Department
for Environment
Food & Rural Affairs

Report on measures for 2018 exceedance of the Target Value for Nickel in Sheffield Urban Area agglomeration zone (UK0007)

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1. Introduction

1.1 Context

Under the EU Directive 2004/107/EC[1], the target value (TV) for nickel (Ni) is an annual mean concentration of 20 nanograms (one billionth of a gram (10^{-9})) per cubic metre (m^{-3}) of ambient air or lower. The Directive requires that Member States shall report on measures in place to address the exceedance of the TV and that all reasonable measures that do not entail disproportionate cost should be taken to ensure this target is not exceeded.

The United Kingdom exited the European Union on 31 January 2020. Upon exit, the UK entered a Transition Period which will end on 31 December 2020. The UK was a Member State during the period this report covers, and the Directive requirements apply to the UK as part of its obligations during the Transition Period.

Once the Transition Period ends on 31 December 2020, the UK will continue to meet its reporting obligations through making this data available to the public to the same timescales

Exceedance of the TV was reported in 2014 and 2016 in the Sheffield Urban Area and reports on measures were published detailing the exceedance and the measures in place[2].

This document reports the exceedance situation for 2018 reflecting the more recent assessment and updating the 2014 and 2016 report on measures.

1.2 Status of zone

This is the report on measures required for exceedances of the TV for Ni within the Sheffield Urban Area agglomeration zone identified within the 2018 UK air quality assessment. Exceedances within this zone were identified on the basis of model results. Fine scale modelling on a 50 m x 50 m grid resolution located around an identified industrial source was used to identify this exceedance. This exceedance was reported via e-Reporting dataflow G[3] on attainment and Air Pollution in the UK[4].

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[1] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2005:023:0003:0016:EN:PDF
[2] https://uk-air.defra.gov.uk/library/bap-nickel-measures
[3] http://cdr.eionet.europa.eu/gb/eu/aqd
[4] http://uk-air.defra.gov.uk/library/annualreport/index

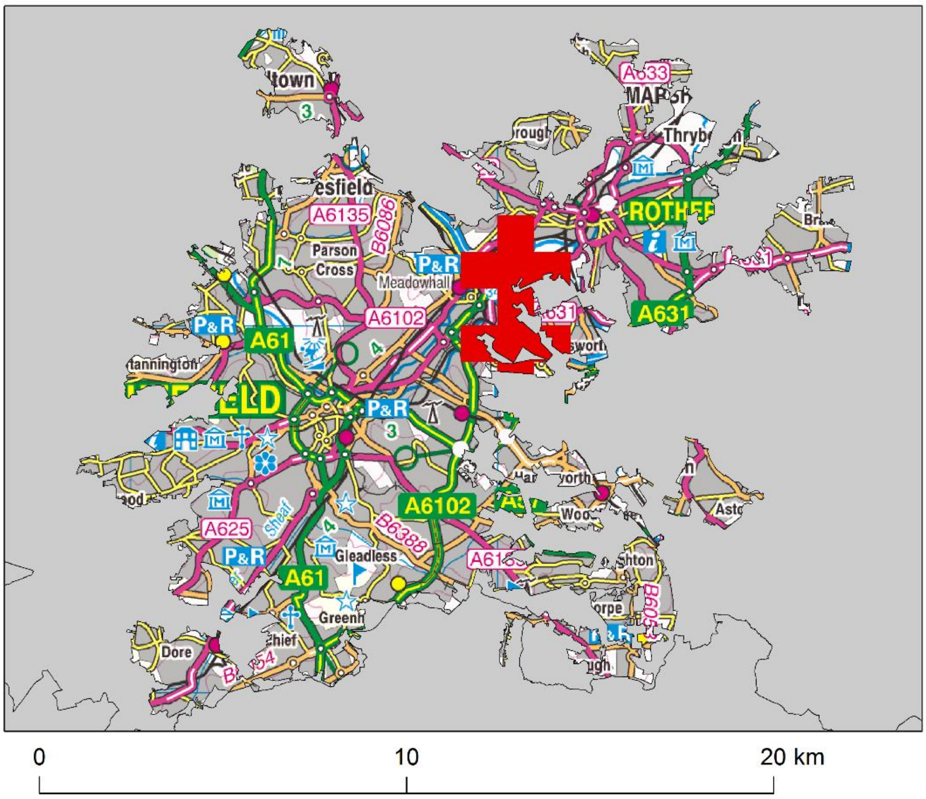
Table 1 summarises the spatial extent and associated resident population for the exceedances identified in this zone, as reported via e-Reporting.

Table 1. Area exceeding Ni target value in 2018 and associated resident population for exceeding areas within Sheffield Urban Area zone UK0007.

Zone code	Zone Name	Area exceeding TV (km^2)	Population exceeding TV
UK0007	Sheffield Urban Area	8	9987

Figure 1 shows the locations of the exceedances in the context of the zone as a whole.

Figure 1. Location of exceedance of the Ni target value in 2018 in Sheffield Urban Area zone UK0007. Areas of the zone in exceeding grid squares are marked in red.



An initial source apportionment was carried out and this analysis identified one exceedance situation within this zone related to industrial emissions:

- Sheffield [Ni_UK0007_2018_1] related to industrial emissions (area of exceedance: 8 km^2)

This report describes the exceedance situation in the zone. The sections below include a description of the exceedance situation, including maps, information on source apportionment and a list of measures already taken or to be taken. Information on measures is reported within e-Reporting dataflow K.

2 Exceedance situation Sheffield [Ni_UK0007_2018_1] related to industrial emissions

2.1 Description of exceedance

This exceedance situation is an area of exceedance of 8 km^2 and is located in the valley of the river Don to the North East of Sheffield City Centre in the Sheffield Urban area agglomeration zone. The exceedance was reported on the basis of the modelling assessment. The resident population associated with this exceedance situation is 9,987. This exceedance situation is adjacent to and shares common sources with the exceedance situation for Yorkshire and Humberside [Ni_UK0034_2018_1].

Table 2 lists measured annual mean concentrations of Ni from monitoring sites in Sheffield Urban Area agglomeration zone from 2004-2019, and Figure 2 indicates the location of measurement sites. The measured concentration at Sheffield Tinsley (GB0538A) in 2018 was compliant. Figure 3 shows the location of the exceedance situation in detail. The concentration of Ni at the other monitoring station within the Sheffield Urban Area agglomeration zone were also below the TV in 2018 and no other exceedances have been reported during the 2004-2019 period apart from the measured exceedances reported for 2014 and 2016.

Figure 3 shows the exceedance situation Ni_UK0007_2018_1 in detail. The figure indicates the location of the measured and modelled exceedances. In addition, the figure presents the results of national modelling on a 1 km x 1 km grid resolution that were submitted to the Commission as a supplementary assessment. Zone boundaries for the 1 km model grid used to assign exceedance situations and associated populations are presented as black hatching. Figure 3 shows the location of several industrial sites located close to Sheffield Tinsley monitoring station.

The measured annual mean concentration of Ni at Sheffield Tinsley (GB0538A) in 2019 was 15 ngm^{-3} (100% data capture).

Figure 2: Location of monitoring sites in Sheffield Urban Area.

