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# Experiences and lessons from the operation of Monrovia sewerage system

## INTRODUCTION

Monrovia,the capital city of Liberia was one of the first cities in West Africa to have a central water borne sewerage system.The system was first constructed in 1952,and was expanded in 1969;major rehabilitation works were carried out in 1983.

In recent years, the system has suffered from a number of problems resulting from operational and maintenance lapses over the years,as well as problems due to unfavourable sewer routing in the original designs. Social and economic factors have also had some influence on the operations of the system.

The purpose of this paper is to highlight some of the problems that have plagued the Monrovia system; their causes, the steps that have been taken to solve them, and the lessons to be learnt from them. Some experiences with management of the system are also mentioned.

## HISTORY OF THE MONROVIA SEWERAGE SYSTEM

The city has a "separate"sewerage system with one network of sewers for the evacuation of sanitary sewage, and another for the evacuation of storm runoff. The Liberia Water and Sewer Corporation has responsibility for the sanitary system whilst the Ministry of Public Works has responsibility for the storm drainage system.

The sanitary sewerage system has developed in three distinct stages.The first system constructed in 1952 consisted of approximately 15 km of sewers ranging from 200mm to 600mm in diameter,and served Central Monrovia only. Sewage collected was discharged without treatment on a beach to the south of the city.

In 1969,the system was extended to serve the suburbs of Sinkor and Bush rod Island. 30km of new sewers with diameters up to 1,500mm were laid, and four lift stations were constructed; a biological treatment plant was also constructed.

In 1983, a rehabilitation project was carried out. This involved the laying of 4 km of new sewers to replace some of the sewers laid in 1952 and the replacement or refurbishment of nearly all mechanical and electrical equipment in the system.

At present the system serves about 80,000 persons representing about 25% of the city's population.

## PROBLEMS IN THE COLLECTION SYSTEM AND THEIR CAUSES

The rehabilitation project of 1983 was undertaken mainly because of very serious problems experienced in the collection system in the period from 1978 to 1980. Among the major problems were the following:-

(i) Permanent or frequent blockage of certain stretches of sewer

(ii) Frequent overflow of sewage through emergency by-passes, leading to the discharge of large quantities of raw sewage into drains and the Mesurado River which runs through the city.

(iii) Massive siltation in almost all sewers, leading to loss of carrying capacity estimated at about 20% of the total(ref.1)

(iv) Structural collapse of certain stretches of sewer.

(v) Presence of large quantities of oil in the sewers and lift station wet wells.

(vi) Frequent breakdown of pumping units in the lift stations, and frequent stoppage of pumps due to the choking of passage ways by rags, bags, etc.

Detailed investigations were carried out in 1981 by the personnel of Liberia Water and Sewer Corporation and also by a team of consulting engineers who were engaged to prepare the rehabilitation programme. From these investigations the underlying causes of the problems were identified as follows:-

(i) Chronic lack of maintenance action for the removal of grit and sand from sewers: The maintenance crews had never been equipped with tools for sand removal and therefore sand had continued to accumulate in the sewers throughout the 30 years history of the system.

(ii) Inadequate operations at the lift stations: These were operating effectively for only 8 hours a day instead of operating around the clock as designed and since the sewers had only limited storage capacity, there was frequent spillage through the emergency overflows

(iii) Buildings constructed over sewers: Many of the sewers laid in 1952 had been laid through easements behind private properties and not in the streets. Because of very loose implementation of building control regulations it had been possible for developers to build on the sewers leading to structural collapse in several instances.

(iv) Abuse of the system by individuals: Some manholes in the system had concrete covers that could easily be opened and individuals had taken advantage of this to use the manholes as refuse dumps where rags, bags, sticks, etc were disposed of; these choked sewers and choked pumps if they got to the lift stations.

(v) Unauthorized discharge of oil into sewers: It was found out that used oil was being discharged into the sewers from the workshop of the local electricity company, and from a private garage. This oil was fouling up the sewers and accumulating in the lift station wet wells.

(vi) Inadequate maintenance of mechanical and electrical equipment: Due to chronic unavailability of spare parts and due also to limited budgets for maintenance, pumps, motors, and switchgear at the lift stations were all in a poor state of repair and were functioning inefficiently.

To remedy these problems, the following measures were included in the rehabilitation project:-

(i) A sewer-cleaning truck with equipment for water-jetting and vacuum-suction was purchased to be used to implement a programme for removing sand and grit from the sewer network. A team of operators was also trained to use the equipment.

