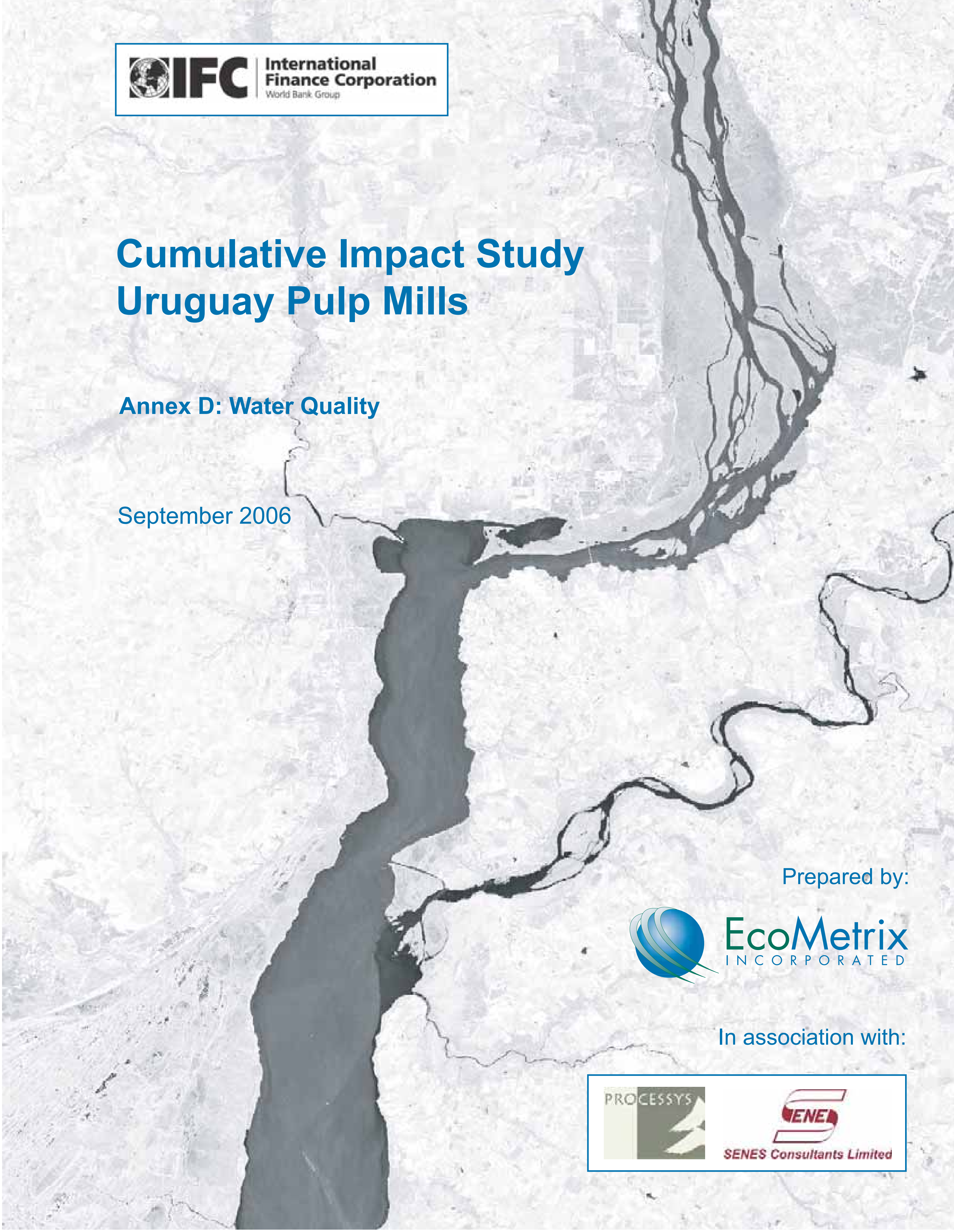

IFC International Finance Corporation
World Bank Group

Cumulative Impact Study
Uruguay Pulp Mills

Annex D: Water Quality

September 2006

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ANNEX D

Water Quality

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D1.0 INTRODUCTION

The International Finance Corporation of the World Bank Group (IFC) is currently assessing two pulp mill projects in Uruguay for financing. The mills are located on the Rio Uruguay near the city of Fray Bentos near the border with Argentina. In addition, the Multilateral Investment Guarantee Agency (MIGA) is evaluating whether to provide political risk insurance to one of the mills.

To complete the assessment of the combined environmental and social effects of the two proposed mills, the IFC commissioned a Cumulative Impact Study (CIS) of the construction and operations of the two pulp mills and their respective raw material sourcing. The draft CIS was prepared by Pacific Consultants International and Malcolm Pirnie Incorporated and issued by IFC in December 2005. Following a period of public review and professionally facilitated consultations in Argentina and Uruguay, the IFC commissioned a panel of independent experts to review existing project documentation and all comments provided by stakeholders. The results of this review are summarized in a report issued by the independent experts in April 2006. The report, referred to as the Hatfield Report, also identifies additional information and analysis required to complete the environmental assessment for the two mills. EcoMetrix Incorporated (EcoMetrix) revised and finalized the draft CIS in response to the recommendations of the Hatfield Report, the published Terms of Reference, original research, stakeholder commentary and other project related documentation.

The following report forms a portion of the revised CIS and specifically addresses the aquatic environment and potential effects arising from the two mills. It includes: an outline of the regulatory context by which the mills will operate within the laws of Uruguay; a review of the background environmental conditions within the Rio Uruguay; a description of the projects and associated effluent quality characteristics; a discussion of the methodology by which potential effects are assessed; a detailed discussion of the potential water quality and environmental effects associated with mill operations; and a discussion of monitoring and public communication strategies to ensure ongoing compliance and transparency with respect to performance standards.

D1.1 Project Background

The two mills are located along the south shore of the Rio Uruguay River east of the city of Fray Bentos, Uruguay, as illustrated in Figure D1.1-1. The mills are being developed by Botnia of Finland and ENCE of Spain.

The Botnia and ENCE mills are designed to produce approximately 1,000,000 tons of air dried pulp on an annual basis (ADt/a) and 500,000 ADt/a, respectively. The mills are proposing to utilize the water resource of the Rio Uruguay for process, cooling and waste assimilation. The expected discharge rate of treated wastewater is approximately 0.83 and 0.55 m^3/s for each mill, respectively. The combined flow represents approximately 0.02% of the average flow of the Rio Uruguay and approximately 0.28% of the extreme low flow condition.

Each mill will have an on-site biological wastewater treatment system that fulfills all recommendations as outlined in the Integrated Pollution Prevention and Control (IPPC) reference documents on best available technologies (BAT) for the pulp and paper industry. The treatment efficiencies are shown in Annex A to be comparable to or exceed the treatment performance of most modern mills.

The high quality effluent is to be discharged to the Rio Uruguay through separate submerged, offshore, multi-port diffusers. Each diffuser is to be located approximately 200 to 400 m from the shoreline into the main channel within Uruguayan waters. A series of nozzles will disperse the wastewater along the length of the diffuser resulting in a high degree of initial mixing of the wastewater within the Rio Uruguay.

The Rio Uruguay is, after the Rio Paraná, the most important river draining to the Rio de la Plata. The average flow in the Rio Uruguay at the Salto Grande dam is approximately 6,200 m^3/s, but can vary from as high as 22,500 m^3/s to as low as 500 m^3/s. Given this magnitude of flow, the Rio Uruguay has a significant capacity to assimilate wastewater, particularly within the main channel of the river. As a result, the water quality of the Rio Uruguay is generally considered to be good, although there are localized issues and exceedances of water quality standards due to the discharge of untreated municipal and industrial wastewaters and agricultural runoffs.

The Rio Uruguay is an important resource for the people of both Uruguay and Argentina. It is a source of freshwater for drinking and irrigation, is used for recreation, and supports a variety of fish species that are of value for commercial and recreational fishing. Specific resource areas of particular note include: the freshwater intake for the city of Fray Bentos; the recreational beach areas at Playa Ubici, near Arroyo Fray Bentos and Las Cañas; and the environmentally sensitive areas at Yaguareté Bay, Rio de la Plata and the Esteros de Farrapos e Islas del Rio Uruguay. The Rio Uruguay on the Argentina side of the river and the beach area at Ñandubaysal, Argentina, are also of particular note since the Rio Uruguay is an international waterway that is shared by Uruguay and Argentina.

D1.2 Purpose and Objectives

The purpose of this Annex is to provide an assessment of the potential effects of the mill operations on the water quality and aquatic resources within the Rio Uruguay. The specific objectives are as follows:

- To determine the degree of initial mixing within the immediate vicinity of the diffusers and to confirm that the design specifications for the diffusers provide optimum dispersion of the wastewater;

- To determine the mixing characteristics of the wastewater within the Rio Uruguay under a range of flow conditions;
- To identify areas within the Rio Uruguay that may be exposed to trace levels of wastewater and areas that are not likely to be exposed;
- To calculate the potential change in water quality at the identified resource areas and to assess the associate affect on sediment quality, aquatic life, aesthetic quality, and overall protection of the aquatic resource;
- To propose a monitoring program that quantifies the potential change to the aquatic environment and to demonstrate if existing regulatory standards are protective of the environment.

D1.3 Study Approach

The water quality assessment was prepared by a team of specialists within the disciplines of aquatic ecology, fisheries biology, ecotoxicology, chemical engineering, fluid mechanics, and computational hydrodynamics. The contributing members of the project team include:

- Don Hart, Ph.D., an ecotoxicologist at EcoMetrix, Brampton, Canada, responsible for the water quality impact assessment;
- Bruce Rodgers, M.Sc., P.Eng, an environmental engineer at EcoMetrix, Brampton, Canada, responsible for the analysis of mixing processes and associated water quality assessment;
- Ismael Piedra Cueva, Ph.D., a professor at the Institute of Fluid Mechanics and Environmental Engineering of the Universidad de la República, Montevideo, Uruguay, responsible for hydrodynamic and water quality modeling;
- Mónica Fosatti, M.Sc., at the Institute of Fluid Mechanics and Environmental Engineering of the Universidad de la República, Montevideo, Uruguay, collaborated on the hydrodynamic and water quality modeling;
- Paul Stuart, Ph.D., a Principal of Processys Incorporated and professor of Chemical Engineering at the Ecole Polytechnique, Montreal, Canada, responsible for characterization of wastewater quality and quantity, and BAT review;
- Dean Fitzgerald, Ph.D., a fish ecologist at EcoMetrix, Brampton, Canada, responsible for the fisheries assessment;
- Brian Fraser, M.Sc., an aquatic ecologist with EcoMetrix, Brampton, Canada, responsible for the environmental monitoring and public communication program.

An understanding of the project context was gained through a visit to Uruguay and meetings with representatives from Botnia, ENCE, the Department of the Environment (Direccion Nacional de Medio Ambiente, DINAMA) and the Administrative Commission of the Rio Uruguay (Comision Administradora del Rio Uruguay, CARU). These meetings provided updated information about water quality, an understanding of the regulatory context, and accurate and up-to-date descriptions of the projects.

Various sources of information were utilized to support the assessment. The environmental impact assessments (EIAs) for the mills (Botnia, 2006; ENCE, 2006) provided background information regarding the existing hydrologic and aquatic environment. Additional information was also provided by DINAMA and CARU. This information is presented in further detail in Section D3.0.

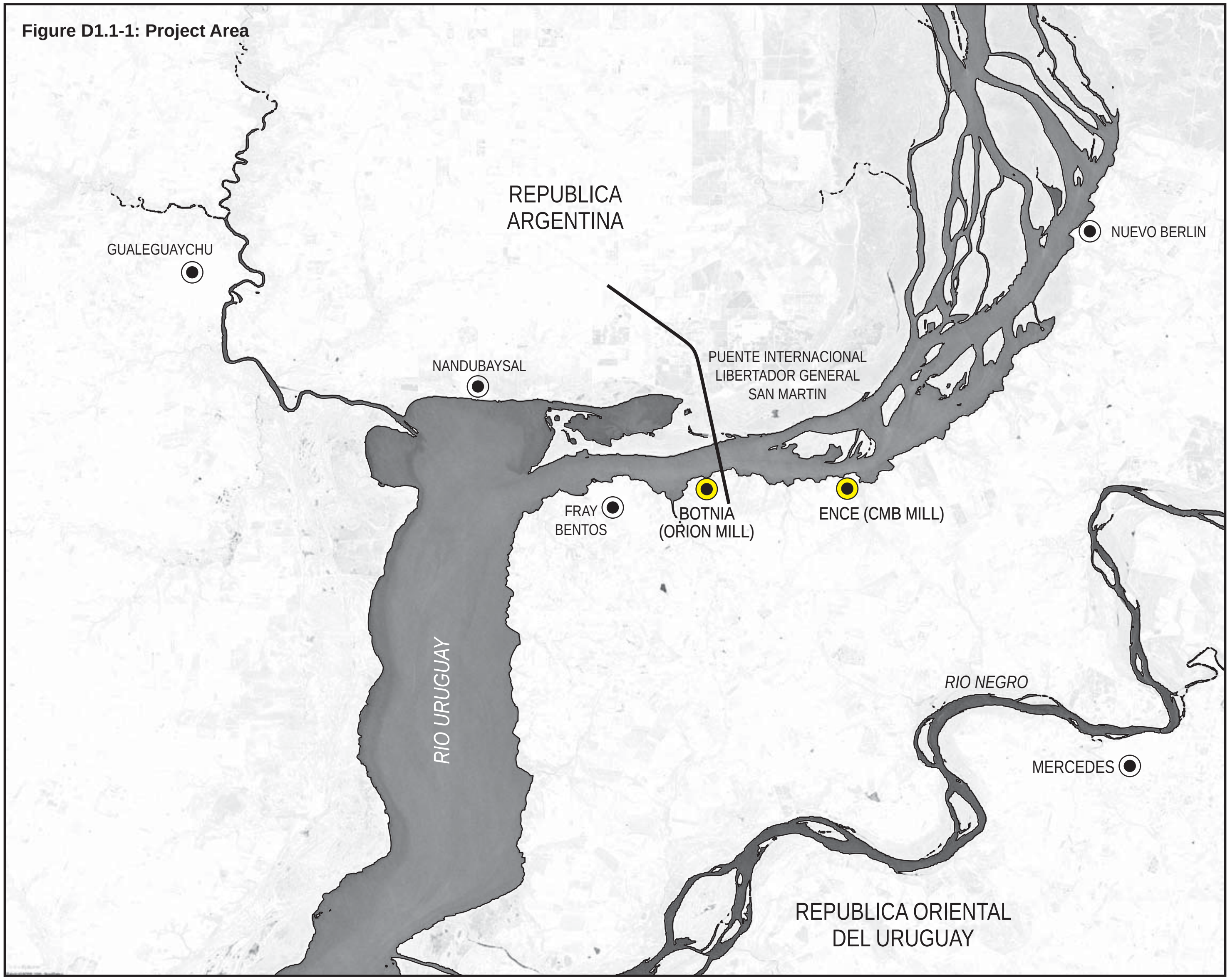
The existing EIAs also provided descriptions of the projects and wastewater treatment systems. The proponents of the mills provided additional information for the CIS to describe the most recent design characteristics for the treatment systems. Details of this review are presented in Annex A of the CIS. Section D4.0 presents a summary of this information specifically relating to the expected quantity and quality of the wastewater.

Mathematical models were utilized to support the assessment of potential effects. These models provide a quantifiable means to predict the change in water quality associated with the mill operations. Literature was also utilized to support the interpretation of potential water quality effects. Details of the mathematical models and literature review are provided in Section D5.0 and the results of the analysis are presented in Section D6.0.

An environmental effect monitoring program is proposed in Section D7.0 to directly measure the potential effects of the mill operations on the aquatic environment. This monitoring program is based on the plans developed by the mill proponents as well as the plan developed by DINAMA. A public communication plan is also proposed to ensure the public are provided with comprehensive information to regarding the operation of the mills.

Comments from various stakeholders were considered in this impact assessment to identify valued resources of concern and to ensure a comprehensive and accurate understanding of the identified concerns. The report from the Consensus Building Institute (2005) provides considerable substantiation of stakeholder concerns and related issues up to the release of the draft CIS report in December 2005. The Expert Panel Report (Hatfield, 2006) provides context of the stakeholder issues through the Spring of 2006, specifically as they relate to the draft CIS report. The court transcripts for the 13 July 2006 Order from the International Court of Justice provides further context regarding the specific concerns of various stakeholders. In addition, various reports and documents provided by the Centre for Human Rights and Environment (Centro de Derechos Humanos y Ambiente, CEDHA), the Citizen’s Assembly of Gualeguaychú, and other organizations provided useful context and identified specific issues that warranted further investigation over that included in the draft CIS.

Figure D1.1-1: Project Area



D2.0 REGULATORY CONTEXT

The regulatory context for the wastewater discharge from the two mills is described in the following section. Authorizations for these discharges are granted through the various laws and regulations for Uruguay which require the mills to maintain standards of environmental protection and pollution prevention. In addition, the mills are required to comply with water quality standards jointly approved by the Governments of Argentina and Uruguay. These various laws, regulations and standards are presented below followed by a comparison of the standards to other regulatory jurisdictions throughout the world.

D2.1 Uruguayan Laws for the Protection of Water Quality

Protection of water quality is a right and duty enshrined in the Constitution of Uruguay. In particular, Article 47 of the Constitution recognizes water as a natural resource that is essential for life and is therefore to be protected. It further recognizes access to drinking water as a fundamental human right. These principles are the foundation upon which all water protection laws in Uruguay are based.

In fulfillment of the rights and obligations to protect the environment embodied in its Constitution, the Government of Uruguay has enacted a series of laws and regulations which seek to ensure that industrial emissions do not cause unacceptable impacts to the water or other environmental media. Specific requirements of these laws and regulations include the following:

- All projects having the potential to cause impact to the environment are required to prepare a comprehensive Environmental Impact Statement (EIS) as per Decree 435/994 (now replaced by Decree 349/005). If all conditions are met, the proponent may be granted a Pre-Environmental Authorization (Authorizacion Ambiental Previa, AAP) for the project.

- All facilities and activities are prohibited from causing unacceptable harm to water quality or water resources as per Decree 253/79. This Decree further establishes water quality standards for water bodies in Uruguay, and sets forth detailed discharge limitations for sources that discharge to those water bodies.

- The EIS must contain a monitoring plan that appropriately demonstrates compliance will the environmental laws and regulations of Uruguay, as per Article 12 of Decree 435/994.

- After a plant has received its initial authorization and authorization to commence construction activities, a separate authorization to operate is required before operations can begin, as required under Decree 349/005. Additional requirements and safeguards may be stipulated at this time. This authorization to operate is reviewed every three years to ensure that operating standards and procedures continue to be state-of-the-art and protective of the environment.

- If adverse impacts to the environment are determined during operation, further environmental protection measures are required and if not complied with, the facility may be required to cease operation, as per Articles 17 and 28 of Decree 253/79.

The Department of the Environment (Direccion Nacional de Medio Ambiente, DINAMA), as part of the Ministry of Housing, Territorial Planning, and Environment (i.e., Ministerio de Vivienda, Ordenamiento Territorial y Medio Ambiente, MVOTMA), is the agency directly responsible for the administration and enforcement of the environmental laws and regulations of Uruguay. DINAMA is specifically responsible for the review of the EIAs and granting of the AAPs and other authorizations for the mills.

The AAPs were granted by DINAMA on 09 October 2003 and 14 February 2005 for ENCE and Botnia, respectively, in compliance with the regulation for environmental impact assessment (Reglamento de Evaluacion del Impacto Ambiental). The AAPs impose certain restrictions on the mills, specifically: compliance with all effluent limitations set forth in Decree 253/79; compliance with CARU and Uruguayan water quality standards; and compliance with limits on other water quality parameters (e.g. AOX, nitrogen and nitrates). The AAPs further obligate both companies to build their respective mills in compliance with the commitments made in their respective EIAs.

To date, ENCE has received approval for construction activities involving earth movement, and Botnia has received approval of its Environmental Management Plan (Plan de Gestión Ambiental, PGA) for construction of the port, chimney, concrete plant, foundations, bleached cellulose plant, wastewater treatment plant, and operation of the harbor terminal during the construction phase of the mill.

D2.2 DINAMA, Water Quality Standards and Discharge Limitations

Decree 253/79 is of particular significance as it sets forth standards for water quality protection and pollution prevention, and classifies water courses according to their main current or potential uses. The four main classifications under Article 3 are as follows:

- Class 1 – waters used or which could be used as drinking water supplies for human consumption with conventional treatment;
- Class 2(a) – waters used for irrigation of vegetables, fruit plants or other crops intended for human consumption in their natural condition, when used in irrigation systems that result in direct application of the water to the product;
- Class 2(b) – waters used for recreational purposes and which involve direct human contact with the water;
- Class 3 – water used to preserve fish in general and other members of the water flora and fauna, and also water used to irrigate crops whose product is not

consumed in its natural condition, or when consumed in its natural condition, with irrigation systems that do not cause the direct application of the water to the product; and

- Class 4 – water in water courses or sections of water courses that pass through urban or suburban zones that must be in harmony with the environment, or water used to irrigate crops when the products are not destined for human consumption in any form.

The water quality standard for each of these respective water classifications are specified under Article 5 as summarized in Table D2.2-1. As outlined, the water quality standard includes a series of conventional contaminants, nutrients, metals and organic toxic compounds. For most parameters, the water quality standard is most restrictive for Class 1 water bodies for protection of drinking water supply and Class 3 water bodies for protection of aquatic life. Exceptions include total suspended solids, sodium adsorption ratio, boron, total chromium and nickel which are most restrictive for Class 2(a) water bodies for protection of irrigation waters.

Article 8 requires that any discharge to a Class 1 water body requires prior authorization from the State Waterworks Agency (Obras Sanitarias del Estado, OSE), which will establish the characteristics that the receiving water must have at the corresponding intake and the minimum distance from such intake in which the characteristics must be maintained.

Article 11 of Decree 253/79 also sets forth standards for the quality of wastewaters discharged to natural water courses, as summarized in Table D2.2-2. The list of water quality parameters is comparable to that of the surface water quality standard. Separate end-of-pipe quality standards are provided for the following three types of discharges: waste pipes from public sewage systems; waste pipes directly discharging to water courses; and outlets by infiltration into the ground. As a minimum, the wastewater discharge for the two mills must comply with the standard specified for Type 2, waste pipes directly discharging to water courses. This standard represents the maximum allowable concentration over a 4-hour averaging period to all parameters except fecal coliform, temperature, pH and sulfides.

D2.3 CARU, Joint Uruguay and Argentina Water Quality Standards

In addition to the applicable Uruguayan environmental laws, the Administrative Commission of the Rio Uruguay (Comision Administradora del Rio Uruguay, CARU) has developed water quality standards with which the mills must also comply. These water quality standards are approved by the Governments of Argentina and Uruguay and are considered by these Governments as acceptable and adequately protective of the aquatic environment of the Rio Uruguay.

The water quality standards of CARU are summarized in Table D2.3-1. Standards are applied to the various use classifications described below:

- Use 1 – raw or crude waters used for public supply with conventional treatment;
- Use 2 – waters used for recreational purposes with direct human contact;
- Use 3 – waters used for agricultural activities; and
- Use 4 – waters used for the conservation and development of aquatic life.

While the water quality standards set forth by CARU are similar to those under Uruguay law, they are not identical. In the few cases where the standards differ, the Decree 253/79 standards are typically slightly more stringent; however, CARU has defined standards for a number of parameters not addressed in Decree 253/79, including colour, hardness, alkalinity, various trace elements and major ions, and total PCBs.

Unlike the Uruguay law, the CARU regulations do not specify effluent limitations with which industrial discharges must comply. Rather, pursuant to the CARU regulations, Argentina and Uruguay have primary authority to develop effluent limitations with which industrial sources in their jurisdictions must comply. Each country's effluent limitations, however, are subject to certain CARU guidelines and must take into account the requirements of complying with CARU water quality standards.

These guidelines include the following considerations: the water quality standard for the river; the properties of the substances present in the effluent, in particular their persistence and physical-chemical and biochemical behavior in the river; the results of dispersion and fate studies; the design of the diffuser; evidence of non-acute toxicity to fauna of the river; and the ratio of the effluent's flow and mass load to the river's flow under low flow conditions in the river. CARU specifically declares that the low flow condition is to be based on the minimum 7-day average low flow with a 5-year recurrence.

CARU further requires that the effluent shall not contain noticeable floating material, sedimentable solids less than 1 mL/L (based on a 2-hour test); n-Hexane extractible oils and fats less than 300 mg/L; hydrocarbons less than 15 mg/L; thick solids cannot pass through a 10 mm bar filter; and cannot contain fibrous elements.

Mixing zones are specifically identified in the CARU regulations. They are defined as an area exceeding one or more of the surface water quality standards. The allowable limits of a mixing zone should consider: the proximity of the water intakes for public supply or irrigation, or of areas defined for recreational activities; and the physical and hydraulic features of the stretch of the river where the discharge is located. The guidelines specifically limit the size of the mixing zone to not exceed 1/5 of the width of the respective section of the river and to be no longer than 1,000 m along the river. The mixing zone should also not overlap with zones defined for Uses 1, 2 or 3.

CARU encourages joint scientific studies on areas of common interest relating to the health and viability of the aquatic resource. Specifically they encourage studies in the following: behavior of substances that may be discharged to the river; testing for acute and chronic toxicity on species of the river's fauna; implementation and operation of water quality database; and development of interpretation patterns for the river's hydrodynamic behavior.

D2.4 Comparison of Surface Water Quality Standards for DINAMA, CARU and International Agencies

Surface water quality standards for DINAMA, CARU and other agencies outside Uruguay are compared in Table D2.4-1. The standards presented for DINAMA and CARU are based on drinking water requirements for Class 1 and Use 1 water courses, respectively (although the most restrictive standards identified by DINAMA and CARU are also presented). These drinking water standards are compared to applicable standards for Australia, the European Union and the World Health Organization. Standards for protection of aquatic life from other international agencies are also presented for comparison.

It should be noted that drinking water standards are derived for protection of human health associated with consumption of (or other forms of direct exposure with) treated water. These standards are compared to surface water quality standards in Table D2.4-1 without consideration of treatment and therefore the interpretation of the standard in this regards is considered conservative. In practice, this is a reasonable assumption since conventional municipal water supply systems do not necessarily treat for all water quality parameters.

In general, the surface water quality standards of DINAMA and CARU are comparable to standards of other agencies. Of the agencies identified, the standards specified by DINAMA are most restrictive for aesthetic quality, and comparable for most other water quality parameters. The DINAMA standards for ammonia and total phosphorus are significantly more restrictive than the drinking water standards for Australian and European Union, and are comparable to Canadian standards for protection of aquatic life. The DINAMA standards for metals are also more restrictive than the drinking water standards for the other agencies, and are within the range of the other agencies for protection of aquatic life. DINAMA and CARU do not have a water quality standard for chlorophenols, or dioxin and furan.

Although there are differences, the surface water quality standards of DINAMA and CARU are comparable and therefore considered as protective of the environment as those of other agencies.

Table D2.2-1: Surface Water Quality Standards from Article 5 of Decree 253/79

Parameter	Units	Notes	Class 1 Drinking water supply	Class 2a Irrigation	Class 2b Recreation	Class 3 Aquatic Life	Class 4 Urban water courses
Aesthetic Parameters							
Odor			not perceptible	not perceptible	not perceptible	not perceptible	not objectionable
Unnatural floating material and foam			absent	absent	absent	absent	virtually absent
Unnatural color	PtCo	max	absent	absent	absent	absent	virtually absent
Turbidity	NTU	max	50	50	50	50	100
Conventional Parameters							
Temperature	°C		-	-	-	-	-
Total Suspended Solids	mg/L	max	-	700	-	-	-
pH			6.5 to 8.5	6.5 to 9.0	6.5 to 8.5	6.5 to 8.5	6.0 to 9.0
Conductivity	µS/cm	max	-	-	-	-	-
Dissolved Oxygen	mg/L	min	5	5	5	5	2.5
BDO	mg/L	max	5	10	10	10	15
AOX	mg/L	max	-	-	-	-	-
Oil and Grease	mg/L	max	virtually absent	virtually absent	virtually absent	virtually absent	10
Detergents	mg/L	max, as LAS	0.5	1	1	1	2
Sodium Adsorption Ratio		max	-	10	-	-	-
Microbiological							
Fecal Coliforms	FC/100 mL	limit	2,000 [a]	2,000 [a]	1,000 [a]	2,000 [a]	5,000 [b]
	FC/100 mL	geometrix mean	1,000 [a]	1,000 [a]	500 [a]	1,000 [a]	-
Schistosomiasis			-	-	-	-	-
Escherichia coli	per/100 mL	geometric mean	-	-	-	-	-
Enterococos	per/100 mL	geometric mean	-	-	-	-	-
Algae	UPA/ml	max	-	-	-	-	-
Nutrients							
Nitrogen (total)	mg/L	max, as N	-	-	-	-	-
Nitrate	mg/L	max, as N	10	10	10	10	-
Ammonia (free)	mg/L	max, as N	0.02	0.02	0.02	0.02	-
Total Phosphorus	mg/L	max, as P	0.025	0.025	0.025	0.025	-
Toxins							
Chlorates	mg/L	max	-	-	-	-	-
Chlorophenols	mg/L	max	-	-	-	-	-
Cyanide	mg/L	max	0.005	0.005	0.005	0.005	0.05
Phenolic Substances	mg/L	max	0.001	0.2	0.2	0.2	-
Plant sterols	mg/L	max	-	-	-	-	-
Resin/fatty acids		max	-	-	-	-	-
Sulphides	mg/L	max	-	-	-	-	-
Dioxin/furans	mg/L	max	-	-	-	-	-
Metals							
Arsenic	mg/L	max	0.005	0.05	0.005	0.005	0.1
Boron	mg/L	max	-	0.5	-	-	
Cadmium	mg/L	max	0.001	0.001	0.001	0.001	0.01
Copper	mg/L	max	0.2	0.2	0.2	0.2	1
Total Chromium	mg/L	max	0.05	0.005	0.05	0.05	0.5
Mercury	mg/L	max	0.0002	0.0002	0.0002	0.0002	0.002
Nickel	mg/L	max	0.02	0.002	0.02	0.02	0.2
Lead	mg/L	max	0.03	0.03	0.03	0.03	0.05
Zinc	mg/L	max	0.03	0.03	0.03	0.03	0.3
Selenium	mg/L	max	-	-	-	-	-
Iron	mg/L	max	-	-	-	-	-
Drinking Water							
Fluorides	mg/L	max	-	-	-	-	-
Alkalinity	mg/L	max	-	-	-	-	-
Chlorides	mg/L	max	-	-	-	-	-
Total Hardness	mg/L	max	-	-	-	-	-
Manganese	mg/L	max	-	-	-	-	-
Total Dissolved Solids	mg/L	max	-	-	-	-	-
Sulphates	mg/L	max	-	-	-	-	-
Organic Toxins							
Aldrin plus Dieldrin	µg/L	max	0.004	0.004	0.004	0.004	0.04
Chlordane	µg/L	max	0.01	0.01	0.01	0.01	0.1
DDT	µg/L	max	0.001	0.001	0.001	0.001	0.01
Endosulfan	µg/L	max	0.02	0.02	0.02	0.02	0.2
Endrin	µg/L	max	0.004	0.004	0.004	0.004	0.04
Heptachlorine plus Heptachlorine Epoxi	µg/L	max	0.01	0.01	0.01	0.01	0.1
Lindane	µg/L	max	0.01	0.01	0.01	0.01	0.1
Metoxichlorine	µg/L	max	0.03	0.03	0.03	0.03	0.3
Mirex	µg/L	max	0.001	0.001	0.001	0.001	0.01
2,4 D	µg/L	max	4	4	4	4	40
2,4,5 T	µg/L	max	10	10	10	10	100
2,4,5 TP	µg/L	max	2	2	2	2	20
Parathion	µg/L	max	0.04	0.04	0.04	0.04	0.4
Polyaromatic compounds	µg/L	max	0.001	0.001	0.001	0.001	0.01

[a] Fecal coliform, limit and geometrix mean shall be determined from at least 5 samples and the limit shall not be exceeded in any of these samples.

[b] Fecal coliform, limit shall not be exceeded in at least 80% of at least 5 samples.

Table D2.2-2: End-of-Pipe Quality Standards from Article 11 of Decree 253/79

Parameter	Units	Notes	Type 1 public sewage system	Type 2 direct discharges	Type 3 land disposal
Physical					
Flow			max flow < 2.5 x mean flow	max flow < 1.5 x mean flow	-
Aesthetic Parameters					
Odor			-	-	-
Floating material			absent	absent	absent
Unnatural color	PtCo	max	-	-	-
Turbidity	NTU		-	-	-
Conventional Parameters					
Temperature	°C	max	35	30	35
Temperature	°C	change		2	
Total Suspended Solids	mg/L	max	-	150	-
Sedimentable Solids	mL/L	up to, Imhoff cone	10	-	10
Total Solids	mg/L	max	-	-	700
pH			5.5 to 9.5	6.0 to 9.0	5.5 to 9.0
Conductivity	µS/cm	max	-	-	-
Dissolved Oxygen	mg/L	max	-	-	-
BOD	mg/L	max	700	60	-
AOX	mg/L	max	-	-	-
Oil and Grease	mg/L	max	200	50	200
Detergents	mg/L	max, as LAS	-	4	-
Sodium Adsorption Ratio (SAR)			-	-	-
Microbiological					
Fecal Coliforms	FC/100 mL	limit	-	5,000	-
Nutrients					
Nitrogen (total)	mg/L	max	-	-	-
Nitrate	mg/L	max	-	-	-
Free Ammonia	mg/L	max, as N	-	5	-
Total Phosphorus	mg/L	max, as P	-	5	-
Toxins					
Chlorates	mg/L	max	-	-	-
Chlorophenols	mg/L	max	-	-	-
Cyanide	mg/L	max	1	1	1
Phenolic Substances	mg/L	max	-	0.5	-
Plant sterols	mg/L	max	-	-	-
Resin/fatty acids		max	-	-	-
Sulphides	mg/L	max, as S	5	1	-
Dioxin/furans	mg/L	max	-	-	-
Metals					
Arsenic	mg/L	max	0.5	0.5	0.5
Boron	mg/L	max	-	-	-
Cadmium	mg/L	max	0.05	0.05	0.05
Copper	mg/L	max	1	1	1
Total Chromium	mg/L	max	3	1	3
Mercury	mg/L	max	0.005	0.005	0.05
Nickel	mg/L	max	2	2	2
Lead	mg/L	max	0.3	0.3	0.3
Zinc	mg/L	max	0.3	0.3	0.3
Selenium	mg/L	max	-	-	-
Iron	mg/L	max	-	-	-
Drinking Water					
Fluorides	mg/L	max	-	-	-
Alkalinity	mg/L	max	-	-	-
Chlorides	mg/L	max	-	-	-
Total Hardness	mg/L	max	-	-	-
Manganese	mg/L	max	-	-	-
Total Dissolved Solids	mg/L	max	-	-	-
Sulphates	mg/L	max	-	-	-
Organic Toxins					
Aldrin plus Dieldrin	µg/L	max	2	0.4	0.4
Chlordane	µg/L	max	5	1	1
DDT	µg/L	max	0.5	0.1	0.1
Endosulfan	µg/L	max	10	2	2
Endrin	µg/L	max	2	0.4	0.4
Heptachlorine plus Heptachlorine Epoxi	µg/L	max	5	1	1
Lindane	µg/L	max	5	1	1
Metoxichlorine	µg/L	max	15	3	3
Mirex	µg/L	max	0.5	0.1	0.1
2,4 D	µg/L	max	2000	400	400
2,4,5 T	µg/L	max	5000	1000	1000
2,4,5 TP	µg/L	max	1000	200	200
Parathion	µg/L	max	20	4	4
Polyaromatic compounds	µg/L	max	0.5	0.1	0.1

Table D2.3-1: Surface Water Quality Standards from CARU, Chapter 4

Parameter	Units	Notes	Use 1 Drinking water supply	Use 2 Recreation	Use 3 Irrigation	Use 4 Aquatic Life
Aesthetic Parameters						
Odor			-	-	-	-
Floating material			-	-	-	-
Unnatural color	PtCo	max	300	-	-	-
Turbidity	NTU		-	-	-	-
Conventional Parameters						
Temperature	°C	max	natural conditions	natural conditions	natural conditions	natural conditions
Total Suspended Solids	mg/L	max	-	-	-	-
pH			6.5 to 9.0	6.5 to 8.3	6.5 to 9.0	6.5 to 9.0
Conductivity	µS/cm	max	-	-	-	-
Dissolved Oxygen	mg/L	min	5.6	5.6	5.6	5.6
BDO	mg/L	max, 5-days, 20°C	6	5	5	5
AOX	mg/L	max	-	-	-	-
Oil and Grease	mg/L	max	virtually absent	virtually absent	virtually absent	virtually absent
Detergents (SAAM)	mg/L	max, as LAS	0.5	1	-	-
Sodium Adsorption Ratio		max	-	-	10	-
Microbiological						
Fecal Coliforms [a]	FC/100 mL	limit	5,000 [b]	500 [c]	-	5,000 [b]
	FC/100 mL	geometric mean	2,000 [b]	200 [c]	1,000 [d]	2,000 [b]
Schistosomiasis			-	absence	-	-
Escherichia coli	per/100 mL	geometric mean	-	126 [e]	-	-
Enterococos	per/100 mL	geometric mean	-	33 [e]	-	-
Algae	UPA/ml	max	100	-	-	-
Nutrients						
Nitrogen (total)	mg/L	max, as N				
Nitrate	mg/L	max, as N	10	-	-	-
Free Ammonia	mg/L	max, as N	0.019	0.019	0.019	0.019
Total Phosphorus	mg/L	max	-	-	-	-
Toxins						
Chlorates	mg/L	max	-	-	-	-
Chlorophenols	mg/L	max	-	-	-	-
Cyanide	mg/L	max	0.005	0.005	0.005	0.005
Phenolic Substances	mg/L	max	0.001	0.001	0.001	0.001
Plant sterols	mg/L	max	-	-	-	-
Resin/fatty acids	mg/L	max	-	-	-	-
Sulphides	mg/L	max	-	-	-	-
Dioxin/furans	mg/L	max	-	-	-	-
Metals						
Arsenic	mg/L	max	0.015	0.015	0.015	0.015
Boron	mg/L	max	-	-	0.5	-
Cadmium	mg/L	max	0.00084	0.00084	0.00084	0.00084
Copper	mg/L	max	0.01	0.01	0.01	0.01
Total Chromium	mg/L	max	0.01	0.01	0.01	0.01
Mercury	mg/L	max	0.0002	0.0002	0.0002	0.0002
Nickel	mg/L	max	0.1163	0.1163	0.1163	0.1163
Lead	mg/L	max	0.007	0.007	0.007	0.007
Zinc	mg/L	max	0.037	0.037	0.037	0.037
Selenium	mg/L	max	0.005	0.005	0.005	0.005
Iron	mg/L	max	1	1	1	1
Drinking Water						
Fluorides	mg/L	max as F	1.5	-	-	-
Alkalinity	mg/L	max as $CaCO_3$	500	-	-	-
Chlorides	mg/L	max as Cl	250	-	-	-
Total Hardness	mg/L	max as $CaCO_3$	200	-	-	-
Manganese	mg/L	max	0.1	-	-	-
Total Dissolved Solids	mg/L	max	500	-	700	-
Sulphates	mg/L	max as SO_4	250	-	-	-
Organic Toxins						
Aldrin	µg/L	max	0.005	0.005	0.005	0.005
Chlordane	µg/L	max	0.005	0.005	0.005	0.005
DDT	µg/L	max	0.002	0.002	0.002	0.002
Dieldrin	µg/L	max	0.005	0.005	0.005	0.005
Endosulfan	µg/L	max	0.02	0.02	0.02	0.02
Endrin	µg/L	max	0.004	0.004	0.004	0.004
Heptachlorine	µg/L	max	0.01	0.01	0.01	0.01
Heptachlorine epoxi	µg/L	max	0.01	0.01	0.01	0.01
Lindane	µg/L	max	0.016	0.016	0.016	0.016
Metoxichlorine	µg/L	max	0.03	0.03	0.03	0.03
Mirex	µg/L	max	-	-	-	-
2,4 D	µg/L	max	4	4	4	4
2,4,5 T	µg/L	max	10	10	10	10
2,4,5 TP	µg/L	max	2	2	2	2
Parathion	µg/L	max	0.065	0.065	0.065	0.065
PCB	µg/L	max	0.001	0.001	0.001	0.001
Radioactivity						
Total ALPHA	Bq/L	max	0.1	-	-	-
Total BETA	Bq/L	max	1	-	-	-

[a] Fecal coliform, analytical method based on filtration by membrane;

[b] Fecal coliform, limit and geometrix mean shall be determined from at least 5 samples and the limit shall not be exceeded in more than 20% of the samples.

[c] Fecal coliform, limit and geometrix mean shall be determined from at least 5 samples collected at equally spaced intervals over a 30-day period during the bathing season, and the limit shall not be exceeded in more than 20% of the samples.

[d] Fecal coliform, geometric mean shall not exceed the limit for irrigation waters used for vegetables and other foods consumed raw.

[e] *Escherichia coli* and *Entrerococos*, geometrix mean shall be determined from at least 5 samples collected at equally spaced intervals over a 30-day period during the bathing season.

Table D2.4-1: Comparison of Surface Water Quality Standards for DINAMA, CARU and International Agencies

Parameter	Units	Notes	DINAMA, Class 1	CARU, Use 1	Most Restrictive of the DINAMA and CARU Standards		Other World Standards for Protection of Aquatic Life			Other World Standards for Protection of Drinking Water		
			Drinking water supply	Drinking water supply			Australia/ Tasmania[A]	U.S. EPA[B]	Canada[C]	Australia[D]	EU[E]	WHO[F]
Aesthetic Parameters												
Odor			not perceptible	-	not perceptible	DINAMA, Class 1	-	-	-	-	-	-
Unnatural floating material and foam			absent	-	absent	DINAMA, Class 1	-	-	-	-	-	-
Unnatural color	PtCo	max	absent	300	absent	DINAMA, Class 1	-	-	-	-	-	-
Turbidity	NTU	max	50	-	50	DINAMA, Class 1	1	-	-	-	-	5
Conventional Parameters												
Temperature	°C		-	natural conditions	natural conditions	CARU, Use 1	-	-	-	-	-	-
Total Suspended Solids	mg/L	max	-	-	700	DINAMA, Class 2a	-	-	-	-	0.080[6]	-
pH			6.5 to 8.5	6.5 to 9.0	6.5 to 8.3	CARU, Use 2	6.5-7.5	6.5-8.5	6.5-9.0	6.5-8.5[6]	6.5-8.5[6]	6.5-8.5[6]
Conductivity	µS/cm	max	-	-	-		90	-	-	-	250	250
Dissolved Oxygen	mg/L	min	5	5.6	5.6	CARU, Use 1	>85% sat[7]	4.58	5.5	-	-	-
BDO	mg/L	max	5	6	5	DINAMA, Class 1	-	-	-	-	40[6]	-
AOX	mg/L	max					-	-	-	-	1.0[6]	-
Oil and Grease	mg/L	max	virtually absent	virtually absent	virtually absent	DINAMA, Class 1	-	-	-	-	-	-
Detergents	mg/L	max, as LAS	0.5	0.5	0.5	DINAMA, Class 1	-	-	-	-	-	-
Sodium Adsorption Ratio		max	-	-	10	DINAMA, Class 2a	-	-	-	-	-	-
Microbiological												
Fecal Coliforms	FC/100 mL	limit	2,000	5,000	500	CARU, Use 2	-	-	-	0	0	-
	FC/100 mL	geometric mean	1,000	2,000	200	CARU, Use 2	-	-	-	-	-	-
Schistosomiasis			-	-	absence	CARU, Use 2	-	-	-	-	-	-
Escherichia coli	per/100 mL	geometric mean	-	-	126	CARU, Use 2	-	-	-	-	-	-
Enterococos	per/100 mL	geometric mean	-	-	33	CARU, Use 2	-	-	-	-	-	-
Algae	UPA/ml	max	-	100	100	CARU, Use 1	-	-	-	-	-	-
Nutrients												
Nitrogen (total)	mg/L	max, as N	-	-	-		0.48-0.50[5]	-		-	-	500
Nitrite (NO_2)	mg/L	max, as N	-	-	-		-	0.001 (as NO_2)	0.06 (as NO_2)	3 (as NO_2)	0.5 (as NO_2)	3 (as NO_2)
Nitrates (NO_3)	mg/L	max, as N	10	10	10	DINAMA, Class 1	0.7 (as NO_3)	0.01 (as NO_3)	13 (as NO_3)	50 (as NO_3)	50 (as NO_3)	50 (as NO_3)
Ammonia (free)	mg/L	max, as N	0.02	0.019	0.019	CARU, Use 1	-	0.005 - 0.08 [1]	0.019	-	-	-
Total Phosphorus	mg/L	max, as P	0.025	-	0.025	DINAMA, Class 1	0.013-0.050[5]	-	0.010-0.020[9]	-	0.16	-
Toxins												
Chlorates	mg/L	max	-	-	-		-	-	-	-	-	-
Chlorophenols	mg/L	max	-	-	-		0.01 – 0.490 [2]	0.015 [2]	0.0002 – 0.007 [2]	0.02		0.002
Cyanide (free)	mg/L	max	0.005	0.005	0.005	DINAMA, Class 1	0.007	0.0052	0.005	0.08	0.05	0.07
Phenolic Substances	mg/L	max	0.001	0.001	0.001	DINAMA, Class 1	320	-	-	-	0.0005	-
Plant sterols	mg/L	max	-	-	-		-	-	-	-	-	-
Resin/fatty acids		max	-	-	-		-	-	-	-	-	-
Sulphides	mg/L	max	-	-	-		-	-	-	-	-	-

Table D2.4-1: Comparison of Surface Water Quality Standards for DINAMA, CARU and International Agencies (cont'd)

Parameter	Units	Notes	DINAMA, Class 1	CARU, Use 1	Most Restrictive of the DINAMA and CARU Standards		Other World Standards for Protection of Aquatic Life			Other World Standards for Protection of Drinking Water		
			Drinking water supply	Drinking water supply			Australia/ Tasmania[A]	U.S. EPA[B]	Canada[C]	Australia[D]	EU[E]	WHO[F]
Metals												
Arsenic	mg/L	max	0.005	0.015	0.005	DINAMA, Class 1	0.024[3]	0.150[4]	0.005	0.007	0.01	0.01
Boron	mg/L	max	-	-	0.5	DINAMA, Class 2a	-	-	-	-	-	-
Cadmium	mg/L	max	0.001	0.00084	0.00084	CARU, Use 1	0.0002[3]	0.0025[4]	0.0017	0.002	0.005	0.003
Copper	mg/L	max	0.2	0.01	0.01	CARU, Use 1	0.0014[3]	0.009[4]	0.001	2	2	2
Total Chromium	mg/L	max	0.05	0.01	0.005	DINAMA, Class 2a	-	-	-	0.05	0.05	0.05
Chromium - Cr^{III}	mg/L	max	-	-	-		-	0.07[4]	0.0089	-	-	-
Chromium - Cr^{VI}	mg/L	max	-	-	-		0.001[3]	0.011[4]	0.001	-	-	-
Mercury	mg/L	max	0.0002	0.0002	0.0002	DINAMA, Class 1	0.0006	0.00077	0.000026	0.001	0.001	0.006
Nickel	mg/L	max	0.02	0.1163	0.002	DINAMA, Class 2a	0.011[3]	0.052[4]	0.025	0.02	0.02	0.07
Lead	mg/L	max	0.03	0.007	0.007	CARU, Use 1	0.0034[3]	0.0025[4]	0.001	0.01	0.01	0.01
Zinc	mg/L	max	0.03	0.037	0.03	DINAMA, Class 1	0.008[3]	0.120[4]	0.03	3	-	3
Selenium	mg/L	max	-	0.005	0.005	CARU, Use 1	-	-	-	-	-	-
Iron	mg/L	max	-	1	1	CARU, Use 1	-	-	-	-	-	-
Drinking Water												
Fluorides	mg/L	max as F	-	1.5	1.5	CARU, Use 1	-	-	-	-	-	-
Alkalinity	mg/L	max as $CaCO_3$	-	500	500	CARU, Use 1	-	-	-	-	-	-
Chlorides	mg/L	max as Cl	-	250	250	CARU, Use 1	-	-	-	-	-	-
Total Hardness	mg/L	max as $CaCO_3$	-	200	200	CARU, Use 1	-	-	-	-	-	-
Manganese	mg/L	max	-	0.1	0.1	CARU, Use 1	-	-	-	-	-	-
Total Dissolved Solids	mg/L	max	-	500	500	CARU, Use 1	-	-	-	-	-	-
Sulphates	mg/L	max as SO_4	-	250	250	CARU, Use 1	-	-	-	500	250	500

A Australian and New Zealand Guidelines for Fresh and Marine Water Quality. 2000. National Water Quality Management Strategy, Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand, Canberra.
B U.S. Environmental Protection Agency. Current National Recommended Water Quality Criteria.
C Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses - Summary Table. Revised, October 2005.
D Australia Drinking Water Guidelines. 2004. National Health and Medical Research Council.
E European Union 1998 Drinking Water Standards. European Union Drinking Water Directive.
F World Health Organisation. Guidelines for Drinking-Water Quality, 3rd (current) edition, including the first addendum.

1 range for pH 6.5 - 8.5, temperature 15 - 30°C, early life stages present; after: 1999 Update of Ambient Water Quality Criteria for Ammonia. December 1999.
2 range of values for individual chlorophenols; EPA value for pentachlorophenol.
3 metal concentration in water with an assumed hardness of 30 mg/L
4 metal concentration in water with an assumed hardness of 100 mg/L
5 range identified for rivers of Tasmania to lowland rivers of Australia
6 parameter concentration identified by organisation as tolerable
7 dissolved oxygen as % saturation
8 EPA Ambient Water Quality Criteria for Dissolved Oxygen for non-salmonid fishes. April 1986.
9 range identified for mesotrophic waters

D3.0 EXISTING ENVIRONMENT OF THE RIO URUGUAY

The existing environment of the Rio Uruguay is reviewed to provide a baseline for the assessment of cumulative effects for the two pulp mills. The review begins with a description of the physical and hydraulic characteristics of the river followed by a review of the existing water quality and sediment quality. A detailed description is also provided of the fish and invertebrate community within the Rio Uruguay.

D3.1 River Setting and Hydraulic Characteristics

The Rio Uruguay is, after the Rio Paraná, the most important river draining to the Rio de la Plata. The watershed for the Rio Uruguay covers a surface area of approximately 365,000 square kilometers (km^2), of which 51% is in Brazil, 33.5% is in Argentine and 15.5 % is in Uruguay. Figure D3.1-1 presents a map of the basin for the Rio Uruguay which shows Fray Bentos, the approximate location of the project sites.

The river originates at the confluence of the Canoas and Pelotas rivers in the Brazilian territory of Serra Geral, and flows in a general southerly direction towards the Rio de la Plata where it eventually discharges to the Atlantic Ocean. The morphology of the river changes along its approximate 1,800 kilometre (km) length as summarized in Table D3.1-1. The upper and middle reaches above the Salto Grande Dam, are characterized as riverine environments with relatively narrow channel width, steep channel slope and various rapids. In contrast, the lower reaches are characterized as estuarine environments with relatively wide and flat channel with various islands. It is within the lower reach where the two projects are located.

Through the lower reaches, the channel continues to change as the river travels across the lowlands of Uruguay and Argentina. The width of the river is the most obvious indicator of this change. Near the Salto Grande Dam, the river is generally less than 500 m wide and gradually increases to 850 m near Paysandú and to 1,600 m at the International Bridge Libertador General José de San Martin. The river continues to widen to 1,800 m near Fray Bentos, to 6,000 m near Las Cañas, to a maximum of 20,000 m near Nueva Palmira.