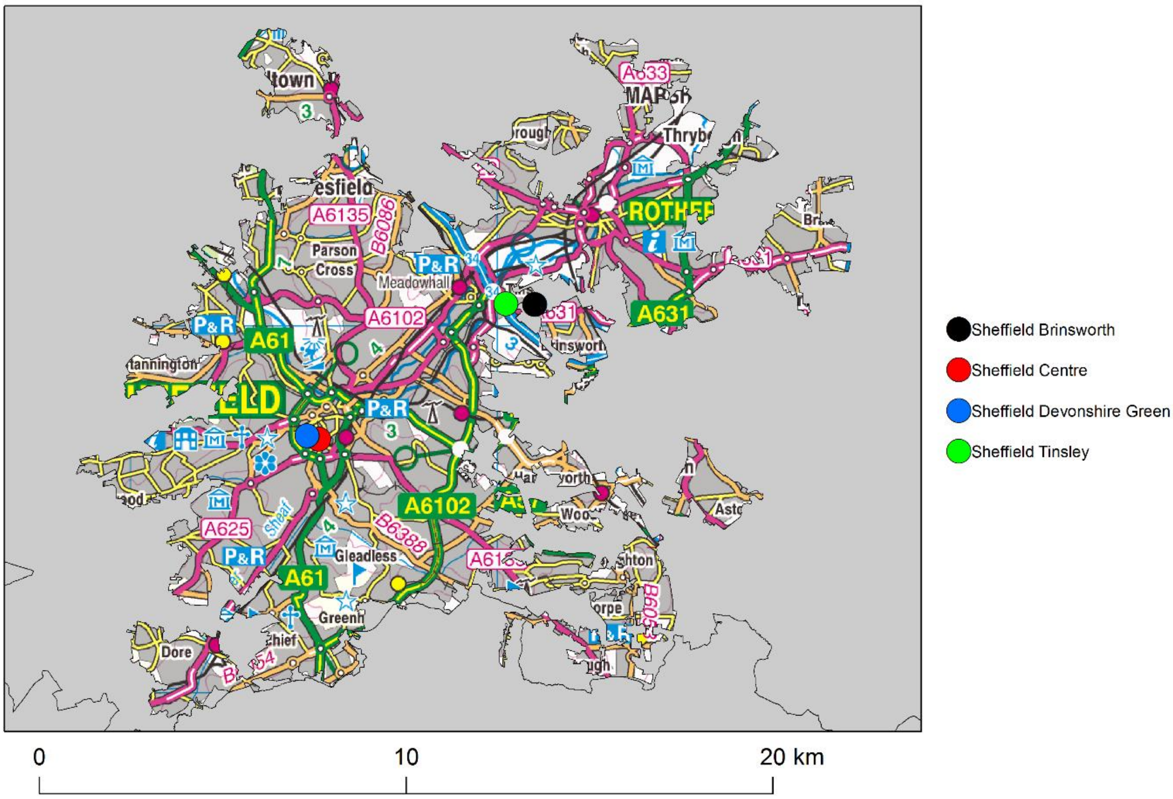
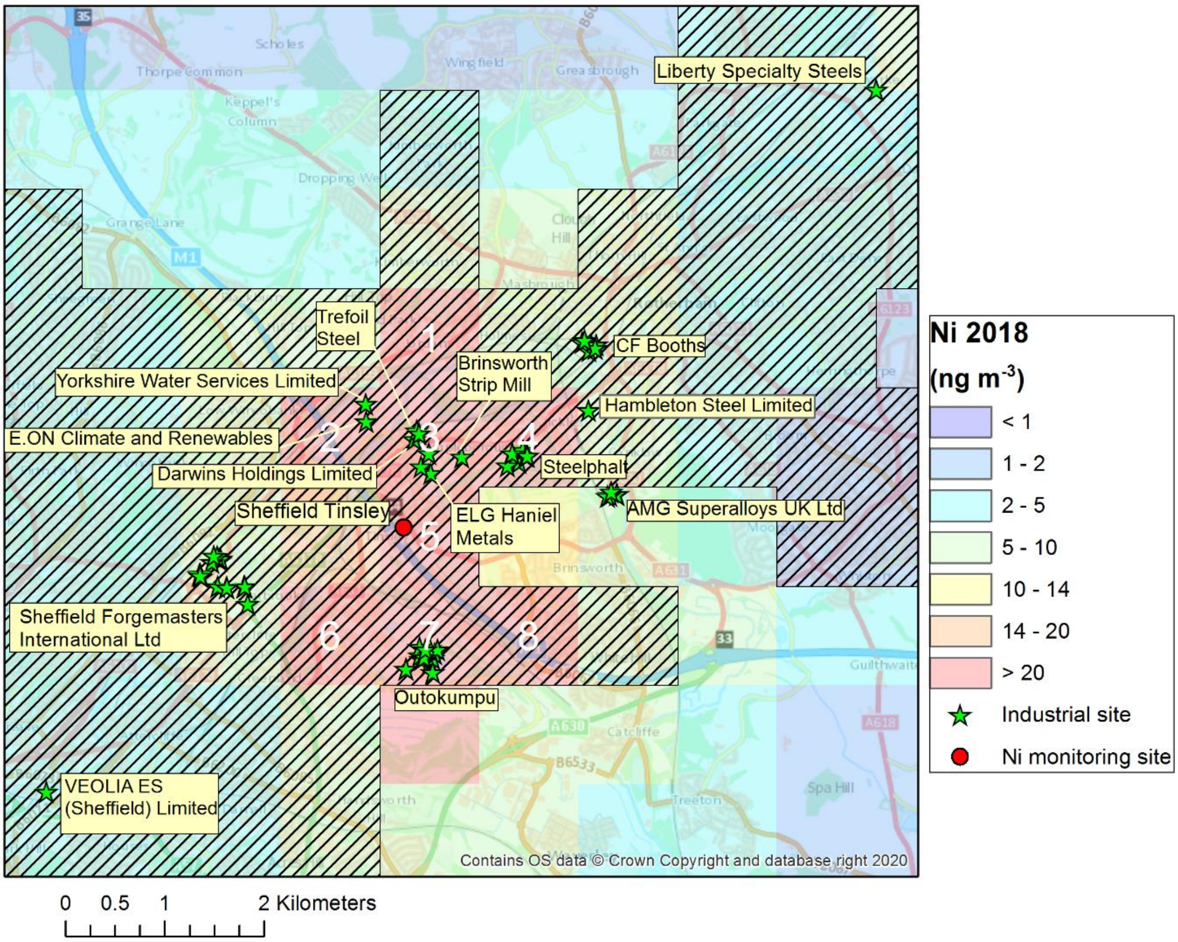


Table 2. Measured annual mean Ni concentrations in the South Wales zone UK0041 from 2004 to 2019 (ngm^{-3}). Percentage data capture is shown in parentheses.

Station (EoI code)	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Sheffield Brinsworth (GB0792A)	20*	14*	12 (98)	11 (100)	12 (94)	9.8 (96)	15 (98)	15 (98)	13 (100)	13 (70)						
Sheffield Centre (GB0615A)					2 (92)	1.7 (98)	2.5 (98)	2.2 (91)	2.6 (88)	3.2 (66)						
Sheffield Devonshire Green (GB1027A)										0.86 (11)	2.6 (99)	1.9 (100)	2.7 (98)	1.7 (100)	2.2 (100)	1.8 (100)
Sheffield Tinsley (GB0538A)										14 (81)	21 (96)	18 (94)	24 (89)	17 (99)	20 (100)	15 (100)

* Data capture not available

Figure 3. Exceedance situation Sheffield [Ni_UK0007_2018_1]. Sheffield Tinsley monitoring station is marked in red. Locations of local industrial sites are also shown. Non-hatched grid squares are assigned to the Yorkshire and Humberside zone UK0034. Note that multiple emissions sources are indicated on the map for some industrial sites (Outokumpu, Sheffield Forgemasters International Ltd, AMG Superalloys UK Ltd, E.L.G. Haniel Metals Limited, Harsco Metals Group Limited (Steelphalt), Trefoil Steel Company Limited, and CF Booths Limited).



2.2 Source apportionment

Modelling has been used to determine the annual mean Ni source apportionment for the exceedance situation. National modelling on a 1 km x 1 km grid resolution apportions the Ni concentration to regional and urban background sources. Additional fine scale modelling has also been carried out in support of the 2018 UK air quality assessment and this Report on Measures to characterise local industrial emissions, this is described in Appendix A1.

Table 3 provides a breakdown of the main emission sources (source apportionment) that have contributed to the grid squares of the modelled exceedances. The penultimate column is the total concentration from all emissions sources. The total concentrations are presented rounded to integers for consistency with the values reported in the compliance assessment. The values in the other columns have been rounded to two decimal places. The other shaded columns are the subtotals for the regional, urban background and local contributions.

Table 3 identifies that local emissions from industrial sources are the most significant source of Ni. Table 4 gives a more detailed source apportionment for the industry sector based on the fine scale modelling study presented in Appendix A1. Due to the way the fine scale modelling was carried out and the results aggregated to values for 1 km squares, this is presented for the location of the Sheffield Tinsley monitoring site only. This shows local industrial emissions contribute 18.11 ngm^{-3} Ni to the annual mean measured concentration. This study shows that the Outokumpu site is the most significant local industrial emissions source contributing 9.90 ngm^{-3}, as indicated in Table 4, which includes contributions from reported emissions and a contribution attributed within the modelling to diffuse sources on the site.

The source apportionment presented here has been informed by the fine scale modelling carried out in support of the 2018 UK air quality assessment that was reported to the Commission in September 2019.

Table 3. Source apportionment for exceedance situation Ni_UK0007_2018_1. Annual mean Ni concentration (ngm^{-3}).

Grid Square Number	OS easting (m)	OS Northing (m)	Zone	a) Regional background: Total	Regional background: From within Member State	b) Urban background increment: Total	Urban background increment: Traffic	Urban background increment: Industry including heat and power production	Urban background increment: commercial and residential	Urban background increment: Shipping	Urban background increment: Off road mobile machinery	Urban background increment: Other	c) Local increment: Total	Local increment: Industry including heat and power production	Total for all emissions sources (a+b+c)	Resident population
1	440500	392500	7	0.5	0.5	1.04	0.04	0.46	0.42	0.00	0.07	0.05	23.01	23.01	25	2924
2	439500	391500	7	1.0	1.0	0.93	0.08	0.39	0.31	0.00	0.09	0.05	23.63	23.63	26	146
3	440500	391500	7	0.6	0.6	1.05	0.04	0.48	0.39	0.00	0.10	0.03	49.90	49.90	52	1982
4	441500	391500	7	0.5	0.5	1.17	0.04	0.65	0.32	0.00	0.13	0.03	21.37	21.37	23	0
5	440500	390500	7	0.8	0.8	1.06	0.06	0.53	0.36	0.00	0.10	0.02	20.63	20.63	23	2545
6	439500	389500	7	0.7	0.7	0.93	0.05	0.45	0.27	0.00	0.14	0.02	21.57	21.57	23	143
7	440500	389500	7	0.6	0.6	0.89	0.04	0.49	0.27	0.00	0.07	0.02	32.23	32.23	34	0
8	441500	389500	7	0.8	0.8	1.00	0.05	0.51	0.36	0.00	0.06	0.02	20.94	20.94	23	2247

Table 4. Detailed source apportionment for industrial sources only for exceedance situation Sheffield [Ni_UK0007_2018_1]. Annual mean Ni concentration (ngm^{-3}).

Grid Square Number	OS easting (m)	OS Northing (m)	Zone	Outokumpu	Scaled contributions from Outokumpu*	AMG Superalloys UK Ltd	Harsco Metals Group Limited, Steelphalt	Other identified industry sources from East**	E.L.G. Haniel Metals Limited	Scaled contributions from North East***	Sheffield Forgemasters International Ltd	Other identified industry sources from West****	Unidentified sources	Local increment: Industry including heat and power production
1	440500	390500	7	9.90	0.01	0.03	0.06	0.001	1.41	6.64	0.05	0.01	0.00	18.11

* Contributions from Outokumpu Stainless Ltd (SMACC) attribute to diffuse emissions from roadways and raw material storage areas, scaled to a measurement-model residual (refer to Appendix A1 for details)
** Other industry sources to the East of the Sheffield Tinsley monitoring site identified as contributing <0.01 ngm^{-3} each, including Speciality Steels UK Ltd (Brinsworth Strip Mill) and CF Booths Limited (Clarence Metal Works).
*** Contributions from sources to the North East of the Sheffield Tinsley monitoring site (including E.L.G. Haniel Metals Limited, Darwin Holdings Limited (Fitzwilliam Works), Trefoil Steel Company Limited (Rotherfield Works)) shown as an aggregated total in the source apportionment since the individual contributions are unknown and scaled to a measurement-model residual (refer to Appendix A1 for details)
**** Other industry sources to the West of the Sheffield Tinsley monitoring site identified as contributing <0.01 ngm^{-3} each, including VEOLIA ES (SHEFFIELD) Ltd and E.ON Climate and Renewables UK Biomass Ltd.

