Teynham Area of Opportunity

Air quality aspects

An analysis of Policy AO 1

Peter Blandon B.Sc., M.Phil., Ph.D
Chairman, Swale Branch Committee of the Campaign to Protect Rural England
February 2021

The countryside charity
Kent

Summary

Policy AO 1 of the Reg. 19 Local Plan identifies

> "An area of land around Teynham …. as an area of opportunity for development of approximately 1,100 homes, proportionate employment and accompanying infrastructure to be commenced in the mid to latter part of the plan period (post 2028)." (Policy AO 1, para. 1)

Paragraphs 5.5.54 to 5.5.51 show that the details of this proposal are yet to be worked out, and the actual area of the proposed development is not yet known. The proposed housing trajectory published alongside the Reg. 19 plan shows that the 1,120 dwellings associated with this policy are to be delivered in the period starting 2027 with the bulk being built out in the final five years of the plan, 2032 to 2037.

While the NPPF allows for the degree of detail associated with developments arriving later in the plan period to be lower than that required for developments coming on-stream in the first few years of the plan, the underlying principles of the NPPF still apply. That is to say, despite this development being phased for the latter half of the plan period, it must be seen to be deliverable, or at the very least be thought of as potentially deliverable.

It is CPRE Kent's view, based in part on the analysis presented here, that Policy AO 1 is not deliverable within the overall policy framework set out in the Reg. 19 Local Plan by virtue of its demonstrable inability to

- **contribute to conserving and enhancing the natural environment and reducing pollution (NPPF para. 17),**
- **include measures to improve air quality through location, linkage and layout (Policy DM 33, para. 1),**
- **locate a reasonable location for the southern by-pass required, in part, to mitigate the pollution resulting from development close to and in an existing AQMA,**
- **locate a reasonable location for the southern by-pass that would not have detrimental effects on the heritage and landscape of the area south of the A2.**

It is CPRE Kent's view, therefore, that the inclusion of the Teynham Area of Opportunity as a significant development for the provision of the required housing renders the Reg. 19 Local Plan unsound.

The Teynham Area of Opportunity

Policy AO 1 of the Reg. 19 Local Plan[1] states that

> "An area of land around Teynham, as shown indicatively on the Proposals Maps and Picture 5.5.1, is identified as an area of opportunity for development of approximately 1,100 homes, proportionate employment and accompanying infrastructure to be commenced in the mid to latter part of the plan period (post 2028)." (Policy AO 1, *para.* 1)

The Teynham Area of Opportunity (TAoA) referred to above is shown in Figure 1, which is adapted from *Picture 5.5.1* found in the Reg. 19 plan.

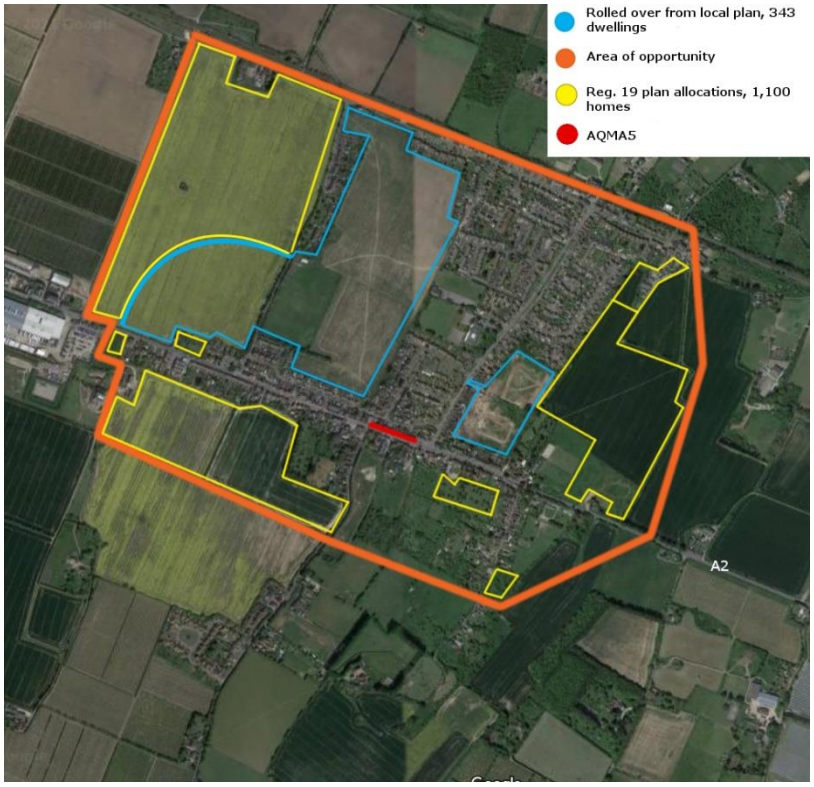

Figure 1 The Teynham Area of Opportunity

Also relevant to the TAoO are three housing allocations that are already part of the current *Bearing Fruits* Local Plan. These allocations, totalling 343 dwellings, are to be "rolled forward", see Appendix Two of the Reg. 19 plan (page 267). These allocations are also shown in Figure 1.