As the river widens, its capacity to carry sediment gradually diminishes. This is most evident by the formation of the Rio Uruguay Island Delta located below Paysandú. Most of the coarse sediment originating from further upstream is deposited in this delta as the widening of the river causes the current velocity, and hence sediment transport capacity, to diminish. By Fray Bentos, most of the coarse sediment load is depleted, although the river still carries a considerable load of fine suspended sediment as evident by the high turbidity of the water. Some of this load of fine sediment may settle in shallow embayments and sheltered areas such as Yaguareté Bay.

Most of the flow in the lower Rio Uruguay originates from the Salto Grande Dam, although tributary inflows and water level variations within the Rio de la Plata also influence flow.

The average flow in the Rio Uruguay at the Salto Grande dam is approximately 6,230 m^3/s, based on historic records over the period 1983 to 2003 (as reported by the Dirección Nacional de Hidrografia). However, flows can vary substantially based on season, precipitation and operation of the dam. As an example, the monthly average flow varied from a minimum of 500 m^3/s to a maximum of 22,500 m^3/s over the 20-year period of record.

The Salto Grande Dam is generally operated to maintain a natural flow regime within the lower Rio Uruguay. The limited storage capacity of the Salto Grande Reservoir does not provide for long-term flood and drought control, but can provide for short-term optimization of hydroelectricity production during periods of peak demand. As a result, the downstream flow in the lower Rio Uruguay can change abruptly as turbines are brought on or off line.

Drought conditions, characterized by the 7-day average low flow, are generally of greatest interest from a water quality perspective. Such conditions generally occur within the Rio Uruguay during January and February as a result of seasonal high temperature and low precipitation. At the Salto Grande dam, the annual drought flow is typically 850 m^3/s, on average, although, a lower flow is expected under extreme drought conditions. Based on statistical analysis completed by the Dirección Nacional de Hidrografia, a drought flow of 580 m^3/s is expected once every 5-years, on average, and a drought flow of 360 m^3/s is expected once every 20-years, on average.

The flow at Fray Bentos is expected to be somewhat higher than the flow at Salto Grande Dam due to the increased drainage area between the two locations. Prorating flow on a drainage area basis yields an estimate of the drought flow for the Rio Uruguay at Fray Bentos. As presented in Table D3.1-2, the annual, 5-year and 20-year drought flows are estimated to be 950, 640 and 400 m^3/s, respectively.

There are a number of smaller tributaries that discharge to the Rio Uruguay below the Salto Grande Dam. One of the largest tributaries is the Rio Negro which is located downstream from Fray Bentos along the Uruguayan side of the river. The annual average flow of the Rio Negro is estimated to be 700 m^3/s, which is approximately 11% of the annual average flow of the Rio Uruguay. The Rio Gualeguaychú discharges to the Rio Uruguay along the Argentinean side directly across from Fray Bentos. The average and low flow for the Rio Gualeguaychú is estimated to be 210 and 20 m^3/s, respectively. A series of smaller tributaries discharge to the Rio Uruguay within the vicinity of the project sites. The smaller tributaries near the Orion mill are summarized in Table D3.1-3.

The flow in the river can also be influenced by wind effects when the flow at the Salto Grande dam is very low. Regional winds over the Atlantic Ocean and local winds over the Rio de la Plata cause wind seiche (which is a rise and fall of the water elevation in response to the wind). This wind seiche in turn can cause the flow within the Rio Uruguay to temporarily increase or decrease in response. Under rare occasions (a few times/year or less), the flow can even reverse direction and travel upstream for short periods of time. These flow reversals have been observed during extreme low flow conditions at the Salto Grande Dam and to last for a few hours in duration. Flow reversals are not expected to occur when the flow at the dam is greater than 1,000 m^3/s, and the upstream excursion distance (i.e., the distance traveled from the start to the end of the flow reversal event) is expected to be less than 10 km within the area of the mills (Piedra-Cueva, 2006).

The average water elevation of the Rio Uruguay at Fray Bentos is approximately 1.28 m above chart datum, although it varies over a range from 0.3 to 4.0 m (based on measurements over the period 1980 to 1996). As illustrated in Figure D3.1-2, the water elevation varies with flow, although the correlation is weak ($r^2 = 0.34$). Lower water elevations tend to correlate with low flow at the Salto Grande Dam and high water elevations tend to correlate with high flow at the dam. When the flow is below 1,000 m^3/s, the water elevation tends to remain in the range of 0.3 to 2.0 m.

The river depth is more than 10 m in the main channel, but 0 to 2 m along the shoreline and in the embayments (Figure D3.1-3). The embayments likely accumulate sediment during low flow periods and are flushed during high flow periods.

Current velocities measurements are available for the Rio Uruguay in the vicinity of the Botnia plant and Yaguareté Bay. Measurements were taken on 16th December 2003 when the flow was moderately high (6,000 to 7,000 m^3/s). The resulting data show higher velocities in mid-channel and lower velocities near the river banks. The data also show a slightly higher velocity near the surface than at depth. Within the main channel, the average velocity was estimated to be 0.57 m/s in comparison to a velocity within Yaguareté Bay of 0.14 to 0.25 m/s. These velocity measures reported by Botnia (2006) were comparable to measurements reported by the Dirección Nacional de Hidrografia in 1998 under a flow of 8,700 m^3/s.

D3.2 Existing Water Quality

In general, the quality of water in the Rio Uruguay is considered good but there are localized issues and exceedances of water quality criteria goals. In 1992, Estudio Nacional Ambiental (OPP-OEA-BID) concluded that the Rio Uruguay is in good general condition considering its large volume of flow and assimilative capacity. This conclusion was based on the studies and monitoring conducted by CARU with the support of other regulatory agencies. It did note that problems were detected in some areas including Bella Union, Salto, Concordia, Paysandú and the mouth of the Rio Gualeguaychú. This localized deterioration of water quality was primarily attributed to runoff from areas of intense agricultural use and discharges from urban centers and industries with inadequate effluent treatment.

The quality of water in the Rio Uruguay has been the subject of numerous studies and water quality sampling events. From 1987 to date, CARU has conducted over 50 water quality monitoring events although only data from events over the periods from 1987–1990 and 2002–2003 have been published (CARU, 1993; CARU, 2004). In addition, both Botnia and ENCE have conducted baseline water quality sampling associated with their projects. Water quality sampling has been conducted also for the CMB port facility. ENCE has also been conducting water quality sampling associated with the existing port facility at the CMB site (Terminal Logistica M'Bopicuá). Based on a review of the data contained in these documents, monitoring data for the vast majority of constituents shows compliance with applicable water quality standards. Parameters showing multiple exceedances of water quality criteria at monitoring locations in the vicinity of the two project sites include fecal coliforms, dissolved oxygen, ammonia-nitrogen, phosphorus, chromium, iron and zinc.

Occasional low dissolved oxygen levels and exceedances of fecal coliform, ammonia-nitrogen and phosphorus standards are believed to be related to the discharge of municipal wastewater effluents that receive inadequate treatment. Industrial effluent and runoff from agricultural uses likely also contribute to the exceedances. Ammonia-nitrogen can potentially cause toxicity in fish, but is not expected to be an issue at typical river pH levels. Phosphorus is a potential concern for eutrophication and increased aquatic plant growth in shallow, slow moving sections of the river. The source of chromium and zinc levels in the river is uncertain. Levels exceeding these criteria are potentially a concern with regard to toxicity to aquatic species. Iron is a naturally occurring element in the river that exceeds the water quality criteria, although this criterion was primarily developed for aesthetic concerns relating to drinking water.

Baseline water quality in the Rio Uruguay, over the 1987-90 period from CARU (1993), is summarized in Table D3.2-1, for stations near Salto, Paysandú, Gualeguaychú and Fray Bentos. While statistical summaries were not provided for metals, station average values in this area for Cr were in the 2 to 4 μg/L range, for Zn they were in the 10 to 35 μg/L range, and for Fe they were in the 0.05 to 0.15 mg/L range.

Water quality data for the 1997-2004 period were summarized in graphic form by CARU (2005a). Two sampling campaigns in 2004 were focused particularly on the river sections in the vicinity of the two mill projects (Figure D3.2-1). The data for nitrates and phenolics are illustrated in Figure D3.2-2. Nitrates are temporally quite variable, ranging from non-detect to approximately 0.35 mg/L at most stations. Phenolics generally range from non-detect to 4 μg/L (above the Class 1 standard of 1 μg/L) with several much higher values (24 and 27 μg/L) on the Argentina side of the river. Metals were generally well below their Class 1 standards, with maximum values of Cr – 38 μg/L, Cu – 10 μg/L, Pb – 20 μg/L and Cd – 0.45 μg/L.

The GTAN (2006) compiled the most recent available data from CARU (2005a) with older CARU data for these stations near the mill projects, and produced an updated summary of key water quality parameters for the area (Table D3.2-2). Average values for the period of record and associated numbers of samples are shown in the table.

The Botnia EIA (2004) presented water quality data collected at five locations on the Rio Uruguay between Las Cañas and the International Bridge (Table D3.2-3). The data were collected in 2002-2003, except for the CARU data at location E70 in front of Fray Bentos, which represent the 1987-1990 period, and the OSE data at the municipal water intake, which represent the 2001-2003 period.

More recent data, collected monthly at four locations between Las Cañas and Nuevo Berlin, are listed bi-monthly in Table D3.2-4, in order to illustrate seasonal patterns. Some measured parameters are omitted from the presentation, including pesticides, which were always non-detect, and major cations; both are of little interest with respect to potential mill effects. Water temperature was lowest in August and highest in January (summer) with a range of 15.6 to 29.8°C. Sulphate cycled with water temperature, being lowest in winter and highest in summer (December to January). Turbidity was lowest in summer (December to January) likely related to low river flow in the summer period. Total coliforms followed a similar pattern, being highest in August and lowest in January. Nitrate was particularly high in the fall (April), possibly related to biological activity over the summer.

The ENCE EIA (Soluziona, 2002) presented water quality data collected at seven locations on the Rio Uruguay between Las Cañas and the mouth of Arroyo M'Bopicuá upstream of the mill site (Table D3.2-5). The data were collected in October 2001, with two sampling days per station. The average values are shown in the table. Some measured parameters, including pesticides, which were non-detect, and major cations are omitted from this presentation. More recent data were collected in 2005 at ten locations between Las Cañas and Arroyo M'Bopicuá (Table D3.2-6). The data were collected under near average flow conditions by Ecotech, and reported by Algoritmos (2006) as a baseline for water quality modelling. The data shown are averages of five samples at each location.

Special baseline studies of AOX, chlorophenolics, resin/fatty acids, phytosterols and dioxins/furans in Rio Uruguay water were undertaken in 2005 by Jukka Tana (2005, 2006). Concentrations in fishes were also measured. Water sampling locations included Nuevo Berlin (upstream of the mill sites), Yaguareté Bay (immediately downstream of the Botnia site), and Las Cañas. The water data are summarized in Table D3.2-7 for April and December sampling campaigns. The chlorophenolics include various chlorophenols, mainly tetra- and penta-chlorophenols, but chloroquaicols are also present at low levels. The resin acids and fatty acids also include various forms. Neoabietic and abietic acid are the most prevalent resin acids. The phytosterols found in December sampling were comprised of sitosterol and sitostanol. The dioxin/furan congeners found in April sampling were 2,3,7,8-TCDD and 1,2,3,4,6,7,8-HpCDD, while those found in December sampling were 1,2,3,4,6,7,8-HpCDD, 1,2,3,4,7,8,9-HpCDF and OCDF.

Special baseline studies of nutrient levels and other water quality parameters relevant to plankton communities in the Rio Uruguay were undertaken in April 2005 and January 2006 by CELA (2005, 2006). Sampling locations included three nearshore transects in each of three river reaches, near Nuevo Berlin, Fray Bentos and Las Cañas. The water quality data are summarized in Table D3.2-8 as averages of three samples per transect.

Water quality sampling was undertaken in the vicinity of the Terminal Logistica M'Bopicuá in 2004. River locations 800 m upstream, 800 m downstream and in front of the Terminal were sampled from April through December. The water quality data are summarized in Table D3.2-9.

D3.3 Existing Sediment Quality

The sediments of the Rio Uruguay were physically characterized by Centro de Estudios Limnológicos Aplicados (CELA, 2005, 2006) based on three samples along each of three transects in each of three river reaches, near Nuevo Berlin, Fray Bentos and Las Caňas. At most locations, the substrate were dominated by sand, while a few locations had either gravel or fines predominant. The average fraction of sand was 85% in April 2005 samples, and 71% in January 2006 samples. Fray Bentos transect 2 in Yaguareté Bay had sand ranging from 74 to 92%.

Sediments were chemically characterized with respect to percent organic matter, phosphorus and nitrogen. Organic matter averaged 2.3% and 3.0% in April 2005 and January 2006 samples. Phosphorus averaged 32.9 μg/g FW and 10.8 μg/g FW, and nitrogen averaged 172.1 μg/g FW and 44.6 μg/g FW in April 2005 and January 2006 samples. The data suggest nutrient enrichment of sediments in the fall as compared to summer months.

The sediments of Yaguareté Bay, downstream of the Botnia mill site, were specifically characterized by CELA in November and December 2005 (CELA, 2005a,b). They were compared to a location just upstream of the proposed Botnia discharge (Figure D3.3-1). The results are summarized in Table D3.3-1. They indicate percent organic matter generally in the 1 to 6% range, phosphorus in the 12 to 26 μg/g FW range, and nitrogen in the 33 to 88 μg/g FW range. These phosphorus and nitrogen levels should be considered representative of the summer season. Higher values may occur in the fall. CELA (2005) reported April 2005 phosphorus and nitrogen levels of 38.3 and 416.6 μg/g FW, respectively, in Fray Bentos transect 2 in Yaguareté Bay.

Sediments were characterized at a station just below the Terminal Logistica M'Bopicuá in 2003 to 2005 (Enviro, 2004). The data are shown in Table D3.3-2. They indicate percent organic matter generally <1% but as high as 3%, and a predominance of fines (less than 62 μ). In addition, "total" (C16) hydrocarbons and halogenated hydrocarbons were determined, at 0.11 to 0.32 μg/g and less than 0.01 to 0.03 μg/g, respectively.

Metal and organic contaminant data for Rio Uruguay sediments have been collected over the years by CARU at various locations of interest. The data have not been synthesized for the river as a whole; however, data relevant to the project locations are listed in Table 3.3-3. The Fray Bentos location is near the municipal discharge, the Gualeguaychú location is at the mouth of the Rio Gualeguaychú, and the Paysandú location is well upstream, near the municipal discharge of that city. Two metals (Cu, Cr) frequently exceed (Canadian) sediment quality guidelines (lowest effect levels). The maximum for Cu (five times guideline) is at Fray Bentos, while the maximum for Cr (eleven times guideline) is at Paysandú. The data are quite variable, with some values at or below guideline levels at all locations.

D3.4 Fish Community and Fish Habitat

Fish Community

More than 200 species of fish have been collected from the Rio Uruguay, as it flows over more than 1,000 km from Brazil in the north to Uruguay in the south (Hahn and Câmara 2000; Nion *et al*., 2002, Reis *et al*., 2003). The fish inventories have been completed by both government agencies and other investigators. Fish diversity on the Rio Uruguay is typical of large rivers in South America (CARU, 1999). Because this river drains to the Atlantic Ocean in the south, at the Rio de la Plata estuary, it is used by freshwater, estuarine, and marine species. The tidal influence on flow extends at least 200 km upstream from the estuary to about the city of Paysandú. However, the intrusion of salt water is confined to areas near Rio de la Plata (CENNAVE, 2000). Thus, the majority of the fishes upstream of Rio de la Plata are freshwater species (CARU, 1999).

The connectivity of the Rio Uruguay for fishes has been interrupted by the presence of dams and associated reservoirs. Although some of these dams possess fish passage structures to help facilitate migrations (Quirós, 1989), they generally act to separate the river into three major sections. These sections correspond to the upper, middle, and lower river, and correspond to decreasing distances from the ocean.

The sites of the proposed pulp mills occur within the lower Rio Uruguay. This section effectively runs about 250 km from the base of the Salto Grande Dam, constructed in the 1980s, to the Atlantic Ocean. This dam possesses modified Borland-type locks to facilitate passage of a range of fish species, of both large and small adult lengths (Delfino *et al*., 1986; Quirós 1989).

Studies have identified that the lower Rio Uruguay contains more than 100 fish species represented by a large number of families (CARU, 1999, Nion *et al*., 2002). The species of fish in the Lower Uruguay with the highest biomass, since the construction of the Salto Grande dam in the 1980s, is the sábalo (*Prochilodus lineatus*, family Prochilodontidae). Other common species, in terms of biomass, include the boga (*Leporinus obtusidens*, Anostomidae), the pati catfish (*Luciopimelodus pati*, Pimelodidae), and the dorado

(*Salminus maxillosus*, Characidae). The most common species can be partitioned among about seven orders (Table D3.4-1). Other frequently observed species include the boga juncalera (*Schizodon nasutus*, family Anostomidae), anchoita de Rio (*Lycengraulis grossidens*, Engraulidae), cichlids (e.g., Juanita *Crenicichla lepidota*, Cichlidae), Uruguay tetra (Cheirodon interruptus, Characidae), and catfish (e.g., armado *Pterodoras granulosus*, Doridae, bagre sapo *Zungaro zungaro* Pimelodidae).

Fisheries of the Lower Rio Uruguay

Studies by CARU have systematically assessed the fishing activities along the Rio Uruguay between 1981 and 2005. These studies have been focused particularly on two sections of the lower Rio Uruguay. The first section extends from the mouth of the river to river kilometer 95 and includes the area of the proposed pulp mills. Upstream of this area, to the base of the Salto Grande Dam and reservoir, represents the second section.

Through the study period, 38 species have been identified in the fishery catch. The most common species from the lower river were the sábalo, boga, Lisa and the catfish (pati, bagre amarillo). Between 1981 and 2005, the catch from the different campaigns of experimental gillnet fishing by CARU have ranged between 25 kg/ha and 170 kg/ha. In spite of the year to year variability in catch, these values are among the highest for large river environments of the world. The high density of fish is due mainly to the presence of the sabalo. The abundance of this species is due directly to the accumulation of fine sediments in the river that are used as food for this species.

Hydroacoustic surveys completed during high water of February 2003 identified the majority of the fish occur in water with depths greater than 8 m.

Three types of commercial fisheries occur in the lower Rio Uruguay. These fishery activities can be described by the methods used:

1. Craft or artisan fishermen use small boats or barges. The gear includes nets, spears, and hook fishing. This catch is highly selective. The fishery extends along the entire lower Rio Uruguay, and so will be considered in detail.

2. Sabalerías, that operate with beach seine nets of 400 to 800 m in length. This fishery primarily occurs in the lower Rio Uruguay near to the Rio de la Plata estuary, and will not be discussed in detail.

3. Ships of 10 to 15 m, use networks of gill nets, fishing lines, and fish fences. This fishery is also primarily located in the lower portion of the Rio Uruguay, in relatively deep water, and will not be discussed in detail.

In the fishery censuses during the 1990s, a total of 161 artisan fishermen were from Uruguay and 130 were from Argentina. About half of these individuals fish full time while 80% fish during the majority of their time but have other jobs.

In Uruguay, the artisan fishery is operated by people primarily from the Fray Bentos area. Other important ports are Villa Soriano, the Concord, and Nueva Palmira (CARU, 2005b). Their catch is typically destined for local markets and restaurants, and to people at the harbour. On a daily basis, a variable amount is exported as fresh whole fish and fillets south to Montevideo, west to Argentina, or north to Brazil.

Generally, about 17 species are captured regularly by the artisan fleet across the lower Rio Uruguay. The biomass of these species varies annually but species representation is generally consistent (Table D3.4-2). For the year 2000, the total declared catch was ~ 1621 tons (DINARA, 2003). Of this total, 374 tons were declared in the ports along the river (Fray Bentos, New Berlin, Paysandú and Salto).

Recent sampling suggested that the most important species were the sábalo (48.1% of catch) and boga (35.6%) while the remainder was represented by tararira, armado and bagre amarillo, and Lisa.

The CARU (2005b) report estimated that the 2004 catch included 1,596 tons from the Uruguayan artisan fishery, and was associated with the area between Fray Bentos and the estuary of the Paraná River. Other fishes are captured but are usually discarded or perhaps used for other purposes (e.g., fertilizer). This list includes non-native carp (*Cyprinus carpio*), sturgeon (*Acipenser baeri,* escaped from aquaculture, Nion *et al.*, 2002), *Leporinus striatus* Anostomidae, and vieja de agua.

The Continuity of the Artisan Fishery

Recent studies indicate that many fishermen have left this practice because they are now working at the construction sites of the pulp mills. In some cases where fishing appears as a preferred activity, the individual has continued to fish. However, when the construction work ends, it is likely these individuals will return to fishing. Continuance of the traditional artisan fishery over time appears to be simply due to the constant income provided and the continued abundance of valued fish species.

Sports Fisheries

Sport fishing for different species occurs from the base of the Salto Grande Dam to the mouth of the Rio Uruguay. However, the area directly below the reservoir is an area where fishing is prohibited. This fishery is popular with domestic and international tourists. The recreational fishery uses boats of various sizes and gasoline powered engines so they can cover large distances in a short amount of time. The fishery extends along the lower Rio Uruguay and, therefore, includes the water in the vicinity of the pulp mills. This industry provides employment to the people who live in the area of Fray Bentos and from the Argentinian side of the river. Such insight was provided by Raúl Almeida- Fishing and River Guide, Gualeguaychú, Argentina. The fishery is advertised to international tourists via the internet (e.g., http://www.fishquest.com). A very small number of species are harvested, and include the dorado and some catfishes. Oversight of this fishery is provided by the government through active monitoring and routine studies by CARU.

Migration and Reproduction

The fishes of the lower Rio Uruguay can be described as either mainstem or tributary migratory species. The mainstem species reproduce and can complete their life history in the main river channel. By contrast, the tributary species may use the lower Rio Uruguay as juveniles and/or adults but they need to migrate to adjacent tributaries, like the Rio Paraná, to spawn and produce larvae. Other species may feed in the river and return to the estuary or ocean to complete their life history. Some species show migrations to tributaries that can surpass large distances, from 100s to more than 1,000 kilometers. Given that salt water can be lethal to the eggs of many fishes, the extent of the salt water influence on the lower Rio Uruguay also acts as a strong influence on where a fish species can spawn (e.g., CARU, 1999, 2005b).

Studies of eggs and larvae in the Lower Rio Uruguay suggest that reproduction generally occurs between October and March; this period is represented with one spawning peak downstream of the Salto Grande Dam in the spring. However, some species are fractional spawners and can reproduce through the entire period or at other times of the year. Tagging studies in the Lower Rio Uruguay have revealed a number of key migratory fish species (e.g., boga, sábalo) reproduce in the Middle Rio Paraná, and this is likely at least partially a response to the tidal influence in the lower Rio Paraná. Bonetto and Pignalberi (1964) studied the fishes of the Argentine section of the Rio Paraná and found that this river shows a distinct pattern of downstream feeding migrations and upstream reproductive migrations. Generally, this pattern of behaviour is common to the majority of tropical and subtropical rivers and is closely linked to the seasonal rains (Filho and Schulz, 2004). In the Rio Paraná, the summer water levels allow upstream migration; flooding of shoreline areas has been identified as providing habitat for larvae and fingerlings of many species.

Biology of Sábalo

The sábalo can be described as a benthivore that feeds on detritus and other plant material, either of river or terrestrial origin. Since this feeding activity links the river to the surrounding watershed, and since sábalo are abundant, the sábalo is an important or keystone species for the food web of the river.

Adult sábalo prefer slower portions of the river, where suspended material settles out and a robust benthic plant community and expansive detritus can develop. These areas are particularly common in the lower stretch of the Rio Uruguay, where the river bed is flat, and at times more than 10 km wide, and also relatively shallow. Thus, this section of the river is ideal for the growth of plant materials and deposition of detritus. However, the sábalo also occurs in faster water associated with a sparse benthic plant community. The larvae and juveniles co-occur with the adults, and can be found along the entire lower Rio Uruguay. This wide distribution also explains the harvest of the species in all three types of commercial fisheries.

In terms of reproduction, the sábalo eggs require flowing water for the incubation phase of four days. Adult females produce large numbers of semi-dense eggs that float and so fertilization occurs in the water column. The age of sexual maturity of both males and females is usually around age three (Breder and Rosen, 1966). After hatch, the larvae begin external feeding. In the first days they require plankton and then graduate to consuming benthic organisms, and then to detrital and plant material.

Studies of reproduction of sábalo previously indicated the main spawning location for this and other species of the lower Rio Uruguay would exist in the middle Rio Paraná (Amestoy, 1992; Sverlij, 1998). Indeed this inference seems to be correct (CARU, 2005b). Tagging studies of adult sábalo completed by CARU (CARU ,2005b) have identified a migratory movement from the lower Rio Uruguay to the middle Rio Paraná for spawning, a distance sometimes in excess of 1,000 km. The presence of larval sábalo in the lower Rio Paraná confirms the inference of spawning from about October to January in the middle Rio Paraná.

Another migratory movement for sábalo seems to be upriver towards the Salto Grande Dam. Larval sábalo collected in the river are younger than those captured in the reservoir above the Salto Grande dam. This discontinuity in age between the reservoir and river confirms spawning of sábalo occurs downstream of the dam (Fuentes and Espinach-Ros, 1999). Recent investigations suggest this spawning likely occurs in the main channel of the river, in close proximity of the base of the dam. However, the exact location(s) of spawning have not yet been documented (CARU, 1999, 2005b; Filho and Schulz, 2004). Sabalo tagged at the base of the Salto Grande dam have been captured up to 620 km downstream in the Rio Parana (Delfino and Bagium, 1985).

Smolders *et al*. (2002) reported a similar pattern of spawning by sábalo in the main channel of an unimpounded large river, the lower Pilcomayo, in Bolivia. In that river, at the end of the rainy season, the adult sábalo release eggs and sperm and fertilization occurs in the water of the main channel. Then these eggs hatch and the larvae drift downstream and typically move to the shallow waters of the floodplain ponds or embayments to feed (Flecker, 1996; Fugi *et al*., 1996).

Other studies of the genetics of sábalo from the lower Rio Uruguay have resolved the existence of two distinct stocks (Sverlij *et al*., 1992) and this is supported by the results of the recent tagging studies (CARU, 2005b). Thus, it can be inferred that one group of sábalo spawns in the middle Rio Paraná while a second group spawns in the Rio Uruguay just downstream of the Salto Grande dam.

Studies of adult sábalo indicated a maximum age of nine years in the lower Rio Uruguay although additional consideration is likely needed to resolve growth rates and age distributions of the populations. The tagging studies to date have identified a difference in growth rates between the two stocks of sábalo in the lower Rio Uruguay (CARU, 2005b). In addition, fish from three to six years of age dominate the Curimbatá populations in the lower Rio Uruguay. Because of the high abundance of this species, it represents an important food resource for predatory fishes and birds.

Biology of Dorado

As noted, the recreational anglers regard the dorado as one of the world's most powerful freshwater sport fish. Studies completed by CARU have revealed that this species moves throughout the lower Rio Uruguay and is also captured in the commercial fishery. The value of the fish to the commercial fishery is considered high and it is only used for human consumption (CARU, 1999, 2005b). Interest in dorado by both the commercial and recreational fisheries has created controversy of late, as the species is perceived to be in decline, which is assumed to be a result of over harvest (CARU, 2005b).

The dorado is known to spawn directly below the Salto Grande Dam, usually between October and December. Studies indicate males mature at age 2 and females at age 3. Spawning activity in the lower Rio Uruguay just below the dam has been observed directly and both commercial and recreational fishing is prohibited at this time. After spawning, the fertilized eggs float downstream and hatch in the main channel of the river. At that time, the larvae move to the shallow and slower waters of the shoreline, embayments, and flood plain ponds. The larvae and juveniles feed on invertebrates like crustaceans and insects. In contrast, the adults feed primarily on fishes and even birds (e.g., de Godoy, 1975).

Studies of adult dorado reveal a maximum age of nine or 10 (Vaz-Ferreira, 1969) although additional studies are likely warranted. Older dorado in this population are likely rare, given the high mortality rates from the fisheries. Other studies indicate that this species moves throughout the lower Rio Uruguay and the Rio de la Plata estuary.

Conservation Status

The conservation status of the fishes of the lower Rio Uruguay is presented in Table D3.4-3. The table considers important fishes of the Lower Rio Uruguay and was modified from Chébez (1994) and Bertonatti and González (1992). Additional data would be needed on these species to frame population management and/or rehabilitation plans. Previously, the catfishes *Loricariichthys edentatus* and *Pseudohemiodon devincenzii* were identified at the proposed mill site, and were described as being of conservation importance in the Río Uruguay (Enviro, 2004). However, neither of these species are listed in the IUCN red list of threatened species and recent studies (Reis and Pereira, 2000; Nion *et al.*, 2004) do not indicate that they are rare in Uruguay.

Fish Habitat

The water quality and aquatic habitats of the lower Rio Uruguay are subject to seasonal changes (Sections D3.1 and D3.2), and this influences the habitats available to fish. These habitats are also influenced by the low gradient and wide channel of the lower sections. This zone is characterized by an abundance of shallow embayments and seasonal floodplain lakes and pools; these three habitat types contribute to the diversity of habitats available to fish and other species and lead to high productivity rates. Because the water elevations and flows vary significantly by season, in excess of 5 m despite the upstream Salto Grande Dam, from highs during the rainy season to lows during the dry season, the seasonal floods would allow fish to migrate in and out of the flood plain ponds and pools on a seasonal basis. These habitats would be suitable for the growth of floating aquatic plants, attached microscopic algae, and invertebrates due to the shallow water and low flows, so it represents ideal fish habitat.

The shallow aquatic habitat adjacent to the main river channel also represents an important habitat, particularly for small fishes, as the large fishes do not remain here after the flood waters recede. During the high flows, the larvae of many species, including some catfishes and dorado, would migrate to these habitats. In addition, other fish species, like carp and some catfishes, may enter these shallow areas to spawn and then migrate back to deeper habitats. Still other fishes, like the Uruguay tetra, madrecita (*Cnesterodon carnegiei* Poeciliidae), Cinolebia or killifish *Austrolebias luteoflammulatus* Rivulidae), and chameleon cichlid (*Cichlsoma facetum* Cichlidae) are likely able to complete their entire life history in these shallow habitats.

In the lower Rio Uruguay, the productivity of aquatic macrophyte vegetation communities is generally low due to the scarcity of pools, the near-absence of marginal lagoons, and high flow rates. However, macrophytes are present in shallow embayments along the shoreline.

In recent studies in the area near the Terminal Logistics M'Bopicuá, both floating and rooted aquatic plants were identified. The floating species included: water hyacinth *Eichhornia crassipes*, water fern *Salvinia bioloba*, water lettuce *Pistia stratiotes.* The rooted species were located primarily along the river shoreline, were frequently emergent species, and included: Cucharero *Echinodorus grandiflorus*, Rush *Schoenoplectus californicus*, Golden purl *Panicum elephantipes*, Lagunilla Alternanthera philoxeroides, Enydra *Hendirá anagallis*, White sarandi - *Phyllanthus sellowianus.*

Stream mouth areas are a specific type of embayment which generally contain more extensive aquatic vegetation in the water and riparian vegetation on the stream banks. These areas are important habitats for riparian wildlife as well as fishes. A common riparian mammal is the Nutria (*Myocastor coypus*) a herbivorous rodent. Less common species include the river otter (*Lutra longicaudis*) a mainly piscivorous mammal. Fish-eating birds also use these areas. These areas will not be subject to water quality impacts from mill effluents, being well off the plume centerlines.

D3.5 Aquatic Invertebrate Community

Benthic Invertebrates

The benthic macroinvertebrate community in the Rio Uruguay was characterized by CELA (2005, 2006) based on three grab samples of sediments along each of three transects in each of three river reaches, near Nuevo Berlin, Fray Bentos and Las Cañas. The taxonomic enumerations were completed at family level. In most samples collected, the dominant taxa were either Mytilidae (mussels), Tubificidae (tubificid worms) or Chironomidae (midge larvae). Hydrobiidae (snails) and Corbiculidae (clams) were also common and were the dominant taxa in some samples. The taxonomic data for April 2005 and for January 2006 are shown in Tables D3.5-1 and D3.5-2, respectively.

Cluster analysis of the April 2005 benthic invertebrate data in each of the river reaches indicated that there were distinctive species assemblages associated with dominance either by mussels (particularly golden mussels) or by tubificid worms, and that these assemblages tended to be less diverse as compared to those at other locations. The golden mussel (*Limnoperna fortunei*) is an introduced invasive species which first appeared in Uruguay in 1994. The tubificid worms (e.g., *Limnodrilus, Aulodrilus*) are indicative of nutrient-enriched low oxygen conditions that many other species do not tolerate. Low oxygen conditions may exist in and near the sediments, even though the water column is well oxygenated.

Phytoplankton

The phytoplankton community is limited by the turbid condition of the Rio Uruguay, which limits light penetration. The dominant species are diatoms and nanoplanktonic phytoflagellates, which are characteristic of turbulent and turbid environments. Blue-green algae also comprise a significant portion of the phytoplankton community, particularly in the summer months when algal blooms can occur. Green algae are present but less important.

Phytoplankton densities are lower in the spring and fall than during the summer. Figure D3.5-1 illustrates the seasonal as well as spatial variation in phytoplankton density, based on transects in the areas of Nuevo Berlin, Fray Bentos and Las Cañas (CELA, 2005, 2006). April 2005 densities did not exceed 800 cells/mL, while January 2006 densities ranged from 5,000 to 70,000 cells/mL. Fray Bentos Transect 2 is in Yaguareté Bay.

Studies by CELA (2005a,b) describe the phytoplankton species composition in detail, for Yaguareté Bay and for a nearshore location upstream of the proposed Botnia discharge. Important diatom species include *Aulacoseira granulata*; important phytoflagellates include *Fitoflagelado* sp. and *Rhodomonas minuta*; important blue-green algae include *Microcystis* *aerugenosa* (in Yaguareté Bay) and *Anabaena spiroides* (important in the upstream location only). *Microcystis* produces a toxin (microcystin) which may be of concern to both people and aquatic life during algal blooms.

Zooplankton

The zooplankton community on the Rio Uruguay consists mainly of micro-crustaceans and rotifers, with larval forms of other invertebrates also numerically important. These larval forms are dominated by golden mussel larvae, but also include larvae of snails and hydroid coelenterates.

Zooplankton densities are lower in the fall than in summer. CELA (2005, 2006) reported densities ranging from 1.52 to 9.04 organisms/L in April 2005, and from 32 to 96 organisms/L in January 2006, in a series of sampling transects encompassing three river reaches, around Nuevo Berlin, Fray Bentos and Las Cañas. Figure D3.5-2 illustrates the high level taxonomic composition and organism density for each transect in January 2006. Fray Benthos Transect 2 is in Yaguareté Bay.

Studies by CELA (2005a,b) describe the zooplankton species composition in detail, for Yaguareté Bay and for a nearshore location upstream of the proposed Botnia discharge. Important rotifers include *Ascomporpha* sp., *Synchaeta* sp. and *Keratella tropica*; important micro-crustaceans include *Bosminopsis deitersi, Moina* sp. and *Notodiaptomus* sp. However, in all these samples, golden mussel larvae were numerically dominant. The taxonomic data for December 2005 are shown in Table D3.5-3.

D3.6 Contaminants in Aquatic Biota

Levels of contaminants in fish tissues in the vicinity of Fray Bentos were investigated by Tana (2005, 2006). The studies included dioxins and furans in fish flesh, as well as chlorophenols, resin and fatty acids and phytosterols in fish bile. The latter analyses were performed on bile, rather than flesh, to permit detection of the compounds. These organic compounds tend to accumulate preferentially in lipid-rich tissues, and particularly in liver tissue since the liver is involved in removal and detoxification of various chemicals that may enter the blood-stream of the fish.

Dioxins and furans, chlorophenols and resin/fatty acids have historically been of concern as agents of fish toxicity. Phytosterols include various endocrine disruptor chemicals which have been shown to mimic fish hormones and to disrupt sexual development and/or reproductive performance of fishes.

Table D3.6-1 shows the baseline concentrations of these organic chemical classes in fish bile or flesh. Fishes were collected at locations shown in Figure D3.3-1. The chlorophenolics are mainly chlorophenols (di- to penta-chlorophenols), but chloroguaiacols, chlorocatechols and trichlorosyringols are also present at lower levels. The resin and fatty acids include many forms. The phytosterols include campesterol, campestanol and sitosterol. The dioxins/furans found in April sampling included tetra- to octa-congeners, with TEQ levels of 0.1 to 0.3 pg/g, well below levels at which fish consumption advisories would be needed.

Polychlorinated biphenyls (PCBs) and organochlorine pesticides in fish flesh in the Rio Uruguay were determined by CARU (2005b) over the 1981 to 2005 period. The fish species included sabalo, boga, tararira and yellow catfish. All concentrations were well below the U.S. Food and Drug Administration (U.S. FDA) action levels. The PCBs averaged 22.9 ng/g (range 1.2 to 162 ng/g) as compared to the FDA limit of 2 μg/g.

D3.7 Summary of Baseline Information

The existing baseline information can be summarized with the following key points:

- Rio Uruguay flow rates average about 6,200 m^3/s, usually range from 500 to 20,000 m^3/s, and are strongly influenced by the Salto Grande dam.
- Flow reversals of the Rio Uruguay occur rarely, from a combination of wind action and extreme low flows due to the operations at the Salto Grande Dam, and have been observed to last for only a few hours; reversals do not generally occur when the flow at the dam is greater than 1,000 m^3/s, and the upstream excursion distance during a flow reversal event is expected to be less than 10 km within the area of the mills.
- The water quality can be considered good given the large flows and assimilative capacity but there are localized exceedances of water quality guidelines for fecal coliforms, metals and nutrients.
- Problems with water quality can be attributed to runoff from areas of agriculture along with effluent from urban centers and communities lacking adequate water treatment.
- Sediments can be considered in good condition at the sites sampled although some locally high concentrations of chromium and copper are observed downstream of urban centers.
- Large numbers of fish occur in the lower Rio Uruguay and some species are harvested by artisan and recreational fisheries; the most abundant species is the sábalo and it is not heavily harvested by these fisheries.
- The conservation status of several fish is of concern but for all of these species, additional data is needed to resolve how to frame population management and/or rehabilitation plans.

- No major migratory fish species or those harvested in the fisheries spawn in the vicinity of the pulp mill sites. Some local fish species, like carp and some catfishes, may spawn in embayments near the mill sites.

- The benthic invertebrate communities are dominated by tubificids, chironomids, snails, and invasive mussels; a patchy community distribution is likely due to spatial variability in microhabitat features along with the variable flow rates.

- Phytoplankton and zooplankton communities are typical of a turbid, turbulent temperate river system.

- The phytoplankton community is dominated by diatoms, nanoplankton phytoflagellates, and blue-green algae; the blue-green algal blooms arising from the discharge of untreated sewage and municipal wastewater, and agricultural runoff may be harmful to wildlife and humans.

- The zooplankton community is dominated by rotifers, microcrustaceans (daphnids, copepods, nauplii), and invasive mussel larvae.

- Fish tissue analyses done to date show signatures of dioxins, furans and PCBs, although at levels not harmful for human consumption, and reflect background concentrations in the river.

Table D3.1-1: Physical Characteristics of the Rio Uruguay

Reach		Length (km)	Elevation Change (m)	Channel Slope (m/km)
Upper	Canoas and Pelotas confluence to the Piratini confluence	820	357	0.44
Middle	Piratini confluence to the Salto Grande Dam	610		0.09
Lower	Salto Grande Dam to the Rio de la Plata	350	10	0.03

Table D3.1-2: 7-Day Average Low Flow Frequency Distribution, Rio Uruguay (1983 to 2003)

Return Period (years)	7-day Average Low Flow (m^3/s)	7-day Average Low Flow (m^3/s)
	at Salto Grande Dam[1]	**at Fray Bentos[2]**
2	850	950
5	580	640
10	450	500
20	360	400
50	260	290

[1] From Dirección Nacional de Hidrografia as presented by Botnia (2003).
[2] Prorated (factor of 1.109) from drainage area between Fray Bentos and Salto Grande Dam.

Table D3.1-3: Summary of Tributaries within Vicinity of the Project Sites

Tributary	Drainage Area (km^2)	Average Flow[1] (m^3/s)	Summer Flow[1] (m^3/s)	Drought Flow[1] (m^3/s)
Las Cañas Creek	1.2	0.016	0.009	0.001
De los Perros Creek	2.1	0.029	0.016	0.001
De Amante Creek	1.0	0.014	0.007	0.001
Yaguareté Creek	36	0.5	0.3	0.02

[1] Flow calculated based on an estimated run-off of 0.0135 $m^3/s/km^2$ for average flows, 0.0074 $m^3/s/km^2$ for summer flows and 0.0006 $m^3/s/km^2$ for drought flows (Botnia, 2003).

Table D3.2-1: Water Quality on the Rio Uruguay (CARU Program, 1987-90; CARU, 1993)

Parameter		Salto (Station 40) (n=36)	Paysandu (Station 50) (n=13)	Gualeguaychú (Station 60) (n=26)	Fray Bentos (Station 70) (n=26)
pH	Average	6.9	7.1	7.1	7.4
	Maximum	7.8	7.9	7.8	9.0
	Minimum	5.8	6.5	6.4	6.6
Dissolved oxygen (mg/L)	Average	7.1	7.9	7.5	7.9
	Maximum	10.2	10.1	9.9	10.0
	Minimum	3.1	4.4	3.6	4.5
BOD$_5$ (mg/L)	Average	3	3	3	4
	Maximum	9	7	9	10
	Minimum	1	1	1	1
Total suspended solids (mg/L)	Average	26	14	12	16
	Maximum	162	29	38	58
	Minimum	3	6	2	2
Total dissolved solids (mg/L)	Average	75	102	106	126
	Maximum	217	158	279	705
	Minimum	21	38	42	29
Alkalinity CaCO$_3$ (mg/L)	Average	24	26	27	28
	Maximum	74	54	70	110
	Minimum	5	2	12	6
Hardness (mg/L)	Average	26	27	29	34
	Maximum	50	42	53	70
	Minimum	9	9	6	13
Conductivity (μS/cm)	Average	65	69	67	71
	Maximum	160	150	160	160
	Minimum	35	40	35	35
Total Kjeldahl nitrogen (mg/L)	Average	0.521	0.590	0.402	0.445
	Maximum	1.37	2.09	0.96	0.93
	Minimum	0.12	0.10	0.01	0.19
Nitrate (mg/L)	Average	0.710	0.586	0.549	0.535
	Maximum	1.400	0.770	0.950	1.870
	Minimum	0.340	0.370	0.001	0.070
Total ammonia (mg/L)	Average	0.080	0.216	0.088	0.077
	Maximum	0.304	1.075	0.542	0.369
	Minimum	0.009	0.023	0.020	0.007
Total phosphorus (mg/L)	Average	0.097	0.093	0.130	0.097
	Maximum	0.310	0.320	0.720	0.240
	Minimum	0.020	0.040	0.010	0.040
Chlorophyll “a”	Average	1.11	1.472	1.37	5.47
	Maximum	11.280	3.300	4.250	55.110
	Minimum	0.050	0.050	0.460	0.050
Fecal coliforms (CFU/100 mL)	Average	500	250	200	100
	Maximum	6,300	12,600	3,200	5,000
	Minimum	15	160	40	10

Table D3.2-2: Historical Record from CARU of Rio Uruguay Water Quality at Points Relevant to the Project (GTAN, 2006)

Location	Station	TSS (mg/L)	n	BOD$_5$ (mg/L)	n	Dissolved oxygen (mg/L)	n	Dissolved oxygen (% sat.)	n	COD (mg/L)	n	Conductivity (μS/cm)	n	pH (units)	n	N$_{total}$ (mg/L)	n	P$_{total}$ (mg/L)	n	Period of Record
Discharge of Gualeguaychú River[1]	6 GUAY (71)	20.37	40	5.29	35	8.4	40	88.5	14	25.5	42	90.82	39	7.3	40	0.549	43	0.102	39	1987/2005
Main Channel (km 93)	72	12.14	37	4.53	37	8.4	37	89.6	13	25.0	42	67.17	39	7.2	39	0.609	43	0.084	40	1987/2005
Playa La Concordia	81	29.64	14	3.33	12	8.4	14	85.1	4	24.4	12	63.58	12	7.9	11	0.449	11	0.130	10	1987/90-2003/05
Playa La Concordia	82	12.26	13	3.31	14	8.3	13	86.8	4	19.5	15	64.79	15	7.9	14	0.493	15	0.107	15	1987/90-2003/05
Playa La Concordia	83	11.35	9	4.01	14	8.5	9	-	0	20.3	14	78.32	14	7.7	12	0.775	15	0.086	15	1987/1990
Balneario Las Cañas	7 FRAY	8.00	10	4.49	8	8.6	10	81.9	9	16.6	9	62.28	7	7.4	8	0.361	8	0.101	10	1998/2005
Collector Fray Bentos	1 FRAY	14.40	10	4.75	11	8.4	10	83.0	10	26.8	10	83.81	10	7.1	11	0.347	11	0.069	11	1998/2005
1 km above M'Bopicuá	1 BOPI	9.00	5	3.58	3	8.6	5	73.2	5	20.0	3	70.70	5	7.3	5	0.376	4	0.061	4	2003/2005
Zone of emission M'Bopicuá	2 BOPI	10.00	4	3.63	2	8.3	4	65.1	4	20.0	2	66.80	4	7.2	4	0.380	3	0.062	3	2003/2005
1 km below M'Bopicuá	3 BOPI	10.80	5	4.05	3	8.3	5	71.2	5	20.0	3	69.20	4	7.3	5	0.762	4	0.104	4	2003/2005
Water Intake Fray Bentos	4 FRAY	15.20	6	3.90	2	7.9	6	64.0	4	20.0	2	69.65	4	7.0	4	0.325	3	0.123	3	1995-2004-2005
SW Isla Sauzal	3 GUAY	26.67	4	5.00	3	7.9	4	69.1	4	23.3	2	103.53	4	7.4	3	0.373	4	0.077	4	2004/2005
Balneario Ñandubaysal	5 GUAY	18.40	4	3.73	2	8.6	4	63.6	4	20.0	3	66.15	4	6.8	4	0.342	3	0.105	3	2004/2005
		15.25		**4.12**		**8.3**		**76.8**		**21.64**		**73.60**		**7.34**		**0.472**		**0.093**		

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[1] In 2005, the Planta Depuradora de Liquidos Cloacales de Gualeguaychú was brought on-line.

Table D3.2-3: Rio Uruguay Water Quality from the Botnia EIA (2004)

	Point 1 – Main Channel Near Fray Bentos Intake		Point 2 – Main Channel in Front of	Point 3 – Main Channel East of International Bridge	Point 6 – Main Channel in Front of Fray Bentos		Point 7 – Las Canas
Parameter	Botnia	OSE	Botnia	Botnia	CARU (Station 70)	CARU (Station 72)	CARU
Date	16 Dec 03	2000-2003	16 Dec 03	16 Dec 03	1987-1990	2003	22 Oct 02
Colour (Colour Pt. Units)	276 (260-295)	61 (24-137)	253 (240-275)	252 (250-255)	n	n	n
Turbidity (NTU)	32 (32-33)	27 (12-52)	32 (31-33)	32 (31-34)	n	n	n
pH	7.2	7.3 (6.7-7.8)	7.2 (7.2-7.3)	7.2	7.4 (6.6-9.0)	7	7.3
Dissolved oxygen (mg/L)	7.19 (7.17-7.20)	7.9 (7.0-8.8)	7.41 (7.4-7.41)	7.55 (7.47-7.60)	7.9 (4.5-10.0)	8.3	7.7
BOD_5 (mg/L)	1.5 (<1-1.5)	n	<1	<1	4 (1-10)	n	<5
Detergents (LAS mg/L)	0.06 (0.05-0.07)	n	<0.05	<0.05	n	n	n
Phenolics (mg/L)	N.D.	n	N.D.	N.D.	n	0.0004	<0.001
Ammonia (mg N-NH_3/L)	0.03 (0.01-0.05)	n	0.04 (0.03-0.04)	0.03 (0.02-0.04)	n	n	n
Nitrites (mg N-NO_2/L)	<0.01	<0.01 (<0.01-0.01)	<0.01	<0.01	0.0028 (0.001-0.007)	n	0.007
Phosphorus (mg P/L)	0.03 (0.02-0.03)	n	0.05 (0.04-0.06)	0.03 (0.02-0.05)	0.1	n	0.05
Fecal coliforms (CFU/100 mL)	N	310 (200-691)	n	n	100 (10-5,000)	n	270
Arsenic (mg/L)	<0.010	n	<0.010	<0.010	n	n	N
Cadmium (mg/L)	<0.010	n	<0.010	<0.010	0.00015 (0.0001-0.0002)	n	<0.00001
Copper (mg/L)	0.018 (0.015-0.025)	n	0.056 (0.050-0.069)	0.044 (0.027-0.065)	0.0105 (0.009-0.012)	n	0.00438
Chromium (mg/L)	0.08 (0.07-0.11)	n	0.06 (0.05-0.07)	0.04 (0.03-0.05)	0.004 (0.002-0.009)	0.001	0.002
Mercury (mg/L)	<0.0005	n	<0.0005	<0.0005	n	n	n
Nickel (mg/L)	<0.020	n	0.050 (0.030-0.067)	<0.020	n	n	0.0056
Lead (mg/L)	<0.010	n	<0.010	<0.010	n	n	0.00373
Zinc (mg/L)	<0.010	n	0.061 (0.059-0.063)	0.107 (0.042-0.169)	0.018 (0.002-0.035)	n	0.029

Table D3.2-3: Rio Uruguay Water Quality from the Botnia EIA (2004) (cont'd)

	Point 1 – Main Channel Near Fray Bentos Intake		Point 2 – Main Channel in Front of	Point 3 – Main Channel East of International Bridge	Point 6 – Main Channel in Front of Fray Bentos		Point 7 – Las Canas
Parameter	Botnia	OSE	Botnia	Botnia	CARU (Station 70)	CARU (Station 72)	CARU
Temperature (°C)	24.1 (24.1-24.2)	22.5	24	23.9 (23.9-24)	n	18	19.4
% Oxygen saturation	85.6 (85.5-85.7)	n	87.9 (87.8-88.1)	89.5 (88.5-90.4)	n	n	83
Conductivity (μS/cm)	42 (40-45)	55 (34-73)	43 (40-45)	42 (40-45)	71 (35-160)	62	60
Total hardness ($CaCO_3$ mg/L)	N	33.8 (30-42)	n	n	34 (13-70)	n	26
Alkalinity ($CaCO_3$ mg/L)	N	34 (22-52)	n	n	28 (6-110)	29	24.1
Total nitrogen (mg N/L)	<2	n	<2	<2	0.445 (0.19-0.93)	n	0.52
Nitrate (mg N-NO_3/L)	1.1	<11 (<11)	1.1 (1.0-1.2)	1.2 (1.1-1.3)	0.549 (0.001-0.950)	n	0.36
Phosphorus (mg P-PO_4/L)	0.08 (0.06-0.09)	n	0.08 (0.09-0.12)	0.07 (0.06-0.09)	0.044 (0.005-0.139)	n	0.02
Ammonia (NH_4 mg/L)	N	0.09 (<0.04-0.42)	n	n	0.077 (0.007-0.369)	n	0.05
COD (mg/L)	<1	n	1	2	n	n	<40
Sulphate (mg SO_4/L)	4.5 (4.0-4.8)	n	4.7 (4.0-5.0)	4.4 (3.9-4.7)	20 (3-80)	2	3.75
Chloride (Cl mg/L)	2.2 (1.9-2.4)	3.63 (1.9-6.4)	2.1 (2.0-2.2)	2.0 (1.9-2.2)	2.8 (0.0-7.0)	2	1.8
Iron (mg/L)	2.29 (2.20-2.39)	1.3 (1.0-1.7)	2.38 (2.20-2.52)	2.18 (2.00-2.30)	0.12	n	0.67
Manganese (mg/L)	<0.010	n	0.054 (0.048-0.057)	0.036 (0.030-0.046)	0.038 (0.030-0.045)	n	0.0598
Fluoride (mg/L)	n	n	n	n	n	n	n
Selenium (mg/L)	n	n	n	n	n	n	n
AOX (mg/L)	0.0075	n	>0.002 detec. lim. <0.006 quant. lim.	-	n	n	n

N.D. – not detectable.
n – not analyzed.

