6. Sewerage and Sewage Treatment Implication

6.1 Introduction

This section presents assessment of the sewage discharge impact to the existing sewerage system during the operation phase of the proposed WKCD Development in accordance with section 3.4.7 of the Study Brief (ESB-237/2011). The necessary mitigation measures and proposal for sewage discharge have been recommended with a principle of having no adverse impact to the existing drainage system.

6.2 Sewerage and Sewage Treatment Legislations, Standards and Guidelines

The sewage flow discharge from the proposed WKCD development is based on the following standards, guidelines and reference for the sewerage and sewage treatment design:

- Sewerage Manual published by Drainage Services Department (DSD);
- Guidelines for Estimating Sewage Flows for Sewerage Infrastructure Planning Version 1.0 by EPD;
- North and South Kowloon Sewerage Master Plan (SMP), April 1993;
- Review of West Kowloon and Tsuen Wan Sewerage Master Plans – Feasibility Study (WK&TW SMP Review) Technical Note No. 3 (TN3) – Population and Land Uses, November 2007; and
- Review of West Kowloon and Tsuen Wan Sewerage Master Plans – Feasibility Study (WK&TW SMP Review) Final Report, February 2011.

6.3 Baseline Conditions

6.3.1 Overall Catchment

The proposed WKCD is located at West Kowloon Reclamation on the northern shore of Victoria Harbour and is bounded by Austin Road West to the north and Canton Road on the east. This area is served by the West Kowloon sewerage catchment. The WKCD is located at the southern portion of the West Kowloon sewerage catchment and this portion comprises of the following existing and planned developments (see **Figure 6.1**):

- Kowloon Station and Topside Development at MTRC Airport Line;
- West Kowloon Terminus (WKT) and the associated development (Site A and B);
- Austin Station and the associated developments at MTRC Kowloon Southern Link (Site C and D);
- Government, Institution and Community (GIC) Facilities at the north of Kowloon Station; and
- Hong Kong Girl Guide Association (HKGGA).

6.3.2 Existing Sewerage Condition

With reference to the WK&TW SMP Review Report, the WKCD will be served by DSD's Sham Shui Po Sewage Screening Plant (SSP SSP). The screened sewage is subsequently conveyed to Cheung Sha Wan Sewage Screening Plant and then discharged to the Stonecutter Island Sewage Treatment Works (SCISTW) for further treatment and ultimate disposal.

Originally there were two existing sewerage manholes located at the southern side of Austin Road West. The two existing sewerage manholes are connected to a sewerage manhole at the northern side of Austin Road West by 450mm and 675mm sewers. The 450mm and 675mm sewers are merged at the sewerage manhole at the northern side of Austin Road West and further connected to a 675mm sewer running eastward. The 675mm sewer is than merged with a 300mm sewer at the junction of Austin Road West and Lin Cheung Road. The merged 750mm sewer then runs northward along Lin Cheung Road and connects to the 1350mm trunk sewer at the north of Jordan Road.

With reference to the sewerage design drawings for Contract 810B West Kowloon Terminus Station South, the original sewerage system along Austin Road West and Lin Cheung Road will be upgraded to a new sewer system with size ranged from 450mm to 900mm in diameter and this sewer system is mainly serving the WKCD, Kowloon Station (including the topside development) and the West Kowloon Terminus development. The new 900mm diameter sewer is further connected to an existing 1350mm diameter trunk sewer located at the eastern boundary of Site B of the West Kowloon Terminus development and runs in north direction towards DSD's SSP SSP within the West Kowloon sewerage catchment and then eventually routes to SCISTW.

Furthermore, there is also an existing sewer with size ranging from 200mm to 750mm in diameter running northward along Canton Road and discharging into the existing truck sewer. Based on the record plans from DSD, there is no existing public sewer within the site of the WKCD.

6.4 Assessment Methodology

6.4.1 Background

According to the WK&TW SMP Review Final Report and the relevant supplementary information from EPD, the average dry weather flow (ADWF) and the peak flow allowed in the WK&TW SMP Review Study for the WKCD are 68.17 L/s and 210 L/s respectively. With reference to Clause 8.5.4 of the final WK&TW SMP report, no sewerage improvement works are required based on the allowed sewage flows. Under the development plan of the proposed WKCD, the estimated ADWF and peak flow from WKCD are 52.50 L/s and 157.50 L/s respectively (refer to **Section 6.5.2** for details of calculated sewage flow) which are lower than those allowed in the WK&TW SMP Review.

