INTRODUCING PUMPED STORAGE IN LEBANON:

TOWARDS A PROSPECTIVE NATIONAL MASTER PLAN

by

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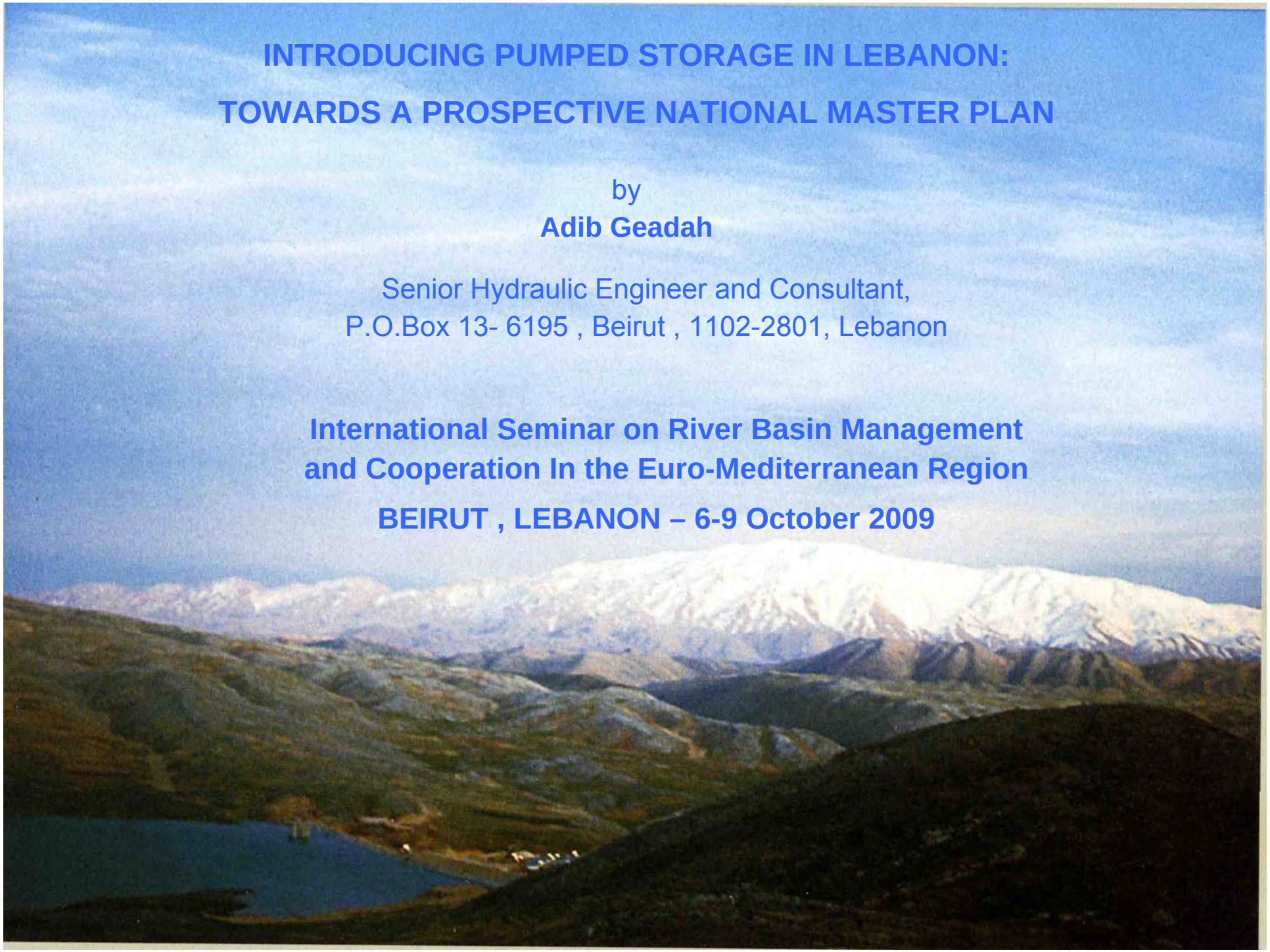
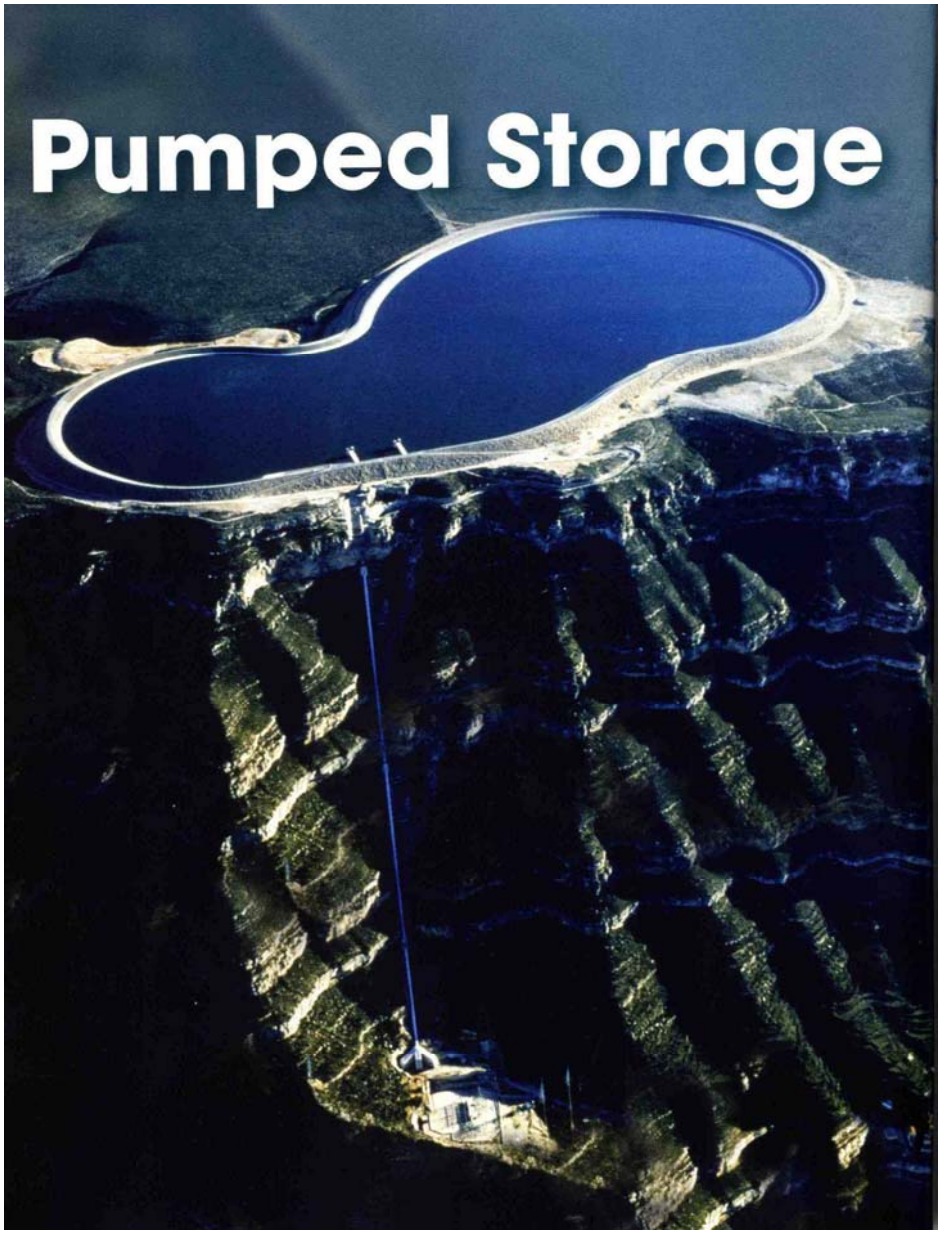
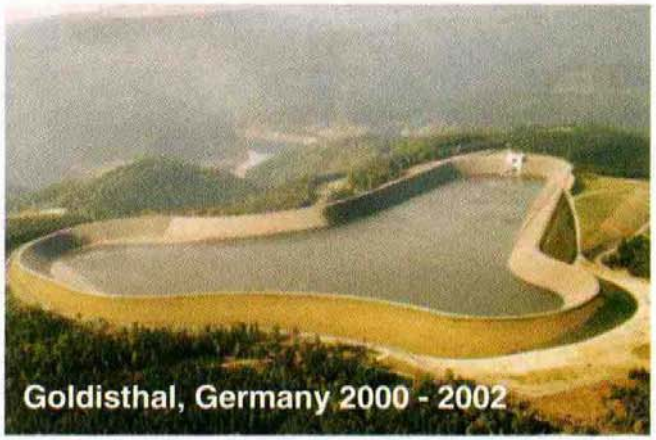


