

5.1.6 Model Performance

5.1.6.1 Understanding of Observed Concentrations

An analysis of the observed NO₂, SO₂, PM₁₀, H₂S, and benzene concentrations at Secunda Club, Embalenhle, Bosjesspruit, and Secunda monitoring stations was completed, in which the concentration values have been categorised into wind speed and direction bins for different concentrations. This information is most easily visualised as polar plots, where the centre of the polar plot refers to the location of the monitoring station, as shown for SO₂ observations in Figure 5-42 (Secunda Club), Figure 5-45 (Embalenhle), Figure 5-49 (Bosjesspruit), and Figure 5-52 (Secunda). The corresponding NO₂ analyses are summarised in Figure 5-43 (Secunda Club), Figure 5-46 (Embalenhle), Figure 5-50 (Bosjesspruit), and Figure 5-53 (Secunda), with PM₁₀ provided in Figure 5-44 (Secunda Club), Figure 5-47 (Embalenhle), and Figure 5-54 (Secunda). Polar plots for benzene (Figure 5-48 - Embalenhle) and H₂S (Figure 5-51 - Bosjesspruit) are also provided.

These polar plots (Carslaw and Ropkins, 2012; Carslaw, 2013) provide an indication of the directional contribution as well as the dependence of concentrations on wind speed. The directional display is fairly obvious, i.e. when higher concentrations are shown to occur in a certain sector, e.g. north-westerly for H₂S at Bosjesspruit (Figure 5-51), it is understood that most of the high concentrations occur when winds blow from that sector. The presence of a high concentration pattern which is more symmetrical around the centre of the plot is an indication that the contributions are near-equally distributed, and occur under calm-wind conditions.

Furthermore, since the observed concentrations have also been categorised according to wind speed categories, it provides an indication of the plume height. As explained in Section 5.1.4.1 (plume buoyancy), stronger winds reduce the amount of plume rise, and may effectively increase ground-level concentrations. However, since an increased wind speed also enhances plume dispersion, a concentration maximum would be reached for a wind speed where the plume rise and dilution effects cancel each other. These conditions would be different for day- and night-time atmospheric stabilities. It is expected that high ground level concentrations from elevated stacks would be more prevalent during stronger wind speeds during stable conditions than daytime, convective conditions, when the plume buoyancy is often not as effective in lifting the plume centreline. Low-level emissions behave differently, and higher concentrations would normally be observed during weak-wind conditions.

The SO₂ concentrations observed at Secunda Club (Figure 5-42) show three distinct wind directions, namely from the south-west (higher concentrations), the north (Secunda town and other more remote emitters) and south-east (remote emitters, possibly power generation). The NO₂ concentrations observed at Secunda Club (Figure 5-43) indicate that most of the high concentrations occur with south-westerly winds of less than 6 m/s. These are most likely due to emissions at SSO. Lower ground-level concentrations observed to originate from the north, may be due to vehicular exhaust emissions in Secunda town and more remote sources of NO₂. The PM₁₀ concentrations observed at Secunda Club (Figure 5-44) are mainly from the western sector where industrial, mining and vehicle activity sources are most likely to contribute to the concentrations. Lower particulate concentrations are associated with winds from the eastern sector.

Median SO₂ concentrations above 70 µg/m³ were observed with winds from the north and east-south-east at Embalenhle (Figure 5-45). The easterly sector is most likely associated with SSO, whilst the northerly sector may also include Sasol, it is also believed that other sources are likely to contribute to these observations. The NO₂ concentrations observed at Embalenhle (Figure 5-46) recorded high concentrations during calm-wind conditions (most-likely localised emitters) with winds from the northerly and easterly directions. The easterly emitters are most likely due to SSO, whereas the northerly observations are due to more remote sources of NO₂. The highest mean PM₁₀ concentrations at Embalenhle were observed with winds from the south-west at all wind speeds (Figure 5-47). The contributing sources of particulate matter would include

vehicle entrainment, domestic fuel burning, industrial and mining activity. The highest observed benzene concentrations at Embalenhle (Figure 5-48) are associated with winds of 10 m/s or greater, from the east of the monitoring station, mostly likely due to emissions from SSO.

The SO₂ concentrations observed at Bosjesspruit (Figure 5-49) indicate that most of the elevated concentrations occur with north-westerly winds of between 5 m/s and 10 m/s and northerly winds of above 8 m/s. High concentrations were also measured with south-easterly winds above 8 m/s. The contribution from the north-westerly sector is most likely associated with SSO, whereas the other two directions are most likely due to other emitters of SO₂. The NO₂ concentrations observed at Bosjesspruit (Figure 5-50) indicate that most of the high concentrations occur with north-westerly winds of between 5 m/s and 10 m/s. Slightly lower concentrations contributions were from the north with winds of about 10 m/s. Concentrations of less than 35 µg/m³ were observed with winds from the south-east. The north-westerly sector is clearly associated with SSO. Whilst the northerly sector may also include SSO, it is also believed that other sources may contribute to these observations, including vehicular exhaust emissions, which can potentially be significant NO₂ emitters. The south-easterly observations are most likely due to emitters of NO₂ other than Sasol. The H₂S concentrations observed at Bosjesspruit (Figure 5-51) indicate that most of the high concentrations occur with north-westerly winds of between 6 m/s and 10 m/s. The concentrations from the north-westerly sector are most likely associated with SSO.

The SO₂ concentrations observed at Secunda (Figure 5-52) indicate that most of the high concentrations occur with north-north-easterly and north-northwesterly winds of between 2 m/s and 8 m/s. Minor contributions at higher wind speeds originate from the south-easterly section. The contribution from the north-north-east is most likely associated with SSO, whereas the other two directions are most likely due to other emitters of SO₂. The NO₂ concentrations observed at Secunda (Figure 5-53) indicate a local source (at low wind speeds) as well as more distant sources (at wind speeds greater than 8 m/s) to the north-west, north-east, and south-east. The local sources, contributing at low wind speeds, could include including vehicular exhaust emissions, which can potentially be significant NO₂ emitters. The highest mean PM₁₀ concentrations at Embalenhle were observed at low wind speeds indicating a local sources, and more distant sources to the south-west, north-west, and north-east at wind speeds greater than 8 m/s (Figure 5-54). The local contributing sources of particulate matter would include vehicle entrainment, domestic fuel burning, while more distant sources (at high wind speeds) could be industrial and mining activity.

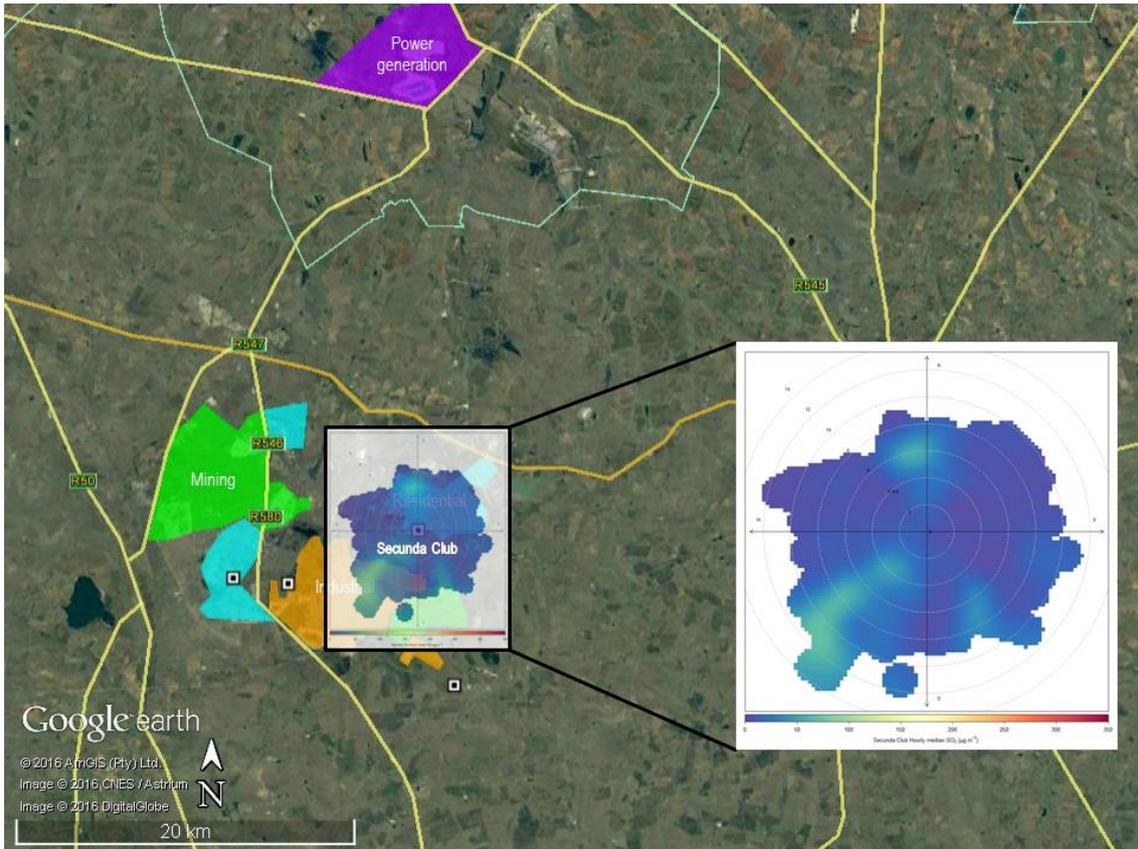


Figure 5-42: Polar plot of hourly median SO₂ concentration observations at Secunda Club for 2013 to 2015

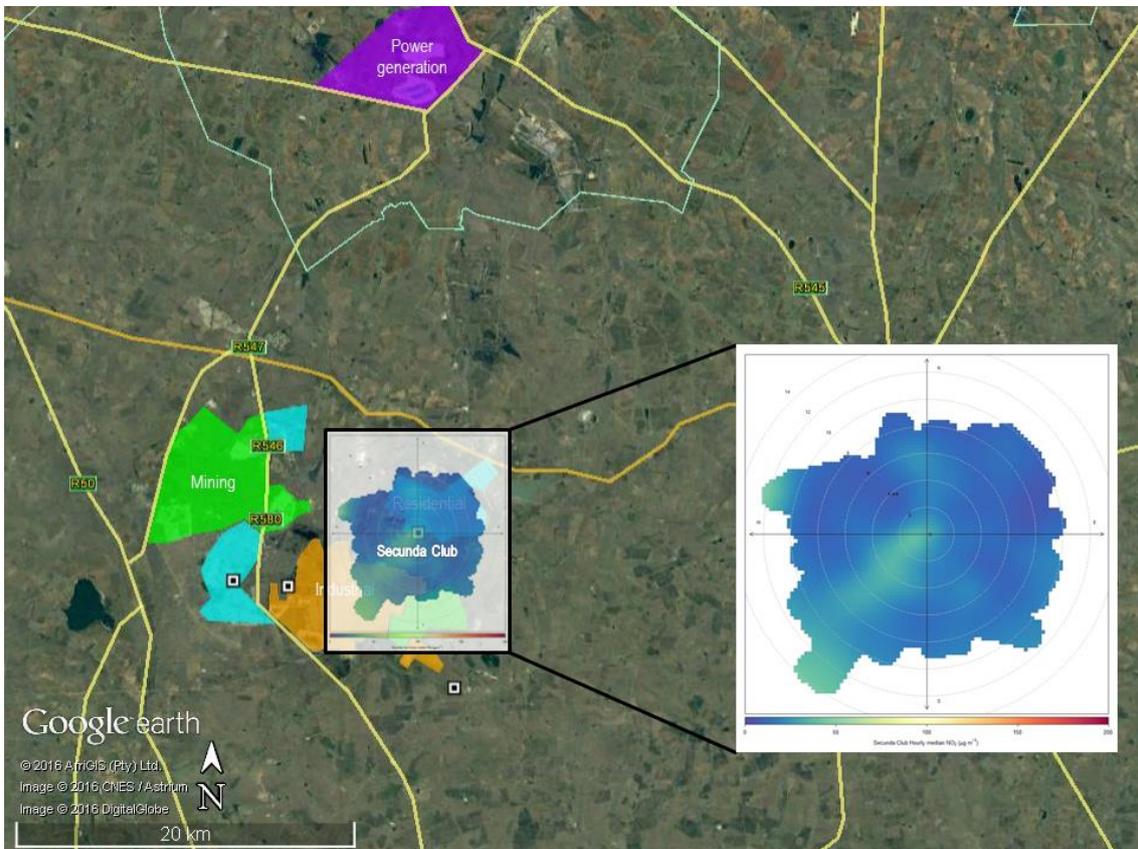


Figure 5-43: Polar plot of hourly median NO₂ concentration observations at Secunda Club for 2013 to 2015

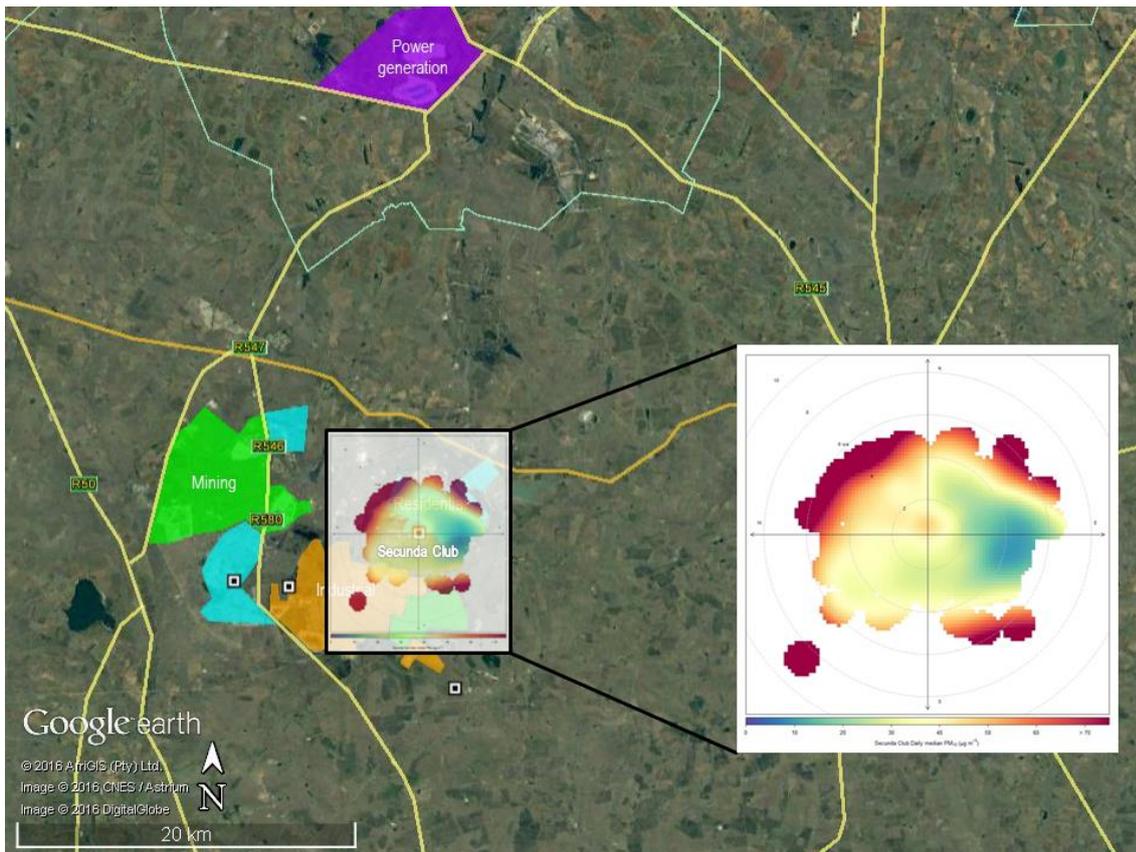


Figure 5-44: Polar plot of median PM_{10} concentration observations at Secunda Club for 2013 to 2015

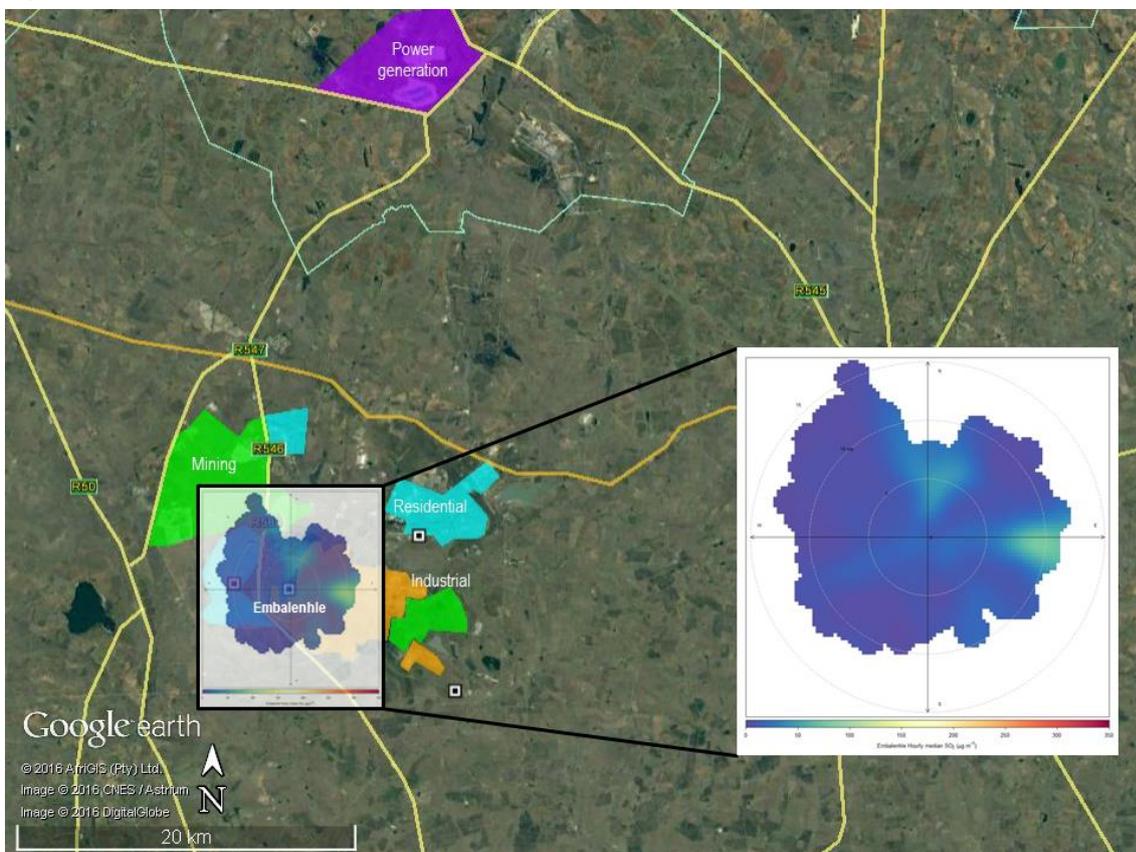


Figure 5-45: Polar plot of hourly median SO_2 concentration observations at Embalenhle for 2013 to 2015

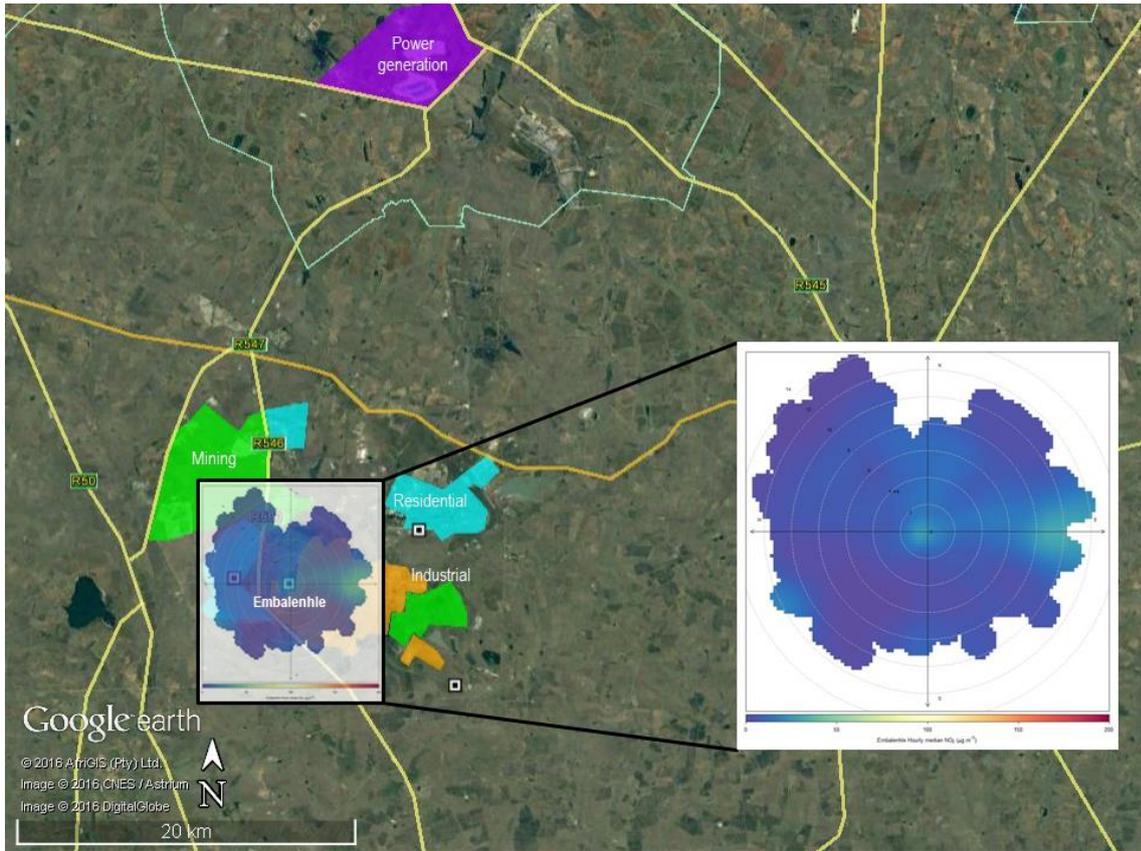


Figure 5-46: Polar plot of hourly median NO₂ concentration observations at Embalenhle for 2013 to 2015

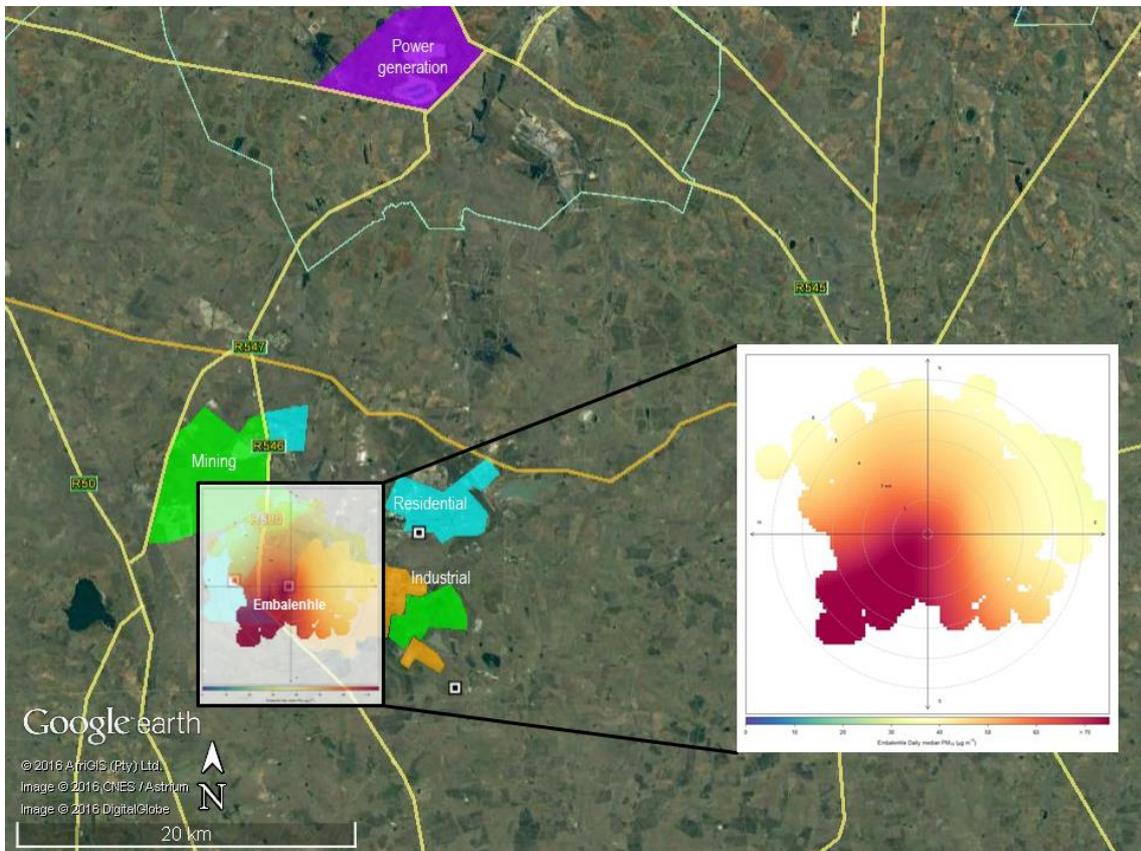


Figure 5-47: Polar plot of hourly median PM₁₀ concentration observations at Embalenhle for 2013 to 2015

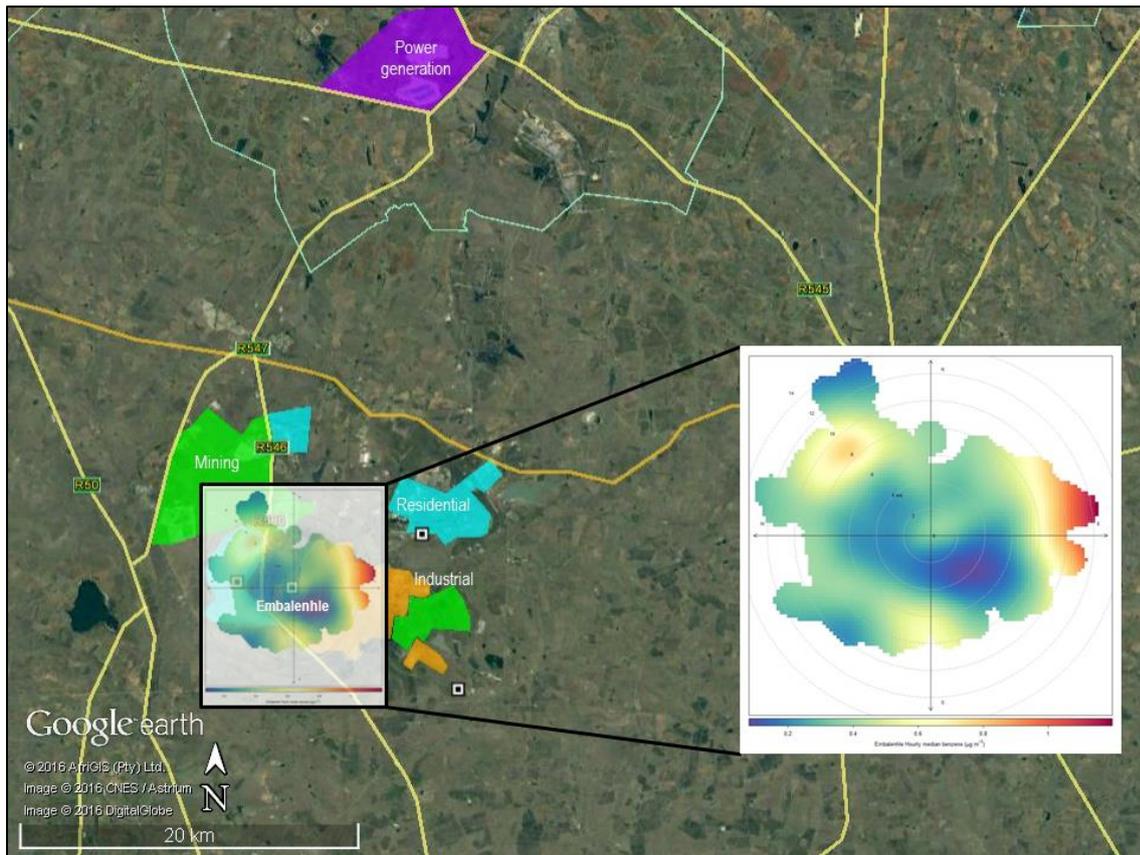


Figure 5-48: Polar plot of hourly median benzene concentration observations at Embalenhle for 2013 to 2015

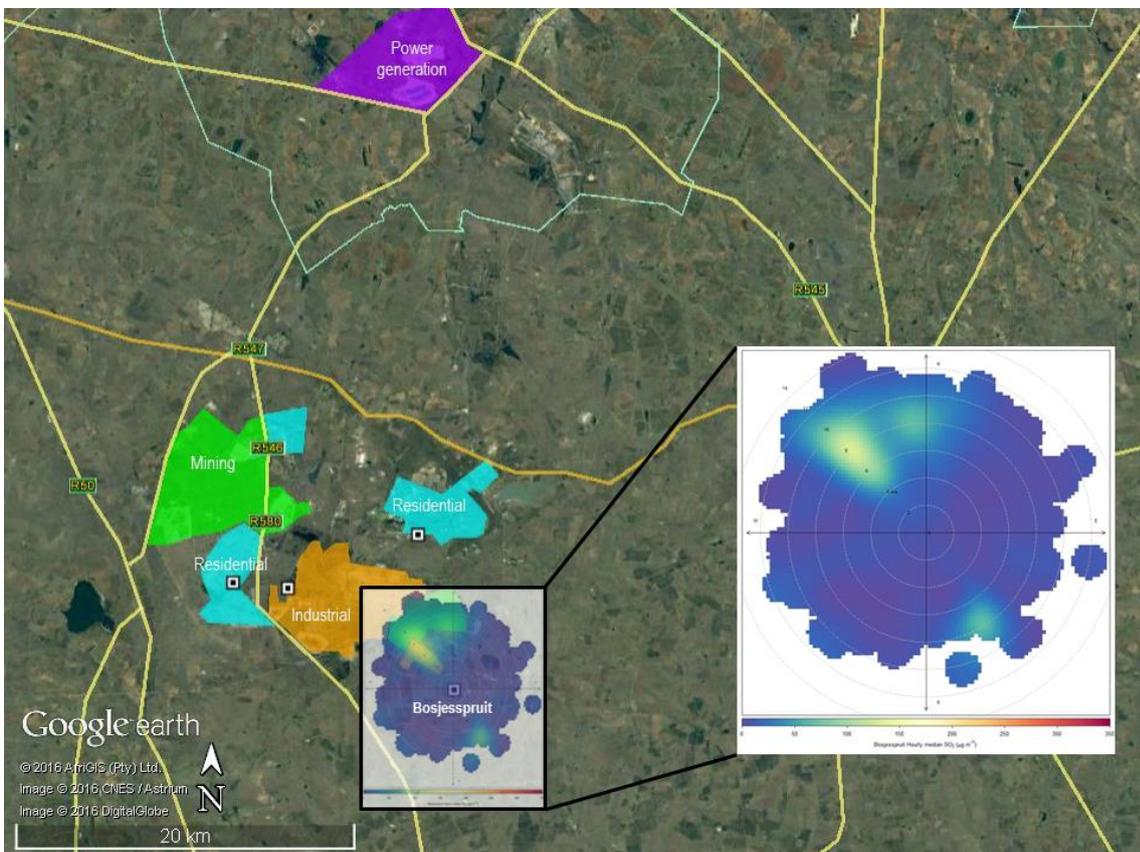


Figure 5-49: Polar plot of hourly median SO₂ concentration observations at Bosjesspruit for 2013 to 2015

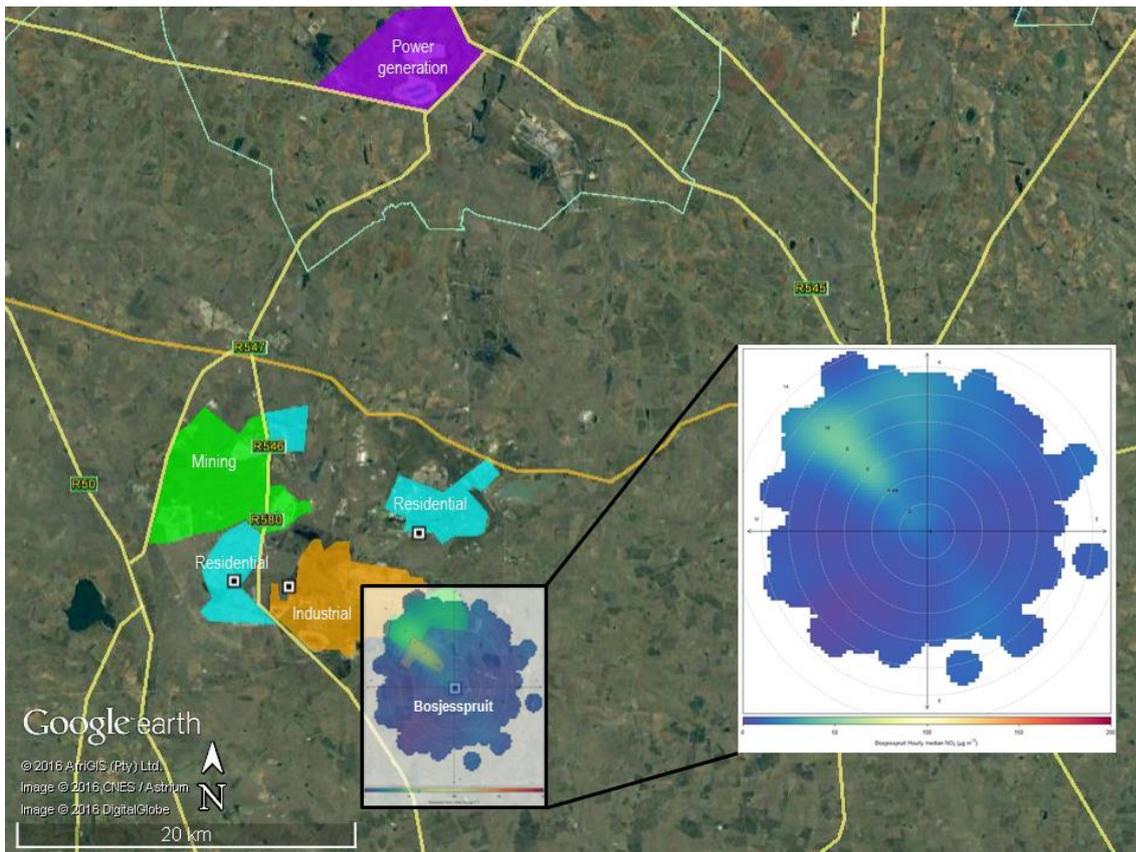


Figure 5-50: Polar plot of hourly median NO₂ concentration observations at Bosjesspruit for 2013 to 2015

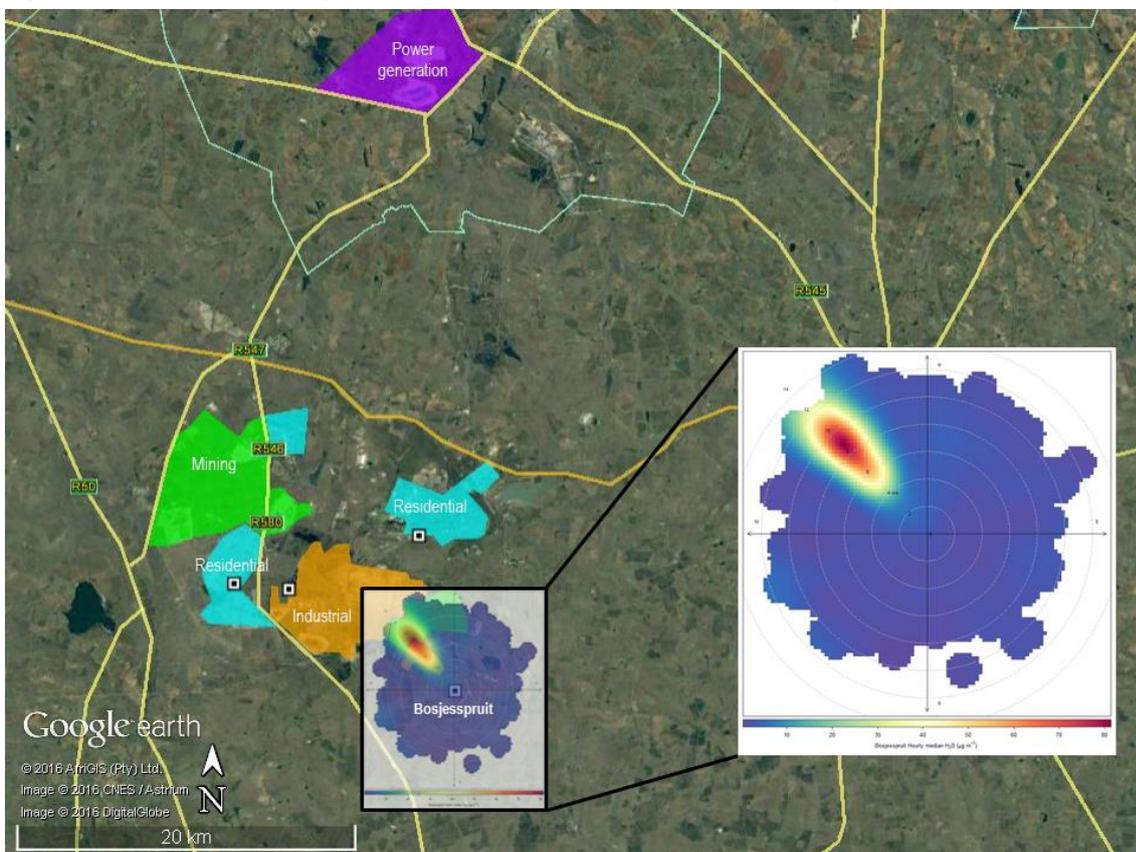


Figure 5-51: Polar plot of hourly median H₂S concentration observations at Bosjesspruit for 2013 to 2015

