Managed Aquifer Recharge (MAR) to supply Libreville, a water-stressed city (Gabon)

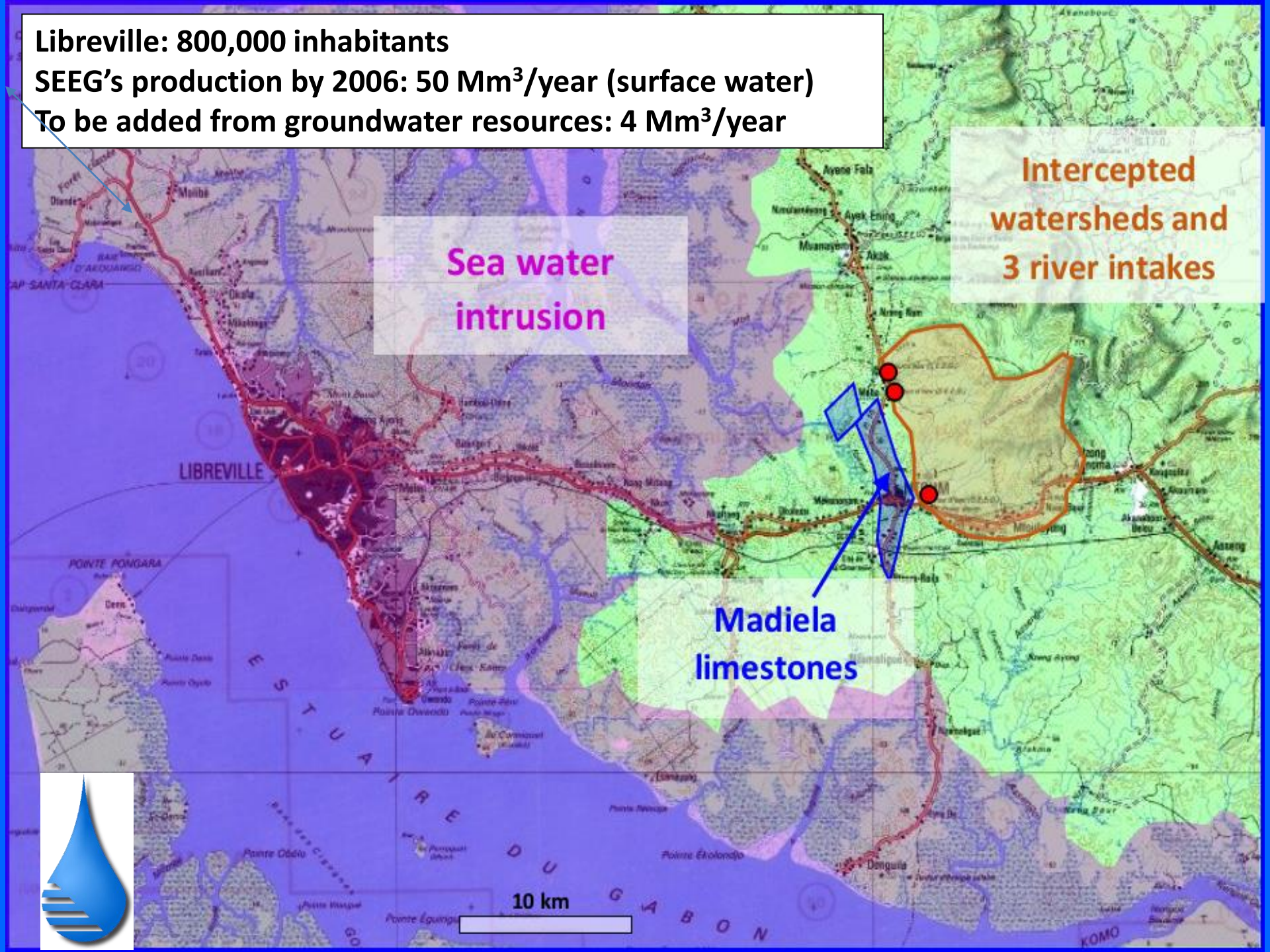
Bernard Collignon

HYDROCONSEIL
www.hydroconseil.com
Water Supply and Sanitation
Environment, Public Services

Claude Ondo

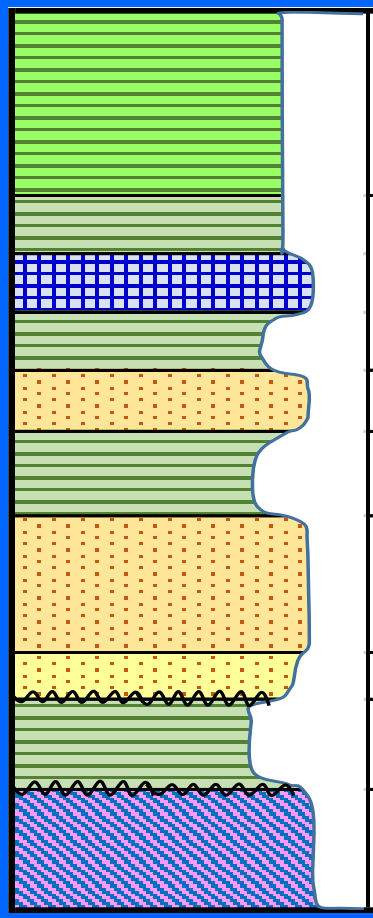
seureca

iah • aih 60 years
25-29th September 2016
Montpellier, France
CORUM CONFERENCE CENTER
43rd IAH congress


Libreville: 800,000 inhabitants
SEEG's production by 2006: 50 Mm³/year (surface water)
To be added from groundwater resources: 4 Mm³/year
Sea water intrusion
Intercepted watersheds and 3 river intakes
Madiela limestones
LIBREVILLE
POINTE PONGARA
ESTUAIRE DU GABON
10 km

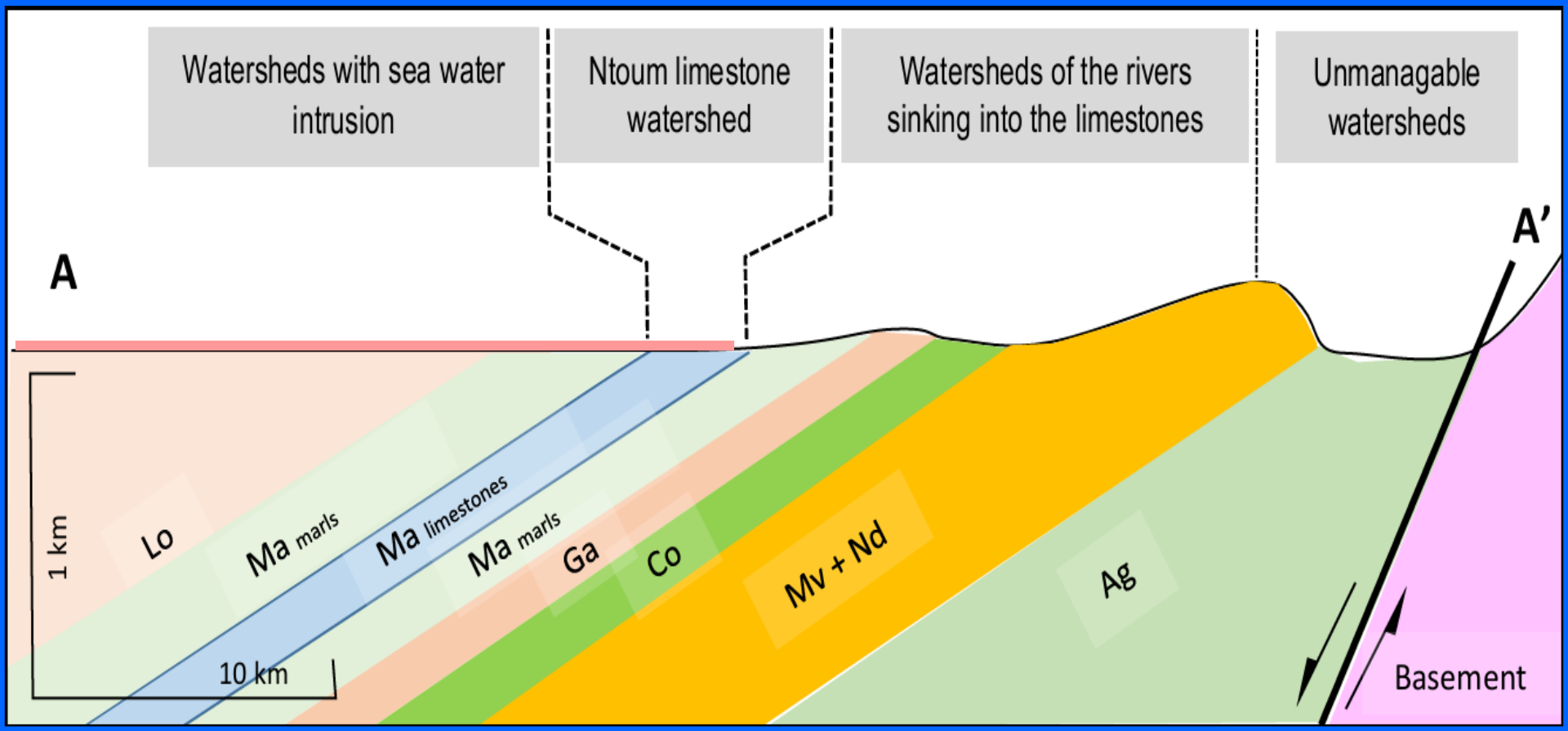
Madiela limestones have been selected

- Mined since 50 years, by Lafarge quary
- Known to be > 200 m thick through oil drilling campaigns
- Never used before for water supply, because outcrops are very limited