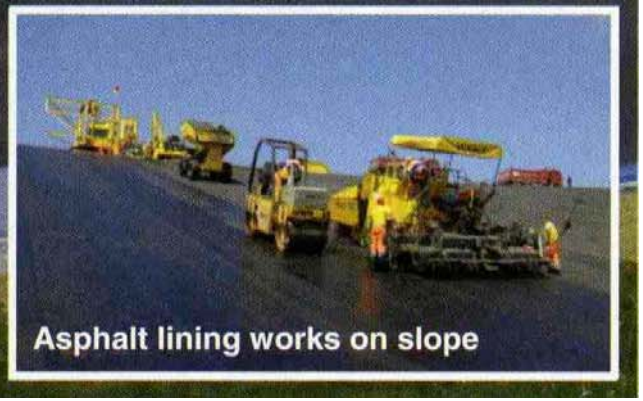
TYPICAL PUMPED – STORAGE SCHEME


Pumped Storage



Bituminous Lining Systems - Pump Storage Schemes

Avče, Slovenia 2008



ENERGY SECURITY CHALLENGE : NEED FOR A GLOBAL RESPONSE

- THE FINANCIAL CRISIS HITS THE GREEN SOLUTIONS (E.G.PUMPED – STORAGE)
- THE VOLATILITY IN OIL PRICES IS CREATING GREAT UNCERTAINITY
- IN AN ECONOMIC DOWNTURN , CAPITAL IS DIRECTED TO PROJECTS THAT ARE SEEN AS HIGHER PRIORITY THAN GREEN ENERGY
- THE DOWNTIME COULD OFFER OPPORTUNITY FOR LOOKING AT WHAT WE NEED GOING FORWARD VIA INNOVATION
- THE PUBLIC AND PRIVATE SECTOR SHOULD WORK TOGETHER AND THERE IS NEEDS TO BE MORE DIRECTION AT THE NATIONAL AND GLOBAL LEVEL
- ENERGY SECURITY BY:
  - ENSURING THAT SUPPLIES AND INFRASTRUCTURE ARE RESENT NOW ,
  - PROVIDING ENOUGH POWER GOWING FORWARD AS DEMAND FOR ENERGY INCREASES,
- A GLOBALLY CO-ORDINATED RESPONSE IS THE ONLY WAY TO TACKLE THIS GLOBAL PROBLEM.THE CHALLENGE IS:

  NATION - WIDE WATER RESOURCES MANAGEMENT

  V/S RIVER BASIN MANAGEMENT.

WHY PUMPED STORAGE FOR LEBANON?

- A CLEAN RENEWABLE ENERGY POTENTIAL WHOSE TIME HAS COME NOW
- A SPECIAL CLASS OF HYDROELECTRIC FACILITIES , THE VALUE OF WHICH IS BEING RECOGNISED WORLD WIDE
- WELL- PROVEN , COST- EFFECTIVE AND UP-TO-DATE TECHNOLOGY
- PUMPED – STORAGE PLANTS ARE THE “RACE CARS” AMONG POWER GENERATION FACILITIES : DYNAMIC AND RAPID REPONSE CAPABILITIES FOR KEEPING THE ELECTRICAL GRID STABLE AND RELIABLE
- ENERGY TRADING BY PUMPING IN OFF-PEAK HOURS , USING LOW- TARIFF THERMAL ENERGY , AND GENERATING IN PEAK TIMES WITH GOLDEN HIGH-TARIFF (VALUE –ADDED)
- BETTER ACCOMMODATION OF INTERMITTENT POWER SOURCES : ABILITY TO RAMP UP OR DOWN HUNDREDS OF MW’S IN SECONDS
- PROVISION OF PEAKING POWER AT COMPETITIVE COST AND IMPROVED EFFICIENCY
- IMPROVEMENT OF TRANSMISSION GRID STABILITY AND FLEXIBILITY , INCLUDING MODULATING GRID FREQUENCY AND PHASE
- PROVIDING EMERGENCY RESERVES (STAND – BY HOT RESERVE GENERATING FACILITY).

PUMPED STORAGE AS THE BEST OPTION FOR SUPPORTING OTHER RENEWABLE ENERGY SOURCES

COMPARAISON OF THE REGULATION CAPACITY OF SEVERAL ELECTRICITY GENERATION TECHNOLOGIES

Type of Electricity Generation / Regulation Capacity Criteria	Conventional Hydro	Pumped Storage
Start –up and Shut-Down Capacity	- The most flexible without a significant detrimental effect on the equipment's service life - Limitation due to its connection to the hydraulic management of rivers.	Same characteristics as conventional hydro . Their operation is not limited by exploitation of the basin in which they are located . Their power is always available even during dry periods
Regulation Velocity (in % of load per minute)	High (100%)	After conventional hydro , the best choice to firm the variability of renewable energy sources
Technical Minimum Load (in % of Maximum Load)	Low (<10%) regulation capacity >90% of rated power	Power from pumped storage is available without the restrictions inherent in conventional hydro.
Fuel Cost	Zero	Disadvantage : cost of pumping = price of the electricity divided by the efficiency of the cycle (~75%)

COMPARISON OF THE REGULTION CAPACITY OF SEVERAL ELECTRICITY GENERATION TECHNOLOGIES

(Continued)

Type of Electricity / Generation Regulation Capacity Criteria	Conventional Thermal	Open Cycle Gas	Combined Cycle
Start –up and Shut-Down Capacity	Limited (substantial amount of energy , substantial cost, reduction of the service life of the plant)	Significant flexibility for continuous start ups and shutdowns	Flexibility in- between conventional thermal and open cycle gas (more robust than conventional thermal to perform continuous start ups and shut downs)
Regulation Velocity (in % of load per minute)	Limited (high thermal inertia) (1%)	Relatively rapid power variations (4%)	Slightly lower than open cycle turbines (higher thermal inertia) (2.5%)
Technical Minimum Load (in % of Maximum Load)	Acceptable (45%) regulation capacity < 55% of rated power	Limited (60%) regulation capacity < 40% of rated Power	Medium (50%) regulation capacity < 50% of rated power
Fuel Cost	Substantial	High (>40% than combined cycle)	Moderate variable cost

