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**AIR QUALITY IMPACT EVALUATION
CUMULATIVE IMPACTS FROM PROPOSED ORION AND CMB PULP MILLS
- URUGUAY**

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

1. INTRODUCTION	11
1.1 PROJECT BACKGROUND.....	11
1.2 PURPOSE AND OBJECTIVES	11
1.3 OVERVIEW OF EVALUATION	12
2. DESCRIPTION OF AIR POLLUTANT EMISSION SOURCES EVALUATED	13
2.1 ORION MILL	13
2.1.1 Location and Site Layout.....	13
2.1.2 Potential Air Pollutant Emission Rates	13
2.1.3 Point of Release Characteristics	13
2.2 CMB MILL	14
2.2.1 Location and Site Layout.....	14
2.2.2 Potential Air Pollutant Emission Rates	14
2.2.3 Point of Release Characteristics	15
3. CHARACTERISTICS OF THE LOCAL AREA	16
3.1 WIND FLOW PATTERN	16
3.2 RURAL/URBAN LAND USE CLASSIFICATION	16
3.3 TOPOGRAPHY	17
4. HEALTH STANDARDS.....	18
5. DESCRIPTION OF AIR QUALITY DISPERSION MODEL.....	19
5.1 OVERVIEW OF MODEL	19
5.2 TECHNICAL OPTIONS AVAILABLE IN THE MODEL.....	19
5.3 AERODYNAMIC DOWNWASH	20
6. DATABASES EMPLOYED IN THE ANALYSIS	21
6.1 EMISSION INVENTORY	21
6.2 METEOROLOGICAL DATA	21
6.3 RECEPTOR GRID.....	21
7. AIR DISPERSION MODELING METHODOLOGY	23
8. AIR DISPERSION MODELING RESULTS.....	25

EXECUTIVE SUMMARY

An independent air quality impact evaluation has been performed by Malcolm Pirnie, Inc. for two proposed pulp mills being considered for construction and operation in southwest Uruguay. The exact location of the two pulp mills is along the Rio Uruguay River just east of Fray Bentos, Uruguay. Refer to Figure 1 for an aerial photograph of the Fray Bentos area (referred to as the “Study Area”) which depicts the location of the two mills.

The two mills to be evaluated are referred to as the Orion Mill and the CMB Mill. The Orion mill has been designed to produce 1,000,000 tons of air dried pulp on an annual basis, while the CMB Mill is anticipated to produce 500,000 tons of air dried pulp. In order to produce pulp at these production rates, each mill will contain several operations critical to the production of Kraft pulp. Because of the nature of these operations, these operations will have the potential to generate air pollutant emissions. Both mills will be incorporating air pollution control techniques and equipment to minimize these emissions in order to meet international emission standards and health standards which represent the most conservative health standards identified worldwide.

To determine the potential impacts on local air quality (i.e., study area) from these two mills, an air quality impact evaluation was performed for emissions of sulfur dioxide (SO₂), oxides of nitrogen (NO_x), particulate matter (PM) and Total Reduce Sulfur (TRS) from the Orion and CMB Mills, taking into account maximum design production rates and air pollution control techniques/equipment. The estimated emissions rates which are summarized below were obtained from documentation developed in support of the Environmental Assessment initially performed for each mill in support of approval from the Uruguay Environmental Ministry.

Air Emissions – Normal Mill Operation

Air Emissions	ORION (Kg/ADT)	CMB (Kg/ADT)	ORION (Kg/hr)	CMB (Kg/hr)
Sulfur (S)	0.4	0.4	47.6	23.8
Sulfur Dioxide (SO ₂)	0.8	0.8	95.2	47.6
Oxides of Nitrogen (NO _x)	1.4	1.2	166.7	71.4
Particulate Matter (PM)	0.4	0.5	47.6	29.8
Total Reduced Sulfur (TRS)	0.1	0.04	11.9	2.4

Note:

1) Kg/ADT = kilograms per air dried ton of pulp, Kg/hr = kilograms per hour

2) Kg/hr emissions rates were based on the individual emission factors and a maximum hourly production rate of 119 tons/hr of air dried pulp for the Orion Mill and 59.5 tons of air dried pulp for the CMB Mill.

Air Emissions – Startup Conditions at Orion and CMB Mills

Air Emissions	Recovery Boiler* (kg/hr)	Lime Kiln* (kg/hr)
Sulfur Dioxide (SO ₂)	512.6	32.1
Oxides of Nitrogen (NO _x)	25.6	1.6
Particulate Matter (PM)	35.2	2.2

* Information provided by Orion Mill based on the anticipated use of No. 6 fuel oil during startup conditions (i.e., 1 kg/sec fuel usage recovery boiler, 0.06 kg/sec fuel usage kiln)

The majority of these air emissions, as presented above, are anticipated to be released from a single point within each mill. This main point of release of these potential air pollutants will be the mill's chimney. Each chimney will contain individual flues that are designed to vent exhaust gases to the atmosphere from certain predefined process operations associated with each mill. The specifics associated with each individual chimney as identified by representatives from the Orion and CMB mills are provided below:

Point of Release Characteristics for Each Mill – Normal Mill Operation

Source Description	Chimney Height (meters)	Diameter of Flue (meters)	Exhaust Gas Temperature (Degrees K)	Exhaust Gas Velocity (meters / second)
Orion Main Chimney (Recovery Boiler Flue)	120	4.6	433.2	22.1
Orion Main Chimney (Lime Kiln Flue)	120	2.5	503.2	14.4
CMB Main Chimney*	100	1.5	423.2	28.0

* Represents worst case stack characteristics associated with the CMB Chimney

To determine the resultant concentrations on the area of influence for each air pollutant emission rate, a mathematical program was employed. This program is referred to as the Industrial Source Complex Dispersion model, version 3.0 (ISC3) and was developed by atmospheric scientists for the sole purpose of simulating plume impacts from industrial facilities. This model is a recommended tool for predicting ambient concentrations of steady state air pollutant emissions from industrial facilities by the U. S. Environmental Protection Agency (USEPA).