Lopez (Lo)	*Cenomanian*	sandy marls
Madiela (Ma)	*Aptian - Albian*	marls
		marly limestones
		marls
Gamba (Ga)	*Neocomian - Barremian*	sandstones
L.Cocobeach (LC)		sandy marls
Ndombo(Nd)	*Lower Cret.*	sandstones
Mvone (Mv)	*Upper Jur.*	sandstones
Agoula (Ag)	*Permian*	marls, gypsum
Basement	*Proterozoic*	granite, gneiss

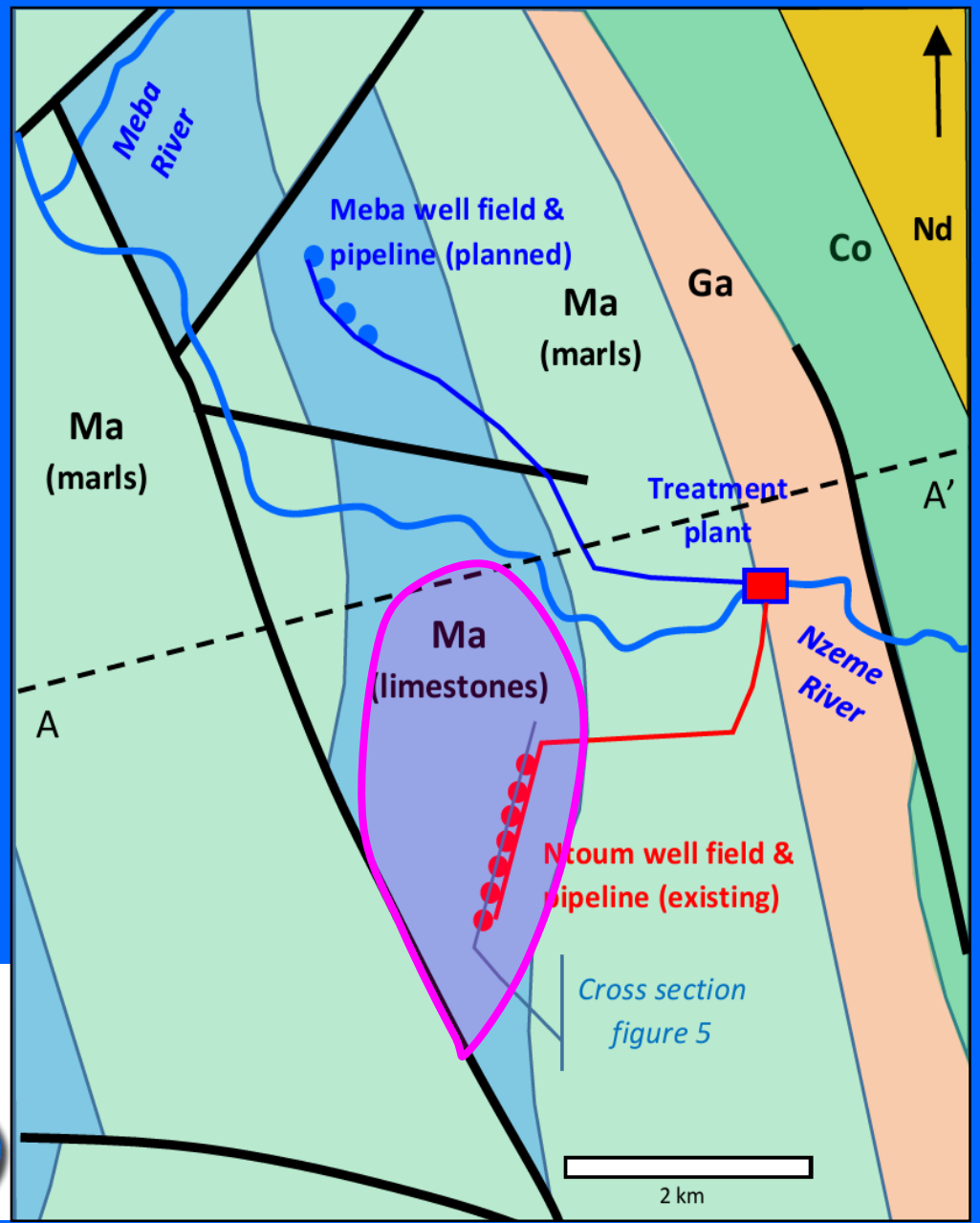
Madiela limestones outcrops are very limited because of Paleocene sand cover



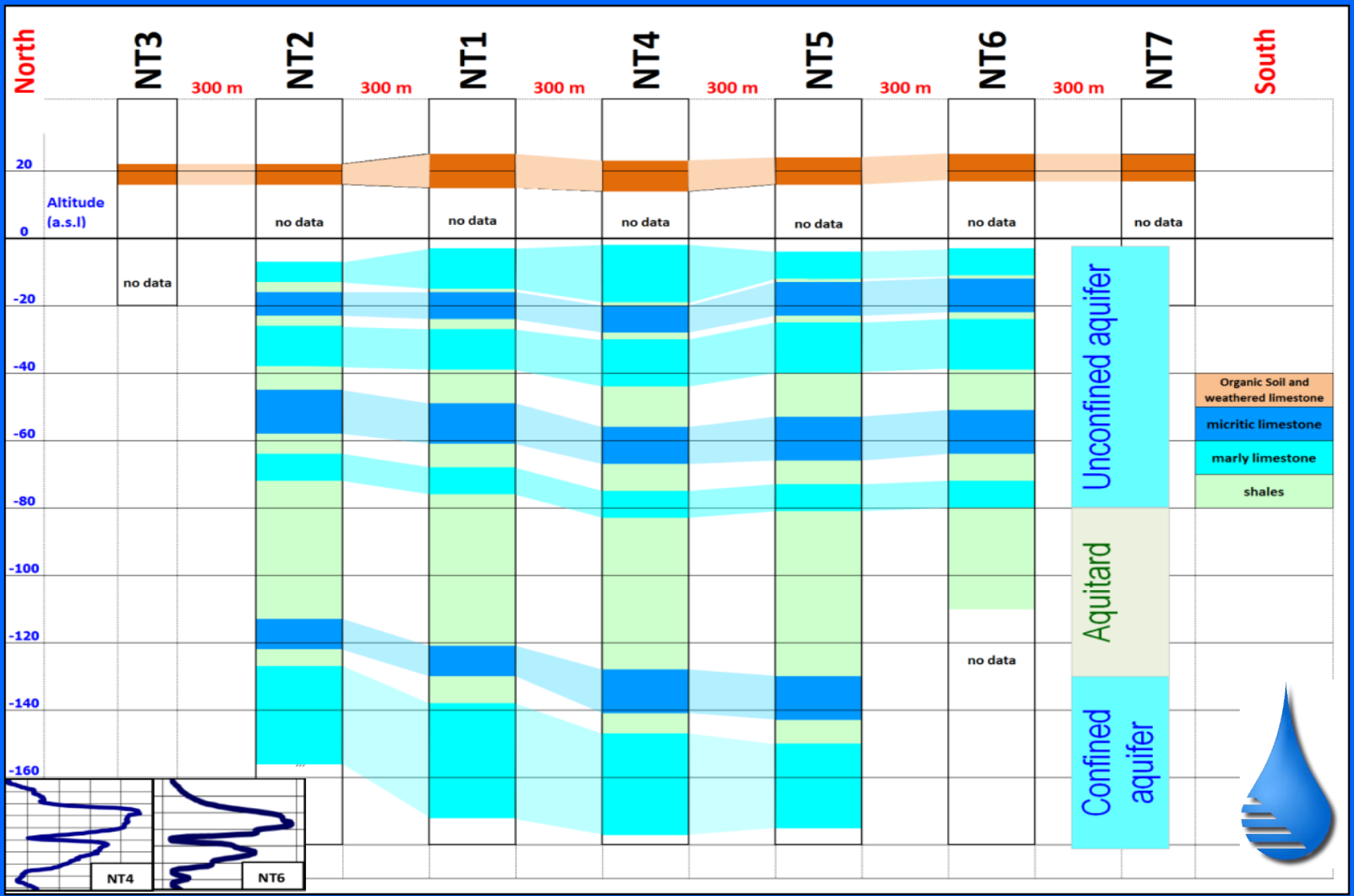
Madiela limestones outcrops in Lafarge quary

