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Study of Plant for energy utilization of waste and landfill of non-hazardous waste impact on air quality of the wider location of the chemical industry complex in Prahovo

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[Project name]	Study of Plant for the energy utilization of waste and landfills of non-hazardous waste impact on the air quality of the wider location of the chemical industry complex in Prahovo

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Table of contents

1. INTRODUCTION

The purpose of this Study is to provide a representative assessment of the impact of thermal waste treatment plant with solidification landfill and expansion of phosphogypsum storage on air quality in the wider domain of the chemical industry complex location in Prahovo. The assessment is based on the use of a computer-based dispersion model to calculate ground-level concentrations of pollutants in the area under consideration. In order to provide a qualitative assessment of the contribution to the existing air quality condition, the results obtained by the model should be compared with the relevant national and international air quality objectives.

For the purposes of this Study, modeling was performed with the AERMOD software package using the appropriate input parameters for the existing and future state of the plant.

This Study considered the identified point and surface emission sources and within them, depending on the scenario, the following pollutants: CO, SO_2, NO_2, PM10, PM2.5, HF, HCl, NH_3, Hg, PCDD/F. The emission inventory, which was used for modeling purposes , was submitted by the Client of the Study.

Considering that the purpose of air quality modeling, within this Study, is to provide a representative assessment of the impact of the Project on air quality in the considered model domain, other sources that do not belong to the chemical industry complex have not been taken into account, nor is background pollution included in the presented modeling results. It should also be noted that within the chemical industry complex in Prahovo there are emitters of two companies, i.e. Elixir Prahovo and Phosphea, and that for the purposes of this study all point and surface emitters of both companies were developed, in order to give a more representative assessment since they represent the dominant sources of air emissions in the domain under consideration. This approach provides an opportunity to clearly see the future impact of a specific Project on air quality.

The results of the modeling, for all identified and modelled pollutants, are presented graphically through spatial distributions of ground-level concentrations (isopleths) as the maximum obtained value in accordance with the respectively time periods of averaging.

2. MODEL DESCRIPTION

2.1 Models of pollutants spreading through the air

The concentration of a pollutant in a specific point or area depends on a number of variables that include, among other things, emission values, distance from the source of pollution, as well as meteorological conditions.

In order to create the possibility of taking adequate preventive, spatial planning and environmental measures to protect the air from excessive pollution, an air quality monitoring system should be provided, with the aim of obtaining an accurate image of air pollution on the territory of the observed area. In cases where field air quality measurement data are not available (at the design stage of new industrial facilities), mathematical modeling, i.e. simulation of processes in the atmosphere with the help of mathematical models, is initiated. Atmospheric dispersion models of pollutants are used to determine the decay of pollutants concentration in the flue gas during the moving away of the smoke plume from the emission source, and thus to estimate ground concentrations.

The dispersion model is a mathematical expression of the action of atmospheric processes on pollutants in the atmosphere. Dispersion models simulate atmospheric conditions (which include wind speed and direction, air temperature, and mixing height) and provide an estimate of pollutant concentrations as they move away from the emitter. By incorporating atmospheric chemistry, these models can also generate estimated values of pollutants generated in secondary reactions. Dispersion models can be used in cases of assessments both when the negative impact of a new source of pollution in an area is determined, and in cases where the application of some measures can positively affect air quality. Therefore, dispersion models are used when it is necessary to provide an estimate of the concentration of pollutants in the ambient air for the purpose of assessing the impact of a new emitter or in cases of verifying the implementation of mitigation measures on existing facilities. Existing dispersion models differ in their complexity. As a minimum, for most models, as input data, it is necessary to provide meteorological data, emission data, as well as certain data on the emitter (stack height, flue gas velocity in the emitter, etc.). For some more complex models, it is necessary to provide data on the topography of the terrain, more detailed data on pollutants as well as data on soil characteristics in the model domain. As a result of these models, concentrations of the considered pollutants in a particular area are obtained, which is of interest for assessing ambient air quality and which depends on the type of model applied.

Models are more reliable to estimate average concentrations of longer time periods than shorter ones, for a given location. They are acceptably reliable in estimating the value of the highest concentration that occurs at some time within the observed area. Modeling generally requires three types of information:

- on the source of emissions,
- on the meteorology of the area under observation,
- about receptors (terrain characteristics).

2.2 Gaussian dispersion models

Gaussian diffusion models are most commonly encountered in methodological research and practice. First of all, it should be said that this Gaussian model is quite empirical. Gaussian diffusion models are the models most commonly applied in practice, the main reasons for the application of these models are, first of all, ease of application as well as relatively good match with physical experiments. Gaussian models start from the assumption that the distribution of the concentration of a passive substance in the plume has a certain mathematical form, so they contain the Gaussian diffusion equation, which, in fact, represents a solution of the Fick diffusion equation with constant coefficients. At the base of the Gaussian smoke plume model lies the equation:

$$C(x,y,z)=\frac{Q}{2\pi u\sigma_y\sigma_z}\exp\left(-\frac{y^2}{2\sigma_y^2}\right)\left\{\exp\left(-\frac{(z-H^2)}{2\sigma_z^2}\right)+\exp\left(-\frac{(z+H^2)}{2\sigma_z^2}\right)\right\}$$

where:

$C(x, y, z)$	- concentration of pollutant at point (x,y,z) [g / m^3]
Q	- mass flow of pollutant at the emitter [g / s]
u	- wind speed [m / s]
σ_y , σ_z	- standard deviation of the smoke plume cross-section [m]
H	- effective stack height [m]
x	- distance from the source, in the direction of wind blowing [m]
y	- horizontal distance from the smoke plume centerline [m]
z	- distance from the ground [m]

For an easier understanding of the principles of Gaussian models operation, i.e. the coordinate system used in them, Figure 2.1 provides a schematic view. In these models, the coordinate origin is the discharge itself, i.e. the emitter, while the calculation of the concentration and the expansion of the smoke plume is observed in the *x*, *y* and *z* direction.

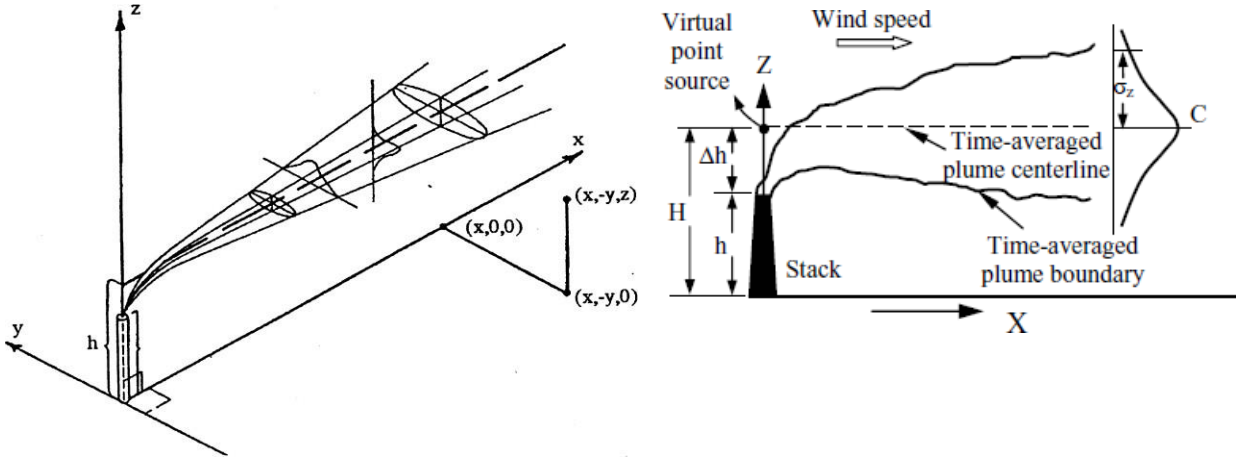


Figure 2.1 Gaussian coordinate system layout at Gaussian distribution in horizontal and vertical direction

H is the effective height of the stack (taking into account the plume rise Δh, up to which the smoke plume rises above the physical height of the stack *h*, i.e. $H = h + \Delta h$), while σ_y and σ_z are parameters of normal distribution in y and z directions, which are also called dispersion coefficients in y and z directions.

The Gaussian equation implies that the smoke plume expands according to the principle of Gaussian distribution in the horizontal and vertical planes. The standard deviation of the distribution of pollutants concentrations in the smoke plume in the horizontal (transverse) plane is denoted by $sigma_y$ (σy) and the corresponding distribution of concentration in the vertical plane is denoted by $sigma_z$ (σ_z). These are often referred to as, as already mentioned, dispersion or diffusion coefficients. The values of diffusion coefficients vary depending on the height above the soil surface, soil roughness, wind speed and distance from the emitter. The values of diffusion coefficients are usually determined based on atmospheric stability classes.

The model introduces the following assumptions:
1. The emission value is constant;
2. The dispersion (diffusion) in the direction (*x*) of wind blowing is negligible;
3. Meteorological conditions in the horizontal plane are constant throughout the model domain. For each modeled hour:
   a. The mean wind speed is used.
   b. The wind direction is constant.
   c. The temperature is constant.
   d. The atmospheric stability class of the atmosphere is constant.
   e. The mixing height is constant.
4. There is no change in the vertical gradient of the wind speed.
5. The characteristics of the smoke plume are finite (the smoke plume is independent for each hour, and the values originating from the previous hour have no effect on its characteristics).

6. Pollutants are viewed as inert gases or aerosols that remain suspended in the air following turbulent atmospheric movements.
7. Dispersion in the transverse (*y* direction) and vertical (*z* direction) is formed in the form of a Gaussian distribution around the central line of the smoke plume.

2.3 Description of the model used in this Study

In order to analyze the impact of the waste incineration plant on air quality in the wider domain of the location of the chemical industry complex in Prahovo, the AERMOD software package was used, otherwise a model based on the Gaussian distribution and recommended by the EPA (U.S. Environmental Protection Agency). AERMOD includes a wide range of opportunities to model the impact of pollutants on air pollution. This model gives the possibility to model a number of pollution sources including point, line, surface and volume. The model contains algorithms for analyzing aerodynamic flow near and around buildings (*building downwash*). The values of pollutant emissions from sources may be treated as constants during the analysis period, or they may vary during the month, observed period, hour or some optional change time.

The results presented in this Study were achieved using a model that included the emissions of particulate matter (PM10 and PM2.5) of SO_2, NO_2, CO, HF, HCl, NH_3, Hg, PCDD/F. These pollutants, depending on the scenario, are emitted from various point and surface sources, of both companies operating within the chemical industry in Prahovo, i.e. Elixir Prahovo and Phosphea, both for the current situation and after the construction of the plant in question. During modelling, other emission sources were not considered, nor was background pollution involved. It is necessary to emphasize that the aim of this modeling and the Study is not to show the air quality in the observed area, but to give a representative assessment of the impact of the thermal treatment plant on air quality in the observed model domain.

AERMOD is a stationary plume model, which starts from the assumption that in a stable boundary layer, the concentration of pollutant in both vertical and horizontal directions can be described by the Gaussian distribution. In the convective boundary layer, in the horizontal direction it is assumed that the concentration of the pollutant takes the Gaussian distribution, while the vertical distribution is described with the bi-Gaussian probability density function. In addition, in the convective boundary layer, AERMOD considers "plum-lofting", where part of the mass of the smoke plume, released from the buoyancy source, rises and remains near the top of the boundary layer before mixing in the convective boundary layer. AERMOD also monitors any mass of smoke plume penetrating the raised stable layer and then allows it to re-enter the boundary layer when and if possible.

Figure 2.2 shows the flow and processing of information in the AERMOD software package. The model consists of one main program (AERMOD) and two preprocessors (AERMET and AERMAP).

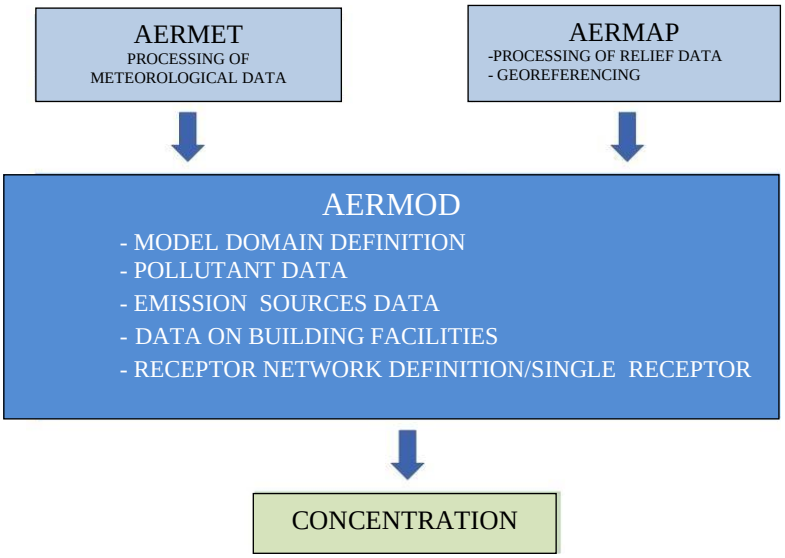


Figure 2.2 Flow and processing of information in the AERMOD software package

The main purpose of the AERMET preprocessor is to determine, on the basis of representative meteorological measurements in the model domain, the boundary layer parameters used to estimate the wind, turbulence and temperature profiles for the needs of the model. The surface layer parameters, which are given by AERMET, are Monin-Obukhov length, surface friction velocity, surface roughness, surface heat flux and convection velocity. AERMET also provides estimates of the height of the convective and mechanical mixed layer.

Although AERMOD has the ability to estimate meteorological profiles with data of only one measurement height, it will use as much data as the user can provide to define the vertical structure of the boundary layer.

Given that it is very difficult to present the actual relief as a set of idealized terrain characteristics and connect it to each receptor, AERMAP (terrain preprocessor for AERMOD), functions from the receptor point of view and takes into account the terrain characteristics around each receptor to objectively determine the representative terrain height associated with a specific receptor. The AERMAP terrain preprocessor uses terrain data to calculate the impact of terrain height. The height of the terrain is uniquely defined for each receptor at the site and is used to calculate the height of the streamline. The data network required for AERMAP is obtained from the DEM model (Digital Elevation Model). AERMAP is also used to create a receptor network. The altitude for each receptor is automatically assigned through AERMAP. For each receptor, AERMAP defines as input data for AERMOD: the location of the receptor, its altitude, and the specific scale of the receptor terrain.

The emission modelling procedure included the following procedures:
1. Development of a plant plan, including sources and facilities;
2. Defining the model domain and receptor location;
3. Preparation of emission inventories of all observed emitters;
4. Characterization of the type of source;
5. Entering and analyzing building data;
6. Processing the necessary meteorological data;
7. Processing of field data;
8. Modeling and analysis of results.

2.4 Terrain data

AERMOD includes significant flexibility in receptor location specification. The user has the option of specifying a complex receptor network in the analysis, whereby a combination of *Cartesian* and polar receptor networks is also possible. When modeling, AERMOD takes into account the terrain relief as well as the height of the receptor in relation to the existing terrain. Terrain elevation data are key to characterizing variability in terrain height, sources, buildings, and receptors in the model domain. Terrain elevations affect emission concentrations by moving the plume bisector closer or further away from the receptor. Computer models accept a digital data file from which elevation data can be interpolated. When creating the model, the Digital Elevation Model (DEM) data was entered into AERMOD, which assigned elevations to receptors, sources and buildings.
During modelling for the purposes of this Study, AERMAP-processed NASA digital maps SRTM1 - Shuttle Radar Topography Mission (resolution ~30m, 1 arc-sec) were used (Figure 2.3).

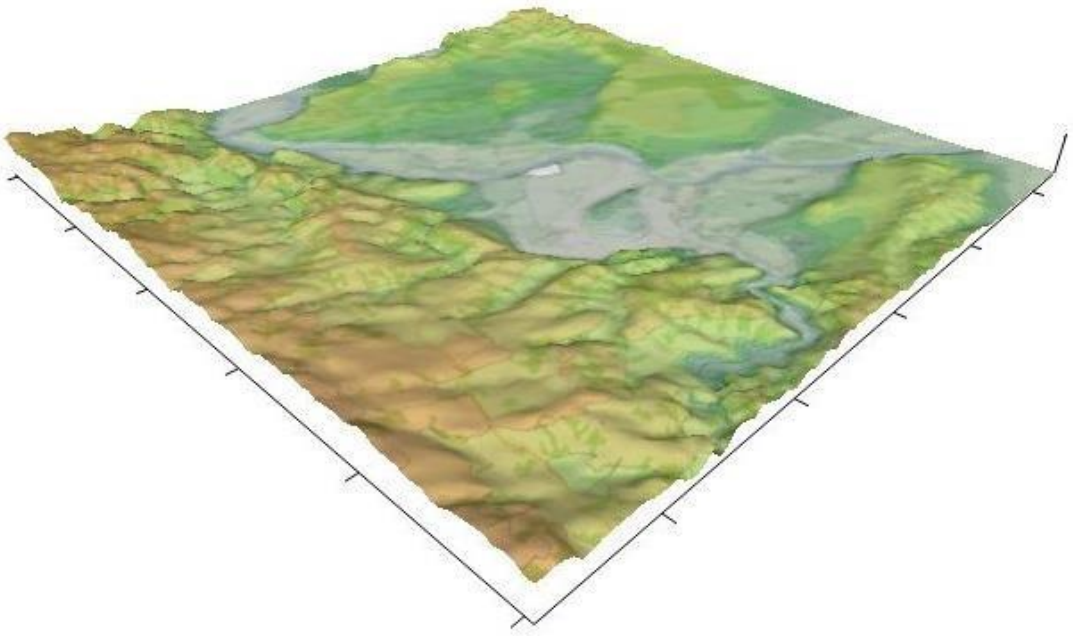


Figure 2.3 Overview of Processed 3D Model Domain Terrain

In addition to the terrain elevation, it was necessary to define the locations and intervals between the receptors as well as the plant based on the Universal Transverse Mercator – UTM coordinate system. Receptors are usually positioned on a grid, as well as on certain specific locations (*discrete*). The receptor network covers a large area, while individual receptors can be defined as objects of special interest (e.g., school, hospital, or nearest neighboring property).

The modelling for the purposes of this Study included an impact zone of 50 km x 50 km, i.e. an area of 2500 km^2 (Figure 2.4). When creating the model, the **Cartesian coordinate system with variable distance (Multi-Tier Grid)** between adjacent points (receptors) was used, as follows:

20m	at a distance of up to 3000 m from the emitter,
100 m	at a distance of up to 5000 m from the emitter,
250 m	at a distance of up to 10000 m from the emitter
1000 m	at a distance of up to 25000 m from the emitter,

which makes a total of 104121 receptors, which are defined by *x* and *y* coordinates expressed in meters and in the Cartesian coordinate system.

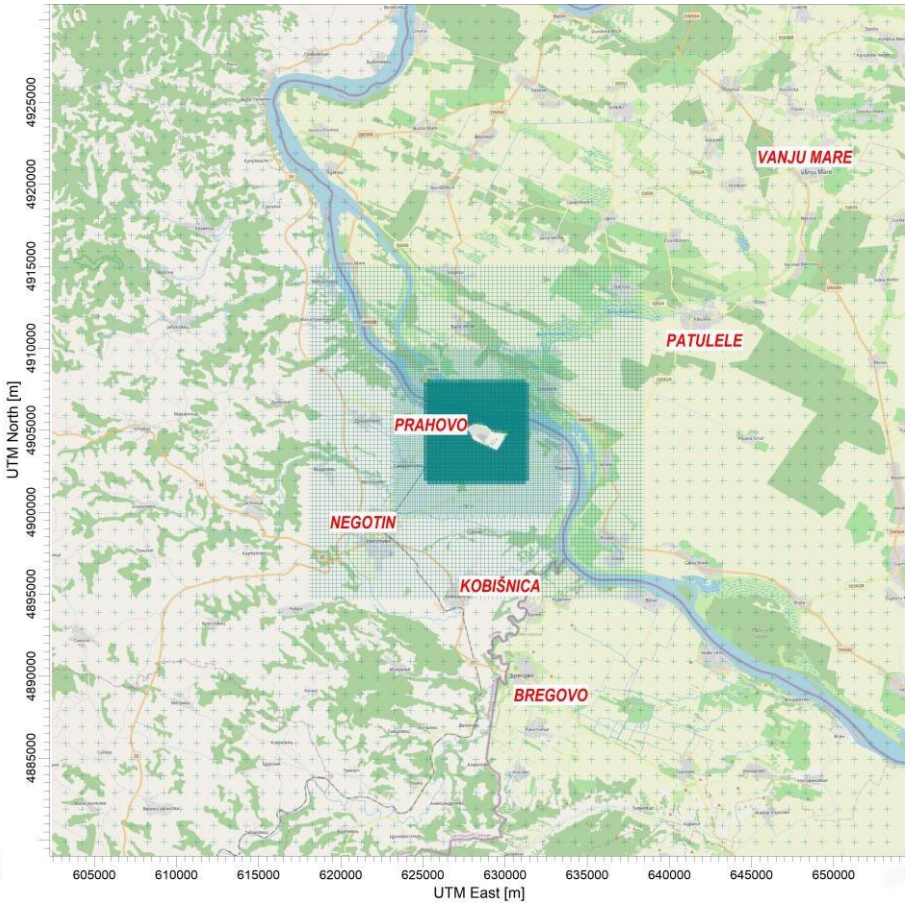


Figure 2.4 Display of 2D model domain terrain and UTM coordinate system

2.5 Meteorological data

AERMET, meteorological preprocessor, prepares hourly values of surface and upper atmosphere data for use in AERMOD. Input data to AERMET are data on surface observations of hourly values of surface level parameters, which include, among other things, wind speed, temperature and cloud cover, while the data file on the upper layers of the atmosphere provides information on the vertical structure of the atmosphere. This includes layer height, pressure, temperature and relative humidity.
The meteorological data used to develop this study include hourly values of:

- wind speeds,
- direction of wind blowing,
- air temperature,
- relative humidity,
- atmospheric pressure,
- cloud cover.

In order to define local prevailing meteorological parameters, WRF-MMIF hourly meteorological data for a specific location (Prahovo Chemical Complex) and for a period of five consecutive calendar years (from 2017 to 2021) were procured from *Lakes Environmental Consultants* from Canada. This dataset consists of information on the surface and upper atmosphere layers, which are required to run the dispersion model. Figures 2.5-2.10 show the analysis of the wind rose (wind blowing direction) and the analysis of the wind blowing frequency, based on meteorological data for the period 2017-2021.

