



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

# Protection of Jeita Spring

## Delineation of Groundwater Protection Zones (project component 2)

Final Project Workshop  
11 July 2014

Dr. Armin Margane



### 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.



## 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



## Objective

### Vulnerability Maps are used as a Decision Tool in the Land Use Planning Process.

High Vulnerability: Areas with a high Pollution Risk.

➤ Which Measures need to be Implemented to Protect the Resources against Pollution ?

Low Vulnerability: Areas with a low Pollution Risk.

➤ Where could Sites and Activities which are Possibly Hazardous to Groundwater be located, such as Waste Disposal Sites, Wastewater Treatment Plants, Industrial Estates, etc. ?





### GW Vulnerability Mapping EPIK & COP

- Geology ▶ geological mapping
  - Karst features ▶ karst feature mapping
  - Soil ▶ soil mapping
- 
- Groundwater Vulnerability Map
  - Groundwater Protection Zones



# Groundwater Vulnerability

Factors determining protective effectiveness of the rock and soil cover :

- mineralogical rock composition,
- rock compactness,
- degree of jointing and fracturing,
- porosity,
- content of organic matter,
- carbonate content,
- clay content,
- metal oxides content,
- pH,
- redox potential,
- cation exchange capacity (CEC),
- thickness of rock and soil cover
- percolation rate and velocity.

GW vulnerability map



# Groundwater Vulnerability

COP Method

C – Concentration of flow,

O – Overlying layers and

P – Precipitation

COP-Index :

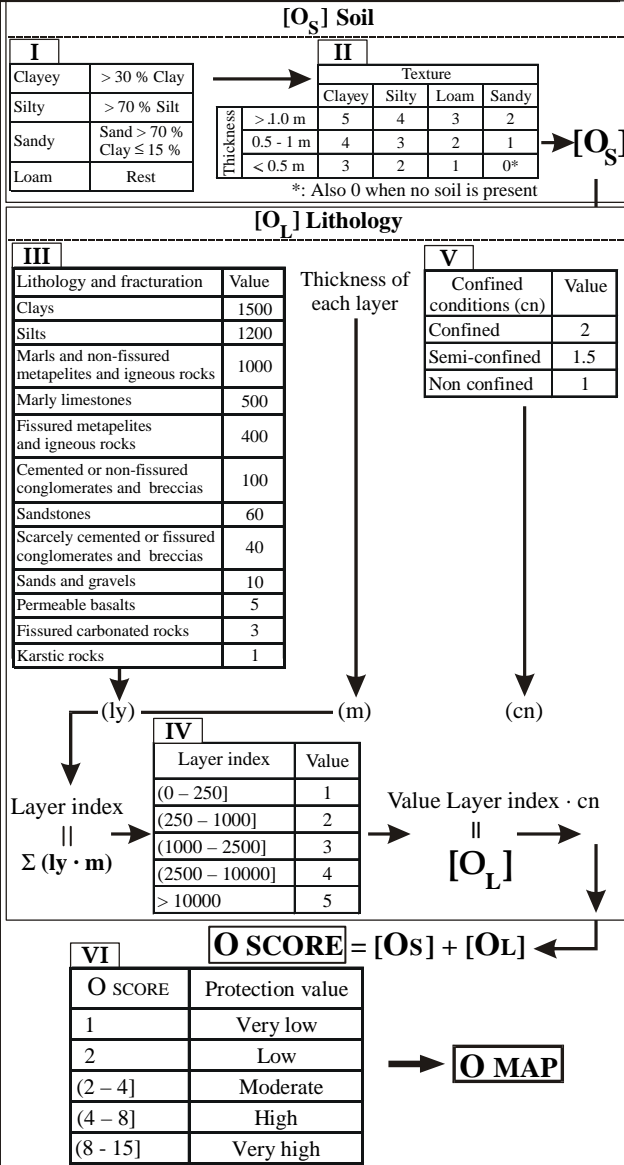
$\text{COP-Index} = (\text{C score}) * (\text{O score}) * (\text{P score})$

- soil
- lithology and thickness of overlying rock layers
- confined / unconfined GW
- infiltration in sinkholes
- infiltration by sinking streams
- slope
- vegetation cover
- rainfall amount
- rainfall intensity

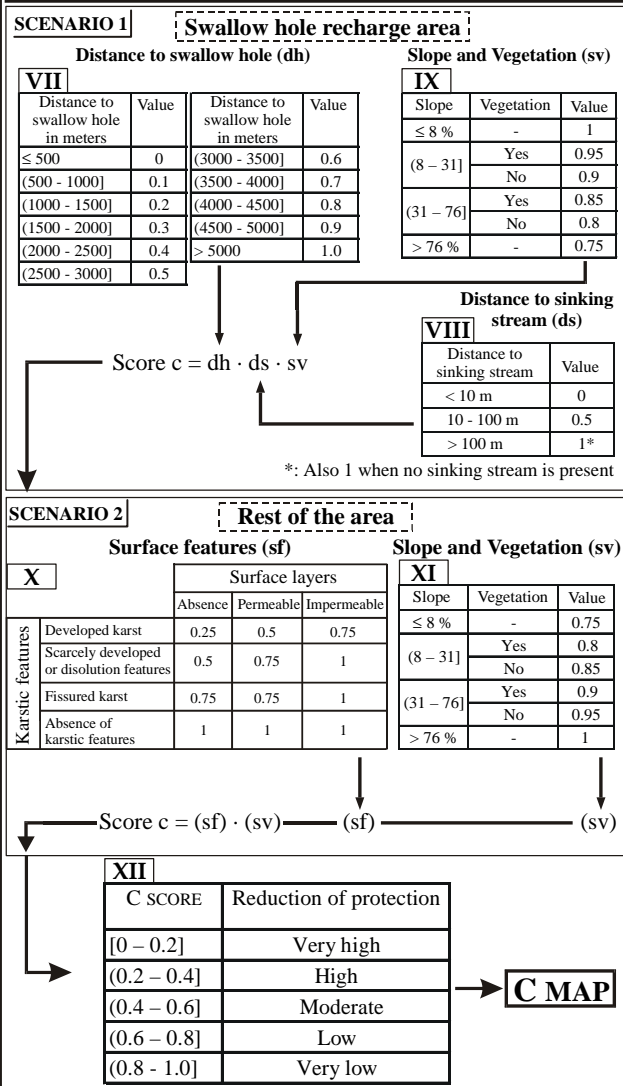


# Groundwater Vulnerability

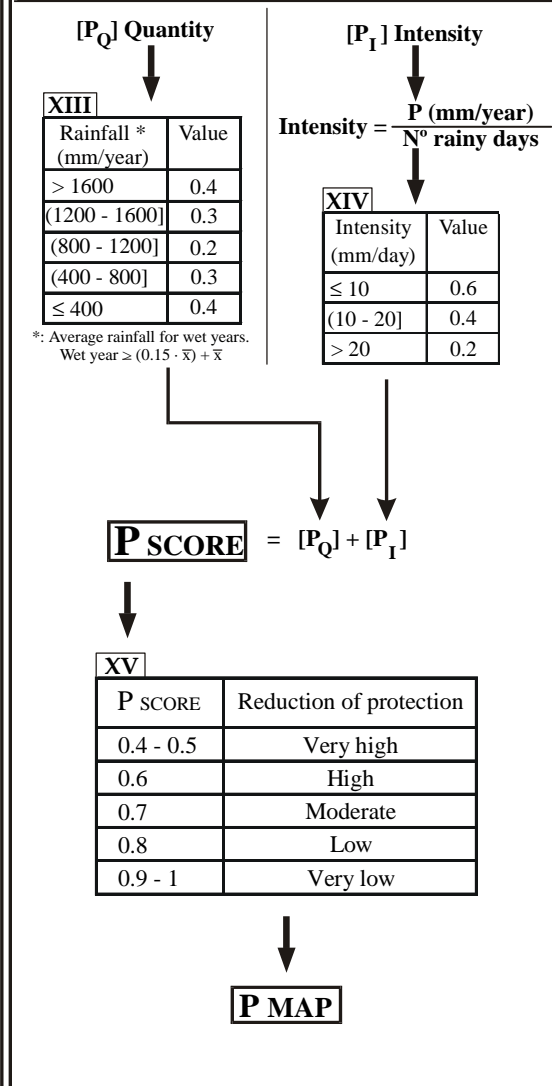
## O FACTOR (Overlying layers)



