OFFSHORE SEAWATER INTAKES FOR DESALINATION PLANTS: AN OPERATING EXPERIENCE MINIMIZING ENVIROMENTAL IMPACTS

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Abstract

Between 2005 and 2007 Fisia Italimpianti was awarded with contracts to engineer, procure and put in service the Ras Abu Fontas B2 and A1 Desalination Plants, extensions of the Ras Abu Fontas station with water capacity productions of 30 and 45 millions of imperial gallons per day (MIGD) respectively.
The new plants are composed by steam production units, sea water intake system, multi stage flash (MSF) evaporators, remineralization plant and potable water reservoirs. Fisia Italimpianti scope of supply included also, for the Ras Abu Fontas A1 station only, the provision of all investigations and studies to prepare the reports (EIA - Environmental Impact Assessment) and monitoring procedures (CEMP - Construction Environmental Management Plan) in order to minimize environmental impacts and to obtain the necessary clearances from the Qatari Environmental Authorities.

The sea water intake systems, composed by large glass reinforced pipes (GRP) pipes, about 2000 nominal diameter (ND), extending 2 km from the shore, were one of the most challenging parts for both projects because of the process constraints, the morphological characteristics of the sea bed as well as the environmental issues, which were exceptionally stringent because of the already existing station intakes/outfalls and because other major construction activities, such as the New Doha International Airport, were in progress in the vicinity of the proposed sea water intake.

This paper describes the main technical issues encountered during the design and the solutions adopted for the sea water intake pipes such as process, mechanical and civil aspects as well as construction methods applied. The particular configuration of the pipes, laid mainly above the sea bed, forced to install an evacuation system of entrapped air; moreover, this paper presents the method used to evaluate the amount of this entrapped air and provides outlines of the installed evacuation system.

Furthermore, a description is provided of the environmental investigations and studies in the marine side carried out, for the Ras Abu Fontas A1 station, for the development of the EIA and of the CEMP along with main Qatari Authorities enforcements.

INTRODUCTION

A sea water intake system has to be designed and constructed to ensure sufficient sea water in terms of quantity and quality. Sea water intakes systems are a fundamental part of a desalination plant and they have to be designed with due care to cater to all conditions of operation and stoppage and also to prevent the carry-over of materials like seaweed and sand.

Each coast has its own specific typical problems for sea water intakes. Furthermore, the sea is dynamic, frequently changing its sea bed profile, with powerful waves capable of changing currents, damaging structures and affecting water depths.

A good design has to grant the performances requested, protect downstream equipment and the intake system itself and reduce environmental impacts on marine life.

This paper highlights the main problems encountered and the various designs solutions adopted for the sea water intakes constructed for two desalination plants at Ras Abu Fontas, Qatar.

Ras Abu Fontas B2 and A1 - Outline of main technical terms

Qatar Electricity and Water Company (QEWC) awarded the engineer, procure and construct contracts (EPC) respectively to the consortium FISIA ITALIMPIANTI & GENERAL ELECTRIC INTERNATIONAL INC. for the development of the Ras Abu Fontas (Raf) B2 plant and to FISIA ITALIMPIANTI for the development of Raf A1 plant.

Both plants are located within the Raf complex.

QEWC owns and operates Raf A, Raf B and Raf B1 stations at Ras Abu Fontas complex, which is located approximately 10 km to the south of Doha, adjacent to the Arabian Gulf. This is depicted in figure 1.

Figure 1: Location of Ras Abu

Raf B facility comprises the existing Raf B and Raf B1 plants, and Raf B2 plant. The Raf B station was designed to be capable of an extension to 1,000 – 1,100 Mega Watts (MW) and 60 MIGD total production capacities.

In addition to the Raf B and B1, QEWC also owns and operates the Raf A power and desalination production facility, which is located adjacent to Raf B facility on its northern boundary. The first phase of Raf A facility was commissioned in 1977 and the station was finally completed in 1993 with an electricity generating capacity of 497 MW and a desalination plant capable of producing 55 MIGD.

The power and desalination capabilities at Raf complex are summarized in table 1 below.

Table 1 – Installed capacities at Ras Abu Fontas

	CAPACITY	
Plant name	Electricity [MW]	Water [MIGD]
Raf A	500	55
Raf B	610	33
Raf B1	380	-
Raf B2	600	30
Raf A1	-	45

Ras Abu Fontas B2 facility

Ras Abu Fontas B2 facility is an independent power and water production facility of about 610 MW and 30 MIGD net power and water production output respectively.
The plant site is located at the southern end of Raf power and water production station. It is an extension of the existing Raf B facility, a co-generation combined cycle power/water plant, as shown in figure 2.
The Plant is composed by the following:

- three gas turbines (GT's), related generators, transformers and an extension of the 220 kv high voltage Substation
- two heat recovery steam generators (HRSG's) with supplementary firing;
- two multi stage flash (MSF) desalination units, related sea water intake piping works, water treatment plant, water storage facilities and product water pumps, pumping station and related facilities;
- mechanical/electrical/instrumentation and control balance of plant and environmental monitoring facilities.

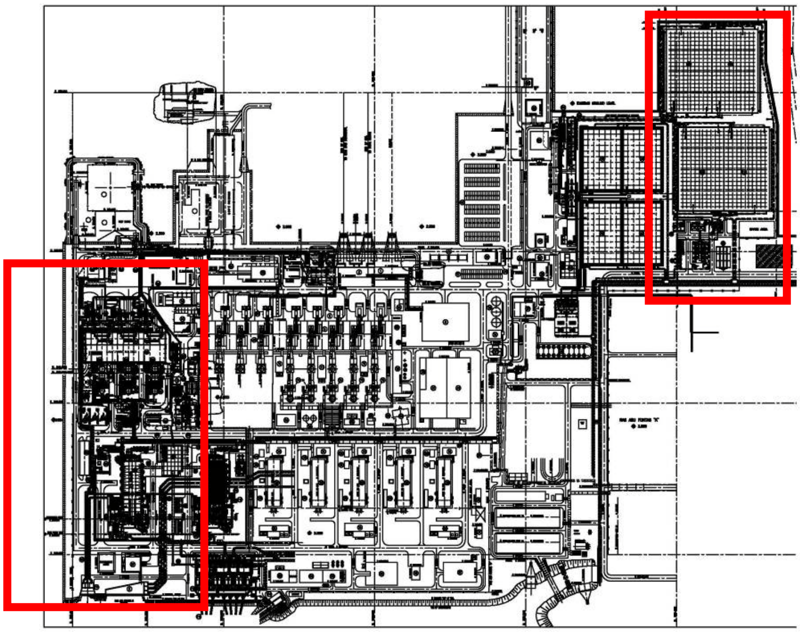


Figure 2: Raf B2 Plot plan – parts highlighted

Raf B2 facility can operate as a fully independent power and water production plant but interfaces and interconnections with the existing plants of Raf B and Raf B1 are also included for a smooth integration.

Raf B2 commenced commercial operation in early spring 2008.

Ras Abu Fontas A1 facility

Ras Abu Fontas A1 desalination plant has a capacity of 45 MIGD potable water production.
The plant site is located at the northern end boundary of Ras Abu Fontas power and water production station, as shown in figure 3. The Raf A1 station is an extension of the Raf B1 facility since new HRSG's are coupled to existing GTs from Raf B1.

