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ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA)

Date 04.08.2020

Reference # 109001759-003-0000-E-1501

PARACEL

Pulp Mill, River Port, Transmission Line and Electrical Substation in Concepción – Paraguay

VOLUME IV - COMPLEMENTARY ENVIRONMENTAL STUDIES

Content	14	COMPLEMENTARY ENVIRONMENTAL STUDIES
Annexes	I	Atmospheric Dispersion Study
	II	Water Dispersion Study
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PARACEL	E
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Orig.	15/07/20 – bvv	15/07/20 – msh	15/07/20 – hfw	15/07/20 – hfw	For information
Rev.	Date/Author	Date/Verified	Date/Aproved	Date/Authorized	Observation
a	31/05/21 – bvv	31/05/21 – hbo	31/05/21 – hfw	31/05/21 – hfw	For information
b	31/07/21 – bvv	31/07/21 – hbo	31/07/21 – hfw	31/07/21 – hfw	For information

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14 COMPLEMENTARY ENVIRONMENTAL STUDIES

This volume presents the complementary environmental studies of the Environmental and Social Impact Assessment (ESIA) regarding the implementation of the PARACEL pulp mill in Concepción, Paraguay.

Therefore, in this Volume, the following are presented as attachments:

- Atmospheric Dispersion Study;
- Water Dispersion Study;
- Preliminary Risk Analysis Study;
- Sound Pressure Level Modeling (PARACEL will meet noise IFC Guidelines);
- Self Depuration Study.

ANNEX I

ATMOSPHERIC DISPERSION STUDY

CataVento Ambientale Meteorologia e Meio Ambiente presents

PRESENTATION

ATMOSPHERIC DISPERSION STUDY

PARACEL – CONCEPCIÓN – PARAGUAY

MAY - 2020

Prepared by ***CataVento Ambientale Meteorologia e Meio Ambiente***

With the expectation that the activities presented in this document are satisfactory to the proposed objectives, we reiterate our expressions of consideration.

Rio Grande, May 10, 2020

SUMMARY

1. INTRODUCTION

This technical report presents the atmospheric dispersion results of the following pollutants: carbon monoxide (CO), total reduced sulfur (TRS), nitrogen dioxide (NO_2), particulate matter (PM_{10}) and sulfur dioxide (SO_2), emitted by PARACEL pulp mill, with a capacity of 1.5 million tons per year of bleached pulp for paper or 900 thousand tons per year of dissolving pulp. PARACEL pulp mill and its emission sources will be installed near the city of Concepción, in Paraguay, at the coordinates 23.241050° S and 57.490110° W (7429711 S; 449862 O UTM). Concepción city is the capital of Concepción department and is located on the left side of Paraguay river, 400 km north of Asunción.

It should be noted that the PARACEL pulp mill, despite being designed to produce 1,500,000 t/year, will be able to produce up to 1,800,000 t/year of bleached pulp as a consequence of higher overall plant efficiency, as well as greater equipment performance without the need to increase the built area or include new additional equipment. Likewise, it will not be necessary to make any modification to the main environmental control equipment, nor any loss in its performance, which can guarantee the same liquid effluent and atmospheric emissions considered in this EIAp/RIMA. Therefore, it can be said that in the event of increasing pulp production up to 1,800,000 t/year, there will be no changes in the environmental impacts identified and evaluated in this EIAp/RIMA.

Simulations of atmospheric dispersion of CO, TRS, NO_2, PM_{10}, and SO_2 are performed using the Aerial Model Dispersion (AERMOD), developed and available by the United States Environmental Protection Agency (EPA). The surface and altitude meteorological data were obtained from a numerical simulation with the WRF mesoscale meteorological model, the MMIF software and the AERMET processor. The meteorological data series covers the period from 01/01/2018 to 01/01/2020, two years of simulated data.

2. METHODOLOGY

2.1 Models Description

Atmospheric dispersion modeling is performed using the AERMET-AERMOD model system, fed with meteorological data simulated by the WRF mesoscale model. The interface between the FRM model and the AERMET-AERMOD model system is done using the MMIF model. Descriptions of the models used for the study are presented in this section.

2.1.1. Modelo AERMOD

AERMOD was developed by the United States Environmental Protection Agency (EPA, 2004a, 2008a). AERMOD is a stationary Gaussian model used to calculate the concentrations associated with industrial sources; the model is an improvement of the ISCST3 (SourceComplex-Short Term3). AERMOD can be applied on complex terrain and under realistic conditions of turbulence of the atmospheric boundary layer (ATC). The model assumes the Gaussian distribution in all directions under any atmospheric condition. However, can treat vertical distribution as non-Gaussian under convective (unstable) conditions. The model is also composed of algorithms to simulate dispersion in light wind conditions and to consider the effect of buildings on the dispersion of pollutants (building downwash).

To run simulations with the AERMOD model, information from two data sets is needed: emission sources and meteorology. Emitting source data includes coordinates, emission rates, exit pollutant temperature, and exit pollutant velocity. The meteorological data set must contain the pressure, wind direction and speed, air temperature, precipitation and the solar radiation, as well as some specific parameters of CLA (microscale parameters). The simulation domain topography can also be reported in several resolutions.

The dispersion processing and concentration calculation by the AERMOD model is performed from a name list file (aermod.inp), in which the appropriate commands are listed and read by the model. Meteorological and micro meteorological information is delivered to the model through files for surface conditions (surface.sfc) and for altitude conditions (profile.pfl). If the pollutant emissions are variable in time, it is possible to create emission files for each pollutant and transfer the information to the model using the HOUREMISS.

2.1.2. Modelo AERMET

The AERMET processor (EPA, 2004b) organizes the meteorological data and estimates the CLA parameters necessary for the dispersion calculations with the AERMOD model. Thus, the AERMET was designed to perform the calculations in three stages. The first stage extracts the data and performs data quality control. The second stage combines the available data for 24 hour periods and writes this data to an intermediate file. The third and last stage reads the data generated in the second stage and calculates the CLA parameters necessary for the AERMOD model [CLA height, friction velocity (u *), convection velocity scale (w *), heat flux sensitive, Obukhov length (L)].

AERMET can extract altitude data in two formats: TD-6201 and *Forecast Systems Laboratory* (FSL). For surface data, the AERMET processor can extract hourly data in the following formats: : Tarjeta Deck 144 (CD-144), Solar and Meteorological Surface Observation Network (SAMSON), Hourly Surface Meteorological Observations (HUSWO), Integrated Surface Hours Database (ISHD) and TD-3280. AERMET may also receive data in a non-standard format to include weather information for a specific site (on-site station). In on-site mode, the AERMET model accepts data in ASCII format and structured by the user. The on-site station format works well for simulations using data from weather stations installed in locations outside of the United States and Canada, where files can be accessed by the user in the formats mentioned.

2.1.3. Modelo WRF

Numerical climate simulations, designed to obtain altitude information, are performed using the Weather Research and Forecasting (WRF) model. The WRF is a mesoscale computerized weather forecasting system designed for both operational service and research needs. The model is fully compressible and can be integrated in non-hydrostatic mode.

The WRF calculates the components of wind speed, potential temperature, geopotential, surface pressure field, and various physical quantities. It also allows other variables to be generated, such as turbulent kinetic energy and ratios for mixing water vapor, rain/snow, and cloud water/ice. Physics model also calculates non-local turbulence for CLA and determine long and short wave radiation in various spectral bands.

The simulation period with the WRF model (the last two consecutive years) allows the study to be carried out taking into account all the meteorological conditions that influence the transport and diffusion of pollutants in the region, including diurnal and seasonal variations. The model is used in a configuration with nested grids centered on the company coordinates. The physical parameters, used in the WRF simulation, include

CLA, surface, cumulus, cloud microphysics, and radiation parameterization. The characteristics of the simulation domains and the model configuration options are presented in Table 1.

Table 1 - Characteristics of the simulation domains and configuration options of the WRF model.

Domain	External Network	Intermediary Network	Internal network
Horizontal network	30 points	30 points	30 points
Network space	27 km	9 km	3 km
Simulation Period	01/01/2018 a 01/01/2020		
Coordinates central point of the networks	23,241050° S e 57,490110° O 7429711 S; 449862 O m UTM		
Initial and contour conditions of meteorology	GFS (0,25º)		
Vertical levels	30 layers		
Spin-up period	15 days (since December, 15 (2017))		
CLA settings	Yonsei University (YSU)		
Surface settings	Monin-Obukhov Similarity Theory (MM5 MRF PBL).		
Cumulus settings	Betts-Miller-Janjic		
Cloud microphysics settings	WSM 3-class scheme (Hong et al., 2004)		
Radiation settings	RRTM		

2.1.4. MMIF Model

After performing numerical simulations with the WRF model, a data conversion to the AERMET and AERMOD models is necessary. To perform, the software provided by the US EPA, called “Mesoscale Model Interface Program” - MMIF (EPA, 2016) is used. The MMIF converts the results of the meteorological forecast models (WRF, MM5, ...) to the AERMET-AERMOD model system (Cimorelli et al., 2005).

With MMIF it is possible to extract the necessary surface and altitude data for the AERMET module and finally generate the files with the necessary data and in the specific format to feed the AERMOD dispersion model. MMIF creates three files, which are read by the AERMET model: a file that contains surface and altitude meteorological information (in situ), a file that contains altitude information only (ascending), and a file that contains information with characteristics of surface (roughness length, albedo and Bowen ratio).

AERMET uses this information to generate new files with the surface conditions (surface.sfc) and the altitude conditions (profile.pfl), which will be read by the AERMOD dispersion model.

2.2. Meteorological data

In this study, altitude and surface characteristics data are extracted from the results generated by the WRF model. This procedure was adopted due to the unavailability of primary (observed) meteorological data that could be used in the AERMOD dispersion model. The closest official and approved meteorological station is located at Teniente Coronel Carmelo Peralta Airport (USAF: 861340 / ICAO: SGCO), about 21 km southeast of the pulp mill (coordinates 23,442 ° S and 57,427 ° W (7407484.94 S ; 456383.89 O m UTM, altitude: 77 m). However, the airport station does not provide hourly meteorological data (1-hour averages) necessary to AERMOD.

Therefore, because the AERMOD model requires hourly meteorological data, and the Teniente Coronel Carmelo Peralta airport station or other official station close to the project does not have it, the AERMOD model was executed with meteorological data generated by numerical simulation by WRF model. This procedure is considered acceptable and the data from that station was used only for climatology and for the evaluation of the WRF weather model, which is presented in Section 3.2.

The files with surface and altitude information are generated from numerical simulations with the WRF model and are subsequently processed by the MMIF software. The MMIF model generates an altitude file in the format of the Forecast Systems Laboratory (FSL) and an on-site file with surface data. The files generated by the MMIF are communicated to the AERMET model to generate the “surface.sfc” and “profile.pfl” files, which serve as input for the AERMOD model. Both surface and altitude information are obtained from the center point of the grid, which coincides with the location of the company's emission sources. The surface and altitude data series, taken from the WRF model, covers the period from January 1, 2018 to January 1, 2020.

2.3. Surface Characteristics

To use the AERMET model to process meteorological data for the AERMOD model, it is necessary to determine the appropriate values for three surface characteristics:

roughness length, albedo, and Bowen coefficient. The length of the roughness is related to the height of the obstacles that the wind runoff will find in the simulation domain; in principle, it is the height at which the average wind speed is zero, considering a logarithmic wind profile. Roughness length is a parameter that directly influences wind shear near the surface and is important in determining the intensity of mechanical turbulence (generated by wind friction at the surface) and also stability in CLA. Albedo is the fraction of incident solar radiation reflected from the surface into space. The Bowen coefficient is the relationship between the sensible heat flux and the latent heat flux. Along with albedo and other meteorological variables; in this way, the Bowen ratio is used to determine the turbulence parameters of CLA under convection conditions (positive sensible heat flow at the surface).

The roughness length, albedo, and Bowen ratio are calculated from the region's ground cover information based on files from the United States Geological Survey (USGS). This information was obtained directly from the FRM model, extracted by the MMIF software. In the WRF model, land cover is based on data monitored by the AVHRR satellite with 24 categories and 1 km resolution. The surface characteristics are calculated and written in a format to be used in the third stage of AERMET. The topographic information, used to study the dispersion, is obtained from the SRTM-NASA database (“Shuttle Radar Topography Mission - NASA”), with a fidelity of 90 m.

2.4. Air Quality Standards

The maximum concentrations evaluation of CO, NO_2, MP_{10} and SO_2, calculated by the AERMOD model, are compared with the air quality standards established by the General Directorate of Air of the Ministry of the Environment (extinct SEAM), through SEAM Resolution 259/15. In the case of H_2S, the limits of perception of odors given by the World Health Organization (WHO, 2003) (11 µg / m^3) are used for the evaluation of air quality. The air quality standards established by SEAM Resolution 259/15 are shown in Table 2.

Table 2 – Air quality standards established by SEAM Resolution 259/15.

Pollutant	Annual average	24 h average	8 h average	1 h average
Particulate Material – $MP_{2,5}$	15 $\mu g/m^3$	30 $\mu g/m^3$		
Particulate Material – MP_{10}		150 $\mu g/m^3$		
Ozone – O_3			120 $\mu g/m^3$	
Nitrogen dioxide – NO_2	40 $\mu g/m^3$			200 $\mu g/m^3$
Sulfur dioxide – SO_2		20 $\mu g/m^3$		
Carbon monoxide - CO			10 mg/m^3	

2.5. Emission Standards

The pulp mill will have four emission sources (chimneys): Recovery Boiler, Lime Kiln 1, Lime Kiln 2 and Biomass Boiler. Emission rates and conditions are presented in Table 3.

Table 3 – Emission rates and conditions

Pollutant	Unit	Recovery boiler	Lime Kiln 1	Lime Kiln 2	Biomass boiler
MP	g/s	8.0	0.6	0.6	1.9
TRS (as H_2S)	g/s	1.8	0.3	0.3	-
SOx	g/s	16.4	2.7	2.7	5.7
NOx	g/s	63.9	10.8	10.8	12.2
CO	g/s	109.5	4.1	4.1	11.4
Flow	Nm^3/s @ 8% O_2	365	27	27	38
Temperature	°C	140	300	300	155
Moisture	%	23.7	23.0	23.0	24.0
Oxygen content	%	2.2	6.0	6.0	3.1
Flow (actual conditions)	m^3/s	500	64	64	57
Velocity	m/s	20.0	20.0	20.0	20.0
Chimney diameter	m	5.64	2.02	2.02	1,90
Chimney height	m	140	140	140	140
Coordinates	m	449867 E 7429710 S	449862 E 7429706 S	449856 E 7429711 S	449862 E 7429716 S

3. RESULTS

3.1. Meteorology and Climatology

Air pollutants dispersion of a region, in addition to the pollutants characteristics and emission sources, depends on the weather conditions and their interactions with the geographical environment. Emission characteristics generally include the type of pollutant, outlet temperature, release rate, emission rate, height, and dimensions of the source.

The analysis of meteorological phenomena and their interactions with geographical aspects represents the most complex part of the air dispersion study. The geographical aspects interfere in the meteorological fields, modifying the radiation balance, generating circulations, humidity flows, turbulence, etc. Therefore, the geographical characteristics of the study region, such as latitude, maritime and the presence of water bodies (lakes, lagoons, etc.), the relief and the predominant land cover, can have a great influence on the resulting circulation. Sea / land, lake / land, valley / mountain breezes and urban / rural circulations are examples of circulations generated due to geographic characteristics.

The pulp mill and its emission sources will be installed in the vicinity of the city of Concepción, in Paraguay, coordinates 23.241050 ° S and 57.490110 ° W (7429711 S; 449862 O m UTM). Concepción is the Capital of the Department of Concepción and is located on the left bank of the Paraguay River, about 400 km north of Asunción. The area where the emission sources will be installed is a predominantly rural region and the topography has altitudes that reach 180 m at sea level (Figure 1).

Paraguay's climate can be classified into three types according to the Köppen-Geiger Classification (Figure 2): 1) humid subtropical (Cfa), with hot summers (temperatures exceed 22 ºC in summer) and with more than 30 mm of rain in the driest month; 2) tropical savanna (Aw), with dry winter, rainy season in summer and average temperature of the coldest month above 18 ºC; 3) hot semi-arid (BSh), characterized by low rainfall, intense solar radiation and high average temperatures (around 27 ºC). For the Concepción region, where the pulp mill is located, the Köppen-Geiger classification indicates a tropical savanna (Aw) climate.

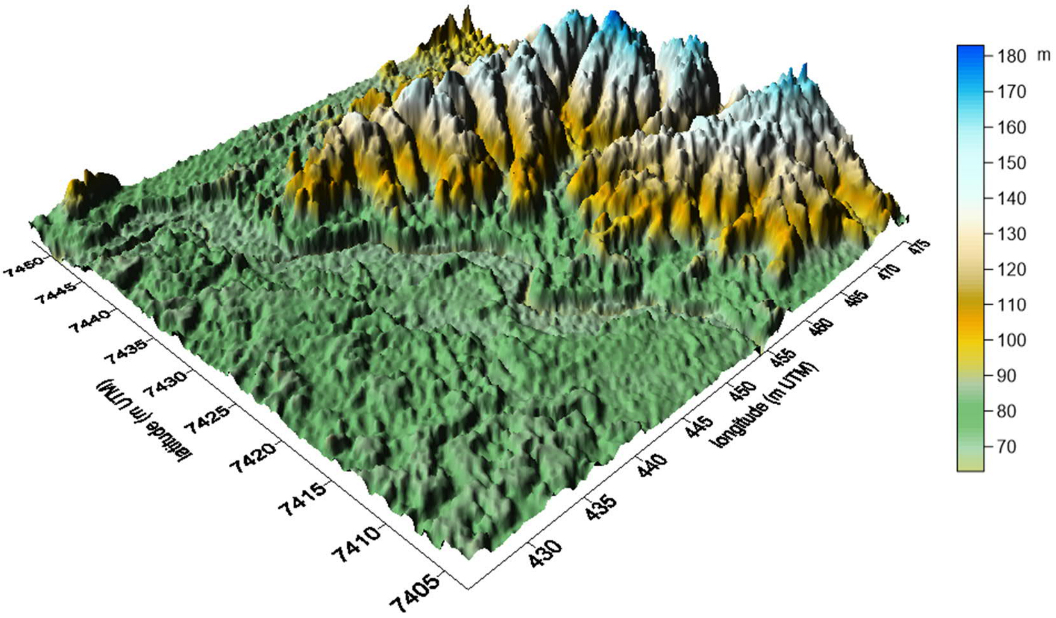
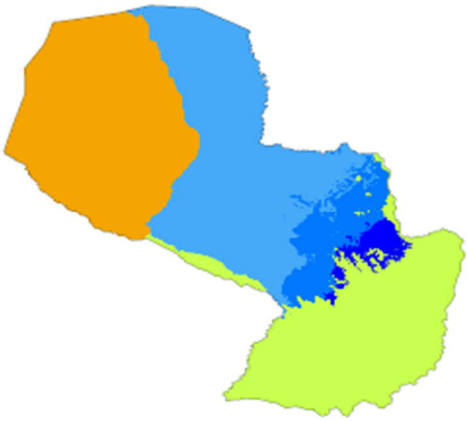


Figure 1 –Three-dimensional orographic map of the study area (2,500 km^2). Source: Generated with SRTM-NASA data (“Shuttle Radar Topography Mission - NASA”) with 90 m of definition.



🟧 Hot semi-arid Climate (BSh) 🟦 Tropical savanna Climate (Aw)

🟩 Humid subtropical Climate (Cfa)

Figure 2 – Second climatic classification of Paraguay Köppen-Geiger (Source: https://es.wikipedia.org/wiki/Clima_de_Paraguay).

The data used for the climate study were obtained from the Integrated Surface Database (DSI), which can be consulted on the website of the National Oceanic and Atmospheric Agency (NOAA). The Integrated Surface Database (ISD) consists of global synoptic and temporal observations compiled from various sources in a single ASCII format. DSI integrates data from more than 100 original sources, including various data formats.

The closest approved station is at Teniente Coronel Carmelo Peralta Airport (USAF: 861340 / ICAO: SGCO), about 21 km southeast of the development (coordinates 23,442 ° S and 57,427 ° W (7407484.94 S; 456383.89 O m UTM, altitude: 77 m) Due to the proximity and completeness of the data, the station can be considered representative for climatological analysis.

For the analysis, 10 years of observed data (from 01/01/2010 to 12/31/2019) of atmospheric pressure (hPa), air temperature (°C), relative humidity (%), wind speed (m/s) and wind direction (degrees) are considered. This series of data allows the composition of the provisional Climatic Norms, which are averages of short periods based on observations that extend over a minimum period of 10 years. Figures 3 to 6 show the evolution over time of the monthly averages observed at the Lieutenant Colonel Carmelo Peralta station.

The atmospheric pressure ranged from 1,001.5 to 1,007.5 hPa, presenting a provisional climatological average of 1,003.9 hPa for the period from 2010 to 2019 (Figure 3). The monthly average temperature varied between 15.5˚C and 29.6˚C, while the provisional climatological average for the period from 2010 to 2019 was 24.3˚C (Figure 4).

The air temperature is defined by the effect of continentality and topographic homogeneity, presenting a wide range. In summer, being a tropical region, maximum temperatures can exceed 30°C, and in winter frost phenomena can be registered as a consequence of cold fronts. The monthly relative humidity varied between 51.4% and 85.5%, with a provisional climatological average for the period of 70.9% (Figure 5). Relative humidity varies considerably in the company region depending on the variability of rainfall in the region. The average monthly wind speed varied between 1.8 and 4.9 m/s, while the provisional climatological average for the period from 2010 to 2019 was 3.2 m/s (Figure 6). The wind rose shows the predominance of winds from the south, followed by those from the northeast and east, and with a less important southeast component, as shown in Figure 7.

The data used is satisfactory for the provisional climatic and meteorological analysis of the region, in which the pulp mill will be located. In summary, the average atmospheric pressure of the region is 1,003.9 hPa, the average air temperature is 24.3˚C, the relative humidity found is 70.9%, the average wind speed is 3.2 m/s with predominance of the north and south directions. The series of variables analyzed reproduce well the climatological behavior of the region of interest.

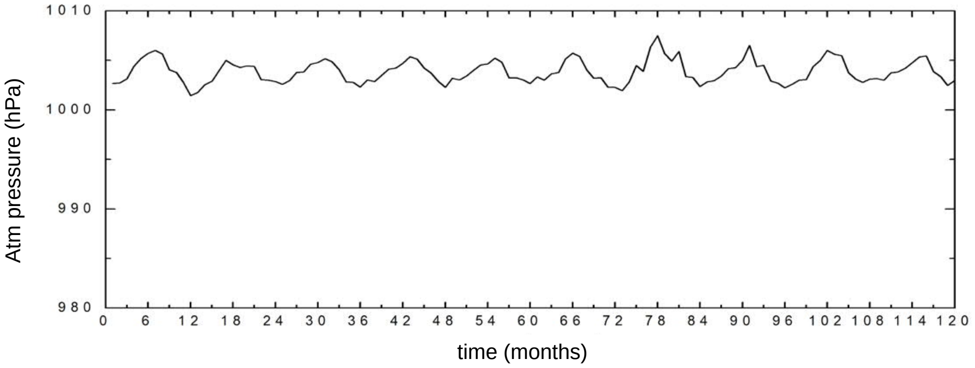


Figure 3 – Average monthly atmospheric pressure observed at the Teniente Coronel Carmelo Peralta Airport station (USAF: 861340 / ICAO: SGCO) in the period from 01/01/2010 to 12/31/2019.

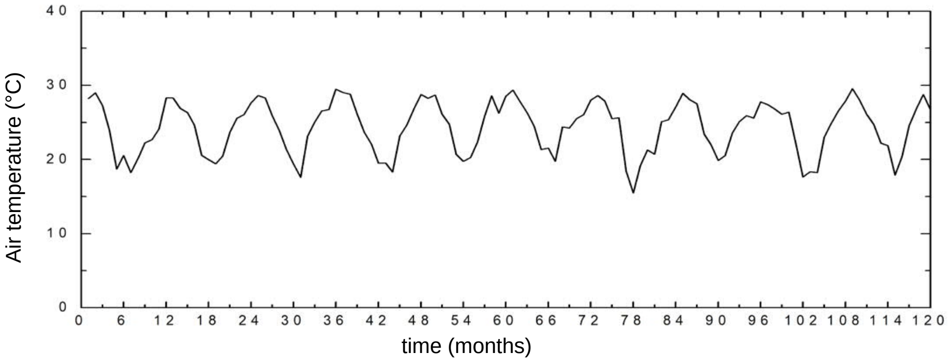


Figure 4 – Average monthly air temperature observed at the Teniente Coronel Carmelo Peralta

Airport station (USAF: 861340 / ICAO: SGCO) in the period 01/01/2010 to 12/31/2019.

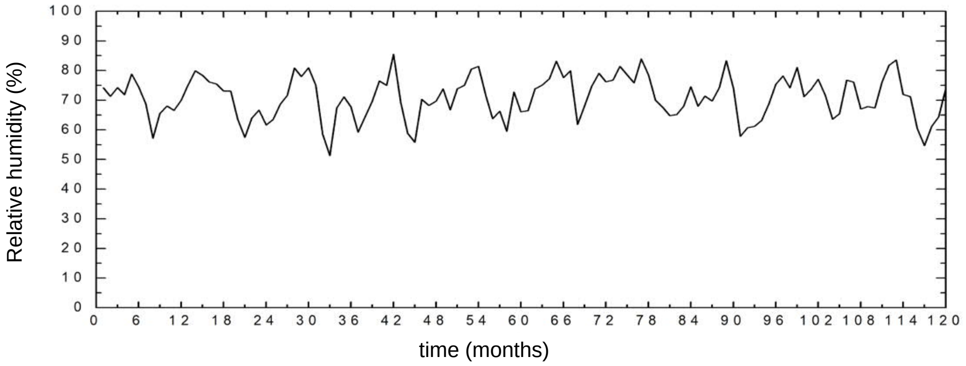


Figure 5 – Monthly average relative humidity observed at the Teniente Coronel Carmelo Peralta Airport station (USAF: 861340 / ICAO: SGCO) in the period from 01/01/2010 to 12/31/2019.

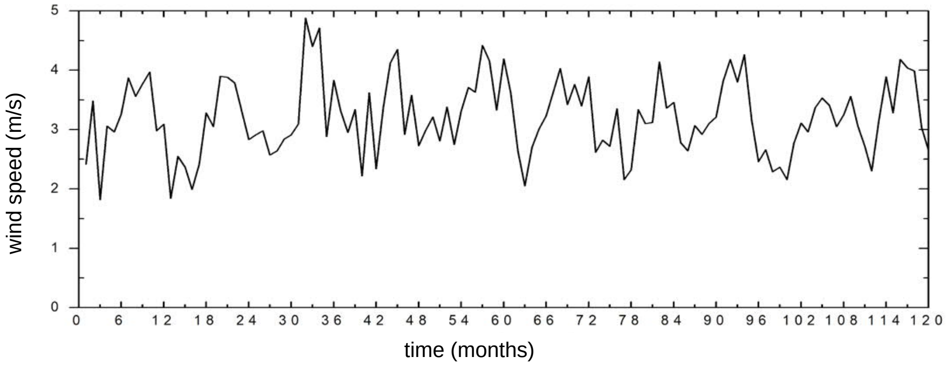
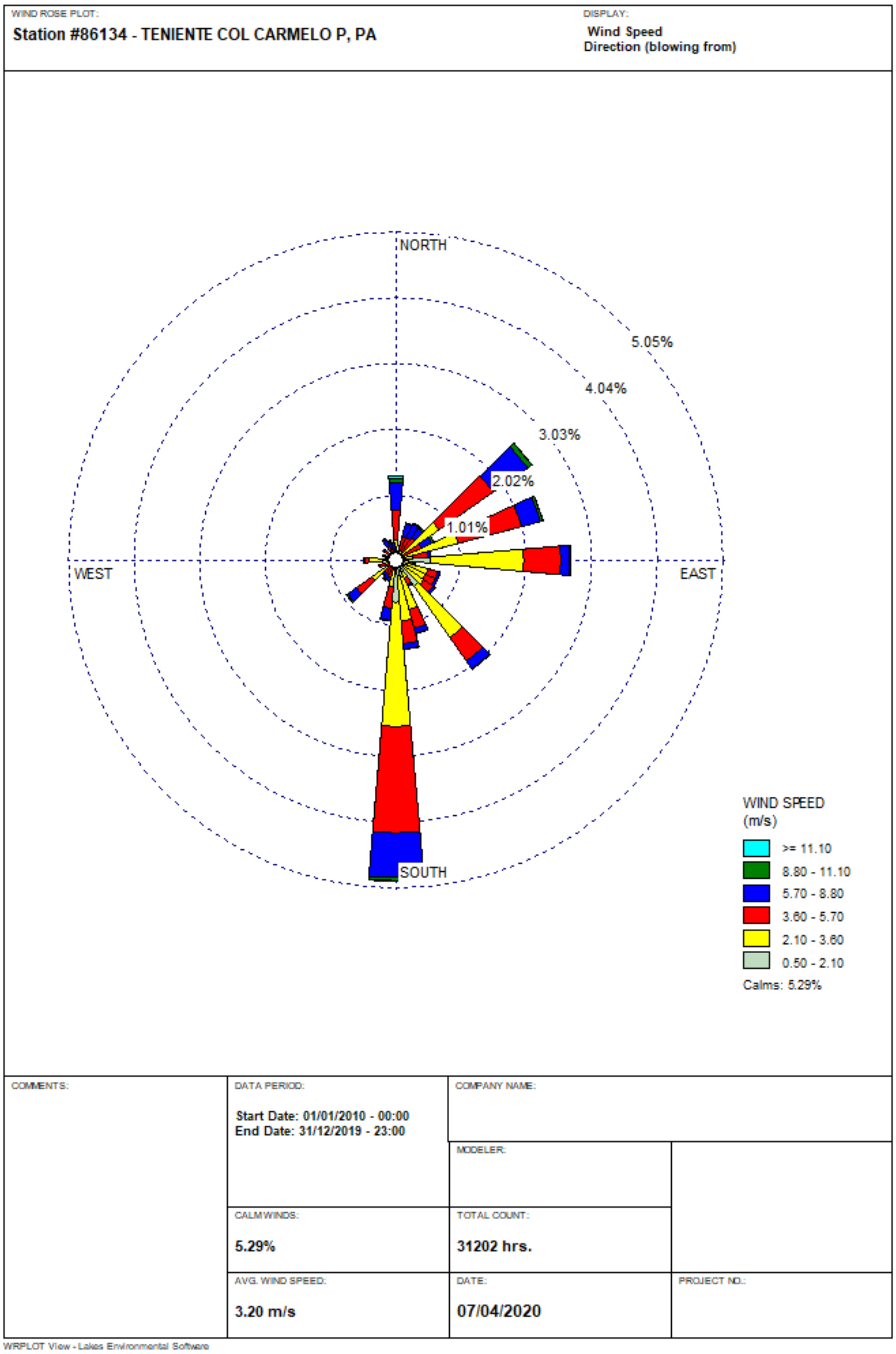


Figure 6 – Average monthly wind speed observed at the Teniente Coronel Carmelo Peralta Airport station (USAF: 861340 / ICAO: SGCO) in the period 01/01/2010 to 12/31/2019.



WIND ROSE PLOT:
Station #86134 - TENIENTE COL CARMELO P, PA

DISPLAY:
Wind Speed
Direction (blowing from)

COMMENTS:

DATA PERIOD:
Start Date: 01/01/2010 - 00:00
End Date: 31/12/2019 - 23:00

COMPANY NAME:

MODELER:

CALM WINDS:
5.29%

TOTAL COUNT:
31202 hrs.

AVG. WIND SPEED:
3.20 m/s

DATE:
07/04/2020

PROJECT NO.:

Figure 7 – Wind rose generated from data observed at the Teniente Coronel Carmelo Peralta Airport station (USAF: 861340 / ICAO: SGCO) in the period from 01/01/2010 to 12/31/2019.

3.2. WRF Model Evaluation

As previously described, the meteorological data used as input parameters in the AERMOD model is derived from the meteorological simulation with the WRF mesoscale model. Therefore, an evaluation of the results is required to check the quality of the simulation. For this evaluation, a direct comparison is made with the data measured by the nearest approved meteorological station, that is, the Teniente Coronel Carmelo Peralta Airport station (USAF: 861340 / ICAO: SGCO).

Figures 8 to 11 show the comparison between the data simulated by the FRM model and those observed at the airport station for the monthly averages of air temperature, atmospheric pressure, relative humidity and wind speed since 01/01/2018 until 12/31/2019. The data simulated by the WRF model was taken from the large point referring to the station coordinates. Regarding air temperature, a very good response is observed from the WRF model to simulate the variable, both the evolution over the months and the maximum and minimum values. Regarding atmospheric pressure, the model follows the evolution over time relatively well, but overestimates the maximum values and underestimates the minimum values. For relative humidity, again the model simulates the evolution of the variable over time well, but it does not follow the decrease in humidity at the end of 2019. Regarding wind speed, the model data show a very evolution similar to observed data, but overestimate observation throughout the period. The variables simulated by the FRM model reasonably well reproduce the weather behavior of the pulp mill region.

Figures 12 and 13 show, respectively, the wind roses obtained from the airport station data and the data simulated by the WRF model at the station location. In a direct comparison, it can be seen that the simulated wind rose presents a configuration similar to the observed wind rose, with predominant components from the south and northeast. The model reproduces the frequencies and intensities of the prevailing winds from the south well, but does not reproduce the winds from the northeast with the same quality. Regarding the average wind intensity for the period, the simulated result (3.94 m/s) is relatively close to the observed value (3.10 m/s). The result of the model, for the direction and speed of the wind, reproduces well the weather behavior in the region of the future pulp mill.

In general terms, the results generated by the FRM model for meteorological variables reproduce well the evolution over time of the observed data, but do not reproduce the maximum and minimum values during the period in the same way. It is important to note that the data series of the Teniente Coronel Carmelo Peralta airport station has countless times without registration (missing data). Throughout the series monitored at the station, the data presents records with a frequency of 3 hours, in most of the period, while the simulated data series has a frequency of 1 hour; the difference in the frequency of the records certainly causes a negative impact on the evaluation of the model. In addition, direct comparison at a specific point in the model grid is hampered by some aspects, such as the resolution of the model grid, the resolution of land cover and topography information, and the influence of obstacles (vegetation, buildings, ...) around the station, which are hardly considered by the model due to the resolution of the simulation matrix.

As an example, the difference in frequency in observing meteorological data can be perceived by comparing the model simulated wind rose with the comparative rose observed at the location of the Silvio Pettirossi International Airport Station, near Asunción. The station of that airport records meteorological data every hour, that is, on a frequency equal to the outputs of the WRF model. Figures 14 and 15 show the comparison of observation and simulation, from which the similarity of the two results can be verified.

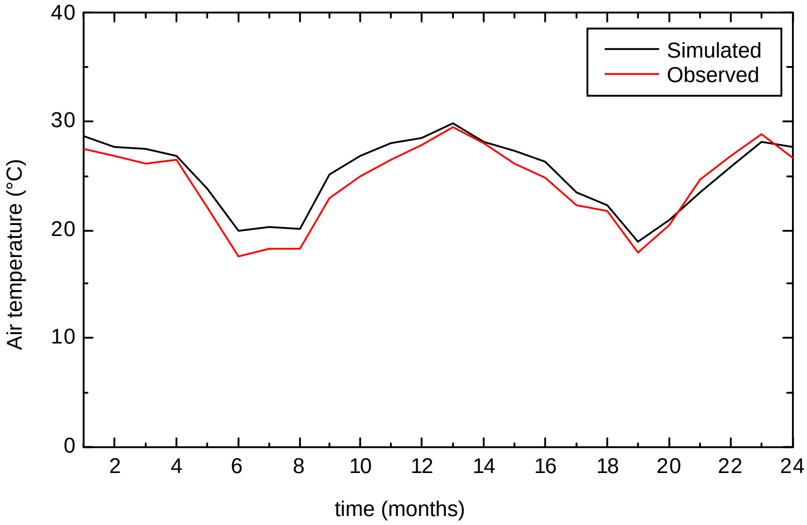


Figure 8 – Comparison between the monthly average air temperature simulated by the WRF and observed at the Teniente Coronel Carmelo Peralta Airport station (USAF: 861340 / ICAO: SGCO) from 01/01/2018 to 12/31/2019.

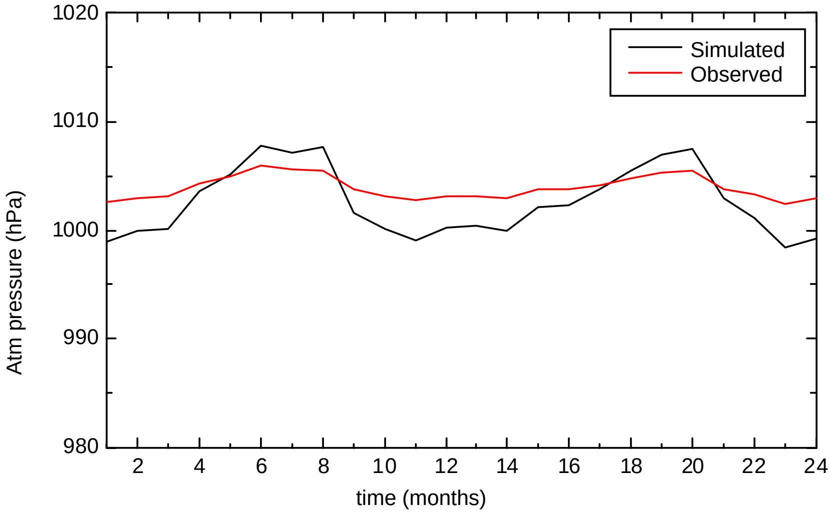


Figure 9 – Comparison between the average monthly atmospheric pressure simulated by the WRF and that observed at the Teniente Coronel Carmelo Peralta airport station (USAF: 861340 / ICAO: SGCO) from 01/01/2018 to 12/31/2019.

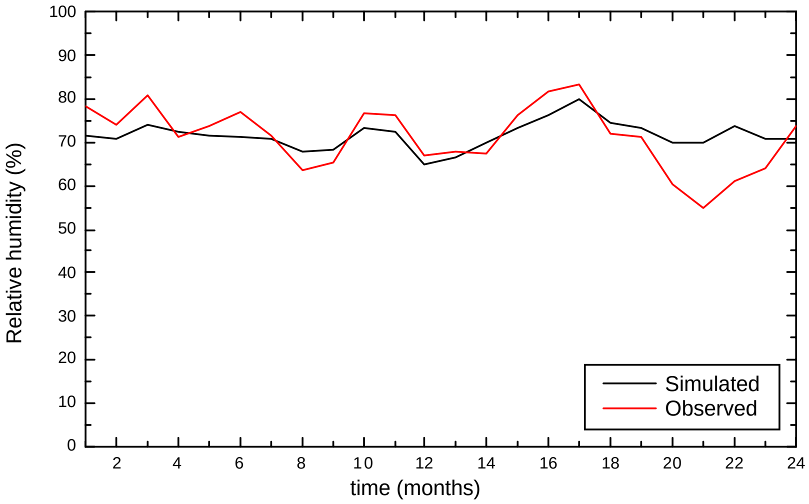


Figure 10 – Comparison between the monthly relative humidity simulated by the WRF and that observed at the Teniente Coronel Carmelo Peralta airport station (USAF: 861340 / ICAO: SGCO) from 01/01/2018 to 12/31/2019.

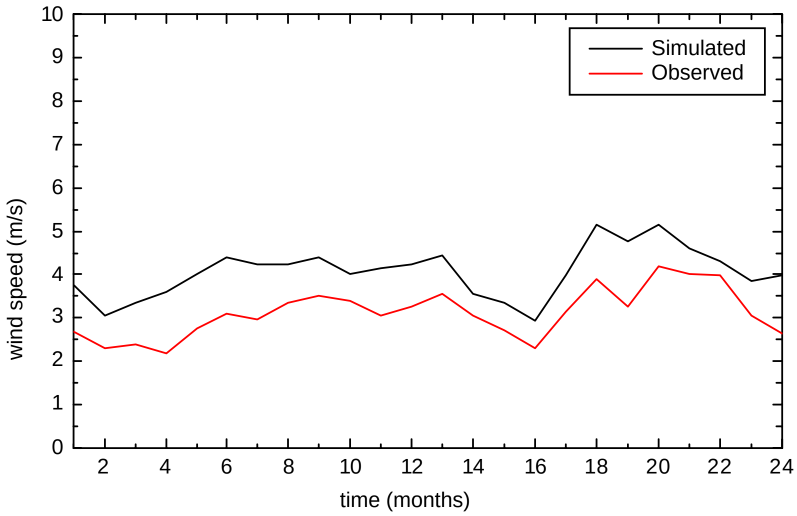
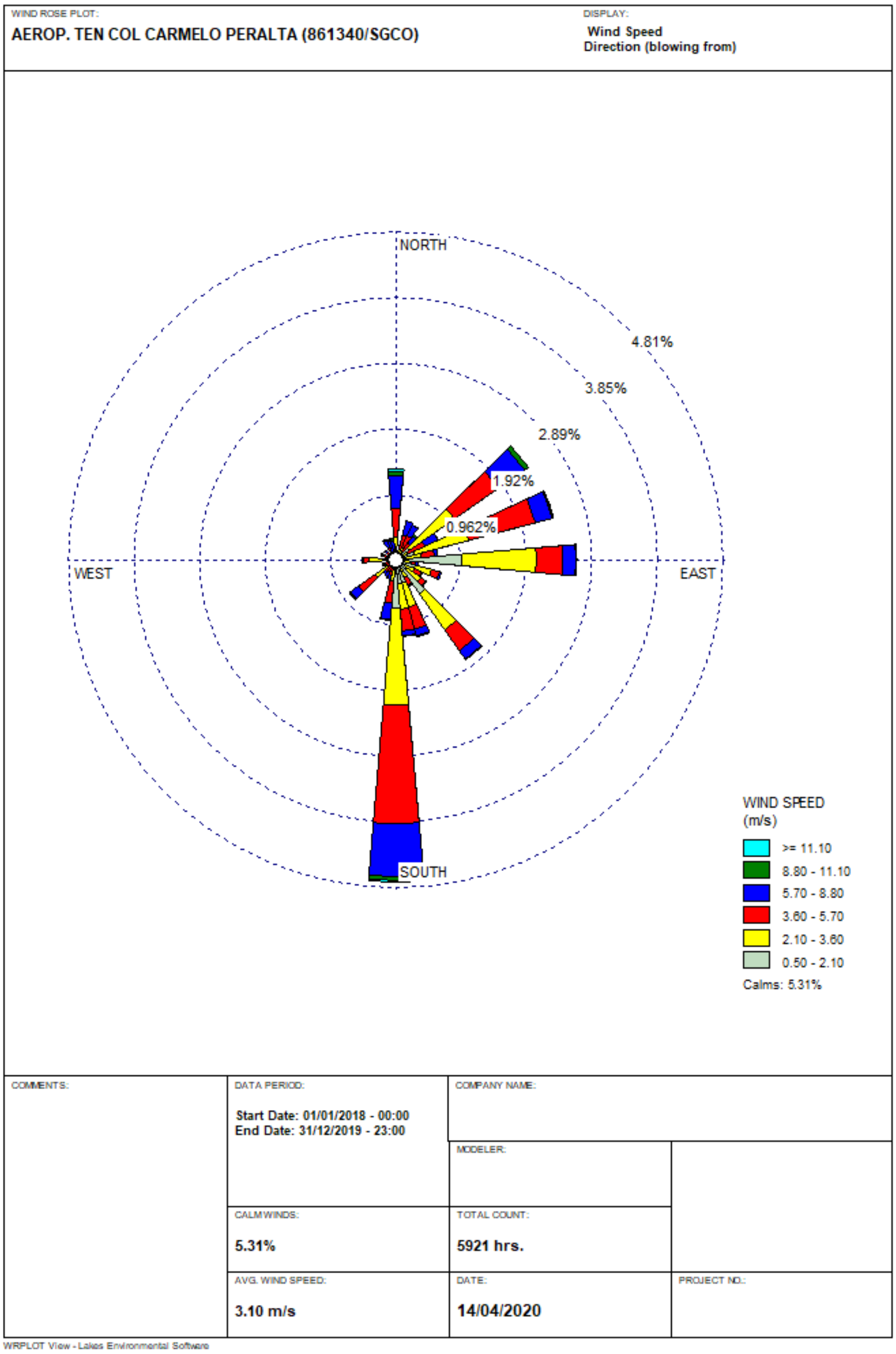


Figure 11 – Comparison between the average monthly wind speed simulated by the WRF and that observed at the Teniente Coronel Carmelo Peralta airport station (USAF: 861340 / ICAO: SGCO) from 01/01/2018 to 12/31/2019.



WIND ROSE PLOT:
AEROP. TEN COL CARMELO PERALTA (861340/SGCO)

DISPLAY:
Wind Speed
Direction (blowing from)

COMMENTS:

DATA PERIOD:
Start Date: 01/01/2018 - 00:00
End Date: 31/12/2019 - 23:00

COMPANY NAME:

MODELER:

CALM WINDS:
5.31%

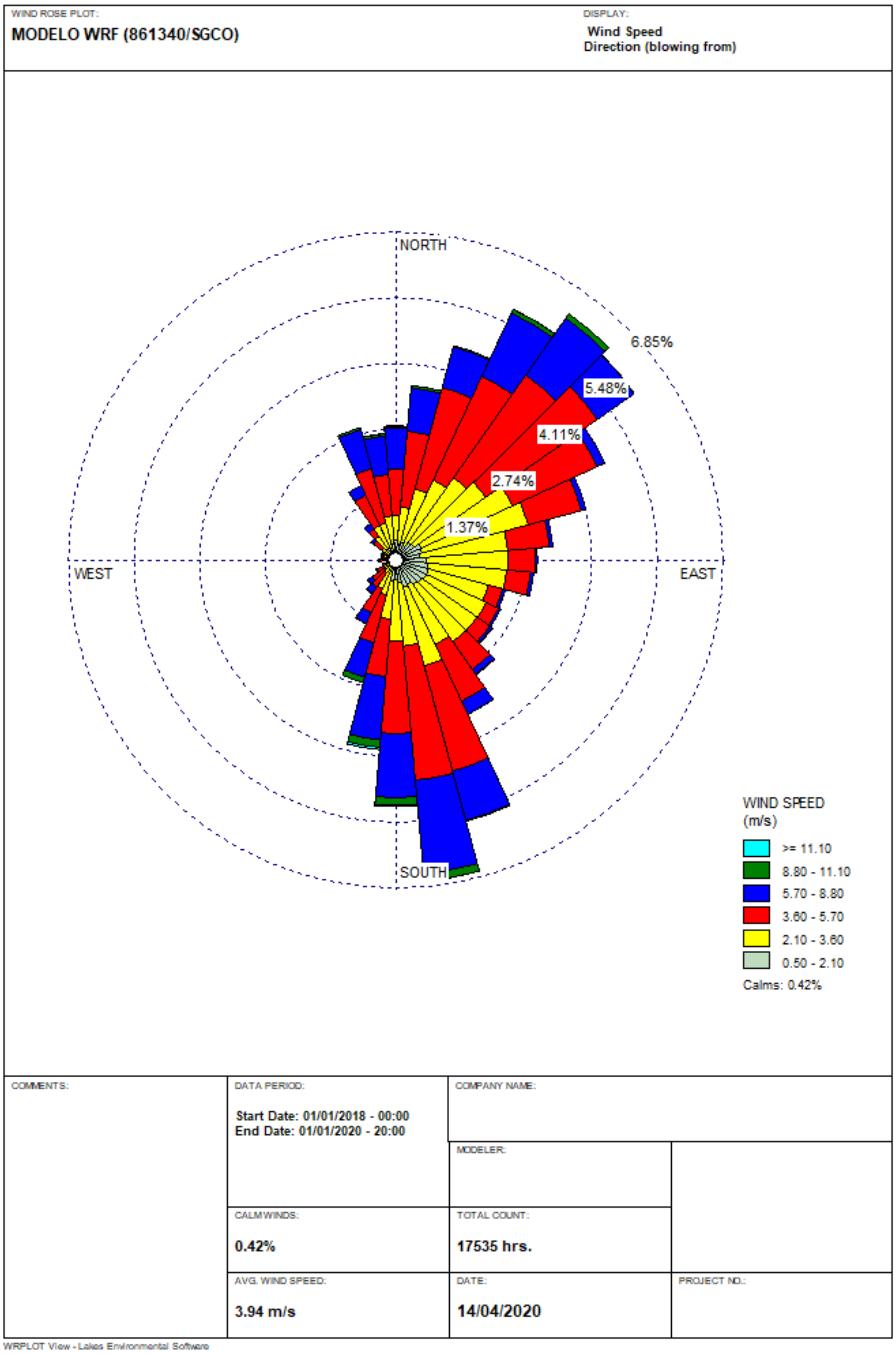
TOTAL COUNT:
5921 hrs.

AVG. WIND SPEED:
3.10 m/s

DATE:
14/04/2020

PROJECT NO.:

Figure 12 – Wind rose generated by data observed at the Teniente Coronel Carmelo Peralta airport station (USAF: 861340 / ICAO: SGCO) from 01/01/2018 to 12/31/2019.



WIND ROSE PLOT:
MODELO WRF (861340/SGCO)

DISPLAY:
Wind Speed
Direction (blowing from)

COMMENTS:

DATA PERIOD:
Start Date: 01/01/2018 - 00:00
End Date: 01/01/2020 - 20:00

COMPANY NAME:

MODELER:

CALM WINDS:
0.42%

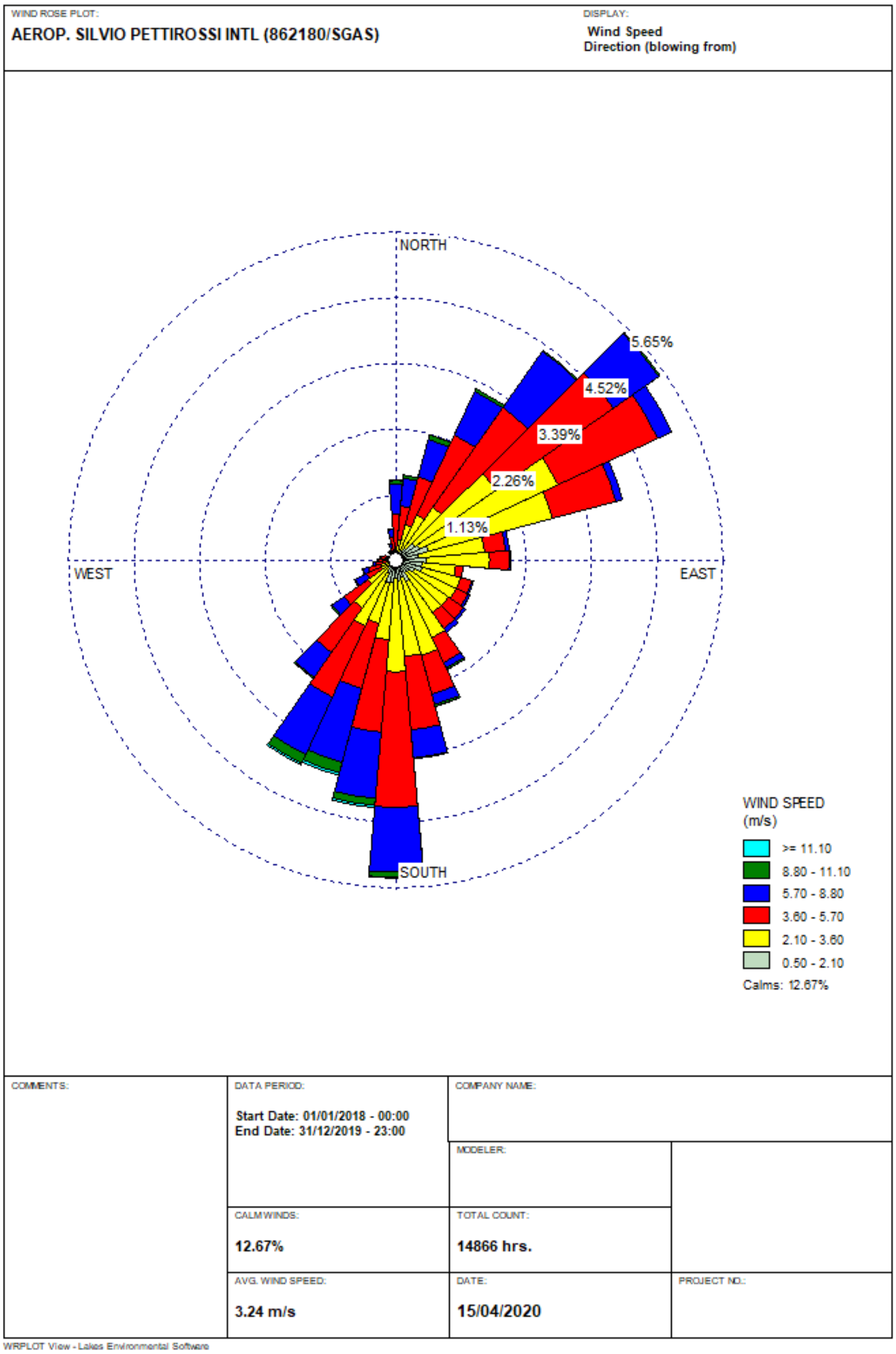
TOTAL COUNT:
17535 hrs.

AVG. WIND SPEED:
3.94 m/s

DATE:
14/04/2020

PROJECT NO.:

Figure 13 – Wind rose generated from data simulated by the WRF model at the coordinates of Teniente Coronel Carmelo Peralta Airport (USAF: 861340 / ICAO: SGCO) from 01/01/2018 to 01/01/2020.



AEROP. SILVIO PETTIROSSI INTL (862180/SGAS)

Wind Speed
Direction (blowing from)

DATA PERIOD:
Start Date: 01/01/2018 - 00:00
End Date: 31/12/2019 - 23:00

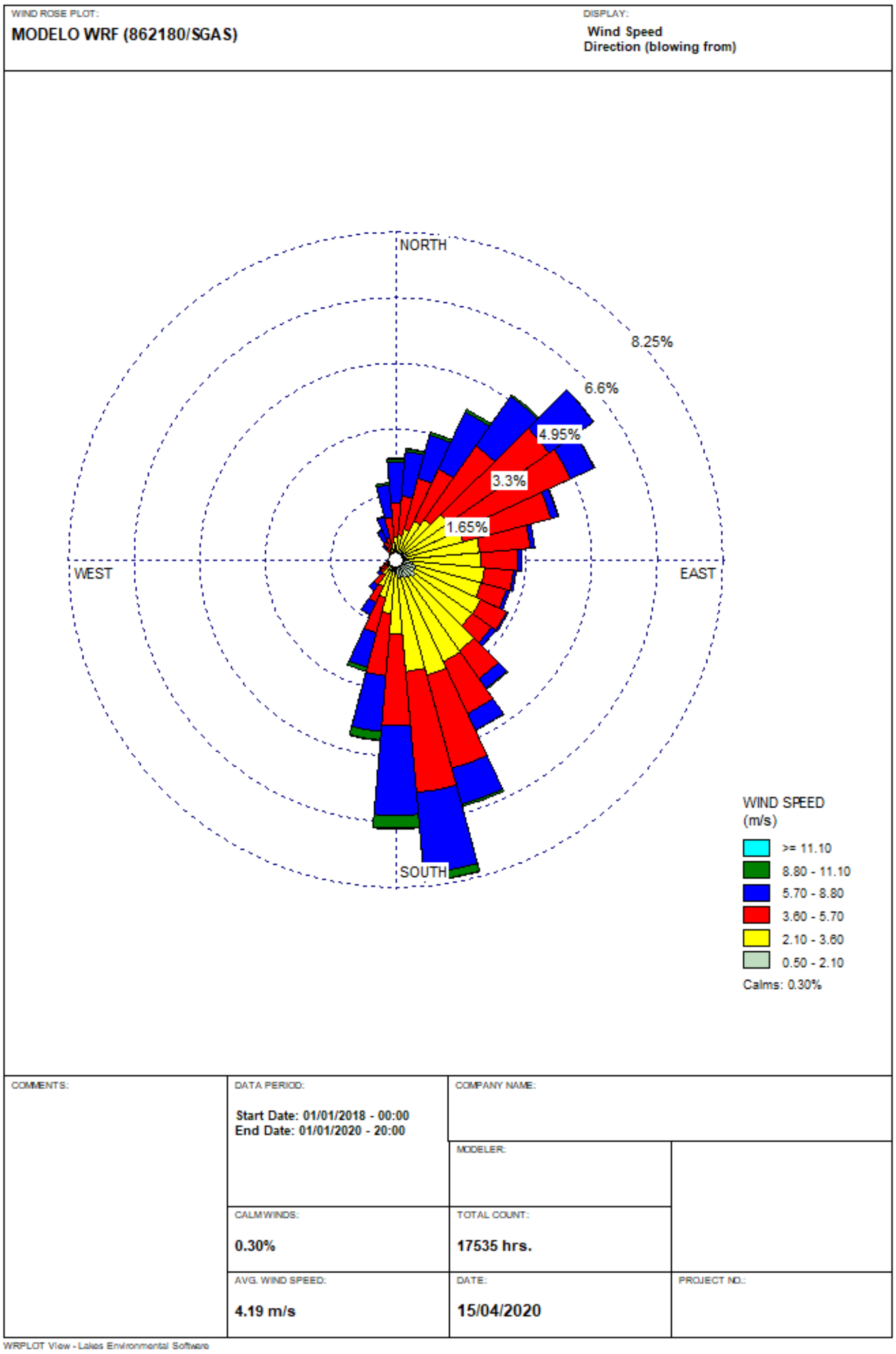
CALM WINDS: **12.67%**

TOTAL COUNT: **14866 hrs.**

AVG. WIND SPEED: **3.24 m/s**

DATE: **15/04/2020**

Figure 14 – Wind rose generated from data observed at the Silvio Pettirossi International Airport station (USAF: 862180 / ICAO: SGAS) from 01/01/2018 to 12/31/2019.



WIND ROSE PLOT:
MODELO WRF (862180/SGAS)

DISPLAY:
Wind Speed
Direction (blowing from)

COMMENTS:

DATA PERIOD:
Start Date: 01/01/2018 - 00:00
End Date: 01/01/2020 - 20:00

COMPANY NAME:

MODELER:

CALM WINDS:
0.30%

TOTAL COUNT:
17535 hrs.

AVG. WIND SPEED:
4.19 m/s

DATE:
15/04/2020

PROJECT NO.:

WRPLOT View - Lakes Environmental Software

Figure 15 – Wind rose generated from data simulated by the WRF model at the coordinates of the Silvio Pettirossi International Airport station (USAF: 862180 / ICAO: SGAS) from 01/01/2018 to 01/01/2020.

To quantitatively analyze the differences between simulation and observation, Table 4 presents the statistical analysis result of the variables evaluated in Figures 8 to 13. The statistical indices considered are RMSE (Root-Mean-Square Error), BIAS and MAPE (Mean Absolute Percentage Error) (Carvalho et al., 2002; Wilks, 2011):

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(P_i - O_i)^2}$$

$$BIAS = \frac{1}{n}\sum_{i=1}^{n}(P_i - O_i)$$

$$MAPE = \left(\frac{1}{n}\sum_{i=1}^{n}\left|\frac{(P_i - O_i)}{O_i}\right|\right) \times 100$$

where P represents the predicted (simulated) value, O represents the observed value and n indicates the number of data.

Root Square Error (RMSE) is a measure of difference between the values predicted by the model and the observed values of the environment being simulated. These individual differences are also called residuals, and the RMSE serves to aggregate them into a single statistical value. BIAS represents the tendency of simulated values to underestimate or overestimate the observed values of the meteorological variables. MAPE is a precision statistical measure of a simulated result; It measures the precision as a percentage and can be considered as the average absolute percentage error in each period of time. The closer the RMSE value is to zero, the better the prediction. The closer the BIAS is to zero, the better the prediction. MAPE values below 10% average high precision, between 10% and 20% is considered good precision and between 20% and 50% the result is reasonable.

According to the statistical values presented in Table 4, it can be concluded that the simulation result with the WRF model is very good. Relatively low values are observed for the statistical parameters RMSE and BIAS, which shows the degree of quality of the numerical simulation. There is a clear tendency for simulated values to overestimate the measured values of almost all meteorological variables, with the exception of atmospheric pressure. It is also observed that ASM remained below 10% for most of the variables, with one exception for wind speed. This last result indicates a high precision of the model in the simulation of the climatic conditions in the region of interest.

Table 4 – Statistical parameters calculated from the comparison between monthly averages simulated by WRF and observed at the Teniente Carmelo Peralta Airport station (USAF: 861340 / ICAO: SGCO) in the period from 01/01/2018 to 12/31/2019.

Parameters	**RMSE**	**BIAS**	**MAPE**
Air temperature	1,323 ºC	0,940 ºC	5,175 %
Atmospheric pressure	2,447 hPa	-1,339 hPa	0,218 %
Humidity	5,761 %	0,348 %	6,815 %
Wind speed	0,998 m/s	0,948 m/s	31,875 %
Wind direction	13,109 degrees	4,757 degrees	9,399 %

3.3. Atmospheric Boundary Layer (CLA)

The Atmospheric Boundary Layer (CLA) is the lowest layer of the atmosphere and is directly influenced by the presence of the Earth's surface. Turbulence is the characteristic phenomenon of this layer, which plays a fundamental role in the evolution of the CLA height and the diffusion of pollutants emitted near the surface. CLA is, therefore, the volume enclosed by the turbulent diffusion process and its height acts as a vertical limit for the transport of pollutants emitted on the surface. CLA evolves in such a way that it is thicker during the day than at night.

The turbulence in the CLA can be of thermal origin, where the convection process is generated from the incidence of solar radiation on the surface during the day, and of mechanical origin, where small turbulent vortices are generated from friction. of the wind on the surface during the day or night. During the day the turbulence has its origin in the competition between the thermal force and the mechanical force, and during the night only the mechanical force is active. Thermal turbulence is more effective for the diffusion of pollutants, since large convection vortices act more effectively to make the concentration field homogeneous.

Therefore, to evaluate the evolution of the CLA height, it is necessary to consider the meteorological variables of wind speed and air temperature. Figure 16 shows the temporal evolution of the heights of the convective and mechanical CLA, between 01/01/2018 and 01/01/2020. The CLA is observed to be higher during the warmer periods of the year, so there is a strong correlation between the evolution of air temperature and the evolution of the height of convective CLA. Specifically, the amplitude of the height of the convective CLA is much greater than the amplitude of the mechanical CLA, showing differences that reach 1,100 m. This result is related to the variability of air temperature and solar radiation throughout the year.

The evolution of the mechanical CLA is correlated with the evolution of the wind speed. The higher the wind intensity, the higher the values of friction velocity (u *) and Obukhov length (L), which generates an increase in the diffusion of pollutants due to mechanical turbulence; (L) represents, in addition to a stability parameter, the height in the CLA up to where the effect of mechanical turbulence is most effective. According to the results, the average height of convective CLA is 1,267 m while the height of mechanical CLA is 523 m.

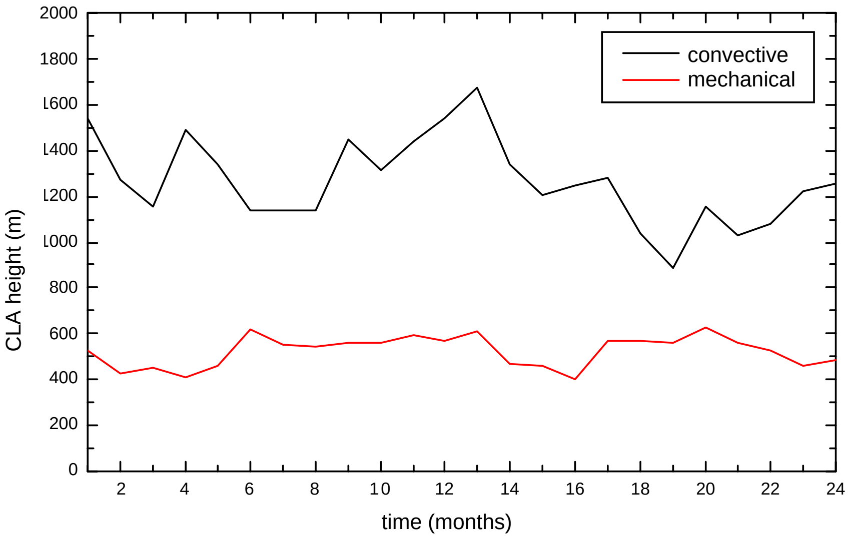


Figure 16 – Temporal evolution (monthly average) of the height of the CLA calculated by AERMET for the pulp mill site in the period between 01/01/2018 and 01/01/2020.

3.4. Pollutant Dispersion

Pollutants dispersion simulations of CO, TRS, NO_2, PM_{10}, and $SO_2$are performed using the dispersion model known as the AERMIC model (AERMOD), which was developed by the United States Environmental Protection Agency (US - EPA) . The meteorological data used as input parameters in the AERMOD model is derived from the meteorological simulation with the WRF mesoscale model. The meteorological data series covers the period from 01/01/2018 to 01/01/2020. This period of time allows the dispersion study, considering all the meteorological conditions that influence the transport and diffusion of pollutants in the region.

The information on emission sources (emission rates and release conditions) presented in Table 3 (see section 2.5) is used to enter data into the AERMOD dispersion model. The simulation domain covers an area of 2,500 km^2 (50 km x 50 km), with a horizontal resolution of 0.25 km. This domain has been configured using three criteria. The first criterion refers to the determination of the World Meteorological Organization (WMO), which indicates that the surface data are representative of a region within a radius of up to 25 km, under homogeneous meteorological conditions. The second criterion takes into account the fact that the AERMOD is a stationary model, that is, that during a determined period of time the value of any meteorological variable at the station location is the same for the entire simulation domain. Thus, the use of a domain over 50 km x 50 km in a non-stationary meteorological region would lead to incorrect weather conditions. The third criterion is related to the fact that, in an initial analysis, the concentration peaks occur at a much shorter distance of 25 km. This ensures that the highest concentrations occur within the simulation domain with a good safety margin.

The topography information is obtained from the SRTM-NASA (Shuttle Radar Topography Mission - NASA) database, with a resolution of 90 m. The surface characteristics (roughness length, albedo and Bowen ratio) are generated by the AERSURFACE model from the files of the United States Geological Survey (USGS) - National Land Cover Data 1992 (NLCD92). The effect of lowering buildings has been considered, since there are constructions near the sources, so that the plume of pollutants can be modified due to the mechanical turbulence caused by obstacles.

Figures 17 to 26 show the maximum surface concentration fields of the pollutants CO, TRS, NO_2, PM_{10} and SO_2 simulated by AERMOD. The maximum concentration is obtained by averaging 1 hour, 8 hours, 24 hours or annually at each point in the grid, depending on the contaminant and its respective air quality standard (see section 2.4). In the sequence, the highest concentration values are determined at each point on the grid to generate the fields presented in the Figures. Considering the time intervals of the averages, the concentration fields of 1h, 8h and 24h are maximum values representative of the short-term averages, while the annual concentration fields are maximum values representative of the long-term averages.

Initially, it is possible to observe the low values of the simulated concentrations of the company's emissions. The maximum concentration values for CO, NO_2, PM_{10} and SO_2 are below the air quality standards established by SEAM Resolution 259/15 (Table 2). Maximum TRS concentration values are well below the WHO (2003) odor perception limit of 11 $\mu g/m^3$. The maximum concentration peaks of all pollutants occur north and south-southwest of the emission sources. Table 4 presents a summary of the simulation results, which highlights the values of the peaks of maximum average concentration and the distances at which they occur from the emission sources.

Figure 27 shows where the three highest concentrations occur relative to the point of emission. Table 5 shows the maximum concentration values in 15 discrete receivers in the region of interest. The choice of receivers took into account people's circulation locations near emission sources and preferred wind directions. Figure 28 presents a map with the location of the 15 discrete receivers in relation to the company. The complete lists with the highest concentrations of CO, TRS, NO_2, PM_{10} and SO_2 are found in Annex A of this technical report.

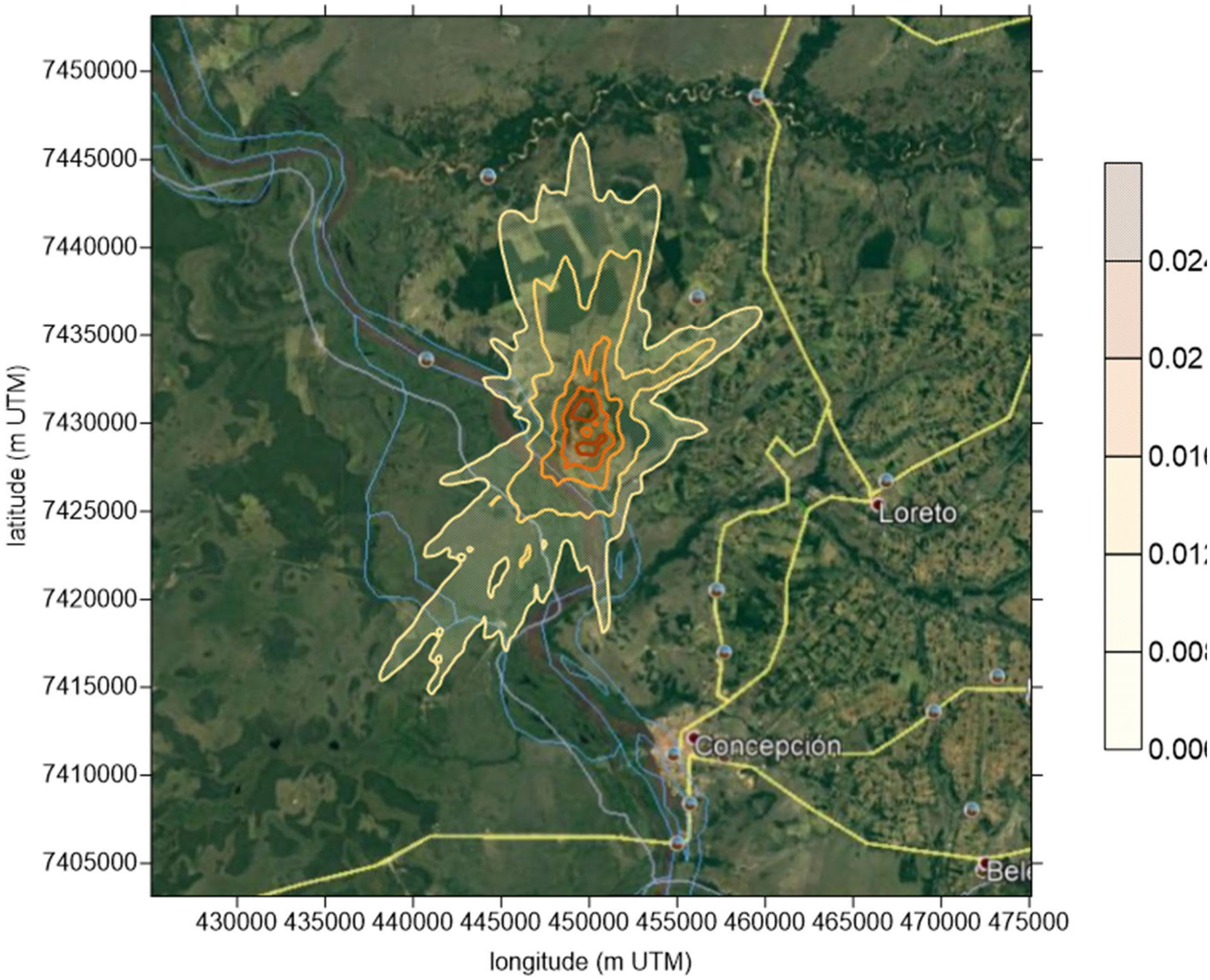


Figure 17 – Maximum average concentration of 8 hours for CO (scale in mg.m^{-3}). Maximum peak concentration of 0.02490 mg.m^{-3} at position 7430625 S and 449875 O (m UTM) on 04/02/2019 at 4 p.m.

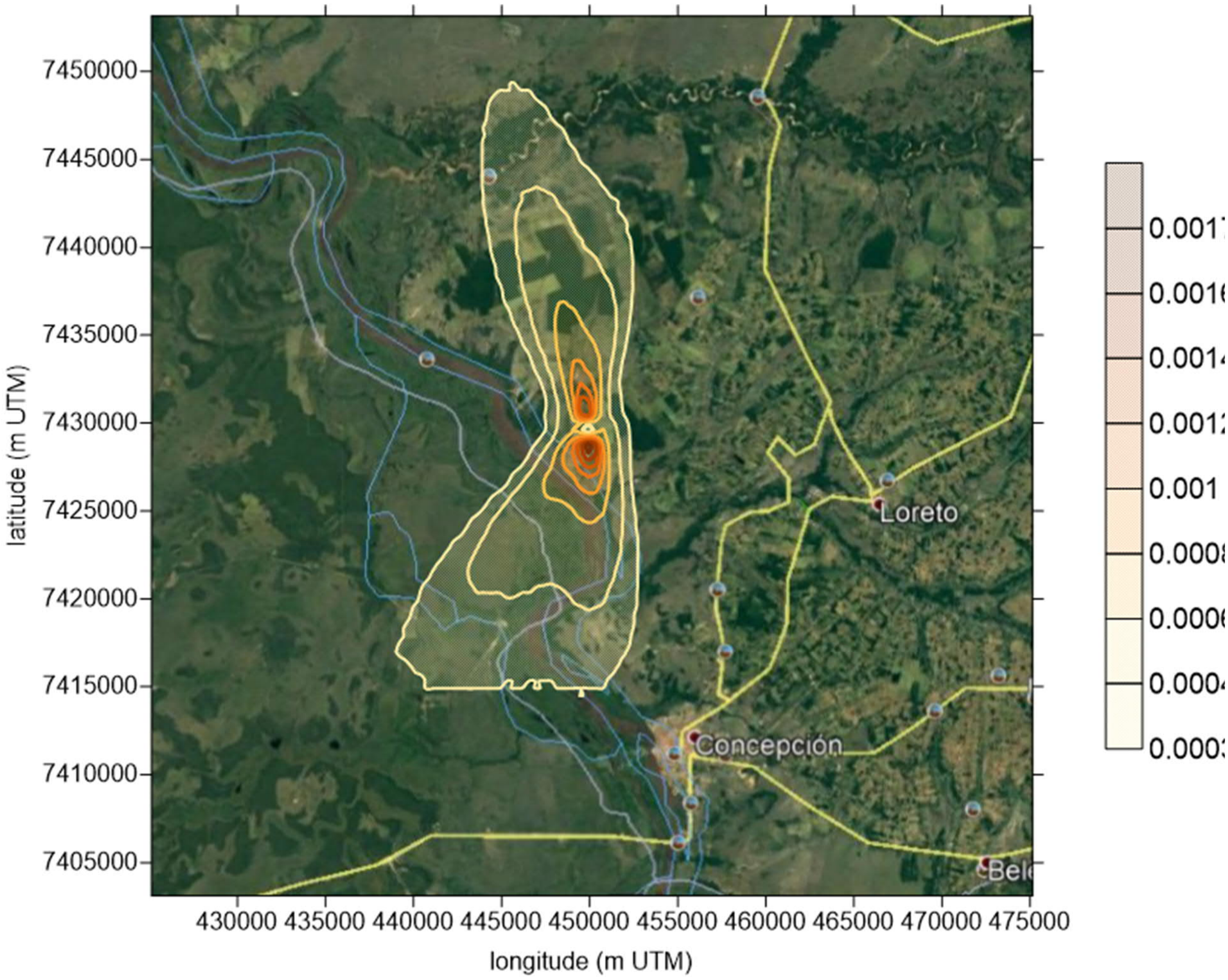


Figure 18 – Annual average maximum CO concentration (scale in mg.m^{-3}). Maximum peak concentration of 0.00174 mg.m^{-3} at position 7428625 S and 449875 O (m UTM).

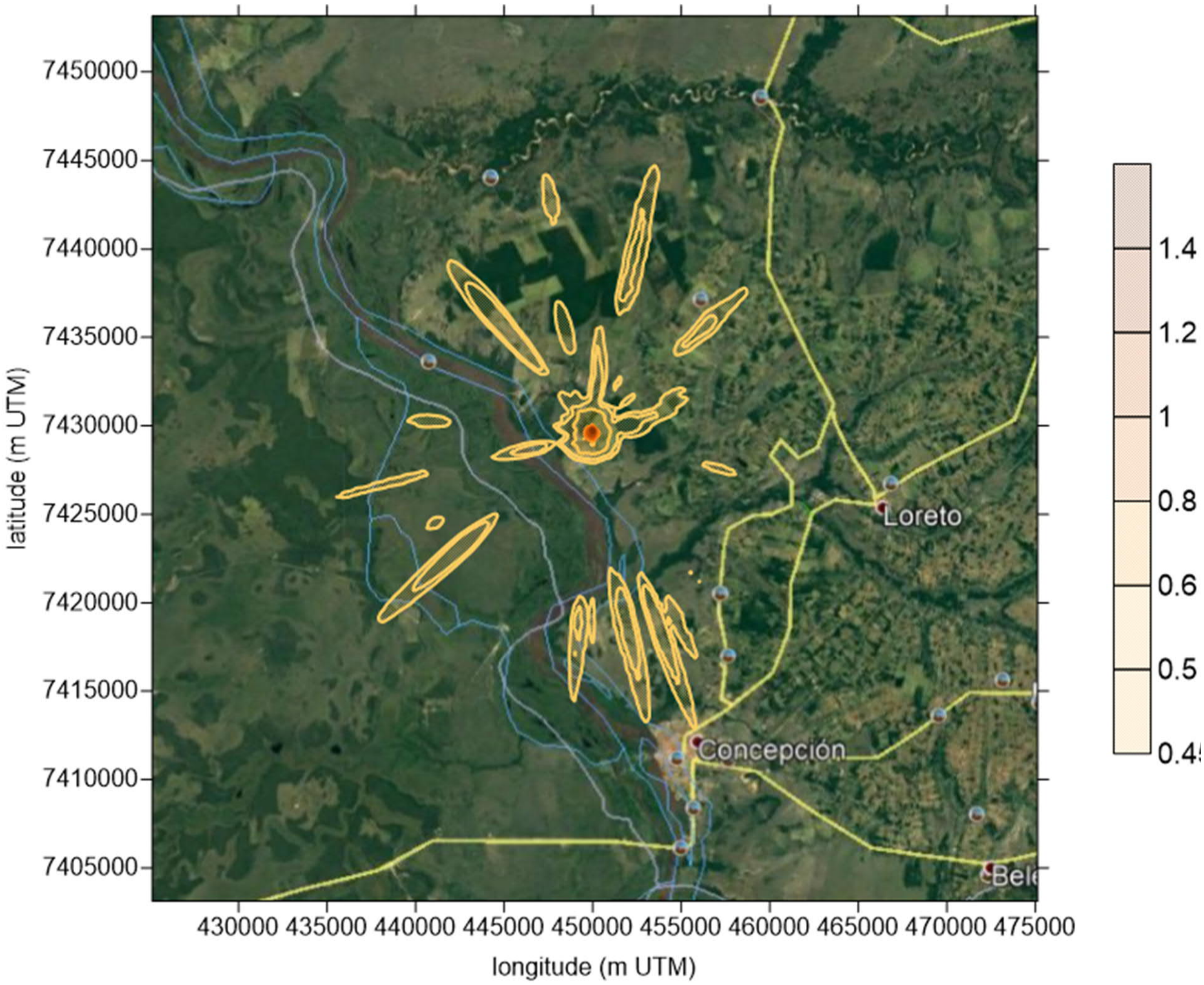


Figure 19 – Maximum average concentration of 1 hour for TRS (scale in µg.m^{-3}). Maximum peak concentration of 1,49240 µg.m^{-3} at position 7429875 S and 449875 O (m UTM) on 02/24/2018 at 12 h.

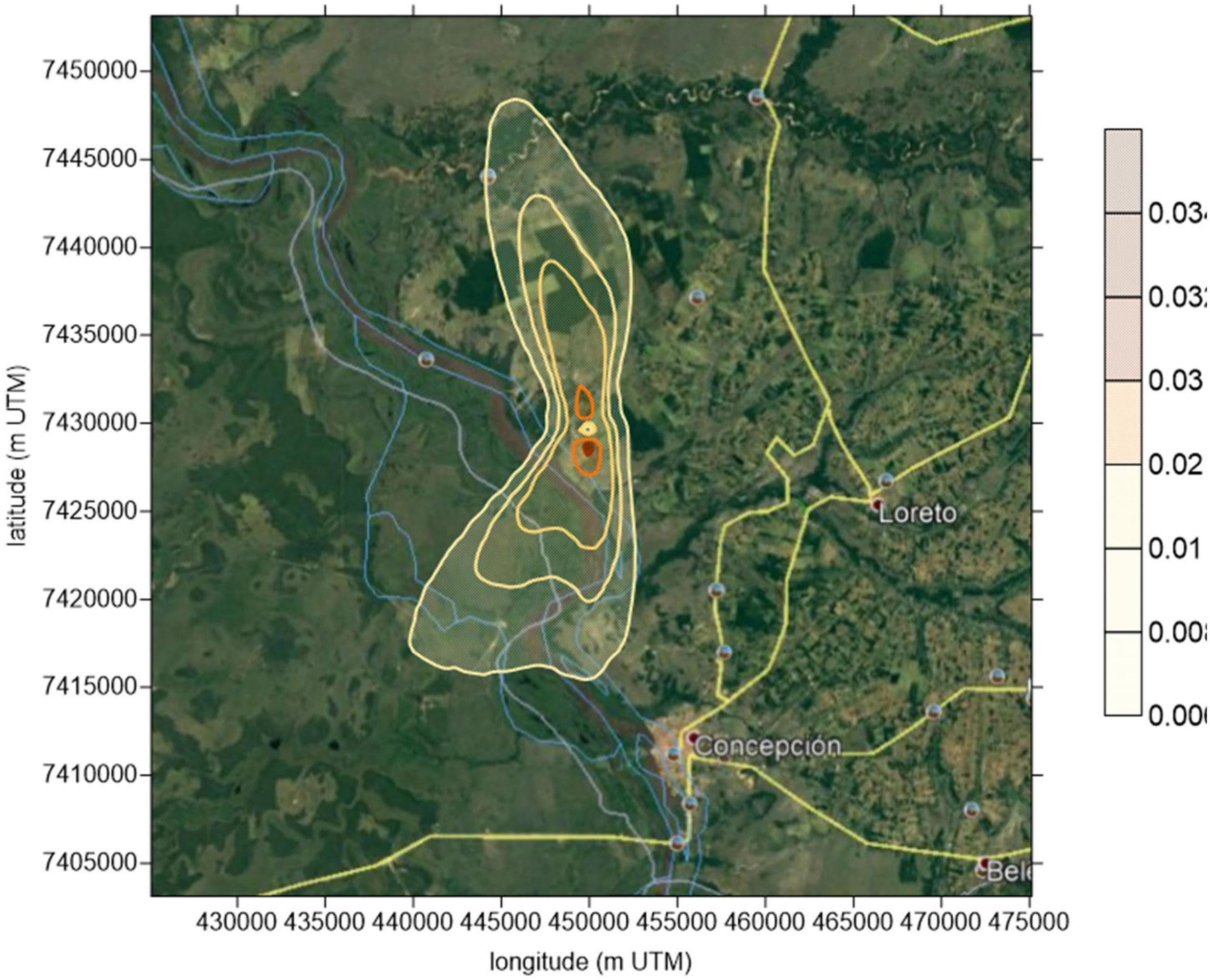


Figure 20 – Maximum annual average concentration for TRS (scale in µg.m^{-3}). Maximum peak concentration of 0.03424 µg.m^{-3} at position 7428625 S and 449875 O (m UTM).

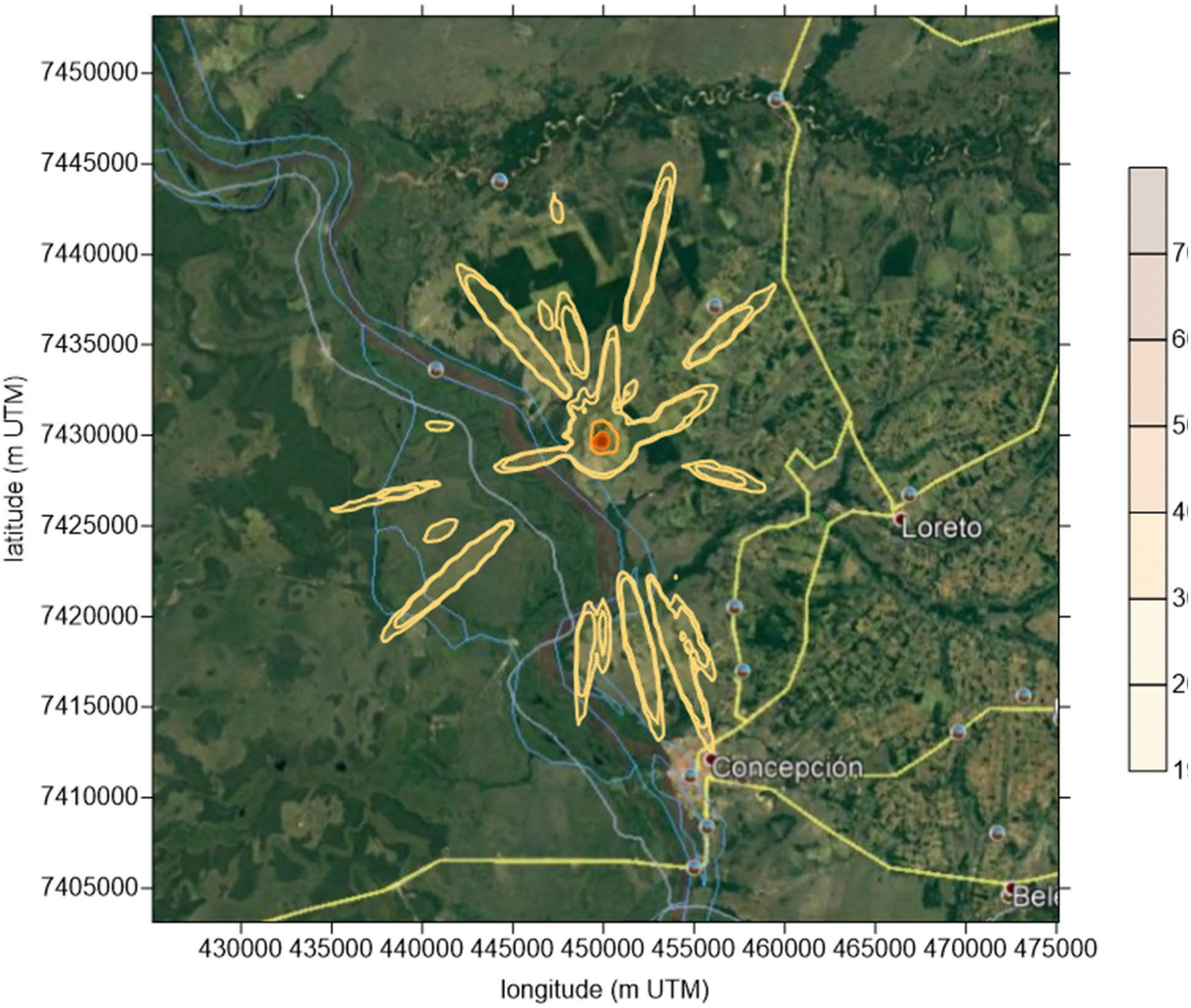


Figure 21 – Maximum average concentration of 1 hour for NO_2 (scale in µg.m^{-3}). Maximum peak concentration of 74.81947 µg.m^{-3} at position 7429875 S and 449875 O (m UTM) on 02/24/2018 at 12 h.

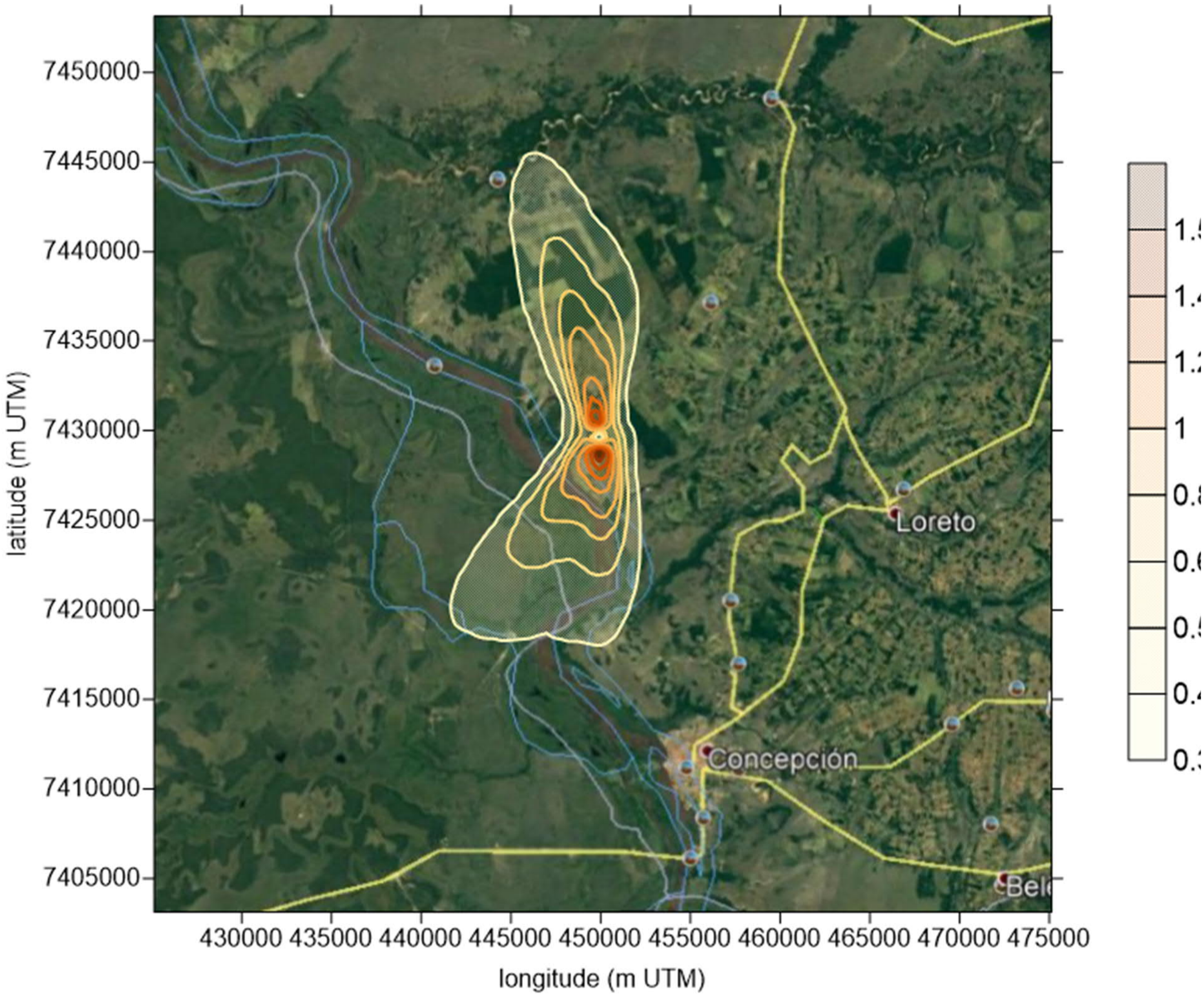


Figure 22 – Maximum annual average NO_2 concentration (scale in µg.m^{-3}). Maximum peak concentration of 1.57742 µg.m^{-3} at position 7428625 S and 449875 O (m UTM).

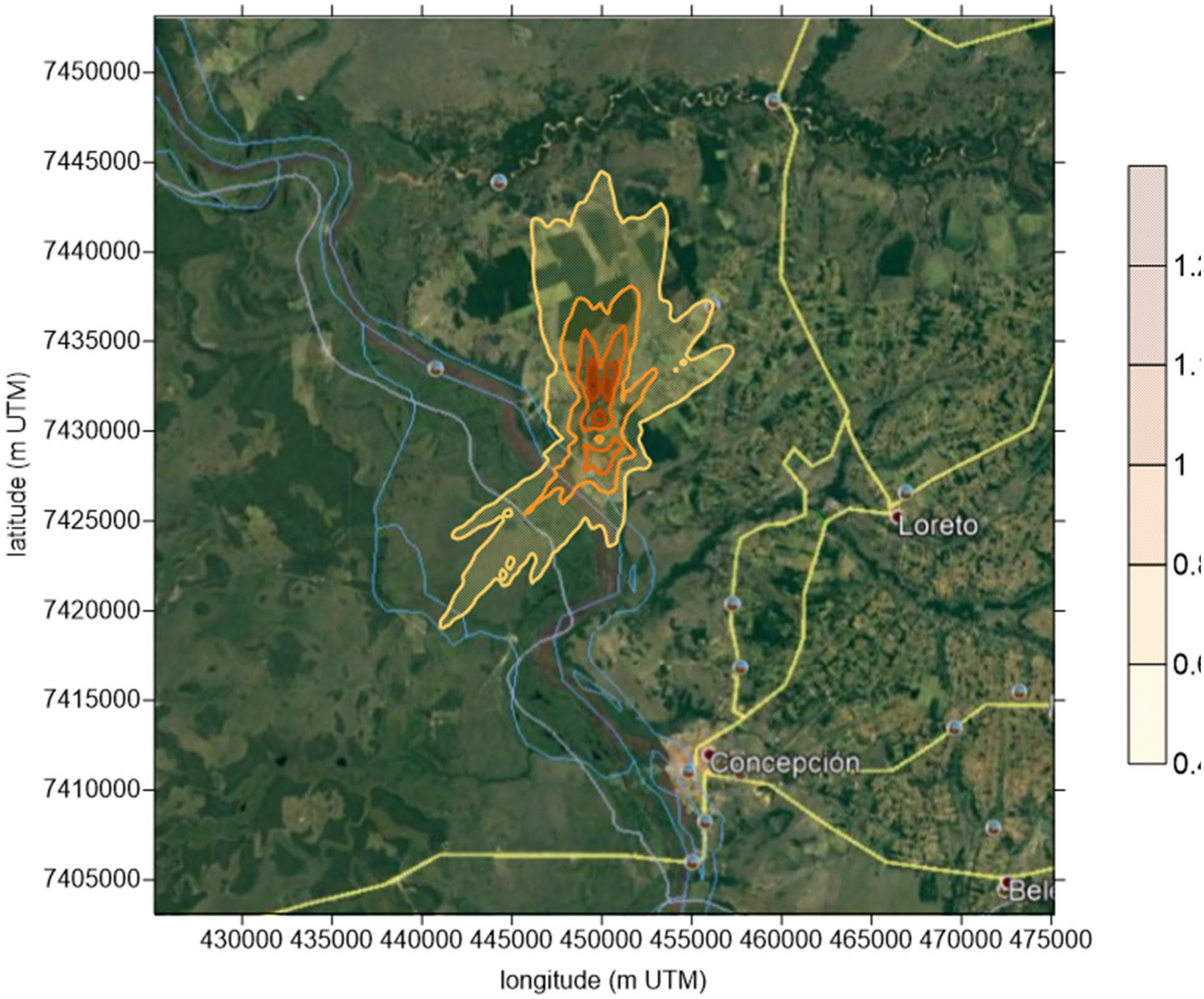


Figure 23 – 24-hour average maximum concentration for PM_{10} (scale in µg.m^{-3}). Maximum peak concentration of 1.23890 µg.m-^{3} at position 7432125 S and 450 125 O (m UTM) on 08/02/2019.

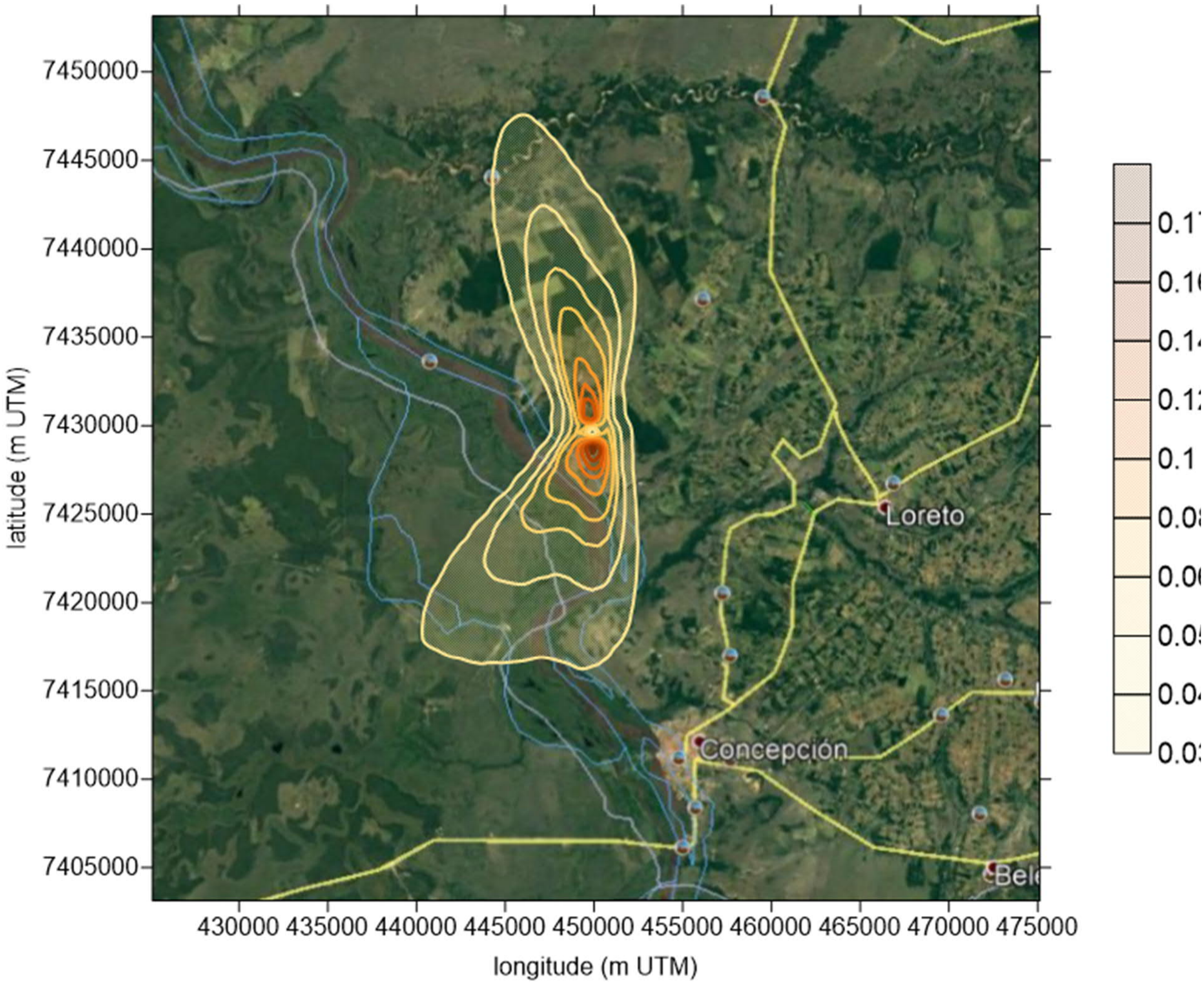


Figure 24 – Maximum annual average concentration for PM_{10} (scale in µg.m^{-3}). Maximum peak concentration of 0.17252 µg.m^{-3} at position 7428625 S and 449875 O (m UTM).

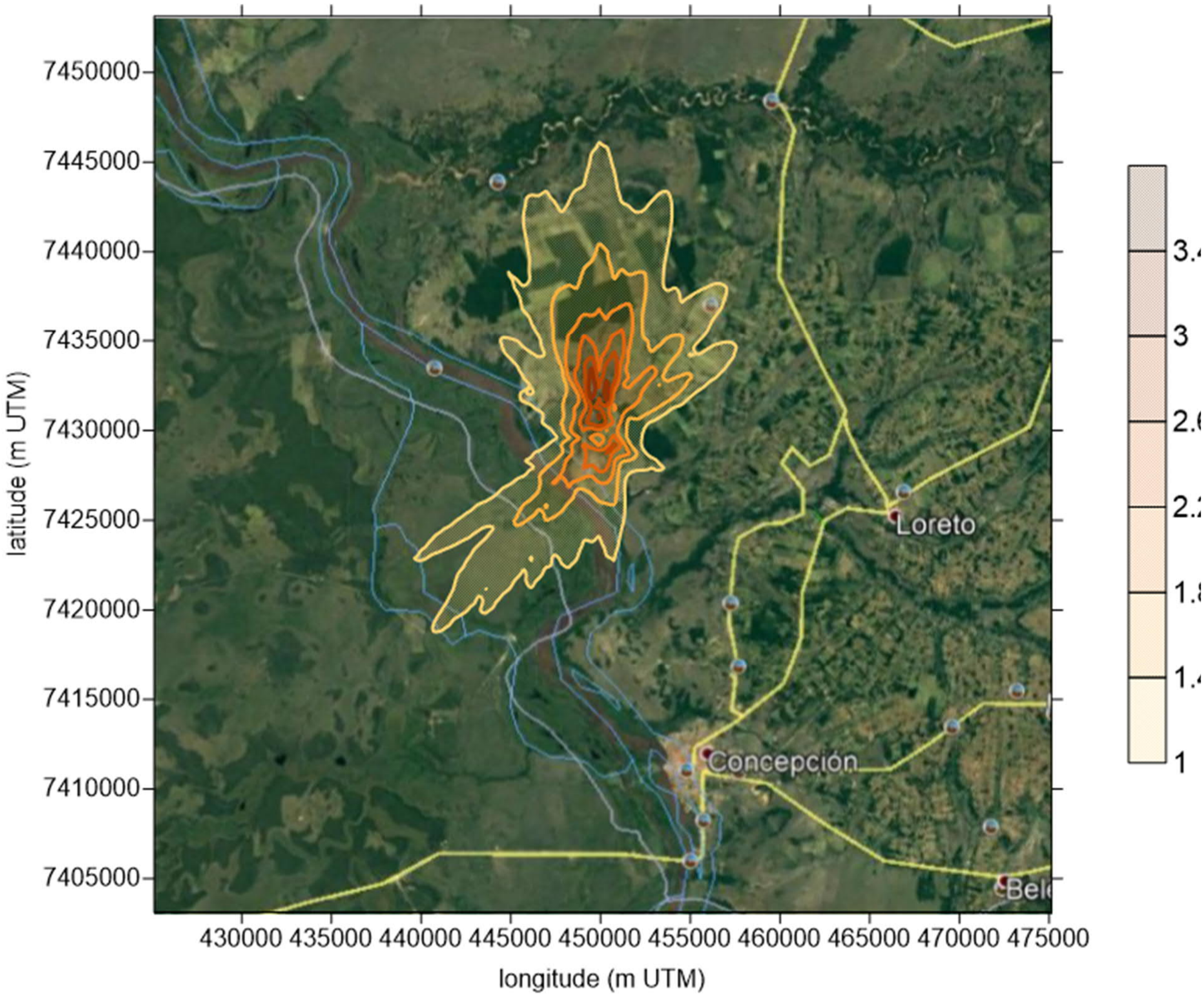


Figure 25 – Maximum 24-hour average concentration for SO_2 (scale in μg.m^{-3}). Peak concentration peak of 3.45833 μg.m^{-}3 at position 7432125 S e 449625 O (m UTM) on 08/13/2019.

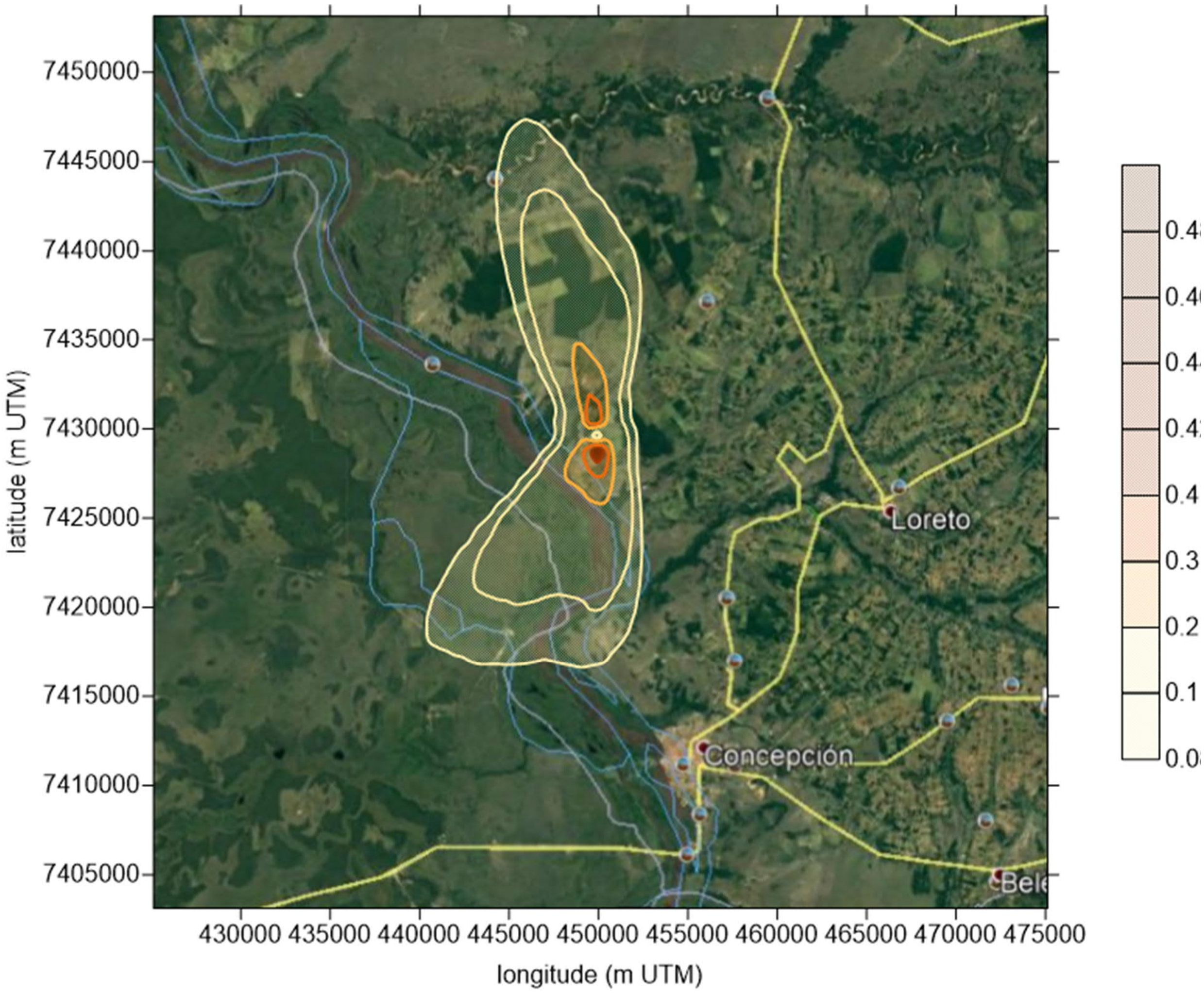
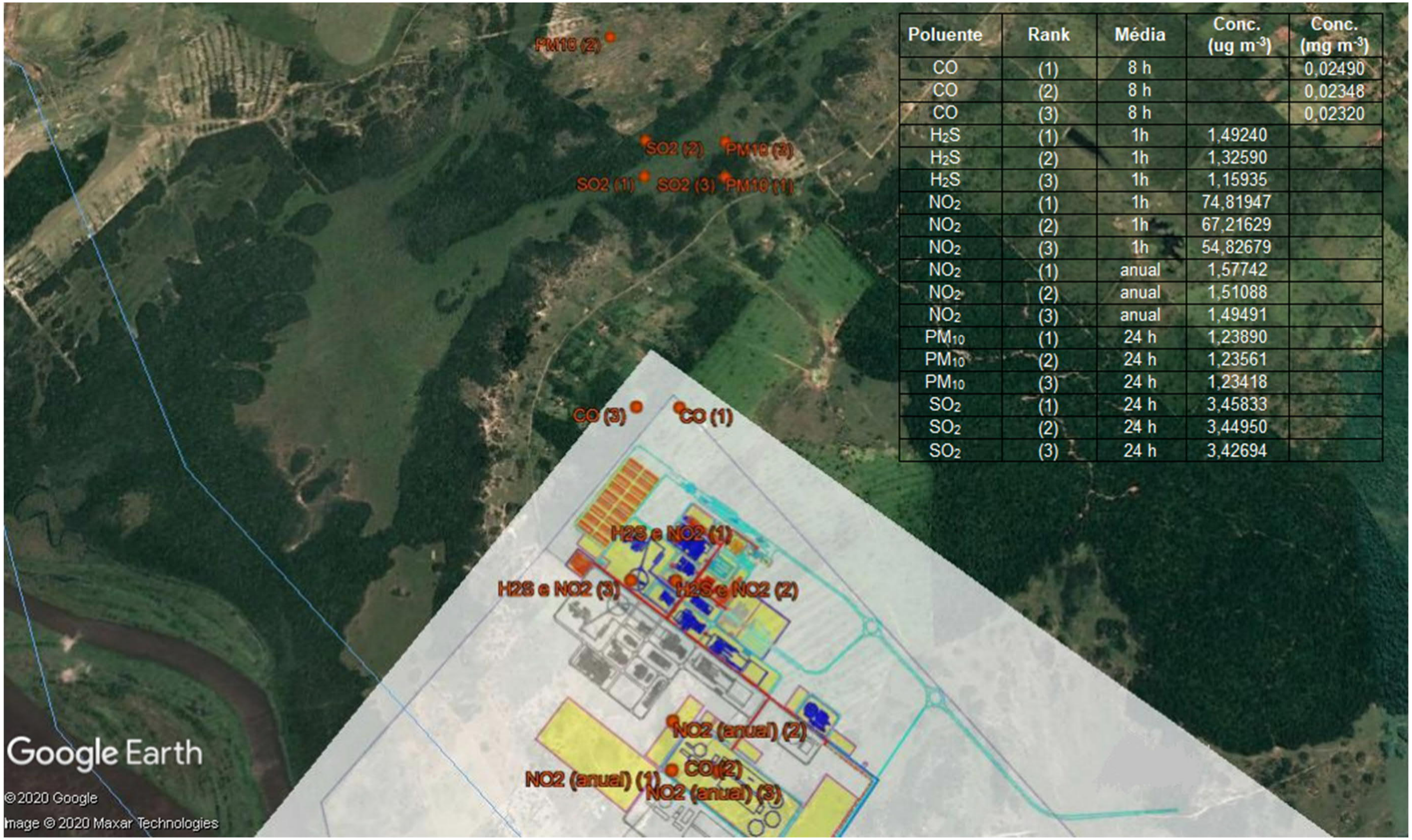


Figure 26 – Maximum annual average concentration for SO_2 (scale in µg.m^{-3}). Maximum peak concentration of 0.47616 µg.m^{-3} at position 7428625 S and 449875 O (m UTM).

Table 5 - Maximum values of the maximum average concentrations, location and altitude.

Pollutant	Average	Conc. ($\mu g\ m^{-3}$)	Conc. ($mg\ m^{-3}$)	Air Quality Standard SEAM Resolution No. 259/15	Location (m UTM)	Altitude (m)
CO	8 h		0.02490	10 mg/m^3	7430625 S; 449875 O	105
CO	annual		0.00174	-	7428625 S; 449875 O	81
H_2S	1h	1.49240		-	7429875 S; 449875 O	93
H_2S	annual	0.03424		-	7428625 S; 449875 O	81
NO_2	1h	74.81947		200 $\mu g/m^3$	7429875 S; 449875 O	93
NO_2	annual	1.57742		40 $\mu g/m^3$	7428625 S; 449875 O	81
PM_{10}	24 h	1.23890		150 $\mu g/m^3$	7432125 S; 450125 O	84
PM_{10}	annual	0.17252		-	7428625 S; 449875 O	81
SO_2	24 h	3.45833		20 $\mu g/m^3$	7432125 S; 449625 O	86
SO_2	annual	0.47616		-	7428625 S; 449875 O	81



Poluente	Rank	Média	Conc. (ug m^{-3})	Conc. (mg m^{-3})
CO	(1)	8 h		0,02490
CO	(2)	8 h		0,02348
CO	(3)	8 h		0,02320
H_2S	(1)	1h	1,49240	
H_2S	(2)	1h	1,32590	
H_2S	(3)	1h	1,15935	
NO_2	(1)	1h	74,81947	
NO_2	(2)	1h	67,21629	
NO_2	(3)	1h	54,82679	
NO_2	(1)	anual	1,57742	
NO_2	(2)	anual	1,51088	
NO_2	(3)	anual	1,49491	
PM_{10}	(1)	24 h	1,23890	
PM_{10}	(2)	24 h	1,23561	
PM_{10}	(3)	24 h	1,23418	
SO_2	(1)	24 h	3,45833	
SO_2	(2)	24 h	3,44950	
SO_2	(3)	24 h	3,42694	

Figure 27 – Location of the highest concentrations around the pulp mill.

Table 6 – Average maximum concentrations of CO, TRS, NO_2, PM_{10} and SO_2 pollutants in 15 discrete receivers.

Receivers	**Latitud (m UTM)**	**Longitud (m UTM)**	**Distance (m)**	**CO (8h) (mg m^{-3})**	**TRS (1h) (μg m^{-3})**	**NO_2 (1h) (μg m^{-3})**	**NO_2 (annual) (μg m^{-3})**	**PM_{10} (24h) (μg m^{-3})**	**SO_2 (24h) (μg m^{-3})**
1PC	7430391.91	449116.83	990	0.02278	0.62720	28.57480	0.62879	1.00221	2.74160
8PC	7431394.05	449676.03	1700	0.01943	0.52123	22.82475	1.18136	0.96854	2.76283
13PC	7432140.83	450453.38	2500	0.01438	0.56375	24.12785	0.66171	0.94413	2.93071
25SC	7432559.04	446004.90	4800	0.00646	0.39077	14.82095	0.20657	0.35561	1.00411
23SM	7425994.00	453141.00	4800	0.00579	0.27218	12.06002	0.20551	0.22369	0.58613
26SD	7434628.66	450930.24	5200	0.01216	0.43091	18.62207	0.46721	0.94560	2.58933
40LP - Centro	7433012.58	454114.85	5470	0.00840	0.35621	15.13918	0.14720	0.46553	1.29691
21PY	7429985.53	455552.36	5700	0.00628	0.33315	13.56784	0.12158	0.23911	0.67922
30SR - Centro	7427494.70	455813.98	6300	0.00490	0.39714	18.27058	0.11276	0.22911	0.62055
AR3	7434430.00	457299.00	8800	0.00748	0.32489	14.45117	0.09836	0.39442	1.02888
50RP - Centro	7436905.19	455528.15	9300	0.00555	0.28749	10.76636	0.11624	0.41794	1.16889
60KP - Centro	7420669.84	457392.36	11700	0.00317	0.33599	15.96352	0.10143	0.13293	0.34587
27HA	7417523.92	454028.61	13000	0.00476	0.55114	24.16594	0.18062	0.20875	0.55525
AR2	7426022.00	466753.00	17300	0.00276	0.27709	10.38484	0.05060	0.07745	0.20585
AR1	7410810.00	454572.00	19500	0.00287	0.32137	13.34266	0.14436	0.18067	0.47359
Standard Air Quality Resolution SEAM no 259/15				**10 mg/m^3**	**-**	**200 μg/m^3**	**40 μg/m^3**	**150 μg/m^3**	**20 μg/m^3**

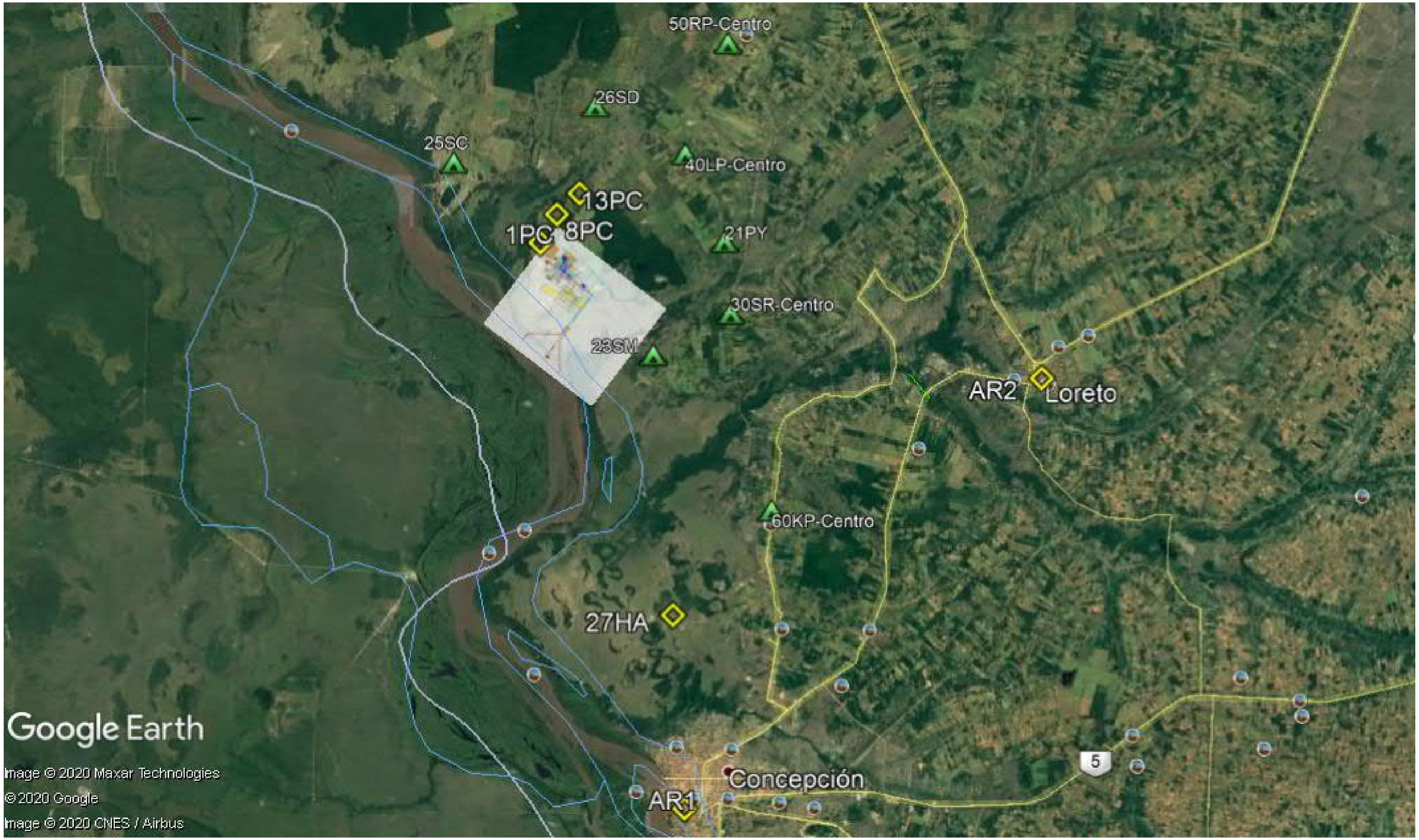


Figure 27 – Location of the 15 discrete receivers around the pulp mill.

