PIAÇAGUERA CHANNEL DREDGING CASE: CONFINED AQUATIC DISPOSAL - CAD AS AN ALTERNATIVE FOR THE DESTINATION OF SEDIMENTS NOT AVAILABLE TO THE OCEAN DISPOSAL.

by

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ABSTRACT

This article presents the history, criteria and premises that support decision making for the use of an underwater Confined Aquatic Disposal - CAD in the interior of the Santos estuary, São Paulo, Brazil, as an alternative of not suitable for oceanic disposal dredging material of the Piaçaguera Channel, as well as the constructive methodology, technical management, environmental controls and learned lessons in the distinct phases of the CAD implementation.

1. INTRODUCTION

The Piaçaguera Channel, located in the Santos Estuary, São Paulo, Brazil, is an important navigation route linking the Terminal Integrador Portuário Luiz Antônio Mesquita - TIPLAM and USIMINAS terminal to the navigation channel of the Port of Santos, considered the most important port of South America (Figure 1).

For years the Piaçaguera Channel could not be fully dredged due to the existence of environmental restrictions on direct oceanic disposal related to the presence of inadequate quality sediments in the channel.

During 2015 and 2016 the environmental restoration process and reestablishing of navigations conditions were initiated with the dredging of approximately 300,000.00 cubic meters of sediment not suitable for oceanic disposal, while TIPLAM new berth implementation dredging occurred. The initial solution for this issue was the use of geobags for sediment confinement at a CDF - Confined Disposal Facility, built at a site close to the TIPLAM area.

As defined by the IADC (2010) a CDF is an area specifically designed to contain contaminated dredged material where it is possible to control releases of lower quality material to the environment occurring during the discharge of treated effluents, so, free of contamination. Dykes or other structures such as geobags can be used to insulate dredged material and the main purpose of a CDF is to keep dredged material solids in the confined area, and to treat the process water so that stay free of contaminants and be discarded or reused.

Due to the significantly larger volume of material that needed to be dredged for maintenance and deepening of the Piaçaguera Channel, in the order of 2.3 million cubic meters, it was necessary to find an alternative solution from the one used in the TIPLAM berths implementation.

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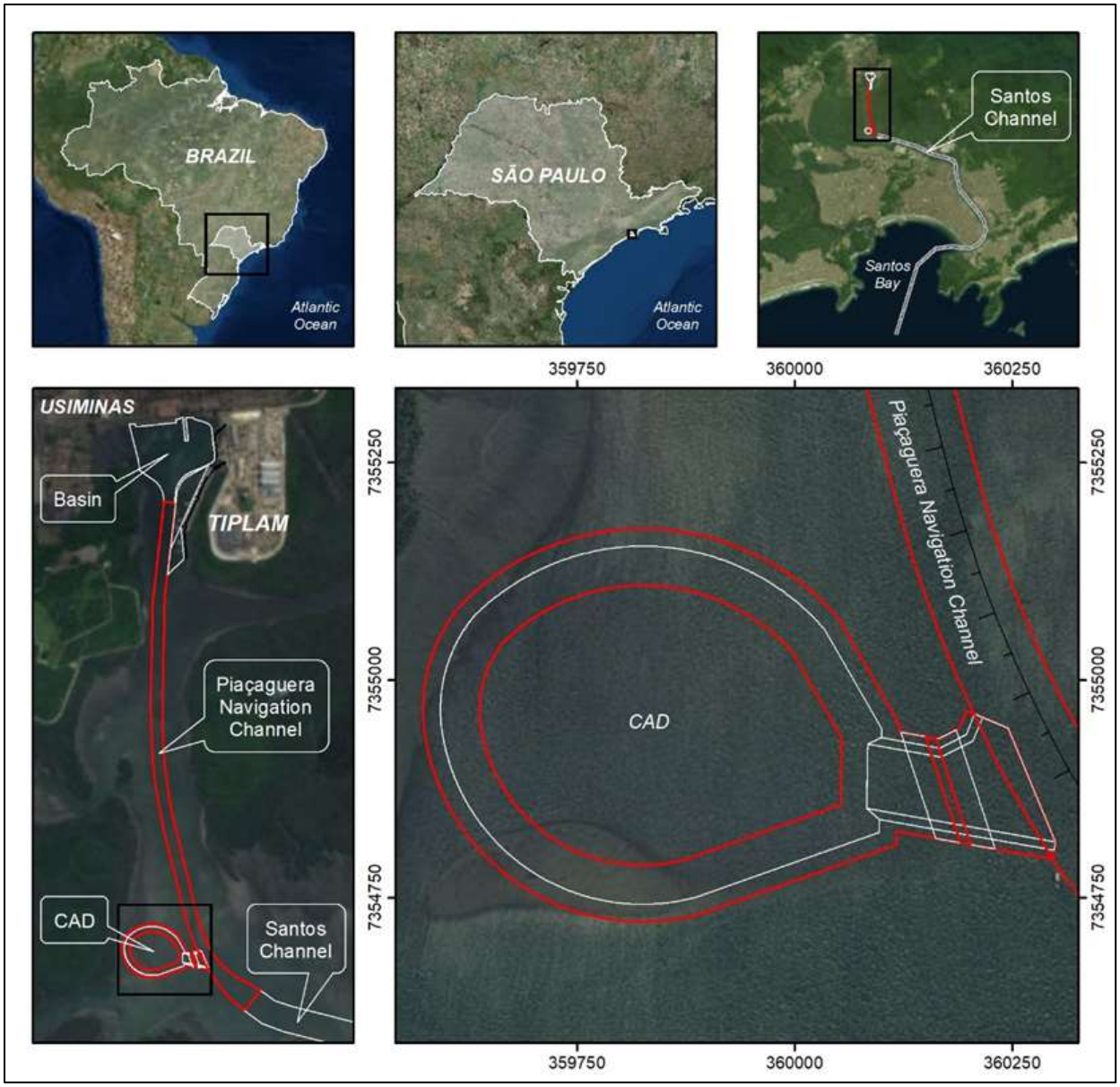

