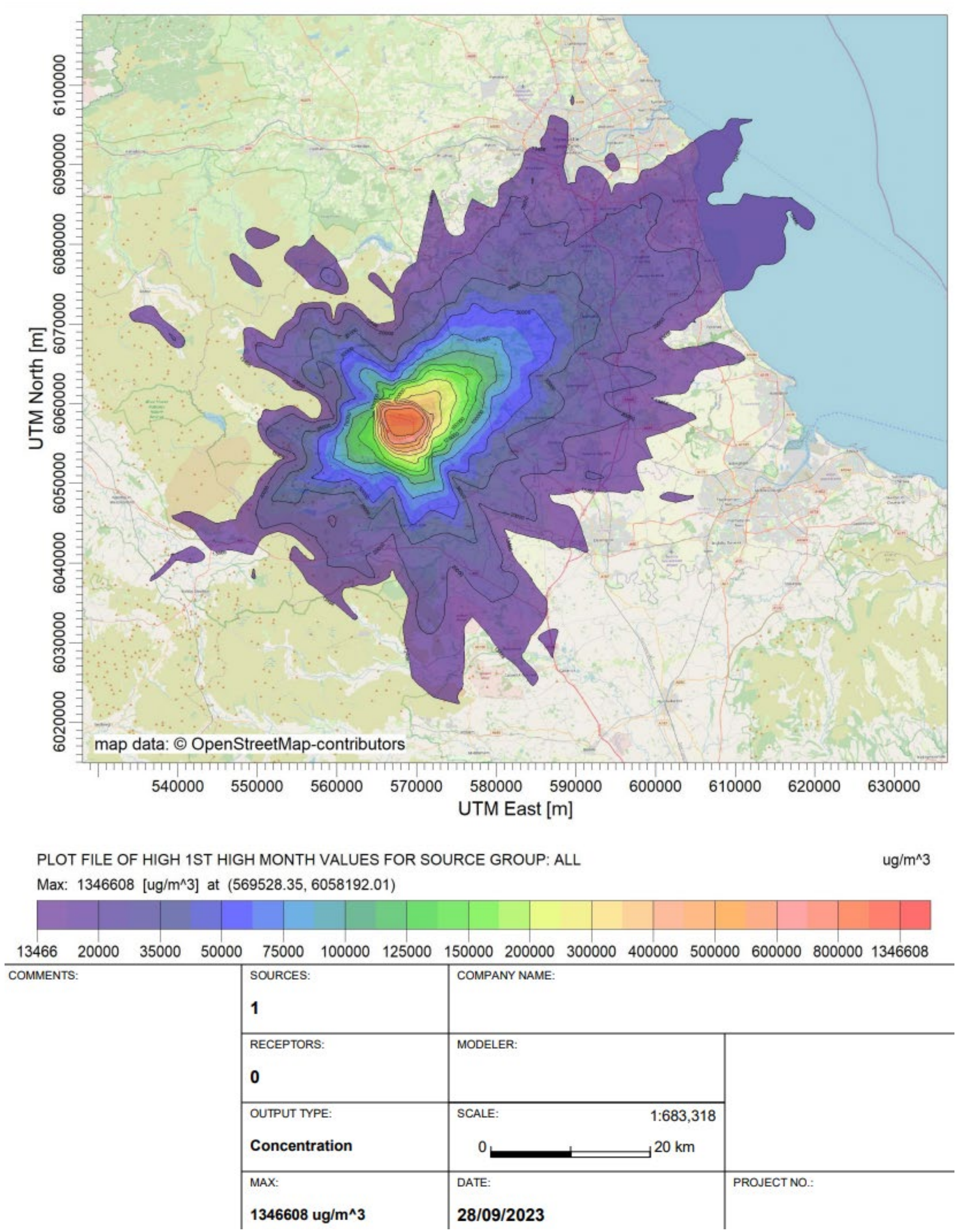
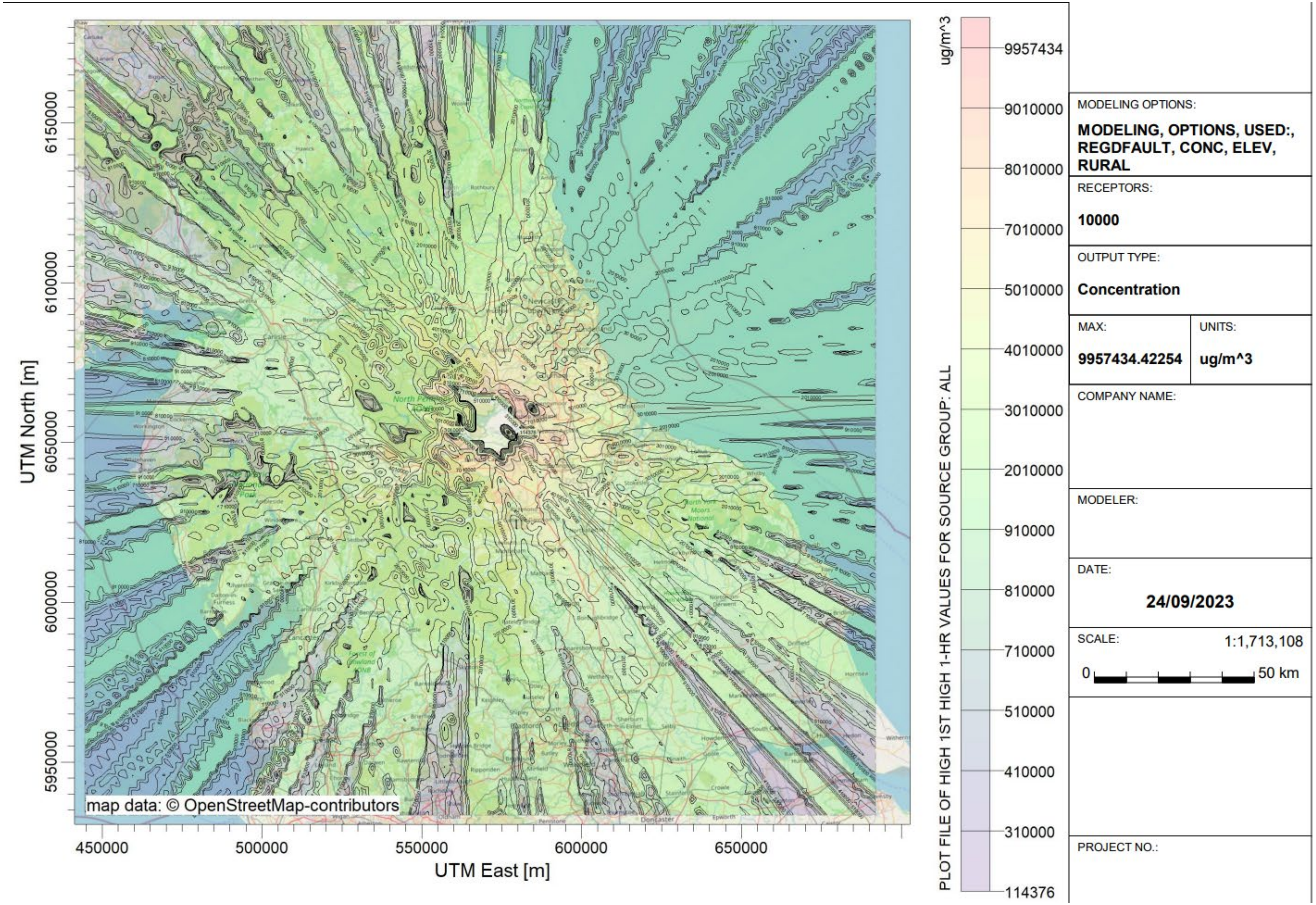


Controlled Burn Strategy

› To reduce the impact of wildfires, strategies can be put in place through monitoring and preplanning. A common and effective management strategy is the implementation of controlled burns and forest thinning. By the removing of often the most assessable fuel through the removal of trees and dry foliage, the effects of the fire are reduced. This has been implemented in the model by reducing the total fuel 20% unevenly distributed in attempt to simulate this procedure (Habeck, 1996 and Stephens et al., 2009).


UTM North [m]
6150000
6100000
6050000
6000000
5950000
UTM East [m]
450000
500000
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600000
650000
map data: © OpenStreetMap-contributors
ug/m^3
9957434
9010000
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7010000
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4010000
3010000
2010000
910000
810000
710000
510000
410000
310000
114376
PLOT FILE OF HIGH 1ST HIGH 1-HR VALUES FOR SOURCE GROUP: ALL
MODELING OPTIONS:
MODELING, OPTIONS, USED:, REGDFAULT, CONC, ELEV, RURAL
RECEPTORS:
10000
OUTPUT TYPE:
Concentration
MAX:
9957434.42254
UNITS:
ug/m^3
COMPANY NAME:
MODELER:
DATE:
24/09/2023
SCALE:
1:1,713,108
0
50 km
PROJECT NO.:

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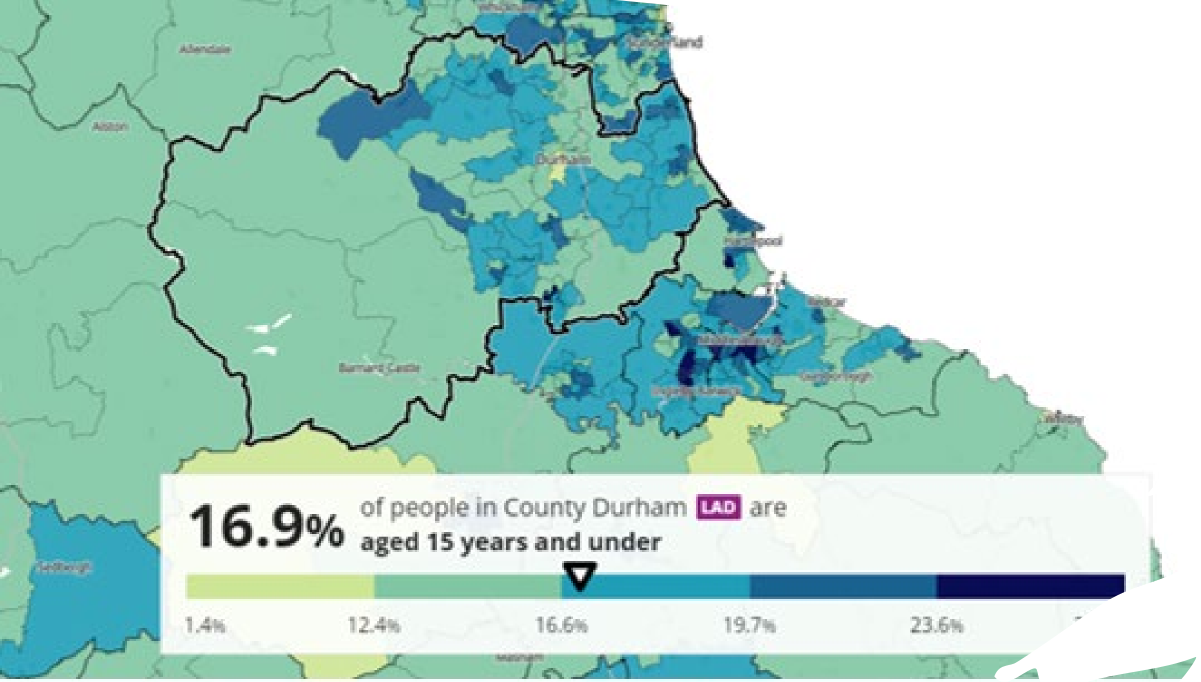
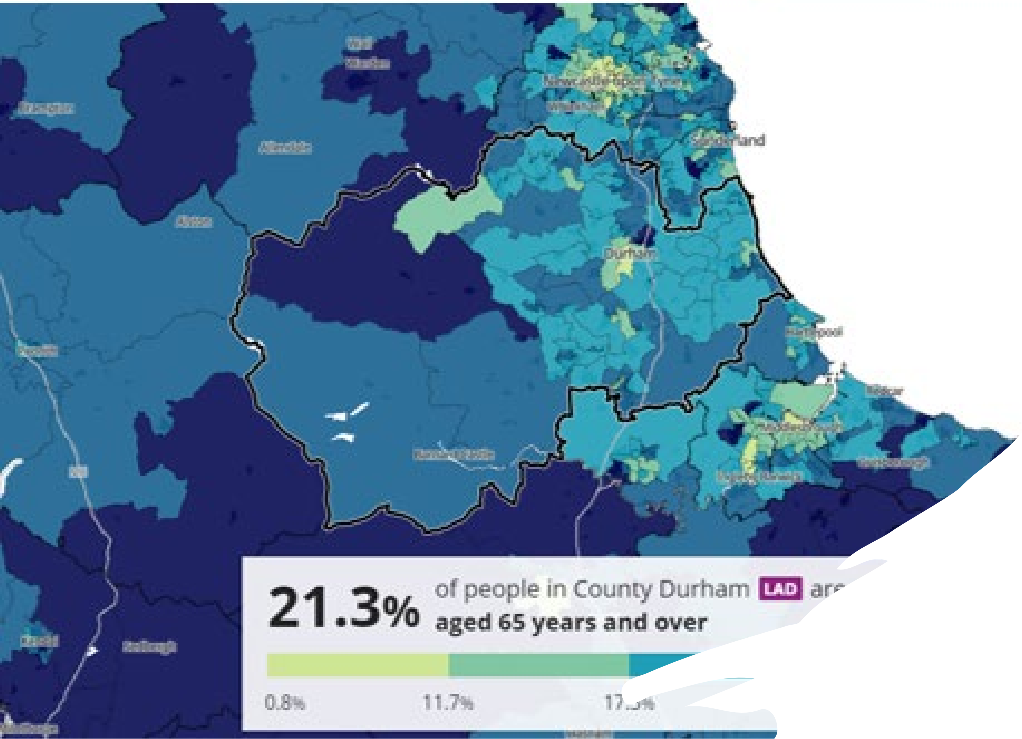
NO_2 Level (ppb)	Mortality Rate %
0 -10	0.5
10 – 20	0.6
20 – 30	0.8
30 – 40	1.0
40 – 50	1.3
50 – 60	1.7
60 – 70	2.2
70 – 80	2.8
80 – 100	3.5
100 – 150	4.5
150 – 200	6.0
200 – 250	8.0
250 – 300	10.5
300 – 350	13.5
350 – 400	17.0

Mortality Rate

- Few studies have looking into the affects of medium term exposures of elevated levels from fires in relation to nitrogen oxide and dioxide levels and have paid more attention to long term elevated levels making it hard to quantify a correlation between exposure rates, times and mortality. By compiling conclusions from the Health effects institute, Belen R, et al,. Miller KA, et at., Cesaroni et al,. Graham et al., SWINLEY FIRE PERSON, and applying related mortality statistics to a Genaraized Additive Model (GAM). This allows for flexible handling of a non-linear relationship between multiple predictive variables. The following equation was used within Python to produce the Table 6:
- Mortality Rate = s (NO2 Level) + s (Temperature) + s (Humidity) multiplied by general health scores for the region (1.27)
- Where: The response variable is the mortality rate. s (): A smooth function applied to model non-linear effects.
- Covariates like temperature and humidity and included to adjust the model.
- Correlation between NO2 (ppb) air quality levels and the mortality rate (%) was quantified in the works from (Tanvir et al., 2020) and is presented in Table 6.
- Table 6: NO2 Concentrations vs Mortality Rate. Contour value must be divided by 720 to translate to the hourly values seen here above. British Air quality standards do not allow for exposure levels of 200 or more for more than 60 hours a year.