4. CONCLUSIONS

This technical report presented the air dispersion study results of carbon monoxide (CO), total reduced sulfur (TRS), nitrogen dioxide (NO_2), particulate matter (MP10) and sulfur dioxide (SO_2) emitted by the future PARACEL pulp mill sources. The pulp mill and its emission sources will be installed near the city of Concepción, in Paraguay, at the coordinates 23.241050 ° S and 57.490110 ° W. Dispersion simulations were carried out with the WRF-MMIF-AERMET-AERMOD model system, so that the surface and altitude data are derived from numerical simulation with the WRF weather model.

The study revealed that there is a good correlation between the analyzed meteorological and climatological conditions and the pollutant plume behavior. Pollutant concentrations at the surface depend mainly on meteorological conditions and the transport of pollutants is under the influence of macro, meso and microscale conditions. According to the meteorological data and the dispersion study results, the directions of the south and northeast winds defined the concentration peaks location.

Finally, the atmospheric dispersion simulations generated low concentration values of the pollutants CO, TRS, NO_2, PM_{10} and SO_2. The maximum concentration values are below the air quality standards established by the Paraguayan regulations for CO, NO_2, PM_{10} and SO_2 and the odor perception limit indicated by the World Health Organization for TRS (Total Reduced Sulfur). Specifically, the maximum concentrations of PM_{10} are even below the air quality standards for $PM_{2.5}$, considering both the daily average (24 h) and the annual average. The maximum concentration peaks of all pollutants occur near the pulp mill, at distances between 165 and 2,428 m. The pollutant concentrations in discrete receivers, chosen to complement the air quality assessment in the area of interest, are below air quality standards.

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Rio Grande, July 15, 2020.

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ANNEX A

TABLES CONTAINING THE VALUES OF THE MAXIMUM CONCENTRATIONS OF CONTAMINANTS CO, TRS, NO_2, PM_{10} AND SO_2

Table A1 – 50 highest concentrations of CO (8h) generated by the AERMOD model.

```
                                    *** THE MAXIMUM   50   8-HR AVERAGE CONCENTRATION   VALUES FOR SOURCE GROUP:  ALL      ***
                                           INCLUDING SOURCE(S):     CALDREC     , FRNCAL1     , FRNCAL2     , CALDBIO     ,

                                                     ** CONC OF CO       IN MILLIGRAMS/M**3                         **

    RANK         CONC    (YYMMDDHH) AT      RECEPTOR (XR,YR) OF TYPE    RANK         CONC    (YYMMDDHH) AT      RECEPTOR (XR,YR) OF
                                                                   TYPE
  - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
                                                                   -
     1.       0.02490 (19020416) AT ( 449875.00, 7430625.00)  DC       26.       0.02171 (18120216) AT ( 449875.00, 7430875.00)  DC
     2.       0.02348 (19022316) AT ( 450125.00, 7428625.00)  DC       27.       0.02167 (19110116) AT ( 449375.00, 7428875.00)  DC
     3.       0.02320 (19022716) AT ( 449625.00, 7430625.00)  DC       28.       0.02167 (18120116) AT ( 449625.00, 7430875.00)  DC
     4.       0.02319 (18022116) AT ( 449875.00, 7430625.00)  DC       29.       0.02166 (18120716) AT ( 449625.00, 7431125.00)  DC
     5.       0.02316 (19020416) AT ( 449875.00, 7430875.00)  DC       30.       0.02157 (19022316) AT ( 450125.00, 7428375.00)  DC
     6.       0.02310 (18111916) AT ( 449375.00, 7430375.00)  DC       31.       0.02150 (18010316) AT ( 449875.00, 7430625.00)  DC
     7.       0.02307 (18031016) AT ( 450125.00, 7428625.00)  DC       32.       0.02148 (18120216) AT ( 449875.00, 7431125.00)  DC
     8.       0.02300 (19021616) AT ( 450125.00, 7430625.00)  DC       33.       0.02147 (18111216) AT ( 449625.00, 7428375.00)  DC
     9.       0.02279 (18021316) AT ( 449625.00, 7430625.00)  DC       34.       0.02146 (19022416) AT ( 450125.00, 7428625.00)  DC
    10.       0.02278 (18112516) AT ( 449125.00, 7430375.00)  DC       35.       0.02143 (19022416) AT ( 450125.00, 7428375.00)  DC
    11.       0.02275 (18010716) AT ( 449375.00, 7430875.00)  DC       36.       0.02141 (19011016) AT ( 450125.00, 7428625.00)  DC
    12.       0.02262 (18021316) AT ( 449625.00, 7430875.00)  DC       37.       0.02139 (18031016) AT ( 450125.00, 7428375.00)  DC
    13.       0.02248 (18011416) AT ( 450875.00, 7429125.00)  DC       38.       0.02136 (19022316) AT ( 450125.00, 7428875.00)  DC
    14.       0.02244 (18120716) AT ( 449625.00, 7430875.00)  DC       39.       0.02134 (19111516) AT ( 449875.00, 7430625.00)  DC
    15.       0.02236 (19123116) AT ( 450875.00, 7429375.00)  DC       40.       0.02132 (18012316) AT ( 450125.00, 7428375.00)  DC
    16.       0.02220 (19112816) AT ( 449875.00, 7430625.00)  DC       41.       0.02131 (19092216) AT ( 449375.00, 7430875.00)  DC
    17.       0.02219 (18110216) AT ( 449875.00, 7428625.00)  DC       42.       0.02130 (19121716) AT ( 449625.00, 7431125.00)  DC
    18.       0.02214 (19022716) AT ( 449625.00, 7430875.00)  DC       43.       0.02128 (19122416) AT ( 449625.00, 7428875.00)  DC
    19.       0.02211 (18111916) AT ( 449125.00, 7430625.00)  DC       44.       0.02128 (19011716) AT ( 450125.00, 7428375.00)  DC
    20.       0.02202 (19112316) AT ( 449625.00, 7430625.00)  DC       45.       0.02121 (19011516) AT ( 450125.00, 7428625.00)  DC
    21.       0.02200 (19112316) AT ( 449625.00, 7430875.00)  DC       46.       0.02120 (19012816) AT ( 449375.00, 7428375.00)  DC
    22.       0.02184 (19112816) AT ( 449875.00, 7430875.00)  DC       47.       0.02118 (19011416) AT ( 450125.00, 7428625.00)  DC
    23.       0.02180 (19123116) AT ( 450625.00, 7429375.00)  DC       48.       0.02116 (19010216) AT ( 450125.00, 7428375.00)  DC
    24.       0.02180 (18020916) AT ( 450125.00, 7428875.00)  DC       49.       0.02115 (19011716) AT ( 450125.00, 7428625.00)  DC
     25.       0.02175 (19121716) AT ( 449625.00, 7430875.00)  DC       50.       0.02114 (18012316) AT ( 450125.00, 7428625.00)
 DC
```

Table A2 – 10 highest concentrations of CO (annual average) generated by the AERMOD model.

```
                              *** THE SUMMARY OF MAXIMUM ANNUAL RESULTS AVERAGED OVER   2 YEARS ***


                                           ** CONC OF CO       IN MILLIGRAMS/M**3 **

                                                                                                                  NETWORK
 GROUP ID                        AVERAGE CONC                RECEPTOR  (XR, YR, ZELEV, ZHILL, ZFLAG)  OF TYPE  GRID-ID
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
                                                           -

     ALL       1ST HIGHEST VALUE IS       0.00174 AT (  449875.00,  7428625.00,    81.00,     0.00,    0.00)  DC
               2ND HIGHEST VALUE IS       0.00168 AT (  449875.00,  7428375.00,    81.00,     0.00,    0.00)  DC
               3RD HIGHEST VALUE IS       0.00166 AT (  450125.00,  7428625.00,    81.00,     0.00,    0.00)  DC
               4TH HIGHEST VALUE IS       0.00163 AT (  450125.00,  7428375.00,    81.00,     0.00,    0.00)  DC
               5TH HIGHEST VALUE IS       0.00162 AT (  449875.00,  7428875.00,    82.00,     0.00,    0.00)  DC
               6TH HIGHEST VALUE IS       0.00154 AT (  449875.00,  7428125.00,    79.00,     0.00,    0.00)  DC
               7TH HIGHEST VALUE IS       0.00153 AT (  450125.00,  7428875.00,    83.00,     0.00,    0.00)  DC
               8TH HIGHEST VALUE IS       0.00152 AT (  450125.00,  7428125.00,    81.00,     0.00,    0.00)  DC
               9TH HIGHEST VALUE IS       0.00150 AT (  449625.00,  7428625.00,    84.00,     0.00,    0.00)  DC
              10TH HIGHEST VALUE IS       0.00148 AT (  449625.00,  7428375.00,    84.00,     0.00,    0.00)  DC
```

Table A3 – 50 highest concentrations of Total Reduced Sulfur (average 1h) generated by the AERMOD model.

```
                     *** THE MAXIMUM   50   1-HR AVERAGE CONCENTRATION   VALUES FOR SOURCE GROUP:  ALL      ***
                                                  INCLUDING SOURCE(S):     CALDREC     , FRNCAL1     , FRNCAL2     ,

                                                     ** CONC OF H2S      IN MICROGRAMS/M**3                          **

    RANK        CONC    (YYMMDDHH) AT      RECEPTOR (XR,YR) OF TYPE    RANK        CONC    (YYMMDDHH) AT      RECEPTOR (XR,YR) OF
                                                                  TYPE
  - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
                                                                  -
     1.       1.49240 (18022412) AT ( 449875.00, 7429875.00)  DC       26.       0.95623 (19112116) AT ( 449625.00, 7429625.00)  DC
     2.       1.32590 (18022412) AT ( 449875.00, 7429625.00)  DC       27.       0.95053 (18022412) AT ( 450125.00, 7429875.00)  DC
     3.       1.15935 (18022412) AT ( 449625.00, 7429625.00)  DC       28.       0.93719 (19041513) AT ( 450125.00, 7429875.00)  DC
     4.       1.15461 (18022413) AT ( 449625.00, 7429625.00)  DC       29.       0.93359 (19112116) AT ( 450125.00, 7429625.00)  DC
     5.       1.11782 (18022413) AT ( 449875.00, 7429875.00)  DC       30.       0.92228 (18030615) AT ( 449625.00, 7429625.00)  DC
     6.       1.11480 (18022413) AT ( 450125.00, 7429625.00)  DC       31.       0.91922 (19112413) AT ( 449875.00, 7429375.00)  DC
     7.       1.08065 (18022413) AT ( 449625.00, 7429875.00)  DC       32.       0.91141 (19112116) AT ( 449625.00, 7429875.00)  DC
     8.       1.07207 (18022412) AT ( 450125.00, 7429625.00)  DC       33.       0.89467 (18030615) AT ( 450125.00, 7429625.00)  DC
     9.       1.06082 (19041513) AT ( 449625.00, 7429625.00)  DC       34.       0.88188 (19041513) AT ( 449875.00, 7429375.00)  DC
    10.       1.05446 (19041513) AT ( 449875.00, 7429875.00)  DC       35.       0.87378 (19041413) AT ( 450125.00, 7429625.00)  DC
    11.       1.03435 (19020212) AT ( 450125.00, 7429625.00)  DC       36.       0.87225 (19041413) AT ( 449625.00, 7429875.00)  DC
    12.       1.03141 (18022413) AT ( 450125.00, 7429875.00)  DC       37.       0.87110 (19112116) AT ( 450125.00, 7429875.00)  DC
    13.       1.02779 (19020212) AT ( 449625.00, 7429875.00)  DC       38.       0.87029 (18022412) AT ( 449875.00, 7429375.00)  DC
    14.       1.02063 (18022412) AT ( 449625.00, 7429875.00)  DC       39.       0.86099 (19041413) AT ( 450125.00, 7429875.00)  DC
    15.       1.01692 (18030615) AT ( 449875.00, 7429875.00)  DC       40.       0.85734 (19041413) AT ( 449625.00, 7429625.00)  DC
    16.       1.01338 (19020212) AT ( 450125.00, 7429875.00)  DC       41.       0.84552 (19112116) AT ( 449875.00, 7429875.00)  DC
    17.       1.01315 (19041513) AT ( 450125.00, 7429625.00)  DC       42.       0.84398 (18012515) AT ( 449875.00, 7429875.00)  DC
    18.       1.01244 (19020212) AT ( 449625.00, 7429625.00)  DC       43.       0.83527 (19020213) AT ( 449625.00, 7429625.00)  DC
    19.       0.98591 (19112413) AT ( 450125.00, 7429625.00)  DC       44.       0.83479 (19020212) AT ( 449625.00, 7429375.00)  DC
    20.       0.98333 (19041513) AT ( 449625.00, 7429875.00)  DC       45.       0.83306 (19020212) AT ( 449875.00, 7430125.00)  DC
    21.       0.97344 (19112413) AT ( 449625.00, 7429875.00)  DC       46.       0.82900 (19020213) AT ( 450125.00, 7429625.00)  DC
    22.       0.97186 (19112413) AT ( 449625.00, 7429625.00)  DC       47.       0.82698 (19041413) AT ( 449875.00, 7429375.00)  DC
    23.       0.96746 (19020212) AT ( 449875.00, 7429375.00)  DC       48.       0.81520 (18030615) AT ( 449625.00, 7429875.00)  DC
    24.       0.95960 (18022413) AT ( 449875.00, 7429375.00)  DC       49.       0.81099 (19112116) AT ( 449875.00, 7429375.00)  DC
    25.       0.95712 (19112413) AT ( 450125.00, 7429875.00)  DC       50.       0.81064 (19020212) AT ( 450125.00, 7429375.00)  DC
```

Table A4 – 10 highest concentrations of Total Reduced Sulfur (annual average) generated by the AERMOD model.

```
                            *** THE SUMMARY OF MAXIMUM ANNUAL RESULTS AVERAGED OVER   2 YEARS ***


                                         ** CONC OF H2S      IN MICROGRAMS/M**3 **

                                                                                                     NETWORK
 GROUP ID                       AVERAGE CONC                RECEPTOR  (XR, YR, ZELEV, ZHILL, ZFLAG)  OF TYPE  GRID-ID
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
                                                           -

      ALL       1ST HIGHEST VALUE IS       0.03424 AT (  449875.00,  7428625.00,    81.00,     0.00,    0.00)  DC
                2ND HIGHEST VALUE IS       0.03276 AT (  449875.00,  7428375.00,    81.00,     0.00,    0.00)  DC
                3RD HIGHEST VALUE IS       0.03260 AT (  450125.00,  7428625.00,    81.00,     0.00,    0.00)  DC
                4TH HIGHEST VALUE IS       0.03206 AT (  449875.00,  7428875.00,    82.00,     0.00,    0.00)  DC
                5TH HIGHEST VALUE IS       0.03170 AT (  450125.00,  7428375.00,    81.00,     0.00,    0.00)  DC
                6TH HIGHEST VALUE IS       0.03010 AT (  450125.00,  7428875.00,    83.00,     0.00,    0.00)  DC
                7TH HIGHEST VALUE IS       0.02998 AT (  449875.00,  7428125.00,    79.00,     0.00,    0.00)  DC
                8TH HIGHEST VALUE IS       0.02949 AT (  450125.00,  7428125.00,    81.00,     0.00,    0.00)  DC
                9TH HIGHEST VALUE IS       0.02946 AT (  449625.00,  7428625.00,    84.00,     0.00,    0.00)  DC
               10TH HIGHEST VALUE IS       0.02900 AT (  449625.00,  7428375.00,    84.00,     0.00,    0.00)  DC
```

Table A5 – 50 highest concentrations of NO_2 (average 1h) generated by the AERMOD model.

```
                                    *** THE MAXIMUM   50   1-HR AVERAGE CONCENTRATION   VALUES FOR SOURCE GROUP:  ALL      ***
                                           INCLUDING SOURCE(S):     CALDREC     , FRNCAL1     , FRNCAL2     , CALDBIO     ,

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

    RANK        CONC    (YYMMDDHH) AT      RECEPTOR (XR,YR) OF TYPE   RANK        CONC    (YYMMDDHH) AT      RECEPTOR (XR,YR) OF
                                                                     TYPE
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
                                                                 -
     1.      74.81947 (18022412) AT ( 449875.00, 7429875.00)  DC       26.      43.85058 (19112413) AT ( 449625.00, 7429625.00)  DC
     2.      67.21629 (18022412) AT ( 449875.00, 7429625.00)  DC       27.      43.66804 (19112413) AT ( 449625.00, 7429875.00)  DC
     3.      54.82679 (18022412) AT ( 449625.00, 7429625.00)  DC       28.      43.29349 (18030615) AT ( 450125.00, 7429625.00)  DC
     4.      52.82401 (18022413) AT ( 449875.00, 7429875.00)  DC       29.      43.25166 (19112116) AT ( 449625.00, 7429875.00)  DC
     5.      52.79425 (18022413) AT ( 449625.00, 7429625.00)  DC       30.      43.06829 (19041513) AT ( 450125.00, 7429875.00)  DC
     6.      52.28682 (18030615) AT ( 449875.00, 7429875.00)  DC       31.      42.75139 (19112413) AT ( 450125.00, 7429875.00)  DC
     7.      51.05697 (19041513) AT ( 449875.00, 7429875.00)  DC       32.      42.58570 (18022413) AT ( 449875.00, 7429375.00)  DC
     8.      50.49182 (18022413) AT ( 450125.00, 7429625.00)  DC       33.      41.98974 (19020212) AT ( 449875.00, 7429375.00)  DC
     9.      50.13500 (18022412) AT ( 450125.00, 7429625.00)  DC       34.      41.19899 (19112116) AT ( 450125.00, 7429875.00)  DC
    10.      49.50687 (19041513) AT ( 449625.00, 7429625.00)  DC       35.      40.58434 (19112413) AT ( 449875.00, 7429375.00)  DC
    11.      48.99142 (18022413) AT ( 449625.00, 7429875.00)  DC       36.      40.53243 (19112116) AT ( 449875.00, 7429875.00)  DC
    12.      47.89336 (18022412) AT ( 449625.00, 7429875.00)  DC       37.      40.09942 (18030615) AT ( 449625.00, 7429875.00)  DC
    13.      46.90867 (19041513) AT ( 450125.00, 7429625.00)  DC       38.      39.94520 (19041413) AT ( 450125.00, 7429625.00)  DC
    14.      46.39094 (18022413) AT ( 450125.00, 7429875.00)  DC       39.      39.85186 (19041513) AT ( 449875.00, 7429375.00)  DC
    15.      45.57274 (19041513) AT ( 449625.00, 7429875.00)  DC       40.      39.76865 (18022412) AT ( 449875.00, 7429375.00)  DC
    16.      45.53535 (19112116) AT ( 449625.00, 7429625.00)  DC       41.      39.75791 (19041413) AT ( 449625.00, 7429875.00)  DC
    17.      45.50227 (19020212) AT ( 450125.00, 7429625.00)  DC       42.      39.53131 (19041413) AT ( 449625.00, 7429625.00)  DC
    18.      45.28503 (18030615) AT ( 449625.00, 7429625.00)  DC       43.      39.10913 (19020213) AT ( 449625.00, 7429625.00)  DC
    19.      45.15472 (19020212) AT ( 449625.00, 7429875.00)  DC       44.      38.98442 (19041413) AT ( 450125.00, 7429875.00)  DC
    20.      44.84967 (18012515) AT ( 449875.00, 7429875.00)  DC       45.      38.57790 (19020213) AT ( 450125.00, 7429625.00)  DC
    21.      44.67380 (19020212) AT ( 449625.00, 7429625.00)  DC       46.      37.98624 (19112116) AT ( 449875.00, 7429375.00)  DC
    22.      44.35921 (19020212) AT ( 450125.00, 7429875.00)  DC       47.      37.73857 (19020213) AT ( 449625.00, 7429875.00)  DC
    23.      44.26685 (19112413) AT ( 450125.00, 7429625.00)  DC       48.      37.01162 (19041413) AT ( 449875.00, 7429375.00)  DC
    24.      44.25133 (19112116) AT ( 450125.00, 7429625.00)  DC       49.      36.51162 (18030615) AT ( 450125.00, 7429875.00)  DC
    25.      44.18416 (18022412) AT ( 450125.00, 7429875.00)  DC       50.      36.33225 (19020213) AT ( 450125.00, 7429875.00)  DC
```

Table A6 – 10 highest concentrations of NO_2 (annual average) generated by the AERMOD model.

```
                            *** THE SUMMARY OF MAXIMUM ANNUAL RESULTS AVERAGED OVER   2 YEARS ***


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

                                                                                                      NETWORK
 GROUP ID                        AVERAGE CONC                RECEPTOR  (XR, YR, ZELEV, ZHILL, ZFLAG)  OF TYPE  GRID-ID
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
                                                          -

     ALL       1ST HIGHEST VALUE IS       1.57742 AT (  449875.00,  7428625.00,    81.00,     0.00,    0.00)  DC
               2ND HIGHEST VALUE IS       1.51088 AT (  449875.00,  7428875.00,    82.00,     0.00,    0.00)  DC
               3RD HIGHEST VALUE IS       1.49491 AT (  450125.00,  7428625.00,    81.00,     0.00,    0.00)  DC
               4TH HIGHEST VALUE IS       1.49017 AT (  449875.00,  7428375.00,    81.00,     0.00,    0.00)  DC
               5TH HIGHEST VALUE IS       1.43693 AT (  450125.00,  7428375.00,    81.00,     0.00,    0.00)  DC
               6TH HIGHEST VALUE IS       1.40948 AT (  450125.00,  7428875.00,    83.00,     0.00,    0.00)  DC
               7TH HIGHEST VALUE IS       1.38774 AT (  449625.00,  7430625.00,   104.00,     0.00,    0.00)  DC
               8TH HIGHEST VALUE IS       1.36688 AT (  449625.00,  7430875.00,   103.00,     0.00,    0.00)  DC
               9TH HIGHEST VALUE IS       1.35961 AT (  449625.00,  7428625.00,    84.00,     0.00,    0.00)  DC
              10TH HIGHEST VALUE IS       1.35616 AT (  449875.00,  7428125.00,    79.00,     0.00,    0.00)  DC
```

Table A7 – 50 highest concentrations of PM_{10} (average 24h) generated by the AERMOD model.

```
                                    *** THE MAXIMUM   50  24-HR AVERAGE CONCENTRATION   VALUES FOR SOURCE GROUP:  ALL      ***
                                           INCLUDING SOURCE(S):     CALDREC     , FRNCAL1     , FRNCAL2     , CALDBIO     ,

                                                     ** CONC OF PM10     IN MICROGRAMS/M**3                         **

    RANK         CONC    (YYMMDDHH) AT      RECEPTOR (XR,YR) OF TYPE    RANK         CONC    (YYMMDDHH) AT      RECEPTOR (XR,YR) OF
                                                                 TYPE
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
                                                                -
      1.       1.23890 19080224) AT ( 450125.00, 7432125.00)  DC       26.       1.06653 19081324) AT ( 449125.00, 7433875.00)  DC
      2.       1.23561 19081324) AT ( 449375.00, 7433125.00)  DC       27.       1.06633 19081324) AT ( 449625.00, 7433375.00)  DC
      3.       1.23418 19080224) AT ( 450125.00, 7432375.00)  DC       28.       1.06514 19080224) AT ( 450375.00, 7432875.00)  DC
      4.       1.22371 19081324) AT ( 449625.00, 7432375.00)  DC       29.       1.06144 19081324) AT ( 449625.00, 7431625.00)  DC
      5.       1.22183 19081324) AT ( 449375.00, 7432625.00)  DC       30.       1.05845 19080224) AT ( 450375.00, 7432625.00)  DC
      6.       1.22049 19081324) AT ( 449375.00, 7432875.00)  DC       31.       1.05619 19080224) AT ( 450125.00, 7433375.00)  DC
      7.       1.21874 19081324) AT ( 449375.00, 7433375.00)  DC       32.       1.05493 19080224) AT ( 450375.00, 7433125.00)  DC
      8.       1.21416 19080224) AT ( 450125.00, 7431875.00)  DC       33.       1.05078 19081324) AT ( 449125.00, 7433375.00)  DC
      9.       1.20598 19081324) AT ( 449625.00, 7432125.00)  DC       34.       1.04975 18082024) AT ( 450625.00, 7433125.00)  DC
     10.       1.20486 19080224) AT ( 450125.00, 7432625.00)  DC       35.       1.04455 18011424) AT ( 450875.00, 7429125.00)  DC
     11.       1.19638 19081324) AT ( 449625.00, 7432625.00)  DC       36.       1.04363 19081324) AT ( 449125.00, 7434125.00)  DC
     12.       1.18226 19081324) AT ( 449375.00, 7433625.00)  DC       37.       1.03720 18082024) AT ( 450625.00, 7433375.00)  DC
     13.       1.17451 19081324) AT ( 449375.00, 7432375.00)  DC       38.       1.03661 18022124) AT ( 449875.00, 7430625.00)  DC
     14.       1.16956 19020424) AT ( 449875.00, 7430625.00)  DC       39.       1.03603 19022324) AT ( 450125.00, 7428625.00)  DC
     15.       1.15599 19081324) AT ( 449625.00, 7431875.00)  DC       40.       1.03504 18021324) AT ( 449625.00, 7430875.00)  DC
     16.       1.15082 19080224) AT ( 450125.00, 7432875.00)  DC       41.       1.03312 19022724) AT ( 449625.00, 7430625.00)  DC
     17.       1.13852 19080224) AT ( 450125.00, 7431625.00)  DC       42.       1.03145 19080224) AT ( 450375.00, 7433375.00)  DC
     18.       1.13490 19081324) AT ( 449625.00, 7432875.00)  DC       43.       1.02975 18082024) AT ( 450625.00, 7432875.00)  DC
     19.       1.12516 19081324) AT ( 449375.00, 7433875.00)  DC       44.       1.02913 18021324) AT ( 449625.00, 7430625.00)  DC
     20.       1.11293 19081324) AT ( 449625.00, 7433125.00)  DC       45.       1.02599 18111924) AT ( 449375.00, 7430375.00)  DC
     21.       1.11120 19020424) AT ( 449875.00, 7430875.00)  DC       46.       1.02533 18082024) AT ( 450625.00, 7433625.00)  DC
     22.       1.09877 19080224) AT ( 450125.00, 7433125.00)  DC       47.       1.02061 18120724) AT ( 449625.00, 7430875.00)  DC
     23.       1.07352 19081324) AT ( 449125.00, 7433625.00)  DC       48.       1.01639 19021624) AT ( 450125.00, 7430625.00)  DC
     24.       1.07134 19081324) AT ( 449375.00, 7432125.00)  DC       49.       1.01607 18082024) AT ( 450875.00, 7433875.00)  DC
     25.       1.06690 19081324) AT ( 449375.00, 7434125.00)  DC       50.       1.01591 19080224) AT ( 450375.00, 7432375.00)  DC
```

Table A8 – 10 highest concentrations of PM$_{10}$ (annual average) generated by the AERMOD model.

```
                                        *** THE SUMMARY OF MAXIMUM ANNUAL RESULTS AVERAGED OVER   2 YEARS ***


                                                      ** CONC OF PM10     IN MICROGRAMS/M**3 **

                                                                                                                        NETWORK
 GROUP ID                       AVERAGE CONC                RECEPTOR  (XR, YR, ZELEV, ZHILL, ZFLAG)  OF TYPE  GRID-ID
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
                                                          -

     ALL       1ST HIGHEST VALUE IS       0.17252 AT (  449875.00,  7428625.00,    81.00,     0.00,    0.00)  DC
               2ND HIGHEST VALUE IS       0.16465 AT (  449875.00,  7428875.00,    82.00,     0.00,    0.00)  DC
               3RD HIGHEST VALUE IS       0.16382 AT (  450125.00,  7428625.00,    81.00,     0.00,    0.00)  DC
               4TH HIGHEST VALUE IS       0.16359 AT (  449875.00,  7428375.00,    81.00,     0.00,    0.00)  DC
               5TH HIGHEST VALUE IS       0.15801 AT (  450125.00,  7428375.00,    81.00,     0.00,    0.00)  DC
               6TH HIGHEST VALUE IS       0.15394 AT (  450125.00,  7428875.00,    83.00,     0.00,    0.00)  DC
               7TH HIGHEST VALUE IS       0.15045 AT (  449625.00,  7430625.00,   104.00,     0.00,    0.00)  DC
               8TH HIGHEST VALUE IS       0.14933 AT (  449875.00,  7428125.00,    79.00,     0.00,    0.00)  DC
               9TH HIGHEST VALUE IS       0.14863 AT (  449625.00,  7430875.00,   103.00,     0.00,    0.00)  DC
              10TH HIGHEST VALUE IS       0.14856 AT (  449625.00,  7428625.00,    84.00,     0.00,    0.00)  DC
```

Table A9 – 50 highest concentrations of SO_2 (average 24h) generated by the AERMOD model.

```
                                    *** THE MAXIMUM   50  24-HR AVERAGE CONCENTRATION   VALUES FOR SOURCE GROUP:  ALL      ***
                                           INCLUDING SOURCE(S):     CALDREC     , FRNCAL1     , FRNCAL2     , CALDBIO     ,

                                                            ** CONC OF SO2      IN MICROGRAMS/M**3                          **

    RANK         CONC    (YYMMDDHH) AT      RECEPTOR (XR,YR) OF TYPE    RANK         CONC    (YYMMDDHH) AT      RECEPTOR (XR,YR) OF
                                                                TYPE
  - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
                                                                -
     1.       3.45833 19081324) AT ( 449625.00, 7432125.00)  DC       26.       2.98840 18082024) AT ( 450625.00, 7433375.00)  DC
     2.       3.44950 19081324) AT ( 449625.00, 7432375.00)  DC       27.       2.98190 19081324) AT ( 449375.00, 7433875.00)  DC
     3.       3.42694 19080224) AT ( 450125.00, 7432125.00)  DC       28.       2.95414 18082024) AT ( 450375.00, 7432375.00)  DC
     4.       3.41879 19080224) AT ( 450125.00, 7431875.00)  DC       29.       2.93071 18082024) AT ( 450375.00, 7432125.00)  DC
     5.       3.39701 19081324) AT ( 449375.00, 7432625.00)  DC       30.       2.91591 18082024) AT ( 450625.00, 7433625.00)  DC
     6.       3.38252 19081324) AT ( 449625.00, 7431875.00)  DC       31.       2.91376 19080224) AT ( 450125.00, 7433125.00)  DC
     7.       3.36691 19080224) AT ( 450125.00, 7432375.00)  DC       32.       2.90844 18021324) AT ( 449625.00, 7430625.00)  DC
     8.       3.35245 19081324) AT ( 449375.00, 7433125.00)  DC       33.       2.90197 18082024) AT ( 450375.00, 7432625.00)  DC
     9.       3.34993 19081324) AT ( 449375.00, 7432875.00)  DC       34.       2.89373 18082024) AT ( 450375.00, 7431875.00)  DC
    10.       3.32468 19081324) AT ( 449625.00, 7432625.00)  DC       35.       2.88112 18111924) AT ( 449375.00, 7430375.00)  DC
    11.       3.31887 19081324) AT ( 449375.00, 7432375.00)  DC       36.       2.87846 19091224) AT ( 450375.00, 7432625.00)  DC
    12.       3.28238 19080224) AT ( 450125.00, 7431625.00)  DC       37.       2.87316 19081324) AT ( 449625.00, 7433375.00)  DC
    13.       3.27520 19081324) AT ( 449375.00, 7433375.00)  DC       38.       2.87202 18021324) AT ( 449625.00, 7430875.00)  DC
    14.       3.25008 19080224) AT ( 450125.00, 7432625.00)  DC       39.       2.87150 19112824) AT ( 449875.00, 7430625.00)  DC
    15.       3.23796 19020424) AT ( 449875.00, 7430625.00)  DC       40.       2.86986 18011424) AT ( 450875.00, 7429125.00)  DC
    16.       3.17601 19081324) AT ( 449625.00, 7431625.00)  DC       41.       2.86623 19081324) AT ( 449125.00, 7433625.00)  DC
    17.       3.15205 19081324) AT ( 449375.00, 7433625.00)  DC       42.       2.86531 19022724) AT ( 449625.00, 7430625.00)  DC
    18.       3.11826 19081324) AT ( 449625.00, 7432875.00)  DC       43.       2.86493 19091224) AT ( 450375.00, 7432875.00)  DC
    19.       3.08807 19081324) AT ( 449375.00, 7432125.00)  DC       44.       2.85597 18082024) AT ( 450875.00, 7433875.00)  DC
    20.       3.07608 19080224) AT ( 450125.00, 7432875.00)  DC       45.       2.84777 19080224) AT ( 450375.00, 7432625.00)  DC
    21.       3.06616 18082024) AT ( 450625.00, 7433125.00)  DC       46.       2.84312 18022124) AT ( 449875.00, 7430625.00)  DC
    22.       3.05650 18082024) AT ( 450625.00, 7432875.00)  DC       47.       2.84253 18082024) AT ( 450875.00, 7433625.00)  DC
    23.       3.02686 19020424) AT ( 449875.00, 7430875.00)  DC       48.       2.83980 19080224) AT ( 450375.00, 7432875.00)  DC
    24.       3.02491 19081324) AT ( 449625.00, 7433125.00)  DC       49.       2.83093 19091224) AT ( 450375.00, 7433125.00)  DC
    25.       2.99504 18082024) AT ( 450625.00, 7432625.00)  DC       50.       2.83064 19081324) AT ( 449125.00, 7433375.00)  DC
```

Table A10 – 10 highest concentrations of SO_2 (annual average) generated by the AERMOD model.

```
                            *** THE SUMMARY OF MAXIMUM ANNUAL RESULTS AVERAGED OVER   2 YEARS ***


                                         ** CONC OF SO2      IN MICROGRAMS/M**3 **

                                                                                                                  NETWORK
 GROUP ID                        AVERAGE CONC               RECEPTOR  (XR, YR, ZELEV, ZHILL, ZFLAG)  OF TYPE  GRID-ID
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
                                                           -

     ALL       1ST HIGHEST VALUE IS       0.47616 AT (  449875.00,  7428625.00,    81.00,     0.00,    0.00)  DC
               2ND HIGHEST VALUE IS       0.46137 AT (  449875.00,  7428875.00,    82.00,     0.00,    0.00)  DC
               3RD HIGHEST VALUE IS       0.45015 AT (  450125.00,  7428625.00,    81.00,     0.00,    0.00)  DC
               4TH HIGHEST VALUE IS       0.44686 AT (  449875.00,  7428375.00,    81.00,     0.00,    0.00)  DC
               5TH HIGHEST VALUE IS       0.43010 AT (  450125.00,  7428375.00,    81.00,     0.00,    0.00)  DC
               6TH HIGHEST VALUE IS       0.42905 AT (  450125.00,  7428875.00,    83.00,     0.00,    0.00)  DC
               7TH HIGHEST VALUE IS       0.42811 AT (  449625.00,  7430625.00,   104.00,     0.00,    0.00)  DC
               8TH HIGHEST VALUE IS       0.41828 AT (  449625.00,  7430875.00,   103.00,     0.00,    0.00)  DC
               9TH HIGHEST VALUE IS       0.41076 AT (  449625.00,  7428625.00,    84.00,     0.00,    0.00)  DC
              10TH HIGHEST VALUE IS       0.40553 AT (  449875.00,  7428125.00,    79.00,     0.00,    0.00)  DC
```

ANNEX II

WATER DISPERSION STUDY

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ENVIROMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA)

Date 05.08.2020

Reference 109001759-003-0000-E-1501
Page 1

Pulp Mill, Port, Transmission Line and Electrical Substation in Concepción - Paraguay

VOLUME IV – COMPLEMENTARY ENVIRONMENTAL STUDIES
Effluent Dispersion Study

Distribution	
PARACEL	E
PÖYRY	-

Orig.	15/07/20 – msh	15/07/20 – bvv	15/07/20 – hfw	15/07/20 – hfw	for information
Rev.	Date /Author	Date /Verified	Date /Approved	Date/Authorized	Remarks
a	31/07/20 - kgz	31/07/20 - bvv	31/07/20 - hfw	31/07/20 - hfw	for information

SUMMARY

LIST OF FIGURES

LIST OF TABLE

1 INTRODUCTION

This document consists of the Treated Effluent Dispersion Study from the future pulp mill of par, which will be discharged in Paraguay River.

In general, the most relevant issues facing contemporary society are the preservation of water resources. In Paraguay, the concern about this issue is evidenced, among others, in SEAM Resolution 222/2002 (water quality standards), SEAM Resolution 50/2006 (national water management), SEAM Resolution 255/2006 (classification of all waters in Paraguay in class 2) and Law 3239/2007 (water resources in Paraguay).

Among the control instruments foreseen in our legislation, we highlight the monitoring and diagnosis of the quality of water resources, especially rivers and estuaries. In this particular, water quality mathematical models can be useful tools.

These models consist of a set of equations that, solved, provide the space-time distribution of constituents that are transported in solution and in suspension by the water body. These equations, as a rule, are solved numerically, generating what is called a numerical simulation, and the model, once calibrated, allows to draw future and past scenarios according to the inputs that are prescribed. Thus, mixing zones, pollutant feather behavior and dispersion can be properly calculated and predicted by the simulation.

The mixing zone is defined as "*the region of the receiving body, estimated on the basis of theoretical models, extending from the point of discharge of the effluent, and delimited by the surface on which the mixing equilibrium between the physical and chemical parameters, as well as the biological equilibrium of the effluent and those of the receiving body, is achieved, being specific to each parameter*".

Therefore, this document presents the Treated Effluent Dispersion Study, aiming to know the zone of mixture of treated effluents from the project of the PARACEL mill in the Paraguay River.

In order to know the dispersion of the effluent from the project of the mentioned mill, simulations were carried out through the mathematical model CORMIX, developed by Cornell University in conjunction with the US Environmental Protection Agency (USEPA), mainly in terms of load (measured in BOD), color, total nitrogen, total phosphorus and AOX, the results of which are presented in this report.

This study is part of the EIAp/RIMA project of bleached pulp mill of PARACEL.

This Study is comprised by following chapters:

- Introduction
- Project Information
- Effluent Dispersion Model
- Mixing Zone Modeling
- Conclusions
- References

2 GENERAL INFORMATION

2.1 General Description

The main activity of the factory is the production of 1,500,000 t/year of bleached pulp or 900,000 t/year of dissolving pulp from PARACEL in Concepción, Paraguay.

For the production of bleached pulp, PARACEL's mill will use *kraft* process - a technology widely known by pulp producers, as well as by engineering, equipment and consulting service providers, with additional advantages to obtain high brightness patterns and fiber quality perfection required by market, associated with energy self-sufficiency capacity and environmental benefits when compared to any production processes.

The process chosen to bleach the pulp was the ECF (*Elemental Chlorine Free*), which does not use elemental chlorine in its process stages, avoiding significant emissions of organochlorines to the effluent.

The pulp mill will also be a source of clean energy, by using forest biomass and wood liquor, which are renewable natural resources. For information, it will be co-generated 220 MW in case of bleached pulp, and considering the plant will consume about 120 MW and there will be a surplus of 100 MW for sale; or in case of dissolving pulp process is chosen, it will be co-generated 240 MW and the mill will consume about 110 MW of electrical energy, with a surplus of 130 MW for sale.

The operational regime will be 24 hours a day, 7 days a week and 12 months a year. The effective production period will be approximately 354 days, considering the general annual maintenance stop for equipment.

The total labor force, considering own employees and third parties, necessary for the operation of the PARACEL pulp mill will be approximately 1,200 people.

This mill will use the best available techniques (BAT), as well as the best practices of environmental management (BPEM), in order to reduce, control and monitor air emissions, liquid effluents and solid waste generated.

It should be noted that PARACEL pulp mill, despite being designed to produce 1,500,000 t/year, it will be set to produce up to 1,800,000 t/year of bleached pulp as a result of greater overall plant efficiency, as well as higher equipment performance without the need to increase its constructed area or include new additional equipment. In addition, no modifications will be required to the main environmental control equipment, nor will there be any loss in performance, which can guarantee the same liquid effluent and atmospheric emissions considered in this Environmental Impact Assessment. Therefore, it can be said that in the event of an increase in pulp production to 1,800,000 t/year, there will be no changes in the environmental impacts identified and evaluated in this EIAp.

2.2 Description of the Effluents Treatment Plant (ETP)

2.2.1 Generation sources y Characteristics of the Effluent Before Treatment

Basically, the sources of liquid effluent generation that will correspond to the activities of the pulp process and other support activities are the following:

- Effluents from the wood preparation area;

- Effluents from the cooking and brown pulp depuration area;
- Alkaline and acid filtrates from bleaching plant;
- Drying machine effluents;
- Effluents from evaporation and recovery;
- Effluents from the causticizing and lime kiln area;
- Contaminated condensate;
- Sanitary effluents;
- Contaminated rainwater; and
- Miscellaneous (spills, leaks, cleaning of various areas, etc.).

The quantitative and qualitative characteristics expected from these effluents before treatment, which are the basis for sizing the liquid effluent treatment station, are shown in the table below.

Table 1 – Characteristics of the effluent before treatment

Parameters	Unit	Value
Flow	m^3/h	5,700
pH	-	3.0 - 10.0
Temperature	^oC	60 - 70
DBO	kg/d	84,000
	mg/L	600
COD	kg/d	193,000
	mg/L	1,400
TSS	kg/d	47,000
	mg/L	350
Colour	kg/d	96,000
	mg/L	750
AOX	kg/d	1,400
	mg/L	10
N_{total}	kg/d	2,000
	mg/L	15
$N_{ammoniacal}$	kg/d	700
	mg/L	5

Parameters	Unit	Value
P_{total}	kg/d	700
	mg/L	5

Source: Pöyry Tecnologia (2020).

2.2.2 Effluent Treatment Plant (ETP)

The pulp mill industrial liquid effluent will be measured for flow, temperature, pH and conductivity and, depending on the results, diverted to emergency lagoon. The other part of the treatment system description is below.

Specific effluent

Effluent from the chlorine dioxide plant, ash leaching and boiler make-up water plant will also be segregated from the main lines, as they have no organic load, requiring only pH control before release. The specific neutralized effluent will be added to the other treated effluent in the treated effluent tank for disposal in the Paraguay River.

Sanitary effluent

Sanitary effluent generated at the mill will be collected from the sanitary effluent network and sent to the ETP directly for biological treatment.

Summary of the Effluent Treatment System

PARACEL's effluent treatment system will basically consist of three stages: solids removal, organic load removal and final polishing. The main units of this system are listed and described below.

The main stages of the effluent treatment process are:

- Screening;
- Primary clarifier;
- Emergency lagoon;
- Neutralization;
- Cooling;
- Activated sludge - aeration tank;
- Secondary clarifier;
- Tertiary treatment;
- Emissary.

Screening

Effluent will be directed by gravity to a screening system to remove coarse materials. This system will have 2 sets composed of a mechanized screen and a manual screen, which will be used when the mechanized screen was subjected to maintenance.

Primary clarifier

After passing through a grid system and flow measurement, the effluent will be sent to two primary clarifiers with a diameter of 68 m to reduce the amount of suspended solids. These clarifiers will be equipped with a scraper to remove sedimentary solids and surface foam. The settled solids and the slag will be removed by pumps that will be sent to the primary sludge dewatering system. The clarified effluent will be sent to the neutralization system.

Primary sludge dewatering system

The primary sludge dewatering system will have a total capacity of 42 tDS/day. Each assembly will consist of a mechanical drum type or gravity type table thickener and a screw type dewatering press. The expected final consistency of the dewatered sludge is between 35 - 45%.

Emergency lagoon

In addition to the systems for preventing and collecting leaks and spills in each department of the mill, there will be a set of emergency lagoon at the effluent treatment plant. The purpose of these lagoons will be to receive all effluent with characteristics that are out of specification. Once discharged into the emergency lagoon, these effluents will be sent at the inlet to the neutralization tank so that no disturbance to the biological treatment is created.

Its operation will be controlled by on-line monitoring of pH, temperature and conductivity. When levels over the acceptable range occur, the valves will be closed and the effluent diverted to the emergency lagoon.

The total volume will be approximately 70,000 m^3 to receive the process effluents considered contaminated.

The lagoons will be constructed with a properly sealed bottom and sloped towards the drainage pumps.

Contaminated rain water

Rain water with the possibility of contamination will be sent to the contaminated rain water retention lagoon to avoid hydraulic overloading in the treatment plant due to high rainfall. Once discharged to the retention lagoon, the rain water will be treated and slowly diverted to the effluent treatment plant.

Effluent neutralization

The effluent clarified in the primary clarifiers will be sent to a neutralization tank. The purpose of this step will be to neutralize the effluent by adding caustic soda or sulfuric acid to maintain a pH between 6 and 8, making it suitable for biological treatment.

The neutralization tank will have a capacity of approximately 2,900 m^3 and will be equipped with mechanical agitators.

Effluent cooling

Because the neutralized effluent has a temperature considered high for biological treatment, the effluent must be cooled to a temperature that does not affect the performance of the biological treatment.

The effluent will be cooled through a cooling tower composed of six cells, which is sized for an inlet temperature of approximately 70°C and an outlet temperature of approximately 35°C.

Activated sludge

The biological treatment system adopted at PARACEL will be the activated sludge aerobic type. The activated sludge process is a proven technology and is commonly used in the pulp and paper industries worldwide.

The biological process requires sufficient concentrations of nitrogen and phosphorus in the effluent for optimum performance. The amounts required will be related to the amount of biodegradable organic matter, i.e. BOD (Biochemical Oxygen Demand) present in the untreated effluent.

Urea and phosphoric acid are considered sources of nitrogen and phosphorus and will be added, if necessary, before the effluent enters the selector tank. The amount required will depend on the amount present in the effluent (only the minimum amounts necessary should be added, to minimize discharges).

After dosing nutrients, the effluent will be sent to the selector tank, which will have a high oxygenation capacity and is intended to eliminate filamentous organisms. From this tank, the effluents will go to the aeration tank, where they will be submitted to the degradation of the organic matter present in a soluble and colloidal form through the activity of aerobic microorganisms. The injection of air into the system will be carried out through fine bubble diffusers that will be installed in the bottom of the aeration tank. These diffusers will supply the necessary oxygen for the development of bacteria and will promote the mixing of the liquid mass contained in the aeration tank, keeping the mixture in suspension.

The aeration tank (including the selector) will have a total volume of approximately 160,000 m^3 and the diffusers will be fed by blowers with a total capacity of approximately 130,000 Nm^3/h, one of which will be reserved for maintenance.

In the activated sludge process, the biological mass (sludge) to be physically separated from the liquid mass (clarified effluent) will be formed by three two clarifiers, each one with a diameter of 82 m.

The secondary (biological) sludge will be constantly removed from the bottom of the clarifiers by scrapers and directed by gravity to a sludge pit, from where it will be pumped to the selector tank, with its recirculation. The excess biological sludge will be sent to the secondary sludge dewatering system.

Secondary sludge dewatering system

The secondary sludge dewatering system will have an estimated total capacity of 30 tDS/day and will consist of mechanical type thickeners and centrifuges. The expected final consistency of the dewatered sludge is between 15 and 20%.

Tertiary treatment

After the biological treatment, the effluent will undergo a tertiary treatment to remove phosphorus, color and COD.

The tertiary treatment will be through a physical-chemical process with the application of aluminum sulfate and polymer in coagulation and flocculation tanks and then directed to the dissolved air flotation (DAF). The flotation system has the advantage of obtaining an approximately thickened sludge, which reaches a consistency of 2.0 to 3.0%. The tertiary sludge is supported by a dedicated dewatering system.

As an alternative to the physicochemical flotation system, tertiary treatment can be carried out by injecting ozone into the effluent. The ozone will be produced on site, through electric discharge in oxygen. In this alternative, the effluent will pass through a sealed contact tank, which will be hermetically sealed, where the ozone will be introduced through fine diffusers. The off gas can be reused and injected into the biological treatment aeration tank. After passing through the contact chamber, the effluent will be sent to the biological filters to retain the suspended solids.

The treated effluent will be discharged through emissaries and diffusers into the Paraguay River. It should be noted that the point of discharge will be located above the point of raw water intake for PARACEL pulp mill .

Tertiary sludge dewatering system

The tertiary sludge from flotation, where a consistency of 2.0 to 3.0% is expected, will be sent to a homogenization tank equipped with a mechanical agitator. This tank will also receive the sludge from the decanters of the Water Treatment Plant (WTP). From the homogenization tank, the mixed sludge (tertiary + WTP) will be pumped to centrifuges, where it will reach a final consistency of about 15%. It is planned to add polymer to the centrifuge inlets to increase dewatering efficiency.

2.2.3 Characteristics of Treated Effluents

The characteristics expected for treated industrial effluents are the following:

Table 2 – Expected emissions from treated effluents

Parameters	Unit	Value	IFC Guidelines*
Flow	m^3/h	5,700	-
	m^3/t	32.3	50 m^3/Adt
pH	-	6.0 - 8.0	6.0 – 9.0
Temperature	ºC	$\leq$ 40	-
BOD	mg/L	25	-
	kg/day	3,200	-
	kg/t	0.76	1
COD	mg/L	150	-
	kg/day	20,500	-
	kg/t	4.8	20
Suspended solids	mg/L	40	
	kg/day	5,500	

Parameters	Unit	Value	IFC Guidelines*
	kg/t	1.3	1.5
Colour	kg/day	34,200	-
	mg/L	250	-
AOX	mg/L	3	-
	kg/day	400	-
	kg/t	0.25	0.09
N_{total}	mg/L	7	-
	kg/day	960	-
	kg/t	0.2	0.2
$N_{ammoniacal}$	kg/day	300	-
	mg/L	2	-
P_{total}	mg/L	1	-
	kg/day	150	-
	kg/t	0.03	0.03

Source: Pöyry Tecnologia (2020).

*Effluent Guidelines for pulp and paper facilities – bleached kraft pulp, integrated

2.3 Effluent Final Disposal

The treated effluent will be discharged into the Paraguay River through an underwater emissary, perpendicular to the left bank of the Paraguay River. The point of discharge of the treated effluent is located at the geographical coordinates UTM 448651 m E;7427135 m S (WGS 84), as shown in the following figure.

Figure 1 – Location of effluent discharge. Source: *Google Earth* (2020).

2.4 Paraguay River

Paraguay has a very important and extensive hydrographic network throughout its territory, in fact the Paraguay River separates and limits two natural regions with very different natural and socio-economic characteristics (MADES, 2020).

The Paraguay River Basin has an area of 1,095,000 km², which covers about 35% of the entire area of the Plata Basin, which is 3,100,000 km². One third of the Paraguay River Basin corresponds to Brazil (370,000 km²), another third to Paraguay (355,000 km²) and the rest is shared between Argentina (165,000 km²) and Bolivia (205,000 km²) (CIC, 2020).

The Paraguay River rises in the Chapada de Parecís (Brazil) and, after 2,550 km, flows into the Paraná River, at the level of the city of Resistencia (Argentina) (CIC, 2020). The city of Asunción, the capital of Paraguay, is located along the main course of the river (CIC, 2017).

The Paraguay River and all surface water resources in Paraguay are classified as a Class 2 river, according to SEAM Resolution 255/2006.

Its left bank tributaries are the Aquidaban, Jejui, Aguaray and Tebicuary rivers and its right bank tributaries are the Pilcomayo and Bermejo rivers (CIC, 2017).

Figure 2 – Vision of the Paraguay River. Source: Pöyry Tecnologia (2019).

The alluvial nature of the land on the banks, the enormous volume of solid material carried by the River Bermejo and the backwaters produced by the waters of the River Paraná, which cause irregularity in its river regime and transformations in its interannual variation, are its main characteristics (CIC, 2020).

2.4.1 Flow rates and Depths

The average ($Q_{average}$) and minimum ($Q_{7,10}$) flows of the Paraguay River were calculated from the data of the Concepción Hydrological Station (latitude: -57.43 / longitude: -23.44). The flows are shown below.

- Minimum flow ($Q_{7.10}$) = 1,093 m^3/s
- Average flow ($Q_{average}$) = 2,179 m^3/s

From the flow data, the respective mean ($Q_{average}$) and minimum ($Q_{7,10}$) flow depths of the Paraguay River were calculated, using the key curve Q=547.43+583.57H-26.18H2 (Source: DHI - Danish Hydrographic Institute). The depths are presented below.

- Depth (H) for minimum flow ($Q_{7,10}$) = 0.98 m
- Depth (H) for average flow ($Q_{average}$) = 3.28 m

2.4.2 Water Quality

Special consideration should be given to mining activity in the upper basin of the Paraguay River in Bolivia and Brazil. There are tin deposits in the form of cassiterite and acid drainage, the result of mining activity and its environmental liabilities, which contaminate rivers and groundwater (CIC, 2017).

Downstream, in Paraguay, the greatest loads of pollutants come from agricultural activity (crops and pastures) and, mainly, from discharges of domestic and industrial effluents in areas near large urban centers such as Concepción, Asunción and Pilar (CIC, 2017).

For the EIAp/RIMA, three (3) water quality monitoring campaigns were carried out on the Paraguay River at (2) two points, one above and one below the intake and discharge points of the future pulp mill.

3 EFFLUENT DISPERSION MODEL

3.1 Mixing Zone Concept

The mixing zone is defined as the region of the receiving body extending from the effluent discharge point and bounded by the surface at which the mixing equilibrium between the physical and chemical parameters is reached, as well as the biological balance of the effluent and the receiver body, being specific to each parameter.

Inside the mixing zone, the water quality level of the receiving body is lower compared to a point upstream of the effluent discharge. In this way, the water quality standards of the receiving body are applied outside the mixing zone, not inside the mixing zone.

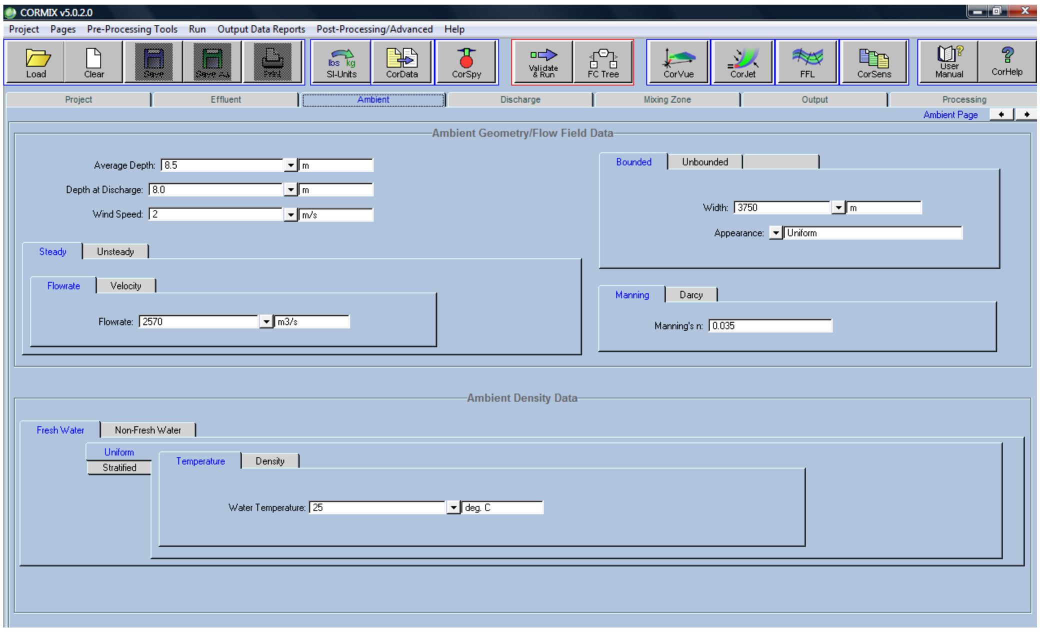
3.2 Cormix Model (Mixing Zone Simulation)

The Cornell Mixing Zone Expert System (Cormix) is a system of computational models developed for the analysis, forecasting and planning of the discharge of effluents into different bodies of water. It was developed through the union between the EPA and Cornell University during the period 1985-1995.

It is a powerful analysis tool in the licensing process of industrial activities regarding the discharge of effluents in the receiving bodies. Although the system places great emphasis on predicting the geometry and dilution characteristics of the initial mixing zone, in order to verify the conformity of water quality with regulatory limits, the system also predicts the behavior of the discharge over longer distances.

CORMIX is composed of three subsystems: (a) CORMIX1, used for the analysis of single port discharges; (b) CORMIX2, for the analysis of multiple multiport diffuser discharges; and (c) CORMIX3, for the analysis of buoyant surface discharges.

Although the CORMIX methodology considers stationary environmental conditions, the system represents an adequate tool for predicting both qualitative features (flow classification, etc.) and quantitative aspects (dilution rates, plume trajectories, etc.) of the processes hydrodynamic mixtures resulting from different discharge configurations and in various types of water bodies, including small streams, large rivers, lakes, reservoirs, estuaries and coastal waters.



Average Depth: 8.5 m
Depth at Discharge: 8.0 m
Wind Speed: 2 m/s
Flowrate: 2570 m3/s
Width: 3750 m
Appearance: Uniform
Manning's n: 0.035
Water Temperature: 25 deg. C

Figure 3 – Screen of CORMIX software.

3.2.1 Hydrodynamic Mixing Processes

The mixing behavior of any wastewater discharge is governed by the interaction of the ambient conditions of the receiving body and the discharge characteristics.

The modeling of the transport of an effluent plume comprises near-field and far-field modeling. The near field corresponds to the initial dilution zone, where the effects of the initial ejection velocity and the density difference between the effluent and the medium prevail. By far-field, it is understood the region where the effects of the local dynamics in the transport and dispersion of the plume predominate. In order to represent the behavior of the effluent plume, the process must be separated into modeling of the near-field and modeling of the far-field.

This report is limited to the study of near-field interactions, since the objective is to know the initial dilution zone.

3.2.2 Type of Discharge

The discharge of effluent from the Paraguay River will have the following design: 3 underwater branches (emissaries) with multipoint pens (3 diffusers each) below the surface of the water.

The emissary is intended for the launching of treated effluents in Paraguay River in a controlled and safe way through the underwater launch under conditions that prevent the formation of foams and promote dispersion in the most efficient way in the receiving body.

The complete system consists of: (a) one treated effluent well; (b) emissary of treated effluents to the margin of the Paraguay River, at the point of launch; (c) control valves; (d) emissary piping in the riverbed; (e) vertical risers with nozzles for underwater launching and dispersal in river waters.

The underwater pipelines will consist of 3 parallel lines (emissaries) of HDPE in the river bed, only 2 of which will be in operant mode and 1 will remain as a reserve. In certain locations favoring better dispersion in the river waters and homogenization of the mixture, there will be steel risers, which will conduct the treated effluent from buried pipelines approximately 50 cm above the river bed. The following figure gives an overview of the system.

At the end of each riser there will be a 90 ° turn to the horizontal. At the end of this curve, a special check valve (duckbill type) will be installed, allowing the discharge of effluent jets optimally, as well as prevent sand and foreign bodies from entering the system. The following figure shows details of the riser and check valve (duckbill type).

Figure 4 – Exemple of special check valve (duckbill type).

The treated effluent is discharged parallel to the flow of the river, remaining initially as cylindrical jets, and later as a single flat jet. The following figure illustrates this type of dilution.

For the present study, CORMIX 2 was used, which analyzes the discharges below the surface of the water, discharged by a subaquatic emissary with multiple diffusers.

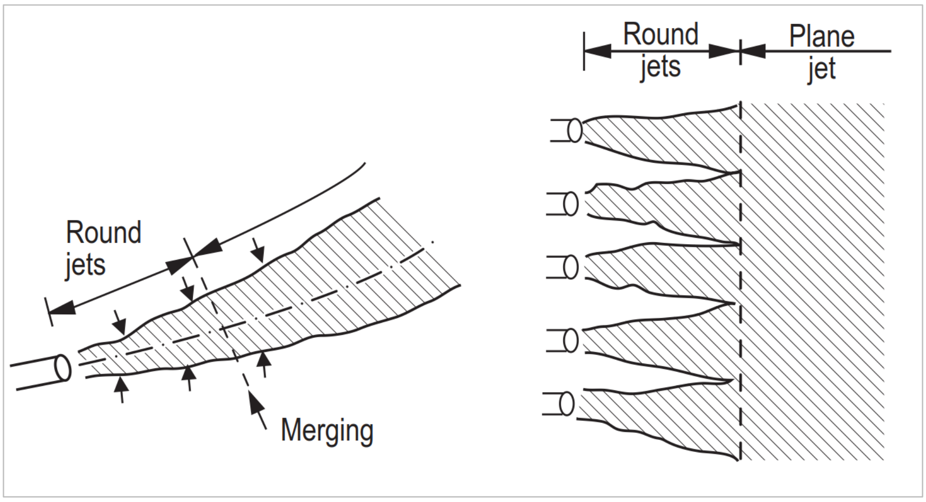


Figure 5 – Discharge of effluent by diffusers.

3.2.3 CORMIX Parameters

CORMIX allows you to work with three types of parameters:

- Conservative: the parameter does not undergo any decay process
- Non-conservative: the parameter suffers a decay of the first order
- High temperature discharge

In the present case it was adopted that the treated effluent of the mill is of the conservative type for BOD, that is, it was not considered a decay of the organic load by reaeration or biological degradation.

4 MIXING ZONE MODELING

4.1 Premises

The type of discharge of the treated effluents in the Paraguay River will be of the jet type of mixture by multiple multipoint diffuser discharges (submerged multiport diffuser discharges). Depending on the type of discharge, CORMIX 2 was used, that is, when an effluent is released through multiple multipoint discharges (diffusers).

4.2 Input Data

There are three types of input data that are required to use the CORMIX model: environmental data, effluent data, and disposal type information.

Environmental data consist of information on temperature, Manning coefficient, river depth, river flow, distance between river banks, among others.

Some physic-chemical properties of the treated effluent are included, such as: concentration of the parameters, flow rate and temperature.

The last set of input data of the model is composed of information about the type of discharge, characteristics of the diffuser, depth and discharge flow, etc.

In this study were used the data presented in the tables below.

Table 3 – Environmental data

Parameters	Unit	Value
Minimum flow ($Q_{7.10}$)	m³/s	1,093
Average flow ($Q_{average}$)	m³/s	2,179
Depth for minimum flow $Q_{7.10}$	m	0.98
Depth for average flow $Q_{average}$	m	3.28
River width	m	740
Water temperature	°C	29

Table 4 – Treated effluent data

Parameters	Unit	Value
Flow	m³/h (m³/s)	5,700 (1.58)
BOD	mg/L	25
Color	mg/L	250
Total nitrogen	mg/L	7
Total phosphorus	mg/L	1
AOX	mg/L	3
Effluent temperature	°C	38

Table 5 – Subaquatic emissary data

Parameters	Unit	Value
Type of discharge	-	CORMIX2
River bank	-	left side
Distance from river bank	m	205
Parallel lines (emissaries)	-	2 (operation) +1 (backup)
Line length	m	50

Parameters	Unit	Value
Duckbill per line (emissary)	-	10 (5 per line)
Duckbill height	m	0.20
Duckbill diameter	m	0.25

The following figure gives an overview of the underwater emissary.

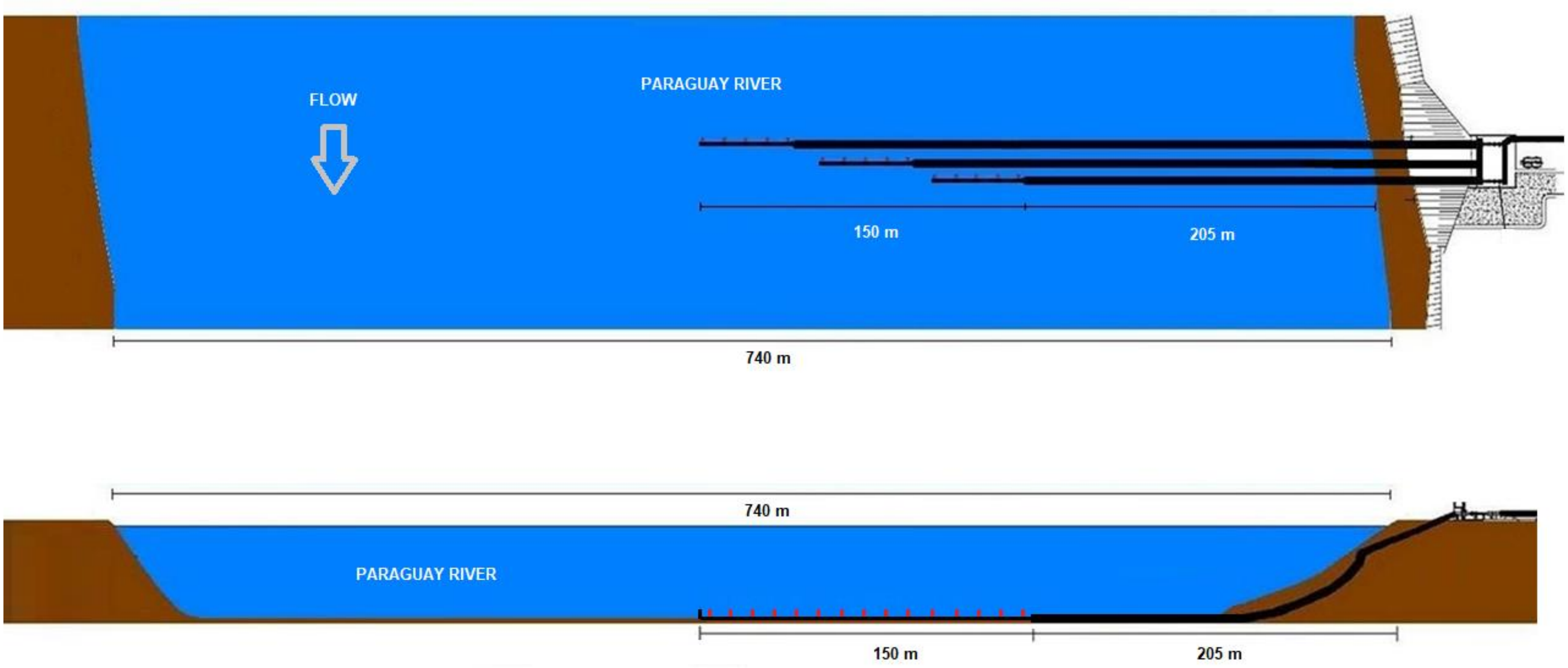


Figure 6 – River Perspectives of the underwater emissary in the Paraguay River.

The concentrations of BOD, colour, total nitrogen, total phosphorus and AOX of the effluent treated in this study are the maximum values, that is, the maximum planned for the pulp mill.

The mathematical model takes into account the BOD and the color, nitrogen, phosphorus and AOX concentrations of the Paraguay River in the initial situation as zero, that is, it does not consider the load of the river along the stretch of study, which varies according to the self-purification and the loads that the river already presents. Therefore, the model presents the results of what happens with the treated effluent from the factory and the increase it causes in this river in terms of organic load and color.

Ten scenarios were considered for this study, varying the river flow (minimum flow of 1,093 m³/s and average flow of 2,179 m³/s) and the variables studied (BOD, colour, total nitrogen, total phosphorus and AOX), as shown in the table below.

As a result, the distances at which the quality of the Paraguay River meets the standards established by SEAM Resolution 222/2002 (for class 2 rivers) for BOD and color variables were verified.

Table 6 – Scenarios evaluated in the present study

Parameter	Scenario nº	River flow (m³/s)
BOD	1	1,093 ($Q_{7,10}$)
	2	2,179 ($Q_{average}$)
Color	3	1,093 ($Q_{7,10}$)
	4	2,179 ($Q_{average}$)
Total nitrogen	5	1,093 ($Q_{7,10}$)
	6	2,179 ($Q_{average}$)
Total phosphorus	7	1,093 ($Q_{7,10}$)
	8	2,179 ($Q_{average}$)
AOX	9	1,093 ($Q_{7,10}$)
	10	2,179 ($Q_{average}$)

4.3 Results of Evaluated Scenarios

4.3.1 Scenario 1 (BOD, Minimum flow - $Q_{7,10}$)

The data used in this scenario are presented in the table below.

Table 7 – Data used in the scenario 1

Parameter	River flow	Effluent flow	BOD concentration
BOD	1,093 m³/s	1.58 m³/s	25 mg/L

The results of the simulation are presented in the figures and table below.

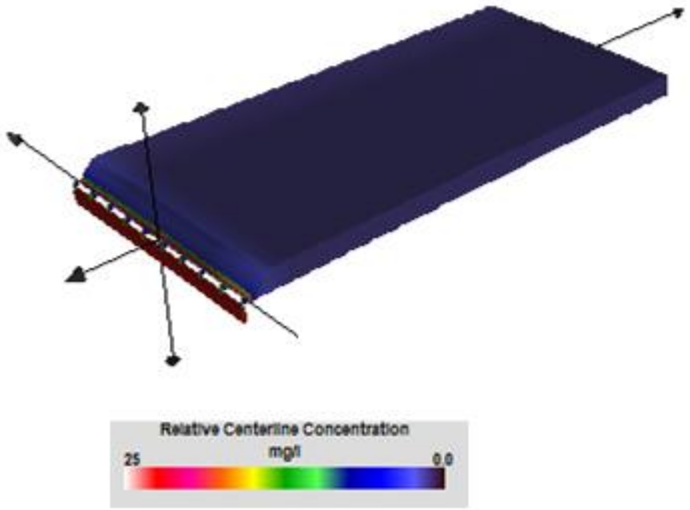


Figure 7 – Simulation of the BOD dispersion plume in 3 dimensions.

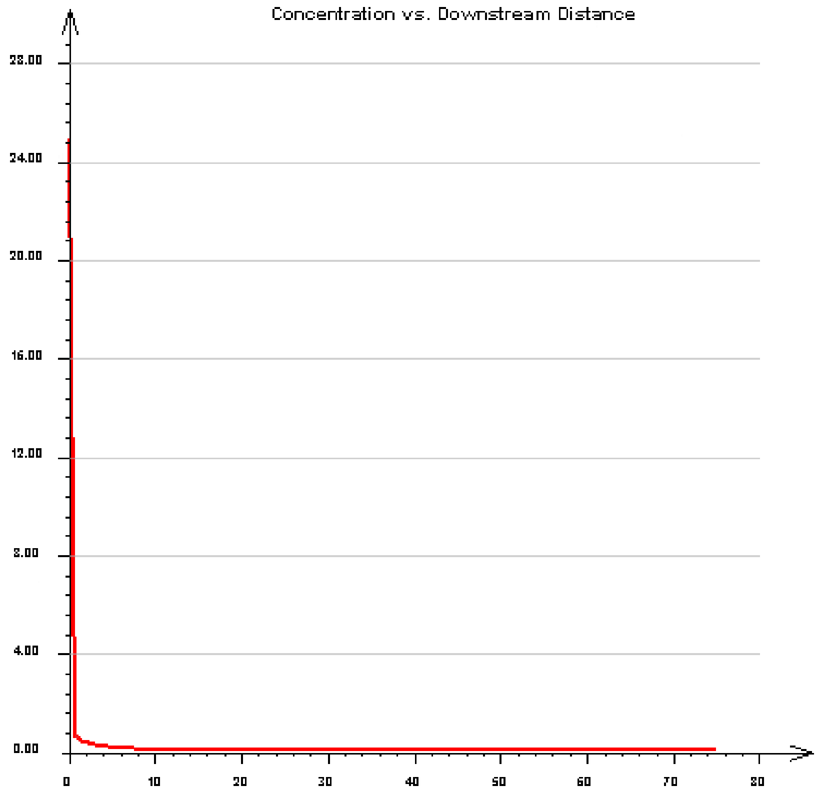


Figure 8 – Graphic of BOD concentration (mg/L) X distance (m).

Table 8 – Scenario results 1

Parameter	Quality standard[1]	Plume width to achieve the quality standard (mixing zone)[1]
BOD	5 mg/L	0.42 m

[1] Quality standard for river class 2, according to SEAM Resolution 222/2002.

4.3.2 Scenario 2 (BOD, Average flow - $Q_{average}$)

The data used in this scenario are presented in the table below.

Table 9 – Data used in this scenario

Parameter	River flow	Effluent flow	BOD concentration
BOD	2.179 m³/s	1.58 m³/s	25 mg/L

The results of the simulation are presented in the figures and table below.

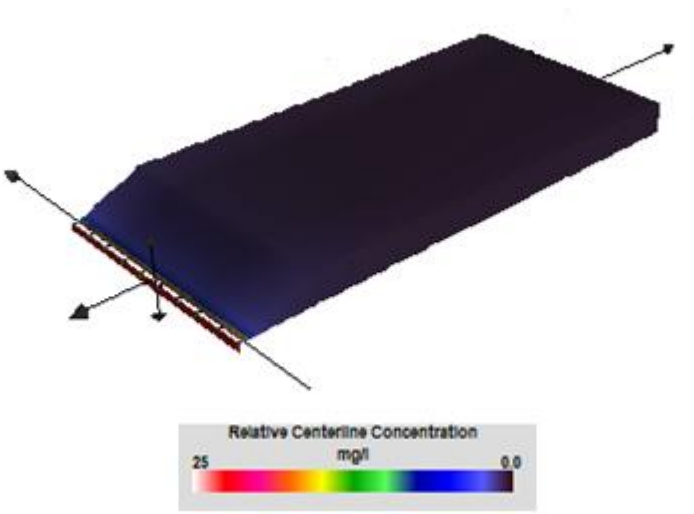


Figure 9 – Simulation of the BOD dispersion plume in 3 dimensions.

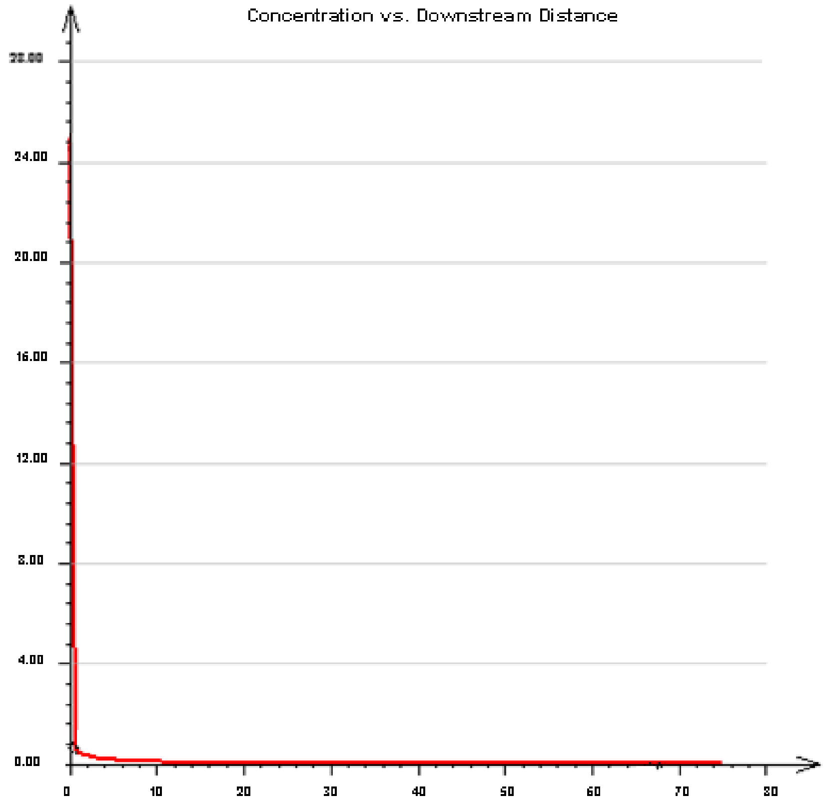


Figure 10 – Graphic of BOD concentration (mg/L) X distance (m).

Table 10 – Scenario results 2

Parameter	Quality standard [1]	Plume width to achieve the quality standard (mixing zone) [1]
BOD	5 mg/L	0.42 m

[1] Quality standard for river class 2, according to SEAM Resolution 222/2002.

4.3.3 Scenario 3 (Color, Minimum flow - $Q_{7,10}$)

The data used in this scenario are presented in the table below.

Table 11 – Data used in this scenario

Parameter	River flow	Effluent flow	Color concentration
Color	1,093 m^3/s	1.58 m^3/s	250 mg/L

The results of the simulation are presented in the figures and table below.

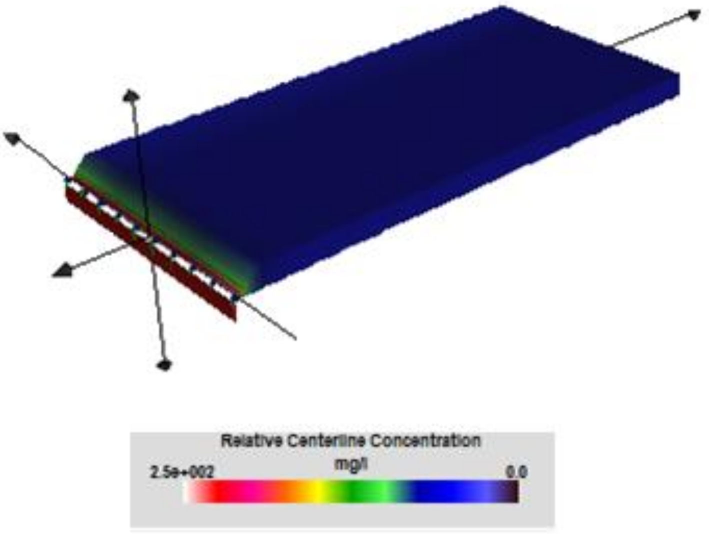


Figure 11 – Simulation of the color dispersion plume in 3 dimensions.

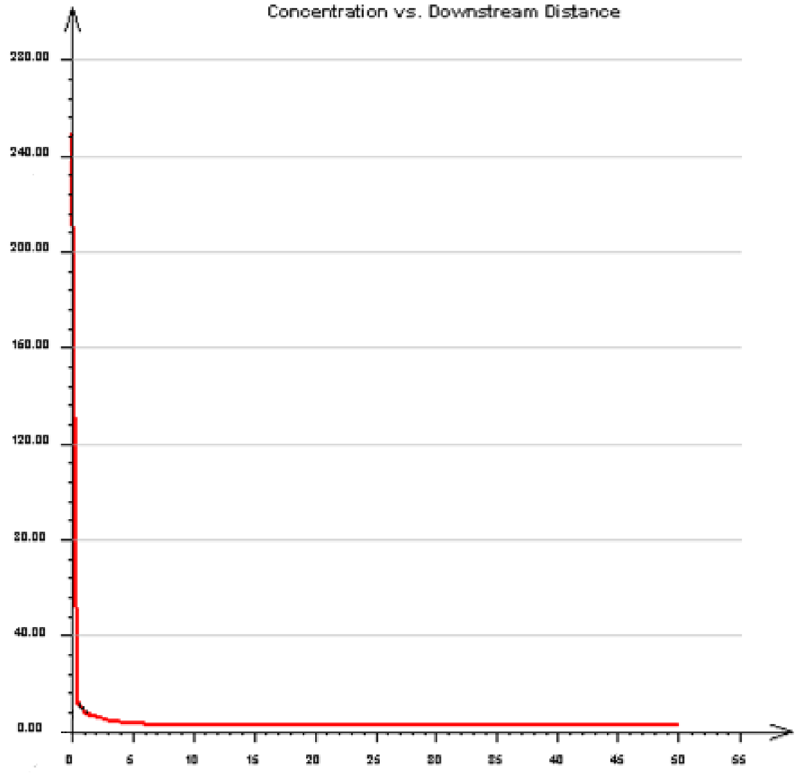


Figure 12 – Graphic of color concentration (mg/L) X distance (m).

Table 12 – Scenario results 3

Parameter	Quality standard [1]	Plume width to achieve the quality standard (mixing zone) [1]
Color	75 mg/L	0.37 m

[1] Quality standard for river class 2, according to SEAM Resolution 222/2002.

4.3.4 Scenario 4 (Color, Average flow - $Q_{average}$)

The data used in this scenario are presented in the table below.

Table 13 – Data used in this scenario

Parameter	River flow	Effluent flow	Color concentration
Color	2.179 m³/s	1.58 m³/s	250 mg/L

The results of the simulation are presented in the figures and table below.

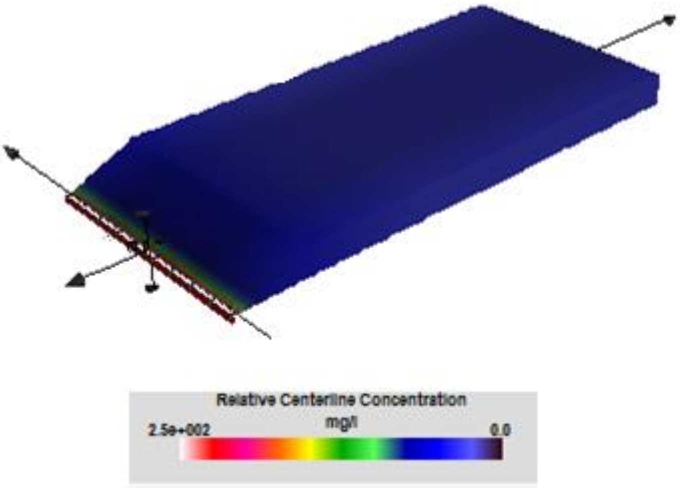


Figure 13 – Simulation of the color dispersion plume in 3 dimensions.

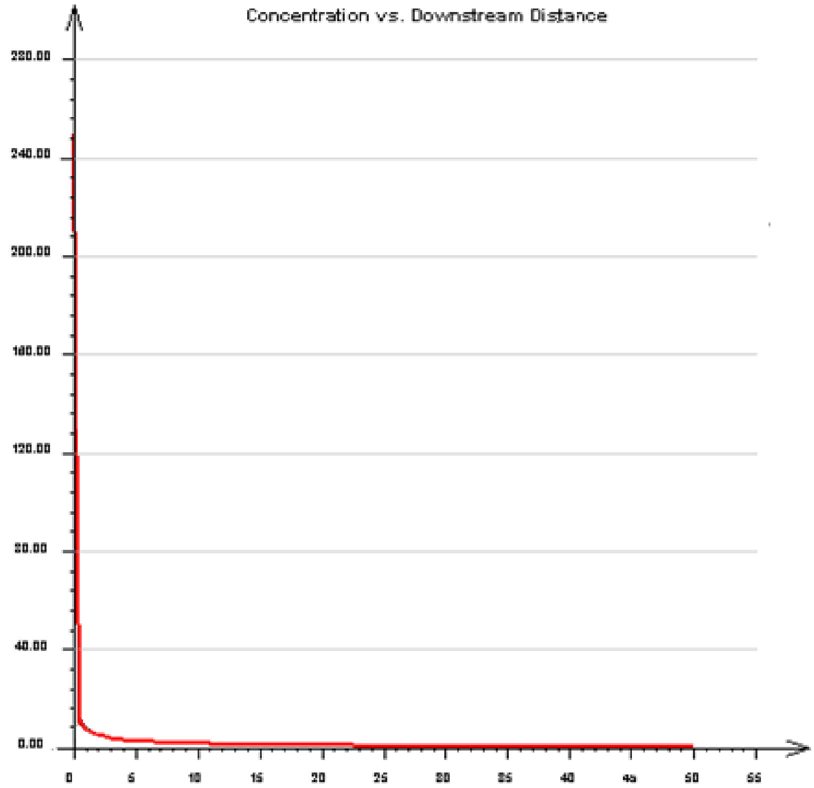


Figure 14 – Graphic of color concentration (mg/L) X distance (m).

Table 14 – Scenario results 4

Parameter	Quality standard [1]	Plume width to achieve the quality standard (mixing zone) [1]
Color	75 mg/L	0.37 m

[1] Quality standard for river class 2, according to SEAM Resolution 222/2002.

4.3.5 Scenario 5 (Total nitrogen, Minimum flow - $Q_{7,10}$)

The data used in this scenario are presented in the table below.

Table 15 – Data used in this scenario

Parameter	River flow	Effluent flow	Total nitrogen concentration
Total nitrogen	1,093 m^3/s	1.58 m^3/s	7 mg/L

The results of the simulation are presented in the figures and table below.

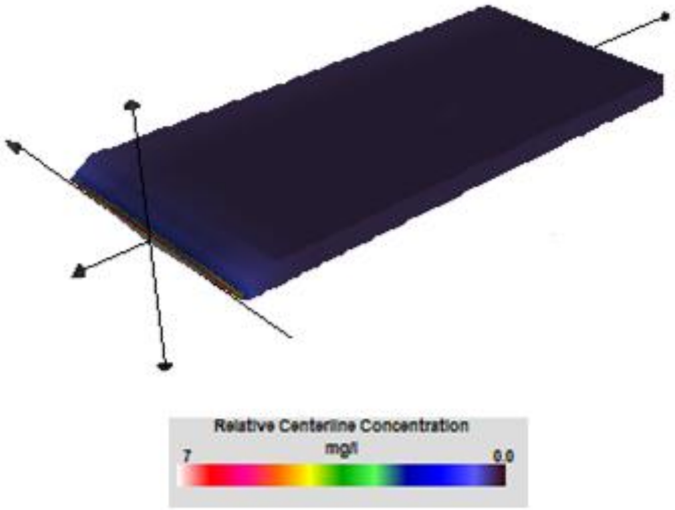


Figure 15 – Simulation of the nitrogen dispersion plume in 3 dimensions.

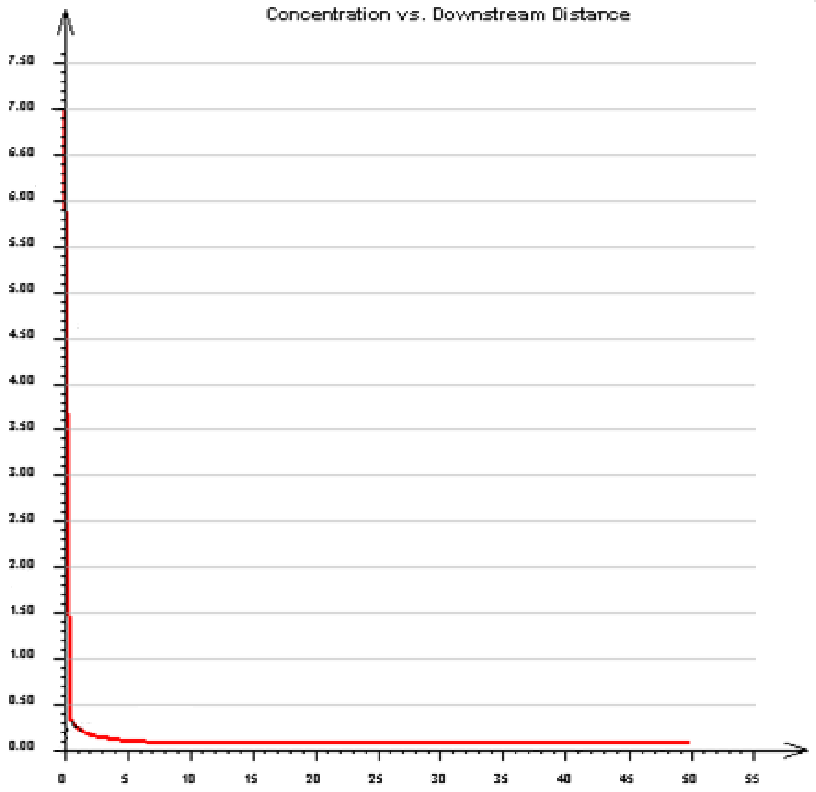


Figure 16 – Graphic of nitrogen concentration (mg/L) X distance (m).

Table 16 – Scenario results 5

Parameter	Quality standard[1]	Plume width to achieve the quality standard (mixing zone)[1]
Total nitrogen	0.6 mg/L	0.48 m

[1] Quality standard for river class 2, according to SEAM Resolution 222/2002.

4.3.6 Scenario 6 (Total nitrogen, Average flow - $Q_{average}$)

The data used in this scenario are presented in the table below.

Table 17 – Data used in this scenario

Parameter	River flow	Effluent flow	Total nitrogen concentration
Total nitrogen	2.179 m³/s	1.58 m³/s	7 mg/L

The results of the simulation are presented in the figures and table below.

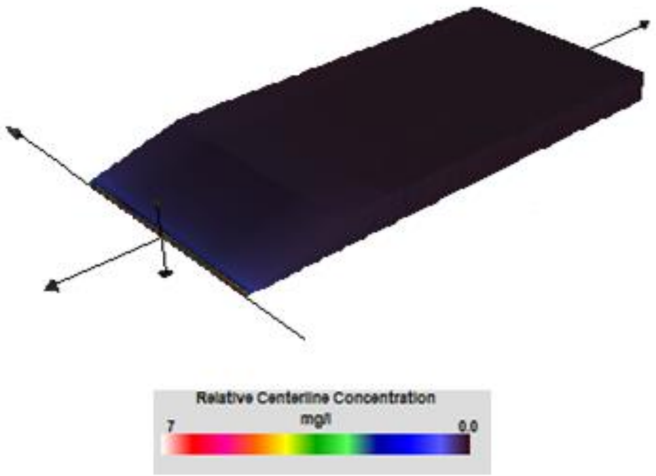


Figure 17 – Simulation of the nitrogen dispersion plume in 3 dimensions.

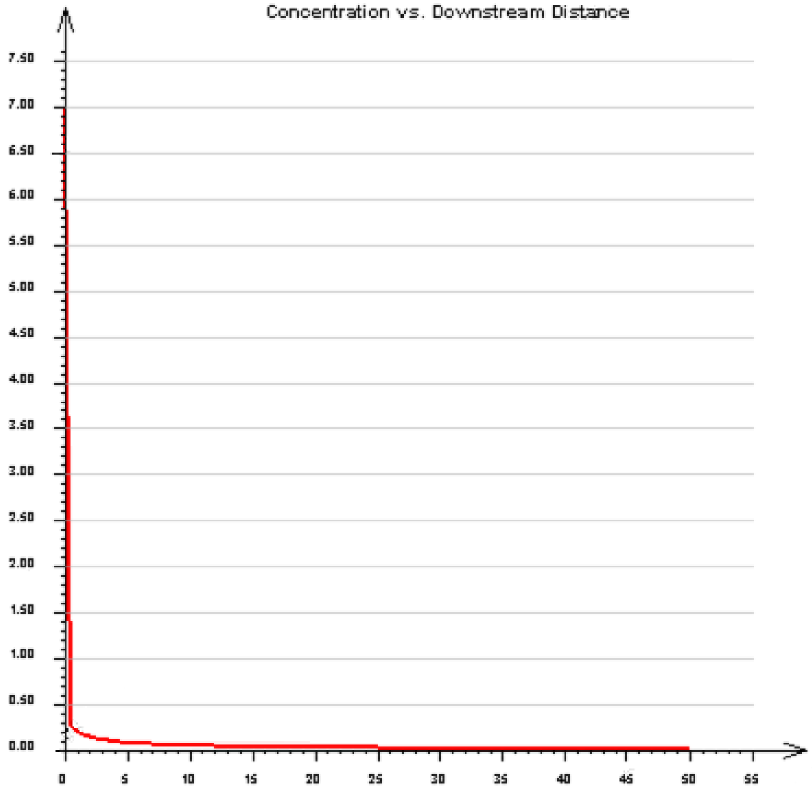


Figure 18 – Graphic of nitrogen concentration (mg/L) X distance (m).

Table 18 – Scenario results 6

Parameter	Quality standard [1]	Plume width to achieve the quality standard (mixing zone) [1]
Total nitrogen	0.6 mg/L	0.48 m

[1] Quality standard for river class 2, according to SEAM Resolution 222/2002.

4.3.7 Scenario 7 (Total phosphorus, Minimum flow - $Q_{7,10}$)

The data used in this scenario are presented in the table below.

Table 19 – Data used in this scenario

Parameter	River flow	Effluent flow	Total phosphorus concentration
Total phosphorus	1,093 m^3/s	1.58 m^3/s	1 mg/L

The results of the simulation are presented in the figures and table below.

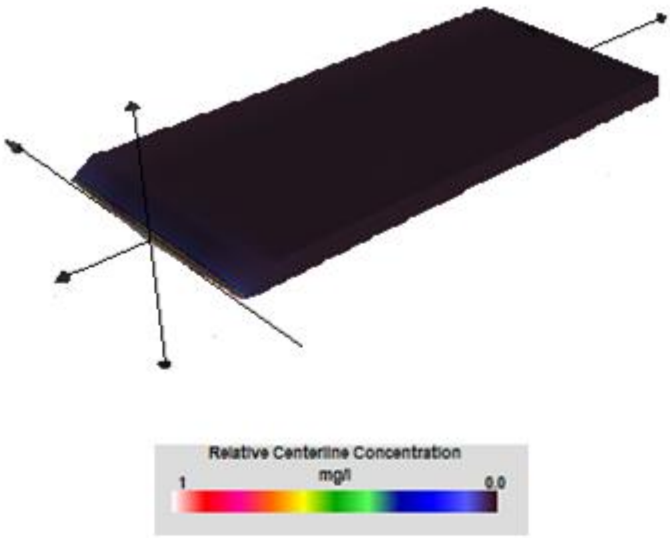


Figure 19 – Simulation of the phosphorus dispersion plume in 3 dimensions.

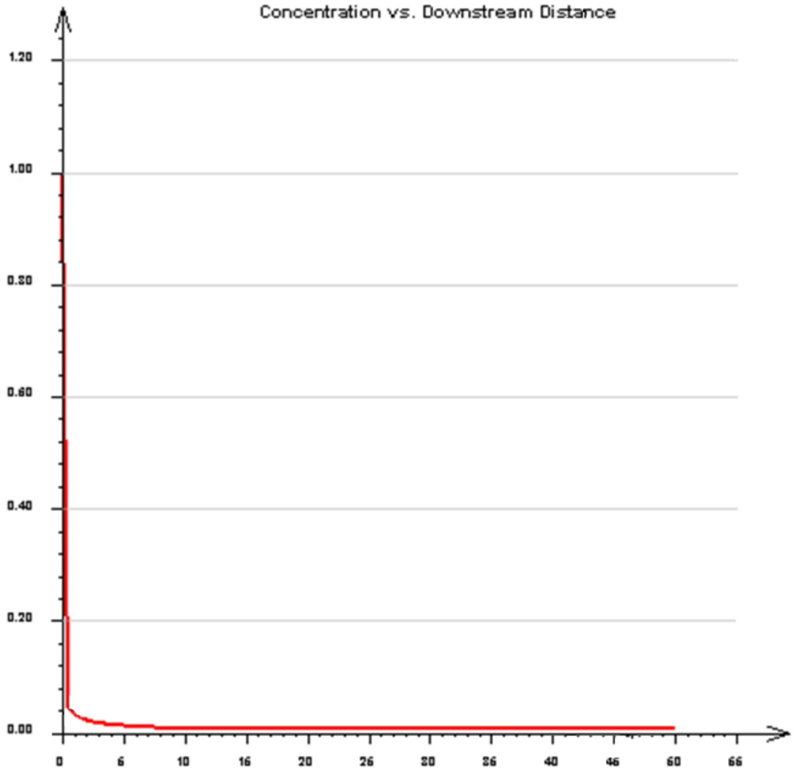


Figure 20 – Graphic of phosphorus concentration (mg/L) X distance (m).

Table 20 – Scenario results 7

Parameter	Quality standard[1]	Plume width to achieve the quality standard (mixing zone)[1]
Total phosphorus	0.05 mg/L	0.50 m

[1] Quality standard for river class 2, according to SEAM Resolution 222/2002.

4.3.8 Scenario 8 (Total phosphorus, Average flow - $Q_{average}$)

The data used in this scenario are presented in the table below.

Table 21 – Data used in this scenario

Parameter	River flow	Effluent flow	Total phosphorus concentration
Total phosphorus	2.179 m³/s	1.58 m³/s	1 mg/L

The results of the simulation are presented in the figures and table below.

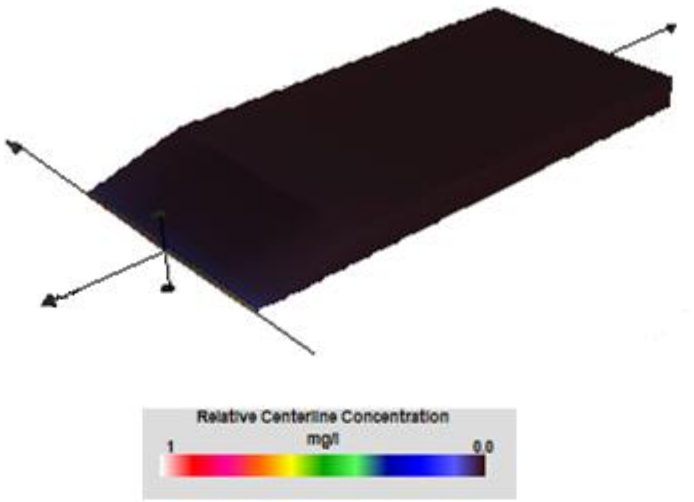


Figure 21 – Simulation of the dispersion plume in 3 dimensions.

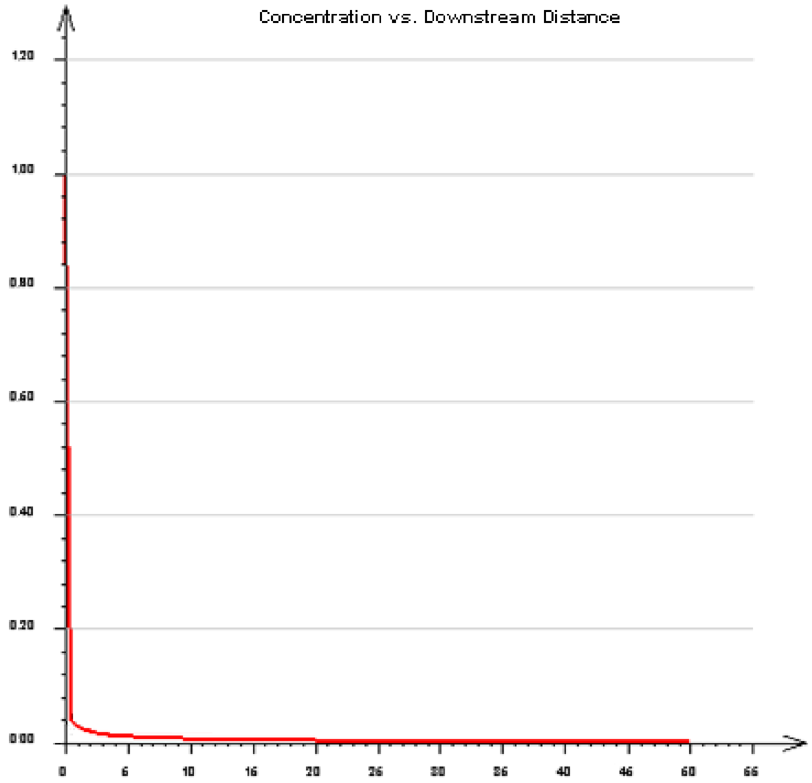


Figure 22 – Graphic of concentration (mg/L) X distance (m).

Table 22 – Scenario results 8

Parameter	Quality standard [1]	Plume width to achieve the quality standard (mixing zone) [1]
Total phosphorus	0.05 mg/L	0.50 m

[1] Quality standard for river class 2, according to SEAM Resolution 222/2002.

4.3.9 Scenario 9 (AOX, Minimum flow - $Q_{7,10}$)

The data used in this scenario are presented in the table below.

Table 23 – Data used in this scenario

Parameter	River flow	Effluent flow	AOX concentration
AOX	1,093 m³/s	1.58 m³/s	3 mg/L

The results of the simulation are presented in the figures and table below.

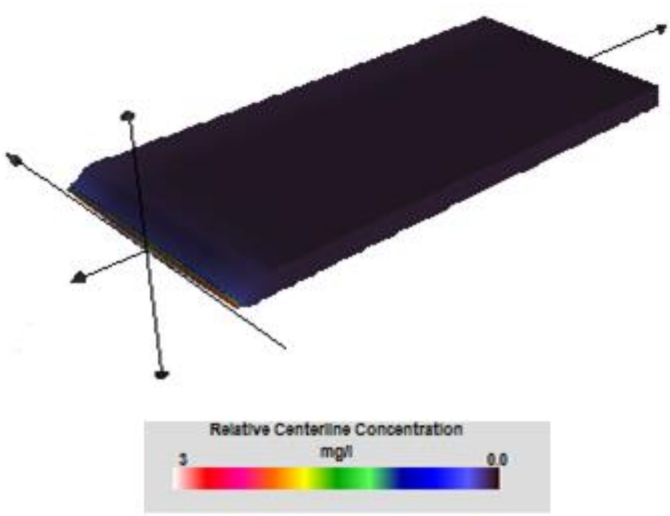


Figure 23 – Simulation of the AOX dispersion plume in 3 dimensions.

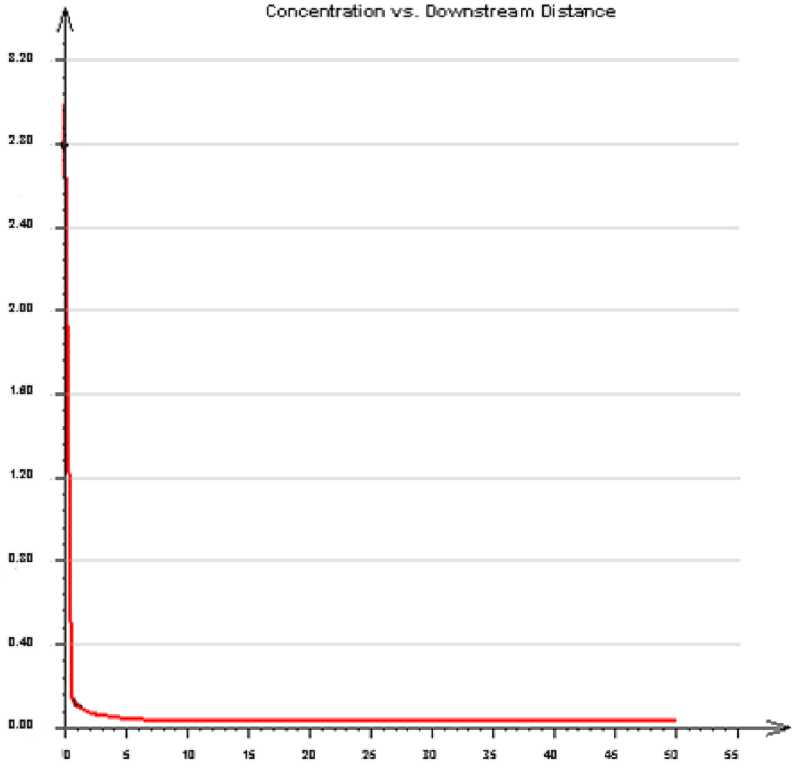


Figure 24 – Graphic of AOX concentration (mg/L) X distance (m).

Table 24 – Scenario results 9

Parameter	Quality standard[1]	Plume width to achieve the quality standard (mixing zone)[1]
AOX	0.15 mg/L	0.50 m

[1] Average AOX concentration obtained in the 3 campaigns of water quality of the Paraguay River at the point of discharge.

4.3.10 Scenario 10 (AOX, Average flow - $Q_{average}$)

The data used in this scenario are presented in the table below.

Table 25 – Data used in this scenario

Parameter	River flow	Effluent flow	AOX concentration
AOX	2.179 m³/s	1.58 m³/s	3 mg/L

The results of the simulation are presented in the figures and table below.

Figure 25 – Simulation of the AOX dispersion plume in 3 dimensions.

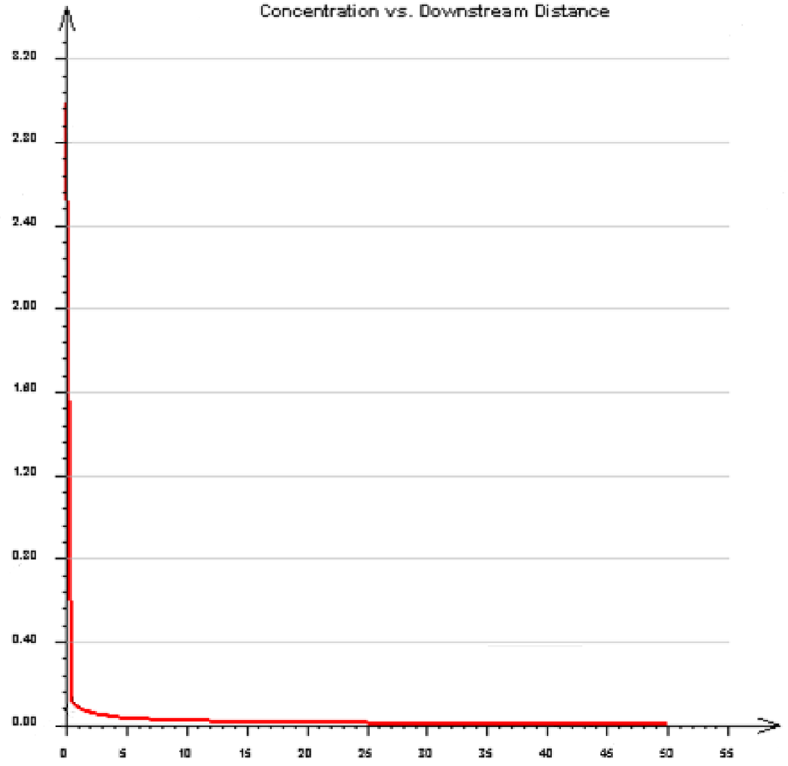


Figure 26 – Graphic of AOX concentration (mg/L) X distance (m).

Table 26 – Scenario results 10

Parameter	Quality standard [1]	Plume width to achieve the quality standard (mixing zone) [1]
AOX	0.15 mg/L	0.50 m

[1] Average AOX concentration obtained in the 3 campaigns of water quality of the Paraguay River at the point of discharge.

5 CONCLUSIONS

For the study of the mixing zone of the Paraguay River, 10 simulations were carried out, varying the flow of the river (flow $Q_{7,10}$ of 1,093 m^3/s and average flow of 2,179 m^3/s) and the parameters under study (BOD, color, nitrogen, phosphorus and AOX), in which the distances at which the quality of the Paraguay River complies with the standards established by Resolution 222/2002 (for class 2 rivers) and with the current quality of the Paraguay River in the case of AOX were verified.

Table 27 – Results of the CORMIX simulations

Parameter	Scenario	River flow (m^3/s)	Quality standard (mg/L)	Plume width to achieve the quality standard (mixing zone)
BOD	1	1,093 ($Q_{7,10}$)	5^1	0.42 m
	2	2.179 ($Q_{average}$)		0.42 m
Color	3	1,093 ($Q_{7,10}$)	75^1	0.37 m
	4	2.179 ($Q_{average}$)		0.37 m
Total nitrogen	5	1,093 ($Q_{7,10}$)	0.6^1	0.48 m
	6	2.179 ($Q_{average}$)		0.48 m
Total phosphorus	7	1,093 ($Q_{7,10}$)	0.05^1	0.50 m
	8	2.179 ($Q_{average}$)		0.50 m
AOX	9	1,093 ($Q_{7,10}$)	0.15^2	0.50 m
	10	2.179 ($Q_{average}$)		0.50 m

[1]Quality standard for river class 2, according to SEAM Resolution 222/2002. [2]Average AOX concentration obtained in the 3 campaigns of water quality of the Paraguay River at the point of discharge.

According to the results of the simulations, it is observed that in order to comply with the quality standards established by SEAM Resolution 222/2002, with respect to the parameters of BOD, color, nitrogen and phosphorus, both under the most critical conditions (minimum flow - $Q_{7,10}$) and under average flow conditions, the distances required for the mixing zone of the effluents treated by PARACEL in the Paraguay River vary between 0.37 and 0.50 m. In the case of AOX, to reach the concentration equal to that obtained in the quality campaigns, the distances required are 0.50 m.

In general, due to the results obtained, the dispersion of treated effluents from PARACEL in the Paraguay River is rapid and occurs very close to the point of discharge of the effluents. Because of this, the simulation for the far field was not performed. However, it is important to note that the mathematical model does not consider the Paraguay River's BOD, color, nitrogen, phosphorus, and AOX concentrations. However, according to the simulation the distance at which the near field variables cease to prevail, i.e. the distance from the near field is 50 m.

It should be noted that the mill's water collection point will be located downstream of the effluent discharge point. This reinforces PARACEL's commitment to environmental issues and demonstrates the commitment and security that PARACEL must have with respect to the factory's future effluent treatment system in order to maintain the water quality standard of the Paraguay River.

In addition, it is important to emphasize that the discharge of effluent from PARACEL's factory will not cause a cumulative impact on the waters of the Paraguay River, due to the existence of few industrial discharges into the river and high flow rates.

6 REFERENCES

CIC – COMITÉ INTERGUBERNAMENTAL COORDINADOR DE LOS PAÍSES DE LA CUENCA DEL PLATA. 2020. Available in: <https://cicplata.org/es/>.

CIC – COMITÉ INTERGUBERNAMENTAL COORDINADOR DE LOS PAÍSES DE LA CUENCA DEL PLATA. Análisis Diagnóstico Transfronterizo de la Cuenca del Plata-ADT. – 1ª ed. - Ciudad Autónoma de Buenos Aires : Comité Intergubernamental Coordinador de los Países de la Cuenca del Plata - CIC ; Estados Unidos : Organización de los Estados Americanos - OEA, 2017. Available in: <https://cicplata.org/wp-content/uploads/2017/09/analisis_diagnostico_transfronterizo_de_la_cuenca_del_plata.pdf>.

DONEKER, R. L.; JIRKA, G. H. Cormix User Manual - A Hydrodynamic Mixing Zone Model and Decision Support System for Pollutant Discharges into Surface Waters. Washington D. C: MixZon Inc, 2007.

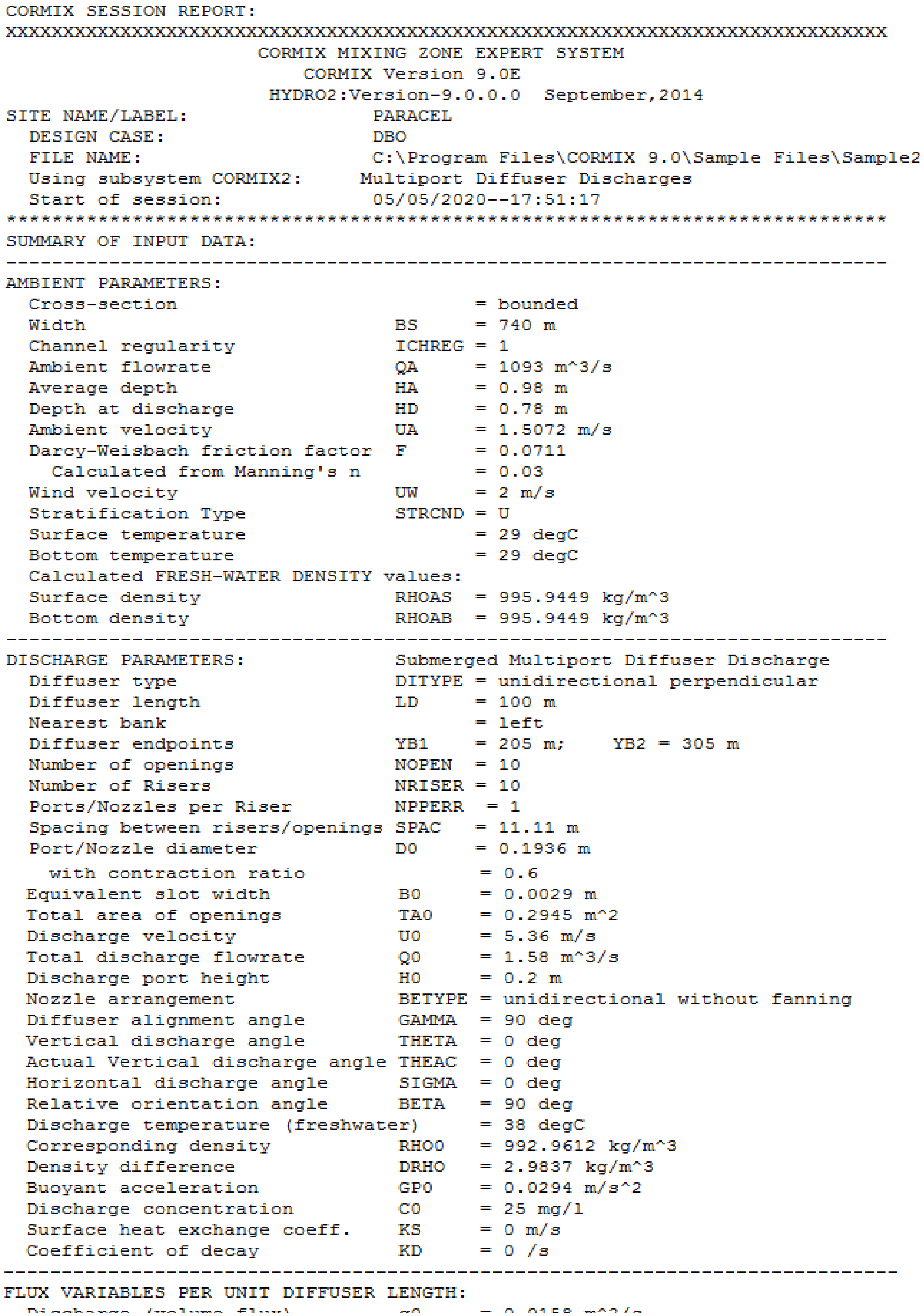
MADES – MINISTERIO DEL AMBIENTE Y DESARROLLO SOSTENIBLE, 2020. Available in: <http://www.mades.gov.py/areas-tematicas/recursos-hidricos/>.

SEAM. Resolution No. 222/2002 – By which the standard of quality of the waters in the national territory is established.

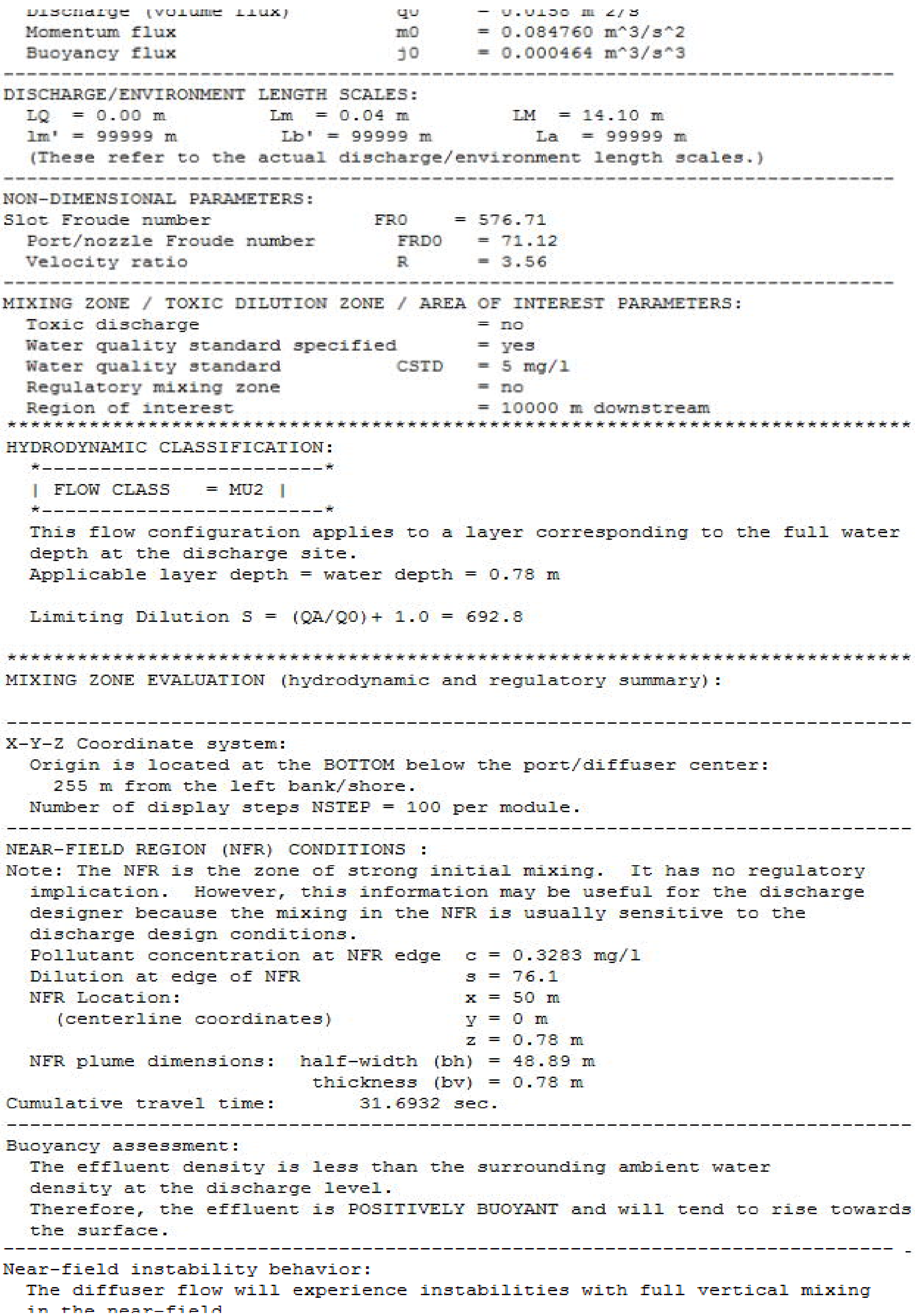
SEAM. Resolution No. 255/2006 – Classification of All Waters of Paraguay in Class 2.