Figure 1: Study area. Piaçaguera channel, Santos, Brazil.

In this way, several engineering and environmental studies were carried out in the search for a technical, economic and environmental solution that would allow the safe handling and disposal of the sediments not suitable for oceanic disposal from the Piaçaguera Channel. The decision matrix indicated the better alternative as an underwater Confined Aquatic Disposal - CAD cell in the interior of the Santos estuary, near the Piaçaguera Channel, in an area duly licensed and authorized by the Brazilian authorities based on rigorous and complex environmental studies carried out to obtain the permitting.

The CAD's main purpose is isolate the dredging material of lower quality inside the subaquatic cell which will be capped with better quality material. According VOGT (2009) the disposal can be in natural depressions in the seafloor, in borrow pits in the seafloor from mining operations (e.g., beach nourishment), or in specifically designed and constructed cells to contain the contaminated dredged material, which is exactly the case of the Piaçaguera Channel.

During the years 2016 and 2017, a CAD cell was built using different dredging methodologies and following strict technical and environmental control and monitoring standards, with the opening of the CAD being completed in June 2017.

Once the CAD was opened, it began to be filled with the dredged material of the Piaçaguera Channel. The first step of filling was finalized on December 2017, since then the deposited material is consolidating by its own weight for a few months until optimum density is reached so the second step of filling can be carried out and, subsequently, the CAD will be capped with suitable material to isolate the lower quality material disposed inside the CAD.

2. CRITERIA AND PREMISES ADOPTED

The CAD was designed to contain all material not suitable for disposal in the open sea in the Piaçaguera Channel, which in the first step of filling was equivalent to a volume of around 2,300,000.00 cubic meters.

Considering recommendations from USACE (2004), was adopted a bulking factor close 50.0%, and it was necessary to excavate a CAD with a useful volume of approximately 3,000,000.00 cubic meters. Figure 2 shows a typical section of the CAD.