The housing trajectory published by Swale[2] shows that the 343 dwellings in the allocations to be rolled over are due to be completed in the period ending 2027/28 whilst those in the TAoO are expected to arrive after that, in the period running from 2027/28 to 2037/38 with ten units being delivered after this time. The expected trajectory of the housing allocation in Teynham is shown in Figure 2.

[1] All references to the Reg 19 Local Plan refer to the Local Plan Review 2021 Pre-submission Document (Regulation 19) found at https://services.swale.gov.uk/assets/Planning%20Policy%202019/FINAL%20Reg%2019%20(RGB)%20119MB.pdf

[2] https://services.swale.gov.uk/assets/Planning%20Policy%202019/Swale%20LPR%20Housing%20Trajectory%20Feb%202021.pdf

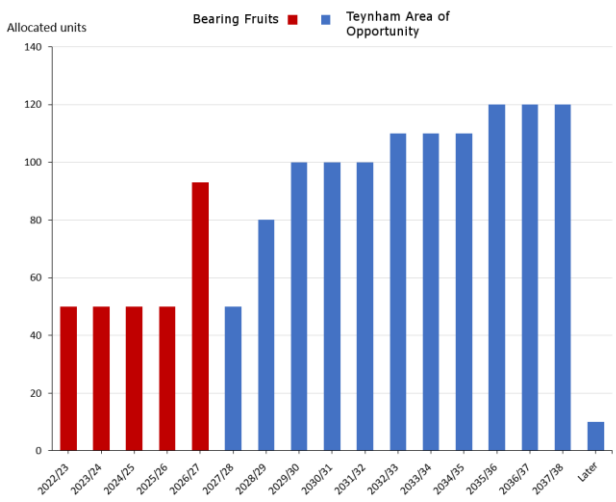

Figure 2 Teynham Housing Trajectory

Paragraph 3.d of Policy AO 1 in the Reg. 19 plan requires that a masterplan be drawn up for the development of the TAoO and that it must include a commitment to

> "Improving air quality and reducing the impact of private vehicles by creating viable alternatives."

This is of critical importance as the A2 in Teynham is home to AQMA5 – see Figure 1. Without some form of extra roading, any development here will create an increase in traffic, not only in AQMA5 on the A2, but also in AQMA6 at Ospringe Street to the east and AQMA3 at Sittingbourne to the west.

Partly to counter the air quality problems in Teynham, a bypass of some form is proposed to the south of the A2. Paragraph 5.5.47 of the Reg. 19 plan says

> "A southern link route would assist in relieving London Road (A2) through the village of traffic and would help unlock development sites to the south of the village."

This is echoed in the *Swale Transport Strategy*[3] which states in para 5.4.14 on page 60 that the masterplan for the TAoO will be required to include the "provision of a new 'movement corridor' to alleviate pressure on the existing A2 and the AQMA."

In the *Sustainability Appraisal of the Swale Local Plan*, by AECOM Ltd[4]. has this to say about the TAoO and bypass.

> "…. the proposed Teynham Opportunity Area gives rise to a cause for concern, given Teynham's distance from a motorway junction and, in turn, its reliance on the A2 for journeys to higher order settlements that will inevitably involve passing through at least one AQMA (typically two or more). The assumption is that development along Lynsted Lane would be avoided, recognising that the junction of Lynsted Lane and the A2 is highly problematic[5]; **and the aspiration is for higher growth to support delivery of a village bypass, which is much needed from a perspective of wishing to address traffic and air pollution within the village centre, including within the designated AQMA** …. "
>
> *para*. 9.2.7, p.43 – our emphasis

Thus, it is fair to conclude that an important part of the rationale for the proposed bypass is that it will help reduce pollution, essentially by spreading pollutants over a wider area.

Paragraph 5.5.47 states that, with regard to the location of the bypass, "no specific potential alignments have yet been identified." While the NPPF allows for the degree of detail associated with developments arriving later in the plan period to be lower than that required for developments and

---

3 https://services.swale.gov.uk/meetings/documents/s16438/Appendix%20III%20Swale%20Transport%20Strategy%202022-2037.pdf from the agenda pack of the Local Plan Panel meeting held on 19th January 2021.

