AGRICULTURAL WATER AND ENERGY MANAGEMENT

PASI 2013: Training Institute on Adaptive Water-Energy Management in the Arid Americas

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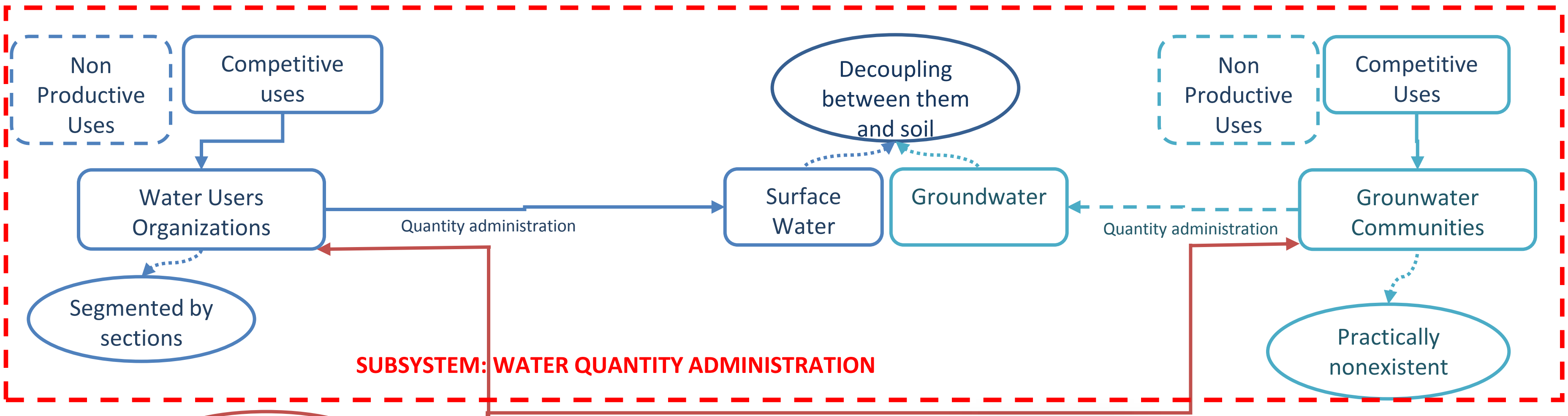
- Context:
  - water management system as key Issue
- Azapa Valley Case:
  - Individual use of water
- Energetic vulnerability
- Copiapó Case:
  - Community use of water
  - Energy and water management

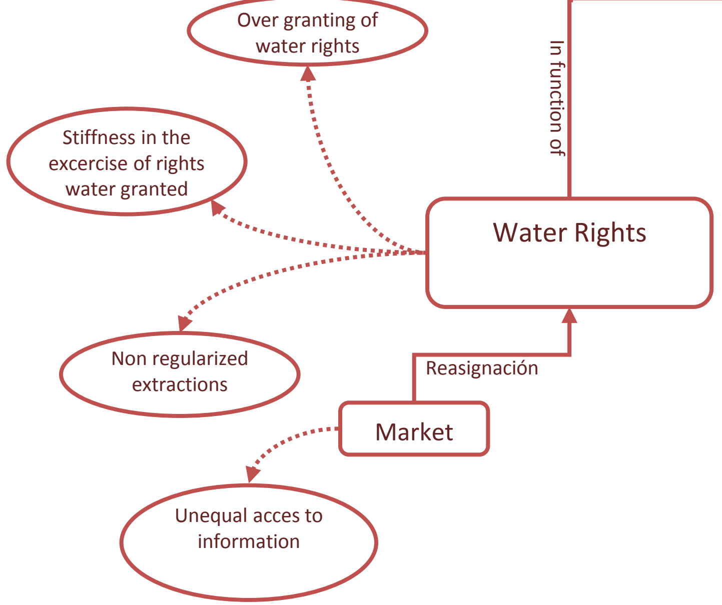
Context: use of water in agriculture

- Management differences
  - Surface water
    - Usually , shared infrastructure use for distribution and use. e.g. Channels “n” users.

  - Groundwater
    - Individual use Dam?
      - In Chile, only one aquifer with an Organization for joint water management

Brief description of water management in Chile





Environmental Aspects

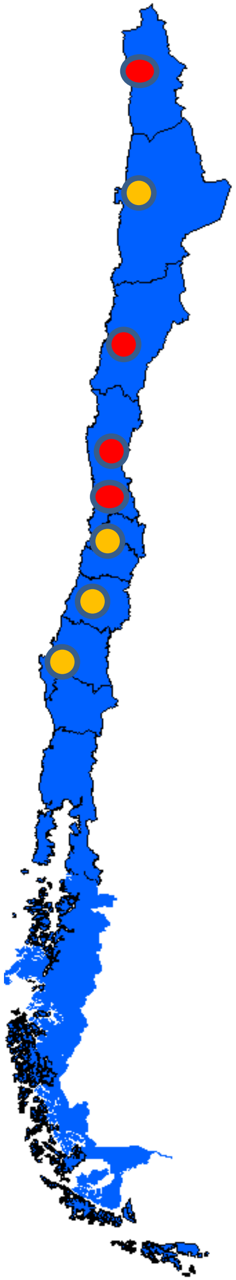
Water Deficit by Basins

Deficit
Risk
Without Risk

Fuente: “Estimaciones De Demanda De Agua Y Proyecciones Futuras”. DGA, 2007. (exceedance scene of 85 % and a 10 years demand)

Water Depletion State

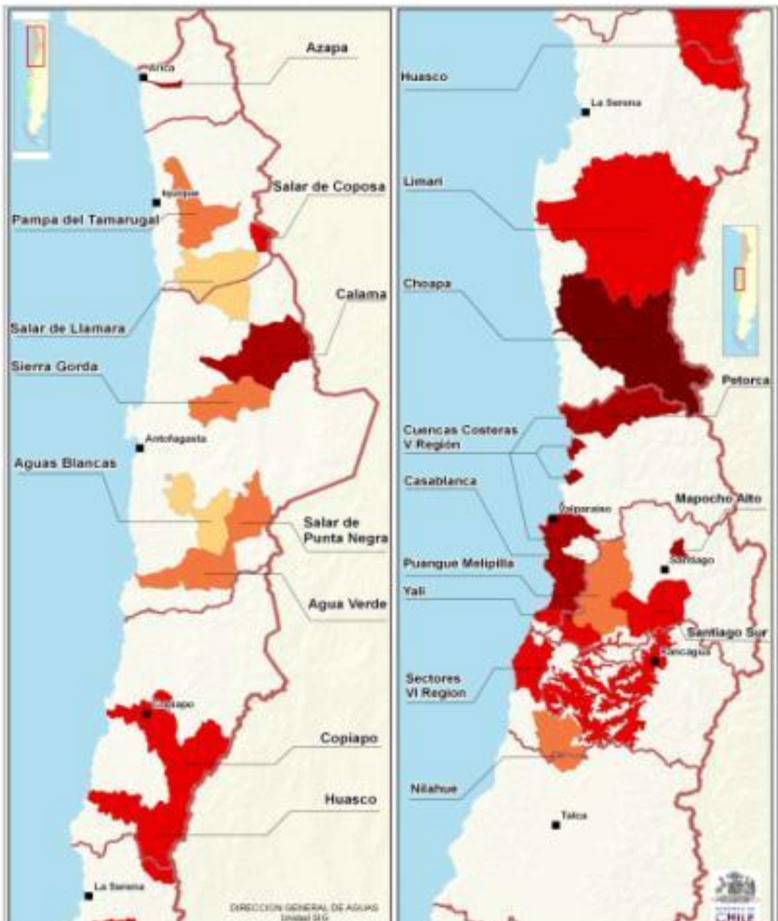
Basin	Physical Availability	
	Surface Waters	Groundwaters
Lluta		
Loa	🟡	
Copiapó	🔴	🔴
Limarí	🔴	🔴
Maipo	🟡	🔴
Maule	🟡	🟡
Biobío	🟡	
Backer		



UChile, 2009

Copiapó

Aquifers cases over granted



- Mop 2012

Challenge

- How energy can play a rol in water management.

- From the State point of view
- From farmers point of view

Azapa Valley case

- We know nothing

Universidad de Chile
Facultad de Ciencias Agronómicas
Departamento de Ciencias Ambientales y
Recursos Naturales Renovables

Azapa Valley

Azapa Valley Case
Atacama Desert

- Absolute aquifer dependence
- WUO's absence
- Individual water extraction

Azapa Valley Case
Atacama Desert

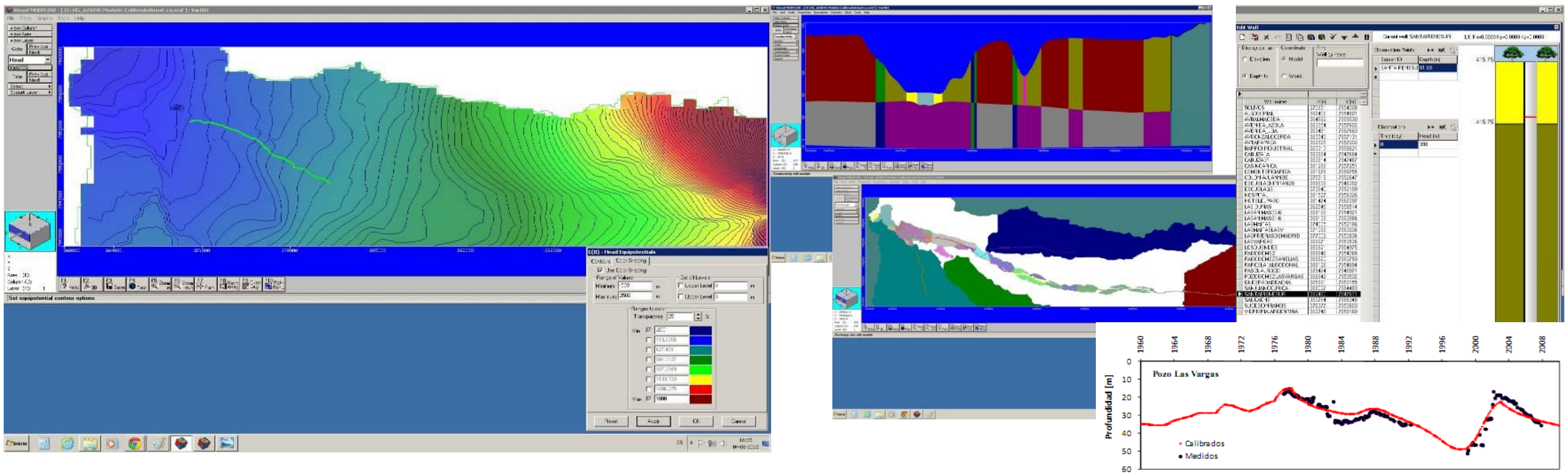
- Absolute aquifer dependence
- WUO’s absence
- Individual water extraction