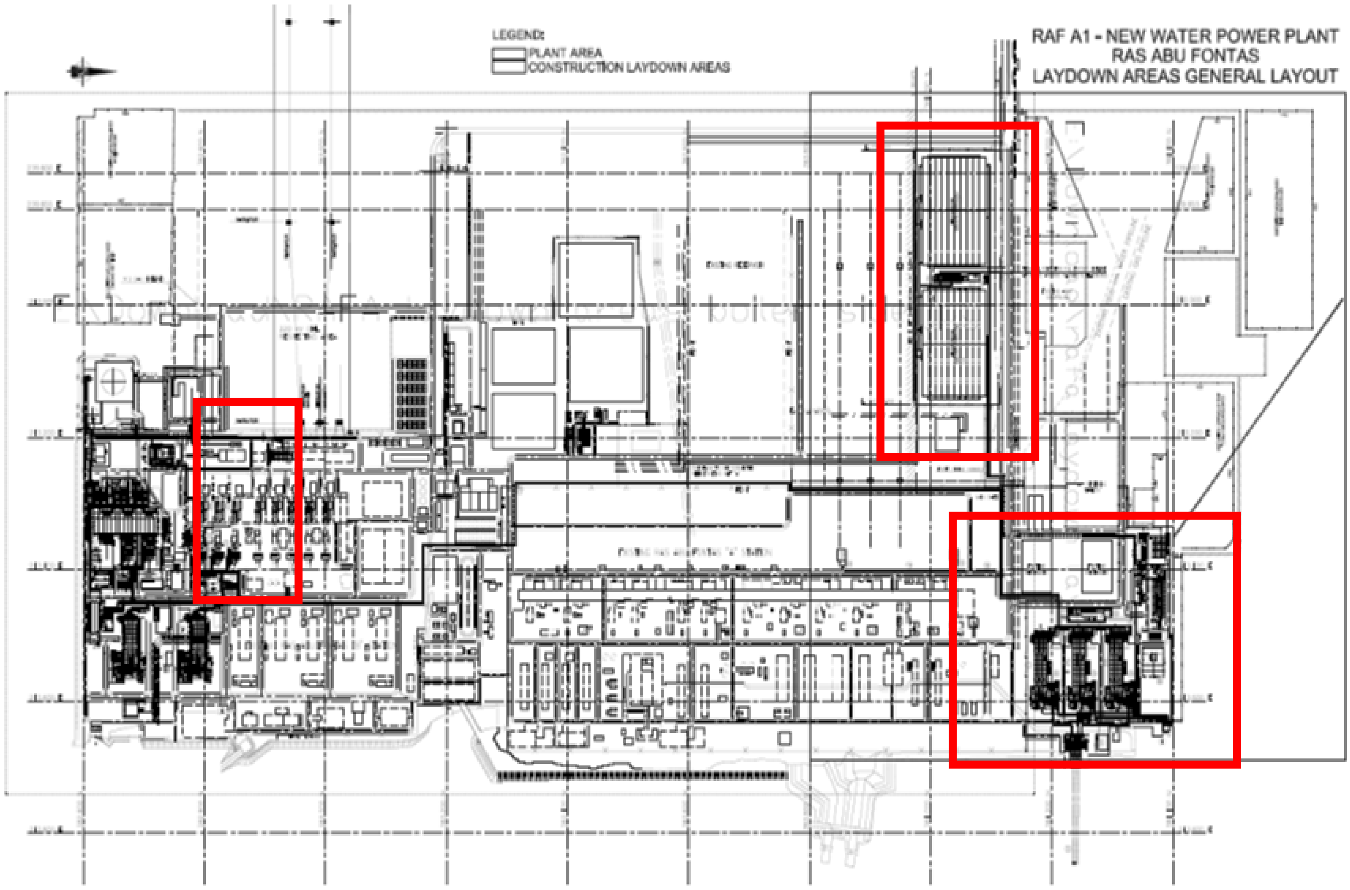


Figure 3: Raf A1 Plot Plan - parts highlighted

The scope of work of the facility was the following:

- three HRSG's with supplementary firing;
- three MSF desalination units, related sea water intake piping works, water treatment plant, water storage facilities and product water pumps, pumping station and related facilities;
- mechanical/electrical/I&C balance of plant and environmental monitoring facilities.

Fisia scope included also the preparation of the report on environmental impact assessment review comprising an assessment of the major issues such as the marine, air and terrestrial impacts and to carry-out an environmental management plan to be complied with during construction activities as well as during operation to implement mitigation measures.
Raf A1 commenced commercial operation in late spring 2010.

Ras Abu Fontas B2 - Sea water intake system

The sea water intake is an integral part of the extension of the Raf B desalination plant: the existing four sea water intake pipelines of Raf B were increased by three, resulting in a total of seven sea water intake pipes for the supply of sea water to the desalination plant. The new three pipelines connect into the existing sea water pumping station through pipe stubs provided in the original construction contract.
The combined sea water supply system of both Raf B and B2 has a total capacity of about 175.000 cubic meter per hour (m^3/h).

Ras Abu Fontas B system

Sea water is delivered to the stilling basin of the pumping station through four GRP pipes of about 1900 mm diameter installed under sea bed to about 2000 meters into the sea from the coast. Under the contract of Raf B, the complete concrete structure for the Raf B2 expansion of the Sea water pumphouse was already built: the below ground concrete had been built to accommodate the three additional intake pipes to be built for Raf B2, as shown in figure 4.

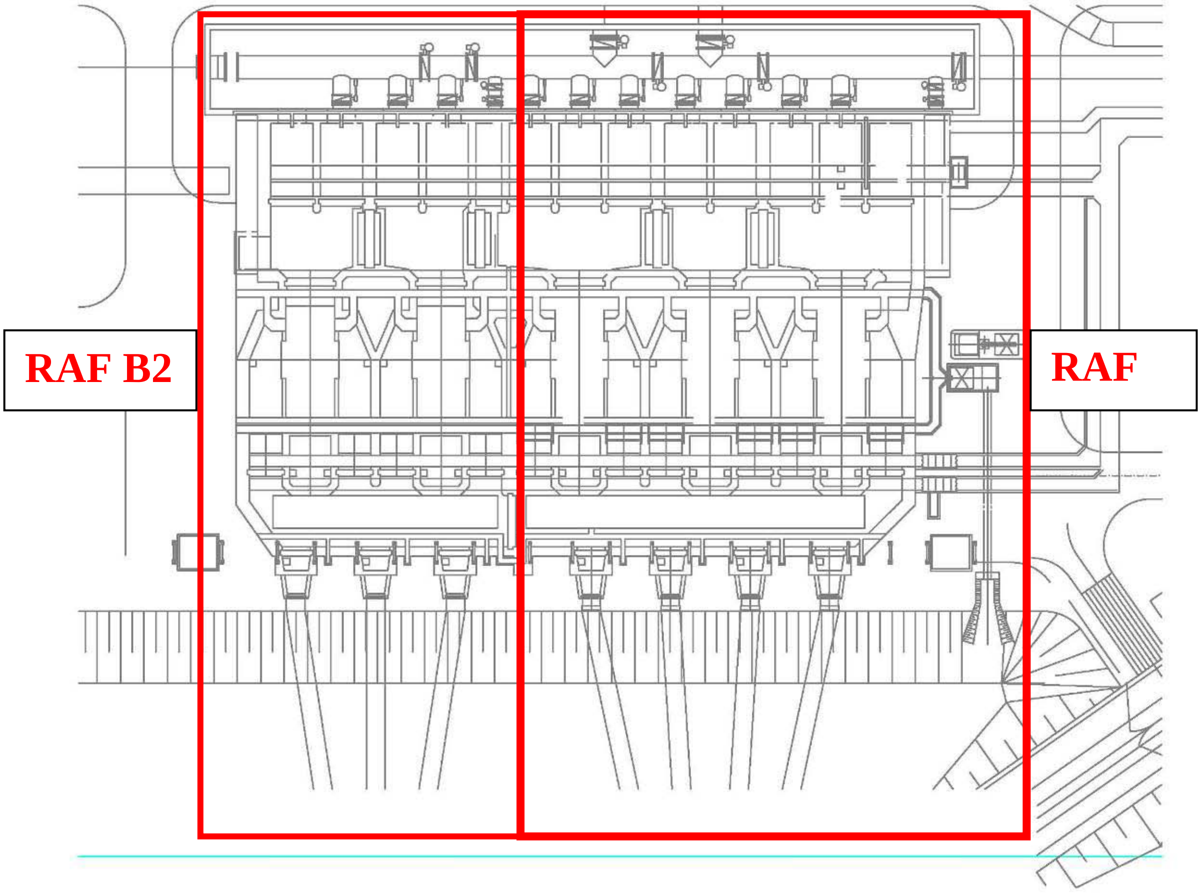


Figure 4: Raf B sea water intake pumping station

The Raf B part of the sea water supply system, four pipelines 1900 mm of diameter, 2000 m long and pumping station, was completed 15 years ago . The works were executed using large rock dredgers and blasting technology.

With such methodology it was possible excavate the hard rock present in the site, and lay the pipes to a depth of about -7.00m QND. Figure 5 shows the construction phase.

Figure 5: Dredging and blasting during construction of Raf B

Ras Abu Fontas B2 - Specification

Tender specification for Raf B2 project called for three additional pipes of ND 1900 of about 2000 m long each, with relevant strainers, manholes etc, in line with Raf B ones, delivering sea water into the common stilling basin interconnected to the phase B basin. In all tide conditions the intake pipes heads (risers) had to be mandatorily flooded with the required submergence of sea water above their top. Additional dredging with possible blasting was allowed to facilitate the laying of Raf B2 suction pipes although this could introduce the danger of damage occurring to the existing phase B pipes, and therefore all precautions had to be taken to avoid such occurrence.

Solution adopted for Ras Abu Fontas B2 sea water intake pipes

Existing sea water intake system of Ras Abu Fontas B station consists of four intake pipes, which include internal chlorine pipes and are buried below the sea bed: the system is extended for B2 phase with three new sea water intake pipes, mainly laid above the sea bed. The pump house for the existing and three new intake pipes has been constructed during B phase.

The Raf B2 facility requires about 54,000 m^3/h of sea water. The sea water supply system for Raf B2 comprises the following:

- three sub-sea intake pipes
- screening stations
- pumping chambers
- pumping station.

The three intake pipes are glass reinforced plastic (GRP) pipelines, 1900 mm diameter each. They are laid mainly above the sea bed and extend two kilometers offshore, running almost parallel and adjacent to the existing Raf B intake pipelines. The initial and final portions only are buried below sea bed, as shown in figure 6.
Intake pipelines are protected by armour stone from waves, small boats anchoring, etc. Sea water flows under gravity to the sea water pumping station.

