WASH
WATER AND SANITATION FOR HEALTH PROJECT

COORDINATION AND
INFORMATION CENTER

Operated by CDM FIVE
for the U.S. Agency
for International Development

1611 N. Kent Street, Room 1002
Arlington, Virginia 22209 USA

Telephone: (703) 243-8200
Telex No. WUI 64552
Cable Address WASHAID

CDM FIVE is operated by Camp Dresser and McKee Incorporated. Principal Collaborators: Center for Educational Development in Health, Boston University; International Science and Technology Institute; Research Triangle Institute; University of North Carolina at Chapel Hill

LEBANON

TECHNICAL RECOMMENDATIONS FOR WASTEWATER TREATMENT DEMONSTRATION (PILOT) PLANTS FOR LEBANON

MARCH 1981

US/AID, HEA, OTD NO. 20

Contract No. AID/DSPE-C-0080

Project No. 931-1176

WATER AND SANITATION
FOR HEALTH PROJECT

WASH

COORDINATION AND
INFORMATION CENTER

Operated by CDM FIVI
for the U.S. Agency
for International Development

1611 N. Kent Street, Room 1002
Arlington, Virginia 22209 USA

Telephone: (703) 243-8200
Telex No. WUI 64552
Cable Address WASHAID

March 25, 1981 File: P3-10-OTD 20

Mr. W. Ernest Popp
Agency for International Development
Beirut, Lebanon

Dear Mr. Popp,

I take pleasure in forwarding to you herewith, for the WASH Project, thirteen copies of a report prepared by A.A. Kalinske on rural wastewater treatment demonstration plants in Lebanon. This study was performed in response to the Lebanon Mission's request on January 6, 1981 via State Department Cable Beirut 0062. The WASH Project was authorized to perform this study by the Office of Health in the Development Support Bureau in AID through Order of Technical Direction No. 20, dated January 16, 1981. The report is based on the work of Mr. Kalinske in Lebanon from February 1st to February 12th, 1981.

If there are any questions about this report we will be happy to try to answer them.

Yours sincerely,

Peter J. Kolsky

Peter J. Kolsky
for the WASH Project

PJK/RS

TECHNICAL RECOMMENDATIONS
FOR
WASTEWATER TREATMENT DEMONSTRATION (PILOT) PLANTS FOR LEBANON

A. A. Kalinske
(Camp Dresser & McKee Inc.)

March, 1981

An Environmental Sanitation Project has been undertaken jointly by the Lebanese government's Council for Development and Reconstruction (CDR), the Lebanese Ministry of Health (MOH) and the American University of Beirut (AUB) with financial assistance from U.S. AID for building two (2) wastewater treatment plants for small villages (1000-5000 population) in the vicinity of Beirut. These treatment plants would be used for refining design criteria for Lebanon conditions, developing operational procedures, providing testing facilities for AUB students, and instructing plant operation personnel from other villages where similar facilities would be built in the future. They would serve as models of treatment plants for other small villages and towns in Lebanon.

The treatment plants are to be designed so as to produce high-quality secondary effluent (30/30 BOD and suspended solids), be simple to operate and maintain, have a minimum of mechanical equipment, and be near Beirut.

1. Existing Wastewater Treatment Plants in Lebanon

Based on the information in a report of the National Waste Management Plan entitled "Existing Conditions: Wastewater and Drainage," prepared by Camp Dresser & McKee, Inc. for the WHO Development Porgram for Lebanon (Dec. 1980), there are at present no municipal wastewater treatment plants in operation in Lebanon.

There was an Imhoff tank-Trickling filter plant at the town of Hammana (25 km. east of Beirut) and a plant of unknown design for the town of Marjiyoun in south Lebanon. Both plants were damaged during the civil war and are inoperative.

The AUB has a stabilzation pond which serves the Agricultural Experiment Station in the Bekaa Plain near Zahle. It has operated satisfactorily but has very light loading. The Regie Tobacco Factory in Hadath (suburb of Beirut) has an Imhoff-tank-Trickling filter (TF) plant which has not operated since the civil war. Inspection of the facilities indicated they were in good condition. Some tests made several years ago by an AUB student for his master's thesis showed the average effluent BOD to be about 90 mg/l. The wastewater is primarily of domestic origin. Such an effluent is normal for Imhoff-tank-TF plants, unless TF loading is very low.

