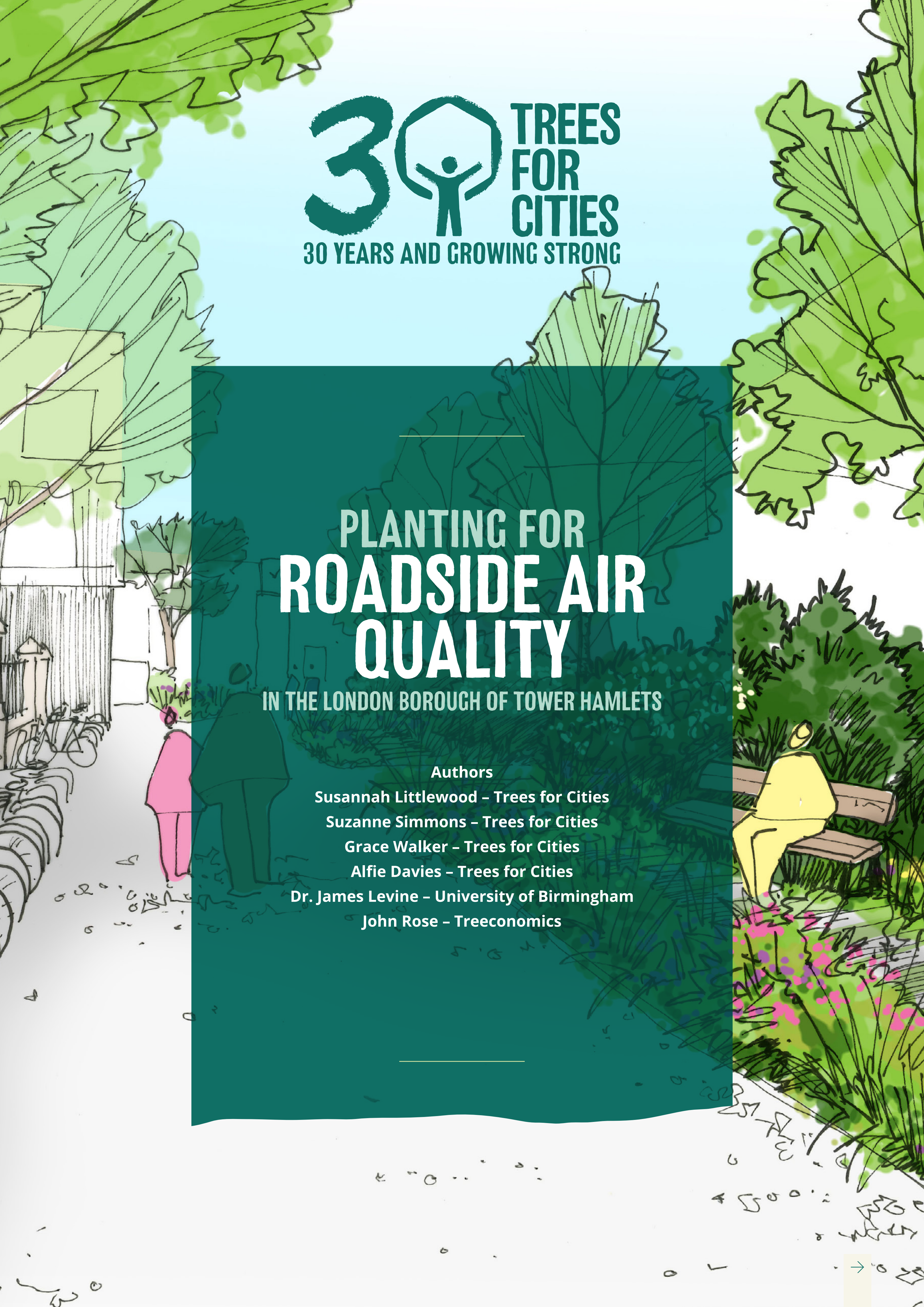

30 YEARS AND GROWING STRONG

PLANTING FOR ROADSIDE AIR QUALITY

IN THE LONDON BOROUGH OF TOWER HAMLETS

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CONTENTS

EXECUTIVE SUMMARY

This guide explores targeted opportunities for future planting of trees and vegetation in the London Borough of Tower Hamlets (LBTH) with a focus on where roadside green infrastructure can be introduced in order to reduce people's exposure to air pollution. The guide focuses on urban outdoor air pollution, the single largest source of which is road transport.

This guide was produced as part of AFFORE3ST (Advancing a planning Framework FOr Regionally Enhanced & Equitable Ecosystem Services from urban Treescapes), a tripartite knowledge-exchange collaboration between Principal Investigator Dr James Levine (JL), host partner Trees for Cities (TfC), and technical training partner UK Centre for Ecology and Hydrology (UKCEH), and using analysis by Treeconomics.

Locations where roadside planting is estimated to deliver meaningful air quality benefits at the roadside, with no significant disbenefits anywhere else were identified by integrating code from the Green Infrastructure for Roadside Air Quality (GI4RAQ) Platform into Geographic Information System software (QGIS).

Alongside this, a map of potential locations where planting dense vegetation was considered viable was created by considering the physical requirements of the vegetation on the one hand, and the space usage requirements of pedestrians on the other. These locations were then cross-referenced to identify a shortlist of locations which were ground truthed to assess their viability. The analysis finds that, in the case of the London Borough of Tower Hamlets, opportunities for new roadside green infrastructure to reduce people's exposure to air pollution are limited due to narrow streets and highly urbanised hard infrastructure.

Nevertheless, the guide identifies priority spaces for tree planting in the borough, and 5 illustrative sites where roadside green infrastructure can be introduced in an effort to reduce people's exposure to air pollution. These illustrative sites demonstrate practical and realistic approaches to the implementation of green infrastructure for roadside air quality, which are also responsive to urban constraints, and consider other benefits such as amenity improvements, provision of shade and habitat, and surface water management.

The guide puts forward the following recommendations as a result of the analysis conducted:

Deliver a Pilot Programme of Linear Parklet Interventions based on GI4RAQ analysis. One or more of the selected interventions could be implemented in collaboration with relevant stakeholders and decision-makers such as the London Borough of Tower Hamlets, Transport for London, and local residents.

Involve multiple public realm stakeholders in planning new interventions. The ground truthing process found cases where poorly considered layout of footways has led to missed opportunities to take a more integrated approach with multiple benefits. This highlights the need for the involvement of multiple stakeholders in planning for new and retrofitting such spaces.

Apply the analysis to other locations. The analysis outlined in this guide could be applied to other less densely built locations with wider footway infrastructure and less competition for other spatial needs in order to assess if these conditions would offer a greater number of opportunities for interventions.

Refine the GI4RAQ tool. The GI4RAQ Platform, and the integration of its underlying code into QGIS could be further developed beyond their current prototype iteration for further application.

Explore other ways to address exposure to poor air quality. Where there is limited opportunity to introduce green infrastructure as a partial barrier to reduce people's exposure to air pollution, it can be applied in other ways. For example, greening low-traffic and low pollution routes to make them more attractive and encourage their use for active travel, and to link existing green spaces and locations frequented by those vulnerable to poor air quality.

1. INTRODUCTION

This guide seeks to strategically explore targeted opportunities for future planting of trees and vegetation in the London Borough of Tower Hamlets (LBTH): it will outline priority areas for planting on council land based on a number of criteria, with a primary focus on exploring where roadside green infrastructure can be introduced in order to reduce people's exposure to air pollution.

This analysis is based on AFFORE3ST (Advancing a planning Framework FOr Regionally Enhanced & Equitable Ecosystem Services from urban Treescapes), a tripartite knowledge-exchange collaboration between Principal Investigator Dr James Levine (JL), host partner Trees for Cities (TfC), and technical training partner UK Centre for Ecology and Hydrology (UKCEH).

It has been produced in collaboration with Treeconomics, who conducted priority hotspot and feasibility mapping to underpin the analysis.

1.1 TREES, GREEN INFRASTRUCTURE AND AIR QUALITY IN THE LONDON BOROUGH OF TOWER HAMLETS

LBTH has outlined its goal to increase tree canopy cover across the borough[1], and to increase tree planting on Council owned land and in parks[2] aligning with the aim of the London Environment Strategy to increase tree canopy cover across London by 10% by 2050.

In addition, Tower Hamlets Council links their tree planting objectives to their aims for air quality in the borough in their Air Quality Action Plan (2022-27)[3], which outlines the actions the borough will deliver to reduce concentrations of pollutants, and exposure to pollution, to benefit the health and quality of life of both residents and visitors.

According to the London Atmospheric Emissions Inventory (LAEI) 2019[4], in that year the Borough of Tower Hamlets had the sixth highest annual average PM2.5 concentration weighted for population of the London Boroughs.

The Air Quality Action Plan (2022-27) sets out Tower Hamlets Council's "aspiration to meet the updated 2021 WHO guideline value for PM2.5 in the shortest possible time using levers that are within our control but also lobbying regional and central government on policies and issues beyond our control and influence".

Among the actions of the plan is the intention to expand and improve green infrastructure, including by planting trees throughout the borough, and lining streets and estates with new trees. It should be noted here, and will be set out below, that different types and specific placement of green infrastructure are recommended when looking to combat people's exposure to air pollution from road transport.

This generally includes dense vegetation from ground level to a height of 2m (this could be in the form of hedgerow) between those people and vehicles in close proximity to them, and may include tree planting where appropriate[5].

The Air Quality Action Plan (2022-2027) recognises that it can be difficult to quantify the benefit of the introduction of new vegetation on air quality, but that green infrastructure can help to mitigate poor air quality on a local scale if designed and implemented well.

The Tower Hamlets Green Grid Strategy: Update 2017[6], integrates with the Air Quality Action Plan, and aims to "create a framework for the design and delivery of appealing walking routes and associated green infrastructure across Tower Hamlets, to secure a healthy and attractive environment for residents, workers and visitors".

With regards to air quality, the Green Grid has two overarching design principles, (i) installation of street trees, planting and other vegetation where appropriate, to provide access to nature, ameliorate poor air quality and deliver climate adaptation and (ii) promoting quiet streets and routes away from main roads and heavy traffic, to encourage pedestrians to travel where they are exposed to less air pollution.

With these ambitions in relation to green infrastructure and air quality, the borough was deemed a suitable area to which the AFFORE3ST analysis could be applied.

1 Tower Hamlets Council. Tree Management Plan (2020-2025). 2020. Available online: https://www.towerhamlets.gov.uk/Documents/Planning-and-building-control/Development-control/Tree/Tree-Management-Plan.pdf
2 Tower Hamlets Council. Net Zero Carbon Plan. 2020. Available online: https://democracy.towerhamlets.gov.uk/mgConvert2PDF.aspx?ID=165906
3 Tower Hamlets Council. Air Quality Action Plan (2022-27). 2022. Available online: https://democracy.towerhamlets.gov.uk/documents/s207950/6.3a%20Appendix%20One%20for%20Air%20Quality%20Action%20Plan%202022-2027.pdf
4 Greater London Authority. London Atmospheric Emissions Inventory (LAEI) 2019. 2019. Available online: https://data.london.gov.uk/dataset/london-atmospheric-emissions-inventory--laei--2019
5 Greater London Authority. USING GREEN INFRASTRUCTURE TO PROTECT PEOPLE FROM AIR POLLUTION. 2019. Available online: https://www.london.gov.uk/sites/default/files/green_infrastruture_air_pollution_may_19.pdf
6 LUC. The Tower Hamlets Green Grid Strategy: Update 2017. 2017. Available online: https://www.towerhamlets.gov.uk/Documents/Planning-and-building-control/Strategic-Planning/Local-Plan/Green_Grid_Update_2017.pdf

1.2 AIR POLLUTION AND 'GREEN INFRASTRUCTURE FOR ROADSIDE AIR QUALITY'

What do we mean by air pollution?

Air pollution is often talked about in the context of climate change, such as the need to reduce our emissions of carbon dioxide (CO_2) and other greenhouse gases to reduce global warming and work towards Net Zero. The focus of this guide, however, is air pollution from a human health perspective, relating to components that are directly harmful to people upon inhalation. These include other gases, such as nitrogen dioxide (NO2), and particulate matter (PM). Perhaps counterintuitively, the smaller the particles, the more harmful they are as they can travel further into our respiratory systems; fine particulate matter (PM2.5; less than 2.5mm across) can penetrate into our lungs and an 'ultrafine' subset of these can directly enter our blood stream from here.

What impacts does air pollution have?

According to the UK Health Security Agency, formerly Public Health England, air pollution claims between 28,000 and 36,000 lives each year in the UK[7;] the World Health Organisation puts the global figure at around three million[8]. This reduces UK life expectancy by an average of six months, but notably longer in the most polluted areas. As important, are the impacts that people live with, sometimes for decades, as air pollution exacerbates other medical conditions, such as asthma and chronic obstructive pulmonary disease (COPD). There is a major economic cost too. The Royal College of Physicians estimates that exposure to air pollution in the UK incurs costs of health care provision and loss of productivity (e.g. sick days) totalling £22.6 billion per year[9].

Where does air pollution come from?

Outdoor air pollution comes from a variety of sources, ranging from industry to agriculture; heating, cooking, cleaning and cosmetics meanwhile contribute to indoor air pollution. This guide focuses on urban outdoor air pollution, the single largest source of which is road transport[10]. Vehicles emit NO2 and PM2.5 in their exhaust, and further PM2.5 – more than in their exhaust – from non-exhaust sources: i.e. brake, tyre and road wear.