16.9% of people in County Durham LAD are aged 15 years and under
1.4%
12.4%
16.6%
19.7%
23.6%
Allendale
Alston
Durham
Hartlepool
Redcar
Barnard Castle
Guisborough
Whitby
Sedbergh


21.3% of people in County Durham LAD are
aged 65 years and over
0.8%
11.7%
Newcastle upon Tyne
Sunderland
Allendale
Alston
Durham
Hartlepool
Redcar
Barnard Castle
Guisborough
Sedbergh

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Thank you

Any questions?

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BRISTOL
CAMBORNE
CARDIFF
EDINBURGH
GLASGOW
GLOUCESTER
HALE
LEEDS
LONDON
LUTTERWORTH (KTA)
MANCHESTER
NEWCASTLE
NORTHAMPTON
PLYMOUTH
PLYMPTON (KTA)
SOUTHAMPTON
STOKE-ON-TRENT
TAUNTON

ENGINEERING | ENERGY | SUSTAINABILITY

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Breathe Warsaw – Low Emission Zone

Air Quality Impact Assessment

Jekabs Jursins

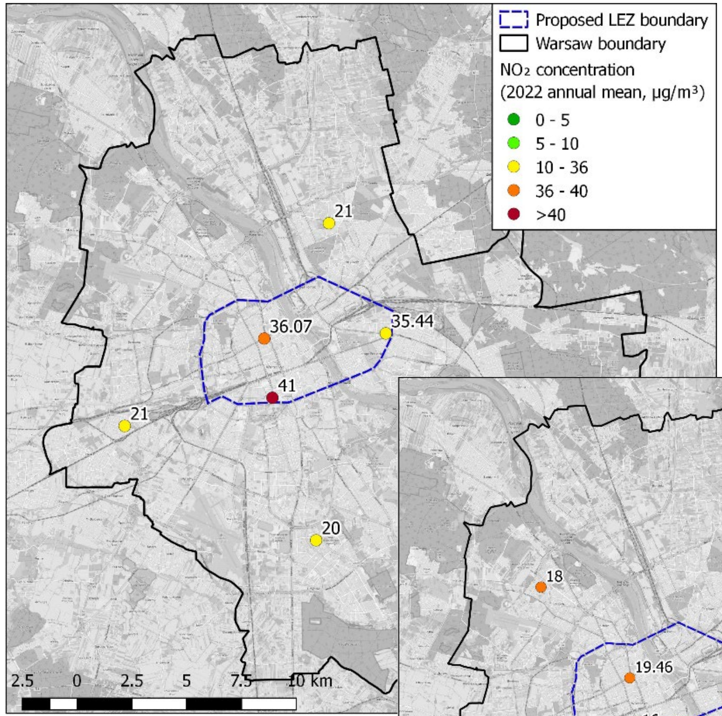
7 December 2023

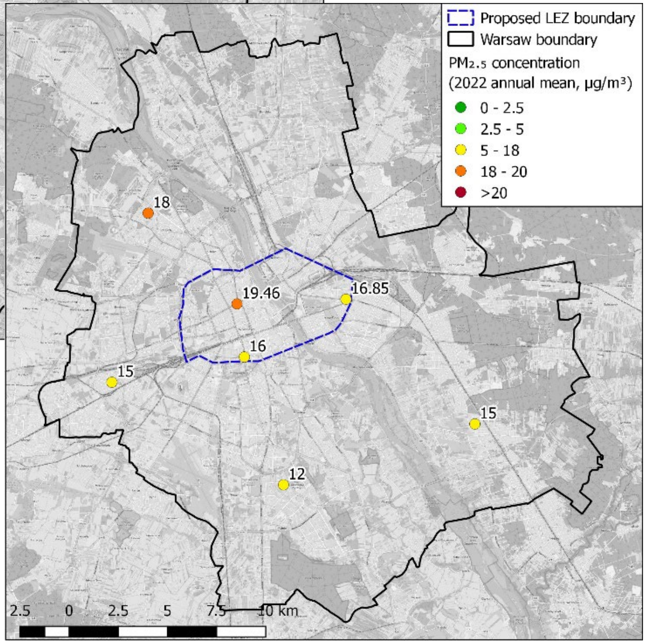
Contents

Air quality monitoring in Warsaw

- 2022 measurements from automatic monitoring sites
  - Exceedances of EU Ambient Air Quality Directive annual limit value (red)
  - At risk of exceedance (i.e. within 10%) (orange)
  - All measurements of NO_2, PM_{10} & $PM_{2.5}$ were above the World Health Organisation (WHO) Air Quality Guidelines (yellow)

Measurement location	Site type	In LEZ?	Year	$PM_{2.5}$	PM_{10}	NO_2
244A Grochowska Street (City)	Urban roadside	Yes	2022	16.85	25.12	35.44
83/89 Solidarności Street (City)	Urban roadside	Yes	2022	19.46	29.46	36.07
Warszawa, al. Niepodległości	Urban roadside	Yes	2022	16.00	32.00	41.00
Warszawa, ul. Wokalna	Background	No	2022	12.00	17.00	20.00
Warszawa, ul. Kondratowicza	Background	No	2022			21.00
Warszawa, ul. Chrościckiego	Suburban roadside	No	2022	15.00	22.00	21.00
Warszawa, ul. Tołstoja	Background	No	2022	18.00	26.00	
Warszawa, ul. Bajkowa	Background	No	2022	15.00	22.00	
European limit value ($\mu g/m^3$)				20	40	40
WHO 2021 AQGs ($\mu g/m^3$)				5	15	10





- Improving AQ is the driving motivation behind implementing a LEZ in Warsaw in 2024

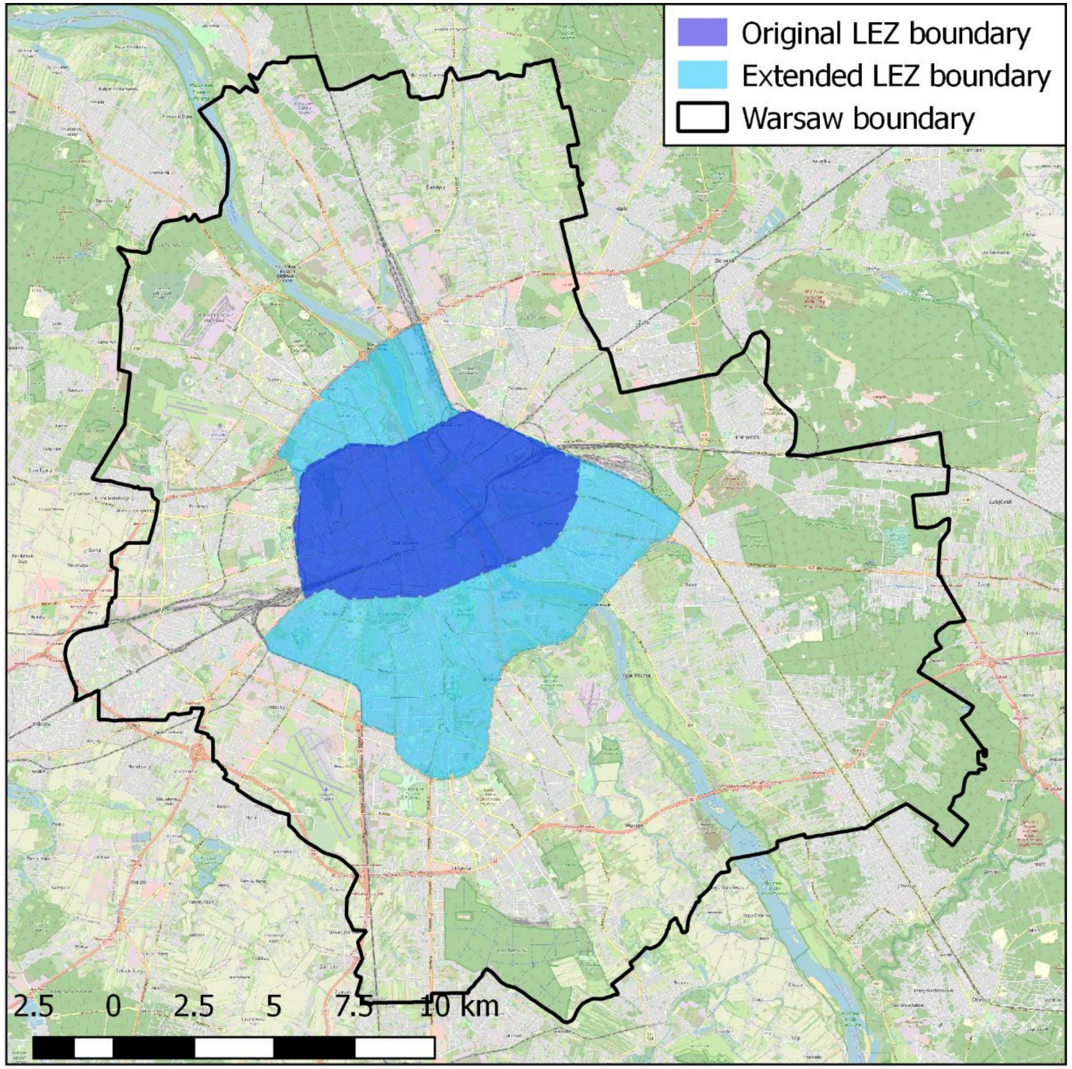
Modelled scheme options

Scenarios

We have provided NO_2, PM_{10} and $PM_{2.5}$ annual mean concentration outputs for:

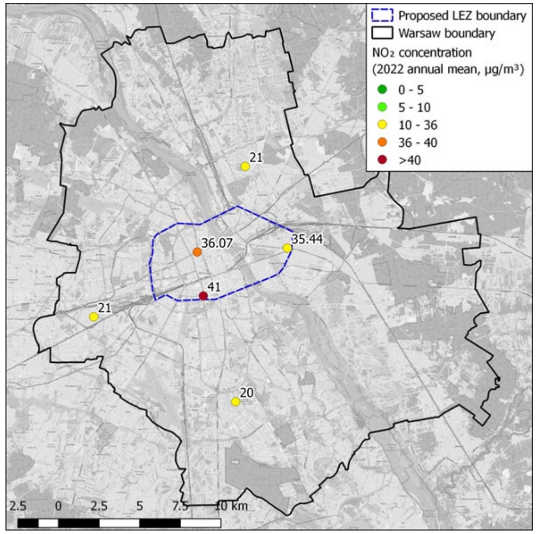
- **2019 base year** for model validation against monitored data
- **2026 Baseline** future scenario against which to compare the LEZ scenarios
- **2026 Phase 2** – Euro 3 Petrol, Euro 5 Diesel
- **2026 Phase 2A** (extended zone with exemptions) – Euro 3 Petrol, Euro 5 Diesel
- **2026 Phase 3** – Euro 4 Petrol, Euro 6 Diesel
- **2026 Phase 3A** (extended zone) – Euro 4 Petrol, Euro 6 Diesel

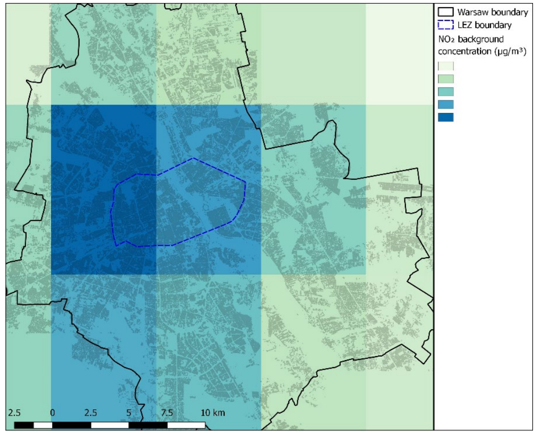
Phase	Minimum Euro Standard		Implementation Year	
-	Diesel	Petrol	Option 1	Option 2
1	Euro 4	Euro 2	2024	2024
2	**Euro 5**	**Euro 3**	**2026**	2025
3	**Euro 6**	**Euro 4**	2028	**2026**
4	Euro 6d	Euro 5	2030	2027
5	Euro 6d	Euro 6	2032	2028
6	Euro 7	Euro 6d	2034	2030
7	Euro 7	Euro 7	2035	2035
8	ZEV	ZEV	2038	2038



Model inputs

- **Model selection**
  - RapidAIR© Urban Air Quality Modelling Platform - Ricardo's proprietary modelling system developed for urban air pollution assessment
- **Air quality monitoring data**
  - Monitoring data provides annual mean concentrations of NO_2, PM_{10} & $PM_{2.5}$ at points across the city
  - Applied to model validation and locations used for reporting of results
- **Background concentrations**
  - Non-road transport emission sources estimated using satellite data and background monitoring sites





- **Street canyons**
  - Determined using building heights data
- **Road gradients**
  - Determined using satellite data
- **Traffic activity and speed data**
  - Local traffic model data provided by the City
  - Traffic count data
- **Vehicle fleet composition**
  - Vehicle age (Euro class) and fuel splits for the different vehicle types were compiled using local (ANPR) and national data
- **Emission factors**
  - Warsaw real-world emissions data (provided by International Council for Clean Transport) were applied to adjust COPERT emissions factors for nitrogen oxides (NOx)
- **Vehicle fleet projections**
  - Vehicle fleets were projected to be representative of the 2026 Baseline using data obtained from TRUE / ICCT and bus fleet upgrade schedule

Behavioural response assumptions – fleet & activity

The following behavioural response assumptions were applied to **non-compliant vehicles** to assess the impact of the LEZ scheme and were split between activity within the LEZ and that outside the LEZ:

Vehicles within LEZ:

- Travel behaviour response - removing the following percentage of non-compliant vehicles before applying the upgrade response to account for vehicles potentially diverting, cancelling their trip or changing mode:

Vehicle type	Cars	Vans	HGVs	City buses	Other buses
Remove AADT (LEZ only)*	29%	16%	8%	0%	10%

- Upgrade response - percentage of the non-compliant fleet (still making journeys inside the LEZ) that upgrade to a compliant vehicle by 2026:

Vehicle type	Cars	Vans	HGVs	City buses	Other buses
Fleet upgrade*	90%	76%	90%	100%	89%

Vehicles outside LEZ:

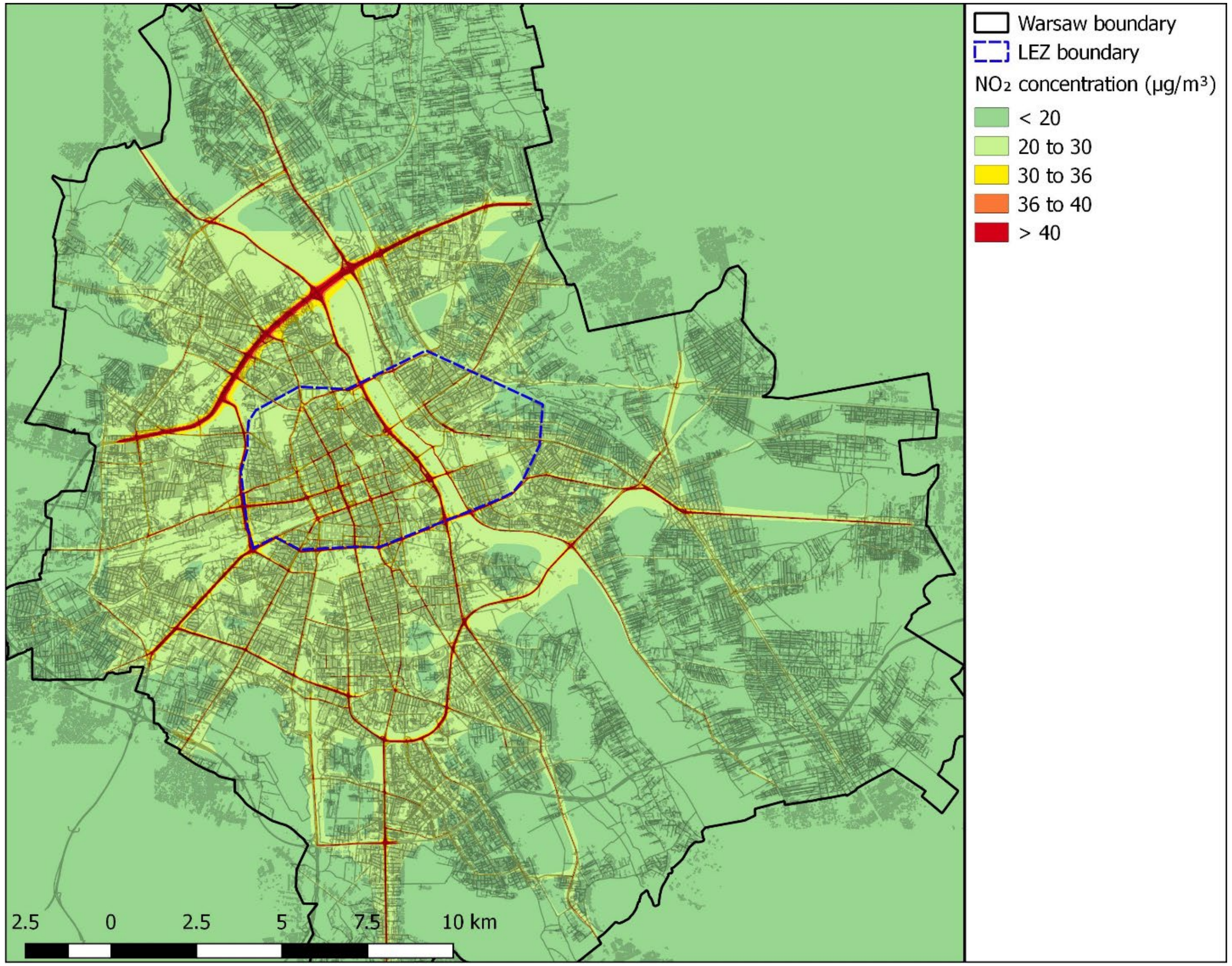
- Travel behaviour response - we did not apply any travel behaviour response as these are uncertain
- Upgrade response - we have assumed that **19% (35% extended LEZ) of non-compliant vehicles will see an upgrade response**. This is because the transport model shows that an average of 19% (35% for extended) of trips that start outside of the LEZ end in the LEZ.

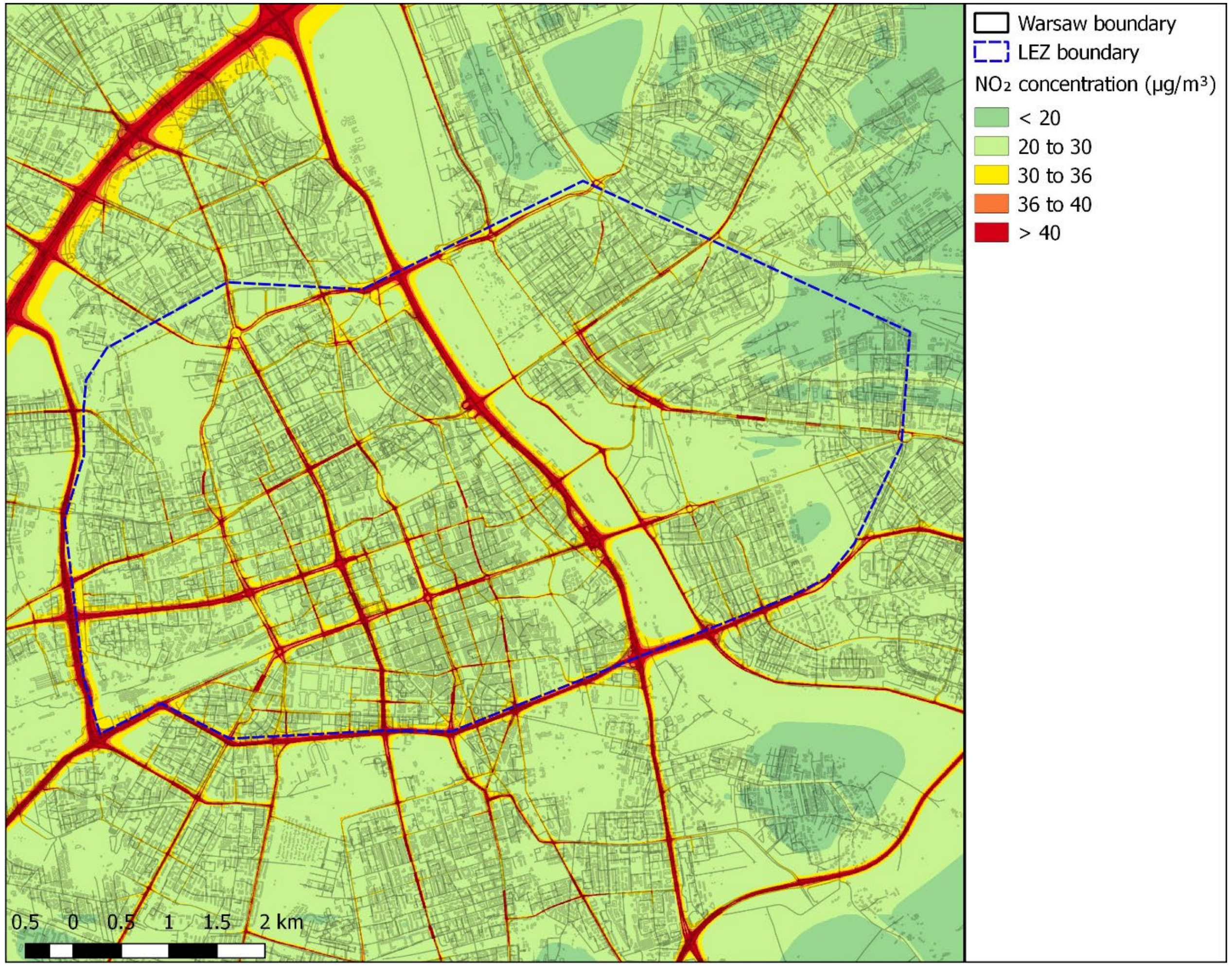
Scheme exemption (Phase 2A) for residents living in the zone :

- The transport model shows that 38% of passenger cars start or end their journey at ‘home’ inside the extended LEZ. The percentage of these vehicles that do not meet the LEZ restrictions were assumed as being exempt from the scheme

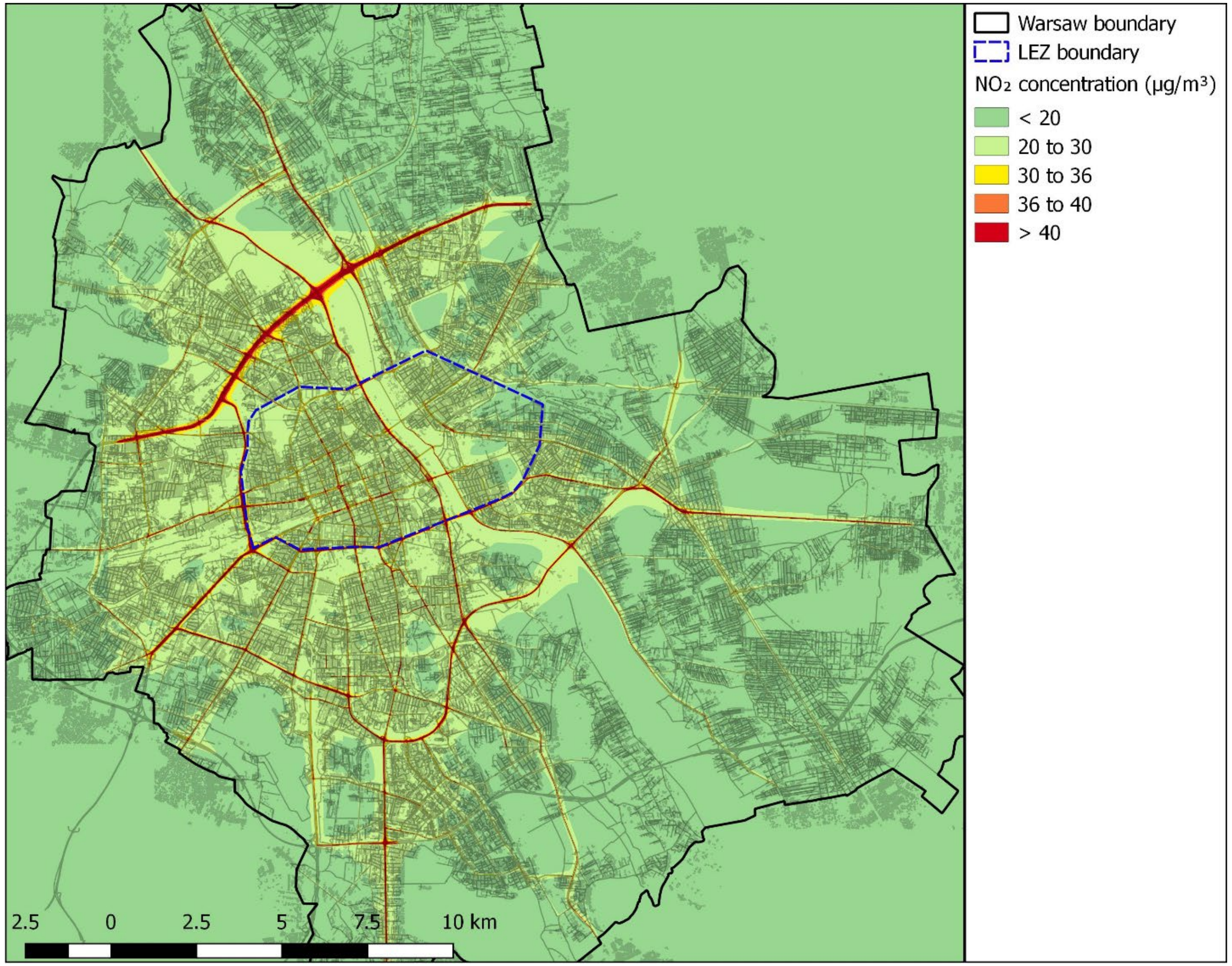
*Assumptions based on London ULEZ data (Ref: JAQU CAZ Appraisal Guidance 2019). Response shown in terms of VKM changes