The only wastewater treatment plant, (other than the AUB pond at the Agricultural Station), presently in operation in Lebanon is that at the College of the Brothers of Mont de LaSalle, a Catholic high school in eastern suburbs of Beirut. The school has a day-time student population of 4,000 and a permanent staff living on the campus of 150. The treatment plant is a compact, concrete structure having an annular aeration channel with a central, hopper-bottomed clarifier. It is of the extended aeration, activated sludge type. It was designed and built by Passavant Werke of Germany and has mechanical surface aerators. No data are taken and the plant is only operated duirng the summer when a good effluent is need for irrigation of the school grounds. At present the sewage flows through the plant and receives only primary treatment, and discharges to a ditch down the hillside.

2. Prosposed Plant Sites

The steering committee set up for this project, with representatives from AUB and MOH, selected the towns of Rabieh and Keifoun as meeting the criteria for this Project. The town governments have indicated a willingness to cooperate on this Project by supplying the plant site an operating technician and paying the operating costs. Rabieh is about 10 km north of Beirut and Keifound is 20 km SE of Beirut. Nearness to Beirut and easy access for AUB personnel was one of the criteria for selection of these towns. The pertinent criteria for plant sizing are:

	Rabieh	Keifoun
Present population	1250	5000
Average Wastewater Flow	$125m^3$/day	$300m^3$/day
BOD (5 day)	145mg/1	400mg/1
Suspended solids	465mg/1	610mg/1

Both towns are in a mountainous area of 600-800m above sea level. The wastewater strengths shown were obtained from grab samples and therefore the values must be used with caution for design of treatment plants. Further sampling will be needed before the final design. Visual inspections of the wastewater discharge confirmed that a relatively weak sewage reached the proposed treatment plant site at Rabieh. Both wastewaters are entirely of domestic origin and are well-aerated due to the steep slopes of the sewers.

The site selected for the Rabieh treatment plant is in a ravine having a spring-fed creek into which the wastewater discharges. This site formerly had an Imhoff tank and sand-drying beds for the sludge, which have not been used for some 15 years and do not appear to be salvageable. The flat area in the ravine is presently used as a solid wastes dump which would have to be abandoned if a WWTP is built since the area is not large enough for both facilities. The site is surrounded by steep, wooded slopes at the top of which are a school and apartment buildings.

The Keifound site is also in a ravine, but the hill sides are devoid of vegetation and extremely rocky. There is a small creek which now carries the Keifoun wastewater and storm drainage. There is dumping of solid wastes at present along the creek banks. The flat area is underlain with large broken rocks and probably some solid rock. The surrounding hill sides are potential residential sites, and the land is very expensive. The town would have to purchase the land area for the treatment plant.

3. <u>Potential Treatment Systems</u>

To meet the treatment requirements and have simplicity of design and operation, with minimal mechanical equipment, the two treatment systems that should be considered are aerated facultative lagoons and the extended aeration activated sludge process. Stabilization ponds without artificial aeration require too much land area for either of the sites: about 100 times that of aerated lagoons. Such stabilation ponds appear to possibly have application in Lebanon in the Bekaa Plain, but flat land is expensive and valuable for agricultural use.

A trickling filter (TF), following primary settling or an Imhoff tank (Clarigester), could be used and after final clarification the required effluent quality could be produced if the loading on the TF was low, about 0.20 kg BOD/m^3/day. Such a system would have a high capital cost and is somewhat complicated, having two clarifier basins. However, it is relatively easy to operate and has lower power consumption than either the aerated lagoon or extended aeration systems.

It is, therefore, recommended that the treatment systems to be considered for this project are the extended aeration activated sludge process and the aerated facultative lagoon. Also, one of these systems would be suitable for the majority of towns and villages in Lebanon having populations below about 10,000. In a few cases, where inexpensive land is available and especially for the smaller communities, the unaerated stabilization pond would be the most suitable system. Such systems should have 2-3 ponds in series with a total detention time of 40-60 days. The depth should be 1-2m. The BOD loading should be 25-50 kg/ha/day, the lower loading used for locations where temperatures approach freezing.

The choice between the extended aeration or aerated lagoon systems will depend primarily on the availability of suitable land area and the total costs at a specific site. In general, the total costs of the two systems wil be about the same. However, the land area required for the extended aeration system is only 1/8-1/10 of that needed for an aerated lagoon system.

The principal advantages that the aerated lagoon system has over the extended aeration system are:

1. Less opeerator attention; there is very little that an operator must do except to maintain the aeration equipment.

2. Requires no attention to or adjustment of sludge recirculation or sludge wasting.

3. Somewhat less total power consumption, perhaps about 1/3 less.

4. No separate sludge storage facilities needed or periodic sludge wasting, dewatering and drying on sand beds. In the lagoon system the solids are stored and digested (anaerobically) in the bottom of the lagoon and removed every 5-10 years. Of course, if the stable sludge can be disposed of as a slurry on the land no dewatering or drying is needed.