Based on the above information, the trunk sewers in West Kowloon sewerage catchment have sufficient capacity to cater the sewage generated from the development of WKCD. Therefore, the assessment in this report will focus on the local impact and sewerage arrangements required for the proposed WKCD under ultimate stage. The sewerage impact arising from WKCD will be identified by making comparison between the generated flow and capacity of existing sewerage network.

The layout of the existing sewerage is shown on **Figure 6.2.**

6.4.2 Collected Information

The following assessments and documents were collected and reviewed to identify the current sewerage master planning in West Kowloon Area and the sewerage provision to the infrastructure works in vicinity of the site area:

- North and South Kowloon Sewerage Master Plan (SMP), April 1993;

- Review of West Kowloon and Tsuen Wan Sewerage Master Plans – Feasibility Study (WK&TW SMP Review) Technical Note No. 3 (TN3) – Population and Land Uses, November 2007;
- Review of West Kowloon and Tsuen Wan Sewerage Master Plans – Feasibility Study (WK&TW SMP Review) Final Report, February 2011;
- Express Rail Link – Detailed Design for West Kowloon Terminus Sewerage Impact Assessment Report for Site A (XRL SIA), October 2009;
- Express Rail Link – Detailed Design for West Kowloon Terminus Sewerage Impact Assessment Report for Site B (XRL SIB), November 2009;
- Drainage Record Plans from Drainage Services Department (DSD); and
- Sewerage design drawings for Contract 810B West Kowloon Terminus Station South.

6.4.3 Design Standard Guideline

This assessment has been prepared in according with the following documents.

EPD's "Guidelines for Estimating Sewage Flows for Sewage Infrastructure Planning Version 1.0 (Report No.: EPD/TP1/05" (GESF) – The recommended unit flow factors and peaking factors have been adopted to estimate the sewage generated from the WKCD.

According to GESF, there is no recommendation on visitor's unit flow factor for art and cultural venues and government institutions. Therefore, the unit flow factor for visitors of cultural venues and government institutions is made reference to Table 3-4 of "Wastewater Engineering Treatment and Reuse" published by Matcalf & Eddy.

For the roughness of sewers, the recommended value in DSD's "Sewerage Design Manuel Part 1" has been adopted.

6.4.4 Design Parameters

Based on the above reference documents, the unit flow factors for different types of population as shown in **Table 6.1** have been used in calculating the sewerage flow from the WKCD.

Table 6.1: Recommended Unit Flow Factors

Development Type	Unit	Unit Flow Factor (m^3/day)
Domestic[1]		
Public Rental	person	0.19
Residential R1	person	0.19
Residential R2	person	0.27
Residential R3	person	0.37
Residential R4	person	0.37
Temporary and non-domestic	person	0.15
Commercial Employment[1]		
Job Type J2	employee	0.33
Job Type J3	employee	0.18
Job Type J4	employee	0.28

Development Type	Unit	Unit Flow Factor (m^3/day)
Job Type J5	employee	0.08
Job Type J6	employee	0.08
Job Type J7	employee	0.08
Job Type J8	employee	0.08
Job Type J9	employee	0.23
Job Type J10	employee	1.58
Job Type J11	employee	0.28
Job Type J12	employee	0.08
School[1]		
Primary, Secondary & Tertiary	student	0.04
Others		
Visitor[2]	person	0.015

Notes:
1. The unit flow factors for domestic, commercial employment and school are according to Table T-1 and Table T-2 of GESF of EPD.
2. The unit flow factor for "Visitor" is according to Table 3-4 of "Wastewater Engineering Treatment and Reuse" published by Matcalf & Eddy

The peaking factors given in Table T-5 in EPD's GESF will be adopted for the peak flow calculation. The peaking factors are listed in **Table 6.2**.