Table D3.2-4: Water Quality Observations by Botnia at Four Rio Uruguay Locations in 2005/06

		Nuevo Berlín Date of Sampling							Bridge							Botnia							Las Cañas						
Parameter	Units	04/05	06/05	08/05	10/05	12/05	01/06	03/06	04/05	06/05	08/05	10/05	12/05	01/06	03/06	04/05	06/05	08/05	10/05	12/05	01/06	03/06	04/05	06/05	08/05	10/05	12/05	01/06	03/06
Temperature	˚C	18.2	18.2	15.6	22.3	26.8	27.9	24.6	18.2	18.2	15.8	22.4	27.4	28.5	24.4	18.0	18.4	15.8	21.9	27.3	29.7	24.4	18.0	18.1	15.7	23.2	27.4	29.8	23.9
Conductivity	µS/cm	109	54.7	81.0	51.0	66.2	84.5	71.3	69.0	51.6	79.9	52.0	57.7	74.3	66.1	73.0	53.9	103.4	55.0	55.3	69.6	69.8	75.0	55.9	101.3	55.0	56.4	76.0	74.5
Colour	Pt-Co	ND[1]	125	75	125	55	55	30	ND	125	75	125	55	55	35	ND	125	75	125	50	55	35	ND	125	75	125	50	55	30
DO	mg/L	8.31	8.71	9.32	8.18	8.22	8.61	8.58	8.14	8.46	9.27	8.13	8.30	9.23	8.55	8.36	8.34	9.16	8.03	8.27	9.15	8.54	8.45	8.05	9.54	8.36	8.26	9.55	8.74
pH	-	7.8	7.04	7.40	7.14	7.92	8.32	7.67	7.7	7.05	7.49	7.24	8.00	8.80	7.75	7.8	7.20	7.58	7.14	8.03	8.98	7.73	7.8	6.96	7.58	7.35	7.72	9.19	7.94
Turbidity	NTU	36.9	23	21	35	9.0	12	11	27	59	20	32	9.3	11	15	19.2	35	17	28	9.4	12	13	20.1	49	29	23	8.5	16	39
TDS	mg/L	43.0	77.0	43.5	64.5	37	54	73.5	66.0	84.5	42.5	49.5	30.0	41.5	65.5	45.0	90.0	91.0	55.0	42	35	73	65.0	86.2	115	54.5	61.0	29.5	66.5
TSS	mg/L	12.0	28.5	7.2	13.8	<5	10.8	<5	16.0	32.5	6.2	8.8	<5	13.4	8.2	8.0	16.0	<5	6.0	<5	7.8	7.2	<5	24.0	17.0	<5	<5	11.0	60.3
Hardness	mg/L	26.6	20.7	30.5	20.0	22	30.2	25.0	27.4	20.2	32.2	20.3	20.8	24.4	24.2	28.0	23.7	44.2	20.8	20.3	23.7	23.4	30.2	22.7	45.8	20.6	34.4	22.4	35
Chloride	mg/L	2.0	1.98	2.15	2.99	2.56	1.96	1.53	2.7	1.36	1.80	1.75	1.59	4.38	1.49	1.3	1.56	3.31	2.45	1.62	2.47	1.61	1.6	1.75	2.11	2.17	2.48	2.73	1.73
Sulphate	mg/L	1.3	1.36	1.32	1.44	2.17	3.04	1.28	1.2	1.31	1.23	1.23	1.95	6.83	1.28	1.4	0.92	1.68	0.94	2.01	3.10	1.44	1.5	1.52	1.54	1.09	2.56	3.54	1.76
Nitrate	mg/L	4.5	0.87	0.56	0.44	0.39	0.17	0.23	2.4	0.93	0.58	0.71	0.37	0.55	0.21	5.9	0.90	0.58	0.46	0.36	0.16	0.24	2.3	0.95	0.66	0.50	0.38	0.04	0.16
Nitrite	µg/L	2.7	3.6	12.2	ND	<5	8.8	44.8	3.5	2.4	12.2	ND	<5	<5	40.0	2.7	1.9	7.7	ND	18.1	<5	31.3	3.2	2.8	8.2	ND	<5	<5	2.9
TKN	mg/L	2.4	0.6	0.01	0.80	1.1	1.2	0.23	1.5	0.8	0.45	0.42	0.37	1.3	0.20	1.5	0.8	0.04	0.48	1.5	1.3	0.47	2.4	0.9	0.47	0.26	1.8	1.6	0.36
Ammonia	mg/L	0.19	ND	0.069	ND	0.12	<DL[2]	0.07	0.54	ND	ND	ND	0.15	<DL	0.06	0.16	ND	ND	ND	0.13	<DL	0.06	0.34	ND	0.06	ND	0.21	<DL	0.07
TP	µg/L	73.7	88.0	49	86.2	26.7	115	68.9	77.8	105	58.8	91.3	29.3	109	90.1	57.0	74.4	88.0	81.0	31.9	75.8	114	43.9	84.7	81.6	83.6	26.7	81.0	94.8
SRP	µg/L	26.6	8.0	15	9.5	23.7	54.2	46.9	27.7	9.0	7.3	18.5	14.6	31.2	42.1	24.8	12.2	14	15.9	6.9	19.8	39.8	27.2	5.5	19	19.8	19.8	24.2	68.2
Arsenic	mg/L	ND	<DL	<DL	<DL	<DL	<DL	<DL[1]	ND	<DL	<DL	<DL	<DL	<DL	<DL	ND	<DL	<DL	<DL	<DL	<DL	<DL	ND	<DL	<DL	<DL	<DL	<DL	<DL
Cadmium	mg/L	ND	<DL	<DL	<DL	<DL	<DL	<DL	ND	<DL	<DL	<DL	<DL	<DL	<DL	ND	<DL	<DL	<DL	<DL	<DL	<DL	ND	<DL	<DL	<DL	<DL	<DL	<DL
Copper	mg/L	ND	<DL	<DL	<DL	<DL	<DL	<DL	ND	<DL	<DL	<DL	<DL	<DL	<DL	ND	<DL	<DL	<DL	<DL	<DL	<DL	ND	<DL	<DL	<DL	<DL	<DL	<DL
Zinc	mg/L	ND	<DL	<DL	<DL	<DL	<DL	<DL	ND	<DL	<DL	<DL	<DL	<DL	<DL	ND	<DL	<DL	<DL	<DL	<DL	<DL	ND	<DL	<DL	<DL	<DL	<DL	<DL
Chromium	mg/L	ND	<DL	<DL	<DL	<DL	<DL	<DL	ND	<DL	<DL	<DL	<DL	<DL	<DL	ND	<DL	<DL	<DL	<DL	<DL	<DL	ND	<DL	<DL	<DL	<DL	<DL	<DL
Iron	mg/L	ND	4.2	2.2	1.8	0.9	1.2	0.74	ND	4.5	1.4	2.3	1.0	0.69	0.53	ND	3.9	1.8	1.6	1.2	1.2	0.59	ND	3.5	2.9	1.7	1.5	0.69	0.46
Magnesium	mg/L	ND	<DL	<DL	<DL	<DL	<DL	<DL	ND	<DL	<DL	<DL	<DL	<DL	<DL	ND	<DL	<DL	<DL	<DL	<DL	<DL	ND	<DL	<DL	<DL	<DL	<DL	<DL
Mercury	mg/L	ND	<DL	<DL	<DL	<DL	<DL	<DL	ND	<DL	<DL	<DL	<DL	<DL	<DL	ND	<DL	<DL	<DL	<DL	<DL	<DL	ND	<DL	<DL	<DL	<DL	<DL	<DL
Nickel	mg/L	ND	<DL	<DL	<DL	<DL	<DL	<DL	ND	<DL	<DL	<DL	<DL	<DL	<DL	ND	<DL	<DL	<DL	<DL	<DL	<DL	ND	<DL	<DL	<DL	<DL	<DL	<DL
Lead	mg/L	ND	<DL	<DL	<DL	<DL	<DL	<DL	ND	<DL	<DL	<DL	<DL	<DL	<DL	ND	<DL	<DL	<DL	<DL	<DL	<DL	ND	<DL	<DL	<DL	<DL	<DL	<DL
COD	mg/L	ND	<11	<11	<11	<11	<11	<11	ND	<11	<11	<11	<11	<11	<11	ND	<11	<11	<11	<11	<11	<11	ND	<11	<11	<11	<11	<11	<11
BOD_7	mg/L	4.8	1.4	1.3	1.0	1.1	1.9	0.8	4.4	1.8	1.1	2.3	0.8	1.5	0.7	4.8	1.3	1.2	2.3	1.2	2.0	0.6	2.8	1.4	1.2	1.5	1.0	2.4	1.2
AOX	µg/L	ND	7	ND	ND	8	ND	7	ND	7	ND	ND	8	ND	7	<2	8	12	ND	7	ND	<DL	ND	8	9	ND	11	ND	8
Phenolics	µg/L	ND	<1	<1	<1	<1	5.7	<1	ND	<1	<1	<1	<1	ND	<1	ND	<1	<1	<1	<1	ND	<1	ND	1.2	<1	<1	<1	ND	<1
Coliforms[3]	MPN/ 100 mL	ND	232	2600	312	130	19.6	62	ND	256	3280	460	58	19.4	54	ND	230	804	196	31.4	266	108	ND	940	1960	1340	640	276	1980

[1] No determination of this parameter on this date.
[2] Below analytical detection limit.
[3] Total fecal coliforms, average of five replicate samples per day per site.

Table D3.2-5: Water Quality on the Rio Uruguay from the ENCE EIA (2002)

Parameter (units)	Point 1 – Above Discharge	Point 2 – Yaguareté Bay – Playa Ubici	Fray Bentos Water Intake	Fray Bentos Municipal Discharge	Beach near Arroyo Fray Bentos	Las Cañas Water Intake	Beach near Arroyo Las Cañas
Alkalinity (mg/L $CaCO_3$)	32	35.5	32	33	32.5	30	31.5
Ammonia (mg/L $N\text{-}NH_3$)	0.175	0.16	0.13	0.155	0.155	0.195	0.09
Arsenic (mg/L As)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chloride (mg/L Cl)	4.2	4.15	4.1	2.1	5.15	5.65	4.1
Copper (mg/L Cu)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
True colour (Pt-Co)	125	125	125	125	125	125	125
Total chromium (mg/L Cr)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
BOD_5 (mg/L)	3	4	3.5	3.5	4	4	4
Detergents (mg/L SAAM)	0.4	0.425	0.285	0.365	0.41	0.24	0.9
Total hardness (mg/L $CaCO_3$)	19.8	21.7	18.1	19.55	19.7	19.85	19.8
Fluoride (mg/L F)	0.12	0.13	0.115	0.12	0.11	0.11	0.11
Iron (mg/L Fe)	3.74	2.89	4.24	3.795	3.525	3.385	3.3
Manganese (mg/L Mn)	0.04	0.02	0.04	0.035	0.03	0.02	0.025
Nickel (mg/L Ni)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Nitrate (mg/L $N\text{-}NO_3^-$)	0.81	0.78	0.845	0.845	0.85	0.855	0.9
Dissolved oxygen (mg/L)	8.5	8.7	8.7	8.1	8.1	8.25	8.4
pH	7	7.345	7.17	7.12	7.105	7.03	6.6
Lead (mg/L Pb)	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Selenium (mg/L Se)	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Temperature (°C)	19.9	19.15	18.9	19.05	19.4	19.95	19.4
Zinc (mg/L Zn)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fecal coliforms (NMP/100 mL)	42.5	170	50.5	9,100	7,400	720	950
AOX (μg/L)	NQ	ND	ND	ND	-	-	-

NQ = Not Quantifiable
ND = Not Detectable

Table D3.2-6: Water Quality on the Rio Uruguay (Algoritmos, 2006)

Parameter	Sampling Locations[1]									
	1	M	2	3	B	4	5	6	7	8
BOD_5 (mg/L)	0.7	0.5	1.8	0.2	0.2	0.1	0.2	0.5	0.1	0.2
COD (mg/L)	<5	<5	14	15	6	<5	<5	<5	24	6
N total (mg/L)	<0.04	<0.04	0.68	1.10	1.02	0.95	0.35	0.97	0.85	0.74
P (mg/L)	0.14	0.14	0.21	0.20	0.15	0.22	0.13	0.14	0.10	0.15
NO_3^- (mg/L)	0.63	0.63	0.54	0.79	0.63	0.36	0.59	0.61	0.38	0.61
Ammonia (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	0.10	<0.01	0.26	<0.01	0.23
SST (mg/L)	4	11	12	5	8	14	8	8	41	10
C_6H_5OH (μg/L)	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40
ClO_3^- (μg/L)	<20	<20	<20	40	30	<20	<20	<20	<20	<20
As (μg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cu (μg/L)	11	10	10	8	12	8	6	7	8	8
Fe (μg/L)	1,400	1,500	1,600	1,880	1,800	2,070	1,730	1,670	2,000	1,640
Cr (μg/L)	3	3	3	3	3	3	2	3	3	2
Hg (μg/L)	0.4	0.6	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.6
Ni (μg/L)	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Pb (μg/L)	39	16	17	23	24	<5	<5	<5	<5	<5
Zn (μg/L)	18	84	22	15	15	11	8	10	15	12
Cd (μg/L)	2	1	1	1	1	<0.5	<0.5	<0.5	<0.5	<0.5
Chlorophenols (μg/L)[2]	1.0	8.3	11.6	3.4	1.4	1.4	2.9	<1.0	11.9	4.9
AOX (mg/L)	0.003	<0.001	<0.001	0.005	0.004	0.004	0.003	0.0068	0.002	<0.001

[1] Identification of sampling locations:
1: Near Arroyo M'Bopicuá
M: 50 m below ENCE discharge
2: Puerto Unzué
3: International Bridge
B: 50 m above Botnia discharge
4: Near Arroyo Yaguareté
5: Playa Ubici Nearshore
6: Fray Bentos Water Intake
7: Balneario Ñandubaysal Nearshore
8: Balneario Las Cañas Nearshore

[2] Chlorophenols shown as a sum of compounds with values above detection limits.

Table D3.2-7: Baseline Concentrations of AOX, Chlorophenols, Resin and Fatty Acids, Phytosterols, and Dioxins and Furans in Rio Uruguay Water (Tana, 2005, 2006)

Location	AOX (μg/L)	Chlorophenols (ng/L)	Resin Acids (μg/L)	Fatty Acids (μg/L)	Phytosterols[2] (μg/L)	Dioxins/Furans[1] (pg/L)	
						Sum	I-TEQ
April 2005							
Nuevo Berlin	11	94	163	786	ND	1.04	0.46
Yaguareté Bay	12	114	183	738	ND	ND	ND
Las Cañas	12	106	202	742	ND	ND	ND
December 2005							
Nuevo Berlin	10	89	224	231	22	ND	ND
Yaguareté Bay	6	80	35	172	ND	ND	ND
Las Cañas	<5	89	53	145	ND	49.8	0.31

[1] Detection limits 0.2 to 2 pg/L.
[2] Detection limits 1 to 3 μg/L.

Table D3.2-8: Nutrient Water Quality on the Rio Uruguay (CELA, 2005, 2006)

Location	Secchi (m)	pH (-)	DO (mg/L)	Temp. (°C)	Conductivity (µS/cm)	NH_4 (µg/L)	NO_2 (µg/L)	NO_3 (µg/L)	DIN (µg/L)	N_{total} (µg/L)	PO_4 (µg/L)	P_{total} (µg/L)
April 2005												
NB 2	0.5	6.7	-	-	70.1	15.8	3.8	204.7	224.3	485.7	16.9	49.5
NB 3	0.5	7.1	-	-	73.4	38.1	4.5	171.0	213.6	509.3	21.7	95.7
FB 1	0.5	7.2	-	-	83.4	21.1	4.8	168.6	194.5	599.7	22.2	84.3
FB 2	0.5	7.1	-	-	72.2	25.0	4.8	177.2	207.1	587.2	20.5	70.4
FB 3	0.5	7.1	-	-	76.9	42.3	3.7	184.5	230.4	694.5	38.6	82.3
LC 1	0.6	7.2	-	-	75.7	27.6	4.7	163.9	196.2	534.5	31.4	71.0
LC 2	0.5	7.0	-	-	69.5	22.0	4.2	182.8	209.0	522.5	25.5	62.5
LC 3	0.4	7.0	-	-	69.1	26.6	4.6	190.1	221.2	623.4	29.0	66.3
January 2006												
NB 1	3.7	0.8	0.0	0.4	2.6	18.3	17.5	15.4	13.0	6.0	-	2.4
NB 2	3.5	0.7	0.0	0.2	0.3	11.5	15.5	6.8	6.7	10.6	-	15.5
NB 3	0.0	0.5	1.5	0.2	0.4	2.4	17.1	15.0	13.6	20.3	-	13.1
FB 1	0.0	0.4	0.8	0.2	5.4	22.7	8.0	1.6	6.1	10.2	-	15.5
FB 2	3.9	1.2	4.3	0.2	8.0	39.5	4.2	3.3	7.9	1.6	-	19.8
FB 3	3.7	1.6	0.0	0.4	16.9	40.3	1.4	16.6	8.3	1.7	-	1.5
LC 1	6.7	0.5	0.8	0.0	1.4	52.9	5.4	5.2	12.9	24.1	-	4.0
LC 2	4.6	0.5	1.2	0.0	2.3	80.7	7.5	3.5	12.0	14.9	-	24.0
LC 3	0.0	2.0	0.7	0.2	4.9	31.1	4.9	15.3	17.4	16.6	-	13.0

NB = Nuevo Berlin, FB = Fray Bentos, LC = Las Cañas

Table D3.2-9: Water Quality on the Rio Uruguay in the Vicinity of the Terminal Logistica M'Bopicuá (Enviro, 2004)

	Location and Date																			
	Upstream	**Upstream**	**Downstream**	**Downstream**	**Terminal**	**Terminal**	**Upstream**	**Downstream**	**Upstream**	**Upstream**	**Downstream**	**Downstream**	**Upstream**	**Upstream**	**Downstream**	**Downstream**	**Upstream**	**Upstream**	**Downstream**	**Downstream**
Parameter	21 Apr 04	17 May 04	21 Apr 04	17 May 04	29 Dec 03	21 Apr 04	19 Jun 04	19 Jun 04	31 Jul 04	30 Aug 04	31 Jul 04	30 Aug 04	16 Sep 04	15 Oct 04	16 Sep 04	15 Oct 04	16 Nov 04	16 Dec 04	16 Nov 04	16 Dec 04
Temperature (°C)	20.8	16.9	21.2	17	23.6	21.0	13	12	-	16.0	12.0	16.0	15.9	18.9	15.5	19.5	27.2	23.5	27.0	23.6
pH	6.3	6.5	6.4	6.6	7.4	6.7	6.9	6.9	6.9	7.0	6.9	7.0	7.0	7.0	6.9	7.0	6.8	7.1	6.8	6.9
DO (mg/L)	9.0	9.4	9.2	9.7	6.7	9.3	13.0	12.0	9.8	12	10	11	12	12	12	12	10	10	11	11
Conductivity (μS/cm)	72	94	69	94	74	70	9.8	10	88	89	96	94	95	70	94	69	77	83	61	80
Total solids (mg/L)	54	107	51	31	-	52	127	102	93	105	120	100	120	93	89	83	161	199	177	202
Total suspended solids (mg/L)	8.0	7.8	6.0	6.9	-	8.0	14	17	8	13	14	17	17	13	20	12	62	31	21	34
Sediment solids (mg/L)	<0.5	<0.5	<0.5	<0.5	-	<0.5	1.0	2.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Oil and grease (mg/L)	17	15	17	15	-	14	<0.5	<0.5	6	14	6	12	15	9.0	10	7.0	6.0	6.0	6.0	7.0
BOD$_5$ (mg/L)	8.0	5.0	7.0	4.1	-	5.0	7.0	4.0	2.0	5.0	2.0	5.0	59	2.0	57	2.0	2.0	4.0	1.8	6.0
COD (mg/L)	76	75	38	75	-	45	64	68	26	94	19	83	3.0	40	3.0	37	37	21	34	25
Arsenic (μg/L)	<1	<1	<1	<1	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Copper (μg/L)	3.2	2.3	3.1	2.4	-	2.3	8.4	10	3.4	1.4	5.1	1.0	3.3	2.5	3.4	2.4	1.7	0.7	1.4	0.8
Chromium (μg/L)	4.9	1.6	4.2	2.1	-	3.6	2.6	2.8	1.2	<0.2	1.6	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Lead (μg/L)	2.1	0.8	2.4	0.7	-	2.9	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium (μg/L)	0.3	<0.1	<0.1	<0.1	-	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nickel (μg/L)	7.1	2.3	6.2	1.5	-	4.8	5.2	3.5	1.1	2.1	1.6	2.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc (μg/L)	9.2	7.8	7.8	5.3	-	7.4	38	32	21	3.5	16	3.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Mercury (μg/L)	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Tannins (mg/L)	1.2	0.69	<1	0.71	-	<1	0.59	0.63	0.91	0.61	0.82	0.68	0.67	0.87	0.55	0.82	1.9	1.4	1.7	1.4
Phenolics (mg/L)	0.005	0.003	<0.005	0.004	0.14	<0.005	0.004	0.005	0.008	0.005	0.008	0.006	0.008	0.003	0.008	0.002	0.043	0.010	0.041	0.011
Fecal coliforms (CFU/100 mL)	50	20	40	10	110	30	11	10	23	4	19	3	18	88	20	76	100	40	112	20

Table D3.3-1: Sediment Quality near the Botnia Site on the Rio Uruguay – Yaguareté Bay and Upstream (CELA, 2005, 2006)

Location	Organic Matter (%)	Phosphorus (µg/g FW)	Nitrogen (µg/g FW)
November 2005			
A Upstream	2.8	12.14	69.4
C Yaguareté Bay	2.9	12.34	59.5
D Yaguareté Bay	6.8	20.88	88.2
E Yaguareté Bay	6.5	14.88	55.4
Average (Yaguareté Bay)	5.4	16.0	67.7
December 2005			
A Upstream	6.5	28.5	108.0
C Yaguareté Bay	1.1	17.5	78.7
D Yaguareté Bay	0.4	17.5	33.5
E Yaguareté Bay	1.8	26.2	85.7
Average (Yaguareté Bay)	1.1	20.4	66.0

Table D3.3-2: Sediment Quality on the Rio Uruguay in the Vicinity of the Terminal Logistica M'Bopicuá (Enviro, 2004)

Parameter	Sampling Date								
	30 Dec 03	17 May 04	19 Jun 04	31 Jul 04	30 Aug 04	26 Sep 04	15 Oct 04	16 Nov 04	16 Dec 04
pH	7.6	7.3	7.8	7.4	7.8	7.8	8.1	8.5	8.5
Porosity (%)	37	66	54	69	46	69	53	61	58
Organic matter (mg/g)	27	3.7	4.2	2.3	2.8	2.8	3.18	2.8	1.6
Fraction <62 μ (%)	6.1	78	89	81	76	81	81	75	64
Total Hydrocarbons (μg C_{16}/g)	0.11	0.16	0.32	0.11	0.21	0.10	0.12	0.21	0.11
Total halogenated carbons (μg/g)	<0.01	0.03	0.02	<0.02	0.02	0.02	<0.01	<0.01	<0.01

Table D3.3-3: Metal and Organic Contaminants in Sediments of the Rio Uruguay (CARU Data, 1997-2004)

Parameter	Units	Fray Bentos (1-Fray)					Paysandu (3-Pay)						Gualeguaychú (6-Guay)			
		11/98	10/02	07/03	07/04	11/04	08/97	05/02	10/02	07/03	07/04	11/04	11/98	10/02	07/03	11/04
Cadmium	µg /g	0.10	1.03	0.17	0.143	0.15	0.18	0.15	0.47	0.17	< 0,005	0.05	0.10	0.96	0.22	0.15
Chromium	µg /g	46.6	52.99	41.86	5.19	14.15	296.6	138.8	20.73	9.03	149.8	98	22.9	24.0	34.74	25.41
Copper	µg /g	ND	80.97	51.72	17.39	16.78	27.9	24.23	12.85	69.49	19.39	12.4	ND	40.0	27.95	42.5
Lead	µg /g	25.9	38.91	35.05	31.48	3.92	16	7.79	5.21	15.05	41.97	4.64	22.1	13.6	15.69	13.0
Nickel	µg /g	28	19.78	ND	ND	ND	9.6	ND	2.25	ND	ND	ND	20.3	10.7	ND	ND
Zinc	µg /g	ND[1]	110.6	ND	ND	35.55	ND	ND	19.6	ND	ND	17.3	111.7	103.7	ND	99.7
Total phenols	µg /g	<0.1	ND	ND	ND	ND	5	<DL	ND	ND	ND	ND	2.0	ND	ND	ND
Total PCBs	ng/g	<1.8	13.6	<DL[2]	31.54	ND	10.5	<DL	<DL	1.55	<DL	ND	<DL	<DL	ND	ND

1- ND: no determination
2- < DL: less than analytical detection limit

For interpretation, Canadian sediment quality guidelines are: metals (µg/g) – Cd - 0.6, Cr - 37.3, Cu - 35.7, Pb - 35.0, Zn - 123; PCBs (ng/g) – 34.1.

Table D3.4-1: Common Fish of the Lower Rio Uruguay by Order and Common Name

Order	Common Species
Characiformes	Boga, dorado, sábalo, tetra
Clupeiformes	Anchoita de Rio, Uruguay river sprat
Cyprinodontiformes	Cinolebia, killifish, madrecita
Mugiliformes	Lisa or mullet
Perciformes	Cichlids
Rajiformes	River ray
Siluriformes	Catfish

Table D3.4.-2: The DINAMA Annual Catch Records for Artisan Fishers in the Vicinity of the Lower Rio Uruguay, by Species (in tons) for Period 1994-2000

	Catch by Year (in tons)						
Genus Species (Common Name)	1994	1995	1996	1997	1998	1999	2000
Pterodoras granulosus (armado)	3.3	1.7	6.0	5.6	1.6	84.6	83.3
Leporinus obtusidens (boga)	23.4	24.6	60.4	55.1	320	135.8	154.6
Salminus maxillosus (dorado)	9.0	2.4	3.1	4.8	46.2	94.6	92.8
Mugil spp. (Lisa or mullet)	205.7	100.0	345.7	213.9	272.3	57.1	194.4
Luciopimelodus pati (pati catfish)	11.3	1.9	7.0	9.0	10.1	18.0	22.5
Prochilodus lineatus (sábalo)	628.1	540.2	189	1623	897.8	1255	1264.2
Hoplias malabaricus (tararira)	244.2	223.5	148.7	240.8	423.1	275.8	178.9
Hypostomus commersoni (viejo de agua)	0	ND	ND	ND	34.6	ND	0
Catfishes (other species like bagre amarillo)	21.4	35.2	72.2	201.3	156.4	216.3	ND

Table D3.4-3: Conservation Status of Fishes in the Lower Rio Uruguay

Common Name	Species	Status[1]
Atigrado surubi	*Pseuodoplatystoma fasciatum*	CT
Sábalo	*Prochilodus lineatus*	CT
Dorado	*Salminus maxillosus*	I
Pacú	*Piaractus mesopotamicus*	I
Manduví	*Ageneiosus militaris*	I
Dientudo jorobado	*Cynopotamus zettii*	I
Boga	*Leporinus affinis friederici*	I
Boga	*Leporinus obtusidens*	I
Piraiba	*Brachyplatystoma filamentosum*	R
Spotted sorubim	*Pseudoplatystoma* coruscans	V

[1] Conservation status:

CT = commercially threatened due to high harvest
I = threatened due to high harvest but lack of population data limits assessment
R = rare and present as small populations
V = vulnerable based on available information and harvest

Table D3.5-1: Taxonomic Composition of Benthic Invertebrate Samples Collected in Three Areas on the Rio Uruguay in April 2005 (organisms/0.053 m^2)

Taxon	NB12	NB13	NB22	NB23	NB31	NB33
Tubificidae		7.3	14.0	1.5	15.3	2.3
Naididae		1.0	2.0			
Chironomidae	1.7	26.7	5.0	2.3	17.7	
Ceratogonidae		1.0			1.0	
Hydrobiidae		1.0			3.0	
Mytilidae	856.0			1.5	1.3	1.0
Corbiculidae		1.0			1.0	
Glossiphonidae		3.0	1.0		1.0	
Nematoda		2.3			3.0	
Total	**857.7**	**39.0**	**14.3**	**4.3**	**39.0**	**3.0**

Taxon	FB11	FB12	FB13	FB21	FB22	FB23	FB31	FB32
Tubificidae	5.7	3.0	2.0	2.0	1.0		12.0	9.0
Naididae		1.0		1.0				1.7
Chironomidae	7.0	3.0	2.0	4.5	1.0	1.7	10.7	3.7
Leptoceridae	1.0			1.0			2.5	
Philopotamidae						2.0		
Hydrobiidae	6.7			2.0		2.5	18.7	
Chilinidae				1.0				
Mytilidae	24.3	135.0	188.0	46.3	50.7	35.7		
Corbiculidae		1.0						
Anodontitidae							1.0	
Glossiphonidae	3.5						2.0	
Planorbiidae	1.0							
Nematoda	1.0							
Total	**47.3**	**139.7**	**190.7**	**52.3**	**52.0**	**39.7**	**44.7**	**14.3**

Taxon	LC11	LC12	LC13	LC21	LC22	LC23	LC31	LC32	LC33
Tubificidae		1.0	1.0	1.3		8.0		4.0	5.7
Chironomidae		2.3	3.0		1.0			2.0	2.0
Hydrobiidae	12.0	1.0		2.0		1.5	1.3	1.0	
Mytilidae	2.0	11.3	2.0	8.3	1.3			65.7	
Corbiculidae		1.0		3.0				3.3	
Nematoda	4.5								
Total	**11.7**	**15.3**	**5.3**	**12.3**	**2.0**	**9.0**	**1.3**	**74.0**	**6.3**

NB = Nuevo Berlin, FB = Fray Bentos, LC = Las Cañas

Table D3.5-2: Taxonomic Composition of Benthic Invertebrate Samples Collected in Three Areas on the Rio Uruguay in January 2006 (organisms/0.053 m^2)

Taxon	NB11	NB12	NB13	NB21	NB22	NB23	NB31	NB32	NB33
Tubificidae	18	2		2			1		
Naididae			1				1	1	
Chironomidae	18			18			9		
Ceratogonidae	1								
Gomphidae	2								
Hydrobiidae	3						7		
Mytilidae	10						1	2	1
Corbiculidae	2			1					
Total	**54**	**2**	**1**	**21**			**19**	**3**	**1**

Taxon	FB11	FB12	FB13	FB21	FB22	FB23	FB31	FB32	FB33
Tubificidae	4			1	3		31	2	1
Naididae				2	1	1		2	
Chironomidae				1	1	11	6	5	
Leptoceridae						1	2		
Gomphidae				1					
Polymitarcyidae						1			
Hydrobiidae	2						24		
Hyriinae							1		
Elmidae							1		
Mytilidae	66	12			651	3			
Corbiculidae	1				1	1	2		1
Glossiphonidae							1		
Total	**73**	**12**	**0**	**5**	**657**	**18**	**68**	**9**	**2**

Taxon	LC11	LC12	LC13	LC21	LC22	LC23	LC31	LC32	LC33
Tubificidae	2			5	2	1	7		
Naididae	3	1					3		
Chironomidae	2	1		4	1	5		3	
Philopotamidae									
Hydrobiidae	13	3		21	2		11	17	1
Elmidae						2			
Mytilidae				2	16		17		
Corbiculidae	1			14	2		6	26	
Total	**21**	**5**	**0**	**46**	**23**	**8**	**44**	**46**	**1**

NB = Nuevo Berlin, FB = Fray Bentos, LC = Las Cañas

Table D3.5-3: Taxonomic Composition of Zooplankton Samples Collected near the Botnia Site on the Rio Uruguay in December 2005 (organisms/L)

Taxon	A	C	D	E	F	G
ROTIFERA						
Ascomporpha sp.	0.18	0.09	0.09	0.36	0.18	0.45
Brachionus caudatus	0.09	0.03				0.09
Collotheca sp.						0.18
Euchlanis sp.	0.18	0.03	0.04		0.04	
Filina opoliensis			0.04			
Hexarthra sp.			0.04		0.04	
Keratella cochlearis			0.04	0.04		
Keratella tropica			0.04	0.18		
Lecane sp.					0.04	
Notothholca sp.		0.03		0.09		
Polyarthra vulgaris	0.18					
Synchaeta sp.	0.80		0.04	0.18	0.13	0.36
Trichocerca sp.			0.09			
CRUSTACEA						
Bosmina huaronensis			0.04	0.13	0.04	
Bosminopsis deitersi	1.16	0.18	0.98	1.12	2.01	4.91
Moina sp.	0.36	0.03	0.04		0.04	0.36
Daphnia sp.		0.06				
Diaphanosoma sp.	0.09			0.09		0.09
Notodiaptomus sp.	0.71	0.24	0.27	0.27	0.22	0.09
Cyclopoida sp.	0.18	0.03		0.04	0.09	
Nauplius	2.23	0.53	0.80	0.80	0.54	1.34
OTHERS						
Larva *Limnoperna fortunei*	4.11	3.90	7.81	7.59	9.06	18.75
Larva Gastropoda		0.03				
Larva Hydroide		0.06				0.09
Nematoda	0.09	0.03	0.04			
Anelida (Oligoqueta)		0.06	0.04			
Chironomidae						0.09
TOTAL ZOOPLANKTON	**10.36**	**5.32**	**10.49**	**10.89**	**12.46**	**26.79**

Locations C to G are in Yaguareté Bay, Location A is upstream of the discharge.

Table D3.6-1: Baseline Concentrations of Chlorophenols, Resin and Fatty Acids, Phytosterols, and Dioxins and Furans in Fishes in the Rio Uruguay (Tana, 2005, 2006)

Location	CPs in Bile[1] (ng/g DW)	RAs in Bile (μg/g DW)	FAs in Bile (μg/g DW)	PSs in Bile (μg/g DW)	D/Fs in Flesh (pg/g FW)	
					Sum	I-TEQ
April 2005						
A Nuevo Berlin	508 (426-590)	13 (12-14)	799 (451-1,146)	167 (151-183)	1.436	0.239
B1 Yaguareté Bay	729 (408-1,382)	49 (8-102)	3,683 (623-9,222)	74 (12-140)	1.037	0.123
C Las Cañas	860 (562-1,158)	53 (39-66)	2,620 (484-4,756)	140 (128-151)	1.770	0.288
December 2005						
A Nuevo Berlin	783 (290-1,475)	20 (0-56)	2,391 (274-6,593)	177 (41-382)	-	-
B1 Yaguareté Bay	316 (82-453)	19 (0-36)	1,354 (149-3,639)	131 (35-194)	-	-
C Las Cañas	566 (232-1,028)	38 (4-80)	2,812 (256-5,228	82 (75-94)	-	-

[1] Values shown for chlorophenols do not include the generally lower levels of other chlorophenolic substances.
[2] Locations are shown in Figure D3.3-1.

Fish Species

April 2005:	A Sabalo*; B1 Bogon, Tararira*, *Bagre amarillo*; C Sabalo*, *B. amarillo*.
December 2005:	A Sabalo, Torito, *Bagre blanco*; B Sabalo, *B. amarillo*, *B. blanco*; C Sabalo, *B. amarillo*, *B. blanco*.

* Indicates fishes used for analysis of dioxins and furans.

Figure D3.1-1: Major Watersheds and Natural Features of the Region

This map was produced by the Map Design Unit of The World Bank. The boundaries, colors, denominations and any other information shown on this map do not imply, on the part of The World Bank Group, any judgment on the legal status of any territory, or any endorsement or acceptance of such boundaries.

Figure D3.1-2: Comparison of Measured Flow and Water Elevation

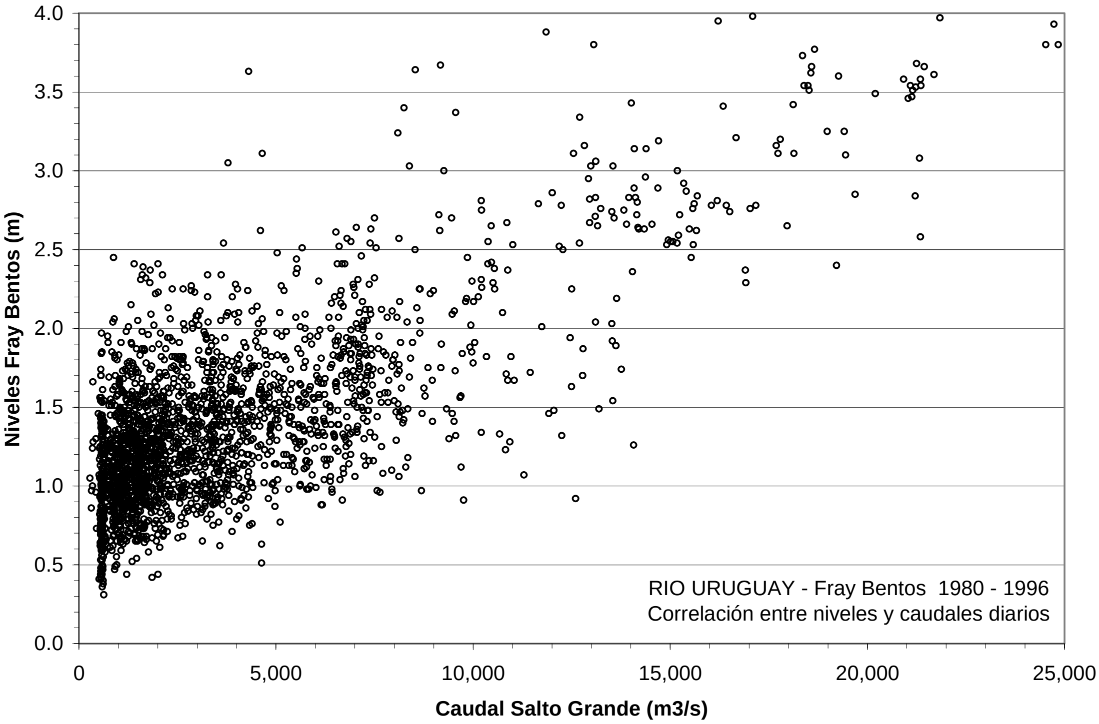
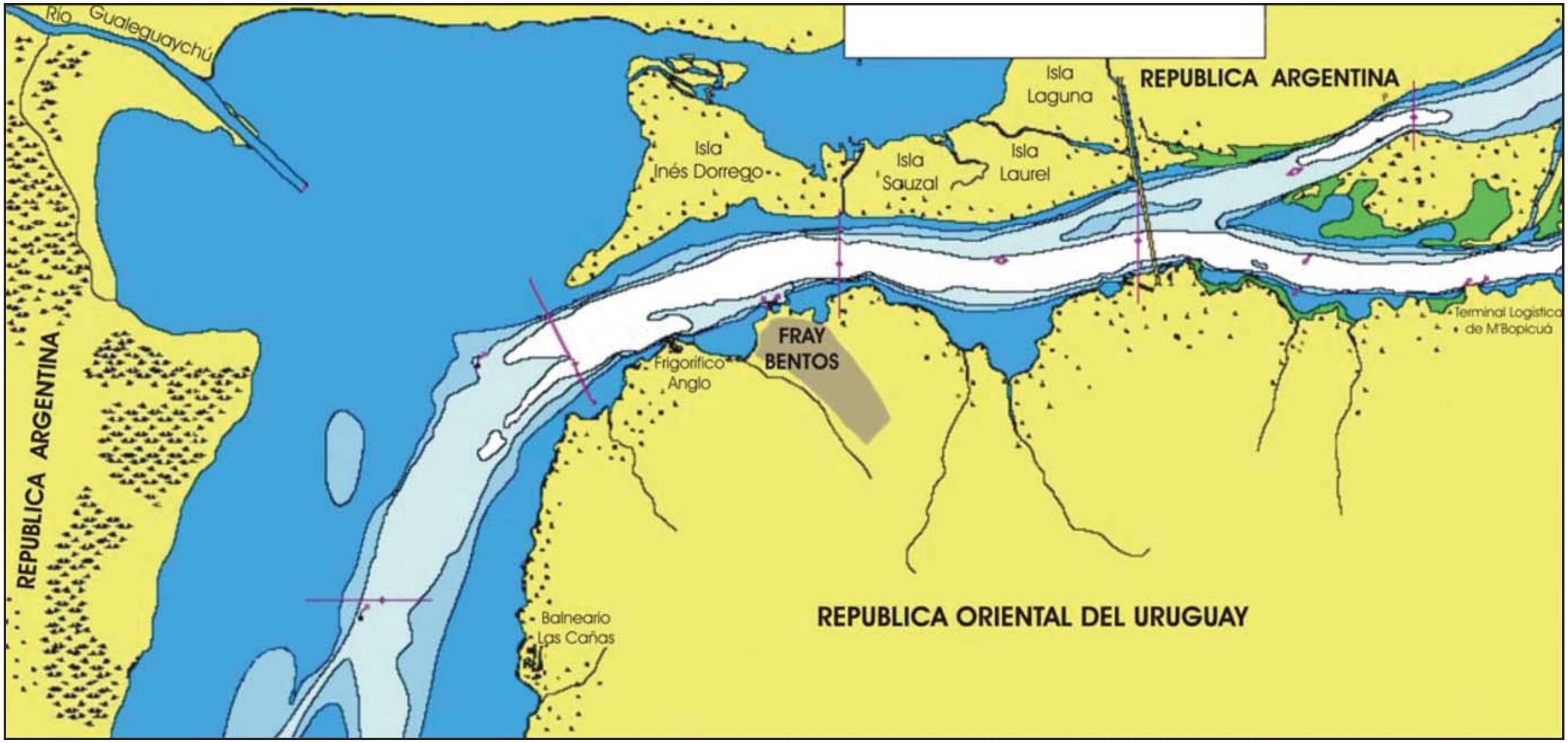


Figure D3.1-3: Bathymetry of the Rio Uruguay Near the Mill Sites



Depth Contours

- 🟦 0-2 m
- 🟦 2-5 m
- 🟦 5-10 m
- ⬜ >10 m

Figure D3.2-1: Locations of CARU Water Sampling Stations on the Rio Uruguay in the Vicinity of the Mill Projects

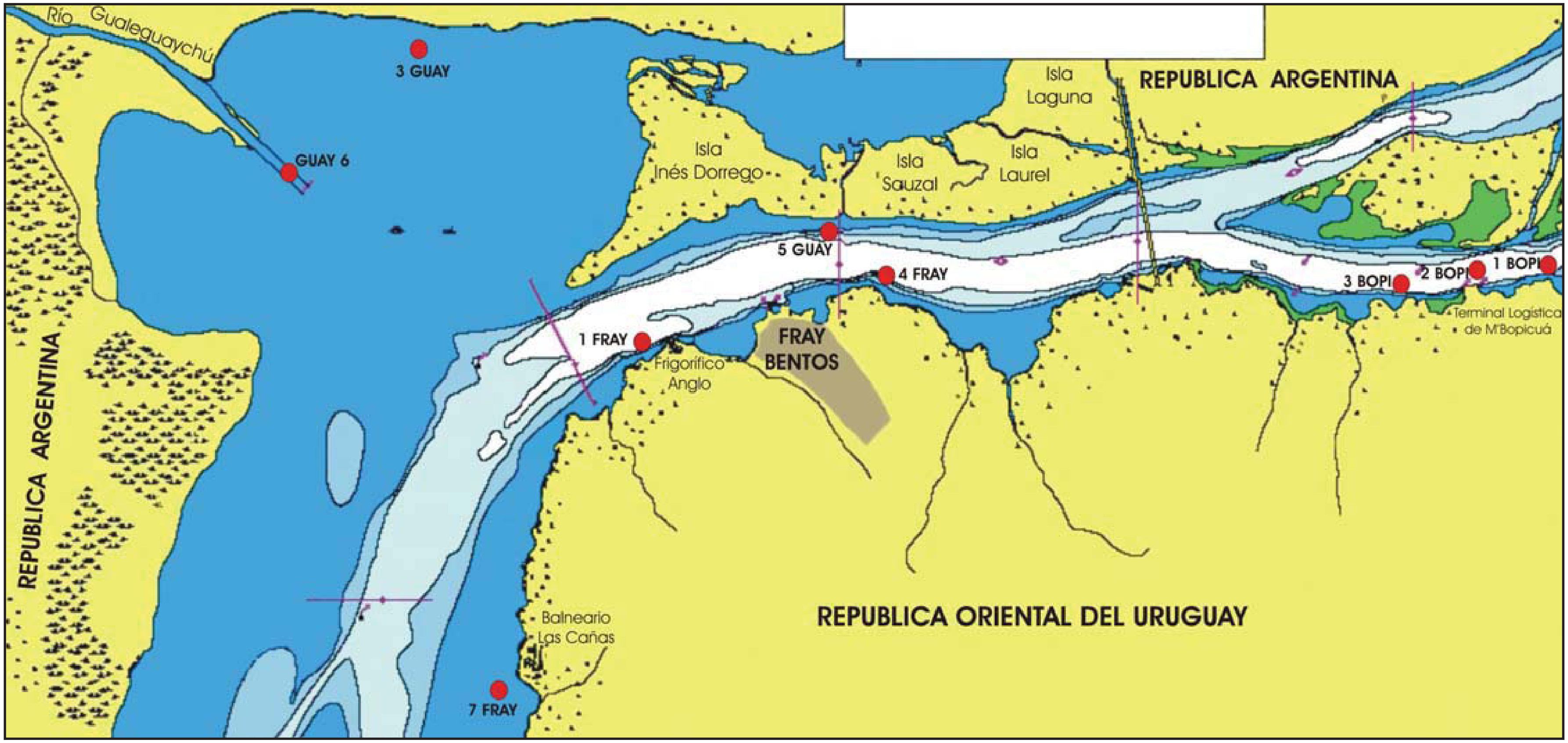
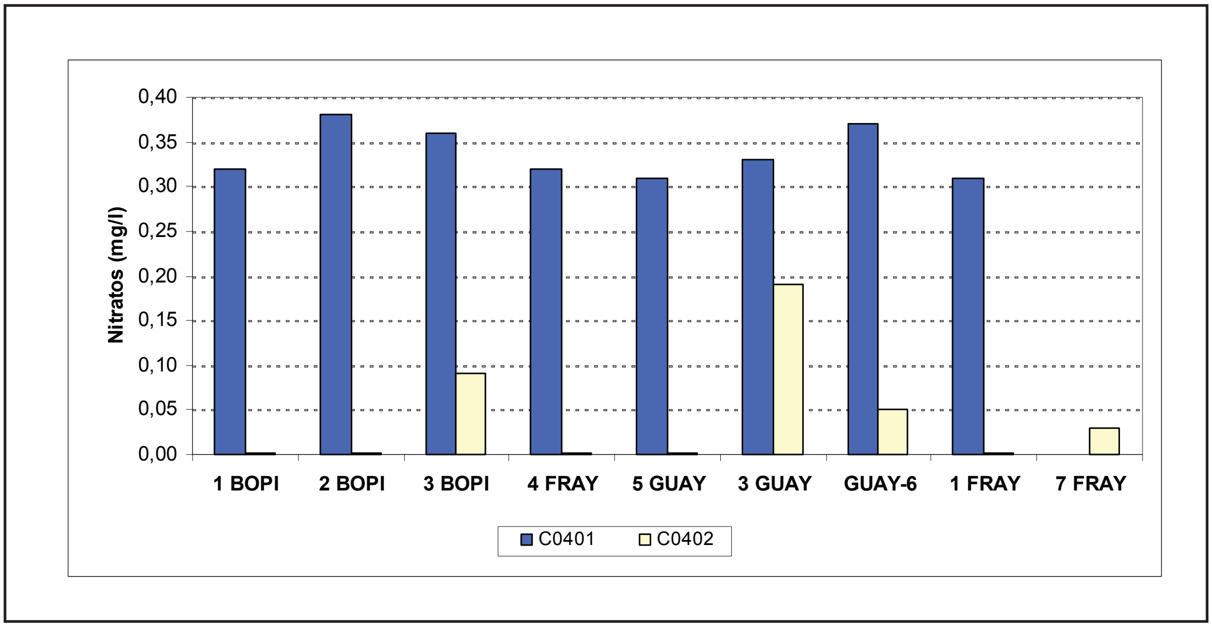
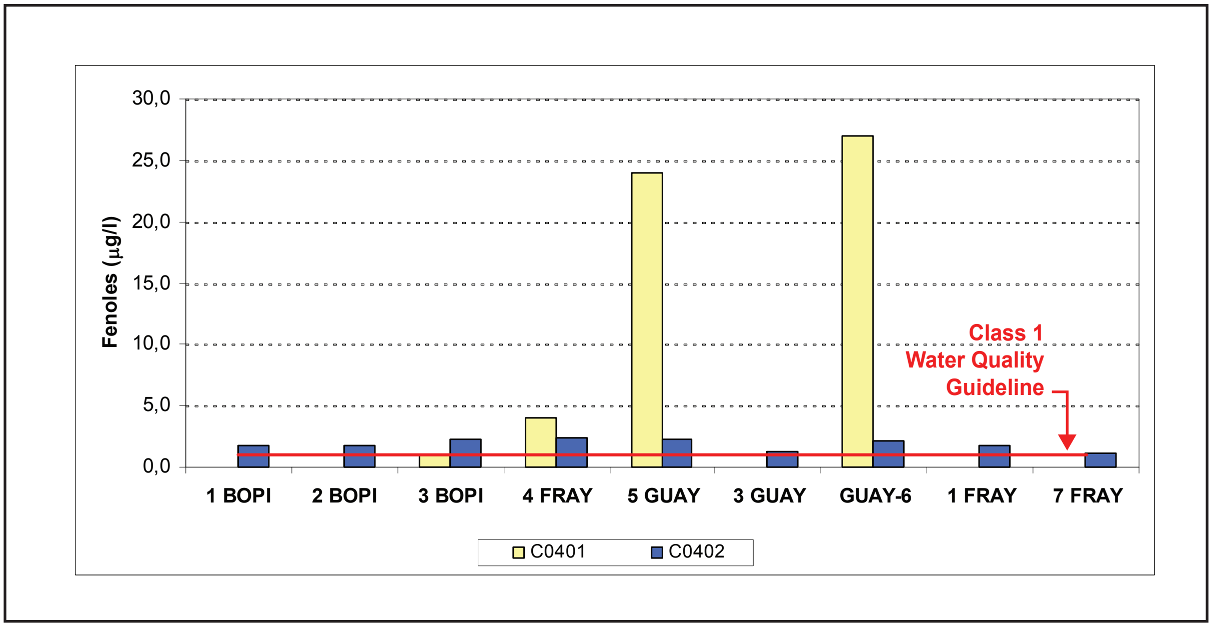


Figure D3.2-2: CARU Data for Nitrates and Phenolics in Rio Uruguay Water in the Vicinity of the Two Mill Projects





Note: C0401 and C0402 are different sampling campaigns in 2004

Figure D3.3-1: Locations of Botnia Sampling Stations on the Rio Uruguay, Upstream and Downstream of the Mill Site

Figure D3.5-1: Taxonomic Composition of Phytoplankton Samples Collected in Three Areas on the Rio Uruguay in April 2005 and January 2006

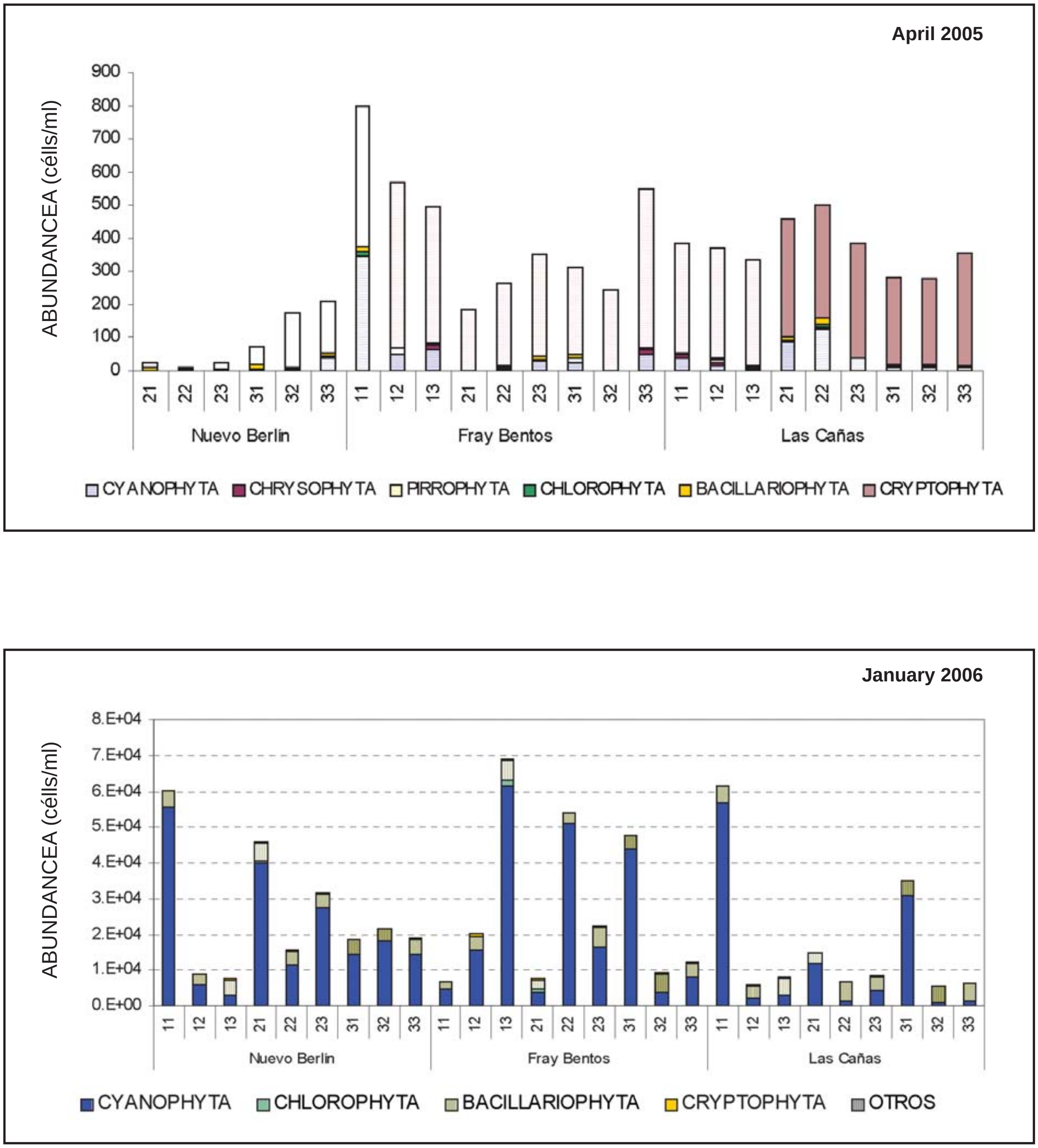
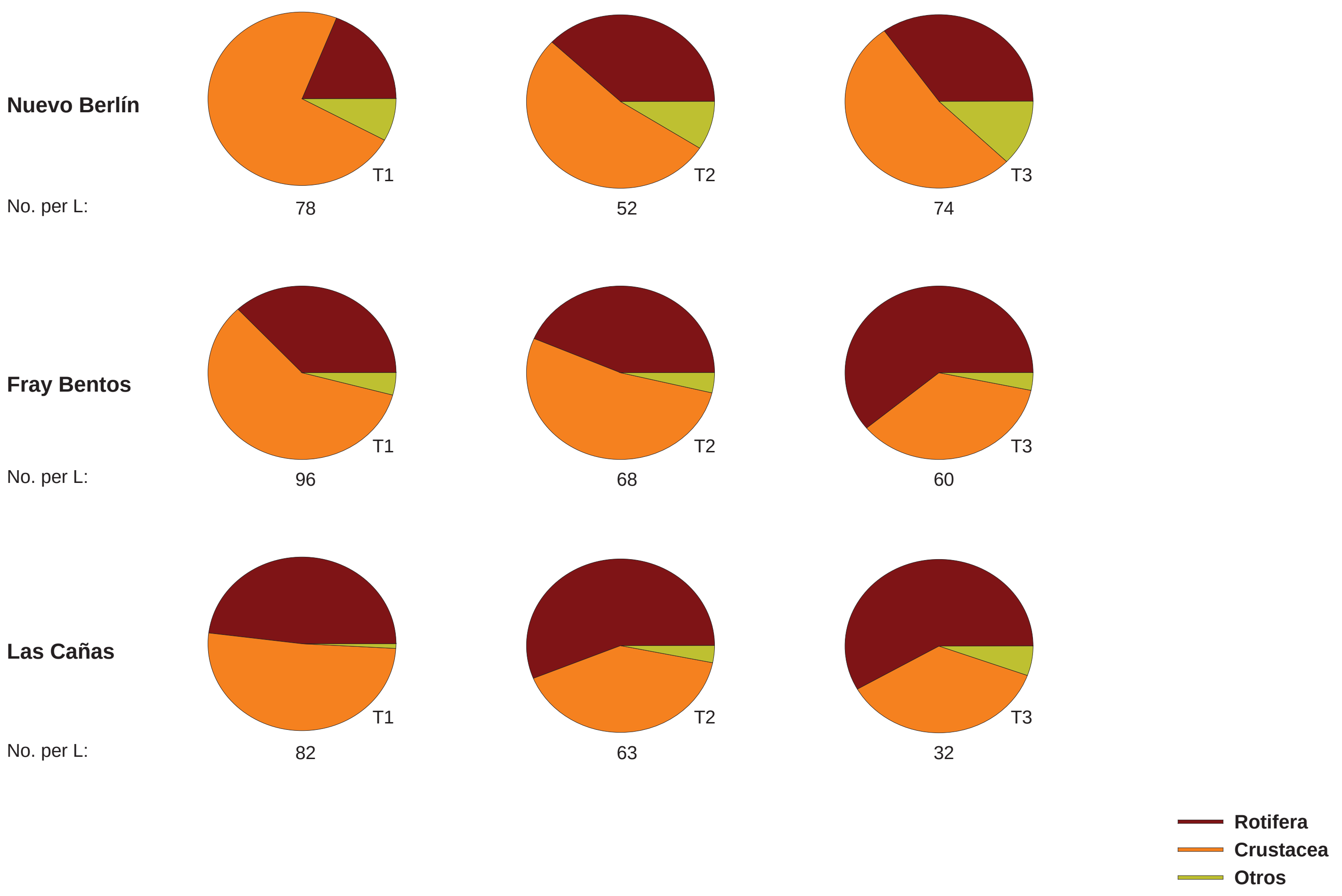


Figure D3.5-2: Taxonomic Composition of Zooplankton Samples Collected in Three Areas on the Rio Uruguay in January 2006



D4.0 PROJECT DESCRIPTION

Botnia of Finland and ENCE of Spain are each developing a pulp mill along the shores of the Rio Uruguay near the town of Fray Bentos in Uruguay. The two pulp mills (the mills) will produce a high quality pulp from locally grown eucalyptus at annual production capacities of 1,000,000 ADt/year for Botnia and 500,000 ADt/year for ENCE. The mills are proposing to utilize the water resource of the Rio Uruguay for process, cooling and waste assimilation. Details of the proposed mills and respective wastewater treatment systems are described in Annex A of the CIS Report. A summary of the proposed effluent characteristics are presented in the following sections. The assessment of potential environment effects is based on this information.