Major features of the ISC3 dispersion model include the following:

- Plume rise due to momentum and buoyancy as a function of downwind distance for stack emissions;
- The influence of building wakes on plume transport and dispersion is evaluated by the Huber and Snyder Method for physical stack heights that are greater than $h_b + 0.5 l_b$, where h_b is the building height and l_b is the lesser of the building height or width, and by the Schulman and Scire Method for stack heights that are less than $h_b + 0.5 l_b$;
- Calm wind treatment of meteorological data;
- Buoyancy-induced plume rise algorithm;
- Procedures suggested by Briggs for evaluating stack-tip downwash; and
- Concentration estimates for 1 hour to annual average.

In order to simulate movement of an industrial plume within a prescribed geographical area, local meteorological conditions (i.e., wind direction, wind speed, temperature, and atmospheric stability) can be entered into the ISC3 dispersion model. The model will then use this data, along with the emission/stack characteristic data, to predict ambient concentrations. To represent local meteorological conditions that may be present in the location of the proposed pulp mill, meteorological data recorded in Gualeguaychú, Argentina was selected. This data consisted of five years (2000-2004) of surface observations, measured every 3-hours and coincident mixing heights from the Gualeguaychú, Argentina meteorological station. Surface observations consist of measurements of wind direction, wind speed, and temperature, and estimates of ceiling

height and cloud cover. Mixing heights were derived using surface data and planetary boundary layer theory since twice daily sounding data were not available for the area. The meteorological data was processed and provided to Malcolm Pirnie by Trinity Consultants.

Two other technical inputs are also required for the ISC3 dispersion model to assist in the simulation of industrial exhaust plume impacts. This includes determination of the topography of the local area, as well as the affect of the local topography on atmospheric stability.

The topography of the area can be described as essentially flat. Since there is no significant change in elevation within a 3-kilometer radius circle of the proposed pulp mills, it was determined that the minimal change in terrain elevation should not affect the dispersive nature of the exhaust stacks associated with the proposed pulp mills. Therefore, terrain elevations were not included in the air quality impact evaluation.

A technique was developed by Irwin to classify a site area as either rural or urban for purposes of using rural or urban dispersion coefficients. The classification can be based on average heat flux, land use, or population density within a 3-kilometer (km) radius from the site of the proposed pulp mills. Of these, the USEPA has specified that land use is the most definitive criterion. The rural/urban classification based on land use is as follows:

Using the land use typing scheme established by Auer, an urban classification of the site area requires more than 50 percent of the following land use types: heavy industrial (I1), light-moderate industrial (I2), commercial (C1), single-family compact residential (R2), and multi-family compact residential (R3). Otherwise, the site area is considered rural.

Based on using the land use classification scheme, the rural classification comprises greater than 50% of the area contained within the 3-kilometer (km) radius circle

surrounding the proposed Orion and CMB pulp mills. Thus, the area surrounding the site of the proposed pulp mills is considered rural, allowing the use of the rural dispersion coefficients that were employed in the ISC3 dispersion model.

The ISC3 dispersion model, in conjunction with the 5-year meteorological database and the rural dispersion coefficients, was employed to predict ambient concentrations due to emissions of SO₂, NO_x, PM and TRS from the Orion and CMB pulp mills during:

- 1) Normal operation at maximum pulp production rates (Orion and CMB Mills);
- 2) Startup conditions at the Orion Mill only (Fuel oil firing - SO₂, NO_x and PM emissions); and
- 3) Startup conditions at the Orion and CMB Mills (TRS emissions).

Predicted concentrations were determined at distinct points within the area of study. As part of the evaluation process, distinct points (referred to as receptor points) were inserted into the ISC3 dispersion model and the model was used to predict concentrations [expressed in micrograms per cubic meter (ug/m³)] at each distinctive receptor point.

The receptor grid selected for the air quality impact study was designed to identify the maximum air quality impact due to the proposed cumulative impacts of the proposed Orion and CMB pulp mills. The receptor grid consists of 25,921 receptors extending to a downwind distance of 20 kilometers from the proposed Orion pulp mill. Receptor points were spaced 250 meters apart throughout this receptor grid.

The concentrations that were predicted by the ISC3 dispersion model based on the cumulative impacts of emissions of SO₂, NO_x, PM and TRS from the Orion and CMB pulp mills under normal operating conditions and startup conditions are summarized below. The results provided reflect the maximum cumulative impacts at the 25,921 receptor points evaluated. It should be noted that health standards do not exist for emissions of TRS gases; however, these emissions are a surrogate to the formation of odors. The potential for the formation of odor is discussed later on in this executive summary.

To determine if the concentrations predicted below would have an impact on human and health and welfare, an evaluation was performed to determine if acceptable standards, expressed in $\mu\text{g}/\text{m}^3$, have been established to protect human health and welfare. This evaluation revealed that several countries, as well as organizations, have established concentration-based standards which are designed to protect human health and welfare from emissions of air pollutants from industrial type facilities. The standards listed in the tables below are the most stringent standards identified from an individual country or organization. It should be noted that the development of any health based standard is typically established based on health affect studies and a margin of safety.

