1.0 THE SEWERAGE INDUSTRY AND COLLECTION SYSTEM IN MALAYSIA

1.1 Introduction

The privatisation of the national sewerage system is a milestone in Malaysia's efforts to safeguard the environment. Indah Water Konsortium Sdn. Bhd. (IWK) has been awarded a 28 years concession agreement which comprises the take over of sewerage services of 144 local authorities in the country. Under this concession, IWK is responsible for the takeover, upgrading, operation and maintenance of the existing sewerage system within the local authority areas.

The objectives of Indah Water's Concession Agreement are to:

1. Connect existing simple toilets and individual septic tanks to modern sewage treatment plants
2. Provide desludging services to owners of individual septic tanks
3. Refurbish existing public sewerage systems
4. Operate and maintain these sewerage systems
5. Collect revenues to fund these sewerage systems.

As for new sewerage systems within the local authority areas, IWK's role is to design, construct, finance, operate, manage and maintain the new systems.

This project specifically focuses on the refurbishment of sewer systems in terms of the available technologies in the market and to identify suitable methods available to undertake sewer rehabilitation in Malaysia. This study will evaluate the various technologies used in the rehabilitation of sewers, their advantages and disadvantages and their feasibility to be used in Malaysia.

This study will provide IWK information on the available rehabilitation technologies of sewers via the trenchless method, its advantages and disadvantages, and finally its effectiveness.

1.2 The Wastewater Collection System

The primary aim of a wastewater collection system is to safeguard the health of the community by collecting the wastewater generated from homes, offices and industries. The collected wastewater will be sent to the nearby treatment plant via a collection system.

A collection system generally consists of many different kind of sewers. Sewers have been in existence almost as long as people have lived in dwellings. It was long thought that sewers in the Indus valley, circa 2500 BC were the oldest, but excavations in the Orkney Islands have shown primitive drainage systems dated about 3000 BC. Roman civilisation was well known for its sanitation and yet in Britain it was not until the late 18th century that any consideration was given to sewerage (Jones, 1998). In old English, sewer means "seaward", which explains why London's sewers were open ditches sloped slightly to drain human wastes toward the River Thames, and ultimately into the sea (Gayman, 1998).

Prior to usage of sewer lines as a means of collection of human waste, pit laterines or cesspits were used. Pit laterines can generally be described as holes underneath the floor. This however caused a nauseating stench, and noxious fumes from the pit, which were commonly ignored by most people. In the seventeenth century, the people of the city of London sealed shut their doors and windows at sunset to protect occupants from entry of the feared "night air." Entire families died of mysterious asphyxiation during the night due to asphyxiation by hydrogen sulfide or oxygen deficiency or methane explosions (Gayman, 1998). These conditions remain common in sewers, septic tanks and confined spaces today. In Malaysia, the pit laterines were typically located at the back of houses to ensure the stench from the pit laterines did not find its way into the houses. Typically, when pit laterines filled to overflow, they were drained to the streets causing sewage to spread under buildings and contaminate shallow wells, cisterns and water ways from which drinking water was drawn, leading to contamination of drinking water and epidemics caused by water bourne organisms.

The night soil from the pit laterines was often used as fertiliser for crops, and were hence collected on a regular basis by the "night soil man", who had to crawl on his hands and knees to drag the waste out (Gayman, 1998). Collection of human waste from the cesspits and pit laterines was neither an honourable or safe job. As the night soil man had to work in a confined space, without proper protective equipment, he was prone to exposure to toxic gases (hydrogen sulphide and methane gas), which in many cases led to explosions.

As removal of night soils was not a profitable job an alternative method of sewage collection was necessary. According to Gayman (1998), in the city of London, police had to be employed to prevent the cesspit cleaner from emptying cesspit ordure due to its highly concentrated and dangerous state. This then led to the construction of large central covered sewers in London in the year 1844, even though no plan had yet been drawn to replace cesspits. However, due to the uneconomic and dangerous practices in cleaning them, the use of temporary "moveable recepticals" (porta-potties!) such as were being used in Paris at the time were used as an alternative (Krupa, 1991).

During the British rule in Malaysia, septic tanks were widely used around the country and sewer lines were laid in the bigger towns. The septic tank itself produce over one million cubic meters of sludge per year and is used by over 5.6 million people in Malaysia (IWK, 1998). These tanks are normally designed to be emptied between 6 months to 3 years on a regular basis, however, it has been documented that only one percent of existing septic tanks were desludged annually prior to 1994. IWK operators routinely desludge septic tanks once every two years to minimise the impact on the local environment.

Most septic tanks in the country are not designed with filter systems. As such, the built up sludge is usually carried over with the effluent into the roadside drains, causing the drains of old residential areas to be septic (blackish and bubbling) with a distinct stench. This is one of the main reasons that IWK intends to connect existing septic tanks to trunk sewers which will eventually lead to a proper sewage treatment facility.