## C FACTOR (Concentration of flow)



## P FACTOR (Precipitation)



**COP Index = C SCORE · O SCORE · P SCORE**

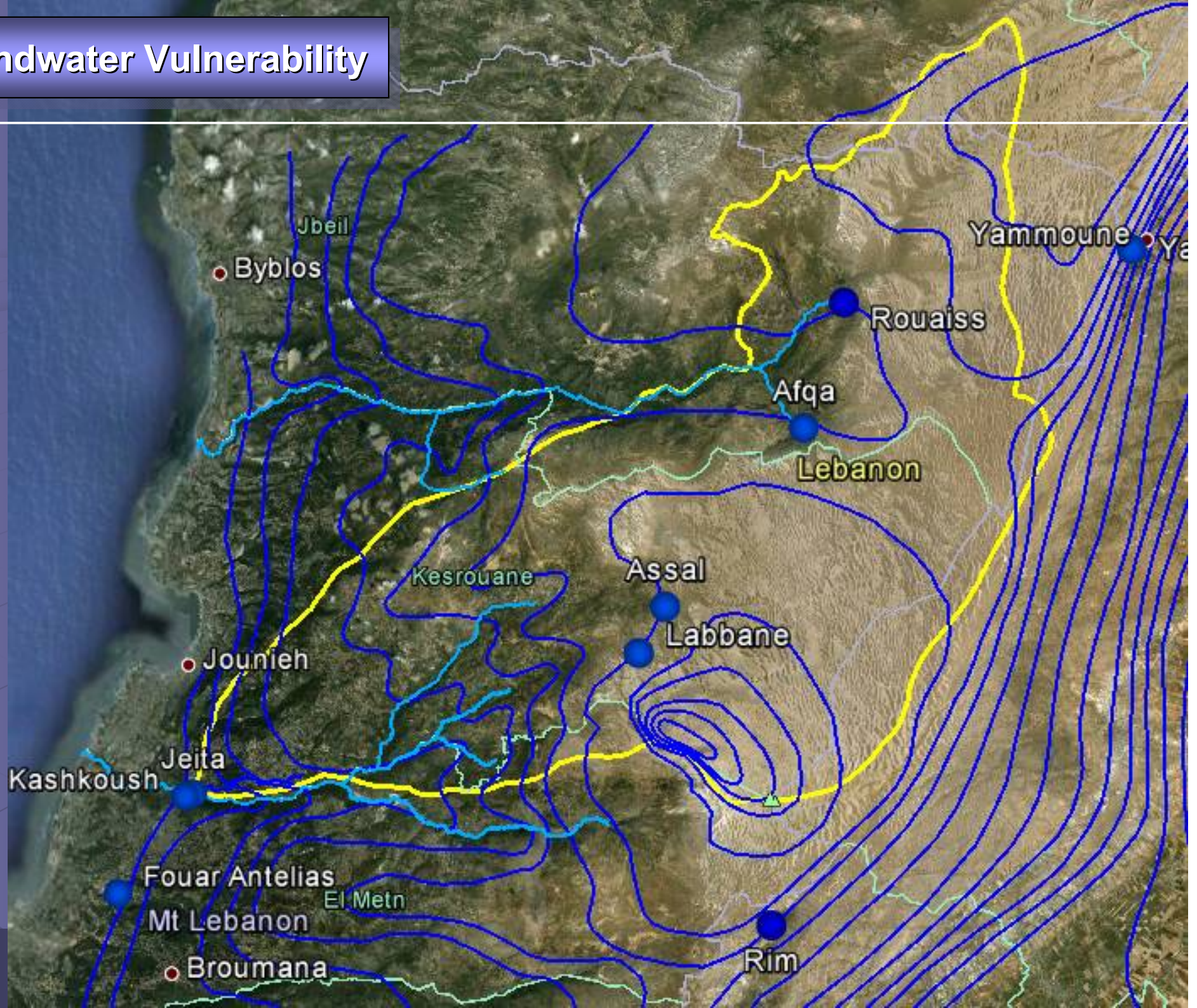
**XVI**

Cop Index	Vulnerability classes
[0 - 0.5]	Very high
(0.5 - 1]	High
(1 - 2]	Moderate
(2 - 4]	Low
(4 - 15]	Very low

**COP Map**



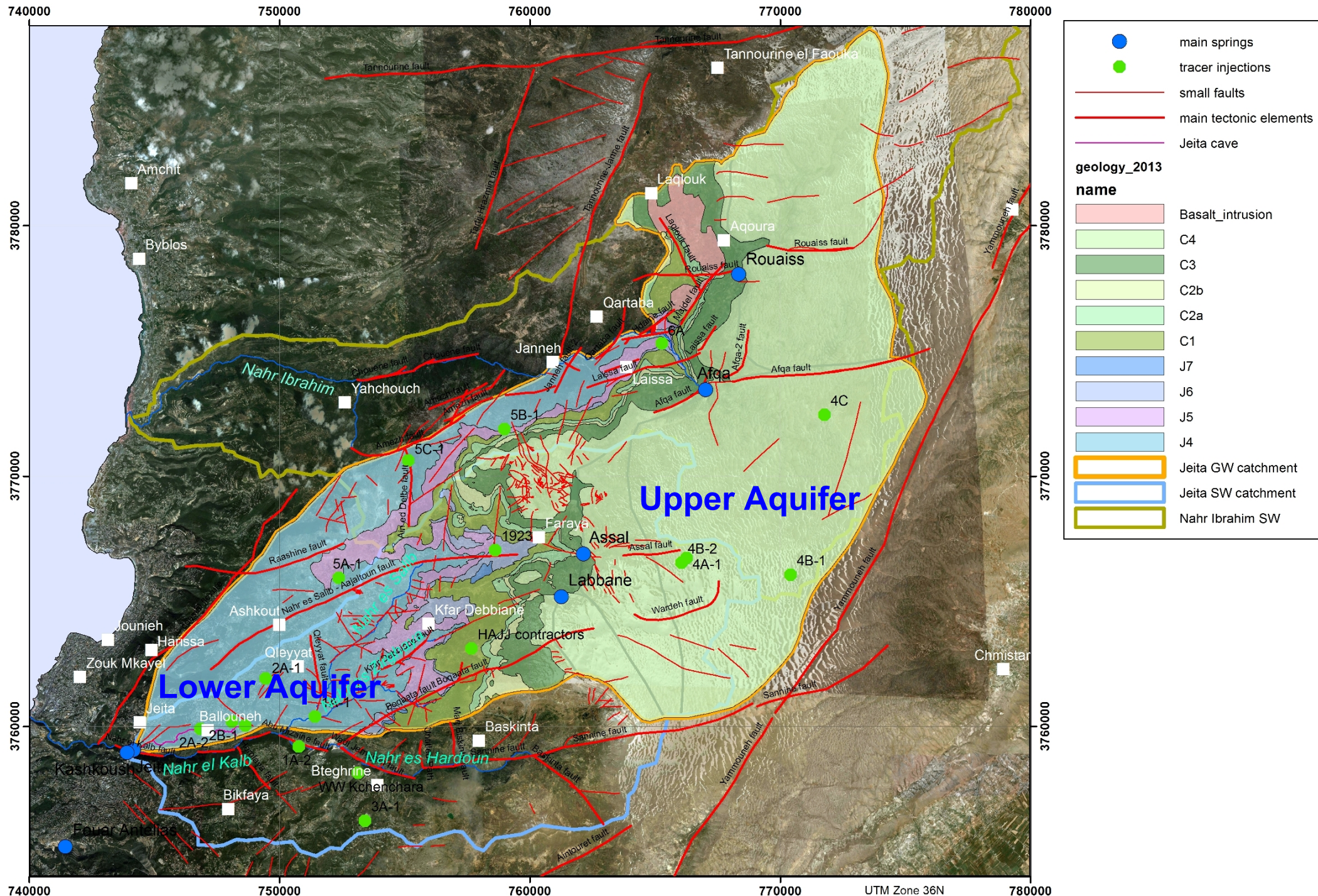
# Groundwater Vulnerability





# Geology

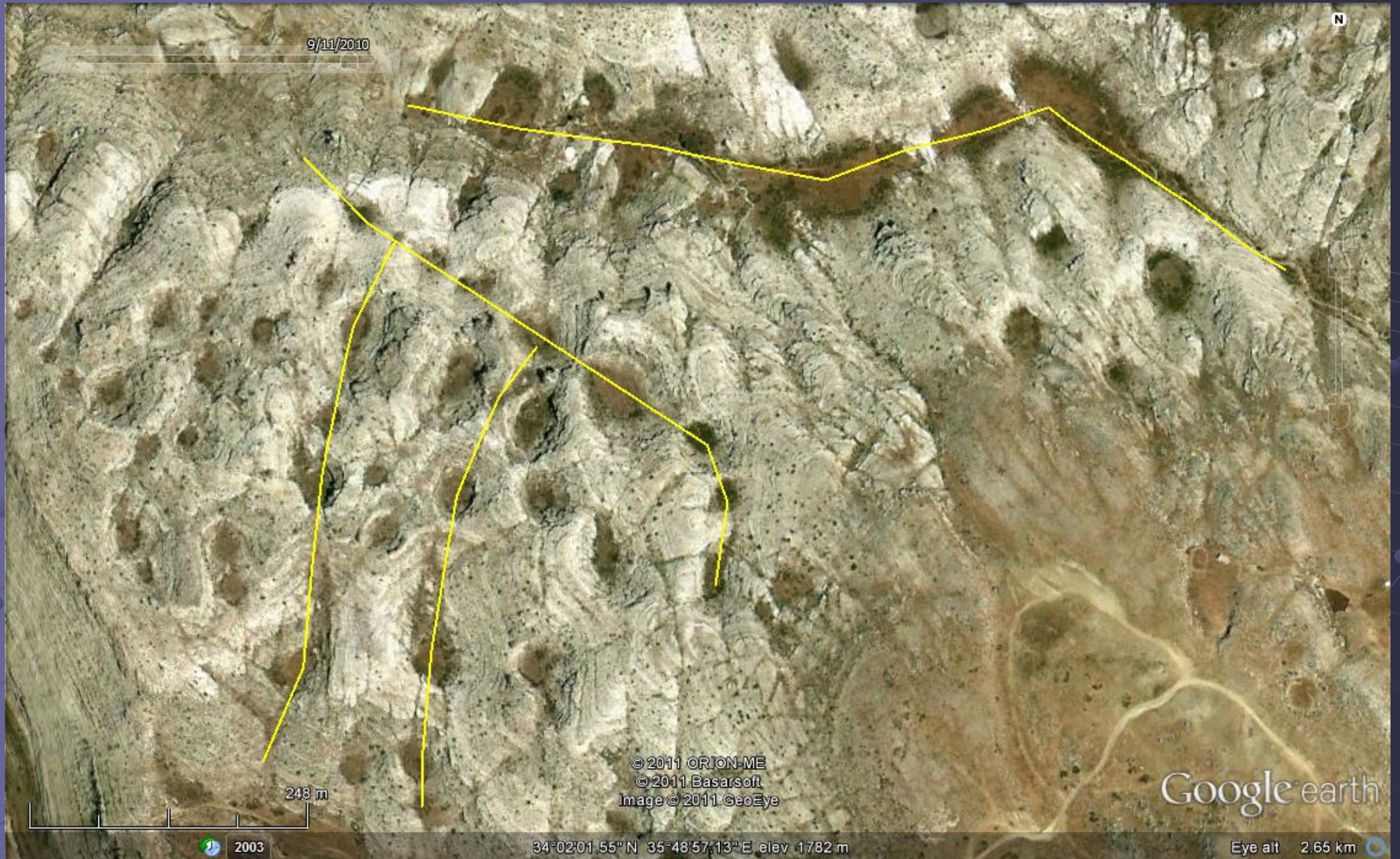
Based on new geological map prepared by BGR





