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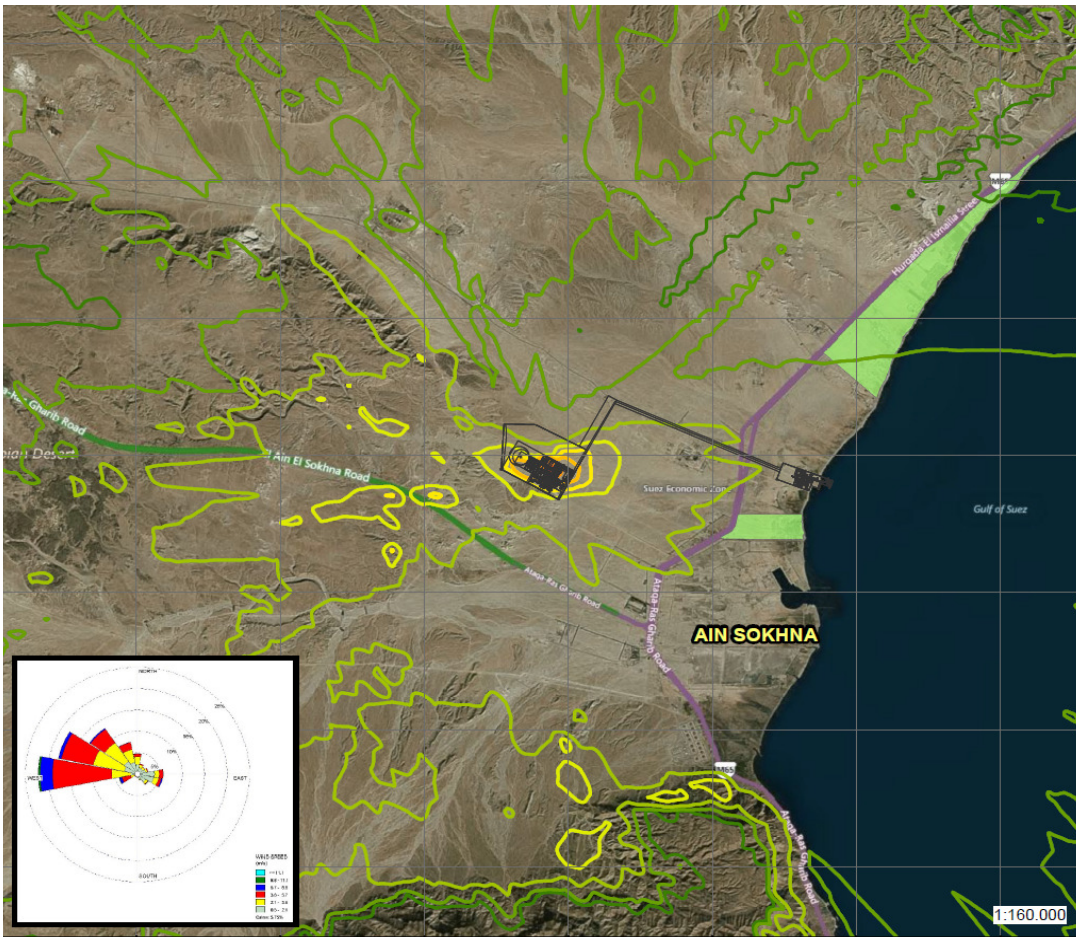
TAHRIR PETROCHEMICALS

AIR DISPERSION MODEL

Tahrir Petrochemicals Complex, Economic Zone, Ain Sokhna, Egypt



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PROJECT 455/EJ6195 - AIR DISPERSION MODEL

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List of Acronyms

A1	Ambient Air Measurement Location number 1
A2	Ambient Air Measurement Location number 2
COPC	Contaminant of Potential Concern
EEAA	Egyptian Environmental Affairs Agency
EHS	Environmental, Health, and Safety
EU	European Union
HDA	Hydrodealkylation Unit
HP	High Pressure
IFC	International Finance Corporation
IPCC	Integrated Pollution Prevention and Control
PM_{10}	Particulate Matter (particle diameter < 10 μm)
US EPA	United States Environmental Protection Agency
WHO	World Health Organisation

EXECUTIVE SUMMARY

WorleyParsons has been retained by TAHRIR PETROCHEMICALS CORPORATION to complete an air dispersion assessment of the Tahrir Petrochemicals Complex to be constructed in the Economic Zone, Ain Sokhna, Egypt. This Air Dispersion Model report is intended to be used as input to the Environmental and Social Impact Assessment (ESIA) of the proposed Complex. The Air Dispersion Model considered the different components of the proposed Complex together with cumulative approach taking into account existing conditions of the ambient air quality.

The main objectives of this report are to provide quantitative information and a better understanding of the potential impacts from pollutants emitted from the Complex under the normal operation of the plant (Scenario A) and under the furnace decoking operations (Scenario B). Cumulative impacts of the facility emissions on the air quality of the area, calculated by combining the modelled contributions from the proposed Complex with background levels measured in the area, have been also assessed.

To accomplish these objectives, the aerial dispersion of contaminants was calculated using the steady-state Gaussian plume dispersion model AERMOD, based on the emission characteristics of the proposed Complex during each of the Scenarios. The results were compared with the applicable national and international Ambient Air Quality Standards.

Results of the study show that under either Scenario A and in Scenario B, the maximum NO_2, CO, SO_2, PM_{10} and benzene contributions to the background are in compliance with the limits set by the national and international regulations. The 1-hour average COPC concentrations modelled across the entire study area are predicted to reach a maximum in a mountainous zone located approximately 6 km northwest of the Main Plant where there are no residents or sensitive receptors. Furthermore, these concentrations are below the allowable national and international applicable limits.

Results under normal and decoking operations indicate that the COPC concentrations predicted at DP Sokhna Port and at the two tourist villages located southeast and northeast of the Main Plant will be lower than 15% of the applicable national and international ambient air limits.

In general, the cumulative impacts, calculated as the addition of maximum predicted contributions from the proposed Complex to the measured background levels in the sampling locations A1 and A2, do not exceed national and international limits.

Based on the Air Dispersion Model results, it can be concluded that the proposed Tahrir Petrochemicals is complying with the national and International ambient air limits presented in the report.

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APPENDIX 3 – REFERENCES FOR THE SOURCE PARAMETERS EMPLOYED IN THE MODEL

1. INTRODUCTION

WorleyParsons has been retained by TAHRIR PETROCHEMICALS CORPORATION to complete an air dispersion assessment of the Tahrir Petrochemicals Complex to be constructed in the Economic Zone, Ain Sokhna, Egypt. This Air Dispersion Model report is intended to be used as input to the Environmental and Social Impact Assessment (ESIA) of the proposed Complex. The Air Dispersion Model considered the different components of the proposed Complex together with cumulative approach taking into account existing conditions of the ambient air quality.

The Complex will include an Ethylene Plant and a Polyethylene Plant, utilities and offsite (Main Plant area), a desalination plant and a dedicated storage area and jetty at the Sokhna 1(McDermott) Port (Port Area). A distance of 7.5 km separates the Main Plant area from the Port Area. The project is proposed in the Economic Zone in Ain Sokhna (Suez), as shown in Figure 1-1 . The nearest potentially populated areas are two (2) tourist villages that are located on the coast northeast and southeast of the Main Plant. The locations of these receptors were primarily identified using Google Earth and verified during WorleyParsons team field visit to the proposed Complex area in August 2014.

Figure 1-1 Tahrir Petrochemicals Complex Location

1.1 Objectives and Scope of Work

The aim of this assessment is to predict the contribution from the proposed Complex to the local air quality. The main objectives of this Air Dispersion Modelling report are to provide quantitative information and a better understanding of the potential impacts from pollutants emitted from the Complex under the following two scenarios:

- **Scenario A**: Normal operation of the plant, for which the following sources were modelled as air pollutant emitters:
  - Nine (9) Cracking Furnaces: 8 (normal Cracker operation) and 1 (standby)
  - Two (2) Gas-fired Heaters: located in the Hydrodealkylation (HDA) Unit
  - Four (4) Gas Turbines: located in the Power Plant of the Facility
  - Three (3) High Pressure (HP) Steam Boilers
  - One (1) Ship Vapour Recovery Unit (VCU)
  - Two (2) Flares: the Sour Gas Flare and the LP Tank Farm Flare
- **Scenario B**: Furnace decoking operation during which a cracking furnace undergoes a cleaning decoking process that lasts 36 hours. This non-continuous operation occurs six (6) times a year per each furnace, and the following sources were modelled as emitters:
  - Nine (9) Cracking Furnaces: 8 (normal Cracker operation) and 1 (decoking)
  - One (1) Decoking Cyclone
  - Two (2) Gas-fired Heaters: located in the Hydrodealkylation (HDA) Unit
  - Four (4) Gas Turbines: located in the Power Plant of the Facility
  - Three (3) High Pressure (HP) Steam Boilers
  - One (1) Ship Vapour Recovery Unit (VCU)
  - Two (2) Flares: the Sour Gas Flare and the LP Tank Farm Flare

To accomplish these objectives, the aerial dispersion of contaminants during normal operation and under the non-continuous furnace decoking operation was calculated using the steady-state Gaussian plume dispersion model AERMOD, based on the emission characteristics of the proposed Complex during each of the Scenarios. The results were compared with the Ambient Air Quality Standards for Industrial Areas specified by the Environmental Law of Egypt (Decree No. 710/2012) and other international guidelines (International Finance Corporation and European Union).

This assessment modelled contributions from the proposed Complex to verify compliance with applicable national legal standards and international guidelines for air quality limits, and calculated cumulative impacts of the facility emissions on the air quality of the area by combining the modelled contributions from the proposed Complex with background levels measured in the area.

The sources modelled in this study are based on the pre-FEED design data and summarized in the References Section (*Documents provided by EPC contractors*). Any later modification[1] in the data presented in this study would require remodelling, since the results here presented would be modified.

1.2 Contaminants of Potential Concern (COPC)

According to the Pre-FEED information, nitrogen oxides (NO_x), carbon monoxide (CO), sulphur dioxide (SO_2) particulate matter (PM_{10}) and benzene (C_6H_6) were identified as Contaminants of Potential Concern (COPC) for the purposes of this air dispersion model. According to the limits set by the national and international air quality standards, described in more detail in Section 2, the following time average periods were used to estimate maximum COPC concentrations: 1-hour, 8-hour, 24-hour and 1-year.

It is worth mentioning that 1-hour concentration represents the highest one hour concentration predicted during the whole air dispersion simulation period (5 years). The 8-hour, 24-hour and annual concentrations represent the highest 8 hours, 24 hours and 1 year average predicted concentration throughout the whole air dispersion simulation period (5 years).

[1] Inclusion or deletion of any source such as flares, or modification of source parameters

2. NATIONAL AND INTERNATIONAL STANDARDS AND GUIDELINES

National and international air quality standards were considered to evaluate compliance of the proposed Complex's emissions during normal operations and under the decoking operation of the furnaces.

Law No. 4, passed in 1994 established the Egyptian Environmental Affairs Agency (EEAA), which has the power to set criteria and conditions, to monitor compliance and to take action against violators of the established criteria and conditions. The EEAA must be notified of any expansions or renewals to existing facilities or of any work that might result in an adverse impact on the environment. Maximum permissible concentrations in industrial zones were updated by Decree No. 710/2012 for nitrogen dioxide (NO_2), carbon monoxide (CO), particulate matter (PM_{10}), and sulphur dioxide (SO_2), as listed in Table 2-1, along with international standards presented in the International Finance Corporation (IFC) Environmental, Health, and Safety (EHS) Guidelines, which refers to the World Health Organisation Air Quality Guidelines (WHO, 2005), and in the European Directive EC/50/2008 on ambient air quality (EU, 2008).

Table 2-1 Comparison of National and International Air Quality Standards for the Modelled COPC

COPC	Average Period	Air Quality Standards (µg/m^3)		
		Egyptian Decree No. 710/2012	IFC Air Quality Guidelines	EU Directive EC/50/2008
NO_2	1-hr	300	200	200
	24-hr	150	--	--
	Annual	80	40	40
CO	1-hr	30,000	30,000 (1)	--
	8-hr	10,000	10,000 (1)	10,000
SO_2	1-hr	350	--	350
	24-hr	150	125(2)	125
	Annual	60	--	--
PM_{10}	24-hr	150	150(2)	50
	Annual	70	70(2)	40
Benzene	Annual	--	--	5

(1) These standards are not included in the WHO Air Quality Guidelines Global Update 2005 but can be found in the WHO Air Quality Guidelines for Europe (WHO, 2000).

(2) Interim Target 1 (IT-1) represents the least stringent allowable limit, World Health Organisation Air Quality Guidelines (2005).

3. BACKGROUND AIR QUALITY MEASUREMENTS

The background air quality in the proposed Complex area was assessed by conducting two (2) 24-hour ambient air active sampling of CO, NO_2, SO_2 and PM_{10}, among other pollutants, at two nearby locations, A1 (29°40'56.80"N and 32°17'6.10"E) and A2 (29°39'58"N and 32°19'59"E), of the proposed Tahrir Petrochemicals Complex, as shown below in Figure 3-1. The background ambient air measurement campaigns were conducted on 13-14 August 2014 (A1) and on 12-13 November 2014 (A2).

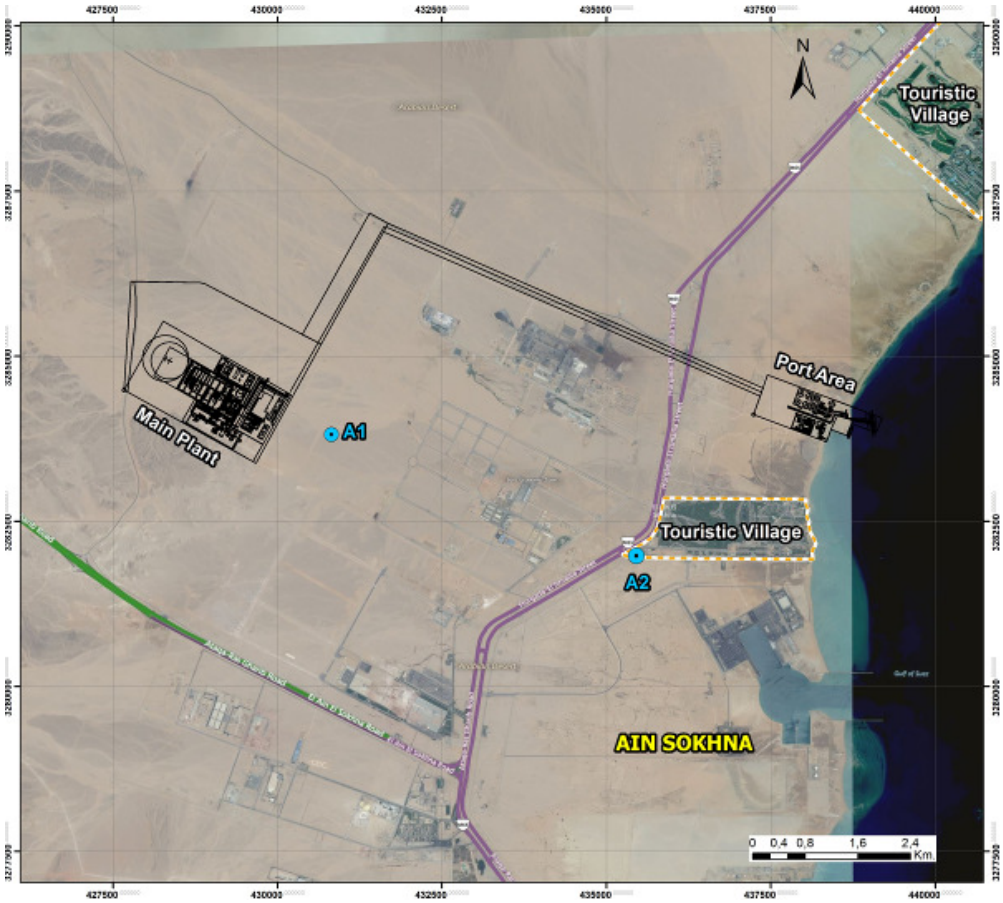

Figure 3-1 Ambient Air Measurement Locations (A1 and A2)

Maximum values for 1-hour, 8-hour and 24-hour average periods obtained from the ambient air sampling locations for COPC (NO_2, CO, SO_2 and PM_{10}) are listed in Table 3-1 with the applicable national and international air quality standards.

Table 3-1 COPC Concentrations Measured at the background monitoring locations (A1 and A2) and Air Quality Standards

COPC	Average Period	COPC Concentration Measured ($\mu g/m^3$)		Air Quality Standards ($\mu g/m^3$)		
		A1	A2	Egyptian Decree No. 710/2012	IFC Air Quality Guidelines	EU Directive EC/50/2008
NO_2	1-hour	7.43	24.61	300	200	200
	24-hour	3.66	9.75	150	--	--
CO	1-hour	860	430	30,000	30,000 (1)	---
	8-hour	200	290	10,000	10,000 (1)	10,000
SO_2	1-hour	0.9	2.22	350	--	350
	24-hour	0.17	1.13	150	125 (2)	125
PM_{10}	24-hour	76	123	150	150 (2)	50

(1) These standards are not included in the WHO Air Quality Guidelines Global Update 2005 but can be found in the WHO Air Quality Guidelines for Europe (WHO, 2000).

(2) Interim Target 1 (IT-1) represents the least stringent allowable limit, World Health Organisation Air Quality Guidelines (2005).

The results summarised in Table 3-1 show that the existing background concentrations measured at the locations A1 and A2 are in compliance with the applicable air quality standards except for PM_{10}, which is above the 50 $\mu g/m^3$ limit established by the European Directive. The following should be taken into consideration when comparing this background PM_{10} concentration with the air quality standards:

- Measurements were carried out in a desert area where particulate measurements are influenced by the presence of particles of biogenic origin (desert dust) and where PM concentrations therefore tend to be high. Consequently, it does not necessarily indicate poor air quality.
- Background results in location A2 might be also affected by traffic emissions, since this monitoring location is nearby a main traffic road.

In general, these concentrations are consistent with the results reported as part of several ambient air quality campaigns conducted in Ain Sokhna area in the past 10 years by WorleyParsons; furthermore, these concentrations are closer to the minimum concentrations reported in the previous ambient air quality campaigns.

For example the historical data results showed that CO 1-h concentration ranged between 340 and 5,950 µg/m^{3,} whereas the reported concentrations at A1and A2 are 860 and 430 µg/m^3 respectively. Similar observation was made for PM_{10} as it ranged between 29.5 and 132 µg/m^3; whereas the reported concentration at A1 and A2 are 76 and 123 µg/m^3 respectively. Similarly, the SO_2 1- h concentrations ranged in Ain Sokhna area between 0.75 and 85.7 µg/m^3. The NO_2 1-h concentrations ranged between 2.7[2] and 61.6 µg/m^3.

[2] This value is based on Passive air sampling campaign conducted in 2003 in Ain Sokhna

4. MODEL DESCRIPTION

4.1 Introduction

AERMOD is a comprehensive multi-level air dispersion modelling system that simulates essential atmospheric physical processes and provides refined concentration estimates over a wide range of meteorological conditions and modelling scenarios (U.S. EPA, 2004). AERMOD is an integrated system that incorporates the U.S. Environmental Protection Agency (EPA) models, ISCST3, ISC-PRIME and AERMOD into one interface. It includes the modules or pre-processors AERMET and AERMAP, which can receive meteorological conditions and terrain elevation data. These parameters, when combined, allow for the calculations of atmospheric mixing conditions for plume dispersion.

AERMOD is the most widely used air quality modelling tool and the appropriate application to replace ISCST3 (US EPA Revision to the Guideline on Air Quality Models 40 CFR Part 51) since 2006.The AERMET pre-processor combines meteorological observations (e.g., wind speed, wind direction, temperature and cloud cover) with surface characteristics in the form of albedo, surface roughness and Bowen ratio. AERMET is used to calculate friction velocity, Monin-Obukhov length, convective velocity scale, temperature scale, mixing height and surface heat flux. These parameters define the status of the layer affecting plume mixing and dispersion behaviour. Terrain influences are accounted for in the AERMAP pre-processor.

AERMOD assumes the concentration distribution to be Gaussian in both vertical and horizontal directions. The concentrations of the pollutants are calculated for each hour of the year and for each receptor within the grid. The maximum values (or average values, depending on the environmental specifications) are calculated for each receptor.

4.2 Model Limitations

The following are the inherent limitations of the AERMOD air dispersion model:

- The model is based on limited meteorological information (five-year dataset) collected from the nearest meteorological stations and prepared with the prognostic model known as MM5, which uses data provided by a vast network of meteorological stations. As such, the meteorological data are not data that were collected at the specific proposed facility locations under study.
- The model assumes steady-state meteorological conditions that are invariant over the entire model space for each hour modelled, and as such, is not highly accurate in areas where significant lateral variations in meteorological conditions exist.
- The model assumes a straight-line plume. In combination with the previous limitation, the plume cannot change direction from the source to the receptors.

- AERMOD is a Gaussian model using a single meteorological station and is essentially reliable to a maximum distance of 50 km.
- The model cannot account for nor be used to model reactive pollutants (e.g., ozone).

4.3 Model Input Data

Pre-FEED Data, summarized in the References Section (*Documents provided by EPC Contractors),* has been used to the maximum extent in the definition of the model inputs. In the case of inputs for which no information was available, estimations have been made based on information available from previous similar assignments and international references such as US EPA AP-42 Emission Factors and IPCC Best Available Techniques (IPCC, 2003). References for all the parameters employed in the sources definition are provided in Appendix 3.

