THE HISTORY OF THE MAR DEL PLATA OUTFALL SYSTEM: A TALE WORTH TELLING

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In a previous issue of Hydrolink, we discussed the contribution of marine outfall systems as part of the solutions for the UN Sustainable Development Goals (SDGs), and introduced general guiding principles for system design, construction, and operation [12]. Because they convey the effluent to the ocean, outfalls are frequently (and erroneously) perceived as a pollution source. As a result, all too often the adoption of marine outfalls encounter fierce social and political resistance taking many years for their construction and implementation, preventing the affected communities from enjoying better sanitation outcomes [15].

This article presents a similar history, of the design and construction of the Mar del Plata, Argentina, Outfall System. But here, we show how the improvements to the water quality of the Mar del Plata's beaches were immediately felt following the outfall construction and commissioning [5], propping up the city's success as one of the premier touristic destinations in Argentina. More than that, Mar del Plata is a great example for reflection and evaluation whether such long times for implementation of solutions can be afforded if we are to achieve the SDGs by 2030.

The City

Founded 146 years ago, the coastal city of Mar del Plata is the most popular vacation destination in Argentina. Its beaches (Fig. 1) are a main attraction to both local residents and tourists, making Mar de Plata one of the largest urban settings in the country [5] with a population nearing one million during the holiday season. As tourism is a vital part of its economy, protecting the water quality of its beaches is paramount to the city.

With over 95% sewerage coverage, a submarine outfall operating since 2014, and a new wastewater treatment plant since 2018, Mar del Plata can be considered to have an advanced level of sanitation. This effort resulted in greatly improved water quality for primary recreation, safeguarding public health and promoting touristic activity. Regular monitoring programs indicate the entire city's coastal waters meet local and international guidelines for primary contact recreation.

We would like to highlight the immediate improvements of the recreational water quality of Mar del Plata since the commencement of the submarine outfall operation. Fig. 2 presents 30 years of entorococci monitoring in Mar del Plata's beaches. It can be readily seen that the water quality standards for indicators of fecal contamination were met almost immediately following the outfall construction. For example, at Delicias Beach approximately 0.9 km from the discharge, the monitored enterococci concentrations reduced considerably from 50,000 to 27 entoro-

Figure 1. Aerial view of Mar del Plata's beaches.

