RATCH-AUSTRALIA CORPORATION PTY LTD

Kemerton Power Station - MS 645 Amendment

Air Quality Impact Assessment

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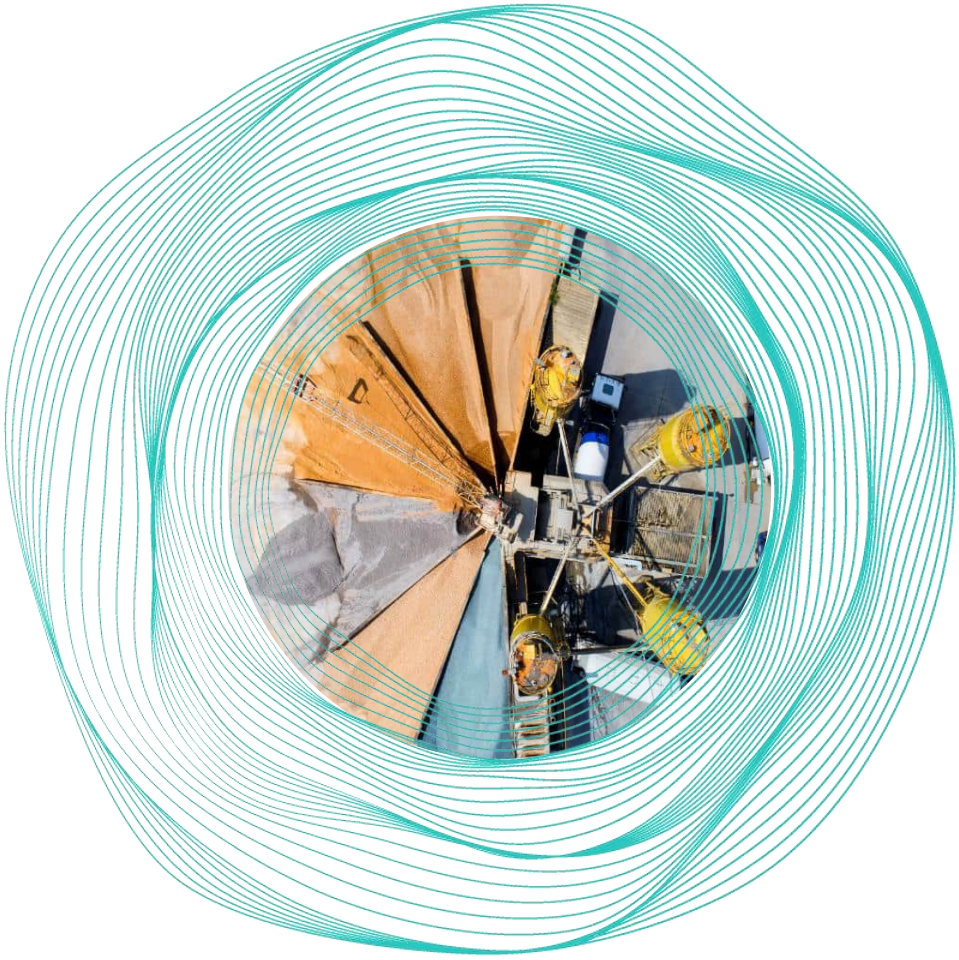

13 March 2024

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Synopsis

The purpose of this assessment was to determine the impacts to local air quality associated with the proposed amendments to Ministerial Statement 645. The AERMOD dispersion model was used to predict the dispersion of pollutants of interest at identified sensitive receptors within a 10 kilometre radius of the Kemerton Power Station site. Modelling was undertaken for three operational scenarios, based on stack testing and Ministerial Statement 645 maximum allowable operations.

Results showed for all modelling scenarios and all pollutants of interest the predicted ground level concentrations were well below the respective Western Australian air quality criteria. Based on this assessment, emissions associated with the proposed amendments to Ministerial Statement 645 are unlikely to have a negative impact on local air quality. Further, the results are sufficiently low to allow for additional, future sustainable development in the airshed.

Disclaimer

PROJECT 411012-00930 - 411012-00930-EN-REP-0001: Kemerton Power Station - MS 645 Amendment - Air Quality Impact Assessment

Rev	Description	Originator	Reviewer	Worley Approver	Revision Date	Customer Approver	Approval Date
Rev A	Draft for Internal Review	Worley Consulting	Worley Consulting	Worley Consulting	01 December 2023		
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Acronyms and abbreviations

Acronym/abbreviation	Definition
Air NEPM	*National Environment Protection (Ambient Air Quality) Measure*
Air Toxics NEPM	*National Environment Protection (Air Toxics) Measure*
AQMS	Air quality monitoring station
CO	Carbon monoxide
DWER	Department of Water and Environmental Regulation
EPA	Environmental Protection Authority
GLC	Ground level concentration
ha	Hectares
KIP	Kemerton Industrial Park
km	Kilometers
KPS	Kemerton Power Station
Kwinana EPP	*Environmental Protection (Kwinana) (Atmospheric Waste) Policy*
MMIF	Mesoscale Modelling Interface Program
MS 645	Ministerial Statement 645
MW	Megawatts
NO_2	Nitrogen dioxide
NSW AMMAAP	*Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*
NMVOC	Non-methane volatile organic compound
PAH	Polycyclic aromatic hydrocarbons
$PM_{2.5}$	Particulate matter with an aerodynamic diameter of 2.5 microns or less
PM_{10}	Particulate matter with an aerodynamic diameter of 10 microns or less
RATCH-Australia Corporation	RATCH
SO_2	Sulphur dioxide
SWIS	South West Interconnected System
TSP	Total suspended particulates
US EPA	United States Environmental Protection Agency
WRF	Weather Research and Forecasting Model

1. Introduction

1.1 Background

RATCH-Australia Corporation (RATCH) owns the Kemerton Power Station (KPS) (operated by Transfield-Worley). KPS is located within the Kemerton Industrial Park (KIP), approximately 130 kilometres (km) south of Perth and 23 km north-east of Bunbury (Figure 1-1). Constructed in 2005, the original intention of KPS was to provide peaking power to the South West Interconnected System (SWIS). Due to reduced generation power from primary suppliers, network demand of KPS has increased substantially, requiring an amendment to the current Ministerial Statement 645 (MS 645), under which the power station operates. To meet demand, RATCH is proposing an increase of the allowable operation time from 2,000 hours per year to 13,800 hours per year.

The proposed amendments to MS 645 meet the Environmental Protection Authority's (EPA) significant impact threshold for greenhouse gas emissions and therefore constitute a 'significant amendment'. As such, RATCH is required to submit a proposed amendment to MS 645 under Section 40AA of the *Environmental Protection Act*.

1.2 Purpose of this report

The Section 40AA referral must identify, quantify, and assess the significance of the environmental impacts associated with the proposed amendment. This assessment pertains to impacts to local air quality associated with the proposed increase in annual operating hours.

The purpose of this assessment is to determine the impacts to local air quality associated with the proposed amendments to MS 645. The information presented within this report is intended to allow the EPA to assess the significant amendment "in the context of the approved proposal and have regard to the combined effect that the implementation of the approved proposal and the significant amendment might have" on the air environment (*Environmental Protection Amendment Act 2020*).

1.3 Scope of work

The scope of work for this assessment is as follows:

- Undertake a desktop assessment to define and review the existing and receiving environment.
- Review relevant air quality standards to be used as assessment criteria in this study.
- Determine emission rates for the two emission to air sources.
- Complete air dispersion modelling of relevant pollutant emissions from KPS for representative operational scenarios.
- Assess predicted ground level concentrations (GLC) against relevant air quality criteria.
- Provide a report (this document) outlining development of the emissions inventory, meteorological data, dispersion modelling, assessment of results and management and mitigation measures where required.

1.4 Limitations

Limitation of this study are identified as follows:

- Worley Ltd have prepared this assessment based on information provided by RATCH, which has not been independently verified.
- Stack testing results were used as input into the modelling carried out as part of this assessment. It is beyond the scope of this assessment to review or assess any stack testing results that do not comply with current MS 645 conditions.

1.5 Assumptions

The following assumptions have been made in this study:

- All information provided by RATCH for the purposes of this assessment is correct.
- The emission rates used in this assessment and taken from stack testing undertaken at KPS are representative of the operating scenarios modelled in this assessment.

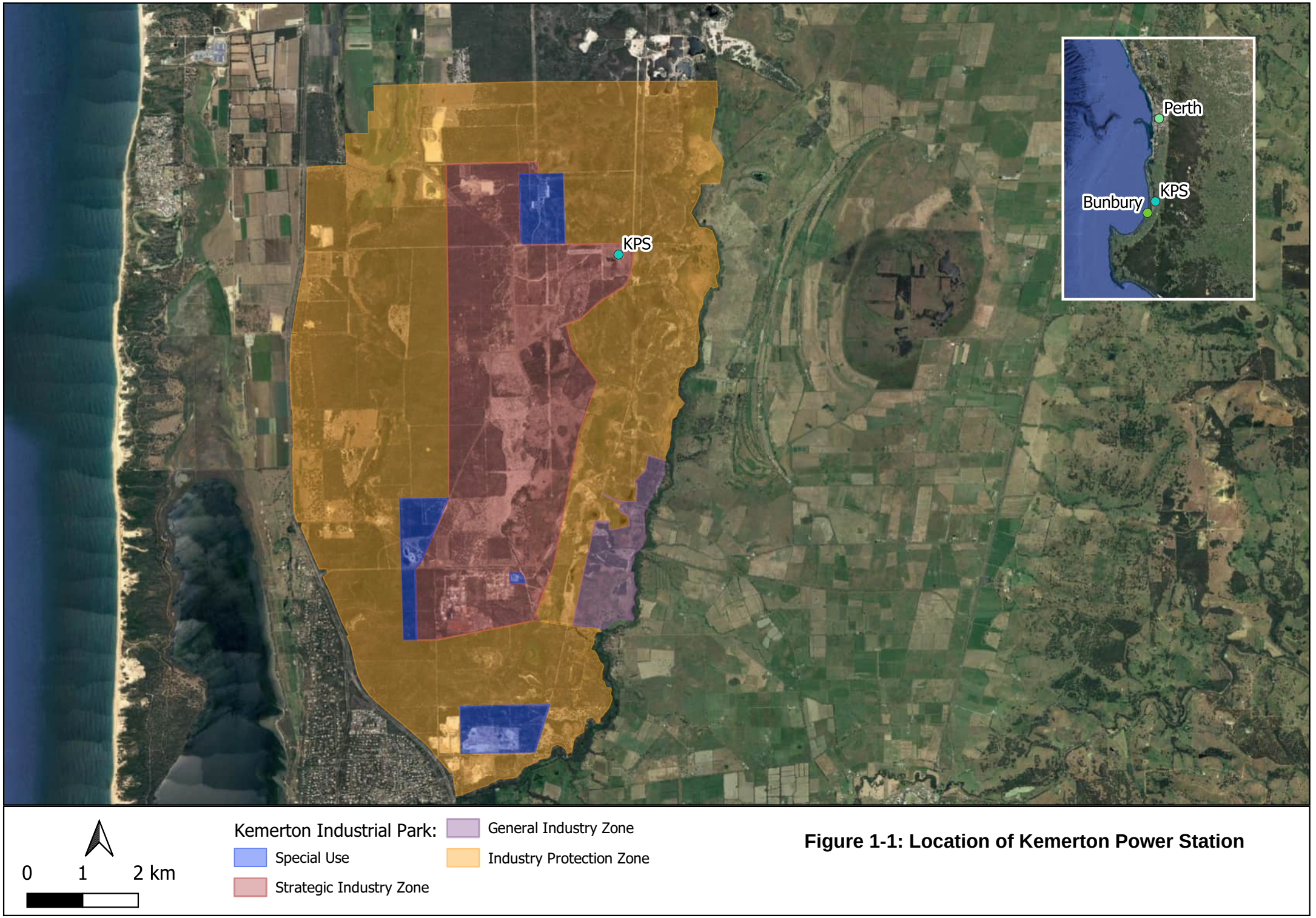

Figure 1-1: Location of Kemerton Power Station

2. Project overview

2.1 Description of operations

KPS is a gas-fired power station constructed to provide peaking power to the SWIS, and to provide spinning reserve with the SWIS to maintain system stability. KPS receives natural gas from the Dampier to Bunbury Natural Gas Pipeline to generate a nominal 260 megawatts (MW) of power. With a proposed project life of 25 years, KPS was initially approved to operate for 1,000 hours per year under MS 645, issued in February 2004. Since its approval, MS 645 has been subject to seven amendments regarding increase in quantities of liquid fuel and increase in allowable time of operation. The most recent amendment to MS 645, Amendment 7, was approved in August 2023 and increases the allowed operation time to 13,800 hours per year. Amendment 7 is valid for one year only and will expire on 11 August 2024.

2.2 Key project elements

Key project elements include the following:

- Two siemens V94.2 gas turbine generators, each capable of producing 130.5 MW.
- Two stacks associated with the gas turbine generators.
- One liquid storage tank (two megalitre capacity).
- Associated buildings and infrastructure.
- KPS uses approximately 30 kilolitres of water per day for domestic purposes.
- The gas turbine generators use approximately six petajoules (1,800 hours per year) of natural gas.
- The gas turbine generators can be operated using diesel fuel as a backup (up to 12 megalitres of ultra-low sulphur diesel per year (200 hours per year)).

2.3 Operational schedule

KPS operates approximately 2,000 hours per year on an ad hoc basis. However, due to high demand, in the 2022 calendar year KPS operated for a total of 3,949 hours.

3. Legal framework and standards

Results from this assessment were compared to appropriate air quality criteria to investigate the acceptability of predicted impacts to the local air environment. A desktop assessment was undertaken to review the most relevant ambient air quality criteria in terms of human sensitive receptors, defined as any place where people are expected to live or regularly spend time (EPA WA, 2015).

The following legal framework and standards were reviewed for relevance to the assessment:

- *National Environment Protection (Ambient Air Quality) Measure* (NEPC, 2021) referred to as the Air NEPM
- *National Environment Protection (Air Toxics) Measure* (NEPC, 2011) referred to as the Air Toxics NEPM

3.1 National Environment Protection (Ambient Air Quality) Measure

The Air NEPM was developed to provide benchmark standards for ambient air quality to ensure all Australians have protection from the potential health effects of air pollution. The Air NEPM standards have been developed for carbon monoxide (CO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), lead, particulate matter with an aerodynamic diameter of 10 microns or less (PM_{10}) and 2.5 microns or less ($PM_{2.5}$). There is a goal to further reduce the maximum concentrations of NO_2, SO_2 and $PM_{2.5}$ from the current standards by the year 2025.

The Air NEPM standards relevant to this assessment are provided in Table 3-1.

Table 3-1: Air NEPM standards

Pollutant	Averaging period	Maximum concentration (µg/m^3)
NO_2	1-hour	247 (goal to reduce to 164 by 2025)
	Annual	62 (goal to reduce to 31 by 2025)
SO_2	1-hour	572 (goal to reduce to 215 by 2025)
	24-hour	229 (goal to reduce to 57 by 2025)
	Annual	57
CO	8-hour	11,354
PM_{10}	24-hour	50
	Annual	25
$PM_{2.5}$	24-hour	25 (goal to reduce to 20 by 2025)
	Annual	8 (goal to reduce to 7 by 2025)

Note: Gaseous concentrations converted from ppm to µg/m^3 at 0°C and 1 atmosphere.

3.2 National Environment Protection (Air Toxics) Measure

The Air Toxics NEPM provides a framework for monitoring, assessing, and reporting on ambient levels of five air toxics, in order to facilitate the collection of information for the future development of air quality standards for these pollutants.

The Air NEPM standards relevant to this assessment are provided in Table 3-2.

Table 3-2: Air Toxics NEPM standards

Pollutant	Averaging period	Maximum concentration
Benzene (a non-methane volatile organic compound; NMVOC)	Annual	11 µg/m^3
Benzo(a)pyrene as a marker for Polycyclic aromatic hydrocarbons (PAH)	Annual	0.3 ng/m^3
Formaldehyde (a NMVOC)	24-hour	54 µg/m^3
Toluene (a NMVOC)	24-hour	4,114 µg/m^3
	Annual	411 µg/m^3
Xylenes (as total of ortho. meta and para isomers) (a NMVOC)	24-hour	1,183 µg/m^3

Note: Concentrations of benzene, formaldehyde, toluene and xylenes converted from ppm to µg/m^3 at 0°C and 1 atmosphere.

3.3 Adopted assessment criteria

Based on the desktop assessment above, adopted relevant assessment criteria are shown in Table 3-3 in µg/m^3, unless otherwise stated.

Table 3-3: Adopted air quality assessment criteria

Pollutant	Averaging period	Criteria (µg/m^3)	Source
NO_2	1-hour	247	Air NEPM
	Annual	62	Air NEPM
SO_2	1-hour	572	Air NEPM
	24-hour	229	Air NEPM
	Annual	57	Air NEPM
CO	8-hour	11,354	Air NEPM
$PM_{2.5}$	24-hour	25	Air NEPM
	Annual	8	Air NEPM
Benzene (a NMVOC)	Annual	11	Air Toxics NEPM
Formaldehyde (a NMVOC)	24-hour	54	Air Toxics NEPM
Toluene (a NMVOC)	24-hour	4,114	Air Toxics NEPM
	Annual	411	Air Toxics NEPM
Xylenes (as total of ortho. meta and para isomers) (a NMVOC)	24-hour	1,183	Air Toxics NEPM
	Annual	947	Air Toxics NEPM
Benzo(a)pyrene as a marker for PAH	Annual	0.3 ng/m^3	Air Toxics NEPM

4. Existing environment

This section provides a summary of the existing environment surrounding the KPS site in terms of site description, land use, climate, ambient air quality and sensitive receptors.

4.1 Site description and surrounding land use

Located within the Kemerton Industrial Park, the KPS facility footprint covers two hectares (ha) and is located on an overall site (including facility buffer) of 28 ha. The site is situated on relatively flat terrain, immediately surrounded by shrubland in all directions. Further east (beyond two kilometres) land use changes to cropland (Figure 4-1).

4.2 Climate

The climate at the site is described as Mediterranean with hot, dry summers and cool, wet winters. There is no local meteorological station near the Project site, so meteorological parameters in the immediate vicinity of the site are unknown. However, the Bureau of Meteorology (BOM) measures a range of meteorological parameters at automatic weather stations (AWS) located at Bunbury (23 km south-west) and Wokalup (10 km east north-east), Although these AWS cannot specifically provide accurate hourly weather data for the KPS site, they can inform an average indication of the likely long term climatic trends. See Figure 4-1 for AWS locations.

Figure 4-2 and Figure 4-3 show long term meteorological parameters measured at Bunbury and Wokalup respectively. A description of the climate based on the BOM data at the two stations is shown below. It is expected the climate at the KPS site is close to this description.

Summer:

- The highest mean maximum temperatures recorded at BOM stations occur in January or February and range from 30.0°C at Bunbury to 31.0°C at Wokalup.
- The highest mean minimum temperatures occur in February and range from 15.9°C at Bunbury to 16.1°C at Wokalup.
- The lowest average monthly rainfall in Bunbury occurs in February with 8.4 mm, and in Wokalup occurs in January with 14.1 mm.

Winter:

- The lowest mean maximum temperatures recorded at the BOM stations occur in July with 16.7°C at Wokalup and 17.3°C at Bunbury.
- The lowest mean minimum temperatures occur in July or August and range from 7.3°C at Bunbury to 7.9°C at Wokalup.
- The highest mean rainfall at Bunbury is 145.5 mm and at Wokalup is 183.4 mm, both occurring in July.

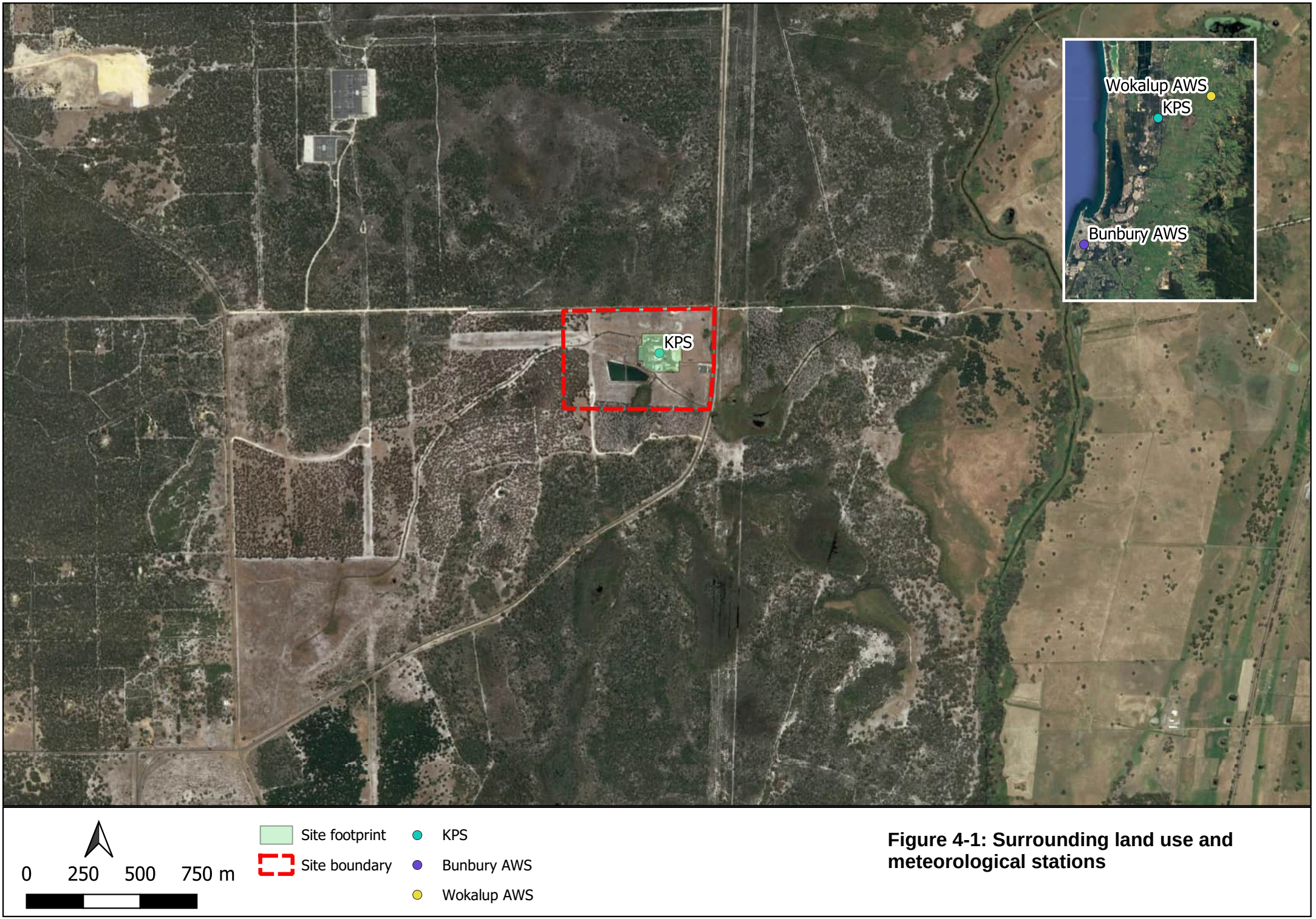

Figure 4-1: Surrounding land use and meteorological stations

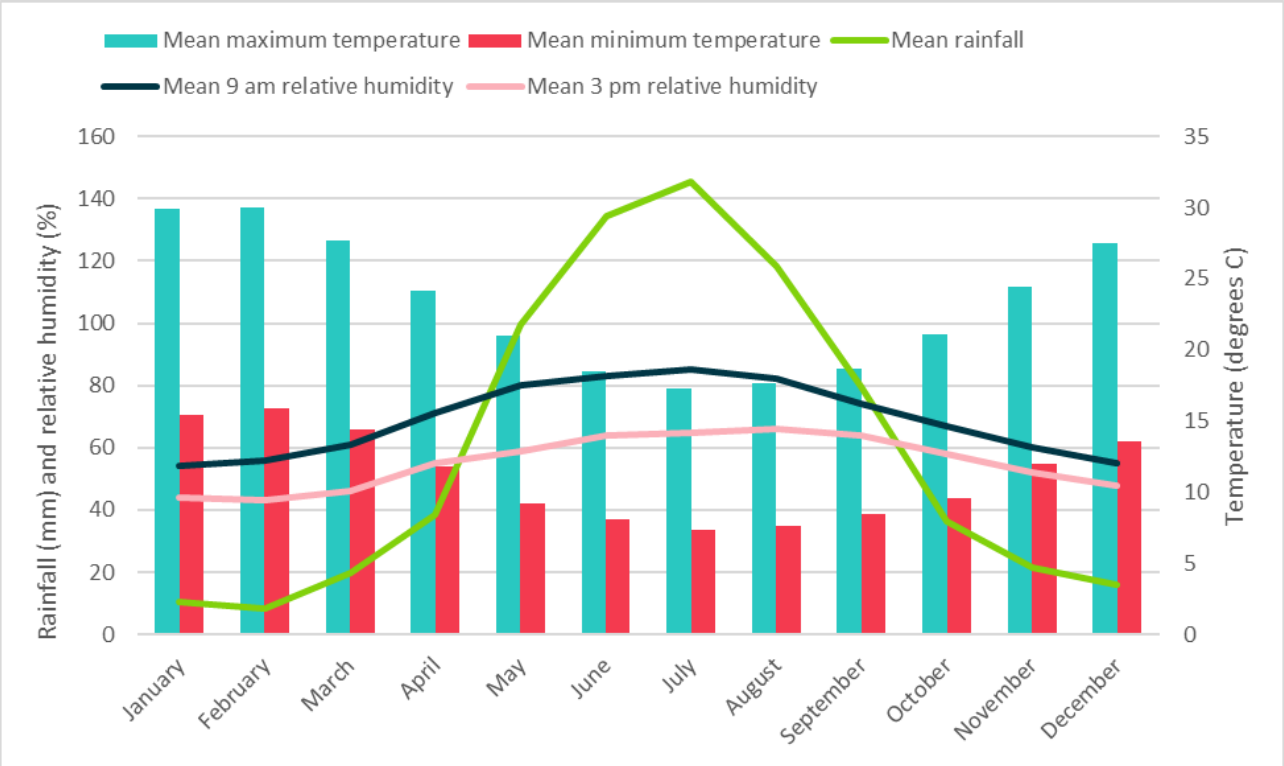

Figure 4-2: Long term climate data for Bunbury AWS (BOM site 009965; BOM, 2023a)

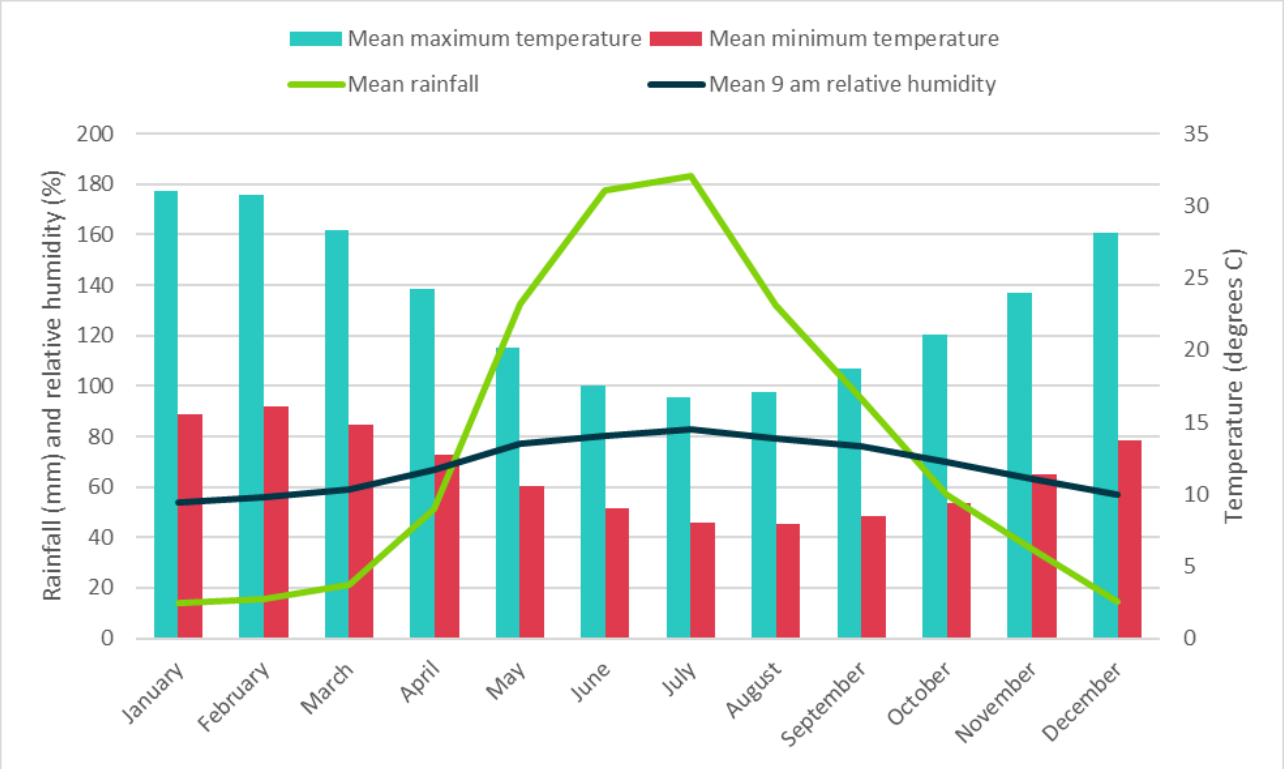

Figure 4-3: Long term climate data for Wokalup AWS (BOM site 009642; BOM, 2023b) (note that mean 3 pm relative humidity is not available at Wokalup AWS)

4.3 Existing ambient air quality

When assessing the impacts to air quality it is important to understand the existing air quality environment in order to quantify the cumulative impact. Ideally, air quality monitoring data would be used to inform the existing air quality of the area of interest; however, there are no air quality monitoring stations near the KPS site. As an alternative, modelled air quality data taken from the KIP expansion air quality assessment (EA, 2010) were reviewed to inform the overall state of existing air quality at the KPS site and beyond the KIP area.

The purpose of the EA assessment was to update air quality modelling for a suite of industries located within the KIP, to predict zones of impact from gaseous emissions from a mix of generic sources located within the KIP. The EA assessment focused on NO_2 and SO_2.and included the following three scenarios:

- Existing industry (at the time of writing – 2010)
- Existing industry and approved future industry, and
- Existing industry, approved future industry and numerous hypothetical future industries representing a 'mature' industrial estate.

The results of the assessment are shown in Table 4-1.

Table 4-1: Results for the KIP expansion air quality assessment (EA, 2010)

Scenario	Maximum predicted 1-hour NO_2 concentration outside the buffer (µg/m^3)	Maximum predicted 1-hour SO_2 concentration outside the buffer (µg/m^3)
Criteria (µg/m^3)	**247**	**572**
1. Existing industry	59	55
2. Existing and approved future industry	65	72
3. Existing, approved, and hypothetical industry	71	169

It is assumed Scenario 3 is the most representative scenario of the likely local air quality associated with current industrial facilities within the KIP. Although these results have not been validated against measurements to determine accuracy, they can be used to inform the general state of air quality at the area of interest. The maximum predicted 1-hour NO_2 beyond the KIP buffer is 71 µg/m^3 (29% of the criterion), and the maximum predicted 1-hour SO_2 beyond the KIP buffer is 169 µg/m^3 (30% of the criterion). Therefore, the current local air quality is considered good.

4.4 Sensitive receptors

The location of the Project site is considered regional, as it is not located in close proximity to a city or town. The closest built-up areas are Harvey (approximately 14 km north-east) and Bunbury (approximately 23 km south-west) (Figure 4-4).

For the purposes of an air quality assessment, a sensitive receptor is generally accepted as any place where a person is expected to work or reside "including a dwelling, school, hospital,

office or public recreational area" (NSW EPA, 2017). A desktop assessment was undertaken to identify nearby sensitive receptors in line with this definition. Aerial imagery (Google Maps, 2023) was reviewed within a radius of 10 km from the Project site and buildings/infrastructure were marked as a sensitive receptor if they appeared to be a residence or facility where people are likely to work or spend a significant amount of time. Where the building use could not be determined, it was conservatively marked a sensitive receptor.

The closest sensitive receptor is located approximately 2 km east of KPS. The 259 identified sensitive receptors within 10 km of the Project site are shown in Figure 4-4 and listed in Appendix A.

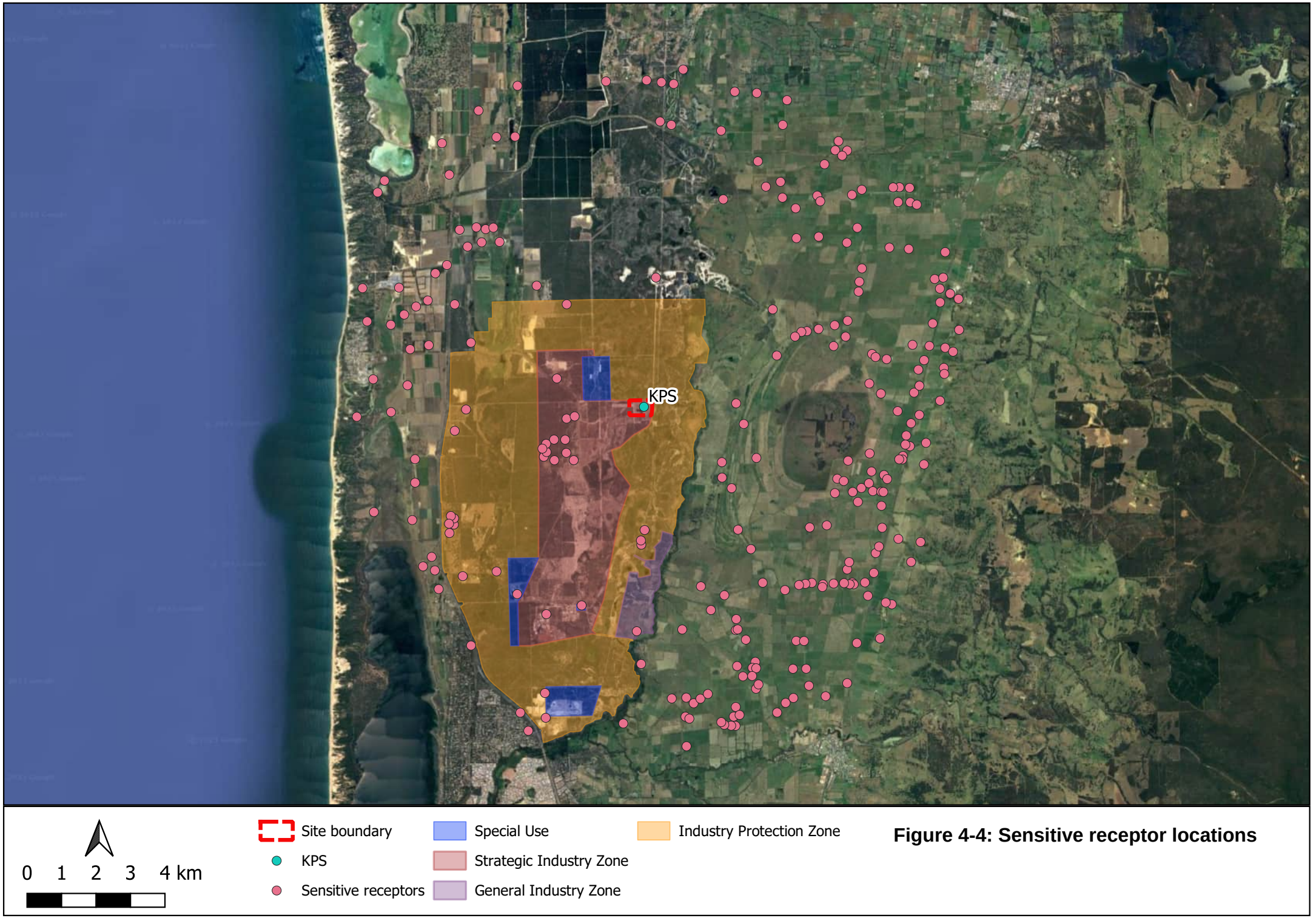

Figure 4-4: Sensitive receptor locations

5. Air dispersion modelling

5.1 Dispersion modelling scenarios

Air dispersion modelling was undertaken for three operational scenarios representing varying plant operating conditions, and further split into gas (a) or diesel (b) process conditions, where the required data was available. Table 5-1 shows the modelling scenarios included in this assessment.

Table 5-1: Air dispersion modelling scenarios

Scenario ID	Scenario name	Plant operating conditions	Process conditions
1a	Low operating load case (a)	Both GTs – 70 MW average operating load	Gas
1b	Low operating load case (b)	Both GTs – 84 MW average operating load	Diesel
2a	High operating load case (a)	GT11 – 162 MW average operating load GT12 – 110 MW average operating load	Gas
3a	MS maximum allowable case (a)	Maximum operating conditions as stated in MS 645	Gas
3b	MS maximum allowable case (b)	Maximum operating conditions as stated in MS 645	Diesel

5.2 Meteorological data file

Air dispersion modelling requires hourly meteorological data for a minimum of one year. Preferentially, much of these data would be obtained from onsite observations to provide a site-specific dataset. However, as mentioned in Section 4.2, such observations are not available for the KPS site. As an alternative, observed data from other representative locations may be used. Data are considered site representative if the meteorological trends, surrounding land uses and topographic features for the site of interest are similar to those of the site at which the data were recorded.

The nearest available meteorological observations to the project site are recorded at the Bunbury BOM AWS (23 km south-west) and Wokalup BOM AWS (10 km east north-east). See Figure 4-1 for AWS locations.

The Bunbury AWS is located within a built-up area (the City of Bunbury). In contrast, the KPS site is surrounded by shrubland, which is likely to have significantly different meteorological land use parameters including albedo, Bowen ratio and surface roughness compared to those at the Bunbury AWS. Therefore, although meteorological measurements taken from the Bunbury AWS can inform the general long-term climatology of the region, hourly data is unlikely to be sufficiently representative of local meteorological conditions at the KPS site for the purposes of air dispersion modelling. Furthermore, the Bunbury AWS does not record cloud observation data, which is required to calculate stability classes. The nearest station that collects suitable cloud observation data is the Wokalup AWS.

The Wokalup AWS is located among cropland with a slightly higher albedo than that of the KPS site (depending on the season)[1], and could be considered generally representative of meteorological trends, surrounding land uses and topographic features. However, the Wokalup AWS only records air temperature to the year 2000 and is therefore not suitable.

Where site representative data is not available, the alternative is to synthesize meteorological data for the site using diagnostic or prognostic three-dimensional (3D) meteorological modelling. Worley obtained third-party generated, site representative hourly surface and upper air meteorological data files. The files were produced as ready for input into AERMOD using the Weather Research and Forecasting Model (WRF) in line with the United States Environmental Protection Agency's (US EPA) *Guidance on the Use of the Mesoscale Modelling Interface Program (MMIF) for AERMOD Applications* (US EPA, 2023).

5.2.1 Representative meteorological period

As outlined in *40 CFR Appendix W to Part 51 – Guideline on Air Quality Models* (US EPA, 2017) enough meteorological data should be used to "ensure that worst-case meteorological conditions are adequately represented in the model results. The use of five years of adequately representative National Weather Service or comparable meteorological data, at least one year of site-specific, or at least three years of prognostic meteorological data are required". As this assessment used prognostic data, four years of data were obtained to satisfy the US EPA guidance (three-year minimum requirement).

To choose the most representative meteorological year(s) (that is, years where wind speed, wind direction and temperature, most closely represent the long-term averages), recorded Bunbury AWS[2] data were reviewed inclusive of years 2011 to 2023. Appendix B shows the seasonal wind roses and monthly temperature data for these years taken from Bunbury AWS.

The most representative years were 2016 and 2019. Therefore, the calendar years of 2016 to 2019 were chosen to obtain a consecutive meteorological data file.

5.2.2 Validation of predicted meteorological data

Key parameters (air temperature, wind speed and wind direction) from the WRF data were compared to observed data from Bunbury AWS to validate the predicted meteorological data file. It should be noted that the location of the BOM AWS and the KPS site (where the WRF meteorological data were generated) are several kilometres apart, and represent different land uses, which have the ability to affect local meteorology, as discussed above.

5.2.2.1 Air temperature

Figure 5-1 shows the mean monthly air temperature at the Bunbury AWS and as predicted by WRF at the KPS site, for the modelling years (2016 to 2019). The comparison between the observed and predicted data demonstrates generally WRF (slightly) overpredicts temperature

[1] The Wokalup AWS location is likely to experience a higher albedo (increased reflectivity of incident radiation) compared to the KPS site, as the land use at Wokalup (crop land) is generally lighter in colour than that of the shrubland surrounding the KPS site. The respective albedos of the two location are likely to change each season as the crop land is cleared and the shrubland dries out over summer.

[2] Data recorded at the Wokalup AWS were not used as temperature data for this station is not available past the year 2000.

by approximately 0.5°C but still follows the seasonal temperature patterns (correlation >99%). The strong correlation between recorded and predicted temperature indicates that WRF has adequately calculated the surface energy balance, which, in turn, adds confidence to the predictions made for atmospheric stability.

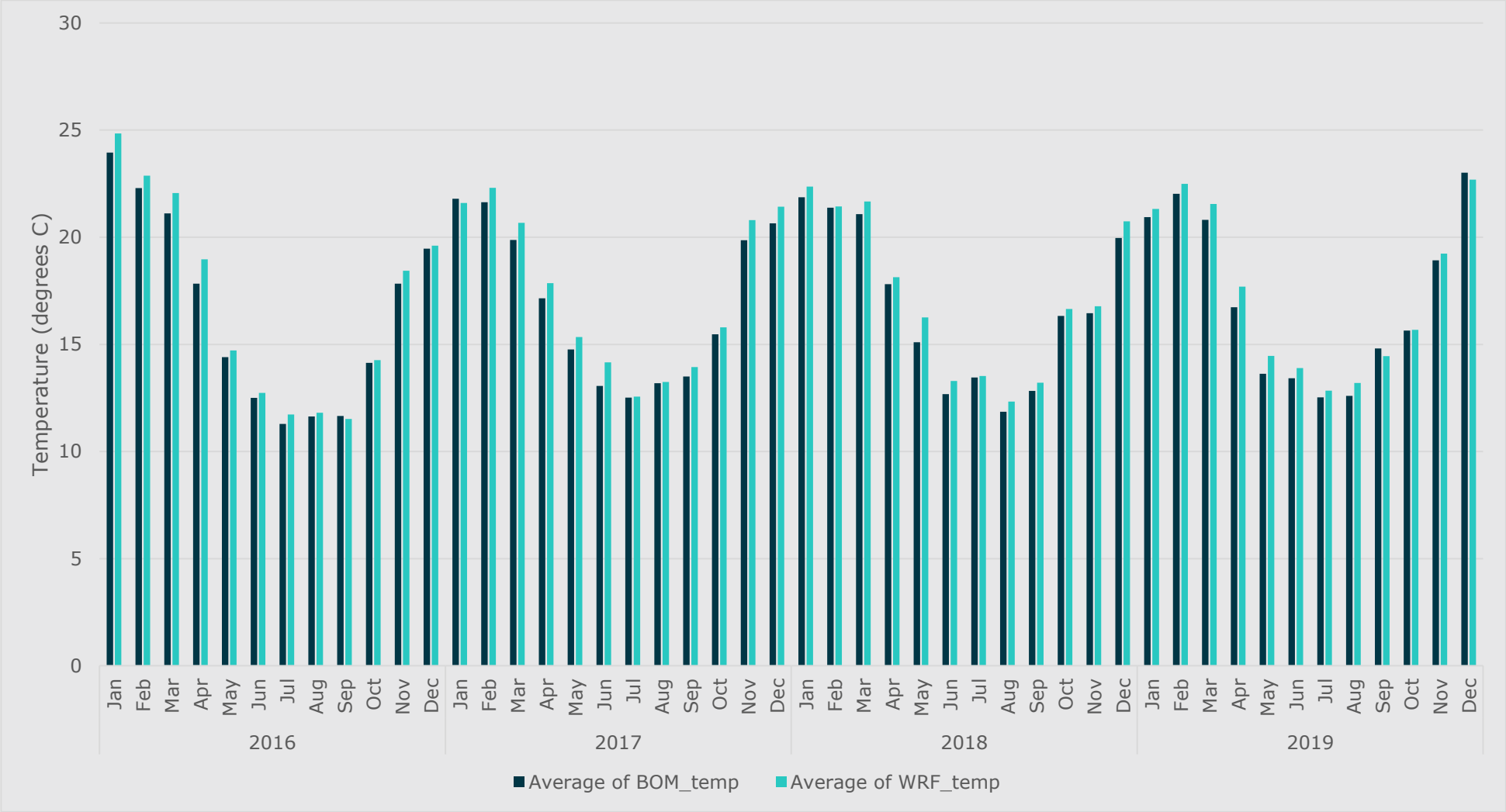

Figure 5-1: Average monthly temperature for years 2016 to 2019 at the Bunbury AWS, and the WRF-generated data

5.2.2.2 Wind distribution

Figure 5-2 shows the average annual wind roses for years 2016 to 2019 at the Bunbury AWS (left), and the WRF-generated data (right). Figure 5-3 shows the same data, delineated by season. Wind roses for individual years are provided in Appendix C. Comparison of the BOM and WRF wind roses shows the following:

- Higher annual wind speeds are predicted by WRF (5.1 m/s) than recorded at Bunbury AWS (3.3 m/s). WRF also appears to significantly underpredict the frequency of calm conditions 'calms' (winds less than 0.4 m/s) in comparison to observed data. This may be due to the Bunbury AWS' location within a built-up area, which is likely subject to a higher surface roughness and hence reduced wind speeds due to turbulence.
- Both observed and predicted annual wind directions are dominated by a southerly component with secondary west south-west components. Predicted winds show a higher frequency of east north-easterly winds compared to observed. Conversely, south-easterly winds and westerly winds are less frequent in the predicted data set compared to observed.
- The seasonal wind roses demonstrate at a finer scale the deviation of winds in the predicted data set from the observed. Wind speed not withstanding:
    - Predicted spring wind direction and frequencies closely resemble those of the observed.
    - In summer, reduced frequencies of south-easterly winds occur in the predicted data set compared to the observed.
    - In autumn, increase southerly, west south-westerly and east north-easterly winds occur in the predicted data set compared to the observed.
    - In winter, the WRF data shows dominant winds from the north north-east, compared to the dominant southerly component in the observed data.
- Despite the variation in wind direction over each season, and overestimation of wind speeds, it is considered the predicted winds generally represent the annual wind climate of observed winds and are generally sufficient for the purposes of air dispersion modelling.

