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

Water Resources Protection for the Water Supply of Beirut

Hydrogeology of Arid Environments
March 14, 2012

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Outline

- Project approach
- Project area and specific problems
- Project activities in the wastewater sector

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.

Project Setup

TC project:

BGR

- Delineate GW/SW 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)

FC project:

KfW

- 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

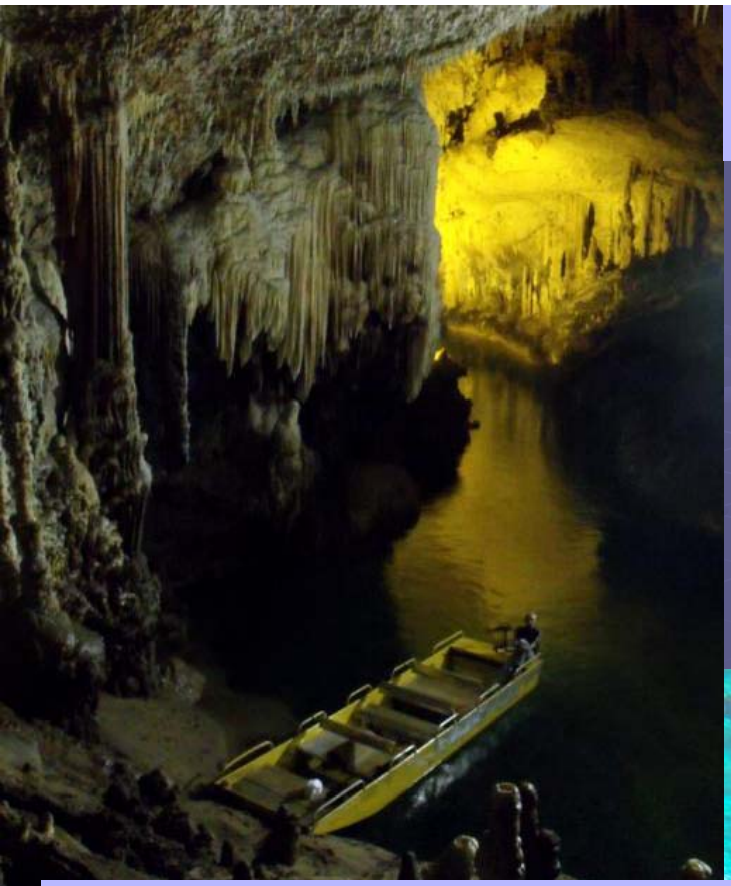
- Council for Development and Reconstruction (CDR)
- Water Establishment of Beirut and Mount Lebanon (WEBML)
- Ministry of Energy and Water (MoEW)

