6.0 CONCLUSIONS AND RECOMMENDATIONS

There is no doubt that the past decade has marked the beginning of a revolution in thinking surrounding construction and rehabilitation of the underground infrastructure. The entire construction industry has experienced tremendous growth, borne out of necessity for a method of construction that allows continued development of the underground infrastructure with minimum adverse impact on public life. This method is generally termed "trenchless technology".

Trenchless technology has a multitude of techniques and definitions as has been described throughout this report. Basically trenchless technology can be defined as a family of methods, materials, and equipment that can be used to repair, renovate, or replace underground infrastructure systems with minimal surface disruption and disturbance by minimising the need for excavation. However, depending on the technique utilised, trenchless technology may require some excavation or even some trenching (for example when a particular technique requires a launch pit).

One of the main reasons for the explosive growth of the trenchless industry is the growing awareness of local authorities and also the public of the decreased social costs associated with the trenchless construction methods. Examples of social costs include traffic disruption, local economic disruption, air and noise pollution, and most importantly, general public annoyance. The constant public complaints

can be a source of frustration for local authorities. As the Malaysian public become more aware of various trenchless construction methods, their willingness to tolerate open-cut construction will invariably decrease.

6.1 Technical Viability

From this study, it has been found that the sewerage industry has much to gain from the various trenchless technology techniques available for sewer rehabilitation. However, prior to deciding on which technique to use, IWK has to perform a nation wide evaluation of the condition of the existing critical sewers, as until and unless the condition of the sewer has been determined, it is not possible to determine which method is most suitable. Once the condition of the most critical sewers have been determined (via CCTV and manual surveys), then it will be possible to narrow down the rehabilitation techniques to the suitable few and choose the most technically viable trenchless technology technique for the rehabilitation works.

This study has highlighted the various techniques available and their advantages and disadvantages. It has also shown that not all trenchless technology techniques used abroad are viable for use in Malaysia. This is primarily because Malaysian sewers are made of either vitrified clay or reinforced concrete as a standard practice, where as, many other countries use more flexible materials such as polyethylene and high density polyethylene, and polyvinyl chloride, etc. Some of these techniques may therefore need to be modified, for example, as jacking of

both clay and concrete pipes will damage the pipes, a steel sleeve may need to be jacked first followed by the clay or concrete pipes.

Furthermore, as trenchless technology is relatively new to the Malaysian construction industry, it is important that as with any new construction method, the processes must first go through a period of evaluation. During this period, it is imperative that local designers and municipal engineers be convinced that they should try these processes on their projects. However, there is no doubt that local designers and engineers may resist change, unless there are certain legal regulations or clauses in the contract that indicate that only trenchless technology may be used, in order to avoid any public disturbance, etc. Another reason engineers and designers may resist trenchless technology techniques is due to its high costs as discussed in Section 5.

It was most difficult in getting quotations from both contractors and suppliers for the various trenchless technology techniques described throughout this study. However, simple comparison of the costs indicate that trenchless technology techniques incur higher costs due to some of the following factors:

- Some of the trenchless technology techniques are proprietary, meaning that only a selected few contractors can install the materials (for example pipe lining materials) or have expert knowledge on how to use trenchless technology equipment.

- Trenchless technology equipment is generally very expensive, especially for replacement techniques such as microtunnelling, pipe jacking and pipe bursting which require hydraulic or pneumatic systems.
- Due to the fact that social disruption, traffic disruption, loss of business and public aggravation is drastically minimised, this is cost is translated or absorbed into the rehabilitation works total costs.
- It is typical that trenchless technology contractors can repair, renovate or replace long stretches of sewers in a relatively short time in comparison to the open-cut method.

6.2 Future Needs and Development

Although there has been significant advancement in the trenchless technology abroad, Malaysian engineers seem to be rather apprehensive in adopting it. This can perhaps be altered once Malaysian design professionals are aware of and feel comfortable with trenchless methods. Therefore, design engineers should be exposed to trenchless construction methods as early as possible in their countries. Our Public Works Department (Jabatan Kerja Raya) for example, should conduct seminars and field demonstrations that serve to expose participants to the various trenchless methods available in the market. However, in order for design engineers to be comfortable with trenchless methods, great effort must be made in ensuring that attendees to such seminars include design engineers and not only contractors. Yet another way of exposing design engineers to trenchless methods

is to ensure that the concept of trenchless technology is taught during their formal education process.

Finally, as IWK has not begun any rehabilitation of sewers, this preliminary study warrants further in-depth study and evaluation of the following:

- To assess the suitability of modern rehabilitation methods already available in industrialised and developed countries.
- To assess if the Malaysian sewerage industry should expand its choice of materials used and not only restrict its rehabilitation works and construction of new sewers to vitrified clay pipes and reinforced concrete pipes. It might be viable to conduct trials using materials such as polyethylene and polyvinyl chloride which are more flexible for rehabilitation works, however not as corrosion resistant.

It is also crucial to understand that trenchless technology methods do not eliminate the problems faced by sewers such as collapse, corrosion and inflow etc., however, trenchless techniques are powerful to overcome the traditional problems associated with open-cut methods.

In conclusion, it may be suggested that it may be worthwhile to conduct an independent third party testing program that can provide a basis for comparison and evaluation of various trenchless construction and rehabilitation products available that differ in composition and characteristics.

In the United States for example, the formation of the North American Society for Trenchless Technology (NASTT) in 1990 marked the development of a national level organisation devoted entirely to trenchless technology. NASTT holds annual conferences in the United States covering all aspects of trenchless technology and serves as a clearinghouse for information and industry contacts. A second development that helped bring structure to the industry was the formation of the Trenchless Technology Centre (TTC) at Louisiana Tech University (Ruston, Louisiana) in 1989, which serves as a research centre and a first point of contact for research and information. A third major development was the introduction of a national monthly magazine, *Trenchless Technology* that focuses on trenchless technology for both new installations and rehabilitation.

Therefore, until such a program is in place and established in Malaysia, design engineers and local authorities or municipal councils will always be at a risk. Without doubt, trenchless construction and rehabilitation methods have a bright future full of opportunities in the next century, especially in developing countries. It is therefore up to local design engineers to see that this technology is used where appropriate, as inappropriate use of these methods could risk tarnishing the positive image that the trenchless industry now has achieved.