WATER REVITALIZATION IN UMM EL-JIMAL

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Photo courtesy of San Diego Zoo

Team CamelBack

Photo courtesy of Cameron Carley

From left to right: Noah Szott, Sarah Bradley, Jason Eisenhart, & Ross Vander Meulen

Client

Photo courtesy of Bert de Vries

Photo courtesy of Calvin College

Problem Definition

Photo courtesy of researchgate.net

Objective

- Revitalization of Roman Era reservoirs
- Treatment of water collected in reservoirs
- Preservation of Umm el-Jimal archeology

Photo courtesy of Bert de Vries

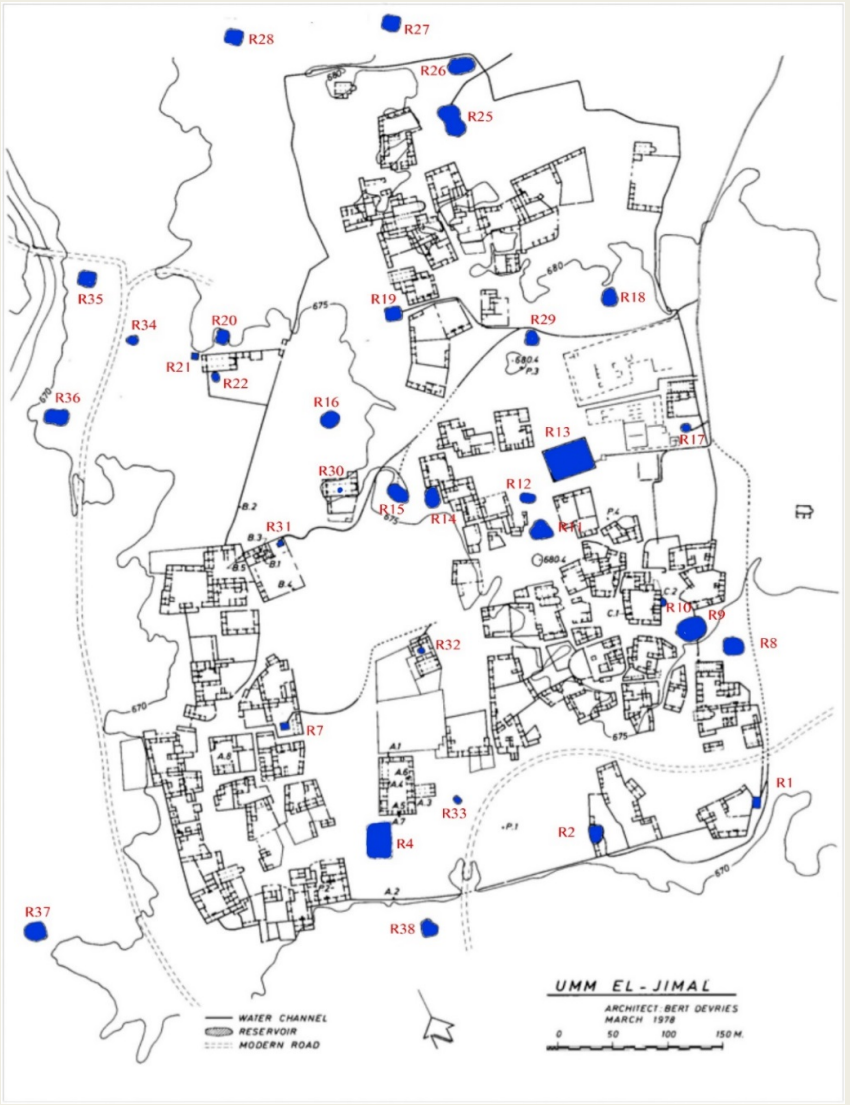


Photo courtesy of Bert de Vries

Water Demand Survey Conclusions

- Water Uses: Domestic Irrigation
- Quantity: Minimum of 57.5 m^3/day
- Cost: 1 JD/m^3 (untreated)

  1.67 JD/m^3 (potable)

Photos courtesy of Udayavani

Water Use	Quantity (m^3/day)
Municipal Distribution	505
Drinking Usage*	22.5
Domestic Usage	304
Irrigation	123
Livestock / animals	113
Deficit	57.5

*drinking usage based on 5L/day rather than data, as the data gives an average of 21.4 L/day, additionally, there is minimal upwards trend for increasing household size.