This is the source apportionment for the value measured at the Sheffield Tinsley monitoring site. The total local increment therefore differs from the modelled value for the whole grid square listed in Table 3.

2.3 Measures

Improving air quality is a high priority for the Government, that published the Clean Air Strategy in January 2019, which sets out new and ambitious goals. An exceedance in this zone was reported in 2014 and in 2016, but not in other years since the TV came into force, including 2017. The Government takes any exceedance seriously whilst ensuring that any measures put in place are proportionate to the exceedance. The Government has brought together the regulators and local industrial operators with emissions of Ni to air in pursuit of this aim. Meetings have enabled:

- the Government to communicate to the industrial regulators and operators the extent of the issue and the seriousness with which it is taken;
- the regulators to demonstrate that the operators are applying all cost-effective measures, and in particular are applying best available techniques as required by Directive 2010/75/EU (IED);
- the operators to cooperate and share best practice in managing their operations; and
- the development of the latest evidence in understanding the predominant sources.

Much of the work in this area has focussed and will continue to focus on the unidentified and scaled source contributions as highlighted in Table 4. Work thus far undertaken has included fine scale modelling (Appendix 1) to model the impact of known emissions to the measurements at Tinsley Monitoring Station and daily and hourly monitoring campaigns at the Tinsley Monitoring station to obtain greater temporal resolution as regards the measurements made at the site (Appendix 2).

Table 5 summarises measures taken or to be taken at local industrial sites identified that may contribute to nickel in ambient air.

Table 5. Table of measures taken or to be taken at local industrial sites.

Measure code	Measure Description	Classification	Implementation dates		Other information		Comment
ELG Haniel Metals Ltd_1	Purchase of shearing machine (@£400K)	Air Quality Planning and Policy Guidance	Start:	Dec 2018	Source affected:	Waste Processing (stainless steel and non-ferrous metals)	The use of the shearing machine will reduce the frequency of oxy-propane cutting, which is carried out in the open. Fugitive emissions (including particulate matter/nickel) will therefore be reduced. **Update:** The shearing machine was commissioned in December 2018 and has proved highly efficient resulting in the decommissioning of one (of the two) oxy-propane cutting stations. The reduction in oxy-propane cutting on site in 2019 compared to 2018 was in excess of 50%.
			Expected end:	N/A			

ELG Haniel Metals Ltd_2	Installation of plasma cutting booth with ventilation and filtration system (@11K)	Air Quality Planning and Policy Guidance	Start:	June 2018	Source affected:	Waste Processing (stainless steel and non-ferrous metals)	Previously plasma cutting was carried out in the open. Fugitive emissions containing nickel from this process will now be abated. **Update**: This has been commissioned. Following the commissioning of the guillotine sheer in September 2019, no plasma cutting was carried out on site between September and December 2019. ELG anticipated very little need for plasma cutting in 2020 and if any is necessary it is now carried out in a cutting booth with filtration system.
			Expected end:	N/A			
ELG Haniel Metals Ltd_3	Monitoring of Densifier Unit by a MCERTS certified monitoring contractor (£2K)	Air Quality Planning and Policy Guidance	Start:	June 2018	Source affected:	Waste Processing (stainless steel and non-ferrous metals)	To determine whether or not the emissions arising from this process contain nickel. **Update**: Monitoring completed. Fugitive releases from the densifier building open doorway contain varying quantities of dust / nickel.
			Expected end:	October 2018			

ELG Haniel Metals Ltd_4	Monitoring of the oxy-propane cutting station (£2K)	Air Quality Planning and Policy Guidance	Start:	June 2018	Source affected:	Waste Processing (stainless steel and non-ferrous metals)	To determine whether or not the emissions arising from this process contain nickel**. Update**: Monitoring completed. Fugitive releases from oxy-propane cutting, as expected, contain varying quantities of nickel. Therefore, reduction plan formulated (including the purchase of shearing machine).
			Expected end:	October 2018			
ELG Haniel Metals Ltd_5	Installation of guillotine sheer (@80K)	Air Quality Planning and Policy Guidance	Start:	April 2020	Source affected:	Waste Processing (stainless steel and non-ferrous metals)	The use of the guillotine sheer will reduce the frequency of plasma cutting therefore reducing dust / nickel releases. **Update:** Guillotine sheer successfully commissioned. Since its installation there has been very little requirement for plasma cutting on site. Plasma cutting now carried out in a cutting booth with filtration system.
			Expected end:	N/A			
ELG Haniel Metals Ltd_6	Installation of PVC curtain on densifier building open doorway (@£8K)	Air Quality Planning and Policy Guidance	Start:	April 2020	Source affected:	Waste Processing (stainless steel and non-ferrous metals)	PVC strip curtains form an effective barrier against dust and airborne contamination. **Update**: CAPEX approved. Installation April 2020.

			Expected end:	N/A			
ELG Haniel Metals Ltd_7	Monitoring of the oxy-propane cutting station	Air Quality Planning and Policy Guidance	Start:	June 2018	Source affected:	Waste Processing (stainless steel and non-ferrous metals)	To determine when oxy-propane cutting is carried out on site.
			Expected end:	N/A			
Outokumpu SMACC_1	Installation of a new oxy-fuel burner system on the electric arc furnace (£900K)	Air Quality Planning and Policy Guidance	Start:	August 2018	Source affected:	Stainless steel slab, bloom, billet and cast ingot production	Operator to install oxy fuel burners in the EAF to improve the speed and efficiency of melting. The ability to close the slag door will benefit the capture efficiency of the furnace extraction system leading to a reduction in fugitive emissions from the melt shop roof.
			Expected end:	N/A			

Outokumpu SMACC_2	Operator to undertake modelling of the emissions from site to determine whether or not the data collated by Kings College London accounted for all emissions from site or just point sources (£2K)	Air Quality Planning and Policy Guidance	Start:	June 2018	Source affected:	Stainless steel slab, bloom, billet and cast ingot production	Detailed modelling will allow the Operator to focus their efforts on the areas that have the most impact. **Update**: A modelling study was carried out in 2019. The emissions from unknown sources such as stockyards were assumed to add up to the remainder of the total site contributions as measured during the King's College study and were estimated by an iterative process. The contributions from the known sources were estimated to account for up to 48 % of the measured values for the whole of 2017. The gap between the modelled values and the contribution estimated by King's College over the course of the study equates to 12% or 2.94 ng/m^3, which can be assumed to be emitted from unknown sources such as stockyards.
			Expected end:	N/A			
Outokumpu SMACC_3	Operator to carry out a dust and PM_{10} monitoring and characterisation assessment for	Air Quality Planning and	Start:	April 2018	Source affected:	Stainless steel slab, bloom, billet and cast	Monitoring will determine the concentrations of nickel and other materials potentially

	the steel works to investigate the concentrations of nickel and other materials potentially migrating off site *(Ref Doc. DS/AG/Outokumpu/01*) (£26K)	Policy Guidance				ingot production	migrating off site. **Update:** A diffuse dust emission apportionment study was carried out in 2019. Combined directional and depositional dust monitoring gauges were installed at four onsite locations. Monitoring was carried out over a six-month period and a selection of samples analysed to determine the elemental composition. Modelling was then carried out to investigate the proportion of emissions associated with area sources. Model results suggested that the raw materials reception and stockyard areas had the highest potential fugitive PM10 emissions. Emissions from these areas may be due to vehicle movements and wind-whip from stockpiles and exposed surfaces, including re-suspension of dust on haul routes. The main control for this type of emission is the bowsering and sweeping of stockyard roadways.
			Expected end:	October 2018			

							In response to this the operator developed a risk assessment tool based on a three-day weather forecast. It will highlight when rainfall, temperature, wind speed and direction will have an adverse effect on the contribution of the stockyard activities on ambient levels in Tinsley, directing bowser and sweeper activities to respond to these conditions.
Outokumpu SMACC_4	Operator to define measurement/monitoring programme for fugitive roof emissions.	Air Quality Planning and Policy Guidance	Start:	May 2018	Source affected:	Stainless steel slab, bloom, billet and cast ingot production	Monitoring will confirm the quantity of fugitive emissions escaping through the melt shop roof. **Update**: Dust and fume from the melting shop are collected by an extraction system within the melting shop building, but from time to time there may be spillages from the system that are emitted from the building ridge vents. The mass emission of these releases was first measured in 1996, and then again in 2001, 2006 and 2007, the latter two occasions before and after modifications to the geometry of the melting shop building to
			Expected end:	N/A			

							minimise such releases. In order to confirm that mass emission levels had not altered significantly since 2007, measurements were repeated in early 2019.
Outokumpu SMACC_5	Operator to carry out measurements as defined in the above monitoring programme for fugitive emissions (10-20K)	Air Quality Planning and Policy Guidance	Start: Expected end	October 2018 N/A	Source affected:	Stainless steel slab, bloom, billet and cast ingot production	Monitoring will confirm the quantity of fugitive emissions escaping through the melt shop roof. **Update**: The estimated 2019 annual mass emission from the roof vents was found to be almost identical to the result from 2007, confirming that estimations used in the impact assessment were sound.
Outokumpu SMACC_6	AOD Fume Hood - scheduled maintenance (£120K)	Air Quality Planning and Policy Guidance	Start:	2018	Source affected:	Stainless steel slab, bloom, billet and cast ingot production	AOD Fume Hood Replacement leading to a reduction in fugitive emissions from the melt shop roof - scheduled maintenance. **Update:** This capital schemes was completed at summer shutdown 2018 (end July / beginning August). Since this time, they have spent a further £400k on ductwork improvements.
			Expected end:	N/A			

Outokumpu SMACC_7	Refurbishment of main air fan in the Melt Shop - Scheduled Maintenance (£70K)	Air Quality Planning and Policy Guidance	Start: Expected end:	2018 N/A	Source affected:	Stainless steel slab, bloom, billet and cast ingot production	Refurbishment of main air fan to increase efficiency of extraction in the Melt Shop leading to a reduction in fugitive emissions from the melt shop roof. **Update**: This capital schemes was completed at summer shutdown 2018 (end July / beginning August). Since this time, they have spent a further £300k on fan refurbishments.
Sheffield Forgemasters International Limited_1	Installation of new Forge Burning extraction (@500K)	Air Quality Planning and Policy Guidance	Start: Expected end:	August 2018 N/A	Source affected:	Steel Processing	Reduction in particulates/nickel emitted to atmosphere is expected. **Update:** The Forge Burning Booth and extraction has been replaced as expected.