Electric vehicles are an improvement as they do not directly emit NO2, and certainly better from a climate perspective as they do not directly emit CO2. However, they continue to emit more than 60% of the PM2.5 produced by their petrol and diesel counterparts[11]; i.e. those from non-exhaust sources.

Moreover, these emissions of PM2.5 are increasing with greater vehicle weight (electric vehicles are heavier due to their batteries[12]) and increasing vehicle movements (the Department for Transport projects a 17-51% increase in traffic in England and Wales by 2050, compared to 2015[13]).

How can we improve urban air quality?

Much as with climate change, the best way to improve air quality from a human health perspective is to reduce emissions of air pollutants at source. As well as changing to electric vehicles, we can reduce vehicle movements by providing excellent public transport and enabling widespread active travel. Other sources can be reduced too; reducing domestic burning, for example, will improve both indoor and outdoor air quality.

How can we further improve health outcomes?

In addition to reducing emissions of air pollutants, we can reduce people's exposure to what is emitted, starting with those most susceptible to the health impacts of air pollution; i.e. the young, the elderly and those with certain pre-existing medical conditions, such as asthma and COPD.

A useful principle is Reduce, Extend, Protect[14]: firstly, reduce emissions of pollutants at source to the fullest extent possible; secondly, extend the distance between remaining sources of pollution and people, as the concentrations of pollutants drop off with distance from their sources and accompanying dilution with cleaner surrounding air; and, thirdly, protect the most vulnerable, i.e. prioritise interventions where these people come close to sources.

7 Public Health England. Review of interventions to improve outdoor air quality and public health. 2019. Available online: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/938623/Review_of_interventions_to_improve_air_quality_March-2019-2018572.pdf
8 World Health Organization. Ambient air pollution: A global assessment of exposure and burden of disease. 2016. Available online: https://www.who.int/publications/i/item/9789241511353
9 Royal College of Physicians. Reducing air pollution in the UK: Progress report 2018. 2018. Available online: https://www.rcplondon.ac.uk/news/reducing-air-pollution-uk-progress-report-2018
10 DEFRA. What are the causes of air Pollution? Available online: https://uk-air.defra.gov.uk/assets/documents/What_are_the_causes_of_Air_Pollution.pdf
11 Air Quality Expert Group. Non-Exhaust Emissions from Road Traffic. 2019. Available online: https://uk-air.defra.gov.uk/assets/documents/reports/cat09/1907101151_20190709_Non_Exhaust_Emissions_typeset_Final.pdf
12 Timmers, V. R. J. H., and P. A. J. Achten, Non-exhaust PM emissions from electric vehicles. Atmos. Environ. 2016, 134, 10–17. Available online: https://doi.org/10.1016/j.atmosenv.2016.03.017
13 Department for Transport. Road Traffic Forecasts 2018. 2018. Available online: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/873929/road-traffic-forecasts-2018-document.pdf
14 Ferranti, E. J. S., A. R. MacKenzie, J. G. Levine, K. Ashworth, and C. N. Hewitt, First Steps in Air Quality for Built Environment Practitioners. Technical Report. University of Birmingham & TDAG. 2019. Available online: http://epapers.bham.ac.uk/3069/

What roles can 'green infrastructure' play?

Nationally, vegetation removes a small but valuable fraction of some air pollutants; the Office for National Statistics and UK Centre for Ecology and Hydrology estimate that this saves the UK, each year, around £1 billion of the £22.6 billion cost posed by air pollution (see above)[15].

At the scale of urban planting, however, the benefit of pollutant removal is subtle and, for reasons we will come to, we can't simply assume that all planting is good for air quality. Green infrastructure has valuable roles to play in reducing our exposure to air pollution but, sometimes, thought is needed to deliver meaningful benefits and avoid unintended disbenefits.

Green spaces, such as parks, are always beneficial. Free from road transport, they offer spaces in which vehicular pollution can disperse. As it spreads out, it mixes with cleaner surrounding air and pollutant concentrations drop off towards their urban background average concentrations. Green spaces thereby offer valuable sanctuaries of cleaner air for recreation and active travel. Trees can not only enliven these spaces – attracting more people to spend longer where they are exposed to less pollution – but also help to stimulate vertical mixing between generally more polluted air at ground level and somewhat cleaner air aloft, as well as bringing multiple other benefits.

Lower-level vegetation, such as hedges or mixtures of small trees and shrubs, also has a valuable role to play – in roadside environments – but it is here where careful thought, and selective planting, are needed to deliver reliable benefits and avoid inadvertent disbenefits. Since these are environments in which many people, including vulnerable people, spend a significant time close to the single largest source of urban outdoor air pollution, they are the focus of planting for improved air quality in the remainder of this guide.

What is 'Green Infrastructure for Roadside Air Quality'?

Green Infrastructure for Roadside Air Quality (GI4RAQ) is a programme of work, led by Dr James Levine (University of Birmingham), to help practitioners identify where, and what type of, street planting could reduce local exposure to vehicular pollution.

When we introduce a hedge, or planting to a similar height, between vehicles and people, and the wind blows from one to the other, it can force a fraction of the polluted air to take a different path – around people in the immediate wake of the vegetation. It can also stimulate mixing, and thereby enhance the dilution of that polluted air with somewhat cleaner surrounding air.

In their report to Defra and the devolved authorities, the Air Quality Expert Group (AQEG)[16] refers to this as changing the local dispersion of pollution close to source. In effect, we are changing the local distribution of pollution relative to people. AQEG[16] estimate that 'vegetation barriers' typically reduce local exposure to proximate vehicular pollution by up to 50%.

As the wind doesn't always blow from the vehicles towards the people, and those people are still exposed to background concentrations of pollutants from vehicles and other sources further away, they may reduce the annual-mean concentrations of pollutants by closer to 5-10%.

15 Office for National Statistics and UK Centre for Ecology and Hydrology. UK airpollution removal: how much pollution does vegetation remove in your area? 2018. Available online: https://www.ons.gov.uk/economy/environmentalaccounts/articles/ukairpollutionremovalhowmuchpollutiondoesvegetation removeinyourarea/2018-07-30

16 Air Quality Expert Group. Impacts of Vegetation on Urban Air Pollution. 2018. Available online: https://uk-air.defra.gov.uk/assets/documents/reports/cat09/1807251306_180509_Effects_of_vegetation_on_urban_air_pollution_v12_final.pdf

Moreover, once variations in wind conditions and their interactions with surrounding buildings have been taken into account, planting between vehicles and people at the roadside isn't always beneficial – and planting here often increases exposure on the trafficked side where it partially traps vehicular emissions. Selective planting is needed if we are to deliver reliable benefits and avoid creating unintended disbenefits.

What is the GI4RAQ Platform, and how can it help?

With the aid of three innovation grants from the Natural Environment Research Council (ref. NE/S00582X/1, NE/S00940X/1 and NE/S013814/1), Dr Levine and his colleagues have developed prototype software to estimate the local air quality impacts of roadside planting, accounting for local conditions: the GI4RAQ Platform (freely accessible at www.GI4RAQ.ac.uk)[17].

Co-designed with partners at Transport for London, the Greater London Authority, Birmingham City Council and AEA Ricardo, this software is intended to be used by a wide range of people; i.e., not limited to academics, or those already familiar with issues of air quality.

The GI4RAQ Platform uses the location of a street (specified by the user) to determine the distribution of wind conditions expected aloft, then models their interactions with the geometry of that street (also specified by the user).

It does so with and without the proposed planting and, folding in information on the strength and location of vehicular emissions, and the background concentrations of pollutants with which those emissions mix, estimates the changes in annual-mean NO2 and PM2.5 concentrations expected due to the planting.

Enabling users to share analyses with each other, and iterate on those with in-built records of authorship, the software supports exploration of planting options, but requires the user to provide quite a lot of information, for example: location of and direction at the cross section of the street being analysed; background air quality data; and heights of buildings on either side of the cross section.

How are we applying this software to Tower Hamlets?

To explore the potential impacts of planting at 50m intervals along every major road in Tower Hamlets, Dr Levine has integrated the GI4RAQ Platform's code into Geographic Information System software (QGIS), in partnership with Trees for Cities and the UK Centre for Ecology and Hydrology.

Making some approximations, all the information needed to estimate the local air quality impacts of planting at each site can now be automatically determined from publicly accessible datasets (see below). This development – for city-region planning purposes – was funded via a NERC Discipline Hopping grant (ref. NERC DH-Levine) and a UKRI Future of UK Treescapes Fellowship (https://www.uktreescapes.org/projects/dr-james-levine/).

At each site, we explore the impacts of adding 2m-high, 20m-long, dense (10% optical porosity, i.e. gaps in the vegetation), evergreen vegetation 0.5m from the kerb on either side of the road; the kerb is not always straightforward to locate but is typically accurate to within a metre or two.

Note, we are exploring the impacts of introducing a significant obstruction to the horizontal flow of polluted air between vehicles and people at the roadside. A mixture of small trees and shrubs could potentially provide such obstruction, provided all gaps in foliage – horizontally (along the street), vertically (between the ground and a height of 2m) and seasonally (due to leaf loss) – are avoided.

Planting of this sort could be augmented with larger trees, offering a wealth of further benefits, but large street trees are no substitute for lower-level planting to obstruct the horizontal flow of polluted air at head height. In the absence of lower-level planting, scattered large trees will have little effect on local air quality, for good or ill. More thought, however, is needed when planting sufficient trees to form a dense canopy.

If the street is free of motorised vehicles, it could improve local air quality by reducing the import of pollution from above. If not, it could exacerbate existing air pollution problems by partially trapping vehicular emissions. (See First Steps in Air Quality for Built Environment Practitioners[13] for further explanation and diagrams).

What data is our GI4RAQ analysis based on?

At each site, the cross-sectional geometry of the street is determined from Ordnance Survey topography and building-height data (the average height of each building), freely available to eligible users via Digimap® (https://digimap.edina.ac.uk/os) subject to an Ordnance Survey Collection License Agreement.

17 Pearce, H., J. G. Levine, X. Cai, and A. R. MacKenzie, Introducing the Green Infrastructure for Roadside Air Quality (GI4RAQ) Platform: Estimating Site-Specific Changes in the Dispersion of Vehicular Pollution Close to Source. Forests, 2021, 12(6), 769. Available online: https://www.mdpi.com/1999-4907/12/6/769

The strength and location of vehicular emissions of NO2 and PM2.5 within the street, and the street's orientation, are meanwhile derived from the 2019 London Atmospheric Emissions Inventory link-level data (https://data.london.gov.uk/dataset/london-atmospheric-emissions-inventory--laei--2019).

Finally, the background concentrations of NO2 and PM2.5, with which those emissions mix, are taken from Defra's Air Information Resource (https://uk-air.defra.gov.uk/data/pcm-data).

What information will our GI4RAQ analysis provide?

The software will estimate, for each planting site, the percentage changes in annual-mean NO2 and PM2.5 concentrations expected in different parts of the street's cross section. It will then highlight those sites where planting could deliver meaningful benefits at the roadside (typically, estimated reductions of 5-10% in the immediate wake of the planting), with no significant disbenefits anywhere else (limited to estimated increases of up to 2.5%). This can allow us to understand if a location is suitable for further investigation and ground truthing on the viability of implementing planting interventions as described.

Disclaimer

The GI4RAQ Platform, and the integration of its underlying code into QGIS, comprise prototype software. All analyses performed with this software and/or presented in this guide are subject to large and currently unspecified uncertainties, and any or all actions taken by people in response to this guide are taken at their own risk. Some of the analyses presented may include estimated impacts in the vicinity of road junctions and/or in particularly narrow/deep 'street canyons' (i.e., streets that are deeper than they are wide). Our prototype software was not designed for these environments, and impact estimates here should be ignored.

2. MAPPING OF PRIORITY AREAS IN TOWER HAMLETS

2.1 TREE PLANTING HOTSPOTS

A tree planting hotspot map is a GIS based tool created to identify areas in which tree planting is of the highest priority. It is built by ranking land on a number of factors; for this project, those factors included air quality (NO2 and PM2.5), urban heat risk, indices of multiple deprivation, flood risk and population density.

These layers are combined to identify areas which are most in need of tree cover to combat environmental and social issues. Selecting planting sites on this basis can be used to ensure new planting contributes to tree equity across a given area.

GIS (Geographical Information System) project boundaries for Tower Hamlets were accessed using the London Datastore. Additional Ordnance Survey background mapping data was obtained from Tower Hamlets Council.

The range of values in each case was normalised to a 4-point scale running from 0 to 4.

The layers used for scoring were:

- air pollution concentration, comprising an aggregate score for concentrations of NO2 and PM2.5, being the two pollutants which public policy focuses upon
- indices of multiple deprivation (IMD) as an aggregated metric
- risk of surface water flooding at a 1 in 30-year incidence
- average peak surface temperature as a proxy for urban heat island effect

The factors were weighted equally with highest priority areas identified as those with a high prevalence of all of them. The resulting range of scores was then normalised to produce a hotspot range running from 1 to 10, where 10 is high and represents those areas where planting is most required in general.

