Council for Development and Reconstruction (CDR)
Ministry of Energy and Water (MoEW)
Water Establishment Beirut and Mount Lebanon (WEBML)

Federal Institute for Geosciences
and Natural Resources (BGR),
Hannover, Germany

German-Lebanese Technical Cooperation Project

TZ-Projekt Schutz der Jeita-Quelle, Libanon

Hauskolloquium BGR
12 März 2013

Dr. Armin Margane, BGR

Outline

- Background of the Project - Tasks
- Description of Project Area
- Project Activities related to
  - Component 1 (Wastewater Sector)
  - Component 2 (GW Protection Zones, Awareness)
  - Component 3 (Monitoring Quantity/Quality, Balance)
  - Component 4 (Improved Jeita Spring Capture) and Conveyor)

Project History

- July War (12th July – 14th August 2006)
- Donor Meeting in Paris (25th January 2007)
- Mission of GTZ und KfW in September 2006 : Concept for short – medium – long-term measures
- Project proposal BGR „Improved Water Resources Mgmt.“ (12/06)
- Draft Sector Strategy Paper (GTZ, KfW and BGR, 03/07;

  focus: GW protection)
- KfW asks BMZ for participation of BGR to provide assistance for FC-project Protection of Jeita Spring through separate TC-project
- Project appraisal mission (GeoSFF, Juni/Juli 2008)
- Project offer (January 2009)
- BMZ: Letter of assignment (June 2009)
- Start of project: mid July 2010 (Decree)

Project Area

Integrated Project Approach

One of the main aims of wastewater projects is to protect (drinking)water resources.

In reality, however, many wastewater projects fail to meet this objective because the **planning of wastewater facilities does not sufficiently integrate the need for water resources protection**.

► failed investment

Reason: lacking geoscientific expertise during planning

The **combination of financial cooperation and technical cooperation projects** is a new approach of the BMZ (German Ministry of Economic Cooperation and Development) that aims to overcome this planning deficit.

First project of BGR in Lebanon.
Similar approach in Syria for water supply of Damascus (until 04/2011).

Project Setup

Four projects, funded by German development cooperation (BMZ), aim to reduce the pollution risk for Jeita spring in Lebanon and Figeh spring in Syria.

Lebanon

close cooperation

BGR: Technical Cooperation project *Protection of Jeita Spring* (July 2010 – May 2012, extended to Dec 2013)
KfW: Financial Cooperation project *Protection of Jeita Spring* (approx. July 2011, 4 years)

exchange

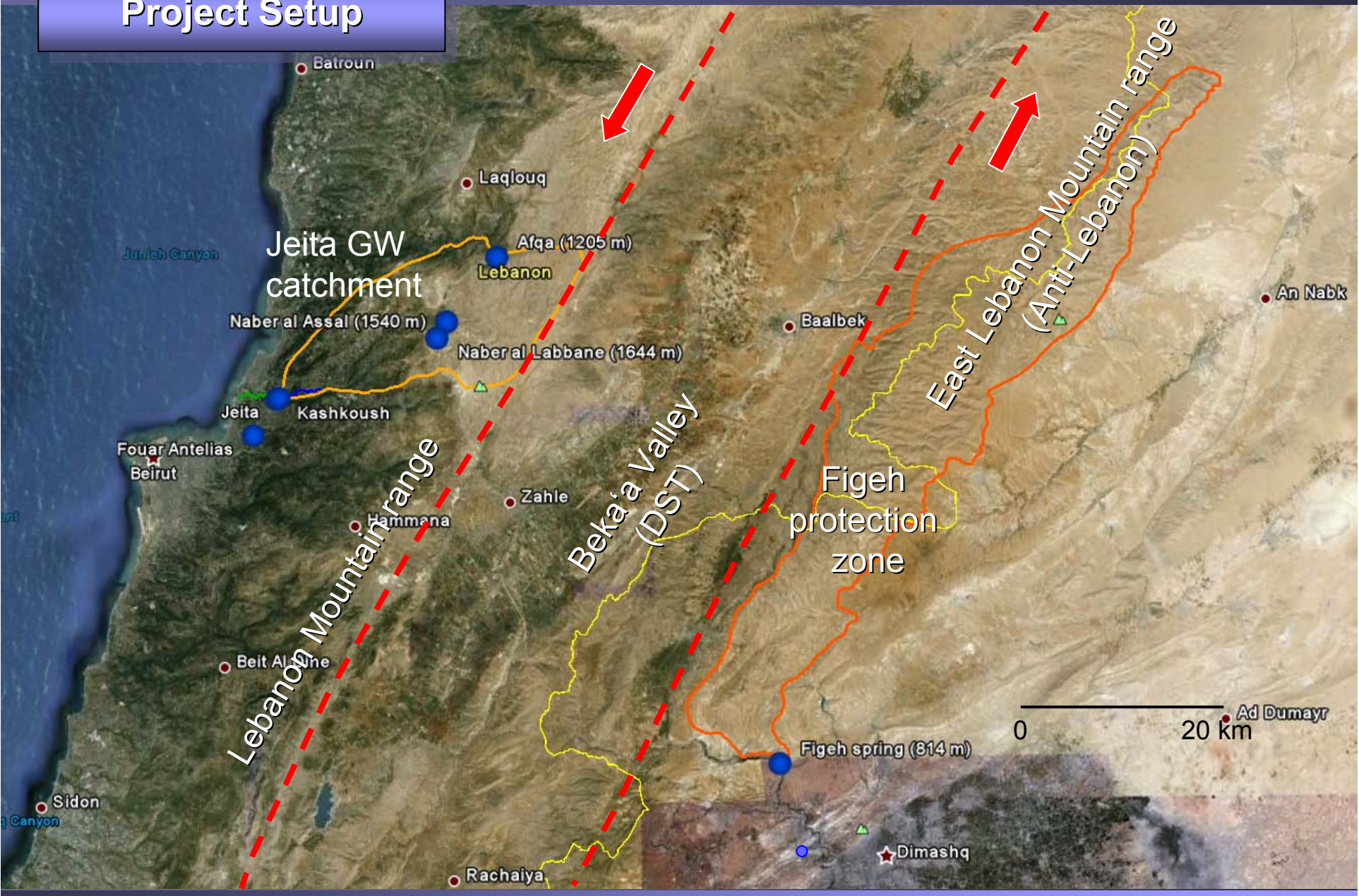
Syria

close cooperation

BGR: Technical Cooperation project *Protection of Figeh Spring* (Juli 2009 – Dezember 2011 + 2nd phase > stopped 04/2011)
KfW: Financial Cooperation project *IWRM Figeh* (2009 - 2013)

Overall goals: reduce pollution risks

Project Setup



Project Setup

BGR

TC project:

- Delineate GW protection zones
- Assessment of water quality problems (monitoring)
- Risk assessment and recommendations for reduction of pollution risks
- Water balance ► propose management options

- Advice to FC project:
  - wastewater master plan (wastewater schemes & priorities)
  - WWTP site searching and related assessment of geoscientific risks (karst features, tectonic movements, landslides, flooding, soil stability)
  - EIAs (hydrogeological parts) for planned WWTPs
  - recommendations for treated wastewater reuse (standards; BMP)
  - recommendations for sludge reuse/management (standards; BMP)

KfW

FC project:

- Wastewater master plan > supported by BGR
- wastewater facilities design
- wastewater facilities construction
- wastewater facilities operation (2 years) > handed over to WE

Project Setup

Duration

1st phase	2 years	July 2010 – June 2012
extension	1.5 years	July 2012 – December 2013

Partners

- Council for Development and Reconstruction (CDR)
- Water Establishment of Beirut and Mount Lebanon (WEBML)
- Ministry of Energy and Water (MoEW)

Funding

In form of a grant

1st phase	1.2 Mio EUR
extension	0.5 Mio EUR

Project Activities

Goal: *Major Risks for the Drinking Water Supply in the Greater Beirut Area are reduced by implementing measures to protect the groundwater contribution zone of the Jeita Spring from pollution.*

Indicators:

Concerning the risk of contamination by wastewater:
The advice of the project concerning issues of groundwater protection has been used in the concept and design of at least one site for wastewater collection and treatment. ✓

Concerning the risk of landuse management: The advice of the project concerning issues of groundwater protection has been used in landuse planning of at least one municipality. ✓

Concerning water quality monitoring: The system for monitoring of water quality is implemented and monitoring data are used at a central location for operation of the water supply network and the drinking water purification plant. (✓)

Awareness concerning GW Protection (extension phase): The awareness of stakeholder and the general public in the catchment of the Jeita spring for the necessity of groundwater protection measures has been raised through awareness measures/events (✓)

Project Activities

1. Integration of water resources protection aspects into the investment planning and implementation process in the wastewater sector

- Support of CDR and other institutions concerning the prioritization of wastewater projects as well as the design and site selection for WWTPs, collector lines and effluent discharge locations; ✓
- Support of CDR concerning the preparation of EIAs for wastewater projects, with regards to their impact on the water resources;
- Preparation of best practice guidelines for the implementation of wastewater projects with special consideration of the aspect of ground and surface water protection. ✓

2. Integration of water resources protection aspects into landuse planning

- Determination of the vulnerability of the groundwater system, preparation of an inventory of hazards to groundwater, and determination of the risk of groundwater pollution; ✓
- Delineation of groundwater protection zones for the Jeita Spring and, if possible, other springs and wells used for drinking water supply in the Jeita groundwater catchment; ✓
- Support of the relevant governmental institutions in implementing the proposed protection zones and urgent protection measures; (✓)
- Providing advice to MoEW concerning the establishment of a legal basis for the implementation of protection zones for ground and surface water resources. (-)
- Conducting Awareness Campaigns on GW Protection with schools, municipalities, army, other institutions (e.g. chamber of commerce) ✓

Project Activities

3. Collection and use of monitoring data concerning quality and quantity of water resources

- Establishment of a monitoring network
  - ► water balance / proposal of water management options ✓
  - ► assessment of water quality problems
- Giving advice to WEBML concerning the use of monitoring data, e.g. concerning the control of the efficiency of the established wastewater treatment facilities or the operation of the water treatment and supply system during times of high contaminant loads. (✓)

4. Support of the partner institutions concerning the implementation of urgent protective measures

- Proposal for an improved capture of Jeita Spring with the aim to reduce the risk of pollution, and, if feasible its implementation; ✓
- Proposal for an improved water conveyance system from the Jeita Spring to the Dbaye treatment plant with the aim to reduce the risk of pollution. ✓

Data Availability

- Insufficient and inadequate meteorological stations/data (not heated > no snow data) (previously >100 stations, now 35 stations in LB)
- No groundwater monitoring > no water levels > no GW model
- Spring discharge monitoring stations not adequately designed, maintained and monitored
- Surface water gauging stations not adequately designed and maintained

► lack of institutional capacity, funds and staff

Water resources assessment needs monitoring system for all water balance components

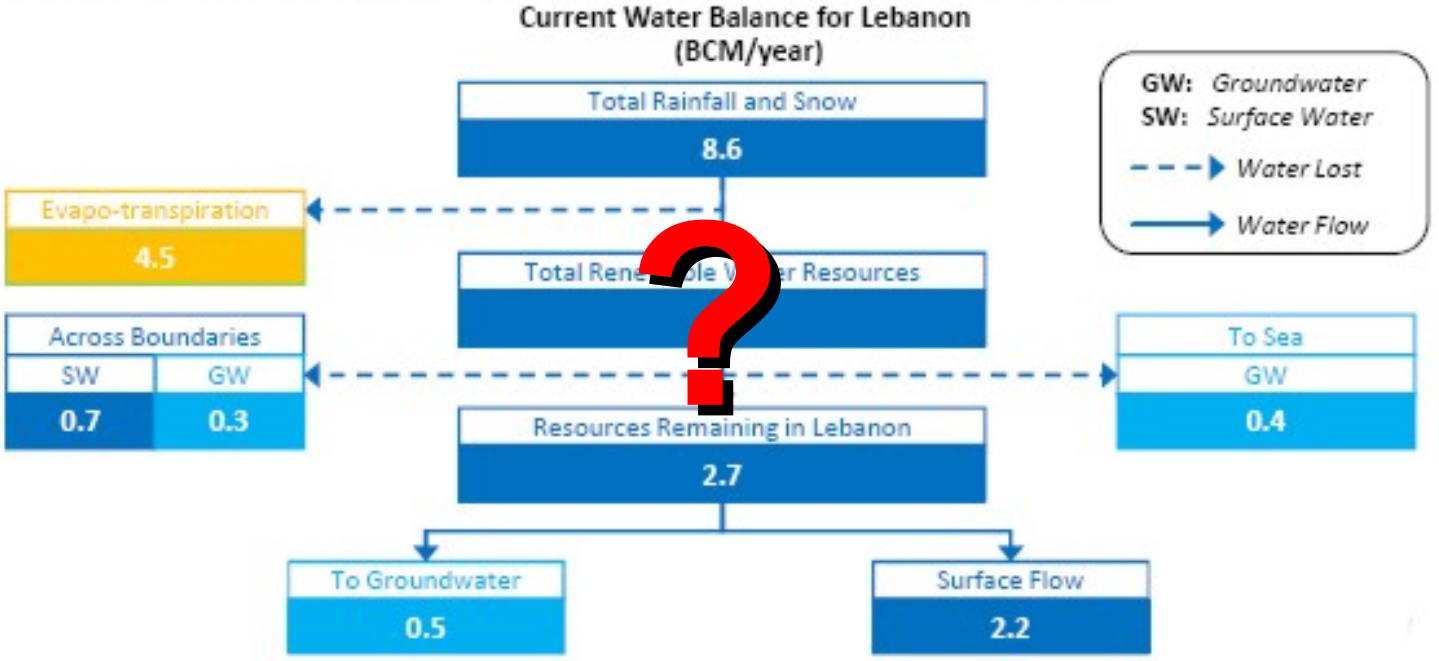
- rainfall / snow
- spring discharge
- runoff (surface water)
- groundwater abstraction
- irrigation water use (return flow)
- domestic water use / losses (return flow)

► no data > no correct water resources assessment
► wrong water resources assessment leads to wrong planning !
► failed investments in the water sector

Current Planning in the Water Sector

None of the Components of the Water Balance is monitored
Water Resources Availability Data are a Fiction
and lead to wrong Planning

Renewable water resources per capita are already slightly below scarcity threshold, with expected decrease in the coming years



water strategy prepared by GIZ

Renewable Water Resources
(m^3/capita/year)

November 2011

Background Info

Israel

Inhabitants: ~7.6 Mio

Area: 22,145 km²

GDP: 242.9 B USD

32,298 USD/ca (nom)

Unemployment: 5.6%

Lebanon

Inhabitants: ~4.1 Mio

Area: 10,452 km²

(E-W: 75 km, N-S: 200 km)

GDP: 39.0 B USD

9,165 USD/ca (nom)

Unemployment: 18.8%

Syria

Inhabitants: ~22.5 Mio

Area: 185,180 km²

GDP: 64.7 B USD

3,095 USD/ca (nom)

Jordan

Inhabitants: ~6.5 Mio

Area: 89,342 km²

GDP: 29.2 B USD

4,556 USD/ca (nom)

Background Info

Lebanon
Independence: 08 NOV1943
Area: 10,452 km²
Population: 4.1 Mio (est. 2012)
Last census: 1932
GDP: 9,165 USD/ca (2011)

405,000 Palestinian refugees (2012)
>200,000 Syrian refugees (02/2013)

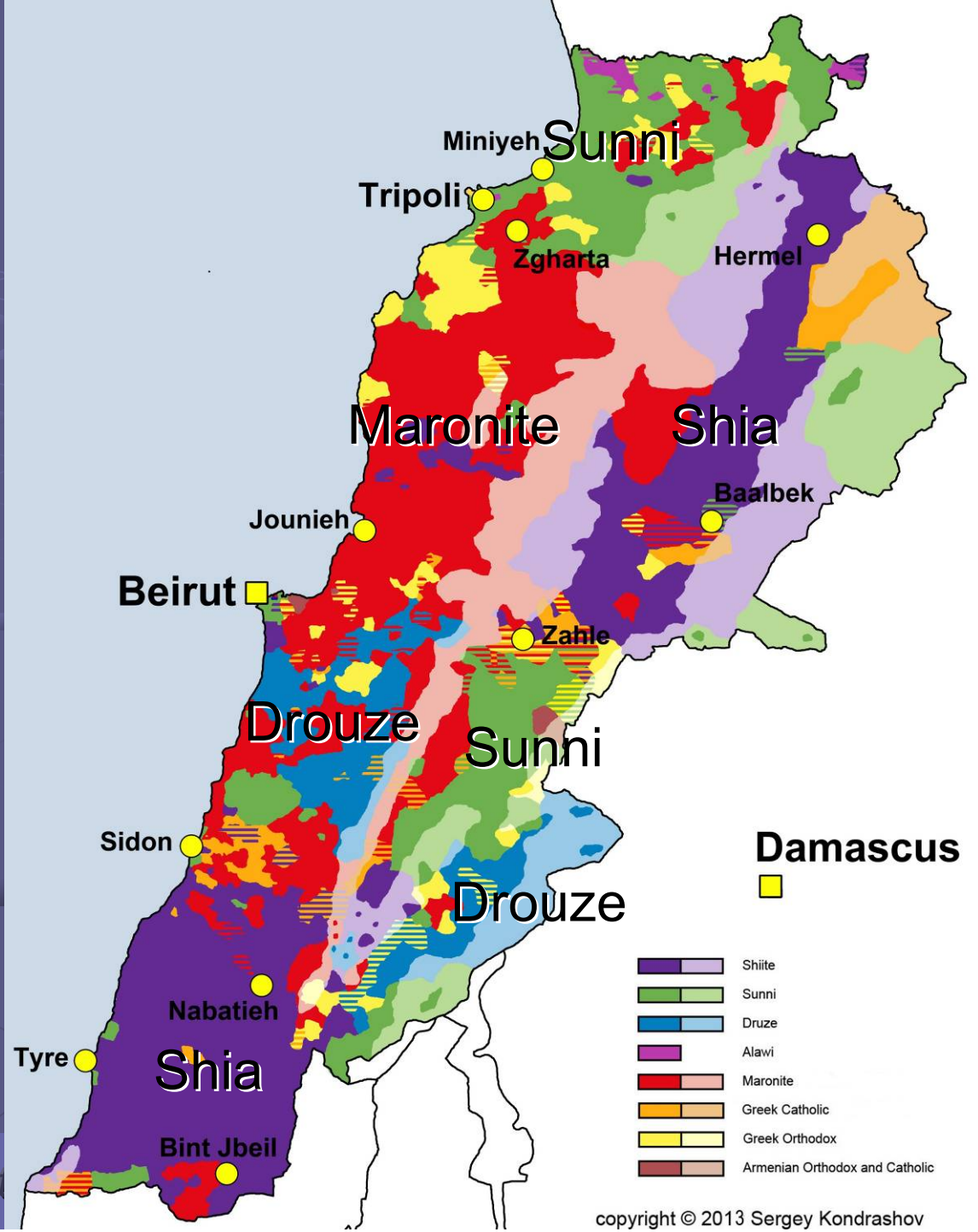
Religion (CIA factbook):
59.7% Muslim
39% Christian (1932: 53%)

27% Sunni, 27% Shi'a, 21% Maronite, 8% Greek Orthodox, 5% Druze, 5% Greek Catholic
18 religious sects: 4 Muslim, 12 Christian, 1 Druze, (1 Jewish)

15-22 Mio Lebanese
Brazil: 7-10 Mio, Argentine 1.5 Mio

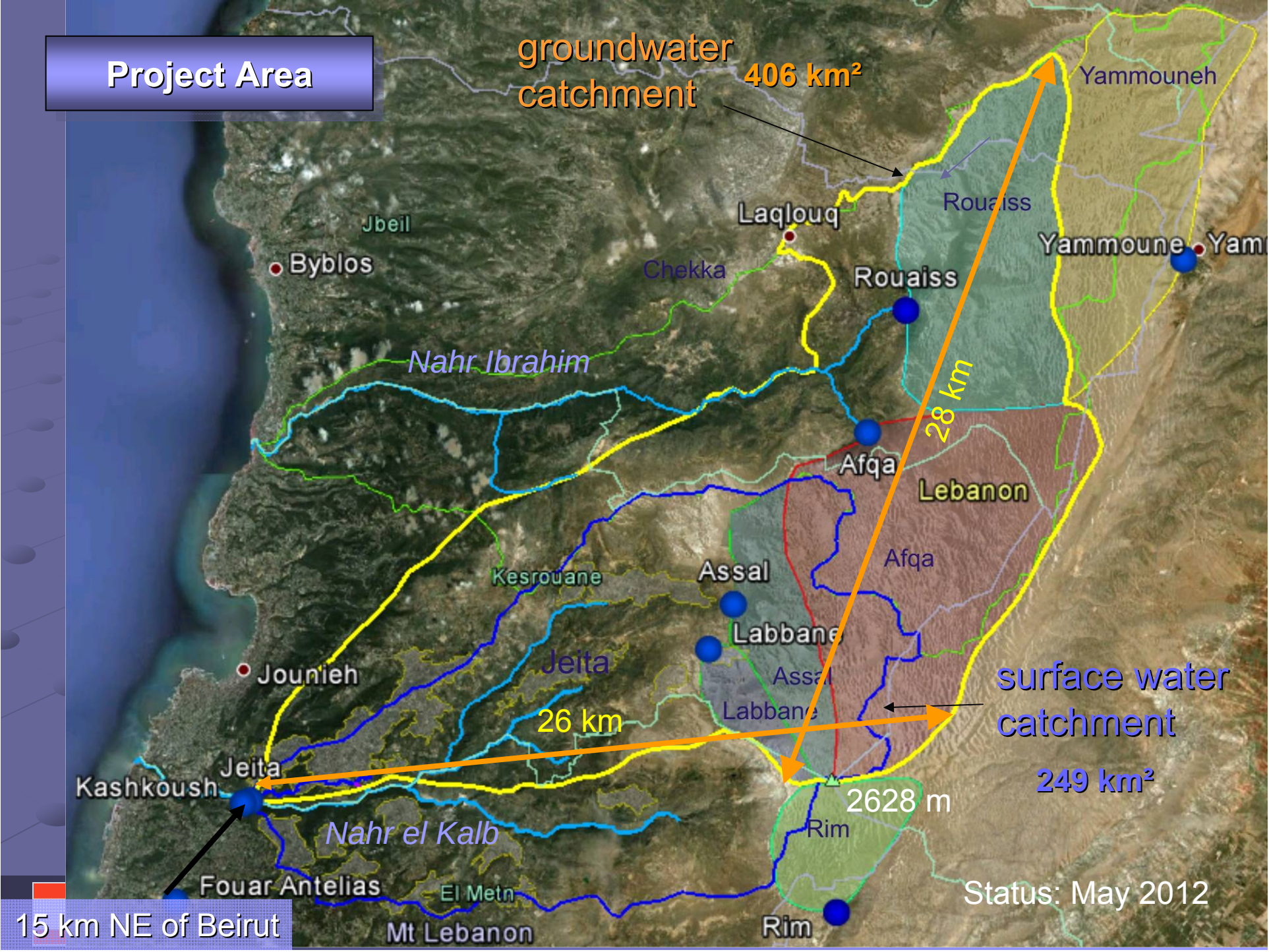
Background Info

Religious fragmentation



Working Conditions

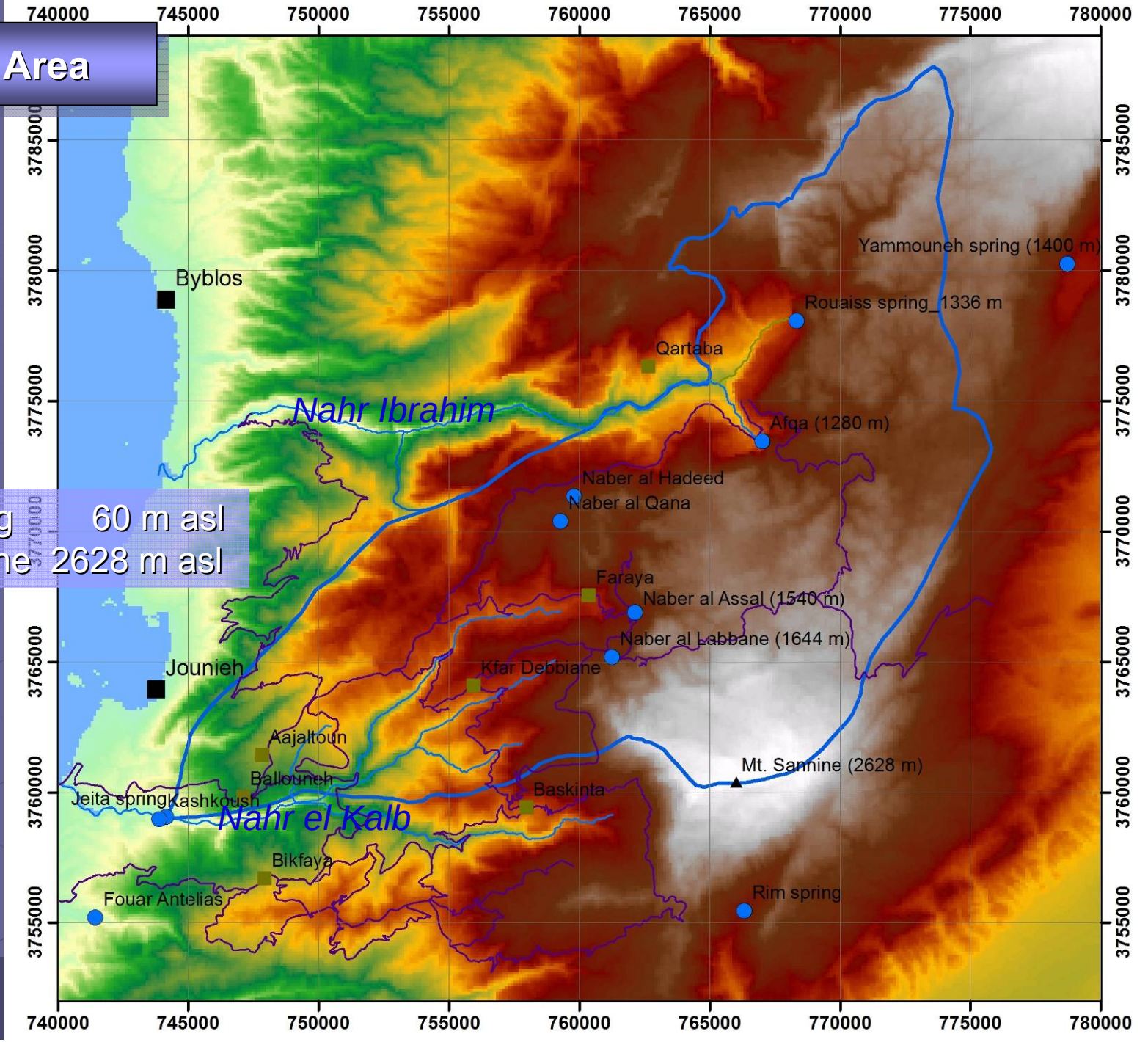
- fight for power between religious sects (& religious infights among Christian sects and among Muslim sects)
- week government – no coordination between ministries
- high level of corruption (Transparency International: rank 128 of 174)
- poor tax & service fee collection rate (flat rate for water: 150 USD/a/household)
- high dependency on foreign donors; high debt (61.5 B USD)
- influence from outside: Iran, Syria (Hizbollah), KSA, Qatar, etc. (Sunni, Palestinians)
- poor infrastructure: water supply, electricity supply, telephone, internet, roads
- poor general security (UN/EU/AA: currently 75% restricted access), increased risk of kidnapping
- impacts of civil war (1975-1990), occupation by Israel (South Lebanon Conflict 1982-2000) and wars with Israel (2006)
- lacking community spirit – everybody for himself