Funding

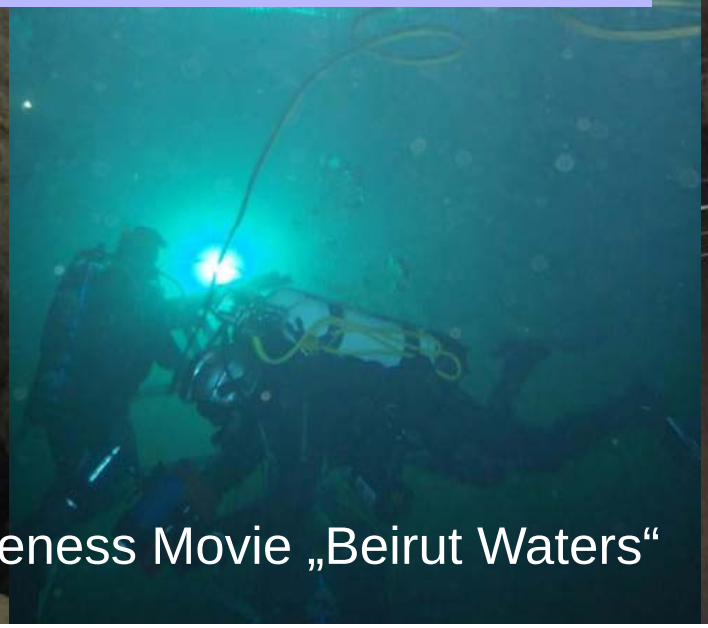
In form of a grant

1st phase	1.2 Mio EUR
extension	0.5 Mio EUR

Jeita Spring
The main Source for Water Supply of Beirut

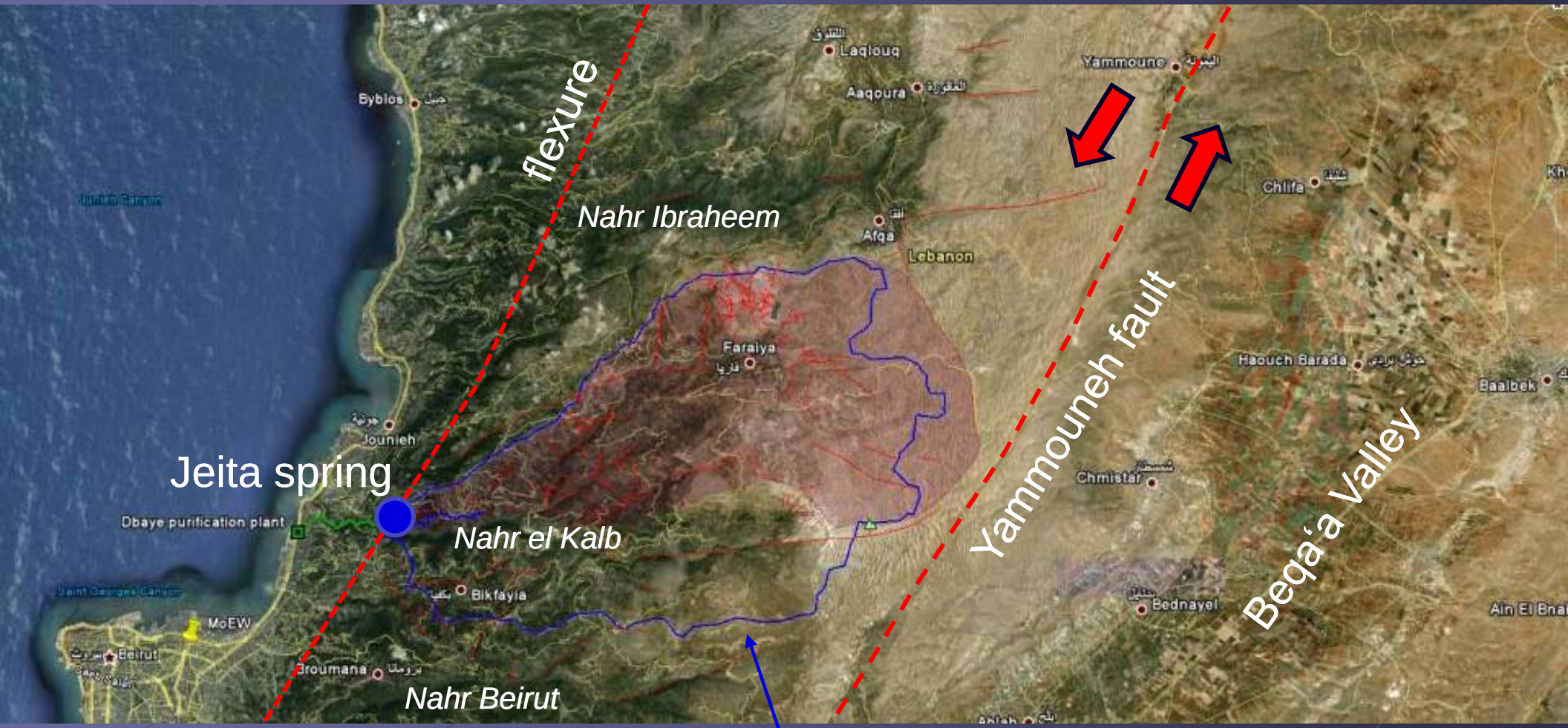


75 % of Beirut‘s water comes from Jeita



Awareness Movie „Beirut Waters“

Project Area

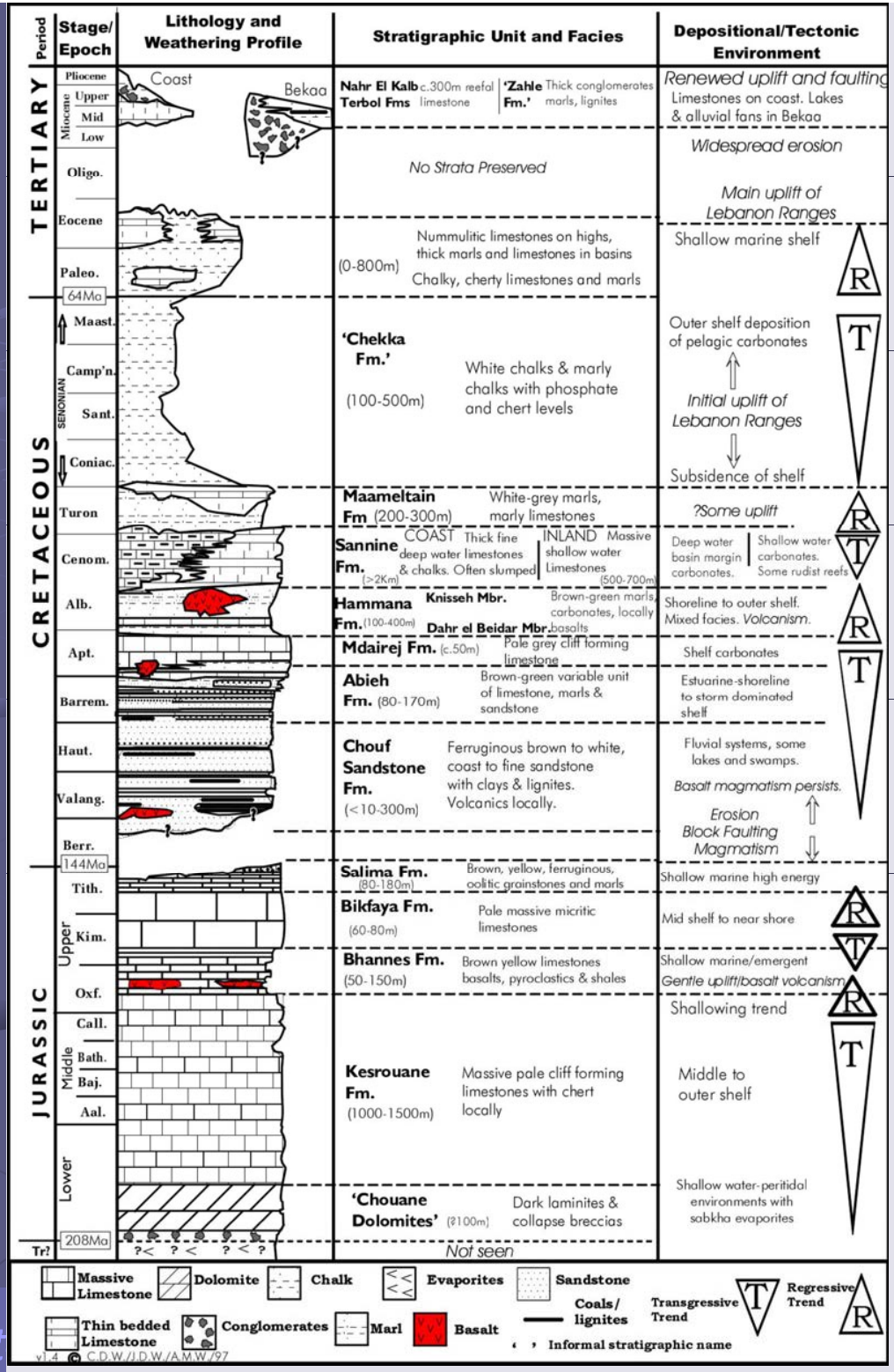


Lithostratigraphy

Upper Aquifer up to 1000 m

Aquitard 500 - 800 m

Lower Aquifer >1100 m