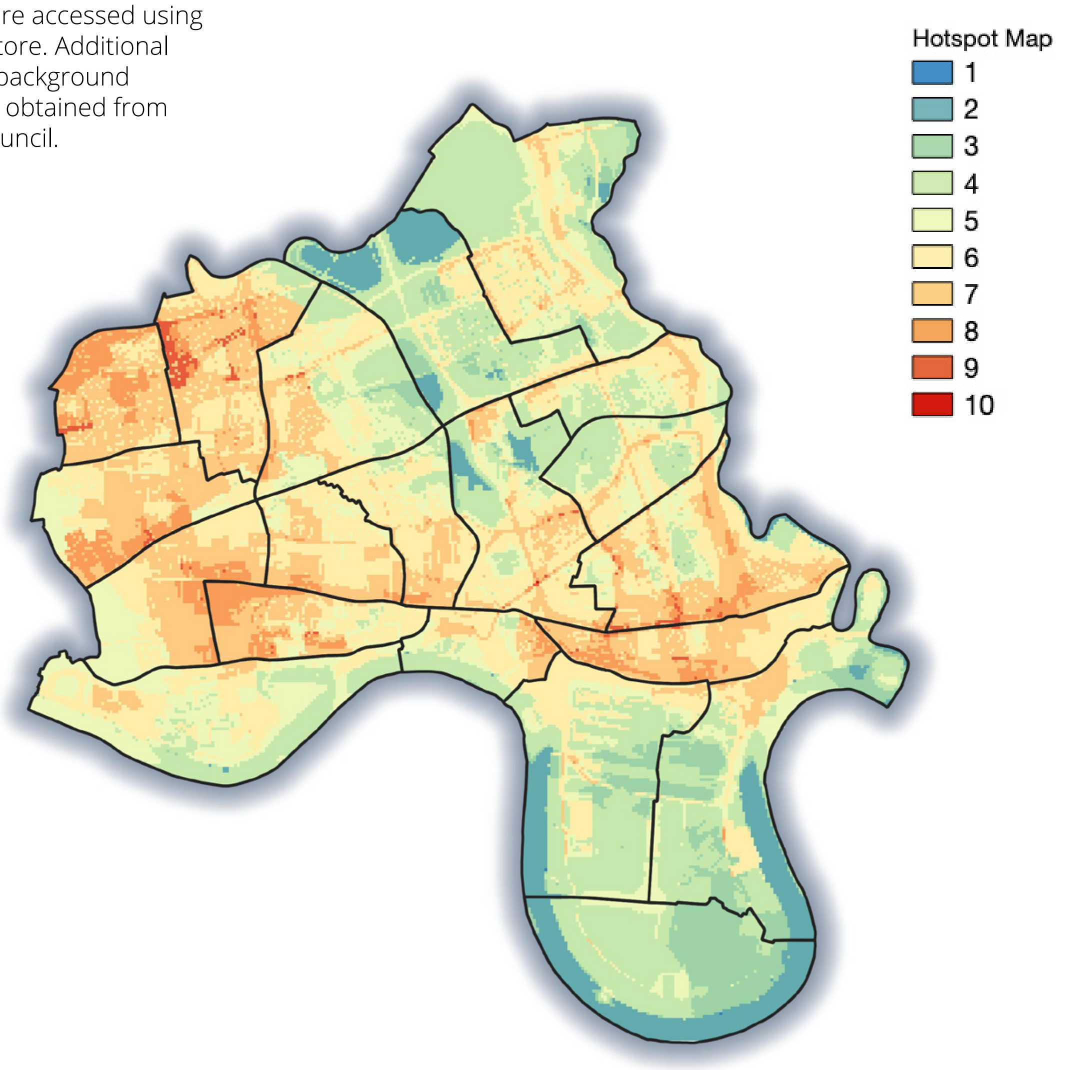


Figure 1. Tree Planting Hotspots

Individual maps for individual factors are shown below.

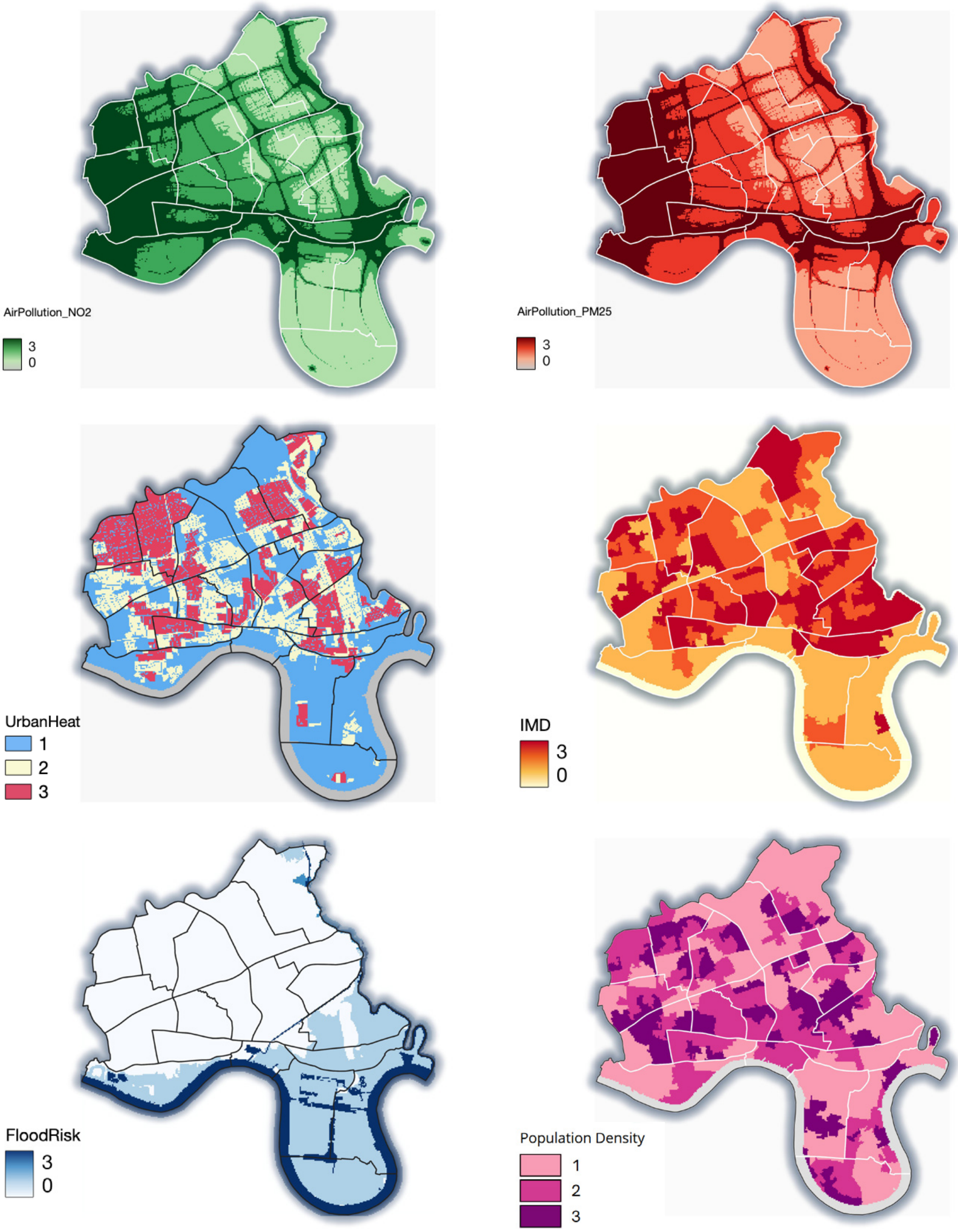


Figure 2. Hotspots based on individual factors

This approach provided the high-level prioritisation framework ahead of carrying out the more detailed pollution-focused prioritisation.

2.2 PRIORITY AREAS

Key hotspot areas of Tower Hamlets (classified as per the 24 places of Tower Hamlets laid out in the Local Plan[18]) were found to be:

- Aldgate (North, East)
- Bethnal Green
- Blackwall
- Poplar
- Poplar Riverside
- Shadwell (Northwest)
- Shoreditch
- Spitalfields
- Stepney (South)
- Whitechapel

With additional hotspots in Bow (East), Bow Common, Globe Town (West), Limehouse (East), and Mile End (focused on Mile End Road).

This hotspot mapping can be used alongside the borough's open spaces map to identify priority sites for new tree planting in parks and open spaces across the borough.

2.3 PRIORITY AREAS FOR AIR QUALITY AT A MACRO-SCALE

Hotspot areas are largely the same for NO2 and PM2.5 and are largely focused on the west of the borough closer to central London, and the major arterial roads which run through the borough (A11, A12, A13, A102, A107, A1202, A1203, A1205, A1208, A1209, A1261, and B103).

Highest priority places are:

- Aldgate
- Bethnal Green
- Blackwall
- Limehouse
- Poplar
- Poplar Riverside
- Shoreditch
- Spitalfields
- Tower of London
- Wapping (North)
- Whitechapel

Other priority places are Globe Town, Stepney and the north of Canary Wharf, as well as where major roads run through Fish Island, Bow, Bromley by Bow, and Mile End.

18 Tower Hamlets Council. Tower Hamlets Local Plan 2031. 2020. Available online: https://www.towerhamlets.gov.uk/Documents/Planning-and-building-control/Strategic-Planning/Local-Plan/TH_Local_Plan_2031_accessibility_checked.pdf

3. APPLYING GI4RAQ TO THE LONDON BOROUGH OF TOWER HAMLETS

3.1 APPLYING GI4RAQ TO THE LONDON BOROUGH OF TOWER HAMLETS

What have we done?

We have used the Green Infrastructure for Roadside Air Quality (GI4RAQ) software[15], in conjunction with mapping software, to explore the potential impacts of planting at 50m intervals along every major road in Tower Hamlets. At each point, the software has estimated the percentage changes in annual-mean NO2 and PM2.5 concentrations expected in different parts of the street's cross section, in response to the addition of 2m-high, dense evergreen vegetation, 0.5m from the kerb on one side of the road. Note that the impacts of adding vegetation on one side of a road often differ markedly from those of adding vegetation on the other side of the same stretch of road, due to asymmetries in the patterns of polluted air flow.

You may recall from section 1.2 that we expect roadside planting primarily to change the local distribution of vehicular pollution rather than to remove it so, whilst kerbside vegetation may reduce pollutant concentrations in some parts of the street's cross section, it may increase them in others. The balance between these increases and decreases varies considerably, depending on the street's geometry, orientation and consequent interactions with winds aloft. In some sites, the software estimates reductions in pollutant concentrations at the roadside (behind the planting) accompanied by no significant increases anywhere else. These are the sites we seek to identify.

What do we find?

We estimate that dense kerbside vegetation could reduce roadside exposure in its immediate wake by 5-10% annually, whilst not increasing exposure anywhere else in the street by more than 2.5%, in around an eighth of the 54,000 sites explored. Across roughly 6,750 sites, the software estimates that dense, tall and evergreen planting, could reduce annual-mean NO2 and PM2.5 concentrations in their immediate wake by an average of around 9% and 7% respectively. These sites are marked in green in the map below (Figure 3), providing a high-level perspective on the detailed potential of individual potential GI4RAQ locations. This map highlights that, in general, priority locations were found to be on major arterial roads. This high-level perspective can be used as a guide as to where to focus within the detailed map of the GI4RAQ analysis, which allows us to determine the precise locations of planting that could potentially improve local air quality, and avoid unintentionally making existing problems of air pollution worse.