Madiela limestones

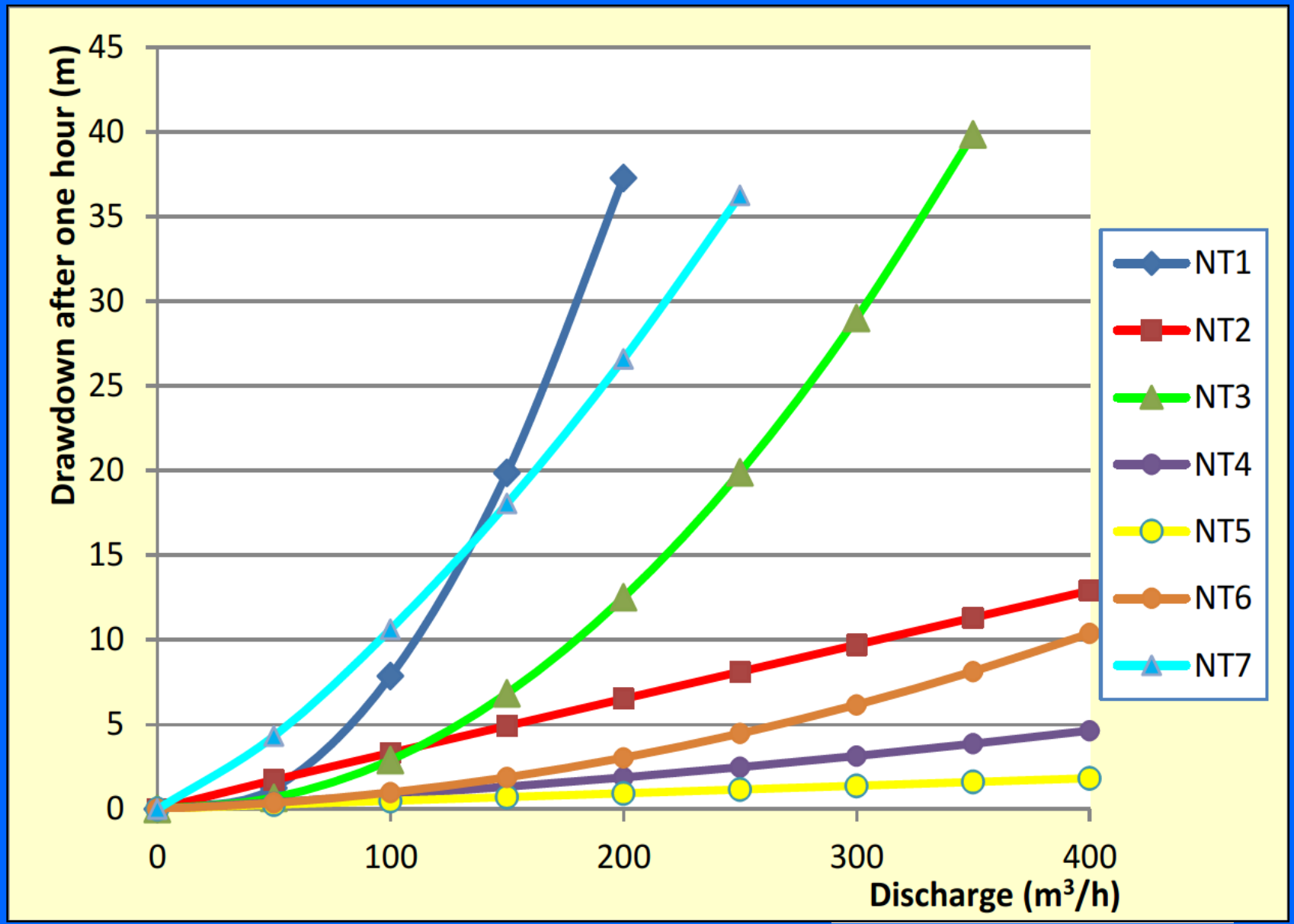
- 4 km²
- Natural inflow = 4 Mm³/year



Two main limestone aquifers

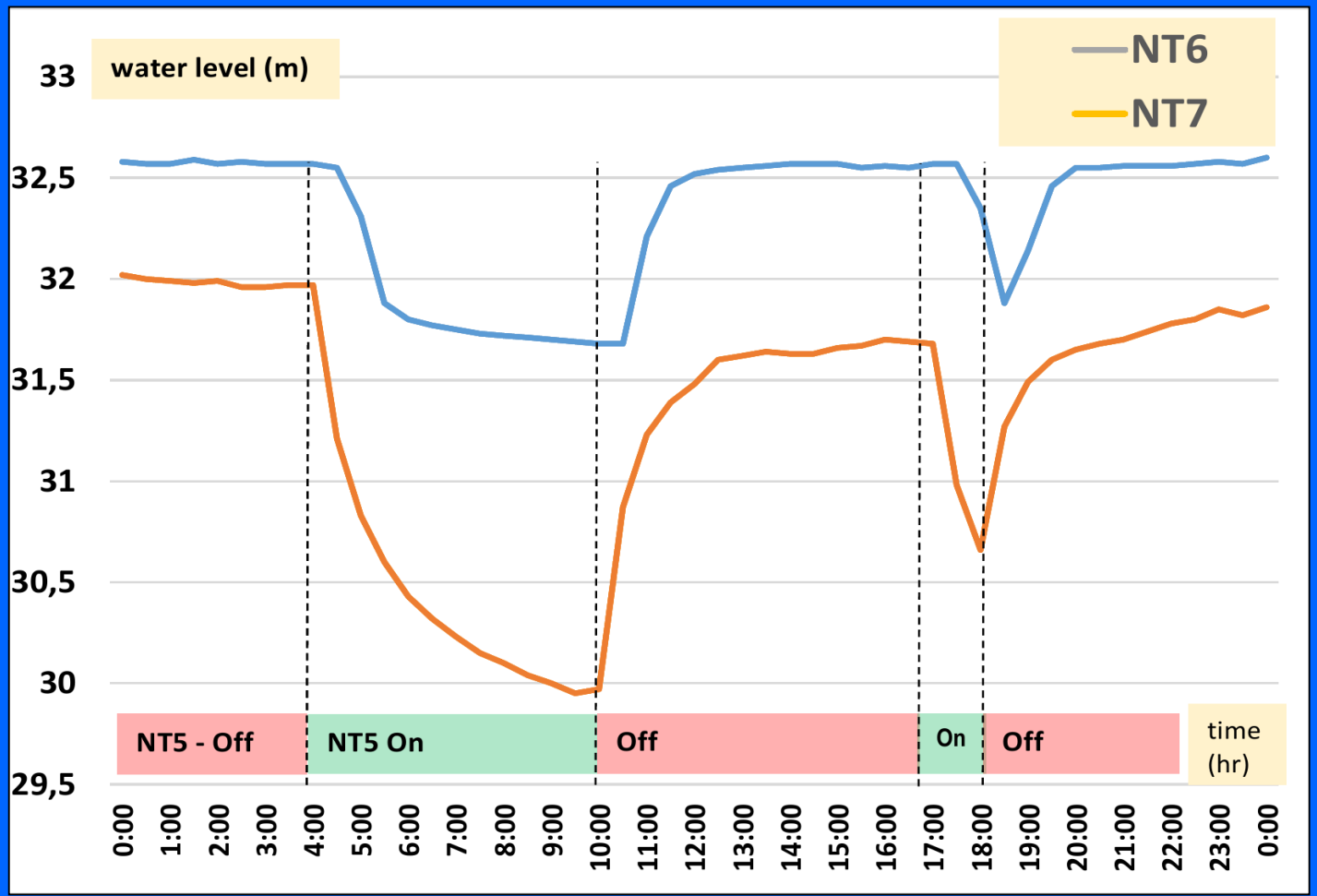


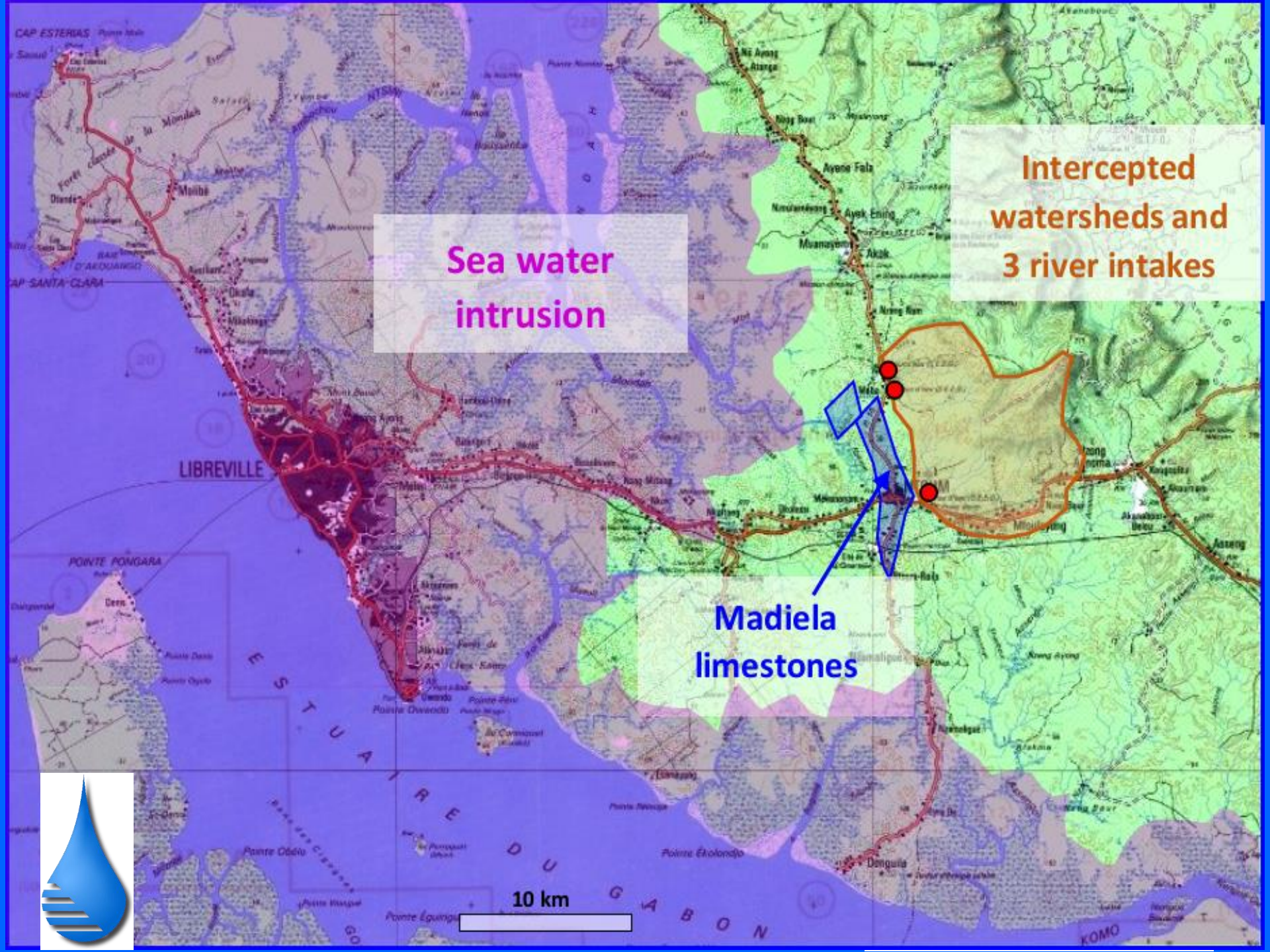
Madiela limestones are very productive



Connectivity through karstic channels

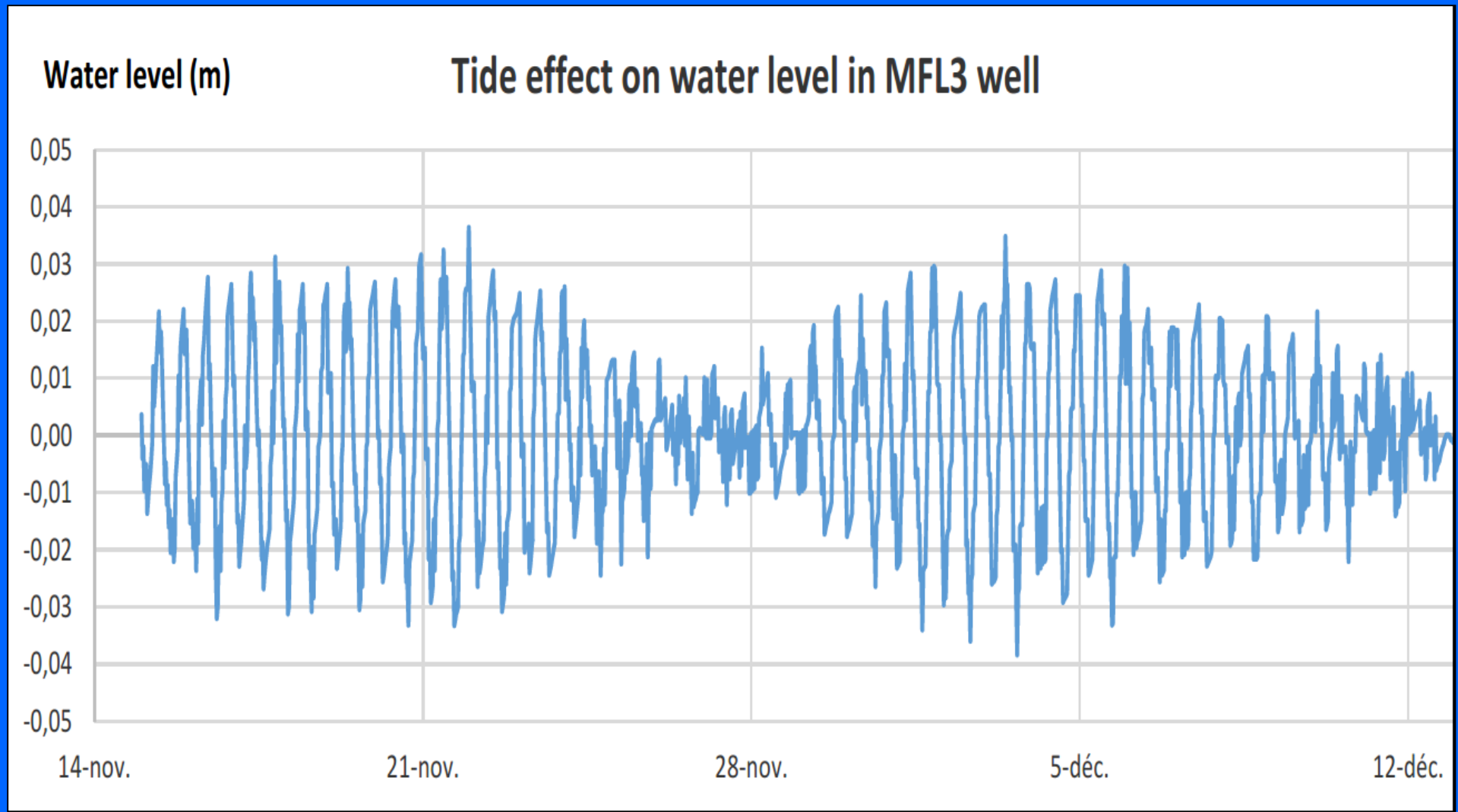
- The well field extents on 1800 m North - South
- Any head change in a single well (pump ON/OFF) impacts all other wells in less than 1 hour
- Because deep karst is well developed, connectivity is very high and efficient (> 2 km/hour), although surface karst is not developed




Sea water intrusion
Intercepted watersheds and 3 river intakes
Madiela limestones
LIBREVILLE
10 km