Source: C. D. Walley

Aquifers

C4

C3

C2b

C2a

C1

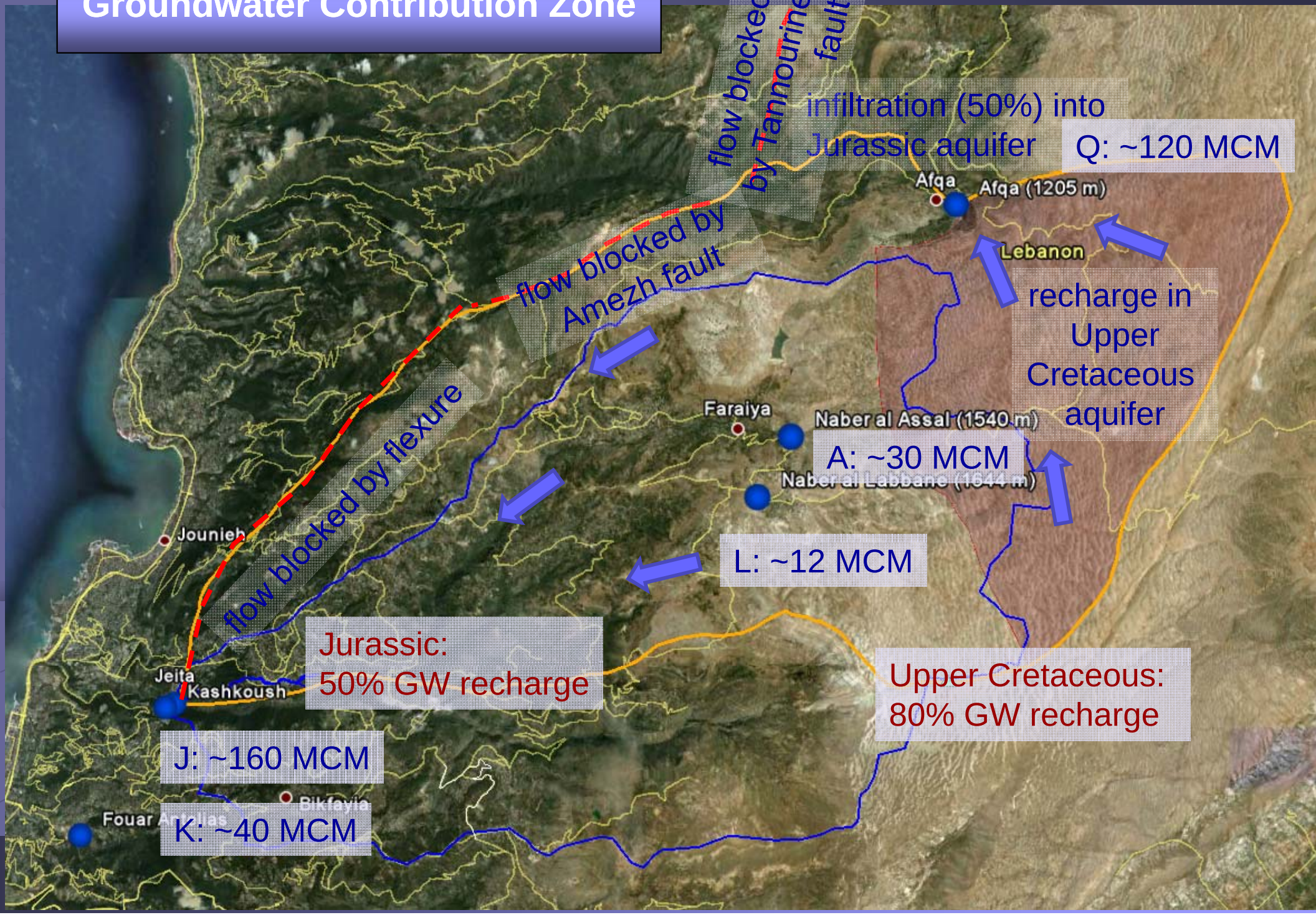
J7

J6

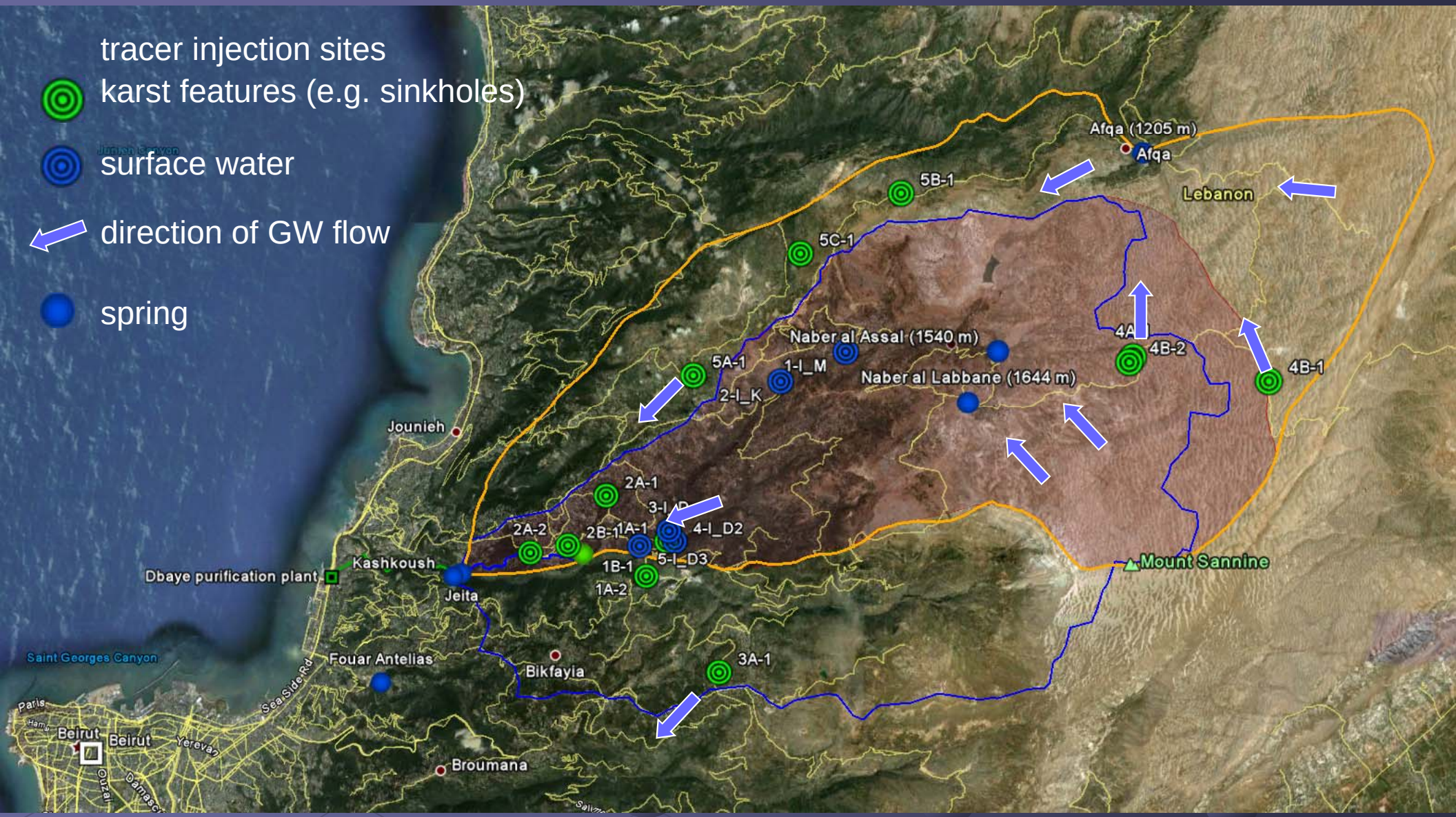
J5

J4

Groundwater Contribution Zone



Tracer Tests



Importance of Water Resources Protection

Though water resources in Lebanon are abundant, they are increasingly at risk. The rapid and uncontrolled urban expansion has caused a severe deterioration of water quality over the past decades.