4 https://services.swale.gov.uk/assets/Planning%20Policy%202019/Swale%20Local%20Plan%20Review%20SA%20-%20SA%20Report%20210209.pdf

5 Application 19/505036/OUT is one of the sites in the TAoO south of the A2. The recommendation from KCC Highways Department (19th Feb. 2021) was that the proposal should be refused as Lynsted Lane's restricted width, poor alignment and sub-standard junction with London Road make it unsuitable to serve as a means of access and the existing road network in the vicinity has insufficient capacity to accommodate the increase in traffic likely to be generated by the proposal.

policies that will come on-stream in the first few years of the proposed plan, the underlying principles of the NPPF still apply. That is to say, despite this development being phased for the latter half of the plan period, it must be deliverable, or at the very least, be known to be potentially deliverable.

It is CPRE Kent's contention that it is possible to show now that a viable route for such a bypass in terms of air quality amelioration does not exist, and hence a key aspect of the Area of Opportunity concept is missing. This contention is based on the analysis in the rest of this paper.

AQMA5

AQMA5 lies in Teynham on the A2 and was declared in December 2015. In the *2020 Air Quality Annual Status Report* produced by Swale Borough Council[6], the council concludes,

> "…. in …. AQMA 5, there were no exceedances of the annual mean air quality standard for NO_2 in 2019 …. this was the case for the second consecutive year. Accordingly, Swale Borough Council will continue to review monitoring data in 2020, with the view of investigating the potential revocation of th[is] AQMA in future." (page 3)

An *Air Quality Modelling Report* by Sweco UK Ltd[7] is contained in the evidence base and, at first sight, it appears to reinforce the point made above. Paragraph 5.3 of the Sweco report concludes,

> "On review of the monitoring data up to 2017 annual mean concentrations appeared to be on an upward trend across many of the monitoring locations …. However, at the time of undertaking this study 2019 measurement data were available. We have only considered the sites where the data are available from 2015 to look at the 5-year trend. [The results] suggest that at the majority of monitoring sites there have seen a downward trend in air quality concentrations since 2017."

By "downward trend in air quality concentrations" they actually mean a decrease in the concentrations of NO_2 and hence an increase in air quality. However, this assertion seems to be made on the basis of a simple comparison of start and end data points, there seems to be no genuine statistical examination of the figures to support this assertion.

Although the Sweco report does not single out AQMA5 for specific analysis, the data contained in that report for the Teynham sensors are collected in Table 1 and the data for one of these, SW80 located at 107 London Road (A2), are shown in Figure 3.

***Table 1 NO_2 Concentrations for Teynham Sensors* (µg/m³)**

Location	2015	2016	2017	2018	2019	trend
SW99		25.5	24.9	28.2	24.7	upward
SW100		16.9	15.8	15.7		downward
SW80	***38.9***	***42.1***	***39.9***	***39.3***	***32.8***	***downward***
SW91	36.4	37.3	35.3	32.3	33.4	downward
SW101		24.2	30.1	24.7	22.4	downward
SW92	37.3	37.3	29.1	32.1	31.9	downward
SW102		24.8	26.0	34.6		upward
SW103		23.9	19.3	19.8		downward

Taking SW80 as an example, the 2019 figure is lower than the 2015 one. But this is very weak evidence of a *genuine* decline in pollution from a statistical point of view. The data points for SW80 in Figure 3 are presented along with the associated trend line[8]. The trend line is downward sloping, suggesting a

[6] https://services.swale.gov.uk/assets/Air-Quality/Air-Quality-Annual-Status-Report-21-July-2020_edited%20(002).pdf

[7] https://services.swale.gov.uk/assets/Planning%20Policy%202019/Final%20Air%20Quality%20Modelling%20Report%20for%20Swale%20LP%20December%202020.pdf

[8] The line is found by ordinary least squares regression.

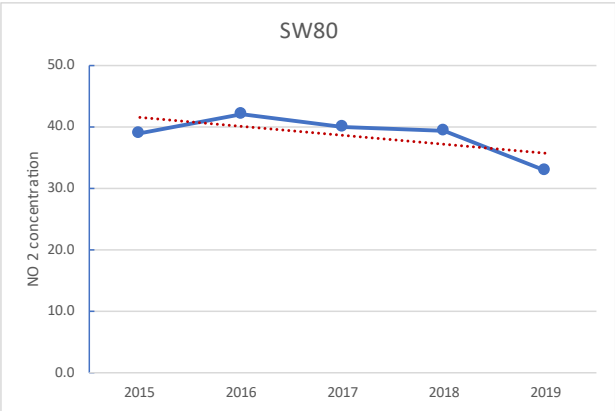

Figure 3 NO_2 concentration at SW80

drop in NO_2 concentration over the years – hence the column labelled "trend" in Table 1 has an entry of "downward" in its final column. The entries for the other sensors have the same meaning.

