ACQWS Paper No. 14 Treated Effluent Reuse at Ngong Ping

I. Introduction

At present, there are neither public sewers nor sewage treatment works at Ngong Ping. 1. Sewage generated at Ngong Ping is either tankered away or disposed of through the privately owned septic tank and soakaway systems. In 1998, the Government decided to develop a cable car system linking Ngong Ping and Tung Chung for tourism promotion. It is estimated that the cable car project may attract around 47,000 visitors a day to Ngong Ping. To cater for the increase in sewage generated at Ngong Ping by this project, it is necessary to construct the proposed Ngong Ping Sewage Treatment Plant (NPSTP). The proposed NPSTP will be the first tertiary sewage treatment plant in Hong Kong. The treated sewage effluent (TSE) will be partly reused at Ngong Ping and partly discharged via a pipeline running downhill passing near the Shek Pik Reservoir to the sea at Tung Wan. The proposed NPSTP is now in the construction stage and will be commissioned before the commissioning of the cable car project by Mass Transit Railway Corporation Ltd. (MTRCL) in August 2005. The TSE reuse scheme at Ngong Ping is also scheduled for operation to tie in with the commissioning of the cable car project in August 2005.

2. In the Policy Agenda announced on 8 January 2003, the Chief Executive promulgated the implementation of a Total Water Management Programme with a view to enhancing water conservation and water resource protection. As the TSE produced by the NPSTP is of very high quality, it was decided that a TSE reuse pilot scheme be implemented at Ngong Ping. The aim of the scheme is to provide key information on the technical, financial, legal and environmental issues that have to be addressed before considerations can be given to extending treated effluent reuse to other areas of the territory. To take forward the pilot scheme, an inter-departmental working group comprising ETWB, WSD, EPD, DSD, DH, TDD, AFCD and FEHD was formed under the chairmanship of WSD in January 2003 to oversee the implementation of the TSE reuse proposals.

II. TSE Reuse Pilot Scheme

3. Under the pilot scheme, TSE will be supplied from the proposed NPSTP via a separate TSE distribution system to the 3 public toilets at Ngong Ping and the cable car terminal and related developments for reuse. The reuses include toilet flushing in the public toilets at Ngong Ping and the toilets in the cable car terminal and related developments, and other potential non-potable reuses (such as irrigation, water features, cooling towers, etc.) in the cable car terminal and related developments. Discussions with MTRCL on the types and quantity of TSE that can be reused in the cable car terminal and related developments at Ngong Ping are still underway. MTRCL initially indicated that TSE supplied from NPSTW

would probably have to undergo further treatment to make it suitable for uncontrolled irrigation in the MTRCL areas. A preliminary estimate indicates that about 600 m³/day to 900 m³/day of TSE could be reused at Ngong Ping for flushing toilets. More TSE could be reused if more reuse opportunities such as irrigation, cooling towers, etc. being investigated are proved to be feasible at a later stage. The actual quantity will depend very much on the tourist patronage and the visiting pattern.

III. The Proposed Ngong Ping Sewage Treatment Plant

4. The proposed NPSTP is located at Ngong Ping close to the cable car terminal and falls within the water gathering ground of Shek Pik Reservoir. With a designed capacity of 2,900 m^3 /day, the NPSTP will be capable of handling 2,900 m^3 /day of sewage on holidays and 1,500 m^3 /day on weekdays.

5. A tertiary treatment process is adopted. The TSE water quality standards shown in Table 1 below is adopted for the design of the NPSTP. The major sewage treatment processes adopted include screening, grease removal, grit removal, biological activated sludge process in the form of sequencing batch reactor (SBR) including nitrification and denitrification, tertiary filtration and UV disinfection. The main reason for adopting SBR in the NPSTP is that SBR does not require a continuous operation mode, and hence can have greater flexibility to cope with very high fluctuation in sewage flows at Ngong Ping between weekdays and holidays. Other considerations include factors such as land availability, the level of treatment required, the scale of the plant, local experience and the operation and maintenance cost. An additional chlorination system will be installed to add chlorine to the part of the treated effluent supplied to the public toilets and the cable car development and related developments at Ngong Ping for reuse. The sludge treatment process adopted includes gravity sludge thickening, sludge digestion and sludge dewatering.