The groundwater resources of Lebanon are mostly stored in limestone aquifers which are highly karstic. In many areas the karst is exposed at the surface (open karst) and rainfall infiltrates easily. Groundwater flow velocities in the karst system are extremely high (up to 2,000 m/h). This is the reason why any contamination will reach the drinking water sources very fast and without any major attenuation. The main contamination risk results from wastewater that is infiltrating the karst aquifers unhindered from cess pits, sinkholes or even wells. Contamination is extremely high at the beginning of the rainy season.

Due to the nature of the karst, the groundwater system dewaters quickly so that at the end of the dry season water shortages frequently occur.

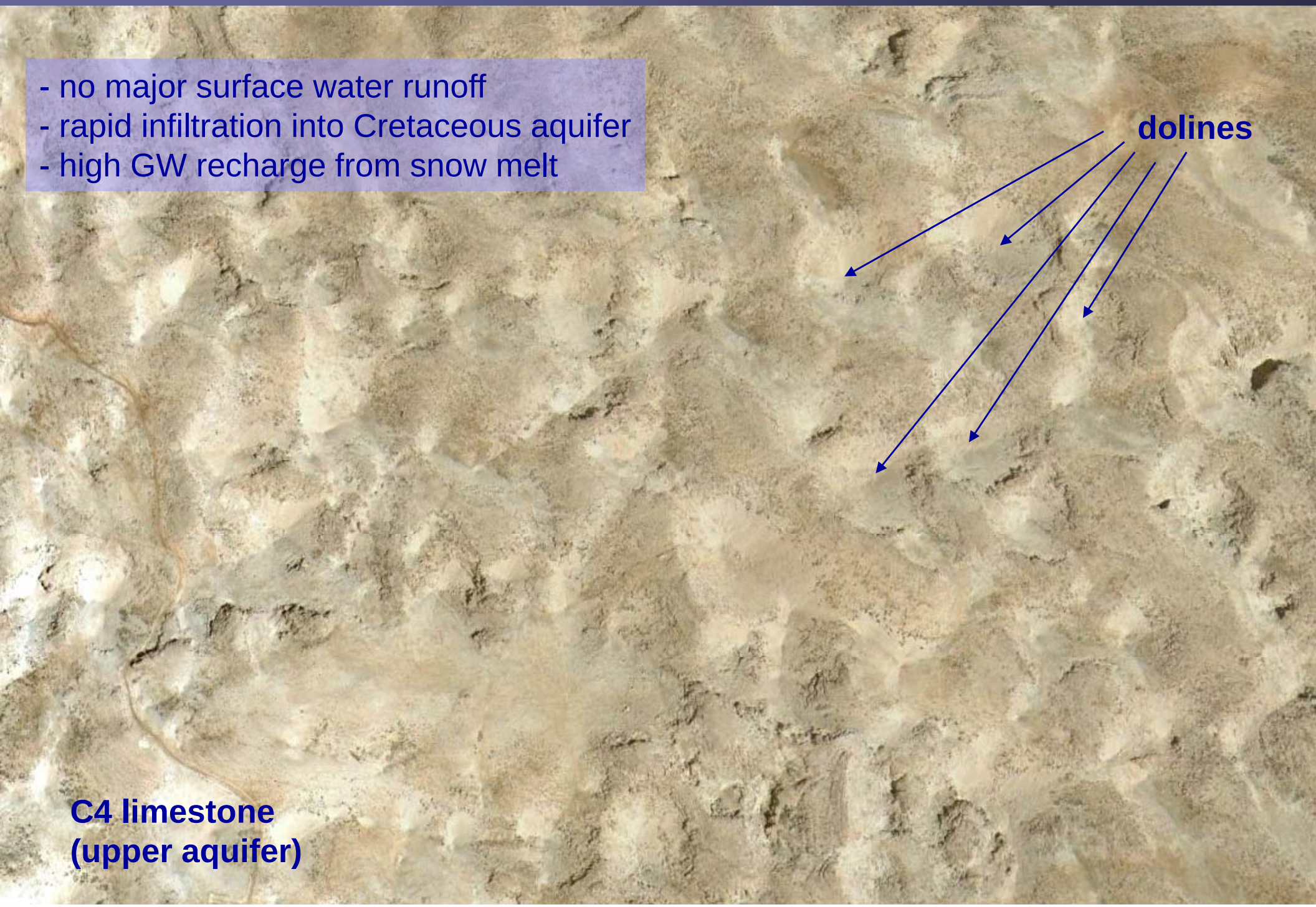
Importance of Snow

Cretaceous plateau (1,800 – 3,000 m asl):
2-4 m snow
November – May

Very important for GW recharge (~ 80%)
Snow is the lifeline of Lebanon

Climate change may lead to a significantly lower groundwater resources availability

Regional climatic scenarios predict less rainfall, higher summer and winter temperatures and thus less snow


- no major surface water runoff
- rapid infiltration into Cretaceous aquifer
- high GW recharge from snow melt
dolines
C4 limestone
(upper aquifer)

GW recharge via dolines


High karstification in
Cretaceous limestone
(Faqra)