4.3.1 Scenarios Modelled

As described in Section 1.1, the following two (2) scenarios were modelled using AERMOD:

- **Scenario A**: Normal operation of the plant, during which 8 of the 9 cracking furnaces operate normally and 1 remains in standby.
- **Scenario B**: Decoking of one furnace while the rest of them operate normally and the standby furnace replaces the furnace that is undergoing decoking. This situation requires 36 hours to complete and will occur 6 times a year per each furnace.

The emitting sources modelled under each Scenario are listed in Table 4-1.

Table 4-1 AERMOD Modelling Cases

Scenario	Description	Duration	Sources
A	**Normal Operation**	Continuous	Nine (9) Cracking Furnaces (01-F01 to 09-F01): - 8 furnaces operating normally - 1 Liquid furnace in standby
			Two (2) Gas-Fired Heaters (F-101 and F-102, located in the HDA unit 68-Y01)
			Four (4) natural gas- fired Gas Turbines, located in the Power Plant
			Three (3) HP Steam Boilers: - 1 boiler (A) running on PGO/PFO and Fuel oil #2 - 1 Boiler (B) running on Fuel Gas from the cracker - 1 Boiler (C) running on Natural Gas
			One (1) Ship Vapor Recovery Unit (VCU) located in the Port Area

Scenario	Description	Duration	Sources
			Two (2) Flares: - Sour Gas Flare (90-F02) - LP Tank Farm Flare (91-F01)
B	**Furnace Decoking**	36 hours (6 times a year per each furnace)	Nine (9) Cracking Furnaces (01-F01 to 09-F01): - 8 furnaces operating normally - 1 furnace under decoking process
			One (1) Decoking Cyclone (15-D31)
			Two (2) Gas-Fired Heaters (F-101 and F-102, located in the HDA unit 68-Y01)
			Four (4) natural gas- fired Gas Turbines, located in the Power Plant
			Three (3) HP Steam Boilers: - 1 boiler (A) running on PGO/PFO and Fuel oil #2 - 1 Boiler (B) running on Fuel Gas from the cracker - 1 Boiler (C) running on Natural Gas
			One (1) Ship Vapor Recovery Unit (VCU) located in the Port Area
			Two (2) Flares: - Sour Gas Flare (90-F02) - LP Tank Farm Flare (91-F01)

4.3.2 Source Parameter Data

Nineteen (19) point sources were modelled with AERMOD under Scenario A, and twenty (20) were modelled under Scenario B. These sources comprise nine (9) cracking furnaces (01-F01 to 09-F01), two (2) gas-fired heaters (F-101 and F-102), four (4) natural gas-fired gas turbines, three (3) HP Steam Boilers, one (1) Ship VCU and, in the case of Scenario B, one (1) decoking cyclone (15-D31). The parameters used as inputs in the AERMOD model for the point sources are listed below in Table 4-2.

Table 4-2 Source Parameter Data for the Point Sources

Source	Coordinates (WGS84)		Height (m)	Diameter (m)	Velocity (m/s)	Temp (K)
	X	Y				
Cracking Furnace 1 (01-F01)	428600.58	3284617.67	50	2.8	23	973
Cracking Furnace 2 (02-F01)	428608.31	3284633.53	50	2.8	23	973
Cracking Furnace 3 (03-F01)	428617.05	3284649.41	50	2.8	23	973
Cracking Furnace 4 (04-F01)	428628.68	3284670.62	50	2.8	23	973

Source	Coordinates (WGS84)		Height (m)	Diameter (m)	Velocity (m/s)	Temp (K)
	X	Y				
Cracking Furnace 5 (05-F01)	428637.68	3284686.13	50	2.8	23	973
Cracking Furnace 6 (06-F01)	428645.68	3284702.10	50	2.8	23	973
Cracking Furnace 7 (07-F01)	428657.33	3284723.56	50	2.8	23	973
Cracking Furnace 8 (08-F01)	428666.02	3284739.46	50	2.8	23	973
Cracking Furnace 9 (09-F01)	428676.05	3284753.01	50	2.8	5.15 (1) 6.43 (2)	973
Decoking Cyclone (15-D31)	428609.87	3284667.03	50	1.0	73	973
Gas Turbine 1 (Natural Gas)	428963.63	3283988.42	30.48	3.16	10.00	456
Gas Turbine 2 (Natural Gas)	428987.25	3283974.92	30.48	3.16	10.00	456
Gas Turbine 3 (Natural Gas)	429010.87	3283961.42	30.48	3.16	10.00	456
Gas Turbine 4 (Natural Gas)	429034.36	3283947.79	30.48	3.16	10.00	456
Heater 1 (F-101)	428947.42	3284396.93	15	1.2	16.48	523
Heater 2 (F-102)	428994.93	3284484.19	15	0.4	14.62	523
HP Steam Boiler A (PGO/PFO)	428899.35	3284079.67	40	4.7	15	458
HP Steam Boiler B (Fuel Gas)	428873.27	3284094.42	40	4.7	15	458
HP Steam Boiler C (Natural Gas)	428847.00	3284109.00	40	4.7	15	458
Ship (VCU)	438562.00	3284132.00	18.3	1.5	20	298

(1) Velocity in standby

(2) Velocity during decoking operation

Additionally, two (2) flares were modelled with AERMOD: the Sour Gas Flare (90-F02); and the LP Tank Farm Flare (91-F01). AERMOD software does not explicitly handle flares; therefore, recommended air modelling equations based on several international references (British Columbia 2008, Idriss and Spurrel 2009, US EPA 1995) were applied to convert the flare sources to point sources (typical stack) by calculating the equivalent stack diameters and heights. Following this procedure, the parameters used as input in AERMOD to model the flares as point sources are listed below in Table 4-3.

Table 4-3 Effective Parameter Data for the Flare Sources

Source	Coordinates (WGS84)		Heat Release (cal/s)	Adjusted Height (m)	Equivalent Diameter (m)
	X (E)	Y (N)			
Sour Gas Flare (90-F02)	428300.72	3284966.17	3.46E6	51.09	1.23
LP Tank Farm Flare (91-F01)	429427.27	3284435.48	1.33E6	83.85	0.76

4.3.3 COPC Emission Rates

Emission rates from the cracking furnaces, heaters, decoking cyclone and the Ship VCU were calculated based on exhaust gas compositions as per the Pre-FEED data. In the case of the Power Plant Gas Turbines and the HP Steam Boilers, emission factors from the US EPA AP-42 Guideline were employed (*Section 3.1: Stationary Gas Turbines, Section 1.3: Fuel Oil Combustion* and *Section 1.4: Natural Gas Combustion*). For the Flares, the emission factors provided in Section 13.5 of the US EPA AP-42 Guideline (*Industrial Flares*) were used for those COPC for which no exhaust composition data was available at this stage of the project. COPC emission rates that were used for each scenario are listed in Table 4-4.

Table 4-4 COPC Emission Rates for Sources Modelled by AERMOD under Each Scenario

	Emission Rates (g/s)				
Scenario A (Normal Operation)	**NO_x**	**CO**	**SO_2**	**PM_{10}**	**Benzene**
Cracking Furnaces in Normal Operation (x8) [(1)]	4.77	1.99	--	0.20	--
Cracking Furnace in Standby	2.67	0.44	--	0.04	--
Heater F-101	2.92	2.43	4.86	0.49	--
Heater F-102	0.29	0.24	0.48	0.05	--
Gas Turbines (x4) [(1)]	1.39	0.32	--	0.19	--
HP Steam Boiler A (PGO/PFO)	10.5	1.12	8.79	1.24	--
HP Steam Boiler B (Fuel Gas)	4.37	1.93	0.01	0.17	--
HP Steam Boiler C (Natural Gas)	6.18	2.73	0.02	0.25	--
Ship Vapor Recovery Unit (VCU)	--	--	--	--	0.002
Sour Gas Flare 90-F02	0.42	0.36	0.93	--	0.27
LP Tank Farm Flare 91-F01	0.16	0.88	--	--	--
Scenario B (Furnace Decoking)	**NO_x**	**CO**	**SO_2**	**PM_{10}**	**Benzene**
Cracking Furnaces in Normal Operation (x8) [(1)]	4.77	1.99	--	0.20	--
Cracking Furnace in Decoking	3.33	0.56	--	0.06	--
Decoking Cyclone 15-D31	--	56.88	--	0.81	--
Heater F-101	2.92	2.43	4.86	0.49	--
Heater F-102	0.29	0.24	0.48	0.05	--
Gas Turbines (x4) [(1)]	1.39	0.32	--	0.19	--
HP Steam Boiler A (PGO/PFO)	10.5	1.12	8.79	1.24	--
HP Steam Boiler B (Fuel Gas)	4.37	1.93	0.01	0.17	--
HP Steam Boiler C (Natural Gas)	6.18	2.73	0.02	0.25	--

Ship Vapor Recovery Unit (VCU)	--	--	--	--	0.002
Sour Gas Flare 90-F02	0.42	0.36	0.93	--	0.27
LP Tank Farm Flare 91-F01	0.16	0.88	--	--	--

(1) Emission rates represent emissions from each individual unit

4.4 Meteorological Data

A meteorological file was prepared with the MM5 prognostic model, which uses data provided by the National Centres for Environmental Prediction (NCEP) Global Reanalysis. The MM5 model is supported by several auxiliary programs referred to collectively as the MM5 modelling system. MM5 is designed to simulate or predict mesoscale (from 5 to 100 km) atmospheric circulation.

Since MM5 is a regional model, it requires an initial condition as well as lateral boundary conditions to run. Obtaining meteorological data for a specific location requires that meteorological records from as many surface meteorological stations as possible are considered, and a large model run is required to set the boundary conditions.

The meteorological file is the complete series of hourly values of surface observations and upper soundings recorded during the period 2009 – 2013 for the study area. According to the US EPA, five years of representative meteorological data should be used when estimating concentrations with an air quality model (US EPA Revision to the Guideline on Air Quality Models 40 CFR Part 51).

The surface dataset includes wind speed, wind direction, dry bulb temperature, cloud cover, and ceiling height. Upper soundings include wind speed, dew point, atmospheric pressure and measurement height. The windrose of the meteorological data for the period 2009 – 2013, with the main wind direction from the West, is shown in Figure 4-1.

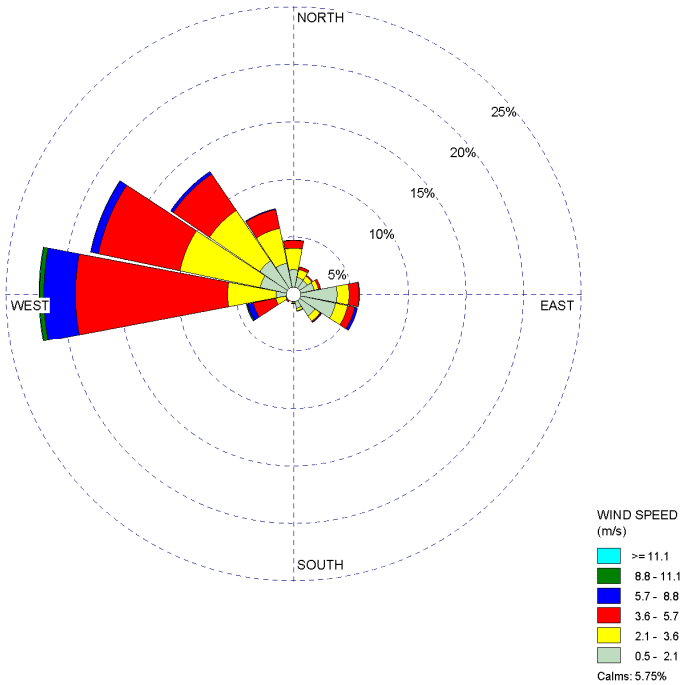

Figure 4-1 MM5 Pre-processed Data Windrose (wind blowing from) for the Project Area, 2009 – 2013

Surface observations, upper soundings and land use parameters (albedo, Bowen ratio and surface roughness) were used as input data in the meteorological pre-processor AERMET to calculate the boundary layer parameters, which include friction velocity, Monin-Obukhov length, convective velocity scale, temperature scale, mixing height and surface heat flux. Based on these output parameters, the behaviour of the plume was estimated. The output of the AERMET pre-processor comprised two files that were used as inputs into the AERMOD air dispersion model.

4.5 Grid of Receptors

A uniform Cartesian grid of 40 x 40 km of 6,561 receptors (81 x 81 receptors, with a spacing of 500 m) was used to cover the study area. In addition, a second nested and finer Cartesian grid of 4 x 4 km and 1,681 receptors (41 x 41 receptors with a spacing of 100 m) was used to better characterize the predicted COPC dispersion in the area close to the emitting sources. The ambient air monitoring stations (A1 and A2) and three locations representing potentially populated and working areas in the vicinity of the proposed Complex, the DP Sokhna Port and two tourist villages located on the coast east of the Main Plant (R1, R2 and R3, respectively shown in Figure 5-1), were incorporated as discrete receptors to estimate the predicted COPC concentrations at these locations.

4.6 Topography

Due to the presence of terrain elevations up to 500 – 600 m above sea level toward the northwest and south of the Main Plant area, elevated terrain was used in the model. The AERMAP pre-processor was used to account for terrain features, using SRTM3 terrain data of the area.

5. RESULTS

The maximum COPC ground concentrations that were predicted using AERMOD under Scenario A and Scenario B are presented in Section 5.1 and Section 5.2, respectively. The COPC ground concentrations were modelled for the following:

- The entire study area domain of 40 km x 40 km
- Three discrete receptors located in the more potentially populated and working zones of the area: the DP Sokhna Port (R1) located southeast of the Main Plant; and the two tourist villages (R2and R3) located on the coast east of the Main Plant. These locations are shown in Figure 5-1.

Figure 5-1 Discrete Receptors for AERMOD Study: R1, R2 and R3

Additionally, the predicted and cumulative ground concentrations of COPC at the Ambient Air Measurement Station (A1, described in Section 3) are presented in Section 5.3.

5.1 Air Quality under Normal Operation (Scenario A)

Air dispersion calculations completed using AERMOD were used to estimate the concentrations of pollutants that will be emitted during normal operations from the proposed Tahrir Petrochemicals Complex. The highest predicted ground level concentrations of NO_x, CO, SO_2, PM_{10} and benzene, are listed below in Table 5-1 with the applicable national and international air quality standards for comparison. Graphical representations of the highest predicted COPC concentrations, as modelled using AERMOD, are provided in Appendix 1.

Table 5-1 Maximum Predicted COPC Concentrations in the Study Area during Normal Operations and Air Quality Standards

COPC	Average Period	Max. Predicted COPC Concentration in the Study Area (µg/m³)	Air Quality Standards (µg/m³)		
			Egyptian Decree No. 710/2012	IFC Air Quality Guidelines	EU Directive EC/50/2008
NO_2(1)	1-hr	164.19	300	200	200
	24-hr	26.45	150	--	--
	Annual	7.56	80	40	40
CO	1-hr	77.19	30,000	30,000(2)	--
	8-hr	45.97	10,000	10,000(2)	10,000
SO_2	1-hr	38.33	350	--	350
	24-hr	11.69	150	125(3)	125
	Annual	2.34	60	--	--
PM_{10}	24-hr	2.3	150	150(3)	50
	Annual	0.63	70	70(3)	40
Benzene	Annual	0.1	--	--	5

(1) Values presented in the Table indicate the estimated NO_2 ground concentration using the NO_2/NO_x ratio of 75% established by US EPA Appendix W of 40 CFR Part 51 (EPA, 2005). The NO_x concentrations predicted by AERMOD for 1-hr, 24-hr and annual are 218.92, 35.26 and 10.08 µg/m³, respectively

(2) These standards are not included in the WHO Air Quality Guidelines Global Update 2005 but can be found in the WHO Air Quality Guidelines for Europe (WHO, 2000).

(3) Interim Target 1 (IT-1) represents the least stringent allowable limit, World Health Organisation Air Quality Guidelines (2005).

Nitrogen oxides (NO_x) concentrations that were modelled using AERMOD cannot be directly compared with the air quality limits specified in Table 2-1 and in Table 5-1. The reason is that these limits are stated for NO_2 (not NO or NO_x). According to the Tier 2 screening analysis presented in US EPA Appendix W of 40 CFR Part 51, a NO_2/NO_x conversion ratio of 75% should be used to convert total NO_x to NO_2. The NO_2 predicted ground concentrations presented in Table 5-1 have been calculated using this 75% factor to the maximum predicted NO_x ground concentrations. Results in Table 5-1 show that compliance with the ambient air standards are obtained (218.92 µg/m³ of NO_x x 0.75 = 164.19 µg/m³ of NO_2).

It must be noticed that all the maximum 1-hour average predicted values presented in Table 5-1 are encountered in a mountainous location located at approximately 6 km north-west from the Main Plant area, as shown in the air dispersion maps included in Appendix 1. Neither residents nor other sensitive receptors are located in this area.

The reason for the maximum 1-hr concentrations to be found in a location north-west of the plant while the wind rose shows prevailing wind directions from the west is related with terrain elevations. Terrain elevation has a significant influence in the maximum ground concentration values predicted by AERMOD, as in elevated receptors the pollutant plume has a narrower distance to reach the receptor, compared to a receptor in flat terrain, and so the COPC in the plume suffers lower dispersion and the predicted concentration in that elevated receptor will be generally higher. For that reason, even if the wind blows to the mountainous region in the north-west only a few hours along the year, the maximum 1-hr concentrations will be encountered in that region due to the effect of the elevated terrain.

For the rest of COPC, results in Table 5-1 indicate that the maximum predicted ground concentrations during normal operations will be below the limits specified by Egyptian National Air Quality Standards and by international guidelines.

The maximum COPC ground concentrations predicted at the discrete receptors R1, R2 and R3 (the potentially working and populated areas locations of the Ain DP Sokhna Port and two tourist villages shown in Figure 5-1) are presented in Table 5-2.

Table 5-2 Maximum Predicted COPC Concentrations at R1, R2 and R3 during Normal Operations and Air Quality Standards

COPC	Av. Period	Max. Predicted COPC Ground Concentration (µg/m³)			Air Quality Standards (µg/m³)		
		R1	R2	R3	Egyptian Decree No. 710/2012	IFC Air Quality Guidelines	EU Directive EC/50/2008
NO_x (1)	1-hr	18.97	22.37	12.42	300	200	200
	24-hr	2.00	2.75	2.42	150	--	--
	Annual	0.59	0.79	0.33	80	40	40
CO	1-hr	11.18	12.6	6.98	30,000	30,000 (2)	--
	8-hr	2.84	2.92	2.3	10,000	10,000 (2)	10,000
SO_2	1-hr	4.4	5.15	2.72	350	--	350
	24-hr	0.5	0.68	0.47	150	125 (3)	125
	Annual	0.15	0.19	0.07	60	--	--
PM_{10}	24-hr	0.19	0.26	0.19	150	150 (3)	50
	Annual	0.05	0.07	0.03	70	70 (3)	40
Benzene	Annual	3.9×10^{-3}	5.7×10^{-3}	2.8×10^{-3}	--	--	5

(1) Values presented in the table indicate the estimated NO_2 ground concentration using the NO_2/NO_x ratio of 75% established by US EPA Appendix W of 40 CFR Part 51 (EPA, 2005). The maximum NO_x concentrations predicted by AERMOD for 1-hr, 24-hr and annual are 25.29, 2.66 and 0.79 µg/m³, respectively at R1. At R2 the NO_x concentrations for 1-hr, 24-hr and annual are 29.83, 3.67 and 1.05 µg/m³, respectively. At R3 the NO_x concentrations for 1-hr, 24-hr and annual are 16.56, 3.23 and 0.44 µg/m³, respectively.

(2) These standards are not included in the WHO Air Quality Guidelines Global Update 2005 but can be found in the WHO Air Quality Guidelines for Europe (WHO, 2000).

(3) Interim Target 1 (IT-1) represents the least stringent allowable limit, World Health Organisation Air Quality Guidelines (2005).

These results of the modelled emission under normal operations indicate that the COPC concentrations predicted at the DP Sokhna Port and at the two tourist villages located southeast and northeast of the Main Plant will be lower than 15% of the applicable national and international ambient air limits.

5.2 Air Quality under Furnace Decoking Operation (Scenario B)

Air dispersion calculations completed with AERMOD were used to estimate the concentrations of pollutants that will be emitted during the decoking operation of the cracking furnaces at the proposed Complex. The highest predicted ground level concentrations of NO_x, CO, and PM_{10} are listed below in Table 5-3 with the applicable national and international air quality standards for comparison. Due to the short duration of the furnace decoking, only 1-hour, 8-hour and 24-hour average periods were modelled. SO_2 and benzene were not modelled under Scenario B, as the emissions of these COPC will remain unchanged and equivalent to those under normal operations. Graphical representations of the highest predicted COPC concentrations, as modelled using AERMOD, are provided in Appendix 2.