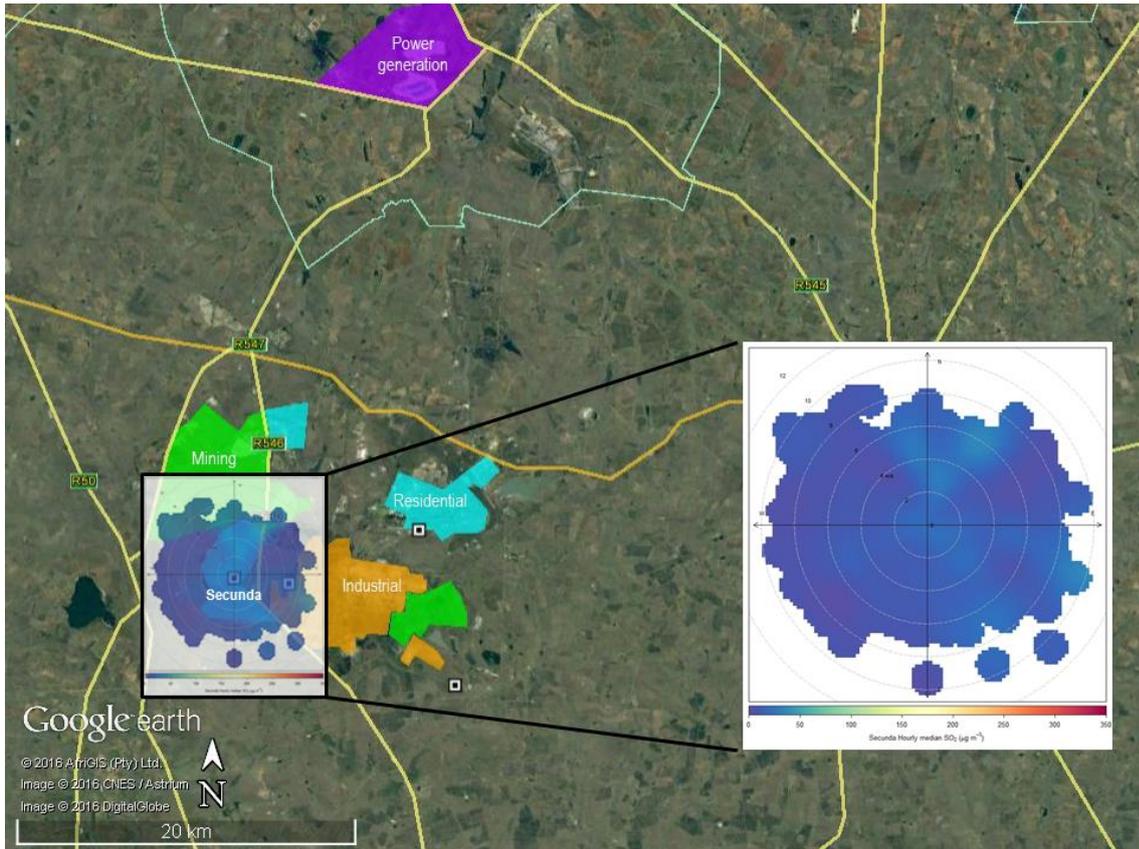


Figure 5-52: Polar plot of hourly median SO₂ concentration observations at Secunda for 2013 to 2015

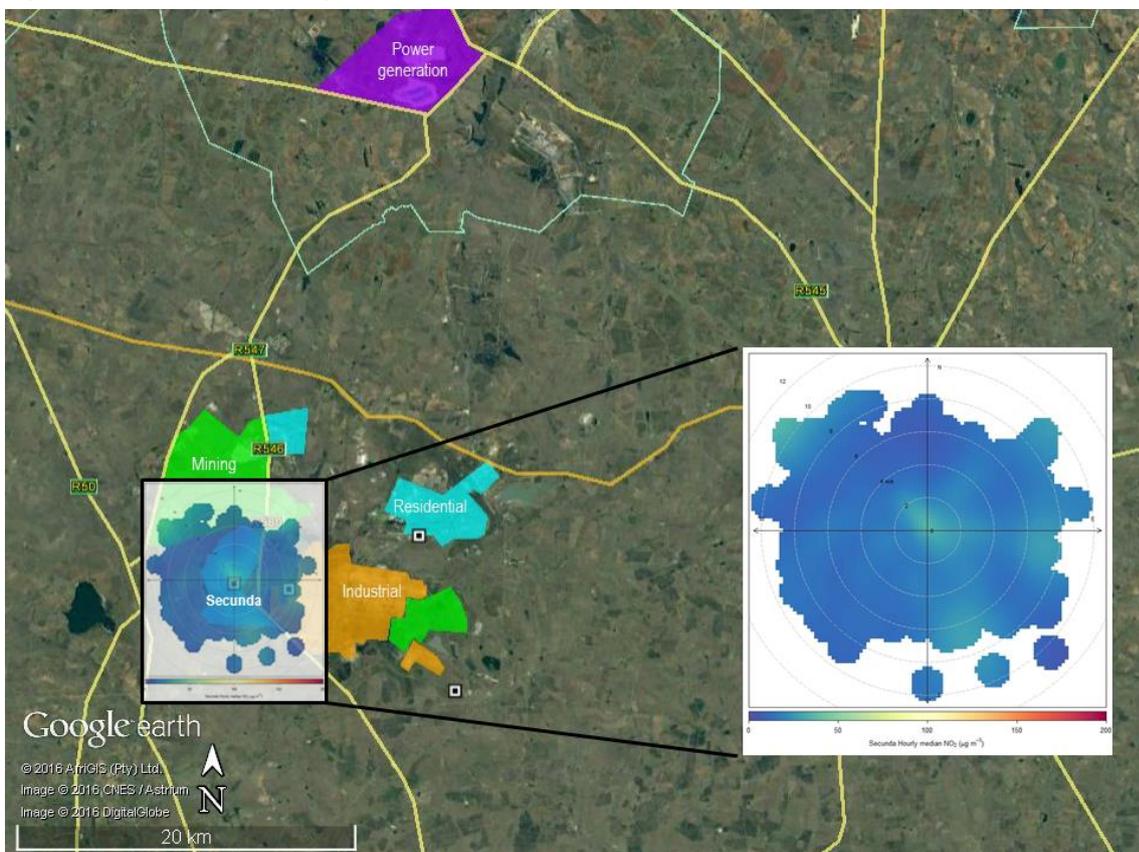


Figure 5-53: Polar plot of hourly median NO₂ concentration observations at Bosjesspruit for 2013 to 2015

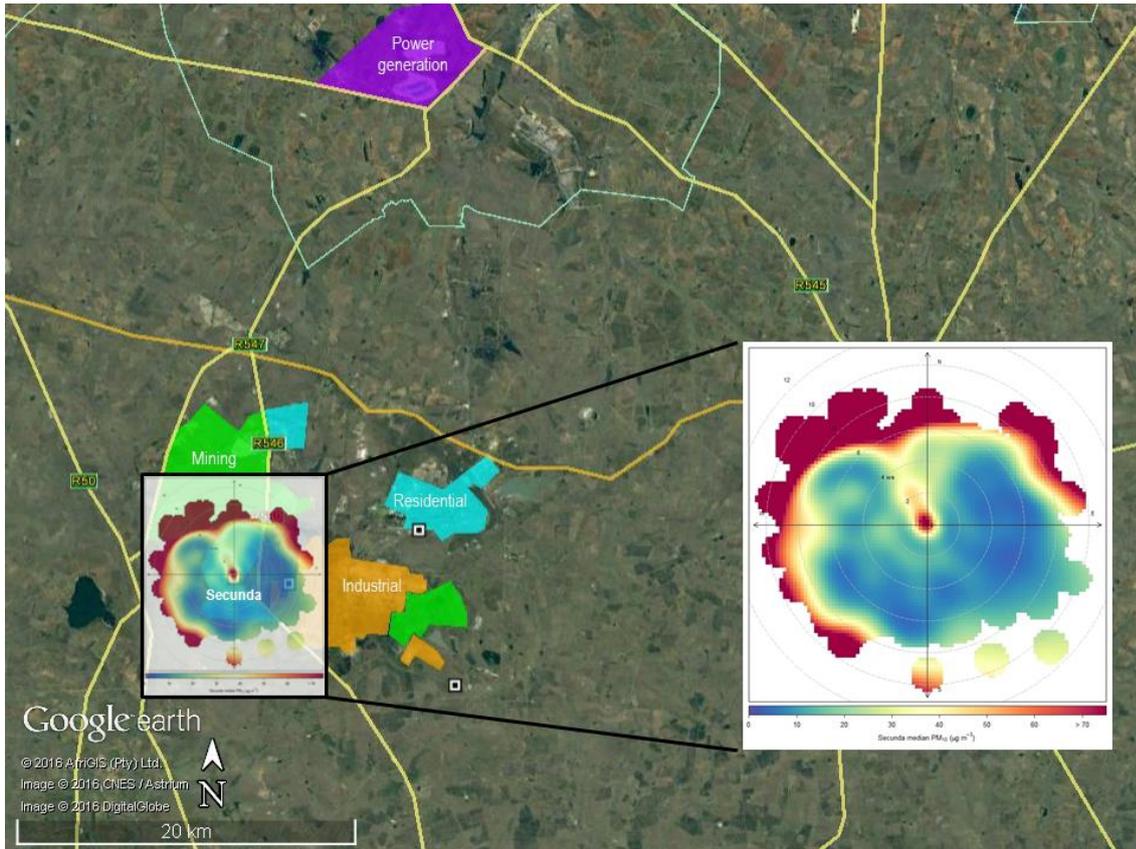


Figure 5-54: Polar plot of hourly median PM₁₀ concentration observations at Secunda for 2013 to 2015

5.1.6.2 Model Validation

Ambient concentrations of NO₂, SO₂, and PM₁₀ measured by Sasol and the DEA in Secunda help provide an understanding of existing ambient air concentrations as well as providing a means of verifying the dispersion modelling. Since the aim of the investigation is to illustrate the change in ground level concentrations from the current levels (i.e. baseline emission scenario) to those levels resulting from the introduction of the required emission limits (i.e. existing and new plant emission standards), the intention was not to comprehensively include all air emissions within Secunda. Unaccounted emissions include those from unintended leaks within the plant (fugitive emissions) and small vents, as well as air emissions from other industries, emissions from activities occurring within the communities, and biomass burning (especially during winter season), as well as long-range transport into the modelling domain. However, information about community activities, such as the amount of traffic within the community and the amount of fuel used for heating is often difficult to estimate.

These emissions, when combined, may potentially add up to be a significant portion of the observed concentrations in the modelling domain. In terms of the current investigation, the portion of air quality due to air emission sources that is not included in the model's emissions inventory constitutes the background concentration.

Discrepancies between predicted and observed concentrations may also be as a result of process emission variations, and may include upset emissions and shutdowns. These conditions could result in significant under-estimating or over-estimating the air concentrations. In order to accommodate these upset emission conditions, a time varying emissions database would be required as input into the model.

A summary of the predicted concentrations and their comparison with observations are given in Appendix G. In order to establish model performance under average emission conditions, it is not uncommon to use a certain percentile of predicted and observed concentrations for comparison. Although these may range from a 90th to 99.9th percentile, it was decided to use the DEA NAAQS for guidance. For criteria pollutants SO₂, NO₂ and PM₁₀, the NAAQS requires compliance with the 99th percentile. As hourly averages, this allows exceedances of the limit value of 88 hours (SO₂ and NO₂) or 4 days (SO₂ and PM₁₀) per year. Estimated short-term (hourly or daily) background concentrations (not associated with the emissions included in the simulations) used the observed concentration value when simulated concentrations from SO indicate very small contributions (0.1 µg/m³).

Table 5-13 to Table 5-15 is a summary of comparisons between simulated and observed SO₂ concentrations at the monitoring stations in the study area. As shown in the tables of the observed peak concentration only 10% at Bosjesspruit and 24% at Secunda could not be accounted for. The difference between simulated and observation increases significantly when considering long-term comparisons (i.e. 50th percentile and annual average), clearly illustrating the contribution of emission sources not included in the dispersion model's emissions inventory.

Table 5-13: Comparison of predicted and observed SO₂ concentrations at Bosjesspruit monitoring station

Description	Bosjesspruit			
	SO ₂ concentration (µg/m ³)			Unaccounted Fraction*
	Simulated	Observed	Unaccounted	
Peak	436.5	485.9	49.4	0.10
99th Percentile	137.8	194.0	56.2	0.29
90th Percentile	7.4	50.4	42.9	0.85
50th Percentile	0.0	6.5	6.5	1.00
Annual Average	6.0	19.4	13.4	0.69

* unaccounted fraction as a percentage of observed concentration

Table 5-14: Comparison of predicted and observed SO₂ concentrations at Secunda Club monitoring station

Description	Secunda Club			
	SO ₂ concentration (µg/m ³)			Unaccounted Fraction*
	Simulated	Observed	Unaccounted	
Peak	685.5	469.2	0.0	-
99th Percentile	136.7	172.5	35.8	0.21
90th Percentile	4.6	49.4	44.8	0.91
50th Percentile	0.0	9.7	9.7	1.00
Annual Average	5.5	20.6	15.1	0.73

* unaccounted fraction as a percentage of observed concentration

Table 5-15: Comparison of predicted and observed SO₂ concentrations at Embalenhle monitoring station

Description	Embalenhle			
	SO ₂ concentration (µg/m ³)			Unaccounted Fraction*
	Simulated	Observed	Unaccounted	
Peak	751.1	462.8	0.0	-
99th Percentile	89.3	170.4	81.1	0.48
90th Percentile	3.0	49.9	46.9	0.94
50th Percentile	0.0	12.6	12.6	1.00
Annual Average	3.6	22.6	19.0	0.84

* unaccounted fraction as a percentage of observed concentration

Table 5-16: Comparison of predicted and observed SO₂ concentrations at Secunda monitoring station

Description	Secunda			
	SO ₂ concentration (µg/m ³)			Unaccounted Fraction*
	Simulated	Observed	Unaccounted	
Peak	367.5	480.6	113.1	0.24
99th Percentile	87.2	161.1	73.9	0.46
90th Percentile	1.6	50.0	48.4	0.97
50th Percentile	0.0	13.2	13.2	1.00
Annual Average	3.0	22.4	19.4	0.87

* unaccounted fraction as a percentage of observed concentration

The performance evaluation was completed using the fractional bias method. Fractional bias is one of the evaluation methods recommended by the U.S. EPA for determining dispersion model performance (U.S. EPA 1992). Fractional bias provides a comparison of the means and standard deviation of both modelled and monitored concentrations for any given number of locations.

In this assessment, the background concentrations were added to the simulated concentrations prior to the calculation of the fractional bias. The 99th percentile (with background concentration) was compared to the same ranked monitored concentrations.

In Figure 5-55, the fractional bias is plotted with the means on the X-axis and the standard deviations on the Y-axis. The box on the plot encloses the area of the graph where the model predictions are within a fractional bias between -0.67 and +0.67; indicating a good correlation). The U.S. EPA states that predictions within a factor of two are a reasonable performance target for a model before it is used for refined regulatory analysis (U.S. EPA 1992). Data points appearing on the left half of the plot indicate an over-prediction and those on the right half of the plot represent under-predictions.

The fractional bias of the means was less than 0.67 at all monitoring sites, clearly showing good model performance (i.e. within a factor of two). The fractional bias of the standard deviation at all monitoring sites was less than 0.67 and is an indication that the model depicted the wide range of SO₂ concentrations at these locations well.

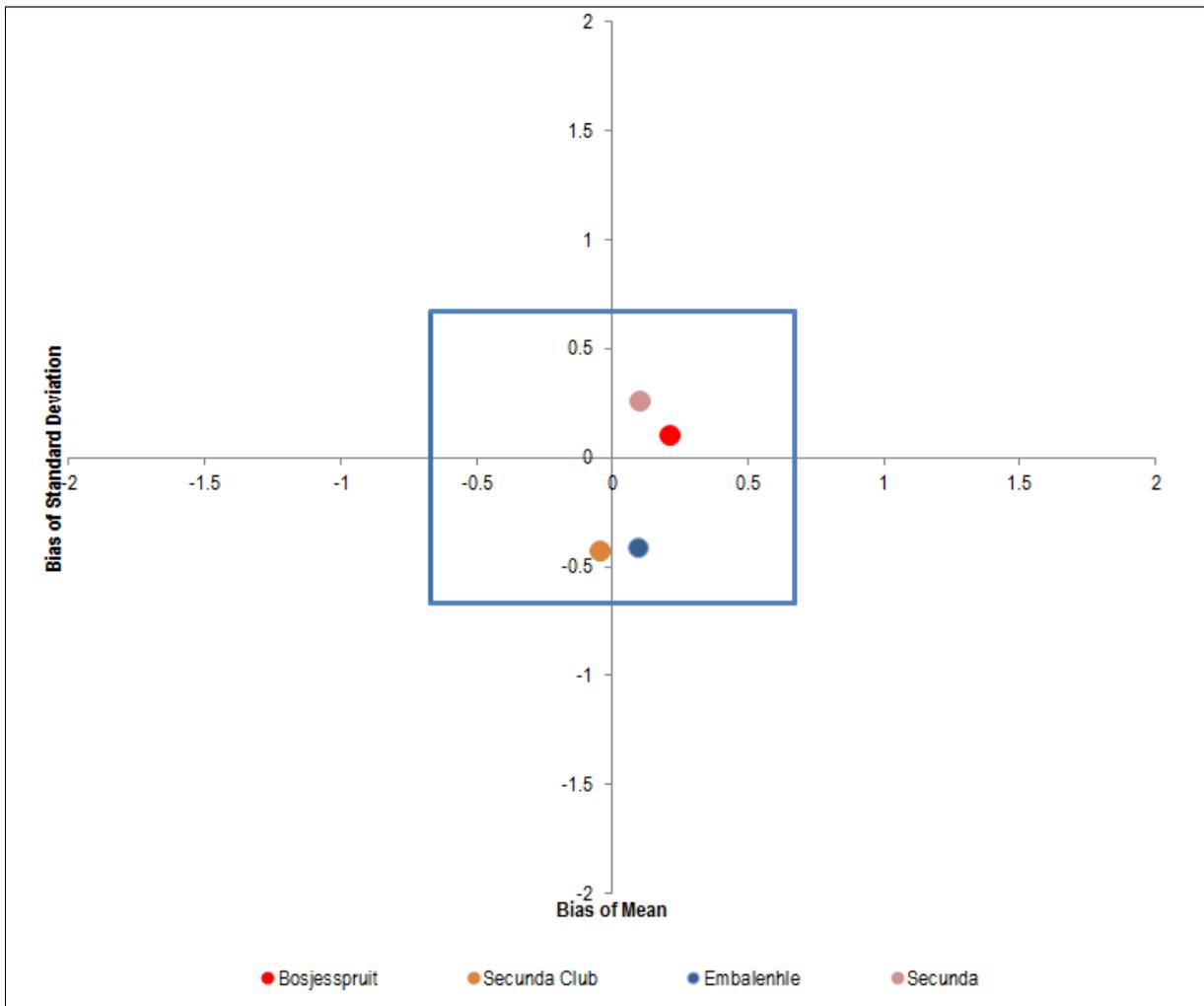


Figure 5-55: Fractional bias of means and standard deviation for SO₂

The same calculations and comparisons were repeated for NO₂ simulations and observations. The CALPUFF simulations were specifically for NO_x and the formation of HNO₃ and other nitrates using the MESOPUFF II chemical transformation mechanism, as discussed in Section 5.1.4.3.

Table 5-17 to Table 5-20 provide summary of comparisons between simulated and observed NO₂ concentrations at the monitoring stations in the study area. As shown in the tables of the observed peak concentration only 14% at Bosjesspruit and 39% at Secunda could not be accounted for.

As for SO₂, the difference between simulated and observation increases significantly when considering long-term comparisons (i.e. 50th percentile and annual average), clearly illustrating the contribution of emission sources not included in the dispersion model's emissions inventory.

Table 5-17: Comparison of predicted and observed NO₂ concentrations at Bosjesspruit monitoring station

Description	Bosjesspruit			
	NO ₂ concentration (µg/m ³)			Unaccounted Fraction*
	Simulated	Observed	Unaccounted	
Peak	127.0	147.3	20.3	0.14
99th Percentile	55.9	68.1	12.1	0.18
90th Percentile	8.6	33.0	24.3	0.74
50th Percentile	0.0	9.2	9.2	1.00
Annual Average	3.6	14.0	10.4	0.74

* unaccounted fraction as a percentage of observed concentration

Table 5-18: Comparison of predicted and observed NO₂ concentrations at Secunda Club monitoring station

Description	Secunda Club			
	NO ₂ concentration (µg/m ³)			Unaccounted Fraction*
	Simulated	Observed	Unaccounted	
Peak	202.8	191.7	0.0	-
99th Percentile	55.6	90.4	34.9	0.39
90th Percentile	4.8	47.8	43.0	0.90
50th Percentile	0.0	18.6	18.6	1.00
Annual Average	2.9	24.0	21.1	0.88

* unaccounted fraction as a percentage of observed concentration

Table 5-19: Comparison of predicted and observed NO₂ concentrations at Embalenhle monitoring

Description	Embalenhle			
	NO ₂ concentration (µg/m ³)			Unaccounted Fraction*
	Simulated	Observed	Unaccounted	
Peak	218.0	150.2	0.0	-
99th Percentile	48.2	78.1	29.8	0.38
90th Percentile	7.6	40.8	33.2	0.81
50th Percentile	0.0	11.6	11.6	1.00
Annual Average	2.6	16.9	14.3	0.85

* unaccounted fraction as a percentage of observed concentration

Table 5-20: Comparison of predicted and observed NO₂ concentrations at Secunda monitoring station

Description	Secunda			
	NO ₂ concentration (µg/m ³)			Unaccounted Fraction*
	Simulated	Observed	Unaccounted	
Peak	107.3	176.0	68.7	0.39
99th Percentile	46.4	100.2	53.8	0.54
90th Percentile	2.5	56.3	53.8	0.96
50th Percentile	0.0	23.7	23.7	1.00
Annual Average	1.8	28.5	26.8	0.94

* unaccounted fraction as a percentage of observed concentration

Fractional biases (i.e. using the 99th percentile simulated concentrations and the estimated background concentration) were calculated for the monitoring stations within the study area. The results are summarised in Figure 5-56. The fractional bias of the means was less than 0.67 at all monitoring sites, clearly showing good model performance. The fractional bias of the

standard deviation at all monitoring sites (with the exception of Secunda) was less than 0.67 and is an indication that the model depicted the wide range of SO₂ concentrations at these locations well. The bias of standard deviation (the range of NO₂ concentrations displayed on the x-axis) at Secunda was 0.82, within the acceptable model performance range (factor of two).

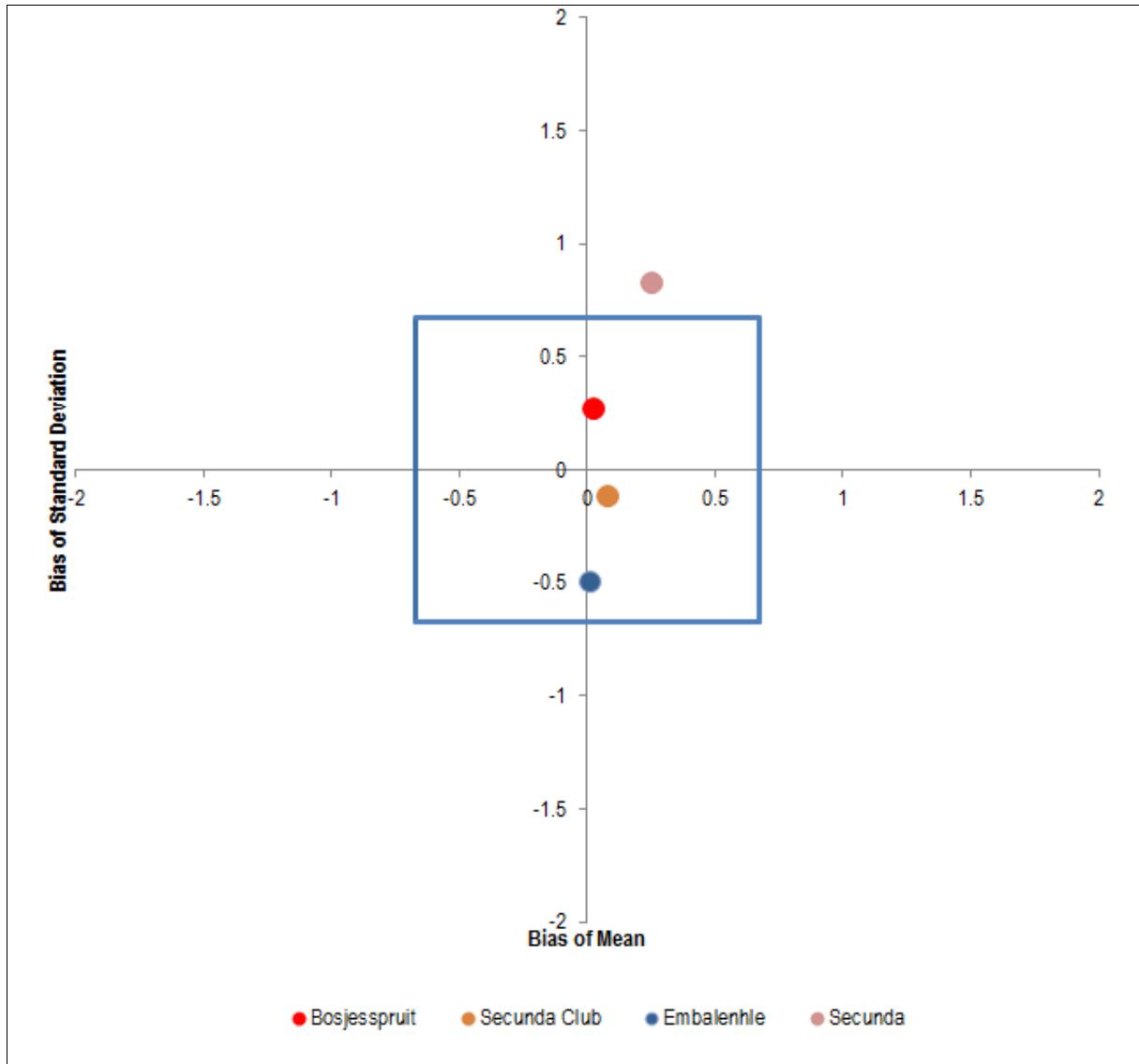


Figure 5-56: Fractional bias of means and standard deviation for NO₂

5.1.7 Scenario Emission Inventory

Dispersion modelling included all point sources in all scenarios (Table 4-1, Table 4-2, Table 4-3, and Table 4-5); however 10 sources had emission rates which varied between the four scenarios assessed. The baseline (i.e. unvarying) sources were modelled as per parameters and emission rates provided in Table 4-1, Table 4-2, Table 4-3, and Table 4-5. The emission parameters of sources for which postponement is applied were unchanged from the baseline (Table 4-1). Emissions per scenario were provided by SSO for the assessment and are given in and Table 5-21.

Table 5-21: Varying source emissions per dispersion modelling scenario provided for SSO (units: g/s)

Source name	SO ₂	NO _x as NO ₂	PM	CO	HCl	HF	TOC	NH ₃	Dioxins & Furans	Sum of Metals	Hg	Cd & Tl	VOCs	Benzene
Baseline														
WA1 (052WK-2102)	0.23	0.97	0.51	12.50	2.08E-02	1.59E-02	1.81E+00	7.12E-02	3.11E-10	7.62E-03	1.70E-03	4.41E-05		
WA2 (052WK-2202)	0.16	2.30	0.93	12.40	3.96E-02	9.13E-03	8.14E+00	4.07E-02	7.70E-10	2.88E-03	2.71E-03	3.58E-05		
WA3 (252WK-2102)	0.42	2.64	1.24	15.60	5.91E-01	3.39E-02	9.61E+00	8.07E-02	1.12E-10	4.14E-03	9.49E-04	5.32E-05		
WA4 (252WK-2202)	0.08	1.60	1.04	8.29	6.23E-02	2.78E-02	2.24E+00	7.09E-02	6.49E-11	3.64E-03	1.21E-03	3.56E-05		
HOW1 (052CI-101)	1.58	11.61	2.22	0.19	1.27E-01	2.90E-02	1.27E-01	1.94E-02	3.18E-09	5.10E-02	2.78E-04	1.03E-04		
HOW1 (252CI-101)	0.53	10.94	3.06	1.32	8.49E-02	2.64E-02	1.20E-01	1.55E-02	9.31E-09	1.27E-02	7.76E-05	4.82E-05		
016VL101 (Phenosolvan Saturation Column)													0.42	0.21
016VL401 (Phenosolvan Saturation Column)													0.42	0.21
216VL101 (Phenosolvan Saturation Column)													0.42	0.21
216VL401 (Phenosolvan Saturation Column)													0.42	0.21
At Existing Plant Emission Standards														
WA1 (052WK-2102)														
WA2 (052WK-2202)	0.27	1.09	0.14	0.41	5.46E-02	5.46E-03	5.46E-02	5.46E-02	5.46E-10	2.73E-03	2.73E-04	2.73E-04		
WA3 (252WK-2102)	0.27	1.09	0.14	0.41	5.46E-02	5.46E-03	5.46E-02	5.46E-02	5.46E-10	2.73E-03	2.73E-04	2.73E-04		
WA4 (252WK-2202)	0.27	1.09	0.14	0.41	5.46E-02	5.46E-03	5.46E-02	5.46E-02	5.46E-10	2.73E-03	2.73E-04	2.73E-04		
HOW1 (052CI-101)	0.27	1.09	0.14	0.41	5.46E-02	5.46E-03	5.46E-02	5.46E-02	5.46E-10	2.73E-03	2.73E-04	2.73E-04		
HOW1 (252CI-101)	0.26	1.03	0.13	0.38	5.13E-02	5.13E-03	5.13E-02	5.13E-02	5.13E-10	2.57E-03	2.57E-04	2.57E-04		
016VL101 (Phenosolvan Saturation Column)													3.00E-03	1.50E-03
016VL401 (Phenosolvan Saturation Column)													3.00E-03	1.50E-03
216VL101 (Phenosolvan Saturation Column)													3.00E-03	1.50E-03
216VL401 (Phenosolvan Saturation Column)													3.00E-03	1.50E-03
At New Plant Emission Standards														
WA1 (052WK-2102)	0.27	1.09	0.05	0.27	5.46E-02	5.46E-03	5.46E-02	5.46E-02	5.46E-10	2.73E-03	2.73E-04	2.73E-04		
WA2 (052WK-2202)	0.27	1.09	0.05	0.27	5.46E-02	5.46E-03	5.46E-02	5.46E-02	5.46E-10	2.73E-03	2.73E-04	2.73E-04		
WA3 (252WK-2102)	0.27	1.09	0.05	0.27	5.46E-02	5.46E-03	5.46E-02	5.46E-02	5.46E-10	2.73E-03	2.73E-04	2.73E-04		
WA4 (252WK-2202)	0.27	1.09	0.05	0.27	5.46E-02	5.46E-03	5.46E-02	5.46E-02	5.46E-10	2.73E-03	2.73E-04	2.73E-04		
HOW1 (052CI-101)	0.26	1.03	0.05	0.26	5.13E-02	5.13E-03	5.13E-02	5.13E-02	5.13E-10	2.57E-03	2.57E-04	2.57E-04		
HOW1 (252CI-101)	0.26	1.03	0.05	0.26	5.13E-02	5.13E-03	5.13E-02	5.13E-02	5.13E-10	2.57E-03	2.57E-04	2.57E-04		
016VL101 (Phenosolvan Saturation Column)													1.50E-03	7.50E-04
016VL401 (Phenosolvan Saturation Column)													1.50E-03	7.50E-04

Source name	SO ₂	NO _x as NO ₂	PM	CO	HCl	HF	TOC	NH ₃	Dioxins & Furans	Sum of Metals	Hg	Cd & Tl	VOCs	Benzene
216VL101 (Phenosolvan Saturation Column)													1.50E-03	7.50E-04
216VL401 (Phenosolvan Saturation Column)													1.50E-03	7.50E-04
At Alternative Emissions														
WA1 (052WK-2102)	1.12	3.90	3.28	24.16	1.58E-01	1.09E-01	23.03	2.84E-01	1.69E-09	1.42E-02	5.19E-03	6.56E-04		
WA2 (052WK-2202)	1.12	3.90	3.28	24.16	1.58E-01	1.09E-01	23.03	2.84E-01	1.69E-09	1.42E-02	5.19E-03	6.56E-04		
WA3 (252WK-2102)	1.12	3.90	3.28	24.16	1.58E-01	1.09E-01	23.03	2.84E-01	1.69E-09	1.42E-02	5.19E-03	6.56E-04		
WA4 (252WK-2202)	1.12	3.90	3.28	24.16	1.58E-01	1.09E-01	23.03	2.84E-01	1.69E-09	1.42E-02	5.19E-03	6.56E-04		
HOW1 (052CI-101)	2.80	19.49	6.95	7.18	2.82E-01	5.13E-02	0.19	6.16E-02	2.15E-08	1.08E-01	1.39E-03	6.16E-04		
HOW1 (252CI-101)	2.80	19.49	6.95	7.18	2.82E-01	5.13E-02	0.19	6.16E-02	2.15E-08	1.08E-01	1.39E-03	6.16E-04		
016VL101 (Phenosolvan Saturation Column)													0.690	0.345
016VL401 (Phenosolvan Saturation Column)													0.690	0.345
216VL101 (Phenosolvan Saturation Column)													0.690	0.345
216VL401 (Phenosolvan Saturation Column)													0.690	0.345

5.1.8 Model Results

Air quality standards are fundamental tools to assist in air quality management. The NAAQS (Section 5.1.2.2) are intended to reduce harmful effects on health of the majority of the population, including the very young and the elderly. In this section, predicted ambient concentrations of criteria pollutants at specific sensitive receptors are compared against the promulgated local NAAQS (Table 5-2).

Prior to dispersion modelling, 53 receptors were identified in the vicinity of SSO (within the 50-by-50 km modelling domain). Sensitive receptors included residential areas, schools, hospitals and clinics, monitoring stations (Figure 5-57 and Table 5-22). Ambient air quality monitoring stations (AQMS) were the first receptors identified because comparison of the predicted concentrations could be compared with measured concentrations for model validation. Schools, hospitals and clinics within the domain were identified and included as sensitive receptors in the dispersion model (full list provided in Appendix K). All receptors are presented in the isopleth plots, where the AQMS are included in results figures and the 20 closest receptors are included in the results tables at increasing distance from the centre of SSO.

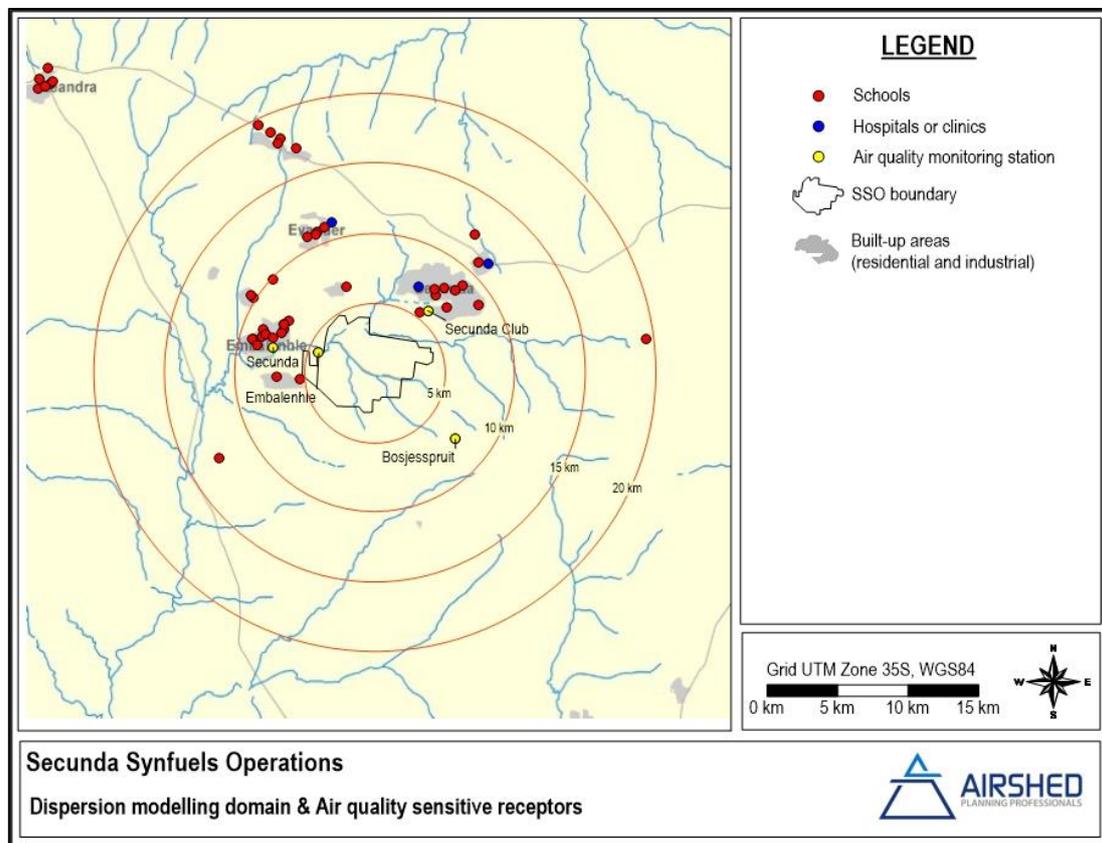


Figure 5-57: Sensitive receptors identified for assessment of impact as a result of SSO

Table 5-22: Receptors identified for assessment of impact as a result of SSO emissions

Receptor code name ^(a)	Receptor details	Distance from centre of operations (km) ^(b)
Embalenhle	Sasol Embalenhle Monitoring Station (previously Langverwacht)	3.3
Secunda Club	Sasol Secunda Club Monitoring Station	6.3
Secunda	DEA Secunda Monitoring Station	6.0
Bosjesspruit	Sasol Bosjesspruit Monitoring Station	8.3
42	Roodebank Combined School	4.5
60	Zamokuthle Primary School	5.8
46	Osizweni Secondary School	6.1
55	Isibanisesizwe Primary School	6.3
41	Maphala-Gulube Primary School	6.3
56	Kiriyatswane Secondary School	6.3
48	Osizweni Primary School	6.4
57	Kusasaletu Secondary School	6.5
58	Laerskool Oranjegloed	6.7
62	Highveld Medi Clinic/Hydromed	7.2
53	Tholukwazi Primary School	7.3
30	TP Stratten Primary School	7.3
59	School	7.5
33	Laerskool Goedehoop	7.5
38	Laerskool Kruinpark	7.5
52	Lifaletu Primary School	7.6
61	Secunda Medi Clinic	7.7
50	Embalenhle Primary School	7.8
51	Buyani Primary School	8.0
54	Allan Makhunga Primary School	8.1

Since the focus of the study is to illustrate the relative changes in ambient concentrations of pollutants theoretically arising from different point source emission scenarios, the predicted concentration differences from scenario to scenario were provided as percentage increase or decrease over the modelled baseline scenario ($C_{Baseline\ Scenario}$).

$$\frac{C_{S, Future\ Scenario} - C_{S, Baseline\ Scenario}}{C_{Baseline\ Scenario}}$$

Equation 1

It should be noted that the changes in ground-level concentrations, at the receptors, between the scenarios shown in the results: (1) are theoretical changes and may not necessarily be technically possible, and; (2) represent the maximum achievable improvements and are, therefore, not indicative of the day-to-day average reduction at every receptor point cumulatively.

5.1.8.1 Criteria Pollutants

The findings for each of the criteria pollutants (SO₂, NO₂ and PM) are presented for the SSO in three forms. The first figure presents the predicted pollutant concentration (99th percentile) at the AQMS (Table 5-22) for each of the emission scenarios (baseline operating conditions, emissions in theoretical compliance with Existing Plant Standards [2015], and with New Plant Standards [2020]; and the Alternative Emission) relative to the appropriate NAAQS. A table then presents the percentage change in ground-level concentrations between the emission scenarios and the baseline at the AQMS and 20 closest sensitive receptors (Table 5-22). Finally, isopleth plots have been included for the all relevant emission scenarios and pollutants.