Contamination Risks from Wastewater

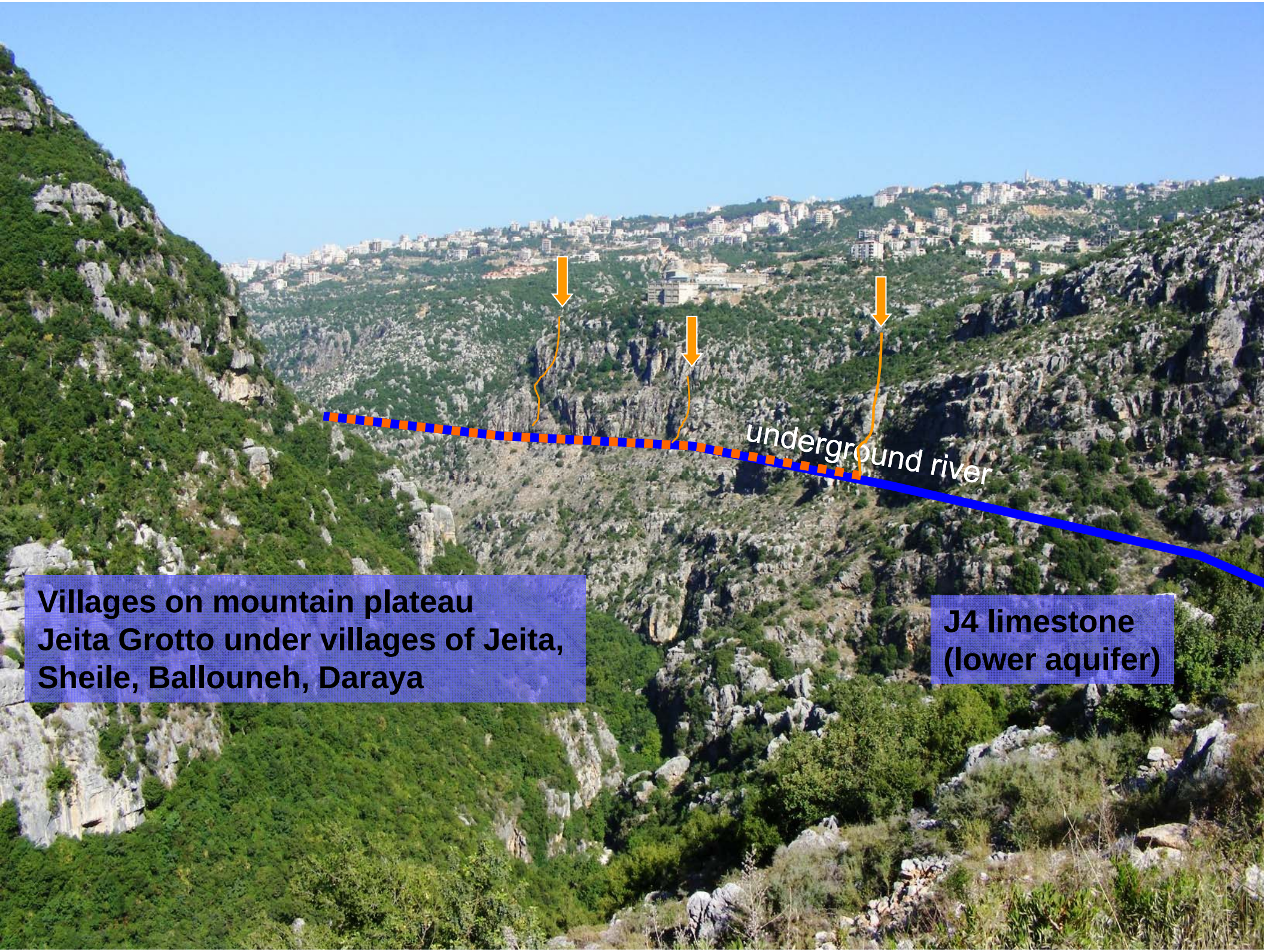
Currently wastewater is discharged
- **into injection wells**
- **into open cess pits or**
- **into nearby creeks/rivers/wadis**

residences with no wastewater collection and treatment

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

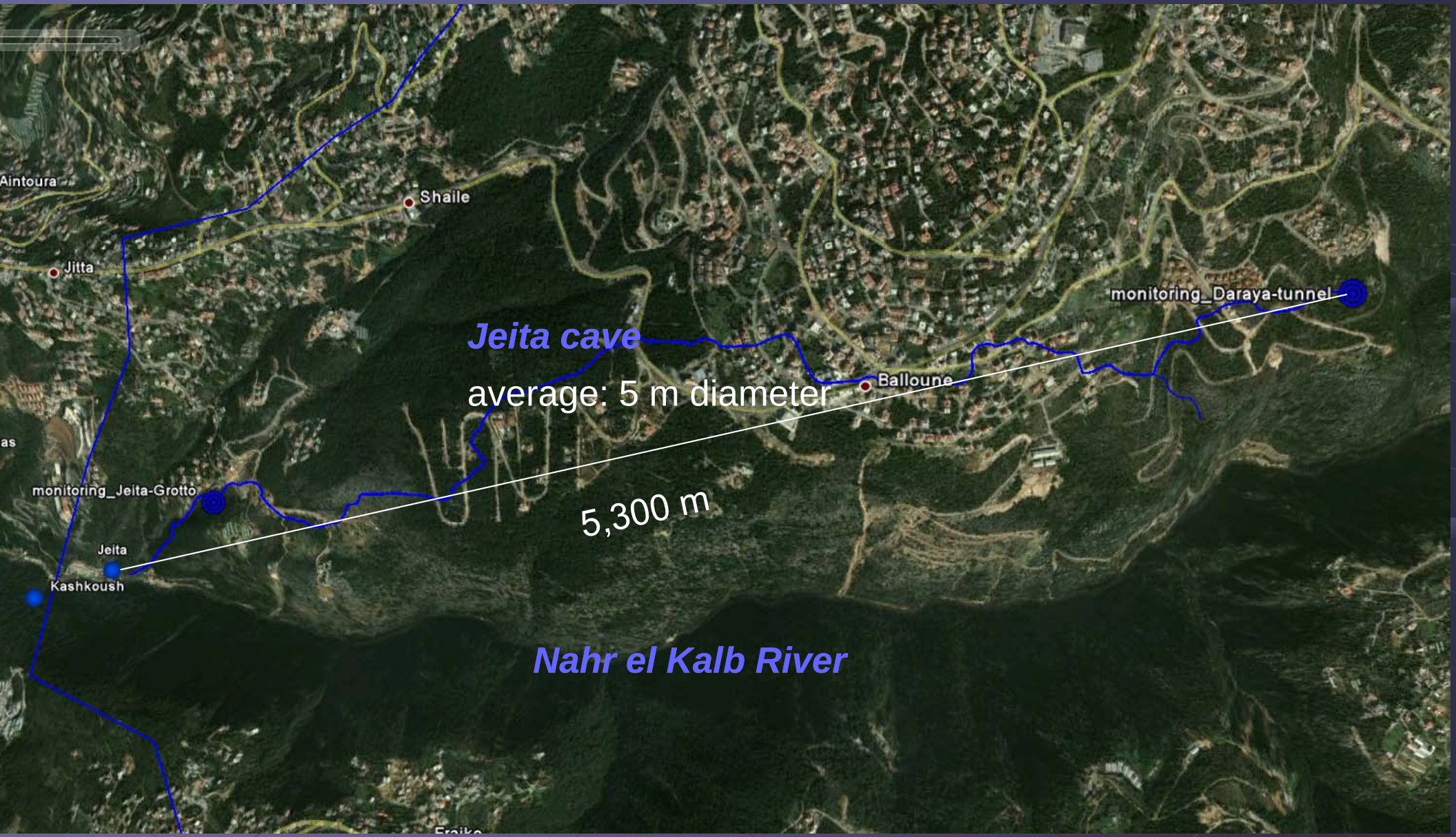
► Bacteriological contamination of Jeita spring


Wastewater is typically „discharged“ through open cess pits or injection wells
KOMATSU
KOMATSU


underground river
Villages on mountain plateau
Jeita Grotto under villages of Jeita, Sheile, Ballouneh, Daraya
J4 limestone
(lower aquifer)