ANNEX I

CORMIX SIMULATIONS



```
CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
                      CORMIX MIXING ZONE EXPERT SYSTEM
                          CORMIX Version 9.0E
                     HYDRO2:Version-9.0.0.0  September,2014
SITE NAME/LABEL:                PARACEL
  DESIGN CASE:                  DBO
  FILE NAME:                    C:\Program Files\CORMIX 9.0\Sample Files\Sample2
  Using subsystem CORMIX2:     Multiport Diffuser Discharges
  Start of session:             05/05/2020--17:51:17
****************************************************************************
SUMMARY OF INPUT DATA:
----------------------------------------------------------------------------
AMBIENT PARAMETERS:
  Cross-section                                  = bounded
  Width                               BS         = 740 m
  Channel regularity                  ICHREG = 1
  Ambient flowrate                    QA         = 1093 m^3/s
  Average depth                       HA         = 0.98 m
  Depth at discharge                  HD         = 0.78 m
  Ambient velocity                    UA         = 1.5072 m/s
  Darcy-Weisbach friction factor      F          = 0.0711
    Calculated from Manning's n                  = 0.03
  Wind velocity                       UW         = 2 m/s
  Stratification Type                 STRCND = U
  Surface temperature                            = 29 degC
  Bottom temperature                             = 29 degC
  Calculated FRESH-WATER DENSITY values:
  Surface density                     RHOAS  = 995.9449 kg/m^3
  Bottom density                      RHOAB  = 995.9449 kg/m^3
----------------------------------------------------------------------------
DISCHARGE PARAMETERS:                 Submerged Multiport Diffuser Discharge
  Diffuser type                       DITYPE = unidirectional perpendicular
  Diffuser length                     LD         = 100 m
  Nearest bank                                   = left
  Diffuser endpoints                  YB1        = 205 m;      YB2 = 305 m
  Number of openings                  NOPEN  = 10
  Number of Risers                    NRISER = 10
  Ports/Nozzles per Riser             NPPERR  = 1
  Spacing between risers/openings SPAC       = 11.11 m
  Port/Nozzle diameter                D0         = 0.1936 m
    with contraction ratio                        = 0.6
  Equivalent slot width               B0         = 0.0029 m
  Total area of openings              TA0        = 0.2945 m^2
  Discharge velocity                  U0         = 5.36 m/s
  Total discharge flowrate            Q0         = 1.58 m^3/s
  Discharge port height               H0         = 0.2 m
  Nozzle arrangement                  BETYPE = unidirectional without fanning
  Diffuser alignment angle            GAMMA      = 90 deg
  Vertical discharge angle            THETA      = 0 deg
  Actual Vertical discharge angle THEAC      = 0 deg
  Horizontal discharge angle          SIGMA      = 0 deg
  Relative orientation angle          BETA       = 90 deg
  Discharge temperature (freshwater)             = 38 degC
  Corresponding density               RHO0       = 992.9612 kg/m^3
  Density difference                  DRHO       = 2.9837 kg/m^3
  Buoyant acceleration                GP0        = 0.0294 m/s^2
  Discharge concentration             C0         = 25 mg/l
  Surface heat exchange coeff.        KS         = 0 m/s
  Coefficient of decay                KD         = 0 /s
----------------------------------------------------------------------------
FLUX VARIABLES PER UNIT DIFFUSER LENGTH:
  Discharge (volume flux)             q0         = 0.0158 m^2/s
```



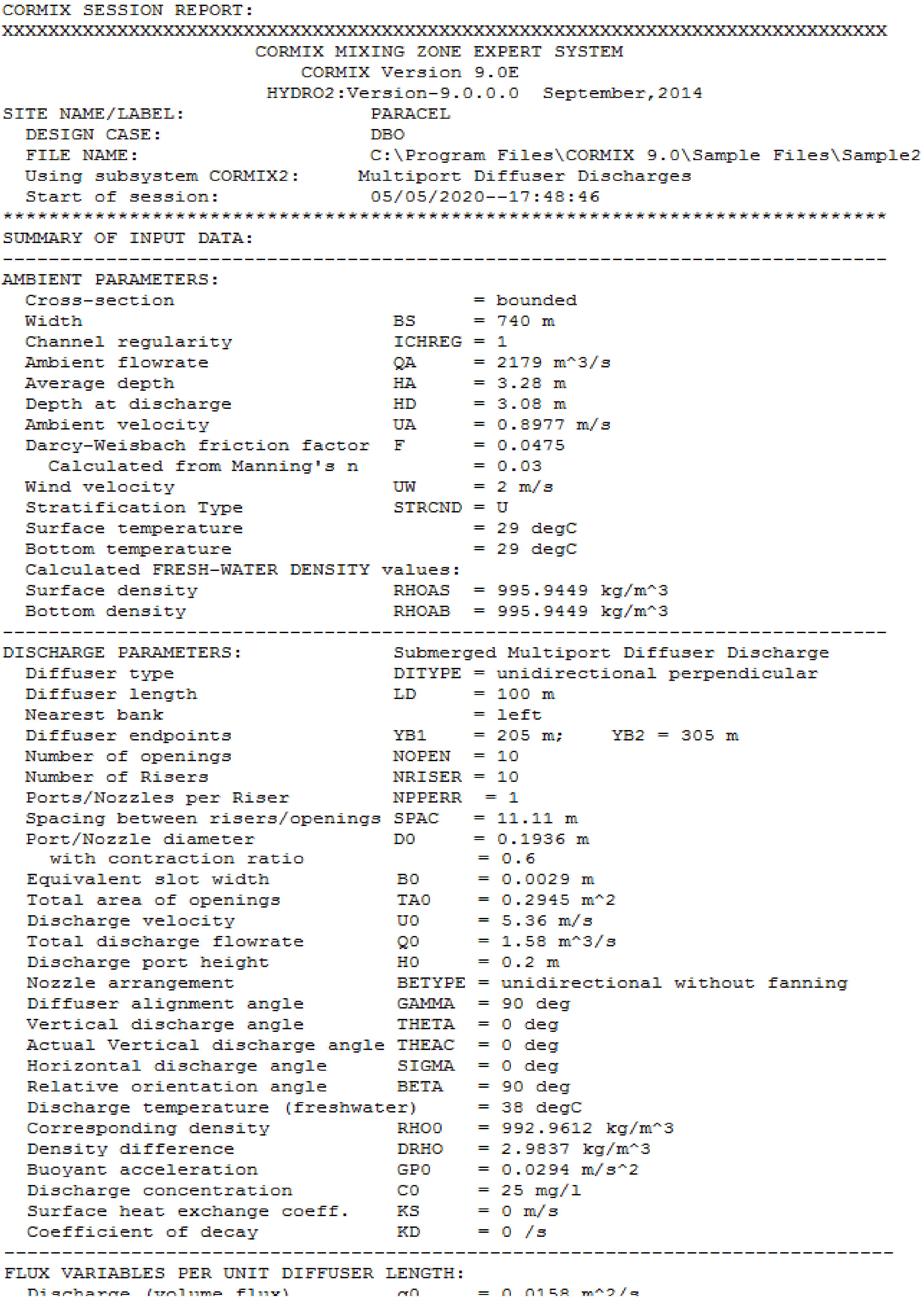
```
  Momentum flux                   m0      = 0.084760 m^3/s^2
  Buoyancy flux                   j0      = 0.000464 m^3/s^3
-----------------------------------------------------------------------------
DISCHARGE/ENVIRONMENT LENGTH SCALES:
  LQ  = 0.00 m          Lm  = 0.04 m          LM  = 14.10 m
  lm' = 99999 m          Lb' = 99999 m          La  = 99999 m
  (These refer to the actual discharge/environment length scales.)
-----------------------------------------------------------------------------
NON-DIMENSIONAL PARAMETERS:
Slot Froude number              FR0     = 576.71
  Port/nozzle Froude number       FRD0    = 71.12
  Velocity ratio                  R       = 3.56
-----------------------------------------------------------------------------
MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
  Toxic discharge                         = no
  Water quality standard specified        = yes
  Water quality standard          CSTD    = 5 mg/l
  Regulatory mixing zone                  = no
  Region of interest                      = 10000 m downstream
*****************************************************************************
HYDRODYNAMIC CLASSIFICATION:
  *------------------------*
  | FLOW CLASS    = MU2 |
  *------------------------*
  This flow configuration applies to a layer corresponding to the full water
  depth at the discharge site.
  Applicable layer depth = water depth = 0.78 m

  Limiting Dilution S = (QA/Q0)+ 1.0 = 692.8

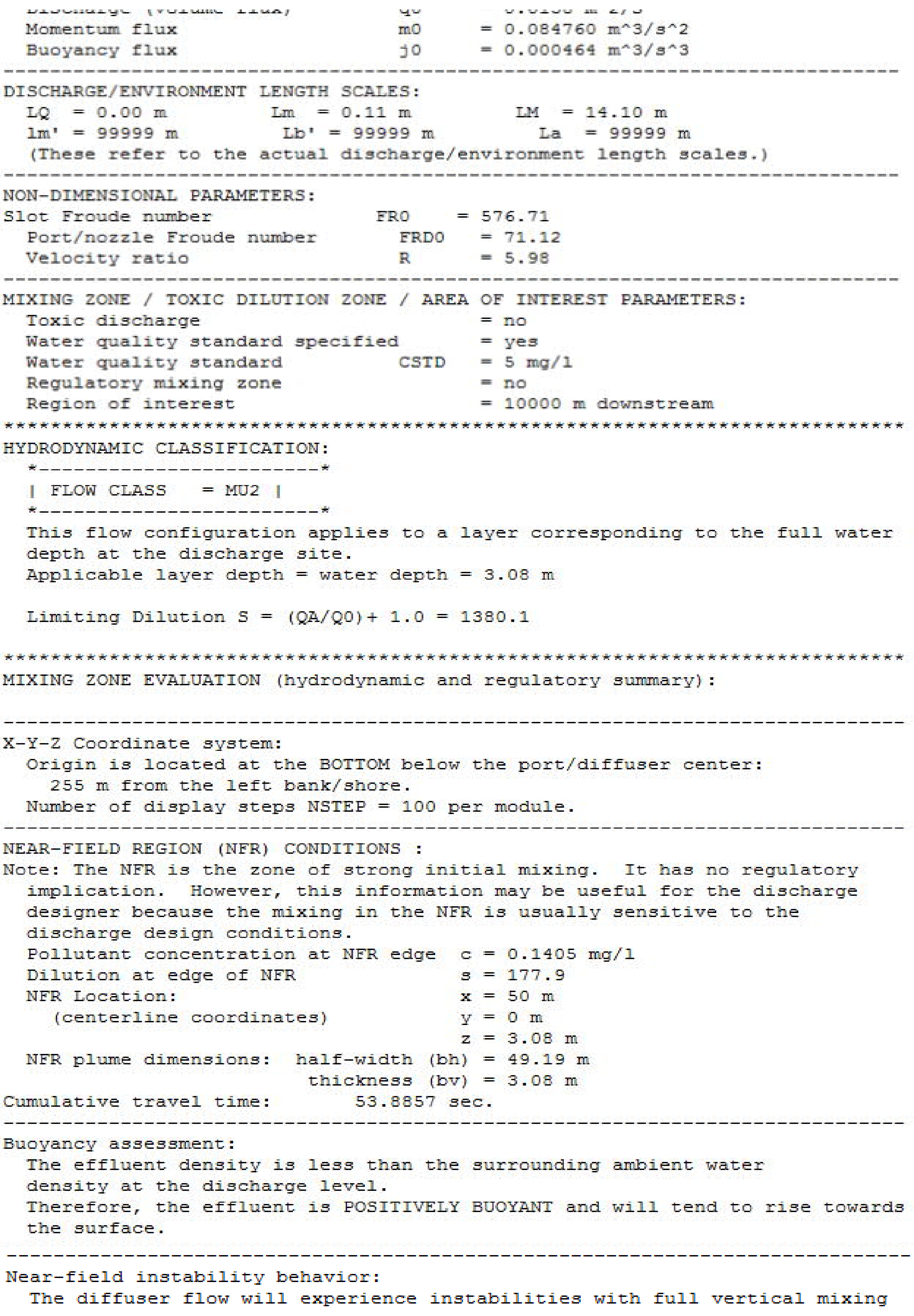
*****************************************************************************
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

-----------------------------------------------------------------------------
X-Y-Z Coordinate system:
  Origin is located at the BOTTOM below the port/diffuser center:
    255 m from the left bank/shore.
  Number of display steps NSTEP = 100 per module.
-----------------------------------------------------------------------------
NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing.  It has no regulatory
  implication.  However, this information may be useful for the discharge
  designer because the mixing in the NFR is usually sensitive to the
  discharge design conditions.
  Pollutant concentration at NFR edge  c = 0.3283 mg/l
  Dilution at edge of NFR              s = 76.1
  NFR Location:                        x = 50 m
    (centerline coordinates)           y = 0 m
                                       z = 0.78 m
  NFR plume dimensions:  half-width (bh) = 48.89 m
                         thickness (bv) = 0.78 m
Cumulative travel time:       31.6932 sec.
-----------------------------------------------------------------------------
Buoyancy assessment:
  The effluent density is less than the surrounding ambient water
  density at the discharge level.
  Therefore, the effluent is POSITIVELY BUOYANT and will tend to rise towards
  the surface.
---------------------------------------------------------------------------- -
Near-field instability behavior:
  The diffuser flow will experience instabilities with full vertical mixing
  in the near-field
```

```
  in the near-field.
  There may be benthic impact of high pollutant concentrations.
-----------------------------------------------------------------------------
FAR-FIELD MIXING SUMMARY:
  Plume becomes vertically fully mixed ALREADY IN NEAR-FIELD at 50 m
  downstream and continues as vertically mixed into the far-field.
-----------------------------------------------------------------------------
PLUME BANK CONTACT SUMMARY:
  Plume in bounded section does not contact bank.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY ***********************
No RMZ has been specified.
However:
The ambient water quality standard was encountered at the following
  plume position:
  Water quality standard                 = 5  mg/l
  Corresponding dilution               s = 17.0
  Plume location:                      x = 0.42 m
    (centerline coordinates)           y = 0 m
                                       z = 0.22 m
  Plume dimensions:      half-width (bh) = 49.97 m
                          thickness (bv) = 0.09 m
```



```
CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
                      CORMIX MIXING ZONE EXPERT SYSTEM
                          CORMIX Version 9.0E
                       HYDRO2:Version-9.0.0.0  September,2014
SITE NAME/LABEL:                PARACEL
  DESIGN CASE:                  DBO
  FILE NAME:                    C:\Program Files\CORMIX 9.0\Sample Files\Sample2
  Using subsystem CORMIX2:     Multiport Diffuser Discharges
  Start of session:             05/05/2020--17:48:46
*****************************************************************************
SUMMARY OF INPUT DATA:
-----------------------------------------------------------------------------
AMBIENT PARAMETERS:
  Cross-section                                = bounded
  Width                             BS       = 740 m
  Channel regularity                ICHREG = 1
  Ambient flowrate                  QA       = 2179 m^3/s
  Average depth                     HA       = 3.28 m
  Depth at discharge                HD       = 3.08 m
  Ambient velocity                  UA       = 0.8977 m/s
  Darcy-Weisbach friction factor  F        = 0.0475
    Calculated from Manning's n              = 0.03
  Wind velocity                     UW       = 2 m/s
  Stratification Type               STRCND = U
  Surface temperature                        = 29 degC
  Bottom temperature                         = 29 degC
  Calculated FRESH-WATER DENSITY values:
  Surface density                   RHOAS  = 995.9449 kg/m^3
  Bottom density                    RHOAB  = 995.9449 kg/m^3
-----------------------------------------------------------------------------
DISCHARGE PARAMETERS:               Submerged Multiport Diffuser Discharge
  Diffuser type                     DITYPE = unidirectional perpendicular
  Diffuser length                   LD       = 100 m
  Nearest bank                               = left
  Diffuser endpoints                YB1      = 205 m;     YB2 = 305 m
  Number of openings                NOPEN  = 10
  Number of Risers                  NRISER = 10
  Ports/Nozzles per Riser           NPPERR  = 1
  Spacing between risers/openings SPAC     = 11.11 m
  Port/Nozzle diameter              D0       = 0.1936 m
    with contraction ratio                   = 0.6
  Equivalent slot width             B0       = 0.0029 m
  Total area of openings            TA0      = 0.2945 m^2
  Discharge velocity                U0       = 5.36 m/s
  Total discharge flowrate          Q0       = 1.58 m^3/s
  Discharge port height             H0       = 0.2 m
  Nozzle arrangement                BETYPE = unidirectional without fanning
  Diffuser alignment angle          GAMMA  = 90 deg
  Vertical discharge angle          THETA  = 0 deg
  Actual Vertical discharge angle THEAC  = 0 deg
  Horizontal discharge angle        SIGMA  = 0 deg
  Relative orientation angle        BETA   = 90 deg
  Discharge temperature (freshwater)       = 38 degC
  Corresponding density             RHO0   = 992.9612 kg/m^3
  Density difference                DRHO   = 2.9837 kg/m^3
  Buoyant acceleration              GP0    = 0.0294 m/s^2
  Discharge concentration           C0     = 25 mg/l
  Surface heat exchange coeff.      KS     = 0 m/s
  Coefficient of decay              KD     = 0 /s
-----------------------------------------------------------------------------
FLUX VARIABLES PER UNIT DIFFUSER LENGTH:
  Discharge (volume flux)           q0     = 0.0158 m^2/s
```



```
  Momentum flux                   m0      = 0.084760 m^3/s^2
  Buoyancy flux                   j0      = 0.000464 m^3/s^3
-----------------------------------------------------------------------------
DISCHARGE/ENVIRONMENT LENGTH SCALES:
  LQ  = 0.00 m         Lm  = 0.11 m         LM  = 14.10 m
  lm' = 99999 m         Lb' = 99999 m         La  = 99999 m
  (These refer to the actual discharge/environment length scales.)
-----------------------------------------------------------------------------
NON-DIMENSIONAL PARAMETERS:
Slot Froude number              FR0     = 576.71
  Port/nozzle Froude number       FRD0    = 71.12
  Velocity ratio                  R       = 5.98
-----------------------------------------------------------------------------
MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
  Toxic discharge                         = no
  Water quality standard specified        = yes
  Water quality standard          CSTD    = 5 mg/l
  Regulatory mixing zone                  = no
  Region of interest                      = 10000 m downstream
*****************************************************************************
HYDRODYNAMIC CLASSIFICATION:
  *------------------------*
  | FLOW CLASS    = MU2 |
  *------------------------*
  This flow configuration applies to a layer corresponding to the full water
  depth at the discharge site.
  Applicable layer depth = water depth = 3.08 m

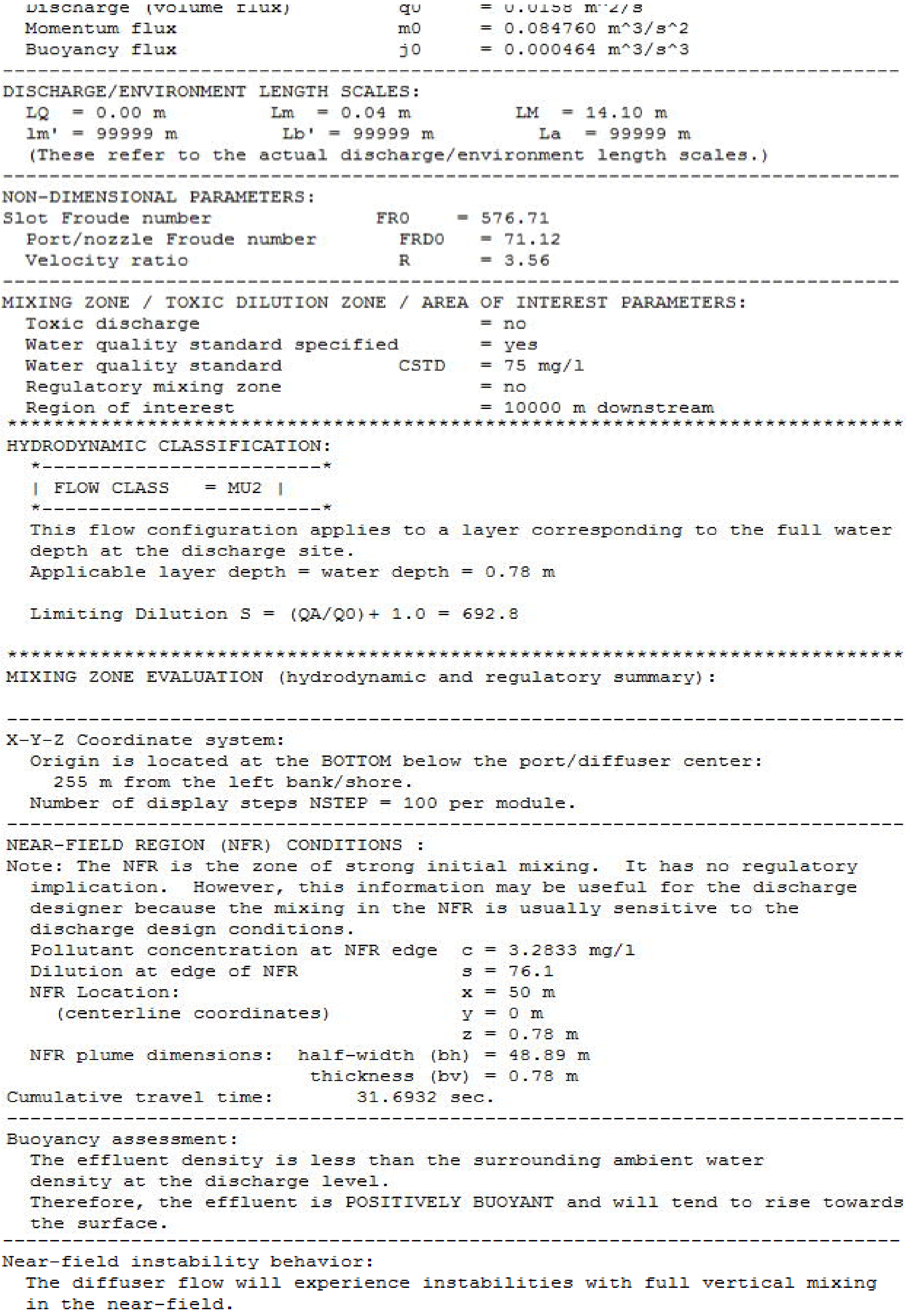
  Limiting Dilution S = (QA/Q0)+ 1.0 = 1380.1

*****************************************************************************
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

-----------------------------------------------------------------------------
X-Y-Z Coordinate system:
  Origin is located at the BOTTOM below the port/diffuser center:
    255 m from the left bank/shore.
  Number of display steps NSTEP = 100 per module.
-----------------------------------------------------------------------------
NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing.  It has no regulatory
  implication.  However, this information may be useful for the discharge
  designer because the mixing in the NFR is usually sensitive to the
  discharge design conditions.
  Pollutant concentration at NFR edge  c = 0.1405 mg/l
  Dilution at edge of NFR              s = 177.9
  NFR Location:                        x = 50 m
    (centerline coordinates)           y = 0 m
                                       z = 3.08 m
  NFR plume dimensions:  half-width (bh) = 49.19 m
                          thickness (bv) = 3.08 m
Cumulative travel time:       53.8857 sec.
-----------------------------------------------------------------------------
Buoyancy assessment:
  The effluent density is less than the surrounding ambient water
  density at the discharge level.
  Therefore, the effluent is POSITIVELY BUOYANT and will tend to rise towards
  the surface.
-----------------------------------------------------------------------------
Near-field instability behavior:
  The diffuser flow will experience instabilities with full vertical mixing
```

```
  in the near-field.
  There may be benthic impact of high pollutant concentrations.
-----------------------------------------------------------------------------
FAR-FIELD MIXING SUMMARY:
  Plume becomes vertically fully mixed ALREADY IN NEAR-FIELD at 50 m
  downstream and continues as vertically mixed into the far-field.
-----------------------------------------------------------------------------
PLUME BANK CONTACT SUMMARY:
  Plume in bounded section does not contact bank.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY ***********************
No RMZ has been specified.
However:
The ambient water quality standard was encountered at the following
  plume position:
  Water quality standard                 = 5  mg/l
  Corresponding dilution               s = 19.8
  Plume location:                      x = 0.42 m
    (centerline coordinates)           y = 0 m
                                       z = 0.24 m
  Plume dimensions:      half-width (bh) = 49.98 m
                          thickness (bv) = 0.09 m
```

```
CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
                      CORMIX MIXING ZONE EXPERT SYSTEM
                          CORMIX Version 9.0E
                       HYDRO2:Version-9.0.0.0  September,2014
SITE NAME/LABEL:                PARACEL
  DESIGN CASE:                  COR
  FILE NAME:                    C:\Program Files\CORMIX 9.0\Sample Files\Sample2
  Using subsystem CORMIX2:     Multiport Diffuser Discharges
  Start of session:             05/05/2020--17:41:58
*****************************************************************************
SUMMARY OF INPUT DATA:
-----------------------------------------------------------------------------
AMBIENT PARAMETERS:
  Cross-section                          = bounded
  Width                             BS     = 740 m
  Channel regularity                ICHREG = 1
  Ambient flowrate                  QA     = 1093 m^3/s
  Average depth                     HA     = 0.98 m
  Depth at discharge                HD     = 0.78 m
  Ambient velocity                  UA     = 1.5072 m/s
  Darcy-Weisbach friction factor    F      = 0.0711
    Calculated from Manning's n            = 0.03
  Wind velocity                     UW     = 2 m/s
  Stratification Type               STRCND = U
  Surface temperature                      = 29 degC
  Bottom temperature                       = 29 degC
  Calculated FRESH-WATER DENSITY values:
  Surface density                   RHOAS  = 995.9449 kg/m^3
  Bottom density                    RHOAB  = 995.9449 kg/m^3
-----------------------------------------------------------------------------
DISCHARGE PARAMETERS:               Submerged Multiport Diffuser Discharge
  Diffuser type                     DITYPE = unidirectional perpendicular
  Diffuser length                   LD     = 100 m
  Nearest bank                             = left
  Diffuser endpoints                YB1    = 205 m;     YB2 = 305 m
  Number of openings                NOPEN  = 10
  Number of Risers                  NRISER = 10
  Ports/Nozzles per Riser           NPPERR  = 1
  Spacing between risers/openings SPAC   = 11.11 m
  Port/Nozzle diameter              D0     = 0.1936 m
    with contraction ratio                 = 0.6
  Equivalent slot width             B0     = 0.0029 m
  Total area of openings            TA0    = 0.2945 m^2
  Discharge velocity                U0     = 5.36 m/s
  Total discharge flowrate          Q0     = 1.58 m^3/s
  Discharge port height             H0     = 0.2 m
  Nozzle arrangement                BETYPE = unidirectional without fanning
  Diffuser alignment angle          GAMMA  = 90 deg
  Vertical discharge angle          THETA  = 0 deg
  Actual Vertical discharge angle THEAC  = 0 deg
  Horizontal discharge angle        SIGMA  = 0 deg
  Relative orientation angle        BETA   = 90 deg
  Discharge temperature (freshwater)       = 38 degC
  Corresponding density             RHO0   = 992.9612 kg/m^3
  Density difference                DRHO   = 2.9837 kg/m^3
  Buoyant acceleration              GP0    = 0.0294 m/s^2
  Discharge concentration           C0     = 250 mg/l
  Surface heat exchange coeff.      KS     = 0 m/s
  Coefficient of decay              KD     = 0 /s
-----------------------------------------------------------------------------
FLUX VARIABLES PER UNIT DIFFUSER LENGTH:
  Discharge (volume flux)           q0     = 0.0158 m^2/s
```



```
  Discharge (volume flux)          q0      = 0.0158 m^2/s
  Momentum flux                    m0      = 0.084760 m^3/s^2
  Buoyancy flux                    j0      = 0.000464 m^3/s^3
-----------------------------------------------------------------------------
DISCHARGE/ENVIRONMENT LENGTH SCALES:
  LQ  = 0.00 m          Lm  = 0.04 m          LM  = 14.10 m
  lm' = 99999 m          Lb' = 99999 m          La  = 99999 m
  (These refer to the actual discharge/environment length scales.)
-----------------------------------------------------------------------------
NON-DIMENSIONAL PARAMETERS:
Slot Froude number                FR0     = 576.71
  Port/nozzle Froude number        FRD0    = 71.12
  Velocity ratio                   R       = 3.56
-----------------------------------------------------------------------------
MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
  Toxic discharge                          = no
  Water quality standard specified         = yes
  Water quality standard           CSTD    = 75 mg/l
  Regulatory mixing zone                   = no
  Region of interest                       = 10000 m downstream
*****************************************************************************
HYDRODYNAMIC CLASSIFICATION:
  *------------------------*
  | FLOW CLASS    = MU2 |
  *------------------------*
  This flow configuration applies to a layer corresponding to the full water
  depth at the discharge site.
  Applicable layer depth = water depth = 0.78 m

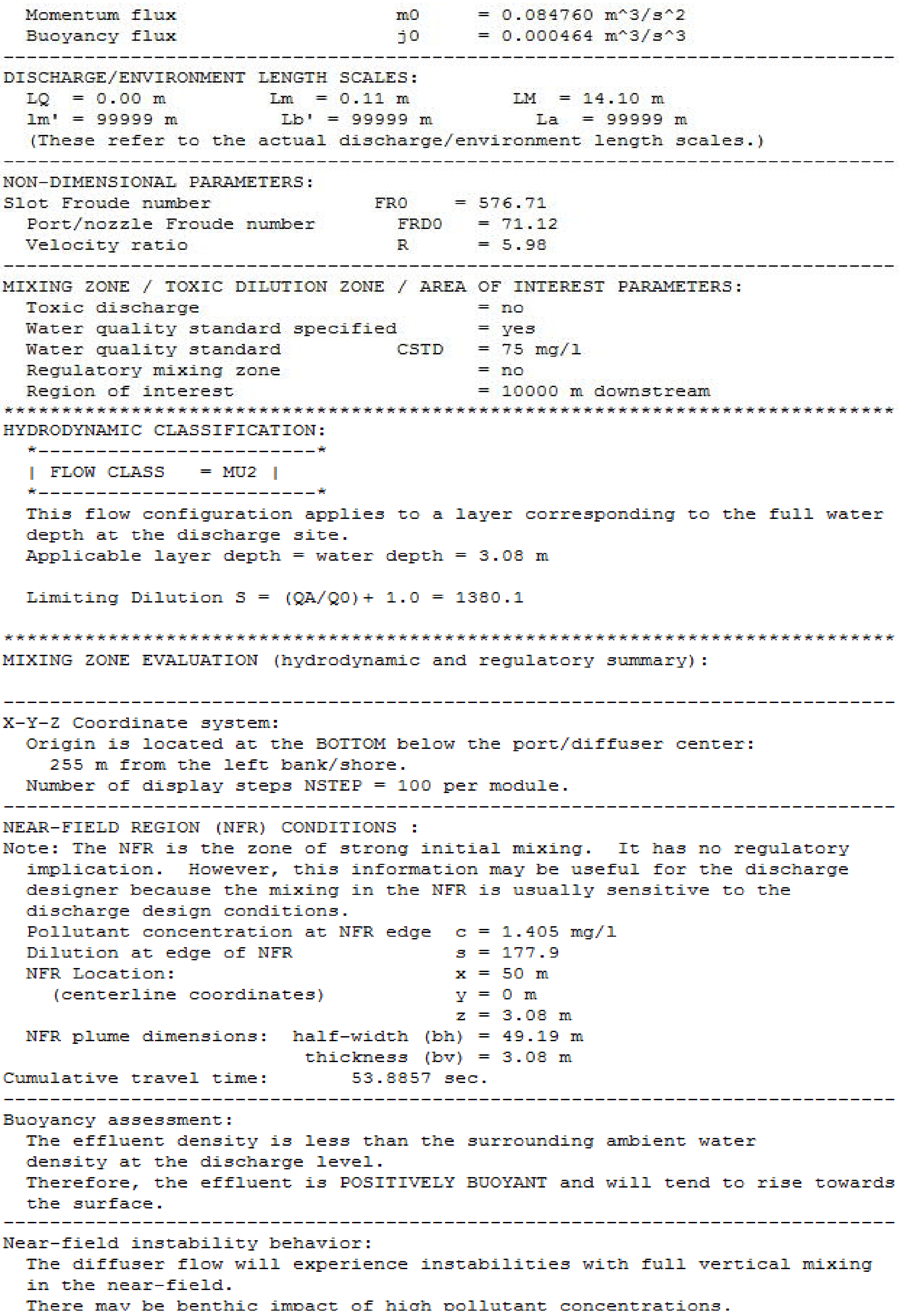
  Limiting Dilution S = (QA/Q0)+ 1.0 = 692.8

*****************************************************************************
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

-----------------------------------------------------------------------------
X-Y-Z Coordinate system:
  Origin is located at the BOTTOM below the port/diffuser center:
    255 m from the left bank/shore.
  Number of display steps NSTEP = 100 per module.
-----------------------------------------------------------------------------
NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing.  It has no regulatory
  implication.  However, this information may be useful for the discharge
  designer because the mixing in the NFR is usually sensitive to the
  discharge design conditions.
  Pollutant concentration at NFR edge  c = 3.2833 mg/l
  Dilution at edge of NFR              s = 76.1
  NFR Location:                        x = 50 m
    (centerline coordinates)           y = 0 m
                                       z = 0.78 m
  NFR plume dimensions:  half-width (bh) = 48.89 m
                          thickness (bv) = 0.78 m
Cumulative travel time:       31.6932 sec.
-----------------------------------------------------------------------------
Buoyancy assessment:
  The effluent density is less than the surrounding ambient water
  density at the discharge level.
  Therefore, the effluent is POSITIVELY BUOYANT and will tend to rise towards
  the surface.
-----------------------------------------------------------------------------
Near-field instability behavior:
  The diffuser flow will experience instabilities with full vertical mixing
  in the near-field.
```

```
  There may be benthic impact of high pollutant concentrations.
-----------------------------------------------------------------------------
FAR-FIELD MIXING SUMMARY:
  Plume becomes vertically fully mixed ALREADY IN NEAR-FIELD at 50 m
  downstream and continues as vertically mixed into the far-field.
-----------------------------------------------------------------------------
PLUME BANK CONTACT SUMMARY:
  Plume in bounded section does not contact bank.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY ***********************
No RMZ has been specified.
However:
The ambient water quality standard was encountered at the following
  plume position:
  Water quality standard                 = 75  mg/l
  Corresponding dilution               s = 15.0
  Plume location:                      x = 0.37 m
    (centerline coordinates)           y = 0 m
                                       z = 0.22 m
  Plume dimensions:      half-width (bh) = 49.98 m
                          thickness (bv) = 0.08 m
```

```
CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
                     CORMIX MIXING ZONE EXPERT SYSTEM
                         CORMIX Version 9.0E
                      HYDRO2:Version-9.0.0.0  September,2014
SITE NAME/LABEL:                PARACEL
  DESIGN CASE:                  COR
  FILE NAME:                    C:\Program Files\CORMIX 9.0\Sample Files\Sample2
  Using subsystem CORMIX2:     Multiport Diffuser Discharges
  Start of session:             05/05/2020--17:45:59
****************************************************************************
SUMMARY OF INPUT DATA:
----------------------------------------------------------------------------
AMBIENT PARAMETERS:
  Cross-section                                = bounded
  Width                              BS        = 740 m
  Channel regularity                 ICHREG = 1
  Ambient flowrate                   QA        = 2179 m^3/s
  Average depth                      HA        = 3.28 m
  Depth at discharge                 HD        = 3.08 m
  Ambient velocity                   UA        = 0.8977 m/s
  Darcy-Weisbach friction factor  F         = 0.0475
    Calculated from Manning's n                = 0.03
  Wind velocity                      UW        = 2 m/s
  Stratification Type                STRCND = U
  Surface temperature                          = 29 degC
  Bottom temperature                           = 29 degC
  Calculated FRESH-WATER DENSITY values:
  Surface density                    RHOAS   = 995.9449 kg/m^3
  Bottom density                     RHOAB   = 995.9449 kg/m^3
----------------------------------------------------------------------------
DISCHARGE PARAMETERS:                Submerged Multiport Diffuser Discharge
  Diffuser type                      DITYPE = unidirectional perpendicular
  Diffuser length                    LD        = 100 m
  Nearest bank                                 = left
  Diffuser endpoints                 YB1       = 205 m;     YB2 = 305 m
  Number of openings                 NOPEN    = 10
  Number of Risers                   NRISER = 10
  Ports/Nozzles per Riser            NPPERR   = 1
  Spacing between risers/openings SPAC      = 11.11 m
  Port/Nozzle diameter               D0        = 0.1936 m
    with contraction ratio                     = 0.6
  Equivalent slot width              B0        = 0.0029 m
  Total area of openings             TA0       = 0.2945 m^2
  Discharge velocity                 U0        = 5.36 m/s
  Total discharge flowrate           Q0        = 1.58 m^3/s
  Discharge port height              H0        = 0.2 m
  Nozzle arrangement                 BETYPE = unidirectional without fanning
  Diffuser alignment angle           GAMMA     = 90 deg
  Vertical discharge angle           THETA     = 0 deg
  Actual Vertical discharge angle THEAC     = 0 deg
  Horizontal discharge angle         SIGMA     = 0 deg
  Relative orientation angle         BETA      = 90 deg
  Discharge temperature (freshwater)           = 38 degC
  Corresponding density              RHO0      = 992.9612 kg/m^3
  Density difference                 DRHO      = 2.9837 kg/m^3
  Buoyant acceleration               GP0       = 0.0294 m/s^2
  Discharge concentration            C0        = 250 mg/l
  Surface heat exchange coeff.       KS        = 0 m/s
  Coefficient of decay               KD        = 0 /s
----------------------------------------------------------------------------
FLUX VARIABLES PER UNIT DIFFUSER LENGTH:
  Discharge (volume flux)            q0        = 0.0158 m^2/s
```

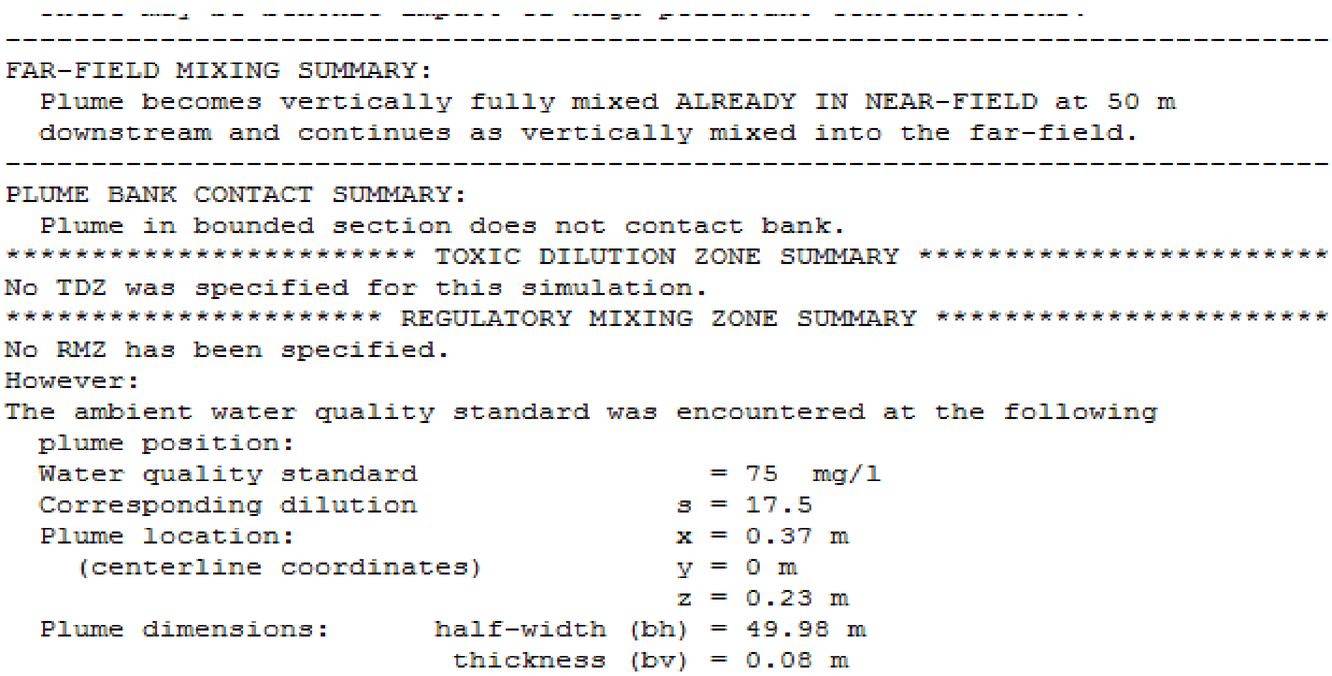


```
  Momentum flux                   m0     = 0.084760 m^3/s^2
  Buoyancy flux                   j0     = 0.000464 m^3/s^3
-----------------------------------------------------------------------------
DISCHARGE/ENVIRONMENT LENGTH SCALES:
  LQ  = 0.00 m         Lm  = 0.11 m         LM  = 14.10 m
  lm' = 99999 m         Lb' = 99999 m         La  = 99999 m
  (These refer to the actual discharge/environment length scales.)
-----------------------------------------------------------------------------
NON-DIMENSIONAL PARAMETERS:
Slot Froude number              FR0    = 576.71
  Port/nozzle Froude number       FRD0   = 71.12
  Velocity ratio                  R      = 5.98
-----------------------------------------------------------------------------
MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
  Toxic discharge                        = no
  Water quality standard specified       = yes
  Water quality standard          CSTD   = 75 mg/l
  Regulatory mixing zone                 = no
  Region of interest                     = 10000 m downstream
*****************************************************************************
HYDRODYNAMIC CLASSIFICATION:
  *------------------------*
  | FLOW CLASS   = MU2 |
  *------------------------*
  This flow configuration applies to a layer corresponding to the full water
  depth at the discharge site.
  Applicable layer depth = water depth = 3.08 m

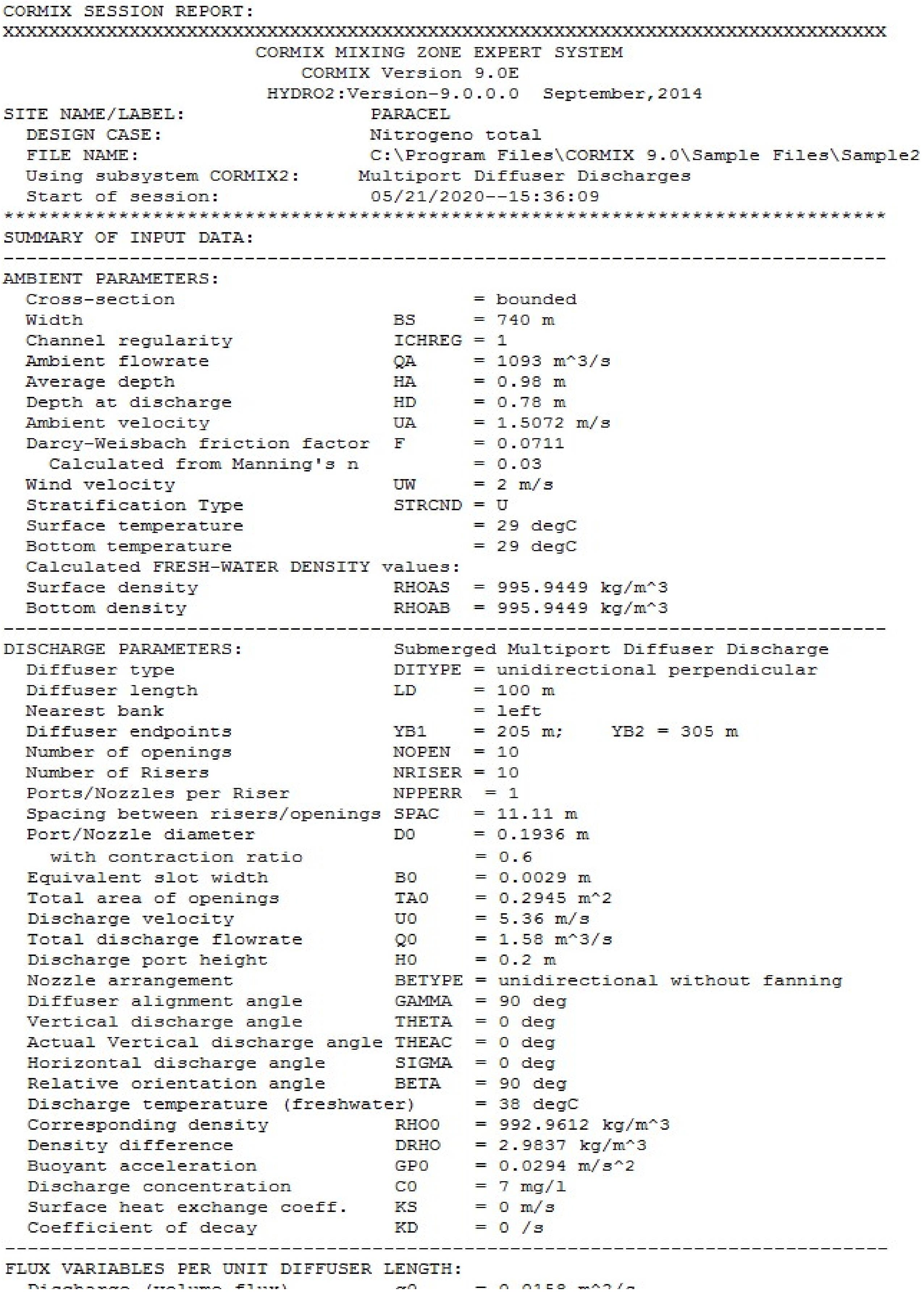
  Limiting Dilution S = (QA/Q0)+ 1.0 = 1380.1

*****************************************************************************
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

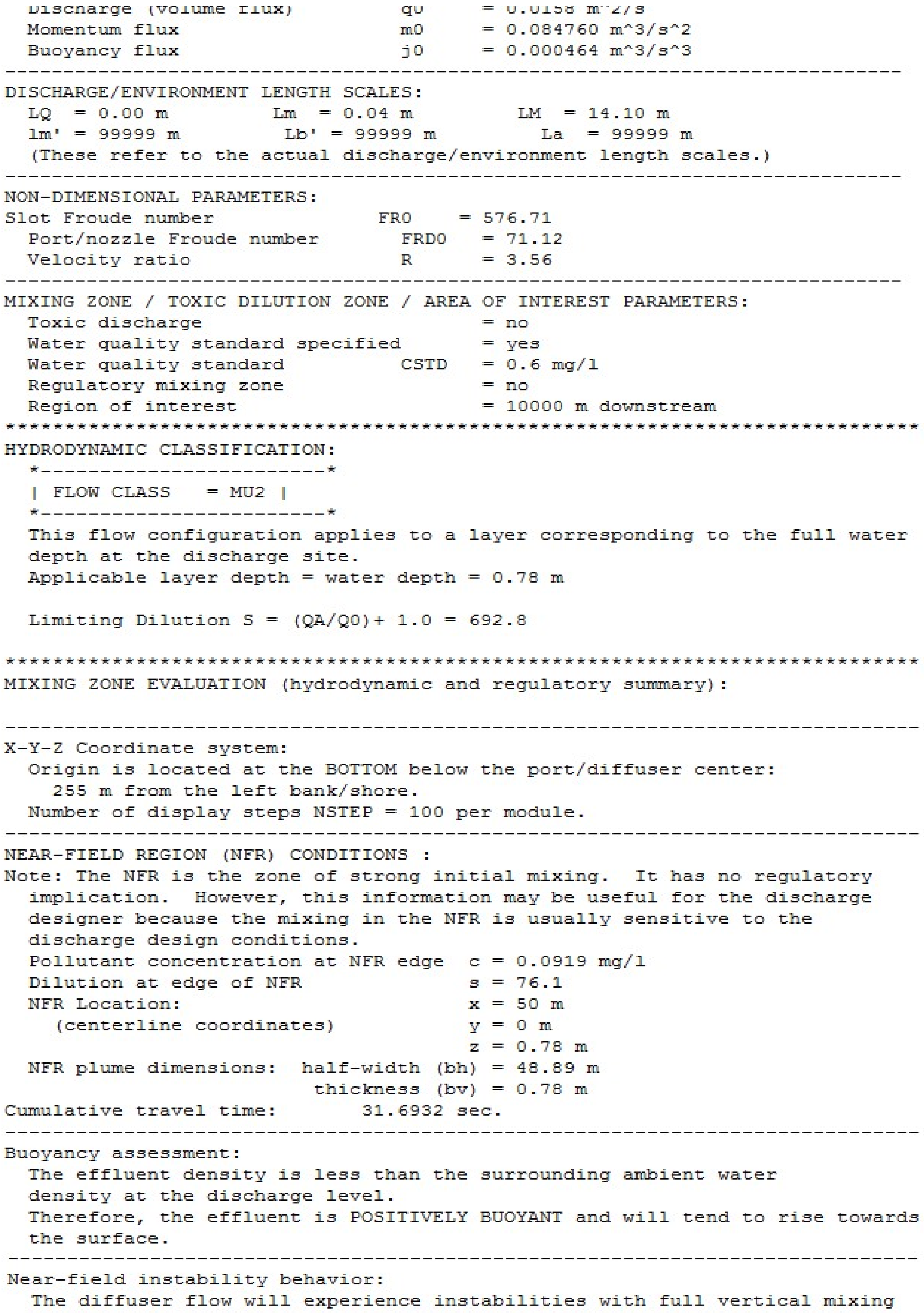
-----------------------------------------------------------------------------
X-Y-Z Coordinate system:
  Origin is located at the BOTTOM below the port/diffuser center:
    255 m from the left bank/shore.
  Number of display steps NSTEP = 100 per module.
-----------------------------------------------------------------------------
NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing.  It has no regulatory
  implication.  However, this information may be useful for the discharge
  designer because the mixing in the NFR is usually sensitive to the
  discharge design conditions.
  Pollutant concentration at NFR edge  c = 1.405 mg/l
  Dilution at edge of NFR              s = 177.9
  NFR Location:                        x = 50 m
    (centerline coordinates)           y = 0 m
                                       z = 3.08 m
  NFR plume dimensions:  half-width (bh) = 49.19 m
                          thickness (bv) = 3.08 m
Cumulative travel time:       53.8857 sec.
-----------------------------------------------------------------------------
Buoyancy assessment:
  The effluent density is less than the surrounding ambient water
  density at the discharge level.
  Therefore, the effluent is POSITIVELY BUOYANT and will tend to rise towards
  the surface.
-----------------------------------------------------------------------------
Near-field instability behavior:
  The diffuser flow will experience instabilities with full vertical mixing
  in the near-field.
  There may be benthic impact of high pollutant concentrations.
```



```
-----------------------------------------------------------------------------
FAR-FIELD MIXING SUMMARY:
  Plume becomes vertically fully mixed ALREADY IN NEAR-FIELD at 50 m
  downstream and continues as vertically mixed into the far-field.
-----------------------------------------------------------------------------
PLUME BANK CONTACT SUMMARY:
  Plume in bounded section does not contact bank.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY ***********************
No RMZ has been specified.
However:
The ambient water quality standard was encountered at the following
  plume position:
  Water quality standard                   = 75  mg/l
  Corresponding dilution                 s = 17.5
  Plume location:                        x = 0.37 m
    (centerline coordinates)             y = 0 m
                                         z = 0.23 m
  Plume dimensions:      half-width (bh) = 49.98 m
                          thickness (bv) = 0.08 m
```



```
CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
                      CORMIX MIXING ZONE EXPERT SYSTEM
                          CORMIX Version 9.0E
                       HYDRO2:Version-9.0.0.0  September,2014
SITE NAME/LABEL:                PARACEL
  DESIGN CASE:                  Nitrogeno total
  FILE NAME:                    C:\Program Files\CORMIX 9.0\Sample Files\Sample2
  Using subsystem CORMIX2:     Multiport Diffuser Discharges
  Start of session:             05/21/2020--15:36:09
*****************************************************************************
SUMMARY OF INPUT DATA:
-----------------------------------------------------------------------------
AMBIENT PARAMETERS:
  Cross-section                        = bounded
  Width                         BS     = 740 m
  Channel regularity            ICHREG = 1
  Ambient flowrate              QA     = 1093 m^3/s
  Average depth                 HA     = 0.98 m
  Depth at discharge            HD     = 0.78 m
  Ambient velocity              UA     = 1.5072 m/s
  Darcy-Weisbach friction factor F     = 0.0711
    Calculated from Manning's n        = 0.03
  Wind velocity                 UW     = 2 m/s
  Stratification Type           STRCND = U
  Surface temperature                  = 29 degC
  Bottom temperature                   = 29 degC
  Calculated FRESH-WATER DENSITY values:
  Surface density               RHOAS  = 995.9449 kg/m^3
  Bottom density                RHOAB  = 995.9449 kg/m^3
-----------------------------------------------------------------------------
DISCHARGE PARAMETERS:           Submerged Multiport Diffuser Discharge
  Diffuser type                 DITYPE = unidirectional perpendicular
  Diffuser length               LD     = 100 m
  Nearest bank                         = left
  Diffuser endpoints            YB1    = 205 m;    YB2 = 305 m
  Number of openings            NOPEN  = 10
  Number of Risers              NRISER = 10
  Ports/Nozzles per Riser       NPPERR  = 1
  Spacing between risers/openings SPAC   = 11.11 m
  Port/Nozzle diameter          D0     = 0.1936 m
    with contraction ratio             = 0.6
  Equivalent slot width         B0     = 0.0029 m
  Total area of openings        TA0    = 0.2945 m^2
  Discharge velocity            U0     = 5.36 m/s
  Total discharge flowrate      Q0     = 1.58 m^3/s
  Discharge port height         H0     = 0.2 m
  Nozzle arrangement            BETYPE = unidirectional without fanning
  Diffuser alignment angle      GAMMA  = 90 deg
  Vertical discharge angle      THETA  = 0 deg
  Actual Vertical discharge angle THEAC  = 0 deg
  Horizontal discharge angle    SIGMA  = 0 deg
  Relative orientation angle    BETA   = 90 deg
  Discharge temperature (freshwater)   = 38 degC
  Corresponding density         RHO0   = 992.9612 kg/m^3
  Density difference            DRHO   = 2.9837 kg/m^3
  Buoyant acceleration          GP0    = 0.0294 m/s^2
  Discharge concentration       C0     = 7 mg/l
  Surface heat exchange coeff.  KS     = 0 m/s
  Coefficient of decay          KD     = 0 /s
-----------------------------------------------------------------------------
FLUX VARIABLES PER UNIT DIFFUSER LENGTH:
  Discharge (volume flux)       q0     = 0.0158 m^2/s
```

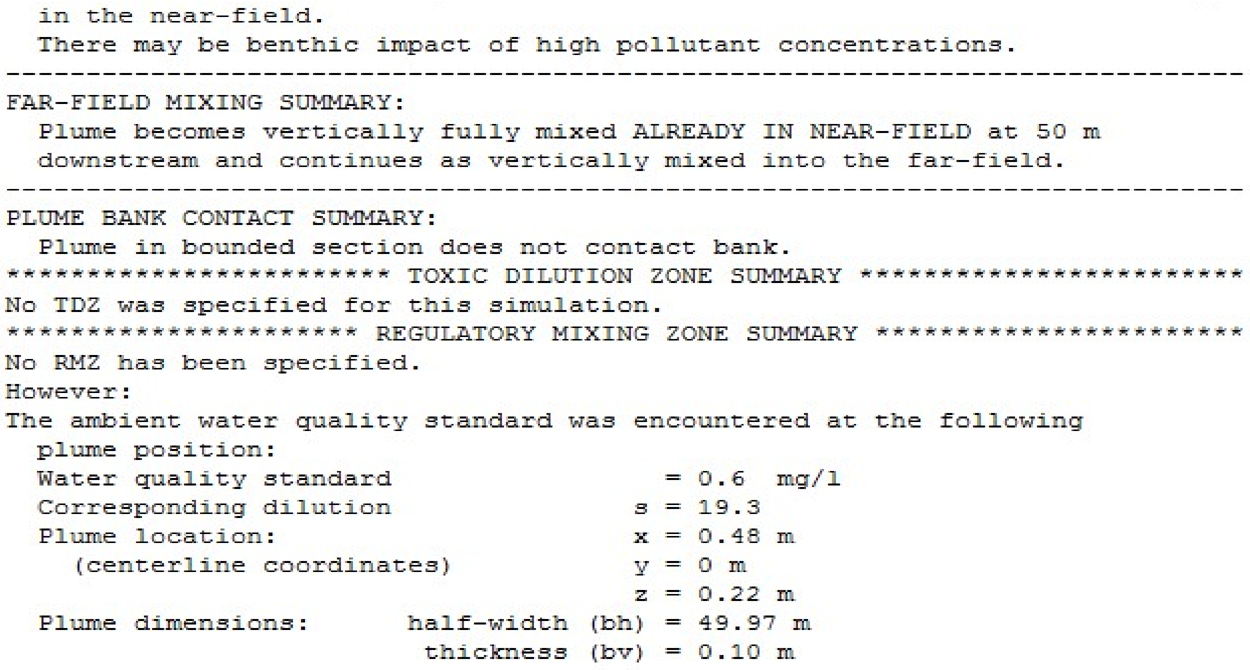


```
  Discharge (volume flux)           q0     = 0.0158 m^2/s
  Momentum flux                     m0     = 0.084760 m^3/s^2
  Buoyancy flux                     j0     = 0.000464 m^3/s^3
-----------------------------------------------------------------------------
DISCHARGE/ENVIRONMENT LENGTH SCALES:
  LQ  = 0.00 m         Lm  = 0.04 m         LM  = 14.10 m
  lm' = 99999 m         Lb' = 99999 m         La  = 99999 m
  (These refer to the actual discharge/environment length scales.)
-----------------------------------------------------------------------------
NON-DIMENSIONAL PARAMETERS:
Slot Froude number                FR0    = 576.71
  Port/nozzle Froude number         FRD0   = 71.12
  Velocity ratio                    R      = 3.56
-----------------------------------------------------------------------------
MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
  Toxic discharge                          = no
  Water quality standard specified         = yes
  Water quality standard            CSTD   = 0.6 mg/l
  Regulatory mixing zone                   = no
  Region of interest                       = 10000 m downstream
******************************************************************************
HYDRODYNAMIC CLASSIFICATION:
  *------------------------*
  | FLOW CLASS   = MU2 |
  *------------------------*
  This flow configuration applies to a layer corresponding to the full water
  depth at the discharge site.
  Applicable layer depth = water depth = 0.78 m

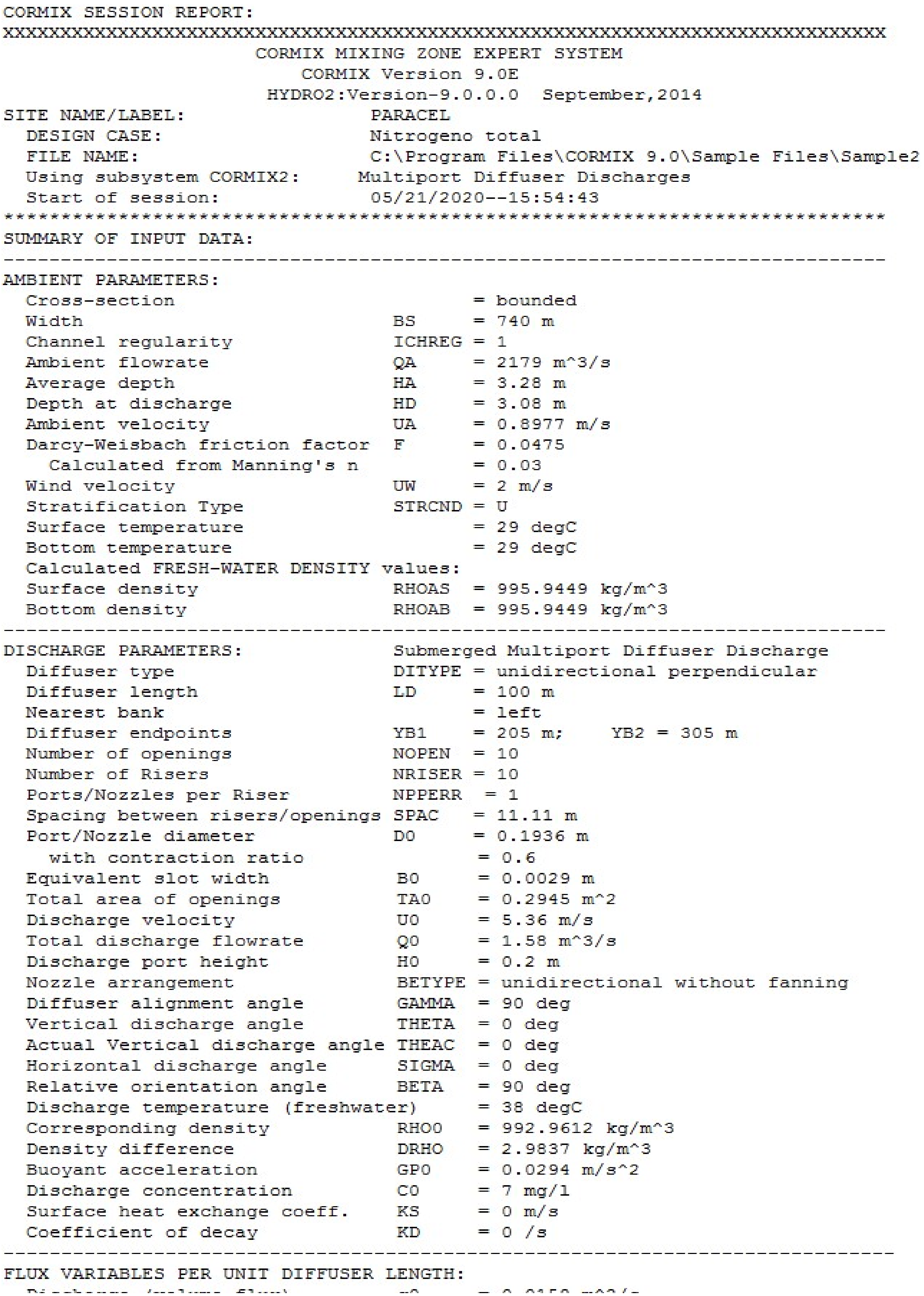
  Limiting Dilution S = (QA/Q0)+ 1.0 = 692.8

******************************************************************************
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

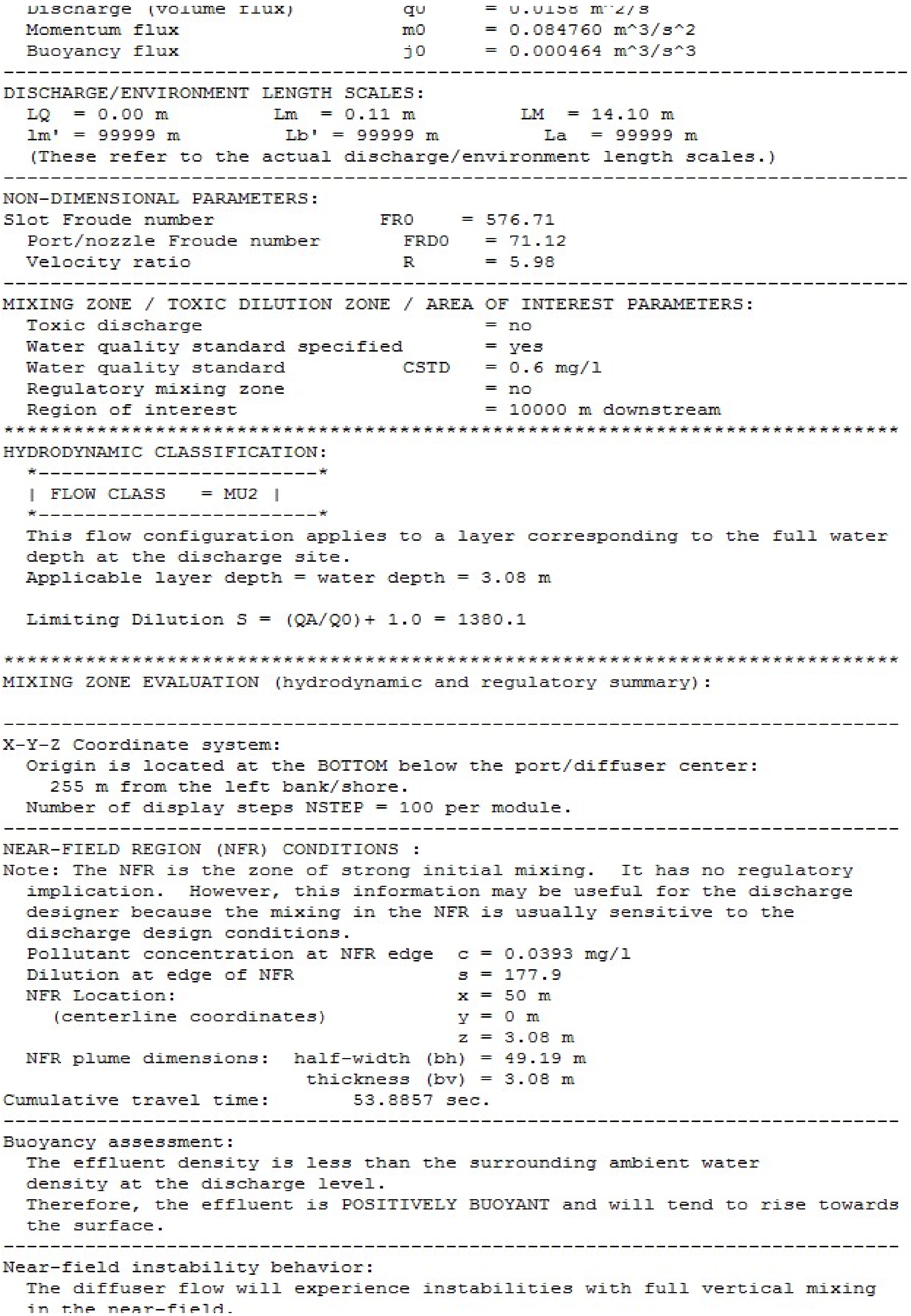
------------------------------------------------------------------------------
X-Y-Z Coordinate system:
  Origin is located at the BOTTOM below the port/diffuser center:
    255 m from the left bank/shore.
  Number of display steps NSTEP = 100 per module.
------------------------------------------------------------------------------
NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing.  It has no regulatory
  implication.  However, this information may be useful for the discharge
  designer because the mixing in the NFR is usually sensitive to the
  discharge design conditions.
  Pollutant concentration at NFR edge  c = 0.0919 mg/l
  Dilution at edge of NFR              s = 76.1
  NFR Location:                        x = 50 m
    (centerline coordinates)           y = 0 m
                                       z = 0.78 m
  NFR plume dimensions:  half-width (bh) = 48.89 m
                          thickness (bv) = 0.78 m
Cumulative travel time:       31.6932 sec.
------------------------------------------------------------------------------
Buoyancy assessment:
  The effluent density is less than the surrounding ambient water
  density at the discharge level.
  Therefore, the effluent is POSITIVELY BUOYANT and will tend to rise towards
  the surface.
------------------------------------------------------------------------------
Near-field instability behavior:
  The diffuser flow will experience instabilities with full vertical mixing
```



```
  in the near-field.
  There may be benthic impact of high pollutant concentrations.
-----------------------------------------------------------------------------
FAR-FIELD MIXING SUMMARY:
  Plume becomes vertically fully mixed ALREADY IN NEAR-FIELD at 50 m
  downstream and continues as vertically mixed into the far-field.
-----------------------------------------------------------------------------
PLUME BANK CONTACT SUMMARY:
  Plume in bounded section does not contact bank.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY ***********************
No RMZ has been specified.
However:
The ambient water quality standard was encountered at the following
  plume position:
  Water quality standard               = 0.6  mg/l
  Corresponding dilution             s = 19.3
  Plume location:                    x = 0.48 m
    (centerline coordinates)         y = 0 m
                                     z = 0.22 m
  Plume dimensions:      half-width (bh) = 49.97 m
                          thickness (bv) = 0.10 m
```



```
CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
                      CORMIX MIXING ZONE EXPERT SYSTEM
                          CORMIX Version 9.0E
                       HYDRO2:Version-9.0.0.0  September,2014
SITE NAME/LABEL:                PARACEL
  DESIGN CASE:                  Nitrogeno total
  FILE NAME:                    C:\Program Files\CORMIX 9.0\Sample Files\Sample2
  Using subsystem CORMIX2:     Multiport Diffuser Discharges
  Start of session:             05/21/2020--15:54:43
******************************************************************************
SUMMARY OF INPUT DATA:
------------------------------------------------------------------------------
AMBIENT PARAMETERS:
  Cross-section                          = bounded
  Width                           BS     = 740 m
  Channel regularity              ICHREG = 1
  Ambient flowrate                QA     = 2179 m^3/s
  Average depth                   HA     = 3.28 m
  Depth at discharge              HD     = 3.08 m
  Ambient velocity                UA     = 0.8977 m/s
  Darcy-Weisbach friction factor  F      = 0.0475
    Calculated from Manning's n          = 0.03
  Wind velocity                   UW     = 2 m/s
  Stratification Type             STRCND = U
  Surface temperature                    = 29 degC
  Bottom temperature                     = 29 degC
  Calculated FRESH-WATER DENSITY values:
  Surface density                 RHOAS  = 995.9449 kg/m^3
  Bottom density                  RHOAB  = 995.9449 kg/m^3
------------------------------------------------------------------------------
DISCHARGE PARAMETERS:             Submerged Multiport Diffuser Discharge
  Diffuser type                   DITYPE = unidirectional perpendicular
  Diffuser length                 LD     = 100 m
  Nearest bank                           = left
  Diffuser endpoints              YB1    = 205 m;     YB2 = 305 m
  Number of openings              NOPEN  = 10
  Number of Risers                NRISER = 10
  Ports/Nozzles per Riser         NPPERR  = 1
  Spacing between risers/openings SPAC   = 11.11 m
  Port/Nozzle diameter            D0     = 0.1936 m
    with contraction ratio               = 0.6
  Equivalent slot width           B0     = 0.0029 m
  Total area of openings          TA0    = 0.2945 m^2
  Discharge velocity              U0     = 5.36 m/s
  Total discharge flowrate        Q0     = 1.58 m^3/s
  Discharge port height           H0     = 0.2 m
  Nozzle arrangement              BETYPE = unidirectional without fanning
  Diffuser alignment angle        GAMMA  = 90 deg
  Vertical discharge angle        THETA  = 0 deg
  Actual Vertical discharge angle THEAC  = 0 deg
  Horizontal discharge angle      SIGMA  = 0 deg
  Relative orientation angle      BETA   = 90 deg
  Discharge temperature (freshwater)     = 38 degC
  Corresponding density           RHO0   = 992.9612 kg/m^3
  Density difference              DRHO   = 2.9837 kg/m^3
  Buoyant acceleration            GP0    = 0.0294 m/s^2
  Discharge concentration         C0     = 7 mg/l
  Surface heat exchange coeff.    KS     = 0 m/s
  Coefficient of decay            KD     = 0 /s
-------------------------------------------------------------------------------
FLUX VARIABLES PER UNIT DIFFUSER LENGTH:
```

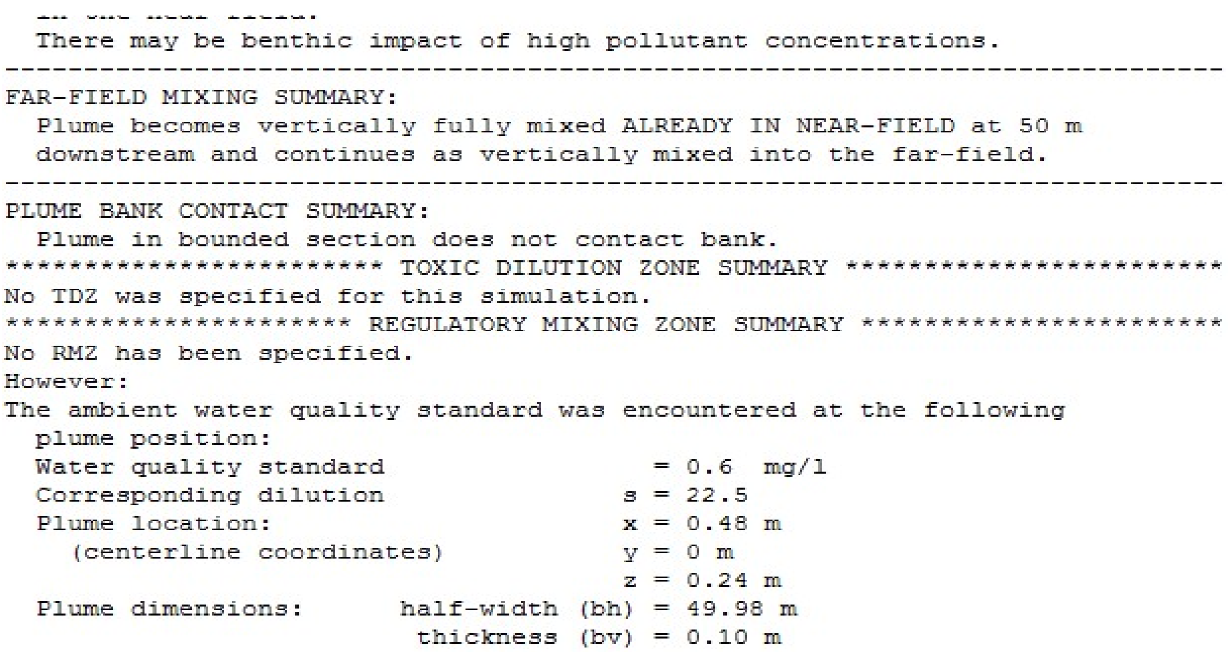


```
  Discharge (volume flux)         q0     = 0.0158 m^2/s
  Momentum flux                   m0     = 0.084760 m^3/s^2
  Buoyancy flux                   j0     = 0.000464 m^3/s^3
-----------------------------------------------------------------------------
DISCHARGE/ENVIRONMENT LENGTH SCALES:
  LQ  = 0.00 m         Lm  = 0.11 m         LM  = 14.10 m
  lm' = 99999 m         Lb' = 99999 m         La  = 99999 m
  (These refer to the actual discharge/environment length scales.)
-----------------------------------------------------------------------------
NON-DIMENSIONAL PARAMETERS:
Slot Froude number              FR0    = 576.71
  Port/nozzle Froude number       FRD0   = 71.12
  Velocity ratio                  R      = 5.98
-----------------------------------------------------------------------------
MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
  Toxic discharge                        = no
  Water quality standard specified       = yes
  Water quality standard          CSTD   = 0.6 mg/l
  Regulatory mixing zone                 = no
  Region of interest                     = 10000 m downstream
****************************************************************************
HYDRODYNAMIC CLASSIFICATION:
  *------------------------*
  | FLOW CLASS   = MU2 |
  *------------------------*
  This flow configuration applies to a layer corresponding to the full water
  depth at the discharge site.
  Applicable layer depth = water depth = 3.08 m

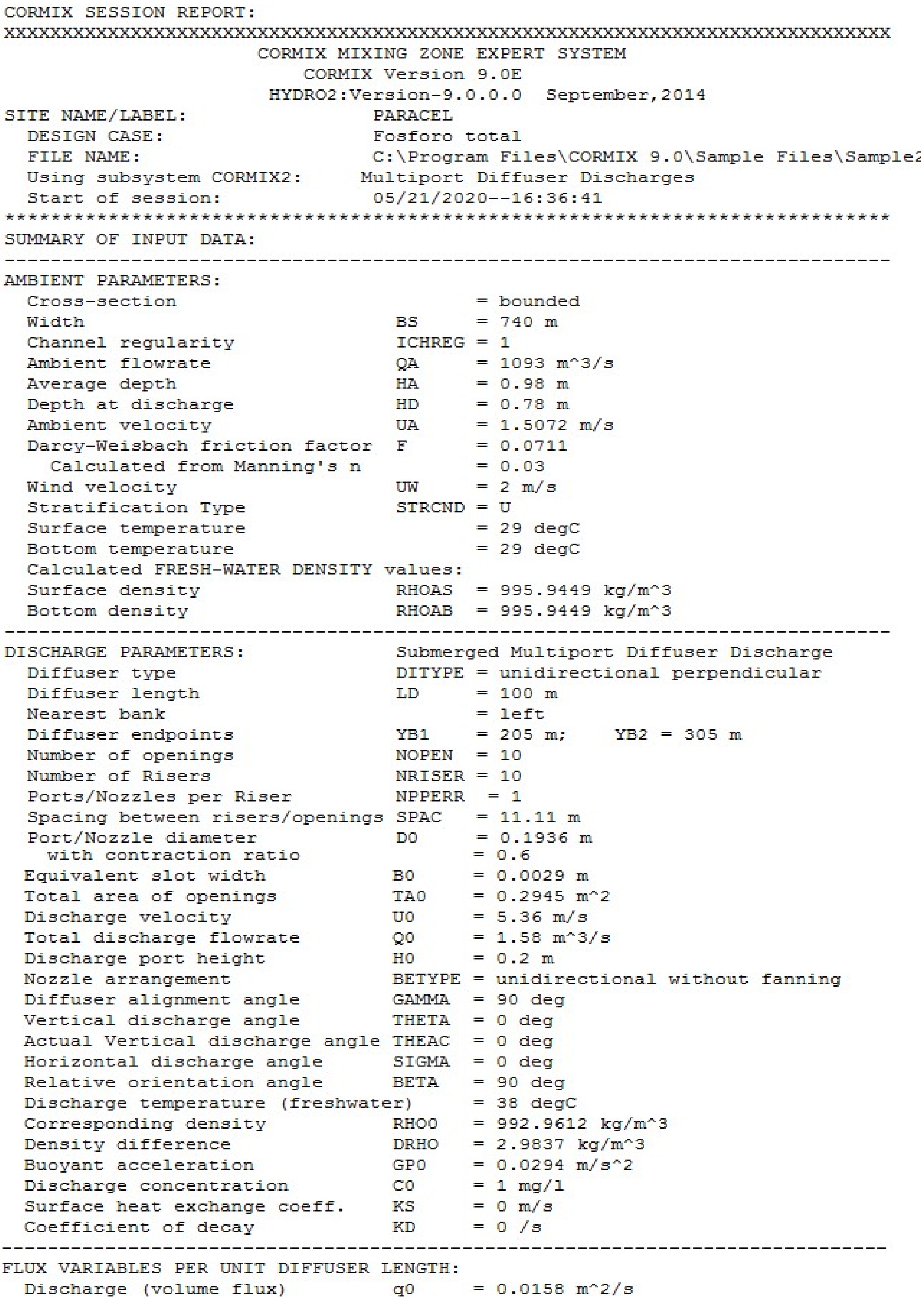
  Limiting Dilution S = (QA/Q0)+ 1.0 = 1380.1

****************************************************************************
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

----------------------------------------------------------------------------
X-Y-Z Coordinate system:
  Origin is located at the BOTTOM below the port/diffuser center:
    255 m from the left bank/shore.
  Number of display steps NSTEP = 100 per module.
----------------------------------------------------------------------------
NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing.  It has no regulatory
  implication.  However, this information may be useful for the discharge
  designer because the mixing in the NFR is usually sensitive to the
  discharge design conditions.
  Pollutant concentration at NFR edge  c = 0.0393 mg/l
  Dilution at edge of NFR              s = 177.9
  NFR Location:                        x = 50 m
    (centerline coordinates)           y = 0 m
                                       z = 3.08 m
  NFR plume dimensions:  half-width (bh) = 49.19 m
                          thickness (bv) = 3.08 m
Cumulative travel time:       53.8857 sec.
----------------------------------------------------------------------------
Buoyancy assessment:
  The effluent density is less than the surrounding ambient water
  density at the discharge level.
  Therefore, the effluent is POSITIVELY BUOYANT and will tend to rise towards
  the surface.
----------------------------------------------------------------------------
Near-field instability behavior:
  The diffuser flow will experience instabilities with full vertical mixing
  in the near-field.
```



```
  There may be benthic impact of high pollutant concentrations.
-----------------------------------------------------------------------------
FAR-FIELD MIXING SUMMARY:
  Plume becomes vertically fully mixed ALREADY IN NEAR-FIELD at 50 m
  downstream and continues as vertically mixed into the far-field.
-----------------------------------------------------------------------------
PLUME BANK CONTACT SUMMARY:
  Plume in bounded section does not contact bank.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY ***********************
No RMZ has been specified.
However:
The ambient water quality standard was encountered at the following
  plume position:
  Water quality standard                 = 0.6  mg/l
  Corresponding dilution               s = 22.5
  Plume location:                      x = 0.48 m
    (centerline coordinates)           y = 0 m
                                       z = 0.24 m
  Plume dimensions:      half-width (bh) = 49.98 m
                          thickness (bv) = 0.10 m
```



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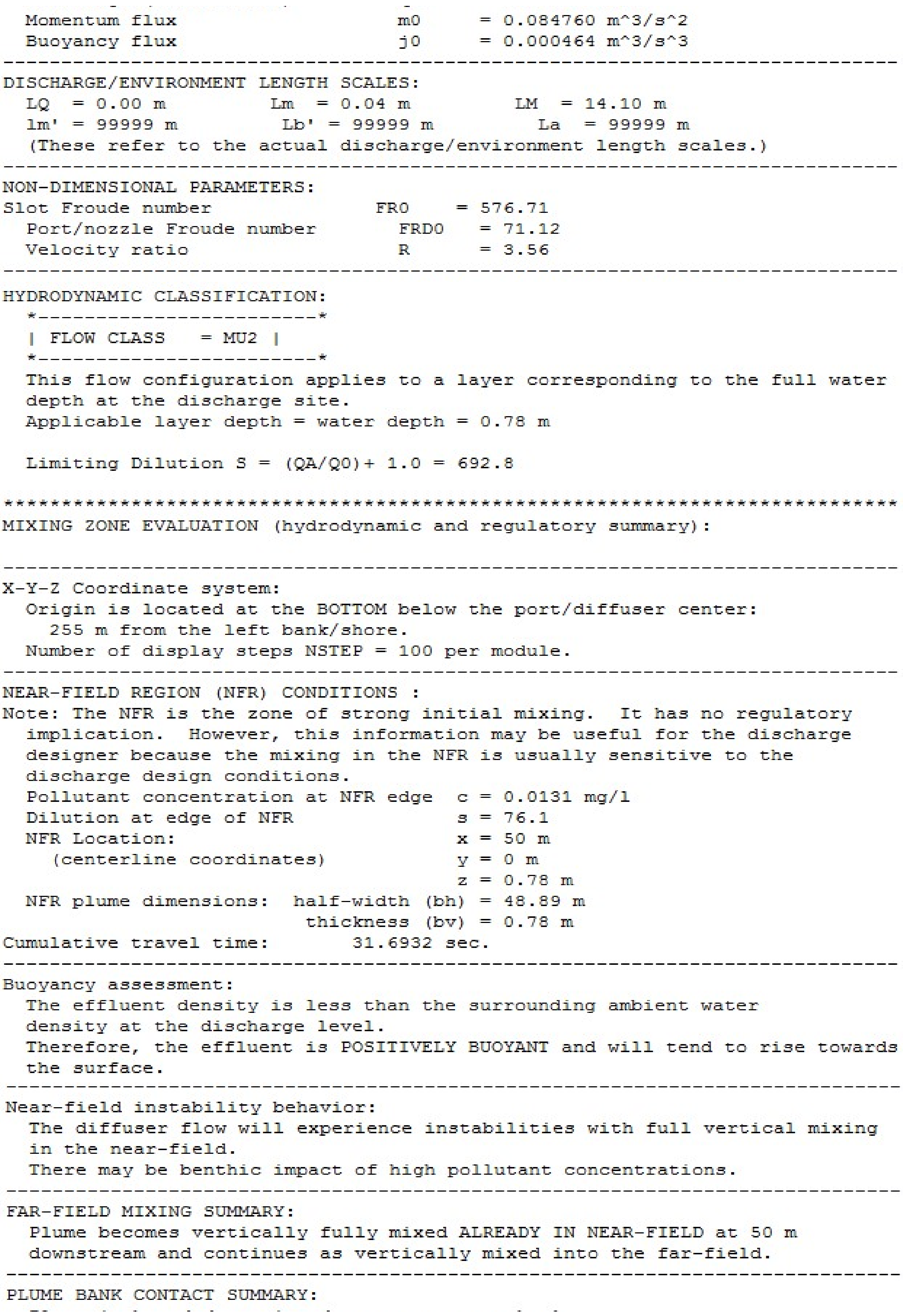
CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
                     CORMIX MIXING ZONE EXPERT SYSTEM
                         CORMIX Version 9.0E
                      HYDRO2:Version-9.0.0.0  September,2014
SITE NAME/LABEL:                PARACEL
  DESIGN CASE:                  Fosforo total
  FILE NAME:                    C:\Program Files\CORMIX 9.0\Sample Files\Sample2
  Using subsystem CORMIX2:     Multiport Diffuser Discharges
  Start of session:             05/21/2020--16:36:41
*****************************************************************************
SUMMARY OF INPUT DATA:
-----------------------------------------------------------------------------
AMBIENT PARAMETERS:
  Cross-section                            = bounded
  Width                           BS       = 740 m
  Channel regularity              ICHREG = 1
  Ambient flowrate                QA       = 1093 m^3/s
  Average depth                   HA       = 0.98 m
  Depth at discharge              HD       = 0.78 m
  Ambient velocity                UA       = 1.5072 m/s
  Darcy-Weisbach friction factor  F        = 0.0711
    Calculated from Manning's n            = 0.03
  Wind velocity                   UW       = 2 m/s
  Stratification Type             STRCND = U
  Surface temperature                      = 29 degC
  Bottom temperature                       = 29 degC
  Calculated FRESH-WATER DENSITY values:
  Surface density                 RHOAS  = 995.9449 kg/m^3
  Bottom density                  RHOAB  = 995.9449 kg/m^3
-----------------------------------------------------------------------------
DISCHARGE PARAMETERS:             Submerged Multiport Diffuser Discharge
  Diffuser type                   DITYPE = unidirectional perpendicular
  Diffuser length                 LD       = 100 m
  Nearest bank                             = left
  Diffuser endpoints              YB1      = 205 m;    YB2 = 305 m
  Number of openings              NOPEN  = 10
  Number of Risers                NRISER = 10
  Ports/Nozzles per Riser         NPPERR  = 1
  Spacing between risers/openings SPAC    = 11.11 m
  Port/Nozzle diameter            D0       = 0.1936 m
    with contraction ratio                 = 0.6
  Equivalent slot width           B0       = 0.0029 m
  Total area of openings          TA0      = 0.2945 m^2
  Discharge velocity              U0       = 5.36 m/s
  Total discharge flowrate        Q0       = 1.58 m^3/s
  Discharge port height           H0       = 0.2 m
  Nozzle arrangement              BETYPE = unidirectional without fanning
  Diffuser alignment angle        GAMMA    = 90 deg
  Vertical discharge angle        THETA    = 0 deg
  Actual Vertical discharge angle THEAC    = 0 deg
  Horizontal discharge angle      SIGMA    = 0 deg
  Relative orientation angle      BETA     = 90 deg
  Discharge temperature (freshwater)       = 38 degC
  Corresponding density           RHO0     = 992.9612 kg/m^3
  Density difference              DRHO     = 2.9837 kg/m^3
  Buoyant acceleration            GP0      = 0.0294 m/s^2
  Discharge concentration         C0       = 1 mg/l
  Surface heat exchange coeff.    KS       = 0 m/s
  Coefficient of decay            KD       = 0 /s
-----------------------------------------------------------------------------
FLUX VARIABLES PER UNIT DIFFUSER LENGTH:
  Discharge (volume flux)         q0       = 0.0158 m^2/s
```

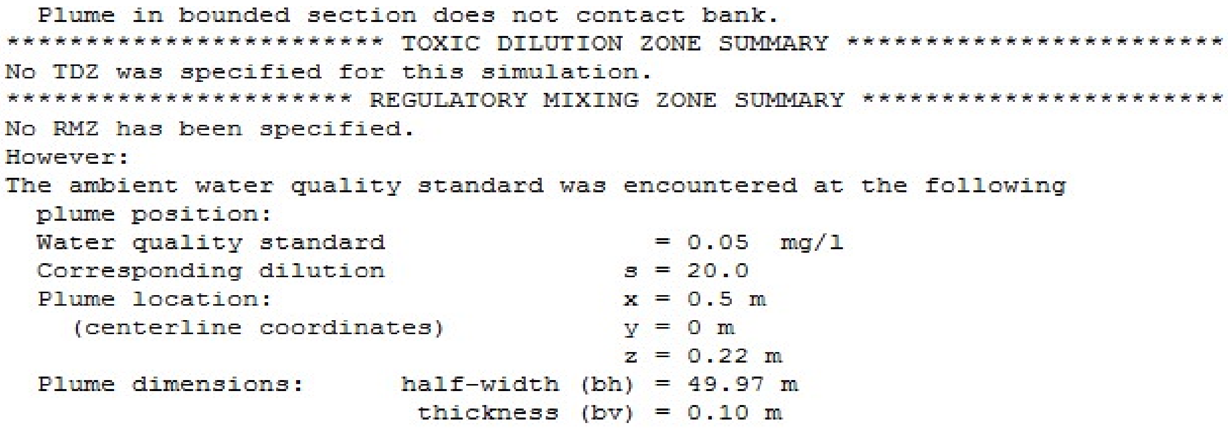


```
  Momentum flux                  m0     = 0.084760 m^3/s^2
  Buoyancy flux                  j0     = 0.000464 m^3/s^3
-----------------------------------------------------------------------------
DISCHARGE/ENVIRONMENT LENGTH SCALES:
  LQ  = 0.00 m          Lm  = 0.04 m          LM  = 14.10 m
  lm' = 99999 m          Lb' = 99999 m          La  = 99999 m
  (These refer to the actual discharge/environment length scales.)
-----------------------------------------------------------------------------
NON-DIMENSIONAL PARAMETERS:
Slot Froude number              FR0    = 576.71
  Port/nozzle Froude number       FRD0   = 71.12
  Velocity ratio                  R      = 3.56
-----------------------------------------------------------------------------
HYDRODYNAMIC CLASSIFICATION:
  *------------------------*
  | FLOW CLASS   = MU2 |
  *------------------------*
  This flow configuration applies to a layer corresponding to the full water
  depth at the discharge site.
  Applicable layer depth = water depth = 0.78 m

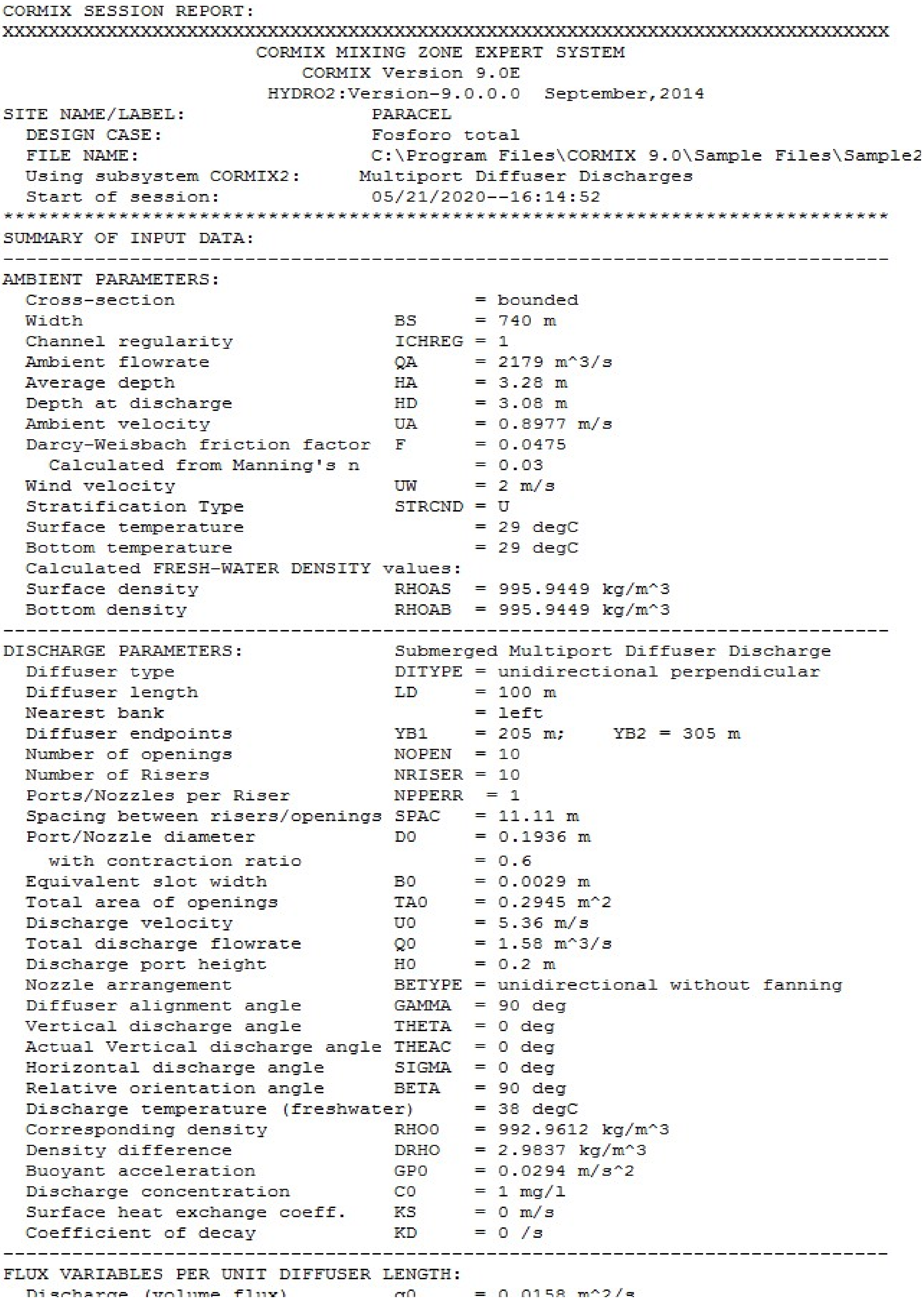
  Limiting Dilution S = (QA/Q0)+ 1.0 = 692.8

*****************************************************************************
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

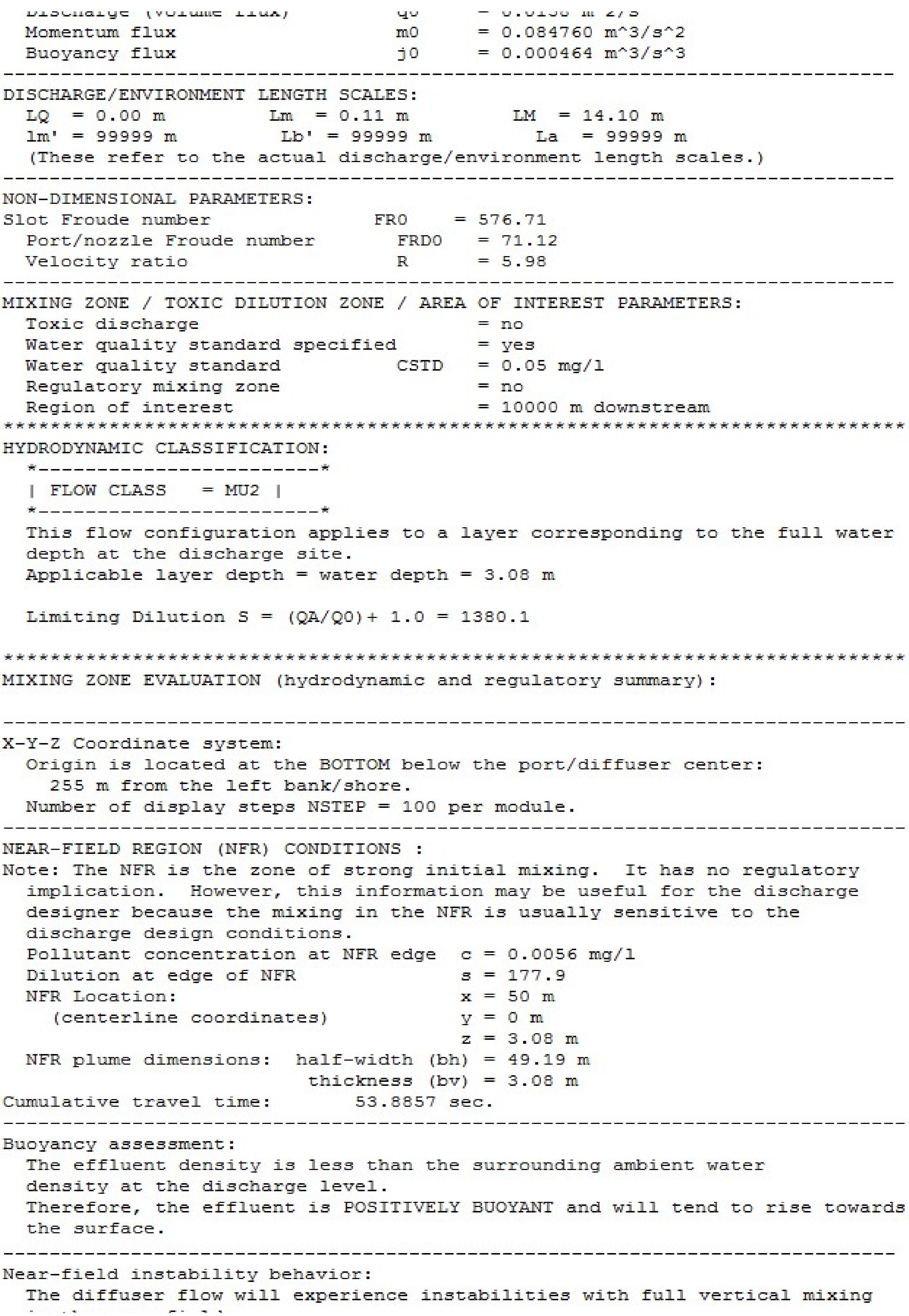
-----------------------------------------------------------------------------
X-Y-Z Coordinate system:
  Origin is located at the BOTTOM below the port/diffuser center:
    255 m from the left bank/shore.
  Number of display steps NSTEP = 100 per module.
-----------------------------------------------------------------------------
NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing.  It has no regulatory
  implication.  However, this information may be useful for the discharge
  designer because the mixing in the NFR is usually sensitive to the
  discharge design conditions.
  Pollutant concentration at NFR edge  c = 0.0131 mg/l
  Dilution at edge of NFR              s = 76.1
  NFR Location:                        x = 50 m
    (centerline coordinates)           y = 0 m
                                       z = 0.78 m
  NFR plume dimensions:  half-width (bh) = 48.89 m
                          thickness (bv) = 0.78 m
Cumulative travel time:       31.6932 sec.
-----------------------------------------------------------------------------
Buoyancy assessment:
  The effluent density is less than the surrounding ambient water
  density at the discharge level.
  Therefore, the effluent is POSITIVELY BUOYANT and will tend to rise towards
  the surface.
-----------------------------------------------------------------------------
Near-field instability behavior:
  The diffuser flow will experience instabilities with full vertical mixing
  in the near-field.
  There may be benthic impact of high pollutant concentrations.
-----------------------------------------------------------------------------
FAR-FIELD MIXING SUMMARY:
  Plume becomes vertically fully mixed ALREADY IN NEAR-FIELD at 50 m
  downstream and continues as vertically mixed into the far-field.
-----------------------------------------------------------------------------
PLUME BANK CONTACT SUMMARY:
```



```
  Plume in bounded section does not contact bank.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY ***********************
No RMZ has been specified.
However:
The ambient water quality standard was encountered at the following
  plume position:
  Water quality standard                    = 0.05  mg/l
  Corresponding dilution                  s = 20.0
  Plume location:                         x = 0.5 m
    (centerline coordinates)              y = 0 m
                                          z = 0.22 m
  Plume dimensions:      half-width (bh) = 49.97 m
                          thickness (bv) = 0.10 m
```



```
CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
                      CORMIX MIXING ZONE EXPERT SYSTEM
                          CORMIX Version 9.0E
                       HYDRO2:Version-9.0.0.0  September,2014
SITE NAME/LABEL:                PARACEL
  DESIGN CASE:                  Fosforo total
  FILE NAME:                    C:\Program Files\CORMIX 9.0\Sample Files\Sample2
  Using subsystem CORMIX2:     Multiport Diffuser Discharges
  Start of session:             05/21/2020--16:14:52
*****************************************************************************
SUMMARY OF INPUT DATA:
-----------------------------------------------------------------------------
AMBIENT PARAMETERS:
  Cross-section                          = bounded
  Width                         BS       = 740 m
  Channel regularity            ICHREG = 1
  Ambient flowrate              QA       = 2179 m^3/s
  Average depth                 HA       = 3.28 m
  Depth at discharge            HD       = 3.08 m
  Ambient velocity              UA       = 0.8977 m/s
  Darcy-Weisbach friction factor F       = 0.0475
    Calculated from Manning's n          = 0.03
  Wind velocity                 UW       = 2 m/s
  Stratification Type           STRCND = U
  Surface temperature                    = 29 degC
  Bottom temperature                     = 29 degC
  Calculated FRESH-WATER DENSITY values:
  Surface density               RHOAS  = 995.9449 kg/m^3
  Bottom density                RHOAB  = 995.9449 kg/m^3
-----------------------------------------------------------------------------
DISCHARGE PARAMETERS:           Submerged Multiport Diffuser Discharge
  Diffuser type                 DITYPE = unidirectional perpendicular
  Diffuser length               LD       = 100 m
  Nearest bank                           = left
  Diffuser endpoints            YB1      = 205 m;     YB2 = 305 m
  Number of openings            NOPEN  = 10
  Number of Risers              NRISER = 10
  Ports/Nozzles per Riser       NPPERR  = 1
  Spacing between risers/openings SPAC   = 11.11 m
  Port/Nozzle diameter          D0       = 0.1936 m
    with contraction ratio               = 0.6
  Equivalent slot width         B0       = 0.0029 m
  Total area of openings        TA0      = 0.2945 m^2
  Discharge velocity            U0       = 5.36 m/s
  Total discharge flowrate      Q0       = 1.58 m^3/s
  Discharge port height         H0       = 0.2 m
  Nozzle arrangement            BETYPE = unidirectional without fanning
  Diffuser alignment angle      GAMMA    = 90 deg
  Vertical discharge angle      THETA    = 0 deg
  Actual Vertical discharge angle THEAC  = 0 deg
  Horizontal discharge angle    SIGMA    = 0 deg
  Relative orientation angle    BETA     = 90 deg
  Discharge temperature (freshwater)     = 38 degC
  Corresponding density         RHO0     = 992.9612 kg/m^3
  Density difference            DRHO     = 2.9837 kg/m^3
  Buoyant acceleration          GP0      = 0.0294 m/s^2
  Discharge concentration       C0       = 1 mg/l
  Surface heat exchange coeff.  KS       = 0 m/s
  Coefficient of decay          KD       = 0 /s
-----------------------------------------------------------------------------
FLUX VARIABLES PER UNIT DIFFUSER LENGTH:
  Discharge (volume flux)       q0       = 0.0158 m^2/s
```

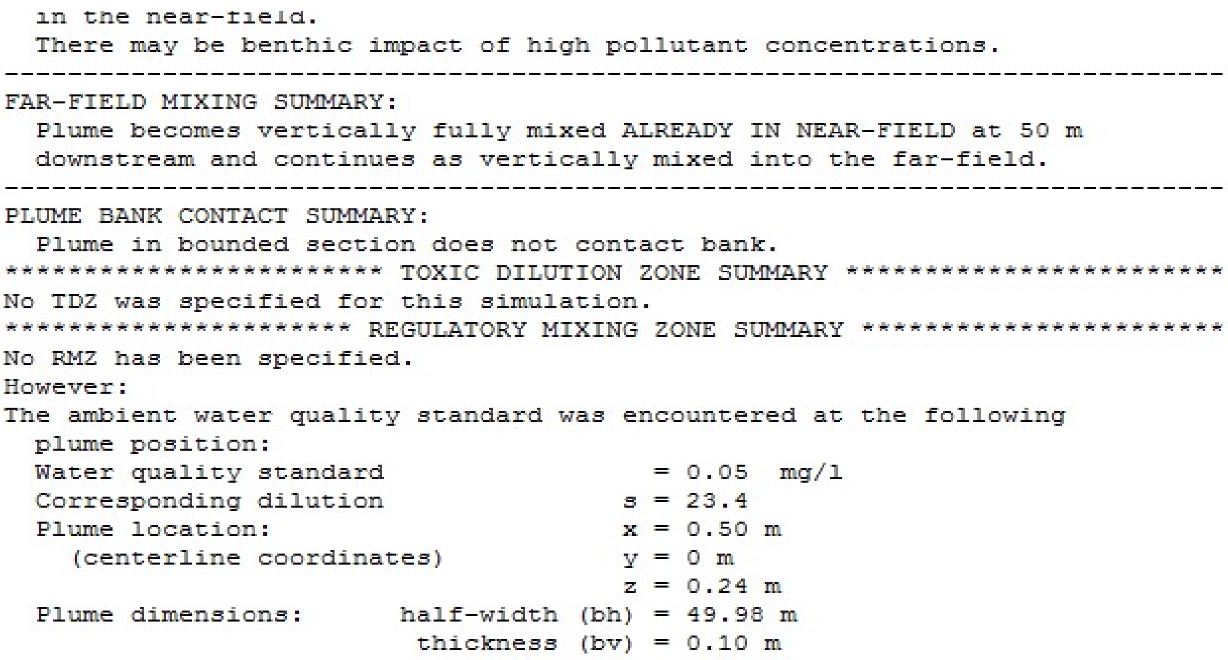


```
  Momentum flux                     m0     = 0.084760 m^3/s^2
  Buoyancy flux                     j0     = 0.000464 m^3/s^3
-----------------------------------------------------------------------------
DISCHARGE/ENVIRONMENT LENGTH SCALES:
  LQ  = 0.00 m         Lm  = 0.11 m         LM  = 14.10 m
  lm' = 99999 m         Lb' = 99999 m         La  = 99999 m
  (These refer to the actual discharge/environment length scales.)
-----------------------------------------------------------------------------
NON-DIMENSIONAL PARAMETERS:
Slot Froude number                FR0    = 576.71
  Port/nozzle Froude number         FRD0   = 71.12
  Velocity ratio                    R      = 5.98
-----------------------------------------------------------------------------
MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
  Toxic discharge                          = no
  Water quality standard specified         = yes
  Water quality standard            CSTD   = 0.05 mg/l
  Regulatory mixing zone                   = no
  Region of interest                       = 10000 m downstream
******************************************************************************
HYDRODYNAMIC CLASSIFICATION:
  *------------------------*
  | FLOW CLASS   = MU2 |
  *------------------------*
  This flow configuration applies to a layer corresponding to the full water
  depth at the discharge site.
  Applicable layer depth = water depth = 3.08 m

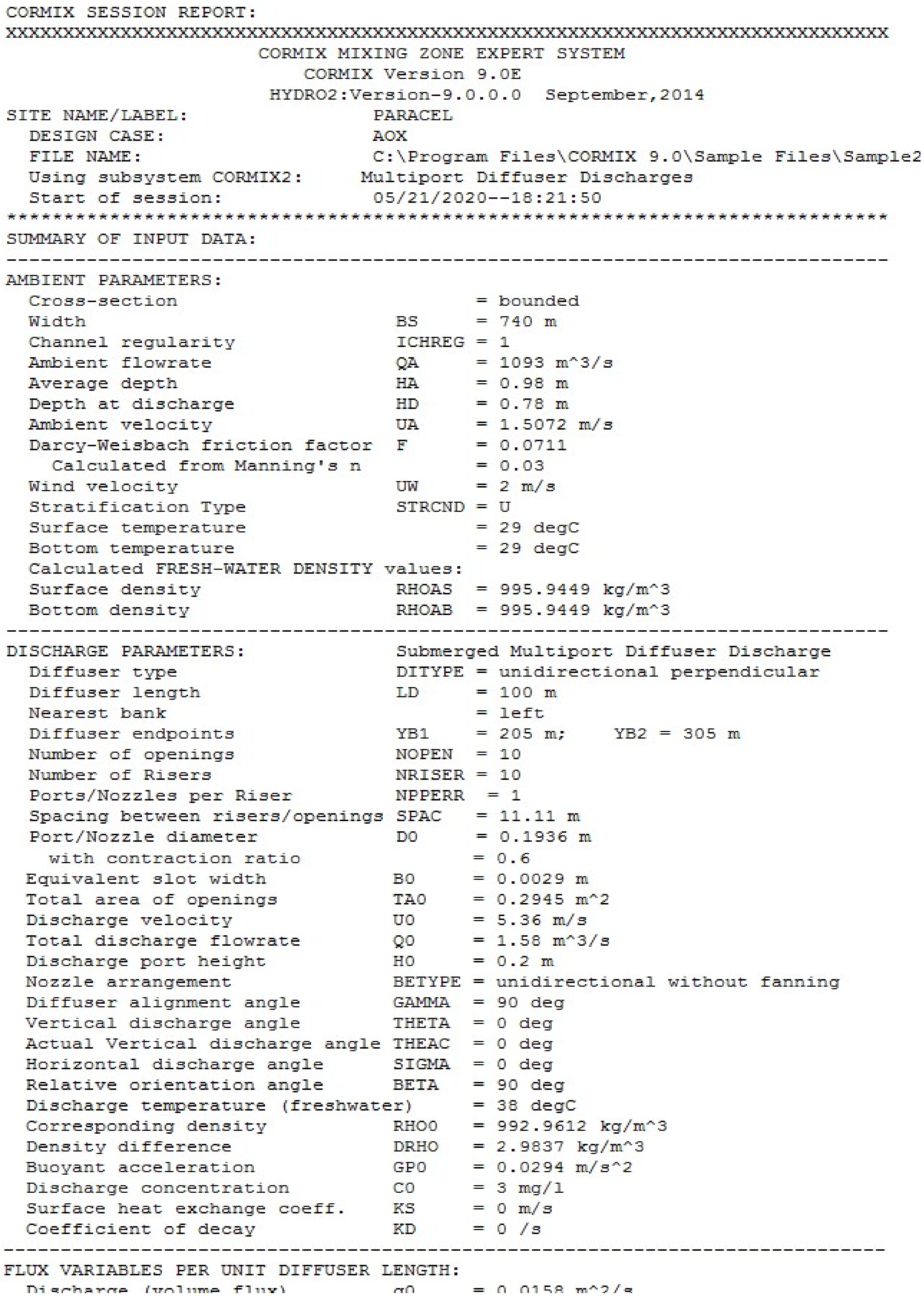
  Limiting Dilution S = (QA/Q0)+ 1.0 = 1380.1

******************************************************************************
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

------------------------------------------------------------------------------
X-Y-Z Coordinate system:
  Origin is located at the BOTTOM below the port/diffuser center:
    255 m from the left bank/shore.
  Number of display steps NSTEP = 100 per module.
------------------------------------------------------------------------------
NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing.  It has no regulatory
  implication.  However, this information may be useful for the discharge
  designer because the mixing in the NFR is usually sensitive to the
  discharge design conditions.
  Pollutant concentration at NFR edge  c = 0.0056 mg/l
  Dilution at edge of NFR              s = 177.9
  NFR Location:                        x = 50 m
    (centerline coordinates)           y = 0 m
                                       z = 3.08 m
  NFR plume dimensions:  half-width (bh) = 49.19 m
                          thickness (bv) = 3.08 m
Cumulative travel time:       53.8857 sec.
------------------------------------------------------------------------------
Buoyancy assessment:
  The effluent density is less than the surrounding ambient water
  density at the discharge level.
  Therefore, the effluent is POSITIVELY BUOYANT and will tend to rise towards
  the surface.
-----------------------------------------------------------------------------
Near-field instability behavior:
  The diffuser flow will experience instabilities with full vertical mixing
```



```
  in the near-field.
  There may be benthic impact of high pollutant concentrations.
-----------------------------------------------------------------------------
FAR-FIELD MIXING SUMMARY:
  Plume becomes vertically fully mixed ALREADY IN NEAR-FIELD at 50 m
  downstream and continues as vertically mixed into the far-field.
-----------------------------------------------------------------------------
PLUME BANK CONTACT SUMMARY:
  Plume in bounded section does not contact bank.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY ***********************
No RMZ has been specified.
However:
The ambient water quality standard was encountered at the following
  plume position:
  Water quality standard                 = 0.05  mg/l
  Corresponding dilution               s = 23.4
  Plume location:                      x = 0.50 m
    (centerline coordinates)           y = 0 m
                                       z = 0.24 m
  Plume dimensions:      half-width (bh) = 49.98 m
                          thickness (bv) = 0.10 m
```



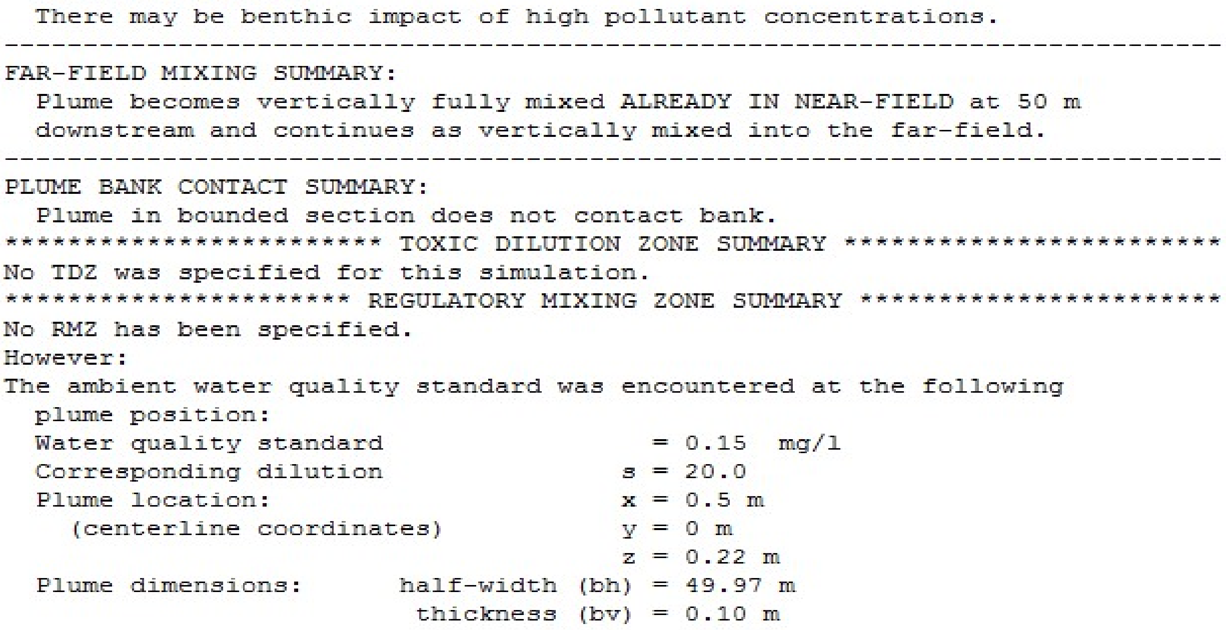
```
CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
                      CORMIX MIXING ZONE EXPERT SYSTEM
                          CORMIX Version 9.0E
                       HYDRO2:Version-9.0.0.0  September,2014
SITE NAME/LABEL:                PARACEL
  DESIGN CASE:                  AOX
  FILE NAME:                    C:\Program Files\CORMIX 9.0\Sample Files\Sample2
  Using subsystem CORMIX2:     Multiport Diffuser Discharges
  Start of session:             05/21/2020--18:21:50
*******************************************************************************
SUMMARY OF INPUT DATA:
-------------------------------------------------------------------------------
AMBIENT PARAMETERS:
  Cross-section                            = bounded
  Width                           BS       = 740 m
  Channel regularity              ICHREG = 1
  Ambient flowrate                QA       = 1093 m^3/s
  Average depth                   HA       = 0.98 m
  Depth at discharge              HD       = 0.78 m
  Ambient velocity                UA       = 1.5072 m/s
  Darcy-Weisbach friction factor  F        = 0.0711
    Calculated from Manning's n            = 0.03
  Wind velocity                   UW       = 2 m/s
  Stratification Type             STRCND = U
  Surface temperature                      = 29 degC
  Bottom temperature                       = 29 degC
  Calculated FRESH-WATER DENSITY values:
  Surface density                 RHOAS  = 995.9449 kg/m^3
  Bottom density                  RHOAB  = 995.9449 kg/m^3
-------------------------------------------------------------------------------
DISCHARGE PARAMETERS:             Submerged Multiport Diffuser Discharge
  Diffuser type                   DITYPE = unidirectional perpendicular
  Diffuser length                 LD       = 100 m
  Nearest bank                             = left
  Diffuser endpoints              YB1      = 205 m;    YB2 = 305 m
  Number of openings              NOPEN  = 10
  Number of Risers                NRISER = 10
  Ports/Nozzles per Riser         NPPERR  = 1
  Spacing between risers/openings SPAC   = 11.11 m
  Port/Nozzle diameter            D0       = 0.1936 m
    with contraction ratio                 = 0.6
  Equivalent slot width           B0       = 0.0029 m
  Total area of openings          TA0      = 0.2945 m^2
  Discharge velocity              U0       = 5.36 m/s
  Total discharge flowrate        Q0       = 1.58 m^3/s
  Discharge port height           H0       = 0.2 m
  Nozzle arrangement              BETYPE = unidirectional without fanning
  Diffuser alignment angle        GAMMA  = 90 deg
  Vertical discharge angle        THETA  = 0 deg
  Actual Vertical discharge angle THEAC  = 0 deg
  Horizontal discharge angle      SIGMA  = 0 deg
  Relative orientation angle      BETA     = 90 deg
  Discharge temperature (freshwater)       = 38 degC
  Corresponding density           RHO0     = 992.9612 kg/m^3
  Density difference              DRHO     = 2.9837 kg/m^3
  Buoyant acceleration            GP0      = 0.0294 m/s^2
  Discharge concentration         C0       = 3 mg/l
  Surface heat exchange coeff.    KS       = 0 m/s
  Coefficient of decay            KD       = 0 /s
-------------------------------------------------------------------------------
FLUX VARIABLES PER UNIT DIFFUSER LENGTH:
  Discharge (volume flux)         q0       = 0.0158 m^2/s
```

```
  Discharge (volume flux)         q0     = 0.0138 m^2/s
  Momentum flux                   m0     = 0.084760 m^3/s^2
  Buoyancy flux                   j0     = 0.000464 m^3/s^3
-----------------------------------------------------------------------------
DISCHARGE/ENVIRONMENT LENGTH SCALES:
  LQ  = 0.00 m         Lm  = 0.04 m         LM  = 14.10 m
  lm' = 99999 m         Lb' = 99999 m         La  = 99999 m
  (These refer to the actual discharge/environment length scales.)
-----------------------------------------------------------------------------
NON-DIMENSIONAL PARAMETERS:
Slot Froude number              FR0    = 576.71
  Port/nozzle Froude number       FRD0   = 71.12
  Velocity ratio                  R      = 3.56
-----------------------------------------------------------------------------
MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
  Toxic discharge                        = no
  Water quality standard specified       = yes
  Water quality standard          CSTD   = 0.15 mg/l
  Regulatory mixing zone                 = no
  Region of interest                     = 10000 m downstream
*****************************************************************************
HYDRODYNAMIC CLASSIFICATION:
  *-------------------------*
  | FLOW CLASS   = MU2 |
  *-------------------------*
  This flow configuration applies to a layer corresponding to the full water
  depth at the discharge site.
  Applicable layer depth = water depth = 0.78 m

