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TETRA TECH

MEMORANDUM

To: [redacted]

Fr: [redacted]

Re: **WO-A-0003 Ghazi Boys High School Sanitation**

Dt: January 31, 2010 (Revised February 22, 2010)

Tetra Tech evaluated wastewater management options for the Ghazi Boy High School (GBHS) based on discussions with USAID, IRD, and the Infrastructure Department of the Ministry of Education (MOE), as well as, standard engineering practices. This analysis includes wastewater flows (both blackwater and greywater), treatment considerations, and disposal options.

Blocks 1 and 2 are currently under construction at GBHS. Each block consists of 72 classrooms and 3 bathrooms on each floor. The total population of the school is 12,000 students in three shifts which are scheduled from 8:00am to 5:00pm. Each shift is 2.5 hours long with 4,000 rotating students and 200 faculty utilizing the facilities. A separate administration building (block 3) is planned with the same operating hours. It is assumed that the modern dry latrine facilities will remain in place.

A. Wastewater Flows

After discussions with MOE regarding cultural norms, it was determined that the MOE design standard to use is 35 lpd (7.9 gpd) per student. Indian design standards are 45 lpd (11.9 gpd)/student and US design standards range between 20 and 40 lpd (5.3 and 10.6 gpd)/student depending on the type of school and its facilities (day school without cafeteria). Based on discussions with USAID, a comparison of these standards and cultural considerations, it is our opinion that 30 lpd/student is a reasonable assumed design standard.

Based on an assumed population of 4,000 per conversations with USAID, the total wastewater generation will be 120,000 lpd (31,700 gpd). Approximately, 50 percent (60,000 lpd) of the wastewater is estimated to be greywater from sinks and from ablution provisions.

Table 1: Wastewater Generation

Design Standard	Students and Faculty	Total Wastewater
30 lpd	4,000	120,000 lpd

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B. Treatment/Disposal Options

Tetra Tech would recommend that the GBHS separate the blackwater (wastewater from toilets) and greywater (sinks) from the bathrooms in Blocks 1 and 2. This would require redesign of the interior building plumbing to a double stacked system. In this scheme, the blackwater discharges to holding tanks and is pumped as necessary. The greywater discharges to a separate holding tank and is used for irrigation or discharged to open channels.

Greywater Management

Below is a list of recommendations for greywater management systems.

1. General
    a. The greywater systems should be designed to minimize human contact.
    b. A potable water connection to the greywater system should be discouraged.
    c. Individual greywater holding tanks are recommended for each building.
2. Building Sewers and Piping
    a. Greywater piping should be clearly marked "Non-Potable Water – Greywater"
    b. Valves should be accessible.
    c. There should be a bypass connection to the wastewater holding tank prior to the greywater tank in case the greywater tank needs to be taken offline for service or other reasons.
3. Greywater Holding Tank
    a. A sign stating "Non-Potable Water - Greywater Irrigation Tank" should be permanently marked on the tank.
    b. The tank should be covered to restrict access and to eliminate habitat such as mosquitoes or rodents and prevent odors.

c. The tank should be designed for no longer than an approximate residence time of 8 hours; this will also help minimize odors due to stagnant water.

d. An access hatch for inspection and cleaning should be provided.

e. The tank shall be properly vented.

f. The greywater tank should have an overflow drain to the wastewater holding tank. This will prevent contamination of the greywater irrigation system in the case of an accidental release of a harmful substance (e.g. bleach). It will also provide additional storage if necessary. The overflow drain should not be less than the size of the inlet pipe. The overflow system must drain by gravity into the wastewater holding tank. There should be a backflow preventer on the drain line to protect against possible wastewater backups into the greywater tank.

g. Table 2 shows recommended setbacks for the greywater tank. It is recommended that the tank be located on the downhill side of the building.

Table 2: Recommended Greywater Tank Setbacks

	Minimum Recommended Setback (m)
Building Structures	1.5
Property Line	1.5
Water Supply Wells	15
Wastewater Holding Tank	0
Water Main	3

4. Irrigation

a. Ponding or runoff of the greywater should be prevented.

b. A sub-surface low pressure drip irrigation system with vegetative cover is recommended. A gravity system could be used but is not preferred due to the existence of high ground water and suspected shallow soils. This will require a small pump that will need to be operated and maintained.

c. Recommended design criteria for the irrigation area are presented in Table 3.