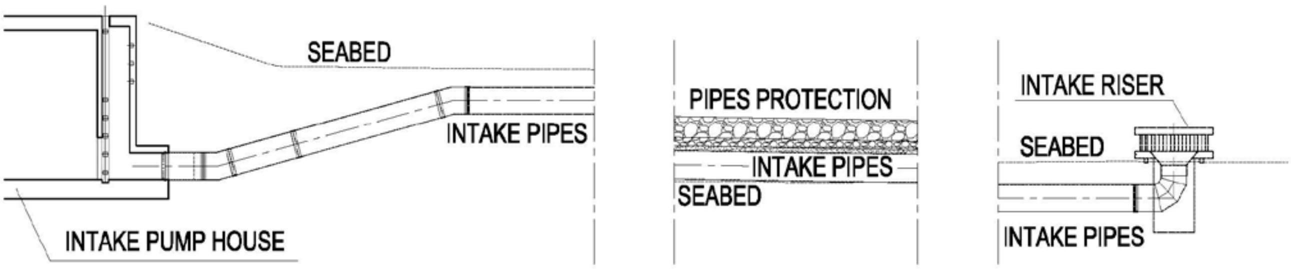


Figure 6: Intake system scheme - From left to right, pump-house, intake pipes and raiser

The sea water intake riser, shown below in Figure 7, uses a velocity cap arrangement and bar screen. This prevent mitigates the entrance of large marine organisms.

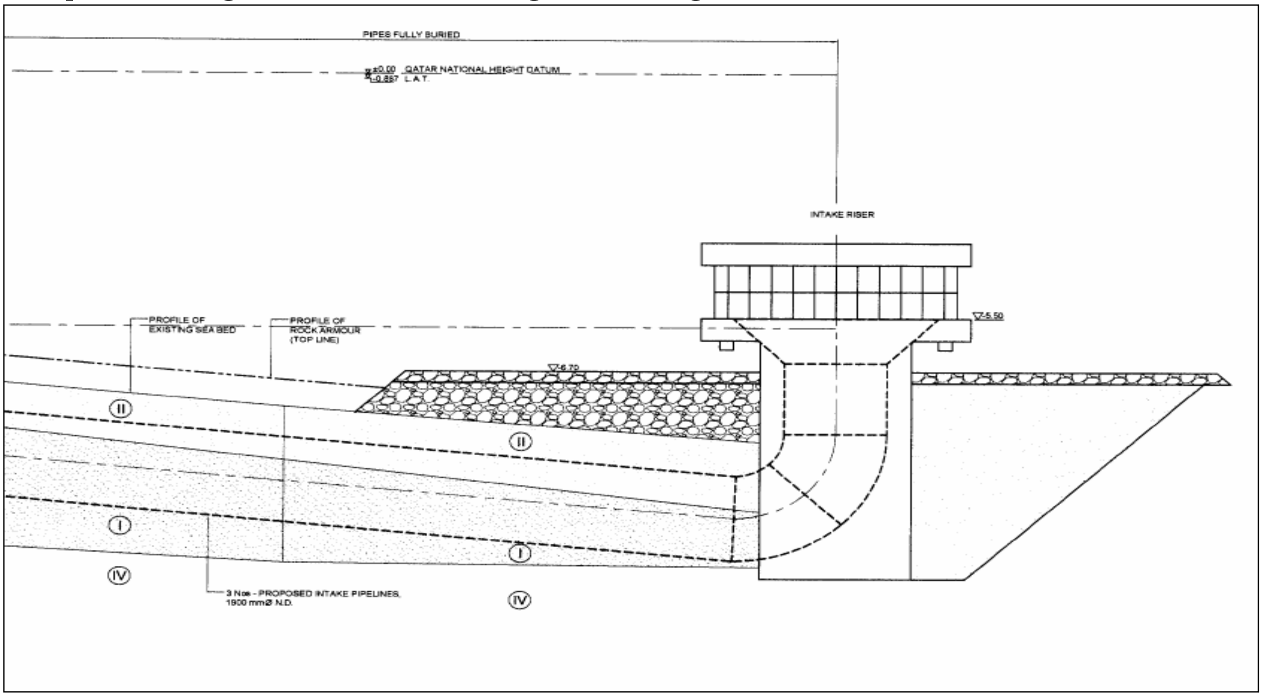


Figure 7: Intake riser (sea water inlet point)

The incoming sea water needs to be treated to prevent microbial growth in pipework, desalination plant and ancillaries.
This is achieved by continuously dosing the sea water in the intake pipework with chlorine: internally to each 1900 mm intake pipe, a small ND 150 pipe runs up to the risers where a suitable solution of sea water with active chlorine is dosed inside the pipe.

Design of the Intake pipes

The design of the intake system has been developed as per following steps:
- assessment of site conditions and evaluation of environmental issues;
- selection of lay-out, pipe characteristics/material and installation method;
- assessment of pipe size, lay-out and characteristics to fulfill process requirements.

Assessment of site conditions, evaluation of environmental issues and selection of location

Bathymetric and geotechnical survey

Bathymetric and geotechnical surveys were carried out to establish water depths and geotechnical characteristics of the sea floor at the site and to enable design, construction and planning to proceed. The objectives of the bathymetric survey were to establish the water depths within the area.
Results were drawings detailing the sea bed elevation in the area of the survey: it was verified that in general, the sea floor slopes from the shore towards offshore even if very slowly. Only at a distance of about two kilometers from the coast the elevation of sea floor permits to fulfill the required submergence required for the intake raisers.
The objectives of the geotechnical investigation conducted by way of drilling boreholes were to establish the sub-surface geology in the area of the new sea water intake pipelines.

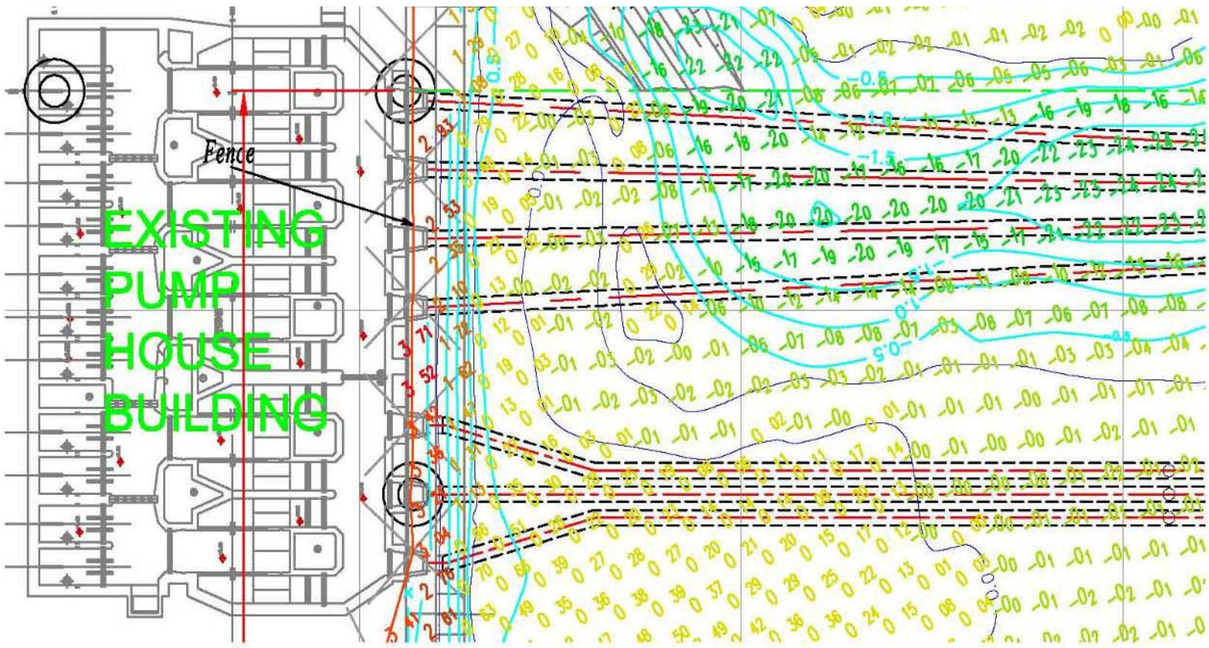


Figure 8: Bathymetry in the area near pump-house

Conclusions were that sea floor could satisfactorily support the proposed structures but materials from the drilled boreholes indicated that the external layers of seabed were mostly composed by caprock (calcarenite layer) and bedrock (sismina limestone): these rocks are strong and hard to be demolished.

Therefore significant works of excavation of the sea bed could be effectively realized only by means of large dredgers and mine blasting.

Marine environmental baseline

A survey provided the existing marine environmental baseline conditions.
Following is a brief summary of the results of the surveys undertaken:
- sediment quality of the sub tidal area;
- assessment of benthic invertebrates;
- underwater video footage of the sub tidal environment;
- collecting information about the mangrove forests located in the vicinity of the project site.

Thermal plume modeling and recirculation

The marine part of the Environmental Impact Assessment (EIA), carried out for the Raf B2 station, developed a model simulations carried out under the existing discharge and intake scenario to simulate water temperature across the model area and through the water column. Thermal plume modelling was developed in consideration of the following:

- bathymetry;
- tidal conditions;
- seasonal temperatures and salinity;
- existing station intake location, flows, salinity;
- the thermal loads of new Raf B2 plant

Table 2: Ras Abu Fontas Station intakes/outfalls capacities

Plant	Intake flow [m3/h]	Plant	Outfall [m3/h]
Raf A	125,000	Raf A South	75,000
		Raf A North	38,000
Raf B	100,000	Raf B	93,000
Raf B2	54,000	Raf B2	48,000

Thermal plume modelling and subsequent recirculation study identified the area admissible for the installation of risers: this was mainly to assure sea water supply entering in risers totally separated from the discharges from outfalls with negligible recirculation.

