

# Offsets Research:

## Proposal for the expansion of Eskom's AQO Program in the Highveld and Vaal

OCTOBER 30

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Revision: 03



### DOCUMENT TITLE

<b>Client</b>	Eskom Holdings SOC Ltd
<b>Title</b>	Proposal for the expansion of Eskom's AQO Program in the Highveld and Vaal
<b>Our Reference</b>	ESK-A16-AQOE-02
<b>Issued to Client</b>	30 <sup>th</sup> October 2024
<b>Classification</b>	Company Confidential

### DOCUMENT CHANGE RECORD

Revision Number	Date	Description of Revision
<b>00A</b>	21 <sup>st</sup> August 2024	Creation of Document
<b>00B</b>	5 <sup>th</sup> October 2024	Peer Review of Document
<b>00C</b>	6 <sup>th</sup> October 2024	Draft issued to Eskom
<b>01</b>	14 <sup>th</sup> October 2024	Revised Report issued to Eskom
<b>02</b>	15 <sup>th</sup> October 2024	Revised Report issued to Eskom
<b>03</b>	30 <sup>th</sup> October 2024	Final Report

### DOCUMENT APPROVAL

	Name	Date
<b>Prepared by</b>	Avishkar Ramandh	21 <sup>st</sup> August 2024
<b>Reviewed by</b>	Fred Goede	11 <sup>th</sup> October 2024
<b>Approved by</b>	Fred Goede	30 <sup>th</sup> October 2024

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# Executive Summary

## 1. Introduction

Eskom's coal and liquid fuel-fired power stations must comply with the Minimum Emission Standards (MES) as mandated by the National Environmental Management: Air Quality Act (NEMAQA). In 2019, Eskom submitted applications for postponements, suspensions, and alternative limits for several power stations, which led to various appeals against the National Air Quality Officer's (NAQO) decisions. In response, the Minister of Forestry, Fisheries and Environment established the National Environmental Consultative and Advisory (NECA) Forum in 2022 to address these appeals. The Minister supported the Forum's recommendation that any granted exemptions should be subject to specific limitations and conditions. Additionally, the NECA Forum advised Eskom to consider expanding its air quality offset program as part of its future emission reduction strategy and to seek legal flexibility regarding emission levels.

## 2. Study Scope

Eskom is preparing a Section 59 exemption application under the National Environmental Management: Air Quality Act (NEMAQA) for its remaining facilities. Air Resource Management (Pty) Ltd (herein referred to ARM) has been appointed by Eskom to support in evaluating options for further expansion of the air quality offset (AQO) program in the Highveld and Vaal, specifically for the Lethabo, Duvha, Matla, Tutuka, Kendal, and Majuba power stations.

## 3. Study Approach

A phased approach was undertaken for the study. Phase 1 reviewed Eskom's criteria utilised for the selection of offset settlements and interventions for Eskom's AQO Program in 2017 (Eskom, 2017a, Eskom, 2017b). Phase 2 evaluated the current Eskom AQO program to determine whether the AQO settlements & interventions selected in 2017 by

Eskom remain relevant. Further Phase 2 investigated potential other offset settlements and interventions that may need to be considered for inclusion in Eskom's AQO Program. The findings from the Phase 2 study were leveraged as input for Phase 3 of this research. In Phase 3, ARM determined the estimated additional number of households for the expansion of Eskom's AQO Program, assessed the associated air quality benefits in terms of net pollutant reductions, and prioritized air quality hotspots for the program's expansion.

## **4. Study Results**

### **4.1 Relevance of 2017 Eskom selected settlements**

The offset settlements selected in 2017 were based on the impact of the emissions from each power station. This information was extracted from the 2014 Atmospheric Impact Reports which was based on the prevailing meteorology and Eskom operating envelope for 2014. ARM used the dispersion modeling simulated results for Eskom's 2024 Exemption Application (uMoyo NILU, 2024) to assess the current air quality impact of the power stations on the surrounding environment in both the Highveld and Vaal regions. Additionally, an assessment of compliance with the NAAQS was conducted utilising data from both modelled and measured data. The analysis showed that elevated PM concentrations were localised around the power stations (Figure i). Furthermore, an analysis of the DFFE ambient air quality monitoring data showed that the NAAQS was exceeded at the selected offset settlements. The results of this assessment clearly demonstrated that the offset settlements identified and selected by Eskom in 2017 are still relevant for the Lethabo, Duvha, Matla, Tutuka, Kendal, and Majuba power stations.

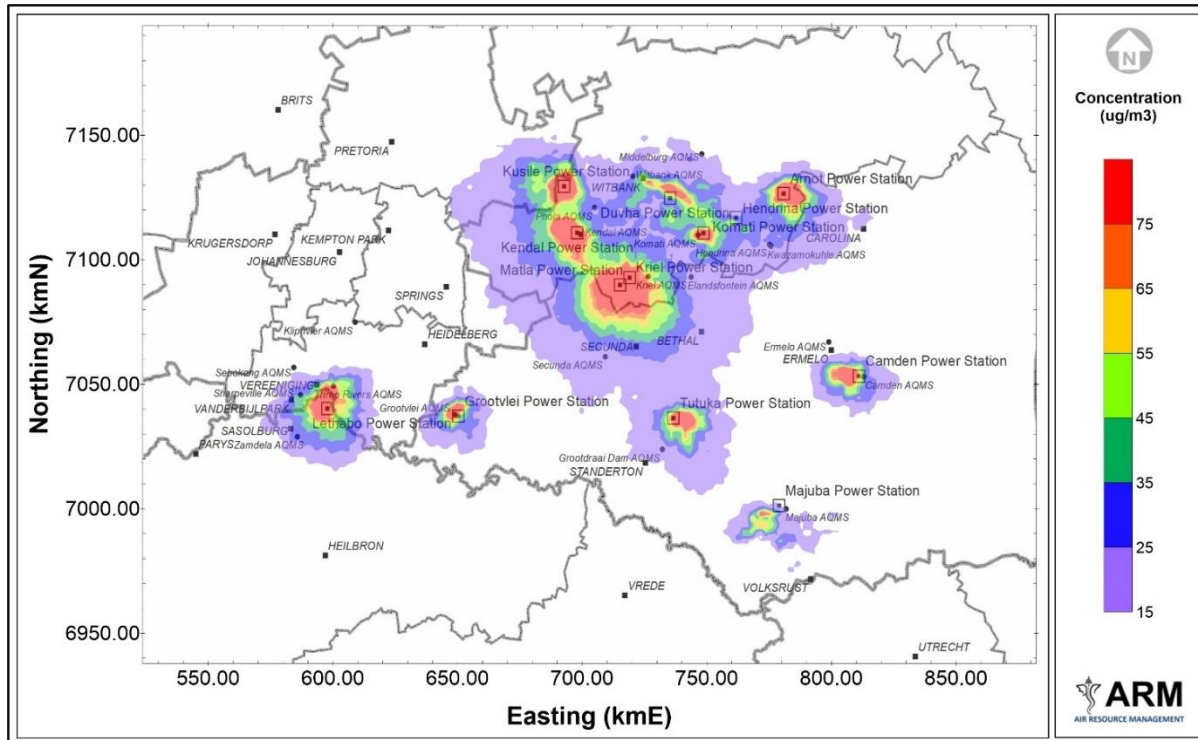


Figure i: Simulated Particulate Matter (PM10), 24-hour, 99th percentile concentrations (NAAQS is 75.0 ug/m3)

## 4.2 Relevance of 2017 Eskom selected interventions

ARM conducted a review of the regulatory air quality offsetting landscape to identify potential other AQO interventions. Additionally, a high-level desktop pre-feasibility study was undertaken to identify the most effective interventions for offsetting emissions from Eskom. The findings of ARM’s literature and high-level desktop feasibility analysis support the current suite of AQO interventions that Eskom is rolling out. ARM recommendation is therefore that Eskom continues with the current suite of interventions for both households and waste. ARM suggests the following improvements for Eskom to consider in the future implementation of these AQO interventions:

- To develop suitable financing models (such as credit) with local retailers & fuel merchants for the supply and access to gas in the community.
- Given the rising cost of living, we propose offering 5kg and 9kg LPG cylinders instead. The more affordable 5kg cylinder will contribute to long-term sustainability of Eskom’s AQO Project.

- To establish a network of community technicians capable of offering both repairs and replacement parts for the provided stoves.
- To consider replacing any rusted components of the roof prior to application of the SPF ceiling.

Additionally, ARM proposes Eskom considers the follows AQO intervention options:

- ✓ Implementing dust suppression/solutions of unpaved roads in low-income settlements
- ✓ Implementing veld fire management solutions
- ✓ Eskom evaluates the feasibility of mini and micro grids in appropriate locations
- ✓ Eskom in conjunction with local municipalities assess the potential for biogas generation from Waste and Sewage treatment plants.

Before implementing these solutions, it is essential that Eskom conducts a thorough study on their viability to ensure they can be effectively realized in practice. Additionally, an in-depth analysis of their economic feasibility is crucial to determine whether the benefits outweigh the costs involved. Practicality must also be assessed to identify any potential challenges or barriers that could hinder successful execution. Only after these detailed evaluations can informed decisions be made regarding the adoption of these solutions as part of Eskom's future AQO Program.

## **4.3 Expansion of Eskom's AQO Program**

### **4.3.1 Scale of the intervention**

The indicative number of households for the expansion of Eskom's AQO Program is shown in Table i. Table i indicates the estimated total number of households available for air quality offsetting; however, the actual number to be targeted will depend on Eskom's financial situation and its capacity to implement the AQO Program in these areas. Due to the absence of ward-level data from the 2022 Census dataset, ARM employed linear extrapolation using municipal and ward data from StatsSA for 2011, 2016, and 2022 to estimate the total number of households presented in Table i. It is recommended that

these household figures be updated once the 2022 StatsSA ward-level data is publicly released later this year.

**Table i: Indicative number of households for the expansion of Eskom AQO Program**

Power Station	Area selected for Offsets	Population		Indicative number of households for air quality offsets			Type of Offset
		Eskom 2017 OIP	ARM 2024 Study	Eskom 2017 OIP	ARM 2024 Study	Potential Expansion of Eskom AQO Program	
<b>Duvha</b>	Masakhane	3 740	4 107	1 108	1 218	<b>110</b>	Household
	eMalahleni	No Data	119 328	2 000	23 211	<b>21 211</b>	Household
<b>Kendal</b>	Rietspruit	No Data	5 724	No Data	1 360	<b>1 360</b>	Household
	Phola	8913 <sup>1</sup>	35 012	6 016	6 608	<b>592</b>	Household
<b>Lethabo</b>	Refengkotso	17 646	18 745	NA	NA	<b>(9035m<sup>3</sup>)<sup>2</sup></b>	Waste
	Sharpeville	37 599	49 269	NA	NA	<b>(9035m<sup>3</sup>)<sup>2</sup></b>	Waste
	Tshepiso	29 271	38 353	NA	NA	<b>(9035m<sup>3</sup>)<sup>2</sup></b>	Waste
	Boipatong	22 167	29 049	NA	NA	<b>(9035m<sup>3</sup>)<sup>2</sup></b>	Waste
<b>Majuba</b>	Daggakraal/Sinqobile	14 856	25 650	2 940	3 819	<b>879</b>	Household
	Ezamokuhle	10 293	14 794	1 850	2 673	<b>823</b>	Household
<b>Matla</b>	Emzimnoni	No Data	32 940	6 065	6150	<b>85</b>	Household
	Kananna Ext 6	No Data	3 238	551	583	<b>32</b>	Household
	Milan Park	No Data	11 952	1 035	2 468	<b>1 433</b>	Household
	Thambo	No Data	2 152	845 <sup>3</sup>	408	<b>NA</b>	Household

<sup>1</sup> The population number provided for Phola in OIP (Eskom, 2017) is erroneously stated as 8913 for 2011, however it was 31,885 in 2011 (StatsSA, 2011).

<sup>2</sup> This estimate is calculated based on the six cleanup campaigns conducted to date as part of Eskom's AQO project for Sharpeville (*pers comm*, Matimolane, 2024)

<sup>3</sup> Its noted that as per StatsSa (2011), only 264 households utilised coal. Further the Eskom OIP (2017) indicated Thambo had a total of 610 households however a larger number than this (1160) total number of households was chosen herein.

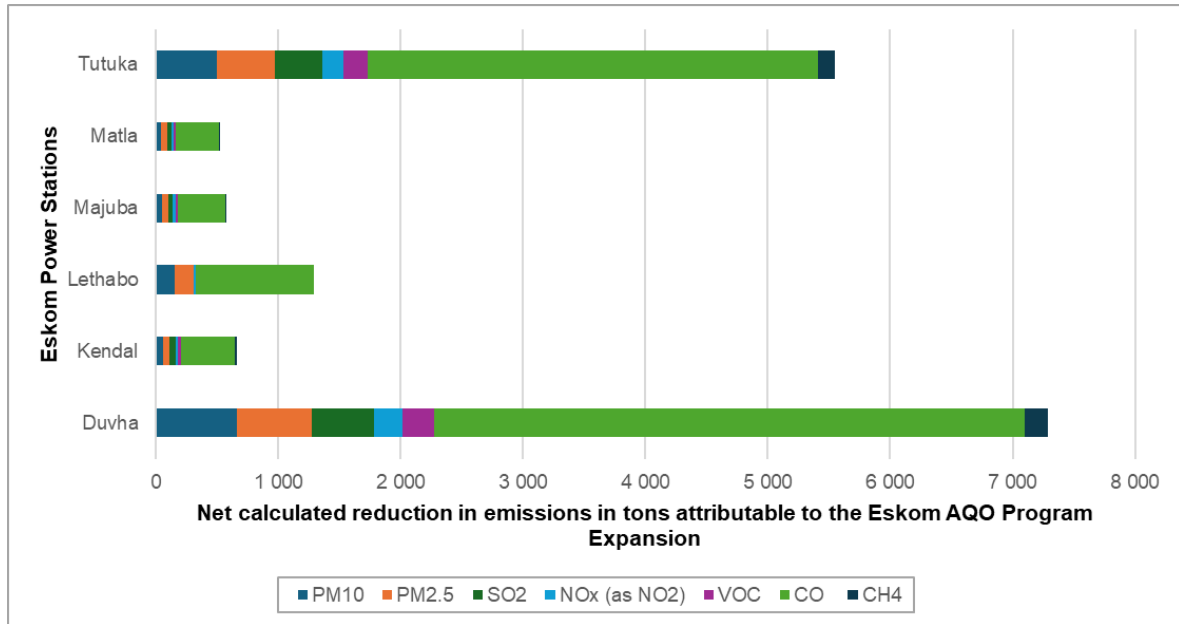
Power Station	Area selected for Offsets	Population		Indicative number of households for air quality offsets			Type of Offset
		Eskom 2017 OIP	ARM 2024 Study	Eskom 2017 OIP	ARM 2024 Study	Potential Expansion of Eskom AQO Program	
Tutuka	Sivukile	5 757	5 954	1160 <sup>4</sup>	1 155	NA	Household
	Thuthukani	2 670	2 757	400	599	199	Household
	Standerton	No Data	45 490	No Data	8 004	8 004	Household
	Sakhile	No Data	41 819	No Data	8 038	8 038	Household
<b>Total</b>		<b>152980</b>	<b>486333</b>	<b>24462</b>	<b>85839</b>	<b>62311</b>	

#### 4.3.2 Potential air quality benefit (Nett emissions avoided)

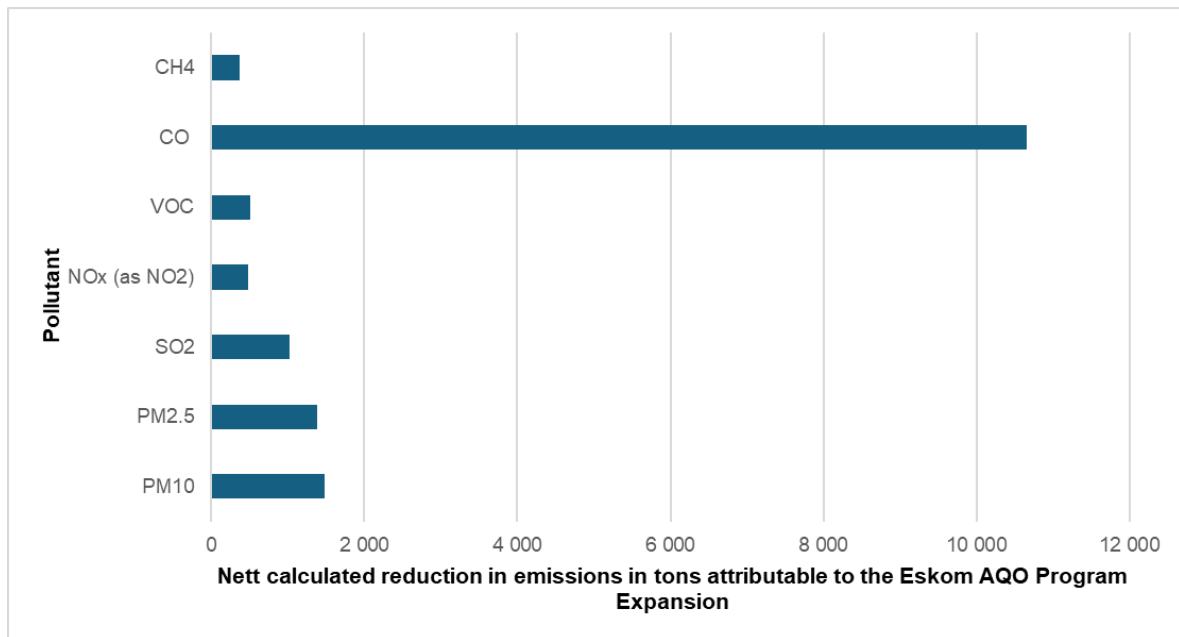
The potential net reductions in: PM<sub>10</sub>; PM<sub>2.5</sub>; SO<sub>2</sub>; NO<sub>x</sub> (as NO<sub>2</sub>); VOC; CO; CH<sub>4</sub> emissions attributable to Eskom's AQO intervention were quantified utilising appropriate emission factors. The net calculated reductions in emissions (tons) attributable to the expansion of Eskom's AQO Program is presented in Figure ii & iii.

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<sup>4</sup> The Eskom OIP (2017) indicated for Sivukile a total of 690 households utilised coal as per StatsSA however a larger number than this (1160) total number of households was chosen herein.



**Figure ii: Nett calculated reduction in emissions (tons) attributable the expansion of Eskom AQO Program per Power Station**



**Figure iii: Summary of the nett calculated reduction in emissions (tons) attributable the expansion of Eskom AQO Program**

### 4.3.3 Prioritisation of offset areas

The Harvard Six Cities cohort study found that fine particulate (PM<sub>2.5</sub>) pose a greater risk to human health because this can penetrate deep into the lungs and is more toxic than larger particles (PM<sub>10</sub>) (Dockery, 1993). Thus, the prioritisation of air quality hotspots for the expansion of Eskom’s AQO program was ranked on the basis of air quality impacts, ie. net emissions avoided for PM<sub>2.5</sub>. This ensures that the areas that potentially pose the greatest risk to human health and the environment are prioritised in the expanded roll-out of Eskom’s AQO program. The results are presented in Table ii directionally indicates rollout of a household offset intervention at eMalahleni should be prioritised first in the expansion of Eskom’s AQO Program.

**Table ii: Prioritisation of areas for the potential expansion of Eskom AQO Program**

Power Station	Area selected for Offsets	PM <sub>2.5</sub>	Type of Offset	Priority
Duvha	eMalahleni	611,39	Household	1
Tutuka	Sakhile	231,69	Household	2
	Standerton	230,71	Household	3
Matla	Milan Park	41,30	Household	4
Kendal	Rietspruit	39,20	Household	5
Lethabo	Refengkotso	38,70	Waste	6
	Sharpeville	38,70	Waste	7
	Tshepiso	38,70	Waste	8
	Boipatong	38,70	Waste	9
Majuba	Daggakraal/Sinqobile	25,34	Household	10
	Ezamokuhle	23,72	Household	11
Kendal	Phola	17,06	Household	12
Tutuka	Thuthukani	5,74	Household	13
Duvha	Masakhane	3,17	Household	14
Matla	Emzimnoni	2,45	Household	15
	Kananna Ext 6	0,92	Household	16

## 5. Conclusion

Air quality offsets represent a critical path aimed at addressing emission sources within communities residing near Eskom's coal-fired power stations (Matimolane, 2024). Offsets must focus primarily on pollutants whose ambient air quality standards are being exceeded or likely to be exceeded in the region (DFFE, 2016). ARM proposes that Eskom

considers, based on the company's financial viability, to implement offset projects in a phased approach to ensure progressive air quality improvement and effective resource allocation. By rolling out the AQO projects incrementally, Eskom can gather valuable insights, unpack potential blindspots and make informed decisions that align with the sustainability principles and objectives outlined in the National Environmental Management Act (NEMA) 107 of 1998. Eskom's AQO interventions can provide an option for achieving improvements in ambient air quality, and thereby improving human health while promoting a sustainable benefit to the community.

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# Glossary

Definitions in terms of the National Environmental Management: Air Quality Act (Act No. 39 of 2004) (NEM:AQA) and definitions of terms as per GN 893 which have relevance herein:

**Existing Plant:** Any plant or process that was legally authorized to operate before 1 April 2010 or any plant where an application for authorisation in terms of the National Environmental Management Act 1998 (Act No.107 of 1998), was made before 1 April 2010.

**Licensing authority** – refers to an authority responsible for implementing the licensing system.

**Listed activity** – In terms of Section 21 of the NEM:AQA, the Minister of Environment, Forestry and Fisheries (formerly Environmental Affairs) has listed activities that require an AEL. Listed activities must comply with prescribed emission standards. The standards are predominantly based on ‘point sources’, which are single identifiable sources of emissions, with fixed location, including industrial emission stacks, called a “point of compliance”.

**New Plant** - Any plant or process where the application for authorisation in terms of the National Environmental Management Act 1998 (Act No.107 of 1998), was made on or after 1 April 2010.

**Point source** – A single identifiable source and fixed location of atmospheric emission and includes smokestacks.

**GN 893** – Government Notice 893, Gazette No. 37054 dated 22 November 2013, published in terms of Section 21 of the NEM:AQA and entitled ‘List of Activities which

Result in Atmospheric Emissions which have or may have a Significant Detrimental Effect on the Environment, Including Health and Social Conditions, Economic Conditions, Ecological Conditions or Cultural Heritage'. GN 893 repeals the prior List of Activities published in terms of Section 21, namely GN 248, Gazette No. 33064 dated. 31 March 2010. GN 893 deal with aspects including: the identification of activities which result in atmospheric emissions; establishing minimum emissions standards for listed activities; prescribing compliance timeframes by which minimum emissions standards must be achieved; and detailing the requirements for applications for postponement of stipulated compliance timeframes. Amendments to GN 893 have been made in 2015 (GN 551) and in 2018 (GN1207).

**GN 1207** - Government Notice 1207, Gazette No. 42013 dated 31 October 2018, published in terms of Section 21 of the NEM: AQA and entitled 'Amendments to the Listed Activities and Associated Minimum Emission Standards Identified in Terms of Section 21 of the National Environment Management: Air Quality Act, 2004 (Act No.39 of 2004).

**Minimum Emissions Standards (MES)** – Prescribed maximum emission limits and the manner in which they must be measured, for specified pollutants. These standards are published in Part 3 of GN 893, as amended by GN551 and GN1207. These standards are referred to herein as MES.

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## List of abbreviations

AAQ	Ambient Air Quality
AEL	Atmospheric Emission License
AQMS	Ambient Air Quality Monitoring Station
ARM	Air Resource Management
DFFE	Department of Forestry, Fisheries and Environment
Eskom	Eskom Holdings SOC Limited
GNR	Gazette Notice
HPA	Highveld Priority Area
MES	Minimum Emission Standard
MINISTER	Minister of Forestry, Fisheries and Environment
NAQO	National Air Quality Officer
NEMA	National Environmental Management Act: No. 107 of 1998
NEMAQA	National Environmental Management: Air Quality Act 39 of 2004
NECA	National Environmental Consultative and Advisory Forum
VTAPA	Vaal Triangle Priority Area

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# 1. Introduction

## 1.1 Background

All of Eskom's coal and liquid fuel-fired power stations are required to meet the Minimum Emission Standards (MES) as regulated in terms of section 21 of the National Environmental Management: Air Quality Act (Act No. 39 of 2004) (NEMAQA). In 2019, Eskom submitted a batch of postponement, suspension and alternative limit applications that included: Duvha, Kendal, Majuba, Camden, Kriel, Matla, Hendrina, Arnot, Komati, Lethabo, Medupi, Matimba, Port Rex and Grootvlei power stations. In 2021, the National Air Quality Officer (NAQO) issued her decisions on the 16 applications received. Table 1 provides a summary of the NAQO's decision.

**Table 1: Summary of NAQO decision for each power station**

Adverse Decisions	Partial refusals	Granted
Matla	Majuba	Grootvlei
Duvha	Tutuka	Arnot
Matimba	Kendal	Komati
Medupi	Kriel	Camden
Lethabo		Hendrina
		Acaia
		Port Rex

The Appeals Directorate within the Department received various appeals against the decisions that were taken by the NAQO in relations to Eskom's suspension applications. In 2022, the Minister of Forestry, Fisheries and Environment established a consultative forum in terms of section 3A of the NEMA as amended, namely the National Environmental Consultative and Advisory (NECA) Forum, to deal with the various issues arising from the appeals lodged against the decisions that were taken by the NAQO in relation to the Listed Activities/ Section 21 Notice.

## 1.2 Ministers' interim solution

The Minister considered and accepted the NECA Forum's recommendation that based on its analysis of the applicable legislative framework, an interim solution is required to address the challenges that Eskom faces, which is lawful and that seeks to balance the competing interests which include, among others, the impact of non-compliance with the MES on health; ambient air quality standards; the energy crisis facing South Africa; the cost of retrofitting plants, socio-economic considerations and commitments to reducing GHG emissions. Thus, the NECA Forum stated that the only way for Eskom to comply is to obtain an exemption from the List of Activities or certain provisions thereof, in terms of section 59 of NEMAQA.

The Minister agreed with the Forum's recommendation that if any section 59 exemption is granted, which will depend on the merits of each application, it be subject to limitations and conditions. The Minister further stated that in terms of the National Environmental Framework of 2017, there are four main sources of emissions (listed Activities contemplated in section 21 of NEMAQA; burning of domestic fuel (coal/wood/paraffin); vehicle emissions; and mining emission) which have an adverse impact on AAQ in the Highveld Priority Area (HPA) and Vaal Triangle Priority Area (VTAPA).

Further the Minister agreed with the Forum that, while there is no explicit legal obligation on Eskom to address emissions from the burning of domestic fuel (coal/ wood/ paraffin); vehicles; and mining activities, it has some of the largest operations in the Priority Areas. Therefore, more is required from Eskom to not only comply with section 21 of NEMAQA, but to implement further measures to address other sources of emissions that adversely affect AAQ in the areas in which it operates. In addition, the National Environmental Framework requires stakeholders to adopt a holistic approach to addressing issues related to air quality.

### 1.3 Ministers’ decision

In relation to the Power stations to be decommissioned (Hendrina, Grootvlei, Arnot, Camden and Kriel) Eskom was directed to submit decommissioning plans within 12 months of the issuance of this decision, including the conditions imposed by the NAQO on Eskom in respect thereof. In respect of the remaining facilities (Matla; Duvha; Tutuka; and Kendal), Eskom was directed to submit, within 60 days of the issuance of this decision, an application in terms of section 59 of the NEMAQA for an exemption in respect of each of these facilities from the provisions of the Act, for the Ministers consideration and determination. The Minister further notes the Forum's work in developing a number of conditions and limitations which may imposed on Eskom should any of its section 59 exemption applications be successful.

### 1.4 Scope of Work

The NECA Forum has advised that Eskom consider expanding its air quality offset program as part of any future emission reduction strategy and request legal indulgence on emission levels. Eskom is preparing a Section 59 exemption application under the National Environmental Management: Air Quality Act (NEMAQA) for its remaining facilities. Air Resource Management (Pty) Ltd (herein referred to ARM) has been appointed by Eskom to support in evaluating options for further expansion of the air quality offset (AQO) program in the Highveld and Vaal, specifically for the Lethabo, Duvha, Matla, Tutuka, Kendal, and Majuba power stations (Table 2). The detailed scope of work is provided in Annexure 2.

**Table 2: List of Power Stations included in the Study**

Power Station	Province	District Municipality (DM)	Local Municipality (LM)
Lethabo	Free State	Fezile Dabi	Metsimaholo
Duvha	Mpumalanga	Nkangala	Emalahleni
Matla			Lekwa
Kendal		Gert Sibande	Dr Pixley Ka Isaka Seme
Tutuka			
Majuba			

## 2. Study Approach

A phased approach was undertaken for the study as illustrated by Figure 1. Phase 1 is a high-level summary of selection criteria utilised for Eskom’s AQO program. Phase 2 of this Study is an assessment and evaluation of the current Eskom AQO program to determine whether the sites & interventions that were selected in 2016 (Eskom, 2017a, Eskom, 2017b) by Eskom remain relevant. Further Phase 2 investigated potential other geographic areas and interventions that may need to be included. Phase 3 provides practical recommendations regarding the prioritisation of areas, interventions, and scale, as well as the potential air quality benefits for Eskom to consider.

Sections 2.1 to 2.3 unpacks the detailed approach for each of these study phases.

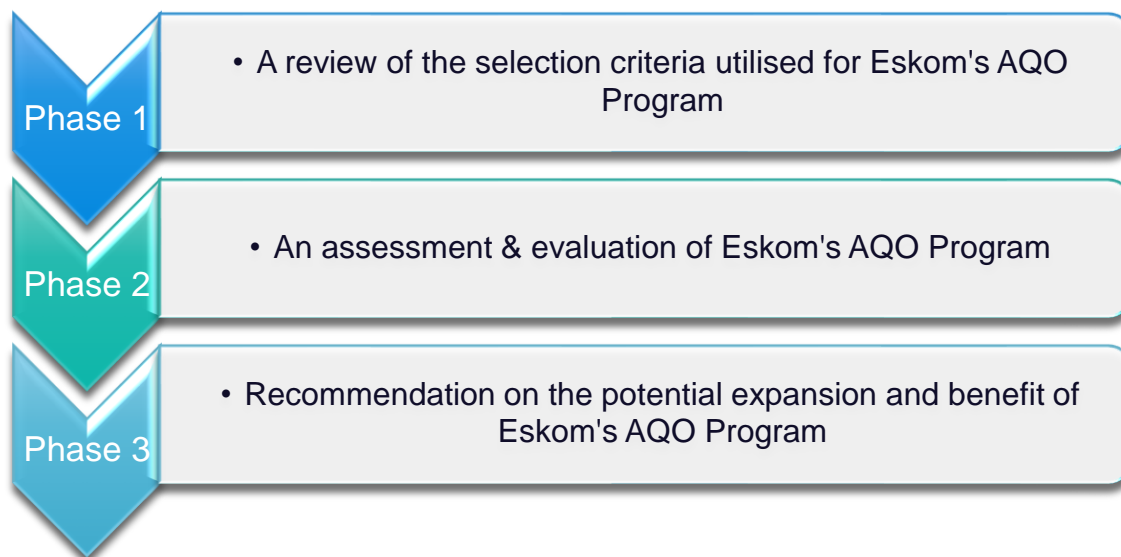


Figure 1: Phased approach to the Study

## 2.1 Phase 1: A review of the selection criteria utilised for Eskom's AQO Program

### 2.1.1 Eskom's approach to AQO

The Department of Forestry, Fisheries and Environment (DFFE) AQO Guideline (DFFE, 2016) sets out the legislative context for air quality offsets, and states that 'offsets can provide an option for achieving improvements in ambient air quality, thereby improving human health while promoting justifiable economic development.' Eskom has adopted the definition of an air quality offsets given in this document as *'an intervention, or interventions, specifically implemented to counterbalance the adverse and residual environmental impact of atmospheric emissions in order to deliver a net ambient air quality benefit within, but not limited to, the affected airshed where ambient air quality standards are being or have the potential to be exceeded and whereby opportunities and need for offsetting exist'* (Eskom, 2017). Thus, AQO represent a critical path aimed at addressing emission sources within communities residing near Eskom's coal-fired power stations located in various district municipalities (Matimolane, 2024). Eskom's offsetting philosophy is underpinned by several principles (Figure 2) (Eskom, 2017).

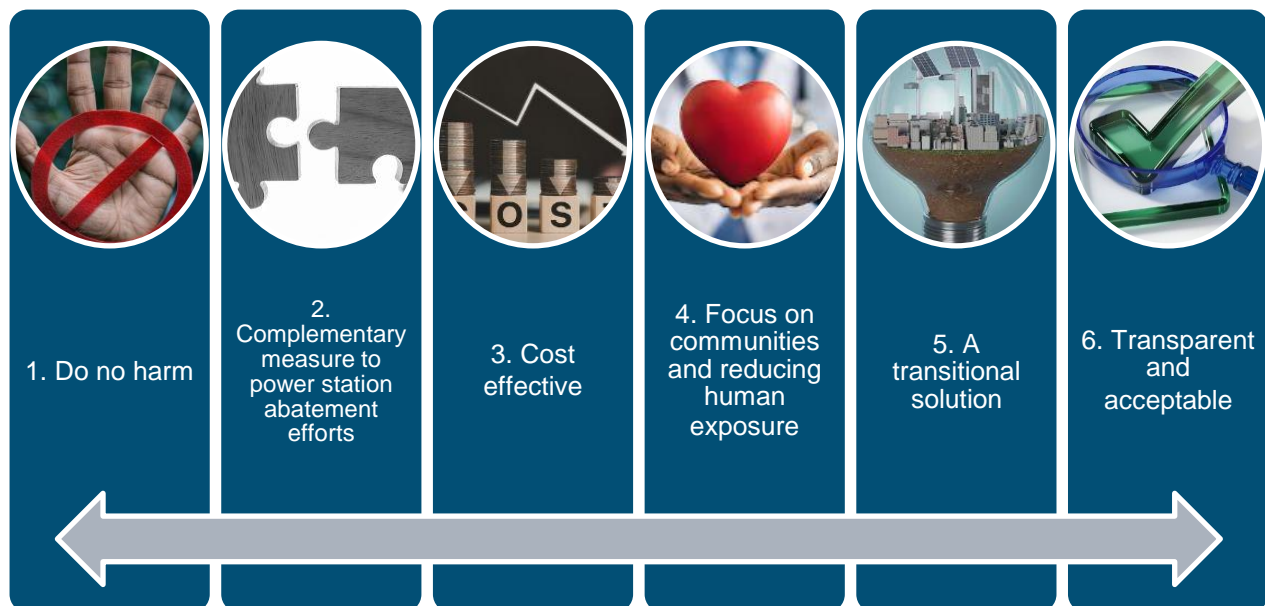


Figure 2: Eskom's AQO Principles

### **2.1.2 Eskom's criteria for the selection of settlements for AQO**

According to Eskom's Air Quality Offset Implementation Plans, initially submitted for Nkangala District Municipality, Gert Sibande District Municipality, and Lethabo Power Station (Eskom 2017a, Eskom 2017b and Eskom 2017c), the methodology used to select the areas for offsetting for each Eskom power station was based on the definitions of an air quality offset in the DFFE's AQO Guideline published on 18 March 2016:

*“an offset is an intervention, or interventions, specifically implemented to counterbalance the adverse and residual environmental impact of atmospheric emissions in order to deliver a net ambient air quality benefit within, but not limited to, the affected airshed where ambient air quality standards are being or have the potential to be exceeded and whereby opportunities and need for offsetting exist.”*

In accordance with this, the following area selection criteria were utilised to select the areas where offsets will be implemented for power stations that are required to implement offsets:

- 1) Areas are prioritised based on the impact of emissions from the power station (in order to achieve the objective of 'counterbalancing the adverse and residual environmental impact of atmospheric emissions').
- 2) Only areas where there is (probably) non-compliance with ambient air quality standards are considered.
- 3) Only areas where opportunities and need for improving ambient air quality through offsetting exist, are considered (i.e. areas where there are local sources of emissions which significantly impact ambient air quality and can be addressed through offsets).

### **2.1.3 Eskom's criteria for the selection of interventions**

The main focus of Eskom's offsets program is to reduce emissions from domestic solid fuel burning, based on scientific evidence that shows that of all sources of air pollution in South Africa, domestic burning has by far the greatest impact on human health (FRIDGE,

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2004; MRC, 2008; Lim et al. (2012)) (Eskom, 2017a, Eskom, 2017b). According to the findings of Fischer and Sanchez (2013), there has been a steady move away from domestic coal burning in the Vaal over the last decade or so, and it is estimated that between 10% and 20% of households in lower income areas use coal for cooking and heating (compared to 50-70% of households in lower income areas in Mpumalanga). Thus, for the Vaal, waste burning has been identified as another significant source of local emissions in many settlements (Eskom 2017c).

## **2.2 Phase 2: An assessment & evaluation of Eskom's AQO Program**

In essence Phase 2 of this study will evaluate two key areas that Eskom utilised in the development of its current AQO program (Eskom, 2017a, Eskom, 2017b, Eskom, 2017c). The first is the “where” ie. the selection of settlements (section 2.1.2) and secondly the “what”, ie. selection of AQO interventions (section 2.1.3). Further Phase 2 will investigate potential other geographic areas and interventions that may need to be included (Figure 3).

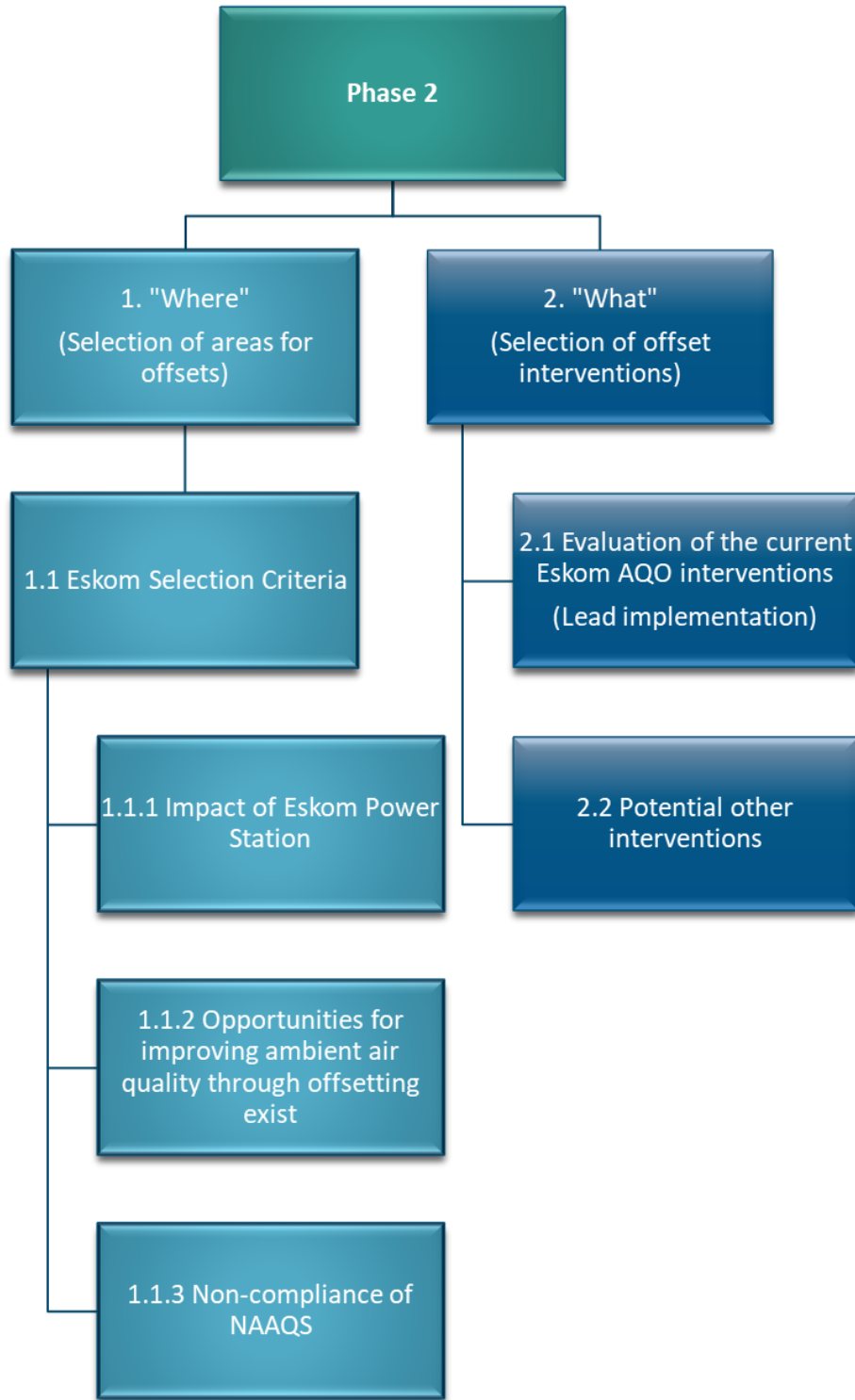


Figure 3: Evaluation of the two key areas utilised in the development of the current Eskom AQO Program

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### 2.2.1 An evaluation of the “Where”

As indicated in section 2.1.2, Eskom’s criteria for the selection of settlements for AQO in 2017 (Eskom 2017a, 2017b, 2017c) was based on 3 variables:

- 1) Areas are prioritised based on the impact of emissions from the power station;
- 2) Only areas where opportunities for improving ambient air quality through offsetting exist, are considered.
- 3) Only areas where there is (probably) non-compliance with ambient air quality standards are considered.

However, its noted that since 2017, these initial findings *may* have since evolved due to the following:

#### 1) Areas are prioritised based on the impact of emissions from the power station

- The area of impact of the emissions from each power station (annual average concentrations in ug/m<sup>3</sup>) were extracted from the 2014 Atmospheric Impact Reports submitted in support of Eskom’s application for postponement of the Minimum Emission Standards compliance timeframes for each of the power stations (uMoya-NILU, 2014)
- Air quality is strongly influenced by meteorology which covers an array of atmospheric processes that determines the evolution of emissions, chemical species, aerosols and particulate matter (Seaman, 2000). Thus, the performance of atmospheric dispersion models depends critically on the meteorological data to simulate the fate and transport of air pollution (Busillo et al., 2005; Davakis et al., 2007). The representativeness of meteorological data is a key factor in accurately modelling the dispersion of these pollutants since meteorological conditions are not uniform over larger distances or in complex terrain, coastal environments, or in urban areas. It’s possible that the prevailing meteorology for the Highveld and/or Vaal may have changed from 2014 to 2024 thus affecting the dispersion and transport of Eskom’s stack emissions & resultant air quality impact.

- These results were based on 2014 operational envelope for the Eskom Power Stations and its plausible that this has changed in 2024 thus these results from 2014 may no longer be representative of Eskom’s air quality impact herein.

**2) Only areas where opportunities for improving ambient air quality through offsetting exist, are considered.**

- According to Eskom’s AQO Implementation Plans (Eskom 2017a, 2017b, 2017c), areas where opportunities for improving ambient air quality through offsetting exist, were considered based on the StatsSA 2011 Census data. The 2011 Census data utilised variables on total population, energy usage patterns and indicative number of households that will participate in the offsets roll-out in the target areas for Eskom’s AQO program. It’s noted that the 2011 Census data is outdated in 2024 as the variables for energy use, income and population has changed. The proportional of households that use dirty fuels as primary energy carriers for cooking, space heating or lighting has plausibly changed as well.

**3) Only areas where there is (probably) non-compliance with ambient air quality standards are considered.**

- Its noted Eskom’s AQO Plan utilised ambient air quality monitoring data pre 2017 (Eskom 2017a, 2017b, 2017c), thus its need to be tested if there are still National Ambient Air Quality Standard (NAAQS) exceedances at these airsheds in 2024.

Figure 4 provides an overview of ARM approach to evaluate the “Where” for Eskom’s current AQO Project. This approach is detailed in sections 2.2.1.1 to 2.2.1.3 to litmus-test the assumptions outlined above.

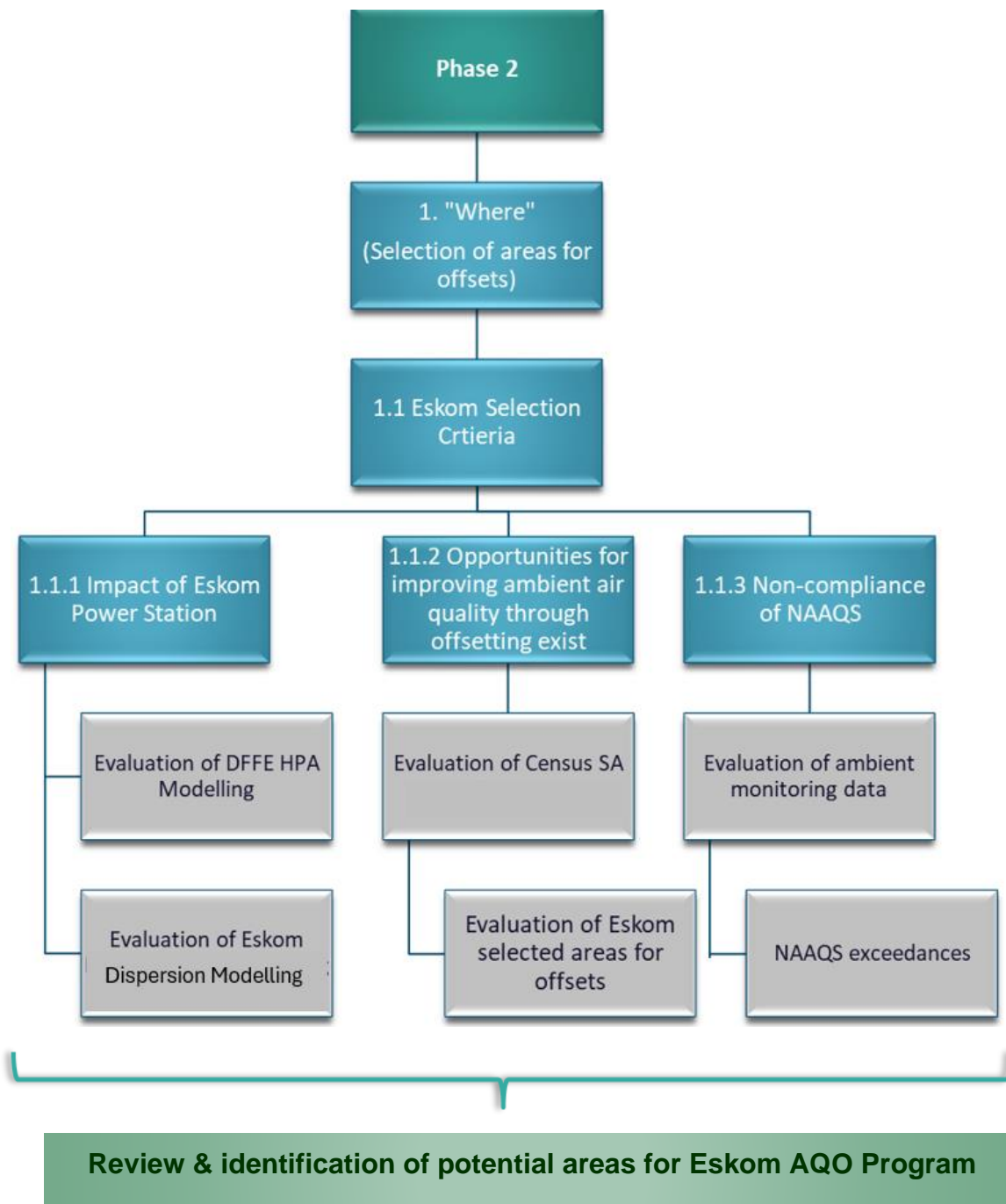


Figure 4: Study Approach for Phase 2 – Process to review the current & potentially new areas for Eskom AQO program

### **2.2.1.1 Areas are prioritised based on the impact of emissions from the power station**

#### **1) 2024 Atmospheric Impact Report in Support of Eskom's MES Exemption Application**

uMoya NILU, an independent consulting firm, was appointed by Eskom to undertake the atmospheric impact assessment reports in support of Eskom's 2024 Exemption Application. A dispersion modelling assessment aligned to the Code of Practice for Air Dispersion Modelling in Air Quality Management in South Africa (Gazette No 37804, 2014) was utilised to determine the potential impact of the Eskom Power Stations on the receiving environment. For this study, a Level 3 (Tier 3) modelling assessment, the US-EPA approved California Puff (CALPUFF) modelling suite was utilised. CALPUFF is a multi-layer, multi-species non-steady-state puff dispersion model that simulates the effects of time- and space-varying meteorological conditions on pollution transport, transformation and removal.

It is noted that ARM utilised the CALPUFF model simulated results for the "*Eskom Current Emissions*" scenario to determine the air quality impact of the Power Stations (Table 2) on the receiving environment. This scenario utilised the actual Power Station performance (load & emissions) for the period 2021 to 2023 (uMoya NILU, 2024). Furthermore, the meteorological dataset utilised in these simulations is for the period 2021 to 2023 and hence is representative of prevailing meteorology for the both the HPA and VTPA.

#### **2) The Second-Generation Air Quality Management Plan For The Highveld Priority Area: Baseline Air Quality Assessment Report**

The objective of *The Second-Generation Air Quality Management Plan for the HPA Baseline Characterisation* was two-fold: to determine the current state of air quality in the HPA, and to assess whether the interventions set by the 2011 HPA AQMP resulted in

ambient air quality improvements (DFFE, 2023). Emissions were quantified for all main sources (industrial, mining, mobile, domestic fuel burning, domestic waste burning, wind-blown dust, biogenic VOC's, agriculture NH<sub>3</sub> and biomass burning) within the HPA for the year 2019, as well as sources from the surrounding areas to form input into air quality modelling. The CAMx chemical air quality model was used to simulate current ambient concentrations of pollutants within the Highveld Priority Area to assess ambient air quality.

ARM digitised the model predicted isopleths from *The Second-Generation Air Quality Management Plan for the HPA Baseline Characterisation* to assess the cumulative air quality impact for all sources located in the HPA and VTAPA airsheds. The detailed explanation for the digitising process is outlined in Annexure 3.

### **2.2.1.2 Only areas where opportunities for improving ambient air quality through offsetting exist, are considered.**

According to Statistics South Africa (via the official Census and annual general household surveys), the percentage of households, as of 2019, with access to electricity is 85% (DFFE, 2023). While this does not necessarily mean the total disuse of fossil fuel combustion in those homes (particularly for heating), it does offer an indication of potentially decreased residential fuel combustion. This could potentially be offset by population growth, particularly in areas predominantly reliant on indoor fuel combustion (DFFE, 2023). Furthermore, it is noted as per the *Second-Generation Air Quality Management Plan for the HPA Baseline Characterisation* that PM emissions increased from residential burning for the HPA (DFFE, 2023).

ARM utilised Stats SA data for the intervention areas for 2011, 2016 and 2022. The 2011 data included total population and number of households on a municipal and ward level. Unfortunately, the 2016 and 2022 datasets only contained total population and number of households on a municipal level. A ratio was calculated between the 2011 municipal and ward level data, and this 2011 ratio was applied to the 2016 and 2022 municipal data

sets, to linearly extrapolate the 2016 and 2022 ward level data. This assumption is that the relationship between variables remains linear. It's noted that currently the 2022 StatsSA ward level data has not been released to the public.