Underground River

Karst conduits



Specific Problems concerning Wastewater Treatment

Jeita Catchment

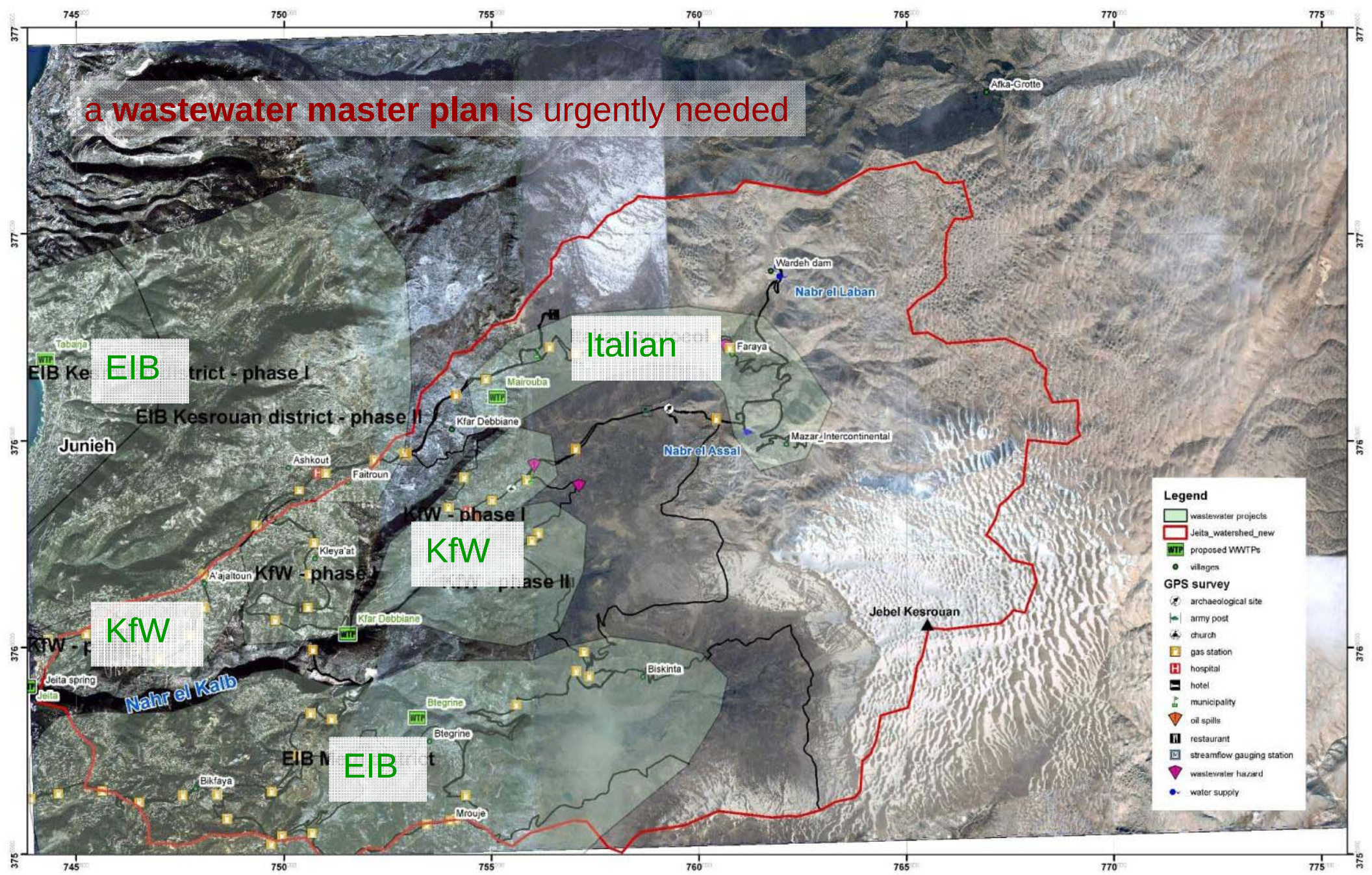
- Topography (WW must be pumped up at several locations; extremely high gradients)
- Electricity not available 24/7 (max 50%)
- Large spacing between residential areas (often only up to 70 % of a village can be serviced by a wastewater scheme)
- Households cannot be forced to connect to WW collector 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, ...

- Geology: karst, tectonics, landslides, rock slides, earthquakes

► wastewater master plan is urgently needed

Wastewater Projects North of Beirut

Fragmented wastewater schemes



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)

Site Selection for Wastewater Facilities

criteria catalogue

- General criteria
- Geological/hydrogeological criteria ← BGR
- Financial criteria

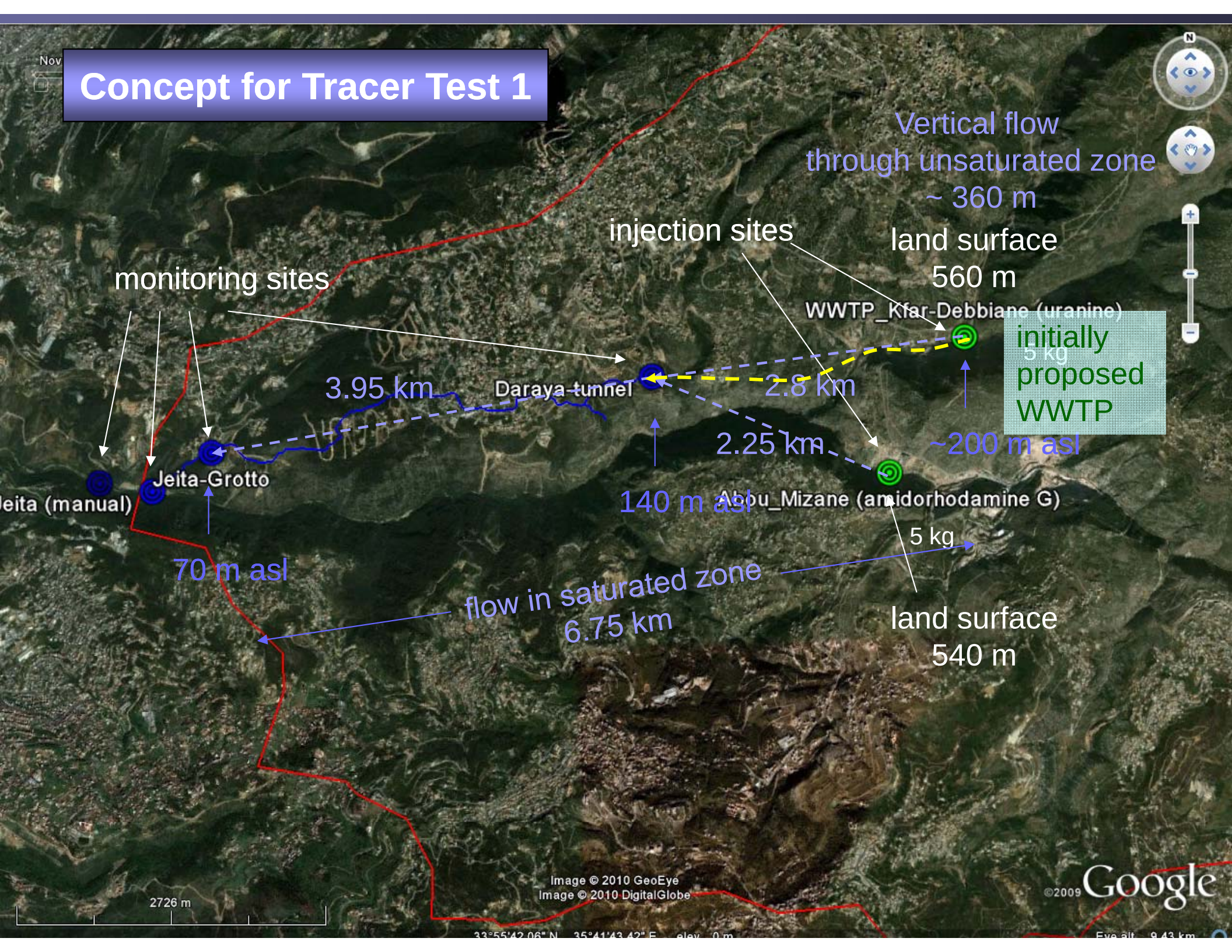
ANNEX 1: Criteria for Site Selection and Design of Wastewater Facilities in Lebanon