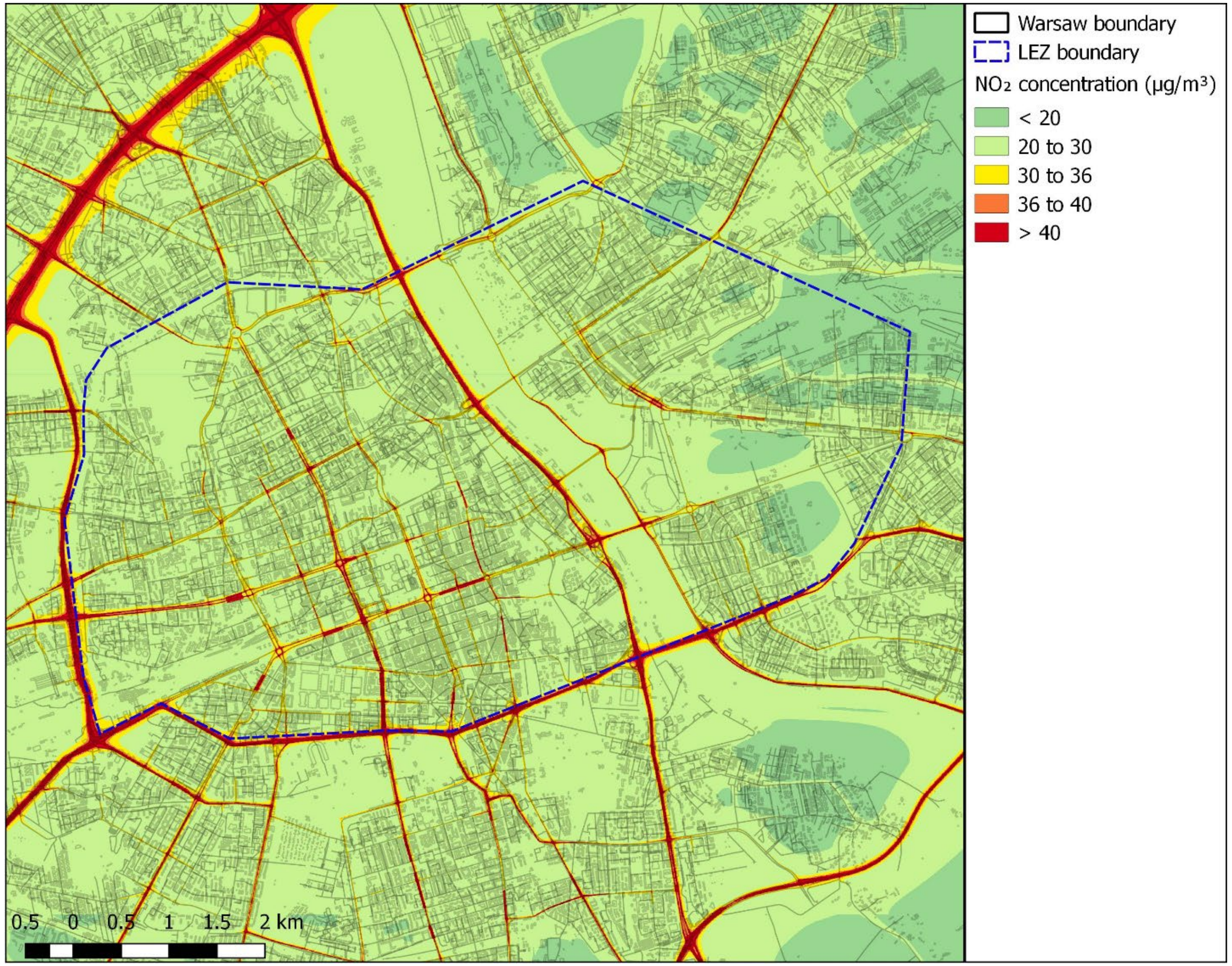
2026 Baseline NO_2 concentration



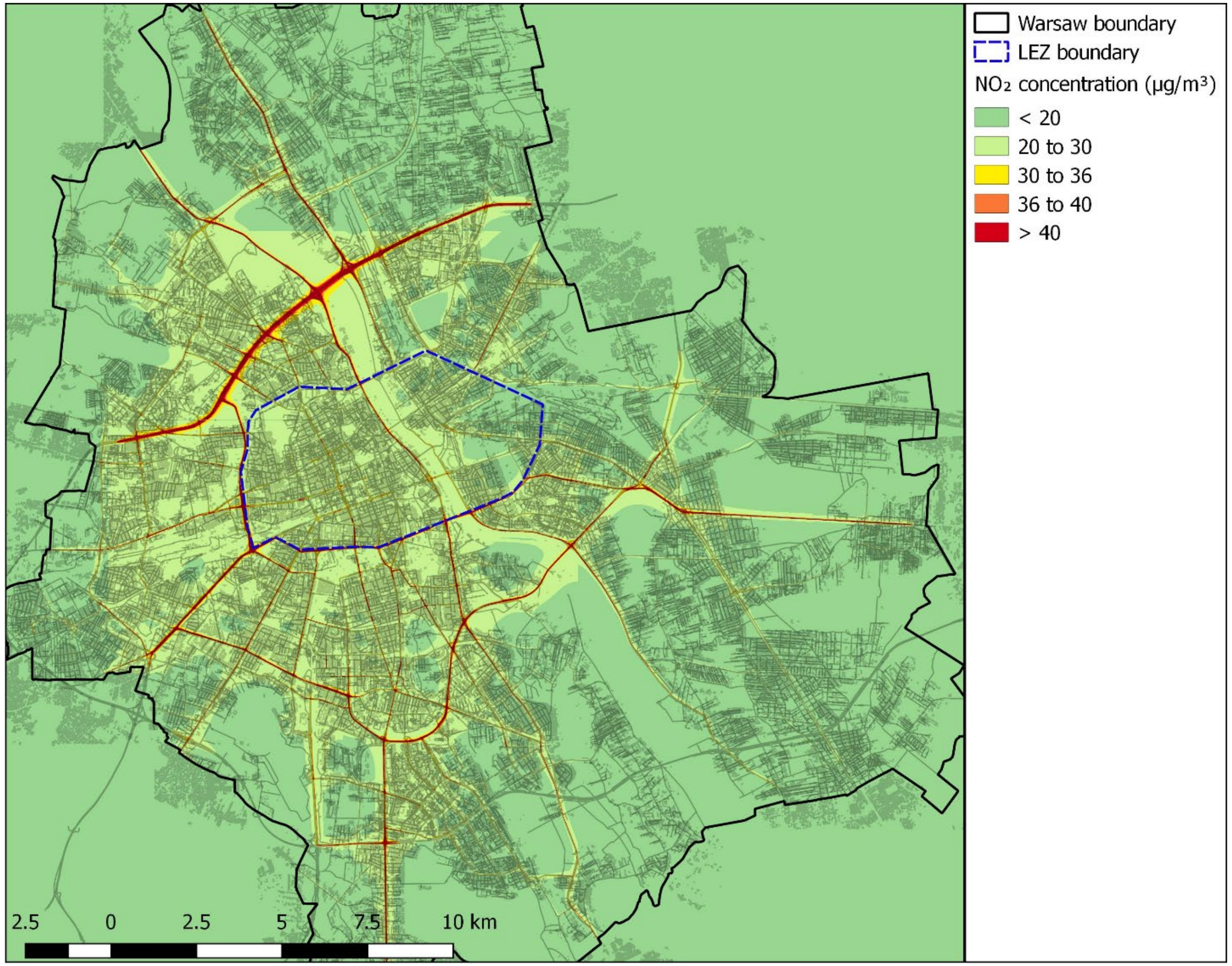


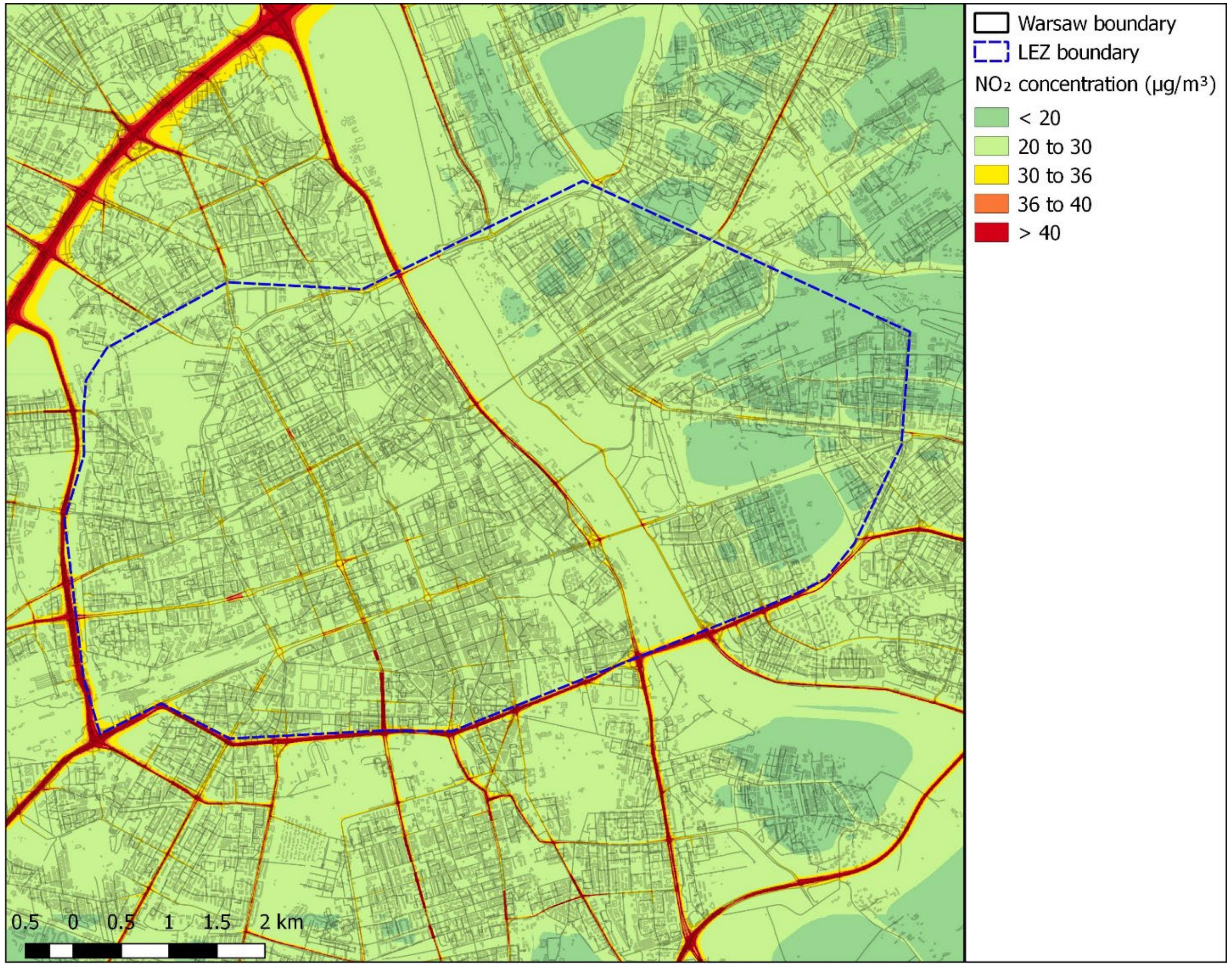
2026 LEZ Phase 2 NO_2 concentration





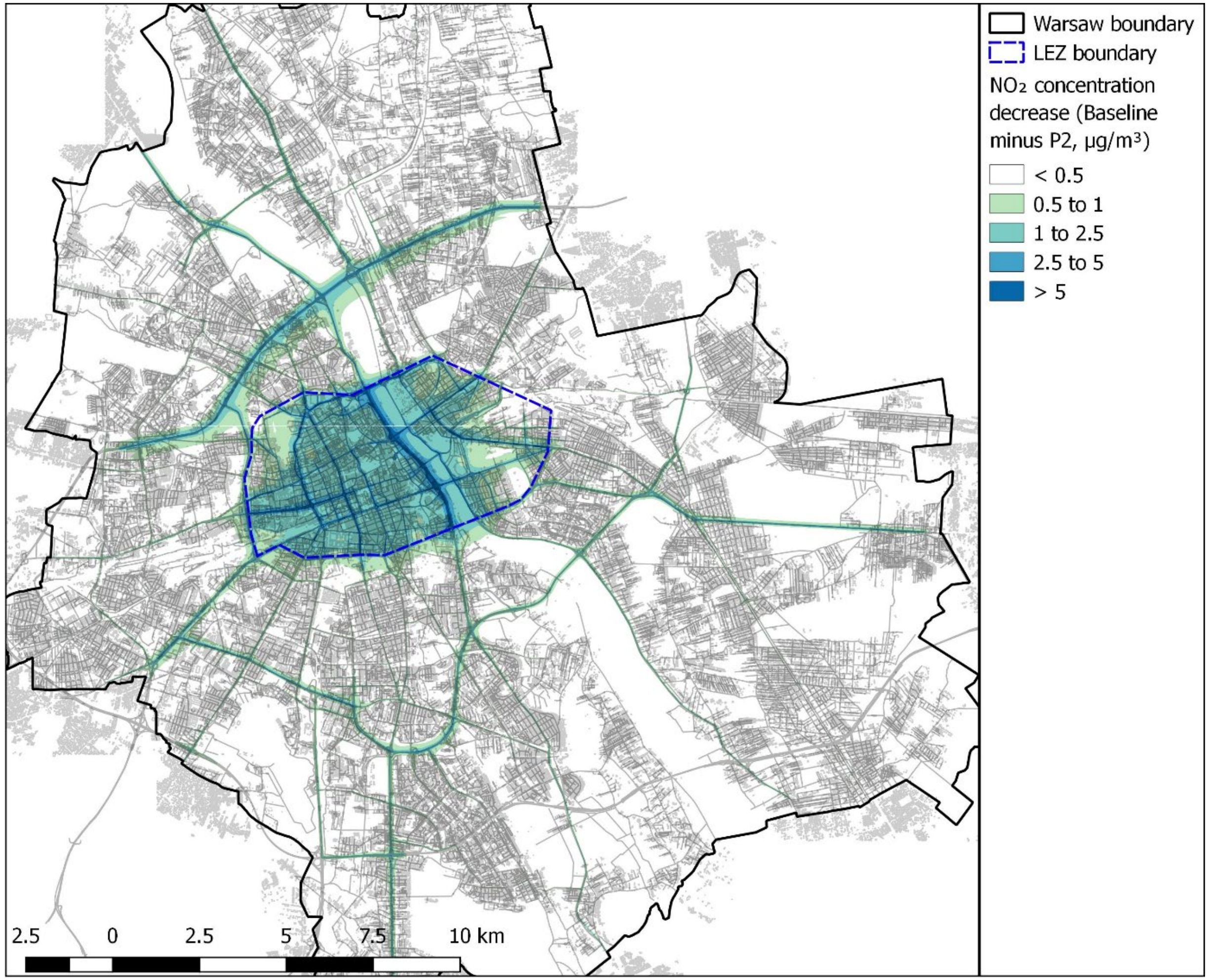
2026 LEZ Phase 3 NO_2 concentration



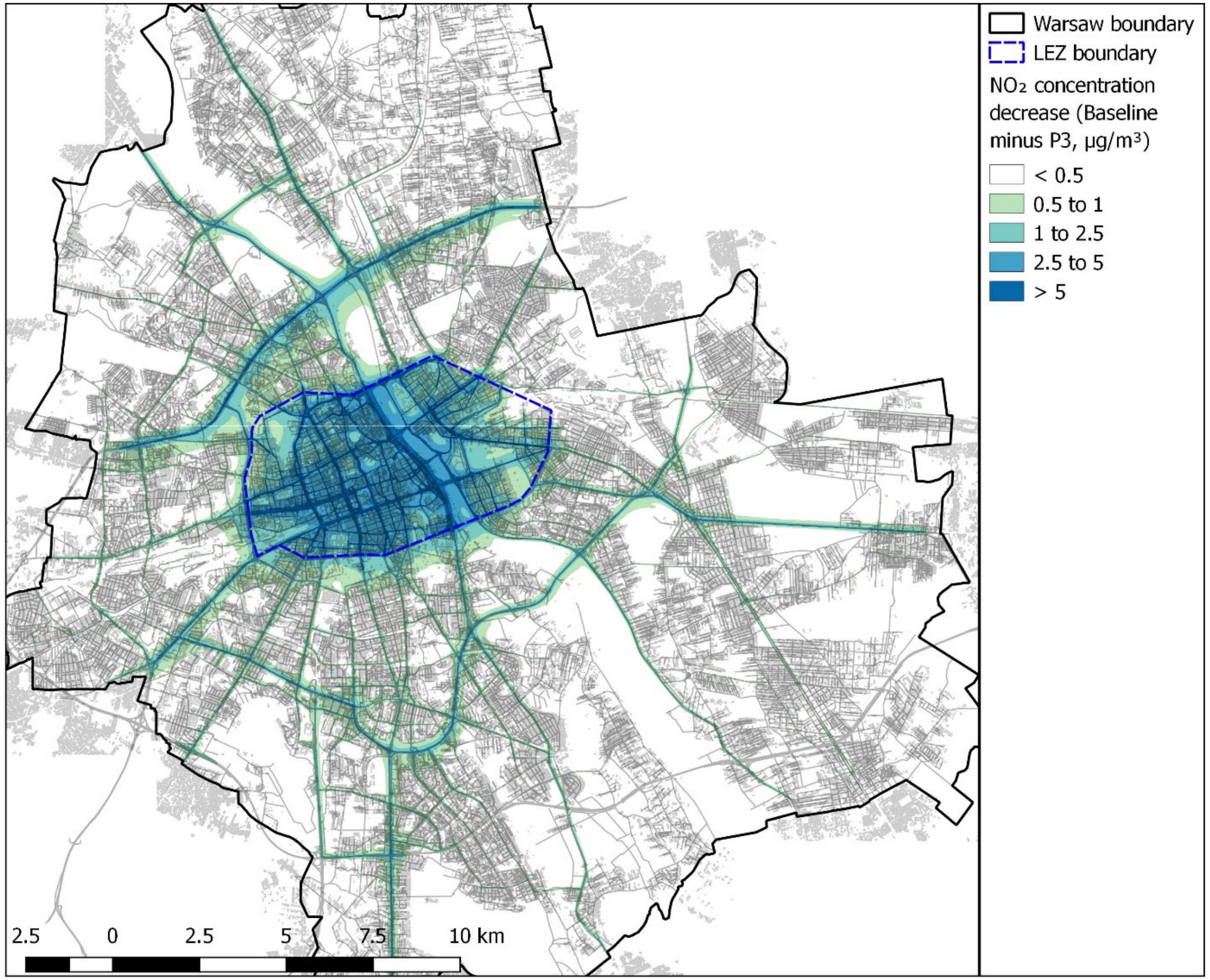


NO_2 concentration decrease as a result of LEZ implementation

Phase 2 - Baseline

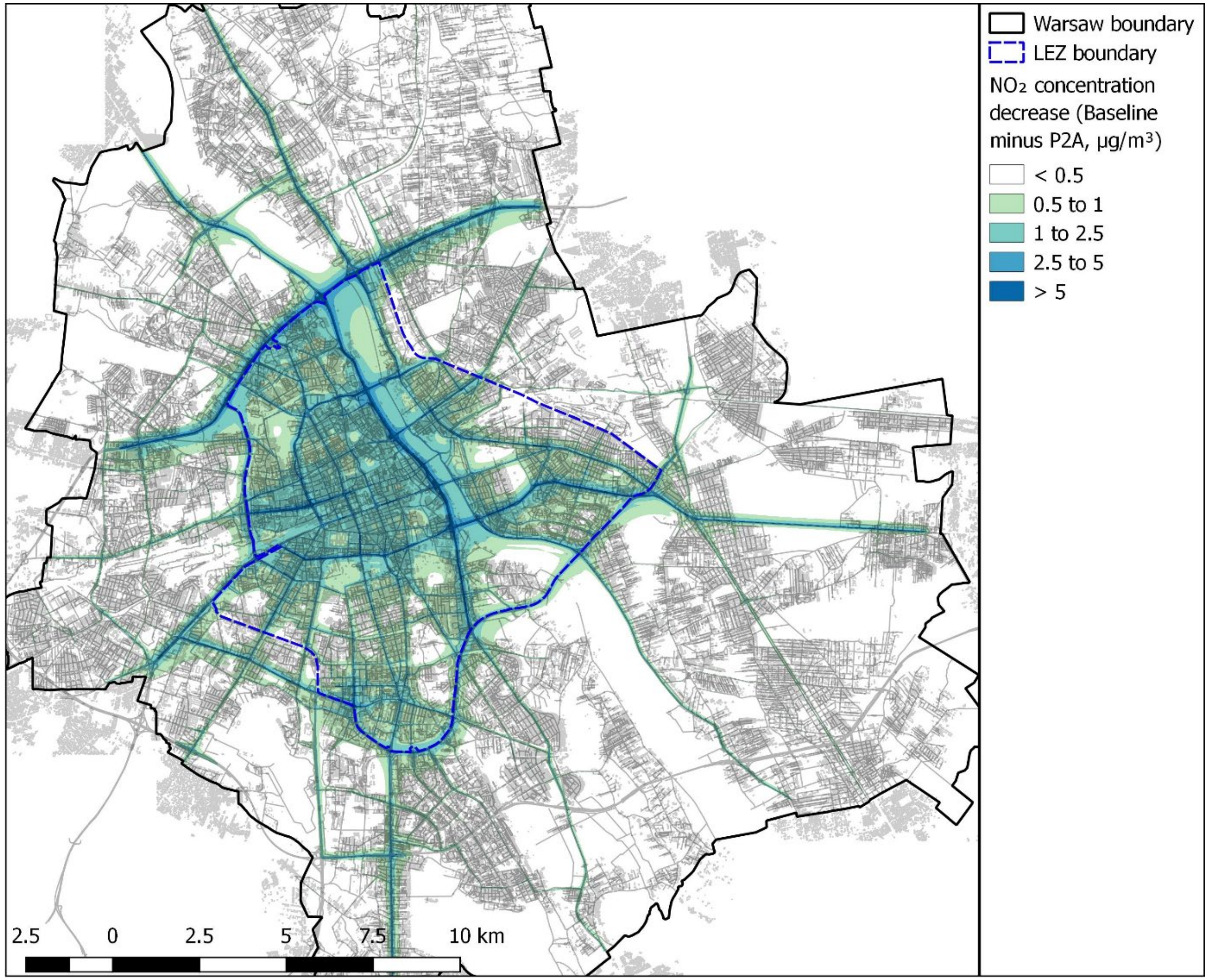


Phase 3 – Baseline

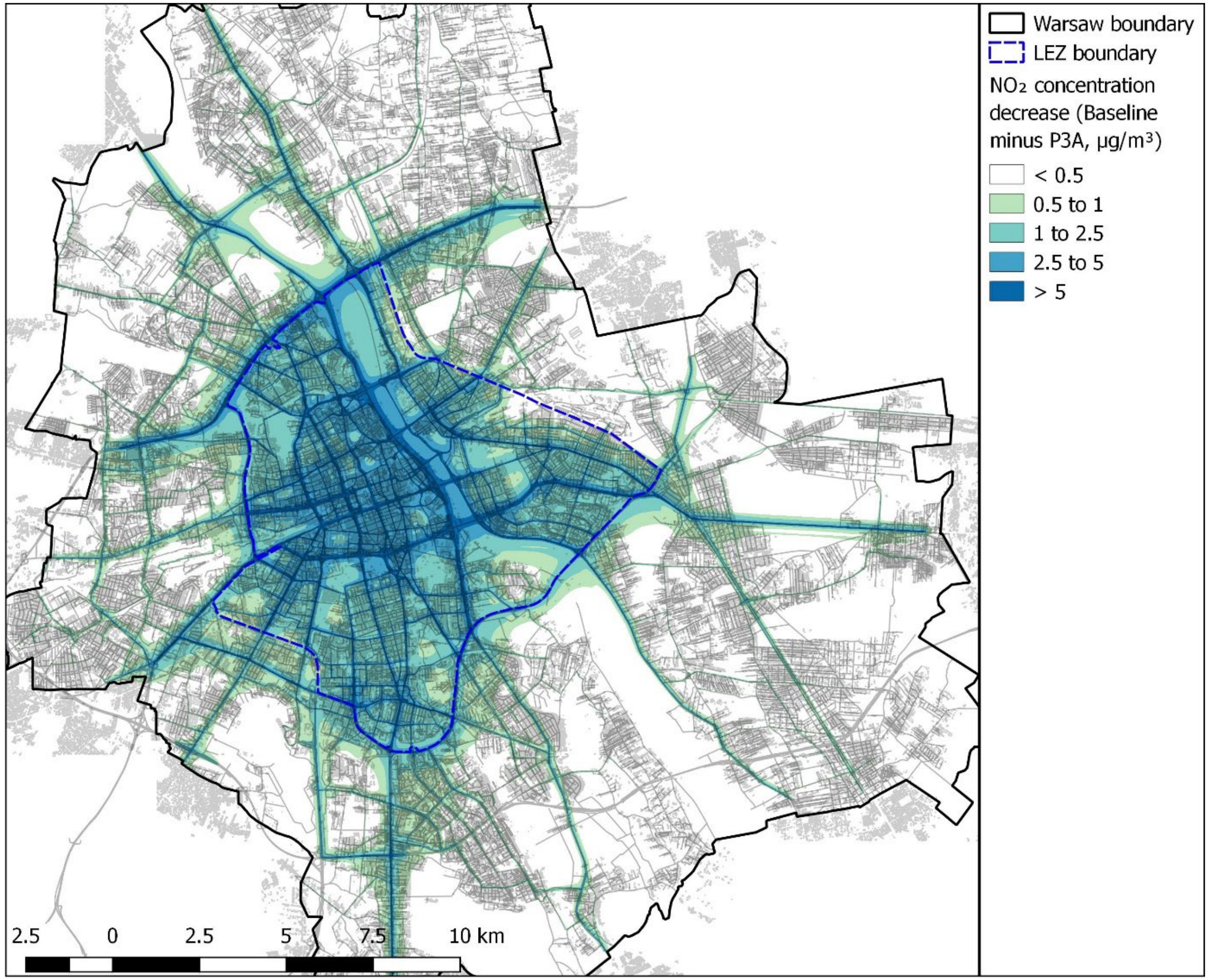


NO_2 concentration decrease as a result of LEZ implementation

Phase 2A - Baseline

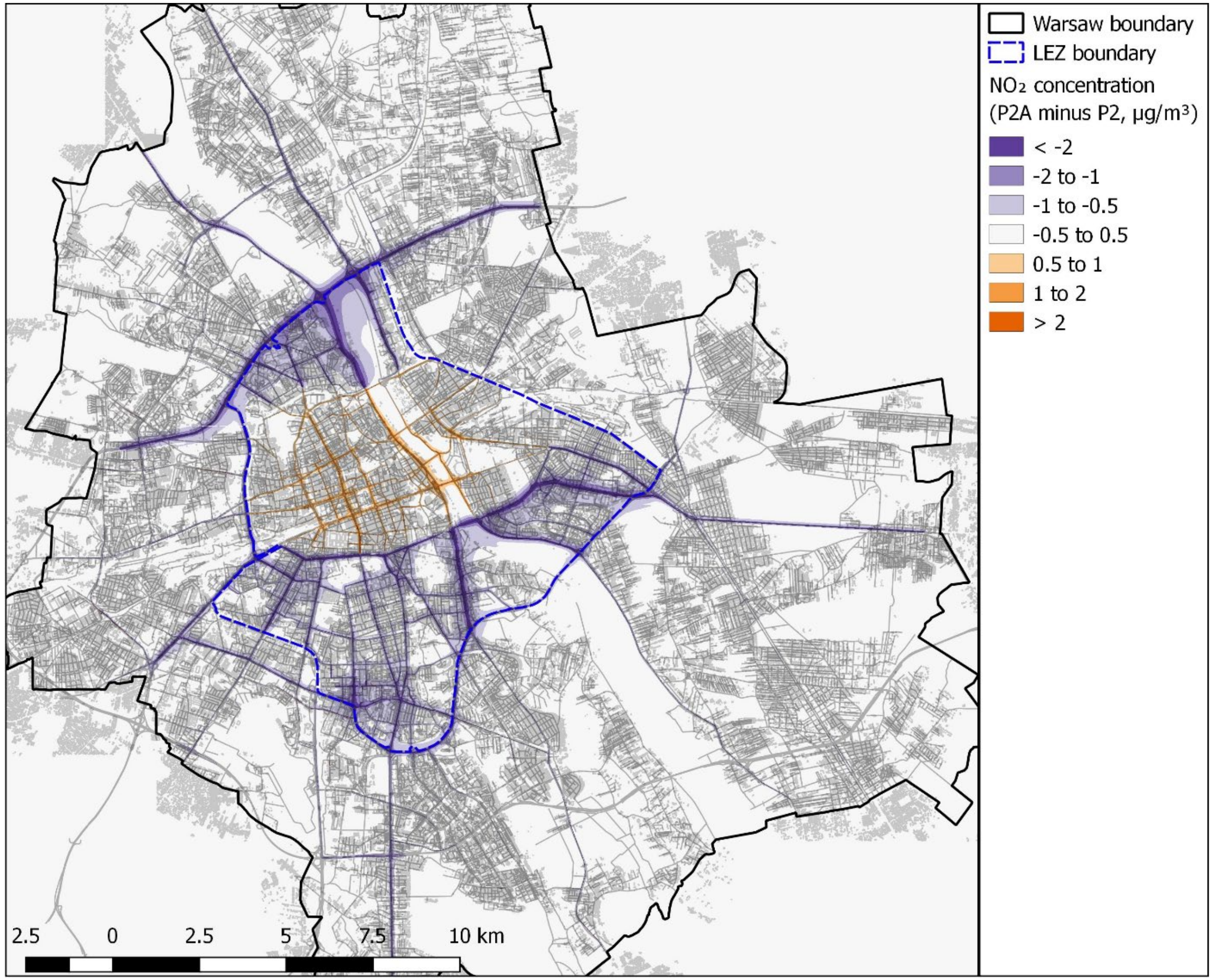


Phase 3A - Baseline

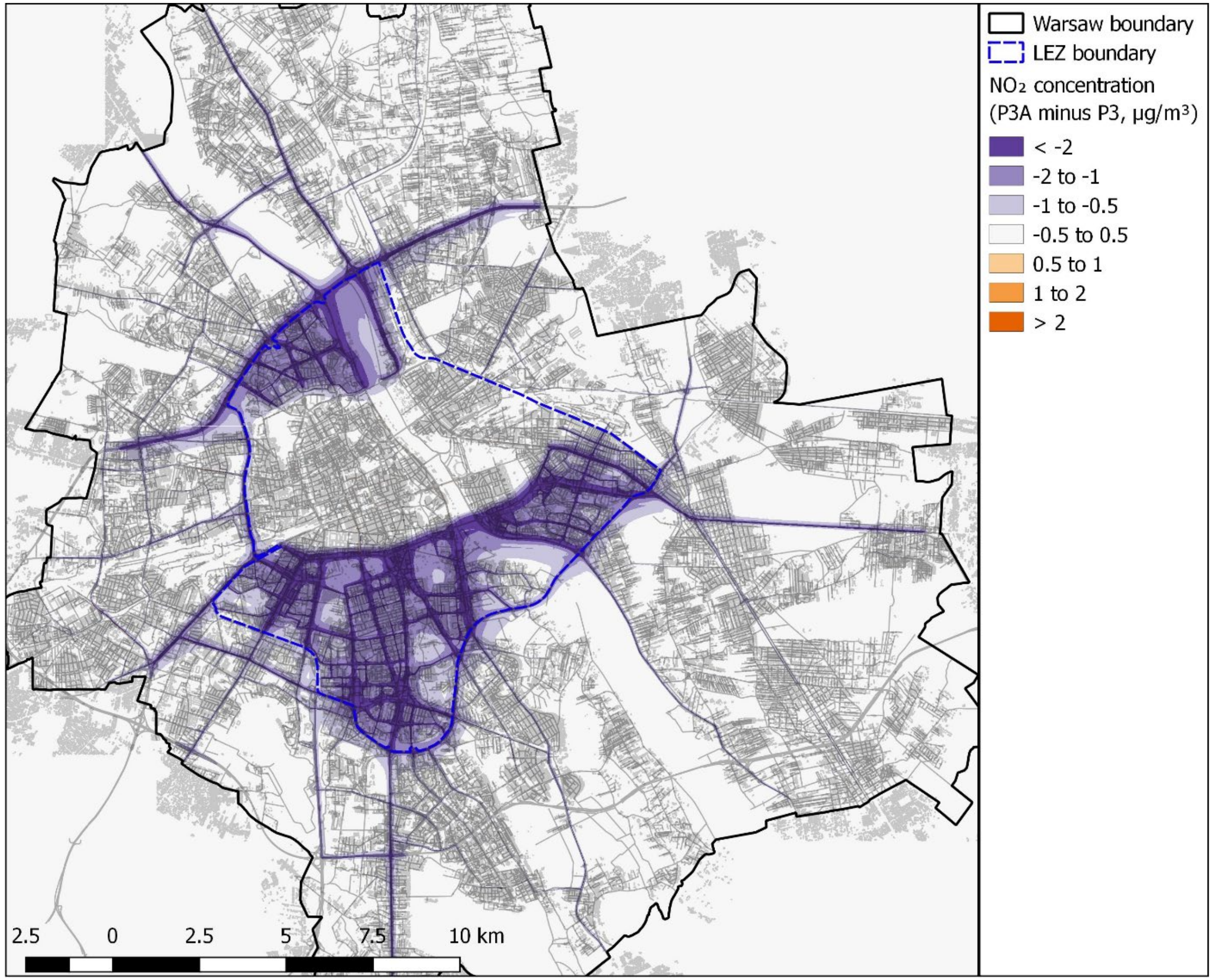


NO_2 concentration: Comparison of original and extended LEZ

Phase 2A – Phase 2



Phase 3A – Phase 3

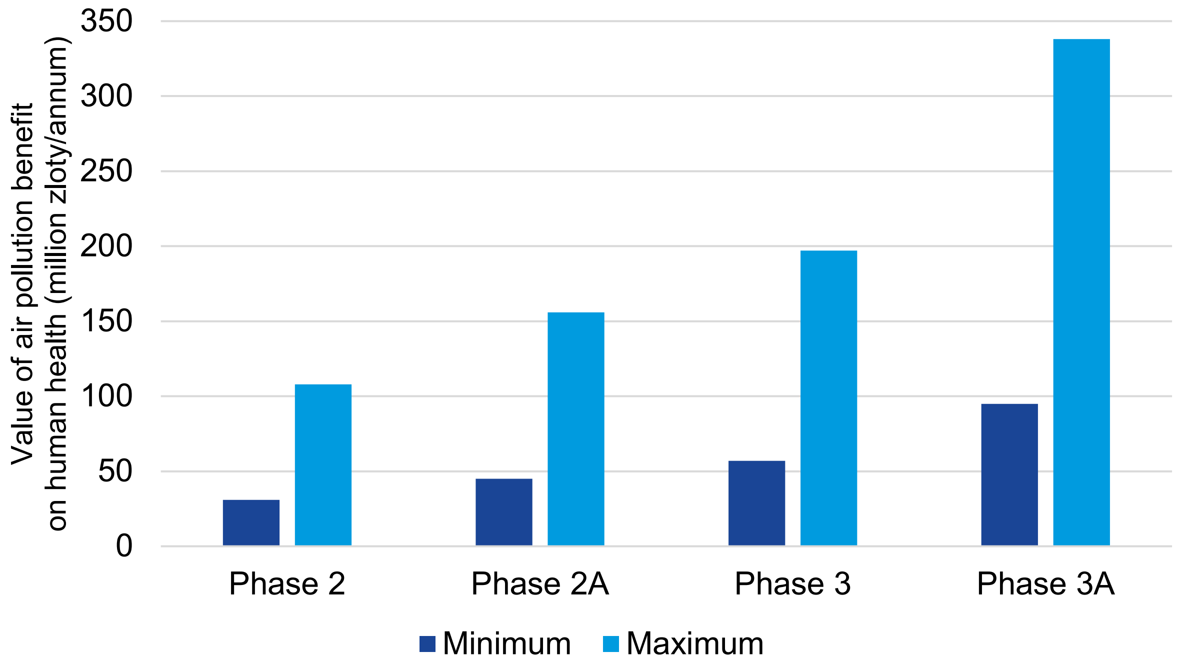


NO_2 concentration: modelled at monitoring sites

Site ID	Original location	Extended location	Modelled NO_2 concentration ($\mu g/m^3$)						
			2026 Baseline	2026 Phase 2A	Phase 2A – Baseline	Phase 2A – Baseline (% of Baseline)	2026 Phase 3A	Phase 3A – Baseline	Phase 3A – Baseline (% of Baseline)
DT_28	LEZ	LEZ	52.37	45.02	-7.35	-14.03%	36.55	-15.82	-30.21%
DT_29	LEZ	LEZ	46.69	41.68	-5.01	-10.73%	33.73	-12.96	-27.76%
DT_98	LEZ	LEZ	45.68	42.18	-3.50	-7.66%	34.66	-11.02	-24.12%
DT_33	LEZ	LEZ	44.57	39.74	-4.83	-10.84%	33.01	-11.56	-25.94%
DT_8	LEZ	LEZ	44.08	39.12	-4.96	-11.25%	31.39	-12.69	-28.79%
DT_51	LEZ	LEZ	44.98	41.26	-3.72	-8.27%	31.32	-13.66	-30.37%
DT_40	LEZ	LEZ	44.27	40.75	-3.52	-7.95%	33.47	-10.80	-24.40%
DT_72	LEZ	LEZ	42.54	36.06	-6.48	-15.23%	29.99	-12.55	-29.50%
DT_57	LEZ	LEZ	42.13	38.42	-3.71	-8.81%	32.27	-9.86	-23.40%
DT_26	LEZ	LEZ	39.54	35.10	-4.44	-11.23%	28.11	-11.43	-28.91%
DT_32	LEZ	LEZ	39.49	35.68	-3.81	-9.65%	28.53	-10.96	-27.75%
DT_64	LEZ	LEZ	38.57	34.73	-3.84	-9.96%	28.44	-10.13	-26.26%
DT_55	LEZ	LEZ	38.91	35.75	-3.16	-8.12%	29.94	-8.97	-23.05%
DT_62	LEZ	LEZ	38.86	35.72	-3.14	-8.08%	29.92	-8.94	-23.01%
DT_75	LEZ	LEZ	38.59	35.24	-3.35	-8.68%	28.56	-10.03	-25.99%
DT_20	LEZ	LEZ	39.34	36.58	-2.76	-7.02%	28.07	-11.27	-28.65%
DT_31	LEZ	LEZ	37.29	32.88	-4.41	-11.83%	27.37	-9.92	-26.60%
DT_52	LEZ	LEZ	37.09	32.50	-4.59	-12.38%	27.01	-10.08	-27.18%
244A Grochowska Street	**LEZ**	**LEZ**	36.27	30.66	-5.61	-15.47%	25.90	-10.37	-28.59%
DT_67	LEZ	LEZ	36.12	33.39	-2.73	-7.56%	27.23	-8.89	-24.61%
DT_43	LEZ	LEZ	35.49	31.28	-4.21	-11.86%	27.09	-8.40	-23.67%
DT_39	LEZ	LEZ	35.05	32.68	-2.37	-6.76%	27.27	-7.78	-22.20%
DT_95	LEZ	LEZ	35.10	32.21	-2.89	-8.23%	26.47	-8.63	-24.59%
83/89 Solidarności Street	**LEZ**	**LEZ**	38.23	35.50	-2.73	-7.14%	29.69	-8.54	-22.34%
DT_86	LEZ	LEZ	34.83	32.63	-2.20	-6.32%	28.65	-6.18	-17.74%

Health impact assessment (HIA) – overall monetised impacts

- HIA captures a range of different health impact pathways, including both mortality and morbidity effects
- Approach follows methodology and assumptions used in EU assessments that captures:
  - savings in healthcare costs,
  - avoidance of lost productivity,
  - value that is placed on own good health and wellbeing



PHASE 3A – 'Attributable' health effects within Warsaw boundary

92 fewer deaths per annum / 950 life-years saved

8 fewer new cases of chronic bronchitis in adults,

23 fewer bronchitis episodes in children

