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

IAH Conference 2012 – Niagara Falls

German-Lebanese Technical Cooperation Project

Protection of Jeita Spring

Hydrogeological Investigations for Investments in the Wastewater Sector to Protect the Drinking Water Resources of Beirut in a Karst Aquifer

Th1-D/Karst Aquifers, Environmental Problems and Global Change I
September 20, 2012

Dr. Armin Margane, BGR & Eng. Ismail Makki, CDR

Outline

- Background of the Project / Aim / Tasks
- Description of Project Area
- Project Activities related to Project Component 1 (Provide Geoscientific Advice in the Wastewater Sector)

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*.

1. **Integration of water resources protection aspects into the investment planning and implementation process in the wastewater sector (geoscientific advice in wastewater sector)**
2. **Integration of water resources protection aspects into landuse planning (delineation of GW protection zones)**
3. **Collection and use of monitoring data concerning quality and quantity of water resources**
4. **Support of the partner institutions concerning the implementation of urgent protective measures**

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.

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 (FC) and technical cooperation (TC) projects** is a new approach of the BMZ (German Ministry of Economic Cooperation and Development) that aims to overcome this planning deficit (pilot projct).

First project of BGR in Lebanon.

Project Setup

BGR

TC project:

- 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

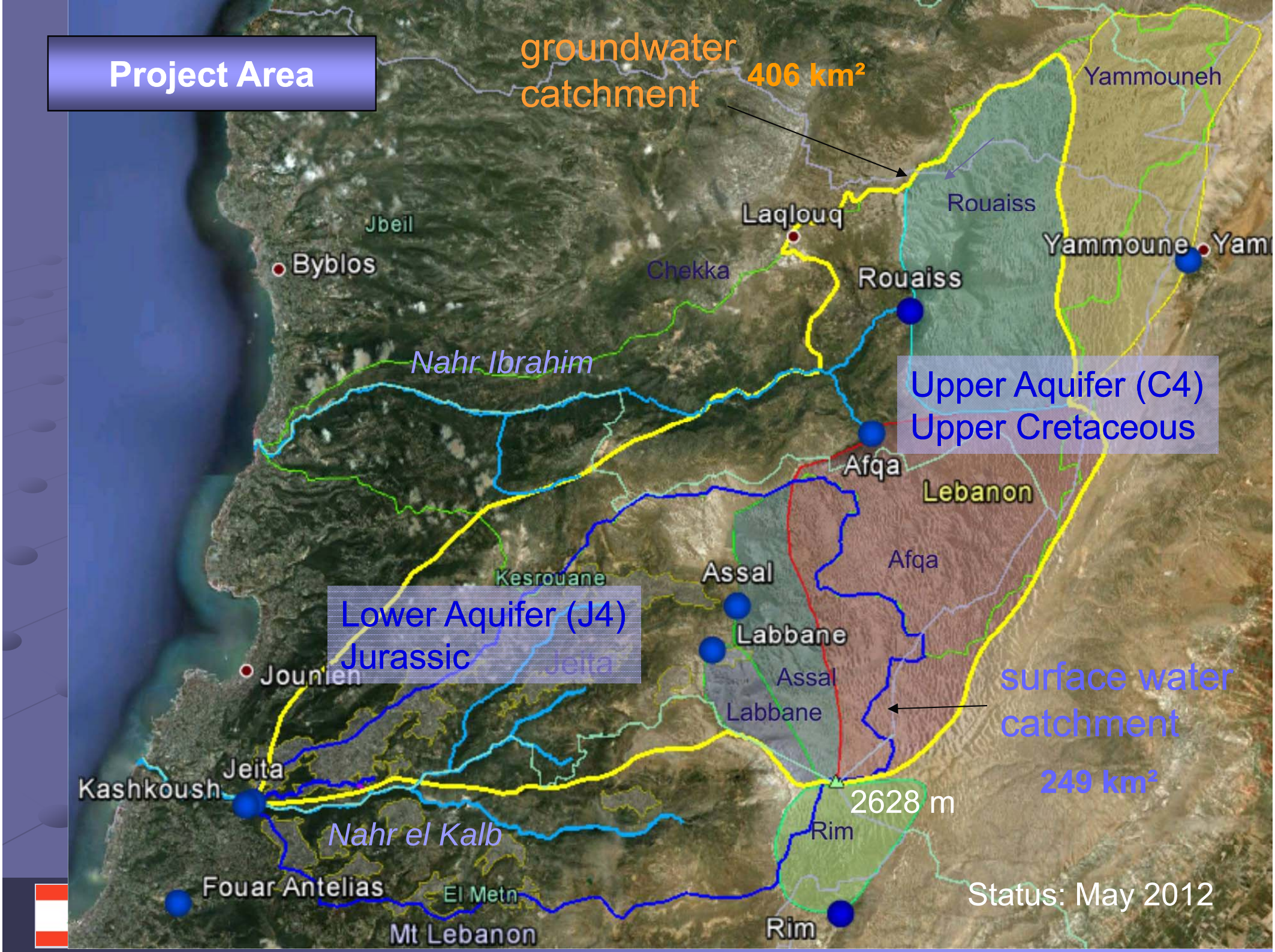
Advice to FC project:

- 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)