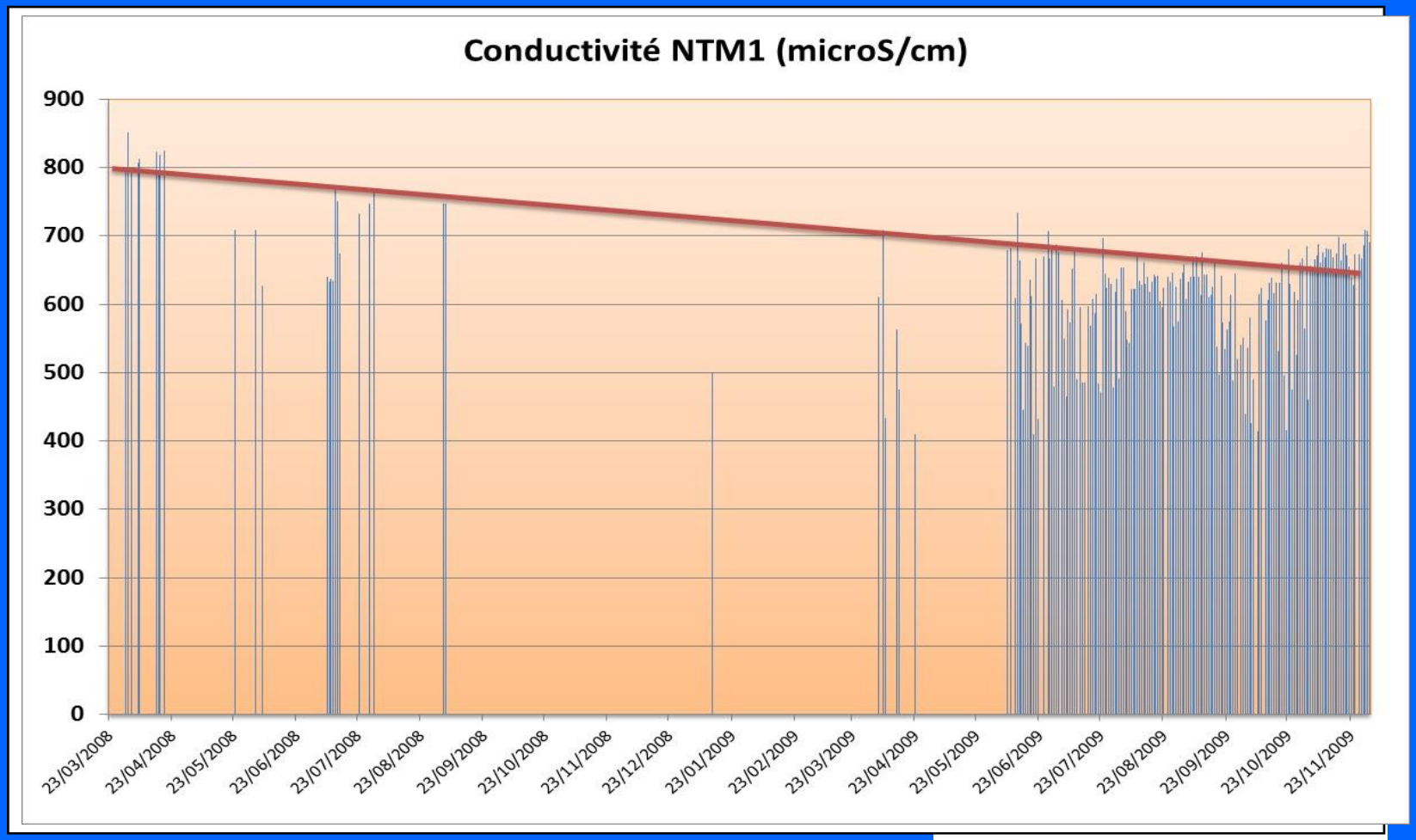
Tidal effects

- Piezometric monitoring is complex because of many interconnected wells
- But a significant tide effect on water level has been demonstrated in 4 wells.
- It could raise the sea water intrusion issue.
- But is it sea tide or earth tide ?



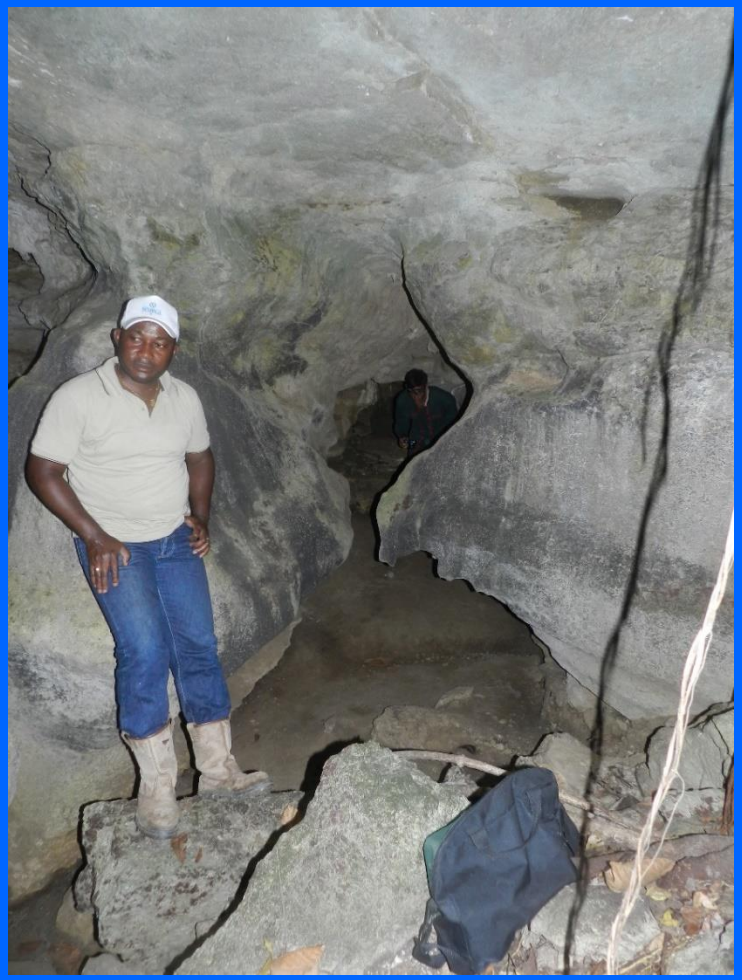
Sustainability issue

- High well productivity encourages increasing abstraction (from 4 to 20 Mm^3/year and potentially 10 Mm^3/year more).
- Are we mining the resource ?
- Conductivity records suggest that we did not yet reach full aquifer potential
- But a new hydrogeological model became necessary



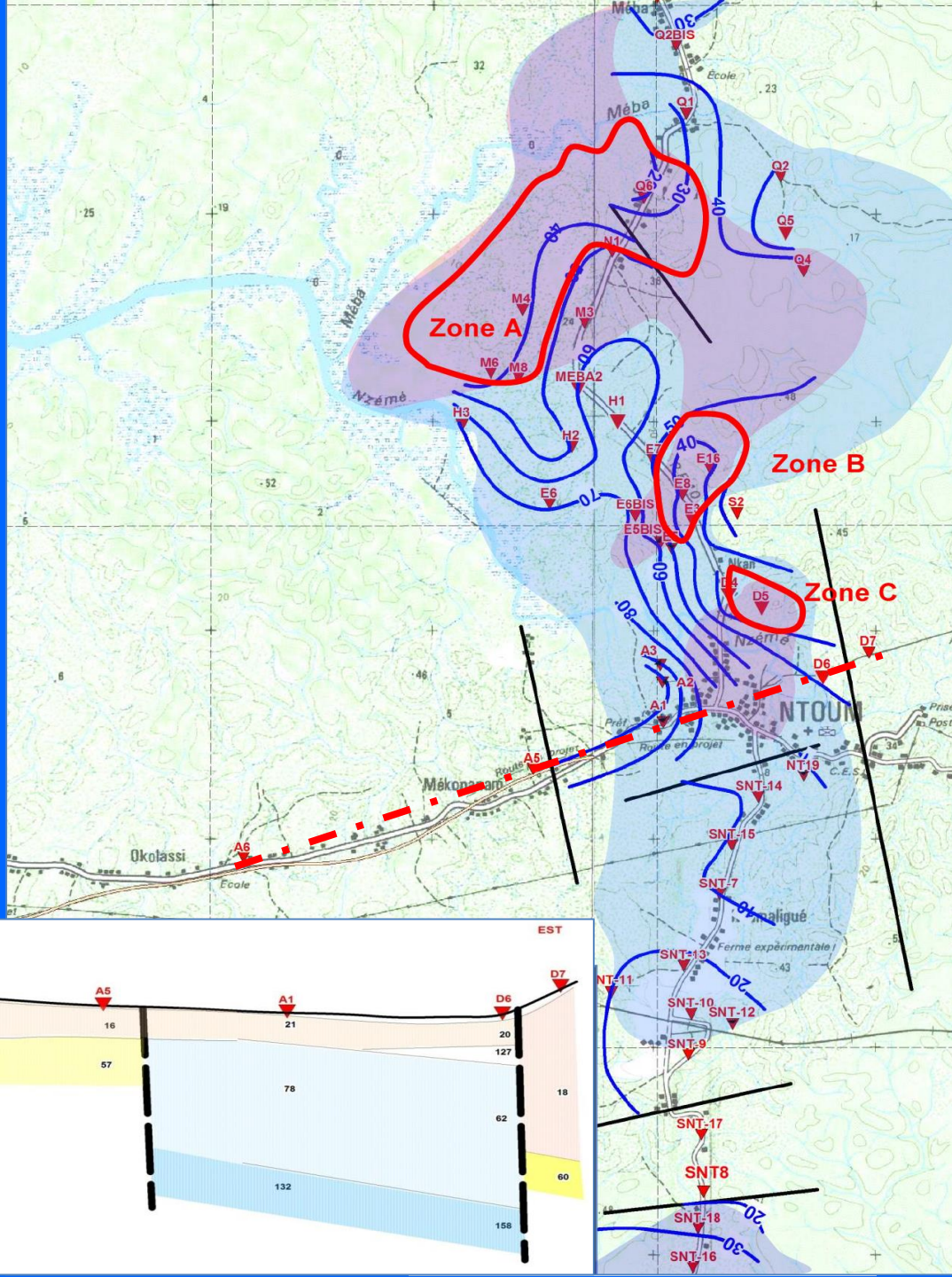
Additional surveys, as to improve the hydrogeological model