### **2.2.1.3 Only areas where there is (probably) non-compliance with ambient air quality standards are considered.**

It's noted Eskom's Air Quality Offset Implementation Plan was published in 2016/17, thus ARM performed an analysis of the applicable monitored data for the HPA and VTAPA to determine whether there are still exceedances of the PM<sub>10</sub> and SO<sub>2</sub> NAAQS at the areas selected by Eskom's current AQO program. The ambient air quality monitoring station (AQMS) which was in closest proximity to the Power station was utilised in the assessment of compliance with the applicable NAAQS.

### **2.2.2 An evaluation of the "What"**

It's noted that Eskom selected offset interventions are based on reducing emissions from domestic solid fuel burning and addressing waste burning for the current Eskom AQO program (Eskom 2017a, 2017b, 2017c). ARM has evaluated both the current set of Eskom AQO interventions as well as other potential interventions and provide a view herein in terms of viability.

Figure 5 provides an overview of ARM approach to evaluate the "What" for Eskom's current AQO Project. This approach is detailed in sections 2.2.1.1 to 2.2.1.3 to litmus-test the assumptions outlined above.

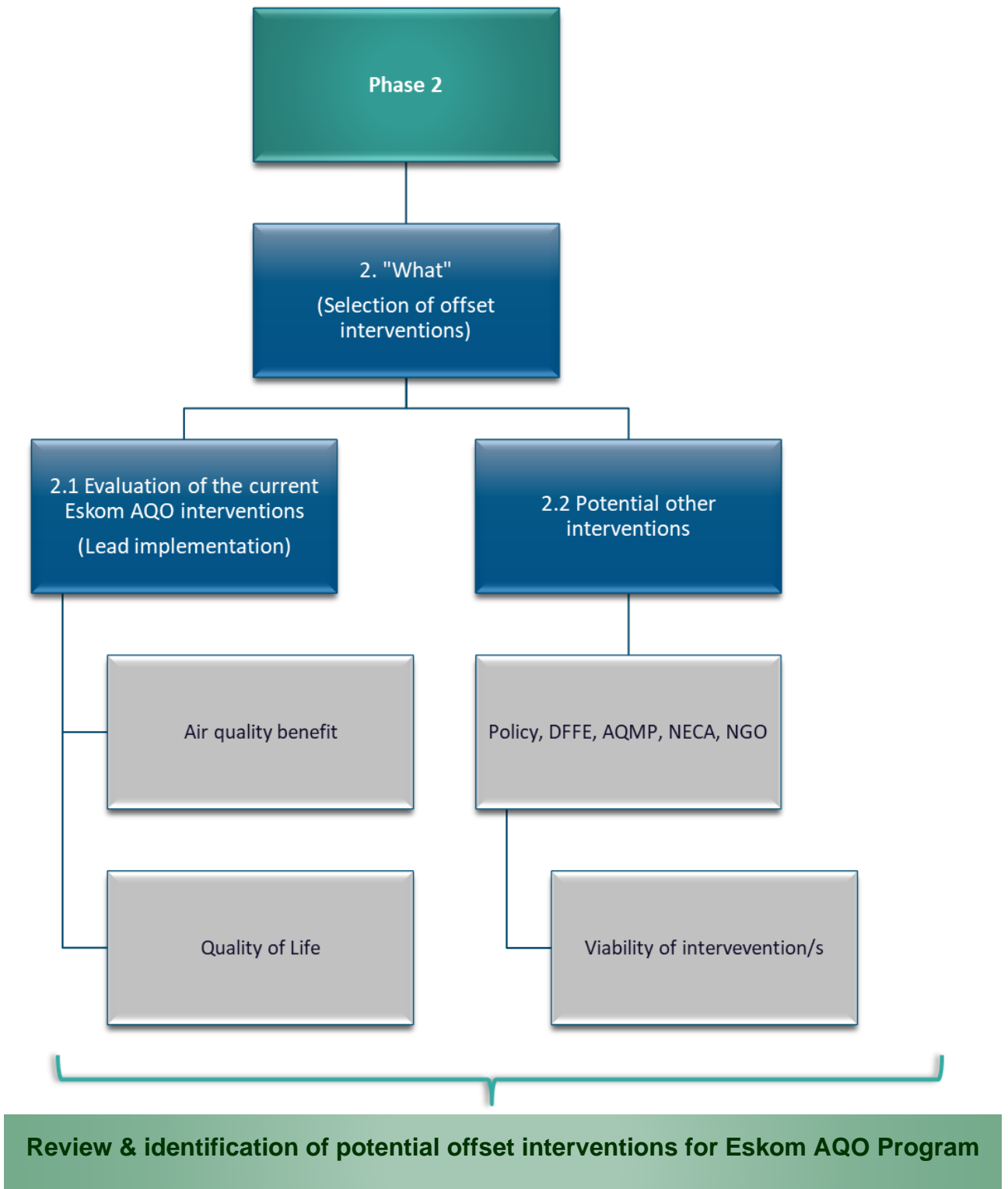


Figure 5: Study Approach for Phase 2 – Process to review the current & potential other interventions for Eskom’s AQO program

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### 2.2.2.1 Potential other interventions

A review of the regulatory landscape for air quality offsetting is critical to understanding how the policies and frameworks impact the current narrative and thinking in terms of AQO and potential other interventions. ARM reviewed *inter alia* the following policies, appeals, reports:

- 1) Ministers decision: Eskom Appeal (DFFE, 2024)
- 2) DFFE, The National Framework for Air Quality Management (DFFE, 2018)
- 3) DFFE, Air Quality Offsets Policy (DFFE, 2016)
- 4) NECA Forum report on Eskom Appeal (DFFE, 2024)
- 5) DFFE NEMAQA - 2nd Gen AQMP Highveld Area (DFFE, 2023)
- 6) DFFE 2019 HPA Health Study Integrated Report (DFFE, 2019)
- 7) DFFE VTAPA Final Second Generation VTAPA AQMP (DFFE, 2020)
- 8) DFFE VTAPA Health Study Report (DFFE, 2020)
- 9) DFFE Strategy to address air pollution in dense low-income settlements (DFFE, 2019)

By synthesizing insights from the various studies and reports, ARM aims to identify potential new interventions that address the unique challenges faced in the target areas. Its noted that a high-level desktop pre-feasibility study was undertaken to identify the most effective interventions for offsetting emissions from Eskom. A comprehensive list of potential interventions was generated, followed by the application of specific criteria to narrow down the options for detailed assessment. The refined list was then evaluated based on a set of weighted criteria, and the selected interventions were recommended for further investigation.

Its noted that the results of this Phase 2 study (sections 2.2.1 and 2.2.2) were utilised as an input to Phase 3 of this Study (Figure 6).

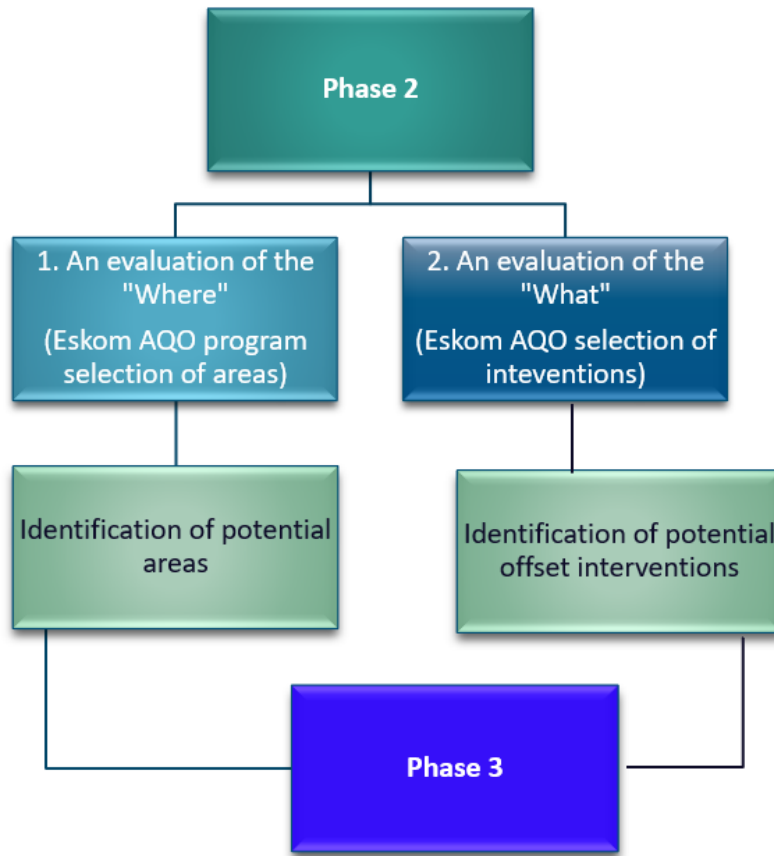


Figure 6: Integration of Phase 2 Study results into Phase 3

## 2.3 Phase 3: General recommendation for expansion of the Eskom AQO program

Phase 3 of this study (Figure 7) provides an estimation of the scale of the intervention; potential air quality benefit and prioritisation of areas.



Figure 7: Study Approach for Phase 3

### 2.3.1 Estimation of the scale of the intervention

The DFFE Second-Generation HPA AQMP (DFFE, 2024) estimated 2.4 tonnes of coal being assumed to be burned at the household (HH) level which was also informed by the HPA Health Study (CSIR, 2017). ARM assumed that 90% of these households for the selected wards (section 2.2.2.1) will opt to participate in the Eskom AQO program.

## 2.3.2 Potential air quality benefit (Nett emissions avoided)

The potential net reductions in: PM<sub>10</sub>; PM<sub>2.5</sub>; SO<sub>2</sub>; NO<sub>x</sub> (as NO<sub>2</sub>); VOC; CO; CH<sub>4</sub> emissions attributable to Eskom's AQO intervention were quantified utilising appropriate emission factors.

### 2.3.2.1 Background to emission factors

An emission factor (EF) is a quantity of a pollutant emitted relative to an activity metric, such as the quantity of fuel or material burned. It is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere, with an activity associated with the release of that pollutant. For instance, an EF for the release of SO<sub>2</sub> from combustion of coal would be expressed in grams (g) SO<sub>2</sub> emitted per kilogram (kg) of coal combusted. EFs are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant. EFs are generally used in calculating the rate at which a pollutant is being released from a source (emission rate), which can be used to simulate the concentration of the pollutant at a receptor. The general equation (1-1) for emissions estimation is:

$$E = A * EF * \left(1 - \frac{ER}{100}\right) \quad \text{Equation 1-1 (US-EPA)}$$

where:

E = emissions;

A = activity rate;

EF = emission factor, and

ER = overall emission reduction efficiency, %

### 2.3.2.2 Emission factors utilised for the waste offsetting initiatives

The most recent compilation of waste emission factors in a South African context are detailed in the *South Africa Emission Factors for Criteria Pollutants from Solid Waste Material Combustion Report* (DRI, 2020). The study accounted for emissions under various burning conditions and calculated a waste generated per capita of 0.612

tonne/person/annum for South Africa (DRI, 2020). It's noted that the DFFE Second-Generation HPA AQMP (DFFE, 2024) adopted this exact waste generated per capita figures as well. The Stats SA 2019 General Household Survey (Stats SA, 2019) study highlighted an average waste removal efficiency of 65%, hence approximately 35% of waste generated will be burned.

The mathematical expression detailed in Equation 1-2 was utilised to calculate emissions from waste burning:

$$Ept_x = ARt * EFp * BF \quad \text{Equation 1-2 (US-EPA, 1995)}$$

Where:

<b><i>Ept<sub>x</sub></i></b>	Total emissions of specific pollutant x (tonnes per annum)
<b><i>ARt</i></b>	Activity rate = amount of waste burnt in a year (ton/year) at a given time, t
<b><i>EFp</i></b>	Emission factor = amount of pollutant, p (gram) associated with burning of a kilogram of waste
<b><i>BF</i></b>	Burning fraction (determinable empirically from combustion test of residual ash)

According to Equation 1-2, not all waste is combustible. As an example, glass and metals will not readily burn, therefore, a burn fraction is required. The IPCC recommended fraction of 0.6 is used, in other words, 60% of the waste generated by people who do not receive removal services is burned. This assumption was also adopted for this study.

Table 3 summarises the measured emission factors reported for the DRI (2020) study, whilst Tables Table 4 and Table 5 summarises the emissions factors utilised in this study. No discrepancy is made in the plastic category (between plastics bottles and plastic bags), and these two subcategories (plastic bottles and bags) were combined to one plastic category in Table 5. An assumption was made that the burning represents the smouldering phase, and a split between paper and plastic of 50:50 was applied to be conservative based on the ARM (2024) waste composition and segregation study undertaken in Sharpeville. Additionally, it was assumed that a total volume of 9035 m<sup>3</sup> of waste will be collected for each area. This estimate is calculated based on the six cleanup

campaigns conducted to date as part of Eskom's AQO project for Sharpeville (*pers comm*, Matimolane, 2024).

**Table 3: Measured emission factors (average ± standard deviation) for waste materials tested (DRI, August 2020).**

Fuel	Burn Type	Emission Factor (g/kg fuel)							
		CO <sub>2</sub>	CO	NO (as NO <sub>2</sub> )	NO <sub>2</sub>	NO <sub>x</sub> (as NO <sub>2</sub> )	SO <sub>2</sub>	PM <sub>2.5</sub>	PM <sub>10</sub>
Paper	Flaming	1530 ± 24	26.2 ± 6.9	0.58 ± 0.04	0.42 ± 0.15	1.00 ± 0.15	0.68 ± 0.58	12.05 ± 3.28	12.19 ± 3.70
	Smouldering	1406 ± 22	101.2 ± 13.3	0.81 ± 0.51	0.86 ± 0.53	1.66 ± 1.00	0.33 ± 0.08	15.21 ± 6.96	15.16 ± 6.67
	Total	1498 ± 7	44.9 ± 3.2	0.63 ± 0.16	0.52 ± 0.19	1.14 ± 0.31	0.57 ± 0.41	13.31 ± 0.77	13.42 ± 1.21
Rubber	Flaming	No Flaming Phase							
	Smouldering	456 ± 41	28.1 ± 3.9	0.31 ± 0.15	2.75 ± 4.44	3.06 ± 4.59	0.16 ± 0.04	141.34 ± 23.01	153.19 ± 20.26
	Total	456 ± 41	28.1 ± 3.9	0.31 ± 0.15	2.75 ± 4.44	3.06 ± 4.59	0.16 ± 0.04	141.34 ± 23.01	153.19 ± 20.26
Textile	Flaming	1540 ± 129	27.3 ± 8.9	9.53 ± 1.95	1.17 ± 0.19	10.70 ± 5.58	4.43 ± 2.12	37.20 ± 22.65	42.78 ± 31.32
	Smouldering	1227 ± 59	149.5 ± 34.5	11.57 ± 8.73	1.19 ± 0.53	12.76 ± 9.87	1.68 ± 0.45	75.56 ± 15.33	87.55 ± 24.71
	Total	1467 ± 104	54.9 ± 7.4	10.37 ± 3.72	1.21 ± 0.15	11.58 ± 6.57	3.72 ± 1.48	47.04 ± 16.83	53.95 ± 26.96
Plastic Bottles	Flaming	No Flaming Phase							
	Smouldering	182 ± 42	90.4 ± 10.6	0.22 ± 0.26	0.12 ± 0.08	0.35 ± 0.34	0.22 ± 0.02	651.00 ± 38.45	722.47 ± 17.98
	Total	182 ± 42	90.4 ± 10.6	0.22 ± 0.26	0.12 ± 0.08	0.35 ± 0.34	0.22 ± 0.02	651.00 ± 38.45	722.47 ± 17.98
Plastic Bags	Flaming	2938 ± 26	21.0 ± 5.1	0.70 ± 0.17	0.72 ± 0.04	1.42 ± 0.14	0.08 ± 0.01	33.48 ± 9.22	36.01 ± 9.62
	Smouldering	2506 ± 247	183.9 ± 13.7	3.74 ± 0.82	6.87 ± 2.62	10.61 ± 3.15	0.36 ± 0.17	85.75 ± 76.56	89.47 ± 76.47
	Total	2934 ± 24	22.4 ± 5.4	0.72 ± 0.17	0.77 ± 0.06	1.50 ± 0.12	0.08 ± 0.01	34.00 ± 8.55	36.55 ± 8.88
Vegetation	Flaming	1574 ± 16	20.1 ± 4.8	3.17 ± 0.19	0.31 ± 0.01	3.49 ± 0.21	0.75 ± 0.18	3.18 ± 0.15	3.14 ± 0.30
	Smouldering	1372 ± 20	152.7 ± 17.2	1.94 ± 0.15	0.28 ± 0.02	2.22 ± 0.12	0.13 ± 0.00	0.73 ± 0.25	0.72 ± 0.21
	Total	1518 ± 17	57.1 ± 5.9	2.82 ± 0.11	0.30 ± 0.00	3.12 ± 0.11	0.57 ± 0.09	2.48 ± 0.10	2.44 ± 0.02
Food	Flaming	No Flaming Phase							
	Smouldering	955 ± 30	76.1 ± 7.6	1.71 ± 0.34	0.27 ± 0.01	1.98 ± 0.34	0.16 ± 0.02	82.97 ± 18.36	87.23 ± 20.76
	Total	955 ± 30	76.1 ± 7.6	1.71 ± 0.34	0.27 ± 0.01	1.98 ± 0.34	0.16 ± 0.02	82.97 ± 18.36	87.23 ± 20.76
Combined	Flaming	1443 ± 8	14.9 ± 0.7	1.66 ± 0.14	0.63 ± 0.03	2.29 ± 0.16	1.13 ± 0.15	6.94 ± 2.32	7.34 ± 2.36
	Smouldering	1302 ± 28	105.1 ± 11.0	2.40 ± 0.19	0.55 ± 0.09	2.95 ± 0.26	0.17 ± 0.06	6.55 ± 3.01	6.95 ± 3.22
	Total	1417 ± 8	31.6 ± 1.8	1.80 ± 0.11	0.61 ± 0.00	2.41 ± 0.11	0.95 ± 0.13	6.86 ± 2.08	7.26 ± 2.12

**Table 4: Measured emission factors (average) for paper and plastic tested (DRI, August 2020).**

Fuel	Burn Type	Emission Factor (g/kg fuel)							
		CO <sub>2</sub>	CO	NO (as NO <sub>2</sub> )	NO <sub>2</sub>	NO <sub>x</sub> (as NO <sub>2</sub> )	SO <sub>2</sub>	PM <sub>2.5</sub>	PM <sub>10</sub>
Paper	Flaming	1530	26.2	0.58	0.42	1	0.68	12.05	12.19
	Smouldering	1406	101.2	0.81	0.86	1.66	0.33	15.21	15.16
	Total	1498	44.9	0.63	0.52	1.14	0.57	13.31	13.42
Plastic Bottles	Flaming	No Flaming Phase							
	Smouldering	182	90.4	0.22	0.12	0.35	0.22	651	722.47
	Total	182	90.4	0.22	0.12	0.35	0.22	651	722.47
Plastic Bags	Flaming	2938	21	0.7	0.72	1.42	0.08	33.48	36.01
	Smouldering	2506	183.9	3.74	6.87	10.61	0.36	85.75	89.47
	Total	2934	22.4	0.72	0.77	1.5	0.08	34	36.55

**Table 5: Emission Factors (EFs) utilised in this study.**

Fuel	Emission Factor (g/kg fuel)					
	NO (as NO <sub>2</sub> )	NO <sub>2</sub>	NO <sub>x</sub> (as NO <sub>2</sub> )	SO <sub>2</sub>	PM <sub>2.5</sub>	PM <sub>10</sub>
Paper	0.81	0.86	1.66	0.33	15.21	15.16
Plastic	3.74	6.87	10.61	0.36	651	722.47

### 2.3.2.3 Emission factors utilised for the household offsetting initiatives

The methodology utilised herein is aligned with DFFE Second-Generation HPA AQMP (DFFE, 2024). The DFFE Second-Generation HPA AQMP (DFFE, 2024) estimated 2.4 tonnes of coal being assumed to be burned at the household (HH) level which was also informed by the HPA Health Study (CSIR, 2017). By multiplying the number of households by the coal combustion at the household level, an estimate of the amount of coal usage at household (ward) level is calculated. Emission factors (Table 6) were then applied to the coal usage value to determine the resultant emissions per pollutant.

**Table 6: Emission factors used for residential coal combustion**

Pollutant	Residential Coal Combustion	
	Emission Factor (g/kg)	Source
SO <sub>2</sub>	9.91	US-EPA AP-42 (CSIR, 2001)
PM <sub>10</sub>	12.91	US-EPA AP-42 (CSIR, 2001)
PM <sub>2.5</sub>	12.01	US-EPA AP-42 (CSIR, 2001)
NO <sub>x</sub>	4.55	US-EPA AP-42 (CSIR, 2001)
VOC	5.0	FRIDGE Study
CO	94.38	Makonese, 2015
CH <sub>4</sub>	3.6	US-EPA AP-42 (CSIR, 2001)

### 2.3.3 Prioritisation of areas

The Harvard Six Cities cohort study found that fine particulate (PM<sub>2.5</sub>) pose a greater risk to human health because this can penetrate deep into the lungs and is more toxic than larger particles (PM<sub>10</sub>) (Dockery, 1993). Thus, the prioritisation of air quality hotspots for the expansion of Eskom’s AQO program was ranked on the basis of air quality impacts, ie. net emissions avoided for PM<sub>2.5</sub>. This ensured that the areas that potentially pose the greatest risk

to human health and the environment are prioritised in the expanded roll-out of Eskom's AQO program.

## **3. Results & Discussion**

### **3.1 Phase 1 Results**

#### **3.1.1 The selection of areas for Eskom's AQO Program**

In accordance with the area selection criteria (section 2.2.1), a number of settlements ( Table 7) were selected for rollout of Eskom's AQO interventions for the Duvha, Kendal, Lethabo, Majuba, Matla and Tutuka Power Stations. Further details herein is provided in Eskom's AQO Offset Implementation Plans (OIP), submitted for Nkangala District Municipality, Gert Sibande District Municipality, and Lethabo Power Station (Eskom 2017a, 2017b, 2017c).

**Table 7: Areas selected for Eskom’s AQO roll-out in the Gert Sibande, Nkangala, Sedibeng and Fezile Dabi District Municipality**

Power Station	Area of Offset	Type of Offset
Duvha	<ul style="list-style-type: none"> <li>Masakhane</li> <li>Neighbouring farms</li> </ul>	Household
Kendal	<ul style="list-style-type: none"> <li>Phola</li> <li>Eskom Triangle</li> <li>Khayaletu community</li> <li>Olympic community</li> <li>Makhosi community</li> <li>Arbor</li> <li>Neighbouring farms</li> </ul>	Household
Lethabo	<ul style="list-style-type: none"> <li>Boipatong</li> <li>Refengkotso</li> <li>Sharpeville</li> <li>Tshepiso</li> </ul>	<ul style="list-style-type: none"> <li>Waste offset (Phase 2)</li> <li>Waste offsets and household (Phase 2 &amp; 3)</li> <li>Waste offset (Phase 1 &amp; 2)</li> <li>Waste offset (Phase 2)</li> </ul>
Majuba	<ul style="list-style-type: none"> <li>Daggakraal</li> <li>eZamokuhle</li> <li>Sincobile</li> <li>Neighbouring farms</li> </ul>	Household
Matla	<ul style="list-style-type: none"> <li>Chris Hani</li> <li>Emzinoni</li> <li>Emzinoni Ext 2</li> <li>Emzinoni Ext 3</li> <li>Emzinoni Ext 4</li> <li>Emzinoni Ext 5</li> <li>Milan Park</li> <li>Milan Park ext 13</li> <li>Milan Park ext 21</li> <li>Milan Park ext 22</li> <li>Milan Park ext 23</li> <li>Kananna Ext 6</li> <li>Thambo</li> <li>Neighbouring farms</li> </ul>	Household
Tutuka	<ul style="list-style-type: none"> <li>Sivukile</li> <li>Neighbouring farms</li> </ul>	Household

### 3.1.2 The selection of interventions for Eskom's AQO Program

The Eskom Air Quality Offsets Pilot Studies, carried out between 2015 and 2018, focused on evaluating interventions designed to reduce emissions from the burning of solid fuels in residential areas. The key findings revealed that coal burning was the primary source of emissions, with socio-economic factors significantly affecting energy choices and underscoring the necessity of community involvement. Based on these results, it was determined that the ambient air quality in the affected communities of the Highveld region (Nkangala and Gert Sibande) could be enhanced by replacing household coal stoves with hybrid gas-electric stoves and LPG heaters, in addition to retrofitting homes with ceilings to improve insulation (Matimolane, 2024).

As indicated by Matimolane (2024) the AQO intervention for Nkangala and Gert Sibande District Municipality thus entails the following (Figure 8):

- Provision of a basic plus retrofit, which consists of;
  - Insulation entailing installation of a SPF ceiling system and draft proofing.
  - Electrical rewiring and issuance of Certificate of Competence (CoC).
- Stove swap, which includes:
  - Provision of electricity-based energy source with LPG backup. This includes a hybrid gas-electric stove, LPG heater plus 2x9 kg LPG cylinders and Compact fluorescent lamp (CFL) for energy efficiency lighting.
  - Removal and disposal of the coal stove



**Figure 8: Eskom’s household AQO interventions (Matimolane, 2024)**

As per the Eskom Air Quality Offset Plan for Lethabo (Eskom 2017c), the following air quality offset interventions are to be implemented in the identified areas as part of Eskom’s AQO program.

- Waste burning intervention: clean-up of illegal dumps in Sharpeville, Tshepiso, Boipatong and Refengkotso.
- Household intervention: Stove swap in Refengkotso.

The cleaning of illegal waste dumping sites in Sharpeville, Tshepiso, Boipatong, and Refengkotso will take place every three months for a period of 18 months in each area, starting in October 2024, subject to Eskom securing the necessary funding. If Eskom budget permits, the stove exchange program in Refengkotso will begin in February 2025 (Matimolane,2024).

## **3.2 Phase 2 Results**

### **3.2.1 The air quality impact of individual Power Station's**

It's noted that ARM utilised the CALPUFF model simulated results for the "Eskom Current Emissions" scenario to determine the air quality impact of the Power Stations (Table 2) on the receiving environment. This scenario utilised the actual Power Station performance (load & emissions) for the period 2021 to 2023 (uMoyo NILU, 2024).

#### **3.2.1.1 Duvha Power Station**

##### **3.2.1.1.1 Air quality impact of the Duvha Power Station**

Figure 9 indicates simulated 24-hour, 99<sup>th</sup> percentile PM<sub>10</sub> concentrations (NAAQS is 75.0 µg/m<sup>3</sup>, indicated by the red areas). High PM<sub>10</sub> concentrations were simulated towards north-westerly, northerly and easterly directions. The impact region is localised close to the Duvha power station from level fugitive dust sources (uMoya Nillu, 2024).

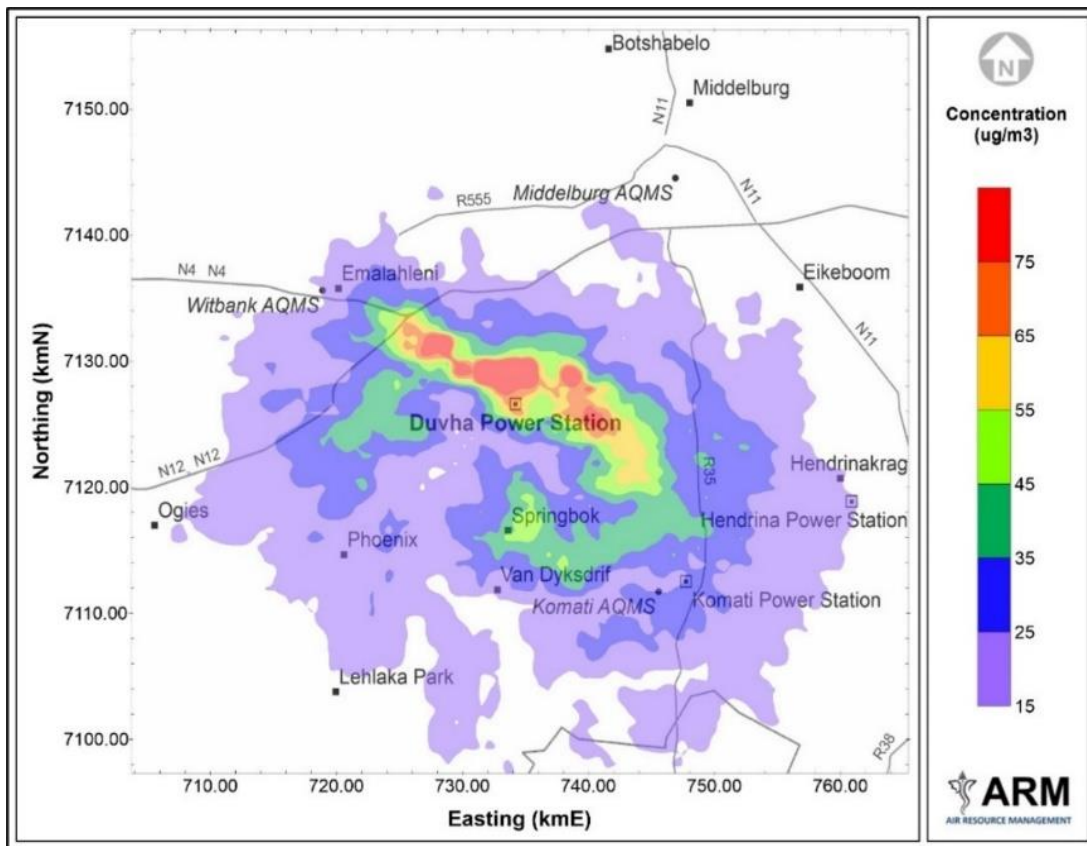


Figure 9: Simulated Particulate Matter (PM<sub>10</sub>), 24-hour, 99<sup>th</sup> percentile concentrations (NAAQS is 75.0  $\mu\text{g}/\text{m}^3$ ).

Figure 10 indicate simulated 1-hour, 99<sup>th</sup> percentile SO<sub>2</sub> concentrations (NAAQS is 350.0  $\mu\text{g}/\text{m}^3$ ). Elevated SO<sub>2</sub> concentrations were simulated towards an easterly direction.

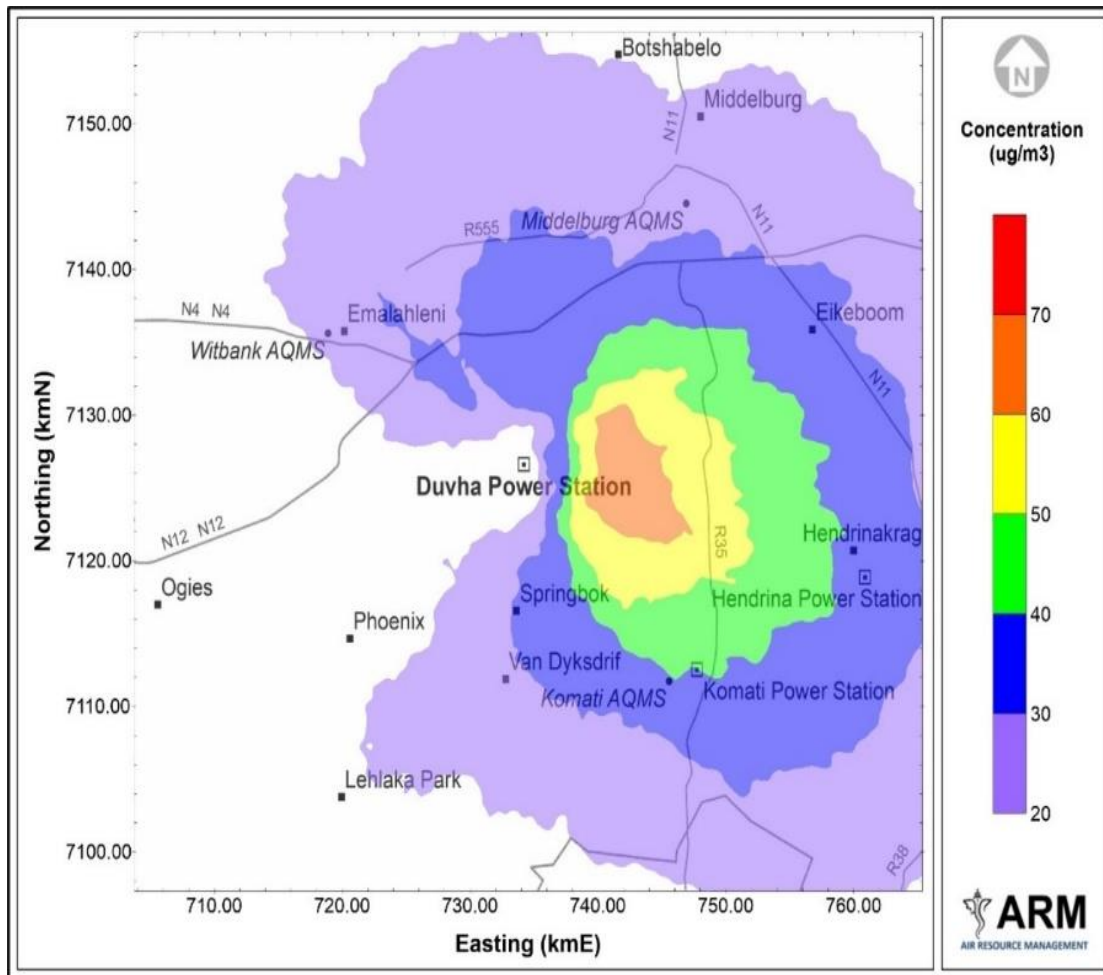
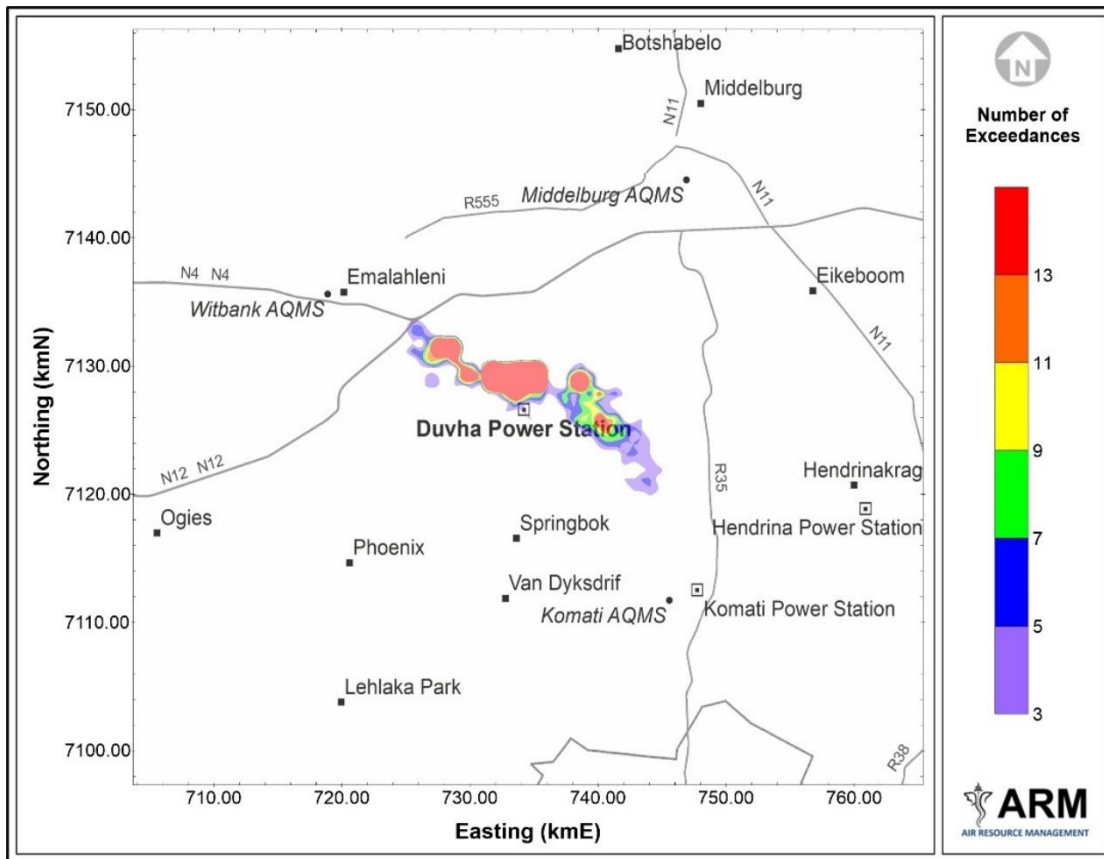


Figure 10: Simulated Sulphur Dioxide (SO<sub>2</sub>), 1-hour, 99th percentile concentrations (NAAQS is 350.0  $\mu\text{g}/\text{m}^3$ )

### 3.2.1.1.2 Non-compliance of NAAQS

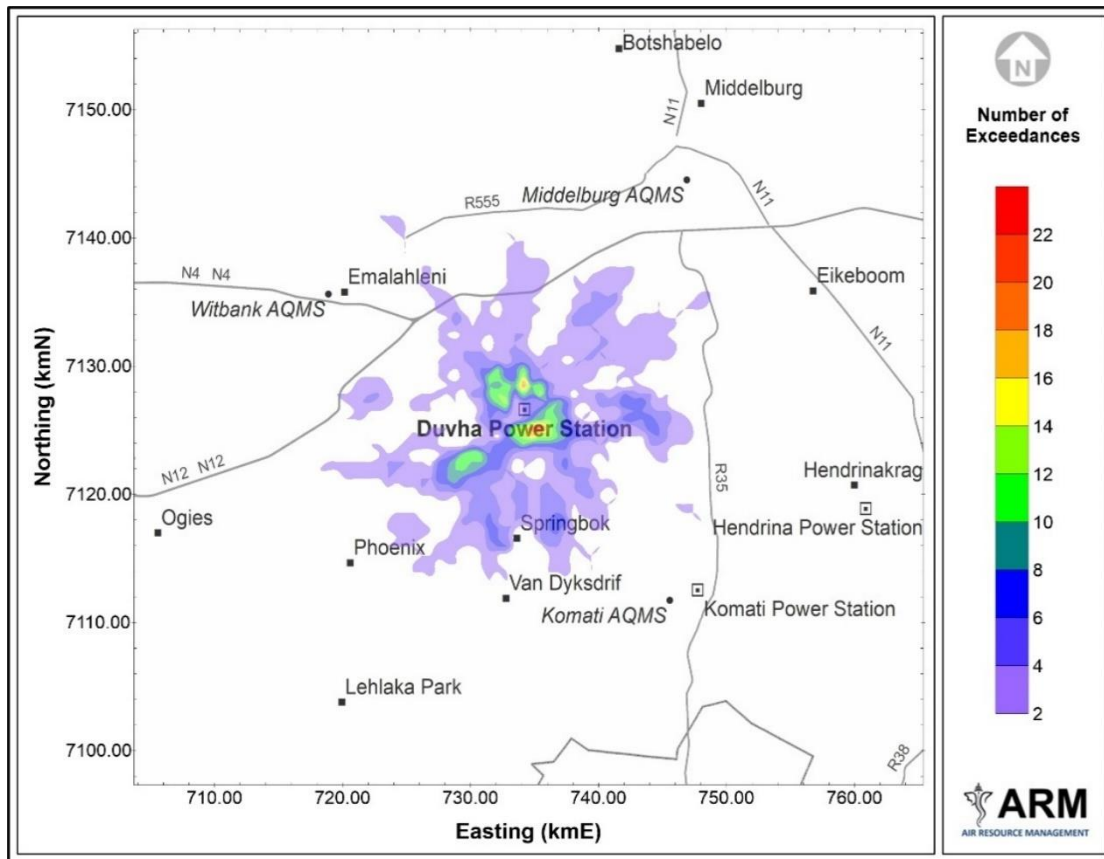
#### 3.2.1.1.2.1 Evaluation of model predicted exceedances

Figure 11 highlights the frequency of PM<sub>10</sub> exceedances (NAAQS) for the 24-hour time averaging period for the three-year simulation period. The permissible number of exceedances is 12 (4 exceedances per year, 3-year simulation period) and the red areas indicates regions exceeding this permissible number of exceedances. These regions are located towards north-westerly, northerly and easterly directions in terms of the Duvha power station placement.



**Figure 11: Simulated Particulate Matter (PM<sub>10</sub>), 24-hour, concentration exceedance counts**

Figure 12 highlights the frequency of SO<sub>2</sub> exceedances (NAAQS) for the 1-hour time averaging period for the three-year simulation period. The permissible number of exceedances are 264 (88 exceedances per year, 3-year simulation period). The simulated number of exceedances are well below the permissible number of exceedances for SO<sub>2</sub>. A maximum of 22 exceedances were simulated towards the south of Duvha power station (red area), whilst 10 exceedances (green area) are localised around the Duvha power station.



**Figure 12: Simulated Sulphur Dioxide (SO<sub>2</sub>), 1-hour, concentration exceedance counts**

Figure 13 is an illustration of an overlay of the PM<sub>10</sub> as well as the SO<sub>2</sub> frequency of exceedances. Although, these simulated exceedances are for two different time averages, a proxy of 6 and 10 exceedances were used for PM<sub>10</sub> and SO<sub>2</sub> respectively. The 6-exceedance isopleth (PM<sub>10</sub>, 24-hour) is indicated by the red isopleth, whilst the 10-exceedance isopleth (SO<sub>2</sub>, 1-hour) is indicated by the blue isopleth.

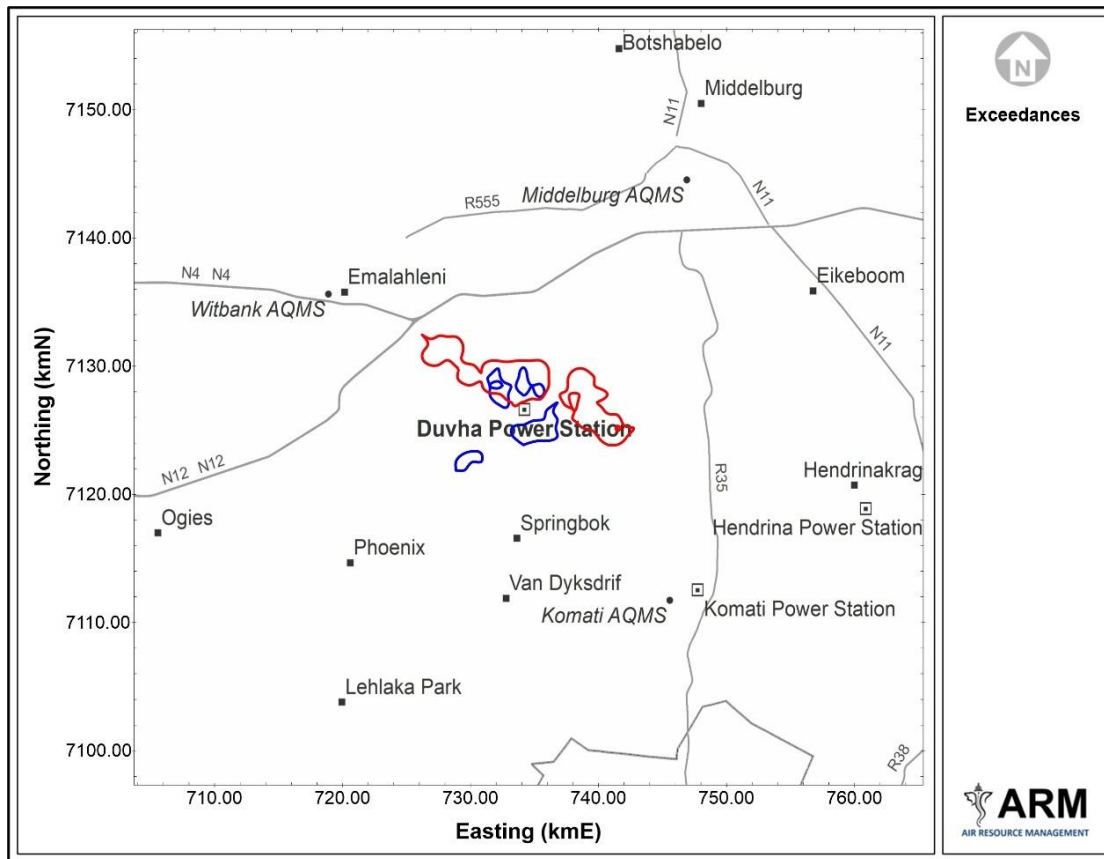


Figure 13: Simulated PM<sub>10</sub> (red isopleth) and SO<sub>2</sub> (blue isopleth) concentration exceedances

### 3.2.1.1.2.2 Evaluation of ambient air quality monitoring data

The AQMS in closest proximity to the Duvha power station is the eMalahleni AQMS operated and maintained by the Mpumalanga province. The eMalahleni AQMS is approximately 10.5km to the west north-west of the power station, as indicated in Figure 14.

Ambient air quality data was obtained from 2007 to 2020 for the eMalahleni AQMS. Table 8 and Table 9 summarises analysed ambient PM<sub>10</sub> and SO<sub>2</sub> data for the specific time periods. Figure 15 to Figure 16 are graphical representations of Table 8, whilst Figure 17 to Figure 19 are graphical representations of Table 9.



Figure 14: Map indicating the location of the eMalahleni AQMS relative to the Duvha power station

Table 8: Ambient PM<sub>10</sub> data for the eMalahleni AQMS for 2007 to 2020

Period	Data Availability	Annual Average	24-Hour 99 <sup>th</sup> Percentile	24-Hour Number of Exceedances
	(%)	(ppb)	(ppb)	(number)
2007	n/av	n/av	n/av	0
2008	17	38.7	160	15
2009	83	50.8	145	80
2010	95	49.2	141.2	72
2011	68	51.4	164.8	57
2012	69	43.9	140.5	48
2013	90	48.3	131.4	69
2014	78	30.4	82.9	11
2015	84	61.6	176.5	112
2016	94	51.5	145.4	87
2017	28	27.8	75.6	1
2018	n/av	n/av	n/av	0
2019	n/av	n/av	n/av	0
2020	22	56.9	n/av	23

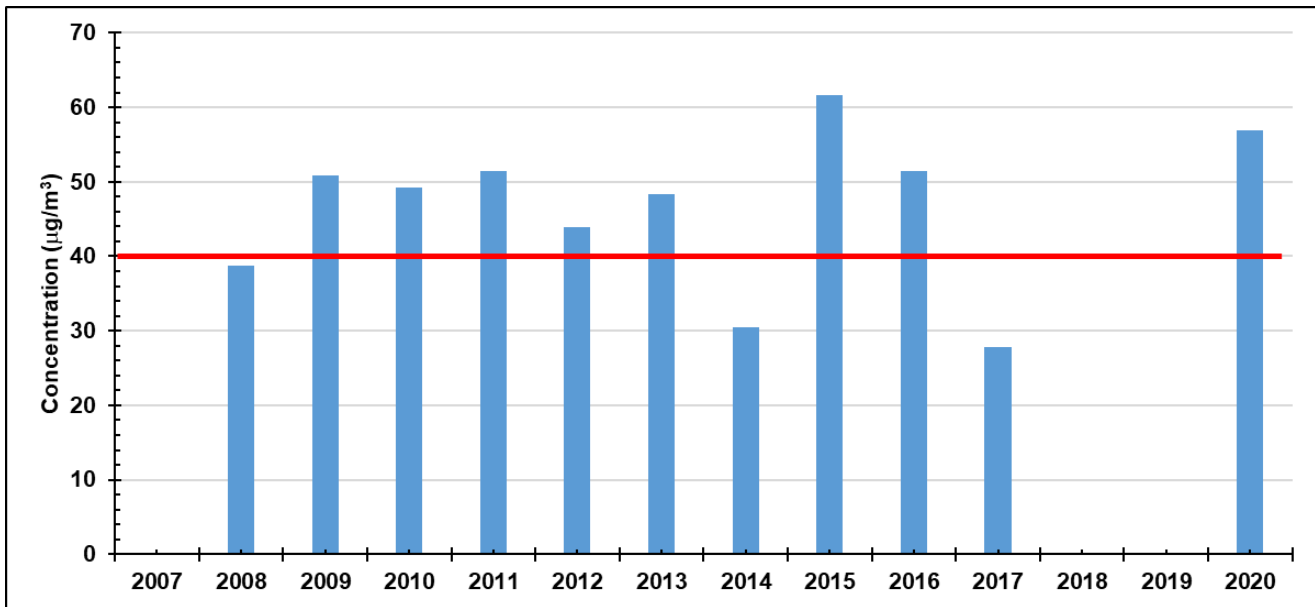


Figure 15: Annual ambient PM<sub>10</sub> concentrations for the eMalahleni AQMS for 2007 to 2020 (NAAQS is 40.0 µg/m<sup>3</sup>).

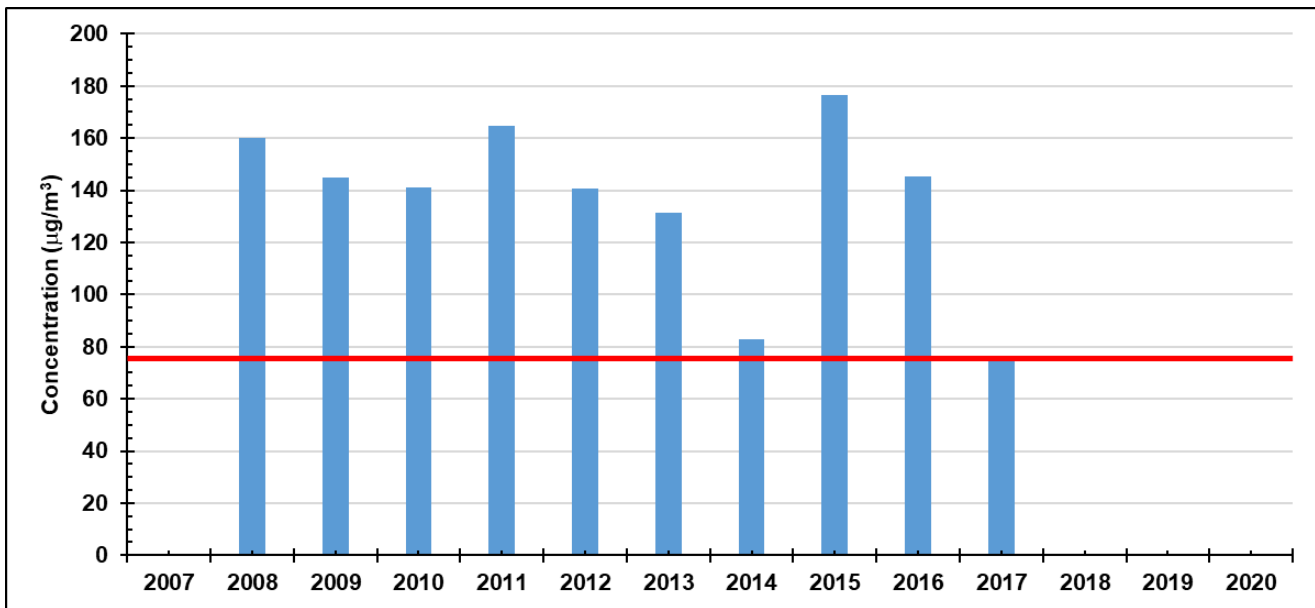


Figure 16: 24-Hour, 99<sup>th</sup> percentile ambient PM<sub>10</sub> concentrations for the eMalahleni AQMS for 2007 to 2020 (NAAQS is 75.0 µg/m<sup>3</sup>).