# Surface Karst Features Mapping

## Dolines



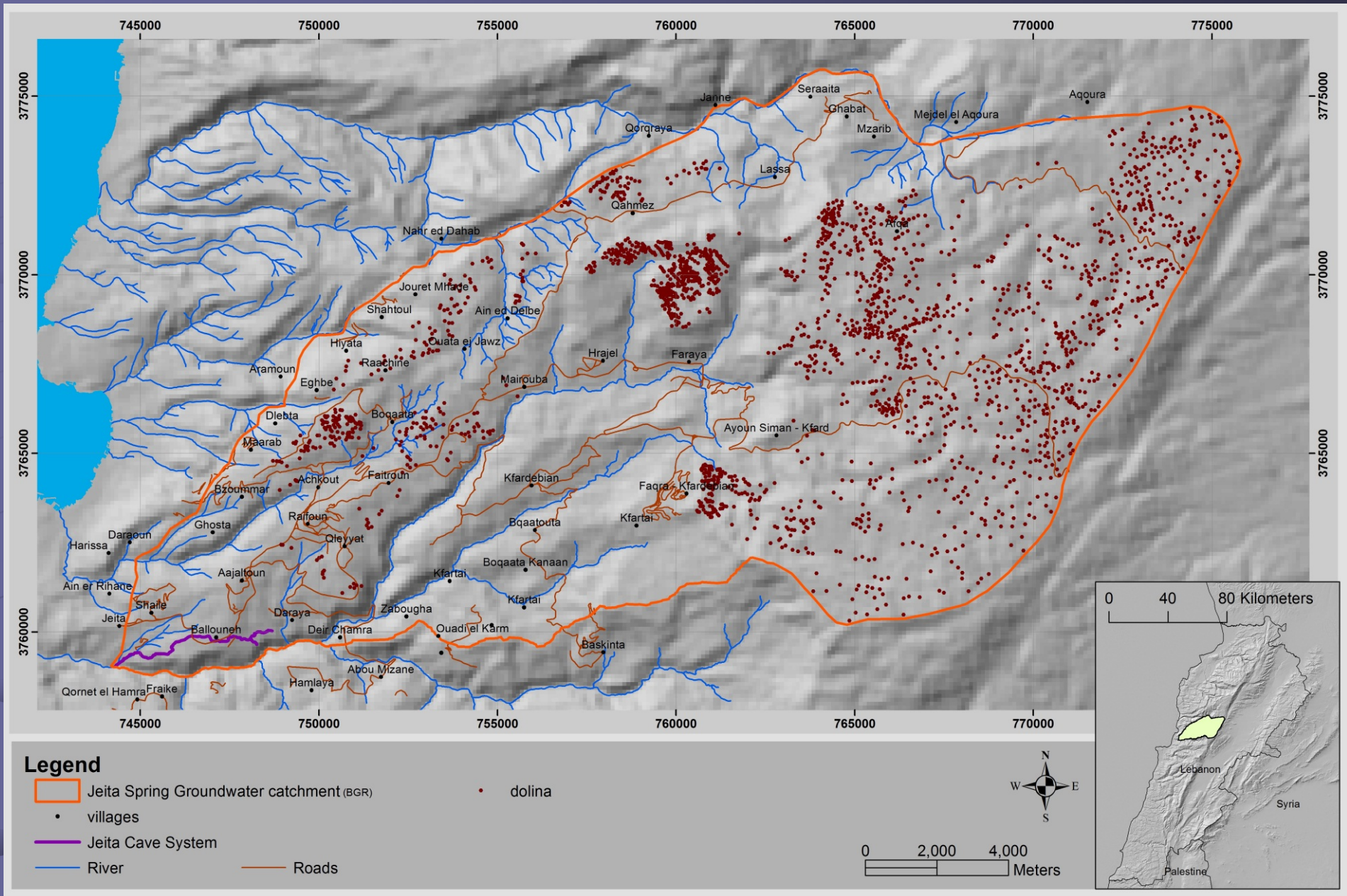
Protection of Jeita Spring





# Surface Karst Features Mapping

## Spatial Distribution of Dolines





# Groundwater Vulnerability



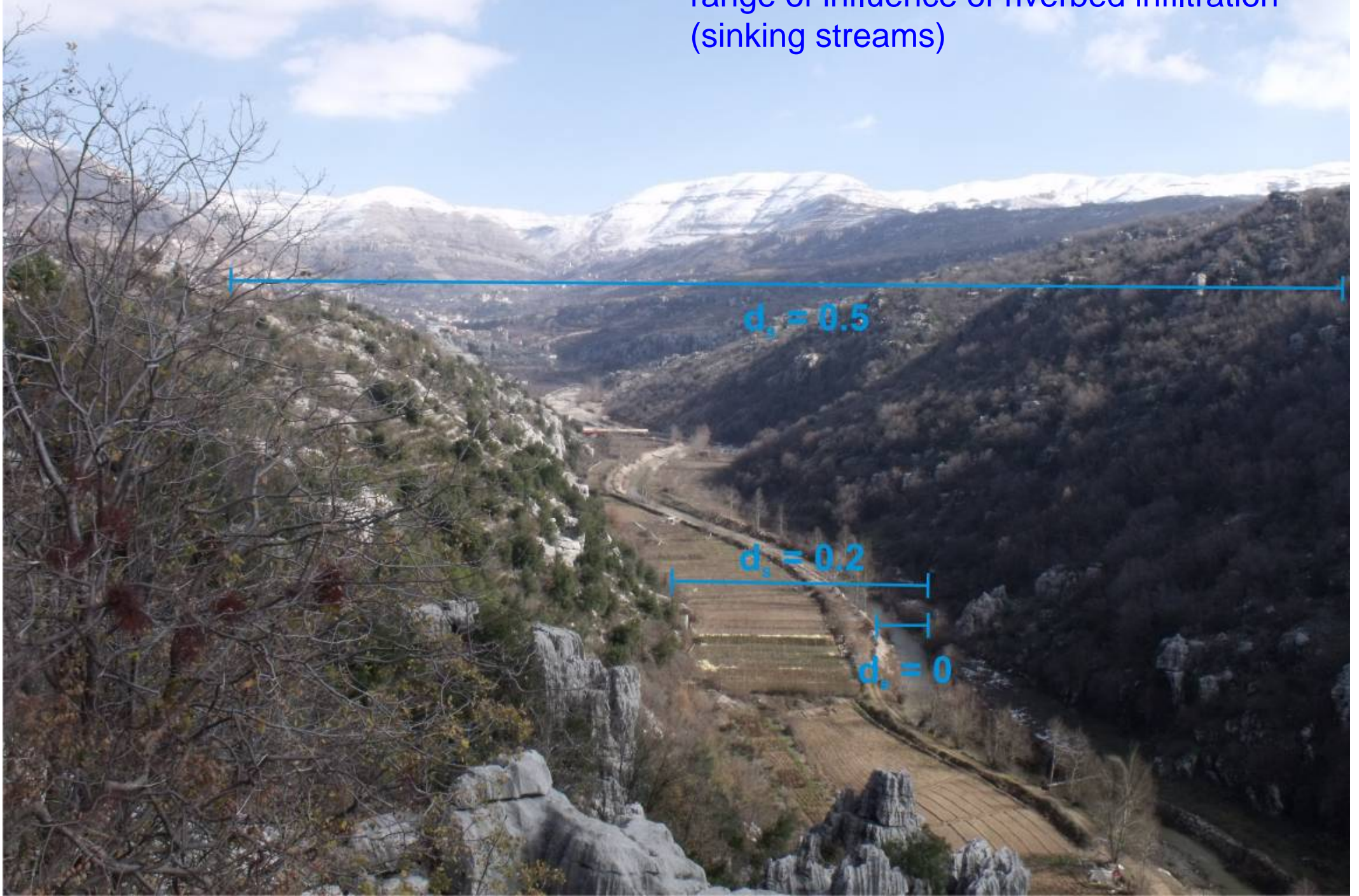
Protection of Jeita Spring





# Groundwater Vulnerability

range of influence of riverbed infiltration  
(sinking streams)





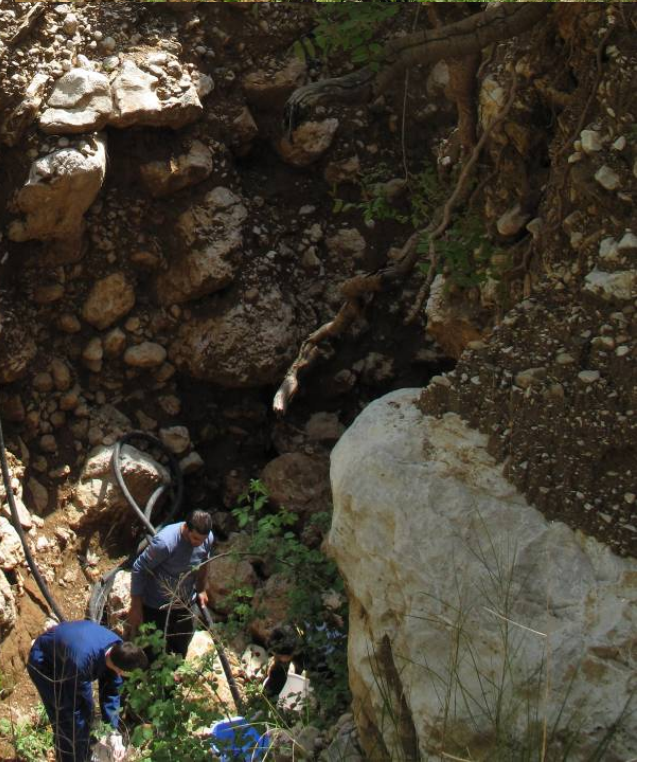
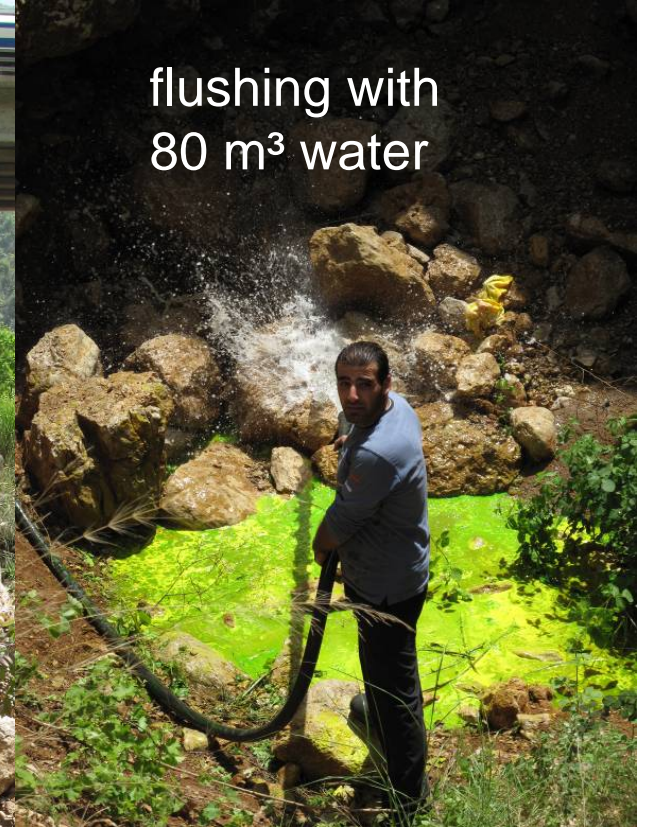
# Tracer Injection (uranine)