Wastewater collection systems are usually based on gravity flow systems, meaning that wastewater flows to the treatment plant by gravity. The characteristics of the land generally determines whether pumps and pumping stations will be required to lift the wastewater to a higher point so that gravity flow can take over again.

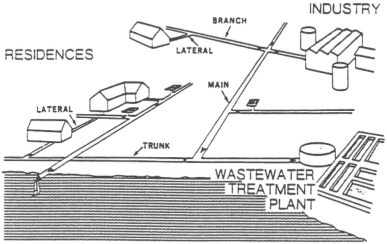
There are three types of wastewater collection systems:

1. Sanitary collection system or separate sanitary system – carries wastewater from residences, commercial and industrial establishments to the wastewater treatment plant. This system is designed to carry all the wastewater and a certain amount of inflow/infiltration from defects in sewers;
2. Storm water collection system – carries storm water, roof and foundation drainage, surface water, street wash and other wash and drainage waters; and
3. Combined collection system – collects the combination of wastewater from residences, industries and businesses as well as storm water and surface runoff form the same area.

In Malaysia, as with most other countries in the world, sewer systems are designed to collect wastewater from domestic and industrial sources. In the United States of America however, the combined collection sewers are more common.

Figure 1.1 shows a typical collection system that is composed of different kinds of sewers, while **Table 1.1** provides definitions of different kinds of sewers.

Figure 1.1 The typical wastewater collection system.



As shown in **Figure 1.1**, a building sewer connects the building plumbing to the wastewater collection system. The wastewater from building sewers is carried to and collected by lateral sewers or property connections, which in turn feeds into larger sewers called branch sewers. The branch sewers carry the wastewater to larger main sewers, which discharge into trunk sewers. The trunk sewers end up at the wastewater or sewage treatment plant.

Table 1.1 Definitions of Different Kinds of Sewers

Sewer Type	Definition
Sewer	A pipe or conduit that carries wastewater or drainage water.
Branch sewer	A sewer that receives wastewater from a relatively small area and discharges into a main sewer serving more than one branch-sewer area.
Building storm sewer	In plumbing, the extension from the building drain to the public sewer or other place of disposal.
Combined sewer	A sewer intended to receive both wastewater and storm water or surface water.
Common sewer	A sewer in which all owners of abutting properties have common rights.
Depressed sewer	A section of sewer constructed lower than adjacent sections to pass beneath a valley, watercourse, or other obstruction, It runs full or at pressure greater than atmospheric because its crown is depressed below the hydraulic grade line.
Egg-shaped sewer	A sewer with a cross-section more or less similar to that of an egg standing upright on its smaller end. Such a section allows higher velocities to be obtained for small flows, because of the relatively smaller wetted perimeter, than circular or rectangular sections.
Flight sewer	A series of steps in a sewer to break up the velocity on a steep grade.
Force main	A pressure pipe joining the pump discharge at a water or wastewater pumping station with a point of gravity flow.
House sewer	A pipe conveying wastewater from a single building to a common sewer or point of immediate disposal.
Intercepting sewer	A sewer that receives dry-weather flow from a number of transverse sewers or outlets and frequently additional predetermined quantities of storm water (if from a combined system), and conducts such waters to a point for treatmetn or disposal.
Lateral sewer	A sewer that discharges into a branch or other sewer and has no other common sewer tributary to it.
Main sewer	(1) In larger systems, the principal sewer to which branch sewers and submains are tributary; also called trunk sewers. In a small system, a small sewer to which one or more branch sewers are tributary. (2) In plumbing, the public sewer to which the house or building sewer is connected.
Outfall sewer	A sewer that receives wastewater from a collection system or from a treatment plant and carries it to a pint of final discharge.
Private sewer	A sewer privately owned and used by one or more properties.

Sewer Type	Definition
Public sewer	A common sewer controlled by a governmental agency or public utility.
Relief sewer	(1) A sewer built to carry the flows in excess of the capacity of an existing sewer (2) A sewer intended to carry a portion of the flow from a district in which the existing sewers are of insufficient capacity, and thus preventing overtaxing the latter.
Sanitary sewer	A sewer that carries liquid and waterborne wastes from residences, commercial building, industrial plants, and institutions, together with minor quantities of ground, storm and surface waters that are not admitted intentionally.
Separate sewer	A sewer intended to receive only wastewater, storm water or surface water.
Storm sewer	A sewer that carries storm water and surface water, street wash and other wash waters, or drainage, but excludes domestic wastewater and industrial wastes, also called storm drain.
Storm overflow sewer	A sewer used to carry the excess of storm flow from a main or intercepting sewer to an independent outlet.
Storm-water overflow sewer	A sewer used to carry the excess of storm flow from a main or intercepting sewer to an independent outlet.
Submain sewer	A sewer into which the wastewater from two or more lateral sewers is discharged and which subsequently discharges into a main, a trunk, or other collector.
Trunk sewer	A sewer that receives many tributary branches and serves a large territory.