Project Area
groundwater catchment
406 km²
Yammouneh
Laqlouq
Jbeil
Byblos
Chekka
Rouaiss
Yammoune
Nahr Ibrahim
28 km
Afqa
Lebanon
Kesrouane
Assal
Afqa
Labbane
Jeita
Jounieh
26 km
surface water catchment
249 km²
Jeita
Kashkoush
2628 m
Rim
Nahr el Kalb
Fouar Antelias
El Metn
Mt Lebanon
Rim
Status: May 2012
15 km NE of Beirut

Project Area

DEM

Min: Jeita spring 60 m asl
Max: Mt. Sannine 2628 m asl



Where does Beirut's drinking water come from

Importance of Snow

Cretaceous plateau (1,800 – 3,000 m asl):
2-4 m snow (2012: up to 10 m and more)
November – May

Very important for GW recharge (~ 85%)
Snow is the lifeline of Lebanon

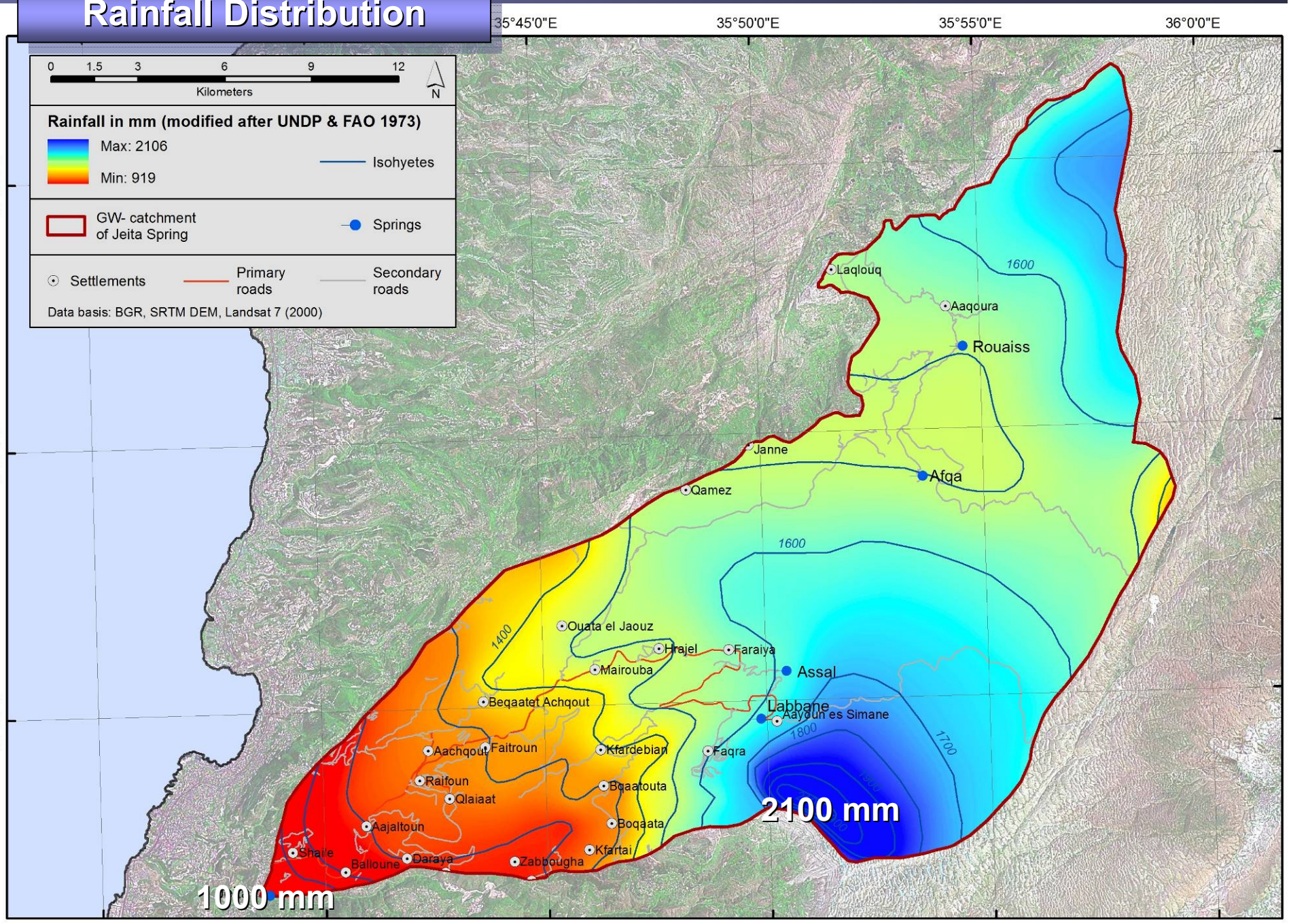
Climate change may lead to a significantly lower groundwater resources availability

Regional climatic scenarios predict less rainfall (15-30%), higher summer and winter temperatures (up to 5°C) and thus less snow and runoff, more evaporation

► shift of orographic snow line

► water shortage in dry season

Rainfall Distribution



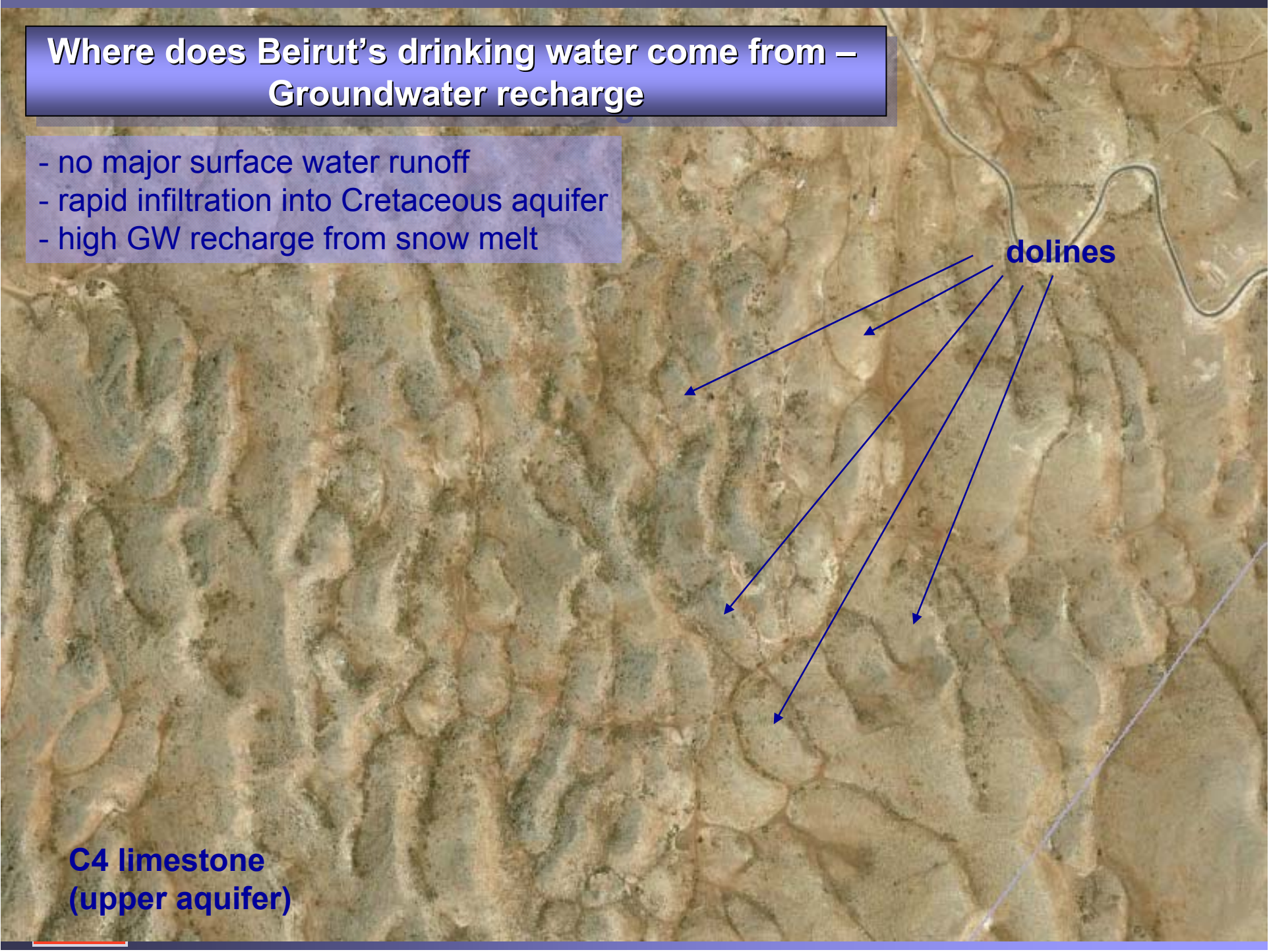

Predominantly western winds


Currently not possible to determine **S**now **W**ater **E**quivalent

Where does Beirut's drinking water come from – Groundwater recharge

Where does Beirut's drinking water come from – Groundwater recharge

- no major surface water runoff
- rapid infiltration into Cretaceous aquifer
- high GW recharge from snow melt



Where does Beirut's drinking water come from – Groundwater recharge

GW recharge via dolines

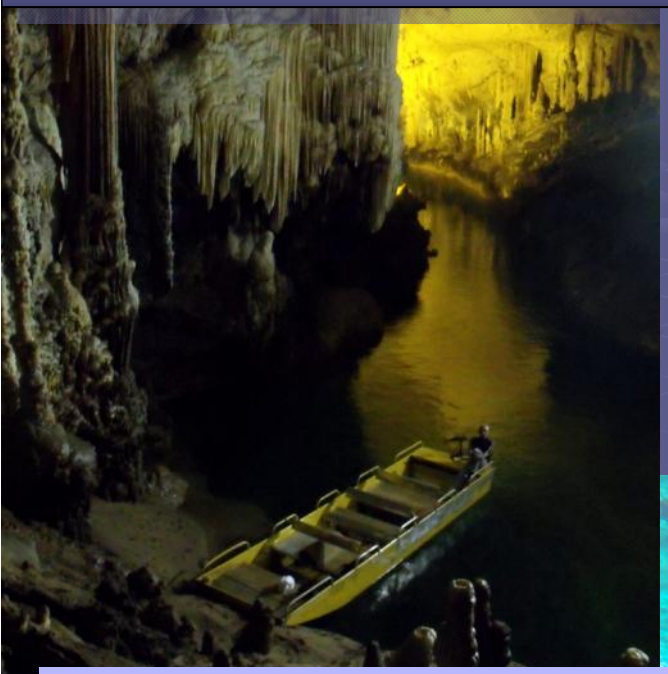
assumed GW recharge 85% in C4

Where does Beirut's drinking water come from – Groundwater recharge

High karstification in Cretaceous limestone (Faqra)

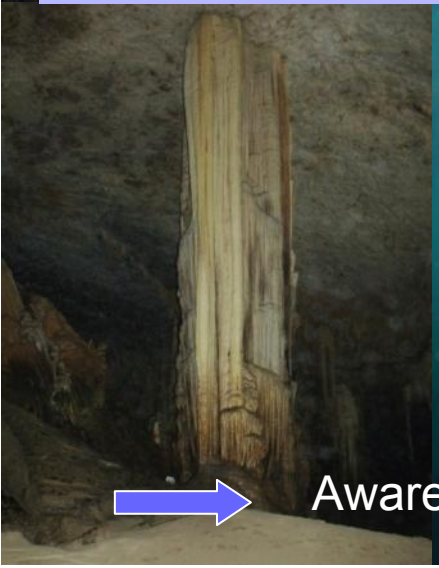

karstification in
uppermost J4 limestone

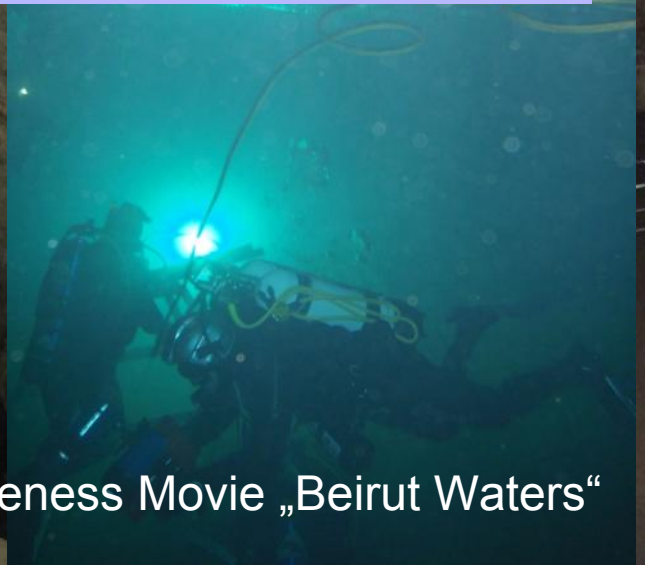
Where does Beirut's drinking water come from – Groundwater discharge



Jeita Spring
The main Source for Water Supply of Beirut

75 % of Beirut's water comes from Jeita





Awareness Movie „Beirut Waters“

Specific Problems

- High rainfall (on average 1450 mm/a)
- high level of karstification
  ► high infiltration / low retention capacity
  ► high spring discharge peaks during January to April (up to 60 m³/s), low flow during dry season (min. 1 m³/s) > water shortage in Oct/Dec
- high GW flow velocity (up to 2,000 m/h)
- rapid and uncontrolled urban expansion (approx. 200.000 inhabitants)
  ► severe deterioration of water quality over the past decades

Main pollution sources:

- wastewater (no WWTPs yet)
- waste (often illegal disposal)
- gas stations (84)
- quarries (cement, decoration stone)
- Jeita – Dbaye water conveyor (up to 140 yrs old)

Tracer Tests

Tracer Injection (uranine)

Tracer Monitoring

Data logger

Tracer substances

- Uranine
- Amidorhodamine G
- Sodium Naphthionate
- Eosine

Detection limit uranine:
0.002 ppb

Time interval:
2 sec – 20 min

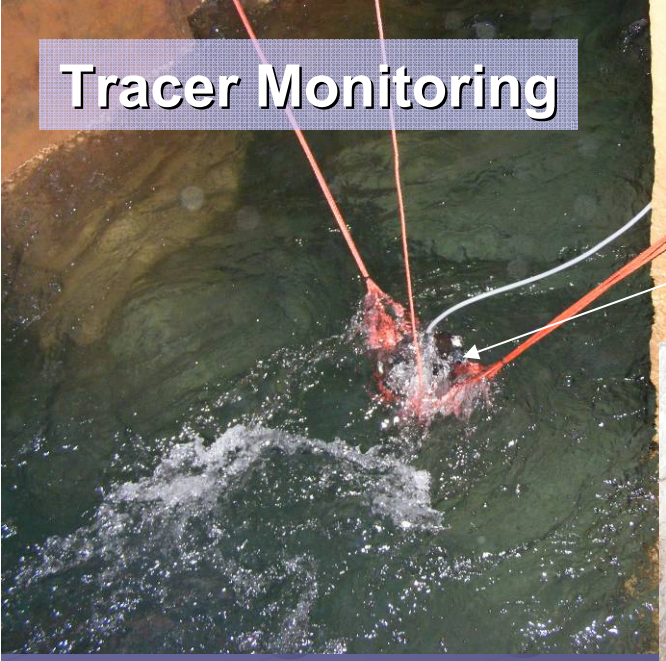
Simultaneous measurement of
3 tracers + turbidity + EC + T

Fluorometer

www.albillia.com

Tracer Monitoring

fluorometer



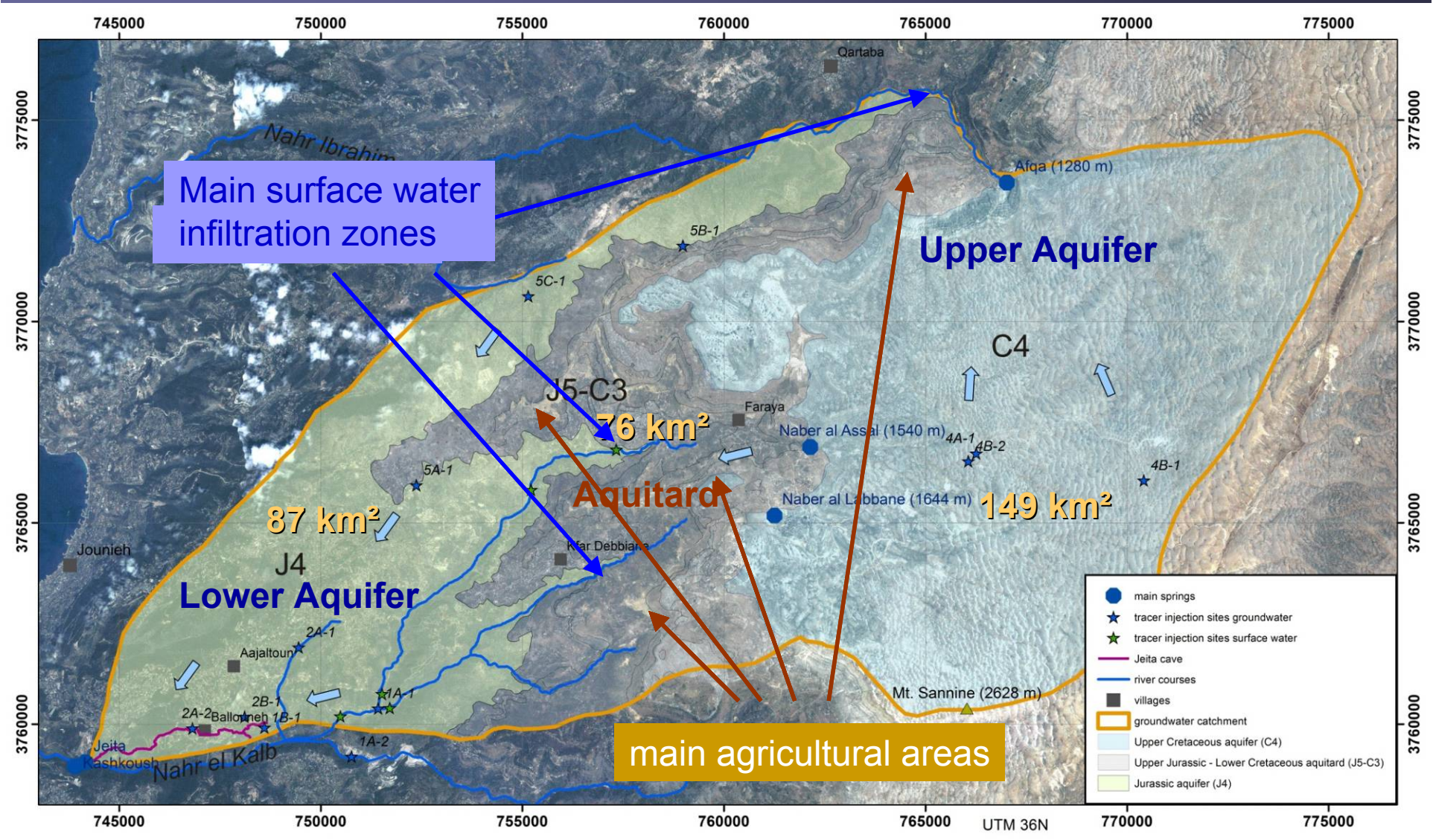
Daraya tunnel

Jeita siphon terminal

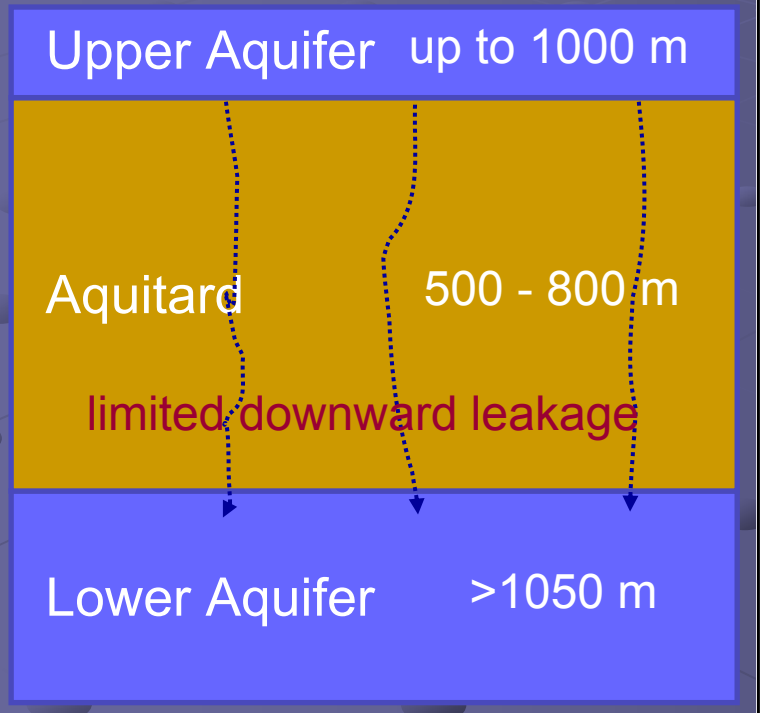
Tracer Test 4A near La Cabane (March 2011)