Table 9: Ambient SO<sub>2</sub> data for the eMalahleni AQMS for 2007 to 2020

Period	Data Availability	Annual Average	1-Hour 99 <sup>th</sup> Percentile	1-Hour Number of Exceedances	24-Hour 99 <sup>th</sup> Percentile	24-Hour Number of Exceedances
	(%)	(ppb)	(ppb)	(number)	(ppb)	(number)
2007	n/av	n/av	n/av	0	n/av	0
2008	18	12.1	83.2	4	47.5	1
2009	78	19.5	149.3	91	79.1	17
2010	90	19.1	138.1	87	67.4	18
2011	74	25.2	192.3	136	76.6	29
2012	66	19.6	132.1	54	71.8	13
2013	90	18.5	154.7	100	61	11
2014	83	19	174.8	119	63.3	11
2015	67	18.7	140.9	65	68.9	10
2016	65	14.5	104	32	67.2	6
2017	23	10	60.9	5	n/av	0
2018	n/av	n/av	n/av	0	n/av	0
2019	4	8.2	67.3	0	n/av	0
2020	33	6.6	64	1	33	0

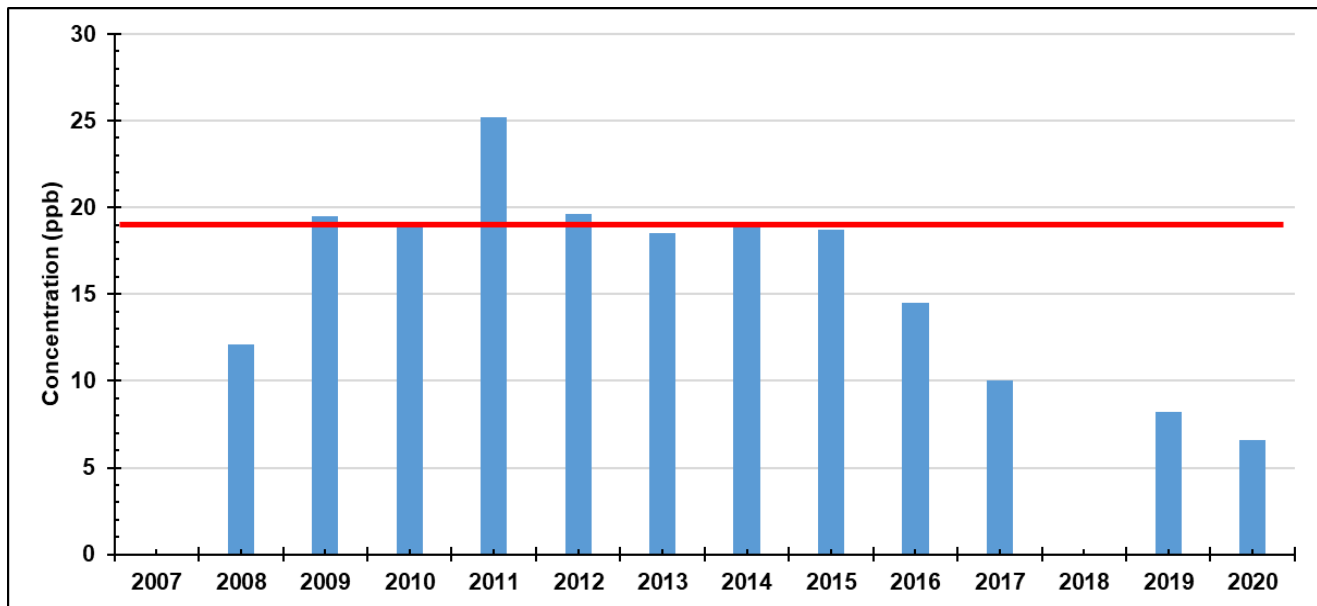


Figure 17: Annual ambient SO<sub>2</sub> concentrations for the eMalahleni AQMS for 2007 to 2020 (NAAQS is 19.0 ppb).

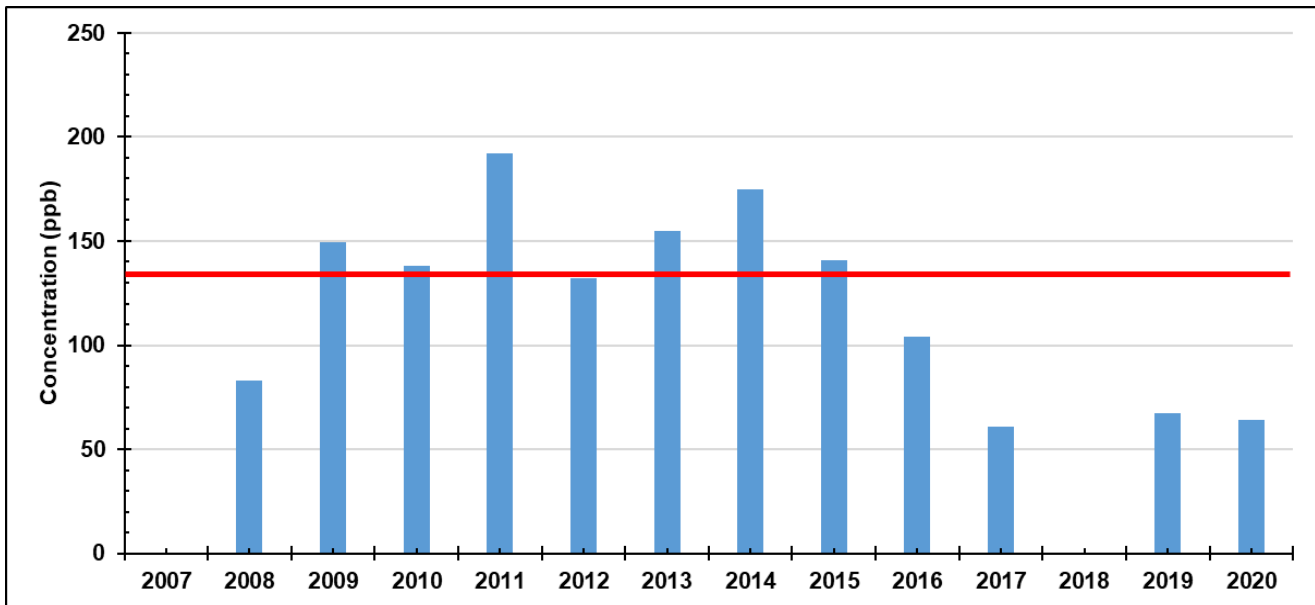


Figure 18: 1-Hour, 99<sup>th</sup> percentile ambient SO<sub>2</sub> concentrations for the eMalahleni AQMS for 2007 to 2020 (NAAQS is 134.0 ppb).

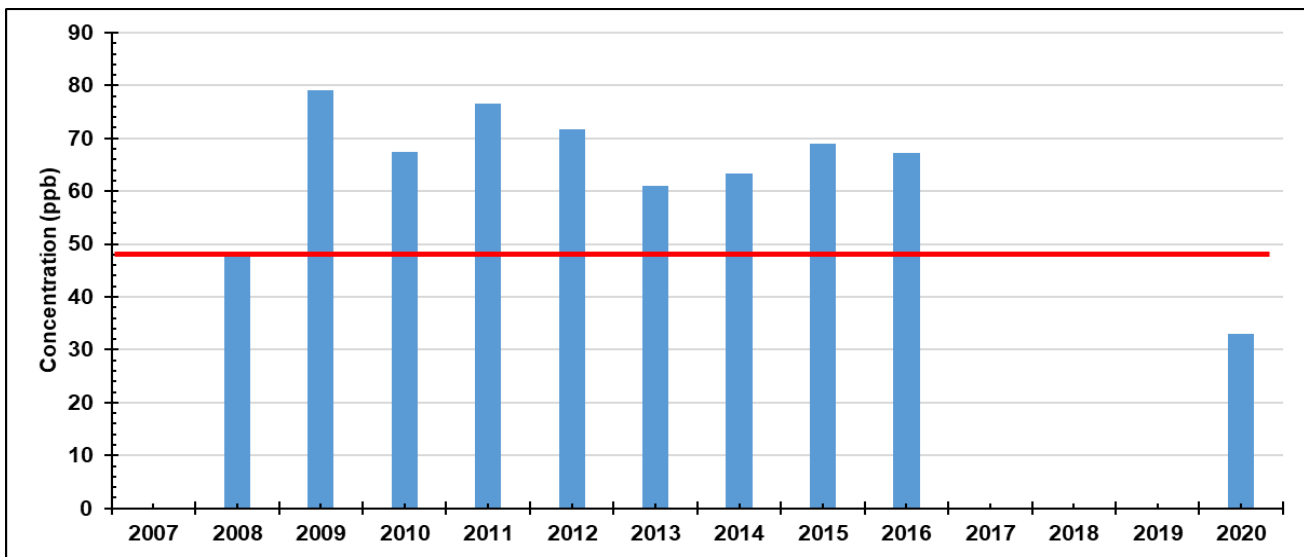


Figure 19: 24-Hour, 99<sup>th</sup> percentile ambient SO<sub>2</sub> concentrations for the eMalahleni AQMS for 2007 to 2020 (NAAQS is 48.0 ppb).

### 3.2.1.1.3 Opportunities for improving ambient quality through offsetting exist

Table 10 To Table 11 summarises the total population, energy usage patterns and indicative number of households for specific settlements that will participate in the offsets roll-out in the target areas for Duva power station AQO offsets program. Its noted that in 2016, 40 721 households were not connected to electricity at all at a Municipal level for Emalahleni (StatsSA Community Services 2016).

**Table 10: Total population, energy usage patterns and indicative number of households for Masakhane that will participate in the offsets roll-out in the target areas for Duva power station offsets program**

Ward	Masakhane	
	Indicative number of households	
	Eskom 2017 OIP <sup>a</sup>	2022 Stats SA <sup>b</sup>
Population	3 740	4 107
Total number of households	1 642	2 255
Number of households using coal	1 232	1 353
Indicative number of households for air quality offsets	1 108	1 218

<sup>a</sup> Based on Eskom AQO Offset Implementation Plan.

<sup>b</sup> Based on ARM Census data extrapolation, assuming 90% choose to participate in the program.

**Table 11: Total population, energy usage patterns and indicative number of households for eMalahleni that will participate in the offsets roll-out in the target areas for Duva power station offsets program**

Ward	eMalahleni	
	Indicative number of households	
	Eskom 2017 OIP <sup>a</sup>	2022 Stats SA <sup>b</sup>
Population	No Data	119 328
Total number of households	No Data	42 983
Number of households using coal	No Data	25 790
Indicative number of households for air quality offsets	2 000	23 211

<sup>a</sup> Based on Eskom AQO Offset Implementation Plan.

<sup>b</sup> Based on ARM Census data extrapolation, assuming 90% choose to participate in the program.

### 3.2.1.2 Kendal Power Station

#### 3.2.1.2.1 Air quality impact of the Kendal Power Station

Figure 20 indicate simulated 24-hour, 99<sup>th</sup> percentile PM<sub>10</sub> concentrations (NAAQS is 75.0 µg/m<sup>3</sup>, indicated by the red areas). High PM<sub>10</sub> concentrations were simulated towards north-westerly, westerly, south-westerly and southerly directions. The impact region is localised close to the Kendal power station.

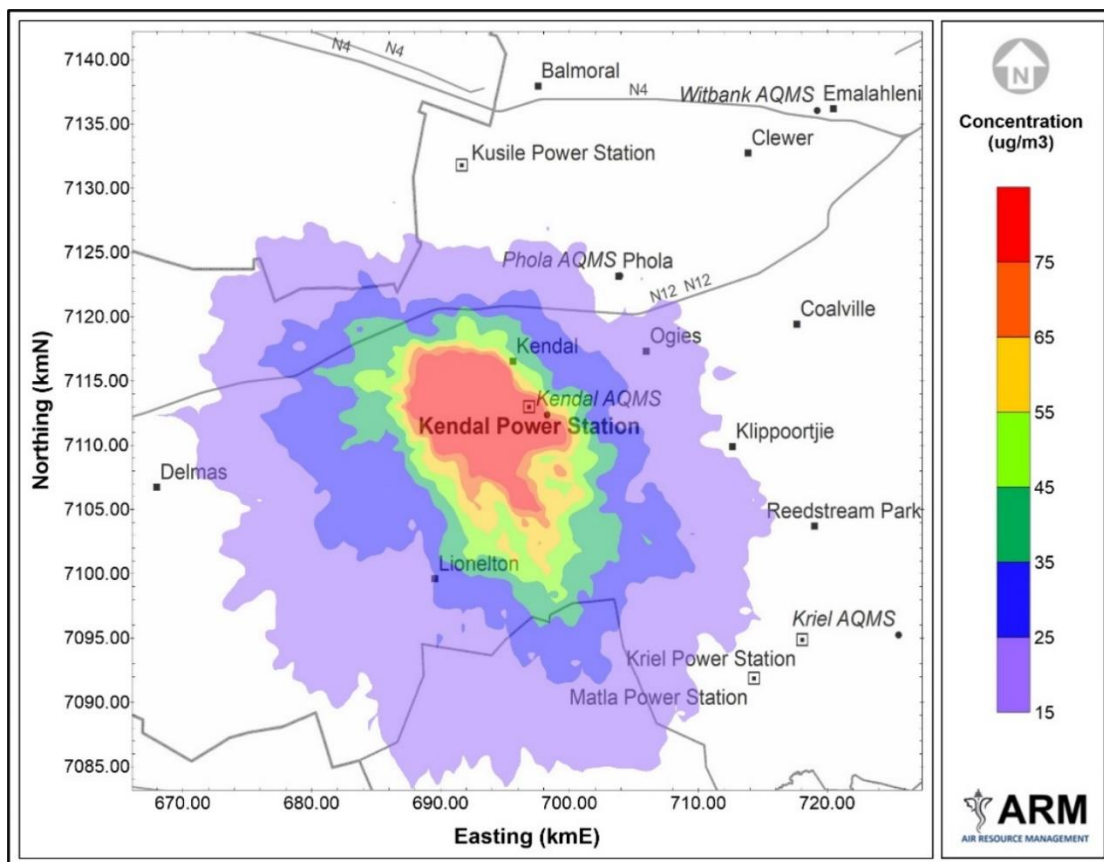


Figure 20: Simulated Particulate Matter (PM<sub>10</sub>), 24-hour, 99<sup>th</sup> percentile concentrations (NAAQS is 75.0 µg/m<sup>3</sup>).

Figure 21 indicate simulated 1-hour, 99<sup>th</sup> percentile SO<sub>2</sub> concentrations (NAAQS is 350.0 µg/m<sup>3</sup>). Elevated SO<sub>2</sub> concentrations were simulated towards north-easterly and south-easterly directions.

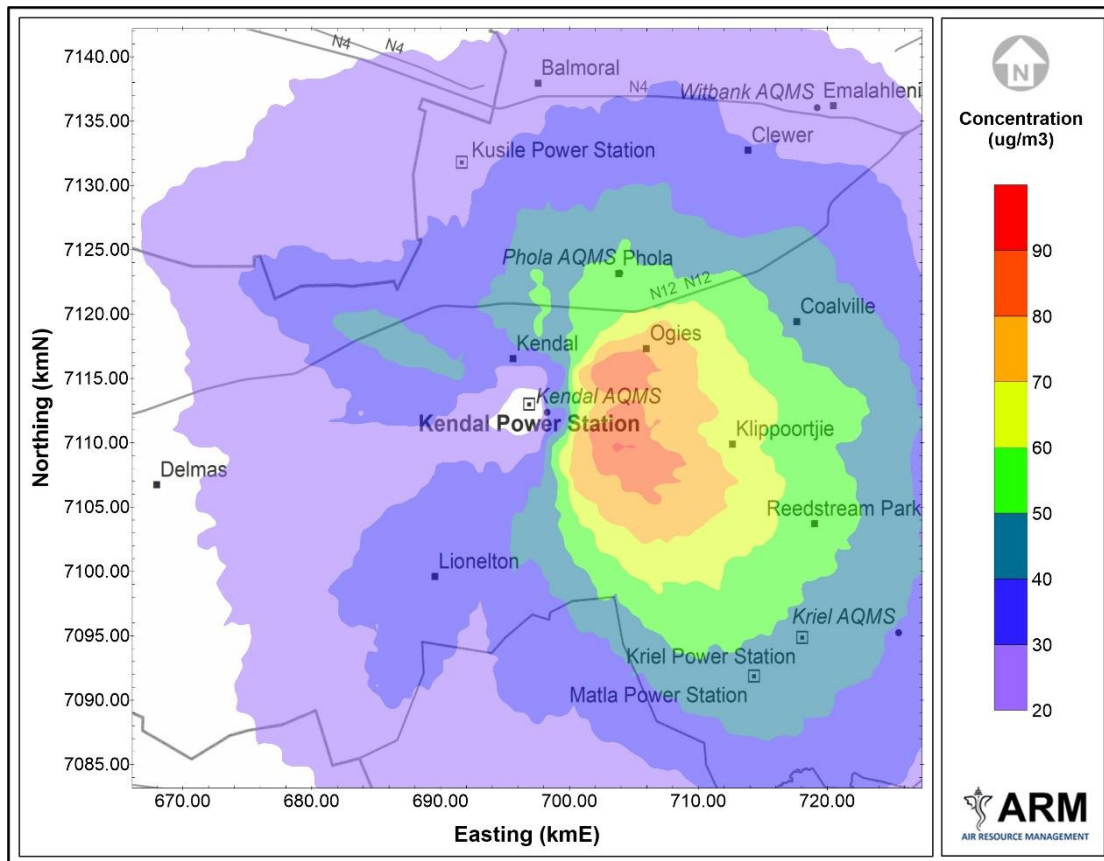
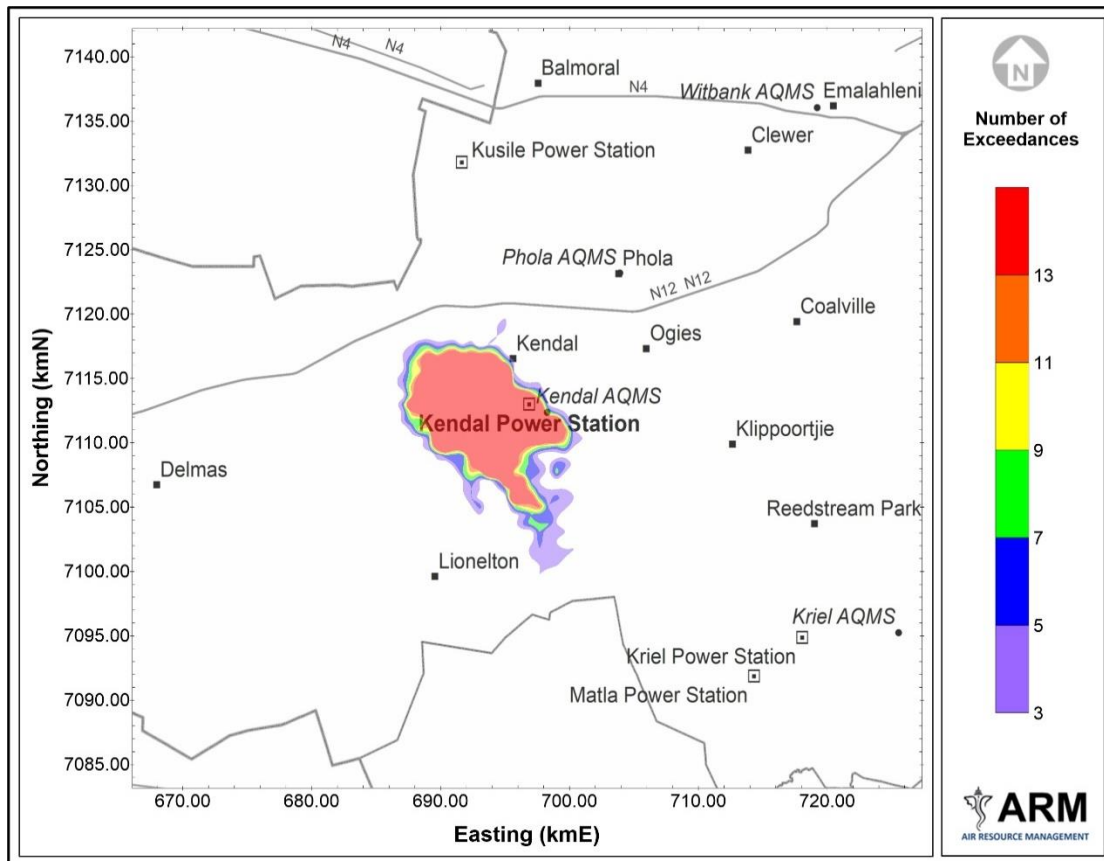


Figure 21: Simulated Sulphur Dioxide (SO<sub>2</sub>), 1-hour, 99<sup>th</sup> percentile concentrations (NAAQS is 350.0 µg/m<sup>3</sup>).

### 3.2.1.2.2 Non-compliance of NAAQS

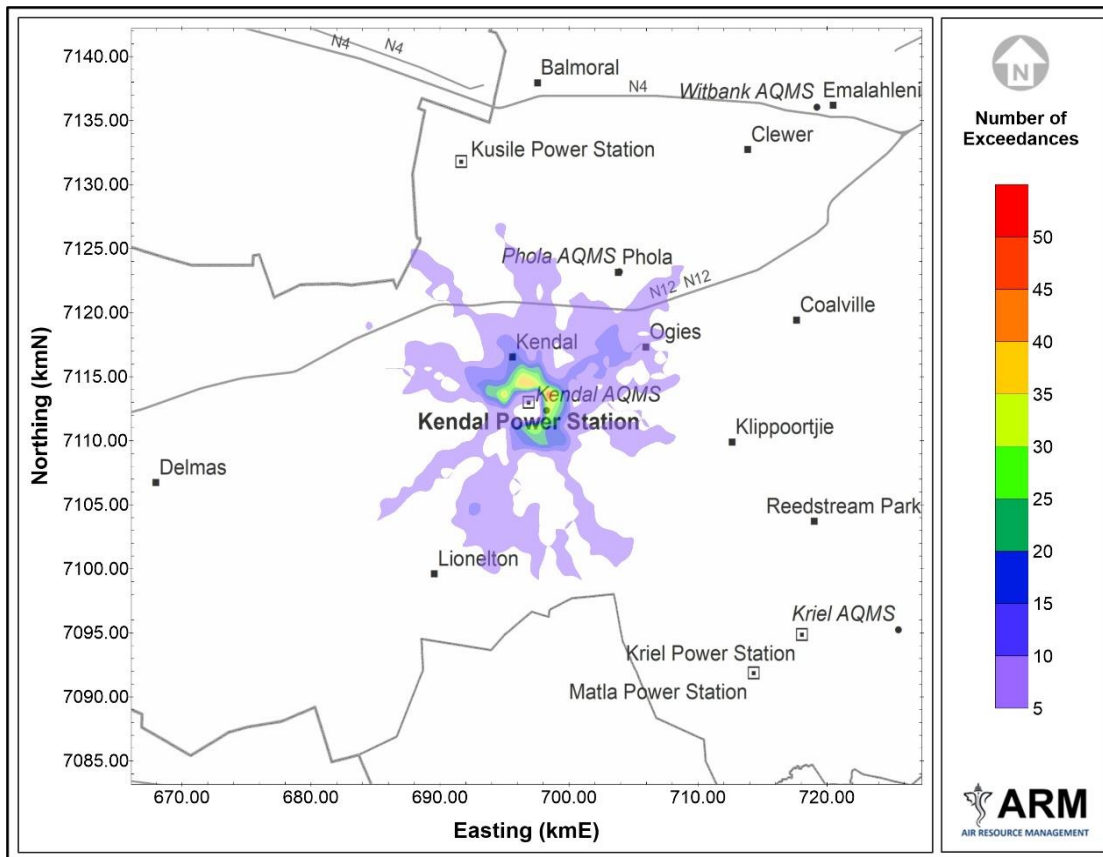
#### 3.2.1.2.2.1 Evaluation of model predicted exceedances

Figure 22 highlights the frequency of PM<sub>10</sub> exceedances (NAAQS) for the 24-hour time averaging period for the three-year simulation period. The permissible number of exceedances is 12 (4 exceedances per year, 3-year simulation period) and the red areas indicates regions exceeding this permissible number of exceedances. These regions are located towards north-westerly, westerly, south-westerly and southerly directions in terms of the Kendal power station placement.



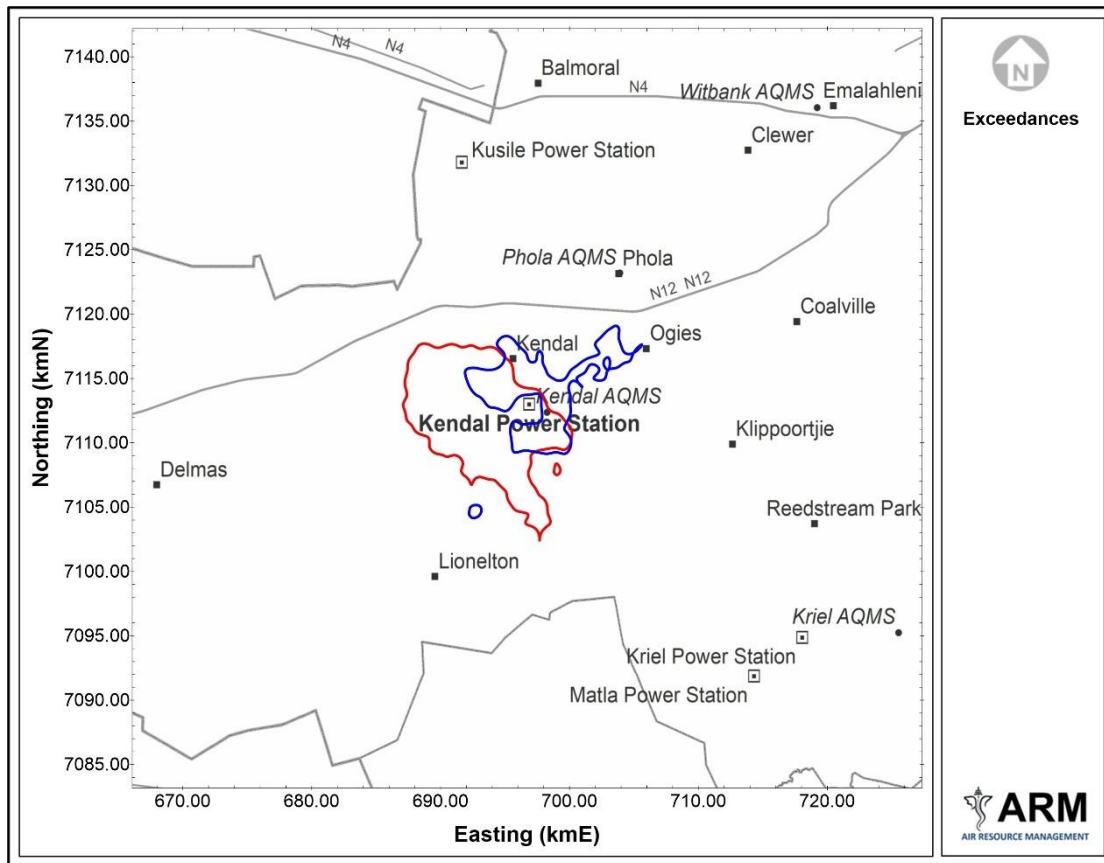
**Figure 22: Simulated Particulate Matter (PM<sub>10</sub>), 24-hour, concentration exceedance counts**

Figure 23 highlights the frequency of SO<sub>2</sub> exceedances (NAAQS) for the 1-hour time averaging period for the three-year simulation period. The permissible number of exceedances are 264 (88 exceedances per year, 3-year simulation period). The simulated number of exceedances are well below the permissible number of exceedances for SO<sub>2</sub>. A maximum of 50 exceedances were simulated towards the east of Kendal power station (red area), whilst 25 exceedances (green area) are localised around the Kendal power station.



**Figure 23: Simulated Sulphur Dioxide (SO<sub>2</sub>), 1-hour, concentration exceedance counts**

Figure 24 is an illustration of an overlay of the PM<sub>10</sub> as well as the SO<sub>2</sub> frequency of exceedances. Although, these simulated exceedances are for two different time averages, a proxy of 6 and 10 exceedances were used for PM<sub>10</sub> and SO<sub>2</sub> respectively. The 6-exceedance isopleth (PM<sub>10</sub>, 24-hour) is indicated by the red isopleth, whilst the 10-exceedance isopleth (SO<sub>2</sub>, 1-hour) is indicated by the blue isopleth.



**Figure 24: Simulated PM<sub>10</sub> (red isopleth) and SO<sub>2</sub> (blue isopleth) concentration exceedances**

### 3.2.1.2.2 Evaluation of ambient air quality monitoring data

The AQMS in closest proximity to the Kendal power station is the Kendal AQMS operated and maintained by Eskom. The Kendal AQMS is approximately 2.2km to the south south-east of the power station, as indicated in Figure 25.

Ambient air quality data was obtained from 2017 to 2020 for the Kendal AQMS. Table 12 and Table 13 summarises analysed ambient PM<sub>10</sub> and SO<sub>2</sub> data for the specific time periods. Figure 26 to Figure 27 are graphical representations of Table 12 whilst Figure 28 to Figure 30 are graphical representations of Table 13.



Figure 25: Map indicating the location of the Kendal AQMS relative to the Kendal power station

Table 12: Ambient PM<sub>10</sub> data for the Kendal AQMS for 2017 to 2020

Period	Data Availability	Annual Average	24-Hour 99 <sup>th</sup> Percentile	24-Hour Number of Exceedances
	(%)	(ppb)	(ppb)	(number)
2017	n/av	n/av	n/av	0
2018	33	71.2	156.5	56
2019	49	65.9	241.4	66
2020	n/av	n/av	n/av	0

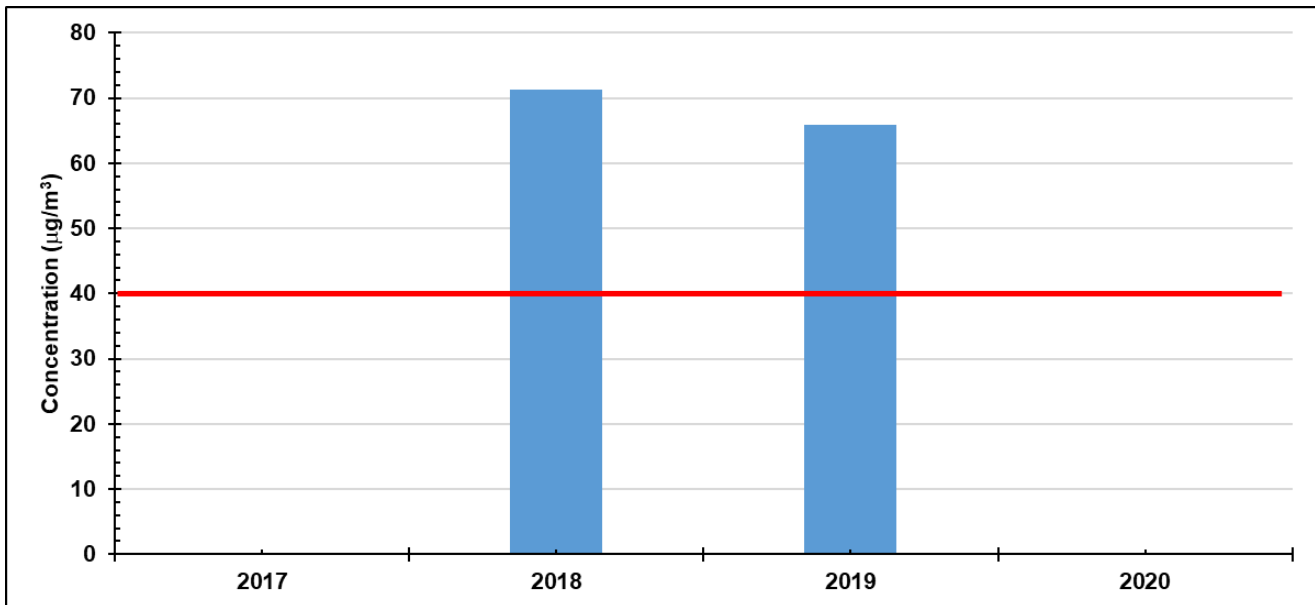


Figure 26: Annual ambient PM<sub>10</sub> concentrations for the Kendal AQMS for 2017 to 2020 (NAAQS is 40.0 µg/m<sup>3</sup>)

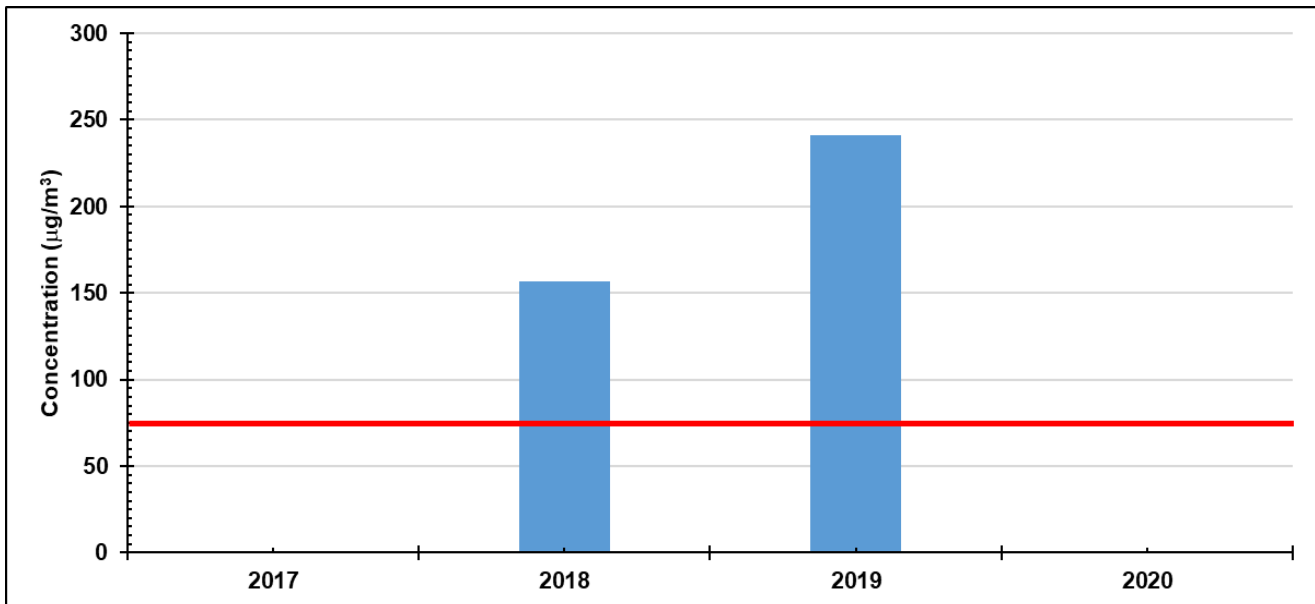
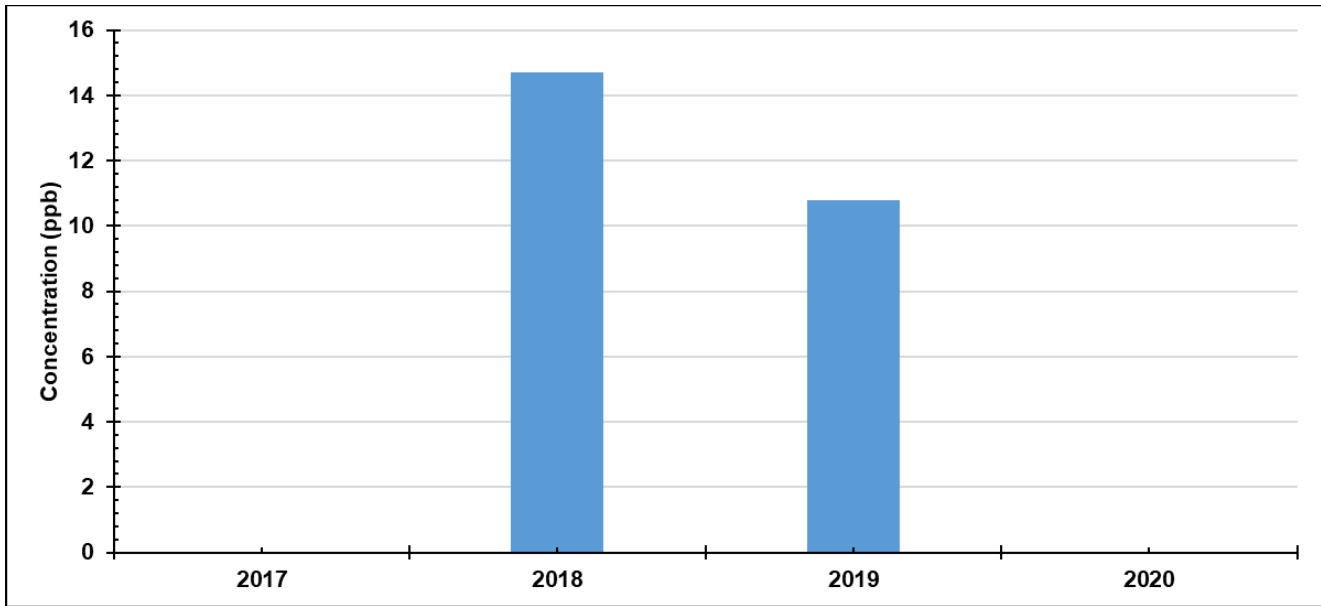


Figure 27: 24-Hour, 99<sup>th</sup> percentile ambient PM<sub>10</sub> concentrations for the Kendal AQMS for 2017 to 2020 (NAAQS is 75.0 µg/m<sup>3</sup>)

**Table 13: Ambient SO<sub>2</sub> data for the Kendal AQMS for 2017 to 2020**

Period	Data Availability	Annual Average	1-Hour 99 <sup>th</sup> Percentile	1-Hour Number of Exceedances	24-Hour 99 <sup>th</sup> Percentile	24-Hour Number of Exceedances
	(%)	(ppb)	(ppb)	(number)	(ppb)	(number)
2017	n/av	n/av	n/av	0	n/av	0
2018	78	14.7	149.2	84	57.9	7
2019	55	10.8	103.2	19	44.7	1
2020	n/av	n/av	n/av	0	n/av	0



**Figure 28: Annual ambient SO<sub>2</sub> concentrations for the Kendal AQMS for 2017 to 2020 (NAAQS is 19.0 ppb).**

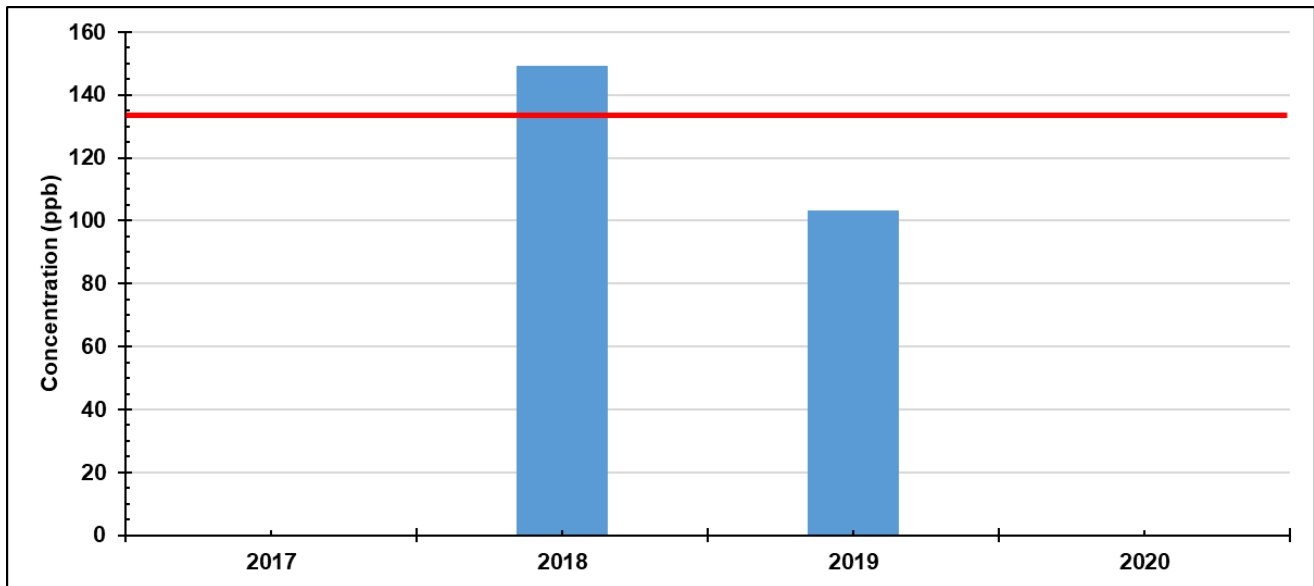


Figure 29: 1-Hour, 99<sup>th</sup> percentile ambient SO<sub>2</sub> concentrations for the Kendal AQMS for 2017 to 2020 (NAAQS is 134.0 ppb)

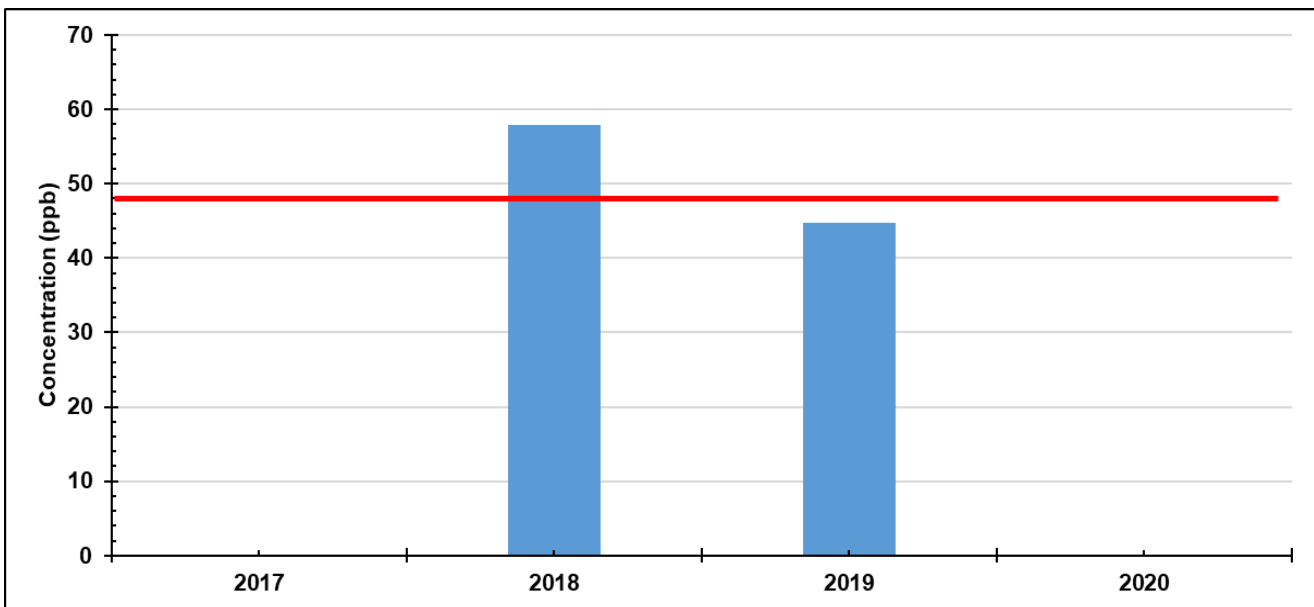


Figure 30: 24-Hour, 99<sup>th</sup> percentile ambient SO<sub>2</sub> concentrations for the Kendal AQMS for 2007 to 2020 (NAAQS is 48.0 ppb)

### 3.2.1.2.3 Opportunities for improving ambient quality through offsetting exist

Table 14 to Table 19 summarises the total population, energy usage patterns and indicative number of households for specific settlements that will participate in the offsets roll-out in the target areas for Kendal power station offsets program.

**Table 14: Total population, energy usage patterns and indicative number of households for Rietspruit that will participate in the offsets roll-out in the target areas for Kendal power station offsets program**

Ward	Rietspruit	
	Indicative number of households	
	Eskom 2017 OIP <sup>a</sup>	2022 Stats SA <sup>b</sup>
Population	5 385	5 724
Total number of households	1 584	2 518
Number of households using coal	No Data	1 511
Indicative number of households for air quality offsets	1 069	1 360

<sup>a</sup> Based-on Eskom AQO Offset Implementation Plan.

<sup>b</sup> Based on ARM Census data extrapolation, assuming 90% choose to participate in the program.

**Table 15: Total population, energy usage patterns and indicative number of households for Phola that will participate in the offsets roll-out in the target areas for Kendal power station offsets program**

Ward	Phola	
	Indicative number of households	
	Eskom 2017 OIP <sup>a</sup>	2022 Stats SA <sup>b</sup>
Population	8 913	35 012
Total number of households	6 685	12 237
Number of households using coal	No Data	7 342
Indicative number of households for air quality offsets	6 016	6 608

<sup>a</sup> Based on Eskom AQO Offset Implementation Plan.

<sup>b</sup> Based on ARM Census data extrapolation, assuming 90% choose to participate in the program.

**Table 16: Total population, energy usage patterns and indicative number of households for Eskom Triangle that will participate in the offsets roll-out in the target areas for Kendal power station offsets program**

Ward	Eskom Triangle	
	Indicative number of households	
	Eskom 2017 OIP <sup>a</sup>	2022 Stats SA <sup>b</sup>
Population	68	No Data
Total number of households	14	No Data
Number of households using coal	11	No Data
Indicative number of households for air quality offsets	9	No Data

<sup>a</sup> Based on Eskom AQO Offset Implementation Plan.

<sup>b</sup> Based on ARM Census data extrapolation, assuming 90% choose to participate in the program..

**Table 17: Total population, energy usage patterns and indicative number of households for Khayaletu Village that will participate in the offsets roll-out in the target areas for Kendal power station offsets program**

Ward	Khayaletu Village	
	Indicative number of households	
	Eskom 2017 OIP <sup>a</sup>	2022 Stats SA <sup>b</sup>
Population	No Data	No Data
Total number of households	15	No Data
Number of households using coal	11	No Data
Indicative number of households for air quality offsets	10	No Data

<sup>a</sup> Based on Eskom AQO Offset Implementation Plan.

<sup>b</sup> Based on ARM Census data extrapolation, assuming 90% choose to participate in the program.

**Table 18: Total population, energy usage patterns and indicative number of households for Olympic community that will participate in the offsets roll-out in the target areas for Kendal power station offsets program**

Ward	Olympic community	
	Indicative number of households	
	Eskom 2017 OIP <sup>a</sup>	2022 Stats SA <sup>b</sup>
Population	No Data	No Data
Total number of households	60 - 80	No Data
Number of households using coal	53	No Data
Indicative number of households for air quality offsets	47	No Data

<sup>a</sup> Based on Eskom AQO Offset Implementation Plan.

<sup>b</sup> Based on ARM Census data extrapolation, assuming 90% choose to participate in the program.

**Table 19: Total population, energy usage patterns and indicative number of households for Makhosi community that will participate in the offsets roll-out in the target areas for Kendal power station offsets program**

Ward	Makhosi community	
	Indicative number of households	
	Eskom 2017 OIP <sup>a</sup>	2022 Stats SA <sup>b</sup>
Population	No Data	No Data
Total number of households	200 - 250	No Data
Number of households using coal	167	No Data
Indicative number of households for air quality offsets	152	No Data

<sup>a</sup> Based on Eskom AQO Offset Implementation Plan.

<sup>b</sup> Based on ARM Census data extrapolation, assuming 90% choose to participate in the program.

### 3.2.1.3 Lethabo Power Station

#### 3.2.1.3.1 Air quality impact of the Lethabo Power Station

Figure 31 indicates simulated 24-hour, 99<sup>th</sup> percentile PM<sub>10</sub> concentrations (NAAQS is 75.0 µg/m<sup>3</sup>, indicated by the red area). High PM<sub>10</sub> concentrations are localised around the Lethabo power station.

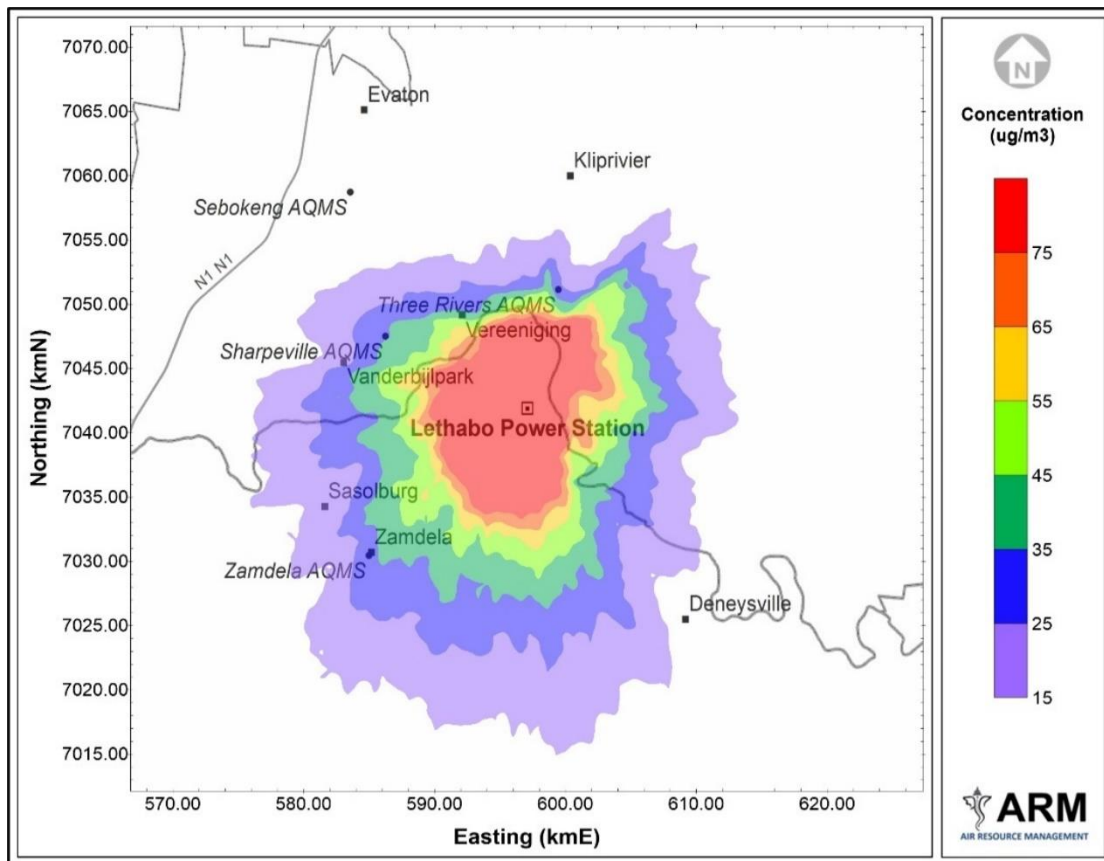


Figure 31: Simulated Particulate Matter (PM<sub>10</sub>), 24-hour, 99<sup>th</sup> percentile concentrations (NAAQS is 75.0 µg/m<sup>3</sup>).

Figure 32 indicates simulated 1-hour, 99<sup>th</sup> percentile SO<sub>2</sub> concentrations (NAAQS is 350.0 µg/m<sup>3</sup>). Elevated SO<sub>2</sub> concentrations were simulated towards a south-easterly direction.

