



## LOCAL INFLUENCES AND THEIR EFFECT ON THE CONCEPT AND DESIGN OF SANITATION PROJECTS

R B Harris Principal Engineer, Howard Humphreys and Partners

J F Jackson Associate, Howard Humphreys and Partners

### INTRODUCTION

This paper considers the provision of improved sanitation facilities to major urban population centres in developing countries and endeavours to demonstrate the significant effect that local circumstances and influences have upon the concept and design of the projects entrusted to consulting engineers.

The first stage in any sanitation project comprises a review of the existing sanitation arrangements, technical controlling factors, demographic data, cost and availability of water, institutional arrangements, public health status and cultural/ethnic aspects. This review would be followed by an appraisal of development and economic planning within the project planning period and a clarification of the client's brief and the project's particular objectives. The concept and design of the sanitation scheme will be developed from this basic groundwork but it must be noted that the depth and scale of this work will be limited by the programme and monetary constraints imposed by the client.

Different technical, institutional, economic and cultural constraints are encountered in each major urban centre and there can be no single sanitation system or scheme which is suited for universal application.

In formulating the appropriate sanitation programme for a particular urban area, the consulting engineer may be severely constrained by local influences and the success of his project will depend upon his response to them.

This paper examines two projects in different locations and shows how the local circumstances and influences were reflected in the formulation of the particular project.

Case Study A demonstrates the role of the consultant where the circumstances, aspirations and resources of the population allow the consultant to pursue a conventional sewerage scheme through the traditional course of project report, detail design and preparation of contract documents.

Case Study B demonstrates the consultant's role when his task is to meet the objectives of the Drinking Water and Sanitation Decade which are to provide as many people as possible

with an adequate and hygienic form of sanitation within the limiting constraints imposed by local resources and the availability of funds.

### CASE A: SANA'A SEWERAGE AND SEWAGE TREATMENT PROJECT, YEMEN ARAB REPUBLIC

#### Project Area

The Yemen Arab Republic is a Muslim country which lies at the south west corner of the Arabian peninsula. Sana'a, the capital of the Yemen Arab Republic is an ancient city situated in the central mountainous region of the Yemen at an altitude of some 2250m.

The city has expanded greatly over recent years. The ancient part of the city has been described as "a living archaeology" and features multi-storey buildings built in stone and brick, and with narrow streets mostly unpaved.

Recent development features multi-storey offices and commercial buildings built with modern techniques, and residential areas where the buildings are either single or multi-storey. The architecture of the recent development has been blended with the ancient buildings, and there is a complete absence of squatter or shanty style dwelling places.

The population is currently estimated at about 200 000 and is expected to rise to about 500 000 by the end of the century.

#### Existing water supply

The traditional source of water for the people of Sana'a was from shallow hand-dug wells situated within the curtilage of properties. From about 1965 onwards, some wells to serve localised communities were constructed to a depth of about 150m using cable tool rigs. The supply from these wells was distributed by a limited pipework system or by tankers. The water consumption per head of population from the traditional source was put at about 20 litres.

The first stage of a new water supply project was inaugurated in 1978. This scheme featured the development of well fields to the north of Sana'a and included transmission, head works, distribution and house connections. The second stage is currently under construction.

### Existing waste disposal

At the present time the city of Sana'a has no public sewerage system. Within the confines of the Old City, where in the past the water consumption per head has been low, the old buildings incorporate a form of internal latrine consisting of a chamber at street level, above which there are squatting areas. Urine and other waste waters are channelled to the outside wall of the building, and then to the street. Modern buildings, outside the Old City area usually enjoy a more plentiful supply of water and deep cesspool or septic tank sanitation.

### Health conditions

In the absence of statistical documentation the only evaluation available in 1976, when proposals for sanitary improvements were formulated, was of a qualitative kind without an economic justification. Quoting from a report by Dr Lantini, who was a member of the Italian Medical Mission to Sana'a, the most commonly occurring diseases were:

- (1) Parasitic, including amoebic dysentery, ascariasis etc.
- (2) Dysentery, in all its forms and in all seasons was extremely frequent, and the consumption of antibiotics to combat it was enormous.
- (3) Viral hepatitis was common in the expatriate community. Milder forms affecting the local community were probably not brought to the attention of a doctor.
- (4) Trachoma affected between 60 - 70% of the school population.