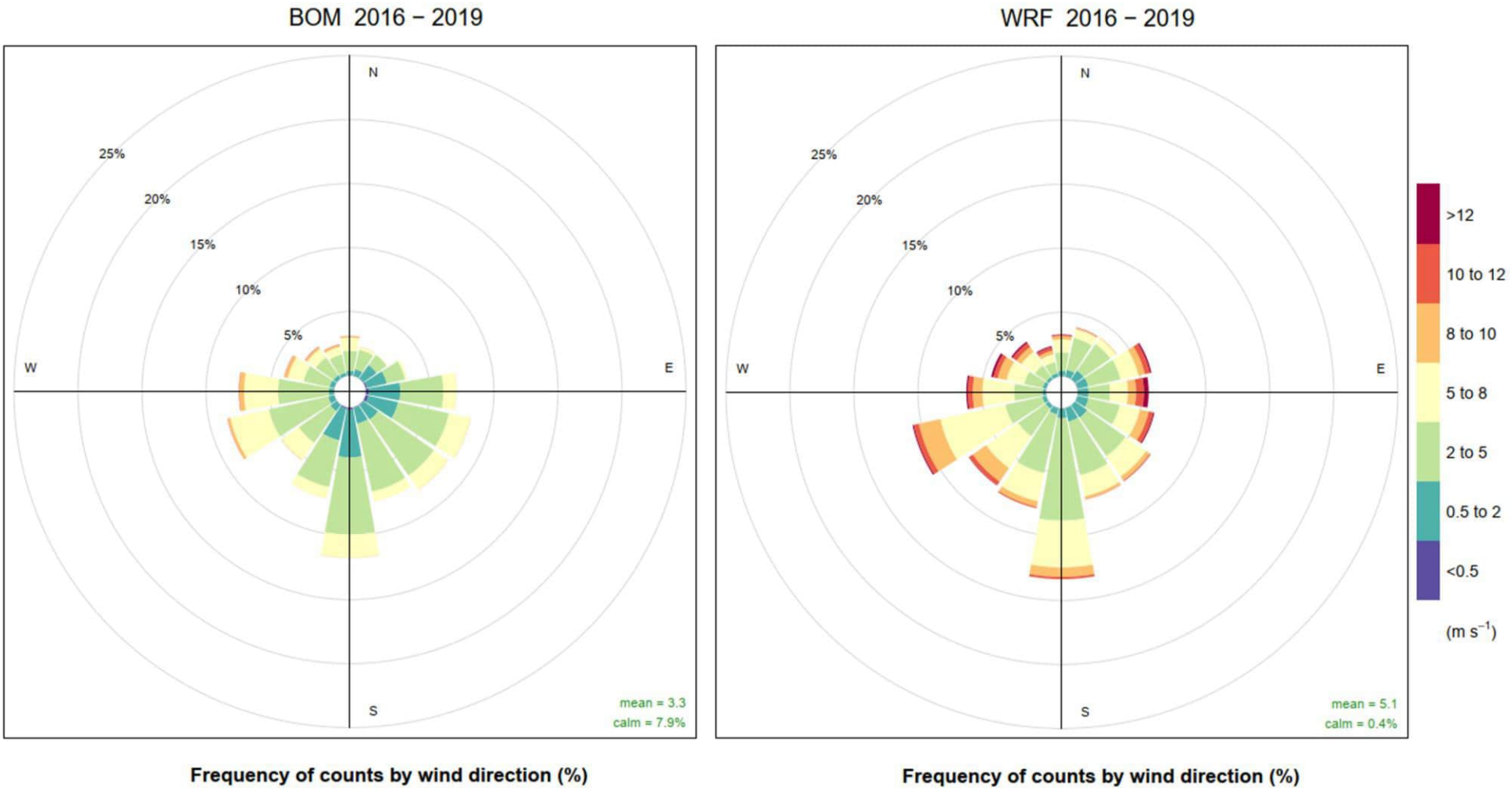

Figure 5-2: Average annual wind roses for years 2016 to 2019 at the Bunbury AWS, and the WRF-generated data

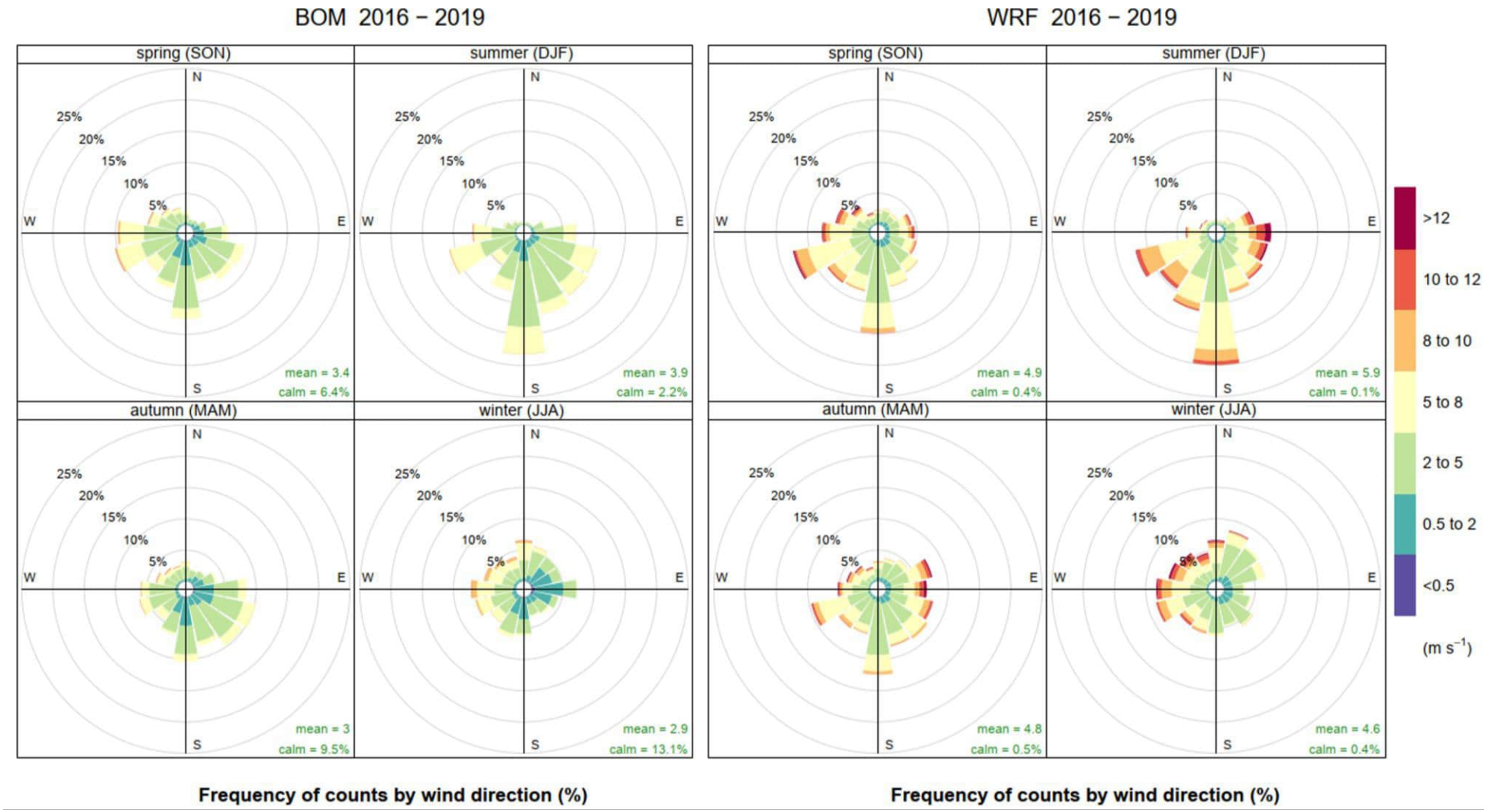

Figure 5-3: Average seasonal wind roses for years 2016 to 2019 at the Bunbury AWS, and the WRF-generated data

5.3 Sources and emission rates

There are two sources of emissions to air at KPS, both of which are stacks associated with the gas turbine generators (GT11 and GT12). Source parameters are shown in Table 5-2.

Table 5-2: Source parameters

Parameter		Source 1	Source 2
Name		GT11	GT12
Reference		Northern stack	Southern stack
Location (m UTM; WGS85, Zone 50)	**Easting**	386331	386331
	Northing	6329960	6329918
Base elevation (m above sea level)		26.4	24.9
Stack height (m)		35	35
Inside diameter (m)		6.5	6.5
Source type		Point	Point

Stack testing was carried out in 2020 and 2023 by Ektimo for varying operational loads. The results of the stack testing were used to inform the modelling scenarios (Scenarios 1a, 1b and 2a) and emission rates used in this assessment. Stack testing was not carried out for the high operational load case with diesel fuel (what would have been Scenario 2b); therefore, no emissions data is available for this operating scenario, which is why this scenario is excluded from modelling.

All results for SO_2 and CO were below the limits of reporting. For these cases, the limit of reporting was used as the nominal emission rate. It is acknowledged that, in reality, the emission rate could possibly be lower than modelled, or equal to zero. Furthermore, for Scenario 2 (high operating load case) some limits of reporting were lower than for Scenario 1 (low operating load case), which results in a discrepancy between operating load relative to emission rates between Scenarios 1a and 2a for SO_2.

The third modelling scenario represents the maximum allowable emission rates as stated in MS 645 and were taken directly from the Ministerial Statement accordingly.

Emission rates used in this assessment are shown in Table 5-3.

Table 5-3: Emission rates

Scenario	Pollutant	Emission rate for GT11 (g/s)	Emission rate for GT12 (g/s)
1a (low operating low case – gas)	Nitrogen oxides (as NO_2)	14	11
	SO_2	3[1]	2[1]
	CO	2[1]	2[1]
1b (low operating low case – diesel)	Nitrogen oxides (as NO_2)	31	31
	SO_2	3[1]	2[1]
	CO	2[1]	2[1]
2a (high operating load case – gas)	Nitrogen oxides (as NO_2)	28	17
	SO_2	1[1,2]	1[1,2]
	CO	3[1]	2[1]
3a (MS maximum allowable case – gas)[3]	Nitrogen oxides (as NO_2)	19.55	19.55
	SO_2	0	0
	CO	10.85	10.85
	Particulate matter (modelled as $PM_{2.5}$)	1	1
	PAH	0.000435	0.000435
	NMVOCs	0.415	0.415
3b (MS maximum allowable case – diesel)[3]	Nitrogen oxides (as NO_2)	7.1	7.1
	SO_2	2.03	2.03
	SO_2 (based on lower sulphur fuel)	0.203	0.203
	CO	10.45	10.45
	Particulate matter (modelled as $PM_{2.5}$)	3.81	3.81
	PAH	0.008	0.008
	NMVOCs	0.08	0.08

Note:

1. Concentration result below limit of reporting. Although actual emission rate of pollutant may be zero, the limit of reporting was adopted as the emission rate for the purpose of this assessment.
2. Limit of reporting lower than that of Scenario 1.
3. The authorized air emissions stated in MS 645 are provided as a total for two units operating at 6,900 hours each. Therefore, the emission rates used in this assessment are divided by two and split across each stack to represent realistic operating conditions.

Variable exhaust parameters (stack exit velocity and exit temperature) were taken from the conditions reported in the stack testing results. Variable exhaust parameters for each scenario are shown in Table 5-4.

Table 5-4: Variable exhaust parameters

Variable parameter	Scenario	GT11	GT12
Exit Velocity (m/s)	Scenario 1a	28	28
	Scenario 1b	30	31
	Scenario 2a	40	35
	Scenario 3a[1]	40	35
	Scenario 3b[1]	40	35

Variable parameter	Scenario	GT11	GT12
Exit temperature (˚C)	Scenario 1a	520	521
	Scenario 1b	508	507
	Scenario 2a	521	518
	Scenario 3a[1]	521	518
	Scenario 3b[1]	521	518

Note:

1. Allowable exhaust parameters are not defined in MS 645. Exhaust parameters were assumed to be equal to those from Scenario 2a.

5.4 Model configuration

This section describes the model used to predict GLCs associated with the proposed amendment based on meteorological data (Section 5.2) and emission rates (Section 5.3) discussed above.

5.4.1 AERMOD dispersion model

AERMOD is a steady state model and assumes that over time, the average concentrations distribution within a plume, is Gaussian. AERMOD was used to predict the dispersion of pollutants of interest at the identified sensitive receptors (Section 4.4). A sample AERMOD output file typical of those used in this assessment is presented in Appendix D. The main model options and assumptions used are described below.

The model was configured as shown in Table 5-5.

Table 5-5: AERMOD model configuration

Parameter	Setting
Meteorological period	2016-2019 inclusive (calendar years)
Model grid centre coordinates (m UTM, GDA 1984)	Easting: 386308 Northing: 6329936
Terrain/topography	Terrain elevation data for the model domain was obtained from the US National Aeronautics and Space Administration's Shuttle Radar Topography Missions (SRTM3/SRTM1) at 30 m resolution. Terrain elevation data was incorporated into AERMOD using the AERMAP terrain processor.
Surrounding land use	Rural dispersion coefficient with land use as per the AERMET definition[1].
Receptors	A uniform cartesian grid system was used in the AERMOD model to predict concentrations of pollutants across an area of 15 km by 15 km. A grid resolution of 100 m was used. In addition to the modelling grid, discrete receptors were included in the model representing the identified sensitive receptors (Section 4.4 and Appendix A).
Buildings	The main buildings were included the model to capture any building downwash/wake effect. Building geometries as included in the model are shown in Figure 5-4.
Source types	Point (see Table 5-2 and Table 5-4)
Emission rates	See Table 5-3
Output (averaging times)	1-hour, 8-hour, 24-hour or annual

Note:

1. The Mesoscale Model Interface Program (MMIF) was used to generate an AERSURFACE output file which contains the surface characteristics (albedo, Bowen ratio, and surface roughness) and is input into AERMET.

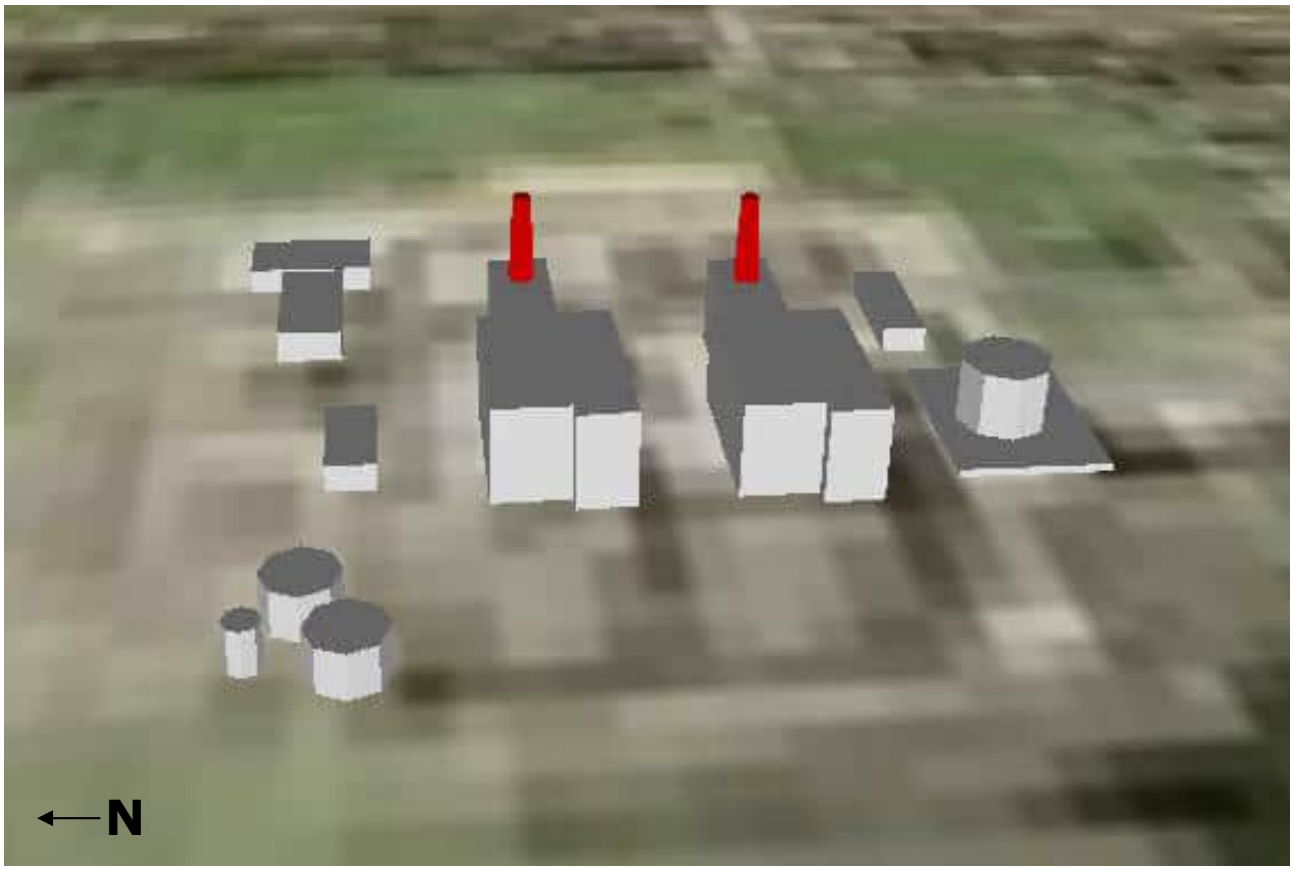

Figure 5-4: Buildings included in the model

5.4.2 Background concentrations

As discussed in Section 4.3, air quality monitoring data were not available for the KPS site, or surrounding area. The EA assessment (2010) provided an indication of the likely existing air quality (1-hour averaged concentrations of NO_2 and SO_2) beyond the KIP boundary associated with current industry. However, the predicted existing air quality within the KIP boundary was not reported. Further, these results have not been validated against recent measurements. Therefore, background concentrations were not included in this assessment.

Alternatively, the maximum predicted GLCs at the identified sensitive receptors (Section 4.4) were assessed in terms of percent of the relative criteria. As a general rule, the World Bank Group suggest emissions from a project should contribute to no more than 25 percent of the applicable criteria to allow for additional, future sustainable development in the airshed (World Bank Group, 2007).

6. Results

Predicted GLCs associated with the proposed amendment of MS 645 are presented in this section. Results focus on the maximum predicted concentrations at the sensitive receptors for each modelling scenario. Results are compared to the respective assessment criteria presented from Table 3-3. Concentration contour figures are provided in Appendix E to demonstrate the predicted spatial dispersion relative to the identified sensitive receptors.

Under MS 645 SO_2 emission rates must be equal to zero (no emissions of SO_2 are permitted) when the turbine generators are operating with gas (Scenario 1a and 2a). However, as mentioned in Section 5.3, all stack testing results for SO_2 were below the limits of reporting. For these cases, the limit of reporting was used as the nominal emission rate. It is acknowledged that in reality the emission rate could possibly be lower than modelled, or equal to zero.

Scenario 1a: Low operating low case – gas

Predicted GLCs of NO_2, SO_2 and CO for Scenario 1a are shown in Table 6-1. The highest predicted GLCs at the identified sensitive receptors comply with the relative assessment criteria for all pollutants. All results are extremely low in comparison to the criteria (maximum of 2% of the criteria).

Table 6-1: Maximum predicted ground level concentrations for Scenario 1a

Pollutant	Averaging Period	Assessment Criteria	Maximum GLC at discrete receptors	Percentage of criterion
NO_2	1-hour	247 µg/m³	5 µg/m³	2%
	Annual	62 µg/m³	0.09 µg/m³	0.1%
SO_2	1-hour	572 µg/m³	2 µg/m³	0.3%
	24-hour	229 µg/m³	0.3 µg/m³	0.1%
	Annual	57 µg/m³	0.02 µg/m³	0.04%
CO	8-hour	11,354 µg/m³	0.5 µg/m³	0.004%

Scenario 1b: Low operating low case – diesel

Predicted GLCs of NO_2, SO_2 and CO for Scenario 1b are shown in Table 6-2. The highest predicted GLCs at the identified sensitive receptors comply with the relative assessment criteria for all pollutants. All results are extremely low in comparison to the criteria (maximum of 5% of the criteria).

Table 6-2: Maximum predicted ground level concentrations for Scenario 1b

Pollutant	Averaging Period	Assessment Criteria	Maximum GLC at discrete receptors	Percentage of criterion
NO_2	1-hour	247 µg/m³	12 µg/m³	5%
	Annual	62 µg/m³	0.2 µg/m³	0.3%
SO_2	1-hour	572 µg/m³	2 µg/m³	0.3%
	24-hour	229 µg/m³	0.3 µg/m³	0.1%

Pollutant	Averaging Period	Assessment Criteria	Maximum GLC at discrete receptors	Percentage of criterion
	Annual	57 µg/m³	0.02 µg/m³	0.03%
CO	8-hour	11,354 µg/m³	0.5 µg/m³	0.004%

Scenario 2a: High operating low case – gas

Predicted GLCs of NO_2, SO_2 and CO for Scenario 2a are shown in Table 6-3. The highest predicted GLCs at the identified sensitive receptors comply with the relative assessment criteria for all pollutants. All results are extremely low in comparison to the criteria (maximum of 3% of the criteria).

Table 6-3: Maximum predicted ground level concentrations for Scenario 2a

Pollutant	Averaging Period	Assessment Criteria	Maximum GLC at discrete receptors	Percentage of criterion
NO_2	1-hour	247 µg/m³	7 µg/m³	3%
	Annual	62 µg/m³	0.1 µg/m³	0.2%
SO_2	1-hour	572 µg/m³	0.5 µg/m³	0.1%
	24-hour	229 µg/m³	0.1 µg/m³	0.04%
	Annual	57 µg/m³	0.01 µg/m³	0.01%
CO	8-hour	11,354 µg/m³	0.5 µg/m³	0.004%

Note:

- Results for Scenario 2a SO_2 are lower than those for Scenario 1a SO_2, despite Scenario 2a representing a higher operational load. This is due to the emission rate being lower in Scenario 2a compared to Scenario 1a. Emission rates were taken from stack testing (Section 5.3) and were below the limit of reporting for both scenarios.

Scenario 3a: MS maximum allowable case – gas

Predicted GLCs of NO_2, CO, $PM_{2.5}$, PAH and NMVOC for Scenario 3a are shown in Table 6-4. The highest predicted GLCs at the identified sensitive receptors comply with the relative assessment criteria. All results are extremely low in comparison to the criteria (maximum of 3% of the criteria).

Table 6-4: Maximum predicted ground level concentrations for Scenario 3a

Pollutant	Averaging Period	Assessment Criteria	Maximum GLC at discrete receptors	Percentage of criterion
NO_2	1-hour	247 µg/m³	6 µg/m³	3%
	Annual	62 µg/m³	0.1 µg/m³	0.2%
CO	8-hour	11,354 µg/m³	2 µg/m³	0.02%
$PM_{2.5}$	24-hour	25 µg/m³	0.1 µg/m³	0.3%
	Annual	8 µg/m³	0.01 µg/m³	0.1%
PAHs	Annual	0.003 µg/m³	0.00 µg/m³	0%
NMVOC	24-hour	54 µg/m³	0.04 µg/m³	0.1%
	Annual	11 µg/m³	0.003 µg/m³	0.03%

Note:

- Scenario 3a modelling was not conducted for SO_2, as under MS 645 SO_2 emission rates must be equal to zero (no emissions of SO_2 are permitted) when the turbine generators are operating with gas.
- The most stringent NMVOC criteria are shown in Table 6-4 (as 24-hour formaldehyde and annual benzene). Where maximum predicted GLCs comply with the most stringent criteria, these results inherently comply with the less stringent criteria for the remaining NMVOCs of interest (toluene and xylene).
- GLCs for annual PAHs at the sensitive receptors are predicted to be zero. The emission rate for PAHs under Scenario 3a is extremely low – low enough that the resulting annual concentrations are below the inherent limitation of the model to be able to calculate. Therefore, concentrations are predicted to be zero. Subsequently, there is no concentration contour figure for Scenario 3a PAHs.

Scenario 3b: MS maximum allowable case – diesel

Predicted GLCs of NO_2, SO_2, CO, $PM_{2.5}$, PAHs and NMVOC for Scenario 3b are shown in Table 6-5. The highest predicted GLCs at the identified sensitive receptors comply with the relative assessment criteria. All results are extremely low in comparison to the criteria (maximum of 2% of the criteria).

Table 6-5: Maximum predicted ground level concentrations for Scenario 3b

Pollutant	Averaging Period	Assessment Criteria	Maximum GLC at discrete receptors	Percentage of criterion
NO_2	1-hour	247 µg/m³	2 µg/m³	1%
	Annual	62 µg/m³	0.04 µg/m³	0.1%
SO_2 – with regular diesel	1-hour	572 µg/m³	1 µg/m³	0.2%
	24-hour	229 µg/m³	0.2 µg/m³	0.1%
	Annual	57 µg/m³	0.01 µg/m³	0.02%
SO_2 – with low sulphur diesel	1-hour	572 µg/m³	0.1 µg/m³	0.02%
	24-hour	229 µg/m³	0.02 µg/m³	0.01%
	Annual	57 µg/m³	0.001 µg/m³	0.002%
CO	8-hour	11,354 µg/m³	2 µg/m³	0.02%
$PM_{2.5}$	24-hour	25 µg/m³	0.3 µg/m³	1%
	Annual	8 µg/m³	0.03 µg/m³	0.3%
PAHs	Annual	0.003 µg/m³	5.00E-05 µg/m³	2%
NMVOC	24-hour	54 µg/m³	0.01 µg/m³	0.01%
	Annual	11 µg/m³	0.0005 µg/m³	0.005%

Note:

- Scenario 3b modelling was conducted for SO_2 in accordance with MS 645 using permitted emission rates of SO_2 for both regular diesel and low sulphur diesel.
- The most stringent NMVOC criteria are shown in Table 6-5 (as 24-hour formaldehyde and annual benzene). Where maximum predicted GLCs comply with the most stringent criteria, these results inherently comply with the less stringent criteria for the remaining NMVOCs of interest (toluene and xylene).

Cumulative assessment

As discussed in Section 5.4.2, air quality monitoring data were not available for the KPS site or surrounding area, so a cumulative assessment could not be made. Alternatively, the World Bank Group's guideline was adopted whereby emissions from a project should contribute to no more than 25% of the applicable criteria to allow for additional, future sustainable development in the airshed (World Bank Group, 2007). For all modelling scenarios and all pollutants of interest maximum predicted GLCs at the sensitive receptors were well below 25% of the respective criteria. Therefore, a quantitative cumulative assessment is not considered necessary.

7. Conclusions

To meet increasing power demand from KPS, RATCH is proposing an increase of the allowable operation time under MS 645 from 2,000 hours per year to 13,800 hours per year. The purpose of this assessment was to determine the impacts to local air quality associated with the proposed amendments to MS 645. The AERMOD dispersion model was used to predict the dispersion of pollutants of interest at identified sensitive receptors within a 10 km radius of the KPS site.

Modelling was undertaken for three operational scenarios, based on stack testing and MS 645 maximum allowable operations:

- Scenario 1a: Low operational load case with gas as a fuel source (emission rates taken from stack testing results)
- Scenario 1b: Low operational load case with diesel as a fuel source (emission rates taken from stack testing results)
- Scenario 2a: High operational load case with gas as a fuel source (emission rates taken from stack testing results)
- Scenario 3a: MS 645 maximum allowable operating conditions with gas as a fuel source (emission rates taken from MS 645)
- Scenario 3b: MS 645 maximum allowable operating conditions with diesel as a fuel source (emission rates taken from MS 645)

Results of the modelling focused on the maximum predicted concentrations at the sensitive receptors and were compared to relevant Western Australian air quality assessment criteria. Results showed for all modelling scenarios and all pollutants of interest (NO_2, SO_2, CO, $PM_{2.5}$, PAHs and NMVOC) the predicted ground-level concentrations were well below the respective criteria.

Based on this assessment, emissions associated with the proposed amendments to MS 645 are unlikely to have a negative impact on local air quality. Further, the results are sufficiently low (less than 25% of the respective criteria) to allow for additional, future sustainable development in the airshed in line with the World Bank Group's *Environmental, Health, and Safety General Guidelines* (2007).

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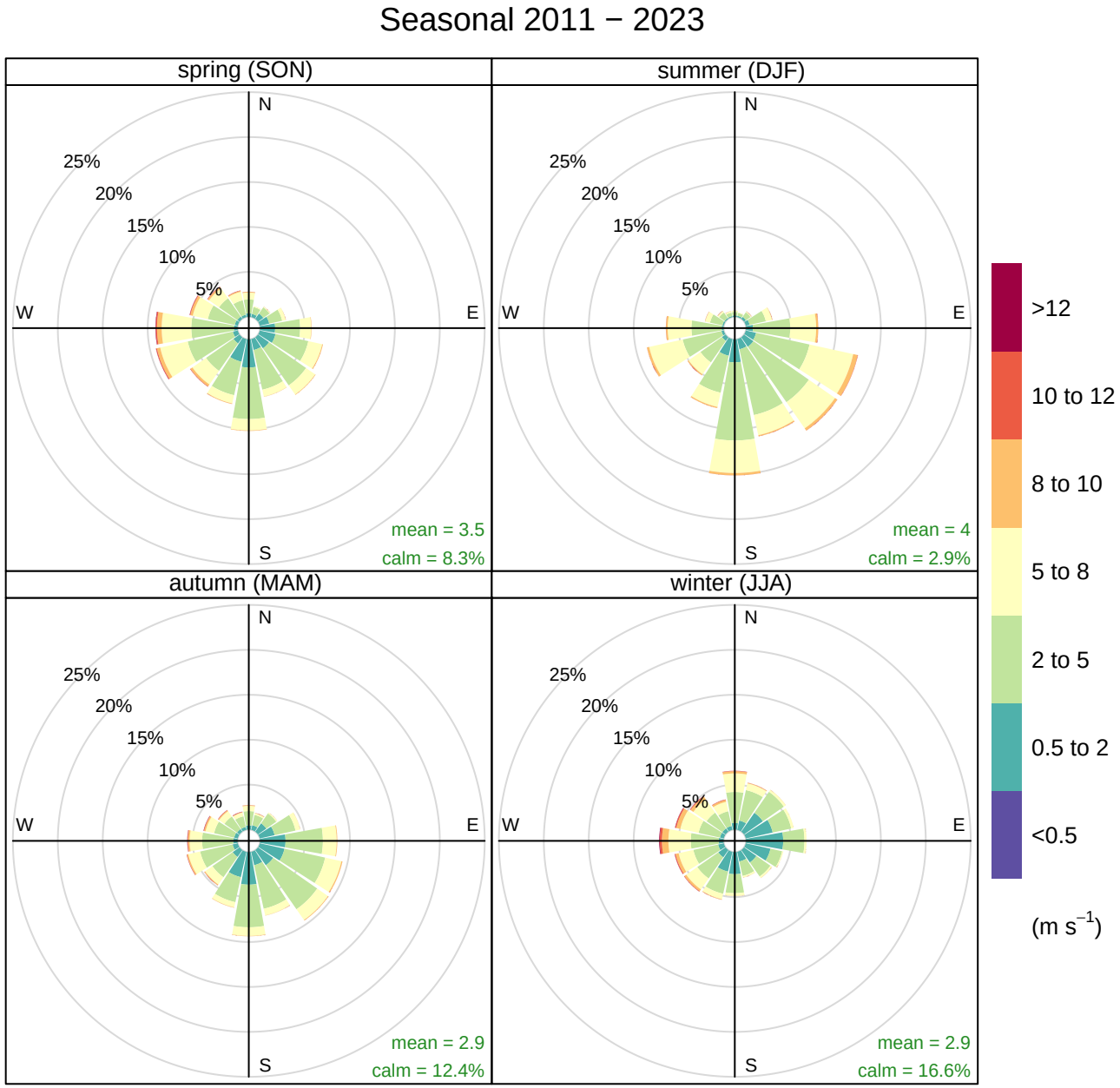
Appendix A. List of sensitive receptors

Number	Easting	Northing	Number	Easting	Northing	Number	Easting	Northing
1	382641	6339252	87	380068	6331725	173	380668	6326272
2	385209	6339379	88	381289	6331797	174	379588	6326650
3	386387	6339413	89	390163	6331424	175	378476	6326883
4	386816	6339355	90	390693	6331974	176	379900	6325305
5	387447	6339725	91	391811	6331698	177	380151	6325581
6	387172	6339306	92	392160	6331972	178	380244	6325190
7	388944	6339081	93	392927	6331469	179	387626	6320887
8	389584	6339042	94	393028	6331380	180	381053	6325022
9	390337	6338117	95	393349	6331320	181	382033	6325159
10	390459	6338835	96	394100	6331735	182	386232	6325935
11	388547	6337949	97	394437	6331290	183	386221	6326058
12	387103	6338116	97	394270	6331014	184	389412	6325807
13	386778	6338216	99	395010	6331066	185	392205	6325218
14	382571	6337775	100	395048	6331649	186	392263	6325429
15	382030	6337763	101	395276	6331536	187	392979	6325116
16	381511	6338532	102	395025	6330891	188	393032	6325691
17	380449	6337585	103	378454	6330736	189	393128	6325882
18	378583	6336157	104	390808	6324766	190	394060	6325437
19	378784	6336498	105	377978	6329647	191	393500	6324204
20	380663	6336671	106	394145	6330347	192	393324	6324256
21	389616	6337060	107	378972	6329784	193	392807	6324452
22	390270	6336464	108	394301	6330548	194	392720	6324839
23	389848	6336324	109	393183	6330319	195	392354	6324834
24	391858	6337382	110	392848	6330612	196	392396	6324786
25	391954	6337646	111	388983	6330036	197	392280	6324788
26	392204	6337372	112	383783	6330759	198	392114	6324820
27	392059	6337224	113	379450	6330561	199	391812	6324807
28	391547	6336975	114	380821	6329240	200	391504	6324783
29	394017	6336290	114	383478	6323919	201	391486	6324707
30	393721	6336307	115	381148	6329859	202	391179	6324826
31	393538	6336303	116	384065	6329594	203	390993	6324799
32	392629	6336236	117	384299	6329660	204	394899	6330113
33	392344	6336087	118	389205	6329437	205	390401	6324618
34	391336	6336064	119	393670	6329811	206	389755	6324831
35	391424	6335900	120	393920	6329103	207	388643	6324469
36	390328	6336006	121	394057	6329459	208	388252	6324039
37	388611	6335958	122	394299	6329701	209	387961	6324726
38	380961	6335072	123	394433	6328264	210	384502	6324173
39	381447	6335144	124	394492	6328890	211	382631	6324501
40	381717	6335091	125	394025	6328793	212	380354	6324646
41	381939	6335134	126	393894	6328839	213	381293	6323009
42	390712	6335697	127	393823	6328508	214	390727	6323145

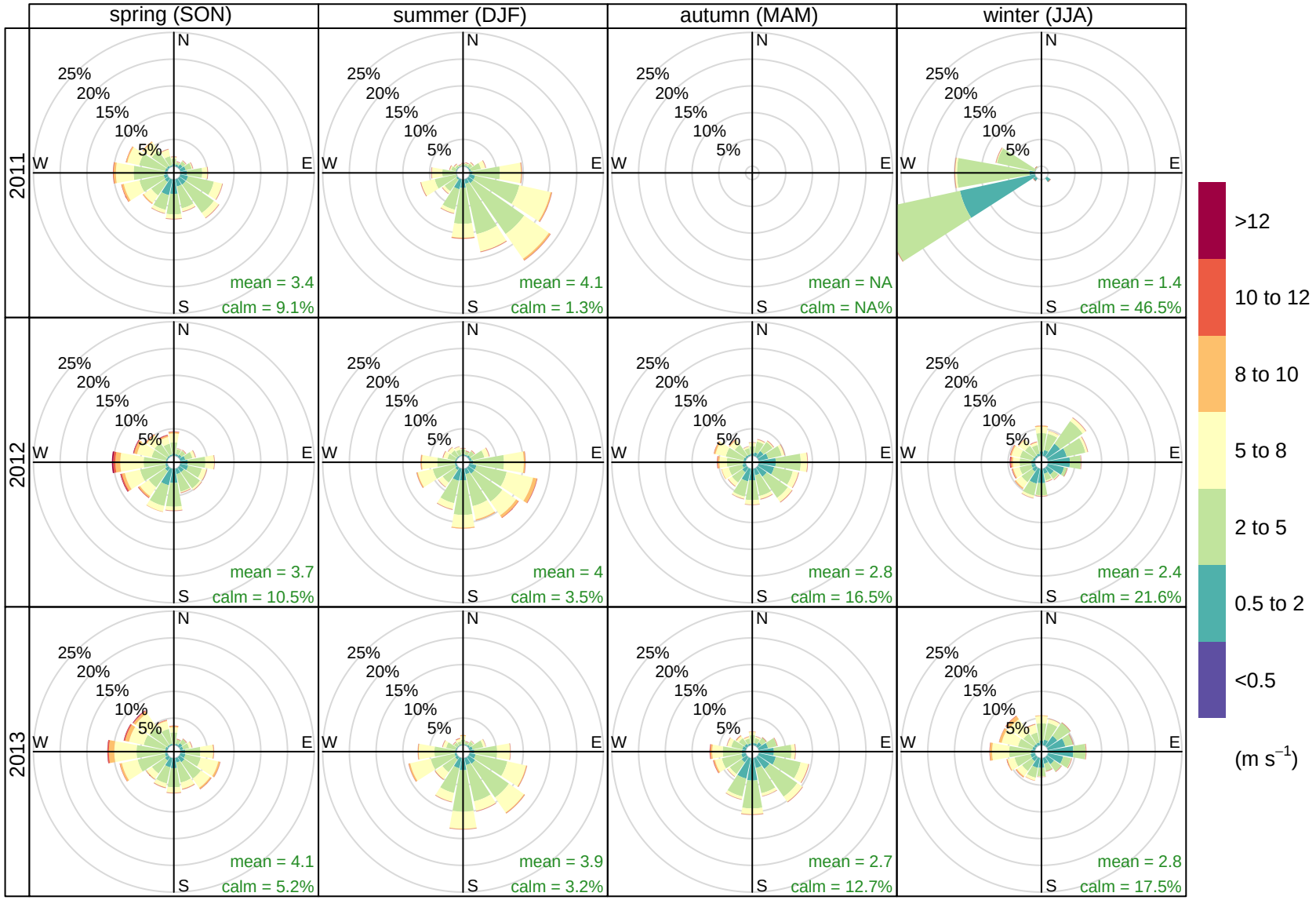
Number	Easting	Northing	Number	Easting	Northing	Number	Easting	Northing
43	392499	6335132	128	393804	6328409	215	386101	6323424
44	393683	6335876	129	393714	6328413	216	387420	6323474
45	394035	6335873	130	392910	6328059	217	388975	6323455
46	394224	6335803	131	392858	6328582	218	389029	6323477
47	395048	6334425	132	392231	6328372	219	388988	6323777
48	393991	6334517	133	389572	6328452	220	389265	6323178
49	393430	6334556	134	388570	6328329	221	390953	6323141
50	392198	6334699	135	384272	6328388	222	392487	6323081
51	391380	6334873	136	383702	6328985	223	393157	6323214
52	390733	6334830	137	383711	6328387	224	391015	6322336
53	382121	6334721	138	383404	6328486	225	390633	6322334
54	381600	6334710	139	383484	6328623	226	389540	6322535
55	381191	6334584	140	383471	6328862	227	389457	6322362
56	380593	6334051	141	384024	6328982	228	389564	6322350
57	378144	6333379	142	383363	6328723	229	389012	6322413
58	379204	6333393	143	379670	6328416	230	389181	6322115
59	380038	6333022	144	384056	6328600	231	389447	6322125
60	380259	6333810	145	383460	6320911	232	386228	6322474
61	383196	6333452	146	379670	6327734	233	382721	6321060
62	386657	6333686	147	388576	6327882	234	382954	6320535
63	392535	6333279	148	388853	6327575	235	383438	6321630
64	392559	6333565	149	391850	6327431	236	387117	6321471
65	392632	6333952	150	391916	6327849	237	387536	6321496
66	394745	6333644	151	392106	6327782	238	387514	6320945
67	394991	6333684	152	392616	6327580	239	387751	6321334
68	394894	6333365	153	392836	6327718	240	387946	6321466
69	395192	6333221	154	392950	6327489	241	388164	6321604
70	395436	6333069	155	392366	6327465	242	388974	6321226
71	395452	6332169	156	392516	6327178	243	389561	6321754
72	394901	6332967	157	393274	6327956	244	389632	6321880
73	394687	6332354	158	393366	6327840	245	390173	6321064
74	392218	6332432	159	393193	6327475	246	390420	6321345
75	391843	6332304	160	393254	6327465	248	391096	6321844
76	391375	6332195	161	393200	6327063	249	391580	6321537
77	391036	6332131	162	394334	6326013	250	392205	6321916
78	390877	6332110	163	393690	6326104	251	388966	6320678
78	394590	6331702	164	393220	6326427	252	388840	6320683
79	390045	6332764	165	391613	6326497	253	388913	6320947
80	384069	6332912	166	391118	6326436	254	389083	6320994
81	380820	6332909	167	389038	6326371	255	388639	6320710
82	379698	6332846	168	386330	6326361	256	388553	6320786
83	379353	6332612	169	380795	6326519	257	390645	6321487

Number	Easting	Northing	Number	Easting	Northing	Number	Easting	Northing
84	378966	6332316	170	380801	6326699	258	387544	6320086
85	378279	6332414	171	380708	6326768	259	385709	6320748
86	379526	6331607	172	380655	6326544			

Appendix B. Bunbury AWS Meteorological Data (2011-2023)

