Río de la Plata Hydrometeorological Data Collection

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Abstract
This paper describes the surveys and field work performed throughout the years 2009 and 2010 in connection with the Río de la Plata River hydrometeorological data collection used as a basis for the Outfall Modeling project for the city of Buenos Aires conducted by Dr. Philip J. W. Roberts.

Agua y Saneamientos Argentinos S.A. (AySA SA) provides Drinking water and Sewerage collection services to the City of Buenos Aires and 17 Districts of the Metropolitan area, covering 1,800km^2, 1,000 km^2 of which are completely urbanized with a population of 11M residents.

The Río de la Plata River is the main source of raw water, from where 4,800,000m^3 are extracted on a daily basis for the production of drinking water, also being the receiving body of its sewage effluents. The Río de la Plata River is an estuary of the Atlantic Ocean formed by the junction of the rivers Paraná and Uruguay, running from Northwest to Southeast with a length of 290km and a width of 48km at the "Paralelo de Punta Gorda" which is the spot taken as its origin. The tide is frequently altered by sudden changes in the air pressure and the dragging effect of the wind, affecting the astronomical tide.

Field work involved the installation, operation and retrieval of information from six ADCPs used to measure current direction and intensity, wave height, conductivity and turbidity. Ten 12-hour drifter tracking campaigns were conducted for the different hydrodynamic conditions. Installation of three weather stations located at the river, over the Water Intake Tower of the San Martín, Manuel Belgrano, and Berazategui plants, performing maintenance, operation and data collection. Preparation of Conductivity-Temperature-Depth (CTD) profiles at the two sites recommended for the diffusers carried out around the clock on a monthly basis. Bathymetry of the area (15km by 10km) in a 1km-resolution grid.

The variables monitored during this period were: Temperature, wind speed and direction, humidity, air pressure, solar radiation and rainfall, current speed and direction, water temperature, water level of the river (depth), wave height, Lagrangian current trajectories, conductivity, turbidity, among others.

The scope of the survey is unprecedented in the Río de La Plata River, considering the time span used to gather the data online and the number of variables being monitored.

Keywords
AySA SA, Río de la Plata, hydrometeorological surveys.

INTRODUCTION

Study Site

The Río de la Plata River (RDLP) is located at the lower La Plata Basin along the East coast of South America (Figure 1a). It is an estuary of the Atlantic Ocean formed by the junction of the Rivers Paraná and Uruguay (Figure 1b). It runs from Northwest to Southeast with a length of

290km and a width of 3km at the spot taken as its origin called "Paralelo de Punta Gorda", reaching 200km at the mouth of the river (Herrero, 2008).

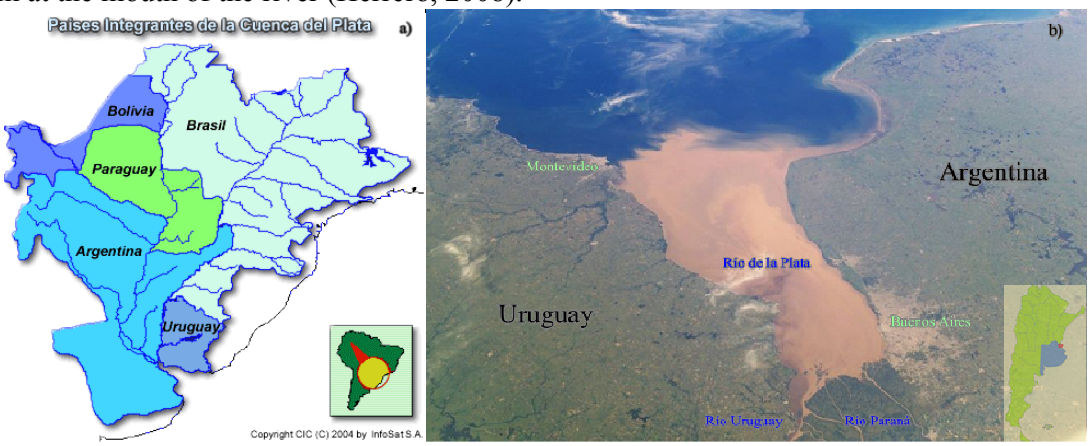

Figure 1. a) La Plata Basin. b) Río de la Plata and its tributaries, Uruguay and Paraná Rivers. Source: NASA, 2006.