Incidentily, both systems produce a stable sludge which requires no furter processing before it can be beneficially used on agricultural land or disposed of with the other soild wastes.

4. Selection of Treatment Systems for the Two Sites

It is recommended that these demonstration plants be sized to handle the wastewater generated by the present populations of Rabieh and Keifoun. The design of the plants should be modular in concept so that additions can be readily made for further population growth.

KEIFOUN SITE

The recommended preferred treatment system is the aerated lagoon; however, the restricted flat land area that is available, the high cost of this land , and the rock-laden ground foundation may make the use of this system infeasible. Therefore, general sizing criteria will be given for both systems.

The aerated lagoon system should consist of three ponds in series with 5 days retention in each. Since air tempartures get down to $0^{o}C$ at times and wastewater temperatures will be down to $8^{o}-10^{o}C$ it is necessary to have 15 days retention in order to produce a 30/30 quality effluent for the raw wastewater strength given.

The dimensions of each pond will be 17m wide by 36m long and the water depth should be 2.5m. The ponds can be at different elevations if needed. The outlet from each pond should be properly baffled in order to control the escape of any settled solids and floating algae. The outlet from the last pond should have a double baffle system which isolates the outlet and provides a quiescent area for settling out of bacterial solids and retains any algae.

The pond sides have about a 45^{o} slope and the inside surface of the pond should have an impervious material such as asphalt, concrete, or plastic lining or perhaps an impervious clay could be used.

The aeration of the ponds can be done with mechanical surface aerators mounted centrally in each pond on a floating platform or by use of compressed air and diffusers laid on the pond bottom. The preferred type of diffusers are the non-clog, static tube type, (made by kenics of USA). The oxygen to be supplied should be equal to about 1.5 kg/kg of applied BOD. More oxygen is req .red in the first two ponds than in the last one. This can be done by use of 5 HP mechanical aerators in the first two ponds and a 3 HP aerator in the last pond. The floating aerators cannot be used if prolonged freezing temperature occur, thus causing icing on the floating aerator supports.

If compressed air and diffussers are used the total air supply available should be about 15 scfm (standard cubic feet per min.), (or 4.25 scmm), at 6 psi pressure. The air and diffusers should be distributed so that the air supplied to the first, second and third ponds is 45%, 35%, and 20%, respectively. This air can be supplied by two 5 HP blowers, with only one used at night during the low flow period. A standby blower is desirable.

For the extended aeration system the following are required: two rectangular aeration basins with a common wal each being 4.5m wide, 12m long, and 3m deep. There should be a continuation of the aeration basin structure for another 4.5m, after a dividing wall, which would form a 4.5m square clarification compartment with a hopper bottom below the 3m depth. The side slopes of the hopper should be at least 55^{o}. A manually operated arrangement for skimming the clarifier compartment water surface area is needed. An overlow effluent launder would be located around the clarifier area.

There would be provision for recirculating the settled sludge at a rate up to 200% of the average inflow from the bottom of the hopper to the head end of the aeration basin by use of a variable-speed, non-clog centrifugal or a positive displacement pump or an air-lift pump. One pump would be needed for each aeration basin-clarifier module. It would be easier to vary and control this recirculation with a mechanical pump. A portion of the settled sludge would b periodically wasted to an aerated sludge storage tank from which the sludge would be hauled away as a liquid, or dewatered and dried on sand beds for eventual disposal. The sludge holding tank should have capacity for one week's sludge production, about $60m^3$.

All structures would be of reinforced concrete.

The aeration would be done by use of efficient, non-clog diffusers (Sanitare type as made in USA). The oxygen requirement is 2 kg/kg of applied BOD. This will require a blower capacity of 200 scfm (5.67 scmm) at 6 psi pressure. This can be supplied by two 7.5 HP blowers. A portion of the air can be used for aerating the sludge storage tank and for air-lift pumps if used. During night low-flow periods only one blower need be operated. This could be done by use of a timer control.

If the effluent should be chlorinated, a one-hour chlorine contact basin should be provided. A hypocrite feed system would be used.

RABIEH SITE

If it is found that the extended aeration system must be installed at Keifoun due to site constraints, or other reasons, then it is recommended that an aerated lagoon system be selected for the Rabieh site. This will provide two different facilities for making observations and tests relating to operation and performance. Both types of treatment plants have application for treating the wastewaters of the smaller communities in Lebanon.

