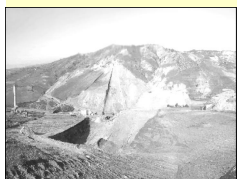
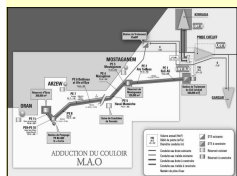
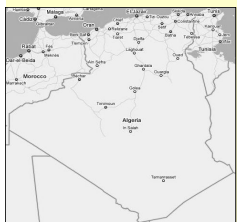
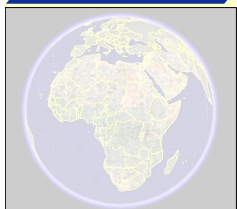




Water in Africa: Hydro-Pessimism or Hydro-Optimism?

Água em África: Hidro-pessimismo ou Hidro-optimismo

Centro de Estudos Africanos da Universidade do Porto
Porto, Portugal, 2-3 October 2008



« WATER IN AFRICA » HYDRO-PESSIMISM OR HYDRO-OPTIMISM

ALGERIA

M.A.O. PROJECT
- KERRADA DAM -



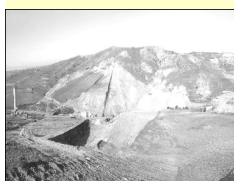
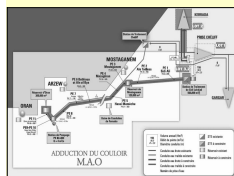
 **TEIXEIRA DUARTE**



cosider Ouvrage d'art
كوسيدار

“ WATER IN AFRICA ” . HYDRO-PESSIMISM OR HYDRO-OPTIMISM

Porto, 2008



CLIMATIC AND HYDROGEOGRAPHIC ENVIRONMENT:

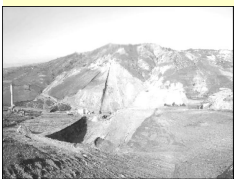
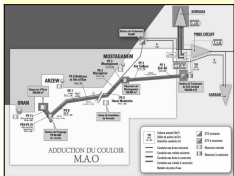
Algeria, second biggest African country

- Total area 2.381,740 km²;
- Population density above 34 million inhabitants, almost half live on coastal areas.

The **argelian climate** shows a huge geographical variation which from year to year changes the average annual precipitation as followed:

- North of the country – 350mm for the West area to 1000mm for the East area;
- Atlas mountains – up to 2000mm
- Sahara Desert – less than 100mm per year.

The raining seasons are becoming shorter along the years. Recently there is a huge variation of the highest precipitations values. These climate changes have a strong impact on the available hydric resources.

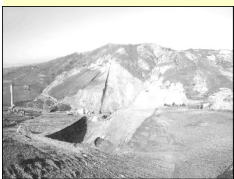
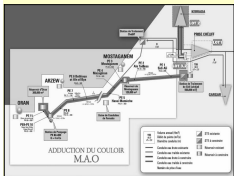


HYDRO-PESSIMISTIC ENVIRONMENT:

Studies made upon the annual precipitation evolution over the past 25 years identified an intense and persistent “Dry Period” which affects the algerian territory.

Precipitation is has been identified as 30% below normal values characteristic to each period. This “Dry Period” has an impact on:

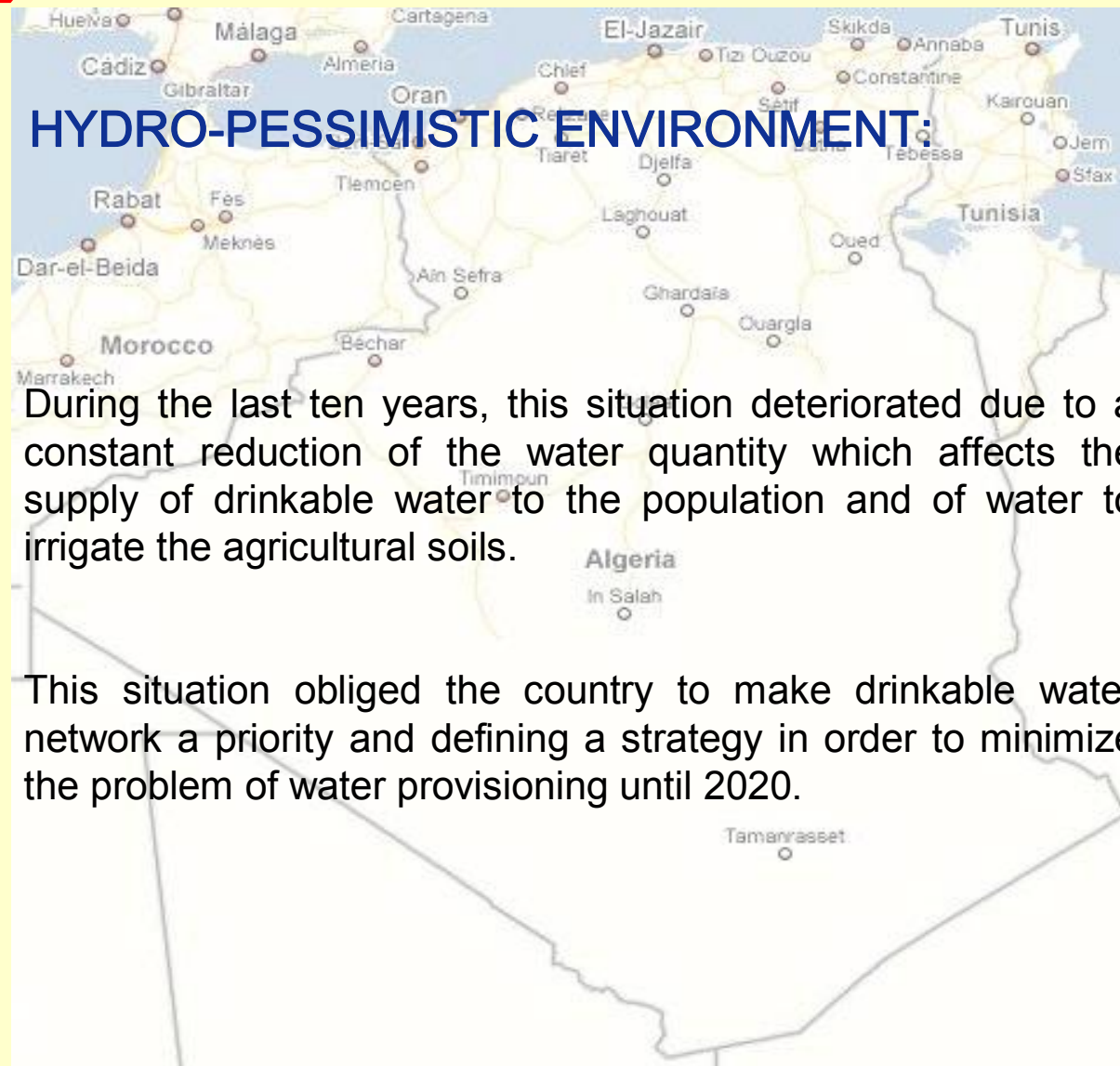
- The rivers disposals;
- The underground aquifers are not fed;
- The reservoirs which stored the water are below maximum levels.