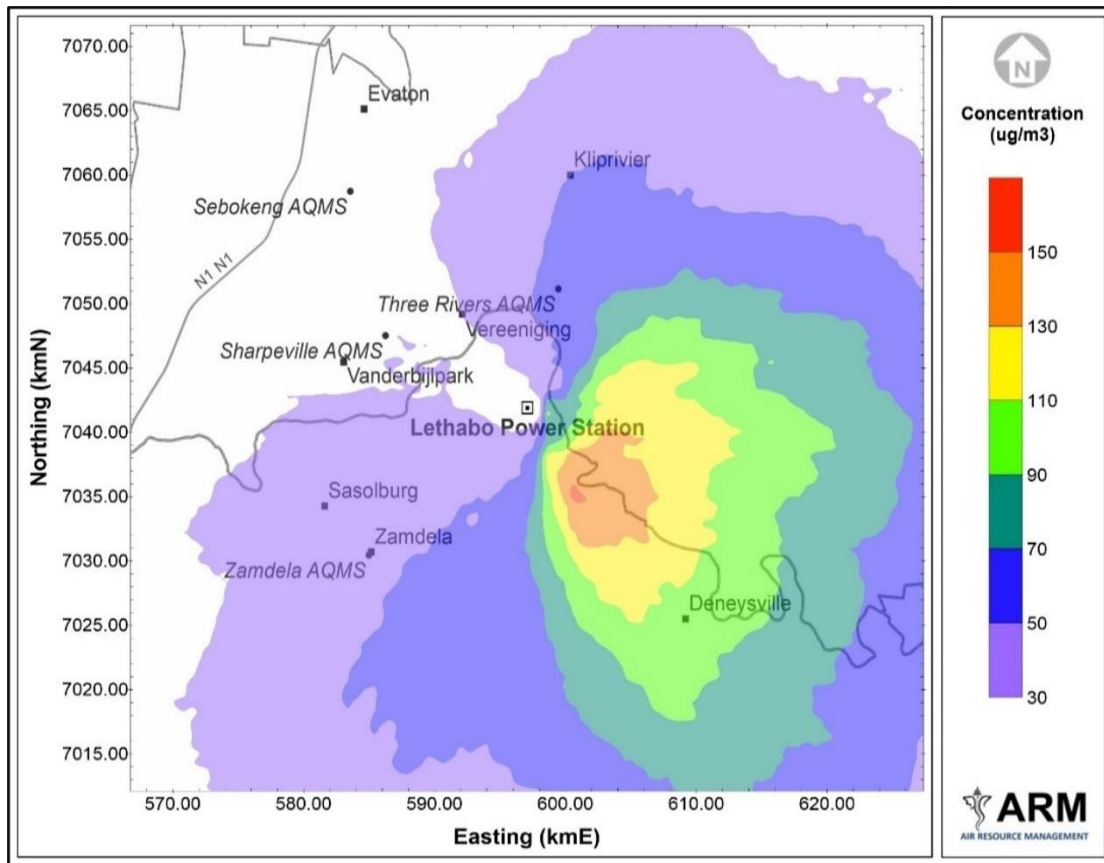
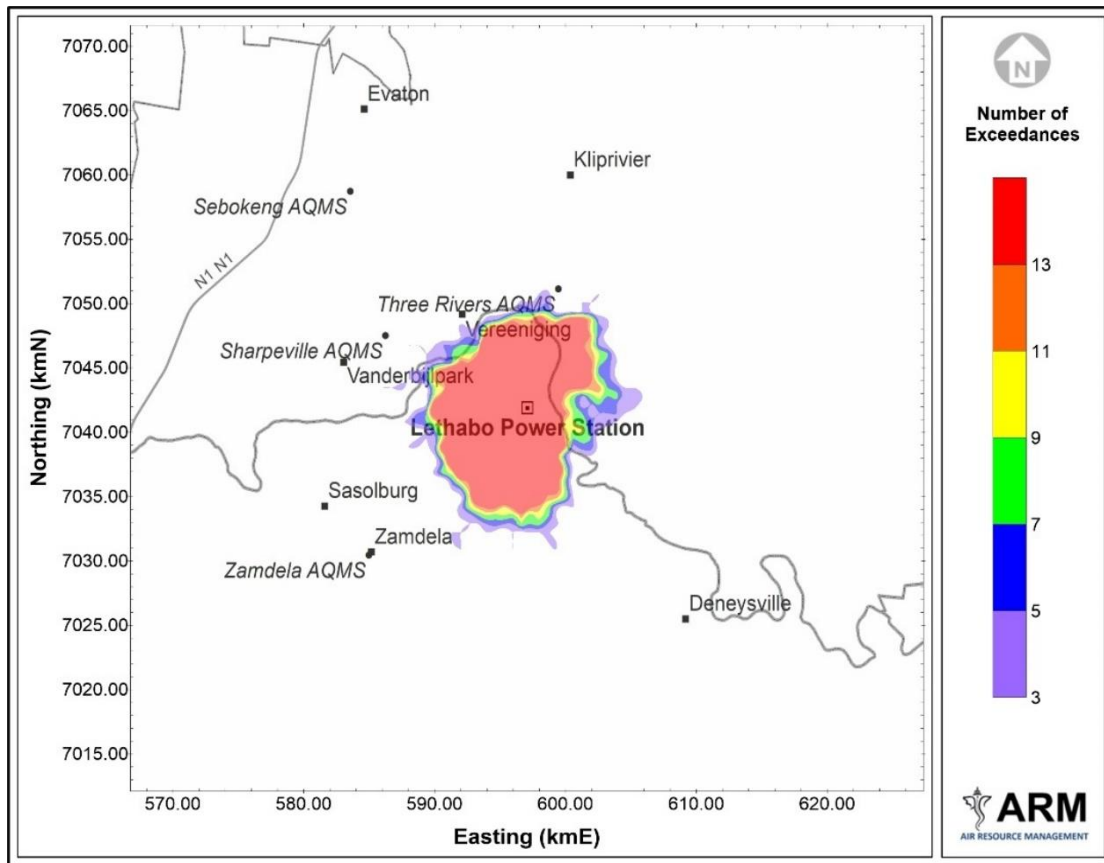


Figure 32: Simulated Sulphur Dioxide (SO<sub>2</sub>), 1-hour, 99<sup>th</sup> percentile concentrations (NAAQS is 350.0 µg/m<sup>3</sup>).

### 3.2.1.3.2 Non-compliance of NAAQS

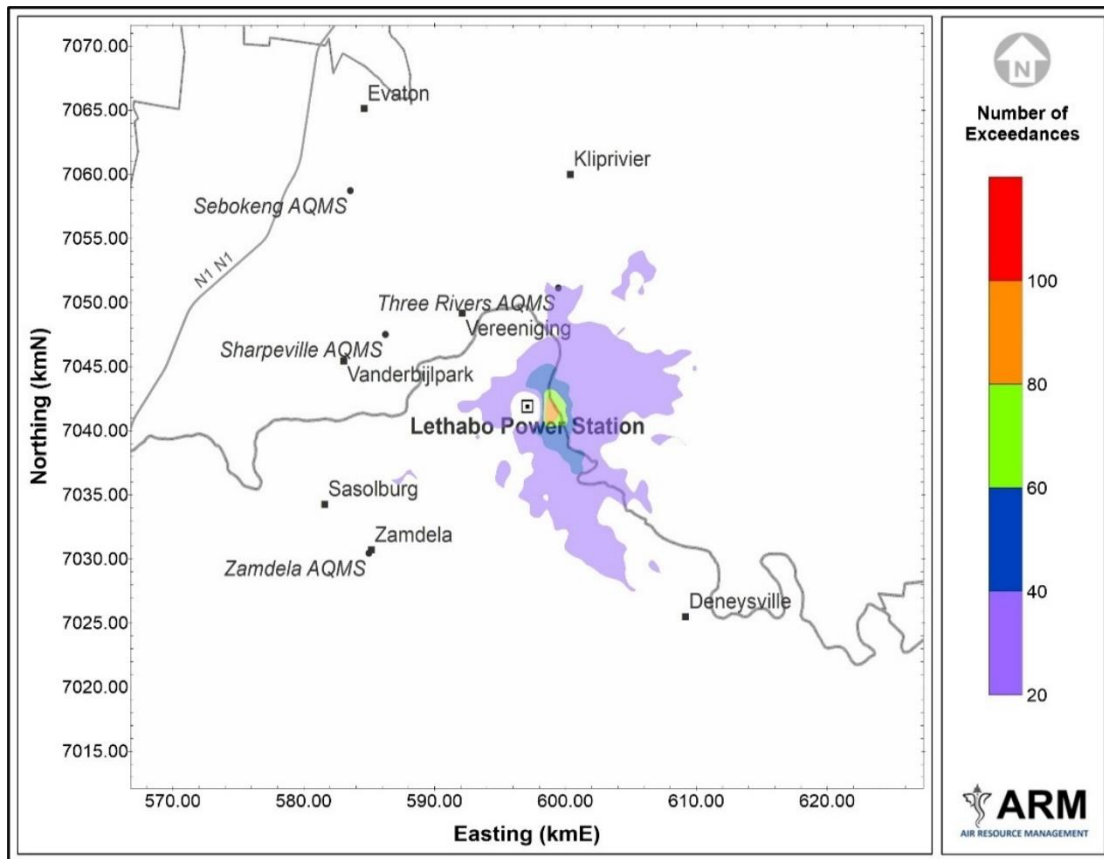
#### 3.2.1.3.2.1 Evaluation of model predicted exceedances

Figure 33 highlights the frequency of PM<sub>10</sub> exceedances (NAAQS) for the 24-hour time averaging period for the three-year simulation period. The permissible number of exceedances is 12 (4 exceedances per year, 3-year simulation period) and the red area indicates regions exceeding this permissible number of exceedances. These regions are localised around the Lethabo power station.



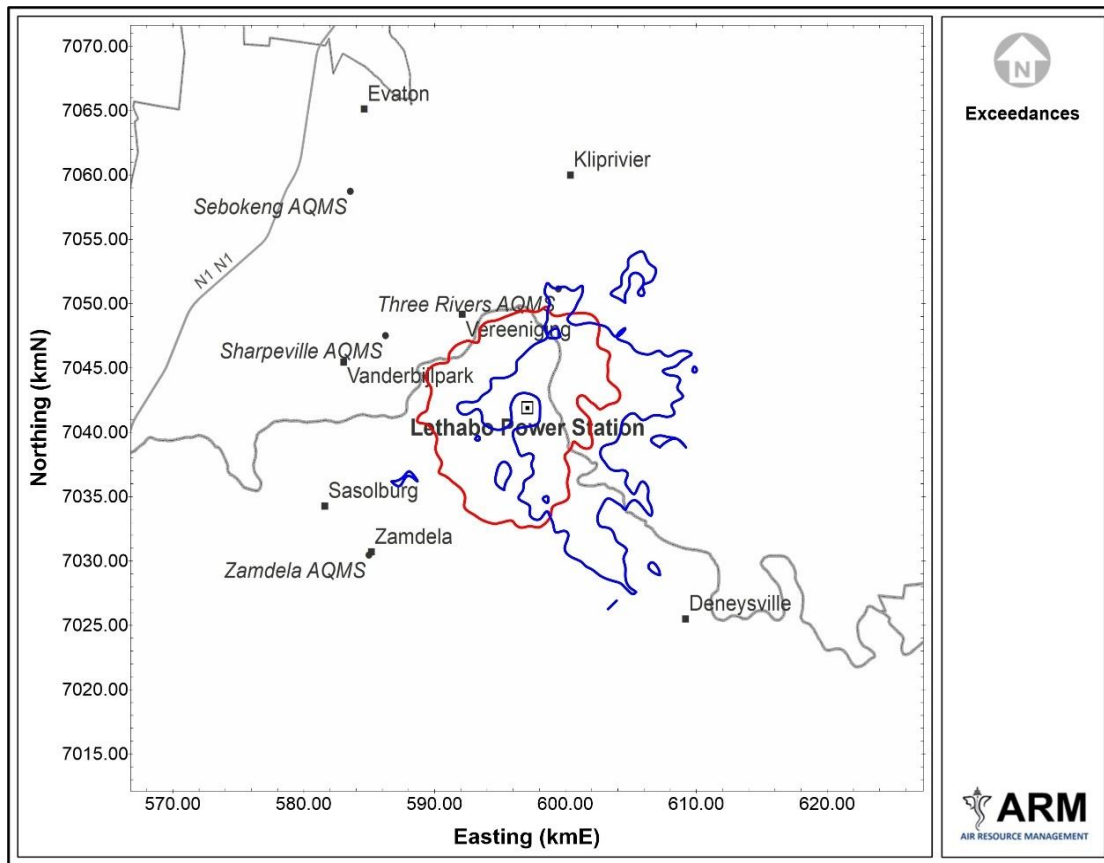
**Figure 33: Simulated Particulate Matter (PM<sub>10</sub>), 24-hour, concentration exceedance counts**

Figure 34 highlights the frequency of SO<sub>2</sub> exceedances (NAAQS) for the 1-hour time averaging period for the three-year simulation period. The permissible number of exceedances are 264 (88 exceedances per year, 3-year simulation period). The simulated number of exceedances are well below the permissible number of exceedances for SO<sub>2</sub>. A maximum of 100 exceedances were simulated towards the east of Lethabo power station (red area), whilst 60 exceedances (green area) are also towards the east of the Lethabo power station.



**Figure 34: Simulated Sulphur Dioxide (SO<sub>2</sub>), 1-hour, concentration exceedance counts**

Figure 35 is an illustration of an overlay of the PM<sub>10</sub> as well as the SO<sub>2</sub> frequency of exceedances. Although, these simulated exceedances are for two different time averages, a proxy of 6 and 20 exceedances were used for PM<sub>10</sub> and SO<sub>2</sub> respectively. The 6-exceedance isopleth (PM<sub>10</sub>, 24-hour) is indicated by the red isopleth, whilst the 20-exceedance isopleth (SO<sub>2</sub>, 1-hour) is indicated by the blue isopleth.



**Figure 35: Simulated PM<sub>10</sub> (red isopleth) and SO<sub>2</sub> (blue isopleth) concentration exceedances**

### 3.2.1.3.3 Opportunities for improving ambient quality through offsetting exist

Table 20 To Table 23 summarises the total population, energy usage patterns and indicative number of households for specific settlements that will participate in the offsets roll-out in the target areas for Lethabo power station offsets program.

**Table 20: Total population and number of households for Refengkotso that will participate in the offsets roll-out in the target areas for Lethabo power station offsets program**

Ward	Refengkotso	
	Indicative number of households	
	Eskom 2017 OIP <sup>a</sup>	2022 Stats SA <sup>b</sup>
Population	17 646	18 745
Total number of households	4 883	5 236

<sup>a</sup> Based on Eskom AQO Offset Implementation Plan.

<sup>b</sup> Based on ARM Census data extrapolation.

**Table 21: Total population and households for Sharpeville that will participate in the offsets roll-out in the target areas for Lethabo power station offsets program**

Ward	Sharpeville	
	Indicative number of households	
	Eskom 2017 OIP <sup>a</sup>	2022 Stats SA <sup>b</sup>
Population	37 599	49 269
Total number of households	12 170	16 470

<sup>a</sup> Based on Eskom AQO Offset Implementation Plan.

<sup>b</sup> Based on ARM Census data extrapolation.

**Table 22: Total population and households for Tshepiso that will participate in the offsets roll-out in the target areas for Lethabo power station offsets program**

Ward	Tshepiso	
	Indicative number of households	
	Eskom 2017 OIP <sup>a</sup>	2022 Stats SA <sup>b</sup>
Population	29 271	38 353
Total number of households	8 998	12 176

<sup>a</sup> Based on Eskom AQO Offset Implementation Plan.

<sup>b</sup> Based on ARM Census data extrapolation,

**Table 23: Total population and households for Boipatong that will participate in the offsets roll-out in the target areas for Lethabo power station offsets program**

Ward	Boipatong	
	Indicative number of households	
	Eskom 2017 OIP <sup>a</sup>	2022 Stats SA <sup>b</sup>
Population	22 167	29 049
Total number of households	7 059	9 552

<sup>a</sup> Based on Eskom AQO Offset Implementation Plan.

<sup>b</sup> Based on ARM Census data extrapolation

### 3.2.1.4 Majuba Power Station

#### 3.2.1.4.1 Air quality impact of the Majuba Power Station

Figure 36 indicate simulated 24-hour, 99<sup>th</sup> percentile PM<sub>10</sub> concentrations (NAAQS is 75.0 µg/m<sup>3</sup>, indicated by the red areas). High PM<sub>10</sub> concentrations were simulated towards south-westerly, southerly and south-easterly directions. The impact region is localised close to the Majuba power station.

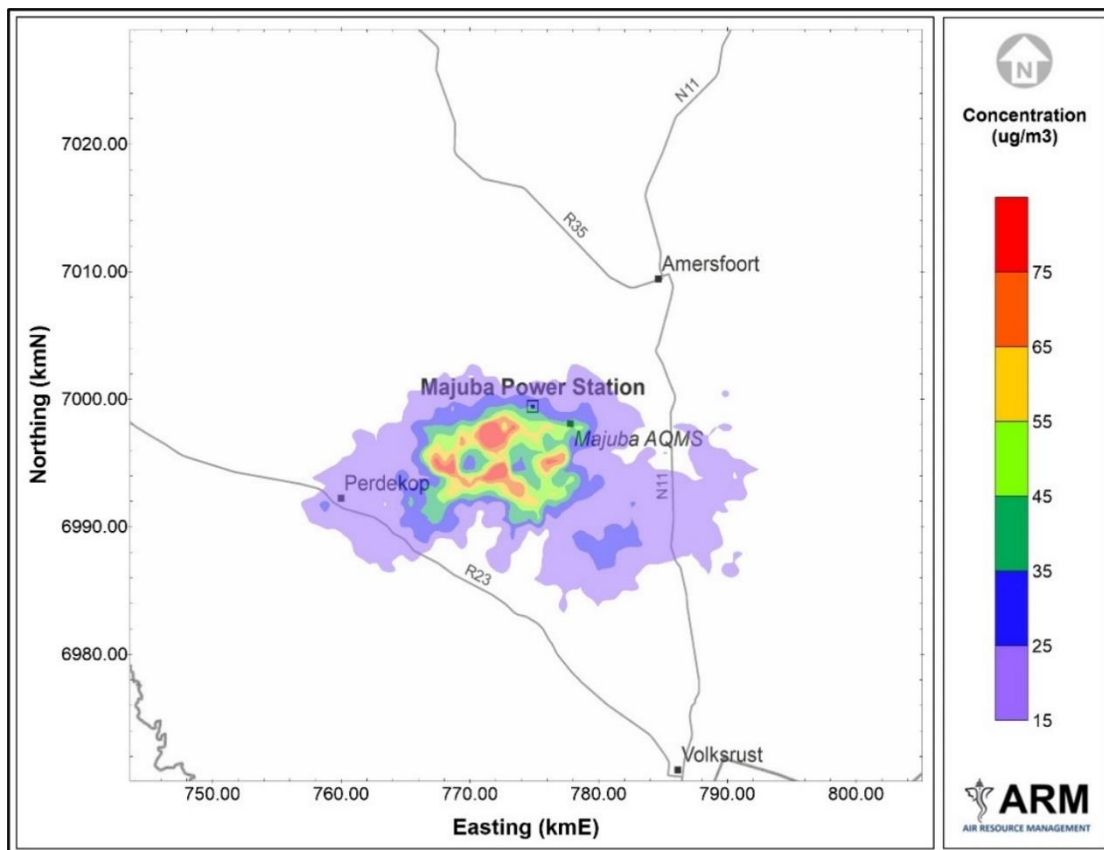


Figure 36: Simulated Particulate Matter (PM<sub>10</sub>), 24-hour, 99<sup>th</sup> percentile concentrations (NAAQS is 75.0 µg/m<sup>3</sup>).

Figure 37 indicate simulated 1-hour, 99<sup>th</sup> percentile SO<sub>2</sub> concentrations (NAAQS is 350.0 µg/m<sup>3</sup>). Elevated SO<sub>2</sub> concentrations were simulated towards a south-easterly direction.

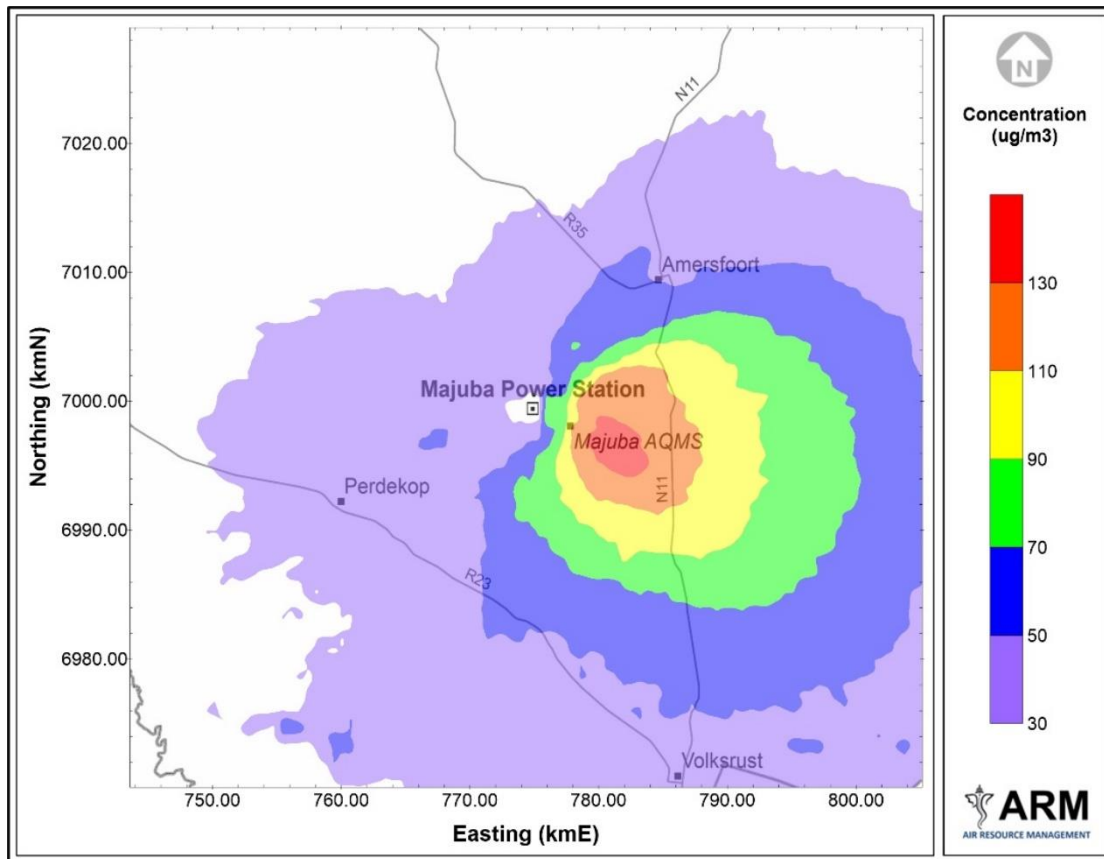
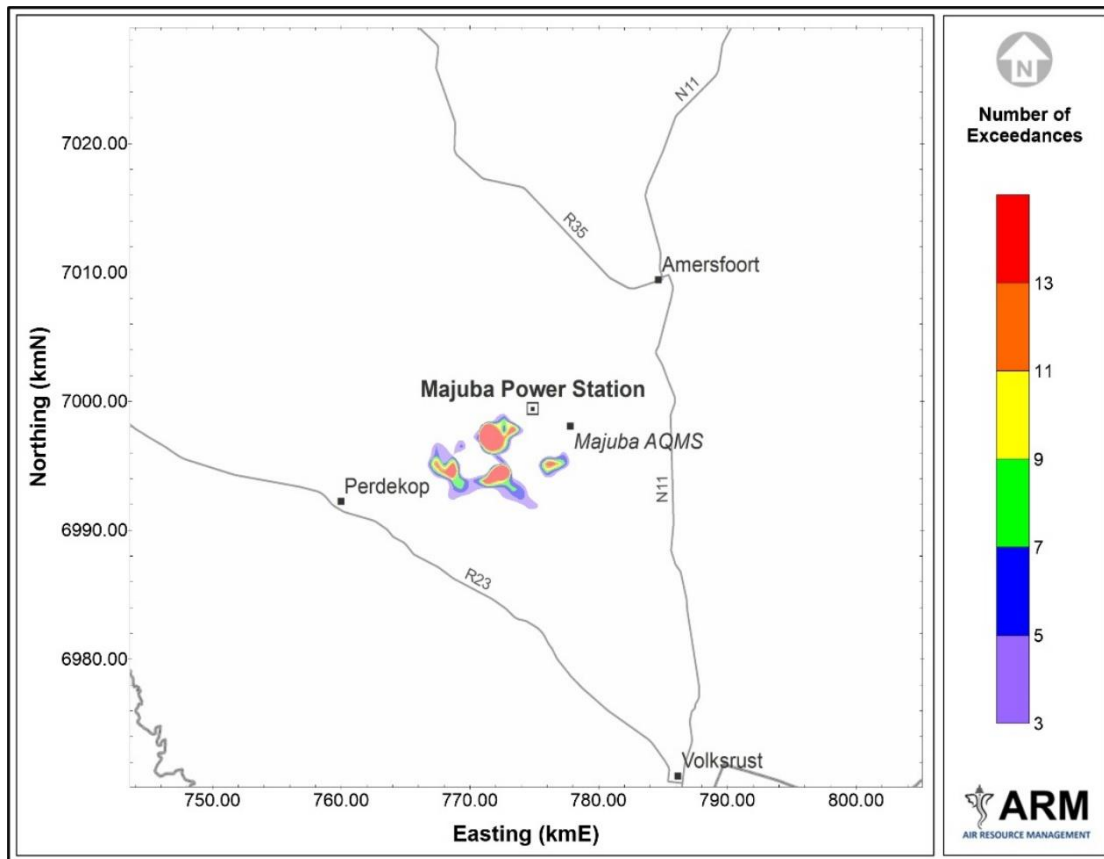


Figure 37: Simulated Sulphur Dioxide (SO<sub>2</sub>), 1-hour, 99<sup>th</sup> percentile concentrations (NAAQS is 350.0 µg/m<sup>3</sup>).

### 3.2.1.4.2 Non-compliance of NAAQS

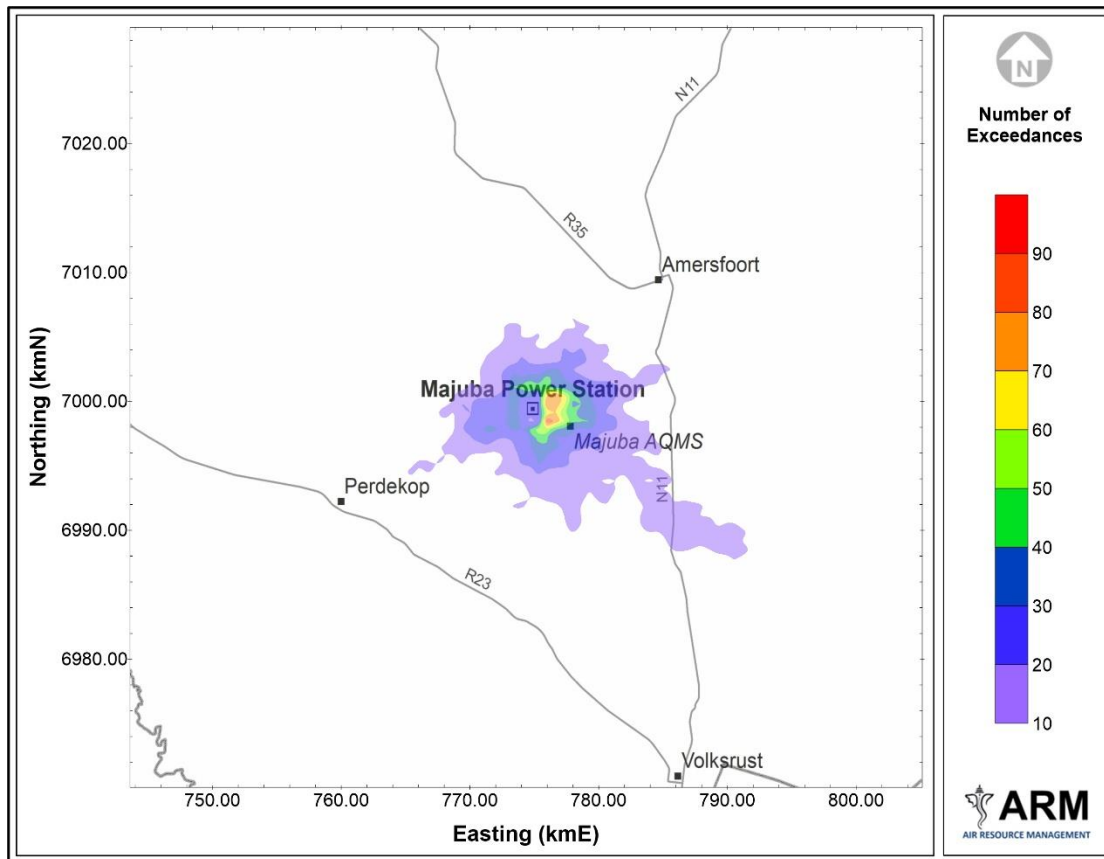
#### 3.2.1.4.2.1 Evaluation of model predicted exceedances

Figure 38 highlights the frequency of PM<sub>10</sub> exceedances (NAAQS) for the 24-hour time averaging period for the three-year simulation period. The permissible number of exceedances is 12 (4 exceedances per year, 3-year simulation period) and the red areas indicates regions exceeding this permissible number of exceedances. High PM<sub>10</sub> concentrations were simulated towards a south-westerly direction.



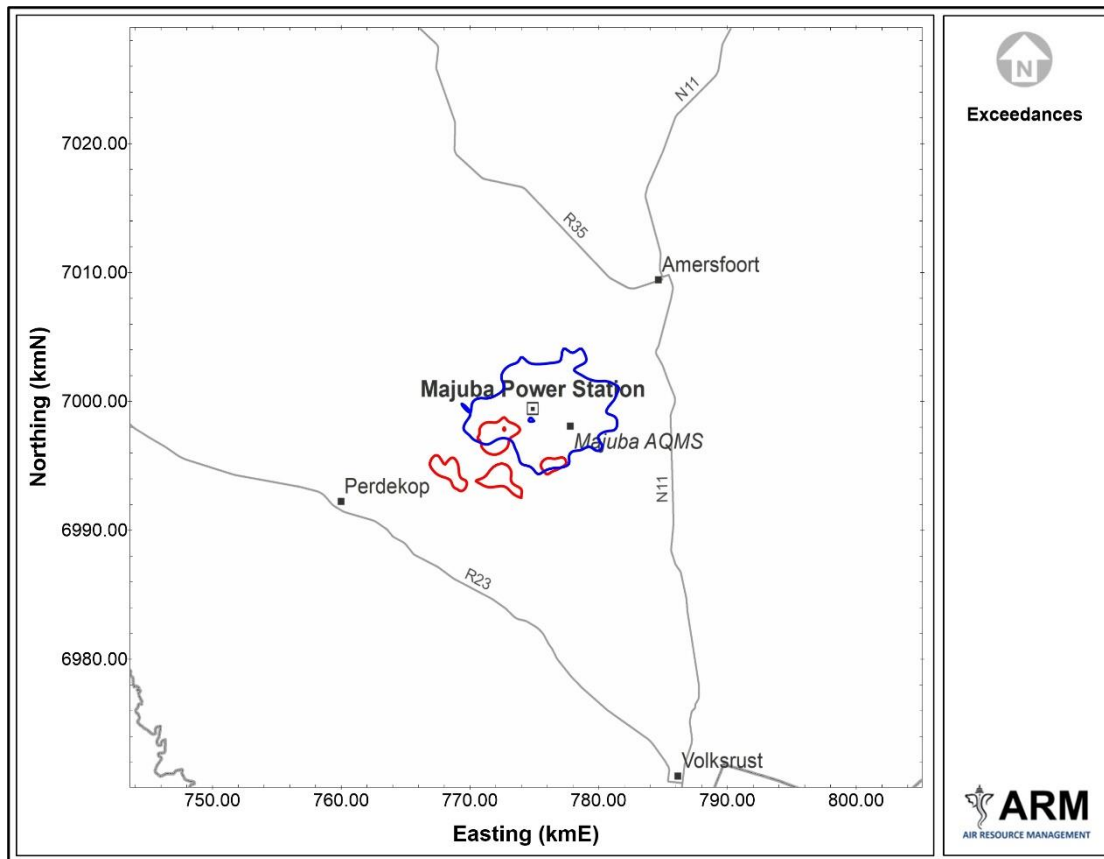
**Figure 38: Simulated Particulate Matter (PM<sub>10</sub>), 24-hour, concentration exceedance counts**

Figure 39 highlights the frequency of SO<sub>2</sub> exceedances (NAAQS) for the 1-hour time averaging period for the three-year simulation period. The permissible number of exceedances are 264 (88 exceedances per year, 3-year simulation period). The simulated number of exceedances are well below the permissible number of exceedances for SO<sub>2</sub>. A maximum of 90 exceedances were simulated towards the east of Majuba power station (red area), whilst 40 exceedances (green area) are also towards the east of the Lethabo power station.



**Figure 39: Simulated Sulphur Dioxide (SO<sub>2</sub>), 1-hour, concentration exceedance counts**

Figure 40 is an illustration of an overlay of the PM<sub>10</sub> as well as the SO<sub>2</sub> frequency of exceedances. Although, these simulated exceedances are for two different time averages, a proxy of 6 and 20 exceedances were used for PM<sub>10</sub> and SO<sub>2</sub> respectively. The 6-exceedance isopleth (PM<sub>10</sub>, 24-hour) is indicated by the red isopleth, whilst the 20-exceedance isopleth (SO<sub>2</sub>, 1-hour) is indicated by the blue isopleth.



**Figure 40: Simulated PM<sub>10</sub> (red isopleth) and SO<sub>2</sub> (blue isopleth) concentration exceedances**

### 3.2.1.4.2.2 Evaluation of ambient air quality monitoring data

The AQMS in closest proximity to the Majuba power station is the Majuba AQMS operated and maintained by Eskom. The Majuba AQMS is approximately 3.3km to the south-east of the power station, as indicated in Figure 41.

Ambient air quality data was obtained from 2010 to 2020 for the Majuba AQMS. Table 24 and Table 25 summarises analysed ambient PM<sub>10</sub> and SO<sub>2</sub> data for the specific time periods. Figure 42 to Figure 43 are graphical representations of Table 24, whilst Figure 44 to Figure 46 are graphical representations of Table 25.



**Figure 41: Map indicating the location of the Majuba AQMS relative to the Majuba power station**

**Table 24: Ambient PM<sub>10</sub> data for the Majuba AQMS for 2010 to 2020**

Period	Data Availability	Annual Average	24-Hour 99 <sup>th</sup> Percentile	24-Hour Number of Exceedances
	(%)	(ppb)	(ppb)	(number)
2010	n/av	n/av	n/av	0
2011	60	4.4	17.8	0
2012	69	30.9	114.7	16
2013	65	37	121.8	31
2014	26	9	74.5	1
2015	30	32.3	132.8	6
2016	57	27.1	95.1	5
2017	8	11.3	n/av	0
2018	29	46.1	176.5	29
2019	n/av	n/av	n/av	0
2020	n/av	n/av	n/av	0

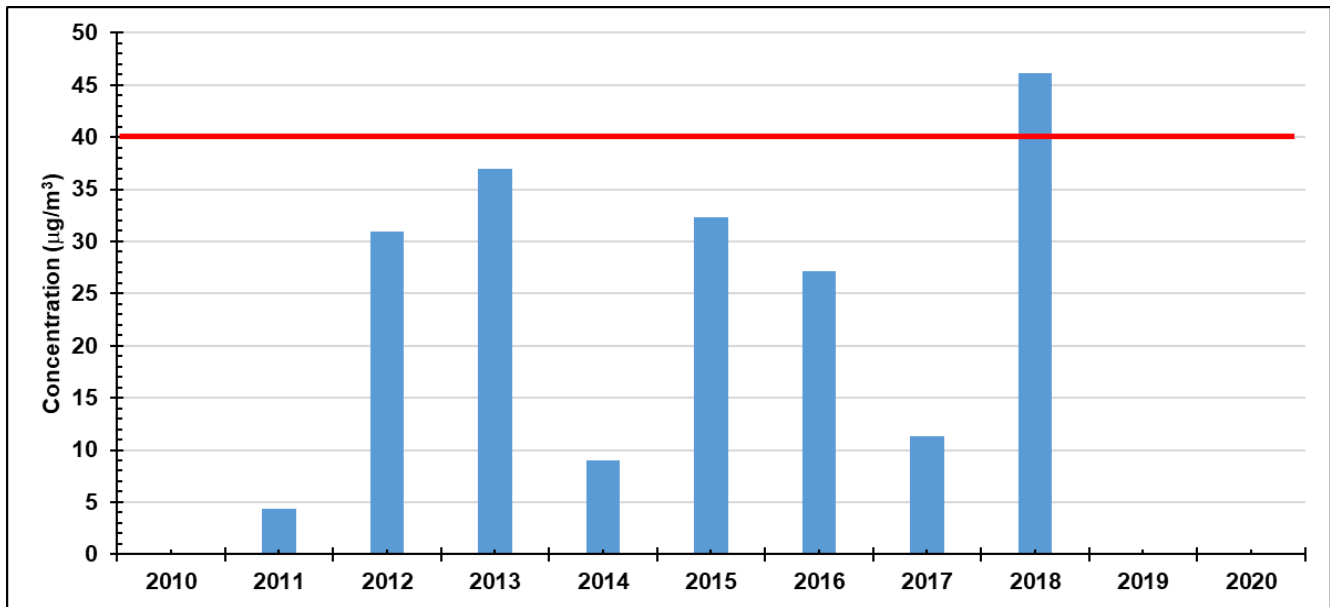


Figure 42: Annual ambient PM<sub>10</sub> concentrations for the Majuba AQMS for 2010 to 2020 (NAAQS is 40.0 µg/m<sup>3</sup>).

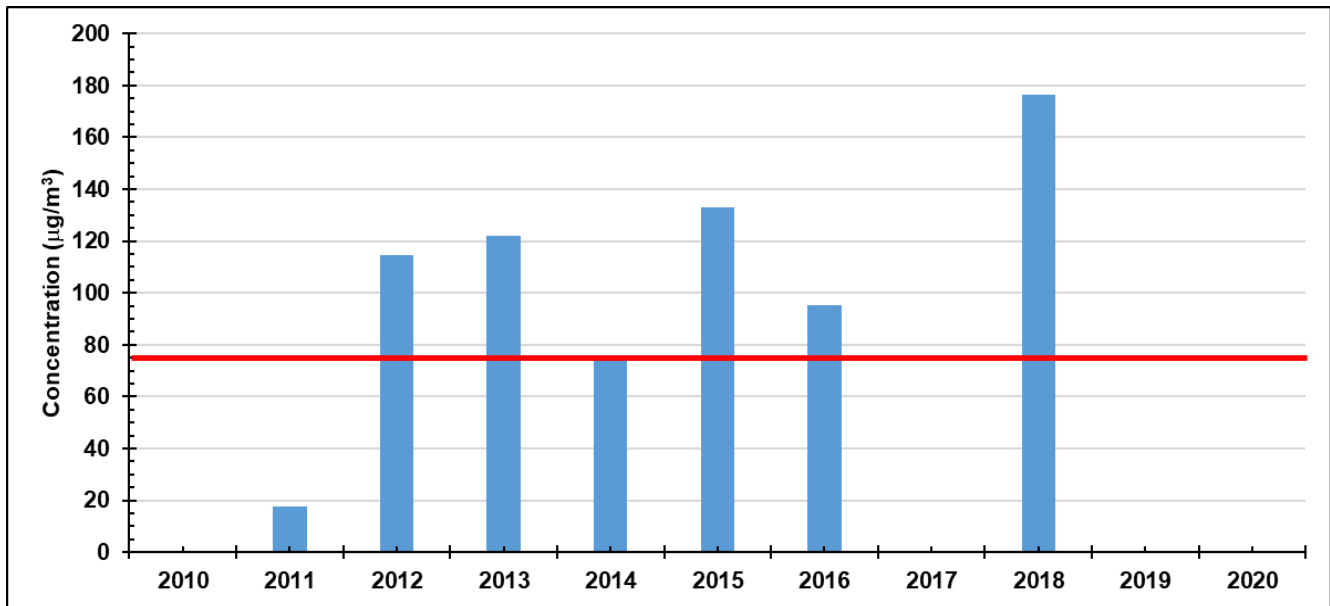
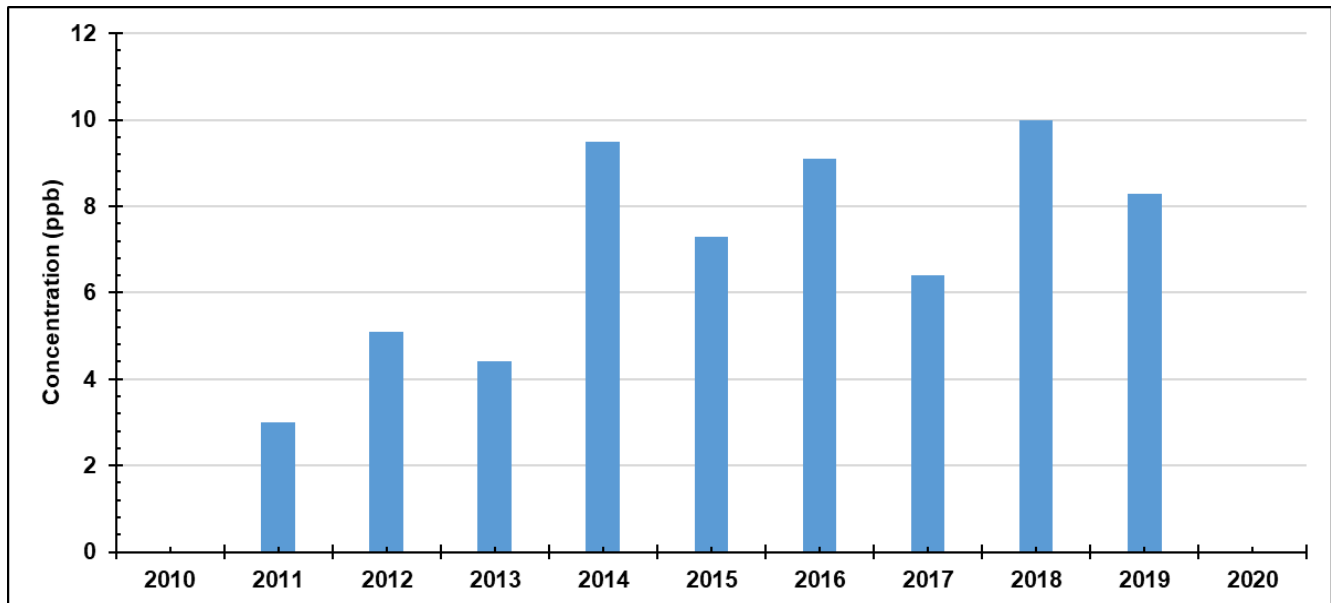


Figure 43: 24-Hour, 99<sup>th</sup> percentile ambient PM<sub>10</sub> concentrations for the Majuba AQMS for 2010 to 2020 (NAAQS is 75.0 µg/m<sup>3</sup>)

**Table 25: Ambient SO<sub>2</sub> data for the Majuba AQMS for 2010 to 2020**

Period	Data Availability	Annual Average	1-Hour 99 <sup>th</sup> Percentile	1-Hour Number of Exceedances	24-Hour 99 <sup>th</sup> Percentile	24-Hour Number of Exceedances
	(%)	(ppb)	(ppb)	(number)	(ppb)	(number)
2010	n/av	n/av	n/av	0	n/av	0
2011	59	3	49.5	9	22.6	0
2012	73	5.1	79.9	19	27.5	0
2013	75	4.4	66.4	12	21.9	1
2014	59	9.5	45.4	4	29.5	0
2015	61	7.3	61.4	4	23.2	0
2016	58	9.1	75.1	9	43.8	1
2017	9	6.4	68.7	3	n/av	0
2018	37	10	97.7	12	38.9	0
2019	44	8.3	89.7	19	48	1
2020	n/av	n/av	n/av	0	n/av	0



**Figure 44: Annual ambient SO<sub>2</sub> concentrations for the Majuba AQMS for 2010 to 2020 (NAAQS is 19.0 ppb)**

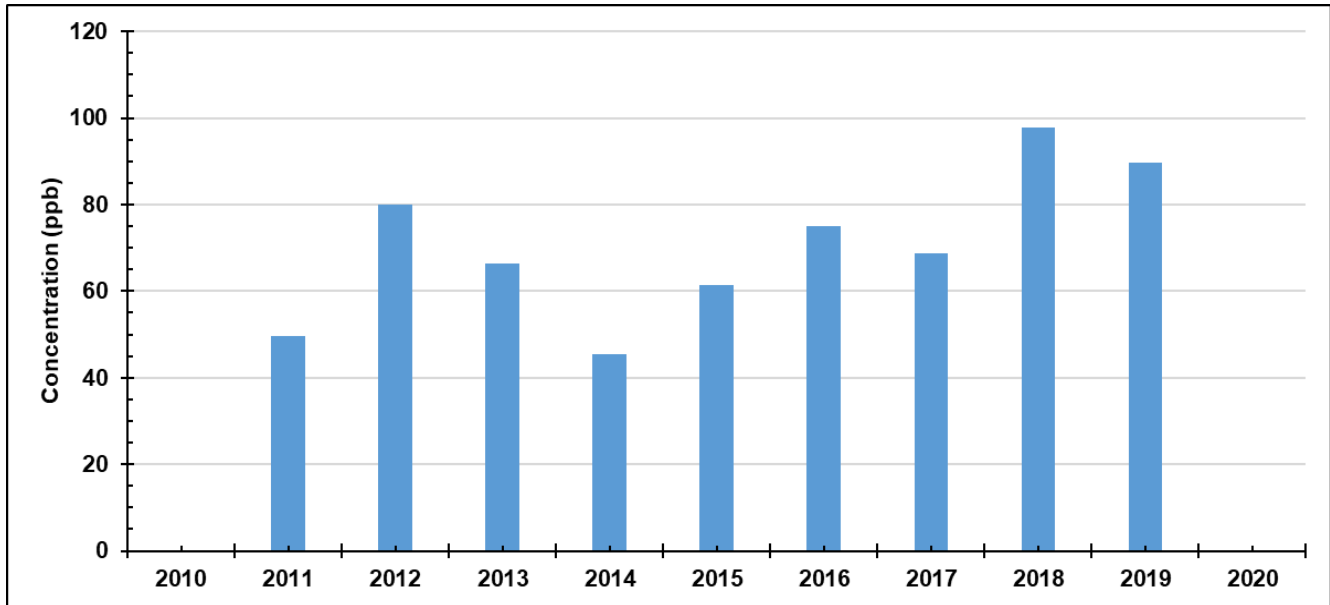


Figure 45: 1-Hour, 99<sup>th</sup> percentile ambient SO<sub>2</sub> concentrations for the Majuba AQMS for 2010 to 2020 (NAAQS is 134.0 ppb)

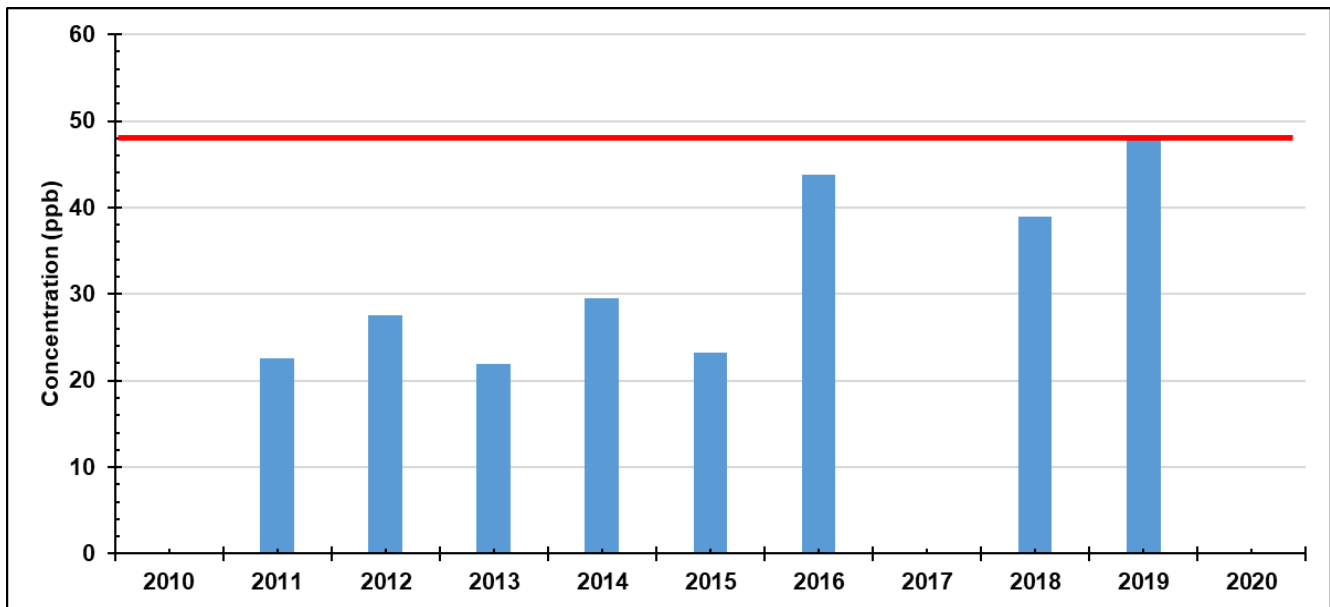


Figure 46: 24-Hour, 99<sup>th</sup> percentile ambient SO<sub>2</sub> concentrations for the Majuba AQMS for 2010 to 2020 (NAAQS is 48.0 ppb)

### 3.2.1.4.3 Opportunities for improving ambient quality through offsetting exist

Table 26 To Table 27 summarises the total population, energy usage patterns and indicative number of households for specific settlements that will participate in the offsets roll-out in the target areas for Majuba power station offsets program.

**Table 26: Total population, energy usage patterns and indicative number of households for Daggakraal/Sinqobile that will participate in the offsets roll-out in the target areas for Majuba power station offsets program**

Ward	Daggakraal/Sinqobile	
	Indicative number of households	
	Eskom 2017 OIP <sup>a</sup>	2022 Stats SA <sup>b</sup>
Population	14 856	25 650
Total number of households	4 112	7 073
Number of households using coal	3 269	4 244
Indicative number of households for air quality offsets	2 940	3 819

<sup>a</sup> Based on Eskom AQO Offset Implementation Plan.

<sup>b</sup> Based on ARM Census data extrapolation, assuming 90% choose to participate in the program.

**Table 27: Total population, energy usage patterns and indicative number of households for Ezamokuhle that will participate in the offsets roll-out in the target areas for Majuba power station offsets program**

Ward	Ezamokuhle	
	Indicative number of households	
	Eskom 2017 OIP <sup>a</sup>	2022 Stats SA <sup>b</sup>
Population	10 293	14 794
Total number of households	2 956	4 950
Number of households using coal	2 054	2 970
Indicative number of households for air quality offsets	1 850	2 673

<sup>a</sup> Based on Eskom AQO Offset Implementation Plan.

<sup>b</sup> Based on ARM Census data extrapolation, assuming 90% choose to participate in the program.

### 3.2.1.5 Matla Power Station

#### 3.2.1.5.1 Air quality impact of the Matla Power Station

Figure 47 indicate simulated 24-hour, 99<sup>th</sup> percentile PM<sub>10</sub> concentrations (NAAQS is 75.0 µg/m<sup>3</sup>, indicated by the red areas). High PM<sub>10</sub> concentrations are localised around the Matla power station.