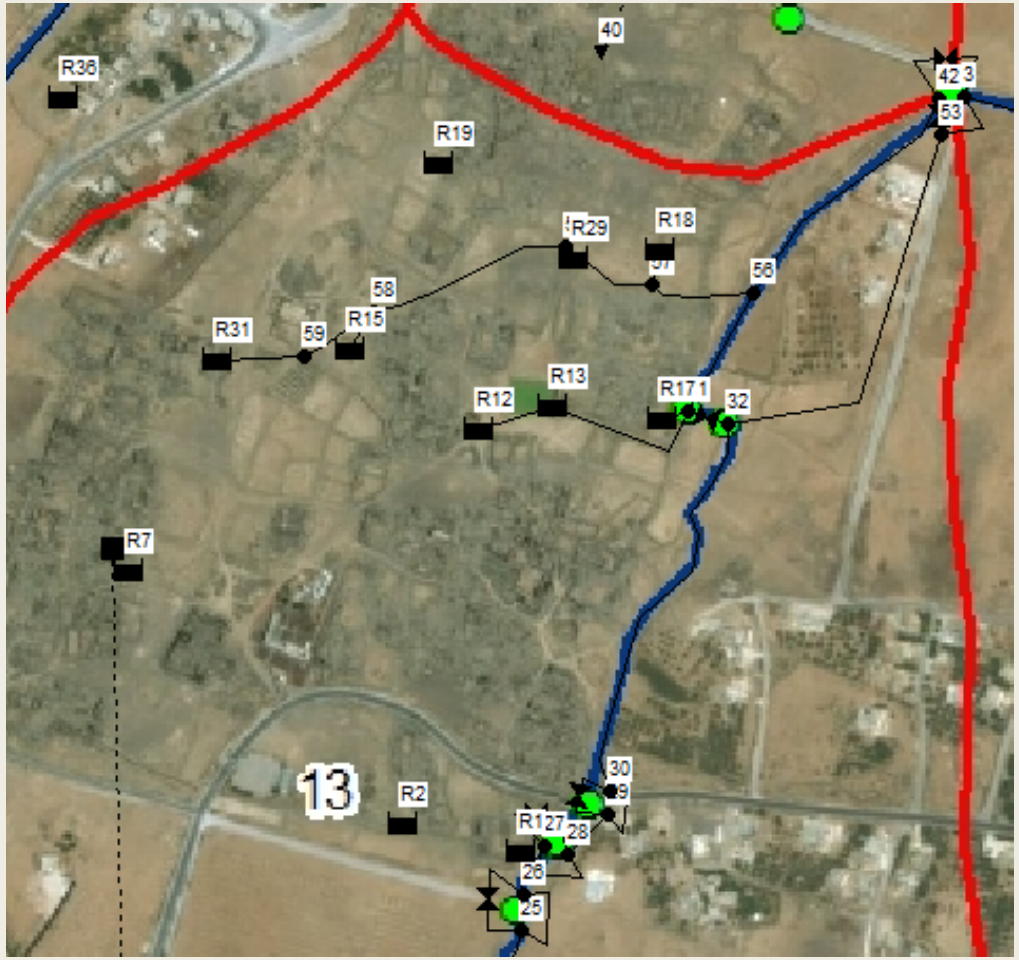
Water Transmission - Research

- Buried Pipe
- Above Ground Pipe
- Open Channel Flow
- Digital Elevation Model (DEM)

Water Transmission - EPA SWMM

- Existing Conditions
  - *Reservoirs*
  - *Channel Cross Sections*
  - *Rain Events*

Rain Event	Frequency
5 mm	9.24
10 mm	5.03
20 mm	1.24
30 mm	0.58
40 mm	0.16



Water Transmission – Modeling Results

	Existing Conditions	Proposed Conditions
Annual Demand (cubic meters)	20,988	
Minimum Possible Annual Volume (cubic meters)	7,679	14,715
Maximum Possible Annual Volume (cubic meters)	14,240	21,541
Volumes based on average rainfall conditions.		