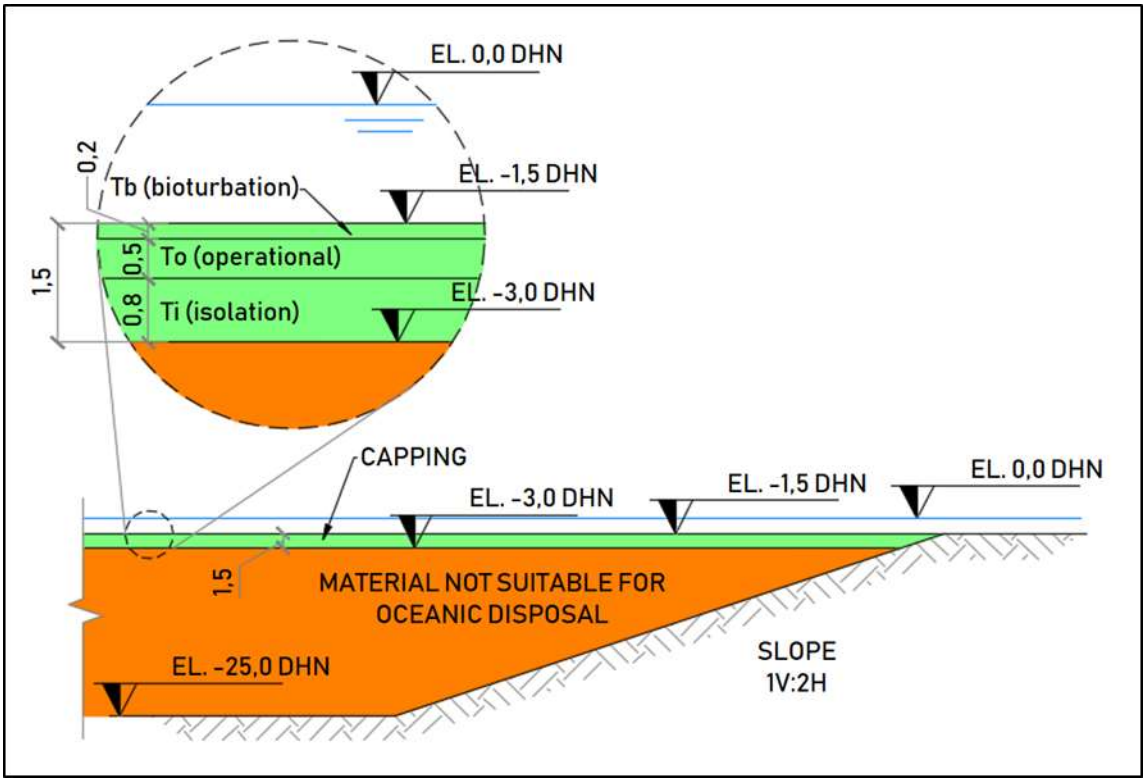

Figure 2: Typical section of the CAD.

Since the location of the CAD was a very shallow area (Figure 3) and to comply with the guidelines of USACE (1998) regarding the thickness of the cap of at least 1.5 meters, it was necessary to excavate another 500,000,00 cubic meters, totaling an excavation of 3,500,000.00 cubic meters for the CAD opening.

To open the CAD, because the depths of the site were very shallow, less than 2.0 meters deep (Figure 3), the excavations were initially carried out using a set of mechanical equipment formed by a clamshell operating with a bucket of 20.0 cubic meters and two barges of 2,800.00 cubic meters each. Monthly, about 200,000.00 cubic meters of material were dredged and disposal in the open sea in the ODP - Oceanic

Disposal Polygon where the good quality dredged material of the Port of Santos is usually disposed. This first phase ended approximately 4.0 months when 800,000.00 cubic meters were dredged.

The set of mechanical equipment was then replaced by two Trailing Suction Hopper Dredger – TSHD with approximately 10,000.00 cubic meters of hopper volume, which alternately excavated the CAD to a maximum depth of 25.0 meters (mean of 22.0 meters) and removed during six months approximately 2,700,000.00 cubic meters. Altogether, approximately 3,500,000.00 cubic meters were dredged in the opening phase of the CAD.

Figure 4 shows images of the equipment used during the CAD opening.