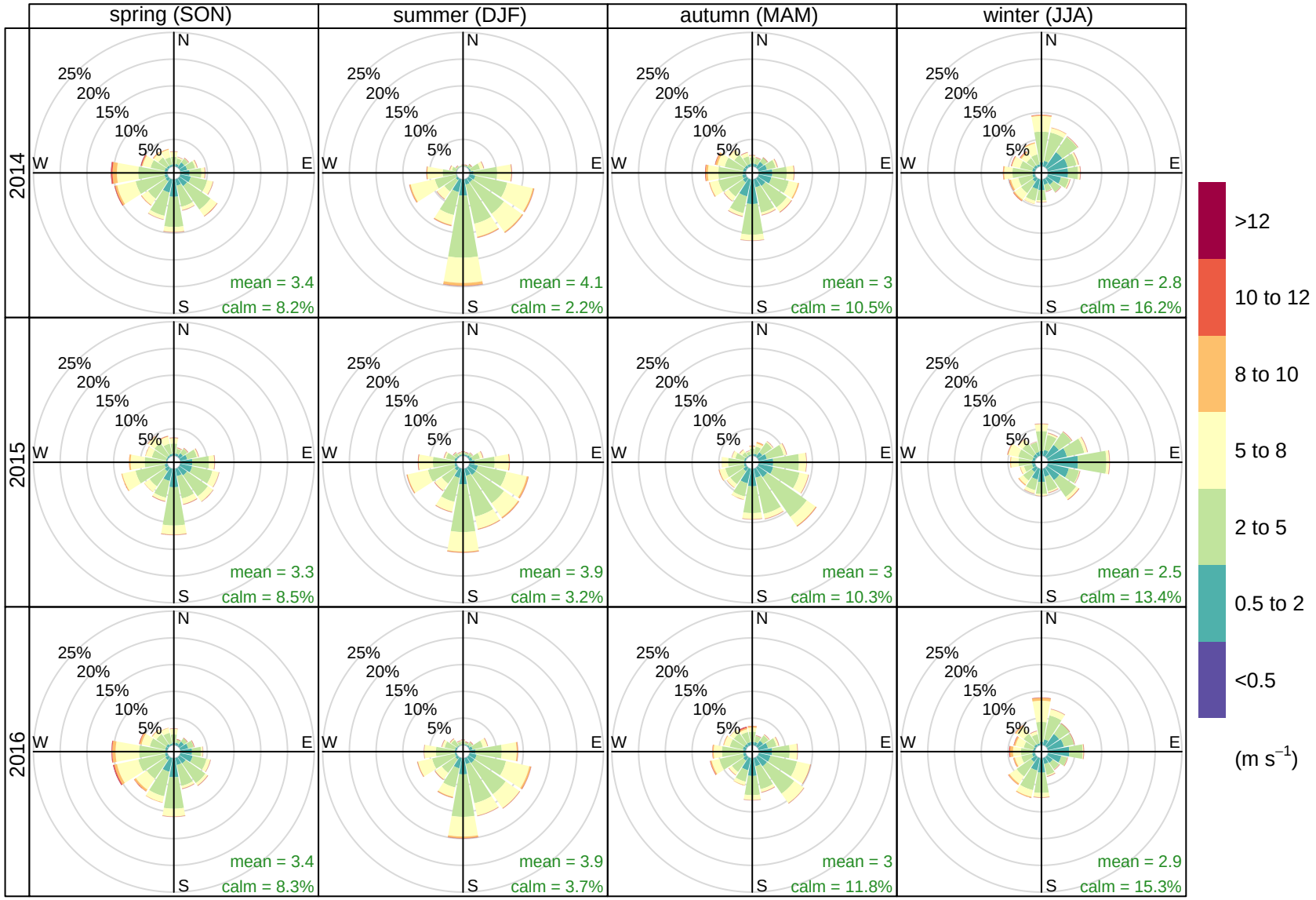

Seasonal 2011 − 2023
spring (SON)
summer (DJF)
autumn (MAM)
winter (JJA)
N
E
S
W
5%
10%
15%
20%
25%
mean = 3.5
calm = 8.3%
mean = 4
calm = 2.9%
mean = 2.9
calm = 12.4%
mean = 2.9
calm = 16.6%
>12
10 to 12
8 to 10
5 to 8
2 to 5
0.5 to 2
<0.5
(m s−1)
Frequency of counts by wind direction (%)

Seasonal



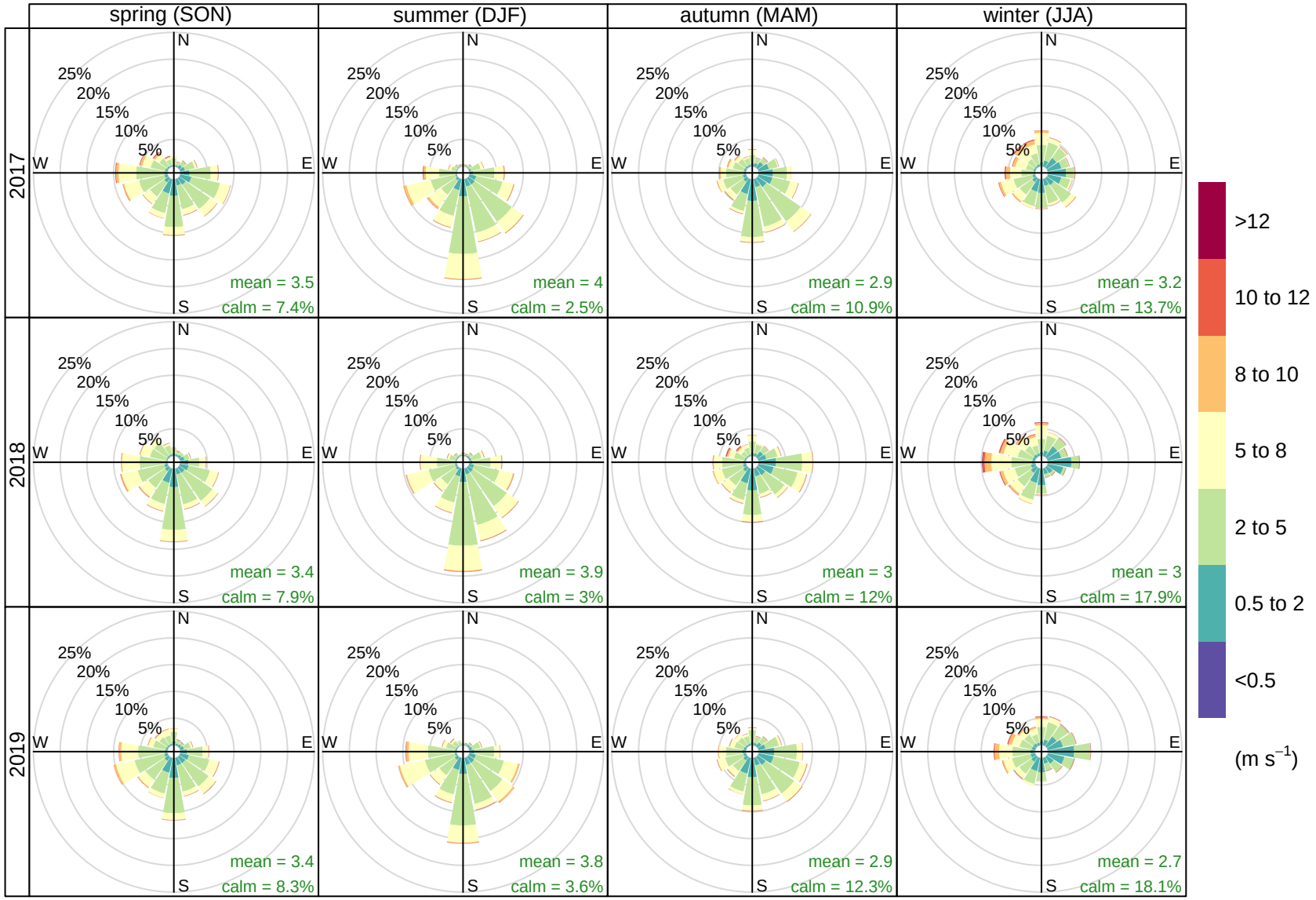
Frequency of counts by wind direction (%)

Seasonal



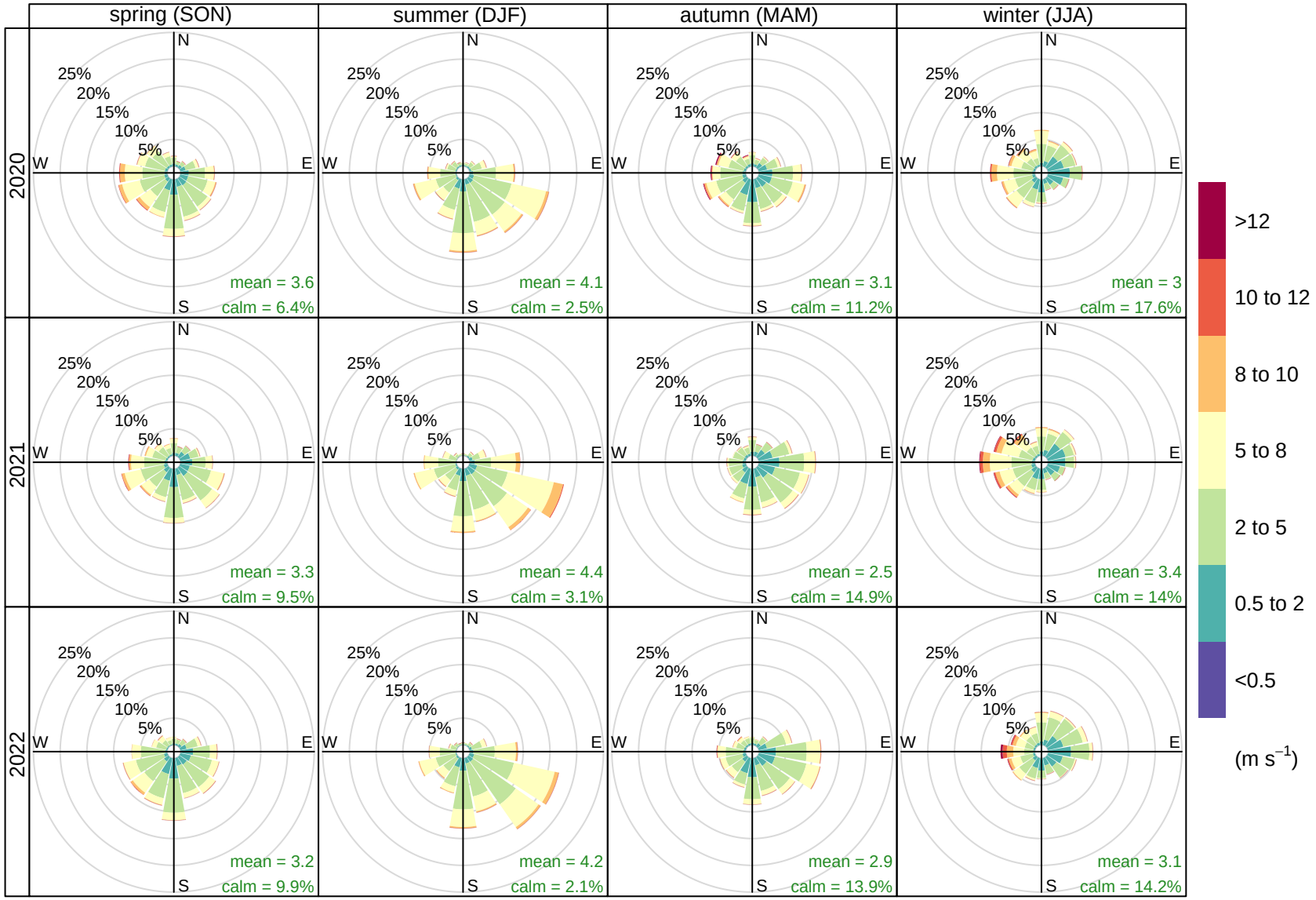
Frequency of counts by wind direction (%)

Seasonal

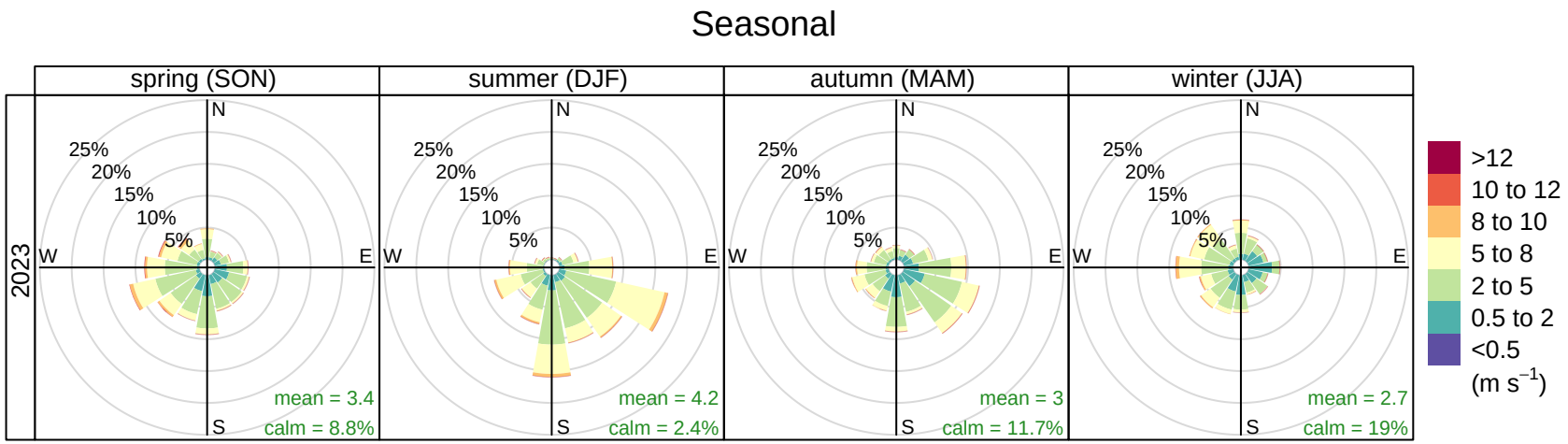


Frequency of counts by wind direction (%)

Seasonal



Frequency of counts by wind direction (%)


Seasonal
spring (SON)
summer (DJF)
autumn (MAM)
winter (JJA)
2023
N
E
S
W
25%
20%
15%
10%
5%
mean = 3.4
calm = 8.8%
mean = 4.2
calm = 2.4%
mean = 3
calm = 11.7%
mean = 2.7
calm = 19%
>12
10 to 12
8 to 10
5 to 8
2 to 5
0.5 to 2
<0.5
(m s−1)
Frequency of counts by wind direction (%)

Climate statistics for Australian locations

Monthly climate statistics - graph

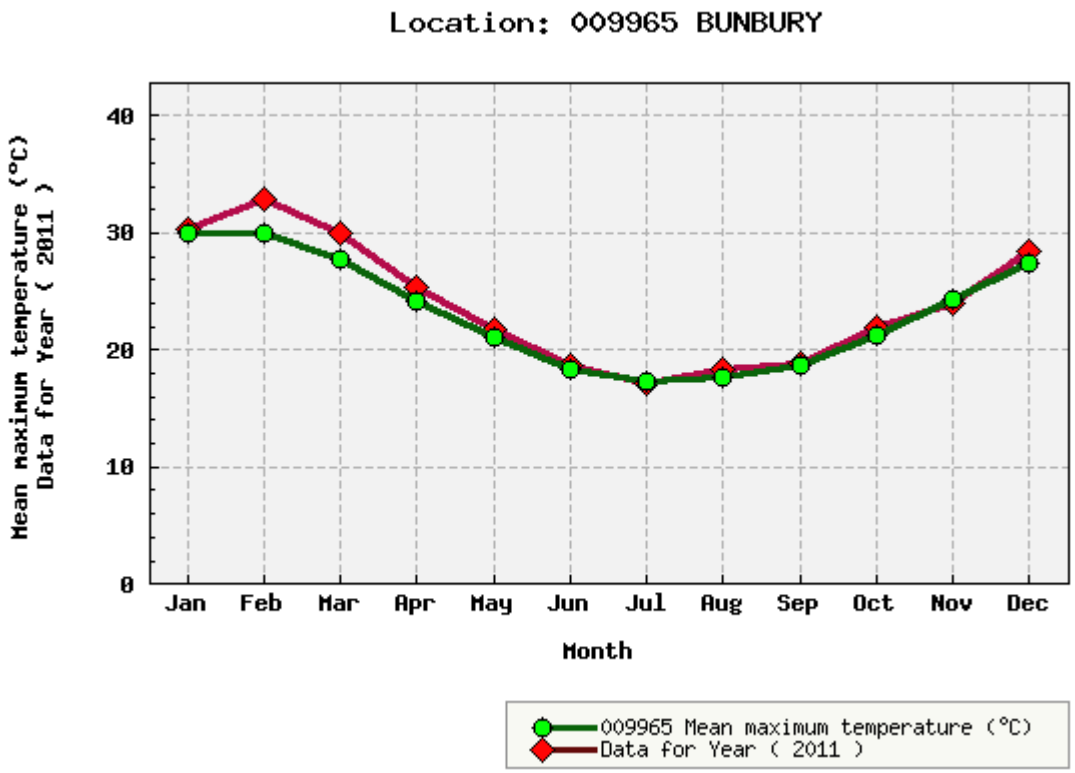
About Climate statistics | Data file of statistics for this site (csv) | Site selection menu

BUNBURY

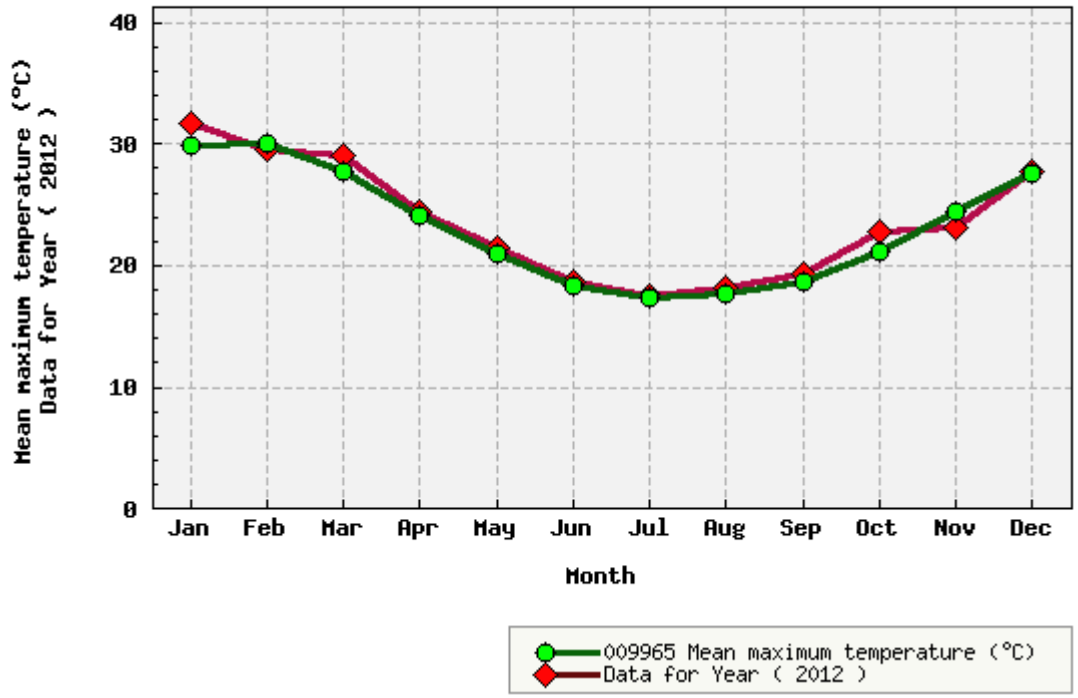
Mean rainfall (mm)

Site details

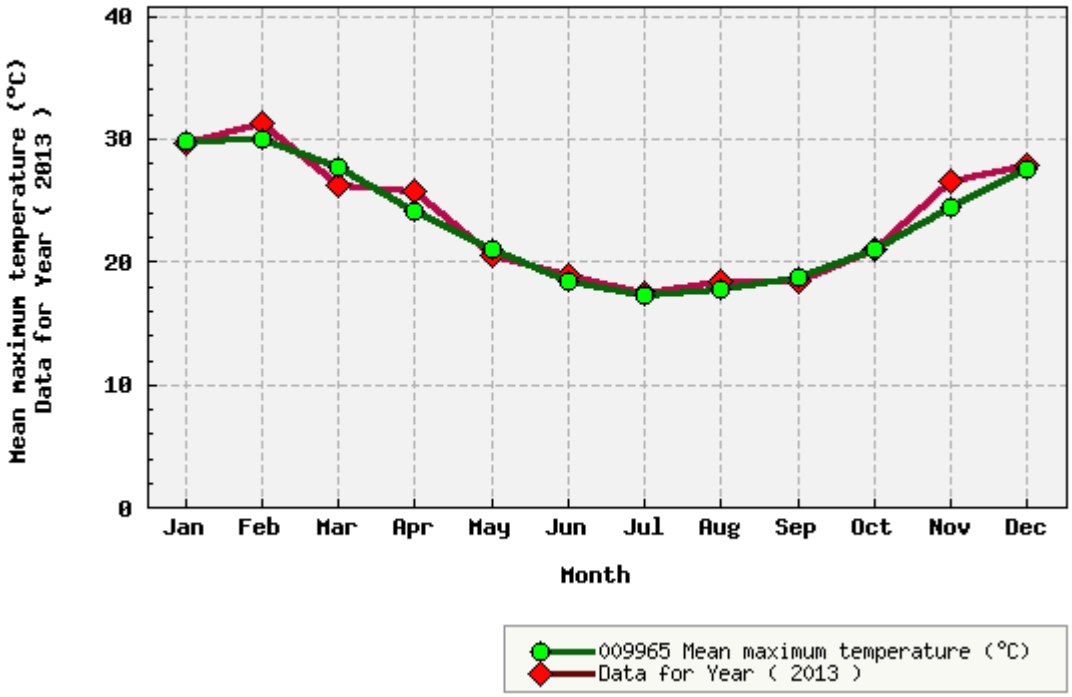
Site name: BUNBURY		**Site number:** 009965	**Commenced:** 1995
Latitude: 33.36 °S	**Longitude:** 115.64 °E	**Elevation:** 5 m	**Operational status:** Still Open



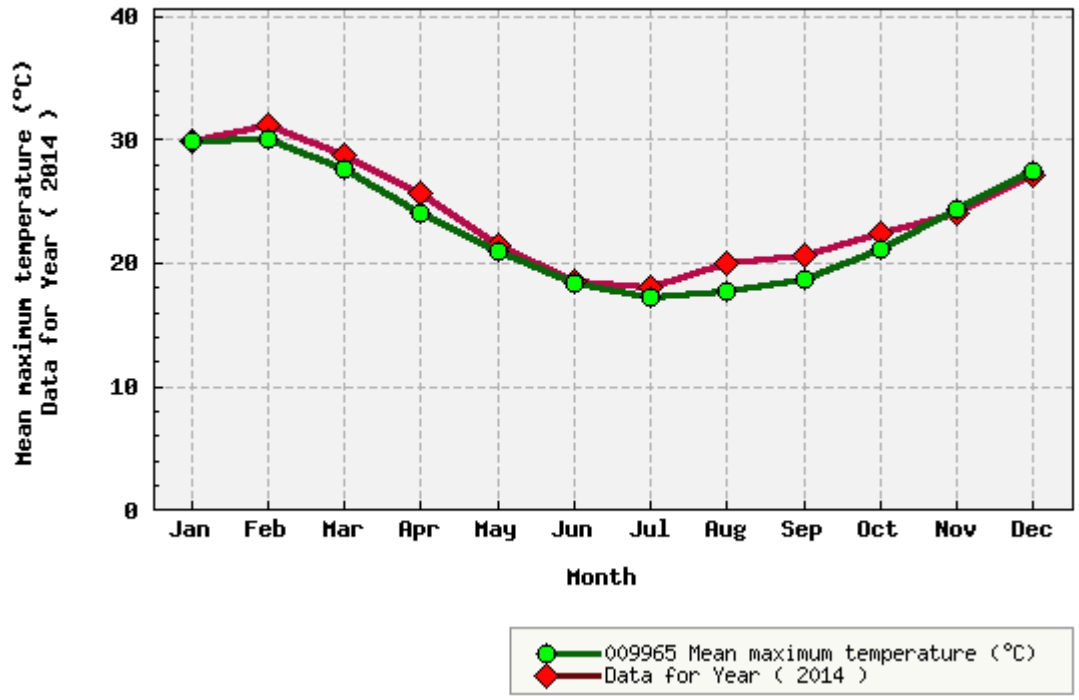
Location: 009965 BUNBURY



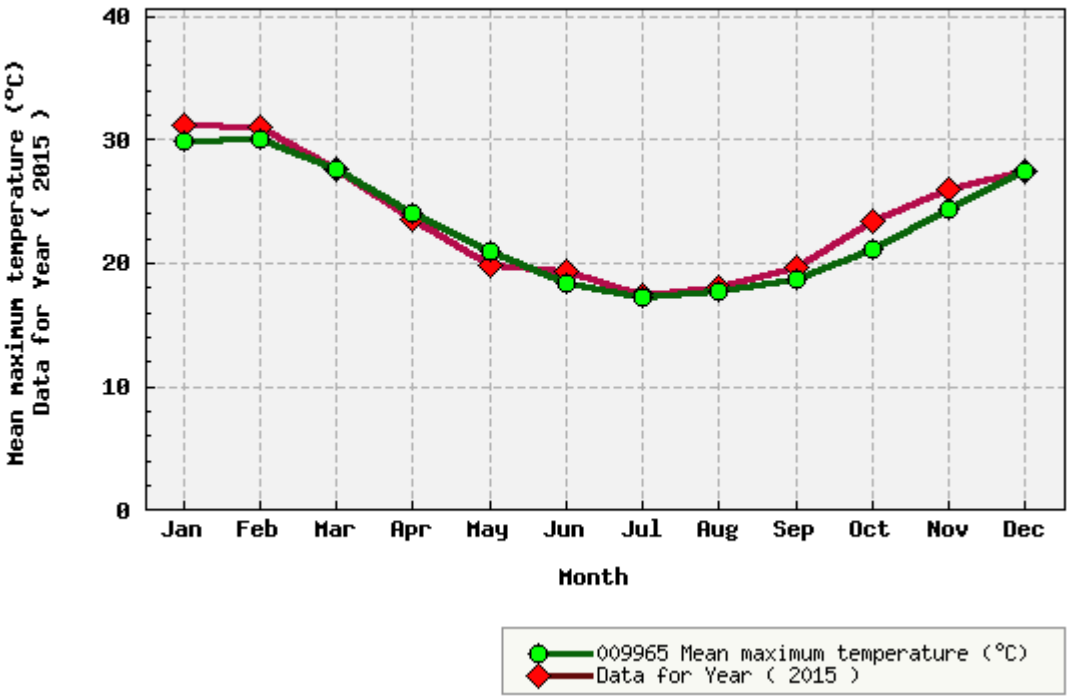
Location: 009965 BUNBURY



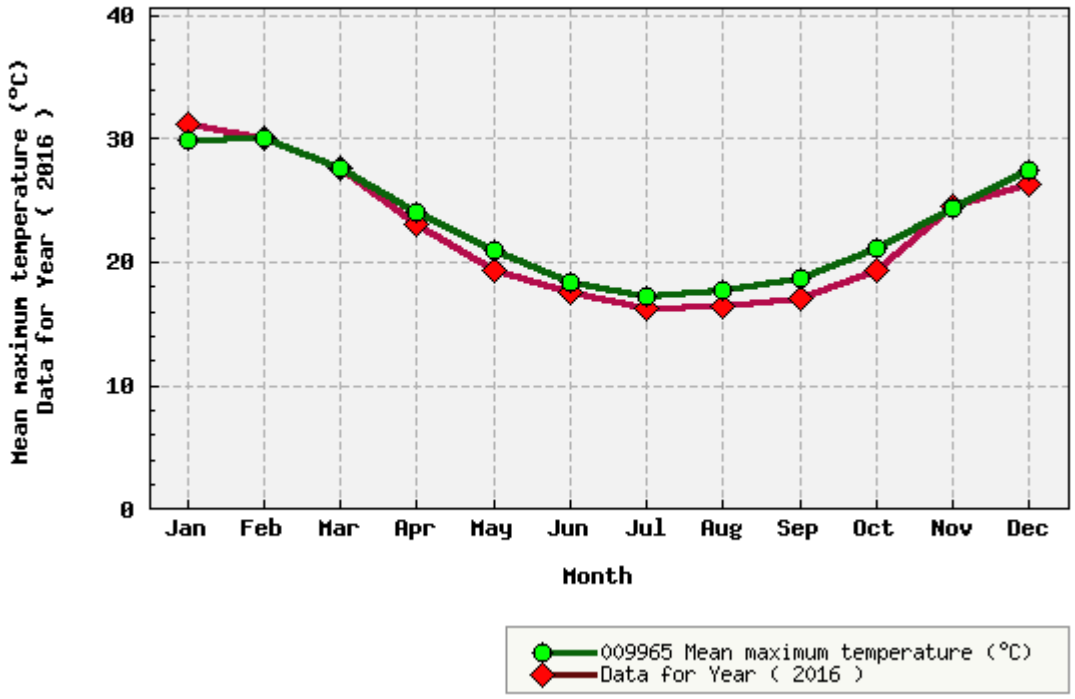
Location: 009965 BUNBURY



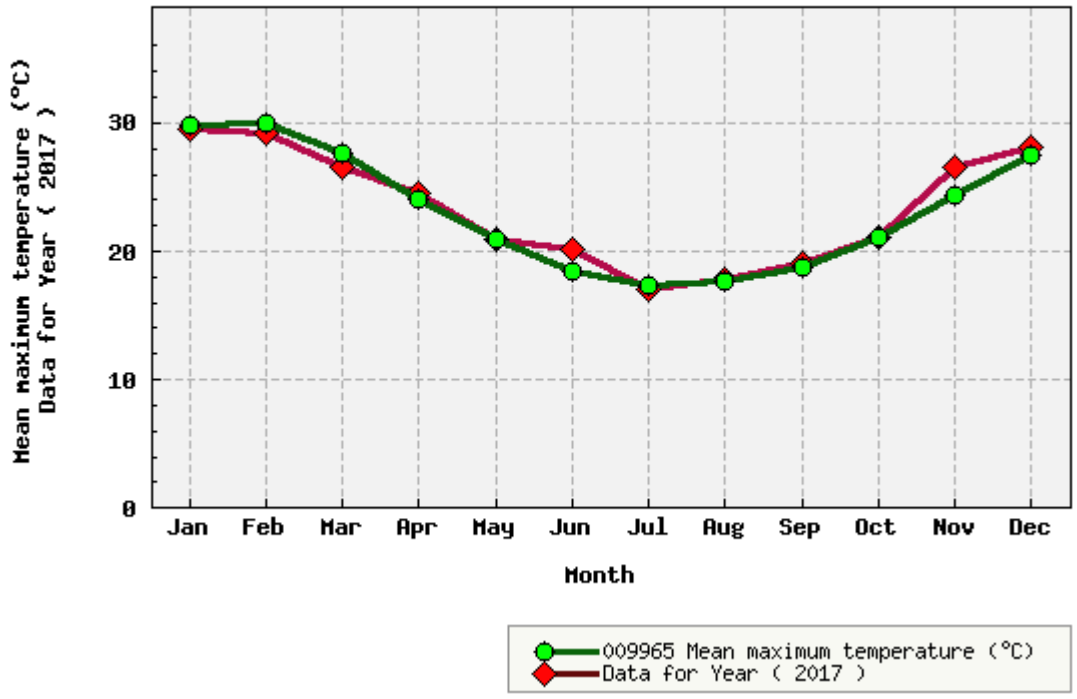
Location: 009965 BUNBURY



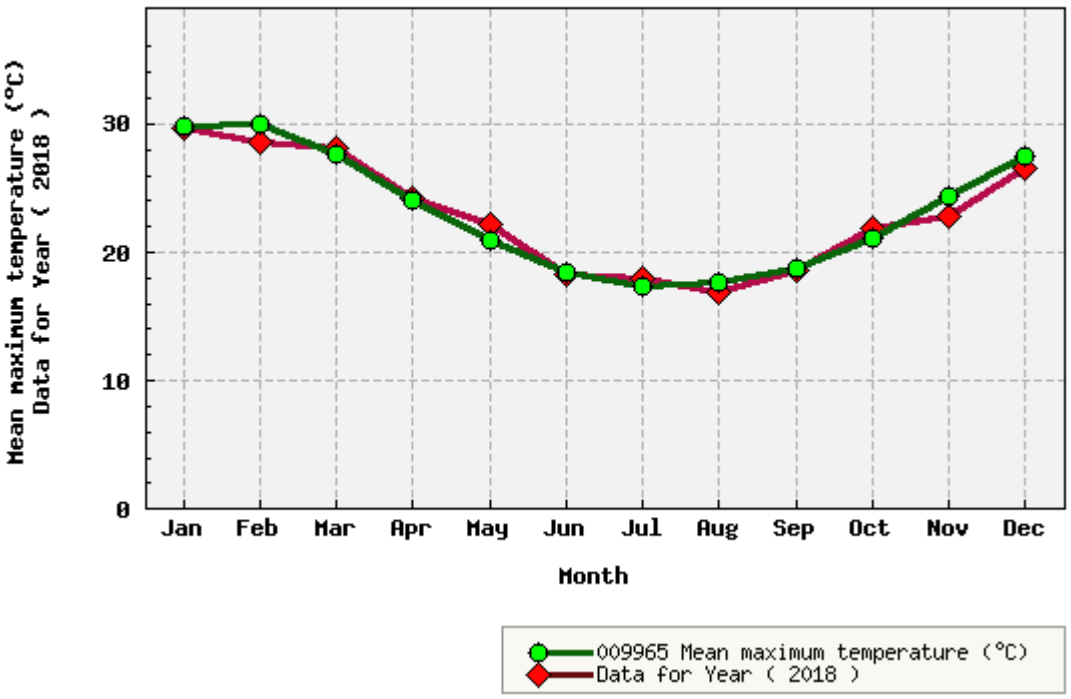
Location: 009965 BUNBURY



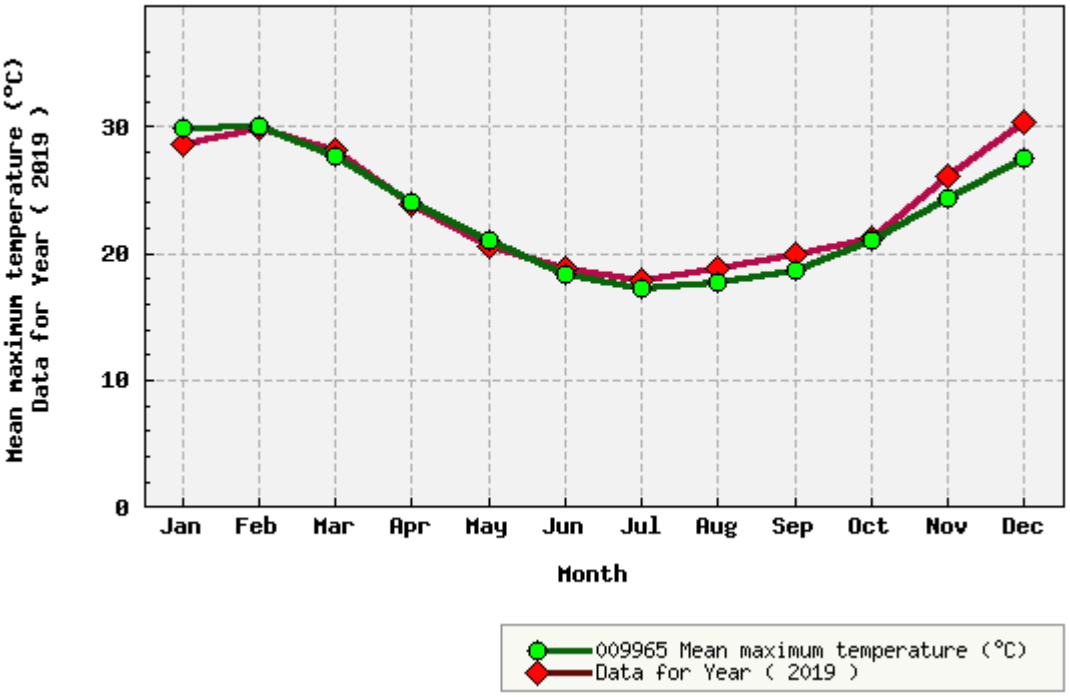
Location: 009965 BUNBURY

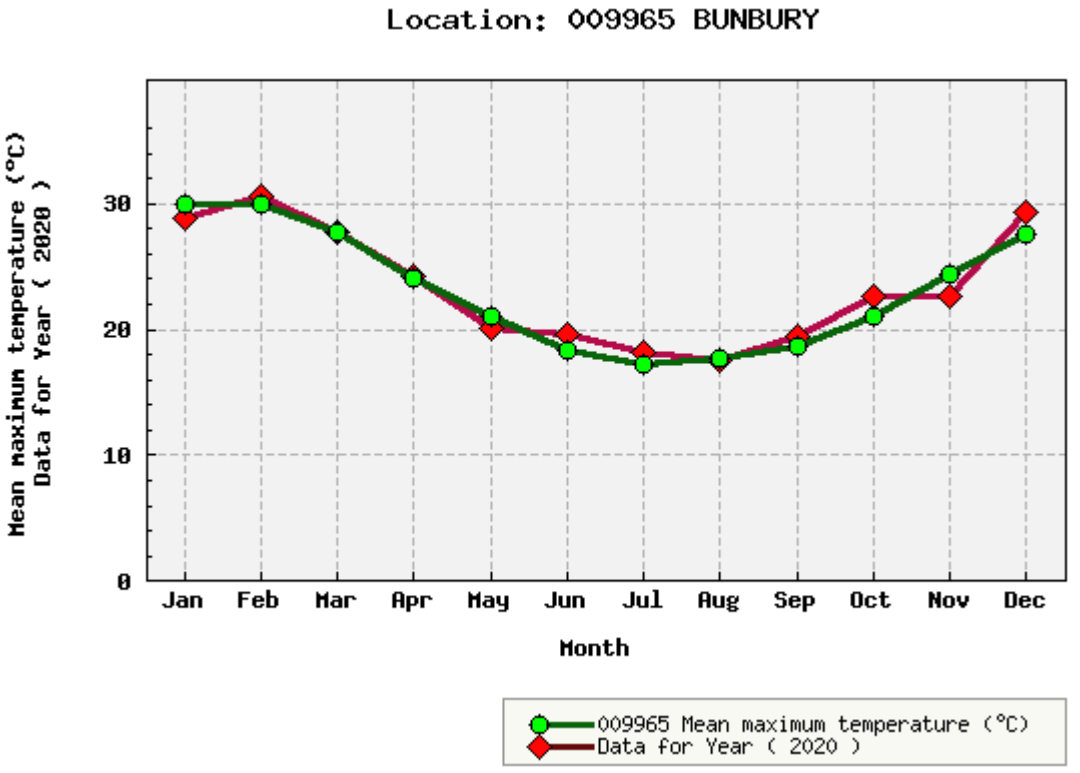


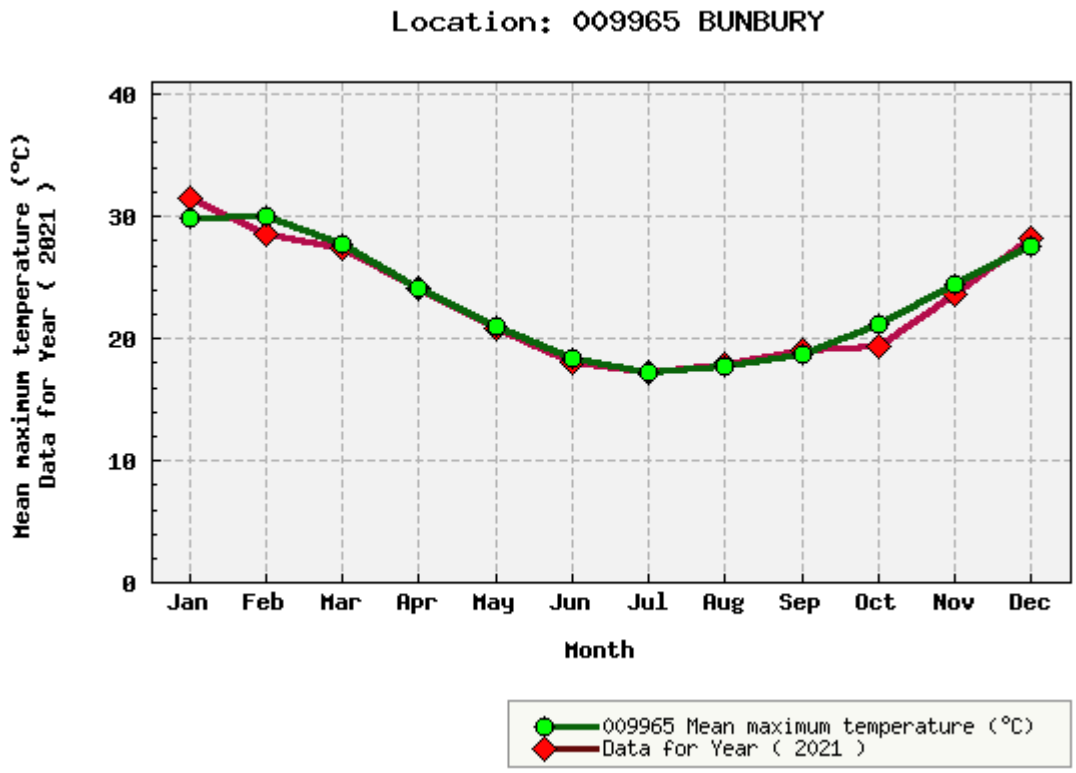
Location: 009965 BUNBURY



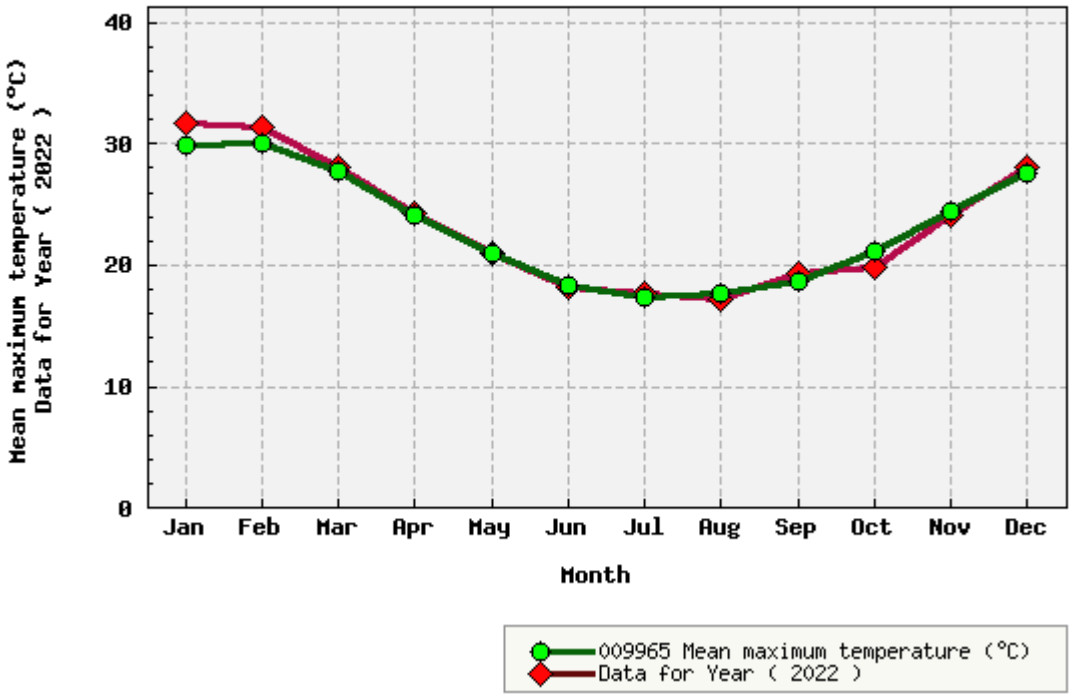
Location: 009965 BUNBURY



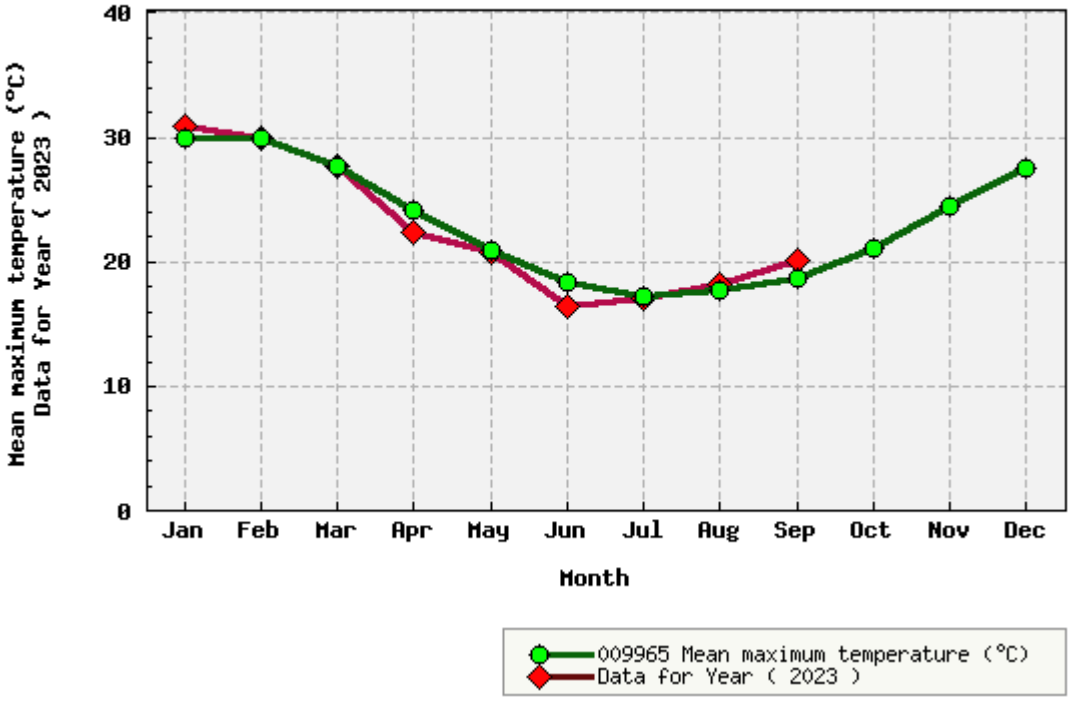

Location: 009965 BUNBURY
Mean maximum temperature (°C)
Data for Year (2020)
0
10
20
30
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
009965 Mean maximum temperature (°C)
Data for Year (2020)