Table 5-3 Maximum COPC Ground Concentrations in the Study Area during Furnace Decoking and Air Quality Standards

COPC	Average Period	Max. Predicted COPC Ground Concentration (µg/m³)	Air Quality Standards (µg/m³)		
			Egyptian Decree No. 710/2012	IFC Air Quality Guidelines	EU Directive EC/50/2008
NO_x (1)	1-hr	168.11	300	200	200
	24-hr	26.45	150	--	--
CO	1-hr	484.58	30,000	30,000 (2)	--
	8-hr	149.11	10,000	10,000 (2)	10,000
PM_{10}	24-hr	2.3	150	150 (3)	50

(1) Values presented in the table indicate the estimated NO_2 ground concentration using the NO_2/NO_x ratio of 75% established by US EPA Appendix W of 40 CFR Part 51 (EPA, 2005). The maximum NO_x concentrations predicted by AERMOD for 1-hr and 24-hr are 224.14 and 35.26 µg/m³, respectively.

(2) This standard is not included in the WHO Air Quality Guidelines Global Update 2005 but can be found in the WHO Air Quality Guidelines for Europe (WHO, 2000).

(3) Interim Target 1 (IT-1) represents the least stringent allowable limit, World Health Organisation Air Quality Guidelines (2005).

As in the results shown in Section 5.1, prior to comparison with the limits specified by Egyptian National Air Quality Standards and by international guidelines, maximum NO_x ground concentrations predicted by AERMOD were converted to maximum NO_2 ground concentrations by using the 75% factor recommended by the US EPA. The maximum predicted 1-hour NO_2 ground concentration (224.14 µg/m³ of NO_x x 0.75 = 168.11 µg/m³ of NO_2) will be below the limits established by national and international guidelines.

Although the furnace decoking operations are expected to require 36 hours each time they are conducted, these operations under Scenario B were modelled continuously using AERMOD. Therefore, the maximum predicted values listed in Table 5-3 represent the worst conditions in the 5-year modelling period and are very unlikely to occur, though technically possible during a furnace decoking operation. Therefore, the actual 1-hour, 8-hour and 24-hour average concentrations of these COPC may be expected to be lower than those listed in Table 5-3.

As discussed in the results in Section 5.1, the maximum COPC 1-hour average concentrations predicted by AERMOD are encountered in the mountainous region located north-west from the Plant location, as shown in the air dispersion maps included in Appendix 2. As also stated in Section 5.1, neither residents nor other sensitive receptors are located in this area.

The maximum COPC ground concentrations predicted at the discrete receptors R1, R2 and R3 (DP Sokhna Port and two tourist villages shown in Figure 5-1) are presented in Table 5-4.

Table 5-4 Maximum Predicted COPC Concentrations at R1, R2 and R3 during Furnace Decoking and Air Quality Standards

COPC	Average Period	Max. Predicted COPC Ground Concentration (µg/m³)			Air Quality Standards (µg/m³)		
		R1	R2	R3	Egyptian Decree No. 710/2012	IFC Air Quality Guidelines	EU Directive EC/50/2008
NO_x (1)	1-hr	19.12	22.55	12.53	300	200	200
	24-hr	2.00	2.77	2.45	150	--	--
CO	1-hr	35.94	38.24	23.86	30,000	30,000 (2)	--
	8-hr	9.08	11.13	8.75	10,000	10,000 (2)	10,000
PM_{10}	24-hr	0.22	0.31	0.24	150	150 (3)	50

(1) Values presented in the table indicate the estimated NO_2 ground concentration using the NO_2/NO_x ratio of 75% established by US EPA Appendix W of 40 CFR Part 51 (EPA, 2005). The maximum NO_x concentrations predicted by AERMOD for 1-hr and 24-hr are 25.49 and 2.67 µg/m³, respectively at R1. At R2 the predicted NO_x concentrations for 1-hr and 24-hr are 30.07 and 3.69 µg/m³, respectively. At R3 predicted NO_x concentrations for 1-hr and 24-hr are 16.71 and 3.27 µg/m³, respectively.

(2) This standard is not included in the WHO Air Quality Guidelines Global Update 2005 but can be found in the WHO Air Quality Guidelines for Europe (WHO, 2000)

(3) Interim Target 1 (IT-1) represents the least stringent allowable limit, World Health Organisation Air Quality Guidelines (2005)

These results of the modelled emission under decoking operations indicate that the COPC concentrations predicted at the DP Sokhna Port and at the two tourist villages located southeast and northeast of the Main Plant will be significantly lower than the maximum values predicted for the entire study area and well below the national and international limits.

5.3 Cumulative Concentrations

The cumulative impact from the proposed Complex on the local air quality has been estimated by adding the background COPC levels measured at the ambient air sampling locations A1and A2 during the two different 24-hour periods to the maximum COPC concentrations predicted by AERMOD at the same locations under each of the two Scenarios modelled. The cumulative concentrations for NO_x, CO, SO_2 and PM_{10} at the A1 and A2 locations for 1-hour, 8-hour and 24-hour time periods are listed in Table 5-5 and Table 5-6.

Table 5-5 Cumulative COPC Concentrations at the Ambient Air Sampling Location (A1) under Normal Operation and Furnace Decoking

COPC	Average Period	Concentration (µg/m³)	Scenario A	Scenario B
NO_2	1-hour	Modelled (Max)	28.79	29.07
		Background	7.43	
		Cumulative	**36.22**	**36.5**
		Standard	**300 (1) / 200 (2)**	
	24-hour	Modelled (Max)	6.20	6.22
		Background	3.66	
		Cumulative	**9.86**	**9.88**
		Standard	**150 (1) (2)**	
CO	1-hour	Modelled (Max)	16.81	57.64
		Background	860	
		Cumulative	**876.81**	**917.64**
		Standard	**30,000 (1)**	
	8-hour	Modelled (Max)	5.73	15.79
		Background	200	
		Cumulative	**205.73**	**215.79**
		Standard	**10,000 (1)**	
SO_2	1-hour	Modelled (Max)	6.85 (5)	
		Background	0.9	

COPC	Average Period	Concentration (µg/m³)	Scenario A	Scenario B
		Cumulative	**7.75** (5)	
		Standard	**350** (1)	
	24-hour	Modelled (Max)	1.69 (5)	
		Background	0.71	
		Cumulative	**2.4** (5)	
		Standard	**150** (1) / **125** (2)	
PM_{10}	24-hour	Modelled (Max)	0.67	0.72
		Background	76	
		Cumulative	**76.67**	**76.72**
		Standard	**150** (1) (2)	

(1) Egyptian Standard (D710/2012)
(2) WHO Air Quality Global Standard (2005)
(3) European Directive EC/50/2008 (EU, 2008)
(4) WHO Air Quality Standard for Europe (2000)
(5) SO_2 emissions are expected to be the same under Scenario A and Scenario B

Table 5-6 Cumulative COPC Concentrations at the Ambient Air Sampling Location (A2) under Normal Operation and Furnace Decoking

COPC	Average Period	Concentration (µg/m³)	Scenario A	Scenario B
NO_2	1-hour	Modelled (Max)	19.07	19.21
		Background	24.61	
		Cumulative	**43.68**	**43.82**
		Standard	**300** (1) / **200** (2)	
	24-hour	Modelled (Max)	2.90	2.92
		Background	9.75	
		Cumulative	**12.65**	**12.67**
		Standard	**150** (1) (2)	
CO	1-hour	Modelled (Max)	10.21	32.51
		Background	430	
		Cumulative	**440.21**	**462.51**
		Standard	**30,000** (1)	
	8-hour	Modelled (Max)	3.25	11.16
		Background	290	
		Cumulative	**293.25**	**301.16**
		Standard	**10,000** (1)	
SO_2	1-hour	Modelled (Max)	4.45 (5)	

COPC	Average Period	Concentration (µg/m³)	Scenario A	Scenario B
		Background	2.22	
		Cumulative	**6.67**	
		Standard	**350** (1)	
	24-hour	Modelled (Max)	0.71 (5)	
		Background	1.13	
		Cumulative	**1.84**	
		Standard	**150** (1) / **125** (2)	
PM_{10}	24-hour	Modelled (Max)	0.27	0.32
		Background	123	
		Cumulative	**123.27**	**123.32**
		Standard	**150** (1) (2)	

1) Egyptian Standard (D710/2012)
(2) WHO Air Quality Global Standard (2005)
(3) European Directive EC/50/2008 (EU, 2008)
(4) WHO Air Quality Standard for Europe (2000)
(5) SO_2 emissions are expected to be the same under Scenario A and Scenario B

Apart from the PM_{10} concentrations, the considerations for which were discussed in Section 3, the cumulative concentrations that are predicted during normal cracking operation of the Plant (Scenario A) and during furnace decoking operation (Scenario B), as listed in Table 5-5 and Table 5-6, are anticipated to be in compliance with the air quality standards. Even in the case of PM_{10}, the contribution from the Plant to the overall concentration will be almost negligible (less than 1% contribution to the existing background concentration).

6. CONCLUSIONS

The results presented in this study are mainly based on the pre-FEED design data (summarized in the References Section: *Documents provided by EPC Contractors*). In case of the non-availability of input data, the input parameters were estimated based on WorleyParsons previous experience with similar projects (summarized in Appendix 3). Any later modification in the data presented in this study would require remodelling, since the results here presented would be modified.

6.1 Background Air Quality

Measurements recorded at the ambient air sampling sites A1 and A2 during 13-14 August and 12-13 November 2014 indicate that the background levels of NO_x, CO, SO_2 are below the limits set by the national and international air quality standards. In the case of PM_{10}, the measured value was above the European Union Standard only and complying with the national and IFC limits. It should be noted that the background measurements were carried out in a desert location where the natural production of PM_{10} concentrations is high (desert dust); therefore, It is not necessarily an indication of poor air quality in the area.

6.2 Air Quality Predictions

6.2.1 Normal Operation (Scenario A)

The maximum NO_2, CO, SO_2, PM_{10} and benzene contributions to the background during the normal operations of the proposed Complex are in compliance with the limits set by the national and international regulations.

6.2.2 Furnace Decoking Operation (Scenario B)

COPC contributions to the ambient air from the proposed Complex during the non-continuous furnace decoking operations are predicted to be below the national and international ambient air quality standards.

6.2.3 General Conclusions about the Predictions

Under either Scenario A and in Scenario B, the 1-hour average COPC concentrations modelled across the entire study area (40 km x 40 km) are predicted to reach a maximum in a mountainous zone located approximately 6 km northwest of the Main Plant where there are no residents or sensitive receptors. Furthermore, these concentrations are below the allowable national and international applicable limits.

In general, the results under normal and decoking operations indicate that the COPC concentrations predicted at DP Sokhna Port and at the two tourist villages located southeast

and northeast of the Main Plant will be lower than 15% of the applicable national and international ambient air limits.

6.3 Cumulative Impacts

The ambient air quality results reported during the two 24-hour baseline monitoring campaigns are consistent with the historical data recorded by WorleyParsons in Ain Sokhna area as detailed in Section 3. The cumulative impacts, calculated as the addition of maximum predicted contributions from the proposed Complex to the measured background levels in the sampling locations A1 and A2, do not exceed national and international limits. It is worth noting that for PM_{10} cumulative concentration, the contribution of the proposed Complex emissions to the total ambient air concentration is lower than 1%.

Based on the Air Dispersion Model results, the proposed Tahrir Petrochemicals emission are complying with the national and International limits presented in the report, however should the model input parameters Change in the detailed engineering phase, a model rerun would be required to assure the as built design compliance before commissioning & Start-up.

7. REFERENCES

External References

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WHO. Air Quality Guidelines for Europe. 2000

WHO. Air Quality Guidelines Global Update 2005.

Documents provided by EPC Contractors

1.Layouts

GENERAL PLOT PLAN (OPTION "C" McDERMOTT): 3816-XX-DG-200-02 (Revision 02)

GENERAL PLOT PLAN OF MAIN PLANT (CRACKING-PE-U&O) (OPTION "C" McDERMOTT): 3816-XX-DG-201-01 (Revision 01)

GENERAL PLOT PLAN OF PORT AREA (STORAGE-DESAL-JETTY) (OPTION "C" McMcDERMOTT): 3816-XX-DG-202-01 (Revision 01)

2. Source Parameters

"&AA S-LU 1001 List of Emissions, Waste Water Flows and Wastes from Cracker Plant including Derivative-Units, Intermediate Tank Farm and PE Flare"

"Suez_Flare Emissions_Additional Data_rev 1_31.07.14"

"TAHRIR PETROCHEMICALS - Base Load Heat and Mass Balance Rev 2 (July 18 2014)" (and subsequent clarifications)

"GT_Stack_Dimensions"

Appendix 1 - AERMOD Predicted COPC Contours under Normal Cracking Operation (Scenario A)

LIST OF FIGURES

1. SCENARIO A

1.1 NO_x

1.1.1 1-hour average
1.1.2 24-hour average
1.1.3 Annual average

1.2 CO

1.2.1 1-hour average
1.2.2 8-hour average

1.3 SO_2

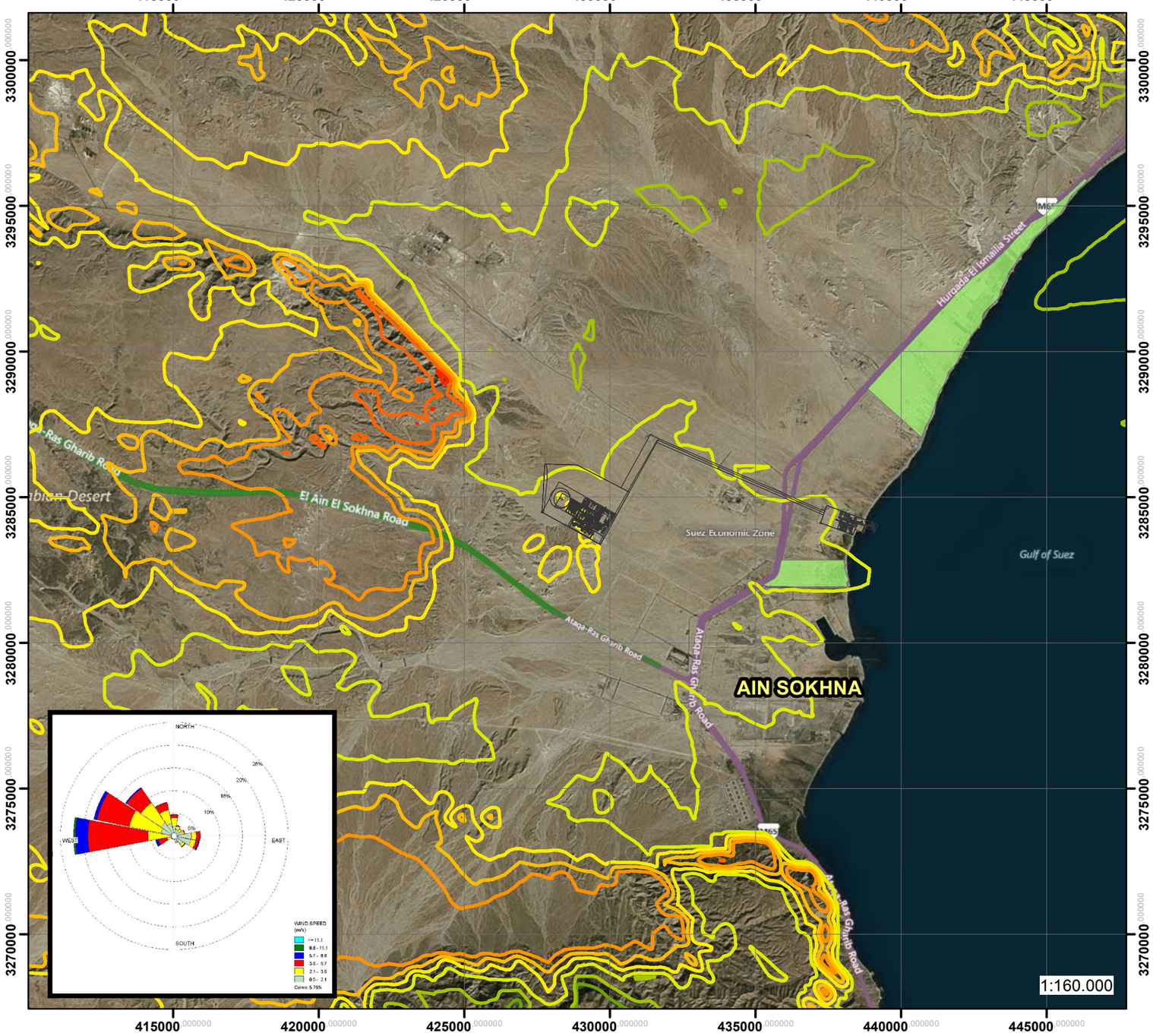
1.3.1 1-hour average
1.3.2 24-hour average
1.3.3 Annual average

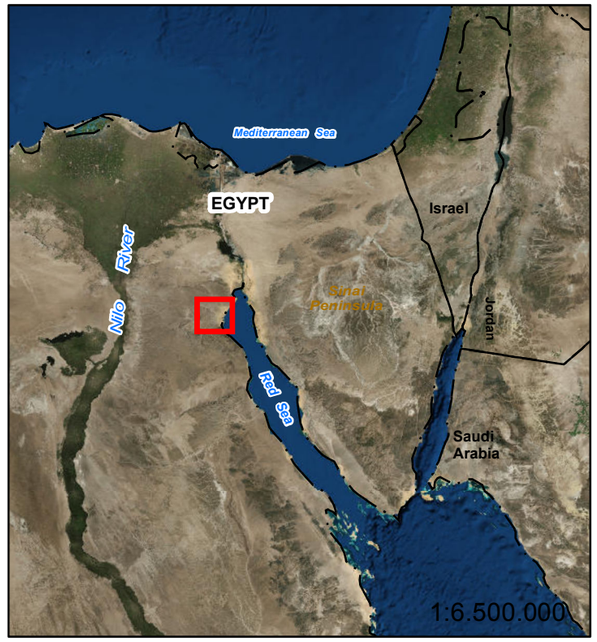
1.4 PM_{10}

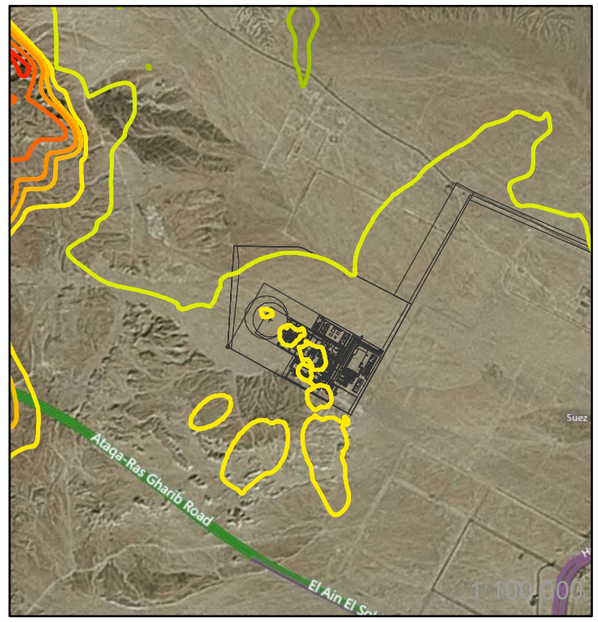
1.4.1 24-hour average
1.4.2 Annual average

1.5 Benzene

1.5.1 Annual average







N

Legend

NOx 1 hour

- 2.5 ug/m3
- 5 ug/m3
- 7.5 ug/m3
- 10 ug/m3
- 25 ug/m3
- 50 ug/m3
- 75 ug/m3
- 100 ug/m3
- 150 ug/m3
- 200 ug/m3
- Touristic Village

Maximum Predicted Concentration = 218.92 ug/m3 (164.2 ug/m3 of NO2)
Egyptian Air Quality Standard (for NO2) = 300 ug/m3
WHO Air Quality Standard (for NO2) = 200 ug/m3
EU Directive EC/50/2008 (for NO2) = 200 ug/m3