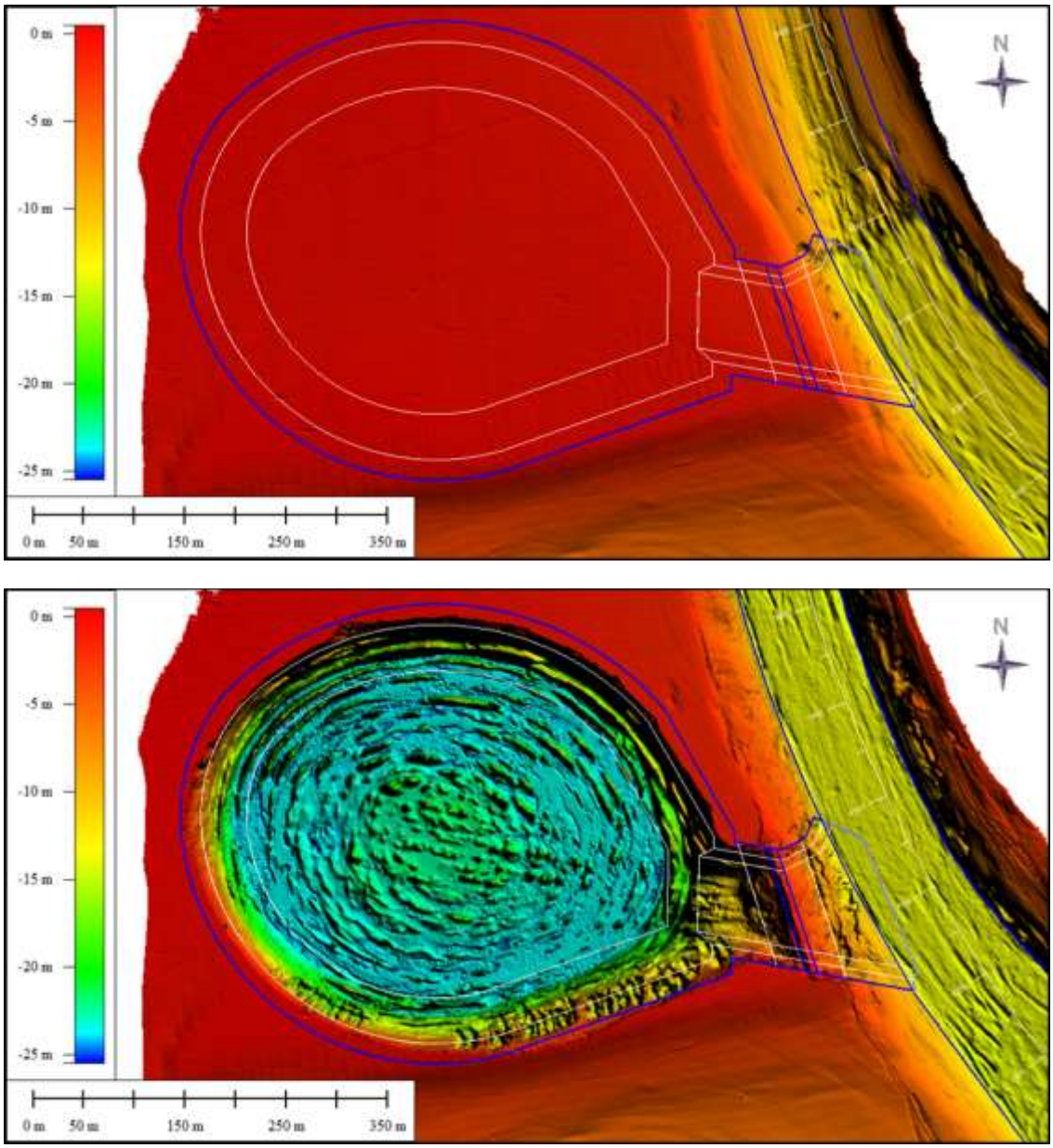

Figure 3: Bathymetric conditions before (above) and after (below) CAD opening.

Clamshell

Barge

TSHD Geopotes 15

TSHD Ham 316

Figure 4: Equipment used during the CAD opening.

3. CONSTRUCTIVE METHODOLOGY

The implementation of the CAD was planned to take place in three distinct phases: i) opening, ii) filling (2 steps) and iii) capping. The first phase was completed.

The total opening of the CAD took place in June 2017 and soon after that began the first step of filling. To do so, before the beginning of the disposals, a silt curtain was implanted around the entire perimeter of the CAD to control the dispersion of suspended solids to the external ambient (Figure 5).

Silt curtains are flexible floating barriers that partially block the streams that carry the suspended solids, reducing the dispersion of these solids outside the perimeter protected by them. Such curtains are widely used in dredging works and the effectiveness of their use has already been evaluated and proven by different and independent laboratory and field studies, especially when the barrier is not open and when there is an “adaptive handling” in the positioning and dimensions (RADERMACHER et al, 2013). This was the case of the Piaçaguera Channel, where a specialized technical team was set up since the installation of the curtain, dedicated 24 hours/day to the handling and maintenance of the barrier.