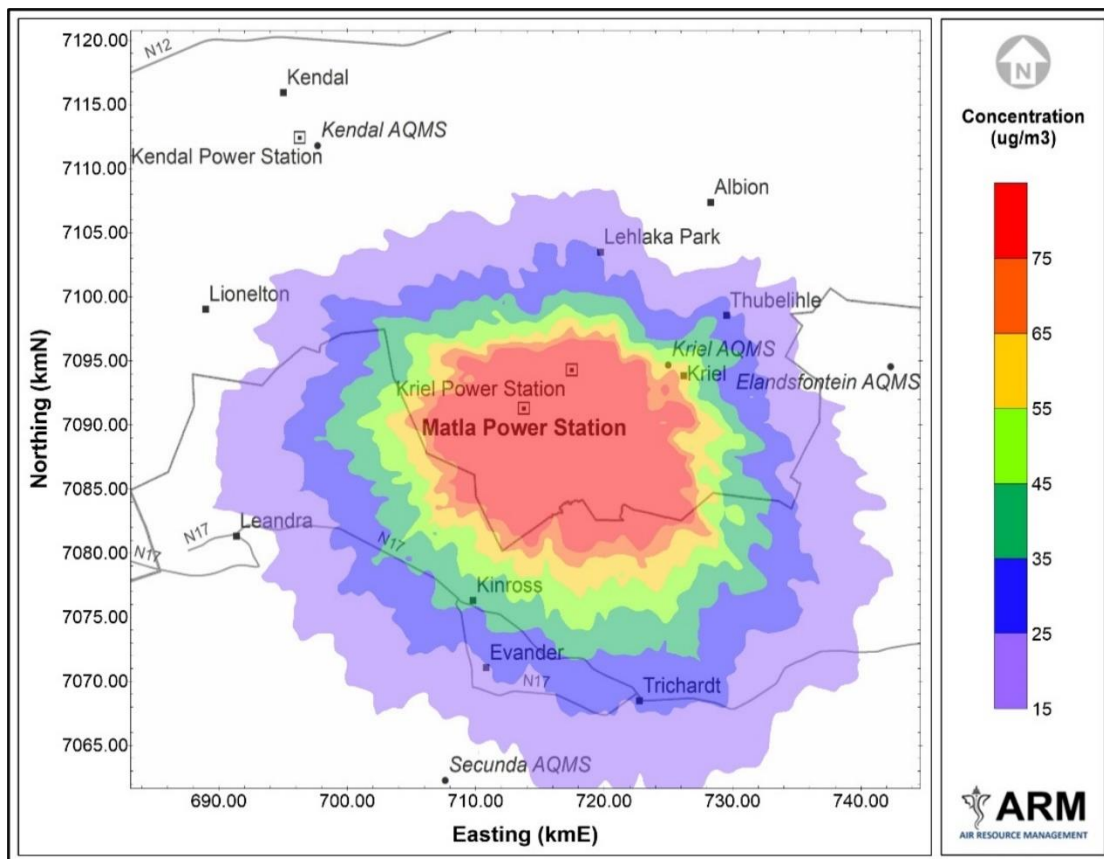


Figure 47: Simulated Particulate Matter (PM<sub>10</sub>), 24-hour, 99<sup>th</sup> percentile concentrations (NAAQS is 75.0 µg/m<sup>3</sup>).

Figure 48 indicate simulated 1-hour, 99<sup>th</sup> percentile SO<sub>2</sub> concentrations (NAAQS is 350.0 µg/m<sup>3</sup>). Elevated SO<sub>2</sub> concentrations were simulated towards a south-easterly direction.

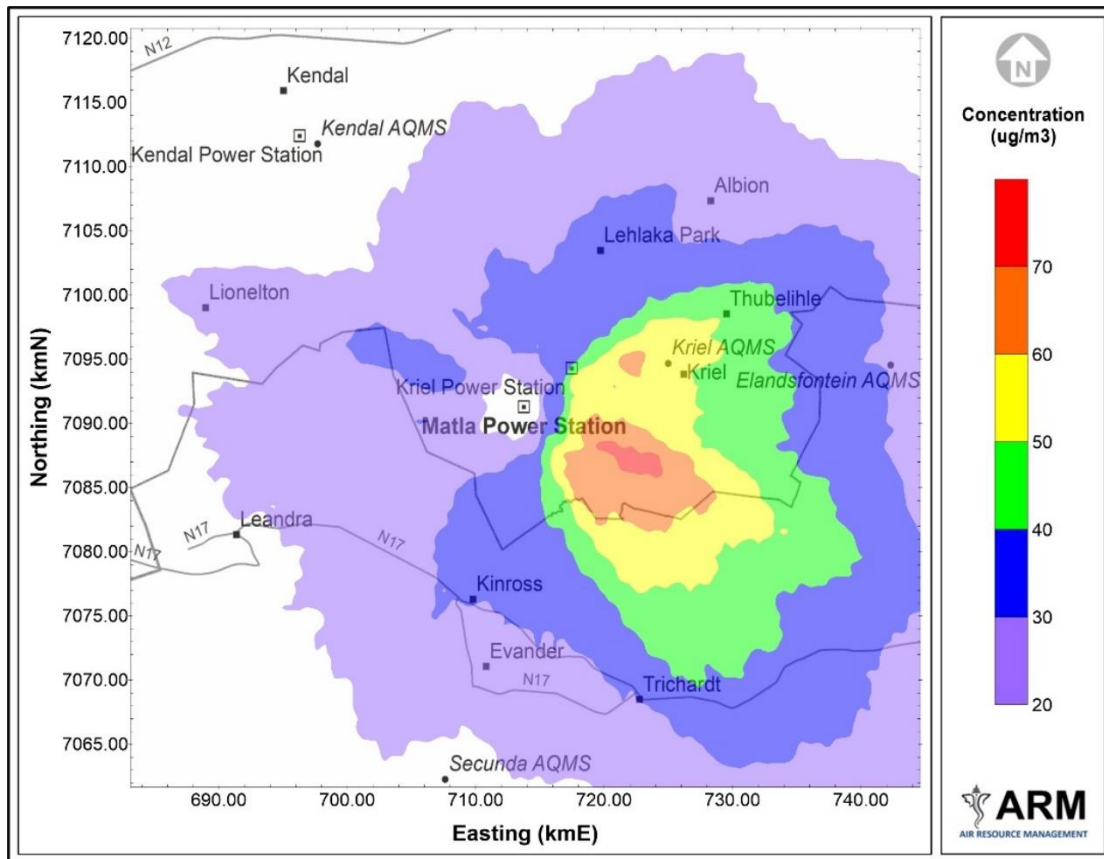
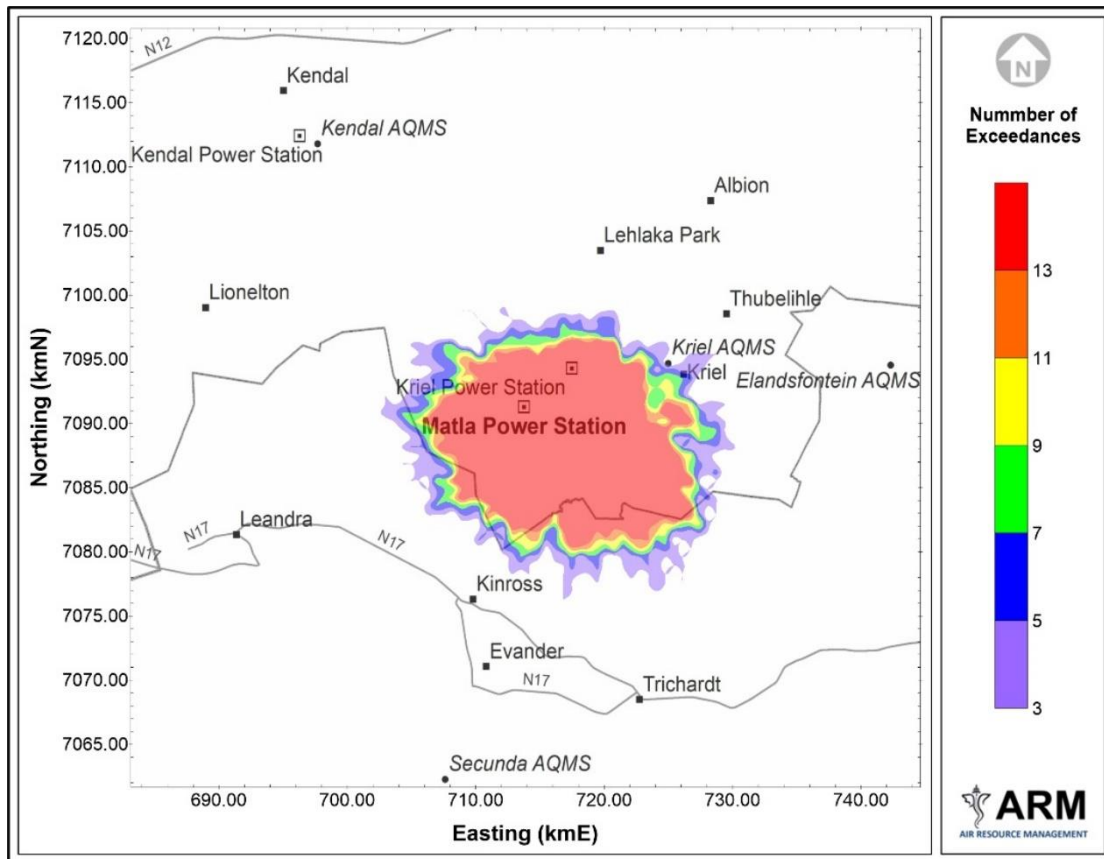


Figure 48: Simulated Sulphur Dioxide (SO<sub>2</sub>), 1-hour, 99<sup>th</sup> percentile concentrations (NAAQS is 350.0  $\mu\text{g}/\text{m}^3$ )

### 3.2.1.5.2 Non-compliance of NAAQS

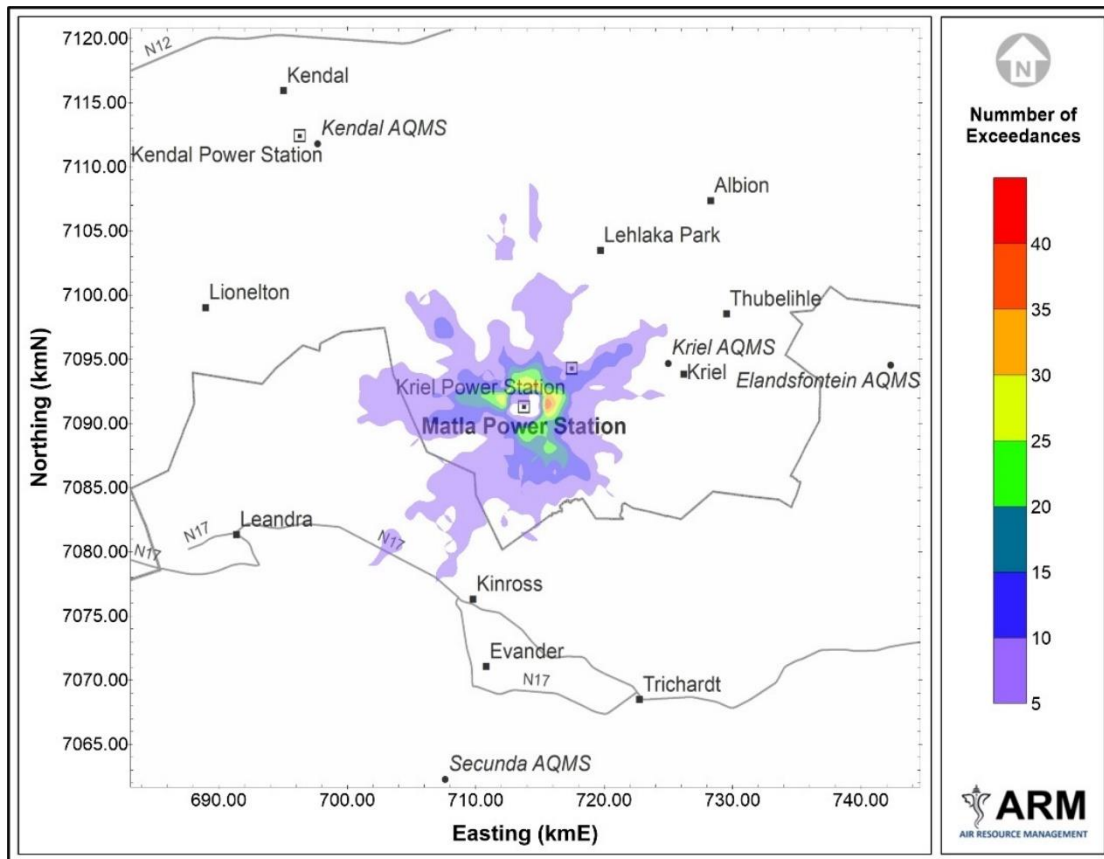
#### 3.2.1.5.2.1 Evaluation of model predicted exceedances

Figure 49 highlights the frequency of PM<sub>10</sub> exceedances (NAAQS) for the 24-hour time averaging period for the three-year simulation period. The permissible number of exceedances is 12 (4 exceedances per year, 3-year simulation period) and the red areas indicates regions exceeding this permissible number of exceedances. A high number of exceedances are localised around the Matla power station.



**Figure 49: Simulated Particulate Matter (PM<sub>10</sub>), 24-hour, concentration exceedance counts**

Figure 50 highlights the frequency of SO<sub>2</sub> exceedances (NAAQS) for the 1-hour time averaging period for the three-year simulation period. The permissible number of exceedances are 264 (88 exceedances per year, 3-year simulation period). The simulated number of exceedances are well below the permissible number of exceedances for SO<sub>2</sub>. A maximum of 40 exceedances were simulated towards the east of Matla power station (red area), whilst 20 exceedances (green area) are localised around the Matla power station.



**Figure 50: Simulated Sulphur Dioxide (SO<sub>2</sub>), 1-hour, concentration exceedance counts**

Figure 51 is an illustration of an overlay of the PM<sub>10</sub> as well as the SO<sub>2</sub> frequency of exceedances. Although, these simulated exceedances are for two different time averages, a proxy of 6 and 20 exceedances were used for PM<sub>10</sub> and SO<sub>2</sub> respectively. The 6-exceedance isopleth (PM<sub>10</sub>, 24-hour) is indicated by the red isopleth, whilst the 20-exceedance isopleth (SO<sub>2</sub>, 1-hour) is indicated by the blue isopleth.

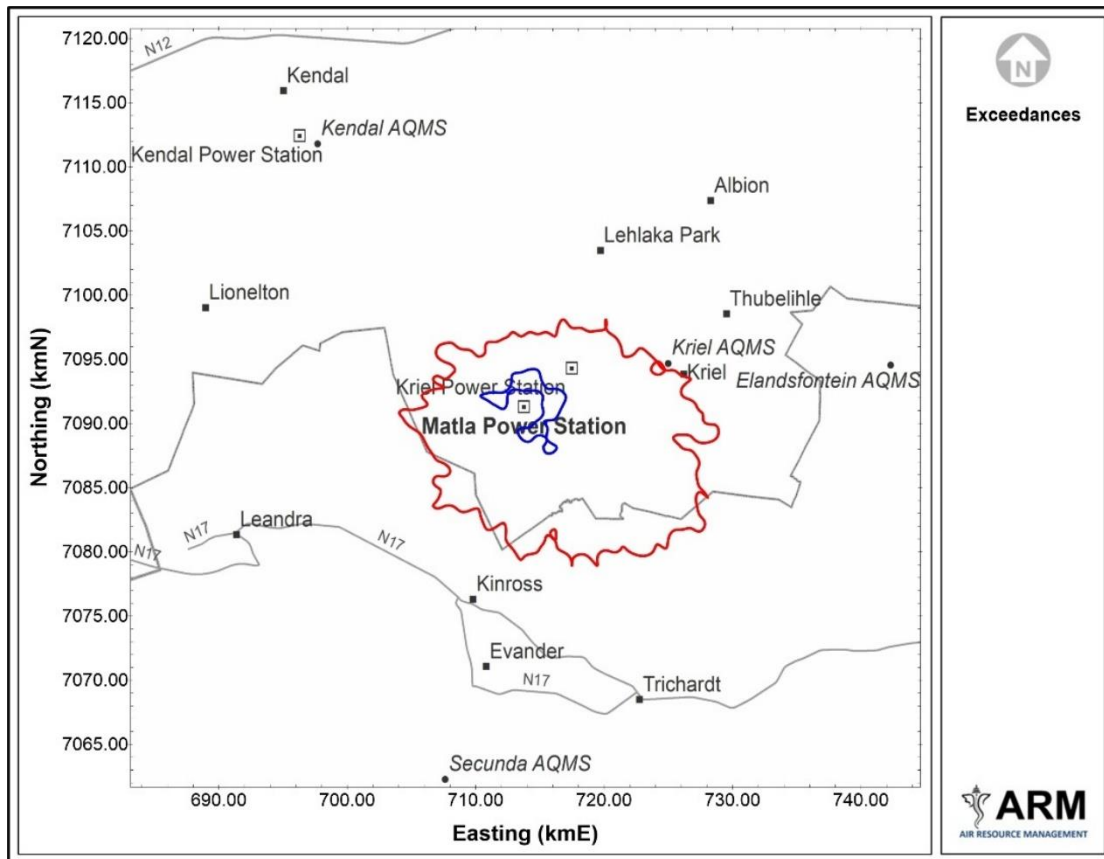


Figure 51: Simulated PM<sub>10</sub> (red isopleth) and SO<sub>2</sub> (blue isopleth) concentration exceedances

### 3.2.1.5.2.2 Evaluation of ambient air quality monitoring data

The AQMS in closest proximity to the Matla power station is the Kriel AQMS operated and maintained by Eskom. The Kriel AQMS is approximately 12.0km to the north-east of the Matla power station, as indicated in Figure 52.

Ambient air quality data was obtained from 2017 to 2020 for the Kriel AQMS. Table 28 and Table 29 summarises analysed ambient PM<sub>10</sub> and SO<sub>2</sub> data for the specific time periods. Figure 53 to Figure 54 are graphical representations of Table 28 whilst Figure 55 to Figure 57 are graphical representations of Table 29.



**Figure 52: Map indicating the location of the Kriel AQMS relative to the Matla power station**

**Table 28: Ambient PM<sub>10</sub> data for the Kriel AQMS for 2017 to 2020.**

Period	Data Availability	Annual Average	24-Hour 99 <sup>th</sup> Percentile	24-Hour Number of Exceedances
	(%)	(ppb)	(ppb)	(number)
2017	n/av	n/av	n/av	0
2018	97	51.5	111.9	70
2019	57	71.4	177	96
2020	n/av	n/av	n/av	0

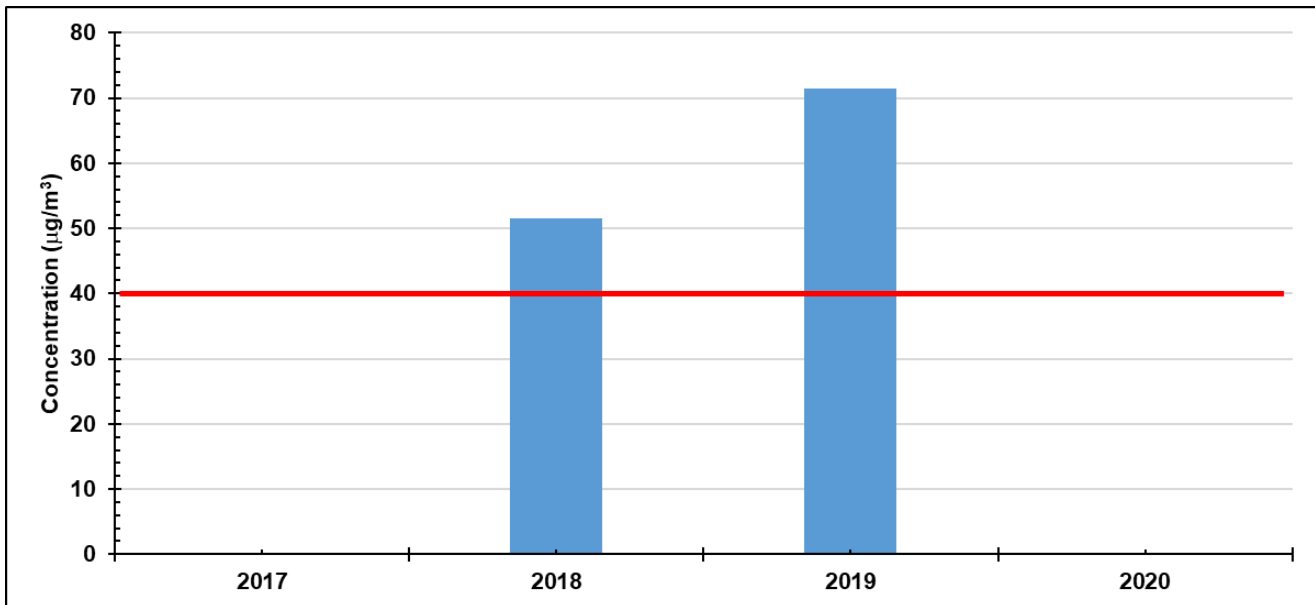


Figure 53: Annual ambient PM<sub>10</sub> concentrations for the Kriel AQMS for 2017 to 2020 (NAAQS is 40.0 µg/m<sup>3</sup>).

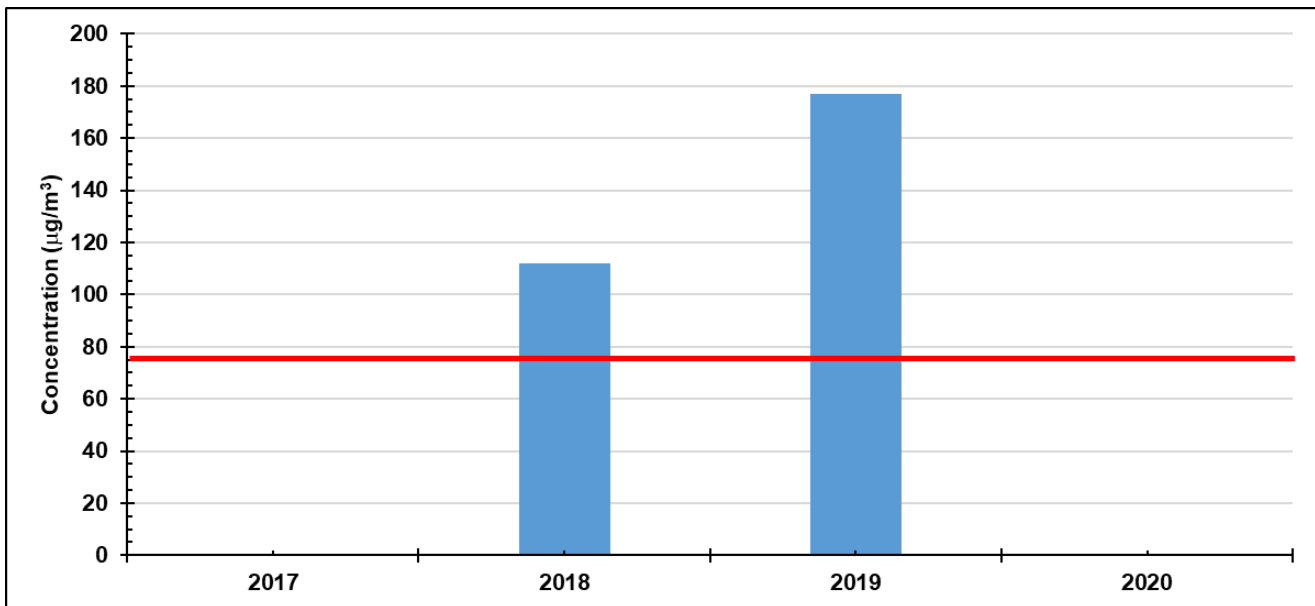
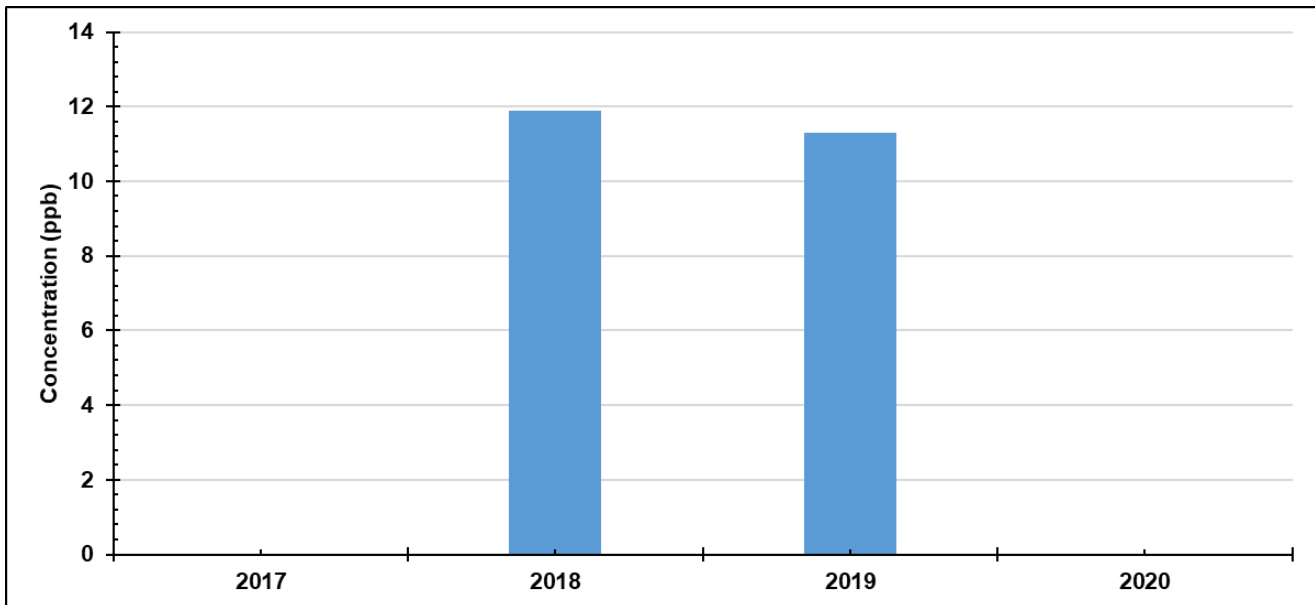


Figure 54: 24-Hour, 99<sup>th</sup> percentile ambient PM<sub>10</sub> concentrations for the Kriel AQMS for 2017 to 2020 (NAAQS is 75.0 µg/m<sup>3</sup>).

**Table 29: Ambient SO<sub>2</sub> data for the Kriel AQMS for 2017 to 2020**

Period	Data Availability	Annual Average	1-Hour 99 <sup>th</sup> Percentile	1-Hour Number of Exceedances	24-Hour 99 <sup>th</sup> Percentile	24-Hour Number of Exceedances
	(%)	(ppb)	(ppb)	(number)	(ppb)	(number)
2017	n/av	n/av	n/av	0	n/av	0
2018	92	11.9	97.7	38	41.9	1
2019	60	11.3	114.9	30	43.7	0
2020	n/av	n/av	n/av	0	n/av	0



**Figure 55: Annual ambient SO<sub>2</sub> concentrations for the Kriel AQMS for 2017 to 2020 (NAAQS is 19.0 ppb).**

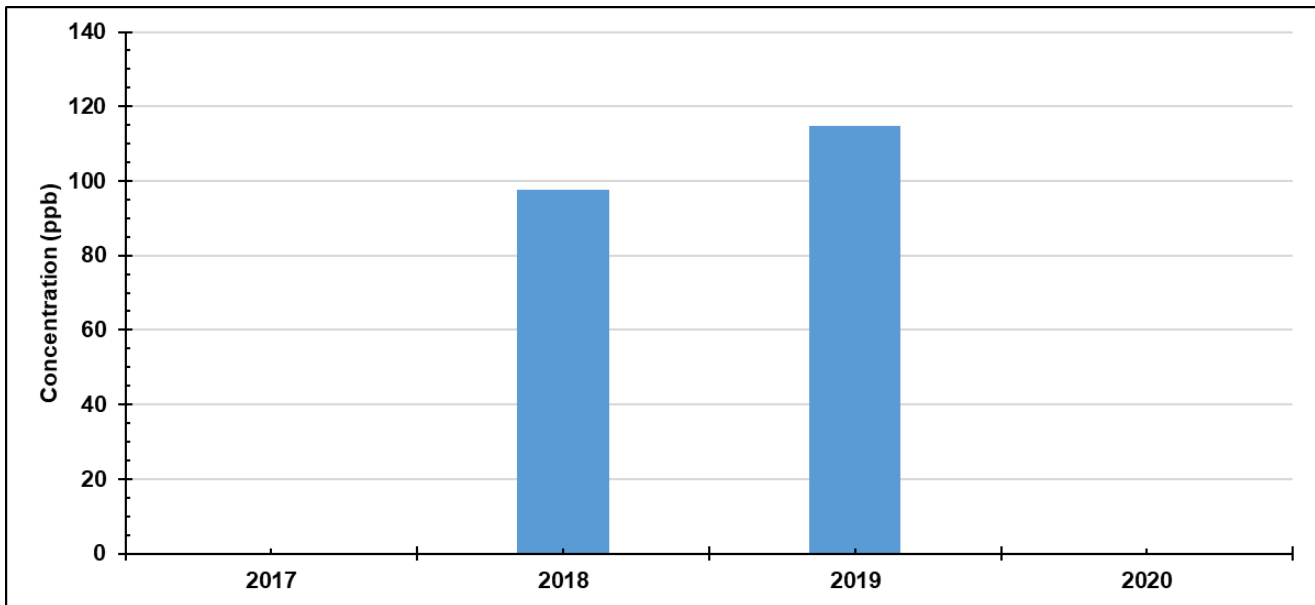


Figure 56: 1-Hour, 99<sup>th</sup> percentile ambient SO<sub>2</sub> concentrations for the Kriel AQMS for 2017 to 2020 (NAAQS is 134.0 ppb)

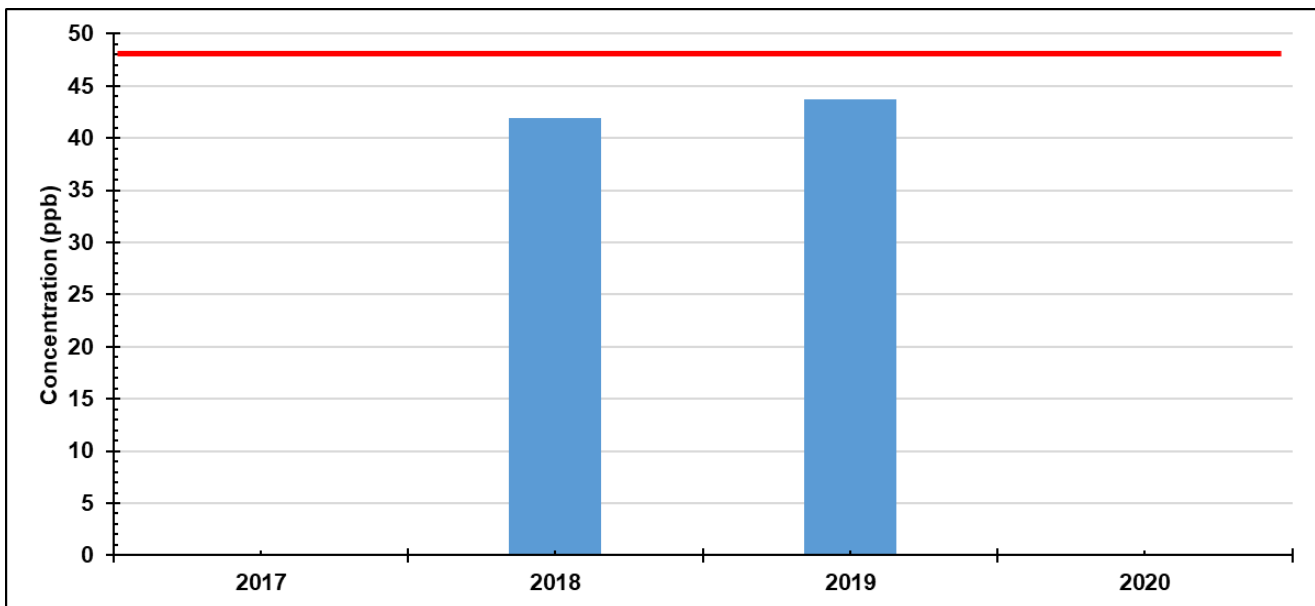


Figure 57: 24-Hour, 99<sup>th</sup> percentile ambient SO<sub>2</sub> concentrations for the Kriel AQMS for 2017 to 2020 (NAAQS is 48.0 ppb).

### 3.2.1.5.3 Opportunities for improving ambient quality through offsetting exist

Table 30 To Table 34 summarises the total population, energy usage patterns and indicative number of households for specific settlements that will participate in the offsets roll-out in the target areas for Matla power station offsets program.

**Table 30: Total population, energy usage patterns and indicative number of households for Chris Hani that will participate in the offsets roll-out in the target areas for Matla power station offsets program**

Ward	Chris Hani	
	Indicative number of households	
	Eskom 2017 OIP <sup>a</sup>	2022 Stats SA <sup>b</sup>
Population	No Data	No Data
Total number of households	405	No Data
Number of households using coal	332	No Data
Indicative number of households for air quality offsets	274	No Data

<sup>a</sup> Based on Eskom AQO Offset Implementation Plan.

<sup>b</sup> Based on ARM Census data extrapolation, assuming 90% choose to participate in the program.

**Table 31: Total population, energy usage patterns and indicative number of households for Emzimnoni<sup>a</sup> that will participate in the offsets roll-out in the target areas for Matla power station offsets program**

Ward	Emzimnoni <sup>a</sup>	
	Indicative number of households	
	Eskom 2017 OIP <sup>b</sup>	2022 Stats SA <sup>c</sup>
Population	No Data	32 940
Total number of households	9 195	11 388
Number of households using coal	3 694	6 833
Indicative number of households for air quality offsets	6 065	6150

<sup>a</sup> Emzimnoni is the total area that include Emzimnoni, Emzimnoni Ext 2, Emzimnoni Ext 3, Emzimnoni Ext 4 and Emzimnoni Ext 5.

<sup>b</sup> Based on Eskom AQO Offset Implementation Plan.

<sup>c</sup> Based on ARM Census data extrapolation, assuming 90% choose to participate in the program.

**Table 32: Total population, energy usage patterns and indicative number of households for Kananna Ext 6 that will participate in the offsets roll-out in the target areas for Matla power station offsets program**

Ward	Kananna Ext 6	
	Indicative number of households	
	Eskom 2017 OIP <sup>a</sup>	2022 Stats SA <sup>b</sup>
Population	No Data	3 238
Total number of households	871	1 079
Number of households using coal	553	647
Indicative number of households for air quality offsets	551	583

<sup>a</sup> Based on Eskom AQO Offset Implementation Plan.

<sup>b</sup> Based on ARM Census data extrapolation, assuming 90% choose to participate in the program.

**Table 33: Total population, energy usage patterns and indicative number of households for Milan Park<sup>a</sup> that will participate in the offsets roll-out in the target areas for Matla power station offsets program**

Ward	Milan Park <sup>a</sup>	
	Indicative number of households	
	Eskom 2017 OIP <sup>b</sup>	2022 Stats SA <sup>c</sup>
Population	No Data	11 952
Total number of households	3 492	4 571
Number of households using coal	1 289	2 743
Indicative number of households for air quality offsets	1 035	2 468

<sup>a</sup> Milan Park is the total area that include Milan Park Ext 13, Milan Park Ext 21, Milan Park Ext 22 and Milan Park Ext 23.

<sup>b</sup> Based on Eskom AQO Offset Implementation Plan.

<sup>c</sup> Based on ARM Census data extrapolation, assuming 90% choose to participate in the program.

**Table 34: Total population, energy usage patterns and indicative number of households for Thambo that will participate in the offsets roll-out in the target areas for Matla power station offsets program**

Ward	Thambo	
	Indicative number of households	
	Eskom 2017 OIP <sup>a</sup>	2022 Stats SA <sup>b</sup>
Population	No Data	2 152
Total number of households	610	756
Number of households using coal	264	454
Indicative number of households for air quality offsets	845	408

<sup>a</sup> Based on Eskom AQO Offset Implementation Plan.

<sup>b</sup> Based on ARM Census data extrapolation, assuming 90% choose to participate in the program.

### 3.2.1.6 Tutuka Power Station

#### 3.2.1.6.1 Air quality impact of the Tutuka Power Station

Figure 58 indicate simulated 24-hour, 99<sup>th</sup> percentile PM<sub>10</sub> concentrations (NAAQS is 75.0 µg/m<sup>3</sup>, indicated by the red areas). High PM<sub>10</sub> concentrations were simulated towards an easterly direction. The impact region is localised close to the Tutuka power station.

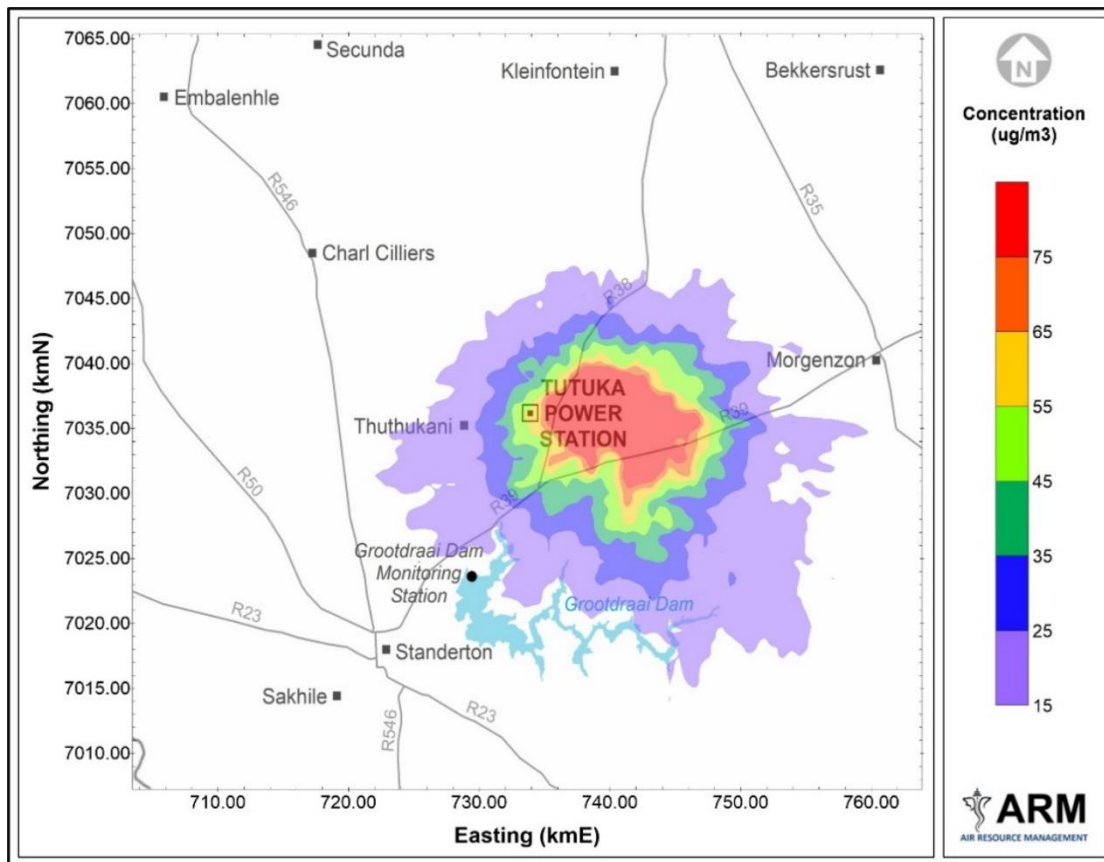


Figure 58: Simulated Particulate Matter (PM<sub>10</sub>), 24-hour, 99<sup>th</sup> percentile concentrations (NAAQS is 75.0 µg/m<sup>3</sup>).

Figure 59 indicate simulated 1-hour, 99<sup>th</sup> percentile SO<sub>2</sub> concentrations (NAAQS is 350.0 µg/m<sup>3</sup>). Elevated SO<sub>2</sub> concentrations were simulated towards north-easterly and south-easterly directions.

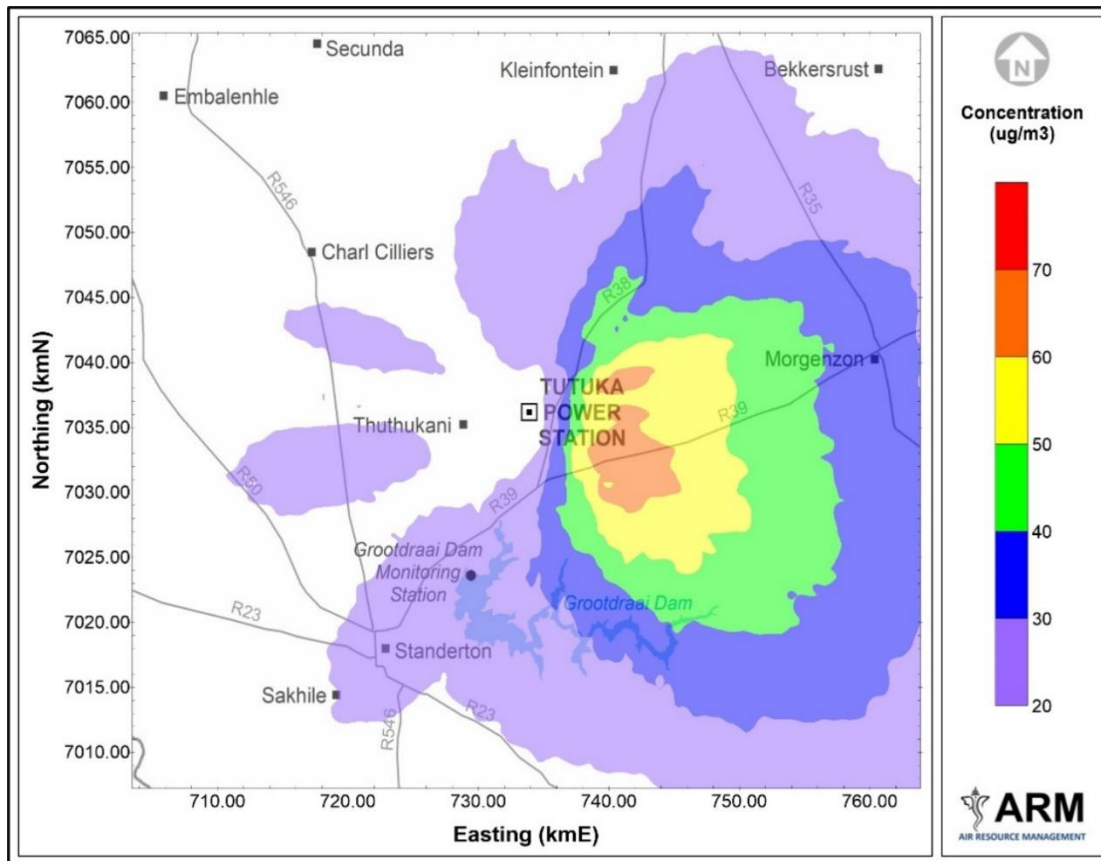
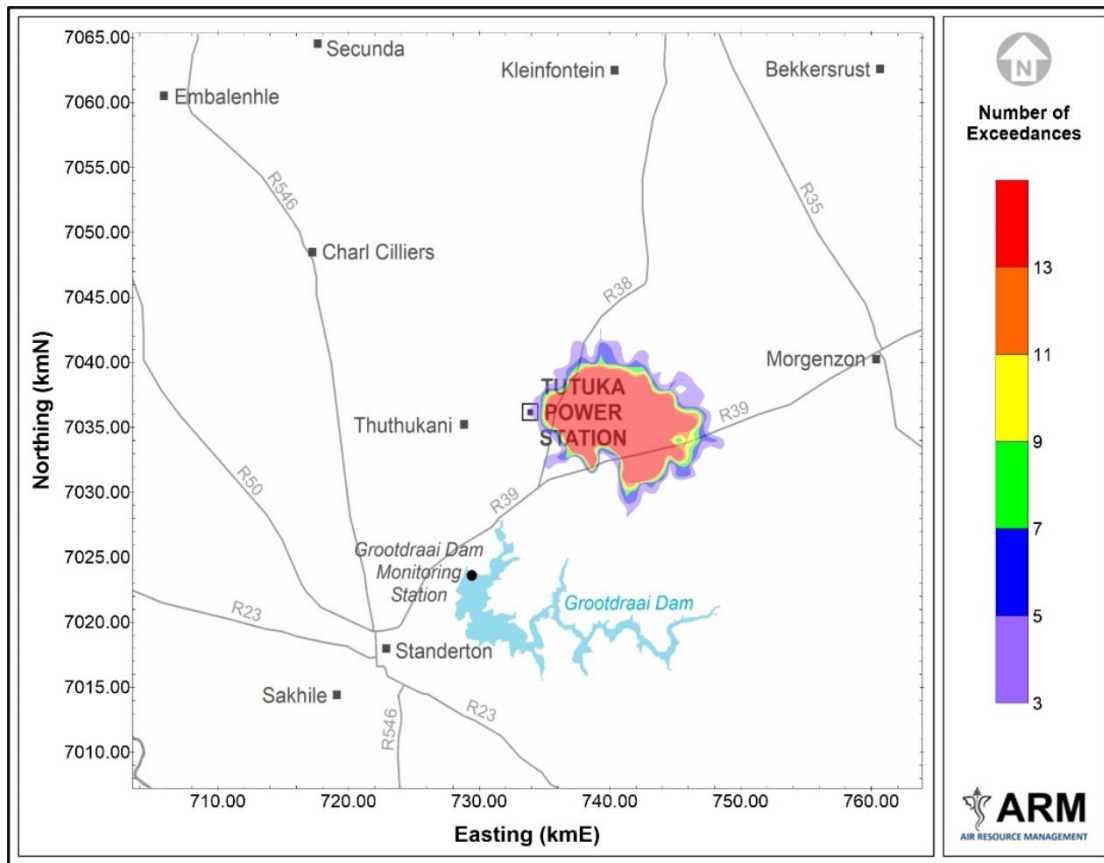


Figure 59: Simulated Sulphur Dioxide (SO<sub>2</sub>), 1-hour, 99<sup>th</sup> percentile concentrations (NAAQS is 350.0 µg/m<sup>3</sup>).

### 3.2.1.6.2 Non-compliance of NAAQS

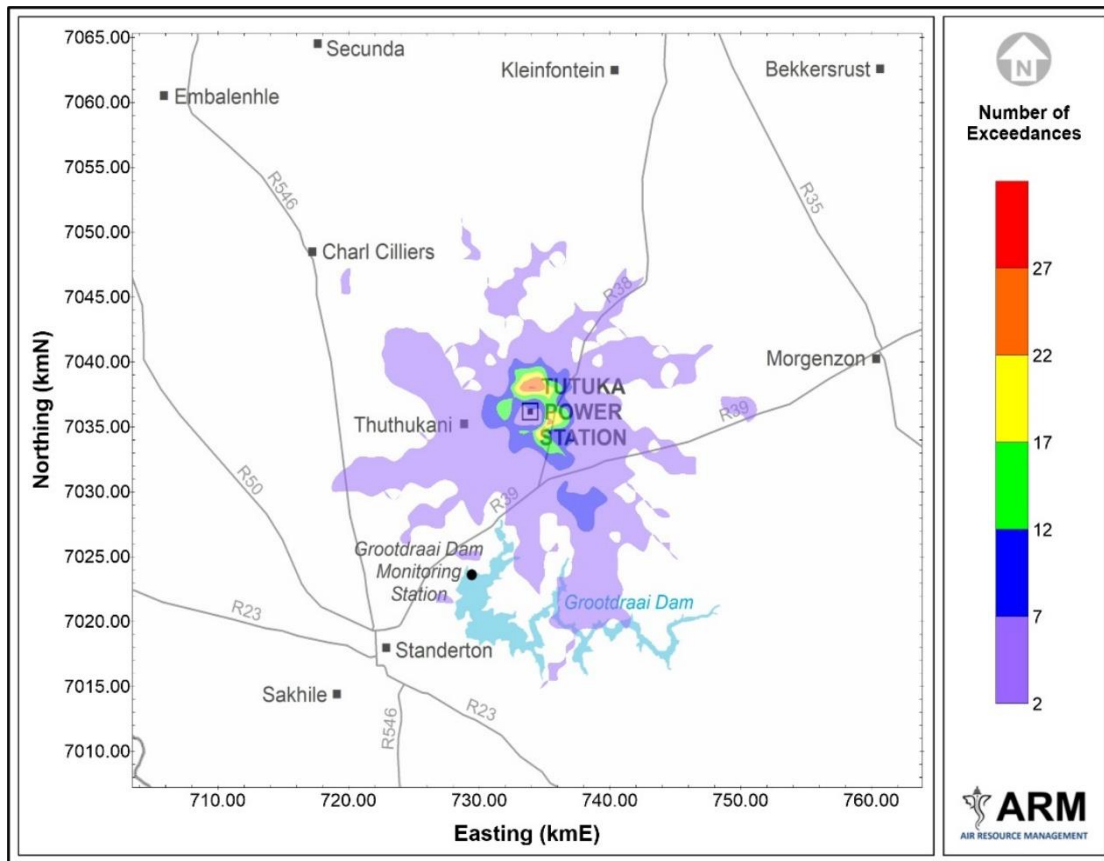
#### 3.2.1.6.2.1 Evaluation of model predicted exceedances

Figure 60 highlights the frequency of PM<sub>10</sub> exceedances (NAAQS) for the 24-hour time averaging period for the three-year simulation period. The permissible number of exceedances is 12 (4 exceedances per year, 3-year simulation period) and the red areas indicates regions exceeding this permissible number of exceedances. A high number of exceedances are simulated in an easterly direction.



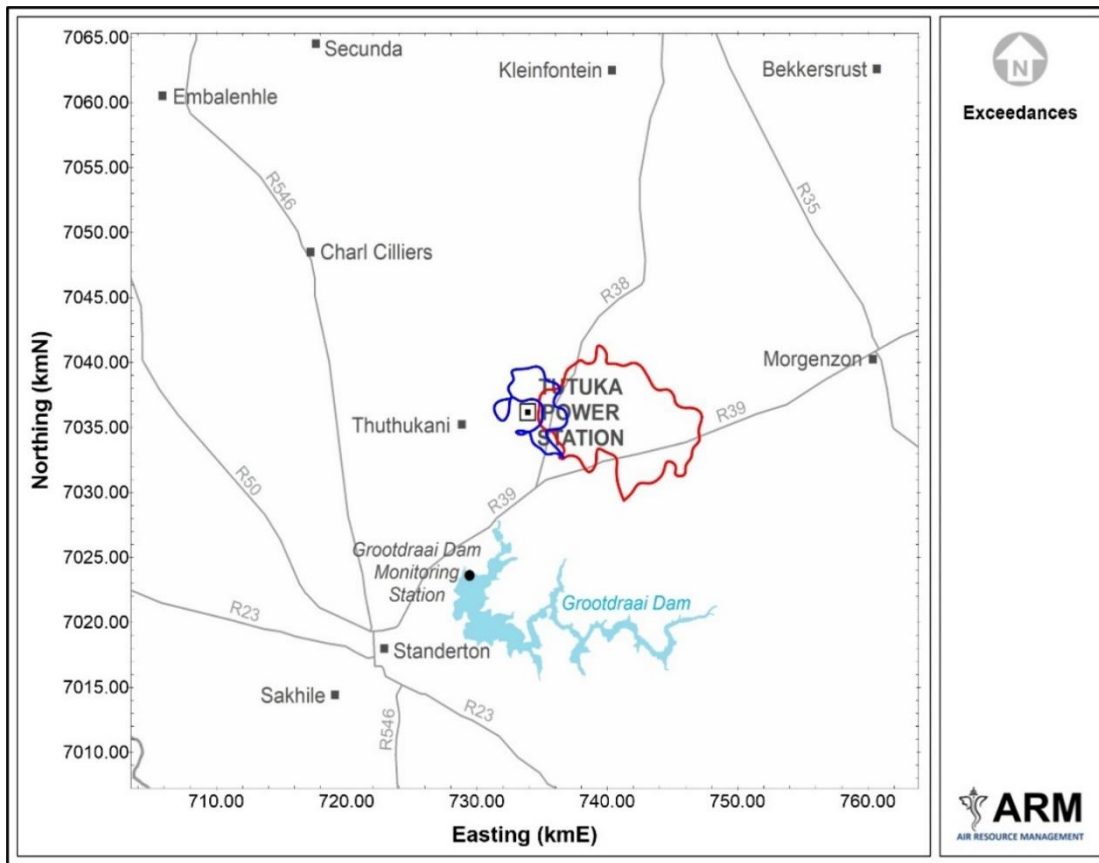
**Figure 60: Simulated Particulate Matter (PM<sub>10</sub>), 24-hour, concentration exceedance counts**

Figure 61 highlights the frequency of SO<sub>2</sub> exceedances (NAAQS) for the 1-hour time averaging period for the three-year simulation period. The permissible number of exceedances are 264 (88 exceedances per year, 3-year simulation period). The simulated number of exceedances are well below the permissible number of exceedances for SO<sub>2</sub>. A maximum of 27 exceedances were simulated towards the north of Tutuka power station (red area), whilst 12 exceedances (green area) are localised around the Tutuka power station.