The Río de la Plata River is the widest estuary worldwide, covering an area of 130,000km^2 and an average annual water flow into the South Atlantic of 22,000m^3/sec. The river system is affected by the flows from the main tributaries as well as by the astronomical tide, which is frequently altered by sudden changes in the air pressure and the dragging effect of the wind. The meteorological tide strongly affects the conditions of the river, in many cases even invalidating the effect of the astronomical tide. This explains the importance of measuring the meteorological variables, together with the hydrological variables. The RDLP is the main source of raw water in the City of Buenos Aires, La Plata and neighboring locations, from where 4,800,000m^3 are extracted on a daily basis for the production of drinking water, also being the receiving body of its sewage effluents.

AySA SA provides Drinking water and Sewerage collection services to the City of Buenos Aires and 17 Districts of the Province of Buenos Aires, covering an area of 1,800km^2, 1,000km^2 of which are completely urbanized with a population of 11M residents. AySA SA's Sewerage Plan embraces the goal to introduce 3.5M inhabitants into the sewerage service by the year 2020. To this end, diverse measures have been outlined, such as the construction of two outfalls, namely Berazategui and Riachuelo (Figure 2).

Figure 2. Diagram of outfalls location. Source: Roberts (2010).

Objectives

The purpose of the present report is to describe the surveys and field work performed throughout the years 2009 and 2010 in connection with the Río de la Plata River hydrometeorological data

collection used as a basis for the Berazategui and Riachuelo Outfalls Modeling project for the city of Buenos Aires conducted by Dr. Philip J. W. Roberts (2010).

MATERIALS AND METHODS

Throughout the 2009/2010 period, numerous field campaigns were conducted, which included:

- Bathymetry of the area where the outfalls are to be located (15km by 10km) in a 1km-resolution grid.
- The installation, operation and maintenance of three weather stations located at the river, over the Water Intake Tower of the San Martín, Manuel Belgrano and Berazategui plants.
- The preparation of Conductivity-Temperature-Depth (CTD) profiles at the two sites recommended for the diffusers carried out around the clock on a monthly basis.
- The installation, operation and retrieval of information from six ADCPs used to measure current direction and intensity, wave height, conductivity and turbidity.
- 12-hour drifter follow-up campaigns for the different hydrodynamic conditions.

Bathymetry

Two bathymetry studies were conducted (2009 and 2010) covering approximately 300km of pipelines, surveying depth jointly with the coordinates in each spot as per the scheduled defeat chart (Figure 3). Each campaign gathered approximately 350,000 survey records.
After processing the survey information, surface models were created and isobaths were marked every 0.5m. Thus, a Bathymetric Map of the area was outlined.

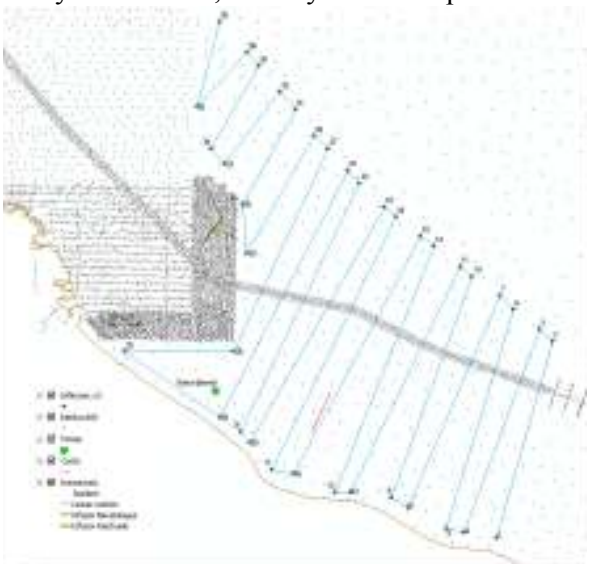

Figure 3. Trajectory followed throughout the bathymetric campaign conducted in early 2009.

Weather stations

AySA SA has installed 3 weather stations in Palermo, Bernal and Berazategui. The first two are located over the raw water intakes, 1,500m and 2,200m away from the coast, respectively. (Figure 4). The one in Berazategui is located on the coast, concordant with said plant.