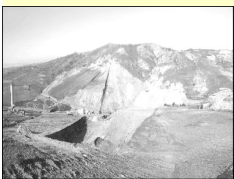
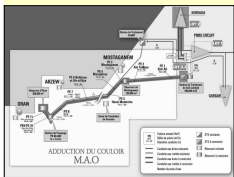


HYDRO-PESSIMISTIC ENVIRONMENT:

During the last ten years, this situation deteriorated due to a constant reduction of the water quantity which affects the supply of drinkable water to the population and of water to irrigate the agricultural soils.

This situation obliged the country to make drinkable water network a priority and defining a strategy in order to minimize the problem of water provisioning until 2020.



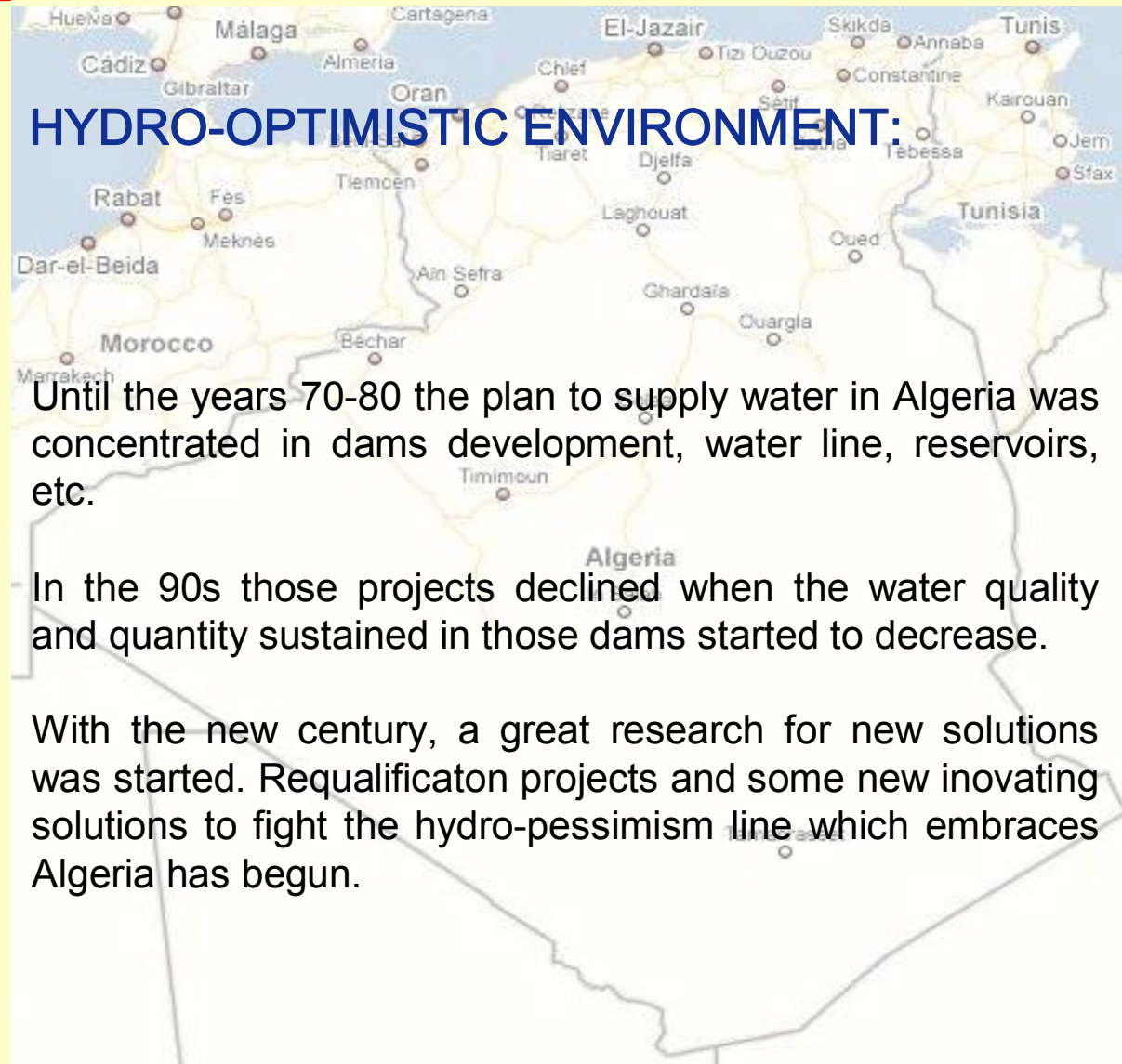


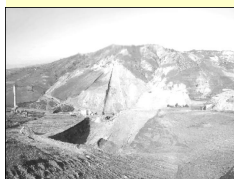
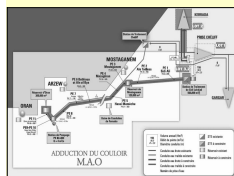
HYDRO-OPTIMISTIC ENVIRONMENT:

Until the years 70-80 the plan to supply water in Algeria was concentrated in dams development, water line, reservoirs, etc.

In the 90s those projects declined when the water quality and quantity sustained in those dams started to decrease.

With the new century, a great research for new solutions was started. Requalification projects and some new inovating solutions to fight the hydro-pessimism line which embraces Algeria has begun.





HYDRO-OPTIMISTIC REACTIONS:

- Desalination units:

The construction of more than 20 desalination units all along the 1,300km algerian coast. The production capacity of all those units may exceed 2.500,00m³/day and supply around 12,5 million inhabitants.

- Existing dam requalification:

The requalification of 12 dams and of all of their hydraulic line, with a fully functioning and a maximum water retention capacity of 1025 hm³.

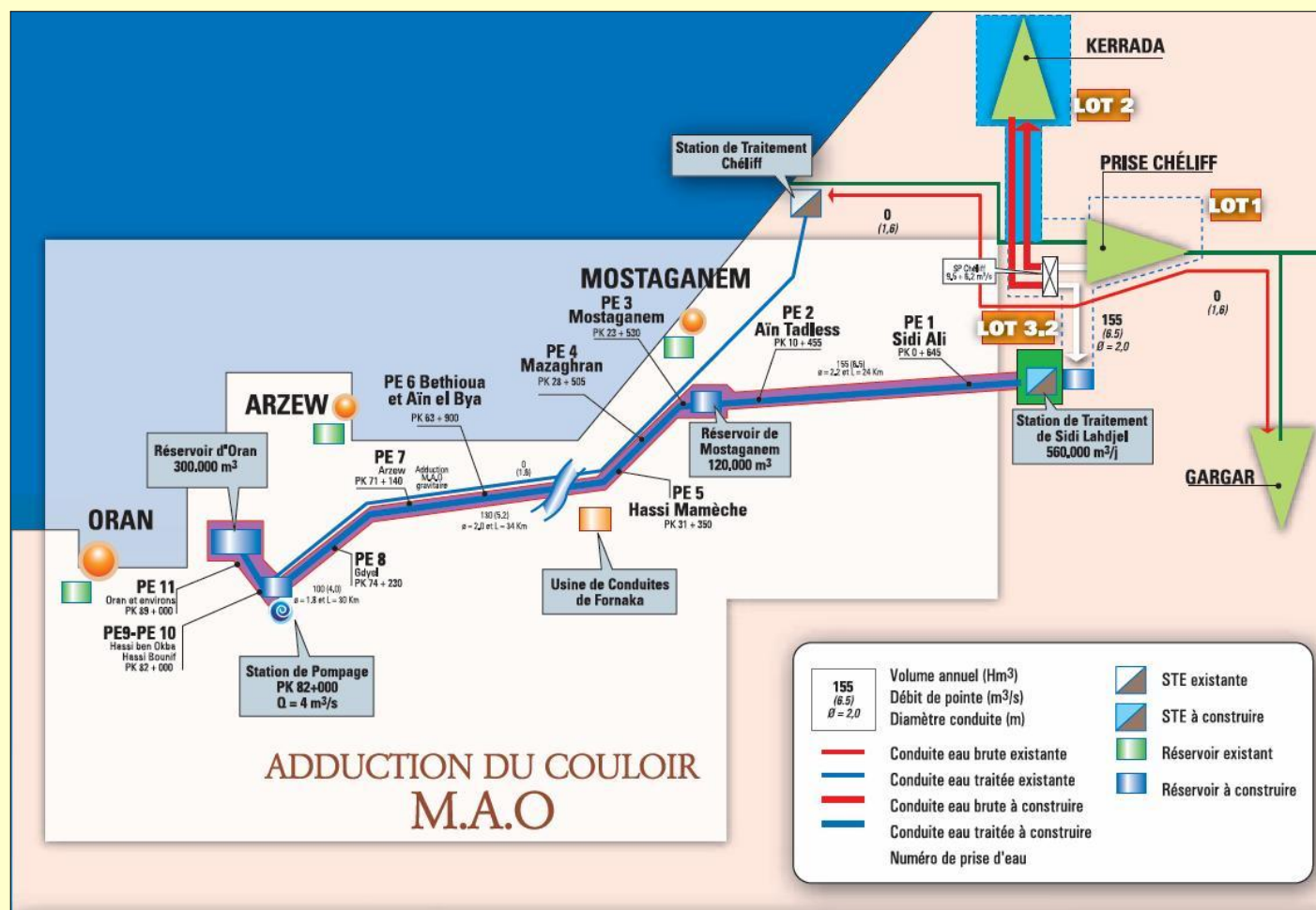
- The implementation of new dams:

It is planned until 2020 the constructions of 30 new dams with a 1555hm³ maximum water retention capacity.

- New hydraulic systems:

A total of 7 new projects which link cities such as the M.A.O. Project (Mostaganem – Arzew – Oran). This projects will allow to supply 155 million de m³/year in water.

STUDY AND REALISATION OF THE M.A.O. PROJECT :



“ WATER IN AFRICA “. HYDRO-PESSIMISM OR HYDRO-OPTIMISM

Porto, 2008

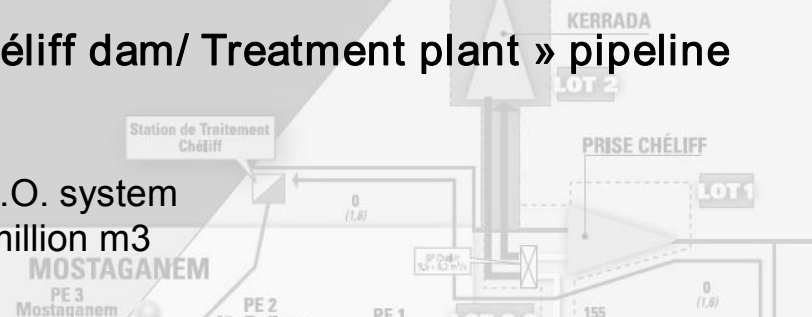
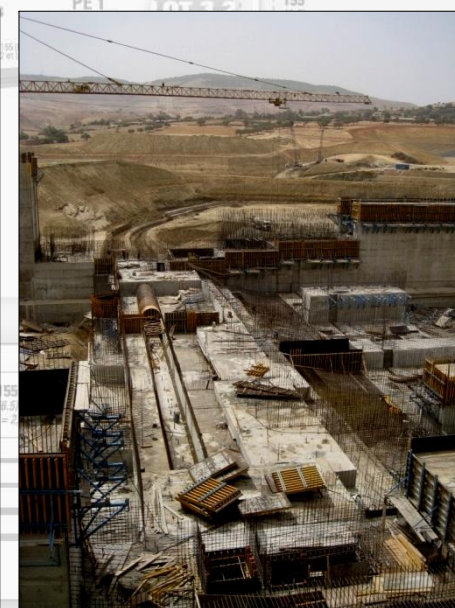
M.A.O. Project – Lot 1.0:

Chélif dam and the « Chélif dam/ Treatment plant » pipeline

Company : M.A.P.A.

Goal : Main dam of all the M.A.O. system

Water retention capacity : 85 million m³



M.A.O. Project – Lot 2.0:

Kerrada dam and « Chélif dam / Kerrada dam » pipeline

Company : ASTALDI, Spa / COSIDER, TP

Foundations outsourcing : TEIXCO Spa

Goal: reservoir dam of the M.A.O. system

Water retention capacity : 70 million m³



Numéro de prise d'eau

“ WATER IN AFRICA “. HYDRO-PESSIMISM OR HYDRO-OPTIMISM

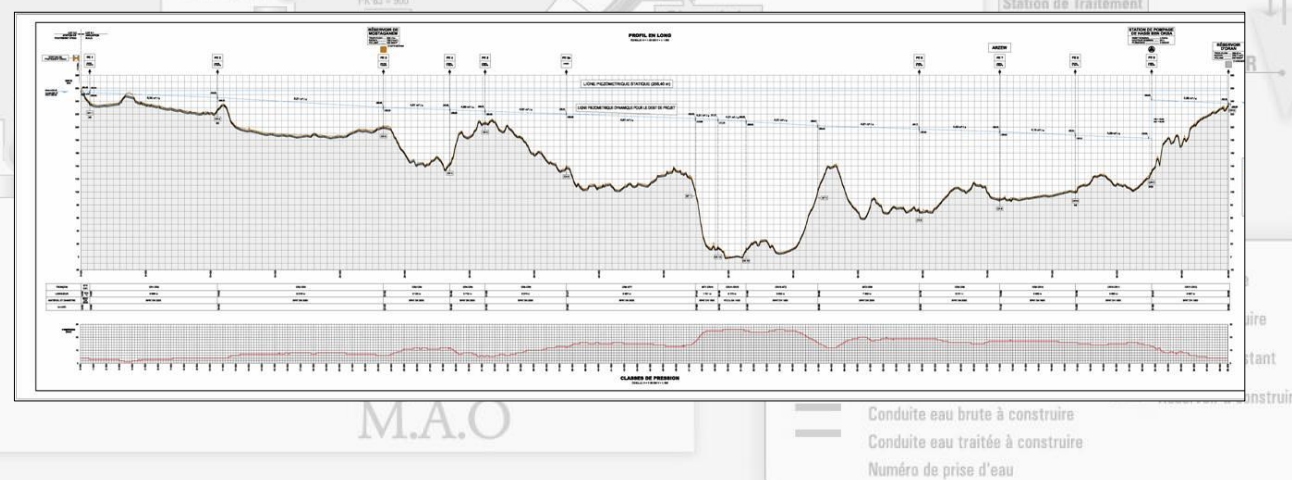
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M.A.O. Project – Lot 3.1:

Pipeline « Pumping Plant– Mostaganem Reservoir– Oran Reservoir »

Company : Teixeira Duarte, S.A. / ETRHB

Goal: Fabrication and installation of a 90km pipeline; Construction of the Mostaganem and Oran reservoirs.



M.A.O. Project – Lot 3.1:

FORNAKA – TUBES PRODUCTION PLANT Construction of BPAT tubes with diameters from DN2200mm to DN1400mm



ADDITION DU COULOIR
M.A.O.