However, given the natural variability in the figures, the most recent figure of 32.8 could easily be a random drop in otherwise static or increasing pollution.

Thus, a more robust test of whether the trend is *actually* downward is to examine the so-called *t*-statistic associated with the slope coefficient of the trend line returned by regression. In the case of SW80, the *t*-value is 1.62 which is less than the critical *t*-value of 2.35[9]. Thus, from a statistical point of view, the slope of the trend line is not significantly downward and, at the 5% level of significance, the hypothesis that there is a genuine downward trend in the concentration of NO_2 over the five years is rejected.

At the slightly weaker significance level of 10% the slope remains insignificant and the conclusion remains the same.

In Table 1, the entries in the "trend" with a green background are insignificant at both the 5% and 10% levels. The one with a yellow background is insignificant at the 5% level but is significant at the weaker 10% level.

It should be noted that the same ideas relate to SW99 and SW102, both of which recorded apparently upward trends in pollution. In neither case, however, were the trends statistically significant and so the idea that there has been an increase in pollution levels at these sites is similarly rejected.

Detailed analysis of this point is given in Appendix One.

As a result, it is CPRE Kent's opinion that there is no compelling evidence that the level of NO_2 pollution in AQMA5 is on a downward trend. Any supposition that concentrations of pollutants are decreasing over the recent past must remain merely an assertion as it has, at best, only very weak statistical basis in the figures presented.

Therefore, given the statistical results and using the precautionary principle, it is best to assume and base policies on the conclusion that pollution in Teynham has not declined in the recent past. Given the proposals to increase traffic in the area, it would be foolhardy to assume a decline in the future without significant mitigation.

Similarly, revoking AQMA5 would, in our view, be premature.

[9] 2.35 is the critical *t*-value with three degrees of freedom in a two-tailed test. Here it is used to determine which of two hypotheses should be accepted: (1) there is not trend in the data (the so-called *null hypothesis*) or (2) there is a trend in the data (the alternative hypothesis). In this case, the *t*-statistic is less than the critical value and so the convention is to accept the null hypothesis of "no trend" and argue that any visible trend is purely fortuitous. At the 10% level of significance the critical value is 1.64 and the *t*-statistic is lower, but by a smaller margin. So, in this weaker test, the null hypothesis is still rejected – but only just.

Air quality modelling report

Paragraph 5.5.47 in the preamble to Policy AO 1 states

> "Air quality modelling has already been undertaken to assess the overall impacts of the local plan. Further to the results of the transport modelling, further air quality modelling may need to be undertaken."

The "modelling that has already been undertaken" is a reference to the study *Air Quality Modelling Report* by Sweco UK Ltd which was looked at in the previous section. There are three points that CPRE Kent would like to make in understanding that report.

- ## Assertion of an improvement in air quality

The Sweco report contains data for a number of sensors in Swale, and at 57 sites there is a full five-years data available. Paragraph 5.3 of the Sweco report, quoted in the previous section, concluded that "at the majority of monitoring sites there have seen a downward trend in air quality concentrations since 2017."

This assertion has been looked at in the previous section in the context of Teynham and was found to be without any real statistical basis. When the same analysis (see Appendix One for details) is applied to the 57 sites in Sweco's report with full five-years, there is virtually no statistical evidence of a downward trend in the NO_2 concentration levels.

Overall, 15 of the sites showed an apparent increase and 42 an apparent decrease in NO_2 levels. But in only two cases out of 57 was there a statistically significant downward trend in NO_2 levels at the 5% level of significance. In the remaining 55 cases no such statistically significant trend occurred. When the test was relaxed slightly to look at a 10% level of significance, the number of sites with a downward trend increased to 11 but one site (in the Newington AQMA) showed a significant increase in pollution.

A summary of the results is shown in Table 2.

Table 2 Recent trends in NO_2 levels

	5% significance level	10% significance level
upward trend	0	1
no trend	55	42
downward trend	2	11

As a result, it is CPRE Kent's opinion that the view that the levels NO_2 concentrations in Swale in general, and Teynham in particular, are falling is optimistic and not supported by any solid statistical evidence.

This makes the importance of the bypass greater than might be assumed from a superficial reading of the air quality data and report.

- ## Absence of relevant modelling

Figure 3e in the appendix of the Sweco report, of which a portion is reproduced here in Figure 4, shows the receptors used in the modelling exercise that looked at future possible pollution levels. The diagram here shows those receptors that are located in Teynham. As can be seen, with the exception of R_29 and R_37, they all lie on the A2. R_29 and R_37 are located to the south of the A2 but only about 200 metres from the main road.