The measurements performed include: Wind speed and direction, Temperature, Relative humidity, Air pressure, Solar radiation, Rainfall Level and Water Level of the River (tide height). These parameters are measured every 15 minutes and reported to a database that can be accessed in real

time at AySA SA's website: www.aysa.com.ar (Figure 5). Maintenance is performed on a monthly basis; and after more than two years of continuous operation, over 2,000,000 records have been gathered to date.

Figure 4. Weather stations installed over the intake towers.

Figure 5. Online measurement results in AySA SA's website.

Conductivity-Temperature-Depth (CTD) Profiles

In order to measure the stratification level, a CTD unit was used that is able to record the conductivity variation, temperature at different depths, and it is also capable of performing turbidity tests by the optical method (OBS). Profiles were performed around the clock at each site, measuring the parameters in the water column every hour (Figure 6).

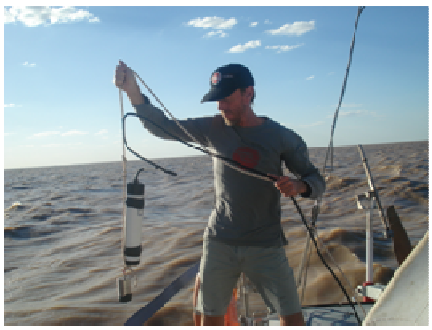

Figure 6. Operation of the CTD at the Río de la Plata.

Current speed and direction meters (ADCP)

Six ADCP units were installed along the inner Río de la Plata River (Figure 7). The position of each ADCP is described by the geographical coordinates in Table 1. These units are able to measure current speed and direction and are equipped with temperature and depth sensor, inclination sensor and compass. They are also capable of measuring salinity (conductivity), turbidity and surface wave height.

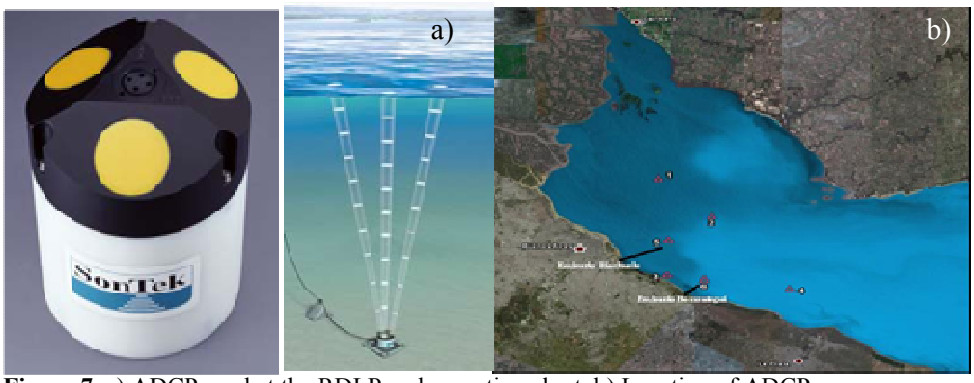

Figure 7. a) ADCP used at the RDLP and operation chart. b) Location of ADCPs.

Table 1. Location of ADCPs as per figure 7.

Station	South Latitude (°)	West Longitude (°)	Location
1	34,4201	58,2485	Playa Honda
2	34,5219	58,1348	Inner Mid-River
3	34,6827	58,2300	Bernal Intake
4	34,7200	57,9676	Opposite Punta Lara
5	34,5884	58,2267	Dock Sud Outfall
6	34,6948	58,1508	Berazategui Outfall

Current measurement is performed through fixed cells and dynamic cells. The dynamic cell always measures the speed of the layer located immediately below the free surface, at constant thickness; therefore, the location thereof relates to the variation of the free surface (Figure 8).

