6 Sewerage Impact Assessment

6.1 Introduction

This preliminary Sewerage Impact Assessment (SIA) is carried out to assess the impact arising from proposed population intake for the Kwu Tung North (KTN) and Fanling North (FLN) NDAs. The assessment establishes the additional sewerage requirements and how these can be accommodated, as well as an assessment of the adequacy of the existing sewerage network to convey the flows from the NDAs to the existing/new sewage treatment facilities. Recommendations on the land requirements for new sewage treatment works (STW) and upgrading works to the sewerage network are also included.

The development includes a planning area of approximately 450 ha at KTN and 164 ha at FLN. The NDAs will accommodate a total residential population of approximately 178,995 and employment of 37,718 including GIC employment. KTN NDA will accommodate a residential NDA population of approximately 105,545 and employment of 31,204. FLN NDA will accommodate a residential population of approximately 73,450 and employment of 6,514. A summary of the NDAs estimated population and employment figures is presented in **Table 6.6**. The overall development parameters are included in **Appendix 6.1**.

The first population intake within proposed NDAs is expected in 2023.

6.2 Methodology and Design Criteria

6.2.1 Methodology

Objectives and Procedure

The following section summarises the objectives of the SIA and procedure of assessment are shown as follows:

- To outline the requirements for additional sewage treatment to support the developments of NDAs, including standards to comply with current discharge policy;
- To assess the available capacities in the existing facilities, including committed works, for sewage treatment and of the sewerage system, and to determine whether there are spare capacities to support the new developments;
- To outline, the sewerage system requirements, i.e. sewers, pumping stations, rising mains, etc;
- To recommend appropriate mitigation measures;
- Establish land requirements.

Relevant Guidelines

The assessment has been carried out in accordance with the guidelines set out in EPD Report No. EPD/TP 1/05 Guidelines for Estimating Sewage Flows (GESF) for Sewerage Infrastructure Planning Version 1.0.

6.2.2 Design Criteria

The criteria are based on EPD's report on GESF. The main relevant criteria are detailed below:

Unit Flow Factors – Domestic Flows

The unit flow factors for domestic flows from residential developments will be in accordance with EPD's GESF and are shown in **Table 6.1**.

Table 6.1 Unit Flow Factors for Domestic Flows

Domestic	Unit Flow Factor (m^3/person/day)
CDA	0.370
G/IC	0.190
PRH	0.190
HOS	0.190
R1	0.190
R2	0.270
R3	0.370
R4	0.370
RR4	0.370
V/VR/AGR	0.270

Notes: (1) For "CDA" with residential development at KTN in this study, Type R3 unit flow factor is adopted.
(2) For "G/IC" with residential development at KTN in this study, Type R1 unit flow factor is adopted.
(3) For "RR4" at KTN in this study, Type R3 unit flow factor is adopted.
(4) The relevant unit flow factor for use in estimating sewage flows for "V" is assumed resembles that for Modern Village.

Unit Flow Factors - Commercial and Institutional Flows

The unit flow factors for commercial and institutional flows due to commercial activities and employed population will be in accordance with EPD's GESF and are shown in **Table 6.2**.

The total unit flow generated from an employee in a particular trade is the sum of the unit flow factor of the employee and the unit flow factor of commercial activities of a particular trade under consideration.

To derive the unit flow factor for visitors, it is assumed that visitors will be staying maximum 8 hrs per day within the development site. The sewage flow will be from two sources, one from flushing and the other from use of wash basin. The unit flow factors from flushing use, has assumed flushing

water consumption of $0.1m^3$/person/day for 16 hours of typical domestic residents, employees and students usage. The unit flow factor from the wash basin use has assumed a consumption of $0.03m^3$/person/day on 8 hours daily basis. This results in UFF of 0.08m3/person/day.

Table 6.2 Unit Flow Factors for Commercial and Student Flows

Commercial	**Unit Flow Factor (m^3/h/d)**
Commercial Employee	0.080
Commercial activities	
(a) Specific trades:	
J2	0.250
J3	0.100
J4	0.200
J5	-
J6	-
J7	-
J8	-
J9	0.150
J10	1.500
J11	0.200
J12	-
(b) General – territorial average	0.200
School student	0.040
Visitor	0.080

Catchment Inflow Factors

The Catchment Inflow Factors (P_{cif}) cater for the net overall ingress of water or waste water to the sewerage system. They are catchment-dependent and applicable to major sewerage facilities of a catchment. They are not applicable to new catchments which are deemed to be free from misconnections and pipe defects. Therefore, the P_{cif} are not applicable in estimating the total flows from the new development areas.

Peaking Factors

Peaking factors cater for seasonal/diurnal fluctuation and normal amount of infiltration and inflow. The peaking factors shall be in accordance to EPD’s GESF and are shown in **Table 6.3**.

Under normal condition, peaking factors (excluding stormwater allowance) are applicable to planning sewerage facilities receiving flow from new upstream sewerage systems which essentially have no misconnections and defects for infiltration.

If the service conditions of the upstream sewerage systems for the planning horizons under consideration are unclear, peaking factors (including stormwater allowance) shall be used. For the design purpose, the peaking factors (including stormwater allowance) shall be used.