- Systematic surface karst prospecting (quite disappointing, few caves and sinkholes)
- Geophysical prospecting (demonstrated the continuity of Madiela limestones)
- Tracer experiment (demonstrated that the deep aquifer is relatively protected from surface polluted runoff)
- River water EC log (proved to be the decisive in the model construction)



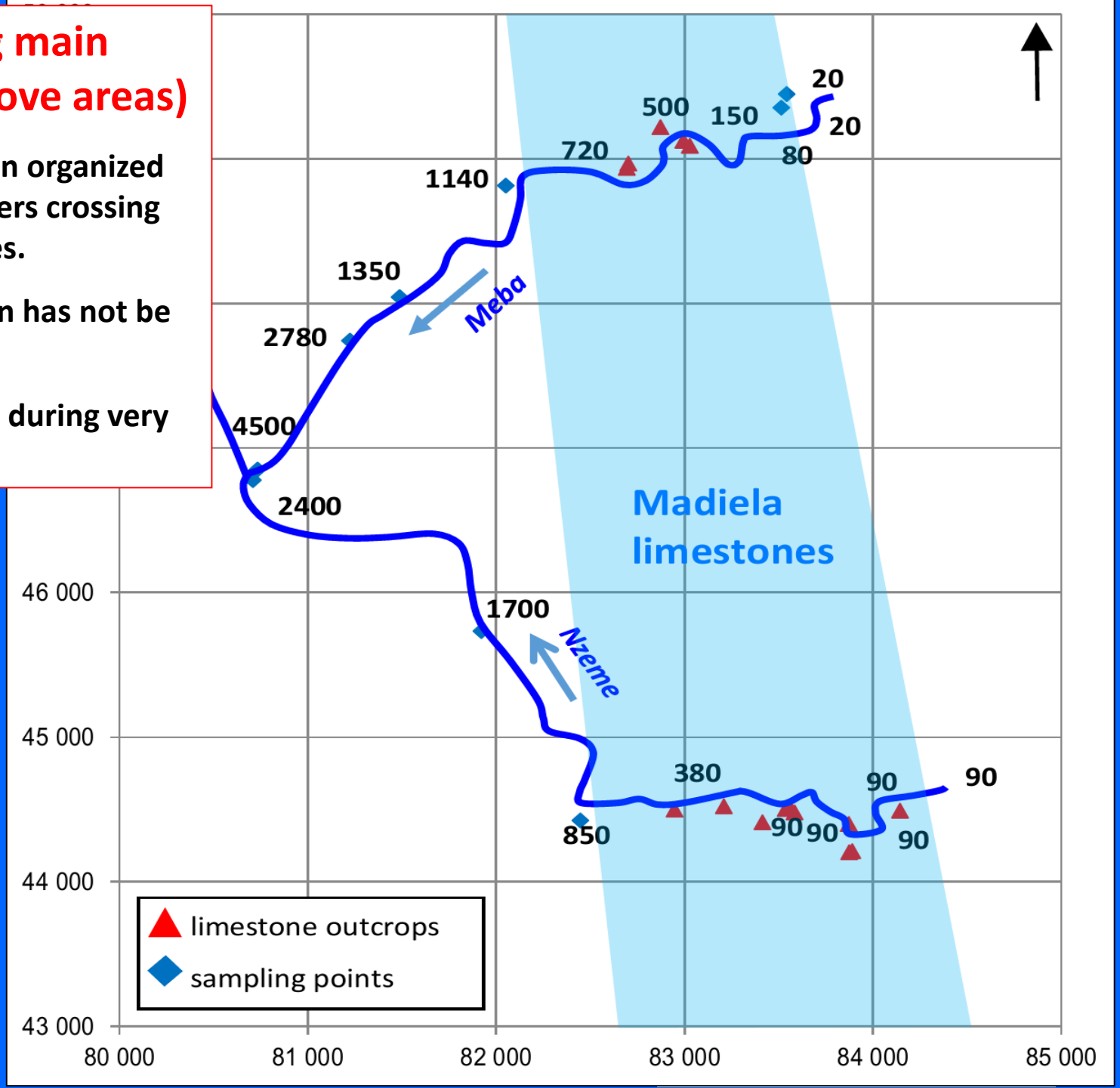
Geophysical prospecting

- Madiela limestones expand further to the North.
- They are buried under marls (with limited recharge by rainfall).
- But probably recharged by two river valleys (intersecting the limited outcrops)