5.1.8.1.1 Sulfur Dioxide (SO₂)

Simulated SO₂ concentrations as a result of SSO baseline operations are below the NAAQS at the AQMS (Figure 5-58 to Figure 5-60) and receptors (Table 5-23 to Table 5-25). Changes in ambient SO₂ concentrations between scenarios are minor, with a maximum change of 5.3% (Table 5-23 to Table 5-25). This is due to the relatively small contribution of the thermal oxidation units to the overall SO₂ emissions from the SSO facility.

Isopleth plots are presented for all averaging period ground-level SO₂ concentrations as a result of all emission scenarios for SSO, as per the figure numbers below:

Scenario	Hourly	Daily	Annual
Baseline concentrations	Figure 5-61	Figure 5-65	Figure 5-69
Existing Plant standards	Figure 5-62	Figure 5-66	Figure 5-70
New Plant standards	Figure 5-63	Figure 5-67	Figure 5-71
Alternative emissions	Figure 5-64	Figure 5-68	Figure 5-72

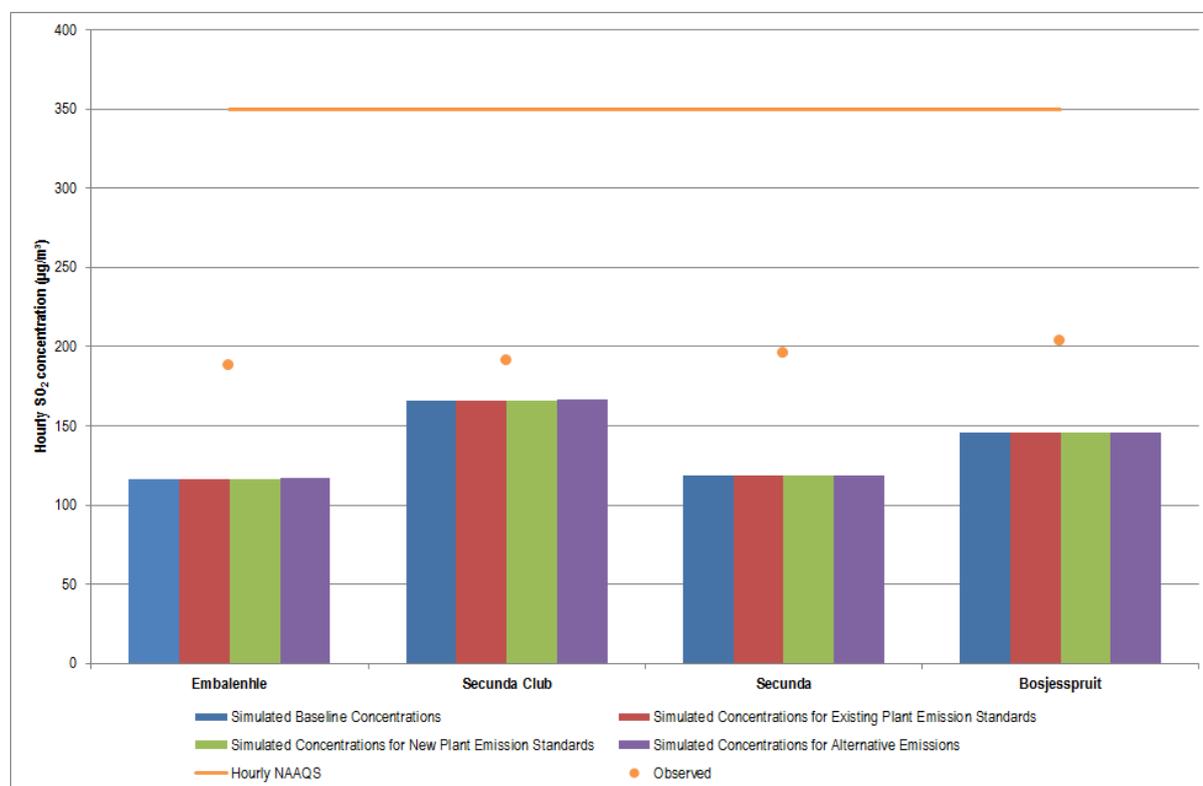


Figure 5-58: Simulated hourly SO₂ concentrations (99th percentile) at AQMS for SSO

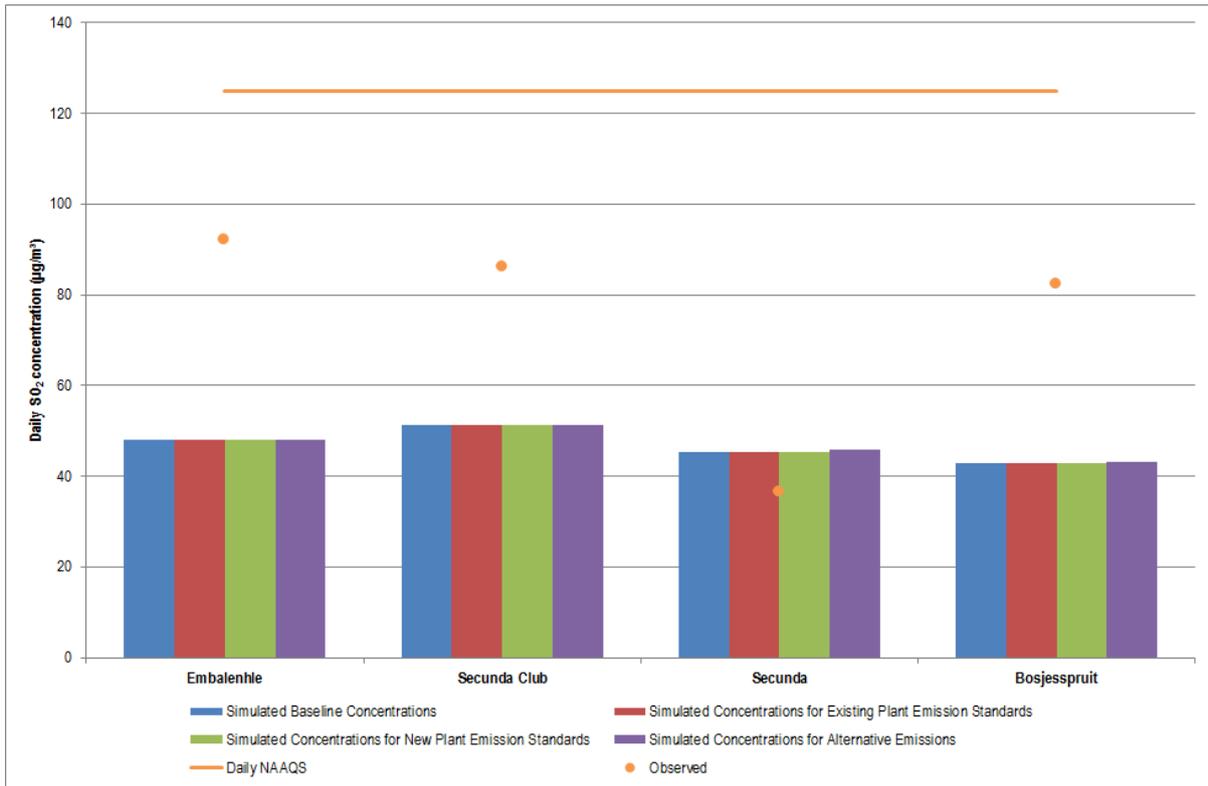


Figure 5-59: Simulated daily SO₂ concentrations (99th percentile) at AQMS for SSO

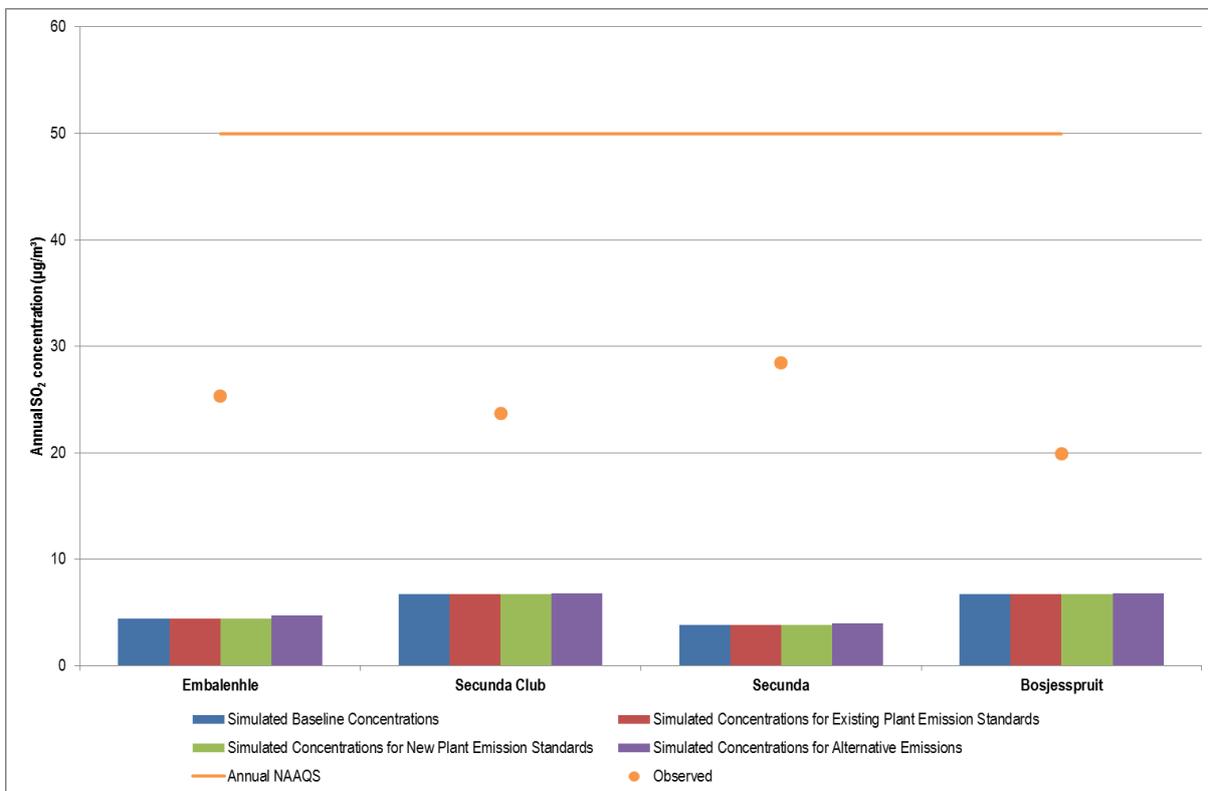


Figure 5-60: Simulated annual SO₂ concentrations at AQMS for SSO

Table 5-23: Simulated baseline hourly SO₂ concentrations and the theoretical change in concentrations relative to the baseline at the AQMS and 20 closest receptors

Receptor	Hourly SO ₂						
	Baseline	Existing		New		Alternative	
	Concentration (µg/m ³)	Concentration (µg/m ³)	Relative change	Concentration (µg/m ³)	Relative change	Concentration (µg/m ³)	Relative change
Embalenhle AQMS	141.1	141.1	0.0%	141.1	0.0%	141.1	0.1%
Secunda Club AQMS	141.1	141.1	0.0%	141.1	0.0%	141.1	0.1%
Secunda AQMS	92.2	92.2	-0.1%	92.2	-0.1%	92.5	0.3%
Bosjesspruit AQMS	137.0	137.0	0.0%	137.0	0.0%	137.3	0.2%
Roodebank Combined School	55.6	55.6	-0.1%	55.6	-0.1%	55.7	0.2%
Zamokuthle Primary School	87.1	87.0	-0.1%	87.0	-0.1%	87.2	0.2%
Osizweni Secondary School	65.3	65.2	-0.1%	65.2	-0.1%	65.6	0.5%
Isibanisesizwe Primary School	80.4	80.3	-0.1%	80.3	-0.1%	80.7	0.4%
Maphala-Gulube Primary School	102.0	102.0	0.0%	102.0	0.0%	102.0	0.0%
Kiriyatswane Secondary School	77.5	77.4	-0.1%	77.4	-0.1%	77.6	0.1%
Osizweni Primary School	64.7	64.7	0.0%	64.7	0.0%	64.8	0.0%
Kusasaletu Secondary School	84.3	84.2	-0.1%	84.2	-0.1%	84.7	0.5%
Laerskool Oranjegloed	144.4	144.3	0.0%	144.3	0.0%	144.5	0.1%
Highveld Medi Clinic/Hydromed	103.9	103.9	0.0%	103.9	0.0%	104.0	0.1%
Tholukwazi Primary School	80.6	80.6	0.0%	80.6	0.0%	80.8	0.2%
TP Stratten Primary School	57.1	57.1	0.0%	57.1	0.0%	57.2	0.2%
School	135.1	135.1	0.0%	135.1	0.0%	135.5	0.3%
Laerskool Goedehoop	122.4	122.3	0.0%	122.3	0.0%	122.5	0.1%
Laerskool Kruinpark	149.9	149.9	0.0%	149.9	0.0%	150.1	0.1%
Lifaletu Primary School	83.8	83.8	0.0%	83.8	0.0%	83.9	0.1%
Secunda Medi Clinic	117.1	117.1	0.0%	117.1	0.0%	117.1	0.0%
Embalenhle Primary School	80.6	80.6	0.0%	80.6	0.0%	80.8	0.2%
Buyani Primary School	78.8	78.7	-0.1%	78.7	-0.1%	79.0	0.3%
Allan Makhunga Primary School	80.0	79.9	0.0%	79.9	0.0%	80.2	0.3%

Table 5-24: Simulated baseline daily SO₂ concentrations and the theoretical change in concentrations relative to the baseline at the AQMS and 20 closest receptors

Receptor	Daily SO ₂						
	Baseline	Existing		New		Alternative	
	Concentration (µg/m ³)	Concentration (µg/m ³)	Relative change	Concentration (µg/m ³)	Relative change	Concentration (µg/m ³)	Relative change
Embalenhle AQMS	47.5	47.5	-0.1%	47.5	0.0%	47.6	0.1%
Secunda Club AQMS	47.5	47.5	-0.1%	47.5	0.0%	47.6	0.1%
Secunda AQMS	39.1	39.1	-0.2%	39.1	-0.1%	39.4	0.6%
Bosjesspruit AQMS	42.7	42.7	0.0%	42.7	0.0%	42.8	0.3%
Roodebank Combined School	28.3	28.3	0.0%	28.3	0.0%	28.4	0.3%
Zamokuthle Primary School	35.2	35.2	0.1%	35.2	0.0%	35.2	0.1%
Osizweni Secondary School	27.0	27.0	0.0%	27.0	0.0%	27.0	0.1%
Isibanisesizwe Primary School	37.2	37.2	0.0%	37.2	0.0%	37.3	0.3%
Maphala-Gulube Primary School	44.4	44.3	-0.2%	44.3	-0.1%	45.1	1.6%
Kiriyatswane Secondary School	33.1	33.1	0.0%	33.1	0.0%	33.1	0.1%
Osizweni Primary School	26.6	26.6	-0.1%	26.6	0.0%	26.7	0.6%
Kusasaletu Secondary School	36.0	36.0	-0.1%	36.0	-0.2%	36.2	0.5%
Laerskool Oranjegloed	44.7	44.7	-0.1%	44.7	0.0%	44.8	0.1%
Highveld Medi Clinic/Hydromed	35.0	35.0	0.0%	35.0	0.0%	35.1	0.3%
Tholukwazi Primary School	33.9	33.9	0.1%	33.9	0.0%	34.1	0.7%
TP Stratten Primary School	22.0	21.9	-0.2%	22.0	0.0%	22.0	0.2%
School	47.3	47.3	0.0%	47.3	-0.1%	47.3	0.0%
Laerskool Goedehoop	39.5	39.4	-0.1%	39.4	-0.1%	39.6	0.4%
Laerskool Kruijnpark	45.2	45.1	-0.1%	45.2	0.0%	45.3	0.1%
Lifaletu Primary School	34.7	34.7	-0.1%	34.7	0.0%	34.8	0.2%
Secunda Medi Clinic	38.4	38.3	-0.1%	38.4	0.0%	38.4	0.1%
Embalenhle Primary School	33.9	33.9	0.0%	33.9	0.0%	34.1	0.6%
Buyani Primary School	34.8	34.7	-0.1%	34.7	0.0%	34.9	0.3%
Allan Makhunga Primary School	35.8	35.8	-0.2%	35.8	-0.2%	37.0	3.2%

Table 5-25: Simulated baseline annual SO₂ concentrations and the theoretical change in concentrations relative to the baseline at the AQMS and 20 closest receptors

Receptor	Annual SO ₂						
	Baseline	Existing		New		Alternative	
	Concentration (µg/m ³)	Concentration (µg/m ³)	Relative change	Concentration (µg/m ³)	Relative change	Concentration (µg/m ³)	Relative change
Embalenhle AQMS	5.5	5.5	-0.2%	5.5	-0.2%	5.6	1.5%
Secunda Club AQMS	5.5	5.5	-0.2%	5.5	-0.2%	5.6	1.5%
Secunda AQMS	3.0	3.0	-0.3%	3.0	-0.3%	3.1	3.2%
Bosjesspruit AQMS	6.0	6.0	-0.2%	6.0	-0.2%	6.1	1.5%
Roodebank Combined School	2.0	2.0	-0.4%	2.0	-0.4%	2.1	3.4%
Zamokuthle Primary School	2.8	2.8	-0.3%	2.8	-0.3%	2.9	3.0%
Osizweni Secondary School	2.2	2.1	-0.2%	2.1	-0.2%	2.2	1.9%
Isibanisesizwe Primary School	2.8	2.8	-0.3%	2.8	-0.3%	2.9	3.1%
Maphala-Gulube Primary School	3.9	3.9	-0.6%	3.9	-0.6%	4.1	5.3%
Kiryatswane Secondary School	2.7	2.7	-0.4%	2.7	-0.4%	2.8	3.2%
Osizweni Primary School	2.1	2.1	-0.2%	2.1	-0.2%	2.2	1.9%
Kusasaletu Secondary School	2.9	2.9	-0.3%	2.9	-0.3%	3.0	3.1%
Laerskool Oranjegloed	5.8	5.7	-0.2%	5.7	-0.2%	5.8	1.1%
Highveld Medi Clinic/Hydromed	4.0	4.0	-0.1%	4.0	-0.1%	4.0	0.9%
Tholukwazi Primary School	2.7	2.7	-0.3%	2.7	-0.3%	2.8	2.7%
TP Stratten Primary School	1.8	1.8	-0.2%	1.8	-0.2%	1.8	1.4%
School	5.2	5.2	-0.3%	5.2	-0.3%	5.3	1.8%
Laerskool Goedeheop	4.7	4.7	-0.2%	4.7	-0.2%	4.7	1.1%
Laerskool Kruinpark	6.2	6.1	-0.1%	6.1	-0.1%	6.2	1.0%
Lifaletu Primary School	2.8	2.8	-0.3%	2.8	-0.3%	2.9	2.8%
Secunda Medi Clinic	4.0	4.0	-0.2%	4.0	-0.2%	4.1	1.7%
Embalenhle Primary School	2.7	2.7	-0.3%	2.7	-0.3%	2.8	2.7%
Buyani Primary School	2.7	2.7	-0.3%	2.7	-0.3%	2.7	2.5%
Allan Makhunga Primary School	2.8	2.8	-0.4%	2.8	-0.4%	2.9	3.3%

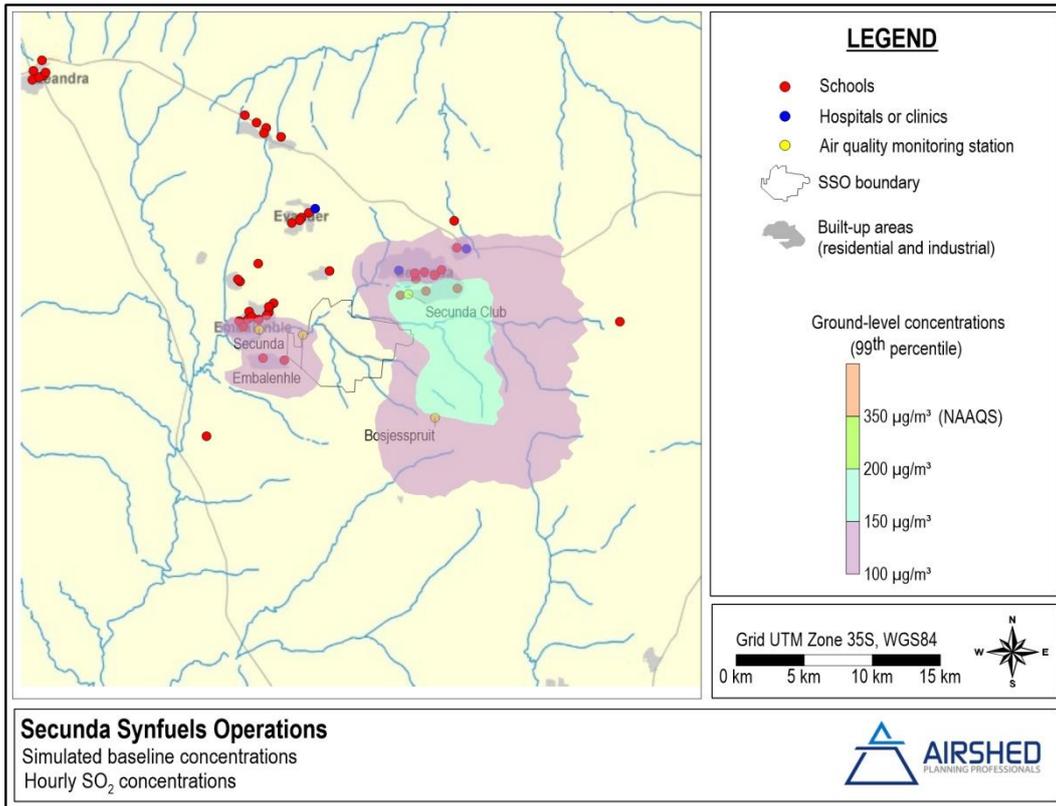


Figure 5-61: Simulated hourly SO₂ concentrations (99th percentile) as a result of baseline emissions

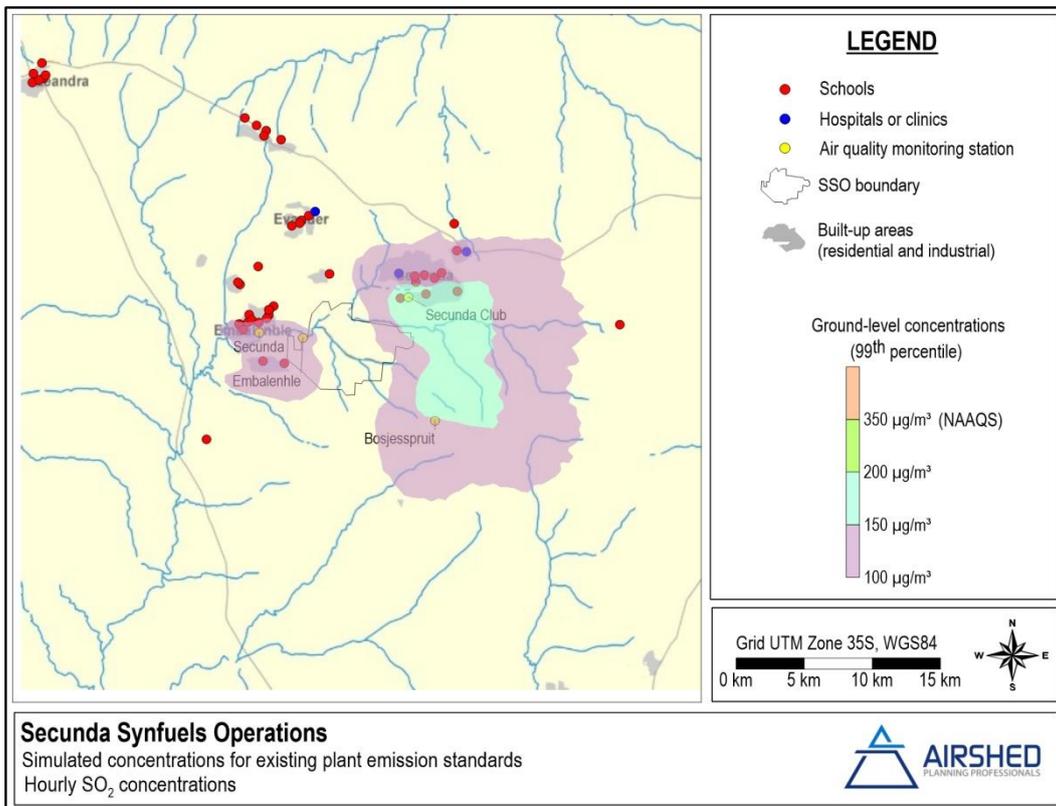


Figure 5-62: Simulated hourly SO₂ concentrations (99th percentile) as a result of theoretical compliance with existing plant emission standards

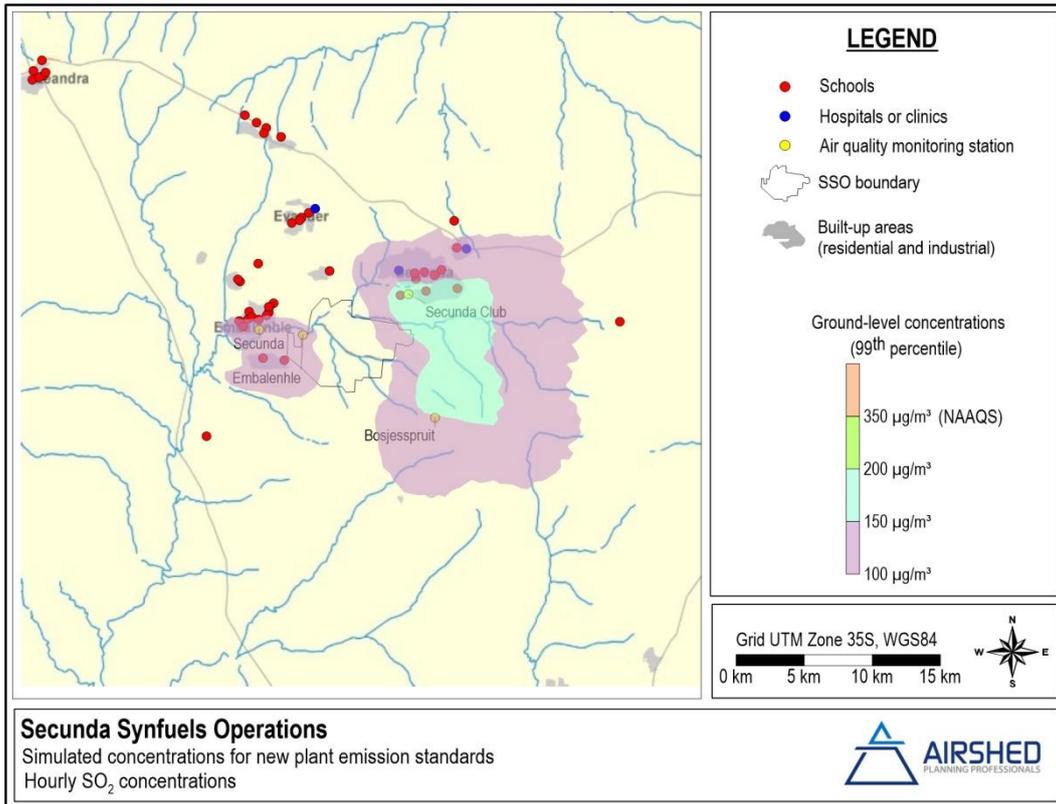


Figure 5-63: Simulated hourly SO₂ concentrations (99th percentile) as a result of theoretical compliance with new plant emission standards

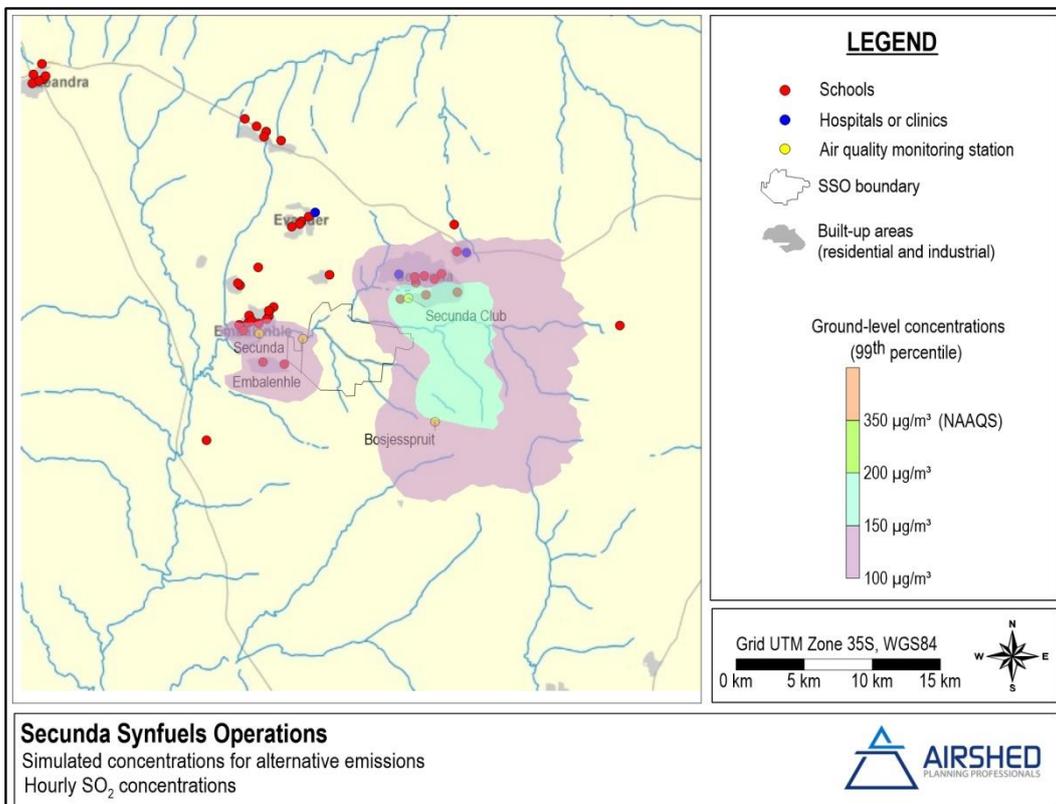


Figure 5-64: Simulated hourly SO₂ concentrations (99th percentile) as a result of alternative emissions

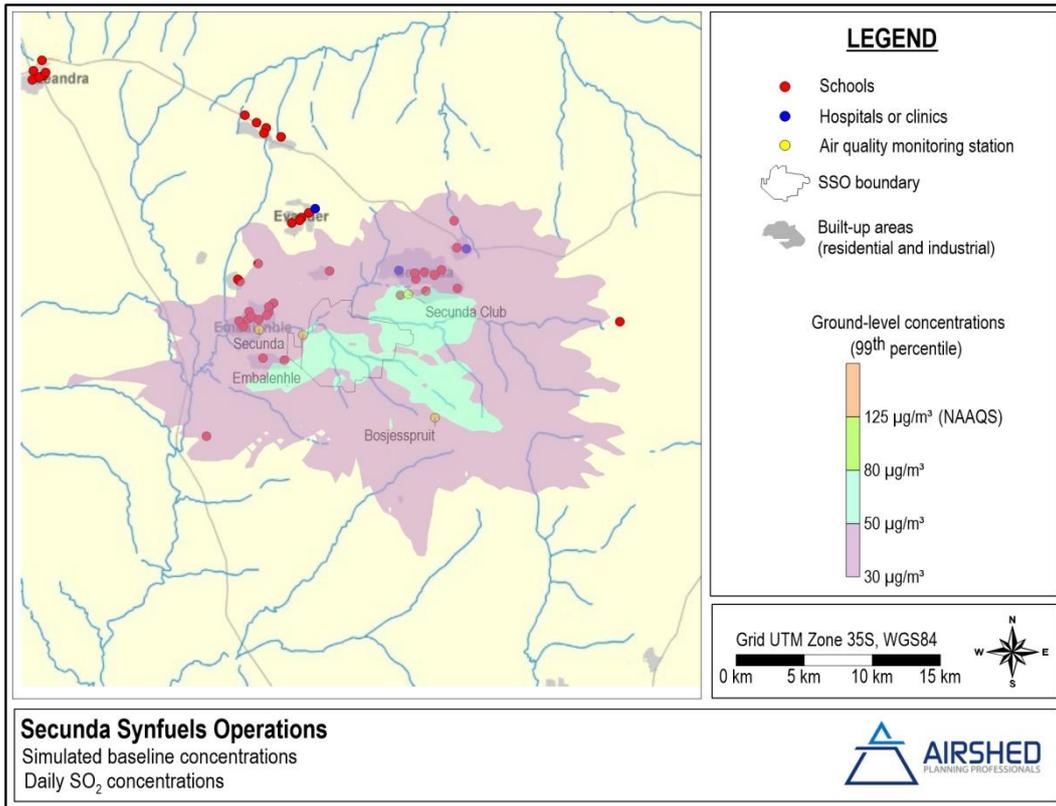


Figure 5-65: Simulated daily SO₂ concentrations (99th percentile) as a result of baseline emissions

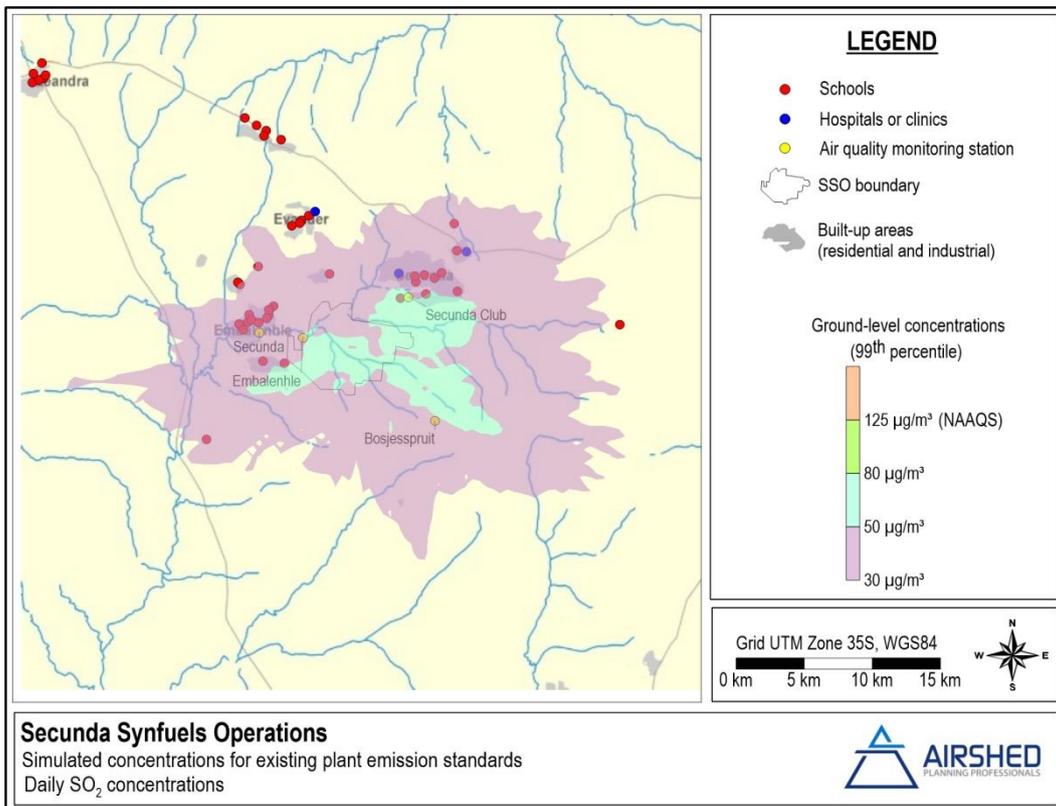


Figure 5-66: Simulated daily SO₂ concentrations (99th percentile) as a result of theoretical compliance with existing plant emission standards

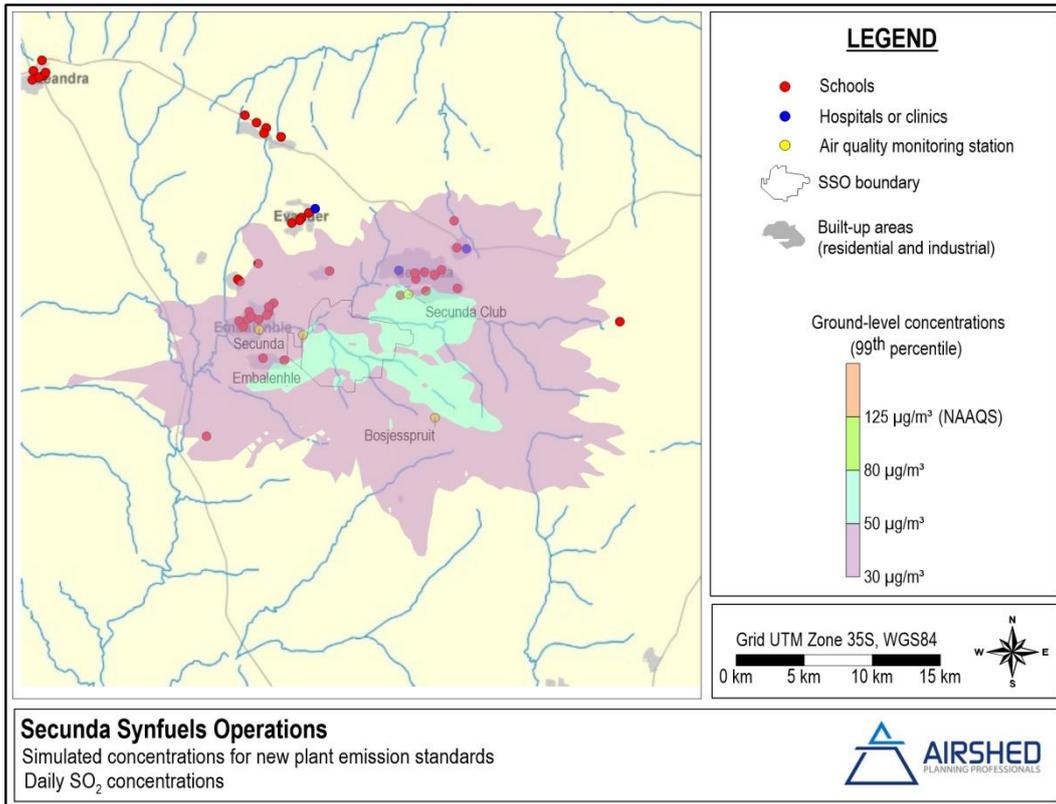


Figure 5-67: Simulated daily SO₂ concentrations (99th percentile) as a result of theoretical compliance with new plant emission standards