11 fewer hospital admissions each year for respiratory or cardio-vascular complaints

18,200 fewer restricted activity days

8,500 fewer work days lost

5 less new stroke cases,

15 less myocardial infarctions,

3 fewer new cases of lung cancer

Cost benefit analysis – updated results

- B:CR of the larger zone (Phase 2A / 3A) is comparable for the respective smaller zone (Phase 2 / 3) but with higher NPV
- Car exemption for Phase 2A does not seem to have a large effect on overall B:CR
- Phase 3A is estimated to deliver a net benefit to society valued at 5.2bn zloty (20% of Warsaw City Council's annual budget)

		Smaller zone		Extended zone	
	Results (Million zloty)	***Phase 2***	***Phase 3***	**Phase 2A**	**Phase 3A**
Savings	Health impacts	*793*	*1,430*	*1,140*	*2,460*
	Change in fuel use	*1,260*	*2,121*	*2,180*	*3,880*
	Change in non-fuel vehicle operating costs	*240*	*297*	*439*	*543*
	GHG Emissions	*201*	*335*	*346*	*612*
Costs	Vehicle upgrade costs	*-753*	*-1,087*	*-1,330*	*-1,990*
	Residual value of scrapped vehicles	*-14.9*	*-48.2*	*-23.6*	*-88.3*
	Welfare impacts of cancelled trips	*-28.9*	*-59.4*	*-33.1*	*-81.5*
	Change in travel time	*-50*	*-102*	*-59.6*	*-136*
	Implementation costs	*-10.8*	*-10.8*	*-19.7*	*-19.7*
	Benefit:Cost ratio	***2.91***	***3.20***	***2.80***	***3.24***
	Net present value	***1,630***	***2,880***	***2,640***	***5,180***

Questions?

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LinkedIn: https://www.linkedin.com/in/jekabs-jursins/

More information at:

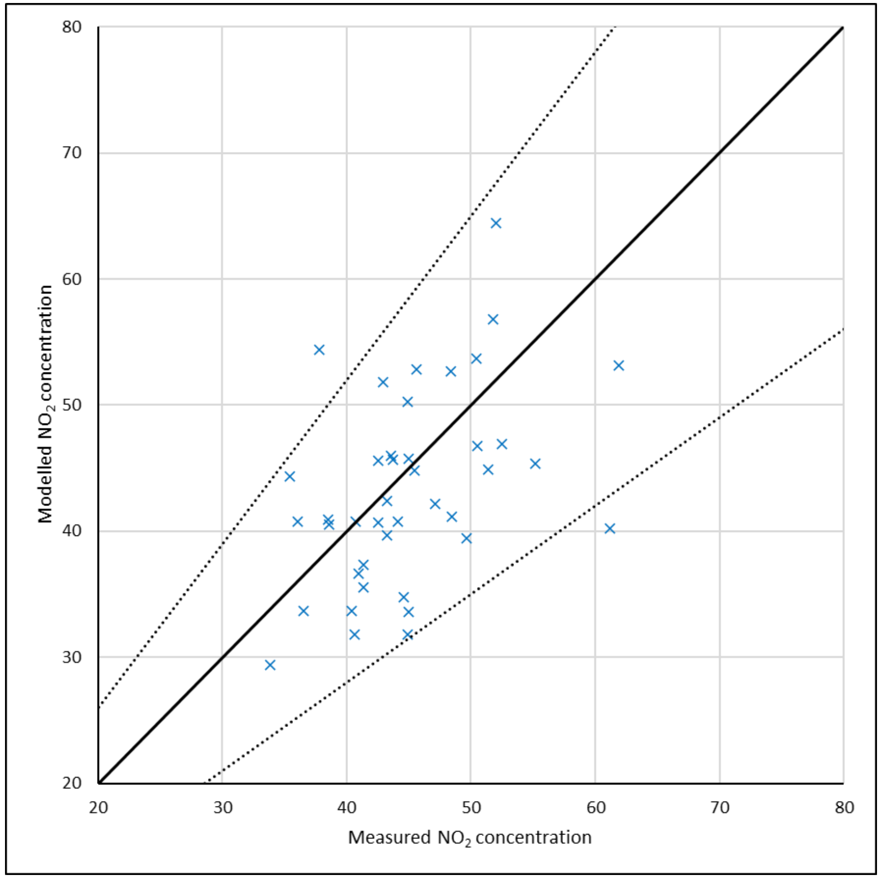
- Ricardo helps City of Warsaw to introduce its first ever Low Emission Zone | 2023 | Press releases | News and insights | Ricardo
- Impacts of a low-emission zone on air pollutant and greenhouse gas emissions in Warsaw - International Council on Clean Transportation (theicct.org)

Model verification and adjustment

Model verification points and NO_2 concentrations

Site ID	Latitude (°)	Longitude (°)	Measured NO_2 (µg/m³)	Modelled NO_2 (µg/m³)	Measured – Modelled
DT_8	52.2492	21.0443	61.90	53.17	8.73
DT_10	52.2466	21.0150	61.18	40.19	20.99
DT_20	52.2299	21.0220	55.19	45.39	9.80
DT_26	52.2557	21.0346	52.51	46.88	5.63
DT_28	52.2370	20.9804	52.00	64.45	-12.45
DT_29	52.2354	21.0090	51.79	56.80	-5.01
DT_31	52.2474	21.0531	51.38	44.92	6.46
DT_32	52.2369	21.0177	50.55	46.77	3.78
DT_33	52.2257	20.9888	50.45	53.70	-3.25
DT_35	52.2195	20.9895	49.62	39.44	10.18
DT_39	52.2624	21.0377	48.49	41.17	7.32
DT_40	52.2422	20.9941	48.38	52.66	-4.28
DT_43	52.2576	20.9942	47.15	42.20	4.95
DT_51	52.2202	21.0154	45.60	52.87	-7.27
DT_52	52.2628	21.0220	45.50	44.79	0.71
DT_54	52.2461	21.0122	44.98	33.58	11.40
DT_55	52.2174	20.9821	44.98	45.76	-0.78
DT_57	52.2353	20.9728	44.88	50.29	-5.41
DT_58	52.2536	21.0221	44.88	31.78	13.10
DT_59	52.2302	21.0625	44.57	34.77	9.80
DT_60	52.2234	21.0167	44.15	40.74	3.41
DT_62	52.2174	20.9824	43.74	45.67	-1.93
DT_64	52.2442	21.0015	43.54	45.96	-2.42
DT_67	52.2259	21.0143	43.23	42.42	0.81
DT_68	52.2372	21.0257	43.23	39.67	3.56
DT_72	52.2307	20.9842	42.92	51.83	-8.91
DT_75	52.2476	21.0473	42.50	45.63	-3.13
DT_76	52.2547	20.9721	42.50	40.65	1.85
DT_82	52.2548	20.9825	41.37	35.54	5.83
DT_83	52.2350	20.9908	41.37	37.32	4.05
DT_84	52.2238	21.0205	40.96	36.67	4.29