(ii) The stretches of sewer most seriously affected by having buildings erected on them were taken out of service and replaced with new mains laid in the streets.

(iii) Lift station pumps and equipment in poor mechanical condition were replaced or refurbished. In particular, all 6 dry-installed vertical-spindle lift pumps in 3 stations were replaced with submersible pumps. Automatic controls were restored at all stations to permit round-the-clock operations, as the stations are not usually manned after the regular day-time working hours.

(iv) Bar-screens at the lift stations were improved to reduce the quantity of gross suspended material reaching pump passage ways.

As at the time of writing, the sewer-cleaning programme is still in progress. It is expected that when it is completed, the performance of the collection system will be greatly improved.

Figure 1. Raw sewage spilling from a manhole forms a rivulet running to an open drain in the Sonnewein sector of Monrovia. The manhole is on a sewer permanently blocked by sand and grit.

Figure 2. A house has been construc ted directly on top of this concrete sewer pipe in the Sonnewein sector of Monrovia.

PERFORMANCE OF THE SEWAGE TREATMENT PLANT

The plant which has a hydraulic capacity of 20,000 $m^3$/day was designed to treat 2,300kg of BOD per day;however actual load at present is estimated to be only 1,400kg BOD per day. This is mainly because there have not been any major extensions to the collection system since 1969 and therefore many newly-developed areas of the city which could have been connected to the sewerage system are still not connected.

The treatment process consists of bar screening, comminution, grit removal, primary sedimentation, biological treatment on trickling filters, and secondary sedimentation.Treated water is discharged to a nearby tidal creek,and settled sludge is treated in a two-stage anaerobic digester. Treated sludge is dried on a sand bed or discharged into a lagoon.

The study carried out in 1981 in preparation for the rehabilitation project showed that all the treatment units were functioning well with the exception of the trickling filters which were found to be achieving only a 33% removal of incoming BOD, instead of about 88% that was to be expected (ref. 1).

The possible causes of the poor performance of the filters were identified as follows:-

(i) Poor air supply:The filter walls are completely below ground level and there are no peripheral openings;air is supplied to the filter bed through 150mm-diameter vertical pipe vents open to the atmosphere and connected to an air passage below the filter bed at underdrain level. There were 8 such vent pipes for each filter 47.25m in diameter and 2.2m deep; these were suspected to be inadequate.

(ii) Inhibition of biological activity by oil in the sewage:Oil reaching the plant as the result of the illegal discharges mentioned earlier,had caused a thin film to form on the filter stones, and this was suspected to be affecting biological activity adversely.

Remedial measures undertaken as part of the rehabilitation project were:-

(i) The 8 existing vent pipes were replaced with sixteen 300mm diameter pipes in order to increase the air supply.

(ii) An oil trap was constructed beween the bar screen and comminu tor to help limit the amount of oil reaching the filters.

The filters have not yet been put back into full operation and therefore it is not possible yet to assess the effects of these improvements

## MANAGEMENT AND PUBLIC RELATIONS

Operation and maintenance of the sewerage system are carried out by a division with about 70 employees headed by a Sanitary Engineer.

Operational expenditures exceed revenue generated, and sewerage operations are in effect subsidized by the water supply operations.

Charges for sewerage services are calculated at 60% of the water bill for any account liable to pay for such services. Premises located within 30m of a public sewer are billed for sewerage services, whether or not they are connected to the system.

The public attitude to the sewerage system is mixed; house owners within the mandatory billing range connect to the system readily enough, but those outside the range often prefer to use septic tanks if it is possible for them to do so. The willingness to pay for sewerage services is not very high in the community and vigorous steps including the disconnection of services are usually necessary before customers pay their bills.

## CONCLUSION

The experiences gained from the operations of the Monrovia System give more "warnings" than "examples". The experiences have shown clearly that a sewerage system needs very careful operation and maintenance in order to operate satisfactorily from year to year. Inadequate maintenance and improper operations can result in serious problems developing in the system, causing it to perform very poorly.

It is the hope of the author that the experiences recorded here will be of benefit to engineers and policy makers planning the construction of new works, as well as those responsible for the operation and maintenance of existing works.

## REFERENCE

1. PWL Consulting Engineers. Monrovia Sewerage Project-Top Priority Measures (a feasibility report), Monrovia 1981.