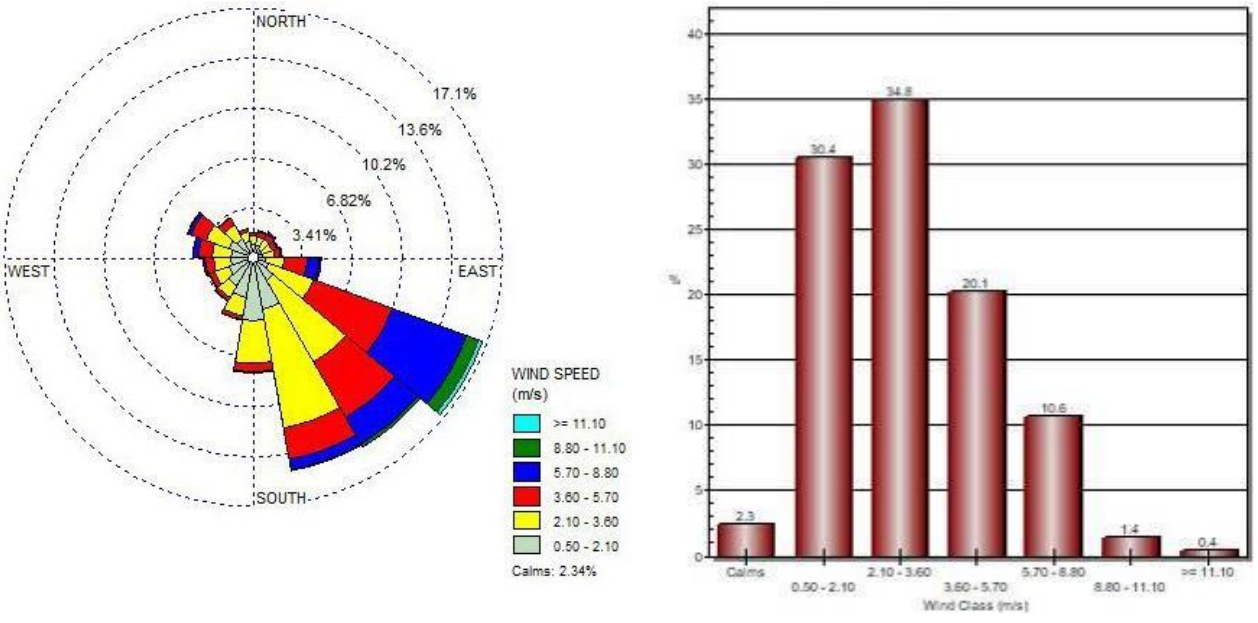


Figure 2.5 Wind Rose and Frequency Diagram 2017-2021

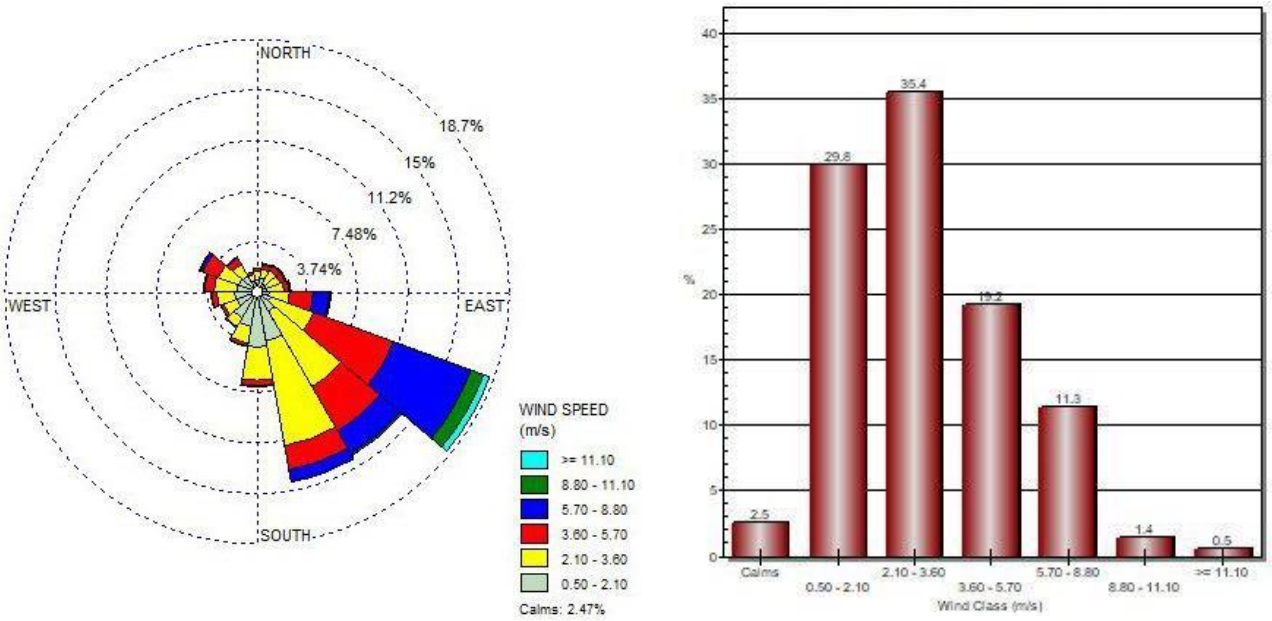


Figure 2.6 Wind Rose and 2017 Frequency Diagram

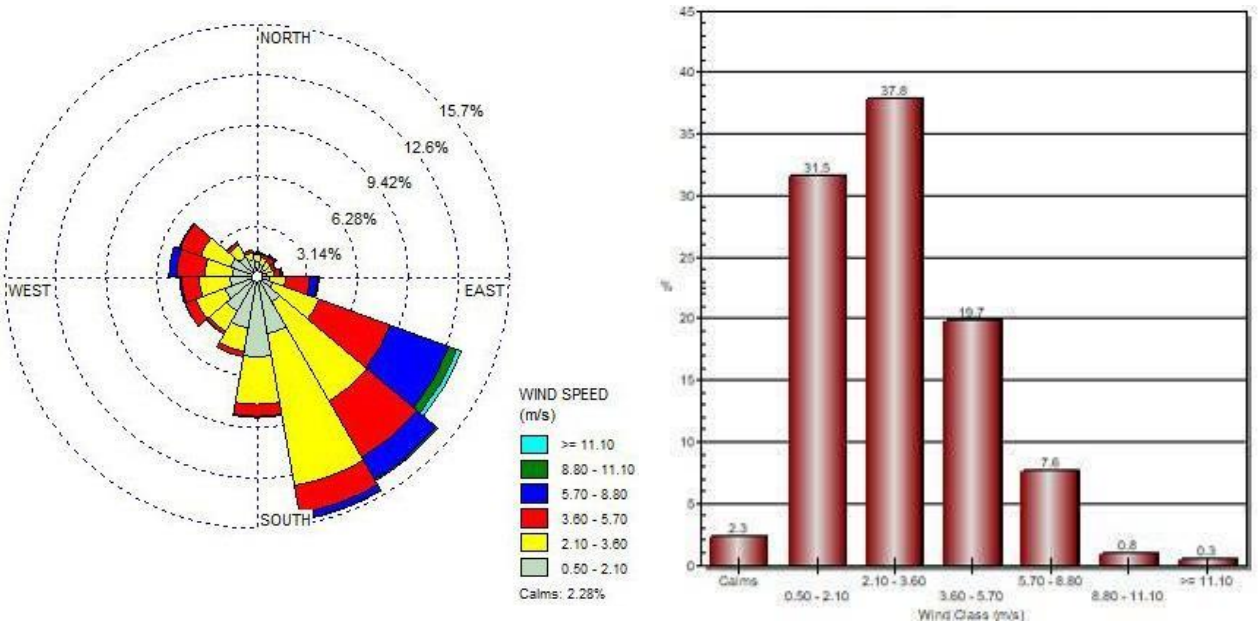


Figure 2.7 Wind Rose and 2018 Frequency Diagram

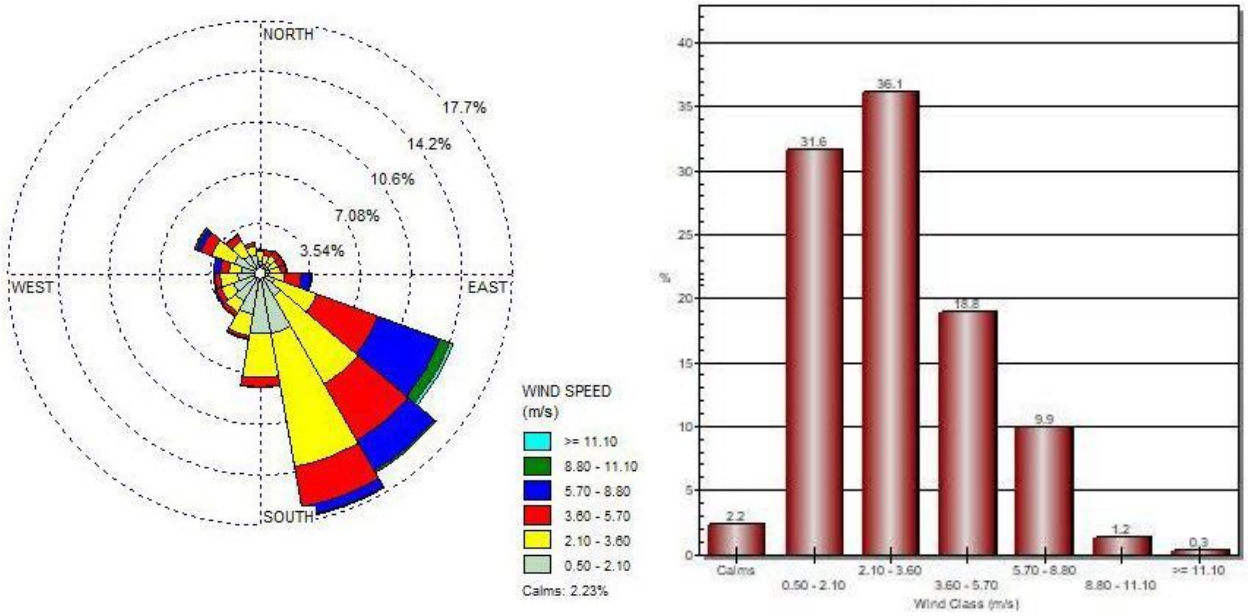


Figure 2.8 Wind Rose and 2019 Frequency Diagram

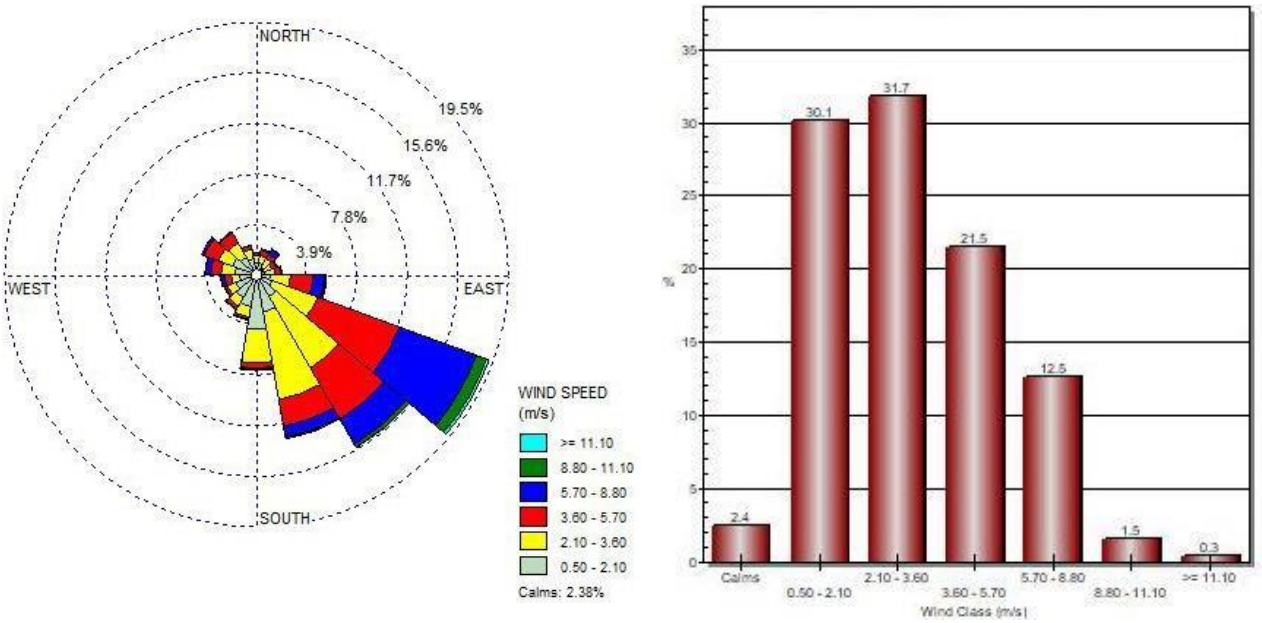


Figure 2.9 Wind Rose and 2020 Frequency Diagram

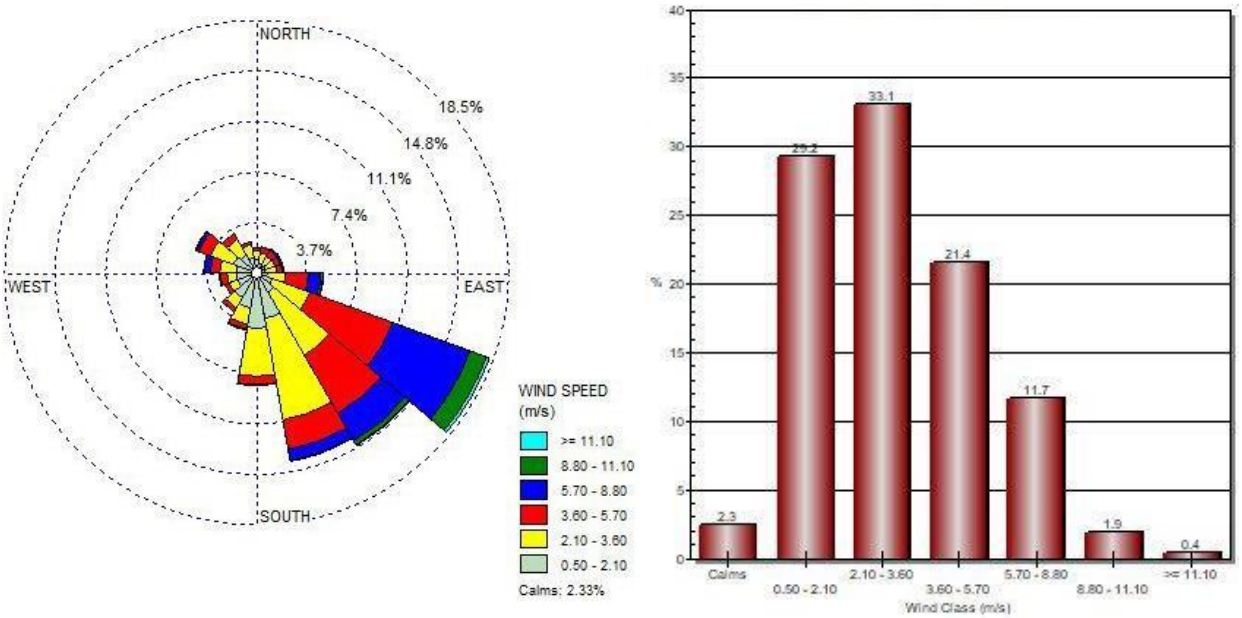


Figure 2.10 Wind Rose and 2021 Frequency Diagram

2.6 Source characteristics

Data on emission sources for the current state and condition after the construction of the plant on the wider domain of the chemical industry complex location in Prahovo, used as input parameters for the model, are given in Appendix I of this Study.

The running time of each project activity is also of great importance for an adequate assessment of the subject plant impact on air quality. In order to model the most unfavorable conditions, during the development of the model, the assumption was introduced that all point sources emit during 24 hours, 365 days a year at full capacity, which is certainly not the case. Therefore, the results obtained by the model, i.e. the expected ground-level concentration of pollutants in the observed area, are higher than real values. Speaking to surface emission sources, i.e. phosphogypsum storage and landfill of non-hazardous waste, these are dependent on the wind speed, as shown in Appendix I of this Study. Considering the characteristics of the solidificate to be deposited, the expected emissions of powdered substances from the landfill of non-hazardous waste will be practically negligible, and they may possibly occur from limited areas in combination with cracking of the surface layer of the solidificate, due to the movement of the truck over the landfill body, and the blowing of strong winds. For the purposes of modeling, a very conservative case was considered, that is, the degree of spreading out decay of 95% and that the aeolian erosion occurs from the entire surface of the landfill due to movement of the machinery at the time of opening Phase 2 of the landfill. Given the introduced assumptions, the results of modeling the dispersion of powdered substances from the landfill of non-hazardous waste will certainly be higher than real ones.

When modeling, it is also necessary to take into account the construction facilities on the site, since, with their dimensions, they can greatly affect the dispersion of pollutants. *Building Downwash* is a phenomenon that occurs when buildings or objects are located as an obstacle in the path of movement of the smoke plume. In this case, the streamlines will rise from the building on the side facing the wind, and descend down the leeward side. The decrease in the speed of movement and friction resistance occur immediately behind the building, and the consequence is the reverse movement of the trajectories at the level of the terrain, whereby recirculation is created – the region of the cavity. Turbulence decreases with increasing distance from the building.

In order to successfully take into account the possible occurrence of the *downwash* effect , it is necessary to have the following data on the facilities in the vicinity of the emitter:

- geographic coordinates of the observed objects,
- orientation of objects in relation to emitters,
- characteristic dimensions of the facilities.

For the needs of this Study, also using AERMOD, a 3D model of the chemical industry complex was developed, the model includes only facilities important for dispersion modeling, i.e. facilities where the *downwash* effect can occur. Figures 2.11a and 2.11.b show a 3D model of the most important construction facilities for the current and future state of the chemical industry complex, as well as all emission sources considered by this Study.

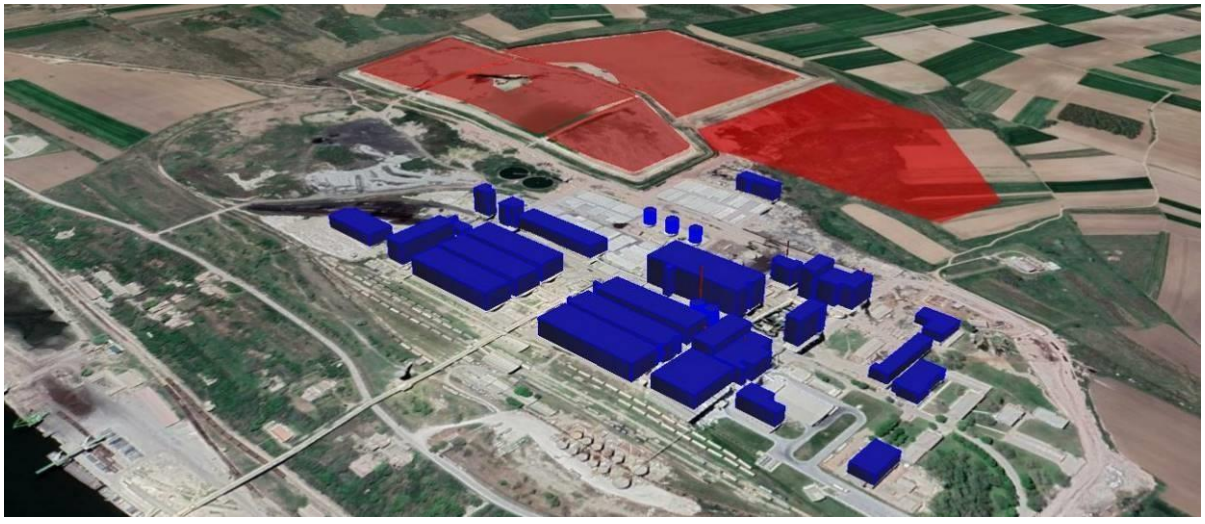


Figure 2.11a 3D model of the chemical industry complex in Prahovo, current state

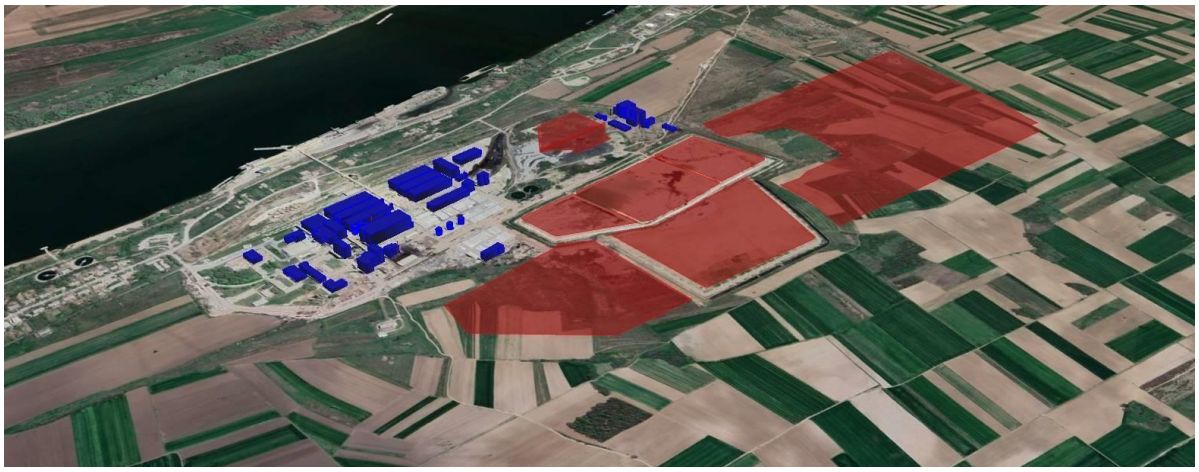


Figure 2.11b 3D model of the chemical industry complex in Prahovo, future state

2.7 Air quality requirements

In order to assess the impact of a plant on air quality, it is necessary to compare the results obtained by modeling with the appropriate air quality requirements prescribed by national legislation. Table 2.3 provides an overview of the limit values of pollutants, i.e. air quality requirements relevant to this Study. Decree on monitoring conditions and air quality requirements *(*Official Gazette Of the Republic of Serbia*"*, No. 11/10, 75/10 and 63/13) represents the basic national regulation for defining air quality. Limit values for polluting components that are not listed in this Decree and for which no limit values are prescribed, are indicated in the table and are given guideline limit values according to the relevant international regulations[1].

Table 2.3 Air quality requirements

Averaging period	*Limit value*
Sulfur dioxide (SO_2)	
One hour	350 µg/m^3, not to be exceeded more than 24 times in one calendar year
Single day	125 µg/m3, not to be exceeded more than 3 times in one calendar year
Calendar year	50 µg/m^3
Nitrogen dioxide ($NO2_)$	
One hour	150 µg/m^3, not to be exceeded more than 18 times in a calendar year
Single day	85 µg/m^3
Calendar year	40 µg/m^3
Carbon Monoxide (CO)	
Maximum daily eight-hour mean	10 mg/m^3
Single day	5 mg /m^3
Calendar year	3 mg/m^3
Mercury (Hg)[1]	
Single day	2 µg/m^3

[1] Ambient Air Quality Criteria, Ontario Ministry of the Environment, Conservation and Parks, 2020.

PM10	
Single day	50 μg/m^3, not to be exceeded more than 35 times in one calendar year
Calendar year	40 μg/m^3
PM2.5	
Calendar year	25 μg/m^3
Ammonia (NH_3)	
Three hours	200 μg/m^3
Single day	100 μg/m^3
Hydrogen chloride (HCl)	
Three hours	50 μg/m^3
Single day	15 μg/m^3
Calendar year	10 μg/m^3
Hydrogen fluoride (HF)	
Three hours	20 μg/m^3
Single day	3 μg/ μg/m^3
PCDD/F[1]	
Single day	0.1 pgTEQ/m^3

3. RESULTS

Bearing in mind that the models, within the framework of this Study, do not take into account background pollution, the results obtained by this modelling do not represent air quality in the area of the model domain, but only the contribution of the presented emitters of the plant in question to the overall air quality. The results, in the form of a graphical presentation of ground-level concentrations of pollutants (isopleths), are presented in accordance with the aforementioned legislation and the defined method of presentation and averaging periods.

It should be borne in mind that the results presented in this Study represent the highest possible ground concentrations of the considered pollutants, which are due to the most unfavorable operating parameters and the most unfavorable meteorological conditions during a given averaging period (1/3/8/24 hours) during five consecutive years (since 2017 to 2021). Namely, for each of the receptors, potentially the highest concentration for the corresponding averaging period over a period of five years is shown. Annual concentrations are shown based on the average for the total number of hours.

3.1 Current status

The current situation implies the operational condition of the factories within the chemical industry complex in Prahovo with all its existing point and surface sources (situation April 2024) with their characteristics as shown in Annex I of this Study, and does not take into account future waste incineration plants or other emission sources.

SO_2 concentration values obtained

Figures 3.1 and 3.2 show the isopleths of ground-level concentrations, which refer to the first maximum of possible SO_2 values for an averaging period of one hour, where the maximum observed concentration is 592 μg/m³, which is above the limit value of 350 μg/m³. This concentration, as well as the zone with the greatest impact for this period of averaging, is located practically immediately next to the northern border of the factory estates. Zones of similar surface area and with concentrations above 350 μg/m³ can be observed at the north-eastern and southern borders of the property, and are a direct consequence of the combination of certain meteorological conditions and characteristics of the emitters. Other parts of the model domain are below the limit values. The shown isopleths of ground concentrations, in Figures 3.3 and 3.4, refer to the 99.73 percentile of the maximum possible SO_2 values for an averaging period of one hour, where the maximum observed concentration is 209 μg/m³, which is far below the limit value of 350 μg/m³.

Since the percentile value of the first maximum for the averaging period of one hour is much lower than the first maximum itself, an additional analysis of the number of hours

exceeding the prescribed limit value for each of the receptors, and the results are graphically shown in Figure 3.5. Bearing in mind that the obtained results indicate that, for the considered period of five years, i.e. 43,824 h, the maximum number of hours at one of the receptors within the zones where exceedances of hourly averages can be expected for only three hours, it can be concluded that exceedances of hourly values can occur extremely rarely and only in extremely unfavorable meteorological conditions.

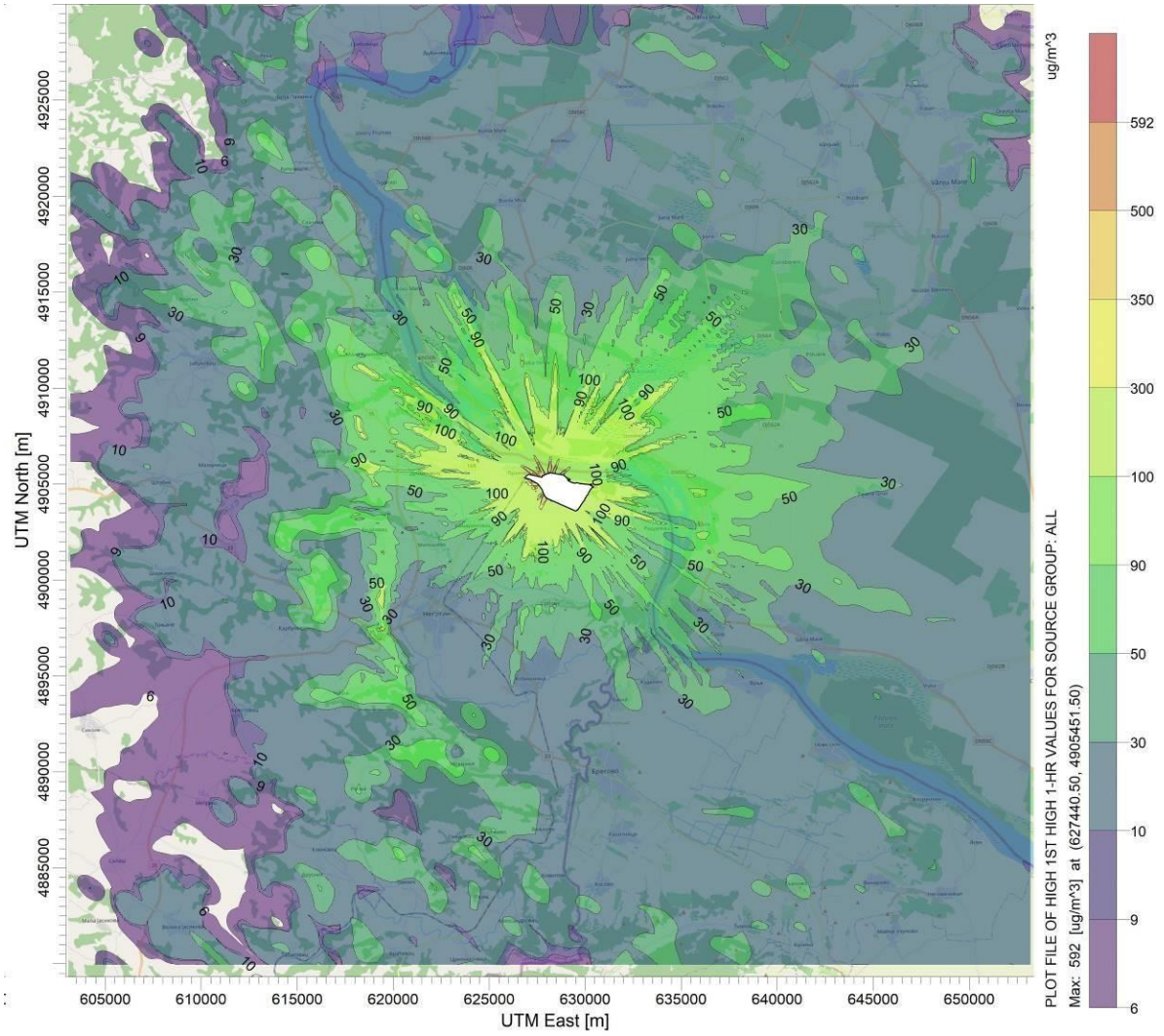


Figure 3.1 Maximum ground level concentrations (first maximum) of SO_2 for an averaging period of one hour [$\mu g/m^3$]

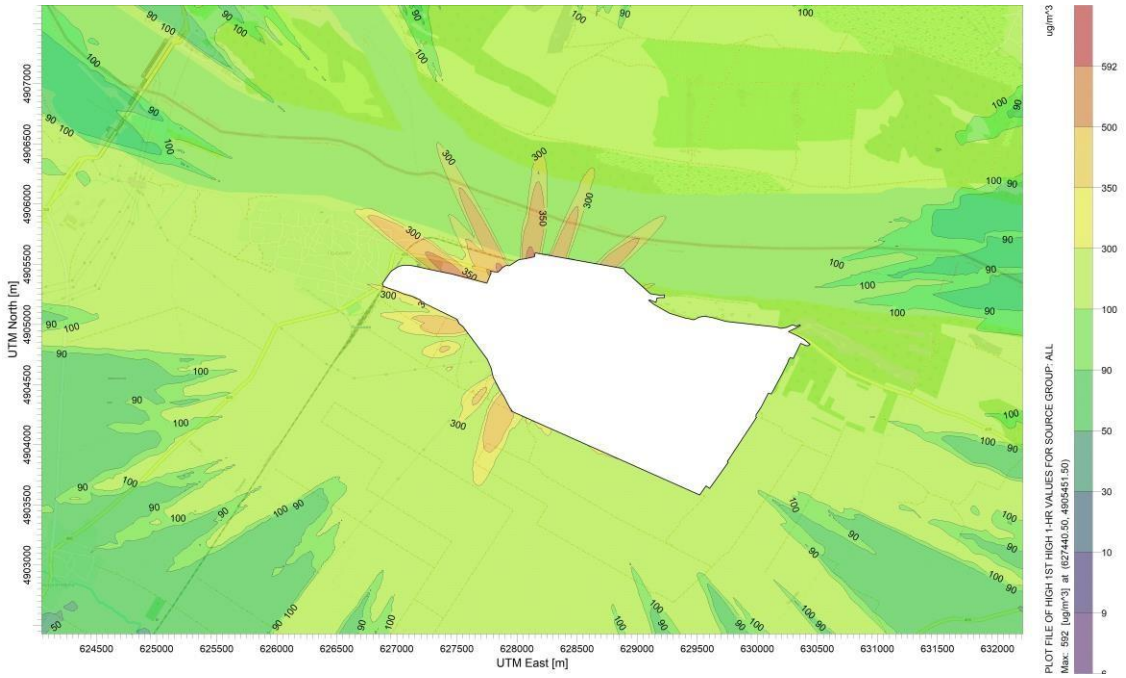


Figure 3.2 Maximum ground level concentrations (first maximum) of SO2 for an averaging period of one hour [μg/m3] (narrower factory location display)

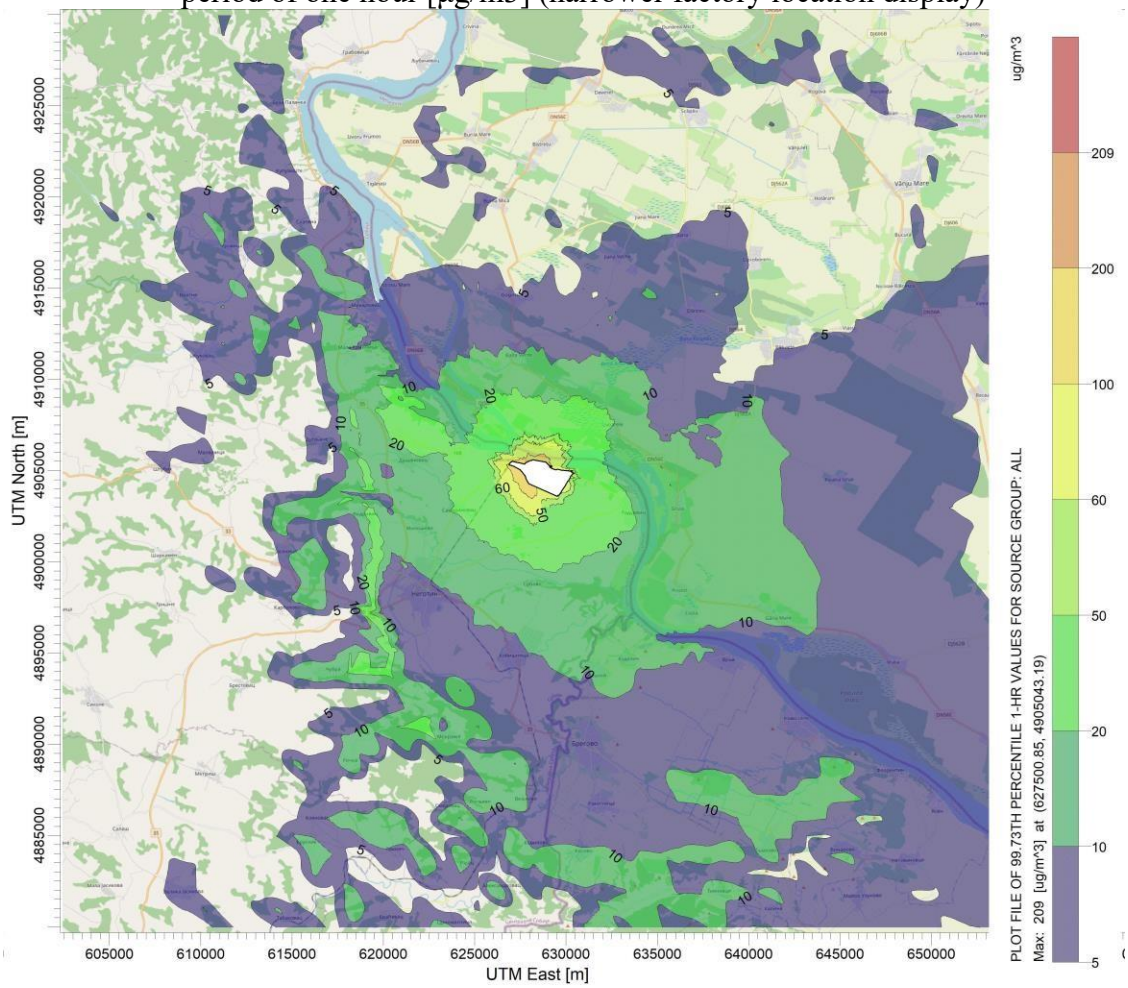


Figure 3.3 Maximum ground level concentrations (99.73 percentile) of SO_2 for an averaging period of one hour [$\mu g/m^3$]

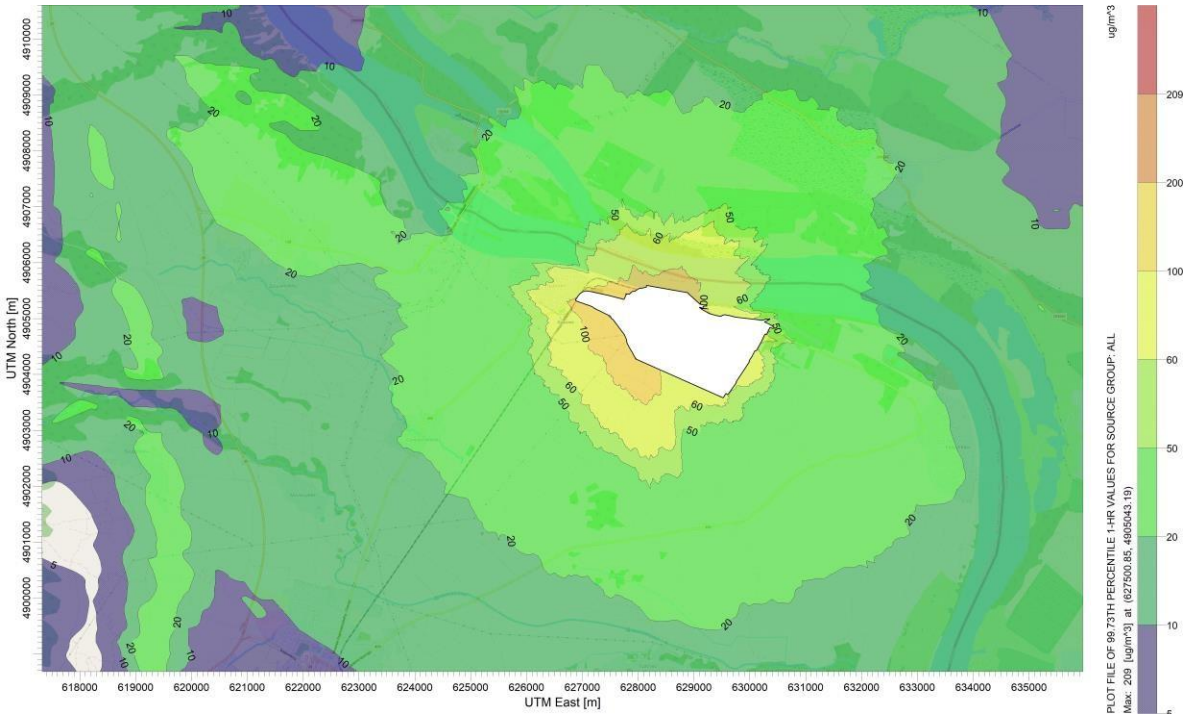


Figure **3.4** Maximum ground level concentrations (99.73 percentile) of SO_2 for an averaging period of one hour [μg/m^3] (narrower factory location display)

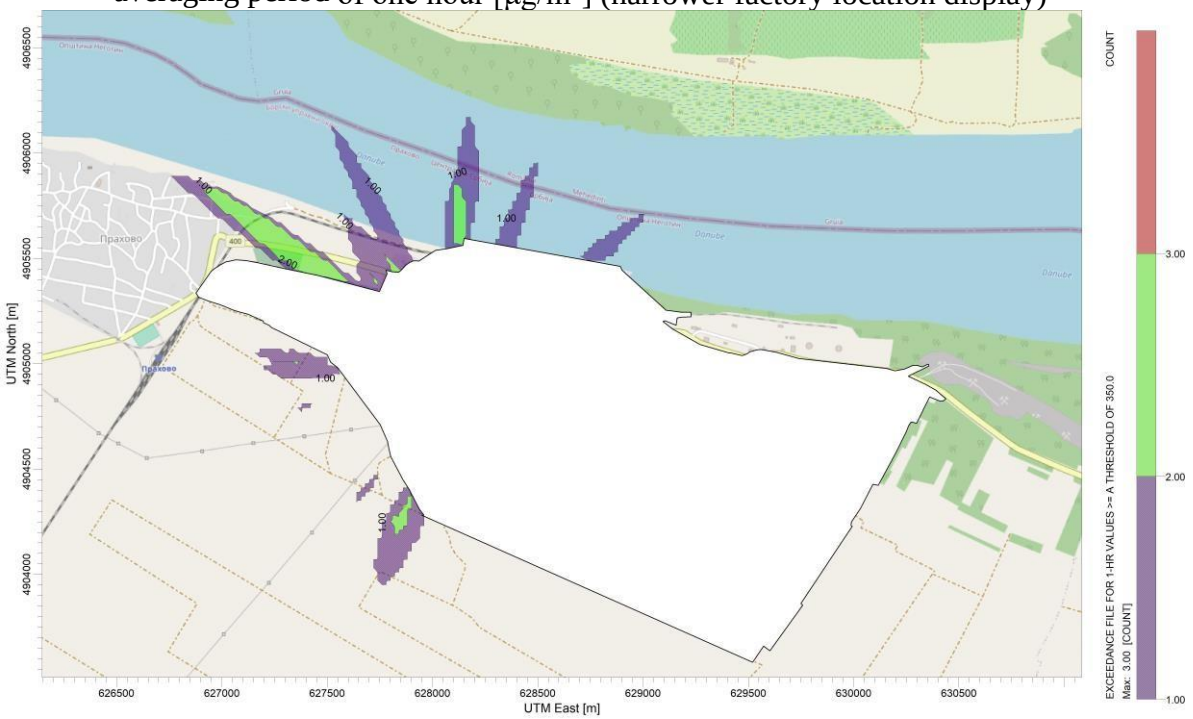


Figure 3.5 Number of SO2 limit exceedances for an averaging period of one hour

In support of the conclusion that extremely high concentrations of SO_2 for an averaging period of one hour can potentially occur very rarely and in short time intervals the results shown in Figures 3.6 to 3.8 where the first maximum and 99.18 percentile of the maximum possible values of SO_2 for an averaging period of one day are shown. Although the value of the first maximum (156 μg/m^3), which occurs immediately

at the western limit of property, above the limit value (125 μg/m^3) all other parts of the model domain remain far below the limit value. By further analysis of the obtained results, it was determined that for the considered period of five years, i.e. 43,824 h, for only one day it is possible to reach a concentration that is above the limit value, as indicated by the results of the 99.18 percentiles of the maximum possible SO_2 values for the averaging period of one day, where all values in the model domain are far below the limit value.