Any viable route for a southern relief road would be off the map presented in the Sweco report and so no predictions have been made regarding air quality in locations that make up a potential route.

Furthermore, the scenarios used in the modelling process do not contain any references to the bypass but rather assume that no traffic mitigation is put in place. Page 16 of the report states that it "doesn't consider how the increase in volume [of traffic] would change traffic movements on the network. It simply assumes that all road links will have the same growth and assumes speeds on each link will remain the same as the 2017 base year."

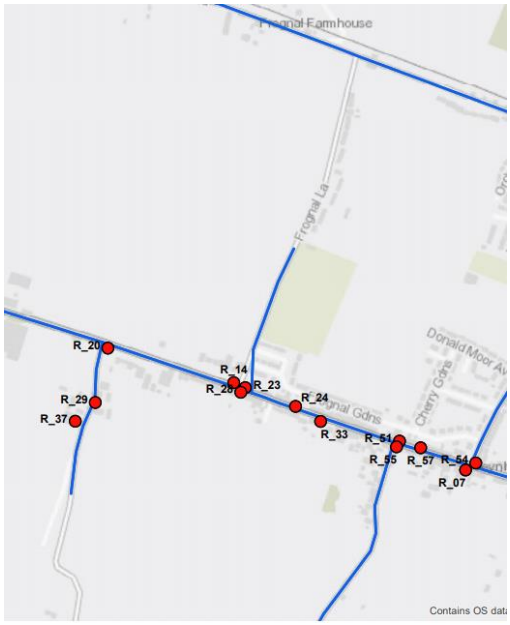

Figure 4 Receptors in the Sweco study

As a result, it is CPRE Kent's opinion that Sweco's air quality report presented as part of the evidence base for the proposed local plan is silent on the levels of pollution that any southern relief road would produce or ameliorate.

- ## NO_2, PM10 and PM2.5

There is a general perception throughout the Reg. 19 plan that air quality will improve into the future with changes in transport modes. However, while it is true that on a national level NO_2 levels are slowly falling and will probably fall into the future, changes to electric vehicles of various kinds are likely to have little or no effect on levels of PM10 and PM2.5 pollutants. A recent study has shown that non-exhaust sources account for 90% of PM10 and 85% of PM2.5 pollutants from traffic and that the particulate matter emissions from electric vehicles are comparable to those of conventional vehicles[10].

Given the detrimental effects of these particulate pollutants it is a matter of some concern that they are downplayed in the local plan.

It is CPRE Kent's opinion that PM10 and PM2.5 pollutants are likely to become the main areas of concern in the future. We welcome Sweco's attention to PM10 but note that the analysis is based, in part, on Swale's only two PM10 monitors, neither of which are located in Teynham. We regret the absence of work on PM2.5.

[10] Victor R.J.H. Timmers, Peter A.J. Achten, "Non-exhaust PM emissions from electric vehicles", *Atmospheric Environment*, Volume 134, 2016

CPRE research

Introduction

As mentioned earlier, Paragraph 5.4.47 point 4 of the Reg. 19 plan states

> "The inclusion of a southern link route for Teynham is being modelled as part of the transport modelling outlined above, although no specific potential alignments have yet been identified."

Details of a southern bypass, particularly a well-defined location, are not required at this stage of the local plan as the housing associated with the TAoO is scheduled to be delivered in ten to twenty years' time. However, it is critical to the idea of the TAoO that a feasible route for the bypass that can help mitigate the increases in pollutants and, at the same time, not violate other plan policies actually exists.

It is CPRE Kent's opinion that it is necessary for Swale, even at this early stage, to show that feasible routes for a bypass can reasonably be assumed exist. If no such routes exist, Policy AO 1 can be considered undeliverable even at this early stage and the Reg. 19 plan becomes unsound.

Diverting some traffic from the A2 should bring about a reduction in pollution on that road, but clearly there will be an equivalent increase in pollutants along the route of the intended bypass. With regards to the A2, the word *reduction* here effectively means *spreading* the pollution elsewhere so that the levels on the A2 are lower than they would otherwise have been.

The implication of this is that any route for the bypass will be located in an area of "fresh" air, into which the pollutants will be placed so that the resulting levels of pollution along the bypass route will increase but not exceed Defra maxima. The diversion of traffic must also reduce the pollution levels on the A2 so that they too do not exceed Defra maxima. Thus, the route finally chosen for the bypass must be in an area of relatively unpolluted air – certainly it must be less polluted than that found along the A2.

Given that the Sweco Air Quality report in the evidence base is silent on the issue of air quality to the south of the A2, CPRE Kent has undertaken research in this area.