2.4 Modelling

Appendix A1 presents fine scale modelling that has identified the emissions sources as potential contributors to the concentrations measured at Sheffield Tinsley monitoring station.

2.5 Monitoring

The Report on Measures for 2014 and 2016 exceedances of the Target Value for Nickel in Sheffield[5] reported the outputs of a daily heavy metals monitoring campaign at Sheffield Tinsley monitoring station over the period from 25th February 2016 to 9th August 2016. Analysis of measured metal concentrations was undertaken to provide measurement-based evidence to identify emissions sources contributing to Nickel concentrations measured in the Tinsley area. This study identified contributions to the measured concentration from sources to the South and sources to North East. The source to the South was consistent with emissions from the Outokumpu site, but the sources to the North East were not identified. The study identified that monitoring to a higher time resolution might provide further insight into dominant sources.

During 2017 King's College London were commissioned to undertake a ten-week high time resolution (hourly) measurement campaign. This campaign took place January and March 2017 with the aim of providing further evidence to identify sources of Ni measured at the Tinsley AURN site. This work identified two sources of Nickel: one related to point source emissions which was characterised by molybdenum and manganese and one fugitive source type, characterised by chromium and calcium, likely to be associated with material handling or transport.

Wind speed and direction measurements were used to quantify where these source types were emitted from. There were three broad source directions –East, West and South. The source from the South, which contributed 47% to the Nickel concentrations measured during the study, was associated with emissions from the Outokumpu facility. This contribution was associated mainly with point source type emissions of Nickel, with a smaller contribution from fugitive source type emissions.

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[5] Report on measures for 2014 exceedance of the Target Value for Nickel in Sheffield Urban Area agglomeration zone (UK0007), https://uk-air.defra.gov.uk/assets/documents/reports/bap-nickel-measures/ni_sheffield_UK0007_reportonmeasures_2014.pdf Report on measures for 2016 exceedance of the Target Value for Nickel in Sheffield Urban Area agglomeration zone (UK0007), https://uk-air.defra.gov.uk/assets/documents/reports/bap-nickel-measures/ni_sheffield_UK0007_reportonmeasures_2016.pdf

The source to the East contributed 40% to the measured Nickel concentrations and was related mainly to industrial sources to the North East. The source from the West represented emissions from over half of the industries in Sheffield, which lie in that direction and was dominated by the point source type emissions. The sources to the West provided the smallest contribution to measured Ni concentrations.

The widespread nature of point source emissions across industries in Sheffield makes this challenging to tackle. However, the high time resolution measurements help to focus resources and identify specific emissions from industrial sources.

3. Industrial Sources of Nickel

3.1 Environment Agency Regulated Plant Part A

Further information about operating processes at individual regulated plant can be found in Appendix A1. From the industrial sites identified to date, Outokumpu has been identified as making the most significant contribution from regulated industry to the levels of Ni measured at Tinsley monitoring site. Outokumpu is regulated by the Environment Agency and is declared as using BAT. Ongoing further analysis of emissions samples from the area is being undertaken, in conjunction with Outokumpu to assist in identification of other potential sources of fugitive emissions that are currently unidentified. Actions to tackle Nickel emissions from Outokumpu are presented in Table 5.

3.2 Local Authority Regulated Plant Part B

Further information about operating processes at individual sites can be found in Appendix A1. The Local Authority has advised that these are all operating within the terms and conditions of their permits.

3.3 Unregulated plant – Local Authority

Sheffield City Council has provided information that none of the other industrial sites identified as potential contributors to Ni emissions in the region fall within the scope of the regulations and as such there are no relevant measures to put forward.

A1. Local scale modelling of the industrial point sources

This annex summarises supplementary modelling work carried out to investigate the sources of the measured exceedance of the 4th Daughter Directive (Directive 2004/107/EC, DD4) annual mean target value (TV) for nickel (Ni) of 20 ng m^{-3} at the Sheffield Tinsley monitoring station for the year 2018. Under DD4 Member States are required to identify zones and agglomerations where exceedances of the TV occur. Exceedance of the TV triggers a requirement within the Directive to prepare a report on measures.

The United Kingdom exited the European Union on 31 January 2020. Upon exit, the UK entered a Transition Period which will end on 31 December 2020. The UK was a Member State during the period this report covers, and the Directive requirements apply to the UK as part of its obligations during the Transition Period.

Once the Transition Period ends on 31 December 2020, the UK will continue to meet its reporting obligations through making this data available to the public to the same timescales

. Source identification is not a formal requirement for this report on measures but is clearly a prerequisite for demonstrating that all measures not entailing disproportionate costs have been taken, and modelling can be useful to evaluate source contributions.

In the 2016 Report on Measures[6] a review of the following sources of information were used to compile a list of the potential sources of Ni relevant to this exceedance:

- a review of the results from high time resolution monitoring campaigns at the Sheffield Tinsley monitoring station
- sources present in the National Atmospheric Emissions Inventory (NAEI) and Pollution Climate Mapping (PCM) national modelling
- sources identified by the Environment Agency (EA), Sheffield City Council (SCC) and Rotherham Metropolitan Borough Council (RMBC).

This annex also describes the modelling approach and model results, including concentration maps, comparison of the model output with observations, modelled source apportionment and compliance situation as modelled. It concludes with

[6] Report on measures for 2016 exceedance of the Target Value for Nickel in Sheffield Urban Area agglomeration zone (UK0007), https://uk-air.defra.gov.uk/assets/documents/reports/bap-nickel-measures/ni_sheffield_UK0007_reportonmeasures_2016.pdf

recommendations for further work to build on the output of this modelling study to further improve understanding of the Sheffield Ni TV exceedance reported in 2018.

A1.1. Ni emissions data and data from related studies

A1.1.1. Review of sources present in the NAEI and national modelling

The PCM modelling of Ni concentrations for 2018 serves as the background for this local study. Due to reporting timescales, the 2018 PCM compliance assessment modelling took NAEI 2017 emission estimates with projections to 2018 as input. For this study GIS analysis was used to identify “local” Ni point sources within the NAEI 2017 and 2018 that are within 15 kilometres of either the Sheffield Tinsley or Sheffield Devonshire Green monitoring stations. The contribution from local point sources of Ni based on the NAEI 2017 were subtracted from the national modelling in order to avoid double counting of these contributions.

Local point sources of Ni based on the NAEI 2017 were reviewed in terms of if there was further local data from either EA and local authority data (see the 2016 report[6], Section A1.1.3.2) or the 2014 study (see the 2014 report[5], Section A1.1.3.3) to avoid duplication.. If there was no further local data to allow detailed treatment, the contribution from these sources were modelled at 1 km x 1 km spatial resolution using the PCM modelling approach including NAEI 2017 emissions and local meteorology and added to the background Ni concentrations for 2018 from the national modelling (see Section A1.2).

A 1.1.2. Review of the 2014 and 2016 studies and compilation of sources considered in the 2018 study

The previous local studies of point source contributions to Ni in Sheffield during 2014 (Brookes (2016)[7], Defra (2016)[5]) and 2016 (Defra (2018)[6]) provides a basis for the modelling approach for 2018. The information gathered for the 2014 and 2016 modelling on emissions, processes and release parameters has been combined with the emission data from the NAEI 2017, EA and local authority data to compile the input for the 2018 modelling.

For a small number of industrial sources or potential releases, 2018 Ni emissions data were indicated as being low and unspecified; these sites have been mapped but not modelled (see Table A1.2 and Figure A1.1). Those sites that have been modelled at higher resolution in the current study are listed in Table A1.3 and mapped in Figure A1.1. Table A1.3 includes descriptions of whether emissions were treated as line (e.g. along a roof vent), point (e.g. from a chimney stack) or volume releases (e.g. diffuse emissions from a storage area or building). The bearings from the Sheffield Tinsley monitoring station to each release point have been calculated and used to relate each source to the three broad source directions identified in the K-means cluster analysis of CPF BPPs in the KCL study (Green et al., 2017)[8] Temporal emission profiles have been applied where information was available on operating hours from the EA 2018 site reports. A categorisation for modelling (a)-(c) has also been made to indicate the level of confidence in the emissions data, where:

a) Indicates reported emissions and release parameters
b) Indicates derived emissions and/or release parameters based on the EA 2018 site reports
c) Indicates scaled contributions from uncertain local point/fugitive/diffuse sources with release parameters based on the 2018 EA site reports

[7] Brookes, D. and R. Rose (2016). Local study of point source contributions to Nickel in Sheffield, 2014, Ricardo Energy & Environment.
[8] "Source Apportionment of Nickel Sources at Sheffield Tinsley"; David C Green, Anna Font, Max Priestman & Anja H Tremper, Environmental Research Group, King's College London; November 2017.

