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# MONTPELLIER SEA OUTFALL: EUROPE'S LONGEST MARINE PE PIPE PROJECT

## ABSTRACT

The Montpellier sewage treatment project (Waste Water Treatment Plant or WWTP) was started in the early 1990s, with the impact study being completed in 1992. Because of marine culture areas 4 km offshore and because of the dilution conditions with respect to the effluent flow, the discharge point was chosen 11 km from shore in 30 m water depth. A preliminary project was established in 1994 and detailed studies were initiated at the end of 1999. Field measurements for the outfall marine part took place during summer 2000 and the tender documents were ready at the beginning of 2001.

After a competitive tendering process, Van Oord (which was formed by the merger of Ballast Nedam Dredging and Van Oord ACZ. at the end of 2003) was awarded the installation of a 10.8 km long polyethylene pipe sea outfall in a joint venture with its French subsidiary Draflumar and two other French contractors. Van Oord was responsible for all marine activities including dredging the trench, installing and coupling of the pipelines and subsequently covering the pipeline with protective concrete mattresses.

Several innovative procedures were developed to ensure the stability of the pipelines.

## INTRODUCTION

The Montpellier (France) sewage treatment project (Waste Water Treatment Plant or WWTP) developed during the 1990s as a major project for the replacement of the existing 260 000 hab WWTP overwhelmed by the steadily growing city of Montpellier by a new 470 000 hab WWTP. The client of Works "Montpellier Agglomération" (MA), appointed Cabinet Merlin as Engineer for the project which included the WWTP process and civil engineering as well as the sea outfall to the Mediterranean Sea. Montpellier being 9 km from the coast and the point of discharge being almost 11 km offshore, the sea outfall was subdivided into three parts designed as "land", "lagoon" and "marine" sections (Figure 1). The 10 800 m "marine" section is the subject of the present article (Figure 2).

## HISTORY OF THE PROJECT

The WWTP extension project started in the early 1990s, with the impact study being

completed in 1992. Because of marine culture areas 4 km offshore and because of the dilution conditions with respect to the effluent flow, the discharge point was chosen 11 km from shore in 30 m water depth.

A preliminary project was established in 1994, with the pipe buried over its whole length. After the solving of local political disputes, the Administrative authorisation was validated in 1999, fixing the pipeline route and discharge point.

Cabinet Merlin started detailed studies at the end of 1999. Field measurements for the outfall marine section took place during summer 2000 and the tender documents were ready at the beginning of 2001. The European "call for candidates" was issued in October 2000 which led to qualification of six European contractors or groups of contractors in December 2000. The tender was initiated on a best design alternative in May 2001. Fourteen offers were received in July 2001, proposing all existing pipe materials and laying methods. After analysis of offers and tendering

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Above, Figure 2. The installation of a 10.8 km long polyethylene pipe sea outfall near Montpellier.