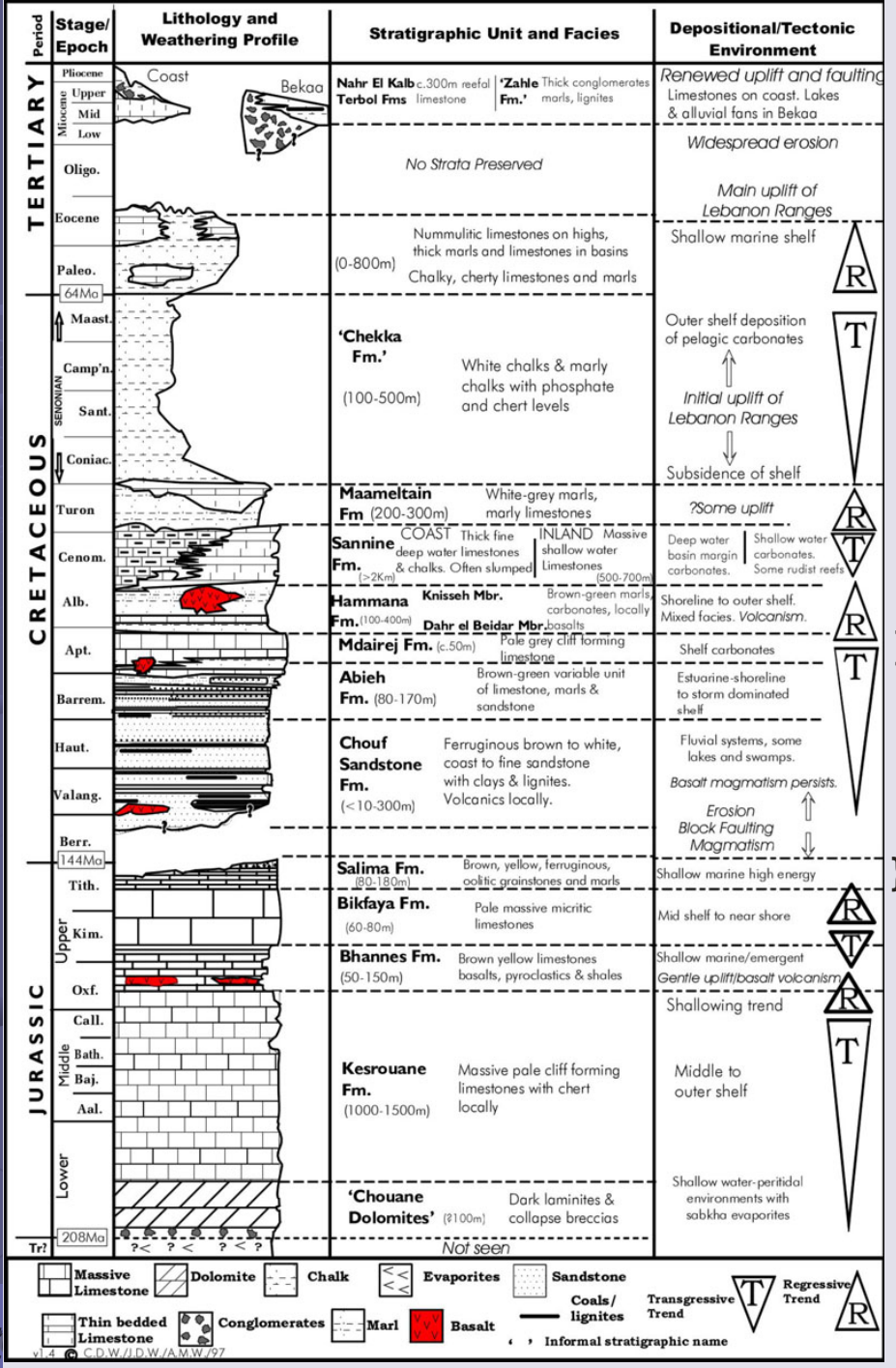
Groundwater System

New geological map prepared by BGR



Lithostratigraphy



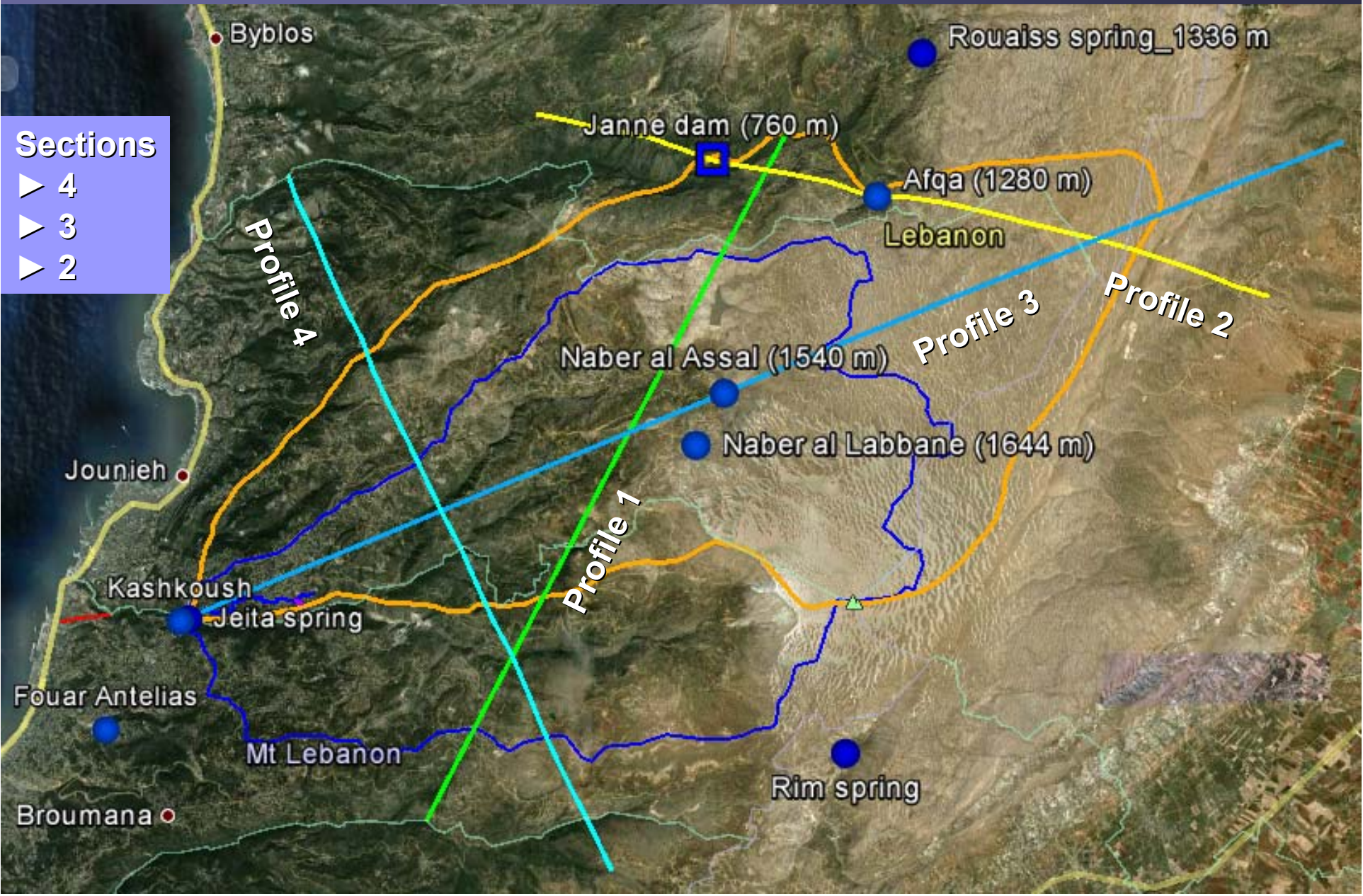


Source: C. D. Walley

Aquifers

C4
C3
C2b
C2a
C1
J7
J6
J5
J4

Geological Cross Sections



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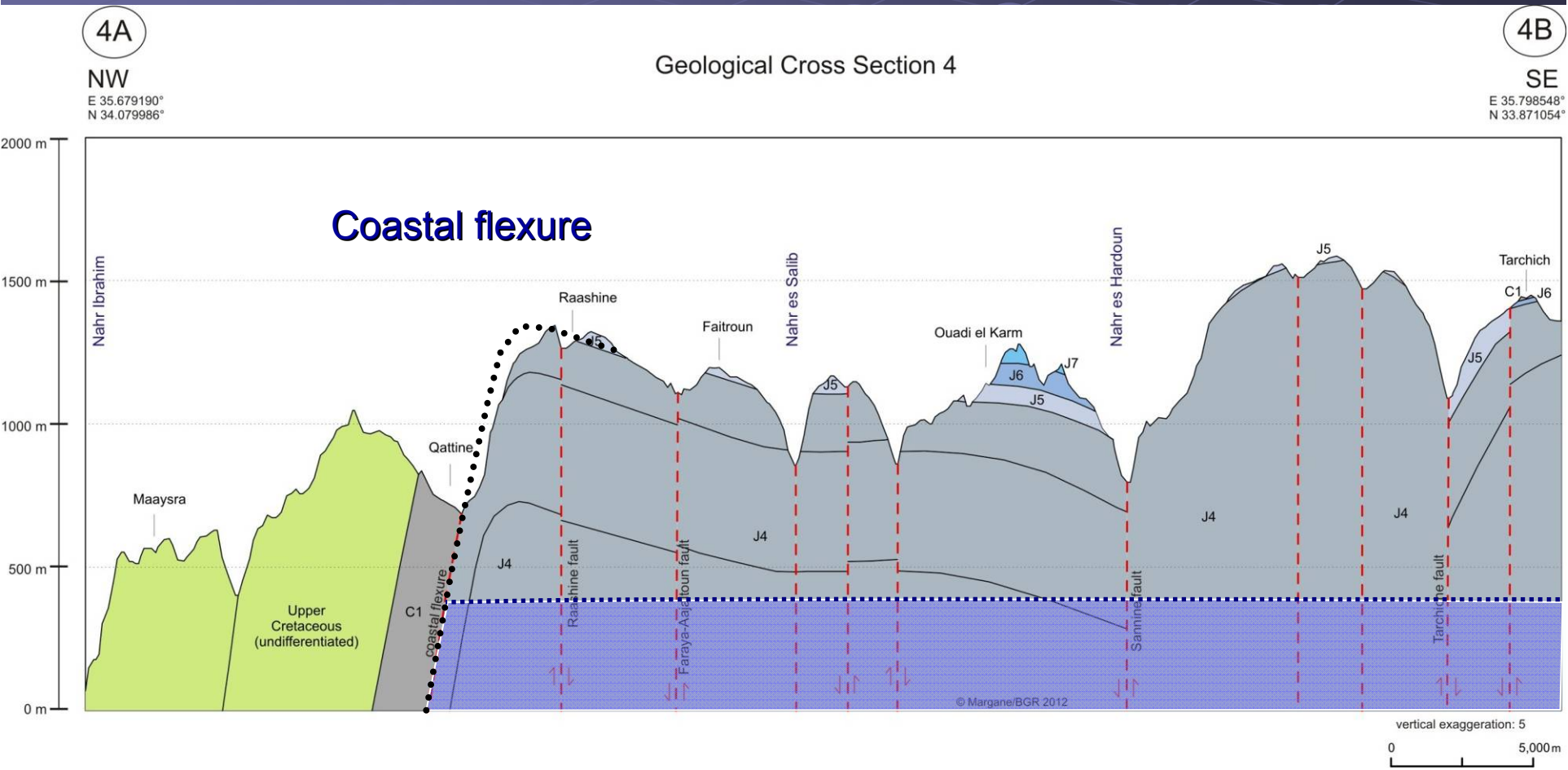
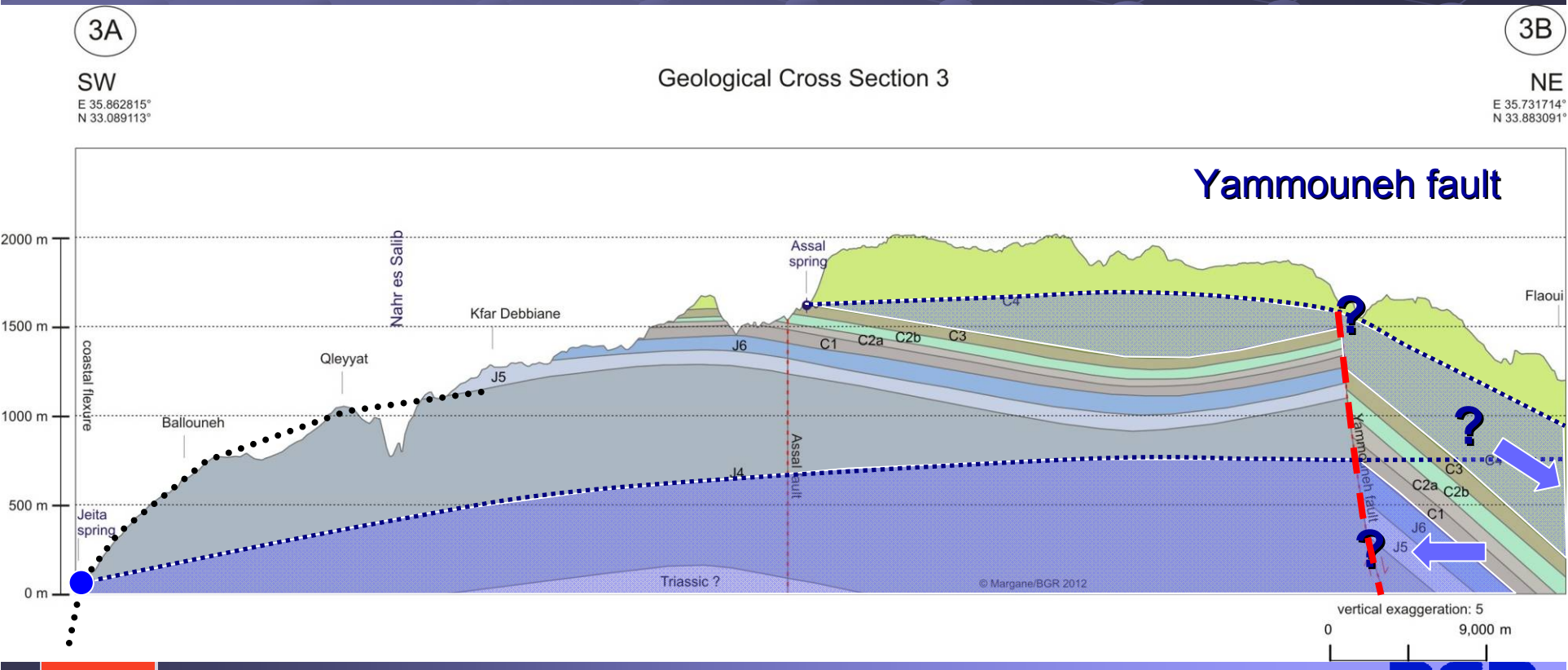
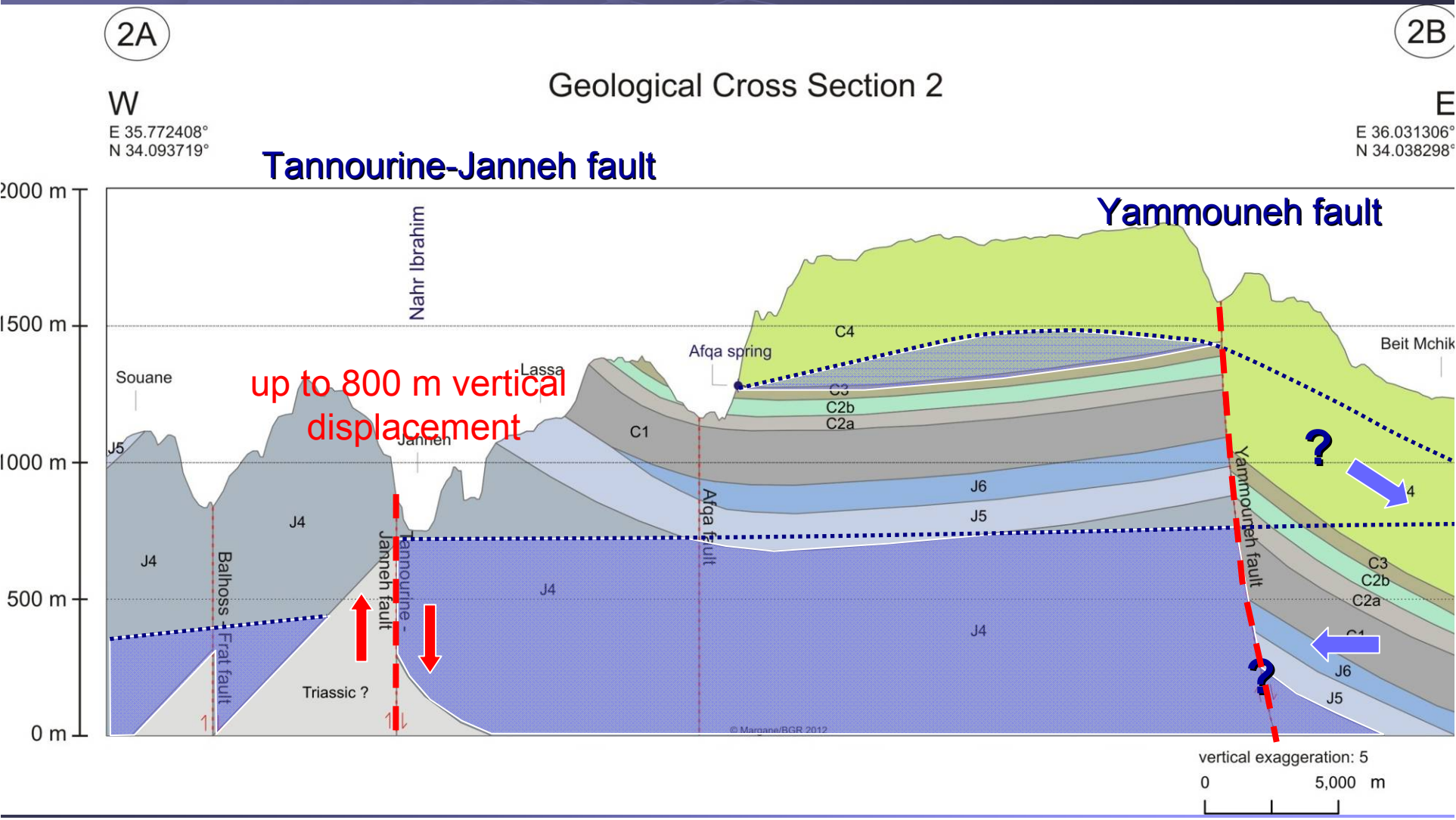