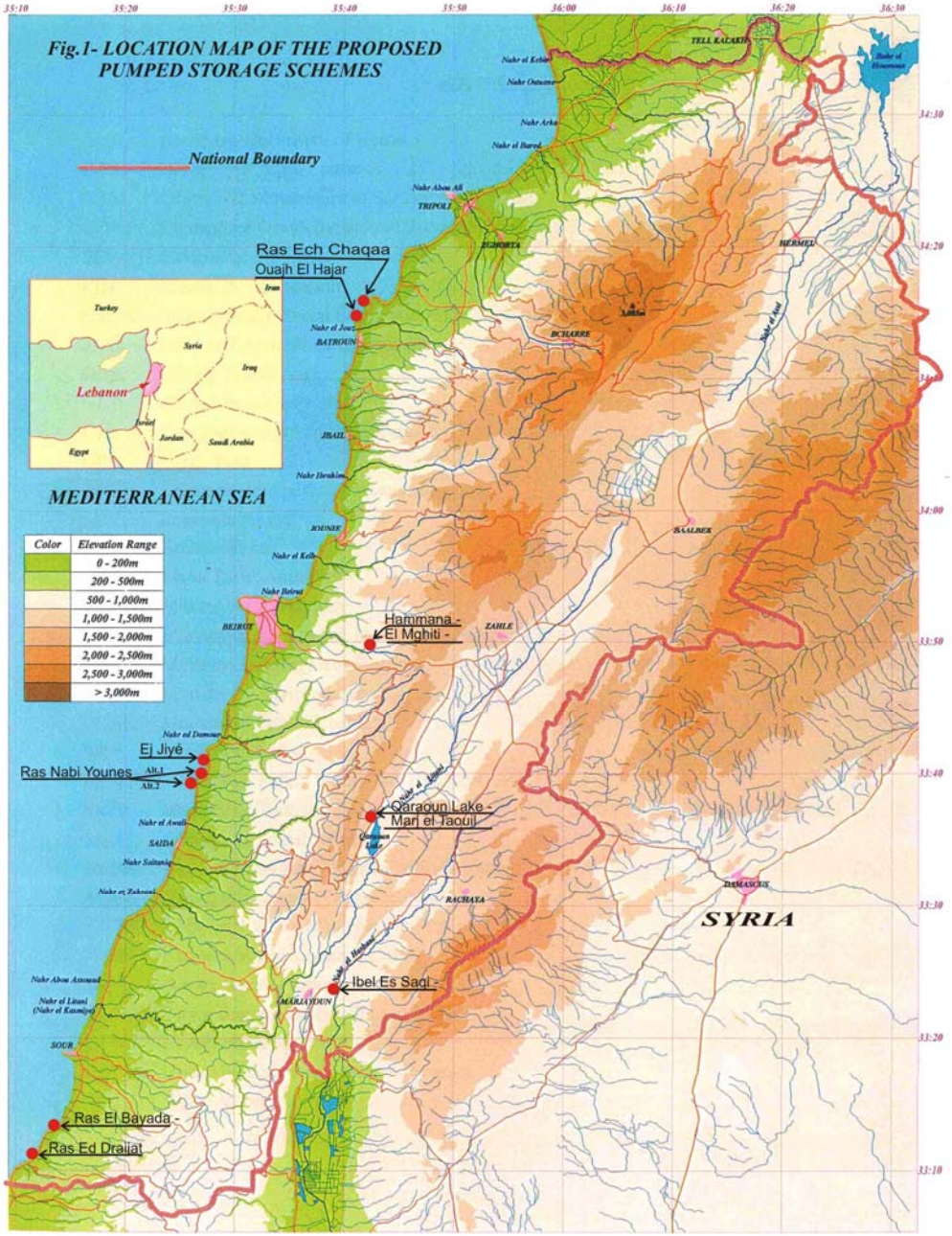


Fig.1- LOCATION MAP OF THE PROPOSED PUMPED STORAGE SCHEMES
National Boundary
Ras Ech Chaqaa
Ouajh El Hajar
Hammana - El Mghiti -
Ej Jiyé
Ras Nabi Younes
Qaraoun Lake - Marj el Taouil
Ibel Es Saqi -
Ras El Bayada -
Ras Ed Drailiat
MEDITERRANEAN SEA
SYRIA
Lebanon
Turkey
Syria
Iraq
Iran
Jordan
Israel
Egypt
Saudi Arabia
Color
Elevation Range
0 - 200m
200 - 500m
500 - 1,000m
1,000 - 1,500m
1,500 - 2,000m
2,000 - 2,500m
2,500 - 3,000m
> 3,000m
TELL KALAKH
TRIPOLI
ZGHORTA
HERMEL
BCHARRE
BATROUN
JBAIL
BEIRUT
ZAHLE
BAALBEK
SAIDA
RACHAYA
DAMASCUS
MARJAYOUN
SOUR

OVER VIEW OF THE SURFACE WATER RESOURCES IN LEBANON

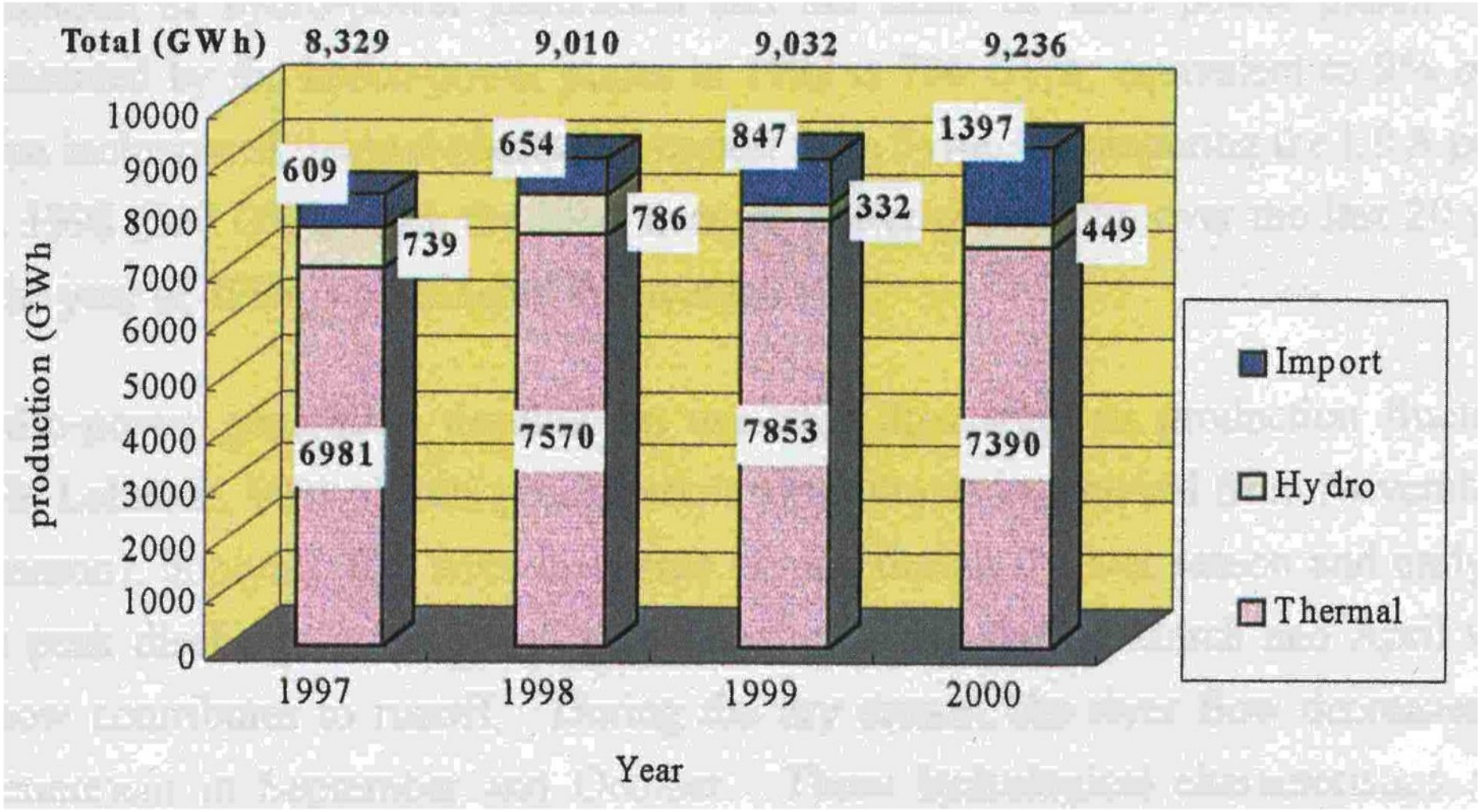
- Typically Mountain's Country Along the Mediterranean Sea (10,452 km2)
- Considerable Spatial Diversity in Terms of:
  - Topography (0-3,090 m a.s.l)
  - Rainfall (200-1,300 mm/year/region)
  - Patterns of Land Use
- 17 Major Perennial Rivers
- Remarkable Seasonality in Rainfall (only 80 rainfall days / year)