Table 6.3 Peaking Factors for Various Population Ranges

Population Range	Peaking Factor (including stormwater allowance) for facility with existing upstream sewerage	Peaking Factor (excluding stormwater allowance) for facility with new upstream sewerage
Sewers		
< 1,000	8	6
1,000 – 5,000	6	5
5,000 – 10,000	5	4
10,000 – 50,000	4	3
> 50,000	Max (7.3/N0.15 , 2.4)	Max (6/N0.175 , 1.6)
Sewage Treatment Works, Preliminary Treatment Works and Pumping Stations		
< 10,000	4	3
10,000 – 25,000	3.5	2.5
25,000 – 50,000	3	2
> 50,000	Max (3.9/N0.065 , 2.4)	Max (2.6/N0.065 , 1.6)

Note:
N = Contributing population in thousands.

$$\text{Contributing population} = \frac{\text{Calculated total average flow (m?day)}}{0.27\text{(m?day)}}$$

Unit Load Factors

The global unit load factors used to estimate the sewage loading from the proposed developments are as referred in Table 4 of Sewage Manual Part 1 and are listed below in **Table 6.4**:

Table 6.4 Summary of Adopted Unit Load Factors

Trades	Unit	Suspended Solid SS (kg/d)	Biological Oxygen Demand BOD (kg/d)	Chemical Oxygen Demand COD (kg/d)	Total Kjeldahl Nitrogen TKN (kg/d)	Ammonia Nitrogen NH3 N (kg/d)	E. Coli (no./d)
Domestic (Residential)	Person	0.04	0.042	0.09	8.5x10^{-3}	5 x10^{-3}	4.3x10^{10}
Commercial[1]	Employee	0.059	0.087	0.173	9.2x10^{-3}	4.8 x10^{-3}	3.5x10^{10}
Schools[2]	Person	0.034	0.034	0.07	6.7x10^{-3}	4 x10^{-3}	3.5x10^{10}
Public and	Person	0.04	0.042	0.09	8.5x10^{-3}	5 x10^{-3}	4.3x10^{10}

[1] Unit Load Factors (Commercial) is the sum of Unit Load Factors for commercial activities and employed population.
[2] Unit Load Factors of Schools is the Unit Load Factor of employed population.

Trades	Unit	Suspended Solid SS (kg/d)	Biological Oxygen Demand BOD (kg/d)	Chemical Oxygen Demand COD (kg/d)	Total Kjeldahl Nitrogen TKN (kg/d)	Ammonia Nitrogen NH3 N (kg/d)	E. Coli (no./d)
Private Housing[3]							
Village Sewerage Connection[4]	Person	0.04	0.042	0.09	8.5×10^{-3}	5×10^{-3}	4.3×10^{10}

6.3 Existing and Planned Sewerage Infrastructure

The majority of the study area falls within the sewage catchment boundary of SWH STW. The existing main sewage treatment works (STWs) within and in the vicinity of Study Area is presented in **Figure 6.1**. Under the present condition there is very limited sewerage infrastructure to serve the proposed NDAs such as Western Trunk Sewer within the vicinity of KTN NDA. The location of existing sewerage system including rising main and pumping station is shown in **Figure 6.1**.

The sewerage works have been proposed under the following package within the vicinity of proposed NDAs and they are summarized in **Table 6.5**.

Table 6.5 Sewerage Improvement Works in Study Area

PWP Item/Ref.	Project Description	Tentative Programme
CE40/2012 (DS)	Shek Wu Hui Sewage Treatment Works – Further Expansion Phase 1A	3/2015 – 3/2021
4061DR	North East New Territories Village Sewerage Phase 2	01/03 – Mid/14
4345DS	North District Sewerage Stage 2 Part 2A	Mid/14 – Mid/20

However, these planned sewerage works are not designed to cater for additional flow generated from the proposed NDAs developments. The proposed SWH STW – Further Expansion Phase 1A under CE40/2012 (DS) is planned to cater for the additional flow generated from local developments and extension of village sewerage.

3 Unit Load Factors of Public and Private Housing is the Unit Load Factor of residential population.
4 Unit Load Factors of Village Sewerage Connection is the Unit Load Factor of residential population.

6.4 Review of Findings under Previous NENT Study

In order to cater for additional sewage flows from NDAs, the previous study recommended expansion of SWH STW for the flows from NDAs and also for the flows from the base growth within the existing sewage catchment areas.

Furthermore, the sewage flow from KTN NDA was proposed to be conveyed to SWH STW via a rising main to be laid along the maintenance road of Sheung Yue River. The flow from FLN NDA was proposed to be conveyed to SWH STW through existing sewerage system and also a new sewerage system which require upgrading of Ma Sik Pumping Station.

6.5 Estimation of Sewage Flows

6.5.1 New Development Areas (NDAs)

The development parameters for the NDAs at KTN and FLN are included in **Appendix 6.1**. A summary of the population and employment figures for the NDAs is presented in **Table 6.6**.

Table 6.6 Summary of Population and Employment Projections for NDAs

New Development Area	Population	Employment (including GIC employment)
KTN	105,545	31,204
FLN	73,450	6,514
Total	178,995	37,718

In order to reserve some spare capacity for the proposed government reserves in both the proposed sewerage system and sewage treatment works, further planning assumptions are made and presented in **Appendix 6.2**.

The estimated sewage flow based on the development parameters is detailed in **Table 6.7** and has been estimated based on the unit flow factors contained in **Section 6.2**. As shown in the table, the total daily flow from the NDAs is 51,507 m^3/day approximately. The detailed breakdown of the sewage flows for individual sites are contained in **Appendix 6.3**.

Table 6.7 Total Sewage Daily Flow Estimate for NDAs

New Development Area	Residential ADWF (m^3/d)	Commercial and Institutional ADWF		Hotel ADWF (m^3/d)	Others* (m^3/d)	Total ADWF# (m^3/d)
		Com-mercial (m^3/d)	School places (m^3/d)			
KTN	23,362	8,711	503	194	951	33,722
FLN	14,874	1,836	364	0	710	17,785
Total ADWF	38,237	10,548	867	194	1,661	51,507

Remarks
* Sewage flows from existing and proposed facilities that are covered by the supplementary development parameters, e.g. government reserve.
# Value of total ADWF might not be the same as the value of sum of individual ADWF due to rounding error.