- Actual use (theorical)
  - Hydrogeological survey and model

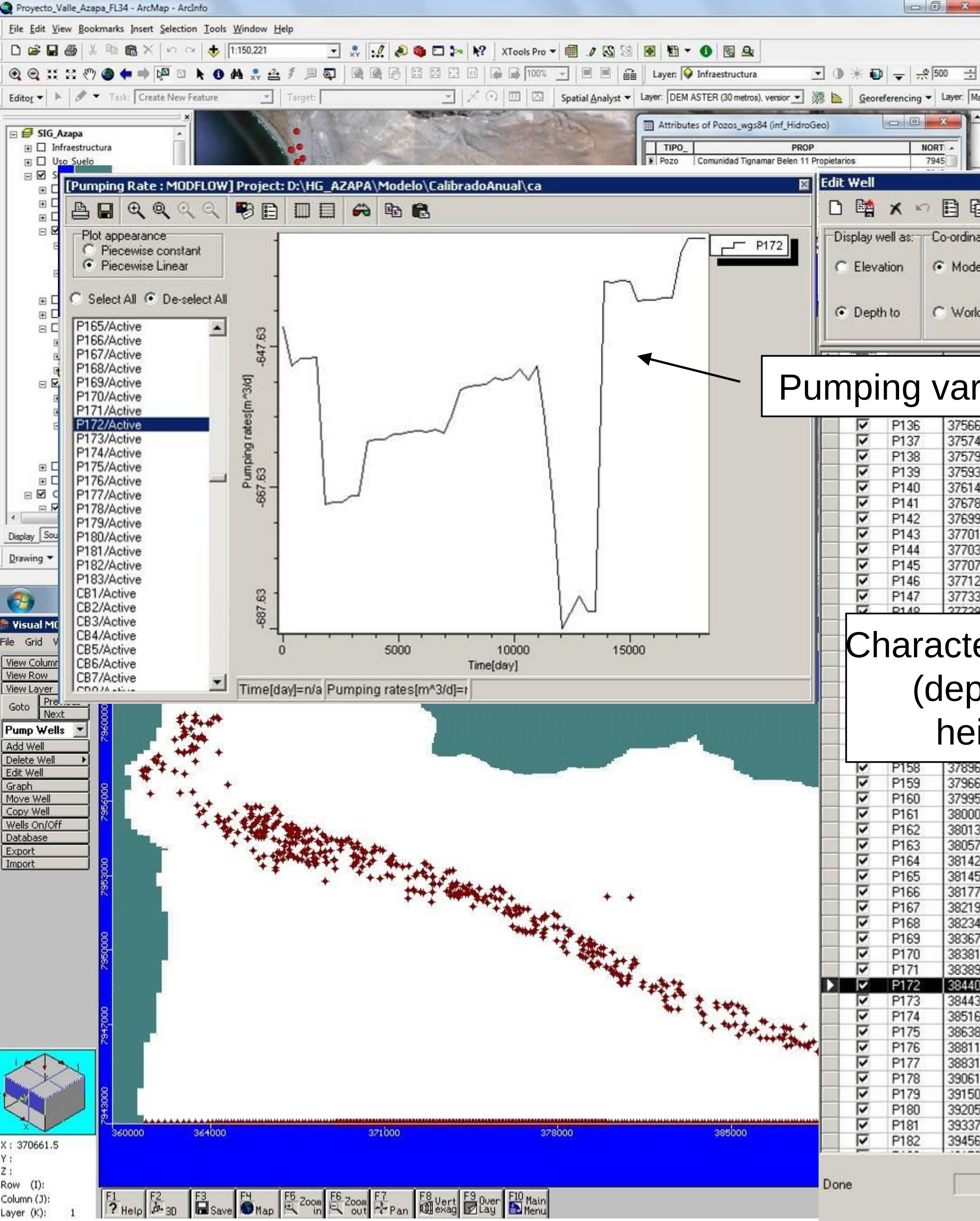

Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google

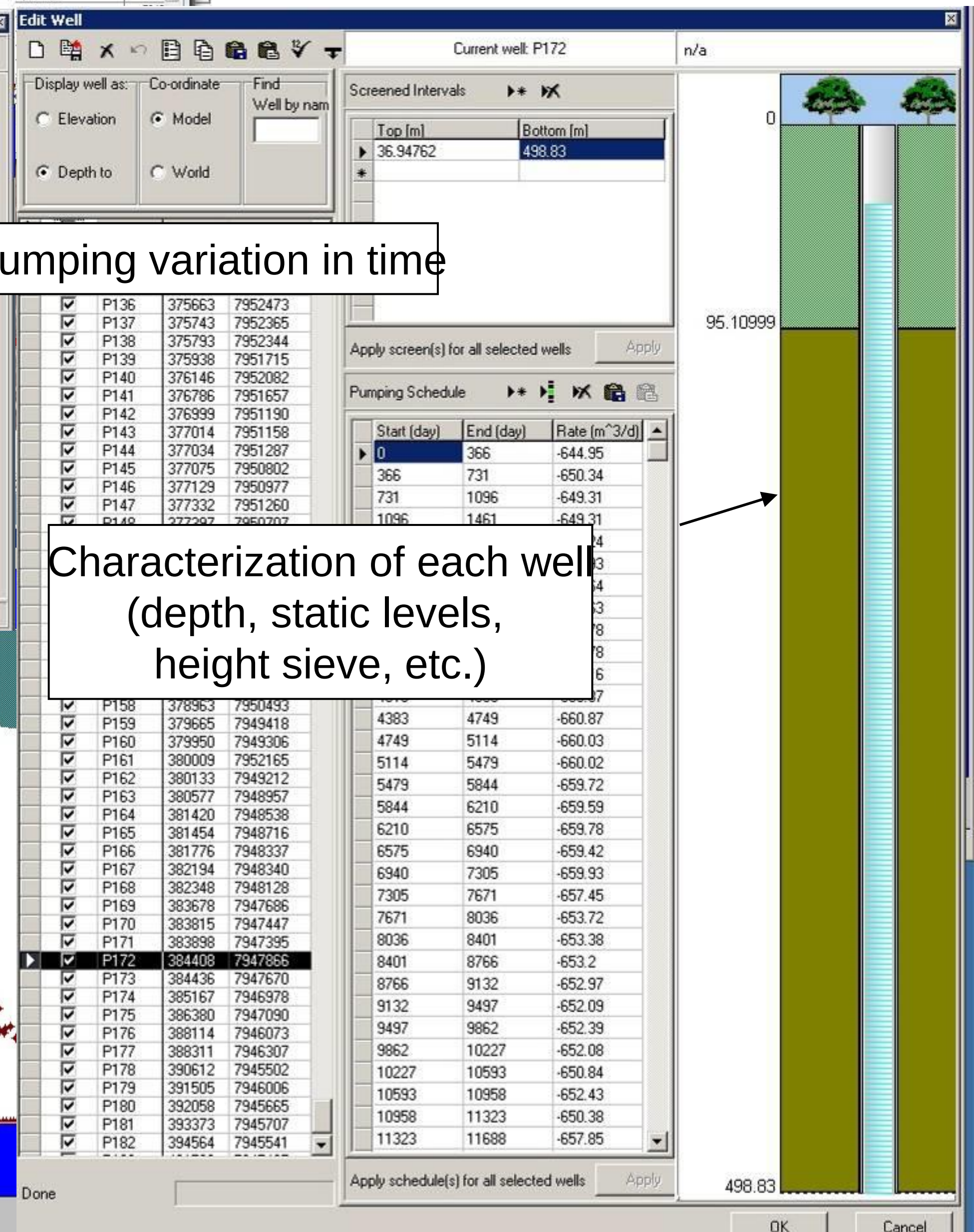
Azapa’s Aquifer Hydrogeological Model (MHG)

- **Allows to simulate static groundwater levels in time and space, according to the characteristics and behaviour of the hydric system components**

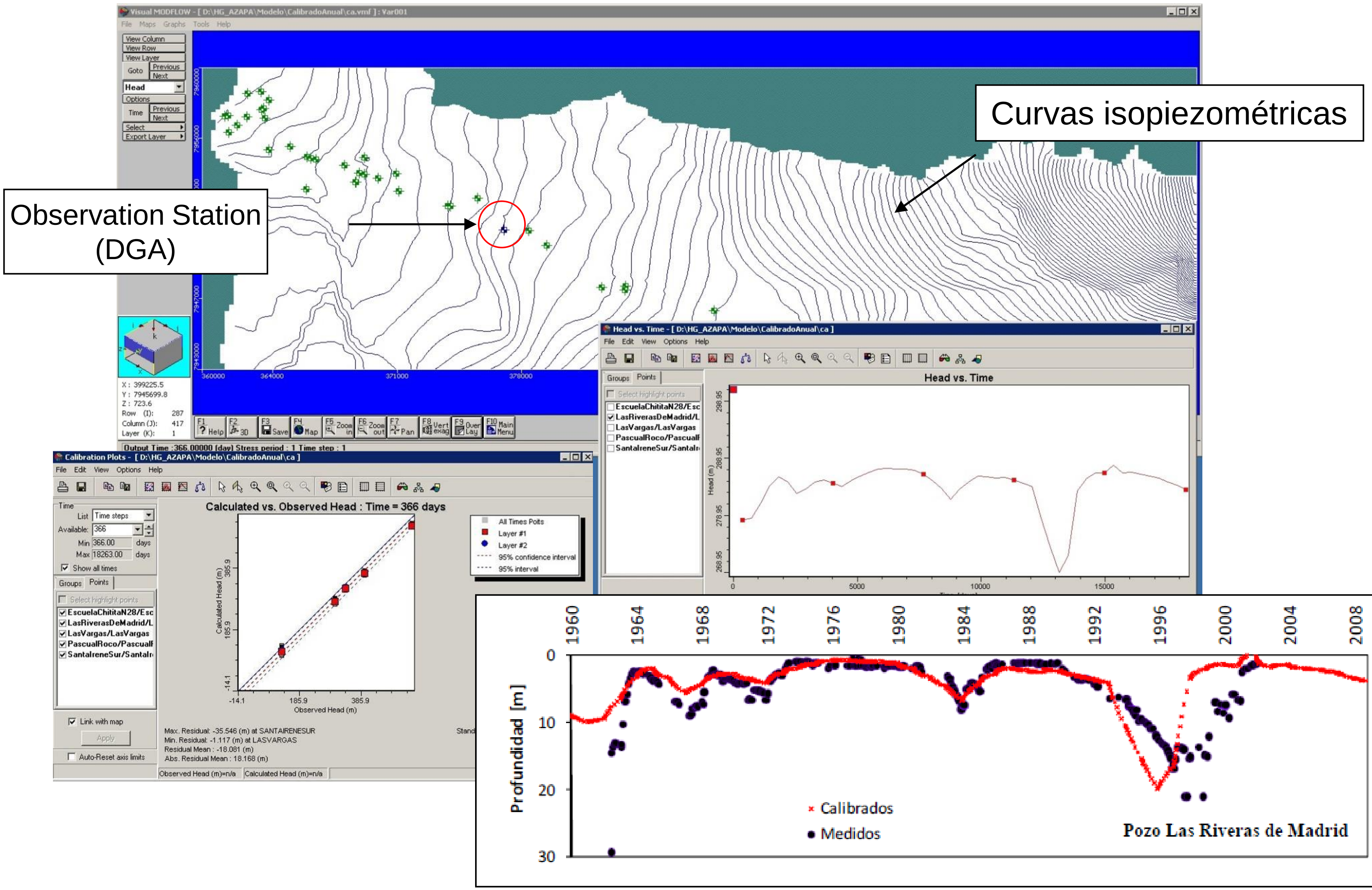


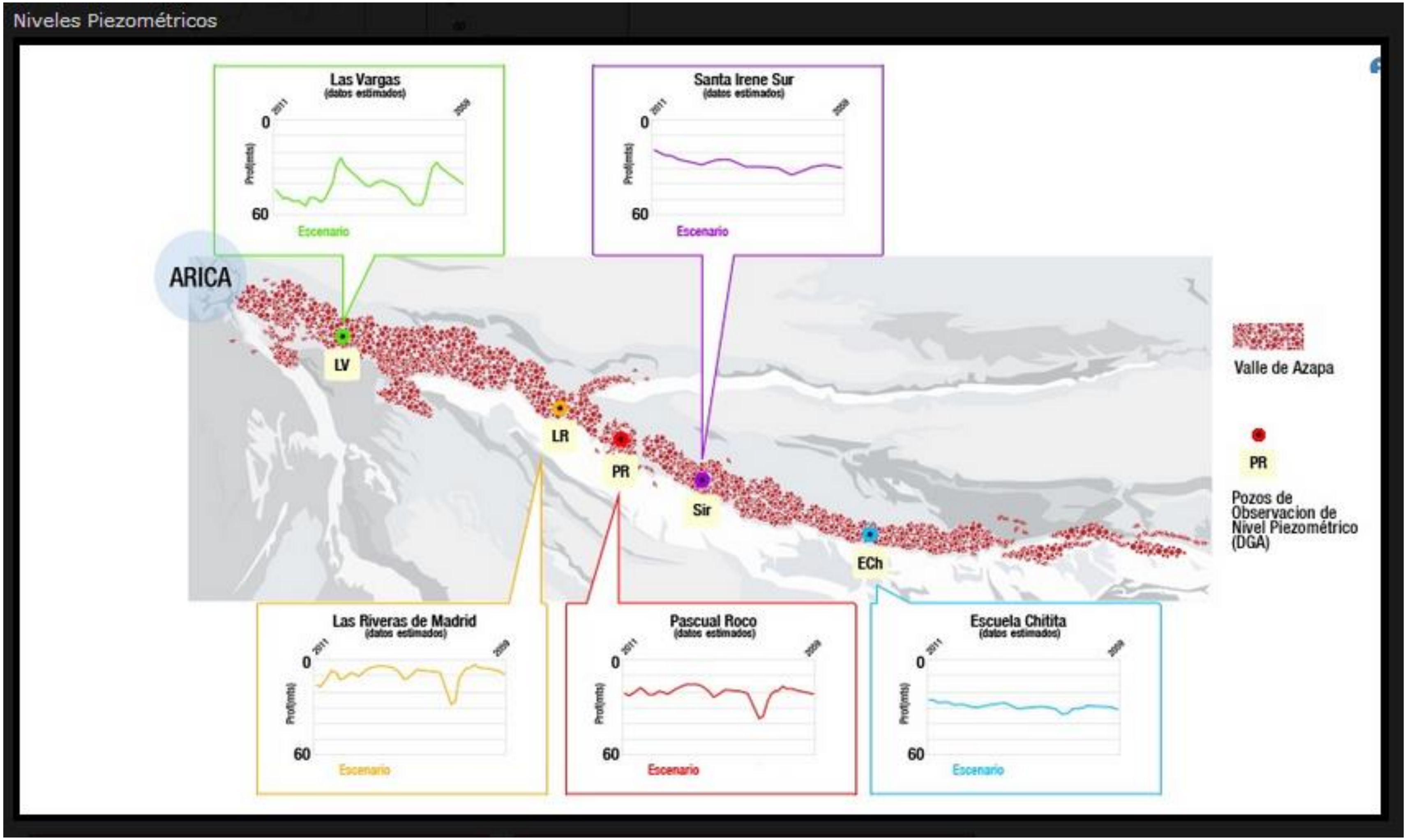
Pumping from Points of Uptake

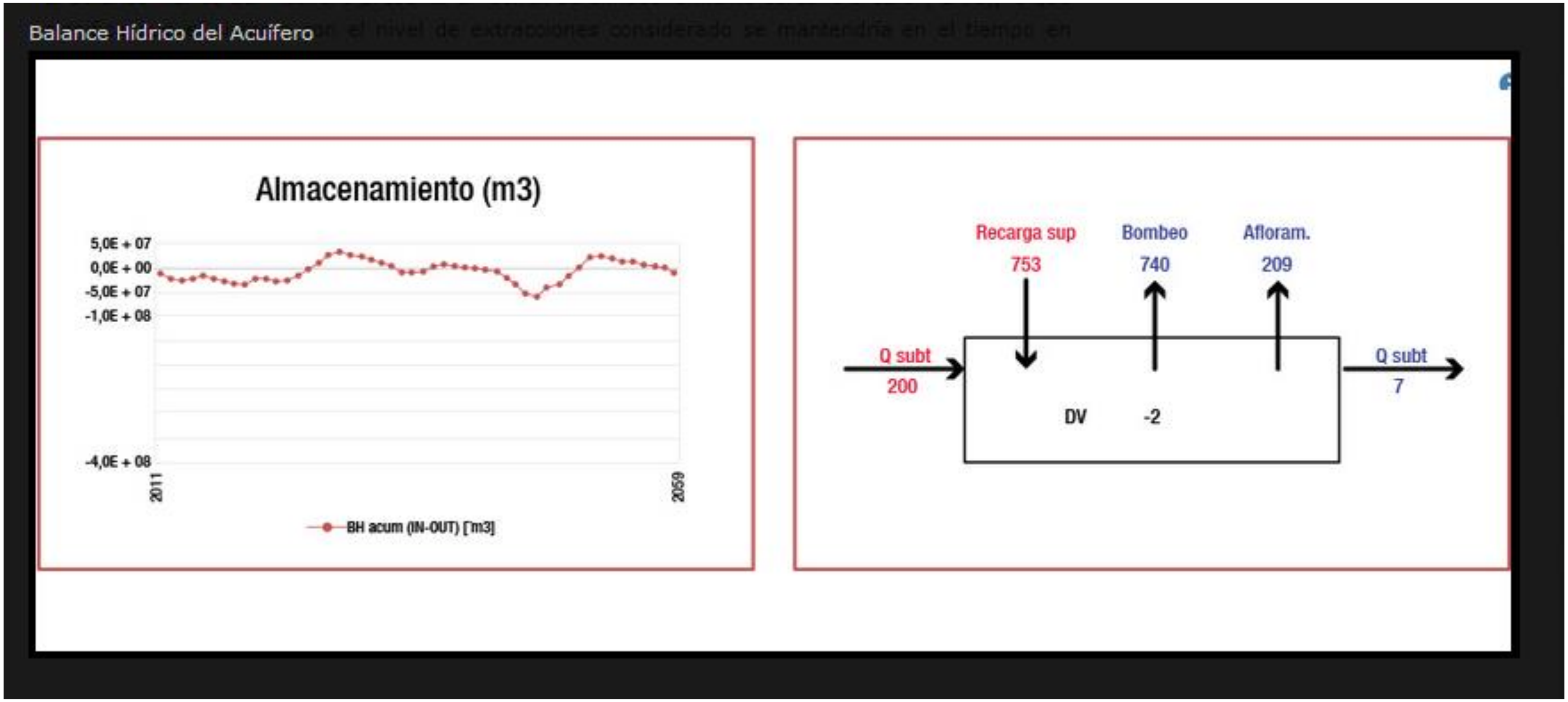




The Hidrogeological Model is Calibrated, allowing Simulate Scenarios by varying the determinant components