Flow velocities  
Hydrogeological interconnections

Mixing 5 kg uranine with water



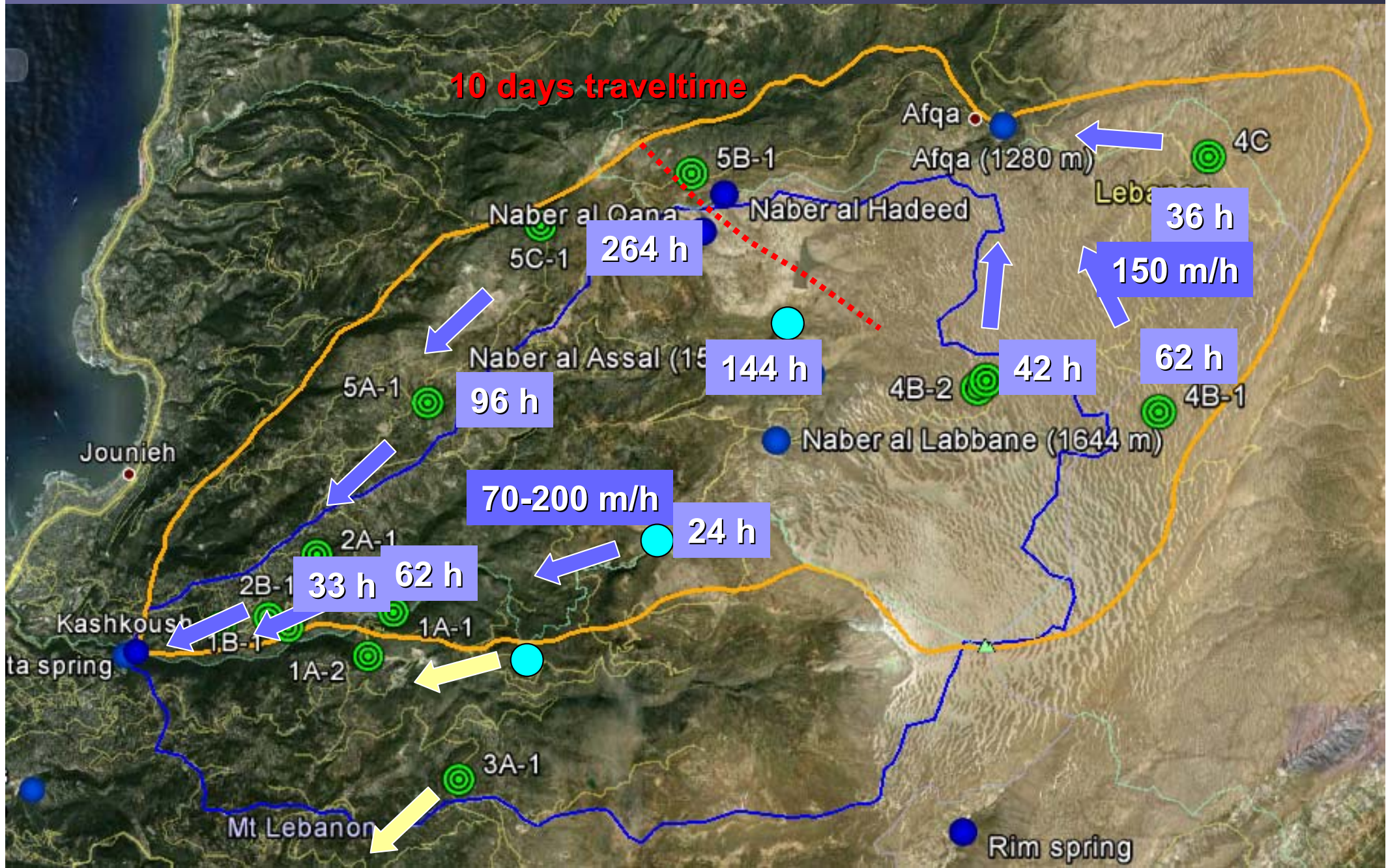
flushing with  
80 m<sup>3</sup> water





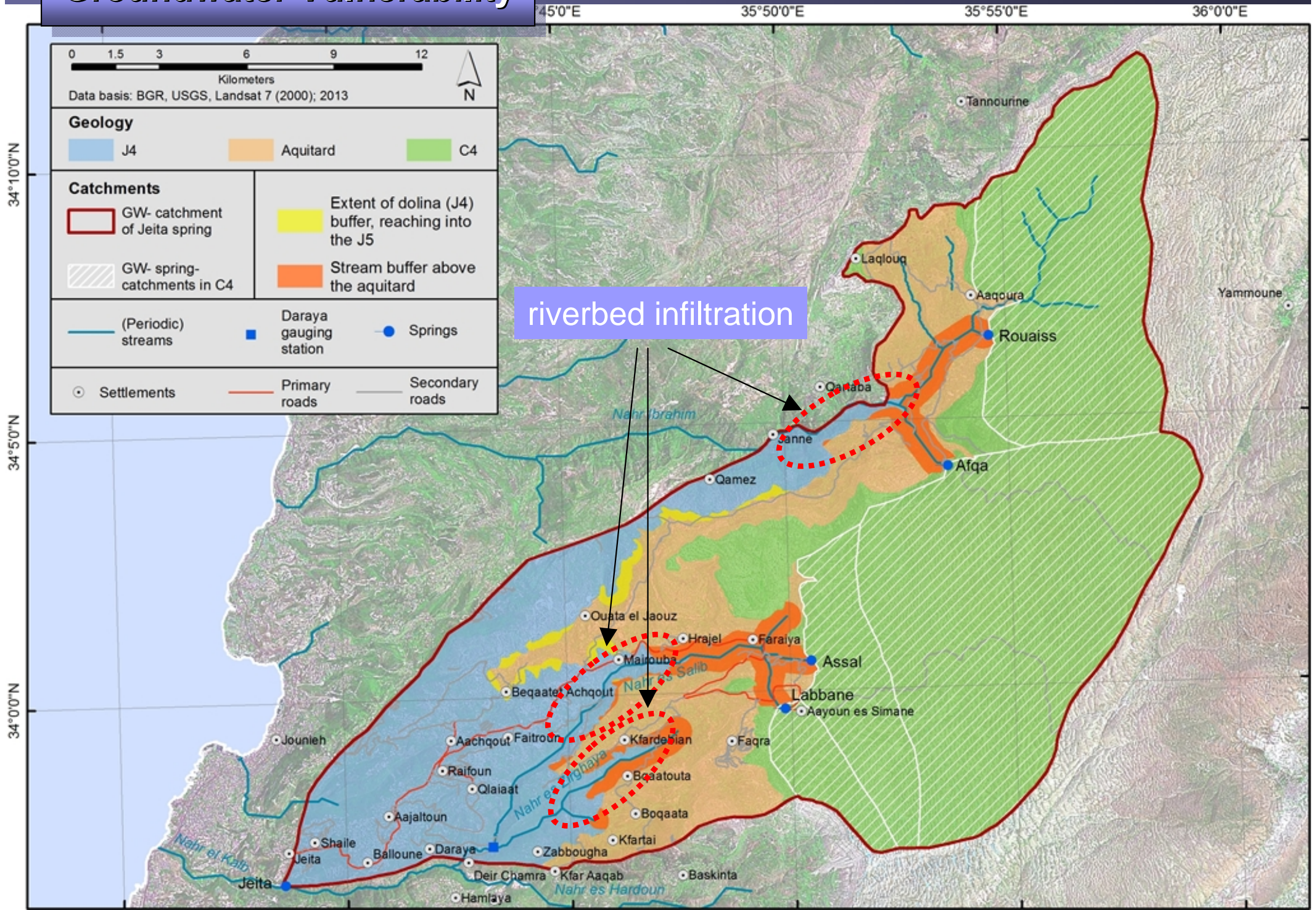
# Groundwater Flow

## Mean travel times





# Groundwater Vulnerability





Range of influence of dolines reduced

Range of influence of sinking streams changed

**O FACTOR (Overlying layers)**

[O<sub>s</sub>] Soil

I		II		Texture (os)	
Loam	Rest	≤ 0.5 m	0	3	2
1	0*	3	2	1	0
2	1	2	1	0	0

\* 0 when no soil is present

[O<sub>l</sub>] Lithology

III	ly	UZ	V	cn
Lithology and fracturation	ly	UZ	Confined conditions (cn)	cn
Clays	1500		Confined	2
Silt	1200			

Igneous rocks	100
Cemented or non fissured conglomerates and Sandstones	100
Scarcey cemented or fissured conglomerates	60
Sands and gravels	40
Permeable basalts	10
Fissured carbonate rocks	5
Karstic rocks	3
	1

(ly) (m) (cn)

Layer Index (ly.m)

Layer Index	ly.m
(0-250)	1
(250-1000)	2
(1000-2500)	3
(2500-10000)	4
>10000	5

Value Layer Index . cn

[O<sub>l</sub>]

[O] Score

**O SCORE = [O<sub>s</sub>] + [O<sub>l</sub>]**

VI

O score	Protection value
1	Very low
2	Low
(2 - 4)	Moderate
(4 - 8)	High
(8 - 15)	Very high

**C FACTOR (Concentration of flow)**

Scenario 1 [C<sub>1</sub>]: Swallow hole recharge area

VII				IX		
Distance to swallow hole (m)	dh	Distance to swallow hole (m)	dh	Slope	Vegetation	sv
≤ 500	0	(300-350)	0.15	≤ 8%	-	1
(50-100]	0.025	(350-400]	0.18	(8-31] %	Yes	0.95
(100-150]	0.05	(400-450]	0.2		No	0.9
(150-200]	0.075	(450-500]	0.23	(31-76] %	Yes	0.85
(200-250]	0.1	> 500	1		No	0.8
(250-300]	0.125			> 76%	-	0.75

Distance to sinking stream\* ds

Distance to sinking stream*	ds
< 10 m	0
10-100 m	0.2
100-500 m	0.5
> 500 m	1

**C<sub>1</sub> SCORE = [dh] . [ds] . [sv]**

\*1 when no sinking stream is present

Scenario 2 [C<sub>2</sub>]: Non-swallow hole recharge area

X				XI		
sf	Absence	Permeable	Imp	Slope	Vegetation	sv
Dev. Karst	0.25	0.5	0.75	≤ 8%	-	0.75
Scarcey developed or dissolution features	0.5	0.75	1	(8-31] %	Yes	0.8
Fissured karst	0.75	0.75	1		No	0.85
Absence of karst features	1	1	1	(31-76] %	Yes	0.9
					No	0.95
				> 76%	-	1

**C<sub>2</sub> SCORE = [sv] . [sf] . [ds]**

[C] Score

**1) C<sub>1</sub> SCORE = [dh] . [ds] . [sv] or 2) C<sub>2</sub> SCORE = [sv] . [sf] . [ds]**

XII

C score	Reduction of Protection
(0 - 0.2]	Very high
(0.2 - 0.4]	high
(0.4 - 0.6]	Moderate
(0.6 - 0.8]	Low
(0.8 - 1]	Very low

**P FACTOR (Precipitation)**

P<sub>0</sub> Quantity

Rainfall (mm/year)	pq
> 1600	0.4
(1200-1600]	0.3
(800-1200]	0.2
(400-800]	0.3
≤ 400	0.4

P<sub>i</sub> Intensity

**Intensity =  $\frac{P \text{ (mm/year)}}{N \text{ of rainy days}}$**

XIV

Intensity (mm/day)	pi
≤ 10	0.6
(10-20]	0.4
> 20	0.2

[P] Score

**P SCORE = [P<sub>0</sub>] + [P<sub>i</sub>]**

XV

P score	Reduction of Protection
0.4-0.5	Very high
0.6	high
0.7	Moderate
0.8	Low
0.9-1	Very low