Study area

Data were collected for NO_2, PM10 and PM2.5 concentrations for a number of days in early 2020 on locations south of the A2. The places sampled are shown in Figure 5. The roads are shown in red and yellow in the picture. The TAoO is reproduced from Figure 1.

The device used for measurement of pollutants was a Plume Laboratories FLOW. Appendix Three gives details of the accuracy of the device. Note that here, *differences* in pollutant levels are being measured, and so absolute accuracy is not necessarily required: relative accuracy is sufficient.

In order for a route for the bypass to be feasible in the area in Figure 5, the levels of pollutants measured on the southern edge of the area sampled (lower edge in diagram) must be lower than those found along the A2. Thus, the test applied was one to find if there were any statistically significant differences between NO_2, PM10 and PM2.5 concentrations on the northern and southern parts of the routes shown in Figure 5.

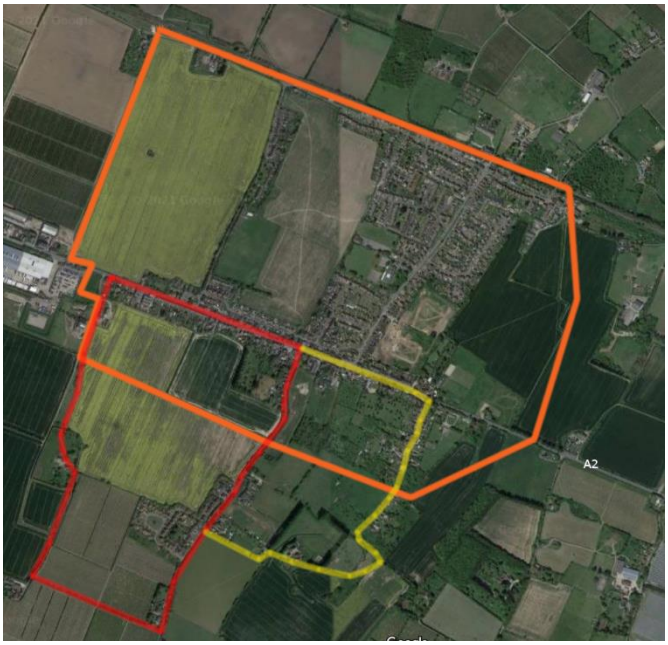

Figure 5 Sampling locations

A detailed analysis of the methods used and the air quality data are presented in Appendix Two of this report. A summary of the findings is shown here in Table 3 and the meanings of the entries are summarised below the table. Two methods of categorising the data were used, as explained in the appendix, and these are referred to as methods one and two in the table.

Table 3 Summary of Air Quality Analyses

	NO_2		PM 10		PM 2.5	
date of sampling	**Method one**	**Method two**	**Method one**	**Method two**	**Method one**	**Method two**
6 Feb 2020	no significant difference	no significant difference	significant but negative	significant but negative	significant but negative	significant but negative
8 Feb 2020	insufficient data	insufficient data	no significant difference	no significant difference	no significant difference	no significant difference
11 Feb 2020	insufficient data	insufficient data	significant but negative	no significant difference	no significant difference	no significant difference
19 Feb 2020	insufficient data	insufficient data	no significant difference	no significant difference	no significant difference	no significant difference
17 March 2020	significant but negative	insufficient data	no significant difference	no significant difference	significant and positive	no significant difference

1. "no significant difference" – in these cases the test found that there was no statistically significant difference at the 5% level between the level of pollutants on the A2 and the level found approximately one kilometre to the south – the southern edge of the route in Figure 5.

2. "significant and negative" – here there was a difference between the pollutants measured at the north and south extremes of the route taken, but it was a negative one, *i.e.* the level of pollutants was lower on the A2 that it was at a distance of one kilometre from the A2.

3. "significant and positive" - here there was a difference between the pollutants measured at the north and south extremes of the route taken, but it was a positive one, *i.e.* the level of pollutants was higher on the A2 than it was at a distance of one kilometre from the A2.

4. "insufficient data" – no test was undertaken as the number of data points recorded by the device was too small to make a meaningful test.

A summary of the results is shown in Table 4.

Table 4 Summary of results

Result	No. of cases
no significant difference	16
significant and negative	6
significant and positive[1]	**1**
insufficient data	7
Total number of tests	30

1 this is the result required Policy AO1

Conclusions

The results clearly show that there is little or no diminution in air quality as one moves south from the A2. Similar results were obtained moving north from the A2 but are not presented here. The result that is required for a bypass in this region to reduce pollution is "significant and positive", *i.e.* the pollution south of the A2 must significantly lower than that it is on the A2. And this result occurred only once.

