

Ticino river crossing

# A borderline HDD

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Satellite view of the jobsite

The project is due to the need of maintaining the existing pipelines in a safe condition.

The river movements, rambling from one shore to the other, eroded significantly the right side shore thus to drastically reduce the pipes coverage. This status imposed to PRAOIL, Italian pipelines Company, the need to relocate the existing pipelines thus to restore the initial safe conditions.

The method chosen was the Horizontal directional drilling technique.

The location, interested by the crossing, falls entirely within the Ticino park protected area and involves the territories of Vigevano, Abbiategrasso and Morimondo municipalities.

## Scope of work

The project foresees the rerouting of the existing pipeline by installing, in a single hole, two new pipes DN 8" and DN 10" plus a cable holder DN 4"

Drilling operations and pipe pull back were completed in 23 calendar days working on two shifts 12 hours each.

## Soil survey

The initial project was based on a preliminary soil survey executed by boreholes drilled on the two sides of the river, at the ends of the pro-

spective HDD. In this way the central part of the crossing was not investigated.

From a first analysis of the initial soil survey it was evident that the soil stratigraphy was fractionated in various discontinuous types of layers with the presence of gravel and cobbles in the superficial portion, up to a depth of 12 meters, and, in one case only, gravel and cobbles appeared to be present in the deeper layer, 23 meters approx.

It was decided to extend the soil survey, where possible, along the internal section in between the two river shores.

## The former exit point

The second borehole campaign was executed during the period in which the river has the minimum water level and when it has been possible to wade the channels that from the Abbiategrasso side leads to the internal island beside the main water stream.

The new boreholes, drilled to a depth of 40 meters, confirmed the presence of gravel and pebbles in the lower layers together with the discontinuity of the various geological formations thus to convince, even more, that the crossing was not feasible by using the HDD technology. As a last chance a new campaign was decided using, this time, the geoelectric technique.

This technique, which utilizes four electrodes, two positive on the extreme and two negatives in the middle, allows to inspect continuously a soil belt 5 meters wide and more than 40 meters deep. The survey was executed along the



Impression of the Ticino landscape





Soil investigation bore in the river.

whole drilling route at 5 meters intervals, including the section in correspondence of the main river's stream.

The data obtained, calibrated with the boreholes stratigraphy, allowed to build a true soil geological profile to be crossed up to a depth of 45 meters.

From an analysis of the new data it was possible to detect the presence of a corridor, mainly sandy, between a depth of 35 and 40 meters

such to contain the drilling, provided that the gravel and pebbles are removed from the superficial layers.

**Drilling profile**

The drilling profile, to be executed, had to satisfy following basic conditions:

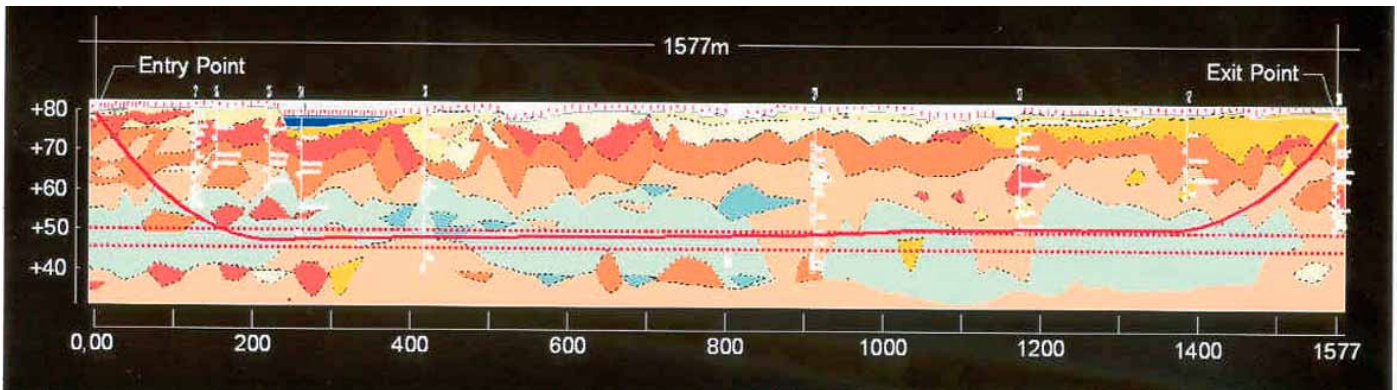
- To reduce to the minimum possible the impact on the wooded areas present at the two

extremis of the drilling route, mainly in correspondence of the exit point;