Criteria	Collector Lines	WWTP Location	WWTP Design	discharge Location	Remarks	Tasks / source
General Criteria						
number of inhabitants to be serviced (capa						
WW indus						
planr /indu plan)						
popu						
planr						
mate appr						
existi mate						
chara inclu						
topoc can b have to be when follov						
land ?)						

Criteria	Collector Lines	WWTP Location	WWTP Design	discharge Location	Remarks	Tasks / source
Geological and Hydrogeological Criteria						
geology (rock type, underground as a barrier, dip direction/angle)	xx	xx			if natural geological barrier is existing, it should be used	geological mapping
stability						
landslic effect						
tectoni						
earthqu affect t						
ground velociti						
thickne velocity						
infiltrat						
karst fe						
risk of becom						
distanc (used f						
risk of						

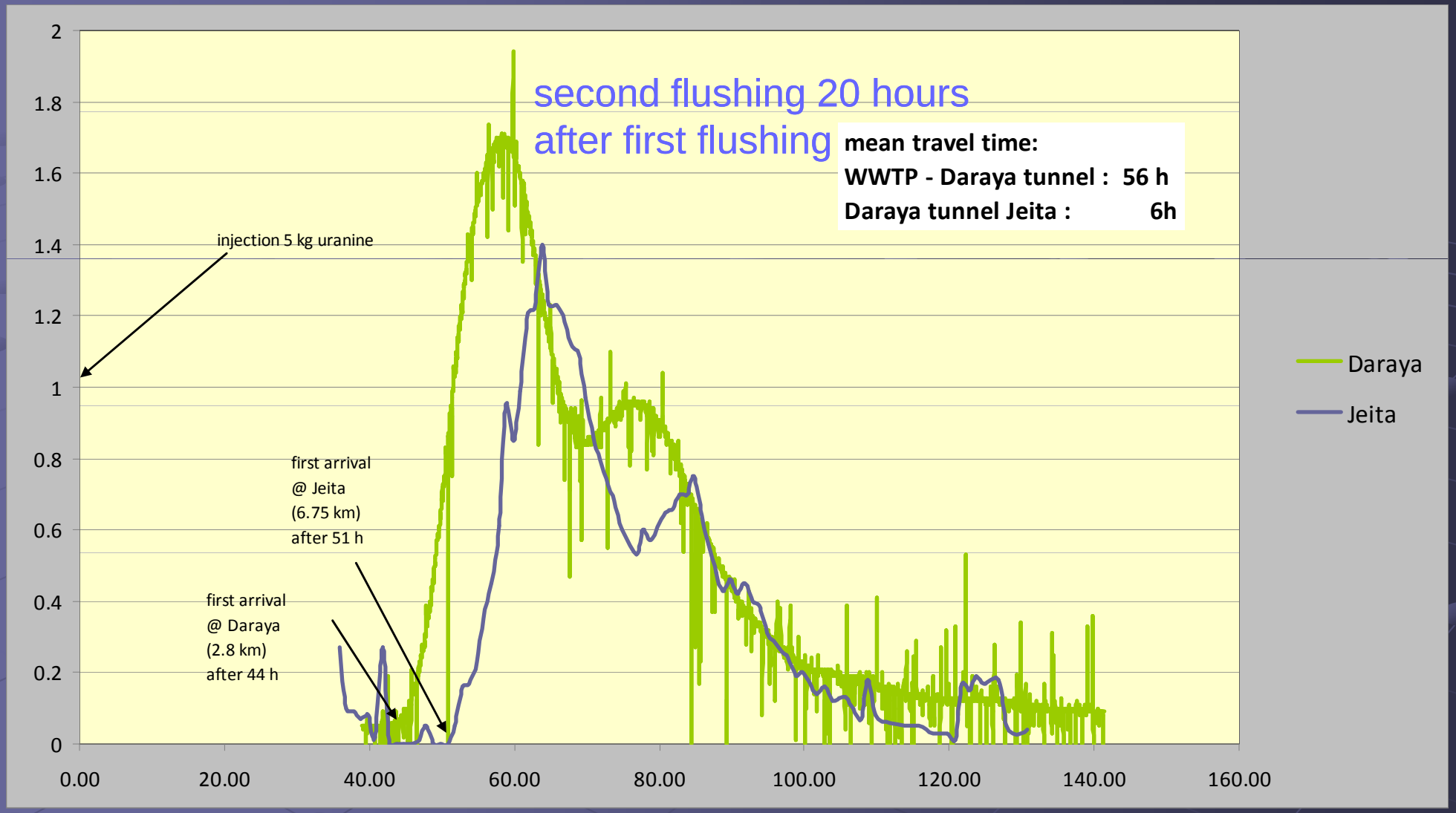
Criteria	Collector Lines	WWTP Location	WWTP Design	discharge Location	Remarks	Tasks / source
Cost related Criteria						
method of treatment (primary / secondary / tertiary)			xxx	xxx	can existing regulations / guidelines for effluent (reuse) quality be maintained at all times ?	
reliability of treatment			xxx	xxx		
storage capacity (bypass in case of overload ?)		xx	xx	xx	must be large enough to guarantee that bypassing untreated WW will not be necessary	
possibility / need for treated WW reuse		xx	xxx	xxx	discharge location must be high enough to use as little energy as possible for reuse	
sludge management / reuse of (treated) sludge for agriculture		xx	xx	xx	can existing regulations / guidelines for quality of (organic) fertilizer be maintained at all times ?	analysis of sludge content; determine sites for sludge application; determine treatment of sludge and related feasibility
costs for primary collector lines						
costs for secondary collector lines						
costs for household connections						
costs for WWTP construction						
costs for effluent discharge pipeline / canal						
overall costs for construction (available funds)					including equipment, laboratory and staff for continuous monitoring of treated WW quality	
annual costs for maintenance and operation (available budget)					including continuous monitoring of treated WW quality and sludge mgmt.	