The report concluded that the high incidence of diseases was attributable to the insanitary conditions prevailing.

### Circumstances in Yemen Arab Republic

Though still a relatively poor country in economic terms, the Yemen Arab Republic has been able to attract much of the funding necessary to finance the development and social improvements to which her people aspired.

Public health projects, such as the Water Supply and Sewerage of Sana'a, were high in the order of priorities, and in 1973 a government body known as the National Water and Sewerage Authority was set up to administer the implementation of such projects.

A Preliminary Engineering and Feasibility Study, under the sponsorship of the World Health Organisation, was commissioned in 1974 and submitted in 1975. This report, prepared by Italconsult, had as its principal objectives the study, definition and planning of works required to effect a change from the rudimentary and inadequate sanitary methods with attendant health hazards, to a modern system for collection, treatment and disposal

to meet the socio-economic demands of a rapidly growing population.

The report concluded with the recommendation for a comprehensive water-borne sewerage system and treatment.

These recommendations were adopted and various tariff studies have been carried out with the intention that the project should be self-supporting with revenue generated by the metered sale of water.

### Procedure for implementation - consultants' role

The appointment of Howard Humphries and Sons as consulting engineers to the National Water and Sewerage Authority for the Sana'a Sewerage Project, was made in May 1976 following selection from proposals submitted in competition with other consulting engineers.

Funding for the project study and design stage of the project was provided partly from internal resources and partly from a credit from the International Development Association.

The duties of the consultant under the Terms of Reference of the Consultancy Agreement may be summarised as:

The preparation of a Project Report incorporating the following main features:

- (i) A review of the Preliminary Engineering and Feasibility Study drawn up by Italconsult under the sponsorship of WHO.
- (ii) Projected water demands and determination of expected per capita sewage flows, peak flows and pollution loads.
- (iii) Definition of drainage areas, location of area pumping stations and the sewage treatment works.
- (iv) Selection of sewage treatment methods and disposal of the final effluent and sludge.
- (v) Preparation of outline designs and cost estimates.
- (vi) Investigation of local stormwater flooding and proposals for remedial action.
- (vii) Investigation of intermediate arrangements for the improvement of sanitary facilities in the areas of Sana'a not served by the initial stages of the sewerage project.

The preparation of detail designs and tender documents in accordance with the scope of works agreed by the Authority from the recommendations made in the Project Report.

### Contract Works - Stage 1

The implementation of the construction stage

of the sanitation element of the project was conceived under three separate contracts.

Contract 1 - Supply of materials

Contract 2 - Civil engineering works

Contract 3 - Mechanical and electrical works

Contract 1 provided for the manufacture and delivery of the major offshore materials of construction such as manhole covers, pipes and steel reinforcement in advance of construction, thus taking advantage of available funding, and the avoidance of cost increases due to escalation.

Contract 2 provided for the construction of the civil engineering works associated with the sewerage system and treatment works.

Contract 3 provided for the procurement, delivery and installation of all the various items of works machinery and equipment under a single contract.

Tenders for all three contracts were invited from selected Contractors.

The funding of the capital cost of Stage 1 of the Sana'a Sewerage Project is provided jointly by the International Development Association and the Saudi Fund for Development with a contribution from internal sources.

The Stage 1 works will cater for some 50% of the present population where priority has been given to sewerage the densely populated areas of the Old City. A further 50% of the present population, representing recent development, will be served under the Stage 2 works as soon as administratively convenient.

The project envisages a third stage in the development of the sewerage scheme as the City continues to expand. Pending the extensions of the sewerage system, drainage will be effected by septic tanks.