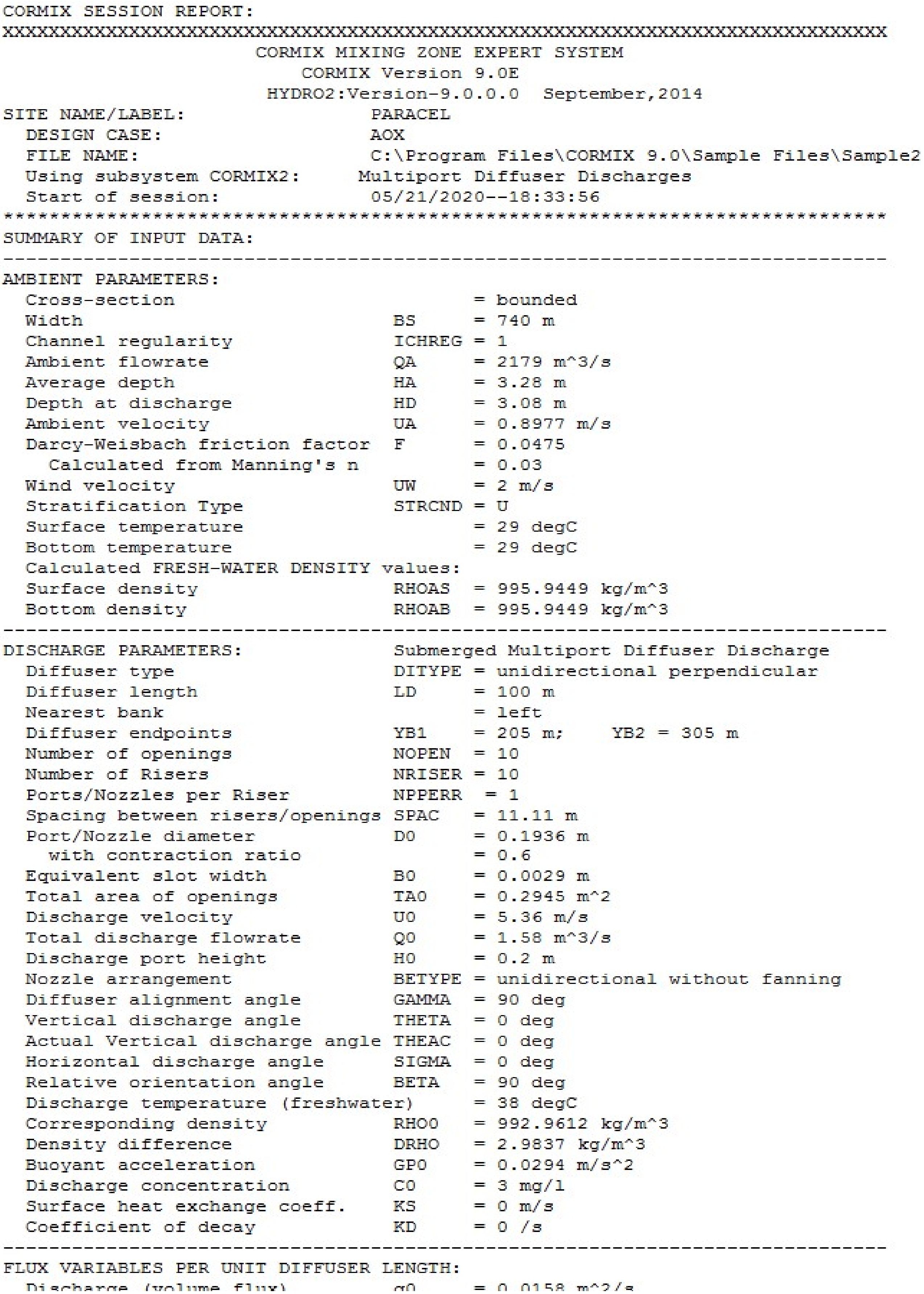
  Limiting Dilution S = (QA/Q0)+ 1.0 = 692.8

*****************************************************************************
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

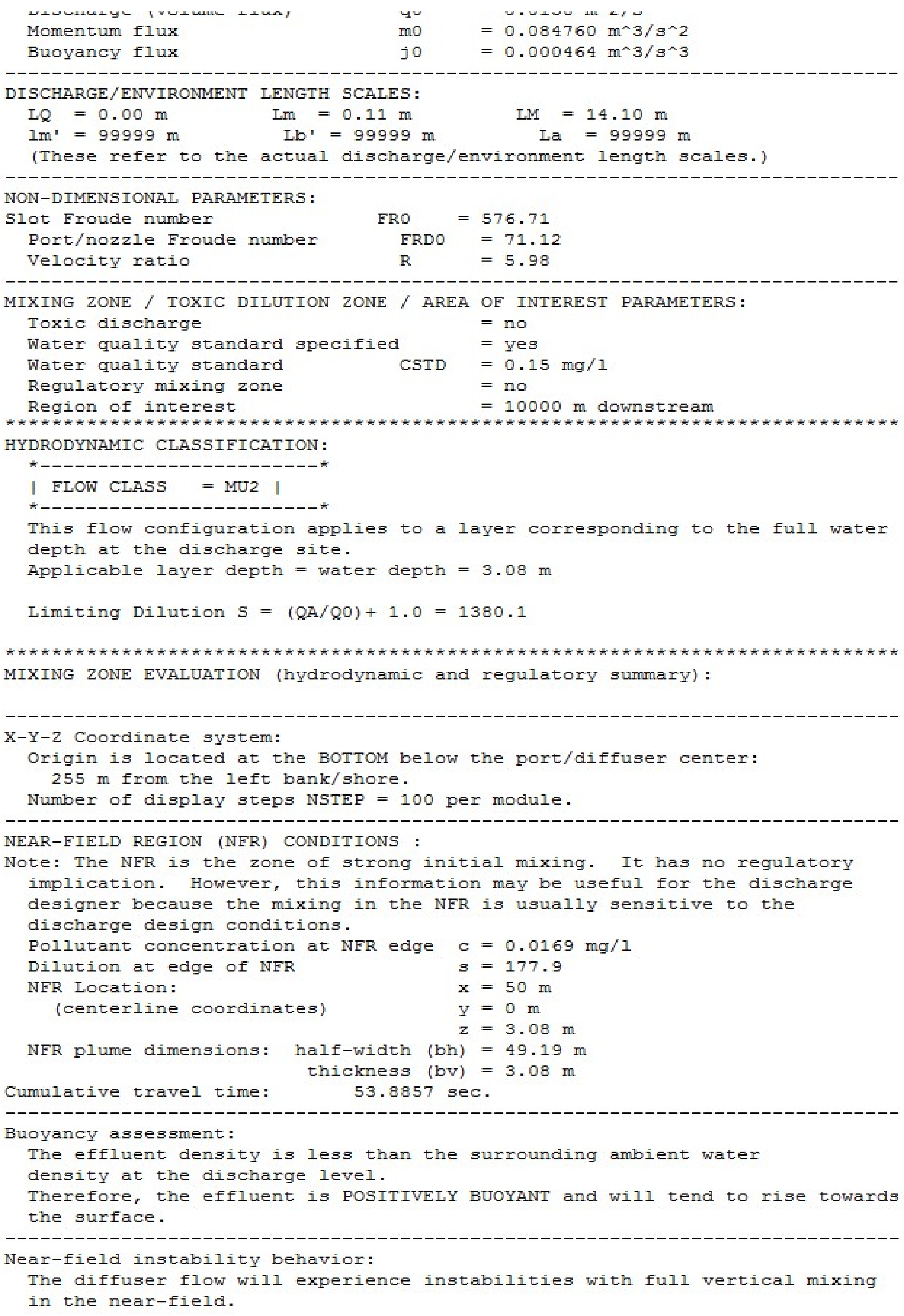
-----------------------------------------------------------------------------
X-Y-Z Coordinate system:
  Origin is located at the BOTTOM below the port/diffuser center:
    255 m from the left bank/shore.
  Number of display steps NSTEP = 100 per module.
-----------------------------------------------------------------------------
NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing.  It has no regulatory
  implication.  However, this information may be useful for the discharge
  designer because the mixing in the NFR is usually sensitive to the
  discharge design conditions.
  Pollutant concentration at NFR edge  c = 0.0394 mg/l
  Dilution at edge of NFR              s = 76.1
  NFR Location:                        x = 50 m
    (centerline coordinates)           y = 0 m
                                       z = 0.78 m
  NFR plume dimensions:  half-width (bh) = 48.89 m
                          thickness (bv) = 0.78 m
Cumulative travel time:       31.6932 sec.
-----------------------------------------------------------------------------
Buoyancy assessment:
  The effluent density is less than the surrounding ambient water
  density at the discharge level.
  Therefore, the effluent is POSITIVELY BUOYANT and will tend to rise towards
  the surface.
-----------------------------------------------------------------------------
Near-field instability behavior:
  The diffuser flow will experience instabilities with full vertical mixing
  in the near-field.
```



```
  There may be benthic impact of high pollutant concentrations.
-----------------------------------------------------------------------------
FAR-FIELD MIXING SUMMARY:
  Plume becomes vertically fully mixed ALREADY IN NEAR-FIELD at 50 m
  downstream and continues as vertically mixed into the far-field.
-----------------------------------------------------------------------------
PLUME BANK CONTACT SUMMARY:
  Plume in bounded section does not contact bank.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY ***********************
No RMZ has been specified.
However:
The ambient water quality standard was encountered at the following
  plume position:
  Water quality standard                 = 0.15  mg/l
  Corresponding dilution               s = 20.0
  Plume location:                      x = 0.5 m
    (centerline coordinates)           y = 0 m
                                       z = 0.22 m
  Plume dimensions:      half-width (bh) = 49.97 m
                          thickness (bv) = 0.10 m
```



```
CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
                      CORMIX MIXING ZONE EXPERT SYSTEM
                          CORMIX Version 9.0E
                       HYDRO2:Version-9.0.0.0  September,2014
SITE NAME/LABEL:                PARACEL
  DESIGN CASE:                  AOX
  FILE NAME:                    C:\Program Files\CORMIX 9.0\Sample Files\Sample2
  Using subsystem CORMIX2:     Multiport Diffuser Discharges
  Start of session:             05/21/2020--18:33:56
*****************************************************************************
SUMMARY OF INPUT DATA:
-----------------------------------------------------------------------------
AMBIENT PARAMETERS:
  Cross-section                            = bounded
  Width                           BS       = 740 m
  Channel regularity              ICHREG = 1
  Ambient flowrate                QA       = 2179 m^3/s
  Average depth                   HA       = 3.28 m
  Depth at discharge              HD       = 3.08 m
  Ambient velocity                UA       = 0.8977 m/s
  Darcy-Weisbach friction factor  F        = 0.0475
    Calculated from Manning's n            = 0.03
  Wind velocity                   UW       = 2 m/s
  Stratification Type             STRCND = U
  Surface temperature                      = 29 degC
  Bottom temperature                       = 29 degC
  Calculated FRESH-WATER DENSITY values:
  Surface density                 RHOAS  = 995.9449 kg/m^3
  Bottom density                  RHOAB  = 995.9449 kg/m^3
-----------------------------------------------------------------------------
DISCHARGE PARAMETERS:             Submerged Multiport Diffuser Discharge
  Diffuser type                   DITYPE = unidirectional perpendicular
  Diffuser length                 LD       = 100 m
  Nearest bank                             = left
  Diffuser endpoints              YB1      = 205 m;    YB2 = 305 m
  Number of openings              NOPEN  = 10
  Number of Risers                NRISER = 10
  Ports/Nozzles per Riser         NPPERR  = 1
  Spacing between risers/openings SPAC     = 11.11 m
  Port/Nozzle diameter            D0       = 0.1936 m
    with contraction ratio                 = 0.6
  Equivalent slot width           B0       = 0.0029 m
  Total area of openings          TA0      = 0.2945 m^2
  Discharge velocity              U0       = 5.36 m/s
  Total discharge flowrate        Q0       = 1.58 m^3/s
  Discharge port height           H0       = 0.2 m
  Nozzle arrangement              BETYPE = unidirectional without fanning
  Diffuser alignment angle        GAMMA    = 90 deg
  Vertical discharge angle        THETA    = 0 deg
  Actual Vertical discharge angle THEAC    = 0 deg
  Horizontal discharge angle      SIGMA    = 0 deg
  Relative orientation angle      BETA     = 90 deg
  Discharge temperature (freshwater)       = 38 degC
  Corresponding density           RHO0     = 992.9612 kg/m^3
  Density difference              DRHO     = 2.9837 kg/m^3
  Buoyant acceleration            GP0      = 0.0294 m/s^2
  Discharge concentration         C0       = 3 mg/l
  Surface heat exchange coeff.    KS       = 0 m/s
  Coefficient of decay            KD       = 0 /s
-----------------------------------------------------------------------------
FLUX VARIABLES PER UNIT DIFFUSER LENGTH:
  Discharge (volume flux)         q0       = 0.0158 m^2/s
```

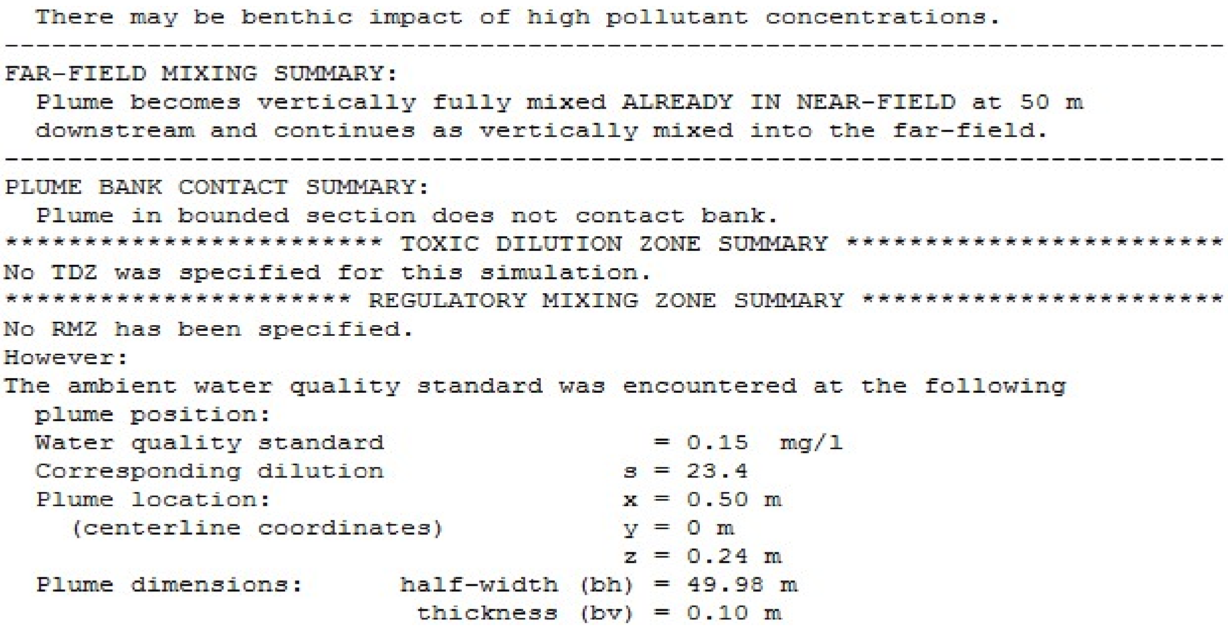


```
  Momentum flux                  m0     = 0.084760 m^3/s^2
  Buoyancy flux                  j0     = 0.000464 m^3/s^3
-----------------------------------------------------------------------------
DISCHARGE/ENVIRONMENT LENGTH SCALES:
  LQ  = 0.00 m         Lm  = 0.11 m         LM  = 14.10 m
  lm' = 99999 m         Lb' = 99999 m         La  = 99999 m
  (These refer to the actual discharge/environment length scales.)
-----------------------------------------------------------------------------
NON-DIMENSIONAL PARAMETERS:
Slot Froude number              FR0    = 576.71
  Port/nozzle Froude number      FRD0   = 71.12
  Velocity ratio                 R      = 5.98
-----------------------------------------------------------------------------
MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
  Toxic discharge                       = no
  Water quality standard specified      = yes
  Water quality standard         CSTD   = 0.15 mg/l
  Regulatory mixing zone                = no
  Region of interest                    = 10000 m downstream
*****************************************************************************
HYDRODYNAMIC CLASSIFICATION:
  *-------------------------*
  | FLOW CLASS   = MU2 |
  *-------------------------*
  This flow configuration applies to a layer corresponding to the full water
  depth at the discharge site.
  Applicable layer depth = water depth = 3.08 m

  Limiting Dilution S = (QA/Q0)+ 1.0 = 1380.1

*****************************************************************************
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

-----------------------------------------------------------------------------
X-Y-Z Coordinate system:
  Origin is located at the BOTTOM below the port/diffuser center:
    255 m from the left bank/shore.
  Number of display steps NSTEP = 100 per module.
-----------------------------------------------------------------------------
NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing.  It has no regulatory
  implication.  However, this information may be useful for the discharge
  designer because the mixing in the NFR is usually sensitive to the
  discharge design conditions.
  Pollutant concentration at NFR edge  c = 0.0169 mg/l
  Dilution at edge of NFR              s = 177.9
  NFR Location:                        x = 50 m
    (centerline coordinates)           y = 0 m
                                       z = 3.08 m
  NFR plume dimensions:  half-width (bh) = 49.19 m
                          thickness (bv) = 3.08 m
Cumulative travel time:       53.8857 sec.
-----------------------------------------------------------------------------
Buoyancy assessment:
  The effluent density is less than the surrounding ambient water
  density at the discharge level.
  Therefore, the effluent is POSITIVELY BUOYANT and will tend to rise towards
  the surface.
-----------------------------------------------------------------------------
Near-field instability behavior:
  The diffuser flow will experience instabilities with full vertical mixing
  in the near-field.
```