Geological Cross Sections

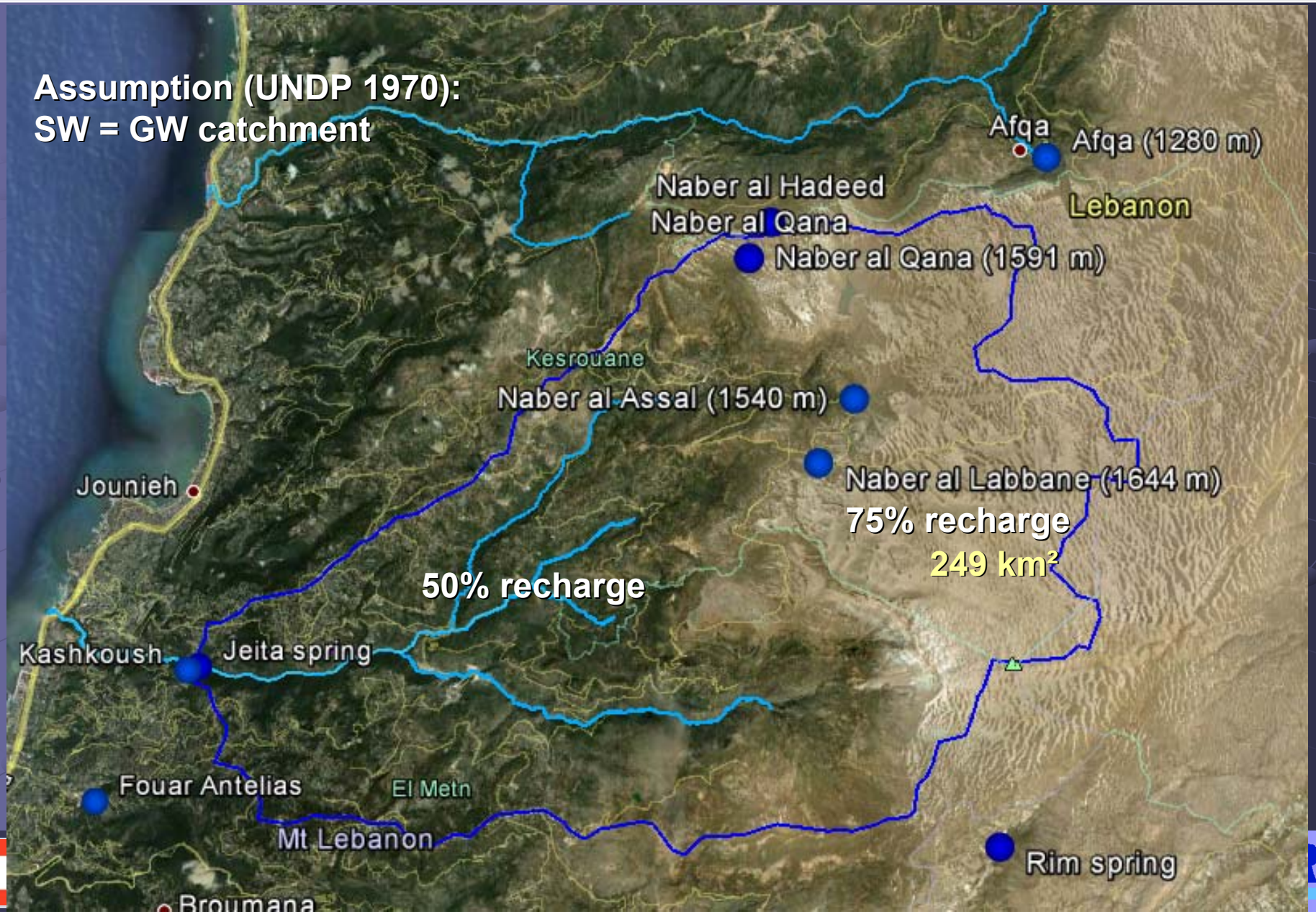


Geological Cross Sections

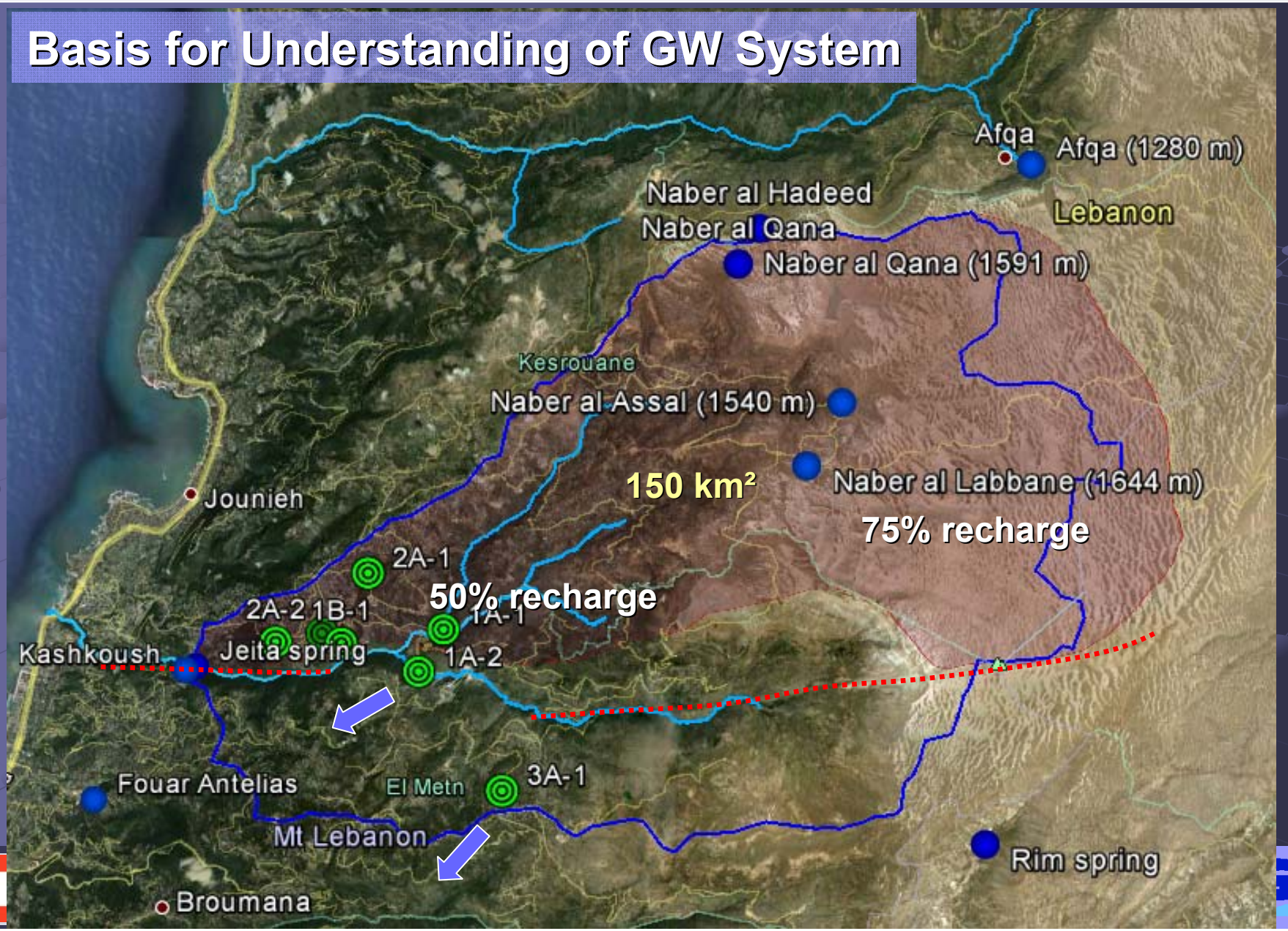


Project Area = Groundwater Catchment

July 2010

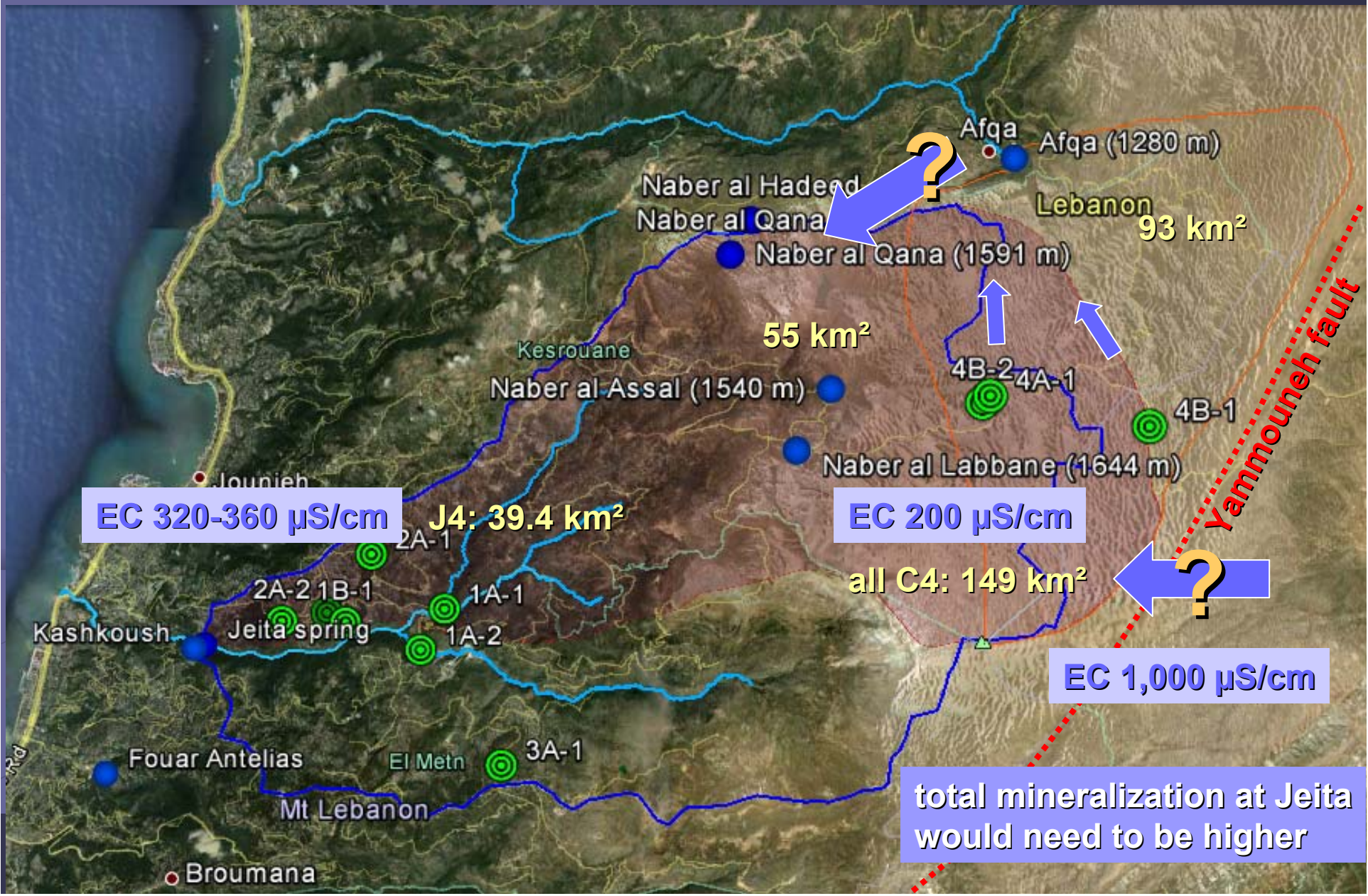


Basis for Understanding of GW System



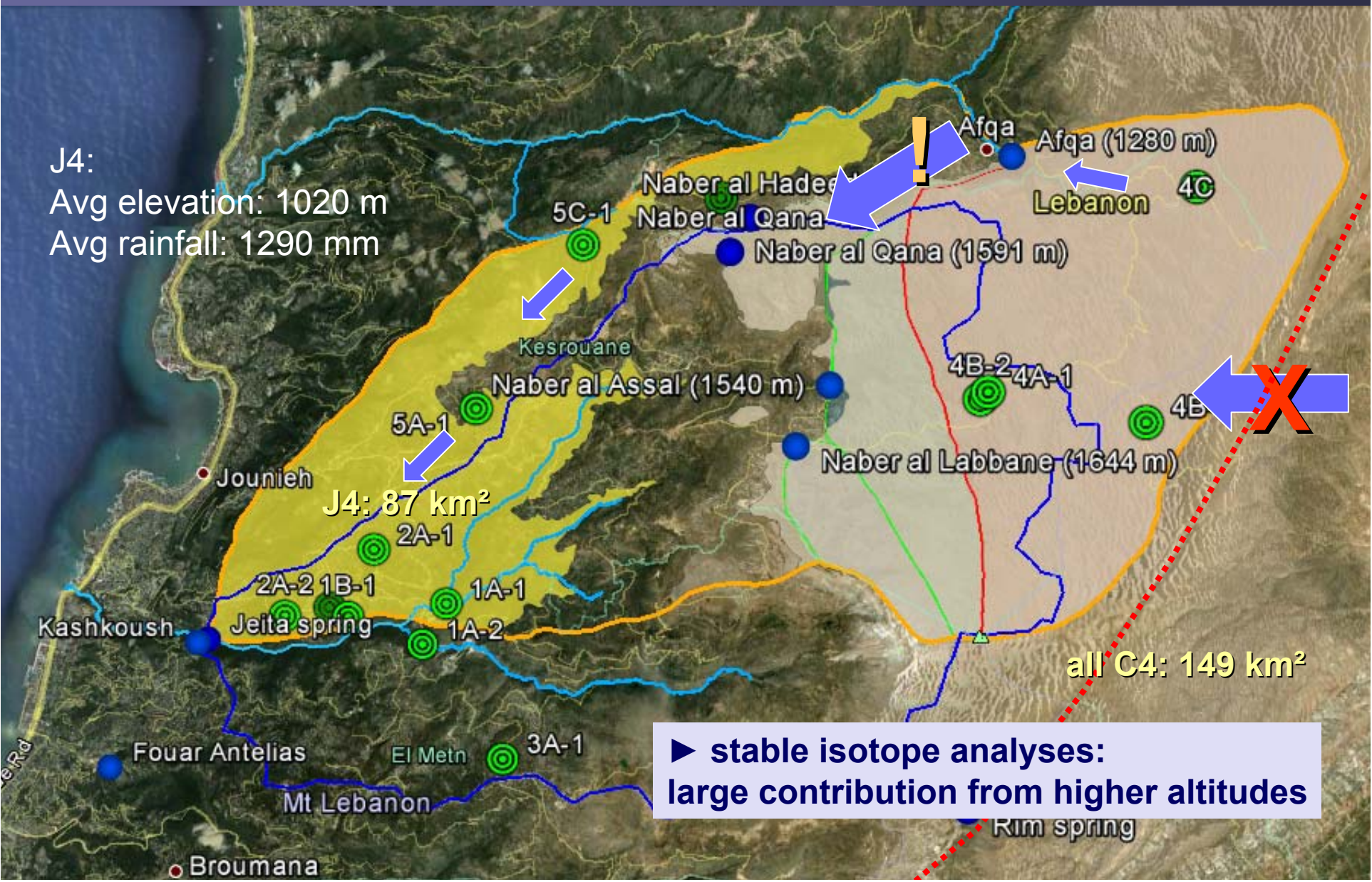
Project Area

May 2011



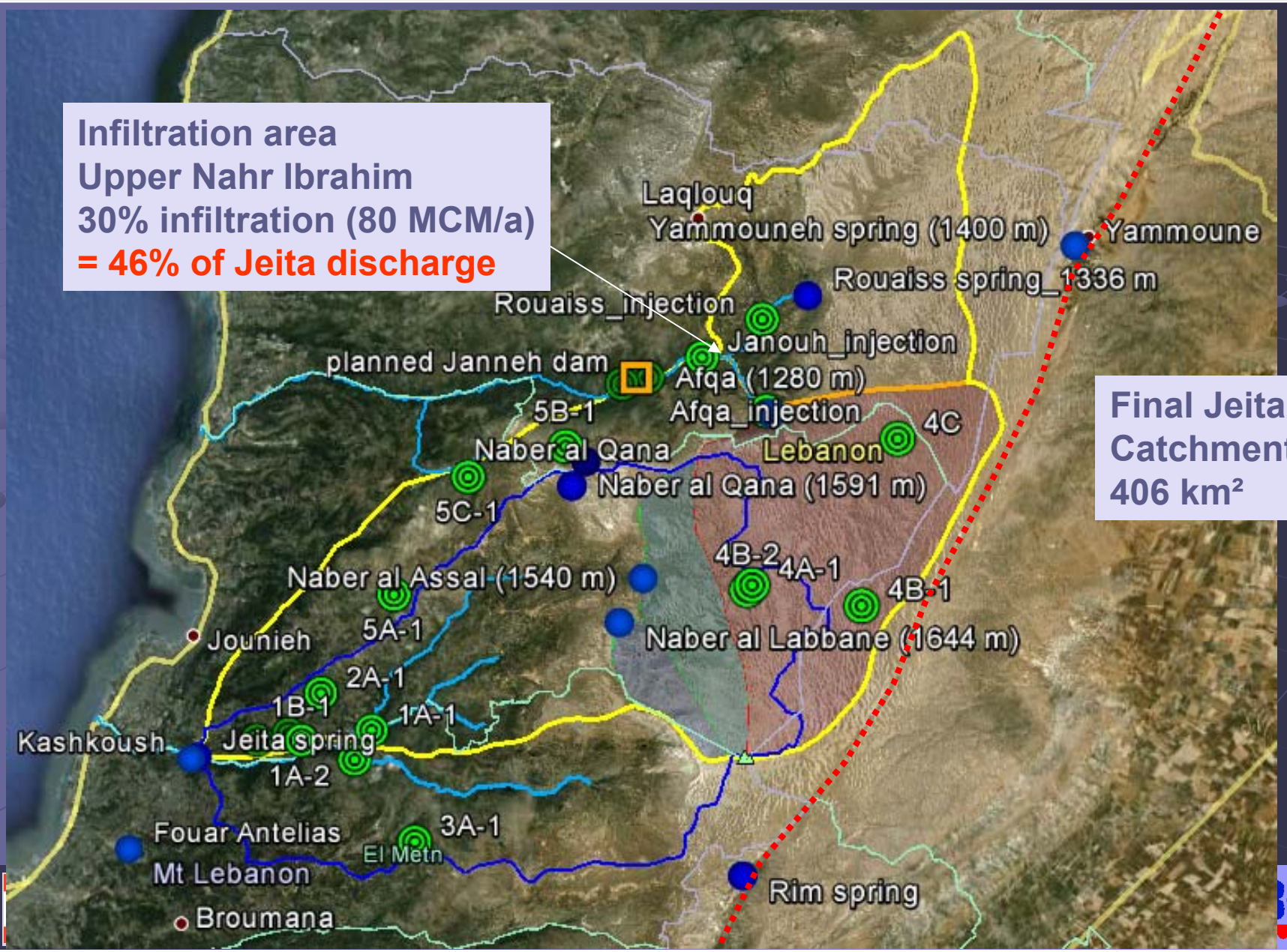
Project Area

September 2011 / April 2012

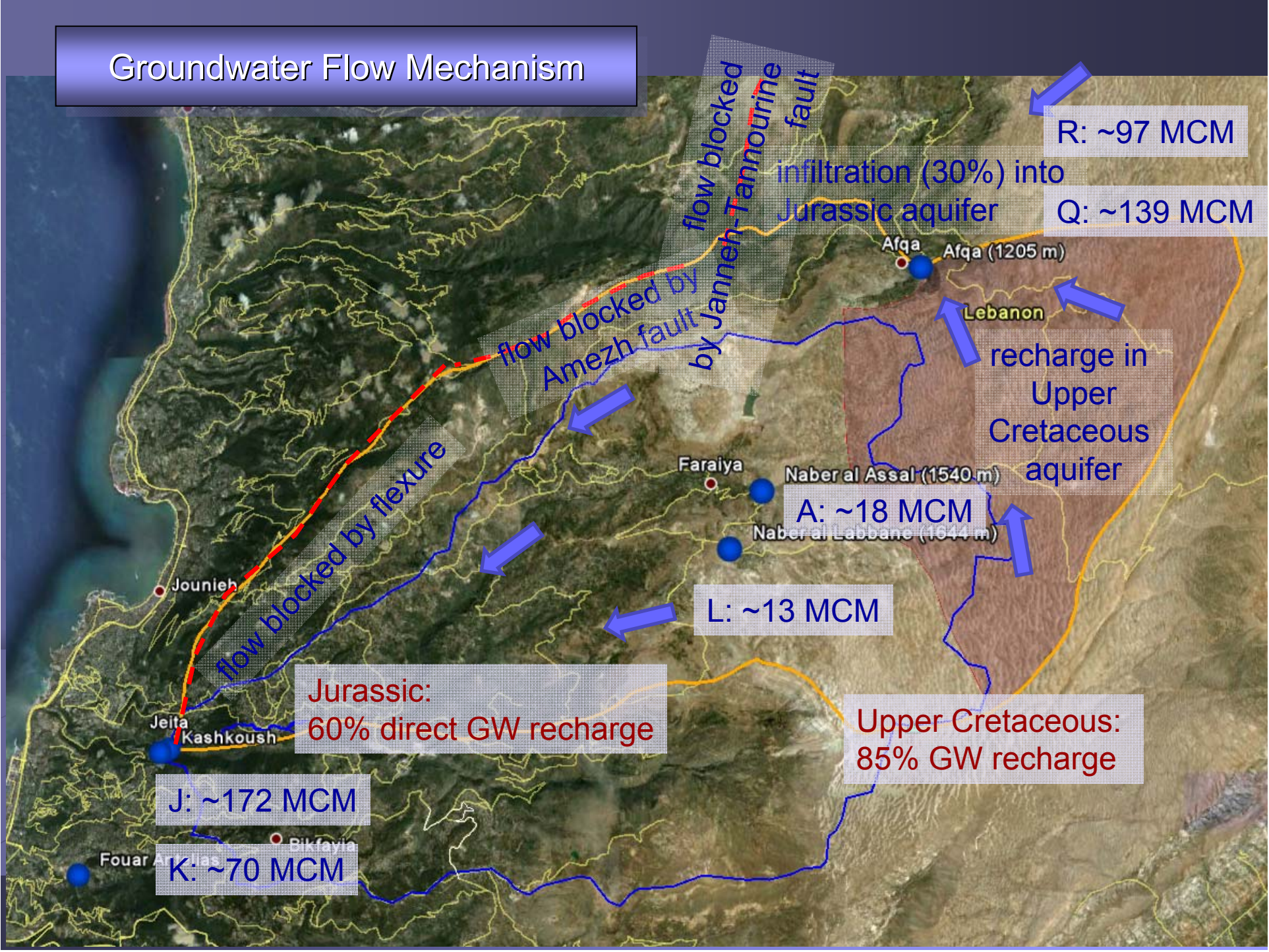


Project Area

April / August 2012



Groundwater Flow Mechanism

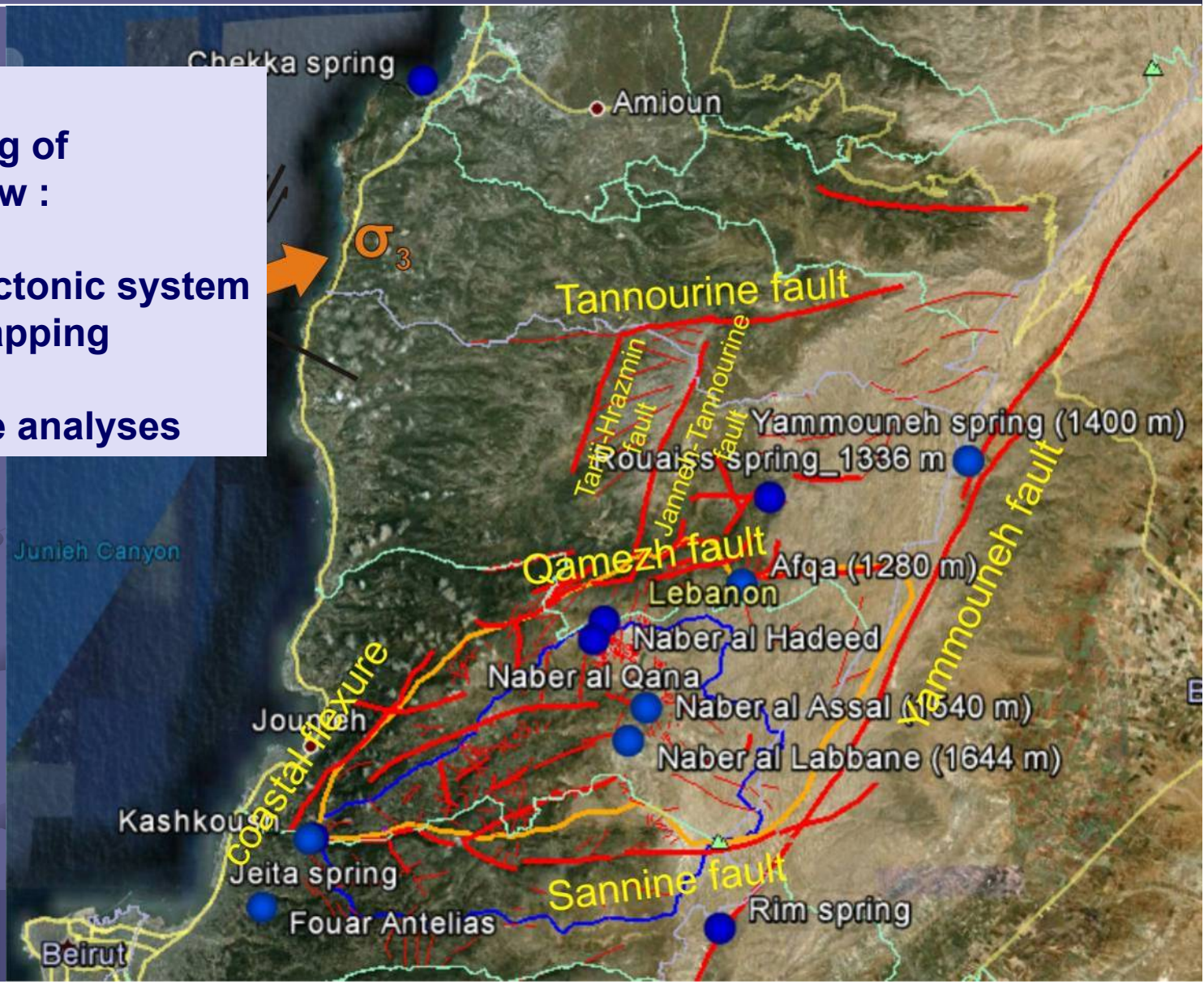


Groundwater Flow

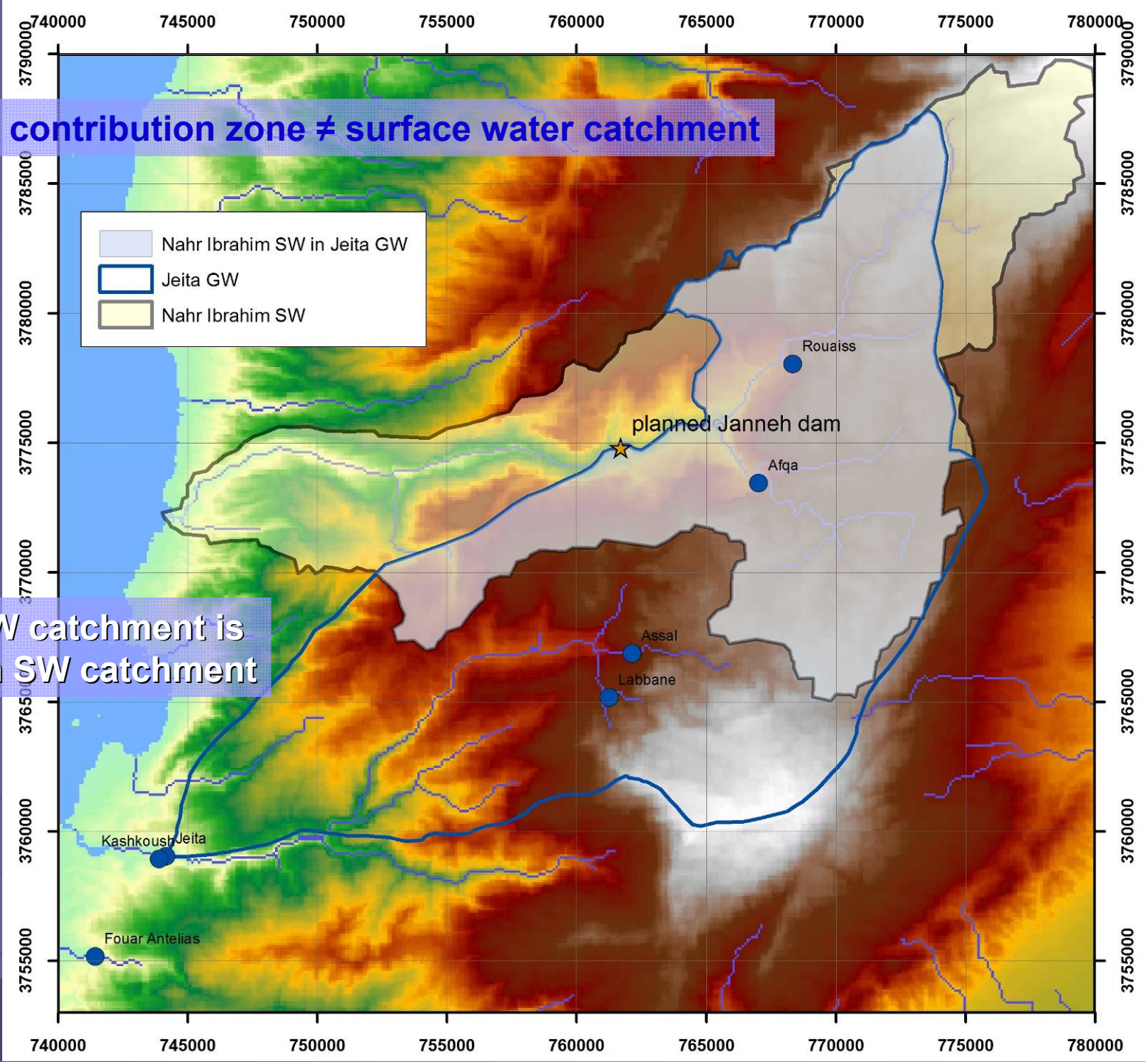
controlled by
- structure (base) and
- tectonics

key elements to understanding of groundwater flow :