Maximum Cumulative Impacts (Orion and CMB Mills) - SO_2

Maximum Predicted Concentration ($\mu\text{g}/\text{m}^3$)	Averaging Period Evaluated	Health Standard ($\mu\text{g}/\text{m}^3$)	Percent of Health Standard	World Bank Standard ($\mu\text{g}/\text{m}^3$)	Percent of World Bank Standard
2.7	Annual	32	8.3	50	5.3
21.7	24-Hour	30	72.3	125	17.4
43.9	3-Hour	1,300	3.4	-	-
49.7	1-Hour	690	7.2	-	-

Maximum Cumulative Impacts (Orion and CMB Mills) - NO_2

Maximum Predicted Concentration ($\mu\text{g}/\text{m}^3$)	Averaging Period Evaluated	Health Standard ($\mu\text{g}/\text{m}^3$)	Percent of Health Standard	World Bank Standard ($\mu\text{g}/\text{m}^3$)	Percent of World Bank Standard
4.0	Annual	30	13.3	-	-
32.6	24-Hour	150	21.7	150	21.7
74.6	1-Hour	190	39.3	-	-

Maximum Cumulative Impacts (Orion and CMB Mills) - PM

Maximum Predicted Concentration ($\mu\text{g}/\text{m}^3$)	Averaging Period Evaluated	Health Standard ($\mu\text{g}/\text{m}^3$)	Percent of Health Standard	World Bank Standard ($\mu\text{g}/\text{m}^3$)	Percent of World Bank Standard
1.7	Annual	50	3.3	50	3.3
13.6	24-Hour	70	19.4	70	19.4
31.1	1-Hour	250	12.4	-	-

Maximum Impacts During Startup Conditions – Orion Mill Only

Air Pollutant	Maximum Predicted Concentration (ug/m ³)	Averaging Period Evaluated*	Health Standard (ug/m ³)	Percent of Health Standard
SO ₂	293.5	1-Hour	690	42.5
NO _x	14.6	1-Hour	190	7.7
PM	20.1	1-Hour	250	8.0

* Impacts based on 2001 meteorological period. Determined to be the worst case meteorological data during the 5-year period evaluated.

As shown above, the potential cumulative impacts of SO₂, NO_x and PM emissions from the Orion and CMB Mills during normal operation are well below the most stringent Health Standards and the World Bank standards. Additionally, emissions from the Orion Mill during startup are well below health standards.

Additional receptor points were modeled in and around the following areas:

- Fray Bentos area;
- International Bridge;
- Mercedes, Uruguay;
- Nuevo Berlin, Uruguay;
- Gualeguaychú, Argentina;
- Nandubaysal, Argentina beach area; and
- Las Canas Resort area.

A single receptor point was modeled at each of the areas noted above with the exception of the Fray Bentos area which included 154 receptors and the International Bridge which included 3 distinct receptor points. The results of the impacts on these additional receptor points are noted below:

- Maximum Cumulative Impacts on Additional Receptor Locations- SO₂

Additional Receptor Location	Maximum Predicted Concentration (ug/m ³)	Averaging Period Evaluated	Health Standard (ug/m ³)	Percent of Health Standard	World Bank Standard (ug/m ³)	Percent of World Bank Standard
Fray Bentos area	3.96	24-Hour	30	13.2	125	3.2
International Bridge	3.11	24-Hour	30	10.3	125	2.5
Mercedes, Uruguay	1.06	24-Hour	30	3.5	125	<1
Nuevo Berlin, Uruguay	1.05	24-Hour	30	3.5	125	<1
Gualeguaychú, Argentina	0.47	24-Hour	30	1.5	125	<1
Nandubaysal, Argentina beach area	1.19	24-Hour	30	4.0	125	<1
Las Canas Resort area	2.47	24-Hour	30	8.2	125	1.7

Maximum Cumulative Impacts on Additional Receptor Locations – NO₂

Additional Receptor Location	Maximum Predicted Concentration (ug/m³)	Averaging Period Evaluated	Health Standard (ug/m³)	Percent of Health Standard
Fray Bentos area	24.52	1-Hour	190	12.9
International Bridge	20.88	1-Hour	190	11.0
Mercedes, Uruguay	12.89	1-Hour	190	6.8
Nuevo Berlin, Uruguay	8.28	1-Hour	190	4.4
Gualeduaychú, Argentina	9.45	1-Hour	190	5.0
Nandubaysal, Argentina beach area	12.24	1-Hour	190	6.4
Las Canas Resort area	16.16	1-Hour	190	8.5

No 1-Hour World Bank standard for NO₂

Maximum Cumulative Impacts on Additional Receptor Locations – PM

Additional Receptor Location	Maximum Predicted Concentration (ug/m³)	Averaging Period Evaluated	Health Standard (ug/m³)	Percent of Health Standard
Fray Bentos area	8.36	1-Hour	250	3.3
International Bridge	7.95	1-Hour	250	3.2
Mercedes, Uruguay	5.37	1-Hour	250	2.1
Nuevo Berlin, Uruguay	3.45	1-Hour	250	1.4
Gualeduaychú, Argentina	3.94	1-Hour	250	1.6
Nandubaysal, Argentina beach area	5.10	1-Hour	250	2.0
Las Canas Resort area	6.73	1-Hour	250	2.7

No 1-Hour World Bank standard for PM

As shown above, the potential cumulative impacts of SO₂, NO_x, and PM emissions from the Orion and CMB mills during normal operation on the additional receptor points are well below the most stringent health standards and World Bank standards for SO₂ emissions.

The process for determining the potential for odor perception in the given study area for TRS gases from the Orion and CMB mills is complex. To minimize this complexity, a technical search was performed for determining the best approaches for predicting the potential for odor detection for exhaust gases associated with normal operation of the Orion and CMB mills. These approaches include:

- 1) Conducting an air quality dispersion modeling analysis using odor detection concentration thresholds,

- 2) Conducting an air quality dispersion modeling analysis using odor units; and
- 3) Conducting odor sampling and performing odor panels.