```
  There may be benthic impact of high pollutant concentrations.
-----------------------------------------------------------------------------
FAR-FIELD MIXING SUMMARY:
  Plume becomes vertically fully mixed ALREADY IN NEAR-FIELD at 50 m
  downstream and continues as vertically mixed into the far-field.
-----------------------------------------------------------------------------
PLUME BANK CONTACT SUMMARY:
  Plume in bounded section does not contact bank.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY ***********************
No RMZ has been specified.
However:
The ambient water quality standard was encountered at the following
  plume position:
  Water quality standard                 = 0.15  mg/l
  Corresponding dilution               s = 23.4
  Plume location:                      x = 0.50 m
    (centerline coordinates)           y = 0 m
                                       z = 0.24 m
  Plume dimensions:      half-width (bh) = 49.98 m
                          thickness (bv) = 0.10 m
```

ANNEX III

PRELIMINARY RISK ANALYSIS STUDY

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ENVIROMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA)

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Pulp Mill, Port, Transmission Line and Electrical Substation in Concepción – Paraguay

VOLUME IV - COMPLEMENTARY STUDIES
Preliminary Risk Analysis Study

Content

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1 INTRODUCTION

1.1 General

For more than four decades, process industries have developed a specific approach to potential failures and hazards arising from their activities, which can cause loss of life and property.

The industrial accidents contributed significantly to attract the attention of government authorities, the industry sector and the society as a whole, in order to look for mechanisms to prevent such episodes that may compromise the human safety and the environmental quality.

In the 1960s, there was a great development specially in the chemical and petrochemical industries, which were the most critical and represented a greater danger. At the same time, process facilities began to grow, and industries processes became more complex.

These developments did not occur in isolated form, the social context was also changing, and other problems, such as environmental pollution, began to be a concern among the people. As a result, the industry was forced to review the effects of its operations and reinforced the need for development in the area of risk assessment and loss prevention.

Therefore, the purpose of this study is to present the Preliminary Risk Analysis Study, which aims to identify, analyze and evaluate the potential hazards imposed on the environment and safety as a result of the activities related to the operation of the PARACEL pulp mill, with a capacity of 1,500,000 t/year of beached pulp for paper or 900,000 t/year of dissolving pulp, located in the municipality of Concepción, Department of Conception, Paraguay.

The mill will also be a source of clean energy, because the burning of biomass and wood liquor are renewable natural resources. 220 MW will be cogenerated in case of option for the production of bleached pulp is chosen, being that the plant will consume about 120 MW of electricity and there will be a surplus of 100 MW for sale in the grid; or in case the dissolving pulp process is chosen, 240 MW will be cogenerated and the mill will consume about 110 MW of electricity, with a surplus of 130 MW to export to the grid.

This study is part of the EIAp/RIMA PARACEL pulp mill and its purpose is to provide guidance to the licensing process for obtaining the environmental permit from the Ministry of Environment and Sustainable Development – MADES.

1.2 Methodology

This Preliminary Risk Analysis Study was carried out on the basis of the criteria of the TERM OF REFERENCE - Development of a Risk Analysis Study - punctual projects, from CETESB P4.261/2011 Standard. It should be noted that, due to the current licensing phase, the study was carried out until the hazard identification stage.

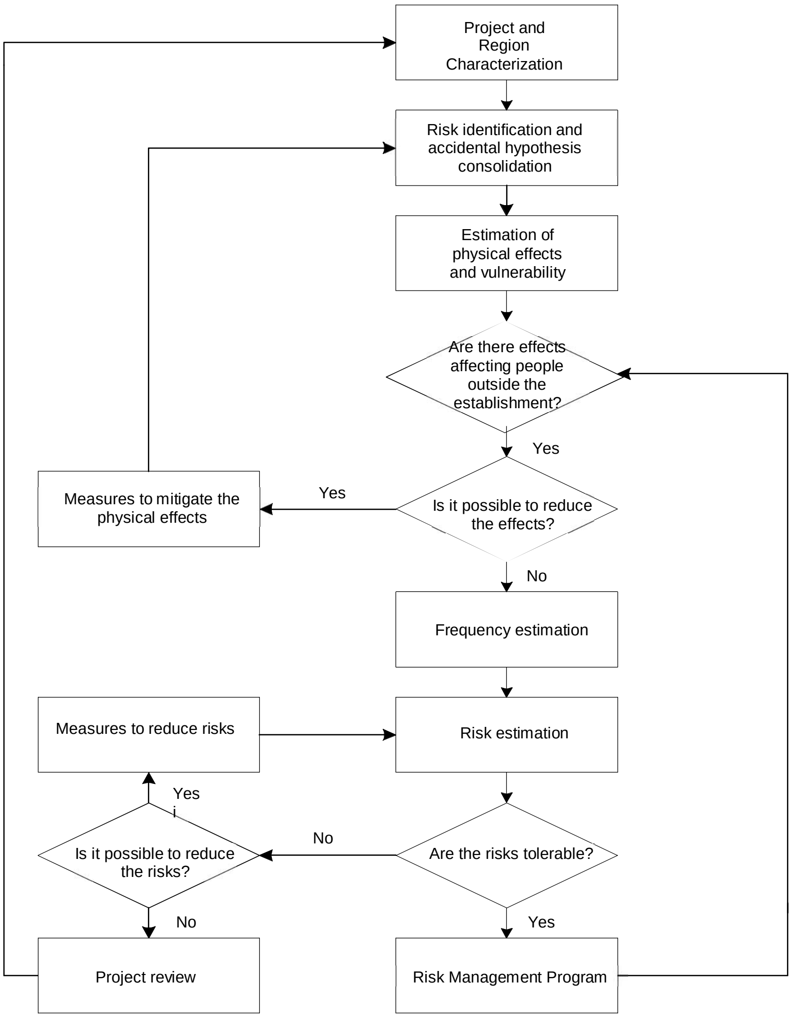


Figure 1 – Stages of the Preliminary Analysis Study elaboration

1.3 Project and Region Characterization

This stage presents the physical and operational aspects of the pulp mill, and the peculiarities of the region, covering the following items:

- Description/company history;
- Description of the design under study;
- Description of the region; and
- Meteorological data.

1.4 Physicochemical Characteristics of the Implicated Products

The physicochemical and toxicological properties of the product handled at PARACEL pulp mill, will be presented through the Material Safety Data Sheet (MSDS).

1.5 Identifying Hazards and Consolidating Accidental Scenarios

It consists on the application of the methodologies developed for the identification and characterization of events that can generate unintended consequences such as injury to people, property damage and impacts on the environment.

There are several techniques that can be applied in hazards identification. The technique applied in this study was Preliminary Hazard Analysis - APP.

2 PROJECT AND REGION CHARACTERIZATION

2.1 Project History

PARACEL is a Paraguayan project arisen from the innovative vision of the Zapag family. This vision, coupled with the experience of the Swedish group Girindus Investments, achieves the accession of other Paraguayan and foreign investors to carry out the largest productive industrial enterprise of the country and the largest private investment in the history of Paraguay.

The strength of this combination with enthusiasm, experience and capital in PARACEL, allowed today to crystallize the project of construction, and operation of a world-class pulp mill, attending the highest standards of environmental and social sustainability, and with the capacity to satisfy the most demanding international markets.

2.2 Project Information

2.2.1 Project Main Activity

The main activity of the mill is the production of 1,500,000 tons per year of bleached pulp for paper or 900,000 tons per year of dissolving pulp.

It should be noted that PARACEL pulp mill, despite being designed to produce 1,500,000 t/year, will be able in the future to produce up to 1,800,000 t/year of bleached pulp as a result of higher overall plant efficiency, as well as higher equipment performance without the need to increase the built area or include additional new equipment. In addition, no modification will be necessary in the main environmental control equipment, nor will there be any loss in their performance, which can guarantee the same emissions of liquid effluents and atmospheric emissions considered in this EIAp/RIMA. Therefore, it can be said that in the eventuality of increasing pulp production capacity up to 1,800,000 t/year, there will be no changes in the environmental impacts identified and evaluated in this EIAp/RIMA.

This mill will use as raw material eucalyptus logs, in addition to various chemical inputs.

To produce bleached pulp, PARACEL mill will use the *kraft* process, which is a technology known by pulp producing industries and engineering and equipment suppliers, and consulting services, as an additional it has advantages to obtain the high standards of whiteness and fiber quality required by the market, combined with energy self-sufficiency capacity and environmental advantages compared to other processes.

The process chosen for pulp bleaching production was ECF (Elemental Chlorine Free), which does not use elemental chlorine in its internal stages, avoiding the emission of organochlorinated compounds into the effluent.

The mill will also be a source of clean energy, because of the burning of biomass and wood liqueur, which are renewable natural resources. 220 MW will be cogenerated in case of option for the production of bleached pulp, being that the plant will consume about 120 MW of electricity and there will be a surplus of 100 MW for sale in the grid; or in case the dissolving pulp process is chosen, 240 MW will be cogenerated and the mill will consume about 110 MW of electricity, with surplus of 130 MW to export to the grid.

This mill will use the Best Available Techniques (BAT) as well as the Best Practices on Environmental Management (BPEM).

It should be noted that, in relation to environmental control systems, this mill will have the capacity to treat and purify the environmental emissions (liquid effluents, atmospheric emissions, solid waste) from production up to 1,800,000 tons per year of bleached pulp for paper or 1,100,000 tons per year of dissolving pulp.

PARACEL pulp mill operation will require the implementation of an internal and external support infrastructure that will include road access, the river port, the reception of raw materials, inputs, water intake and treatment, the proper treatment and disposal of effluents and systems for the treatment and disposal of solid industrial wastes.

2.2.2 Personnel

It is estimated that the labor force required for the implementation of the PARACEL pulp mill is approximately 8,000 workers during the period of greatest work and assembly.

For PARACEL pulp mill operation the total labor force, considering own and third-party employees, will be approximately 1,200 people.

The working day of the industrial area employees will be held in 3 shifts of 8 hours each. In the administrative area, the work day will be carried out in 8 hours during business hours.

2.2.3 Operating Regime

PARACEL pulp mill operation will be carried out 24 hours a day, 7 days a week and 12 months a year. The actual production period will be approximately 354 days, considering the annual equipment maintenance stop.

2.3 Location

PARACEL pulp mill will be located in the municipality of Concepción, near Paraguay River, about 15 km from the city center. The following figure shows the location of the project.

Figure 2 – PARACEL mil location. Source: Google Earth, 2020.

2.4 Brief Description of the Productive Process

Barked eucalyptus logs will be sent to the debarked and chopped/chipping lines, which will cut the wood into pieces named chip. The chips produced by the chippers shall be stored in a pile and then transported to the cooking area.

The chips have controlled dimensions, which allow the penetration of chemicals during cooking, which facilitates the softening of the wood and the decomposition of the fibers, separating them from the lignin, producing the so-called brown paste/pulp (dark cellulose).

Consequently, pulp is previously bleached, through a physicochemical process, using oxygen as the main reagent. The goal is to reduce the consumption of chemical reagents in the bleaching process and generate less organic load for the effluent.

Bleaching is a purification process that aims to remove much of the residual lignin. The goal is to obtain a high degree of whiteness. For this, more selective chemical reagents and milder working conditions are used.

The bleached pulp then goes to the drying and packing section, where the pulp leaf formation occurs, to ensure greater homogeneity and avoid breakage in the machine or irregularities in the product. Pressing aims to remove water by mechanical action, consolidate the position of the fibers and provide greater resistance for the wet leaf to pass through the drying. When dried, the water is removed by evaporation by applying heat to the pulp sheet. At the exit of the dryer, the leaves are cut, weighed and packed in bales of 250 kg. The bales are stacked in two groups of four, forming a load of 2 tons.

Chemical Recovery

The *kraft* pulp industry has a system that allows the recovery of the chemicals used to obtain the pulp.

Recovery begins with the evaporation of black liquor, increasing the dry solids content from 15% to about 80%.

After evaporation, the liquor will be sent for incineration in the recovery boiler. In the boiler, the organic matter presented in the liquor will be incinerated, leaving a molten mass, formed by the inorganic compounds that will be sent to causticizing section.

In causticizing, after clarified the green liqueur there will be produced the subsequent white liqueur.

2.4.1 Detailed Process Description

2.4.1.1 Reception and Wood Processing

The wood to be processed in the pulp mill is composed of six-meters-long eucalyptus logs, which will be debarked in the forests. The wood logs will be transported by road and/or waterway.

Figure 3 – Eucalyptus forest, with separation of bark in the field

The storage capacity of pulp logs in the mill is equivalent to an average consumption of ten days. Logs shall be stored in an internal paved yard near the receiving tables, with wood handling using mobile equipment such as wheel loaders or hydraulic cranes.

The forecast is that approximately 70% of the total wood is fed directly to the tables without going through the storage area.

Figure 4 – Discharge of eucalyptus logs into the wood yard.

Three lines of wood chipping are being considered.

The feeder table will be followed by a belt and roller conveyor to remove residual bark and other contaminants, a log cleaning station and a metal detector to protect the chipper.

The receiving tables will be fed by cranes (mobile or stationary) or diesel loaders.

Figure 5 – Wood chip pile

The chip storage will be based on the FIFO (First In First Out) principle in the open, with automatic stacking and restart, and will consist of two circular stackers / reclaimers with a rotating moving screw removal system. The storage capacity will be 3 days.

The three chip lines will be installed after the storage piles. The surplus will be collected and recovered to use the fibers for pulp production, or optionally, used as biomass for burning in the boiler. Accepted chips will be sent through a line of conveyor belts to the digestors.

The residual bark will be cut and sent together with the filtered residues (fine) to a covered biomass pile, with a storage capacity of two days, with automatic stacking and continuation. The mobile extractors will recover the biomass from the pile, which will then be sent to the biomass boiler.

Log cleaning water will be recovered and recirculated, although an amount of industrial water is needed to replace losses and maintain water quality. Solid waste contaminants in the wash water after it has been decanted into the water recovery system will be largely removed by a drag conveyor and discharged from the process.

2.4.1.2 Fiber Line

Cooking

The objective of cooking is to separate the fibers and other components of the chips through a chemical reaction.

Figure 6 – Cooking

Cooking is a chemical alkaline process, since it uses the chemical reagents sodium hydroxide (NaOH) and sodium sulfide (Na_2S), the main components of the white cooking liquor, to promote the dissolution of the components that bind the fibers to each other, under favorable and optimized pressure and temperature conditions in the digester, which is a large vessel under pressure.

The chips from the wood preparation sector will be fed into a chip silo where they will be heated with steam, then discharged through a chip metering screw, mixed with white liquor and pumped into the upper separator of the digester.

After a suitable reaction time in the digester, the obtained pulp will be removed from the interior by the discharge line and washed with black liquor, to reduce the concentration of organic matter accompanying the pulp.

The light black liquor extracted from the digester during the cleaning process will be sent to the evaporation plant, to be submitted to instantaneous evaporation.

The pulp will be sent to the discharge tank and then to the brown stock washing and knot separation areas. The purified pulp will be washed and delignified with oxygen.

Extraction of Lignin by Oxygen (Delignification)

The lignin extraction process using oxygen is one of the prior stages before bleaching, which additional lignin separation takes place, by means of reactions of the pulp with an oxidant agent in an alkaline environment. The aim is to reduce the consumption of chemical reagents in the final stages of the bleaching process as much as possible, recover the maximum amount of alkali applied and mitigate the generation of organic load for the effluent.

Bleaching

Bleaching is a purification process that aims to remove elements that would prevent complete bleaching of the pulp, such as resins and much of the residual lignin not dissolved in previous operations.

The aim is to obtain ECF (elemental chlorine free) pulp with a high degree of whiteness (90% ISO) and stability, without prejudice its physical-mechanical characteristics. This high degree of whiteness is required in the process and is achieved through the use of appropriate chemical reagents in several stages, each with specific operating conditions.

The bleaching plant will consist of four stages of medium consistency: A/D Eop D P (high-temperature chlorine dioxide, alkaline extraction, chlorine dioxide, and peroxide).

The bleached pulp will be sent to the storage towers, where it will be stored at a medium consistency and then fed to the drying machine.

Figure 7 – Bleaching

2.4.1.3 Drying and Packing

From the bleached pulp storage tower, the pulp is mixed, homogenized, purified and its consistency is precisely regulated. It is then sent to two drying machines in which the fiber suspension in water is subjected to the dewatering process, forming the pulp sheets (plates). The two machines will operate in parallel to satisfy the total production of the PARACEL pulp mill.

The pulp dryer will be the type “floating sheet”, which dries the pulp while keeping it floating on a cushion of steam-heated air.

Then, the pulp sheet will be sent to a cooler, and the output will be taken out through a press and directed to the cutter, which will first cut the sheet in the longitudinal direction, and then in the transverse direction.

The sheets cut to the programmed size will be stored, pressed into packs, and covered for later identification. The packs will also be stacked and unified, following for the pulp warehouse.

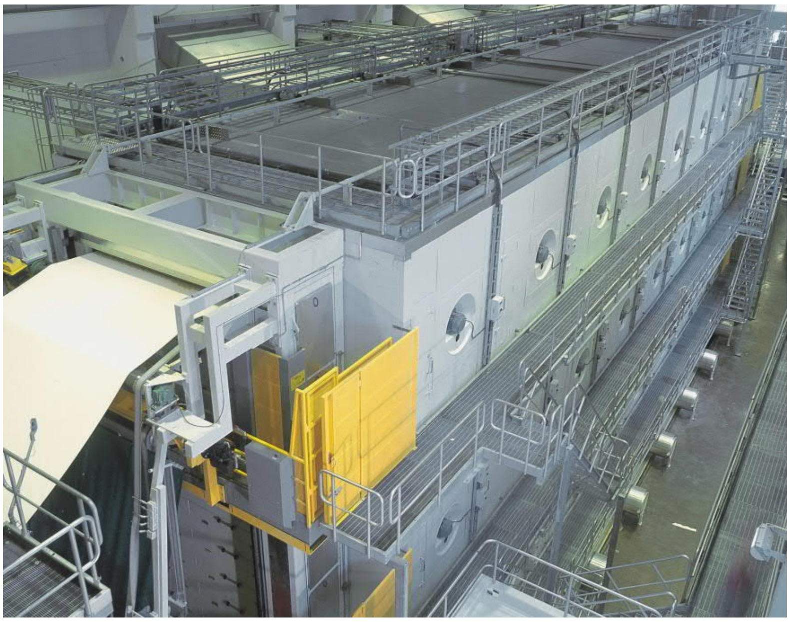


Figure 8 – Drying

2.4.1.4 Recovery

<u>Evaporation Plant</u>

The purpose of evaporation is to concentrate the black liquor from the cooking between initial concentration of 14.0 - 16.0% to final concentration of 80% solids.

The evaporation plant will be a multiple effect plant using low pressure steam. The final concentration of the liquor will be achieved in the various stages of the evaporators. The concentrated liquor produced will be stored for later burning in the recovery boiler.

The evaporation condensates will be segregated into different quality grades. Therefore, segregation is important to ensure sufficient quality in the condensates that will be used in other areas of the plant.

Condensate treatment and methanol rectifier plants will be integrated into the evaporation plant.

Contaminated condensate collected from the process will be treated in the condensate treatment and purification plant. The purified condensate will be used later in the process.

The gases from the extraction column of the condensate purification plant will be sent to the rectifier column for methanol extraction. The methanol produced will be used as an auxiliary fuel in the lime kiln or biomass boiler.

Figure 9 – Evaporation Plant

Recovery boiler

The purpose of the recovery boiler is:

- Recover chemicals used in cooking;
- Reduce sodium sulfate to sulfur;
- Generate steam using the energy resulting from the burning of organic materials extracted from the wood.

The boiler will be high efficiency, low odor type with a multilevel air system to burn liquor at 80%.

The steam generated at high pressure will be sent to the turbogenerators to produce electricity.

The combustion air will be introduced into the furnace on at least four levels, with forced circulation fans, to allow optimum control of combustion, reduction of NOx emissions and reduction of smelt.

The flue gases from the combustion will pass through an electrostatic precipitator, whose efficiency is expected to be over 99.7%. The precipitator's ash treatment system will be integrated into the recovery boiler or evaporation plant.

Concentrated and diluted non-condensable gases from the line will be incinerated in the recovery boiler.

Fuel oil will be used as initial fuel, to stabilize the production process and generating electricity.

Causticizing

In the causticizing, the green liquor from the recovery boiler will be transformed into white liquor, which will then be used to cook the wood. The green liquor is formed from the solubilization of the smelt formed in the recovery boiler.

This transformation is the reaction of sodium carbonate of the green liquor with lime (calcium oxide), obtaining sodium hydroxide and calcium carbonate, which will be separated by filtration.

Before coming into contact with the lime (calcium oxide and aggregates), the green liquor will be filtered to remove impurities (dregs). The dregs will be washed and filtered in a filter or centrifuge, specific equipment for this application.

Secondary condensate from the evaporation plant or warm water will be used to wash the dregs.

The lime residues (grits) will also be washed and, like the dregs, will be sent to the recycling center to generate soil correction, or even to an industrial landfill.

After the reaction of the green liquor with the lime, the white liquor will be obtained by filtering the mixture of sodium hydroxide (white liquor) and calcium carbonate (lime mud) through a pressurized disc filter.

The white liquor will be sent for cooking and the lime mud will be washed and dewatered in a vacuum disc filter before being sent to the lime kilns.

Secondary condensate from the evaporation plant or warm water will be used to dilute and wash the lime mud. The filtrate from the sludge filter will be pumped into the weak liquor tank.

The collection and recovery of all effluent from this area is planned, as well as the closing of the cooling water circuit.

Lime kiln

The purpose of calcination is to transform the calcium carbonate obtained from the causticizing into calcium oxide (CaO + inert) to be used in the reaction with the green liquor.

The calcination will take place in two parallel rotation kilns, lined internally with heat-resistant and insulating bricks and then heated by the combustion of fuel oil or another alternative fuel that can be used in the future (biomass gas).

As an auxiliary fuel, the furnaces can burn methanol from condensate stripper.

The lime kilns will be equipped with an external dryer for the lime mud and coolers for the burnt/calcined lime.

Through an electrostatic precipitator, dust will be removed from the exhaust gases and can be returned to the lime kilns or disposed of (lime mud purge).

The flue gases will be sent to the chimney (common with the recovery boiler), from where they are released to atmosphere.

Figure 10 – Lime Kilns

2.4.1.5 Chemical handling, preparation and storage area (chemical plant)

The description of this area corresponds to differentiated systems to meet the requirements of chemical supply to the pulp mill. All chemical storage tanks shall have retention walls with a volume at least equivalent to the maximum storage volume.

Figure 11 – Chemical Plant

The area of chemical products will include:

- Discharge, handling and storage of sodium hydroxide;
- Discharge, handling and storage of sulfuric acid;
- Discharge, handling and storage of sodium bisulfite;
- Unloading, handling and storage of hydrogen peroxide;
- Unloading, handling and storage of sodium chlorate;
- Unloading, handling and storage of methanol;
- Plant for the production of chlorine dioxide;
- Plant for the production of oxygen;

Storage volumes

The volumes of chemical storage tanks are presented in the following table.

Table 1 – Chemical substances

Chemical substances	Volume (m^3)
Sodium hydroxide 50%	2 x 750
Sulfuric acid	2 x 350
Sodium bisulfite	120
Hydrogen peroxide	600
Sodium chlorate, solution	510
Methanol	160
Chlorine dioxide, 10 g/l	2 x 830

Description of chemical plant processes

Handling and storage of sodium hydroxide

Sodium hydroxide 50% will be unloaded from trucks through centrifugal pumps and deposited in the storage tanks. Most of this solution will be transferred for use in the pulp liquor, lignin extraction (delignification) and bleaching system.

Other areas of the manufacturing process will also use sodium hydroxide, such as water treatment plant, boiler water treatment plant and effluent treatment plant.

Handling and storage of sulfuric acid

The sulfuric acid (96% concentration) will be discharged from trucks by pumping and stored in a closed tank to prevent the entry of moisture. The sulfuric acid will be used in the chlorine dioxide generator, in the acidification of the pulp in the bleaching process, in the treatment of the boiler water and in the effluent treatment plant.

Handling and storage of sodium bisulfite

The sodium bisulfite will be discharged and stored in a tank, and then sent to a storage tank. The sodium bisulfite will be used for bleaching.

Handling and storage of hydrogen peroxide

The hydrogen peroxide will come to the pulp mill by truck, to be supplied in solution. From the storage tank, the product will be distributed for bleaching.

Handling and storage of sodium chlorate

Sodium chlorate will be the main raw material for obtaining chlorine dioxide and will be transported in liquid form in trucks that will be unloaded by the pump and stored in a tank, from where the product will be sent to the chlorine dioxide production plant.

Methanol handling and storage

The methanol will be transported to the pulp mill by truck and then unloaded by pump and stored in a tank. From the storage tank, the product will be sent to the chlorine dioxide production plant.

Chlorine Dioxide Production Plant

Chlorine dioxide is produced by a process in which sodium chlorate reacts with a reducing agent (methanol) in an acidic environment and in a vacuum, the reaction of which is presented below. Sodium sulphate, obtained as a by-product of chlorine dioxide generation, will be used as a sodium and Sulphur make-up in the pulp mill.

$$\mathbf{3\ NaClO_3 + 2\ H_2SO_4 + 1/2\ CH_3OH \rightarrow}$$
$$\mathbf{3\ ClO_2 + 2\ H_2O + Na_3H(SO_4)_2 + x\ HCOOH + y\ CO_2 + z\ CH_3OH}$$

The chlorine dioxide generator will be the main equipment in the process, which is a vessel (recipient usually made of titanium) where the sodium chlorate ($NaClO_3$) reacts to form ClO_2.

The generator will be designed to optimize the efficiency of the reaction, promote the growth of salt cake crystals, promote efficient gas-liquid separation and sufficient volume for easy control of the concentration of the reagents. It should be noted that the design of the components of this circuit aims to eliminate internal cleaning of the reactor.

The rate of evaporation of the water will be equal to the rate of water entering with the supply of chemicals and utilities to the generator. The partial pressure of the chlorine dioxide will be maintained at a safe level by partial vacuum and dilution with water vapor. Normally, the vacuum in the ClO_2 reaction is produced by a steam ejector.

The effluent water from the gas depurator will be transferred to the main absorption tower and consequently all the ClO_2 in the vent gases will be recovered and added to the chlorine dioxide solution.

The resulting chlorine dioxide gas from the generator will be cooled and absorbed in a tower, using cool water. The resulting product will be a strong, chlorine-free ClO_2 solution.

As the ClO_2 generator gas will not have any diluent gas like air or chlorine, the absorption efficiency will be high to reach concentrations above 10 g/l ClO_2.

The chlorine dioxide solution will be pumped into the storage tanks for use in the bleaching process.

Sodium sesquisulphate ($Na_3H(SO_4)_2$) crystals formed in the generator will be pumped for filtration to remove solids. The filter shall be equipped with a hot washing system. The sodium sesquisulphate will be discharged into a dissolution system where it will be neutralized and pumped to the plant.

Oxygen Production Plant

Oxygen production will be carried out through a plant dedicated to execute lignin extraction (delignification), bleaching and white liquor oxidation.

Oxygen generation can be performed by purifying the atmospheric air through the Vacuum Swing Adsorber (VSA) process, through molecular filters.

At the beginning of the process, the atmospheric air will pass through a filtration system, where solid particles will be removed.

The air will then be sucked in and subjected to a vacuum regime, sufficient to allow the air to flow into the purification system.

The air purification system consists mainly of adsorbent vessels, which operate in cycles. By passing through a molecular sieve bed, the moisture, CO_2 and nitrogen from the air will be removed from the main stream.

The purified air, rich in oxygen, will leave the purification system and then go to the oxygen compressor, which will compress it to the conditions necessary for its use. The waste gas will be discharged to the atmosphere through the silencer.

Product transport system

The transport of the main chemical products in liquid form will be done in bulk, using tank trucks.

It is worth mentioning that transport companies must have specific training for drivers and operators in traffic management, education and safety, in order to reduce the risks of accidents.

Chemical Plant Operational Control and Safety System

Safety and control equipment and protection structures

The chemical plant must have the following equipment and structures for storage, containment, control and safety:

- Chemical product unloading platforms, provided with containment systems through low walls;
- Storage of liquid products in metal tanks, made of carbon steel, stainless steel or fiberglass (the material will depend on the type of chemical to be stored);
- Concrete containment dikes for chemical storage tanks;
- Containment channels in the production areas and in the chemical products storage;

- Remotely operated process monitoring instruments (level, pressure, temperature, among others) to minimize the need for operators in the production or chemical storage area. Remote operation can be performed by dedicated remote control systems;
- With respect to chlorine dioxide, the following measures are foreseen:
  - Chlorine dioxide leak detection system;
  - Constant ventilation system for the tanks (with backup source);
  - Fixed foam system around the containment tank to prevent gas emission in case of leakage.
- Atmospheric Discharge Protection Systems provided with grounding networks or lightning arresters;
- One of the points of attention regarding chemical products from PARACEL's pulp mills is the transfer system from the Chemical Plant to the using points, that will be done by pipe rack, which avoids manipulation by operators and minimizes the risk of accidents.

Chemical Plant Fire Control System

The chemical plant's internal network of hydrants will be distributed in the form of a ring that will be fed by the main network of hydrants.

The hydraulic and lubrication units, depending on the volume, can be protected by an automatic sprinkler system controlled by an activation valve and independent alarm. In addition, each hydraulic and lubrication unit will be installed within a containment dyke with a volume sufficient to maintain the full volume of oil in the unit.

Portable fire extinguishers will be installed where necessary in accordance with Fire Department requirements.

Fire Department regulations also require the installation of signs in the area reserved for fire extinguishers.

The methanol storage tank must have a protection system in accordance with FM Global standards. Flood protection systems will be installed for this tank and for all metal structures that may collapse in the event of a fire in the tank or other methanol handling equipment.

The sodium chlorate storage building will be protected by an automatic system with sprinklers controlled by an independently acting system and an alarm valve.

Chemical Plant Environmental Management System

In general, the environmental management system proposed for PARACEL's Chemical Plant will have as its main guidelines the elements described below. It is worth mentioning that this system is commonly used in pulp mills around the world.

- The equipment will be designed to operate with the necessary efficiency to minimize the environmental impacts of the activities in the area;

- Installation of instrumentation to monitor and control the process;
- Implementation of an operational process control system through inspections with determined frequency, including the collection of samples and respective laboratory analysis;
- Characterization of process variables that are critical to the environment, to employee safety and to process safety;
- Maintenance management: characterization and registration of critical process equipment and instruments that require preventive/predictive maintenance, through maintenance programming of specific maintenance control software;
- Operation, maintenance and management teams with adequate training and technical skills to meet the requirements of the area;
- Structured system to identify and manage the environmental aspects and impacts and the hazards and risks of the unit, with the aim of implementing preventive actions to reduce risks and protect people and the environment;
- Implementation of an Emergency Action Plan structured to minimize the impacts of accidents, in case of emergencies;
- Structured system to analyze non-conformities and/or accidents and implement corrective actions to avoid recurrence.

2.4.1.6 Utilities

2.4.1.6.1 Industrial Water Intake and Supply

The construction of a Water Treatment Plant (WTP) is planned to serve the consumption of the PARACEL pulp mill.

The water will be intake from the Paraguay River, through a surface intake system consisting of a channel and a grid.

Figure 12 – Example of surface water collection.

It is important to note that the collection will be "wire operation" type, it means, no dam system will be built.

Four pumping systems of 2,350 m³/h each will be installed, with a total intake flow of 7,000 m³/h to supply the PARACEL pulp mill.

A 1,100 mm diameter raw water pipe will be installed.

The raw water, which arrives at the Water Treatment Plant, will be treated with aluminum sulfate, sodium hydroxide and sodium hypochlorite, the latter being used to promote the elimination of iron, in addition to oxidizing the organic matter present. After the coagulation process, polyelectrolyte will be added to promote flocculation.

Then, by gravity, the flocculated water will go to the solids removal unit, through a dissolved air flotation system or similar. The formed sludge will be periodically and automatically discharged into the central discharge channel. The collected sludge will be compacted and dewatered and then sent for final disposal.

By gravity, the clarified water will be conducted through channels to the gravity filters. After filtration, the treated water will be stored in the treated water tank that will supply the PARACEL pulp mill's various consumption points, including water for fire control and potable water. The total production capacity of treated water will be 6,700 m³/h.

2.4.1.6.2 Boiler Feedwater Plant

The water to replace the non-returned live steam condensate losses from the process will be treated by demineralization, reverse osmosis type, with final polishing through mixed beds.

The replacement water will be pre-purified by filtration through sand filters, activated carbon filters and mechanical cartridge filters before passing through the permeate. The permeate waste will be used to replace the water sealing system.

The deaerator, storage tank and feed water pumps, as well as the steam condensate collection tank, will be installed in the recovery boiler building and serve both the recovery boiler and the power boiler.

The steam condensate collected from the departments will be pumped through mechanical filters into the boiler feedwater tank.

The feed water pumps will be driven by an electric motor with a hydraulic variable speed drive. The backup pump will be powered by a steam turbine.

2.4.1.6.3 Cooling towers

The cooling water system shall be in a closed circuit, and counterflow towers with an air extractor at the top are considered to serve the following pulp mill processes:

- Cooling tower for turbogenerator + utilities: turbogenerator condensers, biomass and recovery boilers, air conditioning system chillers, turbogenerators, causticizing and lime kiln, fiber line, chemical plant, cooking, drying, wood handling and compressed air system.
- Evaporation cooling tower: evaporation plant

Figure 13 – Cooling towers

2.4.1.6.4 Biomass boiler

The function of the biomass boiler will be to supplement the steam generated in the recovery boiler for energy generation, by using waste from the preparation of wood for cooking.

Waste from wood handling and brown pulp disposal will be mixed and stored in a covered biomass pile where it will be sent to the boiler silos.

The steam produced by the biomass boiler will be mixed with the steam from the recovery boiler and sent to the turbogenerators.

An electrostatic precipitator will be installed to control air emissions.

The biomass boiler can burn methanol as an auxiliary fuel, thus being a backup burning system for lime kilns.

Bottom ash from the boiler and the precipitator will be collected in dedicated silos for subsequent disposal.

The fuel oil will be used as a starting fuel, stabilizing the production process and eventually to oxidize non-condensable gases when they are diverted to the biomass boiler.

2.4.1.6.5 Electricity Cogeneration (Turbogenerators)

The cogeneration system begins with the production of high-pressure steam by the recovery boiler and the biomass boiler.

The high-pressure steam will undergo expansion in the turbine blades and will be extracted at different pressure levels for use in the pulp manufacturing process.

Turbogenerators will have the purpose of transforming the thermal energy of the high-pressure steam into mechanical energy to activate the electrical energy generators.

The supply of steam to the turbogenerators will cover the operation, plus the contingency. The contingency is considered to absorb any variation in steam production in the recovery boiler due to variations in the solids contained in the liquor or even considering calorific value.

It is planned to install 2 turbogenerators for total generation of up to 220 MW in case of producing pulp for paper. In the first scenario, pulp production will consume about 120 MW, with a surplus of 100 MW to be exported to the grid. For the dissolving pulp option, the generation will be 240 MW, the PARACEL mill will consume about 110 MW of electrical energy, with a surplus of 130 MW to be exported to the grid.

System control and monitoring measures (including protection of steam overpressure)

Variations in steam consumption can still occur during normal pulp mill operation, with pressure control through turbines and control valves. The control and interlocking of the turbines will be carried out by means of a dedicated system, complemented by controls for the admission and extraction of steam from the turbines: pressure reduction and conditioning valves, exhaust valves and, in the latter case, safety and relief valves.

Operation monitoring covers the following components:

- indicating instruments;
- data logging instruments;
- position indicators;
- audible and visual alarm system.

The values presented by the instruments must be compared with the design values and the measuring instruments must be checked and calibrated at regular intervals.

In case of occurrence and detection of any abnormality, the maintenance team shall be informed so that corrective action can be taken.

Fire prevention and control system

Recovery boiler and biomass boiler

The boiler area will have dedicated fire prevention and control systems, which are described below.

The internal network of hydrants in the recovery boiler and biomass boiler will be distributed in the form of a ring that will be fed by the main network of fire extinguisher. The fire extinguisher will be installed at high levels in the recovery boiler building and the biomass boiler, considering a minimum action flow with adequate pressure.

Depending on the volume, the hydraulic and lubrication units can be protected by an automatic sprinkler system controlled by a separate system of activation valve and alarm. In addition, each hydraulic and lubrication unit will be installed within a containment dyke of sufficient volume to maintain the full volume of oil in the unit. Portable fire extinguishers will be installed where needed in accordance with Fire Department regulations.

Fire Department regulations also require the installation of signs in the area reserved for fire extinguishers.

Turbogenerators

The internal network of fire extinguisher in the Turbogenerators area will be distributed in the form of a ring that will be served by the main fire extinguisher network. The hydraulic and lubrication units, depending on the volume, can be protected by an automatic sprinkler system controlled by an independent activation valve and alarm. In addition, each hydraulic and lubrication unit will be installed within a containment dyke with a volume sufficient to maintain the full volume of oil in the unit.

Sprinklers will be installed:

In the region where the turbogenerator springs are located;

In all areas where oil can flow or accumulate.

Portable fire extinguishers shall be installed in the necessary locations in accordance with the requirements of the Fire Department.

Fire Department regulations also require the installation of signs in the area reserved for fire extinguishers.

Possible fuel oil leakage points, such as flanges, threaded connections, etc., depending on the pressure, may be protected to prevent fires in the form of spray.

Turbogenerator noise emission

The Turbogenerators, which will be enclosed in a dedicated building, will be remotely operated and the control room will be located at a certain distance. In addition, operators, who eventually need access to the area, must use the appropriate Personal Protective Equipment.

Steam and energy balance

The following steam balance shows the steam generated for turbogenerators and other uses.

2.4.1.6.6 Fuel storage

Fuel will be used accordingly in the areas of recovery boilers, biomass boilers and lime kilns, on the following occasions:

- Pulp mill start up;
- Annual preventive maintenance of the pulp mill with the consequent start up;
- Temporary situations of operation.

The volume of fuel oil storage will be 3,000 m³, being heated and distributed to consumers at a temperature of 70 ºC.

Fuel Storage Area Fire Control System

For the fire control system in the fuel storage area, hydrants will be installed in appropriate locations to provide cooling to the tanks, in addition to foam lines to combat occasional spills from the tanks.

All the hydrants around the tanks will be equipped with accessories for the manual supply of foam and adjustable nozzles for the production of water mist.

Portable fire extinguishers will be installed where necessary in accordance with Fire Department regulations, including portable dry chemical and foam extinguishers, which will be installed near the fuel oil pumping and discharge station.

Where appropriate, tanks shall be equipped with a fixed internal foam dispersal system.

Fire Department regulations also require the installation of signs in the area reserved for fire extinguishers.

2.4.1.6.7 Compressed air

Both the service air (pulp process) and the instrument air will be treated in a dryer to remove moisture, but there will be 2 separate air grids, one for the service (process) air and one for the instrument air.

The operating pressure shall be 7 bar (g), using an oil-free centrifugal compressor and an adsorption-type dryer.

2.4.1.6.8 Ventilation and air conditioning

The electrical rooms and the control rooms will be equipped with a fan coil air conditioning system with a chilled water plant. The water for the chiller will come from the cooling tower pumped through a dedicated.

2.4.1.7 Administrative and operational support facilities

Gatehouse

The PARACEL pulp mill will have a gate to control the access of people and vehicles.

Administrative Building

The administrative building will consist of offices, bathrooms, cafeteria and clinic.

Parking for cars and trucks

PARACEL's pulp mill will have parking for employees and visitors. In addition, there will be parking for trucks.

Weigh machine

Two weighing machines will be installed to control the entry and exit of wood and inputs to the pulp mill.

Storage

Next to the administrative building there will be a warehouse to store general materials.

Warehouse

The warehouse will be used to maintain industrial equipment and there will be reinforced concrete floors, waterproofed by masonry walls to contain any spills.

River port

The river port of the pulp mill will be a terminal-type construction on the left bank of the Paraguay River, built as an elevated platform on a structure composed of: an operating platform, an access bridge for vehicles and people, and a shed structure for the pulp transport area. All the structures will be made of reinforced concrete and the loading roof will be made of a metal structure. It will be implemented from the shore through the sustainable methodology of the Cantitraveller type with prefabricated elements.

The port will move the following loads:

- Pulp transport by river barges at an average rate of 1,500,000 t/year;
- Reception of logs with volumes varying between 2 and 5 million m³ s sc/year;
- Reception of inputs for the pulp mill (liquid or bulk) up to 450,000 t/year.

The boats that will operate in the port will be the current models in circulation in the fluvial section of the Paraguay River with the format of convoys according to the official conditions of navigation. The typical pulp convoy will consist of 12 barges (3 x 4) with a unit capacity of up to 2,500 tons each.

The boats for wood and inputs will be suitable for each of the operations/products and will be regulated by the navigation conditions.

No dredging actions will be required for the approach channel, the evolution basin and the anchorage area of the vessels (barges and pusher craft). For platform or access bridge construction services, bottom forming services may occasionally be required at the site of underwater structures.

The selection of the positioning of the river port was defined according to the format of the pulp mill area and the morphological characteristics of the Paraguay river, using the 3320 nautical reference table.

The selected point is characterized by having natural draft conditions for boats (pulp barges) without the need for deepening actions or maintenance of dredging and preserves the conditions of regular distance from the navigation channel, in accordance with the premises and institutional regulations.

The train anchorage areas are located upstream of the river port for empty trains awaiting cargo and downstream for loaded trains awaiting final train formation.

Facilities Description

AWT

The AWT (All Weather Terminal) will have an area of approximately 4,600 m² and will be completely developed in metallic structure, therefore, the covering, the closings and the beams will be metallic. The 56 t capacity crane support columns will be made of precast concrete.

Support Building and Pump Room

These buildings will have a conventional concrete structure, structural masonry, precast slab and metal roof. The support building will house bathrooms, meeting rooms and control rooms with an area of 127 m². The pump room will have an area of approximately 44 m².

Mooring Points

The design includes 12 (twelve) tie-down points, 2 (two) main protection points and 11 (eleven) protection points of the AWT roof columns.

It is planned to use metal jacketed perforated inclined piles filled with reinforced concrete and their respective blocks, which consist of a precast bark element for the second subsequent concreting step.

Barge Pier

The barge dock will have a 133 m x 32 m wide reinforced concrete platform, with an area of 4,256 m². Its structure will be made of perforated metal-clad piles filled with reinforced concrete, beams and precast slabs in solidarity with the reinforced concrete in situ.

Access Bridge

As well as the pier, the access bridge will be made up of a 340 m x 10 m wide reinforced concrete structure with an area of 3,400 m². Its structure will be made of perforated metal-clad piles filled with reinforced concrete, beams and precast slabs in solidarity with the reinforced concrete in situ.

2.5 Environmental Control

2.5.1 Liquid Effluent

2.5.1.1 Generation sources

Basically, the sources of liquid effluent generation that will correspond to the activities of the pulp process and other support activities are the following:

- Effluents from the wood preparation area;
- Effluents from the cooking and brown pulp depuration area;
- Alkaline and acid filtrates;
- Drying machine effluents;
- Effluents from evaporation and recovery;
- Effluents from the causticizing and lime kiln area;
- Contaminated condensates;
- Sanitary effluents;
- Contaminated rainwater; and
- Miscellaneous (spills, leaks, cleaning of various areas, etc.).

2.5.1.2 Spill control system

The spill collection and management system has been designed so that accidental discharges can be collected as close as possible to the source and recycled directly to their own process stage.

The main approaches are:

- Dam with retaining walls around tanks and equipment where there are black or white liquors and chemicals. In the event of an accidental leak or spill, the material will be collected and returned directly to the process;
- Tank systems and equipment that will allow excess liquor to be properly conducted when emptying is required for maintenance. Process liquor will be taken to a spill tank and returned directly to the process instead of being discharged to the effluent network;
- In areas with potential for spills, there will be interconnection of the floor channels with the pumping wells, from which the liquids will be returned to the process;
- Emergency lagoon in Effluent Treatment Plant, where the effluents can also be directed in the event of spills that have not been contained with the means previously provided;
- Appropriate instrumentation for on-line effluent monitoring, and a good monitoring system to help operators detect accidental discharges and take appropriate corrective action; and
- Training of operators, process managers and information systems, where environmental problems and accidental discharges require continuous attention.

Digester and brown pulp line

Accidental discharges from this area may have black liquor and fibers and must be recovered.

A spill tank will be installed. The preferred point of return from this tank will be the dilution at the bottom of the discharge tank.

Whenever possible, overflows and drains from process equipment should be connected directly to the spill tank or, alternatively, to the feed tank before the equipment.

Any additional spills will be collected in floor channels and taken to a well, from where they will be pumped into the spill tank.

Bleaching

Overflows and spills in this area may contain fibers, filtrates and chemicals such as caustic soda, chlorine dioxide and sulfuric acid. Accidental fiber losses will be sent to the effluent treatment plant and separated in the primary treatment. The chemicals will be neutralized before being sent to the effluent treatment plant.

Drying Machine

Overflows and spills from this area contain fibers, but not a significant amount of dissolved elements. If not collected in the area, the fiber losses will be sent to the effluent treatment plant and separated in the primary treatment.

Evaporation

Accidental discharges from this area have a high black liquor content and must be recovered. The basic treatment is similar to that of the cooking area and the brown pulp line.

Spills from this area will be directed to the liquor spill tank, from where they will be sent to the liquor tank, with the proportional feeding. The liquor from the evaporation wash water will also be channeled to this tank, as well as any excess of contaminated condensate, in case of problems with condensate polishing.

The steam condensates from the second to last effect of the evaporator will be segregated and the condensate from the clean section of these effects will be recycled to some of the effects at the front end for internal extraction to produce condensate "A" to be used in the fiber line and in the causticizing area. Condensate "A" is a cleaner condensate, which allows it to be reused in the process.

The floor channels will be connected to a collection pit, from which the spills will be returned to the liquor spill tank. The tank will be installed inside a containment tank.

Recovery boiler

Accidental discharges or spills from this area have a high black liquor content and must be recovered. The basic treatment is similar to the cooking area and the brown pulp line.

Spills from the upper floors will be collected and sent to an unloading tank, and will go to the collection pit, which will also receive spills on the ground floor. These spills will be pumped into an overflow tank at the evaporation plant, where they will be recovered.

Causticizing

In this area, spills will be collected and sent to two collection wells, which have an agitation system, conductivity measurement and pumps. If the spill is within a certain conductivity range, it will be sent to the clarifier for recovery.

A lime mud recovery system is foreseen in case of unscheduled lime kiln stops. The temporary storage of the lime mud will be carried out in a paved place with walls, avoiding its loss.

Other areas

The chemical preparation area will be surrounded by retaining walls. In addition, the chemical tanks will also be contained by dikes. If there is a spill in the area, they will be sent to mixing tanks to adjust the pH and then sent to the effluent treatment plant.

Fuel oil storage will also be contained by retaining walls with a well. In the event of a spill, a pump will be installed to send the fuel to a tanker truck. Fuel oil heaters in process areas should have their own containment walls.

All process areas will have a spill system, gate system, and effluent conductivity. After a certain conductivity, the effluent is recovered in the process.

2.5.1.3 Effluent Treatment Plant (ETP)

The pulp mill industrial liquid effluent will be measured for flow, temperature, pH and conductivity and, depending on the results, diverted to emergency lagoon. The other part of the treatment system description is below.

Specific effluent

Effluent from the chlorine dioxide plant, ash leaching, and boiler make-up water plant will also be segregated from the main lines, as they have no organic load, requiring only pH control before release. The specific neutralized effluent will be added to the other treated effluent in the treated effluent tank for disposal in the Paraguay River.

Sanitary effluent

Sanitary effluent generated at the mill will be collected from the sanitary effluent network and sent to the ETP directly for biological treatment.

Summary of the Effluent Treatment System

PARACEL's effluent treatment system will basically consist of three stages: solids removal, organic load removal and final polishing. The main units of this system are listed and described below.

The main stages of the effluent treatment process are:

- Screening;
- Primary clarifier;
- Emergency lagoon;
- Neutralization;
- Cooling;
- Activated sludge - aeration tank;
- Secondary clarifier;
- Tertiary treatment;
- Emissary.

Screening

Effluent will be directed by gravity to a screening system to remove coarse materials. This system will have 2 sets composed of a mechanized screen and a manual screen, which will be used when the mechanized screen was subjected to maintenance.

Primary clarifier

After passing through a grid system and flow measurement, the effluent will be sent to two primary clarifiers with a diameter of 68 m to reduce the amount of suspended solids. These clarifiers will be equipped with a scraper to remove sedimentary solids and surface foam. The settled solids and the slag will be removed by pumps that will be sent to the primary sludge dewatering system. The clarified effluent will be sent to the neutralization system.

Primary sludge dewatering system

The primary sludge dewatering system will have a total capacity of 42 tDS/day. Each assembly will consist of a mechanical drum type or gravity type table thickener and a screw type dewatering press. The expected final consistency of the dewatered sludge is between 35 - 45%.

Emergency lagoon

In addition to the systems for preventing and collecting leaks and spills in each department of the mill, there will be a set of emergency lagoon at the effluent treatment plant. The purpose of these lagoons will be to receive all effluent with characteristics that are out of specification. Once discharged into the emergency lagoon, these effluents will be sent at the inlet to the neutralization tank so that no disturbance to the biological treatment is created.

Its operation will be controlled by on-line monitoring of pH, temperature and conductivity. When levels over the acceptable range occur, the valves will be closed, and the effluent diverted to the emergency lagoon.

The total volume will be approximately 70,000 m^3 to receive the process effluents considered contaminated.

The lagoons will be constructed with a properly sealed bottom and sloped towards the drainage pumps.

Contaminated rain water

Rain water with the possibility of contamination will be sent to the contaminated rain water retention lagoon to avoid hydraulic overloading in the treatment plant due to high rainfall. Once discharged to the retention lagoon, the rain water will be treated and slowly diverted to the effluent treatment plant.

Effluent neutralization

The effluent clarified in the primary clarifiers will be sent to a neutralization tank. The purpose of this step will be to neutralize the effluent by adding caustic soda or sulfuric acid to maintain a pH between 6 and 8, making it suitable for biological treatment.

The neutralization tank will have a capacity of approximately 2,900 m^3 and will be equipped with mechanical agitators.

Effluent cooling

Because the neutralized effluent has a temperature considered high for biological treatment, the effluent must be cooled to a temperature that does not affect the performance of the biological treatment.

The effluent will be cooled through a cooling tower composed of six cells, which is sized for an inlet temperature of approximately 70°C and an outlet temperature of approximately 35°C.

Activated sludge

The biological treatment system adopted at PARACEL will be the activated sludge aerobic type. The activated sludge process is a proven technology and is commonly used in the pulp and paper industries worldwide.

The biological process requires sufficient concentrations of nitrogen and phosphorus in the effluent for optimum performance. The amounts required will be related to the amount of biodegradable organic matter, i.e. BOD (Biochemical Oxygen Demand) present in the untreated effluent.

Urea and phosphoric acid are considered sources of nitrogen and phosphorus and will be added, if necessary, before the effluent enters the selector tank. The amount required will depend on the amount present in the effluent (only the minimum amounts necessary should be added, to minimize discharges).

After dosing nutrients, the effluent will be sent to the selector tank, which will have a high oxygenation capacity and is intended to eliminate filamentous organisms. From this tank, the effluents will go to the aeration tank, where they will be submitted to the degradation of the organic matter present in a soluble and colloidal form through the activity of aerobic microorganisms. The injection of air into the system will be carried out through fine bubble diffusers that will be installed in the bottom of the aeration tank. These diffusers will supply the necessary oxygen for the development of bacteria and will promote the mixing of the liquid mass contained in the aeration tank, keeping the mixture in suspension.

The aeration tank (including the selector) will have a total volume of approximately 160,000 m^3 and the diffusers will be fed by blowers with a total capacity of approximately 130,000 Nm^3/h, one of which will be reserved for maintenance.

Figure 14 – Aeration tanks

In the activated sludge process, the biological mass (sludge) to be physically separated from the liquid mass (clarified effluent) will be formed by three two clarifiers, each one with a diameter of 82 m.

The secondary (biological) sludge will be constantly removed from the bottom of the clarifiers by scrapers and directed by gravity to a sludge pit, from where it will be pumped to the selector tank, with its recirculation. The excess biological sludge will be sent to the secondary sludge dewatering system.

Secondary sludge dewatering system

The secondary sludge dewatering system will have an estimated total capacity of 30 tDS/day and will consist of mechanical type thickeners and centrifuges. The expected final consistency of the dewatered sludge is between 15 and 20%.

Tertiary treatment

After the biological treatment, the effluent will undergo a tertiary treatment to remove phosphorus, color and COD.

The tertiary treatment will be through a physical-chemical process with the application of aluminum sulfate and polymer in coagulation and flocculation tanks and then directed to the dissolved air flotation (DAF). The flotation system has the advantage of obtaining an approximately thickened sludge, which reaches a consistency of 2.0 to 3.0%. The tertiary sludge is supported by a dedicated dewatering system.

As an alternative to the physicochemical flotation system, tertiary treatment can be carried out by injecting ozone into the effluent. The ozone will be produced on site, through electric discharge in oxygen. In this alternative, the effluent will pass through a sealed contact tank, which will be hermetically sealed, where the ozone will be introduced through fine diffusers. The off gas can be reused and injected into the biological treatment aeration tank. After passing through the contact chamber, the effluent will be sent to the biological filters to retain the suspended solids.

The treated effluent will be discharged through emissaries and diffusers into the Paraguay River. It should be noted that the point of discharge will be located above the point of raw water intake for PARACEL pulp mill.

Tertiary sludge dewatering system

The tertiary sludge from flotation, where a consistency of 2.0 to 3.0% is expected, will be sent to a homogenization tank equipped with a mechanical agitator. This tank will also receive the sludge from the decanters of the Water Treatment Plant (WTP). From the homogenization tank, the mixed sludge (tertiary + WTP) will be pumped to centrifuges, where it will reach a final consistency of about 15%. It is planned to add polymer to the centrifuge inlets to increase dewatering efficiency.

2.5.1.4 Effluent Final Disposal

The treated effluent will be discharged into the Paraguay River through an underwater emissary.

The emissary is intended to discharge treated effluent into the Paraguay River in a controlled and safe manner through underwater discharge under conditions that prevent the formation of foam and promote more efficient dispersion in the water body.

The complete system consists of: (a) treated effluent well; (b) an emissary of treated effluent to the margin of the Paraguay River, at the point of discharge; (c) control valves; (d) drainage pipes in the river bed; (e) vertical diffuser pipes ("risers") with holes for underwater release and dispersion in Paraguay river waters.

The underwater pipes will consist of 3 parallel HDPE (High Density Polyethylene) lines in the river bed. In certain places that favor a better dispersion in the river waters and the homogenization of the mixture, there will be vertical steel pipes ("risers"), which will conduct the treated effluent from the buried pipes approximately 50 cm above the river bed.

At the end of each "riser", there will be a 90° curve towards the horizontal. At the end of this curve, a special check valve will be installed, which will allow the discharge of effluent jets in an optimized way, as well as prevent the entry of sand and dirty particulates into the system.

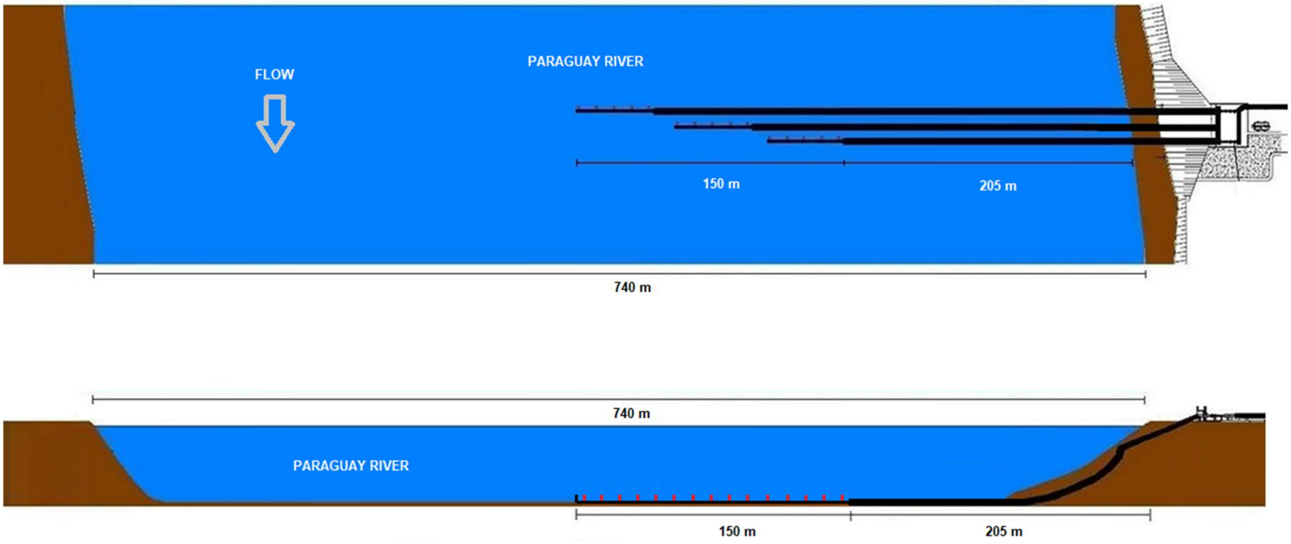


Figure 15 – Illustration of the discharge system

Figure 16 – Effluents emissary pipeline

2.5.2 Rainwater drainage

The rainwater that falls in the process areas, since they have the greatest potential for contamination, will be sent along with the effluents to the PARACEL Effluent Treatment Plant (ETP).

Rainwater falls on the roof areas, streets, etc. as well as the log storage yard, as they have less potential for contamination, will be sent to rainwater lagoons, which will receive pH and conductivity measurements to avoid hydraulic overload in the ETP due to high precipitation. In these lagoons, if pH and/or conductivity parameters are outside acceptable standards, these waters will be sent to the plant's ETP. Otherwise, they will be sent for disposal to the river, which will be done through the treated effluent drainage. It is important to note that this rainwater will be added to the treated effluent after the effluent measurement and sampling point.

2.5.3 Atmospheric Emissions

2.5.3.1 Emission sources

The main air emission sources of PARACEL pulp mill arisen from the following equipment:

- Recovery boiler;
- Lime Kiln; and
- Biomass boiler.

2.5.3.2 Main control parameters

The main control parameters related to significant air emissions from a pulp mill are:

- Particulate Material;
- TRS (total reduced sulfur);
- SOx (Sulphur oxides);
- NOx (Nitrogen oxides); and
- CO (Carbon monoxide).

2.5.3.3 Technologies to minimize, control and monitor air emissions

The mitigation, control and monitoring of air emissions will be based on the technologies already established and used with great success, which are listed below:

- Use of low odor recovery boiler;
- High dry solids content of up to 80% in the liquor burned in the recovery boiler, which minimizes SOx emissions;
- Use of high efficiency electrostatic precipitators for the recovery boiler, biomass boiler and lime kilns;

- Collection of concentrated non-condensable gases (CNCG) from the digester and evaporation, and their incineration in the recovery boiler or biomass boiler (protected flame incineration);
- Extensive collection of diluted non-condensable gases (DNCG) from the digester, brown pulp line, evaporation, with treatment in the recovery boiler;
- Treatment of gases from the dissolving tank in the recovery boiler;
- Efficient cleaning of relief gases from bleaching plant;
- Real-time gas monitoring systems and control system, rapid identification and correction of operational disturbances.

2.5.3.4 Technologies for controlling emissions of air pollutants

Recovery boiler

The recovery boiler will be equipped with a high efficiency electrostatic precipitator to remove particulate material, which will be collected and transported to the mixing tank.

This type of equipment to control air emissions from recovery boilers is used worldwide.

The electrostatic precipitator will promote the removal of solid or liquid micro-particles, charged by flue gases, through the use of static electricity.

The removal process is based on the ionization (localized concentration of electric charges) of these particles, induced by a powerful electric field, through the action of the so-called "corona effect". This effect consists of the release of electrons from the positive electrode to the gas adjacent to it, thus reaching the charged particles, causing a displacement to the other electrode (or plate) that works as a collector. This creates a layer of dust in this collector.

The powder layer is compacted and held together with the electrodes by the forces of the electric field. When this layer becomes sufficiently thick and agglomerated, it is subjected to mechanical action, which causes it to fall to the bottom of the precipitator and is removed dry by a drag conveyor.

The electrostatic capture process is highly efficient, allowing the removal of extremely fine particles.

Due to the high resistivity of the gaseous media, the potential difference to be applied between the electrodes must be high, which explains the high voltage verified in this equipment.

The precipitator to be used will have independent chambers, which will work together, in parallel. In this way, it is possible to eliminate occasionally one of the operation chambers, to provide maintenance and not to affect significantly the general efficiency of the control installation, since the system is already designed to support events of this nature.

As an integral part of the equipment, an automatic operation management and control system will be installed, based on the use of instrumentation coupled to microprocessors. Its function will be to maintain the operating conditions of the precipitator in the ideal operating ranges.

Lime kilns

For air pollution control, lime kilns shall be equipped with high efficiency electrostatic precipitators to remove particulate matter from the flue gases. This material will be returned to the lime kilns. The description of the precipitator control is similar to the description of the recovery boiler.

Biomass boiler

Due to the legal requirements regarding the emission of particles in the flue gases, the best alternative for cleaning the gases generated in the combustion by the biomass boiler will be high efficiency electrostatic precipitators to remove the particulate material.

Non-condensable gas collection and incineration system

The high concentration non-condensable gases generated in the evaporation plant will be incinerated in the recovery boiler. If burning in the recovery boiler is not possible, these gases will be incinerated in the biomass boiler (back-up equipment 1) and, if this is not possible, they will be incinerated in a flare.

Low concentration non-condensable gases collected from various sources in the process areas of the fiber line and evaporation plant will be conditioned before being introduced as secondary air to the recovery boiler or biomass boiler (back-up equipment 1).

The diluted gases from the recovery boiler dissolving tank shall be cooled in a scrubber, reheated and introduced as tertiary air to the recovery boiler.

Ventilation gases from the lime fire extinguisher, causticizing equipment, storage tanks and causticizing equipment will be collected, cooled in a heat exchanger to remove moisture and sent, via a fan, as combustion air to the lime kilns.

2.5.4 Solid Waste

2.5.4.1 Generation Sources

PARACEL pulp mill operation will generate industrial and non-industrial solid waste.

2.5.4.2 Industrial Solid Waste

The industrial solid waste generated by the pulp process will come from the wood handling, causticizing, boiler, and water and effluent treatment plant areas.

The following main waste is included in this category:

- Waste from wood preparation;
- Dregs, grits and lime mud;
- Ash from the biomass boiler;
- Primary, secondary and tertiary sludge from the effluent treatment plant; and
- Sludge from the water treatment plant.

2.5.4.3 Non-Industrial Solid Waste

Non-industrial solid waste will be generated in administrative and operational support activities such as offices, cafeteria and maintenance workshops.

The following primary waste is included in this category:

- Metal
- Paper or cardboard
- Plastic
- Glass
- Recyclable and non-recyclable organics
- Waste from health services
- Materials contaminated with oil and grease
- Used lubricating oil
- Fluorescent lamps and batteries

2.5.4.4 Solid Waste Management System

The management of solid waste generated in the operation of PARACEL's pulp mill will include the best practices, in accordance with Law n. 3,956/2009 and Decree n. 7,391/ 2017 (Integral Management of Solid Waste in the Republic of Paraguay), among which are:

- Adoption of minimization measures;
- Segregation (selective or separate collection);
- Collection, storage and transport in accordance with the law;
- Treatment or processing and use, until final disposal in sanitary (organic) or industrial landfill.

Waste classification

According to Decree 7,391/2017, solid waste in Paraguay is grouped and classified into categories: municipal solid waste, special handling waste (non-hazardous), and hazardous waste.

- Urban solid waste: that generated in each room, housing unit or similar.
- Special handling waste (non-hazardous): industrial waste, waste from agricultural, fishing, forestry and livestock activities, transport services, civil construction and others.
- Hazardous waste: provided for in Law 567/1995, which has explosive, flammable, oxidizing, toxic, infectious, radioactive, corrosive, etc., characteristics that may cause risks to human or environmental health.

Segregation and Conditioning of Solid Waste

The pulp mill's waste management system will have selective or separate collection, which consists of separating waste so that it can be recycled later.

The containers and bins in the offices and operational areas will have the following colors, based on Resolution S.G. 548/96 of the Ministry of Health and Public Welfare, as presented in the table below.

Table 2 – Colors of containers at offices and operational areas

Solid wastes	Color
Metal	**Yellow**
Paper or cardboard	**Blue**
Plastic	**Red**
Glass	**Green**
Hazardous waste	**Orange**
General non-recyclable waste	**Gray**
Health Service	**White**
Wood	**Black**
Organic	**Brown**

In accordance with Decree 7,391/2017, the containers and recipients used for the temporary storage of solid waste will have the following requirements:

- Reusable;
- Properly located and covered;
- Capacity to store the volume of solid waste generated, taking into account the frequency of collection;
- Built with waterproof materials and with the necessary strength for their intended use;
- Identification regarding use and types of solid waste.

Waste from health services (mainly sharps) must be segregated and conditioned in containers or recipients, in accordance with Law 3361/2007.

Non-industrial waste (non-hazardous and hazardous) will be temporarily stored in a facility until it is sent for treatment procedures specific to each type of waste.

The storage facility for non-hazardous waste will be an open, fenced, signposted yard with a compacted floor.

The storage area for hazardous waste will be a warehouse covered with metal tiles, closed at the sides, with natural ventilation, marked and with a concrete floor.

The rainwater that falls on the yard and on the roof of the storage facility (not contaminated) will be conveyed to the plant's rainwater drainage system via drainage channels to the Paraguay River.

2.5.4.5 Treatment and Final Disposal

Solid waste will be destined for treatment or final disposal, as presented in the table below.

Table 3 – Treatment or final disposal

Waste	Treatment or final disposal
Wood waste + sand	Production of compost (forest application) or burning in PARACEL's biomass boiler or industrial landfill
Dregs	Production of soil acidity corrector (forestry application) or PARACEL industrial landfill
Grits	Production of soil acidity corrector (forestry application) or PARACEL industrial landfill
Lime mud	Production of soil acidity corrector (forestry application) or PARACEL industrial landfill
Ashes + sand	Production of soil acidity corrector (forestry application) or PARACEL industrial landfill
Primary sludge ETP	Production of compost (forest application) or burning in the biomass boiler or recycling or industrial landfill PARACEL
Biological sludge ETP	Production of compost (forest application) or burning in PARACEL's biomass boiler or industrial landfill
Tertiary sludge ETP	PARACEL Industrial Landfill
WTP sludge	PARACEL Industrial Landfill
Metal	Recycling
Paper or cardboard	Recycling
Plastic	Recycling
Glass	Recycling
Recyclable and non-recyclable organics	PARACEL sanitary landfill (organic)
Waste from health services	Decontamination and sanitary landfill (external)
Oil contaminated	Incineration or co-processing
Used lubricating oil	Recycling
Fluorescent lamps and batteries	Decontamination and recycling (external)

2.5.4.5.1 Composting Plant

A composting plant will be installed at the pulp mill to treat organic (non-hazardous) industrial waste generated at the effluent treatment plant (primary and biological sludge) and in the wood yard (wood waste).

Composting has been practiced since ancient history and can be defined as an exothermic aerobic bio-oxidation of a heterogeneous organic substrate, in a solid state, characterized by the production of CO_2, water, release of mineral substances and formation of stable organic matter (PROSAB, 1999).

In practice, this means that, from organic waste, the process transforms these residues into compost, which is an agricultural input, easy to handle and free of pathogenic microorganisms (PROSAB, 1999).

The biodegradable organic components undergo successive stages of transformation under the action of various groups of microorganisms, resulting in a highly complex biochemical process (PROSAB, 1999).

Being a biological process, the most important factors influencing the degradation of organic matter are aeration, nutrients and moisture. Temperature is also an important factor, especially with respect to the speed of the biodegradation process and the elimination of pathogens but is the result of biological activity. Nutrients, mainly carbon and nitrogen, are essential for bacterial growth. Carbon is the main source of energy and nitrogen is necessary for cell synthesis (PROSAB, 1999).

The composting process has the following main objectives:

- Recycle properly, through an efficient composting system, the waste generated and likely to be used;
- Systematize and homogenize the return of the nutrients contained in the waste to the forest plantations, making fertilizations with the compost produced;
- Improve the nutritional status and physical parameters of the soil by adding organic matter;
- Promote the partial replacement of fertilizers and chemical correctives used, with environmental and economic gains;
- Ensure the proper disposal of waste generated by industry in accordance with technical standards and environmental law in force.

The use of this type of waste in the composting process to produce compost is a sustainable alternative for waste disposal, aligned with the concepts of circular economy and best available practices. From an environmental point of view there is a reduction in the generation of waste, and from an economic point of view, less agricultural inputs are used with the use of compost.

Design Criteria

An area of 20 hectares (200,000 m^2) is planned for the installation of the composting plant and the soil acidity corrector production plant.

Some criteria were established for the selection of the composting plant area, based on SEAM Resolution 282/2004. The criteria adopted are presented in the table below.

Table 4 – Criteria for selection of the composting plant area

Criteria	Values
Distance from water courses, flood areas, springs and wetlands	More than 200 meters, distance measured from the maximum flood level
Distances from environmental and cultural protection areas	1,000 meters
Depth of groundwater	With base waterproofing through compacted clay layer the distance from the groundwater to the base of more than 3.0 meters and the waterproofing layer must have a permeability coefficient of 1 x 10^{-6} cm or less.
Distance from nearest housing, water supply wells, education and health centers	500 meters

Composting plant description

The design of the composting plant will include the following elements:

- Soil waterproofing system
- Storm water drainage system
- Groundwater monitoring system

The description of the project elements is presented below.

Soil Protection System

The waterproofing of the floors of the open yards and the warehouse will be with a layer of compacted clay (permeability coefficient of 1 x 10^{-6} cm or less) and must be more than 3.0 meters away from the groundwater level.

Rainwater Drainage System

Contaminated Rainwater

Rainwater falling over the open yards will be directed by gravity to a lagoon or tank, where it will be pumped to the Effluent Treatment Plant.

Uncontaminated Rainwater

Rainwater falling on the roofs of the storage (non-contaminated) will be led to the rainwater drainage system of the pulp mill, through natural drainage in the ground or through drainage channels up to the Paraguay river.

Groundwater monitoring system

The groundwater monitoring system will include several monitoring wells in the area surrounding the composting plant.

Description of Compost Production

The waste generated in the effluent treatment (primary and biological sludge) and in the wood yard (wood waste) will be transported to the composting plant, where they will be temporarily stored in open yards (waterproofed floor with a clay layer) or sent directly to the process.

The wood waste will undergo a chipping process to reduce the size of the waste and optimize the composting process.

The waste will be mixed in the open composting yard (waterproof floor with clay layer), where the rows will be formed through a loader.

The composting process (bio-stabilization phase + maturation phase) will last 120 days. At the end of this process, the compost will be ready, but with irregular granulometry. In this way, it will be sent to the beneficiary for evaluation.

During the composting process, windrows will be turned (to provide aeration) and process controls will be carried out (temperature, moisture, pH and C/N ratio). In addition, water irrigation will be carried out to maintain the moisture of the material when necessary.

The compost produced will be transported to a warehouse, where it will undergo mechanical processing, consisting of rotary sieving, to standardize its granulometry.

The finished compost will be transported to its destination using trucks.

The following figure shows the flow chart of compost production.

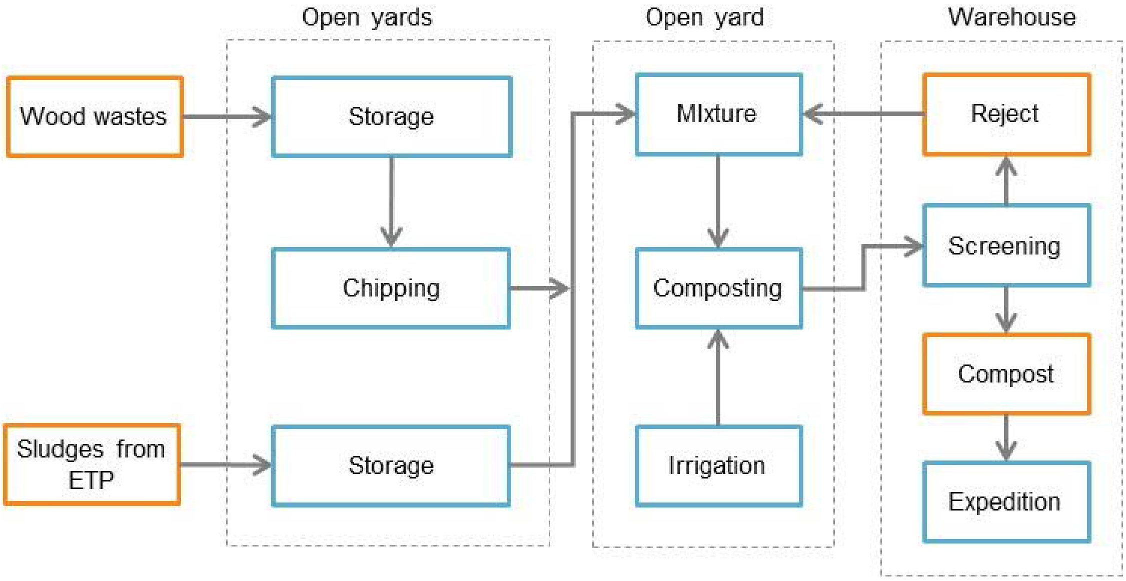


Figure 17 – Flowchart of compost production

2.5.4.5.2 Sludge incineration in biomass boiler

An alternative to the composting process, which can be used by PARACEL, is the burning of primary and biological sludge together with biomass in the biomass boiler (designed for this purpose).

Currently, several companies in the pulp and paper sector have used the biomass boiler to burn primary and biological sludge from the ETP, instead of its destination for composting or industrial landfill, such as Klabin, Suzano, Eldorado, Veracel, Cenibra, CMPC and Arauco.

The use of these wastes as fuel in the biomass boiler, for the generation of steam and electric energy, is a sustainable energy matrix alternative. From an environmental point of view, there is a reduction in the generation of waste, and from an economic point of view, less biomass is used due to the use of sludge.

2.5.4.5.3 Soil Acidity Corrector Production Plant

The pulp mill will be equipped with a plant to produce a soil acidity corrector, to treat the inorganic (non-hazardous) industrial waste generated in the causticizing (dregs, grits and lime mud) and in the biomass boiler (ash).

The production of the soil acidity corrector consists of drying the waste (dregs, grits, lime mud and ashes) and making a balanced mixture.

Depending on their composition, lime mud and ashes can be used individually as soil acidity correctors.

Lime mud and the mixture of dregs and grits are alkaline, basically carbonate by-products, which have a high concentration of nutrients such as calcium and magnesium and have a high capacity for neutralization.

The ash, despite the low capacity of neutralization, has a concentration of macronutrients such as phosphorus, potassium, calcium and magnesium that enrich the acidity corrector of the soil. These nutrients are important for the development of the plantation.

Design Criteria

An area of 20 hectares (200,000 m²) is planned for the construction of the soil acidity corrector production plant and the composting plant.

Some criteria were established for the selection of the area of the corrector production plant, based on SEAM Resolution 282/2004. The criteria adopted are presented in the following table.

Table 5 – Criteria for selecting the area of the corrective production plant

Criteria	Value
Distance from water courses, flood areas, springs and wetlands	Greater than 200 meters, distance measured from the maximum flood level
Distances from environmental and cultural protection areas	1,000 meters
Depth of groundwater	With base waterproofing through plastic membranes the distance from the water table to the base is more than 1.5 meters.
Distance from nearest housing, water supply wells, education and health centers	With base waterproofing through compacted clay layer the distance from the groundwater level to the base of more than 3.0 meters and the waterproofing layer must have a

Criteria	Value
	permeability coefficient of 1 x 10^{-6} cm or less.

Description of the Acidity Corrector Production Plant

The design of the corrector production plant will include the following elements:

- Soil waterproofing system
- Storm water drainage system
- Groundwater monitoring system

The description of the project elements is presented below.

Soil protection system

The soil of the open patios and two greenhouses will be covered with a layer of compacted clay (permeability coefficient of 1 x 10-6 cm or less) and must be more than 3.0 meters away from the groundwater.

The impermeabilization of the warehouse floor will be made of concrete.

Rainwater drainage system

Contaminated rainwater

Rainwater falling on the open yards will be directed by gravity to a lagoon or tank, where it will be pumped to the wastewater treatment plant.

Non-Contaminated Rainwater

The rainwater that falls on the roofs of the warehouses and greenhouses (non-contaminated) will be led to the rainwater drainage system of the pulp mill, through natural drainage in the ground or by means of drainage channels up to the Paraguay river.

Groundwater monitoring system

The groundwater monitoring system will include several monitoring wells in the area surrounding the corrective production plant.

Acidity Corrector Production Description

The waste generated in the pulp production process (dregs, grits, lime mud and ashes) will be transported to the soil acidity corrector production plant, where they will be temporarily stored in open yards or sent directly to the drying process.

Wet waste (dregs, grits and lime mud) will undergo the natural drying process to reduce the moisture content. This drying process will take place in agricultural greenhouses.

After drying, the dry residues can be sent directly to the agricultural crop or to produce the soil acidity corrector.

The dry residues, including boiler ashes, are mixed in ideal proportions, constituting the soil acidity corrector which is then screened to standardize its granulometry. This whole process will take place in a warehouse.

The ready acidity corrector will be temporarily stored or loaded onto trucks. On leaving the plant, these trucks will be weighed, and the corrector will be transported to its final destination.

The following figure shows the flow chart of the production of soil acidity corrector.

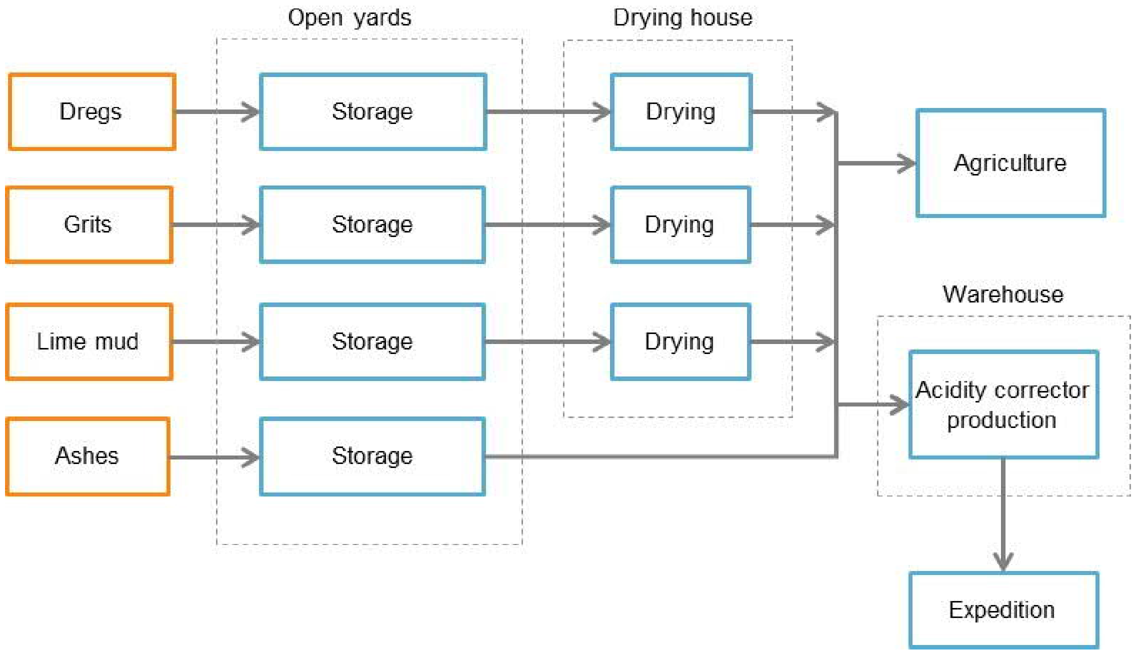


Figure 18 – Flowchart of acidity corrector production.

2.5.4.5.4 Industrial landfill

An industrial landfill will be installed at the pulp mill for the final disposal of industrial (non-hazardous) waste generated in the production process, which cannot be used for the proposed treatments (composting and production of soil acidity corrector).

Industrial landfill description

The industrial landfill project will include the following elements, in accordance with Decree 7,391/2017 and the best available practices:

- Soil protection system
- Leak detection system
- Leachate handling and pumping system
- Gas handling system
- Rainwater drainage system
- Groundwater monitoring system

Soil protection system

In order to protect the soil and groundwater, the landfill will have waterproofing of the base and slopes through a layer of compacted clay soil (50 cm) and a double membrane of High Density Polyethylene (HDPE), with a thickness of 1 mm. In addition, the distance from the groundwater to the base will be more than 1.5 meters, in accordance with Decree 7,391/2017.

The soil permeability coefficient must be at least very low (permeability between 10^{-5} and 10^{-7} cm/s), in order to reduce the possibility of groundwater pollution.

Leak detection system

A leak detection system, consisting of HDPE pipes, will be installed below the base waterproofing between the membranes and connected to a monitoring well.

Leakage control will occur through visual verification of the monitoring well, which must always be dry. On the contrary, leaks are occurring through the HDPE membrane.

Leachate handling and pumping system

Above the base sealed, drainage pipes, of the Kananet type (diameter of 250 mm or similar), will be installed to collect the leachate generated in the decomposition of the waste. The drainage pipes will be protected by a geotextile blanket. In addition, there will be vertical perforated pipes in concrete, also to collect the leachate generated.

The leachate collected in the pipes will be directed by gravity to the pumping tank, where it will be sent to the wastewater treatment plant.

Gas handling system

The gas drainage pipes, of the Kananet type (100 mm diameter or similar), will be connected in the leachate drainage pipes and will rise through the slopes to the surface, where the release of the gases will occur.

This system has the function of dispersing the gases formed in the biodegradation of the waste into the atmosphere, minimizing the risks of accumulation of these gases in the mass of waste (creating gas pockets).

Rainwater drainage system

The rainwater drainage system will include half-round channels that will carry water to the mill drainage system.

Groundwater monitoring system

The groundwater monitoring system will comprise several monitoring wells to be installed in the area surrounding the industrial landfill.

2.5.4.5.5 Sanitary landfill (Organic)

A sanitary landfill (organic) will be installed at the pulp mill for the final disposal of the waste generated in the refectory, in the bathrooms and non-recyclable.

Description of Sanitary Landfill

The landfill project will include the following elements, in accordance with Decree 7,391/2017 and the best available practices:

- Soil waterproofing system
- Leak detection system
- Leachate handling and pumping system
- Gas handling system
- Storm water drainage system
- Groundwater monitoring system

Soil protection system

In order to protect the soil and groundwater, the landfill will have waterproofing of the base and slopes through a layer of compacted clay soil (50 cm) and a double membrane of High Density Polyethylene (HDPE), with a thickness of 1mm. In addition, the distance from the groundwater (phreatic) to the base will be more than 1.5 meters, according to Decree 7,391/2017.

The soil permeability coefficient must be at least very low infiltration (permeability between 10^{-5} and 10^{-7} cm/s), in order to reduce the possibility of groundwater pollution.

Leak detection system

A leak detection system, consisting of HDPE pipes, will be installed below the base waterproofing between the membranes and connected to a monitoring well.

Leakage control will occur through visual verification of the monitoring well, which must always be dry. Otherwise, leaks could have occurred from the HDPE membrane.

Leachate handling and pumping system

Above the ground protection, drainage pipes of the Kananet type (250 mm diameter or similar) will be installed to collect the leachate generated in the decomposition of the waste. The drainage pipes will be protected by a geotextile blanket. In addition, there will be vertical perforated pipes in concrete, also to collect the leachate generated.

The leachate collected in the pipes will be directed by gravity to the pumping tank, where it will be sent to the wastewater treatment plant.

Gas handling system

The gas drainage pipes, of the Kananet type (100 mm diameter or similar), will be connected to the leachate drainage pipes and will rise through the slope to the surface, where the release of the gases will occur.

This system has the function of dispersing the gases formed in the biodegradation of the waste into the atmosphere, minimizing the risks of accumulation of these gases in the mass of waste (creating gas pockets).

Rainwater drainage system

The storm water drainage system will include half-round channels that will carry water to the mill drainage system.

Groundwater monitoring system

The groundwater monitoring system will comprise several monitoring wells to be installed in the area surrounding the sanitary landfill.

2.6 Weather and Meteorological Characteristics

The climatic characterization of the region where the pulp mill is located considered the analysis of the following parameters: temperature, relative humidity, wind direction and speed, precipitation, solar radiation and water balance.

The meteorological and climatic information presented comes from the Climatological and Meteorological Study, carried out by the Company "CATAVENTO AMBIENTALE METEOROLOGIA E MEIO AMBIENTE", the data were obtained by surface meteorological stations approved in the region of the company.

The data used for the study of the region's climate were obtained from the Integrated Surface Database (ISD), which can be consulted on the website of the National Oceanic and Atmospheric Administration (NOAA). Four surface weather stations were chosen for the analysis of climate conditions in the region, which were more representative of the company's area, as shown below.

- Puerto Casado (USAF:860860/ICAO:SGLV), located 116 km of the north of the project, installed in the coordinates 22°16'58.80 "S e 57°55'58.80 "W. The data series examined is composed of 7 years (from 01/01/2013 to 12/31/2019);
- Pozo Colorado (USAF: 861280/ICAO: SGPC), located 136 km west of the project, at coordinates 23°30'0.00 "S e 58°46'58.80 "W. The data series examined is composed of 7 years (from 01/01/2013 to 12/31/2019);
- San Pedro (USAF: 861850/ICAO: SGSP), 99 km south of the project, located at coordinates 24° 4'1.20 "S e 57° 4'58.80 "W The data series examined is composed of 7 years (from 01/01/2013 to 12/31/2019);
- Teniente Coronel Carmelo Peralta (USAF: 861340/ICAO: SGCO), used as a reference station for the region, about 21 km from the project, located at coordinates 23°26'31.20 "S e 57°25'37.20 "W. The data series examined is composed of 10 years (from 01/01/2010 to 12/31/2019).

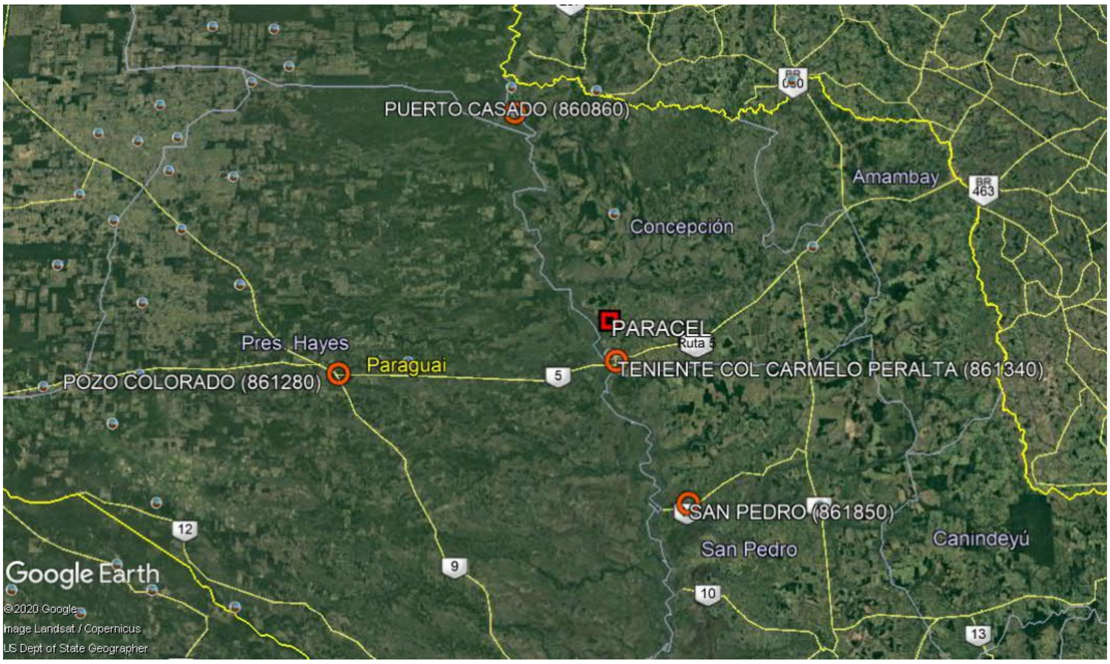


Figure 19 – Map of the location of the weather stations distant from the project. Source: Google Earth, 2020.

The climate type in Paraguay is tropical to subtropical, governed by tropical air mass and polar air mass, with hot and rainy summers and low and less rainy winters. The average annual temperature is 23°C and the average annual maximum is 29°C. There is a marked difference between the distribution of rainfall in the two regions into which the country is divided. In the Eastern Region, the average annual temperature ranges from 21°C to 23°C. In the Western Region, the average annual temperature is 24°C. The average recorded rainfall is 1,700 mm in the eastern region and 400 mm in the western region, near the border with Argentina and Bolivia (DGEEC, 2011).

According to Grassi et al. (2005), the Eastern Region, has an undulating and humid feature confined between the Paraguay and Paraná rivers, has a rugged topography with good drainage and a growing rainfall regime to the east and where the climate varies from humid sub-humid to humid, in the same orientation, giving rise to the large subtropical forests of the Atlantic basin.

According to this classification Pasten et al. (2011), the Eastern Region is defined with two types of climates:

- Tropical Shroud/Dry Winter (Aw): covers much of the department of Concepción and a small portion of northwest San Pedro;
- Temperate/No Dry Season/Hot Summer (Cfa) includes the departments of Amambay, Canindeyú, Central, Cordillera, Caaguazú, Alto Paraná, Paraguarí, Guairá, Ñeembucú, Misiones Itapúa and much of San Pedro.

The result of Köppen's climate classification, which can be seen in the Figure below, determined that in Paraguay there are three types of climate: tropical savannah with dry winter (Aw), semi-arid (Steppe) warm during all year (Bsh) and temperate climate, without dry season and hot summer (Cfa), this is the predominant climate in much of Paraguay (Pasten et al. 2011).

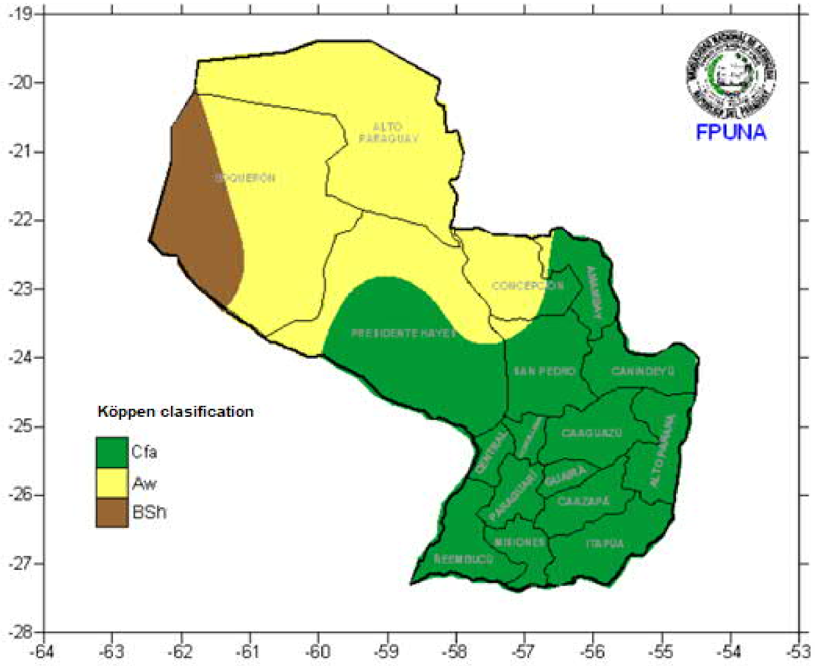


Figure 20 – Climate Classification of Köppen (1971-2010). Source: Pasten et al. (2011)

The parameters analyzed were: precipitation (mm), atmospheric pressure (hPa), air temperature (°C), relative humidity (%), wind speed(m/s) and wind direction (degrees).

2.6.1 Rainfall precipitation

No rainfall data are available in the database used for the study. Therefore, the study of rainfall precipitation was carried out by consulting the bibliography with information from previous studies of the region and the country.

Most of the country's rainfall is convective, produced by isolated storms or lines of instability that are frequent in spring and autumn. The average annual precipitation shows a great spatial variation. The greatest amplitude is towards the south of the country, varying zonally from 400 mm in the northwest of the Chaco to more than 1,800 mm in the Eastern Region.

The Paraná River basin is the wettest, with annual averages above 1,800 mm, while the Paraguay River basin receives maximums of 1,600 mm in the eastern region. Rainfall also shows great seasonal variability. They are lowest in July and August, and the average of the least rainy month usually does not reach 5% of the annual total. The highest volumes of precipitation occur during the months of October to April and are generally recorded in the form of storms or rainfall, as a result of atmospheric instability caused by strong warming of the lower layers of the atmosphere (Mayeregger and Romero 2017).

