Design of a Recharge Well in the Dry Areas of Tunisia

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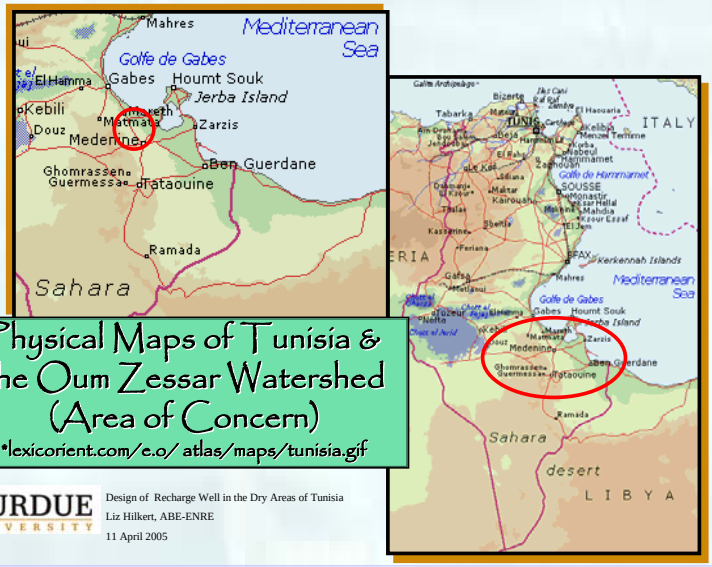
Problem Background:

- In the dry areas of Tunisia, aquifer water is utilized for drinking, irrigation and grazing faster than it can be naturally replenished.
- Storms only occur a few times a year and are high intensity, short duration.
- Because the average annual rainfall is 162 mm, each storm is critical to aquifer replenishment.
- Current recharge wells clog within a few years of installation. Clay accumulation is the main known cause of clogging.
- Currently installed recharge wells do not have a water pretreatment system in place.

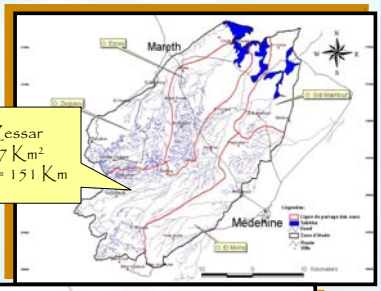
Objective:

Design a recharge well that maximizes the amount of stormwater transported from the ground to the aquifer without affecting the water quality.

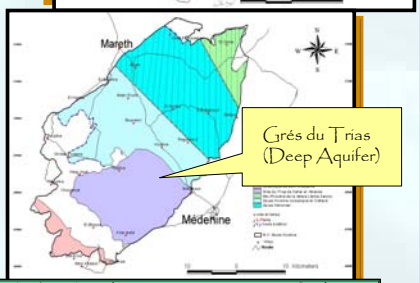


Physical Maps of Tunisia & the Oum Zessar Watershed (Area of Concern)

*lexicorient.com/e.o/ atlas/maps/tunisia.gif



O. Oum Zessar
Area = 387 Km²
Perimeter = 151 Km



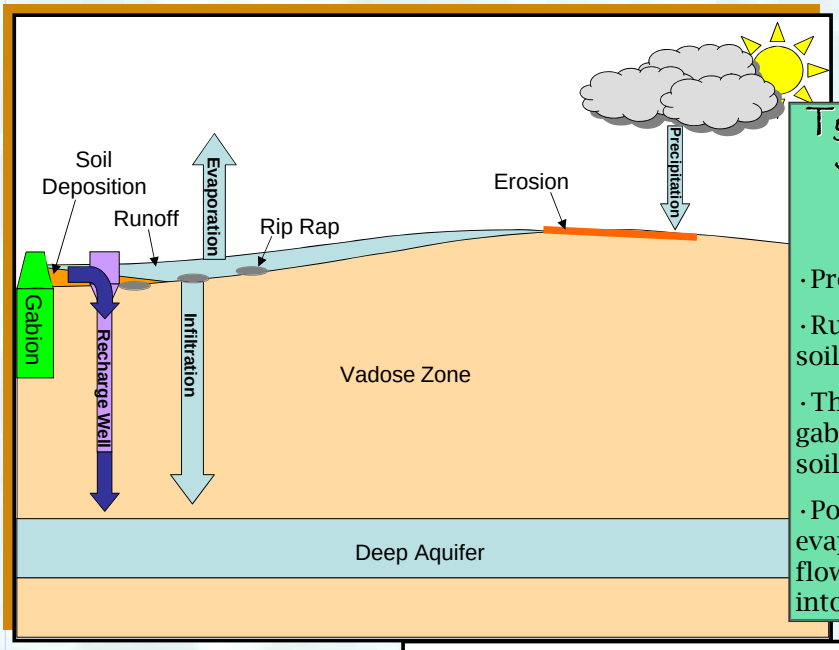
Grés du Trias (Deep Aquifer)

Hydrologic Maps of the Oum Zessar Watershed

(source: Abdelhi)

Oum Zessar Watershed Visit:

- Attended International Workshop on "Watershed Management in Dry Areas" in Djerba, Tunisia from January 4-7, 2005
- Visited water harvesting structures including the gabion (a local dam and erosion control structure) and recharge well
- Exposed to the other areas of dry land hydrology such as economics
- Networked with other scientists, economists and engineers concerned with water harvesting structures