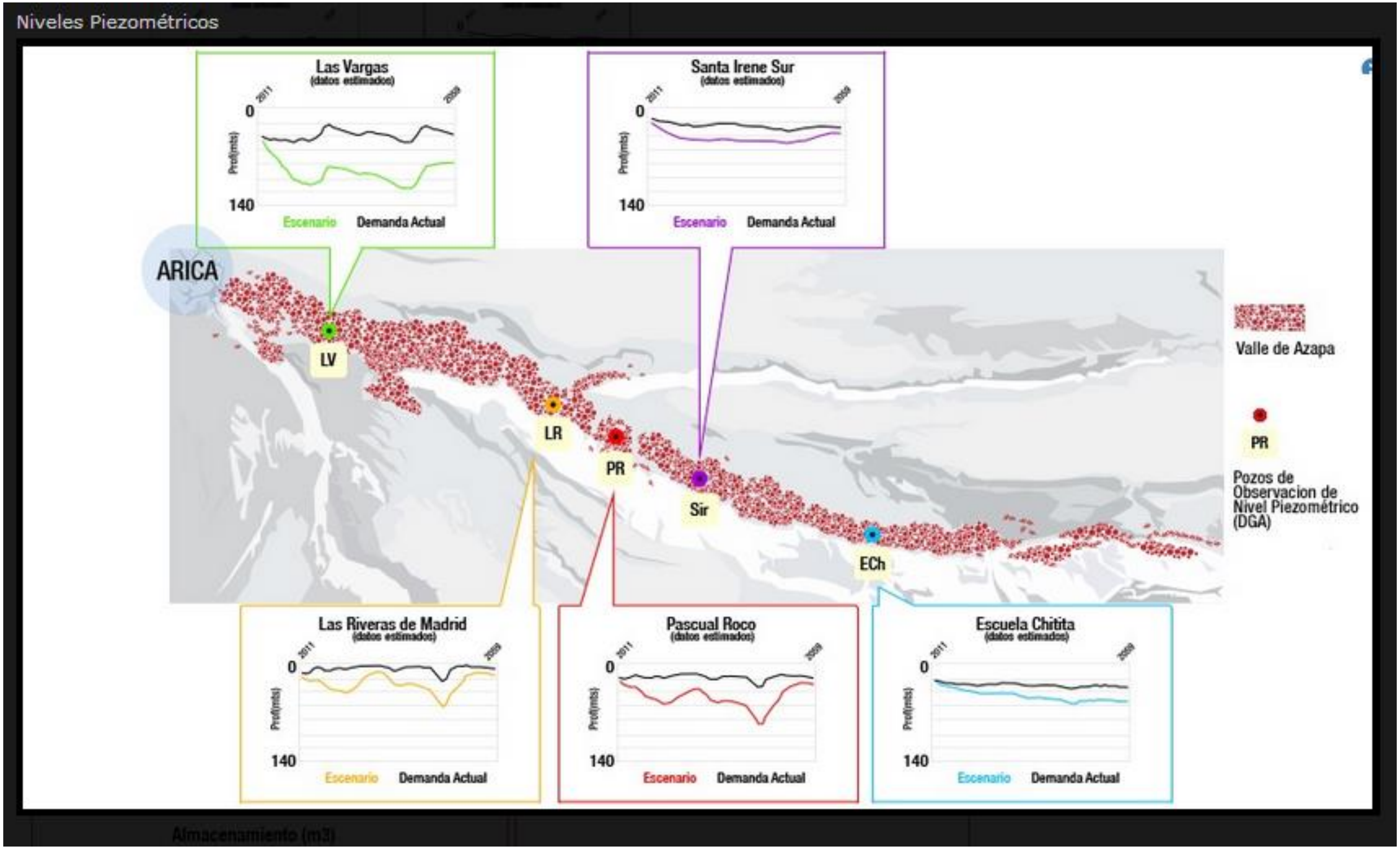

Niveles Piezométricos
Las Vargas
(datos estimados)
0
60
Prof(mts)
Escenario
Santa Irene Sur
(datos estimados)
0
60
Prof(mts)
Escenario
ARICA
LV
LR
PR
Sir
ECh
Valle de Azapa
PR
Pozos de Observacion de Nivel Piezométrico (DGA)
Las Riveras de Madrid
(datos estimados)
0
60
Prof(mts)
Escenario
Pascual Roco
(datos estimados)
0
60
Prof(mts)
Escenario
Escuela Chitita
(datos estimados)
0
60
Prof(mts)
Escenario



Effective use amount to 740 l/s

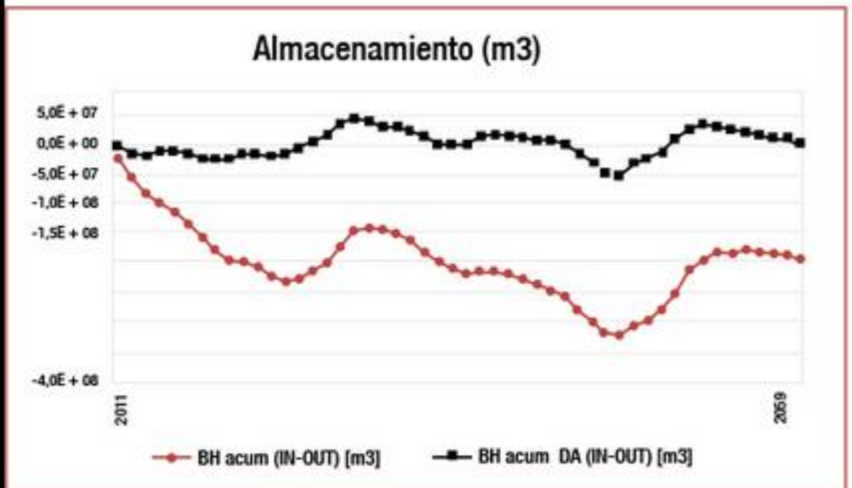
Azapa Valley Case
Atacama Desert

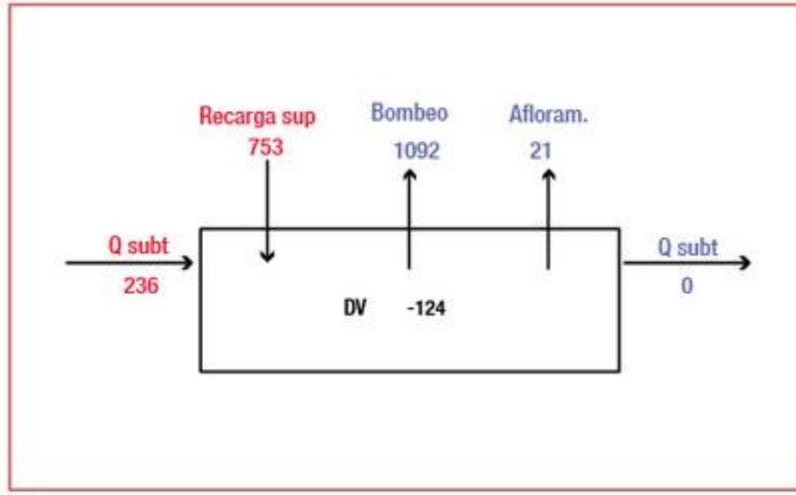
- Potential use



According to CPA (2013), granted water rights amount to 1484 l/s

Balance Hídrico del Acuífero





Azapas Valley Case
Atacama Desert

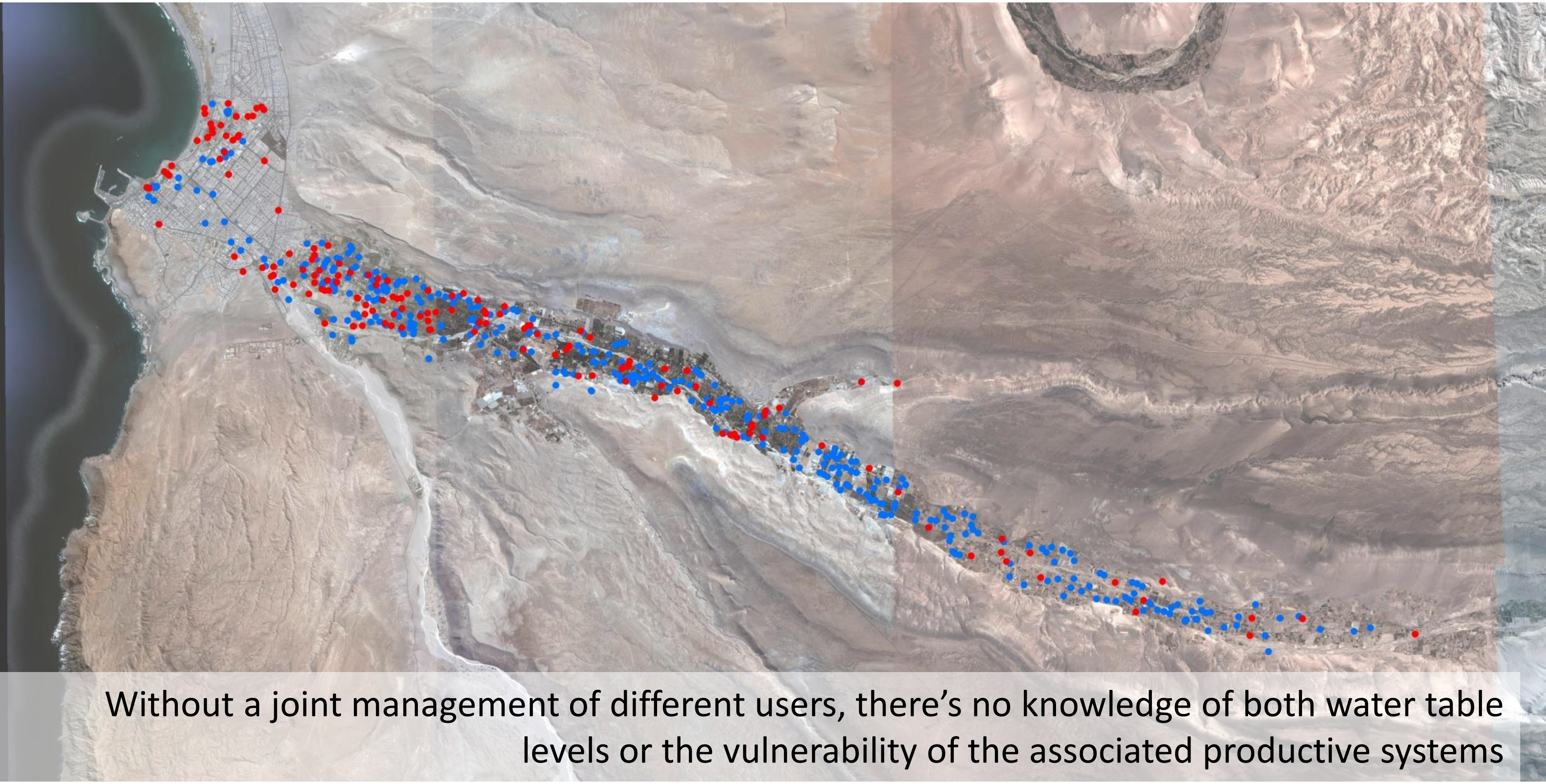
- Energy and water management (sustainability)

- Energy as a control indicator (monitoring)

- Ignorance of critic water table levels

- Impossibility to answer/prevent the crisis.

Groundwater Extraction Wells

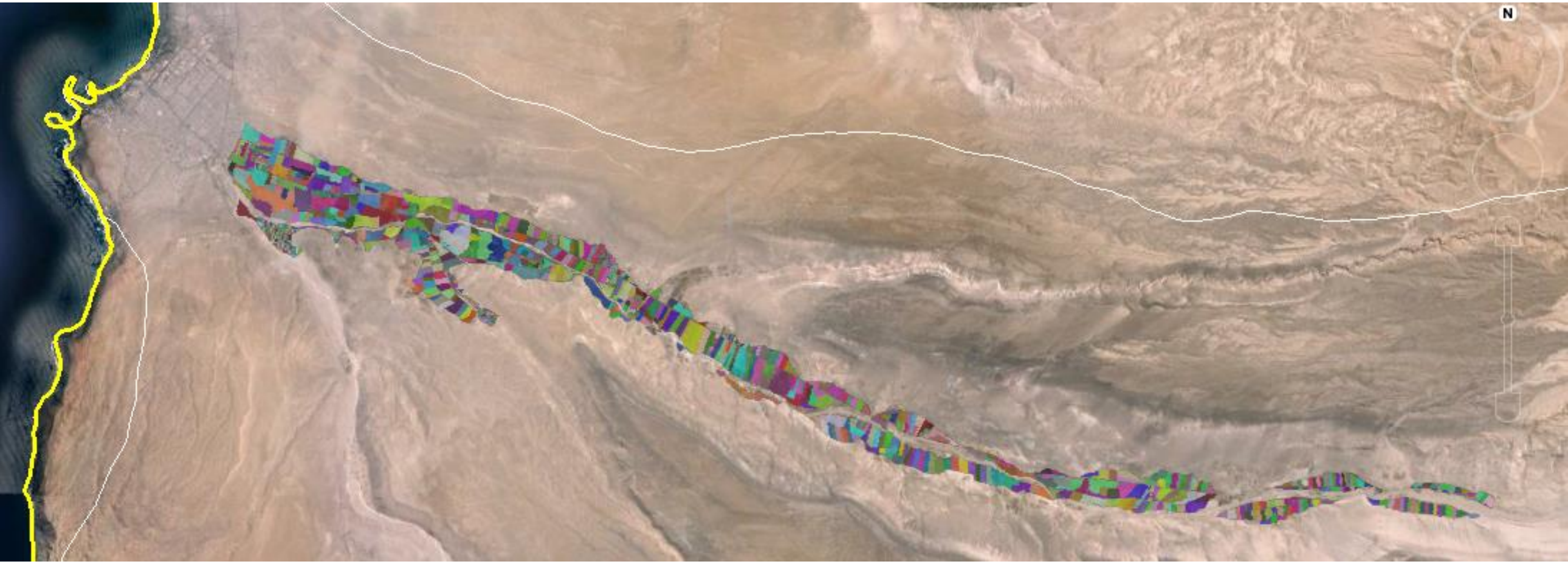


Without a joint management of different users, there's no knowledge of both water table levels or the vulnerability of the associated productive systems