Selection of lay-out, pipe characteristics/material and installation method

Based on all the above information, locations of intake risers and routing of pipes was verified to be adequate.
The new proposed pipelines had an internal diameter of about 1900 mm and extended 2000 m into the sea, perpendicular to the shore line.
The pipelines are positioned almost parallel to the existing ones, at a distance variable from about 10 meters (near the pumping station) diverging of about 5 meters every 100 meters, as schematically shown in figure 9.

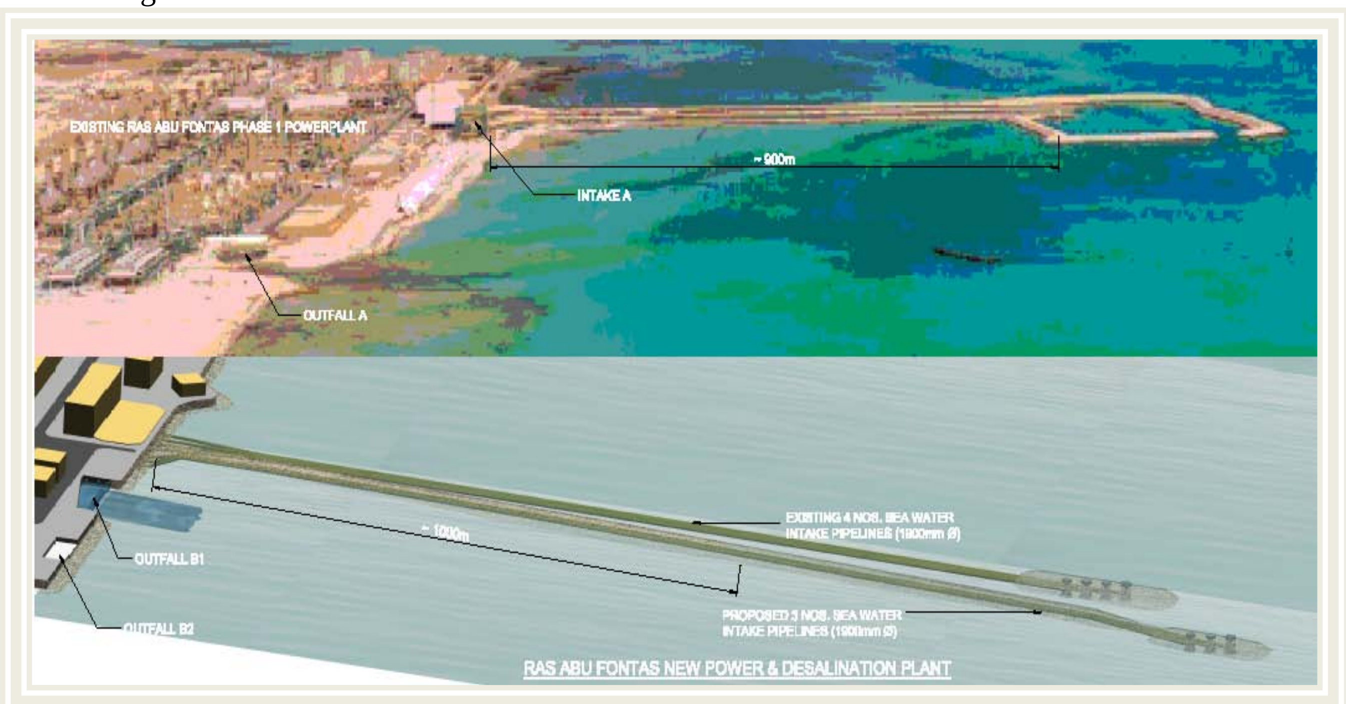


Figure 9: Lay-out of Raf B and Raf B2 intake system

The possibility to execute excavation by using the same technology as per Raf B was evaluated, with the following conclusions:

- dredging in rock was not advisable due to the vicinity of the existing pipelines. The safe engineering practice request for heavy rock dredger an operating width of at least 40 meter and a deep channel to approach the shore area;
- blasting technology was not suggested due to the close presence of concrete structures and GRP pipelines in operation and for its potential devastating effects on marine ecology;
- the risk that during the execution of such works one of the existing pipes was damaged was too high. It is in fact enough a strong vibration due to blasting shock or a touch of a cutter or a spud of the dredger, to damage the existing pipeline and cause a complete black-down of existing desalination and power plant, with serious consequences for all Doha community.

For the above mentioned reasons, it was proposed to install the pipeline mainly above rather than under the seabed. This solution minimized the impacts on the environment, eliminating the necessity to blast and the use of a heavy rock dredger.

Therefore, while four existing Raf B DN 1900 GRP pipes are installed completely buried under the sea bed to about 2000 m into the sea from the coast, the three new intake Raf B2 GRP pipes were installed under the sea bed only for their portion near to the pump house and in the riser location, and above the sea bed in the major part of their way to the sea.

This kind of installation implies that new pipes have a portion rising and one descending: the pipes have their most elevated section at about – 1,00 QND (Qatar National Datum) when the entrance in the pump-house is foreseen at about –6.00 QND.

New intake pipes material were glass reinforced plastic with all required accessories such as inspection manholes, header, suction filters and so on. Chlorine solution dosage pipe of DN 150 was installed inside and fitted to main pipe with proper supports and anchorage.

Assessment of pipe lay-out, size and characteristics to fulfill process requirements

Suitability of solutions adopted in terms of lay-out and characteristics were duly verified against process requirements throughout a detailed hydraulic study carried out both in steady and dynamic conditions.

Pipelines built for Raf B2 sea water feed into the common inlet chamber of the pump house interconnected to the phase B basin: three new intake pipes and old four ones smoothly operate in parallel.

Sea water flows from risers (open sea) to intake pump house (sea water pumps) by gravity.

The first issue was how to evaluate the actual performances/roughness of Raf B intake pipes in operation from many years and heavily fouled. This could be achieved only indirectly, namely measuring the head loss in existing pipes and therefore computing their roughness: a measurement campaign at Raf B was performed recording total sea water supply flows and sea water levels both in open sea and inside the forebay at same time.

The hydraulic study considered the scenarios as per Table 3.

Table 3: Scenarios for the hydraulic study

Case	Flow	Pipes roughness	Tide level	Note
A1 (MAXIMUM DESIGN FLOW)	maximum emergency flow	☐ clean	LAT - HAT	All Raf B2 pipes in operation
A2 (MAXIMUM DESIGN FLOW)	maximum emergency flow	☐ fouled	LAT - HAT	All Raf B2 pipes in operation
B1 (MAXIMUM OPERATING	nominal flow	☐ clean	LAT - HAT	All Raf B2 pipes in operation

DESIGN FLOW)				
B2 (MAXIMUM OPERATING DESIGN FLOW)	nominal flow	☐fouled	LAT - HAT	All Raf B2 pipes in operation
C1	nominal flow	☐clean	LAT - HAT	Two Raf B2 pipes in operation
C2	nominal flow	☐fouled	LAT - HAT	Two Raf B2 pipes in operation
Study in transient condition to evaluate scenario of full pumps trip from both maximum design and maximum operating flows				

Note: Low Average Tide (LAT) - High Average Tide (HAT)

Main subjects and findings of the hydraulic study were the following:
- Indirect evaluation of existing Raf B effective pipe wall roughness and performances;
- assessment of the maximum sea water flow (under clean and fouled conditions) in the existing four intake pipes, for significant tide levels in open sea and minimum sea water level in the pump house (as evaluated throughout the hydraulic model test of pump house);
- verification of the water levels in the pump house when the existing Raf B pipes and the new Raf B2 pipes are in parallel service;
- evaluation of the side flow from the existing to the new fore-bay (pump compartment upstream of band screens), due to the systems differences;
- verification of the water levels in the pump house when the new pipes are in service standalone;
- sensitivity analysis of the following design modifications: removal of the internal chlorine pipe in the new pipes, reduction of the length of the new pipes and variation of diameter.
- evaluation of the additional head losses generated by the two additional elbows of the new pipes (with respect to the existing Raf B pipe configuration).
- evaluation of the air released in the most elevated section of the new intake pipes and definition of the design data for the air priming/vacuum system.

The study demonstrated the suitability of the solution adopted in terms of diameter, characteristics and lay-out of the three additional intake pipes for Raf B2 station

Evaluation of the air released in the most elevated section in the new intake pipes

The new intake Raf B2 pipelines were buried in sea bed for their portion near to pump house and were laid above the sea bed in the major part of their way to the sea .
This kind of installation implies that the new pipes have a portion rising and one descending, as shown in figure 10: the pipes have their most elevated invert section at about – 1,00 QND while the entrance in the pump house is foreseen at –6.00 QND.