DT_86	52.2444	20.9661	40.75	40.76	-0.01
DT_87	52.2511	21.0353	40.65	31.81	8.84
DT_88	52.2508	20.9982	40.44	33.65	6.79
DT_94	52.2502	20.9805	38.58	40.55	-1.97
DT_95	52.2375	21.0522	38.48	40.89	-2.41
DT_98	52.2408	20.9862	37.76	54.42	-16.66
DT_101	52.2467	21.0641	36.52	33.67	2.85
DT_108	52.2373	21.0000	33.84	29.42	4.42
244A Grochowska Street	52.2457	21.0804	35.44	44.31	-8.87
83/89 Solidarnosci Street	52.2436	20.9992	36.07	40.78	-4.71
				RMSE	**7.50**

Modelled vs measured NO_2 annual mean concentrations at receptors



*The dashed lines represent 30% difference between the measured and modelled concentrations

Model uncertainty

- Some clear outliers were apparent during the model verification process, whereby the model inputs could not be refined sufficiently to achieve good model performance at these locations. There are a number of reasons why this could be the case, including:

Model inputs

- Uncertainties in the traffic model outputs
- Local HGV and private bus fleet data were not available for Warsaw, so based on the national average
- Uncertainties in future vehicle fleet projections
- Uncertainties introduced by modelling background concentrations at a low resolution over a large model domain

Monitoring data

- Limited number of annualised concentration measurements available for model verification
- Sites may be located next to a large car park, bus stop or other emission source that has not been explicitly modelled due to unknown activity data
- Sites may be located in unsuitable locations for diffusion tubes to measure NO_2 concentrations effectively

Limitations for modelling LEZ scenarios

- The potential rerouting of traffic as a result of implementation of the LEZ is not included in the transport data for the 2026 LEZ Phase 2 and Phase 3 scenarios, but some increase in traffic is likely around the zone

Distributional analysis – Focus on impacts on businesses

- Businesses could be affected either: directly, indirectly or both. Businesses both inside and outside the proposed LEZ could be affected and across a wide range of sectors, including: taxi drivers and operators, bus and coach operators, logistics, refuse and waste collection and operations, etc.
- But not all businesses and trips would be affected (e.g. 0-24% under Phase 2 smaller zone, and 0-38% under Phase 3 smaller zone, depending on vehicle type)

Costs and affordability risks

- ***Some businesses will face a cost to comply with the LEZ*** (i.e. those operating non-compliant vehicles). ***Size of impact and risk to business will also depend on a number of other variables***, relating to their vehicle ownership and use, response to the zone, and wider operation
- ***Smaller firms are more likely to face greater affordability risks*** due to a number of factors
- Hence should a LEZ be taken forward, ***mitigation measures could also be considered*** for those negatively affected and most at risk. Several potential measures were highlighted in the stakeholder survey and workshop in the first project phase, including:
    - financial subsidy for the purchase of new vehicles/retrofit/alternative means of transport, improvements of the public transport and cycling network, derogations for certain vehicles, and amending taxi licencing conditions.