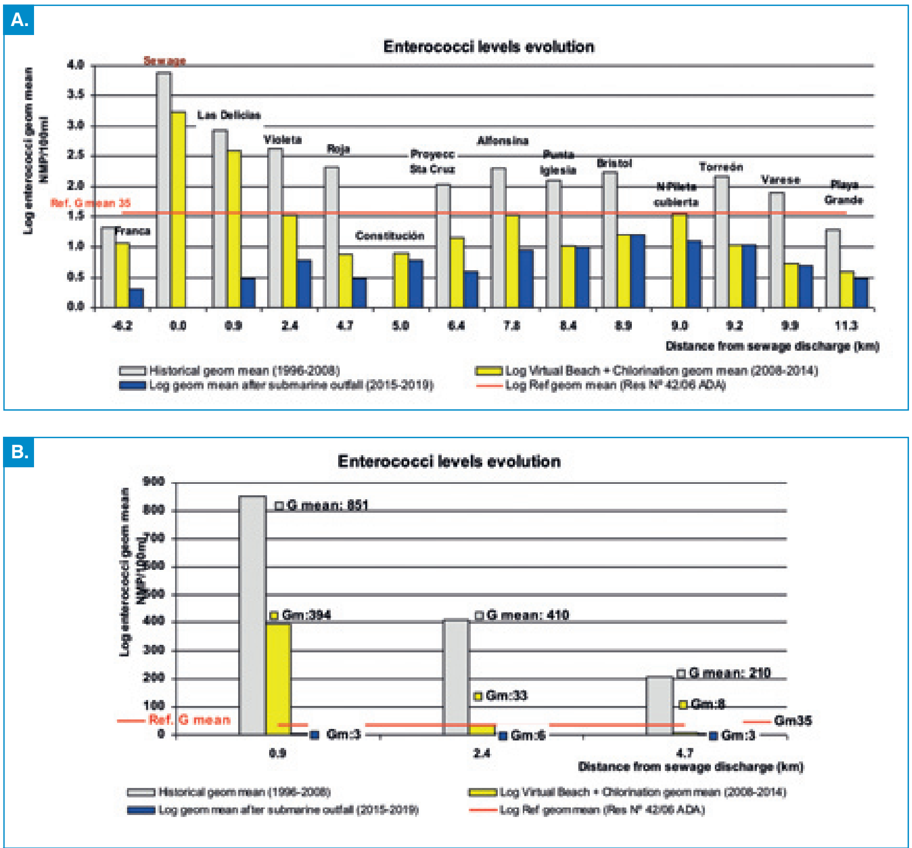

Figure 2. A. Faecal contamination indicators in Mar del Plata's beach before and after the outfall (log scale). B. Details at Las Delicias, Violeta e Roja Beaches. The yellow bar shows monitoring results from the Contamination Monitoring Program (CMP) supported by the Virtual Beach modelling before the outfall operation commenced.

cocci/100 ml following commencement of the outfall operation (Fig. 2b).

In hindsight, one can readily observe the benefits of the outfall operation. However, the project history dates back to the beginning of the 1980's, owing to several serious impediments along the way. It is therefore important to look back at this period to identify and reflect over the reasons why it took so long to complete the outfall project. In doing so, it is also opportune to present the mitigation measures undertaken for recreational water quality improvements before concluding the outfall installation.

Vision and early project stages

In the early 1980's, the sewage discharge was located approximately 10 km north of the city at the existing outfall starting point. Tasked with the challenge of protecting Mar del Plata's beaches, Eng. Alberto Baltar, director of Obras Sanitarias Sociedad de Estado (OSSE) at the time, had the initial vision for a submarine outfall and diffuser system. His vision was based on his knowledge of similar technology applications around the world. Further, Eng. Baltar had a strong perception of the self-purifying capacity of the sea in Mar del Plata, noting its open coast, energetic surf zone, and intermittent storms and erosive processes, all of which indicated a favorable system for assimilation of the organic loads from the urban effluent (Baltar, pers. comm.).

With this initial vision, almost exclusively Eng. Baltar's, the city of Mar del Plata commissioned a study to present an outfall system as an alternative for adequate effluent disposal in the area [9]. The study comprised several field studies, which were the first to characterise the physico-chemical and bacteriological composition of both the wastewater effluent and the water near the discharge. These studies also quantified relevant local oceanographic processes to conclude that a marine outfall could be adopted as a solution for the city's effluent discharges.

Following these preliminary investigations, OSSE hired Eng. Russell Ludwig, a renowned consultant on outfalls, who reviewed the Instituto Nacional de Ciencia y Técnicas Hídricas (INCyTH) [9] studies and recommended additional engineering elements to the diffuser system [11]. Of particular relevance was the recommendation for application of new advanced modeling techniques for assessment of nearfield dilution considering local currents [12]. These new formulations had been proven to be the most accurate when compared to field data of operating outfalls and later became the basis for the model PLUMES [2] that was subsequently adopted for the Mar del Plata outfall design.

New treatment plant and delays

As a first step preceding outfall construction, an effluent pre-treatment plant (later named the Eng. Baltar plant) was tendered and constructed. Starting operation in 1989, this pre-treatment plant comprised 0.5 mm screen filters designed to work in tandem with the submarine outfall. However, the plant and outfall worked together for only four years. In 2019, the plant was dismantled and replaced by a new pre-treatment plant.

Since inception of the outfall system, it took almost an entire decade for the construction of the first pre-treatment plant. Over this period, a series of debates were held between proponents of the outfall and those who were opposed to it in favor of a secondary wastewater treatment plant. (Sarandón, pers. comm.). These discussions, in part responsible for the delays over this first decade, presented convincing arguments for a submarine outfall as the best disposal alternative for Mar del Plata.