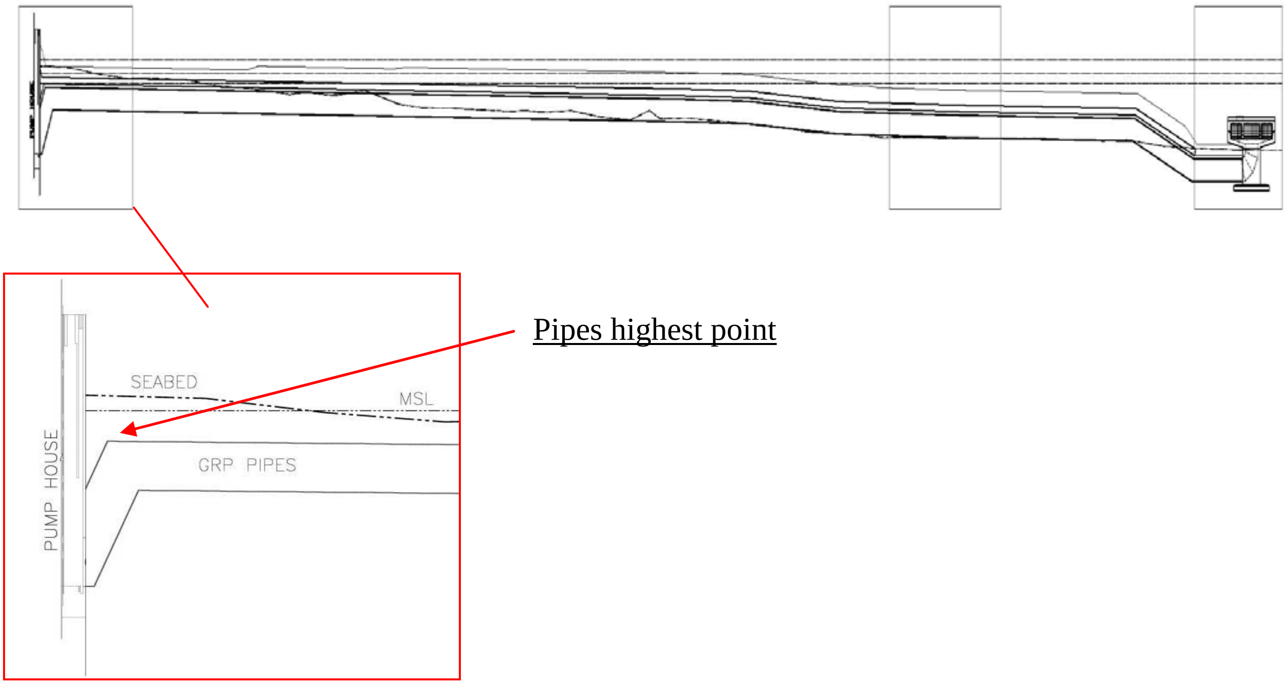


Figure 10: Intake pipes section

The related issue was to evaluate the amount of air which could be entrapped in the most elevated invert section and identify which kind of system could be installed to evacuate this air and its size /performances.
Air entrapment can occur in two different cases: inflow of air via the stilling basin or degassing caused by negative pressures in the pipe.

- **Air inflow**

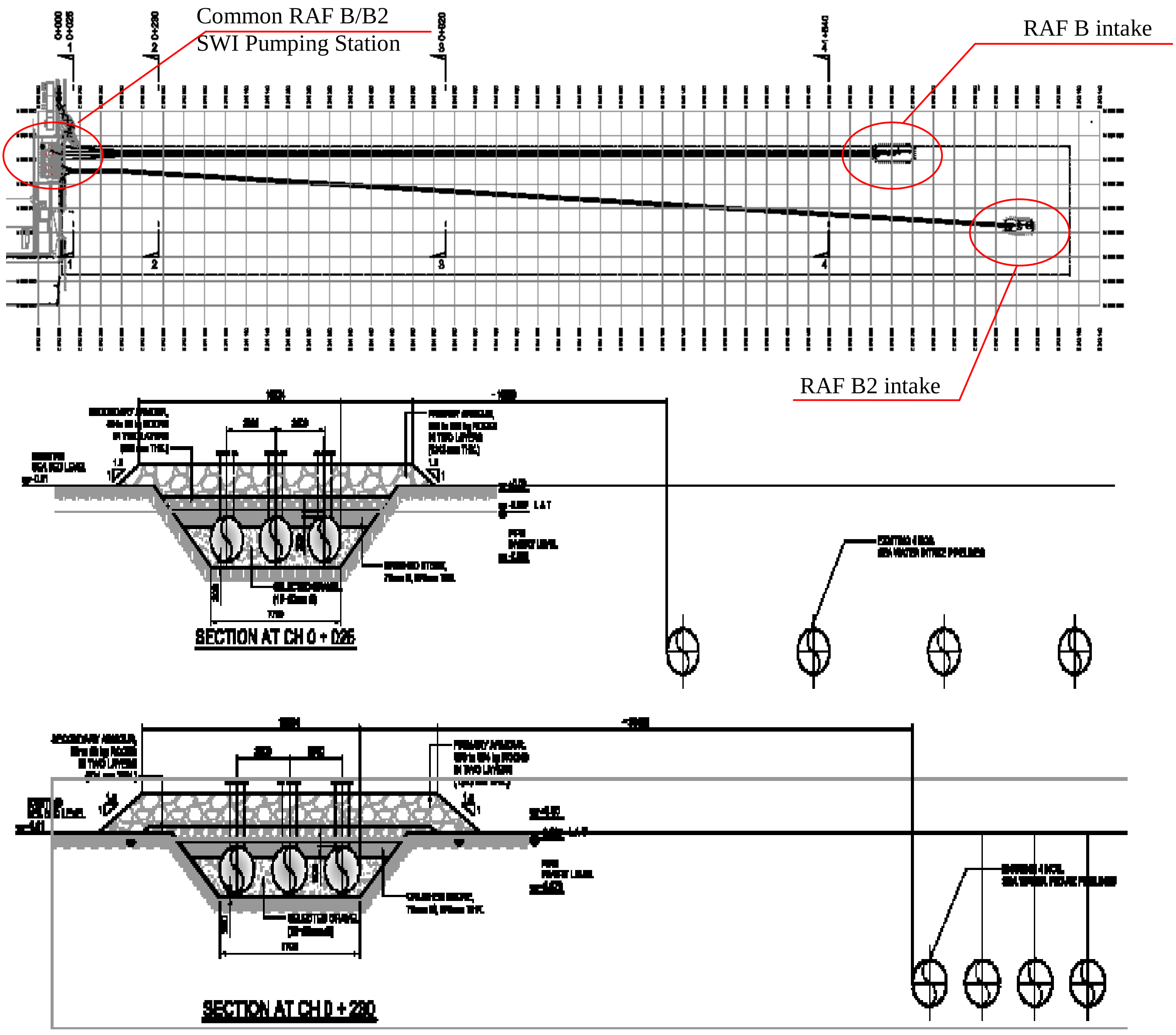
Air can only flow into the pipe from the stilling basin when the water level in the stilling basin drops temporarily below the top of the pipe and the water is flowing backwards into the pipe. In the steady state cases, it was found that for all cases the water level in the stilling basin is above the top of the pipe. In the transient cases, it was found that after the pump trip the water level in the stilling basin increases and never drops below the top of the pipe. So it is not possible for the air to enter into the pipe from the pumping station.
At pumps start-up, the level also drops. This is anyway not much lower than the minimum stationary level because the pumps can be started up in a controlled way and sequentially.

- **Degassing**

In the steady state simulation it was found that for several cases the pressure is below 0 barg. The pressure is negative for about 700 meters of the pipe line. This generates degassing of the water and air can accumulate in the most elevated section of the pipe. The amount of air accumulated depends upon the temperature, flow velocity and degree of saturation. If it is assumed that the water is fully saturated and that no air is transported out of the pipe, the amount of air formed can be calculated with Henry's law. If the water temperature is 18 degree Celsius (°C), about 40 liters per second (l/s) of air can be formed, while for a temperature of 40°C the amount is 30 l/s. These values are for the case when three pipes are in operation.
When air pockets have to pass descending pipe sections (the pipe angle is 15 degrees, directly upstream of the pump sump), the flow velocity has to be sufficiently high: thus air very likely accumulates. This will cause an extra head loss, which could theoretically cause, in the worst case, the water level to drop below the top of the pipe in the forebay. Therefore it was decided to remove this air be means of a particular air extraction system which will be described later .

Offshore pipelines adopted solution – Civil aspects description

In the adopted solution for offshore pipelines installation, only minor quantity of excavation in rock and other material has been carried out, which had to be executed with underwater breaker and cranes pontoon equipped with long boom excavators and clamshell. The total quantity of excavated material has been less than 100.000 m3. Such material has been discharged in approved dumping areas on land. During excavation, the mandatory use of silt curtain has been adopted, in order to avoid undesired siltation effects on the existing intake systems.
After installation, the new pipelines have been protected with various grading of selected quarry material and a final layer of large armour rocks as shown in figure 11.
The new quarry material placed in the sea had the advantage to be clean, environmentally friendly and to create a new habitat for fish recreation and marine life, as experienced in the nearby breakwaters built for Ras Abu Fontas A station.
The total quantity of quarry material used has been about 150.000 m^3.