Positive effects for businesses

- ***For some businesses there will be positive effects***: e.g. those operating cleaner fleets or modes of travel may see an increase in demand for their services. Also businesses (in particular retail and cultural operators) may benefit from the cleaner, safer environment in the city centre.
- Through the engagement activities, ***many stakeholders highlighted the potential benefits of a LEZ in Warsaw***. E.g. in the Workshop:
    - All participants agreed on the need to improve air quality in Warsaw and that a low emissions zone could be helpful, in particular where combined with additional measures around public and active travel which could increase promotion of a healthy and environmentally friendly lifestyles
    - Most businesses noted they could/would upgrade vehicles in response, and noted city centre parking was more of an issue
- Furthermore, ***40 local businesses have signed a letter supporting a LEZ in Warsaw***. They suggest:
    - *[translated Polish to English] Examples from European cities show that Clean Transport Zones and activities limiting car traffic translate into greater activity of residents in urban space, which has a positive impact on local business.*
    - *Clean air, less traffic jams, less noise and more space for people are a necessary direction in the development of the capital if we want it to be a city friendly to its inhabitants and attractive to tourists.*

BURO HAPPOLD

Modelling diverse air pollution sources in a sensitive area

Assessing human and ecological impacts from a proposed greenbelt office campus

7 December 2023

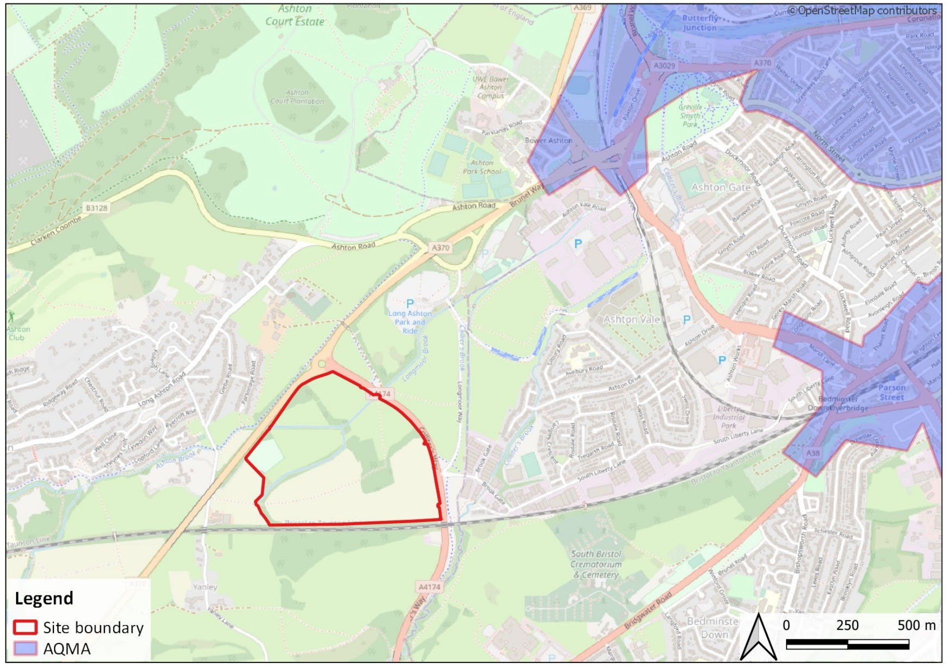
Project context

- Environmental impact assessment for an office campus development in outskirts of Bristol

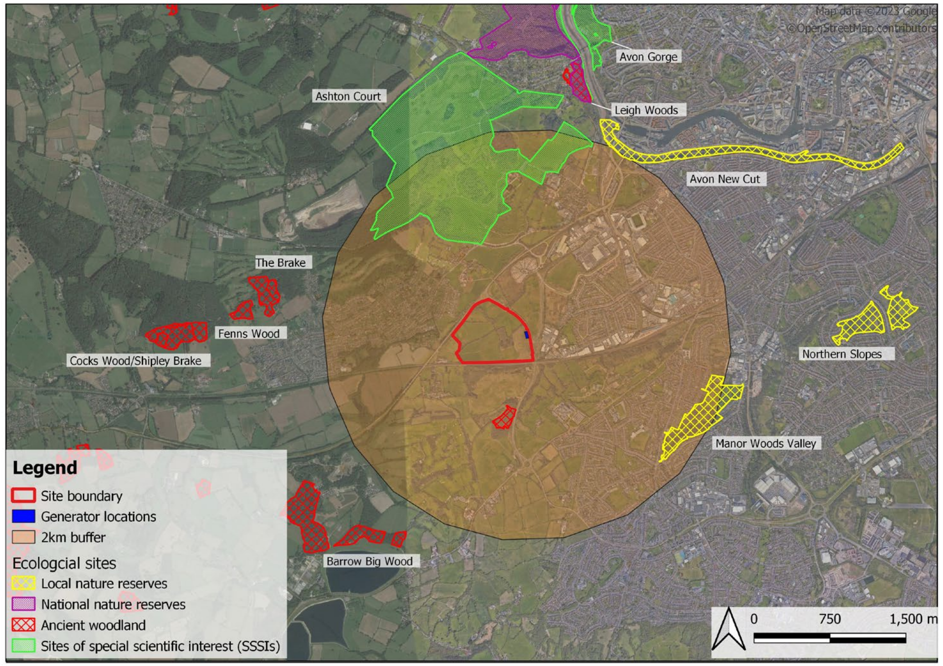
The client's other office campuses in the US

Area context

- Adjacent to feeder roads into the City of Bristol AQMA
- Expecting a large amount of traffic increase



- Greenbelt land with designated ecological sites nearby
  - Ancient woodlands
  - Sites of special scientific interest (SSSI)
    - Ashton Court



RICARDO

Key challenges

Increase in road traffic flow and resultant impacts

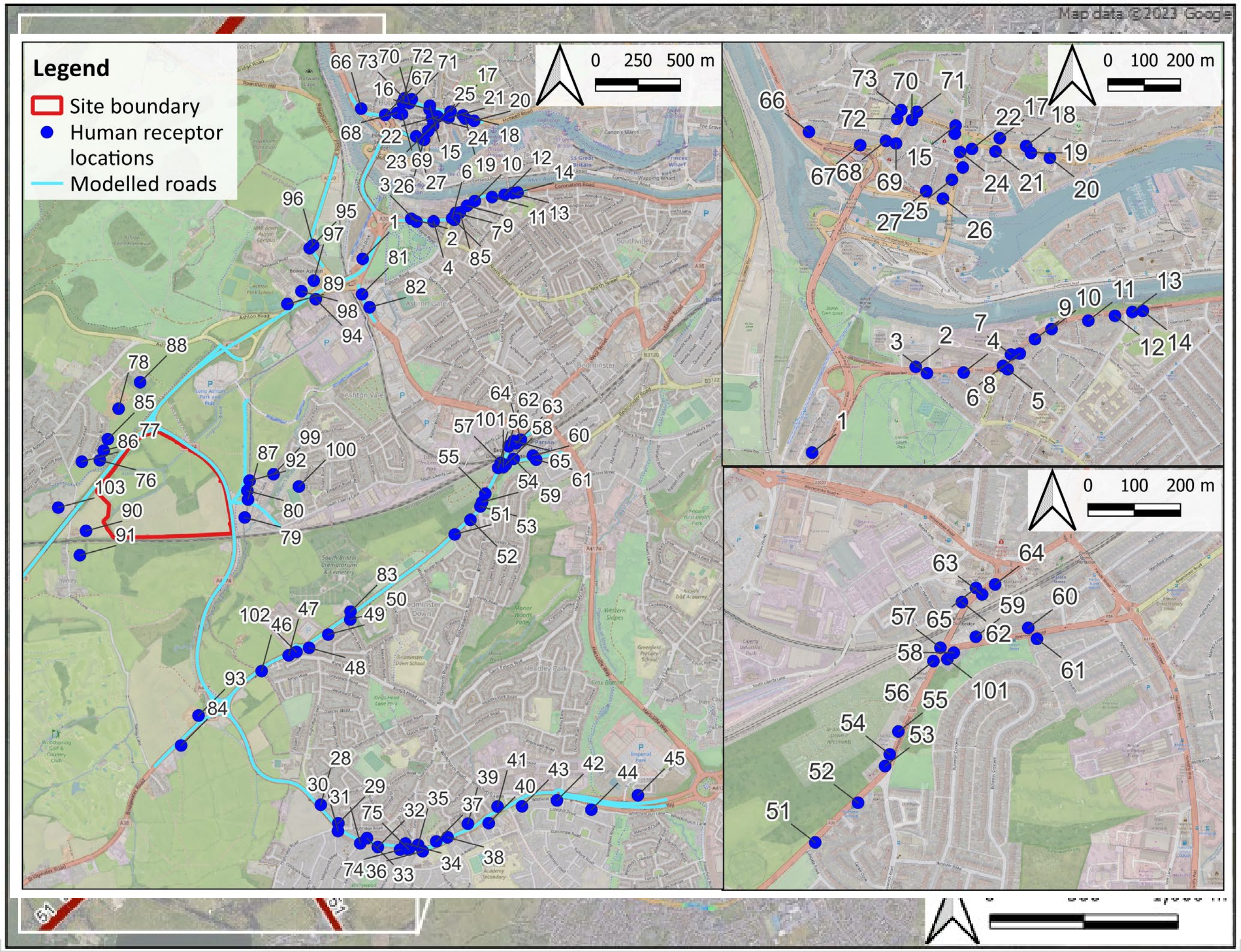
Potential impacts on nearby ecological sites

Short-term impacts of point sources

Quantify impacts from proposed fireplaces

Traffic modelling – human sensitive uses

- ADMS-Roads
- Model verification – verified against site specific monitoring carried out by Buro Happold
- Large model domain due to extent of traffic generated
- Worst case scenario:
  - Traffic data
  - Human receptors at worst case locations along road links at which IAQM thresholds are exceeded
  - no change in background concentrations



Key challenges

Increase in road traffic flow and resultant impacts

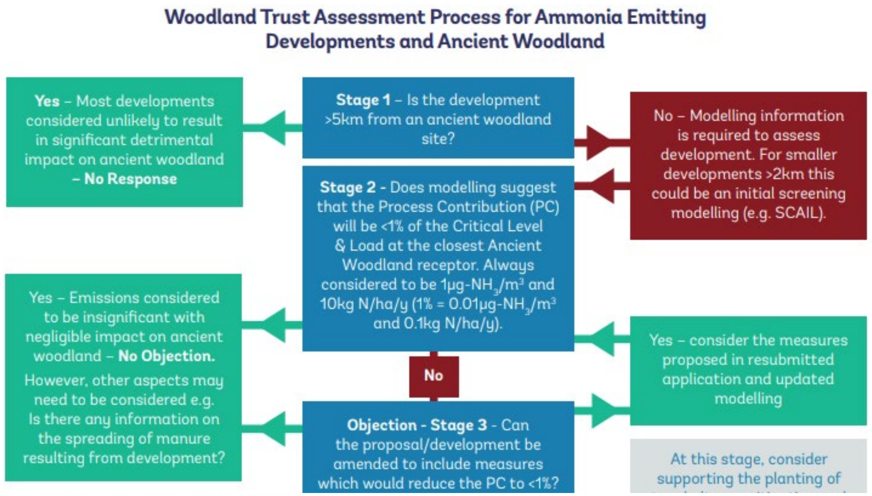
Potential impacts on nearby ecological sites

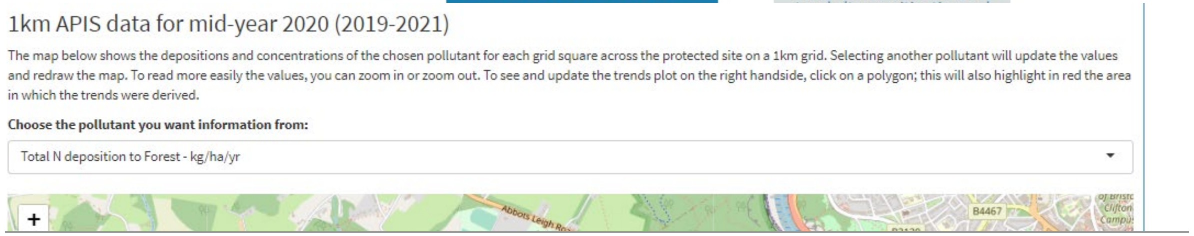
Short-term impacts of emergency generators