Table 6.2: Peaking Factors

Population Range for Sewers	Peaking Factor (including storm water allowance) for facility with existing upstream sewerage	Peaking Factor (excluding storm water allowance) for facility with new upstream sewerage
<1000	8	6
1000 – 5000	6	5
5000 – 10000	5	4
10000 – 50000	4	3
>50000	Max (7.3 / $N^{0.15}$, 2.4)	Max (6 / $N^{0.175}$, 1.6)

Note:

N is the contributing population in thousands. According to Clause 12.1 of EPD's GESF, the contributing population is defined below:

Contribution Population = Calculated total average flow (m^3/day) / 0.27 (m^3/person/day)

The Colebrook White's equation has been adopted for hydraulic analysis of the pipe system. A roughness coefficient, Ks, of 3.0mm for concrete pipe has been adopted in accordance with DSD's "Sewerage Design Manuel Part 1".

6.4.5 Assumptions

The following assumptions have been made in the assessment of the sewerage impact assessment arising from the development of the WKCD.

- The sewage flows from the existing or proposed developments in the southern portion of West Kowloon sewerage catchment that has been adopted in the SIA Report of XRL SIA and XRL SIB are valid and will be adopted in this technical report.

- The sewage generated for Kowloon Station is currently discharged into three existing sewers at Austin Road West, Nga Cheung Road and Jordan Road as shown on **Figure 6.2**. However, the actual sewage flow discharging to each of the sewers is not available. Therefore, it is assumed that all the sewage generated from Kowloon Station is discharged into the upgraded sewer at Austin Road West as a conservative approach.

6.5 Evaluation and Assessment of Sewerage and Sewage Treatment Implications

6.5.1 Proposed Development

The Development Plan for WKCD proposes a number of Core Art and Cultural Facilities (CACF) combined with commercial, catering and retail facilities. A park is also proposed to be located at the south western portion of the WKCD. Under the development plan, the total population of WKCD is about 120,000.

6.5.2 Predicated Sewage Flow

According to the development plan of WKCD, the total estimated ADWF and peak flow from WKCD are 52.50 L/s and 157.50 L/s respectively. The population of WKCD and estimated ADWF are summarized in **Table 6.3**.

Table 6.3: Population and Sewage Flow Estimation for WCKD

Development Type	Population[2]	Unit	Type	Unit Flow Factor UFF (m^3/day)	Sewage Flow ADWF (m^3/day)
Domestic					
Residential	4,051	Person	R1	0.19	769.69
Commercial					
Retail, Dining and Entertainment	4,441	Employee	J4	0.28	1243.48
Core Arts and Cultural Facilities	1,761	Employee	J6	0.08	140.88
Other Arts and Cultural Facilities	758	Employee	J6	0.08	60.64
Government, Institution and Community	0	Employee	J12	0.08	0.00
Office	4,579	Employee	J6	0.08	366.32
Residential	42	Employee	J6	0.08	3.36
Hotel	267	Employee[1]	J10	1.58	421.86
	1,204	Guest[1]		0	0
Visitor	101,985	Person	-	0.015	1529.78
Others	0	Employee	J12	0.08	0.00
					4536.01
				Total	52.50 (l/s)

Notes:

1. UFF of Hotel Guest has been counted in the UFF of Hotel Employee.
2. The population will be subject to review.
3. Based on the above estimated ADWF of WKCD, the contribution population of WKCD is 16,800(4,536.01/0.27=16,800).
). The peaking factor is 3.0 according to Table T-5 of EPD's GESF.

6.5.3 Proposed Sewerage System

The WKCD is proposed to be divided into 8 numbers of sewerage sub-catchments, S1 to S8. The proposed sewerage sub-catchment is presented on **Figure 6.3** and the proposed sewer for the WKCD is also shown on **Figure 6.4**. The sewage flow generated from each sub-catchment is summarized in **Table 6.4**.