Table A1.2 – Identified Ni emitters or emission points that were not modelled due to low emissions rates or lack of information

Operator	Address	Postcode	Process Type	Emission point description	Data provider
E.L.G. Haniel Metals Limited	Sheffield Road, Tinsley, Sheffield	S9 1RT	Started Operating in 2012 - Shredding of Metal	Densifier Outfeed building – 2018 EA site report provides results of short-term monitoring (June 2018) which indicate minimal if any fugitive emissions for this emission point.	EA
Yorkshire Water Services Limited	Blackburn Meadows STW, Alsing Road, Tinsley, Sheffield.	S9 1HF	Prior to October 2013: Incineration of non-hazardous waste. Since March 2016: sewage sludge is anaerobically digested in a bio-energy digestion plant (BED).	Prior to October 2013 a sewage sludge incinerator operated. A composting facility was then used to process sewage sludge from 2014 to early 2016 and could have contributed diffuse Ni emissions during this period. The 2018 EA site report indicates that Ni emissions from the BED operating since March 2016 are negligible.	EA
Harsco Metals Group Limited, Steelphalt	Sheffield Road, The Ickles, Rotherham	S60 1DR	EA regulated – Crushing and screening of metallurgical slag from steel works. RMBC regulated – Road stone coating activity - asphalt plant which involved the use of bitumen mixed together with varying proportions of aggregate, filler and fibre pellets to produce asphalt.	Roadstone coating plant - stack A1. 2018 EA site report indicates Ni emissions are not quantified, abatement is in place for PM emissions for which there is continuous monitoring, this shows PM emissions are significantly below the emission limit.	EA
				Storage of limestone product. EA site report provides no information on Ni emissions.	
				Open roadways. Emissions from roadways are continuously abated which indicates Ni would be minimal compared to open storage areas.	
Hambleton Steel Limited	Hambleton Steels, Fullerton Road, Ickles, Rotherham	S60 1DJ	RMBC regulated – No data.	No data.	EA

Table A1.3– Identified Ni emission points included in the modelling study. Emission rates are not specified for category c sources.

Operator	Site Name	Stack Name/Description	Stack Location (description)	Ni emissions, kg, 2016	Release type	Bearing to Sheffield Tinsley (°)	Temporal profile?	Categorisation for modelling (description) and KCL cluster assignment	Data provider
Outokumpu	Stainless Melting and Continuous Casting	A1	Melt Shop Bag Filter	519.00	Line	173	No	**a** (Emissions split between releases derived from 2014 releases in combination with NAEI 2016 emission total and information on 2017 emissions from the EA.), **KCL South cluster**	EA/NAEI
		A2	DC Arc Furnace	50.91	Point	173	No		
		A3	Grinder Bag Filter	2.16	Point	169	No		
		A4	Grinder Bag Filter	2.38	Point	168	No		
		A5	Grinder Bag Filter	2.16	Point	166	No		
		A6	Radial Saw Bag Filter	0.00	Point	168	No		
		A13	Cast Product cut-off Bag Filter	24.55	Point	169	No		
		A14	Grinder Bag Filter	1.24	Point	164	No		
		A15	Melting Shop Scanvenging Filter (West)	33.55	Point	179	No		

		A16	Melting Shop Scanvenging Filter (East)	38.64	Point	179	No		
		A17	EAF Dust Storage Silo Filter	0.00	Point	172	No		
		N/A	West vent melt shop roof	72.83	Line	178	No		
		N/A	East vent melt shop roof	141.59	Line	173	No		
		N/A	Roadways - Traffic		Volume	171	No	**c** (Modelled contribution scaled after unit emissions applied distributed over the volume of each source derived from the mapped surface area and estimated height.), **KCL South cluster**	EA
		N/A	Raw materials storage area - storage of waste dust		Volume	170	No		EA
Sheffield Forgemasters International Ltd	Sheffield Forgemasters Brightside	A1	Melting Shop, Bag Filter Plant Roof Vents	2.01	Line	244	No	**a** (Emissions split between releases derived from 2014 releases in combination with NAEI 2016 emission total.), **KCL West cluster**	EA/NAEI
		A2	Snow Grinder and Melt Shop Flame Cutting Facility	1.34	Point	251	No		
		A3	Forge Ingot Burning, Bag	2.71	Point	260	No		

			Filter and Plant Stack						
		A4	Gas Fired Boiler Plant Stack	1.20E-04	Point	250	No		
		A5	Gas Fired Boiler Plant Stack	1.20E-04	Point	252	No		
		A6	Gas Fired Boiler Plant Stack	1.20E-04	Point	250	No		
		A7	Gas Fired Boiler Plant Stack	1.20E-04	Point	250	No		
		A8	Forge Heating Furnace No.1 Stack	2.39E-04	Point	260	No		
		A9	Forge Heating Furnace No.7 Stack	1.80E-03	Point	261	No		
		A11	Heavy Forge Roof Vents (exhausts from forge furnaces2, 14, 17, 28, selas furnace and heat treatment	4.19E-03	Line	261	No		

			furnaces NTP1 to 16, 18 and 20a/b)						
		A13	Foundry Shot Blast Stack	0.55	Point	257	No		
		A15	Foundry Burning Booth Stack	10.00	Point	257	No		
		A20	Foundry Heat Treatment Furnace Stacks	3.59E-04	Point	256	No		
		A21	Foundry Heat Treatment Furnace Stacks	5.99E-04	Point	256	No		
		A22	Foundry Heat Treatment Furnace Stacks	3.59E-04	Point	257	No		
		A28 (251-255)	Melting Shop Low Casting Bay Roof Vents (Furnaces 251-255)	5.15	Line	250	No		
		A31	Forge Heating Furnace No.3 stack	8.38E-04	Point	262	No		

Liberty Speciality Steels	Aldwarke Lane	-	-	112.49	Point	47	No	**a** (Modelling parameters from PCM and NAEI 2016 emissions.), **KCL East cluster**	PCM/NAEI
VEOLIA ES (SHEFFIELD) LIMITED	Sheffield Energy Recovery Facility	Release Point A1	Main Stack	5.00	Point	233	No	**a** (modelling parameters from 2014 study and NAEI 2016 emissions), **KCL West cluster**	EA/NAEI
E.ON Climate and Renewables UK Biomass Ltd	Blackburn Meadows Renewable Energy Plant	Release Point A1	Main Stack	5.00	Point	341	No	**a** (Modelling parameters from 2014 study and NAEI 2016 emissions.), **KCL West cluster**	EA/NAEI
AMG Superalloys UK Ltd	Fullerton Road	A1	Arc Furnace	2.12	Point	81	No	**a** (Emissions split between releases derived from 2014 releases in combination with NAEI 2016 emission total, locations based on EA 2018 site report in combination with aerial imagery.), **KCL East cluster**	EA/NAEI
		A2	Arc Furnace	9.20	Point	81	No		
		Mix filter 65	Mix filter 65	0.11	Point	81	No		
		Pangborne Shotblast	Pangborne Shotblast	0.13	Point	81	No		
		Arc Furnace Shop Roof Vent	Arc Furnace Shop Roof Vent	6.49	Line	80	No	**b** (Release parameters derived from EA 2018 site report, height based on EA LIDAR derived building heights, emissions estimated based on EA 2018 site report.), **KCL East cluster**	EA

E.L.G. Haniel Metals Limited	Sheffield Road, Tinsley, Sheffield	Oxy-propane Cutting Area	Oxy-propane Cutting Area		Point	27	Yes	**c** (Modelled contribution scaled after emissions and release parameters estimated from 2018 short term monitoring of fugitive emissions.), **KCL East cluster**	EA
		Plasma Cutting Area	Plasma Cutting Area	63.26	Point	16	Yes	**b** (Release parameters and emissions derived from EA 2018 site report.), **KCL East cluster**	EA
Harsco Metals Group Limited, Steelphalt	Sheffield Road, The Ickles, Rotherham	Open stockpile storage of slag	Storage of slag prior to crushing (South of crushing plant)	3.27	Volume	61	No	**b** (Emissions derived from EA 2018 site report applied distributed over the volume of each source derived from the mapped surface area and estimated height.), **KCL East cluster**	EA
		Open storage of crushed/screened slag	Storage of slag prior to coating (North of coating plant)	3.27	Volume	57	No		EA
		Open storage of crushed/screened slag	Storage of slag prior to coating (South West of coating plant)	3.27	Volume	59	No		EA
		Enclosed crushing plant	Crushing plant	1.31	Volume	60	No		EA