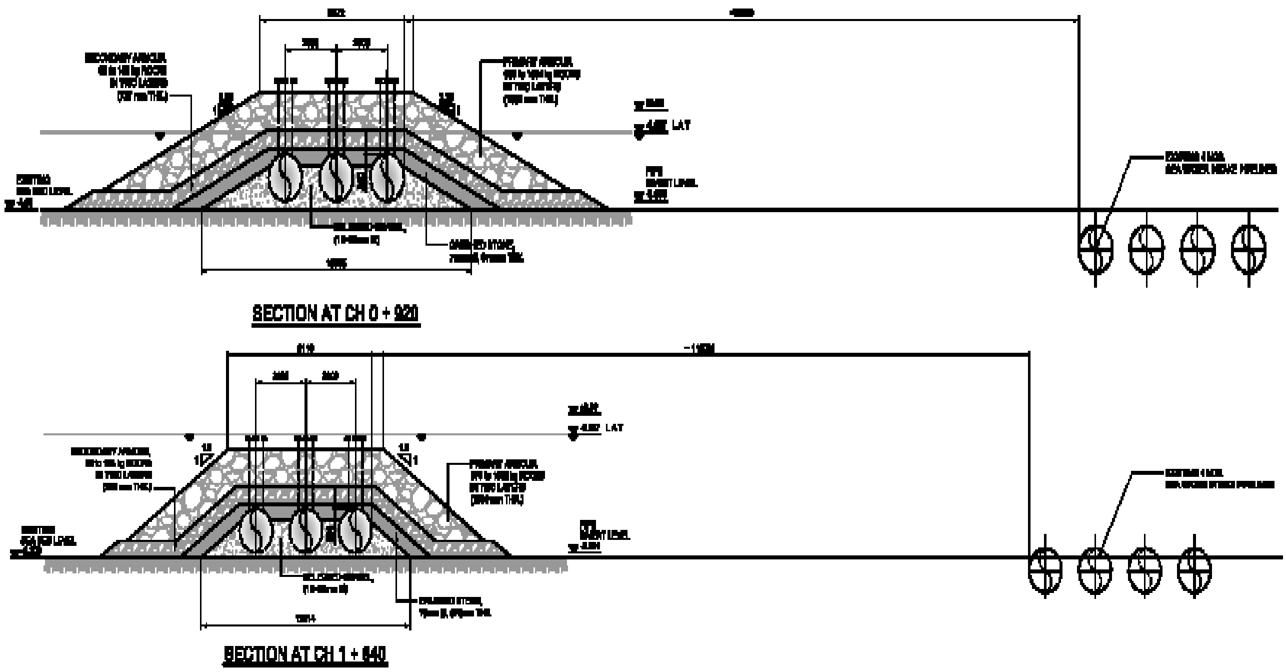


Figure 11: Raf B2 Intake - Longitudinal profile and main sections

The crown level of the armouring protecting the pipeline is out of the water for a length of about 1.000 meters (with tide at Mean Water Level +0.00m QND). This length obviously varies in accordance with the tidal movement.

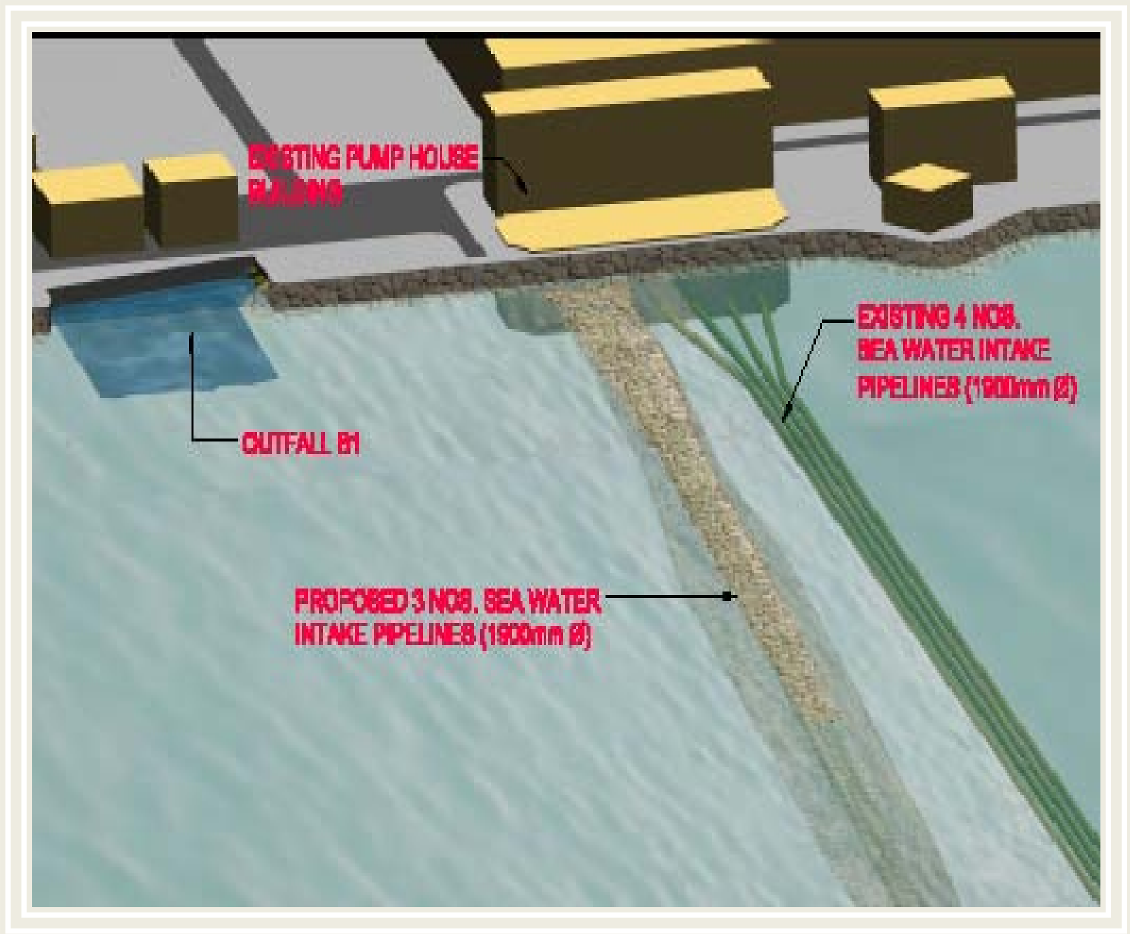


Figure 12: Raf B/B2 intake - area near pumphouse

It should be noted that a similar structure already exists in the area: the sea water intake for Raf A station, constituted by two breakwaters about 900 meters long, located 1000 meters northwards of Raf B/B2 site. Such breakwaters had been constructed more than 25 years ago using large armour stones, and actually are largely populated with fish and marine life.
As temporary works necessary to execute the Raf B2 pipelines works in the shallow area, Fisia Italimpianti has requested and realized the construction of a temporary causeway including a loading/unloading jetty. The causeway, starting from the shore, reached the depth of about -3.00 m QND, were a platform of about 10 by 20 meters has been constructed, for the safe anchoring of the marine equipment, the loading/unloading of the material used in the works and the transportation of the workers. Such temporary works, executed using quarry material and material coming from excavation, have been removed at the end of the construction and the area has been released in the same condition as it was originally. This type of installation and construction methodology was adopted in order to reduce as much as possible the risk of damages to the existing pipelines, and to execute the works in an environmentally friendly system.
During execution of the works, Fisia Italimpianti has strictly monitored that working equipment was operating in the respect of the environment and that any provision to prevent risk of spoiling, siltation and other alterations of existing condition in the area was adopted, also in strict compliance with the recommendations and suggestions observed by Supreme Council of Environment and Natural Reserves (SCENR).

Description of the air evacuation system adopted

Main constraints of the system were the followings:
- calculated evacuation flows has to be granted;
- pressure inside the intake pipes at invert section is about 0,5 barg;

- an air extraction system has to be positioned on top of pump house, in order to be protected against sea storms, as shown in figure 13. Therefore differential geodetic height is about 5 meters between air extraction system and invert section of intake pipes.