Table 6.4: Summary of Sewage Flow for Sub-catchment

Sewerage Sub-catchment	ADWF (L/s)	Peak Flow (L/s)
S1	6.69	33.44
S2	6.89	34.43
S3	7.11	35.57
S4	5.86	29.32
S5	4.73	23.64
S6	6.53	32.65
S7	12.52	62.58
S8	1.93	9.63

The ground level of the road in the Park is ranging from +5.0 to +6.0 mPD which is lower than the road level of Austin Road West. Discharging the sewage from the Park to the existing sewer at Austin Road West through gravity is difficult and pumping facilities for conveying the sewage to Austin Road West is considered necessary. After reviewing the proposed layout of the Park, the location of the 'Freespace' is the optimum location to provide the pumping facilities as it could minimize the length of the rising main. Therefore, the sewage generated from different venues in the Park are proposed to be collected by a new gravity sewer system with pipe size ranging from 225 to 300mm and conveyed to an internal pump sump P1 located at Freespace. The sewage from the Park will then be pumped to a new sewerage manhole F1.1 and from there, will flow along a new section of 450mm gravity sewer to the 450mm gravity sewer at the southern side of Austin Road West.

The sewage generated from sub-catchments S2 and S3 are proposed to be discharged to the new sewerage manholes F1.1 and F1.2 respectively, where the flow will continue to the existing sewer on the southern side of Austin Road West.

For the other 4 sub-catchments S4 to S7, the sewage from these sub-catchments is proposed to be discharged to the new sewerage manholes (F1.5 to F1.8) at Austin Road West and further conveyed to the 675mm sewer crossing Austin Road West.

Once the sewage from S1 to S7 is conveyed to the site boundary at Austin Road West, the sewage will gravitate northwards along a new sewer at Lin Cheung Road and then discharge to the existing 1350mm trunk sewer at the east of Site B. This new sewer at Lin Cheung Road will be constructed by MTRC under West Kowloon Terminus development and increases in size from 675mm to 750mm diameter downstream.

The sub-catchment S8 is for Parcel 1 (Xiqu) at the east of WKCD. Sewage from this sub-catchment is proposed to be discharged to the existing sewer at Canton Road. However, conveying the sewage from sub-catchment S8 to the existing sewer by gravity sewer is not feasible due to existing congested utilities at the junction of Canton Road and Austin Road. Therefore, it is proposed to provide a pump sump together with rising mains for conveying the sewage to a new manhole F3.1 located at the western side of Canton

Road where it further discharges to the existing sewer running northward along Canton Road by a proposed 225mm diameter sewer.

For the buildings in sub-catchments S2 to S7, it is possible to discharge the sewage from the buildings above podium level to the new sewerage manholes through gravity pipes and only the sewage generated from buildings is discharged to the new sewerage manholes through pumping facilities for minimising the size of pump sumps within the basement. The design of the sewerage system for the building and within the basement boundary will be considered in the detailed design stage.

The principal invert levels of the proposed sewers are provided **Figure 6.7** to **6.19**.

As requested by DSD, the gravity sewers F2.1 to 2.14, pump sump P1 and associated rising main to the existing manhole No. FMH4028437 will be maintained by WKCDA. For other sewerage system, as discussed between DSD and WKCDA, the maintenance responsibilities will be discussed and agreed in the detailed design stage.

6.5.4 Sewerage Impact Assessment

Impact to Existing 1350mm Truck Sewer

Based on the SIA reports of XRL SIA and XRL SIB, the sewage flow from different catchments at the area under future condition are summarized in **Table 6.5**.

Table 6.5: Sewage Flow from Different Catchments discharged to the 1350mm Trunk Sewer

Catchment	Sewage Flow (ADWF) (L/s)
Site A (Topside Development)	57.70
Site A (WKT)	39.34 (Peak Flow)
Site B	29.60 (Peak Flow)
Site C & D	36.80
Kowloon Station	166.21
GIC	0.34
HKGGA	5.34
WKCD	58.53
Total Sewage Flow (ADWF) (L/s)	393.86
Peaking Factor	3.64
Design Peak Flow (L/s)	1251.65

Note: The sewage flows are based on the SIA Report of XRL SIA and XRL SIB

According to the SIA report of XRL SIB, the sewage from the above catchments including the WKCD will be discharged to an existing trunk sewer (1350mm diameter sewer) at the east of Site B. The capacity of the existing 1350mm diameter sewer is 2118 L/s and the utilization will be around 58%.