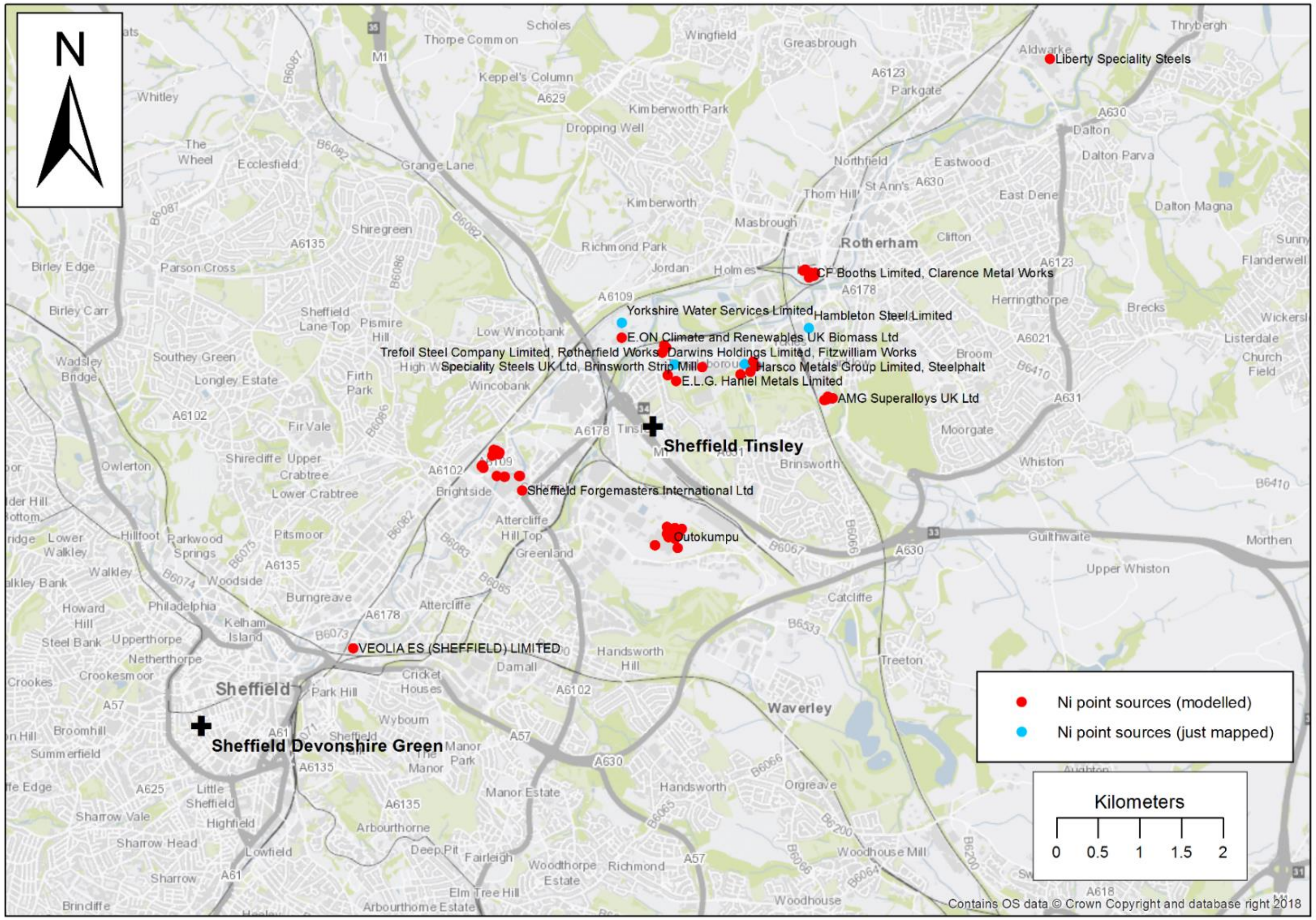
Speciality Steels UK Ltd, Brinsworth Strip Mill	Sheffield Road, Rotherham	A1	Hot Mill Reheat Furnace	0.33	Point	40	Yes	**a** (Modelling parameters from 2014 study and 2016 emissions for A1 stack from EA 2018 site report. A potential fugitive release from the F1 hot mill roof is noted but not treated, because the 2018 site report indicates these emissions are suppressed by BAT process.), **KCL East cluster**	EA
Darwins Holdings Limited, Fitzwilliam Works	Sheffield Road, Tinsley	Roof vents, roller shutter doors etc.	Roof vents, roller shutter doors etc.		Volume	8	Yes	**c** (All processes vent internally into the foundry. Modelled contribution scaled after unit emissions applied distributed over the volume of the building derived from the mapped surface area and height based on EA LIDAR derived building heights.), **KCL East cluster**	EA
Trefoil Steel Company Limited, Rotherfield Works	Dead Man's Hole Lane, Tinsley	Melting shop roof vents (release melting, tapping and finishing emissions which vent internally)	Melting shop roof vents		Line	8	Yes	**c** (Modelled contribution scaled after unit emissions applied distributed over the length of roof derived from aerial imagery and at height derived from EA LIDAR derived building heights and Google Earth. Temperature of release	EA

								assumed near ambient, flow estimated based on reported flows for other EAF roof vents), **KCL East cluster**	
		Arc air cutting cartridge filter grille	Arc air cutting cartridge filter grille		Point	9	Yes	**c** (Modelled contribution scaled after estimated emissions applied with release parameters based on EA 2018 site report. Temperature of release assumed near ambient, position of release from aerial imagery, height of release from Google Earth.), **KCL East cluster**	EA
		DCE shotblasting cartridge filter	DCE shotblasting cartridge filter		Point	9	Yes	**c** (Modelled contribution scaled after estimated emissions applied with release parameters based on EA 2018 site report. Temperature of release assumed near ambient, position of release from aerial imagery, height of release from Google Earth.), **KCL East cluster**	EA
CF Booths Limited, Clarence Metal Works	Armer St, Rotherham	Decontamination units: Addax 1 (rotary gas/oil fired dryers which	Addax 1	0.34	Point	46	Yes	**b** (Release parameters derived from EA 2018 site report in combination with stack monitoring reports	EA

		de-grease by volatilisation)						from the 2014 study. Emissions derived from stack monitoring reports from the 2014 study.), **KCL East cluster**	
		Decontamination units: Addax 2 (rotary gas/oil fired dryers which de-grease by volatilisation)	Addax 2	0.14	Point	46	Yes		
		Decontamination units: C4 (gas oil fired box type batch furnaces, 1000kg capacity)	C4	0.08	Point	46	Yes		
		Furnaces: F3 (gas oil heated crucible furnace <=5 t capacity)	F3	0.10	Point	47	Yes		
		Furnaces: combine F1, F2, F4, F8 (electric induction furnaces), with F5 and F6 (oxy-oil fired rotary furnaces <5 t capacity)	F1, F2, F4, F8, F5 and F6	0.06	Point	47	Yes		
		Furnaces: F9 and F10 (electric induction furnaces <5 t capacity)	F9 and F10	0.08	Point	44	Yes		

		Combined fugitive nickel emissions for the Addax facilities and furnaces	Addax facilities and furnaces	0.09	Volume	46	No	**b** (Volume of the source derived from the mapped surface area and height based on EA LIDAR derived building heights. Emissions derived from EA 2018 site report.), **KCL East cluster**	EA
		Combined diffuse nickel emissions for Raw Materials Storage Area, road transport/Fork lift trucks/diesel cranes and mobile plant	Raw Materials Storage Area, road transport/Fork lift trucks/diesel cranes and mobile plant	0.11	Volume	44	No	**b** (Volume of the source derived from the mapped surface area and height based on Google Earth. Emissions derived from EA 2018 site report.), **KCL East cluster**	EA

Figure A1.1 – Map of local industrial sources of Ni including modelled sources and sources that were not modelled (just mapped). The locations of the Sheffield Tinsley and Sheffield Devonshire Green monitoring stations are also marked.



A1.2. Modelling approach

ADMS v5.2.1 was used for the current modelling study. Detailed source characteristics for the release points summarised in Table A1.3 were derived from data received from the EA, the PCM and the previous 2014 and 2016 modelling studies as discussed in Section 0.

Model input datasets including terrain and meteorology are briefly described below. Table A1.4 summarises generic modelling parameters applied for each model run.

Table A1.4 – Generic modelling parameters

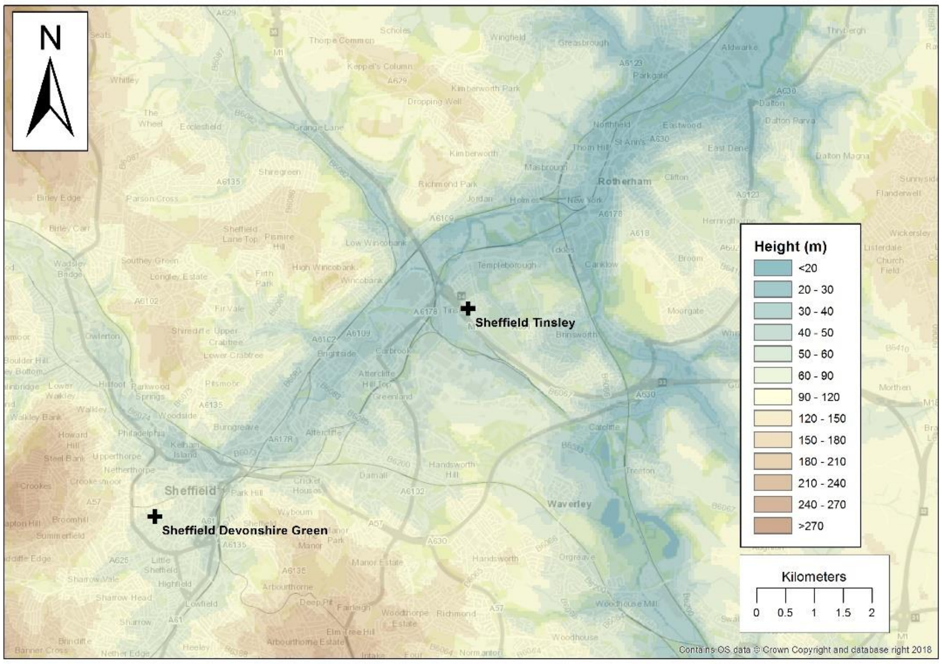
Variable	Parameters
Complex terrain	Y
Terrain grid resolution setting	64x64
Surface roughness at dispersion site	1.0 m[9]
Minimum Monin-Obukhov Length (LMO) at dispersion site	30 m[10]
Surface roughness at met site	0.3 m[11]
Minimum Monin-Obukhov Length (LMO) at met site	20 m[12]
Model output grid resolution	50 m

A1.2.1. Terrain

To treat the effects of terrain on dispersion detailed local terrain data based on OS Terrain 50 was incorporated (see Figure A1.2).

[9] ADMS recommended value for cities, woodlands
[10] ADMS recommended value for cities and large towns
[11] ADMS recommended value for airports
[12] ADMS recommended value for airports

Figure A1.2 - Detailed local terrain based on OS Terrain 50



A1.2.2. Meteorology

An analysis of available meteorological data in the vicinity of Sheffield (not detailed here) was undertaken using the open source R package openair[13]. Data from Sheffield Doncaster Airport and RAF Waddington were evaluated for comparability. Meteorological data for Sheffield Doncaster Airport were used primarily (as the nearest airport meteorological station) and a gap filling procedure based upon the US EPA protocol[14] was followed to compensate for missing data within the Sheffield Doncaster Airport dataset. The protocol was as follows: 1 hour gaps were filled based upon the previous hour, gaps up to 3 hours were filled by interpolation, and larger gaps (>3 hours) were filled with measurements from RAF Waddington.

A1.2.3. Combining model data

As noted in Section A1.1.1. Review of sources present in the NAEI and national modelling, local Ni sources from the NAEI 2017 for which there was no further local data were updated with emissions from the NAEI 2017 and modelled at 1 km x 1 km resolution. The contribution of local sources categorised as (a) and (b) in Table A1.3 were modelled in detail with output on a 50 m x 50 m resolution grid.

[13] https://github.com/davidcarslaw/openair

[14] EPA-454/R-99-005, Meteorological Monitoring Guidance for Regulatory Modelling Applications, 2000, https://www3.epa.gov/scram001/guidance/met/mmgrma.pdf

The contribution of local sources categorised as (c) in Table A1.3 have also been output on a 50 m x 50 m resolution grid. However, since the emissions rates are unknown, these sources were initially modelled with unit emission rates. The contributions from these sources were then scaled in order to provide source apportionment for the annual concentration measured at Sheffield Tinsley.