While economic factors always permeate large infrastructure projects, technical aspects were at the forefront for selection of the best alternative. Notwithstanding this, shortly after commissioning the first pre-treatment plant, Eng. Baltar retired, which proved to be crucial for the project delays. The project benefits were questioned, discussions effectively returned to ground zero, and new technical and political arguments were put forward probing whether a secondary treatment plant would be a better solution than the combined pre-treatment and outfall system.

Secondary treatment or outfall system?

Results obtained in Mar del Plata up to the current day show that these discussions were counterproductive, and that the focus should have been on recreational water quality. Independent of the level of wastewater treatment (primary, secondary, or tertiary), existing marine outfall technology is not only adequate but it can be argued is essential for maintaining water quality for primary contact recreation. Even advanced levels of treatment will still require an outfall that removes the effluent far from shore [13].

Existing mathematical models can be used to define discharge location and diffuser design, to ensure that the self-purifying capacity of the receiving waters is sufficient to maintain water quality in bathing zones. Human enteric bacteria are not endemic to marine systems and as a result undergo significant die-off once discharged in the ocean. A well-designed outfall system takes into consideration bacterial mortality and ensures recreational waters are free from harmful enteric bacteria, thus precluding the need for additional disinfection. Furthermore, the rapid dilution achieved with a marine outfall diffuser (approximately 1:100) greatly improves the assimilation capacity of the receiving marine ecosystem.

A secondary wastewater treatment plant reduces biochemical oxygen demand (BOD) by oxidation of the organic load through a series of distinct microorganisms in succession within a controlled environment. The same result can be achieved by dilution with an outfall diffuser allowing the marine environment itself to undertake the oxidation process, and, as a result, reducing the level of treatment required. Therefore, the type of treatment and outfall design should be thought of as parts of an overall system to be evaluated, and not competing options as often argued.

Unfortunately, this old discussion of 'secondary treatment vs outfall is still common in many proposed sanitation projects. The precedent of Mar del Plata shows that discussions must be supported by an assessment of the marine environment not only as a receptor of effluent discharges, but as a nature-based solution and part of an integrated sanitation system. The assimilation capacity of the receiving environment has enormous implications for the choice of treatment system.

Determination of assimilative capacity requires evaluation of the marine ecosystem centered on baseline data collected prior to discharge and identification of potential ecological vulnerability points. This evaluation permits the design of post-discharge monitoring programs to continuously assess the environmental disturbance resulting from the effluent disposal. Such monitoring programs are important components within the broader context of an Integrated Coastal Management (ICM) system [4].

Sanitation planning within an ICM strategy, which continually evaluates the environmental impact of sewage disposal through ecological studies and monitoring of the receiving environment (both water and sediment water quality variables), allows constant assessment of ecosystem health as well as identification of requirements and opportunities for interventions in case of environmental harm.

Significant savings can result from this continual environmental diagnosis method without necessarily relying on more advanced levels of effluent treatment. These savings can be used for extending the sewerage network to regions with limited coverage, a common situation in developing nations. As such, scarce resources can be better spent on infrastructure and social development to satisfy the basic sanitation needs to be delivered by the Sustainable Development Goals (SDG) initiatives.

Guaranteeing 100% water supply, sanitation and hygiene for the world's population by 2030 will require optimal application of economic resources. Recognised as a solution to protect human health from effluent-borne infections, submarine outfall systems require relatively low capital and operational costs. Our history strongly suggests that, at least initially, economic resources should be used to extend the coverage of sewerage networks in combination with an outfall system (provided there is adequate environmental assimilation capacity). As a result, local communities will enjoy the benefits of proper effluent conveyance and disposal, as well as the ocean as an environmental treatment resource. Mar del Plata is living proof that this strategy for sanitation works.

More on history and additional environmental studies

Returning to our outfall history, it is important to mention that the INCyTH study not only focused on a preliminary assessment of the receiving water but also recommended additional studies that included continual and permanent monitoring for the beach's recreational water quality and the wastewater effluent parameters.