During the adaptive handling of the silt curtains always when some trench is opened, the supervision team promptly held the barrier closing. To facilitate the anchoring and mooring of the barrier, some steel piles were also implanted around the entire cavity as shown in Figure 5.

Silt curtain around the CAD

Maintenance of the barrier

Figure 5: Silt curtain implanted around the entire perimeter of the CAD to control the dispersion of suspended solids.

For the dredging of the Piaçaguera Channel and CAD filling, one of the two TSHD used during the opening step was used. The dredge was excavated and pumped through a PEAD tube piping into the CAD (Figures 6 and 7).

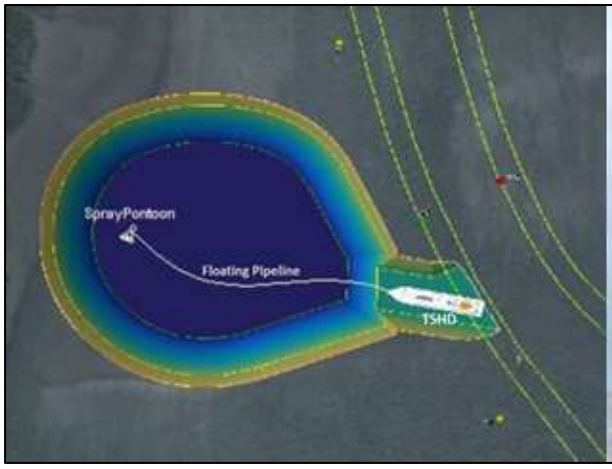

Figure 6: Illustrative image of the material disposal method within CAD and detail (right) of connection between TSHD and floating piping.

Figure 7: TSHD performing pumping through PEAD piping to fill the CAD.

At the end of the tube was installed a diffuser with the objective of directing the fluidized material to the bottom by reducing the transport velocity. Its position was controlled through anchors. The objective of the adoption of the diffuser was to minimize the effects of turbulence during the descent and scattering of the sediment after the bottom plume collapse. This equipment has a controlled flow velocity and a conical shape, increasing the cross-sectional area near the end, which significantly decreases the velocity of the fluid, helping to dissipate the turbulence and minimize the dispersion of sediment during disposal. In addition, the diffuser had a geotextile skirt made in steel to guide the boom to a depth of approximately 10.0 meters, preventing the sediment from spreading on the CAD surface (Figure 8). This skirt had its depth adjusted as the level was raised during the filling of the CAD.

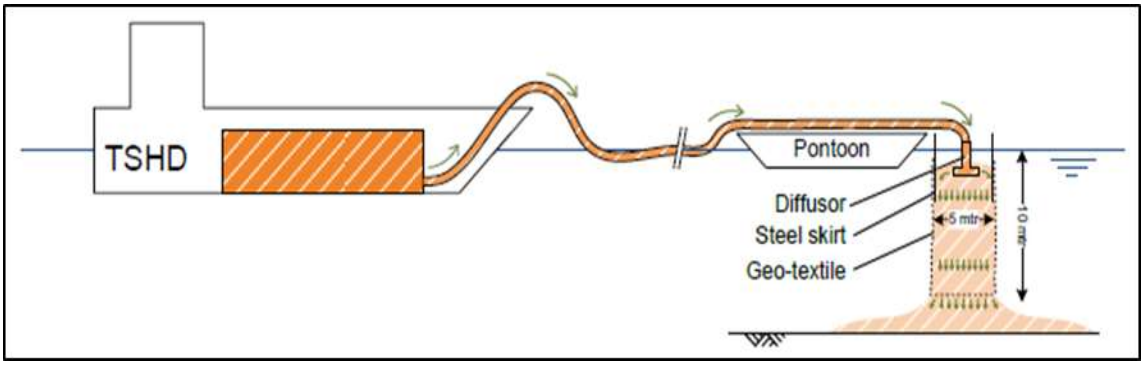

Figure 8: Illustrative image of the TSHD operating in combination with a diffuser.

The first step filling of the CAD and dredging of the Piaçaguera Channel occurred in December 2017. This step lasted 5.5 months and dredged about 2,300,000.00 cubic meters, which were fully dampened inside the CAD.