In order to estimate the additional sewage treatment capacity required for the proposed expansion and upgrading of the SWH STW, the following should be taken into account:

- NENT NDA developments;
- Developments within Frontier Closed Area;
- Sheung Shui Abattoir;
- Poultary Slaughtering House;
- Local developments within the existing sewage catchment of SWHSTW
- Police Training School and Borders Divisional Police Headquarters;
- Extension of NENT Landfill;
- Allowances for base growth, within the sewerage catchment; and
- Spare capacity catered for uncertainty in population projection within the sewerage catchment.

6.5.2 Implementation of Further Expansion of Shek Wu Hui Sewage Treatment Works

The capacity of SWH STW would be increased from 93,000 m^3/d to 133,000 m^3/d under SWHSTW - Further Expansion Phase 1A. The proposed expansion and upgrading works required for the new development areas will be referred to as the Phase 1B and Phase 2 works. In order to assess the additional sewage treatment requirements, an estimate of the existing and future sewage flow to the SWHSTW has been carried out.

Based upon sewage flow estimation from EPD, the preliminary estimate of sewage flow to SWH STW including the flows from

public and private housing and village sewerage collection for year 2021 and 2031 are approximately 126,000 m³/d and 131,001 m³/d respectively without any flows from NDAs. A summary of the estimated flows from the existing development within the sewerage catchment of SWHSTW for 2011, 2016, 2021, 2026 and 2031 based on the figures provided by EPD are presented below in **Table 6.8**.

Table 6.8 Estimate of Sewage Flows within Proposed Sewage Catchment Area (SCA) of SWH STW Based on Figures from EPD without any flows from NDAs

Category	Flow (m³/d)				
	2011	2016	2021	2026	2031
Baseline Flow Projection	90,800	94,000	96,000	101,200	103,407
Public and Private Housing	0	2,400	12,500	10,600	10,646
Village Sewerage Connection	0	3,000	17,500	16,800	16,948
Total	90,800	99,400	126,000	128,600	131,001

The sewage flow from KTN NDA and FLN NDA are proposed to be conveyed to SWHSTW. The SWHSTW- Further Expansion Phase 1B and Phase 2 are proposed to upgrade the capacity of SWHSTW to 153,000 m³/d and 190,000 m³/d respectively. The breakdown of the sources of flows contributing to the SWH STW is shown as follows. The sewage flow built-up at SWHSTW is shown in **Appendix 6.4**.

Table 6.9 Summary of Sewage Flows to SWH STW in Year 2031

Sources	Flow (m³/d)
KTN NDA	33,722
FLN NDA	17,785
Base Line Flow + Natural Growth in 2031*	103,407
Public and Private Housing*	10,646
Village Sewerage Connection*	16,948
Extension of NENT Land fill	1,200
Spare Capacity	6,292
Total	**190,000**

*Sewage Flows Estimation from EPD.

A preliminary construction programme of the further expansion of SWHSTW under different Phases and the resulting capacity enhancement is shown as follows.

6.6 Effluent Quality and Discharge Standards of SWH STW

The SWH STW- Further Expansion will increase the effluent flow from 93,000 m^3/day to 190,000 m^3/day by 2031. The effluent from the expanded SWHSTW is proposed to be discharged to the nearby rivers which flow to the Deep Bay through Shenzhen River. In order to comply with the prevailing water quality policy to ensure no net increase in pollution load to Deep Bay, the total effluent pollution load from proposed STW within the same sewerage catchment and the SWHSTW with expansion works is required to be no more than the existing loads discharging to Deep Bay. The effluent standards which meets both EIAO and no net increase in pollution load to the deep bay policy, assuming no effluent reuse scheme, are presented in **Appendix 6.7** and described in section below.

6.6.1 Compliance to "No Net Increase in Pollution Load"

In order to comply with 'No net increase in pollution loads requirement in Deep Bay' policy, the sewage from SWH STW shall be set to a more stringent standard, and the residual pollutant load from Lok Ma Chau (LMC) Loop development shall be compensated off-site at SWHSTW.

It has been agreed in-principle with the Authority that the three key pollutant parameters namely 5-day biological oxygen demand (BOD_5), total nitrogen (TN) and total phosphorous (TP) are bounded by the "no net increase in pollutant load" requirement. In considering the similar treatment method and domestic influent characteristics for both LMC on-site STW and SWHSTW, the effluent component in various parameters would be comparable. Given that 3 parameters, BOD_5, TN and TP, were calculated in the compliance to "no net increase in pollution load" policy, same compliancy is also anticipated to other parameters such as suspended solids (SS) and E coli. In addition, SS and *E coli* will not contribute algal bloom and will be reduced by settling and degrading. Adverse impact on the receiving water bodies (ie Shenzhen River) due to SS and *E coli* is not anticipated. The discharge limits of pollutants other than BOD_5, TN and TP shall make reference to those for Group B inland waters under Table 4 of the Technical Memorandum - Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters, the Water Pollution Control Ordinance (Cap 358).

Bases and Assumptions

Further expansion of SWHSTW has been studied by EPD under Tender Ref SI 10-120 and it has been proposed in the

study that SWHSTW shall be expanded and upgraded to tertiary treatment adopting membrane bioreactor (MBR) technology, in phases since 2015, to reach the ultimate capacity to 190,000m^3/day average dry weather flow (ADWF) to cater for the projected natural growth and planned sewage from village and public/private housing, as well as the NENT-NDAs development at KTN and FLN. The proposed phasing of SWHSTW further expansion of concern to LMCL developments since the first population intake in 2023 is given in **Table 6.10** below (source of information: EPD Tender Ref SI 10-120 Revised Outline Design Report, July 2012). During all interim years of SWHSTW further expansion, the available capacity of tertiary treatment shall be utilised first for treating the incoming sewage and any excess quantity will receive secondary treatment by existing facilities. It shall be noted that Phase 1A of the further expansion works of SWHSTW is planned to commence in 2015 and should proceed independent from the NENT-NDAs development.