Following Eng. Baltar's retirement, despite the decision-making delays regarding the sanitation alternative choice, data collection for preliminary studies continued and was augmented. Studies looked at a range of environmental aspects, including heavy metals in sediments [16], effluent assimilation capacity [10], permanent bacterial monitoring at the city's beaches [16], [17], [21], permanent monitoring for effluent and pretreatment solid waste characterisation [21], ocean currents [20], marine receiving environment monitoring [21], as well as intertidal and subtidal physico-chemical characterisation [21]. These studies further confirmed the conclusions obtained in the earlier study by INCyTH [9], supporting the recommendation that an outfall and diffuser was the best solution for the city's effluent disposal. These studies were also of fundamental importance in that they determined the baseline conditions prior to outfall construction, and could therefore be used for evaluation of the outfall performance.

Reenactment of the submarine outfall project as part of the sanitation solution for Mar de Plata

Almost one decade after the Eng. Baltar plant commissioning, OSSE with the help of the National Entity of Hydraulic and Sanitation Works [7], recruited an experienced international consultant (Eng. Martí) to review the previous studies and deliberate on whether a secondary treatment plant or an outfall should be adopted as part of the sanitation solution for Mar del Plata. Eng. Martí concluded an outfall would be the most appropriate option for Mar del Plata and himself executed the modeling required to define the outfall design parameters and additional specifications to prepare the corresponding construction tender. The tender was issued in 1999 for the second stage of the treatment plant, comprising upgrades to the existing pretreatment plant and construction of the submarine outfall.

It is to be noted that **another decade had passed** since inauguration of the initial pretreatment plant before tendering for the outfall construction. These delays were largely due to lack of project technical support following Eng. Baltar retirement and recommencement of the old discussions. As a result of this chronology, it is concluded that such important projects cannot be solely vested in a single person for its execution. **When there is a network of professionals to provide support for the project, eventual project impediments can be readily and efficiently overcome, resulting in project improvements and its timely conclusion**. A series of examples in this regard were essential for completion of Mar del Plata's outfall.

First Attempt at Outfall Construction

Tendering for outfall construction started in 1999, financed by OSSE. However, a series of complex tendering processes, technical issues, and a serious economic crisis in Argentina in 2000, rendered the project no longer viable. Once again, the project was delayed and a new tender process could only be undertaken in 2008, thus wasting another decade.

Nevertheless, the effluent and marine environmental monitoring programs continued and were showing serious contamination of Mar del Plata's beaches by the discharge plume. The monitoring data comprised an important environmental baseline to influence decision-making with regards to the sanitation of the city.

Second and Successful Attempt at Outfall Construction

Following more favorable economic and political conditions, supported by the monitoring information, a second attempt to construct the marine outfall was set in motion in 2006. The Argentinean Government and the Municipality of Mar del Plata signed a covenant for the outfall construction, based on the recognition of the importance of Mar del Plata's beaches as a tourist resource for the entire country. Another six years had passed since the first failed construction attempt in 2000.

By this time, 10 years of monitoring data were available, providing an excellent environmental baseline prior to outfall operation with great scientific value. It was the perfect opportunity to present the monitoring data and announce the Mar del Plata outfall construction to the international community at a specialised conference in Antalya, Turkey [19]. Shortly after, a new outfall and diffuser design commenced, including diffuser modeling and pipeline material re-specification. This time, taking the lessons learnt from the first attempt, collaboration was established between ENOHSA, OSSE, international consultants, and the University of Cordoba. A new tender process was established, a contract was awarded and outfall construction finally started in 2008. The works were financed by Argentina's National Treasury and executed under the management of Mar del Plata's municipality government.

Figure 3. Final section of the Mar del Plata outfall showing diffuser ports ready for installation.