Red points are vulnerable farmers

Challenge

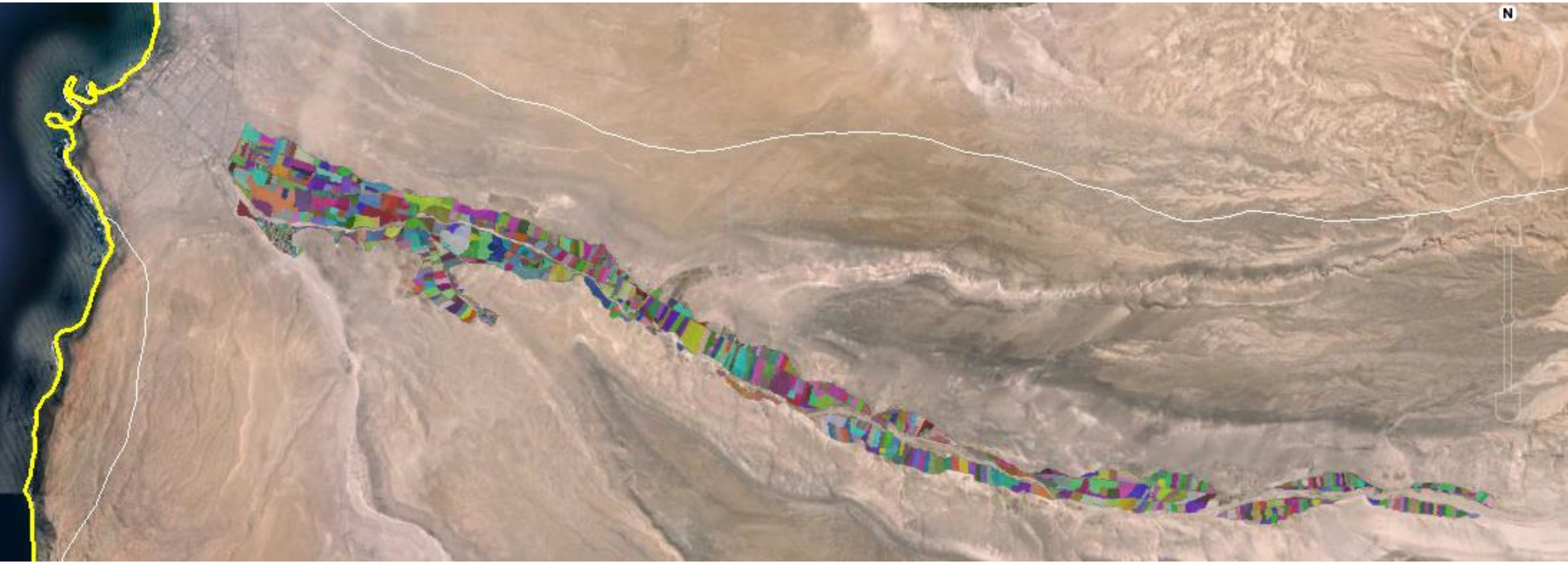
- How much water is pumping?
  - We can estimate ET0 x Kc ➔ L/s



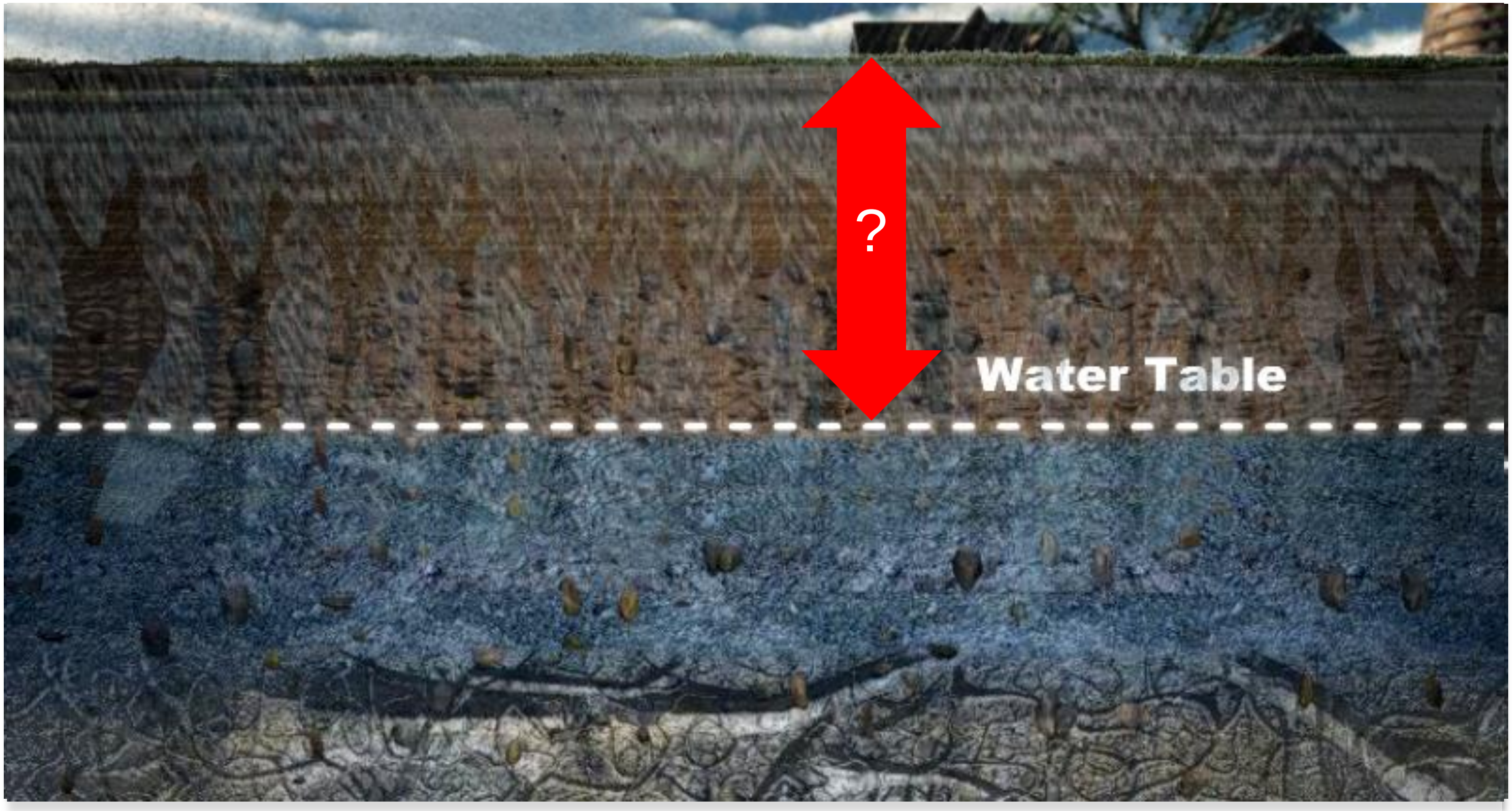
- Etr was calculated (2013) 1590 L/s

Challenge

- How much energy is required?
  - <u>We dont know</u>



What is what defines the *vulnerable condition*?



The profitability of what is produced (kind of farmer and kind of crop)

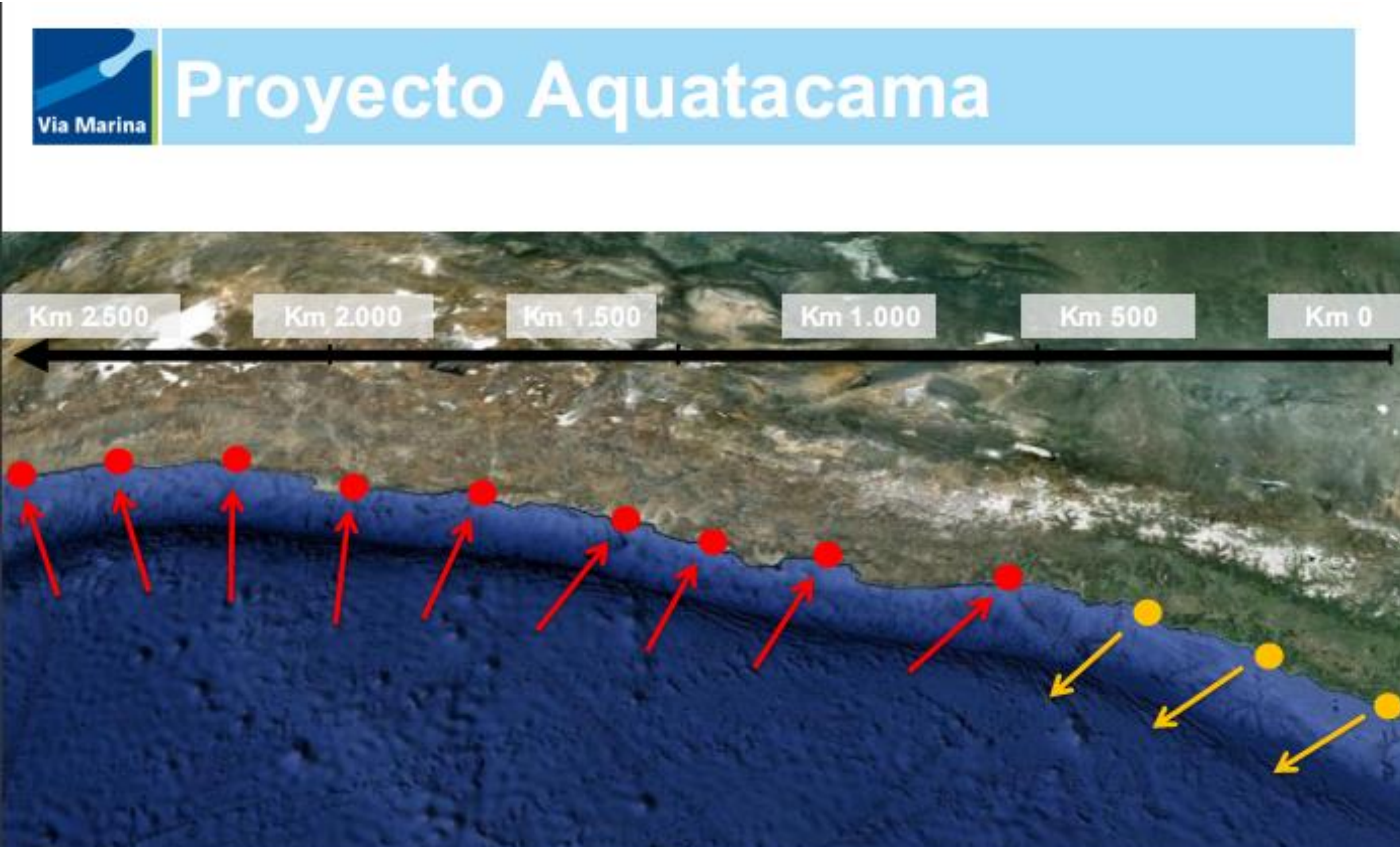
Energetic Vulnerability

Olive trees in Azapa Valley

- Olive trees need an annual average of 0.27 L/s per cultivated ha, varying depending on the month of the year (Torres & Acevedo 2008), these trees have an average yield of 8400 kg of olives per ha, which are sold in around €1 per kg (without any kind of treatment), hence 1 Ha of olive trees offers an average gross profit of €8400.
- On the other side, the costs related to this activity are the rates of pumping groundwater, which has an approximate price of €384 per L/s (DGA 2011), or €103 for the 0.27 L/s needed for 1 Ha of olives (in low rates hours),
- other operational and maintenance costs that can sum up to €670 (depending on the altitude of the land, among others) (DGA 2011), and the costs of labor that can vary between €3500 to €4500 per hectare.
- Thus, 1 ha of olives trees represents a net profit of around €4000 to €3000 per year. (Sotomayor 2000).
    - What happen if the water table descends?

- Personal communication by e-mail with Amador Torres, academic of the University of Tarapacá, May 12th 2013.

CNR project: water transfer

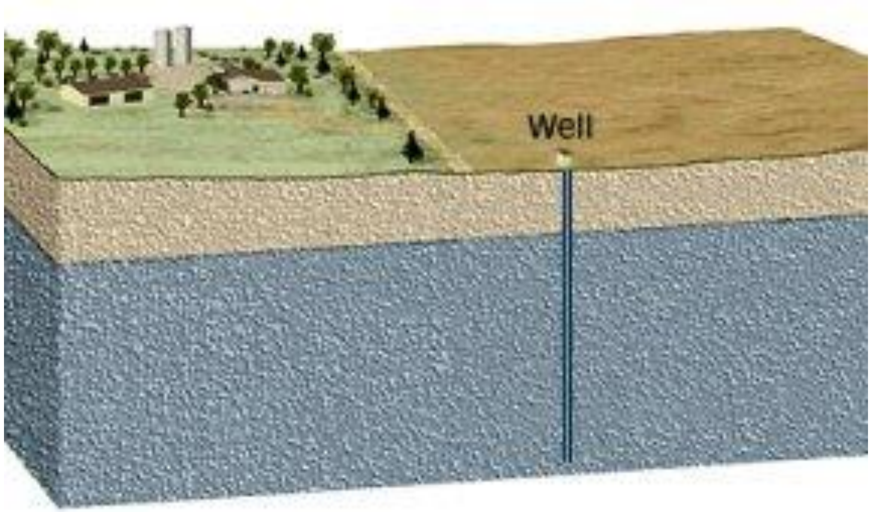


Knowdlege and evaluation of energetic requirements

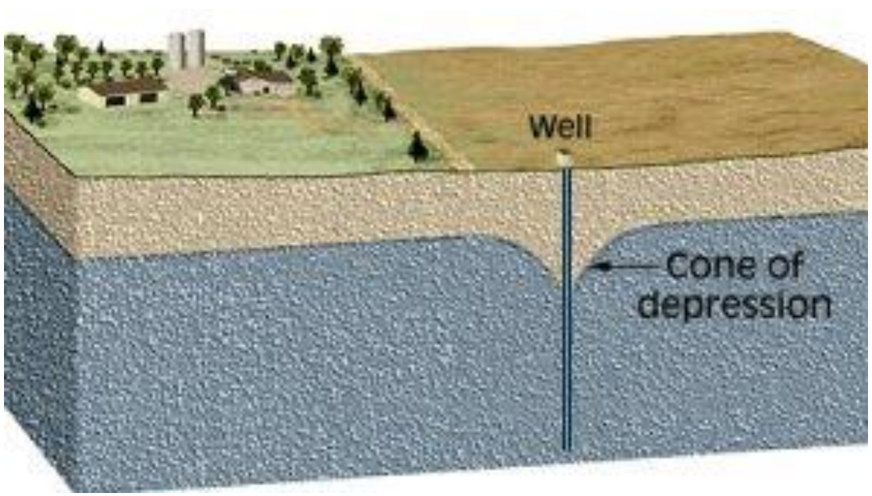
- CNR's research to discuss regarding the crops profitability, the maximum value associated to water use to transform it into energy

- The results are: kind of vulnerable crops and vulnerable users

- How much water is used?
- How much energy is requiered?