KfW

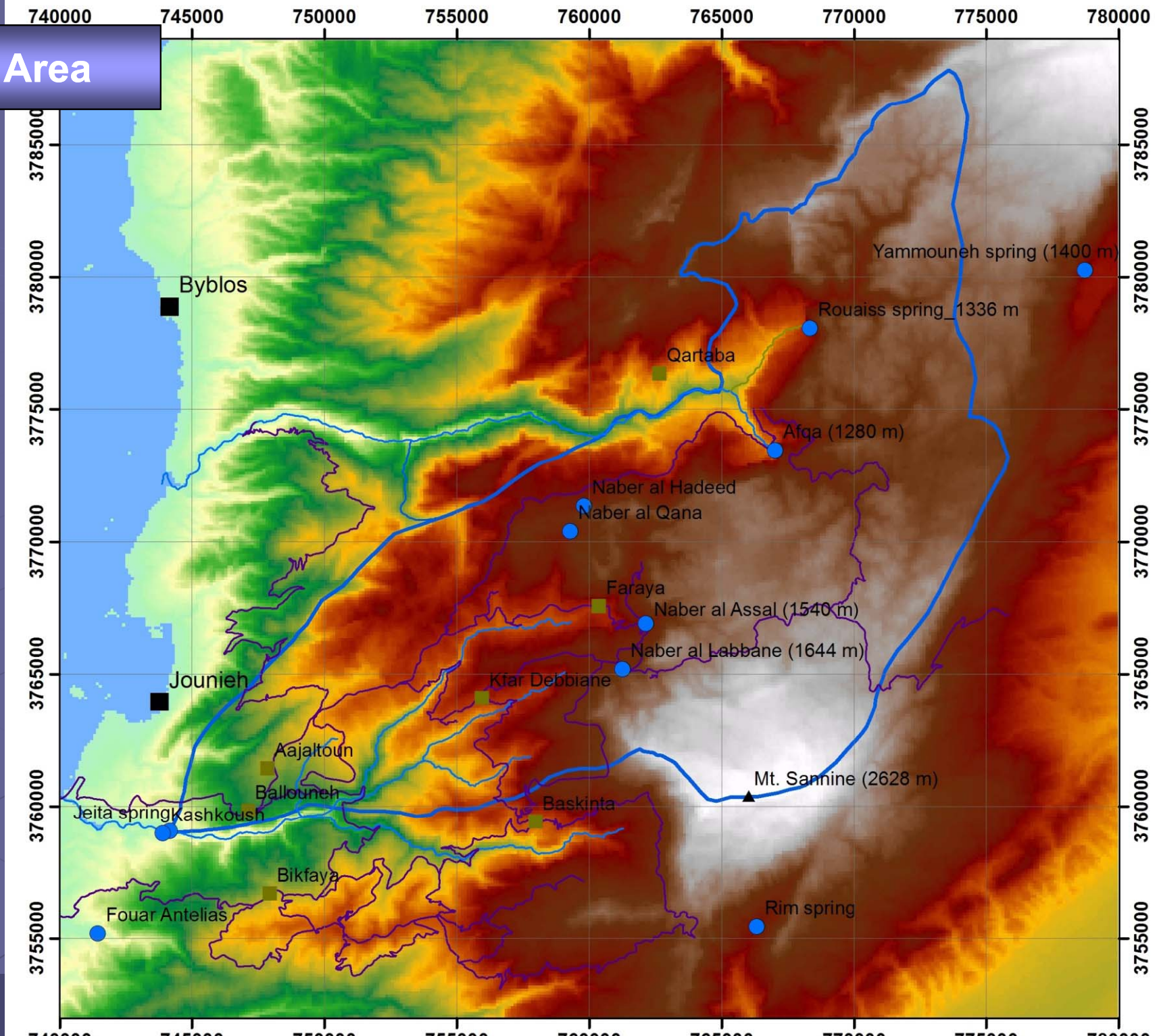
FC project:

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


Project Area
groundwater catchment
406 km²
Yammouneh
Rouaiss
Laqlouq
Jbeil
Byblos
Chekka
Rouaiss
Yammoune
Yam
Nahr Ibrahim
Upper Aquifer (C4)
Upper Cretaceous
Afqa
Lebanon
Afqa
Kesrouane
Assal
Lower Aquifer (J4)
Jurassic
Labbane
Jounieh
Jeita
Assal
Labbane
surface water catchment
249 km²
Jeita
Kashkoush
2628 m
Rim
Nahr el Kalb
Fouar Antelias
El Metn
Mt Lebanon
Rim
Status: May 2012