(Source: Water and Wastewater Control Engineering Glossary, Third Edition 1981)

1.3 Typical Problems Faced In Wastewater Collection Systems

An infrastructure crisis has begun to hit our sewers and waterline utilities. It is a common occurrence that wastewater collection systems receive little attention by the wastewater utilities, until a problem arises. This is largely because the wastewater collection infrastructure is out of sight, hence out of mind. The major problems faced by many countries are collapse of sewers and hydraulic overload due to infiltration and inflows and also from new developments.

It is rare that a sewer collapses, however, with the increasing development in the country, this is becoming a common occurrence. This could occur due to difficult ground conditions, large wastewater flows, adjacent utility impacts, traffic congestion, and deep excavation.

In Malaysia according to IWK's records, up to May 1998, there have been 823 reported incidents of sewer collapses while 51,457 blockages have been resolved. In most cases however, until and unless there is a backflow of sewage, the collapse is often left unidentifiable.

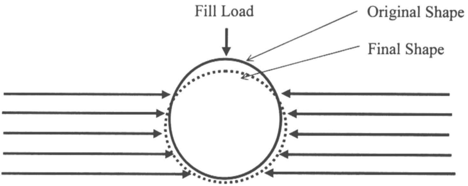
Following are typical reasons for collapses of sewer lines or laterals.

1. **Structural**

   Previously, sewers were constructed mainly of vitrified clay, brick and concrete. Currently however, materials such as plastic, ductile iron, steel, and reinforced concrete are commonly used. These materials have adequate compressive strength and some have tensile strength. In Malaysia, vitrified clay is used for smaller diameter pipes, while reinforced concrete is used for larger diameter sewers. Literature however indicates that in most European countries, there has been a switch from the conventional reinforced concrete and vitrified clay pipes to polyethylene based pipes due to its flexibility and high durability.

   Rigid pipe materials such as ductile iron, steel and reinforced concrete usually have the ability to resist vertical loading on their own, while brick sewers or other flexible materials require side support from the surrounding soil as shown below, to maintain its original shape.

Figure 1.2 Proper pipe side support



Factors that can contribute to deterioration and structural failure of sewers/laterals include the following:

- the size of the defect,
- soil type and soil particles,
- interior hydraulic regime,
- groundwater level and fluctuation,
- corrosion,
- method of construction; and
- loading on a sewer.

A collapse normally occurs due to an initial defect, which is not attended to. Initial defects are typically the result of poor construction, excessive loading, leaky joints, inadequate connections, or third party interference. In the event of a defect, the outside water infiltrates through the sewer wall, allowing the entrance of soil, hence resulting in ground loss and reduced side support. Once this occurs, the sewer will be prone to collapse, which may even be triggered by a random event adjacent to the area of the initial defect.

2. Hydraulic

When a sewer is subjected to surcharge because of insufficient hydraulic capacity, a cycle of exfiltration and infiltration occurs, causing fines to migrate out of or into the sewer. This immediately reduces lateral support from the soil and eventually leads to collapse of the sewer and not to mention pollution of the groundwater.

3. **Infiltration and Inflow (I/I)**

Typical sources of I/I located throughout a sewer system includes the following:

- Open cleanouts/inspection chambers
- Roof leader directly connected to sewers
- Building laterals/property connections
- Leaky manholes
- Cracked or broken pipes
- Open joints

Infiltration

Infiltration involves the entrance of water into a sewer system from the ground through defective pipes, pipe joints, damaged laterals or property connections, or manhole walls. Infiltration is mostly related to high groundwater levels, which have the potential of being influenced by storm events or leaking water mains.

The rate at which groundwater infiltrates into the sewer depends on the number and size of defects within a sewer and the hydraulic head available (Melbourne Water, 1993). In Malaysian weather, the rate of infiltration will be highest during the rainy season where the groundwater flows may increase and significant quantities of groundwater may migrate through the granular bedding. In coastal areas where tides are prevalent, groundwater levels may fluctuate hence causing the sewer to be subjected to varying external head and increased groundwater infiltration.

Inflow

Inflow is extraneous stormwater that enters a sewer system through roof gutters, manhole covers, pump sumps, and drains (foundation drains, illegal roof-drain connections, and back yard drains). Inflow reduces the hydraulic capacity of a sewer and increases the surcharging potential of the pipe, hence contributing to the deterioration of the pipe and the possibility of the pipe to collapse.