D4.1 Description of Wastewater Treatment Systems

The proposed wastewater treatment systems for the mills are described in detail in Annex A of the CIS Report. A brief description of each respective treatment system is provided below.

The wastewater treatment plant for the Botnia mill will employ an activated sludge treatment process that will treat an average discharge flow of approximately 0.83 m^3/s (25 m^3/ADt). The system will include three equalization and safety basins, two aeration basins, degassing tanks, and primary and secondary clarifiers, and will have a hydraulic retention time of approximately 48-hours. As concluded in Annex A, the treatment system fulfills all recommendations of IPPC-BAT and RDPC's AMT. In particular, the treatment efficiency is expected to be at the upper range (or higher) of the recommended treatment efficiency. Of particular note are the removal efficiencies for BOD, AOX, suspended solids, phosphorus and chlorate of 98%, 73%, 93%, 84% and 99%, respectively.

The wastewater treatment plant for the ENCE mill will also employ an activated sludge treatment process, although final details are still under review. The system will treat approximately 0.55 m^3/s (29 m^3/ADt) using a single aeration basin, emergency basin, equalization basin, and primary and secondary clarifiers. The treatment efficiency is expected to be within the mid to upper range for most parameters recommended by IPPC-BAT. The system includes all of the IPPC recommended BAT features for biological treatment with the possible exception of the recommended hydraulic retention time, although it is recommended in Annex A that this be reviewed prior to final design.

D4.2 Effluent Discharge Quantity

The discharge rates for the mills are 25 and 29 m^3/ADt for the Botnia and ENCE mills, respectively. Given a maximum production capacity of 119 and 66 ADt/hour, the effluent flow rate is estimated to be 0.83 and 0.55 m^3/s, respectively, as summarized in Table D4.2-1. The total flow of 1.38 m^3/s represents approximately 0.02% of the average flow of the Rio Uruguay (6,230 m^3/s) and approximately 0.28% of the extreme low flow condition (500 m^3/s) represented by the seven-day average low flow with a ten-year return period.

Both mills are considering the option of pumping additional river water through the diffuser to cool the effluent prior to discharge. This additional water is added to the main effluent flow just prior to the outfall pipe and below the location where monitoring of the effluent occurs. This option will increase the flow through the diffuser by an additional 0.83 and 0.55 m^3/s for the Botnia and ENCE mills, respectively, as further described in Section D4.5.

D4.3 Effluent Discharge Quality

The effluent quality for the mills is summarized in Tables D4.3-1 and D4.3-2 for the Botnia and ENCE mills, respectively. The basis for these load estimates is described in greater detail in Annex A, Process Technologies. Annex A also benchmarks these discharge characteristics and concludes that the effluent quality for the mills is comparable to, and for some parameters exceeds, world standards and the performance of most modern mills in existence.

Values are provided for the annual average, monthly maximum and daily maximum mass load per unit production. The annual average load values of most parameters are estimated based on the design specifications for the various components of the wastewater treatment system, and the mills are expected to operate at these levels on average. However differences in wood supply, raw water quality and operating conditions may cause variances in the quality of the final effluent. These variances are reflected in the differing quality limits for each respective averaging period. The loads for these shorter-term averaging periods are expressed as maximum values that are not to be exceeded.

Uruguayan law (Article 11 of Decree 253/79) also specifies effluent quality based on a 4-hour average. This shorter averaging period provides real-time demonstration of compliance with the end-of-pipe effluent quality standards (Article 11 of Decree 253/79 as presented in Table D2.2-2). It is important to note that the expected annual average loadings are approximately 4 to 6 times less than the loadings permissible by the end-of-pipe effluent standards. This ensures a significantly higher level of environmental protection than the already protective standards.

For several parameters (e.g., metals and toxins) the annual average load values are estimated based on experience and conservative judgment. For example, ENCE has estimated lower annual loadings of metals as compared to Botnia because ENCE has a considerable depth of experience producing pulp from Uruguayan eucalyptus species and can therefore provide a more accurate and less conservative estimate.

Dioxin and furan is another example of where a conservative estimate is provided to account for uncertainty. Experience at other modern ECF mills throughout the world has shown that the most toxic congeners of dioxin and furan are not produced in the bleaching process at detectable levels, and that the less toxic congeners, although detectable, are not necessarily attributable to the mill. For illustration, consider the example presented in Table D4.3-3 of an actual dioxin and furan analysis for an ECF pulp mill in Europe. As presented, there are 17 congeners within the classification of dioxin and furan, and each has differing degrees of toxicity as referenced to the most toxic congener (2,3,7,8-TCDD) by a toxic equivalent factor (TEF). For this example, the most toxic congeners (TEF greater than 0.1) are non detectable at the 0.5 pg/L level in the treated mill effluent, and the less toxic congeners are detectable but at levels below the raw water supply. The resulting TEQ for the treated effluent is in the range of 0.2 to 1.9 pg/L (depending on whether detection limits are included or not), as compared to a TEQ for the raw water ranging from 3.7 to 5.3 pg/L. As a conservative measure, the dioxin and furan loadings presented in Tables D4.3-1 and D4.3-2 assume a concentration of dioxin and furan of less than 10 pg/L, resulting in the calculated loading of less than $2.5x10^{-10}$ kg/ADt and less than $2.9x10^{-10}$ kg/ADt for Botnia and ENCE, respectively.

D4.4 Diffuser Characteristics

The mills are proposing to discharge a high quality, treated effluent to the Rio Uruguay through offshore, submerged, multi-port diffusers. The design of the diffusers for each mill varies somewhat to account for differences in local setting and discharge characteristics. The details of each respective diffuser are described in reports prepared by KWH Pipe (2006) for the Botnia mill and SIDMAR (2006) for the ENCE mill. The specifications for each respective diffuser are summarized in Table D4.4-1 along with recommendations for further refinement of the design configuration.

The two diffusers are fairly similar in design. Both consist of a 200 m outfall pipe extending out from the river bank, and both include a 200 m diffuser extending beyond the outfall pipe. A shorter diffuser could be considered for the ENCE mill considering the lower potential flow of the discharge. The outfall pipes and diffusers are both aligned perpendicular to the main flow of the river in order to position the diffuser into the deepest portion of the river channel and to maximize the distribution of effluent within the river. The depth of water at each diffuser is approximately 13.5 and 19 m for the Botnia and ENCE mills, respectively. These depths provide the greatest mixing potential possible within the respective areas.

Along the length of each diffuser are a series of nozzles through which the effluent is discharged. A total of 80 nozzles are proposed for each diffuser, although fewer nozzles could be considered for the diffuser at the ENCE mill (again due to the lower potential flow of the discharge). The nozzles are evenly spaced at 2.53 m intervals along the length of the diffuser, and each nozzle rises up from the diffuser pipe 1 m from the river bottom on what is referred to as a riser.

The orientation of each nozzle differs somewhat for each mill. The nozzles for Botnia are oriented vertically upward, whereas the nozzles for ENCE are oriented horizontal and parallel to the ambient flow (i.e., co-flowing). An alternative nozzle orientation is recommended since the vertical orientation may induce surface turbulence that may be visible to observers from the International Bridge, and since the horizontal, co-flowing orientation is not ideal during the rare occasions when the river flow reverses direction.

The nozzles are 0.1 m in diameter. The 0.1 m diameter results in a relatively low exit velocity to minimize the potential turbulence at the surface of the river. This turbulence does not pose any risk to public safety or to the environment. However, any visible detection of the effluent discharge by an observer from boat or the International Bridge could be considered objectionable from the perspectives of aesthetics or perceived environmental impact.

This concern is greatest for the Botnia mill due to its close proximity to the International Bridge. The high vantage point of an observer from the bridge maximizes the potential for visual detection of the effluent discharge (see discharge locations in Section D5.1). All measures to minimize this potential should be taken, including positioning the diffuser as far from the bridge as possible. Minimizing turbulence by increasing the size of the nozzles is not recommended since further reduction of exit velocity could cause siltation of the nozzles or reduce mixing performance of the diffuser.

The proposed diffuser configurations are considered superior designs from the perspective of mixing performance. They ensure the highest degree of initial mixing possible for the respective locations within the Rio Uruguay. Alternative diffuser configurations are included in the assessment to confirm the suitability of the chosen design. A summary of alternative diffusers is presented in Table D4.4-2. The summary also presents the performance measure for each diffuser. This measure is based on the distance from the diffuser at which a dilution of 100:1 is achieved under extreme low flow conditions. The distance is computed using a mathematical model called CORMIX as described in further detail in Section D5.1.1. As presented, the 100:1 dilution is achieved within approximately 35 m for the preferred diffuser configuration. Various other configurations provide similar performance.

D4.5 Optional Augmentation of Flow in the Diffuser

Botnia is considering the option of augmenting the flow in the diffuser to provide pre-cooling of the effluent prior to discharge to the Rio Uruguay. This additional water is to be added to the outfall pipe near the river bank and below the compliance monitoring location for the mill effluent. It will therefore not affect the validity of the effluent compliance monitoring.

The purpose of the flow augmentation is to maintain the temperature of the final discharge at or below the 30^{o}C limit specified in Decree 253/79. The thermal load from the mill is small relative to the thermal capacity of the Rio Uruguay. Once fully mixed, it will cause a theoretical temperature change of less than 0.1^{o}C at a low flow of 500 m^3/s. Within the very small mixing zone for the diffuser, the temperature change is estimated to be 0.3^{o}C. Such small changes in temperature are indistinguishable from the natural variability in the river. Therefore cooling is not required to preserve the natural temperature regime of the river.

Other options considered include cooling towers and heat exchangers. However, these options have higher energy requirements than flow augmentation, and a heat exchanger results in the same thermal load to the river as flow augmentation. Therefore, flow augmentation is recommended for further consideration by DINAMA and the Companies as it achieves the stated objective in an environmentally responsible manner.

D4.6 Optional Treatment of the Fray Bentos Municipal Wastewater

The community of Fray Bentos (population of approximately 22,600 in 1996) currently discharges untreated municipal wastewater to the Rio Uruguay. The wastewater is discharged near the shore of the Rio Uruguay downstream of the city. Although the quantity of wastewater is relatively low (approximately 0.04 m^3/s on average) the high concentration of organics, nutrients and bacteria discharged near the shoreline in shallow water has the potential to adversely affect the water quality within the recreational beach areas located further downstream. In particular, the high concentration of nutrients at the shoreline contributes to the growth of nuisance algae and the high density of bacteria within the beach areas poses a health risk to the public.

Botnia is considering the joint treatment of this wastewater at the Botnia wastewater treatment plant. This option presents several significant environmental and social benefits. First and foremost, it improves the water quality within the beach areas downstream from Fray Bentos which should reduce the frequency of algae blooms and health impacts. Second, it reduces the total loading of organics and nutrients, in particular phosphorus, to the Rio Uruguay since the municipal wastewater off-sets the nutrient requirements of the Botnia wastewater treatment plant. Third, it diverts the financial burden of treating the municipal wastewater from the community of Fray Bentos should they choose to independently treat the wastewater in the future. These benefits are significant and warrant further consideration of this option by DINAMA, the community of Fray Bentos, Botnia and other stakeholders.

This assessment is based on discharge characteristics summarized in Table D4.6-1. As presented, the average volume of wastewater produced by Fray Bentos is relatively small compared to the Botnia mill. However, the high concentrations of organics, nutrients and bacteria from the Fray Bentos municipal discharge result in mass loadings that are comparable to that of the Botnia discharge. In particular, the mass loadings of biochemical oxygen demand and total phosphorus are virtually identical for the two discharges.

It can therefore be stated that the discharge from each of the two mills is comparable to the municipal wastewater discharge for a city with a population of approximately 22,600 people. However, since the discharge from the mill is through an offshore multi-port diffuser rather than along the shoreline, the net effect of the mill discharge on the environment is significantly reduced (as further discussed in Section D6.0).

Table D4.6-1 further shows that the total mass loading from the Botnia discharge with treatment of the Fray Bentos wastewater (Option B) is comparable to the Fray Bentos wastewater discharge alone. Therefore, the treatment of the Fray Bentos wastewater virtually off-sets the net loading of organics and nutrients from the Botnia mill to the Rio Uruguay.

The option to treat the Fray Bentos municipal wastewater has significant environmental and social benefits and is recommended for further consideration.

D4.7 Optional Treatment of the Mercedes Pulp Mill Wastewater

The Papelera Mercedes (the Mercedes mill) is a neutral sodium sulphite chemical (NSSC) mill and Kraft mill located along the Rio Negro in the community of Mercedes. The mill produces approximately 5,000 ADt/year of pulp, or approximately 0.3 % of the combined production of the Botnia and ENCE mills. The Mercedes mill does not have any form of chemical recovery or wastewater treatment, and all cooling and process waters are discharged directly to the Rio Negro where it then flows to the Rio Uruguay.

Botnia is considering the possibility of transporting the weak black liquor from the Papelera Mercedes pulp washing plant to the evaporation plant at the Botnia mill, requiring approximately 3 to 4 trucks daily. This option presents significant environmental and social benefits that warrant further consideration by DINAMA, the Mercedes mill, Botnia and other stakeholders.

From an environmental perspective, the option results in a significant benefit to the Rio Negro and Rio Uruguay as it will eliminate this source of potentially harmful chemicals to the rivers. As presented in Table D4.6-2, this option will reduce the total COD, BOD and phosphorus load to the Rio Negro and Rio Uruguay by approximately 22, 8 and 0.004 t/d, respectively. This offsets the net loading of organics and further reduces the net nutrient loading from the Botnia mill. It will also reduce the total loading of caustic soda and sulphuric acid by 3.5 and 1.8 t/d, respectively, generate an additional 0.5 MW of electrical power, and generate 1.5 MW of steam.

From a social perspective, this option may ensure the economic viability of the mill since the cost of on-site recovery may not be viable considering the small production capacity of the mill.

Table D4.2-1: Effluent Discharge Quantity

	Units	Botnia Mill	ENCE Mill
Production Capacity	ADt/year	1,000,000	500,000
	ADt/hour	119	66
Effluent Flow Rate	m^3/ADt	25	29
	m^3/s	0.83	0.55
Optional Flow Addition	m^3/s	0.83	0.55

Table D4.3-1: Effluent Characteristics for the Botnia Wastewater Discharge

Parameter	Units	Botnia Expected Operating Levels Annual Average	 Monthly Maximum	 Daily Maximum
Aesthetic				
Floating material		absent	absent	absent
Color	kg/ADt	9	10	25
Conventional				
Temperature	^oC	28	30	30
TSS	kg/ADt	0.7	1.3	2.6
pH		7.5	6.0 to 9.0	6.0 to 9.0
Conductivity	µS/cm	4,000	5,000	8,000
COD	kg/ADt	8	15	30
BOD	kg/ADt	0.3	0.7	1.5
AOX	kg/ADt	0.08	0.15	0.2
Oil and grease		negligible	0.31	0.63
Detergents		negligible	0.025	0.05
Microbiological				
Fecal coliforms	/100mL	-	-	-
Nutrients				
N total	kg/ADt	0.15	0.26	0.52
Nitrates (NO3)	kg/ADt	0.08	0.13	0.24
Ammonia (total)	kg/ADt	0.016	0.026	0.048
Total Phosphorus	kg/ADt	0.012	0.03	0.06
Toxins				
Chlorophenols	kg/ADt	0.00175	0.00263	0.00525
Cyanide	kg/ADt	negligible	0.00625	0.0125
Phenolic comp	kg/ADt	0.000055	0.0000055	0.00001
Plant sterols	kg/ADt	0.004	0.006	0.012
Resin/fatty acids		negligible	negligible	negligible
Sulphides	kg/ADt	0.006	0.006	0.013
Dioxins/furans	kg/ADt	<2.5E-10	-	-
Metals				
Arsenic	kg/ADt	0.002	0.003	0.006
Cadmium	kg/ADt	0.0002	0.0003	0.0006
Copper	kg/ADt	0.004	0.006	0.013
Chromium	kg/ADt	0.004	0.006	0.013
Mercury	kg/ADt	<0.000125	-	-
Nickel	kg/ADt	0.008	0.013	0.025
Lead	kg/ADt	0.0013	0.0019	0.0038
Zinc	kg/ADt	0.0011	0.0017	0.0038

Table D4.3-2: Effluent Characteristics for the ENCE Wastewater Discharge

Parameter	Units	ENCE		
		Expected Operating Levels		
		Annual Average	Monthly Maximum	Daily Maximum
Aesthetic				
Floating material		absent	absent	absent
Color	kg/ADt	6.4	11	23
Conventional				
Temperature	^{o}C	<30	30	30
TSS	kg/ADt	0.9	1.6	2.4
pH		6.0 to 9.0	6.0 to 9.0	6.0 to 9.0
Conductivity	µS/cm	1,200	2,400	-
COD	kg/ADt	8.7	19	29
BOD	kg/ADt	0.6	1.3	1.74
AOX	kg/ADt	0.10	0.22	0.32
Oil and grease	kg/ADt	negligible	0.35	0.70
Detergents	kg/ADt	negligible	0.09	0.12
Microbiological				
Fecal coliforms	/100mL	<1,000	-	-
Nutrients				
N total	kg/ADt	0.17	0.30	0.60
Nitrates (NO3)	kg/ADt	0.09	0.14	0.30
Ammonia (total)	kg/ADt	0.020	0.030	0.060
Total Phosphorus	kg/ADt	0.017	0.035	0.070
Toxins				
Chlorophenols	kg/ADt	0.0015	0.0024	-
Cyanide	kg/ADt	<0.0003	0.006	0.01
Phenolic comp	kg/ADt	0.000029	0.000046	0.000087
Plant sterols	kg/ADt	0.005	0.0075	-
Resin/fatty acids	kg/ADt	0.0006	0.0006	-
Sulphides	kg/ADt	0.005	0.005	0.005
Dioxins/furans	kg/ADt	<2.9E-10	-	-
Metals				
Arsenic	kg/ADt	0.0003	0.015	0.015
Cadmium	kg/ADt	0.00009	0.0015	0.0015
Copper	kg/ADt	0.000003	0.03	0.03
Chromium	kg/ADt	0.0009	0.03	0.03
Mercury	kg/ADt	-	-	-
Nickel	kg/ADt	0.0021	0.06	0.06
Lead	kg/ADt	0.0003	0.009	0.009
Zinc	kg/ADt	0.00009	0.009	0.009

Table D4.3-3: Example of a Dioxin and Furan Analysis for an ECF Mill in Europe

Parameter	Unit	Toxic Equivalent Factor, TEF	Raw Water	Chemically Purified Water	Treated Effluent
Dioxin					
2,3,7,8-TCDD	pg/L	1	<0.5	<0.5	<0.5
1,2,3,7,8-PeCDD	pg/L	1	<0.5	<0.5	<0.5
1,2,3,4,7,8-HxCDD	pg/L	0.1	<0.5	<0.5	<0.5
1,2,3,6,7,8-HxCDD	pg/L	0.1	<0.5	<0.5	<0.5
1,2,3,7,8,9-HxCDD	pg/L	0.1	<0.5	<0.5	<0.5
1,2,3,4,6,7,8-HpCDD	pg/L	0.01	2.6	2.1	<0.5
1,2,3,4,6,7,8,9-OCDD	pg/L	0.0001	7.3	13	3.6
Furan					
2,3,7,8-TCDF	pg/L	0.1	<0.5	<0.5	<0.5
1,2,3,7,8-PeCDF	pg/L	0.05	<0.5	<0.5	<0.5
2,3,4,7,8-PeCDF	pg/L	0.5	<0.5	<0.5	<0.5
1,2,3,4,7,8-HxCDF	pg/L	0.1	1.7	<0.5	<0.5
1,2,3,6,7,8-HxCDF	pg/L	0.1	1.6	<0.5	<0.5
2,3,4,6,7,8-HxCDF	pg/L	0.1	1.4	<0.5	<0.5
1,2,3,7,8,9-HxCDF	pg/L	0.1	<0.5	<0.5	<0.5
1,2,3,4,6,7,8-HpCDF	pg/L	0.01	320	120	24
1,2,3,4,7,8,9-HpCDF	pg/L	0.01	<0.5	<0.5	<0.5
1,2,3,4,6,7,8,9-OCDF	pg/L	0.0001	280	220	10
Toxic Equivalent, TEQ					
Including detection limit	pg/L		5.3	2.9	1.9
Excluding detection limit	pg/L		3.7	1.2	0.2

Note: analytical detection limit of 0.5 pg/L; 1 pg/L = 10^{-9} mg/L

Table D4.4-1: Physical Characteristics of the Diffusers for Botnia and ENCE

Characteristic	Botnia	ENCE
Length of outfall pipe	200 m	200 m
Diffuser length	200 m	200 m (original) 100 m (recommended)
Orientation of diffuser	90^o to ambient flow	90^o to ambient flow
Number of nozzles	80	80 (original) 40 (recommended)
Nozzle diameter	0.1 m	0.1 m
Nozzle vertical orientation	90^o (original) 0^o (recommended)	0^o
Nozzle horizontal orientation	0^o to ambient flow	0^o to ambient flow
Average water depth	13.5 m	19.5 m

Table D4.4-2: Comparison of Alternative Diffuser Configurations

Diffuser Configuration	Performance Measure (distance to achieve 100:1 dilution)
Selected design – 200 m long diffuser oriented perpendicular to the main flow with 80, 0.1 m diameter nozzles;	**35 m**
Option 1 – 100 m long diffuser oriented perpendicular to the main flow with 80, 0.1 m diameter nozzles;	75 m
Option 2 – 300 m long diffuser oriented perpendicular to the main flow 80, 0.1 m diameter nozzles;	25 m
Option 3 – 200 m long diffuser oriented perpendicular to the main flow, with 40, 0.14 m diameter nozzles;	35 m
Option 4 – 200 m long diffuser oriented perpendicular to the main flow, with 40, 0.1 m diameter nozzles;	30 m
Option 5 – 200 m long diffuser oriented 45^o to the main flow, with 80, 0.1 m diameter nozzles;	220 m
Option 6 – 200 m long diffuser oriented parallel to the main flow, with 80, 0.1 m diameter nozzles;	>1000 m

Table D4.6-1: Summary of Effluent Characteristics for Options With and Without Treatment of the Fray Bentos Municipal Wastewater Discharge

Parameter	Units	Option A: Separate Discharge of Fray Bentos and Botnia Wastewaters		Option B: Treatment of Fray Bentos Discharge at Botnia Wastewater Treatment Plant	
		Fray Bentos	Botnia	Fray Bentos	Botnia
Discharge Rate	m^3/s	0.042	0.83	-	0.872
Concentration					
TSS	mg/L	300	28	-	28
BOD	mg/L	300	12	-	12
AOX	mg/L	0.021	3	-	3
Fecal coliforms	F.C./100 mL	30,000	5,000 max	-	5,000 max
N total	mg/L	48	6.0	-	6.0
P total	mg/L	8	0.5	-	0.5
Mass Load					
TSS	t/d	1.1	2.0	-	2.1
BOD	t/d	1.1	0.9	-	0.9
AOX	t/d	-	0.2	-	0.2
N total	t/d	0.17	0.43	-	0.45
P total	t/d	0.03	0.03	-	0.04
Total Mass Load					
TSS	t/d	3.1		2.1	
BOD	t/d	1.9		0.9	
AOX	t/d	0.2		0.2	
N total	t/d	0.60		0.45	
P total	t/d	0.06		0.04	

Table D4.6-2: Summary of Environmental Benefit of Option to Recover the Weak Black Liquor from Papelera Mercedes

Parameter	Units	Option A: No Recovery of the Weak Black Liquor from Papelera Mercedes		Option B: With Recovery of the Weak Black Liquor from Papelera Mercedes	
		Papelera Mercedes	Botnia	Papelera Mercedes	Botnia
Mass Load					
COD	t/d	20	22	-	22
BOD	t/d	8	0.9	-	0.9
P total	t/d	0.004	0.03	-	0.03
Total Mass Load					
COD	t/d	42		22	
BOD	t/d	8.9		0.9	
P total	t/d	0.034		0.03	

D5.0 METHODOLOGY

Section D3.0 presents background information regarding the physical and biochemical environment of the Rio Uruguay under existing conditions, and Section D4.0 presents a description of the proposed wastewater discharge for the two plants. The purpose of Section D5.0 is to present the methodology by which the potential effects of the proposed discharges are assessed. The results of this assessment are presented in Section D6.0.

The methodology is based on mathematical model investigations and literature review. Mathematical models are widely used to support this type of assessment as they can reliably calculate the change in water and sediment quality based on fundamental laws of physics, chemistry and mass conservation. In the absence of the discharge itself, these models provide the only viable means to estimate change under a wide range of environmental conditions.

Literature is also relied upon for the assessment of certain water quality concerns such as dioxin and furan, endocrine disrupting compounds and fish tainting compounds. The review provides a discussion of the nature of the concern, the experienced gained at similar modern mills, and provides the basis by which the concerns are addressed within the assessment of potential effects.

D5.1 Mathematical Models

There are several types of mathematical models that are utilized to support the assessment of cumulative aquatic effects associated with the two plants. In the most general of terms, these models can be divided into models that predict environmental change near to the point of discharge (referred to as near-field models) and models that predict environmental change farther away from the point of discharge (referred to as far-field models). The distinction is required to account for the inherent strengths in each type of model. For example, near-field models have the distinct advantage of resolving the complex hydraulics associated with the actual discharge structures (referred to as diffusers) where as far-field models have the advantage of resolving the complexities of the natural receiving environment. This distinction is further described in the following sections.

D5.1.1 Near-Field Models

In the absence of the actual diffuser, near-field mathematical models are generally accepted as the most reliable method of assessing the potential environmental change associated with a discharge. Several models are available that have been widely used and accepted. For the present analysis, two modeling packages have been applied – CORMIX and VPLUME. CORMIX was developed by Cornell University (Akar and Jirka, 1990) and is now distributed through an independent company, where as VPLUME is distributed by the U.S. Environmental Protection Agency (Frick *et. al*., 2001). Both models contain a series of sub-models that address a wide array of diffuser types and configurations. The specific sub-models used are CORMIX 2 (for assessment of submerged, offshore, multi-port diffusers), CORMIX 1 (for assessment of individual nozzles), and UM3 (a three-dimensional, Lagrangian model for simulating multi-port submerged discharges).

CORMIX (Cornell Mixing Zone Expert System) is a widely recognized modeling package used to analyze the mixing characteristics of a discharge within a natural receiving environment, such as a river or estuary. The model requires information regarding the ambient environment, the discharge characteristics and diffuser configuration to estimate the concentration of effluent within the downstream environment. Typical inputs to the model include: flow, temperature, river geometry, discharge rate, effluent density and quality, diffuser location, length, orientation, number of nozzles and nozzle diameter. Mixing characteristics are calculated from principles of physics regarding buoyancy, mass conservation and momentum conservation. Further details regarding the CORMIX model are available at www.cormix.info.

VPLUME is also widely used and recognized, and is similar in many respects to CORMIX. It has been used for the present application to provide a cross-check of the CORMIX model to ensure that the analysis is valid and conservative. The model and manual can be obtained at www.epa.gov/ceampubl/swater/vplume/.

The near-field models are used for two main purposes. First, they provide a basis to estimate the mixing characteristics of a diffuser, and therefore, a basis to assess alternative designs to achieve optimal performance. Second, they provide a basis to quantify the potential change in water quality within the nearfield zone surrounding each diffuser and hence a basis to assess the potential environmental affects.

The performance of the alternative diffusers is assessed based on the physical size of the exposure area. The term “exposure area” is defined as the spatial area extending from the diffuser at which 1 part of effluent is mixed with 100 parts of ambient river water (referred to as 100:1 dilution). The smaller the exposure area the greater the performance.

This definition for exposure area is derived from the Environmental Effects Monitoring program for the pulp and paper sector in Canada (Environment Canada, 2003, 2005). This is the most comprehensive national regulatory effects monitoring program for paper mills in the world. Experience at over 130 mills in Canada over the past decade has shown that adverse affects on the aquatic environment are generally limited to this 100:1 dilution zone.

D5.1.2 Far-Field Models

The far-field models are used to calculate the potential change in water quality throughout the natural receiving environment beyond the exposure area. These are required in addition to the near-field models as they provide greater resolution of the complex hydrodynamics, bathymetry and shoreline geometry of the river.

There are two main components of the far-field model – the hydrodynamic component and the water quality component. The mathematics underlying the hydrodynamic component were originally derived by French and English mathematicians, M. Navier and G. Stokes, in the early 1800's. The resulting series of coupled differential equations are referred to as the Navier-Stokes equations and are the foundation of modern fluid mechanics. The mathematics underlying the water quality component were derived from principles of mass conservation and are referred to as the advection dispersion equations. Collectively, these equations can be solved using high speed computers and methods of computational fluid dynamics.

There are various models available that solve the Navier-Stokes and advection-dispersion equations. For this application, the TABS-MD series of models was used, specifically the sub-models RMA-2, RMA-10 and RMA-11. This series of models were developed with the support of the US Army Corps of Engineers Waterways Experiment Station.

This model selection was based on the following criteria: widely used and recognized; full disclosure of equations and numerical solution; able to resolve hydrodynamics and water quality in two and three dimensions; full integration of hydrodynamic and water quality modeling components; and able to simulate decay and chemical interactions. There is also significant experience using the TABS-MD modeling system on the Rio Uruguay (Piedra-Cueva, 2005; Algoritmos, 2006; Malcolm Pirnie, 2005).

The RMA-2 and RMA-10 sub-models are classified as dynamic two- and three-dimensional, respectively, finite element hydrodynamic models. RMA-2 computes the lateral and longitudinal distribution of water surface elevation and horizontal velocity for subcritical, free-surface flow. It is specifically designed for assessment of far-field hydrodynamics in unstratified water bodies in which vertical accelerations are negligible (i.e., hydrostatic conditions) and velocity vectors generally point in the same direction over the entire depth of the water column. RMA-10 expands upon the capabilities of RMA-2 to include the vertical distribution of velocity to enable assessment of far-field hydrodynamics in stratified water bodies.

The water quality sub-model RMA-11 is a three-dimensional finite element model capable of calculating the transport, dispersion and fate of various water quality constituents, including temperature, conductivity, biochemical oxygen demand, nutrients, total suspended solids, dissolved oxygen, absorbable organic halides, and other constituents of potential interest. The model is fully integrated with other components of the TABS-MD series, including RMA-2 and RMA-10.

Further details of the TABS-MD series of models are available from the US Army Corps of Engineers, Coastal and Hydraulics Laboratory.

D5.1.3 Model Implementation

The mathematical models require a significant amount of information to properly characterize the physical and biochemical environment. Much of this information is presented in Sections D2.0 and D3.0. The specific data are presented below to ensure clarity regarding the implementation of the models.

Spatial Domain

The near-field models, CORMIX and VPLUME, were implemented over a spatial domain extending upstream and downstream from the respective diffusers a distance of 10 km. Although a significantly larger area was covered, the near-field models were only used to assess water quality within the initial mixing zone. As shown in Section D5.0, the initial mixing zone extends approximately 35 m from the diffuser under extreme low flow conditions and only a few metres under moderate flow conditions. The 10 km spatial domain for the near-field model ensures inclusion of the initial mixing zone under all conditions of potential interest.

The far-field models, RMA-2, RMA-10 and RMA-11, are implemented over a spatial domain extending along the lower Rio Uruguay from Salto Grande Dam to Las Cañas (downstream from Fray Bentos), as illustrated in Figure D5.1-1. This spatial domain ensures that water elevation variations along the river are properly represented and not constrained by the imposed boundary conditions. This is particularly important for the assessment of potential flow reversals as it ensures that the hydrodynamics and upstream excursion distance are accurately simulated from the Navier-Stokes and advection-dispersion equations.

The portion of the model grid within the vicinity of the two plants is presented in Figure D5.1-2. As illustrated, the model grid incorporates the complexity of the river geometry, including islands and shoreline configuration.

Temporal Domain

The far-field models were implemented in a dynamic mode to capture the complexities of the hydrodynamic environment within the Rio Uruguay. As such, the model calculates the time varying response of the river to changes in upstream flow, downstream water elevation, and other potential factors such as local wind. Boundary conditions (described below) are defined at an hourly time-step from measured data. The simulation period varies depending upon the scenario, but is generally in the range of 10 to 30 days to provide sufficient time for model initialization and assessment.

Temporal domain is not applicable for the near-field models as the response time within the exposure area is relatively short (i.e., less than 30 minutes), and therefore hydraulic and water quality conditions are accurately interpreted as steady-state.

Bathymetry

The bathymetry of the Rio Uruguay is characterized in the model from published hydrographic charts. The bathymetric data is interpolated onto the model grid from the available hydrographic information. The bathymetry for the portion of the model within the vicinity of the two plants is presented in Figure D5.1-3. As illustrated, the bathymetry accounts for the deeper channel along the centerline of the river and shallower areas along either bank. The depth in the vicinity of the diffusers is approximately 13.5 and 19 m for Botnia and ENCE, respectively.

Boundary Conditions

Boundary conditions refer to the hydrodynamic information used to describe the boundaries of the model. More specifically, it refers to the data used to characterize flow at the Salto Grande Dam, water elevation at Las Cañas, and wind throughout the Rio Uruguay. Flow and water elevation data are described in Section D2.0 and wind data are described in Annex C. The boundary conditions used scenarios correspond to a typical flow scenario (6,200 m^3/s), an extreme low flow scenario (500 m^3/s), a flow reversal scenario under an extreme low flow. For the extreme low flow scenario, three different wind conditions were investigated, consisting of calm, a south-west wind and a north-east wind.

The extreme low flow scenario of 500 m^3/s represents a drought condition with a recurrence interval in the range of 5 to 20 years, on average. In comparison, CARU requires that all assessments of receiving water effect be completed using a flow scenario corresponding to a 5-year recurrence interval. The extreme low flow scenario is therefore conservative.

Source Characteristics

The quantity and quality of the proposed discharges for the two plants are described in further detail in Sections D4.2 and D4.3 and presented in Tables D4.2-1, 4.3-1 and 4.3-2. The load scenarios are based on the maximum monthly values estimated for each mill. This provides an additional degree of conservatism over the annual average load since the joint probability of the extreme low flow and occurrence of the monthly maximum load exceed the 5-year recurrence interval specified by CARU. The joint probability of the extreme low flow and occurrence of the daily maximum load was considered far greater than the 5-year recurrence interval and therefore not included in the analysis. However, the maximum monthly and daily loads do not differ greatly, and therefore the conclusions presented in Section D6.0 show extend to both load scenarios.

Ambient Conditions

Ambient water quality within the Rio Uruguay near Fray Bentos is described in Section D2.0. The far-field models are implemented to simulate these water quality characteristics as the baseline conditions for the assessment. The specific conditions used in the model are presented in Section D6.0 and are based on the specific measurements obtained by Algoritmos (2006).

Water Quality Transformations

The model investigation included the following water quality constituents: temperature, color, conductivity, bacteria, biochemical oxygen demand, phosphorus, nitrogen, ammonia, total suspended solids, absorbable organic halides, phenols, dioxin and furan, 2,3,7,8 TCDD, endocrine disrupting compounds, and metals.

As a conservative measure, it is assumed that all water quality parameters remain conservative, and therefore do not react, decompose or transform in anyway within the ambient environment. This conservative assumption may bias the prediction towards an over-estimate of the actual concentration since many of these water quality parameters may undergo some form of biochemical or physical transformation that will reduce the concentration. In particular, bacteria, biochemical oxygen demand, ammonia, total suspended solids and absorbable organic halides are expected to die-off, decompose or settle whereby reducing the concentration from that predicted. Temperature is also treated in a similar manner although heat from the effluent may dissipate to the atmosphere to further reduce potential temperature effects.

Dissolved oxygen was initially included in the model but shown to be unaffected by the mill operations under all possible conditions. Considering the high degree of dilution within the exposure area and extremely short travel time through this 35 m zone, the effect of mill effluent on dissolved oxygen is negligible. (For example, assuming a 5-day biochemical oxygen demand of 60 mg/L, dilution of 100:1 at the edge of the exposure area, decay rate of 0.05 1/day, and travel time through the exposure area of several minutes, the calculated consumption of dissolved oxygen is estimated to be less than 0.05 mg/L in comparison to a background concentration of 8 mg/L.)

The transformation of total suspended solids is also more complex than for most constituents. The potential accumulation of suspended solids derived from the effluent discharges is of interest within the immediate vicinity of the diffusers and within Yaguareté bay. The deposition of suspended solids may occur during quiescent periods, and resuspension of these solids may occur during periods of high flow and/or wind events causing waves. These potential transformations are discussed further in Section D6.3.2.

D5.1.4 Model Calibration and Validation

Model calibration and validation is a process by which to gain confidence in the predictive capacity of the model. The calibration process is used to “fine-tune” model parameters to improve upon the accuracy of the model, where as the validation process compares model predictions to field measurements without adjustment to provide a direct indication of model precision.

Calibration and validation of the far-field hydrodynamic model is completed by comparing predicted and measured water elevation data for various locations along the Rio Uruguay (i.e., Concordia, Colón, Paysandú, Concepción del Uruguay, Nuevo Berlin and Fray

Bentos). Calibration period extended from 05 to 25 January 1997 and the verification period extended from 05 to 25 February 1997, as illustrated in Figures D5.1-4 and 5.1-5. These periods were selected as the flow conditions at Salto Grande dam differed significantly, thereby testing the validity of the model over a fairly wide range of conditions.

During calibration, the coefficient of roughness (referred to as the Manning's coefficient) was adjusted to provide the best prediction. The best estimate was obtained using a Manning's coefficient of 0.03 over the portion of the river extending downstream from the Salto Grande dam to Colón and 0.025 over the lower portion of the river to Las Cañas.

Based on this calibration and verification, it is concluded that the hydrodynamic model provides an accurate presentation of the flow dynamics along the Rio Uruguay below the Salto Grande dam. The model accurately simulates the temporal variability in water elevation along the river. There are a few occasions where the predicted and measured water elevations do not coincide but these are limited and do not distract from the overall validity of the prediction. Further refinement of the bathymetric data, particularly within the region of the Rio Uruguay Island Delta, may resolve these differences.

The far-field water quality model was not calibrated or verified directly since the discharge for the mills presently does not exist to provide appropriate data. Instead, information regarding the dispersion coefficients for the river was obtained from prior investigations of bacteria levels within the vicinity of the city of Paysandú. This prior investigation estimated dimensionless scaling factors for longitudinal and lateral dispersion of 0.50 and 0.10, respectively.

D5.2 Literature Review

Mathematical models of effluent dispersion, with comparison to water quality guidelines, are sufficient to address the potential for environmental effects for many water quality parameters. However, for some parameters, literature information pertinent to expected effluent levels and/or environmental levels of concern, based on experience gained over the years at other facilities, can help to elucidate the potential for environmental effects.

Dioxin and furan, endocrine-disrupting compounds and chemicals associated with fish tainting fall into this category. A brief review of relevant literature on these compounds is provided in the following sections.

D5.2.1 Dioxins and Furans

The polychlorinated dibenzo-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) include 210 different forms, or congeners, of which 17 are toxic, persistent and bioaccumulative. These compounds have different detection limits in water, typically from 0.2 to 2 pg/L (parts per quadrillion). They are often difficult to detect in water, because they are hydrophobic, but will readily accumulate to detectable levels in organic sediments and fish tissues, because they are lipophilic.

The various PCDD and PCDF congeners vary in toxicity over three orders of magnitude, with 2,3,7,8-TCDD being most toxic. Toxic equivalence factors (TEF) are usually used to weight the concentrations of different congeners in a mixture so as to express the concentration of the mixture as an equivalent (TEQ) concentration of 2,3,7,8-TCDD. Two commonly used TEF systems are shown in Table D5.2-1. There are minor differences between systems.

Typical sources of PCDDs and PCDFs in the environment include pesticide manufacturing, industrial and municipal chlorination processes, and various combustion processes. Historically, they have included bleached kraft pulp mill effluents, municipal sewage treatment plant sludges, municipal and medical incinerators, burning of fossil fuels and forest fires.

Pulp mill releases of PCDDs and PCDFs have been drastically reduced since about 1990 with the implementation of ECF bleaching and the installation of secondary wastewater treatment. Haliburton and Maddison (2003) report that Canadian pulp mill discharges of PCDDs and PCDFs were reduced by 99% over this period. The most toxic congeners (2,3,7,8-TCDD and 2,3,7,8-TCDF) were characteristic of effluents from older pulp mills using elemental chlorine bleaching. Figure D5.2-1 from Environment Canada illustrates the declining trend in dioxin/ furan releases.

Shariff *et al*. (1996) studied 17 mills which had replaced elemental chlorine with chlorine dioxide in the first stage of bleaching, and reported that the most toxic congener (2,3,7,8-TCDD) was not found in mill effluents (at detection limits of 0.3-9 pg/L) or in bleached pulp (at detection limits of 0.1-0.3 pg/g). Five mills rarely, and six mills frequently detected the less toxic congener (2,3,7,8-TCDF) in their effluents although these were older mills which may have accumulated TCDF in the historic sludge deposits in the treatment system.

The same investigation by Shariff *et al*. (1996) concluded that the concentrations of the signature congeners in fish downstream of all ECF mills declined rapidly since implementation of ECF bleaching. At one new ECF mill, which had never used elemental chlorine, concentrations of both 2,3,7,8-TCDD and 2,3,7,8-TCDF in fish downstream of the mill were not detected, with a 0.1 pg/g detection limit.

In a study of sediment cores in a lake that had received bleach kraft mill effluent since 1965, with implementation of ECF bleaching over the 1988-93 period, Macdonald (1998) found that PCDDs and PCDFs associated with elemental chlorine bleaching peaked in core segments dating to the mid-1980s, and dropped drastically around 1990 to levels consistent with the pre-1960 background. This indicated that, since the implementation of ECF bleaching, there was virtually no mill contribution to environmental contamination with PCDDs or PCDFs that was discernable in relation to background sources.

These and other studies indicate that releases of dioxins and furans in liquid effluents from modern ECF mills are expected to be very low. UNEP (2003) suggests a release rate of $6x10^{-11}$ kg TEQ/ADt for such mills. In comparison, Botnia and ENCE estimate the release rate to be less than $2.5x10^{-10}$ and $2.9x10^{-10}$ kg/ADt, respectively based on effluent discharge rates of 25 and 29 m^3/ADt, respectively, and a conservative estimate of concentration of less than 10 pg/L TEQ. Review of effluent data for a European mill (Table D4.3-3) shows that there was less dioxin and furan in the effluent than in the raw water. On a TEQ basis, the concentration was less than 2 pg/L in the effluent.

Dioxins and furans in 40 drinking water supplies in Japan averaged 56.4 pg/L (Kim *et al.*, 2002). Similarly, concentrations in raw water from the western end of Lake Ontario, Canada, ranged from 10 to 50 pg/L (MOE, 1986). The more highly chlorinated congeners predominate in raw water. Meyer *et al.* (1989) reported OCDD concentrations from 9 to 175 pg/L in 20 New York State water supplies, but 2,3,7,8-TCDD was found in only one sample, at 1.7 pg/L. The U.S. EPA (2003) drinking water standard for 2,3,7,8-TCDD is 30 pg/L. Rio Uruguay water samples collected by Tana (2005, 2006) in the vicinity of Fray Bentos and Las Cañas ranged from less than 11 to 49.8 pg/L, total PCDD and PCDF, with TEQ values as high as 0.46 pg/L.

The primary route of human exposure to dioxins and furans is through the food chain and, in the context of aquatic contamination, through consumption of fish. Dioxins and furans accumulate in fish flesh, with levels dependent on fish lipid content, feeding habits, and most importantly time spent in contaminated areas. Bioaccumulation potential differs among congeners and is also likely influenced by the particulate organic content (POC) in the water. Dioxin and furan levels of human health concern in fish flesh have been defined in TEQ units at 4 to 20 pg/g FW (e.g., U.S. EPA, 2000; EC, 2001). Advisories on restricted fish consumption begin in this range. They are based on consideration of developmental or carcinogenic effects, which are the limiting human health endpoints.

Measured values of dioxins and furans in fish flesh are quite variable depending on fish species and local histories of aquatic contamination. The U.S. EPA (1992) conducted a nation-wide survey and reported an average of 11.1 pg TEQ/g (range up to 213 pg/g). A more recent study in Finland (Isosaari *et al.*, 2006) found freshwater fish values from 0.1 to 4.6 pg TEQ/g and Baltic Sea fish values from 0.1 to 8.7 pg TEQ/g. In an uninfluenced portion of the Mississippi River, Reed *et al.* (1990) reported average levels of different congener groups in fish flesh ranging from 59 pg/g for OCDD to 3.9 pg/g for TCDD. Fishes in the Rio Uruguay were collected by Tana (2005, 2006) in the vicinity of Fray Bentos and Las Cañas, and were found to have TEQ levels of 0.1 to 0.3 pg/g FW[1]. The unweighted sum of dioxin and furan congeners was in the 1.0 to 1.8 pg/g range.