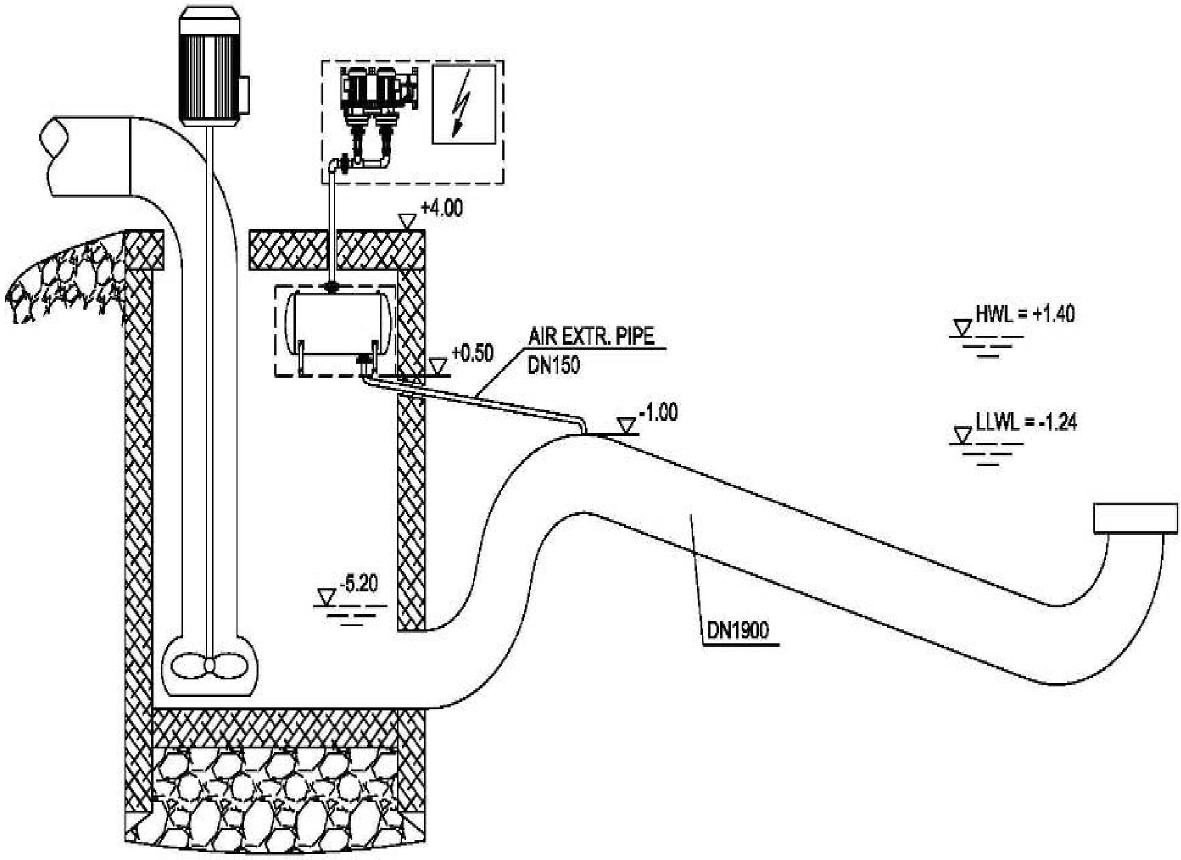


Figura 13: Air extraction scheme

Therefore it was envisaged that one vent pipe, about DN150, is fitted to each intake invert section and routed to the pump house where the air extraction is installed, which is a fully automatic vacuum unit designed for level-controlled, permanent evacuation of the three sea water Intake pipes: a vacuum pump creates the vacuum pressure necessary taking into consideration the levels of the sea water surface (in suction line). The scheme of the system is shown in figure 14.

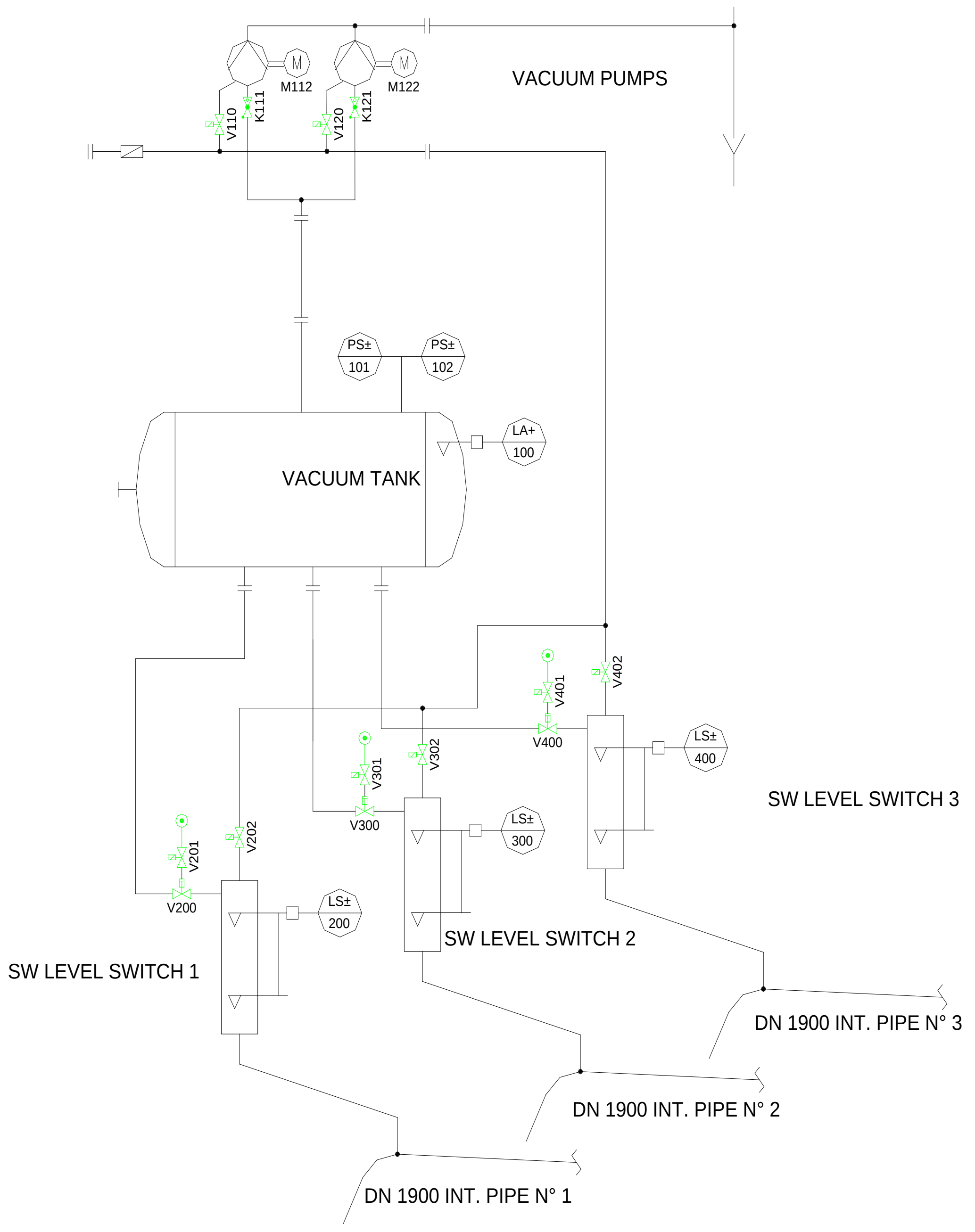


Figure 14: Air extraction schematic P&ID

During sew water intake pipes operation, the level inside the vacuum tank is controlled by means of two upper and lower level switches located mid-way between invert section and vacuum tank: when level decreases, the lower switch automatically operates a vacuum pump, instead when level increases upper switch stops vacuum pump.

The system includes the following:

- liquid ring vacuum pumps;
- vacuum tank;
- level switches;
- all necessary interconnecting piping, valves and control instrumentation.

In figure 15, a picture of vacuum tank and pump skid is shown.

Figure 15: Vacuum tank and pump skid

Raf A1 - Sea water intake system

A new sea water intake system had to be provided to feed the about 55,500 m3/h of sea water for the plant MSF units. The intake system was constituted of an off shore portion and an onshore new screening and pumping station, shown in figure 16, located just in front of the new desalination units.

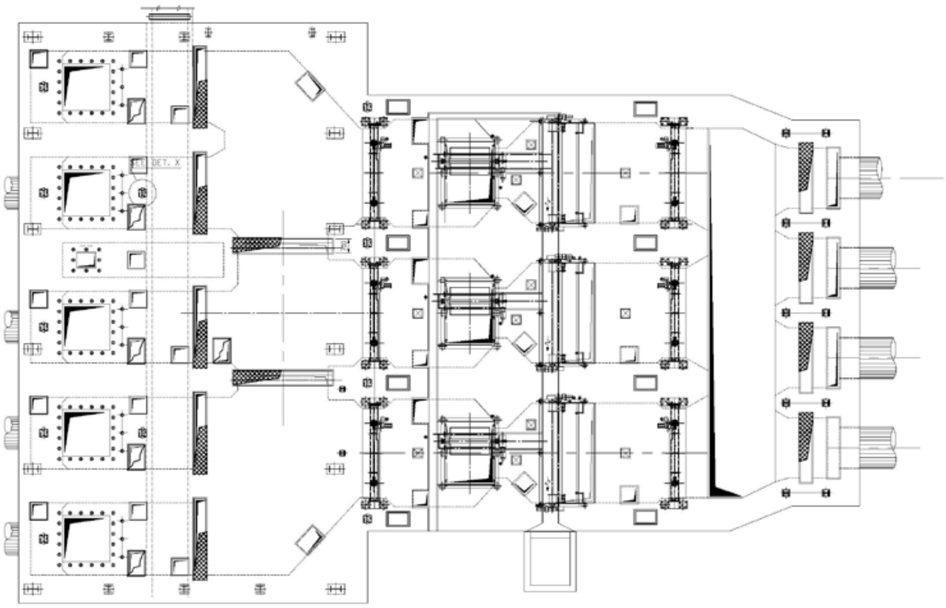
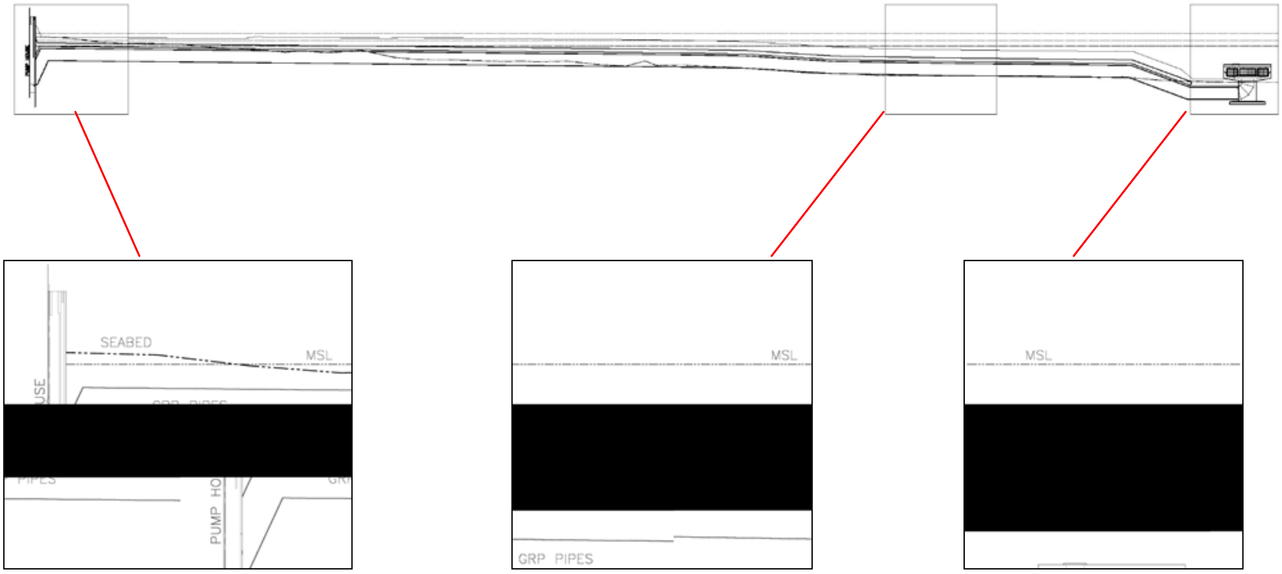