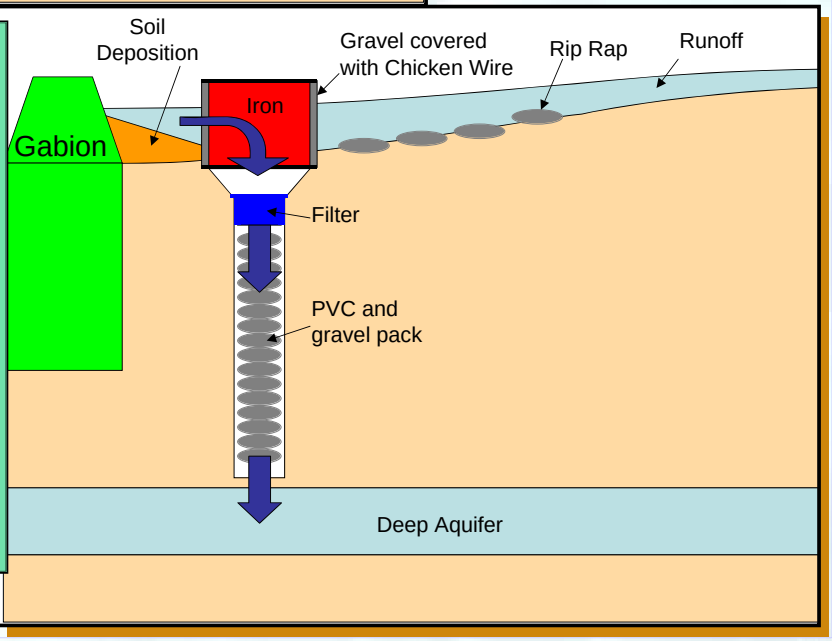


Typical Groundwater Recharge System (Gabion) with Flow Processes and Sediment Transport

- Precipitation causes runoff
- Runoff leads to erosion of the soil
- The runoff is trapped behind the gabion, which allows some of the soil to deposit
- Pooled water can either evaporate, infiltrate in the soil, or flow through the recharge well into the deep aquifer

Detailed Recharge Well System including Improved Design, Water Flow and Sediment Transport

- Exterior gravel, the initial filtration layer for total suspended solids (TSS)
  - Allows easy access for maintenance
- Interior filter, reduces TSS
  - Removable to allow for easier maintenance
- Gravel pack prevents air binding during water transport



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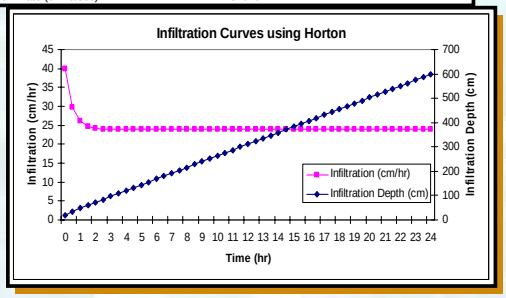
Pipe Size Parameters		
Pipe Outer Diameter (m)	1	
Pipe Material Thickness (cm)	5	
Pipe Inner Diameter (m)	0.9	
Well Depth (m)	150	
Aquifer Depth (m)	150	
Gabion Height (m)	1.5	
Total Well Height (m)	152	
TSS Filter Sizing Parameters		
Filter Outflow Time for 1 m^3 water (min)		
Measured Filter Outflow Rate (m^3/hr)	136.8	
Actual Outflow Rate (cm^3/sec)	38000	
Filter Area (cm^2)	6361.73	
Filter Diameter (cm)	90.00	
Hydraulic Head at Inlet (cm)	66.67	assume an average tank is 1/3 full
Particle Filter Hydraulic Conductivity (cm/sec)	0.02	assumed K for Tabia
Theoretical Filter Height (cm)	0.27082	**requires iteration ....**
Calculated Filter Height (cm)	0.271325023	**must equal above number**
Calculation Error (%)	0.19	
Actual Outflow Rate (cm^3/sec)	37929.27	



Model Testing Methodology

·Designed the pictured setup to test different sand filter material

·Determined the most efficient filter material in mass of sediment trapped per minute

·Tested the efficiency of the entire well system

·Analyzed the clogging rate of the experimental setup by running contaminated water through the system multiple times without cleaning it.

·Determined the maintenance requirements based on the clogging rate of the filter

Recharge Well Design Tasks:

·Brainstormed recharge well designs

·Developed a dynamic spreadsheet for design and analysis with the following analysis sections:

- ·Storm Analysis
- ·Infiltration Analysis
- ·Pipe Size Analysis
- ·TSS Sizing Parameters
- ·Flow Calculations
- ·Economic Analysis

·Designed and developed a small scale model to test the filter designs

·Tested the model to determine the best interior filter and overall system efficiency

·Completed an economic analysis to compare the maintenance costs of recharging the aquifer vs desalinizing water

Experimental Setup for Filter Evaluation

Potential Impacts to the Region

This service learning experience has the potential to impact the dry areas of Tunisia in the following ways:

·Agricultural production (secure food supply)

·Health benefits (adequate safe drinking water)

·Rural and economic development (water available for increased tourism)

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