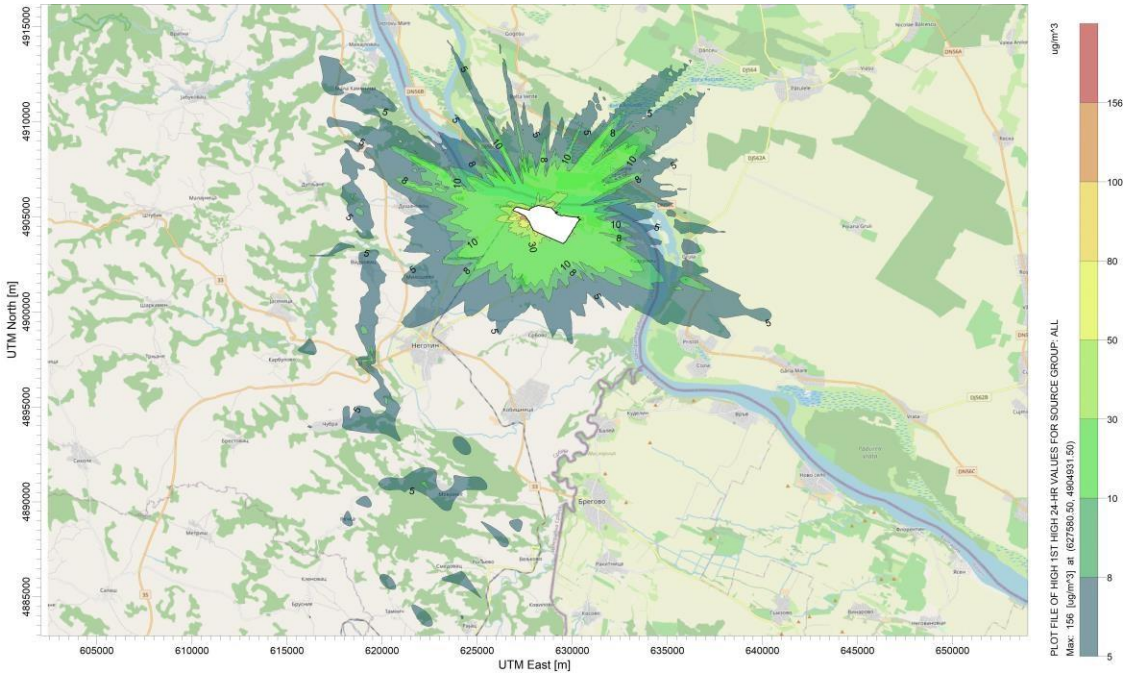


Figure 3.6 Maximum ground-level SO_2 concentrations for an averaging period of one day [μg/m^3]

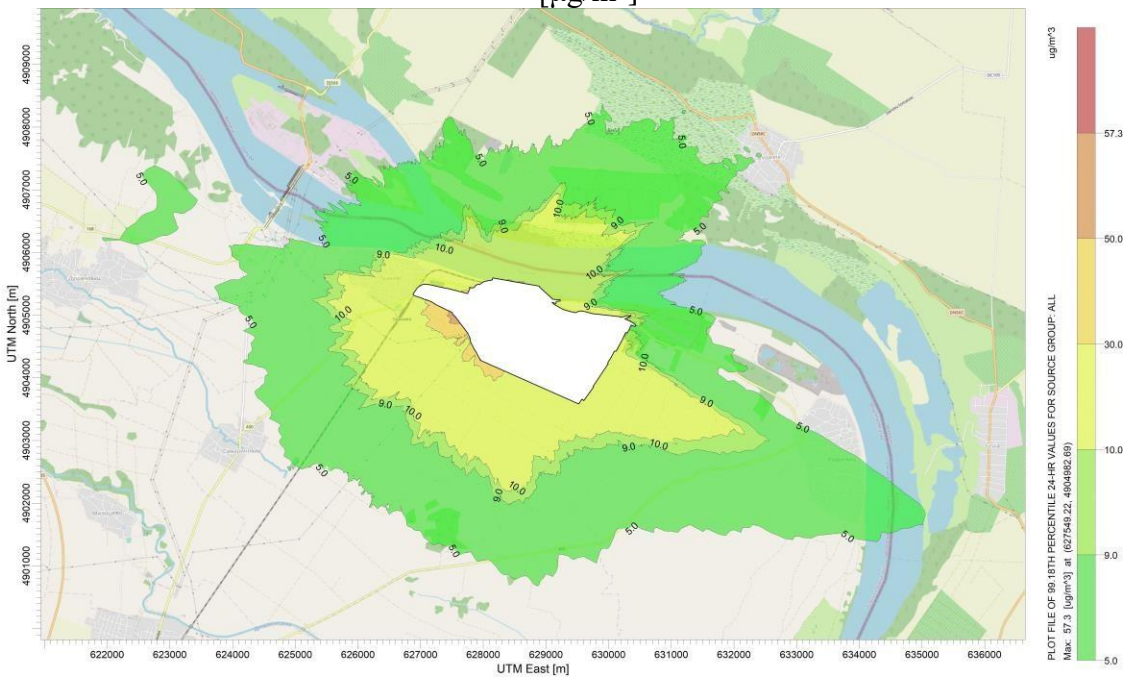


Figure 3.7 Maximum ground level concentrations (99.18 percentile) of SO_2 for the averaging period of one day [μg/m^3]

Figure 3.8 shows the results related to the annual averaging period, where the potential highest ground level concentration is 8.57 μg/m³, what leading to the conclusion that all receptors on the considered domain are under the influence of concentrations that are significantly below the prescribed limit values (50 μg/m³). Narrow zones with the highest annual concentrations are observed predominantly in the southern part of the property boundaries. Such low annual values indicate that despite periods with high episodic pollution, most are periods where the concentration of pollutants is at a low level.

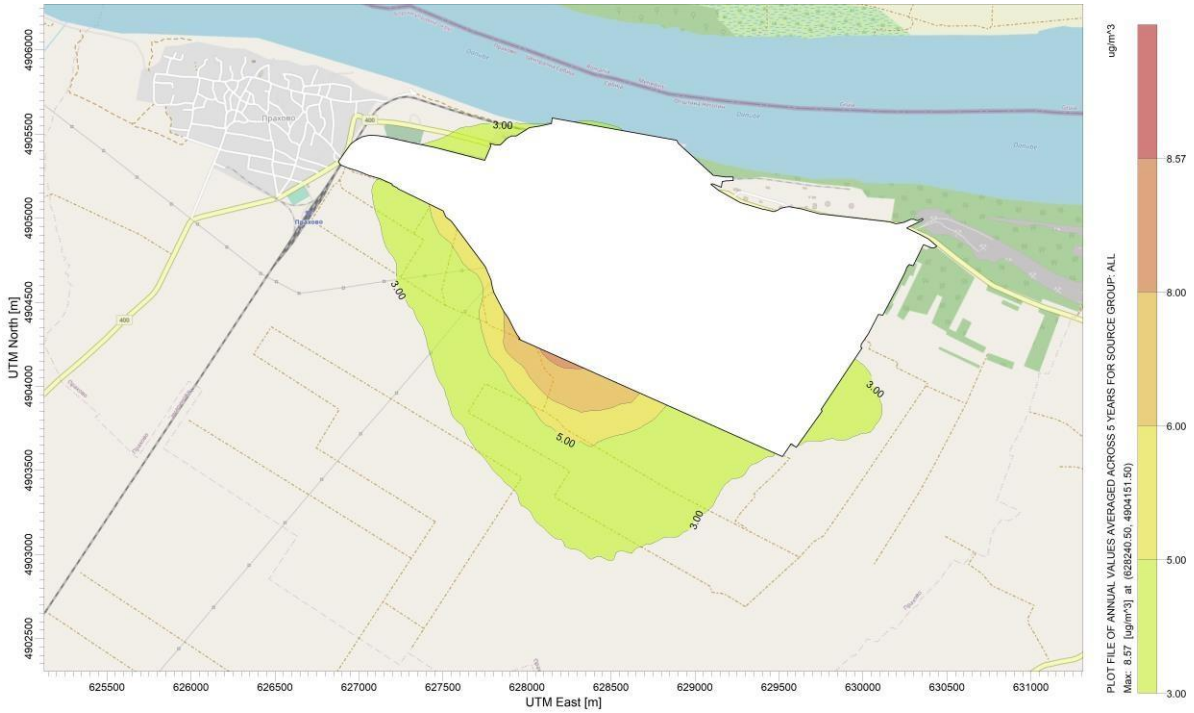


Figure 3.8 Ground-level SO_2 concentrations for the averaging period calendar year [μg/m^3]

NO_2 concentration values obtained

Figures 3.9 to 3.13 show the isopleths of ground concentrations, which refer to the first maximum and 99.79 percentile of the first maximum of possible NO_2 values for the averaging period of one hour, as well as the first maximum of the daily average and the annual average. The highest model values obtained for the averaging periods are: 127 $\mu g/m^3$, 44.8 $\mu g/m^3$, 31.1 $\mu g/m^3$ and 1.8 $\mu g/m^3$, respectively, for all averaging periods and all parts of the NO_2 concentration model domain are far below the prescribed limit values.

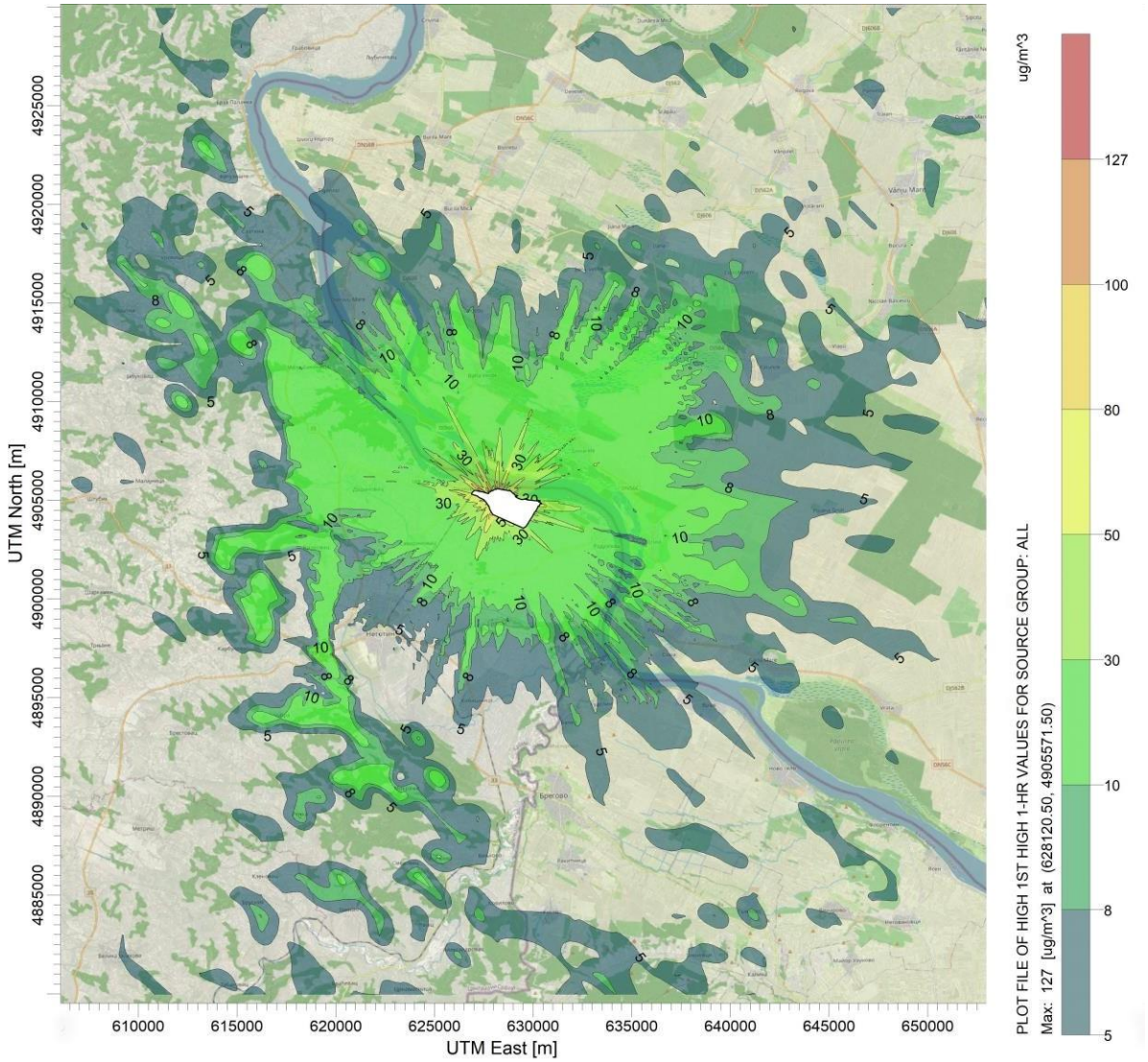


Figure 3.9 Maximum ground-level NO_2 concentrations for an averaging period of one hour [$\mu g/m^3$]

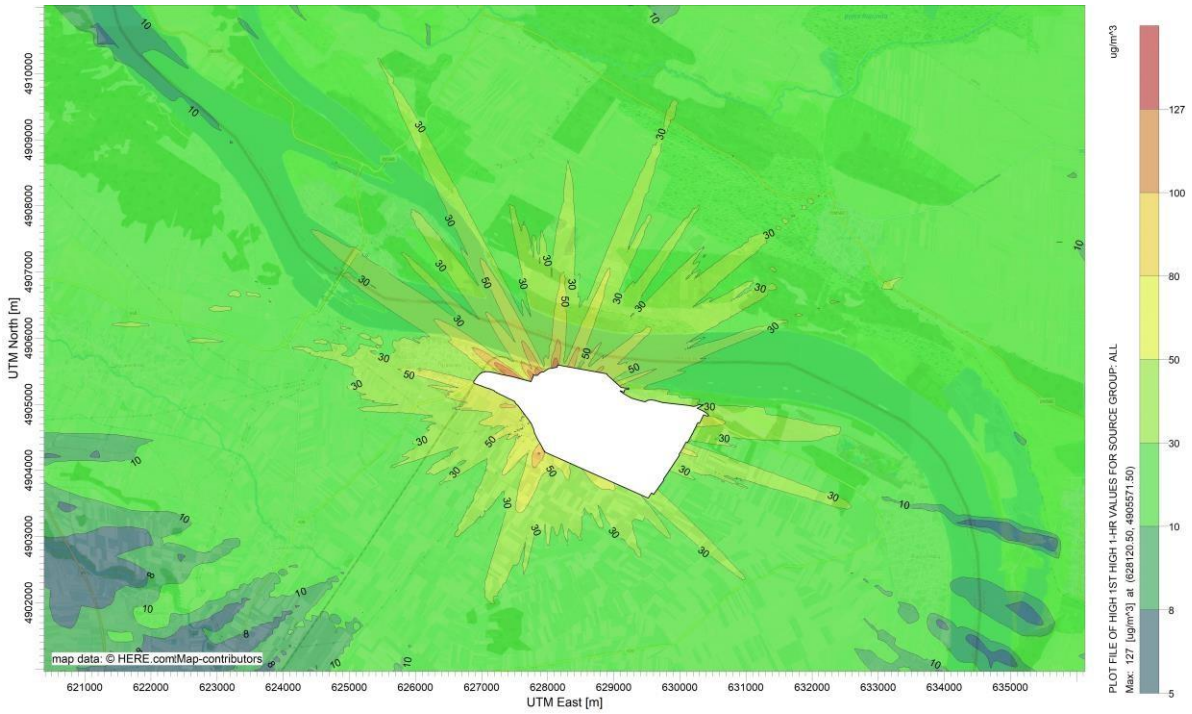


Figure 3.10 Maximum ground level concentrations of NO_2 for an averaging period of one hour [$\mu g/m^3$] (narrower factor y location display)

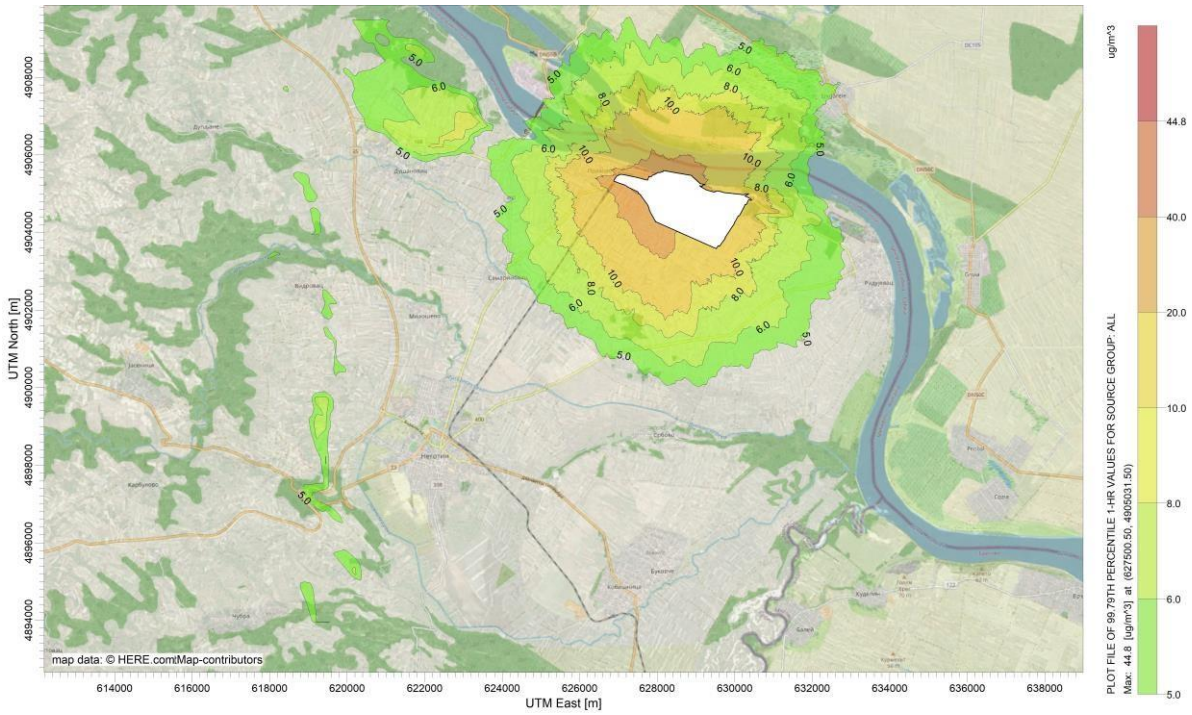


Figure 3.11 Maximum ground level concentrations (99.79 percentile) of NO_2 for an averaging period of one hour [$\mu g/m^3$]

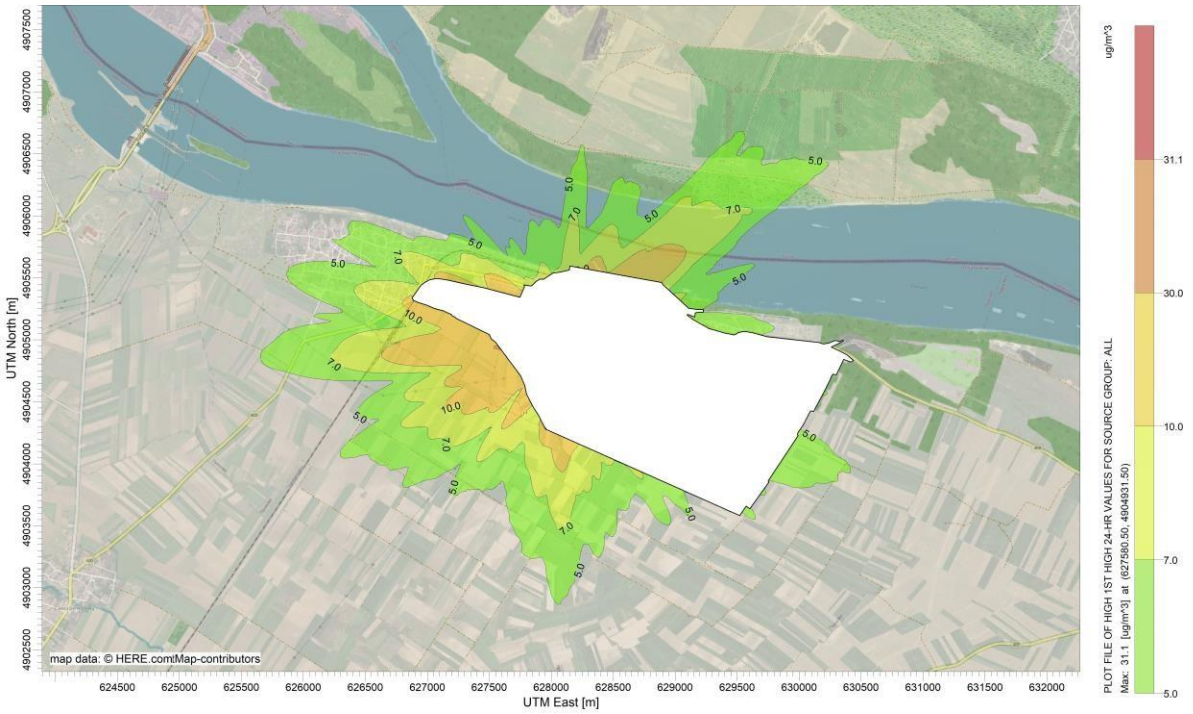


Figure 3.12 Maximum ground-level NO_2 concentrations for an averaging period of one hour [$\mu g/m^3$]

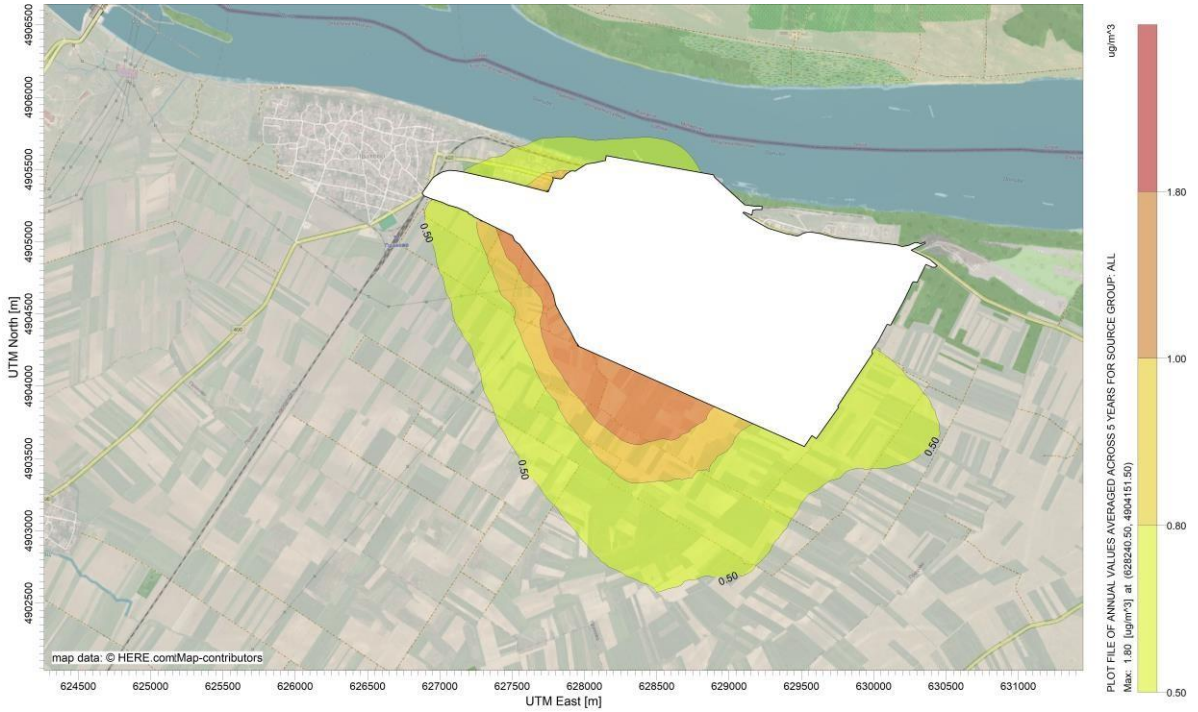


Figure 3.13 Ground-level NO_2 concentrations for the averaging period calendar year [$\mu g/m^3$]

Obtained PM 10 concentration values

Figures 3.14 and 3.15 show the isopleths of ground-level concentrations, which refer to the first maximum possible values of PM10 for the averaging period of one day, where the highest observed concentration is 111 μg/m³, which is far above the limit value of 50 μg/m³. This concentration, as well as the zone with the highest impact for this period of averaging, is located along the southern border of the factory property. Zones with high concentrations over 50 μg/m³ are a direct consequence of a combination of certain meteorological conditions and primarily surface emission sources or phosphogypsum landfills. Other parts of the model domain are below the limit values. Shown isopleths of ground-level concentrations, Figure 3.16 refers to the 90.40 percentile of the maximum possible PM10 values for the averaging period of one day, where the maximum observed concentration is 20.2 μg/m³, which is below the limit value.

Since the percentile value of the first maximum for the averaging period of one day is several times lower than the first maximum itself, an additional analysis of the number of days with exceeding the prescribed limit value for each of the receptors was performed, and the results are graphically presented in Figure 3.17. Bearing in mind that the obtained results indicate that, for the considered period of five years, i.e. 1,826 days, the maximum number of 29 days with exceeding at one of the receptors within the zones where daily averages can be expected to be exceeded, it can be concluded that exceeding the daily values can occur extremely rarely and only in extremely unfavorable meteorological conditions.

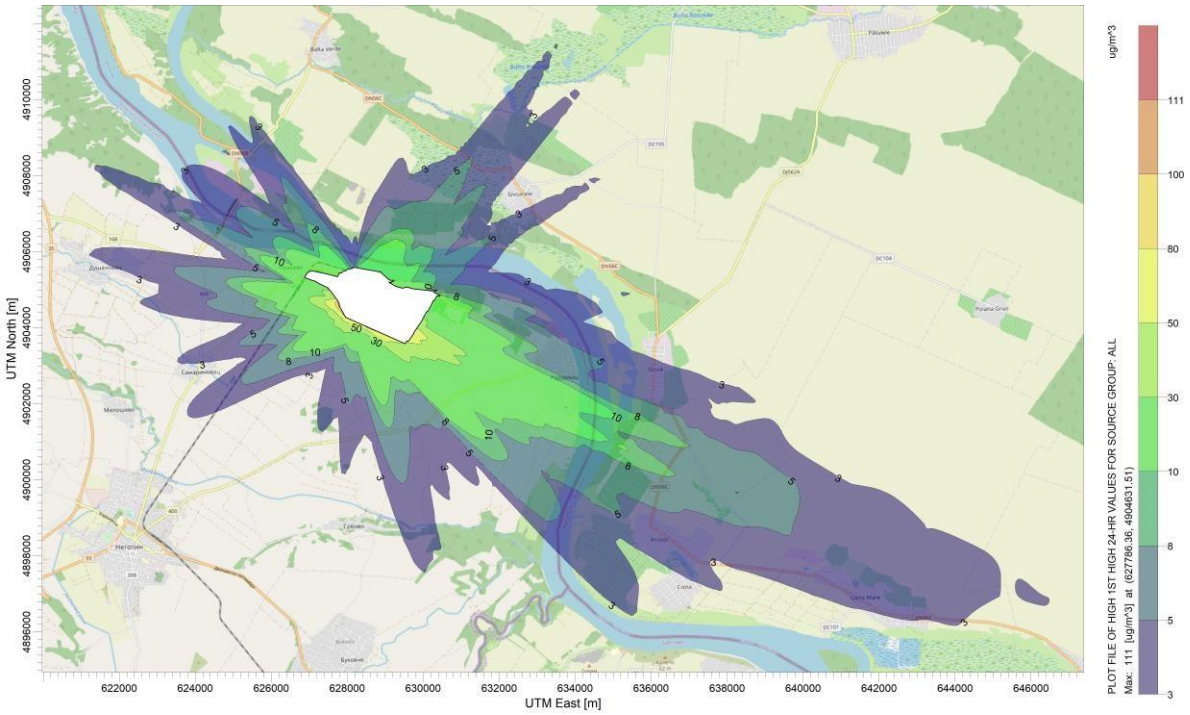


Figure 3.14 Maximum ground-level PM10 concentrations for an averaging period of one day [μg/m^3]

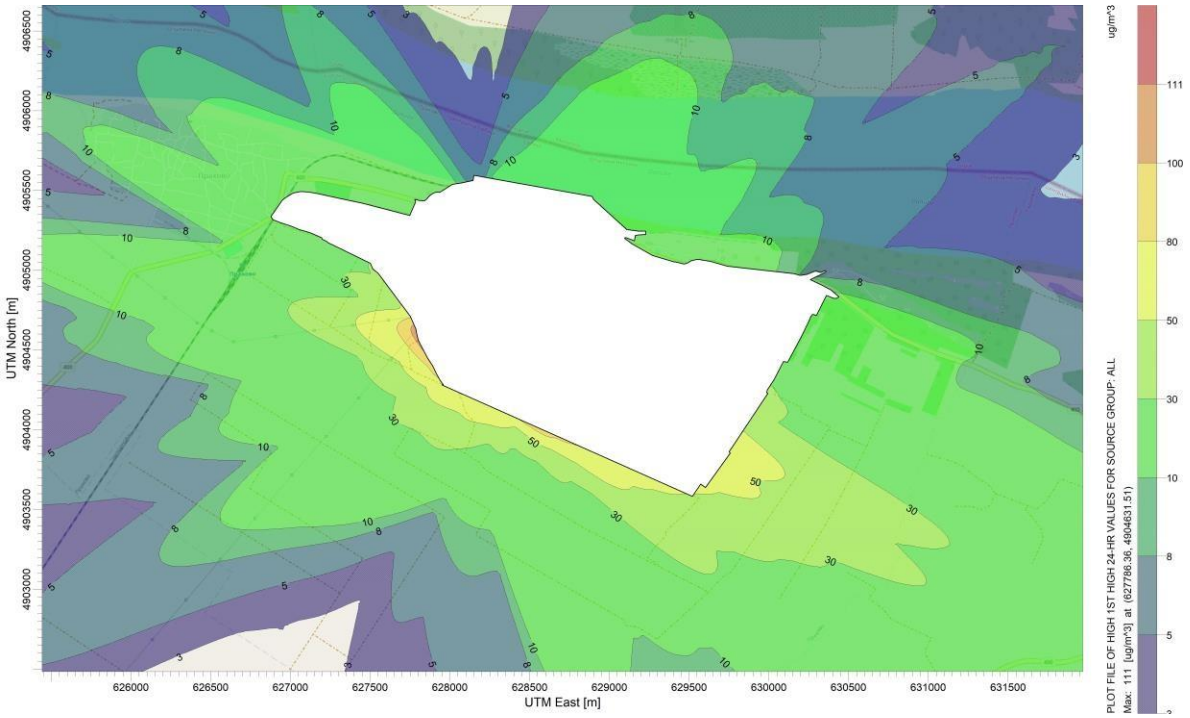


Figure 3.15 Maximum ground-level concentrations of PM10 for an averaging period of one day [μg/m^3] (narrower factory location display)