Project Nº: 60109-01
Tahrir Petrochemicals Complex Air Model

TAHRIR PETROCHEMICALS CORPORATION

AERMOD
Scenario A
Maximum Predicted Concentration
NOx 1 hour

WorleyParsons Consulting

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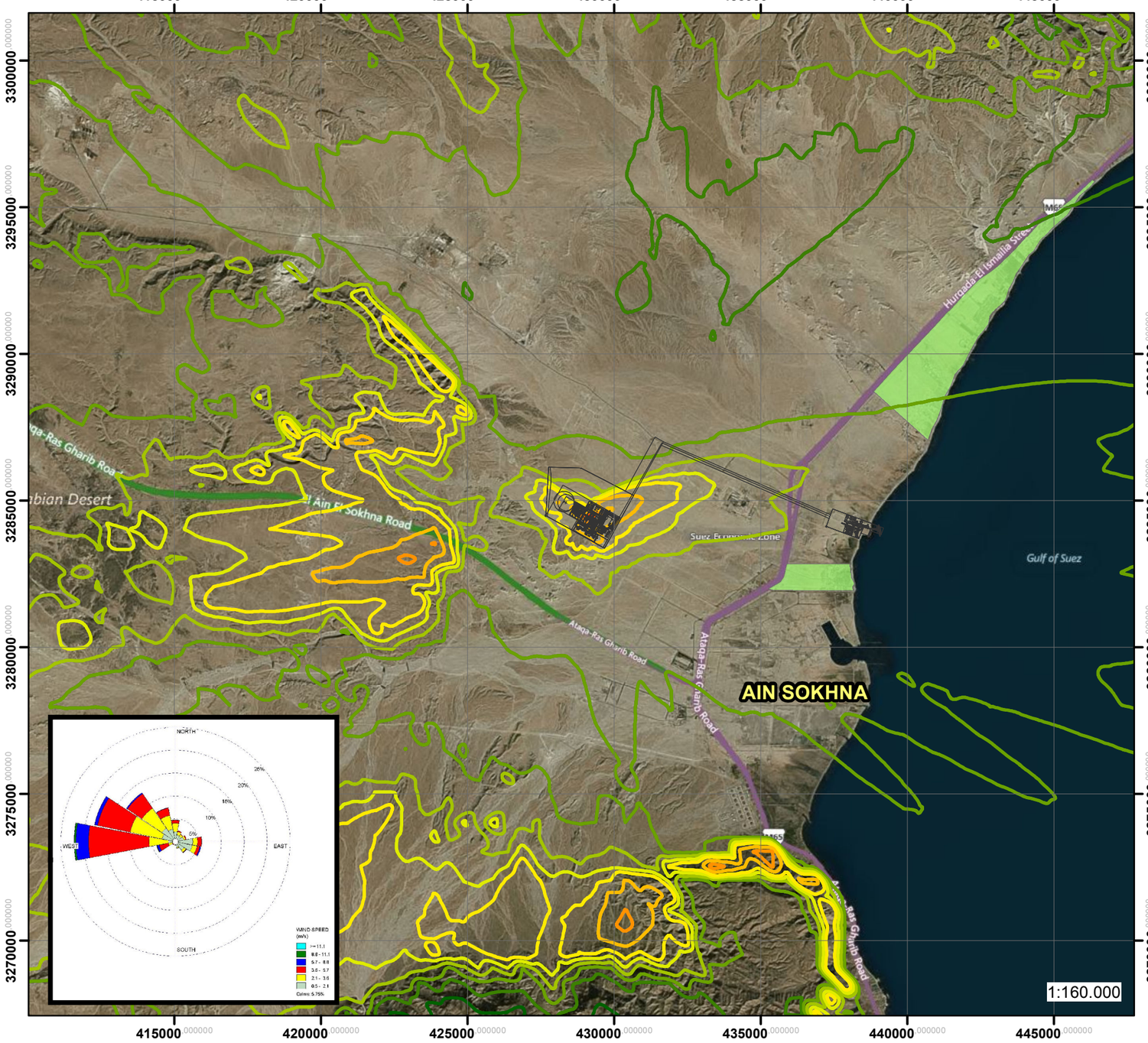

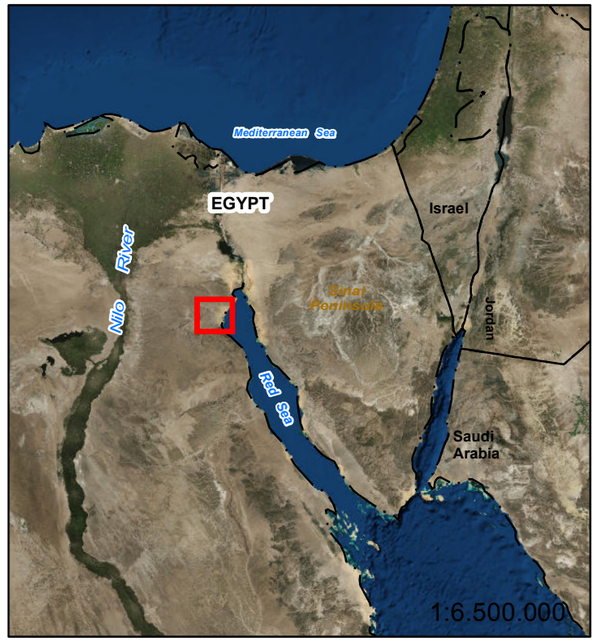

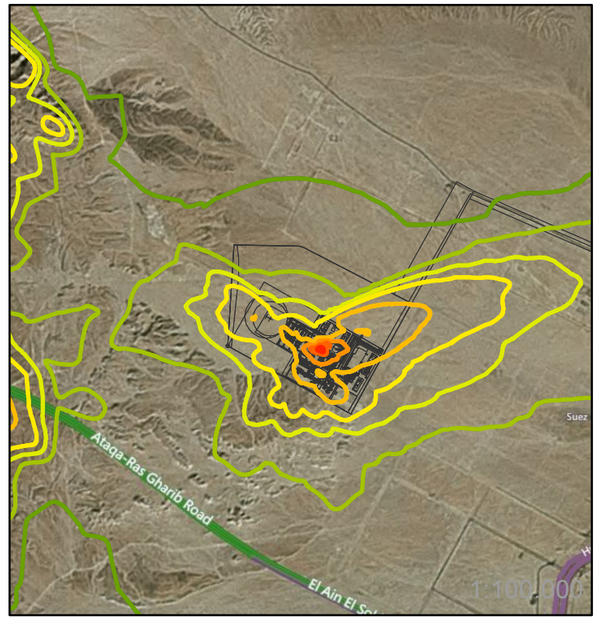

N

Legend

NOx 24 hours

- 0.5 ug/m3
- 1 ug/m3
- 2.5 ug/m3
- 5 ug/m3
- 7.5 ug/m3
- 10 ug/m3
- 15 ug/m3
- 20 ug/m3
- 25 ug/m3
- 30 ug/m3
- Touristic Village

Maximum Predicted Concentration = 35.26 ug/m3 (26.45 ug/m3 of NO2)
Egyptian Air Quality Standard (for NO2) = 150 ug/m3

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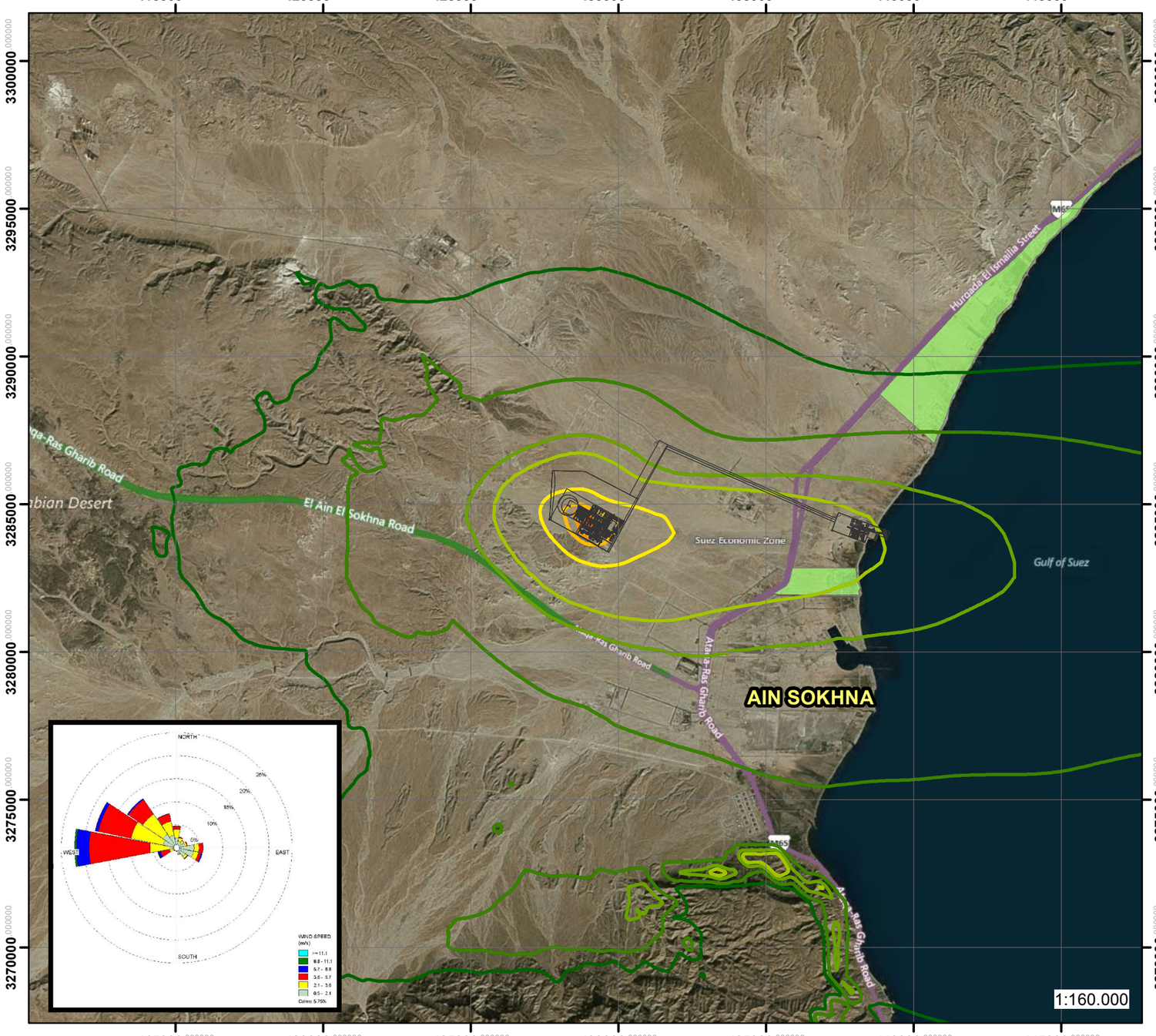

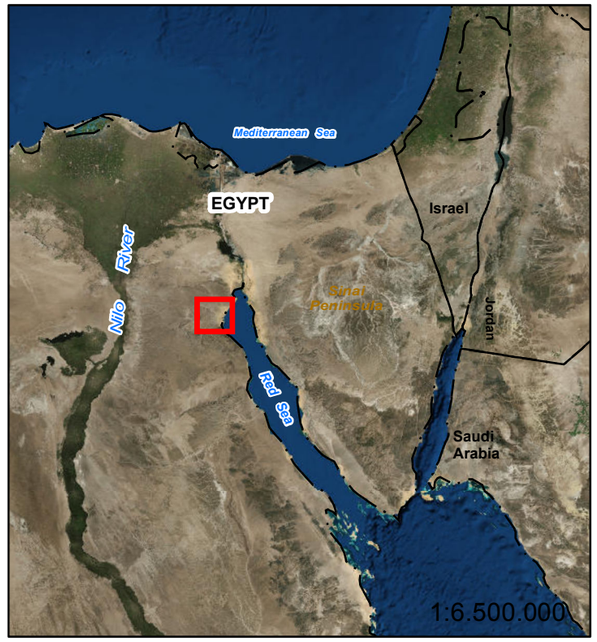

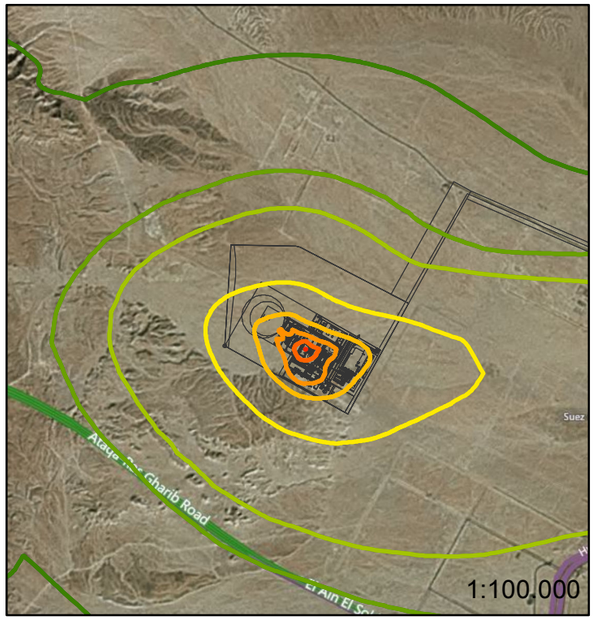

N

Legend

NOx Annual

- 0.3 ug/m3
- 0.5 ug/m3
- 0.8 ug/m3
- 1 ug/m3
- 2 ug/m3
- 4 ug/m3
- 6 ug/m3
- 8 ug/m3
- 10 ug/m3
- Touristic Village

Maximum Predicted Concentration = 10.08 ug/m3 (7.56 ug/m3 of NO2)
Egyptian Air Quality Standard (for NO2) = 80 ug/m3
WHO Air Quality Standard (for NO2) = 40 ug/m3
EU Directive EC/50/2008 (for NO2) = 40 ug/m3

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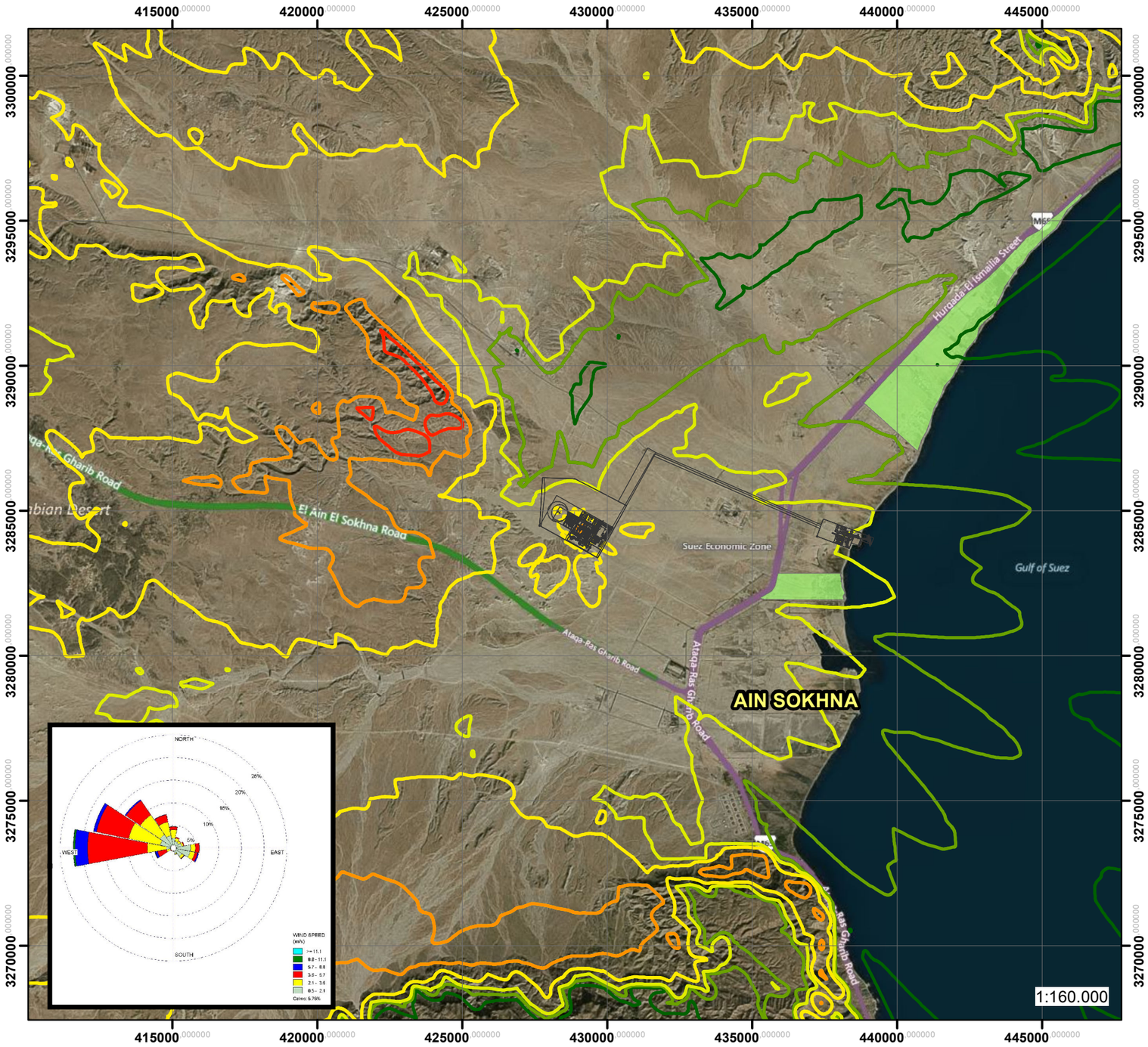

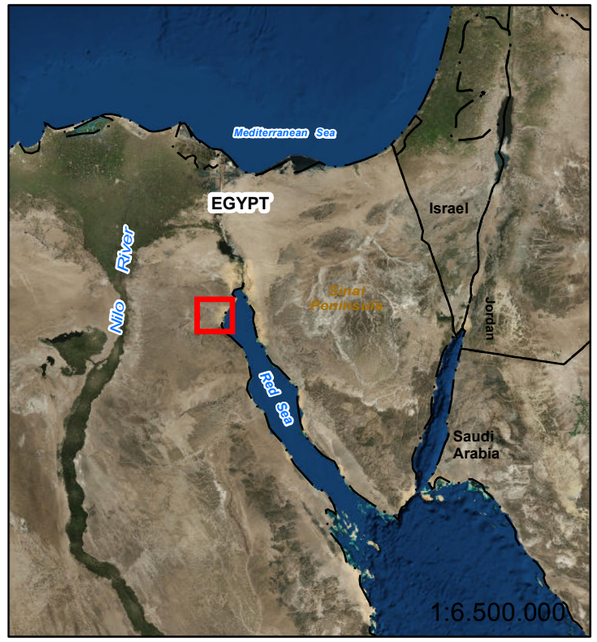

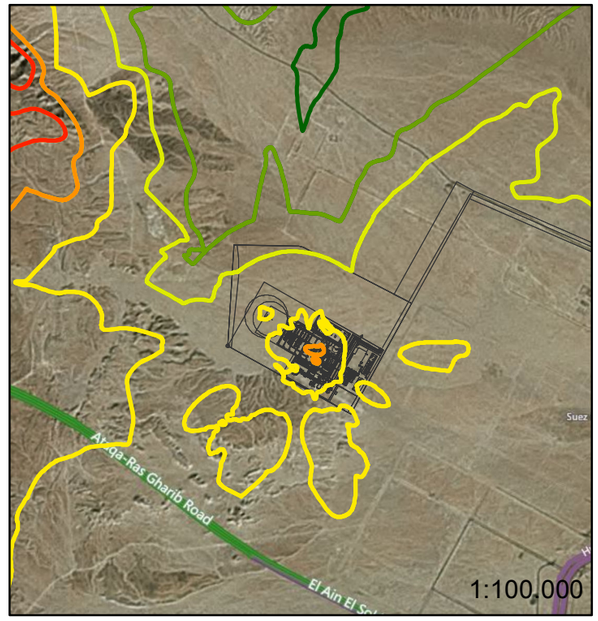

N

Legend

CO 1 hour

- 5 ug/m3
- 7.5 ug/m3
- 10 ug/m3
- 20 ug/m3
- 40 ug/m3
- 60 ug/m3
- Touristic Village

Maximum Predicted Concentration = 77.19 ug/m3
Egyptian Air Quality Standard = 30,000 ug/m3
WHO Air Quality Standard = 30,000 ug/m3

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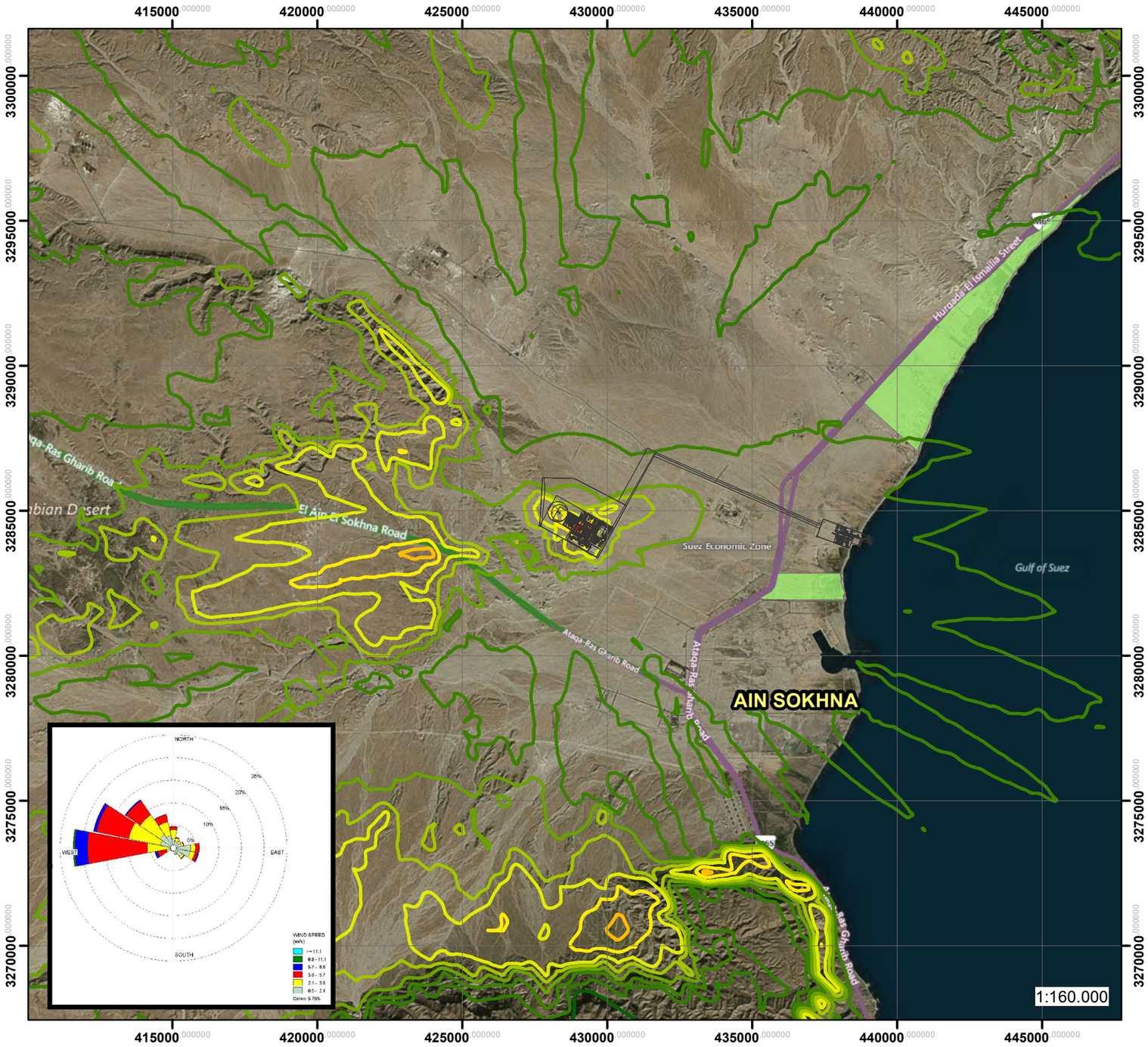