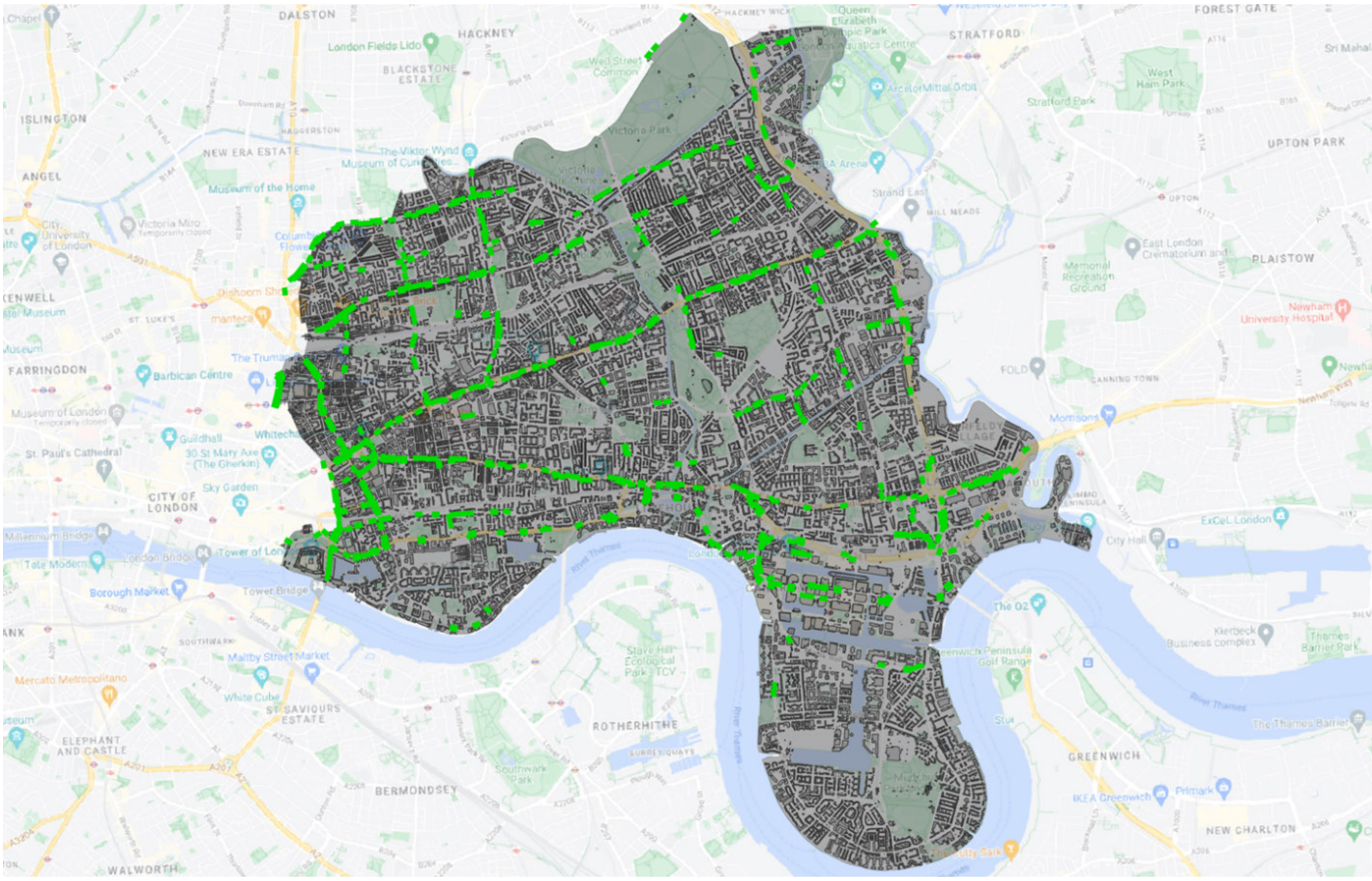


Figure 3. Potential suitable GI4RAQ locations

To reiterate, please disregard all estimates of impacts in the vicinity of road junctions and/or in particularly narrow/deep 'street canyons'.

When we zoom in, we find some areas where vegetation at adjacent sites could have very different impacts. On the short stretch of Parnell Road illustrated in Figure 4, the bright green line in the bottom right hand corner marks the location of dense planting. This planting is estimated to reduce the annual-mean concentration of NO2 in its immediate wake by around 8%, giving way to a smaller reduction of 3% closer to the adjacent buildings, whilst increases elsewhere are limited to around 1%. The colours of the lines straddling the street are indicative of those percentage changes, ranging from blue (reductions), through white (negligible changes), to red (increases), and the coloured lines are annotated with the actual percentage changes estimated (negative = reduction; positive = increase). At the top, however, the addition of dense planting is estimated to increase the annual-mean concentration of NO2 throughout the street's cross section. As it would be unwise to plant here if seeking to improve air quality, the green line marking the location of vegetation explored in this location is omitted. Note, we cannot assume that if planting is beneficial in one location, it is likely to be beneficial in another nearby.

We do also find areas, however, where vegetation at adjacent sites is estimated to have similar impacts. One such area – a short stretch of Commercial Road (A13) – is illustrated below in Figure 5. The bright green lines mark the locations of vegetation estimated to reduce the annual-mean concentration of NO2 in their immediate wake by around 7%, giving way to smaller reductions of 1-3% closer to adjacent buildings and increases of only 0-1% elsewhere. The similar impacts reflect very similar conditions at each site, with respect to:

- the orientation of the street
- the distance between the road and the nearest buildings either side
- the average heights of those buildings

Only where all conditions remain practically the same is there a greater chance that the same planting would be estimated to have similar impacts. Where those impacts are estimated to be consistently beneficial, we might consider a longer stretch of planting. The longer the stretch of road beside which we improve air quality, the greater the number of residents who will benefit, and the longer the period of time for which passers-by will benefit; small pockets of trees and bushes are expected to have little influence on air quality. There may, therefore, be a balance to strike between sites where planting could potentially deliver greater benefits, and clusters of sites permitting longer stretches of planting that might benefit more people for longer.

Figure 4. Illustration of differing impacts of vegetation at adjacent sites

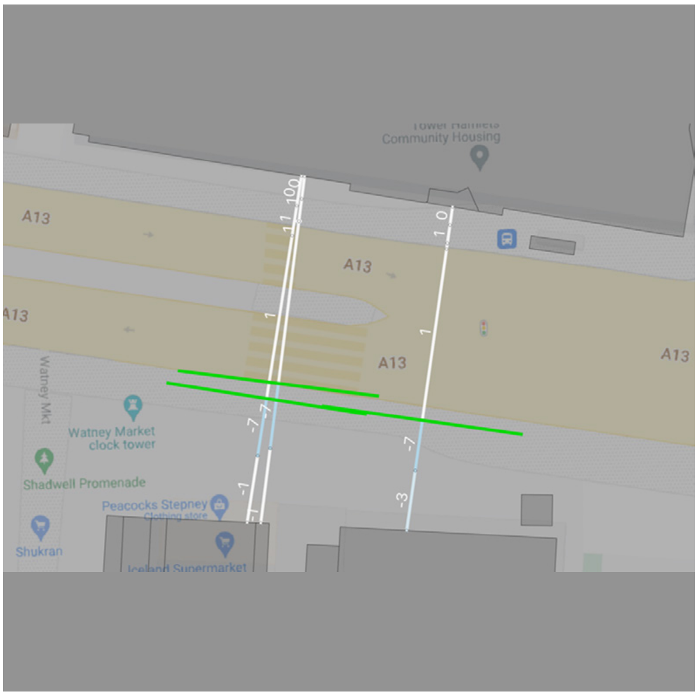


Figure 5. Illustration of similar impacts of vegetation at adjacent sites

3.2 POTENTIAL PLANTABLE SPACE FOR GI4RAQ

A map of potential locations where planting dense vegetation was considered viable was created by considering the physical requirements of the vegetation on the one hand, and the space usage requirements of pedestrians on the other.

Ordnance Survey master map data were used as the base input for the categorisation of all paved areas by 'width', as considered along a line perpendicular to the adjacent highway and thus in keeping with an everyday, common sense understanding of the term.

The paved areas were initially split into widths of under 2m and over 2m. 2m is the minimum threshold for maintaining viable access of 1.5m alongside a physical obstruction of 0.5m wide as the vegetation is intended to be at a minimum. The existing tree canopy was then mapped using Google canopy data with any areas falling under existing tree cover removed.

Finally, an approximation for areas required as visibility splays for drivers approaching junction was created and any overlaps with the paved areas selected were removed.

What remained was a set of paved areas at least 2m wide. As the vegetation is intended to be 20m long and up to 2m high, it was recognised that this minimum limit is unlikely to prove acceptable to pedestrians in reality.

As a consequence, the criteria were broadened and subsets created comprising:

- paved areas at least 20m long and over 4m wide (924 locations identified)
- paved areas at least 20m long and over 5m wide (519 locations identified)
- paved areas at least 20m long and over 6m wide (318 locations identified)

By combining the impact mapping with the viability mapping, it was possible to narrow down some potential sites to be ground truthed.

Figure 6. Example mapping showing canopy cover and potential locations with at least 3m width

4. GI4RAQ INTERVENTIONS

4.1 WHAT COULD GI4RAQ INTERVENTIONS LOOK LIKE?

Urban roadside settings are complex and subject to many considerations which affect their design, including accessibility and sense of safety. These considerations will need to be taken into account when designing Green Infrastructure for Roadside Air Quality interventions. Figure 7 shows example diagrams of 3 different scales of intervention, based on the amount of available space for introducing vegetation.

Option One - Minimum Intervention: Typical cross section in most restricted streetscape to create a linear hedge

Option One could be pursued where there is limited space for the implementation of new green infrastructure. A two metre high screen of dense vegetation in the right locations could deliver local air quality benefits, but may present a number of other challenges for pedestrians and other road users.

These challenges include: poor pedestrian and vehicle visibility; poor visual navigation for pedestrians and as a result sense of safety hindered; limited escape routes from 20 metre length stretches of vegetation; lack of step-out space for kerbside vehicles; significant requirements for regular maintenance of hedge; difficult growing conditions in narrow trench planter, leading to failure of hedge to thrive in harshest urban conditions. This approach can only be applied where conditions are suitable (refer to Site 1 – Commercial Road, next to Stephen Hawking School).

Option Two - Medium Intervention: Typical cross section in wider streetscape adjacent to buildings, used to create a small, linear parklet

Option Two illustrates how additional width in sections of urban streets can create space for small linear parklets that can follow the GI4RAQ recommended 20 metre stretch of road, and create greater depth of vegetation. This approach can enable low level vegetation to the pedestrian side with the taller dense, evergreen vegetation on the roadside.

Small pockets of wider street space can be utilised to create more impactful green infrastructure that breaks through impermeable paving, enabling multiple other benefits to be integrated for pedestrian amenity, surface water management interventions, urban cooling and habitat creation. Many of the problems identified for Option One can be alleviated with additional width.

Ensuring there is sufficient width for the dense evergreen vegetation at 2 metre height (as opposed to a clipped hedge), can significantly reduce the need for pruning, without compromising the reduction in exposure to air pollution from proximate vehicles.

Option Three - Major Intervention: Typical cross section in a wide streetscape with open boundaries, used to create an integrated parklet

Option Three illustrates the best-case scenario to create integrated green infrastructure into an urban streetscape. Locating these wider street spaces that meet the GI4RAQ selection criteria can be difficult, but not impossible in tight urban scenarios, as can be demonstrated in our site selections in Tower Hamlets.

These parklets can create spaces for passive leisure, seating, cycle parking, and a wide range of vegetation at different levels including tree planting and associated multiple benefits.

These spaces can provide wider views and greater sense of safety for pedestrians. With greater space there is greater scope for integrated footway design that can accommodate other road users' needs such as cyclists.

Mapped areas of potential plantable space were layered against locations where the GI4RAQ tool indicated interventions would lead to air quality benefits without any significant disbenefits. Guided by the high-level perspective mapping of the GI4RAQ analysis, manual scanning of these map layers established a long list of 18 potential planting sites (see Appendix 1).

The selection of these sites focused on the mapping of potential space and GI4RAQ analysis, and given how few viable locations emerged, was not further narrowed by the hotspot mapping relating to other criteria (indices of multiple deprivation (IMD), risk of surface flooding at a 1 in 30-year incidence, average peak surface temperature as a proxy for urban heat island effect).

The long-list of sites were visited during a ground-truthing exercise, carried out by Trees for Cities in July 2023. Sites were evaluated against the following criteria:

4.2 SITE SELECTION

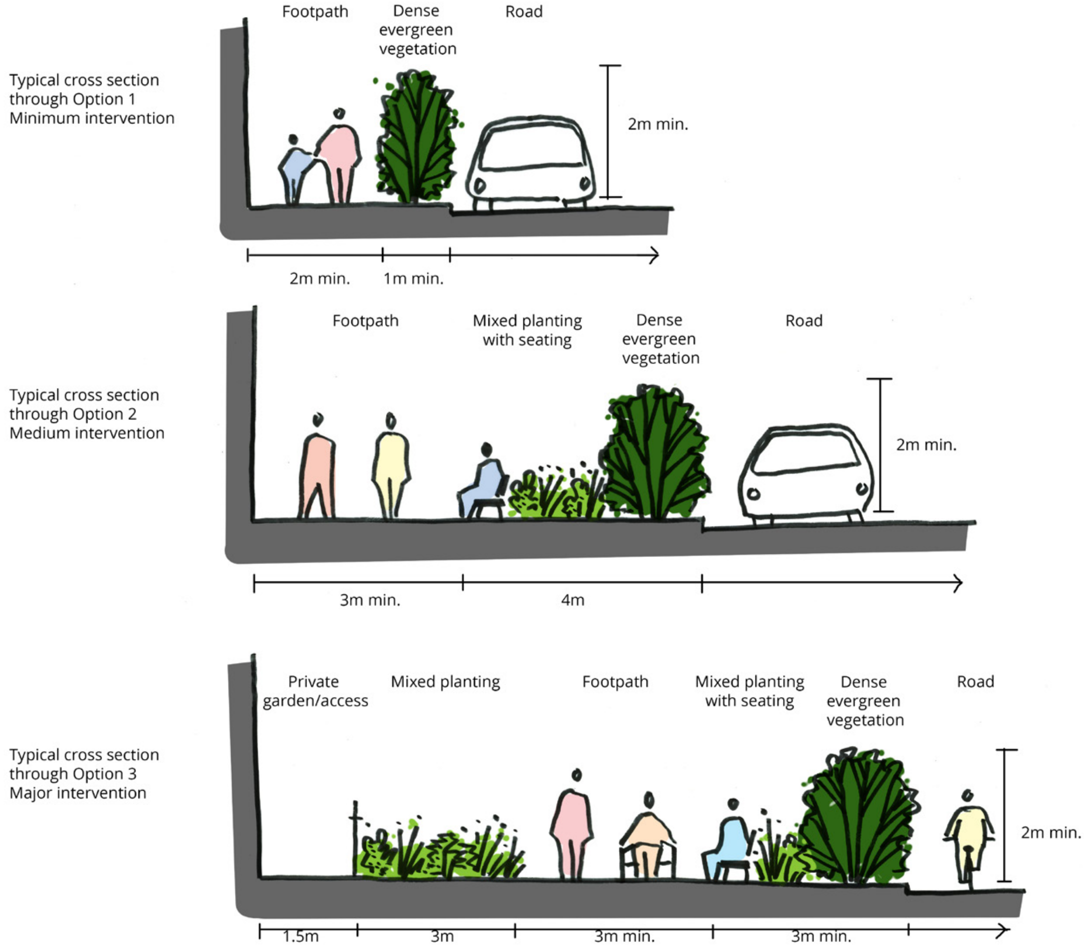


Figure 7. Example diagrams of 3 different scales of intervention

Table 1: Ground-truthing Criteria:

Criteria	Application of Criteria
Community and population in close proximity to each site	Is the location within proximity of those more vulnerable to poor air quality ('vulnerable receptors'). E.g. close to schools, healthcare facilities, sporting facilities, on a public footpath, allotments, play facilities
Accessibility for people and vehicles	Would new vegetation and / green interventions block vehicle access, parking, bus stops, cycle lanes, people movement, visibility splays, people's sense of safety?
Proximity to other green infrastructure	Can the location link into a network of other green interventions? Is there any green infrastructure in the vicinity of the location? Trees, hedges, SuDS, etc. to which the intervention could connect?
Ability of site to accommodate greening interventions	Is there sufficient space in the location to take additional green infrastructure so it will have the desired impact? Has the site sufficient space for new vegetation/ hedges and for them to grow to desired height / width? Is the ground soft or hard? Soft ground will be easier to utilise - harder ground more expensive to break out Can we achieve 20Lm x 0.5Wm minimum of 2m high planting in the location as minimum?
Are there physical barriers that will prevent the interventions from being introduced?	Can you see overhead services wires, built structures, traffic signage / directions, lights, crossing points? Evidence of below ground services - manholes, gullies, grilles, service boxes etc.?