A water quality guideline for 2,3,7,8-TCDD was defined by the U.S. EPA (2002) at 0.005 pg/L. This value is intended for protection of human consumers of fishes, and is based on conservative assumptions about bioaccumulation into fishes, including continuous fish exposure, as well as linear no-threshold dose-response assumptions. It is well below any practical detection limit, and also well below the levels that have been found in some surface water supplies. It is applicable only to the specified congener.

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[1] FW refers to fresh weight

Since dioxins and furans in the proposed mill effluents are expected to be at or below detection limits, only an upper bound can be defined. The project assessment methodology will involve comparison of this upper-bound effluent level, and of diluted effluent concentrations in the Rio Uruguay, to the baseline levels in Rio Uruguay water. Uncertainties about average effluent concentrations, congener composition and bioaccumulation processes preclude quantitative forecasting of small increments (if any) in fish tissues. However, it can be expected that any changes in fish tissue levels will be approximately proportional to changes in dioxin and furan concentrations in the river, particularly in shallow nursery areas such as Yaguareté Bay where fish may feed and reside for some time. This is discussed further in Section D6.3.

D5.2.2 Endocrine Disrupting Compounds

Effects observed in fishes downstream of some paper mills have included nutrient enrichment effects, such as increased weight at age and condition factors, and reproductive effects such as reduced gonad weight and delayed maturity. The reproductive effects have often been attributed to disruption of endocrine functions in fishes (Environment Canada, 2003). Endocrine disruption has been associated with many types of substances, including pesticides in agricultural runoff, alkylphenolics (e.g., nonylphenol) in industrial and municipal effluent, natural hormones and synthetic steroids in municipal effluents (Environment Canada, 1999). Various wood extractives[2] in mill effluents have been shown or suggested to have endocrine activity, either mimicking or blocking fish hormones. These include lignins, stilbenes, phytosterols and triterpene alcohols, as well as some resin acid metabolites such as retene (Norrstrom and Karlsson, 2006). These plant constituents are naturally occurring in the environment and are not associated with the bleaching process.

Reproductive effects in wild fishes have not been associated with pulp mill effluent concentrations lower than about 1% effluent (100:1 dilution) in water (Golder, 2006; Munkittrick *et al*., 1998, McMaster *et al*., 2003). In the Canadian environmental effects monitoring (EEM) program, which is designed to detect possible mill effects on fishes, the fish studies are not required when mill effluent is diluted to 100:1 within 250 m of the discharge (Environment Canada, 2005). This is because the zone of potential effect is so small that fish could spend very little time exposed to effluent concentrations that could produce reproductive effects.

Borton *et al*. (2006) have reported on correlations between chemical constituents of kraft mill effluents and reduced egg production in fish life-cycle tests. Polyphenols, which include lignins and tannins, and phytosterols were both correlated with the reproductive response to effluent exposure. Resin acids, per se, were not correlated with the response.

Reproductive effects in fishes may involve males as well as females. Martel *et al*. (2006) found that untreated TMP mill effluent increased vitellogenin levels in males, as well as

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[2] Non-structural chemical components of wood that are extracted into the wastewater during the wood pulping process.

reducing estradiol levels in females. Both effects were greatly reduced after biological treatment of the effluent. Testosterone levels may also be reduced in males. Hewitt *et al*. (2006) associated this effect in particular with several condensate extractives – stilbene and several terpinoids.

The dose-response pattern for estrogenic effects is complex. Rickwood *et al*. (2006) present evidence for a hormetic response pattern, whereby low concentrations of estrogenic compounds in final mill effluent increase egg production in fishes, while higher concentrations cause a decrease in reproductive output.

Phytosterols have been particularly well studied as inducers of estrogenic responses in fishes. One such compound, β-sitosterol, has been shown to have a threshold effect concentration of approximately 10 μg/L (Lehtinen and Tana, 2001). Baseline concentrations of phytosterols in the Rio Uruguay range from "non-detect" (less than 1 to 3 μg/L) to 22 μg/L (Tana, 2005, 2006). The sitosterol concentration was up to 5 μg/L.

Resin acid metabolites related to endocrine disruption will not be produced as a result of mill operations, because eucalypt wood and effluent does not contain resin acids (ENSIS, 2006). Baseline levels of resin acids in the Rio Uruguay are 35 to 224 μg/L (Tana, 2005, 2006). These levels will not be changed as a result of mill operations. Natural background concentrations in the 1 to 10 μg/L range have been observed in Scandinavian rivers (Soimasuo, 1997; Karels, 2000), and Tana mentions unpublished values over 1,000 μg/L in some tropical rivers.

Biological treatment has been shown to significantly reduce the reproductive effects of mill effluents. A TMP mill effluent, studied by Martel *et al*. (2006) prior to treatment, caused reduced egg production in a fathead minnow bioassay test at a 2% effluent concentration. Estradiol hormone levels in females were also reduced. After biological treatment, the effluent did not produce these effects, even at a 40% effluent concentration, the highest concentration tested. The Swedish EPA (1997) reports that phytosterols and triterpene alcohols are greatly reduced (more than 10-fold) by biological treatment of bleached softwood mill effluents. The two proposed mills on the Rio Uruguay have good biological treatment systems, which means that endocrine disruptor effects are unlikely.

Since a variety of chemicals have been implicated as agents of endocrine disruption, and since there are many possible agents, including some that may not yet be identified, a chemical-specific approach to forecasting of endocrine disruption effects is problematic. Nevertheless, consideration of phytosterol levels in effluents, relative to documented effect levels and river baseline levels, and of whole effluent concentrations in receiving water, relative to documented effect levels at other mills, can provide an indication of the likelihood of such effects in fishes. These considerations are further discussed in Section D6.3.

D5.2.3 Fish Tainting

Fish tainting has been associated with both chlorinated and non-chlorinated constituents of both bleached and unbleached pulp mill effluents (EC/HC, 1991). It may also arise from naturally occurring substances in waters where fish reside, which can complicate the identification of causal agents. Kovacs (1986) reported that bleached kraft mill effluent concentrations as low as 2 to 4% have produced tainting. Tainting effects are generally associated with older mill technologies.

In the Canadian Environmental Effects Monitoring (EEM) program involving more than 100 mills across Canada, fish tainting related to mill effluent was confirmed in one case and suspected in another case (Environment Canada, 2003). Generally, pulp mill effluents in Canada are not impacting the usability of fisheries resources.

Several naturally occurring substances produced by blue-green algae and actinomycetes (slime moulds) have been implicated as causal agents of fish tainting (Yurkowski and Tabachek, 1980). These substances include geosmin and 2-methylisoborneal.

Pulp mill effluent constituents implicated in fish tainting include 2,4-dichlorophenol and 2,4,6-trichlorophenol (Persson, 1984). Water concentrations as low as 0.1 μg/L and 1 μg/L, respectively, were shown in laboratory studies to be sufficient to produce tainting, and to be at or below the levels found in some bleached kraft mill effluents. Paasivirta *et al*. (1983) cited chlorophenols and chloroanisoles (microbial metabolites of chlorophenols) as likely agents of tainting in bleached kraft mill effluents. Neilson *et al*. (1984) also identified tri and tetra-chloroveratroles (microbial metabolites of chlorophenols) as likely causal agents. In sulphite mill effluent, Berg (1983) found fish tainting to be correlated with terpenes and their derivatives. Heil and Lindsay (1988) have also suggested thiophenols and alkylphenols as tainting agents.

Simple aeration and/or secondary treatment of mill effluents has been shown to substantially reduce the tainting effect (Cook *et al*., 1973; Gordon *et al*., 1980; Miettinen *et al*., 1982). Two- to 10-fold reductions in tainting response have been observed following such treatment. The two proposed mills on the Rio Uruguay have good biological treatment systems, which means that fish tainting effects are unlikely.

Since a variety of chemicals have been implicated as agents of fish tainting, and since there are many possible agents, including some that may not yet be identified, a chemical-specific approach to forecasting of fish tainting effects is not feasible. Nevertheless, consideration of whole effluent concentrations in receiving water, relative to documented effect levels at other mills, can provide an indication of the likelihood of such effects. These considerations are further discussed in Section D6.3.

Figure D5.1-1: Spatial Domain of the Far-Field Model

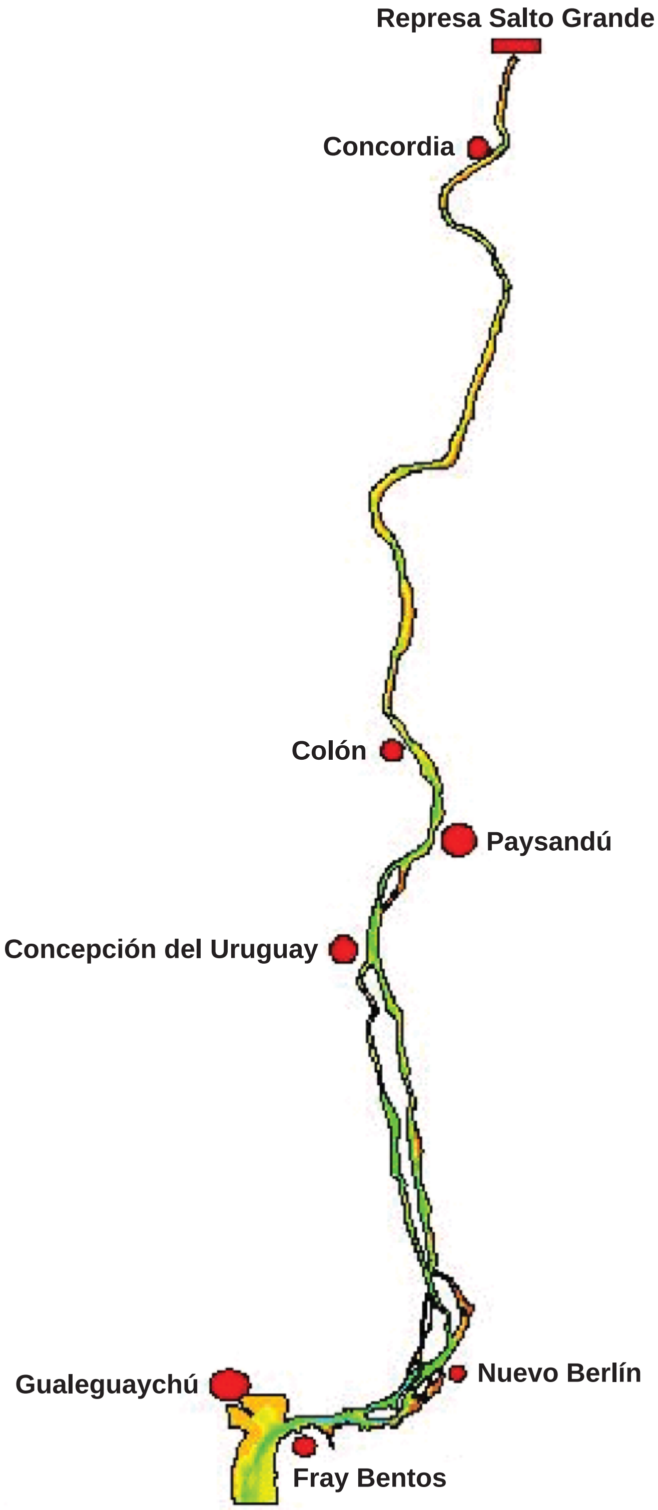


Figure D5.1-2: Model Grid

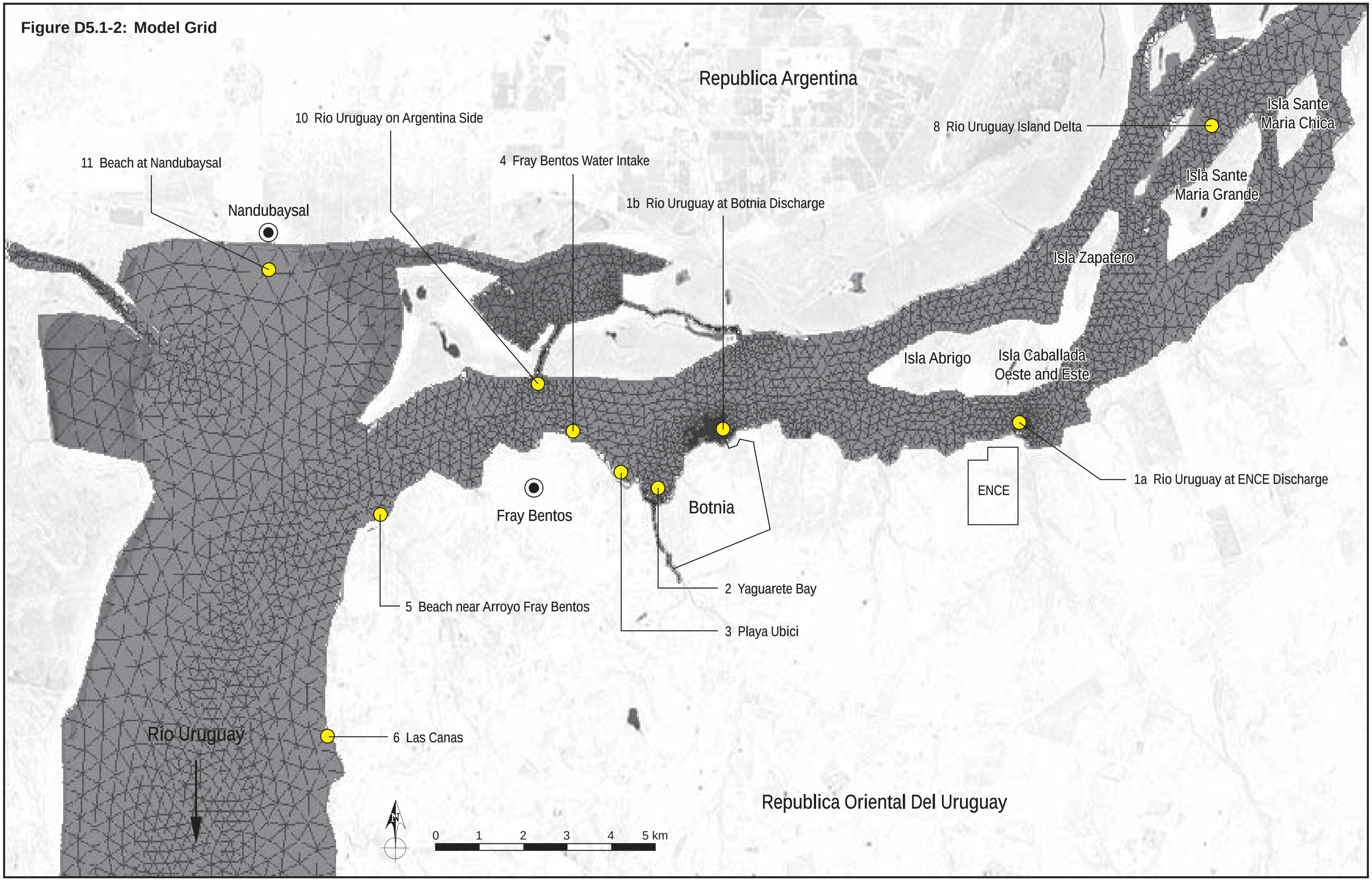
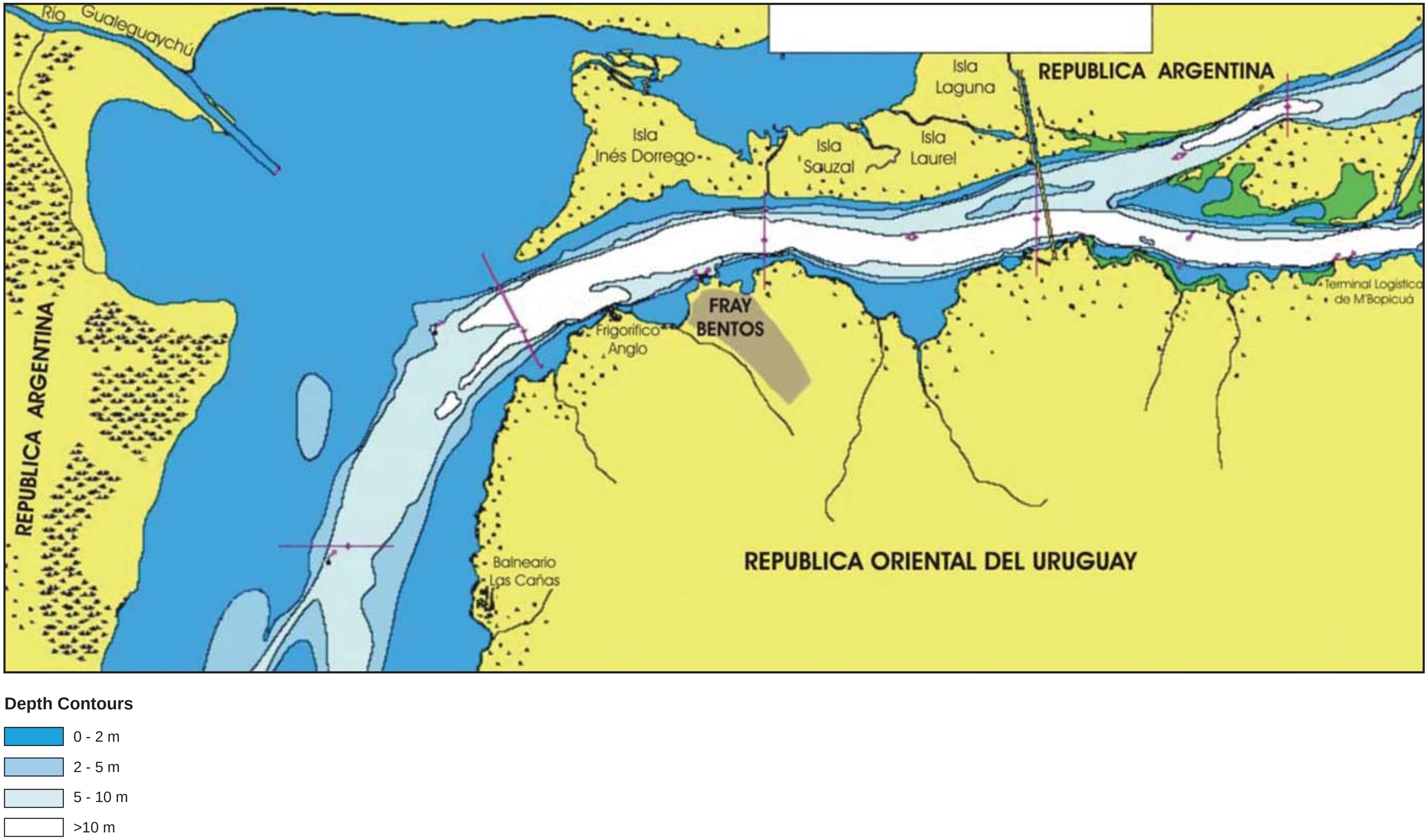


Figure D5.1-3: Bathymetry of the Rio Uruguay Near the Mill Sites



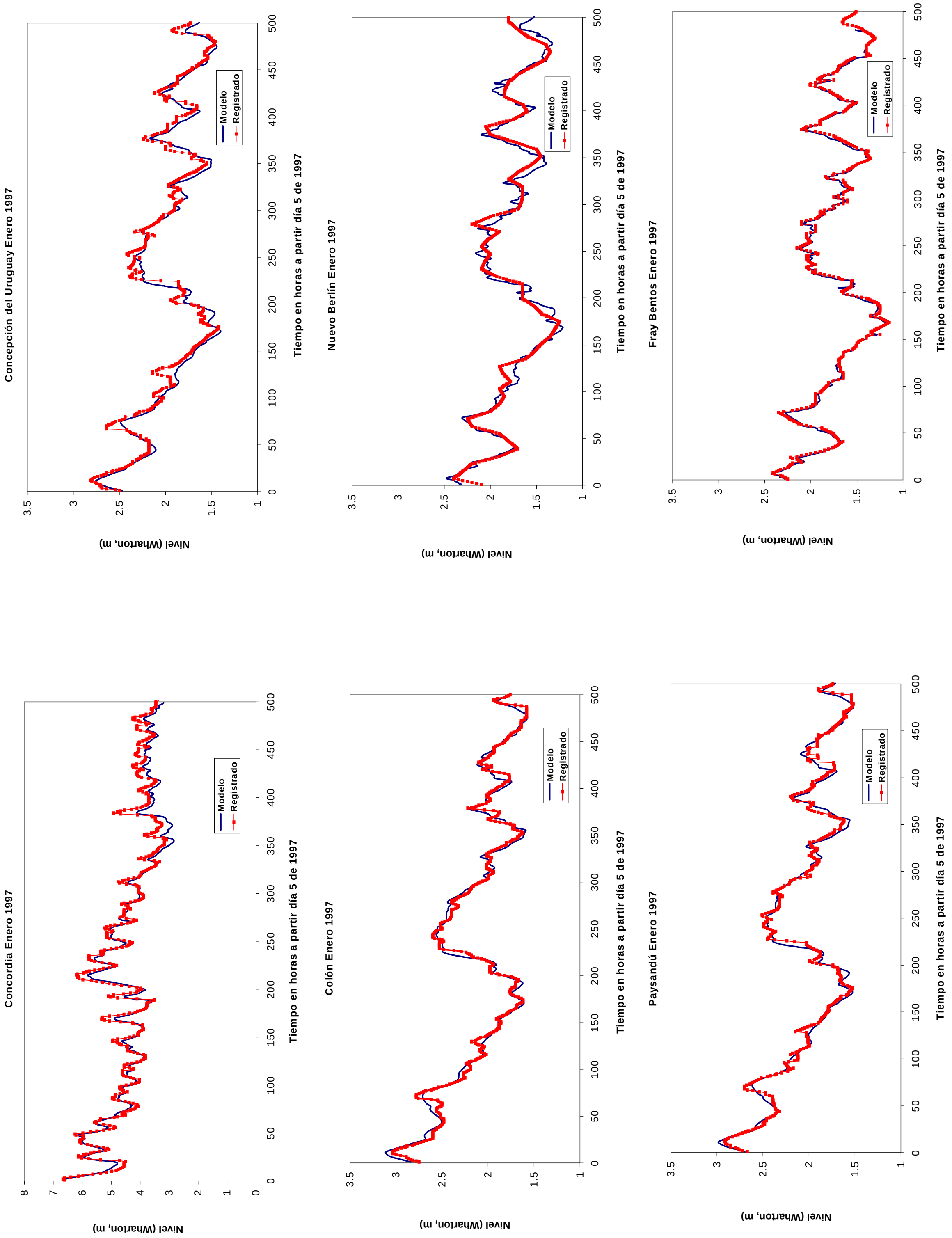


Figure D5.1-4: Calibration of the Far-Field Hydrodynamic Model

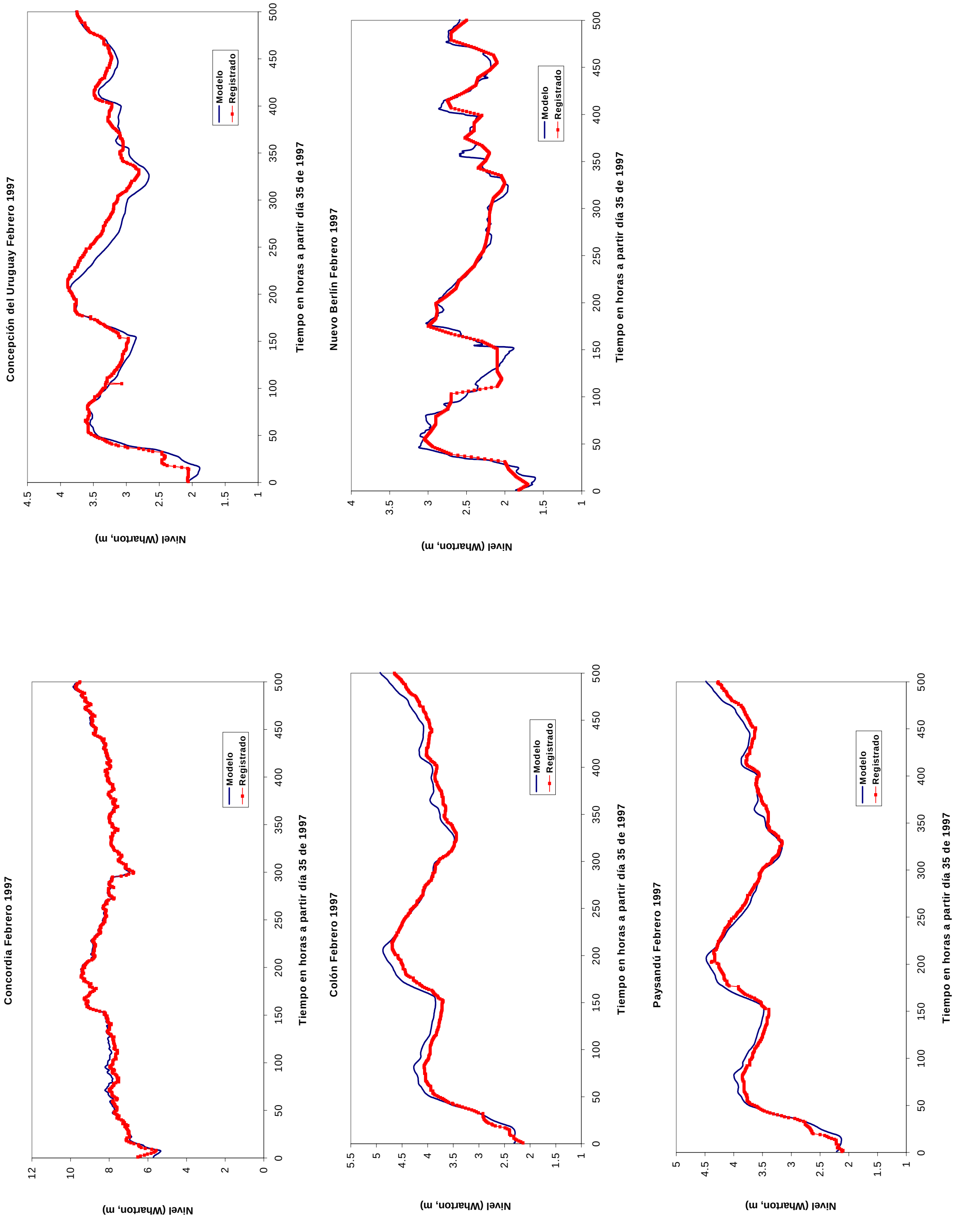
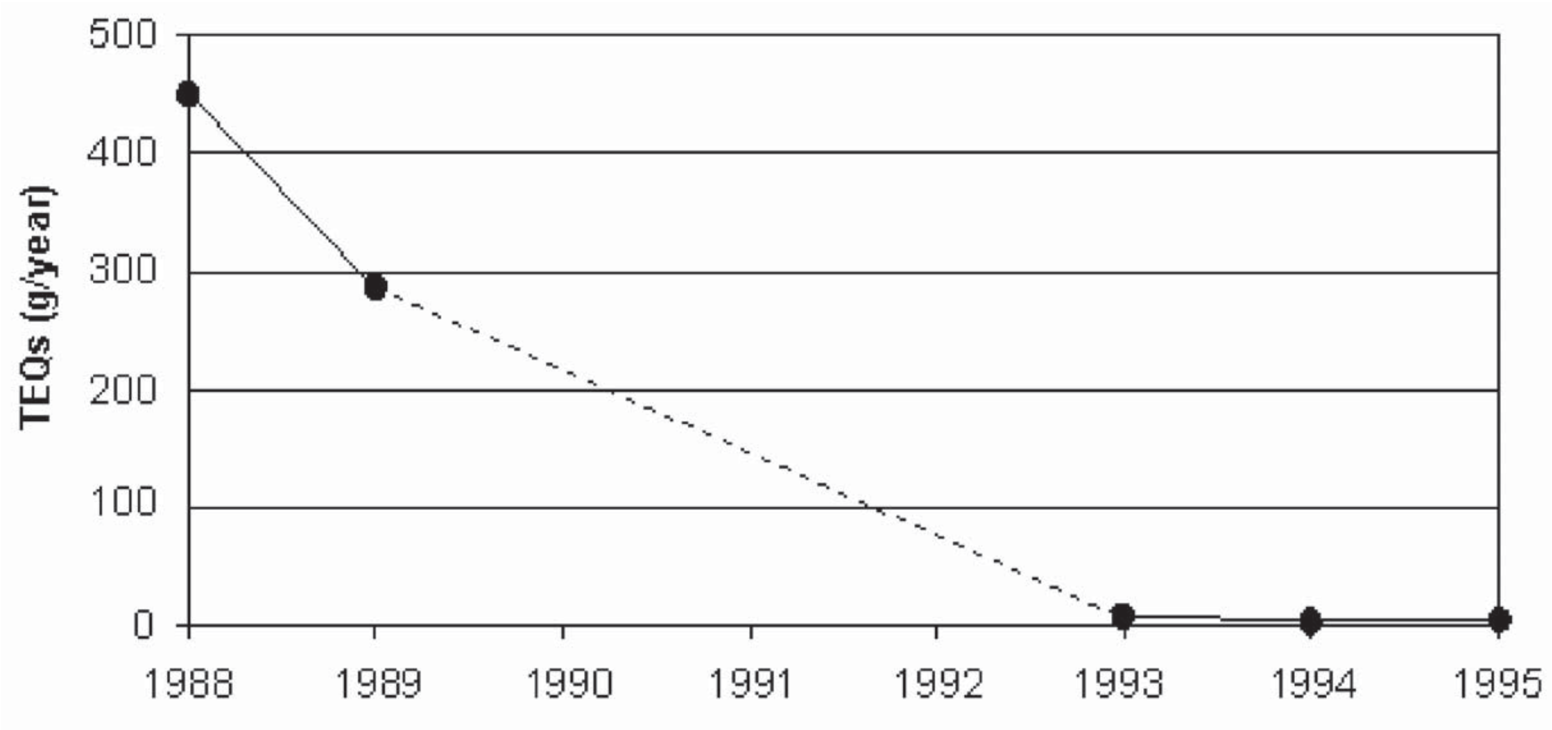


Figure D5.1-5: Verification of the Far-Field Hydrodynamic Model

Figure D5.2-1: Estimates of National Annual Releases of All Dioxins and Furans, in Toxic Equivalents (TEQs), from all Canadian Pulp Mills using Chemical Bleaching Processes



Note: Dashed line represents missing data.

Sources: PAPRICAN and National Office of Pollution Prevention (in preparation).

D6.0 POTENTIAL EFFECTS TO THE AQUATIC ENVIRONMENT

There are various resources within the Rio Uruguay which are of particular interest with respect to the discharge of wastewaters from the two mills. These resources include drinking water supply, valued recreational areas and sensitive environmental areas located within both Uruguay and Argentina. The following sections identify these specific aquatic resources and provide an assessment of the potential effects from the wastewater discharge from the two mills. A separate assessment is presented in Annex C to address specific concerns relating to atmospheric emissions.

D6.1 Sensitive Receptor Locations

Several locations within the Rio Uruguay are of particular interest from the perspective of water quality, recreation and environmental effects due to the value of the aquatic resource. These locations are illustrated in Figure D6.1-1 and briefly identified below. This figure also presents the location of the discharge for the two mills. The sections that follow provide a detailed evaluation of potential effects for each of these receptors.

Sensitive receptors in Uruguay include the following:

- Receptor 1 – The areas of the Rio Uruguay in the immediate vicinity of the two discharges locations are of interest with respect to possible plume visibility, as well as localized changes in fish habitat features such as water velocity and temperature;
- Receptor 2 – The Yaguareté Bay area downstream of the Botnia site is of interest with respect to water quality, sedimentation and sediment quality;
- Receptor 3 – The Playa Ubici area at the downstream edge of Yaguareté Bay is of interest as a recreational area with beach use, which is therefore sensitive to water quality issues;
- Receptor 4 – The Fray Bentos water intake is of interest with respect to drinking water supply;
- Receptor 5 – The beach area near Arroyo Fray Bentos Fray Bentos is of interest since it is located downstream from the municipal discharge for the city of Fray Bentos;
- Receptor 6 – The beach areas further downstream at Las Cañas is an important tourist destination and is therefore sensitive to water quality issues;
- Receptor 7 – The Rio Uruguay flows into the Rio de la Plata which is the most downstream receptor of the wastewater discharges;

- Receptor 8 – The Esteros de Farrapos e Islas del Rio Uruguay is a designated Ramsar site located along the Rio Uruguay between Nuevo Berlin and San Javier (approximately 15 to 60 km upstream from the International Bridge, and has been mentioned by some stakeholders as being potentially influenced by mill effluent during episodes of flow reversal in the Rio Uruguay; and

- Receptor 9 – Rio Negro, a tributary of the Rio Uruguay that presently receives untreated wastewater from Papelera Mercedes, may benefit from the treatment of these wastewaters at the Botnia mill.

Sensitive receptors in Argentina include the following:

- Receptor 10 – The area of the Rio Uruguay on the Argentina side of the international border across from Fray Bentos is of interest in terms of water quality and fisheries resources; and
- Receptor 11 – The beach area on the Argentina side of the river at Ñandubaysal is of interest as it is identified by members of the public as an area of significant value from a tourism and recreation perspective.

D6.2 Effluent Exposure within the Rio Uruguay

The two mills are proposing to discharge a high quality treated effluent to the Rio Uruguay within Uruguayan waters near the city of Fray Bentos. These wastewaters contain organics (e.g., biochemical oxygen demand), nutrients (e.g., nitrogen, phosphorus) and other constituents (e.g., conductivity, AOX) that may cause a relatively small change in the water quality of the Rio Uruguay. As a first step in the assessment of potential effects, it is necessary to provide context regarding which areas of the river are and are not exposed to these wastewaters and at what magnitude.

The mathematical models described in Section D5.1 are used to provide this context. They provide a rational basis to delineate the areas of potential exposure to the wastewater and to quantify the specific change in water quality under varying conditions. Figures D6.2-1 through D6.2-3 provide specific results from these mathematical models to help provide the contextual basis for the assessment of potential effect. These figures correspond to the following three flow conditions for the Rio Uruguay: a typical flow (6,230 m^3/s); an extreme low flow (500 m^3/s); and a flow reversal under the extreme low flow (corresponding to Figures D6.2-1, D6.2-2 and D6.2-3, respectively). For all three scenarios, the discharge rate is 0.83 and 0.55 m^3/s for the Botnia and ENCE mills, respectively[1]. These scenarios are described in the following sections.

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[1] The optional flow augmentation described in Section D4.5 will increase the flow by entraining river water at the diffuser, but will also proportionally decrease the concentration of the respective water quality parameters and therefore will not affect the loadings to the river.

D6.2.1 Effluent Exposure under Typical Flow Conditions

Under the typical flow condition, the combined volume of wastewater represents approximately 0.02% of the river flow (based on the average river flow of 6,230 m^3/s and combined effluent flow of 1.38 m^3/s). This is a very small discharge rate relative to the capacity of the river.

Immediately at the point of discharge to the river, the high flow of the river causes rapid mixing of the wastewater as soon as it enters the Rio Uruguay. The concentration of wastewater reduces by several hundred times within meters of the diffuser, resulting in an exceedingly small exposure area, as illustrated in Figure D6.2-1.

This exposure area is based on the definition used by Environment Canada in their Environmental Effects Monitoring (EEM) program for the Pulp and Paper Sector (Environment Canada, 2003). It defines the exposure area as the area from the diffuser to the point of 100:1 dilution of the effluent. Experience gained through the EEM program over the past decade at over 130 mills in Canada shows that environmental effects are generally confined within this 100:1 dilution zone. It is therefore the region of focus for environmental effects monitoring.

D6.2.2 Effluent Mixing Under Extreme Low Flow Conditions

The extreme low flow is estimated to be 500 m^3/s. This flow condition corresponds to a drought in the Rio Uruguay basin with a recurrence interval in the range of 5 to 20 years. Under this extreme condition, the combined volume of wastewater represents approximately 0.28% of the river flow, which is also very small relative to the capacity of the river.

As illustrated in Figure D6.2-2, the wastewater rapidly mixes with the ambient river flow of the Rio Uruguay resulting in a very small exposure area (based on 100:1 dilution). This exposure area is calculated to extend 35 m downstream from the diffuser and 200 m along the length of the diffuser for this extreme low flow condition. The small size of this exposure area minimizes any potential effects on fish since their range usually extends over a considerably larger area (measured in kilometers rather than meters). For this reason, Environment Canada generally does not require monitoring of fish related effects as part of the EEM program if the exposure area is less than 250 m from the diffuser.

Figure D6.2-2 also presents the calculated conductivity at each of the nine receptor locations. The results are also summarized in Table D6.2-1. Conductivity is used as a conservative tracer to delineate the spatial extent of the effluent plume. As presented, the calculated conductivity at the edge of the exposure area (Receptor 1) is 140 µS/cm in comparison to an ambient conductivity of 100 µS/cm and effluent conductivity of 4,000 µS/cm. Receptors located further from the two discharges have a lower conductivity, such as the Fray Bentos water intake with conductivity of 124 µS/cm and the beach area at Las Cañas with conductivity of 116 µS/cm. Receptors located off the centre line of the plume also have a lower conductivity, such as Yaguareté Bay with conductivity ranging from 103 to 114 µS/cm depending upon the direction of the wind. Within Rio de la Plata, the conductivity is estimated to be indistinguishable from background levels (100 µS/cm) given the inflow of both Rio Uruguay and Rio Paraná.

Conductivities at the two receptors located in Argentina and one receptor located upstream from the ENCE mill are not expected to change appreciably from background levels. These receptors include the Argentina side of the Rio Uruguay, the beach area at Ñandubaysal and the island delta region of the Rio Uruguay. For these three receptors, the dilution of effluent with ambient river water is predicted to exceed 1,000:1. Environment Canada defines areas that exceed 1,000:1 dilution as reference areas and considers them representative of background conditions unaffected by the wastewater discharge.

D6.2.3 Effluent Mixing Under a Flow Reversal and Extreme Low Flow Conditions

As described in Section D3.1, on rare occasions (a few times per year or less) the flow in the Rio Uruguay may reverse direction and travel upstream for a short period of time. This condition occurs only when the flow at the Salto Grande dam is low and only during a strong wind seiche in the Rio de la Plata. The specific analysis described here is based on site measurements of flow and water elevation and are therefore reflective of an actual flow reversal event. Flow at the dam was approximately 700 m^3/s while the water elevation at Fray Bentos varied from approximately 1 m to over 2.5 m over a 24-hour period.

It is important to recognize that the flow reversal event is highly dynamic and lasts for only a few hours. During this time, the wastewater first moves upstream, pauses and then moves downstream in response to the changing direction of the flow. The point at which the wastewater stops moving upstream and starts moving downstream is the farthest distance traveled. It is referred to as the excursion distance and is limited in length by both the magnitude and duration of the flow reversal event.

Figure D6.2-3 presents the results of the analysis at the peak of the flow reversal event when the wastewater has extended the full length of the excursion distance. If this figure could show the elapse of time, it would show the plume reverse direction and return downstream over the next few hours.

As illustrated, at the peak of the event, the exposure areas for each discharge extend approximately 35 m from the respective diffusers, and likewise the excursion distances at 100:1 dilution extends the same distance. Trace levels of the wastewaters will extend beyond 35 m to a maximum extent of approximately 7,000 m from the ENCE mill at 1,000:1 dilution for a few hours before returning downstream. The island delta region of the Rio

Uruguay is located further upstream beyond the influence of the wastewater discharge during flow reversal. At Paso Tres Cruces located towards the downstream end of the island delta, the maximum conductivity during the flow reversal event is predicted to be less than 101 µS/cm with a corresponding dilution greater than 1,000:1.

During the few hours of the flow reversal event, trace levels of wastewater may extend across the Rio Uruguay into Argentina waters at the 700:1 dilution level. The resulting conductivity is estimated to be 101 µS/cm in comparison to an ambient level of 100 µS/cm. This is a theoretical change and not measurable against the natural variability of the ambient water.

D6.3 Potential Effects at Identified Receptors in Uruguay

The potential effects of the proposed discharge of wastewaters from the Botnia and ENCE mills on the aquatic resources of the Rio Uruguay are described in the sections below. The discussion addresses each identified receptor separately. The predicted change in water quality for each receptor is presented in Tables D6.3-1 through D6.3-8 for Receptors 1 through 8, respectively.

D6.3.1 Receptor 1, Rio Uruguay at the Botnia and ENCE Diffusers

The wastewater from the respective treatment plants for the Botnia and ENCE mills will be discharged to the Rio Uruguay through diffuser structures located 200 to 400 m offshore from the river bank and in 13.5 and 19 m of water, respectively. As described in further detail in Section D4.4, each of the diffusers contains a series of nozzles that distribute the wastewater along the 200 m length of the diffuser. This design configuration achieves superior mixing of the wastewater with the ambient river water thereby minimizing the potential effects on water quality.

The exposure areas for each diffuser are confined to an extremely small zone immediately surrounding each diffuser. Under the most extreme condition, the exposure areas extend approximately 35 m from each diffuser and 200 m along the length of each diffuser. Under typical conditions, the exposure areas are limited to a few meters from each diffuser.

The greatest potential effect within these relatively small areas is of an aesthetic nature. There is a slight risk that the discharge for the Botnia mill may be visually detected under extreme low flow conditions by an observer standing on the International Bridge. As illustrated in Figures D6.3-1 and 6.3-2, the close proximity of the Botnia mill to the International Bridge provides a clear view of the diffuser area (to be located near the river marker shown near the centre of the photograph) whereas the ENCE mill is too far away to view the diffuser area from the bridge. The proximity of the Botnia diffuser to the bridge may enable visual detection of the slight change in color of the wastewater relative to the ambient river water and the possible slight disturbance of the surface flow pattern due to the turbulence from the diffuser nozzles. This visual detection of the plume could be objectionable to the public as it may be perceived as an environmental risk, although such detection does not pose any real risk to either public safety or to the environment. These subtle differences are not likely detectable from a boat, and only detectable from the International Bridge because of the height of and view from the bridge.

The water quality within this extremely small exposure area will not pose a risk to humans or aquatic life (Tables D6.3-1a and D6.3-1b). The water quality may exceed one or more of the surface water quality standards of DINAMA and CARU during periods of extreme low flow, although this potential is provided for within the regulatory standards (referred to as a mixing zone). The areas of potential exceedance are relatively small and are confined to areas within the main channel on the Uruguayan side of the river away from sensitive habitat, valued recreational areas and drinking water supplies. They therefore do not pose a direct risk to the valued components of the ecosystem.

Fish may be attracted to these areas because of the warmer temperature and higher velocity immediately at the diffusers. However, the size of this area of exposure is so small relative to the home range for most fish species that the potential for effects on fish is considered minimal. Experience at pulp mills in Canada shows that fish health responses are non-measurable within such small exposure areas, which is the reason why fish surveys are not required as part of the Canadian EEM program if the exposure area extends less than 250 m from the diffuser.

Beyond the edge of the exposure area, the water quality of the Rio Uruguay will be in compliance with all surface water quality standards with the exception of those water quality parameters in exceedance under existing conditions. As described in Section D3.2, the baseline concentration of phosphorus and several metals exceed the surface water quality standards throughout the Rio Uruguay under existing conditions. The discharge of untreated municipal and industrial wastewaters, agricultural fertilizers and other agricultural runoffs all contribute to this existing condition.

Sediments within the immediate vicinity of the diffusers (extending 35 m from the diffuser) may be enriched with nutrients (organic material, nitrogen, phosphorus) as is commonly found near pulp mill diffusers in Canada, and this enrichment may cause a change in the benthic macroinvertebrate community. However, given the extremely small size of the exposure area and high mobility of sediment at moderate and high flows in the main channel, the extent of enrichment is expected to be limited and perhaps transient.

D6.3.2 Receptor 2, Rio Uruguay at Yaguareté Bay

The Yaguareté Bay is a shallow embayment located approximately 1.5 km downstream from the Botnia discharge, as illustrated in Figure D6.3-2. It has been identified as a potentially sensitive aquatic environment since it provides important habitat to various species of fish.

With water depth less than 2 m, it comprises a particularly extensive littoral zone, similar to those existing in other embayments both up and downriver. In general, this littoral zone tends to be more productive than the profundal zone of a river, and as such tends to be used as a feeding area for many fish species, particularly benthivorous species such as catfish and carp. In addition, juvenile fishes of many species feed in these areas due to the high bottom productivity and low density of predatory fishes. Both carp and catfishes tend to use shallow embayments for spawning purposes, and this likely occurs in Yaguareté Bay, as in other shallow embayments up and down the river.

Water velocity is lower in Yaguareté Bay as compared to the main channel, and as such, sedimentation may occur more readily in the embayment than further offshore. At the same time, the embayment is regularly flushed during high flow periods and due to wind/wave action, as evident by the lack of sedimentary features (e.g., islands). Calculations (Yalin, 1992; Dean and Dalrymple, 1984) show that currents of 0.25 m/s and waves of 0.5 m can mobilize silt size sediment in 2 m of water, and these other factors are expected to prevent accumulation of sediment within the embayment.

Suspended sediment discharged from the two mills will not affect the net sedimentation rate within Yaguareté Bay since the potential change in concentration of suspended solids is exceedingly low. As shown in Tables D6.3-2a and D6.3-2b, the change in total suspended solids concentration within the embayment is estimated to range from 0.0 mg/L under average flow to 0.5 mg/L under extreme low flow conditions within the Rio Uruguay. In comparison, the baseline concentration of total suspended solids is approximately 14 mg/L and can range from 2 to 58 mg/L (CARU, 1993). Thus, the predicted change in suspended solids will not measurably change in or near Yaguareté Bay as a result of mill operations, and accordingly, net sedimentation in the bay is not expected to change.

Nutrification is a potential issue for Yaguareté Bay under existing conditions, since algal blooms can occur in the embayment during the summer months. Baseline concentrations of total nitrogen and total phosphorus range from 0.19 to 1.1 mg/L and 0.04 to 0.24 mg/L, respectively (CARU, 1993; Algoritmos, 2006) in comparison to surface water quality standards for total phosphorus of 0.025 mg/L. (A surface water quality standard does not exist for total nitrogen). The discharge from the two mills will not change the concentrations of total nitrogen and total phosphorus in or near Yaguareté Bay under average flow conditions (Table D6.3-2a) and will not measurably change the concentrations under extreme low flow conditions (Table D6.3-2b). Nutrient levels in sediments are unlikely to be measurably changed as a result.

The concentration of chlorinated organics will also remain unchanged in or near Yaguareté Bay as a result of mill operations. Chlorophenolics are chlorinated constituents of particular concern in the mill effluents. Baseline levels of chlorophenolics in the waters of Yaguareté Bay range from approximately 0.0001 mg/L (Tana, 2005, 2006) to 0.0014 mg/L (Algoritmos, 2006). They will not change under average flow conditions and may change marginally by 0.0003 mg/L under the extreme low flow condition. While chlorophenolics may partition to sediments and benthic invertebrates, with minimal changes in water quality and sedimentation in the bay, the levels in sediments and biota are not expected to be measurably changed.

A conservative estimate of the dioxins and furans concentration in the Botnia and ENCE mill effluents is less than 10 pg/L TEQ (note 1 pg/L is equivalent to 10^{-9} mg/L). Based on this conservative estimate, the TEQ concentration within Yaguareté Bay may change by less than 0.035 pg/L TEQ under extreme low flows, as compared to baseline levels as high as 0.46 pg/L TEQ in the Rio Uruguay (Tana, 2005, 2006). This small increment would not measurably change the baseline water quality for dioxins and furans within Yaguareté Bay. Furthermore, as discussed in Section D4.3, the concentration of the most toxic congener (2,3,7,8-TCDD) is expected to be non-detectable (at the 0.5 pg/L level) within the effluent, and therefore water in Yaguareté Bay will be significantly less than the water quality guideline of 0.005 pq/L defined by the U.S. EPA (2002) for protection of fish consumption. Consequently, the concentrations of dioxins and furans in fish tissues are not expected to be measurably changed as a result of releases from the mill.

The baseline concentrations of dioxins and furans in fish tissues are in the 0.1 to 0.3 pg TEQ/g FW[2] range (Tana, 2005, 2006). These values are 13 to 200 times lower than the TEQ levels at which fish consumption advisories would begin. Thus, there is a considerable margin of safety at present with respect to dioxins and furans, and this will continue to be the case when the mills are operating because mill effluent(s) will not measurably increase dioxin and furan levels in the river.

While adverse effects from chlorinated organics in Yaguareté Bay are not anticipated, monitoring of chlorophenolics and dioxins and furans in the sediments and biota of the bay is recommended to confirm that there is no measurable increase in the levels of these substances. A proposed monitoring program is outlined in Section D7.0.

Phytosterols in Botnia mill effluent are expected to be 0.020 to 0.160 mg/L. In ENCE mill effluent, they are expected to be less than 0.170 mg/L. The phytosterols will be diluted at least 300:1 in Yaguareté Bay under the worst case condition, resulting is a potential change in concentration of less than 0.001 mg/L. This increment is below the baseline range for the Rio Uruguay of less than 0.001 to 0.022 mg/L (Tana, 2005, 2006). It is also below the threshold level of 0.010 mg/L for β-sitosterol induction of estrogenic effects in fishes, and well below the levels that have been associated with reproductive effects in wild fishes

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[2] FW refers to fresh weight

(Munkittrick *et al.*, 1998; McMaster *et al.*, 2003; Golder, 2006). It is therefore concluded that effects are very unlikely to be observed in fishes in the vicinity of Yaguareté Bay.

Similarly, fish tainting effects are very unlikely to be observed in the area as a result of mill operations. Even with older bleached kraft mill technologies, fish tainting has not been associated with effluent concentrations below about 25:1 to 50:1 dilution (Kovacs, 1986). In comparison, the effluent concentrations in Yaguareté Bay are estimated to be significantly lower at the 300:1 level or greater. Tainting related to mill effluents is generally not observed today (Environment Canada, 2003) and has never been observed in the vicinity of modern mills with good secondary treatment.

D6.3.3 Receptor 3, Playa Ubici at the Downstream Edge of Yaguareté Bay

Playa Ubici is a recreational beach area located along the downstream edge of Yaguareté Bay approximately 1,500 m from the Botnia discharge. The beach is a valuable resource for the city of Fray Bentos and for tourists who may visit the area. It is used for camping, swimming and other outdoor recreational activities.

Under existing conditions, the water quality along the waterfront of Playa Ubici is in compliance with the surface water quality standards of DINAMA and CARU for all listed parameters with the exception of total phosphorus and possibly bacteria. These two water quality parameters are generally of greatest interest from the perspective of recreational water contact. Phosphorus is of interest as it promotes growth of algae which can affect the aesthetic quality of the water and beach front, and certain species can pose a health risk to humans and aquatic life. Bacteria serve as an indicator of the possible presence of pathogens associated with fecal contamination which pose a risk to human health.

Mill operations will have no effect on the quality of this valued resource. The contribution of phosphorus from mill operations is predicted to be immeasurable (0.003 mg/L under extreme low flows) in comparison to background of 0.130 mg/L (Algoritmos, 2006), as presented in Table D6.3-3. Likewise, the contribution of mill operations to bacteria levels will also be immeasurable relative to the recreational standard of 200 F.C./100 mL. As a result, algal biomass and pathogens associated with fecal material will remain unchanged.

D6.3.4 Receptor 4, Fray Bentos Drinking Water Intake

The water intake for the community of Fray Bentos is located approximately 5 km downstream from the Botnia site, and about 70 m into the Rio Uruguay. The water supplier (OSE) withdraws approximately 0.05 m^3/s and distributes treated water to approximately 22,600 people. The treatment includes flocculation (by alum addition), sedimentation, filtration, disinfection with chlorine and pH adjustment. The chlorine residual in the finished drinking water is typically about 0.8 mg/L.

Primary water quality indicators for potability of water relate to the colour, taste, smell and coliform bacteria count. The first three are aesthetic issues. The latter is not a health concern per se, but serves as an indicator that microbial disease organisms may be present. Water quality associated with chlorinated organic compounds, such as dioxins, furans and chlorophenols, are also of interest from a human health perspective. Nitrites and nitrates are also of interest from a human health perspective. WHO guidelines for nitrite and nitrate in drinking water are 3 and 50 mg/L, respectively.