The highest precipitation rates in the region of Concepción occur in the summer. The month with the lowest rates is August, with an average of 28mm. In February and November, precipitation reaches its highest levels, between 128 and 152 mm on average. The average annual rainfall is approximately 1,190 mm (https://es.weatherspark.com/).

2.6.2 Atmospheric pressure

At the Puerto Casado station (860860), located 116 km north of PARACEL pulp mill, the atmospheric pressure varied between 1,001.4 and 1,004.9 hPa, while the average for the period from 2013 to 2019 was 1,002.9 hPa.

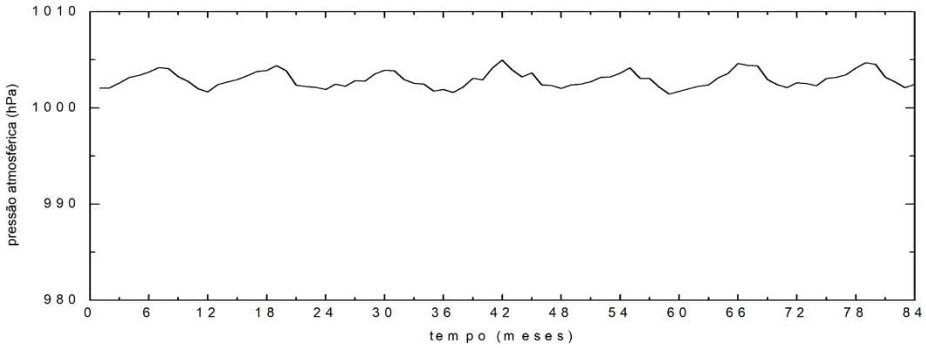


Figure 21 – Average monthly atmospheric pressure at the Puerto Casado station

At the Pozo Colorado station (861280), located 136 km west of the project, the atmospheric pressure varied between 999.4 and 1,002.7 hPa, while the average for the period from 2013 to 2019 was 1,000.8 hPa.

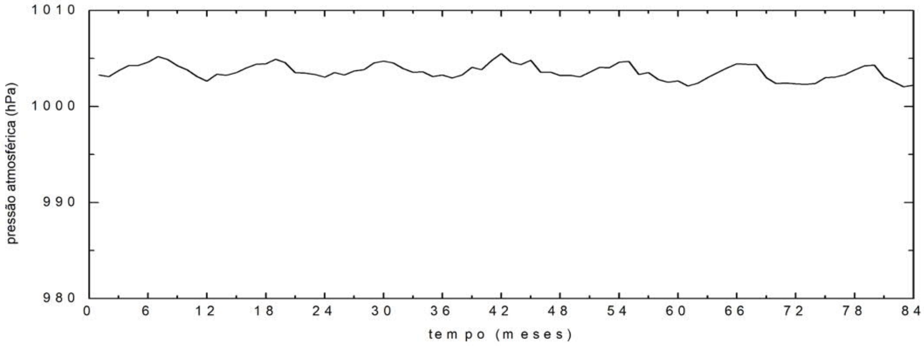


Figure 22 – Average monthly atmospheric pressure at the Pozo Colorado station.

At the San Pedro station (861850), located 99 km southeast of the project, the atmospheric pressure varied between 1,002.1 and 1,005.5 hPa, while the average for the period from 2013 to 2019 was 1,003.6 hPa.

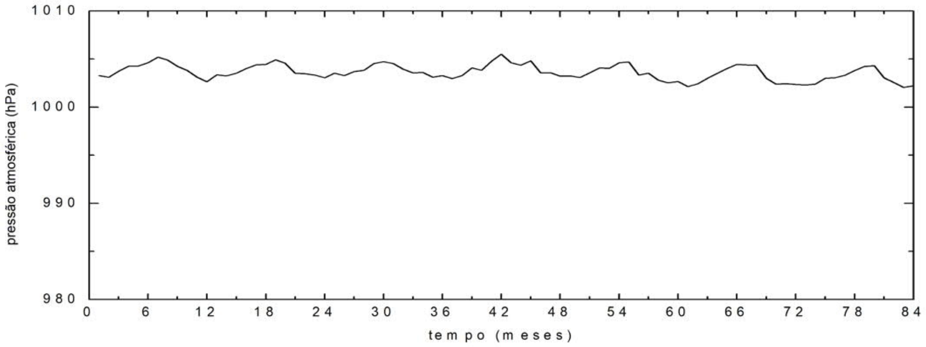


Figure 23 – Average monthly air pressure at San Pedro station

At the Lieutenant Colonel Carmelo Peralta station (861340), 21 km from the project, the atmospheric pressure varied between 1,001.5 and 1,007.5 hPa, while the provisional average climate for the period from 2010 to 2019 was 1,003.9 hPa.

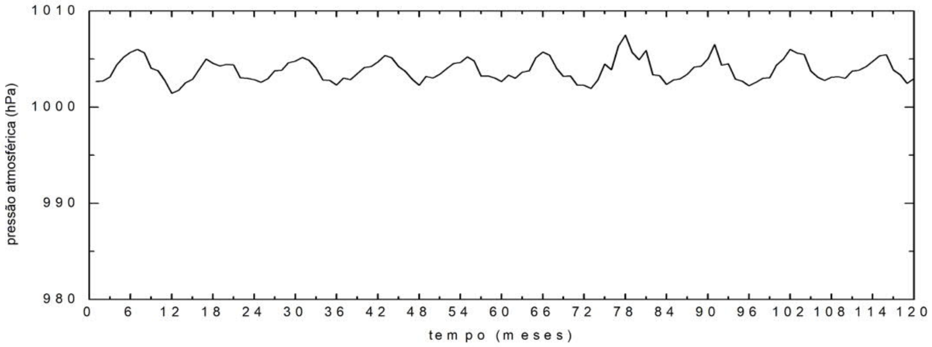


Figure 24 – Average monthly atmospheric pressure at the Teniente Coronel Carmelo Peralta station

Although the four weather stations cover a relatively large area and are separated by considerable distances, the atmospheric pressure behavior was similar in all stations and the average for the region was 1,002.8hPa.

2.6.3 Air Temperature

At the Puerto Casado station, the average monthly temperature varied between 16.9˚C and 31˚C, while the average for the period from 2013 to 2019 was 25.7˚C.

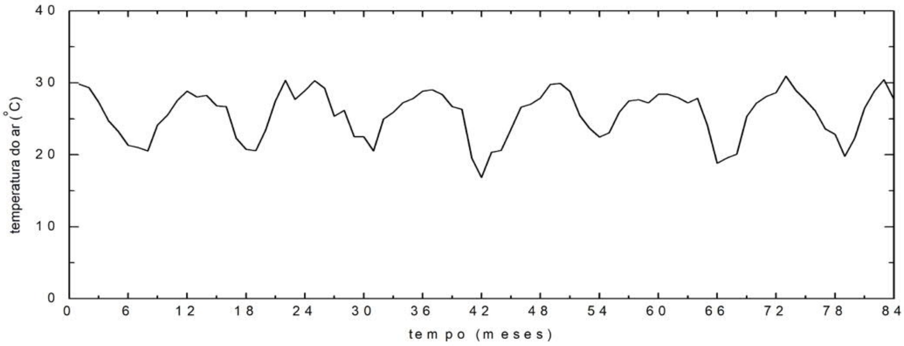


Figure 25 – Average monthly temperature at Puerto Casado station.

At Pozo Colorado station, the monthly average temperature varies between 15.5˚C and 31.2˚C, while the average for the period from 2013 to 2019 was 24.7˚C.

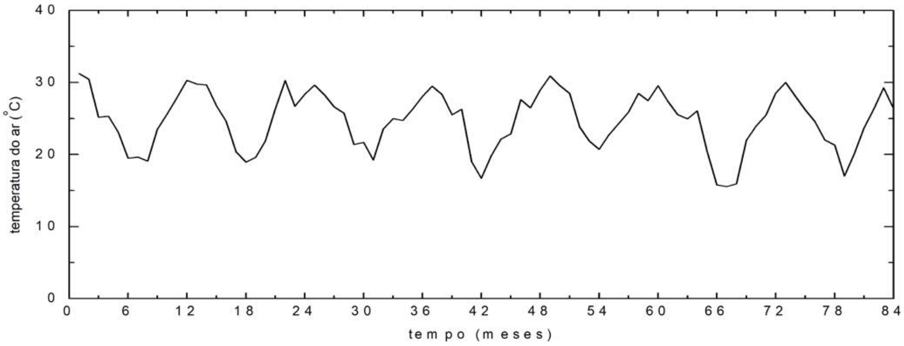


Figure 26 – Average monthly temperature at Pozo Colorado station

At the San Pedro station, the average monthly temperature varied between 16.5˚C and 30.5˚C, while the average climate for the period from 2013 to 2019 was 24.1˚C.

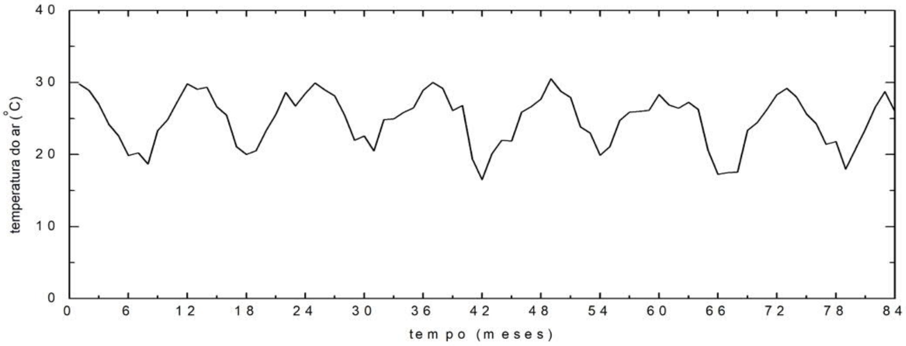


Figure 27 – Average monthly temperature at San Pedro station

At Teniente Coronel Carmelo Peralta station, the average monthly temperature varied between 15.5˚C and 29.6˚C, while the provisional average climate for the period from 2010 to 2019 was 24.3˚C.

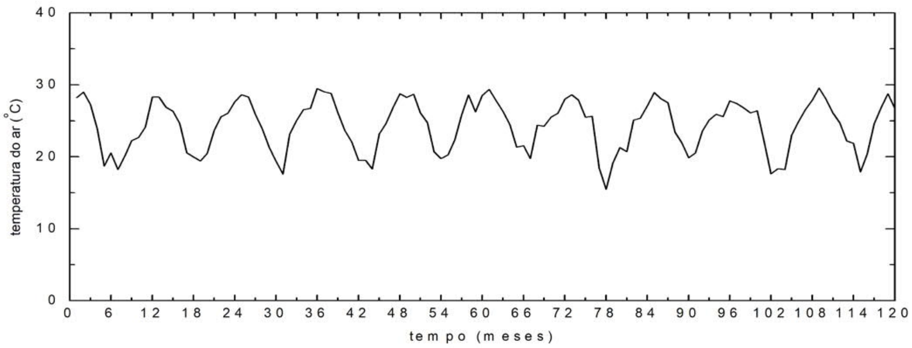


Figure 28 – Average monthly temperature at station Teniente Coronel Carmelo Peralta

The air temperature in the region is defined by the effect of continentality and topographic uniformity, presenting a great amplitude. In summer, as it is a tropical region, the maximum temperatures can exceed 30˚C, and in winter frost phenomena can be registered as a consequence of the entry of cold fronts.

The average temperatures are very similar in all the weather stations, from 24.1˚C in the San Pedro station, which is further south, to 25.7˚C in the Puerto Casado station, located further north. In the large region analyzed, the average temperature was 24.7˚C.

2.6.4 Relative Humidity

At the Puerto Casado station, the monthly relative humidity varied between 46.7% and 79.6%, while the average for the period from 2013 to 2019 was 63%.

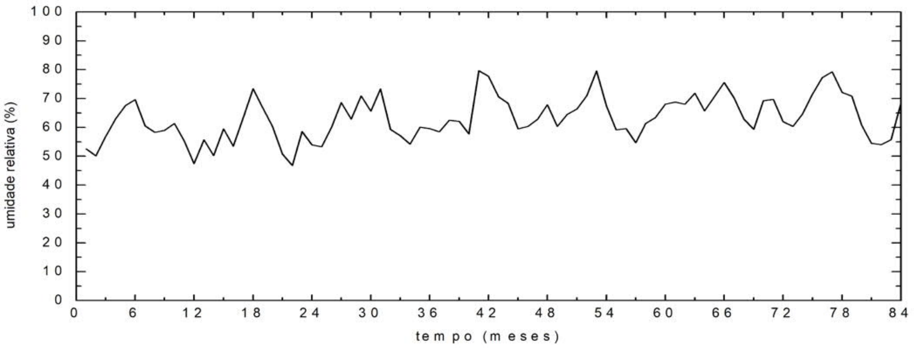


Figure 29 – Average monthly relative humidity at Puerto Casado station

At the Pozo Colorado station, the monthly relative humidity varied between 51.7% and 83.6%, while the average for the period from 2013 to 2019 was 70.2%.

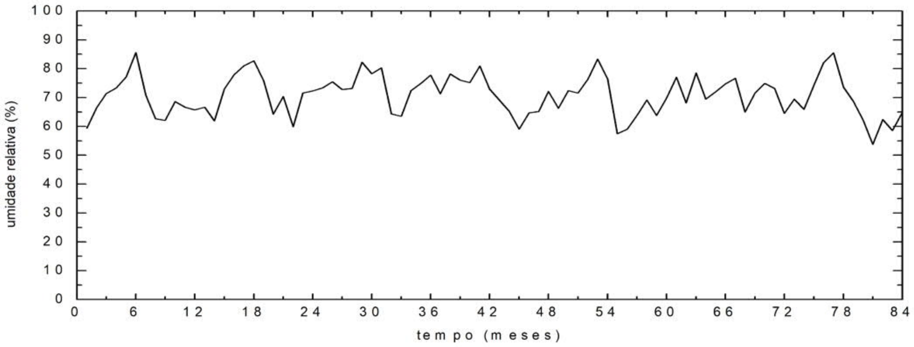


Figure 30 – Average monthly relative humidity at station Pozo Colorado

In the San Pedro station, the monthly relative humidity varied between 56.1% and 85.4%, while the average for the period from 2013 to 2019 was 70.5%.

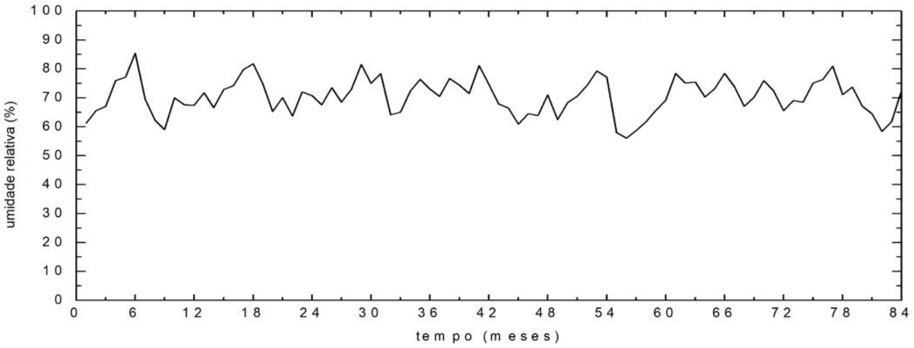


Figure 31 – Average monthly relative humidity at San Pedro station

At Teniente Coronel Carmelo Peralta station, the monthly relative humidity varied between 51.4% and 85.5%, while the provisional average for the period from 2010 to 2019 was 70.9%.

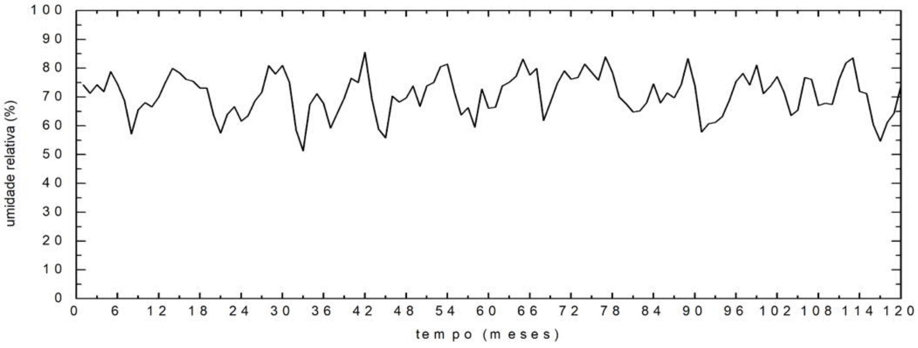


Figure 32 – Average monthly relative humidity at station Teniente Coronel Carmelo Peralta

The relative humidity at the Puerto Casado station, to the north of the future PARACEL factory, has an average relative humidity of 63%. The other regions presented values between 70.2% and 70.9%, the highest value being at the station of Lieutenant Colonel Carmelo Peralta. This difference is due to the variability of rainfall among the regions.

2.6.5 Wind

At the Puerto Casado station, the average monthly wind speed varied between 0.76 and 2.49 m/s, while the average for the period from 2013 to 2019 was 1.47 m/s.

At the Puerto Casado station, the average monthly wind speed varied between 0.76 and 2.49 m/s, while the average for the period from 2013 to 2019 was 1.47 m/s.

The wind rose generated with the data obtained at the Puerto Casado station proves the predominance of south and north winds.

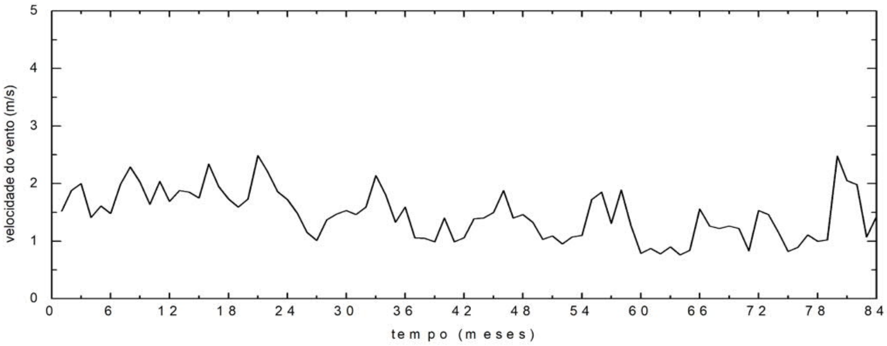
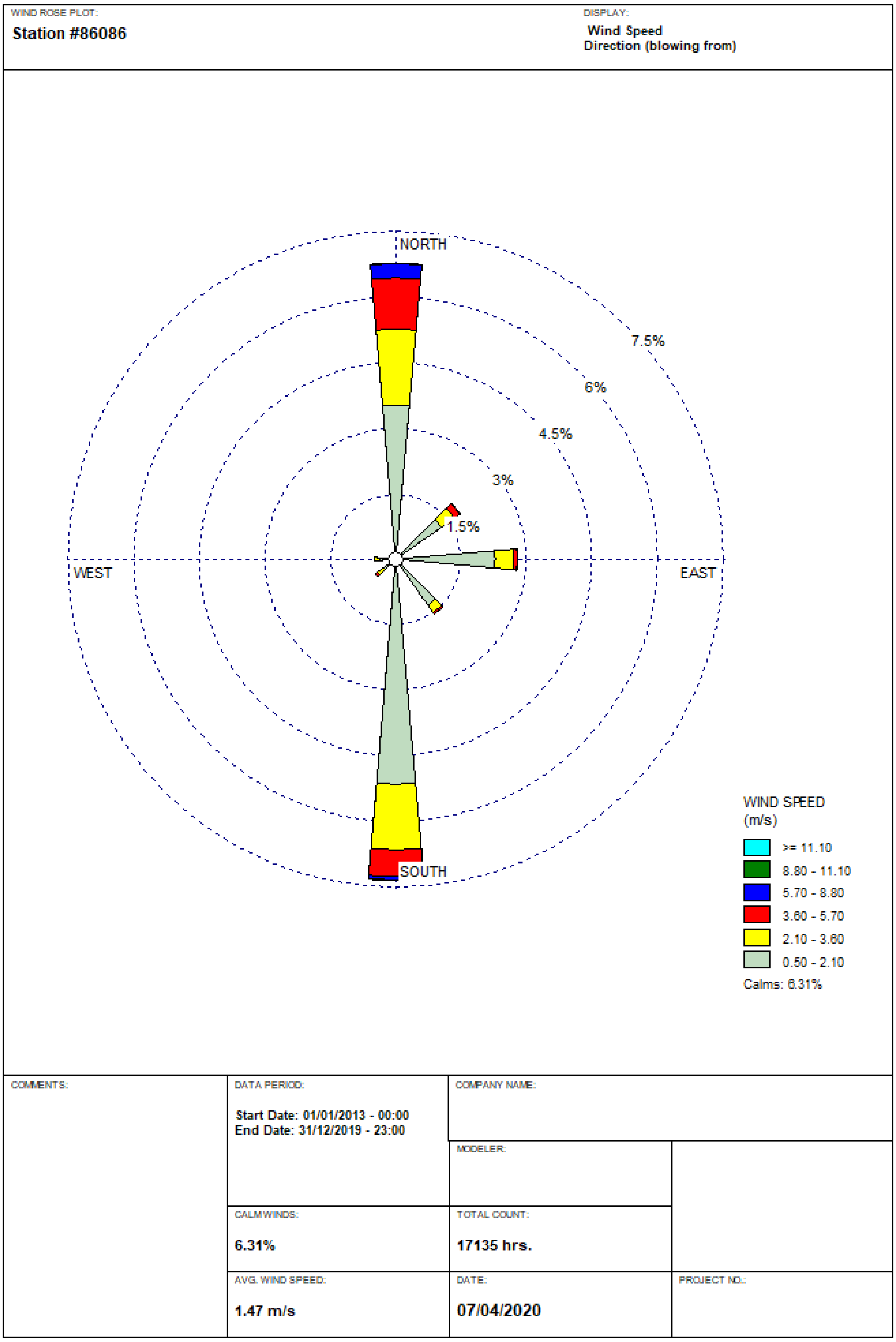


Figure 33 – Average wind speed at Puerto Casado station



WIND ROSE PLOT:
Station #86086

DISPLAY:
Wind Speed
Direction (blowing from)

COMMENTS:

DATA PERIOD:
Start Date: 01/01/2013 - 00:00
End Date: 31/12/2019 - 23:00

COMPANY NAME:

MODELER:

CALM WINDS:
6.31%

TOTAL COUNT:
17135 hrs.

AVG. WIND SPEED:
1.47 m/s

DATE:
07/04/2020

PROJECT NO.:

Figure 34 – Wind rose observed at the station Puerto Casado

At the Pozo Colorado station, the average monthly wind speed varied between 0.7 and 5.0 m/s, while the average for the period from 2013 to 2019 was 2.5 m/s.

The wind rose generated with the data observed at the Pozo Colorado station proves the predominance of south and north winds, with important components from the northeast and east.

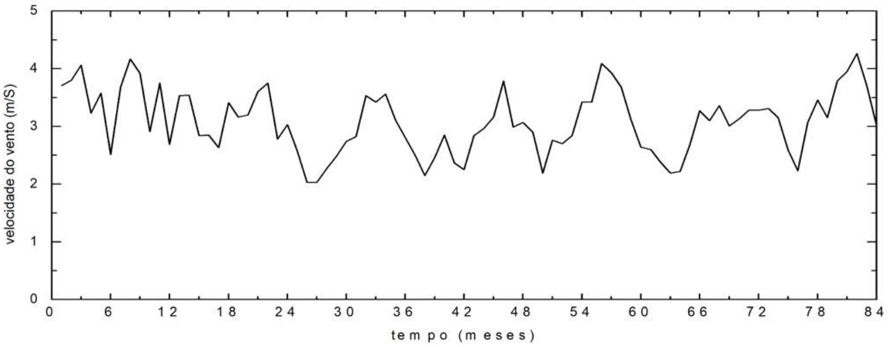
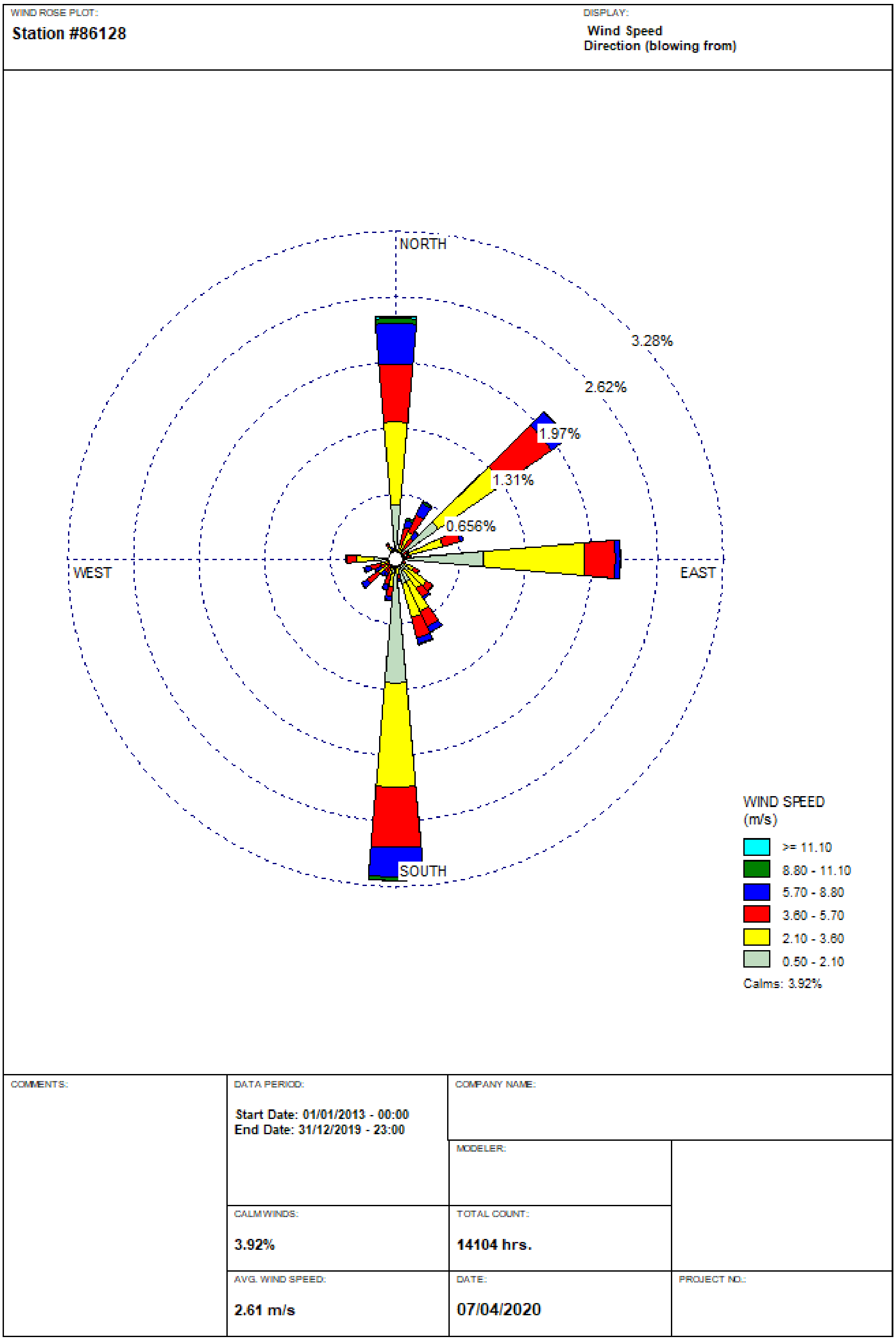


Figure 35 – Average wind speed at station Pozo Colorado



WIND ROSE PLOT:
Station #86128

DISPLAY:
Wind Speed
Direction (blowing from)

COMMENTS:

DATA PERIOD:
Start Date: 01/01/2013 - 00:00
End Date: 31/12/2019 - 23:00

COMPANY NAME:

MODELER:

CALM WINDS:
3.92%

TOTAL COUNT:
14104 hrs.

AVG. WIND SPEED:
2.61 m/s

DATE:
07/04/2020

PROJECT NO.:

Figure 36 – Wind rose observed at Pozo Colorado station

At the San Pedro station, the average monthly wind speed varied between 0.5 and 3.7 m/s, while the average for the period from 2013 to 2019 was 1.9 m/s.

The wind rose generated with the data observed at the San Pedro station proves the predominance of two winds from the south and north, followed by winds from the east.

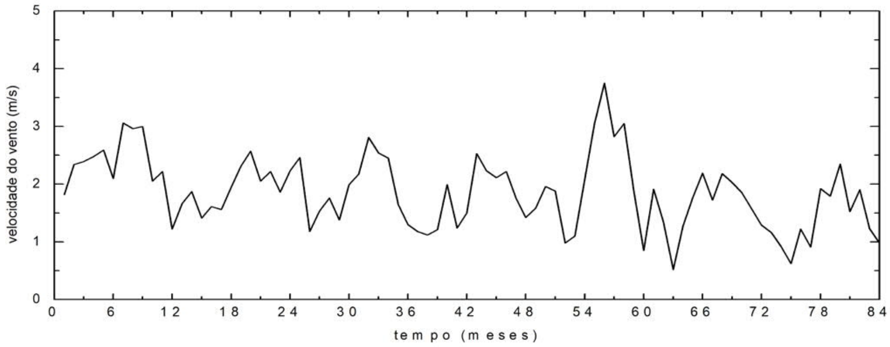
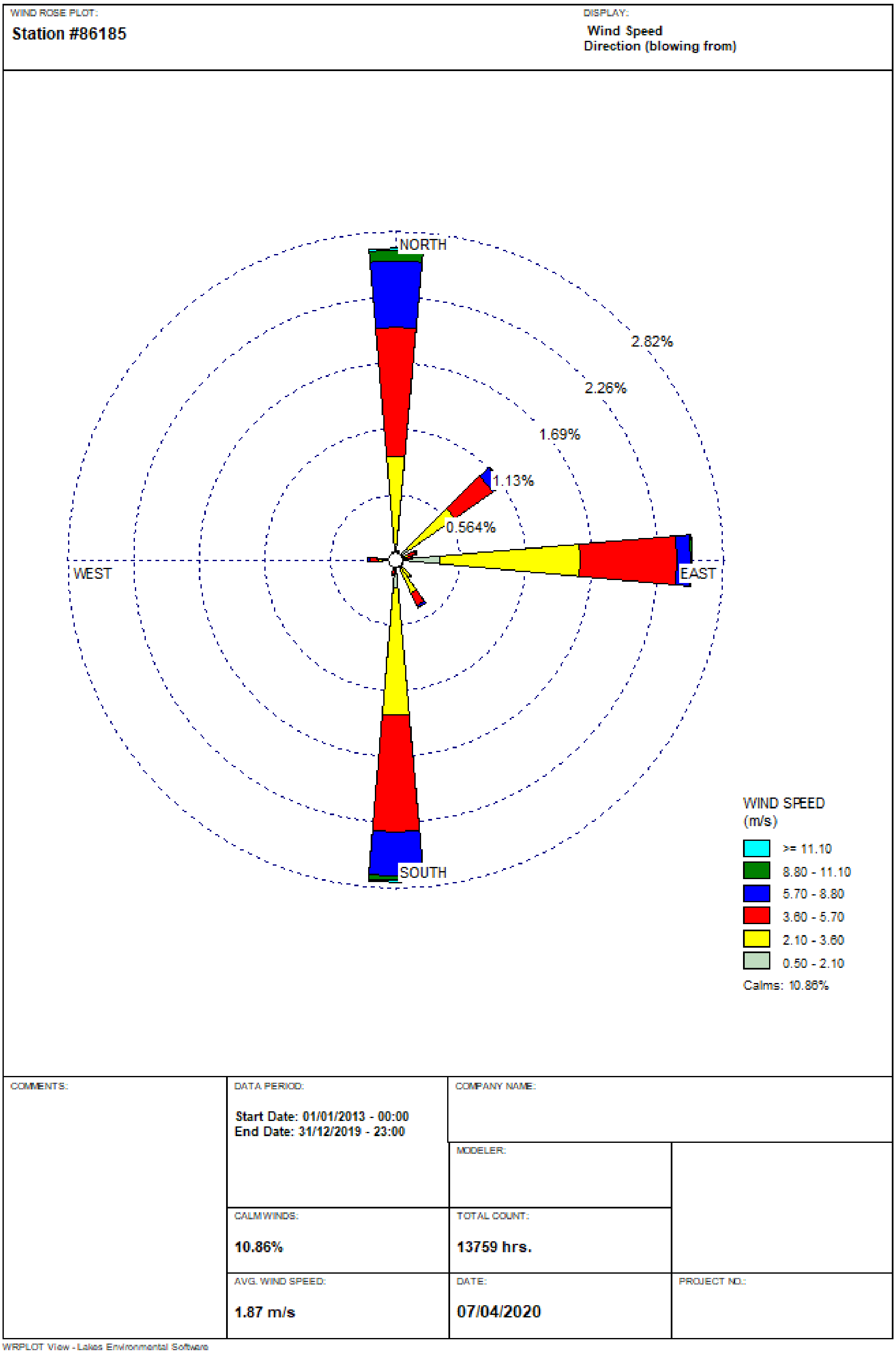


Figure 37 – Average wind speed at the station San Pedro



WIND ROSE PLOT:
Station #86185

DISPLAY:
Wind Speed
Direction (blowing from)

COMMENTS:

DATA PERIOD:
Start Date: 01/01/2013 - 00:00
End Date: 31/12/2019 - 23:00

COMPANY NAME:

MODELER:

CALM WINDS:
10.86%

TOTAL COUNT:
13759 hrs.

AVG. WIND SPEED:
1.87 m/s

DATE:
07/04/2020

PROJECT NO.:

Figure 38 – Wind rose observed at the station San Pedro

At the Teniente Coronel Carmelo Peralta station, the average monthly wind speed varied between 1.8 and 4.9 m/s, while the provisional average for the period from 2010 to 2019 was 3.2 m/s.

The wind rose generated with the data observed at the Teniente Coronel Carmelo Peralta station proves the predominance of two winds from the south, followed by northeast and east, and with a less important component from the southeast.

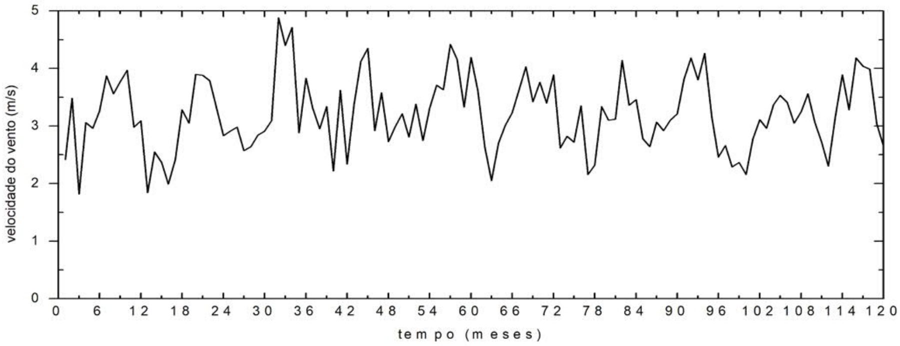
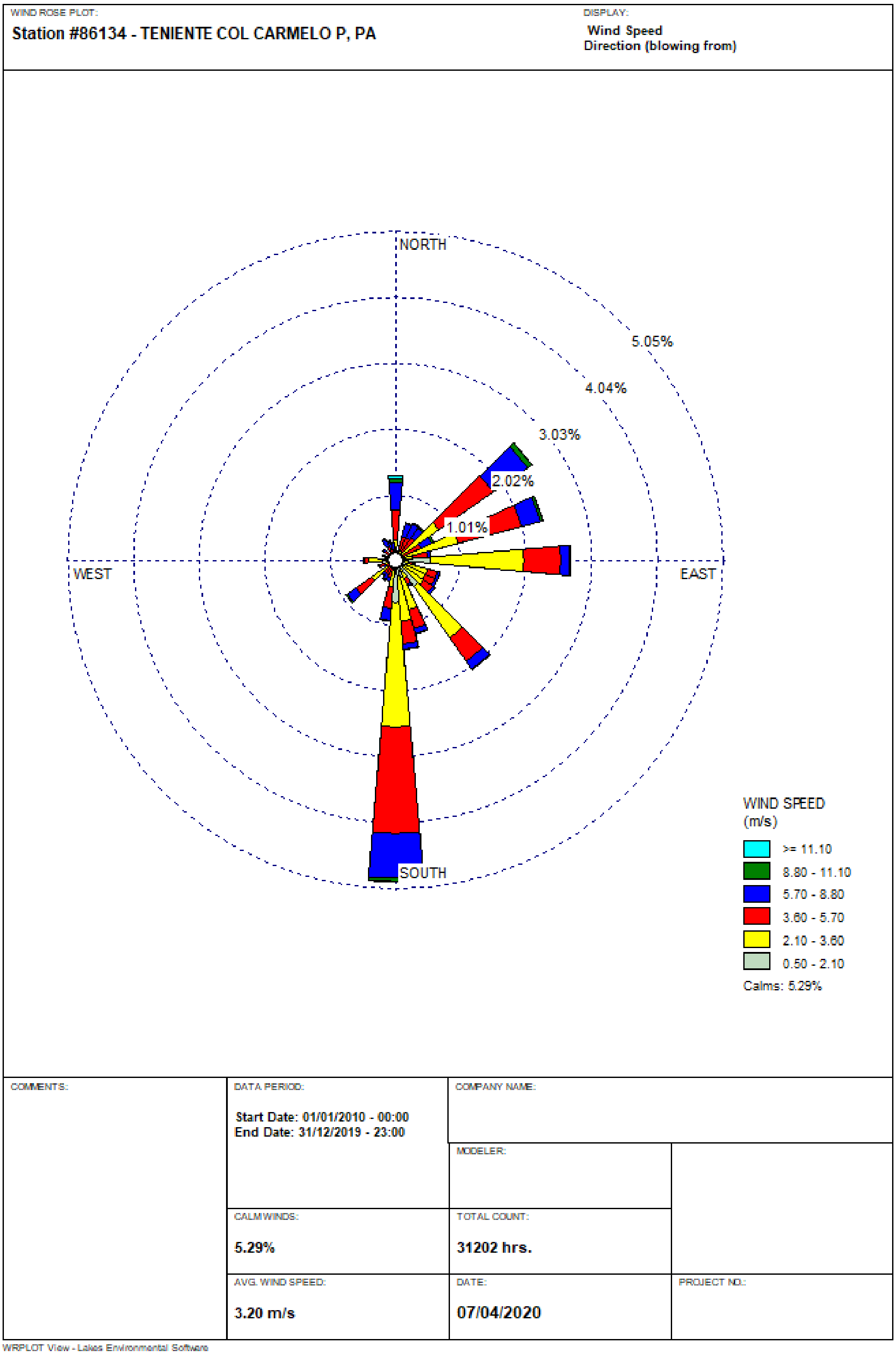


Figure 39 – Average wind speed at the station Teniente Coronel Carmelo Peralta



WIND ROSE PLOT:

Station #86134 - TENIENTE COL CARMELO P, PA

DISPLAY:

Wind Speed
Direction (blowing from)

🟦 >= 11.10
🟩 8.80 - 11.10
🟦 5.70 - 8.80
🟥 3.60 - 5.70
🟨 2.10 - 3.60
🟩 0.50 - 2.10

Calms: 5.29%

COMMENTS:

DATA PERIOD:

Start Date: 01/01/2010 - 00:00
End Date: 31/12/2019 - 23:00

COMPANY NAME:

MODELER:

CALM WINDS:

5.29%

TOTAL COUNT:

31202 hrs.

AVG. WIND SPEED:

3.20 m/s

DATE:

07/04/2020

PROJECT NO.:

WRPLOT View - Lakes Environmental Software

Figure 40 – Wind rose observed at the station Teniente Coronel Carmelo Peralta

The wind intensities in all regions are very similar and can be classified as weak winds, between 1.4 and 3.2 m/s. The highest wind speeds were registered at Teniente Coronel Carmelo Peralta station. The predominant wind directions are north and south, followed by northeast and east winds.

3 PHYSICOCHEMICAL AND TOXICOLOGICAL CHARACTERISTICS OF PRODUCTS

PARACEL pulp mill facilities involve a series of chemical products. The table below presents the main products and respective risk class / subclass established by the ONU.

Table 6 – Main products and risk class/subclass by ONU

Product	ONU Number	Risk Class	Risk Label
Methanol	1230	3 – Flammable Liquid	
Caustic Soda	1824	8 – Corrosive Substance	
Sulfuric acid	1830	8 – Corrosive Substance	
Diesel	1202	3 – Flammable Liquid	
Fuel	3256	3 – Flammable Liquid	
Sodium chlorate	2428	5.1 – Oxidant	
Chlorine Dioxide	3139	6.1 – Toxic Gas	
Sodium bisulphite	2693	8 – Corrosive Substance	
Oxygen	1072	2.2 – Non-toxic compressed gas	

Product	**ONU Number**	**Risk Class**	**Risk Label**
Hydrogen peroxide	2014	5.1 - Oxidant	

NOTE: * It should be noted that, in a conservative way, chlorine was considered as a representative substance of chlorine dioxide, assuming that in a possible release of chlorine, the detached product would be chlorine. It should also be noted that PARACEL will not use chlorine in its bleaching process (it will use the ECF - Elemental Chlorine Free Process).

From the initial characterization of the products, to continue the Preliminary Risk Analysis Study, the most representative liquid or gaseous chemicals substances were selected in terms of flammability and toxicity. For this purpose, the criteria used is the one established by CETESB from Brazil for the classification of chemicals according to their hazard.

The Material Safety Data Sheets (MSDS) are presented in **ANNEX III**.

4 RISK IDENTIFICATION

4.1 Introduction

This chapter describes the methodology used to identify the risks relating to PARACEL pulp mill facilities and presents the identified hazards results through the application of the Preliminary Hazard Analysis (APP) technique.

The following section 4.2 presents a historical analysis of accidents, while section 4.3 provides a brief description of the APP technique and methodology used for risk identification.

4.2 Historical Accident Analysis

The *Major Hazard Incidents Data Service* – MHIDAS is an international database of accidents/incidents in industrial production, transportation and storage of chemicals products that result in a potential risk to the community.

According to the MHIDAS database, accidents with hazardous substances used in the pulp and paper industries have been reported. Since 1974, 6 accidents related to this sector have been found, 1 being related to the explosion of recirculated pulp powder, 1 related to the rupture of an effluent lagoon and the discharge of partially treated effluents, 4 related to the release of chlorine (2 by pipeline rupture and 2 due to explosion in the generation unit).

The following table shows the number of incidents reported in MHIDAS that occurred in different types of industries.

Table 7 – Number of incidents per type of substance

Substance	State	Incidents
Sodium chlorate	Crystallized or powdered	19
Methanol	Liquid	197
Chlorine dioxide	Gas	1
Hydrogen peroxide	Solution	30
Fuel	Liquid	356

Source: MHIDAS

According to MHIDAS, accidents were reported with hazardous substances present in the pulp industry:

- Methanol: Accidents with detachment and formation of puddles, fires and explosions, caused by floods, lightning, human faults and impacts during transport were catalogued.
- Chlorine dioxide: Only a laboratory accident was reported because explosions occurred due to the release of the substance by its misuse.
- Hydrogen peroxide: Peroxide accidents that occurred during loading and unloading of containers or leaks in distributors' warehouses were catalogued, requiring area insulation and cleaning; none of these incidents were identified in the pulp industries.
- Fuel: Accidents with tank explosions with this substance were reported due to human faults, external fires, extreme temperatures. During transport, accidents occurred due to impacts followed by fire and/or explosion.
- Boilers: Explosion accidents caused by low water operating conditions, operator errors or poor maintenance, as well as human supervision failures and lack of knowledge, were responsible for 69% of injuries and 60% of reported deaths.

In addition, some accidents were found in pulp mills, according to information published by the press:

- In Brazil, in 1988, the chemical recovery boiler exploded in the northern region of the country;
- In 1994, at mill in the United States, a digester explosion occurred;
- In 2007, at a plant in northeastern Brazil, the black liquor tank broke;
- In 2017, there was an explosion of a digester at a plant in the United States;
- In 2020, there was an explosion of two digesters at a plant in the United States.

4.3 Preliminary Risk Analysis

4.3.1 Methodology

The Preliminary Risk Analysis (APP) was developed by the military safety program of the United States Department of Defense (MIL-STD-882B).

It is a structure technique having as purpose to identify the hazards existing in an installation, which are caused by undesirable events. Commonly it is used in the initial stage of a project, although it has been also applied in operation units, allowing a critical analysis of the existing safety systems and the identification of possible eventual incidents.

The APP is centered on hazardous events that failures were originated at the installation being analyzed, covering both the intrinsic failures of equipment, instruments and materials, and errors such as human fails.

APP identifies the risks, their causes, the effects and their respective categories of severity, pointing out possible observations and recommendations pertinent to the hazards identified. The results are presented in standardized worksheet, as shown in figure bellow.

APP – PRELIMINARY RISK ANALYSIS							
Area:							
Item	**Hazard**	**Possible causes**	**Possible effects**	**Grade**			***Remarks*** ***Recommendations***
				Frequency	**Severity**	**Risk**	

Figure 41 – APP – Preliminary Risk Analysis Sheet

- **Item:** sequence number of the hazard identified in the study;
- **Hazard:** characterizes the undesired event, which is usually associated with one or more conditions having the potential to cause harm to people, damage property or environment;
- **Causes:** possible causes associated with a certain hazard;
- **Effects:** possible consequences associated with a certain hazard;
- **Severity Category:** qualitative level of the effect associated with the incident scenario;
- **Remarks/Recommendations:** observations pertaining to the hazard and their accidental scenarios, existing safety systems or recommendations for managing the associated risks.

The criteria for the classification of the probabilities of occurrence of hazards, severities applied to associated effects and risk categories are presented in the following section.

Criteria for Frequency Classification and Severity

For the categorization of effects, the criterion of severity levels traditionally adopted in the application of APP was used, as presented in table below.

Table 8 – Severity Categories

Category	Denomination	Description
I	Negligible	Events associated with no non-measurable damage or damage.
II	Marginal	Occurrences with the potential to cause irrelevant damage to the environment, the installation and the internal and external communities.
III	Critical	Situations with potential to cause impacts to the external environment to the facility with reduced recovery time, and may cause moderate injuries in the external population.
IV	Catastrophic	Occurrences with the potential to generate significant environmental impacts in areas outside the facilities and with a high recovery time, which may also cause deaths or serious injuries to the population.

For the categorization of frequency of occurrence, the criterion of frequency levels traditionally adopted in the application of APP was used, as presented in following table.

Table 9 – Frequency Categories

Category	Denomination	Description
A	Very unlikely	Conceptually possible, but extremely unlikely to occur during the lifetime of the facility. Incidents that depend on the occurrence of multiple failures.
B	Unlikely	Not expected to occur during the lifetime of the installation. Incidents associated with several faults or ruptures of large equipment.
C	Remote	Unlikely to occur during the lifetime of the installation. The occurrence depends on a single fault (human or equipment).
D	Probable	Expected to occur at least once during the lifetime of the installation.
E	Frequent	Expected to occur several times during the lifetime of the installation.

The risk matrix, shown in following figure, is the result of the interaction between severity and frequency, resulting in the exposed risk.

		FREQUENCY OF OCCURRANCE				
		A	B	C	D	E
SEVERITY	IV	**Mn**	**M**	**S**	**C**	**C**
	III	**D**	**Mn**	**M**	**S**	**C**
	II	**D**	**D**	**Mn**	**M**	**S**
	I	**D**	**D**	**D**	**Mn**	**M**

Severity		**Frequency**	
I	Negligible	**A**	Very unlikely
II	Marginal	**B**	Unlikely
III	Critical	**C**	Remote
IV	Catastrophic	**D**	Probable
		E	Frequent

Risk	
D	Negligible
Mn	Minor
M	Moderate
S	Serious
C	Critical

Figure 42 – Risk Classification Matrix

4.3.2 Hazard Identification

In the pulp mill of PARACEL, the hazards will basically arise from the accidental release of the products handled; thus, as a basic principle used in the application of APP, typical situations related to large and medium releases, associated with component faults, such as connections, blocking valves, flanges and lines, among others, were identified.

The APP worksheets were completed by PÖYRY Tecnologia technicians based on Process Flowcharts (**ANNEX I**), identifying the main hazards, their causes and their associated effects.

For each of the possible effects generated by the accidental hypotheses a degree of severity was attributed, according to the criterion presented previously. **ANNEX IV** presents the completed worksheets of the APP.

From the application of the APP to identify the hazards related to the installations and operations with the products handled in PARACEL, 53 hazards were identified, always considering relevant accidental situations, that is, events caused by non-condensable gas, methanol and chlorine dioxide leaks, significant at the factory in question, as described in Chapter 2.

The possible effects associated to the accidental hypotheses identified in the APP were classified in terms of severity, always considering two types of phenomena, when pertinent; that is, large and medium leakages, associated with the loss of containment of such products.

The distribution of the effects associated with these accidents (hazard) hypotheses are as follows:

- 13 hazards (24%) classified as Negligible Risk;
- 10 hazards (19%) of Minor Risk;
- 26 hazards (49%) of Moderate Risk;
- 4 hazards (8 %) of Serious Risk;
- No hazard classified as Critical Risk.

The following figure presents the risk matrix with the quantification of the hypotheses according to the classifications adopted.

		FREQUENCY OF OCCURRENCE				
		A	B	C	D	E
SEVERITY	IV	🟦	🟨	🟫	🟥	🟥
	III	🟩	🟦 **3**	🟨 **4**	🟫 **4**	🟥
	II	🟩 **3**	🟩 **10**	🟦 **6**	🟨 **22**	🟫
	I	🟩	🟩	🟩	🟦 **1**	🟨

Figure 43 – Risk matrix with the quantification of the hypotheses

5 CONCLUSIONS

This Preliminary Risk Analysis Study was developed with the aim to qualitatively assess the risks imposed by the operational activities of the PARACEL pulp mill, to be implemented in the municipality of Concepción, in the Department of Conception - Paraguay, which can cause fires, explosions, toxic dispersions, effluent or gases leaks.

In this risk analysis, it was verified, through the application of the APP methodology - Preliminary Risk Analysis, that no hazard was classified as Critical, and that most of the identified risks (92%) are classified as Negligible, Minor or Moderate.

Therefore, the start-up of the pulp mill can be considered feasible, however, by strengthening its complying with the measures to be taken, which are described as follow, in order to keep the risks at acceptable levels.

- Installing the lightning discharge protection system;
- Installation of relief valves in equipment subject to overpressure;
- Construction of containment basin for chemical and flammable storage tanks;
- Implementation of a high level instrumentation equipment to allow monitoring all process variables;
- Implementation of redundancy (additional security) in interlocks at critical safety points and process;
- Development of operational procedures, including instructions on health, safety and the environment aspects;
- Implementation of preventive and corrective maintenance programs at all mill's equipment;
- Periodic training of operators and employees in the maintenance sector;
- Preparation of the Contingency Prevention and Management Program, which includes the Emergency Action Protocol, which specifies the location of emergency alarms and gas detectors, the procedures, escape routes and meeting points;
- Installation of firefighting systems in process areas, auxiliary and administrative buildings, and in the fuel storage area;
- Periodic execution of fire simulation and other types of emergency.

6 BIBLIOGRAPHIC REFERENCES

COMPANHIA AMBIENTAL DO ESTADO DE SÃO PAULO (CETESB). P.4.261 Norma Técnica – Risco de Acidente de Origem Tecnológica – Método para decisão e termos de referência, 2011.

COMPANHIA AMBIENTAL DO ESTADO DE SÃO PAULO (CETESB). Manual de Produtos Químicos Perigosos.

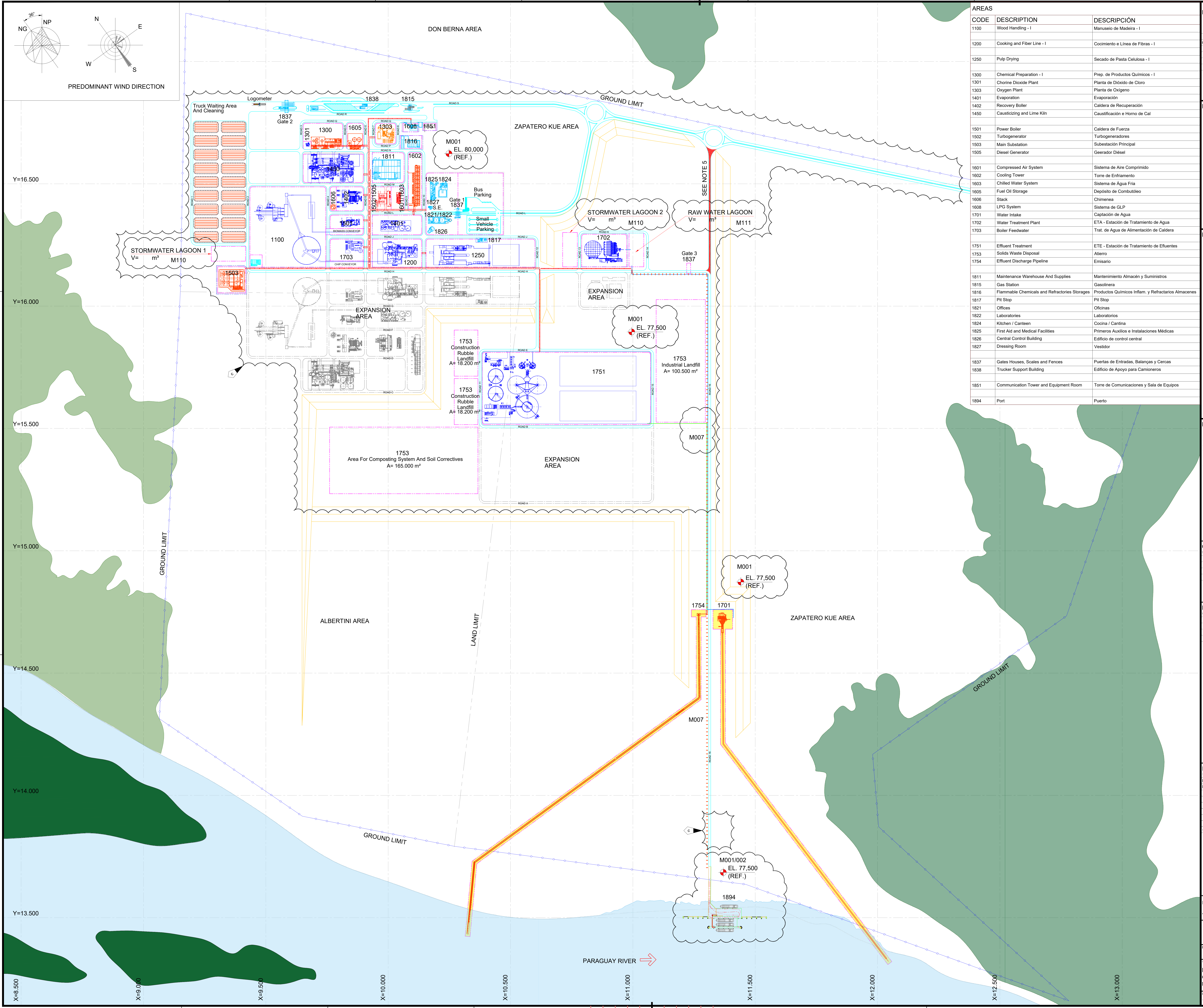
ANXEX I

PROCESS FLOW DIAGRAM


Forest-debarked wood
Line 1
Washing
Chipper 1
Forest-debarked wood
Line 2
Washing
Chipper 2
Forest-debarked wood
Line 3
Washing
Bark
Chipper 3
Chips
Fines
Screening
Chip pile
Chips
Steam
Bark shreder
Bark + Fines
Biomass pile
COOKING
Blow tank
OXYGEN DELIGNIFICATION
Pre-washing
Screening
Pos-washing
Pre-bleached pulp storage
BLEACHING PLANT
EP
D
P
Hot water
White water
Storage Tower 1
Circulating water
Mixing tank
Storage Tower 2
Circulating water
Mixing tank
Screening
Machine tank
Screening
Machine tank
DRYING MACHINE
Sheet cooler
DRYING MACHINE
Sheet cooler
Cutter
Cutter
Baling
Chemical preparation
Oxygen plant
O₂
Oxygen delignification
bags
Dissolving
Talc
Oxygen delignification
NaHSO₃
Sodium bisulphite
Bleaching
NaOH 50%
NaOH 20%
Caustic
Bleaching and other plants
H₂SO₄ 98%
Sulphuric acid
Bleaching and other plants
H₂O₂
Bleaching
Absortion tower
NaClO₃
ClO₂ Reactor
Sodium sulfate
ClO₂ tanks
Bleaching
Cooling towers
Make-up water
Condenser
Condensate
CNCG
TG 2
TG 1
Steam MP
Steam LP
Condensate to deaerator
MeOH column
Foul cond.
Stripper
EVAPORATION
7
6
5
4
3
2
Heavy liquor tanks
Weak black liquor tanks
Biomass Boiler
Purge
Flue gas stack
High pressure steam
DNCG
CNCG Backup 2 Flare
Sootblowing steam
MeOH storage
Electrostatic Precipitator
RECOVERY BOILER
CNCG Backup 1 Biomass Boiler
DNCG Backup 1 Biomass Boiler
Fuel oil
Air
Mix tank
Dissolving tank
MeOH
Fuel oil
Syngas
Lime make-up
Condensate
Electrostatic Precipitator
Lime mud filter
Lime Kiln 1
DNGC (Causticizing)
Lime mud filter
Electrostatic Precipitator
Lime Kiln 2
Raw green liquor tank
Grits
Slaker
Green liquor filters
Filtered green liquor storage
Causticizers
White liquor filters
White liquor tank
Lime mud storage
Dregs washing
Dregs
Weak white liquor tank
Oxygen
O₂ delignification
White liquor oxidation
RAW WATER TREATMENT
Chemicals
Clarifiers
Screen
Pumping station
Sludge tank
Sand filter
ETAC
Fresh water
Fire fighting water
Activated carbon filter
Potable water
Dewatered primary sludge
EFFLUENT TREATMENT
Efluent
Screening
FI
Cond.
TI
pH
Rain water lagoon
Primary clarifiers
Emergency lagoon
Dewatering screw
Dewatered primary sludge
H₂SO₄
NaOH
Neutralization tank
Cooling towers
Sanitary effluent
Aeration tanks
Sludge tank
Sludge dewatering system
Dewatered biological sludge
Chemicals
Secondary decanters
Floculation
Flotation
Saturation tank
Air compressor
Sludge tank
Centrifuge
ETA sludge dewatered
NaOH
FI
Cond.
TI
pH
DBO
Neutralization tank
PÖYRY
PARACEL
1 500 000 ADtB/a

ANNEX II

MILL PROJECT LAYOUT



AREAS

CODE	DESCRIPTION	DESCRIPCIÓN
1100	Wood Handling - I	Manuseio de Madeira - I
1200	Cooking and Fiber Line - I	Cocimiento e Línea de Fibras - I
1250	Pulp Drying	Secado de Pasta Celulosa - I
1300	Chemical Preparation - I	Prep. de Productos Químicos - I
1301	Chorine Dioxide Plant	Planta de Dióxido de Cloro
1303	Oxygen Plant	Planta de Oxígeno
1401	Evaporation	Evaporación
1402	Recovery Boller	Caldera de Recuperación
1450	Causticizing and Lime Kiln	Caustificación e Horno de Cal
1501	Power Boiler	Caldera de Fuerza
1502	Turbogenerator	Turbogeneradores
1503	Main Substation	Subestación Principal
1505	Diesel Generator	Geerador Diésel
1601	Compressed Air System	Sistema de Aire Comprimido
1602	Cooling Tower	Torre de Enfriamento
1603	Chilled Water System	Sistema de Água Fria
1605	Fuel Oil Storage	Depósito de Combutóleo
1606	Stack	Chimenea
1608	LPG System	Sistema de GLP
1701	Water Intake	Captación de Agua
1702	Water Treatment Plant	ETA - Estación de Tratamiento de Agua
1703	Boiler Feedwater	Trat. de Agua de Alimentación de Caldera
1751	Effluent Treatment	ETE - Estación de Tratamiento de Efluentes
1753	Solids Waste Disposal	Atierro
1754	Effluent Discharge Pipeline	Emisario
1811	Maintenance Warehouse And Supplies	Mantenimiento Almacén y Suministros
1815	Gas Station	Gasolinera
1816	Flammable Chemicals and Refractories Storages	Productos Químicos Inflam. y Refractarios Almacenes
1817	Pit Stop	Pit Stop
1821	Offices	Oficinas
1822	Laboratories	Laboratorios
1824	Kitchen / Canteen	Cocina / Cantina
1825	First Aid and Medical Facilities	Primeros Auxilios e Instalaciones Médicas
1826	Central Control Building	Edificio de control central
1827	Dressing Room	Vestidor
1837	Gates Houses, Scales and Fences	Puertas de Entradas, Balanças y Cercas
1838	Trucker Support Building	Edificio de Apoyo para Camioneros
1851	Communication Tower and Equipment Room	Torre de Comunicaciones y Sala de Equipos
1894	Port	Puerto

REVISION TABLE

CODE:
PR -PRELIMINARY
PA -FOR APPROVAL
PI -FOR INFORMATION
PC -FOR QUOTATION
CO-FOR COMMENTS
LE -RELEASED FOR CONSTRUCTION
LD -RELEASE FOR DETAILING
CC -AS BUILT
CA -CANCELED

REV.	DATE	PROJ.	VERIF.	APPROV.	AUTHOR.	CODE	DESCRIPTION
0	03/12/19	jtm	awg	dhy	mnq	PA	INITIAL ISSUE
a	23/01/20	jtm	awg	dhy	mnq	PA	Added area 1851 and changed areas 1701, 1753 and 1754
b	20/02/20	jtm	awg	dhy	mnq	PA	REVISED LAYOUT LEASE
c	27/03/30	jtm	awg	dhy	mnq	PA	CHANGED LAYOUT POSITION

NOTES:
1 - ALL COORDINATES IN METERS (m).
2 - THE COORDINATION SYSTEM USED IS WGS 84, OBTAINED FROM THE SOFTWARE GOOGLE EARTH.
3 - PRELIMINARY DESIGN STUDY, ARRANGEMENT OF THE PROCESS ISLAND IN PROGRESS.
4 - ELEVATIONS INDICATED FOR REFERENCE ONLY, CONFIRMATION OF SURVEY AND STUDY OF THE EARTH IN MOVEMENT BY IMPLEMENTATION.
5 - TEMPORARY ACCESS FOR RECEIVING TORMS BY BARGE FOR WEIGHING AT GATE 2.

LEGEND:

━	NEW STREETS
▭	BATTERY LIMIT, SIDEWALKS AND ACCESS
─○─○─	GROUND LIMITS AND DEFINITE FENCE
━	WATER INTAKE
━	EFFLUENT DISCHARGE PIPELINE
━	EPC
━	BOP
━	OVER THE FENCE
━	NON PROCESS BUILDING
-·-·-	FUTURE EXPANSION
⊠	PIPE RACK (BOP)
▯ ▯ ▯	PIPE WAY (BOP)
▨	TEMPORARY ROAD (NOTA 5)

PENDENT ITEM:
M001 - GROUND LEVEL.
M002 - PORT DEFINITION.
~~M003 - EMERGENCY POND DEFINITION.~~
~~M004 - PIPE RACK DEFINITION.~~
~~M005 - FENCE DEFINITION.~~
M006 - ACCESS DEFINITION.
M007 - BASIC ROAD WATER INTAKE AND EFFLUENT DISCHARGE PIPELINE.
~~M008 - ELECTRICAL ROOM DEFINITION.~~
M110 - STORMWATER LAGOON CAPACITY.
M111 - RAW WATER LAGOON CAPACITY.

CONSULTED DOCUMENTS

TITLE	NUMBER	REV.

REFERENCE DOCUMENTS

TITLE	NUMBER

DISTRIBUTION

TO	REVISION 0	a	b	c	d	e	f
PARACEL	E	E	E	E			
POYRY	E	E	E	E			

N- PRINT/PLOT (HARD COPY) E- ELECTRONIC FILE

FOR
APPROVAL

PÖYRY

PARACEL PROJECT
Basic Engineering Services
Concepción - Paraguay

PARACEL

RESP./TITLE/CREA NUMBER	CUSTOMER NUMBER	REV.

TITLE
PARACEL PROJECT - BASIC ENGINEERING SERVICES
General Mill Site Layout
Master Plan - General Layout

SCALE	UNIT	PROJECTION	PÖYRY NUMBER	REV.
1:5000	mm		109001759-001-1000-M05-0001	c

ANNEX III

MATERIAL SAFETY DATA SHEET (MSDS)

FICHA DE DATOS DE SEGURIDAD:
ACIDO SULFURICO

Concentrado para uso industrial
98,5 % ± 0,5 %

1. Identificación del producto y del proveedor

1.1. Identificación del producto

- Nombre del producto indicado en la etiqueta: Ácido sulfúrico concentrado
- Nombre químico: Ácido sulfúrico
- Fórmula química: H2SO4
- Nº ONU: 1830
- Riesgo principal: 8
- Usos recomendados y restricciones de uso: Fabricación de fertilizantes, detergentes, sulfato de aluminio, sales, explosivos, productos farmacéuticos y numerosos productos químicos. En electrolito para baterías, agente deshidratante y otros diversos usos.

1.2. Identificación de la empresa

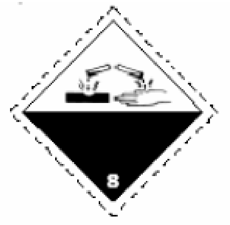
- Fabricante: Industria Sulfúrica S.A. (ISUSA)
- Dirección:
  - Planta Ruta 1: Ruta 1 km 24, Ciudad del Plata, Departamento de San José
  - Planta Agraciada - Camino Vecinal Tramo 154 s/n entre Ruta 21 Km 283½ y Ruta 12 Km 20, Localidad de Agraciada, Departamento de Soriano
- País: República Oriental del Uruguay
- Teléfono:
  - Planta Ruta 1 – 2347 2035
  - Planta Agraciada – 098 392 811/22
- Correo Electrónico: isusa@isusa.com.uy
- Teléfono de Emergencia con atención las 24 horas
  - Planta Ruta 1: 2347 2035, 0800 8522
  - Planta Agraciada: 0800 8638

2. Identificación de peligros

2.1. Clasificación de la sustancia

Corrosivo cutáneo, categoría 1 A.
Sustancia corrosiva para los metales, categoría 1.
Grupo de embalaje II
Número de riesgo: 80

2.2. Elementos de la etiqueta



PELIGRO

PROVOCA GRAVES QUEMADURAS EN LA PIEL Y LESIONES OCULARES

Evite el contacto con los ojos, piel y ropa. Si se produce, lávese con abundante agua por lo menos durante 15 minutos.
No agregue agua al recipiente, el ácido reacciona violentamente con el agua.

2.3. Otros peligros

Es un ácido mineral fuerte que presenta color y olor aceitoso en estado puro, puede presentarse amarillo o marrón en estado impuro. Causa destrucción del tejido corporal y serias quemaduras químicas. Puede descomponerse en altas temperaturas formando gases tóxicos como el dióxido de azufre. No es inflamable pero reacciona violentamente con el agua generando calor y potenciales salpicaduras. Puede carbonizar y posiblemente incendiar materiales combustibles.
En contacto con metales puede desprender hidrógeno, el que forma mezclas explosivas con el aire.

3. Composición e información de los componentes

2.4. Identidad química de la sustancia: Ácido Sulfúrico
2.5. Nombres comunes, sinónimos de la sustancia: Acido de batería, ácido de cámara, ácido fertilizante, aceite de Vitriolo.
2.6. Número CAS y otros identificadores únicos para la sustancia: 7664-93-9
2.7. Impurezas y aditivos estabilizantes que estén clasificados y que contribuyen a la clasificación de la sustancia: No contiene

4. Medidas de primeros auxilios

Es un producto altamente corrosivo para los tejidos corporales por todas las vías de exposición.
La rapidez en el lavado es esencial para evitar consecuencias mayores. En todos los casos obtener atención médica.
Contacto con la piel: Retirar las ropas contaminadas inmediatamente. Lavar las partes afectadas del cuerpo con abundante agua durante 15 minutos.
Contacto con los ojos: Lavar con agua, inmediatamente durante 15 minutos, levantando ocasionalmente los párpados.
Ingestión: Si la víctima está consciente, administrar grandes cantidades de agua inmediatamente.
No intentar hacer vomitar a la víctima. Trasladar inmediatamente el paciente al hospital.
Inhalación: Llevar al accidentado al aire fresco, mantener abrigado y aplicar respiración artificial si fuera necesario. La administración boca a boca puede exponer al administrador. Transportar a la víctima al hospital inmediatamente.
Otros consejos médicos: después de la exposición, el paciente se mantendrá bajo vigilancia médica durante al menos 48 hs, como prevención a un posible desarrollo de edema pulmonar.

5. Medidas de lucha contra incendios

No es inflamable ni combustible pero sin embargo su acción corrosiva sobre numerosos metales es acompañada por desprendimiento de hidrógeno el cual es fuente de incendio y explosiones. El hidrógeno forma mezclas explosivas con el aire, por lo tanto al abrir un recipiente metálico conteniendo ácido evitar fuentes de ignición.
Cuando entra en contacto con combustible finamente dividido, (ejemplo aserrín o papel) puede provocar su ignición.
Medios de extinción apropiados:
Para fuegos pequeños: usar extintores de polvo. Tener en cuenta que el ácido reacciona con el agua produciendo desprendimiento de calor.
En caso de fuegos mayores: usar agua para refrigerar los recipientes, asegurándose que no entre en contacto con el producto.
Protección a bomberos: usar equipos de respiración autónoma y ropa de protección total.
Sustancias liberadas por el calor o descomposición: óxidos de azufre e hidrogeno.

6. Medidas a tomar en caso de derrames accidentales del producto

6.1. Precauciones personales, equipos de protección y procedimientos de emergencia:

Ponerse el equipo de protección antes de entrar en el área de peligro. Ventilar la zona de derrame o fuga. Use equipo antiácido, mascara completa o pantalla facial, guantes antiácidos, botas de PVC, por dentro del equipo.
Proceder con precaución. Restringir el acceso al área. Mantener el personal sin protección en posición contraria a la dirección del viento en el área de derrame. Evitar el contacto con el producto derramado. Tener en cuenta mientras se implementa la respuesta que el ácido

es altamente corrosivo y reactivo. El contacto con metales puede producir hidrógeno, gas inflamable y explosivo.

6.2. Precauciones ambientales:

Tomar precauciones para evitar la contaminación de los cursos de agua y drenajes. Informar a la autoridad correspondiente en caso de contaminación de los cursos de agua.

6.3. Métodos y materiales para la contención y limpieza de vertidos:

Contención: Por succión o bombeo a cisternas o contenedores usando equipos apropiados a tales fines.
Puede contenerse construyendo diques o barreras usando arena o tierra. El ácido contenido en la barrera puede filtrase al suelo aumentando la extensión de la contaminación.
Mitigación: Se puede neutralizar, con carbonato de calcio, carbonato de sodio, calizas o dolomita.
Tener en cuenta que la reacción química produce calor, vapores y salpicaduras. Consultar con un técnico calificado sobre las técnicas seguras de contención y mitigación.
Recoger el líquido procedente de la fuga en recipientes herméticos, no absorber en aserrín u otros absorbentes combustibles.

7. Manipulación y almacenamiento

7.1. Precauciones para el manejo seguro:

Proporcionar una ventilación adecuada. Utilizar protección de ojos y manos cuando se manejen pequeñas cantidades. Usar equipo de protección total cuando exista riesgo de salpicaduras o derrames. Cuando se diluye, adicionar siempre el ácido sobre el agua y nunca el agua sobre el ácido. Evitar la inhalación de altas concentraciones de nieblas, en estos casos usar máscara completa con filtros para gases ácidos.

7.2. Condiciones de almacenamiento seguro:

El ácido sulfúrico concentrado para uso industrial se almacena en recipientes y tanques de hierro, acero inoxidable o bidones de plástico apropiados. Es conveniente ubicarlos en locales bien ventilados y al abrigo de la luz del sol. En caso de depósitos exteriores se recomienda pintarlos exteriormente de colores claros. Se debe tener especial atención a que en recipientes metálicos se genera hidrógeno, que forma mezclas explosivas con el aire, por lo que nunca se deben producir chispas en las proximidades de los tanques. En todos los casos se deberá disponer de pisos resistentes a la corrosión y de desagües con una retención para poder neutralizar el ácido proveniente de fugas accidentales. Se deberá disponer en las proximidades un punto de suministro de agua con abundante caudal. Se aconseja la instalación de una ducha de seguridad para casos de accidentes.

7.3. Incompatibilidades con otras sustancias:

Alejar de los materiales combustibles, agentes reductores, bases fuertes, metales y alimentos y raciones para animales.

8. Control de la exposición y protección personal

8.1. Parámetros de control

<u>Límite de exposición recomendados</u>:

- TLV-TWA: Niebla 0,2 mg/m3(ACGIH 2010).
- TLV-STEL: No disponible (ACGIH 2010).
- OSHA PEL: 1mg/m3
- NIOSH REL: 1mg/m3

8.2. Controles de ingeniería apropiados.

Medidas de precaución y equipos mecánicos: ventilación local asistida. Instalar equipos lava-ojos y duchas de seguridad en cualquier lugar en donde se pueda producir contacto con los ojos y la piel.

8.3. Medidas de protección individual

Protección para ojos y cara: usar pantalla de protección facial.
Protección de la piel: usar equipo antiácido o delantal de PVC, guantes antiácidos, botas de PVC, pantalón por fuera de las botas.
Protección respiratoria: en caso de presencia de niebla ácida se debe usar máscara con cartuchos para gases ácidos.
Medidas de higiene necesarias: no comer, ni beber, ni fumar durante el trabajo.

9. Propiedades físicas y químicas

<u>Aspecto</u>: líquido incoloro a amarillo, viscoso.
<u>Olor</u>: sin olor cuando está frío, si se calienta se desprenden vapores de SO3
<u>Umbral Olfativo</u>: Para niebla de SO3 < 1mg/m3
<u>PH (sin diluir)</u>: < 0.1
<u>Punto de fusión y/o congelamiento</u>: 3º C
<u>Punto de ebullición</u>: entre 310 y 335 ºC
<u>Punto de inflamación</u>: No aplica
<u>Tasa de evaporación</u>: No disponible
<u>Inflamabilidad</u>: No aplica
<u>Presión de vapor</u>: < 0,001 mm Hg a 20 ºC; 1 mm Hg a 146 ºC
<u>Densidad de vapor (aire=1)</u>: 3,4
<u>Densidad relativa</u>: 1.84 g/ml
<u>Solubilidad</u>: completamente soluble.
<u>Coeficiente de reparto</u>: No aplica
<u>Temperatura de autoinflamación</u>: No aplica
<u>Temperatura de descomposición</u>: Se descompone a 340ºC en SO3 y agua

Viscosidad: 25 centipoises a 21ºC

10. Estabilidad y reactividad

10.1. Reactividad.

Es extremadamente reactivo con metales, álcalis y muchos productos químicos orgánicos e inorgánicos.
La dilución con agua genera calor excesivo y pueden ocurrir salpicaduras o ebullición. Siempre añada el ácido al agua, NUNCA AGREGUE AGUA AL ACIDO

10.2. Estabilidad química:

Este producto es muy estable bajo condiciones normales de almacenamiento, manipulación y uso.

10.3. Posibilidad de reacciones peligrosas:

De la reacción con metales se desprende hidrógeno, gas combustible y explosivo. Por contacto con cianuros, sulfuros y carburos se pueden desprender gases peligrosos como cianuro de hidrógeno, sulfuro de hidrógeno y acetileno. El contacto con materia orgánica combustible puede causar fuego o explosión.

10.4. Condiciones que deben evitarse:

Debe evitarse las altas temperaturas

10.5. Materiales Incompatibles:

Materiales combustibles, materiales orgánicos, oxidantes, aminas, bases, agua, calor en exceso y metales.

10.6. Productos de descomposición peligrosos:

Dióxido de azufre, trióxido de azufre e hidrógeno.

11. Información toxicológica

11.1. General.

El ácido sulfúrico concentrado ejerce una acción corrosiva fuerte en todos los tejidos, debido a una acción de deshidratación severa. La severidad de una quemadura química es proporcional a la concentración del ácido y a la duración del contacto. Exposiciones prolongadas a soluciones diluidas o niebla ácida pueden llevar a irritación de los ojos y piel, causando conjuntivitis y dermatitis crónica. La inhalación de niebla de ácido sulfúrico puede resultar en irritación del tracto respiratorio que posiblemente puede llevar a espasmo laríngeo. Los asmáticos pueden ser muy sensibles a inhalar niebla de ácido sulfúrico. IARC y la ACGIH han concluido que hay suficiente evidencia que exposiciones ocupacionales a nieblas de ácidos inorgánicos fuertes conteniendo ácido sulfúrico es carcinogénico o potencialmente carcinogénico a los humanos.

11.2. Efectos agudos.

Contacto con la piel: Provoca quemaduras graves profundas y dolorosas. Las quemaduras extensas pueden tener como resultado el shock y muerte.
Contacto con los ojos: Provoca quemaduras graves profundas y dolorosas
Ingestión: Puede tener como resultado quemaduras graves en boca, garganta, perforación del esófago, estómago, manchas y erosión de dientes, náuseas y vómitos de sangre y tejidos erosionados, y hasta la muerte. No inducir el vómito.
Especies y ruta LD_{50} rata- oral 2140 mg/kg
Inhalación: La niebla ácida puede causar irritación de vías respiratorias. Altas concentraciones pueden causar estornudo, tos, dificultad para respirar y edemas de vías respiratorias, con graves consecuencias.
Especies y ruta LC_{50} rata- inhalatoria 0,375 mg/l (4hr)

11.3. Efectos crónicos.

La exposición prolongada a soluciones diluidas o nieblas puede resultar en irritación a los ojos (conjuntivitis crónica) y producir dermatitis en la piel. La exposición a altas concentraciones de niebla ácida ha causado erosión y decoloración de los dientes anteriores. La International Agency por Research on Cáncer ha concluido que hay suficiente evidencia que la exposición ocupacional a nieblas ácidas inorgánicas fuertes conteniendo ácido sulfúrico son carcinógenos en humanos, resultando en un incremento de incidencia principalmente de cáncer laríngeo. La ACGIH tiene listada la niebla de ácido inorgánico fuerte conteniendo ácido sulfúrico como sospechoso de carcinógeno humano (A2). OSHA no lista la niebla de ácido sulfúrico como carcinógeno.
Mutagénico: mutagenicidad bacteriana: test de Ames negativo
Toxicidad para la reproducción: no teratogénico en experimentos con animales.

12. Información ecotoxicológica

12.1. Toxicidad

Toxicidad en peces (Brachydanio rerio): LC 50 82 mg/l en 24 hs (IUCLID)
Toxicidad en Crustáceos (Daphnia): EC50 29 mg/l en 24 h
(Fuente: Normativa de la CE 91/155/EC)

12.2. Persistencia y degradabilidad:

Los métodos para la determinación de la biodegradabilidad no son aplicables para sustancias inorgánicas. Es improbable que cause efectos perniciosos. Quedaran restos indefinidamente como sulfatos.

12.3. Bioacumulación: Este producto tiene un bajo potencial de bioacumulación.

12.4. Movilidad en el suelo: No se dispone de información

12.5. Otros efectos adversos

Efecto perjudicial en organismos acuáticos. Efecto perjudicial por desviación del pH. Corrosivo incluso en forma diluida. No produce consumo biológico de oxígeno. Existe peligro para el agua potable en caso de penetración en suelos y/o acuíferos.

13. Consideraciones para la eliminación

13.1. Métodos recomendados para disposición final del producto:

Recuperar todo el ácido posible mediante bombeo para reprocesarlo. No lavar hacia drenajes ni permitir que se alcance cursos naturales de agua.

13.2. Métodos recomendados para disposición final de los residuos:

Los desechos de neutralización se dispondrán de acuerdo con los requerimientos regulatorios. Si se neutraliza con piedra caliza o dolomita o ceniza de soda(carbonato de sodio) se requerirá de buena ventilación debido a que se libera dióxido de carbono.

13.3. Métodos recomendados para disposición final de embalajes contaminados:

Devolver al proveedor.

14. Información para el transporte

13.4. Transporte Carretero

- Número de ONU: 1830
- Nombre según ONU: Ácido Sulfúrico
- Clasificación de riesgo para el transporte: 8
- Grupo de embalaje: II

13.5. Transporte Marítimo - IMDG

- Número de ONU: 1830
- Nombre según ONU: Ácido sulfúrico, la sustancia no está considerada contaminante marino.

13.6. Otros

Según el Código RID, la sustancia está clasificada como C1,
Materias corrosivas sin riesgo subsidiario, de carácter ácido, inorgánicas líquidas.
Según el Código ADN: información no disponible.

13.7. Precauciones especiales para el usuario

En caso de derrame neutralizar con carbonato de calcio, carbonato de sodio, cal, calizas o dolomita.
El ácido sulfúrico, reacciona violentamente con el agua.
Evitar el contacto con el producto, de producirse, lávese con abundante agua.
IMDG (Código Marítimo Internacional de Mercancías Peligrosas)
RID (Reglamentos sobre el transporte internacional de Mercancías peligrosas por ferrocarril)

ADN (Acuerdo Europeo relativo al transporte internacional de Mercancías peligrosas por vías de navegación interior)

15. Información reglamentaria

Decreto 560/2003, Reglamento Nacional de Transporte de Mercancías Peligrosas por Carretera.
Cantidad exenta para la aplicación del Decreto 560/2003: 333 Kg

16. Otras informaciones/ bibliografía

La presente ficha de datos de seguridad, está realizada de acuerdo con los requisitos del Sistema Globalmente Armonizado

1. The Manufacture of Sulfuric Acid, W. Duecker. 1959
2. MSDS Canadian centre for occupational health and safety (november, 1995)
3. Fiche toxicologique nº 30 Institut Nacional de Securite.
4. MSDS Fisher Scientific.
5. MSDS EFMA.
6. Acuerdo para la facilitación del transporte de mercancías peligrosas en el Mercosur. Ministerio de Transporte y Obras Públicas. Montevideo,2005
7. Hoja de Datos de Seguridad de Teck Cominco Metals . Vancouver. Canadá. Dic. 2009
8. Ficha de datos de seguridad de Asturiana de Zinc S.A. Castrillón, Asturias, España 2010
9. IUCLID. International Uniform Chemical Information Database version 5.2 2010

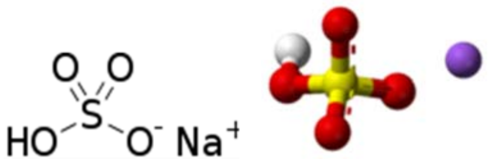
Nota: La información aquí suministrada se basa en nuestros conocimientos actuales sobre el producto, no pretende ser completa y tienen como fin describir al producto con relación a las medidas de seguridad que hay que adoptar. Esta información es una ayuda para que quien la reciba haga sus propias determinaciones para su aplicación particular

Fecha de emisión: Enero 2012
Versión: 02
Sustituye: Versión 01 mayo 2009
M.S.C
M.F.

Hoja de seguridad
Bisulfito de sodio MSDS

Sección 1. Identificación del producto

- **Nombre de la sustancia:** Bisulfito de sodio.
- **Número CAS:** 7631-90-5
- **RTECS**: VZ2000000
- **Fórmula química:** $NaHSO_3$
- **Estructura química:**



- **Masa molar:** 104,07 g/mol
- **Sinónimos:** Sulfito monosódico, ácido sulfuroso, Sódico sulfhídrico.
- **Usos recomendados:** Para disminución del pH y fabricación de joyas.
- **Número de atención de emergencias:** TRANSMEDIC 2280-0999 / 2245-3757 (TM 203 503 Campus Omar Dengo, TM 203 504 Campus Benjamín Núñez) 911 Servicio de emergencia, 2261-2198 Bomberos de Heredia.

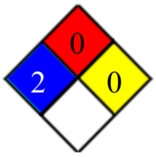
Sección 2. Identificación del peligro o peligros

Descripción de peligros:

Corrosivo 8.1

Información pertinente a los peligros para el hombre y el ambiente:
Sustancia nociva para la salud y peligrosa para el medio ambiente.

Sistemas de clasificación:
-NFPA(escala 0-4):



-HMIS(escala 0-4):

SALUD	2
INFLAMABILIDAD	0
REACTIVIDAD	0

Consejos de prudencia:

- Utilice el equipo de protección indicado para resguardar sus vías respiratorias y la piel.
- Alejar de llamas y fuentes de ignición.

Sección 3. Composición/información sobre los constituyentes

Composición

Número CAS	Componentes peligrosos	% m/m
7631-90-5	Bisulfito de sodio	99.0 %

Sección 4. Primeros auxilios

- **Información general:** Sustancia nociva para la salud, en caso de emergencia buscar atención médica inmediatamente.
- **Contacto ocular:** Enjuague los ojos con agua corriente durante 15 minutos, manteniendo los párpados bien abiertos para eliminar el producto. Si persiste el dolor, consulte con un oftalmólogo.
- **Contacto dérmico:** Después del contacto con la piel, lavar inmediatamente con agua abundante.
- **Inhalación:** Trasladar al aire fresco.
- **Ingestión:** No provocar el vómito sin consejo médico. Enjuague la boca con abundante agua fresca.

Efectos por exposición

- **Contacto ocular:** Puede causar irritación, conjuntivitis química, lagrimeo y dolor.
- **Contacto dérmico**: Puede causar irritación en la piel e hipersensibilidad.
- **Inhalación**: Puede causar irritación en las membranas mucosas.
- **Ingestión:** Puede ser nocivo si se ingiere. Puede causar náuseas, vómitos, diarrea, dolor abdominal dolor, hemorragia gástrica.

Atención médica

- **Tratamiento:** No disponible.
- **Efectos retardados:** No disponible.
- **Antídotos conocidos:** No disponible.

Sección 5. Medidas de lucha contra incendios

- **Agentes extintores:** CO_2, polvo extintor o chorro de agua rociada o espuma de alcohol.
- **Productos peligrosos por combustión:** Produce humos irritantes.
- **Equipo de protección para combatir fuego:** Aparato de respiración autónomo con mascarilla facial completa y traje protector completo.

Sección 6. Medidas que deben tomarse en caso de vertido accidental

- **Precauciones personales, equipo protector y procedimiento de emergencia:** Evacuar o aislar el área de peligro, demarcar las zonas. Restringir el acceso a personas innecesarias y sin la debida protección. Ubicarse a favor del viento. Usar equipo de protección personal.
- **Precauciones relativas al medio ambiente:** No permitir que caiga en fuentes de agua y alcantarillas.
- **Métodos y materiales para la contención y limpieza de vertidos:** Coloque el producto contaminado en un contenedor cerrado, etiquetado y compatible con el producto.

Sección 7. Manipulación y almacenamiento

- **Manipulación de recipientes:** Si se manipulan correctamente, no se requieren medidas especiales. Mantener estrictas normas de higiene, no fumar, beber, ni comer en el sitio de trabajo. Lavarse las manos después de usar el producto.
- **Condiciones de almacenamiento:** Mantener el recipiente cerrado herméticamente y en un lugar fresco.

Sección 8. Controles de exposición/ protección personal

Parámetros de control (valores límite que requieren monitoreo)

TWA	5 mg/m^3
STEL	No disponible

- **Condiciones de ventilación:** Ventilación local y general.
- **Equipo de protección respiratoria:** Usar equipo de seguridad respiratorio cuando el aerosol, vapor, y polvo.
- **Equipo de protección ocular:** Gafas de seguridad.
- **Equipo de protección dérmica:** Usar guantes de carnaza o PVC y delantal, u otra ropa protectora para evitar el contacto con la piel.

Sección 9. Propiedades físicas y químicas

Estado físico	Sólido
Color	Blanco
Olor	Inodoro
Umbral olfativo	No aplica.
pH	No disponible.
Punto de fusión	>300 ºC
Punto de ebullición	No disponible
Punto de inflamación	No aplica
Tasa de evaporación	No aplica
Límites de explosión	No aplica
Presión de vapor a 20°C	23.3 hPa
Densidad relativa de vapor	No aplica

(aire=1)	
Densidad relativa (agua=1)	1.48
Solubilidad en agua	3,5 partes en agua fría.
Solubilidad en otros disolventes	Soluble en 70 partes de alcohol. insoluble en cloruro líquido y amonio.
Coeficiente de reparto n-octanol/agua (Log pow)	No disponible
Temperatura de autoinflamación	No aplica
Temperatura de descomposición	No disponible
Peligro de explosión	No disponible
Viscosidad	No aplica

Sección 10. Estabilidad y reactividad

- **Reactividad:** No disponible.
- **Estabilidad:** Estable bajo condiciones normales.
- **Incompatibilidad:** Agentes oxidantes fuertes.
- **Productos de polimerización:** No ocurrirá.
- **Productos peligrosos de la descomposición:** Óxidos de azufre.

Sección 11. Información toxicológica

- **Toxicidad aguda:** No disponible.
- **Corrosión/irritación cutáneas:** Sí.
- **Lesiones oculares graves/irritación ocular:** Sí.
- **Sensibilización respiratoria o cutánea:** Sí.
- **Mutagenicidad en células germinales:** Mutagénico para bacterias y levaduras.
- **Carcinogenicidad:** No.
- **Toxicidad para la reproducción:** No.
- **Toxicidad sistémica específica de órganos diana-Exposición única:** No disponible.
- **Peligro por aspiración:** Sí.
- **Posibles vías de exposición:** Dermal.
- **Efectos inmediatos:** Irritación.
- **Efectos retardados:** No disponible.
- **Efectos crónicos:** La exposición crónica puede causar náuseas y vómitos, la exposición más importante ocasiona inconsciencia

- **LD/LC50:**

Oral (LD-50)	2 g/Kg (rata)
Dermal (LD-50)	No disponible
Inhalativa (LC-50)	No disponible.

Sección 12. Información ecotoxicológica

- **Toxicidad Acuática:** No disponible.
- **DBO_5=** No aplica.
- **Persistencia y degradabilidad:** Es posible la degradación sin embargo los productos no se espera que sean peligrosos.
- **Potencial de bioacumulación:** No disponible.
- **Movilidad en el suelo:** No disponible.
- **Otros efectos adversos:** No presenta evidencias de carcinogenicidad, mutagenicidad y teratogenicidad según experimentos con animales.

Sección 13. Información relativa a la eliminación de los productos

La eliminación de residuos debe realizarse de acuerdo con su caso Federal, estatal y local. Este producto, si alterada por el uso, se puede disponer de un tratamiento en una permitida instalación o los consejos de su peligrosa locales perder autoridad reguladora. Los residuos de los fuegos extinguidos con este material pueden ser peligrosos.

Sección 14. Información relativa al transporte

- **N° ONU:** 3260
- **Designación oficial de transporte de las Naciones Unidas**: Etiqueta blanca y negro con el número 8 de corrosivo.
- **Riesgos ambientales:** Contaminante para el medio ambiente.
- **Precauciones especiales:** No transporte con agentes oxidantes fuertes ni alimentos.

Sección 15. Información sobre la reglamentación

Regulado por el Reglamento sobre las características y el listado de los desechos peligrosos industriales (Decreto N°27000-MINAE), el Reglamento para el Manejo de los Desechos Peligrosos Industriales (Decreto N° 27001-MINAE), y el Reglamento de transporte terrestre de productos peligrosos (Decreto 27008-MINAE).

Sección 16. Otras informaciones

Frases R:
R22 - Nocivo por ingestión.
R31 - En contacto con ácidos libera gases tóxicos.
R58 - Puede provocar a largo plazo efectos negativos en el medio ambiente

Frases S:
S25 - Evítese el contacto con los ojos.
S46 - En caso de ingestión, acúdase inmediatamente al médico y muéstresele la etiqueta o el envase.
S61 - Evítese su liberación al medio ambiente. Recábense instrucciones específicas de la ficha de datos de seguridad.

Fecha de preparación de la hoja de seguridad: 11 de agosto de 2013.
Versión: No aplica
Modificaciones respecto a versión anterior: 31 de mayo de 2016.

HDS

HOJA de DATOS de SEGURIDAD

1. IDENTIFICACIÓN DEL PRODUCTO Y DEL PROVEEDOR

Producto: **CLORATO DE SODIO, $NaClO_3$,**
Clase 5.1 NU 1495

Fabricante: Eka Chile S. A.
Avda. Rocoto 2911
Talcahuano

Tel. : + 56 41 2129200
Fax : + 56 41 2929006

Fonos Emergencia: PLANTA : + 56 41 2129207 / 2129225 / 09 6268359 – 09 3461557

2. COMPOSICIÓN / INGREDIENTES

Nombre Químico (IUPAC)	Contenido	CAS núm.	Núm. CE	HAZCHEM	Clasificación	FrasesR[1)]
Clorato de Sodio	> 99,5%	7775-09-9	231-887-4	1SE	O (oxidante), N (peligroso para el medio ambiente) Xn (nocivo a la salud)	R9-22

[1)] Ver el punto 15.

3. IDENTIFICACIÓN DE LOS RIESGOS

Clasificación : O: R9 Xn: R22 N: R51/53

Efectos para la Salud : Nocivo por ingestión

Efectos sobre el medio ambiente: Dañino para vegetales, pero tóxico para las algas pardas

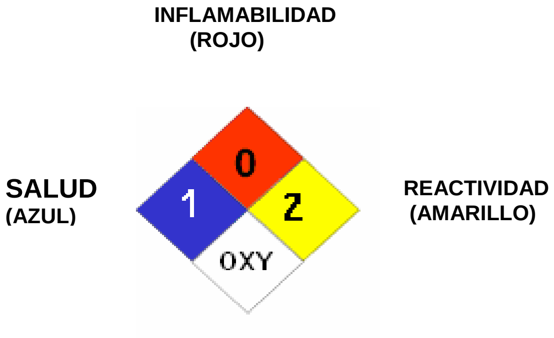
Otras Propiedades Peligrosas : Oxidante

Peligro de explosión mezclado con productos combustibles.

Los ácidos fuertes reaccionan violentamente con los cloratos produciendo gases tóxicos y explosivos como el cloro y el dióxido de cloro.

Marca en etiqueta NCh 2190

Clasificación de riesgos del producto químico (NFPA)



Grado de riesgo
4: Extremo
3: Alto
2: Moderado
1: Leve
0: No significativo

4. MEDIDAS DE PRIMEROS AUXILIOS

Inhalación : Respirar aire puro
Acudir al médico si aparecen síntomas de envenenamiento

Contacto con la piel : Lavar la piel con agua y jabón
Despojarse de la ropa contaminada y lavarla para impedir incendio

Contacto con los ojos : Lavarlos inmediatamente con agua. Acudir al médico si persisten molestias

Ingestión : Lavar la boca y beber inmediatamente un par de vasos de agua o leche. ¡No provocar el vómito!
Acudir al hospital si se ha ingerido algo más que una cantidad insignificante
Hay resto demetahemoglobinemía. No debe tratarse con metiltionina

5. MEDIDAS PARA LUCHAR CONTRA EL FUEGO

Sustancia extintora : Utilizar agua

Sustancia extintora Inadecuada : ¡No utilizar extintores de polvo o nieve carbónica (CO_2)!

Riesgos específicos : En espacios cerrados en los que hay clorato pueden producirse explosiones en caso de incendio Recipientes cerrados que contienen clorato de sodio pueden explotar si se calientan por encima de la temperatura de desintegración (> 250°C)

Métodos específicos : ¡Apagar los incendios con grandes cantidades de agua! ¡No intentar ahogar el fuego con mantas! Hay que alejar inmediatamente los recipientes en las cercanías del foco de calor, o enfriarlos con agua

6. MEDIDAS PARA CONTROLAR DERRAMES O FUGAS

Protección Personal : Cuando hay que tratar derrames de importancia es necesario llevar ropa protectora y otros equipo de protección (ver punto 6). Alejar cualquier material que pueda inflamarse

Protección ambiental : Recoger el clorato contaminado del suelo

No descargar soluciones de líquidos al alcantarillado

Métodos de saneamiento : Cercar con arena o material similar no combustible y recoger todas las impurezas en recipientes de plástico o metal. No utilizar aserrines, turba, cortezas ni otro material que sean combustibles. Lavar con grandes cantidades de agua. Si los vertidos son grandes, llamar a expertos, informar al servicio de salvamento

7. MANIPULACIÓN Y ALMACENAMIENTO

Manipulación : Medidas técnicas

: Utilizar únicamente lubricantes y juntas inertes (sintéticos) para bombas, válvulas y otros equipos donde y cuando se manipula el clorato seco o en solución. Rellenar con lubricantes a intervalos regulares

Consejos para seguridad de manejo

- ♦ A intervalos regulares conviene limpiar los equipos eléctricos del polvo de clorato
- ♦ Evitar el contacto con los productos químicos y materiales indicados abajo (sustancias incompatibles)
- ♦ Mantener los recipientes cerrados cuando no se usan
- ♦ Evitar el contacto con la piel y ojos
- ♦ No manejar el clorato en las cercanías de productos combustibles y fuentes de calor

Medidas de protección

- ♦ Manejar el clorato de modo que se evite la formación de polvo
- ♦ Si ha de manejarse de manera que es inevitable la formación de polvo, hay que disponer de un ventilador de extracción
- ♦ Recoger el polvo e inutilizarlo

Almacenamiento : Medidas técnicas

Ver más abajo

Condiciones de almacenamiento

- ♦ Almacenar el producto en lugar fresco, seco y a prueba de fuego, separado de productos inflamables y fuentes de calor
- ♦ No someter el material a fricción ni a golpes
- ♦ Guardar el producto apartado de productos comestibles

Sacos Grandes

- ♦ Almacenarlos sobre arena, evitar el asfalto.
- ♦ La distancia de seguridad entre las pilas de sacos ha de ser como mínimo de 1,5-3.0 m
- ♦ Mantener la distancia de seguridad a los edificios

A Granel

- Almacenar el producto en espacios que no contengan materiales combustibles
- Almacenar el material separado de otros productos

Productos incompatibles

El clorato de sodio ha de almacenarse separado de materiales orgánicos, ácidos fuertes, fósforo, azufre, sulfuros, polvos metálicos y sales de amonio

Material de envasado

Usar barriles metálicos o sacos de tipo aprobado (con marca UN)

Los sacos no han de volver a utilizarse

8. CONTROL DE EXPOSICION/PROTECCION ESPECIAL

Medidas técnicas : Extracción en puntos

Equipo y medidas personales de protección :
- En atmósferas polvorientas, usar filtro para respirar
- Guantes pvc, botas pvc, delantales de plástico o goma o mono protector
- Gafas protectoras
- Lavaojos
- Las ropas de trabajo han de lavarse diariamente en agua
- Cambiar inmediatamente la ropa que se haya contaminado con clorato

Medidas especiales : Tiene que haber disponibles duchas de emergencia o bañeras llenas con agua. Los materiales que se hayan impregnado con clorato han de ser inutilizados para que no exista riesgo de que se produzcan incendios incontrolables

ESTA PROHIBIDO FUMAR

9. PROPIEDADES FISICAS Y QUIMICAS

Apariencia y olor	: Cristales blancos inodoros, sabor amargo y salado
pH en solución	: Neutro
Punto de fusión	: 248-250 °C
Punto de ebullición	Se desintegra
Desintegración	: A más de 250-300 °C
Punto de inflamación	: No aplicable
Zona de explosión	: Ver punto 10
Densidad, en granel	: 1500 kg/m^3
Solubilidad en agua	: 728 g/l a 20 °C

10. ESTABILIDAD Y REACTIVIDAD

El clorato de sodio es una sustancia fuertemente oxidante que al calentarse desprende fácilmente oxígeno. La desintegración se produce al calentarse a más de 250 °C. Al desintegrarse se forma cloruro de sodio y oxígeno

Circunstancias que hay que evitar: Temperaturas elevadas

Materiales y productos Químicos que hay que evitar :
: Las mezclas de clorato y material orgánico son muy inflamables
: Las mezclas secas pueden inflamarse o explotar mediante la fricción o sometiéndolas a golpes
: Los tejidos, celulosa y cuero contaminados con clorato son fácilmente inflamables

Los ácidos fuertes reaccionan violentamente con el clorato y producen gases tóxicos y explosivos como cloro y dióxido de cloro

11. INFORMACIÓN TOXICOLÓGICA

El clorato de sodio está clasificado como producto nocivo a la salud

Toxicidad aguda : LD$_{50}$ (oral, rata) = 1200 mg/kg.

LD$_{LO}$ (oral, hombre) = 214 mg/kg.

El clorato de sodio tiene efecto oxidante y oxida la hemoglobina de la sangre convirtiéndola en metahemoglobina. Ello conduce a una escasez de oxígeno en los tejidos corporales ya que la metahemoglobina tiene peor capacidad para el transporte del oxígeno

Síntomas

Dolores abdominales, náuseas, vómitos, diarrea, disnea, cianosis, nefritis aguda, anuria, daños renales y hepáticos, convulsiones, coma y muerte. Los primeros síntomas pueden aparecer después de varias horas

Efectos locales : *Inhalación*

La inhalación del polvo causa irritación en las mucosas

Piel y ojos

El clorato de sodio es un irritante ligero

12. INFORMACION ECOTOXICOLOGICA

El clorato daña las plantas, pero es tóxico para las algas pardas. Son especialmente sensibles al clorato las bacterias que participan en la nitrificación, desnitrificación y formación de amoniaco

Movilidad : *Agua*

Permanecer disuelto en el agua

Tierra

Puede percolarse el suelo

Persistencia/degradibilidad : Se degrada lentamente en el suelo en presencia de aire. Degradación más rápida en cloruro sódico y oxígeno en la ausencia de aire (desintegración microbiana)

Acumulación : En las plantas el clorato se convierte en cloruro. Este se acumula en las células hasta concentraciones tóxicas causando la muerte de la planta. No hay pruebas de que se acumule en la célula animal

Ecotoxicidad : Los cloratos son perjudiciales para los organismos acuáticos, pero tóxicos para las algas focáceas (Fucus vesiculosus). Los cloratos producen alteraciones en los microorganismos que hay en sedimentos, por ejemplo, los que intervienen en el ciclo del nitrógeno

Peces 48h LD$_{50}$. Salmón arco iris (Oncorynchus mykiss) = 2750 mg/l

Crustáceos 24 h LC$_{50}$ pulga de agua (Daphnia magna) = 880 mg/l (clorato de potasio)

Algas IC50 alga azul (fucus vesiculosus) = 0,080 mg/l (estudio de larga duración). Tiene efecto inhibidor del plancton verde (Scenedesmeus) a 7 mg/l

13. CONSIDERACIONES SOBRE DISPOSICION FINAL

Vertidos : El clorato de sodio no debe disponerse ni ser vertido en el alcantarillado. Recogerlo en recipientes de plástico o metal

Envases contaminados : Limpiar los envases vacíos de los restos de clorato. El material combustible puede quemarse en recipientes abiertos bajo condiciones controladas

En general : Consultar a las autoridades locales para obtener información sobre el manejo de los residuos

Dirigirse a Eka Chile si se precisa ayuda técnica, ver punto 16

14. INFORMACION SOBRE EL TRANSPORTE

Terrestre por carretera o ferrocarril : ADR/RID

Clase	: 5.1
Núm. UN	: 1495
Grupo de envase	: II
Etiqueta	: 5.1

Vía marítima : IMDG
Clase 5.1
EmS núm. 5.1-06
MFAG 745

Vía aérea : IATA-DGR
Clase 5.1

15. NORMAS VIGENTES

Clasificación y marcas

Clasificación y marcas según la directiva 67/548/EEC, 18 adaptación técnica

Clase de peligrosidad : Oxidante, dañino a la salud
Designación de peligrosidad : O, Xn
Marcas

Frases de riesgo (R9-22-31)

Explosivo si se mezcla con material combustible

Peligroso de ingerir

(Forma un gas tóxico en contacto con lo ácidos) 1)

Frases de seguridad (S(2)-13-17-46)

(Guardar fuera del alcance de los niños) (2)
Guardar separado de productos alimentarios y piensos

Guardar separado de productos inflamables

En caso de ingestión, acudir inmediatamente al médico y mostrarle este envase o etiqueta.

(1) Marcar adicional según Eka Chemicals

(2) Se utiliza únicamente en la marca de productos para el consumo

16. OTRAS INFORMACIONES

Uso recomendado

El uso dominante del clorato de sodio es para la producción de dióxido de cloro, que se utiliza para el blanqueamiento de pasta de papel. Otras aplicaciones son para la producción de clorato de potasio, cloruro de sodio, perclorato de potasio, perclorato de sodio, herbicidas y defoliantes.

No utilizar el clorato de sodio en mezclas para fuegos artificiales de aficionados

Seguir las disposiciones de seguridad en el manejo del clorato de sodio. Su omisión puede ser causa de daños graves personales o materiales

Unidades de protección de Eka Chemicals

ALBY	Dirección	Eka Chemicals AB	AMBES	Dirección:	Eka Chimie S. A.
Suecia		SE-841 44 Alby	*Francia*		Z.I. du Bec
	Fax	+46 69 01 54 35			FR-33810 Ambés
	Tel.:	+46 69 01 54 00		Fax	+33 556 77 05 08
				Tel.	+33 556 77 31 40
			OULU	Dirección:	Eka Chemicals OY
			Finlandia		P.O. Box 198
					FI-99101 Oulu
				Fax	+358 8 3183 3151
				Tel.:	+358 8 3183 3111
STOCKVIK	Dirección	Eka Chemicals AB	TALCAHUANO	Dirección:	Eka Chile S.A.
Suecia		Box 13000	*Chile*		P.O. Box 167
		SE-850 13 Sundsvall			Talcahuano
	Fax:	+46 60 56 93 82		Fax:	+56 41 2929006
	Tel.:	+46 60 13 40 00		Tel.:	+56 41 2129200
					+56 41 2129225 / 2129207 / 2129240
					09 6268359 – 09 3461557

Fichas Internacionales de Seguridad Química

DIOXIDO DE CLORO

ICSC: 0127

DIOXIDO DE CLORO
Peróxido de cloro
Oxido de cloro (IV)
ClO_2

Masa molecular: 67.5

Nº CAS 10049-04-4
Nº RTECS FO3000000
Nº ICSC 0127

TIPOS DE PELIGRO/ EXPOSICION	PELIGROS/ SINTOMAS AGUDOS	PREVENCION	PRIMEROS AUXILIOS/ LUCHA CONTRA INCENDIOS
INCENDIO	No combustible pero facilita la combustión de otras sustancias. Muchas reacciones pueden producir incendio o explosión.	NO poner en contacto con combustibles.	En caso de incendio en el entorno: agua en grandes cantidades, agua pulverizada.
EXPLOSION	Riesgo de incendio y explosión en presencia de chispas, impactos, luz solar, calor o al entrar en contacto con sustancias combustibles.	Sistema cerrado, ventilación, equipo eléctrico y de alumbrado a prueba de explosiones. No exponer a fricción o choque.	En caso de incendio: mantener fríos los bidones y demás instalaciones rociando con agua. Combatir el incendio desde un lugar protegido.
EXPOSICION		¡EVITAR TODO CONTACTO!	¡CONSULTAR AL MEDICO EN TODOS LOS CASOS!
• **INHALACION**	Corrosivo. Tos, dificultad respiratoria, jadeo, dolor de garganta, náuseas. (Síntomas no inmediatos: véanse Notas).	Ventilación, extracción localizada o protección respiratoria. Sistema cerrado y ventilación.	Aire limpio, reposo, posición de semiincorporado, respiración artificial si estuviera indicada y proporcionar asistencia médica.
• **PIEL**	Corrosivo. Enrojecimiento, quemaduras cutáneas graves, dolor.	Guantes protectores y traje de protección.	Aclarar con agua abundante, después quitar la ropa contaminada y aclarar de nuevo y proporcionar asistencia médica.
• **OJOS**	Corrosivo. Enrojecimiento, dolor, visión borrosa.	Gafas ajustadas de seguridad o protección ocular combinada con la protección respiratoria.	Enjuagar con agua abundante durante varios minutos (quitar las lentes de contacto si puede hacerse con facilidad) y proporcionar asistencia médica.
• **INGESTION**			

DERRAMAS Y FUGAS	ALMACENAMIENTO	ENVASADO Y ETIQUETADO
Evacuar la zona de peligro. Consultar a un experto. Ventilar. Eliminar gas con agua pulverizada. (Protección personal adicional: traje de protección completa incluyendo equipo autónomo de repiración).	Separado de sustancias combustibles y reductoras. Mantener en lugar fresco. Ventilación a ras del suelo.	

VEASE AL DORSO INFORMACION IMPORTANTE

ICSC: 0127

Preparada en el Contexto de Cooperación entre el IPCS y la Comisión de las Comunidades Eurpoeas © CCE, IPCS, 1994

Fichas Internacionales de Seguridad Química

DIOXIDO DE CLORO

ICSC: 0127

DATOS IMPORTANTES

ESTADO FISICO; ASPECTO
Gas entre rojo y amarillo, de olor acre.

PELIGROS FISICOS
El gas es más denso que el aire.

PELIGROS QUIMICOS
Puede descomponerse con explosión por choque, fricción o sacudida. Puede explotar por calentamiento intenso. La sustancia es un oxidante fuerte y reacciona violentamente con sustancias combustibles y reductores. Reacciona violentamente con mercurio, fósforo, azufre etc, originando peligro de fuego y explosión. Reacciona con el agua produciendo cloruro de hidrógeno y ácido clórico.

LIMITES DE EXPOSICION
TLV (como TWA): 0.1 ppm; 0.28 mg/m^3 (ACGIH 1993-1994).
TLV (como STEL): 0.3 ppm; 0.83 mg/m^3 (piel) (ACGIH 1993-1994).
MAK: 0.1 ppm; 0.3 mg/m^3 (1992).

VIAS DE EXPOSICION
La sustancia se puede absorber por inhalación y por ingestión.

RIESGO DE INHALACION
Al producirse una pérdida de gas se alcanza muy rápidamente una concentración nociva de éste en el aire.

EFECTOS DE EXPOSICION DE CORTA DURACION
Lacrimógeno. La sustancia es corrosiva de los ojos, la piel y el tracto respiratorio. La inhalación del gas puede originar edema pulmonar (véanse Notas). La exposición por encima del OEL puede producir la muerte. Los efectos pueden aparecer de forma no inmediata. Se recomienda vigilancia médica.

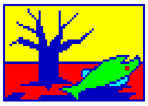
EFECTOS DE EXPOSICION PROLONGADA O REPETIDA
La sustancia puede afectar el pulmón, dando lugar a bronquitis crónica. La sustancia puede causar erosiones dentales.

PROPIEDADES FISICAS

Punto de ebullición: 11°C
Punto de fusión: -59°C
Densidad relativa (agua = 1): 1.6 a 0°C (líquido)
Solubilidad en agua, g/100 ml a 20°C: 0.8
Presión de vapor, kPa a 20°C: 101
Densidad relativa de vapor (aire = 1): 2.3
Límites de explosividad, % en volumen en el aire: >10

DATOS AMBIENTALES

Esta sustancia puede ser peligrosa para el ambiente; debería prestarse atención especial a los organismos acuáticos.



NOTAS

Está indicado examen médico periódico dependiendo del grado de exposición. Los síntomas del edema pulmonar no se ponen de manifiesto, a menudo, hasta pasadas algunas horas y se agravan por el esfuerzo físico. Reposo y vigilancia médica son por ello, imprescindibles. Debe considerarse la inmediata administración de un aerosol adecuado por un médico o persona por él autorizada. Enjuagar la ropa contaminada con agua abundante (peligro de incendio).

INFORMACION ADICIONAL

FISQ: 3-104 DIOXIDO DE CLORO

ICSC: 0127 **DIOXIDO DE CLORO**

NOTA LEGAL IMPORTANTE:

Ni la CCE ni la IPCS ni sus representantes son responsables del posible uso de esta información. Esta ficha contiene la opinión colectiva del Comité Internacional de Expertos del IPCS y es independiente de requisitos legales. La versión española incluye el etiquetado asignado por la clasificación europea, actualizado a la vigésima adaptación de la Directiva 67/548/CEE traspuesta a la legislación española por el Real Decreto 363/95 (BOE 5.6.95).

Fichas Internacionales de Seguridad Química

METANOL

ICSC: 0057

Abril 2000

Alcohol metílico	Carbinol

CAS:	**67-56-1**	**CH_4O / CH_3OH**
RTECS:	**PC1400000**	**Masa molecular: 32.0**
NU:	**1230**	
CE Índice Anexo I:	**603-001-00-X**	
CE / EINECS:	**200-659-6**	

TIPO DE PELIGRO / EXPOSICIÓN	PELIGROS AGUDOS / SÍNTOMAS	PREVENCIÓN	PRIMEROS AUXILIOS / LUCHA CONTRA INCENDIOS
INCENDIO	Altamente inflamable. Ver Notas.	Evitar las llamas, NO producir chispas y NO fumar. NO poner en contacto con oxidantes.	Polvo, espuma resistente al alcohol, agua en grandes cantidades, dióxido de carbono.
EXPLOSIÓN	Las mezclas vapor/aire son explosivas.	Sistema cerrado, ventilación, equipo eléctrico y de alumbrado a prueba de explosión. NO utilizar aire comprimido para llenar, vaciar o manipular. Utilícense herramientas manuales no generadoras de chispas.	En caso de incendio: mantener fríos los bidones y demás instalaciones rociando con agua.

EXPOSICIÓN		**¡EVITAR LA EXPOSICION DE ADOLESCENTES Y NIÑOS!**	
Inhalación	Tos. Vértigo. Dolor de cabeza. Náuseas. Debilidad. Alteraciones de la vista.	Ventilación. Extracción localizada o protección respiratoria.	Aire limpio, reposo. Proporcionar asistencia médica.
Piel	¡PUEDE ABSORBERSE! Piel seca. Enrojecimiento.	Guantes de protección. Traje de protección.	Quitar las ropas contaminadas. Aclarar con agua abundante o ducharse. Proporcionar asistencia médica.
Ojos	Enrojecimiento. Dolor.	Gafas ajustadas de seguridad, o protección ocular combinada con la protección respiratoria.	Enjuagar con agua abundante durante varios minutos (quitar las lentes de contacto si puede hacerse con facilidad), después proporcionar asistencia médica.
Ingestión	Dolor abdominal. Jadeo. Vómitos. Convulsiones. Pérdida del conocimiento (para mayor información, véase Inhalación).	No comer, ni beber, ni fumar durante el trabajo. Lavarse las manos antes de comer.	Provocar el vómito (¡UNICAMENTE EN PERSONAS CONSCIENTES!). Proporcionar asistencia médica.

DERRAMES Y FUGAS	ENVASADO Y ETIQUETADO
Evacuar la zona de peligro. Ventilar. Recoger el líquido procedente de la fuga en recipientes precintables. Eliminar el residuo con agua abundante. Eliminar vapor con agua pulverizada. Traje de protección química, incluyendo equipo autónomo de respiración.	No transportar con alimentos y piensos. **Clasificación UE** Símbolo: F, T R: 11-23/24/25-39/23/24/25; S: (1/2-)7-16-36/37-45 **Clasificación NU** Clasificación de Peligros NU: 3 Riesgos Subsidiarios de las NU: 6.1; Grupo de Envasado NU: II
RESPUESTA DE EMERGENCIA	**ALMACENAMIENTO**
Ficha de emergencia de transporte (Transport Emergency Card): TEC (R)-30S1230. Código NFPA: H 1; F 3; R 0;	A prueba de incendio. Separado de oxidantes fuertes, alimentos y piensos. Mantener en lugar fresco.

IPCS
International
Programme on
Chemical Safety

Preparada en el Contexto de Cooperación entre el IPCS y la Comisión Europea © IPCS, CE 2000

VÉASE INFORMACIÓN IMPORTANTE AL DORSO

Fichas Internacionales de Seguridad Química

METANOL

ICSC: 0057

DATOS IMPORTANTES

ESTADO FÍSICO; ASPECTO:
Líquido incoloro, de olor característico.

PELIGROS FÍSICOS:
El vapor se mezcla bien con el aire, formándose fácilmente mezclas explosivas.

PELIGROS QUÍMICOS:
Reacciona violentamente con oxidantes, originando peligro de incendio y explosión.

LÍMITES DE EXPOSICIÓN:
TLV: 200 ppm como TWA, 250 ppm como STEL; (piel); BEI establecido (ACGIH 2004).
MAK: Riesgo para el embarazo: grupo (DFG 2004).
LEP UE: 200 ppm; 260 mg/m^3 como TWA (piel) como TWA (UE 2006).

VÍAS DE EXPOSICIÓN:
La sustancia se puede absorber por inhalación, a través de la piel y por ingestión.

RIESGO DE INHALACIÓN:
Por evaporación de esta sustancia a 20°C se puede alcanzar bastante rápidamente una concentración nociva en el aire.

EFECTOS DE EXPOSICIÓN DE CORTA DURACIÓN:
La sustancia irrita los ojos la piel y el tracto respiratorio. La sustancia puede afectar al sistema nervioso central, dando lugar a pérdida del conocimiento. La exposición puede producir ceguera y muerte. Los efectos pueden aparecer de forma no inmediata.

EFECTOS DE EXPOSICIÓN PROLONGADA O REPETIDA:
El contacto prolongado o repetido con la piel puede producir dermatitis. La sustancia puede afectar sistema nervioso central, dando lugar a dolores de cabeza persistentes y alteraciones de la visión.

PROPIEDADES FÍSICAS

Punto de ebullición: 65°C
Punto de fusión: -98°C
Densidad relativa (agua = 1): 0.79
Solubilidad en agua: miscible
Presión de vapor, kPa a 20°C: 12.3
Densidad relativa de vapor (aire = 1): 1.1

Densidad relativa de la mezcla vapor/aire a 20°C (aire = 1): 1.01
Punto de inflamación: 12°C c.c.
Temperatura de autoignición: 464°C
Límites de explosividad, % en volumen en el aire: 5.5-44
Coeficiente de reparto octanol/agua como log Pow: -0.82/-0.66

DATOS AMBIENTALES

NOTAS

Arde con llama azulada. Está indicado examen médico periódico dependiendo del grado de exposición. Esta ficha ha sido parcialmente actualizada en octubre de 2006: ver Límites de exposición.

INFORMACIÓN ADICIONAL

Límites de exposición profesional (INSHT 2011):

VLA-ED: 200 ppm; 266 mg/m^3

Notas: vía dérmica.

VLB: 15 mg/L en orina. Notas F, I.

Nota legal Esta ficha contiene la opinión colectiva del Comité Internacional de Expertos del IPCS y es independiente de requisitos legales. Su posible uso no es responsabilidad de la CE, el IPCS, sus representantes o el INSHT, autor de la versión española.

Ficha de Informação de Segurança de Produto Químico - FISPQ

PRODUTO: **OC-3A**

Data: 23/06/2017 **Nº FISPQ:** BR0306 **Versão:** 7 **Anula e substitui versão:** todas anteriores

1 - IDENTIFICAÇÃO DO PRODUTO E DA EMPRESA

Nome do produto:	OC-3A
Código interno de identificação:	BR0306
Principais usos recomendados para a substância ou mistura:	Utilizado para geração de energia térmica em fornos e caldeiras.
Nome da empresa:	PETROBRAS DISTRIBUIDORA S.A.
Endereço:	Rua Correia Vasques 250 20211-140 - Cidade Nova - Rio de Janeiro (RJ).
Telefone:	0800 728 9001
Telefone para emergências:	08000 24 44 33

2 - IDENTIFICAÇÃO DE PERIGOS

Classificação de perigo do produto:	Líquidos inflamáveis – Categoria 4 Corrosivo/irritante à pele – Categoria 3 Carcinogenicidade – Categoria 2 Toxicidade sistêmica ao órgão-alvo após única exposição – Categoria 3
Sistema de classificação utilizado:	Norma ABNT-NBR 14725-2:2009 – versão corrigida 2:2010. Sistema Globalmente Harmonizado para a Classificação e Rotulagem de Produtos Químicos, ONU.
Outros perigos que não resultam em uma classificação:	O produto não possui outros perigos.

ELEMENTOS APROPRIADOS DA ROTULAGEM

Pictogramas:

Palavra de advertência: ATENÇÃO

Frase de perigo:	Líquido combustível. Provoca irritação moderada à pele. Suspeito de provocar câncer. Pode provocar irritação das vias respiratórias. Pode provocar sonolência ou vertigem. Pode ser nocivo se ingerido e penetrar nas vias respiratórias.
Frase de precaução:	Evite inalar vapores e névoas. Use luvas de proteção, roupa de proteção, proteção ocular e proteção facial. EM CASO DE INALAÇÃO: Remova a pessoa para local ventilado e a mantenha em repouso numa posição que não dificulte a respiração. EM CASO DE exposição ou suspeita de exposição: Consulte um médico. Em caso de irritação cutânea: Consulte um médico. Em caso de incêndio: Para a extinção utilize pó químico, espuma resistente a álcool, dióxido de carbono (CO2) e neblina de água.

3 - COMPOSIÇÃO E INFORMAÇÃO SOBRE OS INGREDIENTES

>>>SUBSTÂNCIA DE PETRÓLEO

Nome químico ou comum nome técnico:	Óleo combustível residual.
Grupo de substância de petróleo:	Membros desta categoria formam um grupo abrangendo diversos hidrocarbonetos com uma ampla faixa de pesos moleculares, números de carbonos (C7 a C50) e pontos de ebulição (121 a 600 ºC). Os hidrocarbonetos de petróleo contêm enxofre, nitrogênio, oxigênio e compostos organometálicos
Sinônimo:	Óleo Combustível residual.
Número de Registro CAS:	68476-33-5

Impurezas que contribuam para o perigo:

Componente	Concentração (%)	CAS
Compostos nitrogenados	-	NA
Compostos sulfurados	-	NA
Metais pesados	-	NA

* Concentração de enxofre total: máx. 1% (p/p) – ASTM D4294

NA: Não aplicável.

4 - MEDIDAS DE PRIMEIROS SOCORROS

Inalação:

Remova a vítima para local arejado e mantenha-a em repouso. Monitore a função respiratória. Se a vítima estiver respirando com dificuldade, forneça oxigênio. Se necessário aplique respiração artificial. Procure atenção médica. Leve esta FISPQ.

Contato com a pele:

Remova as roupas e sapatos contaminados. Lave a pele exposta com grande quantidade de água, por pelo menos 20 minutos. Procure atenção médica. Leve esta FISPQ.

Contato com os olhos:

Lave com água corrente por pelo menos 20 minutos, mantendo as pálpebras abertas. Retire lentes de contato quando for o caso. Procure atenção médica imediatamente. Leve esta FISPQ.

Ingestão:

Lave a boca da vítima com água em abundância. NÃO INDUZA O VÔMITO. Procure atenção médica. Leve esta FISPQ.

Notas para médico:

Evite contato com o produto ao socorrer a vítima. Mantenha a vítima em repouso e aquecida. Não forneça nada pela boca a uma pessoa inconsciente. O tratamento sintomático deve compreender, sobretudo, medidas de suporte como correção de distúrbios hidroeletrolíticos, metabólicos, além de assistência respiratória.

5 - MEDIDAS DE COMBATE A INCÊNDIO

Meios de extinção:

Apropriados: Pó químico, espuma resistente a álcool, dióxido de carbono (CO2) e neblina de água.

Não recomendados: Jatos d'água. Água diretamente sobre o líquido em chamas.

Perigos específicos da mistura ou substância:

A combustão do produto químico ou de sua embalagem pode formar gases irritantes e tóxicos como monóxido, dióxido de carbono e sulfeto de hidrogênio. Muito perigoso quando exposto a calor excessivo ou outras fontes de ignição como: faíscas, chamas abertas ou chamas de fósforos e cigarros,operações de solda, lâmpadas-piloto e motores elétricos. Pode acumular carga estática por fluxo ou agitação. Os vapores do líquido aquecido podem incendiar-se por descarga estática. Os vapores são mais densos que o ar e tendem a se acumular em áreas baixas ou

	confinadas, como bueiros, porões, etc. Podem deslocar-se por grandes distâncias provocando retrocesso da chama ou novos focos de incêndio tanto em ambientes abertos como confinados. Os contêineres podem explodir se aquecidos.
Medidas de proteção da equipe de combate a incêndio	Equipamento de proteção respiratória do tipo autônomo (SCBA) com pressão positiva e vestuário protetor completo. Em locais fechados, utilize equipamento de segurança com sistema de ar autônomo. Contêineres e tanques envolvidos noincêndio devem ser resfriados com jatos d'água.

6 - MEDIDAS DE CONTROLE PARA DERRAMAMENTO OU VAZAMENTO

Precauções pessoais

Para o pessoal que não faz parte dos serviços de emergência:	Produto combustível. Remova todas as fontes de ignição.Impeça fagulhas ou chamas. Não fume. Não toque nos recipientes danificados ou no material derramado sem o uso devestimentas adequadas. Evite inalação, contato com os olhos e com a pele. Utilize equipamento de proteção individual conforme descrito na Seção 8.
Para pessoal de serviço de emergência:	Utilizar EPI completo, com óculos de segurança contra respingos, luvas de proteção de PVC, vestuário protetor adequado.
Precauções ao meio ambiente:	Evite que o produto derramado atinja cursos d'água e rede de esgotos.
Métodos e materiais para contenção e limpeza:	Colete o produto derramado e coloque em recipientes próprios. Adsorva o produto remanescente, com areia seca, terra, vermiculite, ou qualquer outro material inerte. Coloque omaterial adsorvido em recipientes apropriados e remova-os paralocal seguro.
Diferenças na ação de grandes e pequenos vazamentos:	Não há distinção entre as ações de grandes e pequenos vazamentos para este produto.

7 - MANUSEIO E ARMAZENAMENTO

MEDIDAS TÉCNICAS APROPRIADAS PARA O MANUSEIO

Precauções para manuseio seguro:	Manuseie o produto em local ventilado ou com sistema geral de exaustão local. Evite formação de vapores ou névoas. Evite contato com materiais incompatíveis. Não fume. Evite inalação e o contato com a pele, olhos e roupas. Evite respirar vapores/névoas do produto. Utilize equipamento de proteção individual ao manusear o produto, descritos na Seção 8.
Medidas de higiene:	Não coma, beba ou fume durante o manuseio do produto. Lave bem as mãos antes de comer, beber, fumar ou ir ao banheiro. Roupas contaminadas devem ser trocadas e lavadas antes de sua reutilização.

Condições de armazenamento seguro, incluindo qualquer incompatibilidade

Prevenção de incêndio e explosão:	Mantenha afastado do calor, faísca, chama aberta e superfícies quentes. — Não fume. Mantenha o recipiente hermeticamente fechado. Aterre o vaso contentor e o receptor do produto durante transferências. Utilize apenas ferramentas antifaiscante. Evite o acúmulo de cargas eletrostáticas. Utilize equipamento elétrico, de ventilação e de iluminação à prova de explosão.
Condições adequadas:	Mantenha o produto em local fresco, seco e bem ventilado, distante de fontes de calor e ignição. Armazenar em tanque de teto fixo, em local bem ventilado, na temperatura ambiente e sob pressão atmosférica. O local de armazenamento deve conter bacia de contenção para reter o produto, em caso de vazamento. O local de armazenamento deve ter piso impermeável, isento de materiais combustíveis e com dique de contenção para reter em caso de vazamento.
Materiais para embalagens:	Não especificado.

8 - CONTROLE DE EXPOSIÇÃO E PROTEÇÃO INDIVIDUAL

Parâmetros de controle

Limite de exposição ocupacional:

Ingredientes	TLV – TWA (ACGIH 2012)
Óleo combustível	5,0 mg/m$^{3.}$

Indicadores biológicos:	Não estabelecidos.
Medida de controle de engenharia:	Promova ventilação mecânica e sistema de exaustão direta para o meio exterior. Estas medidas auxiliam na redução da exposição ao produto. É recomendado tornar disponíveis chuveiros de emergência e lava olhos na área de trabalho.Manter as concentrações da substância ou mistura no ar abaixo dos limites de exposição ocupacional indicados.

Equipamento de proteção pessoal

Proteção dos olhos/face:	Óculos de proteção com proteção facial contra respingos.
Proteção da pele e do corpo:	Luvas de proteção de PVC. Vestuário protetor adequado.
Proteção respiratória:	Recomenda-se a utilização de respirador com filtro para vapores orgânicos para exposições médias acima da metade do TLV-TWA. Nos casos em que a exposição exceda 3 vezes o valor TLV-TWA, utilize respirador do tipo autônomo (SCBA) com suprimento de ar, de peça facial inteira, operado em modo de pressão positiva. Siga orientação do Programa de Prevenção Respiratória (PPR), 3ª ed. São Paulo: Fundacentro, 2002.
Perigos térmicos:	Não apresenta perigos térmicos.

9 - PROPRIEDADES FÍSICO-QUÍMICAS

Aspecto (estado físico, forma e cor)::	Líquido viscoso e escuro.
Odor e limite de odor:	Característico de hidrocarbonetos.
Ph:	Não aplicável.
Ponto de fusão/ponto de congelamento:	< 30ºC
Ponto de ebulição inicial e faixa de temperatura de ebulição:	121 – 600ºC
Ponto de fulgor:	66ºC; Método: vaso fechado.
Taxa de evaporação:	Muito lenta.
Inflamabilidade : (sólido; gás):	Não aplicável.
Limite inferior/superior de inflamabilidade ou explosividade:	Superior: 6% Inferior: 1%
Pressão de vapor:	0,02 – 0,791 kPa a 120°C 0,063 – 0,861 kPa a 150°C
Densidade de vapor:	Não disponível.
Densidade relativa:	Não disponível
Solubilidade:	Insolúvel em água. Solúvel em solventes orgânicos.
Coeficiente de partição – n-octanol/água:	Log kow: 3,9 – 6,0 (dado estimado).
Temperatura de auto-ignição:	250 – 537ºC
Temperatura de decomposição:	Não disponível.
Viscosidade:	2300 cSt a 60ºC (Método MB-293).
Outras informações:	Densidade: 1,026

10 - ESTABILIDADE E REATIVIDADE

Estabilidade e reatividade:	Estável sob condições usuais de manuseio e armazenamento. Não sofre polimerização.
Possibilidade de reações perigosas:	Não são conhecidas reações perigosas com relação ao produto
Condições a serem evitadas	Temperaturas elevadas. Fontes de ignição. Contato com materiais incompatíveis.
Materiais incompatíveis	Agentes oxidantes fortes, como peróxidos, cloratos e nitratos.
Produtos perigosos da decomposição:	Em combustão libera hidrocarbonetos poli-aromáticos na forma de partículas e vapores. Quando aquecido pode liberar sulfeto de hidrogênio.

11 - INFORMAÇÕES TOXICOLÓGICAS

Toxicidade aguda:	Produto não classificado como tóxico agudo. Informações referentes ao: - Óleo combustível: DL50 (oral, ratos): > 5000 mg/kg DL50 (dérmica, ratos): > 3000 mg/kg
Corrosão/irritação da pele:	Causa irritação moderada à pele com vermelhidão e dor no local atingido.
Lesões oculares graves/ irritação ocular:	Pode causar leve irritação ocular com vermelhidão e lacrimejamento.
Sensibilização respiratória ou à pele:	Não é esperado que o produto provoque sensibilização respiratória ou à pele.
Mutagenicidade em células germinativas:	Resultado positivo para ensaio de troca de cromátides-irmãs. Resultado positivo em teste de Ames (Salmonella typhimurium – in vitro). Porém, sem relevância para acarretar em uma classificação.
Carcinogenicidade:	Suspeito carcinógeno humano.
Toxicidade à reprodução:	Não é esperado que o produto apresente toxicidade à reprodução
Toxicidade para órgãos-alvo específicos – exposição única:	Como depressor do sistema nervoso central pode causar efeitos narcóticos como dores de cabeça, tontura, náuseas e sonolência. Pode causar irritação das vias aéreas superiores com tosse, dor de garganta e falta de ar. Pode causar confusão mental e perda da consciência em casos de exposição à altas concentrações.
Toxicidade para órgãos-alvo específicos – exposição repetida:	A exposição repetida e prolongada pode causar dermatite por Ressecamento.
Perigo por aspiração:	Pode causar pneumonia química se aspirado.

12 - INFORMAÇÕES ECOLÓGICAS

Efeitos ambientais, comportamentos e impactos do produto

Ecotoxicidade:	Não é esperado que o produto apresente perigo para organismos aquáticos.
Persistência e degradabilidade:	É esperada baixa degradação e alta persistência.
Potencial bioacumulativo:	É esperado potencial de bioacumulação em organismos aquáticos. Log kow: 3,9 – 6,0 (dado estimado).
Mobilidade no solo:	Não determinada.
Outros efeitos adversos:	Em caso de grandes derramamentos, devido à complexidade do produto, este poderá apresentar comportamentos distintos tais como adsorção ao sedimento e formação de película na superfície, podendo resultar em impacto ao meio ambiente.

13 - CONSIDERAÇÕES SOBRE TRATAMENTO E DISPOSIÇÃO

Métodos recomendados para tratamento e disposição aplicados ao

Produto:	O tratamento e a disposição devem ser avaliados especificamente para cada produto. Devem ser consultadaslegislações federais, estaduais e municipais, dentre estas: Resolução CONAMA 005/1993, Lei n°12.305, de 02 de agosto de 2010 (Política Nacional de Resíduos Sólidos).
Restos de produtos:	Manter restos do produto em suas embalagens originais, fechadas e dentro de tambores metálicos, devidamente fechados, de acordo com a legislação aplicável. O descarte deve ser realizado conforme o estabelecido para o produto, recomendando-se as rotas de processamento em cimenteiras e a incineração.
Embalagem usada:	Nunca reutilize embalagens vazias, pois elas podem conter restos do produto e devem ser mantidas fechadas e encaminhadas para serem destruídas em local apropriado. Neste caso, recomenda-se envio para rotas de recuperação dos tambores ou incineração.

14 - INFORMAÇÕES SOBRE TRANSPORTE

Regulamentações nacionais e internacionais

Terrestre:	Decreto nº 96.044, de 18 de maio de 1988: Aprova o regulamento para o transporte rodoviário de produtos perigosos e dá outras providências. Agência Nacional de transportes terrestres (ANTT): Resolução Nº. 5232/16.
Hidroviário:	DPC – Diretoria de Portos e Costas (Transporte em águas brasileiras) Normas de Autoridade Marítima (NORMAM) NORMAM 01/DPC: Embarcações Empregadas na Navegação em Mar Aberto. NORMAM 02/DPC: Embarcações Empregadas na Navegação Interior. IMO – “International Maritime Organization” (Organização Marítima

	Internacional) International Maritime Dangerous Goods Code (IMDG Code) – Incorporating Amendment 34-08;2008 Edition.
Aéreo:	DAC -Departamento de Aviação Civil: IAC 153-1001. Instrução de Aviação Civil – Normas para o transporte de artigos perigosos em aeronaves civis. IATA – “ International Air Transport Association” (Associação Nacional de Transporte Aéreo) Dangerous Goods Regulation (DGR) - 51
Número ONU:	3256
Nome apropriado para embarque:	LÍQUIDO A TEMPERATURA ELEVADA, INFLAMÁVEL, N.E. (Óleo combustível), com PFg superior a 60,5ºC, a temperatura igual ou superior ao PFg
Classe e subclasse de risco principal e subsidiário:	3
Número de risco:	30
Grupo de embalagem:	III

15 - REGULAMENTAÇÕES

Regulamentações:

Regulamentações: Decreto Federal nº 2.657, de 3 de julho de 1998

Norma ABNT-NBR 14725:2012.

Portaria MTE nº 704 de 28 de maio de 2015 – Altera a Norma Regulamentadora nº 26

16 - OUTRAS INFORMAÇÕES

Informações importantes:

Esta FISPQ foi elaborada baseada nos conhecimentos atuais do produto químico e fornece informações quanto à proteção, à segurança, à saúde e ao meio ambiente.

Adverte-se que o manuseio de qualquer substância química requer o conhecimento prévio de seus perigos pelo usuário. Cabe à empresa usuária do produto promover o treinamento de seus empregados e contratados quanto aos possíveis riscos advindos do produto.

Siglas:

ACGIH - American Conference of Governmental Industrial Hygienists
CAS - Chemical Abstracts Service
DL50 - Dose letal 50%
STEL – Short Term Exposure Level
TLV - Threshold Limit Value
TWA - Time Weighted Average

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[IPCS] INTERNATIONAL PROGRAMME ON CHEMICAL SAFETY – INCHEM. Disponível em: http://www.inchem.org/. Acesso em: outubro de 2010.
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[PETROLEUM HPV] PETROLEUM HIGH PRODUCTION VOLUME. Disponível em: http://www.petroleumhpv.org/pages/petroleumsubstances.html. Acesso em: outubro de 2010.
[REACH] REGISTRATION, EVALUATION, AUTHORIZATION AND RESTRICTION OF CHEMICALS. Commission Regulation (EC) No 1272/2008 of 16 December 2008 amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006 of the European Parliament and of the Council on the Registration, Evaluation, Authorization and Restriction of Chemicals.
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[TOXNET] TOXICOLOGY DATA NETWORKING. ChemIDplus Lite. Disponível em: http://chem.sis.nlm.nih.gov/. Acesso em: outubro de 2010.

Ficha de Informação de Produto Químico

IDENTIFICAÇÃO

Help

Número ONU	Nome do produto	Rótulo de risco
1202	ÓLEO DIESEL	

Número de risco	Classe / Subclasse
30	3

Sinônimos
ÓLEO COMBUSTÍVEL 1 - D ; ÓLEO COMBUSTÍVEL 2 - D

Aparência
LÍQUIDO OLEOSO ; MARROM AMARELADO ; ODOR DE ÓLEO COMBUSTÍVEL OU LUBRIFICANTE ; FLUTUA NA ÁGUA

Fórmula molecular	Família química
NÃO PERTINENTE	HIDROCARBONETO (MISTURA)

Fabricantes
Para informações atualizadas recomenda-se a consulta às seguintes instituições ou referências:
ABIQUIM - Associação Brasileira da Indústria Química: Fone 0800-118270
ANDEF - Associação Nacional de Defesa Vegetal: Fone (11) 3081-5033
Revista Química e Derivados - Guia geral de produtos químicos, Editora QD: Fone (11) 3826-6899
Programa Agrofit - Ministério da Agricultura

MEDIDAS DE SEGURANÇA

Help

Medidas preventivas imediatas
EVITAR CONTATO COM O LÍQUIDO. CHAMAR OS BOMBEIROS. PARAR O VAZAMENTO, SE POSSÍVEL. ISOLAR E REMOVER O MATERIAL DERRAMADO.

Equipamentos de Proteção Individual (EPI)
USAR LUVAS, BOTAS E ROUPAS DE PROTEÇÃO.

RISCOS AO FOGO

Help

Ações a serem tomadas quando o produto entra em combustão
COMBUSTÍVEL. EXTINGUIR COM PÓ QUÍMICO SECO, ESPUMA OU DIÓXIDO DE CARBONO. ESFRIAR OS RECIPIENTES EXPOSTOS, COM ÁGUA.

Comportamento do produto no fogo
NÃO PERTINENTE.

Produtos perigosos da reação de combustão
NÃO PERTINENTE.

Agentes de extinção que não podem ser usados
A ÁGUA PODE SER INEFICAZ.

Limites de inflamabilidade no ar
Limite Superior: 6,0 vol %
Limite Inferior: 1,3%

Ponto de fulgor
38ºC (VASO FECHADO)

Temperatura de ignição
(OBS. 1)

Taxa de queima
4 mm/min

Taxa de evaporação (éter=1)
DADO NÃO DISPONÍVEL

NFPA (National Fire Protection Association)

Perigo de Saúde (Azul): 0
Inflamabilidade (Vermelho): 2
Reatividade (Amarelo): 0

PROPRIEDADES FÍSICO-QUÍMICAS E AMBIENTAIS

Help

Peso molecular NÃO PERTINENTE	Ponto de ebulição (°C) 288 A 338	Ponto de fusão (°C) - 18 A - 34
Temperatura crítica (°C) NÃO PERTINENTE	Pressão crítica (atm) NÃO PERTINENTE	Densidade relativa do vapor NÃO PERTINENTE
Densidade relativa do líquido (ou sólido) 0,841 A 16 °C (LÍQUIDO)	Pressão de vapor 2,17 mm Hg A 21,1 °C	Calor latente de vaporização (cal/g) NÃO PERTINENTE
Calor de combustão (cal/g) - 10.200	Viscosidade (cP) DADO NÃO DISPONÍVEL	
Solubilidade na água INSOLÚVEL	pH NÃO PERT.	

Reatividade química com água
NÃO REAGE.

Reatividade química com materiais comuns
NÃO REAGE.

Polimerização
NÃO OCORRE.

Reatividade química com outros materiais
DADO NÃO DISPONÍVEL.

Degradabilidade
DADO NÃO DISPONÍVEL.

Potencial de concentração na cadeia alimentar
NENHUM.

Demanda bioquímica de oxigênio (DBO)
DADO NÃO DISPONÍVEL.

Neutralização e disposição final
DADO NÃO DISPONÍVEL.

INFORMAÇÕES ECOTOXICOLÓGICAS

Help

Toxicidade - limites e padrões
L.P.O.: DADO NÃO DISPONÍVEL
P.P.: NÃO ESTABELECIDO
IDLH: DADO NÃO DISPONÍVEL
LT: Brasil - Valor Médio 48h: DADO NÃO DISPONÍVEL
LT: Brasil - Valor Teto: DADO NÃO DISPONÍVEL
LT: EUA - TWA: 100 mg/m^3
LT: EUA - STEL: NÃO ESTABELECIDO

Toxicidade ao homem e animais superiores (vertebrados)
M.D.T.: DADO NÃO DISPONÍVEL
M.C.T.: DADO NÃO DISPONÍVEL

Toxicidade: Espécie: RATO

Toxicidade: Espécie: CAMUNDONGO

Toxicidade: Espécie: OUTROS

Toxicidade aos organismos aquáticos: PEIXES : Espécie

Toxicidade aos organismos aquáticos: CRUSTÁCEOS : Espécie

Toxicidade aos organismos aquáticos: ALGAS : Espécie

Toxicidade a outros organismos: BACTÉRIAS

Toxicidade a outros organismos: MUTAGENICIDADE

Toxicidade a outros organismos: OUTROS

Informações sobre intoxicação humana		
Tipo de contato	Síndrome tóxica	Tratamento
Tipo de contato LÍQUIDO	Síndrome tóxica IRRITANTE PARA A PELE. IRRITANTE PARA OS OLHOS. PREJUDICIAL, SE INGERIDO.	Tratamento REMOVER ROUPAS E SAPATOS CONTAMINADOS E ENXAGUAR COM MUITA ÁGUA. MANTER AS PÁLPEBRAS ABERTAS E ENXAGUAR COM MUITA ÁGUA. NÃO PROVOCAR O VÔMITO.

DADOS GERAIS

Help

Temperatura e armazenamento
AMBIENTE.

Ventilação para transporte
ABERTA.

Estabilidade durante o transporte
ESTÁVEL.

Usos
COMBUSTÍVEL PARA MOTORES DIESEL E INSTALAÇÃO DE AQUECIMENTO EM PEQUENO PORTE.

Grau de pureza
DE ACORDO COM NORMA "ASTM".

Radioatividade
NÃO TEM.

Método de coleta
MÉTODO 12.

Código NAS (National Academy of Sciences)
NÃO LISTADO

OBSERVAÇÕES

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1) TEMPERATURA DE IGNIÇÃO : 1- D = 176,8 °C A 329,7 °C 2 -D = 254,6 °C A 285,2 °C POTENCIAL DE IONIZAÇÃO (PI) = DADO NÃO DISPONÍVEL

NOVA CONSULTA

FICHA DE DATOS DE SEGURIDAD

Versión 1.27	Numero de FDS 300000000110
Fecha de revisión 02.05.2017	Fecha 03.11.2018
Sustituye a la versión: 1.26	

SECCIÓN 1: Identificación de la sustancia o la mezcla y de la sociedad o la empresa

1.1. Identificador del producto	: Oxígeno
nº CAS	: 7782-44-7
fórmula química	: O_2
Número de registro en REACH:	Figura en la lista del Anexo IV / V de REACH, exento de solicitud de registro.