Table 6.10 Phasing of SWHSTW further expansion in relation to NENT-NDAs and LMCL developments

Year	Secondary Treatment Capacity (m^3/day)	Tertiary Treatment Capacity using MBR (m^3/day)	Total Capacity (m^3/day)
2020	53,000	80,000	133,000
2021	53,000	80,000	133,000
2022	53,000	80,000	133,000
2023	40,000	113,000	153,000
2024	40,000	113,000	153,000
2025	20,000	141,500	161,500
2026	20,000	141,500	161,500
2027	0	170,000	170,000
2028 Ultimate	0	190,000	190,000

Baseline for offsetting. As a conservative approach, the baseline pollutant load only considers the existing capacity and the projected natural sewage growth within the catchment of SWHSTW, totalling 113,000m^3/day ADWF. The prevailing stringent effluent standards of 20mg/L BOD_5, 15mg/L TN and 5mg/L TP are adopted as the pollutant concentrations. The SWHSTW effluent discharge flowrate together with pollutant concentrations form the baseline of pollutant discharges into Deep Bay (in kg/day) for offsetting.

Development programmes and treatment level

For the new sewage infrastructure namely LMCLSTW the tertiary treatment standard using MBR technology is adopted.

The combined pollutant loads being discharged from LMCLSTW and SWHSTW shall not exceed the baseline pollutant quantities. A summary of planned effluent discharge concentrations from these STWs and the development programmes are given in **Table 6.11** and **Table 6.12** below respectively.

Table 6.11 Phasing of SWHSTW further expansion in relation to NENT-NDAs and LMC Loop developments

Sewage Infrastructure	SWHSTW (baseline for offsetting)	LMCLSTW	SWHSTW (further expanded)
Capacity (m^3/day ADWF)	113,000	18,000	190,000
Effluent BOD_5 (mg/L)	20	5	10
Effluent TN (mg/L)	15	8	8
Effluent TP (mg/L)	5	1	1
BOD_5 Load (kg/day)	2,260	Not to exceed 2,260	
TN Load (kg/day)	1,695	Not to exceed 1,695	
TP Load (kg/day)	565	Not to exceed 565	

Table 6.12 Development programmes for NENT-NDAs and LMC Loop

Year	**LMCL**	**NENT-NDAs**
2020	SWH STW further expansion under Phase 1A completed	
	First population intake	-
2023	-	First population intake of FLN and KTN NDAs
2025	Full development scenario	-
2031	-	Full development scenario
Ultimate	LMCLSTW @ full capacity	SWHSTW @ full capacities

6.6.2 Proposed Effluent Discharge Standards

The set of proposed effluent discharge standards is shown in **Table 6.13**. The proposed standards for effluent reuse (non-potable purposes) namely toilet flushing, landscape irrigation and make-up water for district cooling system (DCS) are recommended in the “Working Group on the Implementation of Reclaimed Water Supply in Sheung Shui and Fanling” and given in **Table 6.14**.

Table 6.13 Summary of Projected Influent Quality and Proposed Discharge Standards for SWH STW

	TSS (mg/L)	BOD (mg/L)	COD (mg/L)	Nitrogen (mg/L)	TP (mg/L)	NH3N (mg/L)	E.Coli (no. / 100mL)
Projected Pollutant Concentration	180	204	428	36	NA	21	1.8E+07
SWH STW Influent	423 420 (Design)	317 320 (Design)	790 790 (Design)	48 as Nitrogen 48 (Design)	NA	26 26 (Design)	- 1.9E+07 (Design)
Existing SWHSTW Effluent Standard (95th percentile)	30	20	NS	12 (as NO_3-N and NO_2-N)	6.2	2	1,500
Proposed Future SWHSTW Effluent Standard (95th percentile)	10	10	NS	8 (as Total N)	1	1.9	1500

Note: 1. except E. coli, maximum standard is 2 x 95th percentile standards;
2. E.coli monthly geometric mean standard is 100 count / 100mL.
NS: not specified. NA: not available.

Table 6.14 Summary of Proposed Reclaimed Water Quality for non-potable uses within NENT-NDAs and Fanling/Sheung Shui areas

Water Quality Parameter	Unit	Recommended Standard for Flushing, Landscape Irrigation and DCS Make-up
E. Coli	cfu/100mL	Not detectable
Total residual chlorine (TRC)	mg/L	≥1 (out of treatment system) ≥0.2 (at point-of-use)
Dissolved oxygen (DO)	mg/L	≥2
TSS	mg/L	≤5
Colour	HU	≤20
Turbidity	NTU	≤5
pH	-	6 – 9
Threshold odour number (TON)	TON	≤100
BOD_5	mg/L	≤ 10
Ammonia nitrogen	mg/L	≤1
Synthetic detergents	mg/L	≤5

6.7 Sewage Treatment in Shek Wu Hui Sewage Treatment Works

6.7.1 Introduction

The existing SWH STW provides treatment to the wastewater generated from Fanling/Sheung Shui areas before discharging it into Mai Po Inner Deep Bay Ramsar Site through Ng Tung River and Shenzhen River.

The treatment capacity of SWH STW had been increased from an Average Dry Weather Flow (ADWF) of 80,000 m^3/day to 93,000 m^3/day after a recent upgrading that was completed in 2009. The existing layout of SWH STW is presented in **Figure 6.2**. To treat the projected ADWF flow in 2031, an increase in SWH STW treatment capacity of 97,000m^3/day is necessary after discussion with EPD and DSD[5].

Alternative sites for expansion were considered and described in **Chapter 2**.

In order to comply with the prevailing water quality policy to ensure ‘no net increase in pollution load to Deep Bay’, the treated water quality of effluent from SWH STW should be enhanced to ensure no net increase in waste-load discharged from the SWH STW to the Deep Bay.