The scaling factors applied to these sources were derived by:

1. Multiplying the annual mean measured Ni concentration for 2018 at the Sheffield Tinsley monitoring station (i.e. 20 ng m^{-3}) by the percentages allocated to the source direction clusters in the KCL study (Green et al., 2017)[8], in order to derive contributions concentrations from each cluster (11.1 ng m^{-3} for South, 9.3 ng m^{-3} for East and 3.2 ng m^{-3} for West). No scaling has been applied to contributions from the West.
2. Allocating the local sources within this study to the clusters.
3. Scaling the contributions for category (c) sources in the South and East clusters to match the residual between the measured proportion allocated to the clusters and the summed contributions of category (a) and (b) sources in the clusters. No scaling has been applied to contributions from the West.

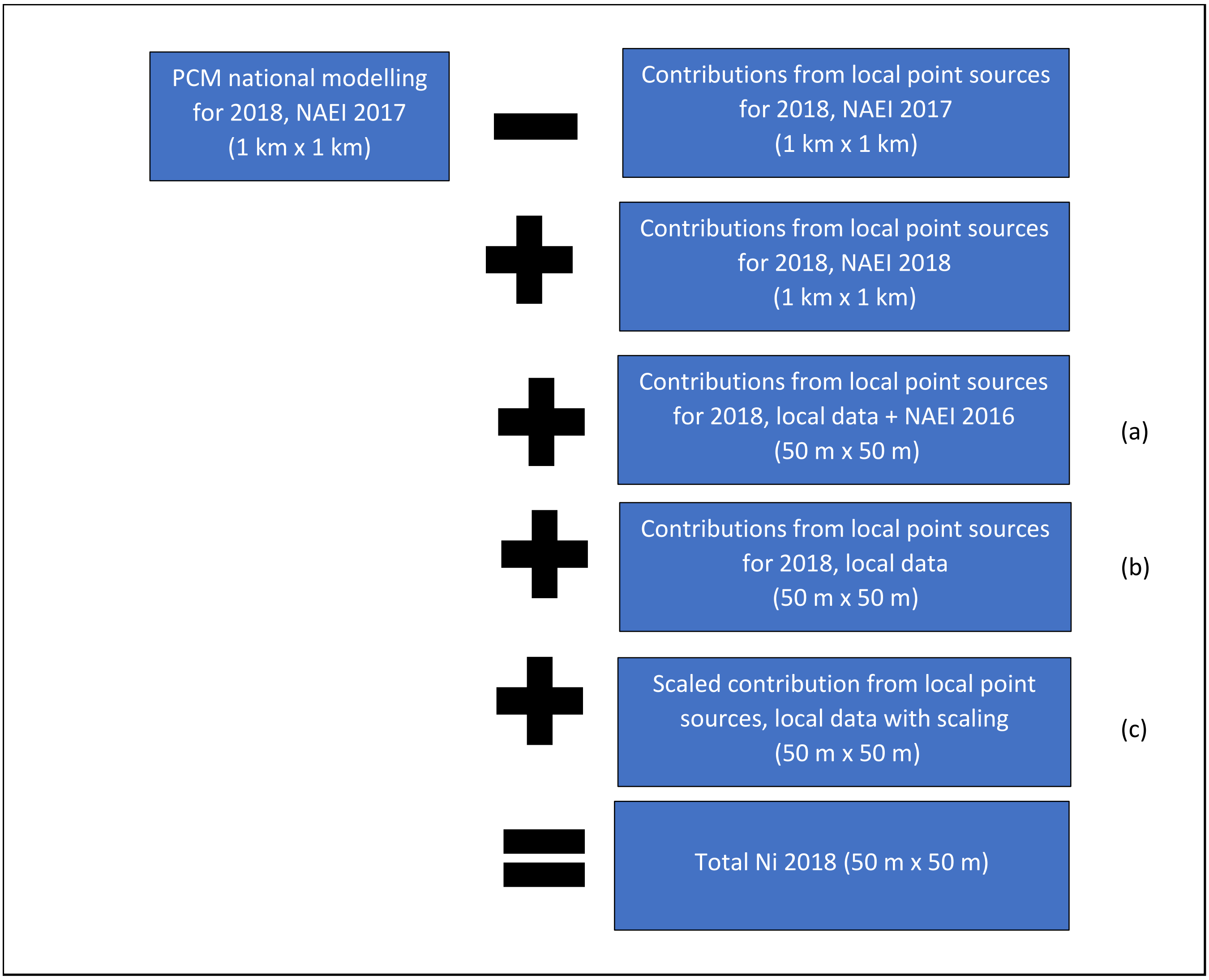
In the KCL study[8] the South cluster contribution is attributed to Outokumpu Stainless Ltd (SMACC), hence the modelled South cluster contribution in this study has been derived by subtracting the modelled contributions from Outokumpu category (a) components from the measured proportion (0.469 x $[Ni]_{measured, 2016}$ = 11.1 ng m^{-3}) to determine a residual. The modelled diffuse contributions from roadways and the raw material storage area (category (c) contributions) have then been scaled to match this residual. Attributing a proportion of the contribution from Outokumpu to the as yet unquantified diffuse sources is consistent with the KCL study, which noted wind driven resuspension as a factor driving elevated concentrations at the Sheffield Tinsley monitoring station.

The KCL study attributes the East cluster contributions to Darwin Holdings and/or Trefoil Steel along with other sources to the East contributing to the mean. The EA/SCC/RMBC 2018 project[6] further identified E.L.G. Haniel Metals Ltd as a Ni source in close proximity and in a similar direction from the Sheffield Tinsley monitoring station (see bearings in Table A1.3). In this study the modelled East cluster contribution has therefore been derived by subtracting the modelled contributions from category (a) and (b) sources from the measured proportion to determine a residual. Since the three unknown contributions within the East cluster are not uniquely identified, and in the absence of other information, the modelled contributions from category (c) sources are combined and a single constant scaling factor has been applied to make the summed contributions match this residual.

The KCL study attributes the remainder of the concentration observed at the Sheffield Tinsley monitoring station to the West cluster contributions, corresponding to emissions from over half of the Ni emitting industries in Sheffield. In this study, the modelled West contribution has been derived from those local sources within this cluster without scaling, and the remaining background contributions from other sources from the PCM national modelling have been added to this and the South and East contributions to make the total modelled Ni concentration for 2018. No attempt has been made to assign the small residual within the West cluster that is not accounted for by the modelled components.

Figure A1.3 shows how different modelled contributions have been combined. It must be noted that the source apportionment derived in this study depends on the representativeness of the KCL study for the year 2018. Within the results (Section A1.3) the combined output is referred to as Ni 2018b.

Figure A1.3 – Schematic of process to combine modelled contributions



A1.3. Model results

The results from the modelling study are presented in terms of concentration maps including a review of compliance impacts within the study domain (Section A1.3.1), and source apportionment in comparison to observations (Section A1.3.2).

A1.3.1. Concentration maps and compliance impact

Figure A1.4 presents a subset of the 2018 annual mean Ni concentration map for the Sheffield area from this study that excludes the contributions from the scaled sources. It is notable that even excluding the scaled contributions, exceedances of the Ni TV (20 ng mg^{-3}) are modelled in the vicinity of the Outokumpu site to the South of the Sheffield Tinsley monitoring station and in the vicinity of sources to the North and North East. The footprint of the modelled exceedance in this case does not extend to the location of the Sheffield Tinsley monitoring station.

Figure A1.5 presents the modelled total 2018 annual mean Ni concentration map for the Sheffield area from this study including the contributions from the scaled sources. The contribution of scaled sources in the East cluster to the mapped total concentration is based on the use of a single constant scaling factor as noted in Section A1.2.3. Including the scaled contributions (noting this adds point, fugitive and diffuse contributions to the local sources identified in the KCL study (Green et al., 2017)[8] and the EA/SCC/RMBC 2018 project[6]) the area of exceedance of the Ni TV (20 ng mg^{-3}) extends from the sources to the North of the Sheffield Tinsley monitoring station down to the Outokumpu site to the South, with the footprint of the modelled exceedance including the location of the Sheffield Tinsley monitoring station. An inspection of the area of modelled exceedance compared to 1 km gridded population (2011 census) indicates population exposure from the area surrounding Outokumpu in the South to the Meadow Bank Road in the North. The model results also show the area of exceedance extends across the zone boundary to the South of Outokumpu into the neighbouring Yorkshire and Humberside non-agglomeration zone (UK0034).

A1.3.2. Source apportionment

Figure A1.6 shows the modelled Ni contribution from different sources at Sheffield monitoring site locations based upon the combined modelling output for 2018 (Ni 2018b). Measured concentrations at the sites are also presented, giving an indication of the level of agreement between modelled and measured concentrations. As noted in Section A1.2.3 the contribution of local sources categorised as (c) in Table A1.3 are uncertain and have been scaled such that the total modelled from the South and East clusters in this study match the percentages apportioned to these clusters in the KCL study[8]. This approach attributes the main industrial sources of Ni at the Sheffield Tinsley monitoring station to the South cluster (Outokumpu) and the East cluster (E.L.G. Haniel Metals, Darwin Holdings, Trefoil Steel). Since the unknown contributions in the East cluster are not separable and have been scaled using a single factor, their contribution is shown as an aggregated total in the source apportionment (labelled “Scaled contributions from North East (c)”). It is notable that excluding the scaled components, the Outokumpu site remains the main industrial source of Ni at both the Sheffield Tinsley and Sheffield Devonshire Green monitoring stations.

With no scaling applied to sources in the West cluster or the other background contributions from the national modelling, a small under prediction remains. The combined modelling output represents 95% of the observed concentration at Sheffield Tinsley, and 70% of the observed concentration at Sheffield Devonshire Green.

