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Sewering two Asian cities

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1. INTRODUCTION

Brunei Darussalam is a small country located on the north-western coast of the island of Borneo. Despite its small size (5765 km^2) and small population (227,000) it has one of the highest per capita incomes of any Asian country. The capital, Bandar Seri Begawan (originally called Brunei Town) and its urban area has a population of approximately 80,000 people and little industrial development. In 1966, proposals were developed to provide a conventional sewerage system to replace then existing sanitation methods including night-soil collection and septic tanks in the town centre and adjacent areas. The scheme was commissioned in 1971 and has since been extended and upgraded to serve new development. The Government have committed themselves to a high standard of public sanitation and have committed significant public expenditure on this and other sewerage schemes in Bandar Seri Begawan and other urban areas of Brunei. A rural sanitation study is currently in progress and proposals will be developed to upgrade sanitation using appropriate technology in these areas.

At the other extreme of the population and affluence spectra is the city of Shanghai in the People's Republic of China. Shanghai is China's and one of the world's most densely populated and heavily industrialised cities. It has a population of some 14 million people, 7 million of which reside in the city centre and fringe areas occupying an area of 300 km^2. Some 4000 significant industrial plants including chemical, petrochemical and heavy engineering complexes are located in the city. A combined sewerage network was constructed in the older parts of Shanghai in the 1920's and 30's and this system still operates today and presently collects the majority of mostly untreated industrial waste and a proportion of the domestic waste. The system discharges the raw, untreated wastewater to the Huangpu River and its tributaries within the city area via a large number of pumping stations and gravity outlets. Over the last 50 years or so, the water quality of the Huangpu and its tributaries has deteriorated significantly as a result of this inadequate treatment and disposal system. Severe constraints on funding in recent decades has meant that little was done about this major problem. However, since the early 1980's, a major liquid waste management strategy for Shanghai has evolved and is currently being implemented with loan assistance provided by the World Bank.

This paper will describe the approach taken to the development of modern collection, treatment and disposal systems for these two cities which are at opposite ends of the population and affluence spectra.

2. BANDAR SERI BEGAWAN - BRUNEI DARASSULAM

2.1 Historical Development of the Town Sewerage System

The town centre of Bandar Seri Begawan (BSB) consisting of shophouses, Government offices and housing was originally provided with a night soil collection system. As the city area grew, newer buildings were provided with septic tanks and in some cases with direct connection and discharge of untreated wastewater to monsoon drains and to the Sungai Brunei estuary (Fig.1). The low lying nature of the area in the town centre and unsuitable soil conditions meant that septic tank absorption systems were inappropriate; more often than not septic tank outlets were connected directly to monsoon drains. In addition to this onshore development there was and still is a large village known as Kampong Air adjacent to the town centre consisting of relatively low grade housing for about 20,000 people built on stilts over the waters of the Sungai Brunei and its tributaries. The village has been located in this position for centuries and is intimately connected with the Malay culture in Brunei and Borneo in general. Kampong Air has no liquid or solid waste sanitation facilities.

Grossly polluted surface water drains, odours, problems with the collection and disposal of nightsoil and health concerns led the Government in the mid 1960's to a decision to implement improved sanitation methods particularly for the town centre where significant new developments were planned. Consultants developed a conceptual design for a conventional separate system to collect toilet, sullage and trade waste for the town centre and the rapidly developing areas immediately to the north and west.