For this impact study, Option #1 was selected. This option was selected based on access to the ISC3 dispersion model and the availability of odor thresholds for selected TRS gases, expressed in ug/m³ from technical organizations.

In information provided as part of the Environmental Assessment for the Orion mill, a breakdown of specific constituents within the TRS gases with high odor potential was presented. The specific breakdown is as follows:

Speciation of TRS Gases – Potential Concentrations of Odor Gases

Constituent	Odor Component Breakdown (%)
Hydrogen Sulfide	13
Methyl Mercaptan	48
Dimethyl Sulfide	8
Dimethyl Disulfide	31

The results obtained from the odor detection evaluation are summarized below for normal mill operation. The maximum predicted cumulative impact at any of the receptor points evaluated has been summarized in this table.

Potential Cumulative Odor Impacts – Orion and CMB Mills Normal Operation

Air Pollutant	Averaging Period	Maximum Predicted Concentration (ug/m ³)	Lower End of Odor Threshold Range (ug/m ³)	% of Threshold
Hydrogen Sulfide	10 minutes	0.69	0.76	90.5
Methyl Mercaptan	10 minutes	3.59	3.93	91.4
Dimethyl Sulfide	10 minutes	0.77	2.79	27.7
Dimethyl Disulfide	10 minutes	4.54	23.1	19.7

As shown above, the predicted concentrations are slightly below the lower end of the odor thresholds range established for a 10 minute concentration. These results indicate that during normal operation of the mills with emissions being released from the mill's main chimney, the likelihood of odors being detected should be minimal.

The potential for odors during startup conditions were evaluated. Provided below is a table summarizing those potential odor impacts:

Potential Cumulative Odor Impacts – Orion and CMB Mills Startup Conditions

Air Pollutant	Averaging Period	Maximum Predicted Concentration (ug/m³)	Lower End of Odor Threshold Range (ug/m³)	% of Threshold
Hydrogen Sulfide	10 minutes	1.25	0.76	164.5
Methyl Mercaptan	10 minutes	6.55	3.93	166.7
Dimethyl Sulfide	10 minutes	1.41	2.79	50.5
Dimethyl Disulfide	10 minutes	8.29	23.1	35.9

As shown above during mill startup conditions the potential for odor detection does exist. Predicted concentrations of hydrogen sulfide and methyl mercaptan exceed their respective odor thresholds. The duration of these conditions where detection of odors may occur has been predicted to be a small fraction of the mills’ operating time, with a maximum downwind distance typically not anticipated to exceed 2 kilometers.

1. INTRODUCTION

1.1 PROJECT BACKGROUND

An independent air quality impact evaluation has been performed by Malcolm Pirnie, Inc. for two proposed pulp mills being considered for construction and operation in southwest Uruguay. The exact location of the two pulp mills is along the Rio Uruguay River just east of Fray Bentos, Uruguay. Refer to Figure 1 for an aerial photograph of the Fray Bentos area (referred to as the “Study Area”) which depicts the location of the two mills.

The two mills to be evaluated are referred to as the Orion Mill and the CMB Mill. The Orion mill has been designed to produce 1,000,000 tons of air dried pulp on an annual basis, while the CMB Mill is anticipated to produce 500,000 tons of air dried pulp. In order to produce pulp at these production rates, each mill will contain several operations critical to the production of Kraft pulp. Because of the nature of these operations, these operations will have the potential to generate air pollutant emissions. Both mills will be incorporating air pollution control techniques and equipment to minimize these emissions in order to meet international emission standards and Health standards.

1.2 PURPOSE AND OBJECTIVES

The purpose of the air quality impact evaluation is to identify the cumulative impacts of emissions of sulfur dioxide, oxides of nitrogen, particulate matter and total reduced sulfur from the proposed mills on the local environment. The objective of the evaluation is to demonstrate that the operation of these two mills will not cause an adverse impact to human health and welfare in the area surrounding the two mill sites (i.e., “Study Area”), as well as a determination as to whether or not these mills will result in potential emissions that could cause odors during various operating modes associated with these types of mills.

The air quality impact evaluation was performed to determine potential impacts out to a distance of 20 kilometers from the Orion mill and included evaluation of areas that people reside or commonly gather. These areas included: 1) Cities such as Fray Bento, Uruguay, Mercedes, Uruguay, Gualeguaychu, Argentina and Nuevo Berlin, Uruguay, 2) Resort areas, such as Nandubaysal, Argentina and Las Canas, Uruguay, 3) Rio Uruguay river area and 4) the International Bridge.

1.3 OVERVIEW OF EVALUATION

The evaluation incorporated air pollutant emissions from both the Orion and CMB pulp mills during normal mill operations and startup conditions. To predict the potential impact on the Study Area, the evaluation employed an air dispersion model created by the United States Environmental Protection Agency (USEPA) which can be used to determine the impacts (i.e., concentrations expressed in micrograms per cubic meter) that could occur from air pollutant emissions being released from industrial sources. The magnitude of the predicted concentration is used to determine whether or not human health or welfare will be adversely impacted. For this evaluation, the model was used to predict the magnitude of the predicted concentrations within the study area that could result from air pollutant emissions from each proposed pulp mill. The primary source of air pollutant emissions from each pulp mill will be the mill's chimney. Operations associated with these mills that have the potential to generate air pollutant emissions will be exhausted through individual flues that will be located inside each mill's chimney. The chimney's are designed for proper dispersion to the atmosphere of the exhaust gases and will be 120 meters in height (above grade level) for the Orion mill and 100 meters in height for the CMB mill.

The concentrations that were obtained from the air dispersion model during normal operating conditions, as well as startup conditions were compared to World Bank health standards, most stringent Health standards and odor threshold concentration levels commonly defined by the pulp industry as levels that people may detect odors.