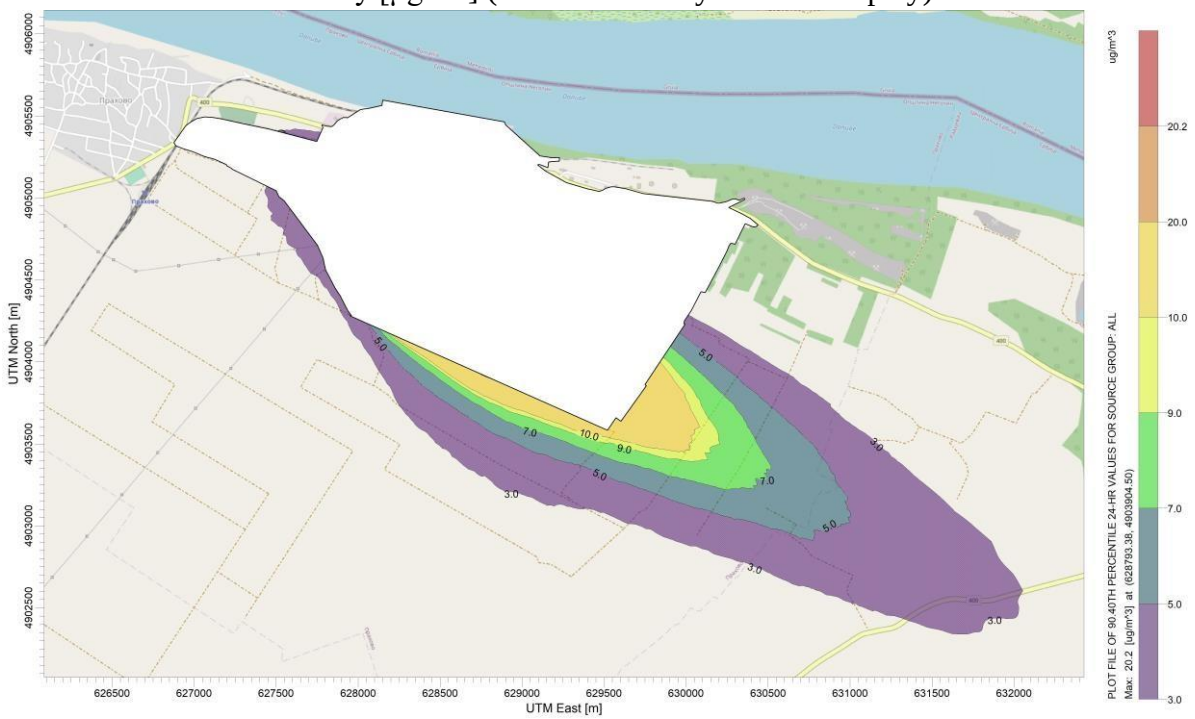


Figure 3.16 Maximum ground-level concentrations of PM10 (90.40 percentile) for a one-day averaging period [μg/m^3]

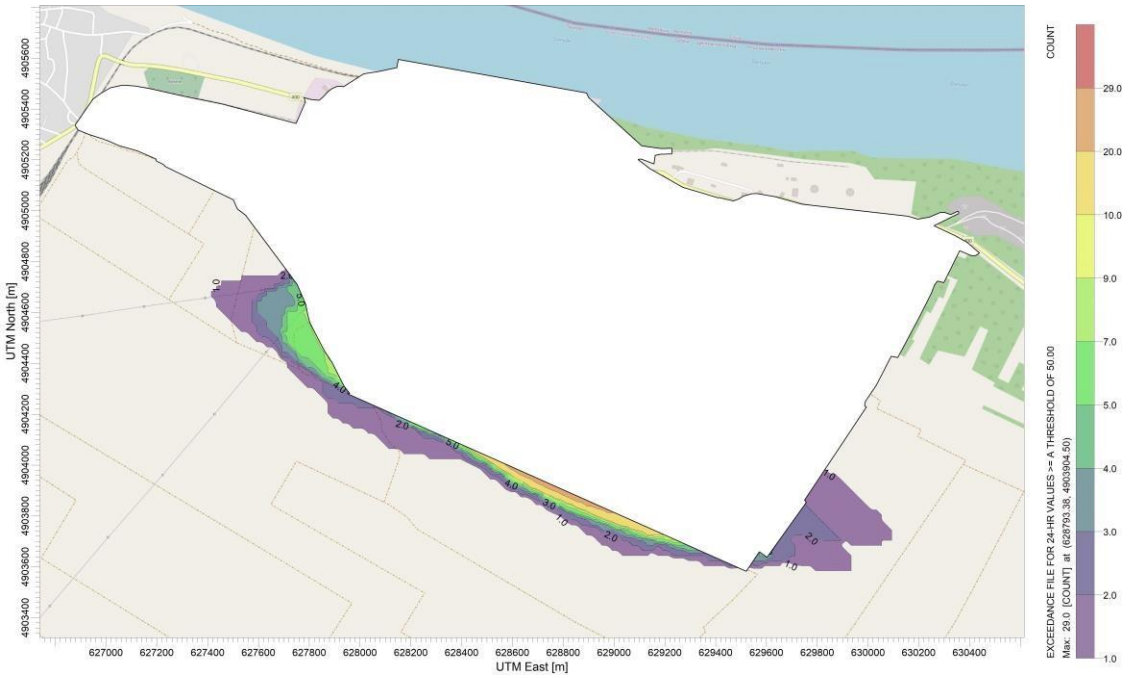


Figure 3.17 Number of exceedances of the PM10 limit value for the averaging period of one day

With a maximum value of 6.57 μg/m³ (3.17), the annual average in no part of the model domain exceeds the limit value. A narrow zone with the highest annual concentrations is observed just in places where limit values of daily averages can potentially be expected to be exceeded, but such low annual values indicate that despite periods with high episodic pollution, most are periods where the concentration of pollutants is at a low level.

Figure 3.18 Maximum ground-level PM10 concentrations for the averaging period calendar year [μg/m^3]

PM2.5 concentration values obtained

Figure 3.19 shows isopleths of ground concentrations, which refer to the annual average PM2.5. For this averaging period, which is only prescribed by the Decree, the highest concentration obtained by the model is 2.36 μg/m³ and is observed along the southern limit of possession, which is far below the prescribed limit value (25 μg/m³).

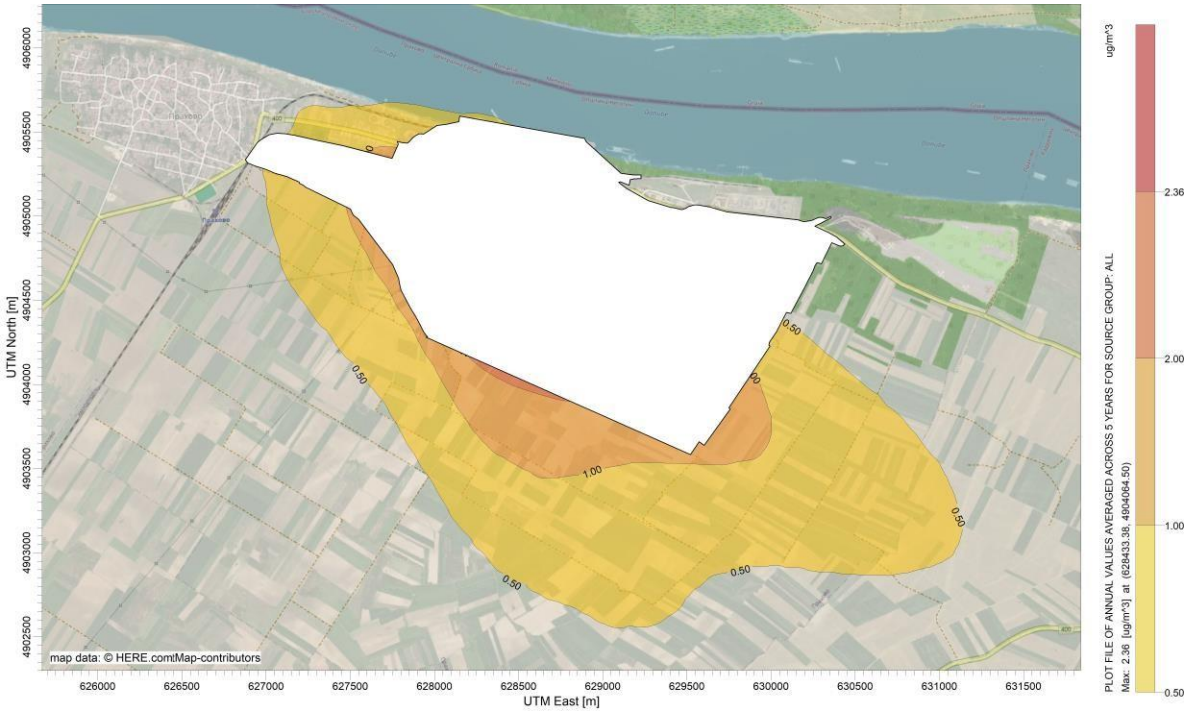


Figure 3.19 Maximum ground-level PM2.5 concentrations for the averaging period calendar year [μg/m^3]

CO concentration values obtained

The modelling results show that the expected ground-level CO concentrations are very low for all averaging periods considered (Figures 3.20-3.22). The highest concentration obtained by modelling, for the averaging period shown as the maximum daily eight-hour mean, is 13.5 μg/m³, while the limit value proposed by the Decree is 10 mg/m³. When it comes to averaging periods for one day and one calendar year, the differences between the respectively expected values and the threshold values are also significant. The highest model values obtained for the averaging periods are: 9.88 μg/m³ and 0.61 μg/m³, respectively.

Figure 3.20 Maximum daily eight-hour mean ground-level CO concentration [μg/m^3]

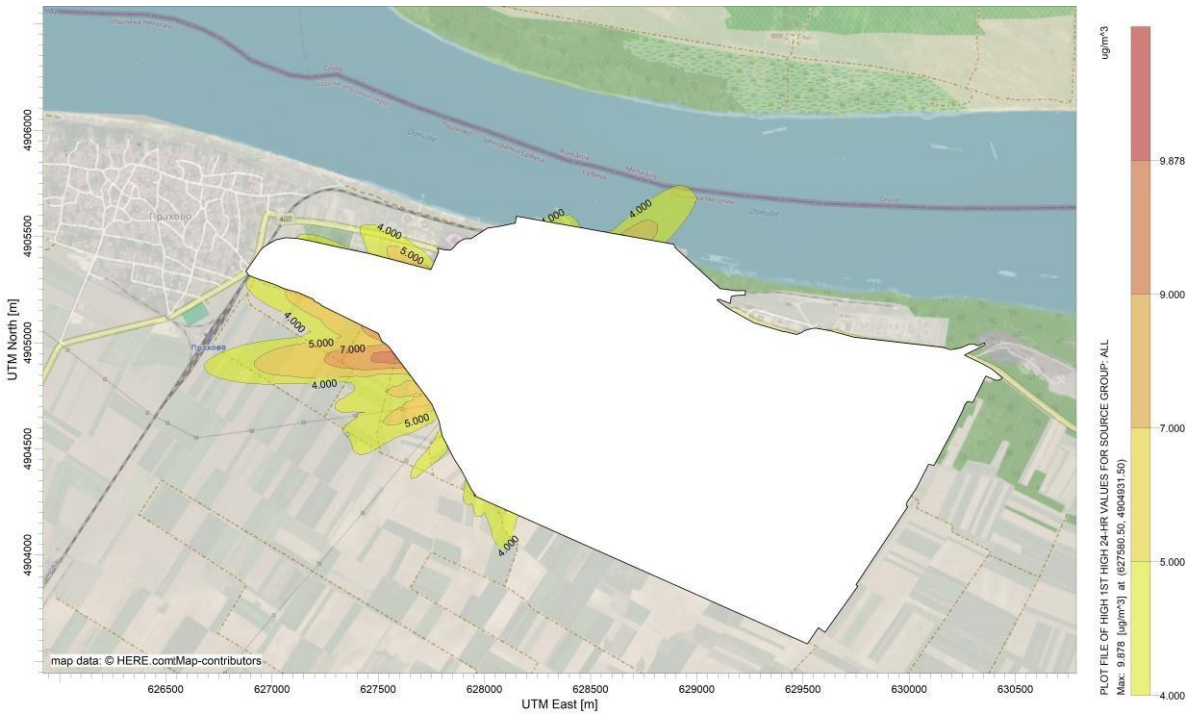


Figure 3.21 Maximum ground-level CO concentrations for an averaging period of one day [μg/m^3]

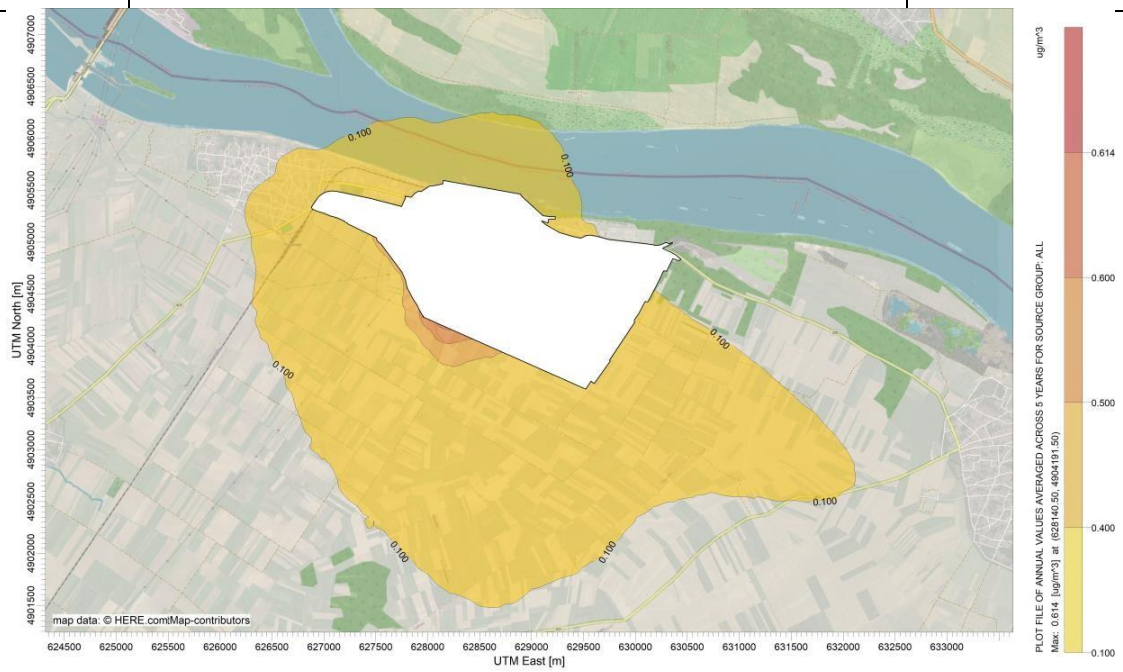


Figure 3.22 Ground-level CO concentrations for the averaging period calendar year [μg/m^3]

HCl concentration values obtained

HCl is emitted from only one point source, namely the emitter of the Final Scrubber. Based on the modeling results, it can be concluded that the prescribed maximum three-hour daily, maximum daily and average annual limit values (50, 15 and 10 μg/m³) will not be exceeded in any part of the model domain (Figures 3.23, 3.24 and 3.25, respectively). The highest values obtained by modelling for the averaging periods specified are: 1.9 μg/m³, 0.92 μg/m³ and 0.074, respectively.

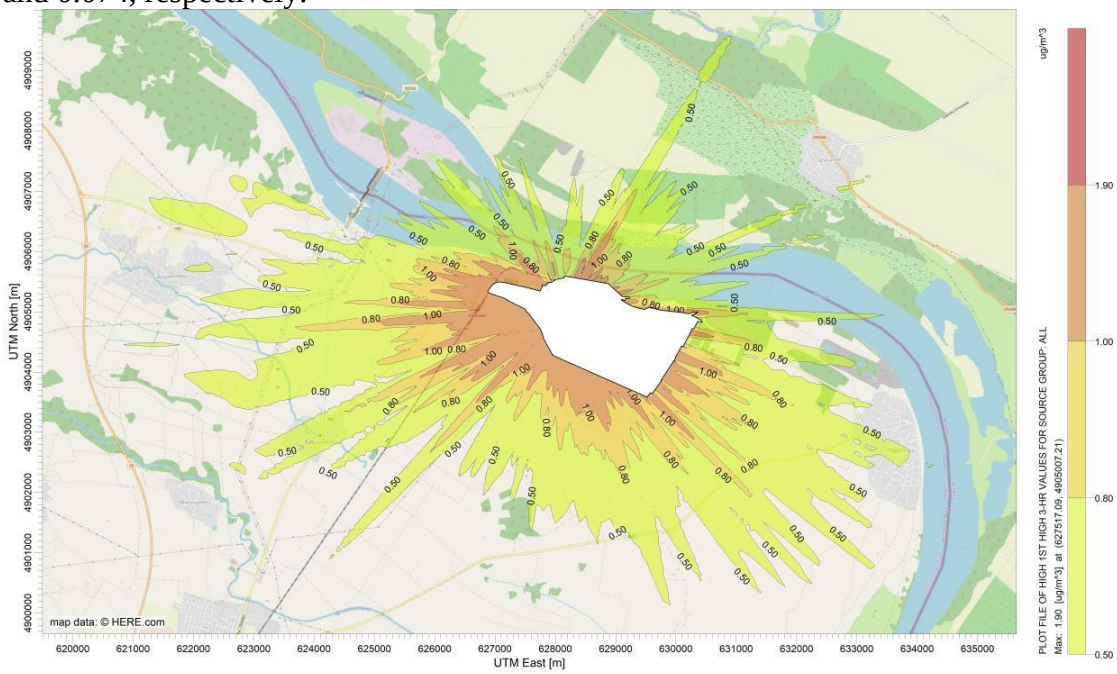


Figure 3.23 Maximum ground-level three-hour daily HCl concentrations [μg/m^3]

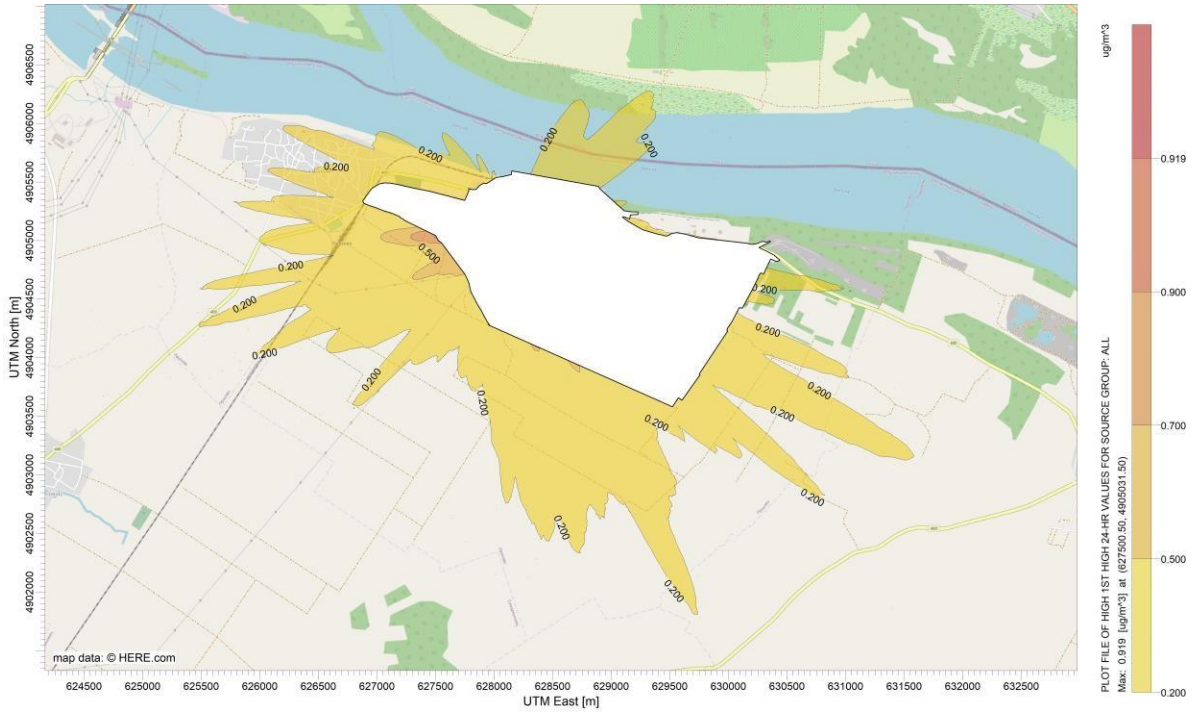


Figure 3.24 Maximum ground-level HCl concentrations for an averaging period of one day [μg/m^3]

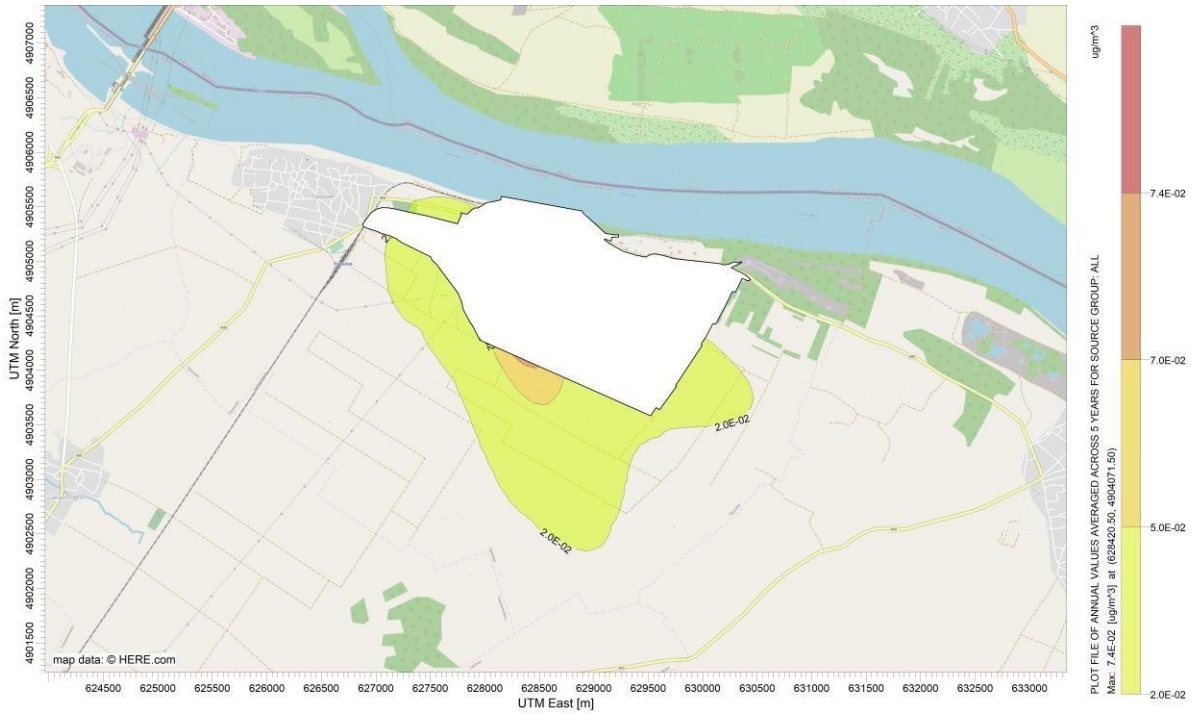


Figure 3.25 Ground-level HCl concentrations for the averaging period calendar year [μg/m^3]

The highest model values obtained for the said averaging periods are: 1.9 μg/m^3, 0.92 μg/m^3 and 0.07 μg/m^3, respectively.

HF concentration values obtained

Based on the modelling results (Figure 3.26 and 3.27), it can be concluded that the highest potential impact (10.1 μg/m^3), for an averaging period of three hours is below the prescribed limit values of 20 μg/m^3, while the highest impact for averaging period of one day, which is 3.73 μg/m^3, is almost at the limit of the prescribed limit value of 3 μg/m^3. A narrow zone with concentrations that are slightly above the limit value is observed only immediately to the south-east border of the factory property. Bearing in mind that the obtained results indicate that, for the considered period of five years, i.e. 1,826 days, a maximum of two days in the mentioned zone can be exceeded, it can be concluded that exceeding the daily values can potentially occur extremely rarely and only under extremely unfavorable meteorological conditions.

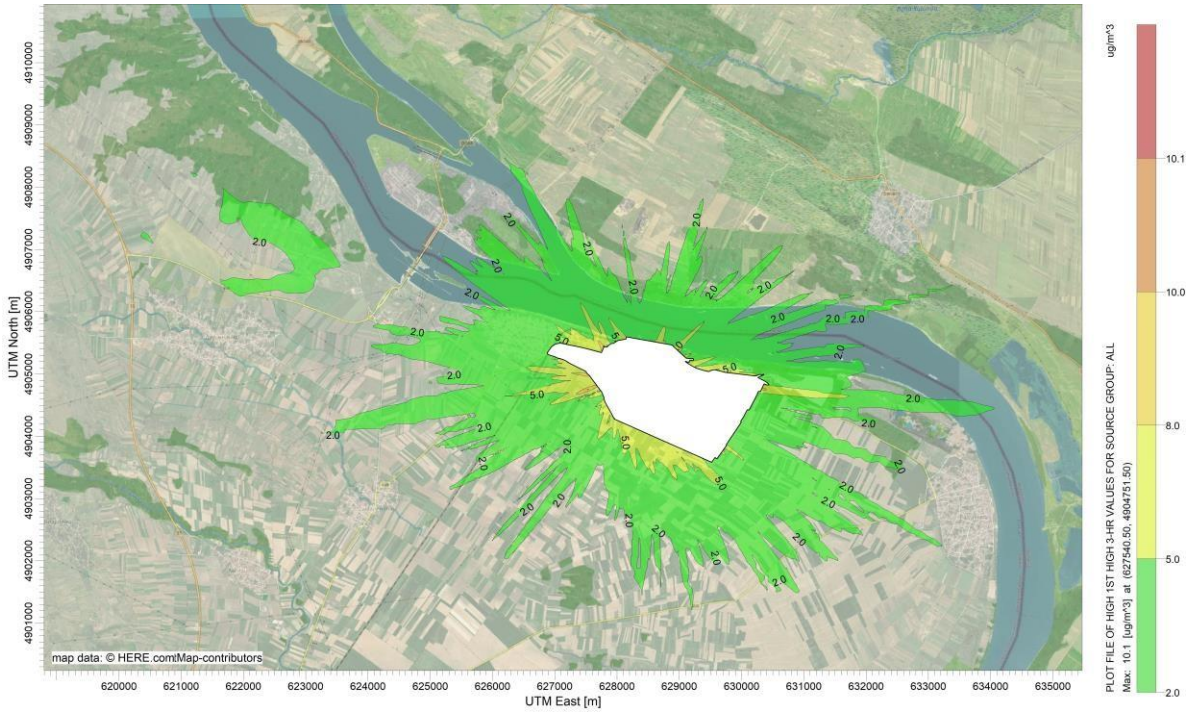


Figure 3.26 Maximum ground-level three-hour daily HF concentrations [μg/m^3]

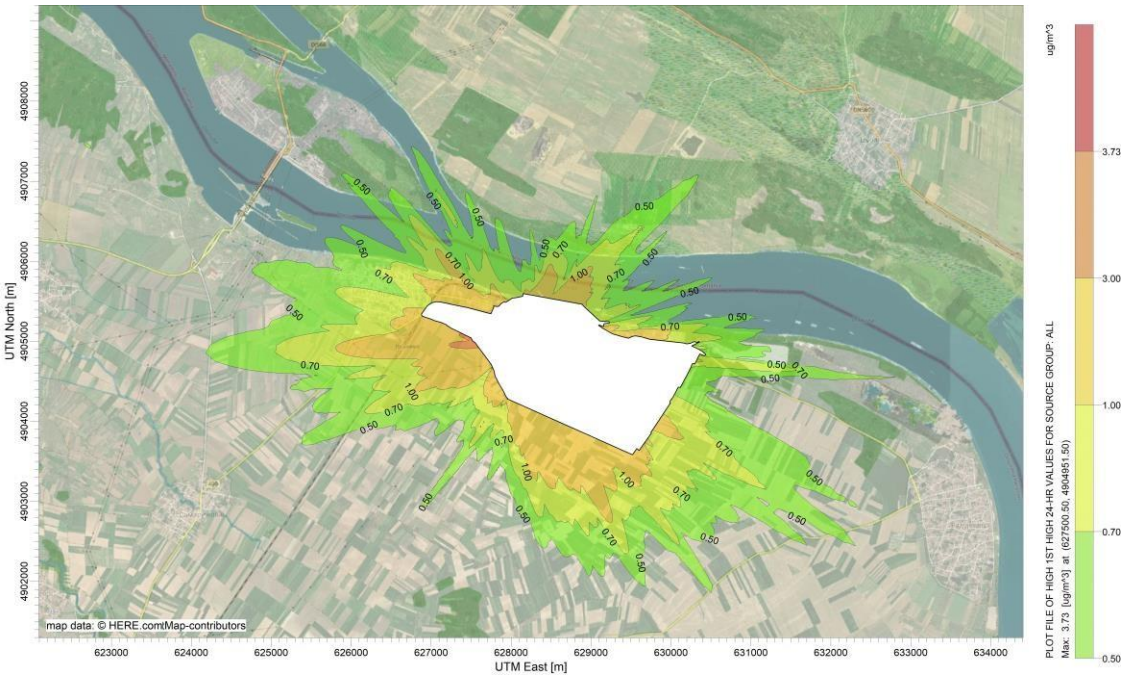


Figure 3.27 Maximum ground-level HF concentrations for an averaging period of one day [μg/m^3]

Obtained NH3 concentration values

NH_3 is emitted from only one point source, namely the emitter of the Final Scrubber. Based on the modelling results, it can be concluded that the highest obtained values, for both averaging periods are 9.18 μg /m3 and 4.45 μg/m3, far below the prescribed maximum three-hour and daily values (200 and 100 μg/m³) (Figures 3.28 and 3.29).