6. The TSE supplied from the NPSTP will be reused for toilet flushing without having to go through further treatment as the risk of direct human contact is very low. For uncontrolled irrigation and water features, which have a higher risk of direct human contact, further treatment of the TSE is required based on the California (2001) standards. The primary objective of the California (2001) standards is to produce an essentially pathogens-free TSE i.e. $5-\log_{10}$ virus inactivation and 7-day median total coliform of 2.2 MPN/100 ml, to avoid any additional health risk through human contact. The further treatment processes necessary would likely comprise coagulation and filtration (granular/membrane) followed by chlorine or UV disinfection.

7. It is noted that the Singapore Water Reclamation Plant also produces TSE for reuse. However, the primary objective of their system is to produce raw water to supplement Singapore's potable water supply. The TSE therefore requires very stringent purification and treatment process with advanced dual-membrane (microfiltration and reverse osmosis) and ultraviolet technologies. On the other hand, the TSE at Ngong Ping is primarily targeted for toilet flushing and limited landscape irrigation only. Hence, media filtration instead of microfiltration and reverse osmosis is adopted at the NPSTP.

IV. Water Quality Standards for Various TSE Reuse Purposes

8. For toilet flushing, the primary objective is to provide water aesthetically acceptable to the toilet users with minimum human health risks. The water quality of the TSE produced by the NPSTP will strictly adhere to the limiting standards established in the Environmental Impact Assessment (EIA) Study, in Table 1 below, which are equivalent to the standards applicable for discharging the TSE to the sea at Tung Wan. The bacterial standards are more stringent than the existing standards applicable to seawater for toilet flushing and the bathing water quality objectives of Hong Kong. As there is a minimal risk of direct human contact with the toilet flushing water, the standards are considered appropriate.

Parameter	Limiting Standards
Colour	20 Hazen Unit
Ammonia Nitrogen	1 mg/l
Odour	100 Threshold odour no.
Dissolved Oxygen	2 mg/l
Biochemical Oxygen Demand 5	10 mg/l
Total Suspended Solids	10 mg/l
Turbidity	10 NTU
E.Coli	100 cfu/100ml
Total Residual chlorine	0.5 mg/l
Synthetic detergents	5 mg/l

Table 1
Water Quality Criteria for
Reuse of Treated Effluent for Flushing at Ngong Ping

9. For uncontrolled irrigation, water features (e.g. irrigation of food crops, parks, playgrounds, school yards, residential landscaping, unrestricted access golf course, etc.) and cooling towers, the primary concern is to minimize the potential health risk due to possible direct human contact. As the sewage will have undergone biological treatment with full

ACQWS Paper No. 14 – Treated Effluent Reuse at Ngong Ping

nitrification and denitrification, it should also be acceptable for irrigation purposes [USEPA (1992)]. The standards being proposed at the moment, summarized in Table 2 below, are mainly based on the fundamental principle proposed by USEPA (1992) for irrigation and the criteria adopted by California (2001) for the production of essentially pathogens-free reclaimed water. In fact, this has been widely used elsewhere, e.g. Florida (2001) reported that about 2 million m³/day of reclaimed water has been used with 44% of which has been used to irrigate publicly accessible areas, such as 122,382 residences' properties, 419 golf courses, 405 parks and 188 schools.