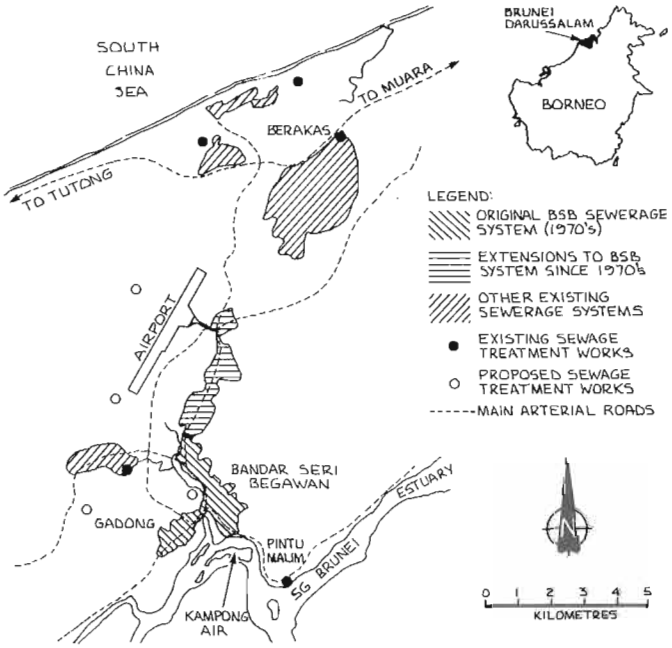

Figure 1

Septic tanks and on-site disposal had already proved inappropriate for the density of development and the soil conditions in the town area. Coupled with this was the Government's desire for a full sewerage system and its ability to fund it and other major public works projects via revenue from sales of oil and gas.

The original BSB sewerage scheme was designed for an ultimate 85,000 equivalent population (EP) based on a contributory Average Dry Weather Flow (ADWF) of 295 L/EP.d. The scheme was commissioned in 1971 (Ref 1) and consisted of 5 subcatchments each served by a wet well/dry well pumping station housing screenings comminutors and standby and duty electrically driven centrifugal pumps. Sewage from all sub-catchments drained to a terminal pumping station located just to the east of the town centre from where it was pumped via twin rising mains to the Pintu Malim sewage works located on the shores of the Sg Brunei, some 4km downstream of the town centre. The Pintu Malim sewage works provided primary treatment for a dry weather flow of 13.6 ML/d with the plant being designed to be doubled in capacity at a later date. Effluent was discharged via an outfall to the Sg Brunei estuary with raw sludge being stored and discharged on the ebbing tide via a separate small diameter outfall.

At the time of the development of the original BSB sewerage scheme, no steps were taken to provide sanitation facilities for Kampong Air as proposals at the time were to scale down the size of the village and to resettle its inhabitants in new onshore housing estates. Initial connections to the sewerage system were relatively slow and mainly consisted of Government offices, housing and shophouses. No legislative procedures were in place at the time to encourage private property owners to connect and inadequate septic tank and other systems continued to be utilised in some areas.

2.2 Extensions to the Original Sewerage Scheme

Considerable Government and private development has taken place during the 1980's along main arteries to the north and west of the town centre. The original scheme has been extended to serve these newer areas, resulting in three additional sub-catchments and associated pumping stations. Further connections have been provided in the older sub-catchments and very few unsewered properties now exist. The original sewerage system has in general performed satisfactorily; existing pumping stations have been mechanically and electrically upgraded and work is in hand to survey and repair isolated parts of the system which have suffered from corrosion.

The connected population of the BSB sewerage system is now approaching 30000EP. As such, action is in hand to increase the capacity of the Pintu Malim sewage works. Construction is presently underway on one additional circular primary sedimentation tank, anaerobic sludge digesters and dewatering facilities and improved administration and laboratory facilities. Treated and dewatered sludge will be disposed to a sanitary landfill.