- **analysis of tectonic system**
- **geological mapping**
- **tracer tests**
- **stable isotope analyses**



Groundwater contribution zone ≠ surface water catchment

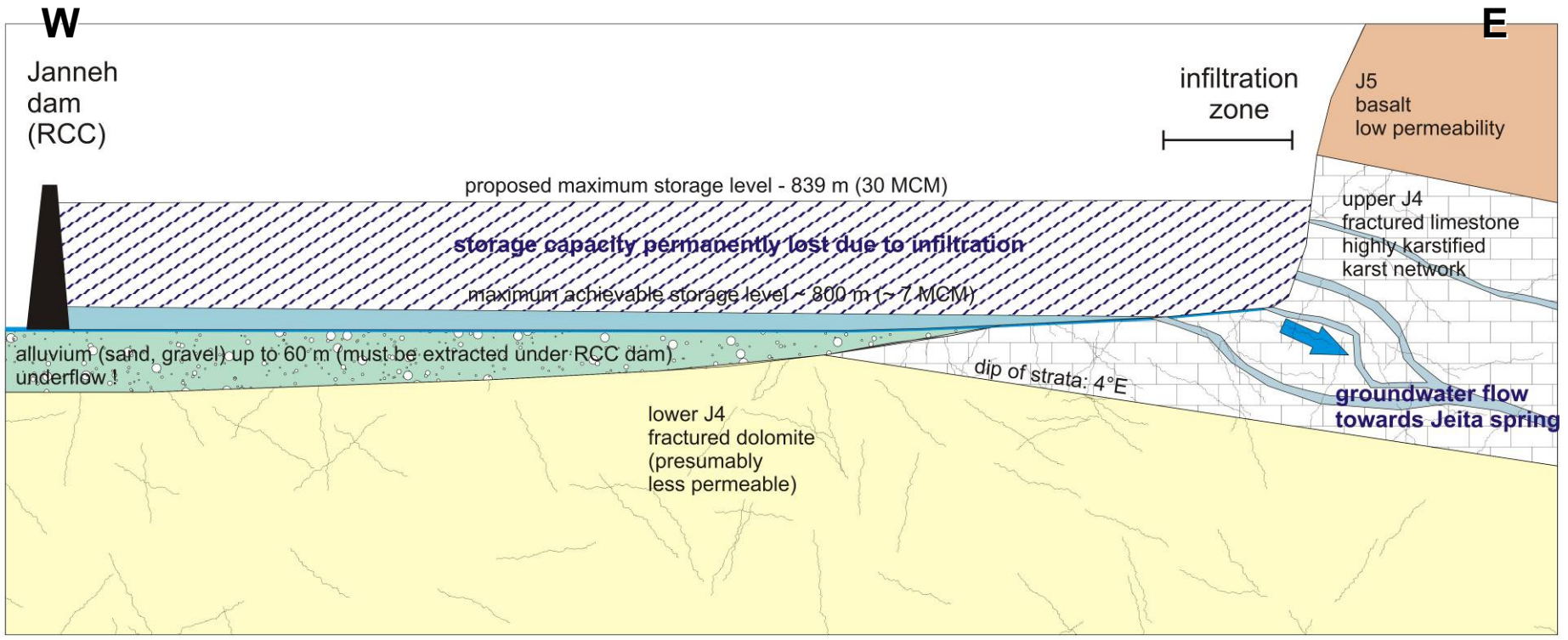


50% of Jeita GW catchment is in Nahr Ibrahim SW catchment

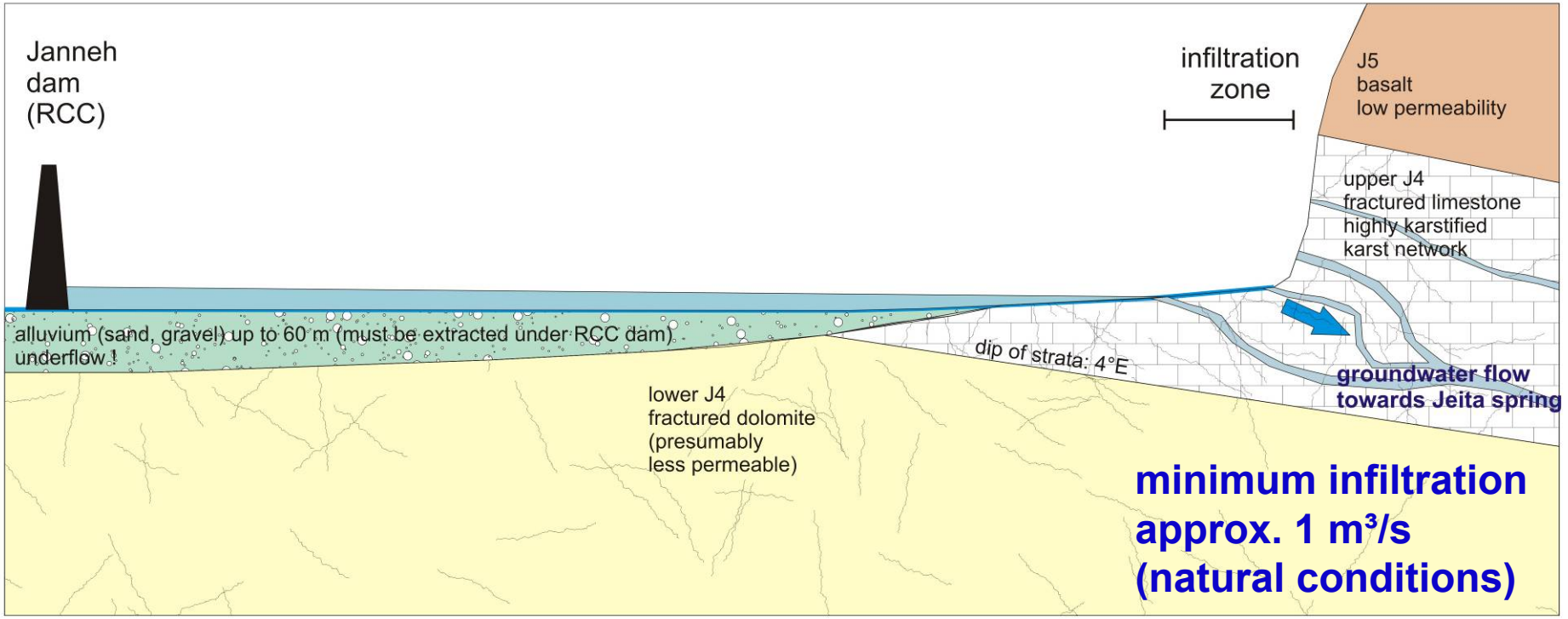
Groundwater Management

Consequences for Planning of Janneh Dam

Janneh dam


W
E
Janneh
dam
(RCC)
infiltration
zone
J5
basalt
low permeability
proposed maximum storage level - 839 m (30 MCM)
upper J4
fractured limestone
highly karstified
karst network
storage capacity permanently lost due to infiltration
maximum achievable storage level ~ 800 m (~ 7 MCM)
alluvium (sand, gravel) up to 60 m (must be extracted under RCC dam)
underflow !
dip of strata: 4°E
groundwater flow
towards Jeita spring
lower J4
fractured dolomite
(presumably
less permeable)

Janneh dam


Janneh
dam
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karst network
alluvium (sand, gravel) up to 60 m (must be extracted under RCC dam)
underflow !
dip of strata: 4°E
groundwater flow
towards Jeita spring
lower J4
fractured dolomite
(presumably
less permeable)
minimum infiltration
approx. 1 m³/s
(natural conditions)

Planned Project Activities

1. Integration of water resources protection aspects into the investment planning and implementation process in the wastewater sector

- Support of CDR and other institutions concerning the prioritization of wastewater projects as well as the design and site selection for WWTPs, collector lines and effluent discharge locations; ✓
- Support of CDR concerning the preparation of EIAs for wastewater projects, with regards to their impact on the water resources;
- Preparation of best practice guidelines for the implementation of wastewater projects with special consideration of the aspect of ground and surface water protection. ✓

Contamination Risks from Wastewater

Currently wastewater is discharged
- **into injection wells**
- **into open cess pits or**
- **into nearby creeks/rivers/wadis**

residences with no wastewater collection and treatment

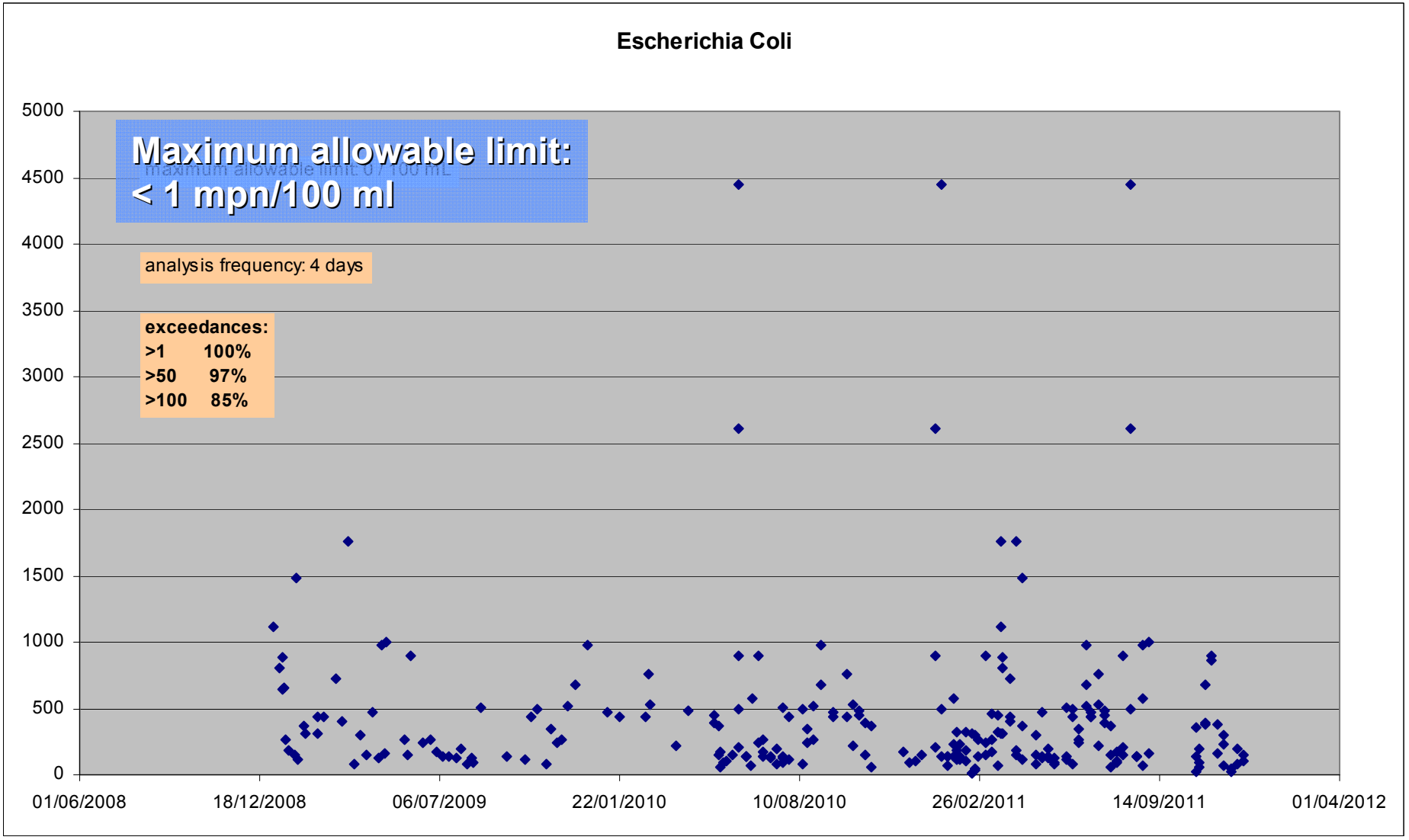
Infiltration of untreated wastewater into highly karstified Jurassic limestone (Faitroun)

► microbiological contamination of Jeita spring


Wastewater is typically „discharged“ through open cess pits or injection wells
KOMATSU
KOMATSU
Permeable areas of the underground are selected so that the cess pits will not need to be emptied so often to avoid costs

Dbayeh raw water (treatment plant)

High and continuous microbiological contamination



Specific Problems concerning Wastewater Treatment

Jeita Catchment

- Topography (WW must be pumped up at several locations; extremely high gradients)
- Electricity not available 24/7 (max 40%)
- Large spacing between residential areas (often only up to 70 % of a village can be serviced by a wastewater scheme)
- Households cannot be forced to connect to WW collector lines
- Municipalities have begun to construct WW collector lines without coordinating with the responsible agencies (aim: divert WW out of the village)
- Their concept, material, etc. does not fit with KfW's/EIBs concept, material, ...

- Geo-risks: karst (sinkholes), tectonics, landslides, rock slides, earthquakes, flooding

► wastewater master plan is urgently needed

Contamination Risks from Wastewater

Currently wastewater is discharged
- into injection wells
- into open cess pits or
- into nearby creeks/rivers/wadis

Some municipalities have started constructing their own wastewater collector lines. These may not fit with those to be established by foreign donor projects in the area (concept, material, diameters, etc.).

► existing network must be removed

overflowing wastewater collector in Hrajel

Wastewater Planning

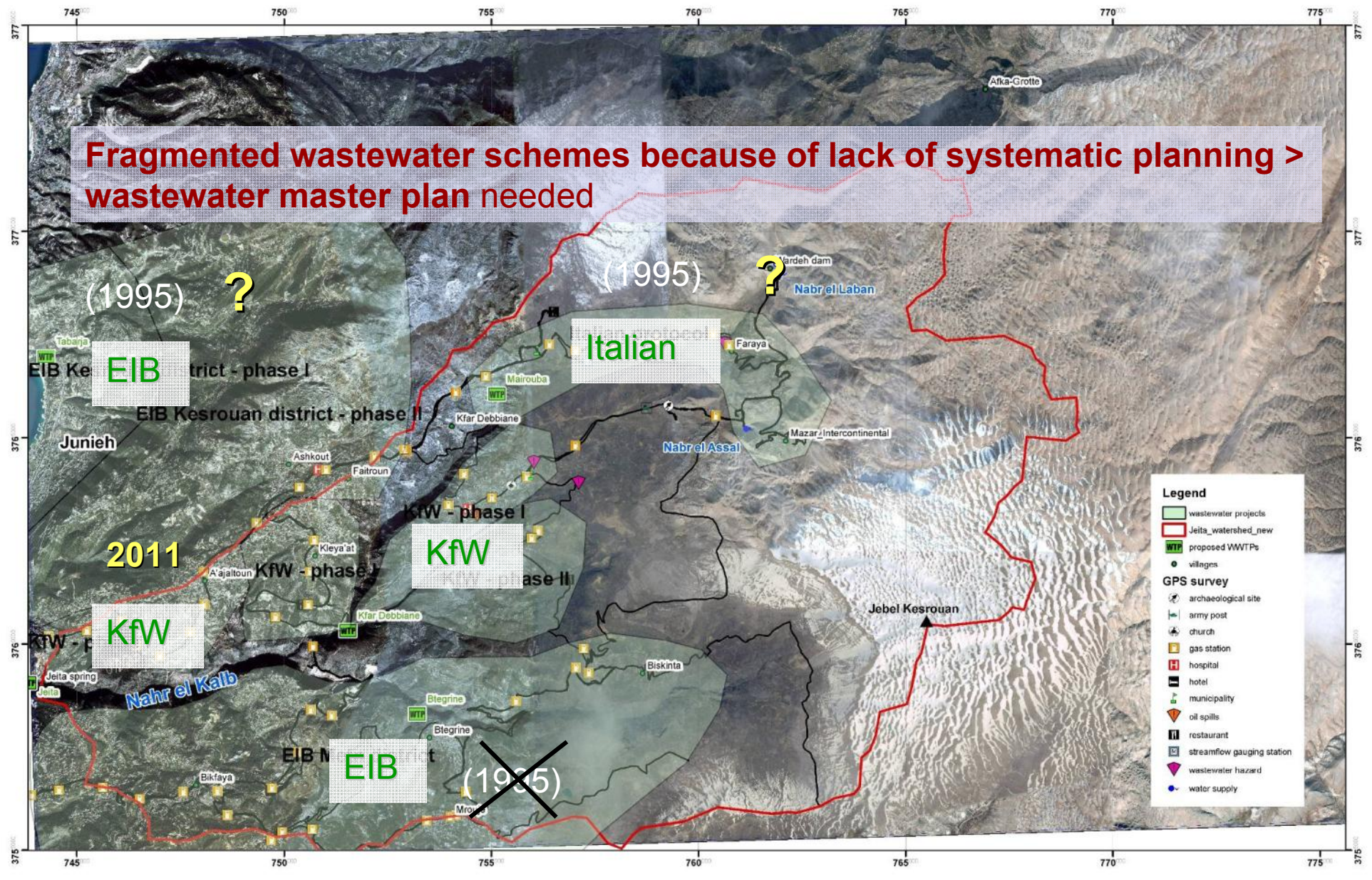
Implementation Procedure (how it should be)

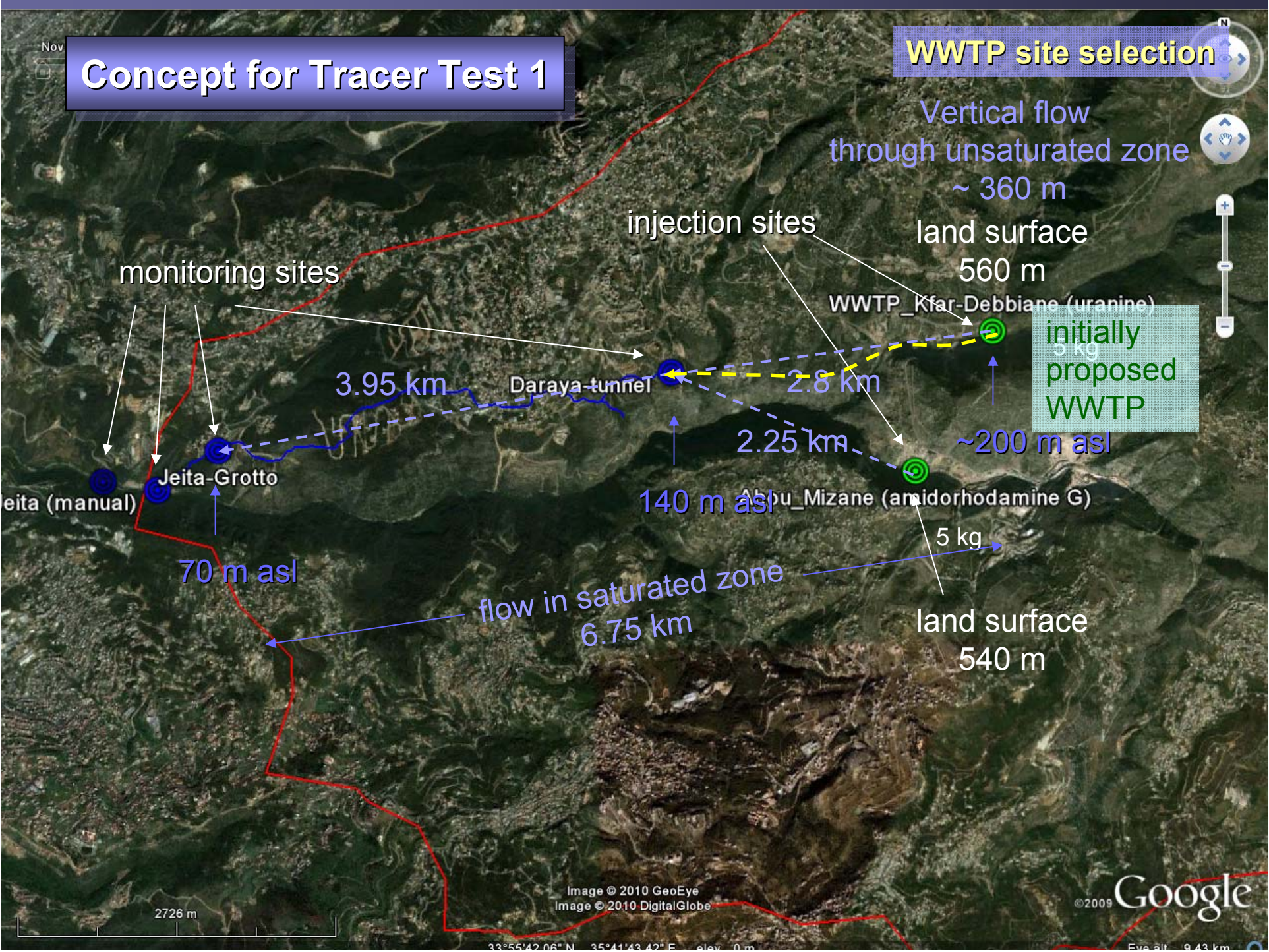
In order to establish a wastewater scheme (collection & treatment),

- a Wastewater Master Plan (WMP) has to be developed. This WMP defines the target for a specific planning horizon (e.g. 25 years), i.e. what principally be done to cover a certain area with adequate collection and treatment facilities. The WMP proposes several individual wastewater schemes and gives a rough estimation of costs.
- An initial site investigation for the proposed wastewater treatment plants (WWTP) has to be conducted to determine their suitability (draft environmental impact assessment (EIA), especially on water resources). Based on this draft EIA the update of the WMP is done.
- The agencies responsible for planning in the wastewater sector (here: CDR, MoEW), according to the available funds, define which wastewater schemes will be implemented, what are the exact boundaries of these schemes and what is the time line for implementation.
- The municipalities involved in the proposed wastewater schemes have to agree to the planned wastewater facilities.
- Tender documents are prepared and a consultant is contracted to build the wastewater scheme.
- The detailed site investigation/planning & EIA for the scheme are prepared by the consultant and discussed with all stakeholders (public participation)
- The wastewater facilities are built and transferred to the agency operating it (WEBML)