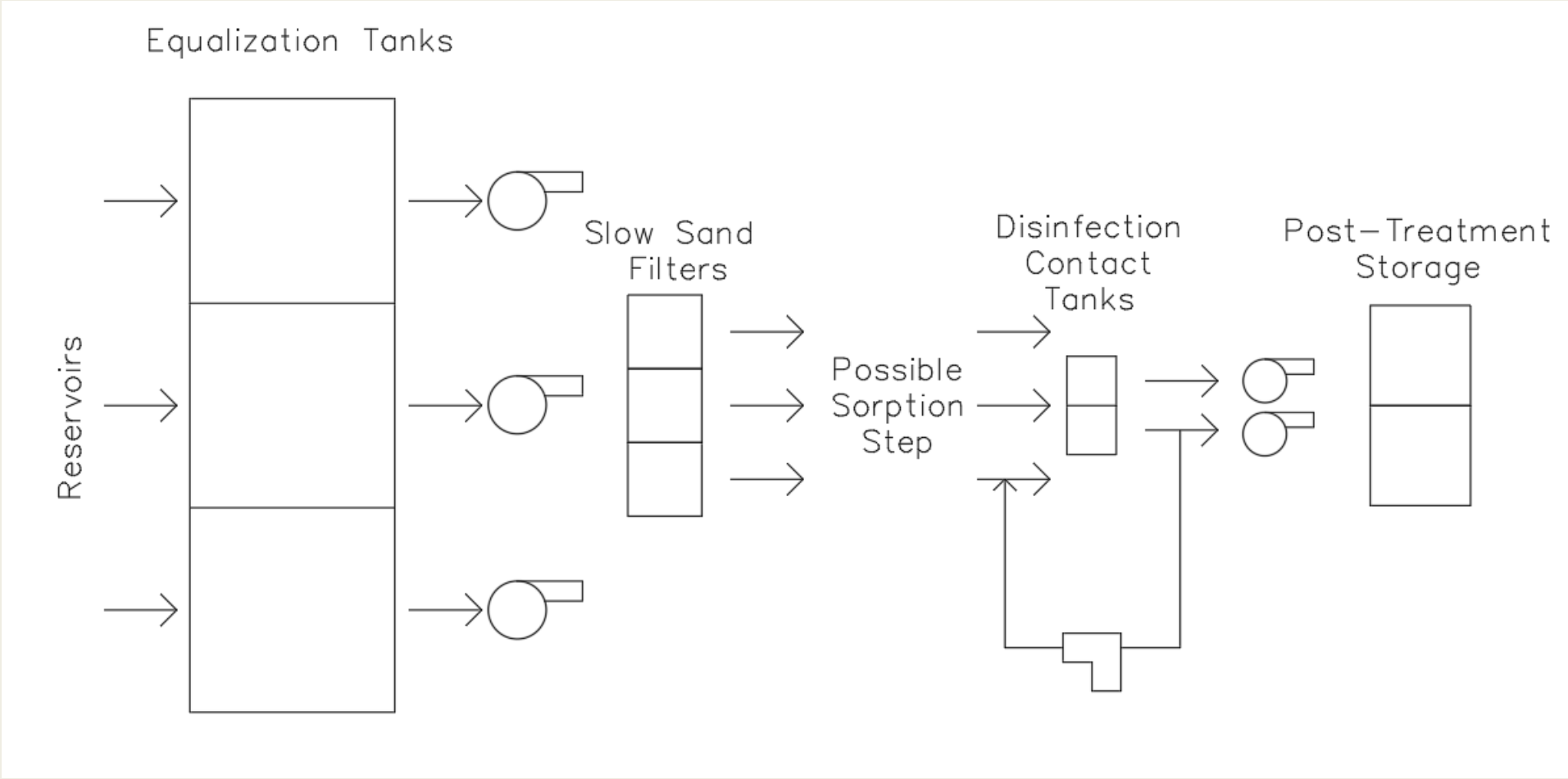
Water Transmission - Design

- Proposed Conditions
  - *Reservoirs*
  - *Channel Improvements*
  - *Destination*
- Pumps Required

Dayton Engine Driven Centrifugal Pump Kit	$6,050.00
4” x 50’ Discharge Hose	$241.00
Total Cost	**$6,291.00**

Photos courtesy of Grainger

Water Treatment Objectives



Equalization Storage

Photo courtesy of Bert de Vries

Filtration

Design Variables

$Q := 57.5\left(\frac{m^3}{day}\right)$	Daily water demand daily deficit calculated -> from water demand survey data
$HLR := 0.1\frac{m}{hr}$	Hydraulic Loading Rate
$L_{bs.start} := 1m$	depth of sandbed after resanding
$d_{10} := 0.3 \cdot mm$	Effective grain size of media
$UC := 2$	Uniformity Coefficient

Collection Efficiency and Fraction Remaining

Bacteria

$$\eta_{sb} := 4 \cdot A_{ss}^{\frac{1}{3}} \cdot N_{peb}^{\frac{-2}{3}} + A_{ss} \cdot N_{Lob}^{\frac{1}{8}} \cdot N_{Rb}^{\frac{15}{8}} \ldots + 3.38 \cdot 10^{-3} \cdot A_{ss} \cdot N_{Gb}^{\frac{6}{5}} \cdot N_{Rb}^{\frac{-2}{5}}$$