2.3 Sungai Brunei Water Quality and Pollution Study

A baseline water quality and pollution study of the estuary was undertaken between 1984 and 1986. The estuary and its tributaries receive the majority of treated and untreated wastewater, septic tank effluent and polluted stormwater generated in Bandar Seri Begawan. The purpose of the study was to establish the existing physical, chemical and biological status of the estuary and to identify the sources and volumes of existing pollutants entering the estuary. A mixed segment computer model of estuary water quality was developed and was used to test future scenarios of wastewater management. The general need to control pollutant discharges was confirmed by monitoring and modelling. The study indicated that the current practice of the discharge of raw sludge from the Pintu Malim sewage works on the ebbing tide caused significant depressions in dissolved oxygen levels in the estuary particularly during periods of extended dry weather when estuary flushing was poor. This supported the decision to

implement sludge treatment, dewatering and offsite disposal at Pintu Malim. The study also indicated that the lack of liquid and solid waste sanitation facilities in Kampong Air contributed to high levels of bacterial contamination of the estuary near the city area, significantly reducing its amenity value.

2.4 New and Proposed Sewerage Schemes

Development has also taken place in the areas outside the catchment of the BSB town sewerage system. The Government has adopted a policy of providing conventional sewerage systems for areas where the density of development justifies it or where ground conditions are unsuitable for on-site disposal of septic tank effluent. Studies have been undertaken for the staged provision of sewerage to the Gadong area. Construction will soon commence on an oxidation ditch type sewage treatment works to serve new developments to the N-E. Sewerage schemes including treatment facilities to serve resettlement schemes and Government housing areas have recently been commissioned. Less densely populated development including ribbon development to the east of the town has been provided with septic tanks with on-site disposal. A waste management study for Kampong Air was conducted in 1986 (Ref 2). Proposals have been developed for the provision of a sewerage system using a combination of conventional gravity and vacuum sewers to serve the village and for wastes to be treated at the Pintu Malim sewage works and a new sewage works.

3. SHANGHAI - PEOPLE'S REPUBLIC OF CHINA

3.1 The Existing Wastewater Disposal System in Shanghai

The city of Shanghai is located on a flat delta plain area on the banks of the Huangpu River, a tributary of the Chang Jiang (Yangtze) estuary (Fig. 2). The Huangpu is the largest in a complex network of streams and canals which provide transport, water supply and waste disposal for the inhabitants of Shanghai. The Chang Jiang estuary dominates the water resources of the region and the complex hydraulics of the flat delta area.

Human domestic waste disposal is centred on the nightsoil system with collected wastes being transported by barge or truck to the countryside, treated with lime and used as a fertilizer/soil conditioner. In redevelopments within the city such as apartments blocks, septic tank systems are utilised and new developments on the urban fringes are fully sewered.