1.2. Usos pertinentes identificados de la sustancia o de la mezcla y usos desaconsejados

Uso de la sustancia o mezcla	: Industrial en general
Restricciones de uso	: Sin datos disponibles.
1.3. Datos del proveedor de la ficha de datos de seguridad	: S.E. de Carburos Metálicos, S.A. Av. de la Fama, 1. 08940 Cornellà de Llobregat (Barcelona) www.carburos.com
Dirección de correo electrónico – Información técnica	: GASTECH@airproducts.com
Teléfono	: +34 (93)2902600
1.4. Teléfono de	: + 34 932 902 600 Servicio de Información Toxicológica (Instituto Nacional de Toxicología

emergencia y Ciencias Forenses) +34 91 562 04 20

SECCIÓN 2: Identificación de los peligros

2.1. Clasificación de la sustancia o de la mezcla

Gases oxidantes - Categoría 1 H270:Puede provocar o agravar un incendio; comburente.
Gases a presión - Gas comprimido. H280:Contiene gas a presión; peligro de explosión en caso de calentamiento.

2.2. Elementos de la etiqueta

Pictogramas/símbolos de riesgos

Palabras de advertencia Peligro

Declaraciones de riesgo:

H270:Puede provocar o agravar un incendio; comburente.
H280:Contiene gas a presión; peligro de explosión en caso de calentamiento.

Declaraciones de precaución:

Prevención : P220:Mantener lejos de la ropa y otros materiales combustibles.
P244:Mantener las válvulas y los accesorios limpios de aceite y grasa.

Respuesta : P370+P376 :En caso de incendio: Detener la fuga, si no hay peligro en hacerlo.

Almacenamiento : P403:Almacenar en un lugar bien ventilado.

2.3. Otros peligros

Gas oxidante a alta presión.
Acelera la combustión vigorosamente.
Mantener lejos de aceites, lubricantes y materiales combustibles.
Puede reaccionar violentamente con materias combustibles.

SECCIÓN 3: Composición/información sobre los componentes

3.1. Sustancias

Componentes	EINECS / ELINCS Nombre	CAS Nombre	Concentración (Proporción de volumen)
oxigeno	231-956-9	7782-44-7	100 %

Componentes	Clasificación (CLP)	Registro REACH #
oxigeno	Ox. Gas 1 ;H270 Press. Gas (Comp.) ;H280	*1

*1:Figura en la lista del Anexo IV / V de REACH, exento de solicitud de registro.
*2:No exige su registro. Sustancias fabricadas o importadas < 1 t/a.
*3:No ha expirado el plazo límite de solicitud de registro.

Consulte la sección 16 para conocer el texto completo de cada indicación de peligro (H) relevante.

La concentración es nominal. Para la composición exacta del producto, referirse a las especificaciones técnicas.

3.2. Mezclas : No aplicable.

SECCIÓN 4: Primeros auxilios

4.1. Descripción de los primeros auxilios

Consejo generales : Retirar a la víctima a un área no contaminada llevando colocado el equipo de respiración autónoma. Mantener a la víctima caliente y en reposa. Llamar al doctor. Aplicar la respiración artificial si se para la respiración.

Contacto con los ojos	: EN CASO DE exposición manifiesta o presunta: Consultar a un médico.
Contacto con la piel	: No se esperan efectos adversos de este producto. EN CASO DE exposición manifiesta o presunta: Consultar a un médico.
Ingestión	: La ingestión no está considerada como una vía potencial de exposición.
Inhalación	: Consultar a un médico después de una exposición importante. Salir al aire libre. Si la respiración es dificultosa o se detiene, proporcione respiración asistida. Se puede suministrar oxígeno suplementario. Si se detiene el corazón, el personal capacitado debe comenzar de inmediato la resucitación cardio-pulmonar.

4.2. Principales síntomas y efectos, agudos y retardados

Síntomas	: Sin datos disponibles.

4.3. Indicación de toda atención médica y de los tratamientos especiales que deban dispensarse inmediatamente

Tratamiento	: En caso de exposición manifiesta o presunta: consulte a un médico.

SECCIÓN 5: Medidas de lucha contra incendios

5.1. Medios de extinción

Medios de extinción adecuados	: Se pueden usar todos los medios de extinción conocidos.
Medios de extinción que no deben utilizarse por razones de seguridad	: Sin datos disponibles.

5.2. Peligros específicos derivados de la sustancia o la mezcla

: Ante la exposición al calor intenso o fuego, el cilindro se vaciará rápidamente y/o se romperá violentamente. Oxidante. Mantiene la combustión vigorosamente. Puede reaccionar violentamente con los materiales combustibles. Algunos materiales no inflamables en el aire, pueden ser inflamables con la presencia de un oxidante. Alejarse del envase y enfriarlo con agua desde un lugar protegido. Mantener los cilindros adyacentes fríos mediante pulverización de gran cantidad de agua hasta que el fuego se apague. Si es posible, detener el caudal de producto.

5.3. Recomendaciones para el personal de lucha contra incendios

: Si es necesario, llevar aparato respiratorio autónomo para la lucha contra el fuego. Vestimenta y equipo de protección standard (aparato de respiración autónoma) para bomberos. Standard EN 137-mascara de cara completa que incluya un aparato de respiración autónomo de aire comprimido en circuito abierto. EN 469: Vestimenta protectora para bomberos.EN 659: Guantes de protección para bomberos.

Información adicional : Algunos materiales incombustibles en el aire, se encenderán en una atmósfera rica en oxígeno (más de 23<(>,<)>5%). La ropa resistente al fuego puede encenderse y no proteger en atmósferas ricas en oxígeno.

SECCIÓN 6: Medidas en caso de vertido accidental

6.1. Precauciones personales, equipo de protección y procedimientos de emergencia

: La ropa expuesta a altas concentraciones puede retener el oxígeno durante 30 minutos o más, y potencialmente existe peligro de incendio. Mantener lejos de fuentes de ignición. Evacuar el personal a zonas seguras. Utilizar equipos de respiración autónoma cuando entren en el área a menos que esté probado que la atmósfera es segura. Ventilar la zona.

6.2. Precauciones relativas al medio ambiente

: No descargar dentro de ningún lugar donde su acumulación pudiera ser peligrosa. Impedir nuevos escapes o derrames de forma segura.

6.3. Métodos y material de contención y de limpieza

: Ventilar la zona.

Consejos adicionales : Si es posible, detener el caudal de producto. Aumentar la ventilación en el área de liberación del gas y controlar las concentraciones. Si la fuga tiene lugar en el cilindro o en su válvula, llamar al número de emergencia. Si la fuga tiene lugar en la instalación del usuario, cerrar la válvula del cilindro, ventear la presión con seguridad y purgar el cilindro con gas inerte antes de intentar repararlo.

6.4. Referencia a otras secciones : Si desea más información, consulte las secciones 8 y 13

SECCIÓN 7: Manipulación y almacenamiento

7.1. Precauciones para una manipulación segura

Todos los indicadores, válvulas, reguladores, tubos y equipo usados en servicio de oxígeno deben ser limpiados para el servicio de oxígeno. El oxígeno no debe ser usado como sustituto del aire comprimido. Nunca usar el chorro del oxígeno para depurar, especialmente la ropa, porque aumenta la posibilidad de incendio. Los gases comprimidos o líquidos criogénicos sólo deben ser manipulados por personas con experiencia y debidamente capacitadas. Proteger los cilindros contra daños físicos; no tirar, no rodar, ni dejar caer. La temperatura en las áreas de almacenamiento no debe exceder los 50ºC. Antes de usar el producto, identificarlo leyendo la etiqueta. Antes del uso del producto se deben conocer y entender sus características así como los peligros relacionados con las mismas. En caso de que existan dudas sobre los procedimientos del uso correcto de un gas concreto, ponerse en contacto con el proveedor. No quitar ni emborronar las etiquetas entregadas por el proveedor para la identificación del contenido de los cilindros. Para la manipulación de cilindros se deben usar, también para distancias cortas, carretillas destinadas al transporte de cilindros. No quitar el protector de seguridad de la válvula hasta que el cilindro no esté sujeto a la pared, mesa de trabajo o plataforma, y listo para su uso. Para quitar las protecciones demasiado apretadas u oxidadas usar una llave inglesa ajustable. Antes de conectar el envase comprobar la adecuación de todo el sistema de gas, especialmente los indicadores de presión y las propiedades de los materiales. Antes de conectar el envase para su uso, asegurar que se ha protegido contra la aspiración de retorno del sistema al envase. Asegurar que todo el sistema de gas es compatible con las indicaciones de presión y con los materiales de construcción. Asegurarse antes del uso de que no existan fugas en el sistema de gas Usar los equipos de regulación y de presión adecuados en todos los envases cuando el gas es transferido a sistemas con una presión menor que la del envase. No insertar nunca un objeto (p.ej. llave, destornillador, palanca, etc.) a las aberturas del protector de la válvula. Tales acciones pueden deteriorar la válvula y causar una fuga. Si el usuario ve cualquier problema durante la manipulación de la válvula del cilindro, debe interrumpir su uso y ponerse en contacto con el proveedor. Cerrar la válvula del envase después de cada uso y cuando esté vacío, incluso si está conectado al equipo. Nunca intente reparar o modificar las válvulas de un envase o las válvulas de seguridad. Debe de comunicarse inmediatamente al proveedor el deterioro de cualquier válvula. No usar envases como rodillos o soportes, o para cualquier otro propósito que no sea contener el gas, tal como ha sido suministrado. Nunca crear un arco voltaico en un cilindro de gas comprimido o hacer que el cilindro forme parte de un circuito eléctrico. No fumar durante la manipulación de productos o cilindros Nunca re-comprimir el gas o la mezcla de gases sin consultarlo previamente con el proveedor. Nunca intente transferir gases de un cilindro / envase a otro. Usar siempre válvulas anti-retorno en las tuberías. Al devolver el cilindro instalar el tapón protector de la válvula o tapón protector de fugas. Nunca permitir el contacto de aceite, lubrificante u otra sustancia combustible con válvulas o envases que contengan oxígeno u otros oxidantes. No usar válvulas de apertura rápida (p.ej: válvulas de bola). Abrir la válvula lentamente para evitar los golpes de ariete. Nunca someter todo el sistema a presión al mismo tiempo. Usar sólo con equipo limpiado para el servicio de oxígeno e indicado para cilindros a presión. Nunca usar fuego directo o calentadores eléctricos para aumentar la presión en el envase. Los envases no deben ser sometidos a temperaturas superiores a los 50ºC (122ºF).

7.2. Condiciones de almacenamiento seguro, incluidas posibles incompatibilidades

Los envases deben ser almacenados en un lugar especialmente construido y bien ventilado, preferiblemente al aire libre. Se deben almacenar los envases llenos de tal manera que los más antiguos sean usados en primer lugar. Los envases almacenados deben ser controlados periódicamente en cuanto a su estado general y fugas. Tener en cuenta todas las leyes y requisitos locales sobre el almacenamiento de envases. Proteger los envases almacenados al aire libre contra la corrosión y las condiciones atmosféricas extremas. Los envases no deben ser almacenados en condiciones que puedan acelerar la corrosión. Los envases deben ser almacenados en posición vertical y asegurados para prevenir las caídas. Las válvulas de los contenedores deben estar bien cerradas y donde sea necesario, las salidas de las válvulas deben ser protegidas con tapones. Los protectores de las válvulas o tapones deben estar en su sitio. Mantener los envases herméticamente cerrados en un lugar fresco y bien ventilado. Los envases deben ser almacenados en lugares libres de riesgo de incendio y lejos de fuentes del calor e ignición. Los cilindros llenos se deben separar de los vacíos. No permitir que la temperatura de almacenamiento alcance los 50ºC (122 °F). Colocar señales "Se prohíbe fumar y usar el fuego abierto" en las áreas de almacenamiento. Devolver los envases con puntualidad

Medidas técnicas/Precauciones

Los recipientes deben ser separados en el área de almacenamiento según las distintas categorías (p.e.: inflamable, tóxico, etc.) y conforme a la reglamentación local.

7.3. Usos específicos finales

Consulte la sección 1 o la hoja de datos de seguridad ampliada, si corresponde.

SECCIÓN 8: Controles de exposición/protección individual

8.1. Parámetros de control

Si corresponde, consulte la sección ampliada de la hoja de datos de seguridad para obtener más información acerca de la materia prima aprobada (CSA).

8.2. Controles de la exposición

Disposiciones de ingeniería

Asegúrese una ventilación apropiada.

Equipos de Protección personal

Protección respiratoria	:	No se precisa en el uso normal. Para respirar en atmósfera deficiente de oxígeno debe usarse un equipo de respiración autónomo o una línea de aire con presión positiva y máscara. Los usuarios de los equipos de respiración autónomos deben ser entrenados.
Protección de las manos	:	Usar guantes de trabajo al manejar envases de gases. Los guantes deben estar limpios y sin aceite o lubricante. Standard EN 388 - guantes que protegen contra riesgos mecánicos.
Protección para los ojos y la cara	:	Se aconseja el uso de gafas de protección durante la manipulación de cilindros. Standard EN 166- Protección para el ojo.
Protección de la piel y del cuerpo	:	Durante la manipulación de cilindros se aconseja el uso de zapatos de protección. Standard EN ISO 20345 - Equipos de protección personal-zapatos de seguridad.
Instrucciones especiales de protección e higiene	:	Asegurarse de una ventilación adecuada, especialmente en locales cerrados.
Controles de la exposición medioambiental	:	Si corresponde, consulte la sección ampliada de la hoja de datos de seguridad para obtener más información acerca de la materia prima aprobada (CSA).

SECCIÓN 9: Propiedades físicas y químicas

9.1. Información sobre propiedades físicas y químicas básicas

(a/b) estado físico/color	:	Gas comprimido. Gas incoloro

(c) Olor : Sin olor que advierta de sus propiedades

(d) Densidad : 0,0013 g/cm3 (0,081 lb/ft3) a 21 °C (70 °F)
Nota: (como vapor)

(e) Densidad relativa : 1,1 (agua = 1)

(f) Punto de fusión / punto de congelación : -362 °F (-219 °C)

(g) Temperatura de ebullición/rango : -297 °F (-183 °C)

(h) Presión de vapor : No aplicable.

(i) Solubilidad en agua : 0,039 g/l

(j) Coeficiente de reparto: n-octanol/agua [log Kow] : No es aplicable a gases inorganicos.

(k) pH : No es aplicable a gases ni a mezcla de gases.

(l) Viscosidad : No se dispone de datos fiables.

(m) características de las partículas : No es aplicable a gases ni a mezcla de gases.

(n) Límites superior y inferior de explosión / inflamabilidad : No inflamable.

(o) Punto de inflamación : No es aplicable a gases ni a mezcla de gases.

(p) Temperatura de autoignición : No inflamable.

(q) Temperatura de descomposición : No aplicable.

9.2. Otros datos

Peligro de explosión	: No aplicable.
Propiedades oxidantes	: Ci =1
Peso molecular	: 32 g/mol
Límite crítico de olores	: La superación de limites por el olor es subjetiva e inadecuado para advertir del riesgo de sobrecarga.
Indicé de evaporación	: No es aplicable a gases ni a mezcla de gases.
Inflamabilidad (sólido, gas)	: Consulte la clasificación del producto en la Sección 2
volumen específico	: 0,7540 m3/kg (12,08 ft3/lb) a 21 °C (70 °F)
Densidad relativa del vapor	: 1,105 (aire = 1) Más pesado que el aire

SECCIÓN 10: Estabilidad y reactividad

10.1. Reactividad	: Sin riesgo de reactividad salvo lo expresado en la sub-sección mas adelante.
10.2. Estabilidad química	: Estable en condiciones normales.
10.3. Posibilidad de reacciones peligrosas	: Oxida violentamente materiales orgánicos.
10.4. Condiciones que deben evitarse	: Nunca por debajo de las condiciones de manejo y almacenamiento (ver sección 7).
10.5. Materiales incompatibles	: Materiales inflamables. Materiales orgánicos. Evitar aceite, grasas y otras sustancias inflamables

10.6. Productos de descomposición peligrosos	:	Sin datos disponibles.

SECCIÓN 11: Información toxicológica

11.1. Información sobre los efectos toxicológicos

Vías de entrada probables

Efectos en los ojos	:	En caso de contacto directo con los ojos, busque asistencia médica.
Efectos en la piel	:	No se esperan efectos adversos de este producto.
Efectos debido a la inhalación	:	La respiración con oxígeno 75% o superior en la atmósfera durante más de unas horas puede taponar la nariz, tos, dolores de garganta, tórax y dificultades en la respiración. Inhalación del oxígeno puro comprimido puede causar lesiones de pulmón y trastornos del sistema nervioso.
Efectos debido a la ingestión	:	La ingestión no está considerada como una vía potencial de exposición.
Síntomas	:	Sin datos disponibles.

Toxicidad aguda

Toxicidad oral aguda	:	No hay datos disponibles sobre este producto.
Toxicidad aguda por inhalación	:	No hay datos disponibles sobre este producto.
Toxicidad dérmica aguda	:	No hay datos disponibles sobre este producto.
Corrosión o irritación de la piel	:	Sin datos disponibles.
Irritación o daños oculares severos	:	Sin datos disponibles.
Sensibilización.	:	Sin datos disponibles.

Toxicidad crónica o efectos debidos a la exposición a largo plazo

Carcinogenicidad	: Sin datos disponibles.
Toxicidad reproductiva	: No hay datos disponibles sobre este producto.
Mutagenicidad en células germinales	: No hay datos disponibles sobre este producto.
Toxicidad sistémica específica de órganos diana (exposición única)	: Sin datos disponibles.
Toxicidad sistémica específica de órganos diana (exposición repetida)	: Los nacidos permaturamente expuestos a concentraciones altas a oxígeno pueden sufrir lesión de retina, que puede progresar hasta sudesprendimiento y ceguera. La lesión de retina puede también aparecer en adultos expuestos al oxígeno 100% durante períodos prolongados (de 24 a 48 horas).A dos o más atmósferas aparece toxicidad en el sistema nervioso central (CNS). Los síntomas incluyen náuseas, vomitos, mareos o vértigo, agarrotamiento de los músculos, cambios de visión, y pérdida de sentido y ataques generalizados. A tres atmósferas, la toxicidad del CNS afecta en menos de dos horas, y a seis atmósferas en solo algunos minutos.
Peligro de aspiración	: Sin datos disponibles.

SECCIÓN 12: Información ecológica

12.1. Toxicidad

Toxicidad acuática	: No hay datos disponibles sobre este producto.
Toxicidad para otros organismos	: No hay datos disponibles sobre este producto.

12.2. Persistencia y degradabilidad

Sin datos disponibles.

12.3. Potencial de bioacumulación

Consulte la sección 9 "Coeficiente de partición (n-octanol/agua)".

12.4. Movilidad en el suelo

Debido a su alta volatilidad, es poco probable que el producto cause contaminación del suelo.

12.5. Resultados de la valoración PBT y mPmB

Si corresponde, consulte la sección ampliada de la hoja de datos de seguridad para obtener más información acerca de la materia prima aprobada (CSA).

12.6. Otros efectos adversos

Este producto no causa daños ecológicos.

Efectos sobre la capa de ozono

Potencial factor reductor de la capa de ozono	:	Sin datos disponibles.
Factor de calentamiento global	:	Sin datos disponibles.

SECCIÓN 13: Consideraciones relativas a la eliminación

13.1. Métodos para el tratamiento de residuos	:	Devolver el producto no usado al proveedor en el cilindro original. Contactar con el proveedor si es necesaria información y asesoramiento. Referirse al código de prácticas de EIGA Doc. 30 "Disposal of Gases" accesible en http://www.eiga.org para mayor información sobre métodos adecuados de vertidos. Lista de residuos peligrosos: 16 05 04: Contenedores de gases a presión (incluido halones) que contienen sustancias peligrosas.
Envases contaminados	:	Devolver el cilindro al proveedor.

SECCIÓN 14: Información relativa al transporte

ADR

No. ONU/ID	: UN1072
Denominación adecuada de envío	: OXIGENO COMPRIMIDO
Clase o división	: 2
Código de restricción en túneles	: (E)
Etiqueta(s)	: 2.2 (5.1)
ADR/RID Peligro ID nº	: 25
Contaminante marino	: No

IATA

No. ONU/ID	: UN1072
Denominación adecuada de envío	: Oxygen, compressed
Clase o división	: 2.2
Etiqueta(s)	: 2.2 (5.1)
Contaminante marino	: No

IMDG

No. ONU/ID	: UN1072
Denominación adecuada de envío	: OXYGEN, COMPRESSED
Clase o división	: 2.2
Etiqueta(s)	: 2.2 (5.1)
Contaminante marino	: No
Grupo de segregación:	: None

RID

No. ONU/ID	: UN1072
Denominación adecuada de envío	: OXIGENO COMPRIMIDO
Clase o división	: 2
Etiqueta(s)	: 2.2 (5.1)

Contaminante marino : No

Transporte a granel con arreglo al anexo II del Convenio MARPOL y del Código IBC

Si desea la información completa para el transporte, comuníquese con un representante de atención al cliente.

Información Adicional

Evitar el transporte en los vehículos donde el espacio de la carga no esté separado del compartimiento del conductor. Asegurar que el conductor está enterado de los riesgos potenciales de la carga y que conoce que hacer en caso de un accidente o de una emergencia. La información de transporte no ha sido elaborada para incluir todos los datos reglamentarios específicos correspondientes a este material. Si desea la información completa para el transporte, comuníquese con un representante de atención al cliente.

SECCIÓN 15: Información reglamentaria

15.1. Reglamentación y legislación en materia de seguridad, salud y medio ambiente específicas para la sustancia o la mezcla

País	Listado de regulaciones	Notificación
EE.UU.	TSCA	Incluido en inventario.
EU	EINECS	Incluido en inventario.
Canadá	DSL	Incluido en inventario.
Australia	AICS	Incluido en inventario.
Corea del Sur	ECL	Incluido en inventario.
China	SEPA	Incluido en inventario.
Filipinas	PICCS	Incluido en inventario.
Japón	ENCS	Incluido en inventario.

Otros regulaciones

REGLAMENTO (CE) nº 1907/2006 DEL PARLAMENTO EUROPEO Y DEL CONSEJO de 18 de diciembre de 2006 relativo al registro, la evaluación, la autorización y la restricción de las sustancias y preparados químicos (REACH), por el que se crea la Agencia Europea de Sustancias y Preparados Químicos, se modifica la Directiva 1999/45/CE y se derogan el Reglamento (CEE) nº 793/93 del Consejo y el Reglamento (CE) nº 1488/94 de la Comisión así como la Directiva 76/769/CEE del Consejo y las Directivas 91/155/CEE, 93/67/CEE, 93/105/CE y 2000/21/CE de la Comisión.

REGLAMENTO (UE) 2015/830 DE LA COMISIÓN de 28 de mayo de 2015 por el que se modifica el Reglamento (CE) no 1907/2006 del Parlamento Europeo y del Consejo, relativo al registro, la evaluación, la autorización y la restricción de las sustancias y mezclas químicas (REACH).

REGLAMENTO (CE) No 1272/2008 DEL PARLAMENTO EUROPEO Y DEL CONSEJO de 16 de diciembre de 2008 sobre clasificación, etiquetado y envasado de sustancias y mezclas, y por el que se modifican y derogan las Directivas 67/548/CEE y 1999/45/CE y se modifica el Reglamento (CE) no 1907/2006.

Acuerdo europeo sobre transporte internacional de mercancías peligrosas por carretera (ADR), celebrado en Ginebra el 30 de septiembre de 1957, en su versión enmendada.

Real Decreto 97/2014, de 14 de febrero (BOE núm. 50, de 27 de febrero de 2014), por el que se regulan las operaciones de transporte de mercancías peligrosas por carretera en territorio español.

Real Decreto 840/2015, de 21 de septiembre (BOE núm. 251, de 20 de octubre de 2015), por el que se aprueban medidas de control de los riesgos inherentes a los accidentes graves en los que intervengan sustancias peligrosas.

REAL DECRETO 374/2001, de 6 de abril (BOE núm. 104, de 1 de mayo de 2001), sobre la protección de la salud y seguridad de los trabajadores contra los riesgos relacionados con los agentes químicos durante el trabajo.

Real Decreto 782/1998, de 30 de abril (BOE núm. 104, de 1 de mayo de 1998), por el que se aprueba el Reglamento para el desarrollo y ejecución de la Ley 11/1997, de 24 de abril, de Envases y Residuos de Envases.

DECRETO 2414/1961, de 30 de noviembre (BOE núm. 292, de 7 de diciembre de 1961), por el que se aprueba el Reglamento de Actividades Molestas, Insalubres, Nocivas y Peligrosas.

Orden de 9 de marzo de 1971 (BOE núm. 64, de 16 de marzo de 1971), por la que se aprueba la Ordenanza General de Seguridad e Higiene en el

Trabajo.

15.2. Evaluación de la seguridad química

Un CSA (Análisis de Seguridad Química) no debe de realizarse para este producto.

SECCIÓN 16: Otra información

Asegurar que se cumplen todas las regulaciones nacionales/locales.

Declaraciones de riesgo:
H270 Puede provocar o agravar un incendio; comburente.
H280 Contiene gas a presión; peligro de explosión en caso de calentamiento.

Indicación del método:
Gases oxidantes Categoría 1 Puede provocar o agravar un incendio; comburente. Método de cálculo

Gases a presión Gas comprimido. Contiene gas a presión; peligro de explosión en caso de calentamiento. Método de cálculo

Abreviaturas y acrónimos:
ATE - Estimación de Toxicidad Aguda
CLP - Reglamento (CE) nº 1272/2008 sobre clasificación, etiquetado y envasado
REACH - Registro, evaluación, autorización y restricción de las sustancias y preparados químicos Reglamento (CE) nº 1907/2006
EINECS - Catálogo Europeo de Sustancias Químicas Comercializadas
ELINCS - Lista europea de sustancias químicas notificadas
CAS# - No. CAS (Chemical Abstracts Service)
PPE - equipos de protección personal
Kow - coeficiente de reparto octanol-agua
DNEL - nivel sin efecto derivado
LC50 - concentración letal para el 50 % de una población de pruebas
LD50 - dosis letal para el 50 % de una población de pruebas (dosis letal media)
NOEC - concentración sin efecto observado
PNEC - concentración prevista sin efecto
RMM - medida de gestión del riesgo
OEL - valor límite de exposición profesional

PBT - sustancia persistente, bioacumulativa y tóxica
vPvB - muy persistente y muy bioacumulable
STOT - toxicidad específica en determinados órganos
CSA - valoración de la seguridad química
EN - norma europea
UN - Organización de las Naciones Unidas
ADR - Acuerdo europeo relativo al transporte internacional de mercancías peligrosas por carretera
IATA - Asociación Internacional de Transporte Aéreo
IMDG - Código marítimo internacional para el transporte de mercancías peligrosas
RID - Reglamento relativo al transporte internacional de mercancías peligrosas por ferrocarril
WGK - clase de peligro para el agua

Principales referencias bibliográficas y fuentes de datos:
ECHA - Directriz sobre la compilación de fichas de datos de seguridad
ECHA - Documento de orientación sobre la aplicación de los criterios del CLP
La base de datos de ARIEL

Indicación de cambios	:	Teléfono de emergencia (24h) 9. PROPIEDADES FISICAS Y QUIMICAS 10. ESTABILIDAD Y REACTIVIDAD 15. INFORMACIÓN REGLAMENTARIA
Preparado por	:	Departamento EH&S Global, Air Products and Chemicals, Inc.

Para información adicional, por favor, visite nuestra página web de Tutela de Producto en la dirección http://www.airproducts.com/productstewardship/

Esta Ficha de Datos de Seguridad ha sido elaborada de acuerdo con las Directivas Europeas aplicables y es de aplicación en todos los países que han traspuesto las Directivas a leyes nacionales. REGLAMENTO (UE) 2015/830 DE LA COMISIÓN de 28 de mayo de 2015 por el que se modifica el Reglamento (CE) no 1907/2006 del Parlamento Europeo y del Consejo, relativo al registro, la evaluación, la autorización y la restricción de las sustancias y mezclas químicas (REACH).

Los detalles dados en este documento se cree son correctos en el momento de su publicación. Aunque se ha tomado el cuidado apropiado en la preparación de este documento, no se puede aceptar ninguna responsabilidad por lesión o daños resultantes de su uso.

HOJA DE DATOS DE SEGURIDAD

Peróxido de Hidrógeno 50% estándar

SDS #: 7722-84-1-50-10
Fecha de revisión: 2015-05-08
Formato: NA
Versión: 1

1. IDENTIFICACIÓN DE PRODUCTO Y EMPRESA

Identificación del producto

Nombre del Producto:	Peróxido de Hidrógeno al 50% estándar.
Otras formas de identificación	
CAS No:	7722-84-1

Uso Recomendado del químico y restricciones de uso:

Uso recomendado:	Blanqueo industrial, tratamiento, reducción de la contaminación y reacciones generales de oxidación.
Restricciones de uso:	Use como se recomienda en la etiqueta.

Fabricante/Distribuidor:

PeroxyChem, LLC
2005 Market Street
Suit 3200
Philadelphia, PA 19103
Teléfono:+1 267/422-2400 (Información General)
sdsinfo@peroxychem.com

PeroxyChem-México
Av. Industria #9, Col. Industrial Cerro Gordo C.P. 55420
Teléfono: 56-99-08-14 (Información General)

Teléfonos de Emergencia

Por fuga, fuego o derrame o emergencia por accidentes llamar a
01 800 /424 93000 (CHEMTREC-USA)
1 703/527 3887 (CHEMTREC- Collect-otros paises)
1 613/ 996-6666 (CANUTEC – Canada)
1 303/ 389-1409 (Medical –US-llamada por cobrar)
01 800 00 214 00 (SETIQ- MEXICO)
55-59-15-88 (SETIQ- MEXICO)
24 hrs del día/365 días del año.

1 281 / 474-8750 (Bayport, Planta en Texas)
1 250 / 561-4221 (Prince George, BC, Planta en Canada)
52-55-56-99-08-00 ext. 0807, 0806, 1335
(Centro de Distribución, México)
(Información Lunes a Viernes 8:30 a17:30 hrs)

2. IDENTIFICACION DE RIESGOS

Clasificación

Regulación OSHA

Este material es considerado peligroso por la OSHA Estandar de Comunicación de Riesgo (29 CFR 1910. 1200).

Toxicidad Aguda-Oral	Categoría 4
Toxicidad Aguda- Inhalación (Vapores)	Categoría 4
Corrosión a la piel / Irritación	Categoría 1, Sub-Categoría B
Daño serio a los ojos/ Irritación a los ojos	Categoría 1
Toxicidad específica en órgano blanco (exposición única)	Categoría 3
Líquidos oxidantes	Categoría 2

Elementos de las etiquetas de SGA Sistema Globalmente Armonizado (GHS), incluyendo las declaraciones de precaución

Consejos de prudencia

Peligro

Indicaciones de Peligro

H314-Causa severas quemaduras en piel y daños en los ojos.
H302-Nocivo por ingestión.
H332-Nocivo por inhalación.
H335-Puede irritar las vías respiratorias.
H272-Puede intensificar un incendio; es oxidante.

Consejos de Prudencia - Prevención

P271-Usar solamente en exteriores o en áreas bien ventiladas.
P260-No respire los vapores, niebla o rocío.
P280-Usar guantes de protección/ropa de protección/protección ocular/careta de protección.
P210-Mantenerse lejos de las fuentes de calor/chispas/llamas abiertas/superficies calientes.- No fumar.
P220-Mantener o almacenar alejado de la ropa o materiales inflamables/combustibles.
P221-Tomar todas las precauciones necesarias posibles para no mezclarse con combustibles /inflamables.

Consejos de Prudencia - Respuesta

P305+P351+P338-Si el contacto es con los ojos: Enjuague cuidadosamente con agua durante varios minutos. Quitar lentes de contacto si están presentes y es fácil retirarlos. Continuar enjuagando.
P310-Llame inmediatamente a un centro de toxicología o a un médico.
P303+P361+P353- Si el contacto es en la piel o en el cabello: Quítese inmediatamente la ropa contaminada, enjuagar la piel con abundante agua/ ducharse.
P363-Lavar perfectamente la ropa contaminada antes de usarse nuevamente.
P304+P340-En caso de inhalación, alejar a la persona al aire libre y mantenerla en una posición que le facilite la respiración.
P312- Si no se siente bien, llamar a un centro de toxicología o a un médico.
P301+P330+P331- En caso de ingestión: Enjuagar la boca, no inducir el vómito.
P310- Llame inmediatamente a un centro de toxicología o a un médico.
P370+P378- En caso de incendio: Utilizar agua para la extinción.

Otros Peligros que no contribuyen en la clasificación.

No fueron identificados

Otra información

Mantener el contenedor en un lugar fresco fuera del sol directo. Almacenar sólo en contenedores ventilados. No almacenar en tarimas de madera. No devuelva el material no utilizado a su envase original. Evitar la contaminación ya que podría causar la descomposición y la generación de oxígeno que puede resultar en alta presión y la posible ruptura del contenedor-. Los porrones vacíos se deben enjuagar tres veces con agua antes de desechar.

3. COMPOSICION/INFORMACIÓN SOBRE LOS COMPONENTES

Fórmula HO-OH

Nombre Químico	CAS-No.	% en Peso
Peróxido de hidrógeno	7722-84-1	50
Agua	7732-18-5	50

Limites de exposición ocupacional, en caso de existir, se presentan en la sección 8.

4. MEDIDAS DE PRIMEROS AUXILIOS

Contacto con los ojos	Enjuague inmediatamente con abundante agua por al menos 15 minutos, levantando tanto el parpado superior como inferior. Remueva lentes de contacto después de los primeros 5 minutos de enjuague, después siga enjuagando. Consulte a un médico u oftalmólogo inmediatamente.
Contacto con la piel	Quítese la ropa contaminada. Enjuague la piel inmediatamente con abundante agua, lave durante 15 a 20 minutos. Consulte a un médico inmediatamente.
Inhalación	Traslade al lesionado donde reciba aire fresco. Si la persona no está respirando, llame al médico y/o ambulancia, entonces dé respiración, preferiblemente de boca a boca si es posible. Acuda al médico para tratamiento adicional.
Ingestión	Enjuague la boca con agua. No induzca el vómito. Si la persona está consciente, dele 2 vasos de agua. Consiga atención médica inmediata. No administrar nada por la boca de una persona que se encuentra inconsciente.
Los síntomas más importantes y efectos agudos y retardados	El peróxido de hidrógeno irrita el sistema respiratorio y, si se inhala, puede causar inflamación y edema pulmonar. Los efectos pueden no ser inmediatos. Síntomas de sobreexposición son tos, dolor de garganta, vértigo. En caso de ingestión accidental, la necrosis puede ser consecuencia de las quemaduras de membrana mucosa (boca, esófago y estómago). La liberación rápida de oxígeno puede causar hinchazón de estómago y hemorragias e incluso lesiones mortales a órganos si una gran cantidad se ha ingerido. En caso de contacto con la piel, puede causar quemaduras, eritema (enrojecimiento de la piel), ampollas o incluso necrosis.
Indicación de atención médica inmediata y tratamientos especiales en caso necesario	El Peróxido de Hidrógeno en estas concentraciones es un fuerte oxidante. El contacto directo con los ojos posiblemente cause daño en las corneas especialmente si no se enjuaga inmediatamente. Se recomienda una cuidadosa evaluación oftalmológica y la posibilidad de terapia local corticosteroide debe ser considerada. Debido a la probabilidad de los efectos corrosivos en el tracto gastrointestinal después de la ingestión, y a la escasa probabilidad de efectos sistémicos, intentar una evacuación estomacal vía inducción del vómito o lavado gastrointestinal debe ser evitado. Existe una posibilidad remota de que una sonda nasogástrica u orogástrica pueda ser requerido para la reducción de distensión severa (grave) debido a la formación de gas.

5. MEDIDAS PARA COMBATIR INCENDIOS

Medios adecuados de extinción.	Agua. No use otra substancia.
Riesgos específicos que se deriven del químico.	En contenedores cerrados sin ventilación existe el riesgo de ruptura debido al incremento de presión derivado de su descomposición. El contacto con material combustible puede causar fuego.
Riesgos de los productos de combustión.	Como producto de la descomposición se libera oxígeno el cual puede intensificar el fuego.
Datos de explosión:	
Sensibilidad a impacto mecánico:	No sensible
Sensibilidad a descarga estática:	No sensible
Equipo de protección y precauciones para bomberos:	Use agua en spray para enfriar las superficies expuestas a fuego y para proteger al personal. Mueva los contenedores del área de fuego si puedes hacerlo sin riesgo. Como en cualquier incendio, use aparatos de respiración autónoma y equipo de protección completo.

6. MEDIDAS EN CASO DE LIBERACIÓN ACCIDENTAL

Precauciones personales	Evite el contacto con la piel, ojos y vestimenta. Use equipo de protección personal. Aisle y delimite el área del derrame. Mantenga a las personas alejadas del derrame y a las personas necesarias para el combate de la emergencia, manténgalas corriente arriba de la dirección del viento en relación del derrame o fuga. Elimine todas las fuentes de ignición y remueva los materiales combustibles.
Otros	Material combustible expuesto al peróxido de hidrógeno deberá ser inmediatamente sumergido en agua o enjuagado con grandes cantidades de agua para asegurar que todo el peróxido de hidrógeno es removido. El peróxido de hidrógeno residual que es permitido se seque (por evaporación del peróxido de hidrógeno puede concentrarse) en materiales orgánicos como papel, telas, algodón, piel madera o otros combustibles puede causar que el material se encienda y resulte en fuego.
Precauciones medioambientales	Ver sección 12 para información ecotoxicológica adicional
Métodos de contención.	Use diques para colectar grandes derrames. Detenga la fuga y contenga los derrames si puede hacerse en forma segura, posteriormente diluya con abundante agua. Para derrames pequeños, diluir con grandes cantidades de agua.
Métodos de limpieza	Enjuague el área hasta anegar con agua. El peróxido de hidrógeno puede descomponerse adicionado metabisulfito de sodio o sulfito de sodio después de haber diluído hasta cerca del 5%.

7. MANIPUACIÓN Y ALMACENAMIENTO

Manipulación	Úselo únicamente en áreas bien ventiladas. Mantenga / almacene fuera del alcance de de materiales combustibles / vestimenta. Nunca regrese el peróxido de hidrógeno no usado al contenedor original. Su contaminación puede causar descomposición y generación de gas oxígeno el cual puede resultar en altas presiones y en posible ruptura del envase o recipiente que lo contiene. Los porrones vacíos deben ser enjuagados tres veces con agua antes de desecharse o disponerse. Los utensilios usados para manipular el peróxido de hidrógeno únicamente deben ser hechos con vidrio, acero inoxidable, aluminio o plástico. Tuberías y equipos deberán ser pasivados antes del primer uso. El peróxido de hidrógeno deberá ser almacenado solamente en contenedores ventilados y transferidos solamente en forma autorizada.
Almacenamiento	Mantenga los contenedores en áreas frescas fuera de la luz solar directa y lejos de combustibles. Provea de ventilación mecánica en forma general o local para ventilación y así evitar la liberación de vapor o niebla en el medio ambiente de trabajo. Los contenedores deben ser venteados. Almacene en el contenedor original solamente. El lugar de almacenamiento debe estar hecho de materiales no combustibles con pisos impermeables. En caso de liberación, el derrame debe dirigirse a un área segura. Los contenedores deberán ser inspeccionados en forma visual en forma regular para detectar anormalidades como (porrones contraídos, inflados, incremento en temperatura, etc.)
Productos incompatibles	Materiales combustibles, aleaciones de cobre, acero galvanizado. Fuertes agentes reductores, metales pesados. Hierro, contacto con metales, iones metálicos, álcalis, agentes reductores y material orgánico (como alcoholes o terpenos). Puede producir descomposición térmica auto acelerada.

8. CONTROL DE DE EXPOSICIÓN / PROTECCIÓN PERSONAL

Parámetros de control

Límite de exposición Parámetros de control en el centro de trabajo

Nombre Químico	**ACGIH TLV**	**OSHA PEL**	**NIOSH**	**México**
Peróxido de Hidrógeno 7722-84-1	TWA:1 ppm	TWA: 1 ppm TWA: 1.4 mg/m^3	IDLH: 75 ppm TWA: 1 ppm TWA: 1.4 mg/m^3	México: TWA 1 ppm México: TWA: 1.5 mg/m^3 México: STEL 2 ppm México: STEL 3 mg/m^3
Nombre Químico	**British Columbia**	**Quebec**	**Ontario TWAEV**	**Alberta**
Peróxido de Hidrógeno 7722-84-1	TWA: 1 ppm	TWA: 1 ppm TWA: 1.4 mg/m^3	TWA: 1 ppm	TWA: 1 ppm TWA: 1.4 mg/m^3

TWA= (Time-Weighted Average) concentración promedio de exposición en una jornada de 8 horas.

STEL= (Short therm exposure limit) limite de exposición a corto plazo.

Controles de ingeniería adecuados

Controles adecuados de ingeniería	Asegure que las estaciones de lava ojos y regaderas de emergencia están cerca del lugar de trabajo. Asegure ventilación adecuada.

Medidas de protección individual, como equipo de protección personal

Protección ocular y facial	Use goggles y careta hecha de policarbonato, acetato, policarbonato/acetato, PETG o termoplástico.
Protección de piel y de cuerpo	Para protección del cuerpo use ropa impermeable, un traje hecho de caucho SBR, PVC, (revestimiento exterior de PVC con sustrato de polyester), Gore-tex (polyester, trilaminado con Gore-tex), o un traje especializado HAZMAT contra salpicaduras o traje protector (nivel A, B o C). Para protección de pies use botas apropiadas hechas de NBR, PVC, Poliuretano o Neopreno. Zapatones hechos de látex PVC, así como botas de bombero o botas especializadas HAZMAT. No use alguna otra bota o zapatón hecho de nylon o mezclas de nylon. No use algodón, lana o piel porque esos materiales reaccionan rápidamente con concentraciones altas de peróxido de hidrógeno. Sumerja completamente en agua ropa u otros materiales contaminados con peróxido de hidrógeno antes de secarse. Si se deja secar el peróxido de hidrógeno residual en materiales orgánicos como papel, telas, algodón, piel madera u otros combustibles pueden causar que el material se encienda y resulte en fuego.
Protección de manos	Para protección de manos, utilice guantes aprobados hechos de nitrilo, PVC, o Neopreno. No use algodón, lana o piel porque esos materiales reaccionan RAPIDAMENTE con concentraciones altas de peróxido de hidrógeno. Enjuague vigorosamente el exterior de los guantes antes de retirarlos. Inspeccionelos por fuga regularmente.
Protección respiratoria	Si se esperan concentraciones por arriba de 10 ppm, use NIOSH/DHHS aprobados, aparato de respiración autónoma (SCBA) u otro respirador con aire suministrado (ASR) aprobado (ejemplo: un respirador de cara completo con línea de aire (ALR)). NO use ninguna forma de purificador de aire (APR) o mascaras para polvo, especialmente aquellos que contengan agentes oxidables como carbón activado.
Medidas de higiene	Evite respirar vapores rocío o gas. Agua limpia debe estar disponible para lavar en caso de contaminación de piel u ojos.
Información general	Soluciones de ingeniería para protección deben ser implementadas y en uso antes de considerar al equipo de protección personal.

9. PROPIEDADES FISICAS Y QUIMICAS

Información en base a propiedades físicas y químicas

Apariencia:	Claro, incoloro
Estado Físico:	Líquido
Color:	Incoloro
Olor:	Inodoro
Olor límite:	No aplica
pH:	<= 3.0
Punto de fusión/Punto de Congelamiento	-52 °C
Punto de ebullición:	114°C
Flash point:	No inflamable
Taza de evaporación:	> 1 (N-Butil Acetato =1)
Inflamabilidad (sólido, gas)	No inflamable
Inflamabilidad límite en aire	No aplica
Límite superior de inflamabilidad:	
Límite inferior de inflamabilidad:	
Presión de vapor:	18 mmHg @ 30°C
Densidad de vapor:	Información no disponible
Densidad	1.2 g/cm^3 @20°C
Gravedad específica:	1.2
Solubilidad en agua:	Completamente Soluble.

Coeficiente de partición:	log Kow=-1.5 @ 20 °C
Temperatura de auto ignición:	No combustible.
Temperatura de descomposición:	100°C (adiabático)
Viscosidad cinemática:	1.17 cp @ 20°C
Viscosidad dinámica:	Información no disponible.
Propiedades explosivas:	Información no disponible.
Propiedades oxidantes:	Fuertemente oxidante
Peso Molécular:	34
Bulk density	No aplica

10. ESTABILIDAD Y REACTIVIDAD

Reactividad	Agente reactivo y oxidante
Estabilidad química	Estable bajo condiciones normales. Se descompone con calor. Estable bajo las condiciones recomendadas de almacenamiento
Posibles reacciones de riesgo	El contacto con sustancias orgánicas puede causar fuego o explosión, el contacto con metales, iones metálicos, álcalis, agentes reductores y materia orgánica (como alcoholes o terpenos) pueden producir descomposición térmica auto-acelerada
Riesgo de polimerización	No ocurre
Condiciones a evitar	Calor excesivo; contaminación; exposición a rayos UV; variaciones de pH.
Materiales incompatibles	Los materiales combustibles. Aleaciones de cobre, hierro galvanizado. Agentes fuertemente reductores. Los metales pesados hierro. Las aleaciones de cobre. El contacto con metales, iones metálicos, álcalis, agentes reductores y materia orgánica (como como alcoholes o terpenos) pueden producir la descomposición térmica de auto-acelerada.
Productos de descomposición peligrosa:	Oxígeno el cual mantiene la combustión. Producirá sobrepresión en el equipo que lo contenga.

11. INFORMACIÓN TOXICOLOGICA

Información del producto

LD 50 Oral	50% solución: LD50 > 225 mg/kg bw (rata) 35% solución: LD50 1193 mg/kg bw (rata) 70% solución: LD50 1026 mg/kg bw (rata)
LD 50 Piel	35% solución: LD50 > 2000 mg/kg bw (conejo) 70% solución: LD50 9200 mg/kg bw (conejo)
LC 50 Inhalación	50% solución: LC50 > 170 mg/m^3 (rata) (4 horas) Vapores de peróxido de hidrogeno: LC0 9400 mg/m^3 (ratón) (5 a 15 min) Vapores de peróxido de hidrógeno: LC50 > 2160 mg/m^3 (ratón)
Daños serios a los ojos / irritación a los ojos	Corrosivo. Riesgo de serio daño a los ojos
Corrosión a la piel / irritación	Corrosivo a la piel. Causa de severas quemaduras.
Sensibilización	No causa sensibilización en animales de laboratorio.

Efectos e información toxicológica

Síntomas	Vapores, rocío o aerosoles de peróxido de hidrógeno puede causar irritación en las vías respiratorias superiores, inflamación de la nariz, ronquera, dificultad para respirar y una sensación de quemazón, opresión en el pecho. Prolongada exposición a vapores concentrados o a soluciones diluidas puede causar irritación y temporal decoloración de piel y cabello. Exposición a vapor, rocío, o aerosol puede causar ardor, dolor y lagrimeo de ojos.

Efectos inmediatos y retardados así como efectos crónicos por la exposición a corto y largo plazo.

Carcinogenicidad	Este producto contiene peróxido de hidrógeno. La agencia internacional para la investigación de cáncer (IARC) ha concluido que es inadecuada la evidencia para carcinogenicidad de peróxido de hidrógeno en humanos, pero limitada evidencia en animales experimentales (grupo 3-no clasificable en cuanto a su carcinogenicidad en humanos). La Conferencia Americana de Higienistas Industriales del Gobierno (ACGIH) 'un carcinógeno confirmado en animales con desconocida relevancia en humanos' (A3).

Nombre del químico	**ACGIH**	**IARC**	**NTP**	**OSHA**
Peróxido de hidrógeno 7722-84-1	A3	3		

Mutagenicidad	Este producto no está reconocido como mutagenico por las agencias de investigación. Pruebas In vivo no muestran efectos mutagénicos.
Toxicidad reproductiva	Este producto no está reconocido como tóxico para la reproducción por agencias de investigación. No es tóxico a la reproducción en estudios en animales.
Toxicidad sistémica específica del órgano blanco-Exposición única	Puede causar irritación respiratoria
Toxicidad sistémica específica del órgano blanco -Exposición repetida	No clasificado
Efecto en órgano blanco	Ojos, sistema respiratorio y piel.
Riesgo de aspiración	Riesgo de aspiración: puede causar daño al pulmón si se ingiere.

12. INFORMACIÓN ECOTOXICOLOGICA

Ecotoxicidad
Efectos ecotoxicológicos

Peróxido de hidrógeno (7722-84-1)				
Ingrediente activo	Duración	Especies	Valor	Unidades
Peróxido de Hidrógeno	96 h LC50	Fish Pimephales promelas	16.4	mg/L
Peróxido de Hidrógeno	72 h LC50	Fish Leuciscus idus	35	mg/L
Peróxido de Hidrógeno	48 h EC50	Daphnia pulex	2.4	mg/L
Peróxido de Hidrógeno	24 h EC50	Daphnia magna	7.7	mg/L
Peróxido de Hidrógeno	72 h EC 50	Algae Skeletonema costatum	1.38	mg/L
Peróxido de Hidrógeno	21 d NOS	Daphnia magna	0.63	mg/L

Persistencia y degradabilidad	El peróxido de hidrógeno en ambiente acuático es sujeto a varios procesos de reducción u oxidación y se descompone en agua y oxígeno. La vida media del peróxido de hidrógeno en agua fresca esta en un rango de 8 horas a 20 días, en aire de 10 a 20 horas, y en suelos de min. a hrs. Dependiendo de su actividad microbiológica y contaminación de metales.
Bioacumulación	El material puede tener algún potencial bioacumulable pero probablemente se degradará en más medioambientes antes de que la acumulación pueda ocurrir.
Movilidad	Probablemente sea móvil en el medio ambiente debido a su solubilidad en el agua pero problablemente se degradará con el tiempo.
Otros efectos adversos	Se descompone en oxígeno y agua. No hay efectos adversos.

13. INFORMACIÓN RELATIVA A LA ELIMINACIÓN DEL PRODUCTO

Métodos de disposición de residuos	Disponga de acuerdo con las regulaciones locales. Puede disponerse como agua residual si está en cumplimiento con regulaciones locales
US EPA Número de desecho	D001 D003
Empaques contaminados	Disponga de acuerdo con regulaciones locales Porrones- vaciarlos tan vigorosamente como sea posible, enjuague tres veces antes de disponer. Evite contaminación; las impurezas aceleran la descomposición. Nunca regrese producto al envase original.

14. INFORMACIÓN DE TRANSPORTACIÓN.

DOT

Número ONU	UN 2014
Nombre correcto de embarque	Peróxido de hidrógeno, solución acuosa
Clase de riesgo	5.1
Sub-Clase	8
Grupo de empaque	II

TDG

Número ONU	UN 2014
Nombre correcto de embarque	Peróxido de hidrogeno, solución acuosa
Clase de riesgo	5.1
Sub-Clase	8
Grupo de embarque	II

ICAO/IATA

Peroxido de hidrógeno mayor de 40% es prohibido en avión de carga o de pasajero. La regulación aérea permite el embarque de peróxido de hidrógeno (<= 40%) en contenedores sin venteo en avión de carga solamente, así como para aviones de pasajeros y de carga. SIN EMBARGO, todos los contenedores de peróxido de hidrógeno son venteados y entonces, los envíos aéreos de peróxido de hidrógeno no están permitidos. Las regulaciones de IATA establecen que sustancias que contengan envases de sustancias oxidantes con venteo no son permitidas para transportación por aire.

IMDG/IMO

Número ONU	UN 2014
Nombre correcto de embarque	Peróxido de hidrógeno, solución acuosa
Clase de riesgo	5.1
Sub-Clase	8
Grupo de empaque	II

OTRA INFORMACIÓN

Proteja de daño físico. Mantenga los porrones en posición vertical con la tapa hacia arriba. Los porrones no deben ser estibados en tránsito. No almacene porrones en tarimas de madera.

15. INFORMACIÓN REGULATORIA

U.S. Regulaciones Federales

SARA 313

La sección 313 del título III del SARA de 1986. Este producto no contiene ningún químico que sea sujeto a requerimientos de reporte del Acta y Titulo 40 del Código de Regulaciones Federales, parte 372.

SARA 311/312 Categorías de Riesgo

Riesgo agudo a la salud	Si
Riesgo crónico a la salud	No
Riesgo de fuego	Si
Riesgo por repentina liberación de presión	No
Riesgo de reactividad	No

Ley de agua limpia

Este producto no contiene ninguna sustancia regulada como promotor de contaminación a la ley de agua limpia (40 CFR 122.21 y 40 CFR 122.42)

CERCLA

Nombre químico	Sustancias peligrosas RQs	Sustancias extremadamente riesgosas RQs	SARA RQ
Peróxido de hidrógeno 7722-84-1		1000 lb	

Peróxido de hidrógeno RQ es para concentraciones mayores a 52% solamente

Inventarios internacionales

Compo-nente	TSCA (EUA)	DSL (Canadá)	EINECS/ELINCS (Europa)	ENCS (Japón)	China (IECSC)	KECL (Korea)	PICCS (Filipinas)	AICS (Australia)	NZloC (Nueva Zelanda)
Peroxido de hidrógeno 7722-84-1 (50)	X	X	X	X	X	X	X	X	X

México-Grado Riesgo serio, Grado 3

CANADÁ

WHMIS Clase del riesgo.

C- Materiales oxidantes
D1B Materiales tóxicos
E – Material corrosivo
F – Material peligrosamente reactivo

16-. OTRA INFORMACIÓN

NFPA	**RIESGO A LA SALUD** 3	**FLAMABILIDAD** 0	**REACTIVIDAD** 1	**RIESGO ESPECIAL** OX
HMIS	**RIESGO A LA SALUD** 3	**FLAMABILIDAD** 0	**RIESGO FISICO** 1	**PROTECCION PERSONAL** H

NFPA/HMIS Clasificación de Leyendas.	Severo= 4, Serio=3, Moderado =2, Ligero=1, Mínimo=0 Riesgo especial: OX= Oxidante Protección = H (Goggles de seguridad, guantes, delantal, el uso de aire suministrado o SCBA es requerido en lugar de un respirador de cartuchos para vapores)
Código de Fuego:	Oxidante: Clase 2- Líquido.
Fecha de revisión:	2015-05-08
Nota de revisión:	Revisión inicial

Acrónimos

TWA: (Time-Weighted Average) concentración promedio de exposición en una jornada de 8 horas.

STEL: (Short therm exposure limit) limite de exposición a corto plazo.

NFPA: National Fire Protection Association. Asociación Nacional de Protección contra Incendios (USA). Clasificación de riesgos creada por la NFPA para atención de emergencias.

HMIS: Hazardous Material Information System. Clasificación de riesgos creada para presentar riesgos a la salud.

PeroxyChem, considera que la información y recomendaciones presentadas aquí (incluyendo los datos, indicaciones y los enunciados) son exactos en la fecha actual. NO SE OFRECEN GARANTIAS SOBRE LA IDONEIDAD PARA CUALQUIER PROPOSITO PARTICULAR, NI GARANTIA DE COMERCIALIZACION O CUALQUIER OTRA, EXPRESA O IMPLICITA, RELATIVA A LA INFORMACIÓN BRINDADA AQUÍ. La información proporcionada aquí está relacionada solamente con el producto específico mencionado y puede no ser aplicable cuando se utilice este producto en combinación con cualquier otro material o en algún proceso. Adicionalmente, debido a que las condiciones y métodos de uso están fuera del control de PeroxyChem, rechazamos expresamente toda responsabilidad legal en relación con los resultados que se obtengan o que se deriven del uso de los productos o del uso de ésta información.

Preparado por:

PeroxyChem

Fin de la hoja de seguridad.

FICHA DE DATOS DE SEGURIDAD

Producto: SODA CAUSTICA LÍQUIDA

1- IDENTIFICACIÓN DEL PRODUCTO	
Identificador SGA del producto:	SODA CAUSTICA LÍQUIDA
Otros medios de identificación:	No aplicable.
Uso recomendado del producto químico y restricciones:	Fabricación de celulosa, aluminio, hilados de rayón, jabón y detergentes e intermedios químicos, utilizados también por la industria siderúrgica y metalúrgica, aditivos alimentarios, mercerización de productos textiles, regeneración de resinas de intercambio iónico y corrección de pH en varios procesos industriales.
Datos sobre el proveedor:	Unipar Carbocloro S/A
Dirección:	Avenida Presidente Juscelino Kubitschek, 1.327 – 22º andar São Paulo/SP - Brasil
Número de teléfono:	(+55) (11) 3704-4200
Número de teléfono para emergencias:	(+55) (13) 3362-8022 (+55) 0800-118270 (PróQuímica Abiquim)

2- IDENTIFICACIÓN DEL PELIGRO O PELIGROS	
Clasificación de la sustancia o mezcla:	Sustancias y mezclas corrosivas para los metales – Categoría 1 Toxicidad aguda por vía cutánea – Categoría 5 Corrosión/irritación cutáneas – Categoría 1B Lesiones oculares graves/irritación ocular – Categoría 1 Toxicidad sistémica específica de órganos diana (exposición única) – Categoría 3 Peligros para el medio ambiente acuático – peligro a corto plazo (agudo) – Categoría 3
Sistema de clasificación adoptado:	Sistema Globalmente Armonizado de Clasificación y Etiquetado de Productos Químicos (SGA), Naciones Unidas.

Elementos de las etiquetas del SGA	
Pictogramas:	
Palabra de advertencia:	PELIGRO
Indicación o indicaciones de peligro:	H290 Puede ser corrosiva para los metales. H313 Puede ser nocivo en contacto con la piel. H314 Provoca graves quemaduras en la piel y lesiones oculares. H335 Puede irritar las vías respiratorias. H402 Nocivo para los organismos acuáticos.
Consejos de prudencia:	**PREVENCIÓN:** P234 Conservar únicamente en el embalaje original. P260 No respirar nieblas y vapores. P261 Evitar respirar nieblas y vapores. P264 Lavarse las manos cuidadosamente después de la manipulación. P271 Utilizar sólo al aire libre o en un lugar bien ventilado. P273 No dispersar en el medio ambiente. P280 Usar guantes, ropa de protección, equipo de protección para los ojos o la cara. **INTERVENCIÓN:** P301 + P330 + P331 EN CASO DE INGESTIÓN: Enjuagar la boca. NO provocar el vómito. P303 + P361 + P353 EN CASO DE CONTACTO CON LA PIEL (o el pelo): Quitar inmediatamente toda la ropa contaminada. Enjuagar la piel con agua o ducharse. P304 + P340 EN CASO DE INHALACIÓN: Transportar a la persona al aire libre y mantenerla en una posición que le facilite la respiración.

	P305 + P351 + P338 EN CASO DE CONTACTO CON LOS OJOS: Enjuagar con agua cuidadosamente durante varios minutos. Quitar las lentes de contacto cuando estén presentes y pueda hacerse con facilidad. Proseguir con el lavado. P310 Llamar inmediatamente a un CENTRO DE TOXICOLOGÍA o a un médico. P312 Llamar un CENTRO DE TOXICOLOGÍA o a un médico si la persona se encuentra mal. P321 Tratamiento específico. P363 Lavar la ropa contaminada antes de volverla a usar. P390 Absorber el vertido para prevenir daños materiales. **ALMACENAMIENTO:** P403 + P233 Almacenar en un lugar bien ventilado. Mantener el recipiente herméticamente cerrado. P405 Guardar bajo llave. P406 Almacenar en un recipiente resistente a la corrosión o con revestimiento interior resistente. **ELIMINACIÓN:** P501 Eliminar el contenido y el recipiente conforme a la reglamentación local.
Otros peligros que no conducen a una clasificación:	El producto no tiene otros peligros.

3- COMPOSICIÓN/INFORMACIÓN SOBRE LOS COMPONENTES

MEZCLA

Componentes que contribuyen al peligro:

Componentes	**Concentración (%)**	**Numero CAS**
Hidróxido de Sodio	49,0 – 51,5	1310-73-2

4- PRIMEROS AUXILIOS	
Vía de exposición	
Inhalación:	Llevar a la víctima al exterior y mantenerla en reposo en una posición confortable para respirar. Si se siente mal, llame a un CENTRO DE TOXICOLOGÍA o un médico. Lleve esta FDS.
Contacto con la piel:	Quitar inmediatamente toda la ropa contaminada. Enjuagar la piel con agua y ducharse. Llamar inmediatamente a un CENTRO DE TOXICOLOGÍA o a un médico. Lleve esta FDS.
Contacto con los ojos:	Enjuague bien con agua durante varios minutos. En caso de lentes de contacto, quitarlas, si es fácil. Continúe enjuagando. Llamar inmediatamente a un CENTRO DE TOXICOLOGÍA o a un médico. Lleve esta FDS.
Ingestión:	No inducir el vómito. No dar nada por la boca a una persona inconsciente. Enjuagar la boca de la víctima con agua en abundancia. Si ocurre vómito espontáneo, proporcione agua adicional y mantenga a la víctima en aire fresco. Si no se siente bien, llame a un CENTRO DE TOXICOLÓGÍA o un médico. Lleve esta FDS.
Síntomas/efectos más importantes, agudos o retardados:	Puede ser nocivo en contacto con la piel. Provoca graves quemaduras en la piel con ampollas, descamación y dolor, y lesiones oculares con ardor, lagrimeo y dolor. Puede causar irritación respiratoria con tos y estornudos.
Indicación de la necesidad de recibir atención médica inmediata y, en su caso, de tratamiento especial:	Evite contacto con el producto para socorrer a la víctima. Si es necesario, el tratamiento sintomático debe incluir principalmente medidas de apoyo tales como la corrección de las alteraciones electrolíticas, metabólicas y cuidados respiratorios. En caso de contacto con la piel no frotar la zona afectada.

5- MEDIDAS DE LUCHA CONTRA INCENDIOS	
Medios de extinción:	Apropiados: Compatible con polvo químico, dióxido de carbono (CO_2) y niebla de agua. No apropiados: Chorro de agua directamente.

Peligros específicos del producto químico:	El producto no es inflamable. La combustión del producto químico o recipientes pueden formar gases y humos tóxicos e irritantes, tales como monóxido de carbono y dióxido de carbono.
Medidas especiales que deben tomar los equipos de lucha contra incendios:	Equipo de protección respiratoria tipo autónomo (SCBA) con presión positiva y ropa de protección completa. Rociar con agua los recipientes implicados en el incendio para mantenerlos fríos.

6- MEDIDAS QUE DEBEN TOMARSE EN CASO DE VERTIDO ACCIDENTAL

Precauciones personales, equipo protector y procedimiento de emergencia

Para el personal que no forma parte de los servicios de emergencia:	Aislar preventivamente las fuentes de ignición. Evacuar el área dentro de un radio de al menos 50 metros. Mantenga a las personas no autorizadas fuera de la zona. Detenga la fuga si puede hacerlo sin riesgo. No fume. No toque en los recipientes dañados o material derramado sin el uso de ropa adecuada. Evite la exposición al producto. No exponerse a la sustancia sin utilizar equipo de protección personal recomendado en la sección 8.
Para el personal de los servicios de emergencia:	Use equipo completo de protección con gafas de seguridad contra salpicaduras, guantes de seguridad, delantal de PVC, vestimenta de protección anti-ácido (PVC u otro material equivalente), botas de PVC. El material utilizado debe ser impermeable. En caso de fuga, donde la exposición es grande, se recomienda el uso de máscara de protección respiratoria (semifacial) con un filtro contra vapores y nieblas o una máscara facial completa con una línea de aire o un aparato de respiración autónomo.
Precauciones relativas al medio ambiente	Evitar que el material derramado llegue a los cursos de agua o sistemas de alcantarillados.
Métodos y materiales para la contención y limpieza de vertidos	No permita que entre agua en los recipientes. Use barreras naturales o de contención de derrames. Recoger el producto derramado y colocar en contenedores apropiados. Se adsorbe el producto restante con arena seca, tierra, vermiculita u otro material inerte. Coloque el material adsorbido en los contenedores apropiados y trasladarlos a un lugar seguro. Para su eliminación, proceda de acuerdo con la Sección 13 de esta FDS.

7- MANIPULACIÓN Y ALMACENAMIENTO	
Precauciones que se deben tomar para garantizar una manipulación segura	
Precauciones para una manipulación segura de la sustancia o mezcla:	Úselo en un área bien ventilada o con el sistema de la ventilación/escape local. Evitar la formación de vapores y nieblas. Evite la exposición al producto. Evite el contacto con materiales incompatibles. Use el equipo de protección personal como se describe en la Sección 8.
Higiene en general:	Lavarse las manos y la cara completamente después de manipular y antes de comer, beber, fumar o ir al baño. La ropa contaminada debe cambiarse y lavarse antes de volver a usarla. Quite la ropa contaminada y el equipo de protección antes de entrar en áreas de alimentación.
Condiciones de almacenamiento seguro, incluidas cualesquiera incompatibilidades	
Prevención de incendio y atmósferas explosivas:	No se espera que el producto presente un riesgo de incendio o explosión.
Condiciones adecuadas:	Almacenar en un lugar bien ventilado, lejos de la luz solar. Mantenga el recipiente cerrado. Mantener almacenado a temperatura ambiente. No es necesario añadir estabilizantes y antioxidantes para asegurar la durabilidad del producto. Este producto puede reaccionar peligrosamente con algunos materiales incompatibles como se describe en la Sección 10.
Materiales de embalaje:	Recomendado: Tanques de acero al carbono o acero inoxidable, horizontal o vertical, cuando su temperatura es inferior a 60ºC. No se recomienda: Metales (aluminio, zinc, estaño y sus aleaciones).

8- CONTROLES DE EXPOSICIÓN/PROTECCIÓN PERSONAL		
Parámetros de control		
Límite(s) de exposición ocupacional:	**Nombre químico o común**	**TLV – C (ACGIH, 2016)**
	Hidróxido de Sodio	2 mg/m^3

Límite biológicos:	No establecidos.
Otros límites y valores	IDLH (NIOSH, 2010): 10 mg/m³
Controles técnicos apropiados:	Promover la ventilación mecánica directa y el sistema de escape al ambiente exterior. Estas medidas ayudan a reducir la exposición al producto. Mantener las concentraciones de aire por debajo de las normas de exposición ocupacionales.
Medidas de protección individual, como equipo de protección personal (EPP)	
Protección de los ojos/la cara:	Gafas de seguridad contra salpicaduras.
Protección de la piel:	Guantes de seguridad, delantal de PVC o de caucho, ropa anti-ácido protectora (PVC u otro material equivalente), botas de caucho o PVC. El material utilizado debe ser impermeable.
Protección de las vías respiratorias:	En caso de fuga, donde la exposición es grande, se recomienda el uso de máscara de protección respiratoria (semifacial) con un filtro contra vapores y nieblas o una máscara facial completa con una línea de aire o un aparato de respiración autónomo.
Peligros térmicos	No es necesario utilizar EPP específicos, ya que el producto no presenta peligros térmicos.

9- PROPIEDADES FÍSICAS Y QUÍMICAS	
Estado físico:	Líquido.
Color:	Transparente a turba blanquecina.
Olor:	Inodoro.
Punto de fusión/punto de congelación:	No disponible (Ausencia de información).
Punto de ebullición o punto de ebullición inicial e intervalo de ebullición:	140°C (Información sobre la solución de NaOH al 50% en peso)
Inflamabilidad:	No aplicable.

Límites inferior y superior de explosión/inflamabilidad:	No disponible (Ausencia de información).
Punto de inflamación:	No disponible (Ausencia de información).
Temperatura de ignición espontánea:	No disponible (Ausencia de información).
Temperatura de descomposición:	No disponible (Ausencia de información).
pH:	14,0 (solución al 0,5%)
Viscosidad cinemática:	No disponible (Ausencia de información).
Solubilidad:	Miscible con agua. Soluble en alcoholes (etanol, metanol y glicerol). Insoluble en acetona y éter.
Coeficiente de reparto n-octanol/agua (valor logarítmico):	No disponible (Ausencia de información).
Presión de vapor:	13 mmHg a 60°C (Información relativa a la solución de NaOH al 50% en peso)
Densidad y/o densidad relativa:	1,5280 g/cm^3 - 1,5506 g/cm^3 a 15,5ºC (el intervalo es igual a una concentración de alcalinidad total entre 49% y 51% de NaOH)
Densidad de vapor relativa:	No disponible (Ausencia de información).
Características de las partículas:	No aplicable.
Otras informaciones:	No aplicable.

10- ESTABILIDAD Y REACTIVIDAD

Reactividad:	No se espera reactividad en condiciones normales de temperatura y presión.
Estabilidad química:	Producto es estable en condiciones normales de temperatura y presión.

Posibilidad de reacciones peligrosas:	Reacciona violentamente con ácidos, aldehídos, metales y otros productos orgánicos. Reacciona con aluminio, zinc, estaño y cobre, que pueden causar la corrosión y la generación de hidrógeno, que pueden formar mezclas explosivas con el aire. Posibilidad de reacción exotérmica cuando se diluye en agua, alcohol y glicerol.
Condiciones que deben evitarse:	Temperaturas elevadas y el contacto con materiales incompatibles.
Materiales incompatibles:	Aluminio, zinc, estaño, cobre, ácidos, aldehídos, productos orgánicos y agua.
Productos de descomposición peligrosos:	No son conocidos materiales productos de descomposición peligrosos.

11- INFORMACIÓN TOXICOLÓGICA

Toxicidad aguda:	Puede ser nocivo en contacto con la piel. Basándose en los datos disponibles, no cumple los criterios de clasificación por vía oral e inhalatoria. ETAmezcla (Estimación de la Toxicidad Aguda) ETAmezcla (cutánea): 2621,359 mg/kg Información relativa al: - Hidróxido de Sodio: DL_{50} (cutánea, ratas): 1350 mg/kg
Corrosión/irritación cutáneas:	Provoca quemaduras graves en la piel con ampollas, descamación y dolor.
Lesiones oculares graves /irritación ocular:	Provoca lesiones oculares con ardor, lagrimeo y dolor.
Sensibilización respiratoria o cutánea:	Basándose en los datos disponibles, no cumple los criterios de clasificación.
Mutagenicidad en células germinales:	Basándose en los datos disponibles, no cumple los criterios de clasificación.

Carcinogenicidad:	Basándose en los datos disponibles, no cumple los criterios de clasificación.
Toxicidad para la reproducción:	Basándose en los datos disponibles, no cumple los criterios de clasificación.
Toxicidad sistémica específica de órganos diana - Exposición única:	Puede causar irritación respiratoria con tos y estornudos. La ingestión del producto en dosis altas puede causar perforaciones en los tejidos de la boca, garganta, esófago y estómago.
Toxicidad sistémica específica de órganos diana - Exposiciones repetidas:	Basándose en los datos disponibles, no cumple los criterios de clasificación.
Peligro por aspiración:	Basándose en los datos disponibles, no cumple los criterios de clasificación.

12- INFORMACIÓN ECOTOXICOLÓGICA

Toxicidad:	Nocivo para los organismos acuáticos. Información relativa al: - Hidróxido de Sodio: CE_{50} (*Ceriodaphnia dubia*, 48h): 40,38 mg/L
Persistencia y degradabilidad:	Debido a la ausencia de datos, se espera que el producto presente persistencia y no sea rápidamente degradable.
Potencial de bioacumulación:	Debido a la ausencia de datos, no se espera que el producto presente potencial bioacumulativo en los organismos acuáticos.
Movilidad en el suelo:	No determinada.
Otros efectos adversos:	Debido al carácter básico del producto, puede causar cambios en los compartimentos ambientales, causando daños a los organismos.

13- INFORMACIÓN RELATIVA A LA ELIMINACIÓN DE LOS PRODUCTOS

Métodos de eliminación

Debe eliminarse como residuo peligroso de acuerdo con las regulaciones locales. El tratamiento y eliminación deberán ser evaluadas específicamente para cada producto. Mantenga el resto del producto en su envase original y debidamente cerradas. La eliminación debe realizarse según lo previsto para el producto. No reutilizar los envases vacíos. Ellos pueden contener restos del producto y debe ser cerrado y enviado para su disposición apropiada como se requiere para el producto.

14- INFORMACIÓN RELATIVA AL TRANSPORTE

Reglamentaciones internacionales

Carretera:	ONU – Organización de las Naciones Unidas Recomendaciones Relativas al Transporte de Mercancías Peligrosas. Reglamentación Modelo.
Número ONU:	1824
Designación oficial de transporte de las Naciones Unidas:	HIDRÓXIDO SÓDICO EN SOLUCIÓN
Clase(s) relativas al transporte:	8
Grupo de embalaje:	II
Ferrocarril:	*Convention concerning International Carriage by Rail (COTIF)* *Appendix C - Regulations concerning the International Carriage of Dangerous Goods by Rail - RID*
Número ONU:	1824
Designación oficial de transporte de las Naciones Unidas:	SODIUM HYDROXIDE SOLUTION

Clase(s) relativas al transporte:	8
Grupo de embalaje:	II
Mar:	*IMO – International Maritime Organization* *International Maritime Dangerous Goods Code (IMDG Code)*
Número ONU:	1824
Designación oficial de transporte de las Naciones Unidas:	SODIUM HYDROXIDE SOLUTION
Clase(s) relativas al transporte:	8
Grupo de embalaje:	II
Contaminante marino:	El producto no se considera un contaminante marino.
EmS:	F-A, S-B
Aire:	*IATA - International Air Transport Association* *Dangerous Goods Regulation (DGR)*
Número ONU:	1824
Designación oficial de transporte de las Naciones Unidas:	SODIUM HYDROXIDE SOLUTION
Clase(s) relativas al transporte:	8
Grupo de embalaje:	II
Riesgos ambientales:	El producto no se considera peligroso para el medio ambiente.
Precauciones especiales:	No hay necesidad de precauciones especiales.

Transporte a granel con arreglo al Convenio MARPOL 73/78, Anexo II, y del Código IBC:	Reglamentaciones consultadas: - *International Maritime Organization. MARPOL: Articles, protocols, annexes, unified interpretations of the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto, consolidated edition. IMO, London, 2006.* - *International Maritime Organization. IBC code: International code for the construction and equipment of shipping carrying dangerous chemicals in bulk: With Standards and guidelines relevant to the code. IMO, London, 2007.*

15- INFORMACIÓN SOBRE LA REGLAMENTACIÓN

Convention concerning Safety in the use of Chemicals at Work (Convention 170) - International Labour Organization, 1990.

16- OTRAS INFORMACIONES

Esta FDS ha sido elaborada sobre la base de los conocimientos actuales sobre el manejo adecuado del producto y en condiciones normales de uso, en conformidad con la aplicación especificada en el envase. Cualquier otro uso del producto que implica su combinación con otros materiales, y el uso de diversas formas de las que se indican, son responsabilidad del usuario. Advierte de que el manejo de cualquier sustancia química requiere el conocimiento previo de sus peligros para el usuario. En el lugar de trabajo es para el producto de la empresa usuaria promueve la formación de sus empleados acerca de los posibles riesgos derivados de la exposición a la sustancia química.

FDS elaborada en Julio, 2017.

Control de cambios:

Versión	Fecha de publicación	Cambios
00	26/07/2017	Elaboración

Abreviaturas:

ACGIH - *American Conference of Governmental Industrial Hygienists*

CAS - *Chemical Abstracts Service*

C – *Ceiling*

CE_{50} - Concentración efectiva 50%

DL_{50} – Dosis letal 50%

IDLH – *Immediately Dangerous to Life or Health*

NA – No aplicable

NIOSH – *National Institute of Occupational Safety and Health*

PVC - Policloruro de vinilo

SCBA – *Self-Contained Breathing Apparatus*

TLV - *Threshold Limit Value*

Referencias bibliográficas:

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIALS HYGIENISTS. TLVs® and BEIs®: Baseados na “Documentação” dos Limites de Exposição Ocupacional (TLVs®) para Substâncias Químicas e Agentes Físicos & Índices Biológicos de Exposição (BEIs®). Tradução Associação Brasileira de Higienistas Ocupacionais. São Paulo, 2016.

NIOSH - NATIONAL INSTITUTE OF OCCUPATIONAL AND SAFETY. International Chemical Safety Cards. Disponible en: <http://www.cdc.gov/niosh/>. Acceso en: julio 2017.

Sistema Globalmente Armonizado de Clasificación y Etiquetado de Productos Químicos (SGA). 6. Rev. Ed. Nueva York: Naciones Unidas, 2015.

UNIPAR CARBOCLORO S/A. FISPQ - Ficha de Informações de Segurança de Produtos Químicos: SODA CÁUSTICA Líquida. Revisión 13. Brasil. Julio, 2017.

ANNEX IV

PRELIMINARY HAZARD ANALYSIS SHEET (APP)

APP – PRELIMINARY RISK ANALYSIS

Area: Wood Yard

Item	**Risk**	**Possible Causes**	**Possible Effects**	**Grade**			**Remarks and/or Recommendations**
				Freq.	**Sever.**	**Risk**	
1	Ignition in the chip silo or biomass pile	• External ignition source	• Fire • Personal accident • Material damages • Air quality modification • Liquid effluent generation from firefighting system	**C**	**II**	**Mn**	• Area will be provided of firefighting system • Fire will be duly controlled inside Wood Yard area
2	Hydraulic unit oil leakage	• Rupture at oil hydraulic unit system, due to: ✓ Mechanical impact ✓ Mechanical failure	• Modification of soil and groundwater quality • Change in surface water quality	**D**	**II**	**M**	• The areas of the hydraulic units shall be provided with containing walls • Providing rainwater pollution protection systems
3	Leakage of leachate of chip pile	• Rupture of the floor of the storage area or containment system	• Modification of soil, groundwater or surface water quality	**B**	**II**	**D**	• Drainage of the pile should be sent to the effluent treatment system • Installation of groundwater monitoring wells • Frequent visual inspection of the area, which will allow quick corrective action, minimizing impact in case of floor rupture

Frequency: A – Very Unlikely, B – Unlikely, C – Remote, D – Likely, E – Frequent
Severity: I – Negligible, II – Marginal, III – Critical, IV – Catastrophic
Risk: D – Negligible, Mn – Minor, M – Moderate, S – Serious, C – Critical

APP – PRELIMINARY RISK ANALYSIS

Area: Cooking, Brown pulp washing and Delignification

Item	**Risk**	**Possible Causes**	**Possible Effects**	**Grade**			**Remarks and/or Recommendations**
				Freq.	**Sever.**	**Risk**	
4	Ignition in the chip silo	• External ignition source	• Fire; • Personal accident • Material damages • Air quality modification	**B**	**II**	**D**	• Firefighting system will be installed
5	Liquor Leakage of liquor (white and / or black)	• Rupture or hole in piping due to: ✓ Corrosion ✓ Mechanical failure ✓ Operational failure ✓ Mechanical impact • Rupture or failure of components (valve, pump, tank)	• Personal accident • Loss of product • Alteration of soil and groundwater quality • Alteration of surface water quality.	**D**	**II**	**M**	• The area will be surrounded by retaining wall • Equipment and piping with liquor will be made of stainless steel
6	Leakage of pulp	• Rupture or hole in piping due to: ✓ Corrosion ✓ Mechanical failure ✓ Operational failure ✓ Mechanical impact • Rupture or failure of components (valve, pump, tank)	• Personal accident • Loss of product • Alteration of surface water quality	**D**	**II**	**M**	• The area will be surrounded by retaining wall

Frequency: A – Very Unlikely, B – Unlikely, C – Remote, D – Likely, E – Frequent
Severity: I – Negligible, II – Marginal, III – Critical, IV – Catastrophic
Risk: D – Negligible, Mn – Minor, M – Moderate, S – Serious, C – Critical

APP – PRELIMINARY RISK ANALYSIS

Area: Cooking, Brown pulp washing and Delignification

Item	Risk	Possible Causes	Possible Effects	Grade			Remarks and/or Recommendations
				Freq.	Sever.	Risk	
7	Leakage (fugitive emissions) of concentrated non condensable gases (CNCG)	• Rupture or hole in piping due to: ✓ Corrosion ✓ Mechanical failure ✓ Operational failure ✓ Mechanical impact • Rupture or failure of components (valve, pump, tank) • Failure of process settings	• Personal accident • Air quality modification	**D**	**II**	**M**	• CNCG generating sources shall be provided with a safety system consisting of lighting arresters and rupture discs for protection against explosions and accidental emissions to the atmosphere • The piping of rupture disc shall be provided with a pressure sensor so that in the event of a ruptured disc, the ON-OFF valve is immediately closed, blocking the sources and avoiding CNCG emission into the atmosphere • Each source will have the emission of CNCG monitored (flow, temperature and pressure) • CNCG collection lines will be individualized for better operational control • Non-condensable gases will be collected and incinerated in the recovery boiler • Fugitive emissions have a low flow rate, which limits their dispersion around the site

APP – PRELIMINARY RISK ANALYSIS							
Area: Cooking, Brown pulp washing and Delignification							
Item	**Risk**	**Possible Causes**	**Possible Effects**	**Grade**			**Remarks and/or Recommendations**
				Freq.	**Sever.**	**Risk**	
8	Explosion of digester	• Overpressure	• Fireball • Materials damage • Alteration of air and soil quality	**B**	**II**	**D**	The design and operation of the Digester is based on the strictest safety criteria in order to prevent accidents and explosions, such as: • High level of instrumentation to allow monitoring of all process variables • Preventive maintenance in relation to the corrosion protection of the digester walls in the occasions of the general stoppings • Redundancy in interlocks at critical safety and process points • In addition, both the operation process and the project preparation phase are based on the full compliance with the safety requirements imposed by Regulatory Norm 13: Boilers and Pressure Vessels (NR-13)

Frequency: **A** – Very Unlikely, B – Unlikely, C – Remote, D – Likely, **E** – Frequent
Severity: I – Negligible, II – Marginal, III – Critical, IV – Catastrophic
Risk: **D** – Negligible, Mn – Minor, M – Moderate, S – Serious, C – Critical

APP – PRELIMINARY RISK ANALYSIS

Area: Bleaching plant

Item	Risk	Possible Causes	Possible Effects	Grade			Remarks and/or Recommendations
				Freq.	Sever.	Risk	
9	Chlorine dioxide leakage	• Rupture or hole in piping due to: ✓ Corrosion ✓ Mechanical failure ✓ Operational failure ✓ Mechanical impact • Rupture or failure of components (valve, pump, tank)	• Personal accident • Loss of product • Alteration of soil and groundwater quality • Alteration of surface water quality.	**C**	**III**	**M**	• The area will have retaining walls around it, and yet, there will be closed channels with a gas collection system • The equipment with chlorine dioxide will be titanium
10	Leakage of chemicals (sulfuric acid, sodium hydroxide, hydrogen peroxide)	• Rupture or hole in piping due to: ✓ Corrosion ✓ Mechanical failure ✓ Operational failure ✓ Mechanical impact • Rupture or failure of components (valve, pump, tank)	• Personal accident • Loss of product • Alteration of soil and groundwater quality • Alteration of surface water quality.	**C**	**II**	**Mn**	• The area will be surrounded by retaining wall

Frequency: **A** – Very Unlikely, B – Unlikely, C – Remote, D – Likely, **E** – Frequent
Severity: I – Negligible, II – Marginal, III – Critical, IV – Catastrophic
Risk: **D** – Negligible, Mn – Minor, M – Moderate, S – Serious, C – Critical

APP – PRELIMINARY RISK ANALYSIS

Area: Drying Machine and Packing

Item	Risk	Possible Causes	Possible Effects	Grade			Remarks and/or Recommendations
				Freq.	Sever.	Risk	
11	Leakage of pulp from bleached pulp towers	• Rupture or hole in piping due to: ✓ Corrosion ✓ Mechanical failure ✓ Operational failure ✓ Mechanical impact • Rupture or failure of components (valve, pump, tank)	• Personal accident • Loss of product • Alteration of soil quality • Alteration of surface water quality	C	II	Mn	• The area will be surrounded by retaining wall
12	Hydraulic unit oil leakage	• Rupture at oil hydraulic unit system, due to: ✓ Mechanical impact ✓ Mechanical failure.	• Alteration of soil and groundwater quality • Alteration of surface water quality	D	II	M	• The areas of the hydraulic units shall be provided with containing walls
13	Ignition of pulp bales	• External ignition source	• Fire • Materials damage • Personal accident • Alteration of air quality	C	II	Mn	• Storage area of the pulp bales shall be provided with a firefighting system • The fire will be properly controlled within the area, there being no propagation

Frequency: **A** – Very Unlikely, B – Unlikely, C – Remote, D – Likely, **E** – Frequent
Severity: I – Negligible, II – Marginal, III – Critical, IV – Catastrophic
Risk: **D** – Negligible, Mn – Minor, M – Moderate, S – Serious, C – Critical

APP – PRELIMINARY RISK ANALYSIS

Area: Evaporation Plant

Item	**Risk**	**Possible Causes**	**Possible Effects**	**Grade**			**Remarks and/or Recommendations**
				Freq.	**Sever.**	**Risk**	
14	Leakage (fugitive emissions) of concentrated non condensable gases (CNCG)	• Failure on process settings.	• Alteration of air quality.	**D**	**II**	**M**	• CNCG generating sources shall be provided with a safety system consisting of flame arresters and rupture discs for protection against explosions and accidental emissions to the atmosphere • The piping of rupture disc shall be provided with a pressure sensor so that in the event of a ruptured disc, the ON-OFF valve is immediately closed, blocking the sources and avoiding CNCG emission into the atmosphere • Each source will have the emission of CNCG monitored (flow, temperature and pressure) • CNCG collection lines will be individualized for better operational control • Non-condensable gases will be collected and incinerated in the recovery boiler • Fugitive emissions have a low Flow rate, which limits their dispersion around the site

Frequency: **A** – Very Unlikely, B – Unlikely, C – Remote, D – Likely, **E** – Frequent
Severity: I – Negligible, II – Marginal, III – Critical, IV – Catastrophic
Risk: **D** – Negligible, Mn – Minor, M – Moderate, S – Serious, C – Critical

APP – PRELIMINARY RISK ANALYSIS

Area: Evaporation Plant

Item	Risk	Possible Causes	Possible Effects	Grade			Remarks and/or Recommendations
				Freq.	Sever.	Risk	
15	Leakage of black liquor	• Rupture or hole in piping due to: ✓ Corrosion ✓ Mechanical failure ✓ Operational failure ✓ Mechanical impact • Rupture or failure of components (valve, pump, tank)	• Personal accident • Loss of product	**D**	**II**	**M**	• Chemical recovery areas will have containment walls
16	Leakage of contaminated condensate	• Rupture or hole in piping due to: ✓ Corrosion ✓ Mechanical failure ✓ Operational failure ✓ Mechanical impact • Rupture or failure of components (valve, pump, tank)	• Personal accident • Loss of product • Alteration of air quality	**C**	**III**	**M**	• Evaporation area will have a containment wall in all its surroundings • Implementation of high and very high level alarms with stop interlocking and deflection of condensate flows • Implantation of redundancy (additional safety) of interlocking to high level in parallel with level switch

Frequency: **A** – Very Unlikely, B – Unlikely, C – Remote, D – Likely, **E** – Frequent
Severity: I – Negligible, II – Marginal, III – Critical, IV – Catastrophic
Risk: **D** – Negligible, Mn – Minor, M – Moderate, S – Serious, C – Critical

APP – PRELIMINARY RISK ANALYSIS

Area: Evaporation Plant

Item	Risk	Possible Causes	Possible Effects	Grade			Remarks and/or Recommendations
				Freq.	Sever.	Risk	
17	Leakage of low or uncontaminated condensate	• Rupture or hole in piping due to: ✓ Mechanical failure ✓ Operational failure ✓ Mechanical impact • Rupture or failure of components (valve, pump, tank)	• Personal accident • Loss of product • Alteration of air quality	**D**	**II**	**M**	• Chemical recovery areas will have containment walls in its surroundings
18	Leakage of concentrated non condensable gases (CNCG) after the condenser	• Rupture or hole in piping due to: ✓ Mechanical failure ✓ Operational failure ✓ Mechanical impact • Rupture or failure of components (valve, pump, tank)	• Formation of toxic jet • Personal accident • Alteration of air quality	**D**	**III**	**S**	• Concentrated non-condensable gases (CNCG) will be collected and incinerated in the recovery boiler

APP – PRELIMINARY RISK ANALYSIS

Area: Evaporation Plant

Item	Risk	Possible Causes	Possible Effects	Grade			Remarks and/or Recommendations
				Freq.	Sever.	Risk	
19	Leakage of process methanol to incineration points	• Rupture or hole in piping due to: ✓ Corrosion ✓ Mechanical failure ✓ Operational failure ✓ Mechanical impact • Rupture or failure of components (valve, pump)	• Formation of puddle which can cause ignition: ✓ Fire in the puddle ✓ Flashfire; ✓ Explosion. • Personal accident • Alteration of air quality	**C**	**III**	**M**	• Piping shall be enveloped • The area will be surrounded by retaining wall
20	Explosion of process methanol storage tank	• Lightning strike over the storage tank • Operational failures in maintenance services (welding) • Failure of the inertization system of the storage tank	• Explosion • Material damage • Personal accident • Alteration of air quality	**C**	**III**	**M**	• Tank will be equipped with Atmospheric Discharge Protection System • Welding services must be performed by highly qualified professionals • Tank inertization should be uninterrupted monitored until the end of maintenance

Frequency: **A** – Very Unlikely, B – Unlikely, C – Remote, D – Likely, **E** – Frequent
Severity: I – Negligible, II – Marginal, III – Critical, IV – Catastrophic
Risk: **D** – Negligible, Mn – Minor, M – Moderate, S – Serious, C – Critical

APP – PRELIMINARY RISK ANALYSIS

Area: Recovery Boiler

Item	Risk	Possible Causes	Possible Effects	Grade			Remarks and/or Recommendations
				Freq.	Sever.	Risk	
21	Explosion of recovery boiler	• Rupture or hole in piping due to: ✓ Corrosion ✓ Mechanical failure ✓ Operational failure • Injection of weak liquor (contains lots of water) • Drag water with the gases • Failure on recovery boiler protection system	• Materials damage • Personal accident	**B**	**III**	**Mn**	The design and operation of the Recovery Boiler are based on the strictest safety criteria in order to prevent accidents and explosions, which are described below: • Alternative water supply through turbine driven pump • Black liquor feed system with redundant refractometers for fuel moisture metering • Redundant smelt spreaders per nozzles • Emergency water tank located in the boiler to guarantee the cooling of the nozzles in the event of a lack of electrical energy in the mill • Dissolving tank provided with a relief system (emergency damper) to relieve possible overpressure • Emergency dedicated drainage system totally independent of the main control system (DCS) • Application of special materials in critical areas of the furnace such as curves, air vents, corners • Application of special materials in critical areas in superheaters • Adoption of chloride and potassium purge system to maintain black liquor concentrations at levels that guarantee low corrosivity • BMS (Burner Management Systems) independent of the DCS configured in dedicated PLC with redundancy • High level of instrumentation to monitor all process variables • Redundancy in critical safety interlocks In addition to the above design criteria, the Recovery Boiler design will follow all recommendations of the Black Liquor Recovery Boiler Advisory Committee, a US entity formed in 1961 that establishes procedures and recommendations to increase the safety of recovery boilers, from concept, design, operation phase and maintenance. The sudden expansion of water will produce an increase in pressure that will deform the boiler structure but without causing an explosion. This type of incident, considering that the furnace will operate at basically atmospheric pressure there is relief at the same time producing serious damage to the boiler but without projection of an explosion. There will be an edge of the boiler called "zip corner", in which there will be rupture and the consequent relief of pressure will occur by it, due to the greater fragility of this part.

APP – PRELIMINARY RISK ANALYSIS

Area: Recovery Boiler

Item	Risk	Possible Causes	Possible Effects	Grade			Remarks and/or Recommendations
				Freq.	**Sever.**	**Risk**	
22	Explosion of electrostatic precipitator	• Excess of carbon monoxide (CO) due to process failure.	• Materials damage • Personal accident	**B**	**II**	**D**	• Pipes with gases that will follow to the precipitator will have a carbon monoxide (CO) detector, which in case of presence of this, will automatically and instantly turn off the precipitator, i.e. the system will be interlocked
23	Explosion of the dissolving tank	• Operational failure causing nozzle clogging • Failure of tank protection system	• Materials damage • Personal accident • Alteration of air quality	**B**	**II**	**D**	• Design, operation, and safety requirements of the dissolving tank follow the recommendations of the Black Liquor Recovery Boiler Committee • Project provides TV camera to monitor the flow of product in the nozzles. In the event of an explosion, the local is restricted to the recovery boiler area, i.e. it is confined • The premises adopted in danger of boiler explosion (water expansion) are valid in this case as well

Frequency: **A** – Very Unlikely, B – Unlikely, C – Remote, D – Likely, **E** – Frequent
Severity: I – Negligible, II – Marginal, III – Critical, IV – Catastrophic
Risk: **D** – Negligible, Mn – Minor, M – Moderate, S – Serious, C – Critical

APP – PRELIMINARY RISK ANALYSIS

Area: Causticizing and Lime Kiln

Item	**Risk**	**Possible Causes**	**Possible Effects**	**Grade**			**Remarks and/or Recommendations**
				Freq.	**Sever.**	**Risk**	
24	Leakage of fuel oil in lime kiln feeding	• Rupture or hole in piping due to: ✓ Corrosion ✓ Mechanical failure ✓ Operational failure ✓ Mechanical impact • Rupture or failure of components (valve)	• Formation of puddle with possibility of ignition • Alteration of air quality	**D**	**II**	**M**	• The area will be surrounded by retaining wall • Instrumentation / automation system may be interlocked if the operating parameters (pressure, temperature, pressure) change
25	Methanol leakage in lime kiln feeding	• Rupture or hole in piping due to: ✓ Corrosion ✓ Mechanical failure ✓ Operational failure ✓ Mechanical impact • Rupture or failure of components (valve)	• Formation of puddle with possibility of ignition: ✓ Fire in the puddle ✓ Flashfire ✓ Explosion ✓ Alteration of air quality	**D**	**III**	**S**	• The area will be surrounded by retaining wall • Implementation of signaling systems at the most impactable points • The instrumentation/automation system shall be provided with an interlocking system in the event of changes in operating parameters (pressure, temperature, flow)
26	Explosion of electrostatic precipitator (lime kiln)	• Excess of carbon monoxide (CO) due to process failure	• Materials damage • Personal accident	**B**	**II**	**D**	• Pipes with gases that will follow to the precipitator will have a carbon monoxide (CO) detector, which in case of presence of this, will automatically and instantly turn off the precipitator, i.e. the system will be interlocked

APP – PRELIMINARY RISK ANALYSIS

Area: Causticizing and Lime Kiln

Item	Risk	Possible Causes	Possible Effects	Grade			Remarks and/or Recommendations
				Freq.	Sever.	Risk	
27	Leakage of liquor	• Rupture or hole in piping due to: ✓ Corrosion ✓ Mechanical failure ✓ Operational failure ✓ Mechanical impact • Rupture or failure of components (valve, pump)	• Personal accident • Loss of product	**D**	**II**	**M**	• Chemical recovery areas will have containment walls around them
28	Contaminated condensate leakage	• Rupture or hole in piping due to: ✓ Corrosion ✓ Mechanical failure ✓ Operational failure ✓ Mechanical impact • Rupture or failure of components (valve, pump)	• Personal accident • Loss of product	**D**	**II**	**M**	• Chemical recovery areas will have containment walls around them

Frequency: **A** – Very Unlikely, B – Unlikely, C – Remote, D – Likely, **E** – Frequent
Severity: I – Negligible, II – Marginal, III – Critical, IV – Catastrophic
Risk: **D** – Negligible, Mn – Minor, M – Moderate, S – Serious, C – Critical

APP – PRELIMINARY RISK ANALYSIS

Area: Biomass Boiler

Item	Risk	Possible Causes	Possible Effects	Grade			Remarks and/or Recommendations
				Freq.	Sever.	Risk	
29	Ignition on biomass silo	• External ignition source	• Fire • Personal accident	**B**	**II**	**D**	• Biomass silo is equipped with a fire-fighting system • Fire will be properly controlled within the area of the Biomass Boiler
30	Explosion of the biomass boiler	• Rupture or hole in the pipe • Failure on boiler protection system	• Materials damage • Personal accident	**B**	**III**	**Mn**	• The design and operation of the Biomass Boiler are based on the strictest safety criteria in order to prevent accidents and explosions, which are described below: ✓ Highly automated and instrumented biomass feed control system with online balance of stable and safe fuel mass for combustion ✓ Adoption of biomass feed through rotary valves to prevent flame return to storage silos ✓ Refractory coating oven to prevent erosion of water pipes in turbulence areas ✓ Application of special materials in critical areas in secondary superheaters (hotter zones) and tertiary superheaters (complete) ✓ BMS (Burner Management Systems) independent of the DCS configured in dedicated PLC with redundancy ✓ High level of instrumentation to allow monitoring of process variables ✓ Redundancy in critical safety interlocks

Frequency: **A** – Very Unlikely, B – Unlikely, C – Remote, D – Likely, **E** – Frequent
Severity: I – Negligible, II – Marginal, III – Critical, IV – Catastrophic
Risk: **D** – Negligible, Mn – Minor, M – Moderate, S – Serious, C – Critical

APP – PRELIMINARY RISK ANALYSIS

Area: Biomass Boiler

Item	Risk	Possible Causes	Possible Effects	Grade			Remarks and/or Recommendations
				Freq.	Sever.	Risk	
31	Explosion of electrostatic precipitator	• Excess of carbon monoxide (CO) due to process failure	• Local materials damage • Personal accident	**B**	**II**	**D**	• Pipes with gases that will follow to the precipitator will have a carbon monoxide (CO) detector, which in case of presence of this, will automatically and instantly turn off the precipitator, i.e. the system will be interlocked

Frequency: **A** – Very Unlikely, B – Unlikely, C – Remote, D – Likely, **E** – Frequent
Severity: I – Negligible, II – Marginal, III – Critical, IV – Catastrophic
Risk: **D** – Negligible, Mn – Minor, M – Moderate, S – Serious, C – Critical

APP – PRELIMINARY RISK ANALYSIS

Area: Utilities – WTP, BFWT and ETP

Item	**Risk**	**Possible Causes**	**Possible Effects**	**Grade**			**Remarks and/or Recommendations**
				Freq.	**Sever.**	**Risk**	
32	Leakage of chemicals in WTP, BFWT and ETP	• Rupture or failure of components (valve) • Rupture or hole in the line due to: ✓ Corrosion ✓ Mechanical failure ✓ Operational failure ✓ Mechanical impact	• Personal accident • Loss of product • Alteration of soil quality	**D**	**II**	**M**	• The areas of chemical unloading and storage will have containment systems
33	Leakage of lagoons and tanks at the ETP	• Mechanical impact • Rupture or perforation of the waterproofing litter	• Change in soil and groundwater quality	**B**	**II**	**D**	• Where applicable, the tanks shall be constructed of concrete. If excavated, they will have protection with compacted clay and HDPE membrane, as well as having a leakage detection system

Frequency: **A** – Very Unlikely, B – Unlikely, C – Remote, D – Likely, **E** – Frequent
Severity: I – Negligible, II – Marginal, III – Critical, IV – Catastrophic
Risk: **D** – Negligible, Mn – Minor, M – Moderate, S – Serious, C – Critical

APP – PRELIMINARY RISK ANALYSIS

Area: Chemicals – Sulphuric Acid (H_2SO_4) Storage

Item	**Risk**	**Possible Causes**	**Possible Effects**	**Grade**			**Remarks and/or Recommendations**
				Freq.	**Sever.**	**Risk**	
34	Leakage of H_2SO_4 from truck unloading to consumption	• Hose rupture • Hose disconnection • Rupture or hole in the line due to: ✓ Mechanical failure ✓ Operational failure ✓ Mechanical impact • Rupture or failure of components (valve, pump).	• Personal accident • Loss of product • Alteration of soil quality	**D**	**II**	**M**	• Product unloading of the truck will be done in an area with containment, and any effluents sent for treatment • Equipment and lines with sulfuric acid will be stainless steel
35	Unwanted product formation	• Shipping of sulfuric acid to another chemical tank due to operational failure	• For the sodium hydroxide tank: pressure increase in the tank with possibility of tank rupture • For hydrogen peroxide tank: possibility of tank rupture	**A**	**II**	**D**	• Unloading of sulfuric acid will be done by properly trained personnel, with verification of the type of product transported versus the destination tank • Daily schedule of product delivery schedules should be confronted. No product out of this daily list will be received • Density and composition of the product will be controlled prior to unloading

Frequency: **A** – Very Unlikely, B – Unlikely, C – Remote, D – Likely, **E** – Frequent
Severity: I – Negligible, II – Marginal, III – Critical, IV – Catastrophic
Risk: **D** – Negligible, Mn – Minor, M – Moderate, S – Serious, C – Critical

APP – PRELIMINARY RISK ANALYSIS

Area: Chemicals – Sodium Bisulphite ($NaHSO_3$) Storage

Item	**Risk**	**Possible Causes**	**Possible Effects**	**Grade**			**Remarks and/or Recommendations**
				Freq.	**Sever.**	**Risk**	
36	$NaHSO_3$ solution leakage	• Hose rupture • Disconnecting the hose • Rupture or failure of components (valve, pump) • Rupture or hole in the line due to: ✓ Mechanical failure ✓ Operational failure ✓ Mechanical impact	• Small-scale SO_2 detachment • Personal accident • Change in soil quality	**D**	**II**	**M**	• Preparation and storage areas will have containment

Frequency: **A** – Very Unlikely, B – Unlikely, C – Remote, D – Likely, **E** – Frequent
Severity: I – Negligible, II – Marginal, III – Critical, IV – Catastrophic
Risk: **D** – Negligible, Mn – Minor, M – Moderate, S – Serious, C – Critical

APP – PRELIMINARY RISK ANALYSIS							
Area: Chemicals – Methanol Storage							
Item	**Risk**	**Possible Causes**	**Possible Effects**	**Grade**			**Remarks and/or Recommendations**
				Freq.	**Sever.**	**Risk**	
37	Methanol leakage from reception to chlorine dioxide plant	• Hose rupture • Disconnecting the hose • Rupture or failure of components (valve, pump) • Rupture or hole in the line due to: ✓ Corrosion ✓ Mechanical failure ✓ Operational failure ✓ Mechanical impact	• Formation of a puddle with the possibility of causing an ignition: ✓ Fire in the puddle ✓ Flashfire ✓ Explosion • Personal accident • Change in air quality	**D**	**III**	**S**	• The truck's product will be unloaded in a containment area, and eventual effluents are sent for treatment
38	Ignition of the methanol vapor phase in the storage tank	• Lightning drop on the storage tank • Operational failures in maintenance services (welding) • Storage tank inertization system failure	• Explosion; • Material damage; • Change in air quality.	**C**	**III**	**M**	• The tank must be equipped with Atmospheric Discharge Protection System • Welding services must be performed by highly qualified professionals. A special order (written) will be required to perform welding work at risk points • The inertization of the tank must be monitored uninterrupted until the end of maintenance