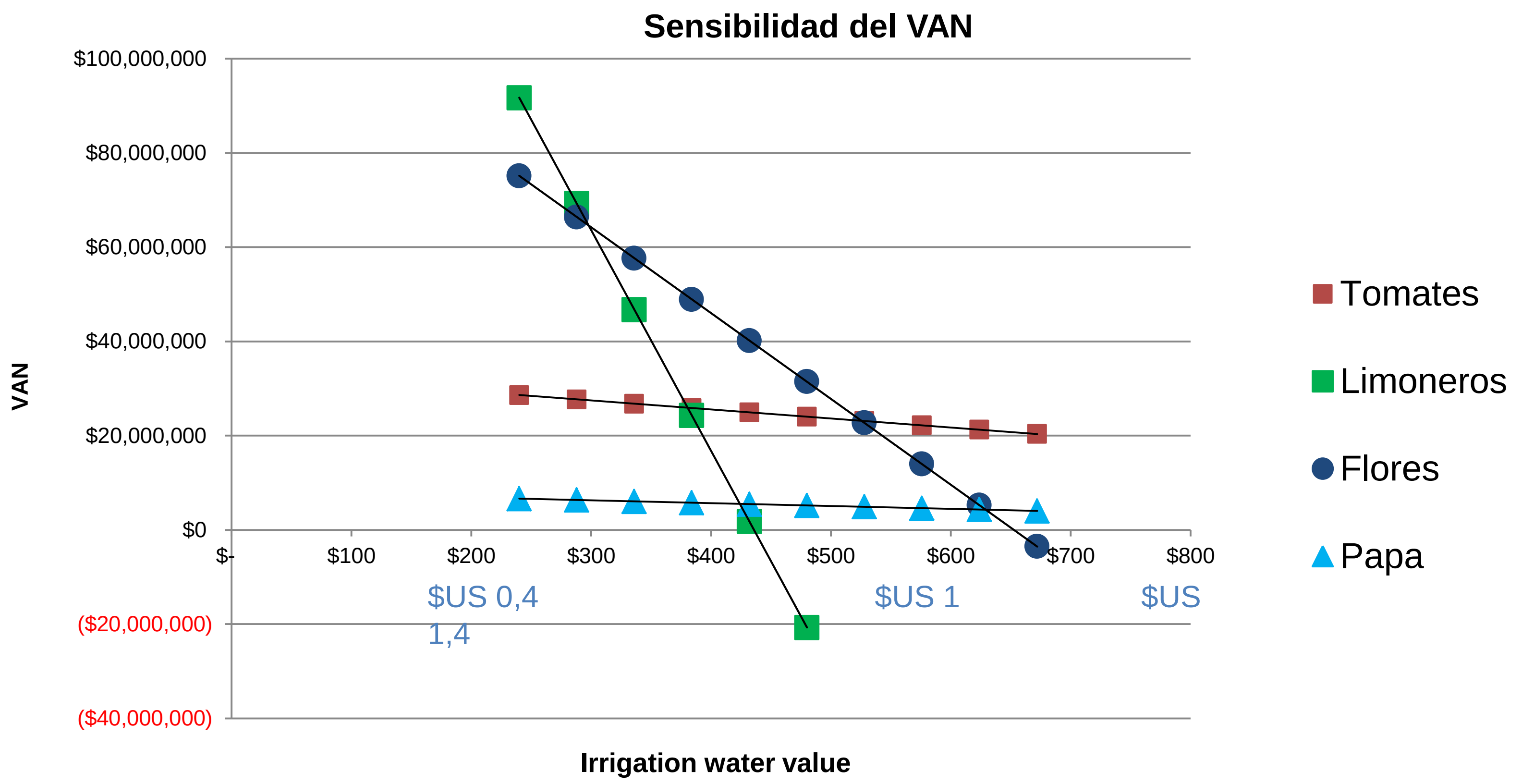
- It depends of how deep the water table is



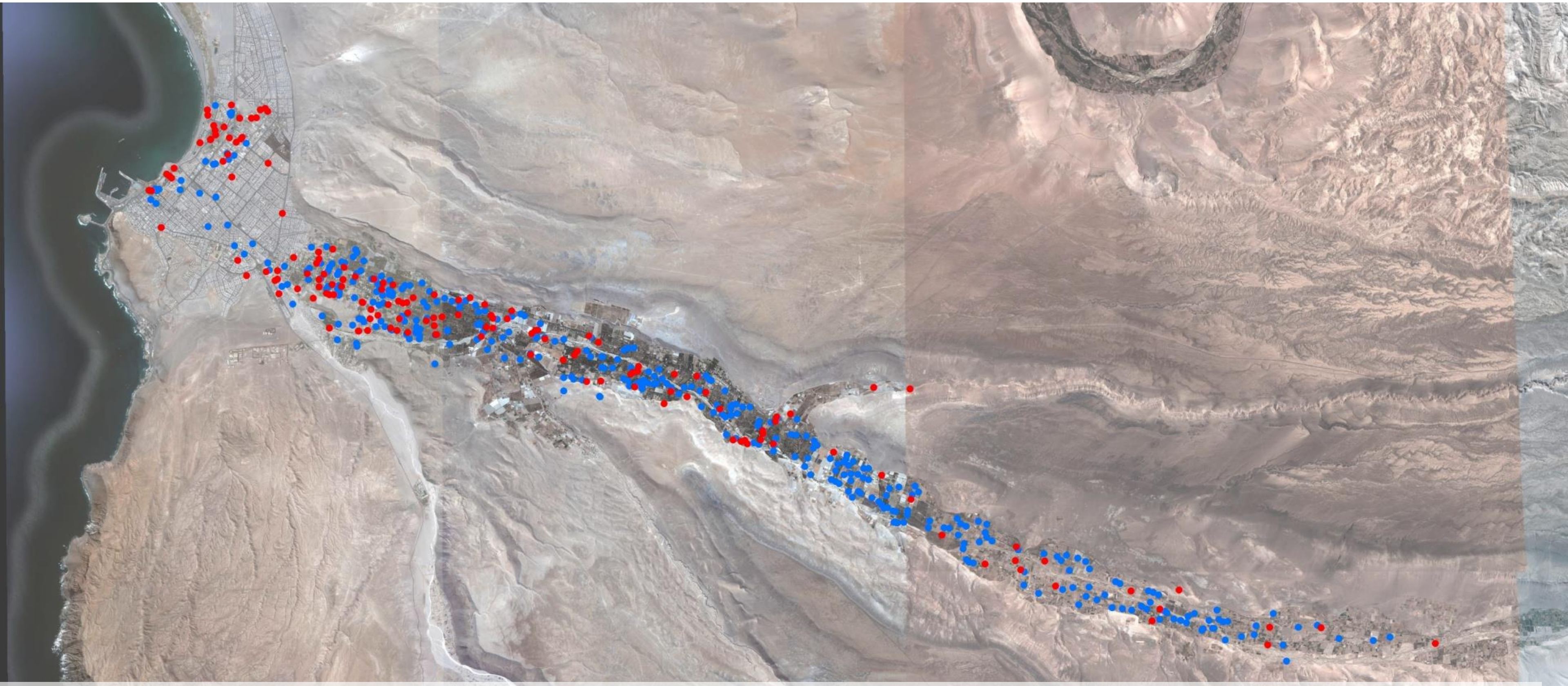
Crops and water profitability

Cultivo	Stage	Water value (energy)	VAN	TIR
Citrus Lemon	No cost of water		$ 201.791.928	33%
	Break even	$ US 0,87	$ 0	15%
Olives	No cost of water		$ 11.132.920	17%
	Break even	$ US 0,04	$ 0	15%
Avocado	No cost of water		$ 174.828.224	27%
	Break even	$ US 0,56	$ 0	15%
Potato	No cost of water		$ 8.074.445	54%
	Break even	$US 2,66	$ 0	15%
Tomato	No cost of water		$ 33.199.295	59%
	Break even	$US 3,5	$ 0	15%

Economic Sensitivity Analysis



Grounwater Extraction Wells



Without a joint management of different users, there’s no knowledge of both water table levels or the vulnerability of the associated productive systems

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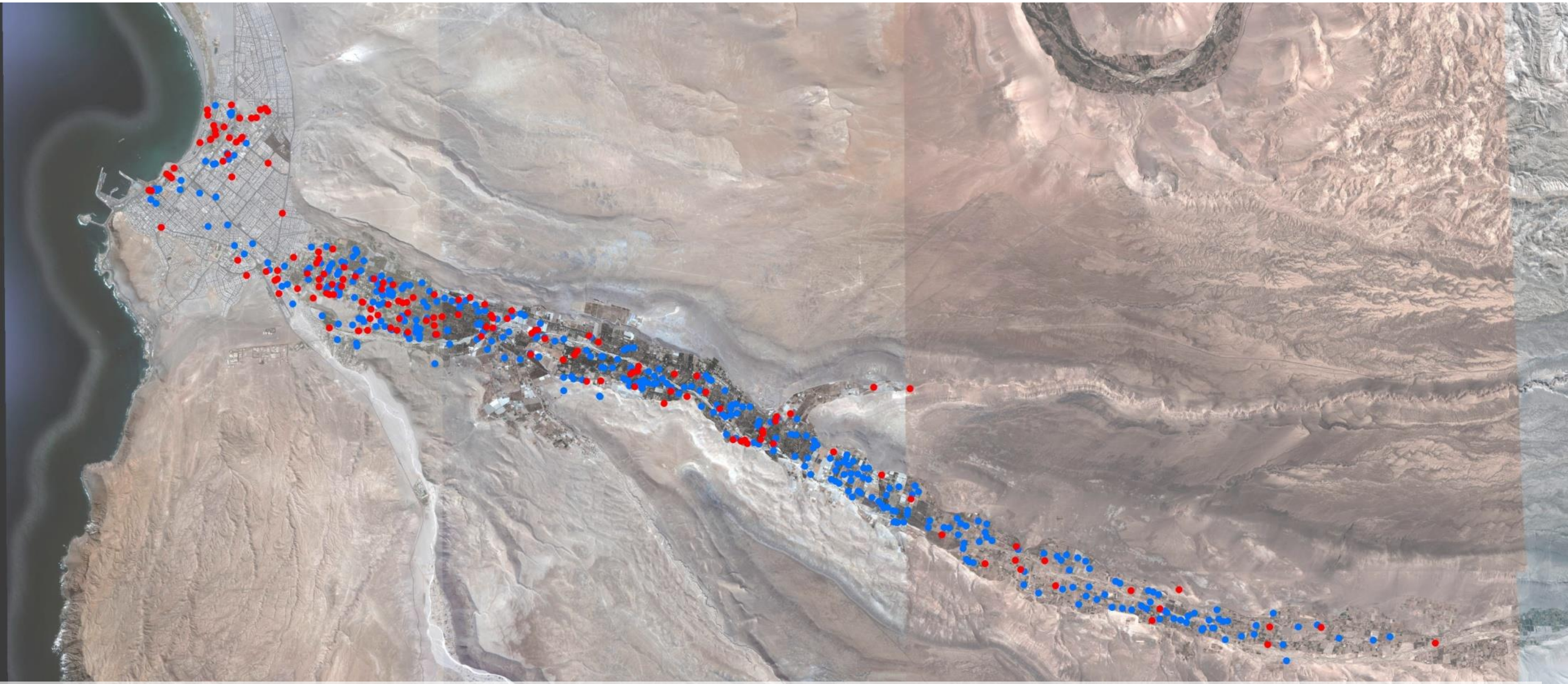
Individual Logic of extracting everything possible, trend to depletion

Grounwater Extraction Wells



WITH joint management of the different users, and WITH knowledge of the water table level, is possible an adaptation to a vulnerability condition

A change in water management system

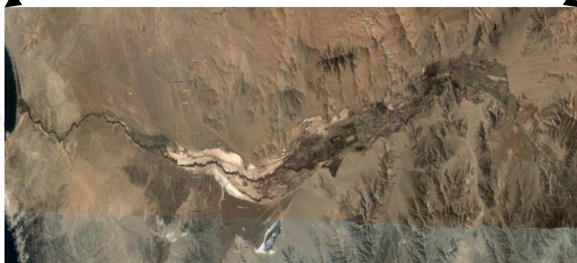
COPIAPÓ CASE

Copiapó Case
Atacama desert

- ✓Absolute aquifer dependence
- There is a WUO
- Regulated water extraction

- Actual Use (teórico)
  - x No existe estudio y modelo hidrogeológico
    - ✓ Existe sistema de monitoreo
  - x Usuarios agrícolas no conocen costo energético.