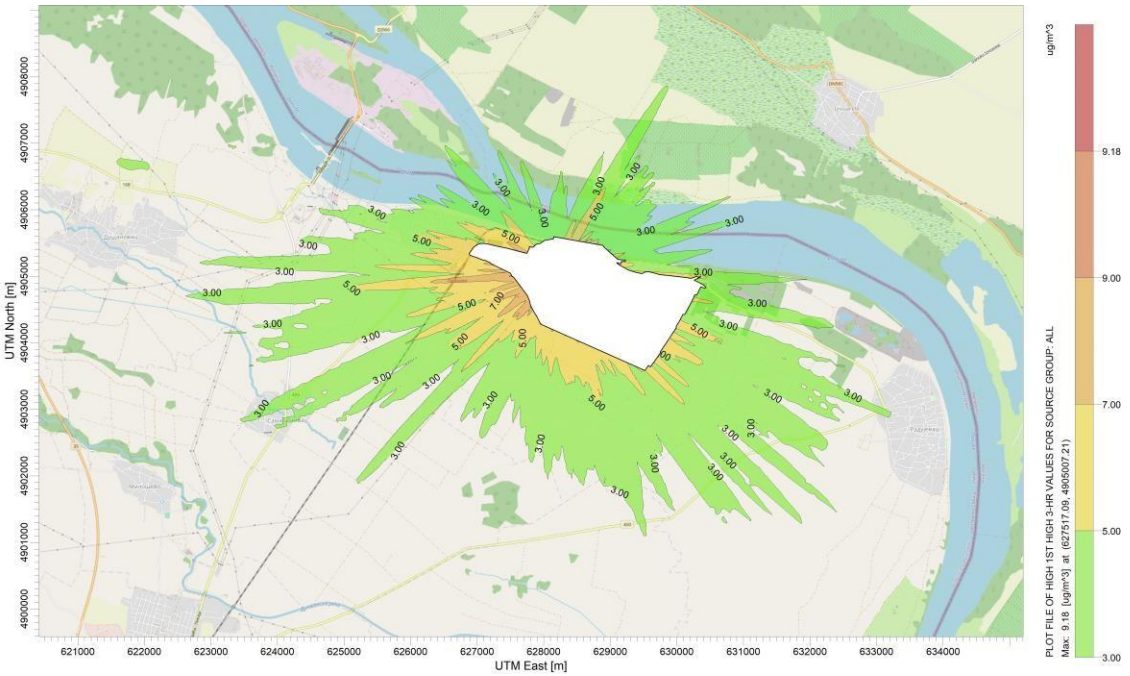


Figure 3.28 Maximum ground-level three-hour daily NH_3 concentrations [μg/m^3]

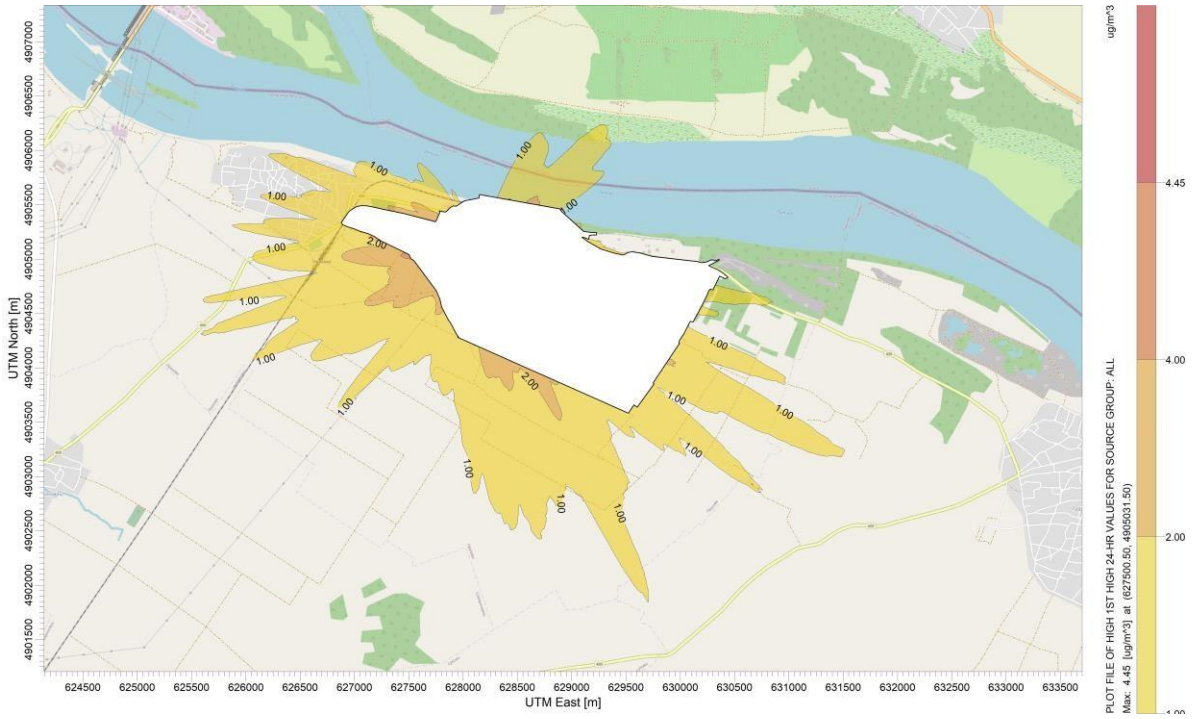


Figure 3.29 Maximum ground-level NH_3 concentrations for an averaging period of one day [$\mu g/m^3$]

3.2 Future status:

The future state implies the operational state of the chemical industry complex in Prahovo with all its existing point and surface sources (state in 2024) with their relevant characteristics as shown in Annex I of this Study, as well as three future point emitters of the plant for energy recovery of waste materials (emitter of the boiler plant, emitter of the filter system of solidification and emitter of the filter system of pre-treatment of waste and activated carbon filters), whose emissions will be fully compliant with the limit values prescribed by the relevant *BAT conclusions* for the combustion of waste[2], as well as with the regulations of the Republic of Serbia. In normal operation, the evacuation of dust and unpleasant odors from the emitter of the waste pre-treatment filter system, which includes an activated carbon filter, is achieved by keeping the hall constantly under pressure, drawing air from the hall and burning it in the boiler plant. For this reason, only the emission of powdered substances was modeled from this emitter as a dominant emission characteristic of the infrequent scenario of unavailability of the boiler plant.

The future state of surface sources, with appropriate mean heights and degree of spreading out decay, refers to all existing phosphogypsum storage facilities as well as an additional eastern field, as well as to the landfill of non-hazardous waste (non-reactive solidificate), as shown in Appendix I of this Study.

[2] Commission Implementing Decision (EU) 2019/2010 establishing the best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for waste incineration.

SO_2 concentration values obtained

Figures 3.30 and 3.31 show the isopleths of ground-level concentrations, which refer to the first maximum of possible SO_2 values for an averaging period of one hour, where the maximum observed concentration is 592 μg/m³, which is above the limit value of 350 μg/m³. This concentration, as well as the zone with the greatest impact for this period of averaging, is located practically immediately next to the northern border of the factory estates. Zones of similar surface area and with concentrations above 350 μg/m³ can be observed at the north-eastern and southern borders of the property, and are a direct consequence of the combination of certain meteorological conditions and characteristics of the emitters. Other parts of the model domain are below the limit values. The shown isopleths of ground concentrations, in Figures 3.32 and 3.33, refer to the 99.73 percentile of the maximum possible SO_2 values for an averaging period of one hour, where the maximum observed concentration is 210 μg/m³, which is far below the limit value of 350 μg/m³.

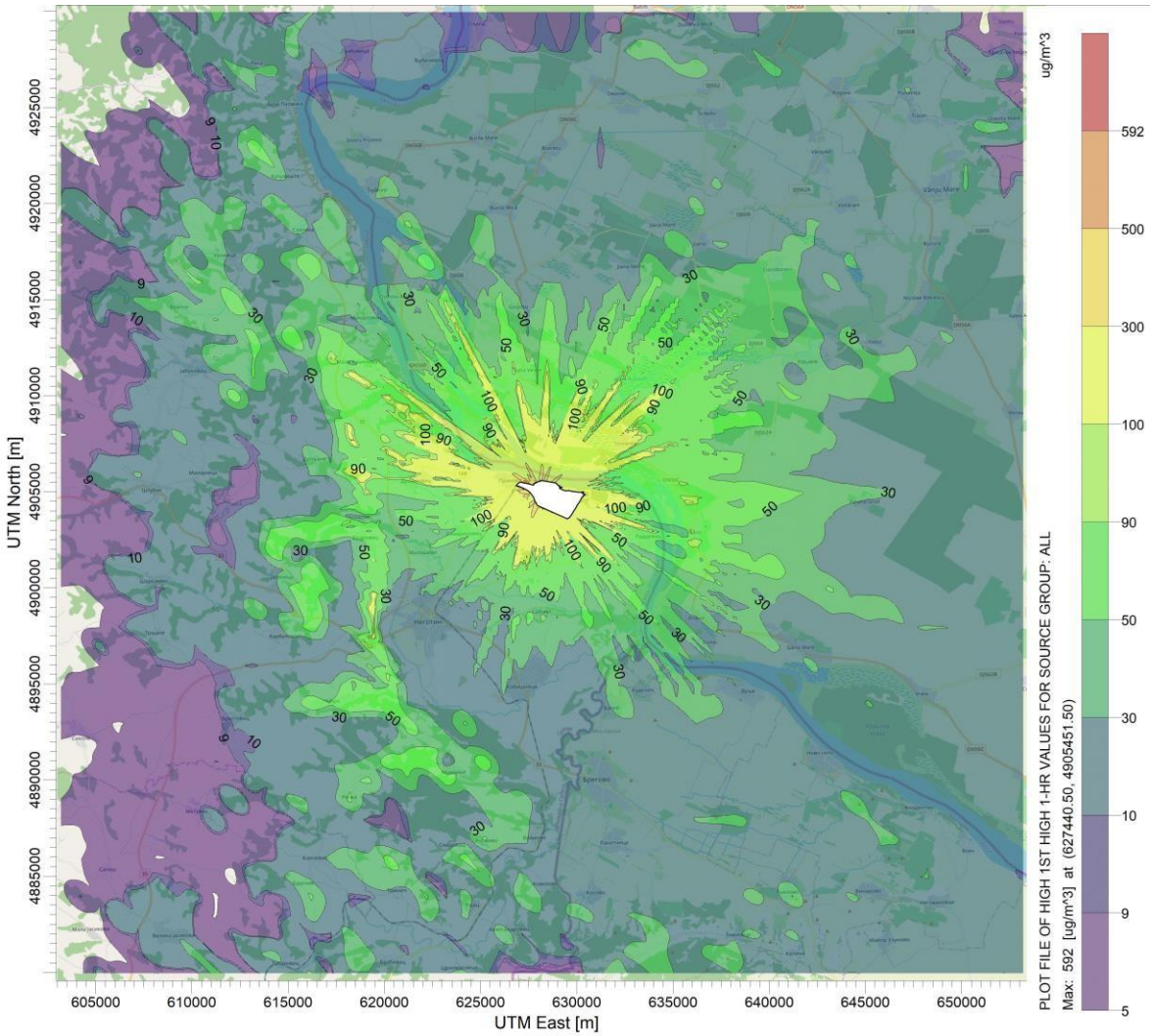


Figure 3.30 Maximum ground level concentrations (first maximum) of SO_2 for an averaging period of one hour [μg/m^3]

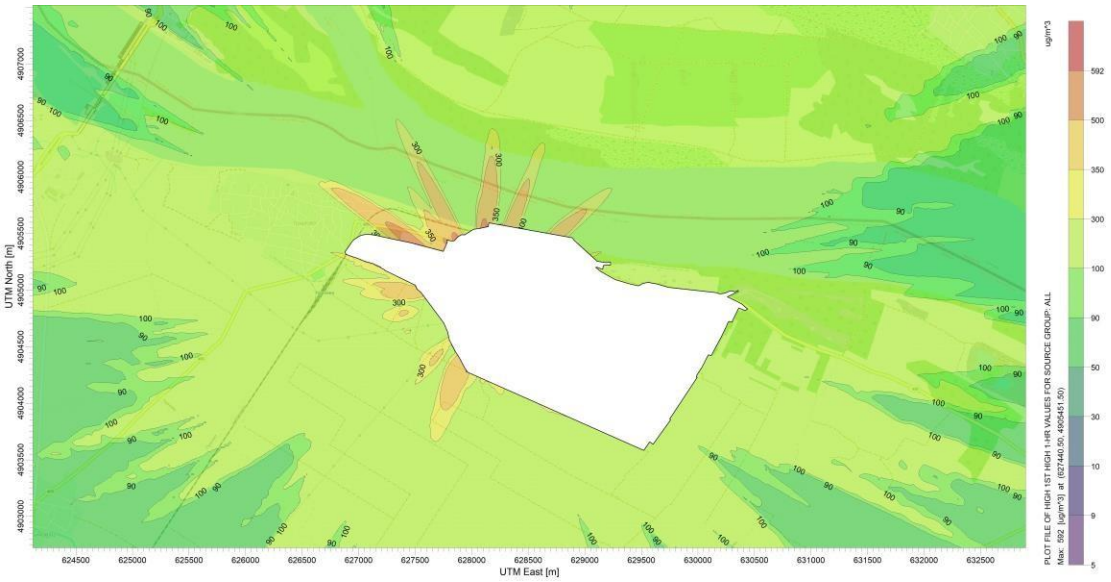


Figure 3.31 Maximum ground level concentrations (first maximum) of SO_2 for an averaging period of one hour [$\mu g/m^3$] (narrower factory location display)

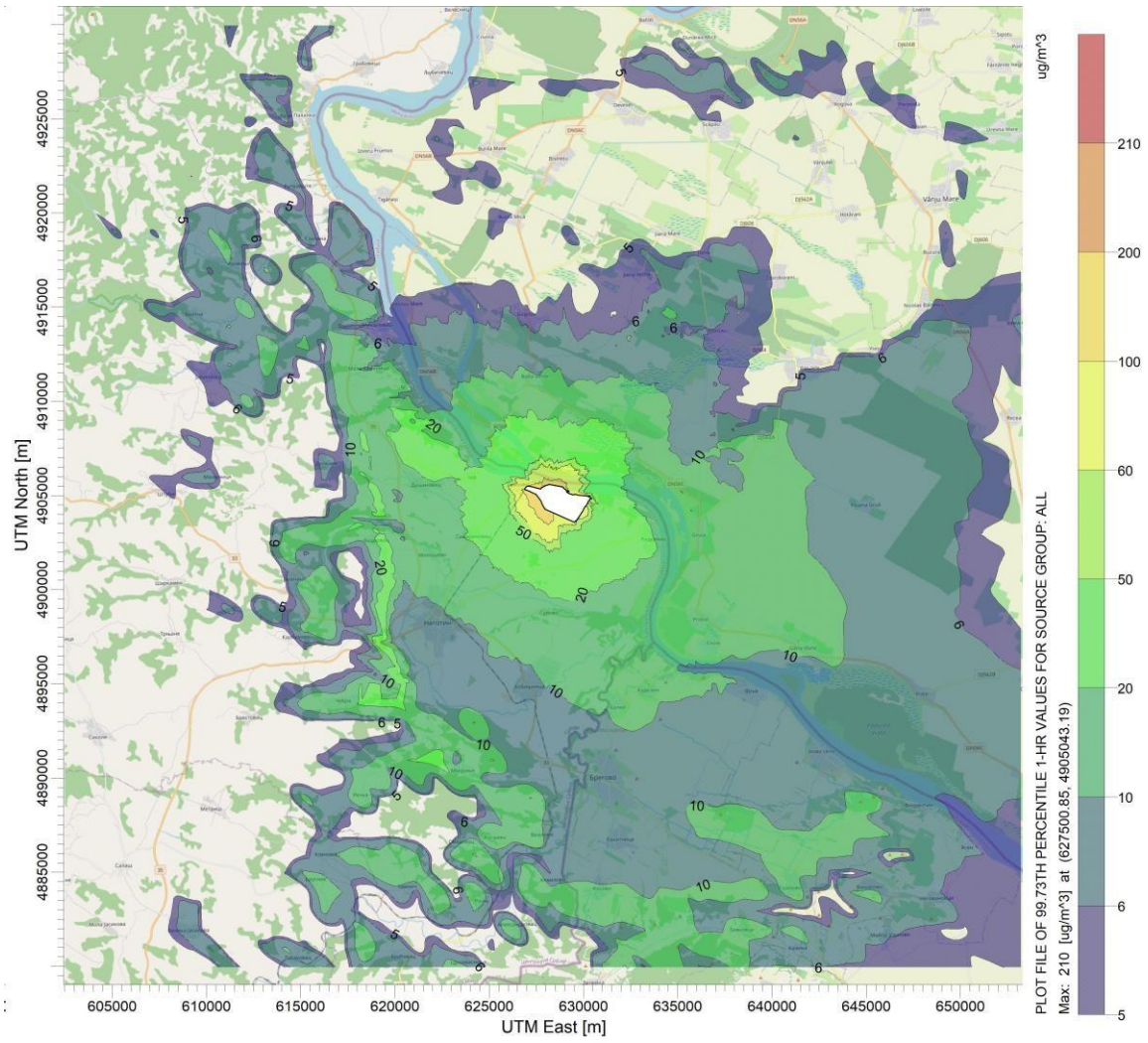


Figure 3.32 Maximum ground level concentrations (99.73 percentile) of SO_2 for an averaging period of one hour [$\mu g/m^3$]

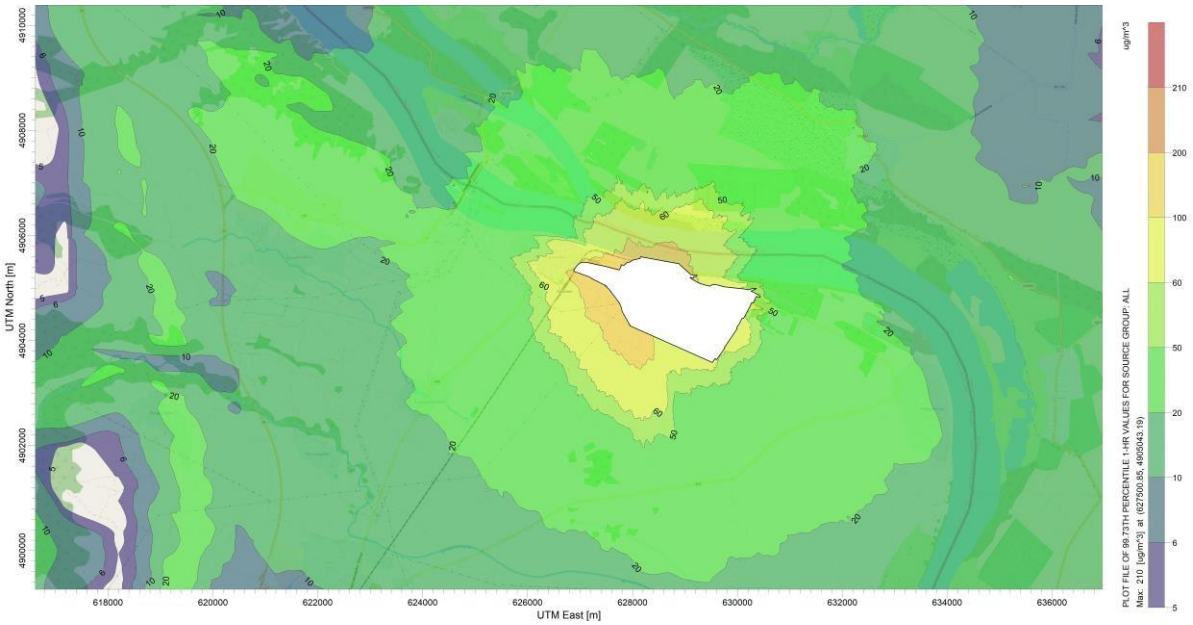


Figure 3.33 Maximum ground level concentrations (99.73 percentile) of SO_2 for an averaging period of one hour [$\mu g/m^3$] (narrower factory location display)

Since the percentile value of the first maximum for the averaging period of one hour is several times lower than the first maximum itself, an additional analysis of the number of hours with exceeding the prescribed limit value for each of the receptors was performed, and the results are graphically presented in Figure 3.34. Bearing in mind that the obtained results indicate that, for the considered period of five years, i.e. 43,824 h, the maximum number of hours at one of the receptors within the zones where exceedances of hourly averages can be expected for only three hours, it can be concluded that exceedances of hourly values can occur extremely rarely and only in extremely unfavorable meteorological conditions.

Figure 3.34 Number of SO_2 limit exceedances for an averaging period of one hour

Given that the obtained values of the first maximums and the distribution of isopleths for the future state, i.e. the state of operation of the plant for the energy utilization of waste materials, for a period of averaging of one hour, are almost identical to the current state, this indicates that the existing emitters have a dominant influence. In order to examine exclusively the impact of the plant for energy recovery of waste materials, additional modeling of this plant was performed only, and the results for the averaging period of one hour are shown in Figure 3.35. Based on the presented results, it can be concluded that the maximum obtained values for this period of averaging, which is potentially the only problematic one, are far below the prescribed limit value. Which is certainly a consequence of several factors, i.e. low pollutant emissions, sufficient stack height as well as relatively high flue gas velocities through the stack. It should be noted that due to the different characteristics of emitters and different meteorological conditions that lead to potential maximum values of ground-level concentrations, it is not possible to simply add or subtract the contributions of individual emitters except for the annual period of averaging.

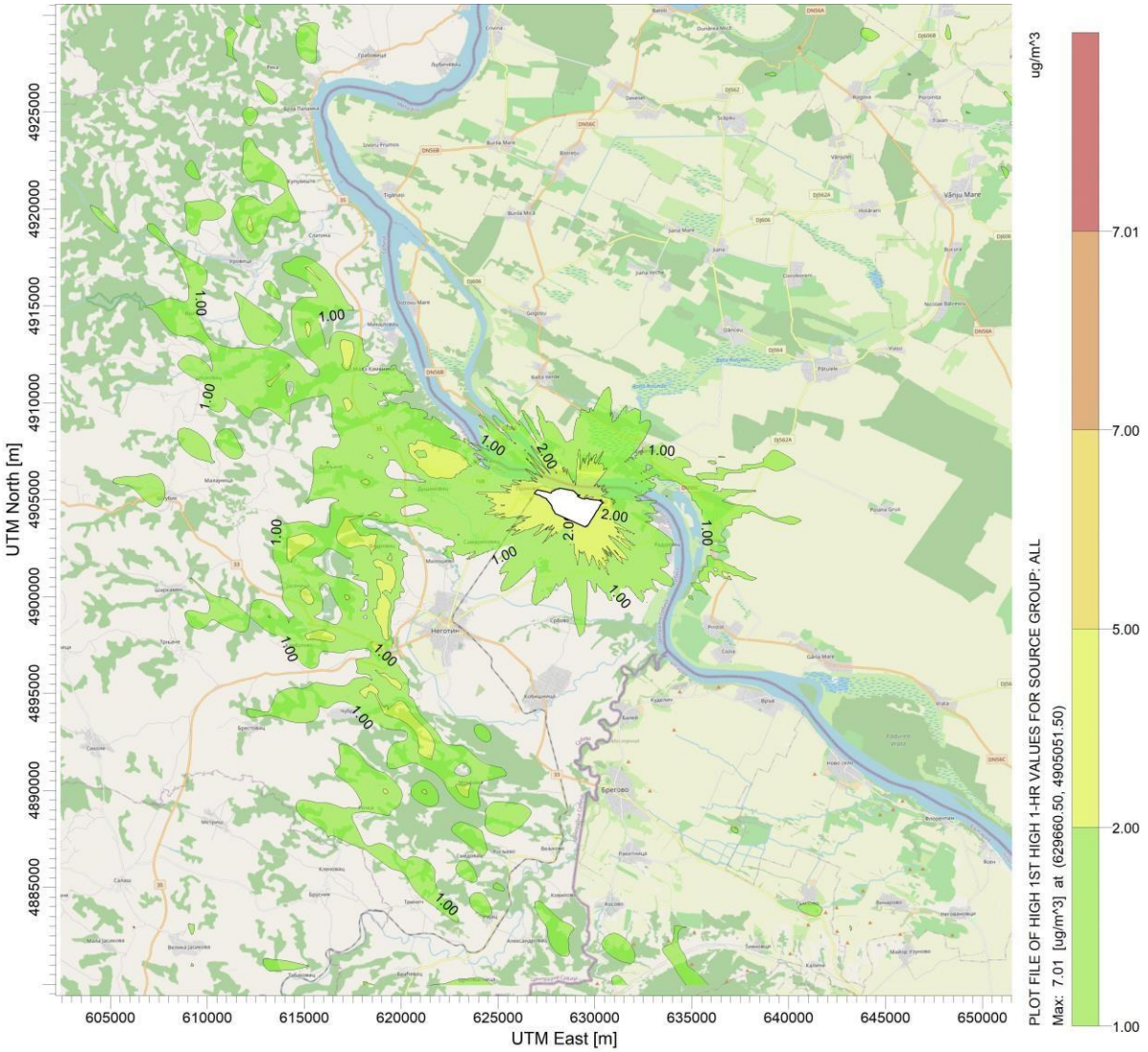


Figure 3.35 Maximum ground level concentrations (first maximum) of SO_2 for an averaging period of one hour [$\mu g/m^3$] – waste incineration plant only

Considering that the modeling results showed that the existing SO_2 emitters will be dominant in the future, which is expected based on the characteristics of the source, and in order to quantitatively assess the impact of the largest SO_2 emitter, an additional analysis of the impact of only the coal-fired steam boiler emitter was performed , and the modeling results are given in Figures 3.36 to 3.39, based on the presented results, it can be concluded that although the first maximums and corresponding percentile values of ground concentrations of SO_2 for the averaging period of one hour are below the limit values, extremely high concentrations (303 μg/m^3, 110 μg/m^3) make this emitter dominant compared to all others, which is a direct consequence of the characteristics of the fuel it uses, but also slightly lower stack height and flue gas velocities through it. Bearing in mind that the future plant will reduce the need to use a coal-fired steam boiler, a positive impact of the new plant on SO_2 emissions is expected.

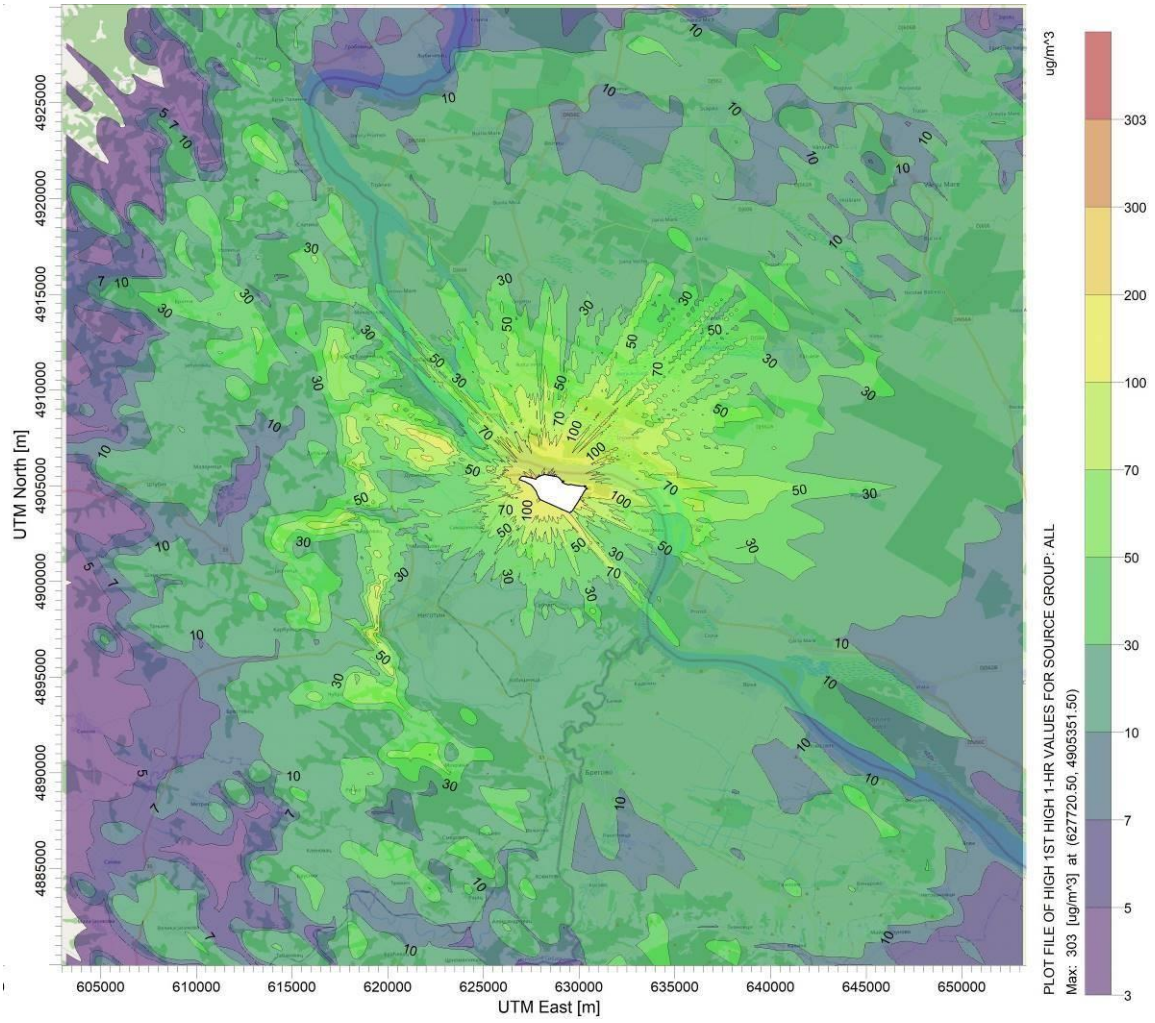


Figure 3.36 Maximum ground level concentrations (first maximum) of SO_2 for an averaging period of one hour [μg/m^3] – coal-fired boiler only

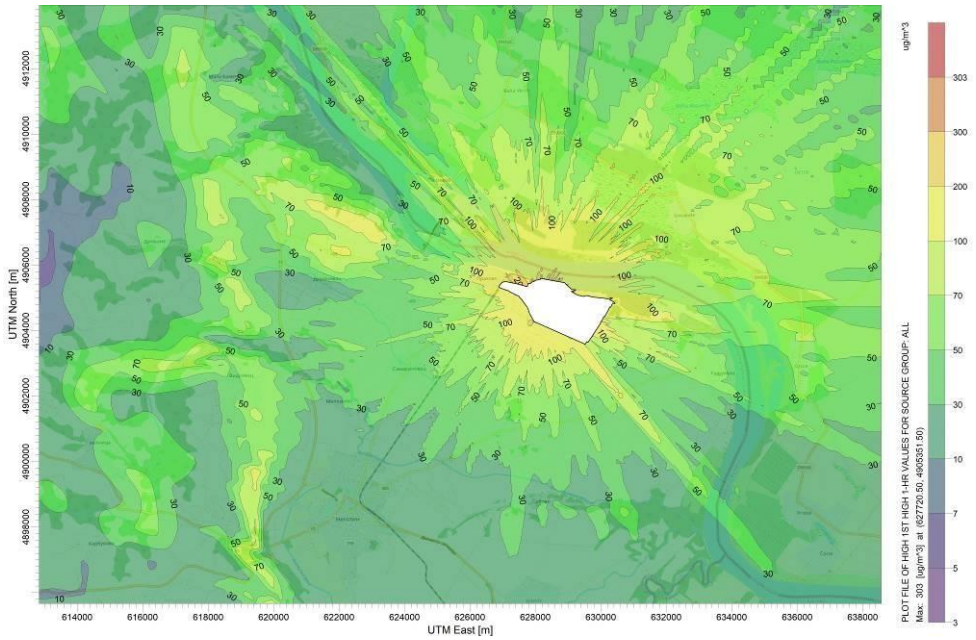


Figure 3.37 Maximum ground level concentrations (first maximum) of SO_2 for an averaging period of one hour [μg/m^3] – coal-fired boiler only (closer location display)

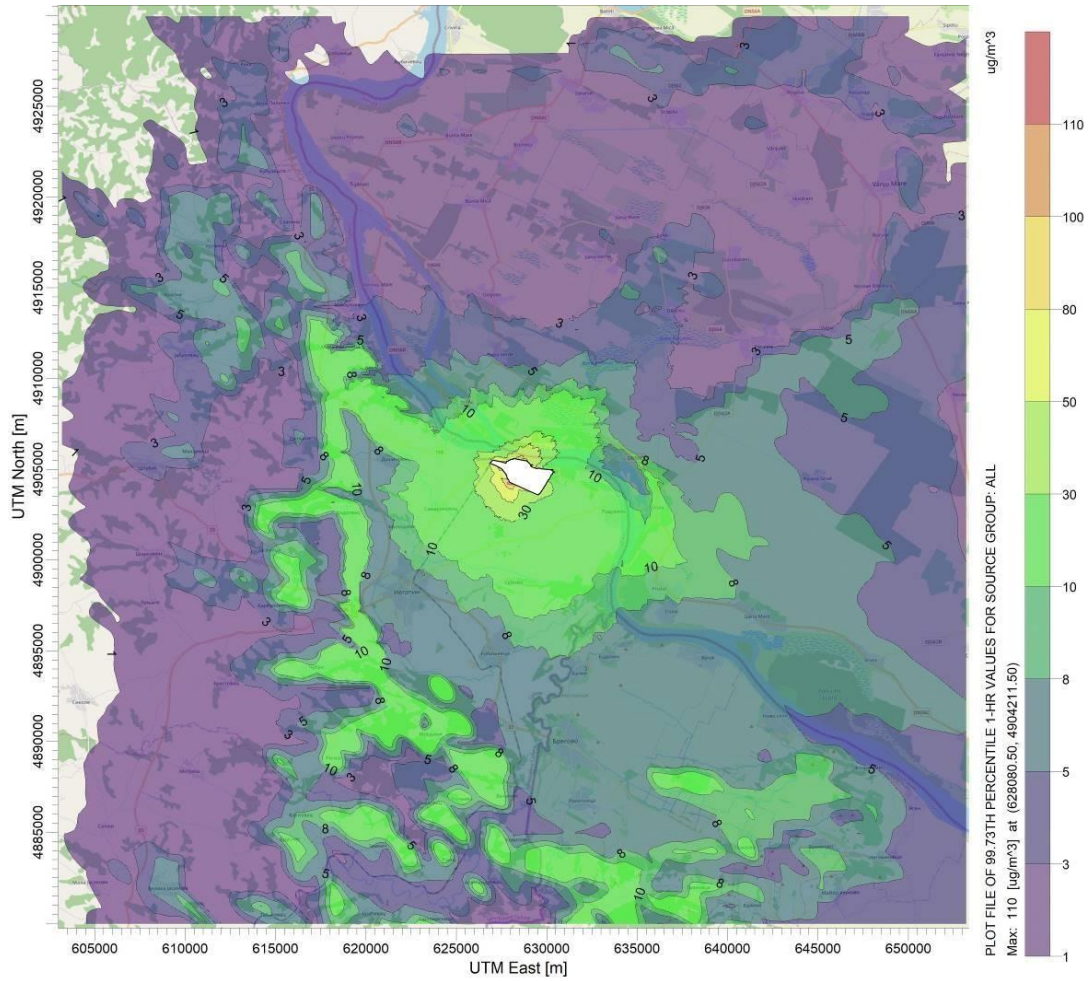


Figure 3.38 Maximum ground level concentrations (99.73 percentile) of SO_2 for an averaging period of one hour [μg/m^3] – coal-fired boiler only

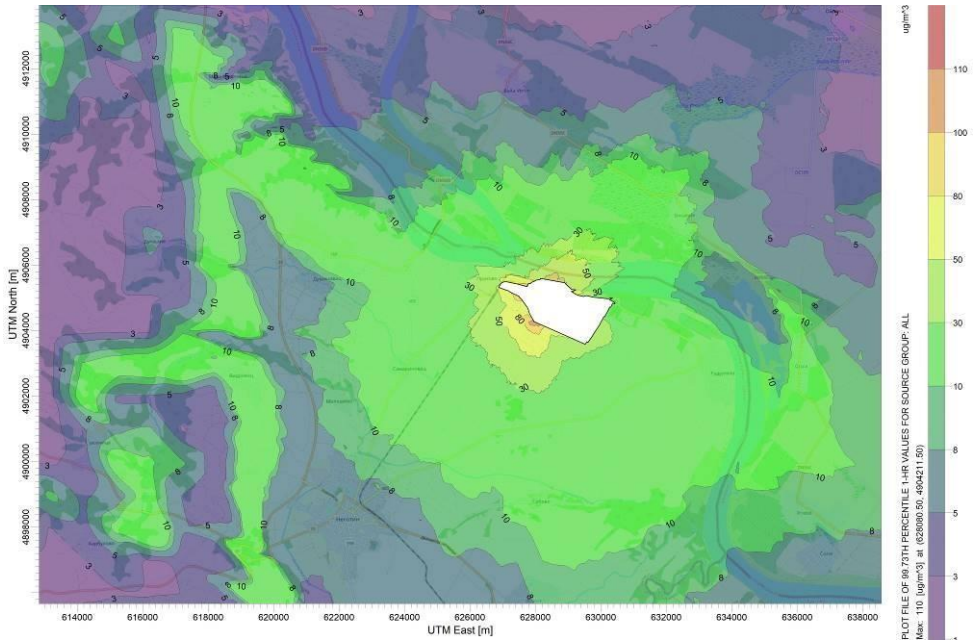


Figure 3.39 Maximum ground level concentrations (99.73 percentile) of SO_2 for an averaging period of one hour [μg/m^3] – coal-fired boiler only (closer location display)

In support of the conclusion that extremely high concentrations of SO_2 for an averaging period of one hour can potentially occur very rarely and in short time intervals, the results shown in Figures 3.40 to 3.41 where the first maximum and 99.18 percentile of the maximum possible values of SO_2 for an averaging period of one day are shown for the case of future state, i.e. for the case involving all present and future emitters. In this case, too, the maximum possible value of the first maximum exceeds the limit value in a narrow area along the south-western limit of property, while all other receptors in the model domain remain far below the limit value (125 μg/m^3), as well as all 99.18 percentile values.