6.7.2 Load Projection

According to **Table 6.8**, the projected flow within Existing Sewage Catchment Area (SCA) at SWH STW for years 2016, 2021, 2026 and 2031 are steady and thus, the projected loads from 2016 to 2031 for SWHSTW are steady as well. The following table shows the projected loads in year 2031 for the SWHSTW - Further Expansion. The load projection is based on the Unit Flow and Load Factors in **Section 6.2.** The loadings from FLN & KTN NDAs, and other proposed/planned developments are included in the projected loading.

Since the main development at FLN and KTN NDAs is mainly residential development, the projected concentration in the future collected wastewater is therefore lower than the pollutant concentration in the existing SWHSTW influent as shown in **Table 6.15**. Conservatively, the pollutant concentrations found in the existing SHWSTW influent are used in designing the treatment facilities.

[5] Meeting amongst EPD/DSD/WSD/CEDD/PlanD/AECOM/Arup on 30 January 2013 refers.

Table 6.15 Summary of Total Projected Pollutant Loading for SWH STW in Year 2031

Load						
Parameter	**Nitrogen**	**BOD**	**TSS**	**COD**	**NH_3N**	**E.Coli**
Unit	kg/d	kg/d	kg/d	kg/d	kg/d	no./d
Domestic						
(KTN)	1,060	5,238	4,988	11,223	624	5.4E+15
(FLN)	511	2,524	2,404	5,409	300	2.6E+15
(Public and Private Housing)	335	1,656	1,577	3,549	197	1.7E+15
(Village Sewerage Connection)	534	2,636	2,511	5,649	314	2.7E+15
Commercial	444	4,201	2,849	8,354	232	1.7E+15
School Student	107	544	544	1,120	64	5.6E+14
Grand Total	2,991	16,799	14,873	35,304	1,731	1.5E+16
Projected Pollutant Concentration by 2031	**33 (mg/L)**	**188 (mg/L)**	**166 (mg/L)**	**394 (mg/L)**	**19 (mg/L)**	**1.6E+07 no./100mL)**
SWH STW Influent*	**48 (mg/L)**	**317 (mg/L)**	**423 (mg/L)**	**790 (mg/L)**	**26 (mg/L)**	**1.9E+07 (no./100mL)**

* The average influent quality at SWH STW.

6.7.3 Unit Treatment Process Alternatives

Alternative processes were evaluated in the NENT-NDAs study as summarised in the following:

Secondary Treatment

- Continuous Flow Activated Sludge Process;
- Sequencing Batch Reactors (SBRs);
- Biological Aerated Filters (BAFs); and
- Membrane Process.

BAFs were not selected due to their higher capital and operating costs, and were usually used only when the site under consideration is severely restricted. SBRs was not selected as it is not comparable to the existing process. The continuous flow activated sludge process was selected due to the consideration of using suitable conventional treatment process with local operational experience and do not require a pilot test and would be equally able to achieve the required effluent discharge standards.

The main factors considered for secondary treatment include:

- Operating experience;

- Land requirements;
- O&M requirements;
- Disruption to the existing STW operation;
- Compatibility to the long-term effluent export scheme, and
- Environmental impact.

6 sites options for the expansion of SWHSTW were considered and the site adjacent to the existing SWHSTW (FLN A2-3) is considered the most suitable option as described in **Chapter 2**. In addition, effluent quality should be further tightened in order to meet the "no net increase in Deep Bay water" policy, and TSE reuse is being actively considered for application for the proposed development. Under such constraints, the option evaluation is biased towards land requirements and effluent quality. It has been deliberated that compact treatment technologies would be considered. With reference to an earlier feasibility study conducted by EPD under Tender Ref SI 10-120, membrane processes adopting membrane biological reactor (MBR) has been recommended and the preliminary process design, feasibility and layout have been developed which shall be adopted for this EIA. Having said that, an investigaion study is being conducted under DSD CE40/2012 (DS) SWH STW – Further Expansion Phase 1A, for which the eventual treatment process technology(ies) and layout to be adopted for SWHSTW might subject to further refinement and improvement.

6.7.4 SHWSTW Expansion Design

The layout plans for further expansion of SWH STW have been developed for the collection, treatment and disposal of additional sewage from proposed NDAs. A preliminary layout plan of extension of SWH STW was shown in **Figure 6.3** which is based on an earlier feasibility study conducted by EPD under Tender Ref SI 10-120. The eventual treatment process technology(ies) and layout to be adopted for SWHSTW might subject to further refinement and improvement, which is currently being undertaken by DSD investigation study of SWHSTW Further Expansion Phase 1A under CE40/2012(DS).

6.7.5 Sludge Generation and Treatment

The screening, grit and sludge will be dewatered to a minimum solid content of 30% weight/weight (w/w) for final disposal to the landfill or Sludge Treatment Facilities (STF). The projected sludge generation from the additional 97,000 m^3/d wastewater flow is summarized below in **Table 6.16**:

Table 6.16 Summary of Projected Sludge Generation from SWH STW

	Projected Sludge Flow (m^3/d)	Dry Solids (% w/w)	Note
Primary sludge	1,017	1.6	65% TSS removal
Surplus activated sludge (SAS)	7,620	0.25	
Thickened primary sludge	407	4	85% solid captured in thickener
Thicken SAS	476	4	90% solid captured in DAF
Combined thicken sludge	883	4	
Digested Sludge	883	2	40% solid reduction
Dewatered Sludge	59	30	

6.8 Kwu Tung North NDA

6.8.1 Baseline Conditions

Construction of Western Trunk Sewer (WTS) along the Fanling Highway from Yin Kong to the junction with Po Shek Wo Road was completed under North District Sewerage Stage 1 Phase 1. This trunk sewer is designed to convey flows from the Kwu Tung area, including the existing villages at Ho Sheung Heung, Tsung Yuen, Kam Tsin, Yin Kong, Tsung Pak Long, Tai Tau Leng and Hang Tau, to the trunk sewer at Fanling which connects to SWH STW. The WTS also includes three pumping stations P11, P12 & P13. Layout of WTS is shown on **Figure 6.1**.