#### CASE B: DAR ES SALAAM

##### General background

Tanzania is a poor country, the gross domestic product (GDP) in 1977 being approximately Shs.1500 per capita (Shs.19 = £Stg 1).

Between 1967 and 1977 it grew at an average rate of 4.5% per annum in real terms, however since the country's population increased by about 3.7% annually during the same period, real per capita growth in GDP increased by less than 1% a year.

Agriculture is still the dominant economic activity in Tanzania, accounting for almost 40% of GDP in 1977. However the gradual decline in its relative importance has been counteracted in recent years more by a growing significance in public administration and services rather than by growth in the direct productive sectors of the economy.

The city of Dar es Salaam is of relatively

recent origin, having been founded in 1862. It is the commercial centre, largest city and main sea port of Tanzania. The relatively modern city centre has several multi-storey buildings and is surrounded by suburbs of traditional permanent housing. The rapid expansion of the city over the past two decades has been largely due to migration into the city from the rural areas of Tanzania and has resulted in the establishment of extensive squatter housing zones in the periurban areas.

The existing urban area and suburbs of Dar es Salaam are mostly situated on a gently seaward sloping plain dissected by old incised and filled valleys. The surface layer is of poorly graded sand and overlies materials of variable permeability creating a complex hydrological situation. The annual average rainfall in the area is 1100mm of which 50% occurs in the March-May period of the S E monsoon.

##### Population

Tanzania is a multi-tribal country and in the coastal region the population are understood to be Muslims. Within the regional boundary of Dar es Salaam the total population is currently in the order of 930 000 of which over 80% are African and the majority of the remainder are Asian. Some 10% of the total population resides in the rural areas on the fringe of the city. Population growth in Dar es Salaam has been at an average rate of 8.5% over the past 15 years which is over twice the national average rate for the period. The trend towards urbanisation in Tanzania is, however, still less intense than in many other African countries, and continued pressures on urban areas, and in Dar es Salaam in particular are expected to continue. The Sewerage and Sanitation Master Plan by Howard Humphreys and Partners prepared for Dar es Salaam was divided into four stages as follows:

Stage I	1980 to 1984 inclusive
Stage II	1985 to 1989 inclusive
Stage III	1990 to 1999 inclusive
Stage IV	2000 to 2010

The projected population distribution in conjunction with these planning stages are shown in Table 1. (see over).

##### Water supply and consumption

A major influence in the selection of appropriate sanitation facilities is the availability, use and cost of potable water. In Dar es Salaam there is an adequate quantity of water available from river resources and it is not foreseen in the project planning period that groundwater resources within the city boundary would need to be drawn upon. There is also a relatively good reticulation system and the majority of the population has ready access to a potable water supply point

TABLE 1 Urban population projections (thousands)

	1979		1984 Stage I		1989 Stage II		1999 Stage III		2010 Stage IV	
	Pop	%	Pop	%	Pop	%	Pop	%	Pop	%
Existing Residential	794	93	888	75	958	62	1005	43	1028	30
- Planned	(316)	(37)	(371)	(31)	(412)	(27)	(440)	(19)	(453)	(13)
- Unplanned (squatter)	(478)	(56)	(517)	(44)	(546)	(35)	(565)	(24)	(575)	(17)
New Residential	-	-	208	18	461	30	1187	50	2180	64
Institutional	55	7	87	7	127	8	177	7	212	6
TOTAL	849	100	1183	100	1546	100	2369	100	3420	100

which for the lowest level of service comprises a standpipe serving a group of dwellings.

Four different levels of consumption for

TABLE 2 Per capita domestic water consumption (litres/day)

Water Demand \ Stage	Stage				
	1979	St. I	St. II	St. III	St. IV
High	240	245	250	260	270
Medium	120	125	130	140	150
Low	60	65	70	80	90
Very Low	30	30	30	30	30

The above water consumption levels were applied to each existing or proposed development area of the city on the basis of the general residential character and income pattern of the area.