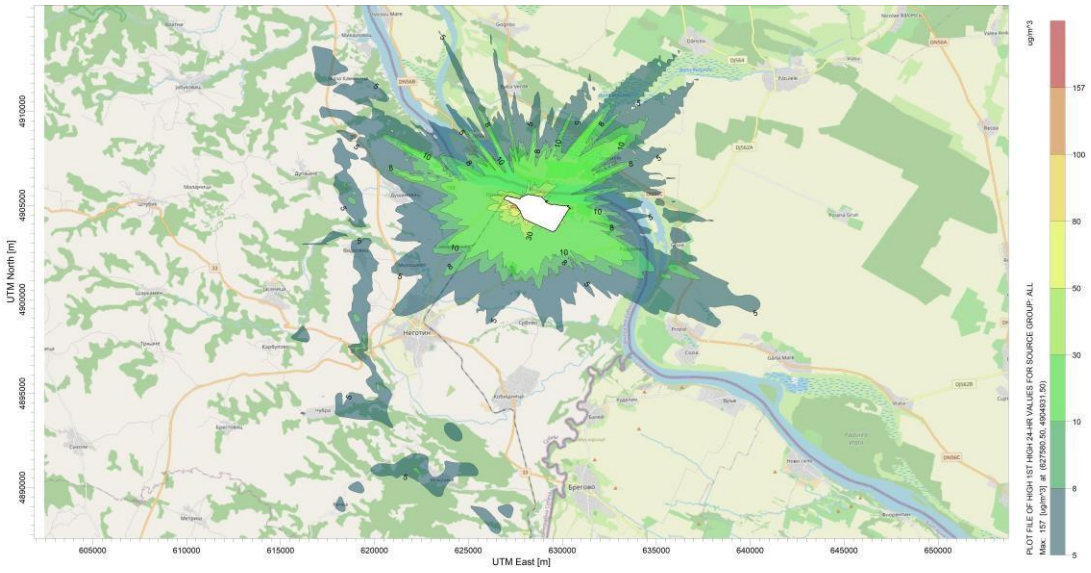


Figure 3.40 Maximum ground-level SO_2 concentrations for an averaging period of one day [μg/m^3]

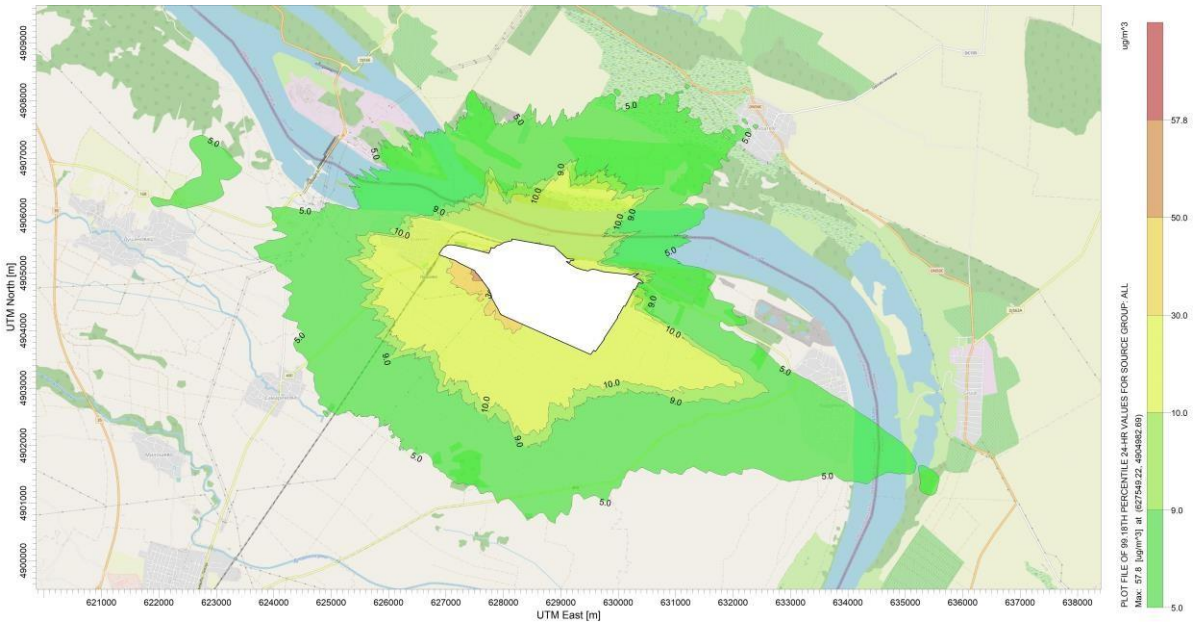


Figure 3.41 Maximum ground level concentrations (99.18 percentile) of SO_2 for the averaging period of one day [μg/m^3]

Figure 3.42 shows the results related to the annual averaging period, where the potential highest ground level concentration is 8.61 μg/m³, leading to the conclusion that all receptors on the considered domain are under the influence of concentrations that are significantly below the prescribed limit values (50 μg/m³). Narrow zones with the highest annual concentrations are observed predominantly in the southern part of the property boundaries. Such low annual values additionally indicate that despite possible periods with high episodic pollution (hourly and daily maximums), periods where the concentration of pollutants is at a very low level definitely prevail.

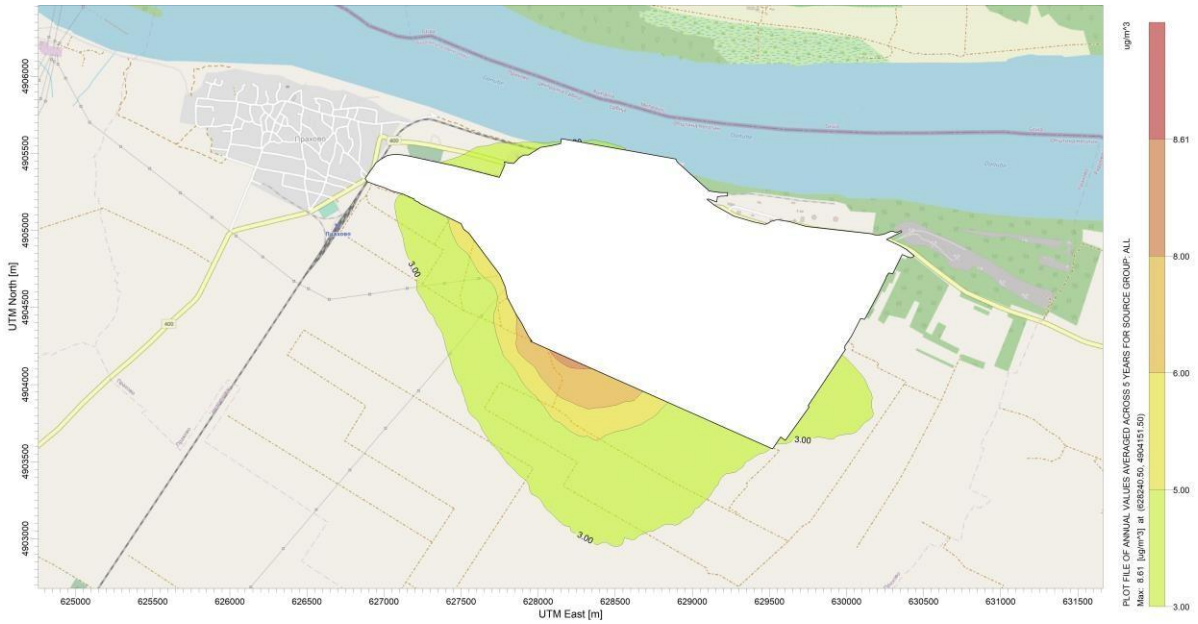


Figure 3.42 Ground-level SO_2 concentrations for the averaging period calendar year [μg/m^3]

NO_2 concentration values obtained

Figures 3.43 to 3.47 show the isopleths of ground-level concentrations, which refer to the first maximum and 99.79 percentile of the first maximum of possible NO_2 values for the averaging period of one hour, as well as the first maximum of the daily average and the annual average. The highest model values obtained for the averaging periods are: 127 μg/m^3, 48.52 μg/m^3, 32.3 μg/m^3 and 1.92 μg/m^3, respectively, for all averaging periods and all parts of the NO_2 concentration model domain are far below the prescribed limit values. These results indicate that, as well as in the case of SO_2, existing emitters have the dominant influence .

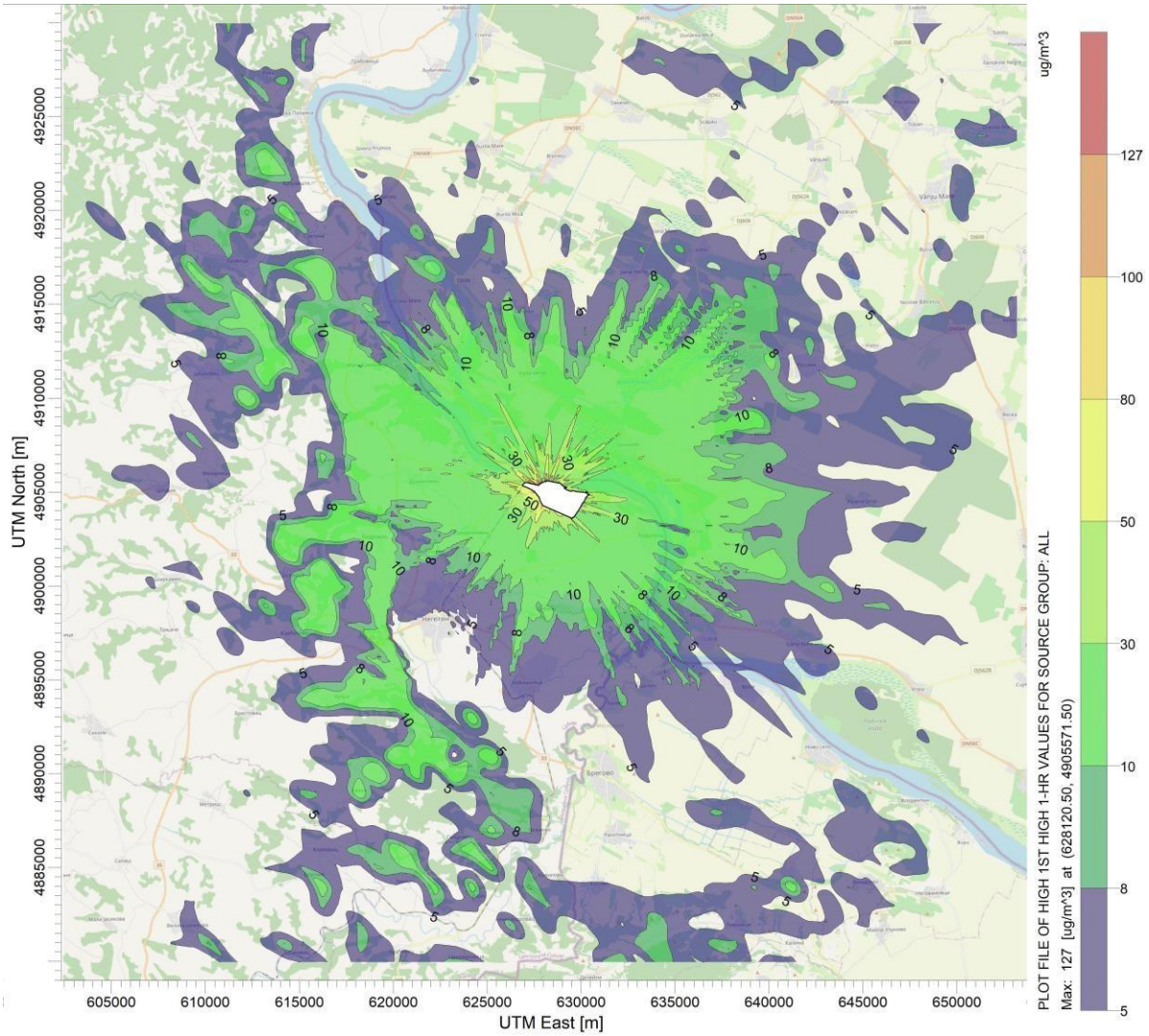


Figure 3.43 Maximum ground-level NO_2 concentrations for an averaging period of one hour [μg/m^3]

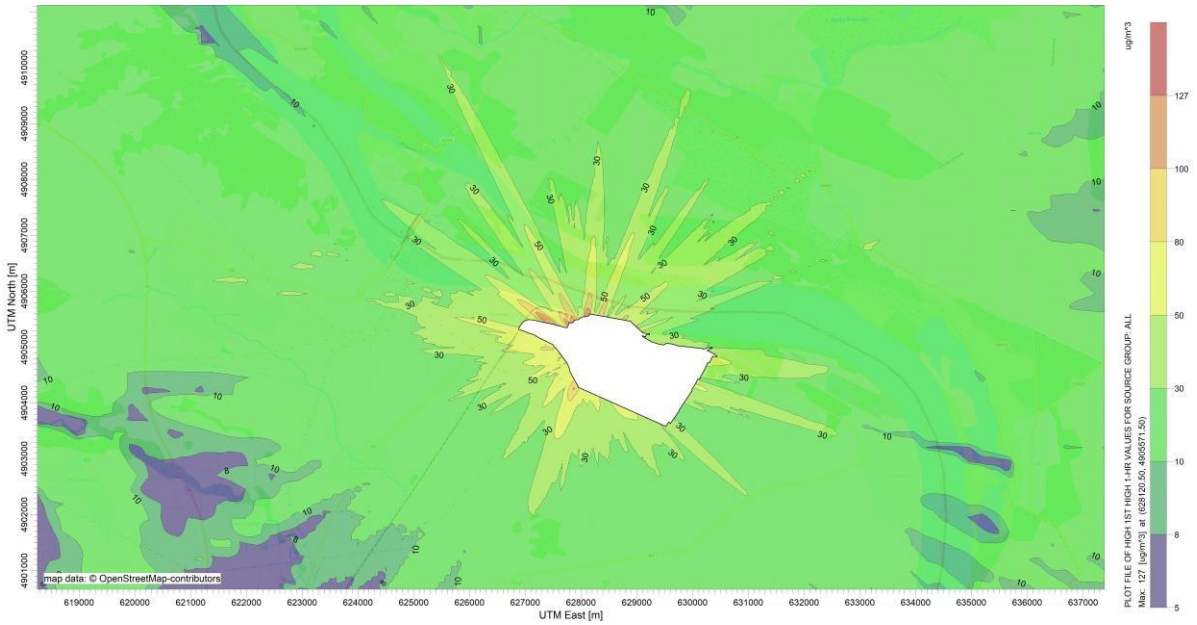


Figure 3.44 Maximum ground level concentrations of NO_2 for an averaging period of one hour [$\mu g/m^3$] (narrower factory location display)

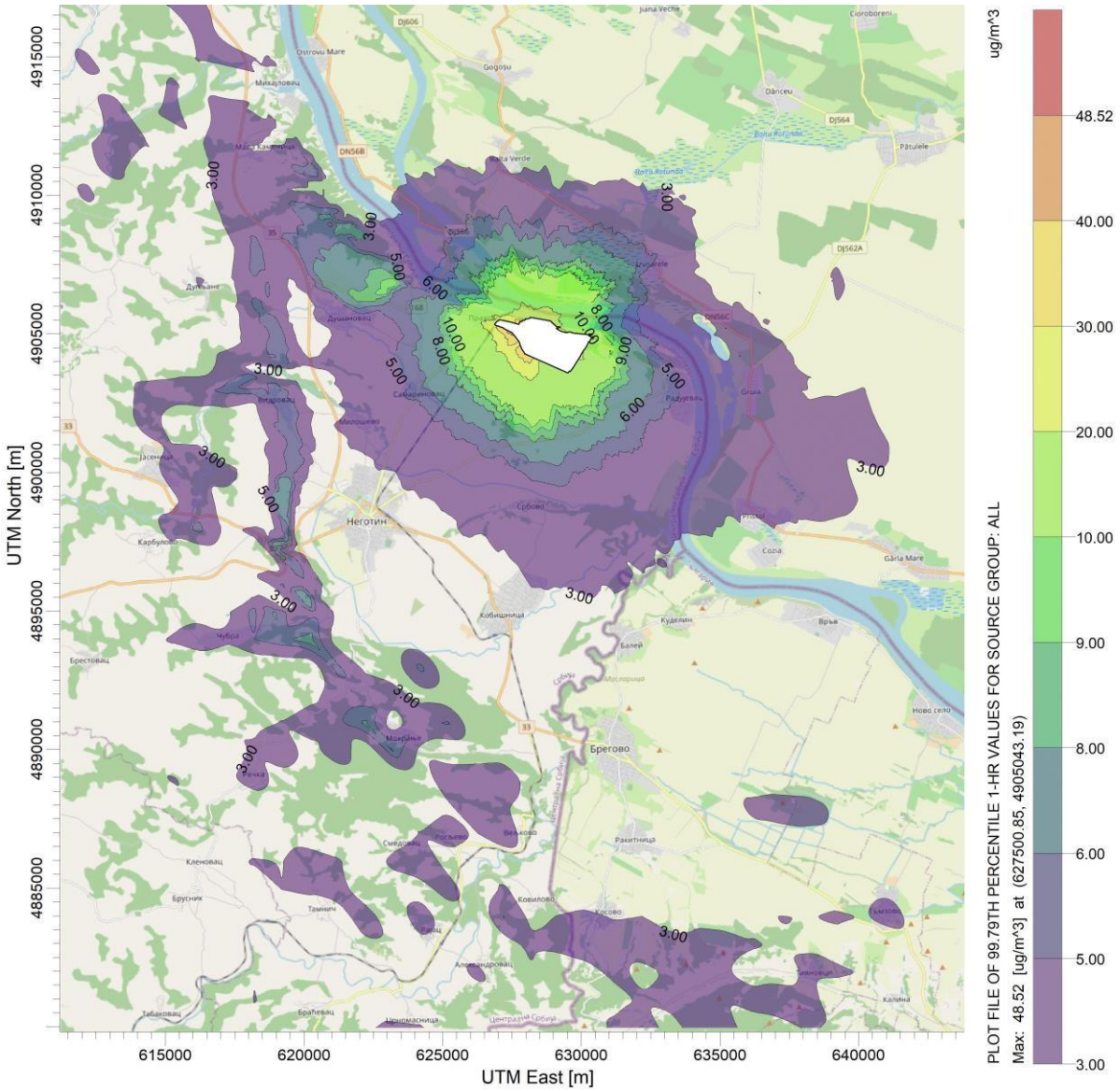


Figure 3.45 Maximum ground level concentrations (99.79 percentile) of NO_2 for an averaging period of one hour [$\mu g/m^3$]

Figure 3.46 Maximum ground-level NO_2 concentrations for an averaging period of one day [μg/m^3]

Figure 3.47 Ground-level NO_2 concentrations for the averaging period calendar year [μg/m^3]

Obtained PM 10 concentration values

Figure 3.48 shows the isopleths of ground-level concentrations, which refer to the first maximum of possible PM10 values for the averaging period of one day, where the maximum observed concentration is 97.76 μg/m³, which is far above the limit value of 50 μg/m³. This concentration, as well as the zone with the highest impact for this period of averaging, is located along the eastern part of the future phosphogypsum landfill, i.e. the south-eastern border of the factory property. Zones with high concentrations over 50 μg/m³ are a direct consequence of a combination of certain meteorological conditions and primarily surface emission sources or phosphogypsum landfills. Other parts of the model domain are below the limit values.

Shown isopleths of ground-level concentrations, Figure 3.49 refers to the 90.40 percentile of the maximum possible PM10 values for the averaging period of one day, where the maximum observed concentration is 38.5 μg/m³, which is below the limit value.

Since the percentile value of the first maximum for the averaging period of one day is several times lower than the first maximum itself, an additional analysis of the number of days with exceeding the prescribed limit value for each of the receptors was performed, and the results are graphically presented in Figure 3.50. Bearing in mind that the obtained results indicate that, for the considered period of five years, i.e. 1,826 days, at one of the receptors, a maximum of 96 days can occur with exceeding the daily averages, as well as the mean annual concentration, it is concluded that exceeding the daily values can occur rarely (less than 20 per year) and only in extremely unfavorable meteorological conditions.

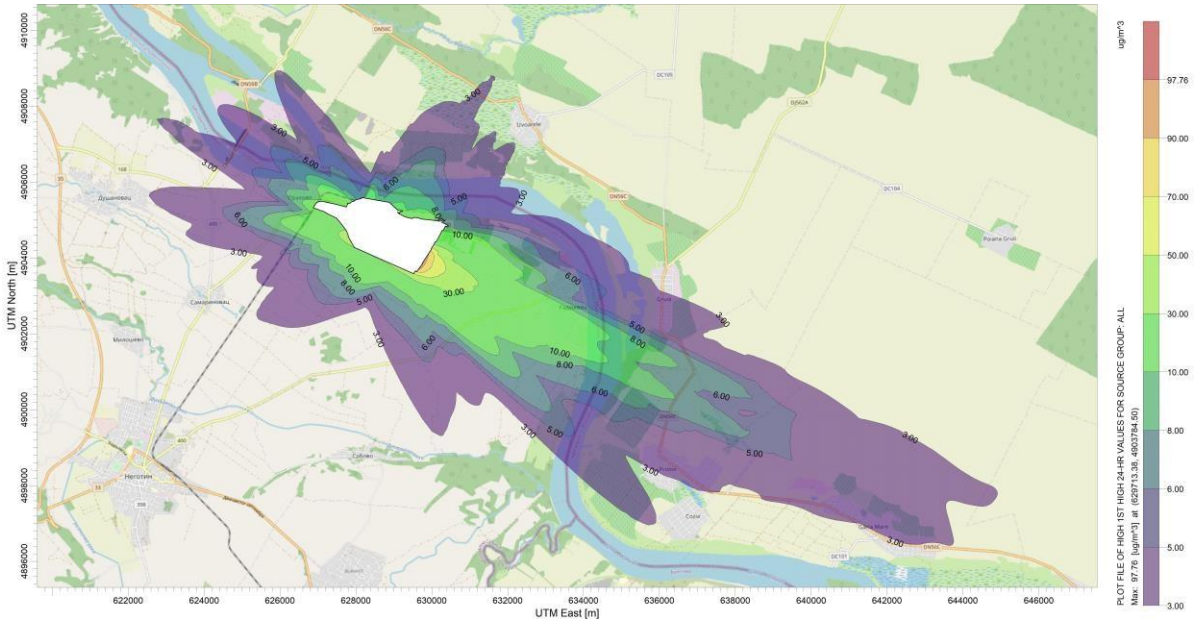


Figure 3.48 Maximum ground-level PM10 concentrations for the averaging period one day [μg/m^3]

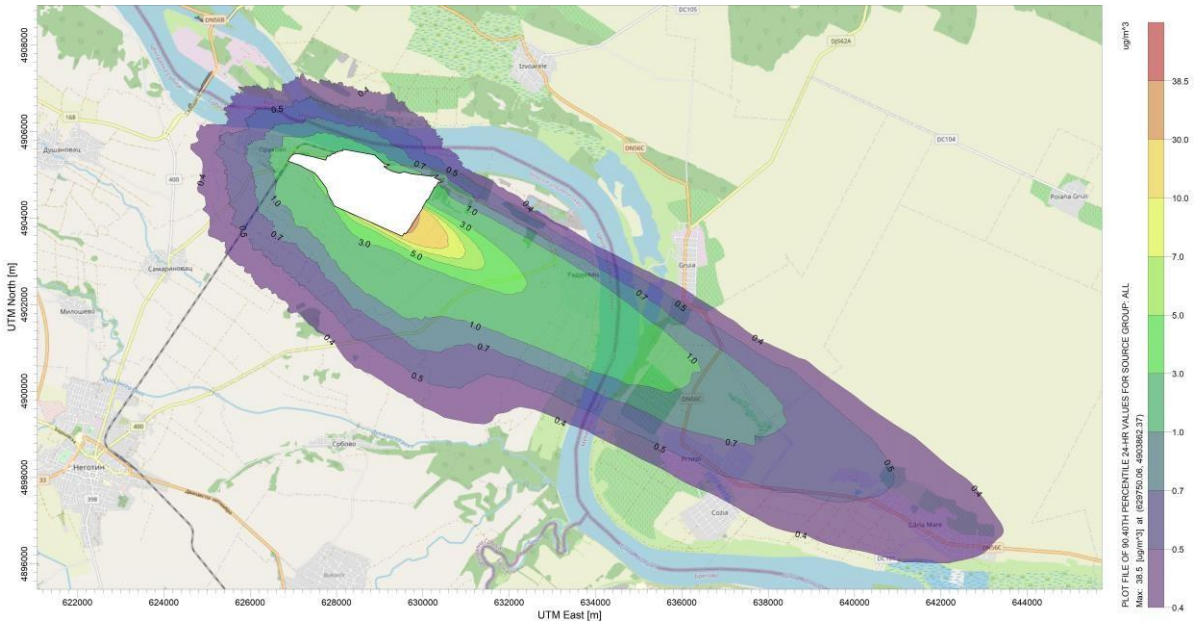


Figure 3.49 Maximum ground-level PM10 concentrations (90.40 percentile) for averaging period one day [µg/m3]

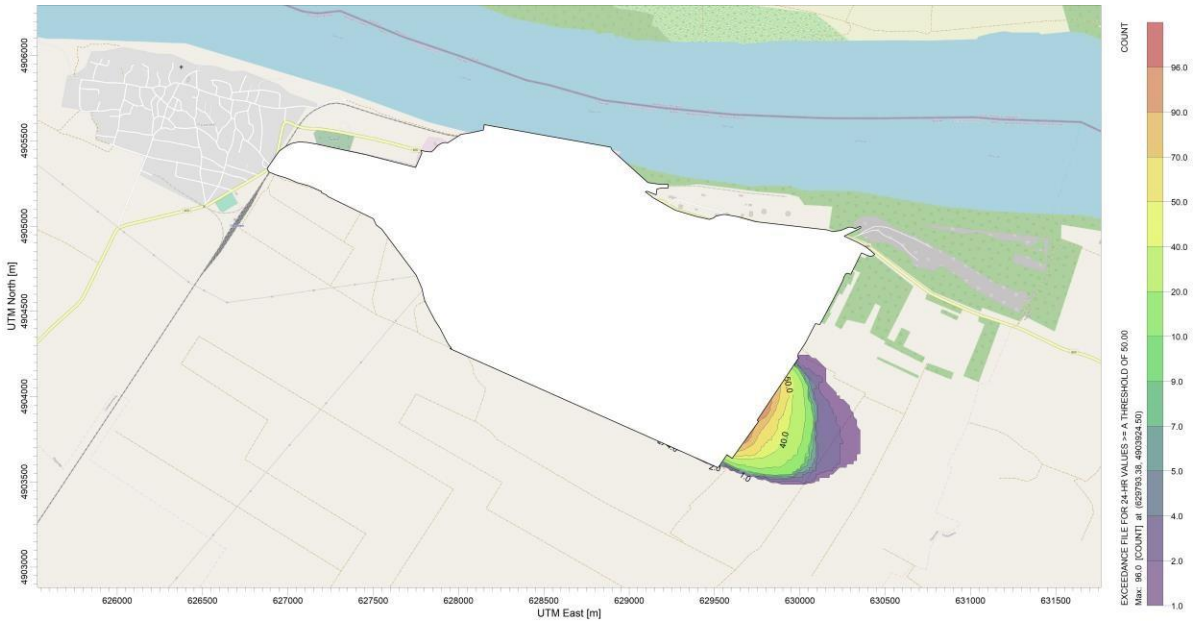


Figure 3.50 Number of exceedances of the PM10 limit value for an averaging period of one day over a period of five years

With a maximum value of 10.7 µg/m³ (3.51), the annual average in no part of the model domain exceeds the limit value. A narrow zone with the highest annual concentrations is observed just in places where limit values of daily averages can potentially be expected to be exceeded, but such low annual values indicate that despite periods with high episodic pollution, most are periods where the concentration of pollutants is at a low level.