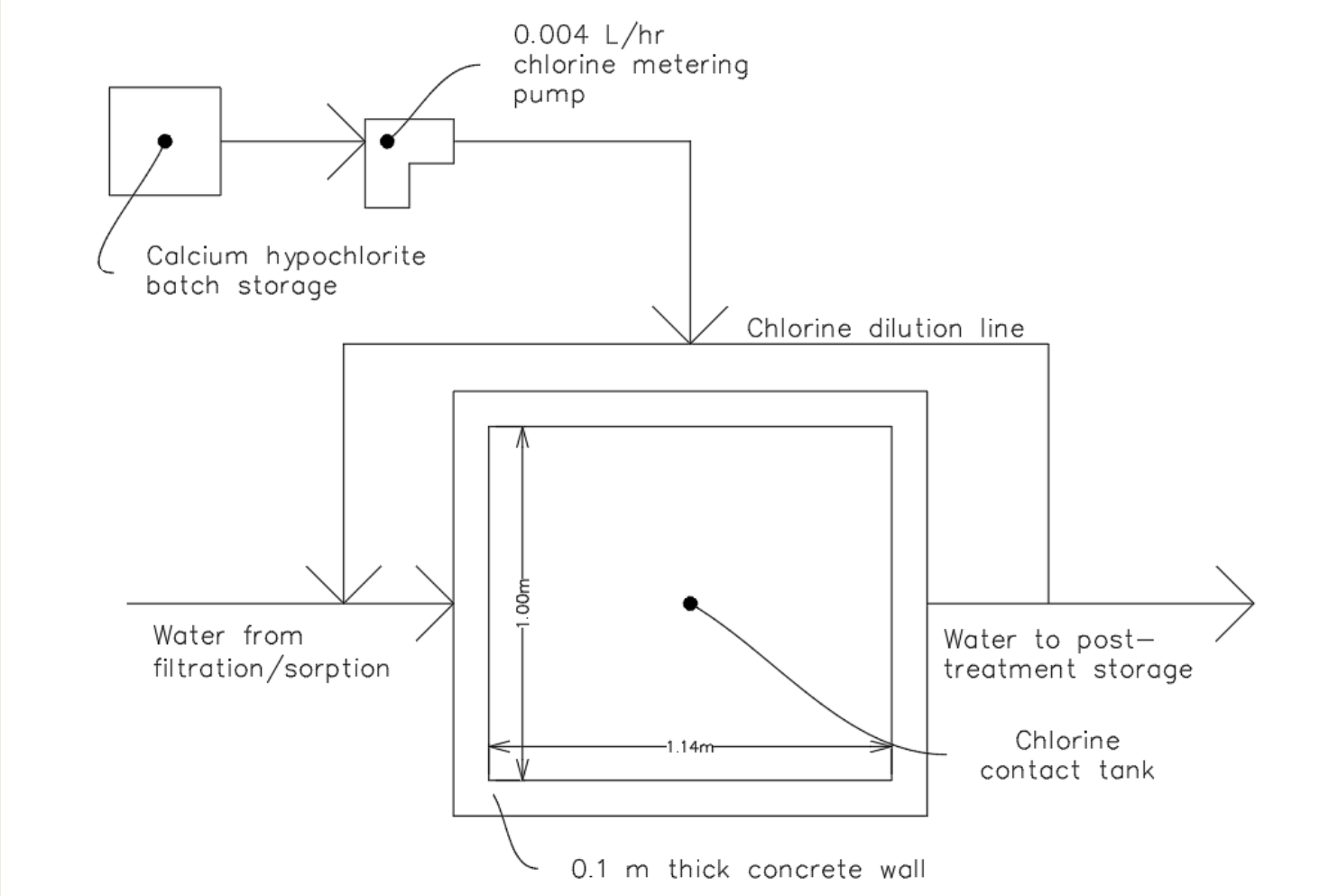
Collection efficiency of bacteria

$$N_{sb} := e^{\left[-1.5 \cdot (1-\varepsilon_s) \cdot \alpha \cdot \eta_{sb} \cdot \frac{L_{bs}}{d_{10}}\right]} = 6.958 \times 10^{-6}$$

Fraction of bacteria remaining in filtrate

$LR_b := -\log(N_{sb}) = 5.158$ Log removal of bacteria

Disinfection



Economic Feasibility

	No Treatment	Treatment
Construction Costs	($361,000.00)	($475,000.00)
Annual Costs	($12,000.00)	($26,000.00)
Annual Income	$30,000.00	$49,500.00
Annuity	$17,500.00	$24,000.00
Present Worth	($99,000)	($120,000)

Lessons Learned

- Communication
- Project Management
- Scope Definition

Photo courtesy of Project-Management.pm

Acknowledgements

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Questions

Photo courtesy of Bert de Vries