The construction of village sewerage connecting to the WTS was also scheduled to be carried out as part of the North District Sewerage Stage 1 Phase 1. However, village sewerage works to Hang Tau, Ho Sheung Heung, Tsung Yuen and Kam Tsin were not completed under North District Sewerage, stage 1 phase 1 due to strong objection and other technical problem. Village sewerage works for Ho Sheung Heung, Tsung Yuen and Kam Tsin are now included in 4345DS – North District sewerage stage 2 part 2A.

In order to minimize the pumping cost, it is proposed to convey sewage generated from proposed development from the east of Sheung Yue River as part of KTN NDA to SWH STW via WTS.

6.8.2 Sewerage Impacts

A new sewerage system and additional sewage treatment facilities will be required to support KTN NDA. The population and employment figures for KTN NDA will be approximately 105,545 and 31,204 respectively. The estimated total daily flow from KTN NDA is 33,722 m³/d. Refer to **Table 6.7** and **Appendix 6.3** for a breakdown of the estimate. As recommended in **Section 6.5**, the existing SWH STW is proposed to be expanded and upgraded to accommodate the additional sewage flow generated from KTN NDA, FLN NDA and other surrounding developments including in Frontier Closed Areas. Based upon latest proposals, existing SWHSTW would retrofit for future expansion and upgrading works.

The newly constructed WTS has not been designed to cater for major development at Kwu Tung and therefore has no allowance for the NDA. The WTS has been designed for a population of approximately 19,000 from Kwu Tung. A new trunk sewerage system will therefore be required to convey the flows from the KTN NDA to the SWH STW. However, it is proposed to convey sewerage generated from proposed development from the east of Sheung Yue River as part of KTN NDA to SWH STW via WTS. Apart from this, sewage flow from west of Sheung Yue River such as Ho Sheung Heung village and others should be intercepted at proposed sewage pumping station (SPS) in KTN NDA and pumped to expanded SWHSTW. This would create spare capacity in WTS which can be used to convey sewage flows from proposed development in KTN NDA in east of Sheung Yue River.

6.8.3 Proposed Sewerage Including Improvement and Mitigation Measures

A new sewerage network will be required to support the development within the KTN NDA. **Figure 6.4** shows the preliminary layout of the proposed sewerage system for KTN NDA. The hydraulic calculation of the sewerage system was presented in **Appendix 6.5**. Hydraulic assessment using software “InfoWorks” was also conducted and the result was presented in **Appendix 6.6**. Gravity sewers will be provided within the NDA connecting to a proposed sewage pumping station (SPS) at the eastern side of the KTN NDA adjacent to the Sheung Yue River.

The proposed sewage pumping station within KTN NDA will pump flows via a twin 900 mm dia. rising main to the SWH STW with single rising main able to convey design peak flows. The rising main will be routed along the footpath/cycle track adjacent to the west bank of Sheung Yue River, cross

underneath the Sheung Yue River by means of pipe bridge, along the footpath/cycle track adjacent to the west bank of Shek Sheung River, cross underneath the Shek Sheung River and the railway track of MTRC by means of pipe jacking, and connect to the inlet works of expanded/upgraded SWHSTWs. The rising main scheme is subject to refinement depending upon further discussion with DSD and MTRC.

Apart from this main pumping station in KTN NDA, one pumping station will also be required to pump the sewage from northern side of the development.

Sewage septicity control measures shall be considered for the proposed SPSs and rising mains as follows. For SPSs and rising mains serving new development areas, they have to be completed and commissioned early on in the development but it can be years before they receives the design flow from full occupancy of the site. This results in low flows entering the wet well and long retention times in the rising main give the opportunity for bacteria to multiply in the anaerobic conditions in which formation of Hydrogen Sulphide would occur. Non-dosing solutions should be considered in prior to dosing solutions.

Non-dosing solutions:

- Direct injection of oxygen into the rising mains;
- Pre-aeration in the wet well of the pumping stations;
- Wet well sumps can be profiled to form a low-flow inner sump thus reducing the volume of sewage retained between pump starts;
- Impellers on pumps can be changed to increase the pumping capacity as the incoming flow increases due to the increased occupancy of the development.

Non-dosing solutions:

- Addition of controlled dosage of nitrate solution.

At this preliminary stage, direct injection of oxygen into the rising mains and pre-aeration in the wet well of the pumping stations are adopted as the sewage septicity control measures with details to be addressed in the detailed design stage.

6.8.4 Drainage Reserves

Drainage reserves will be required where sewers cross through existing land or new development areas. Drainage reserves are not usually required where sewers are routed along roads and footways. In accordance with the Sewerage Manual, the width of a reserve should be determined from the requirements for working space, vehicular access for

construction plant, depth of sewer and clearance from adjacent structures and foundations. In general, a width of 6m plus the outer diameter of the pipeline is recommended.

As proposed twin rising main from SPS to SWHSTW will be laid along the cycle track on west of Sheung Yue River and therefore no drainage reserve will be required. However, there are drainage reserves for the proposed sewers running through open space, i.e. KTN A1-10 and KTN B2-9.

6.8.5 Implementation

The development will be constructed in phases to support the first intake of population targeted in 2023. In order to support the first population in-take, the SWH STW - Further Expansion, the new trunk sewers, sewage pumping stations and rising mains connecting to the SWH STW will need to be completed prior to first population intake. The construction of trunk sewer will be carried out as part of road works. The additional sewage treatment facilities, that are the SWH STW Phase 2 works, will also need to be in place to support the first population in-take.

6.9 Fanling North NDA

6.9.1 Baseline Conditions

The existing sewerage system in the north district of the Study Area was assessed under the Review of North District and Tolo Harbour Sewerage Master Plan (SMP) Study and a number of sewerage improvements works have been recommended. The existing sewerage layout in Fanling and Sheung Shui is shown on **Figure 6.1**.