Figure A1.4 – Map of total annual mean Ni concentrations for 2018 from local fine-scale modelling of industrial sources based on reported (a) or derived (b) emissions, plus scaled contributions from uncertain local point/fugitive/diffuse sources (c) added to the background Ni concentrations from the national model.

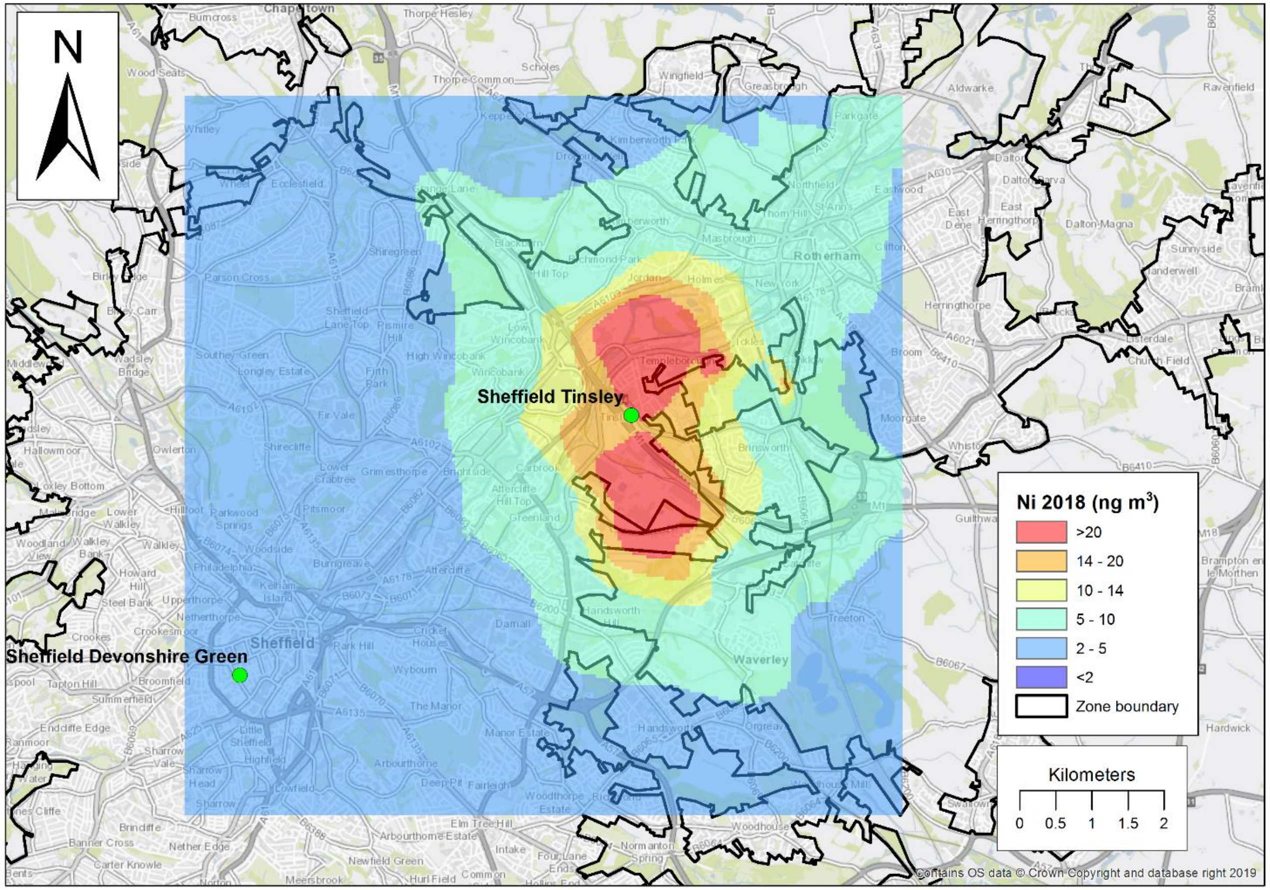
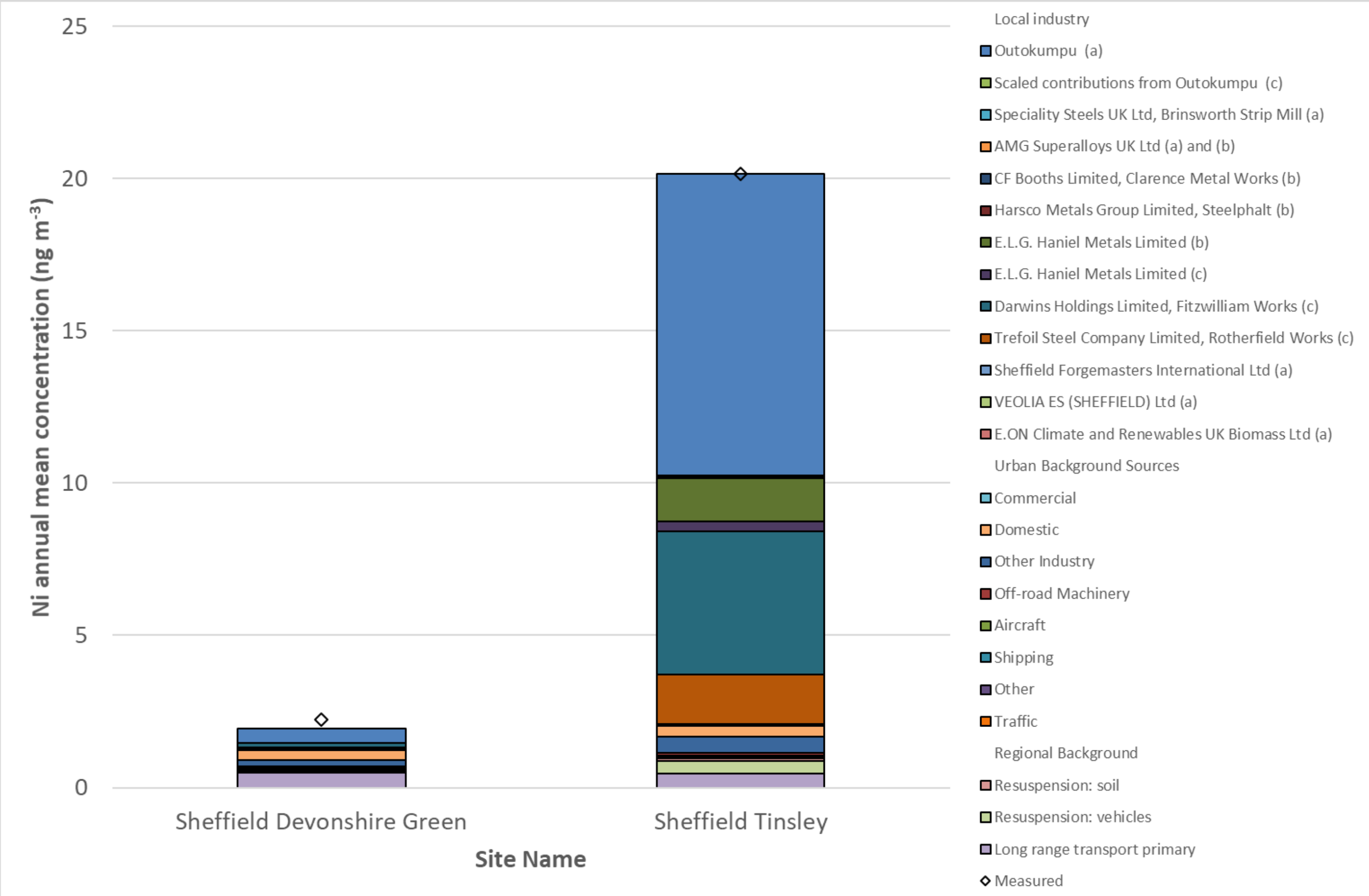


Figure A1.5 - Annual mean Ni source apportionment at Sheffield monitoring sites in 2018 (combined detailed and national modelling output)



A1.4. Conclusions

Based upon the results of the detailed modelling study present here:

- The detailed modelling indicates exceedances of the Ni TV (20 ng mg^{-3}) associated with the Outokumpu site and sites to the North of Sheffield Tinsley (including E.L.G. Haniel Metals, Darwin Holdings, and Trefoil Steel) although the individual contributions of the sources to the North East are not represented, and the magnitude of contributions and spatial extent of exceedances depends on the representativeness of the analysis in the KCL study (Green et al., 2017)[8] for the 2018 annual mean.
- The footprint of the modelled exceedance includes the Sheffield Tinsley monitoring station and inspection of the area of modelled exceedance compared to 1 km gridded population (2011 census) indicates population exposure from the area surrounding Outokumpu in the South to the Meadow Bank Road in the North. The model results also show the area of exceedance extends across the zone boundary to the South of Outokumpu into the neighbouring Yorkshire and Humberside non-agglomeration zone (UK0034).
- The source apportionment analysis suggests that the main industrial source of Ni at both the Sheffield Tinsley and Sheffield Devonshire Green monitoring stations is Outokumpu, with sites to the North of Sheffield Tinsley (including E.L.G. Haniel Metals, Darwin Holdings, and Trefoil Steel) contributing to the measured exceedance there.
- The combined modelling output represents 95% of the observed concentration at Sheffield Tinsley, and 70% of the observed concentration at Sheffield Devonshire Green.

Recommendations:

- A significant proportion of the total Ni concentration modelled in this study has been derived by scaling contributions from uncertain point, fugitive and diffuse emissions from the industrial sites noted above. There is scope for further improving understanding of the emissions, activity levels and timing of operations identified in KCL study[8] and the EA/SCC/RMBC 2018 project[6] which would focus attention on the main Ni emitters and provide information for modelling studies.
- The high temporal resolution monitoring conducted by NPL and KCL has been valuable in that it enables directional analysis and informs source apportionment. Should work be needed to interpret future exceedances or to analyse the impact of measures such monitoring campaigns would be recommended.
- The national modelling for compliance assessment does not capture the observed exceedance because not all of the sources identified in this study are fully captured by the NAEI. Data gathered in this study and resulting from measures to quantify and reduce emissions from industry in Sheffield, could be used to inform future modelling and compliance assessments.