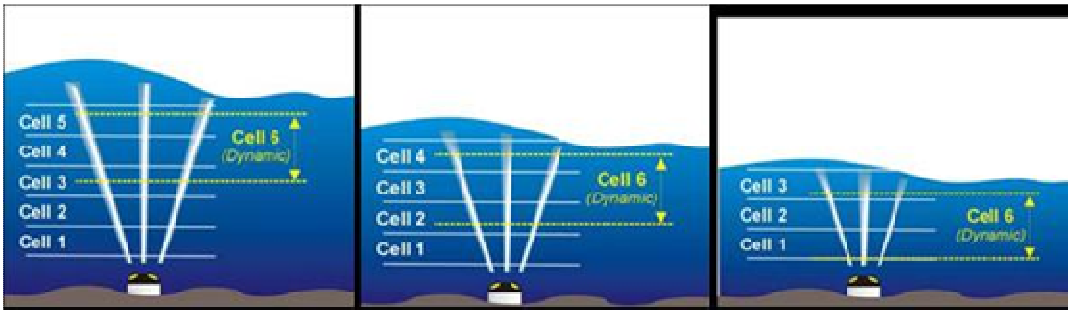

Figure 8. Current speed and direction measurement chart as per the height of the water level.

GPS Drifters

10 drifters were used to measure the Lagrangian current trajectories (Figure 9). Each one is equipped with a GPS that stores the position at all times and that is capable of transmitting its position to a central device. Thus, if the position of a given drifter is required, instant coordinates are received from the drifter, enabling to follow the trajectory and to know where it is at all times. They are placed inside a watertight tube that prevents the passage of water.

Diverse tests were conducted, that consisted in releasing 10 units and following their trajectory for 12h. They were configured at different depths in order to reveal both surface and depth velocity field.

Figure 9. GPS drifters used in the monitoring campaigns.

RESULTS

Bathymetry

Figure 10 shows the bathymetric map. Note that depths range from 3m to 7m in the area surveyed.

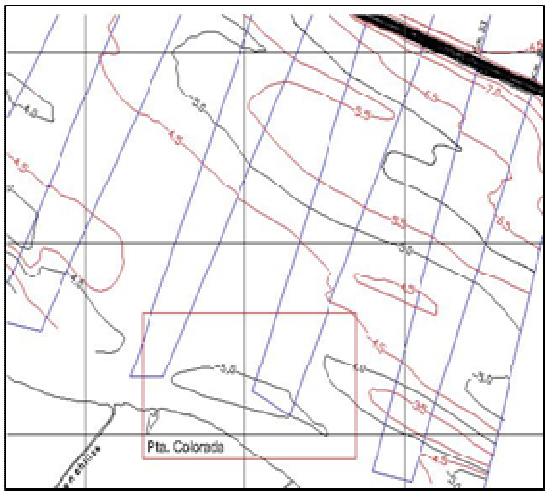

Figure 10. Bathymetric map of the area surveyed in the 2009 campaign.

CTD Profiles

None of the cases revealed stratification. The profiles (Figure 11) show a clear homogeneity in connection with salinity, temperature and turbidity, which proves that the mix formed at the measurement area is important and that there is no presence of the salt wedge.

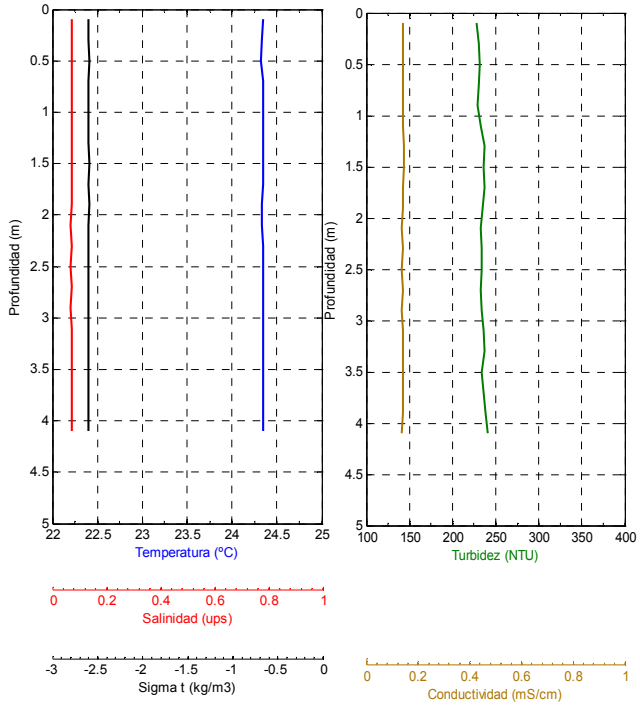

Figure 11. Sample of the CTD profile obtained by one of the 2009 measurement campaigns at the site of the future Berazategui outfall. The red line represents salinity (ups), the blue line represents temperature (°C), the black line is the sigma t (kg/m^3), the green line is turbidity (NTU), and the brown line is conductivity (mS/cm).