Since the Rabieh sewage is relatively weak and since temperatures are milder than at Keifoun, an aerated lagoon having 10 days detention time will provide the effluent quality desired, (30/30 BOD and SS). For the flow of 125m^3/day, two 5-day ponds in series should be used. Each pond would be 2.5m deep, 10m wide and 25m long. The general design of the ponds would be as was indicated for the Keifoun site. The Rabieh site that was selected is restricted in flat land area but by removing some of the dumped solid wastes, or relocating them on the site, sufficient area for the ponds should be available. The dumping of solid wastes at this site would, of course, have to stop.

The required oxygen for the ponds would be supplied by float-mounted mechanical aerators: a 2 HP unit in the first pond and a 1-1/2 HP unit in the second pond. These aerators would be sufficient to provide enough oxygen even if the sewage is 50% stronger than the average BOD given based on grab samples.

If compressed air and diffusers are used, as described for the Keifoun ponds, two 1 HP blowers would supply sufficeint air, (35 scfm, or 1.0 scmm, at 6 psi pressure). The air should be disbtributed in the ratio of 65% in the first pond and 35% in the second pond.

For an extended aeration plant it is recommended that one aeration-clarifier module be used. The aeration basin should be 3m deep, 4.5m wide and 10m long. The clarifier at the end of the aeration basin would be 4.5m square and have a hopper bottom below the 3m depth. The unit would be equipped for skimming and sludge recycle as was described for the Keifoun plant. The aeration oxygen would be supplied by two 1-1/2 HP blowers, with one used during night low-flow periods. Their total capacity would be 50 scfm (1.4 scmm) at 6 psi pressure.

There would be installed an aerated sludge holding tank to hold two week's sludge production, about 45m^3. The sludge would be dewatered and dried on sand beds.

The plant capacity can be readily increased by adding on another similar aeration-clarifier module next to the first unit.

5. Estimated Costs of Treatment Plant

Without a more detailed design of the treatment plants, that have been sized as previously indicated, it is very difficult to make any accurate cost estimates. Neglecting land costs, some estimates can be made for the extended aeration plants based on the costs of reinforced concrete, excavation and grading, blowers, diffusers, sludge pumps, electrical wiring and piping. Though the plant need not be housed, some small building is necessary for providing the operator-technician with some work space, for the housing flowers, and a secure storage space for spare parts, tools and maintenance supplies.

For the Keifoun extended aeration plant, the reinforced concrete structures, including sludge storage tank, will require about 150m^3 of concrete. At $250 per m^3 this cost is $37,500. Excavation and grading is estimated at $30,000. The blowers, diffusers, sludge pumps, electrical wiring, piping, etc. is estimated at $25,000. The building may cost about $30,000. These add up to about $125,000. To be conservative, let's say $150,000. The sludge drying beds might cost $25,000. It thus appears that an extended aeration plant of the design indicated could be built for $175,000$200,000.

The land area required for the extended aeration plant, including the sludge drying beds, will be about 500m^2.

The cost of an aerated lagoon at Keifoun will depend largely on the cost of excavation and grading because of the large area needed for the ponds. These ponds will require, including the earthen banks around the ponds, an area of 3000m2. To this should be added about 200m2 for a building and access area.

The cost of the land plus excavation and grading for the ponds and plus pond lining and aeration equipment will undoubtedly add up to equal the cost indicated for the extended aeration plant, and may be greater.

For the Rabieh site extended aeration plant, based on the general design indicated, the total reinforced concrete required (including that for a sludge storage tank) will be about 60m^3. At $250 per m^3 this amounts to $15,000. Using properly adjusted other cost figures as given for the Keifoun extended aeration plant, a total constructed cost of about $100,000 is obtained.

On the basis of above estimated costs (plus or minus 25%) the extended aeration plants for Keifoun and Rabieh should cost about $200,000 and $100,000, respectively.

The aerated lagoon system for Rabieh as designed should not cost any more than the above indicated estimate for the extended aeration plant. It is understood that the town owns the land for the plant site, and thus its land cost need not be considered.

The above cost figures should be realistic and have been checked against actual U.S. costs for treatment plants of the sizes being considered. Reinforced concrete construction and labor costs in Lebanon are somewhat comparable to those in the U.S.A. Costs associated with shipping mechanical equipment, such as blowers, diffusers, pumps and motors from the U.S.A. have been included. The indicated costs are considerably below the estimated prices quoted for so-called "package" treatment plants in two tenders obtained by the Steering Committee for this project from commercial firms. This may be due to inclusion in the tenders of costs for such items as secruity, insurance, and other items that must be added for construction work in Lebanon. Also, the plant designs indicated herein involve relatively simple concrete structures with a minimum of mechanical equipment, which is not true for the pre-designed, standard package plants.