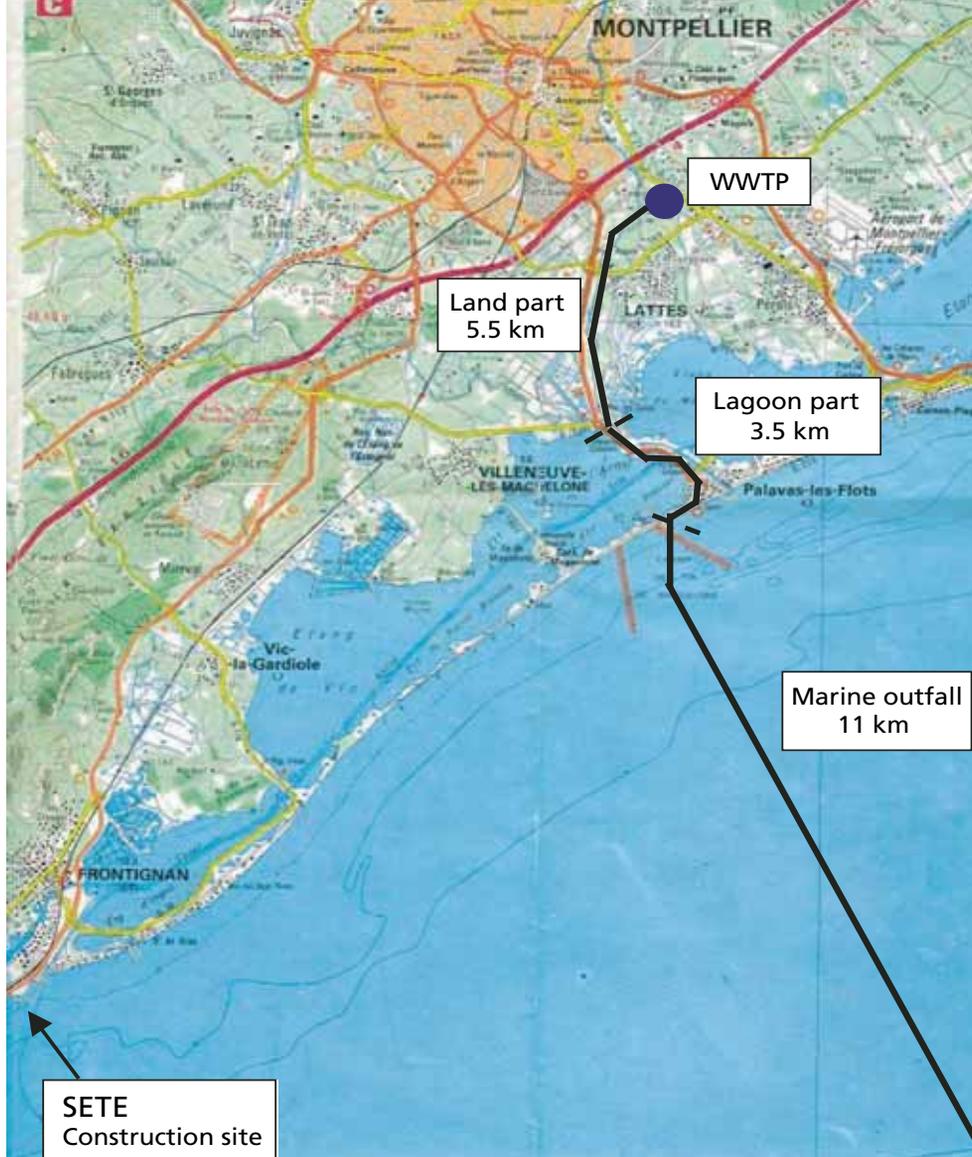


Figure 1. Location of the Montpellier outfall and the Sète construction site.

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Hans Bekendam graduated in 1984 as a Civil Engineer, and worked for several years in the pipeline industry before joining Van Oord in 1991. Since then he has been employed for seven years on pipeline and coastal construction projects worldwide. More recently he was area coordinator and Project Manager for the Montpellier Outfall Project. Presently he is working as Contract Manager Soils&Shores from the main office of Van Oord in Rotterdam.



#### EDWIN OTTENHEIM

Edwin Ottenheim graduated in 1997 in Civil Engineering from the Delft University of Technology. In 1998 he joined Van Oord, and since then has been employed as a Project Engineer on a number of pipeline projects in Ireland, France and the United Kingdom. Presently he is working as Superintendent and Project Engineer in Dubai and involved in the reclamation, rock and harbour extension works.



procedure, contractor EMCC – Van Oord – Draflumar – Sogea was chosen in October 2001 on the basis of a High Density Polyethylene (HDPE) pipe solution. The tender was cancelled in December 2001 by a court order after a complaint from one tenderer because of missing mention of the project funding entity in the October 2000 call for candidates. The Contract for the “lagoon section” followed the same schedule and had the same call for candidates, but no complaint was issued and it was not cancelled.

A new tender for the “marine section” was issued in June 2002 on a HDPE base project. Three offers were received in July 2002. The Contract was finally awarded to the same Consortium EMCC – Van Oord – Draflumar – Sogea in September 2002 with a HDPE alternative, the order to start works being given late December 2002. The administrative authorisation for

working in the marine domain was, however, only obtained by the end of February 2003.

### GENERAL DESCRIPTION OF THE WWTP PROJECT

The WWTP process works on high concentration activated sludge, with an inverse filter on resin pellets. The suspended load at exit is less than 0.3 g/l. The WWTP construction should be completed by mid-2005, a few months late with respect to the initial schedule.

#### The Outfall “land section”

The contract for this 4.5 km part of the outfall was awarded in Autumn 2003 and construction was completed by the end of 2004. The outfall pipe is a 1600 mm cast iron. In the same trench, two cast iron pipes, 500 mm and a 600 mm, run parallel

to bring raw effluent from the coastal area back to the WWTP.

#### The Outfall “lagoon section”

This 4.5 km section crosses the River Mosson by a siphon, and turns around the Prévost coastal lake, a flat and low area, lying between +1 and +2 with respect to sea level; it then crosses the Rhône to Sète Canal. The outfall pipe is a 1600 mm steel pipe.

