Centralized Wastewater Treatment Design: West Bank, Palestine

CAPSTONE EXPERIENCE 2012

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PROBLEM STATEMENT

The goals of our senior capstone project were two-fold:

1. Design a centralized wastewater treatment system for the village of Abwein in West Bank, Palestine
2. Provide educational materials on sanitary water practices in the West Bank

The design includes :

• Justifications for the chosen wetland type to remove pollutants from greywater for reuse in agriculture

•Recommendation for the location, sizing and hookups of a centralized wastewater treatment system

The educational materials to be presented to stakeholders include:

• Information on the benefits of wastewater treatment

•Suggestions for implementation of low-cost treatment units throughout the region

•Recommendations for effluent water use

Figure 1: Typical topography in Ramallah District, Palestine
Figure 2: Collection of raw domestic greywater for use in home gardens
Photos courtesy of Anne Dare, May 2011

Constraints fell under two categories:

1. Design Constraints:
   - •Initial building cost
   - •Simplicity of maintenance
   - •Availability of building materials
   - •Initial lack of water quality education in villages
2. External Constraints:
   - •Political Aspects
   - •Rationing of Treated Water
   - •Building of the Treatment System
   - •Ability to Contact Stakeholders

BACKGROUND

Project location:

Abwein, Ramallah District, West Bank, Palestine

•3,119 people, 574 households[1]

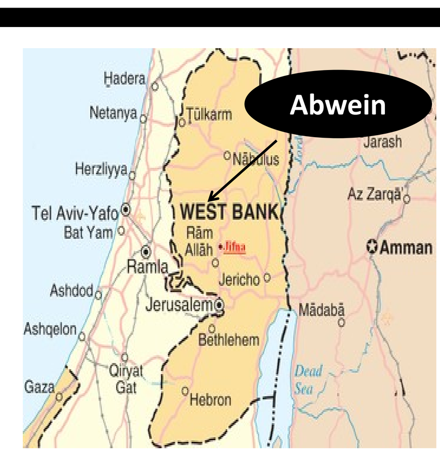


Figure 3: Abwein is located in the West Bank, 37 km north of Ramallah[8]

Literature review:

•Likely influent quality (Beit Doko, Palestine)[2]: 590 mg/l BOD, 1279 mg/l COD, 1396 mg/l TSS, 6.6 pH

•Required effluent quality[3]: 15-60 mg/L BOD, 200-700 mg/L COD, 50-250 mg/L TSS, 0.5 mg/L DO, 12 MPN/100mL FC, 2-12 NTUs turbidity, 30-45 mg/L total nitrogen, SAR 6, pH 6-9

•Estimated flow[4]: 0.5m³/home/day

•Settling tank retention time (treatment of domestic wastewater)[5]: 8 hours

•Wetland retention time (Ben-Gurion, Israel)[6]: 8 hours, recycling encouraged to reduce BOD load

Engineering concepts: The engineering concepts used in this design are listed in table 1

Table 1: Concepts Utilized

Flow definition[9]	$Q =$ [illegible] $/ t =$ [illegible] $/ t$
Darcy's law[10]	$Q =$ [illegible] $/ L$
Manning's equation[9]	$Q =$ [illegible] $/ n$ [illegible] $S_0^{1/2}$

ALTERNATIVE SOLUTIONS

Traditional wastewater treatment plants and constructed wetlands were explored as treatment options. WWTPs were rejected due to high initial and upkeep costs, land use, and building restrictions. The types of constructed wetlands investigated are shown below in table 2:

Table 2: Wetland Type Analysis[7]

	Pros	Cons
Free Surface	• Simplicity of Design • Extensive Design Information • Aesthetically Pleasing	• **Large Surface Area Requirements** • **High Evaporation Rates** • Plant/Animal/Insect Infestations
Sub-Surface	• Extensive Design Information • **Limits Evaporation**	• **Large Surface Area Requirements** • Anaerobic Conditions May Smell
Vertical Flow	• **Small Surface Area Requirements** • **Limits Evaporation** • **Ability to Remove High Concentrations**	• Uncommon Technology (in US) • Anaerobic Conditions May Smell