Based on the current development schedule of the WKCD and the proposed sewerage system, the ADWF discharged to the existing 1350mm trunk sewer from the WKCD is 4369.61 m^3/day (50.57 l/s) (sewage from sub-catchment S1 to S7).

The updated ADWF (50.57 l/s) from WKCD is smaller than that adopted in the SIA Reports of XRL SIA and XRL SIB. The peak sewage flow discharged to the 1350mm diameter truck sewer is also reduced accordingly. Therefore, it is considered that the development of the WKCD will have no adverse impact to the existing 1350mm trunk sewer.

Impact to the sewer along Austin Road West and Lin Cheung Road

The sewage generated from sewerage sub-catchments S1 to S7 are proposed to be discharged to the existing 1350mm diameter trunk sewer through the branch sewer with sizes ranging from 750mm to 900mm along Austin Road West and Lin Cheung Road. With reference to the record plans from DSD, part of the sewage from Kowloon Station is also discharged to the branch sewer along Austin Road West and Lin Cheung Road. In the hydraulic assessment, all the sewage generated from Kowloon Station (166.21 L/s) has been assumed to be discharged to the branch sewer at Austin Road West as a conservative approach.

A hydraulic assessment of the branch sewer has been conducted to assess the sewerage impact on this branch sewer arising from the development of the WKCD. Based on the hydraulic assessment, the flow capacity of the branch sewer is more than 483 L/s and the peak sewage flow discharge to the branch sewer is about 346.86l/s and the maximum utilization of this branch sewer is about 71.74%. The branch sewer has sufficient flow capacity to cater for the sewage generated from the WKCD. The details of the hydraulic assessment are presented in **Appendix 6.2**.

Impact to the sewer along Canton Road

The sewage generated from the sewerage sub-catchment S8 is proposed to be discharged to the existing sewer at Canton Road which further conveys the sewage to the truck sewer at the north.

A hydraulic assessment has been conducted for assessing the sewerage impact on the existing sewer at Canton Road arising from the development of the WKCD. Based on the assessment (see **Appendix 6.1, Appendix 6.2** and **Appendix 6.3**), the existing sewer at Canton Road has a minimum flow capacity of 320.55 L/s. Based on the sewerage record from DSD and the population data provided in WK&TW SMP Review Report, the estimated ADWF flow from the upstream of the proposed connecting manhole (FM4002142) is 98.64 L/s (8522.50 m^3/day) under ultimate stage. The utilization under existing condition is about 92.3%.

The ADWF from sub-catchment S8 is 1.93 L/s (166.40m^3/day). The total peak sewage flow discharged to this existing sewer will become 301.70 L/s which is smaller than the minimum flow capacity of the existing sewer. The utilization of the existing sewer will become approximately 94.1% (only increase by approximately 1.8%). Therefore, it is considered that the impact to the sewer is negligible.

Based on the above, the existing sewers have sufficient flow capacity to cater for the sewage flow generated from the proposed development of WKCD and no upgrading works to the existing sewer is required. Also, according to WK&TW SMP Review Report and the information provided by EPD, the sewerage facilities in West Kowloon has sufficient capacity to cater for the sewage from WKCD.

6.5.5 Emergency Discharge

As discussed above, all the sewage generated from the proposed development would be discharged to the public sewer and treated by public treatment facilities before ultimate disposal. Also, the development of

WKCD has been taken into account in the WK&TW SMP Review Study and the treatment facilities have adequate capacity to cater for the proposed WKCD development according to the WK&TW SMP Review Report.

For the proposed pump sumps, twin rising mains will be provided to ensure continuous operation of pumping when one of the mains is damaged or under maintenance. Standby pumps and electricity supplies will also be provided to ensure the operation can still be maintained during maintenance or mechanical failure. By adopting proper measures, emergency discharging of sewage to watercourse is considered as very unlikely.

6.6 Hydraulic Modelling

InfoWorks CS version 8.0 was adopted for the purpose of hydraulic modelling. A hydraulic model network has been adopted to assess the capacity of the proposed sewer and existing sewer in the vicinity of WKCD.