Current speed and direction meters (ADCP)

Figure 12 shows the results obtained by an ADCP for the period June - July, 2009. As can be noted from the graph, the results show a preferential direction along the NW - SE axis, the secondary axis being negligible compared to the previous one.

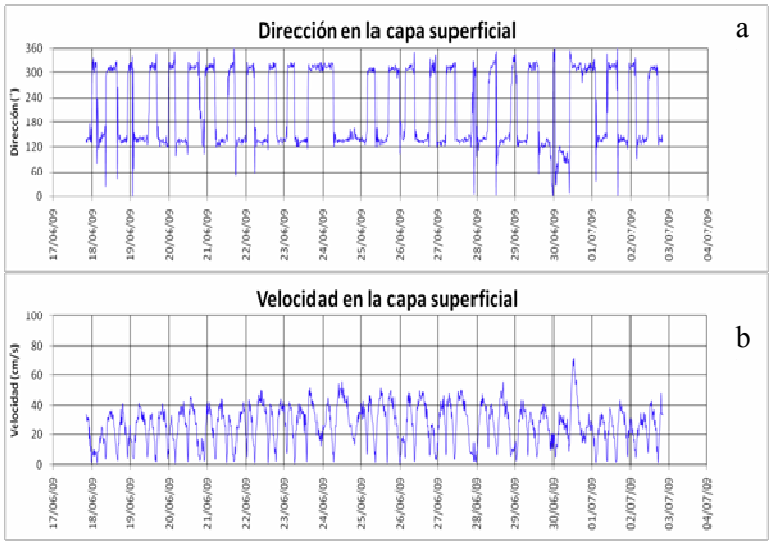

Figure 12. a) Current direction surface layer (°). b) Speed at the surface layer (cm/s).

Figure 13 represents the main direction of the ADCPs at a given tide time and condition.

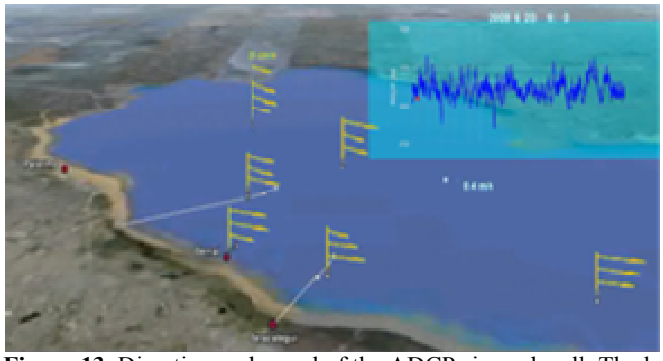

Figure 13. Direction and speed of the ADCPs in each cell. The length of the arrows is directly related to the speed.

Figure 14 shows once again that the prevailing current direction is NW – SE.

Distribución en número de observaciones, por rango de intensidad y dirección

Intensidad	N	NE	E	SE	S	SO	O	NO	Total x intensidad
<= 0 <= 10 cm/s	28	14	23	88	46	40	53	89	371
> 10 <= 20 cm/s	19	6	20	242	39	3	27	226	582
> 20 <= 30 cm/s	3	0	16	410	6	8	7	278	720
> 30 <= 40 cm/s	1	0	7	485	0	8	0	251	724
> 40 <= 50 cm/s	0	0	0	149	0	0	0	91	240
> 50 cm/s	0	0	0	13	0	0	0	16	29
Total x dirección	49	20	66	1386	91	43	87	951	2686

Distribución en porcentajes acumulados

Intensidad	N	NE	E	SE	S	SO	O	NO
<= 10 cm/s	1.0%	0.5%	0.9%	3.3%	1.7%	1.5%	2.0%	3.3%
<= 20 cm/s	1.7%	0.8%	1.6%	12.1%	3.2%	1.6%	3.0%	11.8%
<= 30 cm/s	1.8%	0.8%	2.2%	27.5%	3.4%	1.6%	3.3%	22.2%
<= 40 cm/s	1.8%	0.8%	2.5%	44.9%	3.4%	1.6%	3.3%	31.7%
<= 50 cm/s	1.8%	0.8%	2.5%	56.5%	3.4%	1.6%	3.3%	35.1%
<= máximo	1.8%	0.8%	2.5%	61.0%	3.4%	1.6%	3.3%	35.7%