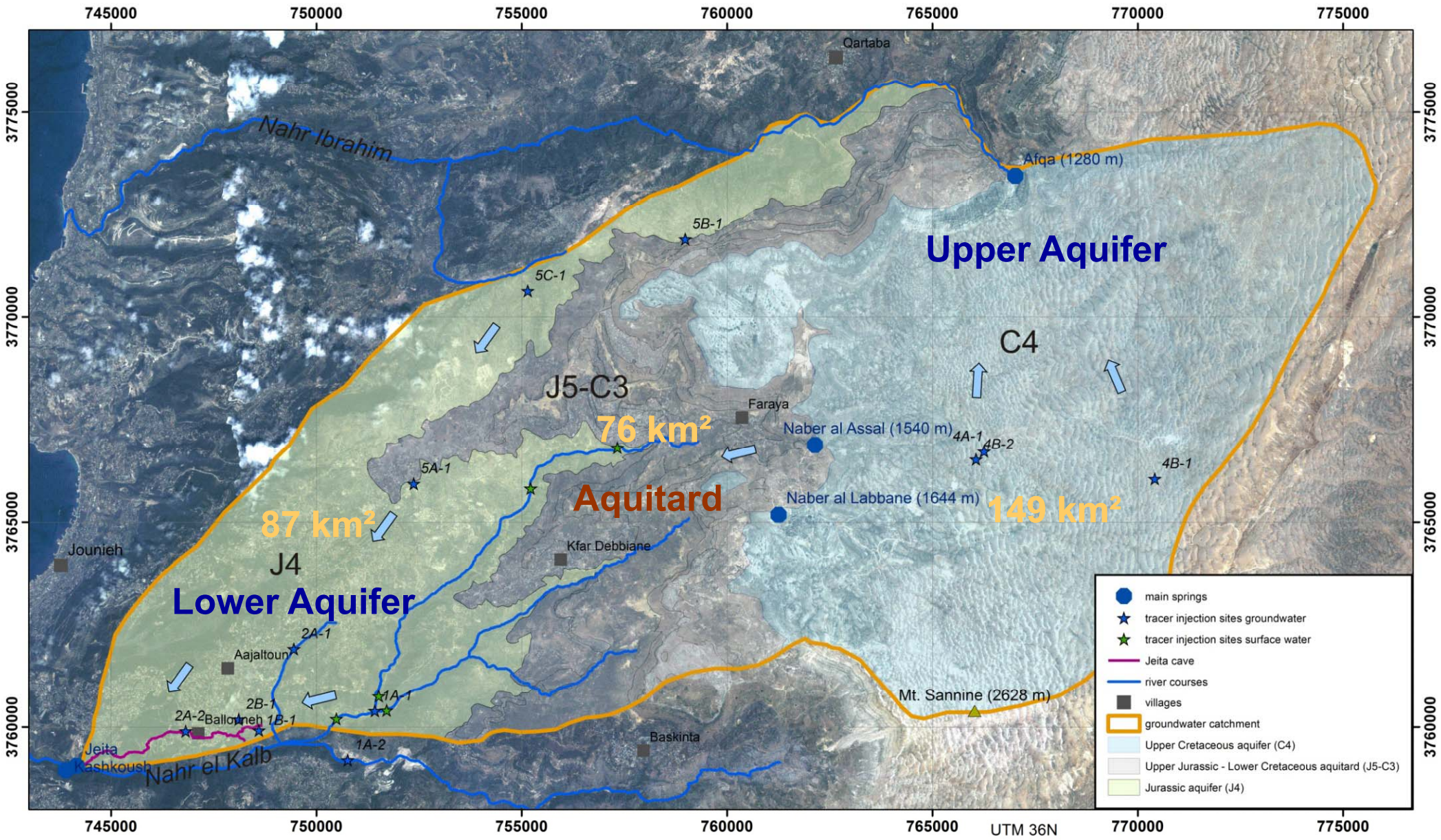
Project Area

DEM



Groundwater System

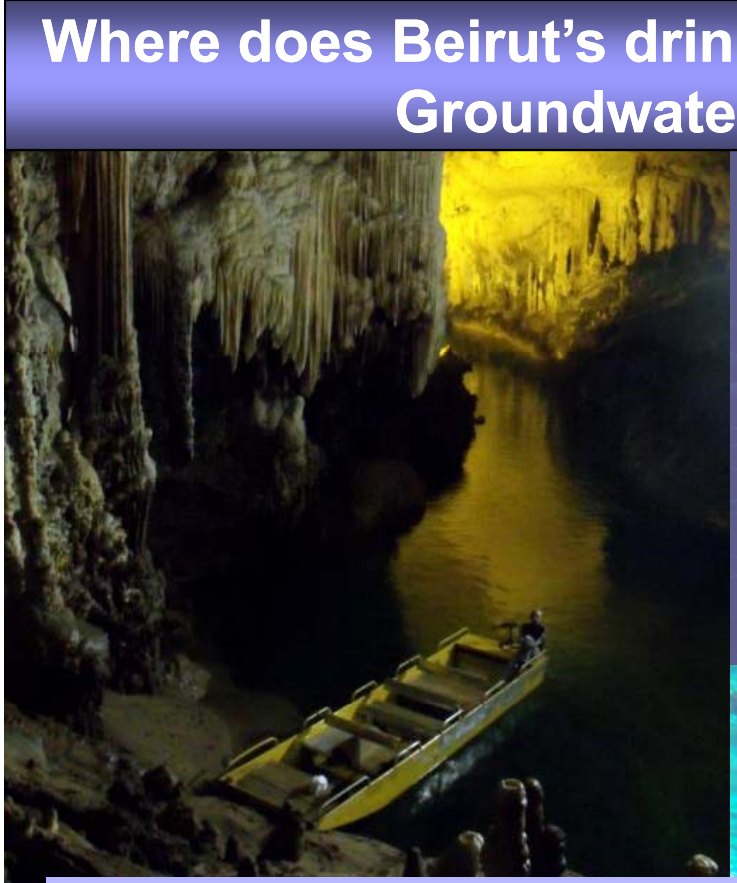
New geological map prepared by BGR

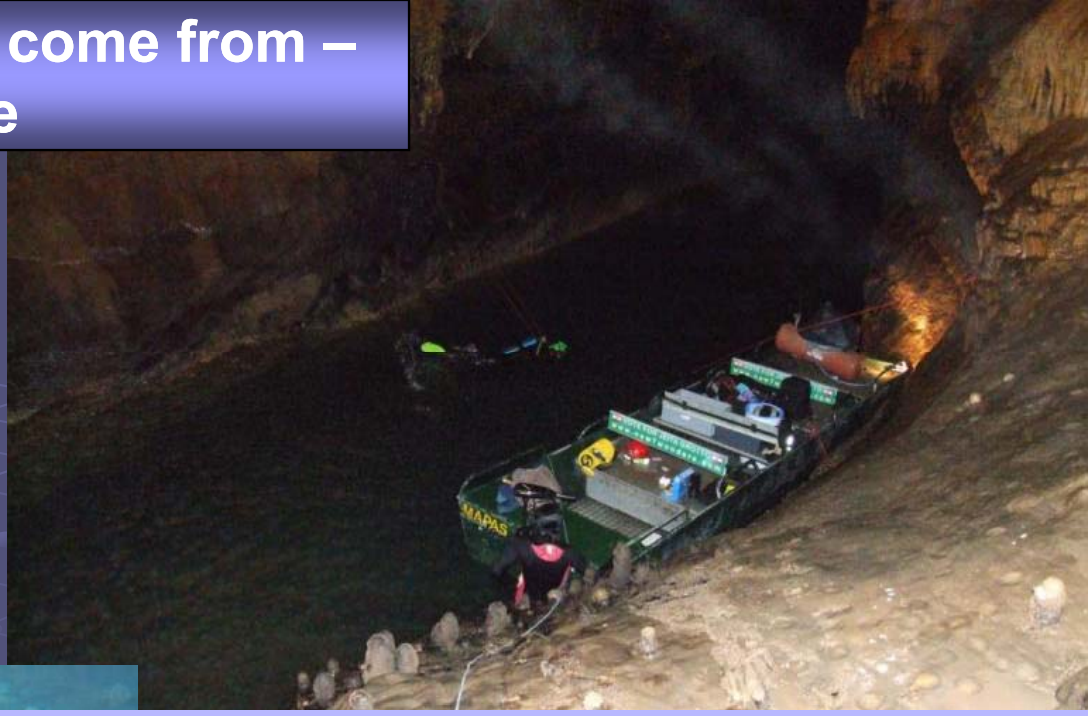


Where does Beirut's drinking water come from – Groundwater recharge