4.3 SELECTED SITES AND ILLUSTRATED EXAMPLES

The following five kerbside sites emerged as having greatest opportunities for GI4RAQ interventions through the desktop and ground-truthing processes. Opportunities to apply GI4RAQ interventions are limited in Tower Hamlets due to narrow streets and highly urbanised hard infrastructure. The selected sites represent the art of the possible, if better, joined-up planning occurred to maximise the benefits gained from these precious but underutilised spaces.

If well considered and optimised urban design is coordinated between stakeholders in public highway planning and design, statutory services, public transportation, and street users to create more space for green infrastructure, then the urban streets in Tower Hamlets have the potential to become more liveable, healthy and green.

For each site, we show a figure with the results of the desktop analysis, showing that kerbside vegetation could potentially improve roadside air quality, and the plantable space (shaded blue) is at least 4m wide (perpendicular to the road) and 20m long (parallel to the road). The black rectangles in each of the map details indicate the potential extent of planting from an air quality perspective, prior to assessing feasibility with regards to the preservation of safety-critical sightlines, access at the kerb etc.

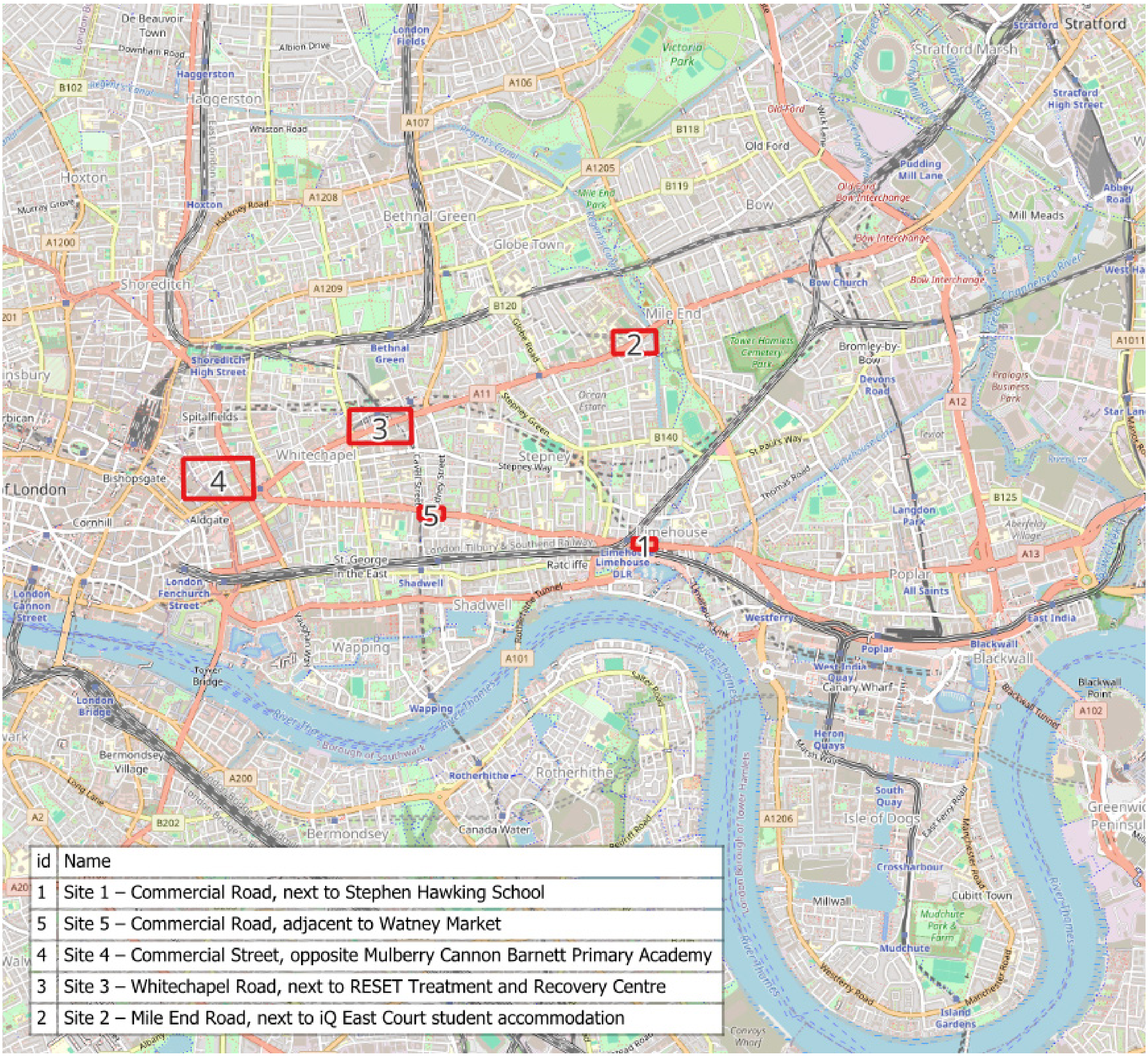


Figure 8. Locations of selected sites within the borough of Tower Hamlets

SITES FOR OPTION ONE - MINIMUM INTERVENTION

Site 1 – Commercial Road, next to Stephen Hawking School

Viability

GI4RAQ analysis found two stretches of the northern side of Commercial Road (A13), in Limehouse, where introducing vegetation is estimated to produce a benefit in roadside air quality. This the narrow northern footway of the A13 Commercial Road between Brunton Place to the west and the Regents canal to the east. This is a busy A-road which accommodates 2 lanes of traffic at this section.

Ground truthing found that approximately 50m of this length, may be viable for the introduction of green infrastructure.

The footway is approximately 4 metres wide, running along the southern boundary of the Stephen Hawking School (where the school has introduced some ivy screens in planters) and bounded by a kerbside protective highway railing. This offers opportunity for Option One, minimum intervention only.

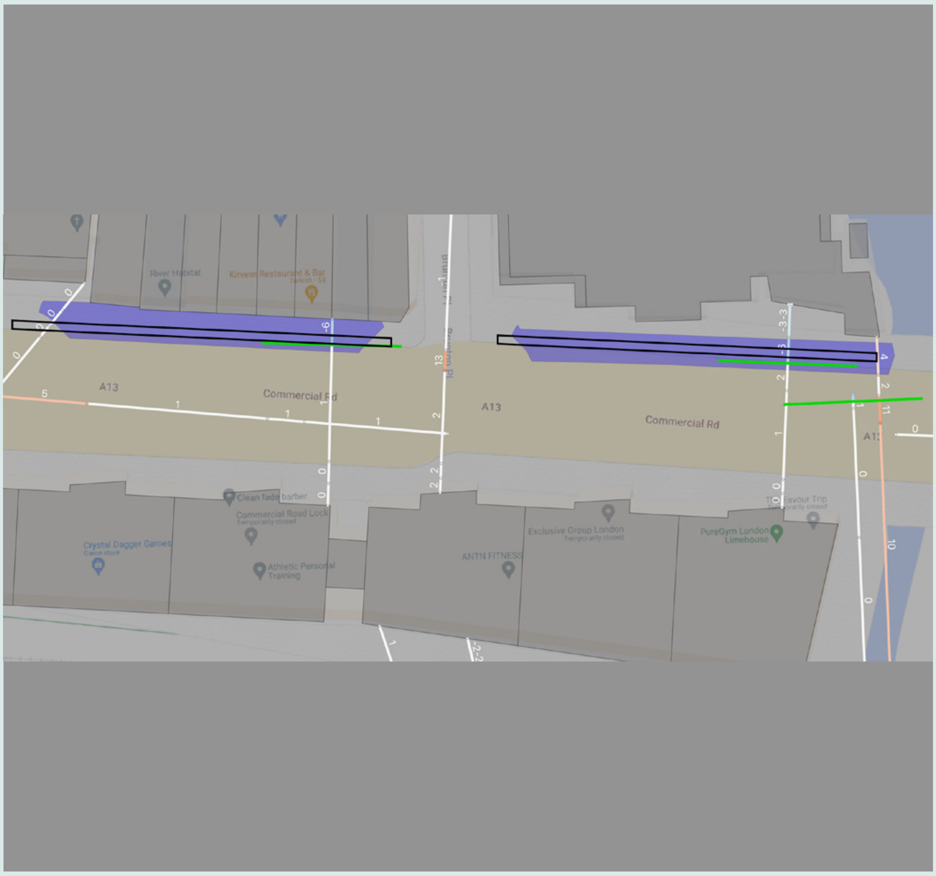


Figure 9. Example diagrams of 3 different scales of intervention

Figure 10. Images showing current conditions at Site 1

Proposal

The 4-metre-wide footway provides sufficient space for a minimum width footpath of 2-3 metres, alongside a 0.5-1.0-metre-wide trench that could house a dense linear hedge. As a heavily trafficked route, the A13, Commercial Road presents severe air quality and acoustic problems for the adjacent school (location of 'vulnerable receptors').

Introduction of a dense evergreen linear hedge could offer benefits based on applying GI4RAQ in this location. The hedge would sit behind the existing highway railing and therefore would not present an additional barrier to access to the road, while also being estimated to reduce the ingress of vehicular pollution onto the footway and into school grounds and filtering views of the busy utilitarian highway.

These benefits can be taken against the consideration of additional maintenance needs for the hedge and the enclosed footway with reduced visibility for pedestrians. This intervention would complement the existing ivy screens implemented by the school, which would act as a secondary green barrier inside their boundary railings.

The linear hedge would further reduce pollution ingress into school grounds whilst offering children and families approaching/leaving the school, as well as others using the footway, some protection from local vehicular pollution which is currently lacking.

Figure 11. Aerial view of site illustrating intervention at Site 1

Section A

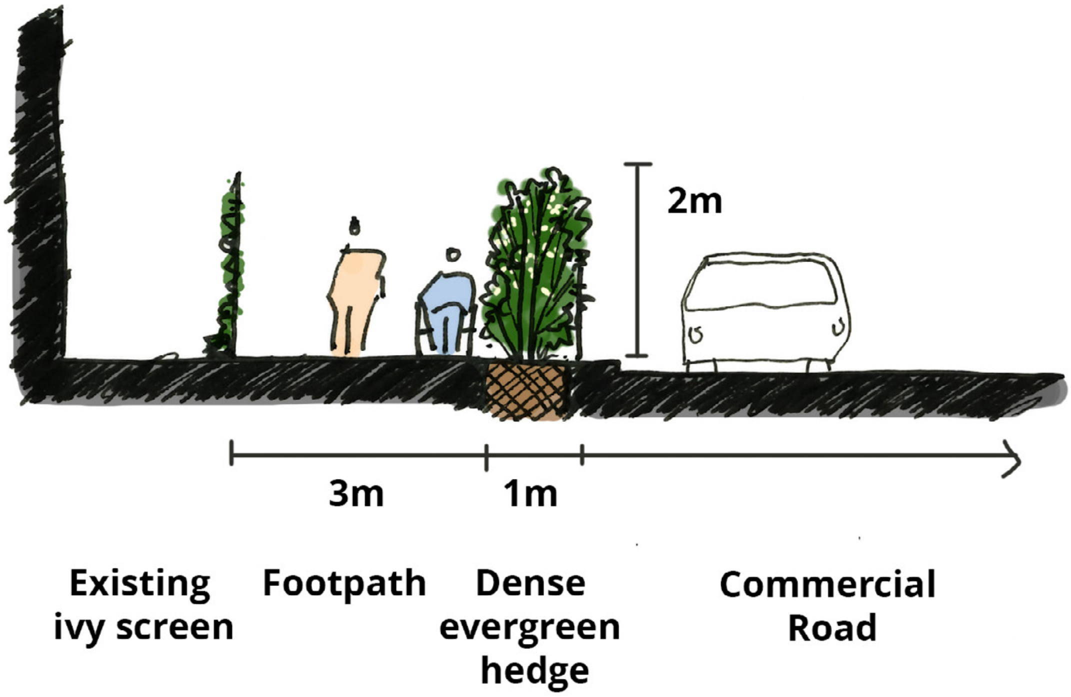


Figure 12. Cross section of Site 1 showing hedge intervention and ivy screening

Site 2 – Mile End Road, next to iQ East Court student accommodation

Viability

This is a short stretch of footway to the south of Mile End Road (A11), just to the west of Regents Canal which offers an opportunity to support a narrow stretch of dense evergreen vegetation to meet GI4RAQ requirements (Option One).