CASUB



Water users by category

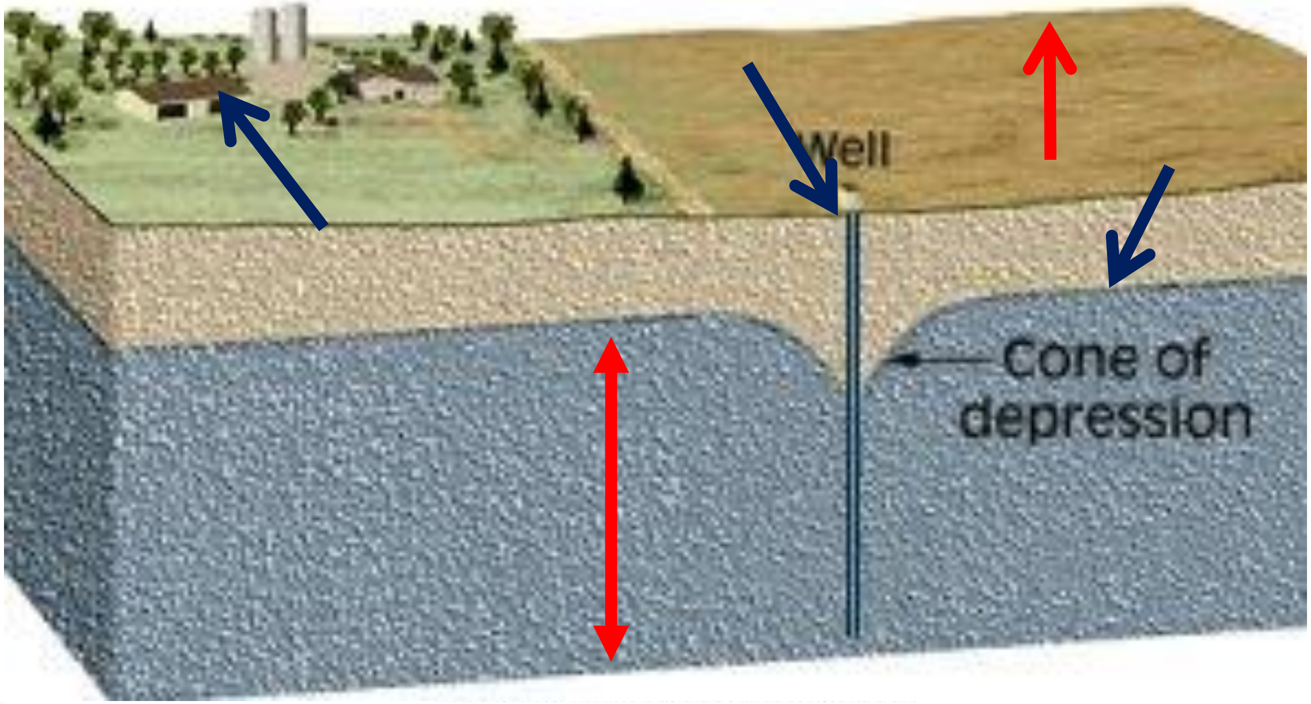
Agriculture : 3.400 ha (grapes, olives, fruit, vegetables)

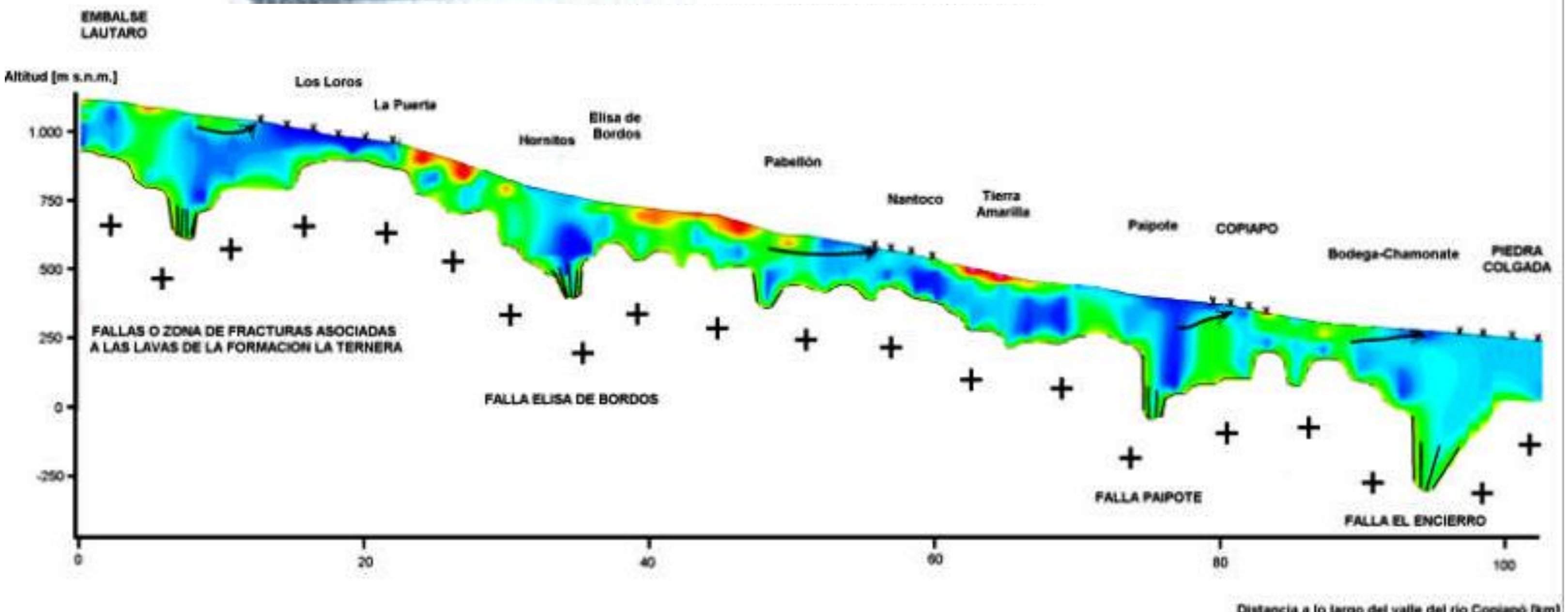
Mining : 4 mineras (Anglo American, Candelaria, CMP y PUCOBRE).

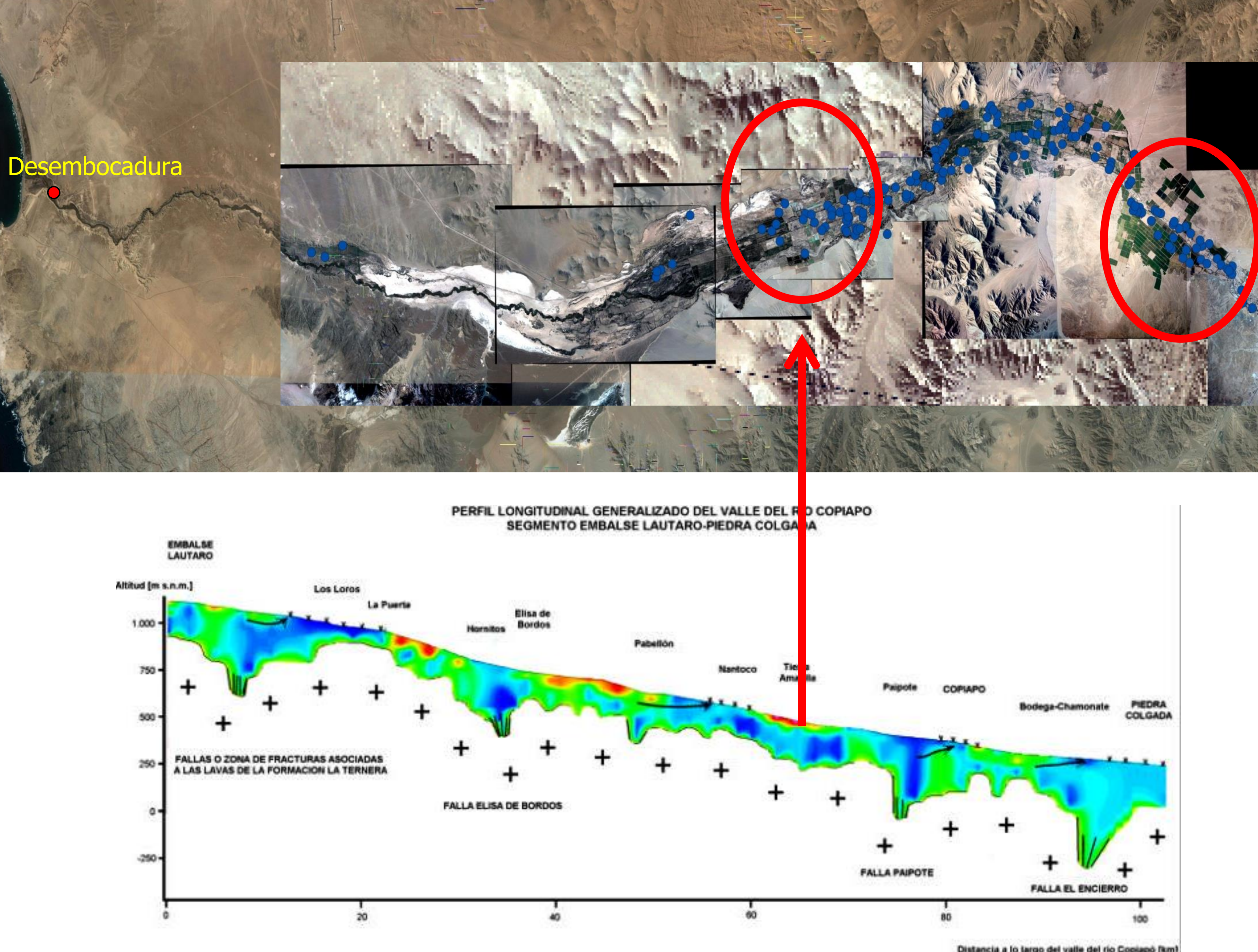
Health : Aguas Chañar

Services : universities, hotelery, tourism, refrigerators, construction, etc.

Dwelling : 200 parcelas

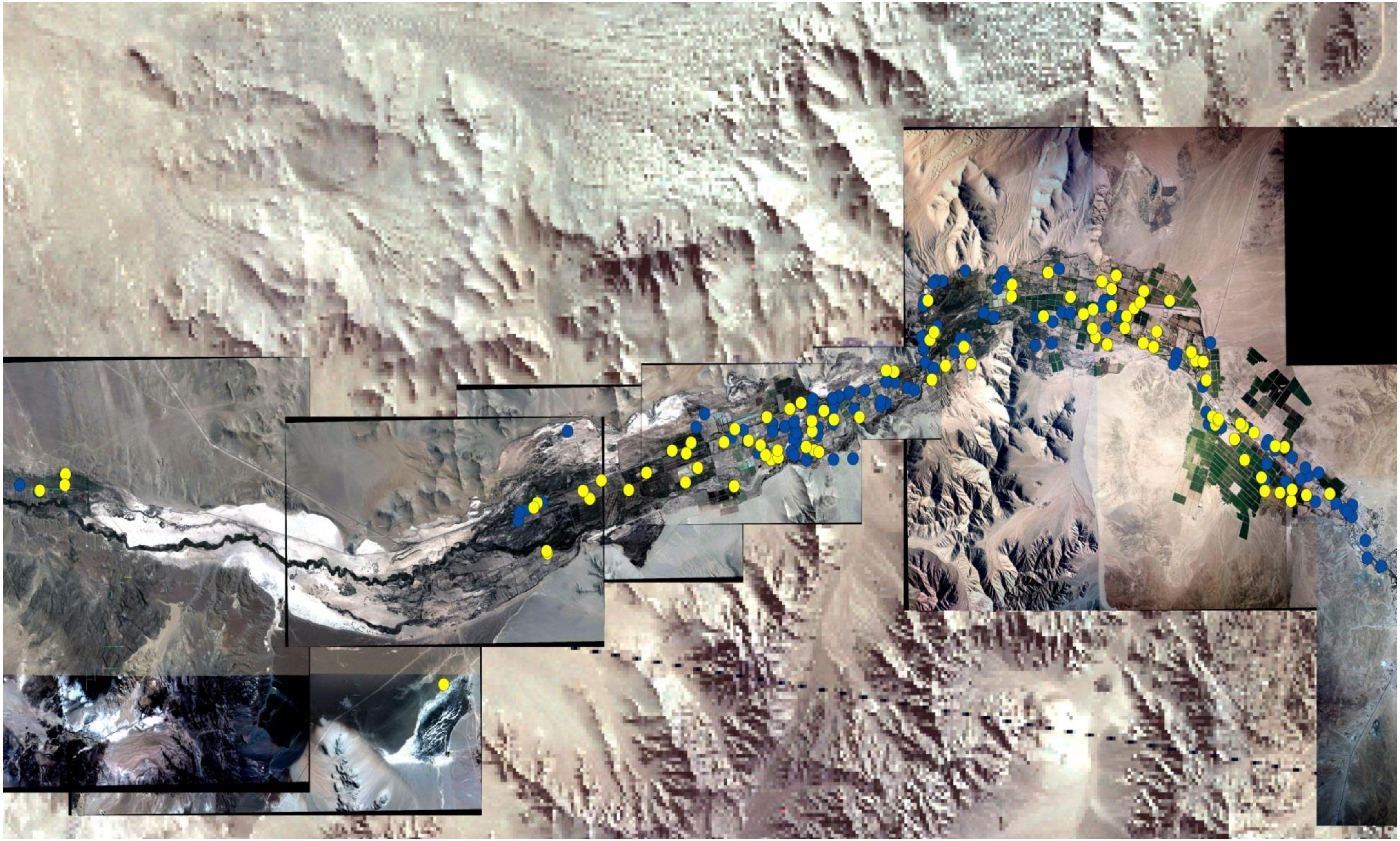

Well
Cone of depression


EMBALSE LAUTARO
Altitud [m s.n.m.]
Los Loros
La Puerta
Hornitos
Elisa de Bordos
Pabellón
Nantoco
Tierra Amarilla
Paipote
COPIAPO
Bodega-Chamonate
PIEDRA COLGADA
1.000
750
500
250
0
-250
FALLAS O ZONA DE FRACTURAS ASOCIADAS A LAS LAVAS DE LA FORMACION LA TERNERA
FALLA ELISA DE BORDOS
FALLA PAIPOTE
FALLA EL ENCIERRO
0
20
40
60
80
100

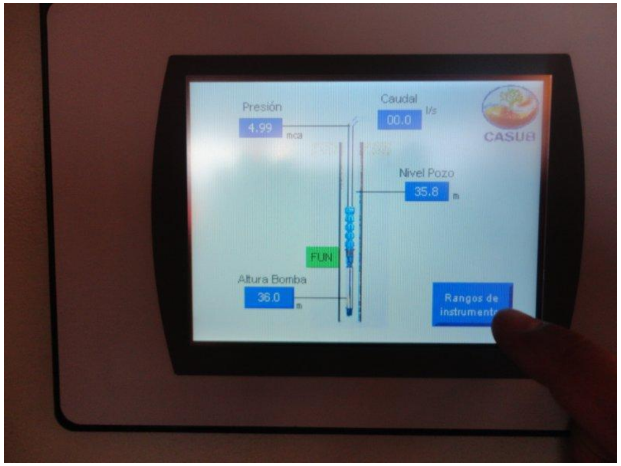


Desembocadura
PERFIL LONGITUDINAL GENERALIZADO DEL VALLE DEL R O COPIAPO
SEGMENTO EMBALSE LAUTARO-PIEDRA COLGA A
EMBALSE LAUTARO
Altitud [m s.n.m.]
Los Loros
La Puerta
Hornitos
Elisa de Bordos
Pabellón
Nantoco
Paipote
COPIAPO
Bodega-Chamonate
PIEDRA COLGADA
1.000
750
500
250
0
-250
FALLAS O ZONA DE FRACTURAS ASOCIADAS A LAS LAVAS DE LA FORMACION LA TERNERA
FALLA ELISA DE BORDOS
FALLA PAIPOTE
FALLA EL ENCIERRO
0
20
40
60
80
100
Distancia a lo largo del valle del río Copiapó [km]