High karstification in Cretaceous limestone (Faqra)

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





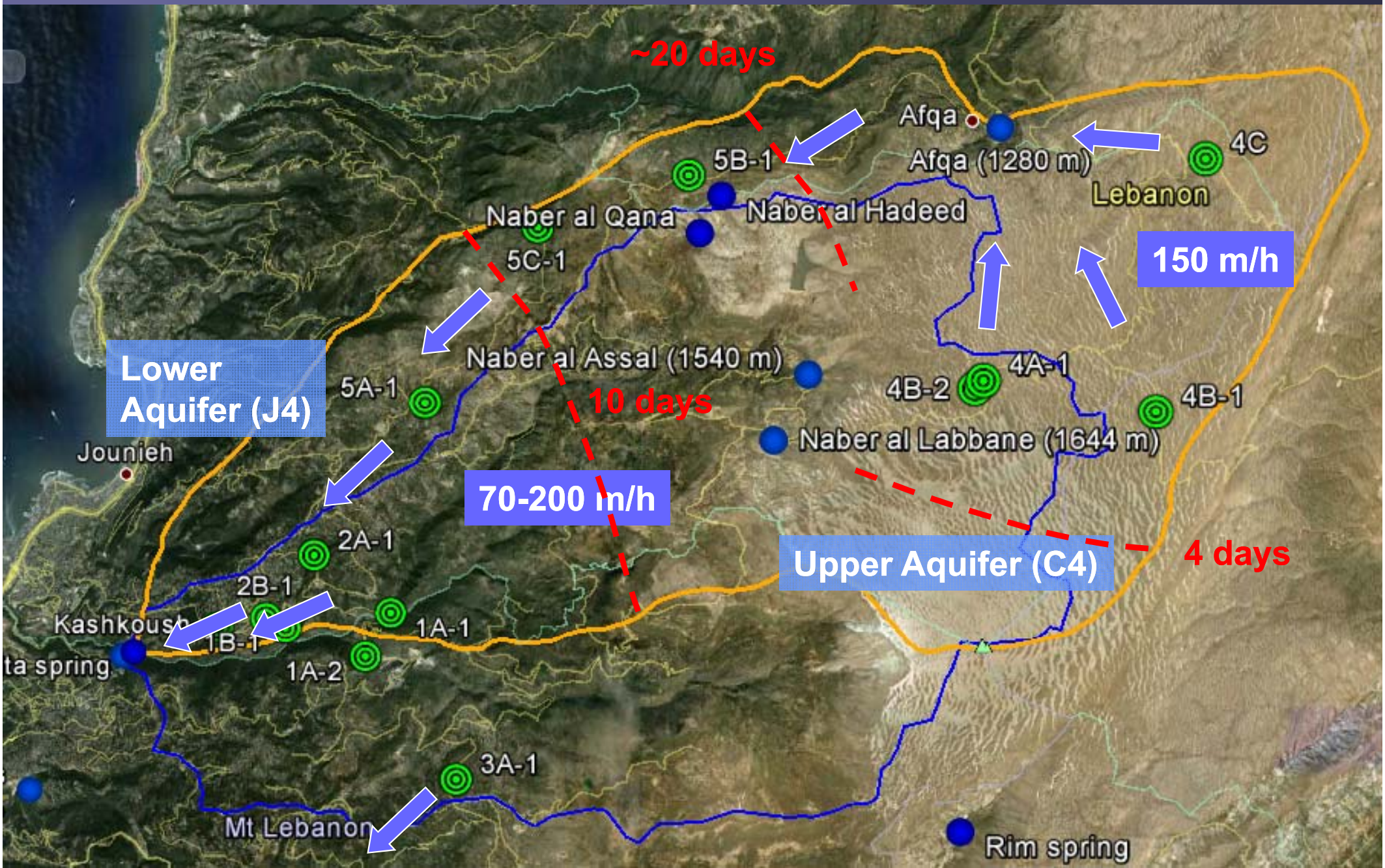
Jeita Spring
The main Source for Water Supply of Beirut