- Diamètre conduite (m)
- Conduite eau brute existante
 - Conduite eau traitée existante
 - Conduite eau brute à construire
 - Conduite eau traitée à construire
 - Numéro de prise d'eau
- RSE à construire
- Réservoir existant
 - Réservoir à construire

“ WATER IN AFRICA “. HYDRO-PESSIMISM OR HYDRO-OPTIMISM

Porto, 2008

M.A.O. Project – Lot 3.1:



“ WATER IN AFRICA “. HYDRO-PESSIMISM OR HYDRO-OPTIMISM

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M.A.O. Project – Lot 3.1:

MOSTAGANEM RESERVOIR Water retention capacity = 120.000 m³



PE 11
Oren et environs
PK 28 + 000

PE9-PE 10
Hassi ben Okba
Hassi Boum
PK 82 + 000

Station de Pompage
PK 82+000
Q = 4 m³/s

ADDUCTION D
M.A.



“ WATER IN AFRICA “. HYDRO-PESSIMISM OR HYDRO-OPTIMISM

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M.A.O. Project – Lot 3.1:

ORAN RESERVOIR
Water retention capacity = 300.000 m³



“ WATER IN AFRICA “. HYDRO-PESSIMISM OR HYDRO-OPTIMISM

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[illegible]

PE9-PE 10
Hassi ben Okbe
Hassi Bounif
PK 82 + 000

Station de Pompage
PK 82+000
 $Q = 4 \text{ m}^3/\text{s}$



M.A.O. Project – Lot 3.2:

Treatment plant

Company : M.A.P.A. / DEGREMONT

Goal: To ensure the quality of the stored water in the dams before its entry in the pipeline system.

Production capacity : 560.000 m³ water / day



“ WATER IN AFRICA “. HYDRO-PESSIMISM OR HYDRO-OPTIMISM

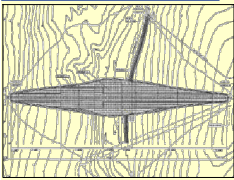
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M.A.O. Project Lot 2.0 – Kerrada dam



Foundation treatment works
- Injections curtain -

“ WATER IN AFRICA “. HYDRO-PESSIMISM OR HYDRO-OPTIMISM
Porto, 2008



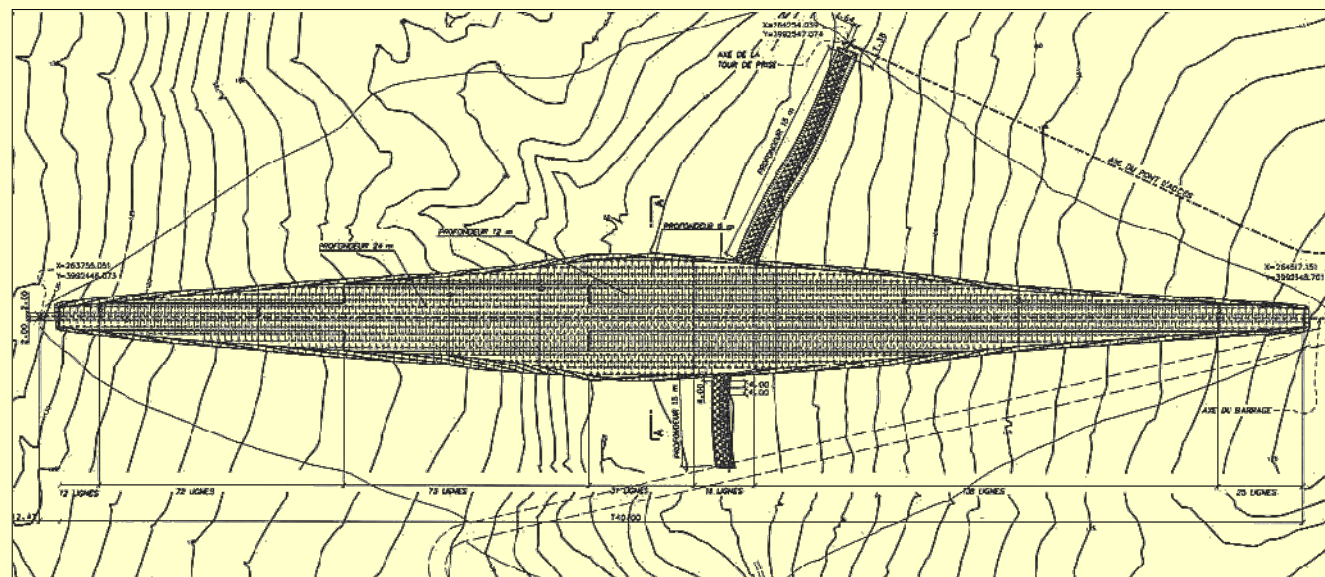
The dam will have a 85m height embankment, a 70 million m³ water retention capacity and several concrete structures:

- A grouting gallery;
- A drainage gallery;
- A water intake linked to the Derivation gallery.



The pumping plant will ensure the transfer of the retained water in the Kerrada Dam to the treatment plant.

M.A.O. Project Lot 2.0 – Kerrada dam

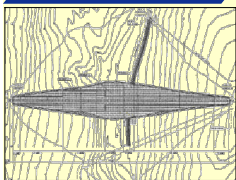


Realization of the treatment of the foundation
Injections curtain

- Project phase -

“ WATER IN AFRICA “. HYDRO-PESSIMISM OR HYDRO-OPTIMISM

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The project of the Kerrada dam foundation treatment planned 2 different Types of intervention:

Consolidation injections:

The main goal of this type of treatment is to improve the geotechnical characteristics of the rocky massive in the most superficial area of the foundation. This intervention not only increases the resistance, reducing the soil's deformation, as it improves the waterproofing, reducing also the cement grout's circulation in the most superficial area.

Injections curtain:

The main goal of this type of treatment is to reduce the water seepage through the dam foundation, reducing the infiltration loss and reducing the internal erosion risks of the foundation.



M.A.O. Project Lot 2.0 – Kerrada dam

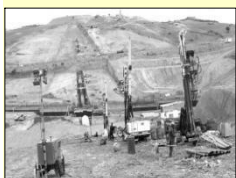
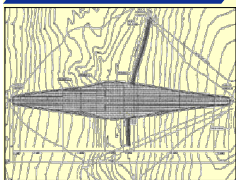