It can be seen from **Figure 6.1** that the FLN NDA is currently unsewered as the area is not developed and mainly located on the flood plain of the Ng Tung River.

6.9.2 Sewerage Impacts

The population and employment figures for FLN NDA will be approximately 73,450 and 6,514 respectively. The estimated sewage flow from FLN NDA is 17,785 m^3/d. A summary of the estimate is included in **Table 6.7** and detailed breakdown in **Appendix 6.3**.

A trunk sewer is proposed along the proposed main road which will connect to SWH STW - Further Expansion Phase 2. Based upon the preliminary estimate, the diameter of the trunk sewer will range from 600mm to 900mm.

Further to proposed retrofitting of existing SWHSTW for future expansion/upgrade, the proposed trunk sewer from FLN NDA

will be routed along the Po Wan Road and Chuk Wan Street to the inlet works at STWs.

6.9.3 Proposed Sewerage Including Improvement and Mitigation Measures

Figure 6.5 shows the preliminary schematic layout of the proposed sewerage system for FLN NDA. The hydraulic calculation of the sewerage system was presented in **Appendix 6.5**. Hydraulic assessment using software “InfoWorks” was also conducted and the result was presented in **Appendix 6.6**.

In order to avoid interfacing with existing sewerage system and to avoid upgrading, a new trunk sewer will be laid along the main road which will eventually discharge to SWH STW Phase 2 works near the Po Wan Road.

Similar to KTN NDA, the sewage flow from the development at FLN NDA will be conveyed to the SWH STW for sewage treatment and disposal. The details of SWH STW - Further Expansion are discussed in **Section 6.7**.

As mentioned in **Section 6.8.3**, direct injection of oxygen into the rising mains and pre-aeration in the wet well of the pumping stations are adopted as the sewage septicity control measures with details to be addressed in the detailed design stage.

6.9.4 Drainage Reserves

Drainage reserves will be required where sewers cross through existing land or new development areas. Drainage reserves are not usually required where sewers are routed along roads and footways. In accordance with the Sewerage Manual, the width of a reserve should be determined from the requirements for working space, vehicular access for construction plant, depth of sewer and clearance from adjacent structures and foundations. In general, a width of 6m plus the outer diameter of the pipeline is recommended.

Based upon the preliminary layout, the sewerage within FLN NDA will be mainly laid along the main road and footpaths. However, there shall be sewers lying along open spaces and drainage reserves are required.

6.9.5 Implementation

The development will be constructed in phases to support the first intake of population targeted in 2023. In order to support the first population in-take, the SWH STW - Further Expansion, the new trunk sewers, sewage pumping stations and rising mains connecting to the SWH STW will need to be completed prior to first population intake. The construction of trunk sewer

will be carried out as part of road works. The additional sewage treatment facilities, that are the SWH STW Phase 2 works, will also need to be in place to support the remaining population in-take.

6.10 Treated Sewage Effluent (TSE) Reuse for NDAs

6.10.1 Projected TSE Reuse Demand

The proposed TSE reuses under this Study include non-potables namely toilet flushing, landscape irrigation and district cooling system. The estimated such demand of the TSE from the NDAs are:

Table 6.17 TSE Demands in different used in NDAs or North Distract from SWH STW

	TSE Demand (m^3/day)
	SWH STW
a. Used for NDAs only	23,500
b. Used for North Districts	33,000
Total	**56,500**

6.10.2 WATER QUALITY STANDARDS FOR TSE REUSE

Since there are currently no approved reuse water quality standards available in Hong Kong, a review of the reuse water quality standards has been carried out and reference standards or guidelines from both individual HK projects and overseas (China, UK (grey water reuse only), USA, WHO) are presented in the following:

EMSD's Code of Practice for Water-cooled AC Systems has one set of standards for seawater, and one set of standard for freshwater, but does not include water quality standards for using TSE as make-up water. Further to the meeting with PlanD and EMSD on 12 August 2011, (Electrical and Mechanical Services Department's) EMSD did not object the reclaimed water quality for flushing and landscape irrigation being adopted for make-up water for DCS. As such, the following set of reuse water standard is proposed for this Study for toilet flushing, landscape irrigation water reuse and make-up water for DCS:

Table 6.18 Summary of Proposed Reclaimed Water Quality for non-potable uses within NENT-NDAs and Fanling/Sheung Shui areas

Water Quality Parameter	Unit	Recommended Standard for Flushing, Landscape Irrigation and DCS Make-up
E. Coli	cfu/100mL	Not detectable
Total residual chlorine (TRC)	mg/L	≥1 (out of treatment system) ≥0.2 (at point-of-use)
Dissolved oxygen (DO)	mg/L	≥2
TSS	mg/L	≤5
Colour	HU	≤20
Turbidity	NTU	≤5
pH	-	6 – 9
Threshold odour number (TON)	TON	≤100
BOD_5	mg/L	≤ 10
Ammonia nitrogen	mg/L	≤1
Synthetic detergents	mg/L	≤5

The proposed reuse water quality standards are based on the most stringent standards found in the reference guidelines and standards as presented in the paper to minimise potential objections from the public. The set of proposed standards is also recommended in the "Working Group on the Implementation of Reclaimed Water Supply in Sheung Shui and Fanling".

6.10.3 TSE Reuse Benefits

Reuse of TSE offers following major benefits:

- Savings in fresh water supply, thus reduces the water to be diverted from the Dongjing River, and helps to relief the fresh water stress in downstream Dongjiang River that is often in needs of fresh water.
- Savings in energy consumption to convey the fresh water from the Dongjiang River, thus reduces the carbon footprint and contributes to the substainabilities of the communities.
- Savings in fresh water supply system expansion requirement.
- Reduces the pollution to be discharged to the environment.