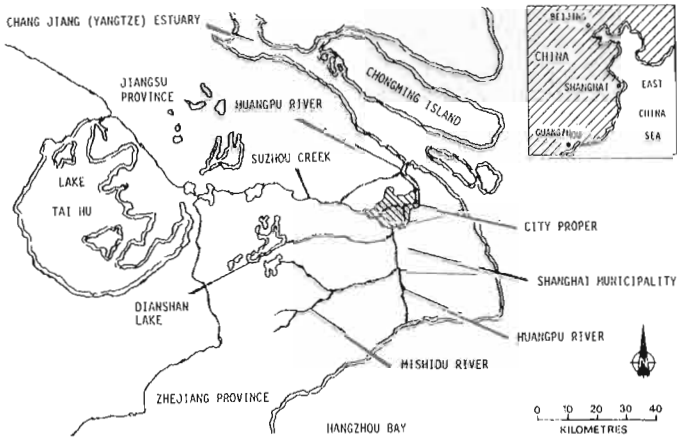

Figure 2

Within the city area, the main drainage system is an interconnected combined sewerage reticulation network which receives industrial and domestic wastes (except for nightsoil and septic tank sludges) as well as stormwater. The system was mostly constructed in the 1920's and 1930's. Subsidence in the city area due to groundwater overpumping and the occasional occurrence of typhoon induced storm surges has necessitated the construction of flood walls along the main rivers and sluice gates on tributary creeks. There are two existing interceptors which carry about 45% of the dry weather flow away from the city and discharges it on the shores of the Chang Jiang with adverse environmental consequences. The remaining 55% of the dry weather flow and the majority of wet weather flows are discharged from the combined sewerage system to the Huangpu and its tributaries under gravity and by pumping when tidal levels and/or flows are high. About 60% of the 4000 significant factories discharge their wastewater, either untreated or partially treated, into the combined sewerage system with the remainder being discharged directly into the Huangpu or its tributaries. The total untreated domestic and industrial wastewater flow entering the Huangpu in the urban area is 1000 ML/d conveying a load of 210 tonnes per day BOD_5. Flows and loads are expected to increase by 80% and 50% respectively by the year 2000 in the absence of any measures to control pollution. The poor quality of the Huangpu and its tributaries is evidenced by the results of regular water quality surveys which indicate low or zero Dissolved Oxygen (DO) levels in the urban area.

3.2 Tackling an Immense Pollution Problem

The Shanghai Municipal Government have adopted the long term goal of achieving the National Water Quality Standards for surface waters. This implies achieving minimum DO levels of 4 and 6 mg/L respectively in the city centre and the upstream reaches of the

Huangpu and its tributaries. With the recent availability of fertilisers at a reasonable cost, there is no longer the desire of farmers to utilise nightsoil for agricultural purposes. This combined with increasing cartage costs and health problems has meant that eventually this system of domestic wastewater disposal will no longer be acceptable in Shanghai.

During 1982 and 1983, agreement was reached between the Chinese Government, the World Bank and the Australian International Development Assistance Bureau (AIDAB) to undertake a major study into liquid waste management in Shanghai. During 1983 and 1984, a strategy was developed by engineers, scientists and other technical staff of various Shanghai Government agencies with the assistance of Australian consultants funded by AIDAB.

Once the present and future wastewater flows and loads were estimated, a mixed segment tidal computer model was used to establish that in order to meet the long-term water quality objectives, more than 90% of present and projected future pollutant loads would need to be removed from the river system. At the very outset of the study and given the very dense population and development it soon became apparent that some form of conventional sewerage system involving collection, conveyance, treatment and disposal would be required. An early decision was also made in principle, mainly on the basis of replacement cost and despite some disadvantages, to retain the combined sewerage system. As the combined sewerage system has a limited hydraulic capacity it was necessary to accept that overflows to waterways would always occur after heavy rain. Modelling was carried out to determine acceptable levels of overflow to attain the water quality objectives.

A wide range of conveyance, treatment and disposal options were developed and systematically analysed to identify the least cost alternative. All viable options required basic on-site pretreatment of industrial wastes.

The adopted least cost and environmentally acceptable strategy was a two stage attainment of water quality objectives using preliminary treatment and deepwater disposal in the Chang Jiang estuary. An investigation of appropriate outfall sites along the Chang Jiang estuary was used to refine the overall strategy. The two stage strategy involving the physical components of the scheme, financial components (adoption of "user pays" principles) and institutional components (establishment of a new self funding sewerage authority for Shanghai, training of staff at all levels) was adopted in principle by the Shanghai Government, World Bank and AIDAB in 1985. The sheer size of the project required a two stage implementation. Stage 1, which is to be implemented immediately will deal with the most heavily polluted areas.

3.3 Preliminary Design, Foreign Exchange Funding and Current Status

Preliminary design of the Stage 1 project was carried out during 1985/6 by a team of some 70 Chinese engineers with the continued assistance of the AIDAB consultants. A description of the preliminary design is contained in Ref 3. World Bank appraisal of the preliminary design, financial and institutional proposals took place in late 1986, resulting in approval of a US$145M loan to cover the majority of the foreign exchange component of the US$430M project. Work is currently being undertaken on the detail design and documentation of the project by various Shanghai engineering design institutes on behalf of the newly formed Shanghai Sewerage Project Construction Company. SSPCC is being advised by Binnie and Partners Pty Ltd, Australia, on technical and project management issues. The Stage 1 project is expected to be commissioned by 1992/3.

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