2. DESCRIPTION OF AIR POLLUTANT EMISSION SOURCES **EVALUATED**

2.1 ORION MILL

2.1.1 Location and Site Layout

The proposed Orion pulp mill is located approximately 5 km east of the Fray Bentos, Uruguay riverfront area as depicted in Figure 1.

2.1.2 Potential Air Pollutant Emission Rates

Certain operations performed in a pulp mill will have the potential to generate emissions of air pollutants that have been identified by the World Bank, as well as other health organizations, as having the potential to impact human health and welfare. To prevent adverse impacts to human health and welfare, acceptable concentrations levels have been established.

As discussed previously, the evaluation was performed for selected air pollutants that were determined to potentially pose the highest likelihood for impacting human health and welfare. The individual air pollutant emissions that were evaluated are identified in Table 1 (a and b). These individual emission rates which reflect normal and startup mill operations were provided by the company designing the Orion mill. Emission factors are presented in units of kg per air dried ton (ADT) which is common for the pulp mill industry. Estimates of the air pollutant emissions for the Orion mill's main chimney, selected for evaluation are provided in Tables 1 and 2 (a and b).

2.1.3 Point of Release Characteristics

As noted previously, exhaust gases associated with operations at the proposed Orion mill with the potential to generate air pollutant emissions will be ducted to individual flues contained within a single structure referred to as the mill's main chimney. This chimney

represents the primary source of air pollutant emissions for the Orion mill. Included in this chimney will be individual flues for the mills recovery boiler, lime kiln, and offgases. The chimney will have a height of 120 meters and will contain individual flues ranging in size from 0.3 meters to 4.6 meters. The volume of air being displaced from each flue, under normal operating conditions will range from 60.1 meters cube per minute to over 22,000 meters cube per minute. Typical exhaust gas temperature will range from 50 degrees C. to 270 degrees C.

As part of the air quality impact evaluation, the chimney was modeled as an exhaust stack (point source) within the air dispersion model. The dispersion model requires the air pollutant emission rate, stack location, stack height, stack diameter, stack exit temperature and stack exit velocity be input for point source air pollutant releases.

2.2 CMB MILL

2.2.1 Location and Site Layout

The proposed CMB pulp mill is located approximately 12 km east of the Fray Bentos, Uruguay riverfront area as depicted in Figure 1.

2.2.2 Potential Air Pollutant Emission Rates

Certain operations performed in a pulp mill will have the potential to generate emissions of air pollutants that have been identified by the World Bank, as well as other health organizations, as having the potential to impact human health and welfare. To prevent adverse impacts to human health and welfare, acceptable concentrations levels have been established.

As discussed previously, the evaluation was performed for selected air pollutants that were determined to potentially pose the highest likelihood for impacting human health and welfare. The individual air pollutant emissions that were evaluated are identified in

Table 1 (a and b). These individual emission rates which reflect normal and startup mill operations were provided by the company designing the CMB mill. Emission factors are presented in units of kg per air dried ton (ADT) which is common for the pulp mill industry. Estimates of the air pollutant emissions for the Orion mill's main chimney, selected for evaluation are provided in Tables 1 and 2 (a and b).

2.2.3 Point of Release Characteristics

As noted previously, exhaust gases associated with operations at the proposed CMB mill with the potential to generate air pollutant emissions will ducted to individual flues contained within a single structure referred to as the mill's main chimney. This chimney represents the primary source of air pollutant emissions for the CMB mill. Included in this chimney will be individual flues for the mills recovery boiler, lime kiln, and biomass boiler. The chimney will have a height of approximately 100 meters and will contain individual flues ranging in size from 1.5 meters to 4.0 meters. The overall chimney will have a diameter of approximately 8 meters. The volume of air being displaced from each flue, under normal operating conditions will range from 31,500 meters cube per hour to over 345,000 meters cube per hour. Typical exhaust gas temperature will range from 105 degrees C. to 170 degrees C.

As part of the air quality impact evaluation, the chimney was modeled as an exhaust stack (point source) within the air dispersion model. The dispersion model requires the air pollutant emission rate, stack location, stack height, stack diameter, stack exit temperature and stack exit velocity be input for point source air pollutant releases.

3. CHARACTERISTICS OF THE LOCAL AREA

Certain site area characteristics may have an effect on the dispersive nature of air pollutant emissions from the proposed Orion and CMB pulp mills. Those that may affect the proposed pulp mills include wind flow, rural/urban land use classification and topography and are discussed in the following subsections.

3.1 WIND FLOW PATTERN

Measurements of surface wind flow data from the meteorological station at Gualeguaychu, Argentina were considered as representative of the local meteorology at the proposed Orion and CMB pulp mills. Figures 2 through 6 present the annual wind roses for each of the five years from 2000 through 2004, respectively. The prevailing wind direction is from the northeast sector. The wind roses presented in these figures reflect the direction from which the wind is blowing. For example the largest spike which corresponds to the northeast sector, indicates that approximately 15% of the time, the wind is blowing from the northeast to the southeast in the general study area.

3.2 RURAL/URBAN LAND USE CLASSIFICATION

A technique was developed by Irwin (United States Environmental Protection Agency {USEPA}, 1979) to classify a site area as either rural or urban for purposes of using rural or urban dispersion coefficients. The classification can be based on average heat flux, land use, or population density within a 3-kilometer (km) radius from the site of the proposed pulp mills. Of these, the USEPA has specified that land use is the most definitive criterion. The rural/urban classification based on land use is as follows:

Using the land use typing scheme established by Auer (Auer, 1978), an urban classification of the site area requires more than 50 percent of the following land use types: heavy industrial (I1), light-moderate industrial (I2), commercial (C1),

single-family compact residential (R2), and multi-family compact residential (R3). Otherwise, the site area is considered rural. (Refer to Table 3).