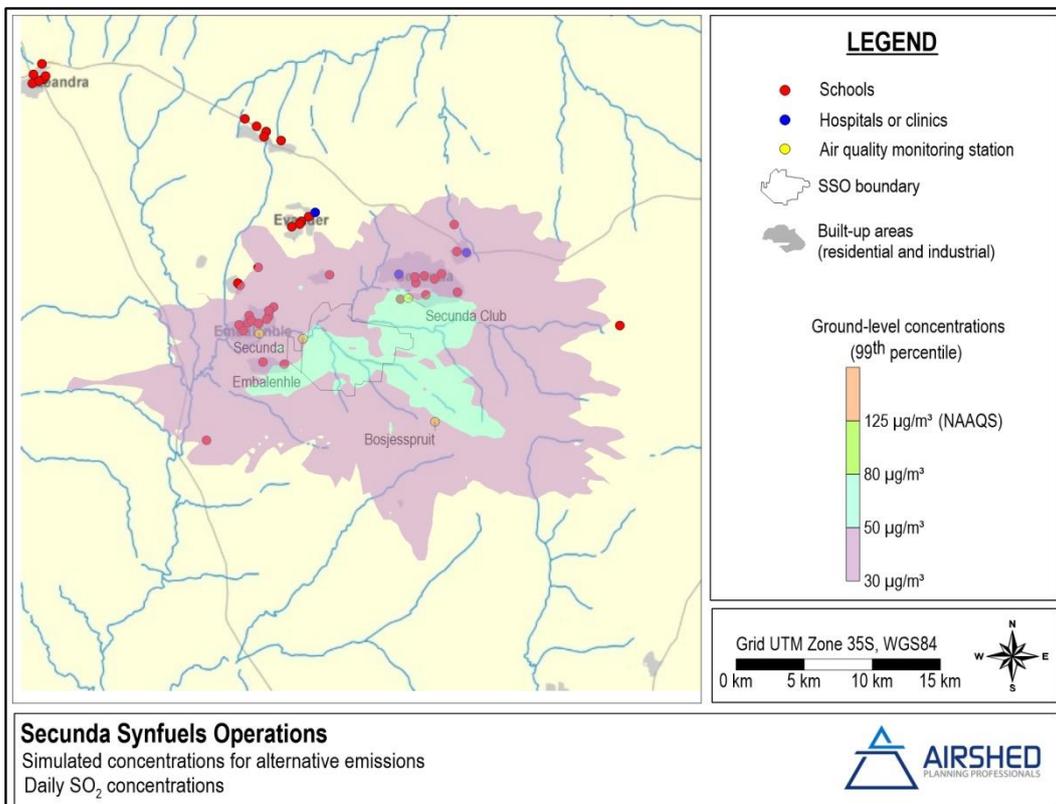


Figure 5-68: Simulated daily SO₂ concentrations (99th percentile) as a result of alternative emissions

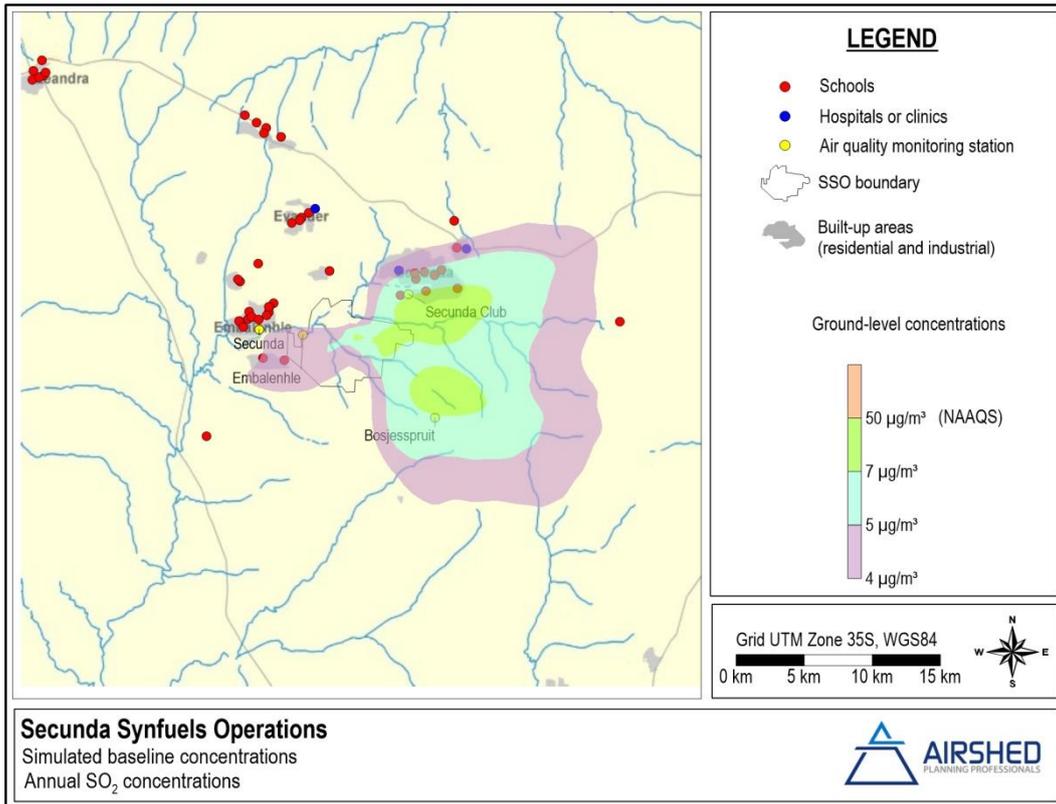


Figure 5-69: Simulated annual SO₂ concentrations as a result of baseline emissions

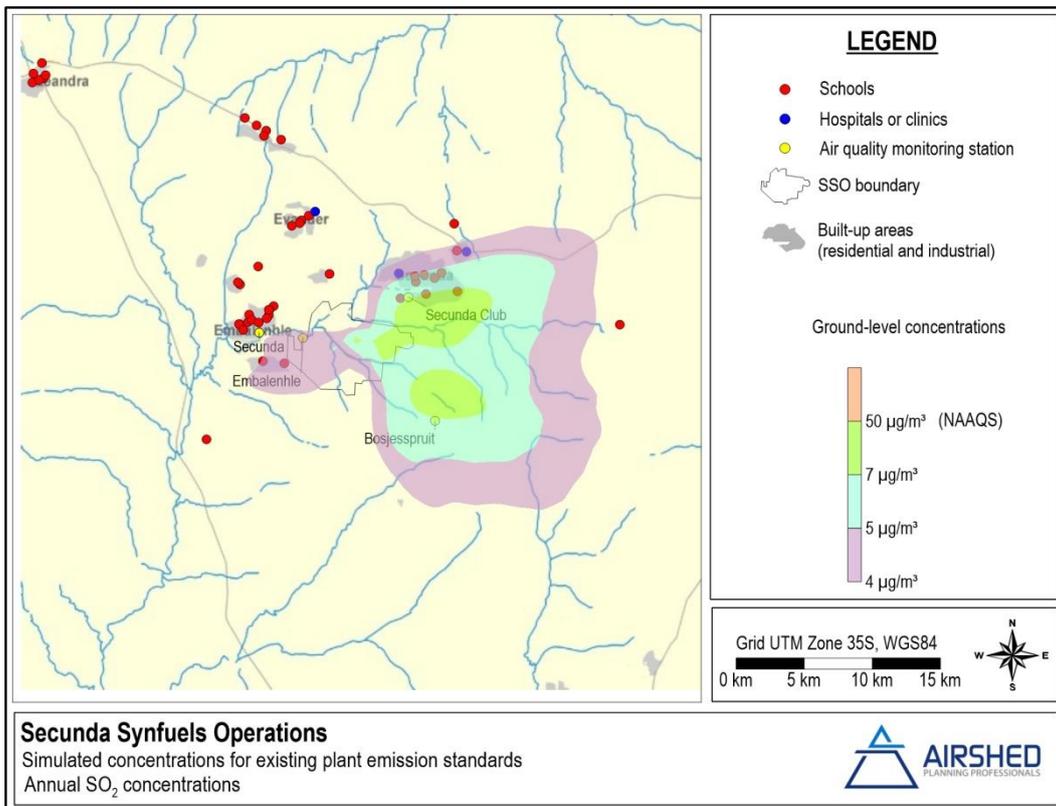


Figure 5-70: Simulated annual SO₂ concentrations as a result of theoretical compliance with existing plant emission standards

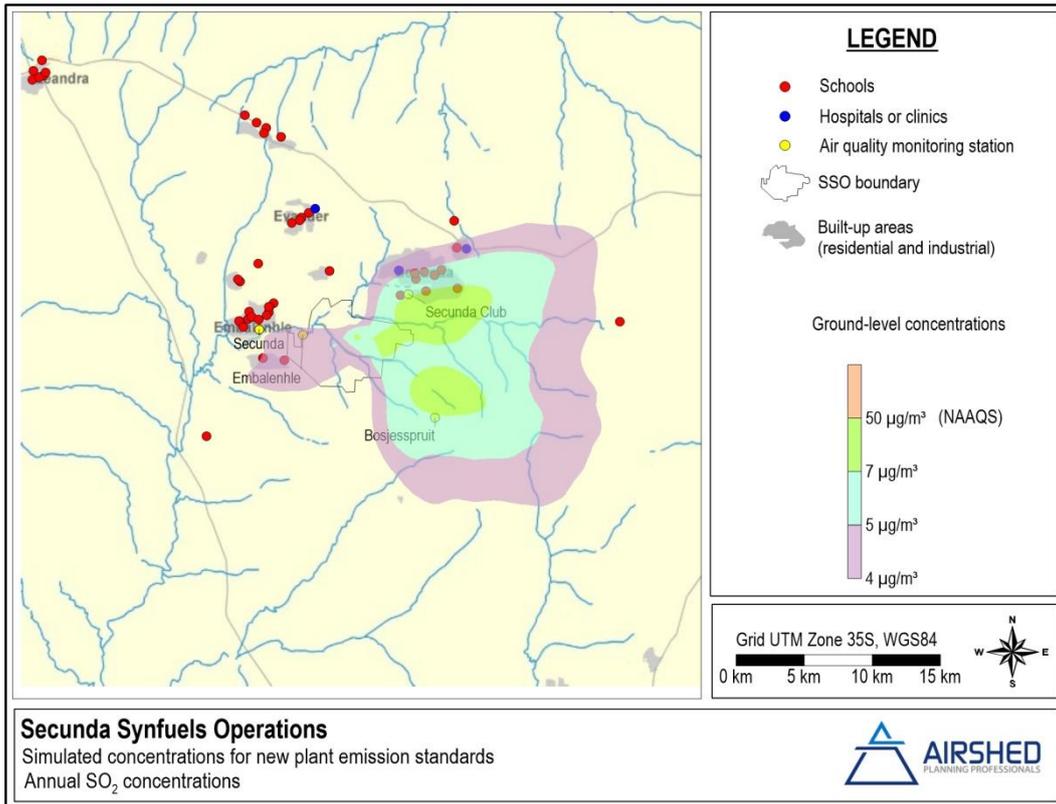


Figure 5-71: Simulated annual SO₂ concentrations as a result of theoretical compliance with new plant emission standards

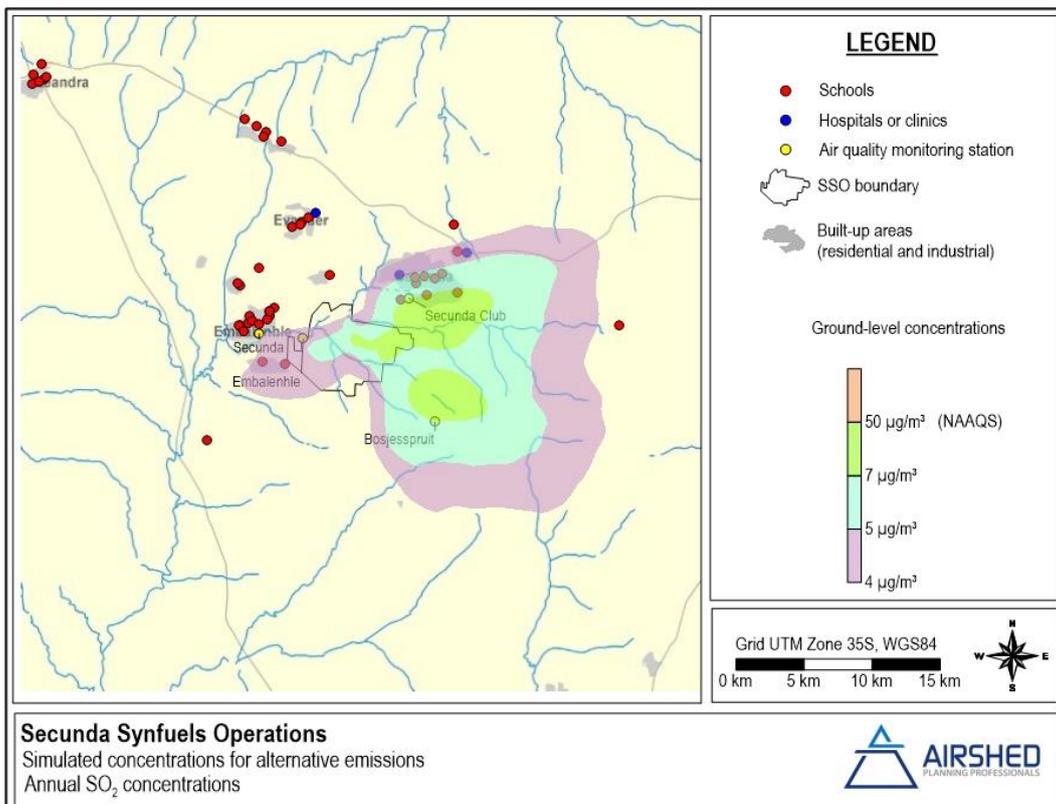


Figure 5-72: Simulated annual SO₂ concentrations as a result of alternative emissions

5.1.8.1.2 Nitrogen Dioxide (NO₂)

Simulated hourly and annual NO₂ concentrations is within compliance with NAAQS at the AQMS (Figure 5-73 and Figure 5-74) and receptors (Table 5-26 and Table 5-27) for all scenarios. Theoretical compliance with the existing and new plant emission standards would result in a reduction in ground-level concentrations by up to a maximum of 19% (Table 5-26 and Table 5-27). On average the reduction of hourly concentrations would be less than 1% at the AQMS and receptors. The Alternative emission scenario would result in slight increases in hourly and annual NO₂ concentrations (maximum of 22% on annual average concentration).

Isopleth plots are presented for all averaging periods ground-level NO₂ concentrations as a result of all emission scenarios for SSO, as per the figure numbers below:

Scenario	Hourly	Annual
Baseline concentrations	Figure 5-75	Figure 5-79
Existing Plant standards	Figure 5-76	Figure 5-80
New Plant standards	Figure 5-77	Figure 5-81
Alternative emissions	Figure 5-78	Figure 5-82

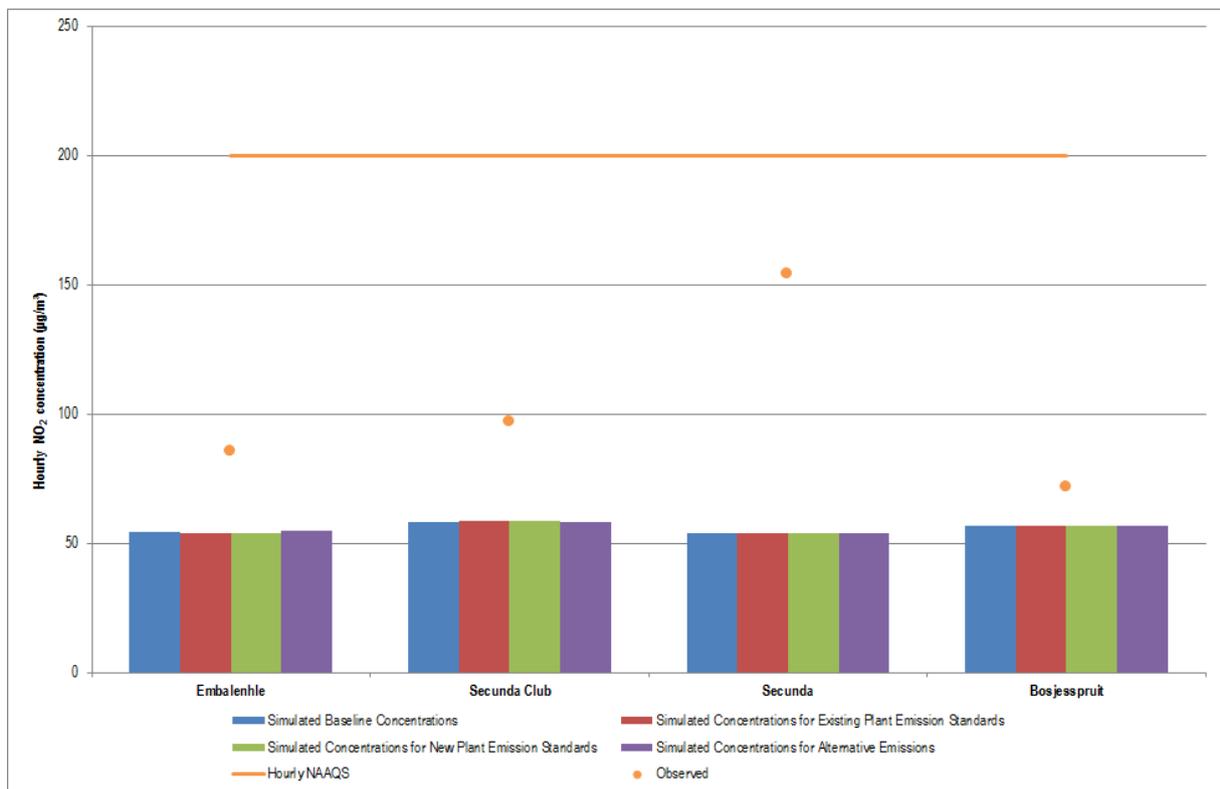


Figure 5-73: Simulated hourly NO₂ concentrations (99th percentile) at AQMS for SSO

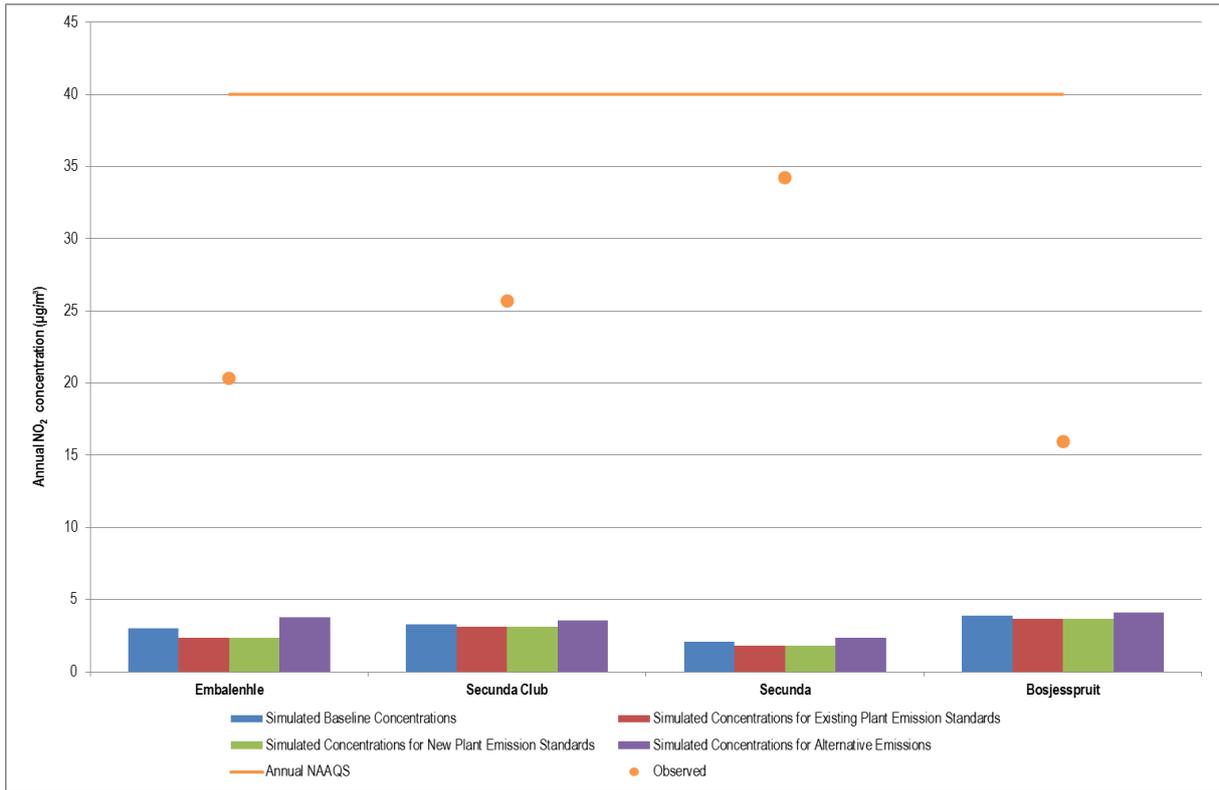


Figure 5-74: Simulated annual NO₂ concentrations at AQMS for SSO

Table 5-26: Simulated baseline hourly NO₂ concentrations and the theoretical change in concentrations relative to the baseline at the AQMS and 20 closest receptors

Receptor	Hourly NO ₂						
	Baseline	Existing		New		Alternative	
	Concentration (µg/m ³)	Concentration (µg/m ³)	Relative change	Concentration (µg/m ³)	Relative change	Concentration (µg/m ³)	Relative change
Embalenhle AQMS	55.5	55.5	0.1%	55.5	0.1%	55.4	0.0%
Secunda Club AQMS	55.5	55.5	0.1%	55.5	0.1%	55.4	0.0%
Secunda AQMS	50.0	50.0	-0.1%	50.0	-0.1%	49.8	-0.4%
Bosjesspruit AQMS	56.0	55.9	-0.1%	55.9	-0.1%	56.0	0.1%
Roodebank Combined School	36.0	35.8	-0.7%	35.8	-0.7%	36.5	1.5%
Zamokuthle Primary School	48.6	48.5	-0.2%	48.5	-0.2%	49.0	0.8%
Osizweni Secondary School	38.9	38.5	-0.9%	38.5	-0.9%	39.6	1.7%
Isibanisesizwe Primary School	47.8	47.1	-1.4%	47.1	-1.4%	48.9	2.3%
Maphala-Gulube Primary School	51.9	51.1	-1.4%	51.1	-1.4%	51.6	-0.5%
Kiryatswane Secondary School	46.5	46.0	-1.0%	46.0	-1.0%	48.0	3.2%
Osizweni Primary School	38.6	38.2	-0.8%	38.2	-0.8%	39.3	1.9%
Kusasaletu Secondary School	48.4	48.3	-0.1%	48.3	-0.1%	49.4	2.0%
Laerskool Oranjegloed	55.8	55.7	-0.2%	55.7	-0.2%	55.9	0.3%
Highveld Medi Clinic/Hydromed	51.8	51.6	-0.3%	51.6	-0.3%	51.9	0.3%
Tholukwazi Primary School	47.1	46.7	-1.0%	46.7	-1.0%	47.4	0.5%
TP Stratten Primary School	33.7	33.5	-0.7%	33.5	-0.7%	35.6	5.7%
School	55.5	55.2	-0.6%	55.2	-0.6%	55.5	-0.1%
Laerskool Goedeheop	54.0	53.9	-0.2%	53.9	-0.2%	54.1	0.3%
Laerskool Kruinpark	56.5	56.5	0.1%	56.5	0.1%	56.5	0.0%
Lifaletu Primary School	47.7	47.6	-0.2%	47.6	-0.2%	48.3	1.1%
Secunda Medi Clinic	53.0	52.9	-0.1%	52.9	-0.1%	53.0	-0.1%
Embalenhle Primary School	47.1	46.6	-1.0%	46.6	-1.0%	46.9	-0.5%
Buyani Primary School	46.7	46.5	-0.5%	46.5	-0.5%	47.6	1.8%
Allan Makhunga Primary School	48.3	48.0	-0.7%	48.0	-0.7%	49.3	1.9%

Table 5-27: Simulated baseline annual NO₂ concentrations and the theoretical change in concentrations relative to the baseline at the AQMS and 20 closest receptors

Receptor	Annual NO ₂						
	Baseline	Existing		New		Alternative	
	Concentration (µg/m ³)	Concentration (µg/m ³)	Relative change	Concentration (µg/m ³)	Relative change	Concentration (µg/m ³)	Relative change
Embalenhle AQMS	2.9	2.7	-7%	2.7	-7%	3.1	8%
Secunda Club AQMS	2.9	2.7	-7%	2.7	-7%	3.1	8%
Secunda AQMS	1.8	1.5	-13%	1.5	-13%	2.0	16%
Bosjesspruit AQMS	3.6	3.4	-6%	3.4	-6%	3.9	7%
Roodebank Combined School	1.4	1.2	-13%	1.2	-13%	1.6	15%
Zamokuthle Primary School	1.6	1.4	-12%	1.4	-12%	1.9	15%
Osizweni Secondary School	1.2	1.1	-8%	1.1	-8%	1.4	9%
Isibanisesizwe Primary School	1.7	1.5	-12%	1.5	-12%	1.9	15%
Maphala-Gulube Primary School	2.7	2.2	-19%	2.2	-19%	3.3	22%
Kiriyatswane Secondary School	1.6	1.4	-13%	1.4	-13%	1.9	15%
Osizweni Primary School	1.2	1.1	-8%	1.1	-8%	1.3	9%
Kusasaletu Secondary School	1.7	1.5	-12%	1.5	-12%	1.9	15%
Laerskool Oranjegloed	3.0	2.8	-5%	2.8	-5%	3.2	6%
Highveld Medi Clinic/Hydromed	2.2	2.1	-4%	2.1	-4%	2.3	5%
Tholukwazi Primary School	1.6	1.4	-11%	1.4	-11%	1.8	13%
TP Stratten Primary School	1.0	0.9	-6%	0.9	-6%	1.1	7%
School	2.8	2.6	-9%	2.6	-9%	3.1	10%
Laerskool Goedehoop	2.5	2.4	-5%	2.4	-5%	2.7	6%
Laerskool Kruijnpark	3.2	3.1	-5%	3.1	-5%	3.4	5%
Lifalethu Primary School	1.6	1.4	-11%	1.4	-11%	1.8	14%
Secunda Medi Clinic	2.2	2.0	-8%	2.0	-8%	2.4	9%
Embalenhle Primary School	1.6	1.4	-11%	1.4	-11%	1.8	13%
Buyani Primary School	1.5	1.4	-10%	1.4	-10%	1.7	13%
Allan Makhunga Primary School	1.7	1.5	-13%	1.5	-13%	1.9	15%

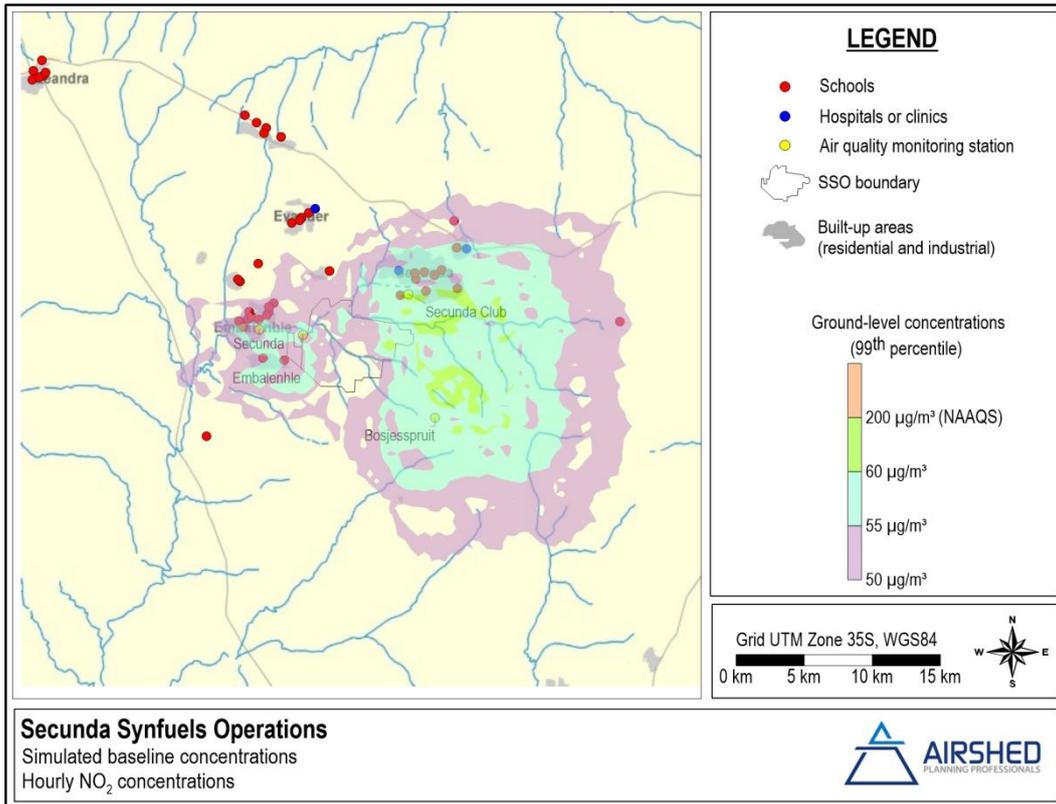


Figure 5-75: Simulated hourly NO₂ concentrations (99th percentile) as a result of baseline emissions

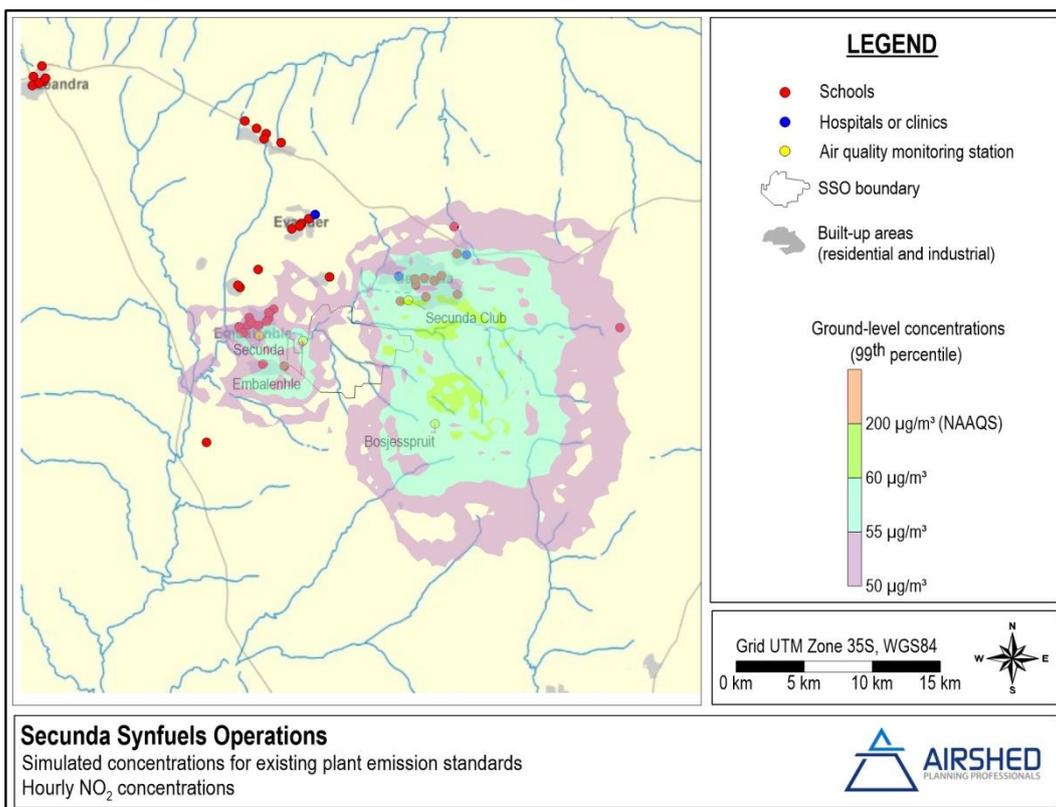


Figure 5-76: Simulated hourly NO₂ concentrations (99th percentile) as a result of theoretical compliance with existing plant emission standards

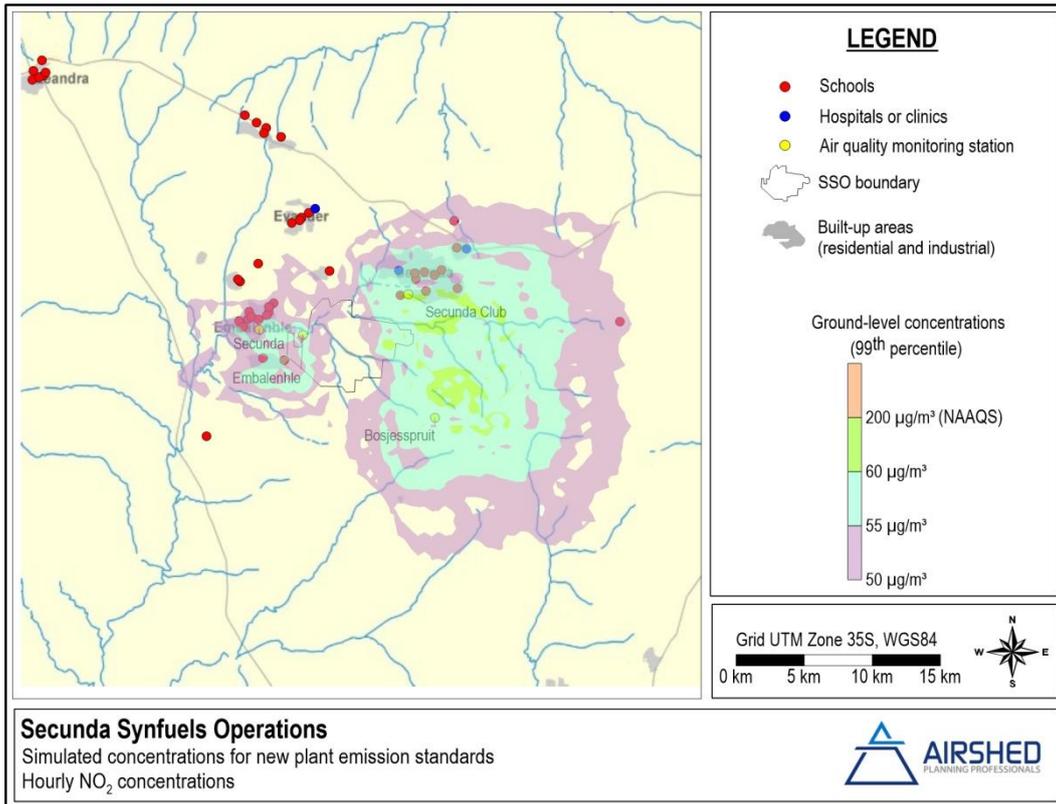


Figure 5-77: Simulated hourly NO₂ concentrations (99th percentile) as a result of theoretical compliance with new plant emission standards

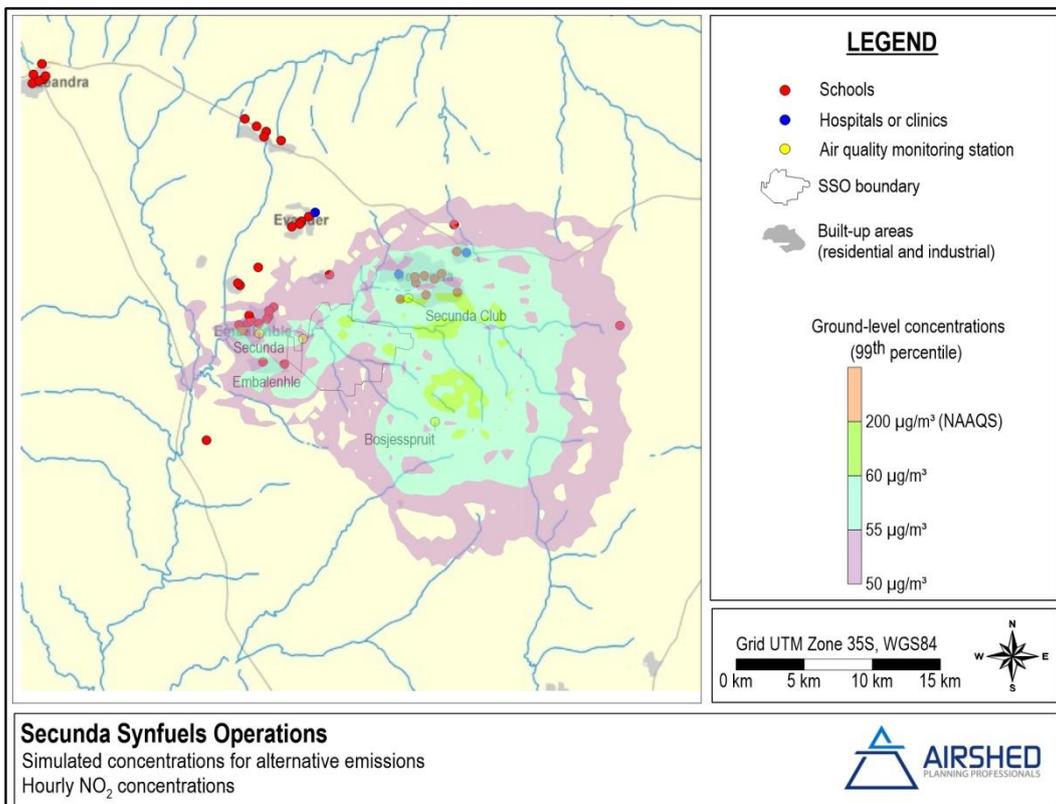


Figure 5-78: Simulated hourly NO₂ concentrations (99th percentile) as a result of alternative emissions

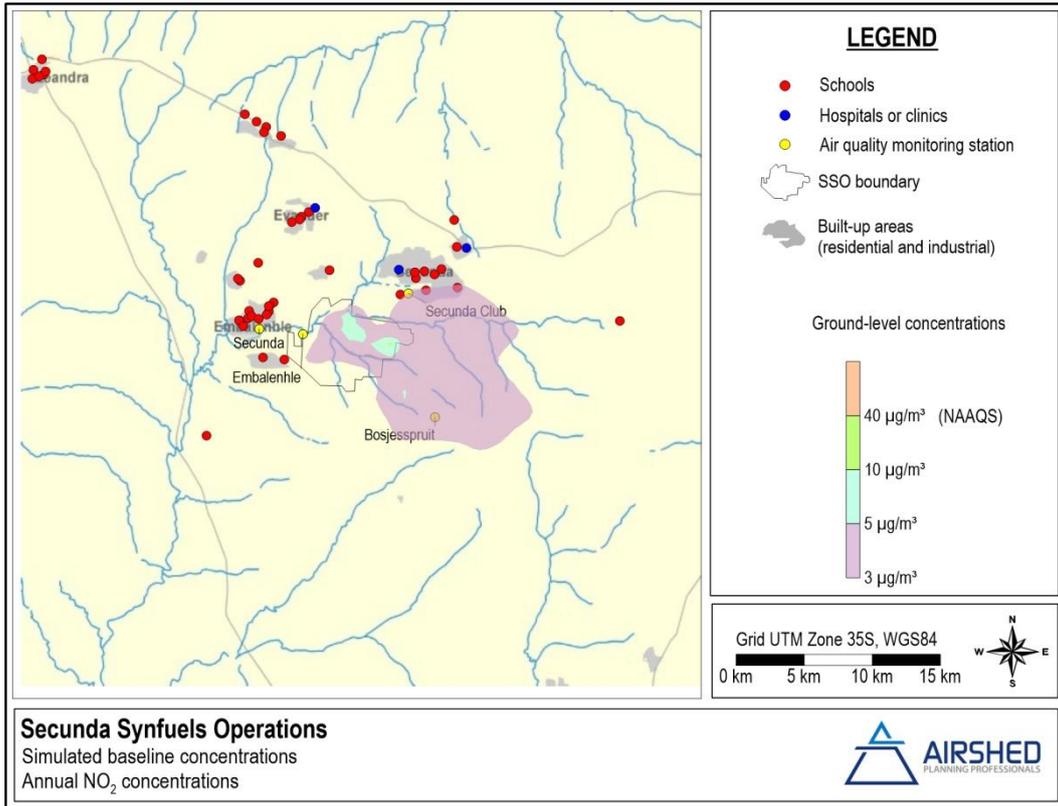


Figure 5-79: Simulated annual NO₂ concentrations as a result of baseline emissions