xxxx - killing arguments, xxx - very important arguments, xx - important arguments, x - less important arguments

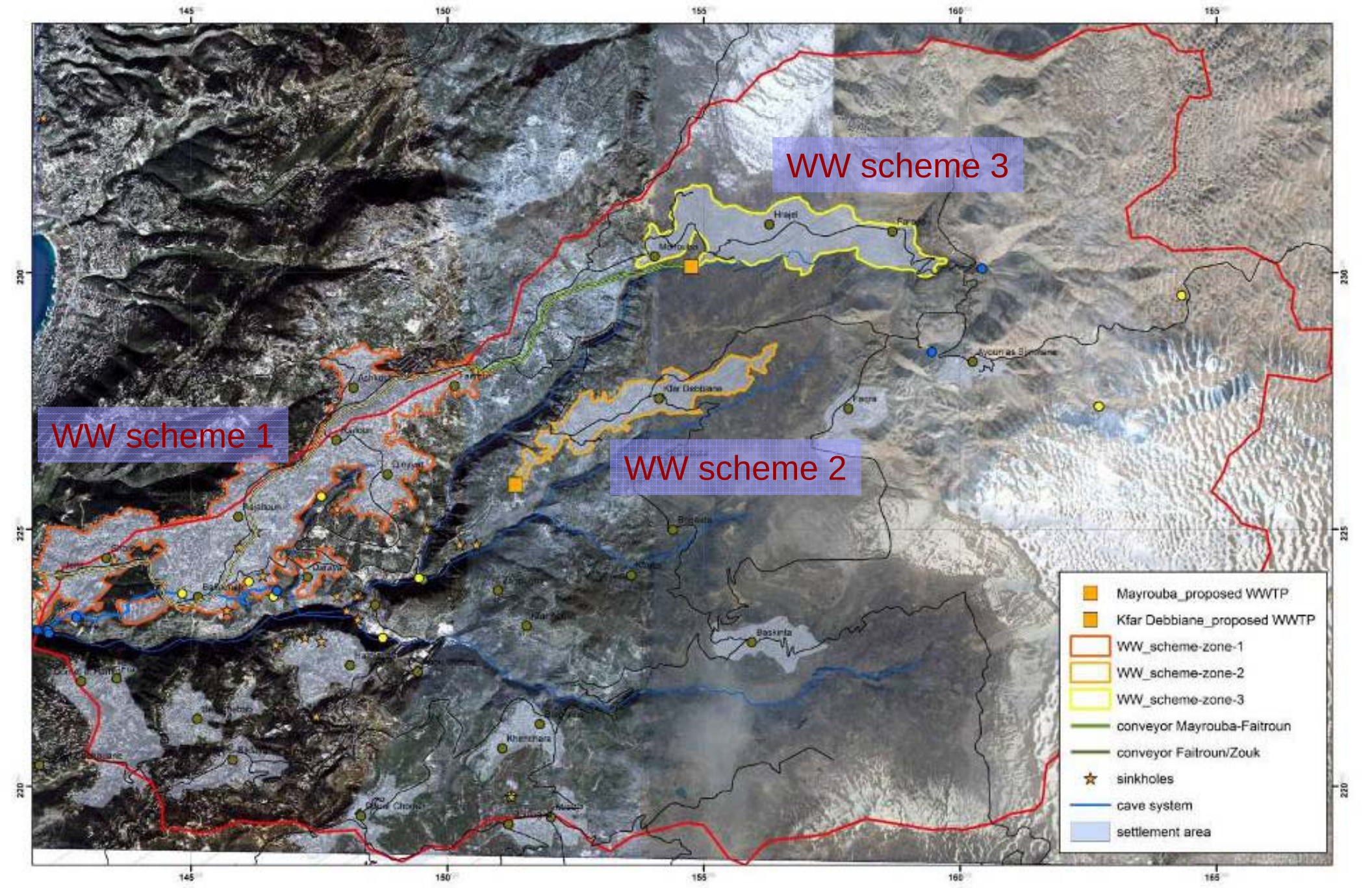

Concept for Tracer Test 1
Vertical flow
through unsaturated zone
~ 360 m
land surface
560 m
injection sites
monitoring sites
WWTP_Kfar-Debbiane (uranine)
initially
proposed
WWTP
5 kg
3.95 km
Daraya-tunnel
2.8 km
2.25 km
~200 m asl
Jeita-Grotto
Jeita (manual)
140 m asl
Abou_Mizane (amidorhodamine G)
5 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



Proposed Wastewater Schemes



Groundwater Protection Zone 2

Priority should be given to wastewater facilities in high-risk zones

Ranking of Alternatives for WW schemes based on Water Resources Protection Aspects

Alternative	Rank	Main Advantages/Disadvantages
Principally acceptable solutions		
B4b*	1	Lowest pollution risk because no Jeita WWTP – Mokhada bridge collector/conveyor would be required but poor feasibility prospects for coast WWTP
B4a*	2	
A2b	3	Special protective measures in protection zone 2 necessary for escarpment collector and Jeita WWTP – Mokhada bridge conveyor/collector
A2a	4	Special protective measures in protection zone 2 necessary for Jeita WWTP – Mokhada bridge conveyor/collector
A1b	5	Uncertain reuse concept for Kfar Debbiane
A1a	6	
B2b	7	High costs for relatively small Jeita WWTP, poor feasibility prospects for coast WWTP
B1b	8	
B2a	9	
B1a	10	
Objected solutions		
A3a		The Daraya WWTP would be located in open karst where sinkholes are reported which are probably connected with Jeita cave. Discharge of treated effluent under these conditions is problematic.
A3b		
B3a		
B3b		

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

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.

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:

- 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

Thank you for your kind attention

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