Based on using the land use classification scheme, the rural classification comprises greater than 50% of the area contained within the 3-kilometer (km) radius circle surrounding the proposed Orion and CMB pulp mills. The area is primarily comprised of agricultural areas, wooded areas, open area (i.e., grasses and weeds), single family dwellings and water areas. All of these areas are classified as rural areas. Thus, the area surrounding the proposed pulp mills is considered rural (see Figure 1), allowing the use of rural dispersion coefficients that will be employed to perform the air quality impact assessment.

3.3 TOPOGRAPHY

The topography of the area can be described as essentially flat. Since there is no significant change in elevation within a 3-kilometer radius circle of the proposed pulp mills, it was determined that the minimal change in terrain elevation should not affect the dispersive nature of the exhaust stacks (i.e., chimneys) associated with the proposed pulp mills. Therefore, terrain elevations were not included in the air quality impact evaluation.

4. HEALTH STANDARDS

Air quality standards represent the maximum acceptable pollutant-specific levels (concentrations) of air pollution in the ambient air that protect human health and welfare. Air quality standards for several countries have been summarized and are provided in Table 4. The most conservative (lowest concentration) standards (pollutant- and averaging period-specific) were selected for comparison with model-predicted concentrations. The standards established by the World Bank are also provided in this table.

5. DESCRIPTION OF AIR QUALITY DISPERSION MODEL

5.1 OVERVIEW OF MODEL

Air quality dispersion modeling analyses were performed to assess the cumulative impacts on ambient air quality for the primary air pollutant emissions to be released from the proposed Orion and CMB mills. A detailed description of the dispersion model and the technical options selected are discussed in this section.

The air quality modeling analyses employed USEPA's Industrial Source Complex (ISC3) model (USEPA, 1995a). The ISC3 model is recommended as a guideline model for assessing the impact of aerodynamic downwash (40 CFR 40465-40474).

5.2 TECHNICAL OPTIONS AVAILABLE IN THE MODEL

The ISC3 model (Version 02135) consists of two programs: a short-term model (ISCST3) and a long-term model (ISCLT3). The difference in these programs is that the ISCST3 program utilizes an hourly meteorological database, while ISCLT3 is a sector-averaged program using a frequency of occurrence based on categories of wind speed, wind direction, and atmospheric stability. The ISCST3 model was used for all pollutants. Major features of the ISC3 model are as follows:

- Plume rise due to momentum and buoyancy as a function of downwind distance for stack emissions (Briggs, 1971 and 1975);
- The influence of building wakes on plume transport and dispersion is evaluated by the Huber and Snyder Method (1976, 1977) for physical stack heights that are greater than $h_b + 0.5 l_b$, where h_b is the building height and l_b is the lesser of the building height or width, and by the Schulman and Scire Method (1980a, 1980b, 1985, 1986) for stack heights that are less than $h_b + 0.5 l_b$;
- Terrain truncation algorithm;
- Regulatory default option;
- Calm wind treatment of meteorological data;
- Buoyancy-induced plume rise algorithm;
- Procedures suggested by Briggs (1973) for evaluating stack-tip downwash;
- Consideration of the effects of gravitational settling and dry deposition on ambient particulate concentrations;
- Capability of simulating line, volume, and area sources;

- Concentration estimates for 1 hour to annual average;
- Use of COMPLEX I model algorithms to determine concentrations of receptors located in complex terrain (i.e., terrain height higher than plume height); and
- Capability of selecting the higher of the simple and complex terrain calculations on an hour-by-hour, source-by-source, and receptor-by-receptor basis for receptors in intermediate terrain (i.e., terrain between release height and plume height).

Details of the algorithms employed by ISC3 may be found in the *User's Guide for ISC3* (USEPA, 1995a). The regulatory default option was selected such that USEPA guideline requirements were met.

5.3 AERODYNAMIC DOWNWASH

The chimney's associated with each mill maybe influenced by aerodynamic downwash. Aerodynamic downwash occurs when nearby building structures cause localized wind eddies that can affect the dispersive nature of a plume exiting an exhaust stack. The recovery boiler building will be the largest solid structure at each mill and will be approximately 85 meters in height. Because of the height of this structure and its overall physical dimensions, there is a possibility that this building could influence the dispersive nature of the individual chimney plumes. This type of influence could involve causing the plume to loosed its buoyancy and result in higher concentrations closer to the individual mills. Chimneys are typically not affected by aerodynamic downwash if the stack height is approximately 2.5 the height of the nearest building structure.

Since the proposed chimneys will not be at heights that are 2.5 times the height of the recovery boiler structure, the potential affect of this phenomenon was selected for consideration within the ISC3 dispersion model. Because downwash is a function of projected building width and height, it is necessary to account for the changes in building projection as they relate to changes in wind direction. Once these projected dimensions are determined, they can be used as input to the ISC3 model. Worst case building dimensions were used for all wind directions around the compass for the proposed chimney's at the Orion and CMB pulp mills. Utilizing worst case building dimensions for all wind directions around the compass is a conservative approach to determine the potential impact of a given building on the plume associated with a given point source.

6. DATABASES EMPLOYED IN THE ANALYSIS

The databases required for the air quality impact assessment included source emission data, meteorological data, receptor points, and background concentrations. The following sections describe the databases required to perform the air quality impact assessment for the cumulative impacts from the Orion and CMB mills.

6.1 EMISSION INVENTORY

The emission inventory for the proposed Orion and CMB pulp mills consists of each mill's main chimney which exhausts various sources. The emission inventory employed in the modeling analyses is presented in Tables 1 and 2 (a and b). Emissions of SO₂, NO_x, TSP and TRS from the proposed Orion and CMB pulp mills were simulated in the ISCST3 dispersion model for operation of the mills during normal operating mode and during anticipated startup conditions.