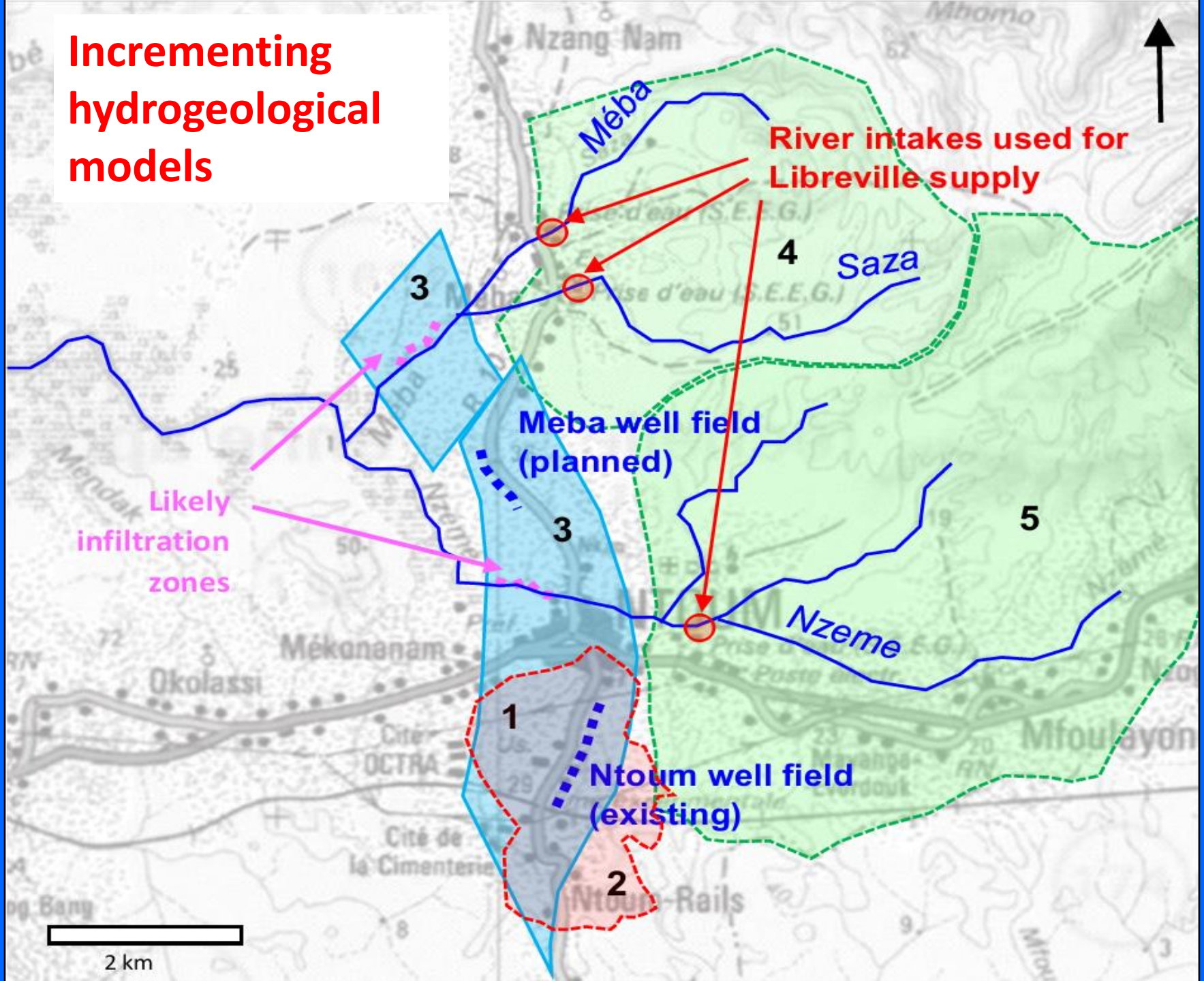


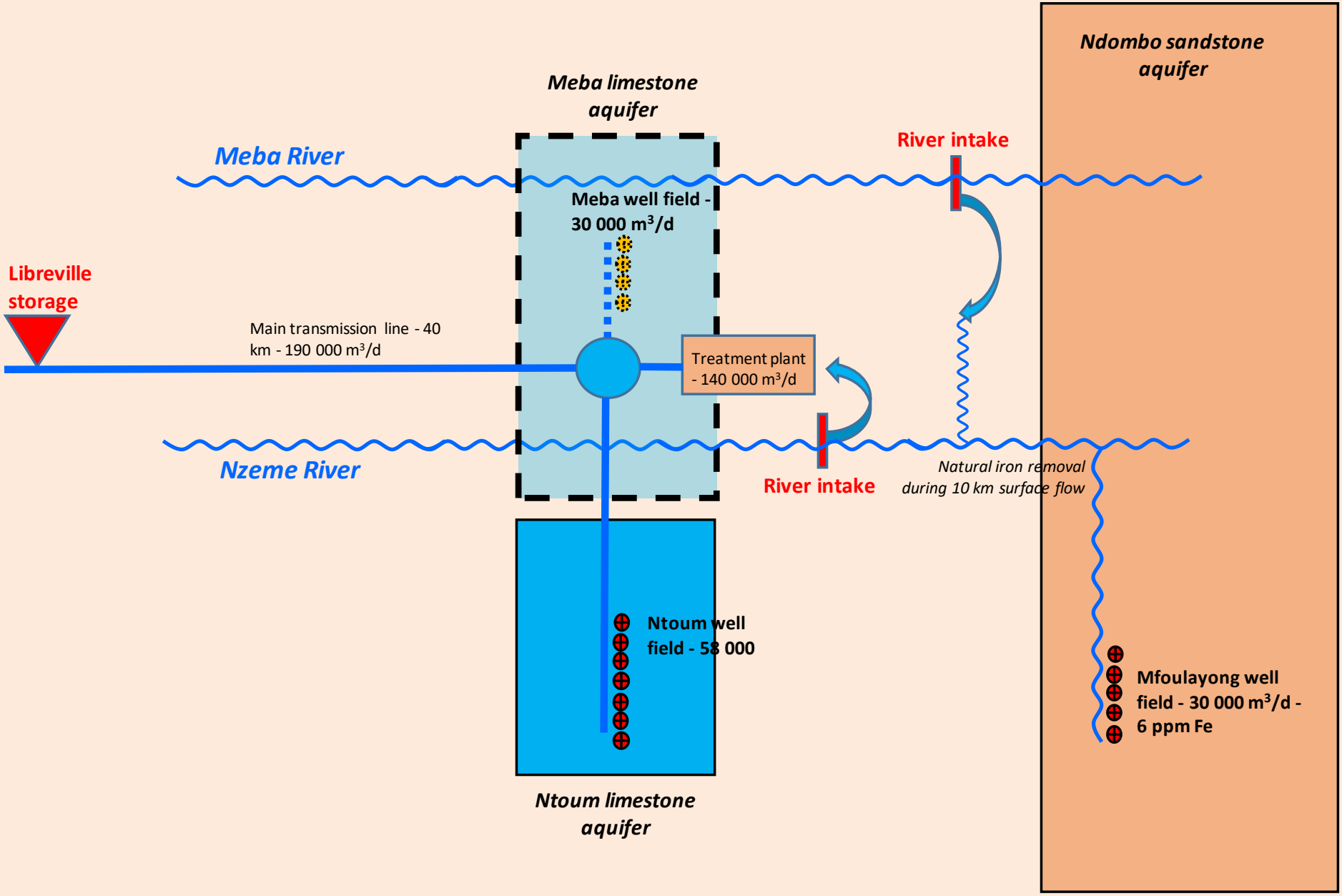
EC logging along main rivers (in mangrove areas)

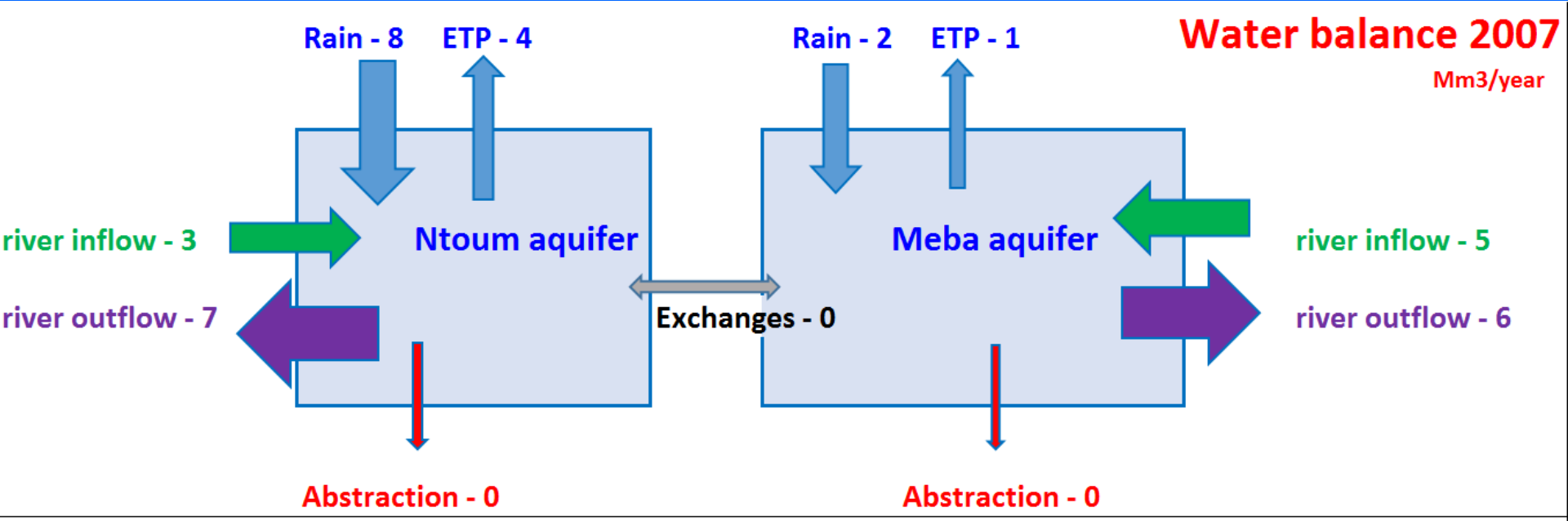
- EC logging has been organized along the main rivers crossing Madiela limestones.
- Sea water intrusion has not be confirmed.
- It could occur only during very high tides