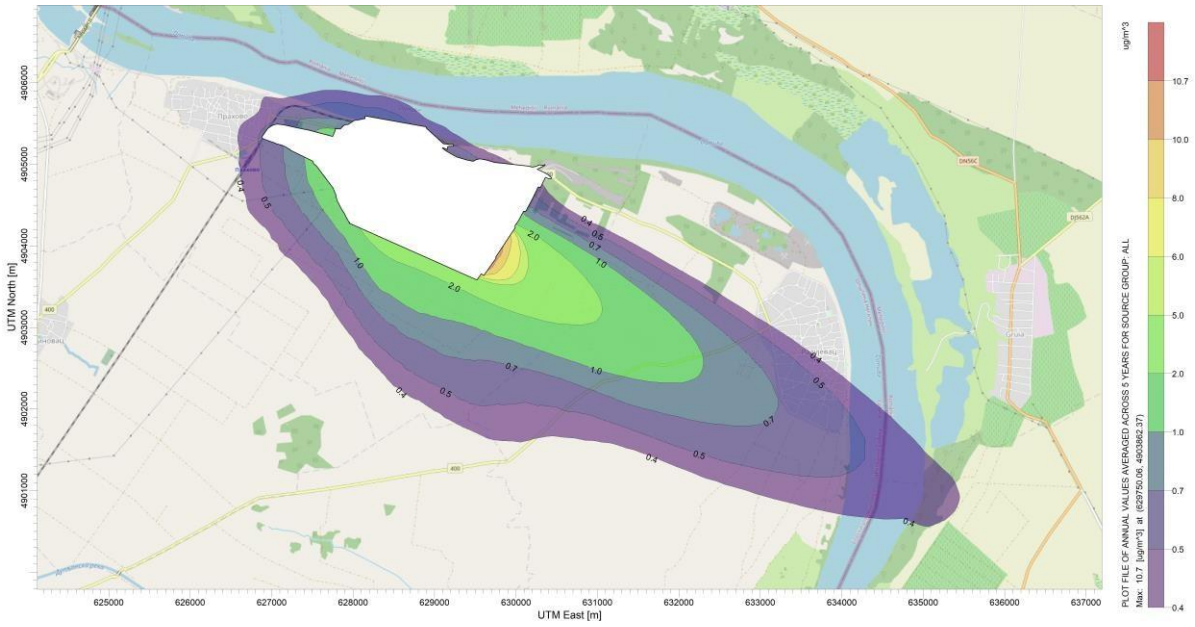


Figure 3.51 Maximum ground-level PM10 concentrations for the averaging period calendar year [μg/m^3]

Considering that the first maximum for the averaging period of one day for the current situation is higher than the first maximum for the future situation involving the landfill of non-hazardous waste (non-reactive solidificate) and an additional three point sources of dust emissions (boiler plant emitter, emitter of the filter system of solidification and emitter of the filter system of pre-treatment of waste and activated carbon filters) as well as a significant expansion of the phosphogypsum storage, it is necessary to provide additional explanation. In this case, the dominant source of powdery matter is the phosphogypsum storage for both the current and future state. The characteristics of surface sources that are important from the aspect of dispersion are primarily the value of emissions from them, then their height and, of course, their total surface area. Currently, the phosphogypsum storage consists of 5 units (~39.2 ha), as shown in Figure 2.11 and in Appendix I of this Study, the average height of the three northern units of the landfill is 7.5 m, while the average height of the southern zone is 3 m, and the eastern zone is at the level of 0 m. The adopted degree of spreading out decay, based on wetting, is 75%. The future state implies the formation of a new landfill zone east of the existing ones (~53.1 ha), but also an increase in the degree of spreading out decay to 90%, while the mean height of all landfill zones will be 7.5 m. It is precisely the higher degree of spreading out decay and the higher mean height that lead to the fact that the ground concentrations are lower in the event of a future condition, despite the increase in the area of the warehouse. Due to its characteristics (as given in point 2.6 of this Study), as well as the position within the complex itself, the load of the solidification landfill, as a surface source of particulate matter emissions, is very low, i.e. practically negligible.

In order to further demonstrate the effect of the future plant for thermal treatment of waste materials on the ground concentration of PM10, modelling was performed, in which only sources related to this plant were considered, i.e. three point emitters and a solidification landfill. The modelling results shown in Figures 3.52 and 3.53 indicate that the overall impact of the thermal waste treatment plant will be almost negligible.

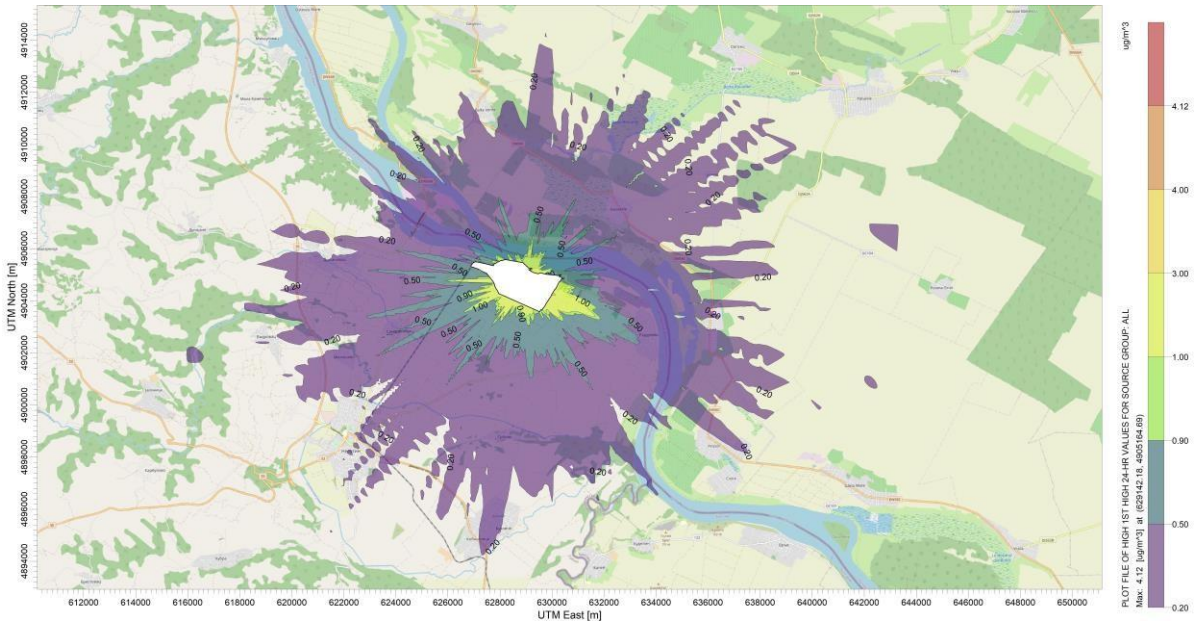


Figure 3.52 Maximum ground-level concentrations of PM10 for an averaging period of one day [μg/m^3] (thermal treatment plant and solidification landfill only)

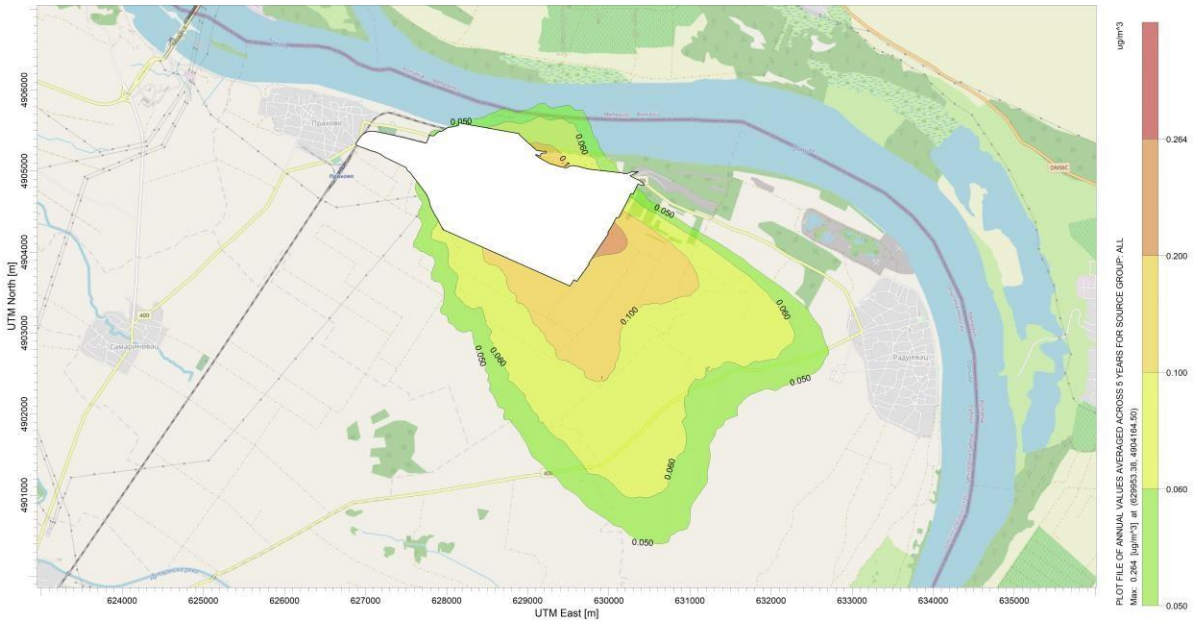


Figure 3.53 Maximum ground-level PM10 concentrations for the averaging period calendar year [μg/m^3] (thermal treatment plant and solidification landfill only)

PM2.5 concentration values obtained

Figure 3.54 shows isopleths of ground concentrations, which refer to the annual average PM2.5. For this averaging period, which is only prescribed by the Decree, the highest concentration obtained by the model is 2.38 μg/m³ and is observed along the southern limit of property, which is far below the prescribed limit value (25 μg/m³).

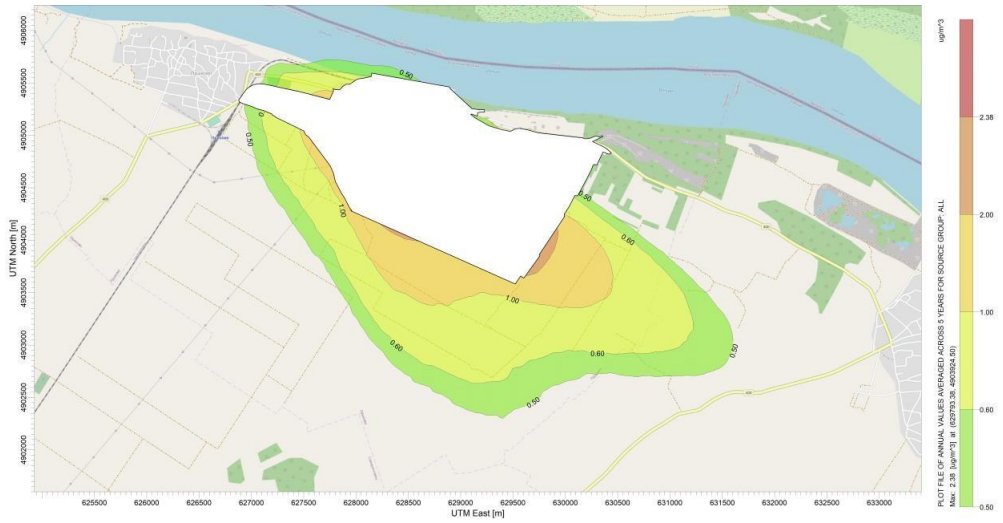


Figure 3.54 Maximum ground-level PM2.5 concentrations for the averaging period calendar year [μg/m^3]

CO concentration values obtained

The modelling results show that the expected ground-level CO concentrations are very low for all averaging periods considered (Figures 3.55-3.57). The highest concentration obtained by modelling, for the averaging period shown as the maximum daily eight-hour mean, is 15.5 μg/m³, while the limit value proposed by the Decree is 10 mg/m³. When it comes to averaging periods for one day and one calendar year, the differences between the respectively expected values and the threshold values are also significant. The highest model values obtained for the averaging periods are: 10.8 μg/m³ and 0.68 μg/m³, respectively.

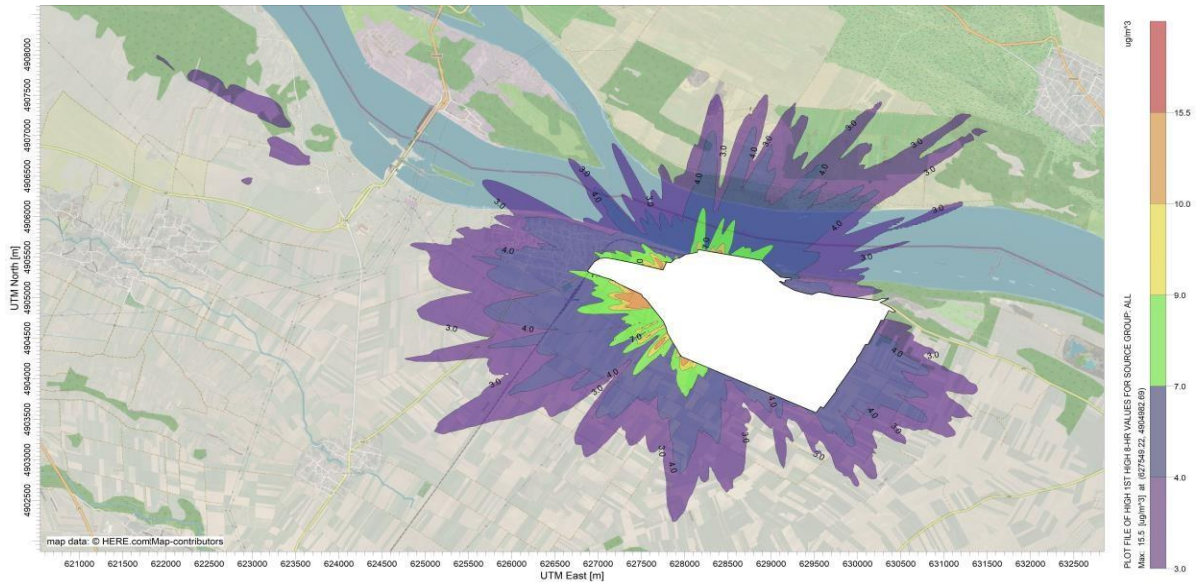


Figure 3.55 Maximum daily eight-hour mean ground-level CO concentration [μg/m^3]

Figure 3.56 Maximum ground-level CO concentrations for an averaging period of one day [μg/m^3]

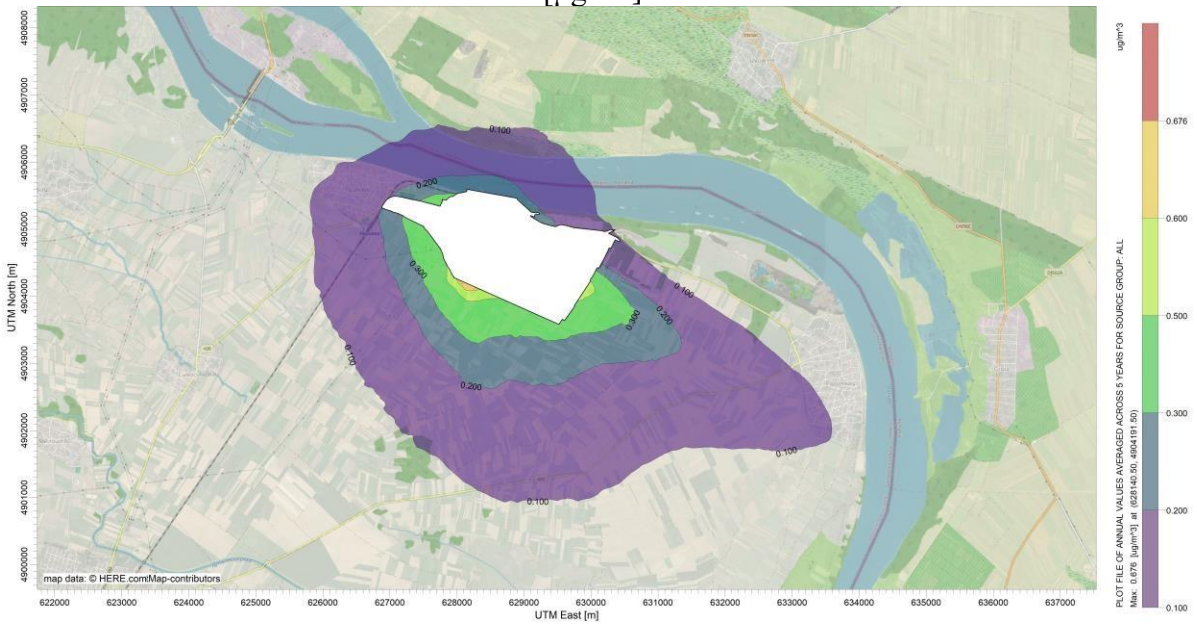


Figure 3.57 Ground-level CO concentrations for the averaging period calendar year [μg/m^3]

HCl concentration values obtained

After the construction of the plant for the incineration of waste materials, HCl will be emitted from the existing emitter of the Final Scrubber as well as from the emitter of the boiler plant (future plant for the thermal treatment of waste materials). Based on the modeling results, it can be concluded that the prescribed maximum three-hour daily, maximum daily and average annual limit values (50, 15 and 10 μg/m³, respectively) will not be exceeded in any part of the model domain (Figures 3.58, 3.59 and 3.60, respectively). Highest values obtained

by modeling for these averaging periods amounts to: 1.9 μg/m³, 0.96 μg/m³ and 0.082 μg/m³, respectively.

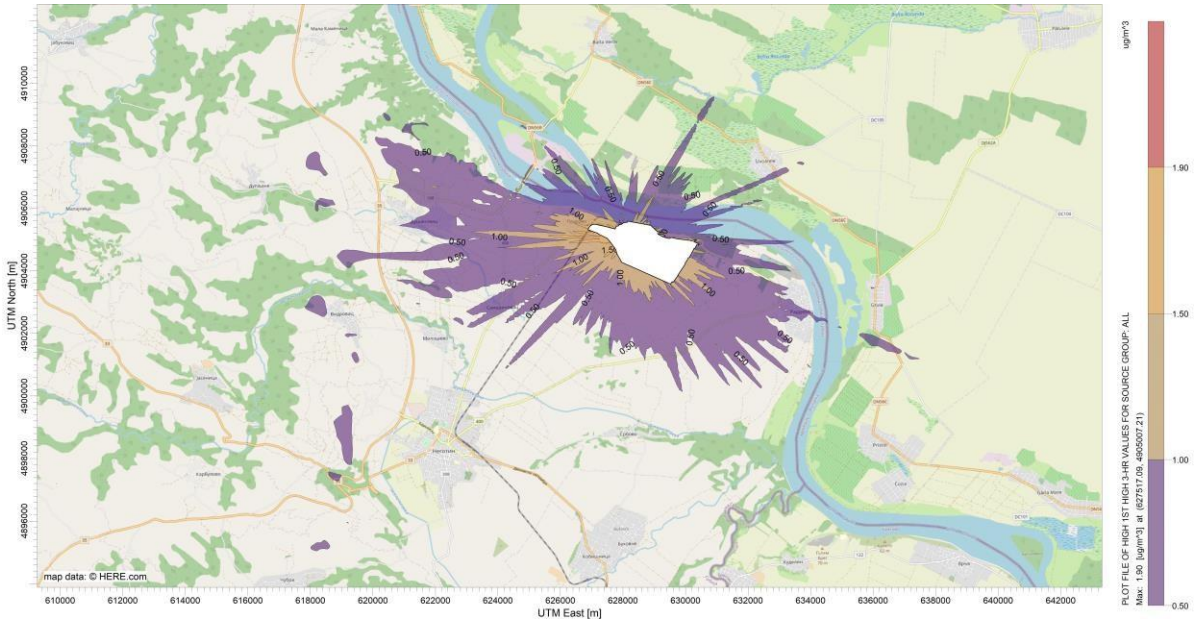


Figure 3.58 Maximum ground-level three-hour daily HCl concentrations [μg/m^3]

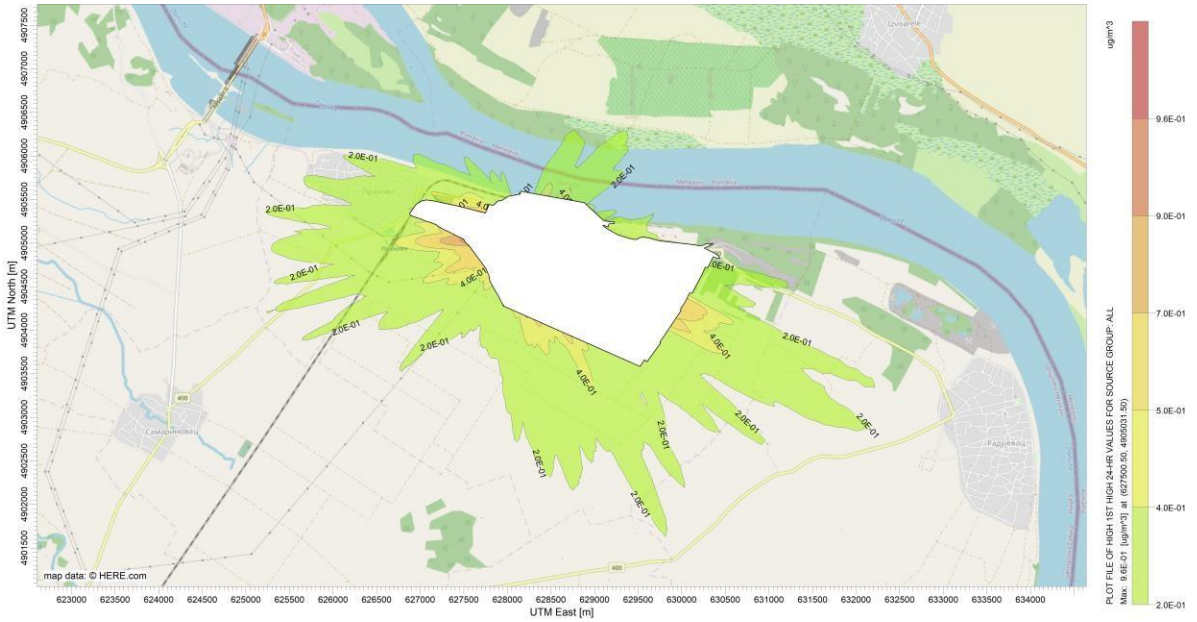


Figure 3.59 Maximum ground-level HCl concentrations for an averaging period of one day [μg/m^3]

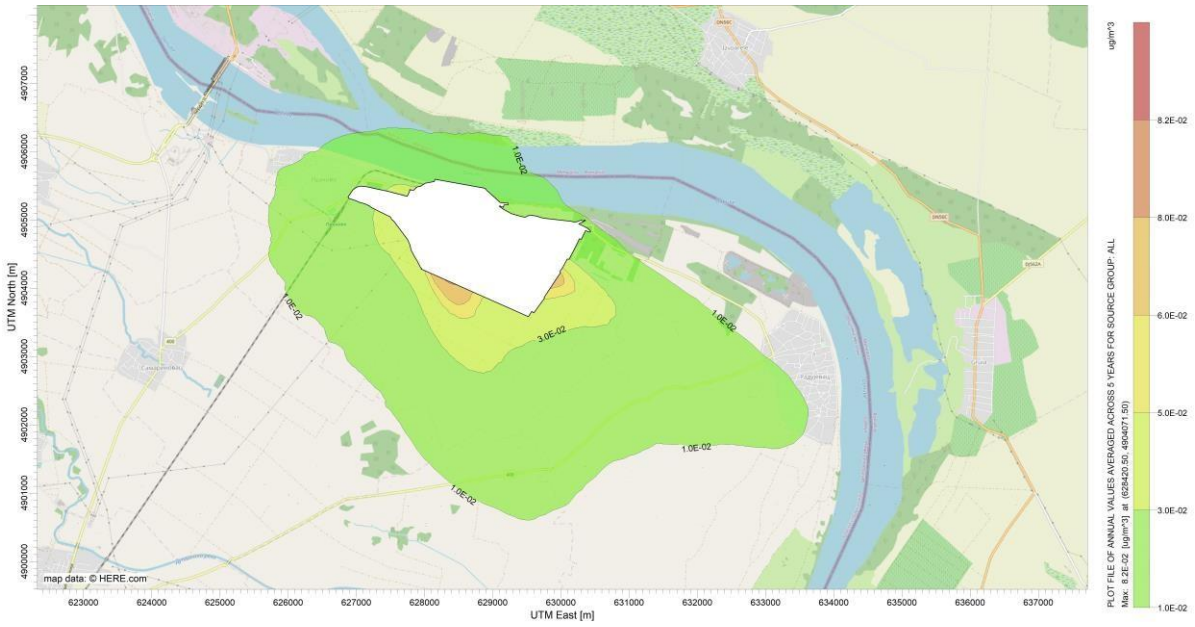


Figure 3.60 Ground-level HCl concentrations for the averaging period calendar year [μg/m^3]

HF concentration values obtained

Based on the modelling results (Figure 3.61 and 3.62), it can be concluded that the highest potential impact (10.1 μg/m^3), for an averaging period of three hours is below the prescribed limit values of 20 μg/m^3, while the highest impact for averaging period of one day, which is 3.75 μg/m^3, is almost at the limit of the prescribed limit value of 3 μg/m3. A narrow zone with concentrations that are slightly above the limit value is observed only immediately to the southeast border of the factory property. Bearing in mind that the obtained results indicate that, for the considered period of five years, i.e. 1,826 days, a maximum of two days in the mentioned zone can be exceeded, it can be concluded that exceeding the daily values can potentially occur extremely rarely and only under extremely unfavorable meteorological conditions. In addition, given the results of the current situation and the position of the zone with the maximum expected situation, it can be concluded that the contribution of the thermal treatment plant for waste materials will be practically negligible.

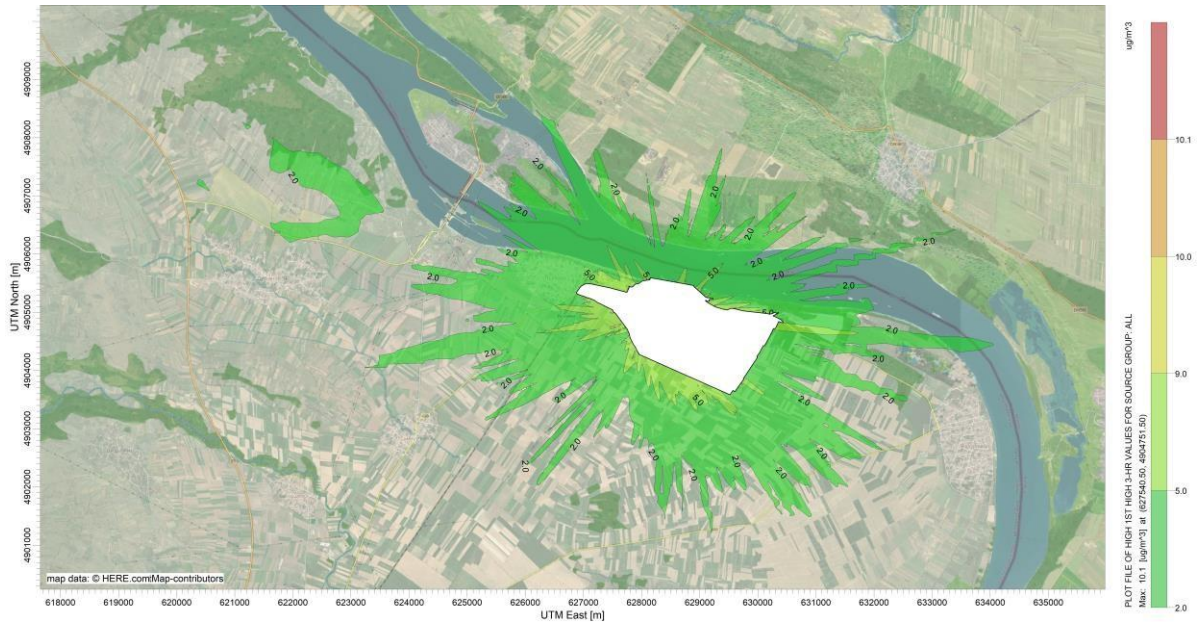


Figure 3.61 Maximum ground-level three-hour daily HF concentrations [μg/m^3]

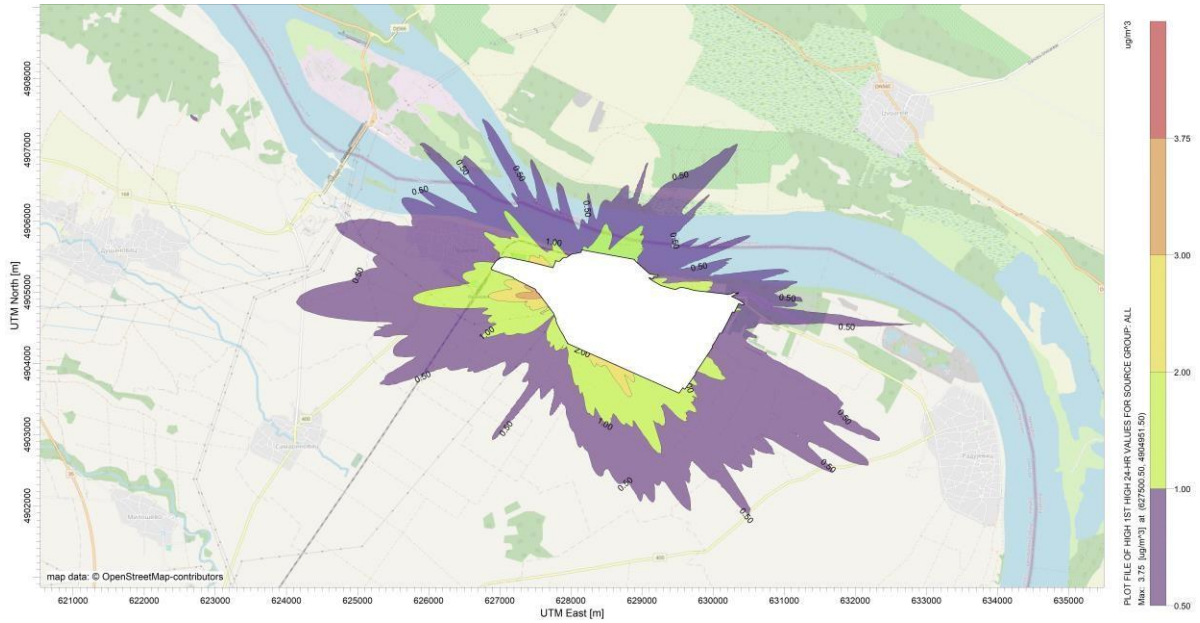


Figure 3.62 Maximum ground-level HF concentrations for an averaging period of one day [μg/m^3]

Obtained NH_3 concentration values

After the construction of the plant for thermal treatment of waste materials, NH_3 will be emitted from the existing emitter of the Final Scrubber as well as from the emitter of the boiler plant (future plant for thermal treatment of waste materials). Based on the modelling results, it can be concluded that the maximum obtained values for both averaging periods, 9.18 μg/m³ and 4.51 μg/m³, are far below the prescribed three-hour daily and daily values (200 and 100 μg/m³) (Figures 3.63 and 3.64).