Frequency: **A** – Very Unlikely, B – Unlikely, C – Remote, D – Likely, **E** – Frequent
Severity: I – Negligible, II – Marginal, III – Critical, IV – Catastrophic
Risk: **D** – Negligible, Mn – Minor, M – Moderate, S – Serious, C – Critical

APP – PRELIMINARY RISK ANALYSIS

Area: Chemicals – Hydrogen Peroxide (H_2O_2)

Item	Risk	Possible Causes	Possible Effects	Grade			Remarks and/or Recommendations
				Freq.	Sever.	Risk	
39	Leakage of H_2O_2 from truck unloading to consumption on fiber line	• Hose rupture • Disconnecting the hose • Rupture or failure of components (valve, pump) • Rupture or hole in the line due to: ✓ Corrosion ✓ Mechanical failure ✓ Operational failure ✓ Mechanical impact	• Personal accident • Loss of product • Alteration of air quality	**D**	**II**	**M**	• Product unloading of the truck will be done in an area with containment, and any effluents sent for treatment • H_2O_2 storage tank will be equipped with a containment basin
40	Decomposition of H_2O_2	• Product heating (by external fire) • Return of the product due to operational failure • Instrumentation failure • Presence of contaminant in dilution water	• Possibility of tank explosion • Change in air quality	**C**	**II**	**Mn**	• A double-closing system and a flow meter indicating the reverse flow will be installed • Measure the conductivity of the water to be used in the dilution of hydrogen peroxide
41	Explosion of H_2O_2 storage tank	• Product contamination • Product heating (external fire)	• Material damage • Change in air quality	**B**	**II**	**D**	• Instrumentation / automation system may be provided with interlocking in case of changes in operating parameters (pressure, temperature, flow) • The storage tanks should have a pressure relief system, with alarm indication in case of high pressure

APP – PRELIMINARY RISK ANALYSIS

Area: Chemicals – Hydrogen Peroxide (H_2O_2)

Item	Risk	Possible Causes	Possible Effects	Grade			Remarks and/or Recommendations
				Freq.	**Sever.**	**Risk**	
42	Unwanted product formation	• Shipping of H_2O_2 to another chemical tank due to operational failure	• For the sodium hydroxide tank: pressure increase in the tank with possibility of tank rupture • For sulfuric acid tank: possibility of tank rupture	**A**	**II**	**D**	• Unloading of hydrogen peroxide will be done by properly trained personnel, with verification of the type of product transported versus the destination tank • The daily schedule of product delivery schedules should be confronted. No product out of this daily list will be received / unloaded • The density and composition of the product will be controlled prior to unloading • The odor will be controlled in the discharge of the product

Frequency: **A** – Very Unlikely, B – Unlikely, C – Remote, D – Likely, **E** – Frequent
Severity: I – Negligible, II – Marginal, III – Critical, IV – Catastrophic
Risk: **D** – Negligible, Mn – Minor, M – Moderate, S – Serious, C – Critical

APP – PRELIMINARY RISK ANALYSIS

Area: Chemicals – Sodium Hydroxide (NaOH)

Item	**Risk**	**Possible Causes**	**Possible Effects**	**Grade**			**Remarks and/or Recommendations**
				Freq.	**Sever.**	**Risk**	
43	Leakage of NaOH from truck unloading to the pump	• Hose rupture • Disconnecting the hose • Rupture or failure of components (valve, pump) • Rupture or hole in piping due to: ✓ Corrosion ✓ Mechanical failure ✓ Operational failure ✓ Mechanical impact	• Personal accident • Loss of product • Alteration of air quality	**D**	**II**	**M**	• Product unloading of the truck will be done in an area with containment, and any effluents sent for treatment
44	Unwanted product formation	• Shipping of sodium hydroxide to another chemical tank due to operational failure	• For the hydrogen peroxide tank: explosion or tank rupture • For sulfuric acid tank: possibility of tank rupture	**A**	**II**	**D**	• Unloading of sodium hydroxide will be done by properly trained personnel, with verification of the type of product transported versus the destination tank • The daily schedule of product delivery schedules should be confronted. No product out of this daily list will be received • The density and composition of the product will be controlled prior to unloading

Frequency: **A** – Very Unlikely, B – Unlikely, C – Remote, D – Likely, **E** – Frequent
Severity: I – Negligible, II – Marginal, III – Critical, IV – Catastrophic
Risk: **D** – Negligible, Mn – Minor, M – Moderate, S – Serious, C – Critical

APP – PRELIMINARY RISK ANALYSIS

Area: Chemicals – Sodium chlorate ($NaClO_3$) Storage

Item	Risk	Possible Causes	Possible Effects	Grade			Remarks and/or Recommendations
				Freq.	Sever.	Risk	
45	Leakage of the $NaClO_3$ solution	• Rupture or failure of components (valve, pump) • Rupture or hole in piping due to: ✓ Corrosion ✓ Mechanical failure ✓ Operational failure ✓ Mechanical impact	• Personal accident • Loss of product • Alteration of soil quality	**D**	**II**	**M**	• The area must be equipped with a leak containment system

Frequency: **A** – Very Unlikely, B – Unlikely, C – Remote, D – Likely, **E** – Frequent
Severity: I – Negligible, II – Marginal, III – Critical, IV – Catastrophic
Risk: **D** – Negligible, Mn – Minor, M – Moderate, S – Serious, C – Critical

APP – PRELIMINARY RISK ANALYSIS

Area: Chemicals – Chlorine Dioxide

Item	Risk	Possible Causes	Possible Effects	Grade			Remarks and/or Recommendations
				Freq.	Sever.	Risk	
46	Reactor relief cover opening	• Overpressure in the reactor due to: ✓ Strong or violent decomposition in the reactor due to vacuum loss ✓ Hydrogen peroxide/methanol overdose with reactor vacuum ✓ Presence of contaminants in raw materials or water	• Small chlorine emission • Change in air quality	D	II	M	• The reactor is designed to stand violent decomposition • Safety interlocking: total stop and activation of emergency showers • Opening the relief cover over the reactor assigned to the roof, restricting the area • Vacuum loss warning light
47	Drain relief cap opening	• Overpressure in the drainage tank is due to: ✓ Continuous chemical feed in the absence of drag air ✓ Strong or violent decomposition in the reactor due to vacuum loss ✓ Hydrogen peroxide/methanol overdose with reactor vacuum ✓ Presence of contaminants in raw materials or water	• Chlorine dioxide release • Change in air quality	D	II	M	• The discharge tank is designed to stand a violent decomposition, equipped with a relief cover • The manual contains instructions for draining the reactor • Drag air will be provided to the scrubber
48	Leakage of reactor or drainage tank	• Rupture or hole in piping due to: ✓ Mechanical failure ✓ Operational failure ✓ Mechanical impact • Pump failure • Drainage failure	• Change in soil quality • Change in air quality • Personal accident	D	II	M	• Most chlorine dioxide tubes will be titanium • Mechanical protection is provided for small pipes • Safety interlock is provided with general stop (in the reactor)

APP – PRELIMINARY RISK ANALYSIS

Area: Chemicals – Chlorine Dioxide

Item	Risk	Possible Causes	Possible Effects	Grade			Remarks and/or Recommendations
				Freq.	Sever.	Risk	
49	Leakage of ClO_2 solution from absorption tower to bleaching plant	• Rupture or failure of components (valve, pump) • Rupture or hole in the line due to: ✓ Corrosion ✓ Mechanical failure ✓ Operational failure ✓ Mechanical impact	• Gas is released from the solution and broken down into chlorine and oxygen • Change in air quality	**D**	**III**	**S**	• ClO_2 storage tank will have containment walls • A separate vacuum switch will be installed for each tank
50	Opening the relief cover on the ClO_2 storage tank	• ClO_2 decomposition in the storage tank due to a very high concentration of ClO_2, no air current (upper tank ventilation) and a very high temperature or external heating • Very low pressure (empty)	• Gas is released from the solution and broken down into chlorine and oxygen • Change in air quality	**C**	**II**	**Mn**	• A separate vacuum switch will be installed for each tank
51	ClO_2 storage tank overflow	• Overload and failure of level transmitters.	• Release of ClO_2 solution$_2$ • Change in air quality	**B**	**III**	**Mn**	• The ClO_2 storage tank shall be provided with a leak containment vessel

Frequency: **A** – Very Unlikely, B – Unlikely, C – Remote, D – Likely, **E** – Frequent
Severity: I – Negligible, II – Marginal, III – Critical, IV – Catastrophic
Risk: **D** – Negligible, Mn – Minor, M – Moderate, S – Serious, C – Critical

APP – PRELIMINARY RISK ANALYSIS							
Area: Chemicals – Oxygen production (O_2)							
Item	**Risk**	**Possible Causes**	**Possible Effects**	**Grade**			**Remarks and/or Recommendations**
				Freq.	**Sever.**	**Risk**	
52	Leakage of O_2	• Rupture or hole in piping due to: ✓ Corrosion ✓ Mechanical failure ✓ Operational failure ✓ Mechanical impact • Component rupture or failure (valve, pump, compressor, vaporizer)	• Personal accident	**D**	**I**	**Mn**	• The instrumentation/automation system shall be interlocked in case of changes in operating parameters (pressure, temperature)

Frequency: **A** – Very Unlikely, B – Unlikely, C – Remote, D – Likely, **E** – Frequent
Severity: I – Negligible, II – Marginal, III – Critical, IV – Catastrophic
Risk: **D** – Negligible, Mn – Minor, M – Moderate, S – Serious, C – Critical

APP – PRELIMINARY RISK ANALYSIS

Area: General

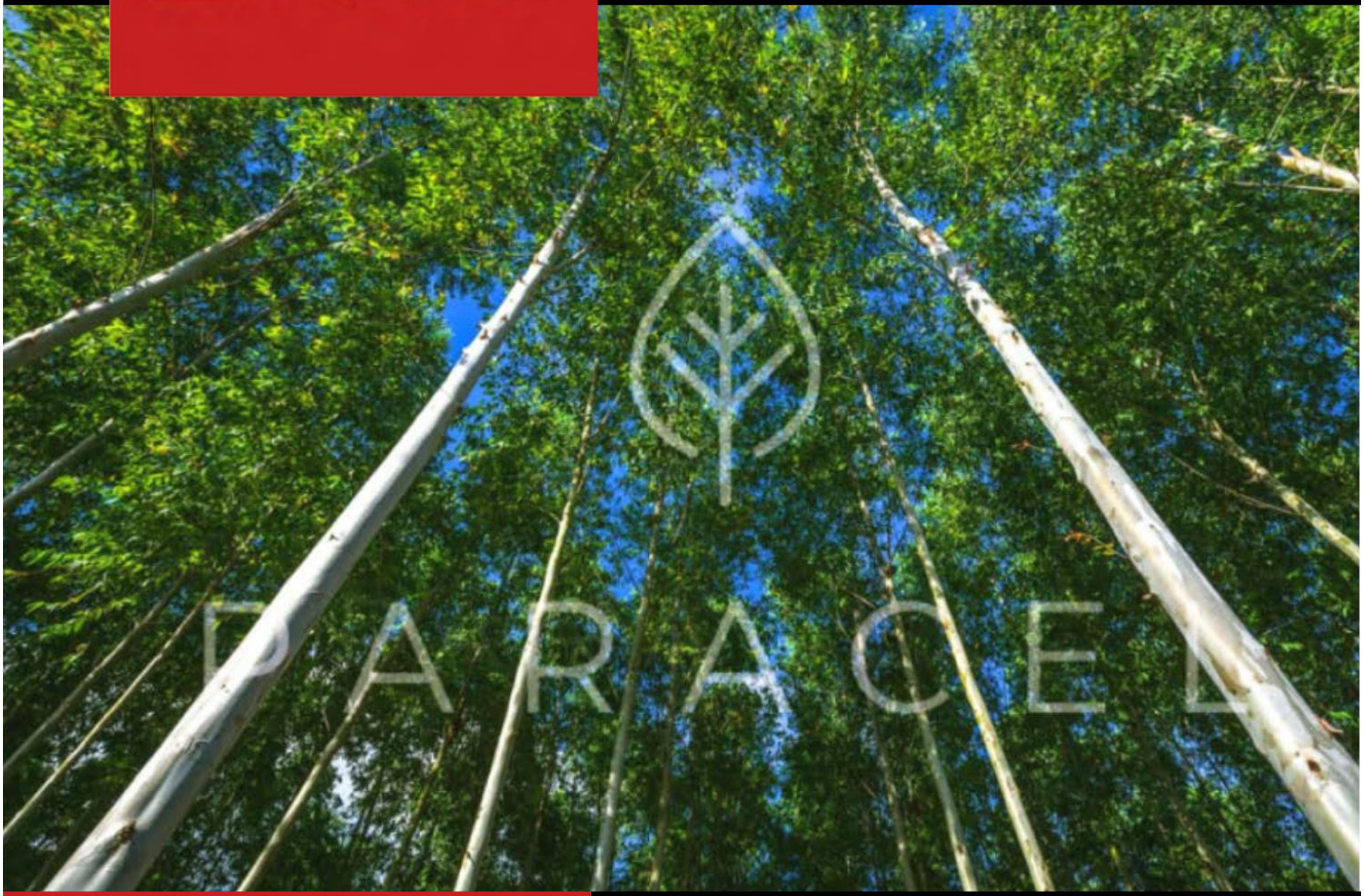
Item	Risk	Possible Causes	Possible Effects	Grade			
				Freq.	Sever.	Risk	
53	Chemical leakage during transport within the Industrial Unit	• Collision of a truck causing a tank rupture	• Material damage • Change in surface water quality • Change in air quality	**D**	**II**	**M**	• Combat, training and retraining brigade training • Direction of street drains with the highest risk potential for ETP • Implementation of signaling (speed limit, etc.)

Frequency: **A** – Very Unlikely, B – Unlikely, C – Remote, D – Likely, **E** – Frequent
Severity: I – Negligible, II – Marginal, III – Critical, IV – Catastrophic
Risk: **D** – Negligible, Mn – Minor, M – Moderate, S – Serious, C – Critical

ANNEX IV

SOUND PRESSURE LEVEL MODELLING

CSI Ingenieros



Paracel

Sound Pressure Level (SPL) Modeling

PARACEL

May 2020

This document has been edited to be printed double face. Blank sheets have been interposed to respect the numbering of the edit style.

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1. Introduction

1.1. Objective

The objective of the report is to present the modelling of sound pressure levels in the environment of the future pulp mill of PARACEL, to be installed on the Paraguay River north of the city of Concepción, in the department of the same name of the Republic of Paraguay.

The modeling allows to characterize the sound environment by studying the propagation of noise generated by the operation of the mill and the baseline data available for the area, determining the incremental contribution of the project.

1.2.Scope

The characterization of the sound environment in the pulp mill is carried out by mathematical modeling of noise propagation, considering the available information of the equipment to be installed, the estimated operational dynamics, the baseline data generated by PARACEL in April 2020 and the receivers defined by the company.

The information integrated into the model is provided by PARACEL, and is supplemented if necessary with basic information from the consultancy. This supplementary information derives from experiences in similar work with pulp mills in Uruguay.

The characterization of the sound environment of the pulp mill is quantified by determining the sound pressure levels in particular receivers. In addition, noise maps are made from the model for the different scenarios considered.

In all cases, the sound pressure levels modeled with the applicable reference standards, as determined by the regulatory framework of reference constituted by Law No. 1.100/97 and the current standards of the Republic of Paraguay that apply, are compared.

2. Modeling methodology

2.1. Scenarios to be modeled

The basic situation for the different scenarios to be modeled considers the most conservative operational dynamics –*worst case scenario*– where the main sources of noise operates simultaneously and the internal traffic of vehicles is maximum (light, heavy vehicles and pulp bullet transport).

Based on the most conservative operational dynamics, different modeling scenarios were defined:

- Scenario 1: Operation of all equipment in the mill, maximum internal vehicle travel and main access to the mill **option A** (maximum flow of trucks and light vehicles).
- Scenario 2: Operation of all equipment in the mill, maximum internal vehicle travel and main access to the option **B** mill (maximum flow of trucks and light vehicles).
- Scenario 3: Operation of all equipment in the mill, maximum internal vehicle travel, backup access for light vehicles (maximum flow) and main access **option A** for heavy vehicles (maximum flow).
- Scenario 4: Operation of all equipment in the mill, maximum internal vehicle travel, backup access for light vehicles (maximum flow) and main access **option B** for heavy vehicles (maximum flow).

Finally, two additional scenarios were modeled to assess the effectiveness of including a mill barrier as a mitigation measure, according to the following detail:

- Scenario 5: Operation of all equipment in mill and maximum internal vehicle travel.
- Scenario 6: Operation of all equipment in the mill, maximum internal vehicle travel and presence of **mill barrier**.

2.2.Modeling software

DataKustik GmbH's CadnaA software (version 2020) was used for the modeling of Sound Pressure Levels (hereinafter SPL). This software is based on SPL numerical calculation tools across different mathematical noise propagation models.

This particular study integrates the ISO 9613-based calculation for the modelling of industrial complexes and the French calculation model NPMB Routes 96 for linear sources (roads, roads and other vehicle roads). Both calculation methodologies are internationally recognized for SPL modeling.

The calculation software allows to incorporate georeferenced elements for the elaboration of the model, such as the contours of the terrain, the emitting and receiver sources with their respective heights, routes and existing neighborhood roads, forested areas, etc. The model considers attenuations by geometric divergence[1] taking into account terrain, attenuation by atmospheric absorption[2],attenuation by effect of the soil, attenuations due to the presence of barriers (including buildings, structures and topography), weather corrections and wave reflections. The criteria for the determination of attenuation factors were based on the recommendations of ISO 9613 and NPMB Routes 96.

As for the barriers specifically, insulation barriers can be incorporated with their respective characteristics, existing and/or projected mill barriers, giving adequate height and thickness.

In the case of the modeling of the PARACEL pulp mill, where it is necessary to combine fixed sources and sources linked to transit, CadnaA software is very useful since it allows to apply calculation models or complementary reference standards in the same run, applying the most suitable model for each type of source (point, linear and surface). Another important advantage of the program is its high calculation speed, even for large-scale projects.

As a result of modeling, within the calculation configuration adopted, the software returns estimated SPL values on the evaluated receivers, as well as a noise map for the entire evaluation zone (calculation grid). Noise maps can be represented as isophone lines or as noise areas.

It should also be noted that the outputs of the calculation model are exportable to specific software of geographical information, such as *Google Earth,* a feature otherwise valuable to visualize in a simple and practical way the result of the model, exportable in addition to formats shape, dwg, dxf, among others, allowing the editing and management of *outputs* with versatility.

2.3.Data entry to the model

The quality of the input data to the model is key to ensuring accurate results, which interpret the modeled scenarios as realistically as possible.

First the physical model of the mill is built, which was realized incorporating the general *Layout* of the PARACEL pulp mill into the software (according to "General *Mill Site Layout"),* assigning names and heights to all buildings, structures and tanks. Annex I presents the detail of the buildings considered with their characteristics.

Second, the receivers are defined. The receivers that were incorporated correspond to 27 sensitive homes located in the closure of the mill, whose identification and location was provided by PARACEL. Four points were also incorporated, corresponding to monitoring sites where SPL baseline measurements were made in April 2020.

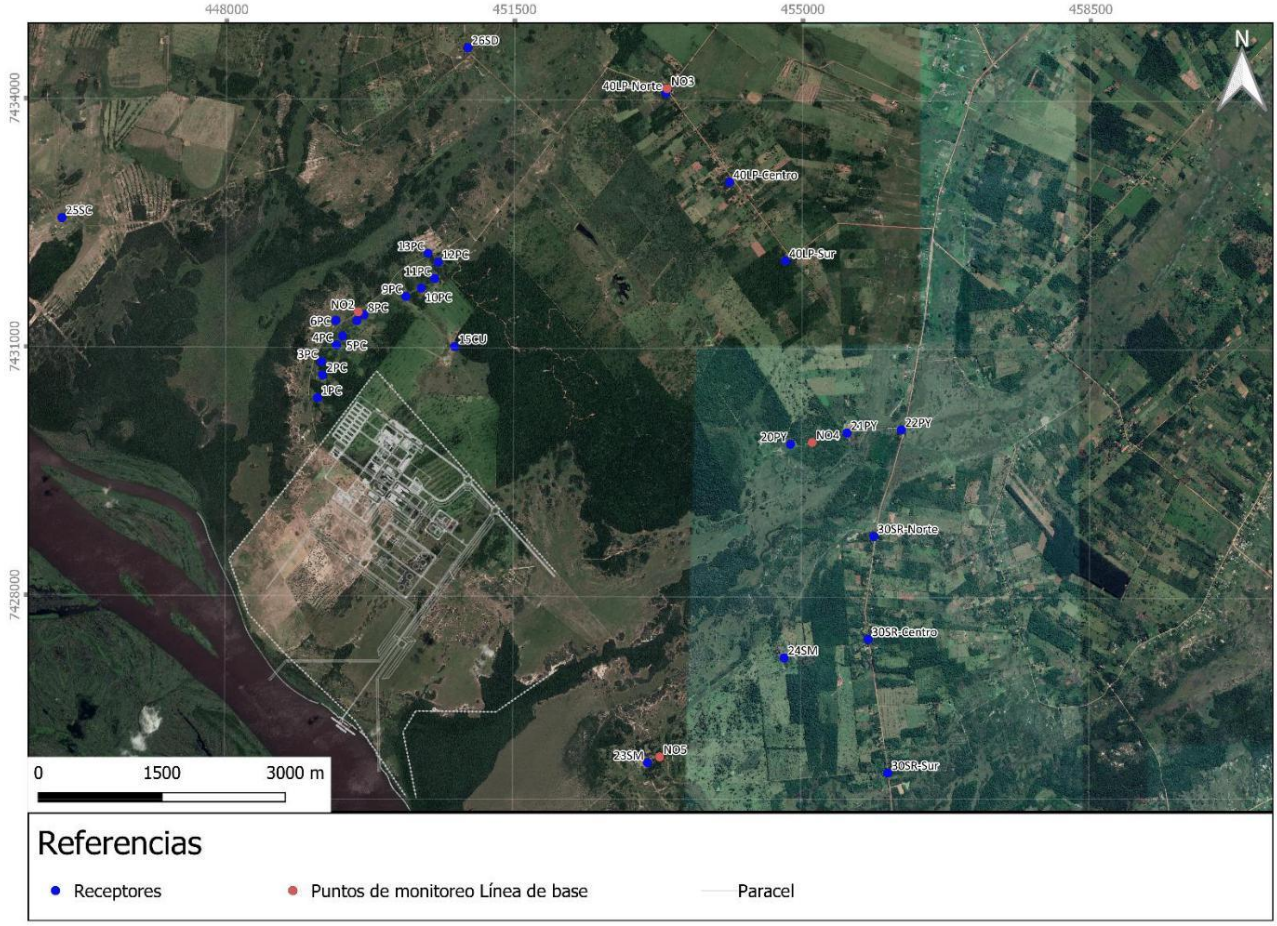
The following figure shows the location of the receivers considered and the points monitored during baseline definition.

---

[1] A_{div}s 20 log(d/d_0) + 11 dB

[2] In CadnaA for the standard frequency of 500 Hz the attenuation by atmospheric absorption A_{atm}x 0.002 dB/m.

Figure 2-1 Relayed receivers



All receivers were assigned a height of 1.60 m, a value commonly defined as a person's average height.

Also, once the physical model of the pulp mill has been developed and the receivers are located, the mill's noise-emitting sources are incorporated, located georeferenced and assigning them the corresponding height. Three types of sources are considered depending on their emission characteristics:

- Linear sources: represent internal streets and access to mill where vehicles circulate.
- Surface sources: represent the emission of sources within buildings.
- Point sources: represent the emission of equipment located outdoors.

The sources under consideration and the operational assumptions considered in some particular cases are detailed in Annex I.

The configuration of the calculation was determined so that in each receiver were considered the sources located within a radius of 10 km, so as to contemplate all the sources of the mill in each case.

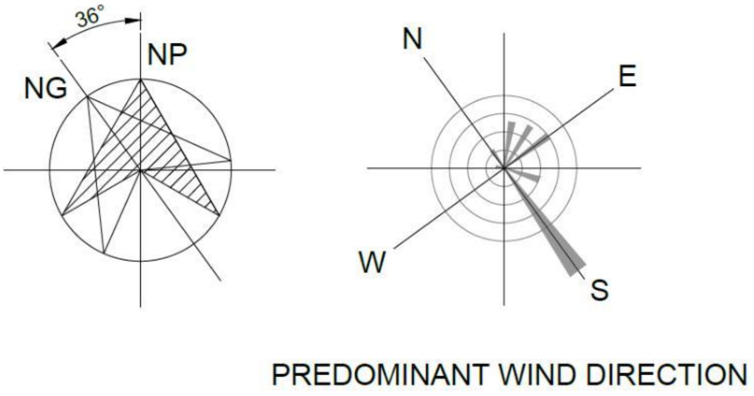
For the absorption of the land was considered a factor G=1 since the majority of the propagation area corresponds to porous land, areas covered with grass, trees and / or vegetation, taking into account that even within the pulp mill there are green areas. The buildings were taken in all cases as reflective surfaces (G=0). The general reflection order of the modeling was set to 1st order.

As mentioned earlier, the base situation considered corresponds to the most conservative operational dynamic or *worst case scenario.* This means considering that all broadcast sources are operational 24 hours simultaneously.

For the mesh calculation, which determines the noise map, a grid size of 10 m x 10 m and a receiver height of 1.60 m was selected.

The weather correction was performed with wind data provided by PARACEL, according to the available wind rose, presented in the following Figure.

Figure 2-2 Wind Rose for PARACEL Pulp mill



3. Results

This chapter presents the results obtained for the various modeled scenarios, noise maps, and estimated emission values on the evaluated receivers. The emission values are represented as A-weighted equivalent continuous SPL, a parameter that is noted as L_{Aeq}.

Table 3-1 presents the estimated L_{Aeq} values for incremental input derived only from the operation of the pulp mill under the conditions described above for scenarios 1 to 4.

Table 3-2 presents the estimated L_{Aeq} values for incremental input derived only from the operation of the pulp mill under the conditions described above for scenarios 5 and 6, where the application of a mill barrier as a mitigation measure is evaluated.

Finally, Table 3-3 presents the estimated L_{Aeq} values that would be recorded at the various monitoring points evaluated on the baseline, in order to be able to make a comparative assessment with the baseline values defined in April 2020.

The generated noise maps are presented as graphical figures, according to the following name:

- Sheet 3–1 Noise Map – Scenario 1.
- Sheet 3–2 Noise Map – Scenario 2.
- Sheet 3–1 Noise Map – Scenario 3.
- Sheet 3–2 Noise Map – Scenario 4.
- Sheet 3–1 Noise Map – Scenario 5.
- Sheet 3–2 Noise Map – Scenario 6.

Table 3–1 SPL modeled for scenarios 1 to 4 - Incremental contribution of pulp mill

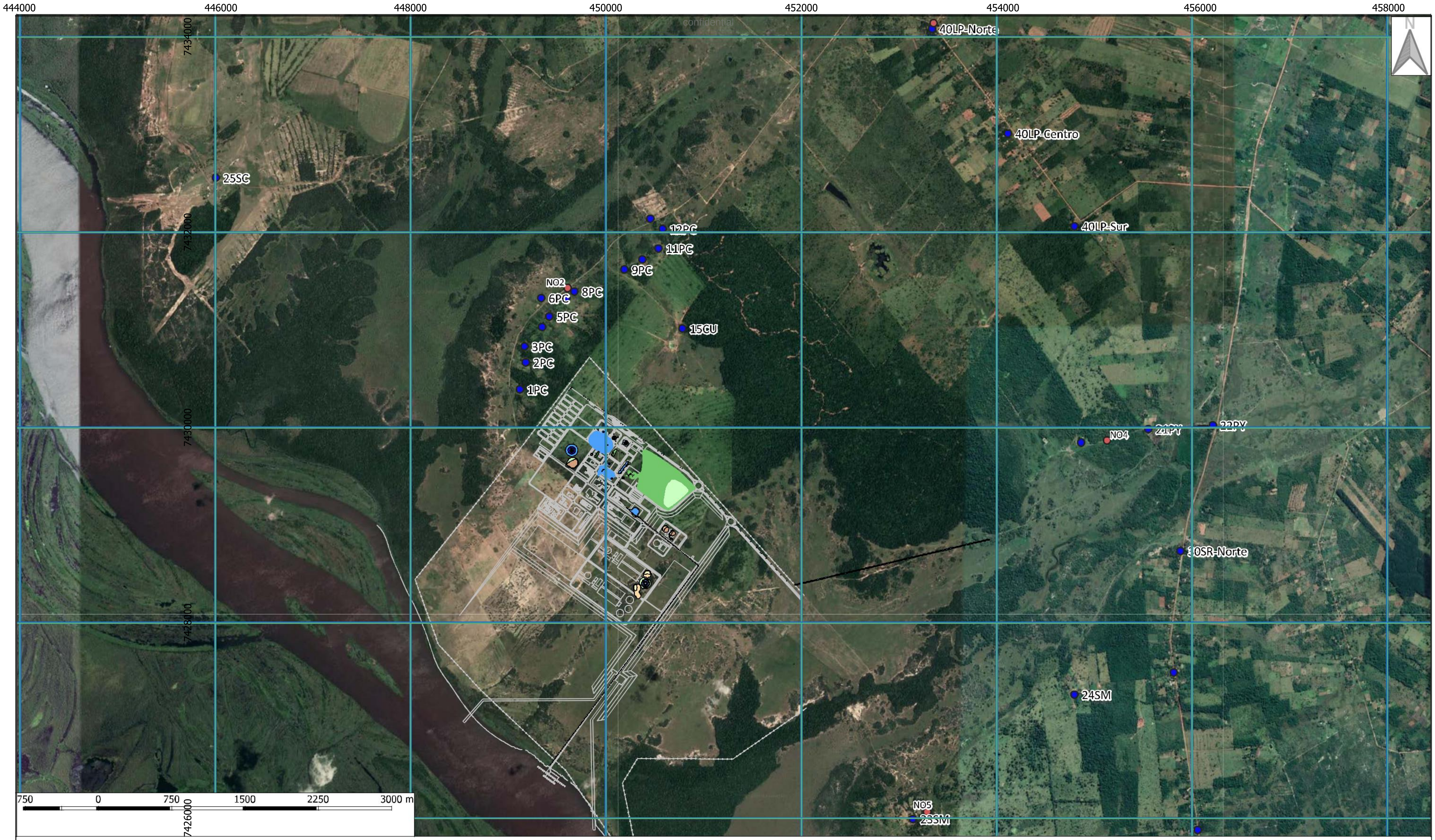
Receiver	Scenario 1 L_{Aeq} (dBA)	Scenario 2 L_{Aeq} (dBA)	Scenario 3 L_{Aeq} (dBA)	Scenario 4 L_{Aeq} (dBA)
1PC	45.3	45.3	45.3	45.3
2PC	42.9	42.9	42.9	42.9
3PC	41.3	41.3	41.4	41.4
4PC	40.3	40.3	40.3	40.3
5PC	39.7	39.7	39.7	39.7
6PC	37.7	37.7	37.8	37.8
7PC	38.5	38.5	38.7	38.7
8PC	37.9	37.9	38.2	38.2
9PC	34.7	34.7	36.2	36.2
10PC	32.3	32.3	35.9	35.9
11PC	28.6	28.6	36.4	36.4
12PC	20.5	20.5	32.7	32.7
13PC	20.0	20.0	29.2	29.2
15CU	38.9	38.9	39.1	39.1
20PY	35.0	< 15	34.6	< 15
21PY	41.5	< 15	41.1	< 15
22PY	61.8	< 15	61.4	< 15
23SM	< 15	31.5	< 15	31.1
24SM	21.3	26.9	20.9	26.5
25SC	< 15	< 15	< 15	< 15
26SD	< 15	< 15	16.0	16.0
30SR-Center	< 15	20.3	< 15	19.9
30SR-North	28.3	< 15	27.9	< 15
30SR-South	< 15	50.9	< 15	50.5
40LP-Center	< 15	< 15	38.1	38.1
40LP-North	< 15	< 15	41.2	41.2
40LP-South	< 15	< 15	35.7	35.7

Table 3–2 SPL modeled for scenarios 5 and 6 - Mill barrier assessment

Receiver	Esc. 5 L_{Aeq} (dBA) No mill barrier	Esc. 6 L_{Aeq} (dBA) With mill barrier	Receiver	Esc. 5 L_{Aeq} (dBA) No mill barrier	Esc. 6 L_{Aeq} (dBA) With mill barrier
1PC	45.3	45.3	20PY	< 15	< 15
2PC	42.9	42.9	21PY	< 15	< 15
3PC	41.3	41.3	22PY	< 15	< 15
4PC	40.3	40.3	23SM	< 15	< 15
5PC	39.7	39.7	24SM	< 15	< 15
6PC	37.7	37.7	25SC	< 15	< 15
7PC	38.5	38.5	26SD	< 15	< 15
8PC	37.9	37.9	30SR-Center	< 15	< 15
9PC	34.7	34.7	30SR-North	< 15	< 15
10PC	32.3	32.3	30SR-South	< 15	< 15
11PC	28.6	28.6	40LP-Center	< 15	< 15
12PC	20.5	20.5	40LP-North	< 15	< 15
13PC	20.0	20.0	40LP-South	< 15	< 15
15CU	38.9	38.9			

Table 3–3 SPL modeled for Scenarios 1 to 4 - Baseline Monitoring Points

Receiver	Scenario 1 L_{Aeq} (dBA)	Scenario 2 L_{Aeq} (dBA)	Scenario 3 L_{Aeq} (dBA)	Scenario 4 L_{Aeq} (dBA)
NO2	29.3	29.3	29.0	29.9
NO3	< 15	< 15	47.2	47.2
NO4	34.6	< 15	34.3	< 15
NO5	< 15	30.9	< 15	30.5



LOCATION MAP

Legend

- ● Receptors
- ● Receptors Baseline
- — Paracel

Scenario 1

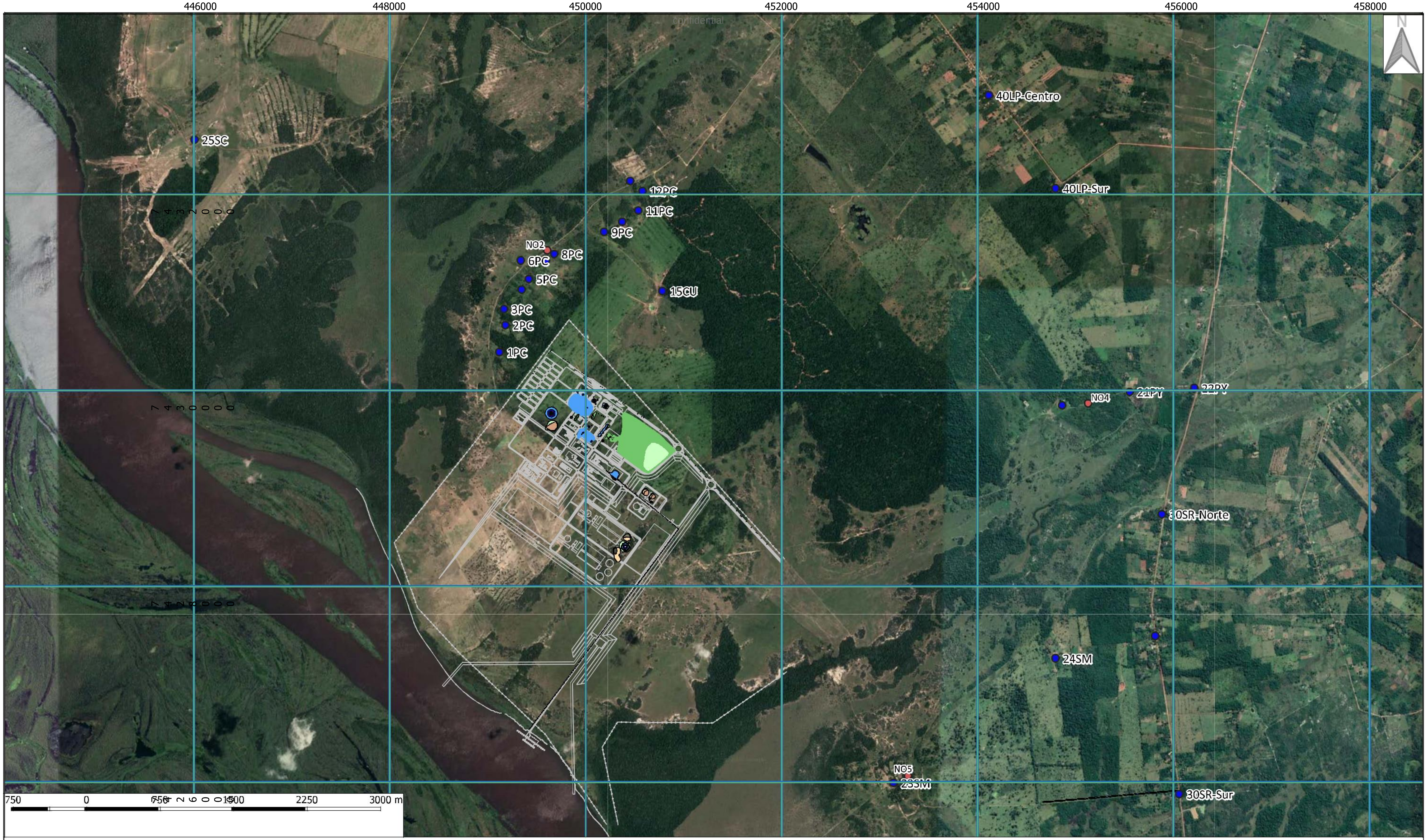
⬜	<= a 30.0 dBA
🟨	30.0 - 35.0 dBA
🟧	35.0 - 40.0 dBA
🟫	40.0 - 45.0 dBA
🟩	45.0 - 50.0 dBA
🟩	50.0 - 55.0 dBA
🟩	55.0 - 60.0 dBA
🟦	60.0 - 65.0 dBA
🟦	65.0 - 70.0 dBA
🟦	70.0 - 75.0 dBA
🟪	75.0 - 80.0 dBA
🟪	80.0 - 85.0 dBA

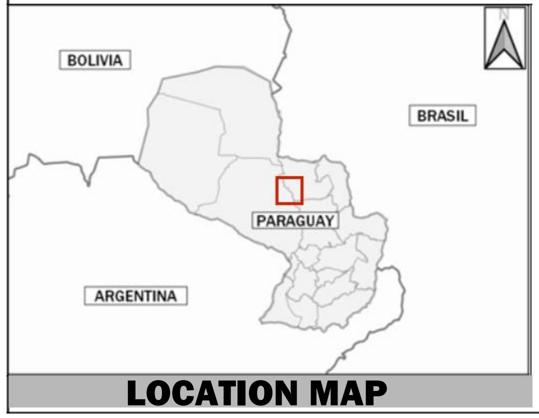
CSI Ingenieros

Noise modeling PARACEL

NPL MAP
SCENARIO 1

NUMBER
4-1





LOCATION MAP

Legend

- ● Receptors
- ● Receptors Baseline
- — Paracel

Scenario 2

- ⬜ <= a 30.0 dBA
- 🟨 30.0 - 35.0 dBA
- 🟧 35.0 - 40.0 dBA
- 🟫 40.0 - 45.0 dBA
- 🟩 45.0 - 50.0 dBA
- 🟩 50.0 - 55.0 dBA
- 🟩 55.0 - 60.0 dBA
- 🟦 60.0 - 65.0 dBA
- 🟦 65.0 - 70.0 dBA
- 🟦 70.0 - 75.0 dBA
- 🟪 75.0 - 80.0 dBA
- 🟪 80.0 - 85.0 dBA

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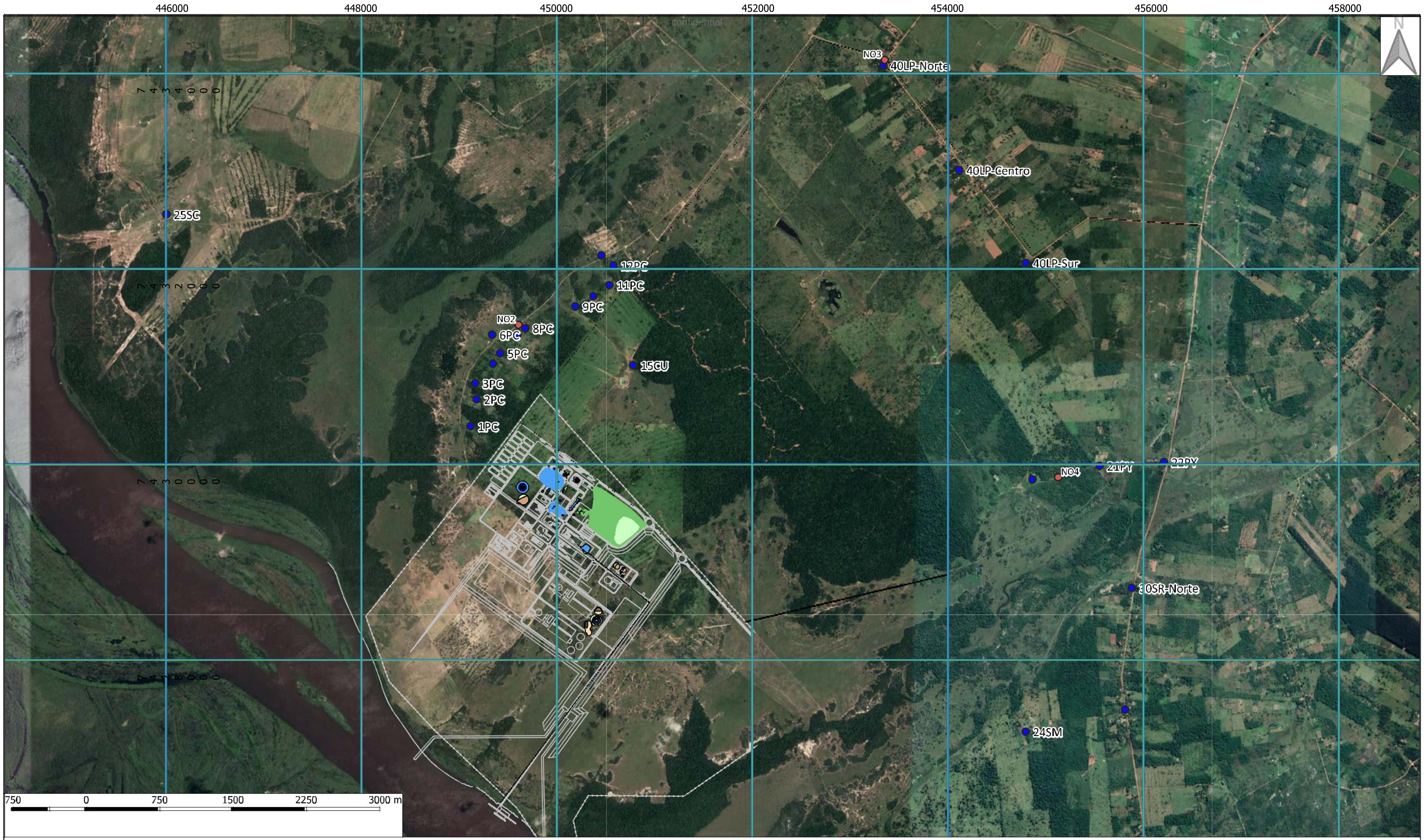
Noise modeling PARACEL

NPL MAP
SCENARIO 2

NUMBER
4-2



LOCATION MAP

Legend

- ● Receptors
- ● Receptors Baseline
- — Paracel

Scenario 3

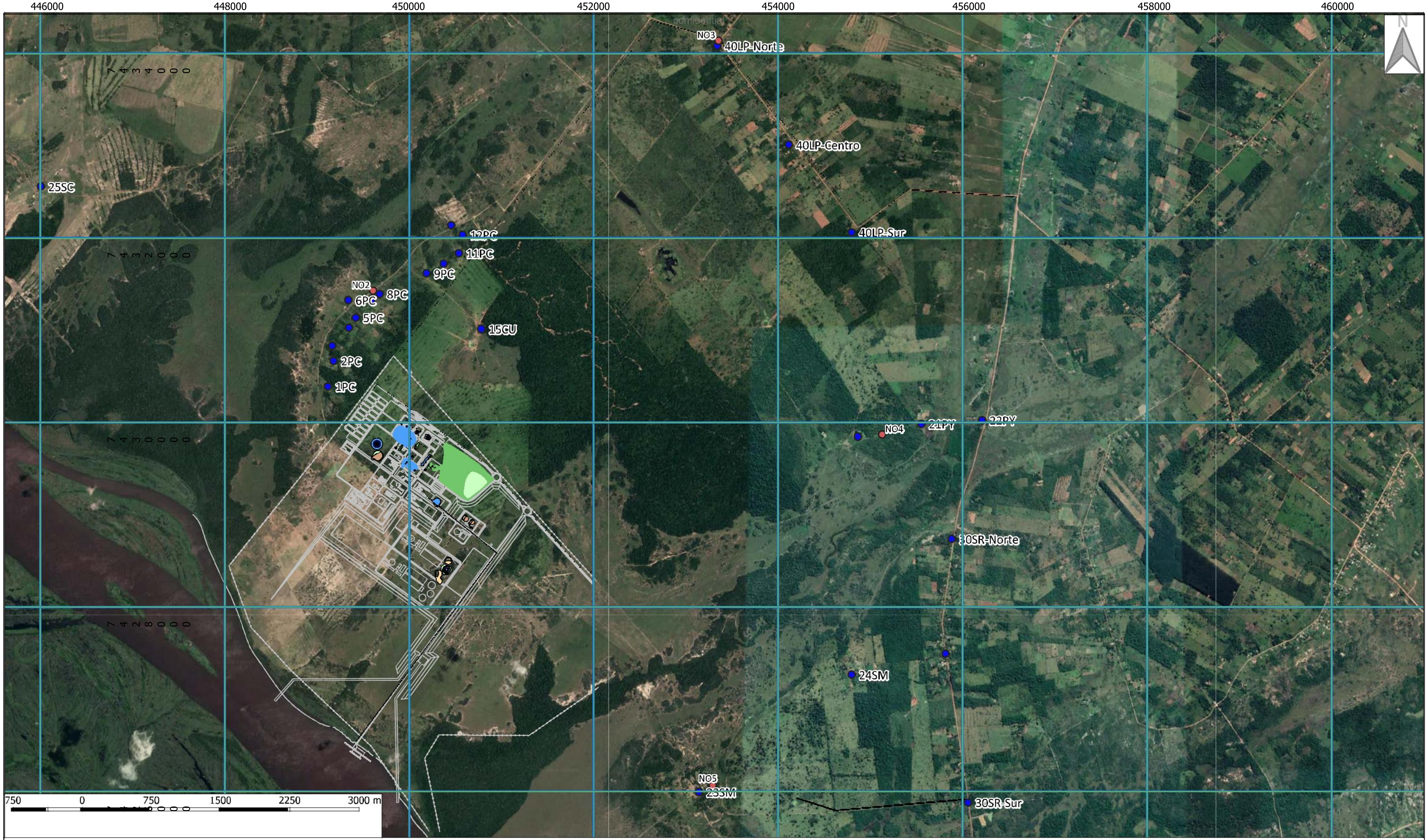
- ⬜ <= a 30.0 dBA
- 🟨 30.0 - 35.0 dBA
- 🟧 35.0 - 40.0 dBA
- 🟫 40.0 - 45.0 dBA
- 🟩 45.0 - 50.0 dBA
- 🟩 50.0 - 55.0 dBA
- 🟩 55.0 - 60.0 dBA
- 🟦 60.0 - 65.0 dBA
- 🟦 65.0 - 70.0 dBA
- 🟦 70.0 - 75.0 dBA
- 🟪 75.0 - 80.0 dBA
- 🟪 80.0 - 85.0 dBA

CSI Ingenieros

Noise modeling PARACEL

NPL MAP
SCENARIO 3

NUMBER
4-3



LOCATION MAP

Legend

● Receptors
● Receptors Baseline
— Paracel

Scenario 4

■	<= a 30.0 dBA
■	30.0 - 35.0 dBA
■	35.0 - 40.0 dBA
■	40.0 - 45.0 dBA
■	45.0 - 50.0 dBA
■	50.0 - 55.0 dBA
■	55.0 - 60.0 dBA
■	60.0 - 65.0 dBA
■	65.0 - 70.0 dBA
■	70.0 - 75.0 dBA
■	75.0 - 80.0 dBA
■	80.0 - 85.0 dBA

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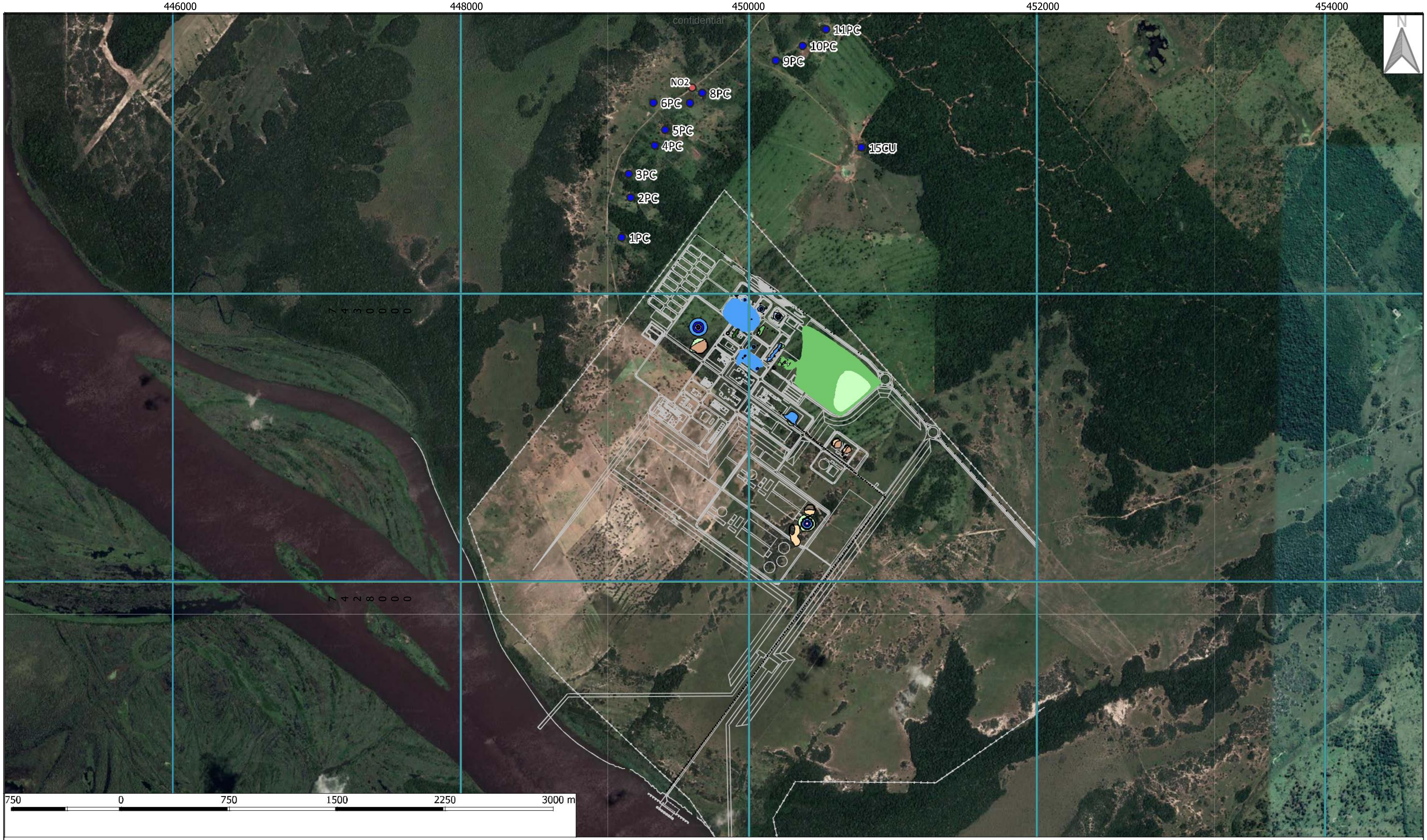
Noise modeling PARACEL

NPL MAP
SCENARIO 4

NUMBER
4-4



LOCATION MAP

Legend

- ● Receptors
- ● Receptors Baseline
- — Paracel

Scenario 5

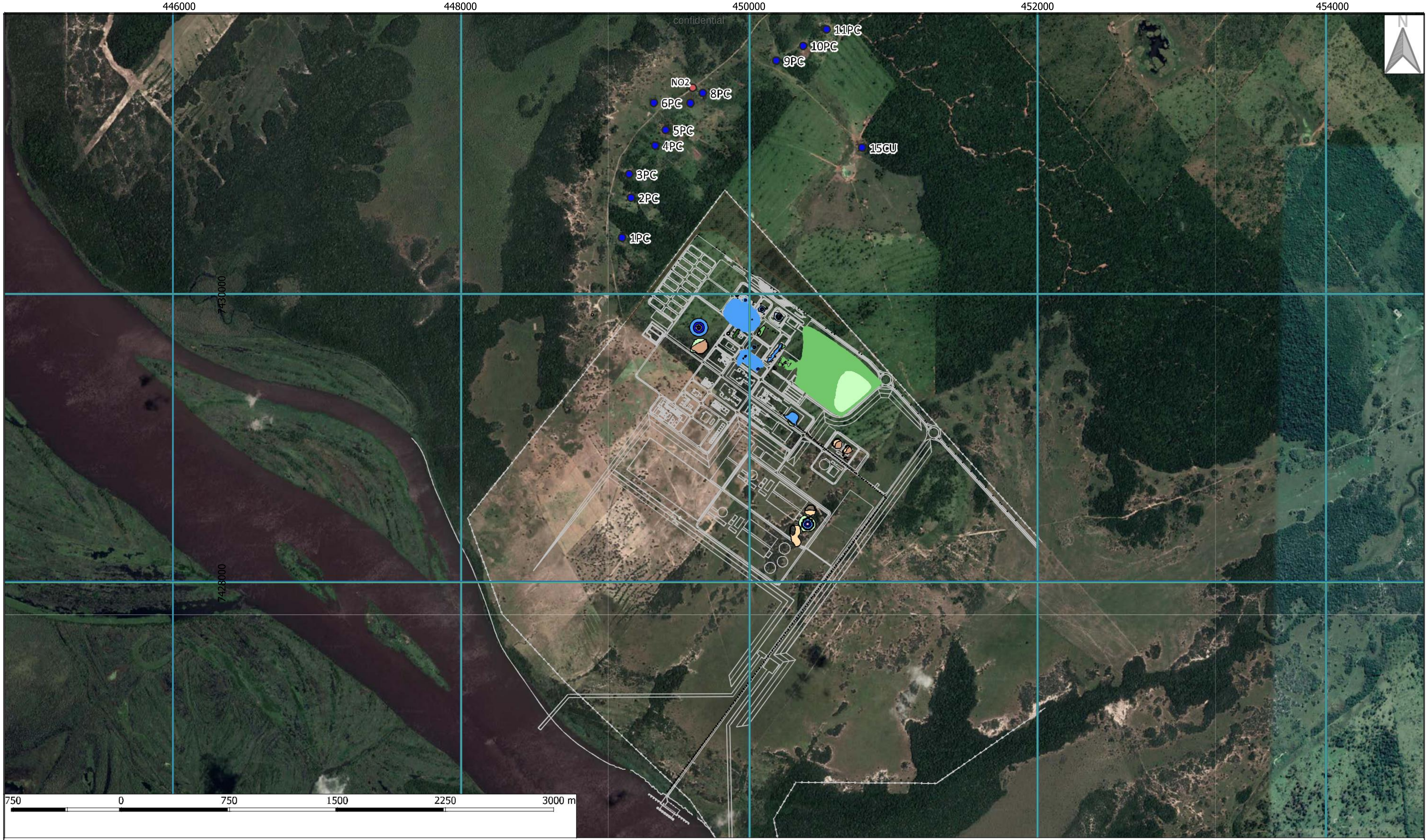
■	<= a 30.0 dBA
■	30.0 - 35.0 dBA
■	35.0 - 40.0 dBA
■	40.0 - 45.0 dBA
■	45.0 - 50.0 dBA
■	50.0 - 55.0 dBA
■	55.0 - 60.0 dBA
■	60.0 - 65.0 dBA
■	65.0 - 70.0 dBA
■	70.0 - 75.0 dBA
■	75.0 - 80.0 dBA
■	80.0 - 85.0 dBA

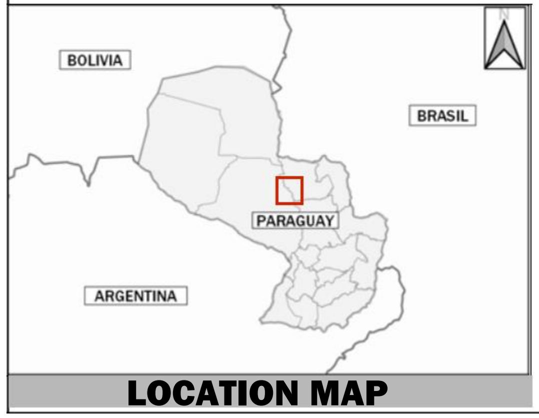
CSI Ingenieros

Noise modeling PARACEL

NPL MAP
SCENARIO 5 - SIN BARRERA VEGETAL

NUMBER
4-5





LOCATION MAP

Legend

- ● Receptors
- ● Receptors Baseline
- — Paracel
- ▨ Barrera Vegetal

Scenario 6

⬜	<= a 30.0 dBA
🟨	30.0 - 35.0 dBA
🟧	35.0 - 40.0 dBA
🟫	40.0 - 45.0 dBA
🟩	45.0 - 50.0 dBA
🟩	50.0 - 55.0 dBA
🟦	60.0 - 65.0 dBA
🟦	65.0 - 70.0 dBA
🟦	70.0 - 75.0 dBA
🟪	75.0 - 80.0 dBA
🟪	80.0 - 85.0 dBA

CSI Ingenieros

Noise modeling PARACEL

NPL MAP

SCENARIO 6 - CON BARRERA VEGETAL

NUMBER

4-6

4. Discussion of results

This chapter presents the analysis and discussion of SPL submission results presented in the previous chapter. This results analysis is performed with three approaches.

A) Compare baseline SPL values recorded in April 2020 at four points, with inputs from the future mill (intake values presented in Table 3-3, model result).

B) Compare the resulting theoretical SPL values on the evaluated receivers, taking into account the mill input (Table 3-1) and the baseline value measured at the nearest station with the applicable standards of reference standards.

C) Evaluation of mill barrier as a mitigation measure.

Regarding the first point of the discussion of the results, the baseline campaign records provided by PARACEL for measurement points NO2, NO3, NO4 and NO5 are presented below.

Table 4–1 Measured baseline values at evaluated receptors

Point of view Monitoring	Period of Measurement	SPL limit value according to Law 1100/97 (dBA)		L_{Aeq} (dBA) Records*
		Mixed area	Industrial area	
NO2	Day	70	75	50.7
	Night	55	60	38.8
NO3	Day	70	75	43.1
	Night	55	60	50.2
NO4	Day	70	75	34.5
	Night	55	60	35.9
NO5	Day	70	75	43.5
	Night	55	60	46.9

*value without pulp mill activity

To obtain the SPL values that would be recorded at each of the above points when the PARACEL pulp mill is operational, the baseline records (Table 4-1) must be sued logarithmically with the values obtained from the CadnaA model (Table 3-3). It is important to note that the sum of SPL is not algebraic under any circumstances, but is always logarithmic.

Table 4-2 presents the results of the addition of baseline SPL and modeled SPL, as well as their comparison with the adopted standards of reference standards. Values that meet the reference standards and orange values that exceed them are marked in green.

Table 4–2 Resulting SPL at baseline monitoring points for the future situation

Station	Period	Scenario 1 L_{Aeq} (dBA)	Scenario 2 L_{Aeq} (dBA)	Scenario 3 L_{Aeq} (dBA)	Scenario 4 L_{Aeq} (dBA)
NO2	Day	50.7	50.7	50.7	50.7
	Night	39.3	39.3	39.2	39.3
NO3	Day	43.1	43.1	48.6	48.6
	Night	50.2	50.2	52.0	52.0
NO4	Day	37.6	34.5	37.4	34.5
	Night	38.3	35.9	38.2	35.9
NO5	Day	43.5	43.7	43.5	43.7
	Night	46.9	47.0	46.9	47.0

According to the results presented in the Table above, the acoustic objectives set out in Law No. 1100/97 would be met at all monitored points and for all defined operating scenarios of the PARACEL pulp mill.

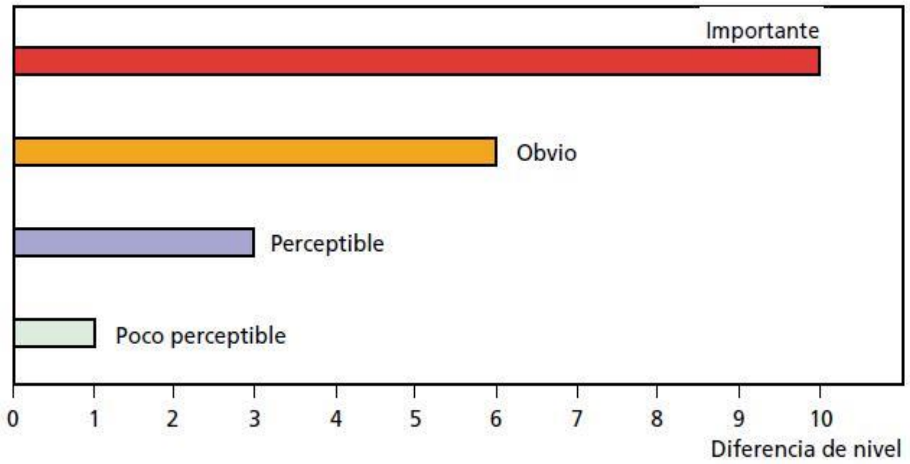
Table 4-3 presents the SPL's difference in in admission between the baseline situation and the future situation with the incremental contribution of the mill at the four baseline points. These contributions are null and void in 50% of cases, and less than 3 dBA in almost all remaining cases (87% of the remaining cases).

An increase of less than 3 dBA is considered to be noticeable according to the commonly used perception scale (Figure 4–1). The only exceptions are given in point NO3, during the day period and considering scenarios 3 and 4. In these cases, the differences between the basic situation and the future situation would be 5.5 dBA and would be obvious on the same level of perception.

Table 4–3 Contribution of the pulp mill to the records of the base situation

Point of view Monitoring	Period	Scenario 1 L_{Aeq} (dBA)	Scenario 2 L_{Aeq} (dBA)	Scenario 3 L_{Aeq} (dBA)	Scenario 4 L_{Aeq} (dBA)
NO2	Day	0.0	0.0	0.0	0.0
	Night	0.5	0.5	0.4	0.5
NO3	Day	0.0	0.0	5.5	5.5
	Night	0.0	0.0	1.8	1.8
NO4	Day	3.1	0.0	2.9	0.0
	Night	2.4	0.0	2.3	0.0
NO5	Day	0.0	0.2	0.0	0.2
	Night	0.0	0.1	0.0	0.1

Figure 4–1 Perception of sound differences in dBA



Source: Ambient Noise, Br.el & Kjor, 2000.

In relation to the second point, the resulting theoretical SPL values in the evaluated receptors are then evaluated, when the modeled mill input (Table 3-1) and baseline values measured at the nearest monitoring point are considered. These theoretical values are also compared with the reference standards of the applicable regulations.

To do this, the values resulting from the addition of the modeled SPL and the assumed baseline records, obtained by logarithmic sum, are presented in Table 4-4. Values that exceed the reference standards of the applicable regulations are marked in orange.

According to the above, the reference standards are exceeded only twice, which means a non-compliance rate of less than 1%. In particular, the reference standard is exceeded on the 22PY receiver, during the night period in scenarios 1 and 3 (scenarios that consider as main vehicle access to option A).

Taking the applicable standards of reference, the calculated values exceed the acoustic quality targets by less than 7 dBA or less than 2 dBA as the area is considered as mixed or industrial.

It is important to note that the calculated surplus is due only to the flow of heavy vehicles, since in scenario 3 light vehicles are considered to be driven entirely through backup access. In addition, the effect of the mill can be relativized by compliance with the reference standards in scenarios 2 and 4, where it is considered as the main access of vehicles to option B.

As regards the third point in the discussion of the results, where the effectiveness of a mill barrier is assessed as a mitigation measure, the calculated values for scenarios 5 and 6, presented in Table 3-2, should be compared. In this sense, it is clear that the mill barrier has a zero effect on the attenuation of the emission SPL for the receivers concerned, since none of the results of the model is modified when the barrier is introduced into the software.

Table 4–4 Mill contribution to each sensitive receptor considering LB

Receiver	Point of view Monitoring Considered	Scenario 1 L_{Aeq} (dBA)		Scenario 2 L_{Aeq} (dBA)		Scenario 3 L_{Aeq} (dBA)		Scenario 4 L_{Aeq} (dBA)	
		Day	Night	Day	Night	Day	Night	Day	Night
1PC	NO2	51.8	46.2	51.8	46.2	51.8	46.2	51.8	46.2
2PC		51.4	44.3	51.4	44.3	51.4	44.3	51.4	44.3
3PC		51.2	43.2	51.2	43.2	51.2	43.3	51.2	43.3
4PC		51.1	42.6	51.1	42.6	51.1	42.6	51.1	42.6
5PC		51.0	42.3	51.0	42.3	51.0	42.3	51.0	42.3
6PC		50.9	41.3	50.9	41.3	50.9	41.3	50.9	41.3
7PC		51.0	41.7	51.0	41.7	51.0	41.8	51.0	41.8
8PC		50.9	41.4	50.9	41.4	50.9	41.5	50.9	41.5
9PC		50.8	40.2	50.8	40.2	50.9	40.7	50.9	40.7
10PC		50.8	39.7	50.8	39.7	50.8	40.6	50.8	40.6
11PC		50.7	39.2	50.7	39.2	50.9	40.8	50.9	40.8
12PC		50.7	38.9	50.7	38.9	50.8	39.8	50.8	39.8
13PC		50.7	38.9	50.7	38.9	50.7	39.3	50.7	39.3
15CU		51.0	41.9	51.0	41.9	51.0	42.0	51.0	42.0
20PY	NO4	37.8	38.5	34.5	35.9	37.6	38.3	34.5	35.9
21PY		42.3	42.6	34.5	35.9	42.0	42.2	34.5	35.9
22PY		61.8	61.8	34.5	35.9	61.4	61.4	34.5	35.9
23SM	NO5	43.5	46.9	43.8	47.0	43.5	46.9	43.7	47.0
24SM		43.5	46.9	43.6	46.9	43.5	46.9	43.6	46.9
25SC	NO2	50.7	38.8	50.7	38.8	50.7	38.8	50.7	38.8
26SD	NO3	43.1	50.2	43.1	50.2	43.1	50.2	43.1	50.2
30SR-Center	NO5	43.5	46.9	43.5	46.9	43.5	46.9	43.5	46.9
30SR-North	NO4	35.4	36.6	34.5	35.9	35.4	36.5	34.5	35.9
30SR-South	NO5	43.5	46.9	51.6	52.4	43.5	46.9	51.3	52.1
40LP-Center	NO3	43.1	50.2	43.1	50.2	44.3	50.5	44.3	50.5
40LP-North		43.1	50.2	43.1	50.2	45.3	50.7	45.3	50.7
40LP-South		43.1	50.2	43.1	50.2	43.8	50.4	43.8	50.4

5. Conclusions

- The installation and operation of the PARACEL pulp mill would not result in significant changes in the local sound environment if the baseline measurements available for the area are taken into account. Only one of the benchmarks would the difference in the emission of SPLs be perceived as obvious when considering the transit of all light vehicles by backup access. However, the scenario where all light vehicles are driven through backup access would occur in exceptional situations, not being part of the expected normal operational dynamics of the mill.
- In relation to the previous point, it should be noted that the reference standards of the applicable regulations would be met at all points of the baseline.
- The installation and operation of the PARACEL pulp mill would not generate incremental contributions to the local sound environment that result in non-compliance with acoustic quality targets in any of the receivers when considering the transit of vehicles through access B.
- For scenarios that consider vehicle traffic through access A, the benchmarks would be exceeded in one of the 27 receivers evaluated (22 PY) during the night period. This surplus would be 7 dBA if the study area is considered mixed and 2 dBA if the area is considered as industrial.
- The above results do not imply that the operation of the pulp mill is imperceptible from the point of view of the SPL's emission, or that it does not have the potential to generate discomfort in some cases, since perception is a subjective parameter that is not directly linked to the absolute values of emission. However, it can be ensured from an objective point of view, through the quantification of the increase effect of SPL and its comparison with the reference standards, that its impact would not be significant when meeting the objective values of acoustic quality.
- Finally, it is emphasized that the mill barrier would have a zero effect on the attenuation of the emission SPL for the receivers concerned, since none of the model results are modified when the barrier is introduced into the modelling.

6. Intervening technicians

- I'm squid. Emilio Deagosto, MSc. (technical manager)
- You're a. I'm squid. Fernando Diaz

ANNEX I
BUILDINGS, TANKS AND FOUNTAINS

Annex Buildings, tanks and fountains

May 2020

Index

Figure index

Table index

1. Introduction

The first step of modeling should be put together the physical model of the mill, for which the main buildings must be loaded into the model, considering both buildings and tanks.

The data on heights and considerations assumed in respect of these structures are summarized in this Annex.

All tanks and buildings were considered as reflective (silent facade/reflective display), i.e. they correspond to an acoustic absorption coefficient of 0.21 according to the model used.

Once the physical model of the pulp mill is lifted, the sound sources to be modeled, located georeferenced and assigning them a certain height are added.

Three types of fonts are considered:

- Linear sources to represent internal streets and floor access;
- Surface sources to represent emission from buildings;
- Point sources to represent the emission of equipment located outdoors.

All information about buildings, sources, location and issuance was provided by PARACEL. In cases where necessary it was supplemented with information from the CSI Ingenieros database, generated in similar studies at pulp mills in Uruguay.

2. Building and Tank Data

2.1. Buildings

Table 2-1 Height and nomenclature of buildings

Name of the building	Relative height considered (m)
Cooking and Fiber Line	78
Drying	26
Chemical preparation	3
Oxygen mill	3
Chlorine Dioxide Plant	3
Oxygen Plant	3
Evaporation	30
Recovery Boiler	82
Causticizing and Lime Kiln	40
Power boiler	39
Turbogenerators/Diesel Generator	26
Cooling Tower	16
Water Treatment Plant	10
Central control building	8
Warehouse maintenance and supplies	15
Office/Laboratory	8
Dressing room	8
First aid and medical facilities	8
Kitchen/Cantina	8

2.2. Tanks

Table 2-2 Tank height and nomenclature

Tank name	Radius (m)	Height (m)
Effluent treatment plant cooling towers	38,8	22
Chimney	3	140
Biomass Silo	57,0	33

3. Sources considered

3.1. Fixed sources

All values were entered as PLW in single band of 500 Hz, i.e. as sound pressure level in dB relative to the reference sound value of 1 pW (when considered at 500 Hz it is interpreted as the A weighted sound level (dBA)).

Table 3-1 List of fixed sources considered

Physical place	Value considered(dBA)	Height (m)
Wood Yard	115	5
Cooking and fiber line	110	Dimensions of the building (h-78)
Drying	105	Dimensions of the building (h-26)
Chemical preparation	100	1
Chlorine dioxide plant	100	1
Oxygen plant	105	1
Evaporation	110	Dimensions of the building (h-30)
Recovery boiler	110	Dimensions of the building (h-82)
Causticizing and Lime Kiln	110	Dimensions of the building (h-40)
Power boiler	105	Dimensions of the building (h-39)
Turbogenerators	85 to 1m, K-2dB	1
Cooling tower	110	Dimensions of the building (h-16)
Water treatment plant	95	Dimensions of the building (h-10)

3.1.1. Point sources

A source is classified as point when its dimensions are very small compared to distances to receivers. In this case the sound energy is propagated spherically. All sources corresponding to equipment, pumps, engines, cooling towers, etc. are considered spot.

3.1.2. Surface sources

Buildings are not only obstacles to the propagation of sound, but can also emit noise in the surroundings, this will be the case for sources that are inside buildings, such as pulp drying buildings, recovery boiler, engine room in the water treatment plant, among others.

In these cases the internal sources are modeled as sources in the facades of the building, these are located 0.05 m from the facade and is considered a transmission loss of 30 dB (value suggested by the model for industrial buildings for 500 Hz).

3.2. Mobile sources - vehicles

The emission generated by transit circulating through the internal accesses and transit routes to the mill is modeled as linear sources, considering for all cases that the transit is evenly distributed throughout the day.

Below are the data provided by PARACEL of routes through possible access to the mill (Table 3-2) and internal route (Table 3-3).

The routes of circulation are those presented in Figure 3-1 for each vehicle typology.

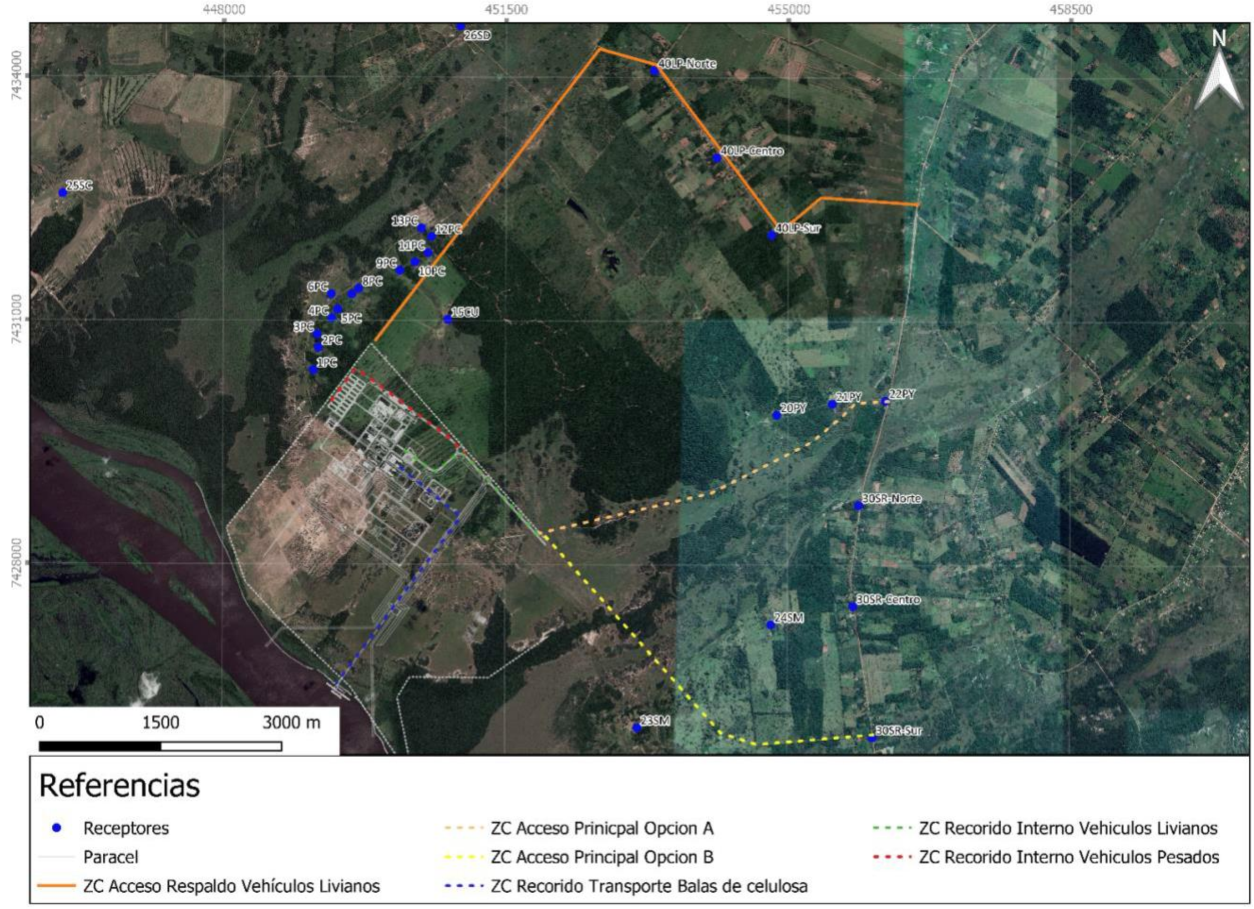
Table 3-2 Mill Access Income Data

Travel	Vehicle Flow Light	Vehicle Flow Heavy	Top speed (km/h)
ZC Main Access Option A	30 vehicles/h	15 trucks/h	60
ZC Main Access Option B	30 vehicles/h	15 trucks/h	60
ZC Main Access Backup Light Vehicles	30 vehicles/h	-	60

Table 3-3 Route Data Within Mill

Travel	Vehicle Flow	Top speed (km/h)
ZC Internal Tour Light Vehicles	30 vehicles/h	30
ZC Internal Tour Heavy Vehicles	15 trucks/h	30
ZC Route Transport Bullets From Pulp	6 trucks/h	30

Figure 3-1 Vehicle tour



ANNEX V

SELF DEPURATION STUDY

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ENVIRONMENTAL NAD SOCIAL IMPACT ASSESSMENT (ESIA)

Date 31.05.2021

Reference 109001759-003-0000-E-1501

PARACEL

Pulp Mill, River Port, Transmission Line and Electrical Substation in Concepción - Paraguay

VOLUME IV – COMPLEMENTARY STUDIES

ANNEX V – SELF-DEPURATION STUDY

Content

Attachments

Distribution	
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Orig.	31/05/21 – bvv	31/05/21 – hbo	31/05/21 – hfw	31/05/21 – hfw	for information
Rev.	Date /Author	Date /Verified	Date /Approved	Date/Authorized	Remarks

SUMMARY

Orig.	31/05/21 – bvv	31/05/21 – hbo	31/05/21 – hfw	31/05/21 – hfw	for information
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1 INTRODUCTION

One of the most relevant issues to contemporary society is the hydric resources preservation. In Paraguay the concern on this matter is evidenced on the federal law of water resources n^o 3239/2007 (PARAGUAY, 2007), which is aimed at to regulate the sustained management of any water and springs, irrespective of their location, physical state or its natural occurrence in Paraguay territory, making it social, economic and environmentally-sustainable for the population. According to Article 37 of this law, the permission to use water resources for effluents discharge into any natural watercourse must be granted (PARAGUAY, 2007).

The increasing water demands for multiple uses result in significant environmental impacts (quantitative and qualitative) and disputes over water use, affecting the maintenance of natural aquatic ecosystems. In this context, the Resolution n^o 222/02 (PARAGUAY, 2002) sets water quality standards and intended levels of effluent treatment for all of the national territory, separated into four classes according to the preponderant use.

According to Jhunior et al. (2020), the seek for solutions to water management problems, on a local or basin scale, becomes more efficient with the use of computational tools which act as decision support system. In this regard, water quality models can be useful tools in the assessment for the support capacity of a receiving water (self-depuration capacity). Such models are based on a set of equations whose solution will provide the spatial and temporal distribution of water quality indicator parameters in solution or suspension of a watercourse.

Most current computing tools generate a numerical solution of advective/diffusive equations for a physical and chemical processes, what is called a numerical simulation. Once the model is calibrated, it will be possible to perform innumerable scenarios.

There are many computational tools available for water quality simulation in rivers and reservoirs, whose choice depends on the water system complexity level. The present study used the computational tool called Water Quality Analysis Simulation Program - WASP, developed by United States Environmental Protection Agency – EPA (EPA, 2021).

The purpose of this study was to evaluate the influence of a punctual discharge of a pulp mill treated effluent in the self-depuration capacity of Paraguay River (approximately 300 km). The treated effluent discharge point is located at 20 km upstream of the urban area of Concepción city – Paraguay. The self-depuration model extends from this point until near the Asunción city – Paraguay.

The water quality indicator parameters analyzed were: pH, total suspended solids (TSS), dissolved oxygen (DO), biochemical oxygen demand (BOD), total phosphorus, ammonium and nitrate. The input data of WASP (climatological data, water discharge, water quality and consumptive demands) were obtained from documents provided by the contractor, National Water Agency (ANA, 2021), National Institute of Meteorology (INMET, 2021), Directorate of Meteorology and Hydrology (DMH, 2021).

2 STUDY AREA

The Paraguay River Basin has a drainage area of almost 365.592 km^2, and a length of 2,695 km from its source to its mouth. Most of their sub-basins are located in Paraguay, which also has areas in Brazil, Bolivia and Argentina. The Paraguay River is the main affluent on the right bank of the Parana River, one of the major tributaries of the Platina Basin.

The source of the Paraguay River is in the Chapada dos Parecis, Brazil, and follows south, continue along the edge between the Amazon and Cerrado biomes entering in the Pantanal biome in the region of Cáceres, where it follows until reach Paraguay (ANA, 2021a).

In Brazil, “the Paraguay river basin district occupies 4.3% of the territory, covering parts of the Mato Grosso and Mato Grosso do Sul states, which included the largest part of Pantanal-matogrossense, the biggest continuous humid area of the planet” (ANA, 2021b). In Paraguayan territory, the Paraguay River flows through the main regions of the country, from north to south, reaching its mouth at Parana River in Paso de Patria. The main tributaries in the Paraguay River in Paraguayan territory include: on the right bank the Yacaré River, Mosquito River, Gonzalez stream, San Carlos River, Verde River, Siete Puntos River, Montelindo River, Negro River and Aguaray Guazú River; on the left bank the APA River, Tagatija River, Aquídaban River, Ypané River, Jejui Guazú River, Manduvirá River e Piribebuy stream.

According to Figure 1, the stretch of Paraguay river analyzed has around 300 km, from the effluent discharge point, 20 km upstream of the urban area of Concepción city (Water Quality Station WQS-2), until near the Asunción city. The stretch between WQS-1 and WQS-4 was used in the calibration process of biochemical and physical coefficients (see Figure 1).

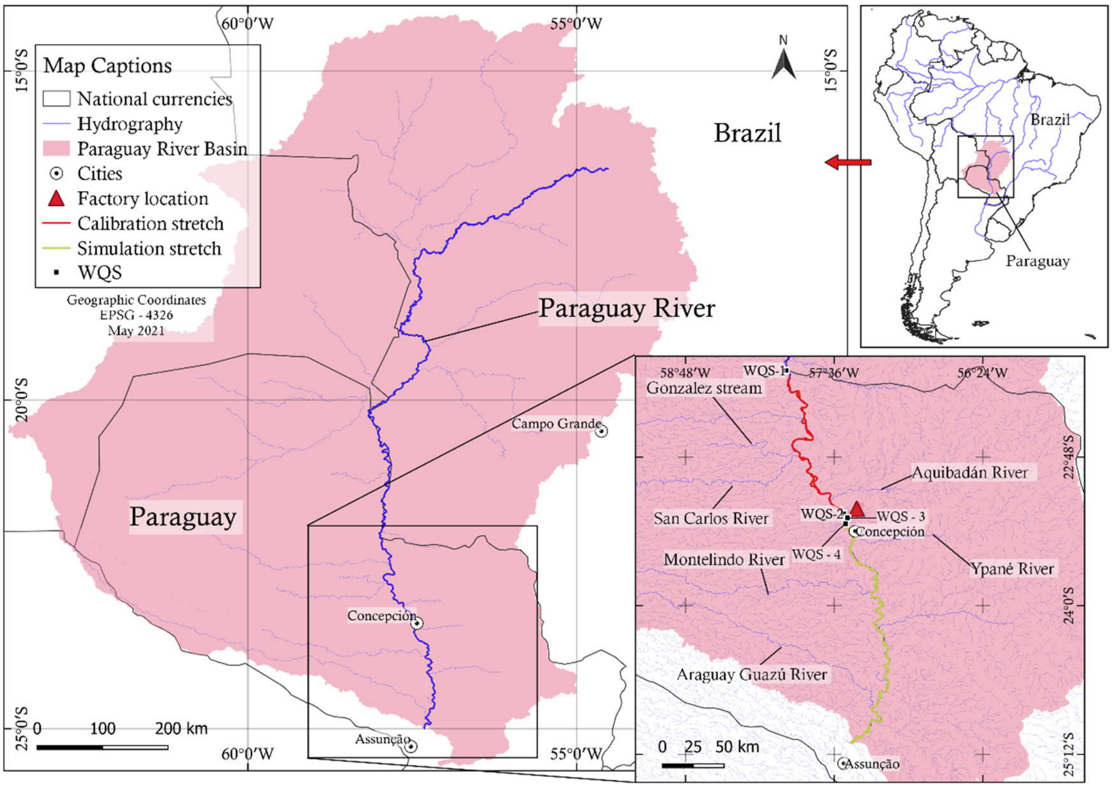


Figure 1 - Identification of stretchs and points of interest in Paraguay River study area. Author (2021)

The region of capital Asunción has a humid hot and temperate environment, with minimum temperature of 13.1ºC in July and maximum of 32.3ºC in January and an average annual rainfall of 1629 mm. Concepción city has a tropical climate, with minimum temperature of 15.1ºC in July and maximum of 32.9ºC in January an average annual rainfall of 1618 mm (CLIMATE, 2021).

The use and occupation of the soil is composed predominantly of natural vegetation (56.5%) and floodplain vegetation (26.4%), with minor uses in pasture (11.2%) and agriculture (7.2%).

Due to the high availability of water resources in Paraguay River and the lack of systematic geo-referenced data, the present study did not consider the possible consumptive demands granted by the environmental agency of Paraguay.

3 WASP TOOL

The computational tool Water Quality Analysis Simulation Program – WASP was developed by the United State Environmental Protection Agency – EPA. It is a dynamic modeling tool in aquatic systems, including the supernatant liquid layer, the benthic layer and the interaction between them. It allows the user to investigate lentic and lotic environments in 1, 2 and 3 dimensions for a variety of water quality parameters. The advective and diffusive process, the punctual and diffuse mass loading and border change processes are represented in the model. The tool can also be linked to hydrodynamic and sediment transport models that can provide flows, temperature, salinity and sediment flows. The WASP8 version predicts the demand for sedimentary oxygen and the nutrient flows of underlying sediments (EPA, 2021). The mathematical equations used by the tool to estimate the behavior of the various water quality parameters in a lentic and lotic environment can be consulted in EPA (2021).

3.1 WASP tool application

According to EPA (2021), WASP is one of the most used water quality models in the United States and worldwide. Due to the modules capacity to integrate various types of pollutants, this tool has application in all the main estuaries in Florida, where it links to a hydrodynamic and watershed model, simulating 12 continuous years in the development of numerical criteria for nutrients in aid to US EPA. Also according to EPA (2019), other uses of WASP include eutrophication from Tampa Bay, FL; phosphorus loading to Lake Okeechobee, FL; eutrophication of the Neuse River estuary, NC; eutrophication of the Coosa River and reservoirs, AL; PCB pollution of the Great Lakes, eutrophication of the Potomac estuary, pollution of the James River estuary, volatile organic pollution of the Delaware estuary, and heavy metal pollution of the Deep River, North Carolina, mercury in the Savannah River, GA. The potential of the WASP computational tool can be confirmed by several scientific publications in qualified journals, such as Knightes et al. (2019), Camacho et al. (2018), Li et al. (2018), Yu et al. (2016), Lai et al. (2013), Lin et al. (2011), Franceschini and Tsai (2010), among others.

4 HYDRIC SYSTEM TOPOLOGY

In this study, before tracing the topology of the water system, it was important to understand the river channel morphology. The course of the Paraguay River in Paraguay takes place in alluvial valleys, characterized by reduced bottom slopes with well accentuated flood plains in some regions due to the dynamics of transport and deposition of sediments.

The sinuosity index in the Paraguay River between Concepción and Asunción is between 1.30 to 1.38, which does not characterize this stretch as meandric but sinuous. It is also observed that in approximately 102 km (37% of the stretch) there is a branched river pattern, with a predominance of 2 to 3 well-defined branches.

In the topology tracing of the water system, in face of the observed morphology, was made the option for the use of a single segment for the single stretches of river and multiple parallel segments for the branched stretches. In these branches, the width coefficient for the flow division was used, according to the explanatory scheme of the flow division shown in Figure 2 and Equations 1 to 3.

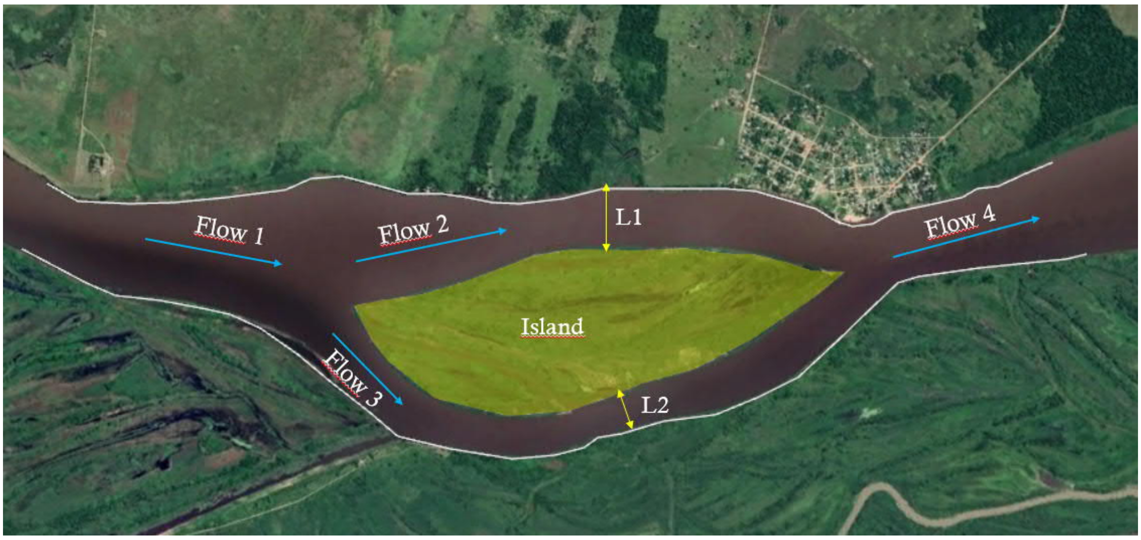


Figure 2 - Flow division scheme in branched segments. Author (2021).

$$\textbf{Flow 1} = \textbf{Flow 2} + \textbf{Flow 3} = \textbf{Flow 4} \qquad (1)$$

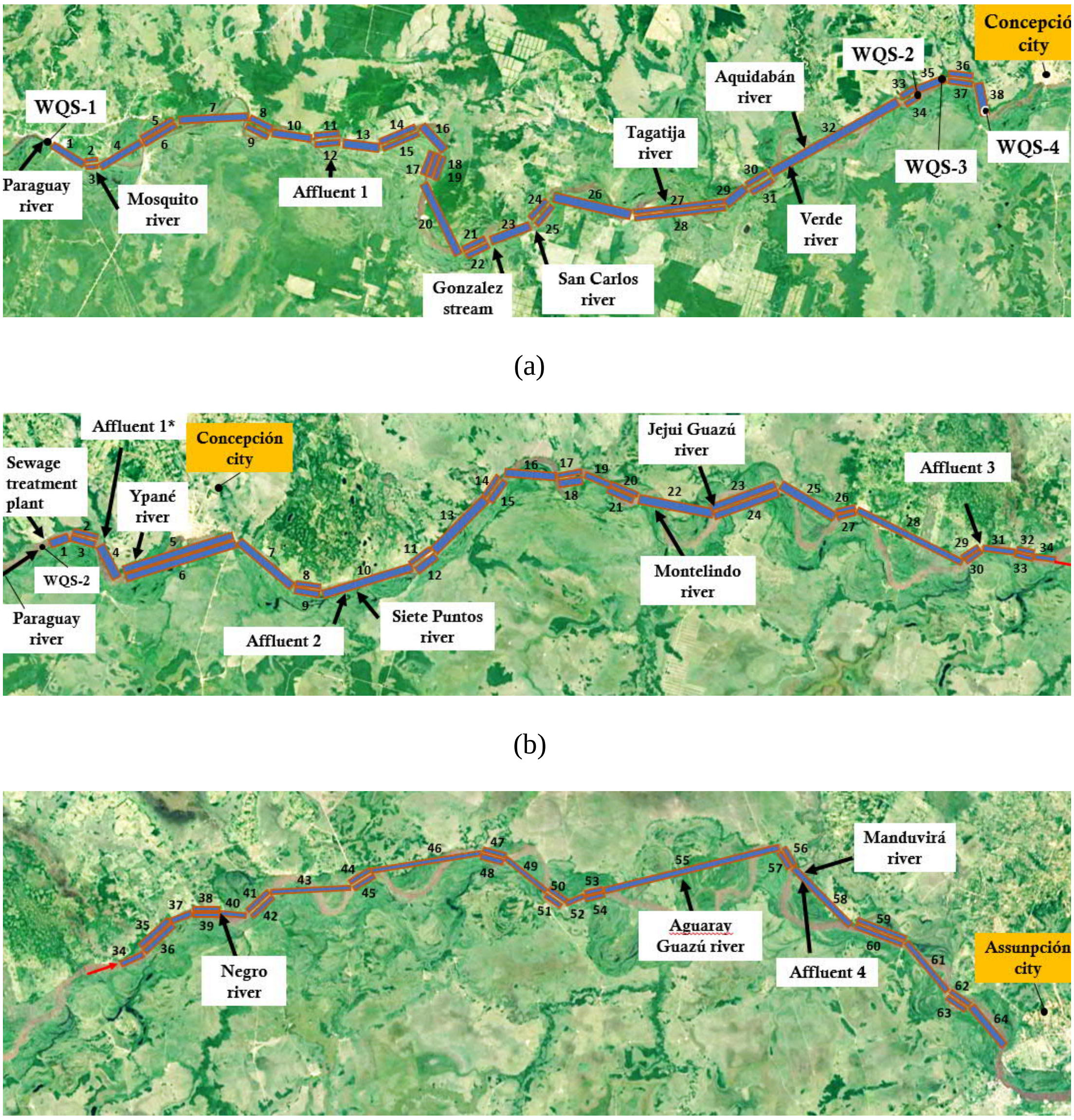
$$\textbf{Flow 2} = \textbf{Flow 1} \times [\, L_1/(L_1 + L_2)] \qquad (2)$$

$$\textbf{Flow 3} = \textbf{Flow 1} \times [\, L_2/(L_1 + L_2)] \qquad (3)$$

In this study, two independent topologies were defined in different sections, being a topology for the calibration of the physical and biochemical coefficients (stretch between the water quality station WQS-1 and WQS-4 - see Figure 3a) and another topology for the study of self-depuration capacity in face of a treated effluent discharge from a paper and pulp industry (stretch between the water quality station WQS-2 and the nearby upstream of Asunción city - see Figures 3b and 3c).

The calibration topology has 38 segments, distributed in 13 single channels and 12 with branched channels (Figure 3a), whose specific contributions considered were: Paraguay river in WQS-1; tributaries on the right bank (Mosquito River, Affluent 1, Gonzalez stream, San Carlos River and Verde River); tributaries on the left bank (Tagatija River and Aquidabán River); direct diffuse contributions on the right and left margins.

The self-depuration capacity topology has 64 segments, distributed in 22 unique channels and 21 with branched channels, whose specific contributions considered were: Paraguay River nearby the treated effluent discharge (WLS-2); effluent from the paper and pulp industry; tributaries on the right bank (Affluent 1, Affluent 2, Siete Puntos River, Montelindo River, Negro River, Aguaray Guazú River and Affluent 4); tributaries on the left bank (Ypané River, Jejui Guazú River, Manduvirá River and Affluent 3); direct diffuse contributions on the right and left margins (Figures 3b and 3c).



(a)

(b)

(c)

Figure 3 – Water system topology: a) calibration stretchs; b) and c) stretchs of self-depuration capacity model. Author (2021).

The water system topology was kept fixed in all simulations, both in calibration process and self-depuration capacity model.

5 INPUT DATA

This item presents the methodologies for obtaining fluviometric input data, consumptive demands, water quality, climatological and hydraulic coefficients and geometries assumed in calibration simulations of physical and biochemical coefficients and in the self-depuration capacity model of the Paraguay River.

5.1 Fluviometric data

5.1.1 Calibration process

As already mentioned in the topology item, the section of Paraguay River used in the process of calibrating the physical and biochemical coefficients starts at WQS-1 and ends at WQS-4 (close to Concepción city). According to Figure 4, the input flows considered include: Paraguay River in WQS-1; tributaries on the right bank (Mosquito River, Affluent 1, Gonzalez stream, San Carlos River and Verde River); tributaries on the left bank (Tagatija River and Aquidabán River); direct diffuse contributions on the right and left margins.

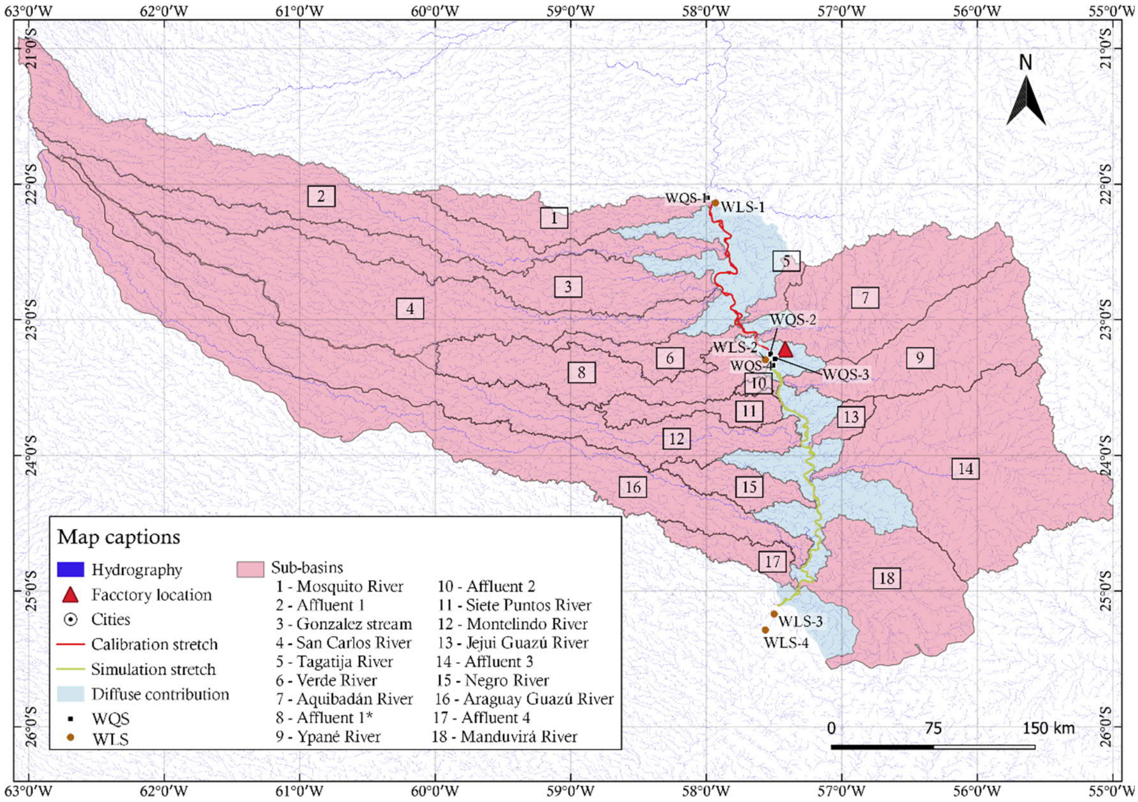


Figure 4 - Watersheds considered in the calibration and simulation stretchs. Author (2021).

Due the absence of fluviometric monitoring stations in this region, a synthetic series were estimated based on hydrological rainfall-flow modeling. The methodology used was:

1º) DMH (2021) has a Water Level Station - WLS next to WQS-2, identified as WLS-2 (see Figure 4). The contracting company provided the turn-key in WLS-2, presented in Equation 4.

$$\mathbf{Q = 547.43 + 583.57 \times H - 26.18 \times H^2} \qquad \mathbf{(4)}$$

Where: Q is the flow in m³/s; H is the water level in meters. With this equation and the water levels available in WQS-2 it was possible to estimate the flows in the section of Paraguay River where these stations are located.

The HBV hydrological model, available in the tool Evaluación de los Recursos Hidricos - EvalHID (COSTA, 2015; MAS, 2013; PAREDES-ARQUIOLA et al. 2014; SALLA et al. 2015), was used to estimate the flow in the input fluviometric datas. The HBV model request as input data the pluviometric and climatological potential evapotranspiration series, provided by ANA (2021) and DMH (2021) stations (see Figure 5). It's also necessary the contribution area of a watercourse (in km^2 – Figure 4) and a series of monitored flows for model calibration (in this case the flows estimated by the Equation 4).

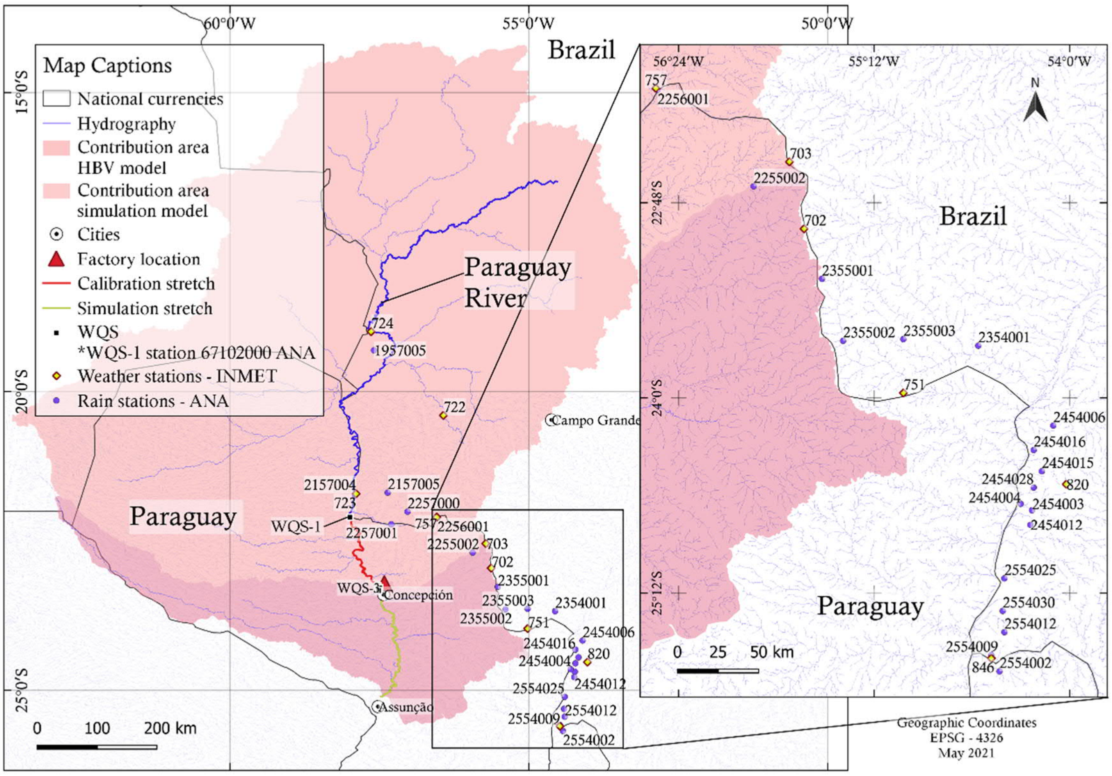


Figure 5 - Pluviometric (rain), climatological (weather) and fluviometric stations used. Author (2021).

The pluviometric and evapotranspiration series in the contribution area centroid of WLS-2 were obtained using the Inverse Squared-Distance Weighting (EUCLYDES et al., 1999; GIRARDI et al. 2013; SILVA, 2011; SOARES, 2000).

The HBV rain-flow hydrological model uses a series of coefficients to estimate surface, subsurface and base flow, being: k_0 - surface flow coefficient (1/T); k_1 - subsurface flow coefficient (1/T); k_2 - base flow coefficient (1/T); $k_{perc.}$ - percolation coefficient (1/T); L_{max}.- maximum subsurface flow limit (L), in addition to adjustment coefficients (PWP, FC and β). The calibration of these coefficients, necessary to adapt the simulations to the characteristics of each sub-basin, was carried out using the SCE-UA evolutionary algorithm (Shuffled Complex Evolution method, University of Arizona), developed by Duan et al. (1992) *apud* Paredes-Arquiola et al. (2014). This algorithm adjusted the synthetic series of simulated flows to the historical series estimated in WLS-2, varying these coefficients. Figure 6 shows the fit between the synthetic and historical flow series in WLS-2. The calibration period (10/2006 to 03/2021) was chosen according to the period of pluviometric and evapotranspiration data available in the stations 724, 722, 723 and 1957005.

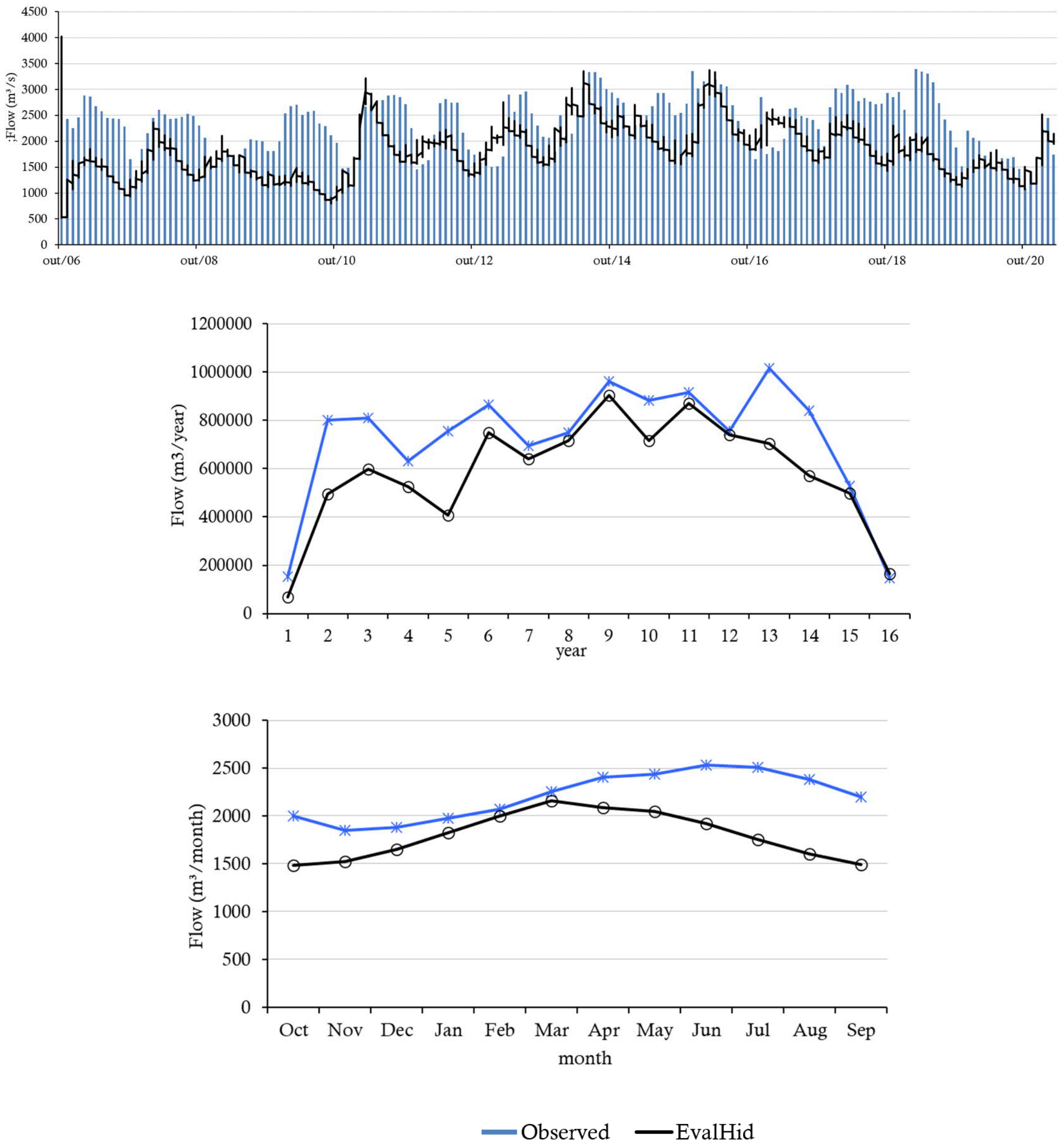


Figure 6 - Adjustment between synthetic and historical flow series in WLS-2. Author (2021).

2º) The concept of hydrologically homogeneous regions was used to estimate the synthetic series of flow in WQS-1 and in the punctual sub-basins and diffuse contributions (BARBOSA et al. 2005; EUCLYDES, 1999; TUCCI, 2005). The hydrological homogeneity is in the similarities of morphological, climatic characteristics and land use and occupation. Figure 7 shows the similarities in land use and occupation in study area, carried out using maps of supervised classification of multispectral images provided by the MapBiomas Chaco project (MAPBIOMAS, 2021). This concept allowed the use of the calibrated coefficients of HBV model obtained in the previous step in other regions and tributaries.

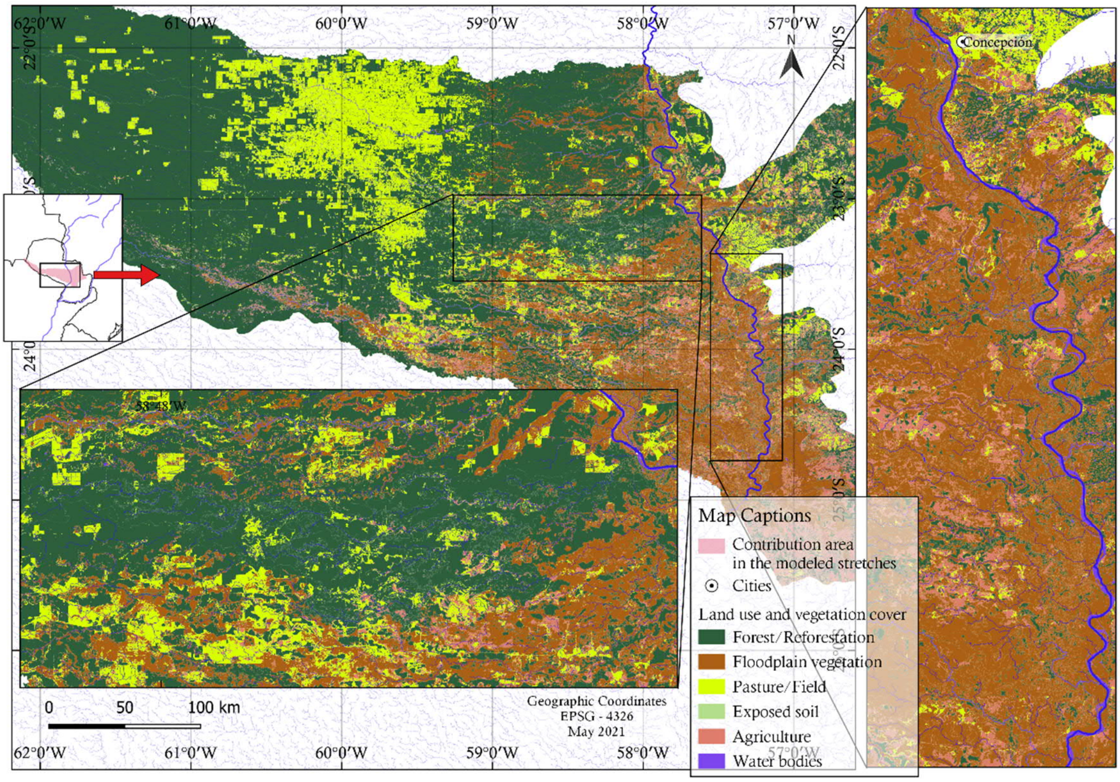


Figure 7 - Land use and vegetation cover in study area. Author (2021)

The hydrological rain-flow modeling HBV, now using as input data the coefficients previously calibrated in WLS-2, the pluviometric and climatological data of the stations presented in Figure 5 (DMH, 2021; ANA, 2021) transported to the centroid of contribution areas of WQS-1 and sub-basins 1 to 7 (Figure 4), it was possible to estimate the synthetic flow series affluent in Paraguay River at WQS-1 and in the punctual and diffuse contributions between WQS-1 and WQS-4. For the period from 09/2001 to 02/2020 (chosen according to the period of water quality data available in WQS-1), the flows considered were:

- Punctual entry in WQS-1 - Paraguay River: minimum flow is 437.9 m^3/s, maximum flow is 3,892.2 m^3/s, average flow is 1,605.8 m^3/s and standard deviation is 355.2 m^3/s;
- Punctual entry in Mosquito River: minimum flow is 3.6 m^3/s, maximum flow is 26.0 m^3/s, average flow is 15.7 m^3/s and standard deviation is 3.2 m^3/s;
- Punctual entry in affluent 1: minimum flow is 13.6 m^3/s, maximum flow is 94.8 m^3/s, average flow is 61.0 m^3/s and standard deviation is 11.4 m^3/s;
- Punctual entry in Gonzalez stream: minimum flow is 9.2 m^3/s, maximum flow is 64.8 m^3/s, average flow is 41.1 m^3/s and standard deviation is 7.9 m^3/s;

- Punctual entry in San Carlos River: minimum flow is 13.4 m^3/s, maximum flow is 94.1 m^3/s, average flow is 60.3 m^3/s and standard deviation is 11.4 m^3/s;
- Punctual entry in Tagatija River: minimum flow is 0.6 m^3/s, maximum flow is 4.5 m^3/s, average flow is 2.9 m^3/s and standard deviation is 0.6 m^3/s;
- Punctual entry in Verde River: minimum flow is 2.0 m^3/s, maximum flow is 13.8 m^3/s, average flow is 8.9 m^3/s and standard deviation is 1.7 m^3/s;
- Punctual entry in Aquibadán River: minimum flow is 8.3 m^3/s, maximum flow is 65.3 m^3/s, average flow is 42.1 m^3/s and standard deviation is 8.1 m^3/s;
- Punctual entry in diffuse sources: minimum flow is 0.1 m^3/s, maximum flow is 0.7 m^3/s, average flow is 0.5 m^3/s and standard deviation is 0.1 m^3/s.

5.1.2 Self-depuration capacity simulation

For the simulations of the self-depuration capacity simulation in Paraguay River, with starting point 20km upstream the urban area of Concepción city (about 300 meters upstream the treated effluent discharge of the cellulose paper industry) and end point nearby upstream of Asunción city, were considered the inflows of: Paraguay River nearby the treated effluent discharge (WLS-2); effluent from the paper and pulp industry; tributaries on the right bank (Affluent 1, Affluent 2, Siete Puntos River, Montelindo River, Negro River, Aguaray Guazú River and Affluent 4); tributaries on the left bank (Ypané River, Jejui Guazú River, Manduvirá River and Affluent 3); direct diffuse contributions on the right and left margins (see Figure 4).

Following the methodology previously described, in the estimation of the synthetic flow series in the punctual sub-basins and diffuse contribution between Concepción and Asunción, the concept of hydrologically homogeneous regions was used (BARBOSA et al. 2005; EUCLYDES, 1999; TUCCI, 2005) to take advantage of the HBV coefficients previously calibrated in the contribution area of WLS-2. For the period from 09/2001 to 02/2020, the flows considered were:

- Punctual entry in WLS-2 - Paraguay River: minimum flow is 499.8 m^3/s, maximum flow is 5,759.3 m^3/s, average flow is 2,162.0 m^3/s and standard deviation is 382.4 m^3/s;
- Punctual entry in affluent 1: minimum flow is 6.1 m^3/s, maximum flow is 51.9 m^3/s, average flow is 31.7 m^3/s and standard deviation is 6.1 m^3/s;
- Punctual entry in Ypané River: minimum flow is 7.3 m^3/s, maximum flow is 66.0 m^3/s, average flow is 41.7 m^3/s and standard deviation is 7.7 m^3/s;
- Punctual entry in affluent 2: minimum flow is 0.3 m^3/s, maximum flow is 2.1 m^3/s, average flow is 1.3 m^3/s and standard deviation is 0.3 m^3/s;
- Punctual entry in Siete Puntos River: minimum flow is 1.9 m^3/s, maximum flow is 15.7 m^3/s, average flow is 9.7 m^3/s and standard deviation is 1.9 m^3/s;
- Punctual entry in Montelindo River: minimum flow is 12.7 m^3/s, maximum flow is 107.4 m^3/s, average flow is 66.9 m^3/s and standard deviation is 12.6 m^3/s;
- Punctual entry in Jejui Guazú River: minimum flow is 0.7 m^3/s, maximum flow is 6.0 m^3/s, average flow is 3.7 m^3/s and standard deviation is 0.7 m^3/s;

- Punctual entry in affluent 3: minimum flow is 14.8 m^3/s, maximum flow is 192.5 m^3/s, average flow is 83.3 m^3/s and standard deviation is 15.9 m^3/s;

  Punctual entry in Negro River: minimum flow is 1.8 m^3/s, maximum flow is 15.4 m^3/s, average flow is 9.7 m^3/s and standard deviation is 1.8 m^3/s;
- Punctual entry in Araguay Guazú River: minimum flow is 15.4 m^3/s, maximum flow is 130.0 m^3/s, average flow is 81.6 m^3/s and standard deviation is 15.2 m^3/s;
- Punctual entry in Manduvirá River: minimum flow is 7.5 m^3/s, maximum flow is 65.0 m^3/s, average flow is 42.0 m^3/s and standard deviation is 7.5 m^3/s;
- Punctual entry in affluent 4: minimum flow is 1.6 m^3/s, maximum flow is 13.5 m^3/s, average flow is 8.6 m^3/s and standard deviation is 1.6 m^3/s;
- Punctual entry in diffuse sources: minimum flow is 0.3 m^3/s, maximum flow is 3.0 m^3/s, average flow is 1.8 m^3/s and standard deviation is 0.3 m^3/s;

The constant flow of effluent discharge from the pulp mill equal to 5,700 m^3/h (1.58 m^3/s) was provided by the contracting company.

5.2 Consumptive demands

The contracting company did not provide any document with users registration and location of any punctual withdrawal and amounts granted for water use, as any other effluent discharge in the study area of Paraguay River. This consultancy also did not find any information in websites of the Paraguayan environmental agencies. The representativeness of the self-depuration capacity simulations of Paraguay River was not affected by the absence of grants information (withdrawal and effluent discharge) since Paraguay River has high water availability, with an average flow in the section of effluent discharge from the pulp mill of 2,162.0 m^3/s and $Q_{7,10}$ of 1,093.0 m^3/s (contracting company information).

5.3 Water quality

5.3.1 Calibration process

Input data for water quality considered include: Paraguay River in WQS-1; tributaries on the right bank (Mosquito River, Affluent 1, Gonzalez stream, San Carlos River and Verde River); tributaries on the left bank (Tagatija River and Aquidabán River); direct diffuse contributions on the right and left banks.

The water quality data monitored at stations WQS-2 (end of the stretch 34), WQS-3 (end of the stretch 35), and WQS-4 (end of the stretch 38) were used in the calibration model process (see item 6).

Only the WQS-1 station has a historical series of water quality monitored by ANA (2021). The MQUAL 1.5 method was used to estimate the affluent load of the parameters Total Phosphorus, Total Nitrogen, Biochemical Oxygen Demand and Total Suspended Solids in the tributaries and diffuse inputs. For the other parameters were considered the limit values defined by Resolution nº 222/2002 for class 2 watercourses.

According to Guimarães (2018), the mathematical model of land use/water quality correlation - MQUAL had its first version in 1998, during the Development and Environmental Protection Plan studies in the Guarapiranga Basin, developed by the

Secretariat of Environment of the São Paulo state. According to SMA (2010), the model was designed to explain the relationships between land use, occupation and management in the Guarapiranga basin (SP), and the water quality for public supply purposes, in order to guarantee best possible knowledge for decision makers of the water system. Further on, SSRH (2016) carried out a pollution assessment study from diffuse sources in the area of influence of Alto Tietê Producer System - SPAT -, including the Taiaçupeba, Jundiaí, Biritiba, Ponte Nova and Paraitinga Reservoirs, which are part of the actions foreseen in the Environmental Sanitation Program for the Upper Tietê Watershed - Mananciais Program.

The model had several revisions in order to improve its functioning and quality of results (MORUZZI et al., 2012; OLIVEIRA and SARDINHA, 2014). According to Moruzzi et al. (2012), the MQUAL model consists in three interrelated modules: load generation module; simulation module of main tributaries and reservoir simulation module. Each module represents a phenomena of generation and self-depuration of polluting loads in three environments considered, a terrain surfaces, where are the sources of polluting loads, the main rivers and their tributaries and the reservoir. In the present study, only the first module was used, which indicates, by means of export coefficients, the pollutant load carried superficially.

The export coefficients adopted were extracted from SSRH (2016). Table 1 shows the export coefficients for dry and rainy season loads adopted.

Table 1 - Export coefficients of dry and rainy season loads according to land use SSRH (2016, adapted).

Dry season				
Land use	**P_{total}**	**N_{total}**	**DBO**	**SST**
	kg/day.km²			
Forest/Reforestation	0.002	0.06	1.172	2.5
Floodplain vegetation	0.002	0.06	1.172	2.5
Pasture/Field	0.001	0.05	1.079	3.75
Agriculture	0.066	0.227	4.917	10.455
Urban	0.272	2.378	40.0	1.1
Exposed fields	0.005	0.09	3.8	8.0
Rainy season				
Forest/Reforestation	0.039	0.6	1.302	20.0
Floodplain vegetation	0.039	0.6	1.302	20.0
Pasture/Field	0.028	0.5	1.079	30.0
Agriculture	0.346	2.95	7.564	230.0
Urban	0.135	2.548	8.0	100.0
Exposed fields	0.05	0.9	2.0	40.0

The mapping of land use and cover in the areas of contribution to the stretch of interest on Paraguay River (between the WQS-1 stations and near Asunción) was carried out using maps of supervised classification of multispectral images provided by MapBiomas Chaco project with 90 meters of spatial resolution for the year 2020

(MAPBIOMAS, 2021). Based on the characteristics of the region, and according to Table 1, the classes of characterization were forest/reforestation, floodplain vegetation, pasture/field, exposed soil, agriculture and water bodies (Figure 7). The areas of land use was obtained through a computational tool (QGIS – Table 2).

The product of the use and occupation area with the pollutant load per area provided by MQUAL model (see Table 1) gives the load produced in the contribution area of a sub-basin or a diffuse area. The average concentration of each parameter, month by month, was obtained from the division between the load produced and the monthly flow (see Table 3). The estimation of nitrogen series (ammonia and nitrate) was based in literature data of the characteristic fractions of total nitrogen concentrations (HEATHWAITE AND JOHNES, 1996; THAYER, 1970; ELSER et al., 2010; RODE AND SUHR, 2007; WIEGNER et al., 2006). For the other parameters, the limit values defined by Resolution nº 222/2002 for class 2 watercourses were considered.

Table 2 - Land use and vegetation cover (km^2 and %) in Paraguay basin between WQS-1 and WQS-4. Author (2021).

Watershed	Land use and vegetation cover (km^2 and %)					
	Forest/ Reforestation	Floodplain vegetation	Pasture/ Field	Exposed soil	Agriculture	Water bodies
Mosquito River	6,259.7 km^2 64.4%	379.2 km^2 3.8%	3,096.5 km^2 31.7%	7.9 km^2 <1%	4.1 km^2 <1%	7.7 km^2 <1%
Affluent 1	11,964.8 km^2 64.7%	991.9 km^2 5.3%	544.9 km^2 29.5%	51.8 km^2 <1%	4.0 km^2 <1%	25.45 km^2 <1%
Gonzalez Stream	13,341.5 km^2 72.2%	1,504.6 km^2 8.1%	3,570 km^2 1.9%	22.5 km^2 <1%	33.1 km^2 <1%	9.2 km^2 <1%
San Carlos River	13,637.0 km^2 74.9%	635.1 km^2 3.5%	3,857.9 km^2 21.2%	17.8 km^2 <1%	41.5 km^2 <1%	7.0 km^2 <1%
Tagatija River	408.2 km^2 46.7%	256.8 km^2 29.4%	141.9km^2 16.2%	0.1 km^2 <1%	62.6 km^2 7%	4.2 km^2 <1%
Verde River	1,561.5 km^2 58.8%	816.7 km^2 30.7%	204.6 km^2 7.7%	0.4 km^2 <1%	41.5 km^2 <1%	7.0 km^2 <1%
Aquibadán River	6,359.9 km^2 56.2%	1,216.1 km^2 10.7%	1,934.0 km^2 17.0%	1.56 km^2 <1%	4.4 km^2 <1%	1,799.3 km^2 15.8%
Diffuse sources	3,923.7 km^2 54.4%	2,228.6 km^2 25.7%	703.7 km^2 9.7%	8.50 km^2 7.50%	139.7 km^2 1.9%	207.0 km^2 2.8%

Table 3 - Water quality data used in the calibration model process. Author (2021).

Punctual entry	T ºC	pH	DO	BOD	TSS	NO	Ammonia	Nitrate	P_{total}
			mg/L						
Paraguay River	16-33	5.0-8.1	0.4-8.1	0.5	13.0-291.0	0.2-0.4	0.05-0.1	2.5-5.5	0.07-0.2
Mosquito River	16-33	5.0-8.1	5.0	3.9-34.2	9.9-470.3	0.2-9.1	0.04-2.3	1.9-114.1	0.07-0.7
Affluent 1	16-33	6.0	5.0	13.6-119.3	34.3-1557	0.5-30.6	0.13-7.6	6.7-382.3	0.07-2.4
Gonzalez Stream	16-33	6.0	5.0	2.8-24.8	6.7-315.1	0.1-6.5	0.03-1.6	1.4-81.6	0.07-0.5
San Carlos River	16-33	6.0	5.0	2.0-17.6	4.8-224.4	0.1-4.6	0.02-1.1	1.0-57.7	0.07-0.4
Tagatija River	16-33	6.0	5.0	1.9-16.9	4.5-313.3	0.1-4.7	0.02-1.2	0.9-58.5	0.07-0.5
Verde River	16-33	6.0	5.0	1.6-13.9	3.6-198.5	0.06-3.8	0.02-0.9	0.8-46.9	0.07-0.3
Aquibadán River	16-33	6.0	5.0	2.9-25.5	6.6-525.8	0.1-7.1	0.03-1.8	1.4-88.6	0.07-0.8
Diffuse sources	16-33	6.0	5.0	1.7-25.6	4.2-1,157.2	0.07-20.1	0.02-5.0	0.8-251.3	0.07-1.8

5.3.2 Self-depuration capacity simulation

Input data for water quality considered include: Paraguay River in WQS-2; the effluent from the paper and pulp industry; tributaries on the right bank (Affluent 1, Affluent 2, Siete Puntos River, Montelindo River, Negro River, Aguaray Guazú River and Affluent 4); tributaries on the left bank (Ypané River, Jejui Guazú River, Manduvirá River and Affluent 3); direct diffuse contributions on the right and left banks (see Figure 4).

The water quality data monitored in WQS-2 were used as input values in the Paraguay River upstream of the discharge point of effluent (300 m), complemented by the resulting data from calibration process.

For the other tributaries and diffuse areas, the methodology used was the same presented in item 5.3.1, using Figure 7 and Tables 1 and the areas of use and occupation of the region of influence between Concepción (Table 4). The load produced in the contribution area of a sub-basin or a diffuse area between Concepción and Asunción are shown in Table 5.

Table 4 - Land use and vegetation cover (km^2 and %) in Paraguay basin between Concepción and Asunción. Author (2021).

Watershed	**Land use and vegetation cover (km^2 and %)**					
	Forest/ Reforestation	**Floodplain vegetation**	**Pasture/ Field**	**Exposed soil**	**Agriculture**	**Water bodies**
Affluent 1*	4,229.1 km^2 51.1%	2,127.8 km^2 39,10%	1,672.9 km^2 20.2%	1.7 km^2 <1%	245.8 km^2 2.9%	1.3 km^2 <1%
Ypané River	4,100.3 km^2 41.3%	2,249.0 km^2 22.6%	2,469.2 km^2 24.8%	1.6 km^2 <1%	1,085.2 km^2 10.9%	23.8 km^2 <1%
Affluent 2	86.7 km^2 25.6%	217.7 km^2 64.2%	20.8 km^2 6.1%	0.05 km^2 <1%	9.2 km^2 2.7%	3.9 km^2 1.1%
Siete Puntos River	931.8 km^2 37.2%	1,011.9 km^2 40,4%	212.7 km^2 8.5%	0.15 km^2 <1%	347.3 km^2 13.8%	0.3 km^2 <1%
Montelindo River	12,507.4 km^2 73.3%	2,542.2 km^2 14.9%	1,130.7 km^2 6.6%	14.5 km^2 <1%	847.7 km^2 4.9%	2.4 km^2 <1%
Jejui Guazú River	348.7 km^2 37.8%	195.9 km^2 21.3%	221.6 km^2 24.0%	0.01 km^2 <1%	152.3 km^2 16.5%	1.9 km^2 <1%
Affluent 3	8,844.9 km^2 44.0%	7,435.5 km^2 37.0%	1,130.4 km^2 5.6%	7.8 km^2 <1%	2.490.7 km^2 12,4%	159.8 km^2 <1%
Negro River	299.0 km^2 12.3%	1,760.2 km^2 72.5%	84.1 km^2 3.4%	0.44km^2 <1%	2.2 km^2 <1%	280.2 km^2 11.5%
Araguay Guazú River	13,027.8 km^2 62.5%	5,352.0 km^2 25,7%	869.5 km^2 4.0%	87.0 km^2 <1%	1.457.4 km^2 7.0%	18.0 km^2 <1%
Manduvirá River	2,112,3 km^2 20.8%	4,179.2 km^2 41.2%	283.6 km^2 2,8%	4.5 km^2 <1%	3,528.1 km^2 34.8%	15.3 km^2 <1%
Affluent 4	269.5 km^2 12.7%	1,498.8 km^2 70.8%	47.9 km^2 2.2%	0.2 km^2 <1%	299.5 km^2 14.1%	0.2 km^2 <1%
Diffuse sources	1,938.4 km^2 19.0%	5,176.1 km^2 50.9%	854.4 km^2 8.4%	3.1 km^2 <1%	1,949.8 km^2 19.2%	227.3 km^2 2.2%

Table 5 - Water quality data used in the self-depuration capacity simulation. Author (2021).

Punctual entry	T °C	pH	DO	BOD	TSS	NO	Ammonia	Nitrate	P_{total}
			mg/L						
Affluent 1*	16-33	6.0	5.0	1.7-15.1	4.2-211.1	0.07-3.6	0.02-0.90	0.8-45.23	0.07-0.33
Ypané River	16-33	6.0	5.0	2.3-20.2	5.4-371.0	0.09-5.0	0.02-1.26	1.1-63.08	0.07-0.55
Affluent 2	16-33	6.0	5.0	2.0-17.6	4.5-350.0	0.08-4.6	0.02-1.14	0.9-56.95	0.07-0.54
Siete Puntos River	16-33	6.0	5.0	2.0-17.6	4.5-350.0	0.08-4.6	0.02-1.14	0.9-56.95	0.07-0.54
Montelindo River	16-33	6.0	5.0	2.1-18.3	4.6-254.1	0.08-4.5	0.02-1.12	1.0-56.07	0.07-0.43
Jejui Guazú River	16-33	6.0	5.0	2.7-23.8	6.4-473.9	0.1-6.0	0.03-1.50	1.3-74.94	0.07-0.71
Affluent 3	16-33	6.0	5.0	1.9-18.6	4.1-338.8	0.07-4.6	0.02-1.14	0.9-57.16	0.07-0.54
Negro River	16-33	6.0	5.0	11.7	2.9-271.7	0.05-3.1	0.01-0.78	0.6-39.04	0.07-0.41
Araguay Guazú River	16-33	6.0	5.0	17.8	4.4-273.3	0.08-4.4	0.02-1.10	1.0-55.20	0.07-0.46
Manduvirá River	16-33	6.0	5.0	28.0	6.9-690.9	0.12-7.6	0.03-1.90	1.5-94.94	0.07-1.05
Affluent 4	16-33	6.0	5.0	28.0	6.9-690.9	0.12-7.6	0.03-1.90	1.5-94.94	0.07-1.05
Diffuse sources	16-33	6.0	5.0	19.7	5.0-453.5	0.08-5.2	0.02-1.30	1.1-64.94	0.07-0.68

The water quality data of the pulp mill effluent were provided by the contracting company (Table 6).

Table 6 - Water quality data used in the self-depuration capacity simulation. Poyry (2021).

Standards	Value
Flow (m^3/h)	5,700.0
pH	6.0 to 8.0
Temperature (ºC)	≤ 40
BOD (mg/L)	25
COD (mg/L)	150
Suspended solids (mg/L)	40.0
Colour (mg/L)	250.0

Standards	**Value**
AOX (mg/L)	3.0
N_{total} (mg/L)	7.0
$N_{ammoniacal}$ (mg/L)	2.0
P_{total} (mg/L)	1.0

5.4 Climatological data

The climatological data used in this study (air temperature, evaporation, relative humidity and solar radiation) for the self-depuration capacity simulation of Paraguay River were obtained from DMH (2021) and ANA (2021), as shown in Figure 5.

5.5 Hydraulic data

The hydrodynamics adopted in WASP to propagate the flow along the segments of this study was the kinematic wave. This model provides a more realistic simulation of the flow dynamics in one-dimensional branched networks. The kinematic wave model allows diverging (branching) and then converging again the river channels, whose hydraulic behavior is similar to the alluvial valleys existing on the Paraguay River. The kinematic wave option is controlled by several hydraulic input data, such as the Manning roughness coefficient, bottom slope, channel width, minimum and average liquid depth and exponents of speed and depth (EPA, 2021). The sequence brings the methodologies and the hydraulic data values adopted in the 38 segments considered in the calibration and 64 segments considered in the self-depuration capacity simulations (see the topology in Figure 3).

Manning roughness coefficient η

There are several methodologies in the literature for estimating the Manning roughness coefficient, including empirical equations based on bottom granulometry and hydraulic characteristics, factors that influence flow resistance, tests and field measurements and analogy to previously existing studied channels. With the absence of granulometric data of bottom material and hydraulic field measurements for the region of interest on Paraguay River, scientific publications and indirect estimates become the only options for estimating the Manning roughness coefficient.

In alluvial channels with high surface widths compared to the liquid depth, the materials of the bottom sediments prevail over the material of the lateral slopes in the calculation of the Manning roughness coefficient. According to Leandro and Souza (2012) and Blettler et al. (2012), the bottom material on the upper course of Paraguay River consists of sand, silt, clay, gravel and benthic plants and organisms.

Paz et al. (2010) carried out a hydrodynamic modeling on the upper course of Paraguay River between the Brazilian cities of Cáceres and Porto Murtinho, getting a Manning roughness coefficient between 0.02 and 0.05. Frigo et al. (2015) estimated values between 0.035 and 0.055 for the Manning roughness coeficiente in the same region. Bahramifar et al. (2013), using a method based on an adaptive neuro-diffuse inference system, proposed an empirical equation to estimate the Manning roughness coefficient in alluvial channels. The empirical equation is a function of the bottom particle size, liquid depth and longitudinal bottom slope, with a high adjustment between the measured and estimated values in the range between 0.03 and 0.07. Kim et al. (2010)

estimated the Manning roughness coefficient in a South Korea river with a length/width ratio between 20 and 30, bottom material formed by coarse gravel and stone (diameter between 10 and 1000 mm) and flow between 6 and 1200 m^3/s. For these hydraulic configurations, using several equations in the literature and field measurements, the authors reached Manning roughness coefficients between 0.04 and 0.08.

In addition to the literature values previously reported, the Cowan method (CHOW, 1959) allows, from Equation (5), a joint analysis of the several factors that influence the flow resistance.

$$\eta = (\eta_o + \eta_1 + \eta_2 + \eta_3 + \eta_4).m \quad (5)$$

Where: η_o is the basic value of the roughness coefficient for a straight, uniform channel with flat surfaces, according to the material associated with the contact surface; η_1 is the additional value corresponding to irregularities present in the watercourse, such as erosions, silting, protrusions and depressions on the surface; η_2 is the value corresponding to the frequency of shape variations in the watercourse, analyzed according to the possibilities of causing disturbances in the flow; η_3 is the value based on the presence of obstructions present in the watercourse, such as depositions of boulders, roots, trunks, among others, evaluated according to their extension in the sense of reducing the section and their possibility of causing turbulence in the flow; η_4 is the value based on the influence of vegetation type in the runoff, and must be evaluated according to the density and height of vegetation on the banks, as well as the obstruction caused in the flow section; m represents the meandering degree of the watercourse, evaluated by the ratio between the effective length of the section and the straight distance covered.

The possible variations and values of the factors inserted in Equation (1) are shown in Table 7.

Table 7 - Factor values of the Cowan method. Chow (1959, adapted).

Factors	Variations	Values	Factors	Variations	Values
η_o	Soil	0.020	η_3	Negligible	0.000
	Rock	0.025		Little	0.010-0.015
	Fine gravel	0.024		Appreciable	0.020-0.030
	Big gravel	0.028		Severe	0.040-0.060
η_1	Smooth	0.000	η_4	Low	0.005-0.010
	Little	0.005		Average	0.010-0.025
	Moderate	0.010		Hight	0.025-0.050
	Severe	0.020		Very Hight	0.050-0.100
η_2	Gradual	0.000	m	Small	1.000
	Occasional alternations	0.005		Appreciable	1.150
	Frequent alternations	0.010-0.015		Severe	1.300

In view of the alluvial characteristics in Paraguay River, the factors inserted in the Cowan method were: η_o equal to 0.020 $m^{-1/3}.s$ (soil) in all stretches, considering the accumulation of granulometry sediments between sand and mud in the benthic layer; η_1 equal to 0.010 $m^{-1/3}.s$ in all stretches, considering the possibility of moderate irregularities due to the erosive process at the margins (degree of sinuosity close to 1.3); η_2 equal to 0.005, considering the existence of occasional variations in the shape of the watercourse due to changes in the cross sections in the winding stretches and the various branches of the main channel; η_3 equal to zero in all stretches, considering the occurrence of turbulence in the flow as a result of depositions of boulders, roots and trunks as negligible, since the length/width ratio is close to 100; η_4 equal to 0.005 in all stretches, considering the influence of the margins vegetation in runoff as low (length/width ratio is close to 100); m equal to 1.30, considering the effective length of the meandering section close to 276 km and the “rectified” length close to 202 km. As result, the Manning roughness coefficient estimated by the Cowan method (CHOW, 1959) provides a value of 0.052 $m^{-1/3}.s$.

Width and length by segment

WASP tool uses width and length of the river segment discretized to calculate the water volume in each segment, with consequent obtaining of the pollutant mass in the segment. These values were obtained from Google Earth images. In order to obtain the width in each segment, a previous analysis of historical images was made to assess the level of flooding of the floodplains in rainy months.

Longitudinal slope by segment

The longitudinal slope in each stretch was obtained from the planialtimetric plan in the Terrain profile tool of QGIS, using the Digital Elevation Model of the Consortium for Spatial Information (CGIAR-CSI), with a precision of 90 m from the orbits srtm_24_16, srtm_24_17, srtm_25_15, srtm_25_16 and srtm_25_17 (CSI-CGIAR, 2021). The slope along the Paraguay River varied between 0,04 to 0,62 m/km in the calibration stretch and 0,04 to 3,05 m/km in the stretch between Concepción and Asunción. Paz et al. (2010) carried out a hydrodynamic modeling on the high course of Paraguay River, between Cáceres and Porto Murtinho cities, reaching a minimum, an average and a maximum longitudinal slopes equal to 0,02; 0,04 and 0,09 m/km.

Depth by segment

WASP tool uses depth by river segment discretized to calculate the water volume, with consequent obtaining of the pollutant mass by segment. The minimum depths by segment are assumed as zero flow, while the average depth is used to estimate the volume water by segment in the beginning of the simulation.

The minimum depths were fixed and equal to 0,001 m in all segments. In obtaining the average depths, WLS-1 (Vallemi), WLS-2 (Concepción), WLS-3 (Rosário) and WLS-4 (Asunción) were considered, all provided by DMH (2021) (see Figure 4). The average depth of each station was considered fixed in the adjacent upstream and downstream segments.

Depth exponent and velocity exponent

These exponents come from the potential relationships of depth and average speed with flow. The absence of historical flow monitoring in the stretch of interest prevented the adjustment of potential relationships from field data. As a result, the mean values recommended by the WASP manual for a cross-section shape "U" in a lotic environment were assumed as exponents of depth and velocity. Tables 8 and 9 show the hydraulic data adopted in the 38 segments considered in the calibration (lotic environment) and 64 segments considered in the self-depuration simulation (also lotic environment).

Table 8 - Hydraulic data adopted in 38 segments during calibration. Author (2021).

Segment	Longitudinal distance (m)	Bottom slope (m/m)	Width (m)	Manning roughness coefficient ($m^{-1/3}.s$)	Minimum depth (m)	Average depth (m)	Velocity exponent	Depth exponent
1	6000	0.000193	800	0.052	0.001	4.64	0.4	0.6
2	3100	0.000374	143	0.052	0.001	4.64	0.4	0.6
3	3510	0.000330	597	0.052	0.001	4.64	0.4	0.6
4	9430	0.000125	559	0.052	0.001	4.64	0.4	0.6
5	8988	0.000129	286	0.052	0.001	4.64	0.4	0.6
6	7362	0.000158	258	0.052	0.001	4.64	0.4	0.6
7	13310	0.000089	435	0.052	0.001	4.64	0.4	0.6
8	3029	0.000383	324	0.052	0.001	4.64	0.4	0.6
9	4625	0.000251	425	0.052	0.001	4.64	0.4	0.6
10	7876	0.000147	614	0.052	0.001	4.64	0.4	0.6
11	4789	0.000242	488	0.052	0.001	4.64	0.4	0.6
12	6842	0.000170	297	0.052	0.001	4.64	0.4	0.6

Segment	Longitudinal distance (m)	Bottom slope (m/m)	Width (m)	Manning roughness coefficient $(m^{-1/3}.s)$	Minimum depth (m)	Average depth (m)	Velocity exponent	Depth exponent
13	6239	0.000189	782	0.052	0.001	4.64	0.4	0.6
14	6915	0.000168	450	0.052	0.001	4.64	0.4	0.6
15	7051	0.000165	358	0.052	0.001	4.64	0.4	0.6
16	8245	0.000141	365	0.052	0.001	4.64	0.4	0.6
17	3553	0.000326	216	0.052	0.001	4.64	0.4	0.6
18	2936	0.000395	154	0.052	0.001	4.64	0.4	0.6
19	3234	0.000359	355	0.052	0.001	4.64	0.4	0.6
20	16000	0.000074	595	0.052	0.001	4.64	0.4	0.6
21	3249	0.000357	353	0.052	0.001	4.64	0.4	0.6
22	3489	0.000332	304	0.052	0.001	4.64	0.4	0.6
23	8231	0.000141	654	0.052	0.001	4.64	0.4	0.6
24	4239	0.000274	363	0.052	0.001	4.72	0.4	0.6
25	5067	0.000229	496	0.052	0.001	4.72	0.4	0.6
26	18376	0.000063	471	0.052	0.001	4.72	0.4	0.6
27	18328	0.000263	179	0.052	0.001	4.72	0.4	0.6
28	17511	0.000202	415	0.052	0.001	4.72	0.4	0.6
29	1871	0.000620	661	0.052	0.001	4.72	0.4	0.6
30	4180	0.000278	229	0.052	0.001	4.72	0.4	0.6
31	4484	0.000259	403	0.052	0.001	4.72	0.4	0.6
32	30475	0.000038	783	0.052	0.001	4.72	0.4	0.6
33	4338	0.000267	143	0.052	0.001	4.72	0.4	0.6
34	3908	0.000297	839	0.052	0.001	4.72	0.4	0.6
35	3293	0.000352	796	0.052	0.001	4.72	0.4	0.6
36	4753	0.000244	362	0.052	0.001	4.72	0.4	0.6
37	3848	0.000301	468	0.052	0.001	4.72	0.4	0.6
38	5060	0.000229	883	0.052	0.001	4.72	0.4	0.6

Table 9 - Hydraulic data adopted in 64 segments during self-depuration simulation. Author (2021).

Segment	Longitudinal distance (m)	Bottom slope (m/m)	Width (m)	Manning roughness coefficient $(m^{-1/3}.s)$	Minimum depth (m)	Average depth (m)	Velocity exponent	Depth exponent
1	3293	0.000352	796	0.052	0.001	4.72	0.4	0.6
2	4753	0.000244	362	0.052	0.001	4.72	0.4	0.6
3	3848	0.000301	468	0.052	0.001	4.72	0.4	0.6

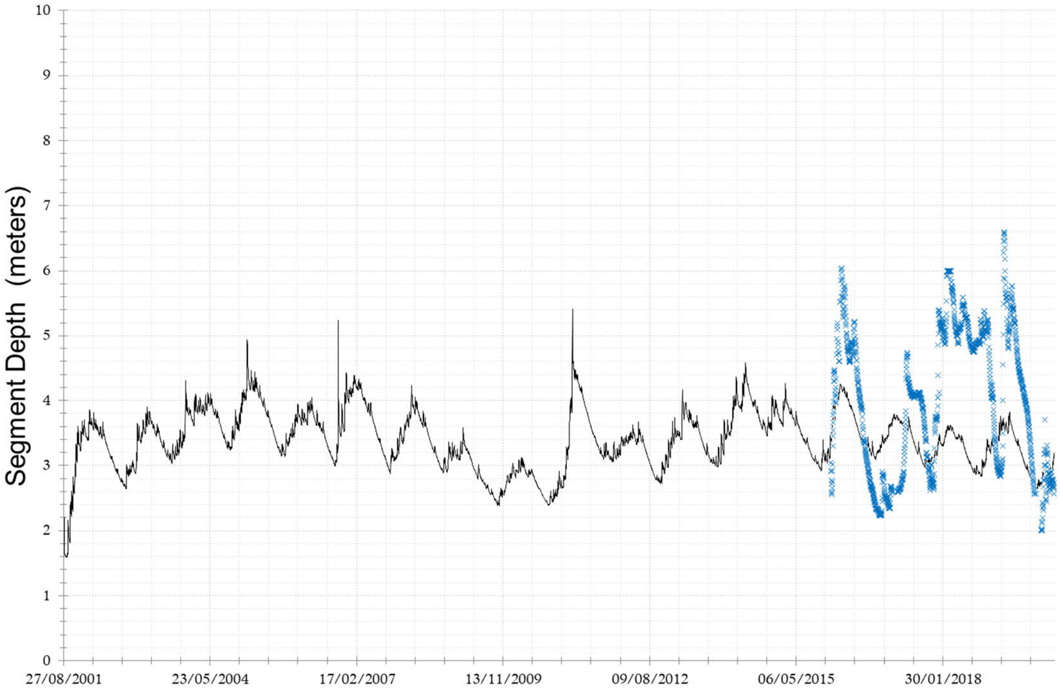
Segment	Longitudinal distance (m)	Bottom slope (m/m)	Width (m)	Manning roughness coefficient (m$^{-1/3}$.s)	Minimum depth (m)	Average depth (m)	Velocity exponent	Depth exponent
4	5060	0.000229	883	0.052	0.001	4.72	0.4	0.6
5	17720	0.000069	478	0.052	0.001	4.72	0.4	0.6
6	17164	0.000071	190	0.052	0.001	4.72	0.4	0.6
7	6585	0.000176	664	0.052	0.001	4.72	0.4	0.6
8	3096	0.000375	157	0.052	0.001	4.72	0.4	0.6
9	1873	0.000619	636	0.052	0.001	4.72	0.4	0.6
10	12260	0.000095	529	0.052	0.001	4.72	0.4	0.6
11	2874	0.000404	326	0.052	0.001	4.72	0.4	0.6
12	3527	0.000329	214	0.052	0.001	4.72	0.4	0.6
13	9430	0.000123	386	0.052	0.001	4.72	0.4	0.6
14	2559	0.000453	180	0.052	0.001	4.72	0.4	0.6
15	2975	0.000390	204	0.052	0.001	4.72	0.4	0.6
16	10284	0.000113	559	0.052	0.001	4.72	0.4	0.6
17	3778	0.000307	530	0.052	0.001	4.72	0.4	0.6
18	5922	0.000196	184	0.052	0.001	4.72	0.4	0.6
19	3892	0.000303	269	0.052	0.001	4.72	0.4	0.6
20	4153	0.000279	310	0.052	0.001	4.72	0.4	0.6
21	4685	0.000248	841	0.052	0.001	4.72	0.4	0.6
22	12889	0.000275	599	0.052	0.001	4.72	0.4	0.6
23	11956	0.000097	308	0.052	0.001	4.72	0.4	0.6
24	12529	0.000093	222	0.052	0.001	4.57	0.4	0.6
25	11380	0.000102	501	0.052	0.001	4.57	0.4	0.6
26	3100	0.000374	441	0.052	0.001	4.57	0.4	0.6
27	2972	0.000390	187	0.052	0.001	4.57	0.4	0.6
28	14058	0.000083	501	0.052	0.001	4.57	0.4	0.6
29	3074	0.000377	622	0.052	0.001	4.57	0.4	0.6
30	3207	0.000362	128	0.052	0.001	4.57	0.4	0.6
31	3188	0.000364	613	0.052	0.001	4.57	0.4	0.6
32	2871	0.000404	583	0.052	0.001	4.57	0.4	0.6
33	2600	0.000446	369	0.052	0.001	4.57	0.4	0.6
34	8919	0.000130	613	0.052	0.001	4.57	0.4	0.6
35	4826	0.000240	348	0.052	0.001	4.57	0.4	0.6
36	5057	0.000229	111	0.052	0.001	4.57	0.4	0.6
37	2756	0.000421	766	0.052	0.001	4.57	0.4	0.6
38	2807	0.000413	264	0.052	0.001	4.57	0.4	0.6
39	2669	0.000435	154	0.052	0.001	4.57	0.4	0.6

Segment	Longitudinal distance (m)	Bottom slope (m/m)	Width (m)	Manning roughness coefficient ($m^{-1/3}.s$)	Minimum depth (m)	Average depth (m)	Velocity exponent	Depth exponent
40	3498	0.000332	906	0.052	0.001	4.57	0.4	0.6
41	2777	0.000418	515	0.052	0.001	4.57	0.4	0.6
42	2989	0.000388	184	0.052	0.001	4.57	0.4	0.6
43	12665	0.000092	455	0.052	0.001	4.57	0.4	0.6
44	3053	0.001160	289	0.052	0.001	4.57	0.4	0.6
45	2373	0.000489	440	0.052	0.001	4.57	0.4	0.6
46	16221	0.000073	494	0.052	0.001	4.57	0.4	0.6
47	2330	0.003047	493	0.052	0.001	4.57	0.4	0.6
48	2727	0.000425	197	0.052	0.001	4.57	0.4	0.6
49	8663	0.000134	457	0.052	0.001	4.57	0.4	0.6
50	970	0.001196	290	0.052	0.001	4.57	0.4	0.6
51	1120	0.001036	583	0.052	0.001	4.57	0.4	0.6
52	3304	0.000351	504	0.052	0.001	4.57	0.4	0.6
53	1943	0.000597	477	0.052	0.001	4.57	0.4	0.6
54	1899	0.000611	194	0.052	0.001	4.57	0.4	0.6
55	30425	0.000038	671	0.052	0.001	4.57	0.4	0.6
56	2633	0.000441	333	0.052	0.001	4.57	0.4	0.6
57	2500	0.000464	99	0.052	0.001	4.57	0.4	0.6
58	12734	0.000091	675	0.052	0.001	4.57	0.4	0.6
59	7467	0.000268	224	0.052	0.001	4.59	0.4	0.6
60	5595	0.000357	557	0.052	0.001	4.59	0.4	0.6
61	7441	0.000134	574	0.052	0.001	4.59	0.4	0.6
62	4839	0.000207	629	0.052	0.001	4.59	0.4	0.6
63	5734	0.000174	290	0.052	0.001	4.59	0.4	0.6
64	3625	0.000276	569	0.052	0.001	4.59	0.4	0.6

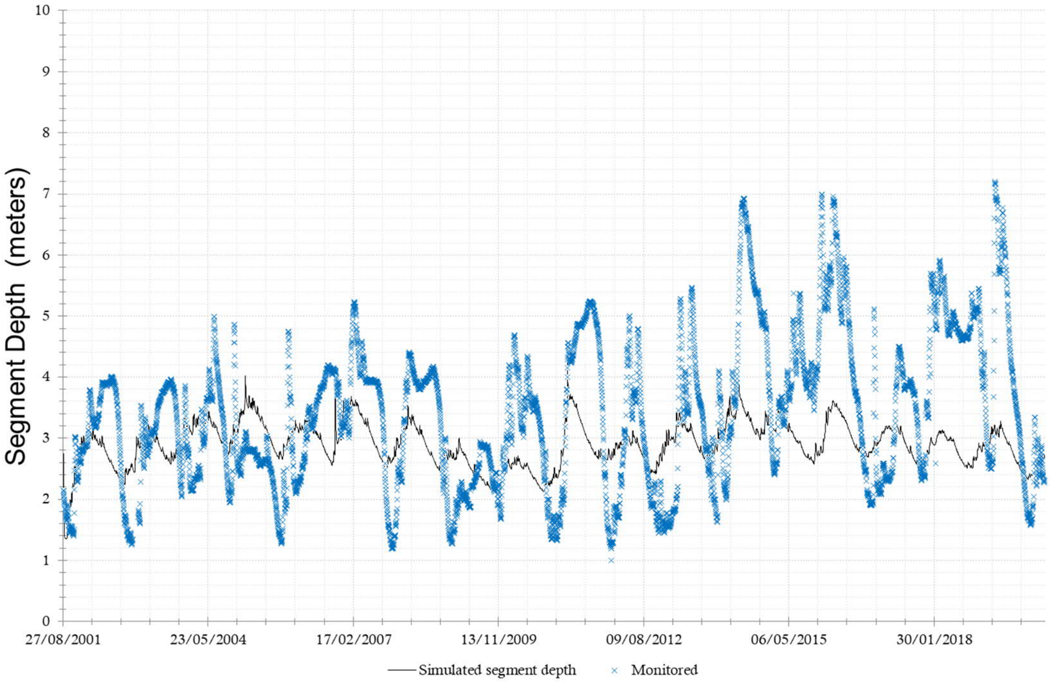
6 MODEL CALIBRATION

The correct representation of hydraulics and hydrogeometry (depth, surface width and average velocity) in each segment is essential for the estimation of the volume and consequent obtaining of the mass and transport of pollutant per segment.

The discharge coefficients that provide the depth, surface width and average velocity as a function of the flow are obtained from fieldwork (Leopold and Maddox, 1953 *apud* WASP, 2021). The absence of empirical data makes it necessary to use values from the literature. The WASP tool define different transverse geometries for the watercourse from exponents of depth, surface width and average velocity in rectangular channels, “U” shape, “V” shape and shallow. As previously mentioned, the mean values recommended by the WASP manual for cross-section type “U” shape were assumed as exponents of depth and velocity. Figure 8 shows the temporal variation of the depth in segment 1 (WLS-1) and segment 38 (WLS-2) from 09/2001 to 12/2020.



(a)



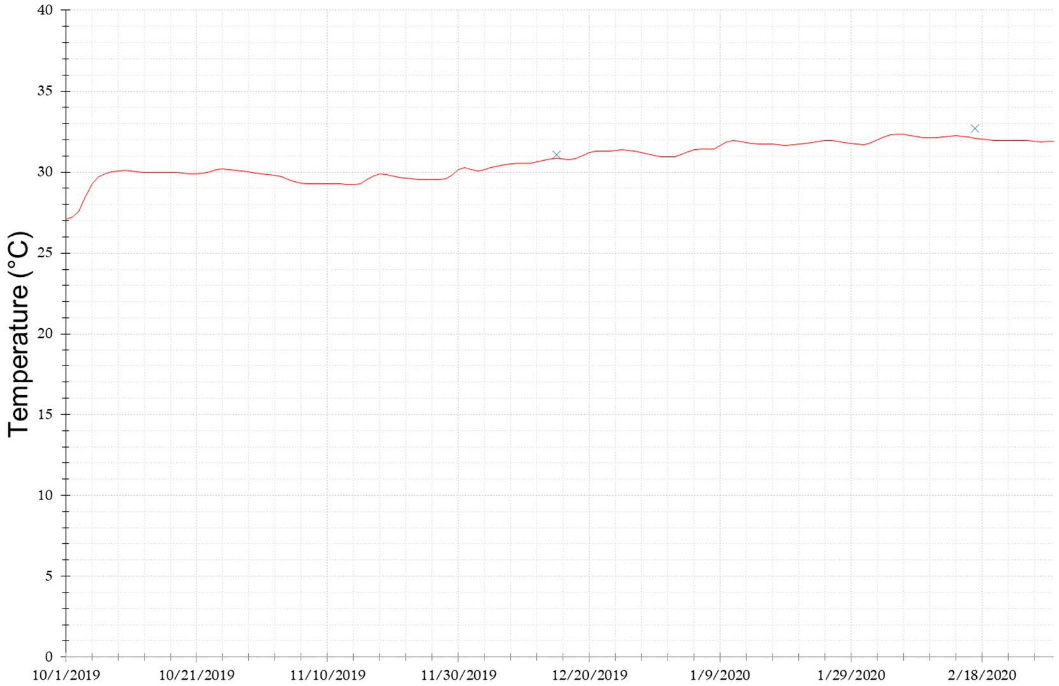
(b)

Figure 8 - Temporal variation of the depth in: a) segment 1 (WLS-1) and b) segment 38 (WLS-2). Author (2021).

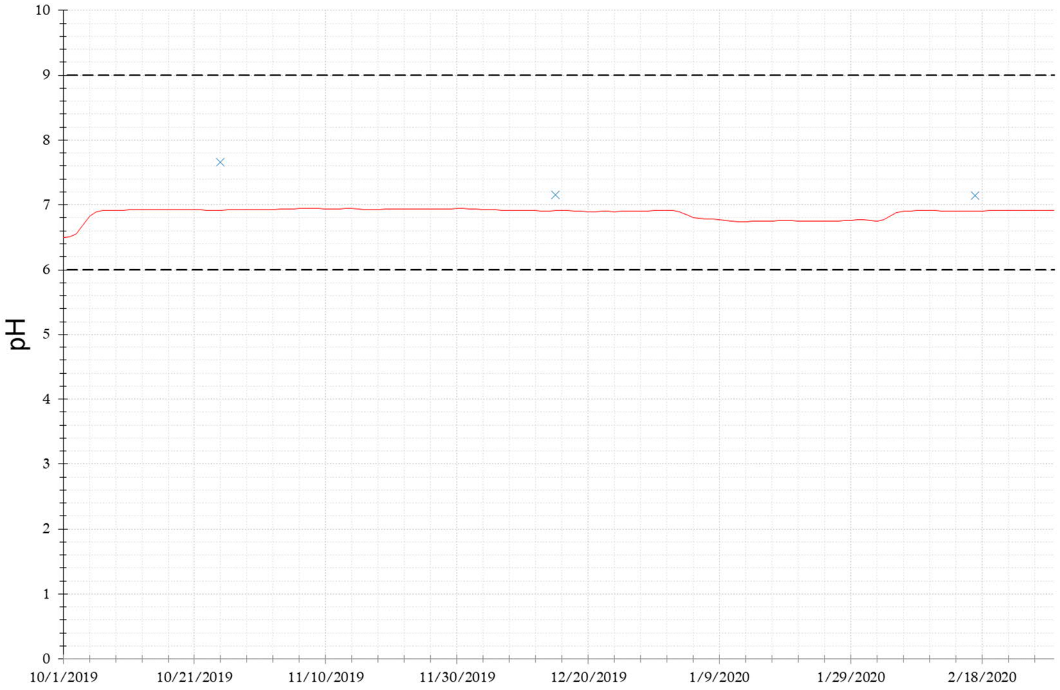
The transverse geometry along the Paraguay River is variable, mainly due to the alluvial character and high sinuosity index, which causes oscillate position of the main channel between the left and right banks. The composite geometry of the river near of the liquid level monitoring stations causes a greater variation in the depth, between 2,0 and 6,6 m for WLS-1 and between 1,0 and 7,2 m for WLS-2 (see Figure 8). WASP tool works with simple sections to represent the geometry of the river in each segment. The actual depths are transformed into hydraulic depths. However, the variation of depth in segments 1 and 38 was smaller, between 1,6 and 5,4 m for WLS-1 and between 1,4 and 4,3 m for WLS-2 (see Figure 8).

The contracting company provided water quality data (physical and chemical parameters) monitored in three Water Quality Stations along Paraguay River (WQS-2, WQS-3 and WQS-4 - see location in Figures 1, 3 and 4), with collections on 10/25/2019, 12/15/2019 and 2/17/2020 for WQS-2 and WQS-3 and 02/2017, 04/2017, 08/2017, 09/2017, 12/2017, 02/2018, 03/2018, 04/2018, 07/208 and 12/2018 for WQS-4. The parameters monitored at stations WQS-2 and WQS-3 were water temperature, pH, total solids, dissolved oxygen, biochemical oxygen demand, total phosphorus, ammonia and nitrate. Only the parameters pH, total solids, ammonia and nitrate were monitored in WQS-4.

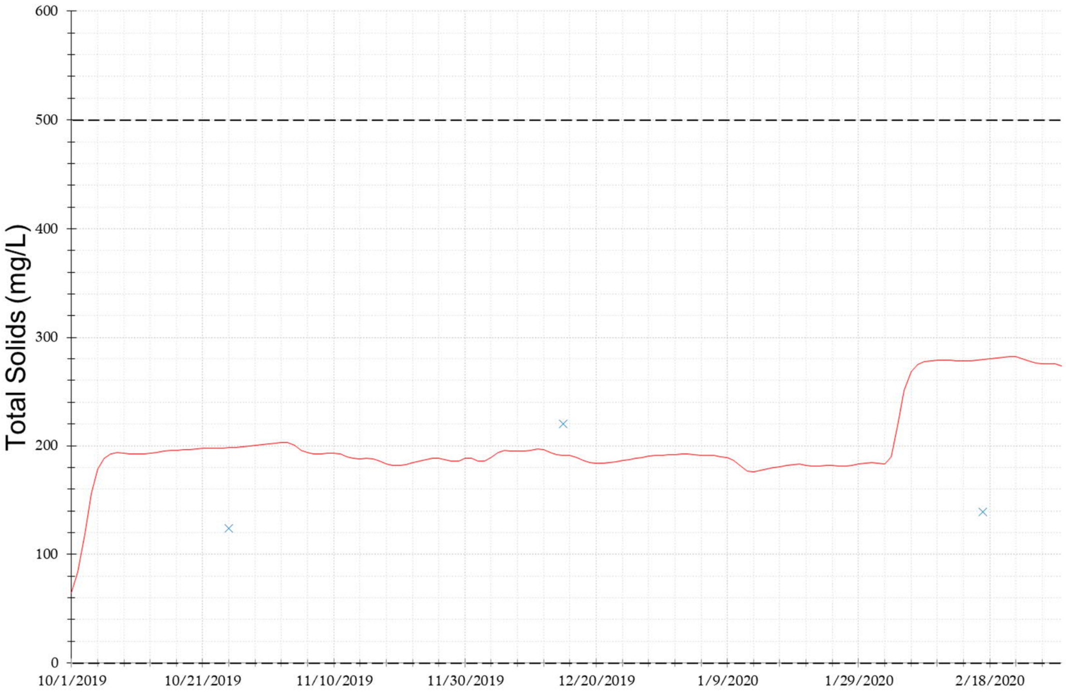
The calibration process of coefficients related to the physical and biochemical processes provided a good fit between the simulated profiles and monitored data in WQS-2, WQS-3 and WQS-4, according Figures 9, 10 and 11. These calibrated coefficients were kept fixed in the analysis of the self-depuration capacity of the Paraguay River with release of effluent from the industry.



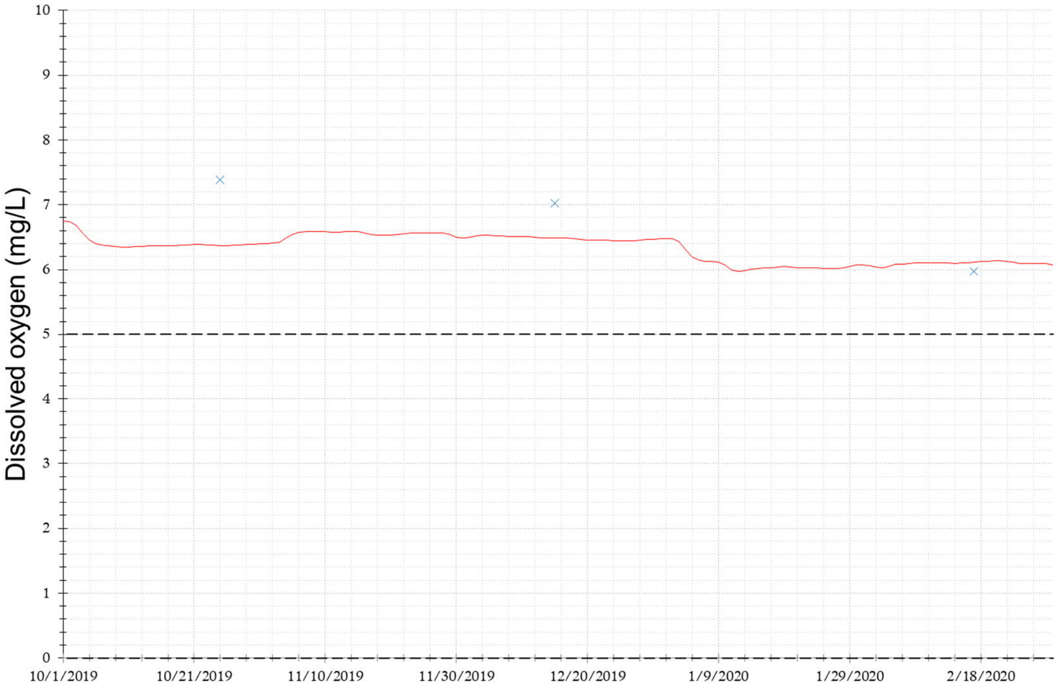
(a) temperature



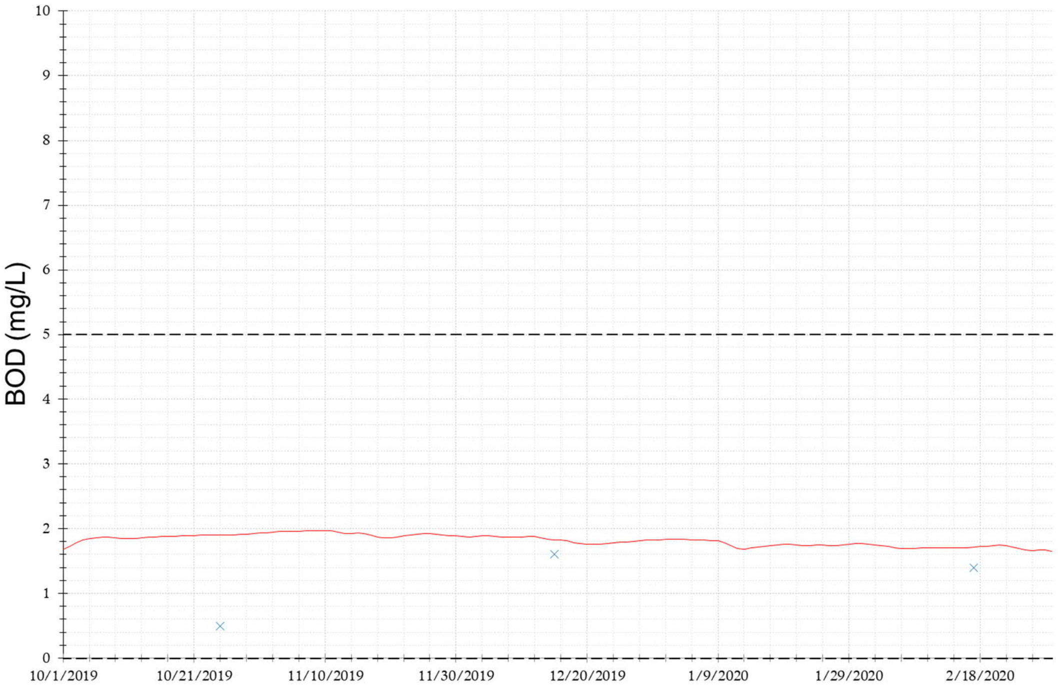
(b) pH



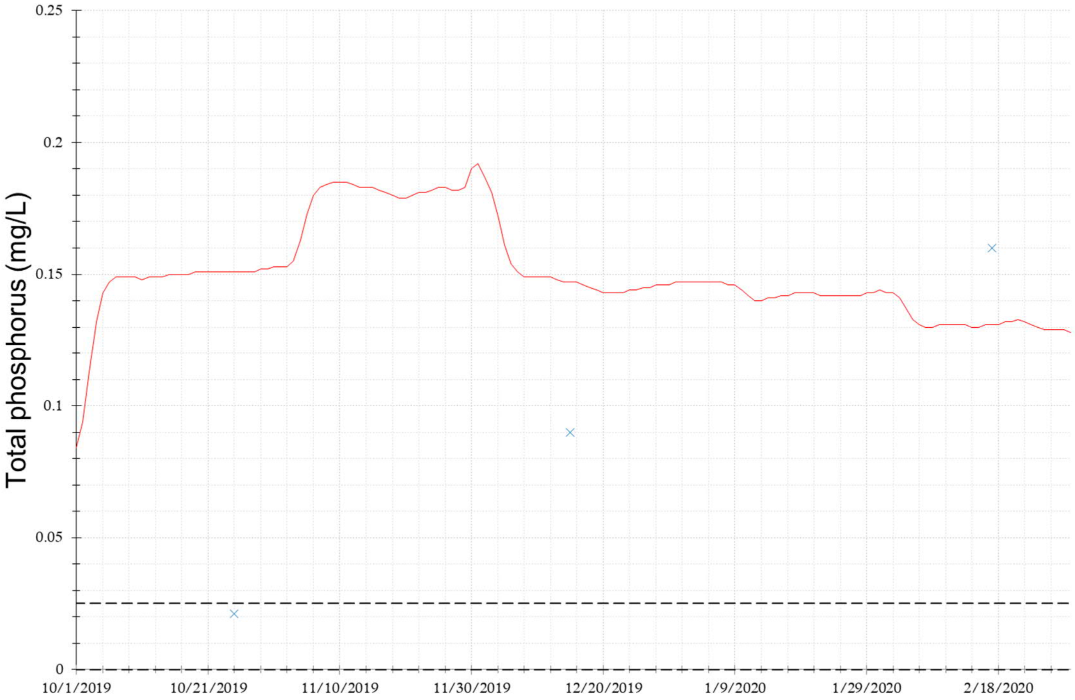
(c) total solids



(d) dissolved oxygen

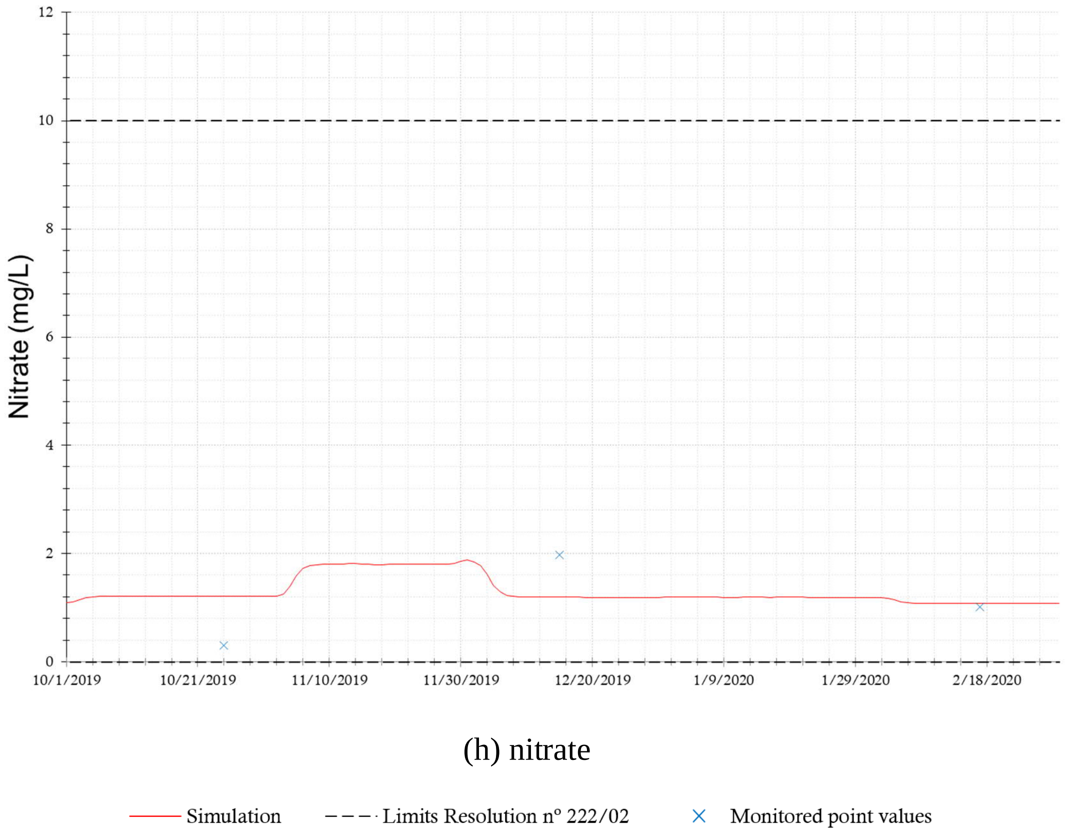


(e) BOD



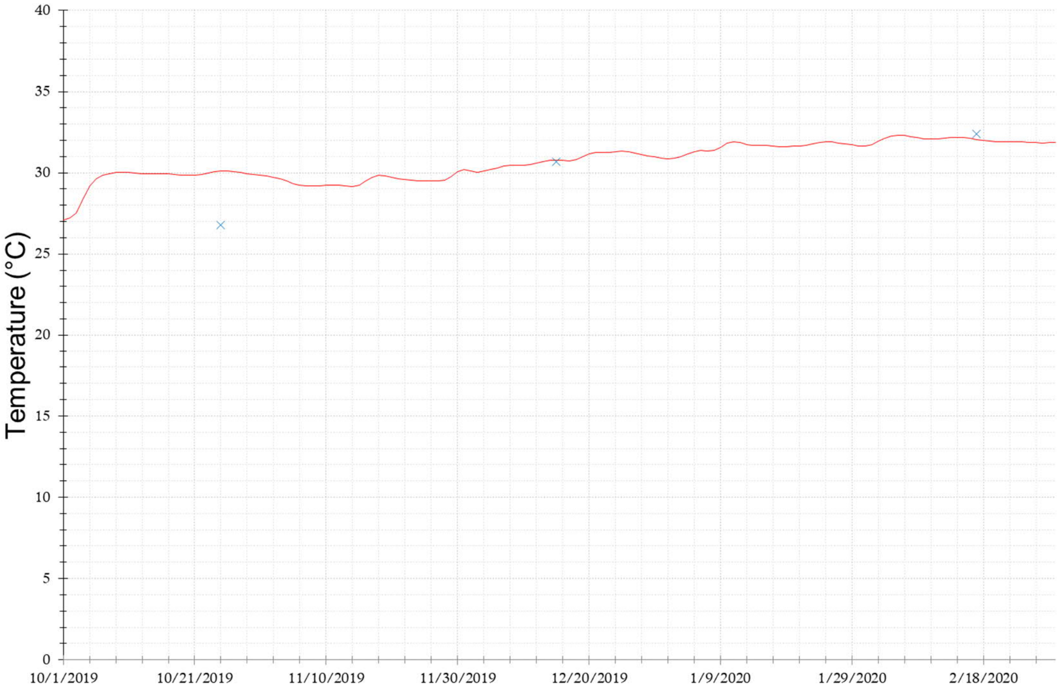
(f) total phosphorus

(g) ammonia

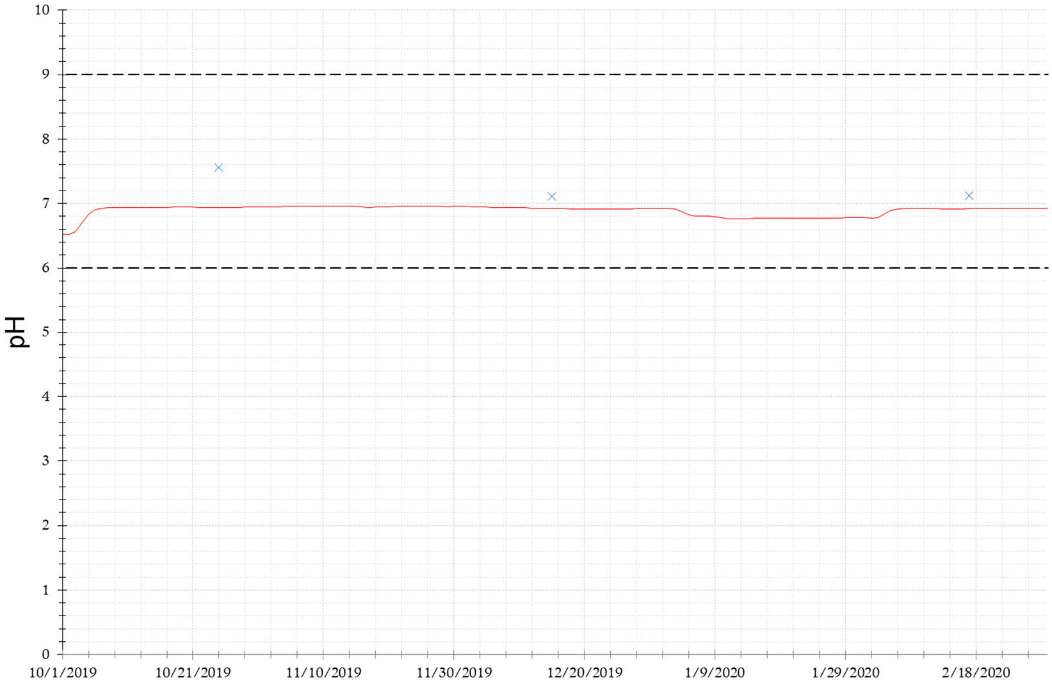


(h) nitrate

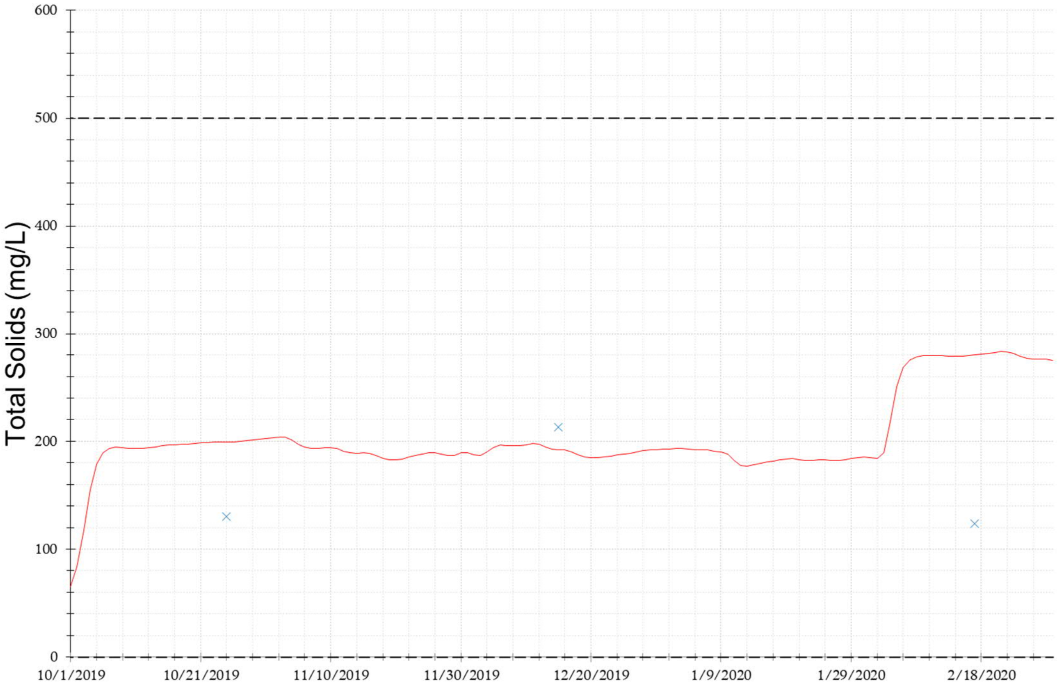
Figure 9 - Fit between simulated profiles and monitored data in WQS-2. Author (2021).



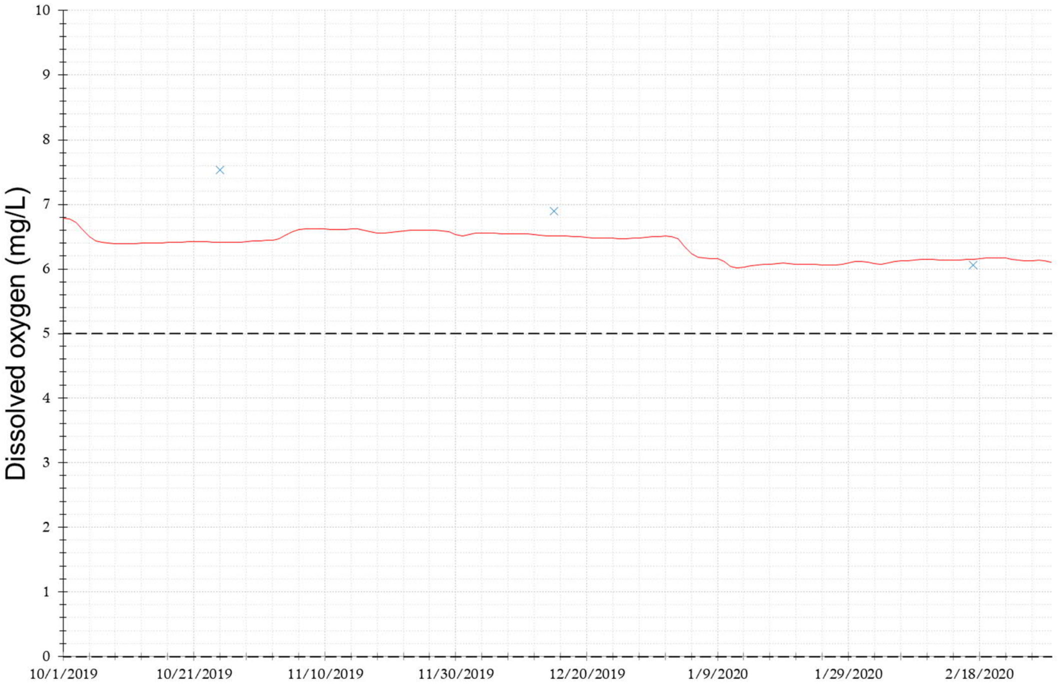
(a) temperature



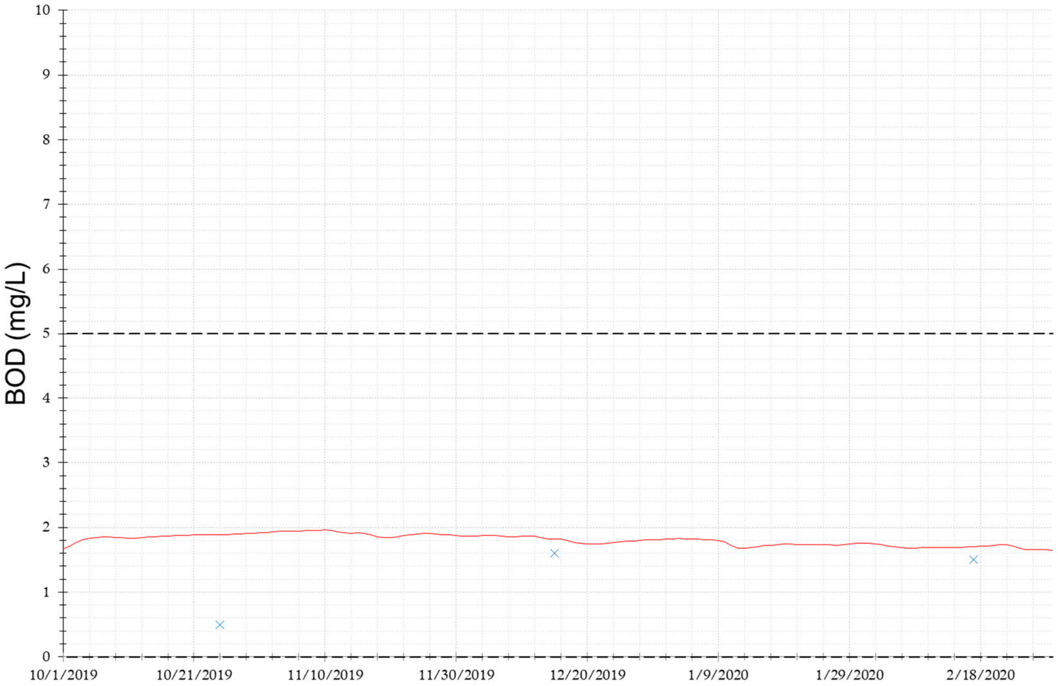
(b) pH



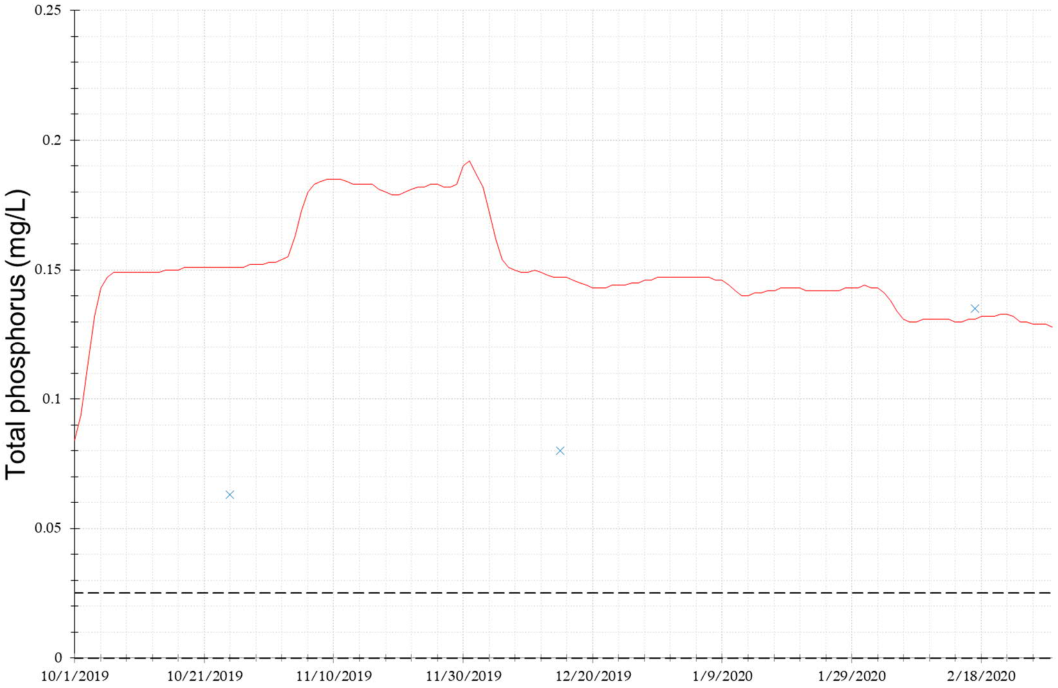
(c) total solids



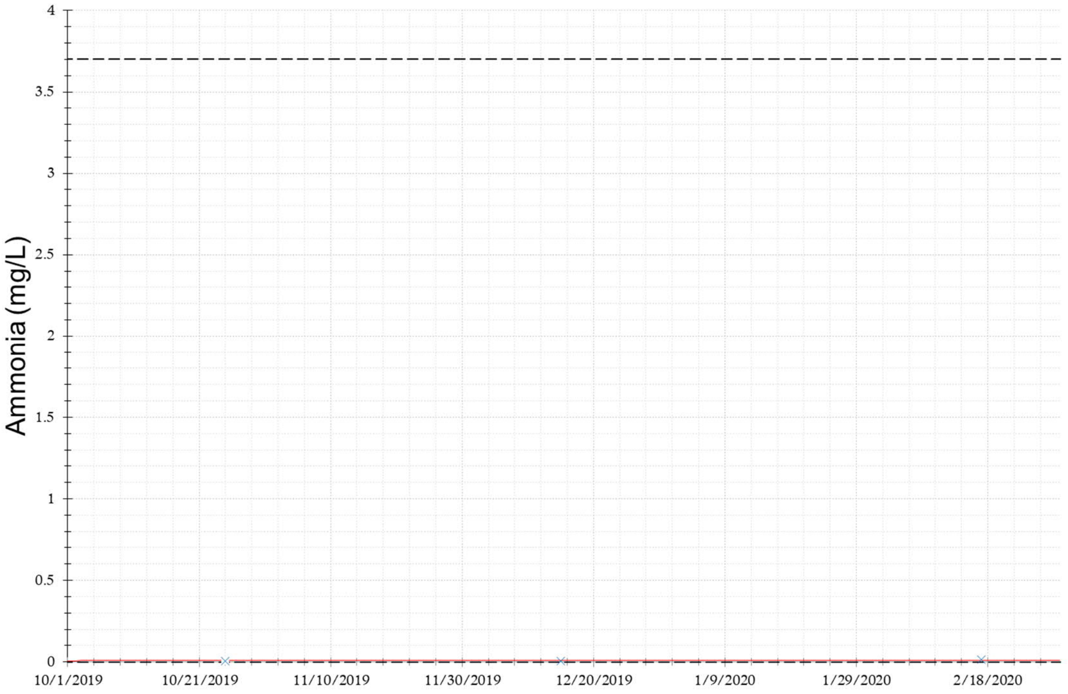
(d) dissolved oxygen



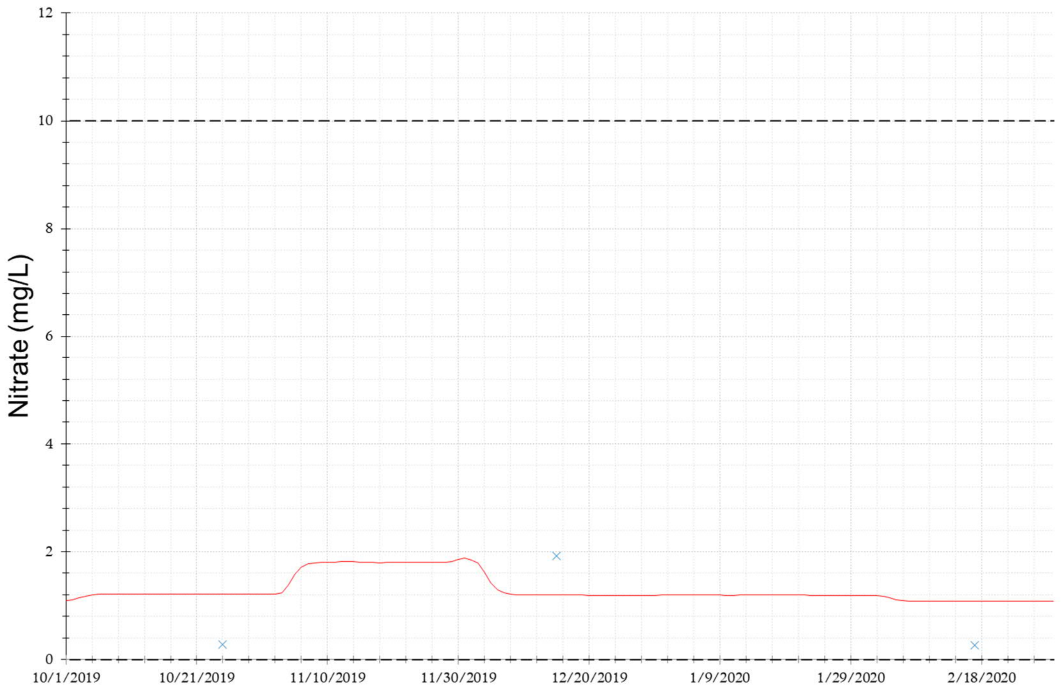
(e) BOD



(f) total phosphorus

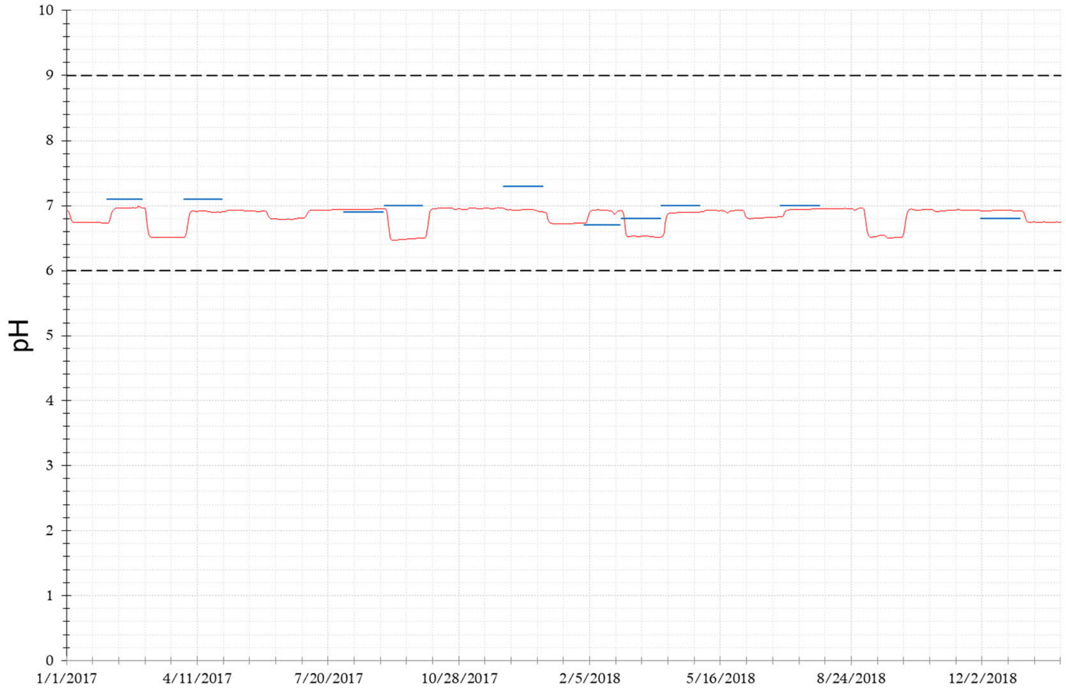


(g) ammonia

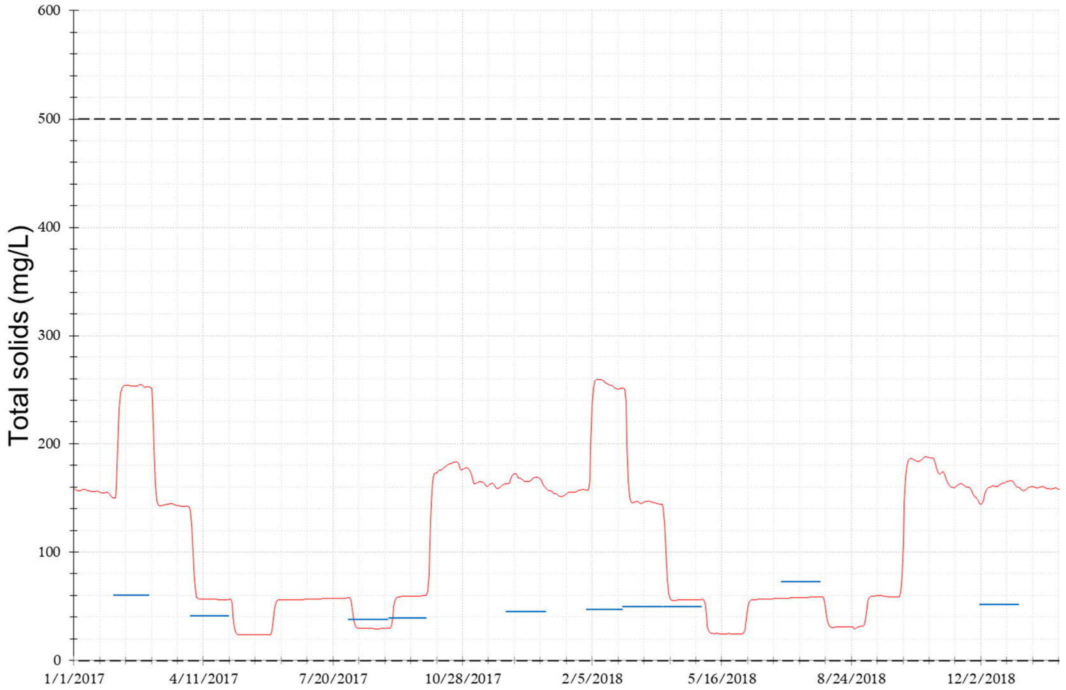


(h) nitrate

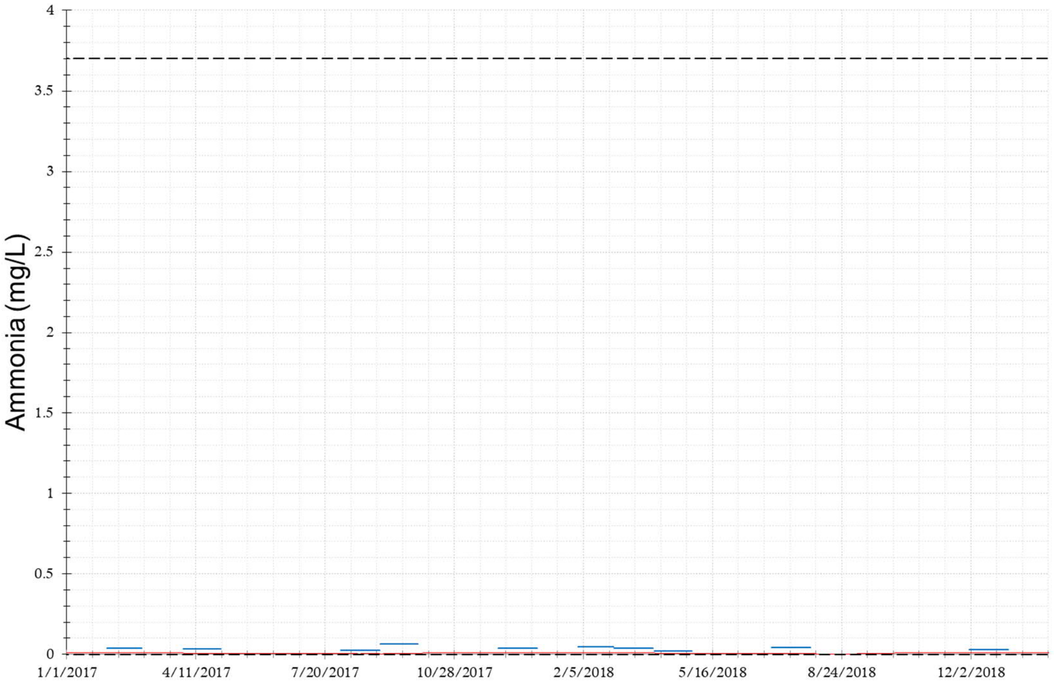
Figure 10 - Fit between simulated profiles and monitored data in WQS-3. Author (2021).



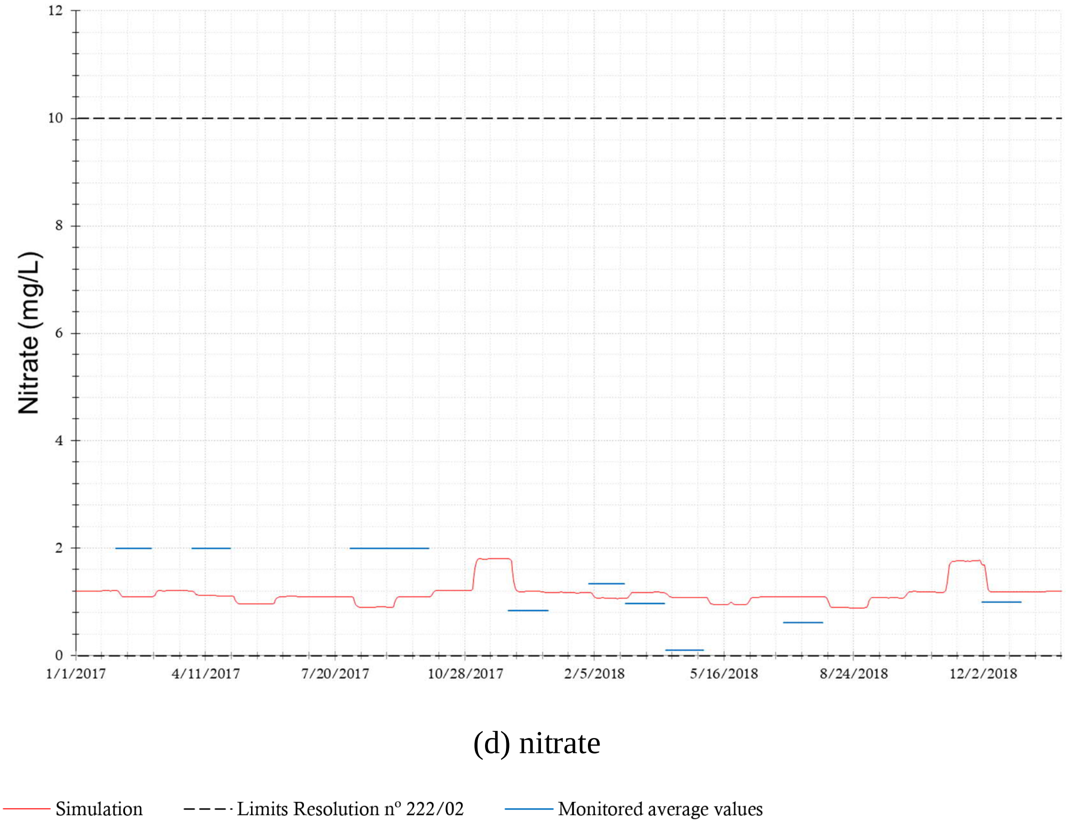
(a) pH



(b) total solids



(c) ammonia



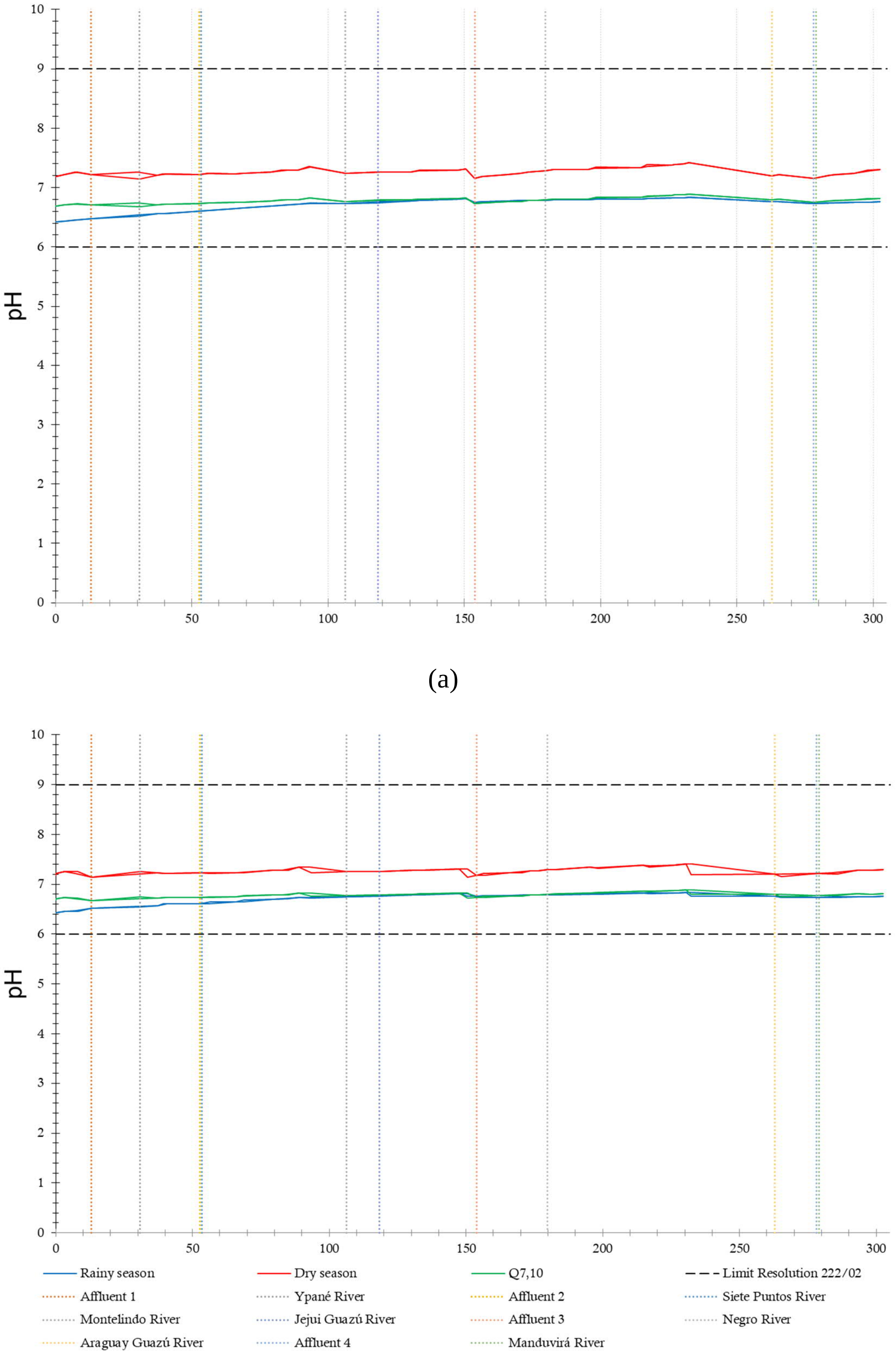
(d) nitrate

Figure 11 – Fit between simulated profiles and monitored data in WQS-4. Author (2021).

7 SELF-DEPURATION SIMULATION

In general, the water quality modeling in lotic environment evaluates if the natural watercourse has a self-depuration capacity against a pollutant. The objective is to adapt the water quality to the minimum limits established in a specific environmental resolution, with a consequent guarantee of balance in the abiotic and biotic processes.

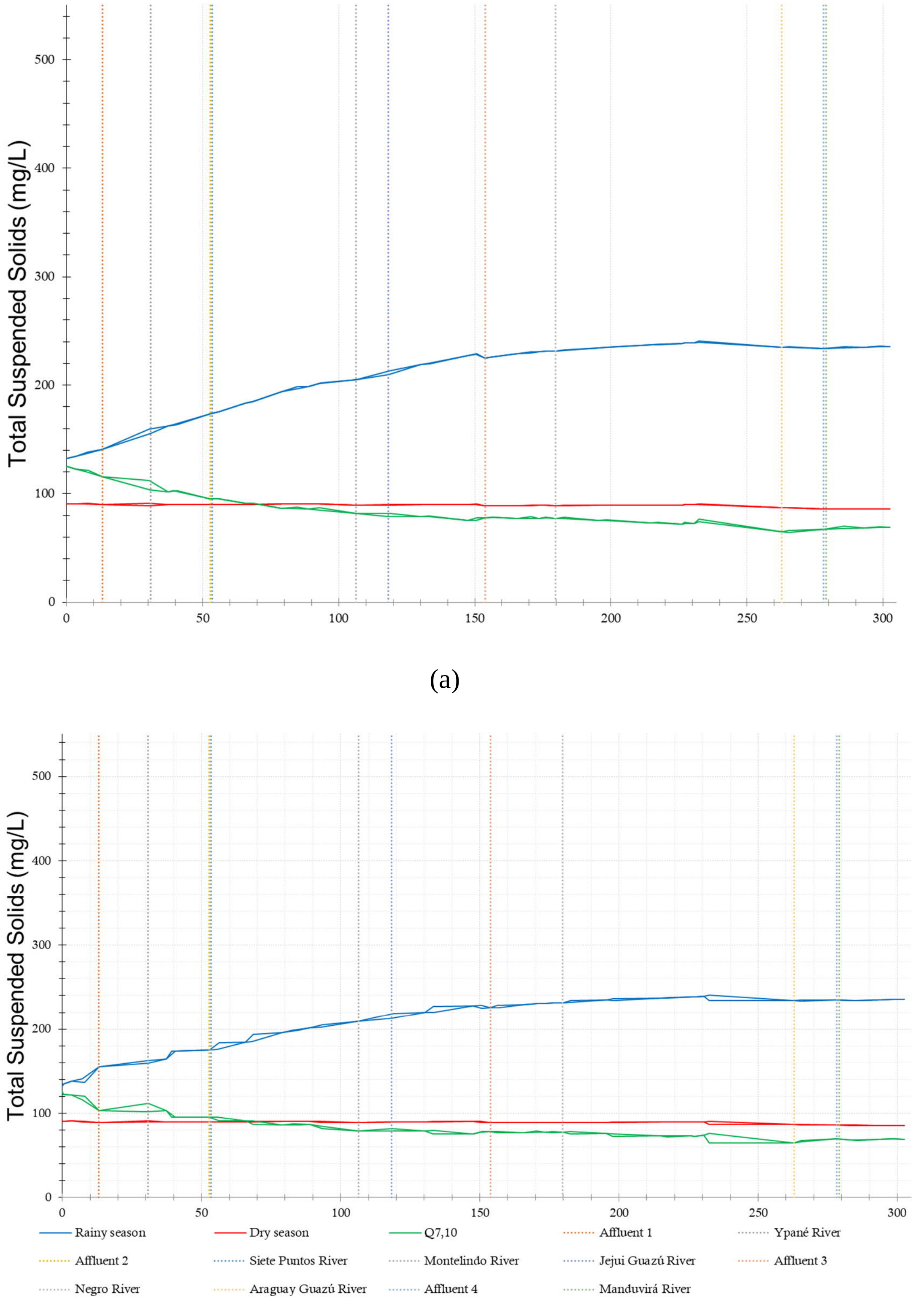
The simulation focus is assessing the influence of the pollutants launched by the pulp mill on the self-depuration capacity of Paraguay River between Concepción and Asunción. For this, considering the maximum flow (5,759.3 m^3/s), minimum (499.8 m^3/s) and critical flows $Q_{7,10}$ (1,093 m^3/s) for period of September 2001 to February 2020, longitudinal profiles of pH, total suspended solids, dissolved oxygen, biochemical oxygen demand, ammonia, nitrate and total phosphorus parameters were compared, in the current situation and in the future situation after the launch of the industry effluent. Comparing the current situation and the future situation after launching of the industrial pollutant, Figures 12 to 18 show, for the maximum, minimum and critical flows ($Q_{7.10}$), the longitudinal profiles of pH, total suspended solids, dissolved oxygen, biochemical oxygen demand, ammonia, nitrate and total phosphorus parameters.



(a)

(b)

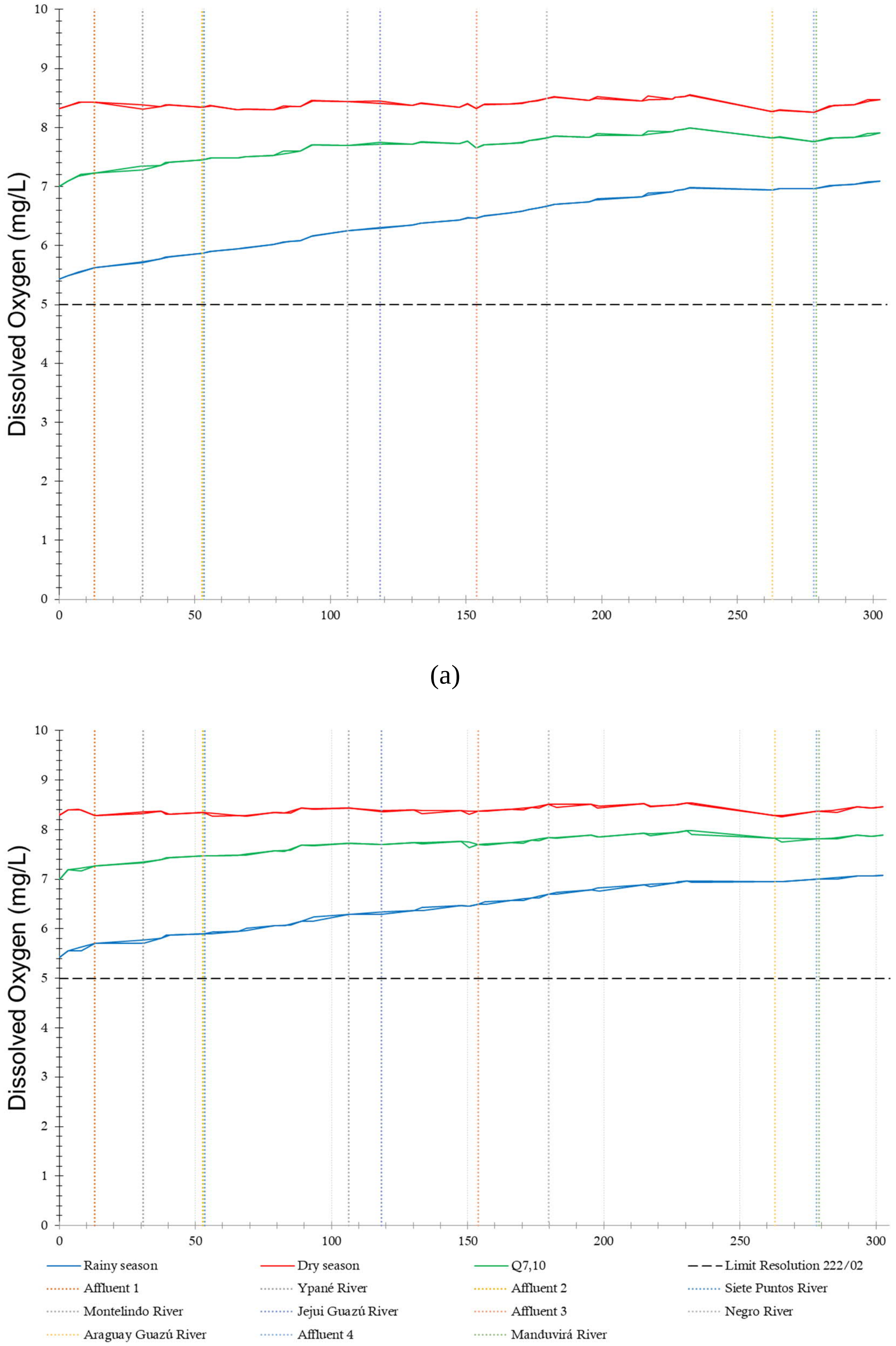
Figure 12 - Longitudinal profiles of pH: (a) Current situation; (b) Future situation after the treated effluent discharge.



(a)

(b)

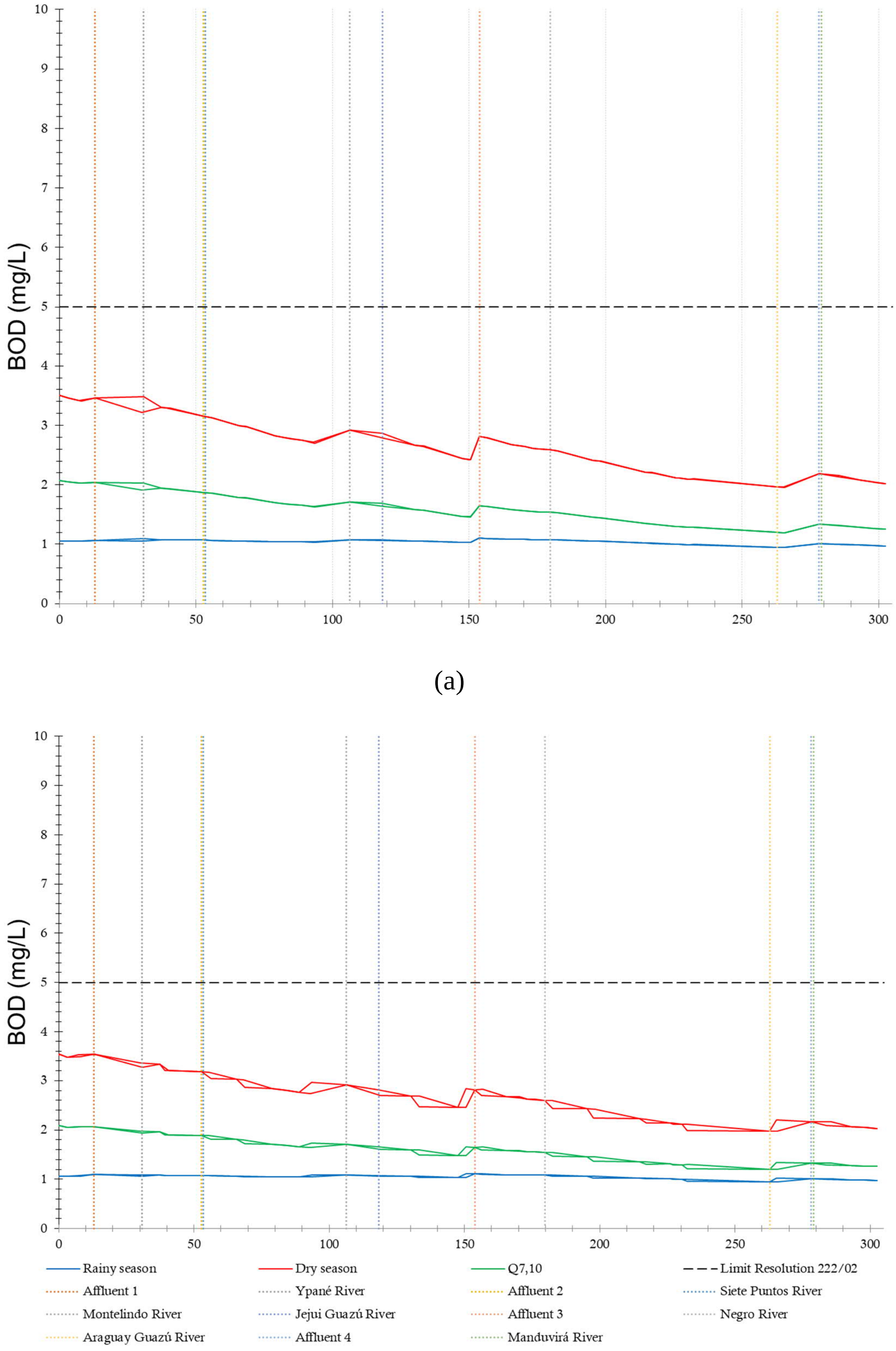
Figure 13 - Longitudinal profiles of total suspended solids: (a) Current situation; (b) Future situation after the treated effluent discharge.



(a)

(b)

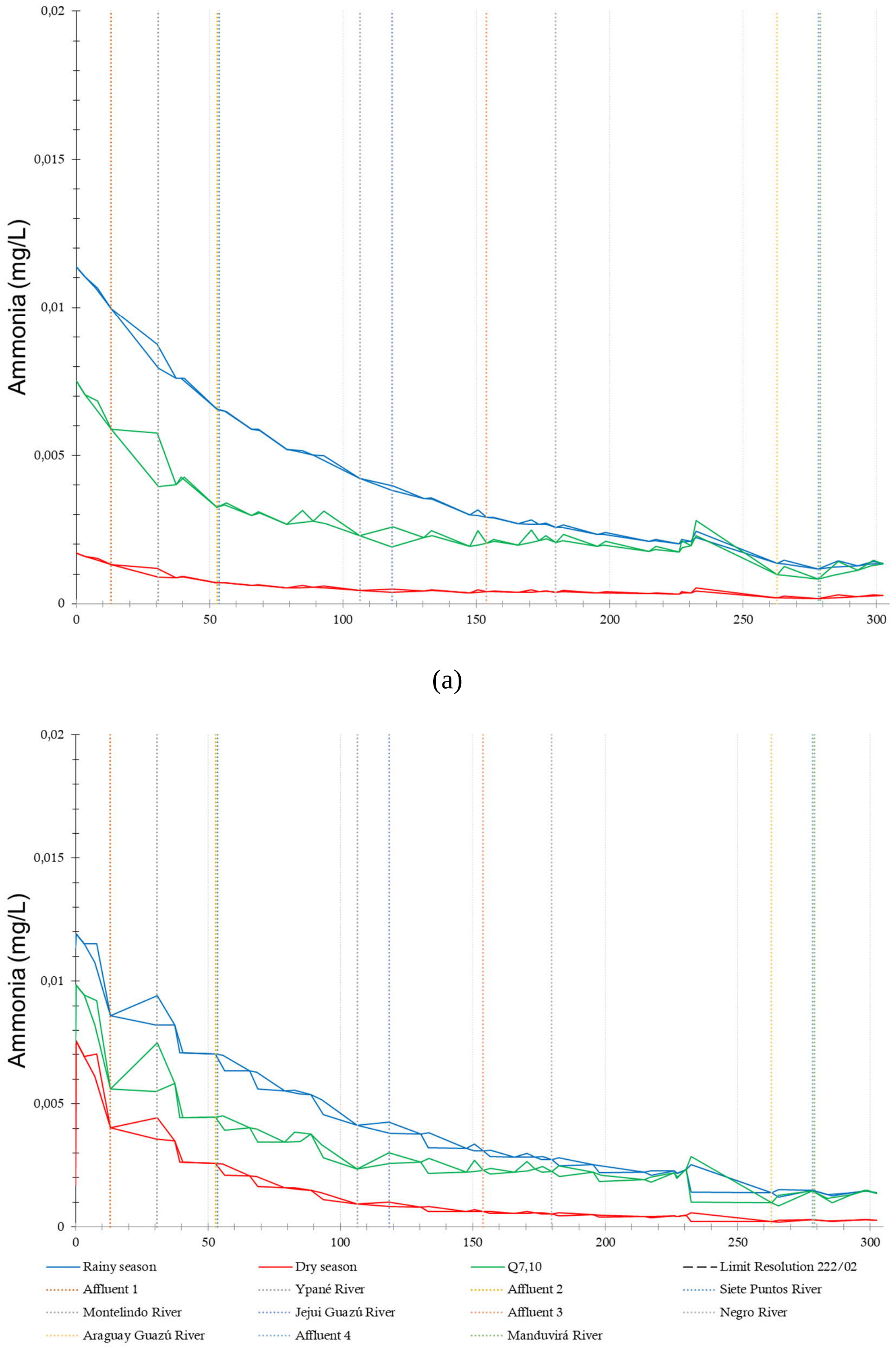
Figure 14 - Longitudinal profiles of dissolved oxygen: (a) Current situation; (b) Future situation after the treated effluent discharge.



(a)

(b)

Figure 15 - Longitudinal profiles of BOD: (a) Current situation; (b) Future situation after the treated effluent discharge.



(a)

(b)

Figure 16 - Longitudinal profiles of ammonia: (a) Current situation; (b) Future situation after the treated effluent discharge.

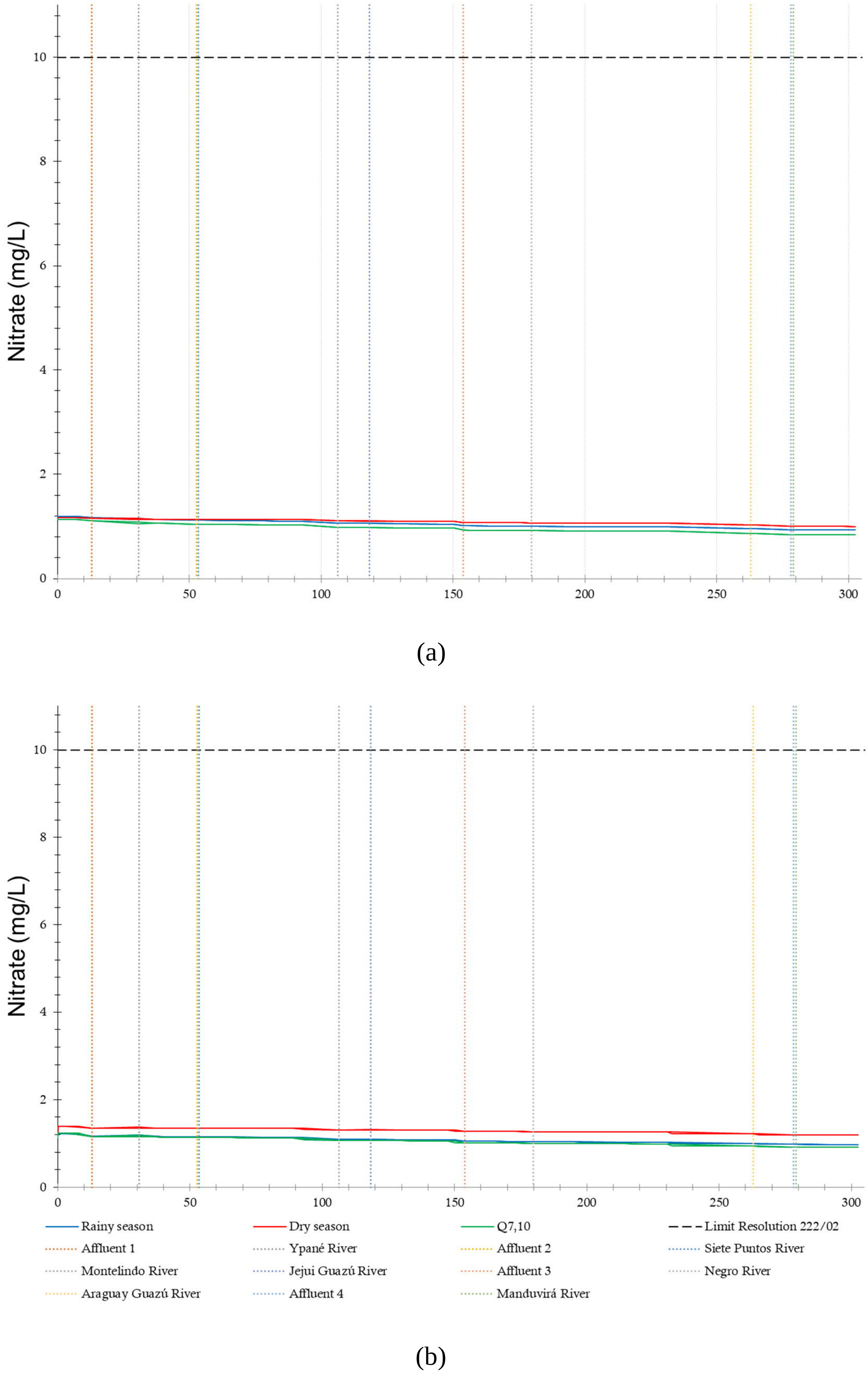
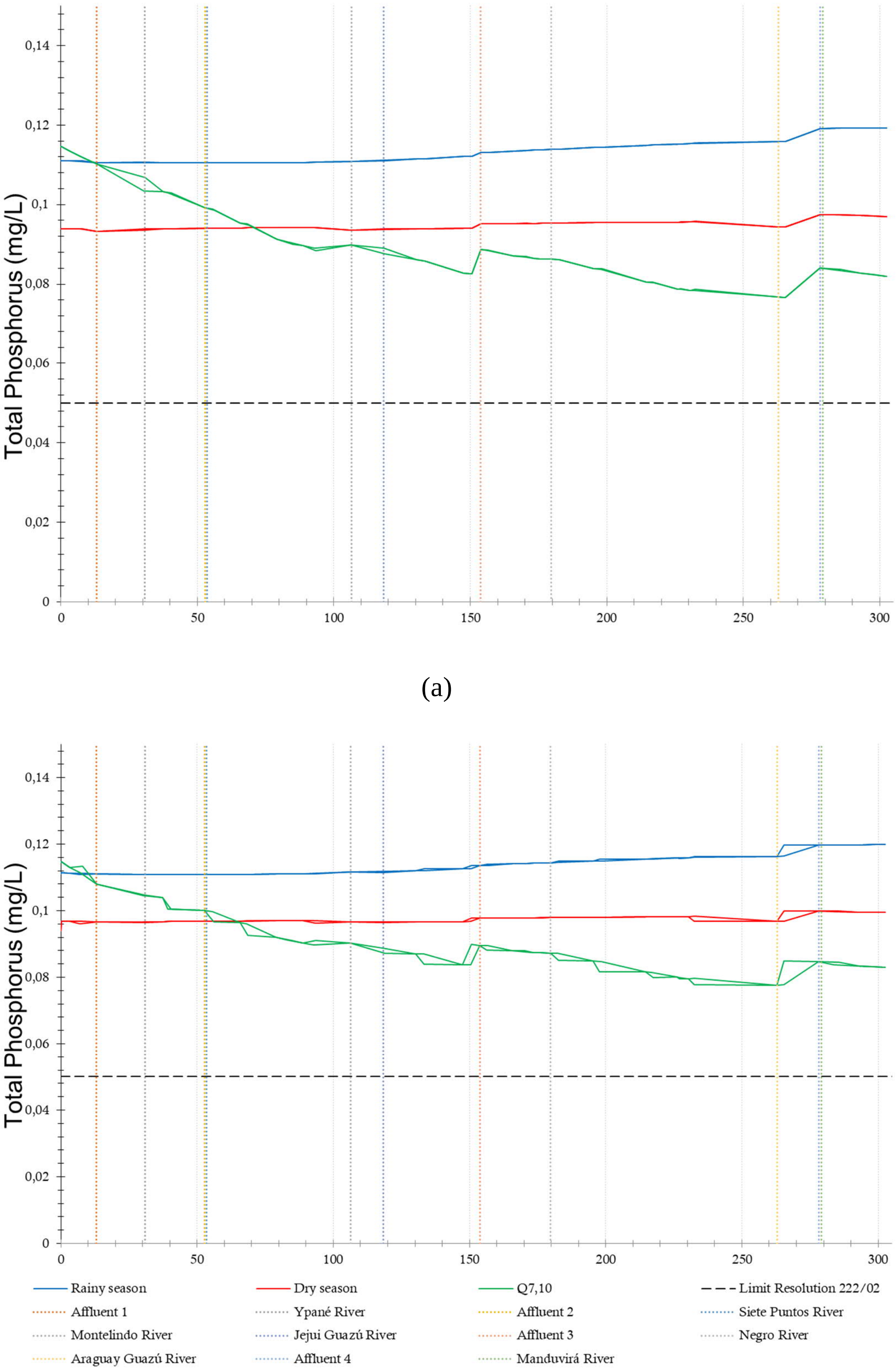


Figure 17 - Longitudinal profiles of nitrate: (a) Current situation; (b) Future situation after the treated effluent discharge.



(a)

(b)

Figure 18 – Longitudinal profiles of total phosphorus: (a) Current situation; (b) Future situation after the treated effluent discharge.

A comparative analysis between the current situation and the future situation after the treated effluent discharge of the industry shows that, for all water quality parameters, there was no significant impact of the industry pollutant launched. The high flows in Paraguay River, between 499,8 and 5,759.3 m^3/s in the section of confluence with the effluent released by the paper and cellulose industry, guarantee a satisfactory dilution capacity of the pollutants. It is also informed that the effluent flow from the paper and cellulose industry represents less than 1% of the critical $Q_{7,10}$ flow in Paraguay River from September 2001 to February 2020.

The Resolution nº 222/2002 (PARAGUAY, 2002) defines the watercourses classification in the Paraguayan territory. According to the contracting company, the Paraguay River is ranked into Class 2, in which the following limits must be respected: pH between 6.0 and 9.0; total dissolved solids ≤ 500.0 mg/L; DO ≥ 5.0 mg/L; BOD ≤ 5.0 mg/L; nitrate ≤ 10.0 mg/L; total phosphorus ≤ 0.05 mg/L. The environmental resolution Paraguayan does not bring the maximum limits for the total suspended solid and ammonia parameters. The limit defined by CONAMA Resolution 357/2005 (BRASIL, 2005) was used to evaluate ammonia parameter.

The parameters pH, total suspended solids, OD, BOD, ammonia and nitrate parameters are within limits of the Resolution nº 222/2002 (PARAGUAY, 2002) and Resolution CONAMA nº 357 (BRAZIL, 2005), where the impact of the diffuse surface load carrying pollutant in the rainy season was noticeable only in the total suspended solid, ammonia and total phosphorus parameters. According to Figures 12 to18, the limit values were:

- pH: 6.4 to 8.3 in the rainy month, 7.1 to 8.3 in the driest month and 6.7 to 8.5 in the critical flow $Q_{7,10}$;
- Total dissolved solids: 132.4 to 240.7 mg/L in the rainy month, 85.7 to 91.2 mg/L in the driest month and 64.5 to 124.9 mg/L in the critical flow Q7,10;
- DO: 5.4 to 7.1 mg/L in the rainy month, 8.3 to 8.5 mg/L in the driest month and 7.0 to 8.0 mg/L in the critical flow $Q_{7,10}$;
- BOD: 1.0 to 1.1 mg/L in the rainy month, 2.0 to 3.5 mg/L in the driest month and 1.2 to 2.1 mg/L at the critical flow $Q_{7,10}$;
- Ammonia: $1.2\text{^}10^{-3}$ to $11.9\text{^}10^{-3}$ mg/L in rainy month, $0.2\text{^}10^{-3}$ to $7.5\text{^}10^{-3}$ mg/L in the driest month and $0.8\text{^}10^{-3}$ to $9.8\text{^}10^{-3}$ mg/L in the critical flow $Q_{7,10}$;
- Nitrate: 1.0 to 1.2 mg/L in the rainy month, 1.2 to 1.4 mg/L in the driest month and 0.9 to 1.2 mg/L in the critical flow $Q_{7,10}$.

Only total phosphorus parameter did not respect the maximum limit of 0,05 mg/L recommended by Resolution nº 222/2002 (PARAGUAY, 2002), both in the current situation and in the future situation. The monitoring of water quality in the WQS-2, WQS-3 and WQS-4 confirms the disagreement of this parameter with the limits recommended in environmental legislation. According to Figure 18, it varied between 0.11 to 0.12 mg/L in the rainy month, 0.09 to 0.10 mg/L in the driest month and 0.08 to 0.11 mg/L in the critical flow $Q_{7,10}$.

The high total phosphorus concentrations in the Paraguay river are observed from the headwater region of the watershed (upper Paraguay river) until of its mouth on the Paraná river (low Paraguay river). Fava (2012) found high total phosphorus concentration in the Bugres River, upper Paraguay River, above that allowed for class 2 of this watercourse, justified by the carrying of soil particles and phosphorus-based fertilizers used in pastures and sugar cane cultivation. According to SEMA (2018), the total phosphorus concentration in the tributaries of the headwaters on the upper Paraguay river are also above the limits recommended by Resolution CONAMA nº 357/2005 (BRASIL, 2005).

8 CONCLUSION

The robustness of the WASP tool enabled the mathematical modeling of the self-depuration process along the Paraguay River between Concepción and Asunción.

The simulations for the current and future situation after the treated effluent discharge of a pulp mill will not impact on the surface water quality of Paraguay River. The behavior of the various parameters is maintained.

The high dissolved oxygen concentrations along the Paraguay River will maintain aquatic life and the ammonia, nitrate and total phosphorus concentrations do not have potential to change trophic state in the watercourse.

9 REFERENCES

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