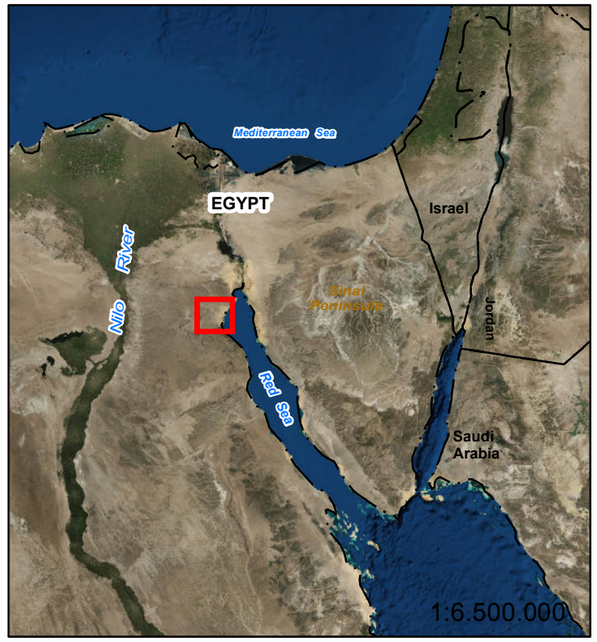

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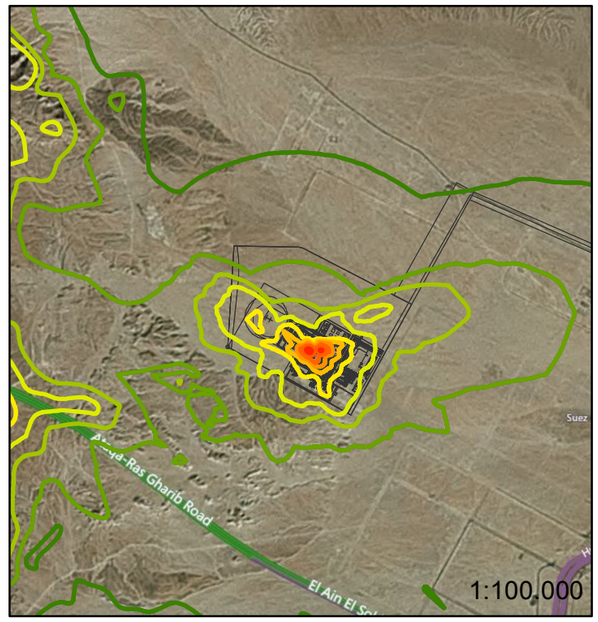

Legend

CO 8 hours

- 0.5 ug/m3
- 1 ug/m3
- 2.5 ug/m3
- 5 ug/m3
- 7.5 ug/m3
- 10 ug/m3
- 15 ug/m3
- 20 ug/m3
- 25 ug/m3
- 30 ug/m3
- 35 ug/m3
- 40 ug/m3
- Touristic Village

Maximum Predicted Concentration = 45.97 ug/m3
Egyptian Air Quality Standard = 10,000 ug/m3
WHO Air Quality Standard = 10,000 ug/m3
EU Directive EC/50/2008 =10,000 ug/m3

Project Nº: 60109-01 **Tahrir Petrochemicals Complex Air Model**	**TAHRIR PETROCHEMICALS CORPORATION**
AERMOD **Scenario A** **Maximum Predicted Concentration** **CO 8 hours**	**WorleyParsons Consulting** *Tel: +34 917 991 092 Fax: +34 913 519 296* *Web: www.worleyparsons.com*

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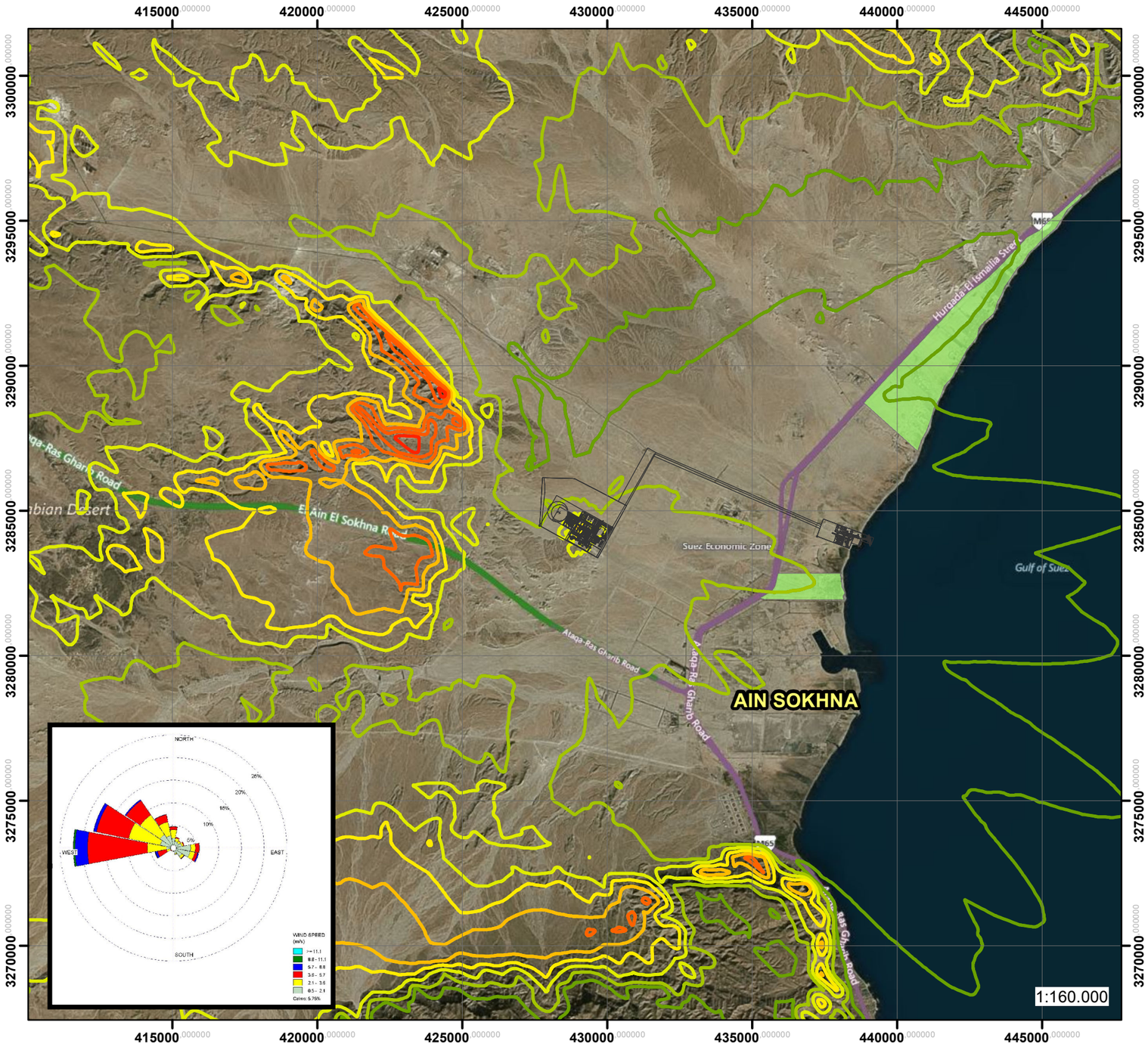

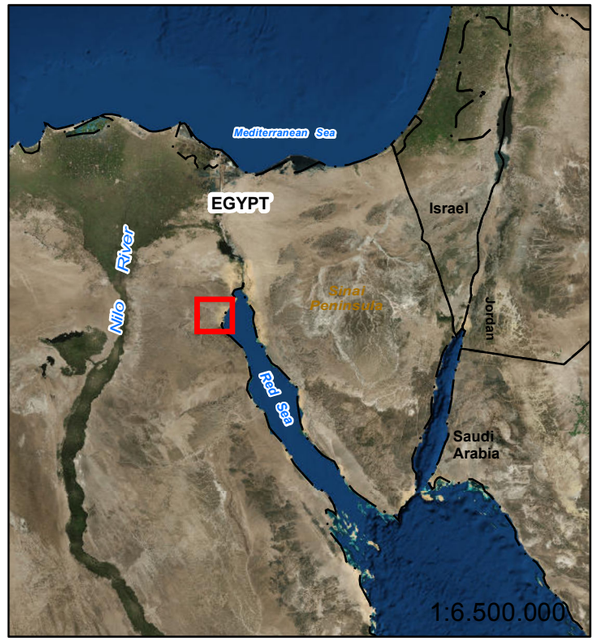

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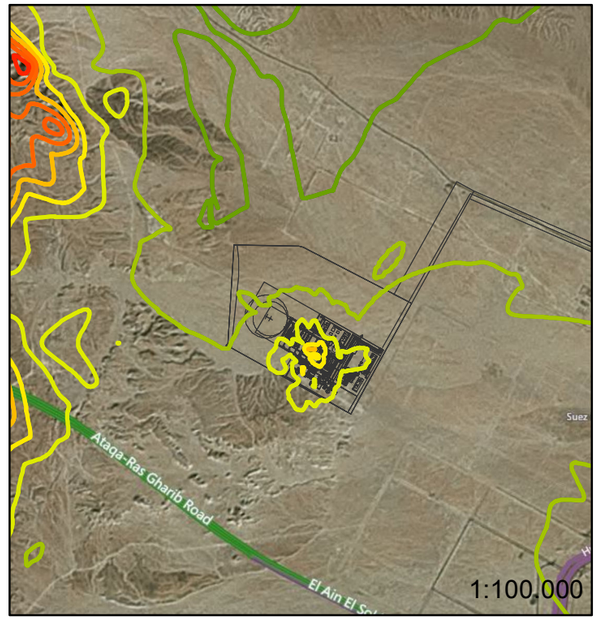

Legend

SO2 1 hour

- 1 ug/m3
- 2.5 ug/m3
- 5 ug/m3
- 10 ug/m3
- 15 ug/m3
- 20 ug/m3
- 25 ug/m3
- 30 ug/m3
- 35 ug/m3
- Touristic Village

Maximum Predicted Concentration = 38.33 ug/m3
Egyptian Air Quality Standard = 350 ug/m3
EU Directive EC/50/2008 =350 ug/m3

Project Nº: 60109-01 **Tahrir Petrochemicals Complex Air Model**							**TAHRIR PETROCHEMICALS CORPORATION**
AERMOD **Scenario A** **Maximum Predicted Concentration** **SO2 1 hour**							**WorleyParsons Consulting** *Tel: +34 917 991 092 Fax: +34 913 519 296* *Web: www.worleyparsons.com*
DRAWN FJPA	STATUS: DRAFT	APPROVED: MSA	ORIGINAL A3	DATE 19/12/2014	SCALE SHOWN	OFFICE MADRID	CODE: **FIGURE 1.3.1**

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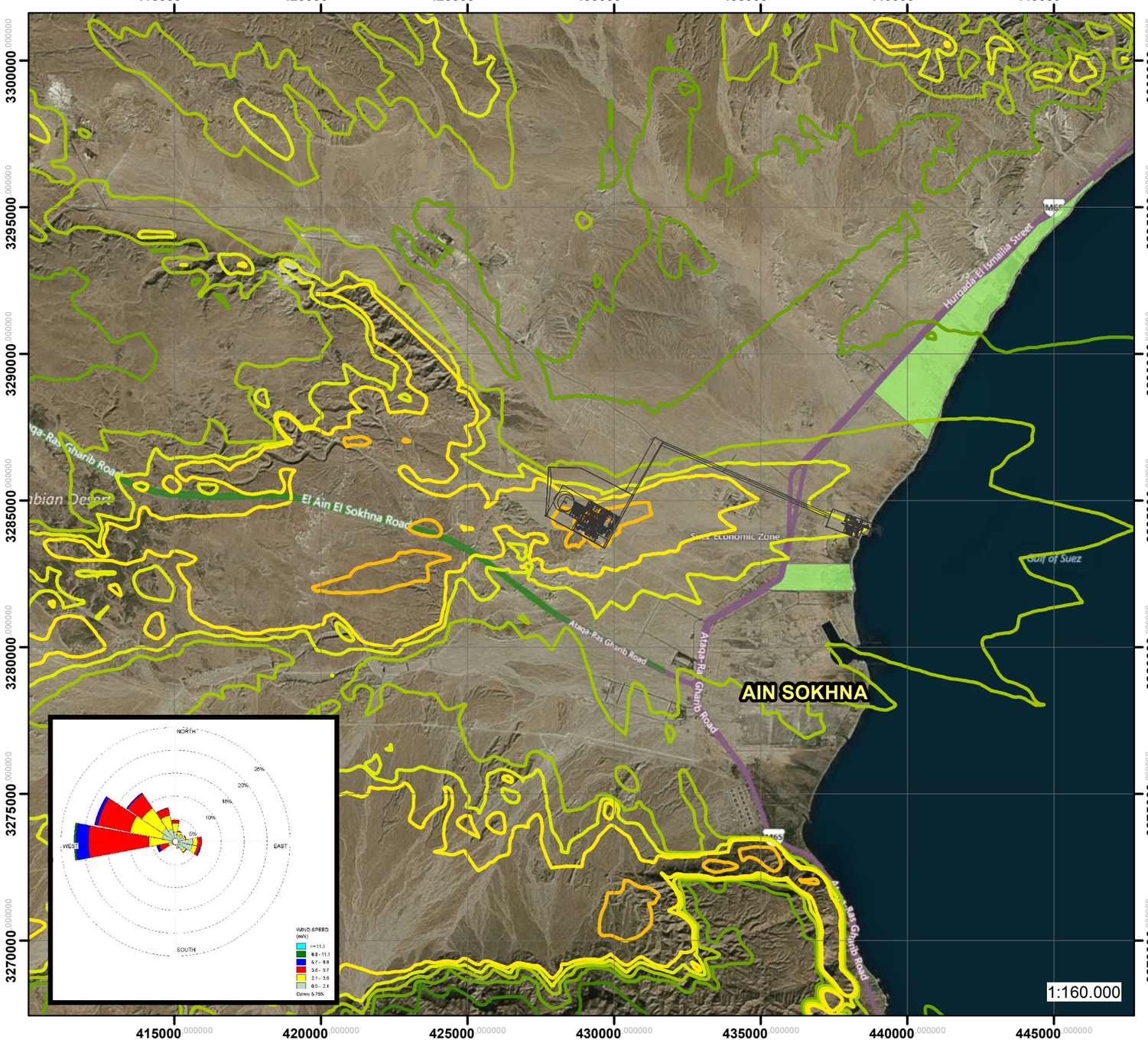

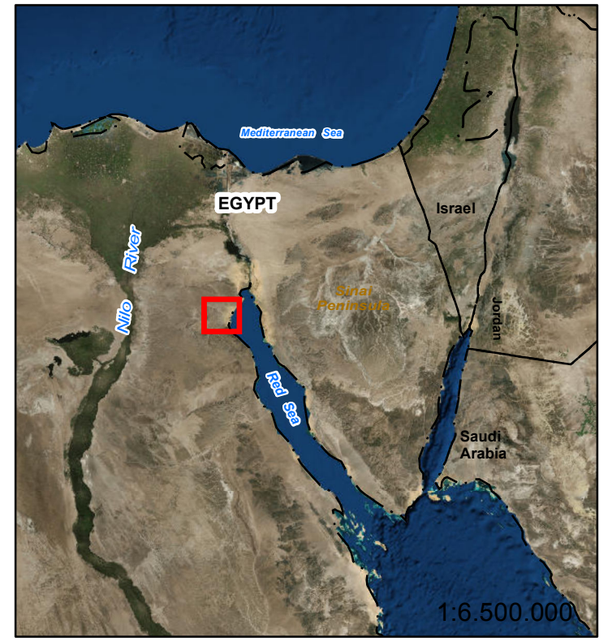

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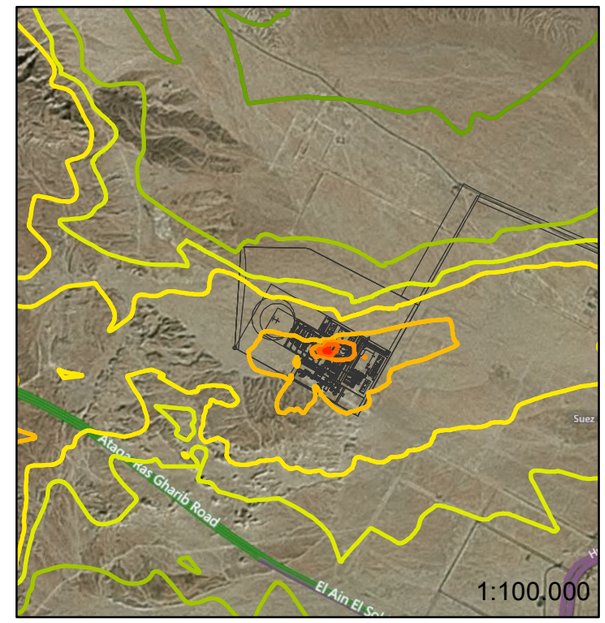

Legend

SO2 24 hours

- 0.1 ug/m3
- 0.25 ug/m3
- 0.5 ug/m3
- 0.75 ug/m3
- 1 ug/m3
- 2.5 ug/m3
- 5 ug/m3
- 7.5 ug/m3
- 10 ug/m3
- Touristic Village

Maximum Predicted Concentration = 11.69 ug/m3
Egyptian Air Quality Standard = 150 ug/m3
WHO Air Quality Standard = 125 ug/m3
EU Directive EC/50/2008 =125 ug/m3

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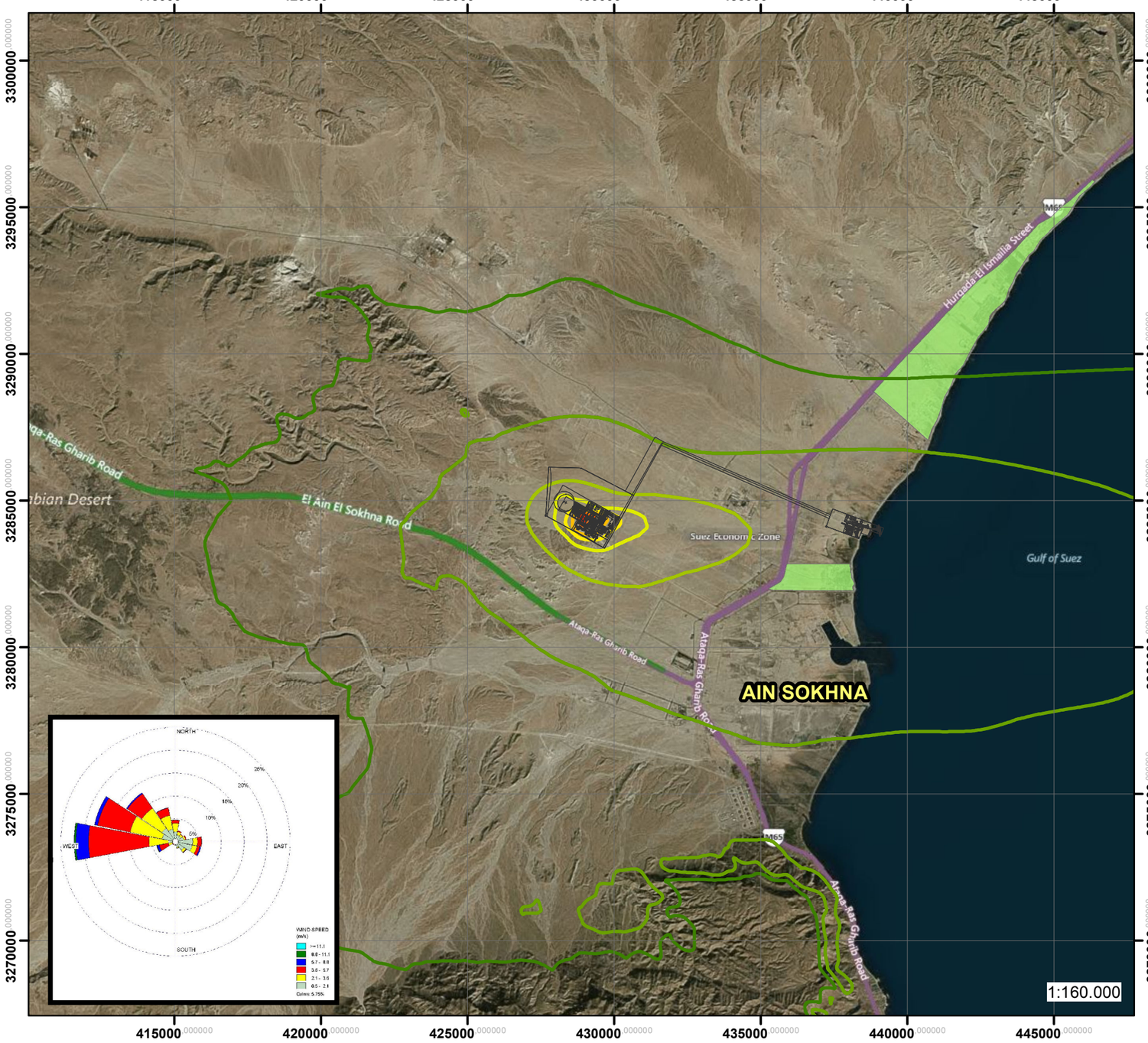