Wastewater Projects North of Beirut

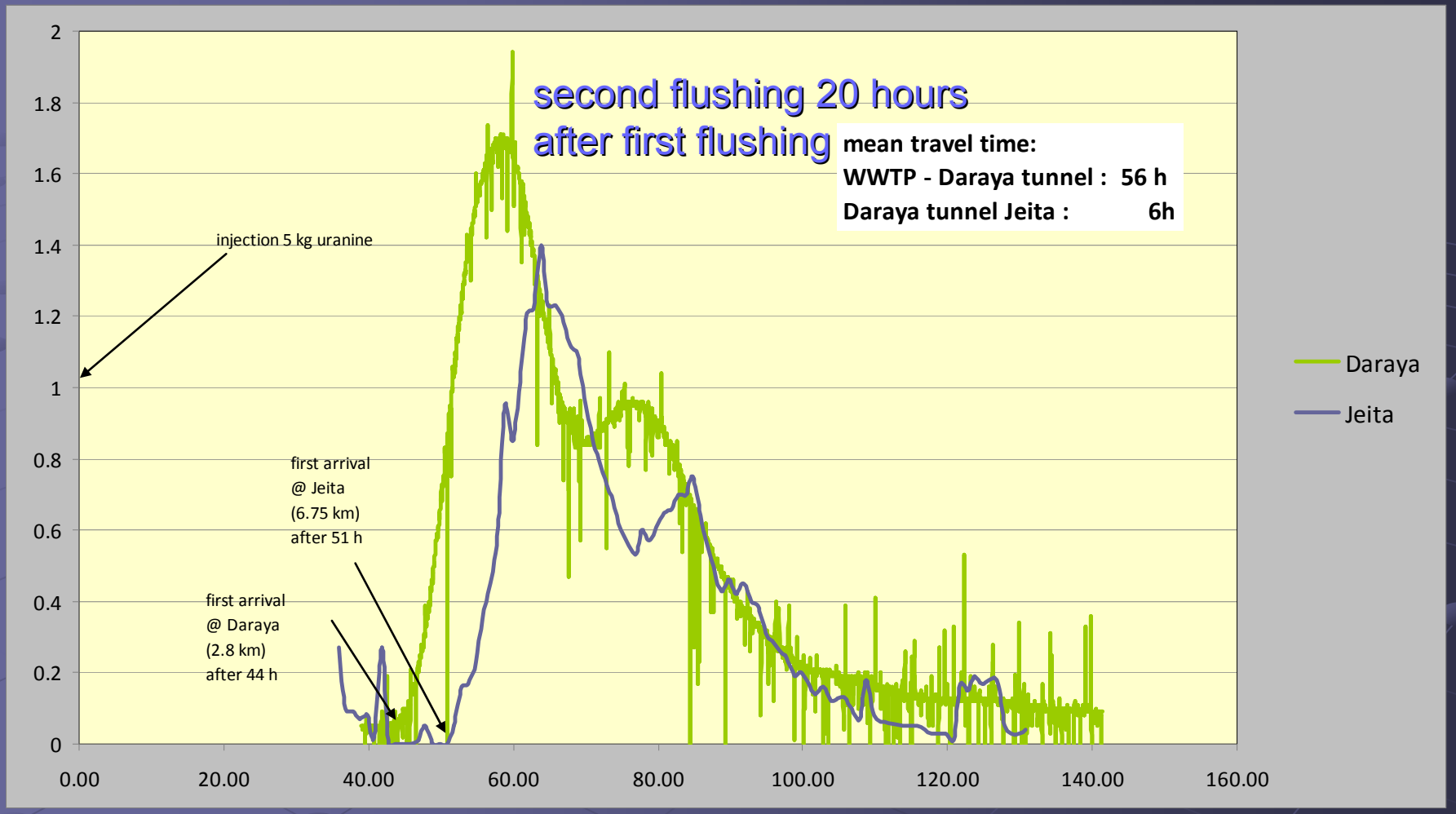
Project Component 1 : Wastewater




Concept for Tracer Test 1
WWTP site selection
Vertical flow
through unsaturated zone
~ 360 m
land surface
560 m
injection sites
monitoring sites
WWTP_Kfar-Debbiane (uranine)
initially
proposed
WWTP
3.95 km
Daraya-tunnel
2.8 km
2.25 km
~200 m asl
Jeita-Grotto
Jeita (manual)
140 m asl
Abou_Mizane (amidorhodamine G)
5 kg
70 m asl
flow in saturated zone
6.75 km
land surface
540 m
Image © 2010 GeoEye
Image © 2010 DigitalGlobe
©2009 Google
2726 m

Results of Test 1

Test 1A - Tracer uranine



Consequence: request to BGR for proposal of alternative locations

Project Activities

Result

Tracer arrival in Jeita after only 62 h leaves no time for attenuation of pollution

In case of by-passing of untreated wastewater (WW) at wastewater treatment plant (WWTP) a direct and concentrated pollution would occur at Jeita

Consequence

No treatment in Nahr el Kalb Valley upstream of spring

KfW asks BGR for proposal of alternate solutions ► TR-1

BGR suggests currently selected option of Jeita WWTP or link to EIB project Zouk Mosbeh (municipality refuses EdL site of EIB project)

➢ Criteria catalogue suggested for planning

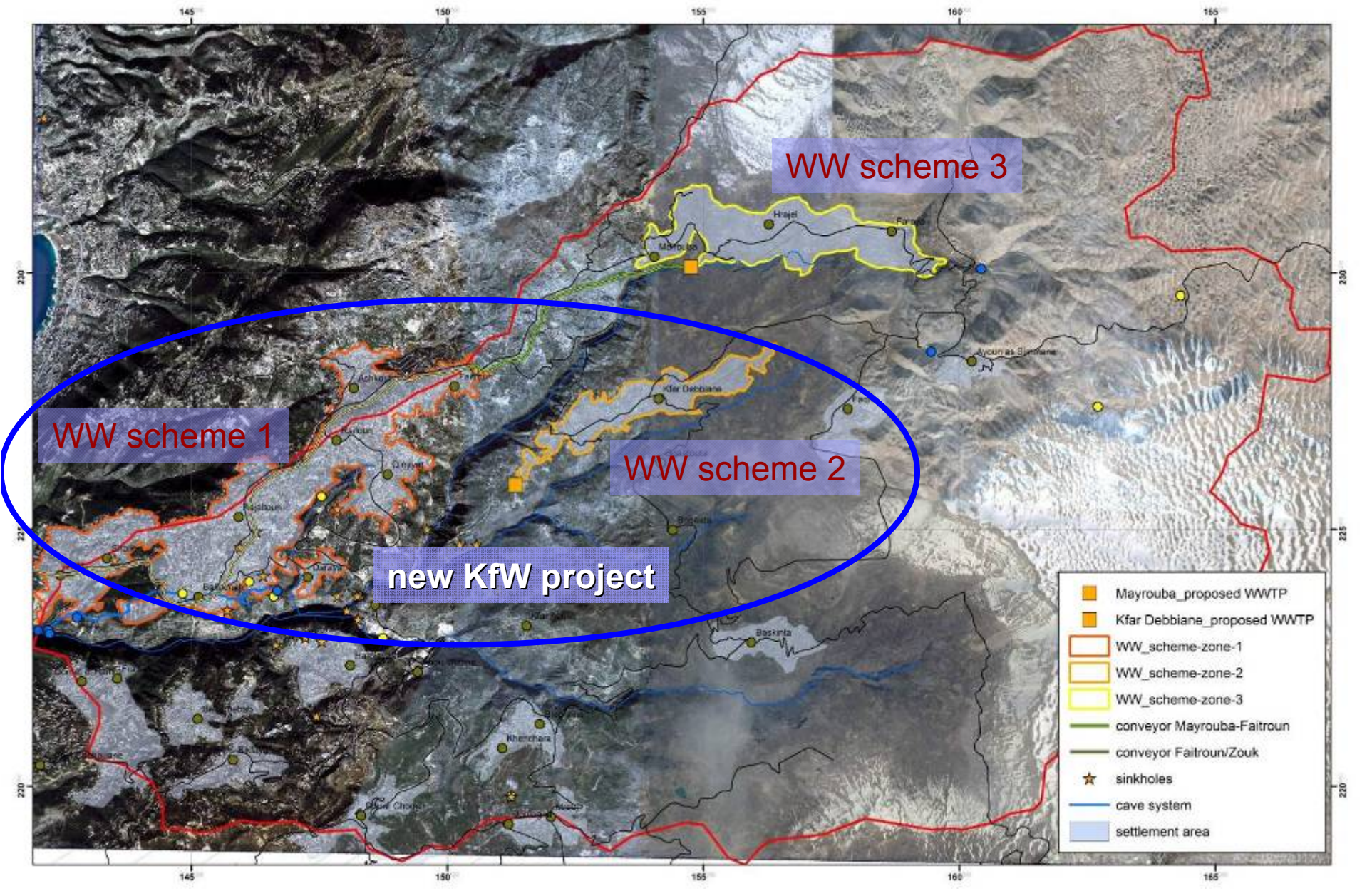
BGR asks KfW to prepare Wastewater Master Plan for entire catchment

► report prepared by GITEC together with BGR

Jeita WWTP selected as best option ► results presented

CDR confirms site selection decision in March 2012

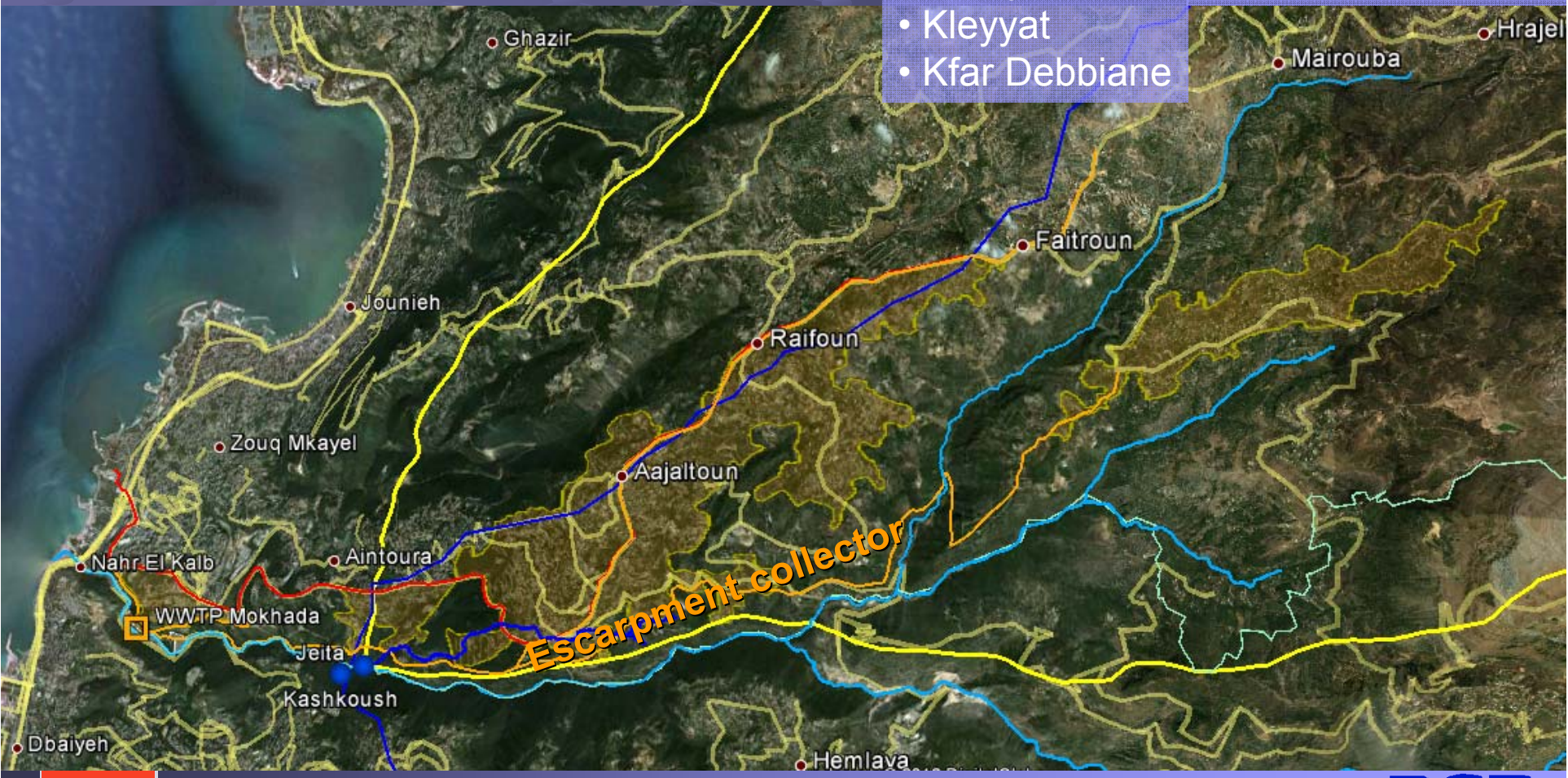
Proposed Wastewater Schemes



KfW Jeita Project

Serviced area
- Jeita
- (Sheile)
- Ballouneh
- Aajaltoun
- Daraya
- Kleyyat
- Kfar Debbiane

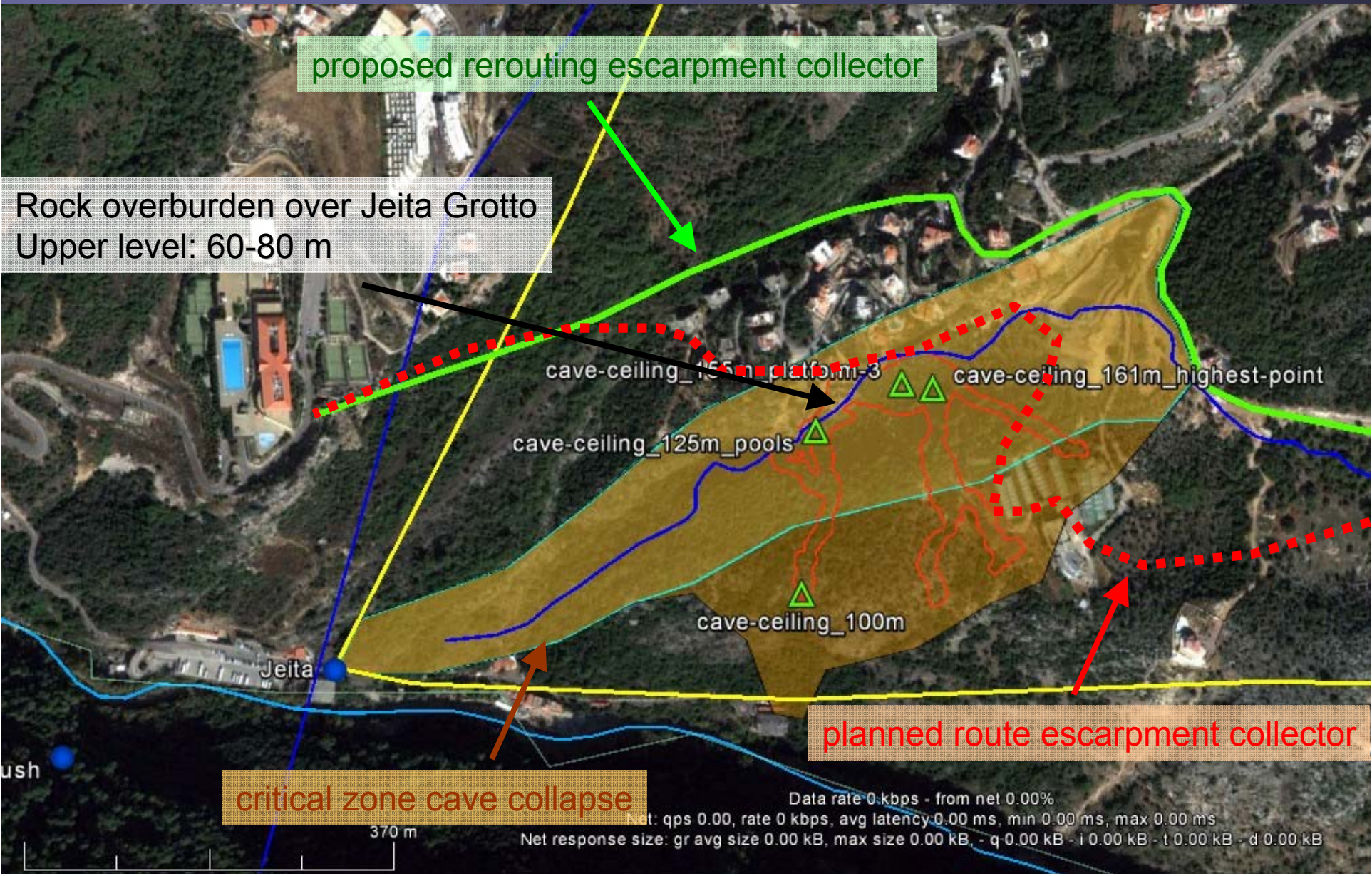
Phase I : 35,000 PE
Phase II: 80,000 PE



KfW Jeita Project

BGR prepares **EIA** for all components of KfW wastewater scheme related to impact on water resources and impact from geohazards (collector line, WWTP site, effluent discharge site)

Geo-risks:
- flooding
- landsides
- rock falls
- land subsidence
- cave collapse
- sinkhole formation
- earthquakes


proposed rerouting escarpment collector
Rock overburden over Jeita Grotto
Upper level: 60-80 m
cave-ceiling_155m_platform-3
cave-ceiling_161m_highest-point
cave-ceiling_125m_pools
cave-ceiling_100m
Jeita
planned route escarpment collector
critical zone cave collapse
370 m
Data rate 0 kbps - from net 0.00%
Net: qps 0.00, rate 0 kbps, avg latency 0.00 ms, min 0.00 ms, max 0.00 ms
Net response size: gr avg size 0.00 kB, max size 0.00 kB, - q 0.00 kB - i 0.00 kB - t 0.00 kB - d 0.00 kB

Reports for Project Component 1

Integration of Water Resources Protection Aspects into the Investment Planning and Implementation Process in the Wastewater Sector

Technical Report 1: **Site Selection** for Wastewater Facilities in the Nahr el Kalb Catchment (January 2011)

Technical Report 2: **Best Management Practice Guideline** for Wastewater Facilites in Karstic Areas of Lebanon (March 2011)

Technical Report 3: Guideline for **Environmental Impact Assessments** related to Wastewater Facilities (draft)

Special Report 4: Proposed **National Standard for Treated Domestic Wastewater Reuse for Irrigation**

And several joint reports with KfW (e.g. EIA for KfW WW facilities)

www.bgr.bund.de/jeita

Best Management Practice Guideline

The guideline gives recommendations on the potential impact on water resources with regards to:

- site selection and design process for wastewater treatment plants, collector lines and effluent discharge points
- selection of the optimal treatment method
- criteria for wastewater reuse
- criteria for sludge management
- proposal for monitoring of the treated wastewater effluent, sludge quality and effects of wastewater reuse and sludge application

► **Technical Report No. 2**

Proposed Standard for Treated WW Reuse

Recommendations:

- Treated industrial wastewater and treated domestic wastewater containing a large share (> 10%) of industrial or commercial wastewater, should not be reused for irrigation.

- Domestic wastewater reuse classes should be based on health concerns, hydrogeological criteria and soil characteristics of the area.
Groundwater vulnerability maps should be used to decide where reuse can be allowed.

- The concept for treated wastewater reuse must be agreed upon with the potential users before the planning of a wastewater facility. Treated wastewater will often have to be pumped to the irrigation area so that treatment for reuse in agriculture will be significantly more costly.

- Public awareness for farmers is needed in order to provide an agricultural production which is safe for human consumption. Moreover the safety of farm workers and local population around farms needs to be taken into consideration.

Proposed Standard for Treated WW Reuse

continued

Recommendations:

• Monitoring of treated wastewater quality is very important in order to provide that no pollution will occur. Monitoring will require a massive increase in laboratory capacities, which needs to be planned for now.

- where to monitor
- what to monitor
- how often to monitor

• The government agency responsible for the operation of the treatment plant should also be responsible for the monitoring of treated wastewater reuse. All impacts of treated domestic wastewater reuse for irrigation on soil, groundwater and humans have to be monitored regularly.

► **Special Report No. 4**

EIAs for Wastewater Facilities

Current situation:

- No clear procedure for EIAs (Min of Environment too weak)
- No guidance how to prepare EIAs (some donors have their own guidance documents & rules)
- No rules for which facilities and sizes EIAs have to be prepared
- No rules for public participation

Proposed EIA Guideline for WW Facilities:

► **Technical Report No. 3**

- Standard outline
- Integration of all relevant geoscientific aspects
  - impacts on water resources
  - impacts from geohazards (tectonic movements, earthquakes, landslides, rock falls, rock collapse structures, soil liquefaction, soil stability, flooding)

Potential negative impacts on the quality of water resources must be considered separately for all individual components of a proposed wastewater facility or scheme (collector lines, treatment plant, effluent discharge location) and mitigation measures must be proposed for each of those

Standard Outline of EIA for WW Facilities

1	Introduction
2	Legislative and Institutional Frameworks
3	Description of the Project
4	Description of the Environment
5	Impact Identification and Analysis
6	Mitigating Adverse Project Impacts
7	Environmental Management Plan
8	Public Involvement and Participation
9	References

Annex 1:	Topographic Map of the Study Area
Annex 2:	Geological Map of the Study Area
Annex 3:	Hydrogeological Map of the Study Area
Annex 4:	Map showing all Components of the Proposed Wastewater Facility (overview and detailed views)

Impact on Water Resources

Impacts on water resources might be caused by :

- inadequate site selection
- inadequate design (methods, technology, capacities, diameters, etc.)
- inadequate materials
- mistakes during installation/construction
- mistakes during operation (e.g. inadequate maintenance, monitoring, etc.)
- impacts of geohazards

Impact of Geohazards

- tectonic movements
- earthquakes
- landslides
- rockfalls
- rock collapse structures (e.g. dolines)
- land subsidence
- soil liquefaction (instable soil)
- flooding

2. Integration of water resources protection aspects into landuse planning

- Determination of the vulnerability of the groundwater system, preparation of an inventory of hazards to groundwater, and determination of the risk of groundwater pollution; ✓
- Delineation of groundwater protection zones for the Jeita Spring and, if possible, other springs and wells used for drinking water supply in the Jeita groundwater catchment; ✓
- Support of the relevant governmental institutions in implementing the proposed protection zones and urgent protection measures; (✓)
- Providing advice to MoEW concerning the establishment of a legal basis for the implementation of protection zones for ground and surface water resources. (-)
- Conducting Awareness Campaigns on GW Protection with schools, municipalities, army, other institutions (e.g. chamber of commerce) ✓

Groundwater Protection Zones

In porous aquifers:
relatively uniform infiltration and groundwater movement
- travel time, e.g. 50 days (Germany) or 10 days (Switzerland)

In karst systems groundwater protection is very difficult:
- diffuse infiltration through fractures (matrix)
- concentrated infiltration through karst network (sinkholes, dolines, conduits)
- non-uniform GW flow

International practice:
Delineation using GW vulnerability maps
- EPIK (used in CH)
- COP (proposed for entire EU), modified

GW Vulnerability Mapping
EPIK & COP

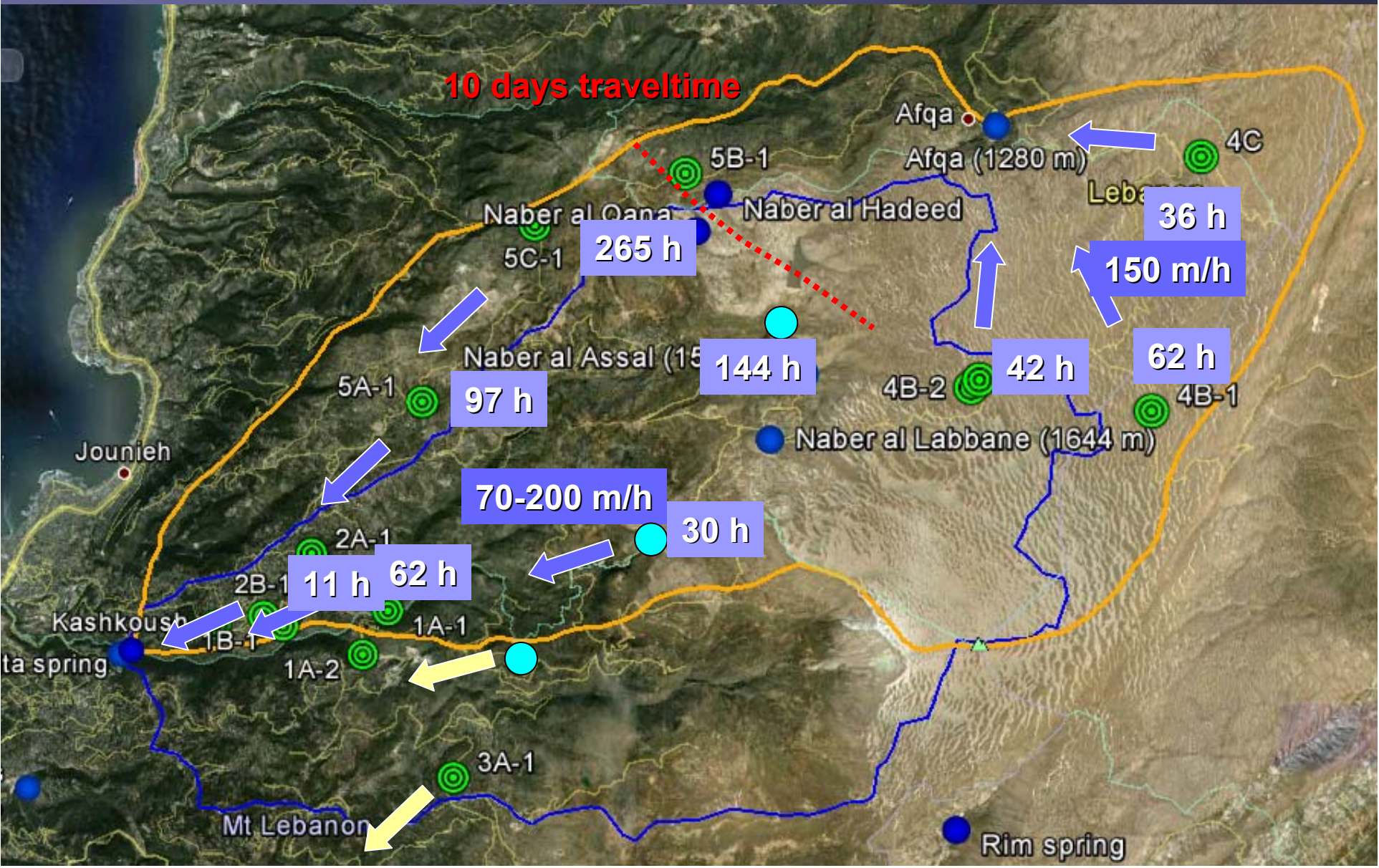
- Geology ► geological mapping
- Karst features ► karst feature mapping
- Soil ► soil mapping