[COP] Score

**COP Index = [C] . [O] . [P]**

XVI

COP Index	Vulnerability classes
(0 - 0.5]	Very high
(0.5 - 1]	high
(0 - 2]	Moderate
(0 - 4]	Low
(0 - 15]	Very low

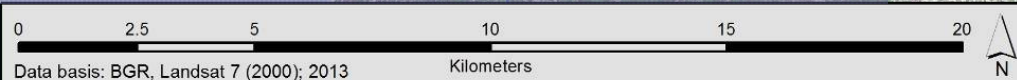




# Groundwater Protection Zones

# Groundwater Vulnerability COP Method (modified)

35°50'0"E

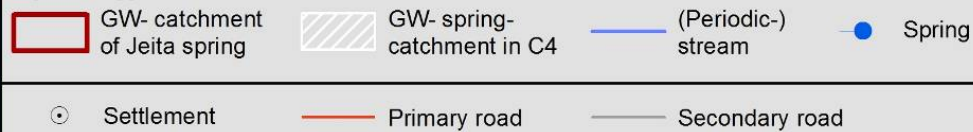


Data basis: BGR, Landsat 7 (2000); 2013

## COP GW- vulnerability



## Hydrology



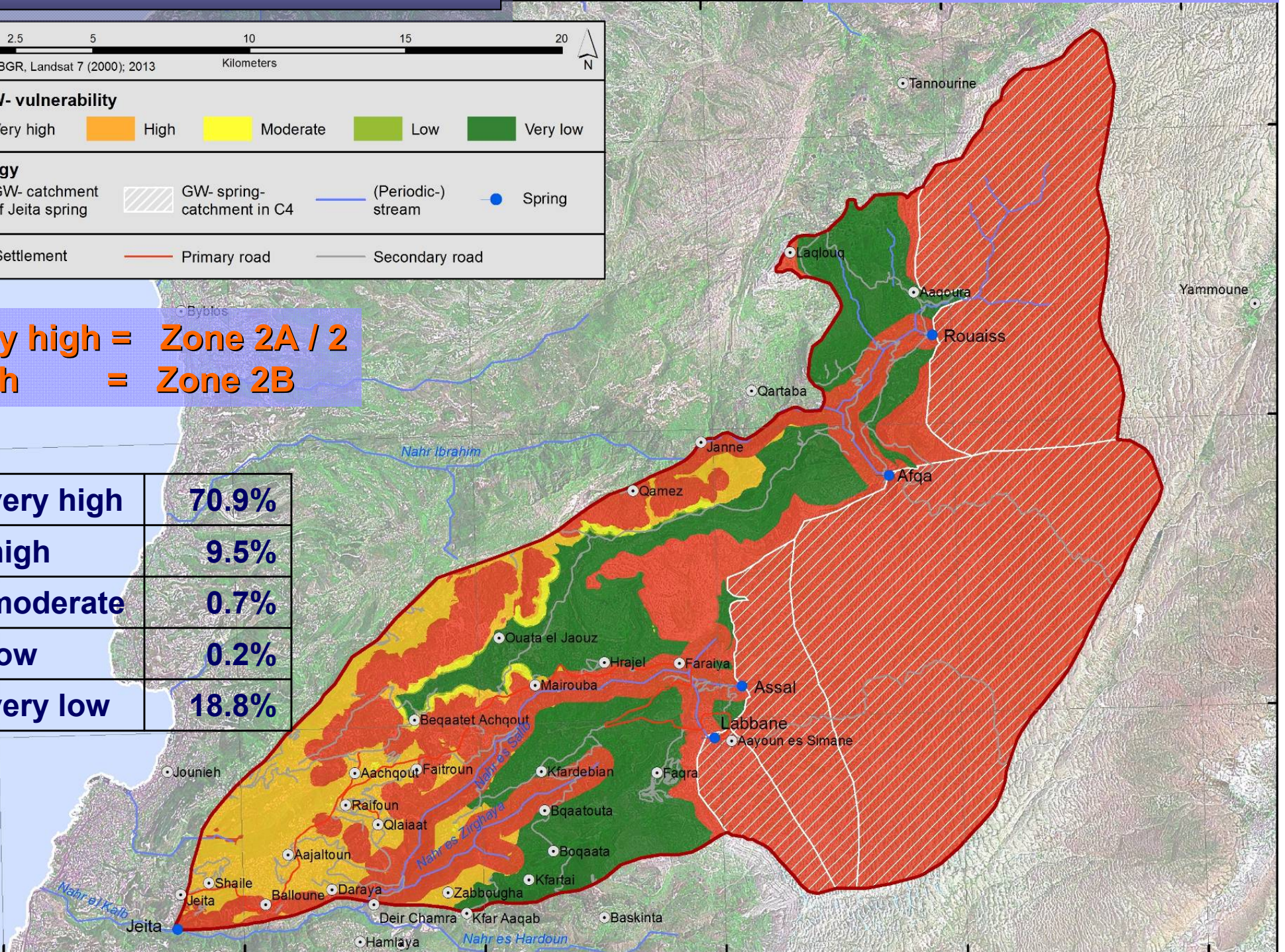
**Very high = Zone 2A / 2**  
**High = Zone 2B**

very high	70.9%
high	9.5%
moderate	0.7%
low	0.2%
very low	18.8%

34°10'0"N

34°5'0"N

34°0'0"N





# Groundwater Protection Zones

for Jeita, Afqa, Rouaiss, Assal and Labbane springs

35°50'0"E



Data basis: BGR, Landsat 7 (2000); 2013

## COP GW- Protection zones

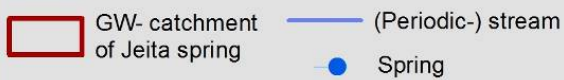
### Jeita Spring



### C4 Springs



### Hydrology



### Infrastructure



71% zone 2

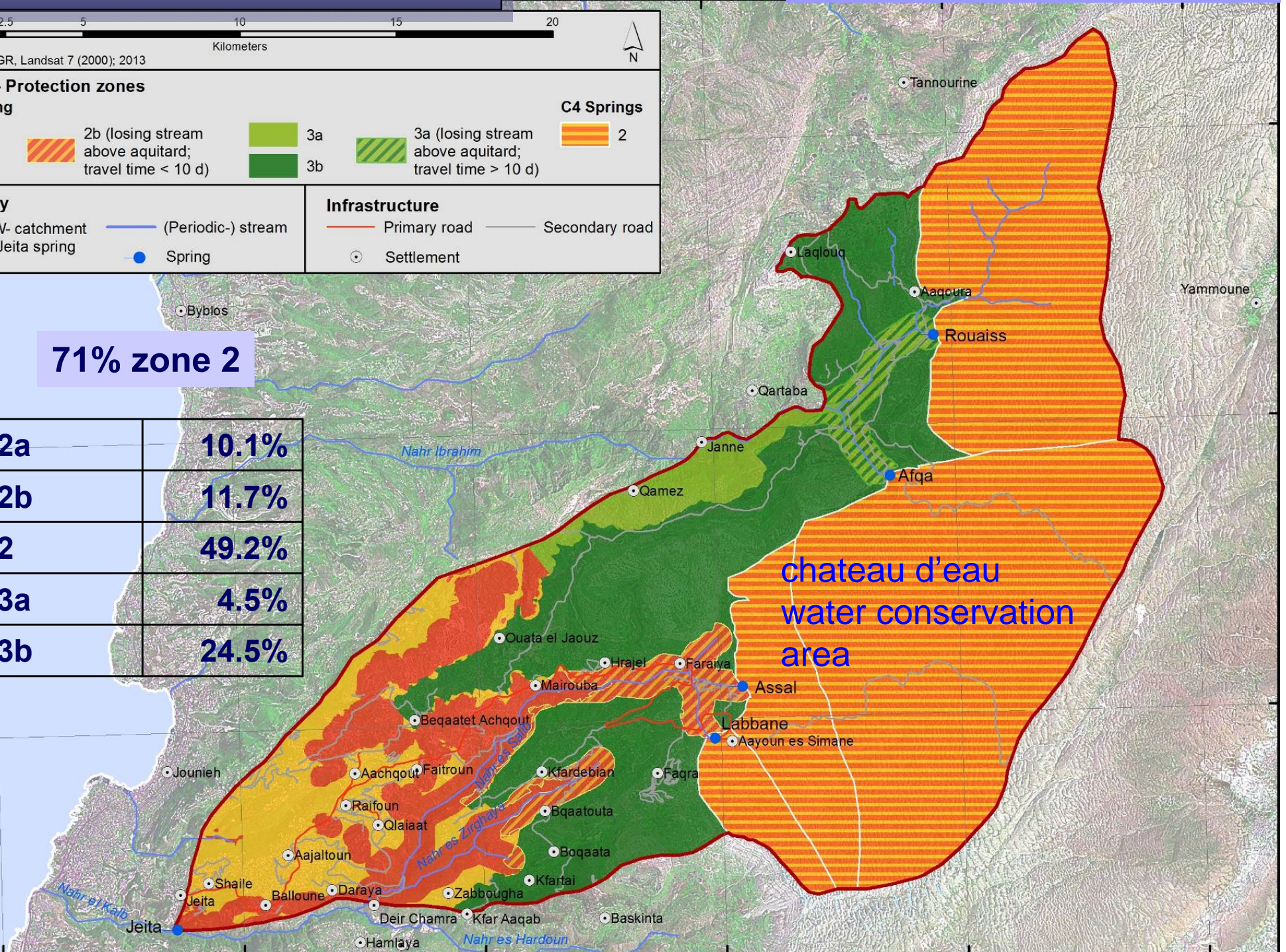
2a	10.1%
2b	11.7%
2	49.2%
3a	4.5%
3b	24.5%

chateau d'eau  
water conservation  
area

34°10'0"N

34°5'0"N

34°0'0"N





# Groundwater Protection Zones

**zone 1:** 50 m upstream, 15 m to each side, 10 m downstream of the spring and 10 m to each side of related water infrastructure, e.g. conveyor line, reservoir, etc. until entry into the actual water supply infrastructure; Zone 1 includes the area over the cave and underground river with a rock cover of less than 100 m;

**zone 2A:** groundwater travel time < 10 days, very high groundwater vulnerability, possible direct infiltration into underlying Jeita underground river: buffer zone 250 m from projected course;

**zone 2B:** groundwater travel time < 10 days, high groundwater vulnerability;

**zone 3A:** groundwater travel time > 10 days, very high groundwater vulnerability and

**zone 3B:** all other parts of the groundwater catchment.



**Landuse in zone 1 by the water utility** must consider the following:

Oil, grease, lubricants, pesticides, fungicides, batteries and any substances that are potentially hazardous to water should not be stored or used in zone 1.

Constructions, other than required for the operation and maintenance of the water conveyance system, are not allowed.