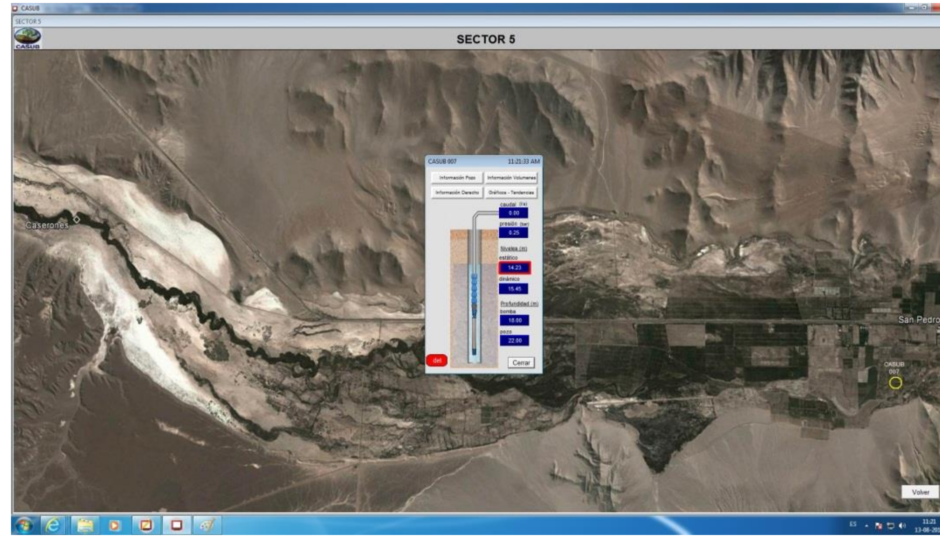
Real time monitoring

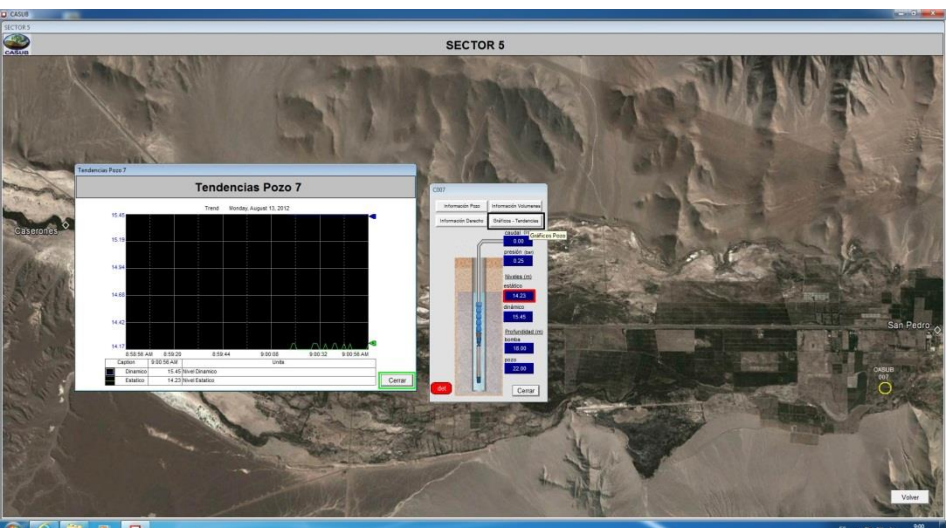


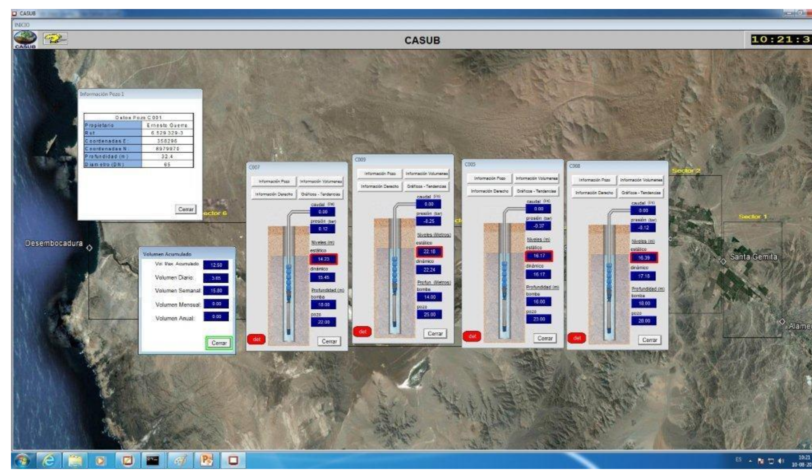

Allen-Bradley
PanelView C600


Presión
4.99
mca
Caudal
00.0
l/s
CASUB
Nivel Pozo
35.8
m
FUN
Altura Bomba
36.0
m
Rangos de


CASUB
TENDENCIAS
Sector 6
Sector 5
Sector 3
Sector 2
Sector 1
Desembocadura
Caserones
San Pedro
Piedra Colgada
Cerro Negro
Santa Gemita
Alameda