  Resulting in a Significant Stress on Available Surface water Resources
- Total Average Annual Runoff : 3,094 Million m3
- Surface Water Development Potential:
  - by Direct Intake from Rivers : 11.3%
  - by Storage Facilities by Dams and Hill Lakes : 87.7%
  - TOTAL : 862 MCM/ Year

EXISTING POWER GENERATION PLANTS IN LEBANON

TYPE	COMPANY/ STATUS	RIVER/ TURBINES	PLANT NUMBER (N)	NOMINAL CAPACITY (MW)
HYDRO-POWER	EDL/ Semi-Public	DAMOUR	1	13.2
	KADISHA / Semi-Public	ABOU ALI	4	21.3
	LRA / Semi-Public	LITANI/AOUALI	3	190.0
	NAHR EL BARED/ Private	EL BARED	2	17.2
	SPHE / Private	IBRAHIM	3	30.1
		TOTAL	13	271.8
THERMAL-POWER	EDL/ Semi-Public	FUEL STEAM GAS COMBINED CYCLE	3 1 2 2	997.7 65.0 140.0 870.0
		TOTAL	8	2,072.7
		GRAND TOTAL	21	2,344.5

Fig 2 - Recent Repartition of the Annual Production and Import of Energy in Lebanon



PRESENT PUBLIC ELECTRICITY TARIFFS IN LEBANON AND ASSUMED PUMPED – STORAGE COSTS

- PRESENT EDL TARIFFS (Base Rate Excluding Vat and Taxes)
  - RESIDENTIAL : 35-200 LBP/KWH Ξ 2.3 –13.3 USÇent/KWH
  - SMALL INDUSTRY : 115 LBP/KWH Ξ 7.7 USÇent/KWH
  - AGRICULTURE : 115 LBP/KWH Ξ 7.7 USÇent/KWH
  - PUBLIC FACILITY : 140 LBP/KWH Ξ 9.3 USÇent/KWH
  -
- ASSUMED PUMPED – STORAGE COSTS (Base Rate Excluding Vat and Taxes)
  - OFF – PEAK PUMPING : 75 LBP/ KWH Ξ 5.0 USÇent/KWH
  - PEAK GENERATING : 200 LBP/ KWH Ξ 13.3 USÇent/KWH