Thus, any road that is in the area studied will, in effect, be located in a region where pollutants are more-or-less at the same level as that found on the A2 itself. Thus, the attempt to "spread" the pollution over a wider area, and hence reduce its quantity at any given point, is doomed to failure. The result will inevitably be to increase the level of pollutants in the area where the proposed road is located and also back to the A2 and the current AQMA.

Any locations further south than the areas studied here will rapidly impinge on the built-up area of Lynsted itself and so be untenable. There are a number of listed buildings in Lynsted and in the lanes running into Lynsted, Lynsted itself holds a large number of listed buildings and so routes close to village are clearly in violation of a number of the plan's policies.

Any location south of Lynsted will be close to the M2. Indeed, Lynsted is located roughly mid-way between the A2 and M2. Thus, similar results are likely apply given the pollution that is generated by the traffic on the M2.

As a result, it is CPRE Kent's opinion that no feasible route exists south of the A2 capable of mitigating the increases in NO_2, PM10 and PM2.5 that the proposed development will inevitably generate.

Appendix One

Data used

Appendix Table 3 of the Sweco report gives the annual mean monitoring results for a number of sites. Of these, only 57 contain data for the years 2015 to 2019. These 57 are referred to by the site codes listed here.

ZW6	ZW8	ZW3	SW66	SW45	SW35	SW42	SW19	SW37	SW38	SW20	SW36
SW78	SW62	SW82	SW52	SW51	SW89	SW71	SW73	SW58	SW83	SW97	SW53
SW56	SW87	SW90	SW76	SW77	SW88	SW07	SW14	SW13	SW84	SW85	SW86
SW99	SW100	SW80	SW91	SW101	SW92	SW102	SW103	SW28	SW30	SW31	SW95
SW32	SW96	SW22	SW29	SW98	SW104	SW105	SW34	SW106			

Some of these related to AQMA5 and were discussed in the main body of the report.

An example of the method

In the section entitled AQMA5, results for the sensors located in Teynham were presented and SW80 was looked at as an example. The regression output (Excel was the software used) the results are shown below.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.683515
R Square	0.467193
Adjusted R Square	0.28959
Standard Error	2.924608
Observations	5

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	22.5	22.5	2.630553	0.203277
Residual	3	25.66	8.553333		
Total	4	48.16			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	3064.1	1865.407	1.64259	0.19901	-2872.46	9000.659
X Variable 1	**-1.5**	0.924842	**-1.6219**	0.203277	-4.44326	1.443261

The statistics referred to in the main text are highlighted with the exception of the critical *t* value which is derived directly from the *t* distribution. The equation derived from the output above is represented in Figure 3 by the red, dotted line. The actual results for the sensors in Table 1 are shown here in Table 5.

***Table 5 NO_2 Concentrations for Teynham Sensors* (µg/m³)**

Location	slope	*t*-stat
SW99	0.073	0.10
SW100	-0.379	-2.08
SW80	***-1.500***	***-1.62***
SW91	-1.100	-2.68
SW101	-0.882	-0.66
SW92	-1.600	-1.68
SW102	3.100	2.29
SW103	-1.297	-1.39

Such tests were applied to all 57 data points and the results collected and presented in Table 2.

Appendix two

Location of study

Air quality data were collected along three different routes on five separate days. The routes ran from the A2, south towards Lynsted, turned west and then north, finally returning to the A2. They are shown in the three diagrams below in Figure 6.

Figure 6 Location of sampling routes

Approximate distances

The maps in Figure 6 are produced by the Plume Laboratories FLOW device using standard GPS locating. They are automatically uploaded in real time.

The map on the left runs (clockwise) along the A2 and then south to a distance about one kilometre from the A2, then east parallel to the A2 before turning north back to the A2, again a distance of approximately one kilometre, and then west along the A2 to the starting point. This route was used for the data sets collected on the 6th, 8th and 11th of February 2020. The route shown in the middle diagram was used on the 19th of February and the route on the right on the 17th of March

Data

Data for NO_2, PM10 and PM2.5 concentrations were collected by the device in question once every minute. An example of the data collected is shown in Table 6[11]: the data were collected on the 8th of February 2020, using the route shown in the left-hand section of Figure 6. The rate of progress around the route was roughly constant.

As can be seen, the device in use sometimes failed to register and upload readings for NO_2 and much more rarely, the other two pollutants under examination. Thus, the results for NO_2 levels are more limited than those for PM10 and PM2.5.

The tests

The data in Table 6 were divided into two groups and a standard *t*-test was applied to test the hypothesis that the means of the pollutant levels change with distance from the A2. That is to say, is there any difference in the air quality on the A2 and at a location approximately one kilometre to the

[11] The complete dataset and calculations are available from CPRE Kent upon request.

south.