**Figure 61: Simulated Sulphur Dioxide (SO<sub>2</sub>), 1-hour, concentration exceedance counts**

Figure 62 is an illustration of an overlay of the PM<sub>10</sub> as well as the SO<sub>2</sub> frequency of exceedances. Although, these simulated exceedances are for two different time averages, a proxy of 6 and 12 exceedances were used for PM<sub>10</sub> and SO<sub>2</sub> respectively. The 6-exceedance isopleth (PM<sub>10</sub>, 24-hour) is indicated by the red isopleth, whilst the 12-exceedance isopleth (SO<sub>2</sub>, 1-hour) is indicated by the blue isopleth.



**Figure 62: Simulated PM<sub>10</sub> (red isopleth) and SO<sub>2</sub> (blue isopleth) concentration exceedances**

### 3.2.1.6.2 Evaluation of ambient air quality monitoring data

The AQMS in closest proximity to the Tutuka power station is the Bosjesspruit AQMS operated and maintained by Sasol, as well as the Standerton AQMS, operated and maintained by the Mpumalanga province. The Bosjesspruit AQMS is approximately 24.0km to the north-west, and the Standerton AQMS is approximately 25.0km to the south-west of the power station, as indicated in Figure 63.

Ambient air quality data was obtained from 2007 to 2020 for the Bosjesspruit AQMS, and 2017 to 2020 for the Standerton AQMS. Table 35 and Table 36 summarises analysed ambient PM<sub>10</sub> and SO<sub>2</sub> data for the specific time periods for the Bosjesspruit AQMS. Figure 64 to Figure 65

are graphical representations of Table 35, whilst Figure 66 to Figure 68 are graphical representations of Table 36.

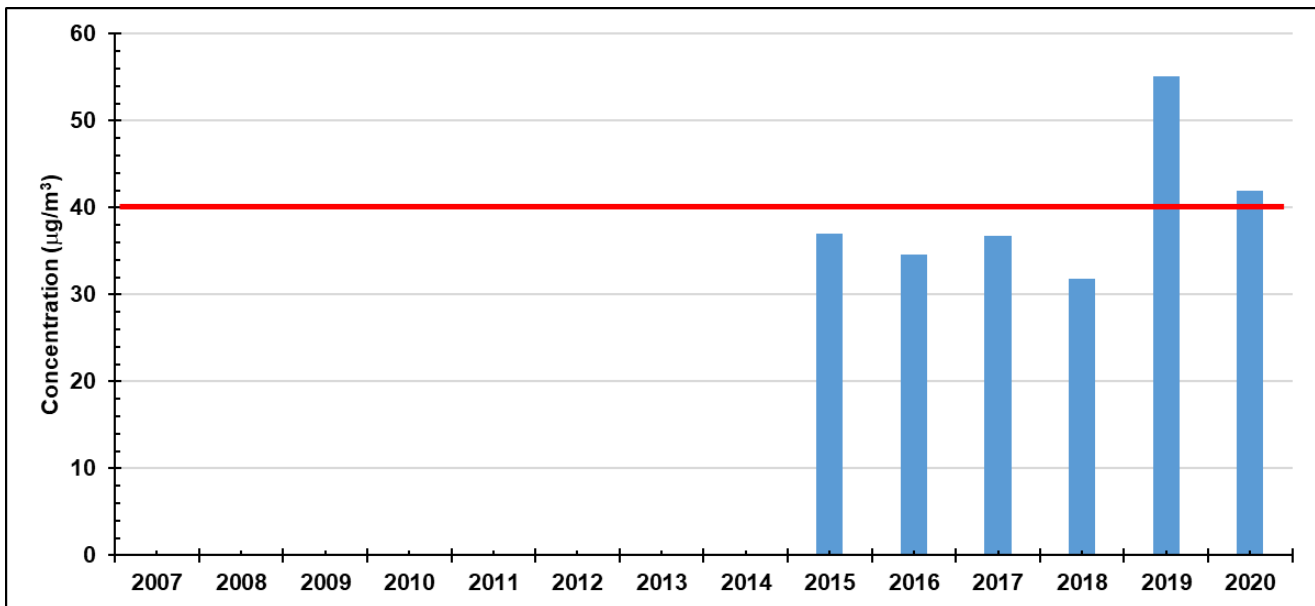
Table 37 and Table 38 summarises analysed ambient PM<sub>10</sub> and SO<sub>2</sub> data for the specific time periods for the Standerton AQMS. Figure 69 to Figure 70 are graphical representations of Table 37, whilst Figure 71 to Figure 73 are graphical representations of Table 38.



**Figure 63: Map indicating the location of the Bosjesspruit & Standerton AQMS relative to the Tutuka power station**

**Table 35: Ambient PM<sub>10</sub> data for the Bosjesspruit AQMS for 2007 to 2020**

Period	Data Availability	Annual Average	24-Hour 99 <sup>th</sup> Percentile	24-Hour Number of Exceedances
	(%)	(ppb)	(ppb)	(number)
2007	n/av	n/av	n/av	0
2008	n/av	n/av	n/av	0
2009	n/av	n/av	n/av	0
2010	n/av	n/av	n/av	0
2011	n/av	n/av	n/av	0
2012	n/av	n/av	n/av	0
2013	n/av	n/av	n/av	0
2014	n/av	n/av	n/av	0
2015	43	37	83.6	5
2016	56	34.6	102.2	15
2017	94	36.7	123.3	27
2018	64	31.8	87.3	5
2019	35	55.1	292.5	24
2020	61	42	260.9	39



**Figure 64: Annual ambient PM<sub>10</sub> concentrations for the Bosjesspruit AQMS for 2007 to 2020 (NAAQS is 40.0 µg/m<sup>3</sup>).**

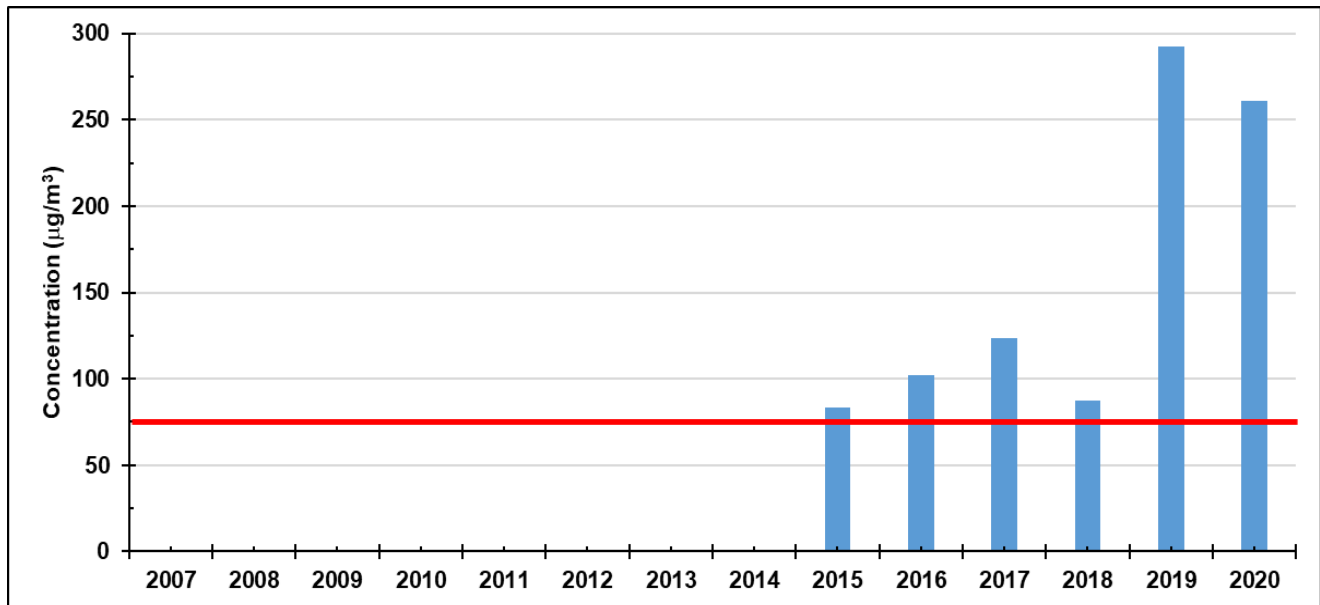


Figure 65: 24-Hour, 99<sup>th</sup> percentile ambient PM<sub>10</sub> concentrations for the Bosjesspruit AQMS for 2007 to 2020 (NAAQS is 75.0 µg/m<sup>3</sup>).

Table 36: Ambient SO<sub>2</sub> data for the Bosjesspruit AQMS for 2007 to 2020.

Period	Data Availability	Annual Average	1-Hour 99 <sup>th</sup> Percentile	1-Hour Number of Exceedances	24-Hour 99 <sup>th</sup> Percentile	24-Hour Number of Exceedances
	(%)	(ppb)	(ppb)	(number)	(ppb)	(number)
2007	80	10.4	90.8	28	39	0
2008	39	15.2	162.1	92	155.9	4
2009	86	9.6	88.9	32	42.9	2
2010	87	10.1	79.4	29	34.1	2
2011	68	15.5	123.1	52	108.7	24
2012	61	12.3	101.7	19	55.3	4
2013	76	9.9	87.5	23	35.7	0
2014	78	10	97.2	41	44.1	2
2015	52	10.4	112.5	26	47.4	2
2016	55	10.3	76.1	5	38.6	1
2017	74	9.9	80.4	21	44.8	2
2018	49	9.5	93	15	47.9	2
2019	37	9.2	87.4	9	29.8	0
2020	85	7.7	76.4	15	28.3	1

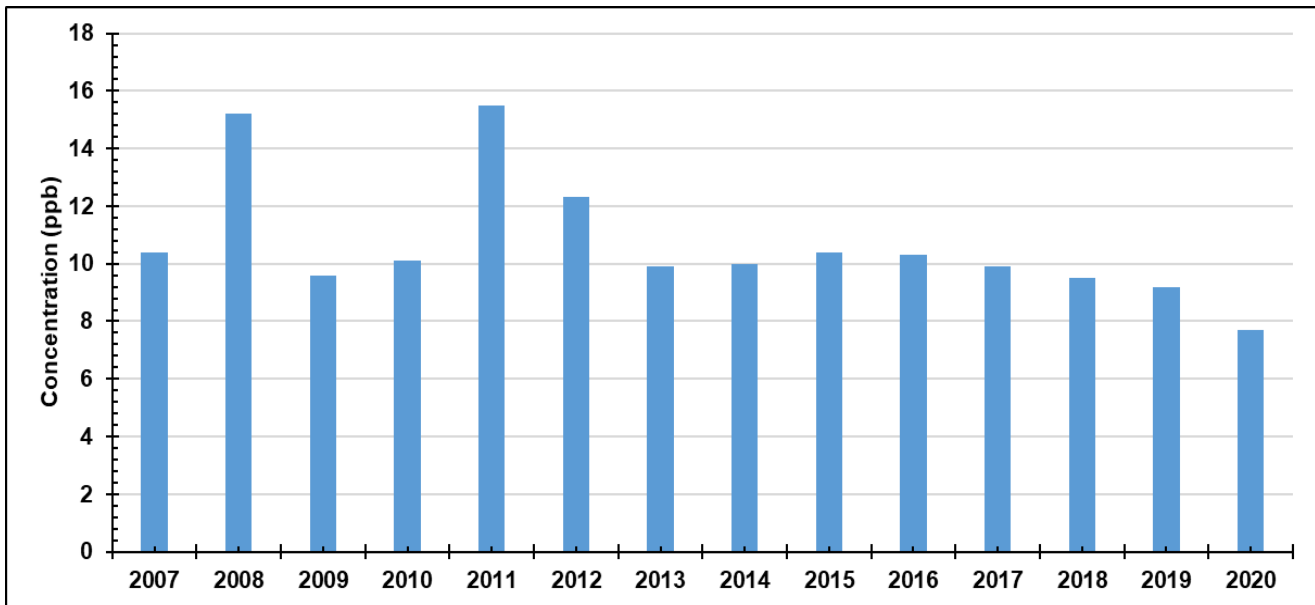


Figure 66: Annual ambient SO<sub>2</sub> concentrations for the Bosjesspruit AQMS for 2007 to 2020 (NAAQS is 19.0 ppb)

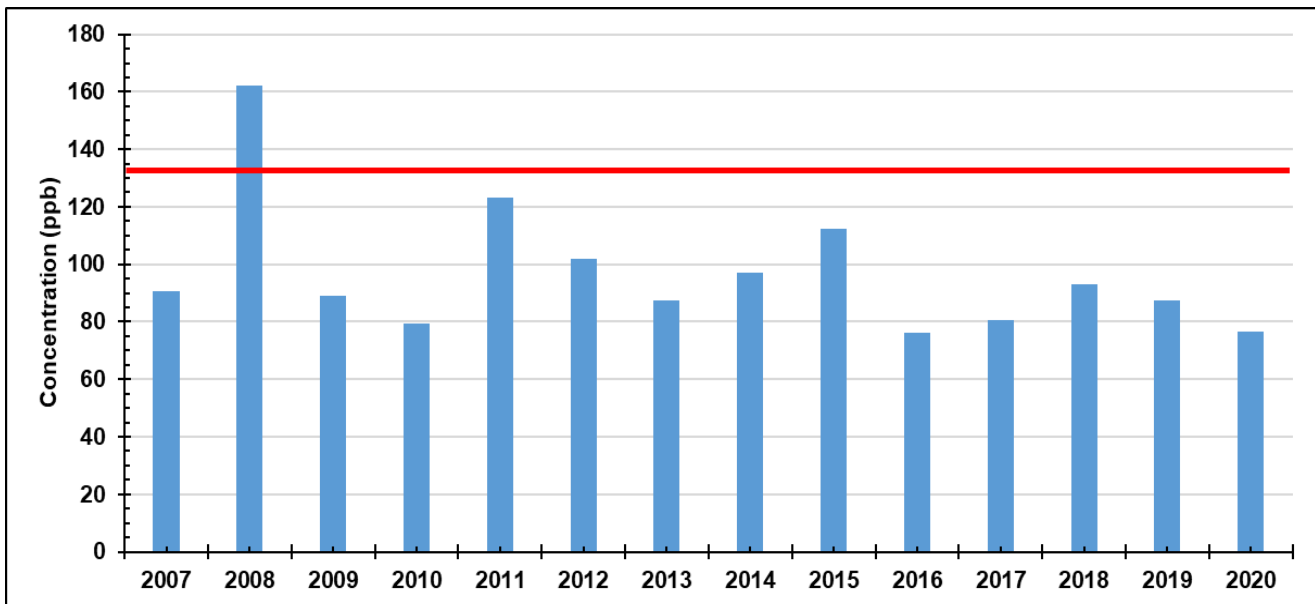


Figure 67: 1-Hour, 99<sup>th</sup> percentile ambient SO<sub>2</sub> concentrations for the Bosjesspruit AQMS for 2007 to 2020 (NAAQS is 134.0 ppb).

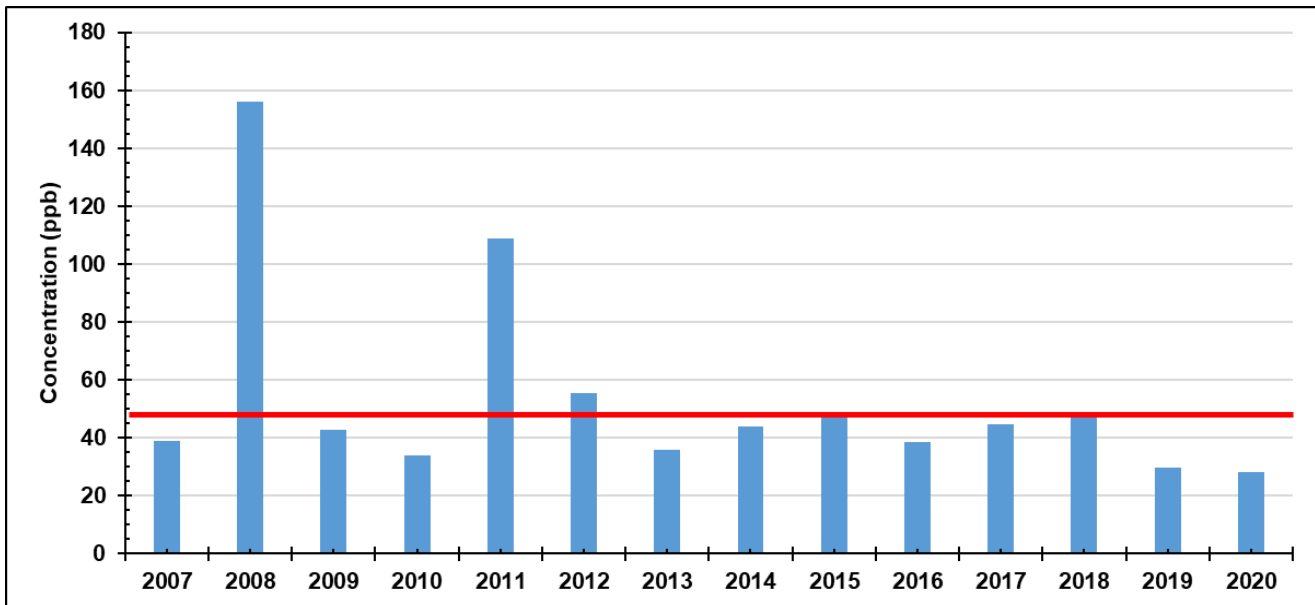


Figure 68: 24-Hour, 99<sup>th</sup> percentile ambient SO<sub>2</sub> concentrations for the Bosjesspruit AQMS for 2007 to 2020 (NAAQS is 48.0 ppb)

Table 37: Ambient PM<sub>10</sub> data for the Standerton AQMS for 2017 to 2020

Period	Data Availability	Annual Average	24-Hour 99 <sup>th</sup> Percentile	24-Hour Number of Exceedances
	(%)	(ppb)	(ppb)	(number)
2017	n/av	n/av	n/av	0
2018	78	90.5	189.4	173
2019	46	74.1	179.2	76
2020	66	69.3	162.8	108

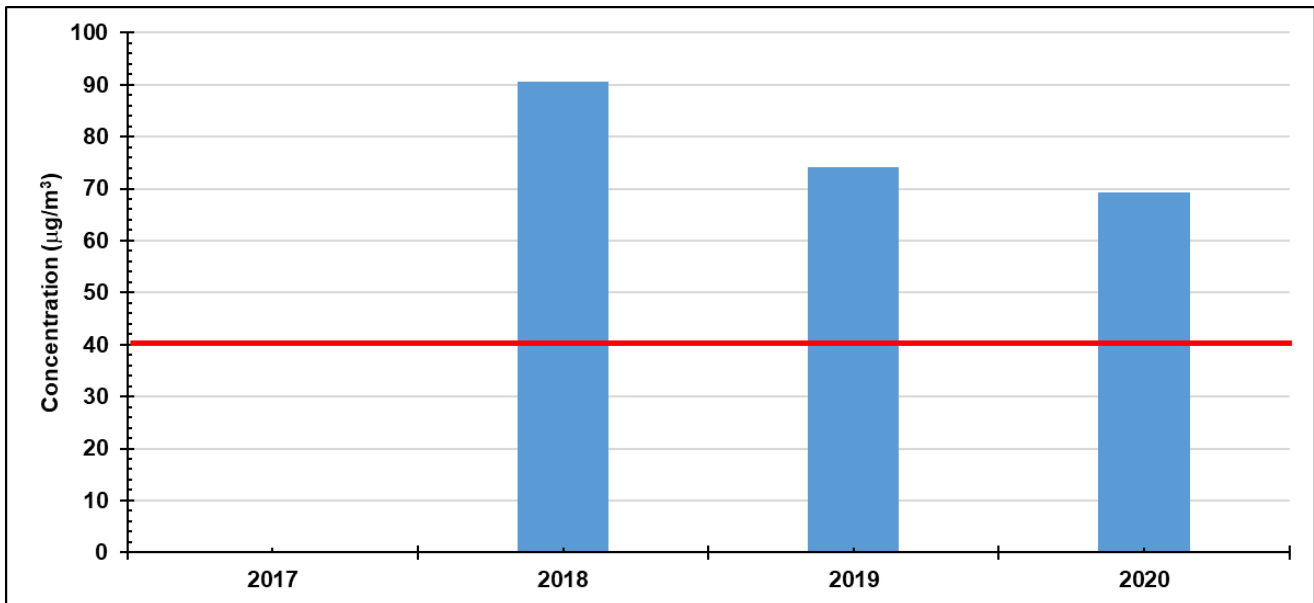


Figure 69: Annual ambient PM<sub>10</sub> concentrations for the Standerton AQMS for 2017 to 2020 (NAAQS is 40.0 µg/m<sup>3</sup>).

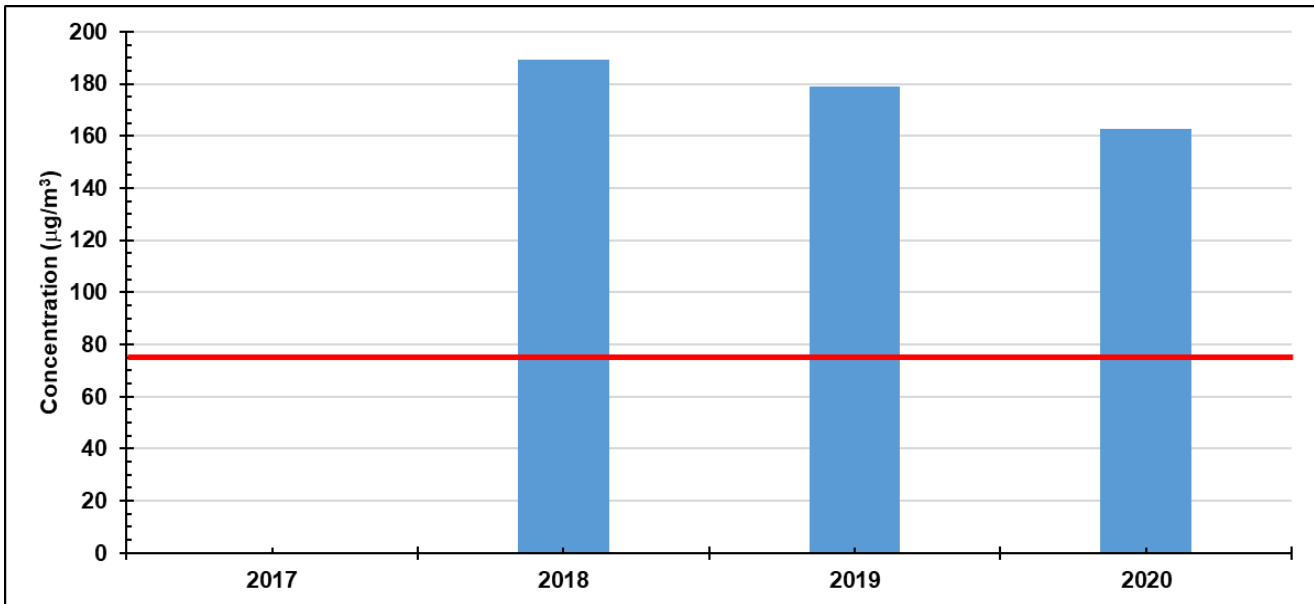
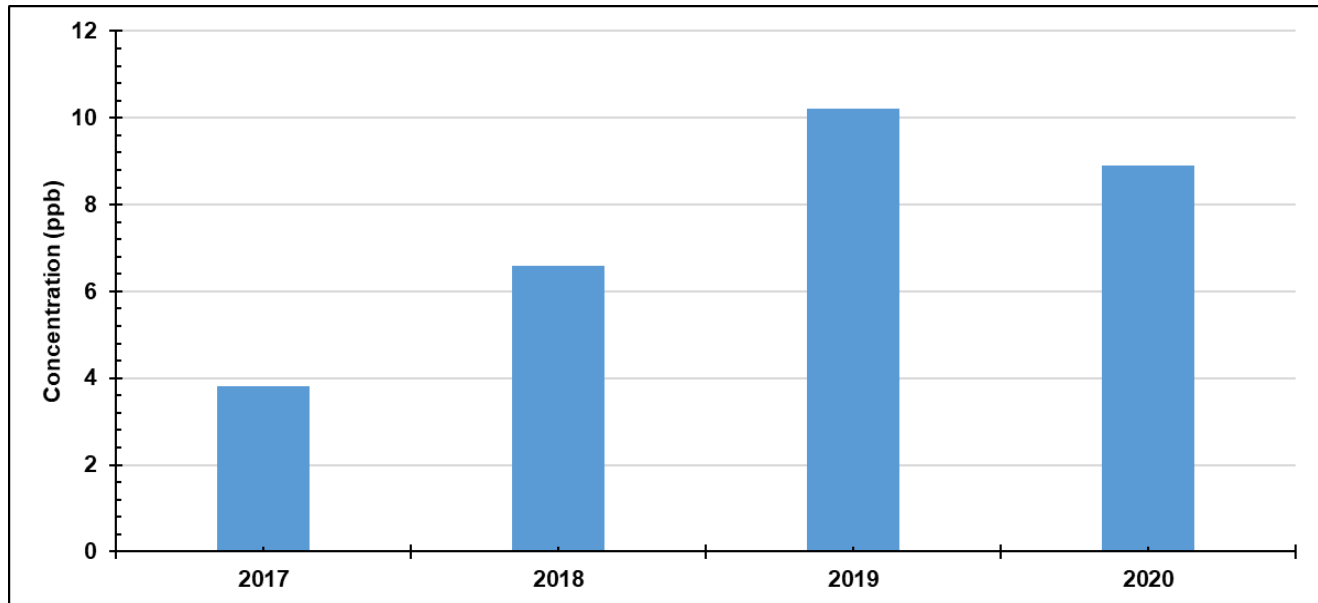


Figure 70: 24-Hour, 99<sup>th</sup> percentile ambient PM<sub>10</sub> concentrations for the Standerton AQMS for 2017 to 2020 (NAAQS is 75.0 µg/m<sup>3</sup>).

**Table 38: Ambient SO<sub>2</sub> data for the Standerton AQMS for 2017 to 2020.**

Period	Data Availability	Annual Average	1-Hour 99 <sup>th</sup> Percentile	1-Hour Number of Exceedances	24-Hour 99 <sup>th</sup> Percentile	24-Hour Number of Exceedances
	(%)	(ppb)	(ppb)	(number)	(ppb)	(number)
2017	12	3.8	26.3	0	n/av	0
2018	93	6.6	44.1	0	24.6	0
2019	48	10.2	50.2	1	35.2	0
2020	81	8.9	45.9	0	36.6	1



**Figure 71: Annual ambient SO<sub>2</sub> concentrations for the Standerton AQMS for 2017 to 2020 (NAAQS is 19.0 ppb).**

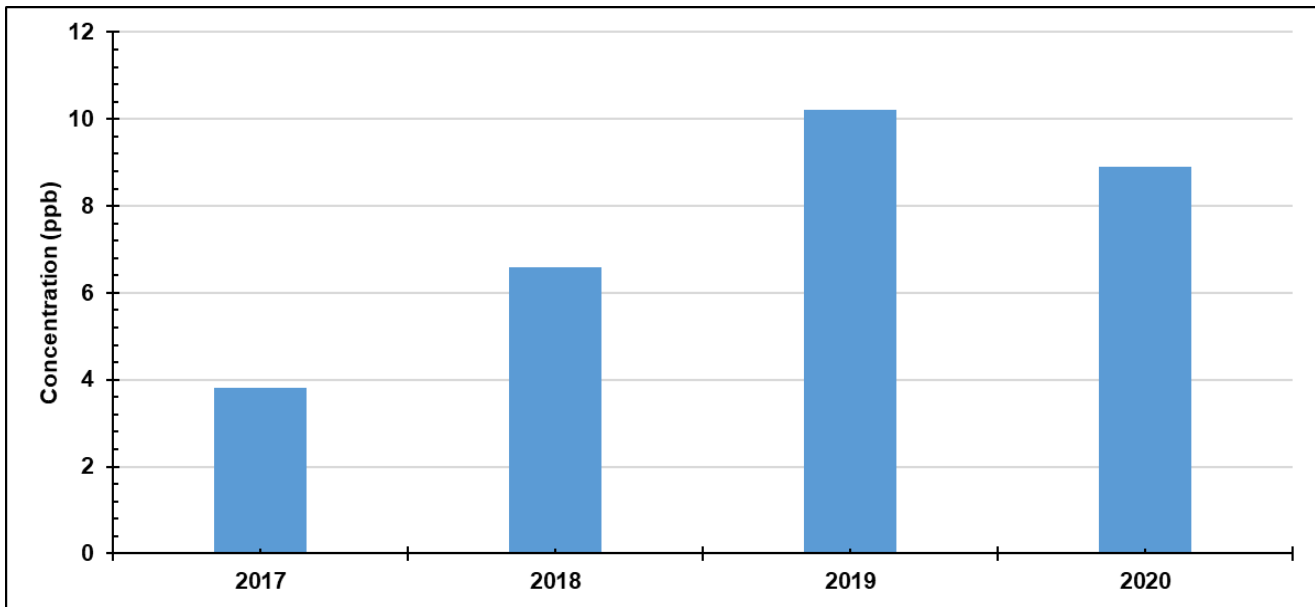


Figure 72: 1-Hour, 99<sup>th</sup> percentile ambient SO<sub>2</sub> concentrations for the Standerton AQMS for 2017 to 2020 (NAAQS is 134.0 ppb).

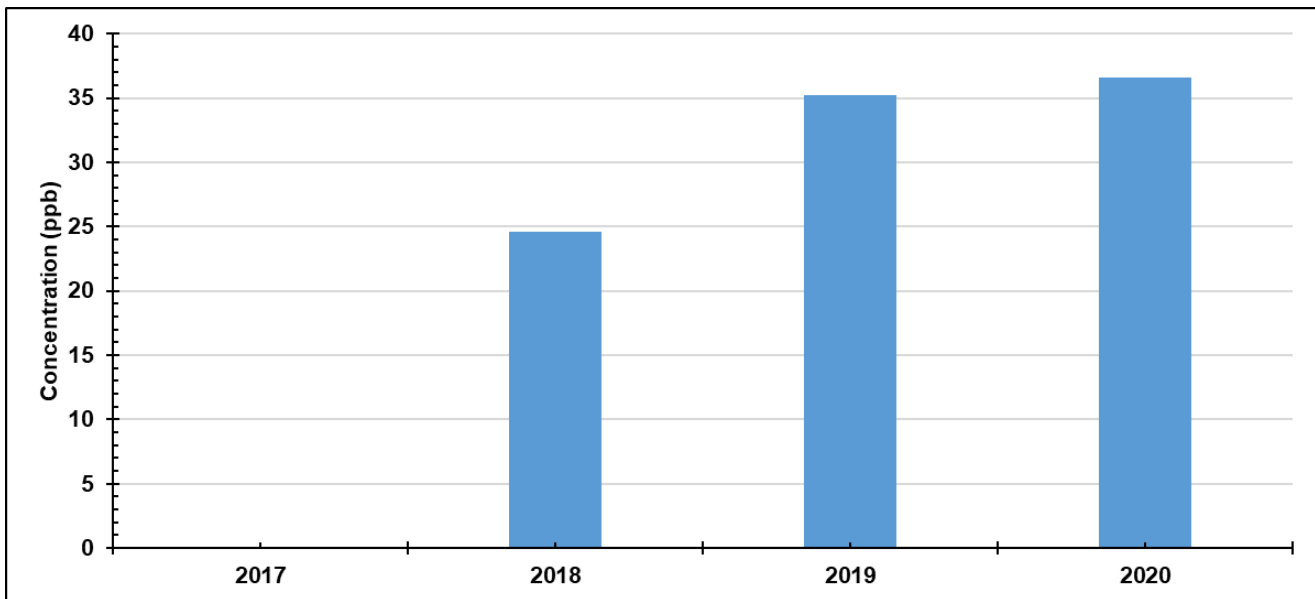


Figure 73: 24-Hour, 99<sup>th</sup> percentile ambient SO<sub>2</sub> concentrations for the Standerton AQMS for 2017 to 2020 (NAAQS is 48.0 ppb)

### 3.2.1.6.3 Opportunities for improving ambient quality through offsetting exist

Table 39 To Table 42 summarises the total population, energy usage patterns and indicative number of households for specific settlements that will participate in the offsets roll-out in the target areas for Tutuka power station offsets program.

**Table 39: Total population, energy usage patterns and indicative number of households for Sivukile that will participate in the offsets roll-out in the target areas for Tutuka power station offsets program**

Ward	Sivukile	
	Indicative number of households	
	Eskom 2017 OIP <sup>a</sup>	2022 Stats SA <sup>b</sup>
Population	5 757	5 954
Total number of households	1 718	2 139
Number of households using coal	690	1 283
Indicative number of households for air quality offsets	1 160	1 155

<sup>a</sup> Based on Eskom AQO Offset Implementation Plan.

<sup>b</sup> Based on ARM Census data extrapolation, assuming 60% of households use coal, and of those 90% choose to participate in the program.

**Table 40: Total population, energy usage patterns and indicative number of households for Thuthukani that will participate in the offsets roll-out in the target areas for Tutuka power station offsets program**

Ward	Thuthukani	
	Indicative number of households	
	Eskom 2017 OIP <sup>a</sup>	2022 Stats SA <sup>b</sup>
Population	2 670	2 757
Total number of households	340 – 500 (RDP)	1 109
Number of households using coal	4	665
Indicative number of households for air quality offsets	400	599

<sup>a</sup> Based on Eskom AQO Offset Implementation Plan.

<sup>b</sup> Based on ARM Census data extrapolation, assuming 60% of households use coal, and of those 90% choose to participate in the program.

**Table 41: Total population, energy usage patterns and indicative number of households for Standerton that will participate in the offsets roll-out in the target areas for Tutuka power station offsets program**

Ward	Standerton	
	Indicative number of households	
	Eskom 2017 OIP <sup>a</sup>	2022 Stats SA <sup>b</sup>
Population	No Data	45 490
Total number of households	No Data	14 822
Number of households using coal	No Data	8 893
Indicative number of households for air quality offsets	No Data	8 004

<sup>a</sup> Based on Eskom AQO Offset Implementation Plan.

<sup>b</sup> Based on ARM Census data extrapolation, assuming 90% choose to participate in the program.

**Table 42: Total population, energy usage patterns and indicative number of households for Sakhile that will participate in the offsets roll-out in the target areas for Tutuka power station offsets program**

Ward	Sakhile	
	Indicative number of households	
	Eskom 2017 OIP <sup>a</sup>	2022 Stats SA <sup>b</sup>
Population	No Data	41 819
Total number of households	No Data	14 886
Number of households using coal	No Data	8 932
Indicative number of households for air quality offsets	No Data	8 038

<sup>a</sup> Based on Eskom AQO Offset Implementation Plan.

<sup>b</sup> Based on ARM Census data extrapolation, assuming 90% choose to participate in the program.

### 3.3 The cumulative air quality impact of Eskom’s Power Stations

#### 3.3.1 Air quality impact of Eskom

Figure 74 indicate simulated annual PM<sub>10</sub> concentrations (NAAQS is 40.0 µg/m<sup>3</sup>, indicated by the red areas). Figure 74 highlight high PM<sub>10</sub> concentrations that are localised around the power stations (red areas).

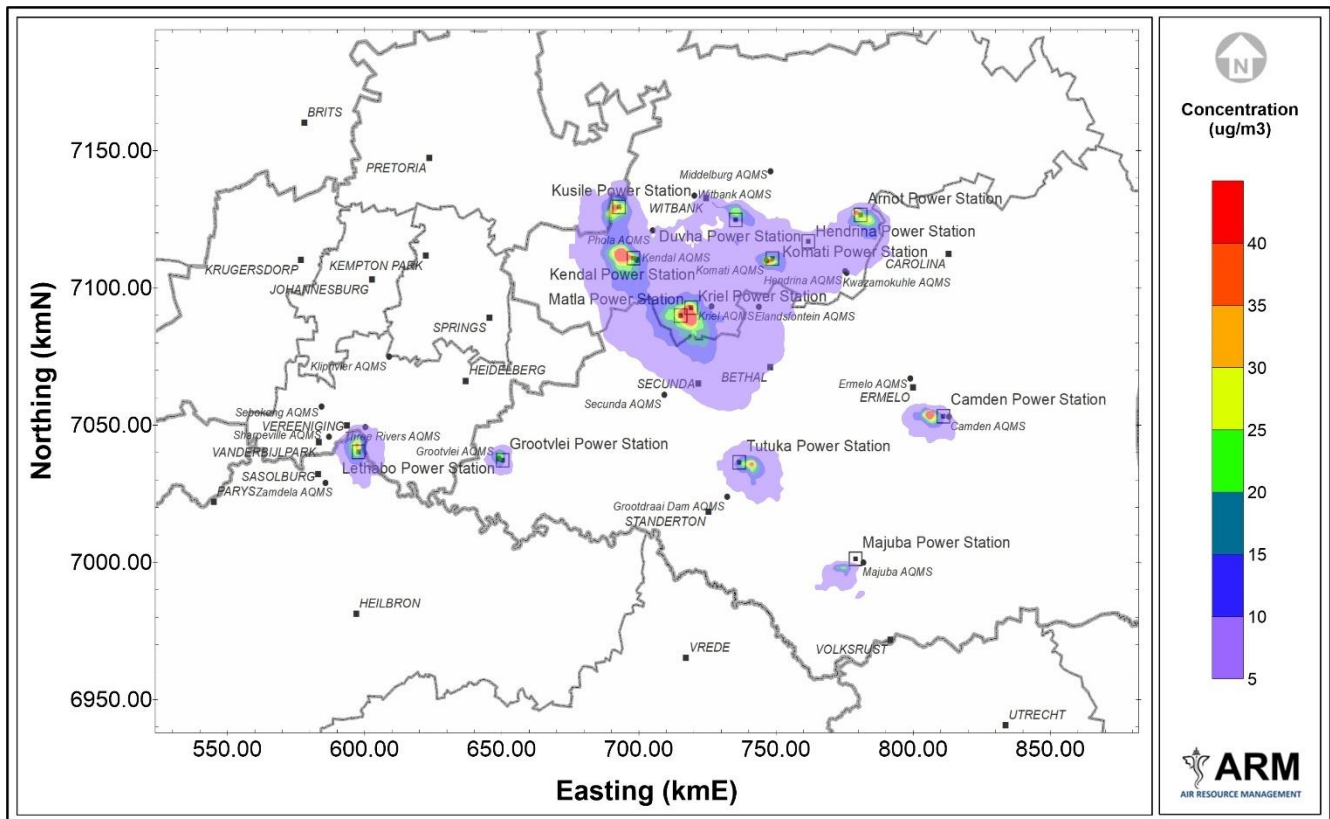


Figure 74: Simulated Particulate Matter (PM<sub>10</sub>), annual (NAAQS is 40.0 µg/m<sup>3</sup>)

Figure 75 indicate simulated 24-hour, 99<sup>th</sup> percentile PM<sub>10</sub> concentrations (NAAQS is 75.0 µg/m<sup>3</sup>, indicated by the red areas). Figure 75 highlight high PM<sub>10</sub> concentrations that are localised around the power stations.

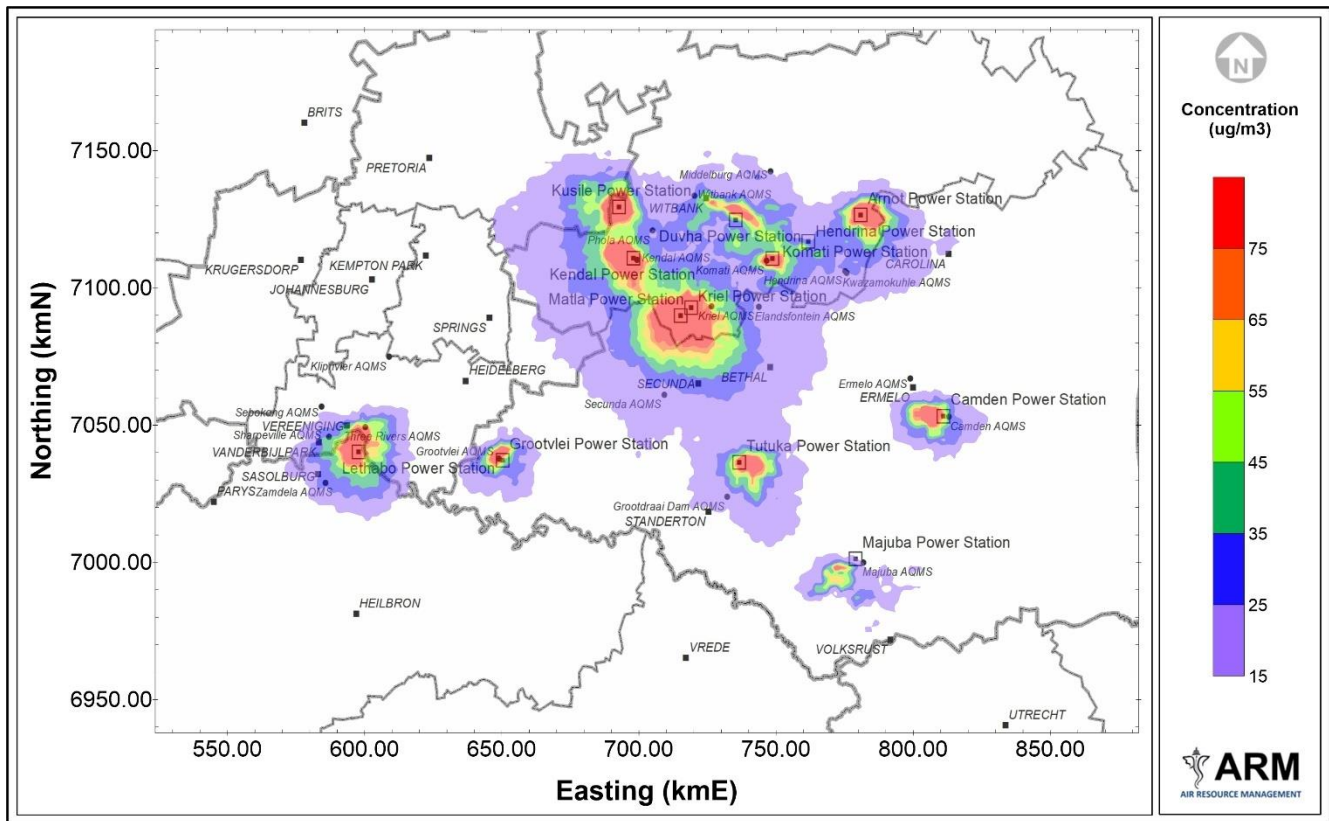


Figure 75: Simulated Particulate Matter (PM<sub>10</sub>), 24-hour, 99<sup>th</sup> percentile concentrations (NAAQS is 75.0 µg/m<sup>3</sup>)

Figure 76 indicate simulated annual SO<sub>2</sub> concentrations (NAAQS is 50.0 µg/m<sup>3</sup>). Elevated SO<sub>2</sub> concentrations were simulated towards the eastern part of the Highveld region.

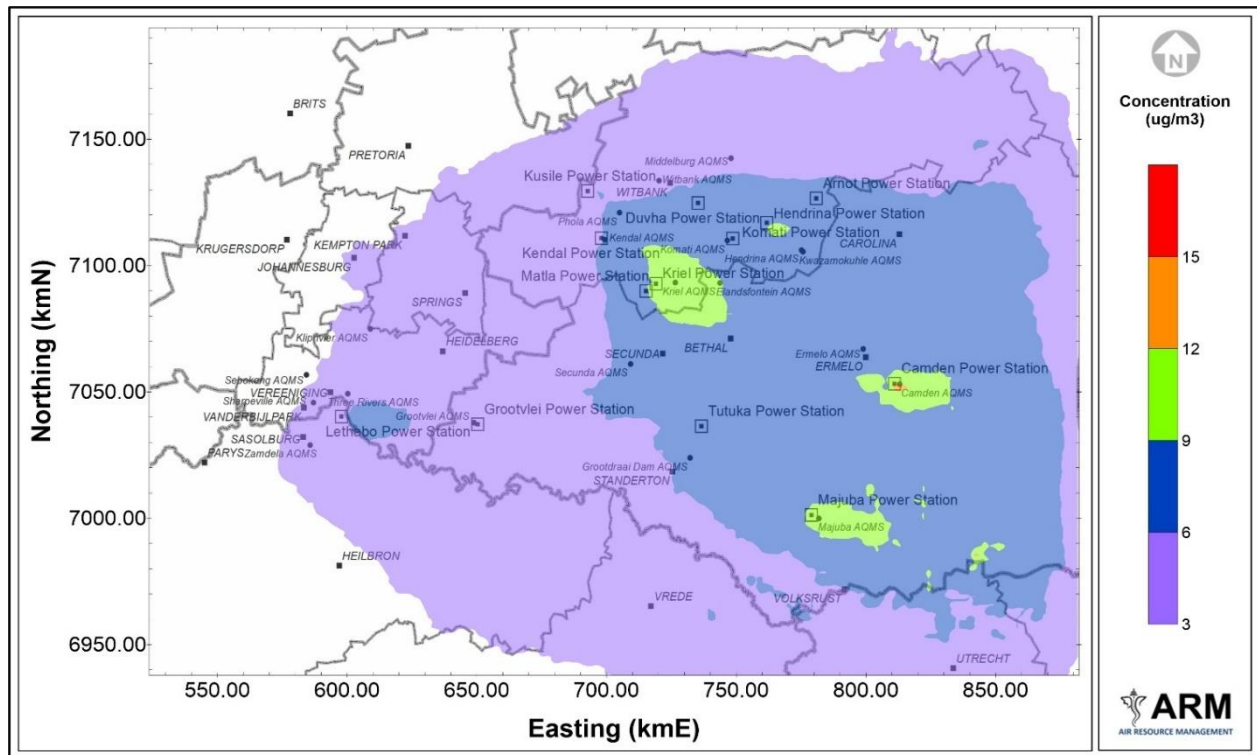


Figure 76: Simulated Sulphur Dioxide (SO<sub>2</sub>), annual concentrations (NAAQS is 50.0 µg/m<sup>3</sup>).

Figure 77 indicate simulated 24-hour, 99<sup>th</sup> percentile SO<sub>2</sub> concentrations (NAAQS is 125.0 µg/m<sup>3</sup>). Figure 77 highlight elevated SO<sub>2</sub> concentrations that are localised around the power stations, as well as the central Highveld region.

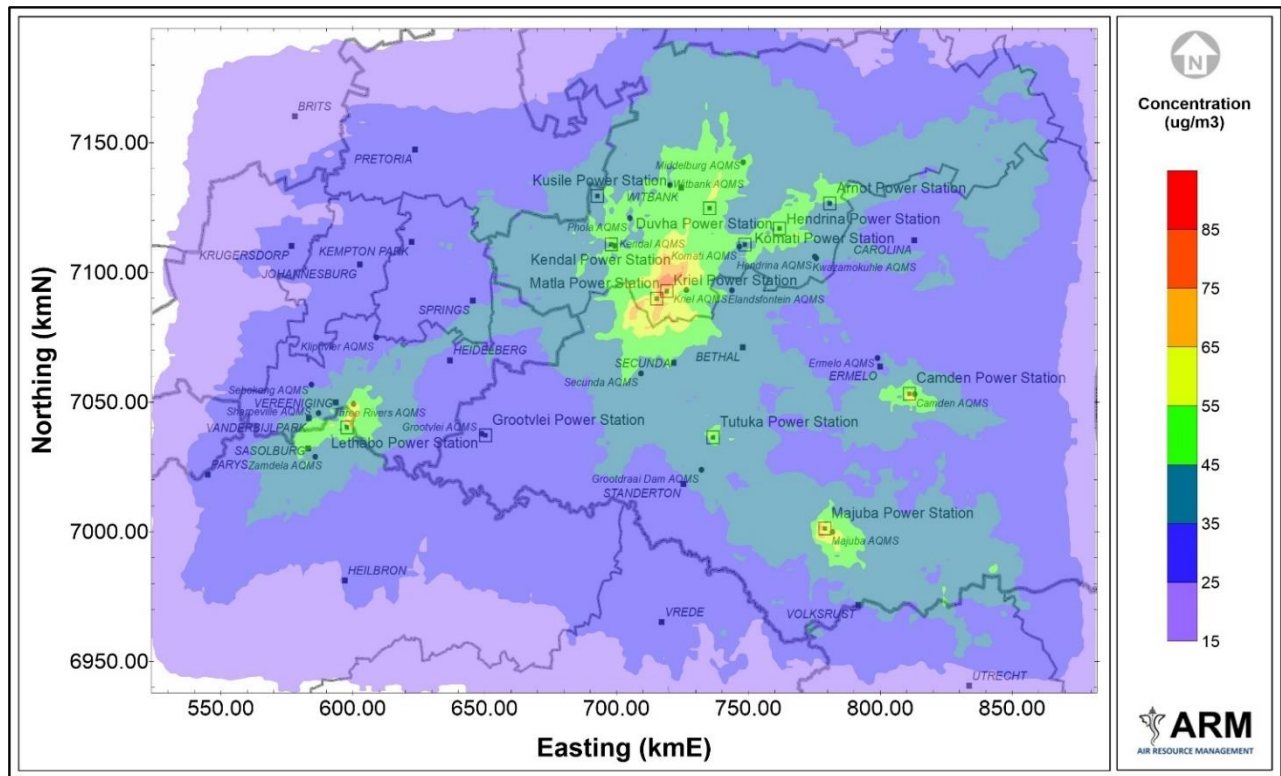


Figure 77: Simulated Sulphur Dioxide (SO<sub>2</sub>), 24-hour, 99<sup>th</sup> percentile concentrations (NAAQS is 125.0 µg/m<sup>3</sup>)

Figure 78 indicate simulated 1-hour, 99<sup>th</sup> percentile SO<sub>2</sub> concentrations (NAAQS is 350.0 µg/m<sup>3</sup>). Figure 78 highlight elevated SO<sub>2</sub> concentrations that are localised around the power stations, as well as the central Highveld region.