Realization of the treatment of the foundation
Injections curtain

- Phase study -

“ WATER IN AFRICA “. HYDRO-PESSIMISM OR HYDRO-OPTIMISM

Porto, 2008



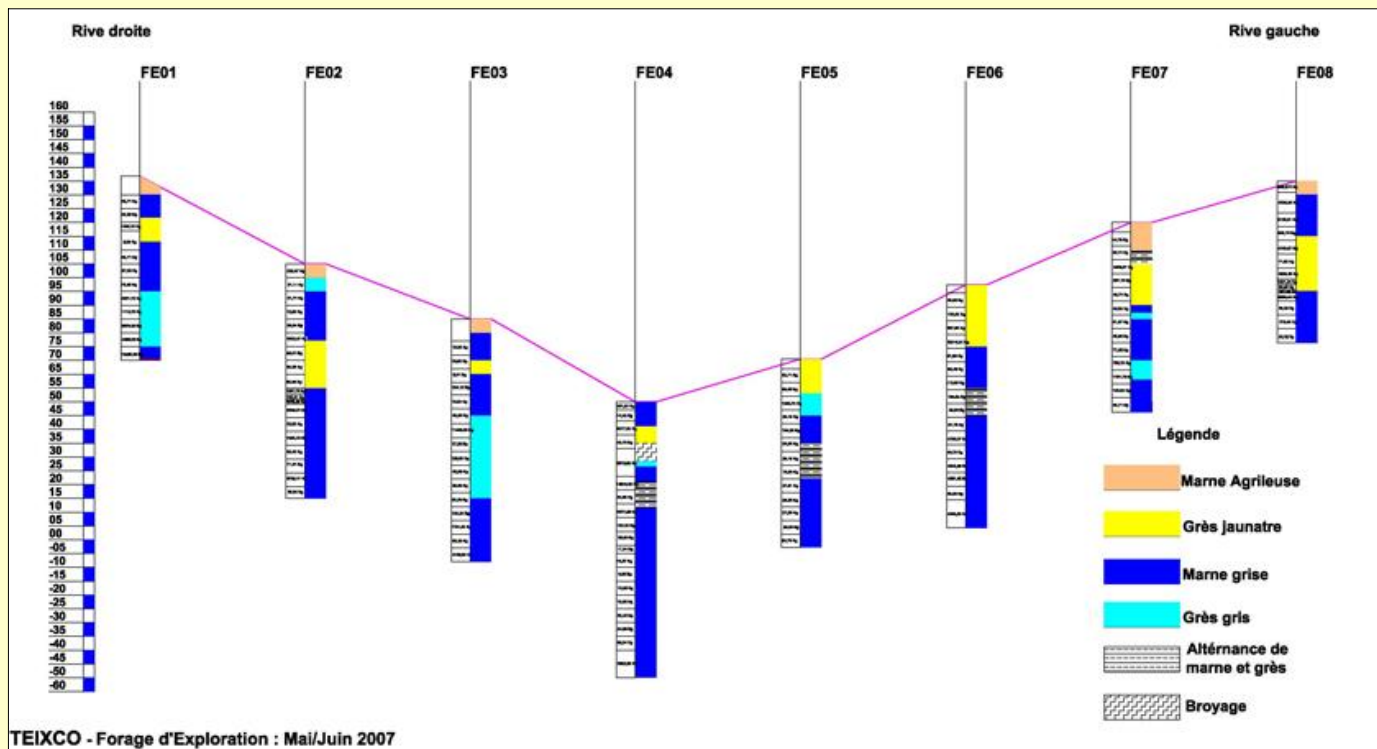
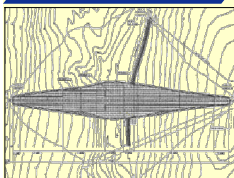
Execution of the Exploration drills

Complementary geological-geotechnical campaign:

In order to complete the study and to get a better geological-geotechnical and also hydro geologically knowledge of the soils foundations, a complementary geotechnical recognition campaign have been done.

Along the axis of the dam, 8 drills have been made, vertical, sampled and with Lugeon tests until a depth that penetrated the waterproof substrate.

In a geological point of view, the soils of the dam foundation are represented as followed:



Grey sandstone and red marls at the surface



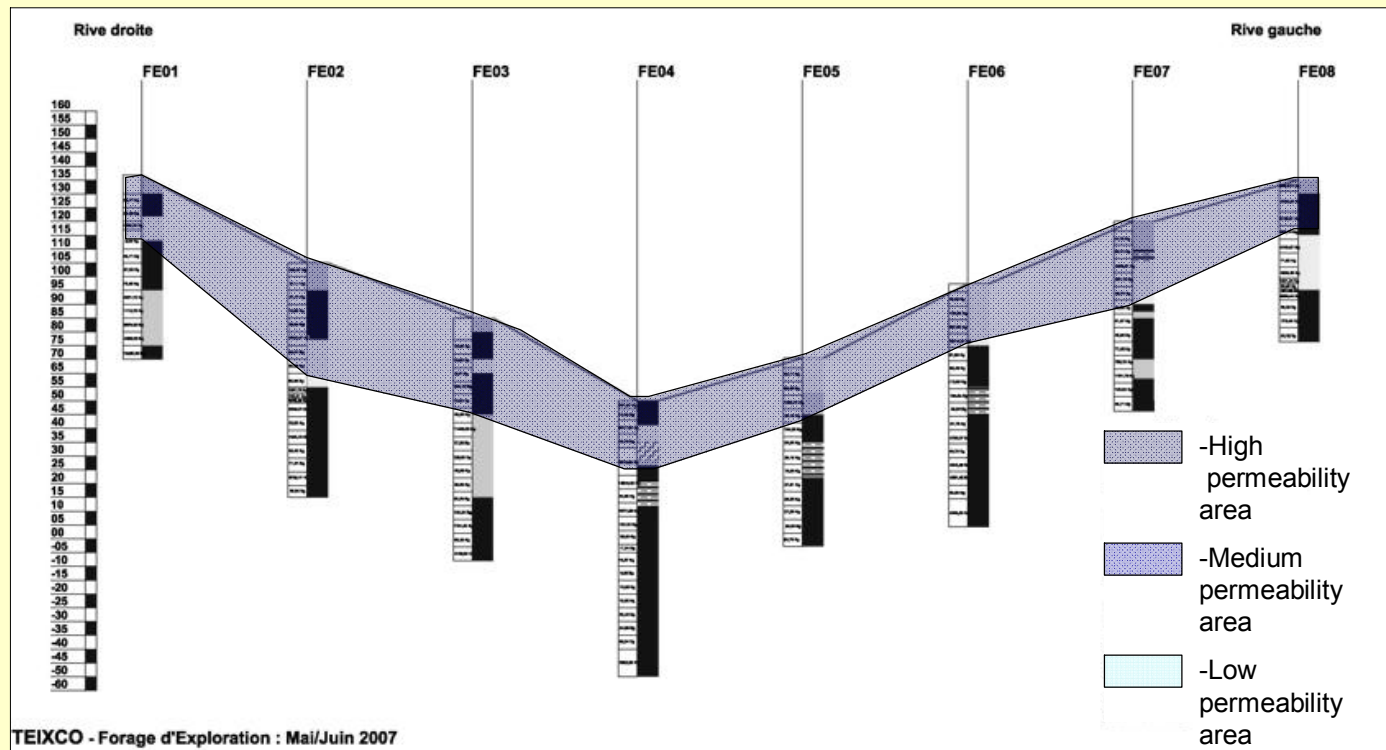
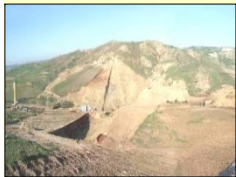
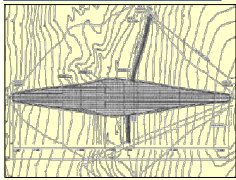
Alternation from sandstone to marls