Baseline OSE data for 2000 to 2003 indicate nitrite concentrations of less than 0.01 mg/L and nitrate concentrations of less than 11 mg/L in the river water supply. Botnia (2004) presents data for nitrate at this location in the 1 to 2 mg/L range. Recent data for this general area in 2005 and 2006 indicate values may be as high as 5.9 mg/L. Nitrates in mill effluents (3 to 10 mg/L) are expected to be below levels of drinking water concern at the point of discharge, and 1,500 times below WHO guidelines at the Fray Bentos water supply.

Adsorbable organic halide (AOX), often used as a surrogate for chlorinated organic compounds, is in the 0.002 to 0.007 mg/L range at the water intake location (SEINCO, 2003). Botnia (2004) data for this location are in the 0.007 to 0.008 mg/L range, and recent data for this general area indicate values may be as high as 0.012 mg/L. AOX in mill effluents is expected to be diluted to the 0.003 to 0.043 mg/L range at the intake location under the average and extreme low flow conditions, respectively. The higher value would suggest that a new source of chlorinated organics may be present; however, at most, a small fraction of the AOX might be in the form of toxic chlorinated organics. In the case of modern ECF mill effluents, chlorophenolics might comprise up to about 1 or 2% of AOX.

It should be noted that AOX may be formed as part of the drinking water treatment process through chlorination, particularly when there are high levels of organic substances in the raw water. Chemical oxygen demand (COD) is a general indicator of organic substances. The baseline COD concentration at the intake ranges from 1 to 2 mg/L reported by Botnia (December, 2003) to 20 mg/L reported by GTAN (2006). The incremental contribution from the mill operations is predicted to range from 0.3 to 4.1 mg/L for the average and extreme low flow conditions, respectively. Thus, there is limited potential for organics from the mills to increase the production of AOX within the water supply facility.

Other studies of drinking water supplies downstream of ECF bleached kraft mills have been reported (McCubbin, 2001, in North America; Grimvall *et al.*, 1994 in Sweden). Studies in the United State, out of 19 mills, AOX increments in the downstream river water ranged from 0.001 to 0.095 mg/L, depending on mill size and river flows, and there were no related problems at the downstream water works. A similar study of seven mills on the St. Lawrence River in Canada, upstream of Montreal (population 1,600,000), reported AOX increments in the river from 0.001 to 0.016 mg/L, and no known issues for the Montreal water supply.

The Swedish study (Grimvall *et al.*, 1994) involved a bleached kraft mill discharge to a river, some 15 km above a city water intake. It found AOX was increased at the water supply intake (0.022 to 0.030 mg/L) as compared to the upstream river baseline (0.015 to 0.016 mg/L). The treated water was further increased in AOX (0.054 to 0.061 mg/L); however, levels around 0.050 mg/L are common in treated drinking water in Sweden. Even higher levels, around 0.100 mg/L, are typical in Finland (Norrstrom and Karlsson, 2006) and are found in many potable waters (Ulrich and Schmidt, 2000). The levels primarily depend on the concentrations of organic material in the water prior to chlorination.

Since AOX levels of 0.050 to 0.100 mg/L in drinking water are not considered problematic, and since the mill projects on the Rio Uruguay are likely to make a small change in AOX levels (up to about 0.05 mg/L during low flow), there is little likelihood of mill effects on the Fray Bentos water supply related to chlorinated organics.

Most modern North American mills report “non-detect” for TCDD in final effluent (at detection limits up to 10 pg/L) and roughly half report occasional detection of TCDF (which may represent river baseline conditions). The U.S. EPA (2003) drinking water standard is 30 pg/L. McCubbin (2001) notes that there has never been proven damage to water users in North America due to TCDD/TCDF in mill effluents, despite the fact that until the 1990s, all mills discharged much greater amounts of TCDD/TCDF than do modern ECF kraft mills.

Consideration of chlorophenols in mill effluents would support the expectation of no adverse effects on the drinking water supply from chlorinated organics. With expected effluent concentrations of approximately 0.070 mg/L and worst case dilution, the concentration in the river near the discharge will be less than 0.0007 mg/L. This is within the baseline range of up to 0.0014 mg/L (Algoritmos, 2006). It is also well below the Health Canada guideline of 0.005 mg/L for 2,4,6-trichlorophenol, the most toxic of the listed chlorophenolics.

D6.3.5 Receptor 5, Beach Area near Arroyo Fray Bentos

The beach area near Arroyo Fray Bentos is a valued resource for the city of Fray Bentos and is used for swimming and other outdoor recreational activities. A photograph of this beach is presented in Figure D6.3-3.

The beach is located downstream from the municipal wastewater discharge for the city of Fray Bentos. It is reported that this beach area experiences elevated levels of phosphorus and fecal coliform bacteria as a result of its close proximity to the municipal discharge. The average contribution of the municipal discharge to phosphorus and bacteria is predicted to be 0.01 mg/L and 70 F.C./100 mL. Higher concentrations are expected during periods of heavy rainfall. Elevated phosphorus concentrations contribute to the growth of algae which can impact the aesthetic quality of the beach area, and elevated bacteria levels can pose a health risk to the public. The mill contribution to phosphorus and bacteria at this location (Table D6.3-5) is negligible.

As discussed in Section D4.6, Botnia is considering the option of treating the municipal wastewater for Fray Bentos at the wastewater treatment system for the mill. This will effectively eliminate the significant municipal source of phosphorus and bacteria to this beach area thereby improving the overall quality of the resource. This is considered a significant benefit that should be considered further by DINAMA, the city of Fray Bentos, Botnia and other stakeholders.

D6.3.6 Receptor 6, Beach Area at Las Cañas

Las Cañas is a beach resort community located further downstream along the shores of the Rio Uruguay. The beach attracts visitors from throughout Uruguay and Argentina, and is therefore an important resource for local tourism.

The beach is also located downstream from the municipal discharge for the city of Fray Bentos. The contribution of phosphorus and bacteria along the shores from this discharge is predicted to be 0.005 mg/L and 30 F.C./100 mL, on average, and potentially considerably higher during heavy rainfall. The treatment of the Fray Bentos discharge by the Botnia mill will eliminate this source of wastewater to Las Cañas and is therefore considered a benefit.

The mill discharges are sufficiently far upstream that the water quality at Las Cañas will not be appreciably changed as a result of mill operations (Table D6.3-6). The mill increments are predicted to be 0.002 mg/L phosphorus and 4 F.C./100 mL bacteria.

D6.3.7 Receptor 7, Rio de la Plata

The Rio de la Plata is an estuary formed by the combination of the Rio Uruguay and the Rio Paraná. It extends approximately 290 km from the rivers' confluence to the Atlantic Ocean. Where the rivers join, it is 48 km wide, and it runs to the southeast growing to 220 km wide where it opens on the Atlantic Ocean. It forms part of the border between Argentina and Uruguay, with the major ports and capital cities of Buenos Aires in the southwest and Montevideo in the northeast.

The basin drained by the main tributaries of the Río de la Plata (the Uruguay and Paraná, and the Paraná tributary, the Paraguay) covers approximately one fifth of South America, including areas in southeastern Bolivia, southern and central Brazil, the entire nation of Paraguay, most of Uruguay and northern Argentina. The average flow from this massive drainage area is approximately 24,000 m^3/s, in comparison to the average flow of the Rio Uruguay of approximately 6,230 m^3/s.

Given the magnitude of flow within the Rio de la Plata, the wastewater discharge from the two mills will have no effect on water quality (Table D6.3-7). All resources within the Rio de la Plata will therefore be unaffected by the mill operations.

D6.3.8 Receptor 8, Esteros de Farrapos e Islas del Rio Uruguay

Esteros de Farrapos e Islas del Rio Uruguay is Uruguay's second designated Ramsar site. In 2004, it was added to the List of Wetlands of International Importance and incorporated into the National Protected Area System. Located along the Rio Uruguay between Neuvo Berlin and San Javier, the site consists of alluvial areas on the river's eastern bank as well as 24 islands that are periodically flooded during periods of high flow. The site is a representative wetland of the transition zone between the humid temperate and the subtropical areas. The site supports a high diversity of birds and serves as an important wildlife refuge and corridor.

As discussed in Section D6.2.0, this area will not be exposed to wastewaters from the mill operations. During most flow conditions, the downstream direction of flow carries the wastewaters from the two mills away from this area thereby preventing all risk of exposure to even trace levels. During rare occasions when the flow reverses direction and travels upstream, the wastewaters move upstream at trace levels, although as presented in Table D6.2-1, the dilution is expected to be greater than 1,000:1 at a point 7 km upriver from ENCE, well below the Island Delta area, and the plume would extend this far only for a few hours. Therefore, there is virtually no potential for mill effluents to impact the Island Delta area.

D6.3.9 Receptor 9, Rio Negro

Papelera Mercedes is an NSSC and kraft mill located along the Rio Negro in the community of Mercedes. This mill does not have any form of chemical recovery or wastewater treatment, and all cooling and process waters are discharge directly to the Rio Negro where it then flows to the Rio Uruguay.

Botnia is also considering the option of recovering the weak black liquor from Papelera Mercedes. Recovery of the weak black liquor by Botnia represents a significant environmental and social benefit. From an environmental perspective, the option results in a benefit to the Río Negro and Río Uruguay as it will reduce this source of potentially harmful chemicals discharged to these rivers (e.g., it will reduce the loadings of phosphorus and biochemical oxygen demand by 0.004 t/d and 7.8 t/d, respectively). From a social perspective, this option may ensure the economic viability of the Mercedes mill since the cost of treatment on-site is not viable for the small production capacity of the mill. This option warrants further consideration by DINAMA, Papelera Mercedes, Botnia and other stakeholders.

D6.4 Potential Effects at Identified Receptors in Argentina

The lower Rio Uruguay is an international water course that is shared by Argentina and Uruguay. As such, the general water quality and ecological effects along the Argentina side of the Rio Uruguay are of interest, and in particular the water quality within the vicinity of the beach area at Ñandubaysal. These two receptors are described in further detail below. The predicted change in water quality for each of these two receptors is presented in Tables D6.4-1 and D6.4-2, respectively.

D6.4.1 Receptor 10, Rio Uruguay on the Argentina Side

As with Uruguay, Argentina values the Rio Uruguay as a resource for drinking water, irrigation water, recreation, and habitat for values aquatic species. Protection of this resource is a priority of the people of Argentina and their Government. As such the Government of Argentina, together with the Government of Uruguay, established CARU as the agency responsible for the oversight of the protection and monitoring of water quality within the Rio Uruguay. As discussed in Section D2.3, CARU has developed water quality standards that the mills must comply with. These standards are approved by the Governments of Argentina and Uruguay and are considered by these Governments as acceptable and adequately protective of the aquatic environment of the Rio Uruguay.

The mill operations will comply with the water quality standards provided by CARU.

As discussed in Section D6.2, the wastewaters from the mill operation will remain on the Uruguayan side of the river and will not cross over to the Argentina side beyond trace levels. Under average and extreme low flows, the dilution of mill wastewaters in Argentina waters will exceed 1,000:1 and therefore considered the same as background from the perspective of water quality and aquatic resource protection. During rare flow reversals the dilution may reduce below 1,000:1; however, the contribution of mill effluents to water quality within Argentina waters will remain extremely small and well within the standards provided by CARU.

Fish and other aquatic animals move throughout the Rio Uruguay and may reside in water along both Uruguay and Argentina sides of the river. As described in Section D6.3.2, the aquatic resources within Yaguareté Bay are not expected to be adversely affected by mill operations, and therefore fish species that move between Yaguareté Bay and Argentina are also considered to be protected from the perspective of the mill operations. It is worth noting that many of the valued fish species of the region spend early life stages in Argentina waters along the Rio Paraná.

D6.4.2 Receptor 11, Beach Area at Ñandubaysal, Argentina

A beach and camping ground is located at Ñandubaysal in Argentina across the Rio Uruguay from Fray Bentos. The site is a popular vacation and tourist destination for people from Argentina and Uruguay during the summer months and particularly during the annual Carnival. A photograph of the beach area is shown in Figure D6.4-1. Figure D6.4-2 is the same beach area but includes a view of the Botnia mill side located at the horizon across the river. The stack is slightly visible in the distance.

The existing water quality at the beach area is within the standards for both CARU and DINAMA with the exception of phosphorus, several metals and possibly bacteria. These elevated levels reflect a general concern throughout the Rio Uruguay associated with the discharge of untreated municipal and industrial wastewaters and agricultural run-offs. Given its close proximity, the quality of water at Ñandubaysal is likely most influenced by the water quality of the Rio Gualeguaychú.

As discussed in Section D6.2, dispersion modeling shows that wastewaters discharged along the Uruguayan side of the river tend to remain along the shoreline and do not disperse across the river, particularly within such a short distance from the source. Studies conducted by CARU provide the same conclusion (CARU, 1996). The calculated dilution at the beach area at Ñandubaysal exceeds 1,000:1 under both average and low flow conditions (Table D6.2-1), and therefore is considered to be unaffected by mill operations.

On rare occasions the flow of the river may reverse directions and during these rare occasions the model predicts movement of trace levels of wastewater across the Rio Uruguay towards Ñandubaysal. The dilution of approximately 700:1 is sufficient to reduce the concentration of wastewater to non-measurable levels. AOX may be a possible exception since it can be detected at trace levels. However, the predicted contribution from mill operations of 0.007 mg/L is within the range of observed background levels and is not considered problematic for drinking water or protection of aquatic life.

D6.5 Summary of Potential Effects to the Aquatic Environment

Table D6.5-1 provides a summary of the potential effects to the aquatic environment associated with the mill operations. As presented, potential effects are limited to the area within the immediate vicinity of each diffuser where the effluent initially mixes with the ambient water. Beyond this small area, the water quality standards are achieved with the exception of those parameters which exceed the standards under present conditions due to the discharge of untreated municipal wastewater and agricultural runoff. Options under consideration for treatment of the municipal wastewater for the city of Fray Bentos and treatment of the industrial wastewater for Papelera Mercedes could result in significant improvements to the water quality downstream of Fray Bentos and within the Rio Negro.

Table D6.2-1: Effluent Exposure at Receptor Locations for Various Flow Conditions

Receptor	Average Flow (6,200 m^3/s)		Extreme Low Flow (500 m^3/s)		Flow Reversal during Low Flow	
	Conductivity (µS/cm)	Dilution	Conductivity (µS/cm)	Dilution	Conductivity (µS/cm)	Dilution
Conductivity of Effluents	4,000	-	4,000	-	4,000	-
Conductivity of Ambient River	100	-	100	-	100	-
Uruguay						
1. At each discharge	-	-	140	100:1	140	100:1
2. Yaguareté Bay [a]	100	>1,000:1	103	>1,000:1	108	516:1
3. Playa Ubici	102	>1,000:1	116	246:1	105	757:1
4. Fray Bentos water intake	102	>1,000:1	124	164:1	105	784:1
5. Beach area at Arroyo Fray Bentos	101	>1,000:1	118	220:1	102	>1,000:1
6. Beach area at Las Cañas	101	>1,000:1	116	247:1	101	>1,000:1
7. Rio de la Plata	100	>1,000:1	101	>1,000:1	100	>1,000:1
8. Rio Uruguay Island Delta	100	>1,000:1	100	>1,000:1	103	>1,000:1
9. Rio Negro	N/A	N/A	N/A	N/A	N/A	N/A
Argentina						
10. Rio Uruguay in Argentina	100	>1,000:1	103	>1,000:1	104	895:1
11. Beach area at Ñandubaysal	100	>1,000:1	100	>1,000:1	106	693:1

[a] values present based on no-wind scenario

Table D6.2-2: Effluent Exposure at Yaguareté Bay for Various Wind Conditions

Wind Condition	Extreme Low Flow (500 m^3/s)	
	Conductivity (µS/cm)	Dilution
No Wind	101	>1,000
North East Wind	110	386
South West Wind	114	288

Table D6.3-1a: Predicted Water Quality at Receptor 1a, at the ENCE Discharge Under Extreme Low Flows (500 m^3/s)

Predicted Water Quality at Receptor #1a, at the Discharge for ENCE Mill
Extreme Low Flow and Monthly Maximum Effluent Loading

Parameter	Units	Baseline	With Mill Discharges	Incremental Change	Most Restrictive Water Quality Standard of DINAMA, CARU	
Aesthetic						
Floating material					absent	DINAMA, Class 1
Color	PtCo	35.0	38.7	3.7	absent	DINAMA, Class 1
Conventional						
Temperature	°C	-	-	0.3	natural conditions	CARU, Use 1
TSS	mg/L	11.0	11.5	0.5	700	DINAMA, Class 2a
pH					6.5 to 8.3	CARU, Use 2
Conductivity	µS/cm	100	140	40	-	-
Dissolved Oxygen	mg/L	-	-	0	5.6	CARU, Use 1
COD	mg/L	5.0	11.3	6.3	-	-
BOD	mg/L	0.5	0.9	0.4	5	DINAMA, Class 1
AOX	mg/L	0.001	0.074	0.073	-	-
Oil and grease	mg/L	-	-	0.1	virtually absent	DINAMA, Class 1
Detergents	mg/L	-	-	0.0	0.5	DINAMA, Class 1
Microbiological						
Fecal Coliforms	FC/100 mL	-	-	10	500	CARU, Use 2
	FC/100 mL				200	CARU, Use 2
Schistosomiasis					absence	CARU, Use 1
Escherichia coli	per/100 mL				126	CARU, Use 2
Enterococos	per/100 mL				33	CARU, Use 2
Algae	UPA/ml				100	CARU, Use 1
Nutrients						
N total	mg/L	0.04	0.14	0.10	-	-
Nitrates (NO3)	mg/L	0.63	0.68	0.05	10	DINAMA, Class 1
Ammonia (total)	mg/L	0.010	0.020	0.010	-	-
Total Phosphorus	mg/L	0.140	0.152	0.012	0.025	DINAMA, Class 1
Toxins						
Chlorates	mg/L	0.020	-	-	-	-
Chlorophenols	mg/L	0.008	0.009	0.001	-	-
Cyanide	mg/L	-	-	0.002	0.005	DINAMA, Class 1
Phenolic comp	mg/L	<0.040	<0.040	0.000	0.001	DINAMA, Class 1
Plant sterols	mg/L	0.022	0.025	0.003	-	-
Resin/fatty acids		-	-	-	-	-
Sulphides	mg/L	-	-	0.002	-	-
Dioxins/furans	pq/L TEQ	0.460	<0.560	<0.100	-	-
2,3,7,8-TCDD	pq/L	<0.500	<0.505	<0.005	-	-
Metals						
Arsenic	mg/L	0.0005	0.0055	0.0050	0.005	DINAMA, Class 1
Cadmium	mg/L	0.0010	0.0015	0.0005	0.00084	CARU, Use 1
Copper	mg/L	0.01	0.02	0.01	0.01	CARU, Use 1
Chromium	mg/L	0.003	0.008	0.005	0.005	DINAMA, Class 2a
Mercury	mg/L	0.0006	-	-	0.0002	DINAMA, Class 1
Nickel	mg/L	0.003	0.005	0.002	0.002	DINAMA, Class 2a
Lead	mg/L	0.016	0.019	0.003	0.007	CARU, Use 1
Zinc	mg/L	0.084	0.087	0.003	0.03	DINAMA, Class 1

Table D6.3-1b: Predicted Water Quality at Receptor 1b, at the Botnia Discharge Under Extreme Low Flows (500 m^3/s)

Predicted Water Quality at Receptor #1b, at the Discharge for Botnia Mill
Extreme Low Flow and Monthly Maximum Effluent Loading

Parameter	Units	Baseline	With Mill Discharges	Incremental Change	Most Restrictive Water Quality Standard of DINAMA, CARU	
Aesthetic						
Floating material					absent	DINAMA, Class 1
Color	PtCo	35.0	39.8	4.8	absent	DINAMA, Class 1
Conventional						
Temperature	°C	-	-	0.4	natural conditions	CARU, Use 1
TSS	mg/L	8.0	8.6	0.6	700	DINAMA, Class 2a
pH					6.5 to 8.3	CARU, Use 2
Conductivity	µS/cm	100	149	49	-	-
Dissolved Oxygen	mg/L	-	-	0	5.6	CARU, Use 1
COD	mg/L	6.0	13.4	7.4	-	-
BOD	mg/L	0.2	0.6	0.4	5	DINAMA, Class 1
AOX	mg/L	0.004	0.081	0.077	-	-
Oil and grease	mg/L	-	-	0.2	virtually absent	DINAMA, Class 1
Detergents	mg/L	-	-	0.0	0.5	DINAMA, Class 1
Microbiological						
Fecal Coliforms	FC/100 mL	-	-	12	500	CARU, Use 2
	FC/100 mL				200	CARU, Use 2
Schistosomiasis					absence	CARU, Use 1
Escherichia coli	per/100 mL				126	CARU, Use 2
Enterococos	per/100 mL				33	CARU, Use 2
Algae	UPA/ml				100	CARU, Use 1
Nutrients						
N total	mg/L	1.02	1.15	0.13	-	-
Nitrates (NO3)	mg/L	0.63	0.69	0.06	10	DINAMA, Class 1
Ammonia (total)	mg/L	0.01	0.02	0.01	-	-
Total Phosphorus	mg/L	0.150	0.153	0.003	0.025	DINAMA, Class 1
Toxins						
Chlorates	mg/L	-	-	-	-	-
Chlorophenols	mg/L	0.001	0.003	0.001	-	-
Cyanide	mg/L	-	-	0.003	0.005	DINAMA, Class 1
Phenolic comp	mg/L	<0.040	<0.040	0.000	0.001	DINAMA, Class 1
Plant sterols	mg/L	0.022	0.025	0.003	-	-
Resin/fatty acids		-	-	-	-	-
Sulphides	mg/L	-	-	0.003	-	-
Dioxins/furans	pq/L TEQ	0.460	<0.583	<0.123	-	-
2,3,7,8-TCDD	pq/L	<0.500	<0.506	<0.006	-	-
Metals						
Arsenic	mg/L	0.0005	0.0028	0.0023	0.005	DINAMA, Class 1
Cadmium	mg/L	0.0010	0.0012	0.0002	0.00084	CARU, Use 1
Copper	mg/L	0.01	0.02	0.00	0.01	CARU, Use 1
Chromium	mg/L	0.003	0.007	0.004	0.005	DINAMA, Class 2a
Mercury	mg/L	0.0005	-	-	0.0002	DINAMA, Class 1
Nickel	mg/L	0.003	0.005	0.002	0.002	DINAMA, Class 2a
Lead	mg/L	0.024	0.025	0.001	0.007	CARU, Use 1
Zinc	mg/L	0.015	0.016	0.001	0.03	DINAMA, Class 1

Table D6.3-2a: Predicted Water Quality at Receptor 2, at Yaguareté Bay Under Average Flows (6,230 m^3/s)

Predicted Water Quality at Receptor #2, at Yaguareté Bay
Average Flow and Monthly Maximum Effluent Loading

Parameter	Units	Baseline	With Mill Discharges	Incremental Change	Most Restrictive Water Quality Standard of DINAMA, CARU	
Aesthetic						
Floating material					absent	DINAMA, Class 1
Color	PtCo	35.0	35.0	0.0	absent	DINAMA, Class 1
Conventional						
Temperature	°C	-	-	0.0	natural conditions	CARU, Use 1
TSS	mg/L	14.0	14.0	0.0	700	DINAMA, Class 2a
pH					6.5 to 8.3	CARU, Use 2
Conductivity	µS/cm	100	100	0	-	-
Dissolved Oxygen	mg/L	-	-	0	5.6	CARU, Use 1
COD	mg/L	5.0	5.0	0.0	-	-
BOD	mg/L	0.1	0.1	0.0	5	DINAMA, Class 1
AOX	mg/L	0.004	0.004	0.000	-	-
Oil and grease	mg/L	-	-	0.0	virtually absent	DINAMA, Class 1
Detergents	mg/L	-	-	0.0	0.5	DINAMA, Class 1
Microbiological						
Fecal Coliforms	FC/100 mL	-	-	0	500	CARU, Use 2
	FC/100 mL				200	CARU, Use 2
Schistosomiasis					absence	CARU, Use 1
Escherichia coli	per/100 mL				126	CARU, Use 2
Enterococos	per/100 mL				33	CARU, Use 2
Algae	UPA/ml				100	CARU, Use 1
Nutrients						
N total	mg/L	0.95	0.95	0.00	-	-
Nitrates (NO3)	mg/L	0.36	0.36	0.00	10	DINAMA, Class 1
Ammonia (total)	mg/L	0.01	0.01	0.00	-	-
Total Phosphorus	mg/L	0.220	0.220	0.000	0.025	DINAMA, Class 1
Toxins						
Chlorates	mg/L	-	-	-	-	-
Chlorophenols	mg/L	0.0014	0.0014	0.0000	-	-
Cyanide	mg/L	-	-	0.000	0.005	DINAMA, Class 1
Phenolic comp	mg/L	<0.040	<0.040	0.0000	0.001	DINAMA, Class 1
Plant sterols	mg/L	0.022	0.022	0.000	-	-
Resin/fatty acids		-	-	-	-	-
Sulphides	mg/L	-	-	0.000	-	-
Dioxins/furans	pq/L TEQ	0.460	<0.460	<0.000	-	-
2,3,7,8-TCDD	pq/L	<0.500	<0.500	<0.000	-	-
Metals						
Arsenic	mg/L	0.0005	0.0005	0.0000	0.005	DINAMA, Class 1
Cadmium	mg/L	0.0005	0.0005	0.0000	0.00084	CARU, Use 1
Copper	mg/L	0.01	0.01	0.00	0.01	CARU, Use 1
Chromium	mg/L	0.003	0.003	0.000	0.005	DINAMA, Class 2a
Mercury	mg/L	0.0005	-	-	0.0002	DINAMA, Class 1
Nickel	mg/L	0.003	0.003	0.000	0.002	DINAMA, Class 2a
Lead	mg/L	0.005	0.005	0.000	0.007	CARU, Use 1
Zinc	mg/L	0.011	0.011	0.000	0.03	DINAMA, Class 1

Table D6.3-2b: Predicted Water Quality at Receptor 2, at Yaguareté Bay Under Extreme Low Flows (500 m^3/s)

Predicted Water Quality at Receptor #2, at Yaguareté Bay
Extreme Low Flow and Monthly Maximum Effluent Loading

Parameter	Units	Baseline	With Mill Discharges	Incremental Change	Most Restrictive Water Quality Standard of DINAMA, CARU	
Aesthetic						
Floating material					absent	DINAMA, Class 1
Color	PtCo	35.0	36.4	1.4	absent	DINAMA, Class 1
Conventional						
Temperature	°C	-	-	0.1	natural conditions	CARU, Use 1
TSS	mg/L	14.0	14.2	0.2	700	DINAMA, Class 2a
pH					6.5 to 8.3	CARU, Use 2
Conductivity	µS/cm	100	114	14	-	-
Dissolved Oxygen	mg/L	-	-	0	5.6	CARU, Use 1
COD	mg/L	5.0	7.1	2.1	-	-
BOD	mg/L	0.1	0.2	0.1	5	DINAMA, Class 1
AOX	mg/L	0.004	0.026	0.022	-	-
Oil and grease	mg/L	-	-	0.0	virtually absent	DINAMA, Class 1
Detergents	mg/L	-	-	0.0	0.5	DINAMA, Class 1
Microbiological						
Fecal Coliforms	FC/100 mL	-	-	3	500	CARU, Use 2
	FC/100 mL				200	CARU, Use 2
Schistosomiasis					absence	CARU, Use 1
Escherichia coli	per/100 mL				126	CARU, Use 2
Enterococos	per/100 mL				33	CARU, Use 2
Algae	UPA/ml				100	CARU, Use 1
Nutrients						
N total	mg/L	0.95	0.99	0.04	-	-
Nitrates (NO3)	mg/L	0.36	0.38	0.02	10	DINAMA, Class 1
Ammonia (total)	mg/L	0.01	0.01	0.00	-	-
Total Phosphorus	mg/L	0.220	0.221	0.001	0.025	DINAMA, Class 1
Toxins						
Chlorates	mg/L	-	-	-	-	-
Chlorophenols	mg/L	0.0014	0.0017	0.0003	-	-
Cyanide	mg/L	-	-	0.001	0.005	DINAMA, Class 1
Phenolic comp	mg/L	<0.040	<0.040	0.0000	0.001	DINAMA, Class 1
Plant sterols	mg/L	0.022	0.023	0.001	-	-
Resin/fatty acids		-	-	-	-	-
Sulphides	mg/L	-	-	0.001	-	-
Dioxins/furans	pq/L TEQ	0.460	<0.495	<0.035	-	-
2,3,7,8-TCDD	pq/L	<0.500	<0.502	<0.002	-	-
Metals						
Arsenic	mg/L	0.0005	0.0013	0.0008	0.005	DINAMA, Class 1
Cadmium	mg/L	0.0005	0.0006	0.0001	0.00084	CARU, Use 1
Copper	mg/L	0.01	0.01	0.00	0.01	CARU, Use 1
Chromium	mg/L	0.003	0.004	0.001	0.005	DINAMA, Class 2a
Mercury	mg/L	0.0005	-	-	0.0002	DINAMA, Class 1
Nickel	mg/L	0.003	0.004	0.001	0.002	DINAMA, Class 2a
Lead	mg/L	0.005	0.005	0.000	0.007	CARU, Use 1
Zinc	mg/L	0.011	0.011	0.000	0.03	DINAMA, Class 1

Table D6.3-3a: Predicted Water Quality at Receptor 3, at Playa Ubici Under Average Flows (6,230 m^3/s)

Predicted Water Quality at Receptor #3, at Playa Ubici
Average Flow and Monthly Maximum Effluent Loading

Parameter	Units	Baseline	With Mill Discharges	Incremental Change	Most Restrictive Water Quality Standard of DINAMA, CARU	
Aesthetic						
Floating material					absent	DINAMA, Class 1
Color	PtCo	35.0	35.2	0.2	absent	DINAMA, Class 1
Conventional						
Temperature	°C	-	-	0.0	natural conditions	CARU, Use 1
TSS	mg/L	8.0	8.0	0.0	700	DINAMA, Class 2a
pH					6.5 to 8.3	CARU, Use 2
Conductivity	µS/cm	100	102	2	-	-
Dissolved Oxygen	mg/L	-	-	0	5.6	CARU, Use 1
COD	mg/L	5.0	5.3	0.3	-	-
BOD	mg/L	0.2	0.2	0.0	5	DINAMA, Class 1
AOX	mg/L	0.003	0.006	0.003	-	-
Oil and grease	mg/L	-	-	0.0	virtually absent	DINAMA, Class 1
Detergents	mg/L	-	-	0.0	0.5	DINAMA, Class 1
Microbiological						
Fecal Coliforms	FC/100 mL	-	-	0	500	CARU, Use 2
	FC/100 mL				200	CARU, Use 2
Schistosomiasis					absence	CARU, Use 1
Escherichia coli	per/100 mL				126	CARU, Use 2
Enterococos	per/100 mL				33	CARU, Use 2
Algae	UPA/ml				100	CARU, Use 1
Nutrients						
N total	mg/L	0.35	0.35	0.00	-	-
Nitrates (NO3)	mg/L	0.59	0.59	0.00	10	DINAMA, Class 1
Ammonia (total)	mg/L	0.01	0.01	0.00	-	-
Total Phosphorus	mg/L	0.130	0.130	0.000	0.025	DINAMA, Class 1
Toxins						
Chlorates	mg/L	-	-	-	-	-
Chlorophenols	mg/L	0.003	0.003	0.0000	-	-
Cyanide	mg/L	-	-	0.000	0.005	DINAMA, Class 1
Phenolic comp	mg/L	<0.040	<0.040	0.000	0.001	DINAMA, Class 1
Plant sterols	mg/L	0.022	0.022	0.000	-	-
Resin/fatty acids		-	-	-	-	-
Sulphides	mg/L	-	-	0.000	-	-
Dioxins/furans	pq/L TEQ	0.460	<0.464	<0.004	-	-
2,3,7,8-TCDD	pq/L	<0.500	<0.500	<0.000	-	-
Metals						
Arsenic	mg/L	0.0005	0.0006	0.0001	0.005	DINAMA, Class 1
Cadmium	mg/L	0.0005	0.0005	0.0000	0.00084	CARU, Use 1
Copper	mg/L	0.01	0.01	0.00	0.01	CARU, Use 1
Chromium	mg/L	0.002	0.002	0.000	0.005	DINAMA, Class 2a
Mercury	mg/L	0.0004	-	-	0.0002	DINAMA, Class 1
Nickel	mg/L	0.003	0.003	0.000	0.002	DINAMA, Class 2a
Lead	mg/L	0.005	0.005	0.000	0.007	CARU, Use 1
Zinc	mg/L	0.008	0.008	0.000	0.03	DINAMA, Class 1

Table D6.3-3b: Predicted Water Quality at Receptor 3, at Playa Ubici Under Extreme Low Flows (500 m^3/s)

Predicted Water Quality at Receptor #3, at Playa Ubici
Extreme Low Flow and Monthly Maximum Effluent Loading

Parameter	Units	Baseline	With Mill Discharges	Incremental Change	Most Restrictive Water Quality Standard of DINAMA, CARU	
Aesthetic						
Floating material					absent	DINAMA, Class 1
Color	PtCo	35.0	36.5	1.5	absent	DINAMA, Class 1
Conventional						
Temperature	°C	-	-	0.1	natural conditions	CARU, Use 1
TSS	mg/L	8.0	8.2	0.2	700	DINAMA, Class 2a
pH					6.5 to 8.3	CARU, Use 2
Conductivity	µS/cm	100	116	16	-	-
Dissolved Oxygen	mg/L	-	-	0	5.6	CARU, Use 1
COD	mg/L	5.0	7.5	2.5	-	-
BOD	mg/L	0.2	0.3	0.1	5	DINAMA, Class 1
AOX	mg/L	0.003	0.030	0.027	-	-
Oil and grease	mg/L	-	-	0.0	virtually absent	DINAMA, Class 1
Detergents	mg/L	-	-	0.0	0.5	DINAMA, Class 1
Microbiological						
Fecal Coliforms	FC/100 mL	-	-	4	500	CARU, Use 2
	FC/100 mL				200	CARU, Use 2
Schistosomiasis					absence	CARU, Use 1
Escherichia coli	per/100 mL				126	CARU, Use 2
Enterococos	per/100 mL				33	CARU, Use 2
Algae	UPA/ml				100	CARU, Use 1
Nutrients						
N total	mg/L	0.35	0.39	0.04	-	-
Nitrates (NO3)	mg/L	0.59	0.61	0.02	10	DINAMA, Class 1
Ammonia (total)	mg/L	0.01	0.01	0.00	-	-
Total Phosphorus	mg/L	0.130	0.133	0.003	0.025	DINAMA, Class 1
Toxins						
Chlorates	mg/L	-	-	-	-	-
Chlorophenols	mg/L	0.003	0.003	0.000	-	-
Cyanide	mg/L	-	-	0.001	0.005	DINAMA, Class 1
Phenolic comp	mg/L	<0.040	<0.040	0.000	0.001	DINAMA, Class 1
Plant sterols	mg/L	0.022	0.023	0.001	-	-
Resin/fatty acids		-	-	-	-	-
Sulphides	mg/L	-	-	0.001	-	-
Dioxins/furans	pq/L TEQ	0.460	<0.501	<0.041	-	-
2,3,7,8-TCDD	pq/L	<0.500	<0.502	<0.002	-	-
Metals						
Arsenic	mg/L	0.0005	0.0019	0.0014	0.005	DINAMA, Class 1
Cadmium	mg/L	0.0005	0.0006	0.0001	0.00084	CARU, Use 1
Copper	mg/L	0.01	0.01	0.00	0.01	CARU, Use 1
Chromium	mg/L	0.002	0.004	0.002	0.005	DINAMA, Class 2a
Mercury	mg/L	0.0004	-	-	0.0002	DINAMA, Class 1
Nickel	mg/L	0.003	0.004	0.001	0.002	DINAMA, Class 2a
Lead	mg/L	0.005	0.006	0.001	0.007	CARU, Use 1
Zinc	mg/L	0.008	0.009	0.001	0.03	DINAMA, Class 1

Table D6.3-4a: Predicted Water Quality at Receptor 4, at Fray Bentos Water Intake Under Average Flows (6,230 m³/s)

Predicted Water Quality at Receptor #4, at Fray Bentos Water Intake
Average Flow and Monthly Maximum Effluent Loading

Parameter	Units	Baseline	With Mill Discharges	Incremental Change	Most Restrictive Water Quality Standard of DINAMA, CARU	
Aesthetic						
Floating material					absent	DINAMA, Class 1
Color	PtCo	35.0	35.2	0.2	absent	DINAMA, Class 1
Conventional						
Temperature	°C	-	-	0.0	natural conditions	CARU, Use 1
TSS	mg/L	8.0	8.0	0.0	700	DINAMA, Class 2a
pH					6.5 to 8.3	CARU, Use 2
Conductivity	µS/cm	100	102	2	-	-
Dissolved Oxygen	mg/L	-	-	0	5.6	CARU, Use 1
COD	mg/L	5.0	5.3	0.3	-	-
BOD	mg/L	0.5	0.5	0.0	5	DINAMA, Class 1
AOX	mg/L	0.007	0.010	0.003	-	-
Oil and grease	mg/L	-	-	0.0	virtually absent	DINAMA, Class 1
Detergents	mg/L	-	-	0.0	0.5	DINAMA, Class 1
Microbiological						
Fecal Coliforms	FC/100 mL	-	-	0	500	CARU, Use 2
	FC/100 mL				200	CARU, Use 2
Schistosomiasis					absence	CARU, Use 1
Escherichia coli	per/100 mL				126	CARU, Use 2
Enterococos	per/100 mL				33	CARU, Use 2
Algae	UPA/ml				100	CARU, Use 1
Nutrients						
N total	mg/L	0.97	0.97	0.00	-	-
Nitrates (NO3)	mg/L	0.61	0.61	0.00	10	DINAMA, Class 1
Ammonia (total)	mg/L	0.26	0.26	0.00	-	-
Total Phosphorus	mg/L	0.140	0.140	0.000	0.025	DINAMA, Class 1
Toxins						
Chlorates	mg/L	-	-	-	-	-
Chlorophenols	mg/L	0.001	0.001	0.000	-	-
Cyanide	mg/L	-	-	0.000	0.005	DINAMA, Class 1
Phenolic comp	mg/L	<0.040	<0.040	0.000	0.001	DINAMA, Class 1
Plant sterols	mg/L	0.022	0.022	0.000	-	-
Resin/fatty acids		-	-	-	-	-
Sulphides	mg/L	-	-	0.000	-	-
Dioxins/furans	pq/L TEQ	0.460	<0.465	<0.005	-	-
2,3,7,8-TCDD	pq/L	<0.500	<0.500	<0.000	-	-
Metals						
Arsenic	mg/L	0.0005	0.0006	0.0001	0.005	DINAMA, Class 1
Cadmium	mg/L	0.0005	0.0005	0.0000	0.00084	CARU, Use 1
Copper	mg/L	0.01	0.01	0.00	0.01	CARU, Use 1
Chromium	mg/L	0.003	0.003	0.000	0.005	DINAMA, Class 2a
Mercury	mg/L	0.0004	-	-	0.0002	DINAMA, Class 1
Nickel	mg/L	0.003	0.003	0.000	0.002	DINAMA, Class 2a
Lead	mg/L	0.005	0.005	0.000	0.007	CARU, Use 1
Zinc	mg/L	0.010	0.010	0.000	0.03	DINAMA, Class 1

Table D6.3-4b: Predicted Water Quality at Receptor 4, at Fray Bentos Water Intake Under Extreme Low Flows (500 m^3/s)

Predicted Water Quality at Receptor #4, at Fray Bentos Water Intake
Extreme Low Flow and Monthly Maximum Effluent Loading

Parameter	Units	Baseline	With Mill Discharges	Incremental Change	Most Restrictive Water Quality Standard of DINAMA, CARU	
Aesthetic						
Floating material					absent	DINAMA, Class 1
Color	PtCo	35.0	37.7	2.7	absent	DINAMA, Class 1
Conventional						
Temperature	°C	-	-	0.2	natural conditions	CARU, Use 1
TSS	mg/L	8.0	8.4	0.4	700	DINAMA, Class 2a
pH					6.5 to 8.3	CARU, Use 2
Conductivity	µS/cm	100	127	27	-	-
Dissolved Oxygen	mg/L	-	-	0	5.6	CARU, Use 1
COD	mg/L	5.0	9.1	4.1	-	-
BOD	mg/L	0.5	0.7	0.2	5	DINAMA, Class 1
AOX	mg/L	0.007	0.050	0.043	-	-
Oil and grease	mg/L	-	-	0.1	virtually absent	DINAMA, Class 1
Detergents	mg/L	-	-	0.0	0.5	DINAMA, Class 1
Microbiological						
Fecal Coliforms	FC/100 mL	-	-	7	500	CARU, Use 2
	FC/100 mL				200	CARU, Use 2
Schistosomiasis					absence	CARU, Use 1
Escherichia coli	per/100 mL				126	CARU, Use 2
Enterococos	per/100 mL				33	CARU, Use 2
Algae	UPA/ml				100	CARU, Use 1
Nutrients						
N total	mg/L	0.97	1.04	0.07	-	-
Nitrates (NO3)	mg/L	0.61	0.64	0.03	10	DINAMA, Class 1
Ammonia (total)	mg/L	0.26	0.27	0.01	-	-
Total Phosphorus	mg/L	0.140	0.142	0.002	0.025	DINAMA, Class 1
Toxins						
Chlorates	mg/L	-	-	-	-	-
Chlorophenols	mg/L	0.0010	0.0017	0.0007	-	-
Cyanide	mg/L	-	-	0.002	0.005	DINAMA, Class 1
Phenolic comp	mg/L	<0.040	<0.040	0.0000	0.001	DINAMA, Class 1
Plant sterols	mg/L	0.022	0.024	0.002	-	-
Resin/fatty acids		-	-	-	-	-
Sulphides	mg/L	-	-	0.001	-	-
Dioxins/furans	pq/L TEQ	0.460	<0.528	<0.068	-	-
2,3,7,8-TCDD	pq/L	<0.500	<0.503	<0.003	-	-
Metals						
Arsenic	mg/L	0.0005	0.0020	0.0015	0.005	DINAMA, Class 1
Cadmium	mg/L	0.0005	0.0007	0.0002	0.00084	CARU, Use 1
Copper	mg/L	0.01	0.01	0.00	0.01	CARU, Use 1
Chromium	mg/L	0.003	0.005	0.002	0.005	DINAMA, Class 2a
Mercury	mg/L	0.0004	-	-	0.0002	DINAMA, Class 1
Nickel	mg/L	0.003	0.004	0.001	0.002	DINAMA, Class 2a
Lead	mg/L	0.005	0.006	0.001	0.007	CARU, Use 1
Zinc	mg/L	0.010	0.011	0.001	0.03	DINAMA, Class 1

Table D6.3-5: Predicted Water Quality at Receptor 5, near Arroyo Fray Bentos Under Extreme Low Flows (500 m^3/s)

Predicted Water Quality at Receptor #5, at Beach near Arroyo Fray Bentos Extreme Low Flow and Monthly Maximum Effluent Loading						
Parameter	**Units**	**Baseline**	**With Mill Discharges**	**Incremental Change**	**Most Restrictive Water Quality Standard of DINAMA, CARU**	
Aesthetic						
Floating material					absent	DINAMA, Class 1
Color	PtCo	35.0	36.8	1.8	absent	DINAMA, Class 1
Conventional						
Temperature	°C	-	-	0.1	natural conditions	CARU, Use 1
TSS	mg/L	10.0	10.2	0.2	700	DINAMA, Class 2a
pH					6.5 to 8.3	CARU, Use 2
Conductivity	µS/cm	100	118	18	-	-
Dissolved Oxygen	mg/L	-	-	0	5.6	CARU, Use 1
COD	mg/L	6.0	8.8	2.8	-	-
BOD	mg/L	0.2	0.4	0.2	5	DINAMA, Class 1
AOX	mg/L	0.001	0.030	0.029	-	-
Oil and grease	mg/L	-	-	0.1	virtually absent	DINAMA, Class 1
Detergents	mg/L	-	-	0.0	0.5	DINAMA, Class 1
Microbiological						
Fecal Coliforms	FC/100 mL	-	-	5	500	CARU, Use 2
	FC/100 mL				200	CARU, Use 2
Schistosomiasis					absence	CARU, Use 1
Escherichia coli	per/100 mL				126	CARU, Use 2
Enterococos	per/100 mL				33	CARU, Use 2
Algae	UPA/ml				100	CARU, Use 1
Nutrients						
N total	mg/L	0.74	0.79	0.05	-	-
Nitrates (NO3)	mg/L	0.61	0.63	0.02	10	DINAMA, Class 1
Ammonia (total)	mg/L	0.23	0.23	0.00	-	-
Total Phosphorus	mg/L	0.150	0.152	0.002	0.025	DINAMA, Class 1
Toxins						
Chlorates	mg/L	-	-	-	-	-
Chlorophenols	mg/L	0.005	0.005	0.000	-	-
Cyanide	mg/L	-	-	0.001	0.005	DINAMA, Class 1
Phenolic comp	mg/L	<0.040	<0.040	0.000	0.001	DINAMA, Class 1
Plant sterols	mg/L	0.022	0.023	0.001	-	-
Resin/fatty acids		-	-	-	-	-
Sulphides	mg/L	-	-	0.001	-	-
Dioxins/furans	pq/L TEQ	0.460	<0.505	<0.045	-	-
2,3,7,8-TCDD	pq/L	<0.500	<0.502	<0.002	-	-
Metals						
Arsenic	mg/L	0.0005	0.0016	0.0011	0.005	DINAMA, Class 1
Cadmium	mg/L	0.0005	0.0006	0.0001	0.00084	CARU, Use 1
Copper	mg/L	0.01	0.01	0.00	0.01	CARU, Use 1
Chromium	mg/L	0.002	0.004	0.002	0.005	DINAMA, Class 2a
Mercury	mg/L	0.0006	-	-	0.0002	DINAMA, Class 1
Nickel	mg/L	0.003	0.004	0.001	0.002	DINAMA, Class 2a
Lead	mg/L	0.005	0.006	0.001	0.007	CARU, Use 1
Zinc	mg/L	0.012	0.013	0.001	0.03	DINAMA, Class 1

Table D6.3-6: Predicted Water Quality at Receptor 6, at Las Cañas Under Extreme Low Flows (500 m^3/s)

Predicted Water Quality at Receptor #6, at Las Cañas
Extreme Low Flow and Monthly Maximum Effluent Loading

Parameter	Units	Baseline	With Mill Discharges	Incremental Change	Most Restrictive Water Quality Standard of DINAMA, CARU	
Aesthetic						
Floating material					absent	DINAMA, Class 1
Color	PtCo	35.0	36.6	1.6	absent	DINAMA, Class 1
Conventional						
Temperature	°C	-	-	0.1	natural conditions	CARU, Use 1
TSS	mg/L	10.0	10.2	0.2	700	DINAMA, Class 2a
pH					6.5 to 8.3	CARU, Use 2
Conductivity	µS/cm	100	116	16	-	-
Dissolved Oxygen	mg/L	-	-	0	5.6	CARU, Use 1
COD	mg/L	6.0	8.5	2.5	-	-
BOD	mg/L	0.2	0.3	0.1	5	DINAMA, Class 1
AOX	mg/L	0.001	0.027	0.026	-	-
Oil and grease	mg/L	-	-	0.0	virtually absent	DINAMA, Class 1
Detergents	mg/L	-	-	0.0	0.5	DINAMA, Class 1
Microbiological						
Fecal Coliforms	FC/100 mL	-	-	4	500	CARU, Use 2
	FC/100 mL				200	CARU, Use 2
Schistosomiasis					absence	CARU, Use 1
Escherichia coli	per/100 mL				126	CARU, Use 2
Enterococos	per/100 mL				33	CARU, Use 2
Algae	UPA/ml				100	CARU, Use 1
Nutrients						
N total	mg/L	0.74	0.78	0.04	-	-
Nitrates (NO3)	mg/L	0.61	0.63	0.02	10	DINAMA, Class 1
Ammonia (total)	mg/L	0.23	0.23	0.00	-	-
Total Phosphorus	mg/L	0.150	0.152	0.002	0.025	DINAMA, Class 1
Toxins						
Chlorates	mg/L	-	-	-	-	-
Chlorophenols	mg/L	0.005	0.005	0.000	-	-
Cyanide	mg/L	-	-	0.001	0.005	DINAMA, Class 1
Phenolic comp	mg/L	<0.040	<0.040	0.000	0.001	DINAMA, Class 1
Plant sterols	mg/L	0.022	0.023	0.001	-	-
Resin/fatty acids		-	-	-	-	-
Sulphides	mg/L	-	-	0.001	-	-
Dioxins/furans	pq/L TEQ	0.460	<0.500	<0.040	-	-
2,3,7,8-TCDD	pq/L	<0.500	<0.502	<0.002	-	-
Metals						
Arsenic	mg/L	0.0005	0.0015	0.0010	0.005	DINAMA, Class 1
Cadmium	mg/L	0.0005	0.0006	0.0001	0.00084	CARU, Use 1
Copper	mg/L	0.01	0.01	0.00	0.01	CARU, Use 1
Chromium	mg/L	0.002	0.003	0.001	0.005	DINAMA, Class 2a
Mercury	mg/L	0.0006	-	-	0.0002	DINAMA, Class 1
Nickel	mg/L	0.003	0.004	0.001	0.002	DINAMA, Class 2a
Lead	mg/L	0.005	0.006	0.001	0.007	CARU, Use 1
Zinc	mg/L	0.012	0.013	0.001	0.03	DINAMA, Class 1

Table D6.3-7: Predicted Water Quality at Receptor 7, at Rio de la Plata Under Extreme Low Flows (500 m^3/s)

Predicted Water Quality at Receptor #7, at Rio de la Plata
Extreme Low Flow and Monthly Maximum Effluent Loading

Parameter	Units	Baseline	With Mill Discharges	Incremental Change	Most Restrictive Water Quality Standard of DINAMA, CARU	
Aesthetic						
Floating material					absent	DINAMA, Class 1
Color	PtCo	-	-	0.3	absent	DINAMA, Class 1
Conventional						
Temperature	^{o}C	-	-	0.0	natural conditions	CARU, Use 1
TSS	mg/L	-	-	0.0	700	DINAMA, Class 2a
pH					6.5 to 8.3	CARU, Use 2
Conductivity	µS/cm	-	-	3	-	-
Dissolved Oxygen	mg/L	-	-	0	5.6	CARU, Use 1
COD	mg/L	-	-	0.4	-	-
BOD	mg/L	-	-	0.0	5	DINAMA, Class 1
AOX	mg/L	-	-	0.005	-	-
Oil and grease	mg/L	-	-	0.0	virtually absent	DINAMA, Class 1
Detergents	mg/L	-	-	0.0	0.5	DINAMA, Class 1
Microbiological						
Fecal Coliforms	FC/100 mL	-	-	1	500	CARU, Use 2
	FC/100 mL				200	CARU, Use 2
Schistosomiasis					absence	CARU, Use 1
Escherichia coli	per/100 mL				126	CARU, Use 2
Enterococos	per/100 mL				33	CARU, Use 2
Algae	UPA/ml				100	CARU, Use 1
Nutrients						
N total	mg/L	-	-	0.01	-	-
Nitrates (NO3)	mg/L	-	-	0.00	10	DINAMA, Class 1
Ammonia (total)	mg/L	-	-	0.00	-	-
Total Phosphorus	mg/L	-	-	0.000	0.025	DINAMA, Class 1
Toxins						
Chlorates	mg/L	-	-	-	-	-
Chlorophenols	mg/L	-	-	0.000	-	-
Cyanide	mg/L	-	-	0.000	0.005	DINAMA, Class 1
Phenolic comp	mg/L	-	-	0.000	0.001	DINAMA, Class 1
Plant sterols	mg/L	-	-	0.000	-	-
Resin/fatty acids		-	-	-	-	-
Sulphides	mg/L	-	-	0.000	-	-
Dioxins/furans	pq/L TEQ	-	-	<0.007	-	-
2,3,7,8-TCDD	pq/L	-	-	<0.000	-	-
Metals						
Arsenic	mg/L	-	-	0.0002	0.005	DINAMA, Class 1
Cadmium	mg/L	-	-	0.0000	0.00084	CARU, Use 1
Copper	mg/L	-	-	0.00	0.01	CARU, Use 1
Chromium	mg/L	-	-	0.000	0.005	DINAMA, Class 2a
Mercury	mg/L	-	-	-	0.0002	DINAMA, Class 1
Nickel	mg/L	-	-	0.000	0.002	DINAMA, Class 2a
Lead	mg/L	-	-	0.000	0.007	CARU, Use 1
Zinc	mg/L	-	-	0.000	0.03	DINAMA, Class 1