Location: 009965 BUNBURY
Mean maximum temperature (°C)
Data for Year (2021)
0
10
20
30
40
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
009965 Mean maximum temperature (°C)
Data for Year (2021)

Location: 009965 BUNBURY



Location: 009965 BUNBURY

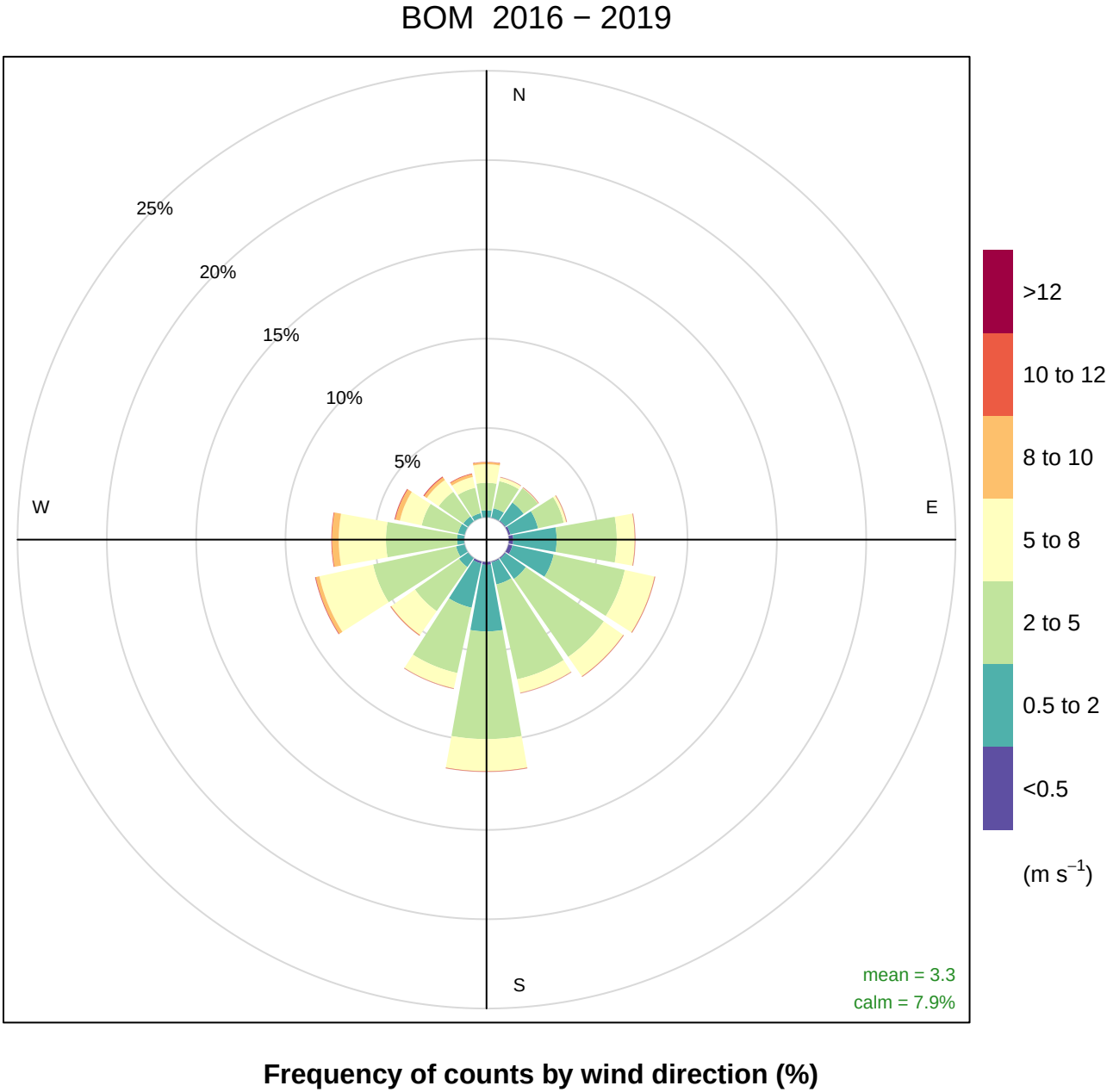


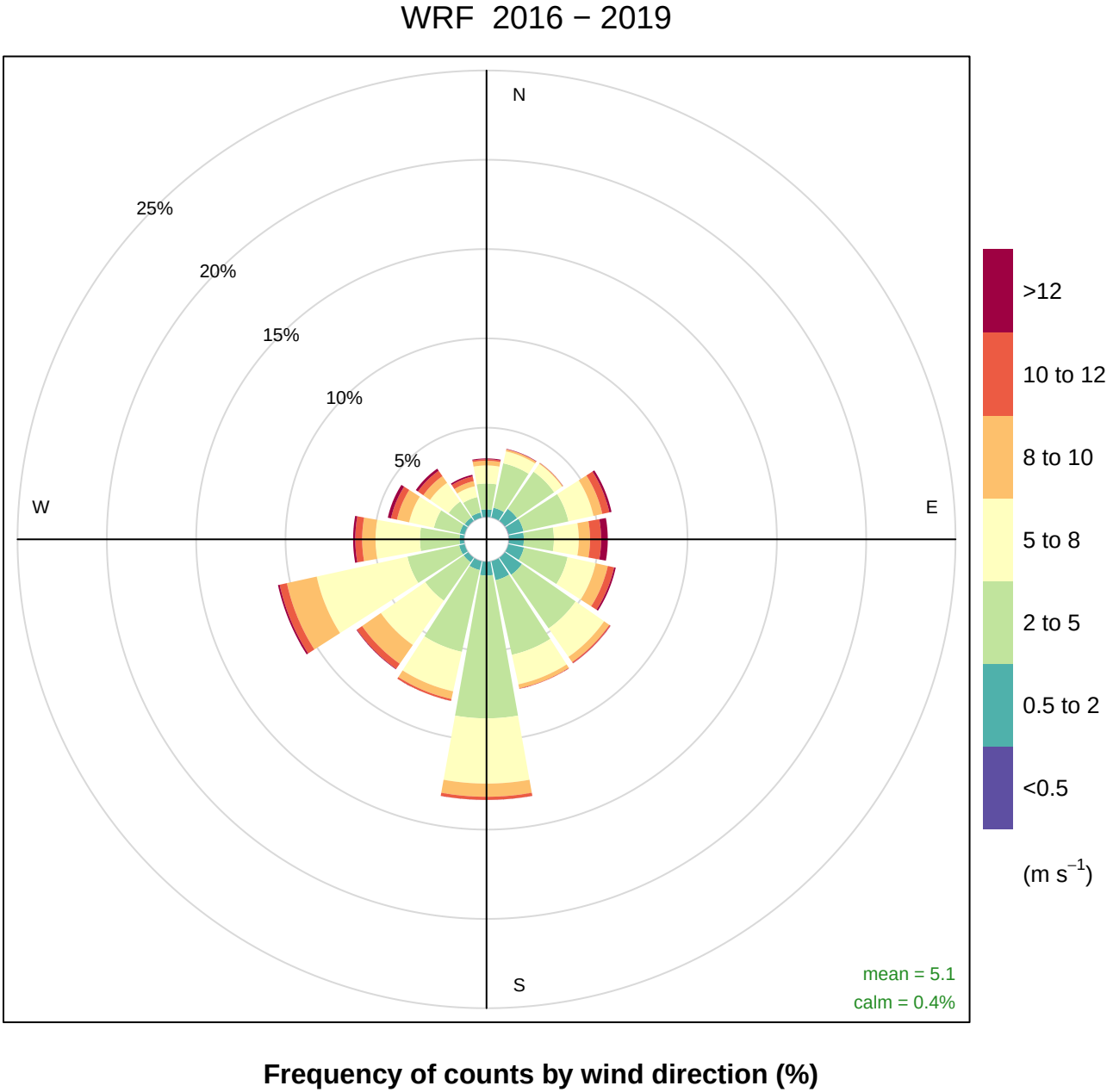
Australian Government
Bureau of Meteorology

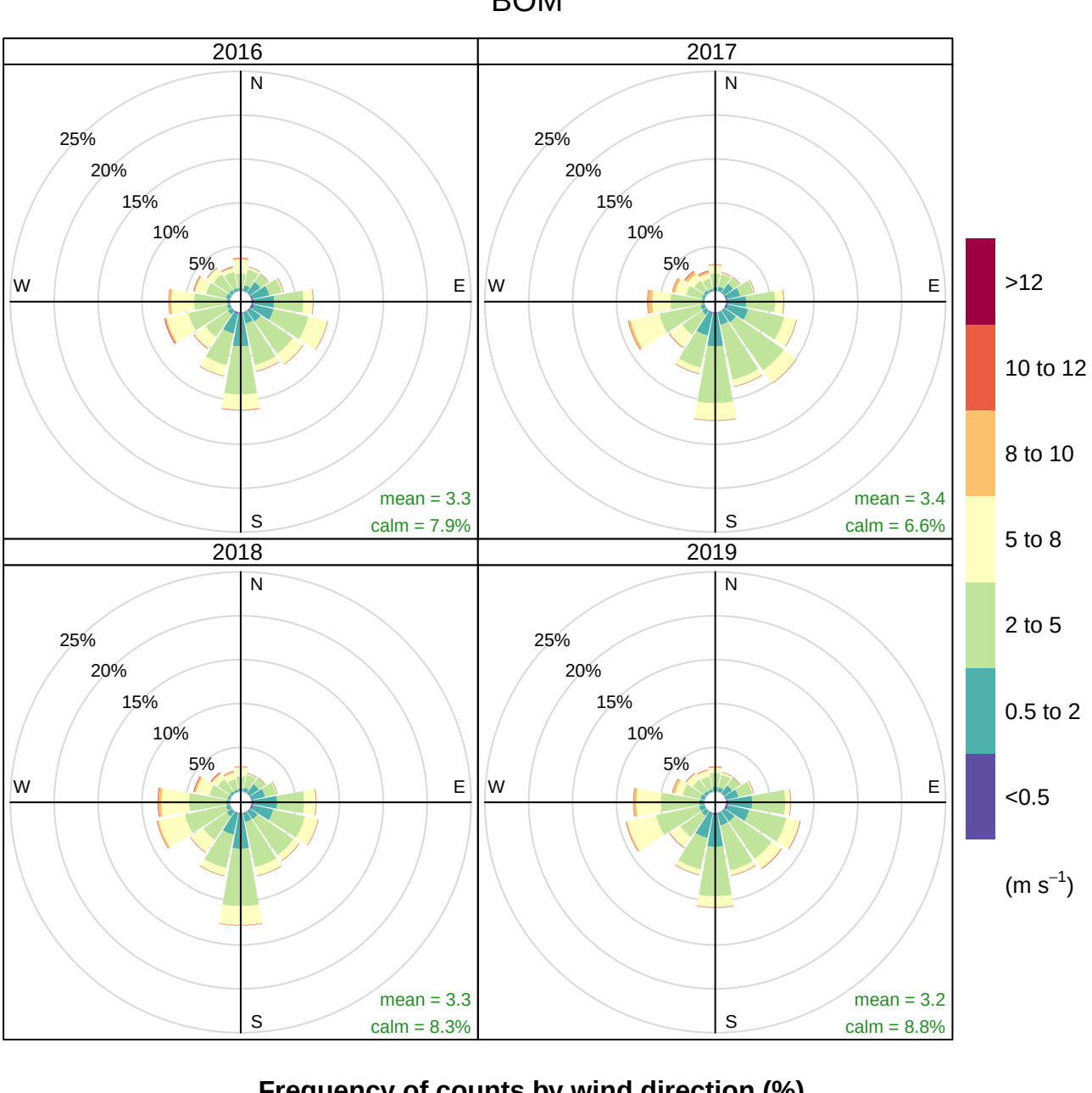
Created on Thu 2 Nov 2023 19:24 PM AEDT

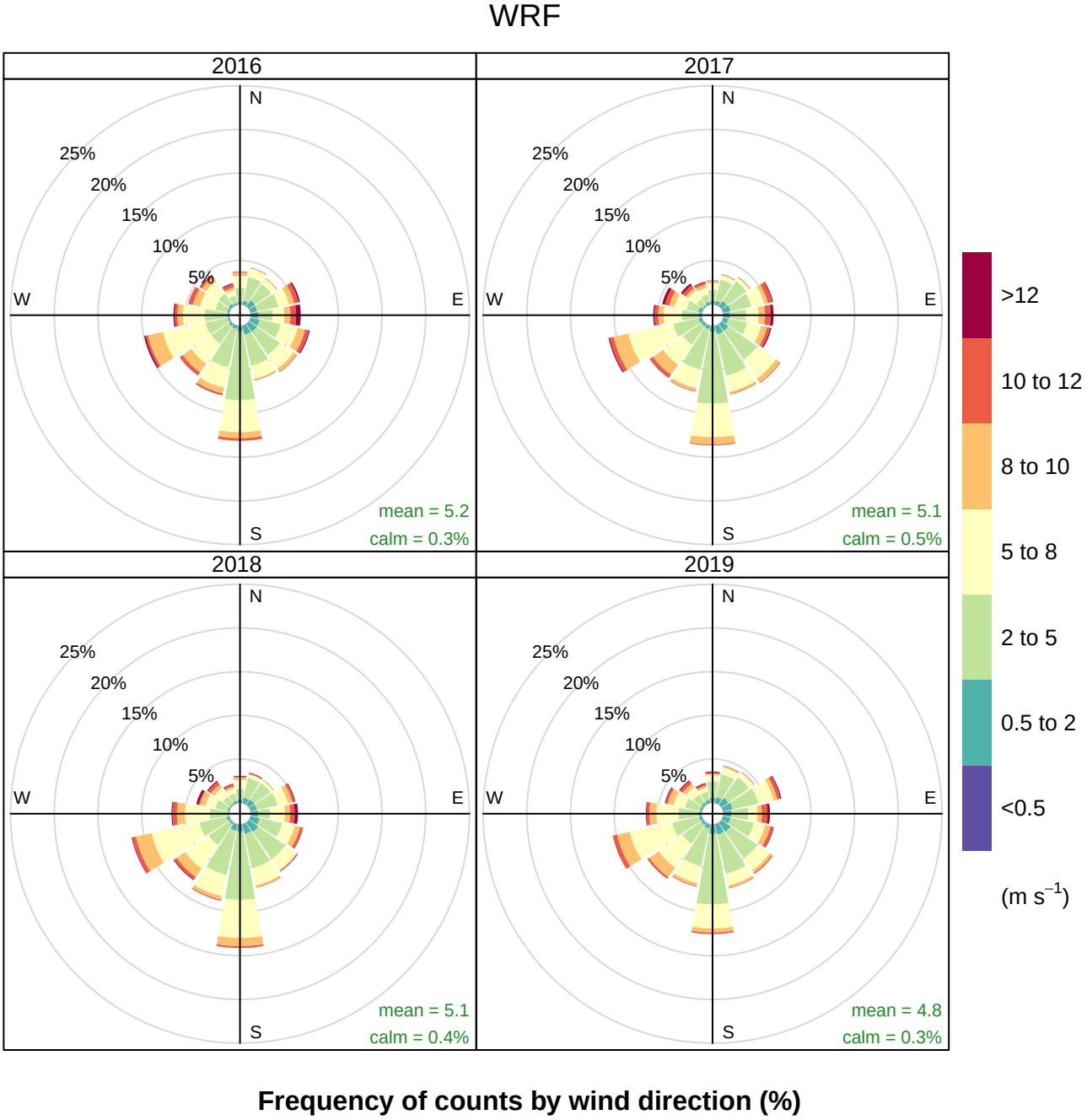
Bureau of Meteorology 2023, Climate Statistics for Australian Locations – Bunbury 009965, Accessed 2/11/2023, from: http://www.bom.gov.au/jsp/ncc/cdio/cvg/av

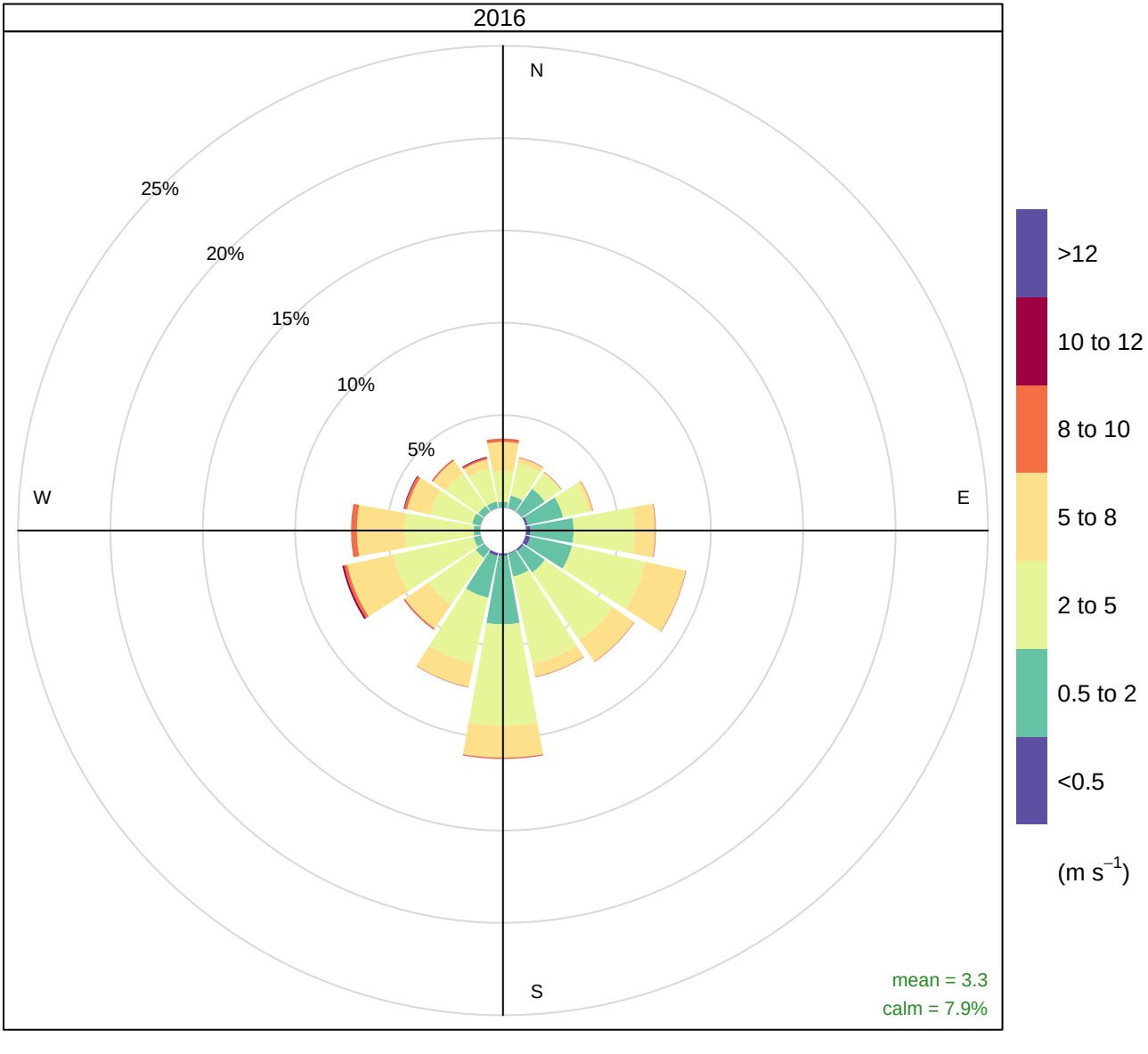
Appendix C. Yearly Wind Rose Comparison for Observed and Predicted Meteorological Data (2016-2019)

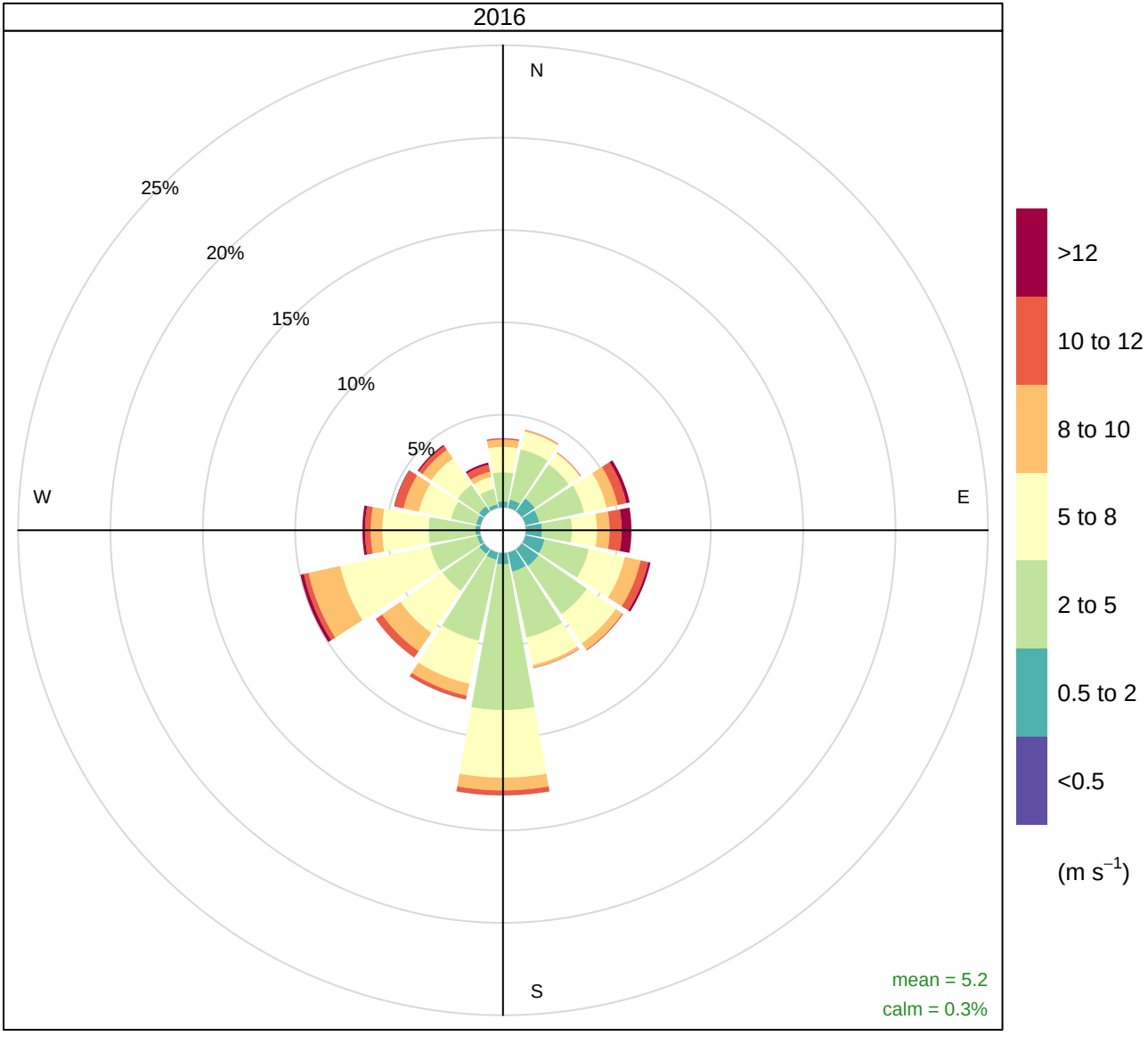

BOM 2016 − 2019
N
E
S
W
25%
20%
15%
10%
5%
>12
10 to 12
8 to 10
5 to 8
2 to 5
0.5 to 2
<0.5
(m s−1)
mean = 3.3
calm = 7.9%
Frequency of counts by wind direction (%)

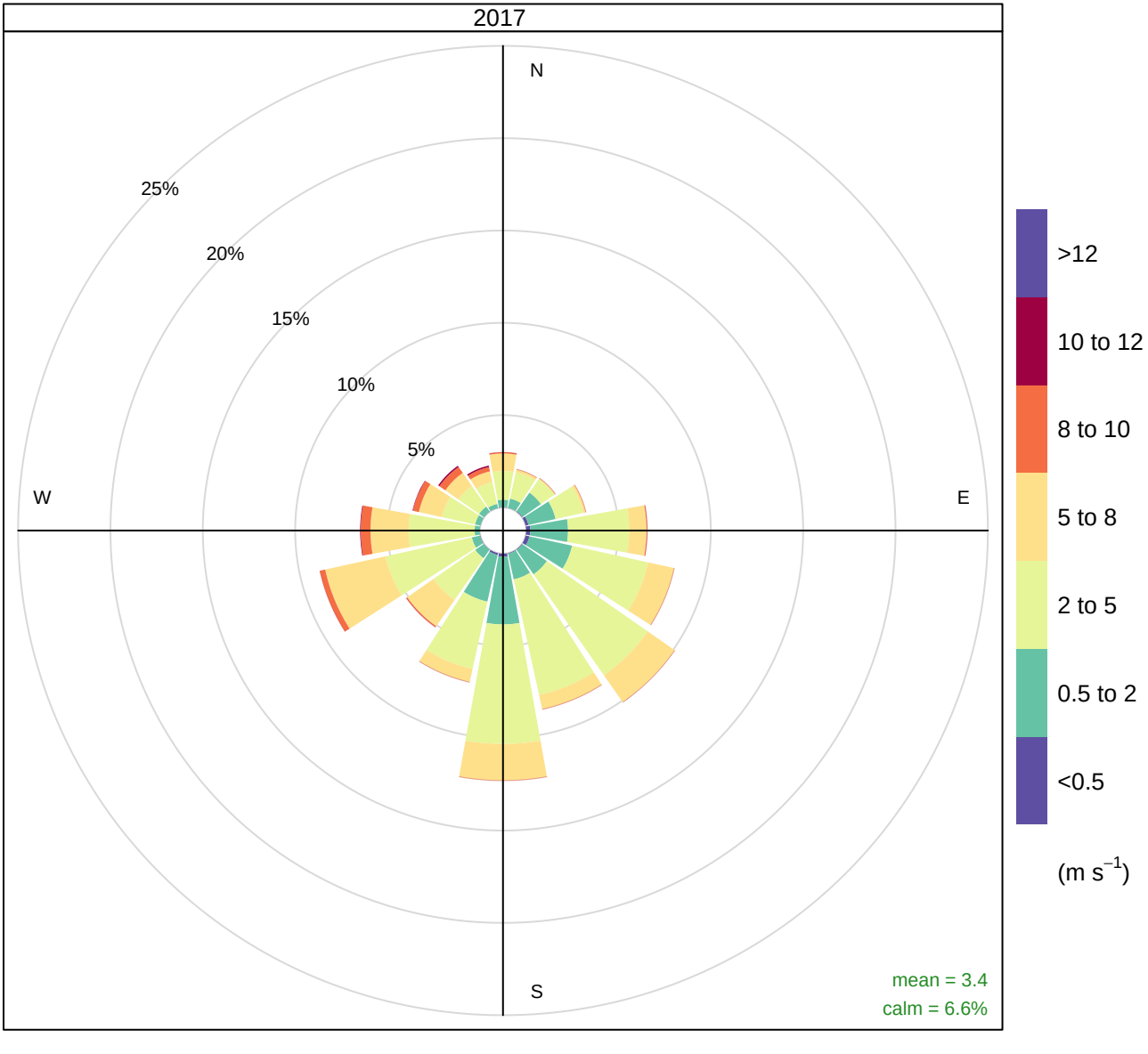

WRF 2016 − 2019
N
E
S
W
5%
10%
15%
20%
25%
>12
10 to 12
8 to 10
5 to 8
2 to 5
0.5 to 2
<0.5
(m s−1)
mean = 5.1
calm = 0.4%
Frequency of counts by wind direction (%)

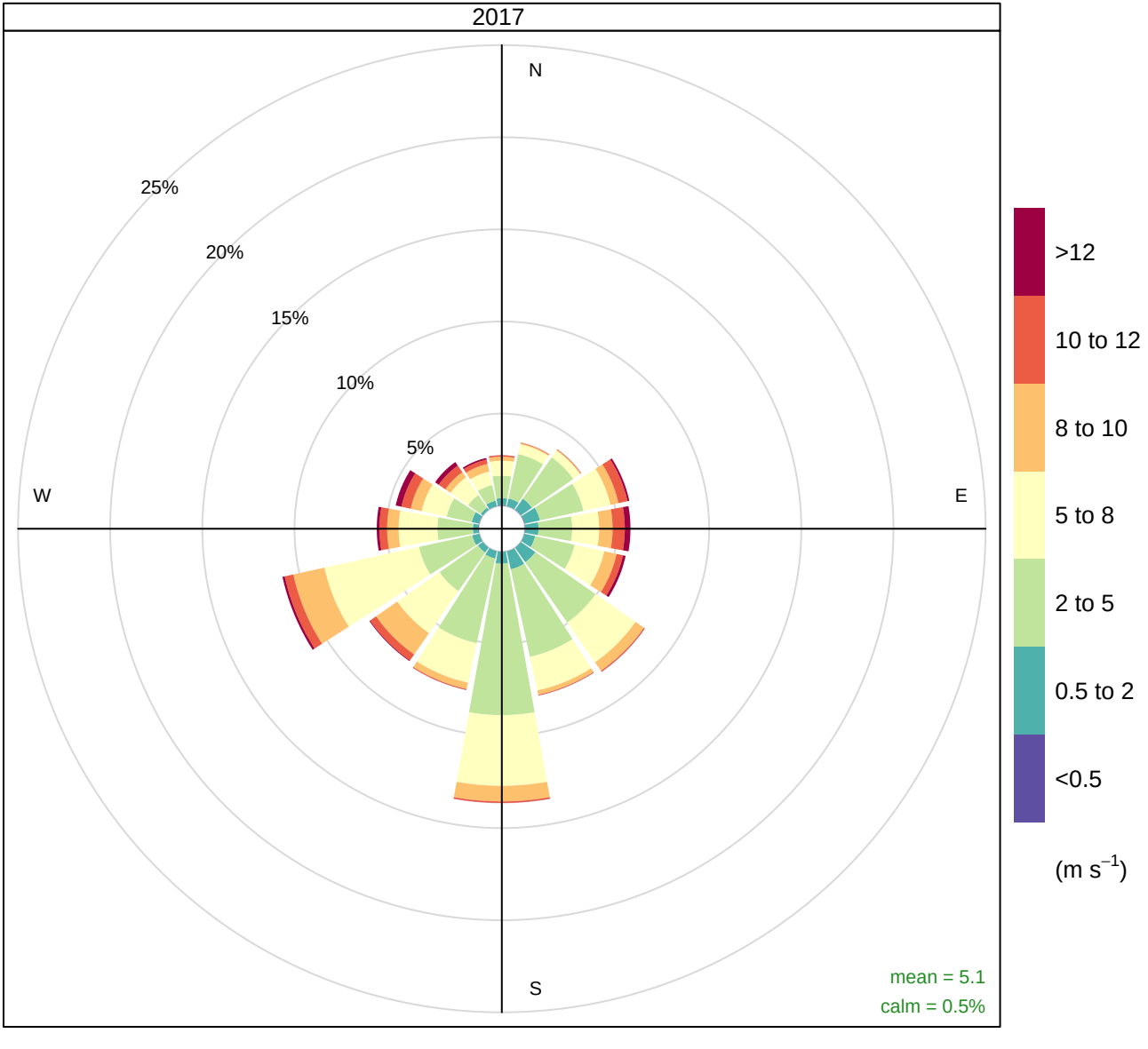

BOM
2016
2017
2018
2019
N
S
E
W
25%
20%
15%
10%
5%
mean = 3.3
calm = 7.9%
mean = 3.4
calm = 6.6%
mean = 3.3
calm = 8.3%
mean = 3.2
calm = 8.8%
>12
10 to 12
8 to 10
5 to 8
2 to 5
0.5 to 2
<0.5
(m s−1)
Frequency of counts by wind direction (%)

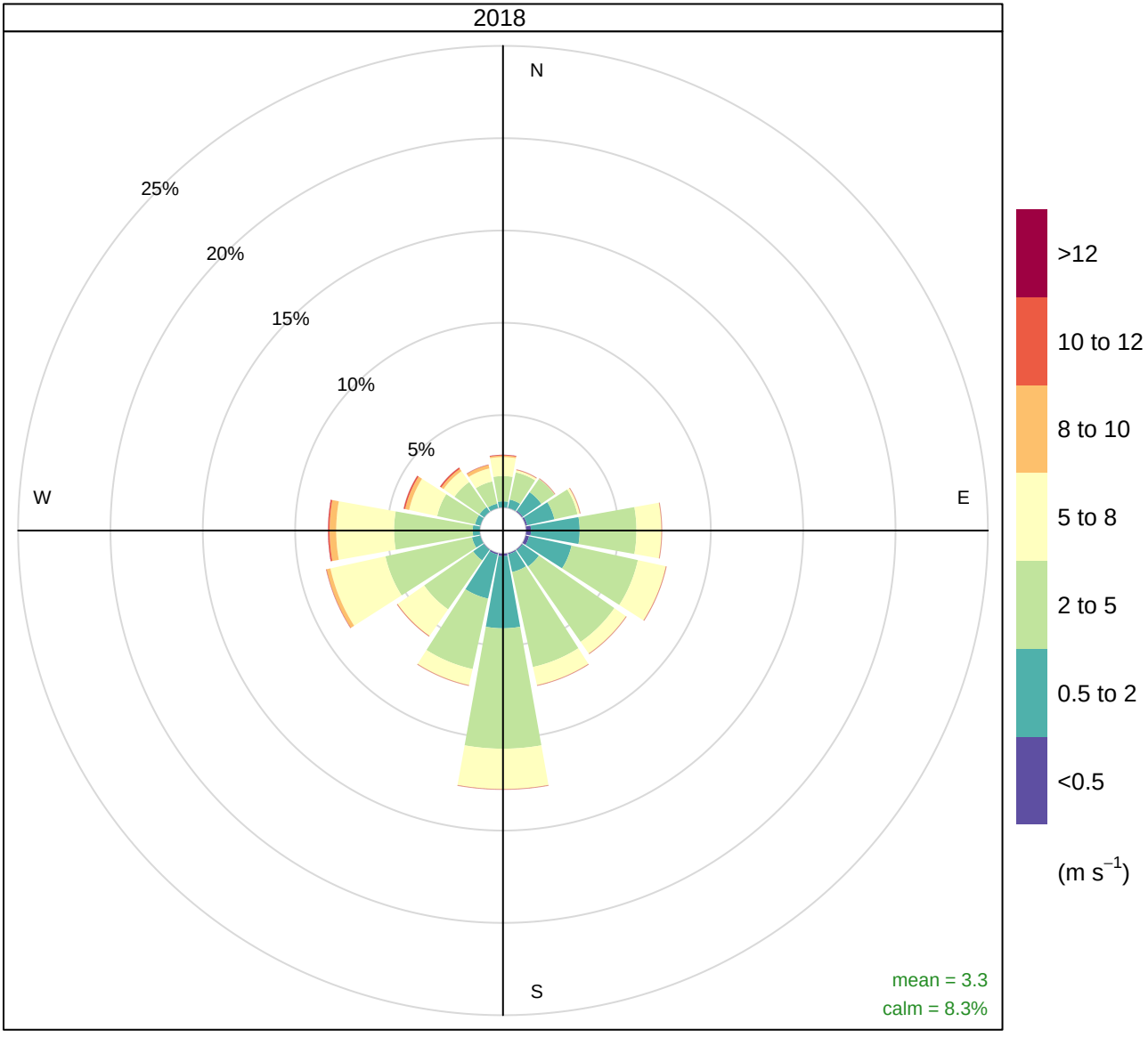

WRF
2016
2017
2018
2019
N
S
W
E
25%
20%
15%
10%
5%
mean = 5.2
calm = 0.3%
mean = 5.1
calm = 0.5%
mean = 5.1
calm = 0.4%
mean = 4.8
calm = 0.3%
>12
10 to 12
8 to 10
5 to 8
2 to 5
0.5 to 2
<0.5
(m s−1)
Frequency of counts by wind direction (%)

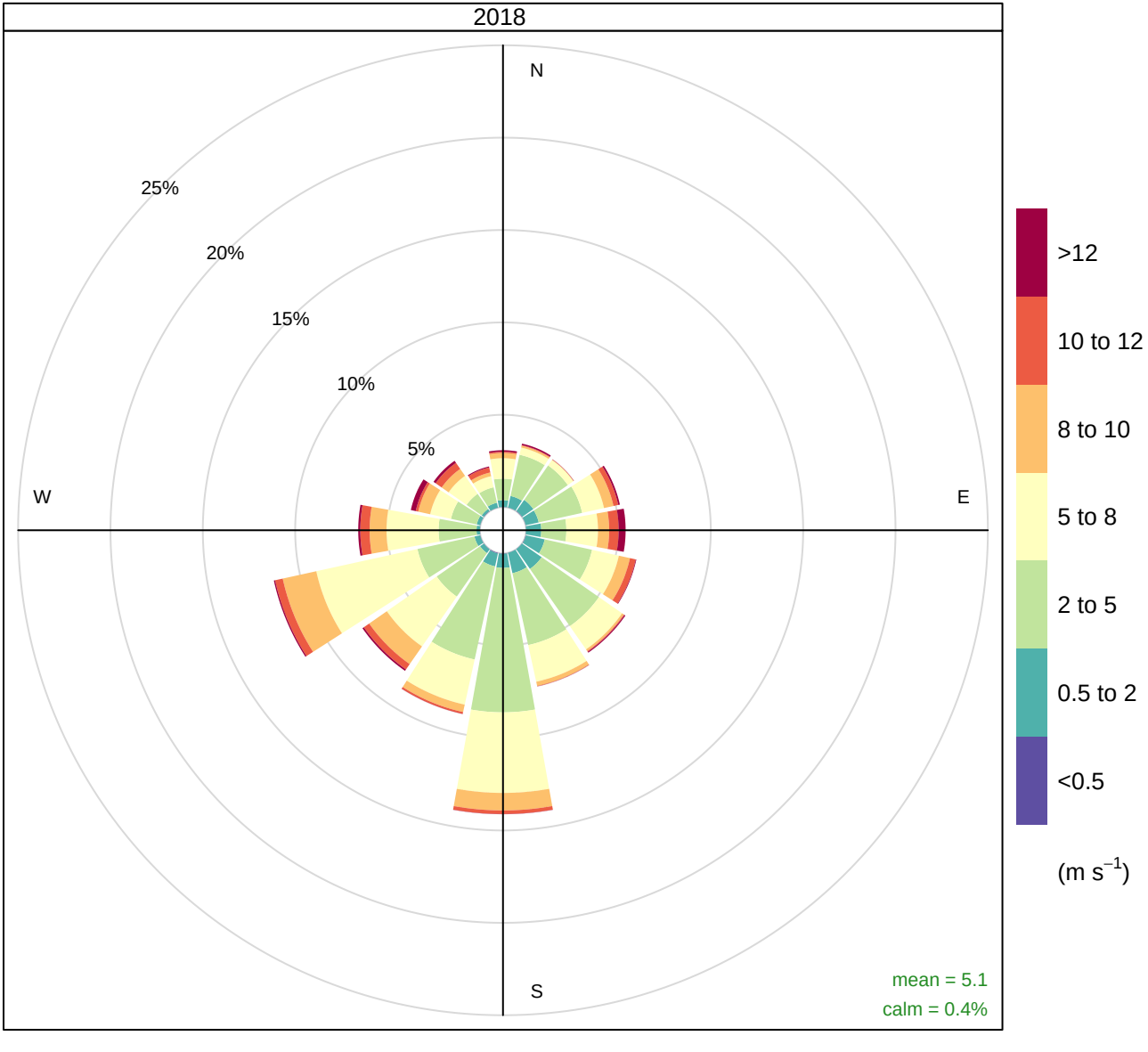

BOM
2016
N
E
S
W
25%
20%
15%
10%
5%
mean = 3.3
calm = 7.9%
>12
10 to 12
8 to 10
5 to 8
2 to 5
0.5 to 2
<0.5
(m s−1)
Frequency of counts by wind direction (%)

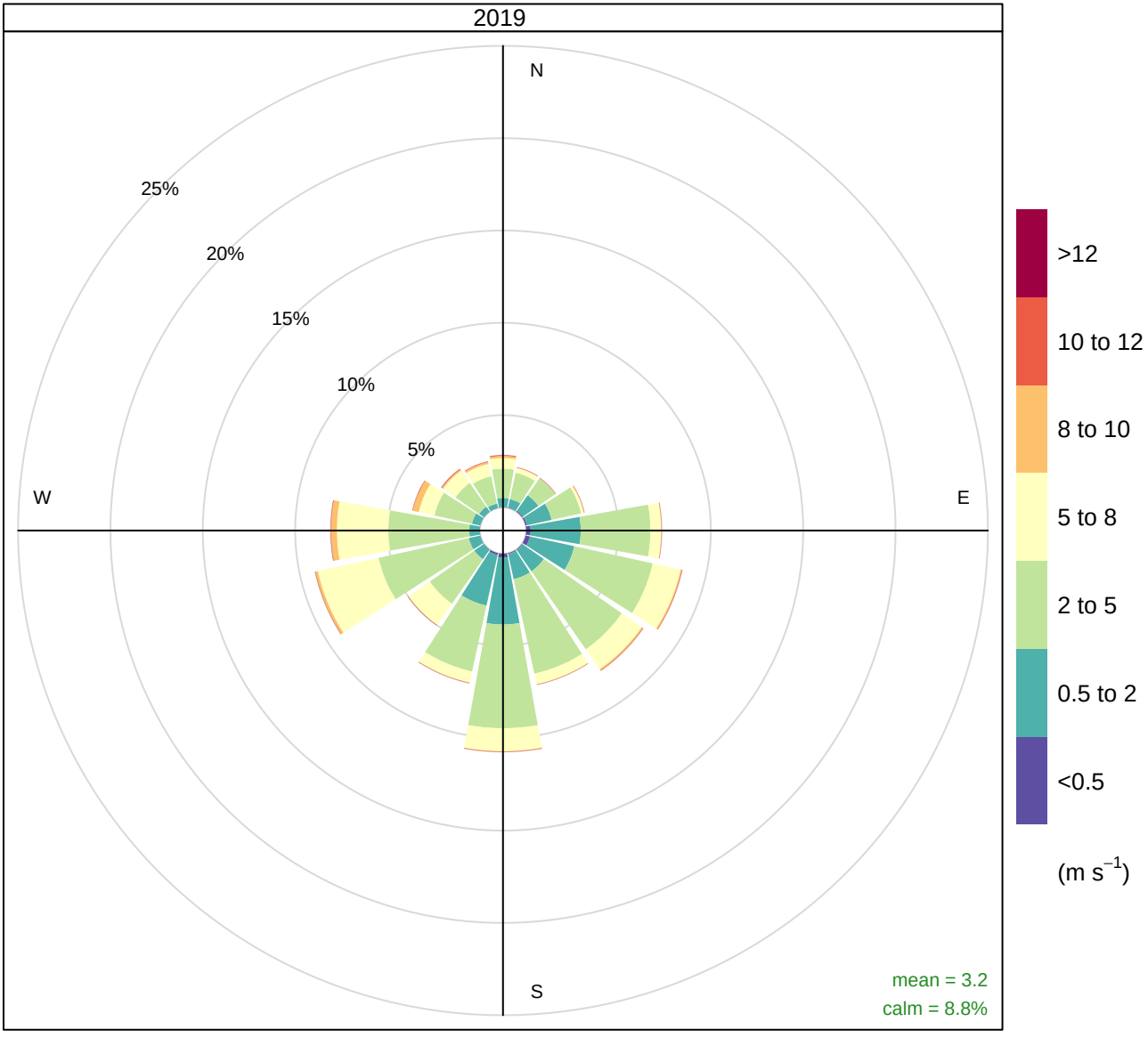

WRF
2016
N
E
S
W
25%
20%
15%
10%
5%
>12
10 to 12
8 to 10
5 to 8
2 to 5
0.5 to 2
<0.5
(m s−1)
mean = 5.2
calm = 0.3%
Frequency of counts by wind direction (%)