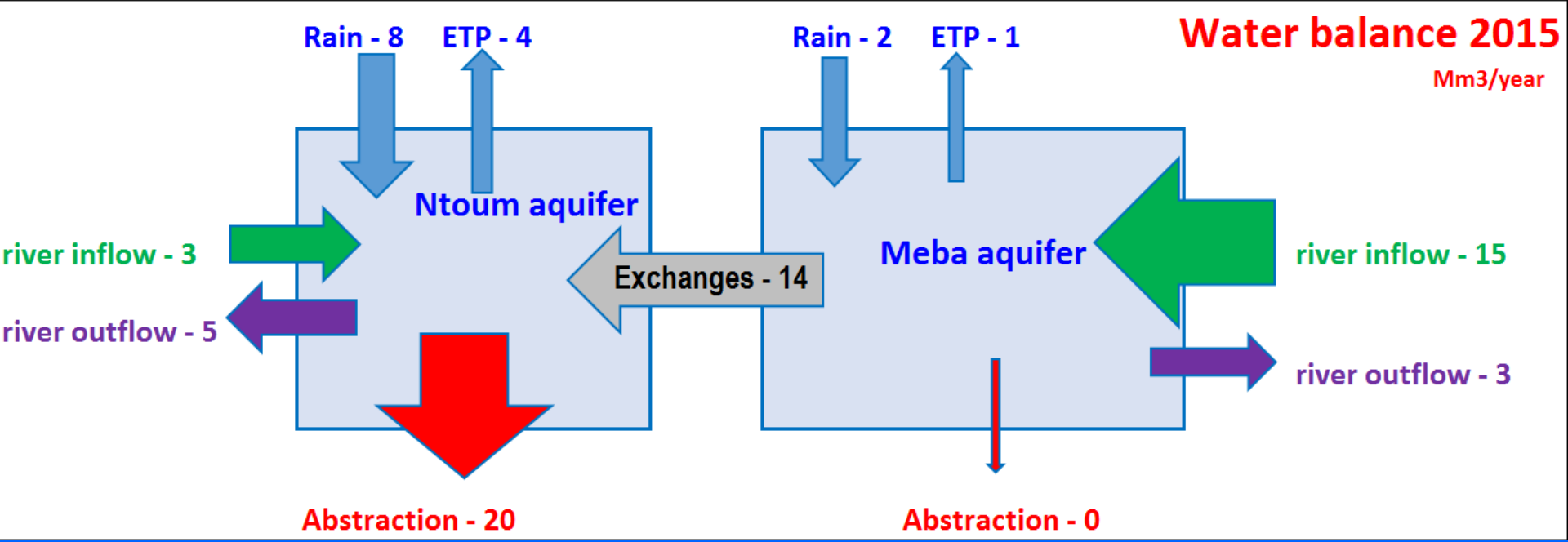


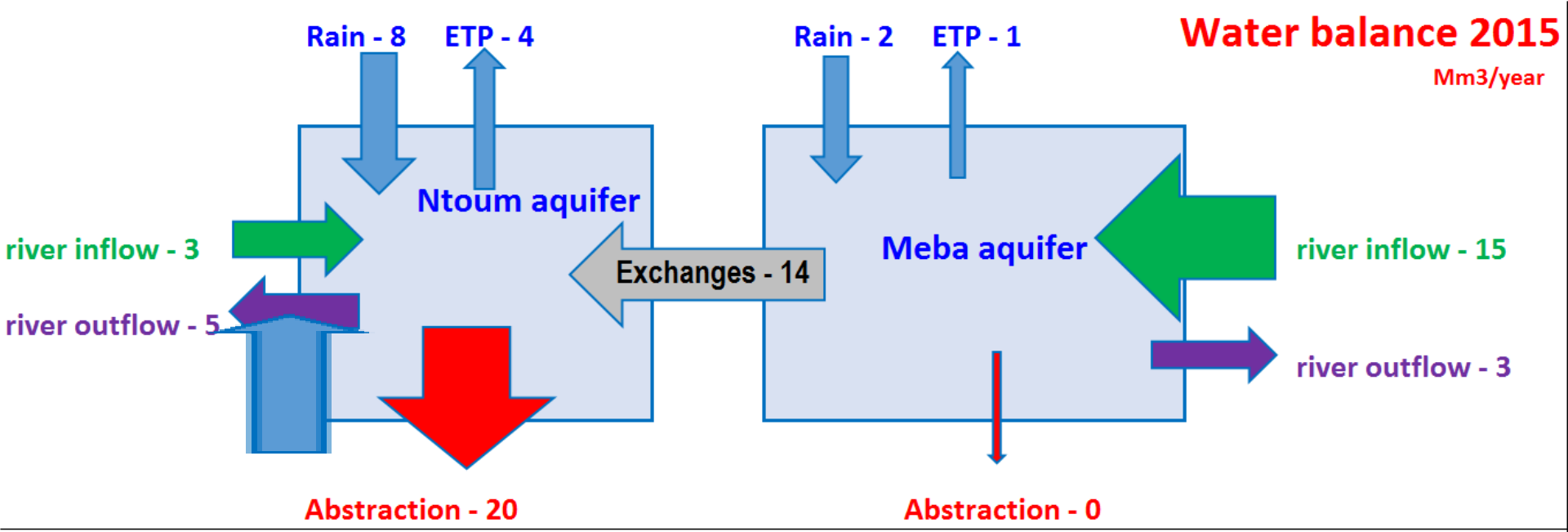
Incrementing hydrogeological models

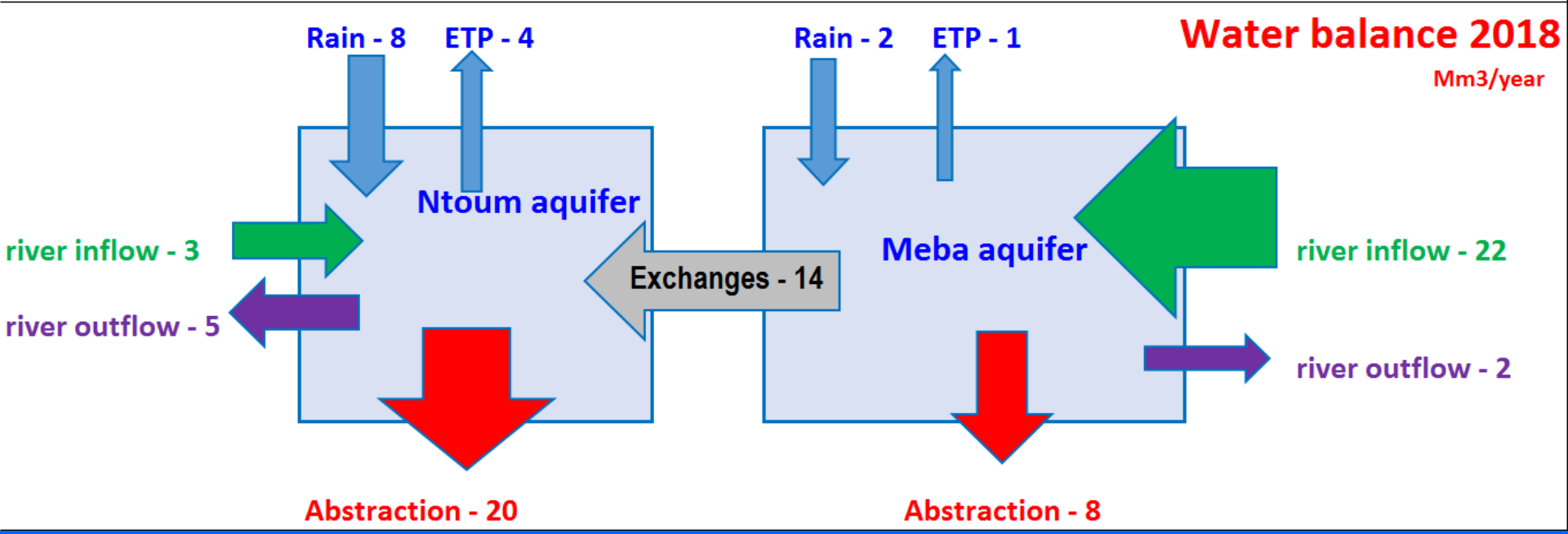



Ndombo sandstone aquifer
Meba limestone aquifer
Meba River
River intake
Meba well field - 30 000 m³/d
Libreville storage
Main transmission line - 40 km - 190 000 m³/d
Treatment plant - 140 000 m³/d
Nzeme River
River intake
Natural iron removal during 10 km surface flow
Ntoum well field - 58 000
Mfoulayong well field - 30 000 m³/d - 6 ppm Fe
Ntoum limestone aquifer


Water balance 2007
Mm3/year
Rain - 8
ETP - 4
Rain - 2
ETP - 1
river inflow - 3
Ntoum aquifer
Meba aquifer
river inflow - 5
river outflow - 7
Exchanges - 0
river outflow - 6
Abstraction - 0
Abstraction - 0


Water balance 2015
Mm3/year
Rain - 8
ETP - 4
Rain - 2
ETP - 1
Ntoum aquifer
river inflow - 3
Exchanges - 14
Meba aquifer
river inflow - 15
river outflow - 5
river outflow - 3
Abstraction - 20
Abstraction - 0


Water balance 2015
Mm3/year
Rain - 8
ETP - 4
Rain - 2
ETP - 1
Ntoum aquifer
Meba aquifer
river inflow - 3
river outflow - 5
Exchanges - 14
river inflow - 15
river outflow - 3
Abstraction - 20
Abstraction - 0


Water balance 2018
Mm3/year
Rain - 8
ETP - 4
Rain - 2
ETP - 1
Ntoum aquifer
Meba aquifer
river inflow - 3
river outflow - 5
Exchanges - 14
river inflow - 22
river outflow - 2
Abstraction - 20
Abstraction - 8

Managed Aquifer Recharge (MAR) to supply Libreville, a water-stressed city (Gabon)

Bernard Collignon

HYDROCONSEIL
www.hydroconseil.com
Water Supply and Sanitation
Environment, Public Services

Claude Ondo

seureca

iah • aih 60 years
25-29th September 2016
Montpellier, France
CORUM CONFERENCE CENTER
43rd IAH congress