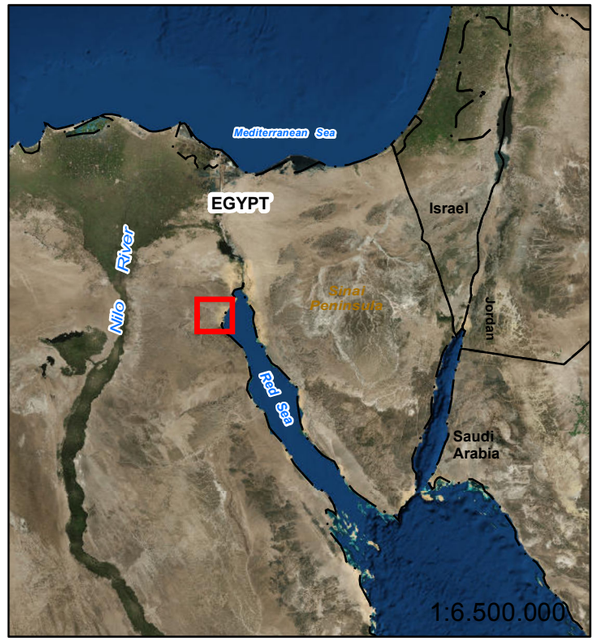

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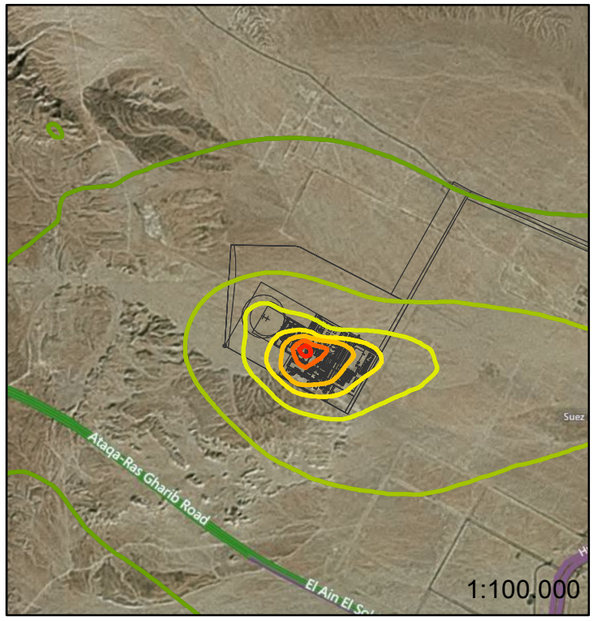

Legend

SO2 Annual

- 0.05 ug/m3
- 0.1 ug/m3
- 0.25 ug/m3
- 0.5 ug/m3
- 0.75 ug/m3
- 1 ug/m3
- 1.5 ug/m3
- 2 ug/m3
- Touristic Village

Maximum Predicted Concentration = 2.34 ug/m3
Egyptian Air Quality Standard = 60 ug/m3

Project Nº: 60109-01
Tahrir Petrochemicals Complex Air Model

TAHRIR PETROCHEMICALS CORPORATION

AERMOD
Scenario A
Maximum Predicted Concentration
SO2 Annual

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FIGURE 1.3.3

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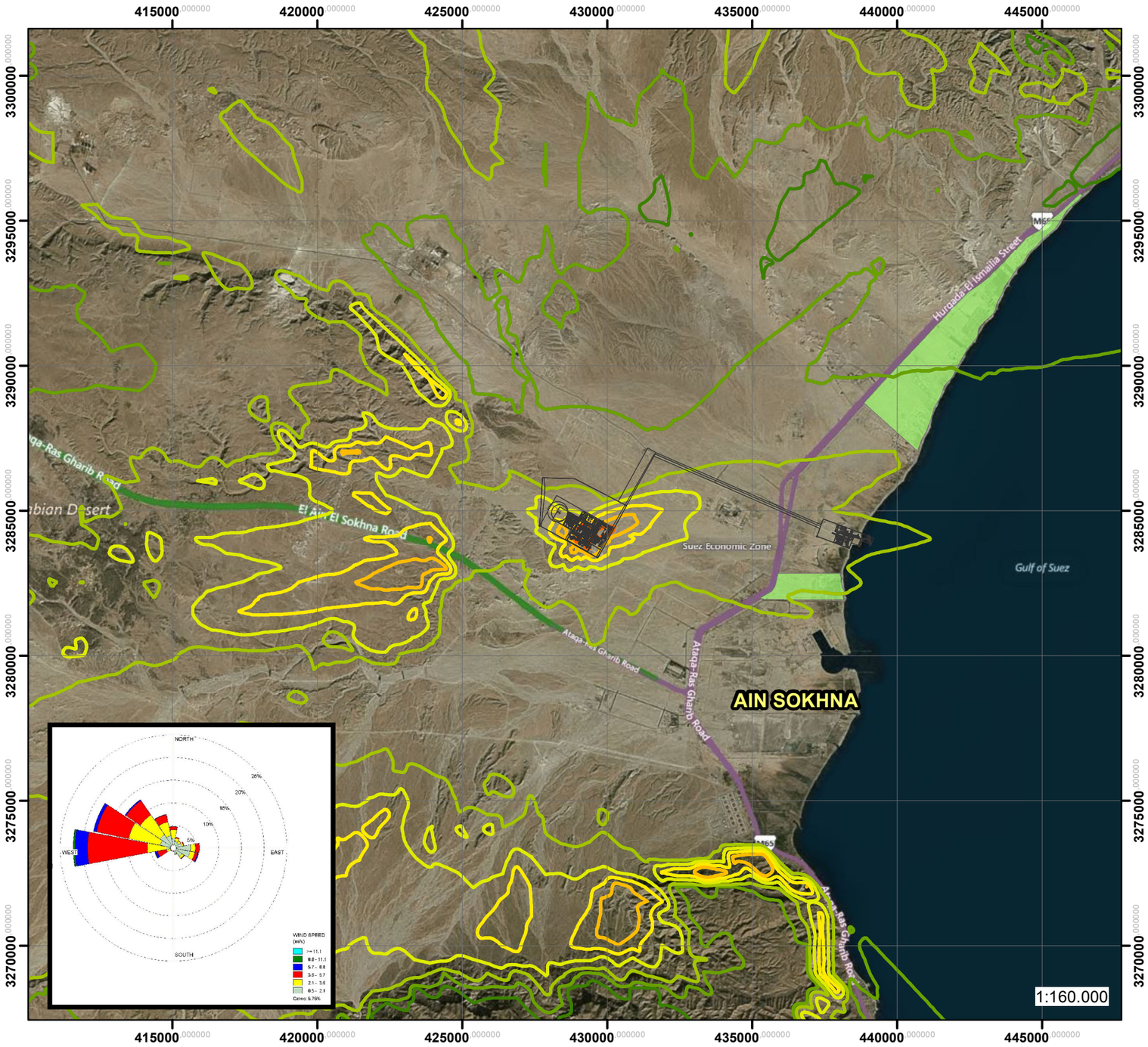

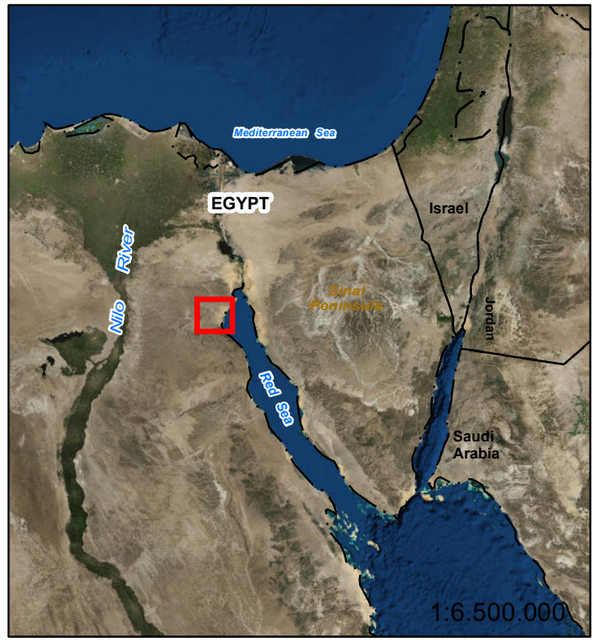

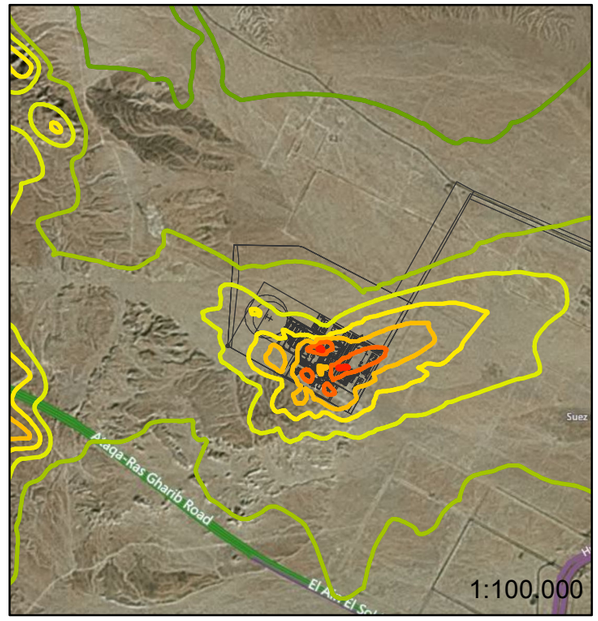

N

Legend

PM10 24 hours

- 0.05 ug/m3
- 0.1 ug/m3
- 0.25 ug/m3
- 0.5 ug/m3
- 0.75 ug/m3
- 1
- 1.5 ug/m3
- 2
- Touristic Village

Maximum Predicted Concentration =2.3 ug/m3
Egyptian Air Quality Standard = 150 ug/m3
WHO Air Quality Standard = 150 ug/m3
EU Directive EC/50/2008 = 50 ug/m3

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DRAWN FJPA	STATUS: DRAFT	APPROVED: MSA	ORIGINAL A3	DATE 19/12/2014	SCALE SHOWN	OFFICE MADRID	CODE: FIGURE 1.4.1

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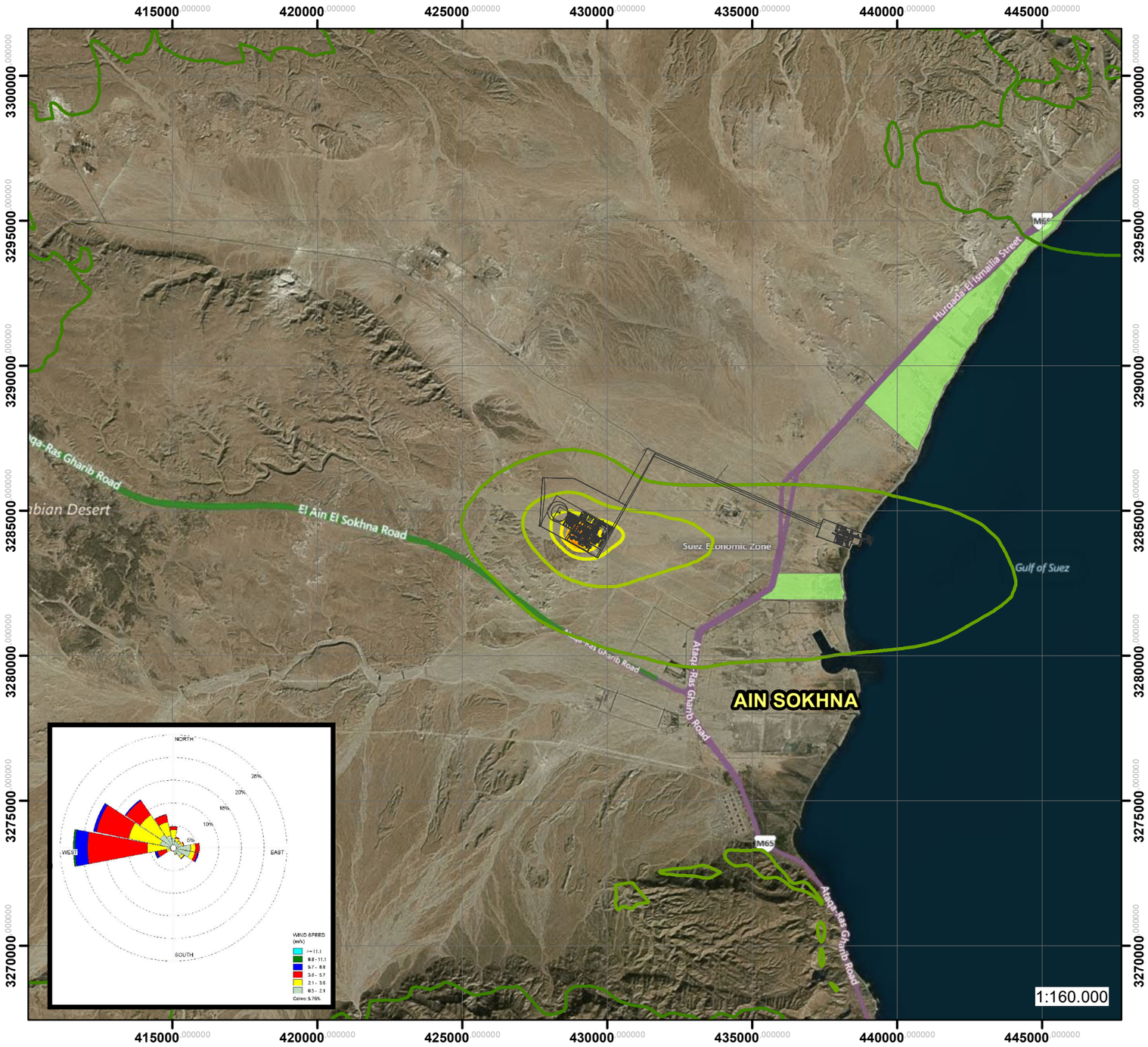

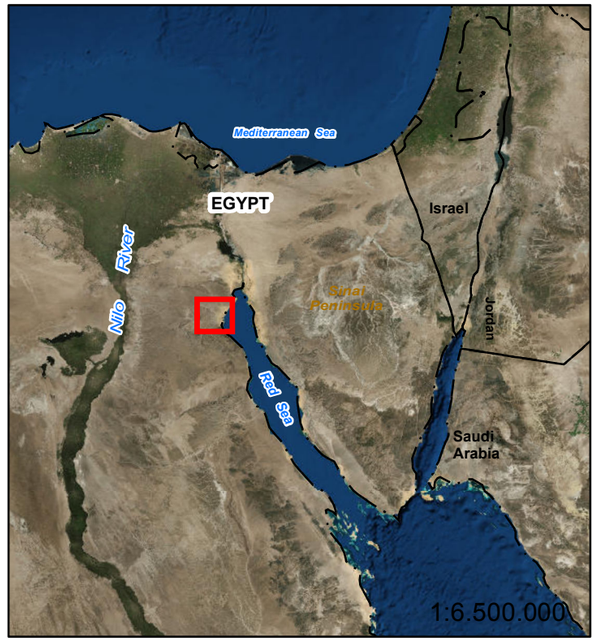

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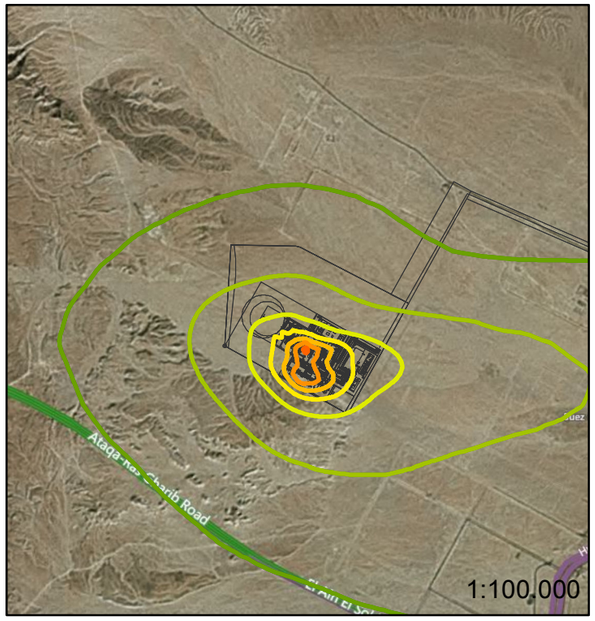

Legend

PM10 Annual

- 0.01 ug/m3
- 0.05 ug/m3
- 0.1 ug/m3
- 0.2 ug/m3
- 0.3 ug/m3
- 0.4 ug/m3
- 0.5 ug/m3
- 0.6 ug/m3
- Touristic Village

Maximum Predicted Concentration = 0.63 ug/m3
Egyptian Air Quality Standard = 70 ug/m3
WHO Air Quality Standard = 70 ug/m3
EU Directive EC/50/2008 = 40 ug/m3

Project Nº: 60109-01
Tahrir Petrochemicals Complex Air Model

TAHRIR PETROCHEMICALS CORPORATION

AERMOD
Scenario A
Maximum Predicted Concentration
PM10 Annual

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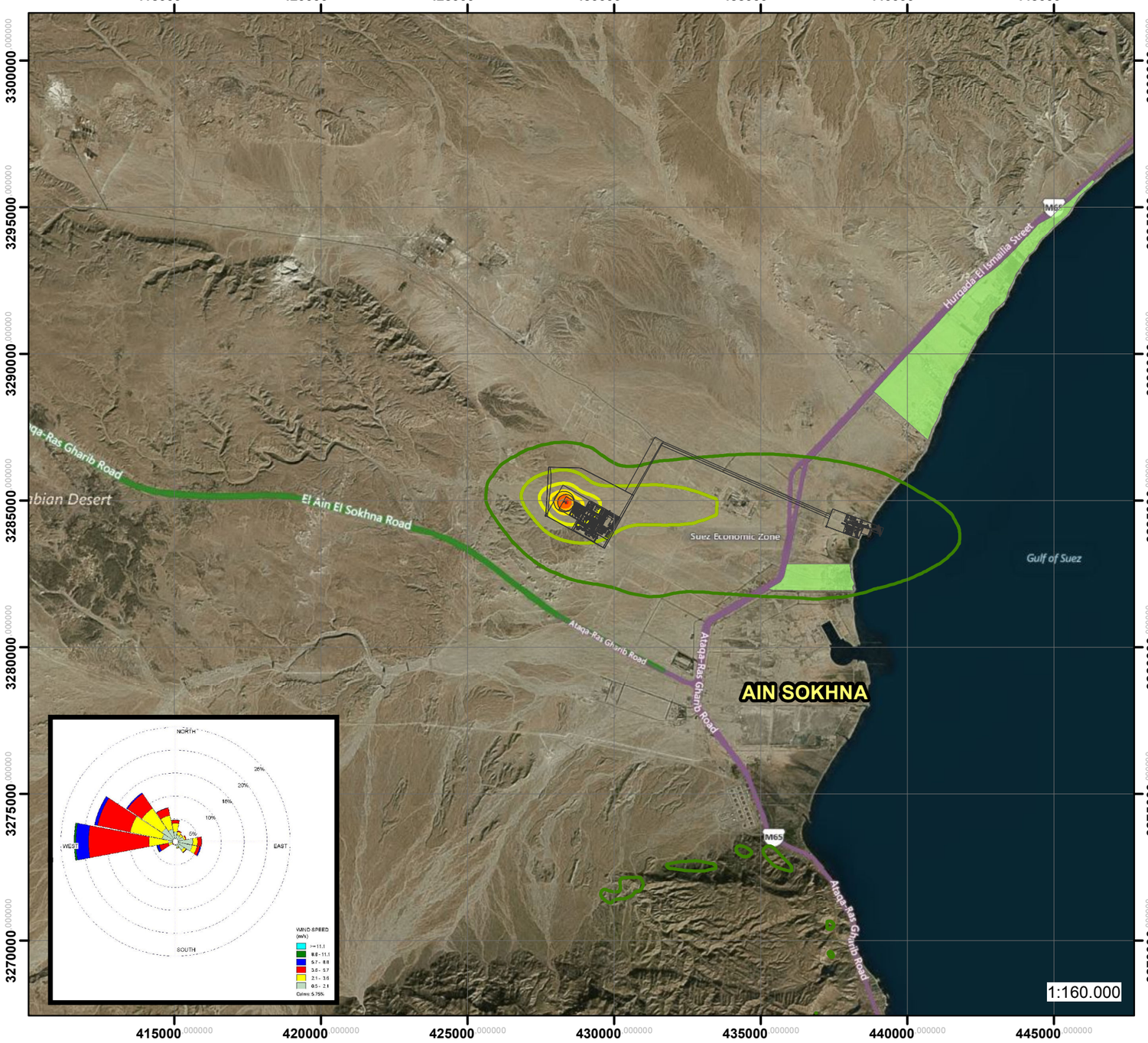