75 % of Beirut's water comes from Jeita

Awareness Movie „Beirut Waters“

Groundwater Flow

Mean travel times



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

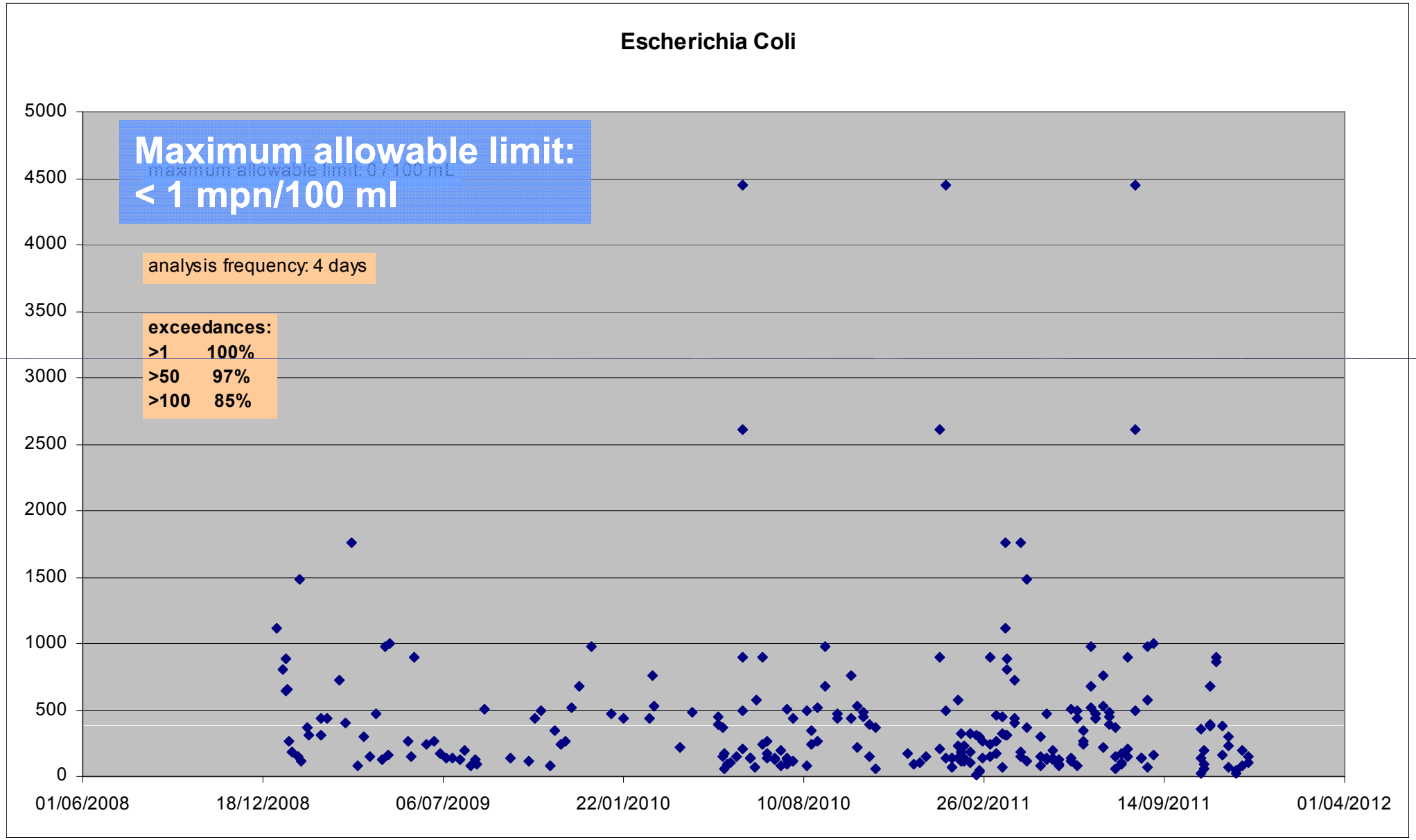
Infiltration of untreated wastewater into highly karstified Jurassic limestone (Faitroun)

► microbiological contamination of Jeita spring


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

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, ...