Table D6.3-8a: Predicted Water Quality at Receptor 8, at Rio Uruguay Island Delta Under Extreme Low Flows (500 m^3/s)

Predicted Water Quality at Receptor #8, at Rio Uruguay Island Delta
Extreme Low Flow and Monthly Maximum Effluent Loading

Parameter	Units	Baseline	With Mill Discharges	Incremental Change	Most Restrictive Water Quality Standard of DINAMA, CARU	
Aesthetic						
Floating material					absent	DINAMA, Class 1
Color	PtCo	35.0	35.0	0.0	absent	DINAMA, Class 1
Conventional						
Temperature	°C	-	-	0.0	natural conditions	CARU, Use 1
TSS	mg/L	11.0	11.0	0.0	700	DINAMA, Class 2a
pH					6.5 to 8.3	CARU, Use 2
Conductivity	µS/cm	100	100	0	-	-
Dissolved Oxygen	mg/L	-	-	0	5.6	CARU, Use 1
COD	mg/L	5.0	5.0	0.0	-	-
BOD	mg/L	0.5	0.5	0.0	5	DINAMA, Class 1
AOX	mg/L	0.001	0.001	0.000	-	-
Oil and grease	mg/L	-	-	0.0	virtually absent	DINAMA, Class 1
Detergents	mg/L	-	-	0.0	0.5	DINAMA, Class 1
Microbiological						
Fecal Coliforms	FC/100 mL	-	-	0	500	CARU, Use 2
	FC/100 mL				200	CARU, Use 2
Schistosomiasis					absence	CARU, Use 1
Escherichia coli	per/100 mL				126	CARU, Use 2
Enterococos	per/100 mL				33	CARU, Use 2
Algae	UPA/ml				100	CARU, Use 1
Nutrients						
N total	mg/L	0.04	0.04	0.00	-	-
Nitrates (NO3)	mg/L	0.63	0.63	0.00	10	DINAMA, Class 1
Ammonia (total)	mg/L	0.01	0.01	0.00	-	-
Total Phosphorus	mg/L	0.140	0.140	0.000	0.025	DINAMA, Class 1
Toxins						
Chlorates	mg/L	-	-	-	-	-
Chlorophenols	mg/L	0.008	0.008	0.000	-	-
Cyanide	mg/L	-	-	0.000	0.005	DINAMA, Class 1
Phenolic comp	mg/L	<0.040	<0.040	0.000	0.001	DINAMA, Class 1
Plant sterols	mg/L	0.022	0.022	0.000	-	-
Resin/fatty acids		-	-	-	-	-
Sulphides	mg/L	-	-	0.000	-	-
Dioxins/furans	pq/L TEQ	-	-	<0.000	-	-
2,3,7,8-TCDD	pq/L	-	-	<0.000	-	-
Metals						
Arsenic	mg/L	0.0005	0.0005	0.0000	0.005	DINAMA, Class 1
Cadmium	mg/L	0.0010	0.0010	0.0000	0.00084	CARU, Use 1
Copper	mg/L	0.01	0.01	0.00	0.01	CARU, Use 1
Chromium	mg/L	0.003	0.003	0.000	0.005	DINAMA, Class 2a
Mercury	mg/L	0.0006	-	-	0.0002	DINAMA, Class 1
Nickel	mg/L	0.003	0.003	0.000	0.002	DINAMA, Class 2a
Lead	mg/L	0.016	0.016	0.000	0.007	CARU, Use 1
Zinc	mg/L	0.084	0.084	0.000	0.03	DINAMA, Class 1

Table D6.3-8b: Predicted Water Quality at Receptor 8, at Rio Uruguay Island Delta During Flow Reversal and Low Flows (700 m^3/s)

Predicted Water Quality at Receptor #8, at Rio Uruguay Island Delta
Flow Reversal under Low Flow and Monthly Maximum Effluent Loading

Parameter	Units	Baseline	With Mill Discharges	Incremental Change	Most Restrictive Water Quality Standard of DINAMA, CARU	
Aesthetic						
Floating material					absent	DINAMA, Class 1
Color	PtCo	35.0	35.3	0.3	absent	DINAMA, Class 1
Conventional						
Temperature	°C	-	-	0.0	natural conditions	CARU, Use 1
TSS	mg/L	11.0	11.0	0.0	700	DINAMA, Class 2a
pH					6.5 to 8.3	CARU, Use 2
Conductivity	µS/cm	100	101	1	-	-
Dissolved Oxygen	mg/L	-	-	0	5.6	CARU, Use 1
COD	mg/L	5.0	5.5	0.5	-	-
BOD	mg/L	0.5	0.5	0.0	5	DINAMA, Class 1
AOX	mg/L	0.001	0.007	0.006	-	-
Oil and grease	mg/L	-	-	0.0	virtually absent	DINAMA, Class 1
Detergents	mg/L	-	-	0.0	0.5	DINAMA, Class 1
Microbiological						
Fecal Coliforms	FC/100 mL	-	-	1	500	CARU, Use 2
	FC/100 mL				200	CARU, Use 2
Schistosomiasis					absence	CARU, Use 1
Escherichia coli	per/100 mL				126	CARU, Use 2
Enterococos	per/100 mL				33	CARU, Use 2
Algae	UPA/ml				100	CARU, Use 1
Nutrients						
N total	mg/L	0.04	0.05	0.01	-	-
Nitrates (NO3)	mg/L	0.63	0.63	0.00	10	DINAMA, Class 1
Ammonia (total)	mg/L	0.01	0.01	0.00	-	-
Total Phosphorus	mg/L	0.140	0.141	0.0009	0.025	DINAMA, Class 1
Toxins						
Chlorates	mg/L	-	-	-	-	-
Chlorophenols	mg/L	0.008	0.008	0.000	-	-
Cyanide	mg/L	-	-	0.000	0.005	DINAMA, Class 1
Phenolic comp	mg/L	<0.040	<0.040	0.000	0.001	DINAMA, Class 1
Plant sterols	mg/L	0.022	0.022	0.000	-	-
Resin/fatty acids		-	-	-	-	-
Sulphides	mg/L	-	-	0.000	-	-
Dioxins/furans	pq/L TEQ	0.460	<0.468	<0.008	-	-
2,3,7,8-TCDD	pq/L	<0.500	<0.500	<0.000	-	-
Metals						
Arsenic	mg/L	0.0005	0.0009	0.0004	0.005	DINAMA, Class 1
Cadmium	mg/L	0.0010	0.0010	0.0000	0.00084	CARU, Use 1
Copper	mg/L	0.01	0.01	0.00	0.01	CARU, Use 1
Chromium	mg/L	0.003	0.003	0.000	0.005	DINAMA, Class 2a
Mercury	mg/L	0.0006	-	-	0.0002	DINAMA, Class 1
Nickel	mg/L	0.003	0.003	0.000	0.002	DINAMA, Class 2a
Lead	mg/L	0.016	0.016	0.000	0.007	CARU, Use 1
Zinc	mg/L	0.084	0.084	0.000	0.03	DINAMA, Class 1

Table D6.4-1: Predicted Water Quality at Receptor 10, Argentina Side of Rio Uruguay Under Extreme Low Flows (500 m^3/s)

Predicted Water Quality at Receptor #10, along the Argentina Side of the Rio Uruguay
Extreme Low Flow and Monthly Maximum Effluent Loading

Parameter	Units	Baseline	With Mill Discharges	Incremental Change	Most Restrictive Water Quality Standard of DINAMA, CARU	
Aesthetic						
Floating material					absent	DINAMA, Class 1
Color	PtCo	35.0	35.4	0.4	absent	DINAMA, Class 1
Conventional						
Temperature	°C	-	-	0.0	natural conditions	CARU, Use 1
TSS	mg/L	5.0	5.1	0.1	700	DINAMA, Class 2a
pH					6.5 to 8.3	CARU, Use 2
Conductivity	µS/cm	100	104	4	-	-
Dissolved Oxygen	mg/L	-	-	0	5.6	CARU, Use 1
COD	mg/L	15.0	15.6	0.6	-	-
BOD	mg/L	0.2	0.2	0.0	5	DINAMA, Class 1
AOX	mg/L	0.005	0.012	0.007	-	-
Oil and grease	mg/L	-	-	0.0	virtually absent	DINAMA, Class 1
Detergents	mg/L	-	-	0.0	0.5	DINAMA, Class 1
Microbiological						
Fecal Coliforms	FC/100 mL	-	-	1	500	CARU, Use 2
	FC/100 mL				200	CARU, Use 2
Schistosomiasis					absence	CARU, Use 1
Escherichia coli	per/100 mL				126	CARU, Use 2
Enterococos	per/100 mL				33	CARU, Use 2
Algae	UPA/ml				100	CARU, Use 1
Nutrients						
N total	mg/L	1.10	1.11	0.01	-	-
Nitrates (NO3)	mg/L	0.79	0.79	0.00	10	DINAMA, Class 1
Ammonia (total)	mg/L	0.01	0.01	0.00	-	-
Total Phosphorus	mg/L	0.200	0.201	0.001	0.025	DINAMA, Class 1
Toxins						
Chlorates	mg/L	-	-	-	-	-
Chlorophenols	mg/L	0.003	0.003	0.000	-	-
Cyanide	mg/L	-	-	0.000	0.005	DINAMA, Class 1
Phenolic comp	mg/L	<0.040	<0.040	0.000	0.001	DINAMA, Class 1
Plant sterols	mg/L	0.022	0.022	0.000	-	-
Resin/fatty acids		-	-	-	-	-
Sulphides	mg/L	-	-	0.000	-	-
Dioxins/furans	pq/L TEQ	0.460	<0.470	<0.010	-	-
2,3,7,8-TCDD	pq/L	<0.500	<0.500	<0.000	-	-
Metals						
Arsenic	mg/L	0.0005	0.0009	0.0004	0.005	DINAMA, Class 1
Cadmium	mg/L	0.0010	0.0010	0.0000	0.00084	CARU, Use 1
Copper	mg/L	0.01	0.01	0.00	0.01	CARU, Use 1
Chromium	mg/L	0.003	0.003	0.000	0.005	DINAMA, Class 2a
Mercury	mg/L	0.0005	-	-	0.0002	DINAMA, Class 1
Nickel	mg/L	0.003	0.003	0.000	0.002	DINAMA, Class 2a
Lead	mg/L	0.023	0.023	0.000	0.007	CARU, Use 1
Zinc	mg/L	0.015	0.015	0.000	0.03	DINAMA, Class 1

Table D6.4-2a: Predicted Water Quality at Receptor 11, Ñandubaysal, Argentina Under Extreme Low Flows (500 m^3/s)

Predicted Water Quality at Receptor #11, at Beach near Ñandubaysal, Argentina
Extreme Low Flow and Monthly Maximum Effluent Loading

Parameter	Units	Baseline	With Mill Discharges	Incremental Change	Most Restrictive Water Quality Standard of DINAMA, CARU	
Aesthetic						
Floating material					absent	DINAMA, Class 1
Color	PtCo	35.0	35.2	0.2	absent	DINAMA, Class 1
Conventional						
Temperature	°C	-	-	0.0	natural conditions	CARU, Use 1
TSS	mg/L	41.0	41.0	0.0	700	DINAMA, Class 2a
pH					6.5 to 8.3	CARU, Use 2
Conductivity	µS/cm	100	103	3	-	-
Dissolved Oxygen	mg/L	-	-	0	5.6	CARU, Use 1
COD	mg/L	24.0	24.4	0.4	-	-
BOD	mg/L	0.1	0.1	0.0	5	DINAMA, Class 1
AOX	mg/L	0.002	0.007	0.005	-	-
Oil and grease	mg/L	-	-	0.0	virtually absent	DINAMA, Class 1
Detergents	mg/L	-	-	0.0	0.5	DINAMA, Class 1
Microbiological						
Fecal Coliforms	FC/100 mL	-	-	1	500	CARU, Use 2
	FC/100 mL				200	CARU, Use 2
Schistosomiasis					absence	CARU, Use 1
Escherichia coli	per/100 mL				126	CARU, Use 2
Enterococos	per/100 mL				33	CARU, Use 2
Algae	UPA/ml				100	CARU, Use 1
Nutrients						
N total	mg/L	0.85	0.86	0.01	-	-
Nitrates (NO3)	mg/L	0.38	0.38	0.00	10	DINAMA, Class 1
Ammonia (total)	mg/L	0.01	0.01	0.00	-	-
Total Phosphorus	mg/L	0.100	0.101	0.001	0.025	DINAMA, Class 1
Toxins						
Chlorates	mg/L	-	-	-	-	-
Chlorophenols	mg/L	0.012	0.012	0.000	-	-
Cyanide	mg/L	-	-	0.000	0.005	DINAMA, Class 1
Phenolic comp	mg/L	<0.040	<0.040	0.000	0.001	DINAMA, Class 1
Plant sterols	mg/L	0.022	0.022	0.000	-	-
Resin/fatty acids		-	-	-	-	-
Sulphides	mg/L	-	-	0.000	-	-
Dioxins/furans	pq/L TEQ	0.460	<0.467	<0.007	-	-
2,3,7,8-TCDD	pq/L	<0.500	<0.500	<0.000	-	-
Metals						
Arsenic	mg/L	0.0005	0.0008	0.0003	0.005	DINAMA, Class 1
Cadmium	mg/L	0.0005	0.0005	0.0000	0.00084	CARU, Use 1
Copper	mg/L	0.01	0.01	0.00	0.01	CARU, Use 1
Chromium	mg/L	0.003	0.003	0.000	0.005	DINAMA, Class 2a
Mercury	mg/L	0.0004	-	-	0.0002	DINAMA, Class 1
Nickel	mg/L	0.003	0.003	0.000	0.002	DINAMA, Class 2a
Lead	mg/L	0.005	0.005	0.000	0.007	CARU, Use 1
Zinc	mg/L	0.015	0.015	0.000	0.03	DINAMA, Class 1

Table D6.4-2b: Predicted Water Quality at Receptor 11, Ñandubaysal, Argentina During Flow Reversal and Low Flows (700 m^3/s)

Predicted Water Quality at Receptor #11, at Beach near Ñandubaysal, Argentina
Flow Reversal under Low Flow and Monthly Maximum Effluent Loading

Parameter	Units	Baseline	With Mill Discharges	Incremental Change	Most Restrictive Water Quality Standard of DINAMA, CARU	
Aesthetic						
Floating material					absent	DINAMA, Class 1
Color	PtCo	35.0	35.6	0.6	absent	DINAMA, Class 1
Conventional						
Temperature	^{o}C	-	-	0.0	natural conditions	CARU, Use 1
TSS	mg/L	41.0	41.1	0.1	700	DINAMA, Class 2a
pH					6.5 to 8.3	CARU, Use 2
Conductivity	µS/cm	100	101	1	-	-
Dissolved Oxygen	mg/L	-	-	0	5.6	CARU, Use 1
COD	mg/L	24.0	24.9	0.9	-	-
BOD	mg/L	0.1	0.2	0.1	5	DINAMA, Class 1
AOX	mg/L	0.002	0.012	0.010	-	-
Oil and grease	mg/L	-	-	0.0	virtually absent	DINAMA, Class 1
Detergents	mg/L	-	-	0.0	0.5	DINAMA, Class 1
Microbiological						
Fecal Coliforms	FC/100 mL	-	-	4	500	CARU, Use 2
	FC/100 mL				200	CARU, Use 2
Schistosomiasis					absence	CARU, Use 1
Escherichia coli	per/100 mL				126	CARU, Use 2
Enterococos	per/100 mL				33	CARU, Use 2
Algae	UPA/ml				100	CARU, Use 1
Nutrients						
N total	mg/L	0.85	0.86	0.01	-	-
Nitrates (NO3)	mg/L	0.38	0.39	0.01	10	DINAMA, Class 1
Ammonia (total)	mg/L	0.01	0.01	0.00	-	-
Total Phosphorus	mg/L	0.100	0.101	0.001	0.025	DINAMA, Class 1
Toxins						
Chlorates	mg/L	-	-	-	-	-
Chlorophenols	mg/L	0.012	0.012	0.000	-	-
Cyanide	mg/L	-	-	0.000	0.005	DINAMA, Class 1
Phenolic comp	mg/L	<0.040	<0.040	0.000	0.001	DINAMA, Class 1
Plant sterols	mg/L	0.022	0.022	0.000	-	-
Resin/fatty acids		-	-	-	-	-
Sulphides	mg/L	-	-	0.000	-	-
Dioxins/furans	pq/L TEQ	0.460	<0.474	<0.014	-	-
2,3,7,8-TCDD	pq/L	<0.500	<0.501	<0.001	-	-
Metals						
Arsenic	mg/L	0.0005	0.0009	0.0004	0.005	DINAMA, Class 1
Cadmium	mg/L	0.0005	0.0005	0.0000	0.00084	CARU, Use 1
Copper	mg/L	0.008	0.01	0.00	0.01	CARU, Use 1
Chromium	mg/L	0.003	0.004	0.001	0.005	DINAMA, Class 2a
Mercury	mg/L	0.0004	-	-	0.0002	DINAMA, Class 1
Nickel	mg/L	0.003	0.003	0.000	0.002	DINAMA, Class 2a
Lead	mg/L	0.005	0.005	0.000	0.007	CARU, Use 1
Zinc	mg/L	0.015	0.015	0.000	0.03	DINAMA, Class 1

Table D6.5-1: Summary of Potential Effects on the Aquatic Environment

Receptor 1	**Vicinity of Botnia and ENCE Discharges**
Water quality	• Exposure Area extending approximately 35 m from each diffuser and 200 m along each diffuser. • Possible exceedance of surface water quality objectives within this exposure area during extreme low flow conditions. • Potential for aesthetic effect associated with visual detection of the effluent plume within a very small area at each diffuser during extreme low flow conditions.
Sediment quality	• Possible enrichment of sediments (e.g., organic material and nutrients) within the small exposure area at each diffuser.
Fish community	• Possible fish attraction to the diffusers due to warmer temperature and higher velocity. • Minimal potential health effects on fish, since exposure area is small relative to the home range for most fish species.
Aquatic invertebrate community	• Possible change in benthic macroinvertebrate community within the exposure area at each diffuser due to sediment enrichment.
Receptor 2	**Yaguareté Bay**
Water quality	• Water quality in compliance with DINAMA surface water quality standards (with the exception of phosphorus which exceeds the standard under background condition due to discharge of untreated municipal wastewater and agriculture runoff). • Trace levels of wastewater from mill operations will not adversely affect water quality.
Sediment quality	• Potential for sedimentation due to the lower water velocities within the embayment but limited change expected due to mill operations. • Monitoring of sediment quality recommended to confirm conclusion of no adverse effect.
Fish community	• Trace levels of wastewater from mill operations will not adversely affect the health of fish communities within Yaguareté Bay. • Monitoring of selected fish species recommended to confirm conclusion of no adverse effect.
Aquatic invertebrate community	• Trace levels of wastewater from mill operations will not adversely affect the invertebrate communities within Yaguareté Bay. • Monitoring of benthic macroinvertebrate community recommended to confirm conclusion of no adverse effect.

Table D6.5-1: Summary of Potential Effects on the Aquatic Environment (cont'd)

Receptor 3	**Playa Ubici**
Water quality	• Water quality in compliance with DINAMA surface water quality standards (with the exception of phosphorus and possibly bacteria which exceed the standard under background condition due to discharge of untreated municipal wastewater and agriculture runoff). • Trace levels of wastewater from mill operations will not adversely affect water quality.
Sediment quality	• Sediment quality unaffected within beach area.
Fish community	• Fish community unaffected within beach area.
Aquatic invertebrate community	• Aquatic invertebrate community unaffected within beach area.
Receptor 4	**Fray Bentos Drinking Water Supply**
Water quality	• Water quality in compliance with DINAMA surface water quality standards for Class 1 waters (with the exception of phosphorus, ammonia and possibly bacteria which exceed the standard under background condition due to discharge of untreated municipal wastewater and agriculture runoff). • Trace levels of wastewater from mill operations will not adversely affect water quality.
Sediment quality	• Not applicable
Fish community	• Not applicable
Aquatic invertebrate community	• Not applicable
Receptor 5	**Beach Area near Arroyo Fray Bentos**
Water quality	• Water quality in compliance with DINAMA surface water quality standards (with the exception of phosphorus and possibly bacteria which exceed the standard under background condition due to discharge of untreated municipal wastewater and agriculture runoff). • Trace levels of wastewater from mill operations will not adversely affect water quality. • Option to treat the municipal wastewater for the city of Fray Bentos at the Botnia mill will improve water quality within the beach area.
Sediment quality	• Sediment quality unaffected within beach area.
Fish community	• Fish community unaffected within beach area.
Aquatic invertebrate community	• Aquatic invertebrate community unaffected within beach area.
Receptor 6	**Beach Area near Las Cañas**
Water quality	• Potential for improved water quality if municipal wastewater for the city of Fray Bentos is treated at the Botnia mill.
Sediment quality	• Sediment quality unaffected within beach area.
Fish community	• Fish community unaffected within beach area.
Aquatic invertebrate community	• Aquatic invertebrate community unaffected within beach area.

Table D6.5-1: Summary of Potential Effects on the Aquatic Environment (cont'd)

Receptor 7	**Rio de la Plata**
Water quality	• Water quality unaffected.
Sediment quality	• Sediment quality unaffected.
Fish community	• Fish community unaffected.
Aquatic invertebrate community	• Aquatic invertebrate community unaffected.
Receptor 8	**Esteros de Farrapos e Islas del Rio Uruguay**
Water quality	• Water quality unaffected.
Sediment quality	• Sediment quality unaffected.
Fish community	• Fish community unaffected.
Aquatic invertebrate community	• Aquatic invertebrate community unaffected.
Receptor 9	**Rio Negro**
Water quality	• Potential improvement in water quality in Rio Negro if untreated wastewater from Papelera Mercedes is treated at Botnia mill.
Sediment quality	• Potential improvement in sediment quality in Rio Negro if untreated wastewater from Papelera Mercedes is treated at Botnia mill.
Fish community	• Reduced risk to fish community in Rio Negro if untreated wastewater from Papelera Mercedes is treated at Botnia mill.
Aquatic invertebrate community	• Reduced risk to invertebrate community in Rio Negro if untreated wastewater from Papelera Mercedes is treated at Botnia mill.
Receptor 10	**Rio Uruguay along the Argentina Side**
Water quality	• Water quality unaffected.
Sediment quality	• Sediment quality unaffected.
Fish community	• Fish community unaffected.
Aquatic invertebrate community	• Aquatic invertebrate community unaffected.
Receptor 11	**Beach Area at Ñandubaysal, Argentina**
Water quality	• Water quality unaffected.
Sediment quality	• Sediment quality unaffected.
Fish community	• Fish community unaffected.
Aquatic invertebrate community	• Aquatic invertebrate community unaffected.

Figure D6.1-1: Identified Sensitive Receptors in Uruguay and Argentina

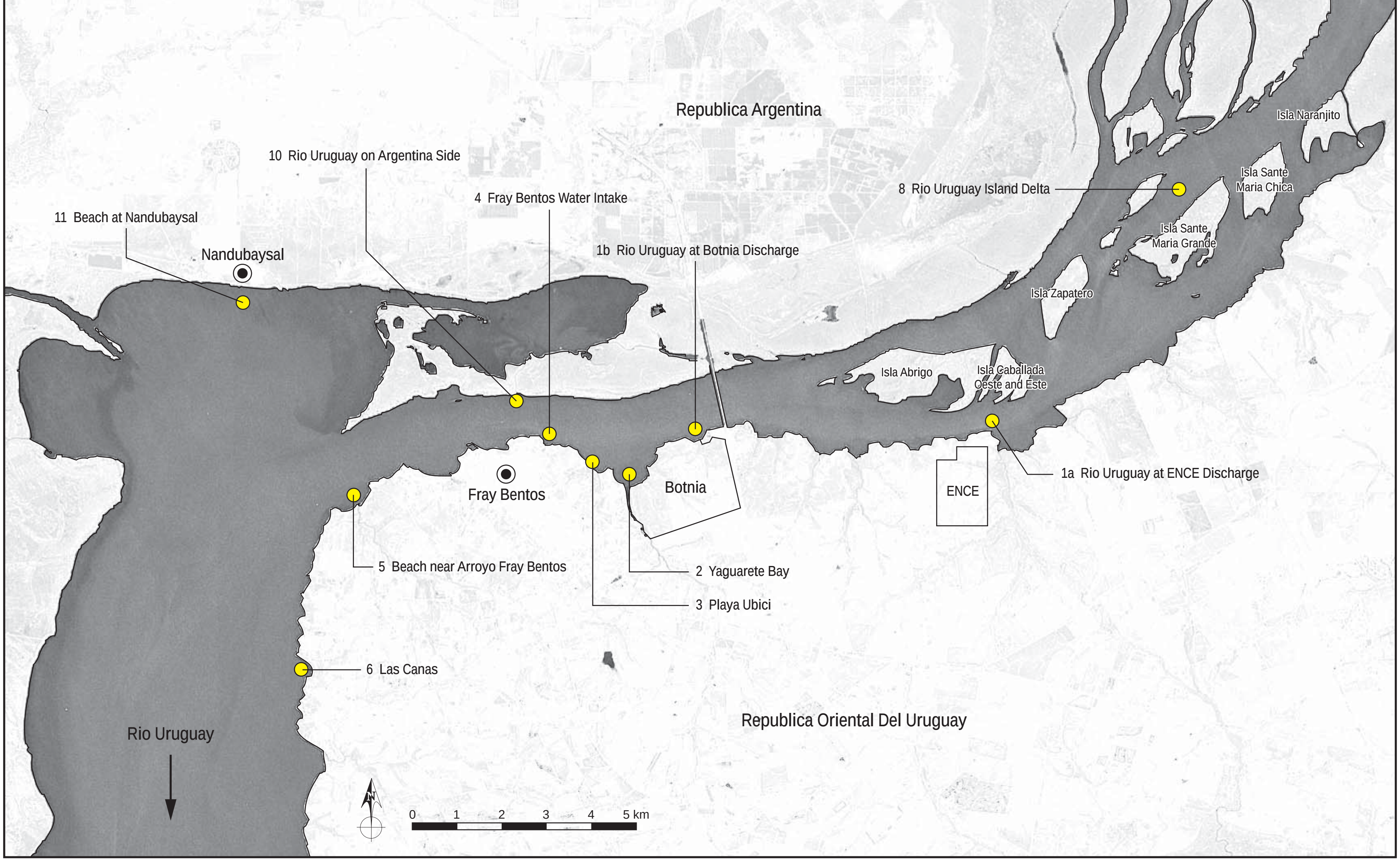
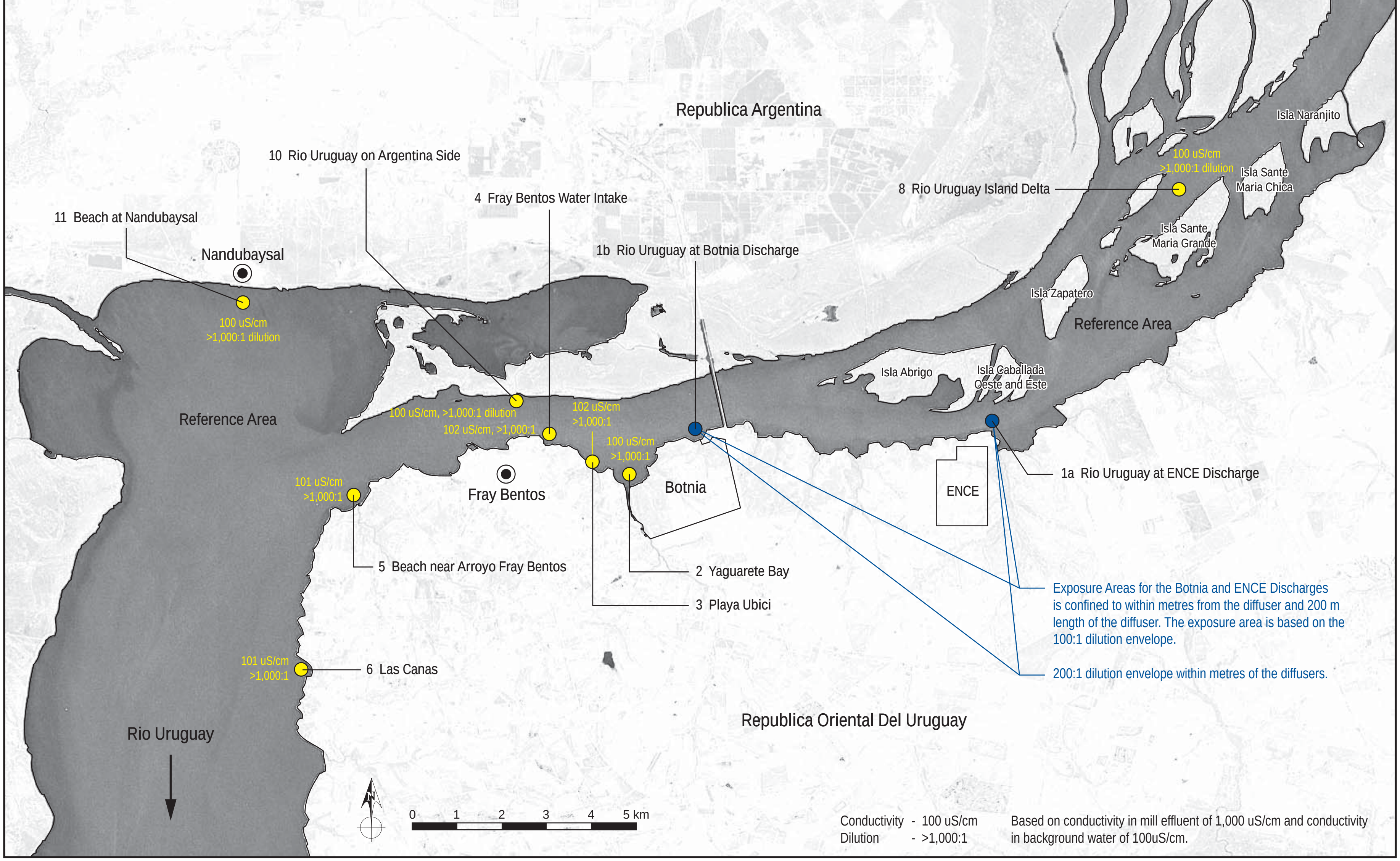


Figure D6.2-1: Effluent Exposure Under Typical Flow Conditions (6,200 m^3/s)



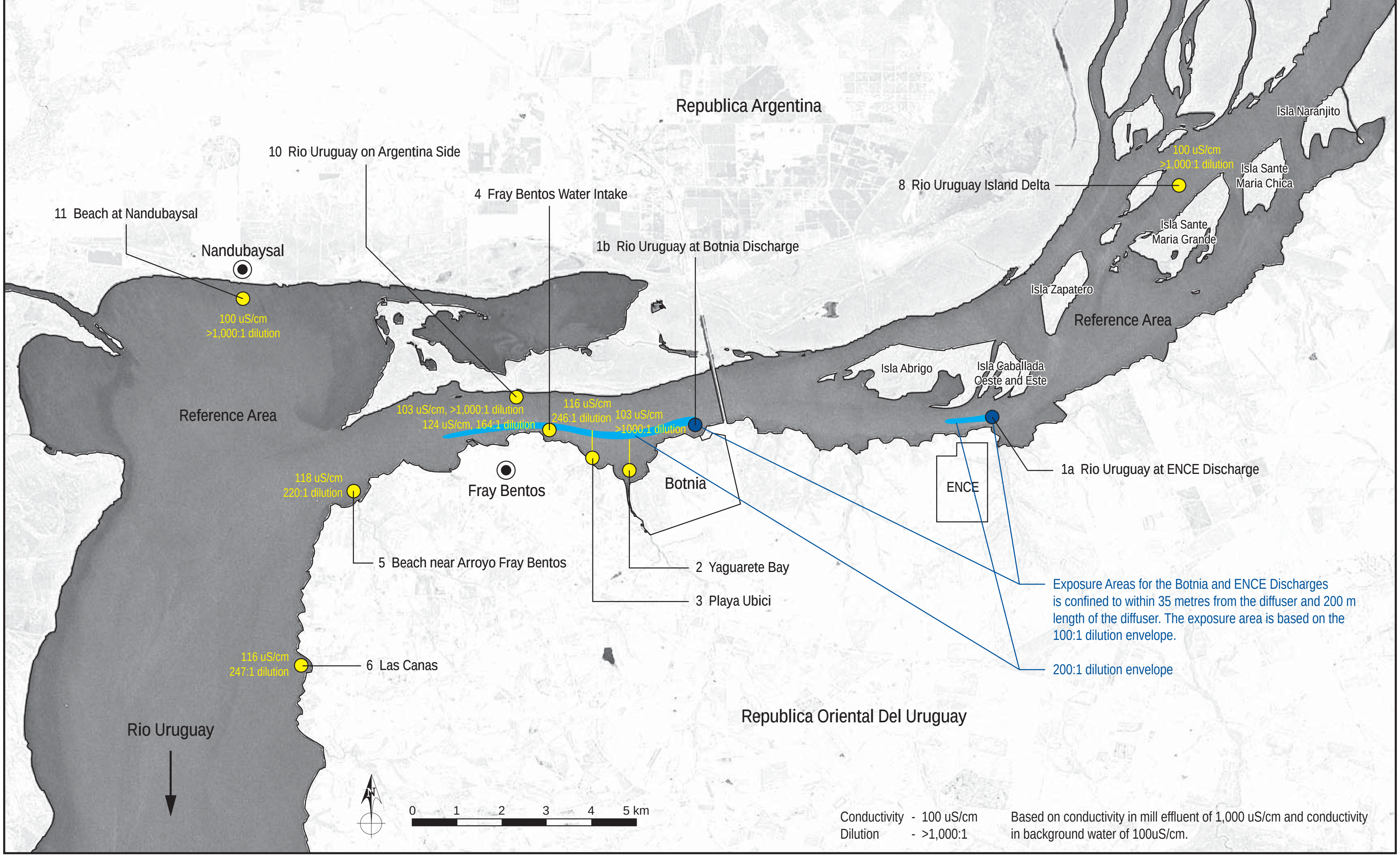
Exposure Areas for the Botnia and ENCE Discharges is confined to within metres from the diffuser and 200 m length of the diffuser. The exposure area is based on the 100:1 dilution envelope.

200:1 dilution envelope within metres of the diffusers.

Conductivity - 100 uS/cm
Dilution - >1,000:1

Based on conductivity in mill effluent of 1,000 uS/cm and conductivity in background water of 100uS/cm.

Figure D6.2-2: Effluent Exposure Under Extreme Low Flow Conditions (500 m³/s)



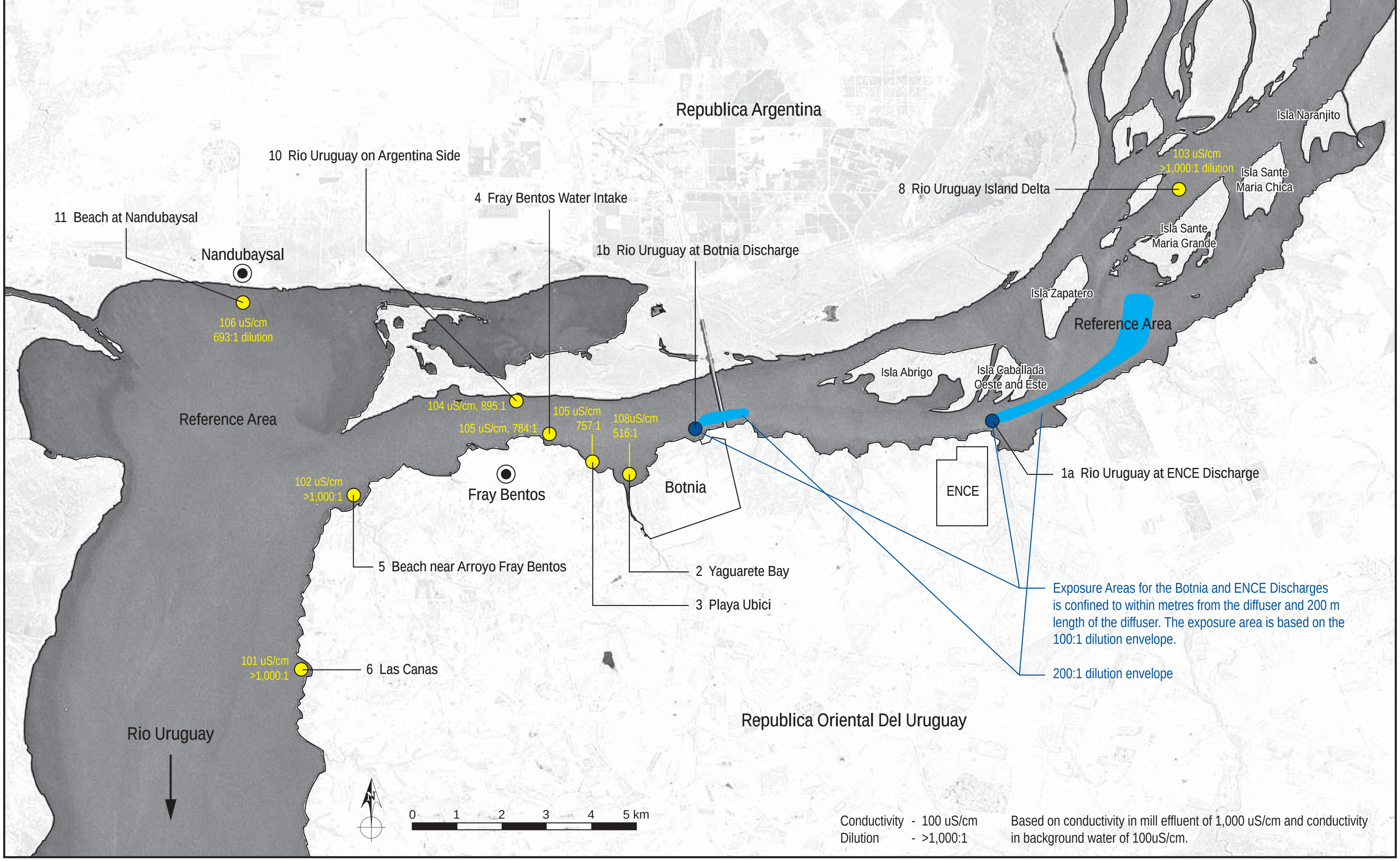
Exposure Areas for the Botnia and ENCE Discharges is confined to within 35 metres from the diffuser and 200 m length of the diffuser. The exposure area is based on the 100:1 dilution envelope.

200:1 dilution envelope

Conductivity - 100 uS/cm
Dilution - >1,000:1

Based on conductivity in mill effluent of 1,000 uS/cm and conductivity in background water of 100uS/cm.

Figure D6.2-3: Effluent Exposure During a Rare Flow Reversal and Under Extreme Low Flow Conditions (500 m³/s)



Exposure Areas for the Botnia and ENCE Discharges is confined to within metres from the diffuser and 200 m length of the diffuser. The exposure area is based on the 100:1 dilution envelope.

200:1 dilution envelope

Conductivity - 100 uS/cm
Dilution - >1,000:1

Based on conductivity in mill effluent of 1,000 uS/cm and conductivity in background water of 100uS/cm.

Figure D6.3-1a: Receptor 1a, Botnia Site Viewed from the International Bridge

Figure D6.3-1b: Receptor 1b, ENCE Site Viewed from the International Bridge

Figure D6.3-2: Receptor 2, Rio Uruguay at Yaguareté Bay

Figure D6.3-3: Receptor 5, Beach Area near Arroyo Fray Bentos

Figure D6.4-1: Receptor 11, Beach Area at Ñandubaysal, Argentina

(photo taken with 44mm lens)

Figure D6.4-2: Receptor 11, Ñandubaysal Showing Botnia Site in Distance

(photo taken with 36mm lens)

D7.0 EFFLUENT AND RECEIVING ENVIRONMENT QUALITY MONITORING

As part of the Botnia and ENCE mills' overall commitment to operate in a sustainable manner, as well as their commitment to meet all regulatory reporting requirements, routine effluent and receiving environment quality monitoring programs will be implemented. Below, the basis for these programs is described within the context of expected operational, effluent treatment and effluent release scenarios. Monitoring of mill effluents will include both chemical and toxicological measures. Receiving environment monitoring will comprise measurements of chemical and biological endpoints with the overall objective of determining whether mill effluents have an adverse effect on the Rio Uruguay. As discussed elsewhere in this CIS, it is predicted that there will be no adverse effects. If adverse effects are discovered, the companies are committed to take immediate corrective action, and will be subject to regulatory oversight by DINAMA.

It should be noted that water quality monitoring in the Rio Uruguay has been and will continue to be performed by government agencies independently of the mill monitoring programs. For example, DINAMA has proposed and implemented its own water quality monitoring plan for the Rio Uruguay. This monitoring program is available on DINAMA's website at www.dinama.gub.uy. In addition, the binational commission, CARU, had proposed and began implementing a monitoring program, PROCEL, for the Rio Uruguay. Implementation of the PROCEL program is currently suspended.

D7.1 Effluent Monitoring

Routine monitoring of mill effluent quality is necessary from both regulatory and mill performance perspectives. Mill monitoring plans will need to be approved by DINAMA prior to the time the mills commence operations. In addition, the mills are required to meet effluent quality criteria prescribed by DINAMA and therefore collection of effluent quality data allows the mills to demonstrate compliance with these criteria. From the mills' perspective, effluent quality data also permit mill personnel to continuously monitor mill and effluent treatment system performance. Deviation of key performance indicators (e.g., conductivity, COD) from design or operational norms will alert personnel to potential upsets in the system allowing appropriate mitigative action. Dissemination of effluent quality monitoring information also allows the mills to communicate measures of performance to their local stakeholder constituency and provides these stakeholders with the tools to evaluate mill performance for themselves.

Routine effluent quality monitoring for both the Botnia and ENCE mills will comprise chemical, as well as toxicological, characterization of mill effluent. Monitoring of effluent chemistry is addressed in Annex A, Process Technologies. Details of the effluent toxicity monitoring are provided below.

The potential toxicity of industrial effluents is currently evaluated by a number of means using a suite of organisms representing different trophic levels. Though bioassay terminology ranges widely from jurisdiction to jurisdiction (see Power and Boumphrey, 2004), generally speaking effluent bioassay tests can be classified into two groups, based on whether the tests measure organism survival with short-term exposure (i.e., acute toxicity) or alternatively a relative change in some sublethal endpoint with longer-term exposure (i.e., chronic toxicity).

In a typical acute toxicity test, whole organisms are placed in undiluted effluent for relatively short periods of time (e.g., 72 to 96 hours). Test endpoints are expressed as simply “pass” or “fail” (i.e., did the test animals, or a pre-established proportion of the test animals, survive the test or not), or in some cases as effluent concentrations (% by volume) in which a given proportion of the test animals do not survive (e.g., an LC50 – the lethal concentration at which 50% of test organisms do not survive).

A chronic toxicity test is one used to determine the concentration of a substance that produces an adverse effect from prolonged exposure of an organism to that substance. In practical terms, these tests can last from, for example, seven to ten days (however, some may be shorter in duration) and their focus is on an endpoint that is a direct measure of growth, reproduction or the like. A common way to express chronic bioassay test results is as an “inhibition concentration” (IC). The IC concentration describes an effluent concentration that has resulted in a given reduction in some test endpoint. For example, an IC25 is an effluent concentration that results in a 25% reduction in a test endpoint.

D7.1.1 Trends in Bioassay Use

Power and Boumphrey (2004) recently completed a review of international trends in bioassay use for effluent management. The status of the current regulatory use of effluent bioassays in North America, the European Union (EU) and Australia and New Zealand are summarized in Table D7.1-1. Although there is no need to provide the results of this review in detail some general trends were noted that are relevant to this discussion. Firstly, bioassay requirements vary between different jurisdictions, reflecting different protection goals, requirements for ecological relevance, timing for adoption of bioassay use, and external factors (e.g., restricted use of *in vivo* testing). Second, effluent bioassays are used to assess regulatory compliance with effluent criteria (e.g., Canada, USA, Germany), with the nature of their use related to the given regulatory regime. Third, the historical trend has been to start with chemical hazard-based systems (source protection), then add effluent bioassays (first lethal, then sublethal measures) as the regulatory system evolves. Fourth, statistical design for effluent bioassays has improved considerably in recent years and, in many jurisdictions, is likely optimized and defines good practice.

D7.1.2 Rationale for the Use of Toxicity Testing at the Botnia and ENCE Mills

The assessment of acute toxicity of mill effluents is a useful measure of effluent quality. In the case of both Botnia and ENCE, the mills have been designed with BAT and the expectation is that treated mill effluents will not show acute toxicity to aquatic biota. In order to ensure that the mills maintain a high quality of operation, and to assure both regulators and local stakeholders that this is in fact the case, the mills will implement a testing program to empirically determine the level of lethality, if any, of the effluents.

Similarly, a chronic toxicity testing program is also proposed. Although modern pulp mill effluents generally do not show acute toxicity, there are compounds (e.g., endocrine disruptors) that may perhaps negatively influence biota in receiving environments. This imparts a need for more subtle means by which potential mill effects might be assessed, and provides the rationale for the use of controlled chronic bioassay testing of mill effluents.

D7.1.3 Proposed Acute Toxicity Testing Program

Mill effluents will be assessed for acute toxicity as a means to quantifiably demonstrate that mill effluents are not acutely toxic and also to track effluent quality over time. Toxicity testing will be conducted using a single concentration test according to standardized protocols using the invertebrate *Daphnia magna* and as yet to be determined fish species. Single concentration testing procedures (i.e., pass/fail) have been selected over multi-concentration (LC50) tests as there is high likelihood that mill effluents will have no acute toxicity. Single concentration tests are easier to implement but will nevertheless provide the required information.

Toxicity testing in Uruguay is carried out by the Laboratorio Tecnológico del Uruguay (LATU). LATU currently has the capacity to complete testing using *Daphnia magna*, but does not have the capacity to complete toxicity testing with a fish species. With this in mind, the mills will commit to helping LATU develop this capacity (i.e., chose appropriate native organisms for testing, develop new or adapt existing appropriate testing procedures, define a quality assurance and quality control program). It is suggested that this capacity could be developed in time for the commencement of operations at the BOTNIA mill.

Initially, testing will be completed weekly using the appropriate reference methods for grab samples of undiluted effluent collected from as close to the final discharge point as is possible, but before any dilution of the effluent with river water. Test results will be provided as “pass” or “fail”, with a failure corresponding to any sample in which mortality is seen in greater than 50% of the test organisms. It is proposed that weekly testing would continue for six months under normal mill operating conditions. At this time, the need for further or ongoing testing would be reviewed with the appropriate stakeholders and agencies. It is proposed that reduced testing frequency might be appropriate if at this time the mills have demonstrated that their effluents are not acutely toxic during routine operations.

D7.1.4 Proposed Chronic Toxicity Testing Program

At present, there is no capacity in Uruguay to implement a chronic toxicity testing program using a suite of test organisms that is representative of various trophic levels. Nevertheless the mills are committed to using chronic toxicity testing as a means to monitor effluent quality. With this in mind it will be necessary to develop the testing capacity. It is suggested that two years is a reasonable time frame over which this capacity could be developed. Over this period it would be necessary to chose appropriate organisms for testing, develop new or adapt existing appropriate testing procedures (including organism culturing capacity) and define a quality assurance and quality control program. Guidance to help move this process forward is available from a number of sources, such as Johnson *et al.* (2004). The testing capacity would be in place before the commencement of mill operation, either within Uruguay or elsewhere until local capacity exists. It is suggested that capacity building would be a cooperative process involving the mills and scientific authorities and personnel from LATU and DINAMA.

A general outline of the proposed chronic toxicity testing program is as follows. Testing would be completed according to standardized testing procedures on a suite of organisms representing different trophic levels including an invertebrate, a plant and a fish species. It is generally accepted that it is preferable to employ a battery of testing organisms so as to span a range of species sensitivities. This approach has been adopted by numerous jurisdictions including Australia and New Zealand (ANZECC and ARMCANZ, 2000), Canada (Environment Canada, 1999), Germany (Power and Boumphrey, 2004), the Netherlands (Tonkes *et al.*, 1999) and the UK (UKWIR, 2001). Initially, testing would be implemented on a monthly basis. Monthly testing would continue for one year after which testing frequency would be reduced to quarterly or biannually following review with appropriate stakeholders and agencies. The purpose of the initial year long monthly testing program is to establish the typical range of test endpoint values over a range of mill operating conditions. Testing in subsequent years is meant as a means to monitor long term trends in effluent quality.

D7.2 In-Field Empirical Confirmation of Effluent Dispersion Simulations

The mills will confirm the results of the most recent effluent plume modelling scenarios with in-field studies (see Annex D, Section D6.0). The proposed field programs, which will be implemented in a manner consistent with guidance provided by Kilpatrick and Cobb (1985), USGS (1986) and JWEL and Natech (2003), are described below.

In general, the plume delineation studies involve the measurement of a chemical tracer within the receiving environment. The chemical tracer can be either a substance added to the effluent (e.g., Rhodamine WT dye) or a property of the effluent that can be measured at higher concentrations than in the natural environment (e.g., conductivity). Ideally, the chemical tracer will be measured in the field, as opposed to collection of samples for laboratory analysis. This enables identification and delineation of the effluent plume while in the field, and immediate adaptation to any unforeseen circumstances. This is particularly important for these two sites since the size of the effluent plumes are expected to be very small and therefore difficult to identify in the field.

These studies are to be implemented once the mills have reached effluent discharge rates that are typical of normal operating conditions. Field sampling will be conducted during a period that approaches annual low river flow, ideally less than 1,000 m^3/s. Detection of the effluent plume may not be possible at higher flows. The surveys will be conducted generally as described in the following sections.

D7.2.1 Field Methodology Using Conductivity

Conductivity is often a suitable indicator of a wastewater discharge within freshwater environments. The high conductivity of the wastewater discharge (approximately 1,000 µS/cm) relative to ambient water (approximately 100 µS/cm) generally enables detection of the wastewater plume at the 100:1 dilution level.

The surveys are conducted from a boat equipped with temperature and conductivity probes, a depth sounder, and a Global Positioning System (GPS). Ideally the temperature and conductivity probes include depth sensors (or else the cable is accurately marked with depth), and the GPS used to determine location should be accurate within 5 m. Initially, a series of measurements should be taken within the immediate vicinity of the diffuser to locate the effluent plume. Once located, measurements should be taken over an orderly grid extending along and perpendicular to the direction of the plume. Vertical profiles of temperature and conductivity should also be taken at fixed locations along the centerline of the plume to determine the degree of vertical mixing.

Conductivity of the effluent should be monitored frequently during the field program to record possible temporal variations. Conductivity of the ambient river water should also be recorded frequently at various upstream and downstream locations beyond the influence of the two plumes to accurately record the temporal and spatial variability attributed to other inflows, such as Rio Gualeguaychu and Fray Bentos municipal wastewater. This will ensure proper resolution of the effluent plume.

D7.2.2 Field Methodology Using Dye Tracer

A conservative dye tracer should be used in addition to conductivity to further distinguish the mills' effluents from river water and other possible effluents within the Rio Uruguay. Rhodamine WT is commonly used for this purpose since it is relatively stable in the environment, poses no environmental threat in itself, and is relatively easy to measure in the field.

The procedure involves the release of the dye into the effluent stream using a continuous flow-rate injection system. This type of injection system makes field measurements more reliable. Care must be exercised to ensure the dye is not visually detectable to observers.