6.10.4 Proposed TSE Reuse System

The TSE will be delivered through a separate distribution system to the end users. The proposed distribution system

includes pumping station in the STW, service reservoirs and distribution mains as shown in **Figure 6.6** to **Figure 6.8**.

The actual phasing of SWHSTW - Further Expansion is under discussion with EPD and DSD. The feasibility, agreed phasing and layout shall be reported at a later stage. It should be noted that, regardless of which treatment technology is adopted, adequate footprint should be allowed for accommodating effluent reuse facilities, such as holding tank and pumping station. The preliminary layout plan of extension of TSE system was shown in **Figure 6.3**.

6.10.5 Environmental Impact and Public Health

TSE reuse has the advantage of reducing wastewater discharge in the receiving water bodies 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.

TSE reuse is a designated project under the Environmental Impact Assessment Ordinance (EIAO) and an environmental permit (EP) is required for this usage.

Several previous TSE projects, including Ngong Ping STW TSE reuse for toilet flushing and control landscape irrigation; Lo Wu Correctional Institution TSE reuse for toilet flushing; and Sai Kung Outdoor Training Camp TSE reuse for toilet flushing and irrigation have confirmed by EPD that the proposed reuse is environmentally acceptable.

In general, the following precautionary measures should be adopted for TSE reuse:

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 (exact colour code to be reviewed) for distinguishing them from the pipes and fittings used for the fresh water supply and distribution systems.

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.

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.

Hazard to life in relation to TSE reuse operation is storage of sodium hypochlorite solution (liquid chlorine) or chlorine gas cylinders. Requirements of Fire Services Department (FSD)

for bulk storage shall be properly observed under the Dangerous Goods Ordinance (Cap. 295).

The usual practice to distinguish reclaimed water pipe work from potable pipework is by colour code. Under CE16/2004 (DS) Demonstration Scheme on Reclaimed Water Uses in the Northern District – Investigation, for example, purple/lavender coloured pipes were used between SWHSTW to respective user's premises for easy differentiation from existing pipework. Some of the example pipework is shown below.


Apart from that, proper signage, promotion and education to the general public especially potential local users of reclaimed water for landscape irrigation shall be considered and implemented.

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 above, and the adoption of stringent health-based water quality standards for the TSE, significant increase in health risk is not expected.

6.11 Interface with Other Projects

6.11.1 Planning and Engineering Study on Development of Lok Ma Chau Loop – Investigation

The proposed development of Lok Ma Chau Look (LMCL) study is on-going. Based upon the planning proposals for LMCL development, on-site sewage treatment is proposed and the residual load is proposed to be compensated off-site at the further expanded and upgraded SWHSTW. A total residual pollutant load from the LMCL STW and SWHSTW under different planned development years shall comply with the "no net increase in pollution loading" requirement for Deep Bay catchment.

6.11.2 Sewerage Works proposed under Review of North District and Tolo Harbour Sewerage Master Plans

Review of North District and Tolo Harbour Sewerage Master Plan Study proposed number of sewerage improvement works in North District. The proposed NDAs development will not

have any direct interface with those works except works proposed under 4345DS at KTN and also Western Trunk Sewer along Fanling Highway, which is already completed. The western trunk sewer may be realigned due to proposed widening of San Tin Highway between Kwu Tung and Fanling. These interfaces will be resolved after reaching agreement with relevant parties on the planning proposal for the NDAs.

6.11.3 Land Use Planning for the Closed Area – Feasibility Study

With the opening of The Closed Area, the planning study in Frontier Closed Area proposed expansion of number of recognised villages to cater for next 10 year housing demand. Although, there is no interface in terms of Study Area boundary between two studies, an integrated approach needs to be adopted for the collection, treatment and disposal of sewage from the developments under both the studies.

6.11.4 North District Sewerage Stage 2 (Reminder) and Sewerage to Chuen Lung, Kau Wa Keng Old Village and Lo Wai – Investigation, Design and Construction

The proposed sewerage works at Tsung Yuen/Ho Sheung Heung villages under the captioned study will have interface with proposed KTN NDA. This will affect the sewerage scheme for KTN NDA especially capacity of proposed SPS and diameter of rising main to convey the sewage flow from KTN NDA to SWH STW.

After the completion of sewerage works at KTN NDA, the sewage flow from Tsung Yuen/ Ho Sheung Heung will be conveyed to SWHSTW via the proposed twin rising main.

6.12 Conclusion and Recommendation

The proposed NDAs will generate additional sewage flows which cannot be handled by existing sewerage system and SWH STW and therefore will require additional sewerage infrastructure. The proposed sewerage master layout plan is presented in **Figure 6.1** along with existing and planned sewerage system. In order to meet the prevailing water quality policy to ensure no net increase in pollution load to Deep Bay, SWH STW needs to be upgraded apart from expansion of STW to cater for additional loading.

Reuse of treated sewage effluent is recommended for non-potable uses such as toilet flushing, irrigation and DCS. The discharge effluent to the Deep Bay will be reduced. Even without TSE reuse, pollutant loading from SWHSTW shall be able to comply with the "no net increase in pollution loading" requirement for Deep Bay catchment.

Based upon preliminary sewerage impact assessment as described in this section, it can be concluded that proposed development is sustainable from sewerage collection, treatment and disposal perspective.

6.13 Reference

[6-1] Report No. EPD/TP 1/05- Guidelines for Estimating Sewage Flows for Sewage Infrastructure Planning Version 1.0, EPD.

[6-2] Sewerage Manual, DSD, May 1995

[6-3] Review of North District and Tolo Harbour Sewerage Master Plans, Interim Report (Draft), Montgomery Watson, August 2001.

[6-4] Environmental Monitoring and Audit for Expansion of Shek Wu Hui Sewage Treatment Works and Upgrading of Ting Kok Road Pumping Station No. 5 – Investigation, 7th Monitoring and Assessment Report on Implementation of Village Sewerage Projects, CH2M Hill HK Limited, October 2008.