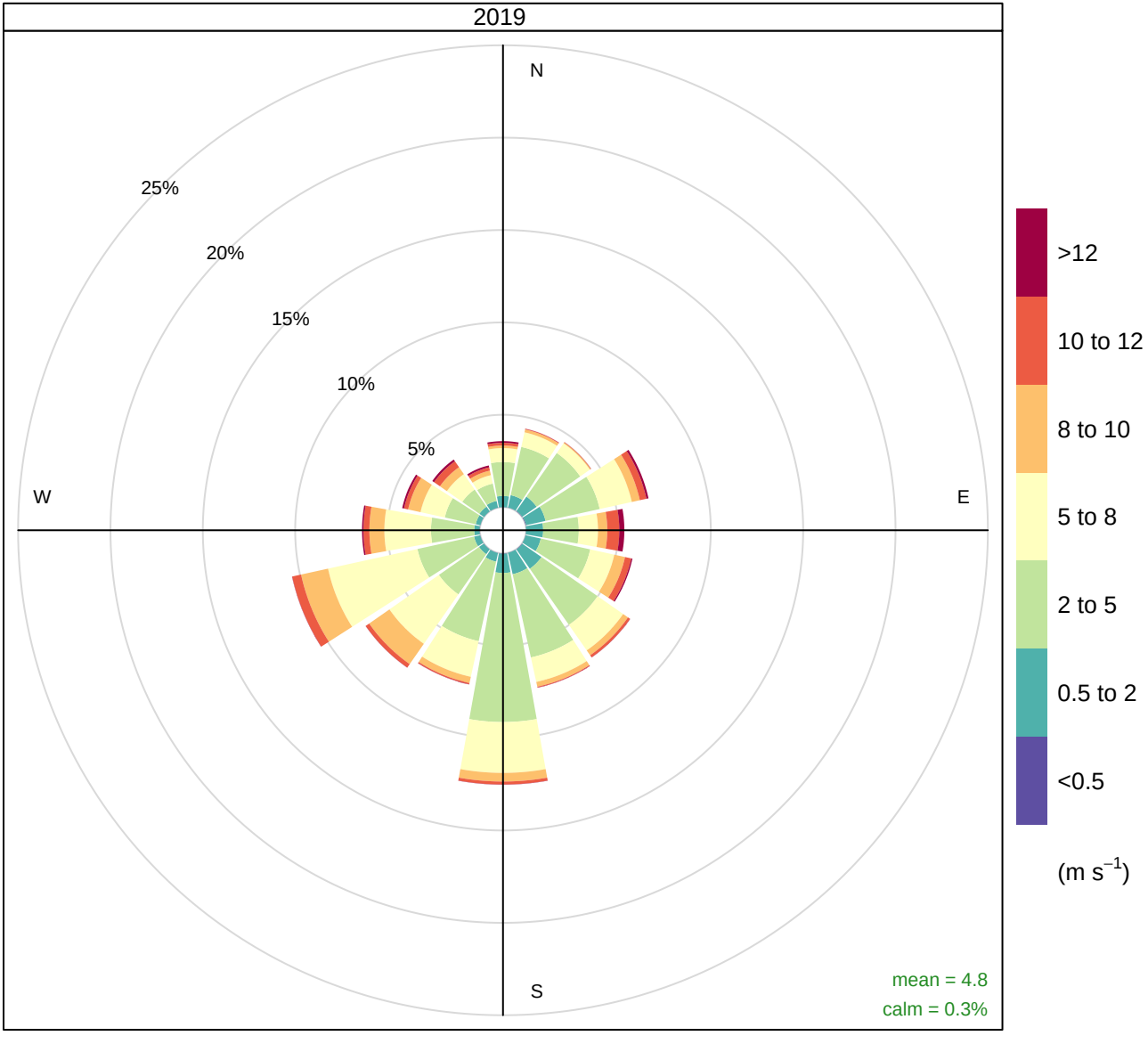

BOM
2017
N
E
S
W
25%
20%
15%
10%
5%
>12
10 to 12
8 to 10
5 to 8
2 to 5
0.5 to 2
<0.5
(m s−1)
mean = 3.4
calm = 6.6%
Frequency of counts by wind direction (%)


WRF
2017
N
E
S
W
25%
20%
15%
10%
5%
>12
10 to 12
8 to 10
5 to 8
2 to 5
0.5 to 2
<0.5
(m s−1)
mean = 5.1
calm = 0.5%
Frequency of counts by wind direction (%)


BOM
2018
N
E
S
W
25%
20%
15%
10%
5%
mean = 3.3
calm = 8.3%
>12
10 to 12
8 to 10
5 to 8
2 to 5
0.5 to 2
<0.5
(m s−1)
Frequency of counts by wind direction (%)


WRF
2018
N
E
S
W
25%
20%
15%
10%
5%
>12
10 to 12
8 to 10
5 to 8
2 to 5
0.5 to 2
<0.5
(m s−1)
mean = 5.1
calm = 0.4%
Frequency of counts by wind direction (%)


BOM
2019
N
E
S
W
25%
20%
15%
10%
5%
>12
10 to 12
8 to 10
5 to 8
2 to 5
0.5 to 2
<0.5
(m s−1)
mean = 3.2
calm = 8.8%
Frequency of counts by wind direction (%)


WRF
2019
N
E
S
W
25%
20%
15%
10%
5%
>12
10 to 12
8 to 10
5 to 8
2 to 5
0.5 to 2
<0.5
(m s−1)
mean = 4.8
calm = 0.3%
Frequency of counts by wind direction (%)

Appendix D. Sample AERMOD Summary Configuration File

*** MODELOPTs: RegDFAULT CONC ELEV ARM2 RURAL ADJ_U* MMIF_Data

*** MODEL SETUP OPTIONS SUMMARY ***

** Model Options Selected:
* Model Uses Regulatory DEFAULT Options
* Model Is Setup For Calculation of Average CONCentration Values.
* NO GAS DEPOSITION Data Provided.
* NO PARTICLE DEPOSITION Data Provided.
* Model Uses NO DRY DEPLETION. DDPLETE = F
* Model Uses NO WET DEPLETION. WETDPLT = F
* Stack-tip Downwash.
* Model Accounts for ELEVated Terrain Effects.
* Use Calms Processing Routine.
* Use Missing Data Processing Routine.
* No Exponential Decay.
* Ambient Ratio Method Ver 2 (ARM2) Used for NO2 Conversion
with a Minimum NO2/NOx Ratio of 0.500
and a Maximum NO2/NOx Ratio of 0.900
* Model Uses RURAL Dispersion Only.
* ADJ_U* - Use ADJ_U* option for SBL in AERMET
* MMIFData - Use MMIF met data inputs
* BULKRN - Use BULKRN Delta-T and SolarRad option for SBL with MMIF
* CCVR_Sub - Meteorological data includes CCVR substitutions
* TEMP_Sub - Meteorological data includes TEMP substitutions
* Model Assumes No FLAGPOLE Receptor Heights.
* The User Specified a Pollutant Type of: NO2

**Note that special processing requirements apply for the 1-hour NO2 NAAQS - check available guidance.
Model will process user-specified ranks of daily maximum 1-hour values averaged across the number of years modeled.
For annual NO2 NAAQS modeling, the multi-year maximum of PERIOD values can be simulated using the MULTYEAR keyword.
Multi-year PERIOD and 1-hour values should only be done in a single model run using the MULTYEAR option with a single multi-year meteorological data file using STARTEND keyword.

**Model Calculates 1 Short Term Average(s) of: 1-HR
and Calculates ANNUAL Averages

**This Run Includes: 2 Source(s); 1 Source Group(s); and 23061 Receptor(s)

with: 2 POINT(s), including
0 POINTCAP(s) and 0 POINTHOR(s)
and: 0 VOLUME source(s)
and: 0 AREA type source(s)
and: 0 LINE source(s)

and: 0 RLINE/RLINEXT source(s)
and: 0 OPENPIT source(s)
and: 0 BUOYANT LINE source(s) with a total of 0 line(s)
and: 0 SWPOINT source(s)

**Model Set To Continue RUNning After the Setup Testing.

**The AERMET Input Meteorological Data Version Date: 22112

**Output Options Selected:
Model Outputs Tables of ANNUAL Averages by Receptor
Model Outputs Tables of Highest Short Term Values by Receptor (RECTABLE Keyword)
Model Outputs External File(s) of Concurrent Values for Postprocessing (POSTFILE Keyword)
Model Outputs External File(s) of High Values for Plotting (PLOTFILE Keyword)
Model Outputs Separate Summary File of High Ranked Values (SUMMFILE Keyword)

**NOTE: The Following Flags May Appear Following CONC Values: c for Calm Hours
m for Missing Hours
b for Both Calm and Missing Hours

**Misc. Inputs: Base Elev. for Pot. Temp. Profile (m MSL) = 18.88 ; Decay Coef. = 0.000 ; Rot. Angle = 0.0
Emission Units = GRAMS/SEC ; Emission Rate Unit Factor = 0.10000E+07
Output Units = MICROGRAMS/M**3

**Approximate Storage Requirements of Model = 6.4 MB of RAM.

**Input Runstream File: aermod.inp
**Output Print File: aermod.out

**Detailed Error/Message File: Sc_2a_NO2.err
**File for Summary of Results: Sc_2a_NO2.sum

```
*** AERMOD - VERSION 22112  ***   *** Scenario 2a                                   ***        11/23/23
*** AERMET - VERSION  22112 ***   *** NO2                                           ***        14:04:23
                                                                                PAGE   2
*** MODELOPTs:    RegDFAULT  CONC  ELEV  ARM2  RURAL  ADJ_U*  MMIF_Data

                              *** METEOROLOGICAL DAYS SELECTED FOR PROCESSING ***
                                             (1=YES; 0=NO)

      1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1
      1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1
      1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1
      1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1
      1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1
      1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1
      1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1
      1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1

        NOTE:  METEOROLOGICAL DATA ACTUALLY PROCESSED WILL ALSO DEPEND ON WHAT IS INCLUDED IN
THE DATA FILE.


                         *** UPPER BOUND OF FIRST THROUGH FIFTH WIND SPEED CATEGORIES ***
                                          (METERS/SEC)

                                 1.54,   3.09,   5.14,   8.23,  10.80,
```

*** MODELOPTs: RegDFAULT CONC ELEV ARM2 RURAL ADJ_U* MMIF_Data

*** UP TO THE FIRST 24 HOURS OF METEOROLOGICAL DATA ***

Surface file: ..\Met\MET2324011_AERMET_2016-2019.SFC Met Version: 22112
Profile file: ..\Met\MET2324011_AERMET_2016-2019.PFL
Surface format: FREE
Profile format: FREE
Surface station no.: 0 Upper air station no.: 99999
Name: UNKNOWN Name: UNKNOWN
Year: 2016 Year: 2016

First 24 hours of scalar data

YR	MO	DY	JDY	HR	H0	U*	W*	DT/DZ	ZICNV	ZIMCH	M-O LEN	Z0	BOWEN	ALBEDO	REF WS	WD	HT	REF TA	HT
16	01	01	1	01	-16.1	0.796	-9.000	-9.000	-999.	461.	2837.3	0.01	7.65	1.00	13.77	105.	10.0	288.9	2.0
16	01	01	1	02	-20.4	0.787	-9.000	-9.000	-999.	453.	2158.1	0.01	7.65	1.00	13.63	102.	10.0	288.4	2.0
16	01	01	1	03	-24.0	0.773	-9.000	-9.000	-999.	442.	1739.8	0.01	7.65	1.00	13.39	100.	10.0	288.1	2.0
16	01	01	1	04	-27.6	0.761	-9.000	-9.000	-999.	417.	1440.6	0.01	7.65	1.00	13.19	99.	10.0	287.8	2.0
16	01	01	1	05	-30.6	0.754	-9.000	-9.000	-999.	430.	1267.6	0.01	7.65	1.00	13.08	97.	10.0	287.5	2.0
16	01	01	1	06	0.0	0.651	-9.000	-9.000	-999.	420.	8888.0	0.01	7.65	0.61	11.25	98.	10.0	287.7	2.0
16	01	01	1	07	82.6	0.810	1.020	0.007	466.	1749.	-581.9	0.01	7.65	0.30	13.85	94.	10.0	290.1	2.0
16	01	01	1	08	235.2	0.738	1.619	0.007	654.	1532.	-154.8	0.01	7.65	0.20	12.38	93.	10.0	293.3	2.0
16	01	01	1	09	372.5	0.713	1.995	0.007	774.	1447.	-88.0	0.01	7.65	0.17	11.75	91.	10.0	295.6	2.0
16	01	01	1	10	483.4	0.643	2.313	0.005	929.	1246.	-49.8	0.01	7.65	0.16	10.36	90.	10.0	297.8	2.0
16	01	01	1	11	562.3	0.618	2.696	0.005	1264.	1168.	-37.9	0.01	7.65	0.16	9.82	90.	10.0	299.8	2.0
16	01	01	1	12	604.6	0.590	2.954	0.007	1546.	1090.	-30.7	0.01	7.65	0.16	9.27	89.	10.0	301.5	2.0
16	01	01	1	13	579.6	0.553	3.004	0.007	1695.	989.	-26.3	0.01	7.65	0.16	8.61	89.	10.0	303.0	2.0
16	01	01	1	14	530.3	0.543	2.958	0.007	1766.	961.	-27.2	0.01	7.65	0.16	8.47	93.	10.0	304.3	2.0
16	01	01	1	15	463.3	0.525	2.903	0.007	1909.	915.	-28.2	0.01	7.65	0.16	8.21	93.	10.0	305.4	2.0
16	01	01	1	16	377.8	0.504	2.730	0.007	1946.	859.	-30.5	0.01	7.65	0.17	7.91	90.	10.0	306.2	2.0
16	01	01	1	17	260.9	0.496	2.410	0.007	1938.	838.	-42.1	0.01	7.65	0.18	7.92	92.	10.0	306.6	2.0
16	01	01	1	18	129.6	0.499	1.875	0.007	1836.	847.	-86.4	0.01	7.65	0.22	8.23	94.	10.0	306.1	2.0
16	01	01	1	19	26.8	0.399	0.881	0.005	918.	614.	-213.9	0.01	7.65	0.37	6.74	115.	10.0	304.1	2.0
16	01	01	1	20	-30.6	0.464	-9.000	-9.000	-999.	617.	294.4	0.01	7.65	1.00	8.21	117.	10.0	300.8	2.0
16	01	01	1	21	-20.0	0.682	-9.000	-9.000	-999.	527.	1430.6	0.01	7.65	1.00	11.84	110.	10.0	298.4	2.0
16	01	01	1	22	-12.5	0.836	-9.000	-9.000	-999.	469.	4190.3	0.01	7.65	1.00	14.46	104.	10.0	296.2	2.0
16	01	01	1	23	-10.5	0.880	-9.000	-9.000	-999.	456.	5841.0	0.01	7.65	1.00	15.21	100.	10.0	295.0	2.0
16	01	01	1	24	-17.1	0.883	-9.000	-9.000	-999.	459.	3628.7	0.01	7.65	1.00	15.27	96.	10.0	294.2	2.0

*** MODELOPTs: RegDFAULT CONC ELEV ARM2 RURAL ADJ_U* MMIF_Data

First hour of profile data

YR	MO	DY	HR	HEIGHT	F	WDIR	WSPD	AMB_TMP	sigmaA	sigmaW	sigmaV
16	01	01	01	2.0	0	-999.	-99.00	288.9	99.0	-99.00	-99.00
16	01	01	01	10.0	0	105.	13.77	-999.0	99.0	-99.00	-99.00
16	01	01	01	18.8	0	105.	15.08	288.8	99.0	-99.00	-99.00
16	01	01	01	50.0	0	104.	17.77	288.6	99.0	-99.00	-99.00
16	01	01	01	75.0	0	104.	19.10	288.4	99.0	-99.00	-99.00
16	01	01	01	100.0	0	104.	20.12	288.2	99.0	-99.00	-99.00
16	01	01	01	125.0	0	104.	21.07	288.1	99.0	-99.00	-99.00
16	01	01	01	150.0	0	104.	22.00	287.8	99.0	-99.00	-99.00
16	01	01	01	175.0	0	104.	22.46	287.7	99.0	-99.00	-99.00
16	01	01	01	206.2	0	104.	23.31	287.5	99.0	-99.00	-99.00
16	01	01	01	250.0	0	103.	24.36	287.2	99.0	-99.00	-99.00
16	01	01	01	300.0	0	103.	25.39	286.9	99.0	-99.00	-99.00
16	01	01	01	350.0	0	103.	26.17	286.9	99.0	-99.00	-99.00
16	01	01	01	400.0	0	102.	26.42	287.0	99.0	-99.00	-99.00
16	01	01	01	450.0	0	103.	26.05	287.4	99.0	-99.00	-99.00
16	01	01	01	512.5	0	104.	23.54	288.9	99.0	-99.00	-99.00
16	01	01	01	600.0	0	107.	18.30	291.1	99.0	-99.00	-99.00
16	01	01	01	700.0	0	108.	14.68	292.2	99.0	-99.00	-99.00
16	01	01	01	800.0	0	109.	11.20	292.8	99.0	-99.00	-99.00
16	01	01	01	900.0	0	112.	7.95	292.9	99.0	-99.00	-99.00
16	01	01	01	1100.0	0	136.	4.86	291.9	99.0	-99.00	-99.00
16	01	01	01	1500.0	0	149.	3.27	289.2	99.0	-99.00	-99.00
16	01	01	01	2000.0	0	328.	1.15	286.1	99.0	-99.00	-99.00
16	01	01	01	2500.0	0	300.	3.96	282.5	99.0	-99.00	-99.00
16	01	01	01	3000.0	0	306.	6.42	278.9	99.0	-99.00	-99.00
16	01	01	01	3500.0	0	308.	7.98	275.5	99.0	-99.00	-99.00
16	01	01	01	4000.0	0	304.	9.13	272.2	99.0	-99.00	-99.00
16	01	01	01	4500.0	0	298.	10.17	269.4	99.0	-99.00	-99.00
16	01	01	01	5000.0	1	289.	11.40	265.8	99.0	-99.00	-99.00

F indicates top of profile (=1) or below (=0)

*** MODELOPTs: RegDFAULT CONC ELEV ARM2 RURAL ADJ_U* MMIF_Data

*** THE SUMMARY OF MAXIMUM ANNUAL RESULTS AVERAGED OVER 4 YEARS ***

** CONC OF NO2 IN MICROGRAMS/M**3 **

GROUP ID	AVERAGE CONC	RECEPTOR (XR, YR, ZELEV, ZHILL, ZFLAG)	OF TYPE	NETWORK GRID-ID
ALL	1ST HIGHEST VALUE IS	0.55613 AT (386908.00, 6330336.00, 22.70, 22.70, 0.00)	GC	UCART1
	2ND HIGHEST VALUE IS	0.54492 AT (387008.00, 6330436.00, 24.50, 24.50, 0.00)	GC	UCART1
	3RD HIGHEST VALUE IS	0.53129 AT (386808.00, 6330236.00, 19.70, 19.70, 0.00)	GC	UCART1
	4TH HIGHEST VALUE IS	0.52358 AT (386808.00, 6330336.00, 18.00, 18.00, 0.00)	GC	UCART1
	5TH HIGHEST VALUE IS	0.52096 AT (386908.00, 6330436.00, 20.40, 20.40, 0.00)	GC	UCART1
	6TH HIGHEST VALUE IS	0.51954 AT (387008.00, 6330336.00, 20.50, 20.50, 0.00)	GC	UCART1
	7TH HIGHEST VALUE IS	0.51702 AT (387108.00, 6330436.00, 23.30, 23.30, 0.00)	GC	UCART1
	8TH HIGHEST VALUE IS	0.50465 AT (387108.00, 6330536.00, 22.10, 22.10, 0.00)	GC	UCART1
	9TH HIGHEST VALUE IS	0.50455 AT (386708.00, 6330236.00, 17.90, 17.90, 0.00)	GC	UCART1
	10TH HIGHEST VALUE IS	0.50448 AT (386908.00, 6330236.00, 20.10, 20.10, 0.00)	GC	UCART1

*** RECEPTOR TYPES: GC = GRIDCART
GP = GRIDPOLR
DC = DISCCART
DP = DISCPOLR

*** MODELOPTs: RegDFAULT CONC ELEV ARM2 RURAL ADJ_U* MMIF_Data

*** THE SUMMARY OF MAXIMUM 1ST-HIGHEST MAX DAILY 1-HR RESULTS AVERAGED OVER 4 YEARS ***

** CONC OF NO2 IN MICROGRAMS/M**3 **

GROUP ID	AVERAGE CONC	RECEPTOR (XR, YR, ZELEV, ZHILL, ZFLAG)	NETWORK OF TYPE	GRID-ID
ALL	1ST HIGHEST VALUE IS	84.93758 AT (386208.00, 6329936.00, 28.40, 28.40, 0.00)	GC	UCART1
	2ND HIGHEST VALUE IS	81.94189 AT (386408.00, 6330036.00, 26.50, 26.50, 0.00)	GC	UCART1
	3RD HIGHEST VALUE IS	80.79610 AT (386308.00, 6329836.00, 23.50, 23.50, 0.00)	GC	UCART1
	4TH HIGHEST VALUE IS	79.82686 AT (386308.00, 6330036.00, 26.50, 26.50, 0.00)	GC	UCART1
	5TH HIGHEST VALUE IS	77.84480 AT (386408.00, 6329836.00, 25.50, 25.50, 0.00)	GC	UCART1
	6TH HIGHEST VALUE IS	75.74028 AT (386408.00, 6329936.00, 24.50, 24.50, 0.00)	GC	UCART1
	7TH HIGHEST VALUE IS	74.38556 AT (386308.00, 6329936.00, 25.90, 25.90, 0.00)	GC	UCART1
	8TH HIGHEST VALUE IS	71.16566 AT (386208.00, 6330036.00, 25.30, 25.30, 0.00)	GC	UCART1
	9TH HIGHEST VALUE IS	66.71035 AT (386208.00, 6329836.00, 25.20, 25.20, 0.00)	GC	UCART1
	10TH HIGHEST VALUE IS	59.30481 AT (386508.00, 6329936.00, 25.50, 25.50, 0.00)	GC	UCART1

*** RECEPTOR TYPES: GC = GRIDCART
GP = GRIDPOLR
DC = DISCCART
DP = DISCPOLR

*** MODELOPTs: RegDFAULT CONC ELEV ARM2 RURAL ADJ_U* MMIF_Data

*** Message Summary : AERMOD Model Execution ***

--------- Summary of Total Messages --------

A Total of 0 Fatal Error Message(s)
A Total of 9 Warning Message(s)
A Total of 0 Informational Message(s)

A Total of 35064 Hours Were Processed

A Total of 0 Calm Hours Identified

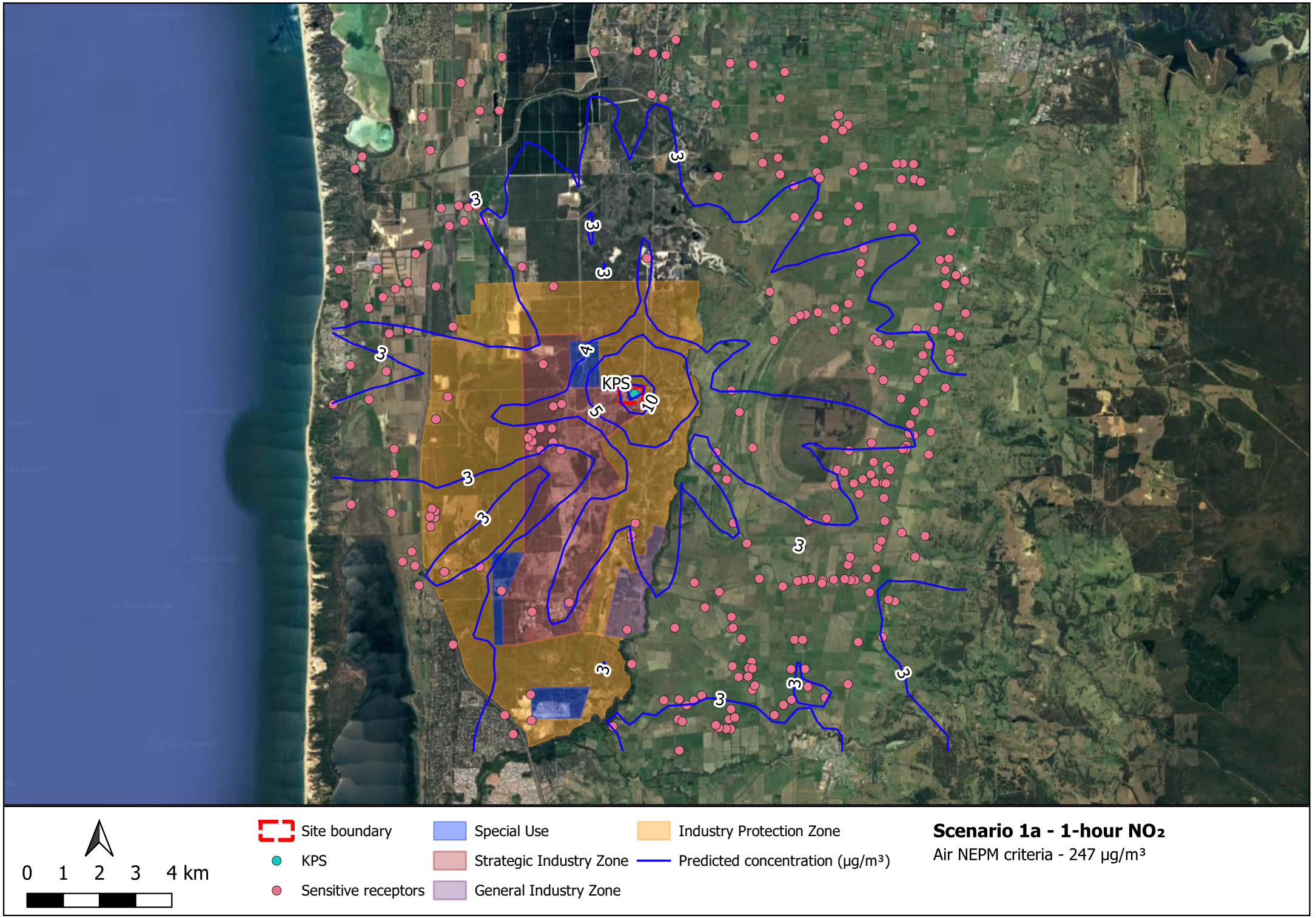
A Total of 0 Missing Hours Identified (0.00 Percent)

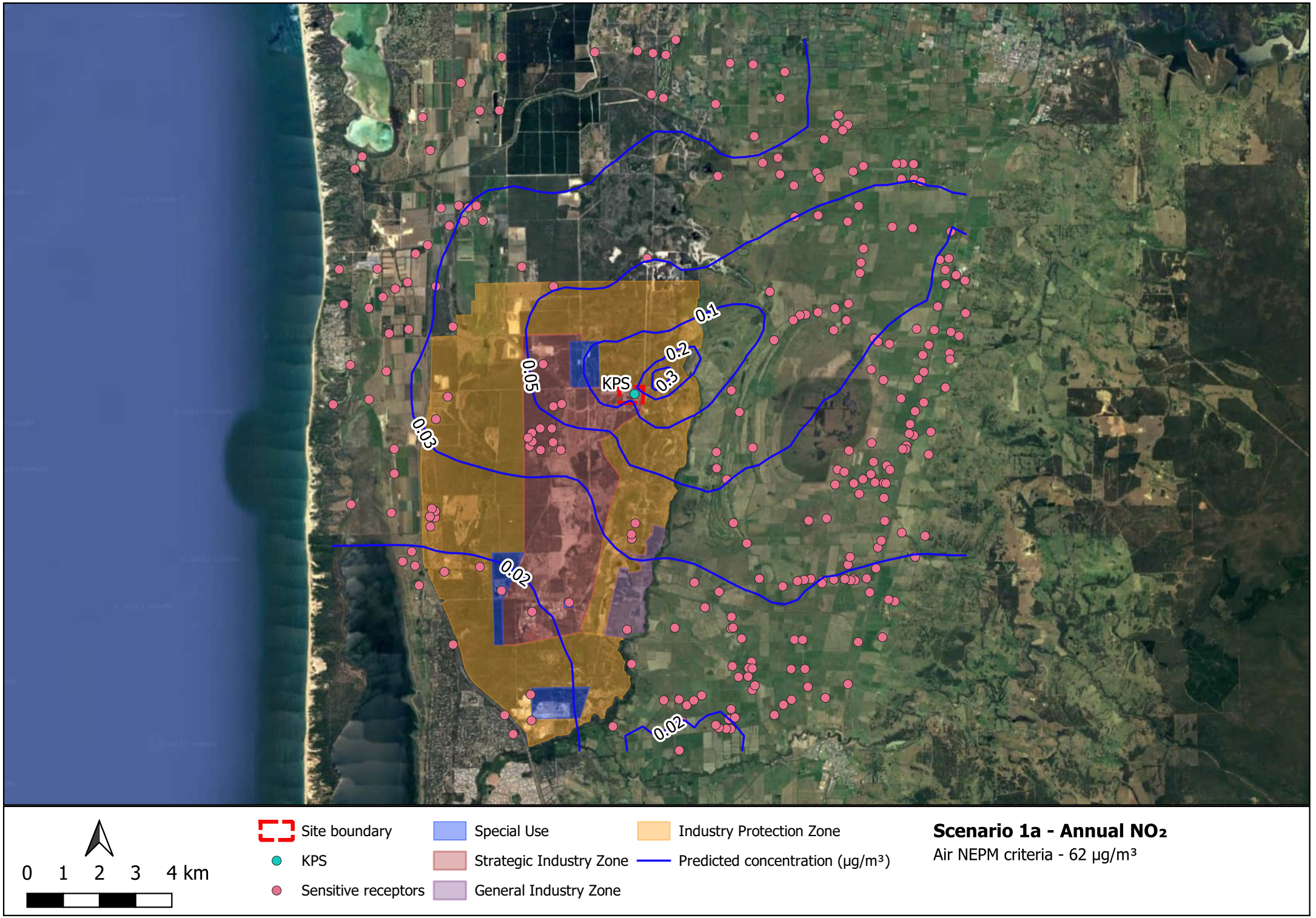
******** FATAL ERROR MESSAGES ********
*** NONE ***

******** WARNING MESSAGES ********
CO W361 28 COCARD: Multiyear PERIOD/ANNUAL values for NO2/SO2 require MULTYEAR Opt
ME W187 141 MEOPEN: ADJ_U* Option for Stable Low Winds used in AERMET
ME W182 141 MEOPEN: MMIF-generated meteorological inputs were used
ME W181 141 MEOPEN: BULKRN Delta-T & SolarRad option for SBL was used with MMIF
MX W479 20956 TGINIT: Potential temperature gradient is out-of-range: TG4PFL=0.503
MX W479 20974 TGINIT: Potential temperature gradient is out-of-range: TG4PFL=0.525
MX W479 20975 TGINIT: Potential temperature gradient is out-of-range: TG4PFL=0.536
MX W479 20978 TGINIT: Potential temperature gradient is out-of-range: TG4PFL=0.503
MX W479 30041 TGINIT: Potential temperature gradient is out-of-range: TG4PFL=0.520

Appendix E. Predicted Concentration Contour Figures

Scenario 1a - Maximum predicted concentrations	
Figure E-1	1-hour NO_2
Figure E-2	Annual NO_2
Figure E-3	1-hour SO_2
Figure E-4	24-hour SO_2
Figure E-5	Annual SO_2
Figure E-6	8-hour CO
Scenario 1b - Maximum predicted concentrations	
Figure E-7	1-hour NO_2
Figure E-8	Annual NO_2
Figure E-9	1-hour SO_2
Figure E-10	24-hour SO_2
Figure E-11	Annual SO_2
Figure E-12	8-hour CO
Scenario 2a - Maximum predicted concentrations	
Figure E-13	1-hour NO_2
Figure E-14	Annual NO_2
Figure E-15	1-hour SO_2
Figure E-16	24-hour SO_2
Figure E-17	Annual SO_2
Figure E-18	8-hour CO
Scenario 3a - Maximum predicted concentrations	
Figure E-19	1-hour NO_2
Figure E-20	Annual NO_2
Figure E-21	8-hour CO
Figure E-22	24-hour $PM_{2.5}$
Figure E-23	Annual $PM_{2.5}$
Figure E-24	24-hour NMVOC
Figure E-25	Annual NMVOC
Scenario 3b - Maximum predicted concentrations	
Figure E-26	1-hour NO_2
Figure E-27	Annual NO_2
Figure E-28	1-hour SO_2
Figure E-29	24-hour SO_2
Figure E-30	Annual SO_2
Figure E-31	1-hour SO_2 (low sulphur fuel)
Figure E-32	24-hour SO_2 (low sulphur fuel)
Figure E-33	Annual SO_2 (low sulphur fuel)
Figure E-34	8-hour CO
Figure E-26	24-hour $PM_{2.5}$
Figure E-27	Annual $PM_{2.5}$
Figure E-28	Annual PAH
Figure E-29	24-hour NMVOC
Figure E-30	Annual NMVOC