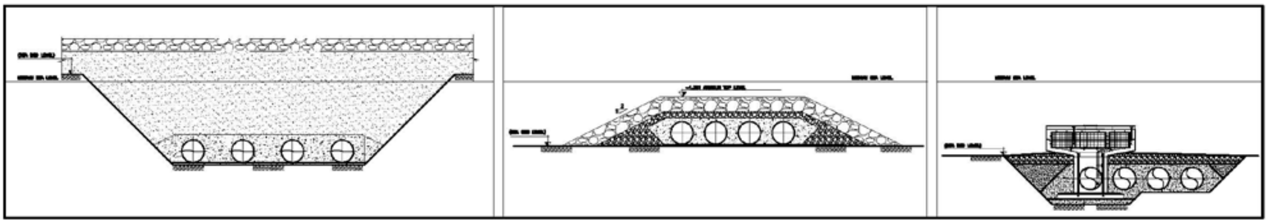
Figure 16: Raf A1 pump house

The offshore intake is constituted by four submerged pipelines of about ND 2000 which extend for about 2 km offshore into the sea to reach a suitable submergence.
For the Raf A1 station, the design assessments and verifications as well as their findings and results were very similar to the ones reported in the part of this paper relevant to Raf B2 station.
Process requirements (sea water flows), water depths and geotechnical characteristics of sea floor and marine baseline were very similar to the ones of the Raf B2 station.
Thermal plume modelling and related recirculation study was carried out and sea area admissible for the installation of risers were identified.

Based on all the above, locations of intake risers was identified and the routing of pipes was defined.



Section at landside – Buried pipe Middle section – Pipe above seabed Section at risers – Buried pipe



Section at landside – Buried pipe Middle section – Pipe above seabed Section at risers – Buried pipe

Figure 17: Raf A1 intake pipes profile and main sections

The intake pipelines have been located to the far north eastern corner of the Raf station. The pipes were protected by rock armouring throughout their length. The pipelines run approximately 500 m to the north and parallel to the existing Raf A intake structure. Intake pipelines are protected by armour stoned from waves, small boats anchoring, etc, and, for a distance of approximately 1850 m from shore, are above high water level, while are exposed over low tide level for 1600 m from shore. Sea water flows under gravity to the sea water intake structure at four corresponding intake heads. The pipes are mainly laid above the sea floor. Close to the pumping station and at intake risers, the pipeline are partially buried into the sea bed as shown in figure 17.
Some excavation was required at intake risers, pumping station and shallow area near the pumping station. A large excavator has been used for the pumping station and the tidal area near the same pumping station, whilst an excavator mounted on a barge has been used for the area near risers.
The incoming sea water was treated to prevent microbial growth in pipework and desalination plant equipment. This was achieved by continuously dosing the sea water in the intake pipework and at the sea water pumping station with chlorine.
Suitability of solutions adopted in terms of lay-out and characteristics had to be verified against process requirements throughout a detailed hydraulic study which demonstrated their suitability.
An air extraction system was installed for permanent evacuation of the invert sections of the intake pipes.

Raf A1 environmental Impact Assessment Process – marine aspects

Raf A1 EPC contract included in Fisia scope the preparation of the Environmental Impact Assessment Report (EIA) which is a procedure for identifying and assessing negative and positive impacts of a new project on the environment, society and the economy to minimize the negative and enhance the positive ones. A scheme of the various aspects considered and of their potential impact on the environment is shown in figure 18.

The assessment of cooling water discharge impact on the marine ecology covers both thermal load and physical-chemical water quality. The marine assessment considers impacts to ecology along pipeline route.

The EIA study identifies discharges to the marine environment and conduct a marine baseline study to establish condition and status of local marine ecology and water quality.

Based on the information presented in the baseline conditions section above and the findings of the marine survey it was concluded that both the marine and intertidal environments, with some exception, has limited habitats vulnerable to impact from the Raf A1 plant.

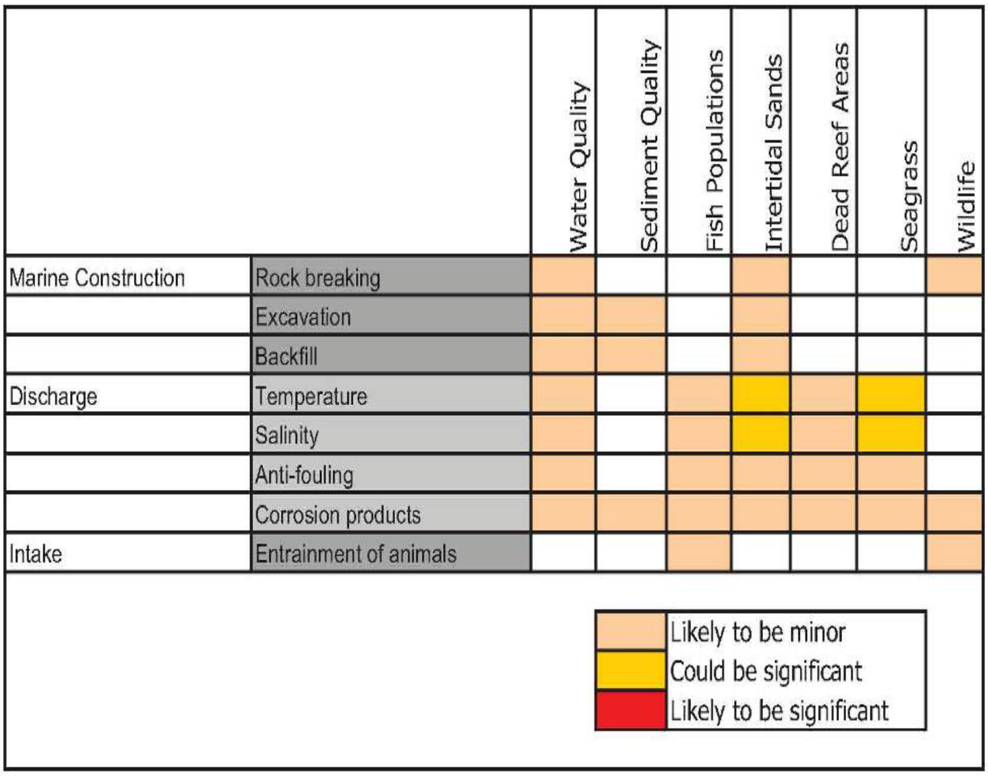


Figure 18: Potential impacts associated with Raf A1 plant

Construction Environmental Management Plan

Construction impacts were an integral part of Raf A1 project and thus needed to be assessed, planned and managed appropriately in order to ensure that potential adverse environmental impacts were negated or minimized. One of the outcome of the EIA is the environmental management and monitoring plan which had the purpose to provide both compliance with relevant legislation and realization of the conclusions reached by the EIA.

Conclusions

The definition of the design and construction of sea water intakes for large desalination plants requires a heavy and time consuming effort of coordination where many different disciplines are involved having often different perspectives and opposite targets conflicting one against the other.

Stringent environmental, legal, process, mechanical, civil, operational and safety issues have to be solved. Short delivery terms and the fact that the construction of the intake system is always in the critical path, are a further cause of criticality.
A sea water intake will be effective and good whether a delicate compromise between environmental ecology, acceptable costs and construction time is reached.

The development of Ras Abu Fontas B2 and A1 intakes involved the evaluation of the existing marine baseline conditions and the related constraints on the intake configurations.
Environmental, civil, process, mechanical and operational disciplines were involved carrying out a common analysis and confrontation on the above which resulted in the definition of the solutions adopted such us pipes lay-out and installation method, with pipes mainly laid on sea bed and not buried.
The idea to lay the pipes on the sea bed permitted to avoid mine blasting and minimizing dredging and therefore was a key factor since allowed simpler and faster construction activities and a minimization of environmental impacts related to the construction activities even if forced to install an air evacuation system of new conception.
Special consideration has also to be given to the process to obtain the environmental clearance from the Qatari Authorities whose enforcements were mandatory and had to be properly taken into consideration during the project development.
The development of the Ras Abu Fontas B2 and A1 intake system is a successful example of the achievement of the proper compromise among the complicated aspects of this peculiar part of a desalination plant taking into consideration the multi-disciplinary constraints.