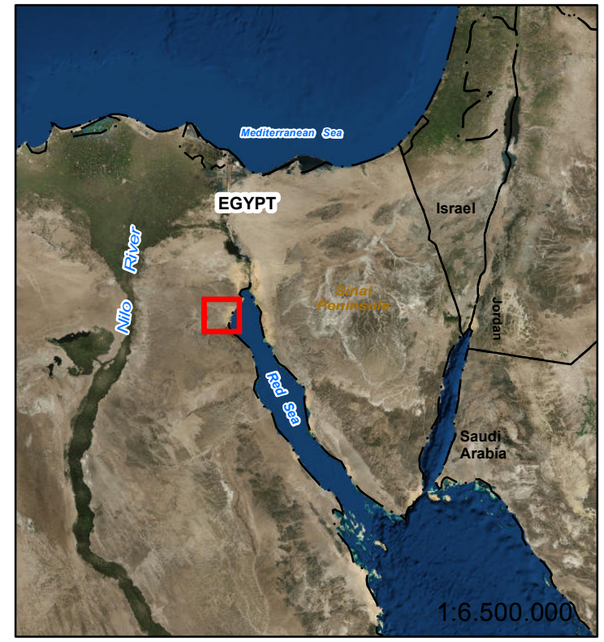

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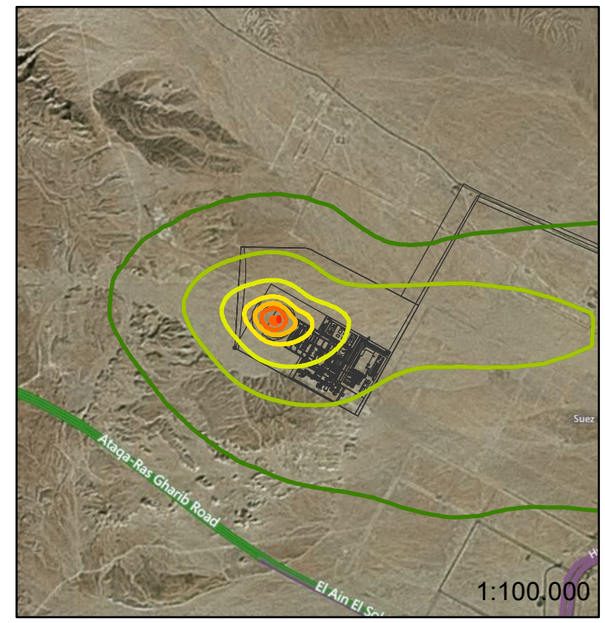

Legend

Benzene Annual

- 0.005 ug/m3
- 0.01 ug/m3
- 0.02 ug/m3
- 0.04 ug/m3
- 0.06 ug/m3
- 0.08 ug/m3
- 0.1 ug/m3
- Touristic Village

Maximum Predicted Concentration = 0.1 ug/m3
EU Directive EC/50/2008 = 5 ug/m3

Project Nº: 60109-01 Tahrir Petrochemicals Complex Air Model	TAHRIR PETROCHEMICALS CORPORATION
AERMOD **Scenario A** **Maximum Predicted Concentration** **Benzene Annual**	WorleyParsons Consulting *Tel: +34 917 991 092 Fax: +34 913 519 296* *Web: www.worleyparsons.com*

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FJPA	DRAFT	MSA	A3	19/12/2014	SHOWN	MADRID		FIGURE 1.5.1

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Appendix 2 - AERMOD Predicted COPC Contours under Furnace Decoking Operation (Scenario B)

LIST OF FIGURES

2. SCENARIO B

2.1 NO_x

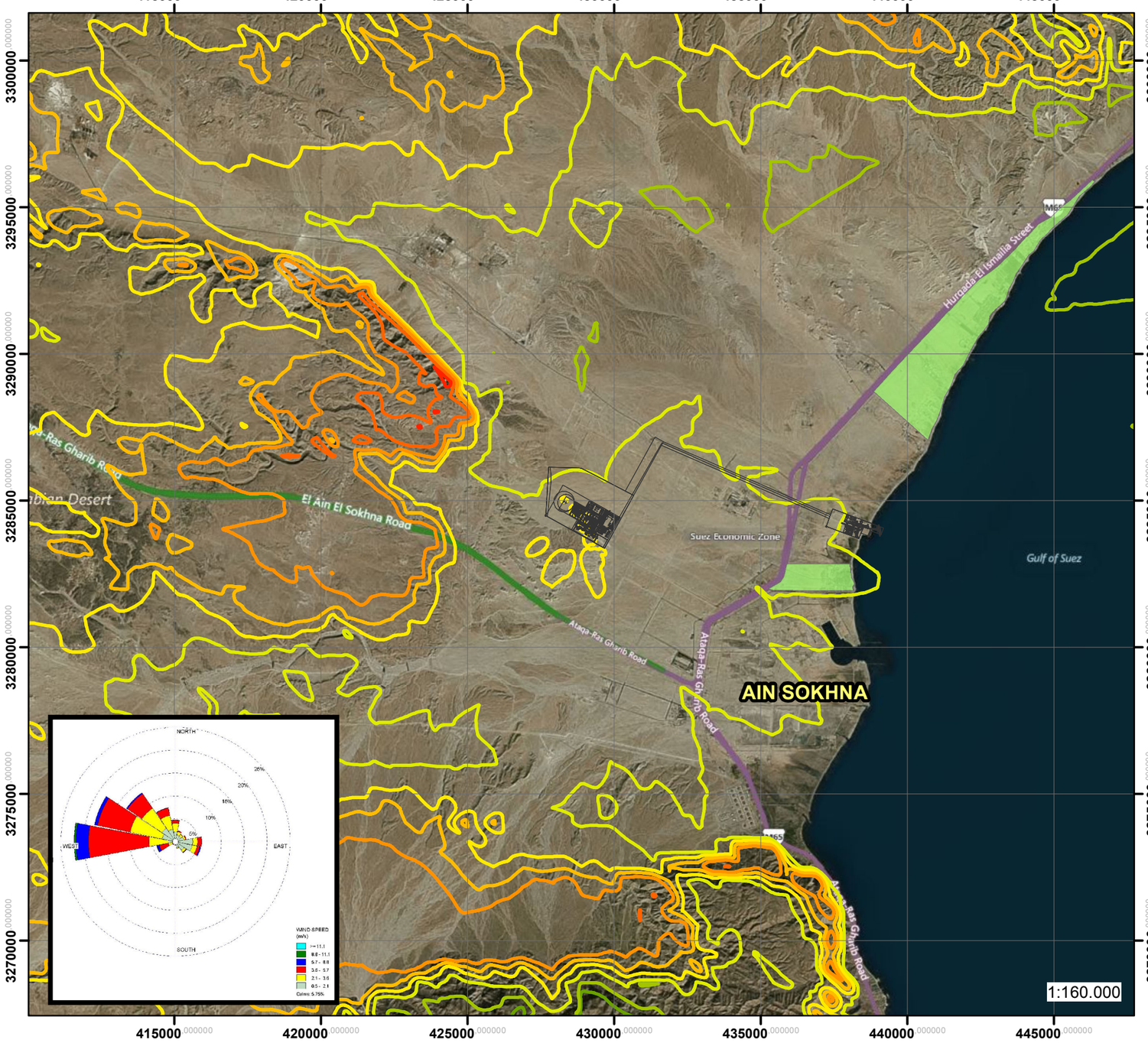
2.1.1 1-hour average
2.1.2 24-hour average

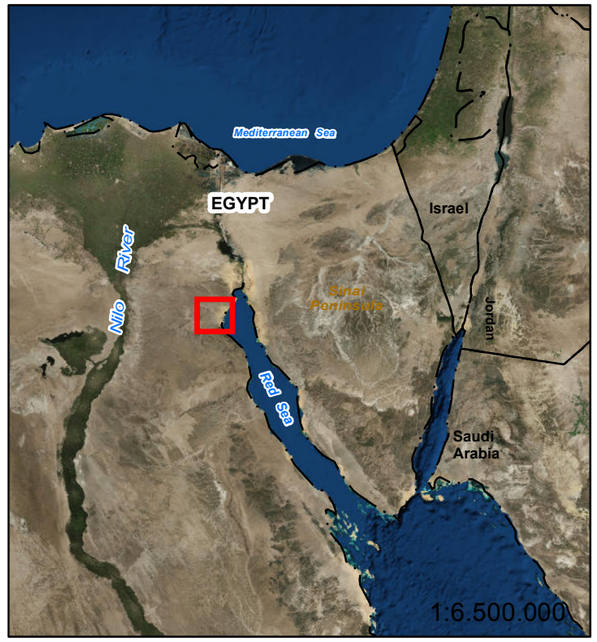
2.2 CO

2.2.1 1-hour average
2.2.2 8-hour average

2.3 PM_{10}

2.3.1 24-hour average





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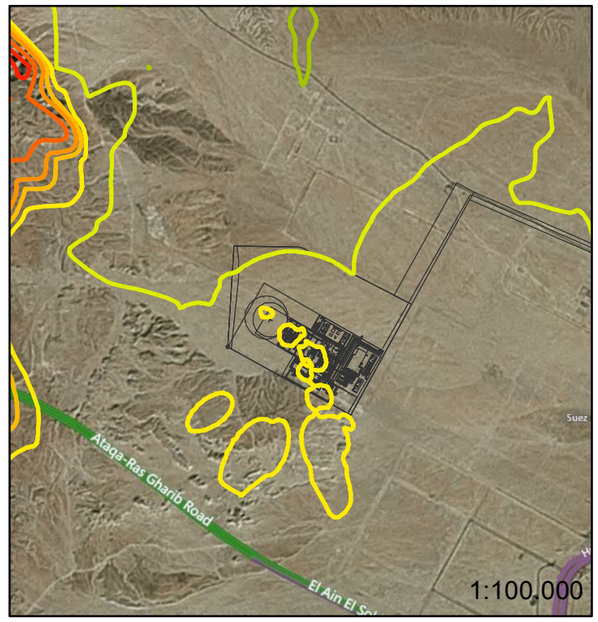

Legend

NOx 1 hour

- 2.5 ug/m3
- 5 ug/m3
- 7.5 ug/m3
- 10 ug/m3
- 25 ug/m3
- 50 ug/m3
- 75 ug/m3
- 100 ug/m3
- 150 ug/m3
- 200 ug/m3
- Touristic Village

Maximum Predicted Concentration = 224.14 ug/m3 (168.11 ug/m3 of NO2)
Egyptian Air Quality Standard (for NO2) = 300 ug/m3
WHO Air Quality Standard (for NO2) = 200 ug/m3
EU Directive EC/50/2008 (for NO2) = 200 ug/m3

Project Nº: 60109-01
Tahrir Petrochemicals Complex Air Model

TAHRIR PETROCHEMICALS CORPORATION

AERMOD
Scenario B
Maximum Predicted Concentration
NOx 1 hour

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FJPA	DRAFT	MSA	A3	19/12/2014	SHOWN	MADRID	**FIGURE 2.1.1**

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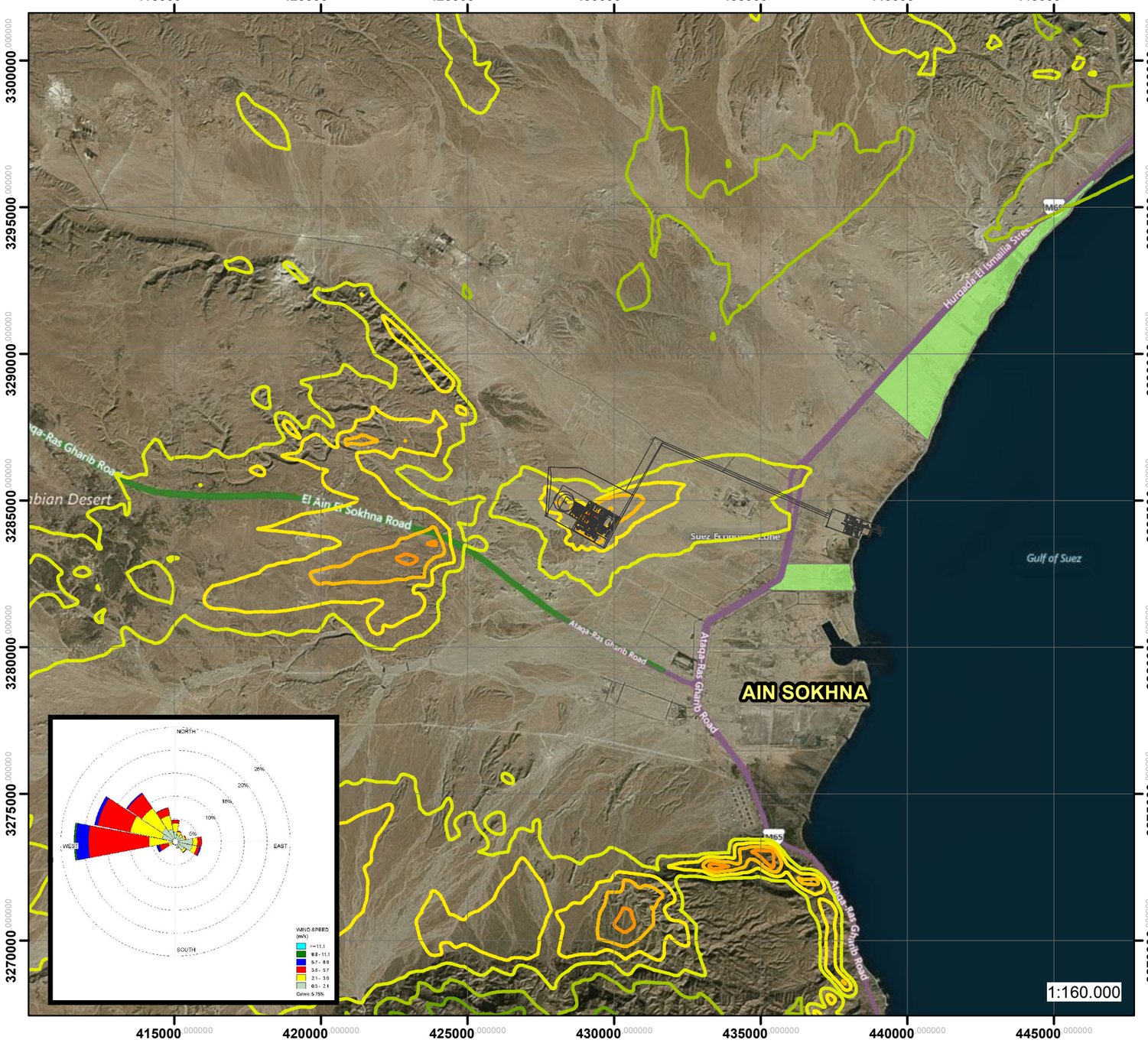

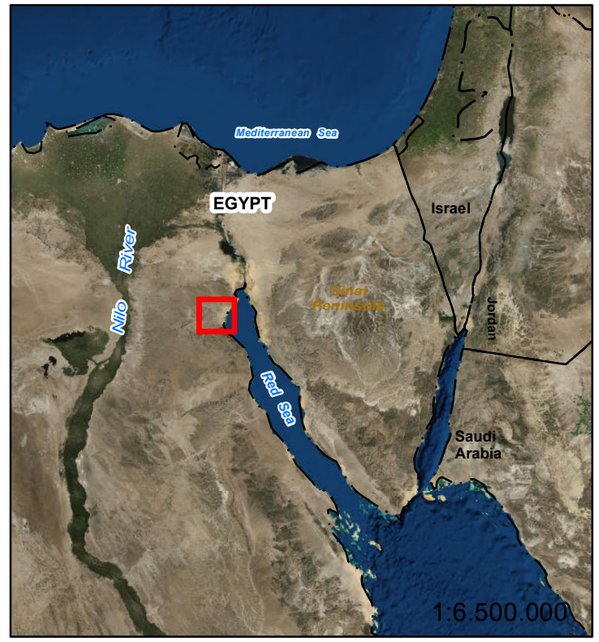

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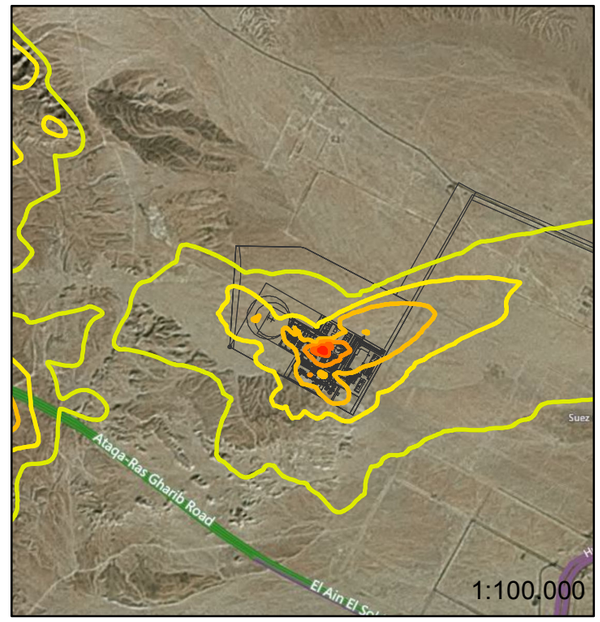

Legend

NOx 24 hours

- 0.25 ug/m3
- 0.5 ug/m3
- 1 ug/m3
- 5 ug/m3
- 10 ug/m3
- 15 ug/m3
- 20 ug/m3
- 25 ug/m3
- 30 ug/m3
- Touristic Village

Maximum Predicted Concentration = 35.26 ug/m3 (26.45 ug/m3 of NO2)
Egyptian Air Quality Standard (for NO2) = 150 ug/m3

Project Nº: 60109-01 **Tahrir Petrochemicals Complex Air Model**	**TAHRIR PETROCHEMICALS CORPORATION**
AERMOD **Scenario B** **Maximum Predicted Concentration** **NOx 24 hours**	**WorleyParsons Consulting** *Tel: +34 917 991 092 Fax: +34 913 519 296* *Web: www.worleyparsons.com*

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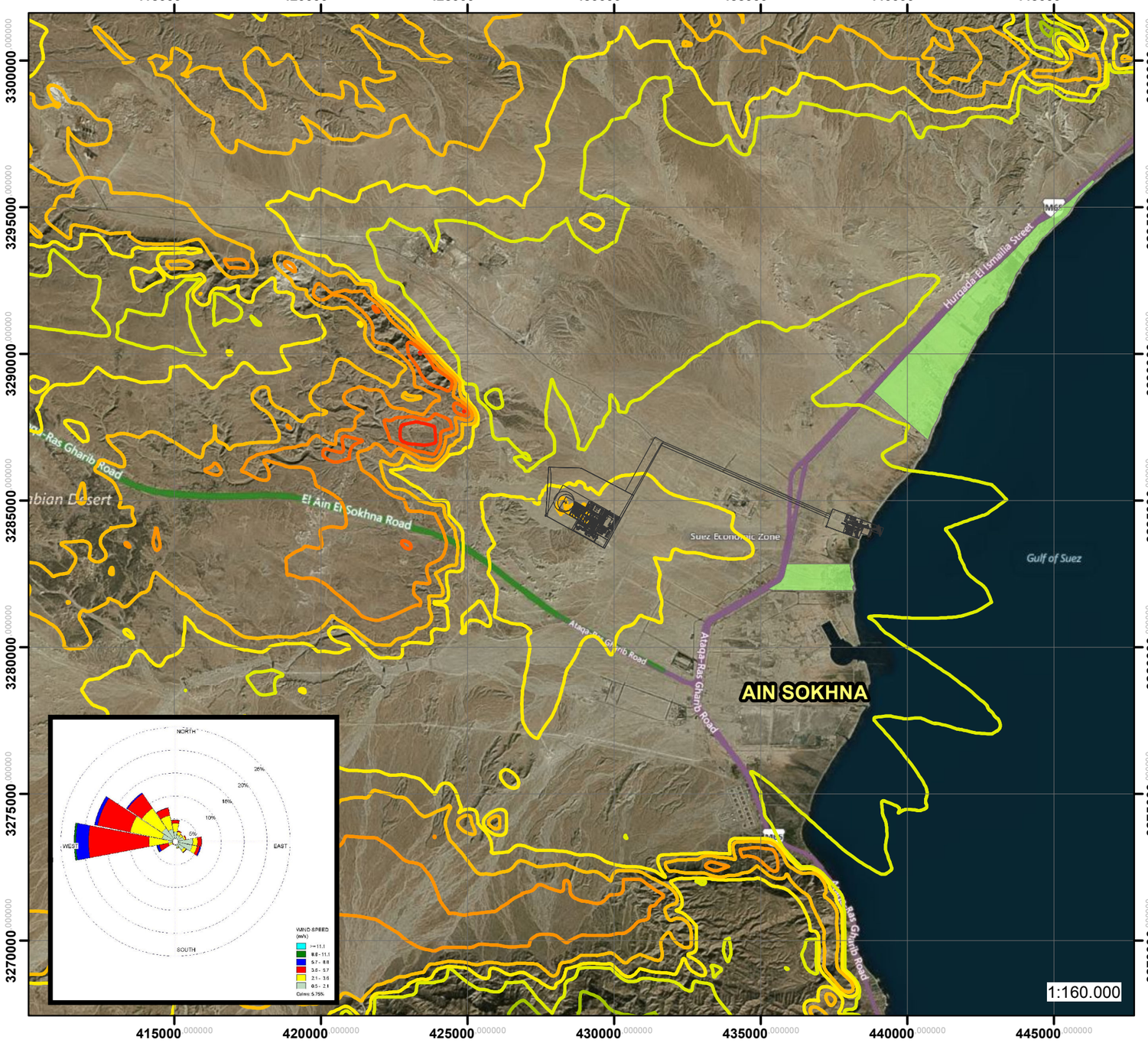