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

► wastewater master plan is urgently needed

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 must principally be done to cover a certain area with adequate collection and treatment facilities. The WMP proposes several individual wastewater schemes. It includes 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 an 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 EIA for the scheme is prepared by the consultant and discussed with all stakeholders (public participation)
- The wastewater facilities are built and transferred to the agency operating it (WEBML)

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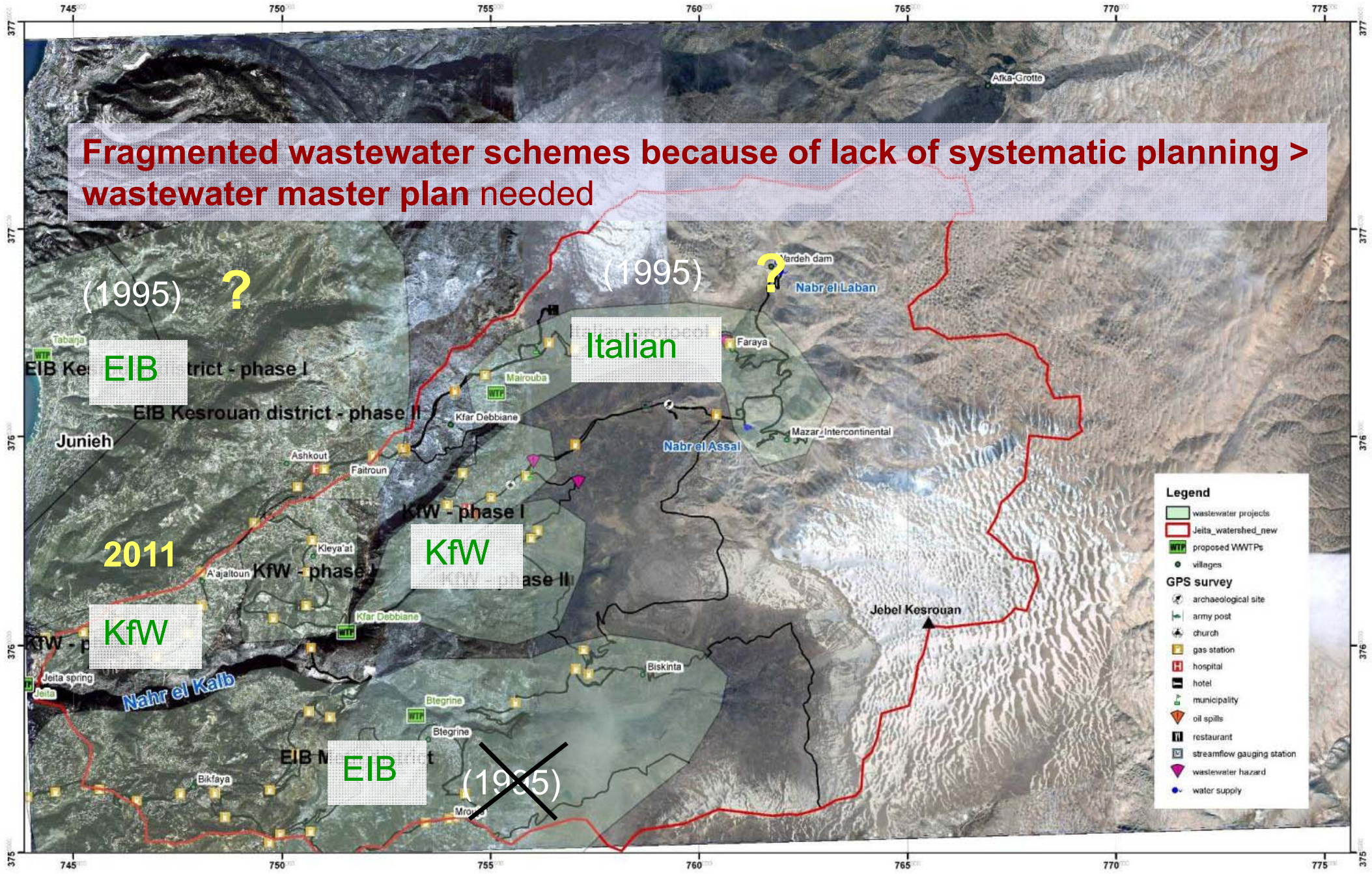
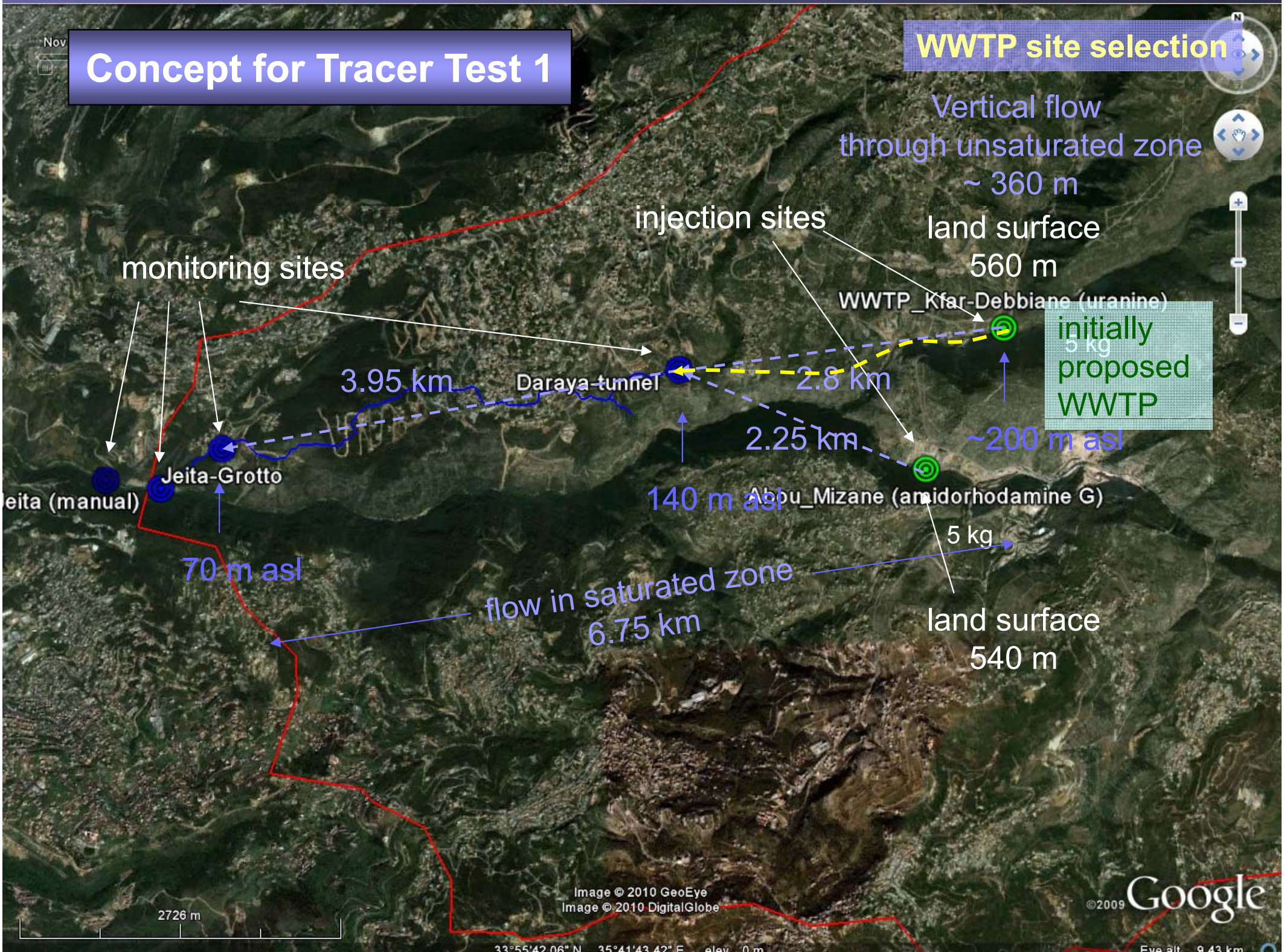
Wastewater Projects North of Beirut