Table 6 An example of the data
(data rounded to one decimal place)

	NO_2 (ppb)	PM 10 (µg/m³)	PM 2.5(µg/m³)
10:54	19.0	49.0	10.1
10:55	21.0	55.4	11.4
10:56	23.0	45.8	9.4
10:57	24.0	51.2	10.3
10:58	9.0	50.9	*n.a.*
10:59	2.0	30.5	6.1
11:00	*n.a.*	38.5	8.0
11:01	*n.a.*	56.6	10.4
11:02	*n.a.*	33.2	6.7
11:03	*n.a.*	46.4	8.7
11:04	*n.a.*	42.2	12.7
11:05	*n.a.*	47.7	9.7
11:06	*n.a.*	53.7	9.9
11:07	*n.a.*	44.6	8.2
11:08	*n.a.*	48.7	9.5
11:09	*n.a.*	42.0	8.0
11:10	*n.a.*	36.0	8.2
11:11	*n.a.*	58.6	12.8
11:12	*n.a.*	56.0	9.2
11:13	*n.a.*	58.3	12.0
11:14	*n.a.*	55.7	9.8
11:15	*n.a.*	44.8	9.3

Two methods of splitting and analysing the data were used.

1. Method one

The data were split into four quarters. In the example in Table 6 the four quarters were from 10:54 to 10:59, 11:00 11:04, 11:05 to 11:10 and 11:11 to 11:15[12]. Given the rough rectangularity of the routes taken, it was assumed that quarters one and four represented the northern part of the "rectangle", nearer to the A2 and along it. Quarters two and three represent the southern half of the rectangle, furthest from the A2.

Thus, given the dimensions of the route, quarters one and four show data at a distance of up to 500 metres from the A2 and quarters two and three show data taken at distances from 500 to 1,000 metres from the A2.

The results of a simple *t*-test (different variances), on these two data sets is shown in Table 7. As can be seen, the *t*-statistic in both cases is less than the critical value. Thus, the conclusion is drawn that there is no significant difference between the level of PM10 and PM2.5 concentrations on the A2 and away from it.

[12] Note that as there are 22 data points, which is not divisible by four, the numbers of data points in each of the "quarters" were 6, 5, 6 and 5.

Table 7 Results of a t-test – first method

	PM2.5 (µg/m³)		PM10 (µg/m³)	
	Quarters 1&4	**Quarters 2&3**	**Quarters 1&4**	**Quarters 2&4**
Mean	10.03	9.09	50.55	44.51
Variance	3.36	2.58	66.61	50.98
Observations	10	11	11	11
t-statistic	1.24		1.85	
Critical *t*-stat (5%, two-tail)	2.10		2.09	

2. Method two

To increase the "separation" of the two data sets – but at the same time reducing the number of data points - the data were split into two groups. Referring to Table 6, the first group included data from 10:54 to 10:56 and 11:13 to 11:15. The second group contained data from 11:03 to 11.07[13]. Again, given the rough rectangularity of the route taken, it was assumed that these two data groups represented the northern edge of the rectangle, nearer and along the A2, and the southern edge of the rectangle, furthest from the A2. The data ignored are those observations roughly corresponding to the eastern and western sides of the rectangular route.

The results of a simple *t*-test (different variances), on these two data sets is shown in Table 8.

Table 8 Results of a t-test – second method

	PM2.5 (µg/m³)		PM10 (µg/m³)	
	Group one	**Group two**	**Group one**	**Group two**
Mean	10.32	9.83	51.49	46.94
Variance	1.19	3.03	32.56	18.75
Observations	6	5	6	5
t-statistic	0.54		1.51	
Critical *t*-stat (5%, two-tail)	2.45		2.26	

As can be seen, the *t*-statistic in both cases is less than the critical value and so the conclusion is drawn that there is no significant difference between the level of PM10 and PM2.5 concentrations on the A2 and away from it.

Identical tests were carried out on all five data sets and the results are drawn together in Table 4.

[13] Note that as there are six data points in the first group and five in the second.

Appendix three

Device used

Device used was a Plume Laboratories – FLOW.

Note that here, as differences in pollutant levels are being measured, absolute accuracy is not necessarily required: relative accuracy is sufficient. Given the nature of the tests, the results from the device used can be any linear transformation of the underlying, genuine figures for the results found to hold.

The following are the correlation results, provided by Plume Laboratories, for the Flow device against the relevant reference devices.

NO_2: average correlation > 95%

PM2.5: average correlation 88.5%

PM10: average correlation 85.8%

Fuller details are available here.

https://plumelabs.zendesk.com/hc/en-us/articles/360025092554-How-Accurate-is-Flow-