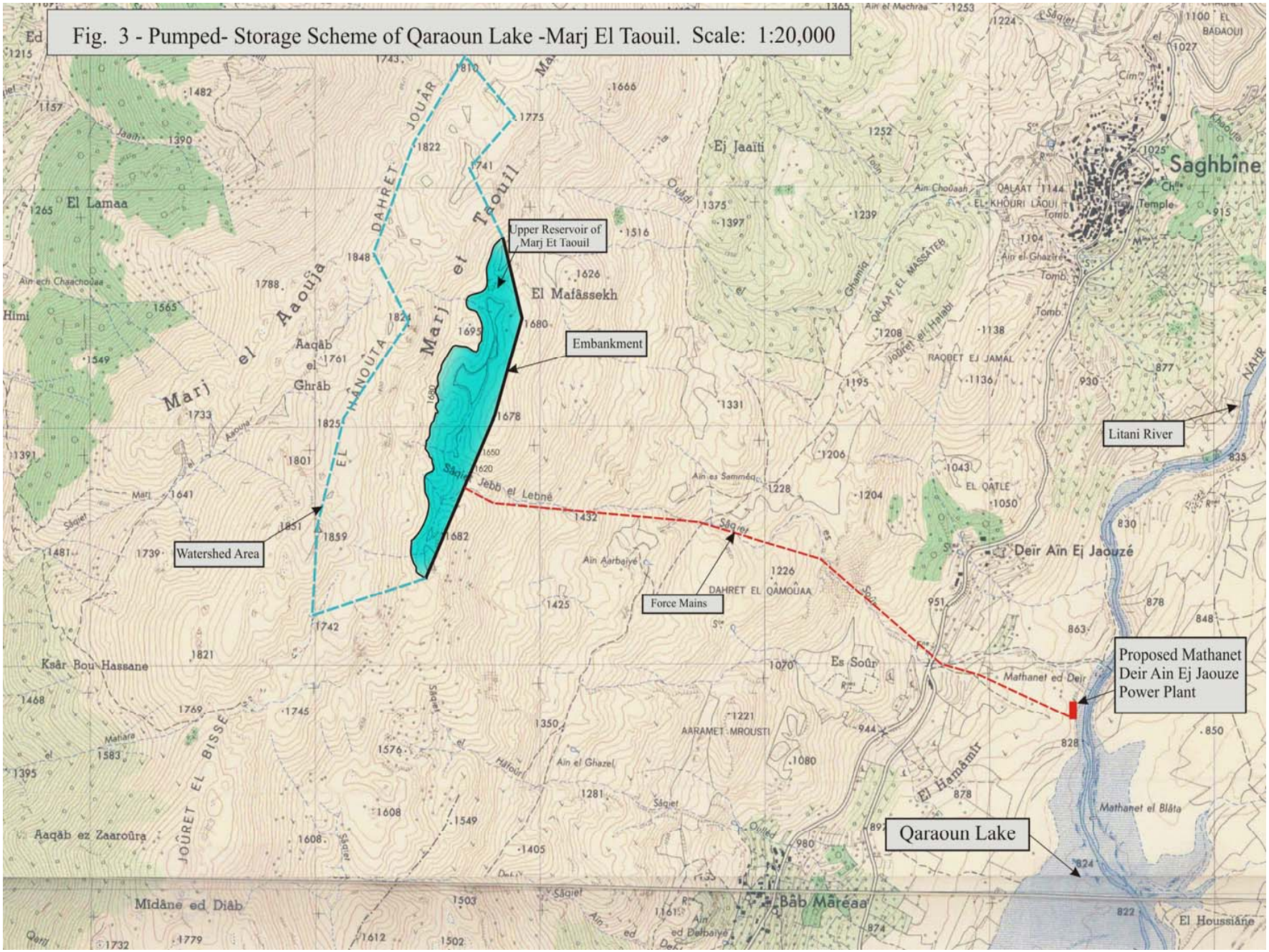


Fig. 3 - Pumped- Storage Scheme of Qaraoun Lake -Marj El Taouil. Scale: 1:20,000
Upper Reservoir of Marj Et Taouil
Embankment
Watershed Area
Force Mains
Litani River
Proposed Mathanet Deir Ain Ej Jaouze Power Plant
Qaraoun Lake
El Mafâssekh
Ej Jaaïti
Saghbîne
Deïr Aïn Ej Jaouzé
Es Soûr
Bâb Mâréaa
El Houssiâne
Mathanet el Blâta
Mathanet ed Deir
Jebb el Lebné
DAHRET EL QAMOUAA
JOUÂR
DAHRET
Marj et Taouil
Marj el Aaouja
EL HÂNOUTA
JOÛRET EL BISSE
Aaqâb ez Zaaroûra
Midâne ed Diâb
Ksâr Bou Hassane
El Lamaa
Aaqâb el Ghrâb
Ain es Samméq
Ain Aarbaïye
Ain el Ghazel
AARAMET MROUSTI
EL QATLE
QALAAT EL MASSÂTEB
RAQBET EJ JAMAL
EL KHOURI LAOUI
Ain Choûaah
Ain el Ghazire
Ain ech Chaachoûaa
Himi
Marj
Jaaïti
Ghamiq
Oulâd
Halâoûi
Qalâa
Temple
Tomb.
Litani
Saqiet

TYPICAL PUMPED STORAGE SCHEME OF QARAOUN LAKE-MARJ ET TAOUIL
PROJECT FEATURES

HYDROLOGY AND RESERVOIRS DATA

	Upper Reservoir	Lower Reservoir
Catchment's Area (km^2)	1.13	1,545
Reservoir Max surface Area (km^2)	0.26	12.6
High Water Level (m a.s.l.)	1678	862
Average Water Level (m a.s.l.)	1655	835
Low Water Level (m a.s.l.)	1630	820
Dam Height (m)	50	63
Effective Depth (m)	48	42
Gross Storage (10^6 m^3)	1.6	220
Active Storage (10^6 m^3)	1.4	160
Average River Discharge (m^3/s)	( )	9.34

PLANT DATA

Installed Capacity (MW)
- -Pumping Mode : 560
- -Generating Mode : 388

Max.Pumping Discharge (m^3/s) : 48

Max.Generating Discharge (m^3/s) : 64

Force Mains:

4*DN 2,200mm (ml) : 2,940

Steel , PN 80-60-40 bars

Rated Net Head (m):
- -Pumping Mode : 838
- -Generating Mode : 776

N° of Units (N) : 4

Reversible Pump-Turbines,

FRANCIS , 2- Stages

TYPICAL PUMPED STORAGE OF QARAOUN LAKE- MARJ ET TAOUIL
BASE DEVELOPMENT COST AND OPERATION INDICATORS

BASE DEVELOPMENT COST (MILLION USD)	
Upper Reservoir	: 16
Acess Roads	: 5
Force Mains	: 33
Head Race , Tail Race, Shafts' Structures and Water Hammer Protection	: 15
HPP	: 446
Hv Transmission Lines and Transformers' Stations	: 18
Expropriations and Rights-Of- way	: 4
Full Engineering Services	: 28
TOTAL	565

OPERATION INDICATORS	
Daily Max : Off-Peak Pumping Hours	: 8
Daily Max : Peak Generating Hours	: 6
Average Annual Operation Days	: 300
Annual Pumping Consumption (GWH)	:1,334
Annual Generation Production (GWH)	: 713
Annual Pumping Cost (Million USD)	: 67
Annual Generation Sales (Million USD)	: 95
Annual Gross Profit (Million USD)	: 28
Capital Cost Recovery Period/ Estimated Pay Back Period (year)	: 20