Project Component 1 : Wastewater




Concept for Tracer Test 1
WWTP site selection
Vertical flow
through unsaturated zone
~ 360 m
injection sites
land surface
560 m
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

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 (capacity)	xxx	xxx	xxx		financial feasibility	municipalities
WW facilities used for domestic, industrial, commercial WW	x	x	xxx	xx	integration of industrial and commercial WW will require special treatment	decision/agreement needed which to include
planned extension of residential /industrial / commercial areas (landuse plan)	xx	xx	xx		WW planning must be coordinated with landuse planning authorities	municipalities / Landuse Planning Dept.
population growth rate	xx	x	xx			municipalities / Landuse Planning Dept.
planning horizon	x	x	xx			
material to be used (by law / regulation; appropriate ?)	xx	xx	xx		material must be appropriate to support geological/tectonic stresses, temperature, pressure, etc.	determine appropriate material for each condition
existing network (location / diameters / material / design)	xxx	x	xx		previous concepts must fit with new concepts	compile location/condition/diameter/material of existing network
character of WW (composition, including seasonal variability)		xx	xxx		amount of sludge; reuse potential of sludge (limited if industrial WW is treated and treatment method does not ensure complete removal of all hazardous substances)	chemical analyses
topography (which (parts of) villages can be connected / combined ? Where have primary / secondary collector lines to be laid down ? pumping required ? when / where ? Can collector lines follow roads / existing infrastructure ?)	xxxx	xxx	xxx	xx	pumping costs should be minimized / avoided	establish detailed DEM, determine optimal trace lines of primary/secondary conveyors; discuss with municipalities (land ownership)
land ownership (need for expropriation ?)	xx	xx		xx		cadastre map (not up-to-date)

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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 of geological underground	xxx	xxx	xxx		unstable underground (e.g. landslide material or alluvium, may need special foundatation	geotechnical study (e.g. Using cone penetration tests/CPT)
landslide / rockfall probability / likely effect	xxx	xxx	xxx		damages by landslides or rockfalls must be avoidded	geological mapping
tectonics (existing faults, direction)	xxxx	xxxx	xxxx		sites on active faults bear an elevated risk of damage	geological mapping
earthquake probability (likelihood to affect the site)	xxxx	xxxx	xxxx		sites near zones with high probability of earthquakes bear an elevated risk of damage	analysis of previous earthquake events (location, depth, strength/effect)
groundwater flow direction / flow velocities	xx	xxx		xxx	high GW flow velocities (even if only seasonal) bear a high pollution risk	tracer tests
thickness of unsaturated zone / flow velocity in unsaturated zone	xxx	xxx	xxx	xxxx	leakage loss from network; reuse possibility	tracer tests
infiltration / GW recharge	xx	xx	xx	xxx	unhindered infiltration into the underground (aquifer) at high GW recharge rates bear a high risk of pollution	water balance/hydrological modelling
karst features (degree of karstification)		xxx		xxxx	high karstification near WW facilities bear a high pollution risk; flow paths in karst system are often not sufficiently known	geological mapping
risk of downstream water resources to become polluted		xxxx		xxxx		
distance / travel time to water source (used for drinking purposes)	xxx	xxx	xxx	xxx	the higher the travel time the lower the pollution risk	tracer tests
risk of flooding	xxx	xxx	xxx	x	WWTP and collector lines must be protected against flooding	DEM, hydrological model