Table 2Standards for Uncontrolled Irrigation,Water Features and Cooling Towers

Parameter	Criteria
Turbidity	If Media Filtration is used, it shall not exceed: Average 2 NTU within a 24-hour period
	 S N1U for 5% of the time within a 24-nour period 10 NTU at any time
	 If Membrane Filtration is used, it shall not exceed: ▶ 0.2 NTU for 5% of the time within a 24-hour period ▶ 0.5 NTU at any time
Total Coliform	 7-day median not to exceed 2.2 MPN per 100 mL Not to exceed 23 MPN per 100 mL in more than one sample in any 30-day period. Not to exceed 240 MPN per 100 mL in any sample

10. The water quality standards for uncontrolled irrigation, water features and cooling towers proposed above will be considered and finalized as EP conditions in the future statutory EIA process.

V. Environmental Impact of TSE Reuse at Ngong Ping

11. TSE reuse has the advantage of reducing wastewater discharge in the receiving waterbodies thereby reducing the pollution load to the environment. It also reduces demand on raw water, which is a scarce natural resource deserved for preservation to the maximum extent practicable.

Ordinance (EIAO) and an environmental permit (EP) is required for this usage.

13. Drainage Services Department (DSD) has completed an EIA for the NPSTP and sewerage at Ngong Ping. This EIA was discussed and endorsed by the Advisory Council on the Environment in October 2002. After the public inspection and the Advisory Council on the Environment consultation, the EIA report for the NPSTP and sewerage was approved under the EIAO in November 2002. The relevant EP was granted in March 2003.

14. For the reuse of TSE from the NPSTP for toilet flushing in the public toilets at Ngong Ping, DSD has submitted a Project Profile applying for permission to apply directly for an EP in February 2003. With the consent from the Secretary for the Environment, Transport and Works, the EP was granted with conditions in April 2003. It confirms that the proposed reuse is environmentally acceptable. There should not be any insurmountable environmental problem associated with the proposed reuse as the flushing water will eventually become sewage and collected by sewers leading to the NPSTP for treatment.

15. MTRCL is responsible for conducting the EIA for the proposed TSE reuse for toilet flushing and other potential non-potable uses in the cable car terminal and related developments at Ngong Ping. MTRCL has submitted an EIA report for the cable car project including the proposed treated effluent reuse for toilet flushing, irrigation and water features. The details of MTRCL's TSE reuse proposal have yet to be finalised.

16. In general, the following precautionary measures will be adopted for TSE reuse:

- (a) To avoid cross connection and hence contamination, all pipes and fittings used for the TSE water supply and distribution system should be purple in colour for distinguishing them from the pipes and fittings used for the fresh water supply and distribution systems.
- (b) Regular checking/inspections of the TSE supply and distribution systems for possible cross connection to the fresh water supply and distribution system should be carried out. The use of non-toxic dye may be adopted in the checking/inspections.
- (c) Warning signs should be permanently displayed where public access to TSE is possible (except for toilets) notifying the employees, visitors and the public at large that treated effluent is being used and is not suitable for drinking.
- 17. Ngong Ping is located in the water gathering ground of Shek Pik Reservoir. In

accordance with the Technical Memorandum on Standards for Effluent Discharged into Drainage and Sewerage Systems, Inland and Coastal Water (TM), all discharges in water gathering grounds must comply with the Group A inland waters standards under the Water Pollution Control Ordinance. In addition, the level of total residual chlorine for all discharges to the Group A waters should not exceed 0.2 mg/l. If MTRCL intends to use the TSE for uncontrolled irrigation and water features, further treatment will have to be provided to produce an essentially pathogens-free TSE. WSD will monitor the impacts to the water gathering ground, but this should be minimal.

VI. Public Health Concerns

18. The main health concern with TSE reuse is the small but definite risk of diarrhoeal diseases associated with accidental ingestion of insufficiently treated TSE. With the implementation of precautionary measures set out in paragraph 16 above, and the adoption of stringent health-based water quality standards for the TSE, significant increase in health risk is not expected.

VII. Monitoring Requirements for TSE Reuse

19. The existing communicable disease surveillance system may not be sensitive enough to detect the very small increase in risk for diarrhoeal diseases associated with TSE reuse. However, as the water quality standards for the various types of reuses have been set in a way to offer sufficient protection to public health, monitoring the compliance of the quality of TSE with the required water quality standards at the consumers end should be sufficient as a mean to monitor the impact of TSE reuse on health.