Grey marls in depth

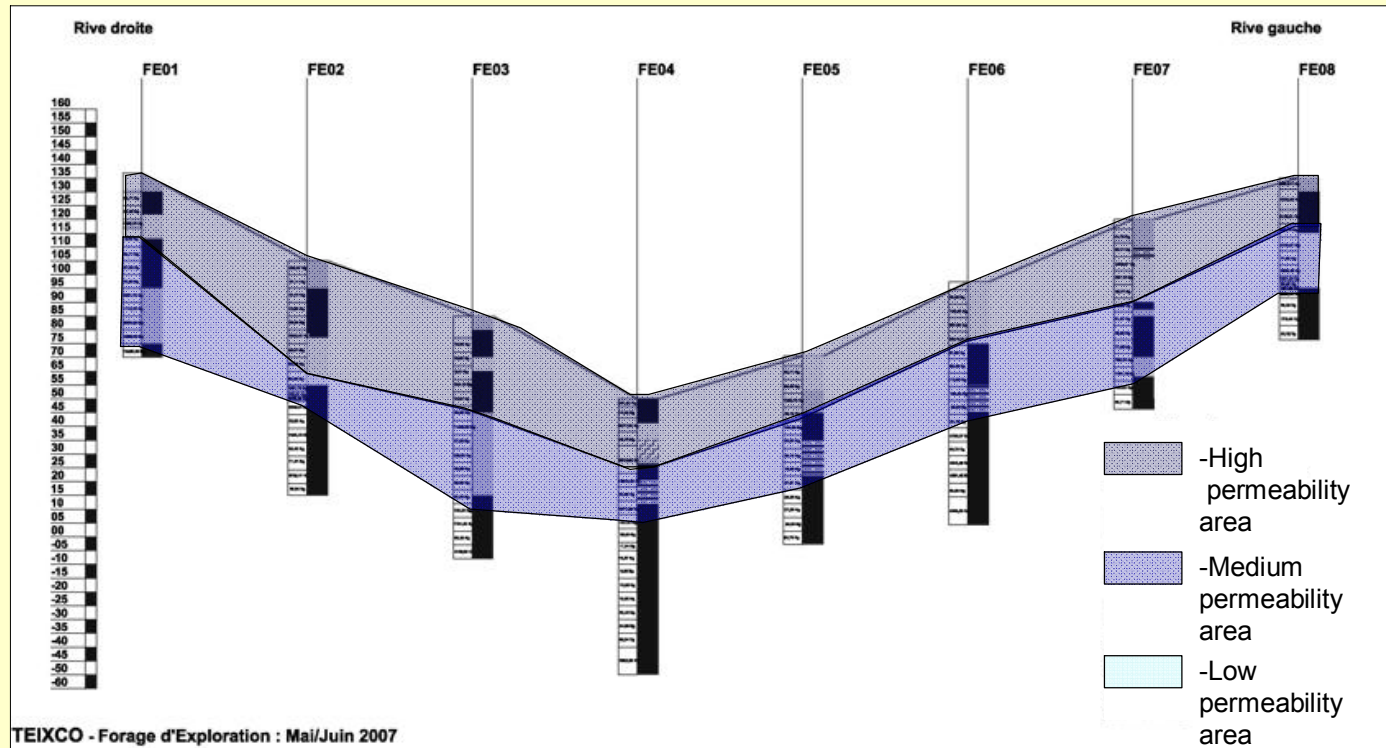
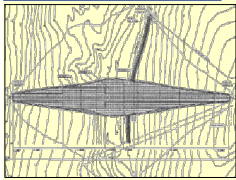
" WATER IN AFRICA ". HYDRO-PESSIMISM OR HYDRO-OPTIMISM

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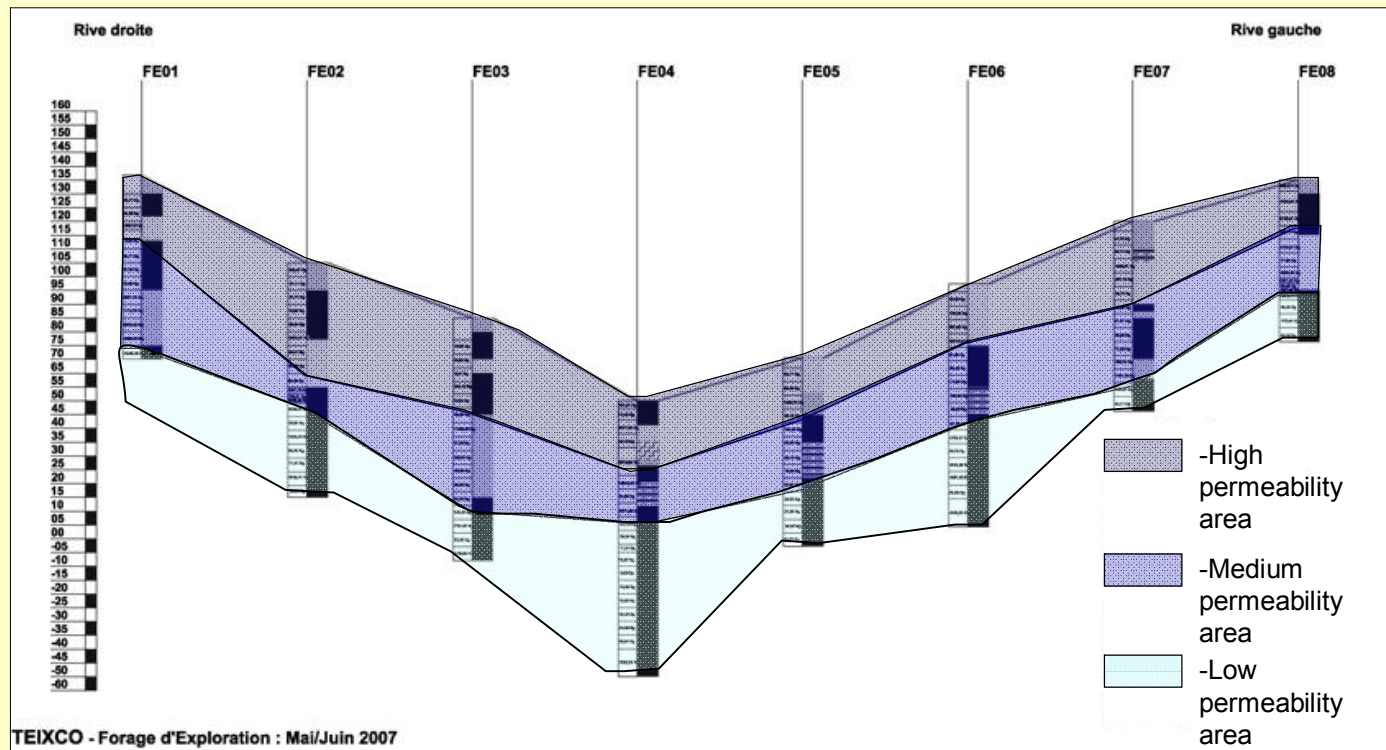
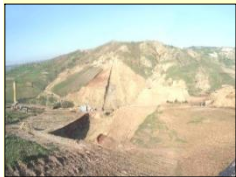
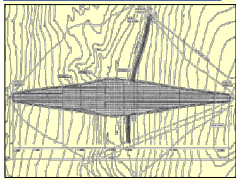
High permeability area:

Superficial levels made of friable sandstone and decompressed marls, where we can notice permeability values between $UL=20$ and $UL > 100$



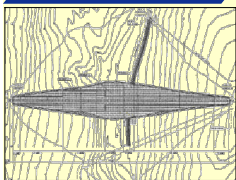
Medium permeability area:

Transition area between the intercalations of marls and sandstone and the marls unit, with values $5 < UL < 15$



Low permeability area:

This is an area made by levels of very strong marls and some very compact sandstone and a little fractured, with permeability values $UL < 1$.