This is generally not an issue since the detection limit of the instrument used to measure the dye concentration (referred to as a fluorometer) is very low relative to the visual detection limit. However, this concern generally limits the amount of dye used and therefore limits the resolution of the plume.

The dye tracer study must be carefully planned in advance to ensure that the correct amount of dye is used, at the correct injection rate and over the correct duration. Modification of the study plan is generally not possible once the test is initiated. The mathematical model described in Section D5.1 can help in this regard as it can be used to test the study plan in advance (e.g., to confirm the correct amount of dye is being used to achieve the desired resolution, and to determine the time required to achieve steady state conditions).

Fluorescence is converted to an effluent concentration through a calibration process. A series of dilutions are prepared by adding a measured volume of effluent with dye to river water and corresponding fluorometer readings are obtained. The effluent sample is to be obtained downstream from the dye injection point, and the river water sample is to be obtained from a location upstream of the mills, outside the possible influence of the effluent. A calibration curve is developed from the series of dilutions. The curve will be corrected for temperature differences since fluorescence is inversely related to water temperature (2.1% per C°). Effluent and river water have near-neutral pH and therefore a correction for pH is not necessary.

Rhodamine WT is photosensitive and will degrade (albeit at a relatively slow rate) over time when exposed to direct sunlight. With this in mind, a dye degradation test will be conducted to ensure that the fluorescence of the dye within the effluent remains constant over the duration of the injection period. The test will be performed on samples of 100%, 50% and 10% effluent in receiving water. Fluorescence will be measured immediately after mixture of the samples and at regular intervals over the duration of the field program to assess degradation rates.

The concentration of the dye in the river can be measured using a fluorometer fitted with a continuous flow-through sampling port. The surveys are conducted from a boat equipped with a fluorometer, a continuous flow-through pump, temperature and conductivity probes, a depth sounder, and a GPS. The GPS, used to determine location, should be accurate to least 5 m. Initially, a series of measurements (dye concentration, temperature, conductivity, position) will be taken at fixed depths (e.g., 0.3, 2.0, 4.0 m) as the boat traverses the river in transects perpendicular to the shore line downstream of the discharge. These measurements are used to determine the horizontal spatial extent of the effluent plume within river. Second, a series of measurements are taken at fixed positions as the sampling equipment is raised from the bottom of the water column to the surface. These measurements are used to determine the vertical location and thickness of the effluent plume.

Sampling in the initial mixing zone is difficult since effluent concentrations may vary significantly around the point of discharge. With this in mind, sampling will be focused in the area where the plume breaks the surface or is arrested in its vertical ascent. This point is likely to be tens, or several tens, of metres downstream of the discharge point. Beyond the initial dilution zone, the effluent plume should typically move horizontally, borne by the velocity of the receiving waters. As indicated, sampling transects will be made at right angles to the flow of the plume and should be spaced at appropriate intervals based on the computer simulations of plume dispersion.

D7.3 Receiving Water Monitoring

Direct measurement of key receiving environment endpoints is proposed to quantify the influence of mill effluents (if any) on the Rio Uruguay. The mills are committed to implementing a routine monitoring program that encompasses a wide range of elements to assess, in a holistic manner, any potential mill-related influences. Proposed routine monitoring is to include water quality, sediment quality, benthic invertebrates, fish health and fish usability (contaminants in fish and invertebrate tissues).

The mills also recognize that CARU and DINAMA, as well as the local stakeholder community, may bring forward issues of concern that do not necessarily fit within the framework of routine monitoring. Both Botnia and ENCE have indicated they are committed to addressing potential concerns in a proactive manner and are looking to make a positive contribution to understanding overall aquatic ecosystem function in the greater Fray Bentos area. While much of this contribution will be made through routine monitoring programs, opportunities may arise whereby the mills may wish to support basic aquatic research that furthers the basic objectives of CARU and/or DINAMA. The mills are willing to commit to this process and will evaluate opportunities for collaboration on a case-by-case basis.

The routine monitoring program envisioned is consistent with the overall objectives of the monitoring program that DINAMA has developed for the area, and includes all of the elements of DINAMA's program in one form or another. The program proposed by the mills is more streamlined and is more focused on evaluating potential mill-related influences than the DINAMA plan, and we think will be more practical to execute in many respects. Nevertheless, the mills' plan will provide a holistic assessment of the mill receiving environment, in terms of potential effluent impacts, as well as contribute to the general advancement of fisheries and aquatic information in the area.

D7.3.1 Water Quality

The Botnia and ENCE mills will discharge treated liquid effluents into the Rio Uruguay. Both mills are committed to confirming water quality modelling predictions that suggest that mill effluents will be rapidly diluted to the 100:1 level within several tens of metres from their respective diffusers, and that overall water quality will not be adversely impacted in the receiving environment. Accordingly, a water quality sampling program for the Rio Uruguay is proposed. Water quality will be measured at several locations upstream and downstream of the mills, and at several other locations that are of local significance (e.g., water intake at Fray Bentos). In particular, the water quality sampling program proposed includes:

- Sample collections at a total of eleven locations between about kilometre 90 of the river (Isla Zapatero) and kilometre 115 at Las Cañas. Proposed sampling stations are as follows (see Figure D7.3-1):
    - upstream of the proposed ENCE mill across from Isla Zapatero;
    - immediately downstream of the proposed ENCE mill effluent discharge;
    - downstream of the ENCE mill discharge across from Islote Chaja;
    - at the international bridge between Uruguay and Argentina;
    - immediately upstream of the proposed Botnia mill effluent discharge;
    - immediately downstream of the proposed Botnia mill effluent discharge;
    - the upstream end of Yaguareté Bay
    - the downstream end of Yaguareté Bay;
    - at the City of Fray Bentos water intake;
    - at the City of Fray Bentos municipal sewage discharge; and
    - at Las Cañas.
- Samples to be collected from a location in the river that is in line with the centerline of the modelled effluent plumes from the mills.
- Samples to be collected as “grabs” from the surface layer (upper 1.5 metres) of the water column.
- Samples to be collected on a bi-monthly basis.
- Samples to be analyzed for all parameters designated as “primary analytes”, as well as all or a subset of parameters designated as “recording analytes”. “Primary analytes” are those chemicals/compounds in mill effluents that have the potential to directly impact the Rio Uruguay. Conversely, “secondary analytes” are those chemicals/compounds that are not relevant to potential impacts from mill effluent discharges, but nevertheless have been identified as important water quality measures (by CARU or DINAMA) and whose measurement would be a positive contribution to the scientific knowledge base in the area. “Primary” and “secondary” analytes are identified in Table D7.3-1.
- The program will include quality assurance and quality control (QA/QC) elements to ensure that the data generated by the program are of high and known quality. Samples will be collected according to standard operating procedures (SOPs). The program will include the analysis of duplicate samples (as a general rule, duplicates would be collected for 10% of all samples), field

blanks and trip blanks. Laboratory analyses will be completed by a certified laboratory, and all laboratory QA/QC measures (run blanks, standards, etc.) will be reported.

D7.3.2 Sediment Quality

Suspended solid losses from the mills are predicted to be at relatively low levels (up to about 30 mg/L) and within typical background levels measured in the river (2 to 85 mg/L). No significant accumulation of solids (or various contaminants potentially associated with the solids) is anticipated in areas downstream of the mills. A routine sediment sampling program, however, is proposed so that these predictions can be tested and any potential influence of mill losses on sediment quality can be tracked.

The routine monitoring program will evaluate sediment quality at locations both upstream and downstream of the mill effluent discharge locations. Chemical and/or physical characterization of sediments will focus on parameters that have the potential to be influenced by the mill, or alternatively those that may be of relevance from a benthic macroinvertebrate community composition perspective. In particular, it is proposed that:

- Sampling will be conducted at the same stations used for benthic macroinvertebrate collections (see Figure D7.3-2). This includes mid-river channel (if possible) and embayment locations downstream of the mills and similar reference area locations. This distribution of stations (mid-river channel and backwater embayment areas) is adequate for monitoring potential mill-related effects, and has the added benefit of providing data that will aid in interpreting the invertebrate data. Sediments may be sparse in the mid-river channel, and if they cannot be found this will be noted.
- Samples will be collected with a dredge or grab sampler appropriate for the habitat type. Only the top 2.5 cm of sediment will be subsampled from each grab for subsequent analysis. The top 2.5 cm is of greatest interest from both a sediment deposition point of view (i.e., provides an indication of the nature of new material that has been deposited) and from a biological point of view (i.e., the top 2.5 cm, or so, is where most of the benthic community resides). If it is necessary to collect more than one grab from an individual sampling station to meet sample volume requirements for proposed analysis, the top 2.5 cm from each grab will be composited and homogenized prior to submission.
- Samples will be collected once every two to three years coincident with benthic macroinvertebrate collections.
- Samples will be submitted to a certified analytical laboratory for the analysis of total organic carbon, total phosphorus, total nitrogen, grain size, pH, AOX, EOX, TOX, total phenolics, chlorophenolics, and dioxins and furans.

- Routine sampling, as well as laboratory analyses, will incorporate and report on QA/QC measures implemented during the program. For example, sediment sampling will be conducted according to standardized operating procedures. Sample submission will include the submission of split samples for analysis. Laboratory analysis will include the analysis of standard reference materials.

D7.3.3 Benthic Invertebrates

Benthic invertebrates have long been used as tools for biomonitoring. Records of their use in this capacity date back at least as far as the late 1800s when studies of the survival of freshwater invertebrates exposed to metals and organic compounds were completed (Rosenberg, 1998). Overall, macroinvertebrates are used extensively in biomonitoring, as they offer a number of advantages (that greatly outweigh their disadvantages) including (Rosenberg and Resh, 1993):

- they are ubiquitous, so they are affected by perturbations in many different habitats;
- they are species-rich, so the larger number of species produces a range of responses;
- they are sedentary, so they stay put, which allows determination of the spatial extent of a perturbation;
- some are long-lived, which allows temporal changes in abundance and age structure to be tracked; and
- they integrate conditions temporally so, like any biotic group, they provide evidence of conditions over long periods of time.

A routine benthic invertebrate monitoring program is proposed. Although specific details regarding the design of the program are not offered at this time, the following provides an accounting of key program elements and/or principles to which the programs will adhere:

- The programs will follow a Control-Impact design whereby sampling will be conducted both upstream (“reference” or “control”) and downstream (exposure or impact) of the mill effluent discharges.
- Sampling will be conducted in two habitat types including mid-river, where effluents are released, and backwater embayment areas, which have been identified as areas of interest because of the potential for sediment deposition (and associated adsorbed chemical contaminants) as water velocities are slower there (see Figure D7.3-2).
- Sampling will be conducted at the time of year (season) when benthic invertebrate diversity is at its maximum and at a time when the resident benthos are at a life cycle stage that permits or eases taxonomic identification. Early life

history stages of aquatic insect larvae (i.e., early instars) are often not distinguishable to low (i.e., precise) taxonomic levels.

- Sampling effort will be such that the programs will be quantitative and statistically rigorous. In Canada's EEM program for example, individual sampling areas in a Control-Impact study design comprise a minimum of five replicate sampling stations. This level of replication is sufficient to detect a difference of ±2 standard deviations (considered an ecologically significant difference) with α (the likelihood of committing a type I error) and β (the likelihood of committing a type II error) equal to 0.1 (Environment Canada, 2005).
- The program will be cyclic in nature. That is, surveys will be completed at regular intervals (e.g., every two to three years) to allow for assessment of potential changes in benthic community structure through time and in part to facilitate the evolution of the program in response to changes in mill process or effluent treatment or changes in the river that may occur independent of mill operations.
- Sample collection will include collection of various supporting environmental variables (sediment and water chemistry) to aid in the overall interpretation of the macroinvertebrate community data. Sediment quality sampling will be conducted as described in Annex D, Section D7.3.2. Water quality measures should be collected in sufficient replication to adequately capture variability in water quality within individual sampling areas, with analyses focused on variables that might be influenced by effluent discharge and would also be likely to affect macroinvertebrate community structure (e.g., dissolved oxygen, suspended solids).
- Taxonomic analyses of invertebrates will be completed to the lowest practical level (LPL) using appropriate, site specific taxonomic keys. Although some monitoring programs (e.g., EEM in Canada; Environment Canada, 2005) or protocols (e.g., U.S. EPA rapid bioassessment; Barbour *et al.*, 1999) suggest that taxonomic identification to family level (or higher) is adequate for monitoring purposes, LPL (which typically is to genus or species) is preferred here. LPL will permit a more complete ecological interpretation of any patterns seen in the invertebrate community data.
- Data will be summarized to determine key benthic community metrics, which summarize benthic community structure and provide insight into the relative status (e.g., healthy vs. impaired) of the community. Typically used community metrics includes measures of density (e.g., total number of invertebrates per unit surface area, number of invertebrates from individual taxonomic groups per unit surface area), diversity (e.g., number of discrete taxa; Simpon's Diversity Index) and community composition (e.g., Bray-Curtis). Guidance as to the appropriate

use of benthic invertebrate metrics is provided in a number of sources (e.g., Mandaville, 2002).

- Interpretation of the results of the surveys will be objective in nature and use appropriate statistical tests (e.g., comparison of key metrics for reference and exposure areas using ANOVA) to assess potentially important patterns in the data. The results of statistical testing will be considered together with the supporting environmental information and the taxonomic information to provide a holistic interpretation of the data.
- The sampling programs will include quality assurance and quality control components so that there is assurance that the data generated by the programs are of known and high quality. QA/QC elements will include things such as sample collections according to standard operating procedures, sample analysis by qualified or certified laboratories, estimates of subsampling error and precision.

D7.3.4 Fish Health

It is generally accepted that there are no acute fish toxicity issues in the receiving environment, as the result of effluents discharged from modern pulp and paper mills under normal operating conditions. There is a body of evidence however which demonstrates that, in certain circumstances, effluents can have sublethal ecosystem effects on fishes (unlikely in the case of the Botnia and ENCE mills). Some of these effects are related to increased food availability as the result of increased benthic production through eutrophication. Life history consequences for fish related to eutrophication might include increased liver size (via increased glycogen stores) or increased growth rates (Lowell *et al.*, 2003). Eutrophication could also lead to increase in fish productivity (numbers and types of fish), especially in receiving environments that were once more oligotrophic in nature (BEAK, 2000). While these effects result in fish, or fish assemblages, that are different from “reference”, it is unclear whether these differences are truly representative of negative impacts.

Conversely, in some cases negative impacts on the reproductive status of fish by endocrine disruption have been seen (e.g., Munkittrick *et al.*, 1998). In this instance, phytosterols (which are formed in plant materials) are released as constituents of effluents and disrupt the production of sex steroid hormones and pituitary hormones in fish. The practical life history consequence of these compounds could include reduced gonad weights and egg production, delayed sexual maturity and/or altered secondary sexual characteristics (e.g., Van Der Kraak *et al.*, 2001). Typically however, these types of effects are only observed in instances where fish are exposed to relatively high effluent concentrations for extended periods (or constantly) during key developmental stages. Effluent dispersion modelling for both the Botnia and ENCE mills indicates that mill effluents will be diluted rapidly in the receiving environment and therefore the type of exposure associated with negative reproductive effects is not expected.

Draft monitoring programs under consideration by DINAMA and CARU have referenced fish health surveys as implemented in Canada's national monitoring program. It is unclear at present whether this survey component will be required. It would not be required under Canadian regulations at mills with such small effluent plumes (100:1 dilution within approximately 35 m)[1]. A conceptual fish survey plan is presented here in case it may be desired in Uruguay.

Like the benthic survey, specific details regarding the design of the fish health monitoring program are not provided herein, however the following provides an overview of key program elements and/or principles to which a program should adhere:

- The program would follow the sentinel species approach currently used for receiving environment studies at pulp and paper mills in Canada.
- Two fish species (adults) would be targeted for collection, with collections to take place in areas downstream of the mills ("exposure") and areas well beyond the potential area of mill influence ("reference"). Likely candidate "exposure" areas include the embayment habitats downstream of each mill (e.g., at the mouth of Arroyo Las Cañas for ENCE; Yaguareté Bay for Botnia) (Figure D7.3-3). No specific candidate reference areas are provided herein, but care would be taken to ensure reference area habitats are similar to those in the exposure area.
- Ideal sentinel species are those that have high site fidelity (i.e., limited home ranges), as their overall health and condition will more accurately represent the environmental conditions of the area in which they are collected. Migratory species would not necessarily be excluded as candidate species, however some knowledge about their utilization of local river reaches vs. other non-local areas would be required to adequately assess patterns seen in fish health.
- Fish would be collected at a time of the year when they are sexually mature, but prior to the initiation of spawning, so that reproductive capacity can be assessed.
- As a general rule of thumb, collection targets would be in the range of 20 male and 20 female fish. Practical experience suggests that this number of fish ensures high statistical power for analysis of key fish health endpoints (see below).
- Morphological measurements would be collected for individual fish that are representative of survival, energy use and energy storage. A list of the typical measurements that are collected as part of EEM fish health surveys in Canada is summarized in Table D7.3-2. A list of the endpoints that are derived from

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[1] In Canada, fish health surveys, as part of environmental effects monitoring, are not required at pulp and paper mills where 100:1 effluent dilution occurs within less than 250 m (Environment Canada, 2005).

these measures, which are typically used to evaluate fish health is provided in Table D7.3-3.

- Male and female fish would be treated separately for statistical comparison purposes. It is well established that male and female fish allocate energy for life processes differently, especially during periods of reproductive development, and therefore for comparison purposes they must be treated separately.
- Data would be analyzed consistent with the goal of identifying potential differences in key health related endpoints between or among sampling areas.

At what level differences (downstream vs. reference) would be considered statistically significant and/or ecologically meaningful are not defined here, but this would need to be addressed prior to the initial sampling campaign. For instance, in environmental effects monitoring studies in Canada, differences are considered statistically significant when the probability of committing a Type I error (rejecting the null hypothesis when it is true) is less than 5% (Environment Canada, 2005). Differences are considered to be potentially ecologically significant when they are in the order of 10 to 25%, or more (Environment Canada, 2005).

D7.3.5 Fish Usability

Fish usability, as affected by contaminant levels in fish, is an important concept within the context of the development of the proposed pulp mills. There is exploitation of the local fishery and therefore any potential threat to the fishery (real or perceived) may be of significant stakeholder concern. However, it is not likely that contaminants from the proposed mills will impair fish usability given the rapid dilution of effluent and the small size of the plumes. In Canada's national monitoring program, analysis of dioxins and furans in fish tissues is only required if 2,3,7,8-TCDD or 2,3,7,8-TCDF are present in effluent at measurable concentrations (using an approved reference method), or if concentrations >15 pg/g FW in fish flesh have been found in recent monitoring in the mill exposure area.

As discussed previously (see Annex D, Section D3.0) baseline fish tissue sampling was completed in 2004 and 2005 (Tana, 2005, 2006). Levels of various organic compounds (dioxins and furans, chlorophenols, phytosterols, resin and fatty acids) were measured in flesh and bile from several fish species from several locations around Fray Bentos. The data collected to date and the mill effluent modeling results do not suggest the need for a detailed fish tissue monitoring program, however the following conceptual program is outlined should DINAMA wish to implement one:

- for baseline collections, as well as additional locations in relative close proximity of the proposed ENCE effluent discharge (see Figure D7.3-4). Overall, these sampling areas include locations in close proximity to the mills ("near field"), at some distance from the mills ("far field") and in locations beyond any potential mill influence ("reference").

- Target species would include sábalo (*Prochilodus lineatus*), bogon (*Leporinus obtusidens*), tararira (*Hoplias malabaricas*) and bagre amanillo (*Pimelodus maculatus*). Ideally, each fish species would be collected in each sampling area during each survey.
- Dioxin and furan levels would be measured in fish flesh from each of the species collected.
- Chlorophenols, resin and fatty acid and phytosterol levels would be measured in fish bile samples for each of the fish species collected (these compounds are fat soluble and would likely only be found at levels above normal method detection limits in tissues such as bile).
- Sampling would be conducted on an annual or bi-annual basis.

As indicated, the purpose of this component of the monitoring program would be to confirm the prediction that mill effluents will not impact fish usability (as measured via contaminant levels in fish tissues) and the data collected as part of the proposed program would at least in part fulfill this purpose. These data, however, would need to be interpreted with some caution. An example of why this is so is provided below.

Three of the four fish species that are proposed for sampling (and have been used in baseline monitoring) are migratory in nature. Because of this, it is possible that the contaminant levels in fish tissues may not be truly representative of contaminant inputs from the mills. This, in fact, has been identified as a likely possibility at this time (i.e., prior to the initiation of mill operations) with one of the proposed fish species. Sábalo are known to travel significant distances in the Rio Uruguay and use the area around Fray Bentos as feeding habitat. Their movement patterns take them to areas as far as the Rio Paraná, for example, and there they are exposed to untreated pulp mill effluent, potentially for extended periods. Increased contaminant levels in Sábalo would need to be considered, therefore, within this context.

To attempt to provide greater interpretive power related to potential issues of contaminants in biota, chemical characterization of a benthic invertebrate is proposed as part of routine monitoring. In particular, the program will include the collection of a benthic taxon from several areas of interest as habitat for bottom-feeding fishes (Figure D7.3-4). The program will be implemented on the same schedule and with the same frequency as fish tissue collections. Likely candidate taxa include the Asian clam (*Corbicula fluminea*) or the golden muscle (*Limnoperna fortunei*), both sessile molluscs whose tissue burdens will accurately reflect the local conditions in which they have developed.

Tainting assessments are not proposed as part of routine monitoring. Generally speaking tainting is not an issue in areas downstream of modern mill effluent discharges (following the advent of secondary effluent treatment). This has been most effectively demonstrated in Canada which has had the most extensive experience in systematically monitoring fish tainting. Tainting was initially part of environmental effects monitoring for the pulp and paper industry in Canada, but has been eliminated from the program, as it is not a national issue. Only one of the more than hundred mills in Canada currently is engaged in ongoing tainting evaluation studies. Should tainting issues arise, although none are expected, they will be dealt with in an appropriate, investigative manner.

D7.4 Public Reporting

Both the ENCE and Botnia mills are committed to ensuring that data pertaining to the operation and potential influence of the mills is readily available for public dissemination and is in a form that the lay public can understand. As required, all routine effluent and receiving environment monitoring program data will be provided to DINAMA as scheduled in the mills' individual operations permits. As such, once in DINAMA's hands, the information will be in the public domain and should be made widely available. In practice, however, it is suggested that the mills should also disseminate key performance data in a proactive manner. It should be noted that DINAMA has required that each mill proponent participate in a "Follow-Up Committee" once operations have commenced. These committees will be presided over by MVOTMA, and will be made up of various governmental entities and representatives of the local communities. These committees will allow both the government and the local community to access information about the environmental impacts of the mills. In addition to the committees, the mills should use a public information/community development centre in Fray Bentos, or similar mechanism, as a means to distribute information. The centre should have an area dedicated to the measurement of environmental performance and should include, among other things, data relevant to effluent and receiving environment quality.

Effluent quality data will be represented by several key measures that are indicative of the performance of the effluent treatment plants and the overall quality of the effluents. It is proposed that flow, COD and conductivity data will be reported to the public to reflect daily operating performance. It is also proposed that acute toxicity data also be reported to demonstrate continued non-toxic effluent. Along with the data itself, regulatory criteria (if applicable) and measures of "typical" mill performance will also be shown for comparative purposes. "Typical" mill performance is to be expressed as the long-term monthly average value (i.e., the average of monthly averages for all available data) and the maximum monthly average (i.e., maximum monthly average for all data available). As indicated, these data will be in a format readily understood by the lay public (pictorial where possible) with full and clear explanation of the information provided where appropriate and/or necessary.

Receiving environment quality data generated by the proposed routine monitoring will also be reported to the public in a timely manner. It is suggested that data for a few key water quality parameters (e.g., conductivity, dissolved oxygen, nutrients) be tracked and shown graphically as data permit for a subset of the proposed sampling stations. Data for the stations upstream and downstream of the mill discharges, as well as at Yaguareté Bay and the City of Fray Bentos water intake, would serve for these purposes, providing the public a broad spatial understanding of water quality conditions in the area. Other routine monitoring data (fish, benthos) would be available on a regular but less frequent basis (as defined by the proposed schedule for each), and would be brought forward when available.

It is suggested that a quarterly information circular might be the best vehicle to do so. This quarterly publication would track the environmental performance at the mill and summarize the real time data that are also provided as stand-alone performance indicators. It is also suggested that the mills use the Internet to distribute this information to help broaden public/stakeholder access. Although common, Internet access/use is by no means universal in the greater Fray Bentos area. Nevertheless, it would seem reasonable to expect that local Internet use will grow in the future, and that at some point this medium will become a much more significant component of the overall communications plan of each mill. The Internet can also enable more frequent reporting of some of the key environmental quality monitoring results indicated above.

Finally, although the audience might be somewhat limited for the detailed scientific reports that will be generated through routine environmental monitoring, hardcopies (paper) and electronic copies (PDF) of all receiving environment and effluent-related studies will be maintained in a catalogued library at the proposed public information centre in Fray Bentos.

Table D7.1-1: State of Current Regulatory Use of Effluent Bioassays (recreated from Power and Boumphrey, 2004)

Characteristics of Effluent Bioassays	United States	Canada	Belgium	Denmark	France	Germany	Norway	Spain	Sweden	United Kingdom	Australia	New Zealand
Entry point to applying effluent bioassays[1]	Regulatory requirement under Clean Water Act[a]	Regulatory requirement under general provisions of Fisheries Act as well as for specific industry-specific sections (e.g., Fisheries Act, Pulp and Paper Effluent Regulations; Metal Mining Effluent Regulations (MMER))	Effluent bioassays not routinely applied	Non-statutory application of strategy	Bioassays (acute daphnid) used for regular monitoring of industrial effluents and used as a basis for taxation	Applied under the Wastewater Ordinance (AbwV) and the Wastewater Charges Act	May be applied as regulatory requirement	Regional regulations on discharges to Sea of Andaluca, regarding discharges to sewers in Madrid (Ley 10/93), and a number of regulations regarding taxation of discharges (regional).	Regulatory requirement under Characterization of Industrial Discharges Guidelines	No regulatory compulsion to use bioassays but may be used under IPPC and Water Resources Act. Proposals to phase in bioassay use will prioritize those areas where existing biological quality is poor.	Site-specific, can be effluent chemistry or a receiving water quality problem. Philosophy is to use a tiered risk-based approach.	Site-specific – philosophy is to use a risk-based approach. Screening level in AEE investigations. Regulatory (permit) requirement for standard or native site-specific_ species bioassays
Management Framework[2]	Primarily source control, but augmented by receiving environment bioassays in some situations[a] and states	Primary source control but, for some industries in some situations, receiving environment bioassays may be required	• Sector-based conditions based on best available technology (BAT) • Site-specific conditions to protect receiving water	• Sector-based conditions based on BAT • Site-specific conditions to protect receiving water	• Sector-based conditions based on BAT • Site-specific conditions to protect receiving water	Source control. Occasionally ambient toxicity close to effluents is determined. Early warning monitoring using (e.g., Daphnids) used in large rivers. Emission reduction at source is the overriding principle. Load conditions based on BAT to direct and indirect discharges to surface waters. No "backsliding" allowed. Sector-based discharge limits applied. Risk assessment of receiving waters not routinely used.	• Source control. Total emission factors (TEF) as well as site-specific concentration values used. • Land based industry: emission limits and site-specific conditions to protect receiving water used. • Offshore industry: discharge permits required. Ecotoxicological assessment (including biodegradability) of chemicals, drilling fluids, products to be used, etc., is needed before use for hazard assessment.	Source control, hazard based. No requirements for receiving water monitoring, although biomonitoring is carried out in numerous areas as part of state and Water Basin Authority programmes. Few efforts have been made in relating emission data to receiving water quality. Chemical source emission limits generally applied for discharges to surface waters and sewers. Specific water quality objectives for listed substances apply to surface waters.	Source control, however, the STORK protocol uses bioassays in field experiments Predominately focuses on predicting receiving water effects. Treatment plants can refuse to accept industrial waste and restrictions are determined at a municipality level. A load value "Toxicity Emission Fact" is also used.	• Primarily source control, but other frameworks in development. Effluent testing may be supplemented by testing in the receiving water. • Risk-based approaches taking account of the potential receiving water effects. • Sector-specific emission limits using Bat under Integrated Pollution Prevention and Control (IPPC).	Primarily source control, but receiving environment monitoring is required in some cases, or is conducted as R&D. Responsibility is at state or territory level. Effluent regulation is a state and territory responsibility, although national guidance is provided. Water quality guidelines (ANZECC and ARMCANZ, 2000) are not mandatory	Traditionally, based on source control but recent regulatory changes have resulted in greater emphasis on receiving environment effects. Some receiving water bioassays – primarily bivalve bioaccumulation and health. Effluent regulation is under national legislation (Resource Management Act (1991[a]), but responsibility is usually delegated to regional level. Consents for water are "effects-based", judged from the results of an "assessment of Environmental Effects (AEE)". Ambient water quality guidelines (ANZECC and ARMCANZ, 2000) are not mandatory.
Phyla Used[3]	Algae, invertebrate and fish[a]	Algae, macrophyte, invertebrate and fish (depending on permit, maybe only one of these)[b]								Fish, invertebrates, plants/algae, bacteria. A laboratory regulatory bioassay quality control programme has been developed.		

Table D7.1-1: State of Current Regulatory Use of Effluent Bioassays (recreated from Power and Boumphrey, 2004) (cont'd)

Characteristics of Effluent Bioassays	United States	Canada	Belgium	Denmark	France	Germany	Norway	Spain	Sweden	United Kingdom	Australia	New Zealand
Bioassay Endpoints[4]	Acute and chronic[a]	Acute and sublethal[b]	Acute and chronic	Acute and chronic	Acute, chronic and mutagenicity. Use group parameters (e.g., AOX, total metals, BOD, etc.) as part of WEA	Acute, chronic, genotoxicity, mutagenicity. Use biodegradation and group parameters (TOC, AOX, COD) as part of WEA	NI	Acute	• Acute, chronic, mutagenicity, enzymatic (plus physiological and morphological for field bioassays). • WEA approach includes biodegradation and bioaccumulating substances screens.	Acute and chronic	Acute and chronic	Acute, sub-lethal and chronic
Effluent Bioassay Data Used[5]	Statutory/ enforceable requirements	• Statutory/ enforceable requirement (in most cases under effluent permits)[b,c,d] • Part of an Environmental Effects Monitoring (EEM) framework for some industries[b,c,d] • Not required for many sewage discharges[e]								Few (<200 enforceable permits in place		
Experience of applying effluent bioassay approaches		Regulatory requirement for major industry. Extensive R&D experience	A few specific research studies on industrial effluents	Characterization survey covering 23 industries plus a number of specific research studies	Routine monitoring and occasional use in licensing	Routine use of standardized tests since 1976. Acute fish tests used as basis for taxation. Extensive regulatory and R&D testing undertaken.	Land based industry: bioassays used in characterization and licensing of effluents on case-by-case basis.	Experience in regulatory use of Daphnid and *Vibrio fischeri* tests in effluent control. A few specific research studies on industrial effluents.	Bioassays are used in licensing effluents and have been part of the Characterization of Industrial Discharges (CID) guidelines since 1989, but are only applied to larger industries. Many studies on specific industry sectors undertaken.	No regulatory requirement for bioassay use nationally, however, some local use for regulatory compliance monitoring. Extensive R&D experience including a collaborative government/industry "demonstration programme". Bioassays are also used in national programme for receiving water monitoring of coastal waters.	Broad experience	Broad experience

[1] Entry point to applying effluent bioassays (e.g., screening process, regulatory requirement, chemical criteria failures, etc.).
[2] Overall management framework within which effluent bioassays are located (e.g., receiving environment approach, source control approach, combination).
[3] Level(s) of biological testing for effluent bioassays (algae, invertebrate, fish).
[4] Type of test endpoints (acute, chronic, sublethal, other measures).
[5] What is the requirement for effluent bioassay data (e.g., statutory/enforceable requirement, voluntary for self-management, negotiated by individual case, part of a tiered decision framework, etc.).
[6] If applicable, consequence of "non-compliance" (relative to decision criteria) for effluent bioassay data (e.g., legal action, toxicity reduction evaluation, process management).
[7] both of these questions are trying to describe regulatory use of bioassays – how broadly are effluent bioassays used, and where they are used, do they show compliance with regulatory goals?
[8] Does the effluent bioassay program get evaluated or audited and, if so, how?
[a] Grothe *et al.* (1996).
[b] Environment Canada (1999).
[c] Scroggins *et al.* (2002a,b).
[d] ESG International and Lakefield Research (2002).
[e] R. Scroggins (pers. comm., 2002).
[f] Herber *et al.* (1996).
[g] Fisher *et al.* (1998).

Table D7.3-1: Primary and Secondary Analytes for the Proposed Water Quality Sampling Program in the Rio Uruguay

	Mode of Measurement
PRIMARY ANALYTE	
Temperature	*In situ* via sensor
Conductivity	*In situ* via sensor
Dissolved oxygen (mg/L, % saturation)	*In situ* via sensor
pH	*In situ* via sensor
Transparency	*In situ* via sensor
Turbidity	*In situ* via sensor
Total suspended solids	Certified laboratory
Biological oxygen demand	Certified laboratory
Chemical oxygen demand	Certified laboratory
Colour	Certified laboratory
Hardness	Certified laboratory
Alkalinity	Certified laboratory
Sulphate	Certified laboratory
Nitrate	Certified laboratory
Nitrite	Certified laboratory
Ammonia	Certified laboratory
Total nitrogen	Certified laboratory
Total phosphorus	Certified laboratory
Total dissolved phosphorus	Certified laboratory
Dissolved organic carbon	Certified laboratory
Total organic carbon	Certified laboratory
Total phenols	Certified laboratory
Chlorophenols	Certified laboratory
Bacteria	Certified laboratory
Adsorbable organically-bound halogens (AOX)	Certified laboratory
Extractable organically-bound halogens (EOX)	Certified laboratory
Total organically-bound halogens (TOX)	Certified laboratory
Plant sterols	Certified laboratory
SECONDARY ANALYTES	
Trace metals (Cu, Cr, Cd, Fe, Mn, Mg, Ni, Se, Zn)	Certified laboratory
Heavy metals (Hg, Pb)	Certified laboratory
Microcystin	Certified laboratory
Chlorides	Certified laboratory
Chlorine (free and residual)	Certified laboratory
Oil and grease	Certified laboratory
Pesticides	Certified laboratory

Table D7.3-2: Typical Fish Survey Measurements Collected as Part of EEM Surveys in Canada Along with Expected Precision Levels and Reporting Requirements

Measurement Requirement	Expected Precision	Reporting Requirement
Length (fork or total or standard)*	± 0.2 cm	Individual measurements, mean, standard deviation
Total body weight (fresh)	± 5.0%	Individual measurements, mean, standard deviation
Age	± 1 year (10% to be independently confirmed)	Individual measurements, mean, standard deviation
Gonad weight	± 1.0%	Individual measurements, mean, standard deviation
Egg size	± 1.0%	Weight, minimum sub-sample sizes of 100 eggs
Fecundity**	± 1.0%	Total number of eggs per female
Weight of liver or hepatopancreas	± 1.0%	Individual measurements, mean, standard deviation
External condition	NA	Obvious abnormalities, prevalence of lesions, tumours, parasites, etc.
Sex	NA	

* If caudal fin is forked, use fork length. Otherwise, use total length. Cases where fin erosion is prevalent, standard length should be used.

** Fecundity can be calculated by dividing total ovary weight by weight of individual eggs (individual egg weight can be estimated by counting the number of eggs in a sub-sample. The sub-sample should contain at least 100 eggs).

Table D7.3-3: Typical Fish Response Variables, Morphometric Endpoints and Statistical Analyses Used to Assess Fish Health as Part of EEM in Canada

Response Variable	Endpoint	Appropriate Statistical Test
Survival	Age	Mann-Whitney
Energy Use	Size-at-age (body weight at age)	ANCOVA
	Body weight (whole)	ANOVA
	Length	ANOVA
	Size-at-age (length at age)	ANCOVA
	Reproduction	ANCOVA
	Relative gonad size (gonad weight adjusted for body weight)	ANCOVA
	Relative gonad size (gonad weight against length)	ANCOVA
	Relative fecundity (# of eggs/female against body weight)	ANCOVA
	Relative fecundity (# of eggs/female against length)	ANCOVA
	Relative fecundity (# of eggs/female against age)	ANCOVA
Energy Storage	Condition (body weight against length)	ANCOVA
	Relative liver size (liver weight against body weight)	ANCOVA
	Relative liver size (liver weight against length)	ANCOVA
	Relative egg weight (mean egg weight against body weight)	ANCOVA

Figure D7.3-1: Proposed Water Quality Sampling Locations for Routine Water Quality Monitoring

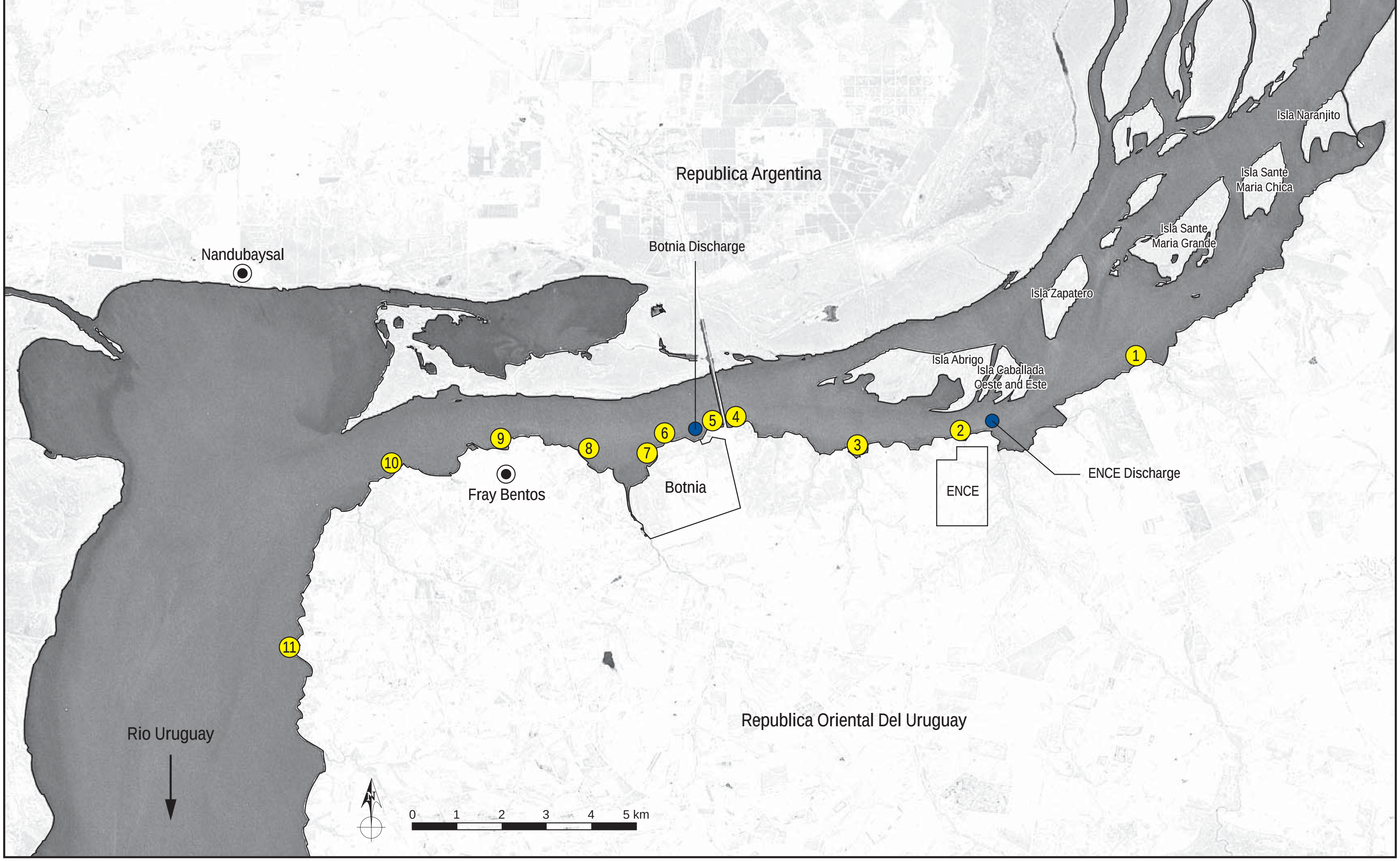


Figure D7.3-2: Sediment and Benthic Invertebrate Sampling Areas for the Proposed Routine Monitoring Programs

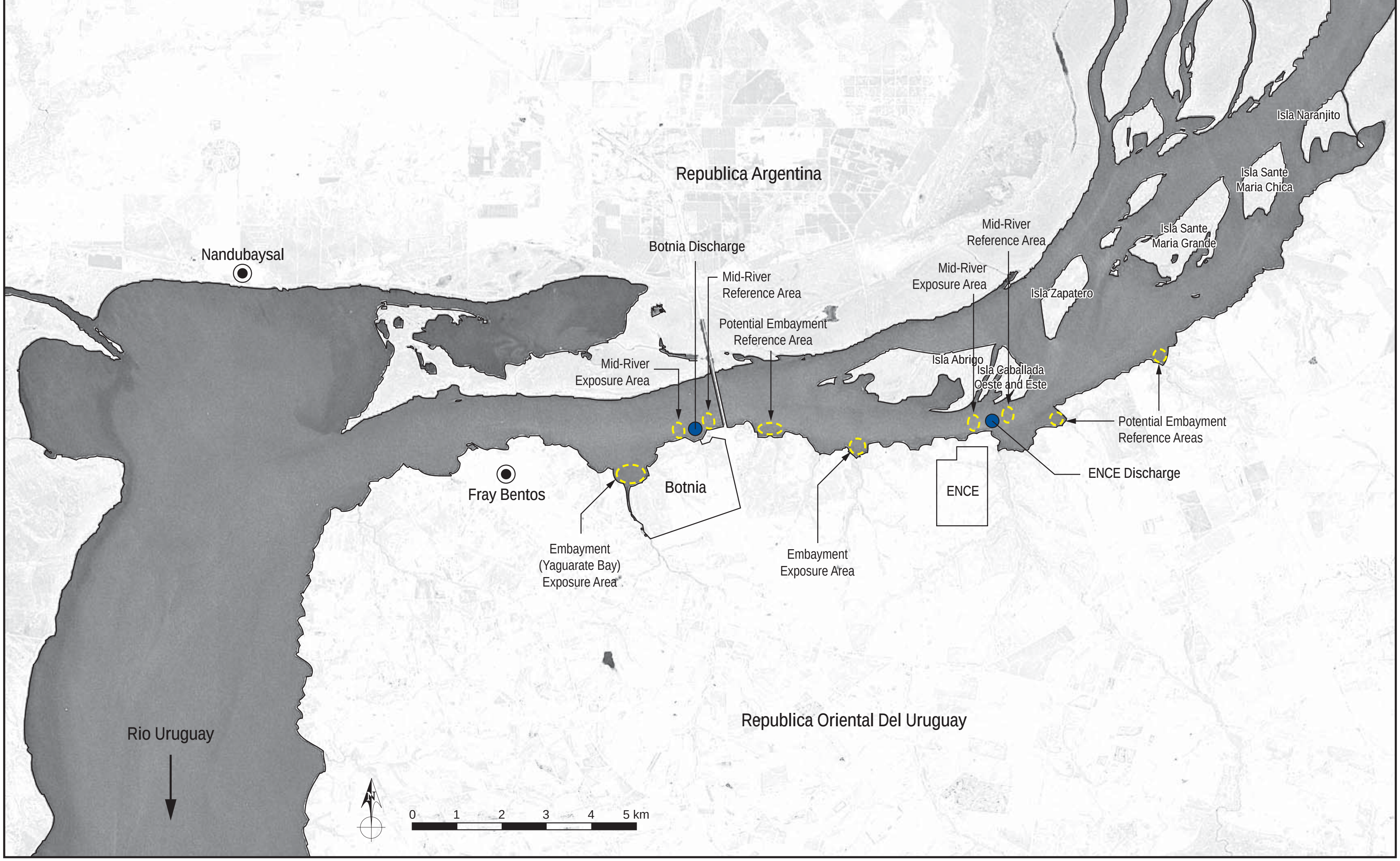
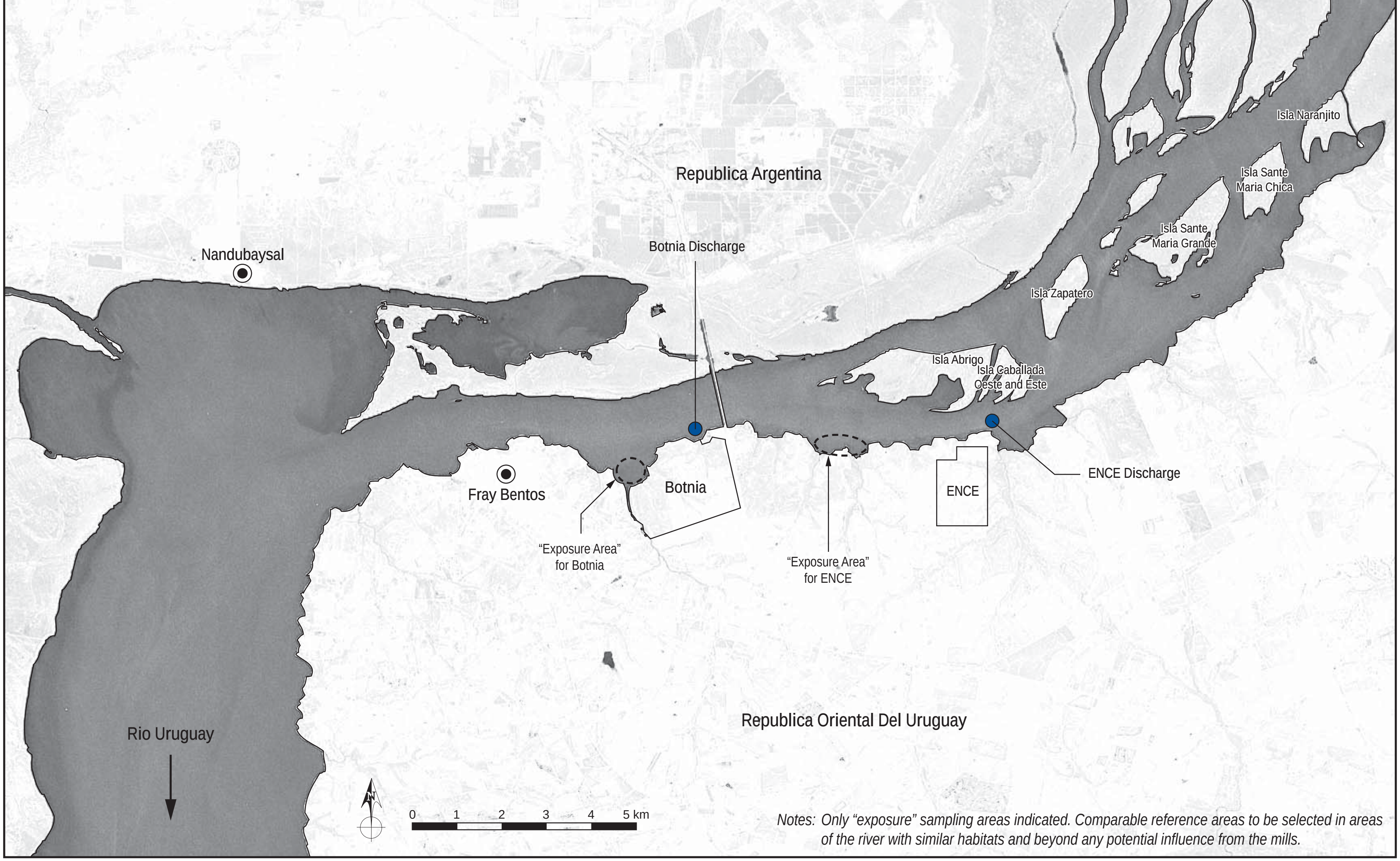
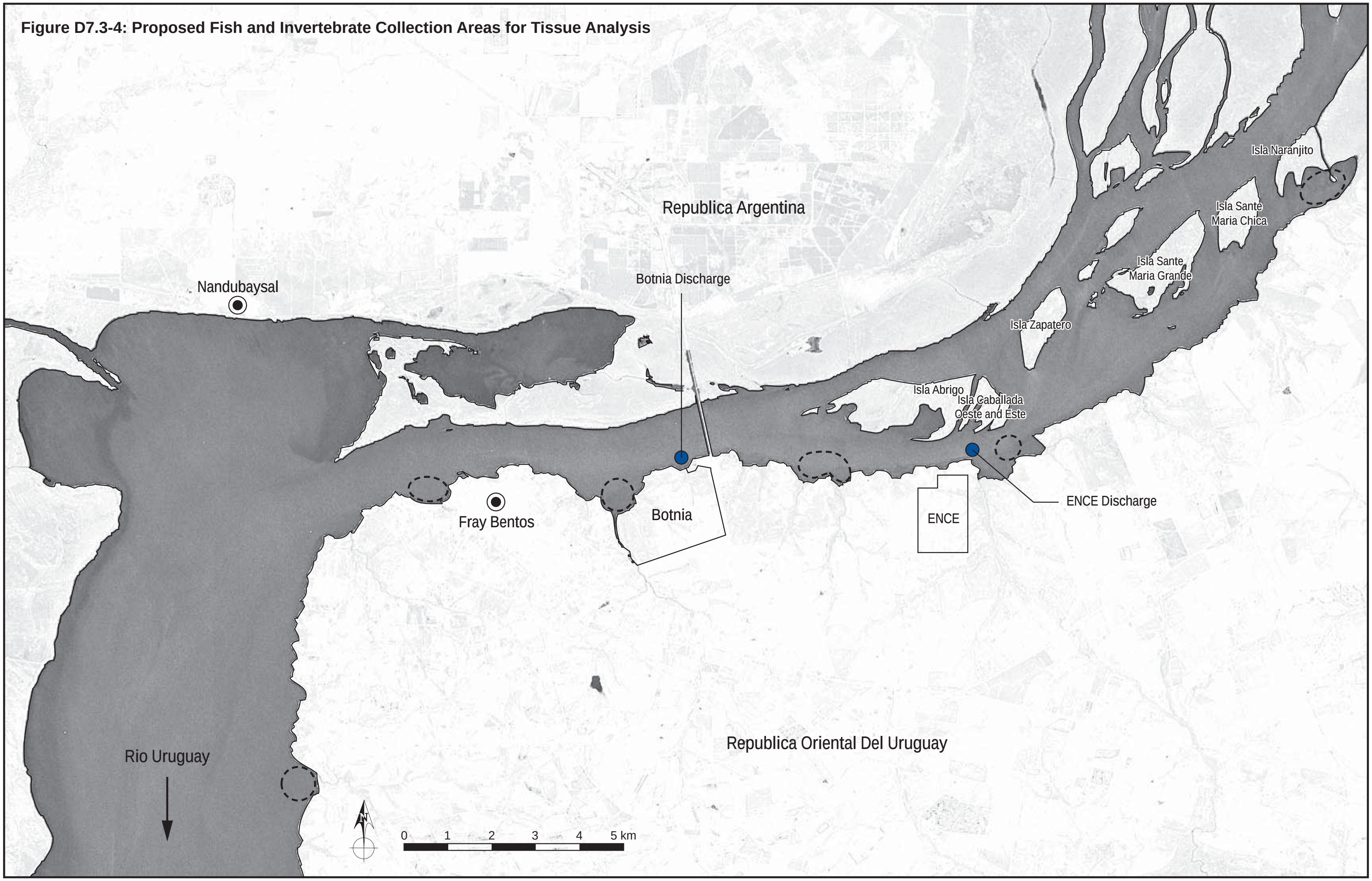


Figure D7.3-3: Proposed Fish Health Survey Sampling Areas in the Rio Uruguay



Notes: Only "exposure" sampling areas indicated. Comparable reference areas to be selected in areas of the river with similar habitats and beyond any potential influence from the mills.

Figure D7.3-4: Proposed Fish and Invertebrate Collection Areas for Tissue Analysis



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