6.2 METEOROLOGICAL DATA

The meteorological data used in the dispersion modeling analyses for the proposed Orion and CMB pulp mills consisted of five years (2000-2004) of hourly surface observations and coincident mixing heights from the Gualeguaychu, Argentina meteorological station. Surface observations consist of hourly measurements of wind direction, wind speed, and temperature, and estimates of ceiling height and cloud cover. Mixing heights were derived using surface data and planetary boundary layer theory since twice daily sounding data were not available for the area. The meteorological data was processed and provided to Malcolm Pirnie by Trinity Consultants.

The wind roses for the 2000-2004 database are presented in Figures 2 through 6.

6.3 RECEPTOR GRID

The receptor grid for the ISCST3 dispersion model was designed to identify the maximum air quality impact due to the proposed cumulative impacts of the proposed Orion and CMB pulp mills. The receptor grid consists of 25,921 receptors (locations on a map where concentrations are predicted by the ISCST3 dispersion model) extending to

20 km from the proposed Orion pulp mill. Receptor points were spaced 250 meters apart throughout the receptor grid.

Additional receptor points were also placed at areas inhabited by people or frequently visited by people:

- Fray Bentos area;
- International Bridge;
- Mercedes, Uruguay;
- River area near Fray Bentos;
- River area near the CMB mill;
- Nuevo Berlin, Uruguay;
- Gualeguaychu, Argentina; and
- Nandubaysal, Argentina beach area.

7. AIR DISPERSION MODELING METHODOLOGY

To determine the potential impacts on local air quality (i.e., study area) from these two mills, an air quality impact evaluation was performed for emissions of sulfur dioxide (SO₂), oxides of nitrogen (NO_x), particulate matter (PM) and Total Reduce Sulfur (TRS) from the Orion and CMB Mills, taking into account maximum design production rates and air pollution control techniques/equipment. The estimated emissions rates of each individual air pollutant from each mill are summarized in Tables 1 and 2 (a and b).

These air emissions are anticipated to be released from a single point within each mill. This main point of release of these potential air pollutants will be the mill's chimney. Each chimney will contain individual flues that are designed to vent exhaust gases to the atmosphere from certain predefined process operations associated with each mill. The specifics associated with each individual chimney as identified by representatives from the Orion and CMB mills are provided in Tables 1 and 2 (a and b).

To determine the potential cumulative impact on air quality within the study area for each air pollutant being evaluated, a mathematical program was employed. This program is referred to as the Industrial Source Complex Dispersion model, version 3.0 (ISC3) and was developed by atmospheric scientists for the sole purpose of simulating plume impacts from industrial facilities. This model is a recommended tool for predicting ambient concentrations of steady state air pollutant emissions from industrial facilities by the U. S. Environmental Protection Agency (USEPA).

In order to simulate movement of an industrial plume within a prescribed geographical area, local meteorological conditions (i.e., wind direction, wind speed, temperature, and atmospheric stability) can be entered into the ISC3 dispersion model. The model will then use this data, along with the emission/stack characteristic data, to predict ambient concentrations. To represent local meteorological conditions that may be present in the location of the proposed pulp mill, meteorological data recorded in Gualaguaychú, Argentina was selected. This data consisted of five years (2000-2004) of surface

observations, measured every 3-hours and coincident mixing heights from the Gualeguaychú, Argentina meteorological station. Surface observations consist of measurements of wind direction, wind speed, and temperature, and estimates of ceiling height and cloud cover. Mixing heights were derived using surface data and planetary boundary layer theory since twice daily sounding data were not available for the area. The meteorological data was processed and provided to Malcolm Pirnie by Trinity Consultants. The wind roses for the 2000-2004 data period are presented in Figures 2 through 6.

The ISC3 dispersion model, in conjunction with the 5-year meteorological database and the rural dispersion coefficients, was employed to predict ambient concentrations due to the cumulative emissions of SO₂, NO_x, PM and TRS from the Orion and CMB pulp mills during:

- 1) Normal operation at maximum pulp production rates, and
- 2) During startup conditions.

Predicted concentrations were determined at distinct points within the area of study. As part of the evaluation process, distinct points (referred to as receptor points) were inserted into the ISC3 dispersion model and the model was used to predict concentrations [expressed in micrograms per cubic meter (ug/m³)] at each distinctive receptor point.

The receptor grid selected for the air quality impact study was designed to identify the maximum air quality impact due to the proposed cumulative impacts of the proposed Orion and CMB pulp mills. The receptor grid consists of 25,921 receptors extending to a downwind distance of 20 kilometers from the proposed Orion pulp mill. Receptor points were spaced 250 meters apart throughout this receptor grid. Additional points were also included based on locations where people live and visit for recreational purposes in Uruguay and Argentina.

8. AIR DISPERSION MODELING RESULTS

The concentrations that were predicted by the ISC3 dispersion model based on the cumulative impacts of emissions of SO₂, NO_x, and PM from the Orion and CMB pulp mills under normal operating conditions are summarized below in Tables 5 through 7. The results provided reflect the maximum cumulative impacts on the 25,921 receptor points evaluated. In addition, the maximum cumulative impacts of SO₂, NO_x and PM for the mills at selected locations where people are located are all less than 13% of the most stringent standards identified from an individual country or organization. Refer to summary tables in Executive Summary for details. It should be noted that Health standards do not exist for emissions of TRS gases; however, these emissions are a surrogate to the formation of odors. The potential for the formation of odor is discussed later in this result section.

To determine if the concentrations predicted below would have an impact on human and health and welfare, an evaluation was performed to determine if acceptable standards, expressed in ug/m³, have been established to protect human health and welfare. This evaluation revealed that several countries, as well as organizations, have established concentration-based standards which are designed to protect human health and welfare from emissions of air pollutants from industrial type facilities. The standards listed in the tables below are the most stringent standards identified from an individual country or organization. It should be noted that the development of any health based standard is typically established based on health affect studies and a margin of safety.