This first step of the CAD filling and channel dredging has been done to remove as much material as possible and to establish a depth of 13.5 meters along the channel to improve the conditions of navigability.

The second step of completion is expected to occur in 2018, when dredging of the channel will continue until depth of 14.5 meters is reached so the total channel cleanup occurs and, in the future, during maintenance dredging, will only be dredging of good quality sediment originating from natural channel silting that can then be dampened in the open sea.

Currently the material inside the CAD are in the process of consolidation by its own weight. Often bathymetric surveys and other tests are carried out with the objective of monitoring the consolidation process for the decision making on the best moment to conclude the dredging and perform the capping to definitive isolation of the material. In parallel, environmental controls are being carried out, which will be presented below.

4. MANAGEMENT AND CONTROLS

The management of the dredging works was performed to ensure that the opening and filling of the CAD as well as the dredging of the channel were executed as foreseen in the engineering project, obeying the contractual deadlines and prices and in accordance with the environmental permitting and governmental authorizations.

During the entire period of the work, a technical team was made of engineers, supervisors, HSE technicians, environmental experts and managers who checked and registered all the activities carried out both on land and on board, ensuring that dredging and dumping of material were carried out at the sites previously determined and authorized and that the activities were carried out to the highest HSE standards.

Among the technical controls established during the work, it is worth mentioning the online continuous registration by satellite navigation and positioning of the equipment allocated, time record and place of the beginning and end of the dredging and disposals, the frequent monitoring of the bathymetric conditions in the dredging areas (CAD and channel) and the dumping sites (ODP and CAD) and the slopes monitoring of the CAD area.

Considering that the CAD implementation has not yet been finalized being necessary to carry out the second step to fill and finally the capping, actually the monitoring of the material consolidation within the CAD is being carried out through bathymetric surveys, sample collections and analyzes, as well as *in situ* measurements of density.

As previously mentioned, a silt curtain was also implemented, which contributed to reduce the dispersion of suspended solids during disposals to fill the CAD. This barrier will continue to be installed until the end of the material capping.

Specifically, in relation to environmental controls, an extensive monitoring program was implemented, which involves the sampling and analysis of soils and water in the Piaçaguera Channel CAD and adjacent region, as well as monitoring fish, local fishing communities, birdlife monitoring, monitoring of vessel traffic and some other specific environmental programs and action.

5. LEARNED LESSONS AND FINAL CONSIDERATIONS

Comparing the planning with what was executed concludes that there was a good correlation. The dimensions designed for CAD, as well as the bulking factor and geotechnical slopes adopted were adequate for the type of material and the total volume of sediments to be dredged and confined.

The constructive methodology adopted, which employed two large hopper dredgers as a function of the need to perform the CAD opening phase rapidly and assertively, proved to be successful. Although the hopper dredges operated in a shallow and confined area, there were no significant interruptions even in the face of the difficulties of maneuverability and the need for precise cuts to obtain the depths and slopes

designed for CAD. It should also be noted that the implantation of silt curtains and their adaptive management, as well as the diffuser at the end of the pipeline, shown adequate measures to control the dispersion of the turbidity plumes generated during the disposals.

The case of the Piaçaguera Channel broke paradigms where substantial volumes of sediments not suitable for the oceanic disposal were managed in a safe way allowing the implementation of more favorable and competitive navigation conditions along the Piaçaguera Channel and, above all, the establishment of better environmental quality standards, almost reducing the presence of contaminated sediments along the channel.

After completion of the filling and capping of the CAD and the consequent total cleanup of the channel, associated with several other social-environmental actions, it is hoped that the Piaçaguera Channel will present environmental quality much better than the current one.

6. REFERENCES

IADC – International Association of Dredging Contractors. (2010). Facts about Confined Disposal Facilities: An information update from the IADC. Number 1.

RADERMACHER, M, VAN DER GOOT, F, RIJKS, D.C, & DE WIT, L. (2013) The art of screening: effectiveness of silt screens. Terra et Aqua, Number 132, pp. 3-12.

USACE - US Army Corps of Engineers. (2004). Dredged material sedimentation study for Piaçaguera canal and Cubatao harbor, Brazil.

USACE - US Army Corps of Engineers. (1998). Guidance for subaqueous dredged material capping. Technical Report DOER-1. Vicksburg, MS.