Interaction with Marine Outfall Technical Committee

Virtual Beach Model Calibration

As a result of participation in Marine Waste Water Disposal (MWWD) conference in 2006 [19], a fruitful collaboration between OSSE and the IAHR-IWA Technical Committee on Marine Outfall Systems was initiated, which was fundamental for the completion of the outfall project. Over the same period, in 2006, new regional recreational water quality norms were enacted for recreational water quality in Argentina. Suffice to say, the water quality of Mar del Plata's beaches did not meet the standards at the time [1](see also Fig. 2). It was then decided that a mitigation strategy to protect the recreational water quality was required while outfall construction was underway [3].

Data from the 10-year environmental monitoring were adopted for calibration of the Virtual Beach bacterial dispersion model [8], such that bacterial contamination levels at Mar del Plata's beaches could be predicted one day in advance [11]. This same model was then adopted with other studies undertaken by OSSE on local water currents (Scagliola et al. 1998) and bacterial decay [18], [23] to design a Contamination Mitigation Program based on sewage effluent hypochlorite dosing.

A central aspect of the Mitigation Program was the identification of days requiring effluent chlorination, the level of dosing, and the start and end times of the operation. This Program, which was in place between 2008 and 2014, was an effective effluent management measure that ensured Mar del Plata's beaches met recreational water quality standards prior to outfall construction [24], [25]. On average, chlorination was undertaken in 25 of the 90 summer days considered in the Mitigation Program, allowing not only significant cost savings but also minimization of secondary detrimental chlorination effects [4], [6]. The Mar del Plata effluent disinfection based on the Virtual Beach predictive model proved to be a valuable innovation that can be recommended to locations that do not meet water quality standards while sanitation solutions (i.e. a marine outfall) are yet to be completed. Such innovation could only be accomplished by collaboration between local investigators with water quality modeling experts.

The interaction between OSSE and the IAHR-IWA TC on Marine Outfall Systems culminated in the organisation of the International Symposium of Marine Outfall Systems in Mar del Plata in 2011 congregating over 300 participants from across the globe to share their experiences on diverse aspects of outfall design, construction and operation.

Outfall Installation Problems

The Mitigation Program proved to be efficient in improving the city's recreational water quality while construction of the outfall was underway. However, over this second construction attempt, new problems came to light. Originally, the design considered a buried manifold across the entire outfall reach. However, due to the vigorous local sediment dynamics, the dredged trench was reburied before installation of the pipeline could be undertaken.

As a result, an alternative trenchless design was presented as a solution to the problem. The new design comprised anchoring the outfall to the seabed and adjustment to its last 700 m alignment. Given these modifications, OSSE consulted the IAHR-IWA TC on Marine Outfall Systems who recommended a qualified consultant to review the alternative design. The positive interaction between the construction team and the design reviewer permitted continuation of construction through to completion in 2014 (fig. 3).

New Wastewater Treatment Plant

Simultaneously to the submarine outfall design and construction, a new treatment plant design was undertaken to replace the Eng. Baltar pretreatment plant. Installed in a nearby larger building, the new location could accommodate future upgrades that might become necessary, depending on either the receiving marine water quality monitoring indicators or in case new and more stringent water quality standards are put in place. This plant, functioning since 2018, adopts new technology, including primary treatment followed by a pre-staged de-aerator and degreaser system, all of which are essential to dealing with the urban effluent characteristics that are highly affected by the local fishing industry.

The plant discharges to the 4.2 km long marine outfall. The outfall terminates in a diffuser along its final 500 m that consists of ninety 15 cm diameter ports. Together, the sewage collectors, new treatment plant and outfall form Mar del Plata's sanitation system. With these installations, the environmental monitoring of Mar del Plata's beaches showed that recreational water quality standards for fecal *Enterococci* were not exceeded (fig. 2). Further, near field monitoring shows there is neither organic enrichment nor heavy metal and hydrocarbon contamination in the sediments [22]. Moreover, benthic organism studies indicate good conditions and a healthy marine receiving environment [5], [25]

Discussion and Conclusions

We have described an extensive project process that involved multiple technical and institutional actors. Noting the long times to complete the outfall construction, as well as past and current wastewater treatment plants, the sanitation plan for Mar del Plata had to progress at all levels (local, provincial, and national), as a state policy independent of government changes.