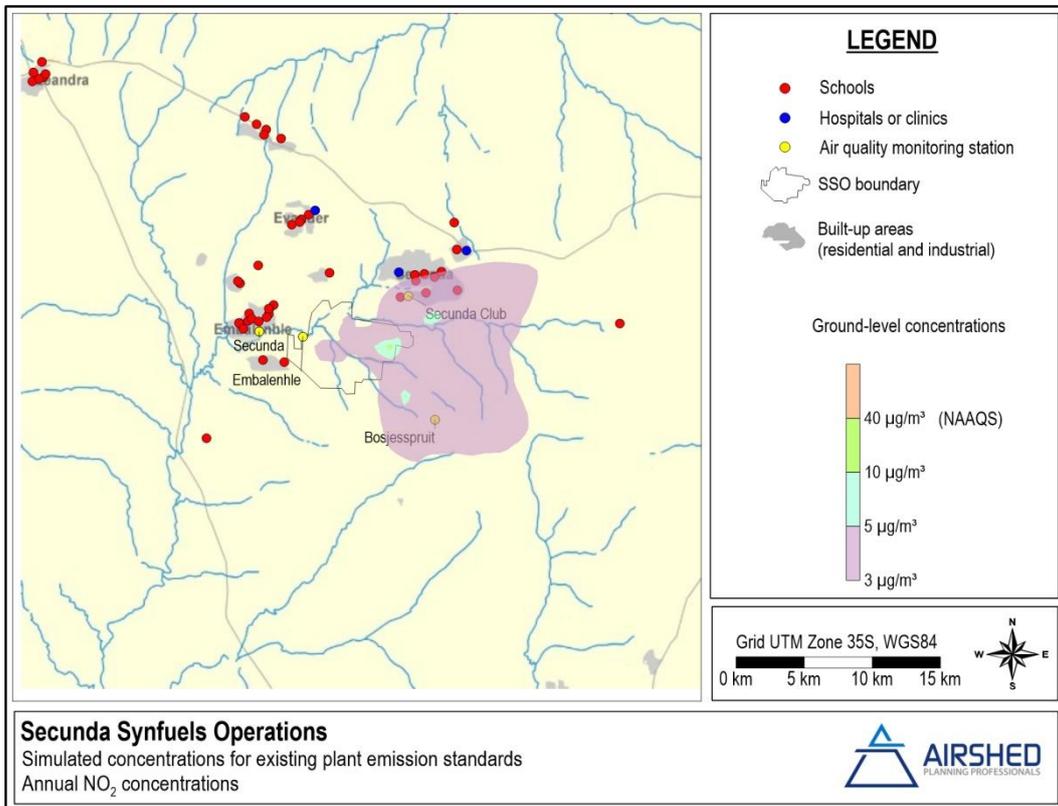


Figure 5-80: Simulated annual NO₂ concentrations as a result of theoretical compliance with existing plant emission standards

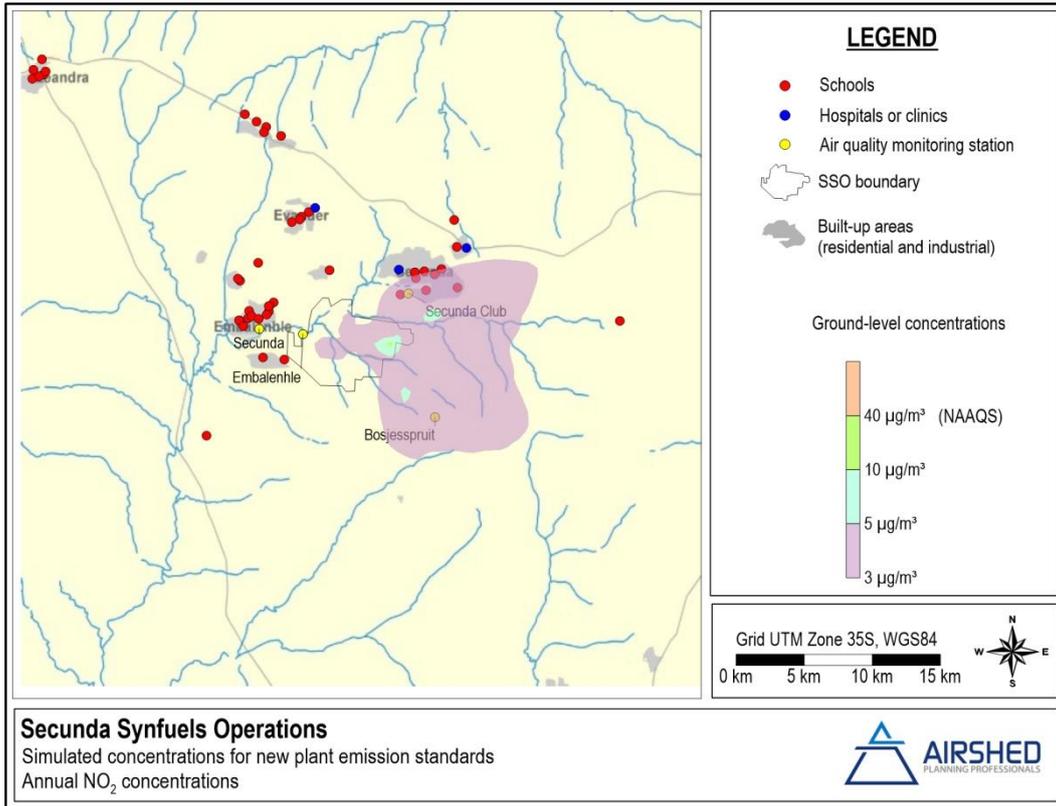


Figure 5-81: Simulated annual NO₂ concentrations as a result of theoretical compliance with new plant emission standards

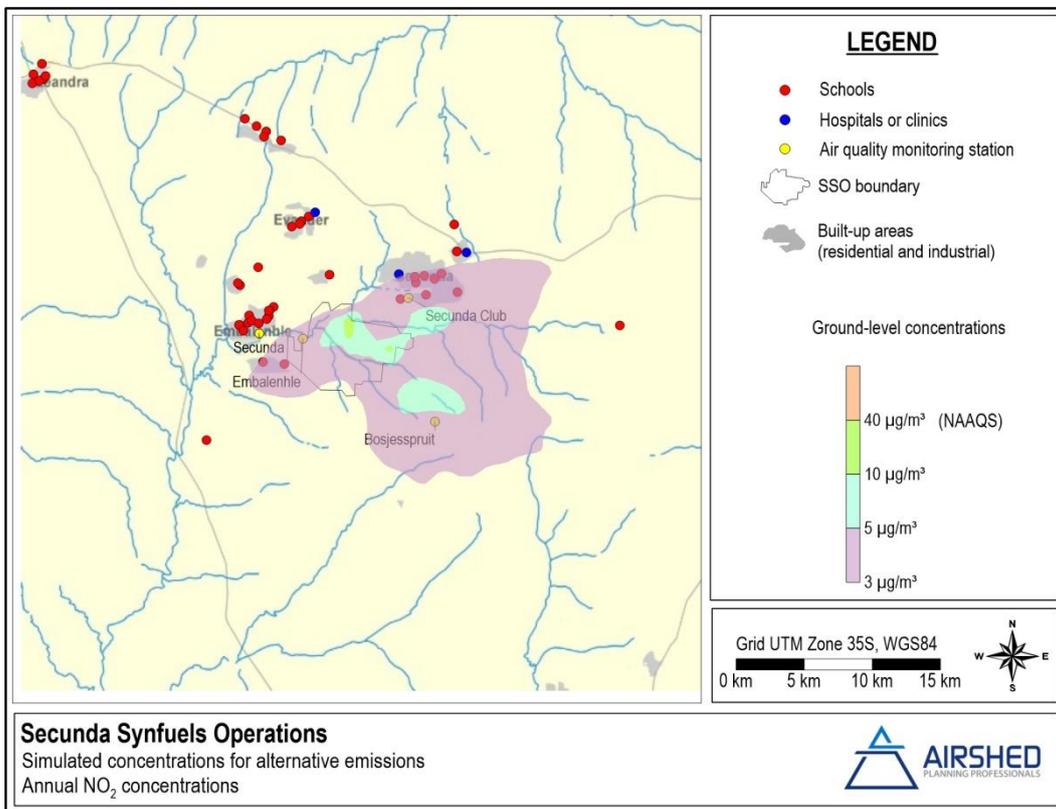


Figure 5-82: Simulated annual NO₂ concentrations as a result of alternative emissions

5.1.8.1.3 Particulate Matter (PM₁₀ and PM_{2.5})

For particulate matter, NAAQS are available for PM₁₀ and PM_{2.5}. Ambient air quality impacts for both particulate fractions (i.e. PM₁₀ and PM_{2.5}) thus need to be considered. Simulated concentrations of particulate matter (PM) were conservatively assumed to be PM_{2.5} since it was not possible to establish the PM_{2.5}/PM₁₀ split. Furthermore, the monitoring of PM at the Embalenhle, and Secunda Club AQMS only include PM₁₀. However, the figures present predicted PM concentrations relative to both the PM_{2.5} and PM₁₀ NAAQS.

The baseline operations from SSO result in low ground-level concentrations of PM; less than 10 µg/m³ at all AQMS (Figure 5-83 and Table 5-28). Simulate annual PM concentrations are less than 1 µg/m³ at all AQMS (Figure 5-84 and Table 5-29). Theoretical compliance with the existing and new plant standards results in reduction of ground-level PM concentrations by up to 28%, while the alternative emissions results in increased ground-level concentrations by up to 61% (Table 5-28 and Table 5-29).

Isolepth plots are presented for all averaging periods ground-level PM concentrations as a result of all emission scenarios for SSO, as per the figure numbers below:

Scenario	Daily	Annual
Baseline concentrations	Figure 5-85	Figure 5-89
Existing Plant standards	Figure 5-86	Figure 5-90
New Plant standards	Figure 5-87	Figure 5-91
Alternative emissions	Figure 5-88	Figure 5-92

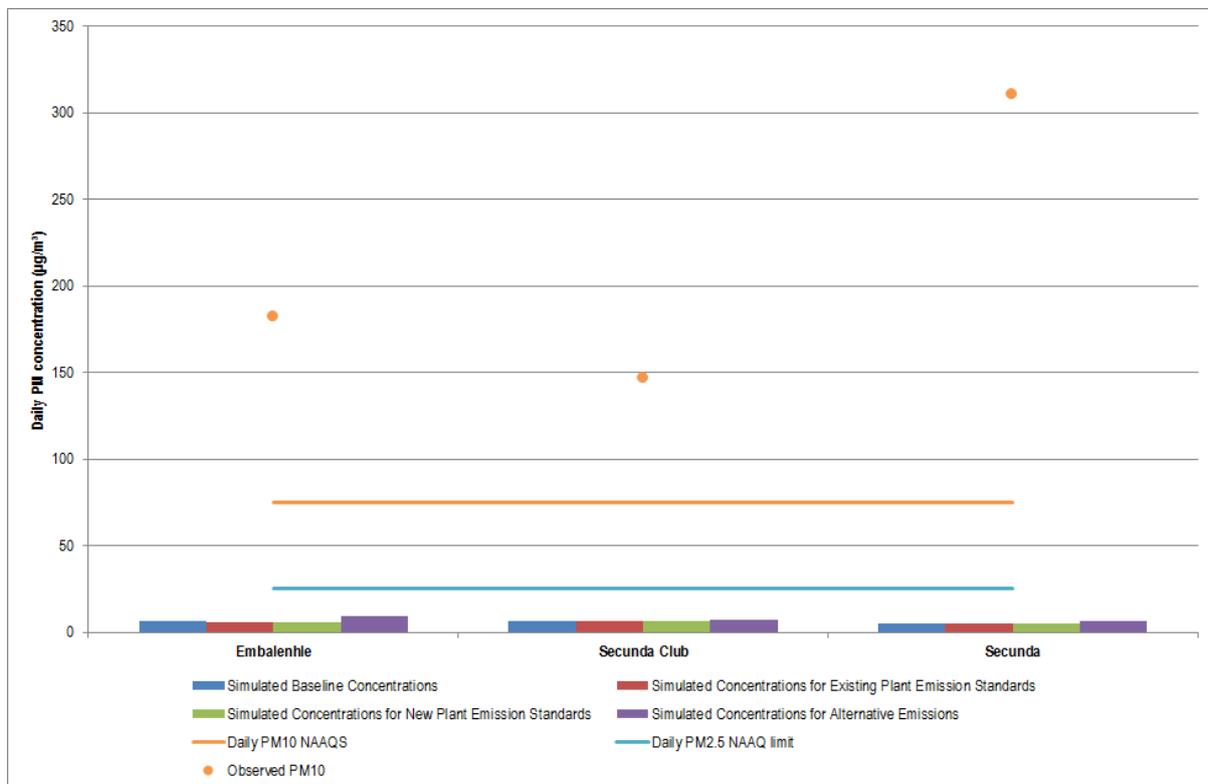


Figure 5-83: Simulated daily PM concentrations (99th percentile) at AQMS for SSO

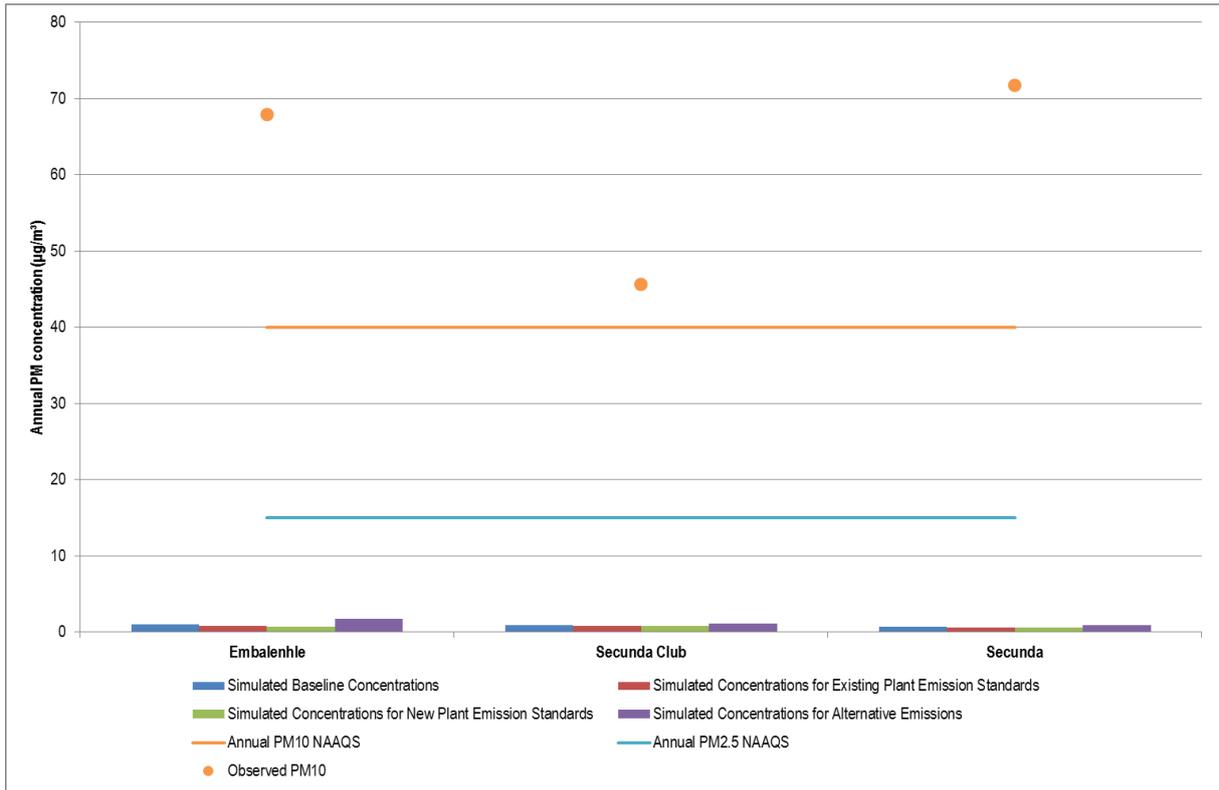


Figure 5-84: Simulated annual PM concentrations at AQMS for SSO

Table 5-28: Simulated baseline daily PM concentrations and the theoretical change in concentrations relative to the baseline at the AQMS and 20 closest receptors

Receptor	Daily PM						
	Baseline	Existing		New		Alternative	
	Concentration (µg/m³)	Concentration (µg/m³)	Relative change	Concentration (µg/m³)	Relative change	Concentration (µg/m³)	Relative change
Embalenhle AQMS	5.8	5.8	-1%	5.7	-2%	6.1	5%
Secunda Club AQMS	5.8	5.8	-1%	5.7	-2%	6.1	5%
Secunda AQMS	4.9	4.7	-6%	4.5	-8%	6.2	26%
Bosjesspruit AQMS	5.3	5.2	-3%	5.1	-3%	6.8	28%
Roodebank Combined School	3.9	3.7	-6%	3.6	-7%	4.7	19%
Zamokuthle Primary School	4.9	4.5	-7%	4.4	-10%	6.0	22%
Osizweni Secondary School	4.2	3.7	-11%	3.7	-11%	4.6	12%
Isibanisesizwe Primary School	4.7	4.5	-5%	4.4	-5%	5.8	23%
Maphala-Gulube Primary School	6.7	6.1	-8%	6.1	-9%	9.2	38%
Kiriyatswane Secondary School	4.6	4.3	-6%	4.2	-8%	5.7	22%
Osizweni Primary School	4.1	3.7	-9%	3.6	-11%	4.6	12%
Kusasaletu Secondary School	4.9	4.7	-5%	4.6	-7%	6.0	22%
Laerskool Oranjegloed	5.4	5.3	-2%	5.3	-2%	5.8	7%
Highveld Medi Clinic/Hydromed	4.3	4.2	-1%	4.2	-1%	4.6	9%
Tholukwazi Primary School	4.8	4.6	-5%	4.5	-7%	5.6	16%
TP Stratten Primary School	4.0	3.9	-4%	3.8	-5%	4.2	6%
School	5.8	5.6	-4%	5.5	-6%	6.2	7%
Laerskool Goedehoop	4.9	4.8	-2%	4.8	-2%	5.2	7%
Laerskool Kruinpark	5.3	5.1	-3%	5.1	-3%	5.8	11%
Lifaletu Primary School	4.8	4.6	-5%	4.5	-7%	5.6	17%
Secunda Medi Clinic	4.9	4.9	-1%	4.8	-3%	5.4	10%
Embalenhle Primary School	4.8	4.6	-5%	4.5	-7%	5.6	16%
Buyani Primary School	4.6	4.4	-3%	4.3	-6%	5.6	21%
Allan Makhunga Primary School	4.8	4.5	-6%	4.4	-8%	5.8	22%

Table 5-29: Simulated baseline annual PM concentrations and the theoretical change in concentrations relative to the baseline at the AQMS and 20 closest receptors

Receptor	Annual PM						
	Baseline	Existing		New		Alternative	
	Concentration (µg/m³)	Concentration (µg/m³)	Relative change	Concentration (µg/m³)	Relative change	Concentration (µg/m³)	Relative change
Embalenhle AQMS	0.8	0.7	-10%	0.7	-13%	1.0	27%
Secunda Club AQMS	0.8	0.7	-10%	0.7	-13%	1.0	27%
Secunda AQMS	0.6	0.5	-16%	0.4	-21%	0.8	45%
Bosjesspruit AQMS	0.9	0.9	-9%	0.8	-12%	1.2	26%
Roodebank Combined School	0.5	0.4	-14%	0.4	-19%	0.6	40%
Zamokuthle Primary School	0.5	0.4	-14%	0.4	-19%	0.7	42%
Osizweni Secondary School	0.4	0.3	-10%	0.3	-13%	0.5	29%
Isibanisesizwe Primary School	0.5	0.4	-15%	0.4	-20%	0.8	44%
Maphala-Gulube Primary School	0.9	0.7	-21%	0.6	-28%	1.4	61%
Kiriyatswane Secondary School	0.5	0.4	-16%	0.4	-20%	0.7	44%
Osizweni Primary School	0.4	0.3	-10%	0.3	-13%	0.5	28%
Kusasaletu Secondary School	0.5	0.5	-15%	0.4	-20%	0.8	44%
Laerskool Oranjegloed	0.8	0.7	-8%	0.7	-10%	1.0	21%
Highveld Medi Clinic/Hydromed	0.6	0.6	-6%	0.5	-8%	0.7	17%
Tholukwazi Primary School	0.5	0.4	-13%	0.4	-18%	0.7	39%
TP Stratten Primary School	0.3	0.3	-8%	0.3	-10%	0.4	22%
School	0.8	0.7	-12%	0.7	-15%	1.0	32%
Laerskool Goedehoop	0.7	0.6	-8%	0.6	-10%	0.8	21%
Laerskool Kruinpark	0.9	0.8	-7%	0.8	-9%	1.0	20%
Lifaletu Primary School	0.5	0.4	-14%	0.4	-18%	0.7	40%
Secunda Medi Clinic	0.6	0.6	-11%	0.5	-14%	0.8	30%
Embalenhle Primary School	0.5	0.4	-13%	0.4	-18%	0.7	39%
Buyani Primary School	0.5	0.4	-13%	0.4	-17%	0.7	37%
Allan Makhunga Primary School	0.5	0.4	-16%	0.4	-21%	0.8	46%

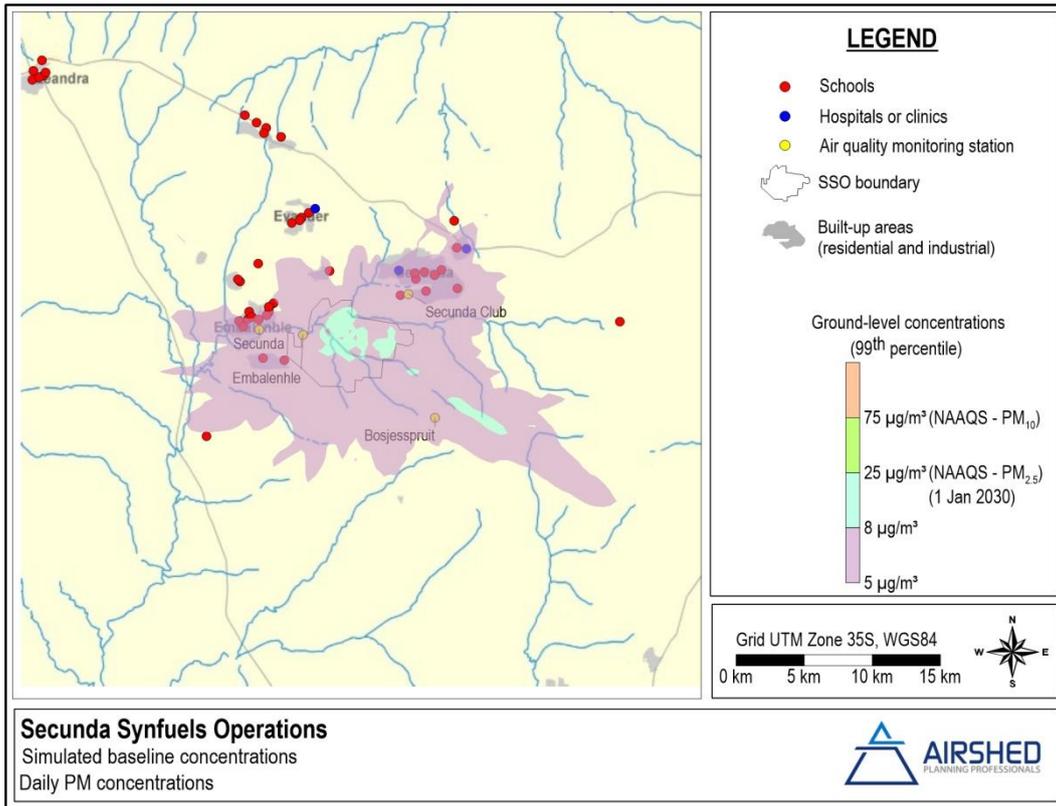


Figure 5-85: Simulated daily PM concentrations (99th percentile) as a result of baseline emissions

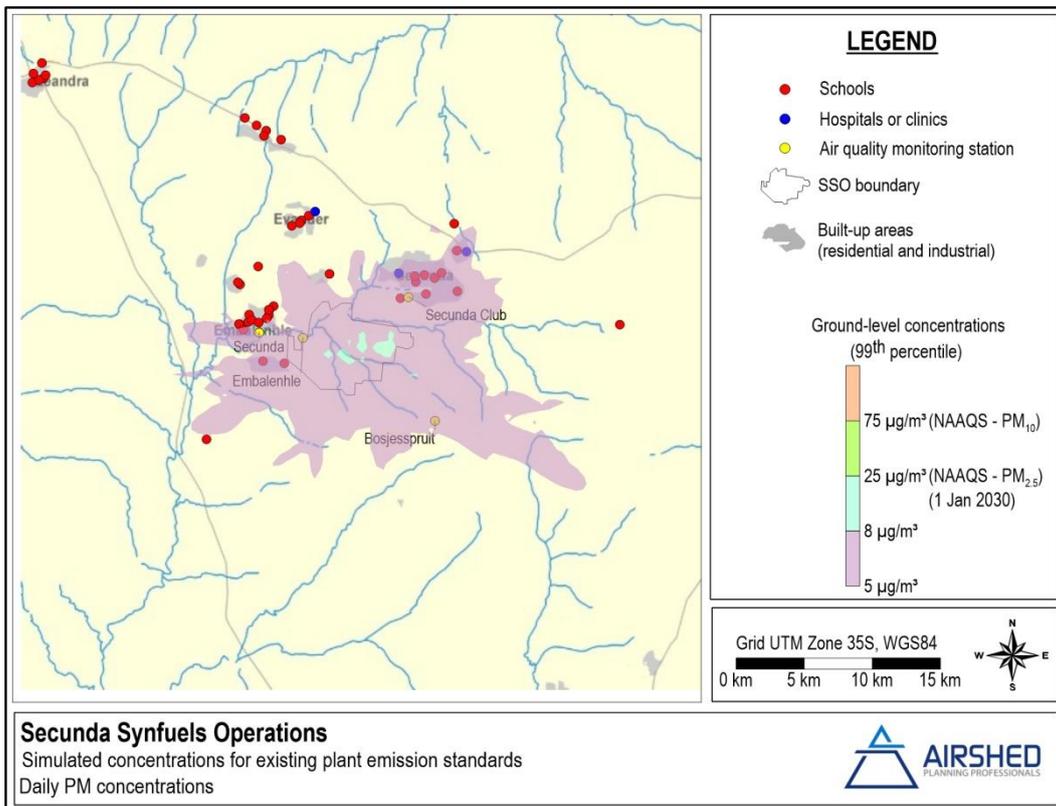


Figure 5-86: Simulated daily PM concentrations (99th percentile) as a result of theoretical compliance with existing plant emission standards

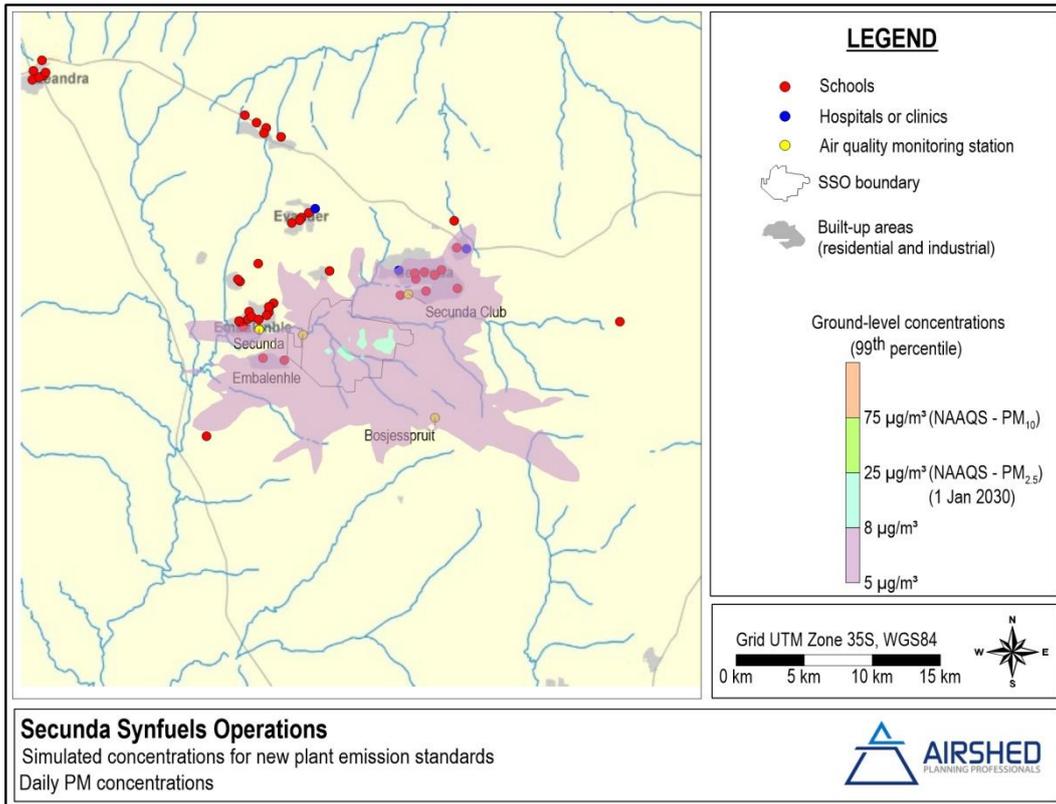


Figure 5-87: Simulated daily PM concentrations (99th percentile) as a result of theoretical compliance with new plant emission standards

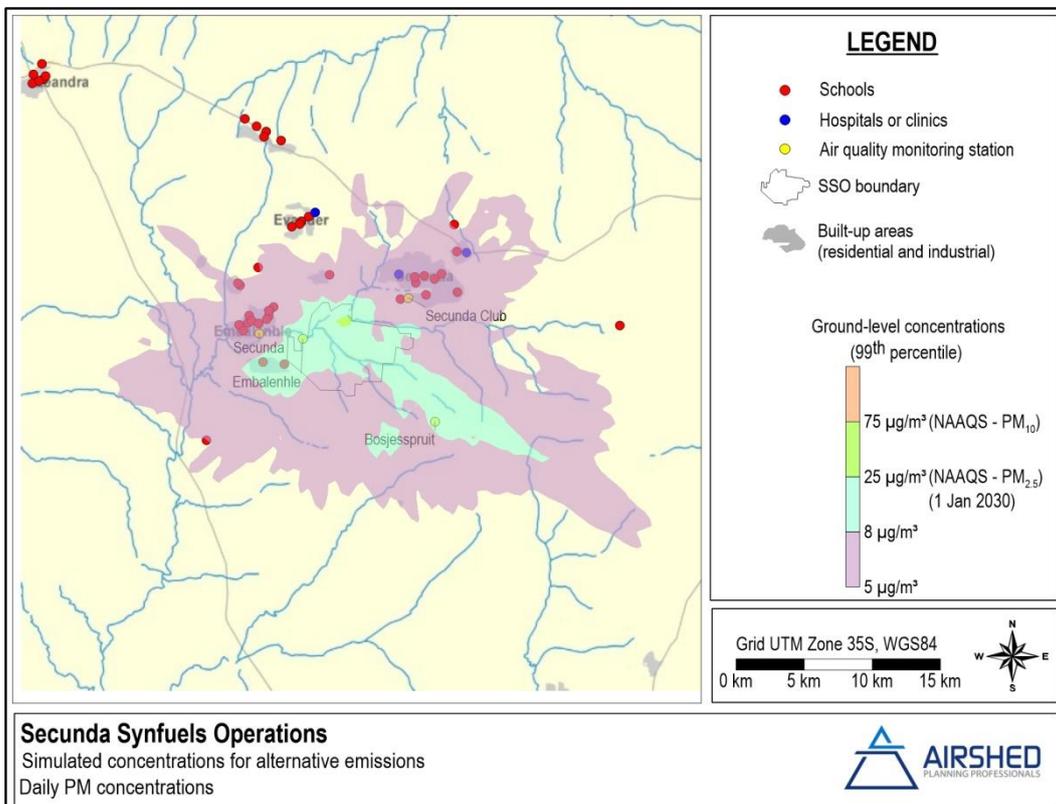


Figure 5-88: Simulated daily PM concentrations (99th percentile) as a result of alternative emissions

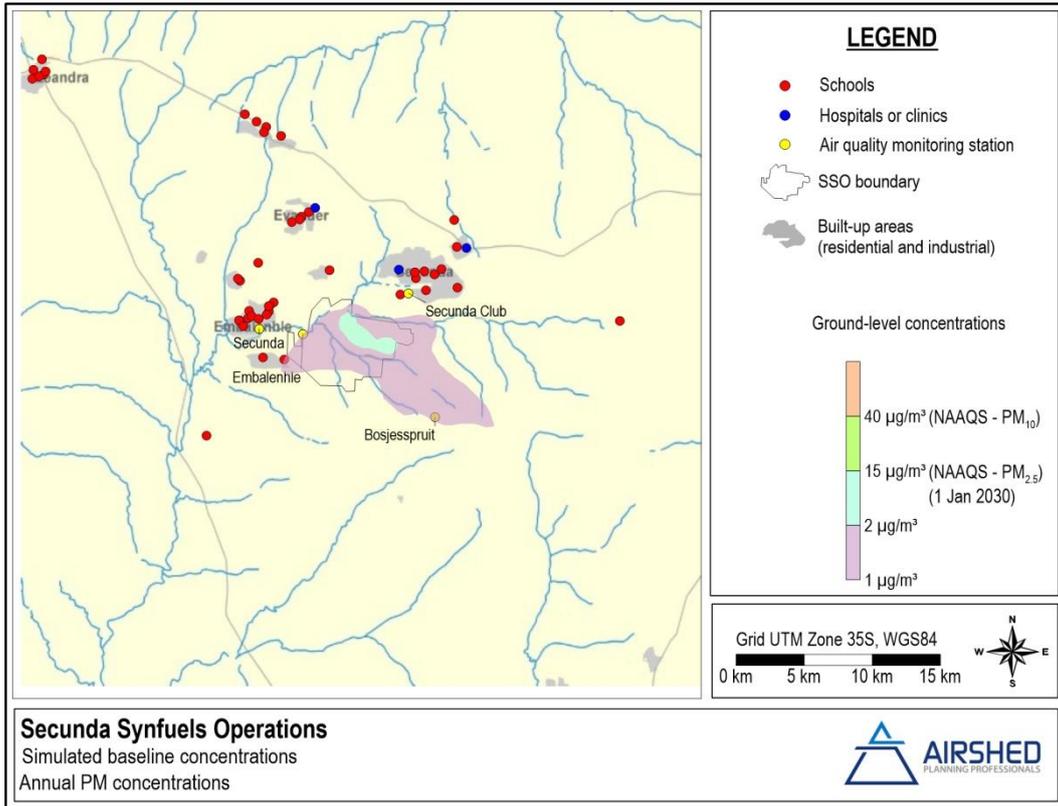


Figure 5-89: Simulated annual PM concentrations as a result of baseline emissions

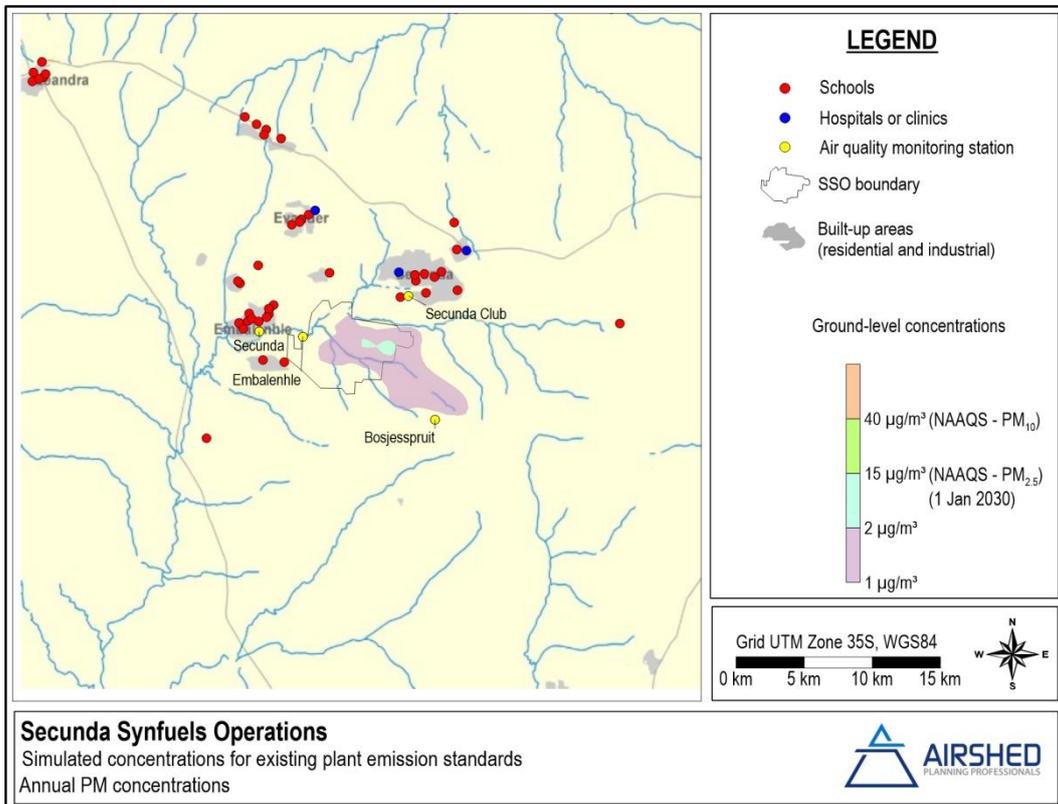


Figure 5-90: Simulated annual PM concentrations as a result of theoretical compliance with existing plant emission standards