#### Existing sanitation

More than 80% of the population of Dar es Salaam is currently served by on-site sanitation systems. Pit latrines are the type most commonly employed and considerable design improvements can be made to provide a more hygienic, efficient and economic unit. The majority of latrines are of the standard type but mound latrines have been constructed in some of the areas where high water tables are experienced.

The small proportion of the population served by foul sewerage systems (approximately 12%) comprises the city centre where flows are discharged via a sea outfall. There are also a number of outlying areas where flows are conveyed to waste stabilisation ponds for treatment. The city centre system was constructed some 25 years ago but all other systems are of much more recent origin. Almost without exception the systems are in a poor state of repair and require urgent rehabilitation.

Less than 5% of the population of Dar es Salaam was found to have no sanitation facilities at all.

residential areas were determined in the Sewerage and Sanitation Master Plan Study for existing and future development areas and are set out in Table 2.

#### Public health aspects

A major benefit sought from any proposed sewerage and sanitation scheme is a reduction of disease levels in the community. There are three main groups of diseases which can be affected by improved sanitation: faecal-oral infections, mosquito borne diseases and schistosomiasis.

Faecal-oral diseases such as diarrhoeal diseases, infectious hepatitis and most of the intestinal parasitic worm infections, notably roundworm (*Ascaris*) and hookworm are all experienced in Dar es Salaam. These are the classic diseases of the poorer and more crowded sections of a community and particularly of children in all hot countries. The chain of transmission starts with poor excreta disposal, and is compounded by poor personal and environmental hygiene and crowded living conditions.

The two mosquito-borne diseases of major importance in Dar es Salaam are malaria and filariasis. The vector of filariasis in Dar es Salaam is *Culex quinquefasciatus* which prefers breeding in polluted waters, especially when these are enclosed. Wet pit latrines, septic tanks and stormwater drains are particularly important sites as are poor sullage disposal practices.

Schistosomiasis, though a major problem within Tanzania, is predominantly a disease of rural

areas and as such does not greatly affect Dar es Salaam.

The scale of the problem of sanitation related diseases in Dar es Salaam is indicated by infant and child mortality (15% of children die before they are 1). Life expectancy at birth is less than 45 years. It was found that water-borne and water-related diseases in the study area affected up to a quarter of the population at least annually and that despite treatment the incidence of these diseases was increasing. There is always the danger of typhoid and cholera outbreaks as evidenced by the 1978 cholera epidemic.

#### Sanitation system selection

Criteria based on water consumption and population density were established in order to determine those areas of the city where foul sewerage was a practical system to instal. However, financial limitations and economic projections indicated that for the majority of the population the only feasible form of improved sanitation in the planning period would be a pit latrine of improved design. In order to determine the appropriate type and form that improved latrines should take a household survey was executed, based on ten representative areas of the city which were selected with the help of government public health officials. By this means sociological preferences could be determined and scope for construction improvements identified bearing in mind local construction techniques. A great deal of thought was given to the format of the questionnaire used in the survey. It was so arranged that householders merely had to answer yes or no or give a number or a date. In this way a large amount of information could be recorded in a relatively short time. The object of the questions was to provide information on the type of housing, method of excreta disposal, details of usage, emptying services, age of latrine, type of construction, personal preferences and dislikes.

It is important that local help be recruited for the execution of such a household survey and such help should be trained for the job. Teams should comprise personnel with public health and sociological experience. In Dar es Salaam we were fortunate to be assisted in the preparation of the questionnaire and the execution of the household survey by the Low Cost Sanitation Unit of the Ministry of Lands, Housing and Urban Development.

The survey results were analysed and produced some interesting and useful findings. The major local preferences and therefore influences on design were found to be:

- (i) Each property to have its own latrine.
- (ii) Latrine facilities to incorporate separate units for male and female use.

(iii) Latrine superstructure to be large enough to permit washing or showering therein.

(iv) Water to be used for anal cleansing.

These factors and other minor ones derived from the analyses of the survey results were taken into account in the formulation of the designs of improved pit latrines.