KPS
3
4
5
10
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 1a - 1-hour NO₂
Air NEPM criteria - 247 µg/m³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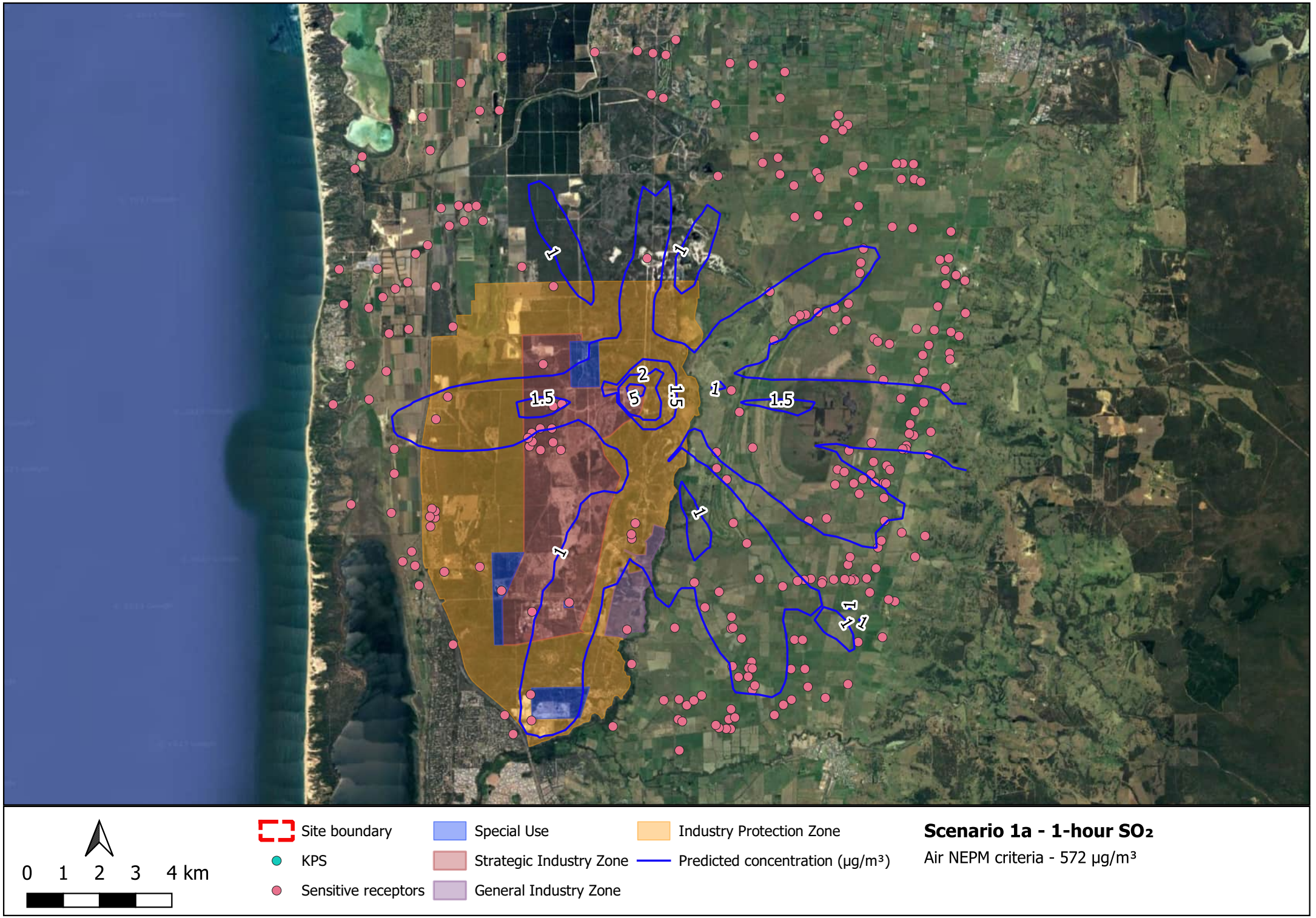
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 1a - Annual NO₂
Air NEPM criteria - 62 µg/m³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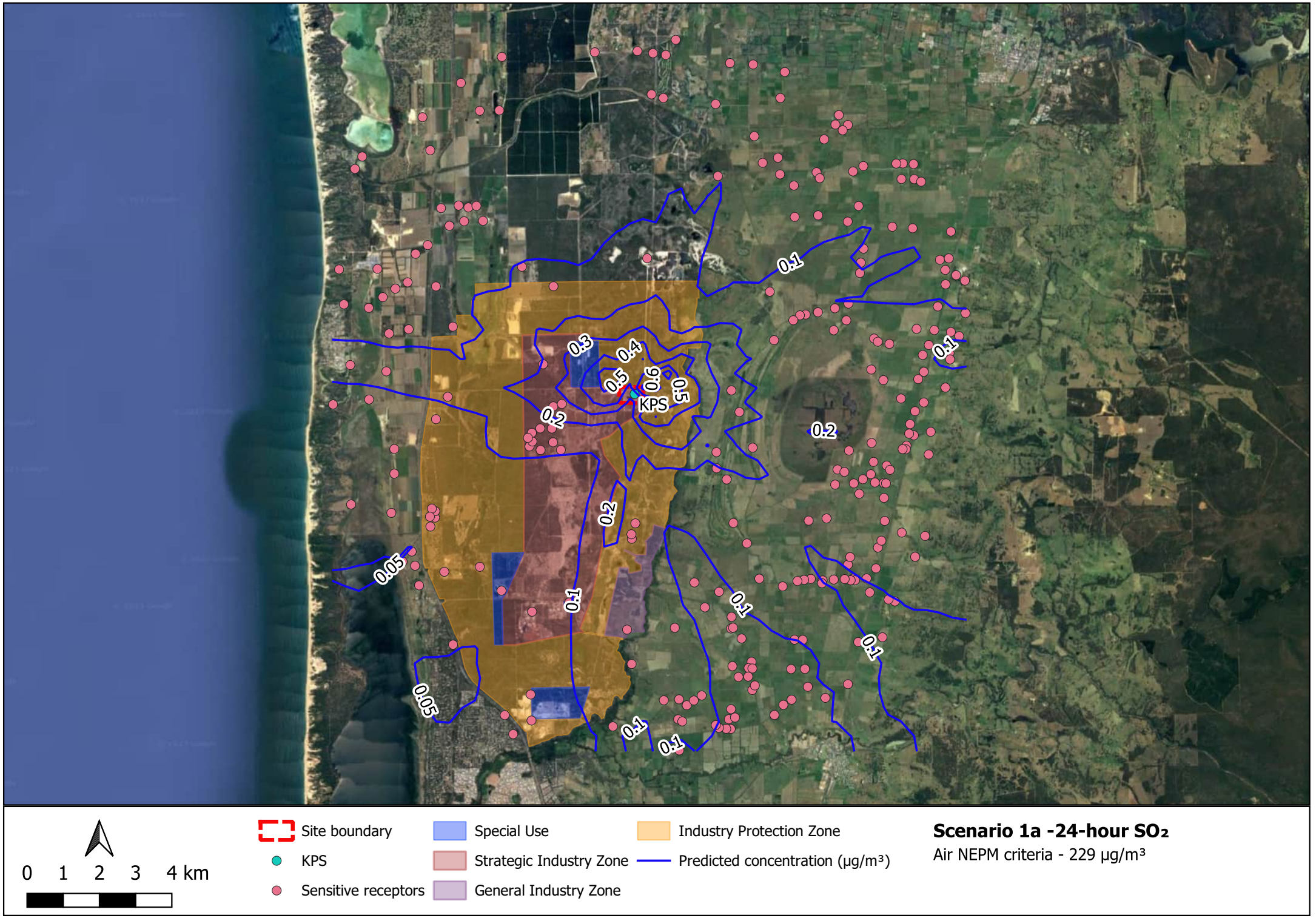
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 1a - 1-hour SO₂
Air NEPM criteria - 572 µg/m³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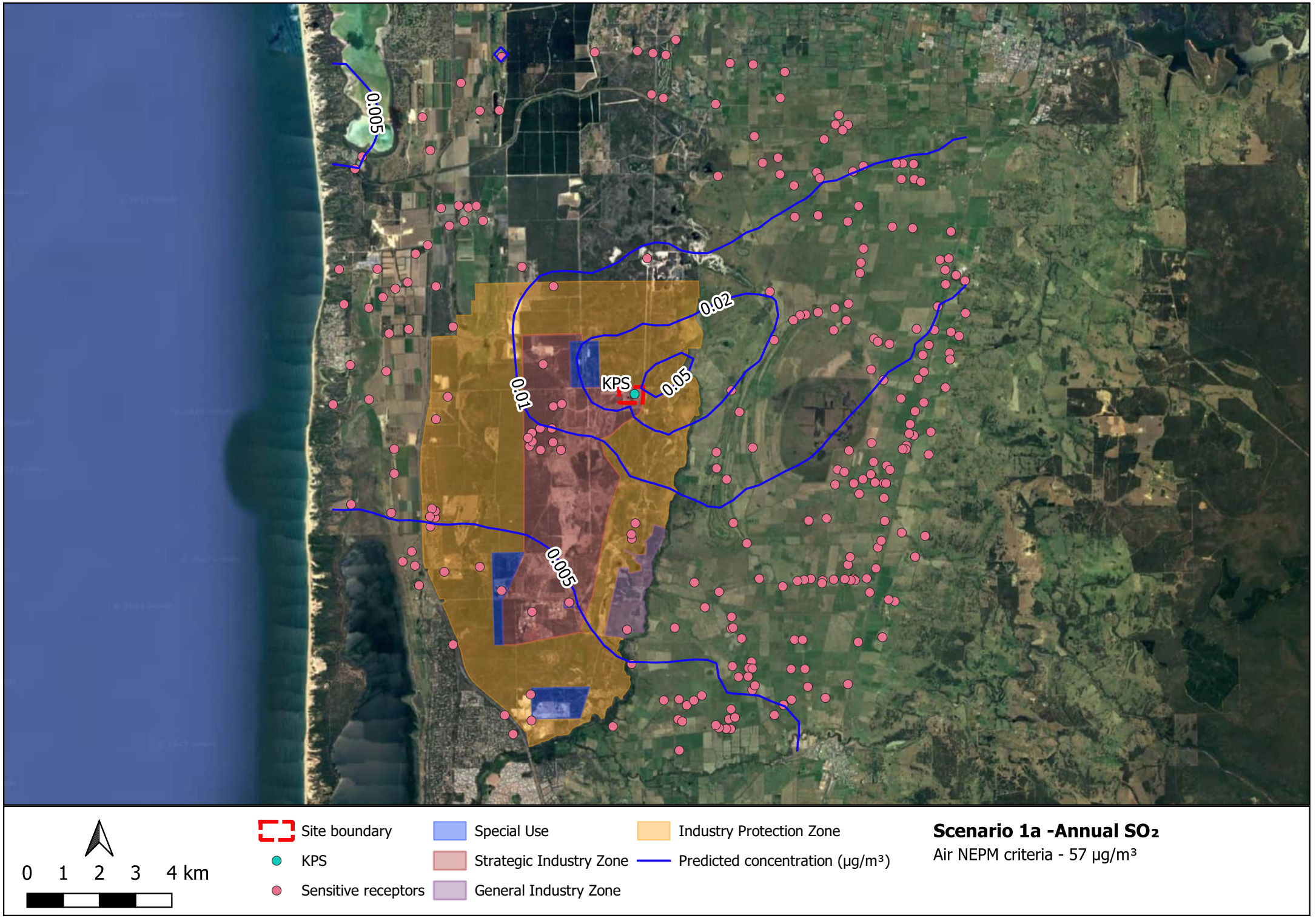
0.1
0.05
0.1
0.1
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 1a -24-hour SO₂
Air NEPM criteria - 229 µg/m³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KPS
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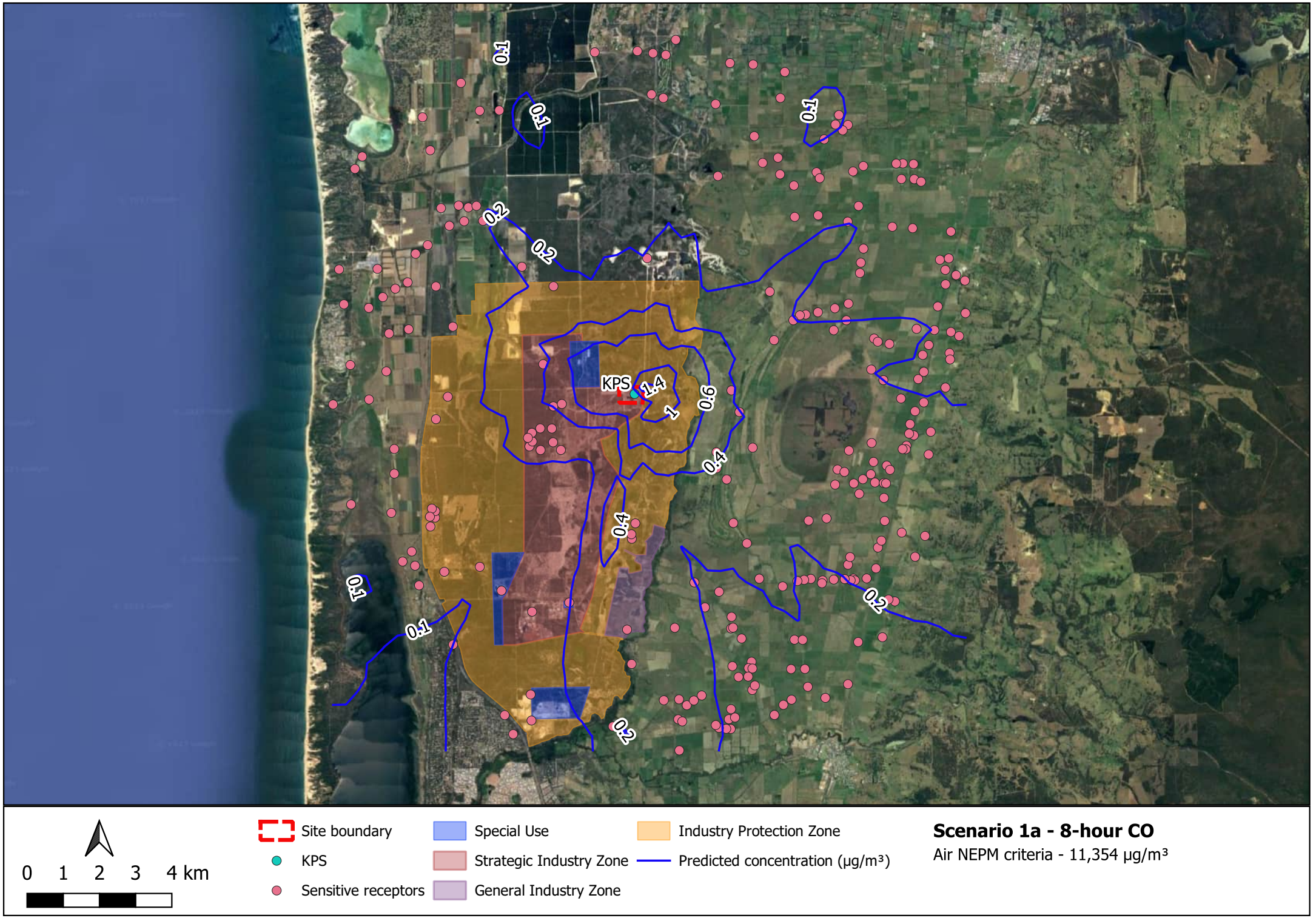
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 1a -Annual SO2
Air NEPM criteria - 57 µg/m³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Site boundary
KPS
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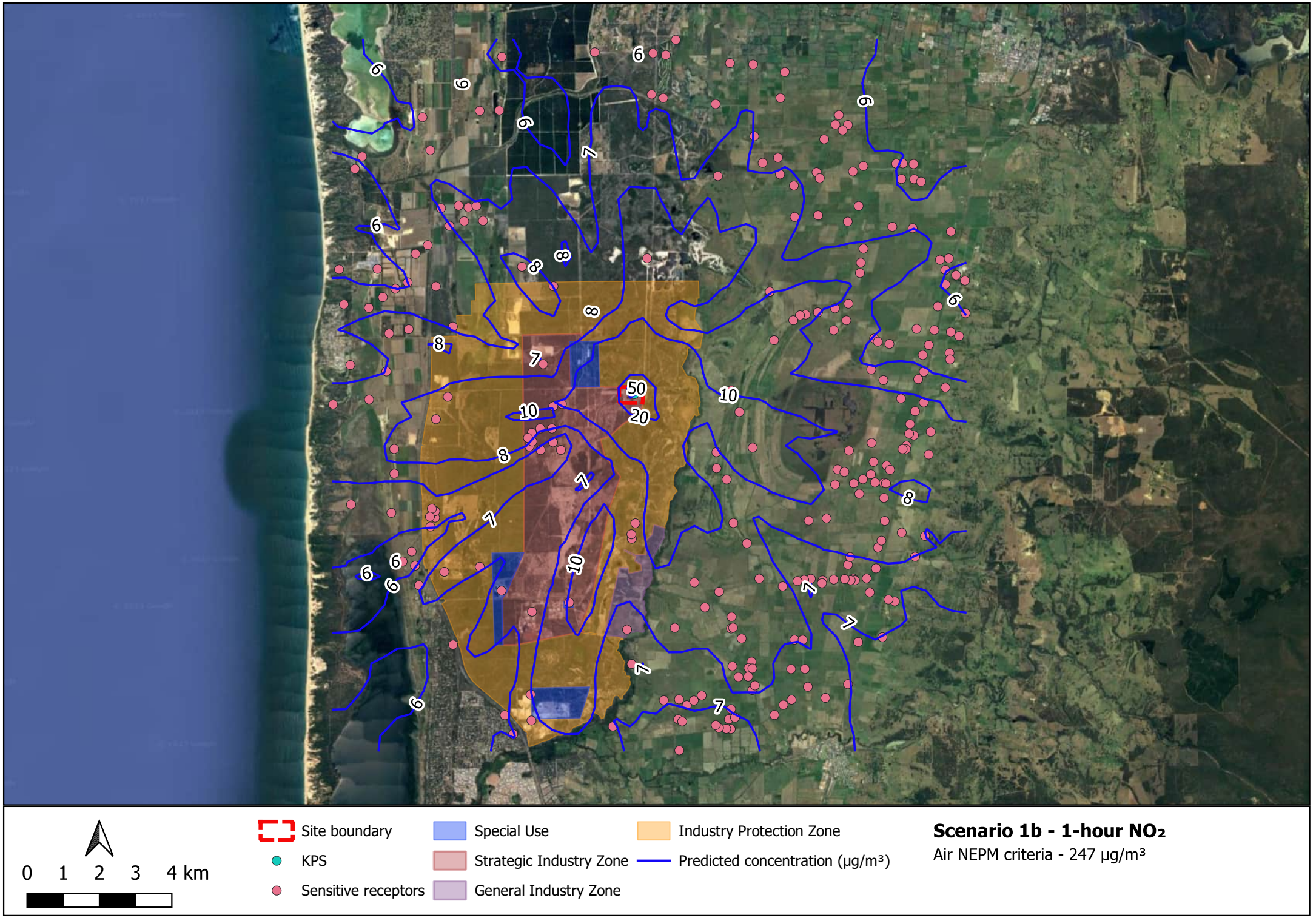
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 1a - 8-hour CO
Air NEPM criteria - 11,354 µg/m³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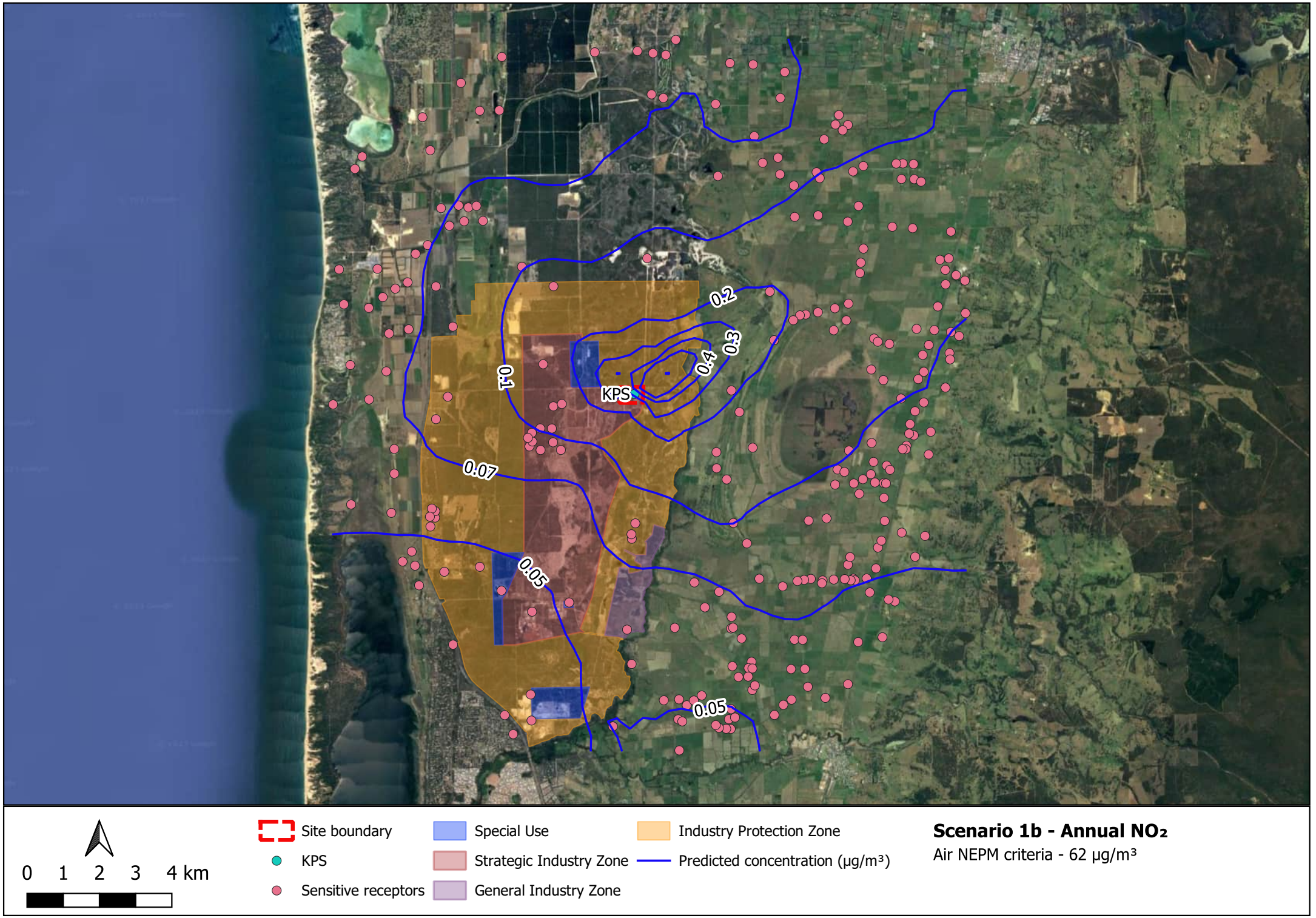
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 1b - 1-hour NO₂
Air NEPM criteria - 247 µg/m³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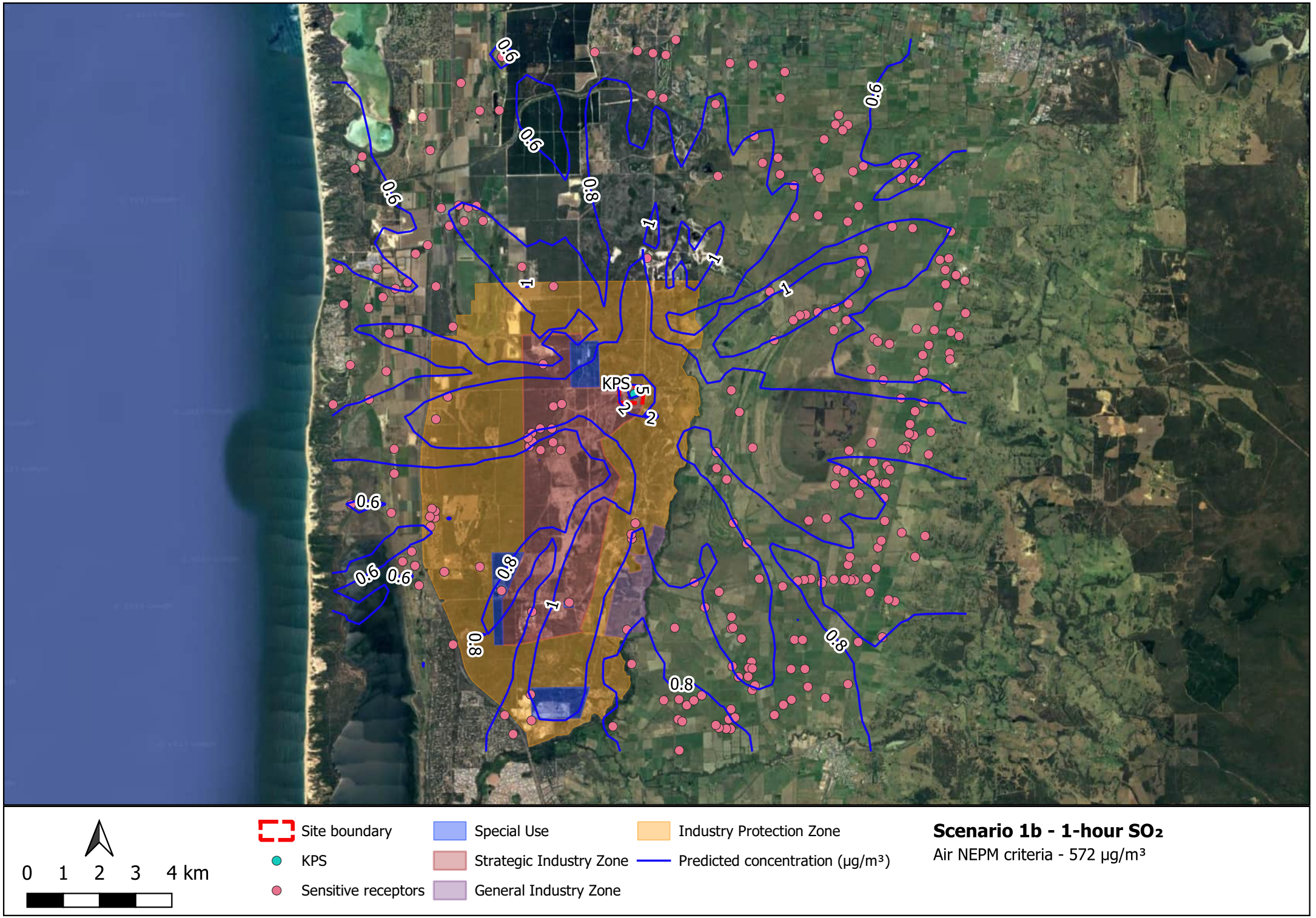
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 1b - Annual NO₂
Air NEPM criteria - 62 µg/m³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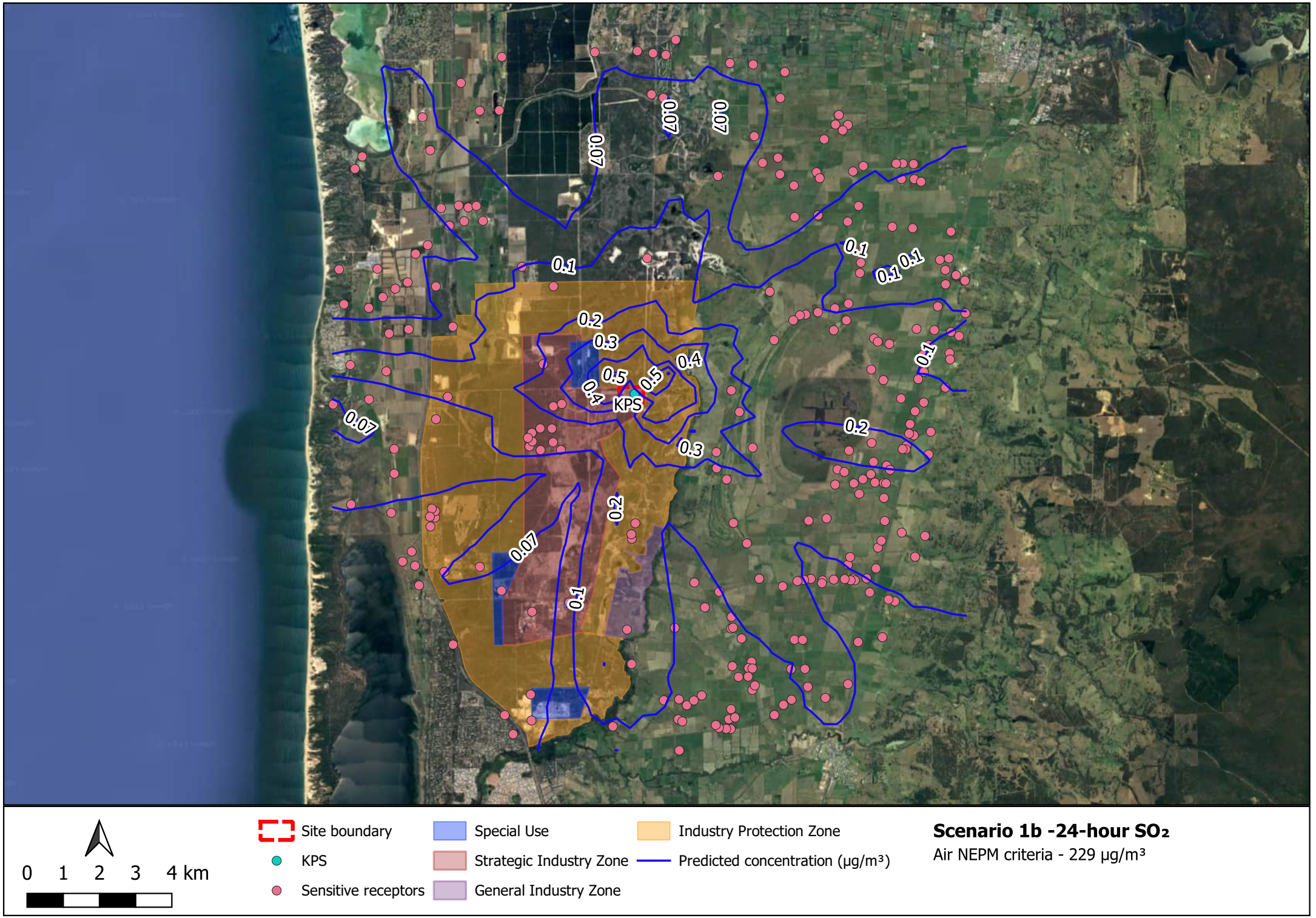
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 1b - 1-hour SO₂
Air NEPM criteria - 572 µg/m³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KPS
0.07
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0.2
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0.07
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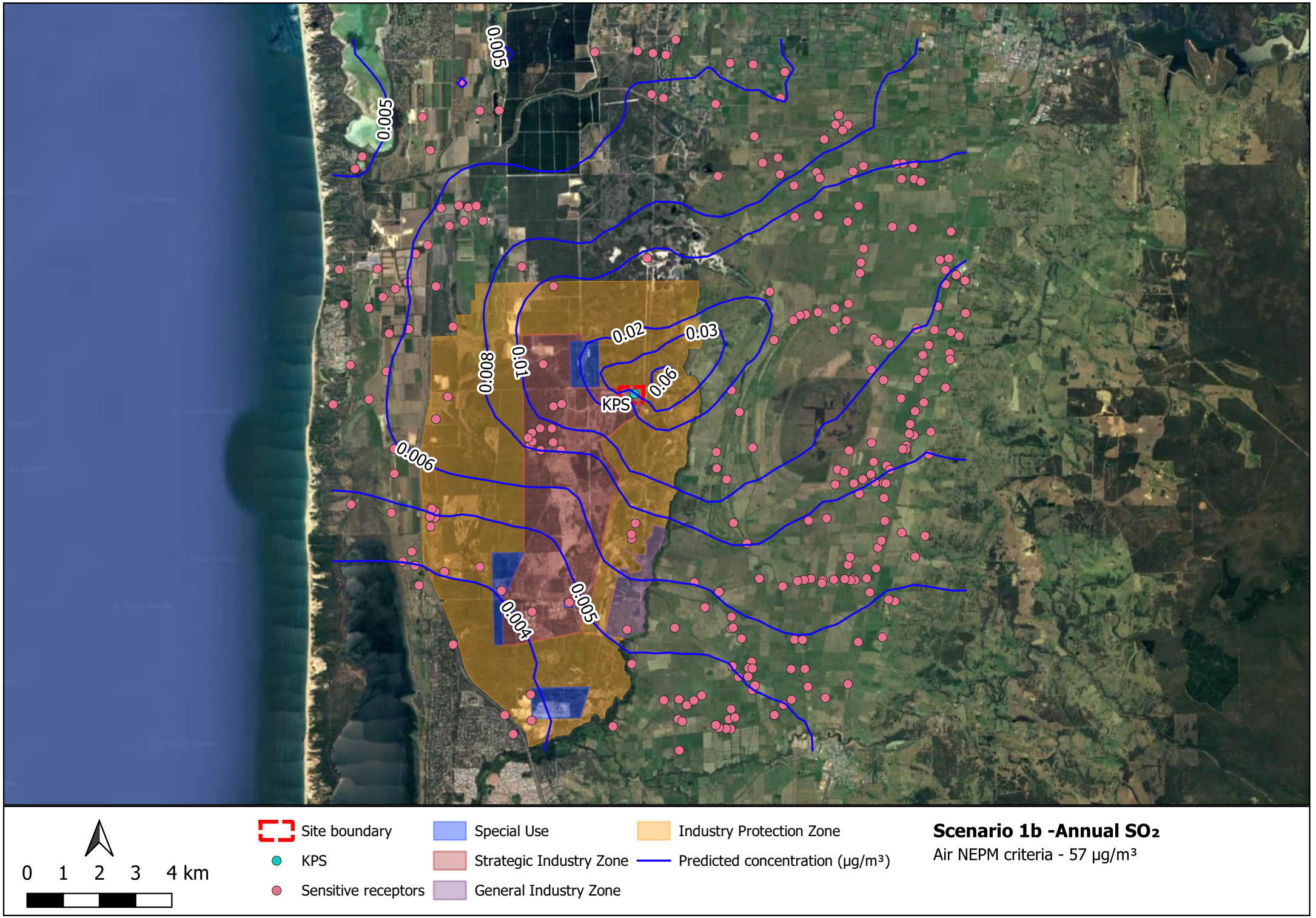
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 1b -24-hour SO₂
Air NEPM criteria - 229 µg/m³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0.02
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0.01
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KPS
0.006
0.004
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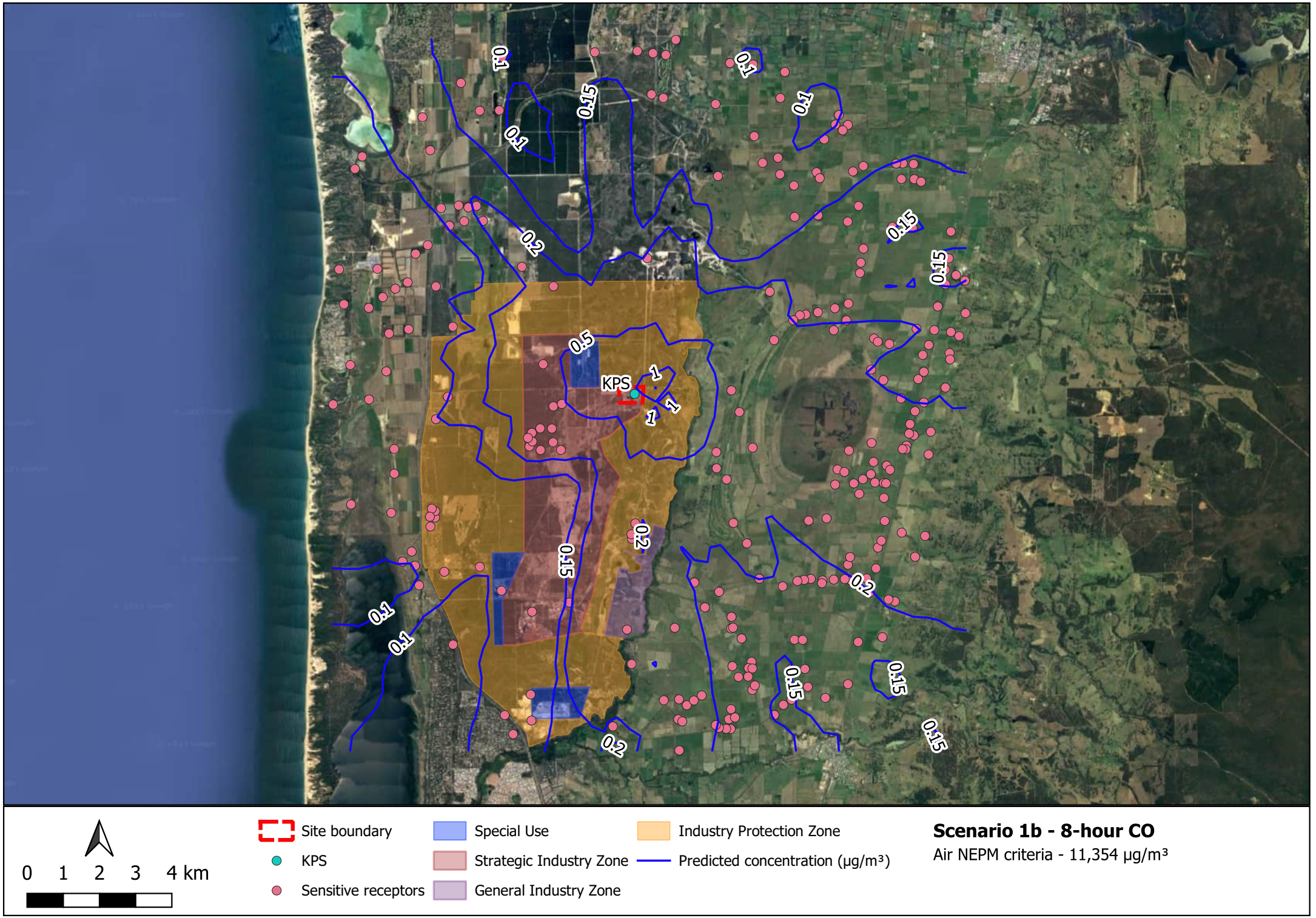
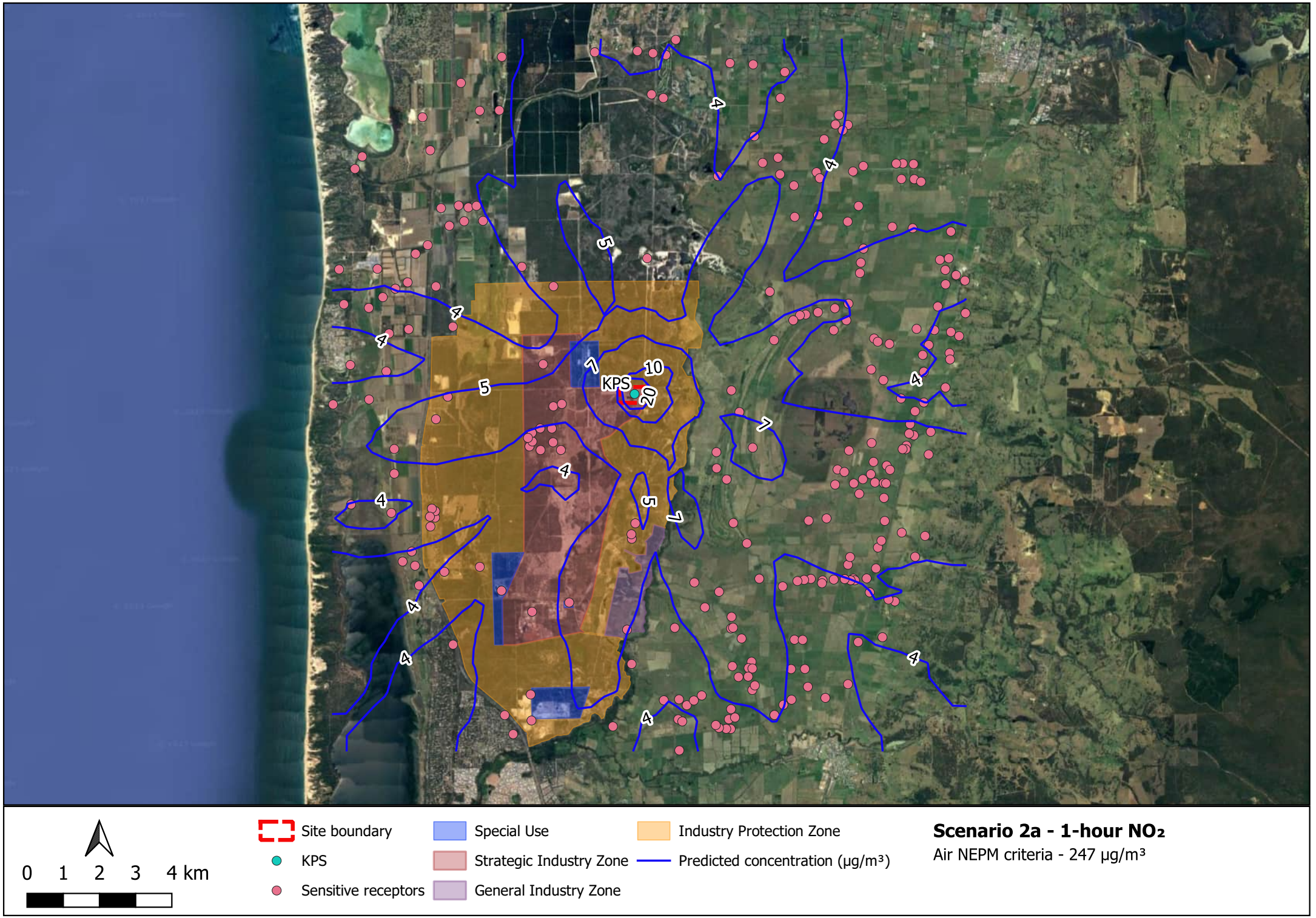
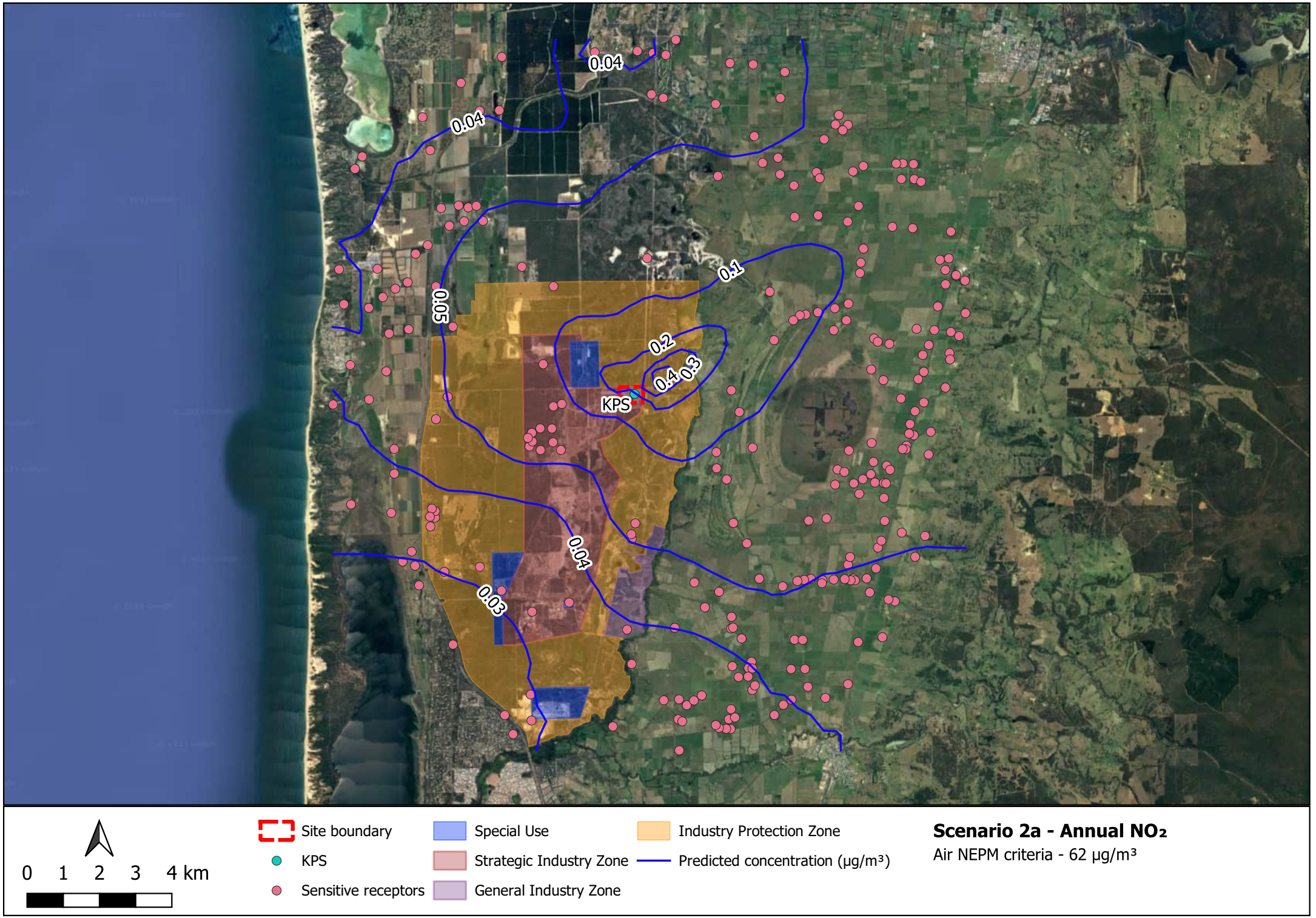
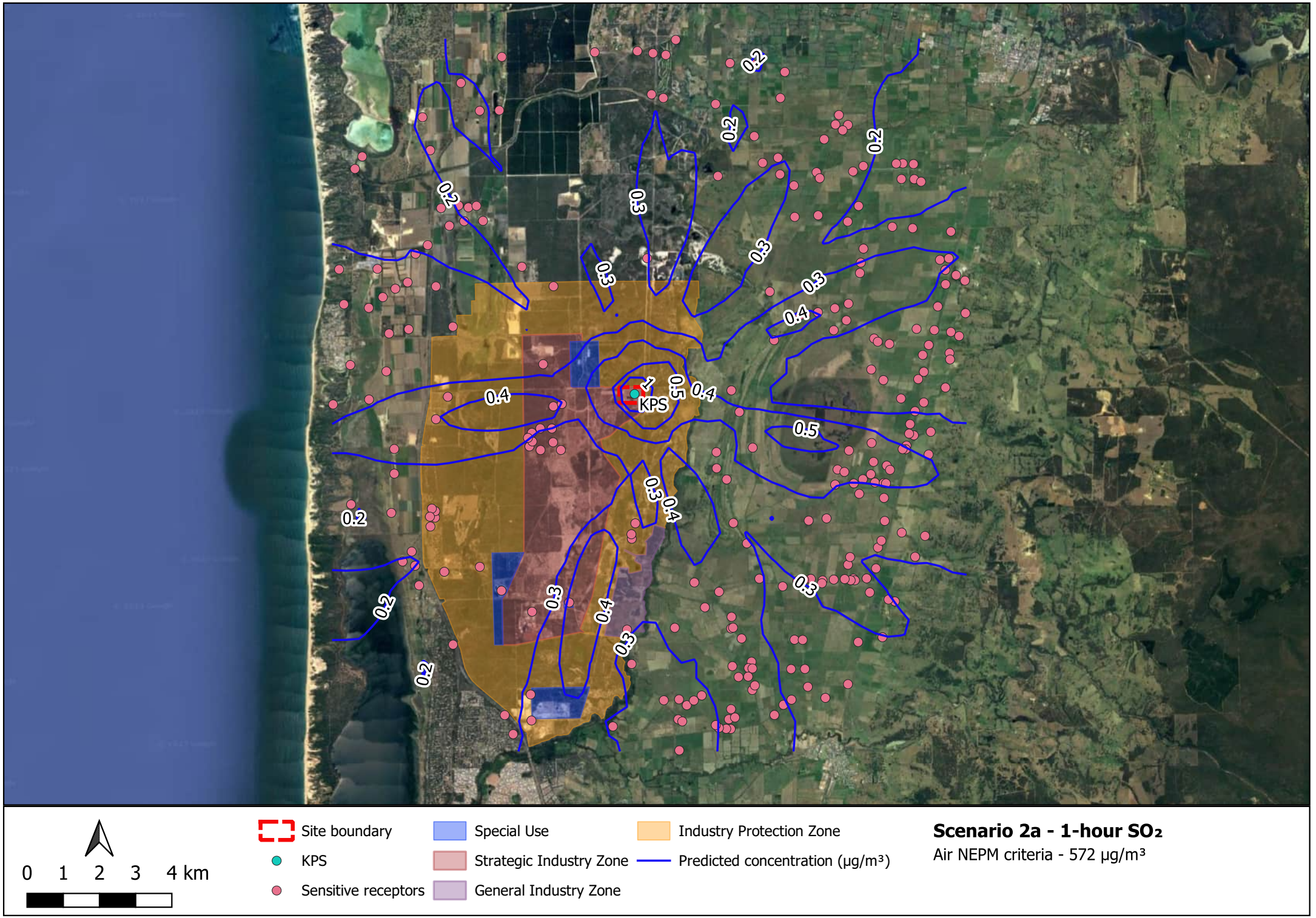
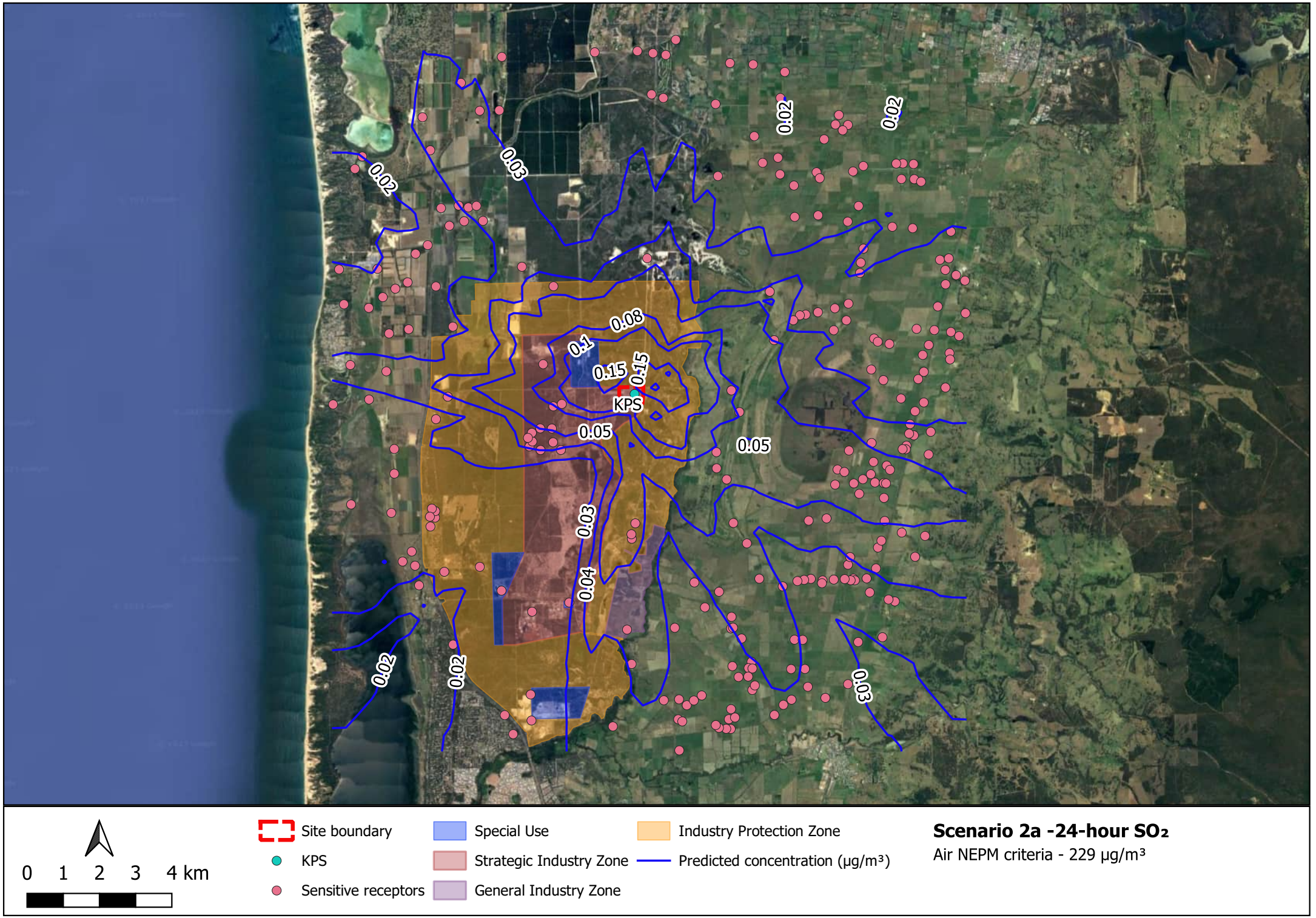
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 1b -Annual SO₂
Air NEPM criteria - 57 µg/m³

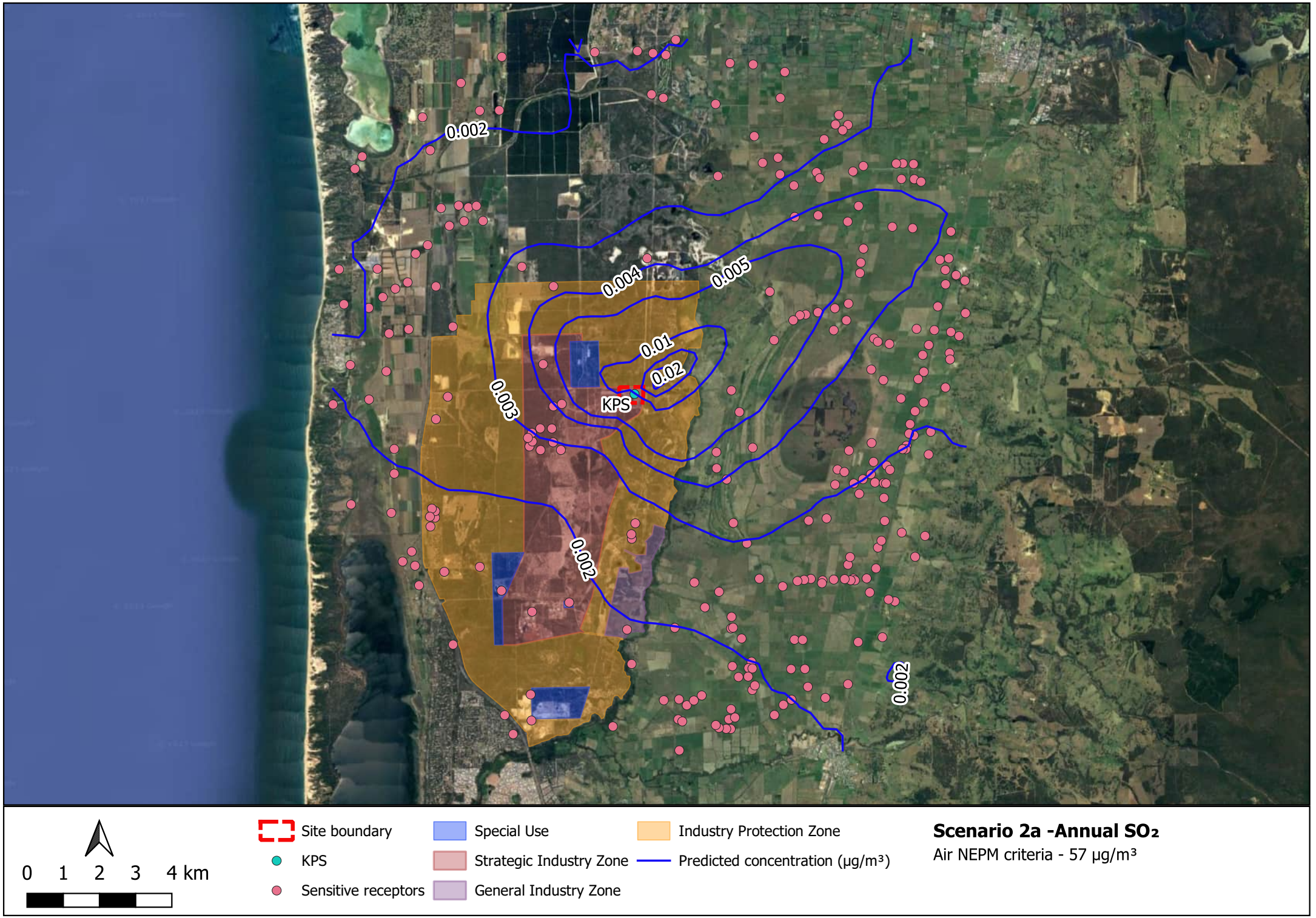

0.1
0.15
0.2
0.5
1
KPS
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 1b - 8-hour CO
Air NEPM criteria - 11,354 µg/m³