Table 3: Recommended Irrigation Area Design Criteria

Soil Type	Min Irrigation/Adsorption Area (SM/l of greywater)	Max Adsorption Capacity (l/SM/24-h)
Clay with small amounts of sand or gravel	0.03	32.6

d. Sub-surface systems are not as effective as above-ground spray systems for turf areas but are effective for providing root zone irrigation of plant beds, shrubbery, and trees.

e. The system's area requirement is determined by the site's soil and slope characteristics. The soil must be investigated for permeability or plastics liners should be considered underneath the bed which prevents the greywater from seeping into the ground and water table. Some additional water from other sources will probably be needed on a seasonal basis.

f. Greywater irrigation systems typically cost more than conventional spray and drip irrigation systems due to the use of a holding tank used in greywater systems. A filter and special emitters are also needed for greywater drip irrigation systems.

g. Year-round outputs of greywater through sub-surface systems make greywater irrigation ideal for maintaining evergreen trees and shrubs. The irrigation benefits of greywater should be integrated with the landscape design. Seasonal constraints will need to be integrated into the design.

h. Areas to be irrigated should be identified with the assistance of a Landscape Architect skilled in sustainable design strategies. Bio-swales, constructed wetlands and rock/plant systems that assist with pre-filtering should be considered. A greywater irrigated vegetable garden could be a possibility for a sustainable student project that tracks the effectiveness of the greywater use and potentially generates profit from the sale of the produce or is donated to a charitable organization.

Greywater Application to GBHS

- To provide the recommended 8 hours of storage for the greywater, a total of 20 cubic meters (CM) of storage would need to be provided. Assuming individual tanks are used for the two blocks, two 10 CM tanks are recommended.

- Based on the irrigation capacity of 32.6 lpd/SM from Table 3, approximately 1,850 square meters (SM) (0.46 acres) of land could be irrigated, which is approximately 4% of the total site area.

Wastewater Treatment and Disposal

We evaluated the following Wastewater treatment/disposal options.

1. Holding tank and pumping offsite

2. Treatment and onsite disposal

3. Treatment and offsite disposal

Holding Tank and Pumping Offsite. Recommendations for the wastewater holding tank are presented below.

1. Individual Wastewater holding tanks are recommended for each building.

2. Vehicular access needs to be provided to each tank for the pump trunk

3. Items 3 (b), (d), and (e) from above apply to the wastewater holding tank as well.

4. The tank should be designed to provide at least 7 days storage.

5. The liquid level of the tank should be inspected daily to ensure timely pumping of the tank and prevent wastewater backups into the building.

6. Table 4 shows recommended setbacks for the wastewater tank. It is recommended that the tank be located on the downhill side of the building.

Table 4: Recommended Wastewater Tank Setbacks

	Minimum Recommended Setback (m)
Building Structures	3
Property Line	3
Water Supply Wells	15
Greywater Holding Tank	0
Water Main	3

Application to GBHS

- To provide the recommended 7 days storage for the wastewater, a total of 420 CM of storage would need to be provided. Assuming individual tanks are used for the two blocks, two 210 CM tanks would be required.

  Wastewater holding tanks of this capacity are not viable. During hot summer days, the tank would likely become septic resulting in odor issues. Also, it would be physically impossible to pump that volume of wastewater. Based on research with three local vendors, we found that all had both 8,000 and 10,000 liter trucks (larger trucks are available from limited vendors). Assuming only one day holding time of 60 CM and a pump truck capacity of 8,000 liters (8 CM) 8 trucks a day would be required (10,000 liters – 10 CM = 6 trucks). At a current cost of $32 USD per pump out (provided by the local vendors) this would equate to $256 USD per day or $93,400 annually.