Total de datos: 2686 — Máximo de intensidad: 72.00 cm/s

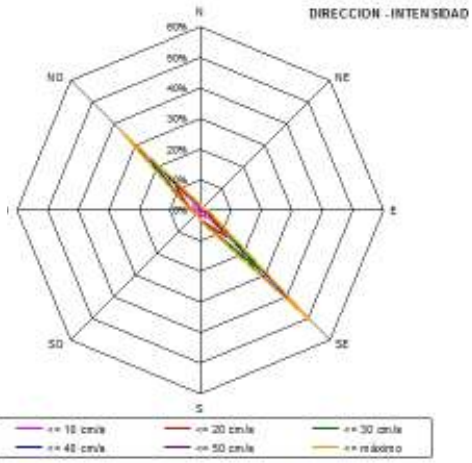

Figure 14. Distribution of the current direction in each cell of the ADCPs.

GPS Drifters

Figure 15 shows the trajectories in connection with the 10 GPS drifters.

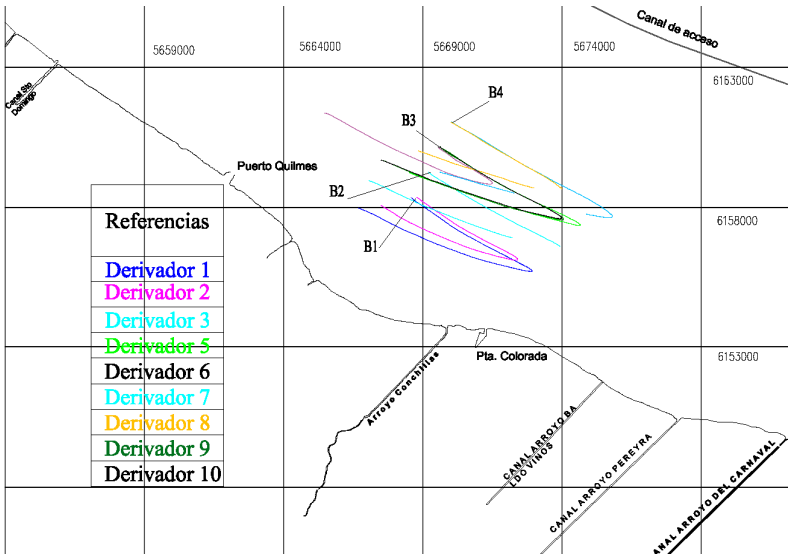

Figure 15. Trajectories of the 10 GPS drifters. The references are Gauss-Krüger coordinates zone 5, WGS84 ellipsoid.

CONCLUSIONS

Information was gathered and processed in connection with the Inner Río de la Plata River throughout a 2-year period, with a 15-minute frequency, which represents over 70,000 records for each parameter being monitored.

The variables monitored throughout the period were: Temperature, wind speed and direction, humidity, air pressure, solar radiation and rainfall, current speed and direction, water temperature, water level of the river (depth), wave height, Lagrangian current trajectory, conductivity, turbidity, among others.

Bathymetries in the area surveyed showed depths between 3m and 7m. The analyses of the currents show a preferential main direction along the NW-SE axis, the secondary axis being negligible compared to the previous one.

This database allowed for the mathematical modeling of the area being surveyed for the purposes of the design of the city of Buenos Aires outfall performed by Dr. Philip J. W. Roberts.

The scope of the survey in unprecedented in the Río de La Plata River, considering the time span used to gather the data online and the number of variables being monitored.

REFERENCES

Herrero, A. C. (2008). *Metropolitan Basins of Buenos Aires*. Chapter 1, part II. Editorial TEMAS. At the press.

Roberts, P. J. W., and Villegas, B. (2010). *Modeling the Proposed Buenos Aires Outfalls: Final Report*. Prepared for Agua y Saneamientos Argentinos S.A. (AySA SA).