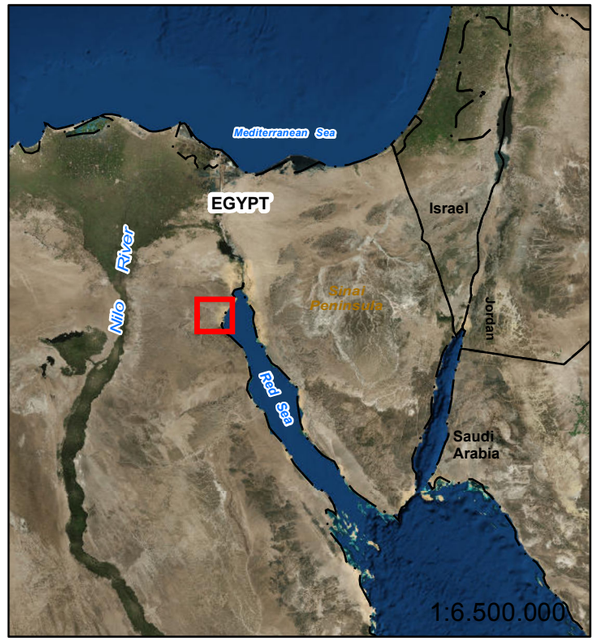

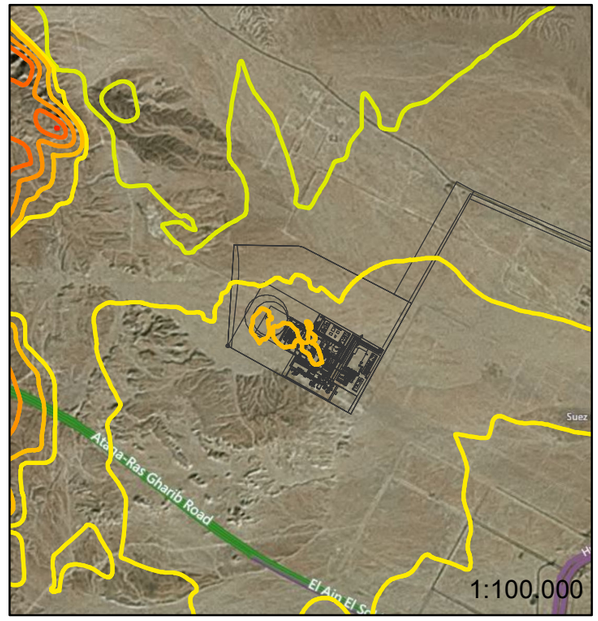

N

Legend

CO 1 hour

- 5 ug/m3
- 7.5 ug/m3
- 10 ug/m3
- 25 ug/m3
- 50 ug/m3
- 100 ug/m3
- 200 ug/m3
- 300 ug/m3
- 400 ug/m3
- Touristic Village

Maximum Predicted Concentration = 484.58 ug/m3
Egyptian Air Quality Standard = 30,000 ug/m3
WHO Air Quality Standard = 30,000 ug/m3

Project Nº: 60109-01
Tahrir Petrochemicals Complex Air Model

TAHRIR PETROCHEMICALS CORPORATION

AERMOD
Scenario B
Maximum Predicted Concentration
CO 1 hour

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FIGURE 2.2.1

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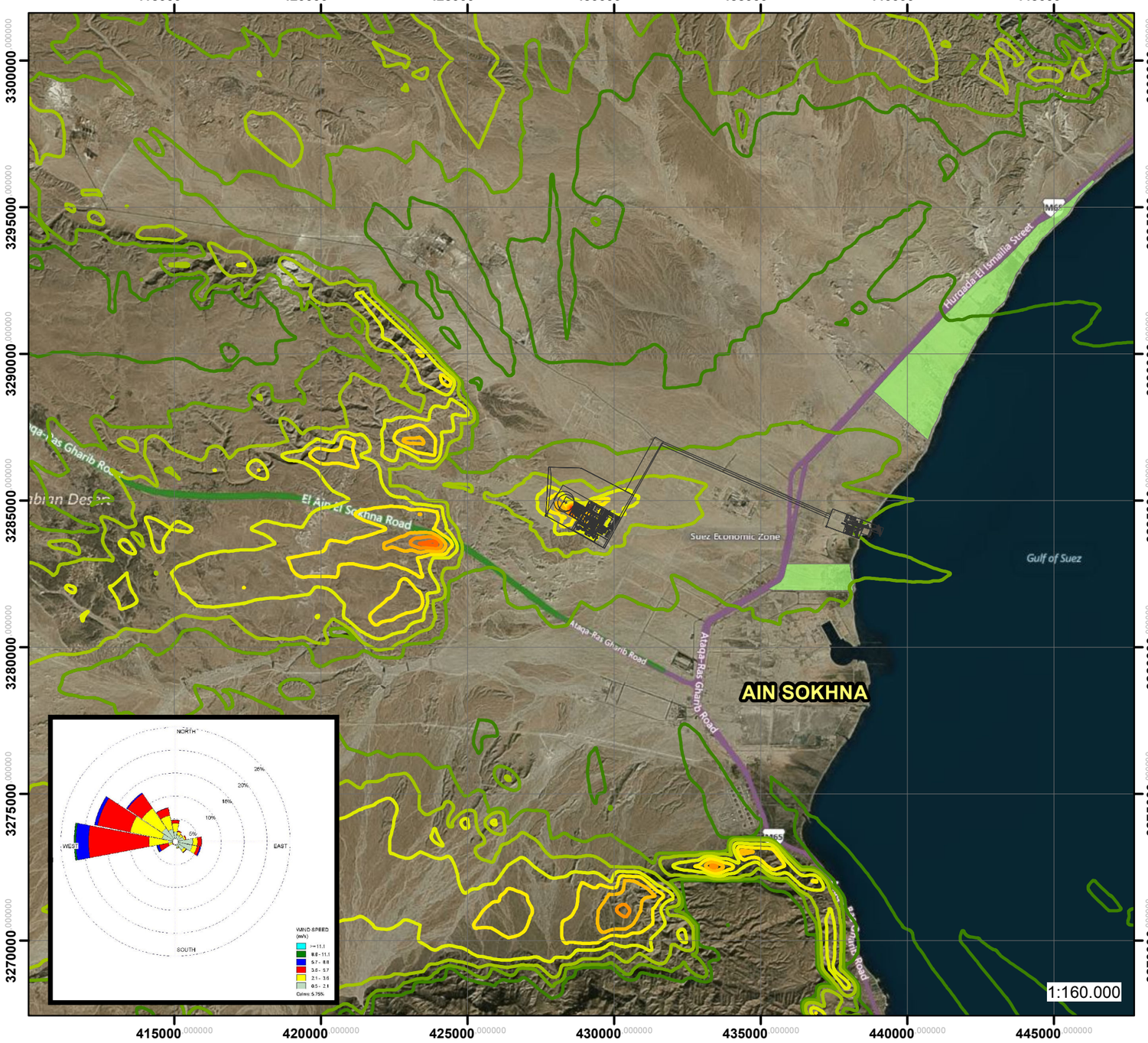

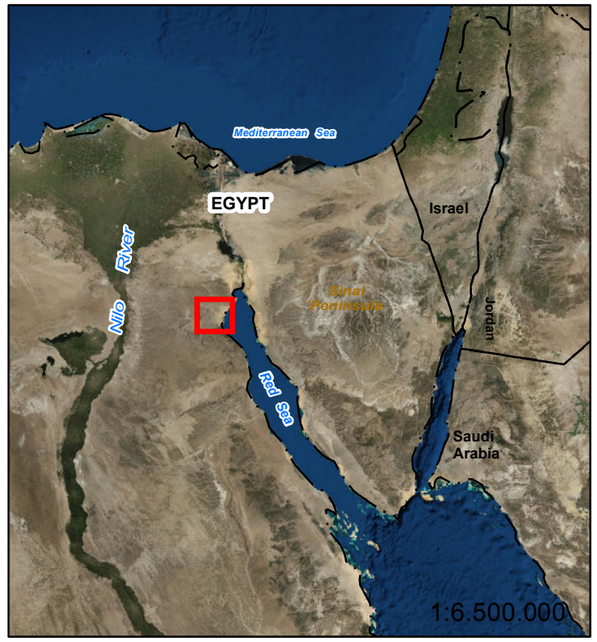

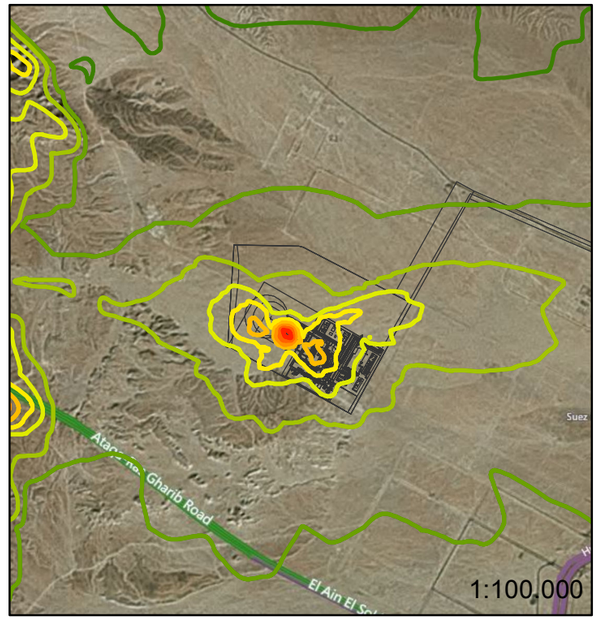

N

Legend

CO 8 hours

- 5 ug/m3
- 10 ug/m3
- 20 ug/m3
- 40 ug/m3
- 60 ug/m3
- 80 ug/m3
- 100 ug/m3
- 120 ug/m3
- 140 ug/m3
- Touristic Village

Maximum Predicted Concentration = 149.11 ug/m3
Egyptian Air Quality Standard = 10,000 ug/m3
WHO Air Quality Standard = 10,000 ug/m3

Project Nº: 60109-01 Tahrir Petrochemicals Complex Air Model	TAHRIR PETROCHEMICALS CORPORATION
AERMOD Scenario B Maximum Predicted Concentration CO 8 hours	WorleyParsons Consulting Tel: +34 917 991 092 Fax: +34 913 519 296 Web: www.worleyparsons.com

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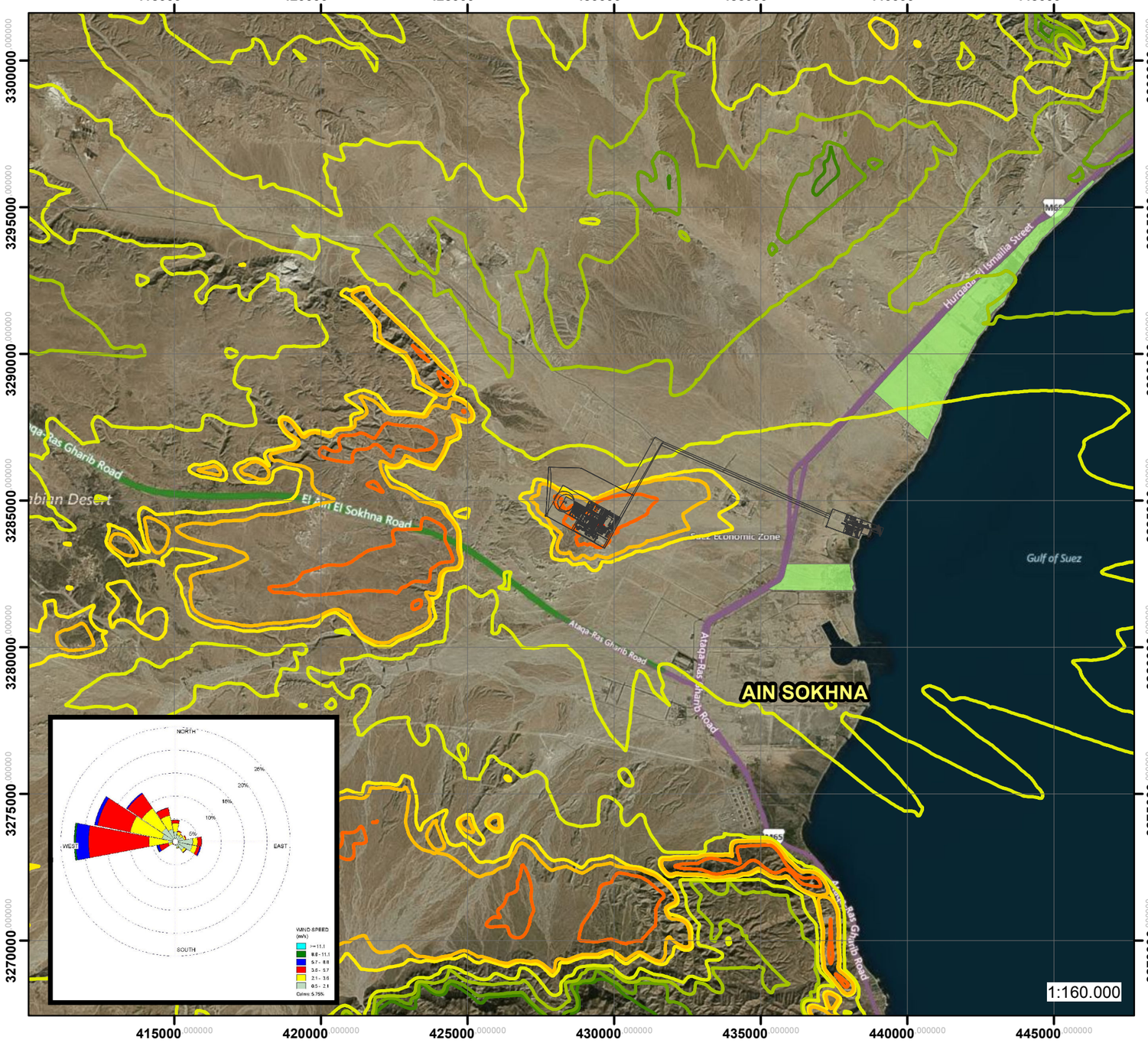

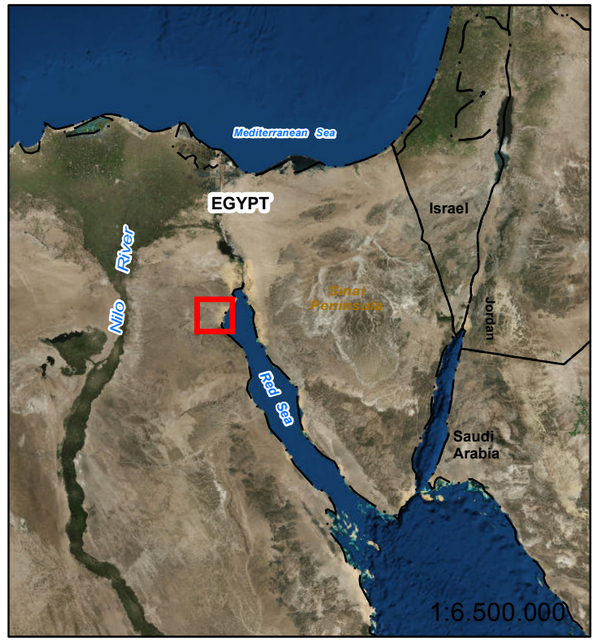

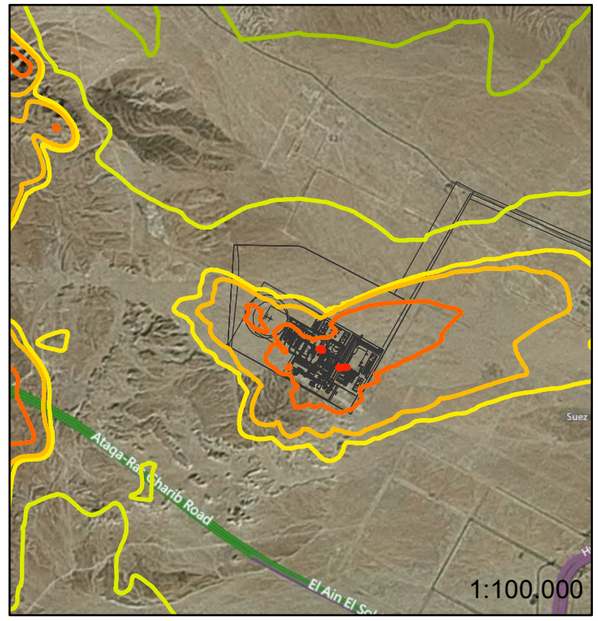

N

Legend

PM10 24 hours

- 0.05 ug/m3
- 0.06 ug/m3
- 0.1 ug/m3
- 0.2 ug/m3
- 0.5 ug/m3
- 0.6 ug/m3
- 1 ug/m3
- 2 ug/m3
- Touristic Village

Maximum Predicted Concentration =2.3 ug/m3
Egyptian Air Quality Standard = 150 ug/m3
WHO Air Quality Standard = 150 ug/m3
EU Directive EC/50/2008 = 50 ug/m3

Project Nº: 60109-01 **Tahrir Petrochemicals Complex Air Model**	**TAHRIR PETROCHEMICALS CORPORATION**
AERMOD **Scenario B** **Maximum Predicted Concentration** **PM10 24 hours**	**WorleyParsons Consulting** *Tel: +34 917 991 092 Fax: +34 913 519 296* *Web: www.worleyparsons.com*

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Appendix 3 - References for the Source Parameters Employed in the Model

Source	Stack Parameters	COPC Emission Rates
Cracking Furnace 01-F01 to 08-F01 **Cracking Furnace 09-F01 (Standby/Decoking)** **Decocking Cyclon 15-D31**	• **Stack Height and Diameter**: provided by EPC Contractors • **Exit Temperature**: based on BAT document [1]. • **Exit Velocity**: calculated to match the exit flow rate provided by EPC Contractors. This flow rate was converted from the reference conditions into actual volumetric flow at exit temperature	Calculated according to: • Exhaust flow rate and • Exhaust COPC concentrations Both data were provided by EPC Contractors
Heater F-101 and F-102 (in HDA unit 68-Y01)	• **Stack Height and Diameter**: provided by EPC Contractors • **Exit Temperature**: provided by EPC Contractors • **Exit Velocity**: calculated to match the exit flow rate provided by EPC Contractors. This flow rate was converted from the reference conditions into actual volumetric flow at exit temperature	Calculated according to: • Exhaust flow rate and • Exhaust COPC concentrations Both data were provided by EPC Contractors
Gas Turbines 1 to 4 (Natural Gas)	• **Stack Height and Diameter**: provided by EPC Contractors • **Exit Temperature**: provided by EPC Contractors • **Exit Velocity**: estimated based on WorleyParsons previous	Calculated using AP-42 Emission Factors for Natural Gas -fired Turbines[2]. These factors are based on the amount of fuel consumed by each unit (provided by EPC Contractors)

Source	Stack Parameters	COPC Emission Rates
	experience with similar projects.	
HP Steam Boilers A (PGO/PFO), B (Fuel Gas from the Cracker) and C (Natural Gas)	• **Stack Height and Diameter**: provided by EPC Contractors • **Exit Temperature**: provided by EPC Contractors • **Exit Velocity**: estimated based on WorleyParsons previous experience with similar projects	Calculated using AP-42 Emission Factors for: - Fuel Oil Combustion in the case of Boiler A[3]. - Natural Gas Combustion in the case of Boilers B and C[4] These factors are based on the amount of fuel consumed by each unit (provided by EPC Contractors)
Ship Vapor Recovery Unit (VCU)	• **Stack Height**: provided by EPC Contractors • **Stack Diameter**: estimated based on WorleyParsons previous experience with similar projects. • **Exit Temperature**: estimated. **Exit Velocity**: estimated based on WorleyParsons previous experience with similar projects.	Calculated according to: • Exhaust flow rate and • Exhaust COPC concentrations Both data were provided by EPC Contractors
Sour Gas Flare 90-F02	• **Stack Height**: provided by EPC Contractors • **Total Heat release:** calculated according to fuel consumed and fuel LHV. Both data were provided by EPC Contractors	• **NOx and CO:** calculated using AP-42 emission factors for Industrial Flares[5] • **SO_2 and benzene:** calculated based on exhaust flow rates and exhaust COPC concentrations provided by EPC Contractors
LP Tank Farm Flare 91-F01		

(1) IPCC. Reference Document on Best Available Techniques in the Large Volume Organic Chemical Industry. February 2003.

(2) U.S. EPA Emission Factor Documentation for AP-42 Section 3.1, Stationary Gas Turbines. 2000

(3) U.S. EPA Emission Factor Documentation for AP-42 Section 1.3, Fuel Oil Combustion. 2000

(4) U.S. EPA Emission Factor Documentation for AP-42 Section 1.4, Natural Combustion. 2000

(5) U.S. EPA Emission Factor Documentation for AP-42 Section 13.5, Industrial Flares. 2000