Treatment and Onsite Disposal. Treatment and onsite disposal into an open sand bed or leach field was also considered. However, this was not considered a practical option either due to the large land area requirements for the disposal and the shallow groundwater table. Reports indicate the groundwater is within 2 meters of the ground surface during the summer months. It is standard practice to have about 1.5 meters of separation between the bottom of the leach field and the seasonal high groundwater elevation. Assuming low permeability soils and a loading rate of 8.15 lpd/SM, we estimate that approximately 7,400 SM (0.74 Ha, 1.8 acres) would be required for wastewater disposal using this method. Additional land would be required for treatment prior to discharge into the leach field.

Treatment and Offsite Disposal. Onsite treatment with discharge to an open ditch like the one on the east side of the site is the recommended option (the existing ditch discharge point does needs confirmation). The objective would be to provide an adequate level of treatment so that the discharged wastewater would not have an adverse impact on the receiving water quality, but minimize the power and operation and maintenance requirements. To that end, we evaluated several potential technologies.

Lagoons are relatively simple treatment processes that have been implemented in many countries/regions with similar environments to Kabul. Lagoons are large basins filled with wastewater undergoing some combination of physical, chemical, and/or biological treatment processes that render the wastewater more acceptable for discharge to the environment. It is one of the most prevalent natural wastewater treatment processes. Lagoon treatment can be classified based on lagoon depth and biological reactions that occurred in the lagoon. Different types of lagoons include aerobic lagoon, facultative lagoon, aerated lagoon and anaerobic lagoon.

Facultative lagoon treatment is the most prevalent lagoon. It requires the largest area since aeration occurs naturally and no surface aeration is needed. Aerated lagoons have the smallest space requirements for lagoon treatment. Table 5 summarizes design parameters for facultative lagoon and aerated lagoons.

Table 5. Summary of Lagoon Treatment Design Parameters

Parameter	Facultative Lagoon	Aerated Lagoon
HRT (days)	30-180	3 (max)
Power (kW/10^6 L)	0	5.8 kW
Depth (m)	1-2.5	3
Min # cells	3	2
BOD loading (kg/ha-d)	20-60	200-600

Facultative lagoons are large in size, perform best when segmented into at least three cells, obtain necessary oxygen for treatment by surface reaeration from the atmosphere, combine sedimentation of particulates with biological degradation, and produce large quantities of algae. Considering the substantially long cold weather period in Kabul, a hydraulic residence time (HRT) of 120 days is recommended. Preliminary calculations indicate that a 6,000 SM (0.60 Ha) (1.48 acre) 1.20 m deep pond would be required for GBHS. This would require the majority of the playing field area to be used for wastewater treatment. In order to preserve that space for recreation, an aerated lagoon could be used. This would reduce the wastewater treatment footprint to about 600 SM (0.06 Ha) (0.15 acre) or roughly 10 percent of the facultative lagoon footprint.

The footprint could be further reduced by using a more complex treatment process such as a trickling filter or aerated sludge process. A pre-packaged treatment plant that accommodates campus facility expansion should be considered. These would also provide a higher level of treatment with increased operations and maintenance.

C. Conclusions

1. The total wastewater generation is estimated at 120,000 lpd based on a 24-hour average. 4,000 students and 200 faculty will utilize the facilities for an 8 hour day in three 2.5 hour shifts.

2. Tetra Tech recommends separation of the greywater from sewage to reduce costs and volume of wastewater requiring treatment. The greywater could be used onsite for irrigation or discharged to bioswales or constructed wetlands prior to release to existing ditches. Direct discharge is not recommended. The irrigation demand and feasibility of installing an irrigation system should be discussed and evaluated further with a landscape architect.

3. Holding tanks and pumping the wastewater offsite is not a viable option because of the volume of wastewater (120,000 lpd).

4. Onsite disposal of the wastewater is not a viable option because of the high groundwater elevation and area requirements.

5. Treatment with discharge to an open channel such as the ditch on the east of the site is a recommended option (the ditch discharge tributary needs confirmation). Due to land area requirements, an aerated lagoon appears to be a feasible option for the proposed use. It is relatively low maintenance and has relatively low costs when compared to other treatment technologies. More complex treatment options could be explored to further reduce the footprint, allow for campus expansion, and improve the effluent water quality however; operations and maintenance costs should be considered as part of this exploration.