For more than 30 years, different city mayors, hundreds of technical professionals and workforce from OSSE, local and international consultants, and National and Provincial Entities and Authorities participated and contributed to the sanitation project. It is impossible to name every single person without unjustly missing important contributions, but it is fair to say those involved were genuinely interested in obtaining the best solutions. There were long periods during which the project was put into question. The doubts with regards to the project were generally of a technical nature, whereby the choice between outfall and a secondary treatment plant promoted a debate that ultimately allowed the project's continuation. Therefore, the technical basis behind such projects must be sustained by a network of professionals that are able to understand and solve the myriad of problems that may occur throughout a project's lifetime, from inception through construction and into operation, and eventually until decommissioning.

Today's accomplishments were only possible thanks to the assembled network effort, knowledge and will to see the project to completion. Specially, the concerted actions from OSSE and successive local and national governments were crucial to overcome obstacles to the outfall construction. These institutions had the foresight to prioritise the development and implementation of public policies as a vehicle to guarantee the water quality of the beaches enjoyed by visitors from across the country. It is therefore imperative to have water quality objectives and receiving environmental values ahead of any specific technical solution, and not the other way around.

Likewise, the implementation of the Marine Environment Monitoring Program in conjunction with adequate assessment of its

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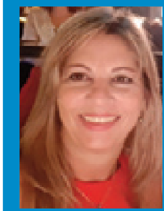

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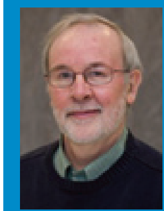

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results were fundamental, not only for evaluation of ecosystem health and recreational water quality during the project progression, but also for recognition that the outfall construction was essential for the sanitation needs of the city. The program was also crucial to demonstrate that, once the project was initiated, no additional steps would be required to complement the overall city's sanitation plan. Further, the monitoring allowed the design of a Contaminant Mitigation Program using the Virtual Beach system that was based on sampled parameters, maritime conditions and modeling predictions. For other localities still requiring completion of their sanitation programs, application of a similar system is recommended as an effective means of reducing the risk of beach fecal contamination.

Possibly, the most important conclusion from this story is the importance of networks to advance, improve, and finalise projects. Along the way, the project largely benefited from the interaction of professionals through the IAHR-IWA TC on Marine Outfall Systems. These interactions culminated in the adoption of tools developed by Committee members, as well as the identification of experienced consultants for crucial project adjustments. Further, the meetings organised by the TC and other relevant organisations created optimal conditions for the establishment of an effective network of professionals, which proved to be the best conduit for reduction of project uncertainties and timelines, and for the development of solutions to drive the project towards its final objectives.

This experience shows how Technical Committees are invaluable for the collective construction of sanitation projects around the world. Technical meetings, such as the International Symposium on Outfall Systems held in Mar del Plata in 2011, are not only important for the outfall technical community but also offer an important vehicle for communication of sanitation activities to the public at large, and are therefore an integral part of achieving SDGs 6.6*.

As previously discussed, marine outfall systems can play an important role to achieve SDG's by 2030. However, long periods of inaction cannot be justified nor afforded. The professional networks and dissemination of learned lessons between projects were demonstrated to be the best approach to reduce delays and conclude projects. The cost-benefit ratio provided by marine outfalls is likely to lead to improved sanitation conditions for achievement of SDGs.

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On behalf of the IAHR-IWA Joint Committee on Marine Outfall Systems, COFES (Federal Council of Sanitary Entities of Argentina) and OSSE (Public Water and Sanitation Company of Mar del Plata - Argentina) the authors would like to cordially invite all IAHR members to the 3rd International Symposium on Outfall Systems to take place in Buenos Aires from 12 to 19 September 2021. Further details can be found at https://www.cofes.org.ar/simposio/.

* Goal 6.6.a: Expand international cooperation and capacity-building support of development countries in water and sanitation related activities and programs, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies.
Goal 6.6.b: Support and strengthen the participation of local communities in improving water and sanitation management

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