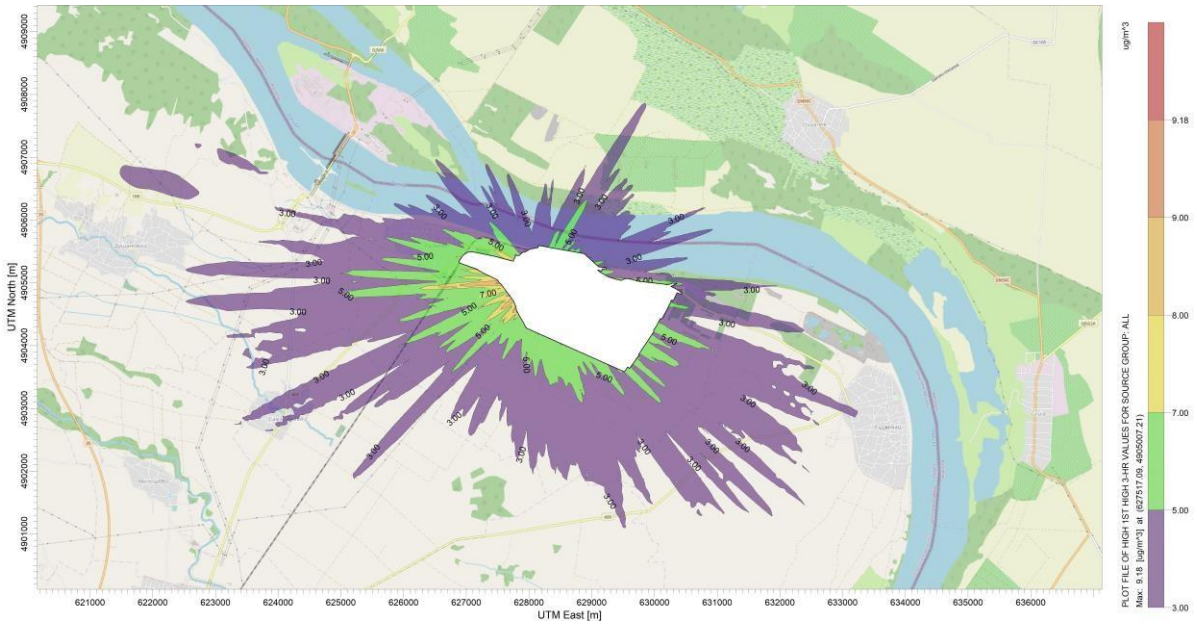


Figure 3.63 Maximum ground-level three-hour daily ammonia concentrations [μg/ m³]

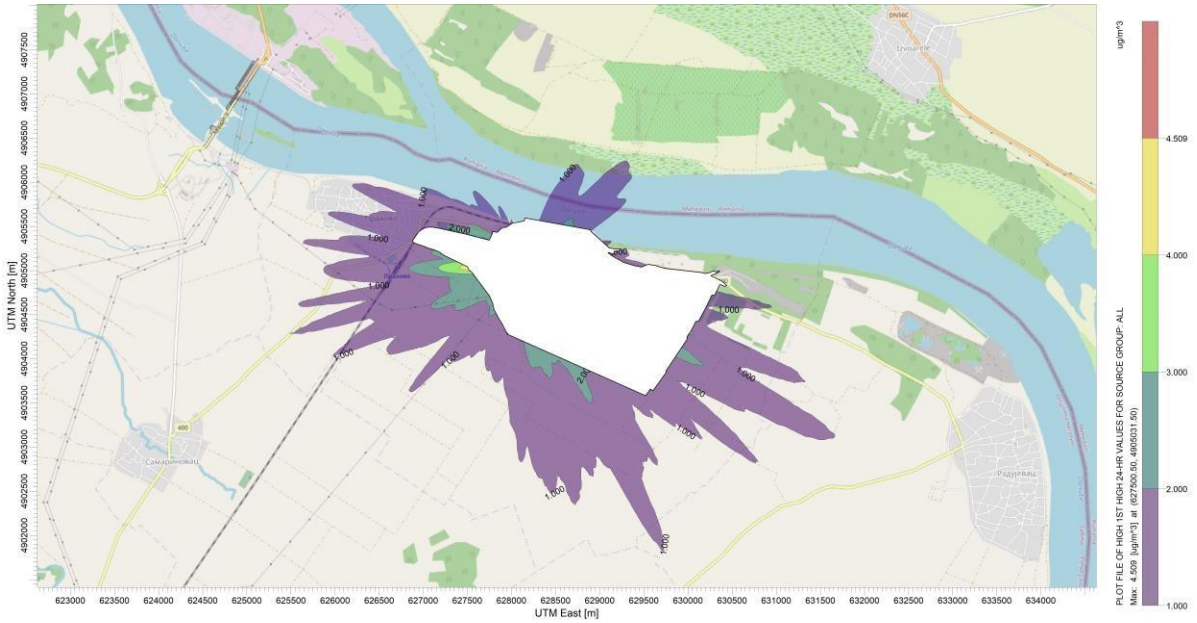


Figure 3.64 Maximum ground-level ammonia concentrations for averaging period one day [μg/ m³]

Hg concentration values obtained

Mercury is currently not emitted from the existing emitters of the chemical industry complex in Prahovo, but after the construction of the plant for thermal treatment of waste materials, it will potentially be emitted only from the emitters of the boiler plant. Based on the modeling results, for the highest emission values, it can be concluded that the highest value obtained (0.0014 μg/m³), for the prescribed daily average, is far below the limit value (2 μg/m³) (Figure 3.65).

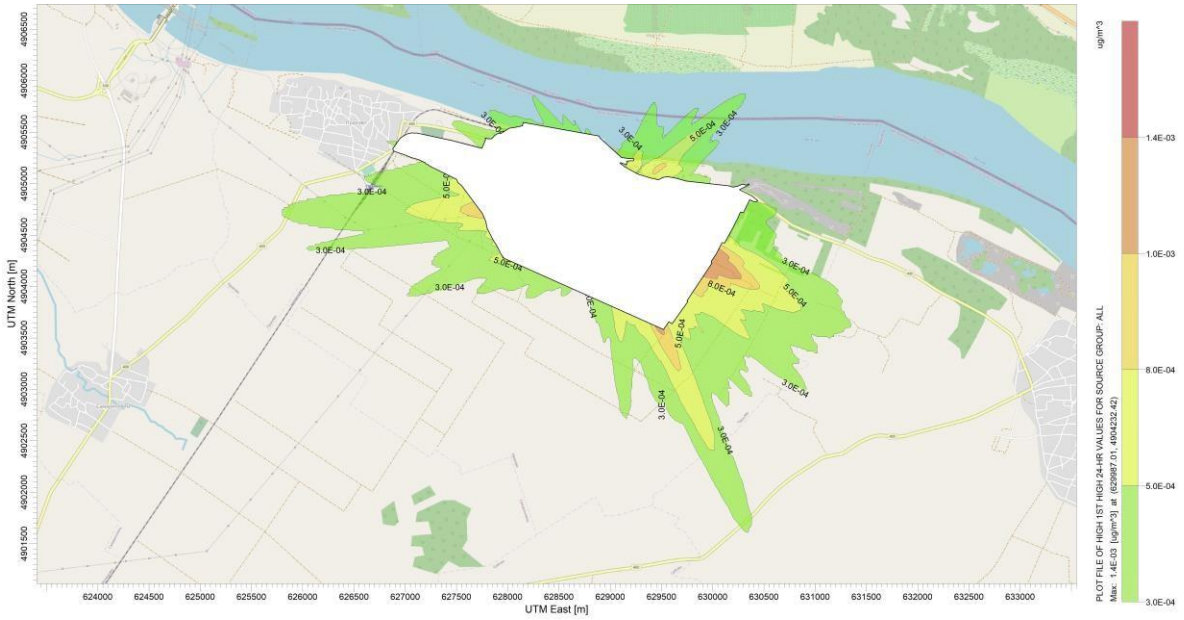


Figure 3.65 Maximum ground-level Hg concentrations for averaging period one day [μg/ m³]

Obtained values of PCDD/F and dioxin concentrations as PCBs

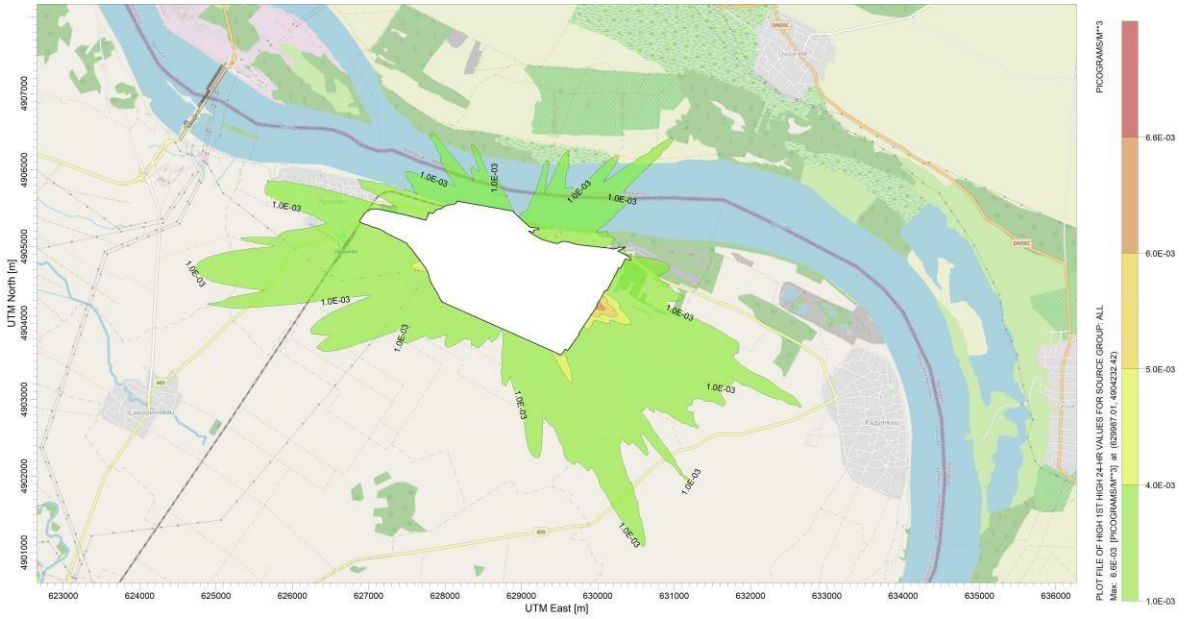


Figure 3.66 Maximum ground concentrations of PCDD/F and dioxins as PCBs for the averaging period of one day [pg/ m³]

PCDD/F is currently not emitted from the existing emitters of the chemical industry complex in Prahovo, but after the construction of the plant for thermal treatment of waste materials, it will potentially be emitted only from the emitters of the boiler plant. Based on the modeling results, for the highest emission values, it can be concluded that the highest value obtained (0.0066 pg/m³), for the prescribed daily average, is far below the limit value (2 μg/m³).

4. CONCLUSION

This Study considered the impact of the thermal waste treatment plant, solidificates landfill and expansion of phosphogypsum storage on air quality in the wider domain of the chemical industry complex in Prahovo (Elixir Prahovo). For the purposes of this Study, modeling was performed with the AERMOD software package using the appropriate input parameters for the existing and future state of the plant.

By analyzing the obtained results, it can be concluded that when it is about components that are currently emitted (CO, SO_2, NO_2, PM10, PM2.5, HF, HCl, NH_3) and which will also be emitted from the emitters of the future thermal treatment plant with a solidification landfill, the dominant influence is on the existing emitters or, in the case of dusty substances, surface sources for both the current and future conditions, while the impact of the future incineration plant, whose all emissions will be harmonized with the relevant *BAT conclusions*[2] and relevant national legislation, is practically negligible. It was found that in the case of some components (SO_2, PM10 and HF), there is a possibility of episodic high concentrations in the case of extremely unfavorable, from the point of view of dispersion, meteorological conditions, but that the number of hours/days with these concentrations is extremely small, i.e. there is little probability of this happening at all. It has been established that the cause of these potential episodic elevated concentrations are the existing SO_2 and HF emitters, i.e. phosphogypsum landfills in the case of PM10, both for the current and future state. Also, potential zones with exceedances of the limit values of these components occur on uninhabited areas in the immediate vicinity of the property limit of the chemical industry complex in Prahovo. When it comes to components that are currently not emitted and that will be emitted only from the emitters of the thermal treatment plant for waste materials (Hg and PCDD/F) in the future, the modeling results indicate that the concentrations of these pollutants will be far below the prescribed limit values.

Considering that due to the location of the chemical industry complex in Prahovo, there is a potential cross-border impact on air quality, it should be mentioned that the modelling results indicate that for both the current and future conditions, this impact is generally negligible.

ANNEX I

DATA ON EMITTERS

Existing point emitters

Emitter name: E1 - Steam boiler emitter 2941 (natural gas and fuel oil)			
Parameters	**Value**		**Unit**
Emitter height	25 m in relation to level 0		[m]
The inner diameter of the emitter at its top	1.1		[m]
Flue gas characteristics depending on fuel*	Natural gas	Fuel oil	-
Flue gas temperature at the top of the emitter	205.07 ± 1.88	231.38 ± 1.88	°C
Flue gas volume flow through the emitter	≈ 7418.66	≈ 7060	($Nm3/^{h}$)
Carbon monoxide mass flow, CO	≈ 0.308	≈ 0.253	kg/h
Mass flow of sulphur dioxide, SO_2	< 0.003	≈ 5.753	kg/h
Nitrogen oxides mass flow, NO_x	≈ 1.04	≈ 1.213	kg/h
Geographical coordinates of the emitter	44.28665 22.605681		[Lat/Long]

*For modelling purposes, the most unfavorable case was taken for each pollutant.

Emitter name: E2 – steam boiler emitter 4679 (natural gas and fuel oil)*			
Parameters	**Value**		**Unit**
Emitter height	25 m in relation to elevation 0		[m]
The inner diameter of the emitter at its top	1.4		[m]
Flue gas characteristics depending on fuel*	Natural gas	Fuel oil	-
Flue gas temperature at the top of the emitter	199.3 ± 1.88	212.12 ± 1.88	°C
Flue gas volume flow through the emitter	≈ 12 869	≈ 14 367	(Nm3/h)
Carbon monoxide mass flow, CO	≈ 0.145	≈ 0.137	kg/h
Mass flow of sulphur dioxide, SO_2	< 0.006	≈ 11.46	kg/h
Nitrogen oxides mass flow, NO_x	≈ 1.189	≈ 2,452	kg/h
Geographical coordinates of the emitter	44.28665 22.605681		[Lat/Long]

*For modelling purposes, the most unfavorable case was taken for each pollutant.

Emitter name: E3 – Steam boiler emitter (coal fired)		
Parameters	**Value**	**Unit**
Emitter height	40 m in relation to level 0	[m]
The inner diameter of the emitter at its top	1.5	[m]
Flue gas temperature at the top of the emitter	154.27 ± 1.88	°C
Flue gas volume flow through the emitter	29,367.33	(Nm3/h)
Individual mass flows of all pollutants dispersion of which is the subject of the Study		
Carbon monoxide mass flow, CO	≈ 4.339	kg/h
Mass flow of sulphur dioxide, SO_2	≈ 44.82	kg/h
Nitrogen oxides mass flow, NO_x	≈ 8.176	kg/h

Mass flow of particulate matter, PM	≈ 1.201	kg/h
Geographical coordinates of the emitter	44.286642 22.605533	[Lat/Long]

Name of the emitter: E4 – HTL device emitter		
Parameters	**Value**	**Unit**
Emitter height	35 m in relation to level 0	[m]
The inner diameter of the emitter at its top	0.4	[m]
Flue gas temperature at the top of the emitter	245.23 ± 1.88	°C
Flue gas volume flow through the emitter	2,999.67	(Nm3/h)
Individual mass flows of all pollutants dispersion of which is the subject of the Study		
Mass flow of particulate matter, PM	5.695	g/h
Geographical coordinates of the emitter	44.286478 22.610283	[Lat/Long]

Emitter name: E5 – Burner Emitter		
Parameters	**Value**	**Unit**
Emitter height	35 m in relation to level 0	[m]
The inner diameter of the emitter at its top	0.40	[m]
Flue gas temperature at the top of the emitter	228.27 ± 1.88	°C
Flue gas volume flow through the emitter	≈ 708.33	(Nm3/h)
Individual mass flows of all pollutants dispersion of which is the subject of the Study		
Carbon monoxide mass flow, CO	≈ 12.56	g/h
Mass flow of sulphur dioxide, SO_2	< 0.315	g/h
Nitrogen oxides mass flow, NO_x	≈ 59.38	g/h
Geographical coordinates of the emitter	44.286478 22.610283	[Lat/Long]

Emitter name: E6 – Emitter after scrubber, Emitter ALPHA		
Parameters	**Value**	**Unit**
Emitter height	40.6 m in relation to level 0	[m]
The inner diameter of the emitter at its top	0.6	[m]
Flue gas temperature at the top of the emitter	41.67 ± 1.88	°C
Flue gas volume flow through the emitter	≈ 8423	(Nm^3/h)
Individual mass flows of all pollutants whose dispersion is the subject of the Study		
Hydrogen fluoride mass flow, HF	≈17.35	g/h
Mass flow of particulate matter, PM	≈ 77.97	g/h
Geographical coordinates of the emitter	44.286478 22.610283	[Lat/Long]

Emitter name: E7 – Emitter of the final rinser (tower) NPK		
Parameters	**Value**	**Unit**
Emitter height	44.5 m in relation to level 0	[m]
The inner diameter of the emitter at its top	2.8	[m]
Flue gas temperature at the top of the emitter	63.63 ± 1.30	[°C]
Flue gas volume flow through the emitter	≈ 169 351.33	[Nm^3/h]
Individual mass flows of all pollutants whose dispersion is the subject of the Study		
Mass flow of chlorine compounds expressed as HCl	≈ 0.558	kg/h
Hydrogen fluoride mass flow, HF	≈ 0.709	kg/h
Ammonia mass flow, NH_3	≈ 2.691	kg/h
Mass flow of particulate matter, PM	≈ 2.020	kg/h
Geographical coordinates of the emitter	44.287122 22.606778	[Lat/Long]

Emitter name: E8 – Emitter of old fluidization cooler		
Parameters	**Value**	**Unit**
Emitter height	26.5 m in relation to level 0	[m]
The inner diameter of the emitter at its top	2	[m]
Flue gas temperature at the top of the emitter	51.47 ± 1.88	[°C]
Flue gas volume flow through the emitter	≈ 82 936	(Nm^3/h)
Individual mass flows of all pollutants whose dispersion is the subject of the Study		
Mass flow of particulate matter, PM	≈ 1.232	kg/h
Geographical coordinates of the emitter	44.287122 22.606778	[Lat/Long]

Emitter name: E9 – Emitter of the new fluidization cooler		
Parameters	**Value**	**Unit**
Emitter height	21 m in relation to level 0	[m]
The inner diameter of the emitter at its top	0.7	[m]
Flue gas temperature at the top of the emitter	58.67	[°C]
Flue gas volume flow through the emitter	≈ 10 755	(Nm^3/h)
Individual mass flows of all pollutants whose dispersion is the subject of the Study		
Mass flow of particulate matter, PM	≈ 0.180	kg/h
Geographical coordinates of the emitter	44.287122 22.606778	[Lat/Long]

Emitter name: E10 – Phosphoric acid production plant emitter - end tower		
Parameters	**Value**	**Unit**
Emitter height	34.5 in relation to level 0	[m]
The inner diameter of the emitter at its top	2.1	[m]
Flue gas temperature at the top of the emitter	48.90 ± 1.88	[°C]
Flue gas volume flow through the emitter	187 413.67	(Nm^3/h)
Individual mass flows of all pollutants whose dispersion is the subject of the Study		
Hydrogen fluoride mass flow, HF	≈ 2.019	kg/h
Mass flow of particulate matter, PM	≈ 1.254	kg/h
Geographical coordinates of the emitter	44.286719 22.603942	[Lat/Long]

Emitter name: E11 – Emitter of phosphate grinding mills plant		
Parameters	**Value**	**Unit**
Emitter height	31 m in relation to level 0	[m]
The inner diameter of the emitter at its top	0.6	[m]
Flue gas temperature at the top of the emitter	42.63 ± 1.88	[°C]
Flue gas volume flow through the emitter	14 919.33	(Nm^3/h)
Individual mass flows of all pollutants whose dispersion is the subject of the Study		
Mass flow of particulate matter, PM	0.271	kg/h
Geographical coordinates of the emitter	44.286642 22.605533	[Lat/Long]

Emitter name: E12 – Vibro sieve and hopper plant emitter		
Parameters	**Value**	**Unit**
Emitter height	28 in relation to the level 0	[m]
The inner diameter of the emitter at its top	0.9	[m]
Flue gas temperature at the top of the emitter	25.67 ± 1.88	[°C]
Flue gas volume flow through the emitter	≈ 35 475	(Nm^3/h)
Individual mass flows of all pollutants whose dispersion is the subject of the Study		
Mass flow of particulate matter, PM	≈ 0.093	kg/h
Geographical coordinates of the emitter	44.286642 22.605533	[Lat/Long]

Emitter name: E13 – Emitter of dryer's dust separator and granulator, rotary cooler and process sieve, chain mill, recycling silo, bands and elevators**		
Parameters	**Value**	**Unit**
Emitter height	28 in relation to the level 0	[m]
The inner diameter of the emitter at its top	2.8	[m]
Flue gas temperature at the top of the emitter	52.50 ± 0.2	[°C]
Waste gas flow	119 556 ± 6576	(Nm^3/h)
Dry waste gas flow under standard conditions	93 111	(Nm^3/h)
Individual mass flows of all pollutants whose dispersion is the subject of the Study		
Mass flow of particulate matter, PM	4.678	kg/h
Geographical coordinates of the emitter	44.288139 22.605764	[Lat/Long]

**Emitter belongs to Phosphea company

Emitter name: E14 – Fluidized cooler emitter **		
Parameters	**Value**	**Unit**
Emitter height	18.5 m in relation to level 0	[m]
The inner diameter of the emitter at its top	0.8	[m]
Flue gas temperature at the top of the emitter	30.2 ± 0.1	[°C]
Waste gas flow	18 433 ± 1014	(Nm^3/h)
Dry waste gas flow under standard conditions	15 411	(Nm^3/h)
Individual mass flows of all pollutants whose dispersion is the subject of the Study		
Mass flow of particulate matter, PM	0.014	kg/h
Geographical coordinates of the emitter	44.288189 22.605375	[Lat/Long]

**Emitter belongs to Phosphea company

Emitter Name: E15 – Ball Mill Emitter **		
Parameters	**Value**	**Unit**
Emitter height	25m in relation to level 0	[m]
The inner diameter of the emitter at its top	0.5	[m]
Flue gas temperature at the top of the emitter	52.1 ± 0.2	[°C]
Waste gas flow	8 608 ± 473	(Nm^3/h)
Dry waste gas flow under standard conditions	6712	(Nm^3/h)
Individual mass flows of all pollutants whose dispersion is the subject of the Study		
Mass flow of particulate matter, PM	0.058	kg/h
Geographical coordinates of the emitter	44.288044 22.6053	[Lat/Long]

**Emitter belongs to Phosphea company

Emitter name: E16 – Steam generator-boiler emitter**		
Parameters	**Value**	**Unit**
Emitter height	17 in relation to the level 0	[m]
The inner diameter of the emitter at its top	0.5	[m]
Flue gas temperature at the top of the emitter	117.57 ± 0.7	[°C]
Waste gas flow	3 339.67 ± 87	(Nm^3/h)
Dry waste gas flow under standard conditions	1960	(Nm^3/h)
Individual mass flows of all pollutants whose dispersion is the subject of the Study		
Carbon monoxide mass flow, CO	0.106	kg/h
Mass flow of nitrogen oxides expressed as NO_2	0.231	kg/h
Geographical coordinates of the emitter	44.288333 22.605167	[Lat/Long]

**Emitter belongs to Phosphea company

Emitter name: E17 – Emitter of dust remover of finished products**		
Parameters	**Value**	**Unit**
Emitter height	19 in relation to the level 0	[m]
The inner diameter of the emitter at its top	0.6	[m]
Flue gas temperature at the top of the emitter	28.8 ± 0.1	[°C]
Waste gas flow	12 022 ± 661	(Nm^3/h)
Dry waste gas flow under standard conditions	10 098	(Nm^3/h)
Individual mass flows of all pollutants whose dispersion is the subject of the Study		
Mass flow of particulate matter, PM	0.092	kg/h
Geographical coordinates of the emitter	44.287936 22.605522	[Lat/Long]

**Emitter belongs to Phosphea company

Future point emitters

As already stated in the Study, the future state implies the operation of all current emitters with the already listed characteristics, as well as three point emitters of the plant for thermal treatment of waste materials:

Emitter name: E18 – Boiler plant emitter (W-C14)		
Parameters	**Value**	**Unit**
Emitter height	56 in relation to the level 0	[m]
The inner diameter of the emitter at its top	1.7	[m]
Flue gas temperature at the top of the emitter	147 ± 3	[°C]
Flue gas volume flow through the emitter	70,000	(Nm^3/h)
Individual mass flows of all polluting		

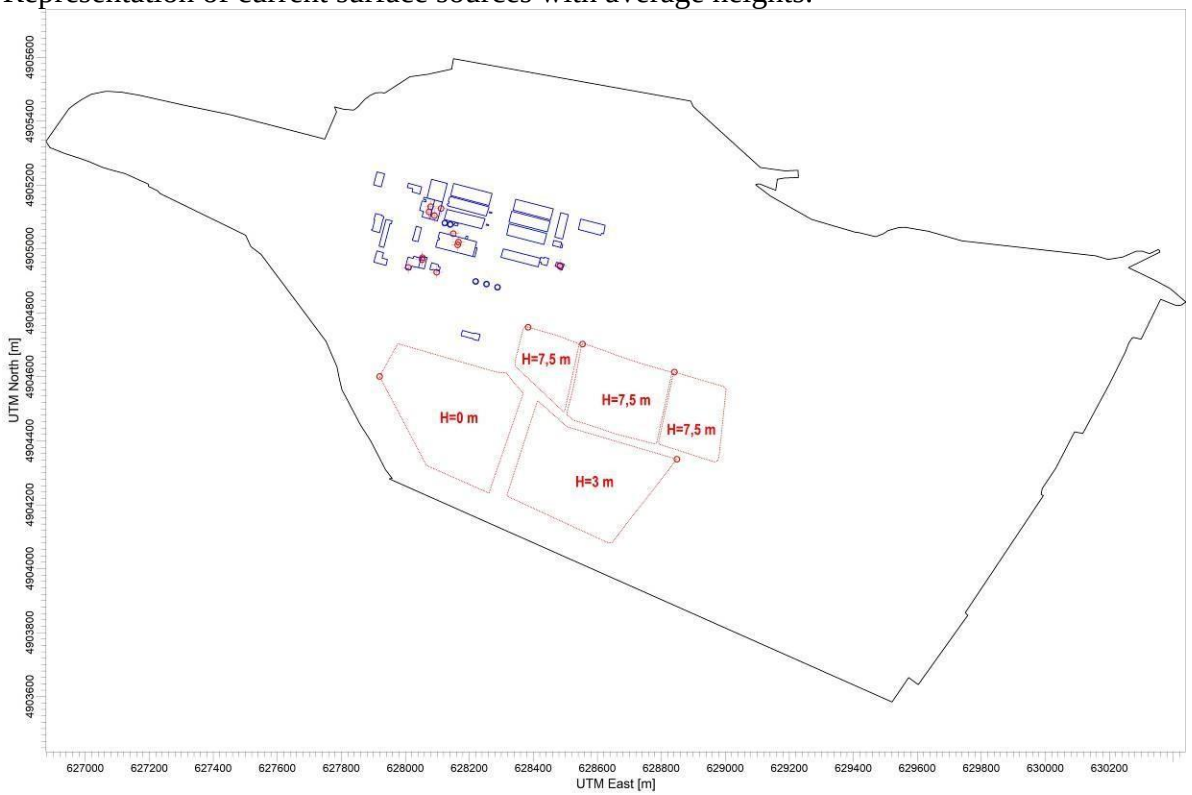
substance whose dispersion is the subject of the Study		
Mass flow of particulate matter, PM	0.35	kg/h
Hydrogen fluoride mass flow, HF	0.07	kg/h
Carbon monoxide mass flow, CO	3.5	kg/h
Sulphur dioxide mass flow, SO_2	2.1	kg/h
Nitrogen oxides mass flow, NO_x	8.4	kg/h
Mass flow of chlorine compounds expressed as HCl	0.42	kg/h
Ammonia mass flow, NH_3	0.7	kg/h
Mass flow of mercury, Hg	0.0014	kg/h
Mass flow of PCDD/F and dioxins as PCBs	0.0000000028	kg/h
Geographical coordinates of the emitter	44.284570 22.616845	[Lat/Long]

Emitter name: E19 – Emitter of solidification plant (W-C16)		
Parameters	**Value**	**Unit**
Emitter height	21.5 m in relation to level 0	[m]
The inner diameter of the emitter at its top	1.2	[m]
Flue gas temperature at the top of the emitter	ambient	[°C]
Flue gas volume flow through the emitter	25,000	(Nm^3/h)
Mass flow of particulate matter, PM	0.125	kg/h
Geographical coordinates of the emitter	44.284418 22.616549	[Lat/Long]

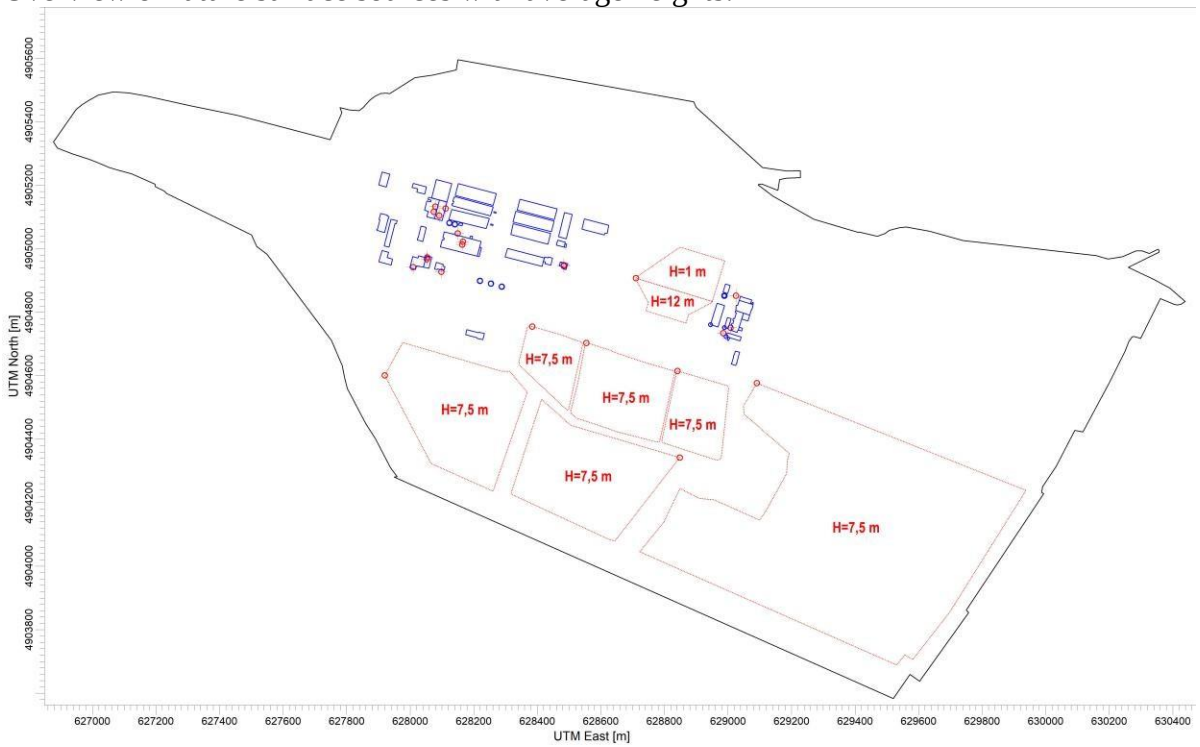
Emitter name: E20 – Emitter of the Waste Pre-treatment Filter System and Activated Carbon Filter (W-C09)		
Parameters	**Value**	**Unit**
Emitter height	21.5 m in relation to level 0	[m]
The inner diameter of the emitter at its top	1.2	[m]
Flue gas temperature at the top of the emitter	ambient	[°C]
Flue gas volume flow through the emitter	24,000	(Nm^3/h)
Mass flow of particulate matter, PM	0.45	kg/h
Geographical coordinates of the emitter	44.285472 22.617081	[Lat/Long]

Surface emitters

Representation of current surface sources with average heights:



Overview of future surface sources with average heights:



Emissions of particulate matter from surface sources are defined in accordance with the recommendations of US EPA AP42, Air Emissions Database:

$$E_{PM10} = 1.8 \cdot u \cdot 0.5\ (1-\eta)\ [g/(m^2 \cdot s)]$$
$$E_{PM2.5} = 1.8 \cdot u \cdot 0.075\ (1-\eta)\ [g/(m^2 \cdot s)]$$

where:

u – wind speed [m/s],
η – the degree of spreading out decay.

Emissions of particulate matter from existing surface sources (phosphogypsum storage) depending on the wind speed and the degree of spreading out decay of 75%:

u	**PM10**	**PM2.5**
[m/s]	[g/(m^2·s)]	[g/(m^2·s)]
< 5.14	-	-
5.14 – 8.23	0.00004181	0.000006272
8.23 – 10.8	0.00005950	0.000008925
> 10.8	0.00008925	0.000013387

Emissions of particulate matter from the future phosphogypsum storage depending on the wind speed and the degree of spreading out decay of 90%:

u	**PM10**	**PM2.5**
[m/s]	[g/(m^2·s)]	[g/(m^2·s)]
< 5.14	-	-
5.14 – 8.23	0.000016725	0.000002509
8.23 – 10.8	0.0000238	0.00000357
> 10.8	0.0000357	0.000005355

Emissions of particulate matter from the future solidificate landfill (at the moment as defined in point 2.6 of this Study) depending on the wind speed and the degree of spreading out decay of 95%:

u	**PM10**	**PM2.5**
[m/s]	[g/(m^2·s)]	[g/(m^2·s)]
< 5.14	-	-
5.14 – 8.23	8.3625E-06	1.25438E-06
8.23 – 10.8	0.0000119	1,785 E-06
> 10.8	0.00001785	2.6775E-06