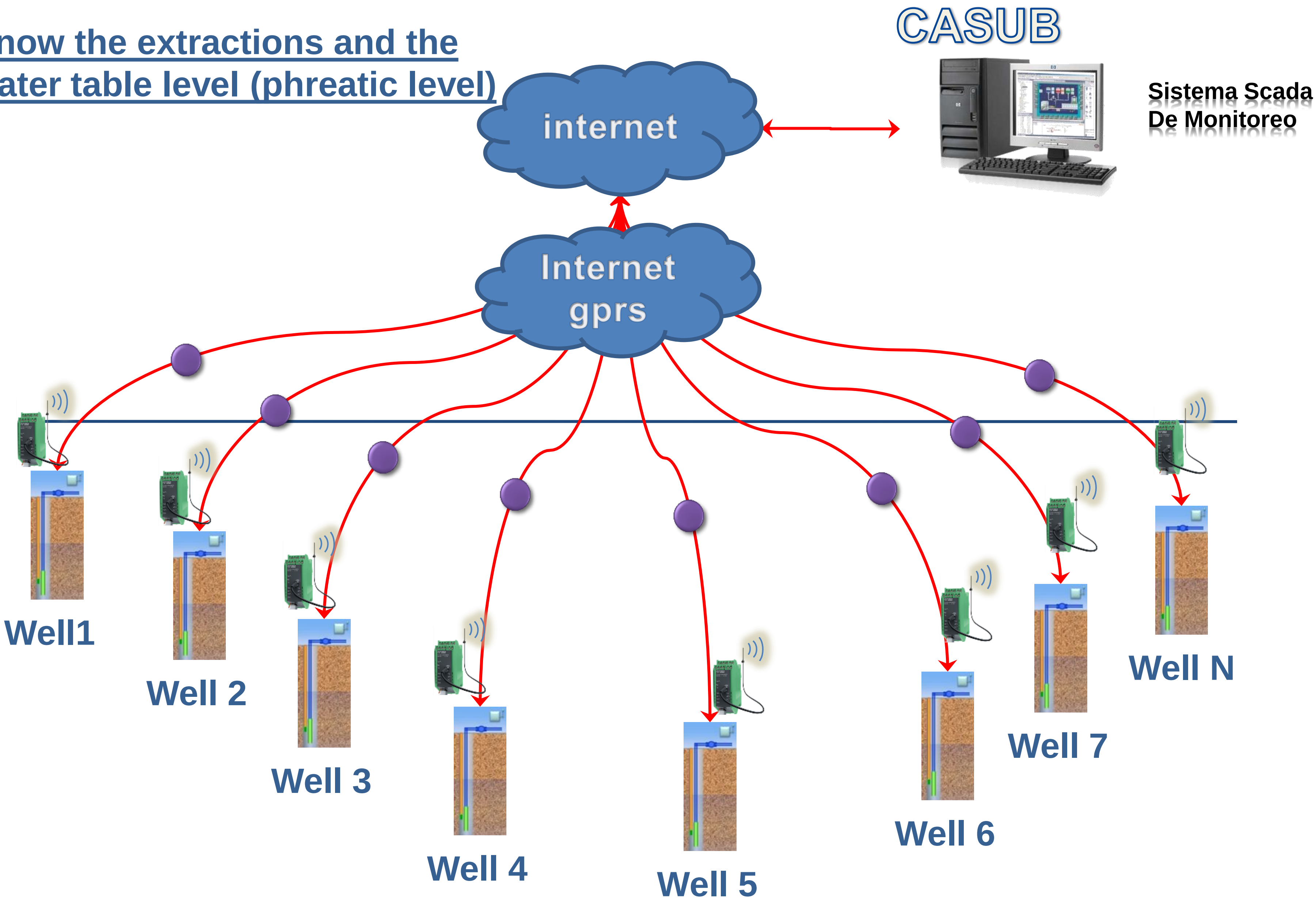

SECTOR 5
Caserones
San Pedro
Cerrar
Volver

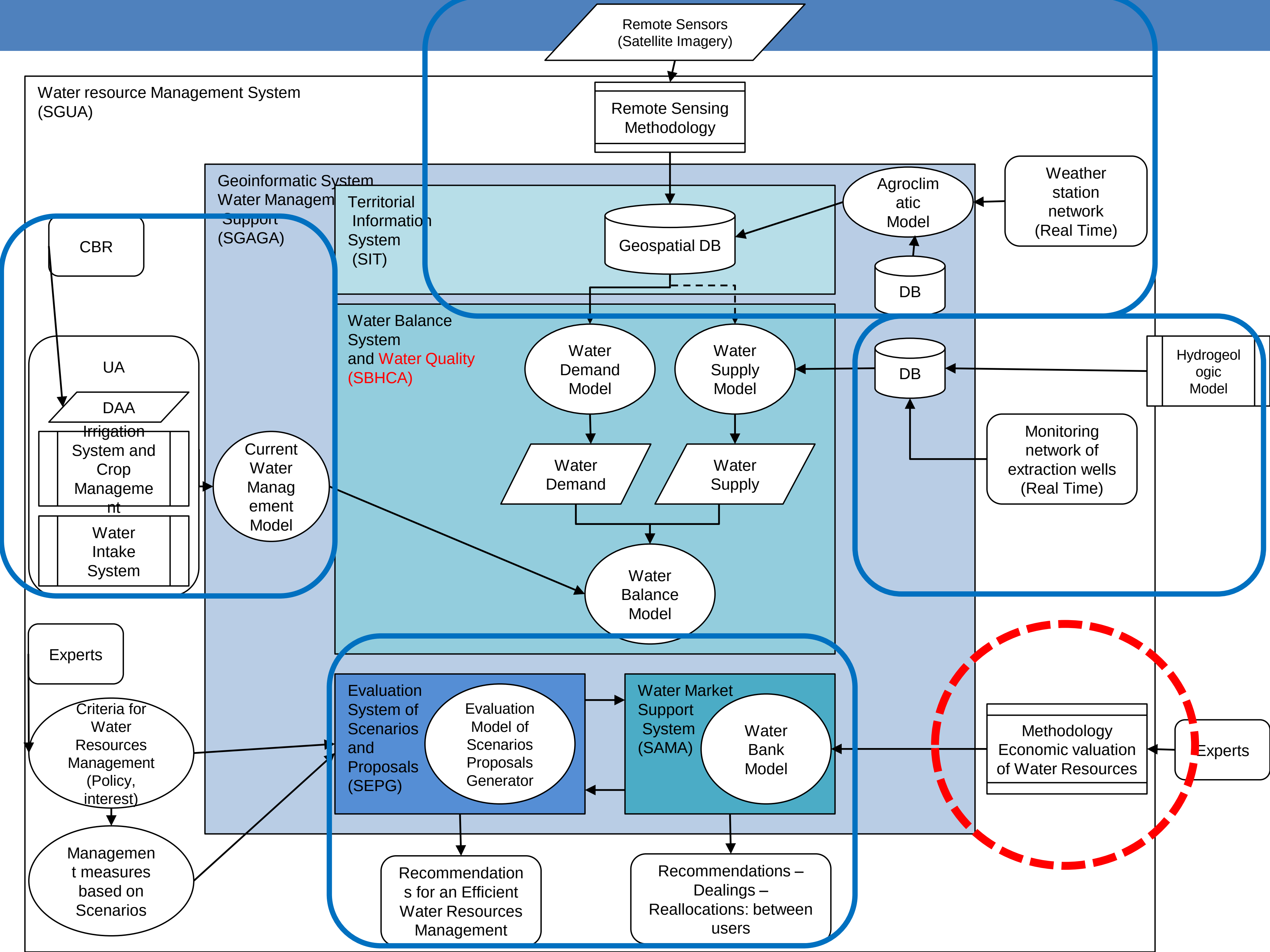

SECTOR 5
Tendencias Pozo 7
Caserones
San Pedro
Cerrar
Volver


CASUB
10:21:39
Desembocadura
Santa Gemita
Alameda
Cerrar

PLATFORM OF MONTIORING OSMATIC

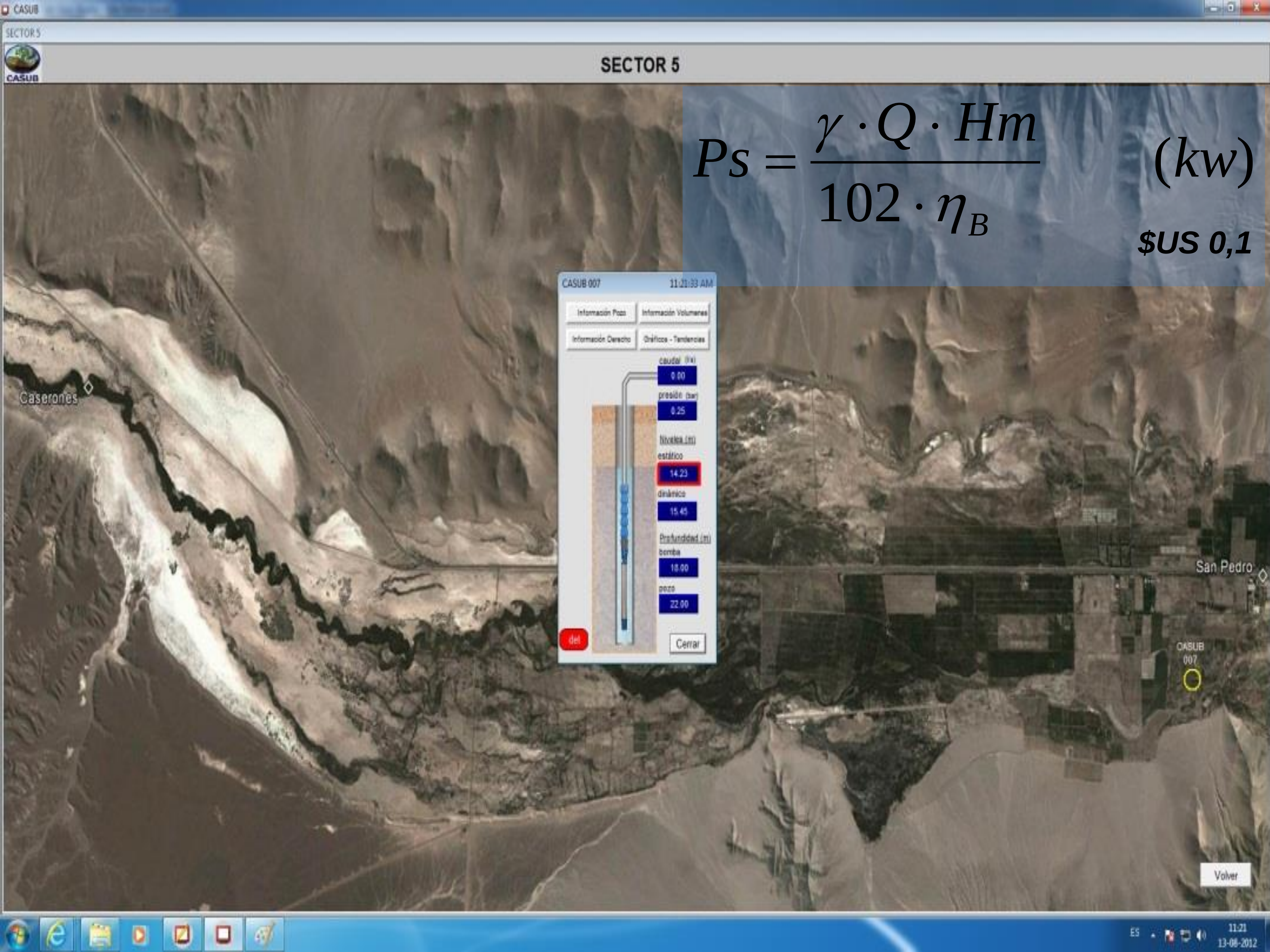
Know the extractions and the water table level (phreatic level)

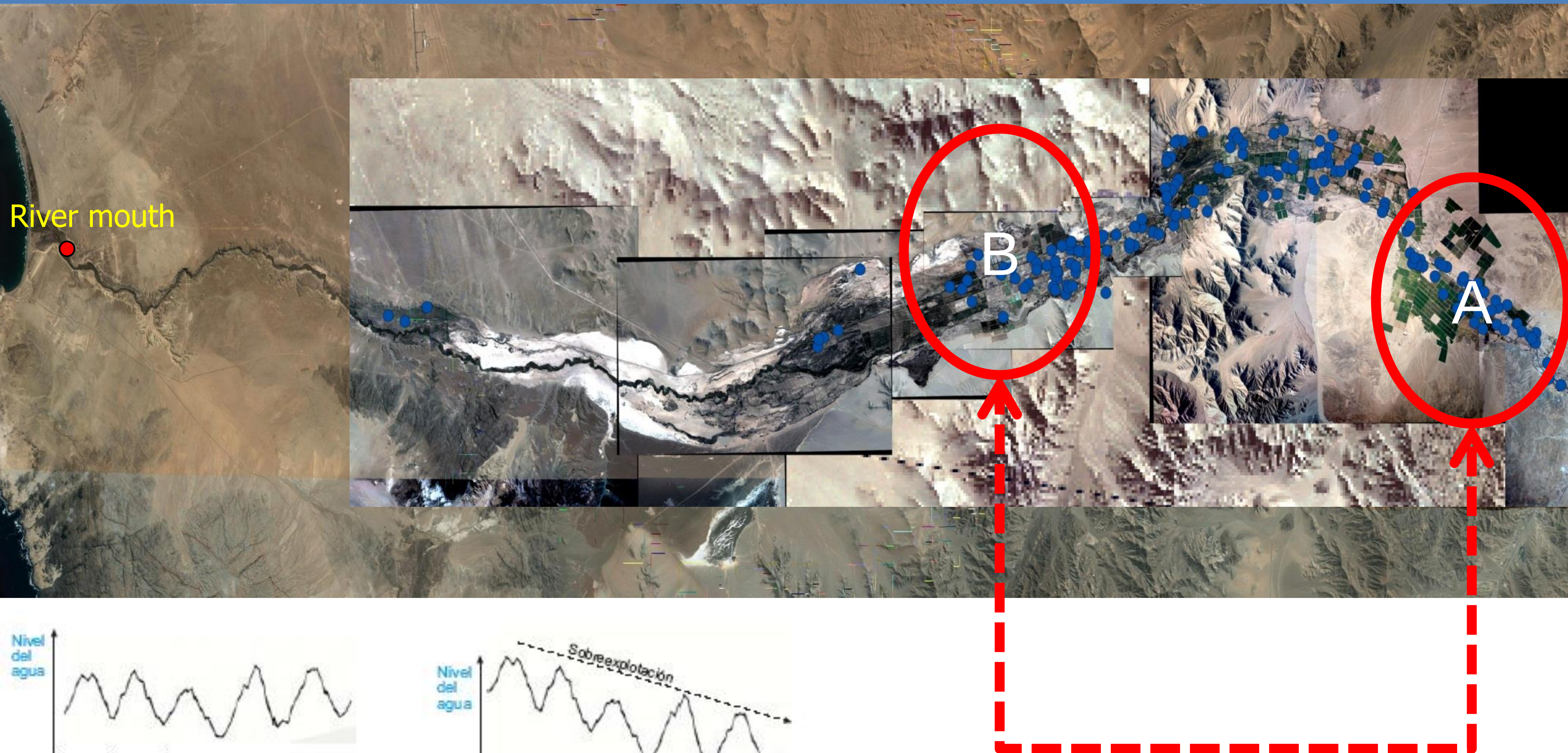


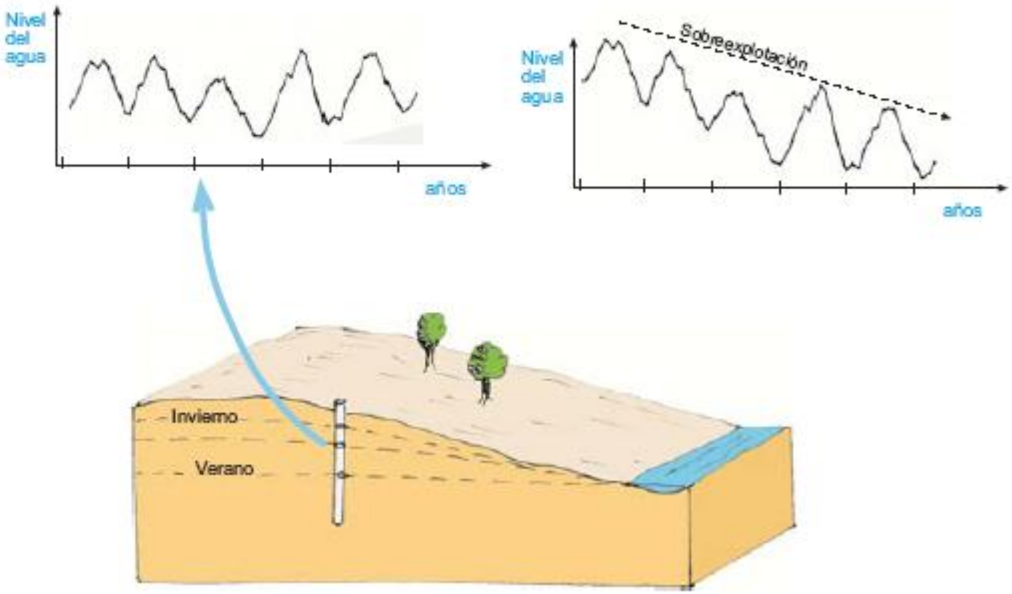

Remote Sensors (Satellite Imagery)
Water resource Management System (SGUA)
Remote Sensing Methodology
Geoinformatic System Water Management Support (SGAGA)
Territorial Information System (SIT)
Geospatial DB
Agroclimatic Model
Weather station network (Real Time)
DB
CBR
UA
DAA
Irrigation System and Crop Management
Water Intake System
Current Water Management Model
Water Balance System and Water Quality (SBHCA)
Water Demand Model
Water Supply Model
DB
Hydrogeologic Model
Monitoring network of extraction wells (Real Time)
Water Demand
Water Supply
Water Balance Model
Experts
Criteria for Water Resources Management (Policy, interest)
Management measures based on Scenarios
Evaluation System of Scenarios and Proposals (SEPG)
Evaluation Model of Scenarios Proposals Generator
Water Market Support System (SAMA)
Water Bank Model
Methodology Economic valuation of Water Resources
Experts
Recommendations for an Efficient Water Resources Management
Recommendations – Dealings – Reallocations: between users

$$Ps = \frac{\gamma \cdot Q \cdot Hm}{102 \cdot \eta_B} \quad (kw)$$

$US 0,1



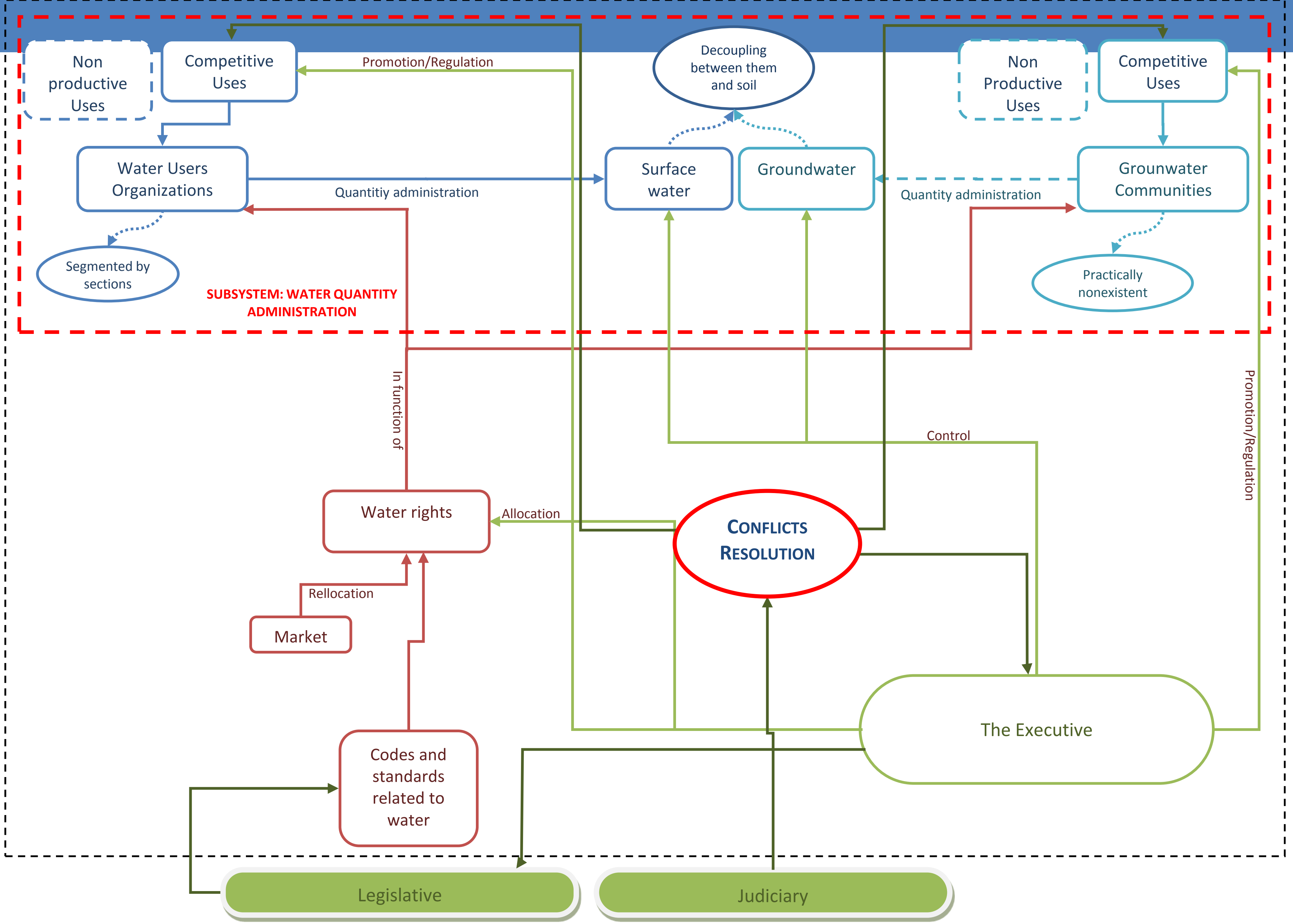




Mobilize the available water volume (insufficient in A) from users energetically vulnerables to demanding users (B)

Final remarks

- The link between water use and energy is indissoluble, water management is to manage energy.
- Institutional context defines the conditions for the management of water and energy.
- Key factor, having a community organization to manage common resources.



Non productive Uses
Competitive Uses
Promotion/Regulation
Decoupling between them and soil
Non Productive Uses
Competitive Uses
Water Users Organizations
Surface water
Groundwater
Grounwater Communities
Quantitiy administration
Quantity administration
Segmented by sections
Practically nonexistent
SUBSYSTEM: WATER QUANTITY ADMINISTRATION
In function of
Promotion/Regulation
Control
Water rights
Allocation
Conflicts Resolution
Rellocation
Market
The Executive
Codes and standards related to water
Legislative
Judiciary