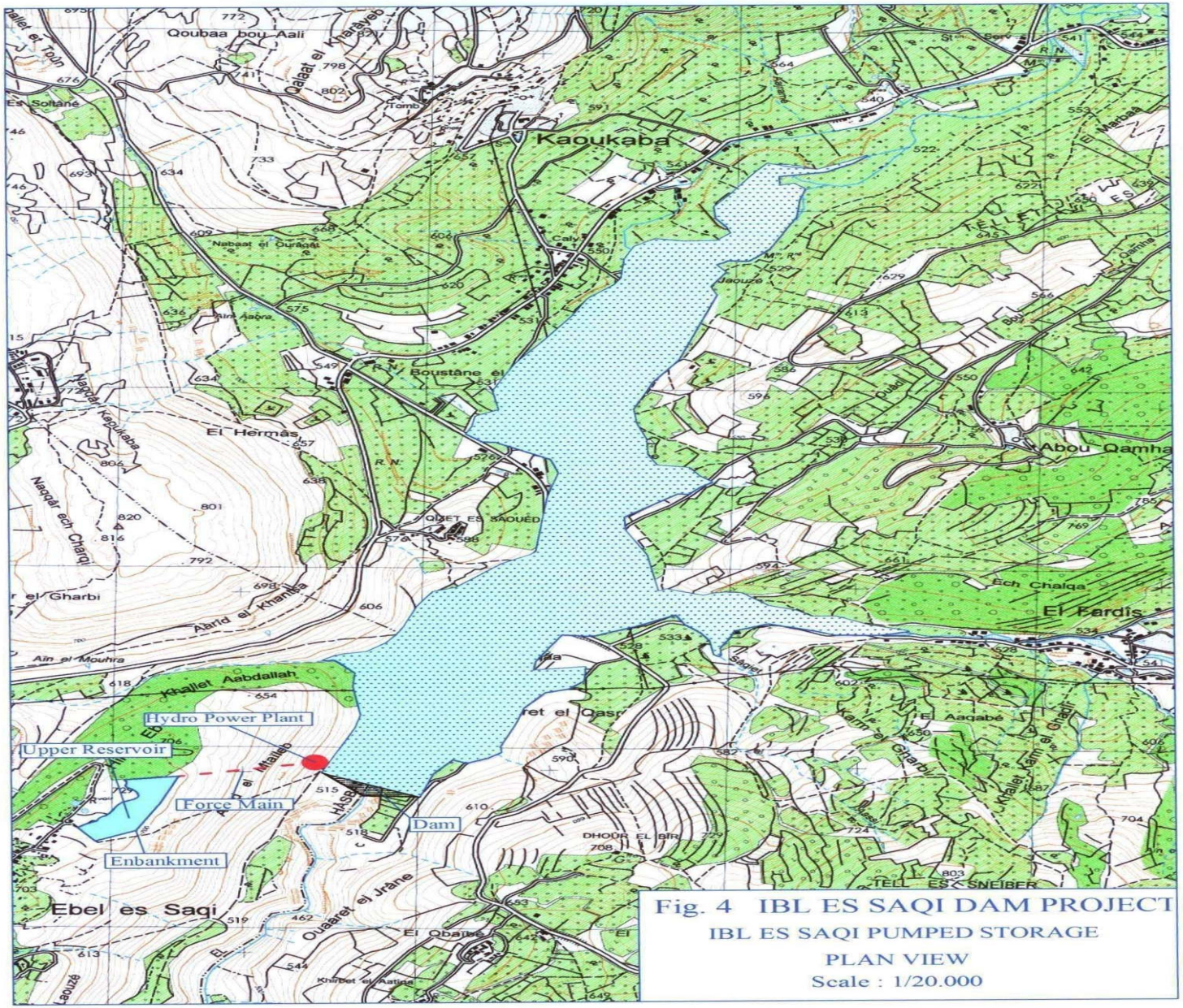


Fig. 4 IBL ES SAQI DAM PROJECT

IBL ES SAQI PUMPED STORAGE

PLAN VIEW

Scale : 1/20.000

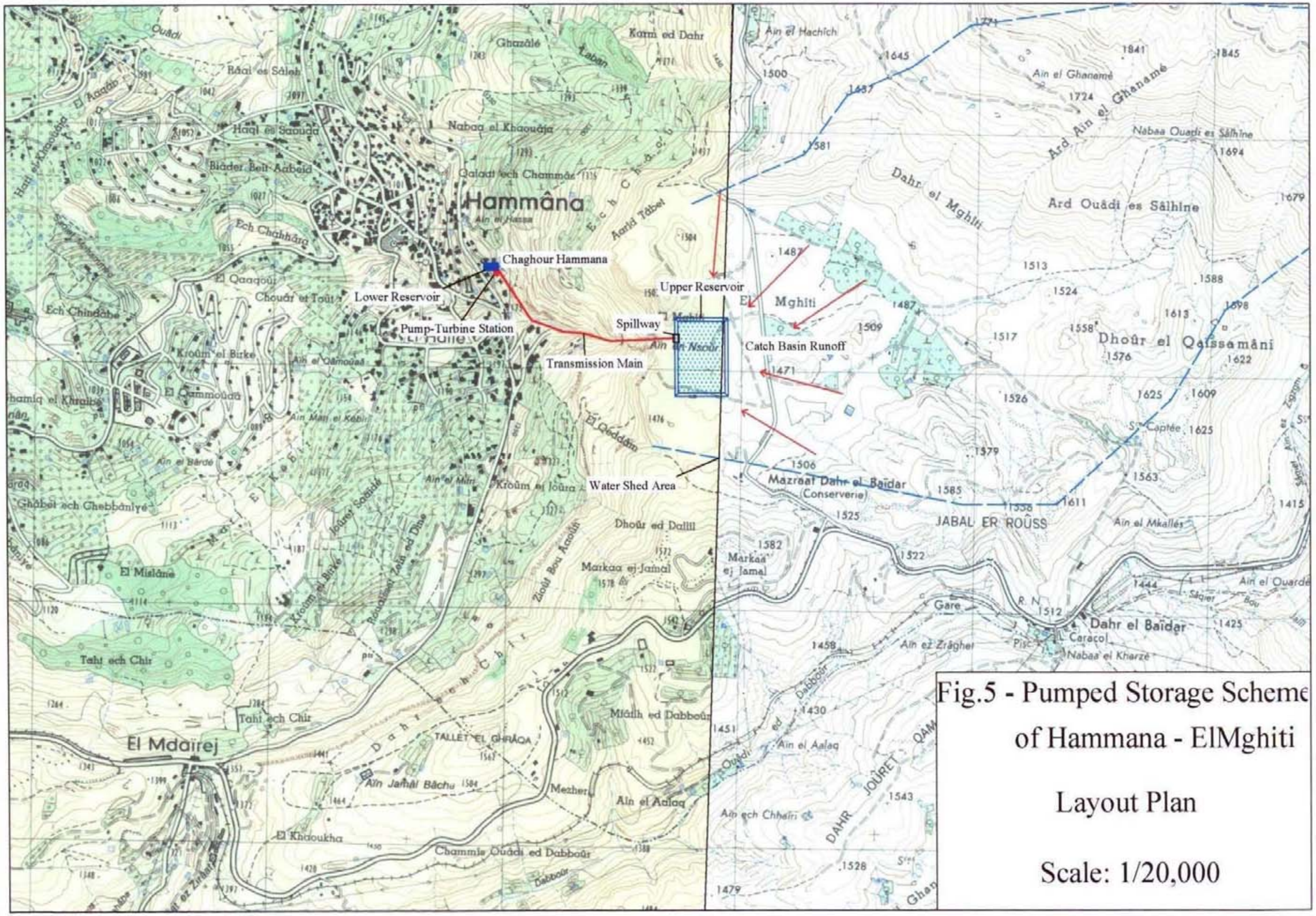


Fig.5 - Pumped Storage Scheme of Hammana - ElMghiti

Layout Plan

Scale: 1/20,000

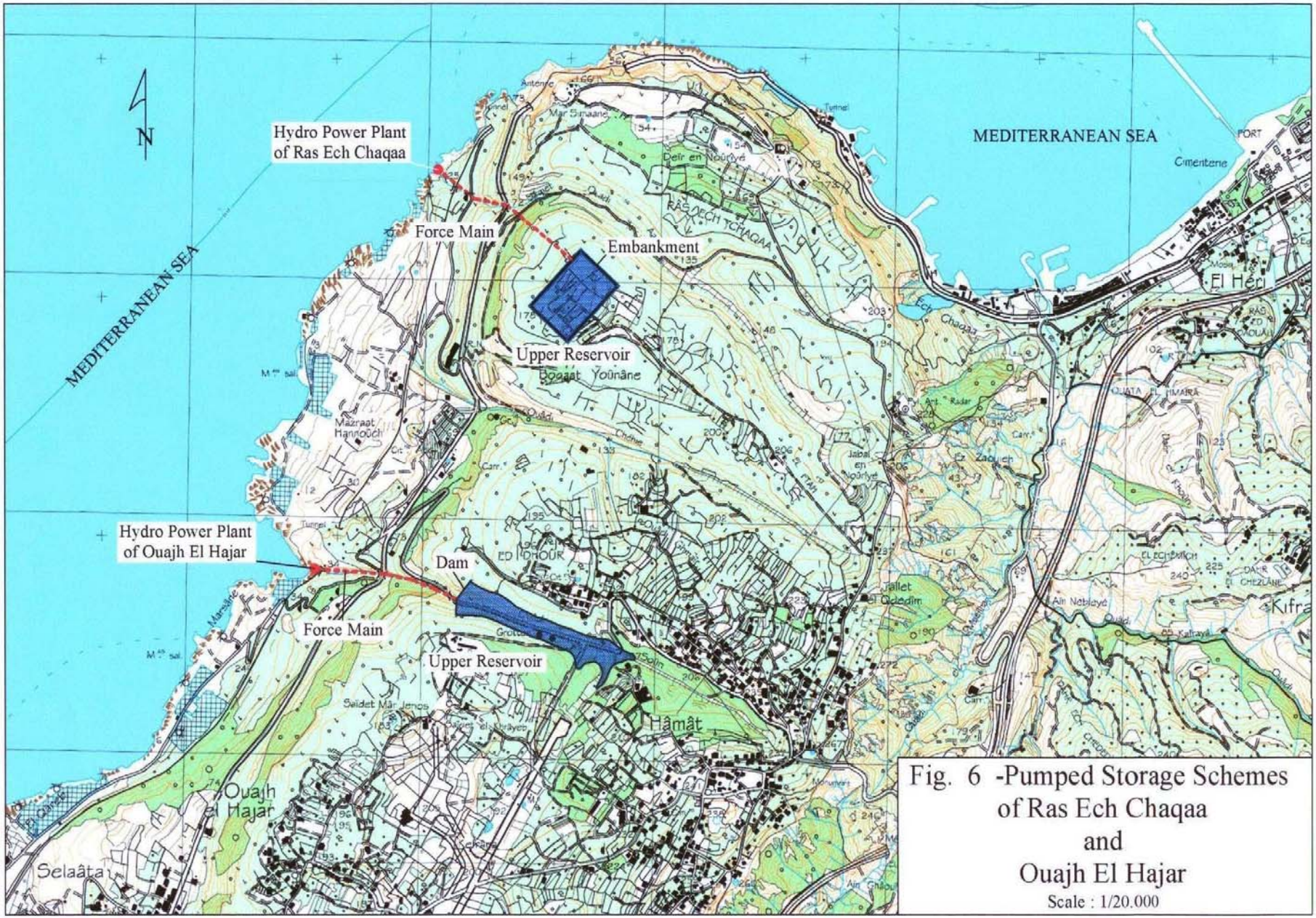


Fig. 6 -Pumped Storage Schemes
of Ras Ech Chaqaa
and
Ouajh El Hajar
Scale : 1/20.000