#### The Outfall “marine section”

This part takes the effluent from the coast to the discharge point 10.8 km offshore in 30 m depths and is detailed further below.

With the WWTP at elevation +12, the outfall is designed to run by gravity until 1.5 m<sup>3</sup>/s. Later when this flow is exceeded, pumps will be installed in a chamber already built next to the Rhône to Sète Canal crossing. The outfall is designed for a maximum 4 m<sup>3</sup>/s discharge.

## MARINE OUTFALL ELEMENTS

### The Pipe

The Montpellier marine outfall is a PE100 pipe, outer diameter 1600 mm, SDR26 (PN6.3). This pipe was chosen for four main reasons:

- Technically the most preferred bid: Totally non-corrosive pipe solution in combination with a minimum of welded joints ensured a long service life with low maintenance and operational costs.
- Execution time at sea for pipe installation was the shortest among all solutions proposed, which reduces financial risks of stand-by during works for the Client.
- Minimum land works reducing the disturbance to tourist life on the beaches.
- Most attractive overall cost.

The pipe with a wall thickness of 61.2 mm was produced in a continuous extrusion process and supplied in lengths up to 550 m. Such heavy-walled pipe required a raw material which has good processing properties as well as low sag properties. The PE raw material selected was HE 3490-LS from Borealis, a material specifically engineered for large diameter thick wall pipe. The production took about 8 months.

The 10,800 m of PE pipes were delivered in four tows in lengths up to 550 m from Pipelife Norge AS. The first tow in March 2003 faced quite high sea conditions in the Bay of Biscay but arrived without significant damage.



Figure 4. Map showing route of the towing of pipes from Norway via the English Channel, Bay of Biscay and the Strait of Gibraltar to Sète in France, a distance of 2330 nautical miles..



Figure 3. Pipes up to 550 m long were prepared with end plugs and towing clamps for transport by sea.

The pipes were prepared with end plugs and towing clamps for sea transport by towing (Figure 3). The four deliveries took place from March to August 2003. The journey from Norway, via the English Channel, Bay of Biscay and the Strait of Gibraltar to Sète in France, a distance of 2330 nautical miles took approximately 19 days (Figure 4).

Figure 5. Glass Reinforced Polyester (GRP) couplings, which were specially designed, for the Montpellier Sea Outfall are shown being tested.

### Connections Between Pipes

Connections between the PE pipes were made by Glass Reinforced Polyester (GRP) couplings specially designed, tested and fabricated for the Montpellier Sea Outfall project (Figure 5). Each coupling consists of two sleeves sliding on each pipe end and pushing against stub ends, welded to the ends of the pipes. The two sleeves are entered in a central element which is consequently locked in place by a polyamide rod.



## Weights

Ballasting of the floating PE pipes was realised by sliding circular concrete collars over the PE pipes resulting in continuous protection of the pipes. In total more than 5000 concrete collars, each with a weight of 3 tonnes, were prefabricated in a concrete factory 100 km from Montpellier (Figure 6).



Figure 6. Flexible mattresses and collars stored at construction site in Sète.

## Pipeline Trench

To minimise impact of the outfall on the environment and marine life, dredging had to be reduced as much as possible. This was achieved by limiting the trench depth in such way that the topside of the outfall would be at seabed level. Only at the beaches and the shallow coastal zone, where the seabed is mobile during storms, the trench had to be deeper to avoid exposure of the pipe (Figure 7).

Two dredgers were used on the project: the backhoe dredger Piet Ponton (Figure 8) for the shallow coastal zone and the trailing suction hopper dredger Dravo Costa Blanca (Figure 9) for the offshore section. In accordance with environmental regulations, the dredged material had to be pumped back through the suction pipe of the dredger and deposited next to the trench in order to limit the increase of seawater turbidity.