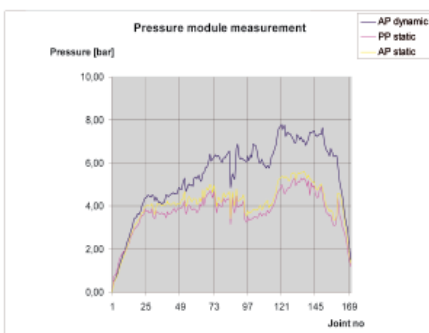
- Maintain the drilling entry and exit angles within values such to reduce to the minimum the friction of the pipe during the pull back phase, especially with a crossing exceeding the length of 1500 meters;
- Use, anyway, steeper entry and exit angles thus to reduce to the minimum possible the volume of soil to be treated and rapidly cross the superficial gravel and pebbles layer;
- Avoid, when the length of the crossing and soil characteristics are considered, the possible mud break outs due to the pressure inside a long hole;

In consideration of above restrictions it was decided to:

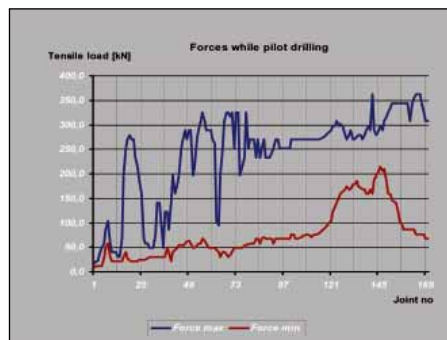
- Move the entry point 30 meters forward thus to avoid damages to the bush present at the border of the site area;
- Increase the crossing length to 1.568 meters thus to obtain the minimum interference with the woods present at the exit point.
- Install, in the initial 230 meters of the drilling, a pipe sleeve 12" 3/4 o.d. thus to protect against a possible mud break out, where the soil is less consistent, and prevent drill pipes from buckling due do the point load



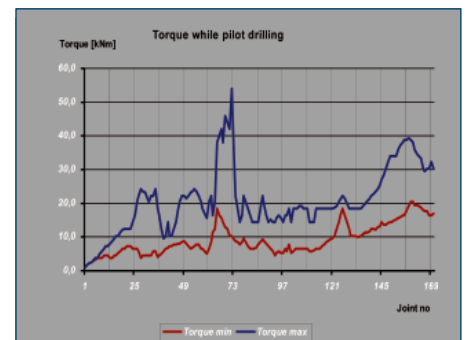
The bore profile.



Fluid pressure in the annulus [bar] AP pilot bore PP upsizing subject to the drill rods.



Thrust [kN] during the pilot bore.



Torque [kNm] during the pilot bore.

necessary to push them forward in such a long crossing, especially when the weight of each drill pipe, 950 kg, is considered;

- Create a pilot hole with a diameter sufficient to maintain the mud flow, inside the annular chamber, at a backpressure sufficient to allow a continuous flow toward the surface without reaching excessive values which might lead to break outs.

**Horizontal directional drilling**

Once the Client has approved the final engineering the site has been mobilized using our 350 tons rig and its ancillary equipment. The steering system used was based on the Para track 2nd generation, which allowed the maximum directional accuracy.

The steering cable was laid along the whole drilling route, including the section crossing the main river stream.

Down hole pressure measurement was provided of high accuracy pressure gauges measuring annular and bore hole pressure.

During pilot hole drilling various inconveniences, due to soil characteristics, where met. It

was experienced, along the route, various and opposite situations, both very cohesive and consistent or the contrary soil very loose.

In more than one case underground loss of mud was experienced or the hole collapsed thus blocking the drill pipes, which had to be pulled back. Drilling progress continued with alternate phases, either the certainty that the project was to be abandoned, or, to the contrary that it could have been completed successfully within an acceptable timing.

**Meeting the target**

An accurate mud management and mud mixtures adequate for the case allowed to complete the project satisfactorily.

For this project 110 tons of drilling fluid have been handled. Pipe pull back was accomplished within the contractual terms.

**Acknowledgements**

The success of this crossing, which difficulties are due to the area and ground in which it has been executed thus confirming that it was to the limit of feasibility, is mainly due to:

- Alessandro Olcese, Client's representative, whom supported this project from its very beginning and provided all necessary assistance to overcome all technical and bureaucratic difficulties which accompanied this project.
- Prime Horizontal technicians, whom managed the steering system in a very accurate manner notwithstanding the soil condition.
- Robert Osikowicz, on behalf of Heads, supplier of all products utilized to compose the drilling mud, whom made available all of its technical and professional capability necessary to execute a stable hole in such a soil formation and very awkward for an Horizontal Drilling.

Special acknowledgement goes to LMR Technical Manager, Günter Kruse, whom made available to this project all of his experience and capability in selecting the most adequate resources necessary to accomplish such a project, and, obviously, to the technicians and personnel, employed by LMR on this project, whom provided the maximum of their capability and commitment during the long working hours necessary to reach the success and completion of the works.



Exit of the bore at the aiming dowel after 1600 meters.



Top bend construction during pipe pulling.



LMR's Rig 3500.9