Since the water supply in Dar es Salaam is from an external location it proved feasible to adopt a design of pit latrine from which the liquid contents could be permitted to leach into the surrounding soil with no detriment to the water supply and therefore to the public health of the community.

A key factor which influences the selection and design of a sanitation system is the ability of the local community to afford and maintain a selected system. In Dar es Salaam it was clear that great difficulty was being experienced in adequately maintaining the existing foul sewerage system, although this was partly due to past administrative problems and this clearly had to be taken into account in formulating any new proposals. In selecting the appropriate combination of sanitation systems great emphasis was therefore placed upon the need for extensive strengthening of the existing institutional structure and the engineering proposals were of the most straightforward form in order to both simplify maintenance procedures and to minimise costs.

In addition to working within the above mentioned constraints dictated by local influences it is necessary to consider the effects of future social changes as well as government policies such as those related to housing. The selected scheme must be flexible in order to allow for the upgrading of the sanitation project from its initially conceived form. Future economic developments are difficult to predict accurately and it is important in terms of optimising design and economising on initial construction costs that the design data adopted is reliable. This task could be assisted by the application of risk analysis as discussed in the paper of Lumbers and Harris (Ref 1).

#### Project implementation strategy

In Dar es Salaam the occurrence of diseases which improved sewerage and sanitation can be expected to reduce are the faecal-oral diseases and filariasis. In both cases health improvements will be small unless the improved environmental sanitation reaches all sections of the community. Three major tasks were recommended for implementation as the first stage of the phased Master Plan programme in order to obtain the maximum improvement to public health, namely:

- rehabilitation of existing sewerage systems and sewage treatment works.



- development of manpower and institutional capabilities to support present and future activities (including education) in the sector.

- installation of new sanitation systems.

For maximum impact these tasks had to be directed at works which would produce results in the shortest time and to the area of the city with the greatest health hazards.

Specific activities considered necessary in association with these tasks ranked in priority are as follows:

- A - implementation of community health education campaigns.
  - rehabilitation of the pit latrine emptying service, and expansion to meet demand.
  - rehabilitation of existing sewerage systems and sewage treatment works.
- B - installation of improved pit latrines in houses without any excreta disposal facility, or with poorly constructed traditional pit latrines.
  - installation of improved pit latrines in squatter upgrading areas.
  - installation of improved pit latrines in areas of high water table.
- C - installation of improved sullage disposal systems in those areas served by pit latrines.
- D - campaigns/assistance to promote the connection of houses with suitable water supplies to existing sewers.
- E - installation of foul sewerage in areas already developed where problems exist with other forms of sanitation because of adverse ground conditions and where adequate flows can be attained to ensure self cleansing sewer operation.
- F - expansion of existing foul sewer systems and pre-development installation of new systems to serve appropriate sections of new development areas.

Proposals are currently in hand to implement tasks A-E and the role of the consulting engineer is being finalised.

#### CONCLUSION

Each major urban centre in the world imposes its own highly individual constraints on the consulting engineer designing a sanitation project to meet its future planned needs. In addition to technical and monetary constraints, major influences on the selection of the appropriate scheme are made by the local factors attributed to the social and cultural background of the people.

Water borne sewerage remains a practical and economically viable solution to some particular circumstances but for the poorer and the majority of countries low-cost sanitation systems such as pit latrines offer a

considerably cheaper but at the same time effective alternative to improving public health for the benefit of the majority of the people.

In the latter circumstances the role of the consulting engineer will undergo change. The circumstances of such schemes require the involvement of institutional support and project management staff accompanied by specialist advice from sociologists and health educationalists.

#### REFERENCES

1. J.P.LUMBERS and R.B.HARRIS - Risk and uncertainty in the master planning of sewerage and sanitation in developing countries. Paper presented to the Institution of Public Health Engineers, January 1981.

#### ACKNOWLEDGEMENTS

The authors wish to thank the Partners of Howard Humphreys, the Ministry of Lands, Housing and Urban Development, Tanzania, and the National Water and Sewerage Authority, Yemen Arab Republic for their permission to present this paper.