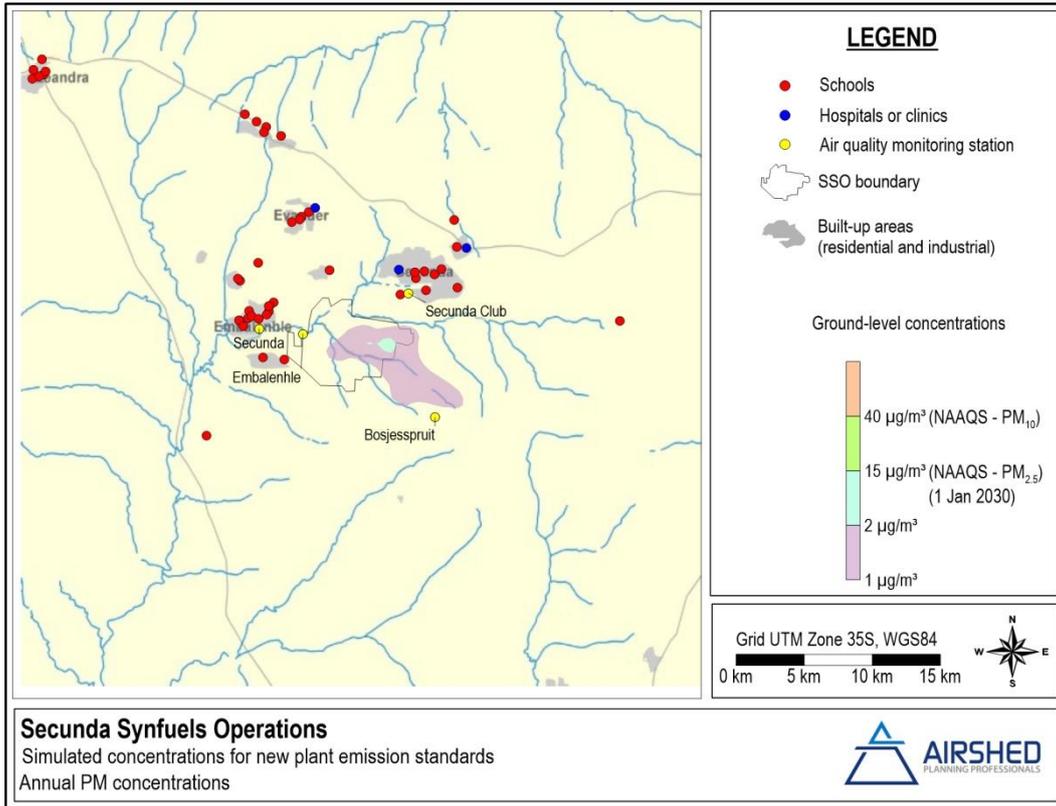


Figure 5-91: Simulated annual PM concentrations as a result of theoretical compliance with new plant emission standards

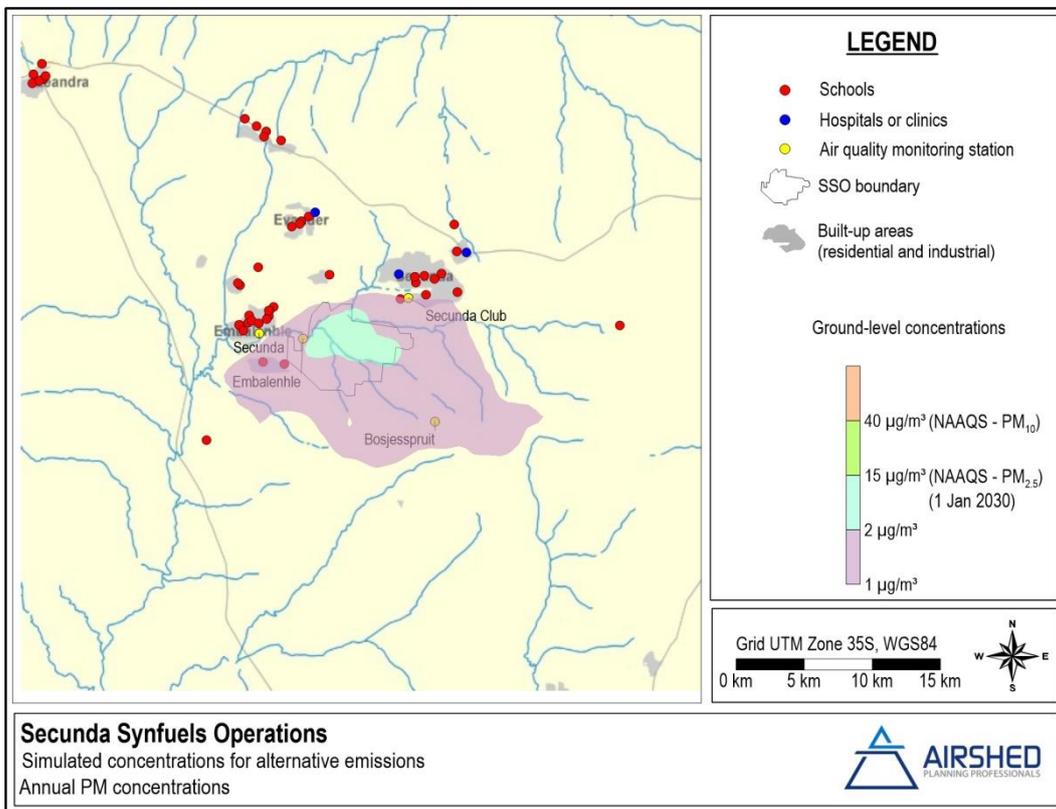


Figure 5-92: Simulated annual PM concentrations as a result of alternative emissions

5.1.8.1.4 Carbon Monoxide (CO)

Only CO sources included in the AEL, was simulated, i.e. the Subcategory 8.1 Thermal Oxidation sources (incinerators). Simulated hourly CO concentrations are in compliance with NAAQS at the AQMS (Figure 5-93) and receptors (Table 5-30) for all scenarios. Theoretical compliance with the existing and new plant emission standards results in a reduction in ground-level concentrations by up to a maximum of 97% (Table 5-30). The alternative emission scenario results in substantial increases in hourly CO concentrations relative to the baseline (94% or greater). The large variation between the ground-level CO concentrations at the AQMS and receptors is related to the small number of sources with highly variable emission rates.

Isoleth plots are presented for all averaging periods ground-level CO concentrations as a result of all emission scenarios for SSO, as per the figure numbers below:

Scenario	Hourly
Baseline concentrations	Figure 5-94
Existing Plant standards	Figure 5-95
New Plant standards	Figure 5-96
Alternative emissions	Figure 5-97

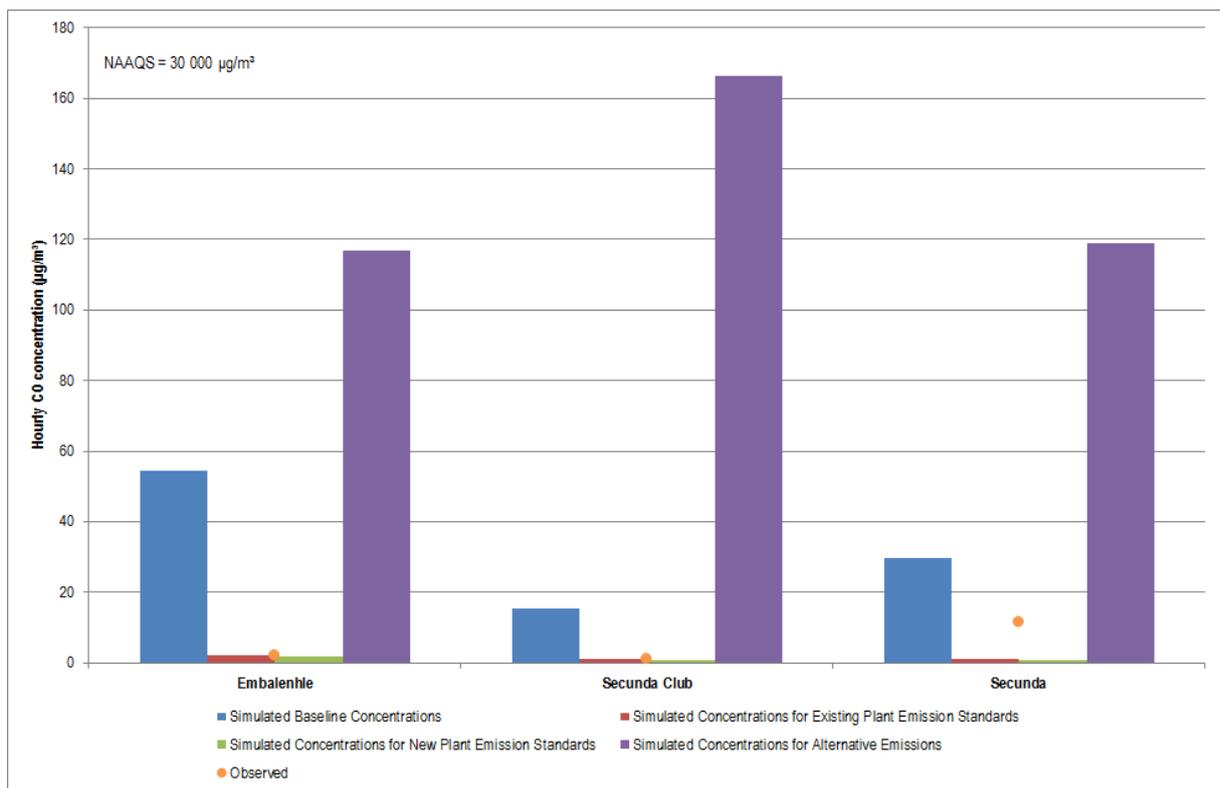


Figure 5-93: Simulated hourly CO concentrations (99th percentile) at AQMS for SSO

Table 5-30: Simulated baseline hourly CO concentrations and the theoretical change in concentrations relative to the baseline at the AQMS and 20 closest receptors

Receptor	Hourly CO						
	Baseline	Existing		New		Alternative	
	Concentration (µg/m³)	Concentration (µg/m³)	Relative change	Concentration (µg/m³)	Relative change	Concentration (µg/m³)	Relative change
Embalenhle AQMS	14.7	0.9	-94%	0.8	-95%	141.1	857%
Secunda Club AQMS	14.7	0.9	-94%	0.8	-95%	141.1	857%
Secunda AQMS	27.5	1.1	-96%	0.8	-97%	92.5	236%
Bosjesspruit AQMS	22.9	1.0	-96%	0.8	-97%	137.3	498%
Roodebank Combined School	19.8	0.8	-96%	0.5	-97%	55.7	181%
Zamokuthle Primary School	24.3	1.0	-96%	0.7	-97%	87.2	260%
Osizweni Secondary School	11.6	0.5	-96%	0.4	-97%	65.6	465%
Isibanisesizwe Primary School	26.9	1.1	-96%	0.8	-97%	80.7	200%
Maphala-Gulube Primary School	52.5	2.2	-96%	1.5	-97%	102.0	94%
Kiriyatswane Secondary School	25.6	1.0	-96%	0.8	-97%	77.6	204%
Osizweni Primary School	11.2	0.5	-96%	0.4	-97%	64.8	479%
Kusasaletu Secondary School	27.1	1.1	-96%	0.8	-97%	84.7	213%
Laerskool Oranjegloed	11.0	0.8	-93%	0.7	-94%	144.5	1212%
Highveld Medi Clinic/Hydromed	7.7	0.4	-95%	0.3	-96%	104.0	1251%
Tholukwazi Primary School	22.5	0.9	-96%	0.6	-97%	80.8	258%
TP Stratten Primary School	6.4	0.3	-95%	0.3	-96%	57.2	790%
School	16.5	1.0	-94%	0.8	-95%	135.5	722%
Laerskool Goedehoop	11.0	0.6	-94%	0.5	-95%	122.5	1010%
Laerskool Kruinpark	13.5	0.7	-94%	0.6	-96%	150.1	1009%
Lifaletu Primary School	24.7	1.0	-96%	0.7	-97%	83.9	239%
Secunda Medi Clinic	15.4	1.0	-93%	0.8	-95%	117.1	663%
Embalenhle Primary School	22.6	0.9	-96%	0.6	-97%	80.8	258%
Buyani Primary School	21.1	0.9	-96%	0.6	-97%	79.0	275%
Allan Makhunga Primary School	27.2	1.1	-96%	0.8	-97%	80.2	195%

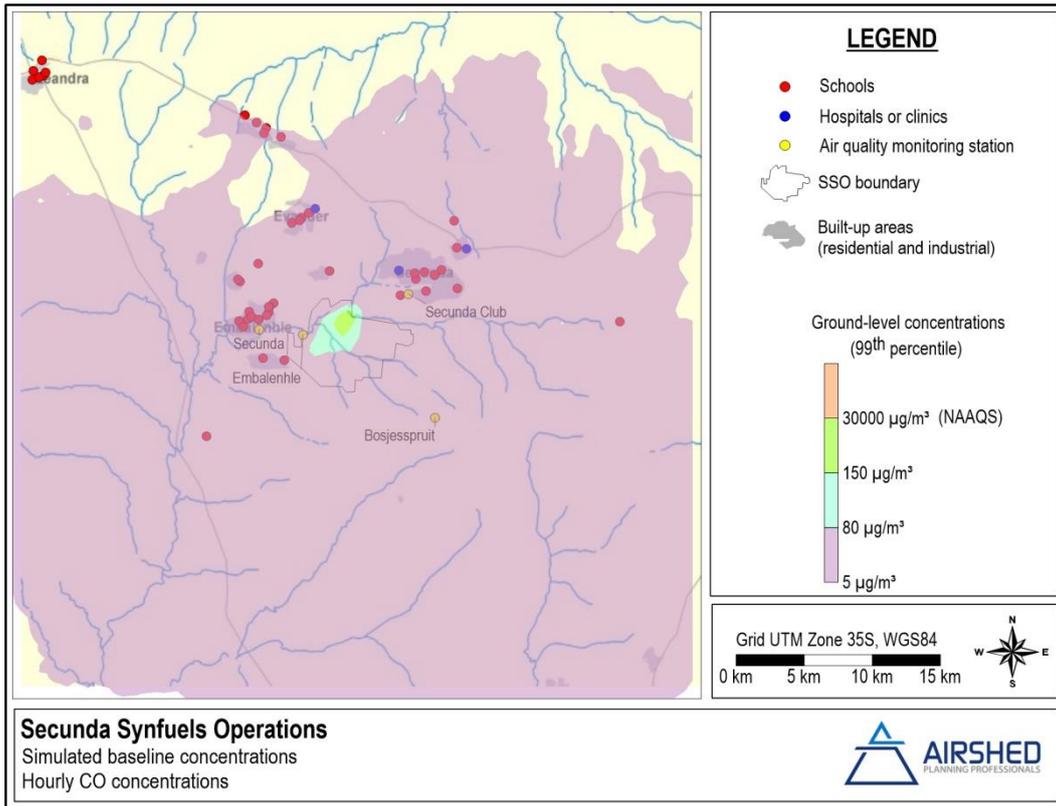


Figure 5-94: Simulated hourly CO concentrations (99th percentile) as a result of baseline emissions

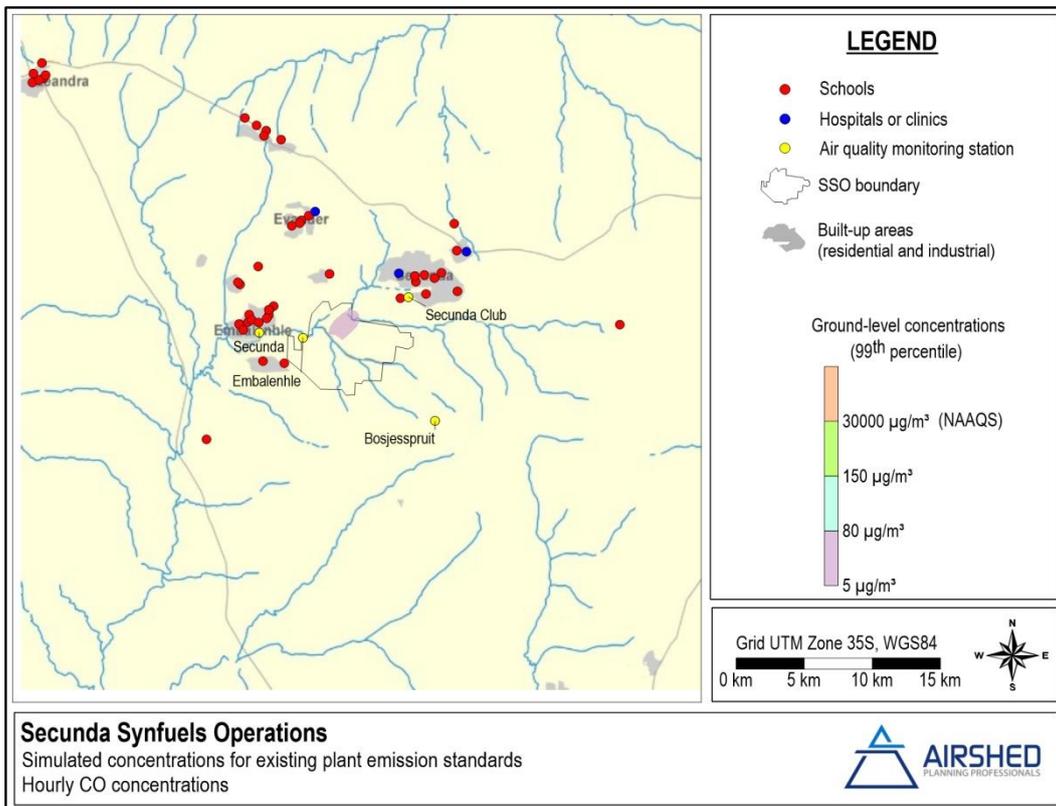


Figure 5-95: Simulated hourly CO concentrations (99th percentile) as a result of theoretical compliance with existing plant emission standards

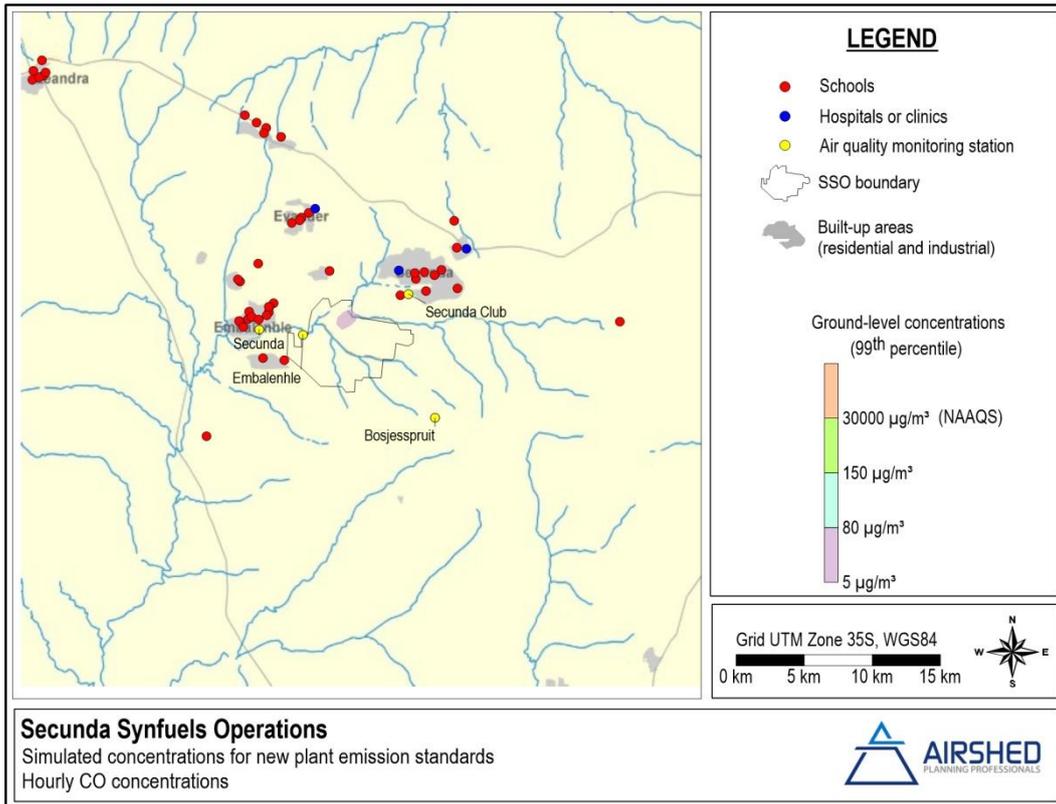


Figure 5-96: Simulated hourly CO concentrations (99th percentile) as a result of theoretical compliance with new plant emission standards

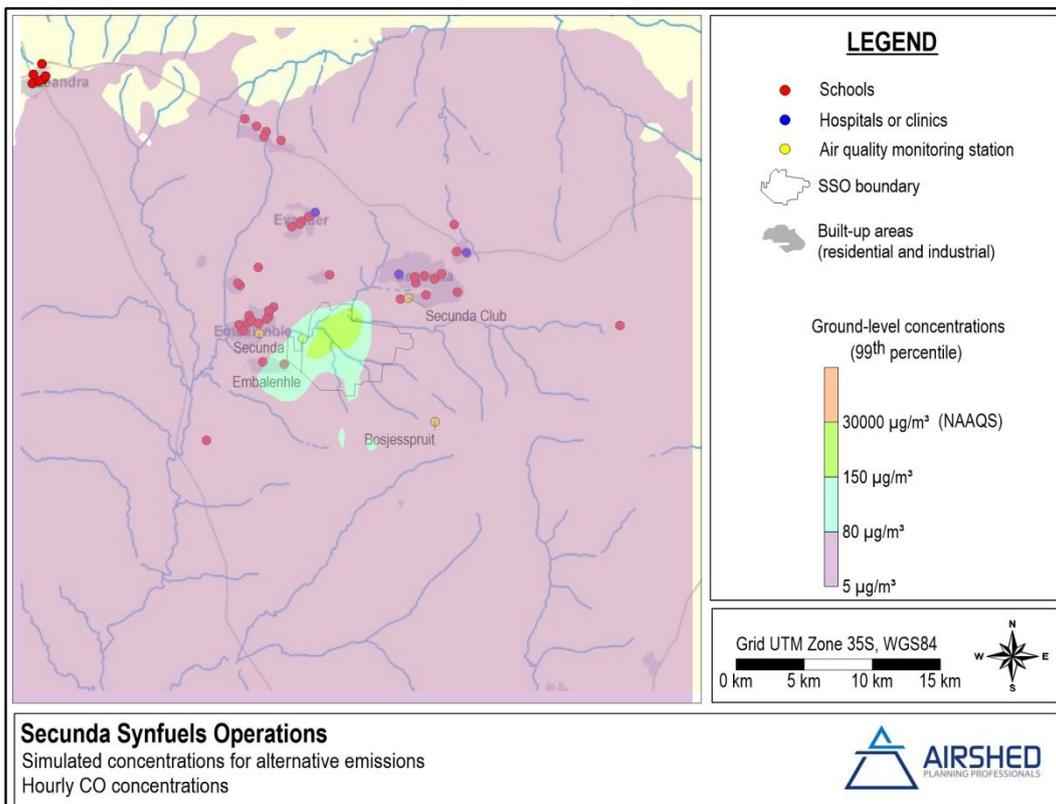


Figure 5-97: Simulated hourly CO concentrations (99th percentile) as a result of alternative emissions

5.1.8.1.5 Benzene (C₆H₆)

Benzene emissions from three source groups (Rectisol, tar value chain storage tanks, and Phenosolvan saturation columns) at SSO were simulated. Four emission scenarios were simulated as described in Section 5.1.1.2. The TOC emissions from the incinerator units are likely to be associated with complex hydrocarbon molecules. In addition, TOCs were measured as a total and a fractional breakdown of components was not possible.

Simulated annual benzene concentrations are below the NAAQS for four scenarios (Figure 5-98 and Table 5-31). Theoretical compliance with the existing and new plant emission standards would likely reduce annual benzene concentrations by up to 9.1%, however the alternative emissions would likely result in increased benzene concentrations relative to the baseline (by a maximum of 5.9%) (Table 5-31).

Isopleth plots are presented for annual average ground-level benzene concentrations as a result of all emission scenarios for SSO, as per the figure numbers below:

Scenario	Annual
Baseline concentrations	Figure 5-99
Existing Plant standards	Figure 5-100
New Plant standards	Figure 5-101
Alternative emissions	Figure 5-102

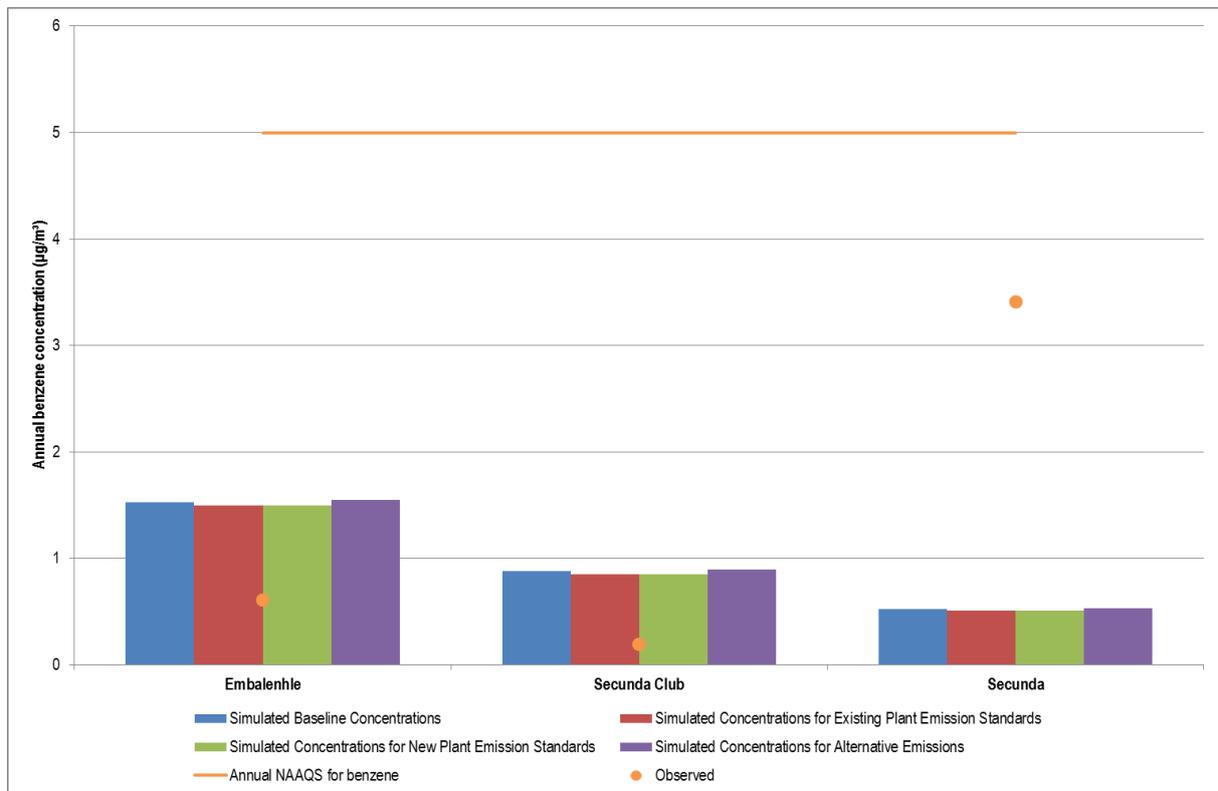


Figure 5-98: Simulated annual benzene concentrations (99th percentile) at AQMS for SSO

Table 5-31: Simulated baseline annual benzene concentrations and the theoretical change in concentrations relative to the baseline at the AQMS and 20 closest receptors

Receptor	Annual benzene						
	Baseline	Existing		New		Alternative	
	Concentration (µg/m³)	Concentration (µg/m³)	Relative change	Concentration (µg/m³)	Relative change	Concentration (µg/m³)	Relative change
Embalenhle AQMS	0.8	0.8	-2.8%	0.8	-2.8%	0.8	1.8%
Secunda Club AQMS	0.8	0.8	-2.8%	0.8	-2.8%	0.8	1.8%
Secunda AQMS	0.5	0.5	-3.0%	0.5	-3.0%	0.5	2.0%
Bosjesspruit AQMS	0.6	0.5	-8.1%	0.5	-8.1%	0.6	5.2%
Roodebank Combined School	0.3	0.3	-5.5%	0.3	-5.5%	0.3	3.5%
Zamokuthle Primary School	0.4	0.4	-3.5%	0.4	-3.5%	0.4	2.3%
Osizweni Secondary School	0.2	0.2	-4.0%	0.2	-4.0%	0.2	2.6%
Isibanisesizwe Primary School	0.5	0.5	-2.9%	0.5	-2.9%	0.5	1.9%
Maphala-Gulube Primary School	1.6	1.6	-2.7%	1.6	-2.7%	1.7	1.7%
Kiryatswane Secondary School	0.5	0.5	-3.0%	0.5	-3.1%	0.5	2.0%
Osizweni Primary School	0.2	0.2	-4.1%	0.2	-4.1%	0.2	2.6%
Kusasaletu Secondary School	0.5	0.5	-3.0%	0.5	-3.0%	0.5	1.9%
Laerskool Oranjegloed	0.6	0.6	-3.7%	0.6	-3.7%	0.6	2.4%
Highveld Medi Clinic/Hydromed	0.2	0.2	-6.5%	0.2	-6.6%	0.2	4.2%
Tholukwazi Primary School	0.3	0.3	-3.6%	0.3	-3.6%	0.3	2.3%
School	1.0	0.9	-2.3%	0.9	-2.3%	1.0	1.5%
TP Stratten Primary School	0.2	0.1	-7.1%	0.1	-7.2%	0.2	4.6%
Laerskool Goedeheop	0.4	0.3	-7.9%	0.3	-7.9%	0.4	5.1%
Laerskool Kruijnpark	0.4	0.4	-9.1%	0.4	-9.1%	0.4	5.9%
Lifaletu Primary School	0.4	0.4	-3.3%	0.4	-3.3%	0.4	2.1%
Secunda Medi Clinic	0.6	0.6	-3.0%	0.6	-3.0%	0.6	2.0%
Embalenhle Primary School	0.3	0.3	-3.6%	0.3	-3.6%	0.3	2.3%
Buyani Primary School	0.3	0.3	-3.4%	0.3	-3.5%	0.3	2.2%
Allan Makhunga Primary School	0.5	0.5	-2.9%	0.5	-2.9%	0.6	1.9%

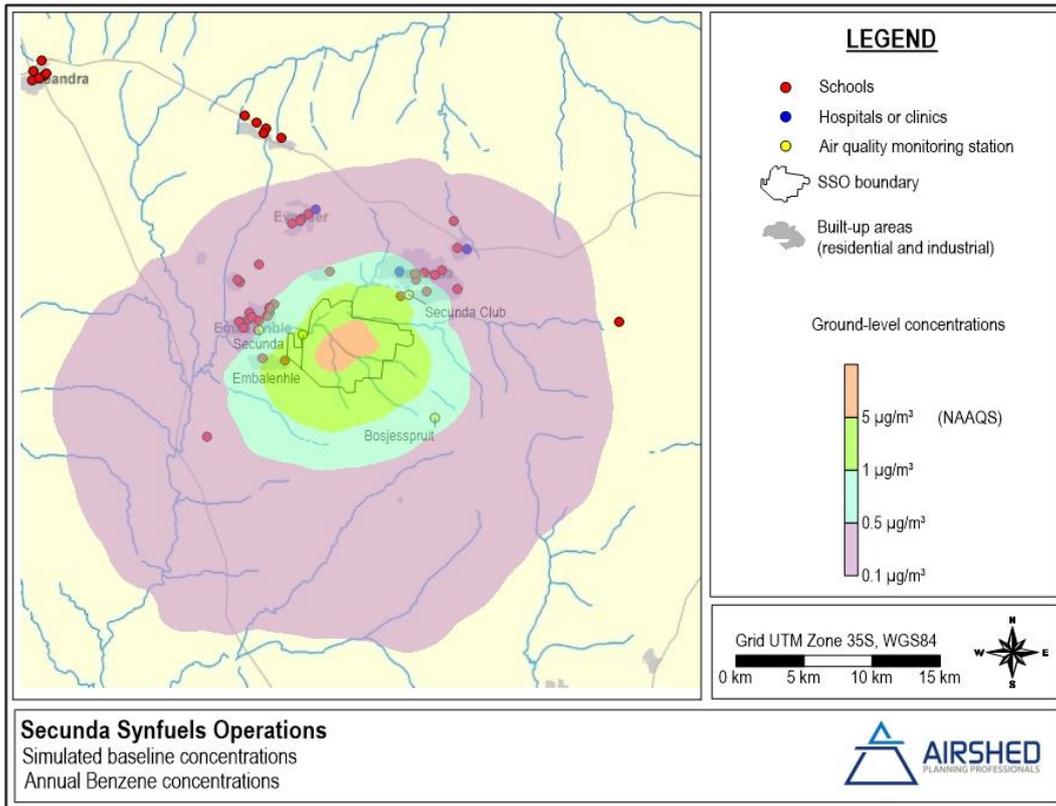


Figure 5-99: Simulated annual benzene concentrations as a result of baseline emissions

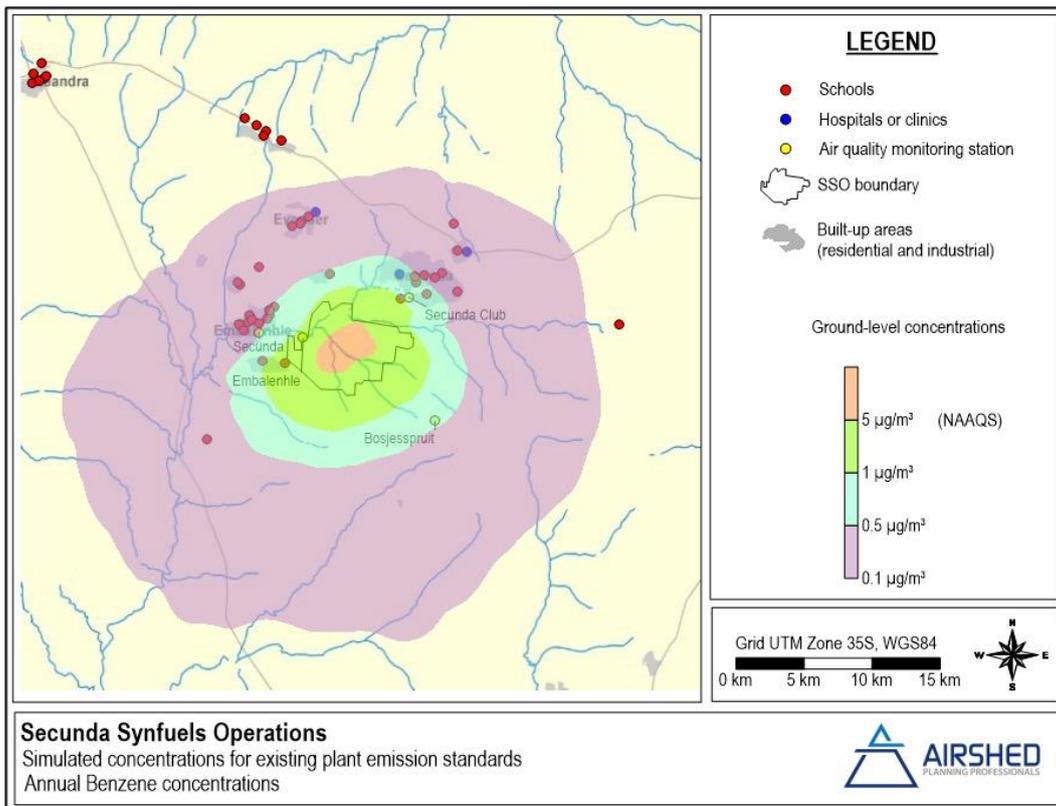


Figure 5-100: Simulated annual benzene concentrations as a result of theoretical compliance with existing plant emission standards

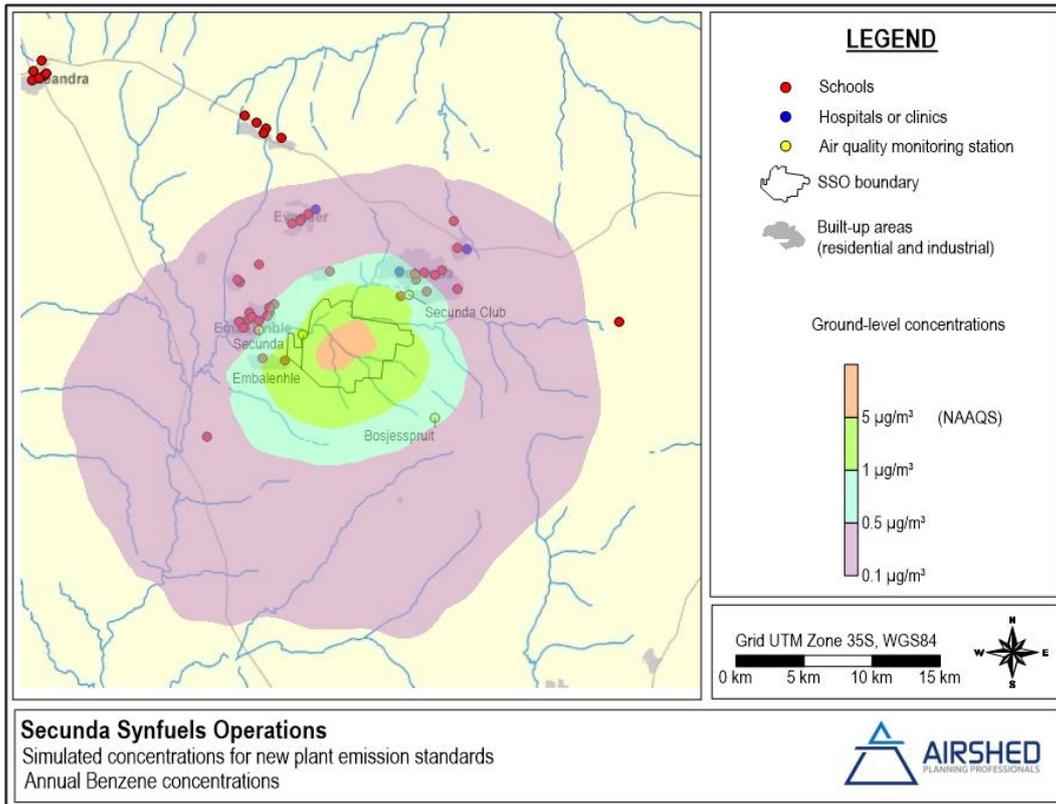


Figure 5-101: Simulated annual benzene concentrations as a result of theoretical compliance with new plant emission standards

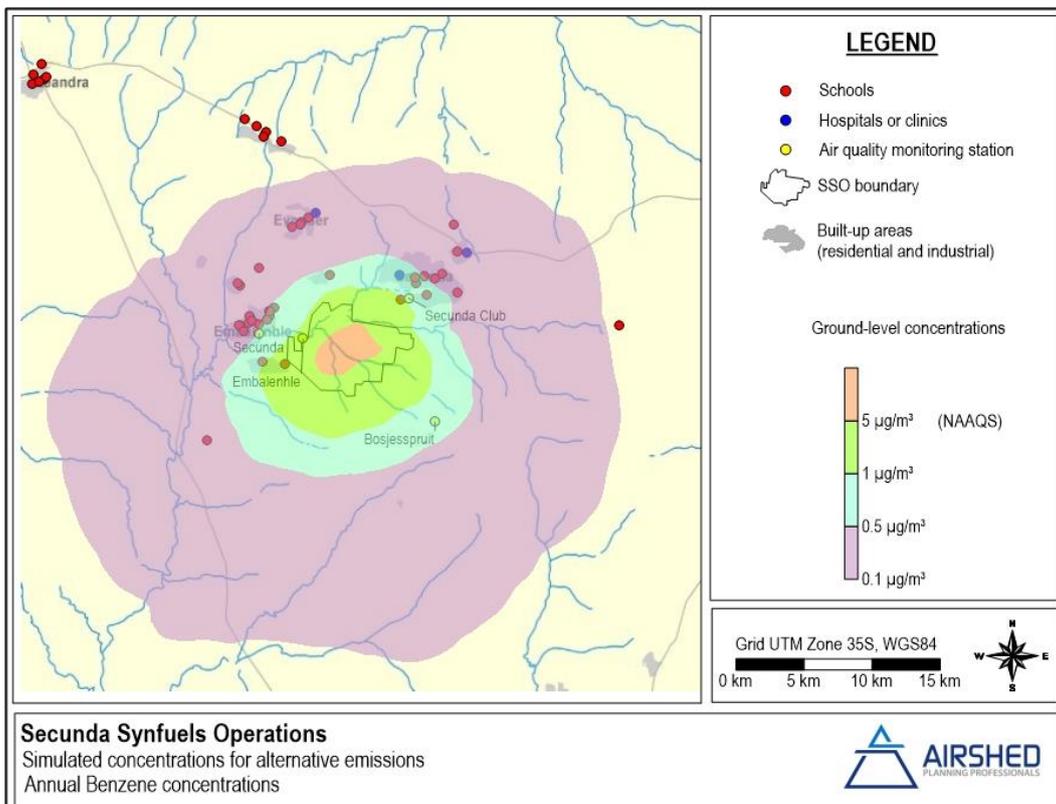


Figure 5-102: Simulated annual benzene concentrations as a result of alternative emissions

5.1.8.2 Non-Criteria Pollutants

Ambient pollutant concentrations, either from the dispersion modelling or from direct physical measurements, are typically compared to defined standards or other thresholds to assess the health and/or environmental risk implications of the predicted or measured air quality. In South Africa, NAAQS have been set for criteria pollutants at limits deemed to uphold a permissible level of health risk and the assessment has accordingly been based on a comparison between the predicted concentrations and the NAAQS. The measured concentrations have been used to ascertain the representativeness of the modelling and to assess compliance with the NAAQS as a function of all sources of emissions.