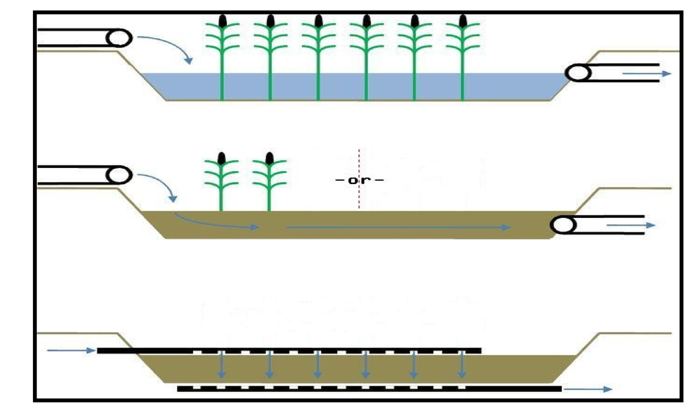


Figure 4: Three potential constructed wetland types (top to bottom): FSW, SSW, VFW.[8]

A vertical flow wetland was chosen because low space requirements, climate, and high influent pollutant concentrations were high priority design considerations.

The team originally considered designing an aerobic system (to retain nutrients for agricultural benefits), but changed to an anaerobic system due to lesser maintenance requirements and a nitrogen pollution problem in the area.

FINAL DI

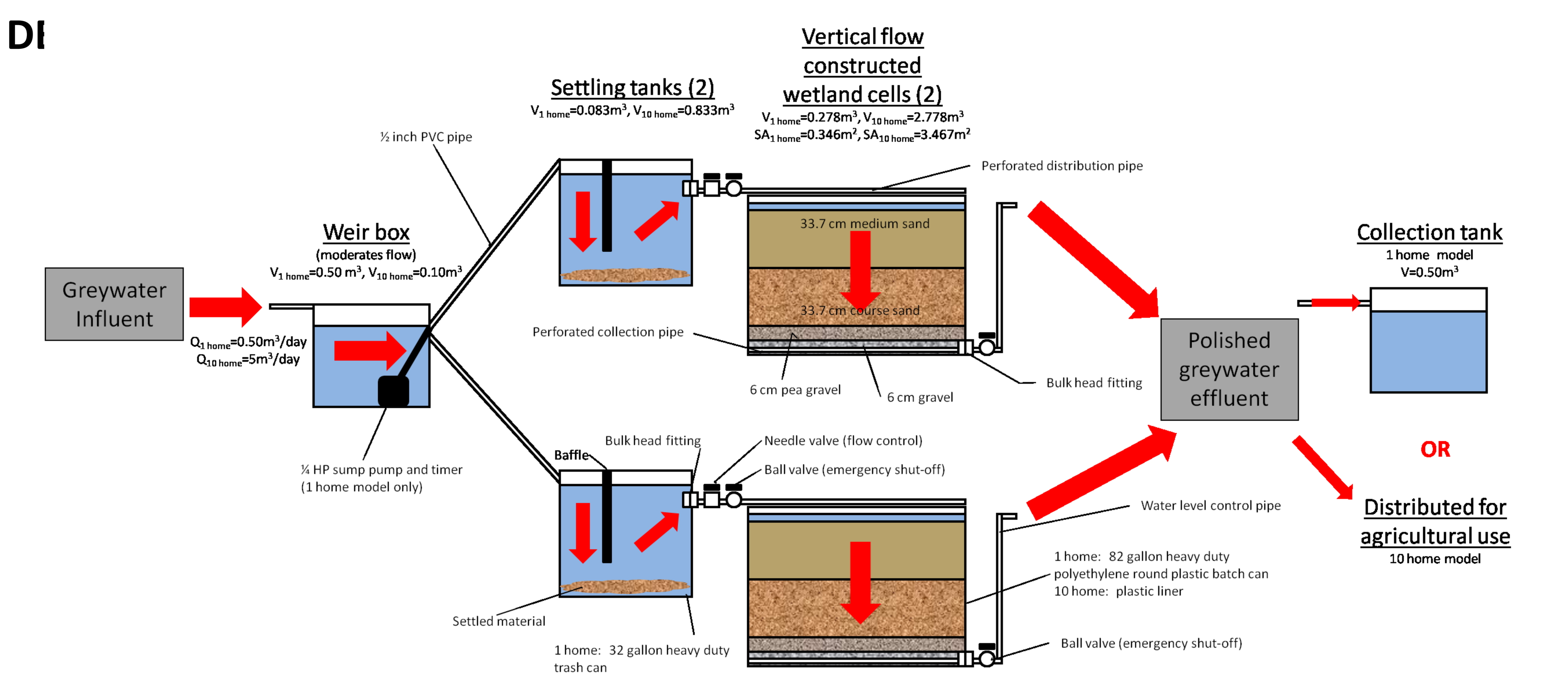
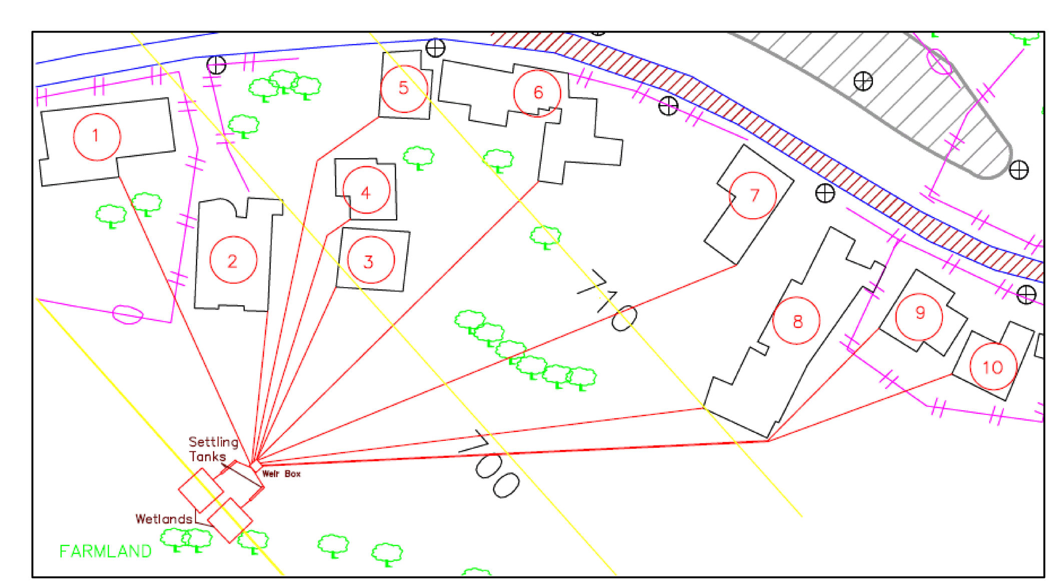