**Modifications required in Protection Zone 1:**

A **fence** must be erected along the canal at 10 m distance from the canal.

Houses and commercial businesses at the canal must be removed (10 m distance).

**Construction ban in the critical zone (risk of cave collapse)**



**New residential buildings should not be allowed to be built downgradient of the new wastewater collector line (escarpment collector).**

The stormwater drainage along the main road (Jeita - Faraiya highway) should be enlarged to ensure that all stormwater can be drained to a location outside protection zone 2A.

The following activities shall not be allowed in zones 2A and 2B:

- Gas stations,
- Industrial sites,
- Commercial businesses using hazardous substances,
- Quarries, rock cutting facilities, brick factories,
- Dumping of waste,
- Animal farms,
- Slaughterhouses,
- Application of pesticides and chemical fertilizers.



### Modifications required in Protection Zone 2A

#### Wastewater:

- urgent implementation of KfW, EIB & Italian Protocol WW projects  
**(following centralized approach: treatment & effluent discharge outside catchment)**
- enforce connection to the new wastewater network
- in all houses the existing drainage must be diverted to the new collection system and the existing cesspits must be closed
- new network in protection zone 2A must be constructed in such a way that leakage of untreated wastewater into groundwater is not possible

Gas stations should be forced to install double-layer tanks (in zones 2A, 2B)

In zone 2A some gas stations may need to be removed (not in compliance with environmentally sound practices)





### Modifications required in Protection Zone 2B

Waste dumps: all existing illegal waste dumps should be removed. Deposition of construction waste should not be allowed in protection zones 2A and 2B, but only at designated locations in zone 3. The construction waste must not contain any other substances than rocks, cement and bricks.

The slaughterhouses located in zone 2, in Ajaltoun (Murr) and Ghosta should be closed.

[The animal farms in the Beit Chebab, Mar Boutros, Safilee and Hemlaya area pose a high risk to Kashkoush spring > Kashkoush spring is almost continuously highly polluted and cannot be used due to this]