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stability						
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earthqu affect t						
ground velociti						
thickne velocity						
infiltrati						
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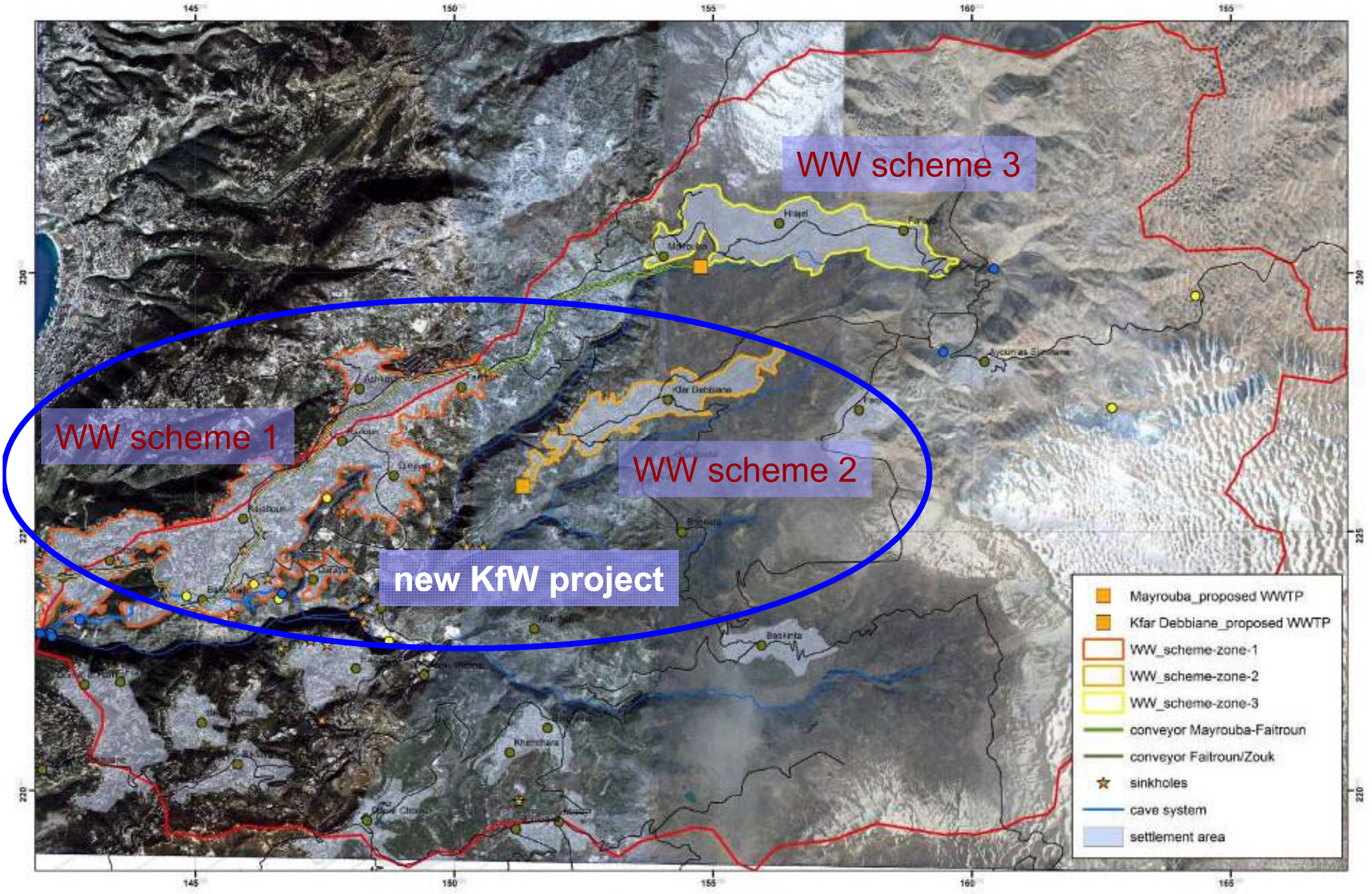
risk of becom						
distanc (used f						
risk of f						

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

Proposed Wastewater Schemes



KfW Jeita Project

BGR prepares **EIA** for all components of KfW wastewater scheme related to impact on water resources and impact from geohazards

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

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

Project Activities

No efficient treatment plants yet in Lebanon but many in planning

Need for good management of WWTPs:

- capacity building at Water Establishments (GIZ project)
- effluent water quality monitoring (WW lab)
- control mechanism
- decisions concerning treated WW reuse & sludge management / reuse ► TR-2 BMP WW Mgmt
- standard for WW & sludge reuse ► SR-4 Standard
- EIA guideline for WW Facilities ► TR-3 EIA Guideline

Results presented

Discussions with municipalities & investors (e.g. CIL Group)

Remaining activity: EIA for Jeita WWTP (hydrogeological & geohazards part)

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)

Thank you for your kind attention

www.bgr.bund.de/jeita

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