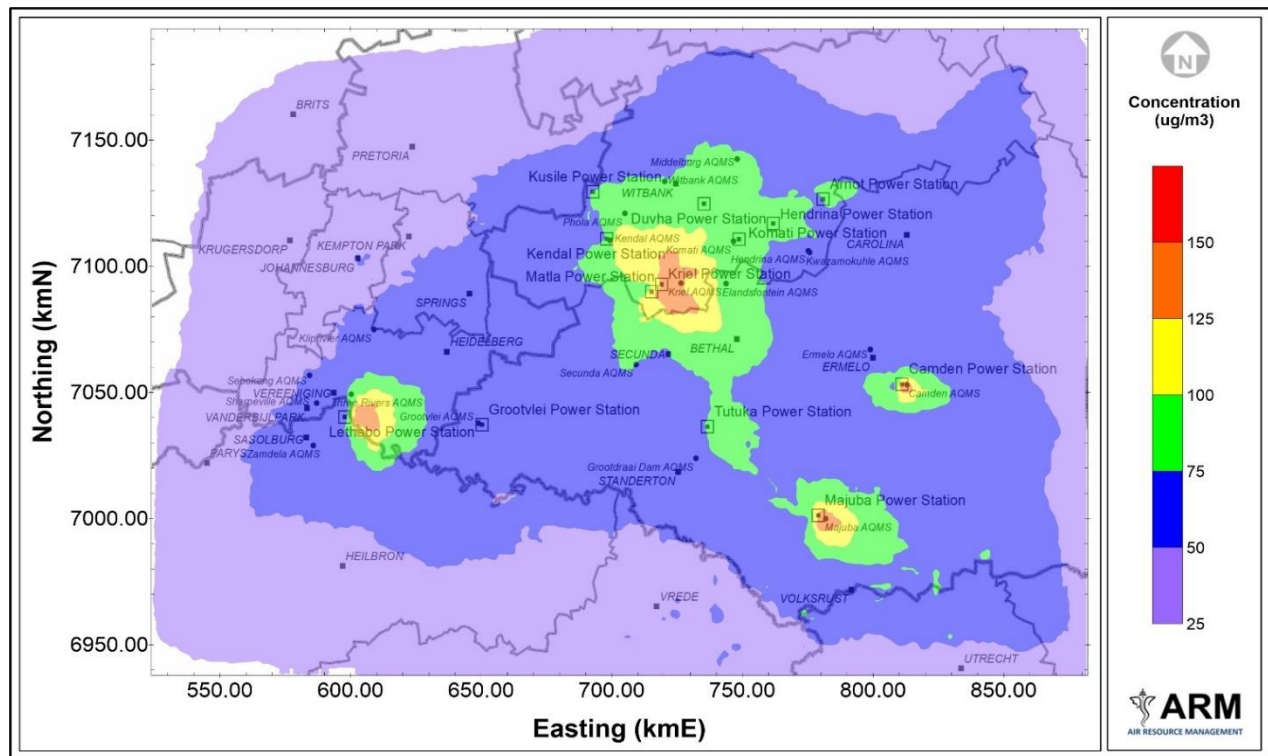
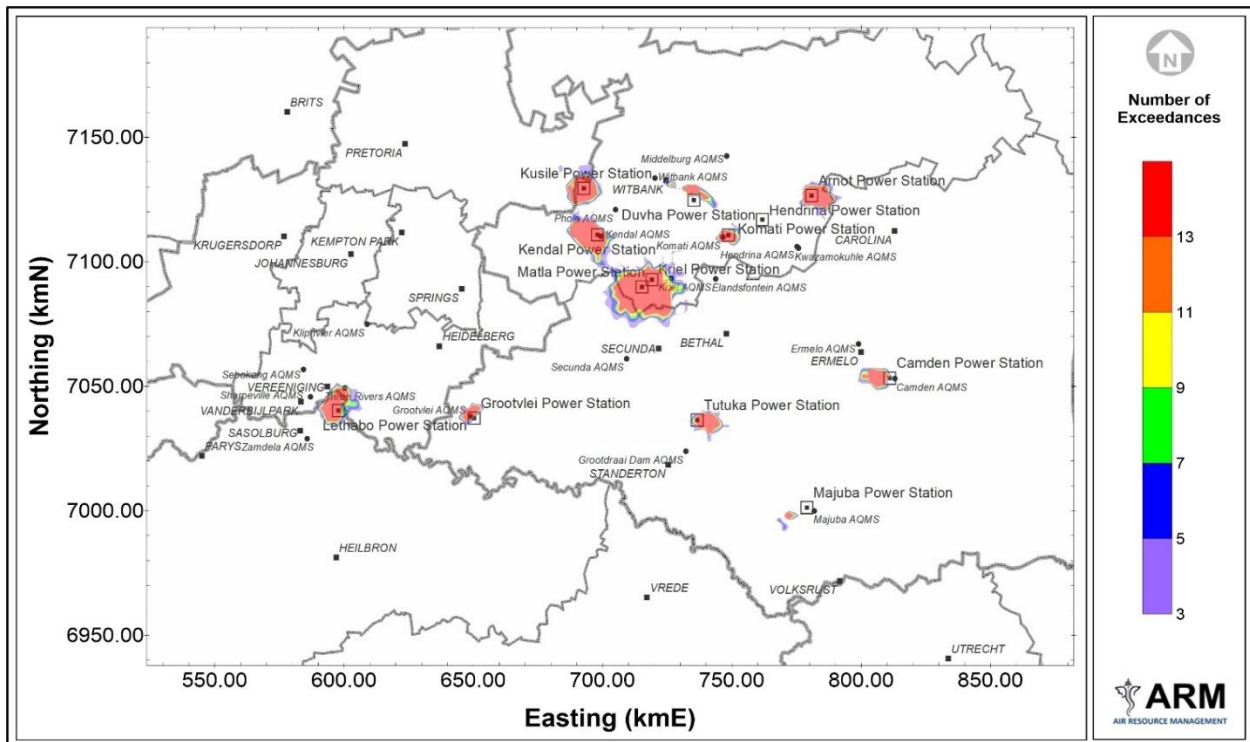


Figure 78: Simulated Sulphur Dioxide (SO<sub>2</sub>), 1-hour, 99<sup>th</sup> percentile concentrations (NAAQS is 350.0 µg/m<sup>3</sup>)

### 3.3.2 Non-compliance of NAAQS

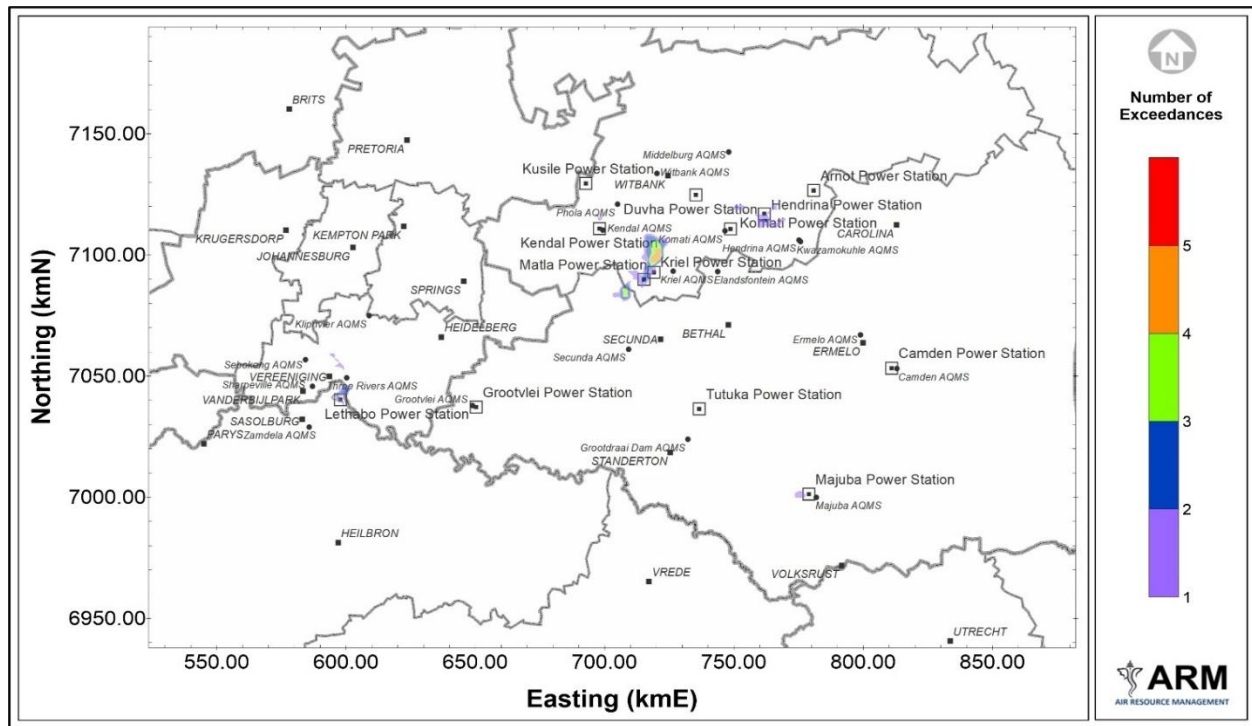
#### 3.3.2.1 Evaluation of model predicted exceedances

Figure 79 highlights the frequency of PM<sub>10</sub> exceedances (NAAQS) for the 24-hour time averaging period for the three-year simulation period. The permissible number of exceedances are 12 (4 exceedances per year, 3-year simulation period) and the red areas indicates regions exceeding this permissible number of exceedances. A high number of exceedances are simulated close and localised around the power stations.



**Figure 79: Simulated Particulate Matter (PM<sub>10</sub>), 24-hour, concentration exceedance counts**

Figure 80 highlights the frequency of SO<sub>2</sub> exceedances (NAAQS) for the 24-hour time averaging period for the three-year simulation period. The permissible number of exceedances are 12 (4 exceedances per year, 3-year simulation period). The simulated number of exceedances are well below the permissible number of exceedances for SO<sub>2</sub>.



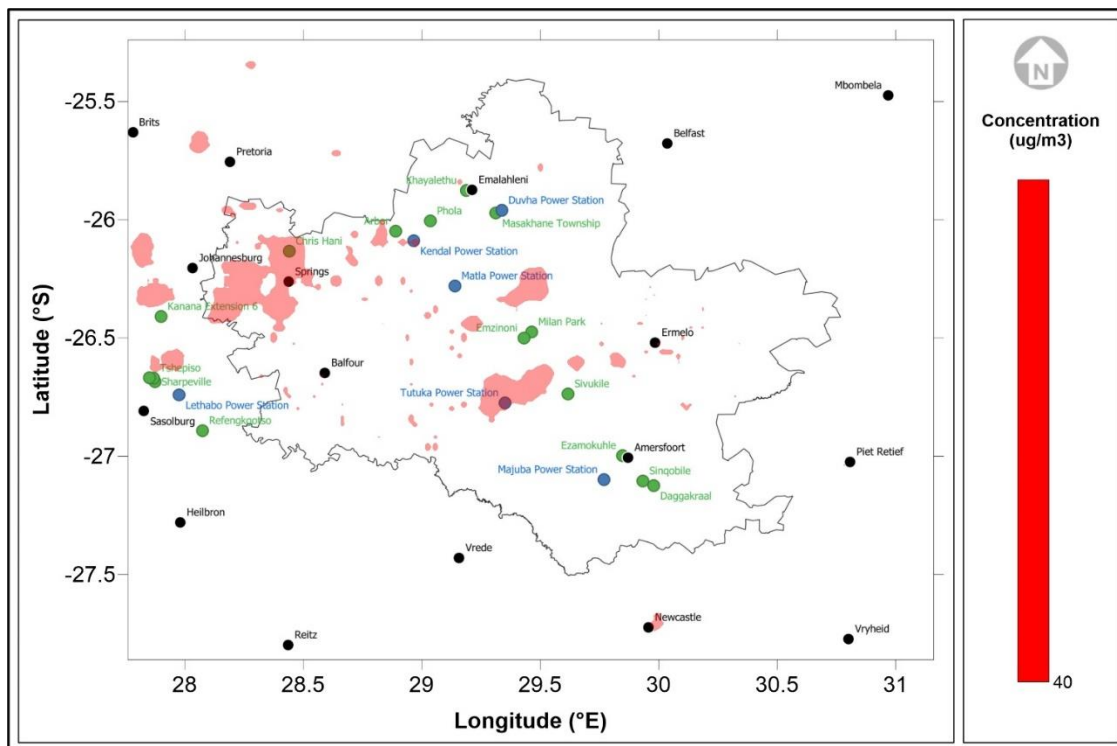
**Figure 80: Simulated Sulphur Dioxide (SO<sub>2</sub>), 24-hour, concentration exceedance counts**

Figure 81 highlights the frequency of SO<sub>2</sub> exceedances (NAAQS) for the 1-hour time averaging period for the three-year simulation period. The permissible number of exceedances are 264 (88 exceedances per year, 3-year simulation period). The simulated number of exceedances are well below the permissible number of exceedances for SO<sub>2</sub>.



Cognizance should also be applied that the figures displayed were the result of all emission source categories over the HPA. A different atmospheric model (CAMx, a photochemical model), as well as a different meteorological dataset were also utilized to simulate these results.

Figure 82 illustrates simulated annual mean PM<sub>10</sub> concentrations over the HPA region. High PM<sub>10</sub> concentrations (NAAQS is 40.0 mg/m<sup>3</sup>, indicated by the red areas) are simulated over the central and western region of the HPA (Secunda, Tutuka, Kriel and majority of the CoE, Johannesburg, Vereeniging, and Tshwane). There are also smaller regions around eMalahleni, Middelburg and Ermelo.



**Figure 82: Simulated Particulate Matter (PM<sub>10</sub>), annual (NAAQS is 40.0 ug/m<sup>3</sup>)**

Figure 83 illustrates simulated annual mean SO<sub>2</sub> concentrations over the HPA region. Figure 83 highlights that the annual SO<sub>2</sub> NAAQS (19 ppb, indicated by the red isopleths) is exceeded

primarily towards the west (Sasolburg area, part of the VTAPA) with Secunda, Kriel, eMalahleni, Middelburg and CoE, also illustrating areas of exceedances.

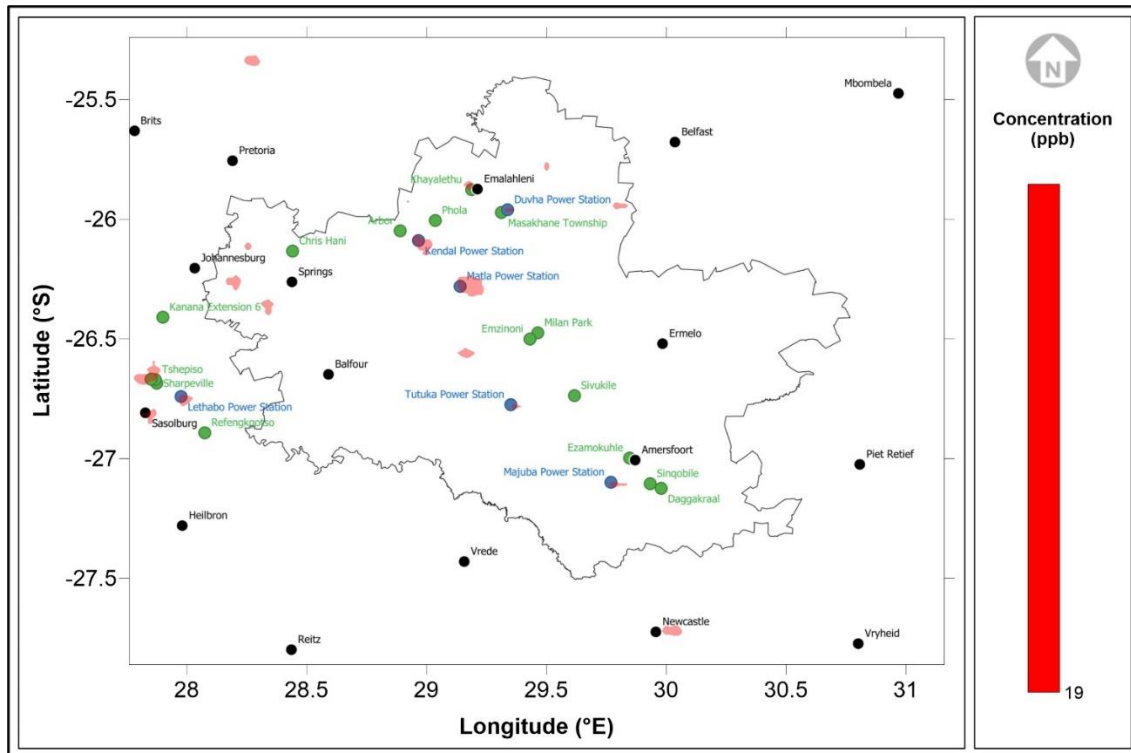
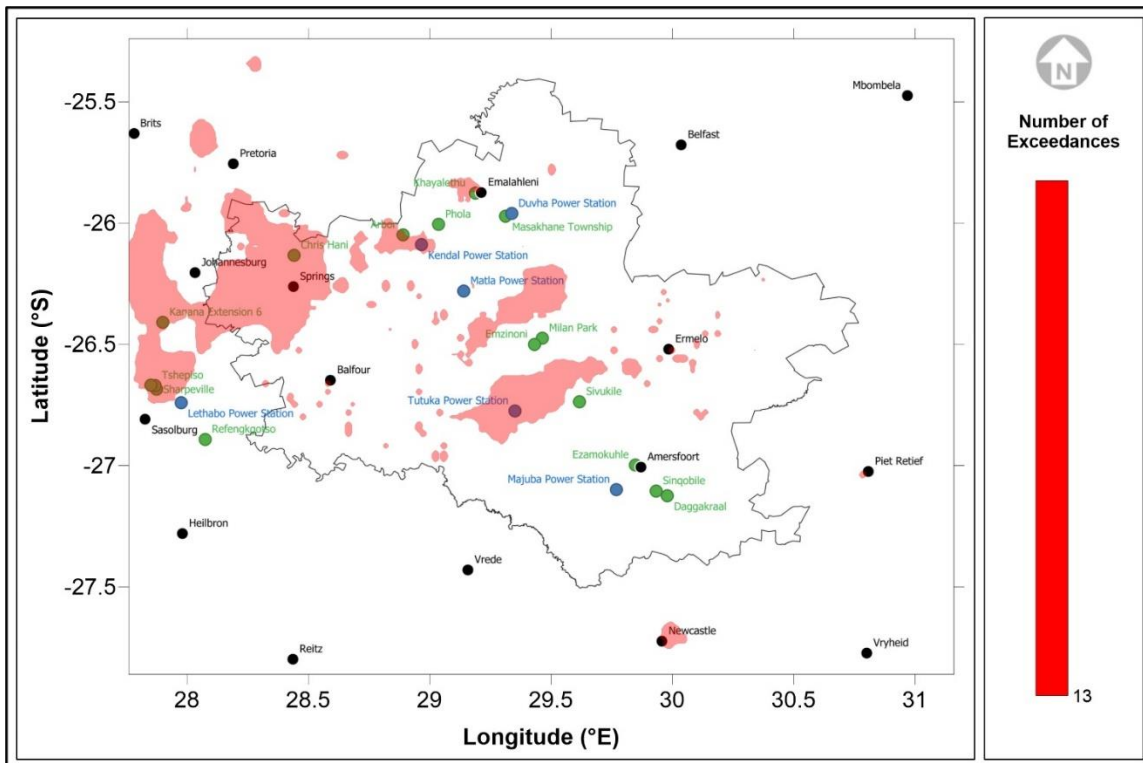


Figure 83: Simulated Sulphur Dioxide (SO<sub>2</sub>), annual (NAAQS is 19 ppb).

### 3.4.2 Non-compliance of NAAQS

#### 3.4.2.1 Evaluation of model predicted exceedances

Figure 84 highlights the frequency of PM<sub>10</sub> exceedances (NAAQS) for the 24-hour time averaging period for the three-year simulation period. The permissible number of exceedances are 12 (4 exceedances per year, 3-year simulation period) and the red areas indicates regions exceeding this permissible number of exceedances. It must be highlighted that Figure 84 includes all emission source categories for the HPA.



**Figure 84: Simulated Particulate Matter (PM<sub>10</sub>), 24-hour, concentration exceedance counts**

Figure 85 highlights the frequency of SO<sub>2</sub> exceedances (NAAQS) for the 1-hour time averaging period for the three-year simulation period. The permissible number of exceedances are 264 (88 exceedances per year, 3-year simulation period). It must be highlighted that Figure 85 includes all emission source categories for the HPA.

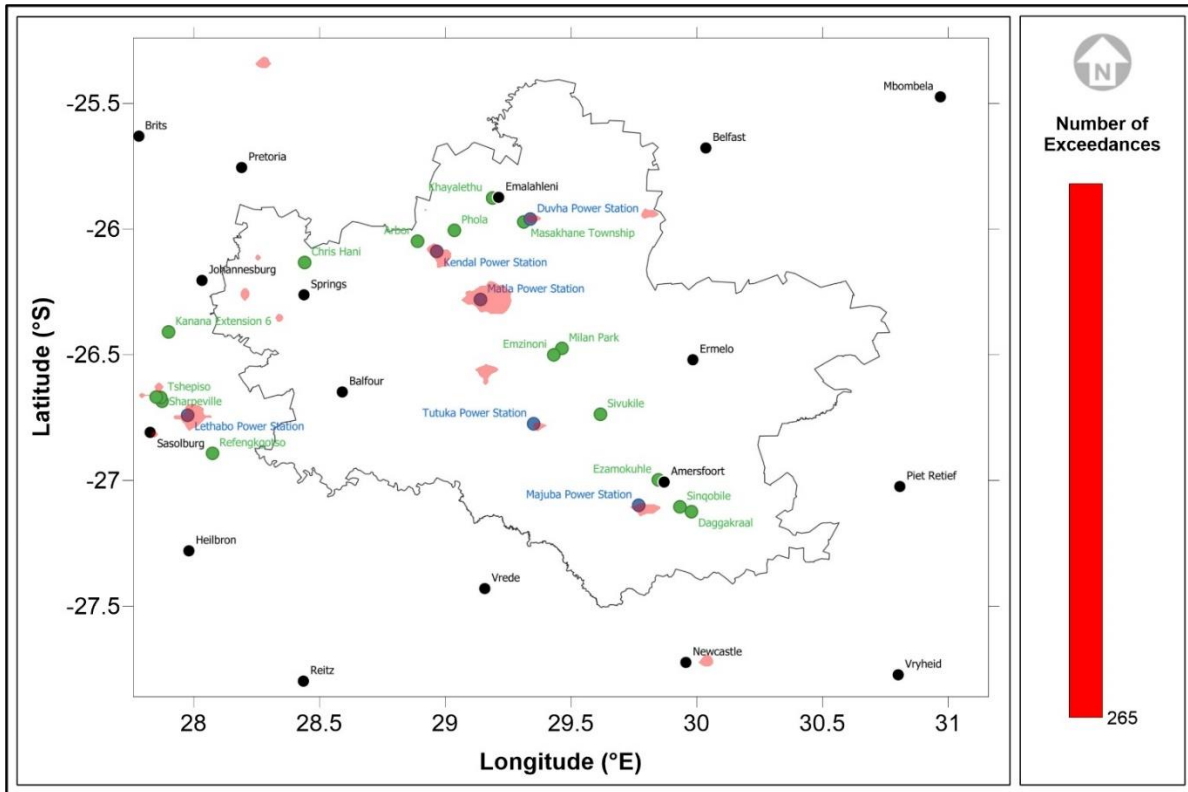


Figure 85: Simulated Sulphur Dioxide (SO<sub>2</sub>), 1-hour, concentration exceedance counts

## 3.2.2 An evaluation of the “What”

### 3.2.2.1 An evaluation of the current Eskom AQO Program

Eskom’s selected offset interventions are based on reducing emissions from domestic solid fuel burning and addressing waste burning for the current Eskom AQO program (Eskom 2017a, 2017b, 2017c). Since 2022, some 4255 houses (*pers comm*, Matimolane, 2024) have received interventions in Kwazamokuhle and Ezamokuhle, and six (6) waste interventions have been undertaken in the Vaal as part of the phase 1 implementation program (data until mid-March 2024). Some 211 local people have been employed in the program since 2022 and approximately R40 million of local spend has been recorded. The effectiveness of the air quality offsetting regime depends on how well the interventions are planned, monitored and verified. Three indicator domains are monitored before, during and after the Eskom AQO implementation, namely the state of ambient air, emissions and quality of life. Over every monitoring period, the project scenario (as it actually took place) will be compared to a credible baseline scenario (i.e., the situation that would have been the case if the project was not implemented) (Matimolane, 2024).

#### 3.2.1.1.1 Air quality benefit

The principal indicator for the success of the intervention will be related to a change in exposure to air pollution and nett emissions avoided as a result of Eskom AQ offsets interventions. This will be expressed mainly as a reduction in the ambient concentration of particulate matter (Figure 86).

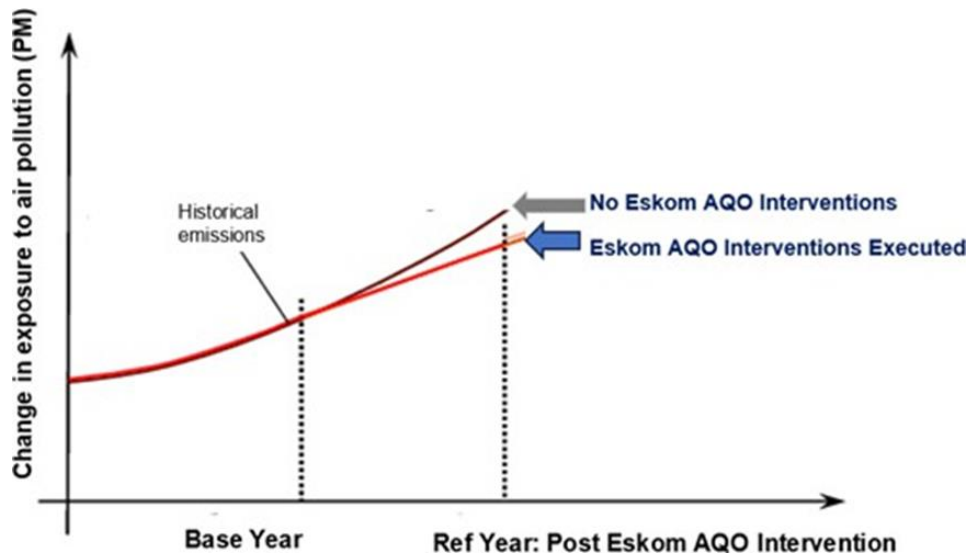
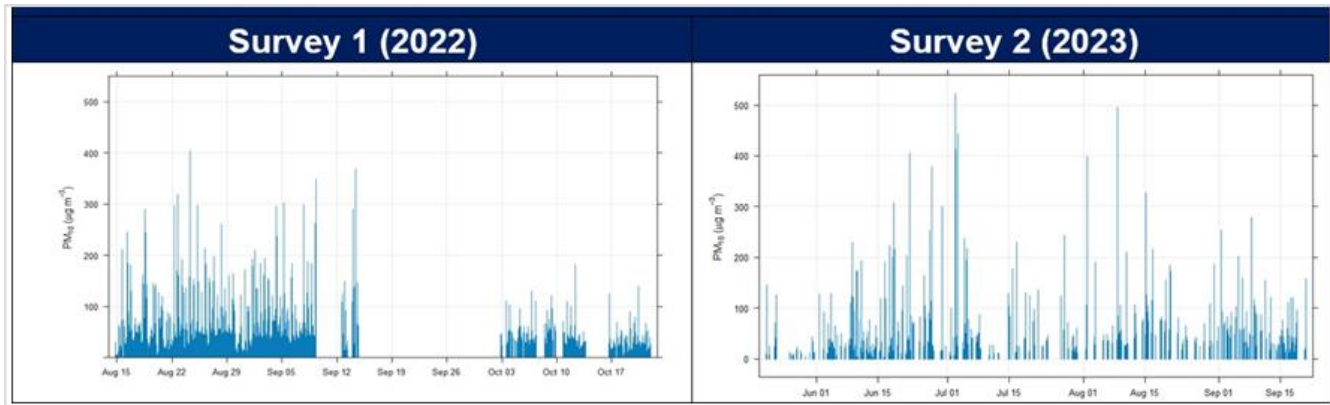


Figure 86: Principal indicator of success for Eskom AQO project

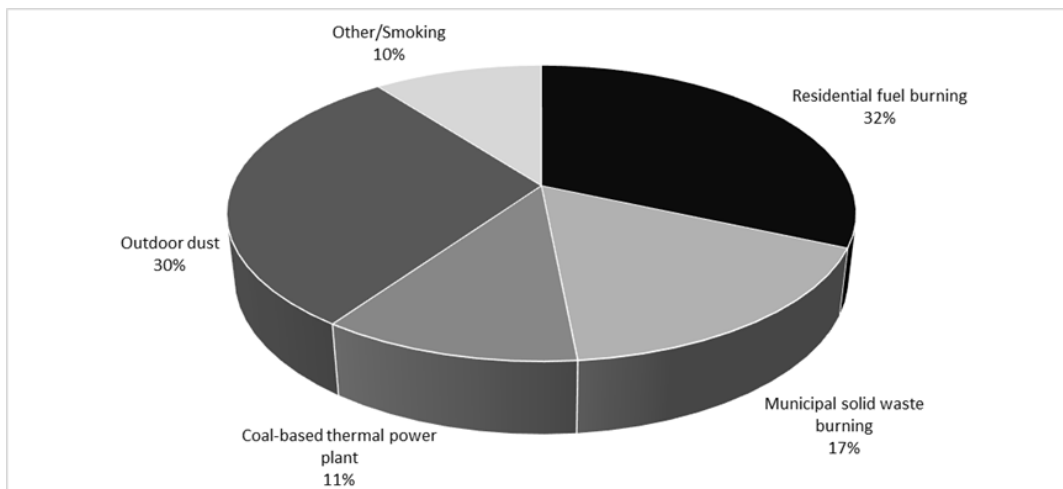
- **Ambient air quality measurements for Eskom’s Phase 1 AQO Program for household interventions**

ARM has undertaken status quo ambient air quality measurements for Eskom’s Phase 1 AQO Program for the selected offset settlements of both Kwazamokuhle and Ezamokuhle. ARM deployed Environmental Beta Attenuation Monitors (E-BAM) to measure a longer-term baseline winter particulate matter (PM<sub>10</sub> and PM<sub>2.5</sub>) ambient concentrations in these areas. Both the 2022 and 2023 survey campaigns have consistently demonstrated that elevated short term particulate matter (PM<sub>10</sub> & PM<sub>2.5</sub>) in the winter months are clearly attributable to residential fuel burning in both Ezamokuhle and Kwazamokuhle (ARM 2023c, ARM 2024b). The daily NAAQS for particulate matter (PM<sub>10</sub> & PM<sub>2.5</sub>) was exceeded at the Ezamokuhle & Kwazamokuhle residential sampling sites in both the 2022 & 2023 surveys. The Openair analysis further supported that the elevated particulate matter concentrations occurring during winter were associated with localized non-bouyant sources (residential fuel burning) as opposed to tall stack emissions.



**Figure 87: Ambient PM<sub>10</sub> concentrations (µg/m<sup>3</sup>) measured at the E-BAM household sampling location**

Based on the ground, aerial and PM measurement assessments it was evident that residential fuel burning poses a significant health risk to the communities of Ezamokuhle & Kwazamokuhle. To understand the contribution of indoor sources to Particulate Matter (PM), ARM undertook a scientifically credible source apportionment study during the winter baseline for Ezamokuhle. The University of North Carolina (UNC) passive sampler was utilised to capture the ambient particulates. The source apportionment results showed that residential fuel burning is the most significant contributing source of PM in the Ezamokuhle households (Figure 88). Further supporting that residential fuel burning poses a significant adverse health risk to the community of Ezamokuhle.



**Figure 88: Particulate source contribution average in indoor air for all sampled households in Ezamokuhle**

Furthermore, ARM has undertaken an indoor air quality measurement campaign for Eskom’s Phase 1 AQO Program. The monitoring was conducted for 6 weeks in winter. This included a 3-week window before intervention and 3-week window post installation of the Eskom AQO intervention (ceiling retrofit, rewiring, stove replacement and LPG heater). The results for are illustrated by . It is clear that post the installation of the Eskom AQO intervention, there is a real, quantifiable and verifiable reduction in PM emissions and associated pollution.

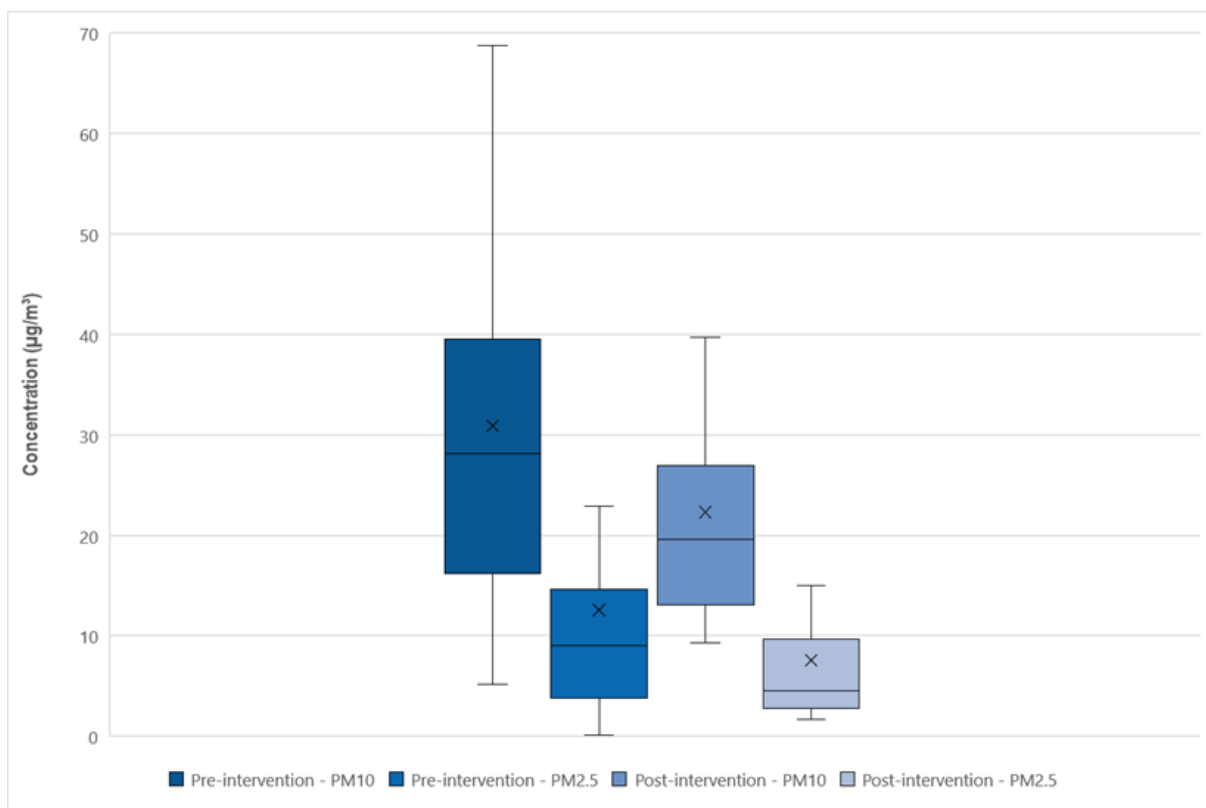
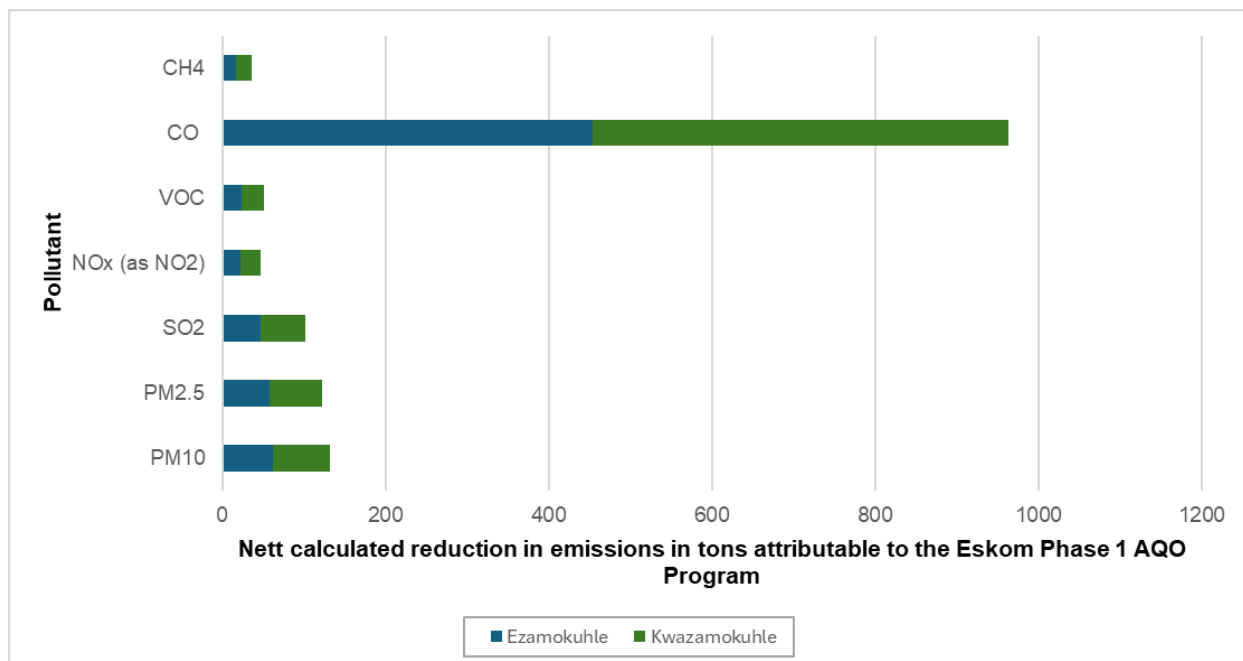


Figure 89: Box and whisker plot of PM<sub>10</sub> and PM<sub>2.5</sub> concentrations at Ezamokuhle during the pre- and post-intervention winter campaign (ARM, 2024c)

- **Ambient air quality improvement attributable for Eskom’s Phase 1 AQO Program for the waste AQO intervention**

- *Eskom’s Ezamokuhle and Kwazamokuhle Household AQO Project*

Since 2022, some 4255 houses (*pers comm*, Matimolane, 2024) have received interventions in Kwazamokuhle and Ezamokuhle. These interventions include the ceiling retrofit, rewiring, stove replacement and LPG heaters. ARM employed the methodology (section 2.3.2.3) consistent with the DFFE Second-Generation HPA AQMP (DFFE, 2024) to determine the net emissions avoided as a result of Eskom's AQO offset intervention in these regions. This is illustrated in Figure 90.

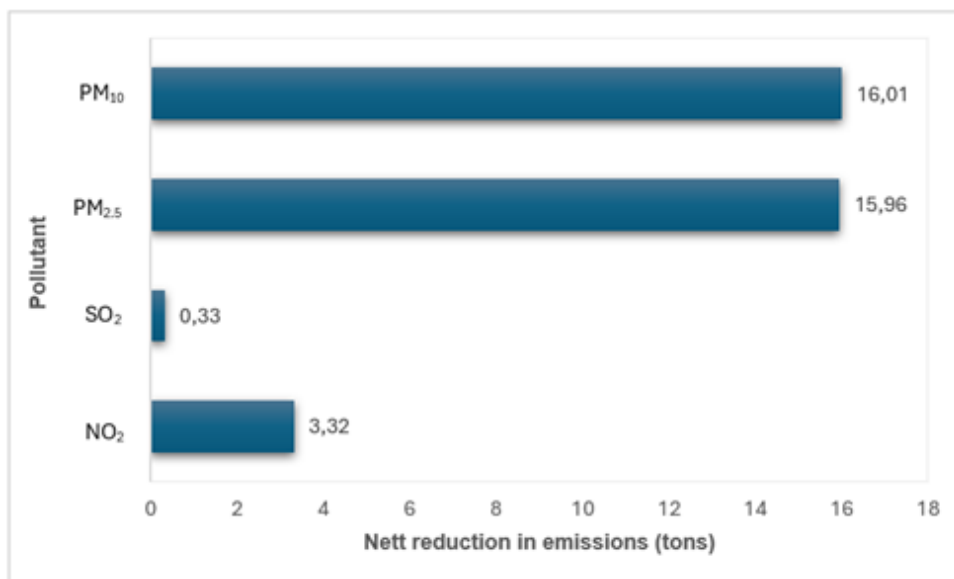


**Figure 90: Total net reduction in emissions attributable to Eskom's Phase 1 AQO Project (tons) for Ezamokuhle and Kwazamokuhle**

- *Eskom’s Sharpeville Waste AQO Project*

As part of Eskom’s AQO program for Lethabo power station, a waste clean-up campaign of designated illegal waste sites has been introduced in Sharpeville. A phased study was

conducted to determine the impact on air quality of the first three Eskom AQO waste clean-up campaigns in Sharpeville. The nett emissions avoided attributable to Eskom’s AQO offset intervention were quantified utilising the waste collected in conjunction with appropriate emission factors for these waste streams. The net reductions in PM, SO<sub>2</sub> and NO<sub>2</sub> emissions attributable to Eskom's Sharpeville AQO Project during clean-up campaigns 1 to 3 is provided in Figure 91.



**Figure 91: Total net reduction in emissions attributable to Eskom's Sharpeville AQO Project (tons) for campaigns 1 to 3**

Based on this emissions inventory (Figure 91), a tier-3 dispersion modelling assessment was utilised to determine the potential nett ambient air quality benefit of Eskom’s Sharpeville AQO Project. Table 43 summarises the potential nett ambient air quality benefit of Eskom’s Sharpeville AQO Project during clean-up campaigns 1 to 3.

**Table 43: The potential improvement in ambient air quality due to Eskom's Sharpeville AQO Project**

Model predicted maximum concentration in ug/m3							
Pollutant	PM <sub>10</sub>		PM <sub>2.5</sub>		SO <sub>2</sub>		NO <sub>2</sub>
Averaging period	1-hour	24-hour	1-hour	24-hour	1-hour	24-hour	1-hour
<b>Campaign 1</b>	19,1	2,4	19,1	2,3	0,4	0,05	2,1
<b>Campaign 2</b>	33,9	4,4	33,8	4,4	0,6	0,09	3,5
<b>Campaign 3</b>	278	28,87	277,45	28,75	5.6	0,58	28,6

It's noted that the highest impacts are predicted to occur with a close proximity of each site. The short-term (1-hourly) maximum ambient air quality improvement ranged between:

- 19 µg/m<sup>3</sup> to 278 µg/m<sup>3</sup> for PM
- 0.4 µg/m<sup>3</sup> to 5.6 µg/m<sup>3</sup> for SO<sub>2</sub>
- 2.1 µg/m<sup>3</sup> to 28 µg/m<sup>3</sup> for NO<sub>2</sub>

Whereas the long-term (24-hourly) maximum ambient air quality improvement ranged between:

- 2.4 µg/m<sup>3</sup> to 28 µg/m<sup>3</sup> for PM
- 0.05 µg/m<sup>3</sup> to 0,58 µg/m<sup>3</sup> for SO<sub>2</sub>

It is worth noting that the daily PM<sub>10</sub> NAAQS is 75 µg/m<sup>3</sup>. Therefore, these results suggest that waste-burning incidents may have the potential to locally increase PM<sub>10</sub> concentrations in certain instances. Theoretical evidence from this study suggests that Eskom's Sharpeville AQO Project has a beneficial impact on ambient air quality in the Sharpeville airshed.

### 3.2.1.1.2 Quality of Life

One of the key metrics for Eskom is to ascertain the improvement in the quality of life for the communities wherein the Eskom AQO intervention is rolled out. ARM conducted an Annual Household and Monitoring of Project Effectiveness Survey on 403 households in KwaZamokuhle and 401 households in Ezamokuhle (ARM,2024d). All households that were sampled received the full Eskom AQO intervention suite.

It was clear from the Project Effectiveness Survey that 99% of the households in viewed the Eskom provided interventions (stove, LPG heater & ceiling) as of good quality. Additionally, 99% of the households would recommend the LPG heater installation to other households who had not participated as yet in Eskom AQO intervention project. Respondents also provided feedback that it was both cheaper (91%) and quicker (98.6%) to cook on the Eskom provided hybrid stove as opposed to a traditional coal stove. Furthermore, 99% of the respondents indicated that food tasted the same as a meal cooked on a traditional coal stove. An overwhelming majority responded that were completely satisfied (Figure 92) with the Eskom AQO intervention as it improved their quality of life for the household.

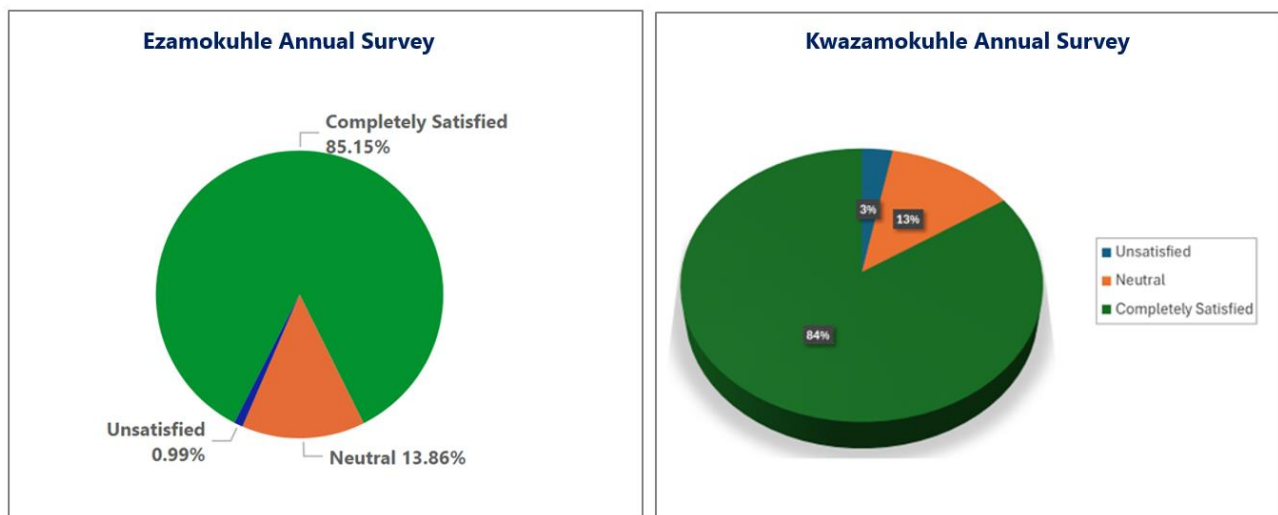


Figure 92: Household satisfaction with Eskom AQO Phase 1 interventions

### 3.2.2.1 Potential other AQO interventions

Eskom’s current suite of AQO interventions (section 3.2.1) were informed by a prefeasibility conducted by NOVA in 2013. Nova (2013) utilised the Analytical Hierarchy Process (AHP), to narrow the list (Figure 93) to 6 potential interventions:

- 1) Electricity subsidy;
- 2) Retrofit full suite of thermal shell insulation (ceilings and walls), draft proofing and Trombe wall on all existing subsidy houses [Full retrofit]
- 3) Install ceilings in all houses [Ceilings]
- 4) Optimise house size, shell insulation, ventilation, orientation and solar heat absorption for new subsidy houses and social housing [EE RDP]
- 5) Replace coal / wood stove with multi-purpose, high quality, low emission stove [New stove] and
- 6) Gas subsidy with equipment [LPG subsidy & heater]

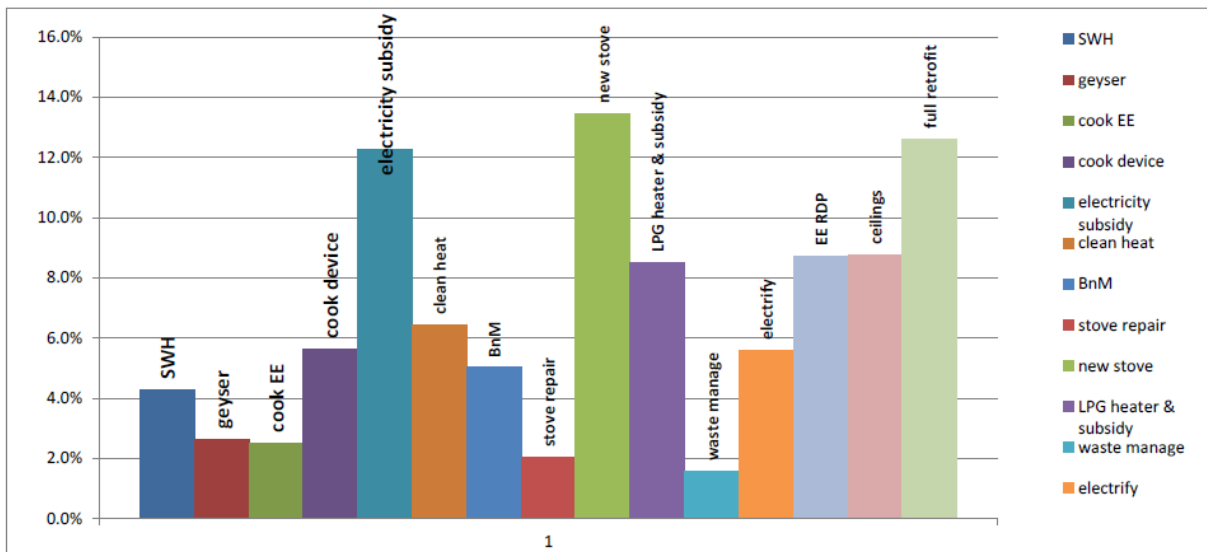


Figure 93: Result of applying the evaluation criteria (relative weighting on the y-axis) (NOVA, 2013)

NOVA (2013) concluded that Household acceptance of the proposed offset projects was the most important determinant that would inform the success of the offset projects, followed by acceptance by licencing authorities and the Eskom Board.

ARM has conducted a review of the current regulatory landscape for AQO interventions to understanding how the policies and frameworks impact the current narrative and thinking in terms of AQO and potential other interventions. Additionally, a high-level desktop pre-feasibility study was undertaken by ARM to identify the most effective interventions for offsetting emissions from Eskom. This is presented in the next sections.

### **3.2.2.1.1 Summary of emission reduction interventions identified by the DFFE**

ARM reviewed the current air quality regulatory landscape to identify emissions interventions identified for the VTAPA and HPA. Table 44 provides a summary of these interventions. It is noted that overlapping themes for both VTAPA AQMP, HPA AQMP and *Strategy to Address Air Pollution in Dense Low-income Settlements* include interventions identified for the reduction of residential fuel burning, domestic waste burning, veld fire burning and reducing windblown dust in residential areas.