➢ Groundwater Vulnerability Map

➢ Groundwater Protection Zones

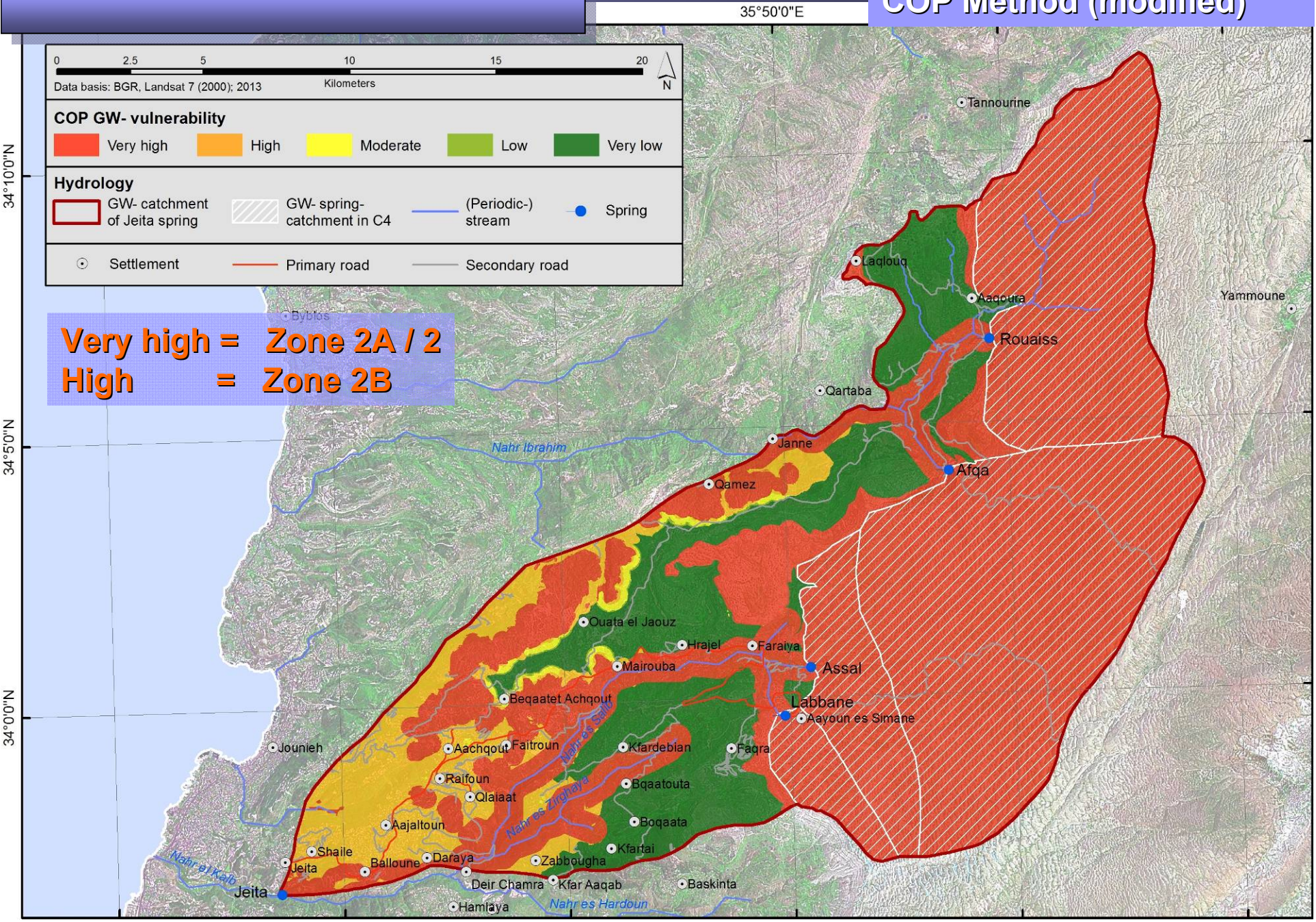
Groundwater Flow

Mean travel times



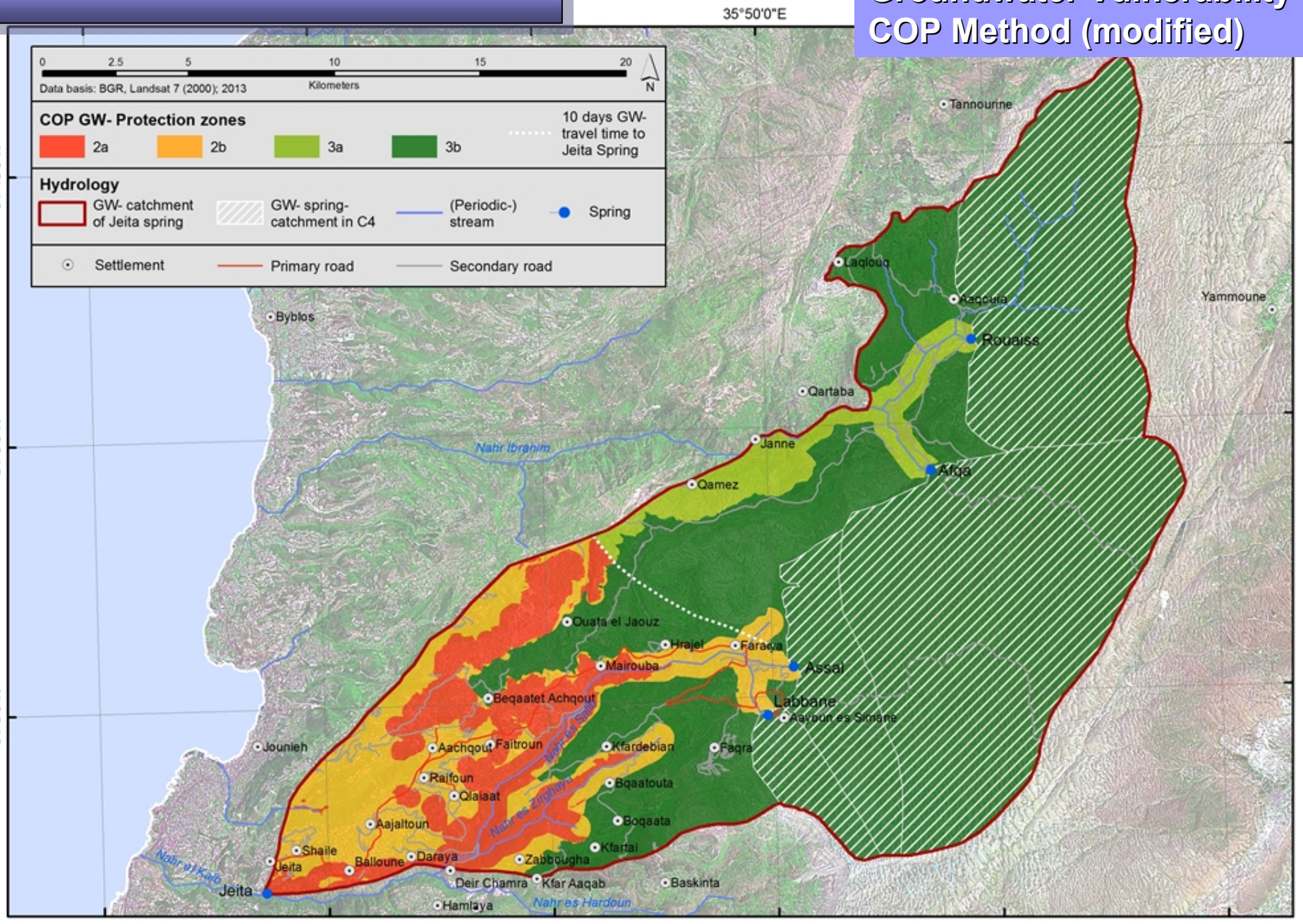
Groundwater Protection Zones

Groundwater Vulnerability COP Method (modified)



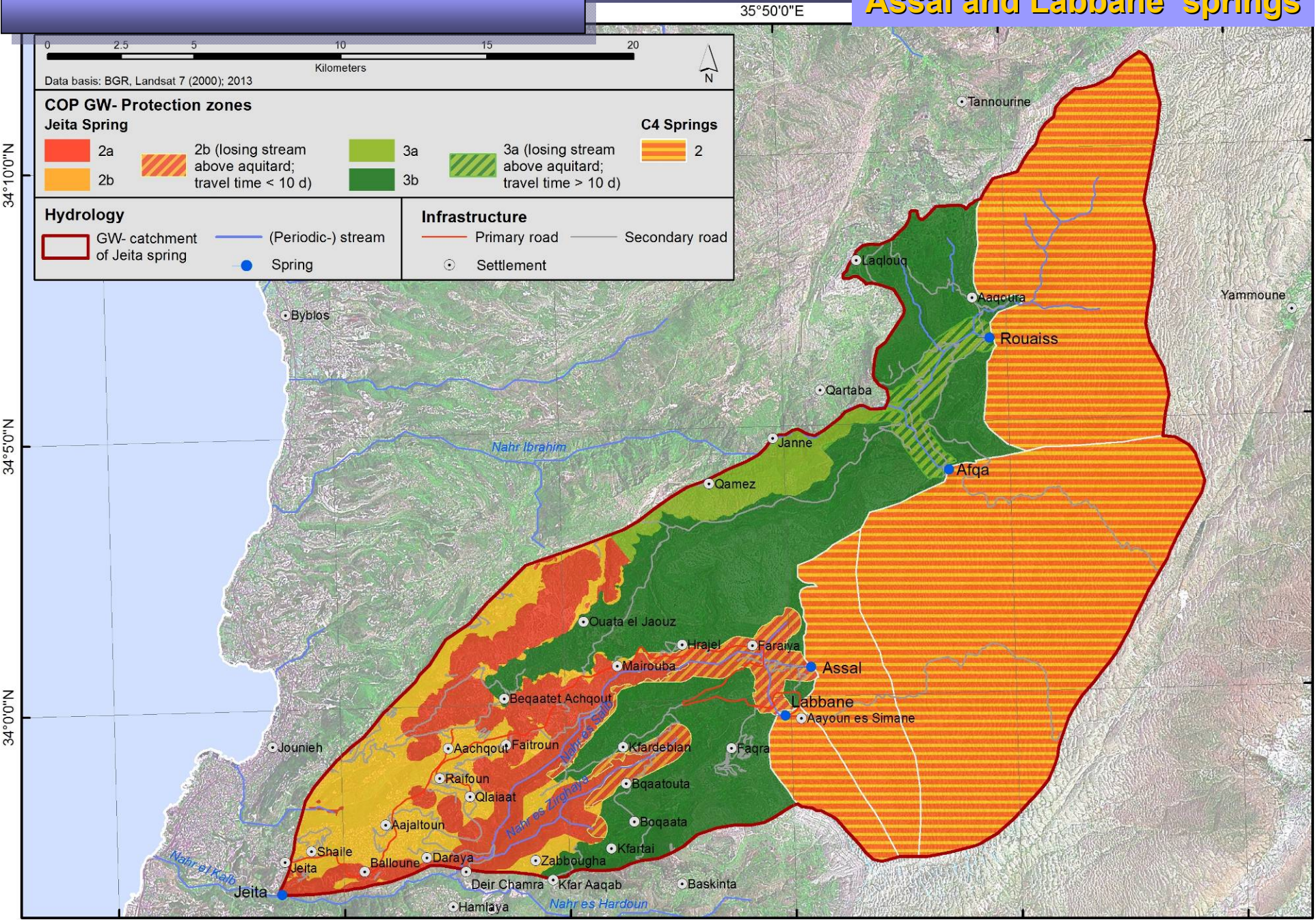
Groundwater Protection Zones

for Jeita Spring based on Groundwater Vulnerability COP Method (modified)



Groundwater Protection Zones

for Jeita, Afqa, Rouaiss, Assal and Labbane springs



Integration of Water Resources Protection Aspects into Landuse Planning

Technical Report 4: **Geological Map, Tectonics and Karstification** in the Groundwater Contribution Zone of Jeita Spring (September 2011) ✓

Technical Report 5: **Hydrogeology** of the Groundwater Contribution Zone of Jeita Spring (~ June 2013)

Technical Report 7: **Groundwater Vulnerability** in the Groundwater Catchment of Jeita Spring and **Delineation of Groundwater Protection Zones** Using the COP Method (September 2012; January 2013) ✓

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Integration of Water Resources Protection Aspects into Landuse Planning

Special Reports 1 / 2 / 5 / 6 / 11 : Tracer Tests 1-5 (July 2010 - July 2012) ✓

Special Report 7: Mapping of Surface Karst Features in the Jeita Spring Catchment (October 2011) ✓

Special Report 9: Soil Survey in the Jeita Spring Catchment Balance (November 2011) ✓

Special Report 12: Stable Isotope Investigations in the Jeita Spring Catchment (~ April 2013)

Integration of Water Resources Protection Aspects into Landuse Planning

Special Reports 14: Guideline for Gas Stations - Recommendations from the Perspective of Groundwater Resources Protection (May 2012) ✓

Special Report 16: Hazards to Groundwater and Assessment of Pollution Risk in the Jeita Spring Catchment (February 2013) ✓

3. Collection and use of monitoring data concerning quality and quantity of water resources

- Establishment of a monitoring network
  - ► water balance / proposal of water management options
  - ► assessment of water quality problems
- Giving advice to WEBML concerning the use of monitoring data, e.g. concerning the control of the efficiency of the established wastewater treatment facilities or the operation of the water treatment and supply system during times of high contaminant loads.

Spring Monitoring

- multiparameter probes
- gauging stations (weir, ADCPs)
- direct discharge measurement
  (> 300 dilution tests)


Labbane spring


Daraya tunnel

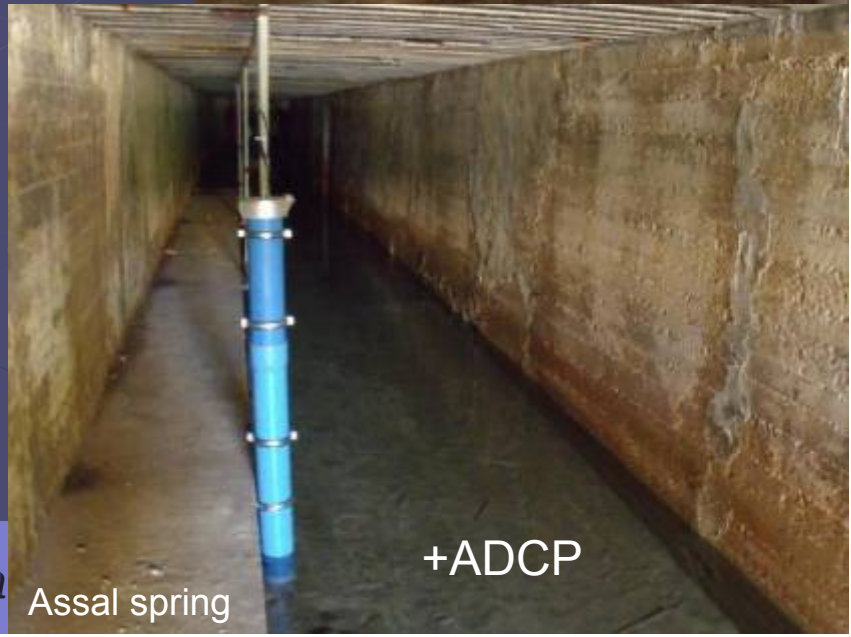

Kashkoush spring


Jeita spring

+ADCP

Multiparameter probes
parameters:
Water level
Temperature
EC
pH
ORP
DO
(ammonium)
(ISE)

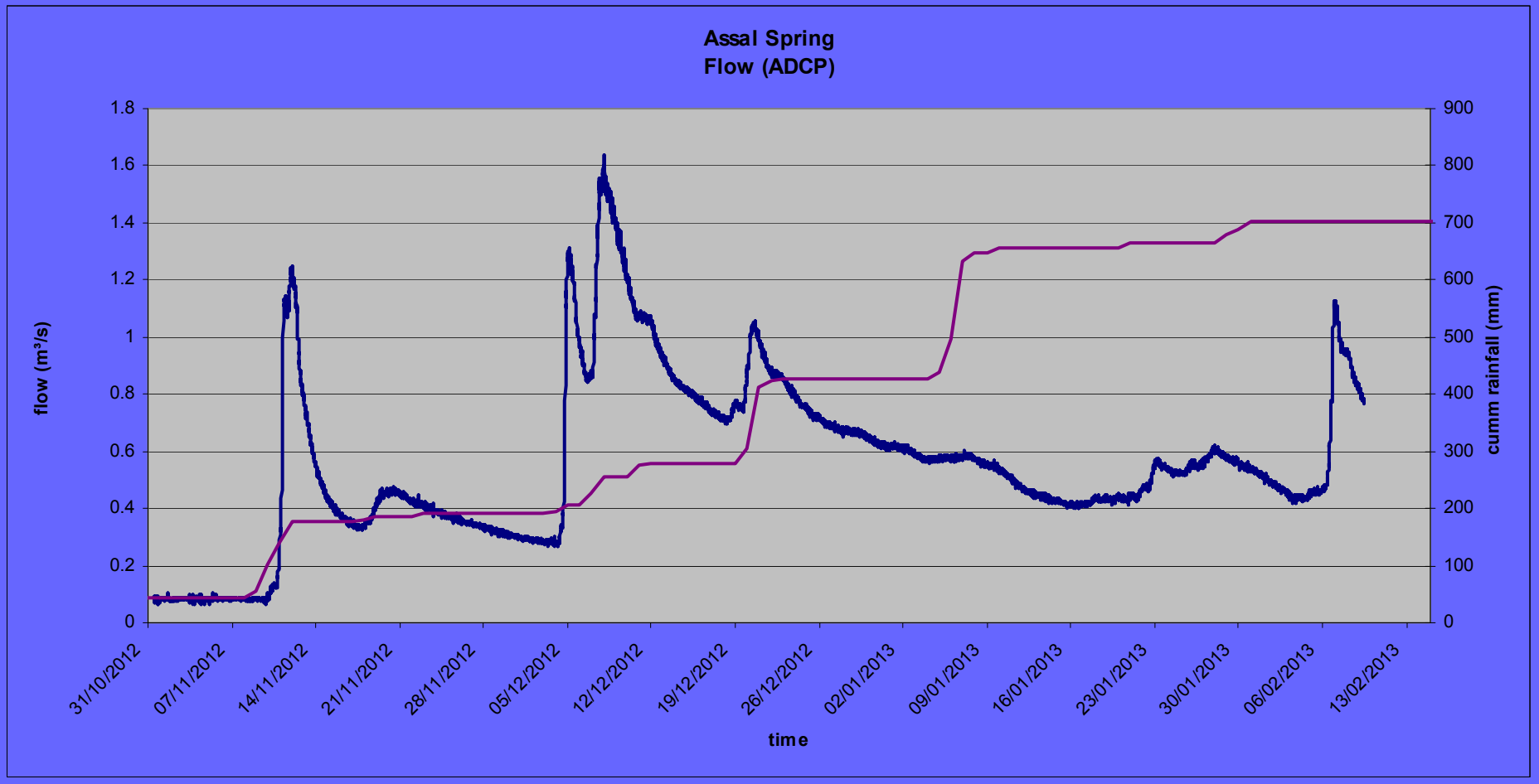
Telemetric data transfer


Assal spring

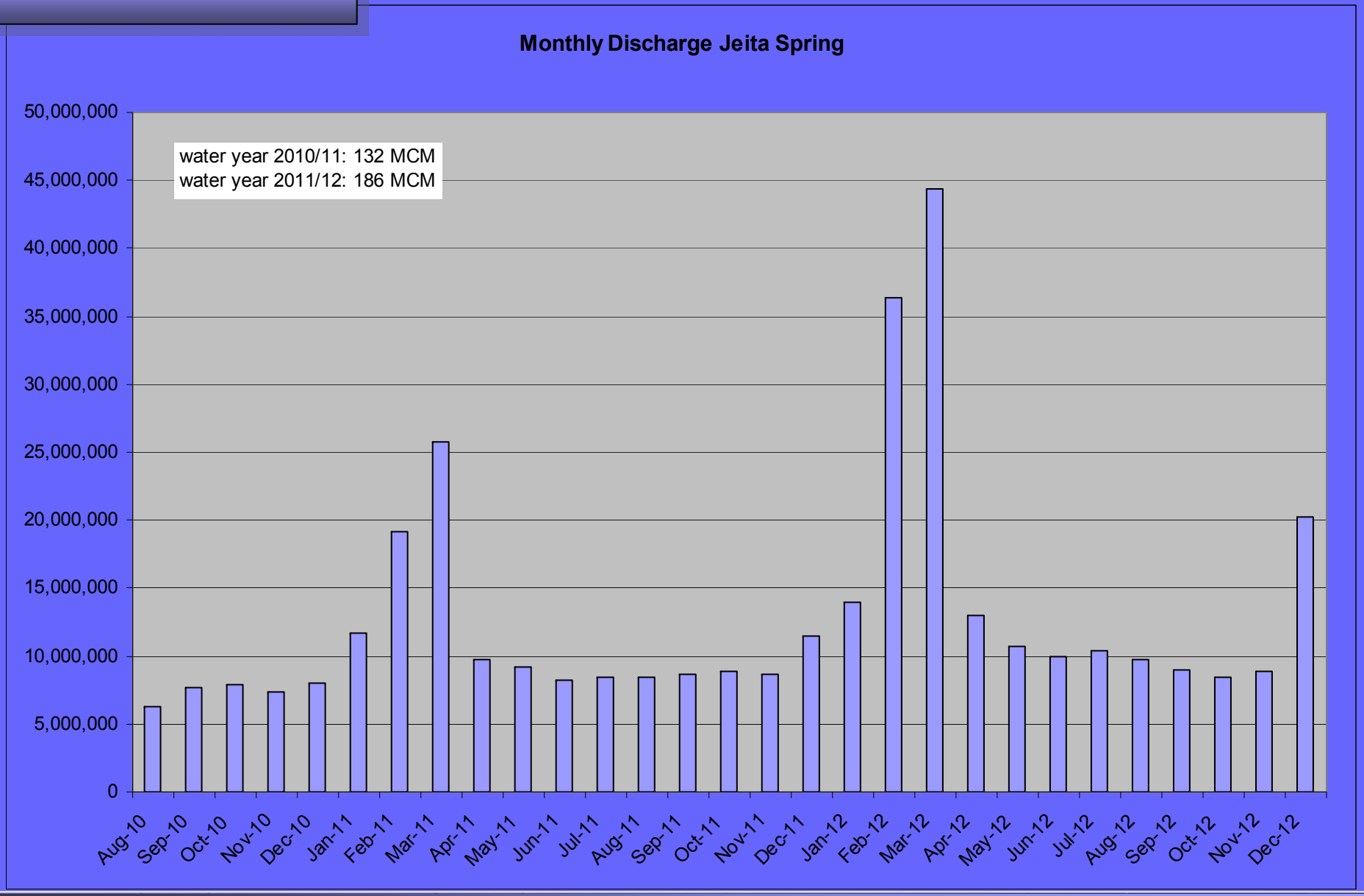
+ADCP

Spring Monitoring

Assal – Monitoring by ADCP & multiparameter probe



ADCP : every **15 min** multiparameter probe: every **20 min**


Monthly Discharge Jeita Spring
water year 2010/11: 132 MCM
water year 2011/12: 186 MCM
50,000,000
45,000,000
40,000,000
35,000,000
30,000,000
25,000,000
20,000,000
15,000,000
10,000,000
5,000,000
0
Aug-10
Sep-10
Oct-10
Nov-10
Dec-10
Jan-11
Feb-11
Mar-11
Apr-11
May-11
Jun-11
Jul-11
Aug-11
Sep-11
Oct-11
Nov-11
Dec-11
Jan-12
Feb-12
Mar-12
Apr-12
May-12
Jun-12
Jul-12
Aug-12
Sep-12
Oct-12
Nov-12
Dec-12