Test drills execution :

In order to get a better definition of the injection curtain, 3 tests zones have been made (1 at the right bank and 2 at the left bank) which allow to study some variables and parameters about the drilling and injection methodology :

- Drilling methodology (compressed air / circulating water);
- Configuration of the injection curtain:
 - Distance between each drill
 - primary drills at 12m
 - secondary drills at 6m
 - tertiary drills at 3m
 - quaternary drills at 1.5m
 - Number of lines to be executed for the injection curtain:
 - Monolinear Injection Curtain to be made upon the dam axis
 - Bilinear Injection Curtain with a line at the upstream and one at the downstream of the dam axis, with a 2.10m separation between the lines
- Cement grout types

M.A.O. Project Lot 2.0 – Kerrada dam

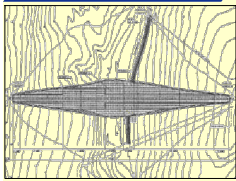


Realization of the treatment of the foundation
Injections curtain

- Constrution phase -

“ WATER IN AFRICA “. HYDRO-PESSIMISM OR HYDRO-OPTIMISM

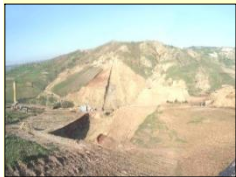
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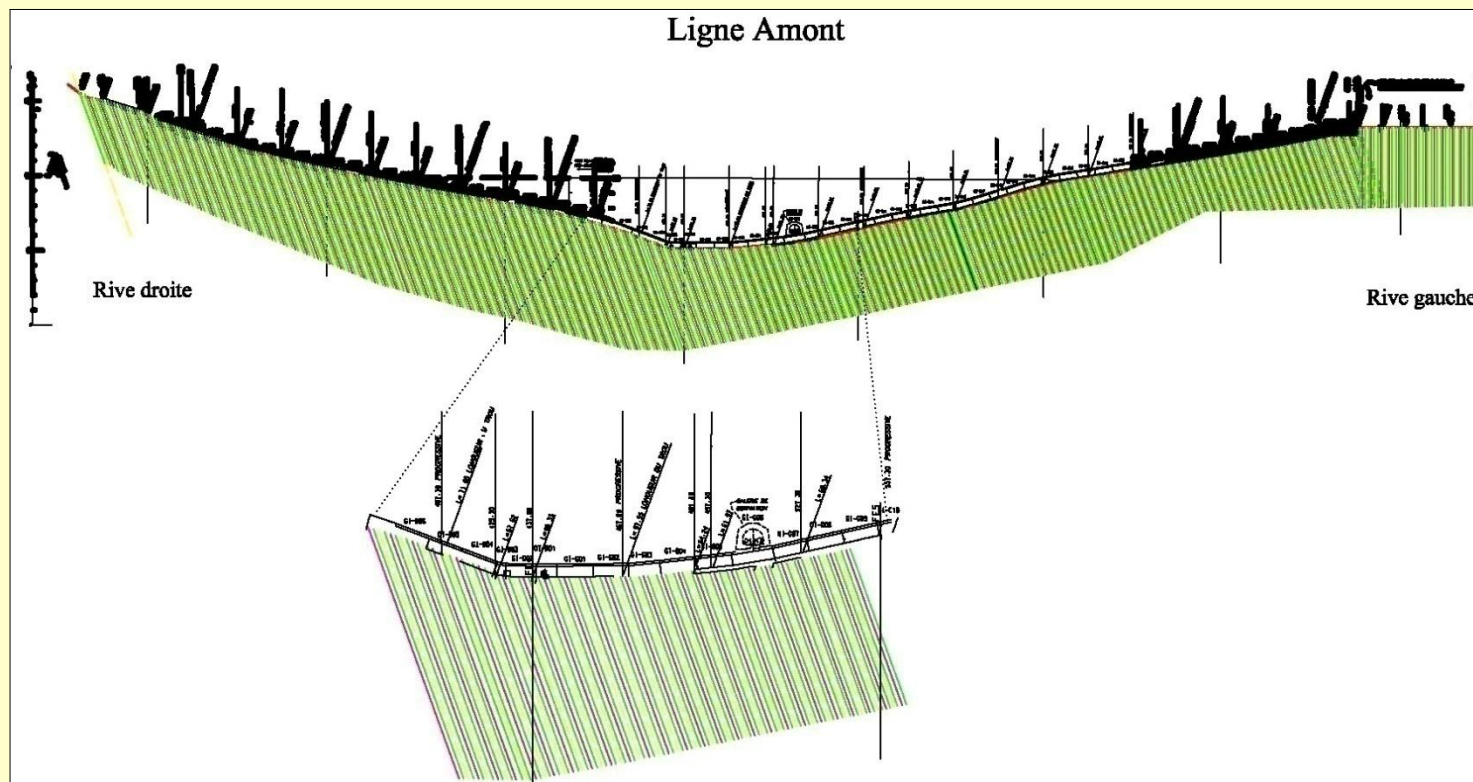
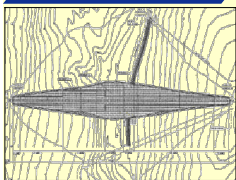


Works quantities

At the beginning, the project have described the execution of a monolinear injection curtain with a total of 30 000 ml and 21 000 ml for the consolidating injections.

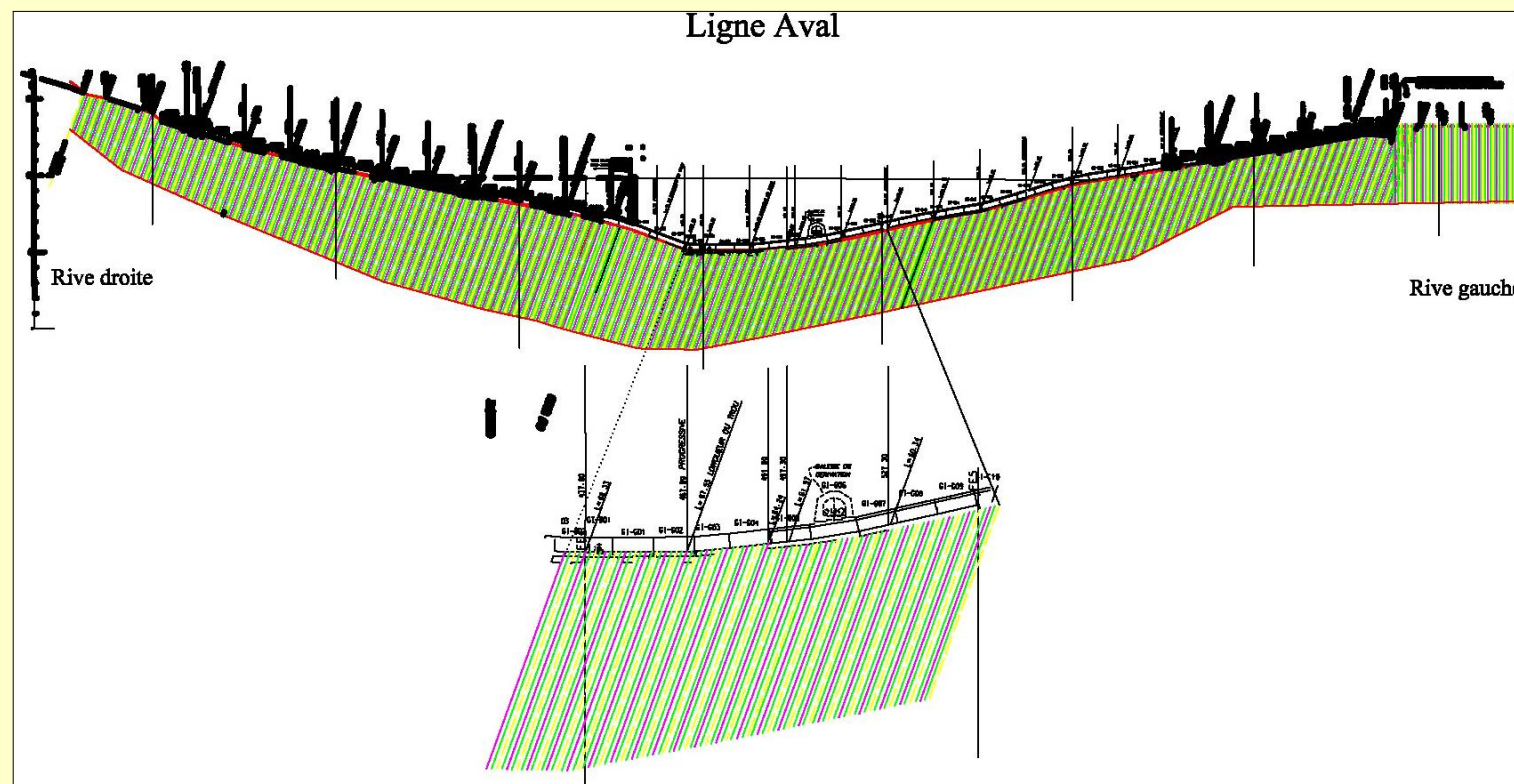
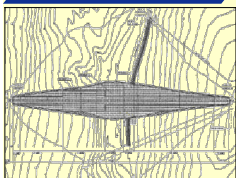
After having realised 8 “exploring drills” and 3 test zones, a bilinear injection curtain has been chosen – with an upstream and one downstream alignment upon the dam axis, eventually completed with the realisation of a third central alignment, which totalizes 100.000 ml drilling for the Injection Curtain, to be made wthin 15 months.