Figure 5, above: The final wetland design for 1 and 10 homes in Abwein, Palestine is shown in the schematic above. The 1 home model requires a pump at the weir box to ensure even flow. After, the weir box flow will be separated into two parallel branches. This allows for occasional system cleaning and repair.

Figure 6, right: A possible AutoCAD layout of a 10 home constructed wetland in Abwein is shown in figure 6. The influent greywater will be piped from each home to the wetland with ½ inch PVC pipe, polished, and piped down hill for agricultural use.



BUDGET/PROFITABILITY ANALYSIS

Table 3: Bench Scale Budget

Category	Item	Cost	Percent of Budget	Totals
Testing	Sand	$6.88	--	Total spent: $569.45 Total allotted: $800.00 Percent spent: 71%
	Gravel	$6.32	--	
	Total	$13.20	2%	
Wetland Media	Sand	$38.35	--	
	Gravel	$18.42	--	
	Total	$56.77	7%	
Wetland Infrastructure	PVC	110.08	--	
	Containers	289.69	--	
	Electrical	60.73	--	
	Other	38.99	--	
	Total	499.48	72%	

This budget does not include the costs for building a bench scale on site in the West Bank or the costs of building the 10 home pilot scale wetland. This is because the prices in West Lafayette, IN cannot be extrapolated to the West Bank directly. Costs and specifics on construction or materials will be obtained in-country.

While the a cost analysis is difficult to do, this design is an affordable step toward preventing cesspool drainage into groundwater systems, helping to mitigate potential costly cleanup.

PROJECT IMPACT

The potential impacts of this design in the West Bank are:

1. Simple and low cost wastewater disposal
   - •Prevention groundwater degradation
   - •Can replace current insufficient infrastructure
2. Increased availability of water, impacting quality of life
   - •Re-use of water in agriculture allows for redistribution of spring and municipal water

This design is only one step towards solving the water security problem in the West Bank. Possibilities for future work include:

•Testing of the bench scale model in Abwein

•Develop neighborhood and village constructed wetlands in Abwein

•Design wetlands for villages in the area surrounding Abwein

All research and groundwork conducted by this team is available to GEP to be developed further and potentially implemented in years to come.

The opportunity to work with international partners and the team's upcoming trip to the West Bank in May, have provided cultural learning experiences and valuable lessons in communication throughout the duration of the project.

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[10]Jury, W. A, Horton, R. 2004. Water movement in soil. *Soil Physics*, 6th ed, 78.

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- •Dr. Marwan Ghanem, Birzeit University Geography Department
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