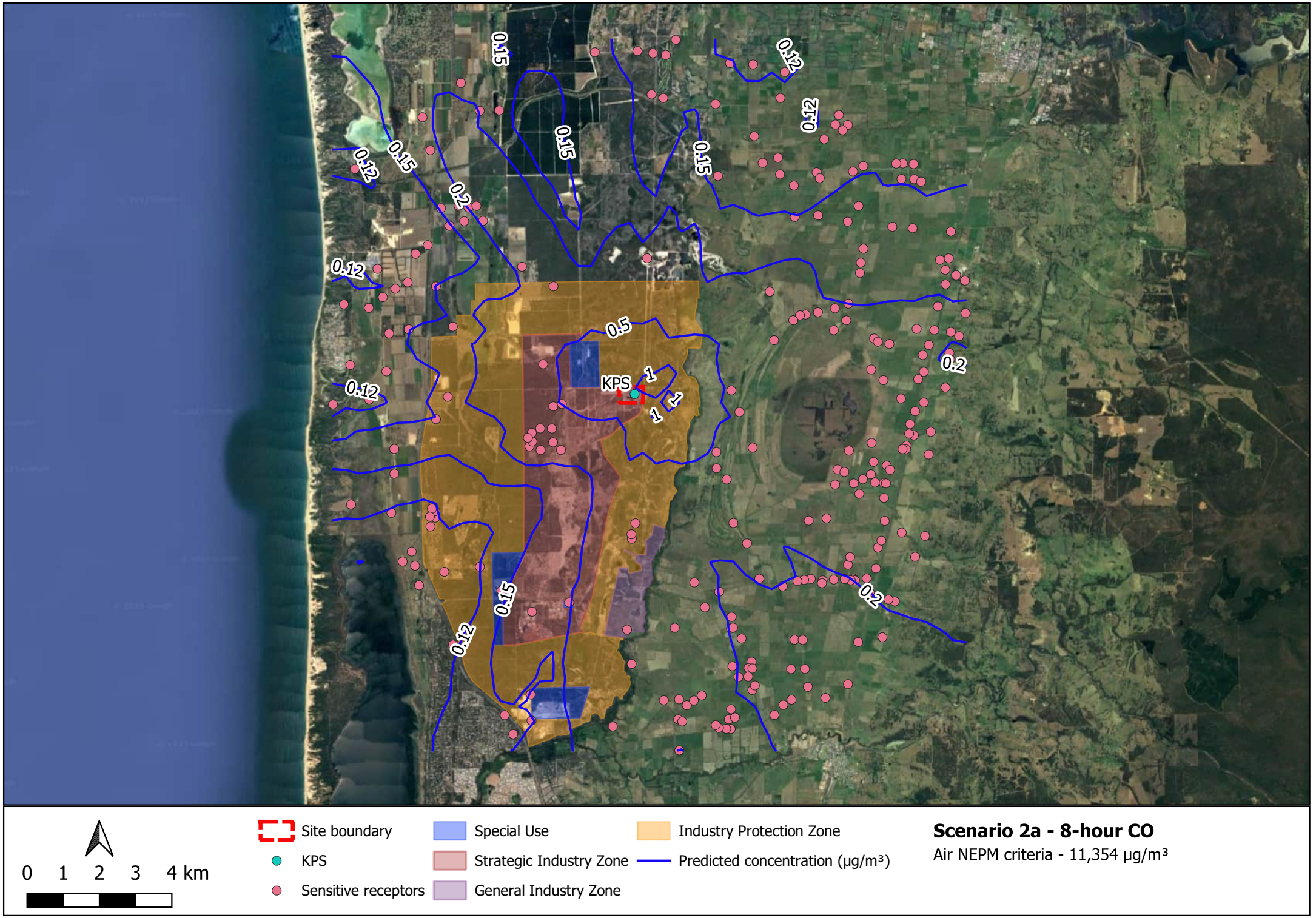

KPS
10
20
7
5
4
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 2a - 1-hour NO₂
Air NEPM criteria - 247 µg/m³

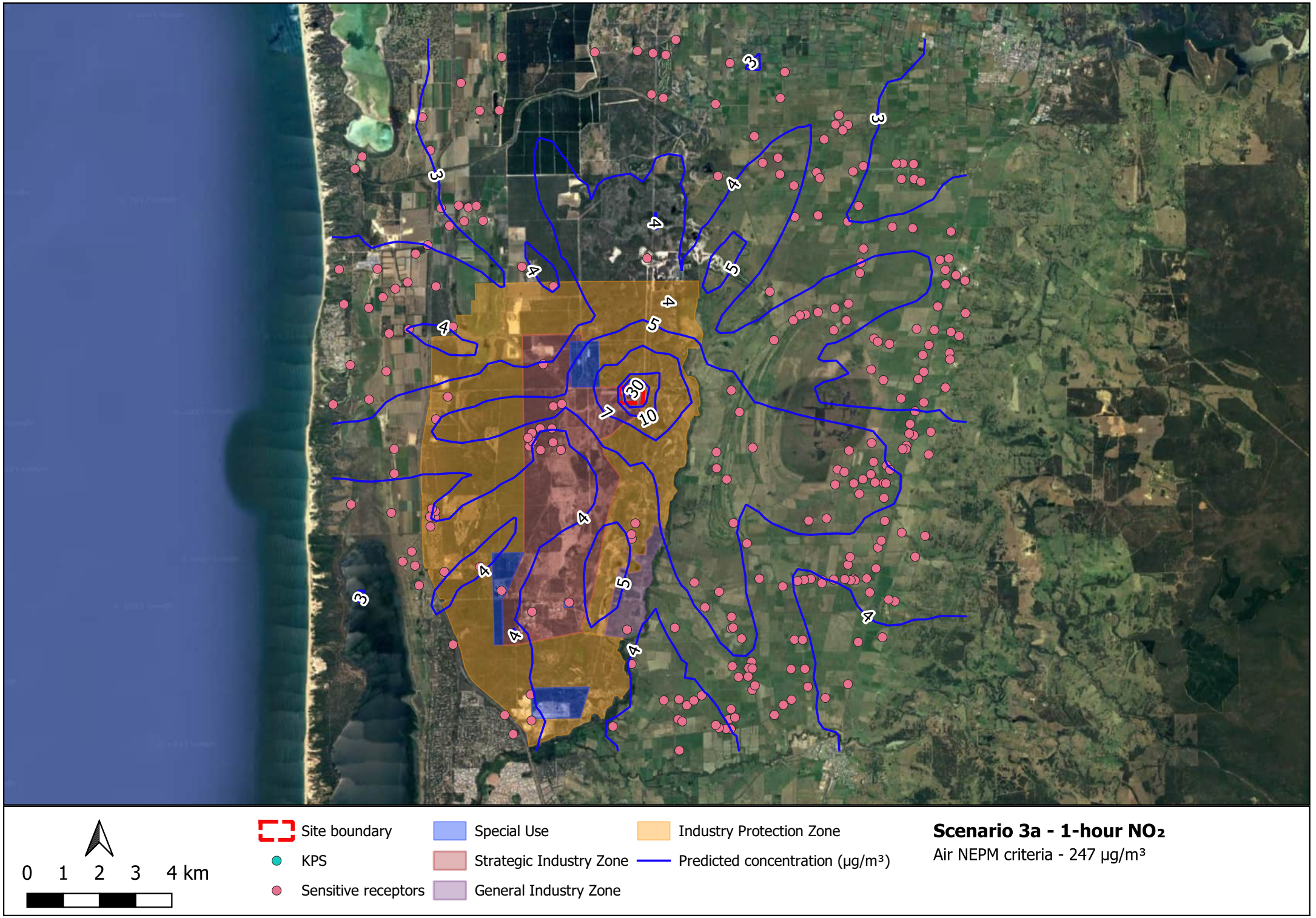

0.04
0.04
0.1
0.05
0.2
0.4
0.3
KPS
0.04
0.03
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 2a - Annual NO₂
Air NEPM criteria - 62 µg/m³

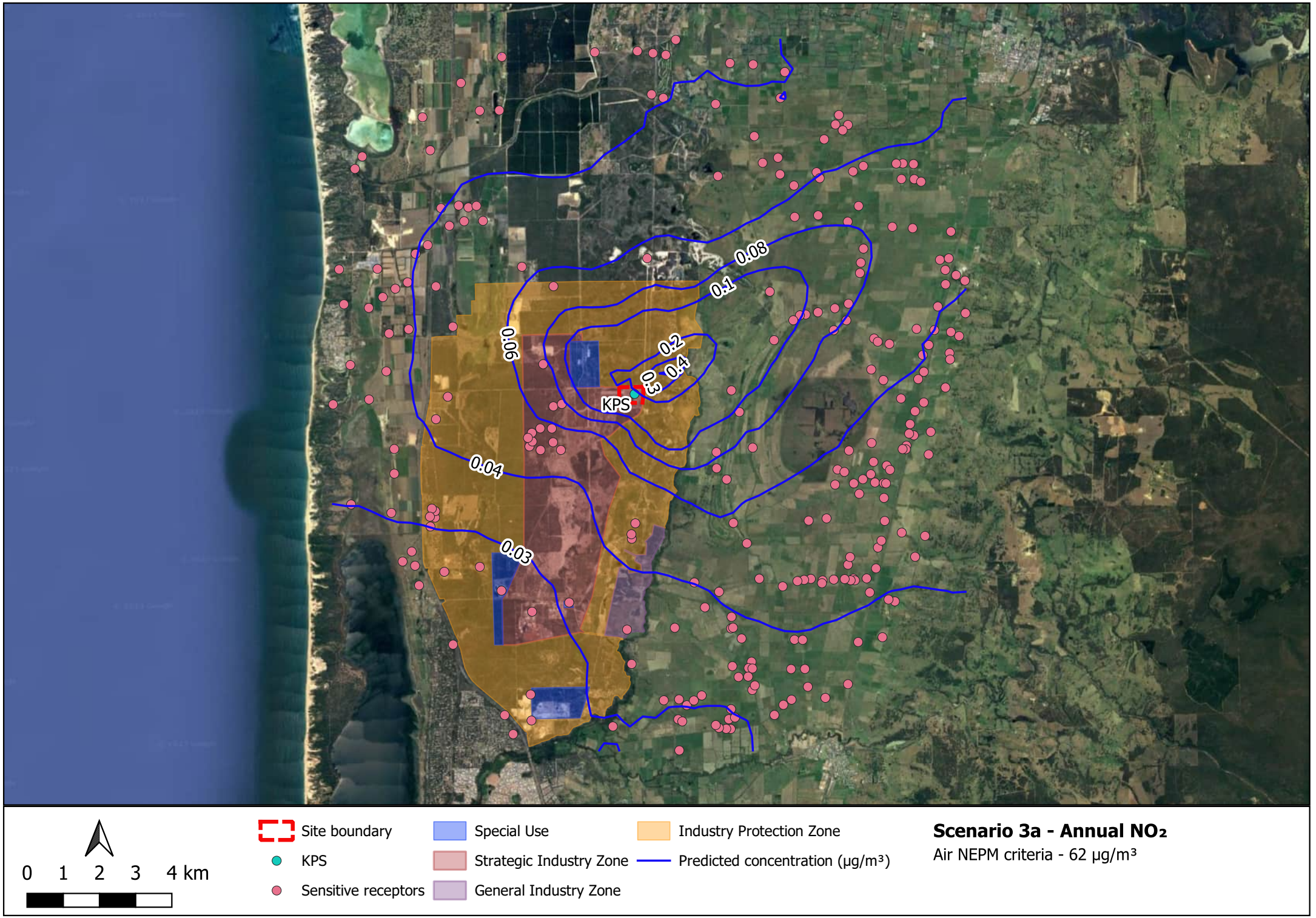

0.2
0.2
0.2
0.2
0.3
0.3
0.3
0.3
0.4
0.4
0.4
0.5
0.5
0.3
0.4
0.2
0.2
0.3
0.4
0.3
0.3
0.2
KPS
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 2a - 1-hour SO₂
Air NEPM criteria - 572 µg/m³

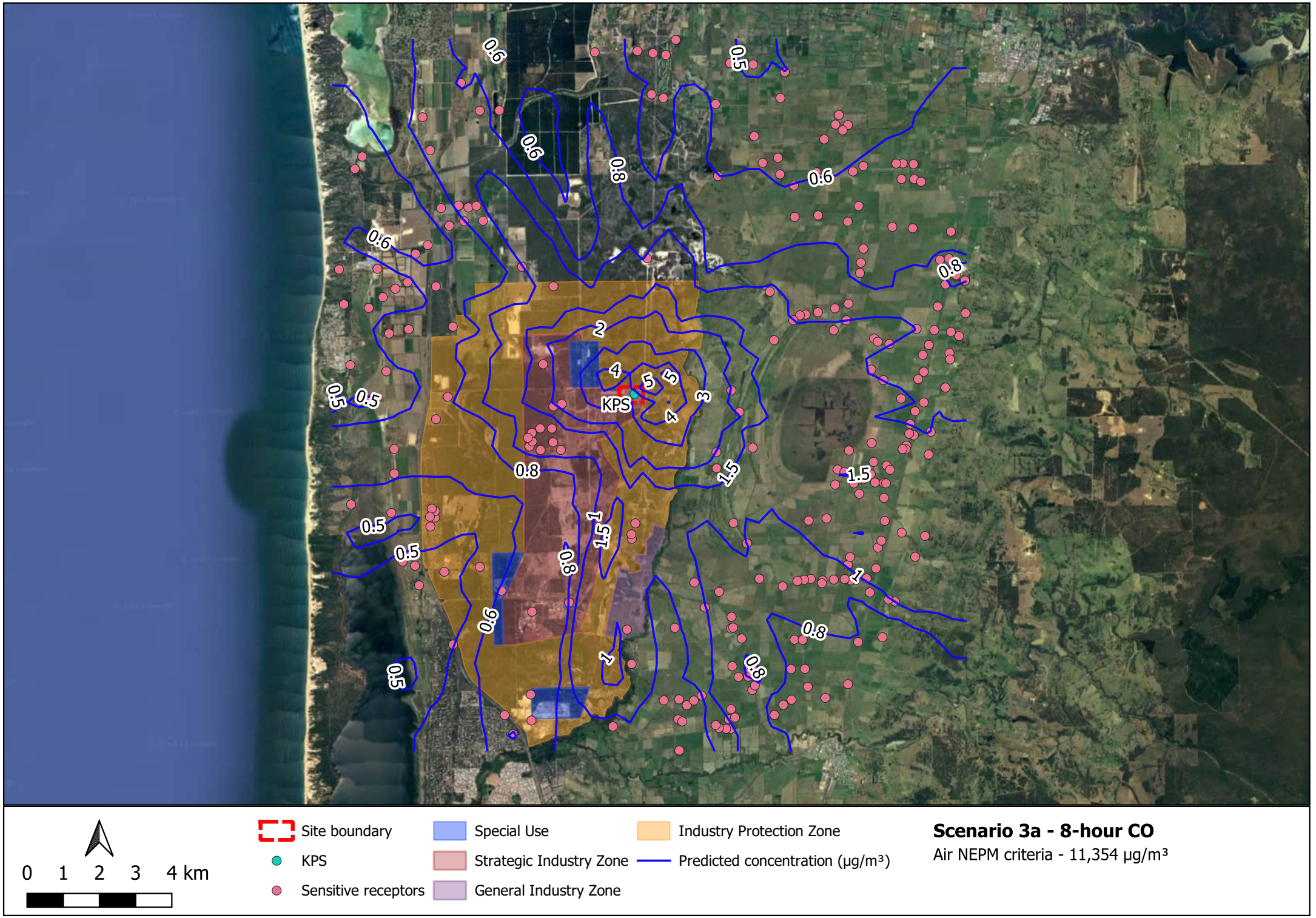

0.02
0.03
0.02
0.02
0.08
0.1
0.15
0.15
KPS
0.05
0.05
0.03
0.04
0.02
0.02
0.03
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 2a -24-hour SO₂
Air NEPM criteria - 229 µg/m³

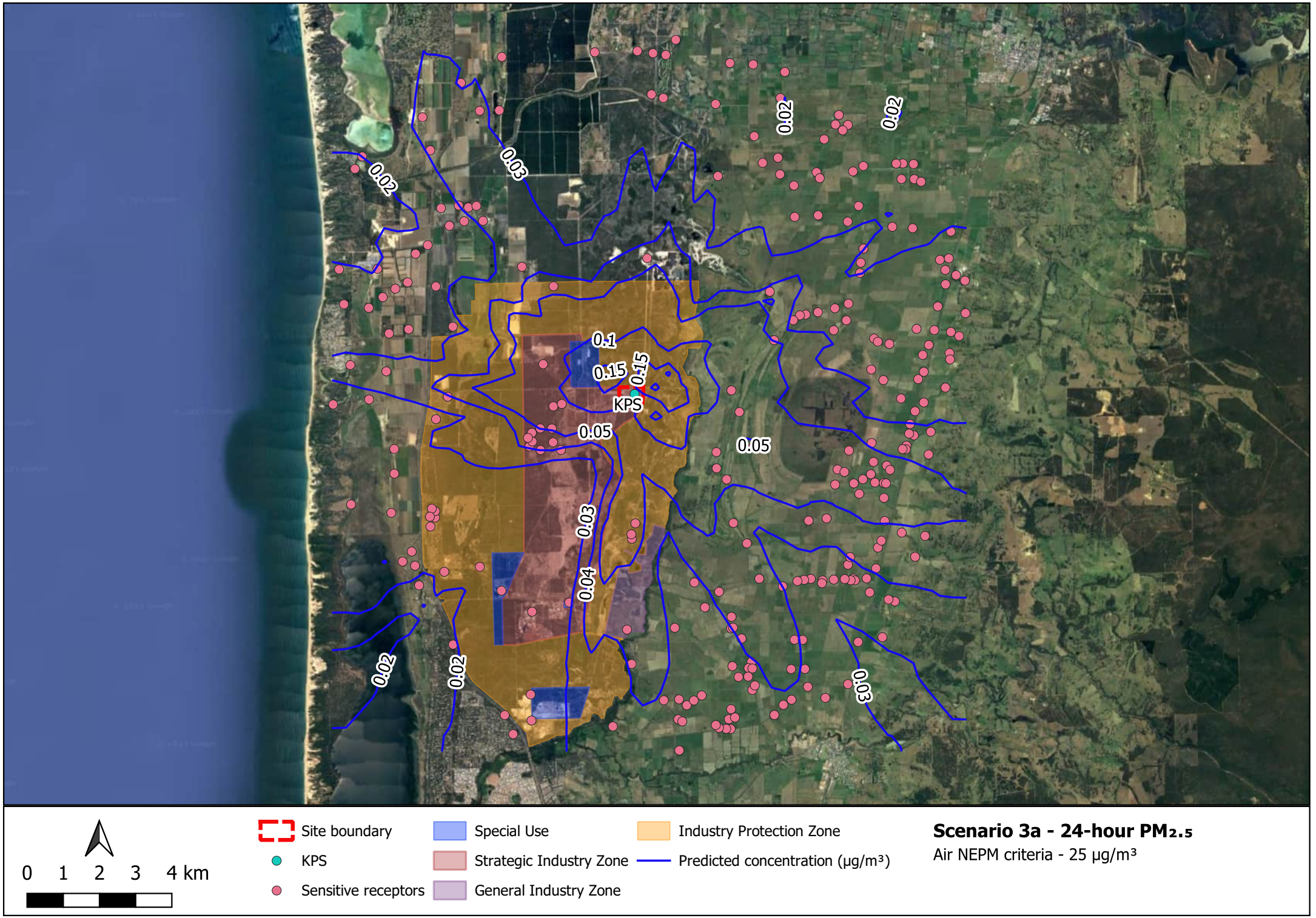

0.002
0.004
0.005
0.01
0.02
0.003
KPS
0.002
0.002
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 2a -Annual SO₂
Air NEPM criteria - 57 µg/m³

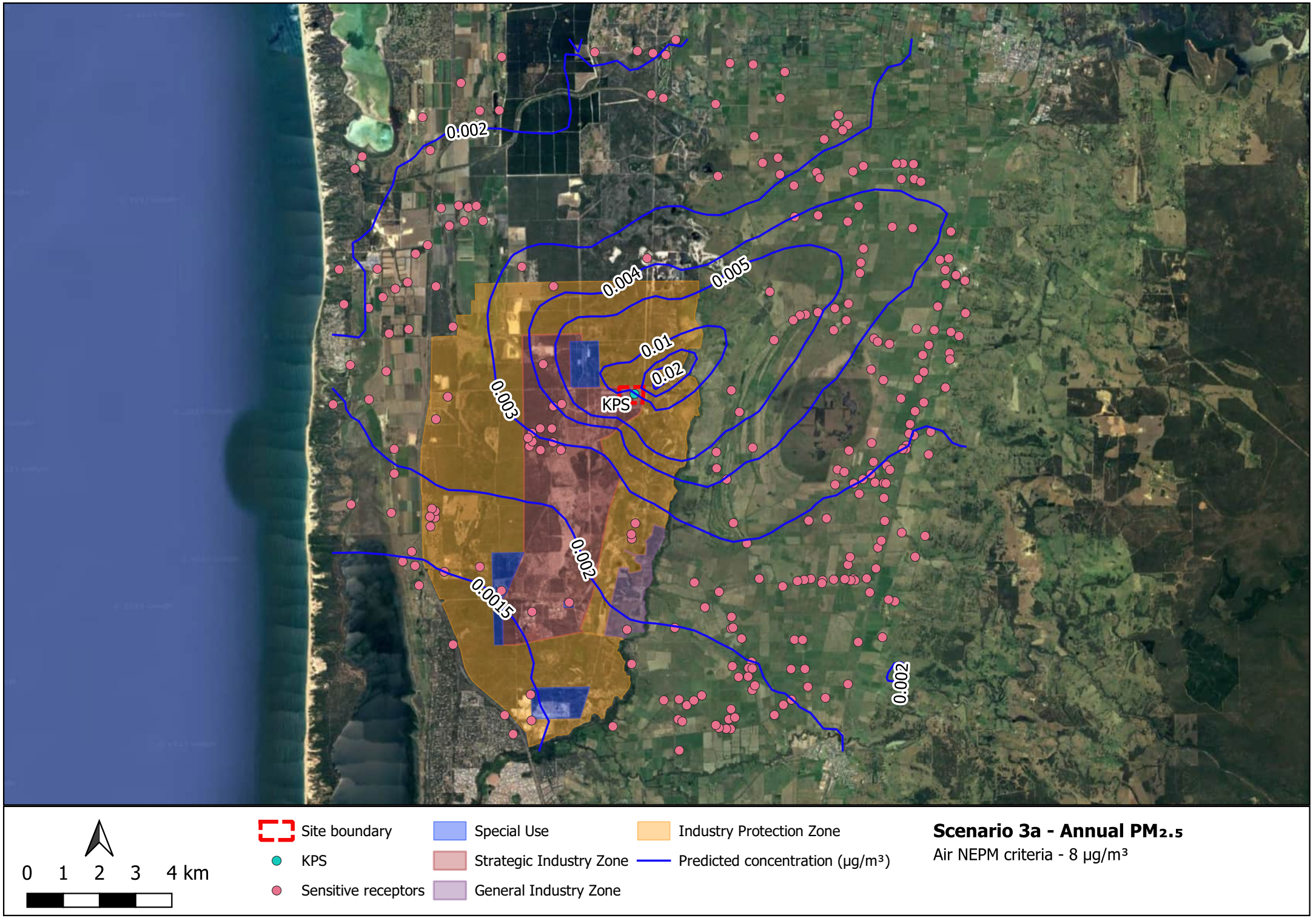

0.15
0.12
0.15
0.15
0.15
0.2
0.12
0.15
0.12
0.5
KPS
1
1
1
0.2
0.12
0.15
0.12
0.2
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 2a - 8-hour CO
Air NEPM criteria - 11,354 µg/m³

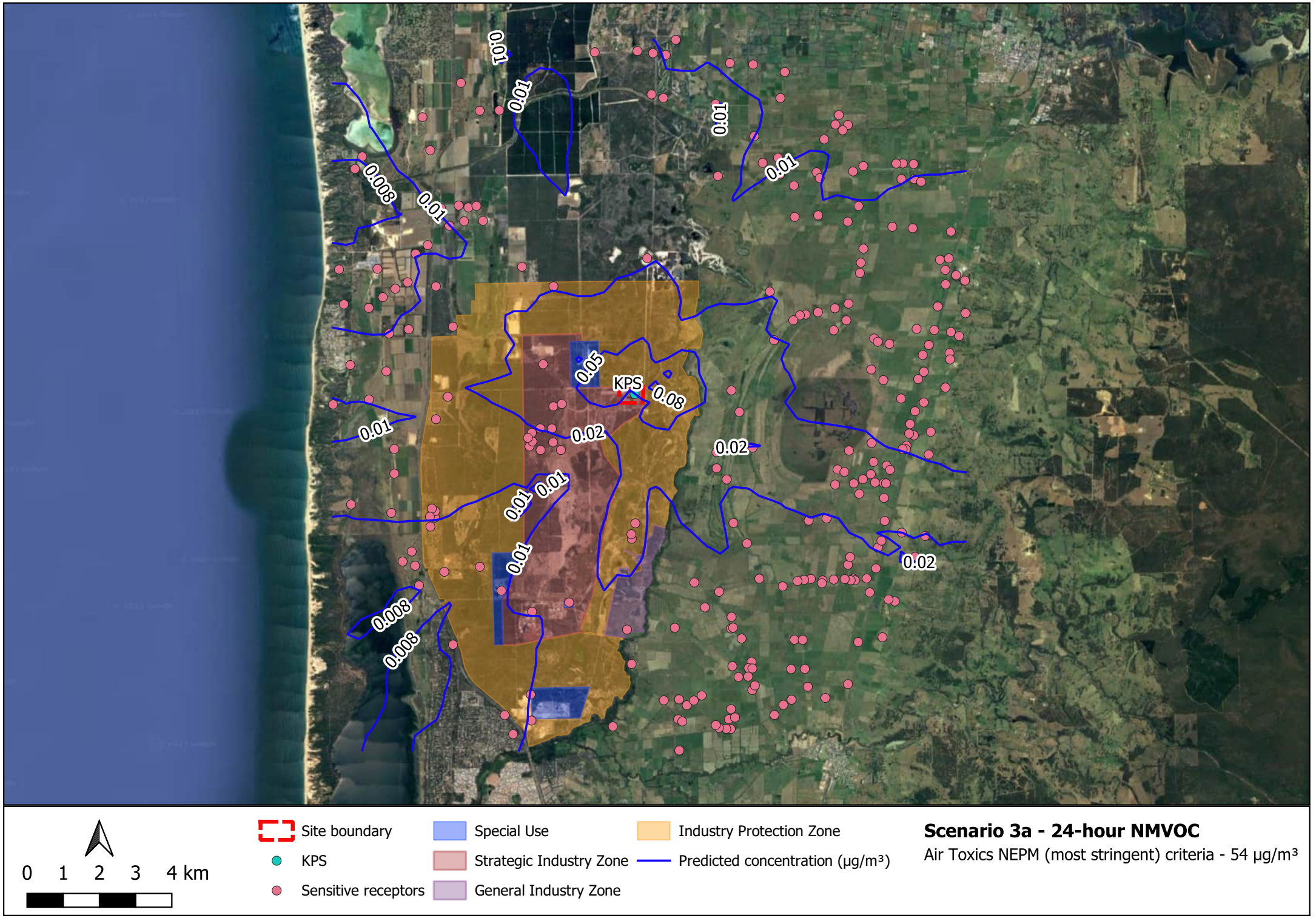

3
3
4
4
4
4
4
5
5
30
7
10
4
4
4
5
4
4
4
3
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 3a - 1-hour NO₂
Air NEPM criteria - 247 µg/m³

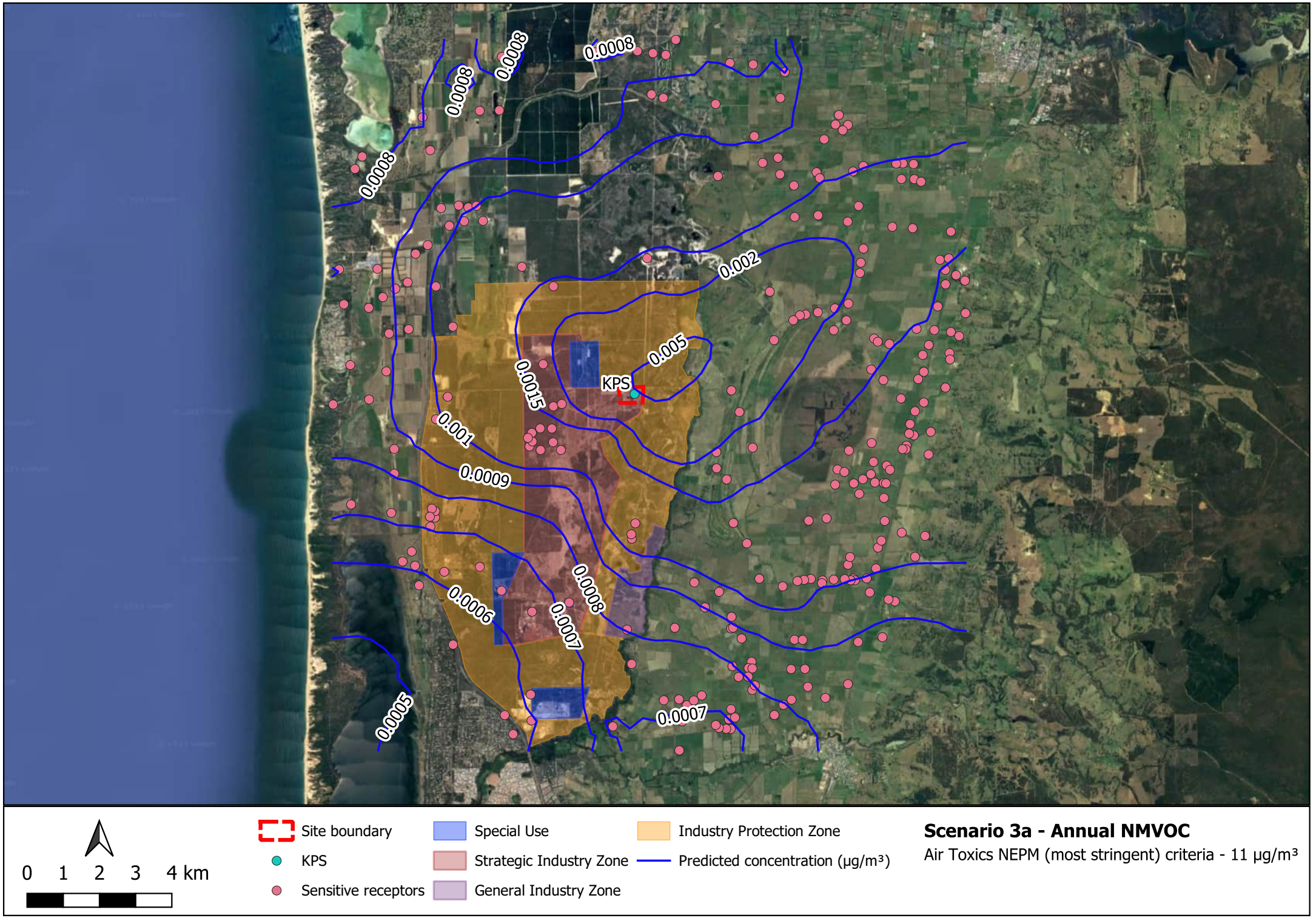

0.08
0.1
0.06
0.2
0.4
0.3
KPS
0.04
0.03
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 3a - Annual NO₂
Air NEPM criteria - 62 µg/m³

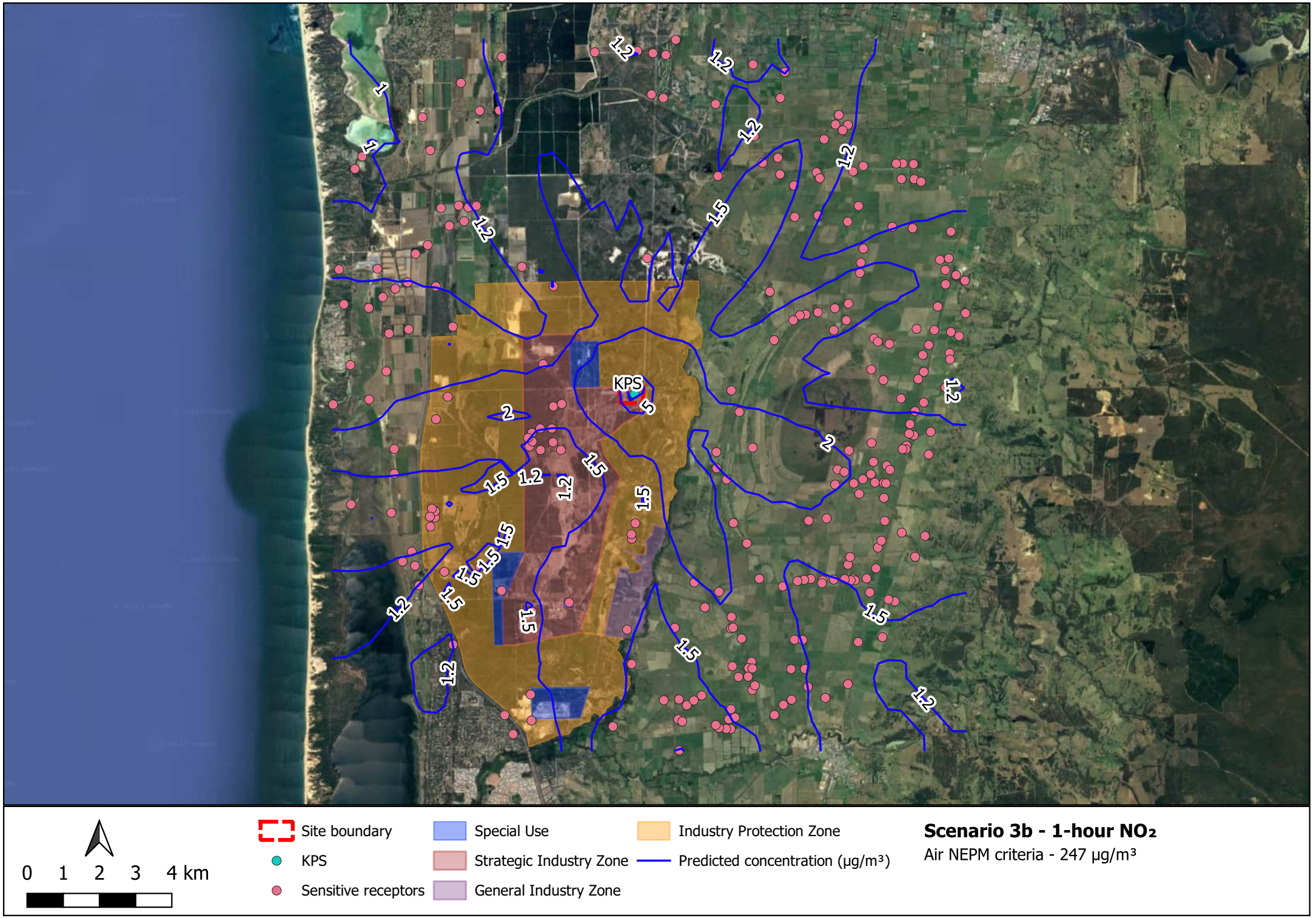

0.6
0.5
0.6
0.8
0.6
0.6
0.8
2
4
5
5
3
4
KPS
0.5
0.5
0.8
1.5
1.5
0.5
0.5
0.8
1
1.5
1
0.6
0.8
1
0.8
0.5
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 3a - 8-hour CO
Air NEPM criteria - 11,354 µg/m³

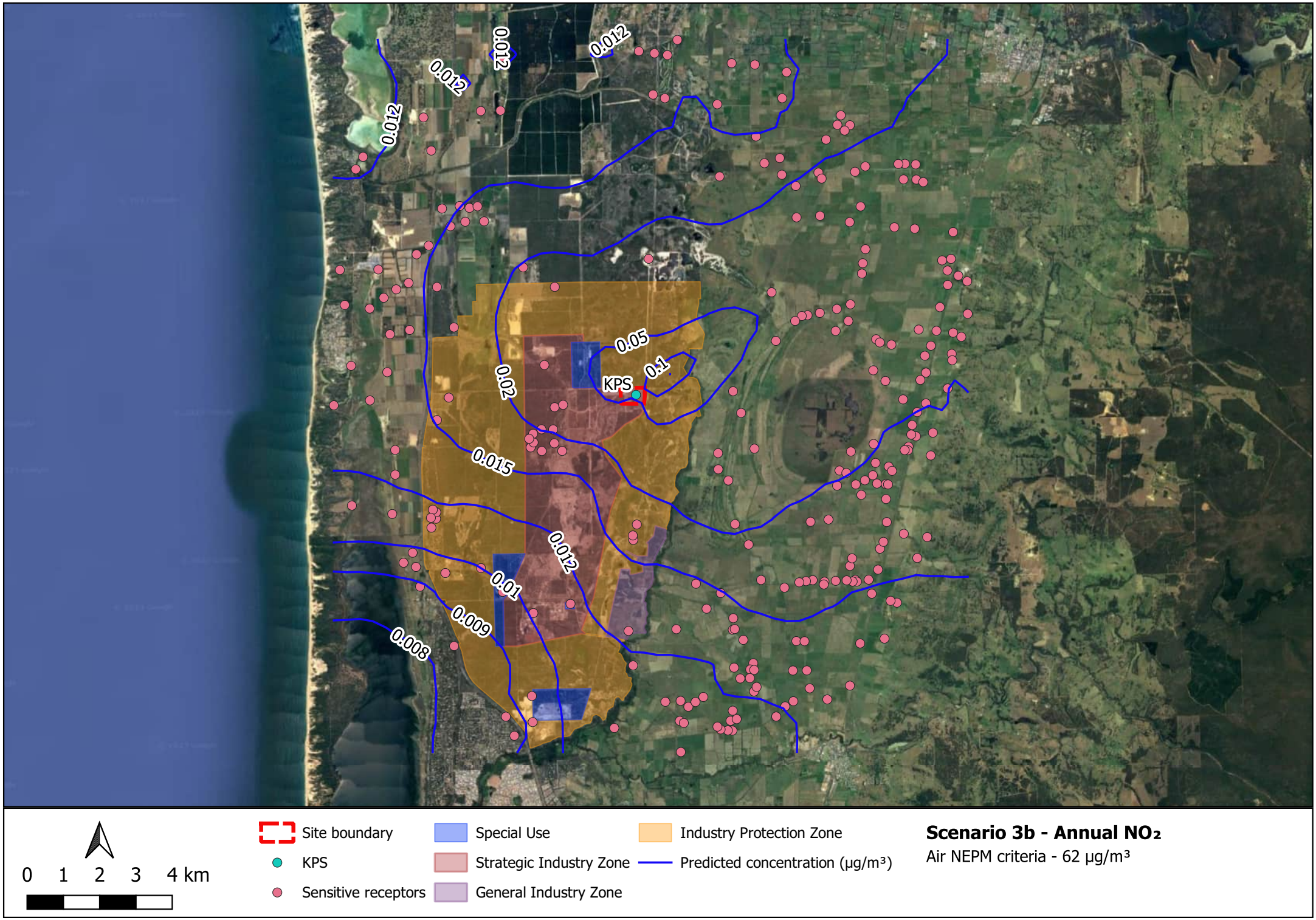

0.02
0.03
0.02
0.02
0.1
0.15
0.15
KPS
0.05
0.05
0.03
0.04
0.02
0.02
0.03
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 3a - 24-hour PM2.5
Air NEPM criteria - 25 µg/m³

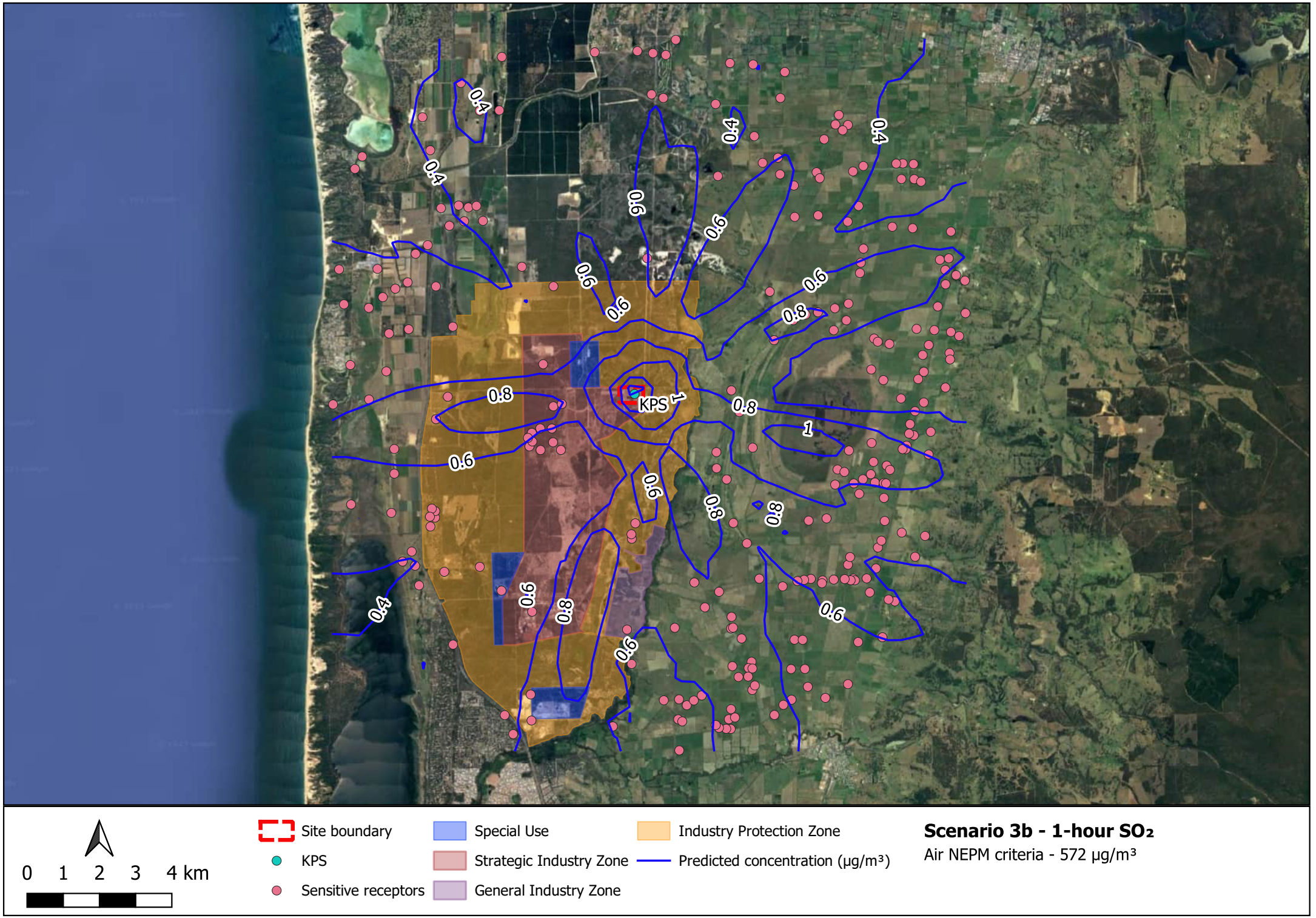

0.002
0.004
0.005
0.01
0.02
0.003
KPS
0.002
0.0015
0.002
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 3a - Annual PM2.5
Air NEPM criteria - 8 µg/m³