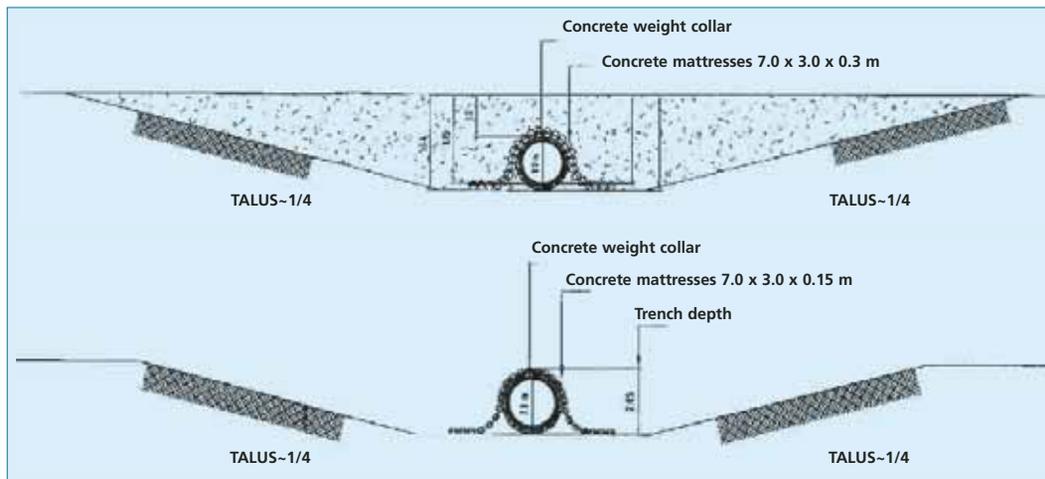


Figure 7. Schematic drawing of pipeline trench.

Subsequently, the beaches and seabed at the coastal zone had to be reinstated by backfilling using the sand previously dredged from the trench.

Figure 8. The backhoe dredger Piet Ponton was used for the shallow coastal zone.



Figure 9. The trailing suction hopper dredger Dravo Costa Blanca was used for the offshore section.



Figure 10. Two views of the installation of flexible concrete mattresses which improved the stability of the pipe. In total 3300 mattresses were installed.

### Protective Mattresses

Outside the coastal zone, offshore of the 9-m-depth contour line, no backfill was required and 7-m-long, 3-m wide flexible concrete mattresses were placed on the outfall pipe to provide additional protection against potential impact from trawler boards used by the local fishery community. Furthermore the 7-tonne mattresses placed on the outfall pipe improve the stability of the pipe as required by the client. Approximately 3300 mattresses were required and were manufactured in a concrete prefab factory near Montpellier (Figure 10).

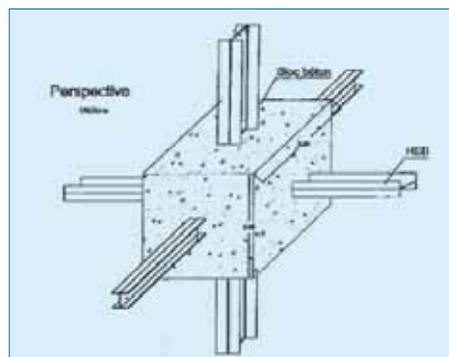
### Diffuser

The last 400 m of the outfall pipe is used to disperse the treated effluent into the sea and consists of 78 diffuser ports, each of 200 mm diameter. Before the commissioning of the outfall, duckbill valves are fitted onto the ports to avoid ingress of sand and silt in the outfall pipe. The flanges of the ports do not protrude above the concrete mattresses so that adequate protection is provided from trawler nets and boards (Figure 11).



Figure 11. Close up of diffuser ports.

Figure 12. Perspective of the concrete blocks around the diffuser.



Before the discharge capacity is increased to the maximum of 4 m<sup>3</sup>/s, a proportion of the diffuser ports are temporarily blanked off. In order to further protect the diffuser from trawlers, a dissuasive protection was placed around the diffuser, which consisted of 2 m square blocs crossed by H beams. Thirty concrete blocs of 20 tonne each have been placed at random around the diffuser (Figure 12).

## EXECUTION OF THE WORKS

The order to start works was given in December 2002. The 14-month contract included the constraint of no works allowed in the 300-m coastal zone and on land in the summer from 15 June to 15 September. Therefore a first string of pipe had to be installed before mid June, and some time left to prepare the construction site for the summer season.

Despite poor sea conditions at the beginning of 2003, the 325-m long cofferdam across the beach and the trench of the near-shore part was completed on time. As the pipe production was started a few weeks before the contract was actually signed, the first pipe delivery was also made on time at the end of March. The first two 550-m sections were assembled together in the port of Sète and towed 20 km to the installation site in Palavas les Flots, where the first 1100-m long pipe string was successfully submerged into the trench on 3 June (Figure 13).

During the summer period, the other pipe deliveries arrived at Sète from Norway, the couplings arrived from the Netherlands, and the concrete collar and mattresses were produced in France. The 500-m pipe strings were prepared in Sète and stored in the harbour basin. The TSHD Costa Blanca completed the trench in August (Figure 14).



Figure 13. Installation of the first string at site in Palavas.