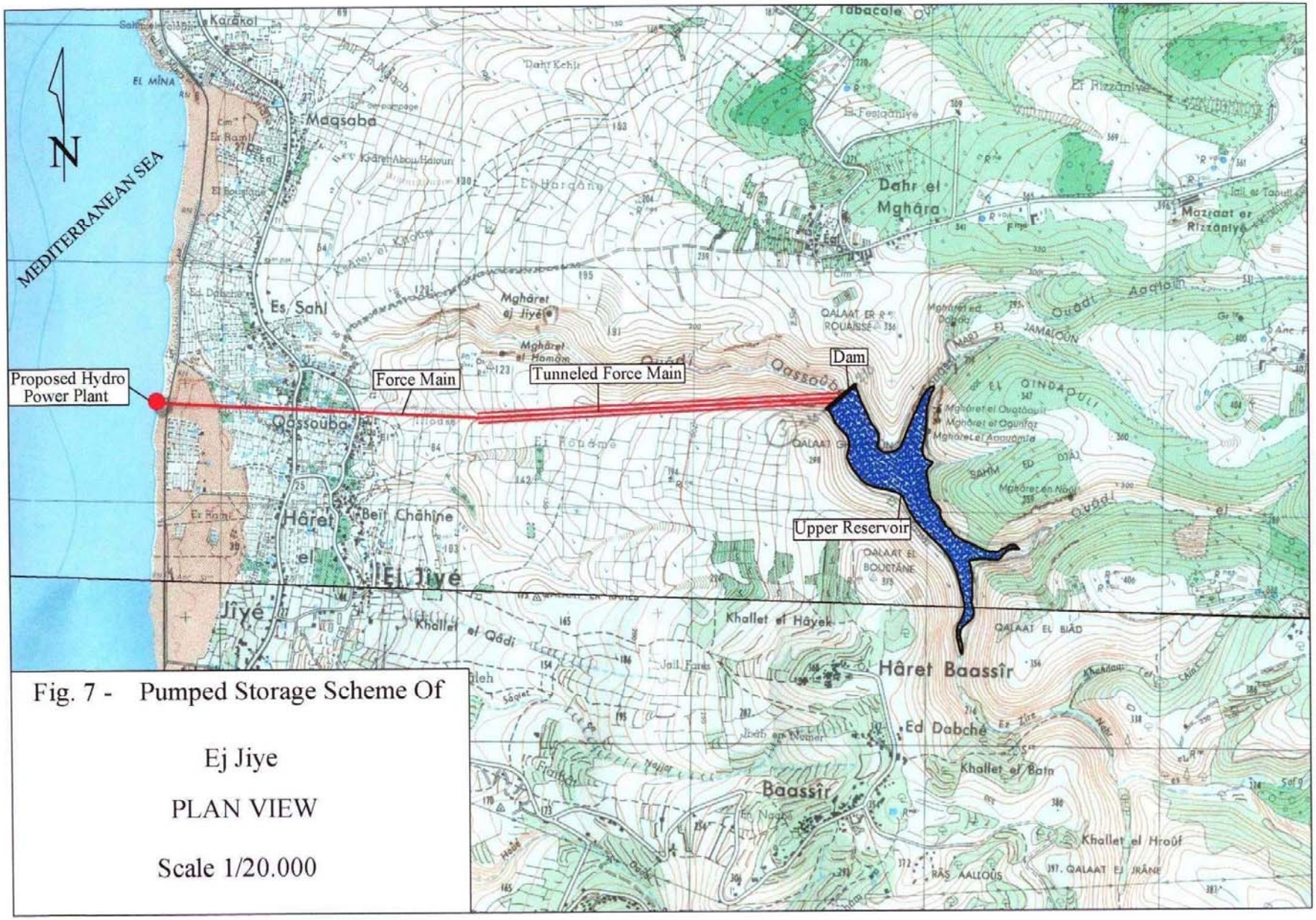


Fig. 7 - Pumped Storage Scheme Of

Ej Jiye

PLAN VIEW

Scale 1/20.000

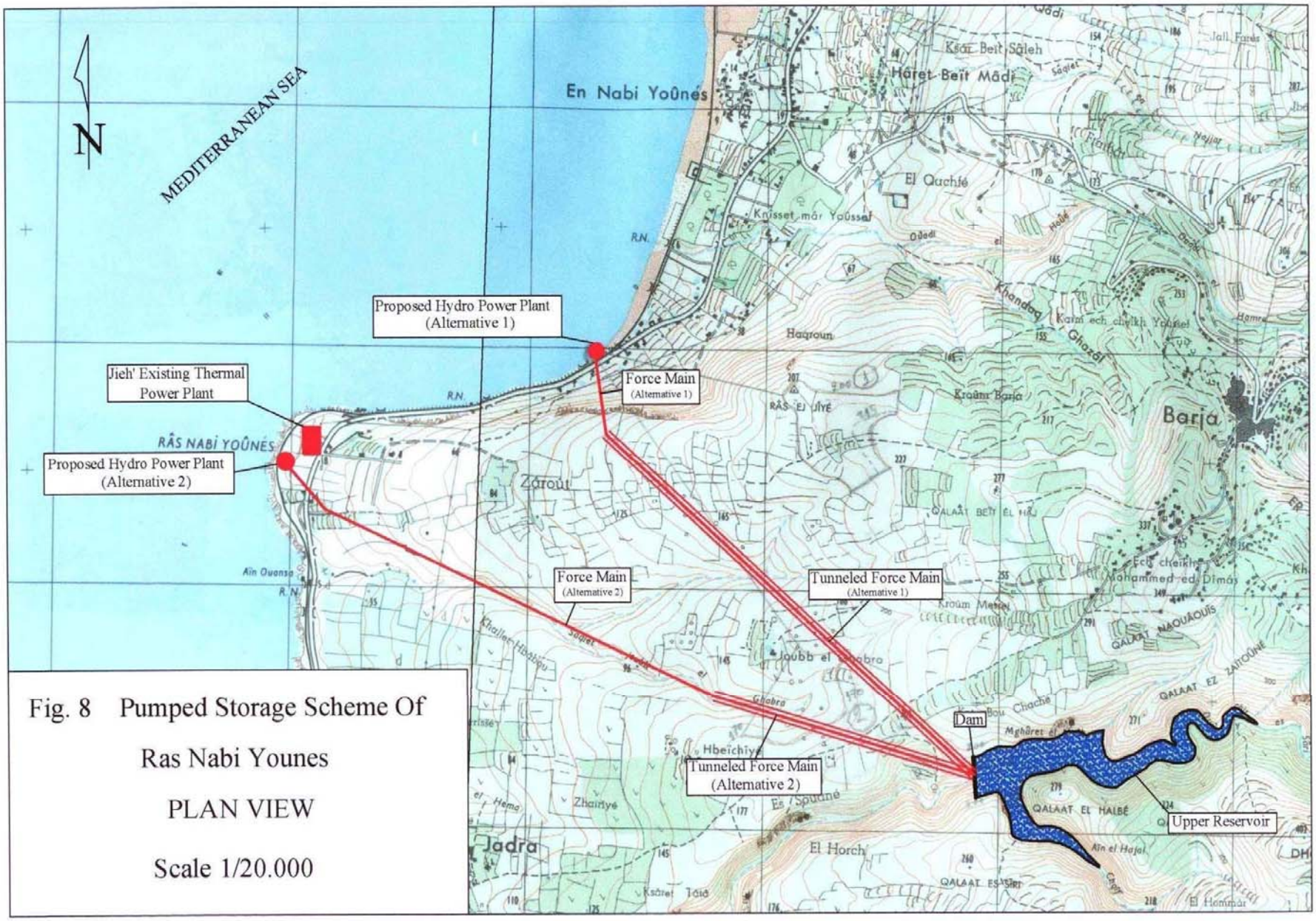


Fig. 8 Pumped Storage Scheme Of

Ras Nabi Younes

PLAN VIEW

Scale 1/20.000

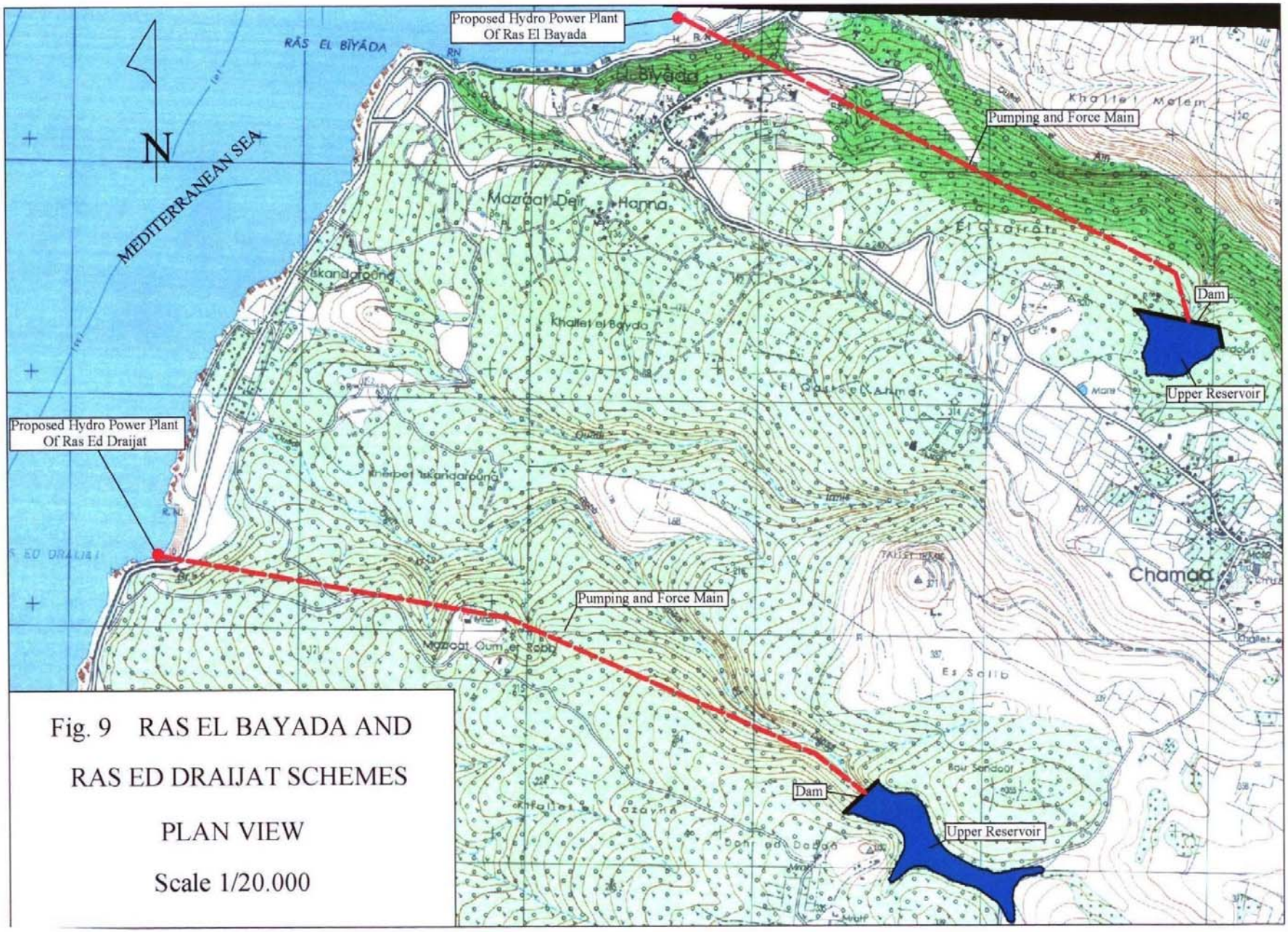


Fig. 9 RAS EL BAYADA AND RAS ED DRAIJAT SCHEMES

PLAN VIEW

Scale 1/20.000

LEBANON'S PUMPED STORAGE MASTER PLAN
DATA OF IDENTIFIED TYPICAL POTENTIAL PROJECTS

Category/Type	Project		Generating Capacity (MW)	Expected Annual Peak Generation (GWH)	Base Investment Cost (Million USD)	Estimated Pay Back Period (Year)	Rank
I-Inland / Qaraoun Lake / Litani River	Qaraoun Lake– Marj Et Taouil		388	713	565	20	2
II-Inland / River Basin Dam	Hasbani River- Ibl Es Saqi Dam		21	37	34	31	4
III-Inland/ Perennial Spring – Hill Lake	Hammana- El Mghiti		12	9	31	35	5
IV- Sea Shore / Coastal Cliffs	Ras Ech Chaqaa		30	54	50	37	5
	Ouajh El Hajar		33	60	52	16	1
	Ej Jiye		225	405	344	16	1