Climate data

Installation of meteorological stations at

- Sheile
- Aajaltoun
- Kfar Debbiane
- Bakeesh
- Chabrouh dam

Surface water data

Proposal for installation of streamflow gauging stations at
- Daraya (Nahr es Salib)
- Daraya (Nahr es Zirghaya)
- Jeita/Kashkoush (Nahr el Kalb)

LRA station 226 Daraya
(Nahr es Salib + Nahr es Zirghaya)

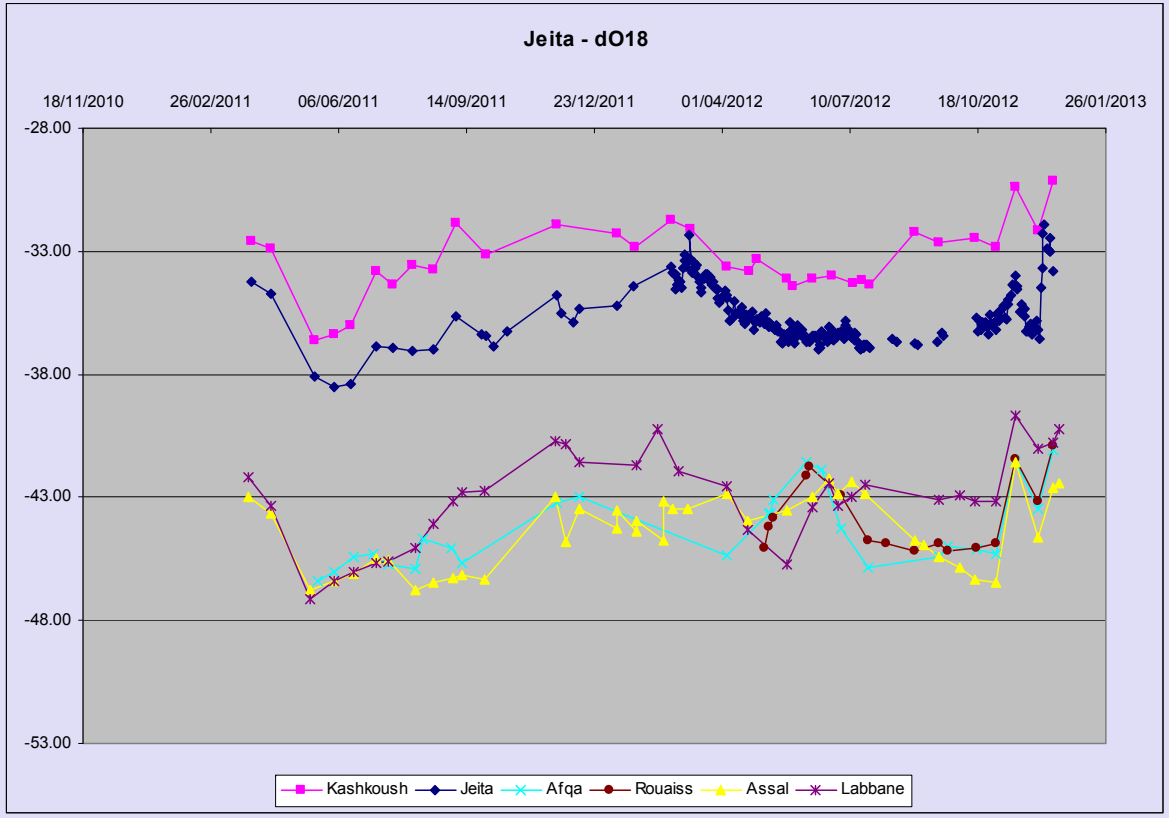
Unsuitable location and profile
Highly turbid flow
Difficult calibration
No maintenance

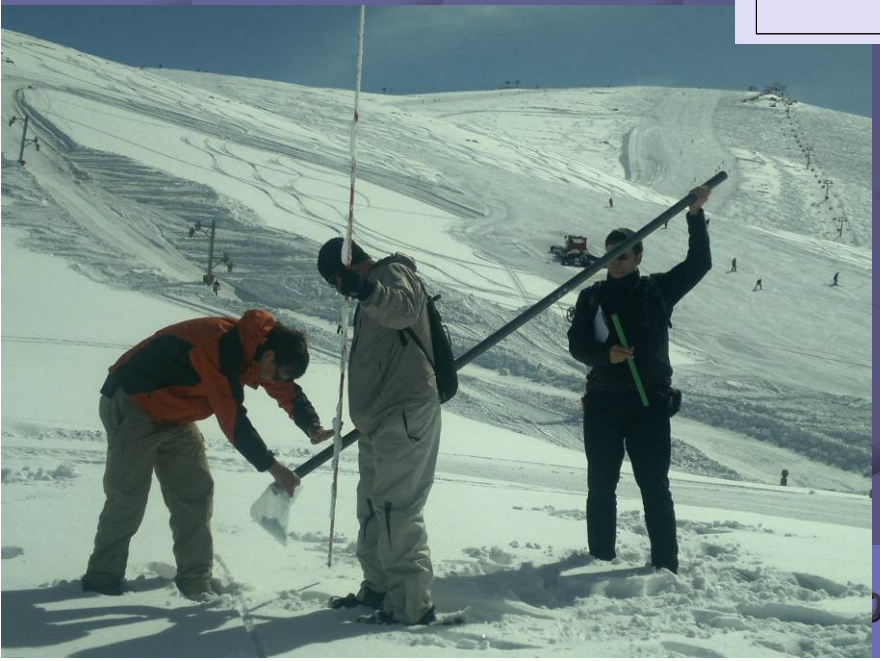
Parshall flume weir Daraya (Nahr es Salib)

Isotope data

- deuterium/oxygen-18
- tritium/helium
- CFC (chlorofluorocarbon)

D/18O > 500 analyses
- 6 springs
- rainfall – 6 stations @ diff elev.
- snow sampling campaigns





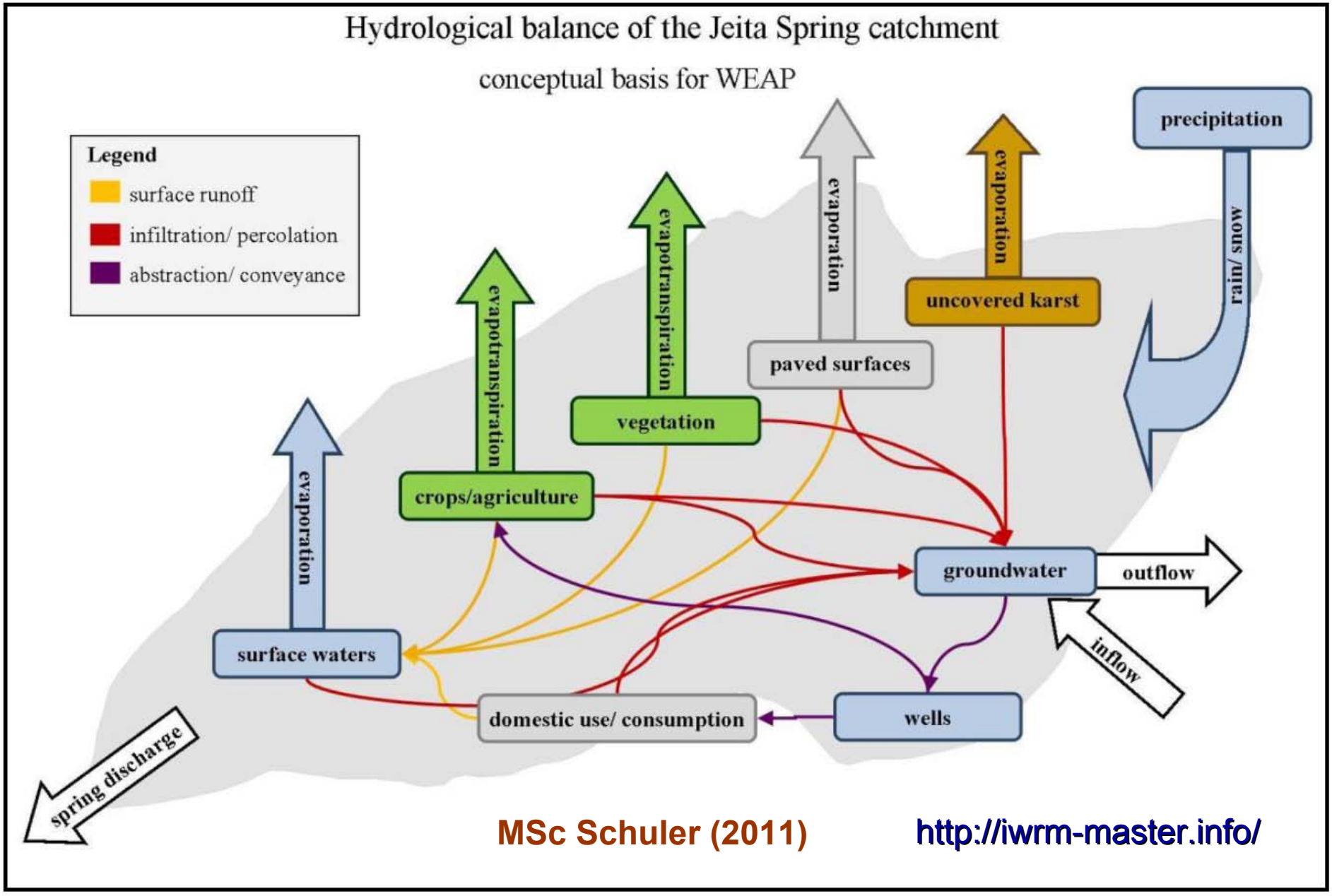
D/^{18}O
Springs Jurassic Aq (J4) :
- Jeita : daily
- Kashkoush : every 15 days

Springs Upper Creataceous Aq (C4) :
- Assal, Labbane, Afqa, Rouaiss : 15 days

Rainfall: Jeita, Sheile, Aajaltoun, Raifoun, Kfar Debbiane, Chabrouh : every 15 days

Snow: integral & 10 cm depth intervals, 2 winter seas.

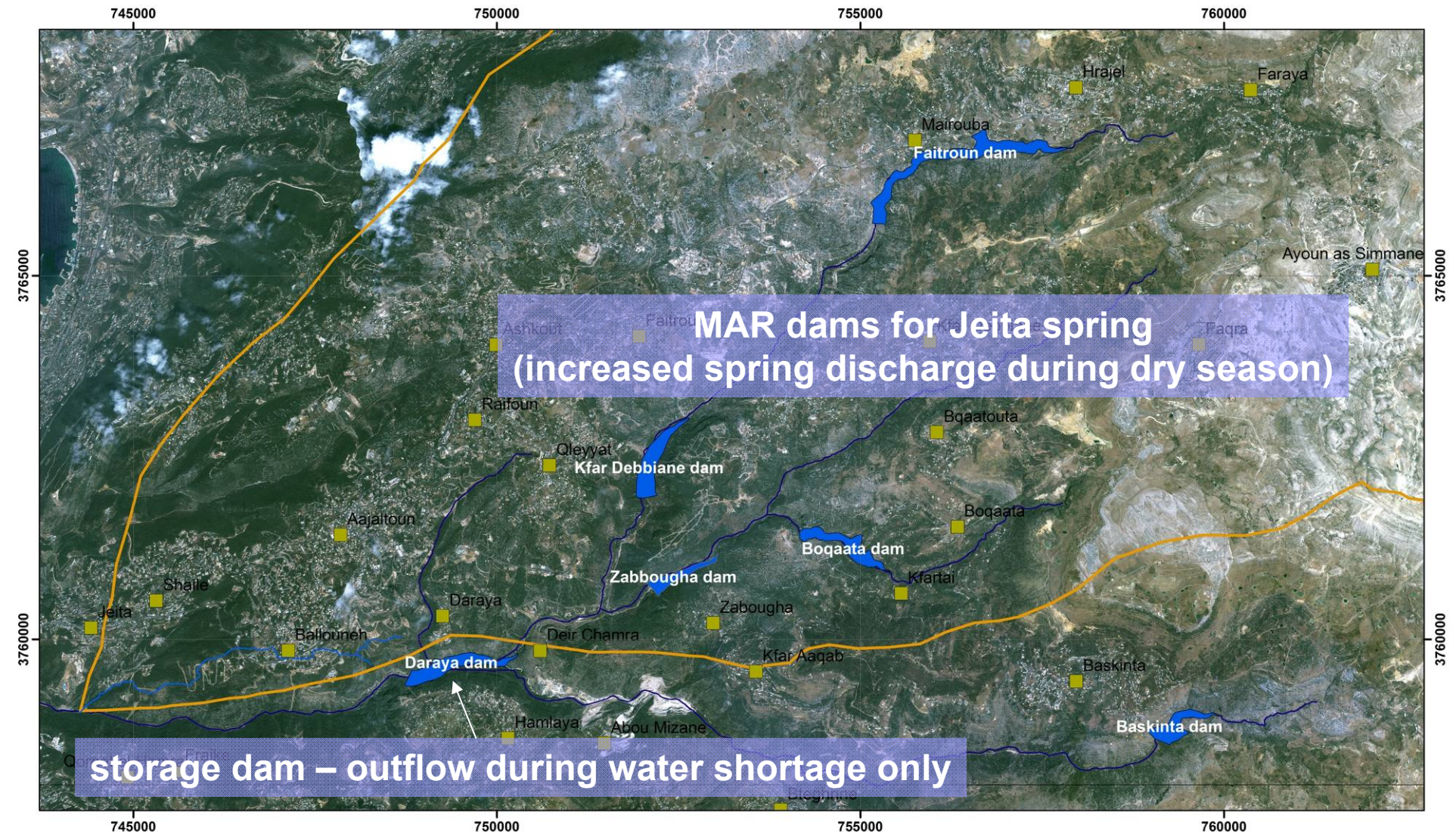
BGR



MSc Schuler (2011)

http://iwrm-master.info/

Proposed Storage & MAR Dams



Collection and Use of Monitoring Data concerning Quality and Quantity of Water Resources

Technical Report 6: Water Balance for the Groundwater Contribution Zone of Jeita Spring using WEAP including Water Resources Management Options and Scenarios (Master Thesis December 2011; ~ August 2012) ✓

Special Reports 8: Monitoring of Spring Discharge in the Jeita Spring Catchment (~ July 2012)

Special Report 10: Mapping of the Irrigation System in the Jeita Catchment (~ October 2012) ✓

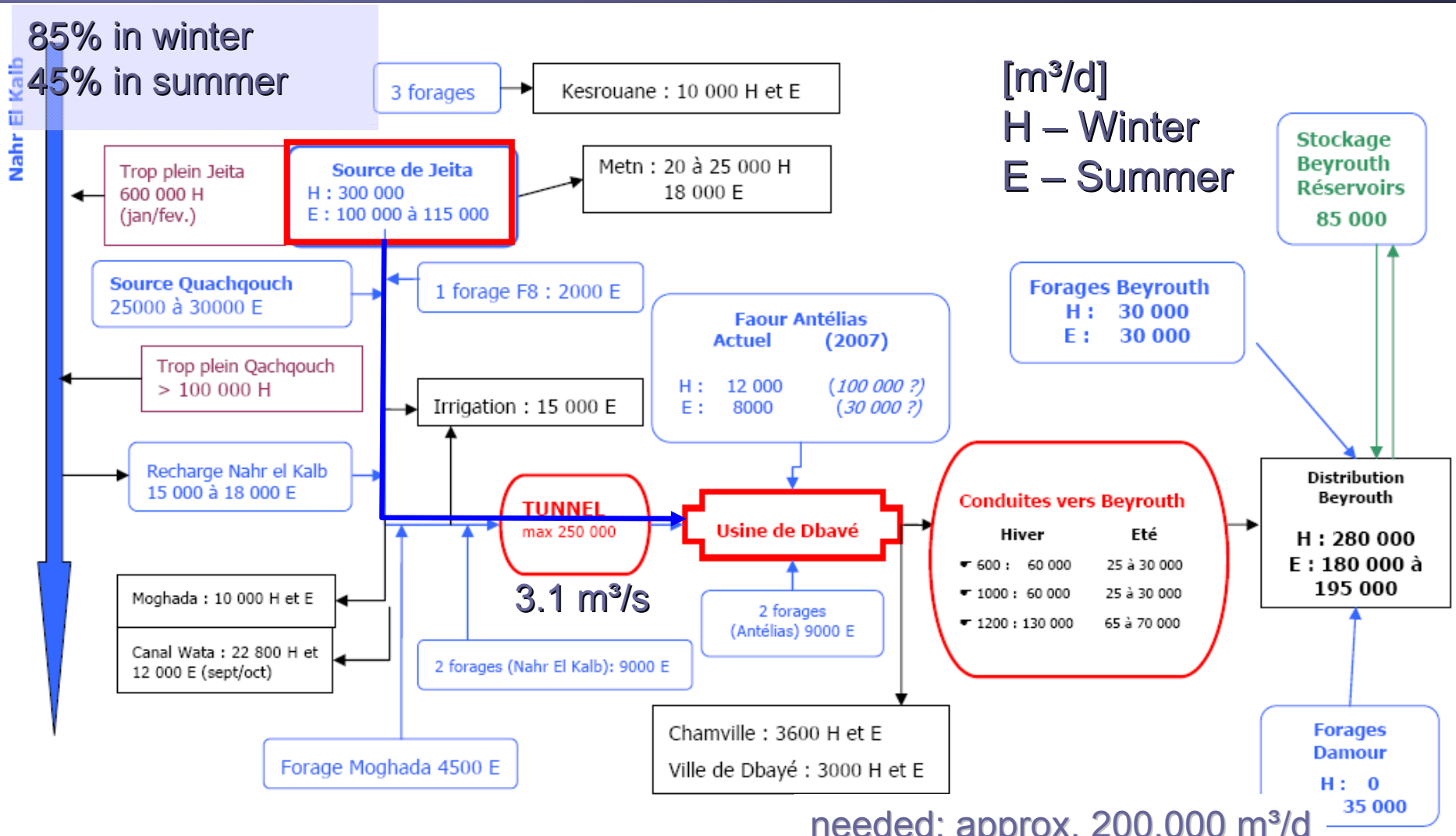
Special Report 13: Micropollutant Investigations in the Jeita Spring Catchment (May 2012) ✓

Advisory Service Document 1: Quantification of Infiltration into the Lower Aquifer (J4) in the Upper Nahr Ibrahim Valley (May 2012) ✓

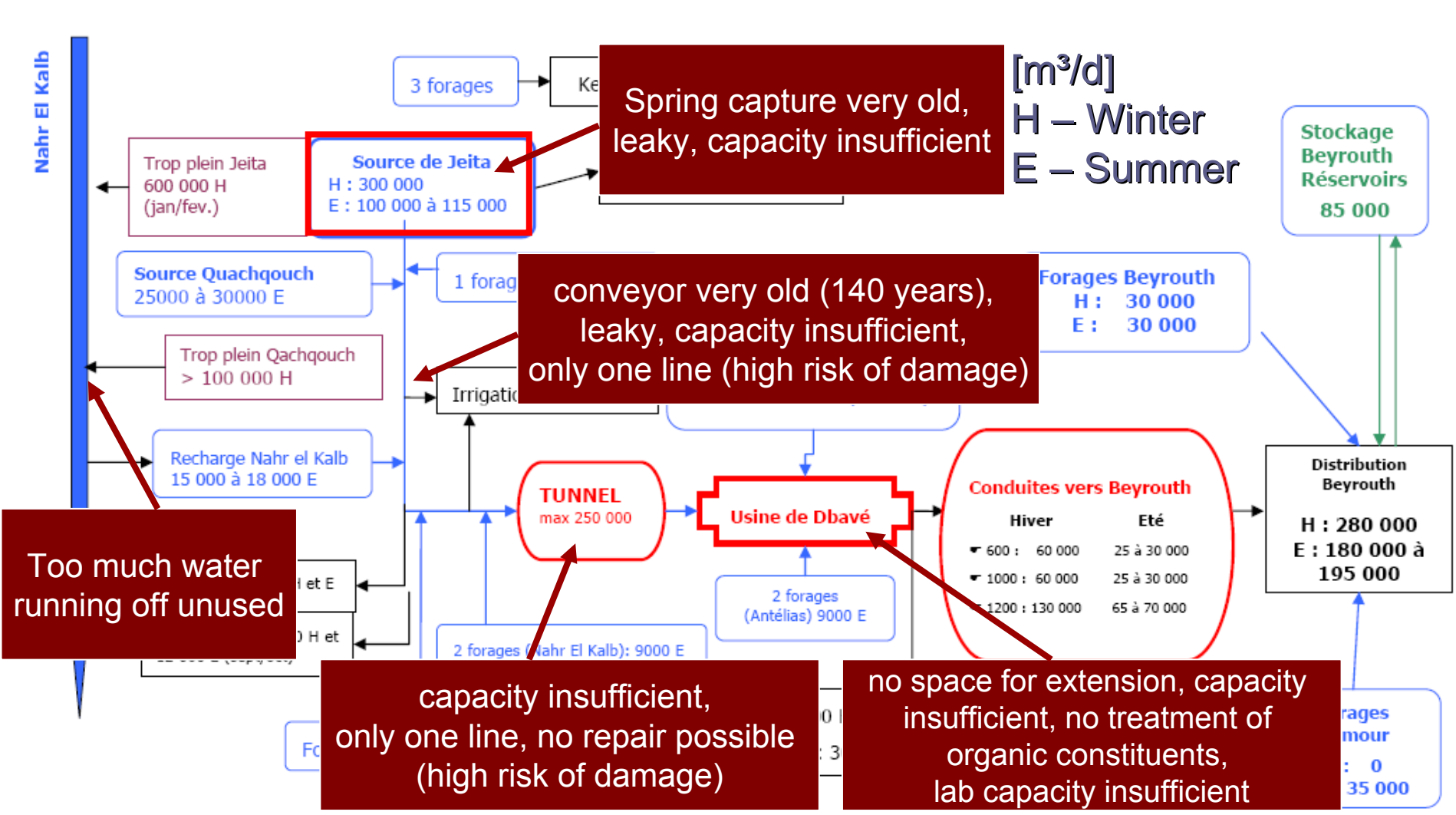
4. Support of the partner institutions concerning the implementation of urgent protective measures

- Proposal for an improved capture of Jeita Spring with the aim to reduce the risk of pollution, and, if feasible its implementation; ✓
- Proposal for an improved water conveyance system from the Jeita Spring to the Dbaye treatment plant with the aim to reduce the risk of pollution. ✓

WEBML Water Supply System



WEBML Water Supply System



WEBML Water Supply System

WEBML Water Supply System – what must be done ?

- Improve capture of Jeita spring → **30-50 Mio USD**
- Establish a new raw water conveyor (pipelines/new tunnel) with increased capacity (7 m^3/s)
  (2 separate lines because one line could be damaged; redundancy)
- Establish dam with medium capacity (Daraya dam: 9 MCM) to overcome water shortages at end of dry season
- Do not allow illegal connections and illegal uses (“irrigation”)
- Increase capacity of treatment & improve treatment process
- Establish water quality monitoring & increase laboratory capacities
- Reduce water losses in Beirut

Thanx to all who have contributed to the project:

Project team:
- Jean Abi Rizk
- Eng. Renata Raad
- Philip Schuler
- Elias Saadeh
- Rony Tabet

BGR STE:
- Dr. Kai Hahne (geological mapping)
- Dr. Anke Steinel (WW BMP & standard)
- Dr. Jobst Maßmann (WEAP model)
- Dr. Paul Königer (stable isotopes)
- Leo Stöckl (hydrology)
- Dr. Rebecca Bahls (tracer test)
- Dr. Annalena Hesshaus (tracer test)

University Göttingen:
- Dr. Joanna Doummar (tracer tests, micropollutants)
- Dr. Tobias Geyer (He/^{3}H isotopes, CFC)
- Prof. Martin Sauter

Partner institutions:
- Eng. Ismail Makki / CDR Director Planning
- Dr. Fadi Comair / MoEW Director Water Resources
- Eng. George el Kadi / WEBML Technical Director
- Eng. Maher Chrabieh / WEBML Director Dbayeh Treatment Plant
- Dr. Paul Souaid / WEBML Director Water Lab

Thank you for your kind attention

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