Where NAAQS have not been set health-effect screening levels, appropriate for assessing the non-criteria pollutants emitted from SO, were identified from literature reviews and internationally recognised databases. These non-criteria pollutants for which screening levels were identified include, various emissions from the incinerators, namely lead (Pb), arsenic (As), antimony (Sb), chromium (Cr), cobalt (Co), copper (Cu), manganese (Mn), nickel (Ni) and vanadium (V). The health-effect screening levels used are listed in Table 5-32.

Table 5-32: Most stringent health-effect screening level identified for all non-criteria pollutants assessed

Compound	Acute exposure ^(a) [units: µg/m ³]	Chronic exposure ^(b) [units: µg/m ³]
Lead (Pb)	(c)	(d)
Arsenic (As)	0.2 (g)	0.015 (g)
Antimony (Sb)	(c)	(d)
Chromium (Cr)	(c)	0.1 (e)
Cobalt (Co)	(c)	0.1 (f)
Copper (Cu)	100 (g)	(d)
Manganese (Mn)	(c)	0.05 (e)
Nickel (Ni)	0.2 (g)	0.014 (g)
Vanadium (V)	0.8 (f)	0.1 (f)
Ammonia (NH ₃)	1 184 (f)	(d)
Hydrogen chloride (HCl)	2 100 (g)	(d)
Hydrogen fluoride (HF)	240 (g)	(d)
Volatile organic compounds (VOCs)	(c)	200 (h)

(a) Hourly concentrations compared with short-term / acute exposure health effect screening level
(b) Annual concentrations compared with long-term / chronic exposure health effect screening level
(c) No hourly health-effect screening level
(d) No annual health-effect screening level
(e) US-EPA IRIS Inhalation Reference Concentrations (µg/m³)
(f) US ATSDR Maximum Risk Levels (MRLs) (µg/m³)
(g) Californian OEHHA (µg/m³)
(h) ECA (1992) – Chronic comfort range upper level

5.1.8.2.1 Metal Elements

A screening exercise of non-criteria pollutants emitted from the incinerators at SSO, including all non-criteria pollutants listed in Table 5-21, was undertaken to identify pollutants that would be likely to exceed the most stringent health-effect screening levels identified (Table 5-32). The non-criteria pollutants that would possibly exceed the screening level concentrations included: As, Cr, Co, Mn, Ni, and V. Further analysis, using the emission rate of each metal element rather than the sum of

metals, showed that predicted ground-level arsenic concentrations for the alternative emission scenario may exceed the evaluation criterion (Table 5-33). An isopleth plot of the results shows that the potential exceedances are not likely to occur outside of the SSO boundary (Figure 5-103). All other pollutants comply (Table 5-33) with the strictest health effect screening level concentrations across the modelling domain.

Table 5-33: Screening of non-criteria pollutants against health risk guidelines

Metallic element	Acute exposure ^(a) [units: µg/m ³]			Chronic exposure ^(b) [units: µg/m ³]		
	Minimum concentration ^(c)	Maximum concentration ^(d)	Strictest health effect screening level	Minimum concentration ^(c)	Maximum concentration ^(d)	Strictest health effect screening level
<i>Baseline Emissions</i>						
As	4.00E-03	9.23E-02	0.2 ^(g)	1.40E-06	1.70E-03	0.015 ^(h)
Ni	1.93E-04	2.59E-02	0.2 ^(g)	6.11E-07	5.90E-04	0.014 ^(h)
V	9.82E-05	1.53E-02	0.8 ^(f)			
<i>Existing Plant Standards and New Plant Standards</i>						
As	3.00E-04	6.18E-02	0.2 ^(g)	8.62E-07	1.10E-03	0.015 ^(h)
Ni	8.57E-05	1.57E-02	0.2 ^(g)	2.90E-07	3.19E-04	0.014 ^(h)
<i>Alternative Emissions</i>						
As	1.40E-02	3.23E-01	0.2 ^(g)	4.62E-06	5.85E-03	0.015 ^(h)
Cr				1.53E-06	1.76E-03	0.1 ^(e)
Co				1.54E-07	2.03E-04	0.1 ^(f)
Mn				1.53E-05	2.13E-02	0.05 ^(e)
Ni	7.33E-04	1.19E-01	0.2 ^(g)	2.41E-06	2.81E-03	0.014 ^(h)
V	3.69E-04	4.70E-02	0.8 ^(f)	1.21E-06	1.05E-06	0.1 ^(f)

- (a) hourly concentrations compared with short-term / acute exposure health effect screening level
- (b) annual concentrations compared with long-term / chronic exposure health effect screening level
- (c) minimum concentration simulated across the domain
- (d) maximum concentration simulated across the domain
- (e) US-EPA IRIS Inhalation Reference Concentrations (µg/m³)
- (f) US ATSDR Maximum Risk Levels (MRLs) (µg/m³)
- (g) Californian OEHHA (µg/m³) – acute
- (h) Californian OEHHA (µg/m³) – chronic

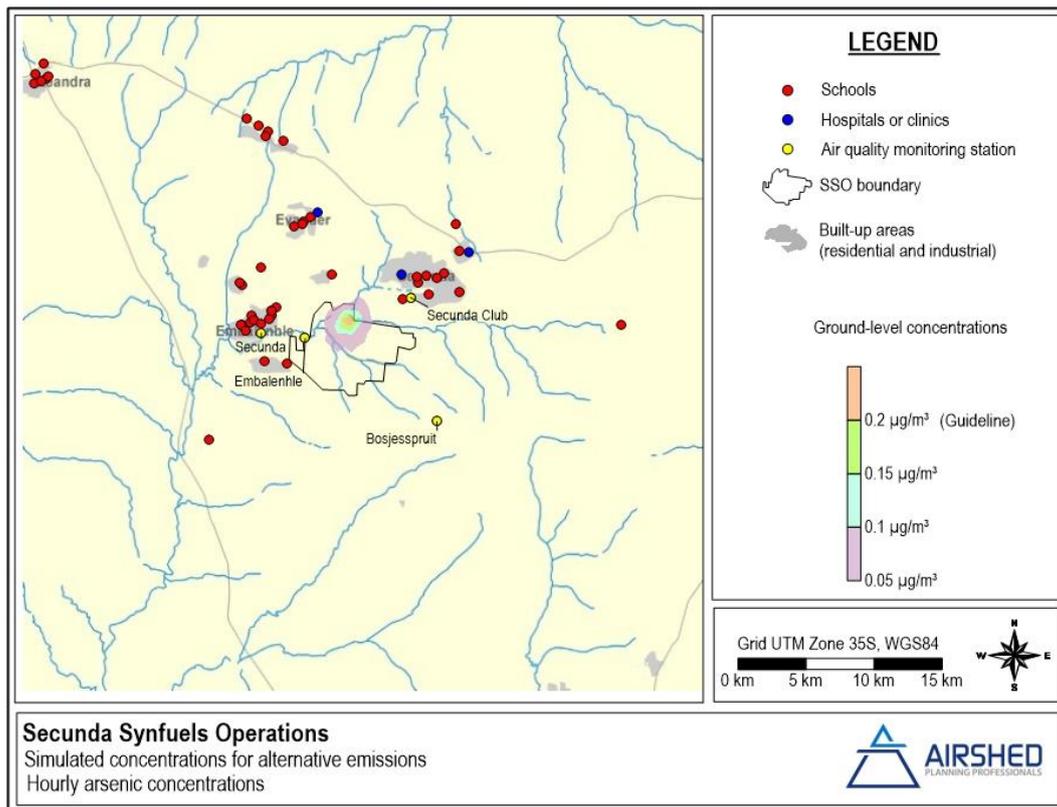


Figure 5-103: Simulated hourly arsenic concentrations as a result of alternative emissions

5.1.8.2.2 Volatile Organic Compounds (VOCs)

Total VOC emissions from four source groups (Rectisol, tar value chain storage tanks, Phenosolvan saturation columns, and incinerators) at SSO were simulated. Four emission scenarios were simulated as described in Section 5.1.1.2. The sources where emissions varied across the scenarios were the Phenosolvan saturation columns and the incinerators.

Simulated annual VOC concentrations are below the (non-statutory) evaluation criterion of 200 µg/m³ (ECA, 1992) for four scenarios (Figure 5-104 and Table 5-31). Theoretical compliance with the existing and new plant emission standards would likely reduce annual benzene concentrations by up to 32%, however the alternative emissions would likely result in increased benzene concentrations relative to the baseline (by a maximum of 97%) (Table 5-31).

Isopleth plots are presented for annual average ground-level benzene concentrations as a result of all emission scenarios for SSO, as per the figure numbers below:

Scenario	Annual
Baseline concentrations	Figure 5-105
Existing Plant standards	Figure 5-106
New Plant standards	Figure 5-107
Alternative emissions	Figure 5-108

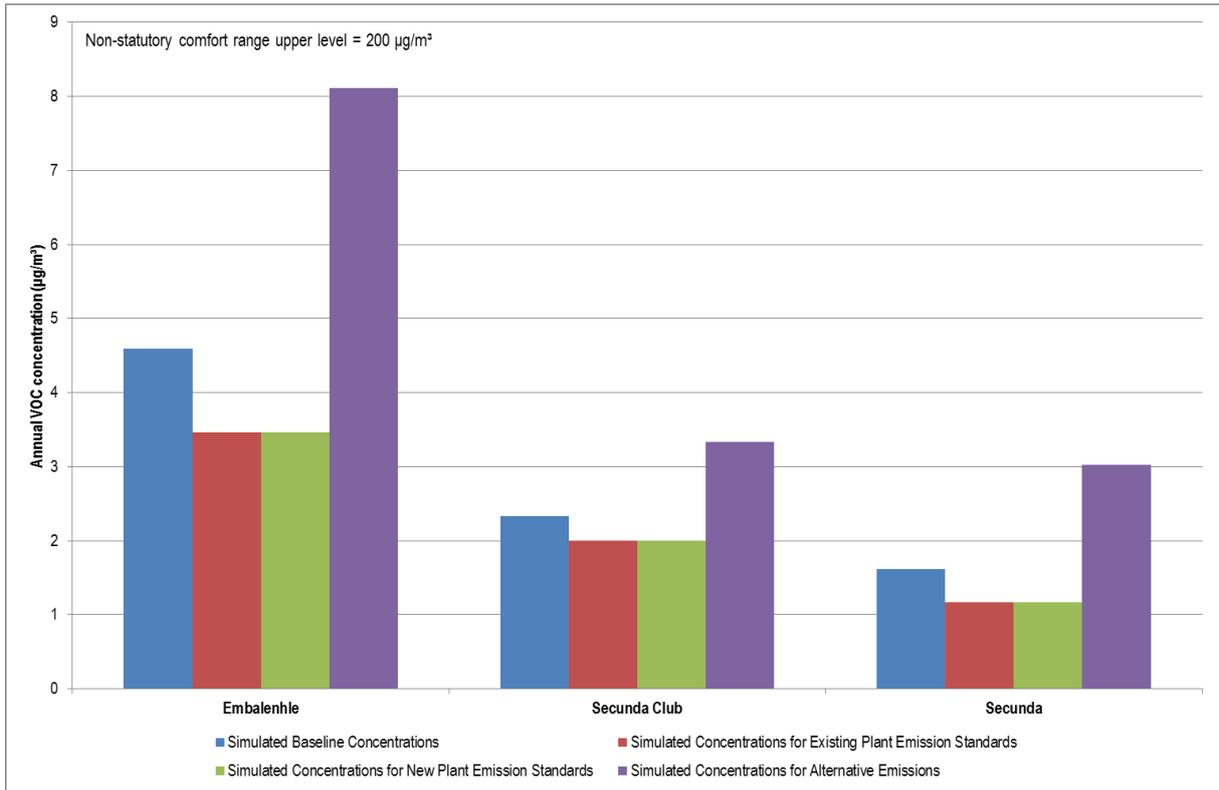


Figure 5-104: Simulated annual VOC concentrations at AQMS for SSO

Table 5-34: Simulated baseline annual VOC concentrations and the theoretical change in concentrations relative to the baseline at the AQMS and 20 closest receptors

Receptor	Annual VOC						
	Baseline	Existing		New		Alternative	
	Concentration (µg/m³)	Concentration (µg/m³)	Relative change	Concentration (µg/m³)	Relative change	Concentration (µg/m³)	Relative change
Embalenhle AQMS	2.2	1.9	-15.1%	1.9	-15.1%	3.2	44.9%
Secunda Club AQMS	2.2	1.9	-15.1%	1.9	-15.1%	3.2	44.9%
Secunda AQMS	1.5	1.1	-27.7%	1.1	-27.7%	2.8	86.9%
Bosjesspruit AQMS	1.6	1.2	-26.1%	1.2	-26.1%	2.8	71.3%
Roodebank Combined School	1.0	0.7	-31.3%	0.7	-31.3%	1.9	92.5%
Zamokuthle Primary School	1.2	0.8	-29.9%	0.8	-29.9%	2.3	93.7%
Osizweni Secondary School	0.6	0.5	-27.4%	0.5	-27.4%	1.2	85.4%
Isibanisesizwe Primary School	1.5	1.1	-24.9%	1.1	-24.9%	2.7	79.7%
Maphala-Gulube Primary School	4.6	3.7	-20.6%	3.7	-20.6%	7.4	60.5%
Kiriyatswane Secondary School	1.5	1.1	-23.8%	1.1	-23.9%	2.6	77.1%
Osizweni Primary School	0.6	0.4	-27.3%	0.4	-27.3%	1.1	84.7%
Kusasaletu Secondary School	1.4	1.1	-26.7%	1.1	-26.7%	2.6	84.0%
Laerskool Oranjegloed	1.6	1.3	-16.5%	1.3	-16.5%	2.3	47.7%
Highveld Medi Clinic/Hydromed	0.6	0.5	-26.3%	0.5	-26.3%	1.1	75.7%
Tholukwazi Primary School	1.0	0.7	-30.8%	0.7	-30.8%	2.0	96.7%
School	2.6	2.2	-14.4%	2.2	-14.4%	3.7	44.2%
TP Stratten Primary School	0.5	0.3	-25.9%	0.3	-25.9%	0.8	76.4%
Laerskool Goedehoop	1.0	0.8	-23.8%	0.8	-23.8%	1.7	66.2%
Laerskool Kruinpark	1.1	0.8	-27.0%	0.8	-27.1%	2.0	75.5%
Lifaletu Primary School	1.2	0.9	-27.9%	0.9	-27.9%	2.2	88.1%
Secunda Medi Clinic	1.6	1.3	-17.8%	1.3	-17.8%	2.5	54.4%
Embalenhle Primary School	1.0	0.7	-30.8%	0.7	-30.8%	2.0	96.6%
Buyani Primary School	1.0	0.7	-28.0%	0.7	-28.0%	1.9	89.5%
Allan Makhunga Primary School	1.6	1.2	-24.0%	1.2	-24.0%	2.8	77.7%

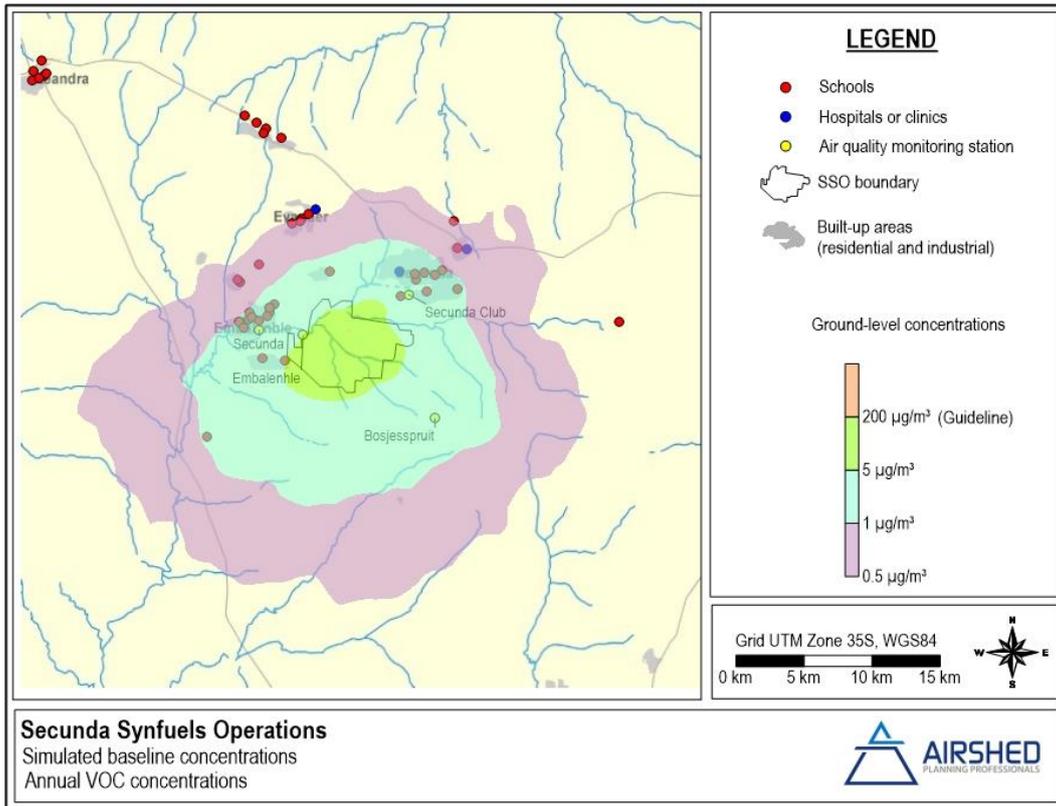


Figure 5-105: Simulated annual VOC concentrations as a result of baseline emissions

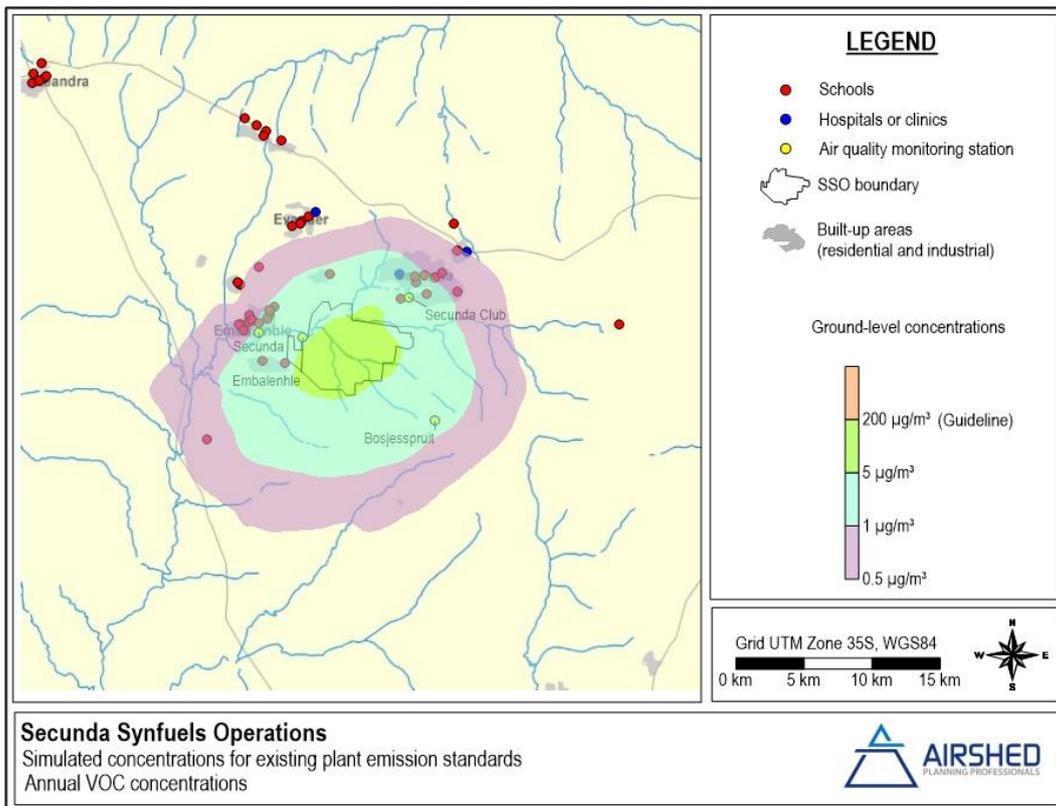


Figure 5-106: Simulated annual VOC concentrations as a result of theoretical compliance with existing plant emission standards

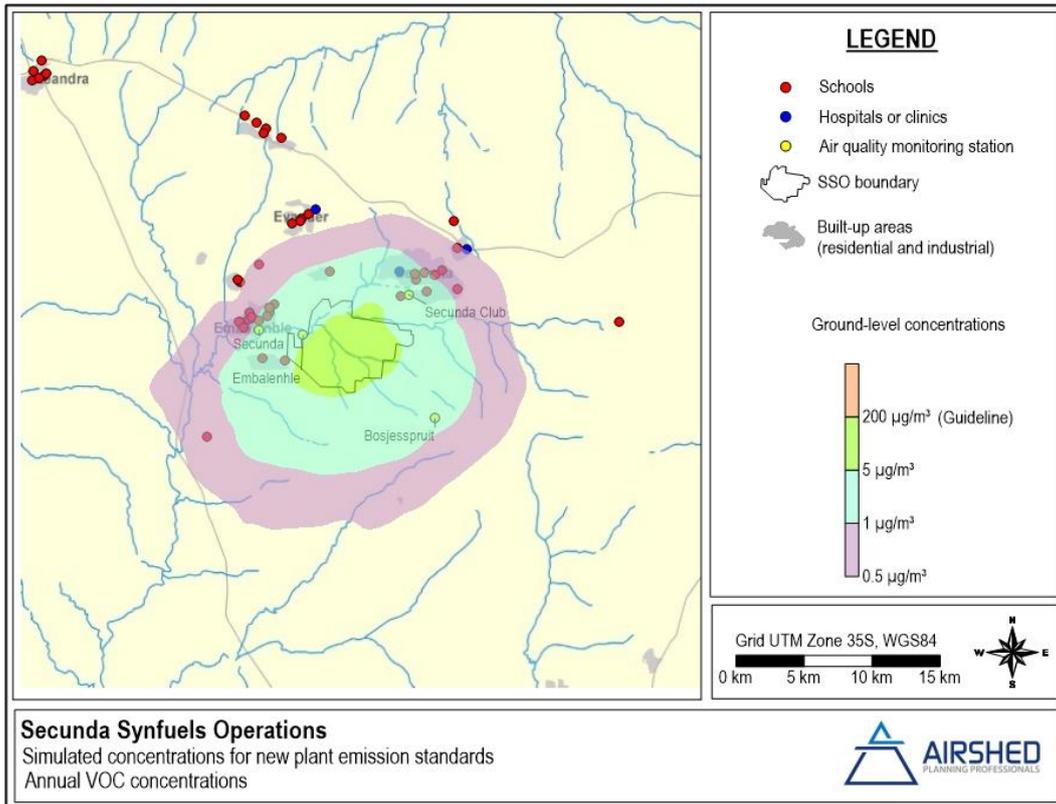


Figure 5-107: Simulated annual VOC concentrations as a result of theoretical compliance with new plant emission standards

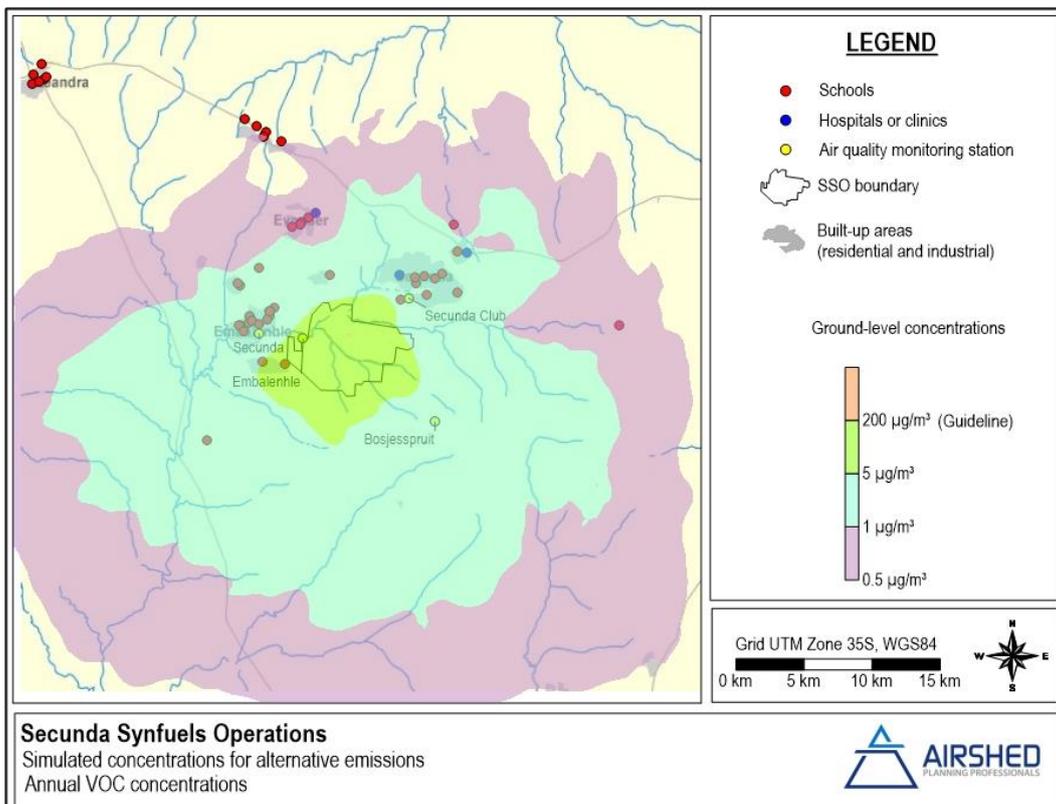


Figure 5-108: Simulated annual VOC concentrations as a result of alternative emissions

5.1.8.2.3 Hydrogen Sulphide (H₂S)

Dispersion modelling included assessing the ambient impact of baseline H₂S emissions from the SSO Sulfur Recovery Plant. Predicted daily H₂S concentrations were compared against the WHO (2000) 24-hour health-based guideline (150 µg/m³) for Sulfur Recovery Plant Emissions (Figure 5-109) where no exceedances of the guideline were predicted.

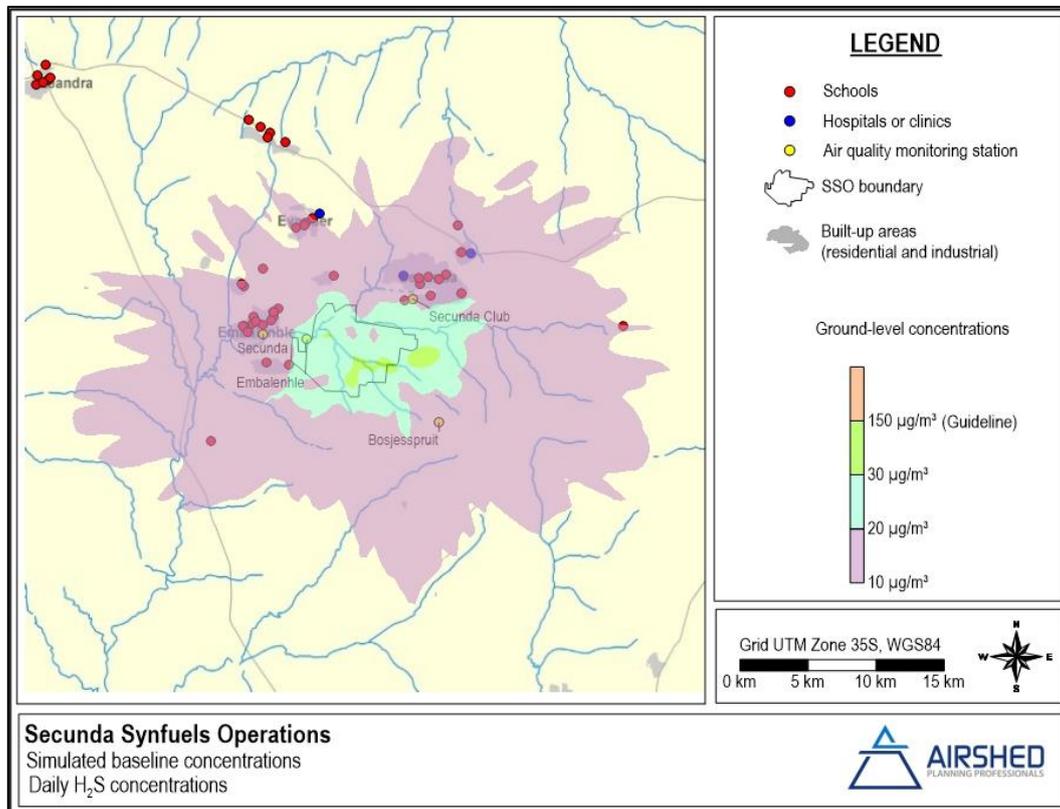


Figure 5-109: Simulated daily H₂S concentrations as a result of baseline emissions from the Sulfur Recovery Plant

After consultation with Dr WCA van Niekerk (Infotox²), the simulated 4-hourly ambient H₂S concentrations were compared against the more conservative 135 µg/m³ health effect screening level (4-hour average) recommended by Haahtele *et al.* (1992). At this exposure level, health effects include difficulty breathing, irritation of eyes, headache and nausea.

The dispersion modelling findings show that for the baseline emissions, off-site receptors are not likely to experience H₂S concentrations above the health-effect screening level (Figure 5-110).

² Report to SASOL Document number 032-2013 Rev 1.0: Toxicological review for Hydrogen Sulphide

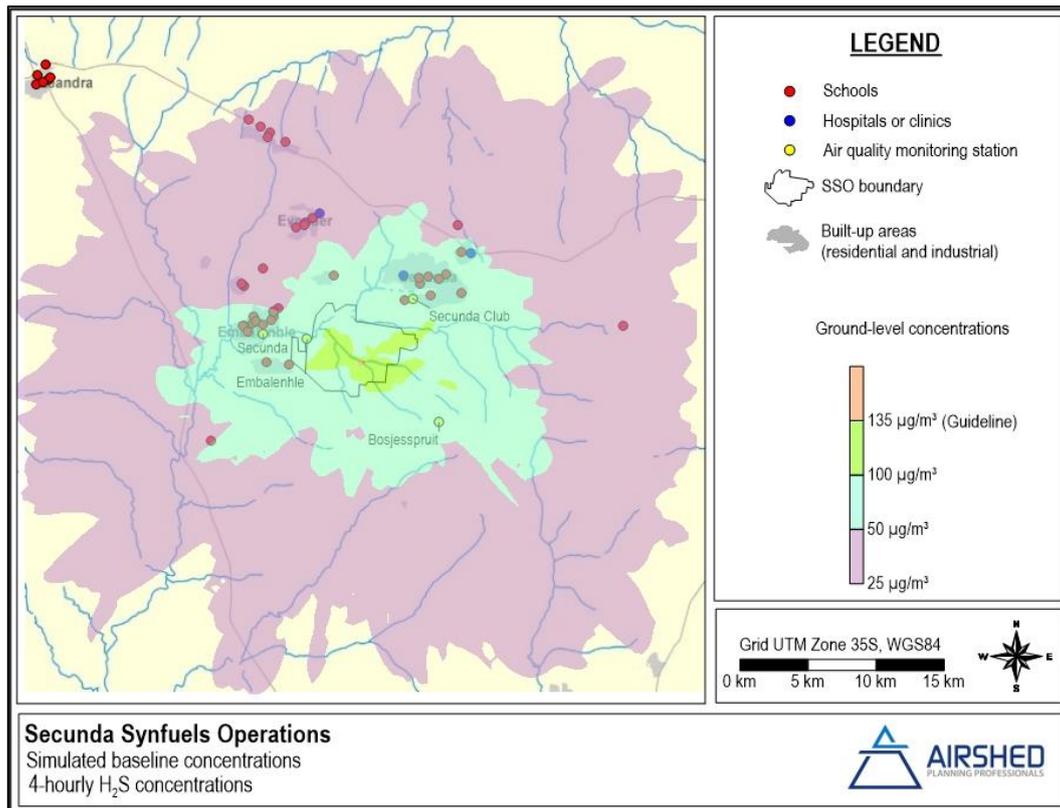


Figure 5-110: Simulated 4-hourly H₂S concentrations as a result of baseline emissions from the Sulfur Recovery Plant

5.1.9 Uncertainty of Modelled Results

The main steps of uncertainty management are to:

- identify and understand uncertainties;
- understand whether uncertainties matter for decisions being made at the time;
- if they do matter, decide what to do about them; and,
- recommend a way forward.

Managing uncertainties attempts to eliminate the source of technical disagreements and failure to understand them often leads to a conclusion that all uncertainties need to be eliminated before project decisions can be made. The first decision about how to manage uncertainties relates to their significance given the decision being addressed. In the current context, the different parts of the investigation were grouped into similar uncertainty regimes, namely:

- dispersion model uncertainties;
- input data uncertainties;
- the methodology of validating model results; and,
- the methodology of expressing the modelled scenarios.

A comprehensive discussion on uncertainties is provided in Appendix I.

As discussed in Section 5.1.6, the baseline predictions with the inclusion of estimated background concentrations performed well within the generally accepted (U.S. EPA 2005) “factor of two” accuracy of dispersion models. Unless greater general experience is gained or some further formal validation studies are conducted, it is not possible to say how much more confidence can be given to well-executed plume and puff models.

However, with the incremental differences between scenarios expressed as a ratio of the baseline concentration, the impact of model inaccuracies are essentially eliminated. As discussed in Appendix I, it is estimated that the ambient monitoring has an uncertainty of 5% with a 95% confidence interval and the emissions monitoring an uncertainty of 10% with a 95% confidence interval. Based on these uncertainties, it is estimated that the concentration ratios of the different emission scenarios have an uncertainty of -22.9% and +27.4%.

The Intergovernmental Panel on Climate Change (IPCC) produced a qualitative method for consistent communication of uncertainties in the IPCC Fifth Assessment Report. This Guidance Note has been summarised in Appendix J. On application of this guide, the results from this investigation is considered to be of “high confidence” based on a “high agreement” of the baseline predictions with observations, albeit based only on three monitoring sites, i.e. “medium evidence”.

5.2 Analysis of Emissions’ Impact on the Environment

5.2.1 Critical Levels for Vegetation

The impact of SO emissions on surrounding vegetation was assessed by comparing the simulated annual SO₂ and NO₂ concentrations for each of the four emission scenarios against the critical levels for vegetation as defined by the United Nations Economic Commission for Europe (UNECE) Convention on Long Range Trans-boundary Air Pollution Limits (CLRTAP, 2015) (Table 5-35).

Table 5-35: Critical levels for SO₂ and NO₂ by vegetation type (CLRTAP, 2015)

Pollutant	Vegetation type	Critical Level (µg/m ³)	Time Period ^(a)
SO ₂	Cyanobacterial lichens	10	Annual average
	Forest ecosystems (including understorey vegetation)	20	Annual average and Half-year mean (winter)
	(Semi-)natural vegetation	20	Annual average and Half-year mean (winter)
	Agricultural crops	30	Annual average and Half-year mean (winter)
NO ₂	All	30	Annual average and Half-year mean (winter)
		75	Daily average
Notes:			
(a) For the purposes of mapping of critical levels and exceedances CLRTAP recommend using only the annual average, due to increased reliability of mapped and simulated data for the longer time period. It is also noted that long-term effects of NO _x are considered to be more significant than short-term effects (CLRTAP, 2015).			