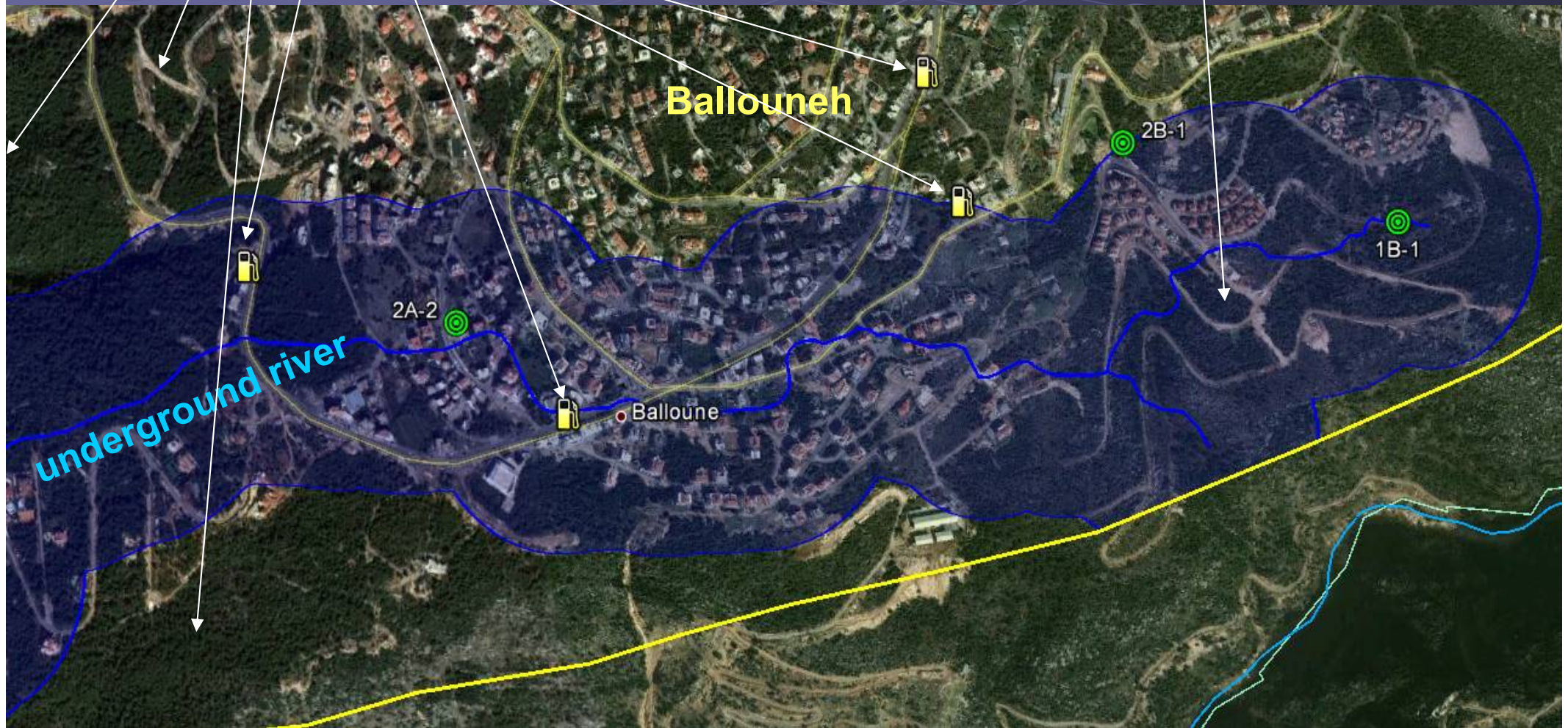
# Groundwater Protection Zones

## Jeita Spring

CIL group housing projects

gas stations

George Matta housing project  
Ajaltoun Valley



Protection of Jeita Spring





# Groundwater Protection Zones

# Jeita Spring

35°45'0"E

35°46'0"E

35°47'0"E

35°48'0"E

34°10'N

34°0'0"N

33°59'0"N

33°58'0"N

Extent of main map

0 0.25 0.5 1 1.5  
Kilometers

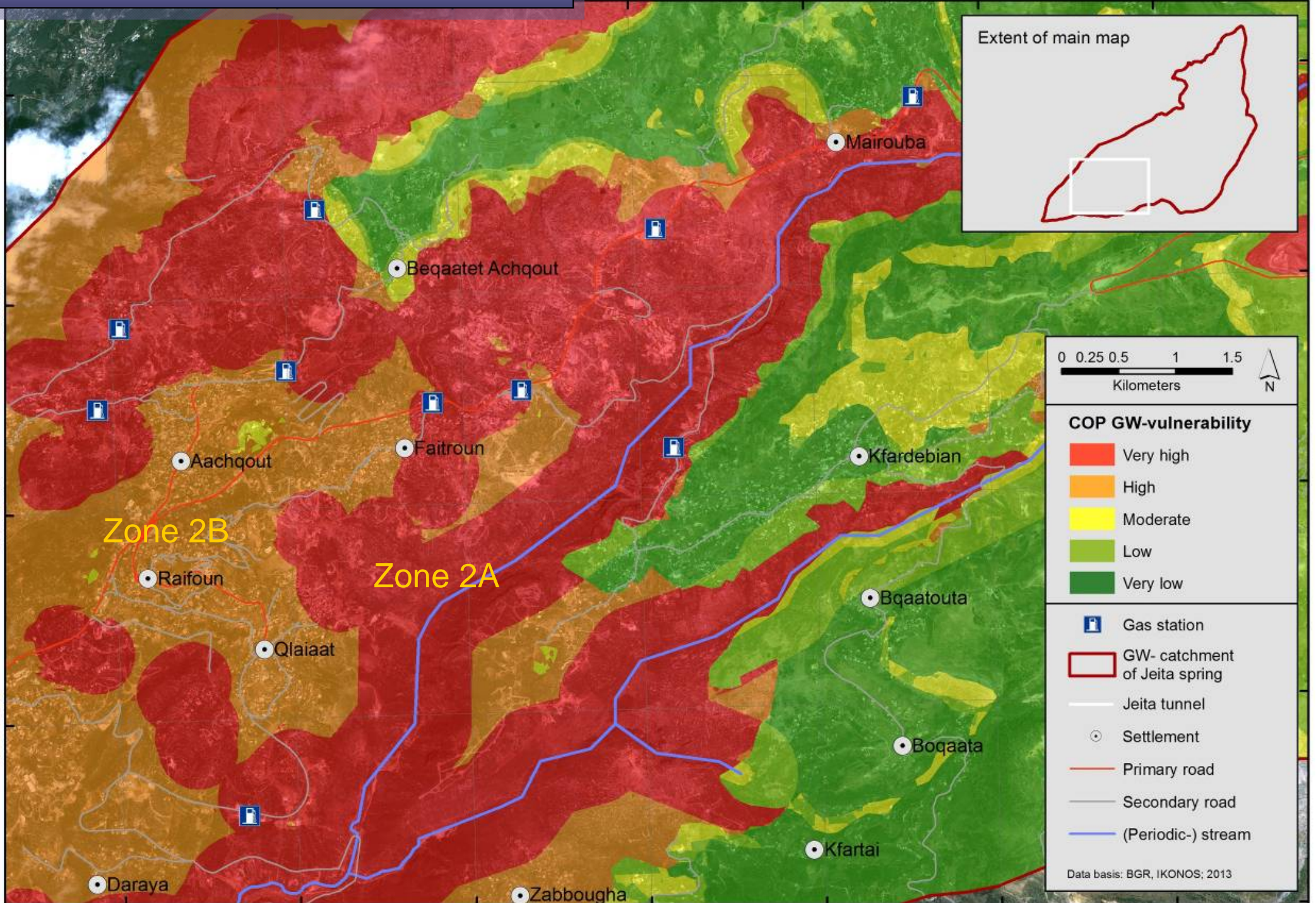


### COP GW-vulnerability

- Very high
- High
- Moderate
- Low
- Very low

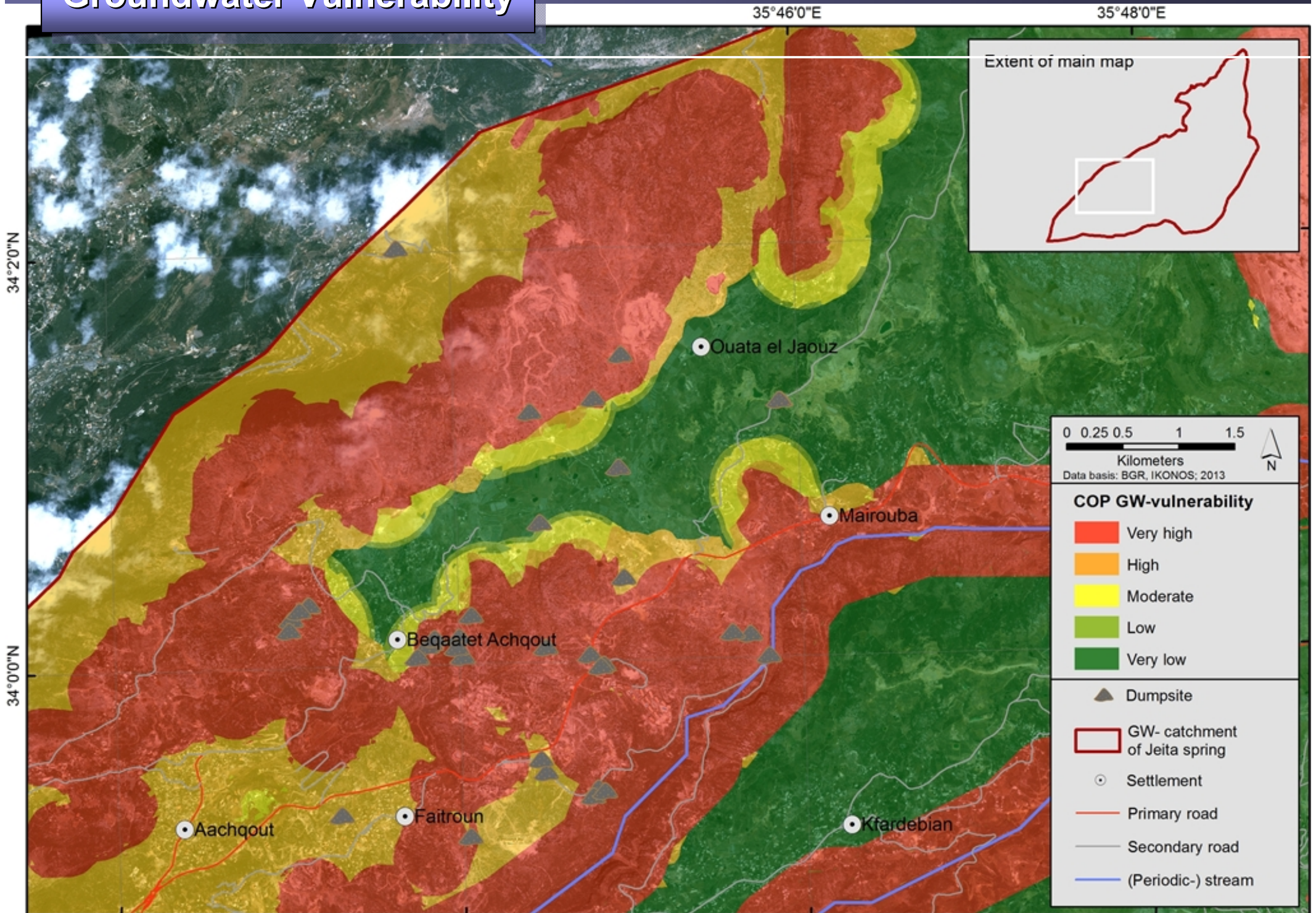
- Gas station
- GW- catchment of Jeita spring
- Jeita tunnel
- Settlement
- Primary road
- Secondary road
- (Periodic-) stream

Data basis: BGR, IKONOS; 2013





# Groundwater Vulnerability





# Implementation

To achieve a successful implementation of GW protection zones the following measures are needed:

## Zone I

**Awareness campaigns**

**Boundaries of GW protection zones have to be clearly marked**

**Control mechanism (environmental rangers)**

## Zone II

Signposts for protection zones in Jordan implemented by MWI & BGR 1999-2010: 33% of national drinking water sources protected

**منطقة الحماية الأولى لمصادر المياه**  
( أنت الآن في منطقة الحماية الأولى )

**لحماية مصادر المياه من التلوث يجب:**

- عدم إلقاء النفايات
- عدم الرعي وسقاية الحيوانات
- عدم تجاوز هذا السياج

الرجاء التبليغ عن أي من التجاوزات أعلاه أو أي أعمال قد تؤدي الى تلويث المياه والبيئة على رقم الخط الساخن للشرطة البيئية:

USAID BGR

**منطقة الحماية الثانية لمصادر المياه**  
( أنت الآن في منطقة الحماية الثانية )

**لحماية مصادر المياه من التلوث يجب:**

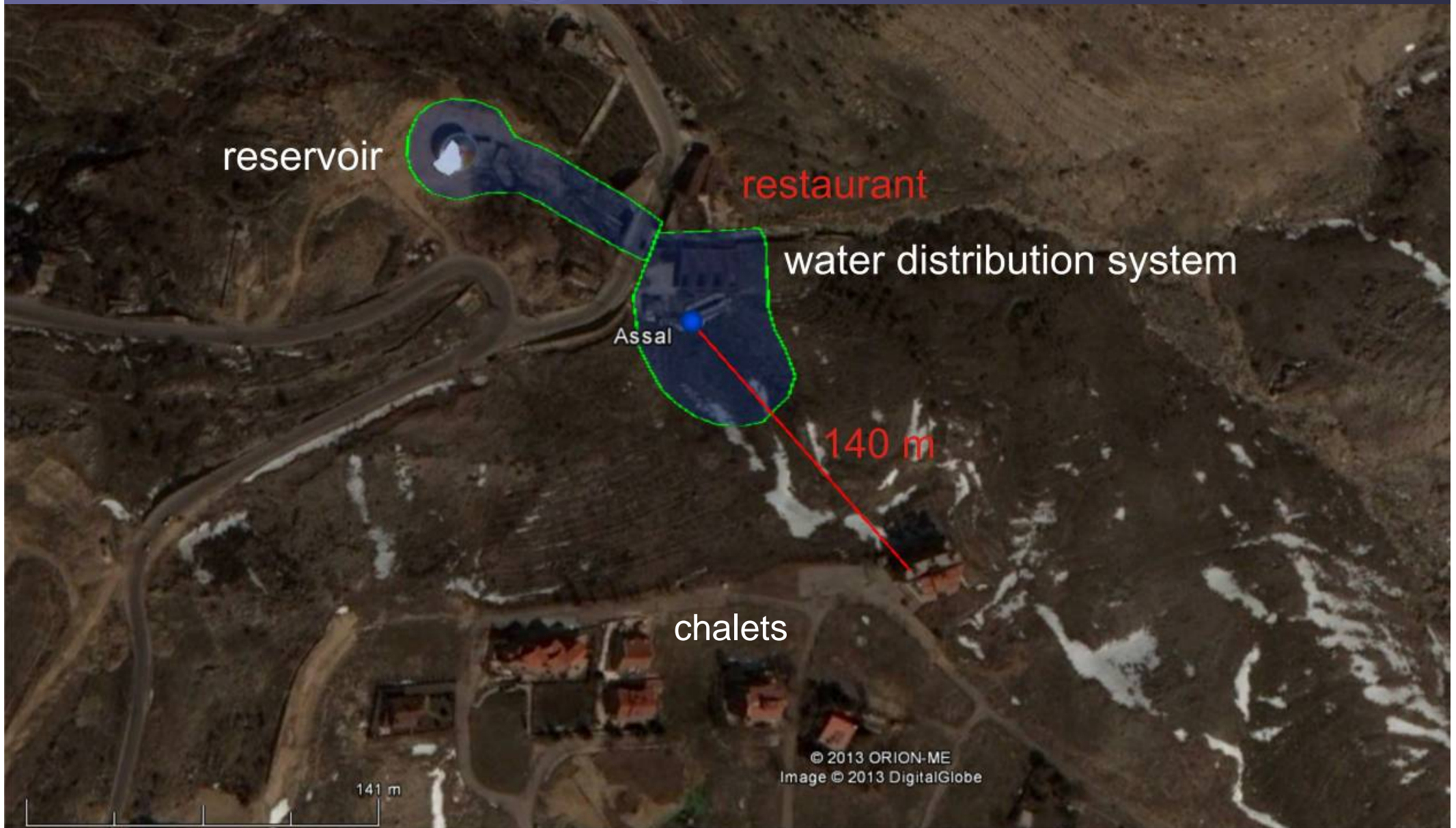
- عدم إلقاء النفايات الصلبة، والتخلص منها في
- التفريغ الحضري الامتصاصية بانتظام والتخلص من الحمولة في
- عدم طرح المشتقات البترولية والزيوت
- عدم استخدام المبيدات والأسمدة الكيماوية

الرجاء التبليغ عن أي من التجاوزات أعلاه أو أي أعمال قد تؤدي الى تلويث المياه والبيئة على رقم الخط الساخن للشرطة البيئية:

USAID BGR

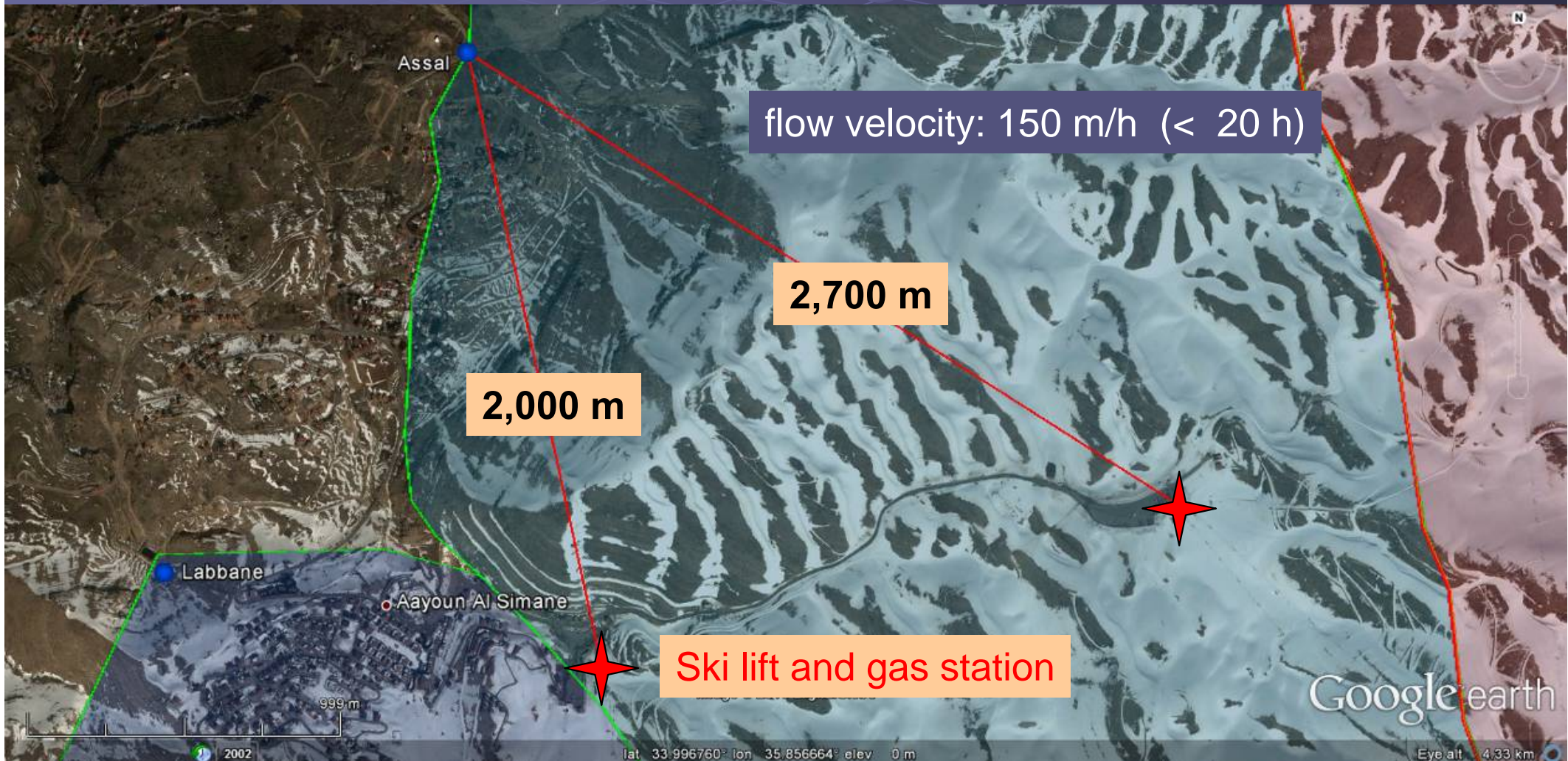


### Protection Zone 1 for Assal Spring





Distance from ski stations





Hotels: the building of **new or extensions of exiting hotels** with more than 20 rooms should **not** be allowed in zone 2.

Restaurants: **new restaurants should not be allowed** unless they are connected to the new wastewater collection system.

Ski lift stations: It is also recommended **not to allow building new or extensions of exiting ski lift stations** unless environmental impact assessments (EIAs) have been prepared proving that negative impacts on water resources (groundwater and surface water) cannot occur. **The gas station at the ski lift must be removed or equipped with a double-layer tank and leakage detection and alarm system.**

Skidoo and quad bike rentals: No new or extensions of existing **skidoo and quad bike rentals should be allowed**. The existing skidoo and quad bike rentals should not be allowed to store fuel or undertake repairs on their premises.

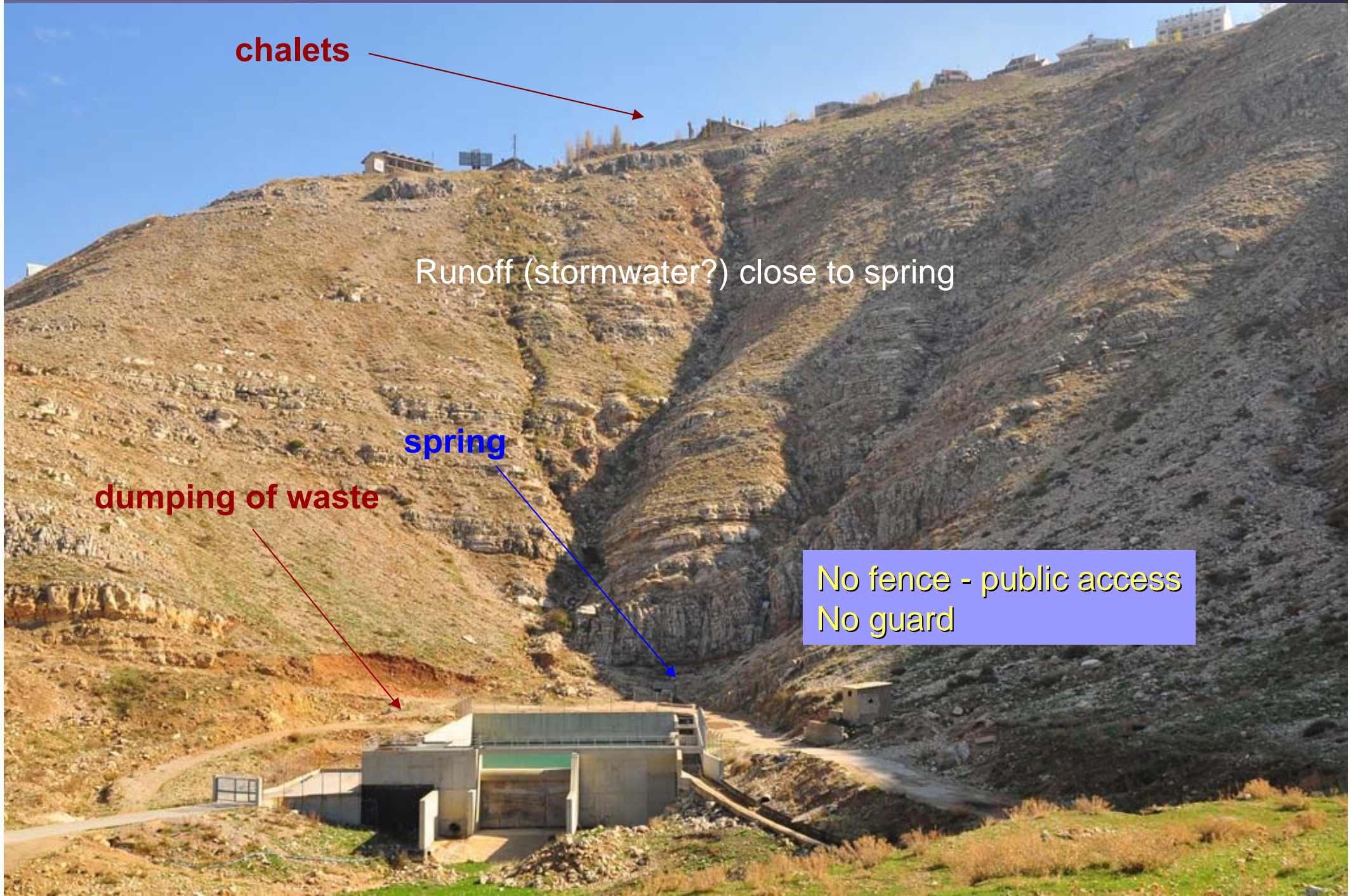
Army: The army check point at Wardeh has to consider environmental-friendly operation. **Fuel** should not be stored here.











**chalets**



Runoff (stormwater?) close to spring

**spring**



**dumping of waste**



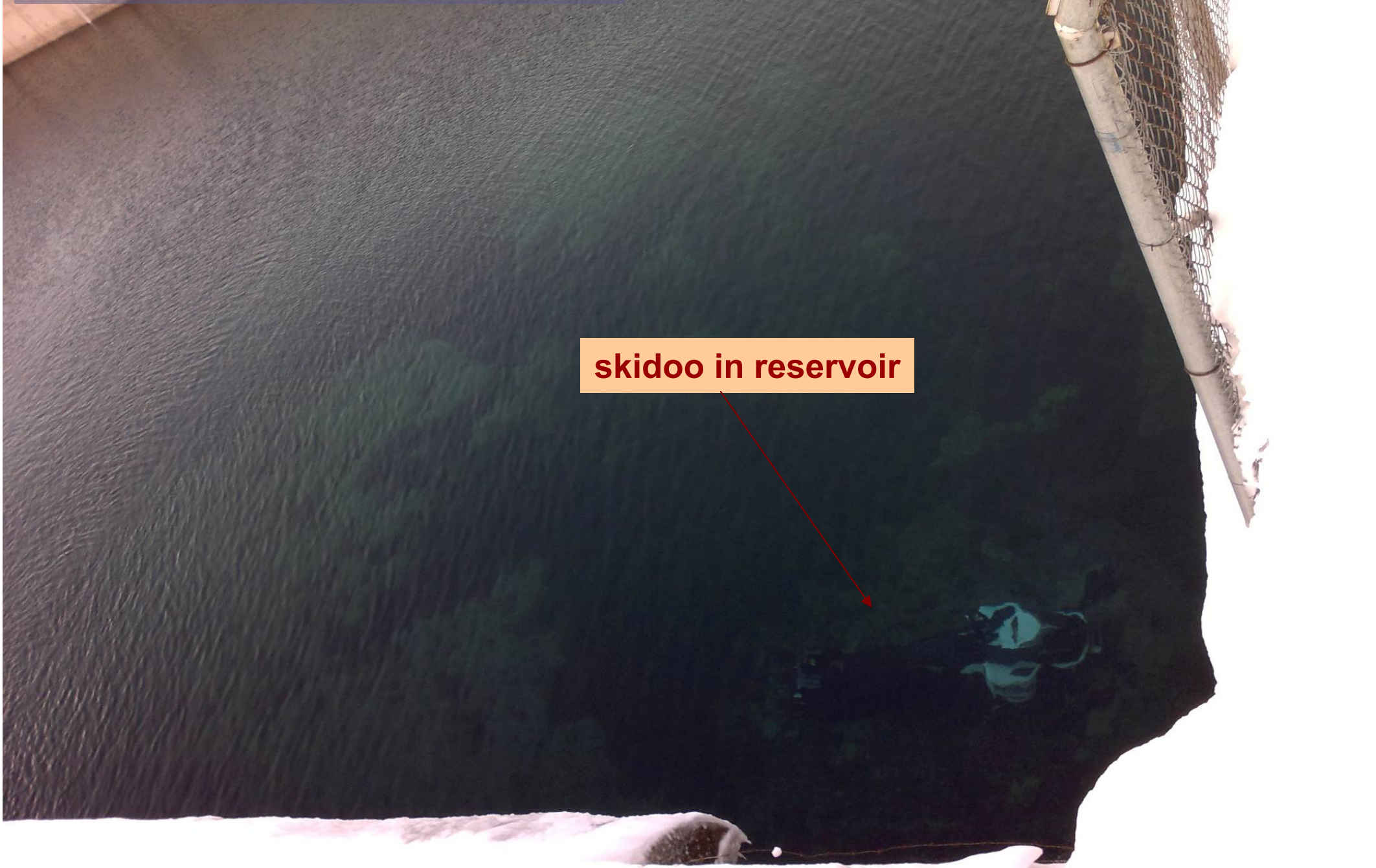
No fence - public access  
No guard



# Groundwater Protection Zones

Labbane Spring

skidoo in reservoir





## Reports for Project Component 2

# 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) ✓

[www.bgr.bund.de/jeita](http://www.bgr.bund.de/jeita)





## Reports for Project Component 2

# Integration of Water Resources Protection Aspects into Landuse Planning

Special Reports 1 / 2 / 5 / 6 / 11 / 17: **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)





# *Thank you for your kind attention*

[www.bgr.bund.de/jeita](http://www.bgr.bund.de/jeita)

Dr. Armin Margane – Project Team Leader  
Raifoun, Saint Roche Street  
armin.margane@bgr.de +961 70 398027



*Protection of Jeita Spring*