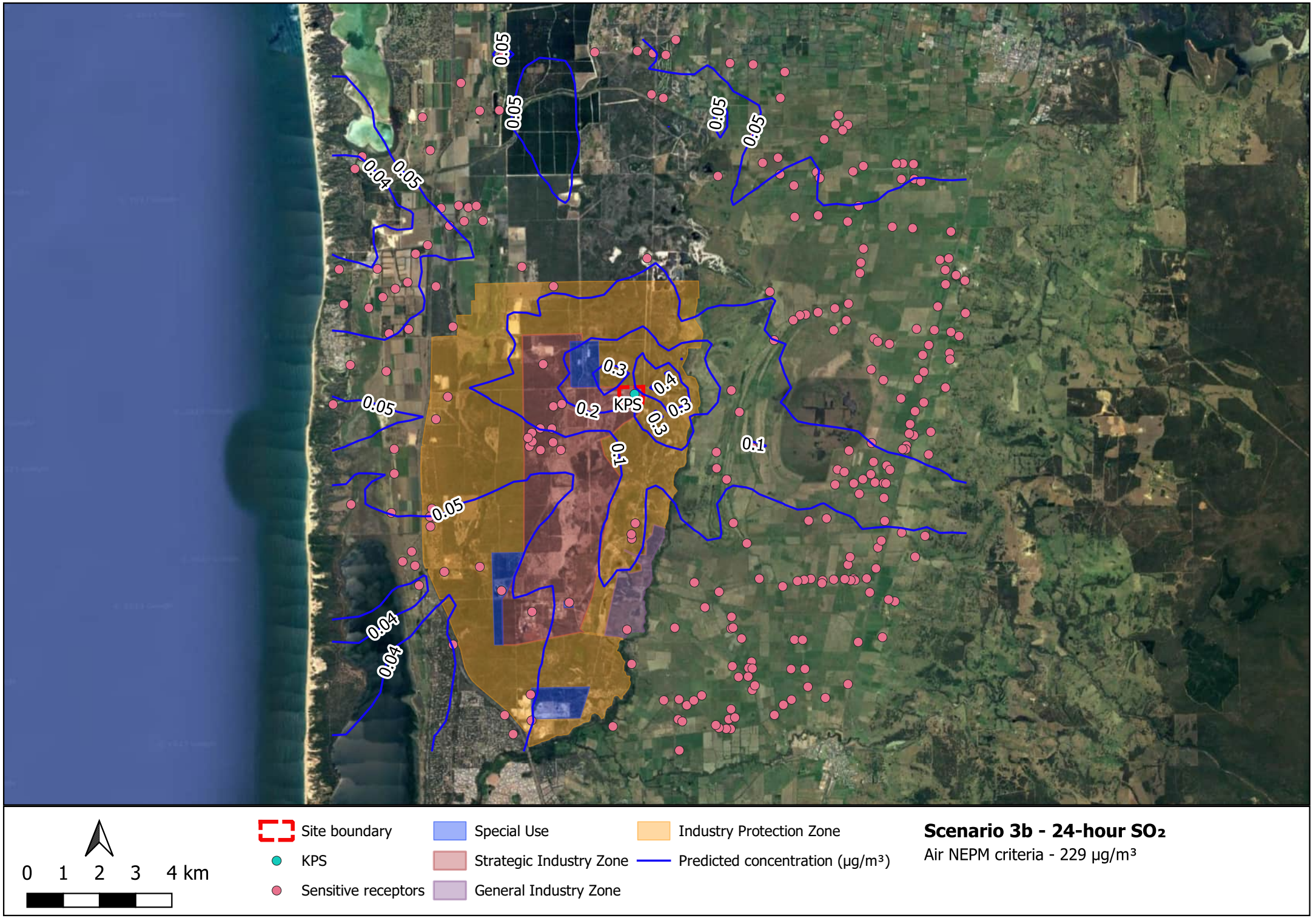

0.01
0.01
0.01
0.008
0.01
0.01
0.05
KPS
0.08
0.02
0.02
0.01
0.01
0.01
0.01
0.02
0.008
0.008
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 3a - 24-hour NMVOC
Air Toxics NEPM (most stringent) criteria - 54 µg/m³

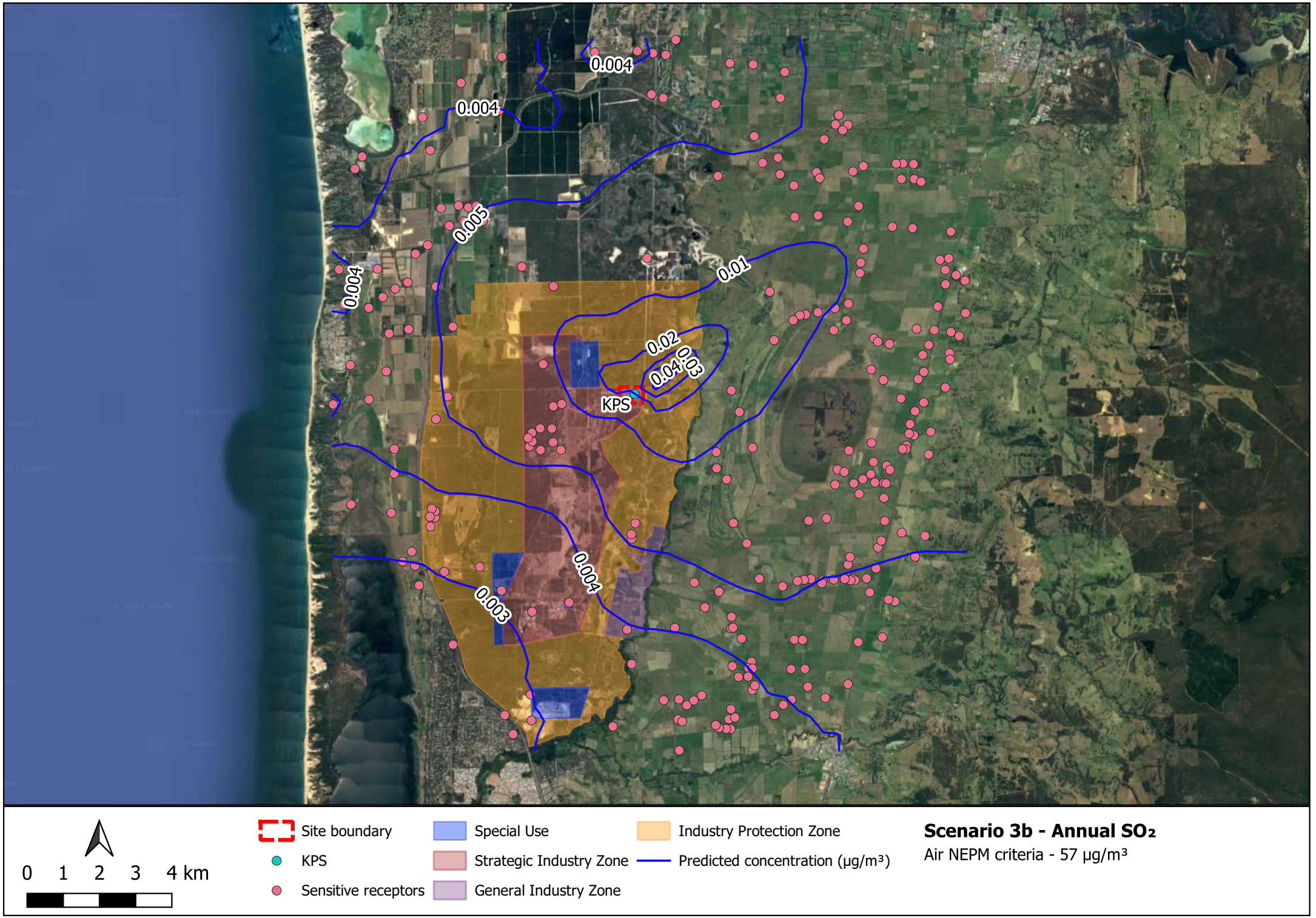

0.0008
0.0008
0.0008
0.0008
0.0008
0.002
0.005
KPS
0.0015
0.001
0.0009
0.0008
0.0006
0.0007
0.0005
0.0007
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 3a - Annual NMVOC
Air Toxics NEPM (most stringent) criteria - 11 µg/m³

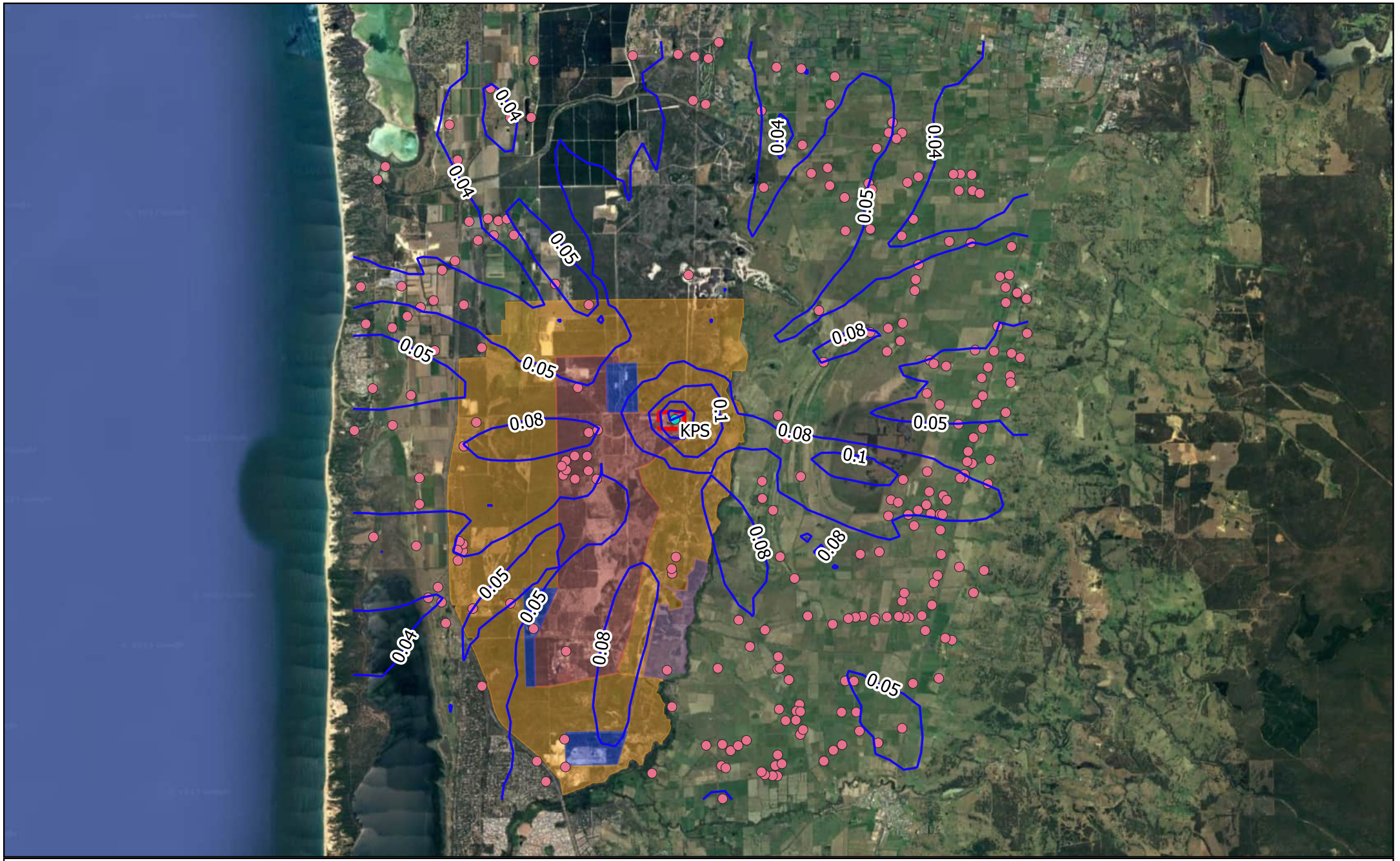

KPS
1
1.2
1.5
2
5
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 3b - 1-hour NO₂
Air NEPM criteria - 247 µg/m³

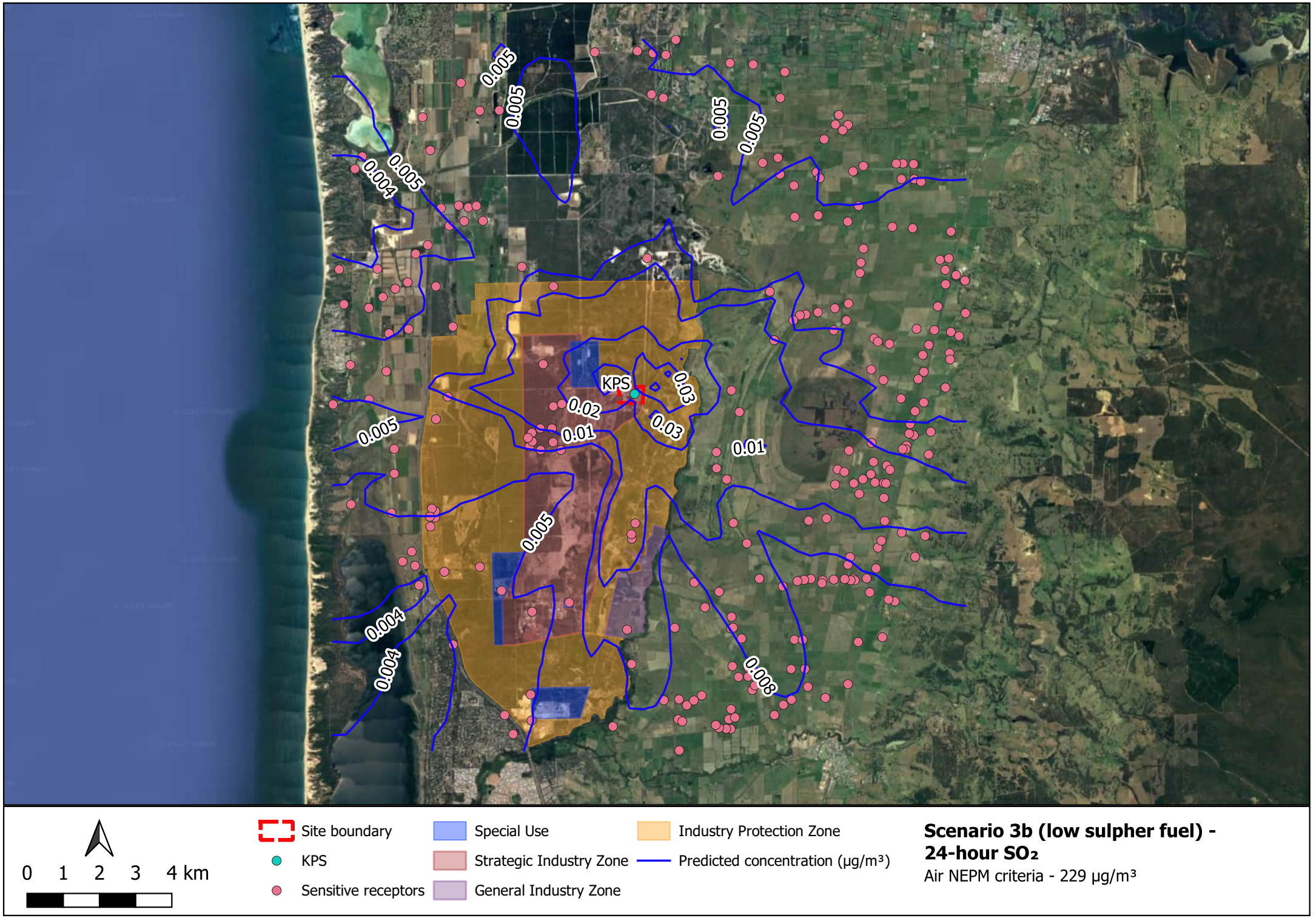

0.012
0.012
0.012
0.012
0.05
0.1
KPS
0.02
0.015
0.012
0.01
0.009
0.008
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 3b - Annual NO₂
Air NEPM criteria - 62 µg/m³

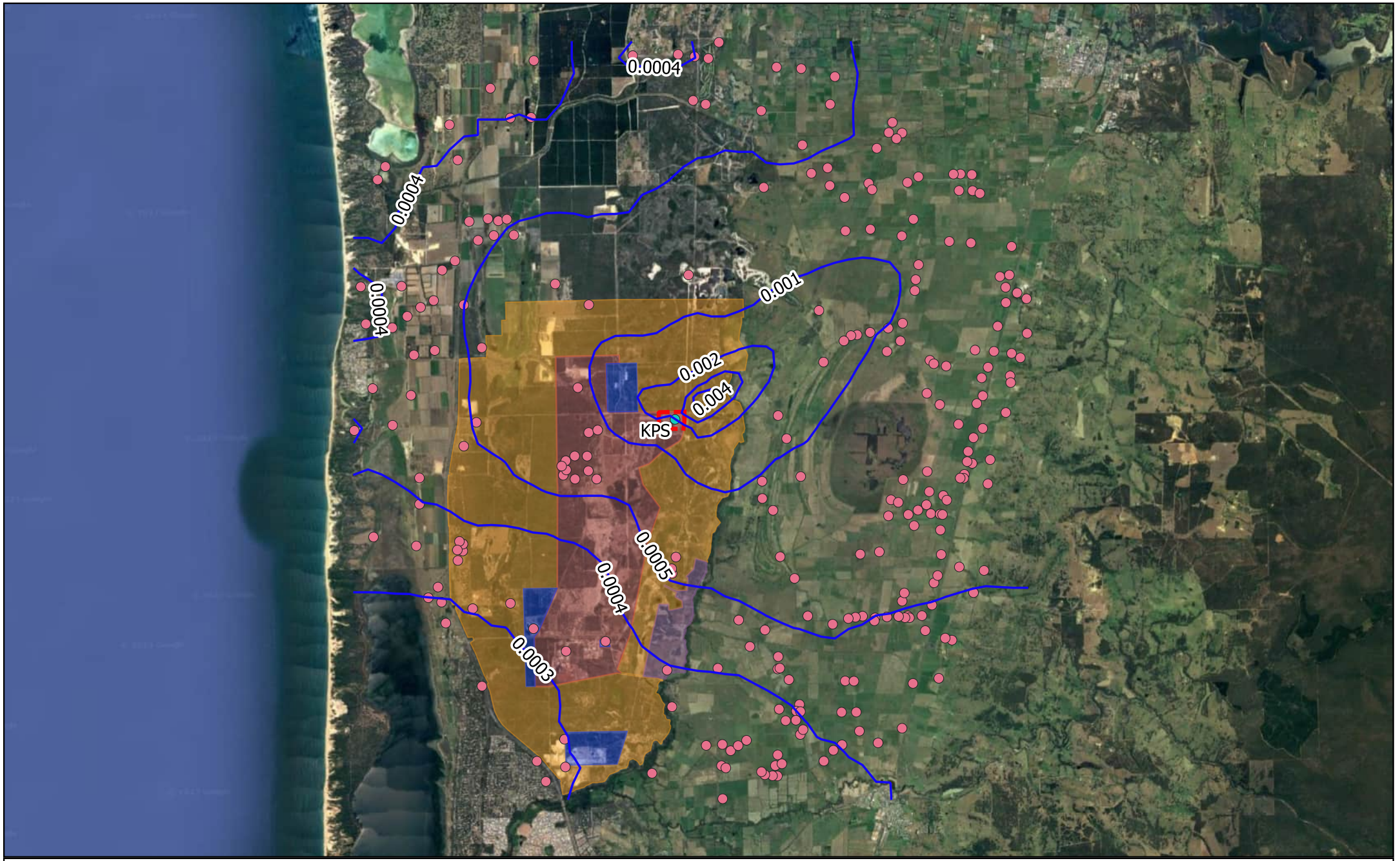

0.4
0.4
0.4
0.4
0.6
0.6
0.6
0.6
0.6
0.8
0.8
KPS
1
0.8
1
0.6
0.6
0.8
0.8
0.6
0.6
0.8
0.4
0.6
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 3b - 1-hour SO₂
Air NEPM criteria - 572 µg/m³

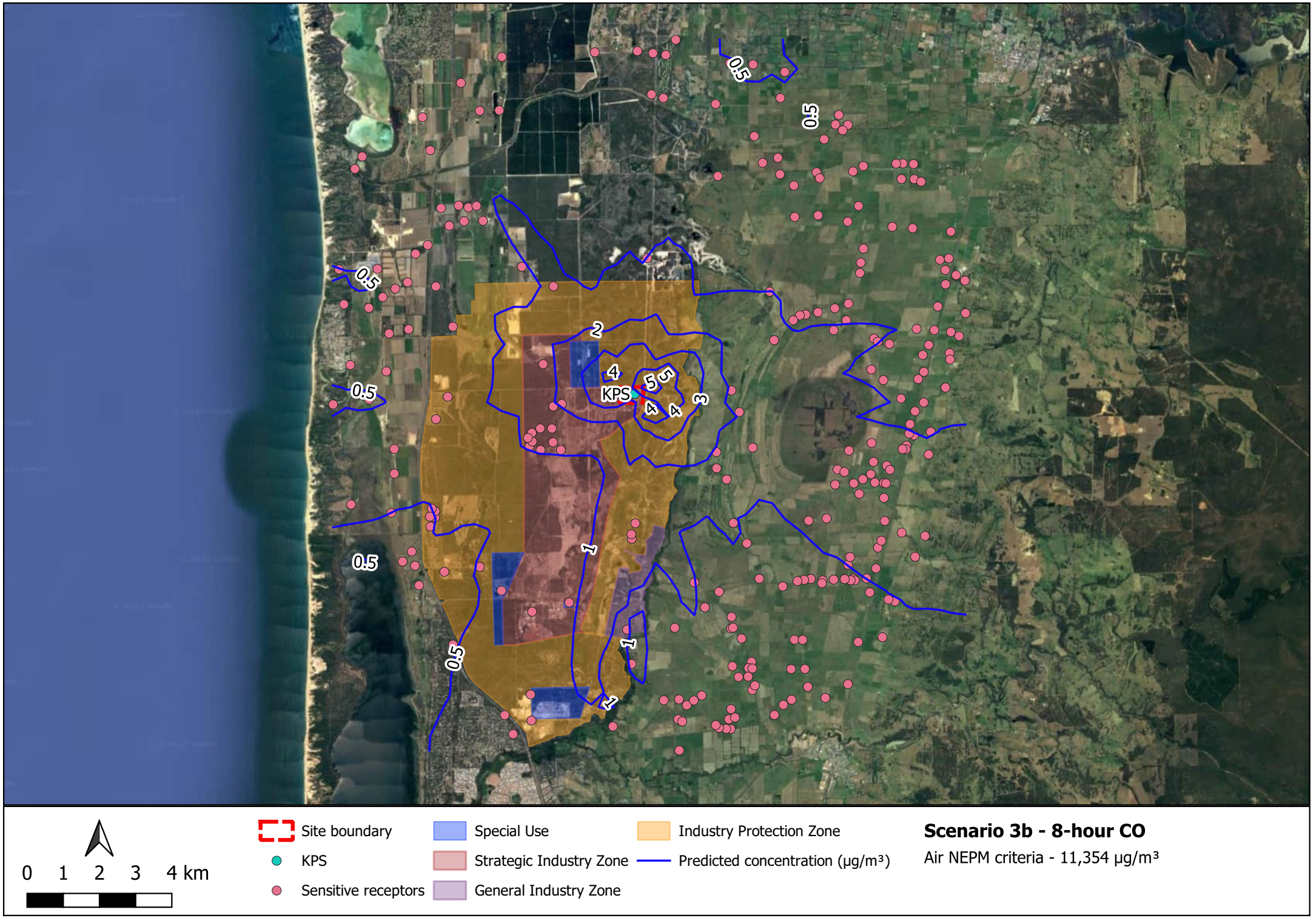

0.05
0.05
0.05
0.05
0.04
0.05
0.3
0.4
KPS
0.2
0.3
0.3
0.1
0.1
0.05
0.05
0.04
0.04
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 3b - 24-hour SO₂
Air NEPM criteria - 229 µg/m³

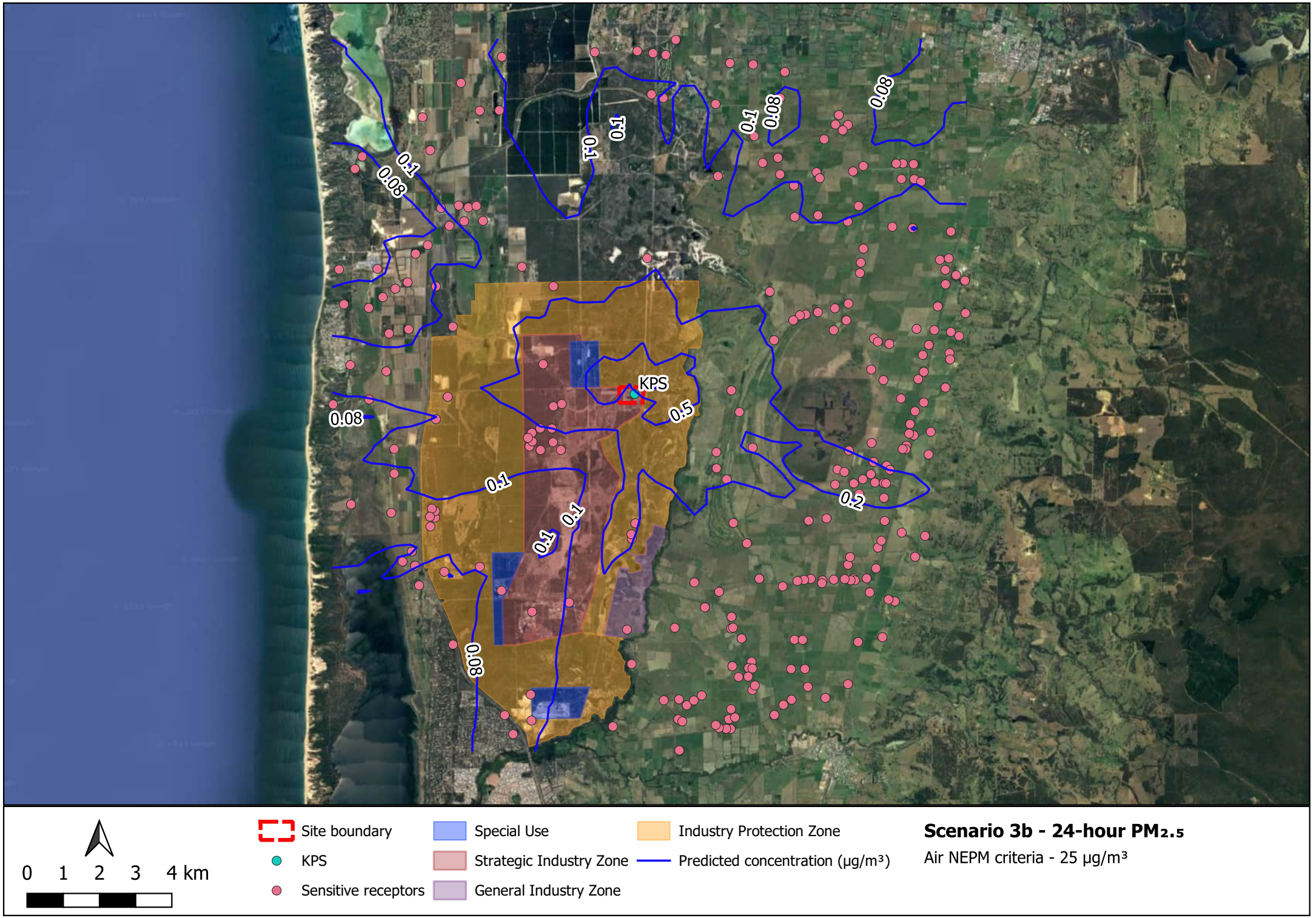

0.004
0.004
0.005
0.004
0.01
0.02
0.04
0.03
KPS
0.004
0.003
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 3b - Annual SO₂
Air NEPM criteria - 57 µg/m³

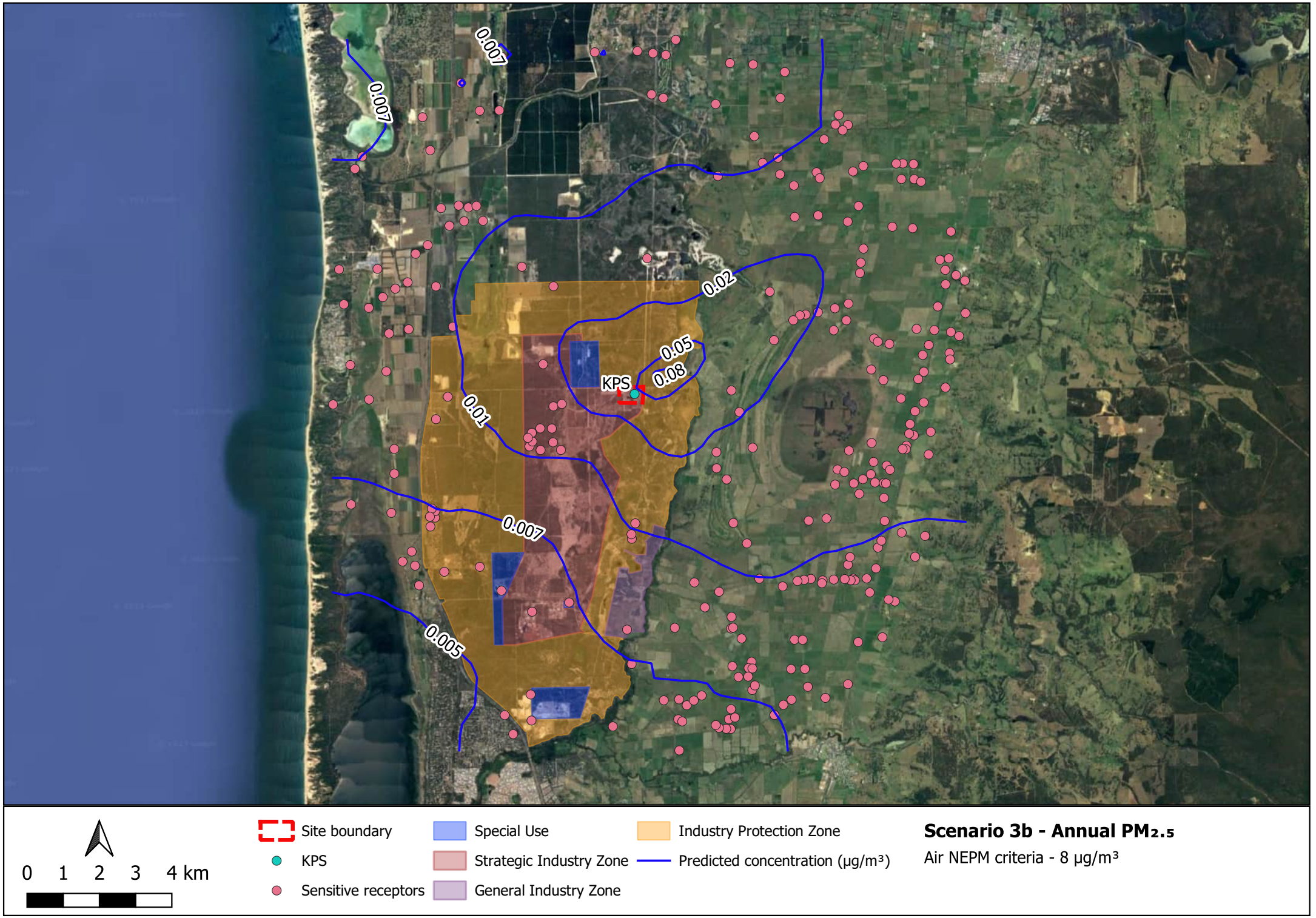

0.04
0.05
0.08
0.1
KPS
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 3b (low sulpher fuel) - 1-hour SO₂
Air NEPM criteria - 572 µg/m³

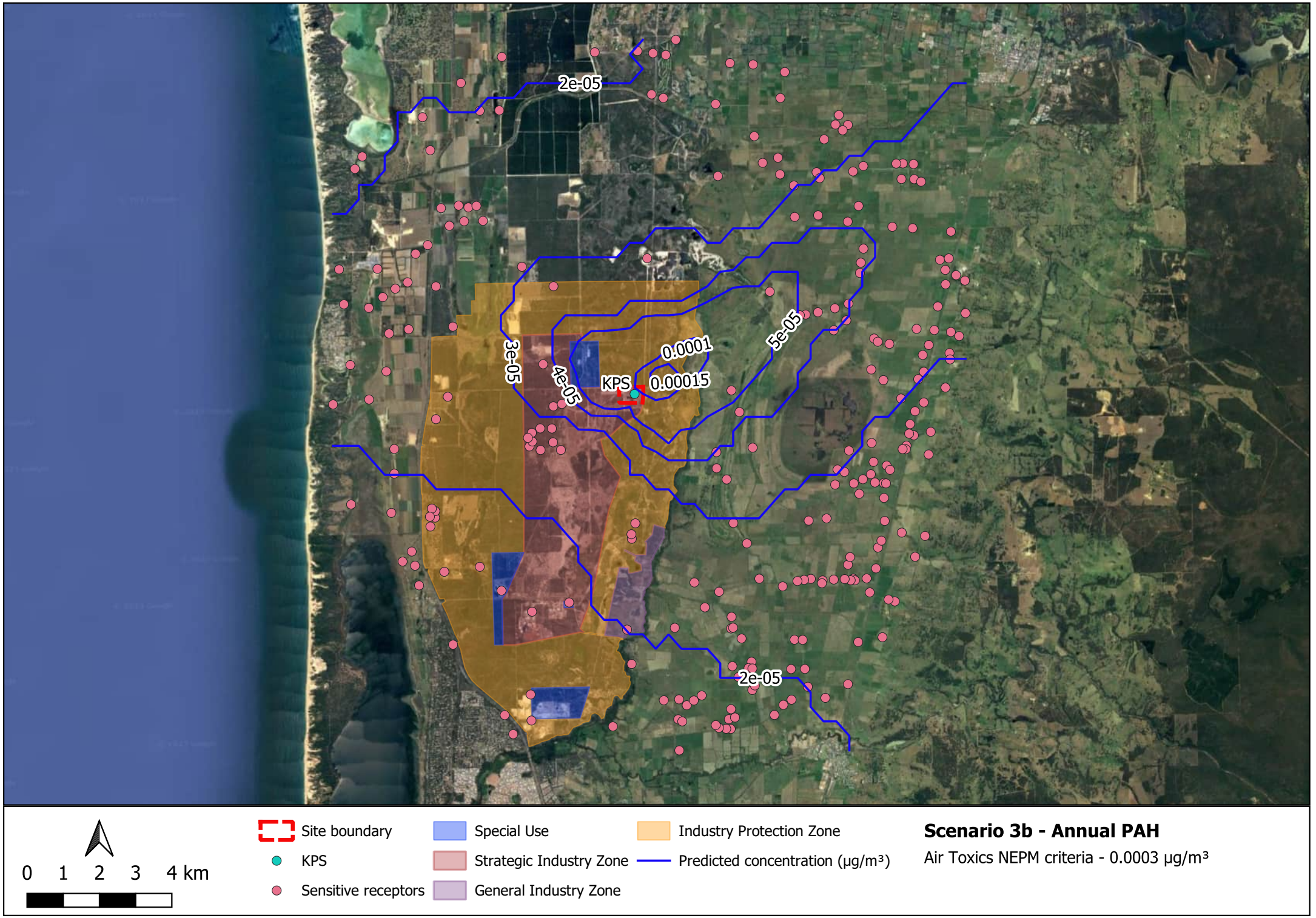

0.005
0.005
0.005
0.005
0.004
0.005
KPS
0.03
0.02
0.03
0.01
0.005
0.01
0.005
0.004
0.004
0.008
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 3b (low sulpher fuel) - 24-hour SO₂
Air NEPM criteria - 229 µg/m³

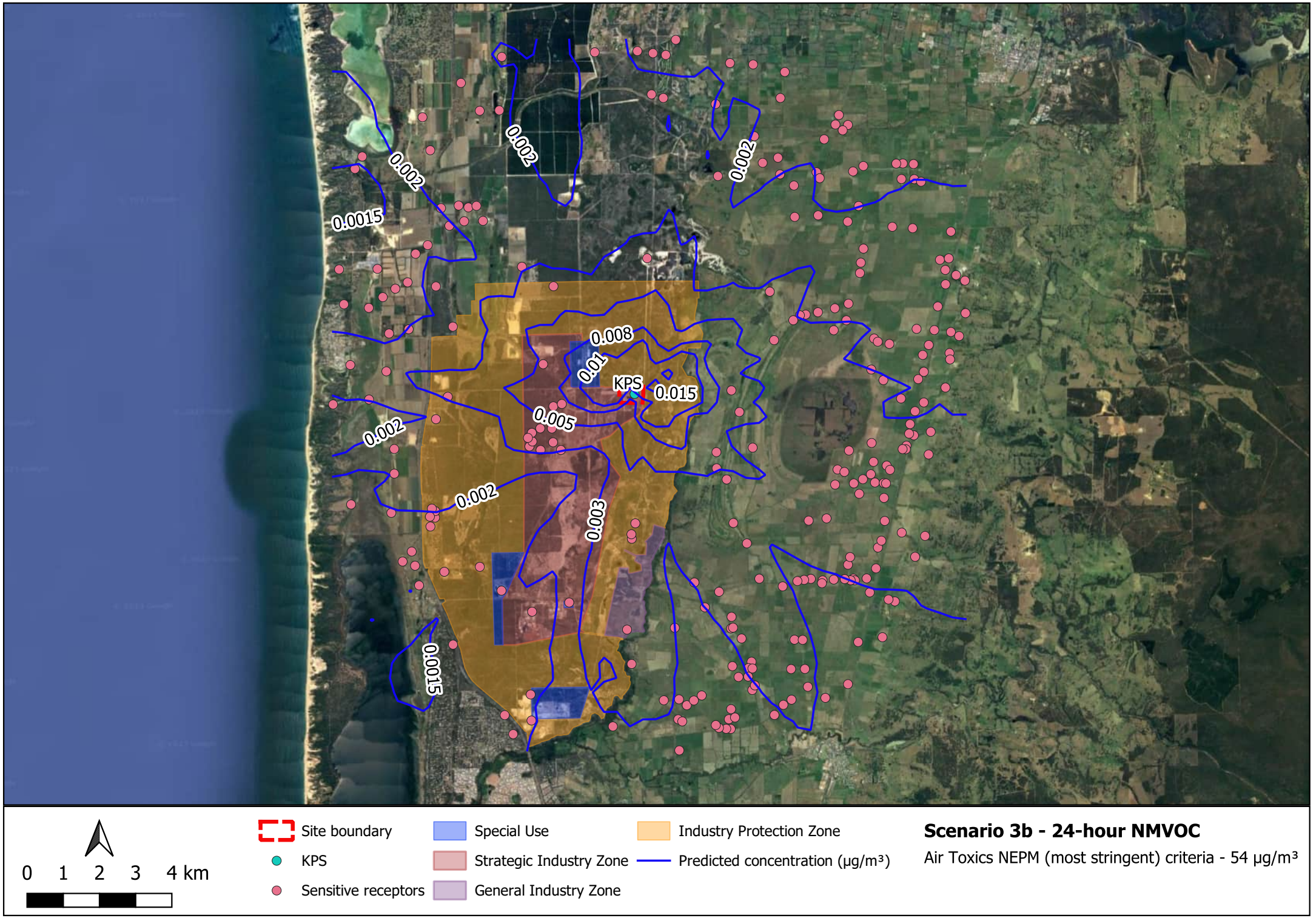

0.0004
0.0004
0.0004
0.001
0.002
0.004
KPS
0.0005
0.0004
0.0003
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 3b (low sulpher fuel) - Annual SO₂
Air NEPM criteria - 57 µg/m³

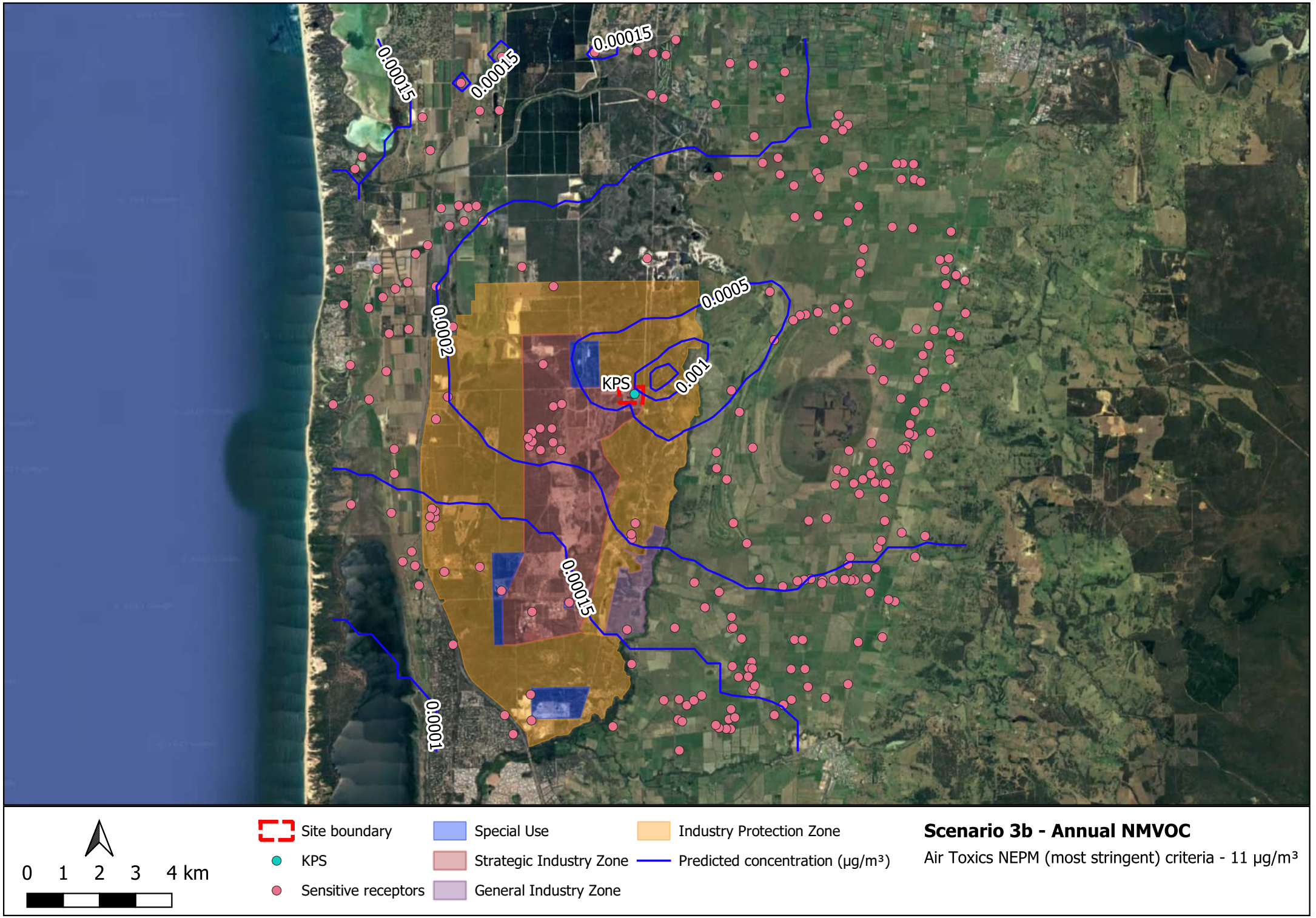

0.5
0.5
0.5
0.5
2
4
5
5
KPS
4
4
3
1
1
1
0.5
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 3b - 8-hour CO
Air NEPM criteria - 11,354 µg/m³


0.08
0.1
0.08
0.1
0.1
0.1
0.08
0.08
KPS
0.5
0.08
0.1
0.2
0.1
0.1
0.08
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 3b - 24-hour PM2.5
Air NEPM criteria - 25 µg/m³


0.007
0.007
0.02
0.05
0.08
KPS
0.01
0.007
0.005
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 3b - Annual PM2.5
Air NEPM criteria - 8 µg/m³


2e-05
3e-05
4e-05
5e-05
0.0001
0.00015
KPS
2e-05
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 3b - Annual PAH
Air Toxics NEPM criteria - 0.0003 µg/m³


0.002
0.002
0.002
0.0015
0.008
0.01
KPS
0.015
0.005
0.002
0.002
0.003
0.0015
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 3b - 24-hour NMVOC
Air Toxics NEPM (most stringent) criteria - 54 µg/m³


0.00015
0.00015
0.00015
0.0005
0.0002
0.001
KPS
0.00015
0.0001
0 1 2 3 4 km
Site boundary
KPS
Sensitive receptors
Special Use
Strategic Industry Zone
General Industry Zone
Industry Protection Zone
Predicted concentration (µg/m³)
Scenario 3b - Annual NMVOC
Air Toxics NEPM (most stringent) criteria - 11 µg/m³