20. For TSE reuse for uncontrolled irrigation and water features, the users will have to carry out continuous turbidity monitoring of the TSE to ensure proper protection to the general public. The TSE should also be sampled at least once daily for coliform analysis. However, as the TSE has gone through tertiary treatment and essentially pathogens free, environmental monitoring requirements, such as groundwater or surface run-off monitoring programme, can be waived. The details of the monitoring requirements will be further formulated when MTRCL finalizes the TSE reuse proposal.

21. The monitoring requirements for TSE reuse proposed above will be considered and finalized as EP conditions in the future statutory EIA process for the cable car project.

VIII. Publicity and Education

22. With a view to arousing public awareness of the TSE reuse scheme and to educating the public on TSE reuse, the TSE reuse pilot scheme will be publicized. The publicity and education programme will include:

- (a) Announcement of the commencement of the pilot scheme through the media.
- (b) Exhibition of information on the tertiary sewage treatment process adopted for NPSTP and the benefits of TSE reuse and the relevant applications in other countries in the education center at NPSTP.
- (c) Inclusion of information of TSE reuse in the educational facilities of MTRCL at the Ngong Ping cable car terminal subject to the agreement of MTRCL.
- (d) Organizing open days for NPSTP and visits to the education center at NPSTP and MTRCL's educational facilities (if they are available) for the public and the school students.
- (e) Production of TSE information pamphlets for distribution to the public.
- (f) Creation of a TSE reuse web page in the homepage of the Government of HKSAR for public access.
- (g) Production of a television documentary on TSE reuse.
- (h) Inclusion of TSE reuse in the school curriculum and holding of seminars especially for teachers, news media and elected officials.
- (i) Preparation of a guideline, drawing on the experience of the pilot scheme at Ngong Ping, for other potential TSE users.

IX. Implementation Programme

23. The NPSTP and the TSE supply and distribution system are scheduled to be commissioned to tie in with the commissioning of the cable car project in August 2005. TSE will then be supplied to the public toilets at Ngong Ping and the cable car terminal and related developments for reuse. Operation and monitoring data will be collected for the purpose of facilitating evaluation of the scheme. An interim review and a full review on the successfulness of the pilot scheme will be conducted 1 year and 2 years after the commissioning of the scheme respectively.

X. Evaluation of TSE Reuse Pilot Scheme

24. The successfulness of the TSE reuse at Ngong Ping under the pilot scheme will be evaluated taking account of the following aspects:

- (a) How best can the scheme help reducing effluent discharge into the environment and the quantity of potable supplies that can be saved by TSE reuse?
- (b) What are the types of reuses that are applied successfully?

- (c) How effective are the sewage treatment processes in producing TSE for reuse?
- (d) How compliant is the TSE to the required water quality standards?
- (e) How suitable are the adopted TSE water quality standards for the various types of reuses at Ngong Ping?
- (f) How cost-effective is TSE reuse as a source of water supply?
- (g) What are the environmental impact associated with TSE reuse?
- (h) How effective does TSE reuse for landscape irrigation help in pollution control?
- (i) What are the users' feedback and how far the public accept TSE reuse at Ngong Ping?

25. Based on the review, consideration will be made on the further studies required to establish the feasibility of extending TSE reuse to other parts of the territory, particularly in areas where the effluent discharge requirements are stringent.

XI. References

- 1. California (2001) "Water Recycling Criteria" California Code of Regulations Title 22, Division 4 Environmental Health, Chapter 3.
- 2. Florida (2001) "Reuse Inventory Report", Department of Environmental Protection.
- 3. USEPA (1992) "Manual Guidelines for Water Reuse" U.S. Environmental Protection Agency. Office of Water Office of Wastewater Enforcement and Compliance Washington DC.