	Ras Nabi Younes	Alt.1*	234	421	348	18	1
		Alt.2	221	398	351	23	3
	Ras El Bayada		90	163	135	18	1
	Ras Ed Draijat		140	252	219	20	2
TOTAL			1,173	2,114	1,778	16-37	( )

*** Proposed**

PROSPECTIVE MASTER PLAN OF PUMPED STORAGE

	PERIOD 2010-2015	PERIOD 2016-2022	TOTAL
TARGET CAPACITY IN THEGENERATING MODE(MW)	613	560	1,173
N° OF PLANTS (N)	2	7	9
BASE INVESTMENT NEEDS (MILLION USD)	909	869	1,778
PREPARATION OF THE MASTER PLAN (MILLION USD)	5	4 (UP DATE)	9

FINANCIAL ENGINEERING TOOLS AND PACKAGES

- PARIS-3 FUNDS AND SOFT LOANS
- LOI- PROGRAMME FOR 10 YEARS
- RESPECTIVE PUBLIC BONDS FOR 10 YEARS
- PPP : PRIVATE PUBLIC PARTNERSHIP :

  PARTIAL INCORPORATION AND PRIVATIZATION OF EDL IN CONFORMITY WITH REGULATION LAW Nº 462/2002

- BOT , BOOT , ….
- EPC (ENGINEERING , PROCUREMENT , CONSTRUCTION)
- CARBON TRADES (KYATO PROTOCOL)

  FLEXIBLE MECHANISMS TO DEVELOP JOINT IMPLEMENTATION PROJECTS BETWEEN LEBANON AND THE EU COUNTRIES.

THANK YOU