The simulated off-site annual concentrations of SO₂ for all emission scenarios are not likely to exceed the levels for even the most sensitive vegetation type (lichen) (Figure 5-111 to Figure 5-114). Similarly, off-site NO₂ concentrations are likely to be below the critical levels for all vegetation types (Figure 5-115 to Figure 5-118)

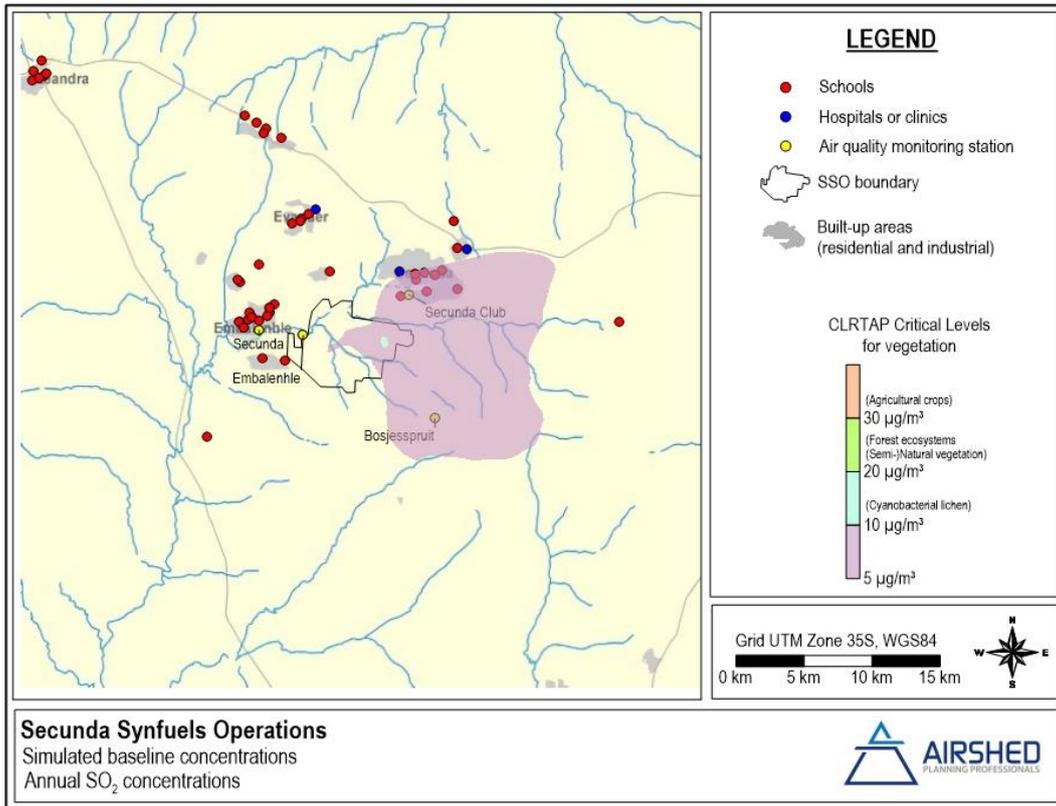


Figure 5-111: Annual SO₂ concentrations as a result of baseline emissions compared with CLRTAP critical levels

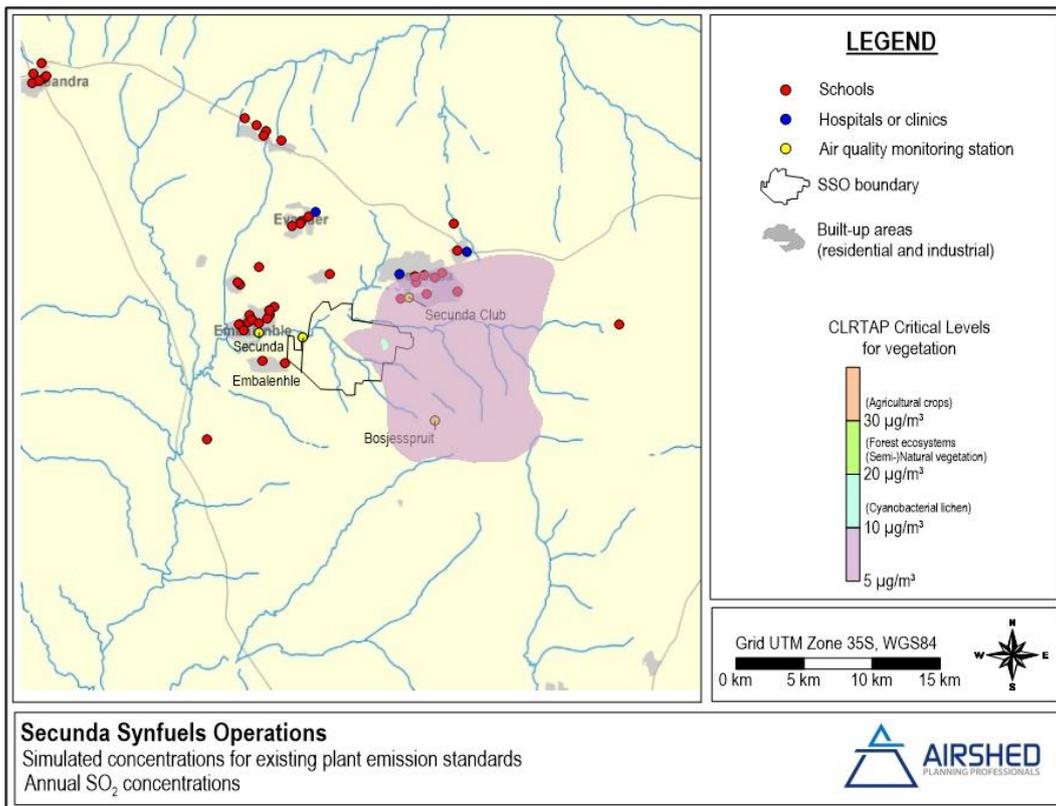


Figure 5-112: Annual SO₂ concentrations as a result of theoretical compliance with existing plant emission standards compared with CLRTAP critical levels

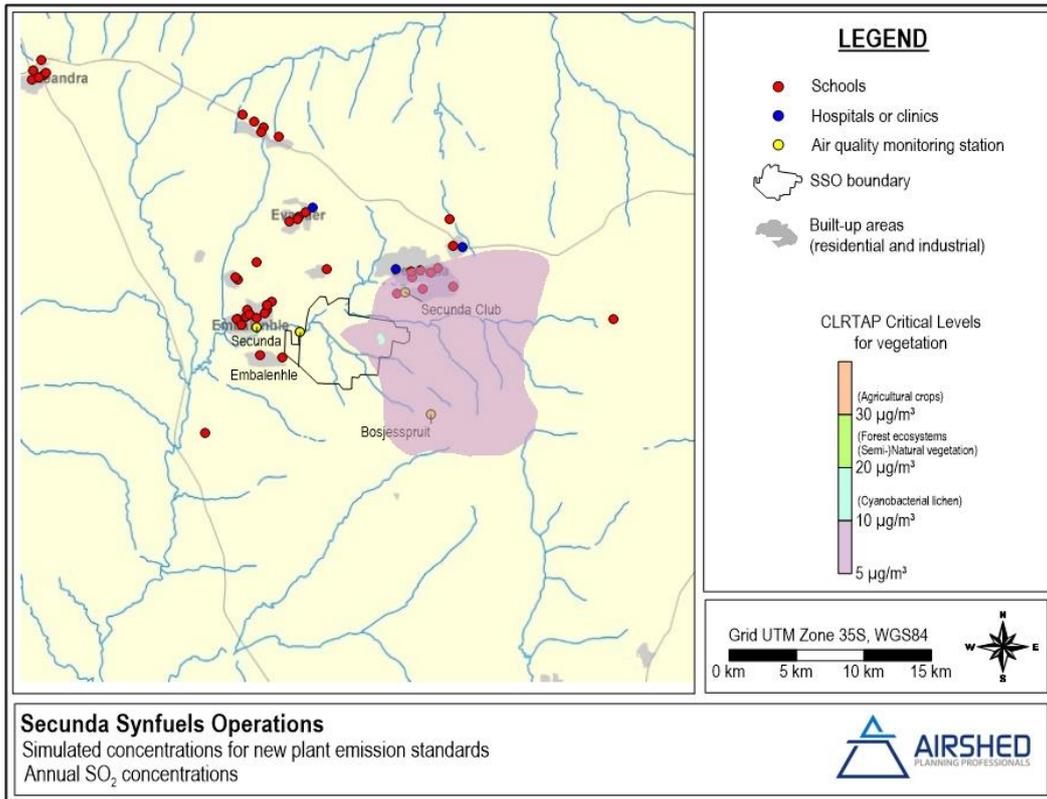


Figure 5-113: Annual SO₂ concentrations as a result of theoretical compliance with new plant emission standards compared with CLRTAP critical levels

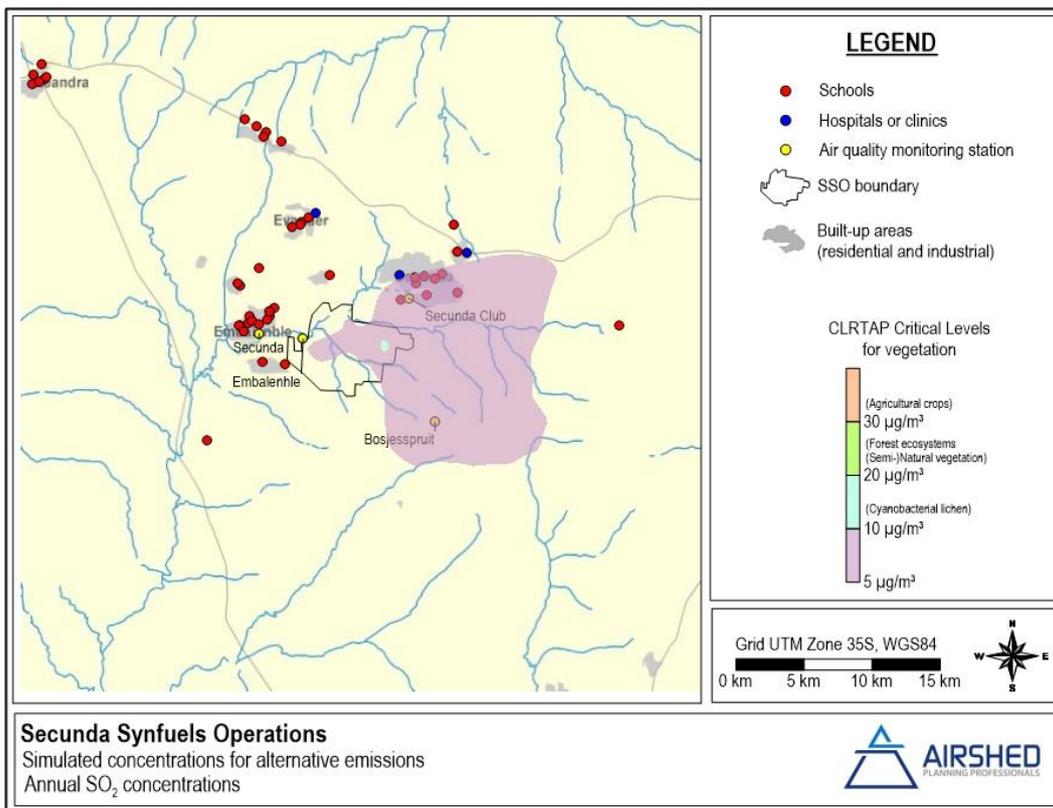


Figure 5-114: Annual SO₂ concentrations as a result alternative emissions compared with CLRTAP critical levels

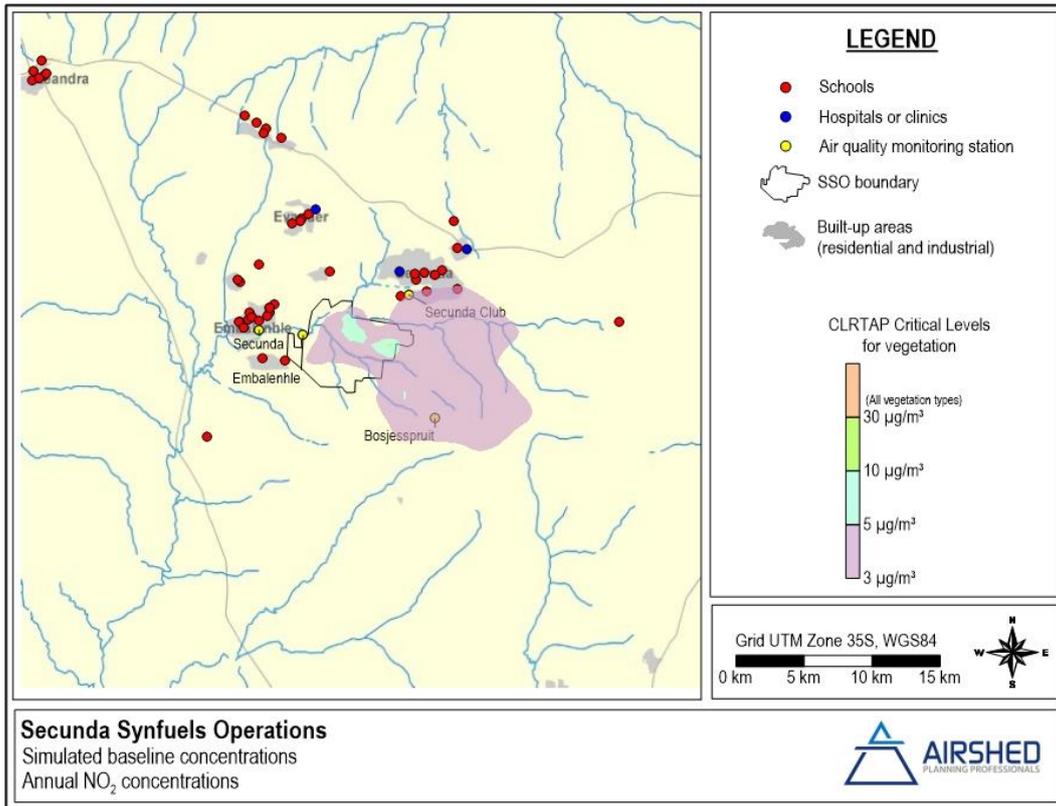


Figure 5-115: Annual NO₂ concentrations as a result of baseline emissions compared with CLRTAP critical levels

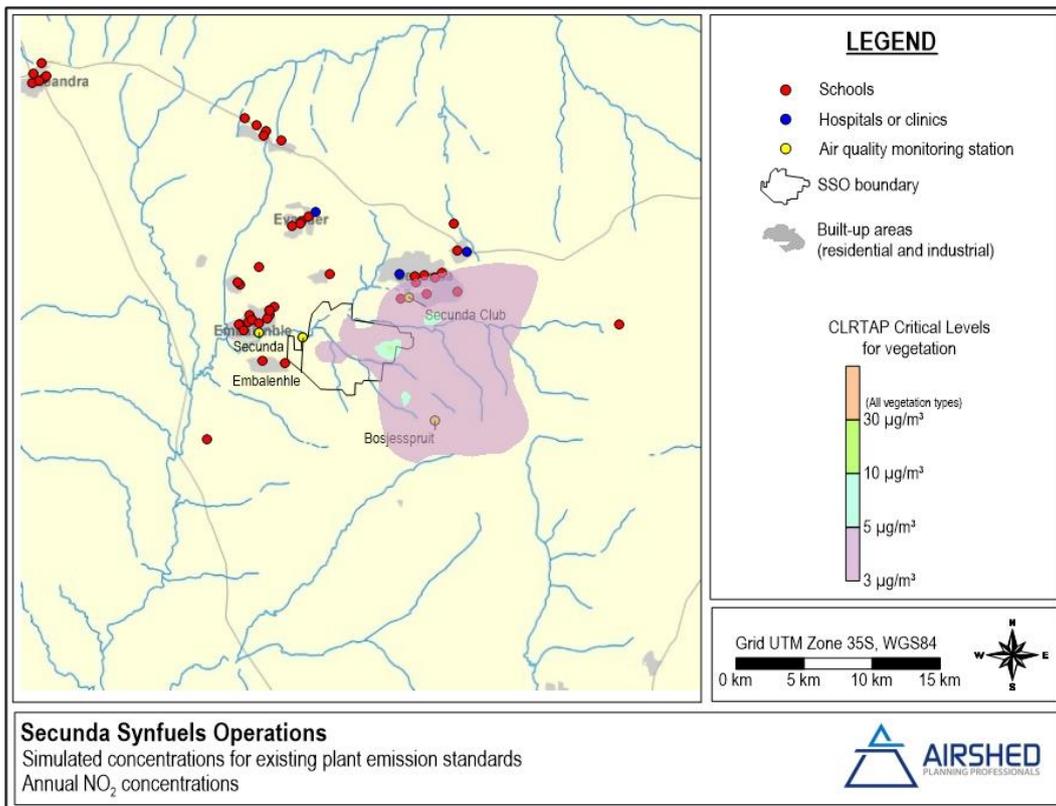


Figure 5-116: Annual NO₂ concentrations as a result of theoretical compliance with existing plant emission standards compared with CLRTAP critical levels

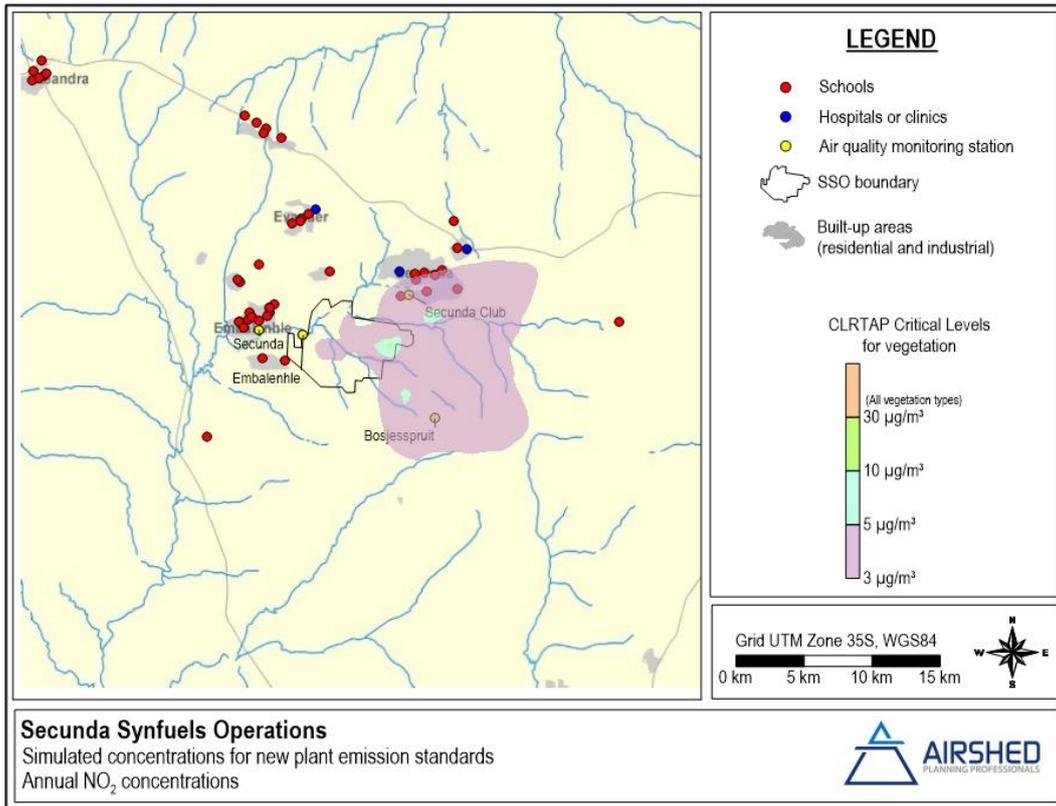


Figure 5-117: Annual NO₂ concentrations as a result of theoretical compliance with new plant emission standards compared with CLRTAP critical levels

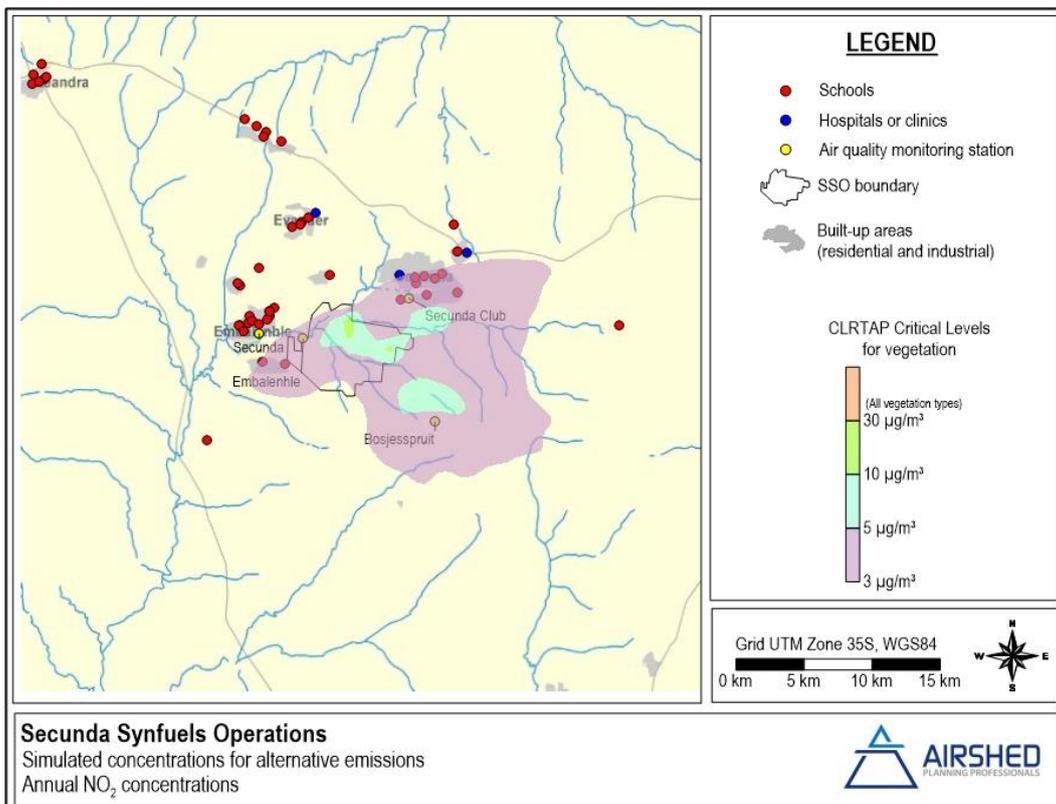


Figure 5-118: Annual NO₂ concentrations as a result of alternative emissions compared with CLRTAP critical levels

5.2.2 Dustfall

Dustfall deposition rates were estimated as a result of particulate emissions from the SSO point sources. The simulated PM concentrations (Section 5.1.8.1.3) were converted to deposition rates by assuming a settling velocity of 6.43×10^{-3} m/s (based on a $10 \mu\text{m}$ particle with a density of 2.1 g/m^3). Estimated dustfall rates for the four simulation scenarios were less than $22 \text{ mg/m}^2\cdot\text{day}$ where theoretical compliance with the existing and new plant emission standards would likely result in the lowest dustfall rates (Table 5-36). Isopleth plots are presented for dustfall deposition rates for the four scenarios in Figure 5-119 to Figure 5-122. Simulated dustfall rates have been compared to the acceptable dustfall rate applicable to residential areas as defined by the NDCR (Table 5-3).

Table 5-36: Summary of dustfall deposition rates as a result of particulate emissions from SSO

Criteria	Daily dustfall rate ($\text{mg/m}^2\cdot\text{day}$)			
	Simulated Baseline Concentrations	Simulated Concentrations for Existing Plant Emission Standards	Simulated Concentrations for New Plant Emission Standards	Simulated Concentrations for Alternative Emissions
Min	0.61	0.61	0.61	0.62
Max	8.25	8.20	8.19	21.38

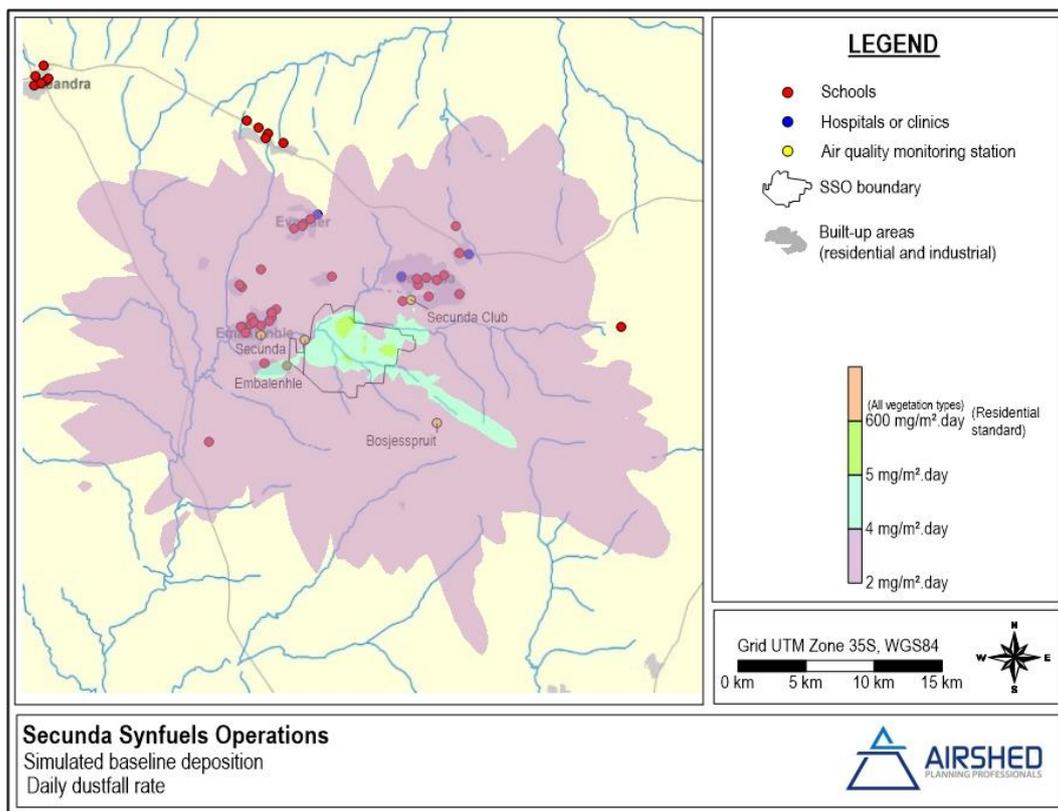


Figure 5-119: Simulated daily dustfall as a result of baseline emissions

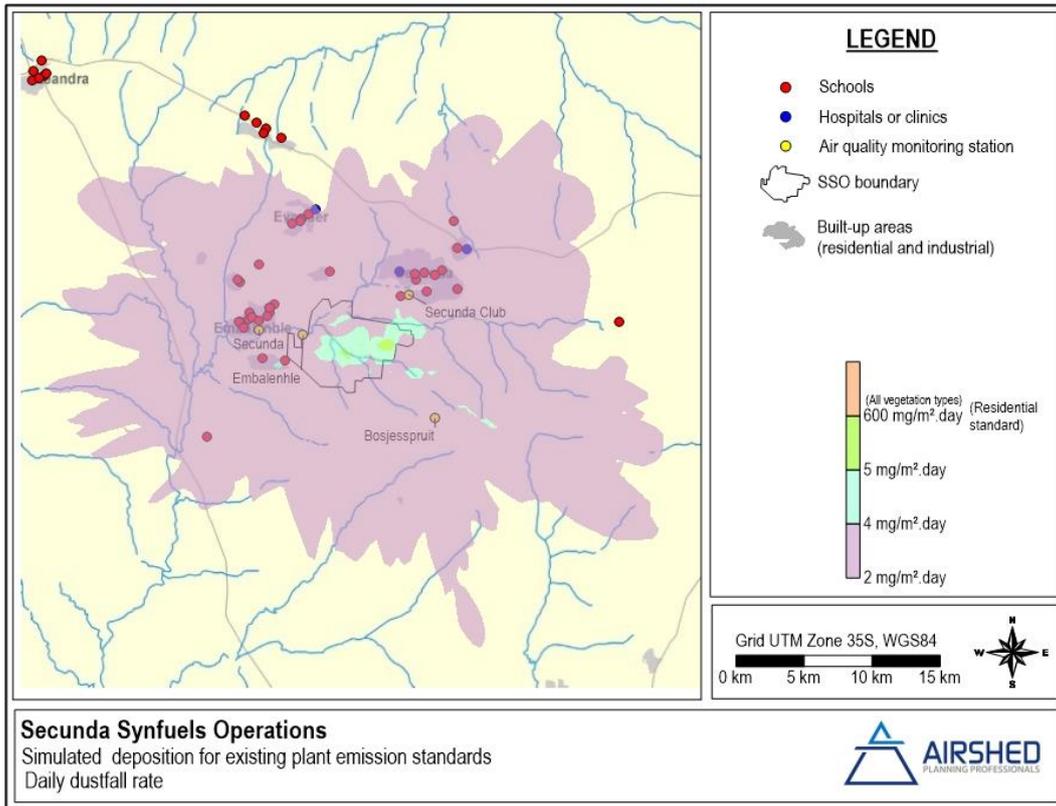


Figure 5-120: Simulated daily dustfall as a result of theoretical compliance with existing plant standards

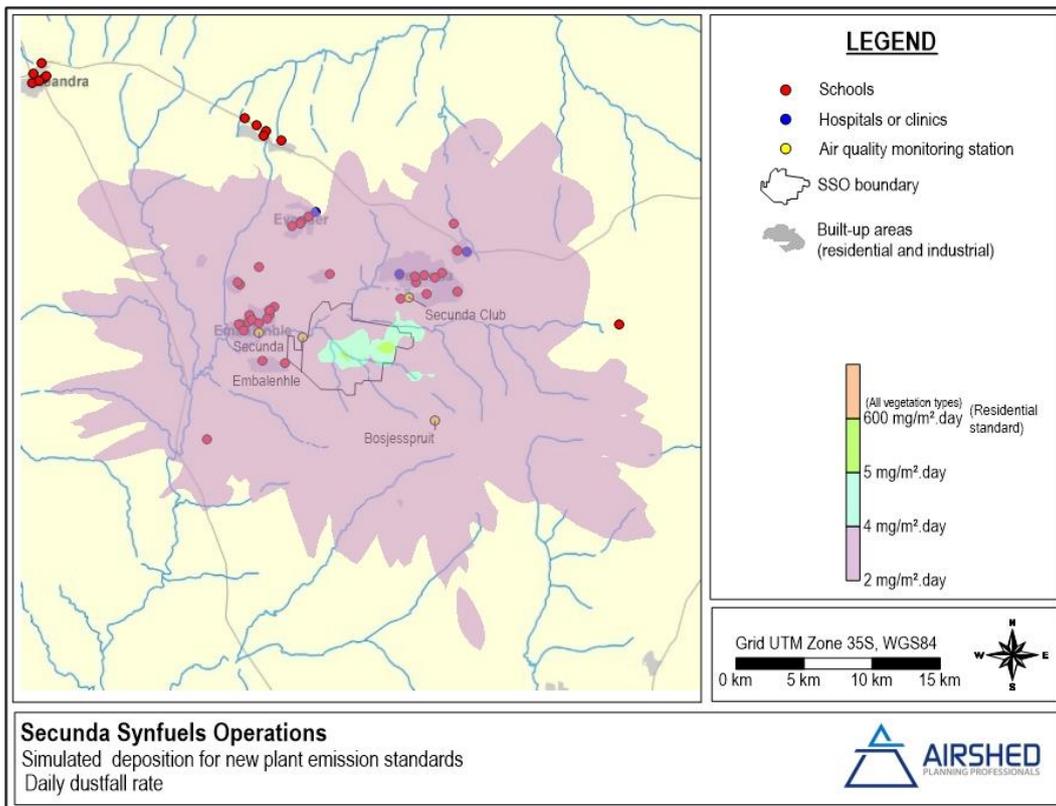


Figure 5-121: Simulated daily dustfall as a result of theoretical compliance with new plant standards

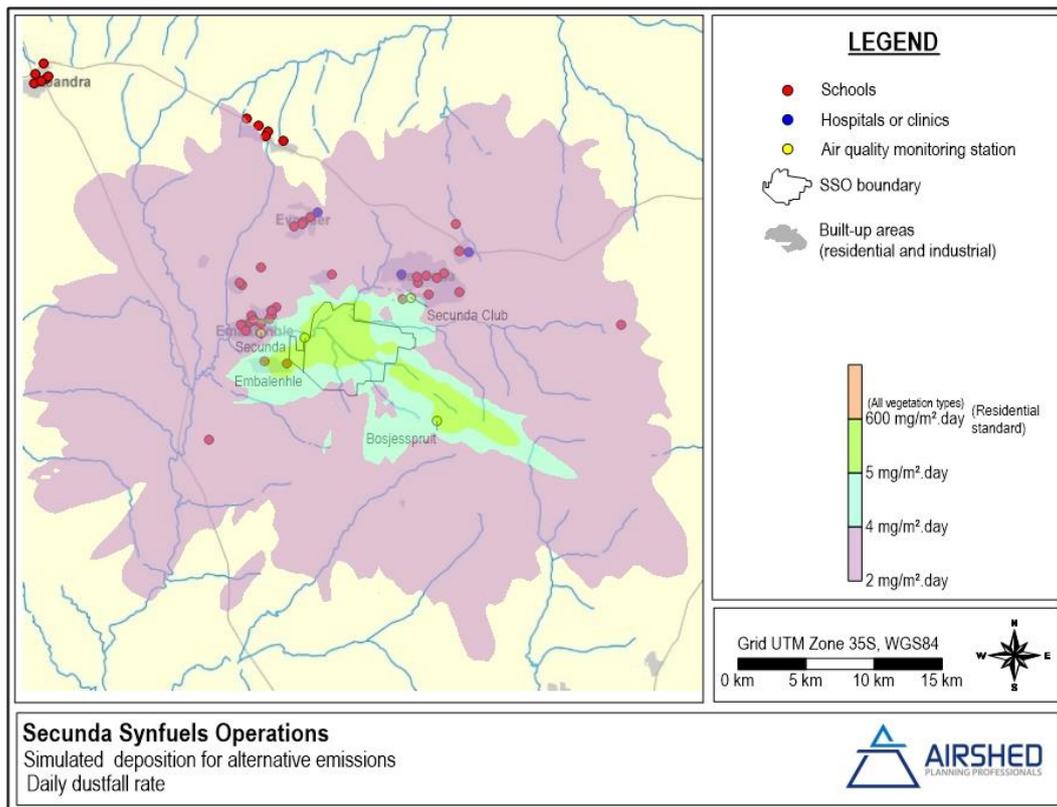


Figure 5-122: Simulated daily dustfall as a result of alternative emissions

5.2.3 Corrosion

5.2.3.1 Factors Affecting Corrosion

The most important corrosion stimulators are water (humidity) and air pollutants, such as SO₂, ammonia (NH₃), and acids such as HCl and formic acid (HCOOH), as well as aerosols and particles containing chlorides (Cl⁻), nitrates (NO₃⁻), and sulfates (SO₄²⁻). The presence of a moisture film on the surface allows these pollutants to dissolve and dissociate into its respective positive and negative ions, and therefore constitutes the electrolyte for corrosion to take place. The thickness of this aqueous layer depends on the relative humidity and surface properties, and is typically a few to a few tens of nanometres (nm) at room temperature (Phipps and Rice 1979).

Dry deposition near emission sources in urban and industrial areas consists largely of the adsorption of criteria pollutants such as SO₂ and NO_x on surfaces, with the deposited amount proportional to the content in air. The deposition rate is high at elevated humidity, especially on some metals; e.g., steel and zinc (Sydberger and Vannerberg, 1972). Corrosion due to SO₂ exposure is perhaps the most significant. Although NO_x may also contribute to corrosion of metals, it is considerably less significant. Like SO₂, this pollutant is mainly emitted from combustion processes such as boilers, power stations, motor vehicle exhausts, etc. It is predominantly emitted as nitrogen oxide (NO) and oxidised in the atmosphere to nitrogen dioxide (NO₂). This oxidation process is a relatively fast process, but further oxidation of NO₂ to nitric acid (HNO₃), i.e. the form conducive for corrosion, occurs at a slow rate and therefore exposure is normally at comparatively low concentrations.

Very little work has been reported on the effect of HCl on the degradation of materials in the environment. This is probably because HCl, which is present outdoors in markedly reduced concentrations when compared with SO₂, has not been

considered to contribute to significant degradation of materials. The first major study of atmospheric degradation of metals by HCl was carried out by Feitnecht (1952) who exposed zinc, iron and copper to HCl vapours at varying humidity's between 50% and 95%. Feitnecht found that HCl reacted with metals only when a critical relative humidity was exceeded, which he linked to the vapour pressure of a saturated solution of the metal chloride formed during corrosion. He regards the mechanism as electrochemical, with the oxide-film as cathodes and small areas of metal exposed at breaks as anodes; the interaction between the hydroxide ions (OH⁻ ions), formed by the cathodic reduction of oxygen, and the metal ions, formed by the anodic reaction, leads to hydroxide or basic chloride. Barton and Bartonova (1969) carried out an extensive investigation of the corrosive effect of HCl gas at concentrations between 7 and 10 ppm on zinc, mild steel, and copper at temperatures between 20°C and 50°C and at relative humidity's of 70% and 95%. Two distinct stages were seen in the behaviour:

- Stage 1 was characterized by a non-linear increase in mass loss with time; termed the "indication period for steady-state corrosion".
- Stage 2, after about 16 days' exposure, showed steady-state corrosion with a linear increase in mass-loss with time.

The primary corrosion products found on iron were FeO(OH), Fe₃O₄ and FeCl₂, whilst those found on zinc were 4Zn(OH)₂, ZnCl₂, Zn(OH)₂ and ZnO. The amount of chloride in the corrosion product tended to decrease slowly with time. After the steady state corrosion stage had been reached, the composition of the corrosion product remained unchanged.

Barton and Bartonova (1969) measured the corrosion rate at different temperatures in the steady state region. For zinc, the corrosion rate decreased as the temperature increased; for iron, the corrosion rate increased with temperatures up to 40°C, but decreased at 50°C. The rate of the reactions did not appear to depend on the diffusion of HCl to the surface since the corrosion rate was similar in flowing and stationery atmospheres. The implication is that the corrosion rate is dependent on chemical reaction rate. The kinetics of corrosion is controlled by the transfer of HCl to the corrosion product atmosphere interface, its adsorption and the subsequent production of soluble ZnCl₂. The corrosion rate also depends on the hydroxide / chloride ratio in the corrosion product as the hydroxides are more protective than the chlorides.

No literature could be obtained on the combined corrosive effects of gaseous SO₂ and HCl pollutant. Furthermore, no dose-response relationships between hydrochloric acid concentration or deposition rates and corrosion rates could be obtained. Most literature on chloride exposures discusses the corrosion rates associated with marine environments. Whilst the chemical reactions may be similar, it is not clear whether an assumption of equivalence may be made between hydrochloric acid and sodium chloride. Whilst both are donors of chloride ions, the former would also reduce the pH of the moisture layer on the metal surface. Given these limitations, and in an attempt to provide an indication of the corrosion potential that the proposed facility may have on the surrounding environment, it was decided to make reference to the International Standard Organisation (ISO) corrosion classification which considers SO₂ and chloride deposition rates to establish the rate of corrosion of a number of different metal types.

5.2.3.2 *International Standard Organisation*

The ISO provides a classification scheme that can directly be used for technical and economic analyses of corrosion damage due to atmospheric SO₂ and chlorides, and for the rational choice of protection measures. As such, the corrosivity of the atmosphere is divided into five categories (C1 to C5), ranging from very low to very high corrosivity. These corrosivity categories are estimated using a combination of the meteorological parameters, sulfate deposition and airborne salinity (chloride ion). These are discussed below.