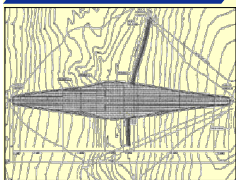
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Injection methodology :

In the particular case of Kerrada dam, the foundation treatment will be mainly made with ascending injections in some 5m length sections.

But, in case of water losses detected during the drilling, instability of the drill walls or problems related to the drilling it will be necessary to apply the descending injection technique.

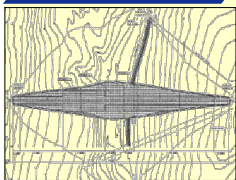
« Stop injection » criteria :

The refusal criteria shall be bimodal:

- The calculated manometric injection pressure ;
- Injection volume;

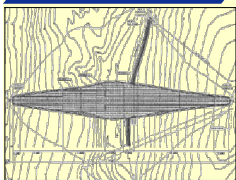
Drilling equipments

Consolidating Injections :



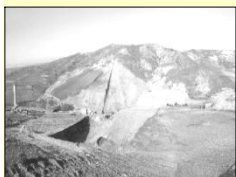
“ WATER IN AFRICA “. HYDRO-PESSIMISM OR HYDRO-OPTIMISM

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Drilling equipments

Injection curtain :

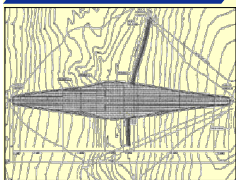


Right bank



“ WATER IN AFRICA “ . HYDRO-PESSIMISM OR HYDRO-OPTIMISM

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Drilling equipments

Injection curtain :

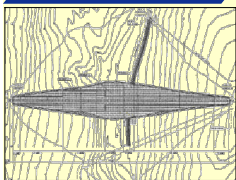


Left bank



“ WATER IN AFRICA “. HYDRO-PESSIMISM OR HYDRO-OPTIMISM

Porto, 2008



Drilling equipments

Injection curtain :



Inside the Gallery



“ WATER IN AFRICA “. HYDRO-PESSIMISM OR HYDRO-OPTIMISM

Porto, 2008

Injection equipments

Automatic injection plants

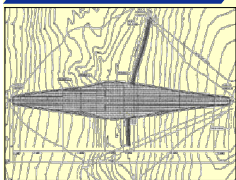


“ WATER IN AFRICA “. HYDRO-PESSIMISM OR HYDRO-OPTIMISM

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Injection equipments

Self-powered injection plants – Open area



“ WATER IN AFRICA “. HYDRO-PESSIMISM OR HYDRO-OPTIMISM

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Injection equipments

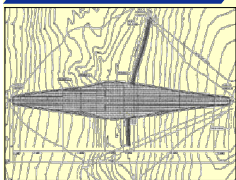
Self-powered injection plants – Inside the gallery



“ WATER IN AFRICA “. HYDRO-PESSIMISM OR HYDRO-OPTIMISM

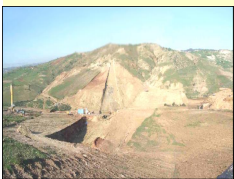
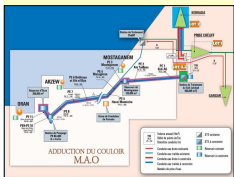
Porto, 2008

M.A.O. Project Lot 2.0 – Kerrada dam



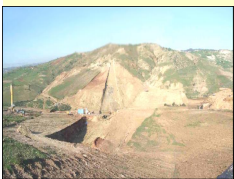
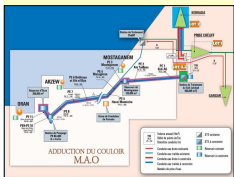
“ WATER IN AFRICA “. HYDRO-PESSIMISM OR HYDRO-OPTIMISM

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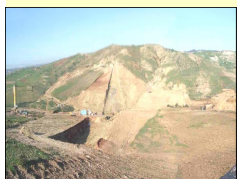
Conclusions

- Algeria is a country where it has been verified an intensive and persistent “**Dry Period**” for more than 25 years. This phenomenon has an obvious impact on:
 - The river disposals;
 - The underground aquifers are not feeded;
 - The reservoirs which stored the water are below maximum levels.
- The deterioration of this situation in the last decade, where average annual precipitation values already show a 50-60% deficit in comparison to the normal values for each season, has contributed to the existence of a **HYDRO-PESSIMISTIC** script.
- This persistent phenomenon forced the country to make of the drinkable water network its priority and to define a strategy to minimize the consequences of the “Dry Period”, invertting this hydro-pessimistic tendency until 2020.



Conclusions

- Consequently, several **HYDRO-OPTIMISTIC** solutions have been studied, giving a strategical direction which planned the execution of a group of large and medium size projects to minimise the present problems related to the water supply, mainly :
 - Construntion of 23 new desalination plants;
 - Requalification of 12 dams;
 - Construntion of 30 new dams;
 - Construntion of 7 huge regional hydraulic systems to transfer water between cities, such as the M.A.O. Project and its Kerrada reservoir dam.
- The implementation of the M.A.O. Project is one example of the **HYDRO-OPTIMISTIC** reactions/solutions for a country who gowing through an almost extreme **HYDRO-PESSIMISM** phase.
- In fact, the contruction of this huge project will allow drinkable water to be provided to the 3 largest cities of West Algeria (Mostaganem – Arzew – Oran), *id est*, for 2,5 million inhabitants with a 155 million m³/year total.



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