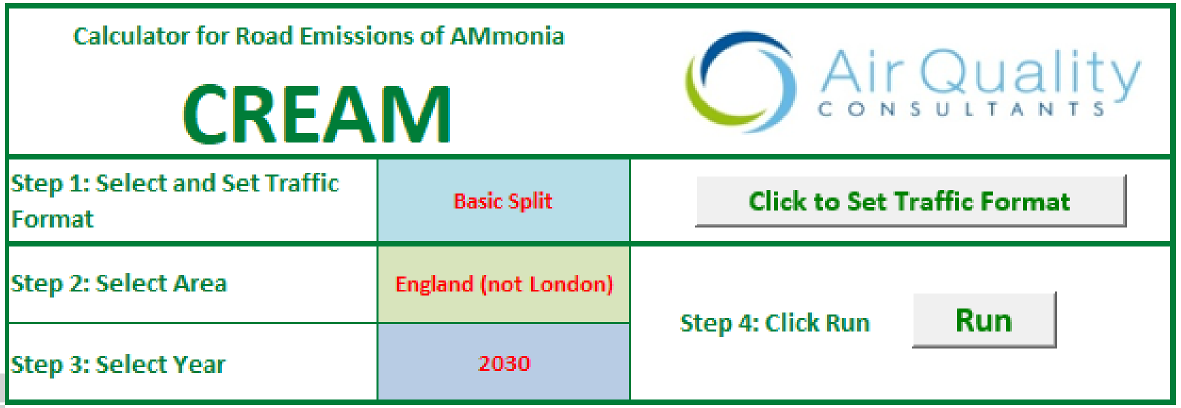
Quantify impacts from proposed fireplaces

Impacts on sensitive ecological sites

- **Key methodology:**
  - IAQM: A guide to the assessment of air quality impacts on designated nature conservation sites
  - Air Quality Advisory Group: AQTAG06
  - Woodland Trust: *Assessing air pollution impacts on ancient woodland – ammonia*
  - Ecological sites within 200 m of road at which a 1000 AADT increase in traffic
- **Four key parameters:**
  - NOx concentration
  - Ammonia concentration
  - Nitrogen deposition
  - Acidification
- **Critical level and critical load**
  - Air Pollution Information System
- **Ammonia emission factors:** CREAM

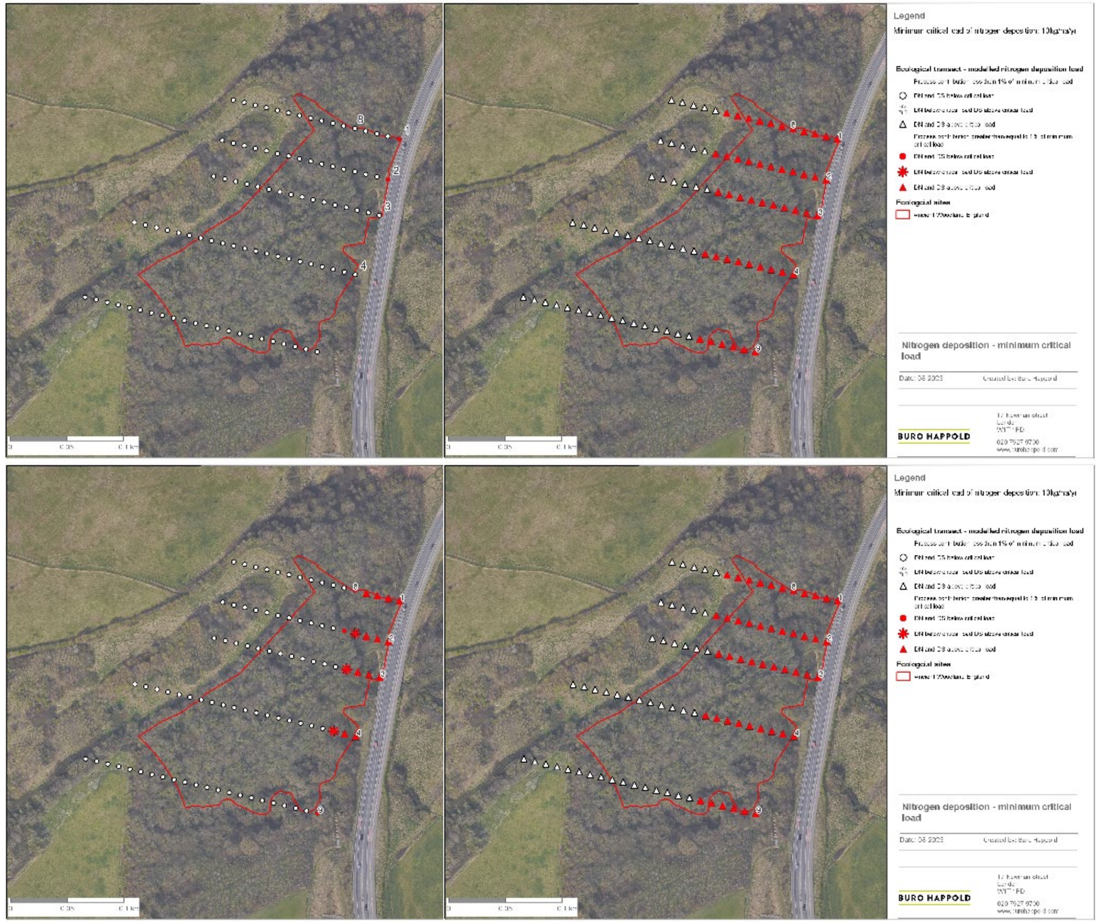






Sensitive ecological sites

- Screening threshold:
  - 1 % process contribution of critical level/critical load
- Model along transects perpendicular to the road
- Collaborate with the project ecologist to determine significance of impacts



65

Key challenges

Increase in road traffic flow and resultant impacts

Potential impacts on nearby ecological sites

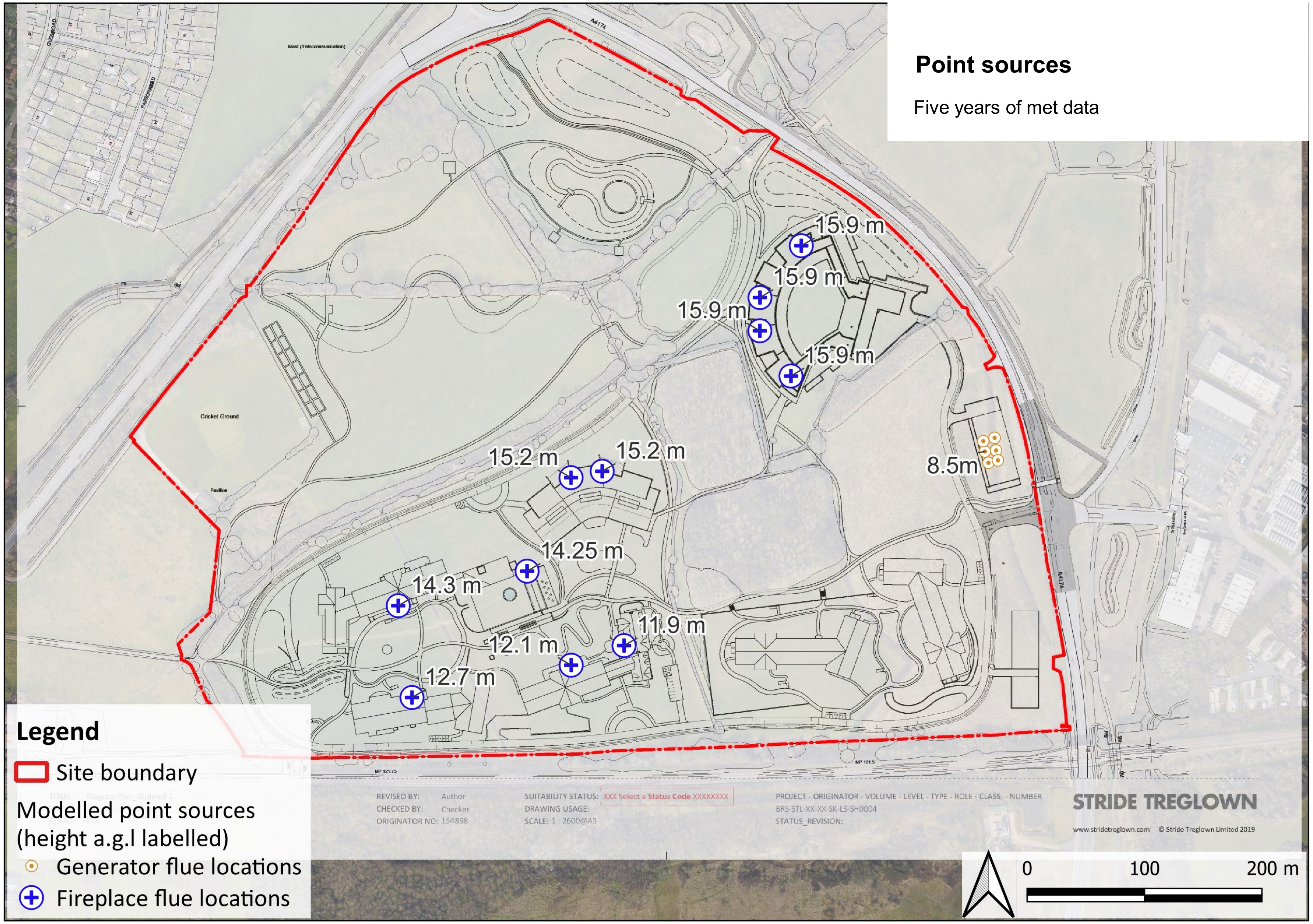
Short-term impacts of emergency generators

Quantify impacts from proposed fireplaces

66

Point sources

Five years of met data



Key challenges

Increase in road traffic flow and resultant impacts

Potential impacts on nearby ecological sites

Short-term impacts of emergency generators

Quantify impacts from proposed fireplaces

Emission rate factor for each hour in the day

Weekday

Saturday

Sunday

```
FacVersion4
1
fireplaceweeklyprofile
0,0,0,0,0,0,0,0,1,1,1,1,1,1,1,1,1,1,0,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

0

1
fireplacemonthlyprofile
1,1,1,0.5,0,0,0,0.25,1,1,1,1

Fireplace 1,1,1,0
fireplaceweeklyprofile
fireplacemonthlyprofile
```

Emission rate factor for each day in the month

Fireplaces

- Emission profile – .fac file
- Challenge of determining emission rate
  - Emission factors (EEA air pollutant emission inventory guidebook, 2019)
  - Calorific value of wood (Forest Research, 2023)
  - Weight of wood burned per day – reasonable worst case assumption
- Challenge determining parameters such as flue diameter and efflux temperature
- Concern with on-site exposure and short-term effects

69

Emergency generators – short term impacts

- Short term usage – have little impact on annual average concentrations but potential for exceedance of short term objectives
- Exact times of operation not known – emission profile could lead to underprediction of impacts
- Short term output from ADMS
- 35% NOx to NO_2 conversion factor (Environment Agency guidance)
- Added the hourly generator contribution to double the annual average to get an hourly overall concentration.
- No exceedances of short term objectives - statistical tests not required

Diesel generator set QSK78 series engine

2750kVA - 3000kVA 50 Hz

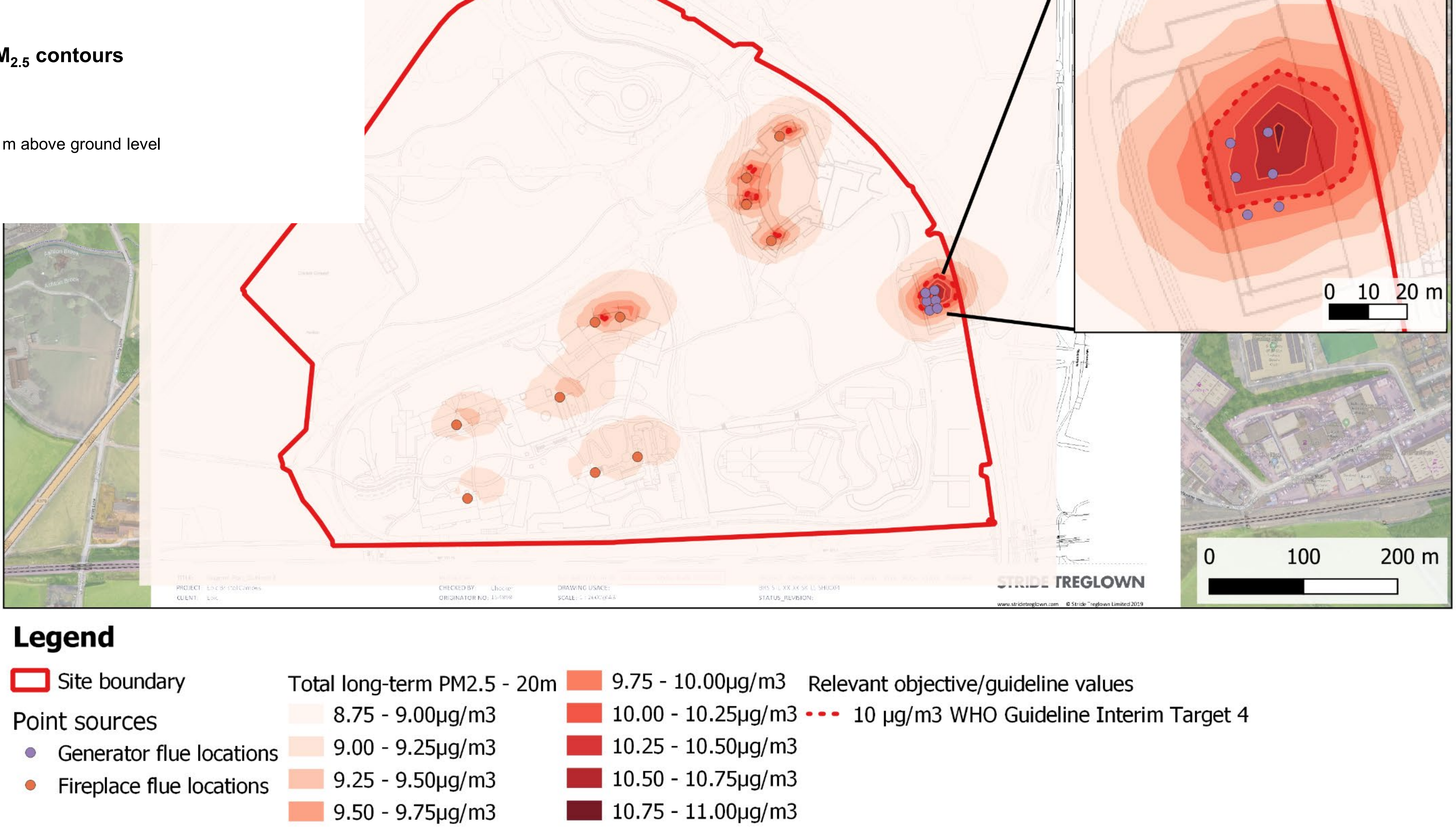
Pollutant output (2/2)

New | Delete | Delete all | Save...

Name	Include	Short /Long	Av. time	Av. time unit	Extra condition
NOx	✔	ST	1	Hour	None
PM10	✔	ST	24	Hour	None

$PM_{2.5}$ contours

20 m above ground level



Conclusion and lesson learned

- No significant impacts from the development
- Stay closer to design developments - could not dissuade the client to abandon fireplaces
  - Time constraints – agreement of methodology with local authority
- Close collaboration with ecologist – communication and early engagement is key
  - Ensure that it is clear what is required from them. They may not be familiar with process we follow (IAQM guidance).

Thank you for listening

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