The GI4RAQ analysis of this section showed potential to improve roadside air quality through planting on either the northern side or southern side. It would be recommended to plant to one side of Mile End Road or the other, but not to both, as the impacts of planting on both sides are difficult to predict, and they would not necessarily be beneficial.

Although the analysis presented a shorter viable stretch to the south side - from an air quality perspective, planting on the southern side should be avoided west of Toby Lane - the feasibility mapping and ground truthing found that the southern side would be preferable as the northern side lacked sufficient space for a GI4RAQ intervention.

The southern side has sufficient space in a pertinent location outside the entrance to student accommodation. Students are exposed to poor air quality in this space, using this location to congregate, and enter and leave the building. The busy road, and cycle lane bounded by bollards, already greatly limit movement onto the busy Mile End Road and mean this area is unlikely to be used as a crossing point.

Therefore, the inclusion of a hedge or other dense vegetation along this route would not present an additional movement barrier over what is already present.

Figure 13. GI4RAQ analysis at Site 2, North side

Figure 14. GI4RAQ analysis at Site 2, South side

Proposal

At this site, a 2-metre-high linear hedge along up to approximately 60 metres of footway could divert some of the local vehicular emissions away from the accommodation entrance.

This could reduce exposure to proximate vehicular pollution for the users of this building (primarily students), as well as any members of the public using the footway at this site.

The new vegetation would need to be incorporated into the existing row of trees to the east of the accommodation entrance.

SITES FOR OPTION TWO - MEDIUM INTERVENTION, SMALL LINEAR PARKLET

Site 3 – Whitechapel Road, next to RESET Treatment and Recovery Centre

Viability

This site is an approximately 160m stretch of wide payment on the north side of the A11 in Whitechapel. The GI4RAQ analysis showed that introducing vegetation could bring air quality benefit across a significant stretch a little further east along the A11 at the site of Whitechapel Market. However, the use of the site for the market limits the feasibility of implementing new green infrastructure. At this site just west of Whitechapel Market, a short stretch of footway of approximately 45m is found by the analysis and by ground truthing to be suitable for a GI4RAQ intervention. Either side of this stretch, 2m high dense vegetation would be estimated to lead to a disbenefit on the road side of the intervention.

This stretch is sufficiently wide to accommodate a number of potential interventions. It is located along a busy road, and is next to the RESET Treatment and Recovery Centre which provides services for Tower Hamlets residents who are experiencing difficulties with drugs and/or alcohol. This links the location directly to potential 'vulnerable receptors'.

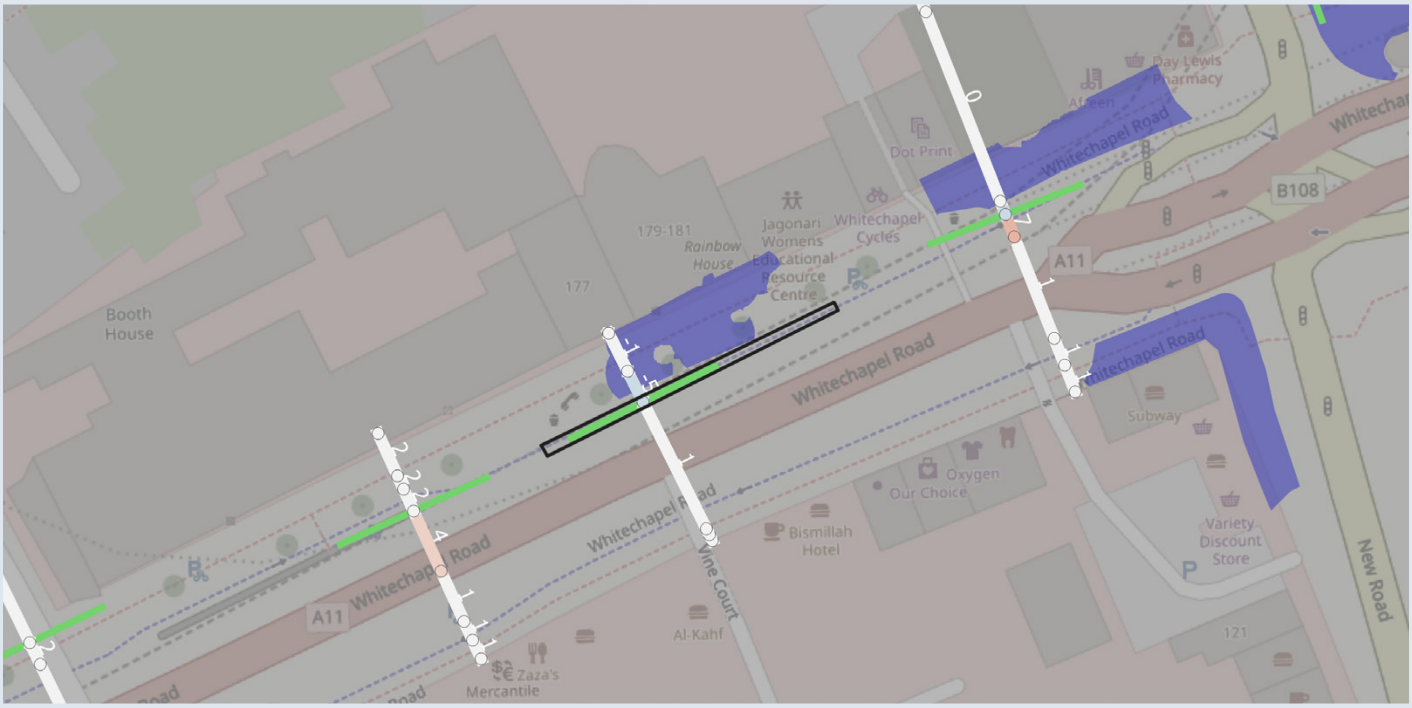


Figure 15. GI4RAQ analysis at Site 3

Figure 16. Images showing current conditions at Site 3

Proposal

The street provides a bus stop, a cycleway and footway and has several mature and recently planted trees that could be incorporated into a mixed planting which could run the length of approximately 90m, including a shorter stretch of dense evergreen vegetation, where a GI4RAQ intervention is deemed to be appropriate by the analysis. Provision of a multi-functional parklet can create an improved space for pedestrians, residents and other users of the cycleway and bus stop.

Other multiple benefits may emerge from improved screening and shade, as well as through depaving and potential integration of raingardens. Opportunities exist for better seating and multi-layered planting, signage, cycle racks etc. without compromising local visibility or sense of safety due to wide available space on the footway.

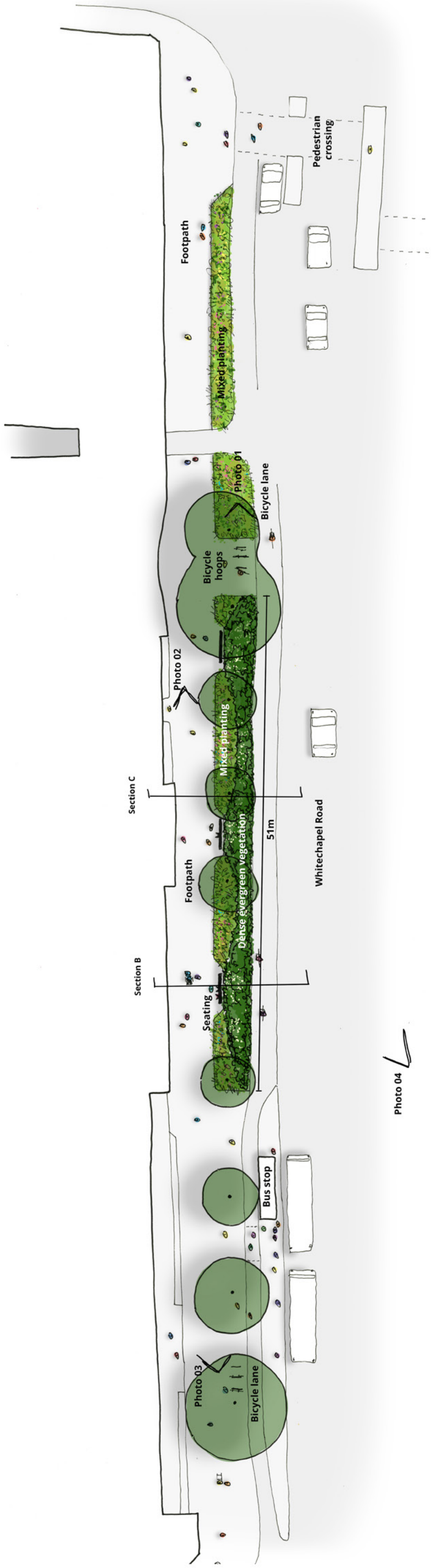
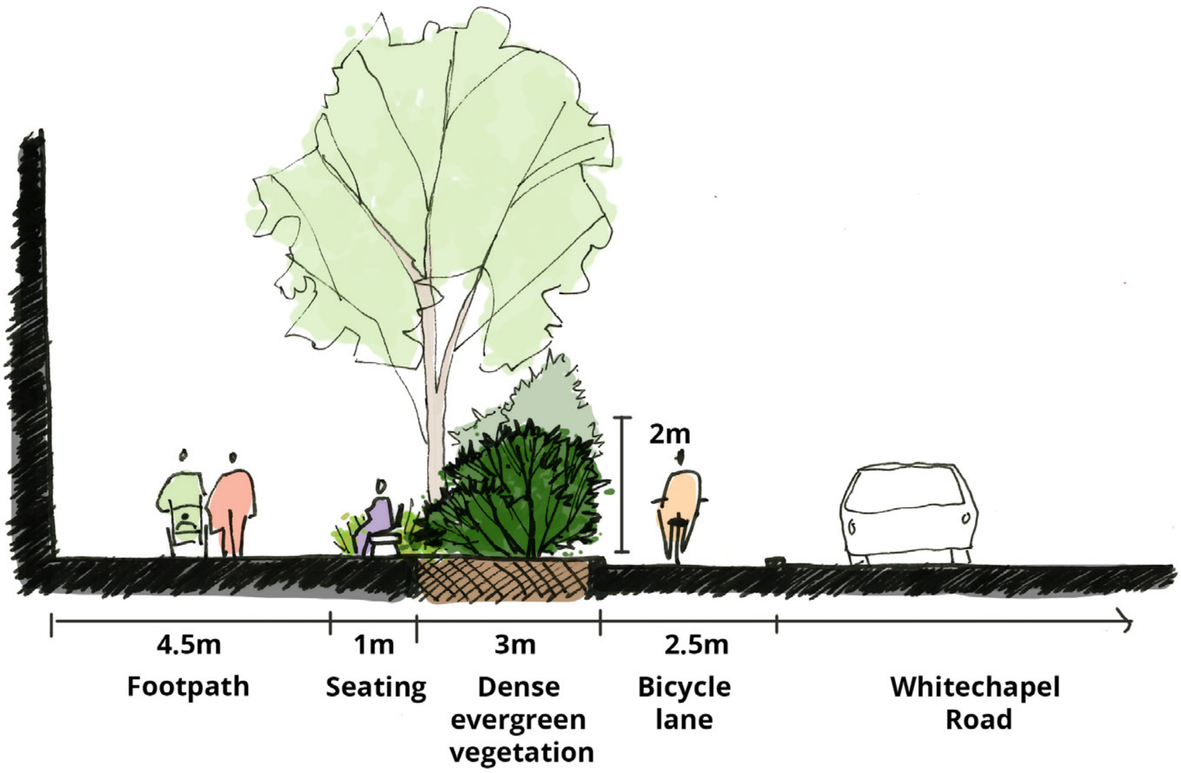