As shown above, the potential cumulative impacts of SO₂, NO_x and PM emissions from the Orion and CMB Mills during normal operations are well below the most stringent Health Standards. Refer to Figures 7, 8, and 9 which show the locations of the maximum predicted cumulative impacts during normal operation.. Figure 10 depicts the locations of the maximum predicted impacts due to startup for SO₂, NO_x and PM emissions.

Additional receptor points were modeled in and around the following areas:

- Fray Bentos area;
- International Bridge;
- Mercedes, Uruguay;
- Nuevo Berlin, Uruguay;
- Gualeguaychú, Argentina
- Nandubaysal, Argentina beach area; and
- Las Canas Resort area.

A single receptor point was modeled at each of the areas noted above with the exception of the Fray Bentos area which included 154 receptors and the International Bridge which included 3 distinct receptor points. The concentrations that were predicted by the ISC3 dispersion model based on the cumulative impacts of emissions of SO₂, NO_x, and PM from the Orion and CMB pulp mills under normal operating conditions for these additional areas indicate that the potential cumulative impacts on the additional receptor points are well below the most stringent Health standards, including the World Bank standards.

The process for determining the potential for odor perception in the given study area for TRS gases from the Orion and CMB mills is complex. To minimize this complexity, a technical search was performed for determining the best approaches for predicting the potential for odor detection for exhaust gases associated with normal operation of the Orion and CMB mills. These approaches include:

- 1) Conducting an air quality dispersion modeling analysis using odor detection concentration thresholds,
- 2) Conducting an air quality dispersion modeling analysis using odor units; and
- 3) Conducting odor sampling and performing odor panels.

For this impact study, Option #1 was selected. This option was selected based on access to the ISC3 dispersion model and the availability of odor thresholds for selected TRS gases, expressed in ug/m³ from technical organizations.

In information provided as part of the Environmental Assessment for the Orion mill, a breakdown of specific constituents within the TRS gases with high odor potential was presented. The specific breakdown is as follows:

Speciation of TRS Gases – Potential Concentrations of Odor Gases

Constituent	Odor Component Breakdown (%)
Hydrogen Sulfide	13
Methyl Mercaptan	48
Dimethyl Sulfide	8
Dimethyl Disulfide	31

The results obtained from the odor detection evaluation during normal mill operations are summarized below. The maximum predicted cumulative impact at any of the receptor points evaluated has been summarized in this table.

Potential Cumulative Odor Impacts – Normal Mill Operation

Air Pollutant	Averaging Period	Maximum Predicted Concentration (ug/m³)	Lower End of Odor Threshold Range (ug/m³)	% of Threshold
Hydrogen Sulfide	10 minutes	0.69	0.76	90.5
Methyl Mercaptan	10 minutes	3.59	3.93	91.4
Dimethyl Sulfide	10 minutes	0.77	2.79	27.7
Dimethyl Disulfide	10 minutes	4.54	23.1	19.7

Refer to Figures 11, 12, 13 and 14 which depict the location of the maximum cumulative impacts for emissions of hydrogen sulfide, methyl mercaptan, dimethyl sulfide and dimethyl disulfide, respectively.

As shown above, the predicted concentrations are slightly below the lower end of the odor thresholds range established for a 10 minute concentration. These results indicate that during normal operation of the mills with emissions being released from the mill's main chimney, the duration for odor detection should be minimal.

There are three sets of conditions when odorous gases are likely to be released and odor will be detectable outside the plants.

Initial Plant Startup: Both plants expect that there will be an initial period of three to four months when the plants are first being commissioned and when testing of subsystems is taking place. During this period, there may be releases of some odorous gases, but quantities and times are difficult to predict. Computer modeling is not possible due to the complexity of the situation.

Planned Plant Startup and Shutdown: These are normal events for routine maintenance, and may reflect shutdowns of specific equipment or even the whole plant. These can be planned and carried out to minimize the release of odorous gases, although some release will occur when switching from one treatment unit to another (i.e., from the recovery boiler to the odorous gas boiler in the case of Orion, or to the flare in the case of CMB). Modeling of these conditions, using representative data, indicates that some odor exceeding threshold values would be detected within one to two kilometers of the mills, and these odor events would last for a short period (one hour or less) and would occur one or two times per year on average at each mill.

Unplanned Plant Startup and Shutdown: These events cannot be predicted in advance, but are known to occur—unplanned power outages or equipment (pump, motor) failures can affect normal operation and result in odorous gases being released into the stacks. Depending on the circumstances, these events may result in wider odor impacts than for the planned startup/shutdown situations.

The potential for odors during startup conditions were evaluated. Provided below is a table summarizing those potential odor impacts:

Potential Cumulative Odor Impacts – Orion and CMB Mills Startup Conditions

Air Pollutant	Averaging Period	Maximum Predicted Concentration (ug/m³)	Lower End of Odor Threshold Range (ug/m³)	% of Threshold
Hydrogen Sulfide	10 minutes	1.25	0.76	164.5
Methyl Mercaptan	10 minutes	6.55	3.93	166.7
Dimethyl Sulfide	10 minutes	1.41	2.79	50.5
Dimethyl Disulfide	10 minutes	8.29	23.1	35.9

As shown above during mill startup conditions the potential for odor detection does exist. Predicted concentrations of hydrogen sulfide and methyl mercaptan exceed their respective odor thresholds. As discussed above, the duration of these conditions where detection of odors may occur has been predicted to be a small fraction of the mills' operating time, with a maximum downwind distance typically not anticipated to exceed 2 kilometers.