**Table 44: Summary of emissions interventions identified for the VTAPA and HPA**

	DFFE Report		
	HPA AQMP (DFFE, 2024)	VTAPA AQMP (DFFE, 2020)	Strategy to Address Air Pollution in Dense Low-income Settlements
<b>Objective</b>	Activities towards reducing emissions		
<b>1. Residential Fuel Burning</b>	Conduct public awareness on air pollution	Rollout of low smoke and LPG stoves and heaters, and alternative energy sources	Cleaner cooking & heating alternatives
	Conduct public awareness on indoor air pollution	Promote use of clean/green fuels such as LPG, biogas etc.	Clean cook-stoves
	Solar Water Heating installed in beneficiary households in participating municipalities	Promote and fit RDP houses with sufficient insulation	Solar Water geysers
	Households electrified with grid		Free basic electricity with efficient appliances
	Develop and implement emission reduction and management plan		Subsidised LPG
			Ensure low-income households are energy efficient (ceilings insulation, plastering of internal walls, eco glass)
			Conduct public awareness on air pollution
			Electrification
<b>2.Domestic Waste Burning</b>	Development and review of Intergrated Waste Management Plans (IWMP)	Waste separation at source & recycling	Regular refuse removal
	Implementation of updated IWMP	Waste collection & clean- up	
	Development an Implementation of emission reduction plans	Management of municipal and privately-owned landfill sites	
	Improve public awareness on waste minimisation, reuse, recycling and the health impacts of waste		
	Initiation of projects/programs for Waste diversion		
<b>3. Forestry and Veld Fire (Biomass) Burning</b>	Develop and finalise a national strategy for reducing emissions from deforestation degradation	Municipalities to implement Veld fires guidelines (establish relation with EPWP working for fire. Establish veld fire hotline. Induction of employees in management of veld fires.)	

	DFFE Report		
	HPA AQMP (DFFE, 2024)	VTAPA AQMP (DFFE, 2020)	Strategy to Address Air Pollution in Dense Low-income Settlements
	Establish partnerships with Fire Protection Associations that enforce Veld and Forest Fires Act	Conduct education and awareness campaigns on burning and veld fires.	
	Development an Implementation of emission reduction plans		
	Conduct education and awareness campaigns in the communities on the impact and prevention of veld fires.		
<b>4. Reduce windblown dust emissions in residential areas</b>	Identify unpaved roads with high traffic activity and implement mitigation measures to minimise dust on these roads		Road surfacing
	Plant vegetation near unpaved roads to serve as a dust barrier		
	Create partnerships between municipalities and stakeholders on upgrading unpaved roads in low-income settlements		
	Plant trees outside the forest footprint		
	Improve the number of hectares approved for afforestation.		

### **3.2.2.1.2 Summary of other emission reduction interventions Eskom could consider**

Domestic emissions can be reduced by encouraging households to replace coal and biomass burning with cleaner fuels such as low smoke fuels and LPG. The transition could follow an ‘energy ladder’ model whereby households move from traditional energy carriers to transitional and then to modern energy carriers as their income improves. The ‘energy stacking’ model indicates that households will utilize a combination of energy carriers on the upper and lower stages of the energy ladder, depending on their needs. Households transition from traditional fuels to modern fuels as income rises in accordance with the energy ladder approach. In the case of energy usage for heating purposes, income is not a statistically significant determinant of energy usage, which means households will not necessarily switch to modern fuels as income rises, in line with the energy stacking model. A study conducted by the Department of Energy came to a similar conclusion as their results indicated that poorer households relied on multiple sources of energy regardless of electrification status, which further points to an energy stacking model rather than the energy ladder theory (DOE,2012).

The energy ladder (Figure 94) suggests that households completely switch the fuels they use with increasing income whilst the energy stacking rejects that and suggests an alternative behavior of using multiple fuels at the same time. This is an important consideration for alternative, complimentary solutions to improve air quality for Eskom. A more holistic approach to ambient air quality, will require Eskom to also consider other emission point sources such as dust from unpaved roads, veld fires and burning of waste material which is an unfortunate reality in the townships. Interventions to address these are also explored in the following section.

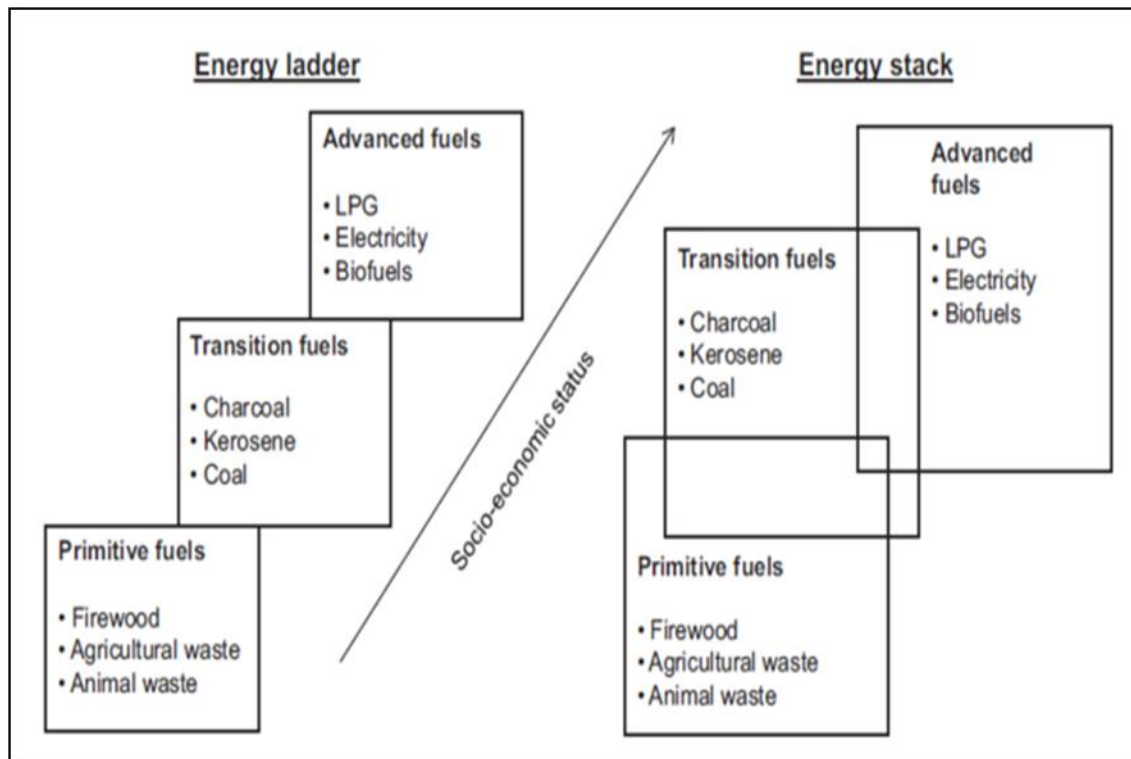


Figure 94: The Processes of Energy Transition

### 3.2.2.1.2.1 Dust suppression of unpaved roads

Unpaved “roads “is an inconvenient reality for many townships. Unpaved roads produce a lot of dust which contributes to poor ambient air quality. Addressing this issue will result in an overall improvement of general ambient air quality in the affected areas. Below are some tried and tested methods to achieve this:

#### ✓ Windbreaks

Dust itself isn’t so much the problem as is what happens when the dust is blown away by wind or passing vehicles. Preventing wind from blowing dust on a roadway can be a good start to a dust control strategy. This can be achieved by installing windbreaks like hedges, plants, fences, or berms. This may present an affordable solution but must be evaluated for each context and location before application.

### ✓ **Spraying Water**

Dust mitigation can also be achieved through spraying water. Wetting the topsoil of a road prevents it from blowing away in the wind. This is a good dust palliative for humid areas, but in dry areas, it doesn't last very long. Plain water can be used for this process as well as water mixed with another type of chemical adhesive or oil. Water mixed with an additional coagulant will typically perform a bit better than just plain water. However, in the South African context, water availability will be a challenge and this option should only be considered as a possible last resort.

### ✓ **Application of Gravel**

Gravel itself can also be a solution to dust control on unpaved roads. Adding gravel to the top layer of soil on a road gives the road a hard surface which can act as a buffer between the wheels of vehicles and the road itself. This is not a long-term strategy for road dust suppression, however, because gravel needs to be constantly anchored to the road surface with soil adhesives or aggregate mixes. Gravel, depending on the hardness, can become pulverized and turn into dust over time, adding to the problem. Frequent maintenance is required with a gravel only solution.

### ✓ **Salt**

Salt is one of the best road dust control products available. Lignin Sulfonate and Calcium Chloride are two of the most popular unpaved road dust control products. These salts are mixed in a 35% solution and applied directly on the unpaved road. They work by soaking up water from the air, thus keeping the top level of soil damp enough to prevent it from turning into dust. When it comes to road dust control products, salts like these two are some of the most effective options. They do come with environmental concerns, however. Eskom should consider approaching the Pulp and Paper industry for potential partnership and source of lignin sulfonate.

### ✓ **Ash with Binders**

Fly Ash is a by-product at thermal power stations, also otherwise known as residues of fine particles that rise with flue gases. Eskom produces copious amounts of fly ash which can be bound with polymers additive etc and applied to road surfaces. Eskom has piloted an ash polymer road at Kusile with good success. This entailed applying ash, with an activator and water to the roads and could potentially be a cheaper affordable intervention to stabilise the road and prevent dust.

### ✓ **Ecobond resin additive**

Ecobond improves aggregates providing more durable infrastructure at lower cost as a reinforcement for bitumen, gravel, ash etc. As part of the next phase, Eskom could explore such additives.

### ✓ **Rubber Modified Asphalt**

In locations with particularly significant waste tyres, Eskom could explore the option of rubber crumbing to be utilised in thereafter in road surfacing. If economical this solves the duality of waste tyre burning and suppressing fugitive dust emissions as well as the potential for job opportunities.

#### **3.2.2.1.2.2 Preventing veld fires**

Another significant source of fugitive emissions is the prevalence of veld fires particularly during the dry winter months. Through community education and other interventions such as establishing fire breaks, vegetation control, controlled burning and employing fire response teams to put out fires, fugitive emissions from veld fires can be adequately controlled.

#### **3.2.2.1.2.3 Waste to Watts**

Integrated sewage and solid waste bioreactors presents a potential opportunity to Eskom to harness power and heat from waste through anaerobic digestion and biogas production. There

are a number of examples of this globally, not least a facility opened in Cape Town in 2017 but also a renewable energy project, generating 20kw of electricity and distributing via a mini-grid to approximately 550 individuals was implemented in Rije, Abuja, Nigeria. The project focuses on converting agricultural waste (poultry, livestock, crop waste) and communal waste (kitchen and human wastes) into electricity, cooking fuel using a bio-gas digester.

Biogas can be utilized as a source of energy by the anaerobic digestion of organic waste including household waste and sewerage sludge. Biodigester septic tanks can be localized, is a cheap, quick and effective way to provide dignified sanitation, and removes the need for bulk sanitation and sewerage works. If perfected, biogas can be an important technology for both waste management and as energy source. Kenya has successfully introduced the concept of biocentres. The biocentre technology provides multiple social, environmental and economic benefits to the communities residing in informal settlements. This technology provides dignified sanitation and responds to the high energy demand through supply of safe bio-gas for household application and natural compost for improved urban gardening hence improving household nutrition.

#### **3.2.2.1.2.4 Minigrids and microgrids**

Minigrids and microgrids present local authorities and companies with an opportunity to serve a discrete geographic footprint with a self-sufficient energy system. Microgrids are localized grids that can disconnect from the traditional grid to operate autonomously. Microgrids support a flexible and efficient electric grid by enabling the integration of growing deployments of distributed energy resources such as renewables like solar.

Given the need to provide all communities with access to electricity, particularly marginalised communities, Eskom is considering the development and deployment of microgrids to fast-track universal access to sustainable and reliable electricity services. The development of containerised microgrids will not only provide communities with electricity but will

simultaneously contribute to local economic development and the attainment of NDP 2030 objectives.

In terms of the microgrid deployment, Eskom has demonstrated the successful use of microgrids with the establishment of a solar-powered microgrid at Wilhelmina Farm in Ficksburg (Figure 95). Although not containerized, the plant produces 32 kW of electricity and is equipped with three sets of lithium-ion batteries that have a cumulative storage capacity of 90 KWh. Furthermore, the plant has successfully delivered electricity to 14 households with a total of 81 family members (Pombo-van Zyl, 2018). It is noted that the Highveld currently lacks the transmission network for this solution hence it may not be as effective hereto.



**Figure 95: Ficksburg Microgrid**

A cost-effective way, to get RDP homes off the national grid is to install rooftop PVs and battery storage and solar geysers (Figure 96). Assuming a 3 KW peak demand for an RDP home, we estimate that a R30 000 – R40 000 solar PV, inverter and battery solution is possible.



Figure 96: Solar panels and geysers

### **3.2.2.1.2.5 Waste Recycling Facility & Waste to Energy**

Waste-to-energy plants burn municipal solid waste (MSW), often called garbage or trash, to produce steam in a boiler that is used to generate electricity. MSW is a mixture of energy-rich materials such as paper, plastics, yard waste, and products made from wood. There are different types of waste-to-energy systems or technologies. The most common type used is the mass-burn system, where unprocessed MSW is burned in a large incinerator with a boiler and a generator for producing electricity. Another less common type of system processes MSW to remove most of incombustible materials to produce refuse-derived fuel (RDF).

### **3.2.2.1.2.6 Municipal Wastewater Treatment & Biomass to Energy**

The treatment of residual sludge from sewage treatment plants is a challenge that municipalities can overcome by recovering the sludge to produce biogas by a process of thermal hydrolysis and anaerobic digestion. Transforming sludge into biogas (which is a source of green energy) gives value to materials previously deemed harmful or even dangerous for

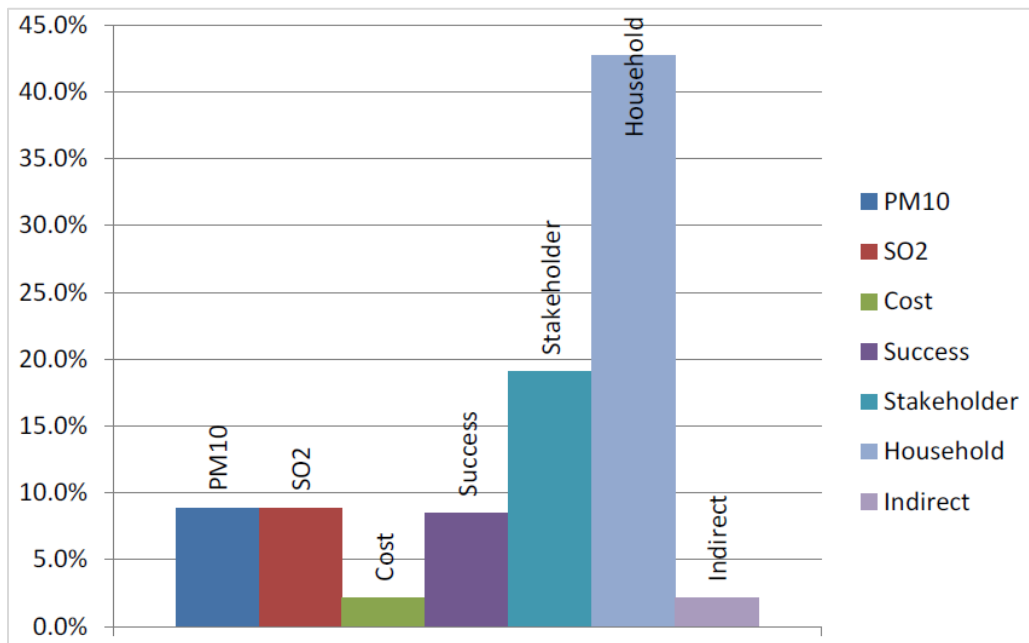
the environment. It also helps combat the scarcity of raw materials and the use of fossil fuels. For sewage treatment plant operators, converting sewage sludge into biogas complies with environmental regulations, drastically reduces residual sludge volumes and creates a new revenue stream, either by using the energy produced on-site, or by selling it to the local grid. The American Biogas Council estimates roughly 80% of the latent energy in wastewater is thermal, 20% is chemical, and less than 1% of the potential exists in hydraulic generation. Largely, the energy recovered from wastewater as biogas produced by anaerobic digestion is one of the most robust and valuable resource streams. Biogas contains about 70% methane, but yields depend on the concentration of putrescible (digestible) feedstock in the source water.

### **3.2.2.1.3 High-level desktop pre-feasibility study to identify the most effective interventions for offsetting emissions from Eskom**

As noted in section 3.2.1, Eskom's current set of AQO interventions include the following:

- Provision of a basic plus retrofit, which consists of;
  - Insulation entailing installation of a SPF ceiling system and draft proofing.
  - Electrical rewiring and issuance of Certificate of Competence (CoC).
- Stove swap, which includes:
  - Provision of electricity-based energy source with LPG backup. This includes a hybrid gas-electric stove, LPG heater plus 2x9 kg LPG cylinders and Compact fluorescent lamp (CFL) for energy efficiency lighting.
  - Removal and disposal of the coal stove
- Additionally, a waste burning intervention has been implemented for the clean-up of illegal dumps in Sharpeville, Tshepiso, Boipatong and Refengkotso.

ARM utilised the same weighted criteria (Figure 97) as calculated by NOVA (2013) for the Eskom OIPs (Eskom 2017a, 2017b, 2017c) to assess whether Eskom current set of interventions (section 3.2.1) are still valid and should be continued.



**Figure 97: Weighting of the criteria used to evaluate the proposed offset interventions (NOVA, 2013)**

Using the Delphi technique amongst ARM air quality experts, each of the interventions were ranked according to their impact on each of the above criteria (Figure 97) on a 5-point scale with 1 being low and 5 being high. The results are summarised in Table 45.

**Table 45: Delphi Technique to rank AQO Interventions**

	Intervention	Reduced human exposure to ambient PM	Reduced human exposure to ambient SO2	Implementation cost attractiveness of intervention	Success probability of intervention	Government and Eskom Board acceptance of intervention	Sustainability of intervention	Household acceptance of intervention	Total
<b>Cooking</b>	Energy Efficient / Clean Stoves (still use coal/wood) w/o hood or chimneys	3	3	4	4	4	4	4	26
	Energy Efficient / Clean Stoves (still use coal/wood) with hood or chimneys	4	4	4	5	5	5	5	32
	Stoves that use clean fuels eg. Ethanol gel, LPG, biogas	5	5	3	4	4	3	3	27
	Electric Stoves without subsidy eg. Free basic electricity	5	5	3	3	5	3	3	27
	Electric Stoves with subsidy eg. Free basic electricity	5	5	5	5	5	5	5	35
	Solar Stove	5	5	5	3	4	3	3	28
<b>Lighting</b>	Electricity for lighting without subsidy eg free basic electricity	5	5	3	3	5	3	3	27
	Electricity for lighting with subsidy eg free basic electricity	5	5	5	5	5	5	5	35
	Solar Lighting	5	5	5	5	5	3	5	33
	LPG Light	5	5	3	3	3	3	4	26
	Paraffin lamps	5	5	4	4	3	4	3	28

	Intervention	Reduced human exposure to ambient PM	Reduced human exposure to ambient SO2	Implementation cost attractiveness of intervention	Success probability of intervention	Government and Eskom Board acceptance of intervention	Sustainability of intervention	Household acceptance of intervention	Total
<b>Space Heating</b>	Electricity for heating (electric heater) without subsidy eg free basic electricity	5	5	3	3	5	3	3	27
	Electricity for heating (electric heater) with subsidy eg free basic electricity	5	5	5	5	5	5	5	35
	Energy Efficient / Clean Stoves (still use coal/wood) w/o hood or chimneys	3	3	4	4	4	4	4	26
	Energy Efficient / Clean Stoves (still use coal/wood) with hood or chimneys	4	4	4	5	5	5	5	32
	Stoves that use clean fuels eg. Ethanol gel, LPG, biogas	5	5	3	4	4	3	3	27
	LPG / Biogas Heater	5	5	3	4	4	3	3	27
<b>Dwelling Retrofits</b>	Ceilings	5	5	3	3	3	4	4	27
	Retrofit and Insulation	5	5	3	3	3	4	4	27
	Improved Ventilation	4	4	3	4	4	4	4	27
<b>Other Opportunities</b>	Waste to Energy	3	3	2	2	3	2	4	19
	mini and microgrids using wind and solar	5	5	2	3	4	3	4	26
	Biodigester septic tanks to produce biogas	5	5	2	2	3	3	2	22

	Intervention	Reduced human exposure to ambient PM	Reduced human exposure to ambient SO2	Implementation cost attractiveness of intervention	Success probability of intervention	Government and Eskom Board acceptance of intervention	Sustainability of intervention	Household acceptance of intervention	Total
	Dust Suppression	4	1	3	4	4	4	4	24
	Veld Fire Control	5	4	4	4	4	4	4	29

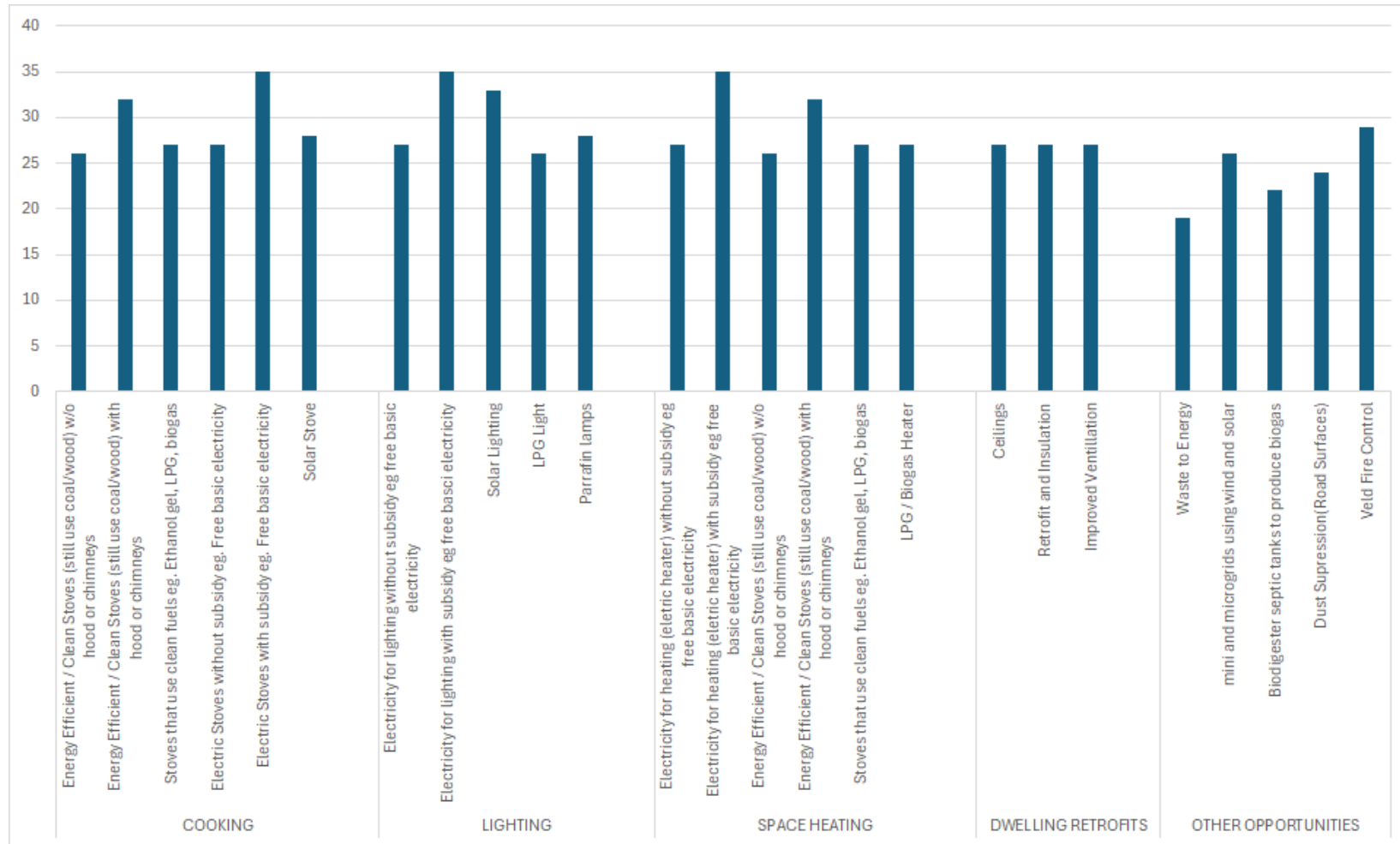


Figure 98: Ranking of Potential AQO Interventions for Eskom

From the above rankings (Figure 98), it is clear that electricity with subsidies for cooking, space heating and lighting will provide the best outcome. However, cognisant of the South African context and with the understanding that this represents the final or ultimate step on the energy stack or ladder, it may be premature at this stage of Eskom's offset projects. It is however a useful peg to aspire to and where its economically possible and practical to do so, should be the first intervention to be employed. If this is not feasible, the next option would be to use energy-efficient stoves or switch to stoves that utilise cleaner fuels such as LPG or biogas. However, it must be noted that these solutions alone without ventilation, insulation and insulated ceilings will not realise the ultimate goal of clean air, cost effectiveness and sustainability as outlined by the principles of the DFFE Air Quality Offset Guideline (DFFE, 2016).

Supplementing household or indoor interventions with outdoor interventions is necessary if the ultimate goal is to improve ambient air quality and improve health. To this extent, Eskom should consider exploring opportunities to reduce fugitive emissions from dust and veld fires such as dust suppression from unpaved roads and veld fire management techniques. Eskom has already piloted ash polymer roads in Kusile with success and this can be replicated in other areas after due diligence with some of the ideas proposed such as salt application or rubber crumbing. Veld fire management techniques such the establishment of fire breaks, vegetation control, employment of fire response teams etc will also alleviate fugitive emissions from veld fires in the various locations. These two interventions rank highly in the priority of interventions to be employed and should be explored further by Eskom to test both its viability and air quality benefit.

It's noted that the findings of ARM's high-level desktop feasibility analysis (Table 45) is aligned to the current suite of AQO interventions (section 3.1.2) that Eskom is rolling out. Our recommendation is therefore that Eskom continues with the following AQO interventions:

- ✓ Insulation entailing installation of a SPF ceiling system and draft proofing.
- ✓ Stove swap with the provision of a hybrid gas-electric stove,
- ✓ The provision of a LPG heater plus 2x9 kg LPG cylinders

- ✓ The provision of compact fluorescent lamp (CFL) for energy efficiency lighting.
- ✓ The rollout of the waste burning interventions for the clean-up of illegal dumps

ARM suggests the following improvements for Eskom to consider in the future implementation of these AQO interventions:

- To develop suitable financing models (such as credit) with local retailers & fuel merchants for the supply and access to gas in the community.
- Given the rising cost of living, we propose offering 5kg and 9kg LPG cylinders instead. The more affordable 5kg cylinder will contribute to long-term support of Eskom's AQO Project.
- To establish a network of community technicians capable of offering both repairs and replacement parts for the provided stoves.
- To consider replacing any rusted components of the roof prior to application of the SPF ceiling.

Additionally, ARM recommends Eskom considers the follows AQO intervention options:

- ✓ Implementing dust suppression/solutions of unpaved roads in low-income settlements
- ✓ Implementing veld fire management solutions
- ✓ Eskom evaluates the feasibility of mini and micro grids in appropriate locations
- ✓ Eskom in conjunction with local municipalities assess the potential for biogas generation from Waste and Sewage treatment plants.

Before implementing these solutions, it is essential that Eskom conducts a thorough study on their viability to ensure they can be effectively realized in practice. Additionally, an in-depth analysis of their economic feasibility is crucial to determine whether the benefits outweigh the costs involved. Practicality must also be assessed to identify any potential challenges or barriers that could hinder successful execution. Only after these detailed evaluations can informed decisions be made regarding the adoption of these solutions as part of Eskom's future AQO Program.

## 3.3 Phase 3 Results

### 3.1.1 Estimation of the scale of the intervention

For the selected offset areas (section 2.2.2.1), ARM calculated the number of households that utilise coal (60% for Mpumalanga as per StatsSa GHS 2019) and assumed that that 90% of these households will opt to participate in the Eskom AQO program. The indicative number of households for the expansion of Eskom's AQO Program is shown in Table 46 and illustrated by Figure 99.

It's noted that due to the lack of ward level from the 2022 Census dataset, ARM utilised linear extrapolation of the StatsSA 2011 (municipal & ward data), 2016 (municipal data) and 2022 (municipal data) to estimate the total number of households herein (Table 46). It's recommended that the household figures below are updated once the 2022 StatsSA ward level data is released publicly later this year.

Further whilst Table 46 presents the indicative of number of total households available for air quality offsetting, the actual number to be targeted will be based on Eskom's financial situation and capacity to roll-out the AQO Program in these areas. Based on Eskom's Very Rough Order of Magnitude Costing (VROM), it's estimated the cost of a single household intervention is ~R54 796,26 (this excludes Eskom internal RTD & Stakeholder costs) whilst the cost for six clean-up campaigns is R4 598 583.65 (Matimolane, 2024). ARM utilised these Eskom VROM costs (Matimolane, 2024) to estimate the cost for the expansion of the Kendal, Lethabo, Matla and Majuba Power stations. This calculation assumed a 100% rollout to all the expanded households identified in the study for the Kendal, Lethabo, Matla and Majuba Power Stations and six clean-up campaigns for each of the areas identified for Lethabo Power Station. The results are summarised in Table 47 & Figure 100. It's noted that due to significant number of households identified for both the Duvha and Tutuka Power Stations, guidance is first required from Eskom in terms of estimated number of households that can be provided with household AQO intervention based on Eskom's financial situation.

**Table 46: Indicative number of households for the expansion of Eskom AQO Program**

Power Station	Area selected for Offsets	Population		Indicative number of households for air quality offsets			Type of Offset
		Eskom 2017 OIP	ARM 2024 Study	Eskom 2017 OIP	ARM 2024 Study	Potential Expansion of Eskom AQO Program	
<b>Duvha</b>	Masakhane	3 740	4 107	1 108	1 218	<b>110</b>	Household
	eMalahleni	No Data	119 328	2 000	23 211	<b>21 211</b>	Household
<b>Kendal</b>	Rietspruit	No Data	5 724	No Data	1 360	<b>1 360</b>	Household
	Phola	8913 <sup>5</sup>	35 012	6 016	6 608	<b>592</b>	Household
<b>Lethabo</b>	Refengkotso	17 646	18 745	NA	NA	<b>(9035m<sup>3</sup>)<sup>6</sup></b>	Waste
	Sharpeville	37 599	49 269	NA	NA	<b>(9035m<sup>3</sup>)<sup>6</sup></b>	Waste
	Tshepiso	29 271	38 353	NA	NA	<b>(9035m<sup>3</sup>)<sup>6</sup></b>	Waste
	Boipatong	22 167	29 049	NA	NA	<b>(9035m<sup>3</sup>)<sup>6</sup></b>	Waste
<b>Majuba</b>	Daggakraal/Sinqobile	14 856	25 650	2 940	3 819	<b>879</b>	Household
	Ezamokuhle	10 293	14 794	1 850	2 673	<b>823</b>	Household
<b>Matla</b>	Emzimnoni	No Data	32 940	6 065	6150	<b>85</b>	Household
	Kananna Ext 6	No Data	3 238	551	583	<b>32</b>	Household
	Milan Park	No Data	11 952	1 035	2 468	<b>1 433</b>	Household
	Thambo	No Data	2 152	845 <sup>7</sup>	408	<b>NA</b>	Household
<b>Tutuka</b>	Sivukile	5 757	5 954	1160 <sup>8</sup>	1 155	<b>NA</b>	Household

<sup>5</sup> The population number provided for Phola in OIP (Eskom, 2017) is erroneously stated as 8913 for 2011, however it was 31,885 in 2011 (StatsSA, 2011).

<sup>6</sup> This estimate is calculated based on the six cleanup campaigns conducted to date as part of Eskom’s AQO project for Sharpeville (*pers comm*, Matimolane, 2024)

<sup>7</sup> Its noted that as per StatsSa (2011), only 264 households utilised coal. Further the Eskom OIP (2017) indicated Thambo had a total of 610 households however a larger number than this (1160) total number of households was chosen herein.

<sup>8</sup> The Eskom OIP (2017) indicated for Sivukile a total of 690 households utilised coal as per StatsSA however a larger number than this (1160) total number of households was chosen herein.

Power Station	Area selected for Offsets	Population		Indicative number of households for air quality offsets			Type of Offset
		Eskom 2017 OIP	ARM 2024 Study	Eskom 2017 OIP	ARM 2024 Study	Potential Expansion of Eskom AQO Program	
	Thuthukani	2 670	2 757	400	599	199	Household
	Standerton	No Data	45 490	No Data	8 004	8 004	Household
	Sakhile	No Data	41 819	No Data	8 038	8 038	Household
<b>Total</b>		<b>152980</b>	<b>486333</b>	<b>24462</b>	<b>85839</b>	<b>62311</b>	

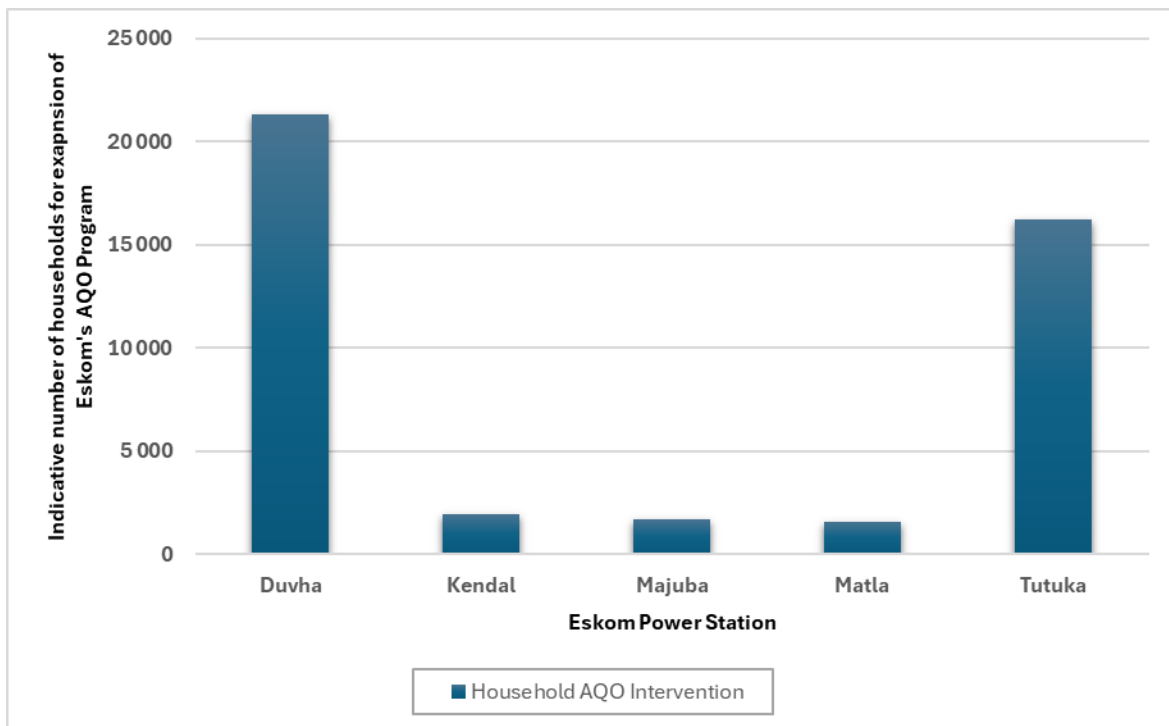
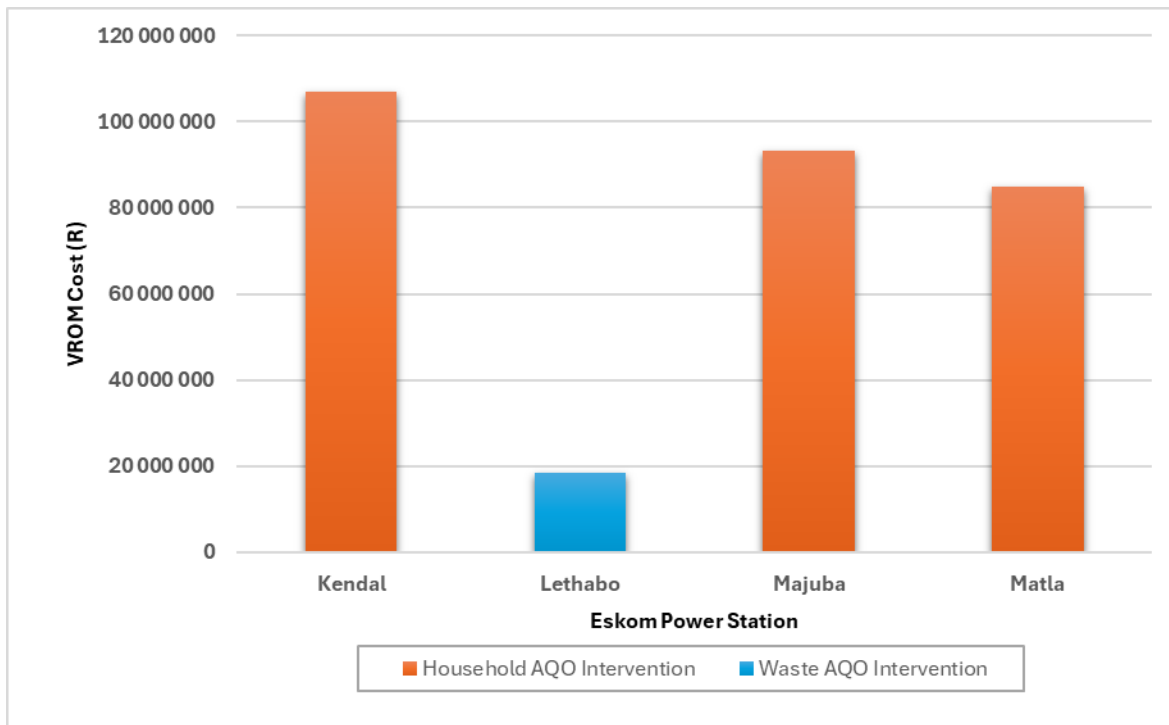


Figure 99: Indicative number of households for the expansion of Eskom AQO Program

**Table 47: VROM total cost estimate for the expansion of the AQO Program for Kendal, Lethabo, Matla and Majuba Power stations**

Power Station	Cost in Rands (R)	
	Household AQO Intervention	Waste AQO Intervention
Kendal	R106 962 300	
Lethabo		R18 394 335
Majuba	R93 263 235	
Matla	R84 934 201	
<b>Total</b>	<b>R285 159 735</b>	<b>R18 394 335</b>



**Figure 100: VROM cost estimate for the expansion of the AQO Program for Kendal, Lethabo, Matla and Majuba Power stations**

### 3.1.2 Potential air quality benefit (Nett emissions avoided)

The potential net reductions in: PM<sub>10</sub>; PM<sub>2.5</sub>; SO<sub>2</sub>; NO<sub>x</sub> (as NO<sub>2</sub>); VOC; CO; CH<sub>4</sub> emissions attributable to Eskom's AQO intervention were quantified utilising appropriate emission factors. The net calculated reductions in emissions (tons) attributable to the expansion of Eskom's AQO Program is presented in Table 48 and Figure 101 and Figure 102.

**Table 48: Nett calculated reduction in emissions attributable the expansion of Eskom AQO Program per Power Station**

Power Station	Nett reduction in emissions (tons)						
	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>2</sub>	NO <sub>x</sub> (as NO <sub>2</sub> )	VOC	CO	CH <sub>4</sub>
Duvha	661	615	507	233	256	4 829	184
Kendal	60	56	46	21	23	442	17
Lethabo	155	154	3	16		963	
Majuba	53	49	40	19	20	386	15
Matla	48	45	37	17	19	351	13
Tutuka	503	468	386	177	195	3 679	140
<b>Total</b>	<b>1 480</b>	<b>1 387</b>	<b>1 020</b>	<b>483</b>	<b>513</b>	<b>10 650</b>	<b>369</b>

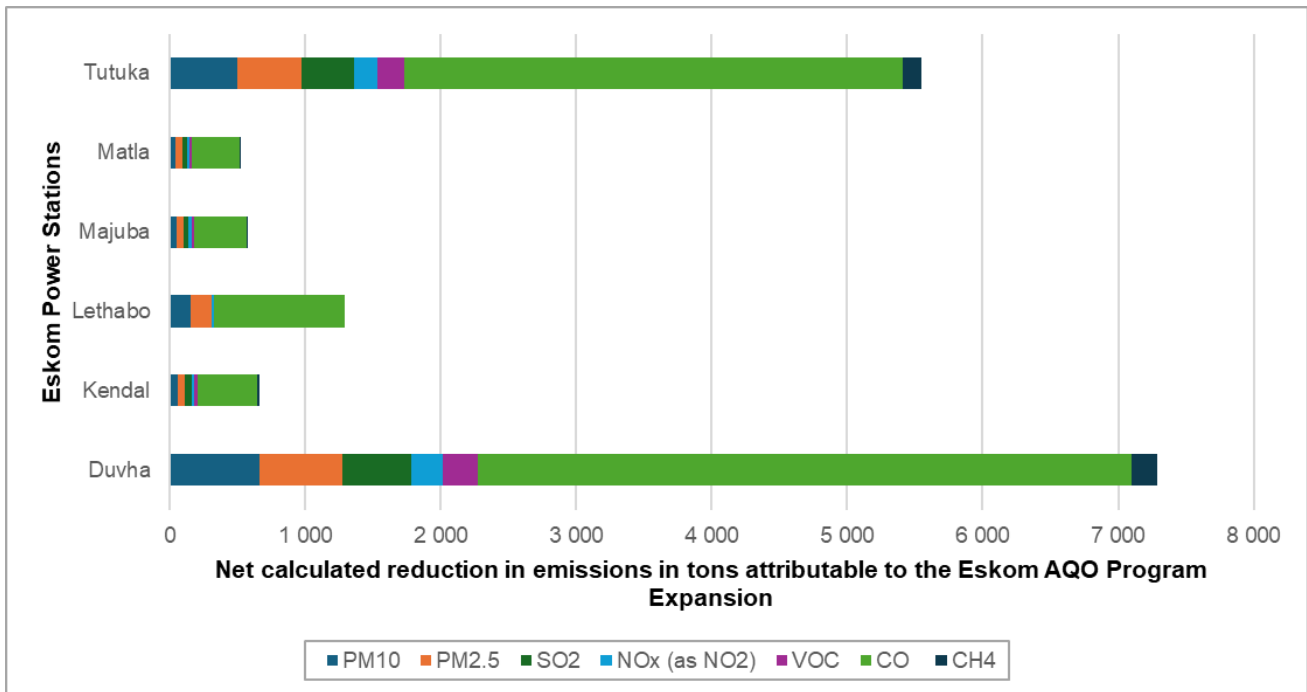


Figure 101: Nett calculated reduction in emissions attributable the expansion of Eskom AQO Program per Power Station

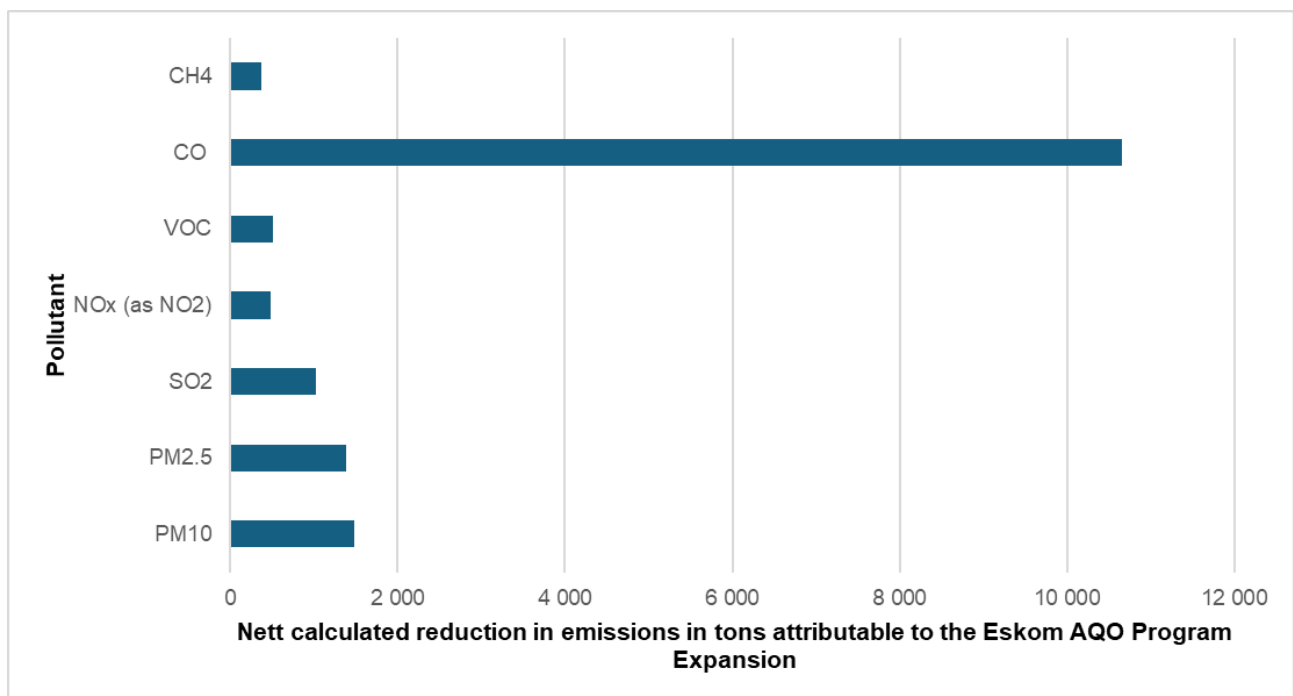


Figure 102: Summary of the nett calculated reduction in emissions attributable the expansion of Eskom AQO Program

### 3.1.3 Prioritisation of offset areas

The Harvard Six Cities cohort study found that fine particulate (PM<sub>2.5</sub>) pose a greater risk to human health because this can penetrate deep into the lungs and is more toxic than larger particles (PM<sub>10</sub>) (Dockery, 1993). Thus, the prioritisation of air quality hotspots for the expansion of Eskom’s AQO program was ranked on the basis of air quality impacts, ie. net emissions avoided for PM<sub>2.5</sub>. This ensures that the areas that potentially pose the greatest risk to human health and the environment are prioritised in the expanded roll-out of Eskom’s AQO program. The results are presented in Table 49 directionally indicates that the the rollout of a household offset intervention at eMalahleni should be priortised first in the expansion of Eskom AQO Program. ARM proposes that Eskom considers, based on the company's financial viability, to implement projects in a phased approach to ensure progressive air quality improvement and effective resource allocation.

**Table 49: Prioritisation of areas for the potential expansion of Eskom AQO Program**

Power Station	Area selected for Offsets	PM <sub>2.5</sub>	Type of Offset	Priority
<b>Duvha</b>	eMalahleni	611,39	Household	1
<b>Tutuka</b>	Sakhile	231,69	Household	2
	Standerton	230,71	Household	3
<b>Matla</b>	Milan Park	41,30	Household	4
<b>Kendal</b>	Rietspruit	39,20	Household	5
<b>Lethabo</b>	Refengkotso	38,70	Waste	6
	Sharpeville	38,70	Waste	7
	Tshepiso	38,70	Waste	8
	Boipatong	38,70	Waste	9
<b>Majuba</b>	Daggakraal/Sinqobile	25,34	Household	10
	Ezamokuhle	23,72	Household	11
<b>Kendal</b>	Phola	17,06	Household	12
<b>Tutuka</b>	Thuthukani	5,74	Household	13
<b>Duvha</b>	Masakhane	3,17	Household	14
<b>Matla</b>	Emzimnoni	2,45	Household	15
	Kananna Ext 6	0,92	Household	16

## 4. Conclusion

Air quality offsets represent a critical path aimed at addressing emission sources within communities residing near Eskom's coal-fired power stations (Matimolane, 2024). Offsets must focus primarily on air pollutants whose ambient air quality standards are being exceeded or likely to be exceeded in the region (DFFE, 2016). ARM proposes that Eskom considers, based on the company's financial viability, to implement offset projects in a phased approach to ensure progressive air quality improvement and effective resource allocation. By rolling out the AQO projects incrementally, Eskom can gather valuable insights, unpack potential blindspots and make informed decisions that align with the sustainability principles and objectives outlined in the National Environmental Management Act (NEMA) 107 of 1998. Eskom's AQO interventions can provide an option for achieving improvements in ambient air quality, and thereby improving human health while promoting a sustainable benefit to the community.

# Annexure 1: Report Disclaimer

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## Annexure 2: Scope of Work

The scope of work, involves supporting Eskom in evaluating options for further expanding the air quality offset (AQO) program in the Highveld and Vaal regions, specifically targeting the Lethabo, Duvha, Matla, Tutuka, Kendal, and Majuba power stations. The original terms of reference (TOR) for Eskom's air quality offset plans outlined a range of communities for potential offset interventions. The current implementation of these plans has prioritized the most critical sites. The consultant will be responsible for reviewing Eskom's original plans to determine whether additional sites remain relevant and to assess the scope and number of interventions required.

### Additional Areas for Review:

1. Identification of Additional Offset Areas: Identify and assess additional offset areas and numbers beyond Eskom's original plans.
2. Estimation of Offset Volume and Impact: Estimate the projected volume of offsets and their potential impact.
3. Risk Assessment: Confirm the scope of additional work required to validate the above, including the associated risks.
4. Review of Eskom Offset Solutions: Evaluate Eskom's current offset strategies, such as the stove swap initiative in the Highveld and waste clean-up in Vaal. Determine if alternative offset solutions could be more effective for large- scale deployment, considering the costs and risks. This will be a desktop review utilizing existing work from Eskom and other sources. The potential deployment of renewable technologies as household offset solutions should also be explored.
5. Assessment of Ambient Air Quality Improvements: Analyze the improvements in household ambient air quality and the reduction in total emissions. Determine if these changes impact compliance with the National Ambient Air Quality Standards (NAAQS) and predict future trends.
6. Relevance of Offset Criteria: Review and confirm the continued relevance of Eskom's criteria for selecting offset areas.
7. Alignment with Draft HPA or Vaal Plans: Assess whether the draft Highveld Priority Area (HPA) or Vaal plans suggest additional areas or actions that should be considered.

8. Validation of Existing Solutions: Reevaluate the household stove swap and waste clean-up initiatives to ensure their continued appropriateness as offset solutions.
9. Exploration of Alternative Solutions: Identify and evaluate other potential offset solutions, including a high-level cost-benefit analysis, to determine which would have the most significant impact. Determine whether general solutions can be recommended, or if detailed community assessments are necessary.
10. Value of Waste Clean-Ups and Solar PV: Assess the effectiveness of waste clean-ups and household solar photovoltaic (PV) installations as offset strategies.
11. Relevance of Phase Plans: Evaluate the continued relevance of Eskom's phased plans (Phase 1, Phase 2a, 2b, and 3). Identify any additional areas that should be included based on existing information, considering ambient air quality, coal use, and potential hazards.
12. Rollout Capacity and Emission Reductions: Estimate the number of households Eskom can reach with its stove swap initiative during Phases 2a, 2b, and 3, and assess the potential reductions in household and ambient emissions. Provide recommendations on prioritizing these efforts.
13. General Recommendations: Provide overarching recommendations for expanding the AQO program.

## **Annexure 3: Digitisation of isopleths**

To digitize the model isopleths from the HPA AQMP, the process started with importing the scanned image into Geographic Information System (GIS) software, wherein it was georeferenced to align the map with real-world coordinates. This involved identifying key control points on the map that corresponded to known locations on a coordinate system. Once georeferencing was complete, the next step was to create vector layers by tracing over the model isopleths by using digitization tools in the GIS software. The final step involved quality control, where the digitized data was checked for accuracy and consistency, and exporting the vector layers into a suitable format for future analysis or integration into other GIS projects. This systematic approach ensured that the digital representation retained the integrity and usability of the original HPA AQMP modelled isopleth.