Figure 17. Aerial view of site showing mixed planting at Site 3

Section B



Section C

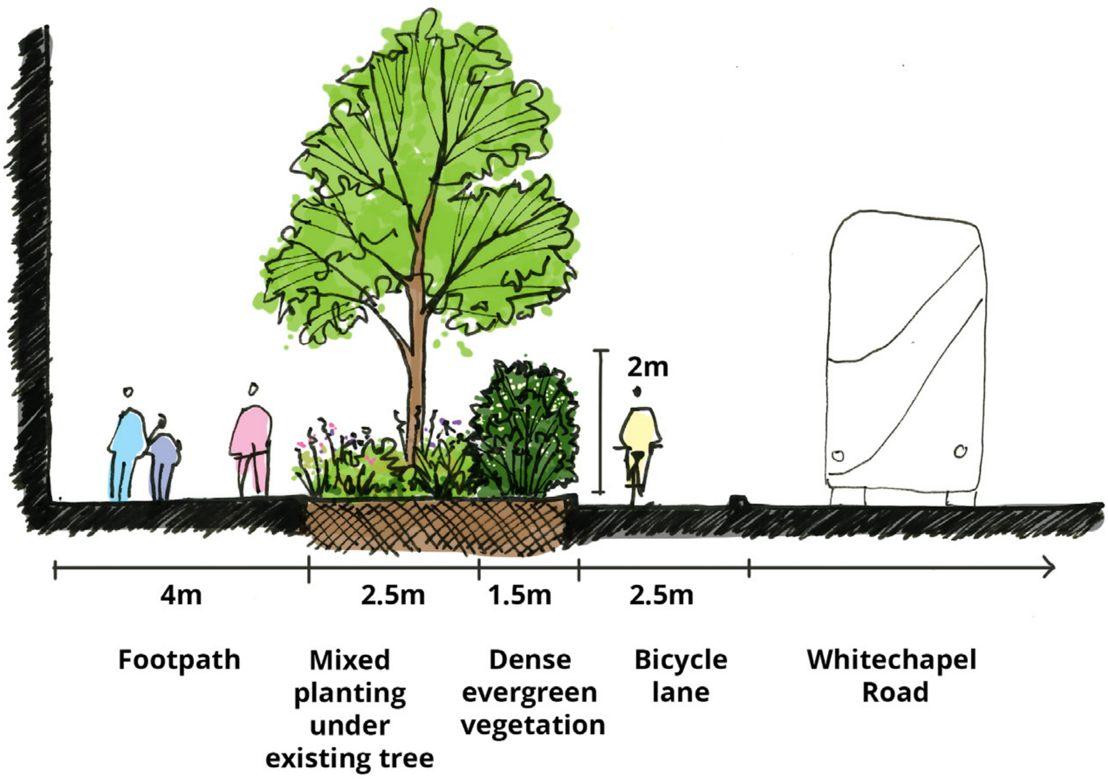


Figure 18. Cross sections of Site 3 showing mixed planting including 2m high dense vegetation for air quality intervention

Site 4 – Commercial Street, opposite Mulberry Cannon Barnett Primary Academy

Viability

This is a stretch of footway of approximately 120m on the west side of Commercial Street, between Pomell Way and Brushfield Street. This stretch of footway serves pedestrians using the adjacent parade of shops and businesses and is opposite one of the entrances to Mulberry Cannon Barnett Primary Academy.

Despite the lack of blue shading indicating available space in Figure 19, the footway is sufficiently wide to enable integration of a range of green interventions and our estimates of the impacts of kerbside hedging suggest it could potentially be beneficial here too. The space currently has a row of existing mature and newly planted trees which could be incorporated into the new planting.

The stretch houses street furniture such as litter bins and cycle racks which could be relocated to integrate with a revised GI4RAQ layout. Existing utilities would need to be taken into consideration and could impact the viability of the site.

Proposal

A redesign of this space would be suitable for Option Two - Medium intervention and could accommodate a linear parklet which incorporates the existing trees, while adding dense 2m-high evergreen planting as a GI4RAQ intervention.

This could include additional functional and amenity interventions including seating and bike racks and different layers of vegetation.

It would need to integrate access routes to the highway through the parklet but within the 20 linear metre hedge restrictions to ensure the GI4RAQ principles are followed.

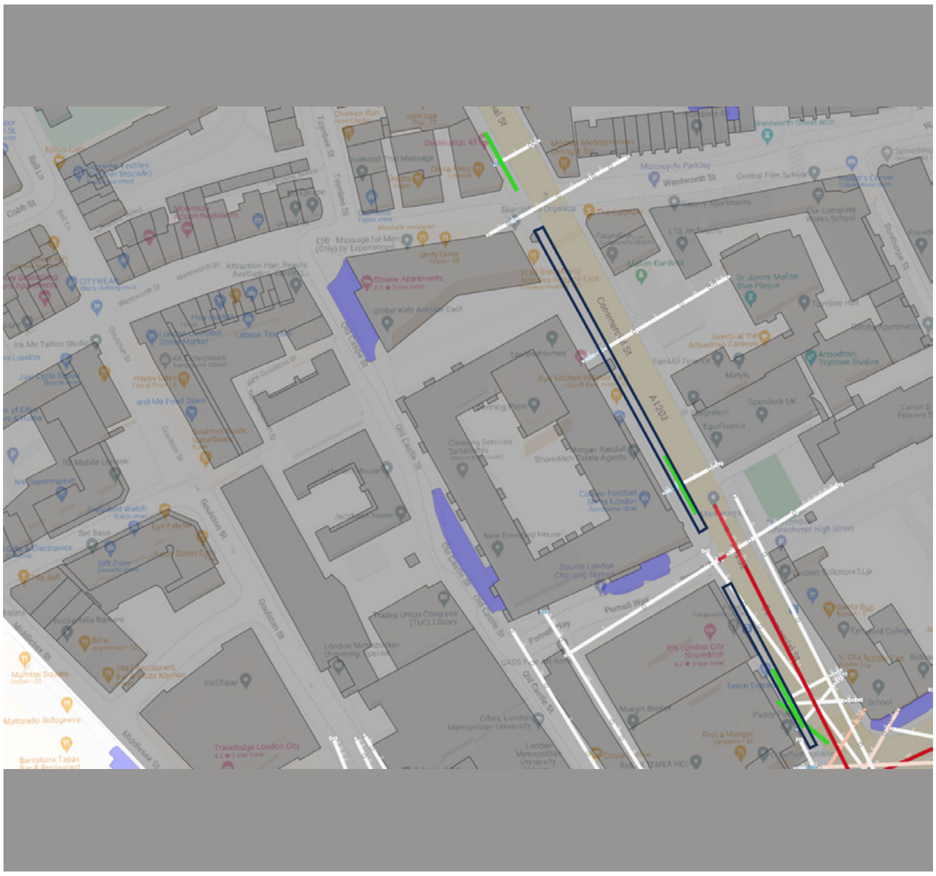


Figure 19. GI4RAQ analysis at Site 4

SITE FOR OPTION THREE - FULL SCALE INTERVENTION, LINEAR PARKLET

Site 5 – Commercial Road, adjacent to Watney Market

Viability

This is a stretch of approximately 110m on the southern side of Commercial Road (A13) in Shadwell between Watney Market and Deancross Street. This stretch of the A13 is a four-lane highway with heavy pedestrian footfall close to shopping facilities and the adjacent Watney Market. The GI4RAQ analysis showed that the introduction of green infrastructure here could reduce exposure to air pollution within this space. This site of all locations identified, offers greatest scope for an extensive integrated parklet, one that can provide significant improvements to an urban and underutilised piece of precious urban space. The site consists of hard surfaced land adjacent to an Iceland store and to a residential parking lot. At its narrowest the site is approximately 10 metres wide, increasing in places to a maximum available width of c.14 metres. Of that width approximately 2.5 metres is dedicated to a roadside footway. A row of 50 rental cycle docks, have been placed in the site in a way which divides and takes up a central part of the site, and is therefore insensitive to future site improvement and alternative uses and configurations of the site.

The viability of this idealised proof of concept is based on 2 key assumptions:

First, the re-imagining of this space assumes that the cycle docks could be relocated within the same site to leave greater space for a better integrated range of facilities. This approach would continue to support the active-travel option provided by the rental cycles.

Second, the space currently has a clear surface change between a c.2.5m width of footway at the roadside, and the rest of the pavement area which may indicate a change of ownership. Our re-design assumes the full width is available for reworking, regardless of ownership.

Figure 20. GI4RAQ analysis at Site 5

Figure 21. Images showing current conditions at Site 5

Proposal

With our proposed adjustments and assumptions, the site provides scope for significant parklet intervention, with space not only for the linear dense vegetation, but a depth and variety of other planting, allowing open views to the market and flexibility to rehouse the cycle docks in an easy to access space.

Elsewhere the site can be better utilised for seating, signage, and for provision of improved shade, habitat and surface water management (e.g. via the inclusion of SuDS) through carefully designed and integrated planning.

The proposal would integrate the existing roadside trees.