The multi-purpose barge Manta arrived in Sète during the second half of September to be used for joining the pipes during pipe installation at open sea (Figure 15). For this purpose a special pipe-coupling structure was designed and prefabricated during the months before in the Netherlands and installed on the Manta after its arrival in Sète. The pipes were installed with the float and sink method by pumping water in the pipes in a controlled way with pumps placed at the shore end of the pipe. This allowed the pipe to be installed accurately along the partly winding route of the outfall.

Figure 14. Assembly of the first string in the Port of Sète.

## Software for Simulations of Pipe Installation

The contractor's in-house engineering capabilities were utilised to simulate the pipe installation conditions using specialist software. From the results of these simulations the minimum pipe bending radius and the maximum pipe stresses during sinking were determined.

With these results, the factors of safety against buckling and overstressing were calculated using established theories from literature in combination with practical data obtained on previous PE pipeline projects carried out by the contractor. The unique behaviour of PE pipes with continuous weight collars, opposed to commonly applied spaced collars, could therefore be included as well in the analyses.

Tables with installation requirements were produced to guarantee that the pipes were installed safely. These additional requirements included air over pressure, buoyancy pipes and the requirement to provide a continuous pull force of up to 35 tonnes during sinking and coupling of the pipes. The effect of the diffuser ports on the strength of the PE pipe had been modelled and tested and, consequently, it was concluded that the diffuser pipe could also be installed with the float and sink method (Figure 16).

## Difficult Weather Conditions

Pipe installation was expected to finalise at the end of October 2003. However, the sea conditions deteriorated with a storm every week in October, with significant wave heights measured of more than 5 m, impeding a steady progress in pipe installation. These storms brought sediments in the first 5 km trench down to the 25-m water depth. The Costa Blanca had to clean up the trench over a distance of approx. 2.5 km to bring the trench bed back to the design level.

After several interruptions because of bad weather, the 10,800 m PE-pipe was installed on the bottom of the trench, with 400 m of pipe 0.5 m above design level.



Figure 15. Pipe coupling pontoon Manta.

This high spot has been lowered by dredging surrounding sediments with the TSHD Costa Blanca and submersible sludge pumps guided by divers.

After the post-lay pipe survey was approved, the laying of 3300 mattresses was started. This was done from the barge Manta with a specially made frame placing 7 mattresses simultaneously.

Figure 16. Pipe installation by "float and sink" method.





Figure 17. The sea outfall works continued through the winter and were completed in February 2004.

## Fishing Trawlers

Immediately after the diffuser pipe was installed and before it could be protected by concrete mattresses, fishing trawlers damaged the pipe by dragging their nets over the diffuser. Three diffuser outlets were slightly damaged and had to be repaired. Three nets were found stuck on the pipe. A dive survey carried out after the placing of protection mattresses showed other nets entangled in the mattresses but no damage was observed on the outfall. After then the protection blocks with extruding steel bars were placed around the diffuser, resulting in fishers avoiding the area to trawl with their nets.

In February 2004, while the last mattresses were being laid, a court order stopped all works on WWTP, “land”, “lagoon” and “sea” outfall construction sites maintaining that the discharge authorisation was not legally valid. A few days were allowed for securing the sites, and these were sufficient for the sea outfall works to be completed. Despite the adverse weather conditions encountered during pipe installation, the Montpellier Sea Outfall project was completed prior to the contractual

completion date and to the satisfaction of the client (Figure 17).

At present a new authorisation demand is underway, the outfall is ready and the WWTP construction was completed in mid-2005, a few months late with respect to the initial schedule.

## CONCLUSIONS

The Montpellier outfall is the longest marine PE pipe project in Europe. Owing to the extreme length of the project, the sea outfall was subdivided into three parts designed as “land”, “lagoon” and “marine” sections. The marine section is the focus of this article.

The extreme length of the marine section (10,800 m) required heavy-walled pipe with low sag properties. The PE raw material selected was HE 3490-LS from Borealis, a material specifically engineered for large diameter thick wall pipe. Also, special couplings to connect the PE pipes were made of Glass Reinforced Polyester (GRP). Circular concrete collars were slid over the floating PE pipes as ballast and protection. In addition, flexible concrete mattresses were placed on the outfall pipe to provide

additional protection against potential impact from fishing trawlers. Computer simulations of pipe installation conditions were extremely important in the successful and timely execution of the project, allowing the contractor to compare various methods and choose the most optimal.

Despite tendering and contractual delays caused by local political and legal disputes, as well as difficult weather conditions and damage caused by fishing trawlers, work on the Montpellier Sea outfall was completed as contractually planned. The WWTP construction was completed only a few months late.

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