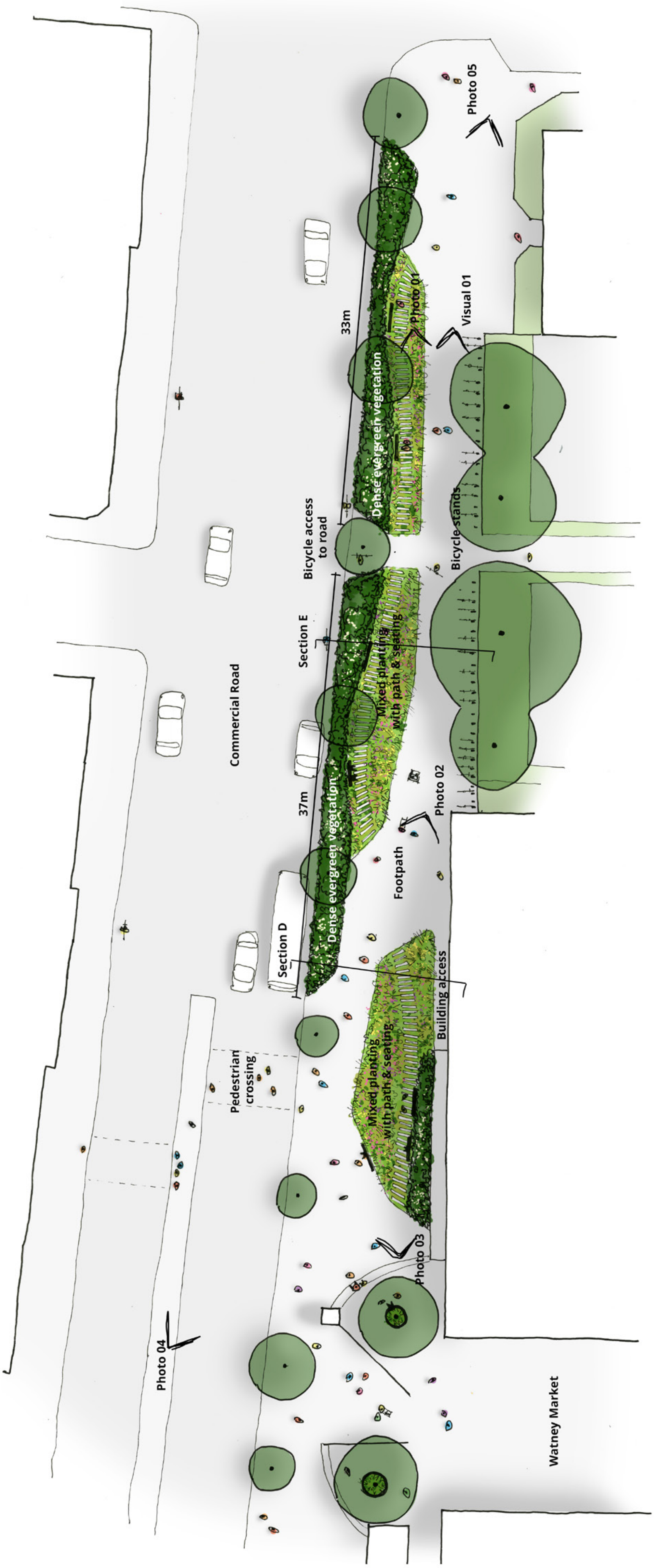


Figure 22. Aerial view of linear parklet at Site 5

Site 5 – Commercial Road, adjacent to Watney Market: Continued

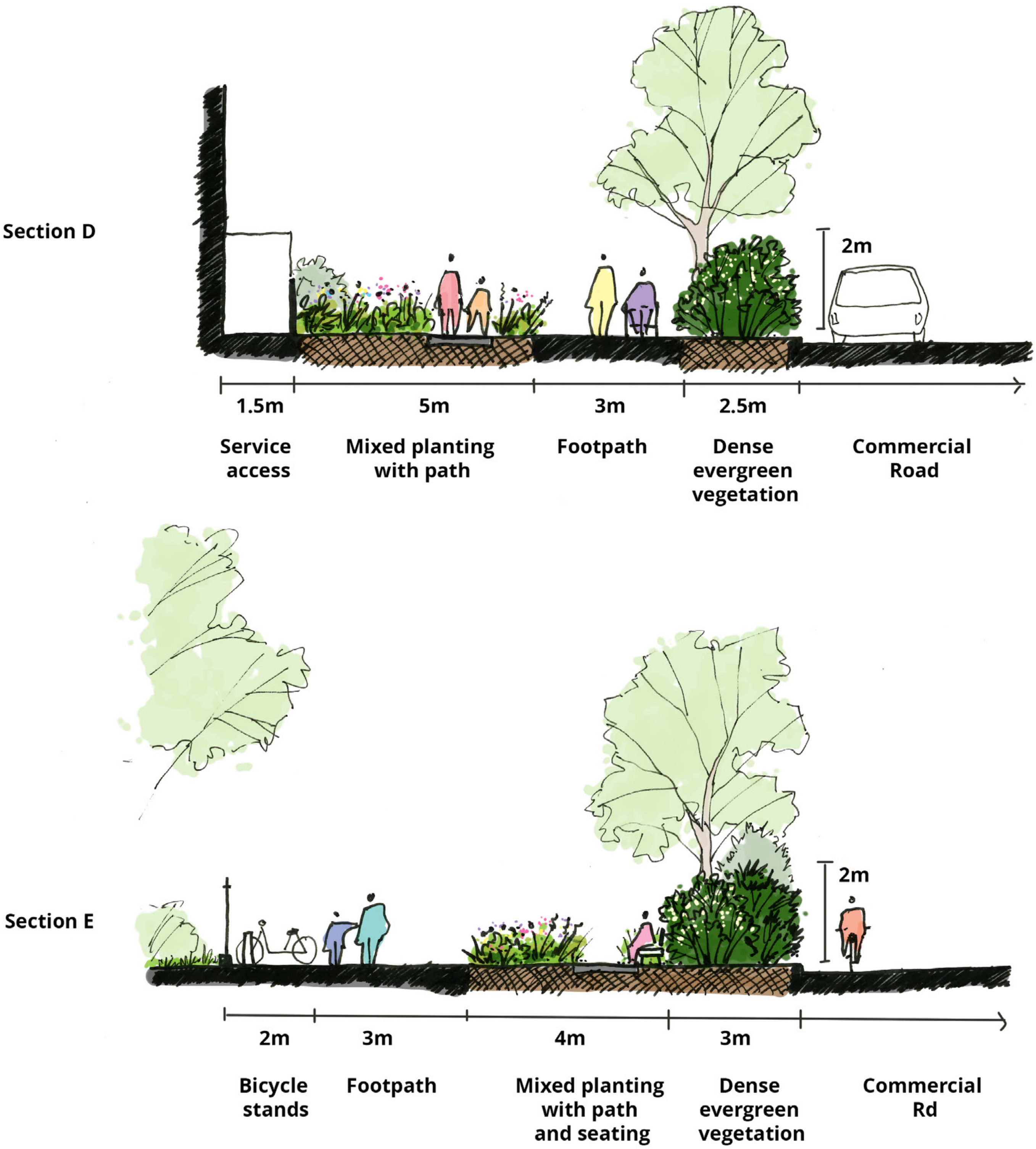


Figure 23. Cross sections of Site 5 showing linear parklet mixed planting including 2m high dense vegetation for air quality intervention

Figure 24. Side by side of current conditions and visual of proposed linear parklet at Site 5

5. CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

Through the application of GI4RAQ analysis across LBTH, and priority hotspot and feasibility mapping, this guide has identified priority spaces for tree planting in the borough, and 5 illustrative sites where roadside green infrastructure can be introduced in an effort to reduce people's exposure to air pollution.

While the LBTH Air Quality Action Plan (2022-2027)[3] describes an intention to line streets with new trees, the research which underpins the GI4RAQ analysis (e.g., summarised in Impacts of Vegetation on Urban Air Pollution[14]) finds that in urban settings, the effect on local air quality of tree planting alone is complex and not necessarily beneficial in relation to people's exposure to air pollution.

Where vegetation is expected to be most effective in this regard is where it forms a barrier between people and sources of air pollution (speaking to the Protect element of Reduce, Extend, and Protect principle), something which should be highlighted in relevant local authority plans and strategies. The GI4RAQ analysis can be used to estimate the local air quality impacts of such roadside planting, including benefits and/or disbenefits in different locations.

Moreover, this report demonstrates practical and realistic approaches to the implementation of green infrastructure for roadside air quality, which are also responsive to urban constraints, and consider other benefits such as amenity improvements, provision of shade and habitat, and surface water management.

In the case of the London Borough of Tower Hamlets, opportunities for planting which meet the conditions of the site selection processes are limited due to narrow streets and highly urbanised hard infrastructure. In theory, approximately 6750, an eighth of the 54,000 sites explored, were estimated to offer local air quality benefit without significant disbenefits.

The number of viable locations is then significantly narrowed by identifying potentially available space (924 possible locations of at least 20m long and over 4m wide), and again further by assessing feasibility on the ground (even without the consideration of checks for underground services).

Where the analysis identifies potentially suitable sites, it enables schemes to be designed and implemented well, as advocated for in the LBTH Air Quality Action Plan (2022-2027)3. Different scales of intervention are possible, with the most attractive being where the greatest space is available at the roadside (Option Two or Three – Linear and Integrated Parklets).

This allows for impactful green infrastructure that breaks through impermeable paving, enabling multiple other benefits to be integrated for pedestrian amenity, surface water management interventions, urban cooling and habitat creation.

Alongside this, this scale of intervention can ensure that the design is responsive to the needs of pedestrians and other road users (e.g. visibility, sense of safety) and to requirements of the planting (e.g. reduced maintenance need compared to clipped hedging, adequate planting space to provide sufficient growing conditions).

5.2 LIMITATIONS

Limited number of viable sites due to the location of interest

The London Borough of Tower Hamlets is a dense urban area (it is the most densely populated area in the UK[19]), with much competition for use of space in the public realm, and thus proved a challenging location to find suitable locations for GI4RAQ interventions.

For example, many of the locations identified through the desktop analysis were found to be unsuitable through the ground truthing process due to the presence of other urban infrastructure such as bus stops and pedestrian crossings.

The desktop analysis and ground truthing did not take location of underground utilities into consideration at this stage, which may further reduce the number or viable locations.

Limitations of the desktop analysis

The GI4RAQ Platform, and the integration of its underlying code into QGIS, comprise prototype software, and have limitations, including being subject to large uncertainties.

The process of integrating the code into QGIS, requires in depth knowledge of its workings, and it can be a lengthy process to run the code for an area the size of Tower Hamlets when using a computer with an everyday level of computing power.

In addition, the maps produced in QGIS are thorough and detailed but may be difficult to navigate and interpret for those unfamiliar with the GI4RAQ software, and therefore may have reduced utility as a tool for decision makers.

It was not possible in the process of drawing up this report to use the QGIS mapping software to straightforwardly identify locations where estimated beneficial GI4RAQ sites overlapped with potentially available space for new green infrastructure interventions. The desktop site selection process therefore relied on manual scanning of the GI4RAQ and 'available space' map layers, which could have led to potential sites being missed.

The desktop analysis of potentially viable locations included removing areas currently under existing canopy cover as these were assumed at the outset not to be available for planting.

However, through the ground truthing process it was established that in some locations, new planting could be implemented underneath existing trees. The desktop analysis therefore excluded areas which may have been viable locations.

19 ONS. Population estimates for the UK, England, Wales, Scotland, and Northern Ireland: mid-2022. 2022. Available online: https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/bulletins/annualmidyearpopulationestimates/mid2022

5.3 RECOMMENDATIONS

Delivering a Pilot Programme of Linear Parklet Interventions based on GI4RAQ data

One or more of the selected interventions could be implemented in collaboration with relevant stakeholders and decision-makers such as LBTH, Transport for London, and local residents. This would be subject to further investigation of their viability (e.g. in relation to location of underground services).

This would act to develop the proof of concept for this type of roadside green infrastructure. To ensure this new parklet is viable, there needs to be a direct connection with the multiple benefits gained through the scheme to justify the up front and ongoing costs invested. Those in charge of the public realm at the site would need to commit to the maintenance of the parklet to ensure it delivers the benefits as designed.

Involve multiple public realm stakeholders in planning new interventions

The ground truthing process found cases where poorly considered layout of footways which cater to single function interventions (e.g. placement of street furniture such as cycle docking stations, litter bins, or bus shelters) can lead to missed opportunities to take a more integrated approach with multiple benefits.

This highlights the need for the involvement of multiple stakeholders (e.g. arboriculturalists, urban and landscape designers, transport planners, highways officers and engineers) in the planning of such spaces, whether that is in the case of new developments, or in cases of retrofitting new infrastructure into existing spaces such as those that have been explored in this guide.

Applying the analysis to other locations

The analysis outlined in this guide could be applied to other less densely built locations with wider footway infrastructure and less competition for other spatial needs in order to assess if these conditions would offer a greater number of opportunities for interventions.

If applying the analysis again, it would be recommended not to conduct the step of removing potential space which is currently under existing canopy cover, since ground-truthing showed that some locations with existing trees could be viable for underplanting of vegetation as GI4RAQ interventions.

In addition, it may be beneficial to conduct analysis to identify particular hotspot locations, for example, where air pollution levels are highest or locations frequented by 'vulnerable receptors' (e.g. schools, nurseries, hospitals, care homes), and subsequently apply the GI4RAQ analysis to these targeted locations. This would reduce the number of locations which need to be processed and therefore could combat the issue of lengthy processing times.

The map layers showing potentially plantable space could be used by stakeholders interested in looking into available space for tree planting, independent of air quality considerations.

Refining the GI4RAQ tool

The GI4RAQ Platform, and the integration of its underlying code into QGIS could be further developed beyond their current prototype iteration. There could be particular improvements made around reducing uncertainties, making the output maps in QGIS more easily legible for users and decision makers, and increasing the ease with which mapping outputs could be cross referenced with mapping showing potentially plantable space.

Explore other ways to address exposure to poor air quality

In the case of LBTH, opportunities found for the introduction of green infrastructure as a partial barrier to reduce people's exposure to pollution from proximate vehicles have been limited. However, green infrastructure can be applied in other ways to reduce exposure, focusing on the tenet of extending the distance between sources of pollution and people. This is acknowledged in the Tower Hamlets Green Grid Strategy: Update 2017[5] which advocates for "(ii) promoting quiet streets and routes away from main roads and heavy traffic, to protect pedestrians from poor air quality".

One way of promoting such routes could be through 'greening': introducing green infrastructure to make routes with little or no traffic more attractive and linking up existing green spaces and locations frequented by those vulnerable to poor air quality (e.g. nurseries, schools, healthcare facilities, care homes etc.).

In addition, as highlighted in the Greater London Authority report, Using Green Infrastructure to Protect People from Air Pollution[4], in street canyons (a street with multi-storey buildings on both sides) with little or no traffic, where air quality at street level is better than above surrounding buildings, it is proposed that "a dense avenue of trees can provide effective protection from polluted air above and create a clean 'green corridor' for active travel". Such opportunities could be further explored in the Borough of Tower Hamlets and elsewhere.

APPENDIX 1

Long list of sites

Sites visited			
Address	**Ref.**	**Notes**	**Shortlisted?**
Commercial Road, E14 7LL	51.512680, -0.037201	Stephen Hawking School	Yes Option One - Minimum intervention, clipped hedge/screening
Mile End Road, E1 4GG	51.523504, -0.038322	Student accommodation	Yes Option One - Minimum intervention, clipped hedge/screening
187 Whitechapel Road, London E1 1DN	51.518408, -0.063475	Reset Recover Centre; Booth House Salvation Army Accommodation	Yes Option Two - Medium intervention, consideration of cycle lane
17 Commercial Street, E1 6NE	51.516033, -0.072557	Opposite Cannon Barnett Primary (identified as school among the worst impacted by poor air quality in the borough) Identified on site visit	Yes Option Two - Medium/parklet intervention, incorporating existing trees
Watney Market, E1 2PR	51.514261, -0.056063	Santander Cycle Rank within the space, Assumption made that Cycle Rank location could be adjusted to meet overriding need for green space intervention	Yes Option Three – Integrated large linear park intervention
Mile End Road, E1 4UJ	51.520849, -0.050990	Identified on site visit	No Potential for large parklet intervention but further GI4RAQ investigation using the platform reveals the AQ picture is not clear enough for a GI4RAQ intervention
Edward Passage Road, E1 4TP	51.520301, -0.053976	Identified on site visit	GI4RAQ software difficult to apply here with A11 Mile End Road running parallel to Edward Passage
Cambridge Heath Road, E1 5QJ	51.522866, -0.055033	2 possible sites	No Not practical with other use of space (pedestrian crossings and bus stops)
100-84 Leman Street, London	51.512627, -0.069674	Santander Cycle Rank	No Not practical with other use of space (pedestrian crossings and bus stops)
Roman Road, E2 0QY	51.529521, -0.045720	Row of shops	No Not practical with other use of space (shop fronts)
Hackney Road, E2 7AS	51.531322, -0.064878	Social housing Identified on site visit	No Not practical with other use of space (pedestrian crossings and bus stops)
Stepney Green, E1 3JJ	51.519660, -0.048025		No Not a priority location due to proximity to Stepney Green which already provides alternative walking route
Sites not visited			
Whitechapel Market, London E1	51.519223, -0.059938	Not visited because Whitechapel Market takes available space here – any intervention would be significant change that would be difficult to make compatible with Market use	
East India Dock Road, E14 2AA (opportunities on both sides)	51.512376, -0.002408	Not chosen because not heavy footfall area/limited impact	
Chrisp Street, E14 0EA	51.511364, -0.013590	Not visited due to junction/corner visibility	
East India Dock Road, E14 0DG (SITE 5)	51.510760, -0.019646	Not visited due to available space being housing land/bus stop/space and visibility considerations	
Bishopsgate, EC2A 2EH	51.519348, -0.079234	Not visited as the many factors of this very busy road mean that any intervention would need to be a whole street redesign taking all these into account alongside the GI4RAQ interventions, which is not in the scope of this project	
Commercial Street (Spitalfields), E1 6LY	51.518559, -0.074549	Not visited due to space/ competing considerations e.g. bus stop and cycle racks	

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