The InfoWorks network for sewerage assessment is shown on **Figure 6.6**. The following boundary conditions shown in **Table 6.6** have been obtained from EPD and adopted in the hydraulic model for assessment.

Table 6.6: Boundary Conditions for Hydraulic Model

Location	ADWF (L/s)	Max Water Level (mPD)
Kowloon Station's discharge point (Node FMH4028439)	38.28	-
Downstream of Austin Road West sewer (Node Outfall 1)	-	0.194
Downstream of Canton Road sewer (Node Outfall 2)	-	3.138

Inflows for each sub-catchment were assigned to the proposed discharge points for the hydraulic analysis. The peaking factor of 3 for WKCD has been adopted as the global peaking for the whole network. The summary of the model result is shown in **Table 6.7**.

Table 6.7: Summary of Hydraulic Model Results

Node ID	Ground Level (mPD)	Maximum Water Level (mPD)	Freeboard (m)
F1.4	7.3	1.737	5.563
F1.10	7.3	1.239	6.061
F3.1	5	3.851	1.149
P1	7.67	1.149	6.521
P5	5.68	0.605	5.075
FMH4028439	8.19	1.185	7.005
FMH4002142	5	3.339	1.661

Based on the model results, all the sewers have sufficient capacity to cater for the designed flow with free broad more than 1m. Therefore, it is considered that there should be no adverse sewerage impact to the existing sewerage system.

6.7 Mitigation Measures

As discussed in **Section 6.5**, the proposed WKCD has been taken into account in the WK&TW SMP Review. Based on the above assessment, the sewage flow generated from the proposed WKCD is smaller than the flow allowed in the WK&TW SMP Review Study and the sewerage facilities are adequate for the proposed development. Therefore, no new proposed improvement work to existing sewerage system and treatment facilities in West Kowloon is required.

Furthermore, the assessment has identified that the proposed WKCD will not cause adverse impact to the local sewerage network, which should have sufficient capacity to cater for the sewage flow generated from the proposed WKCD. Therefore, no mitigation measures and upgrading works to the existing local sewer is required for the proposed development. Recommendations for the design, operation and maintenance of the sewerage system are provided in the following sections.

6.7.1 Design, Operation and Maintenance Requirements

6.7.1.1 General Requirements

The design of the sewerage system should follow the guidelines stipulated in:

- Stormwater Drainage Manual by DSD;
- Sewerage Manual Part 1 & Part 2 by DSD;
- Drainage Services Department Standards Drawings; and
- Structures Design Manual for Highways and Railways by Highways Department.

The detailed design of the proposed sewerage system should be circulated to DSD, EPD and other relevant parties for comment during planning and detailed design stage to ensure acceptance by relevant parties. Access for plant, equipment and personnel for maintenance of the works should be adequately provided. A plan showing the maintenance access to the proposed sewers has been provided in **Figure 6.5**.

As discussed between DSD and WKCDA, the maintenance responsibilities for the above proposed sewerage system, include gravity sewers, rising mains and pumping facilities, will be discussed and agreed in the detailed design stage.

6.7.1.2 Gravity Sewers

The design of gravity sewers should be according to the guidelines stipulated in Sewerage Manual Part 1. The general requirements are summarized below:

- Pipe size: The minimum pipe size of gravity sewer is 225mm in diameter.
- Capacity: The gravity sewer should be designed to avoid under surcharge condition. 1m freeboard should be provided if surcharge condition cannot be avoided.
- Flow velocity: The flow velocity should be not less than 1m/s under full bore flow for self-cleansing purpose. The maximum velocity should be limited to 3m/s.
- Alignment: The alignment of the proposed sewer should be reviewed to avoid conflicting with existing utilities and affecting traffic flow as far as possible.

- Hydraulic Design: The detailed hydraulic design should follow the guidelines provided under Section 5.2 of Sewerage Manual Part 1.
- Pipe Material: Selection of pipe material shall be based on its suitability for the proposed application. The selection process includes an evaluation of the possible conditions to which the pipes may be exposed in order to specify the appropriate material and installation requirements for the specific application.
- Pipe Joints: In order to accommodate differential settlement that may occur between sewers and adjacent structures (including manholes), two flexible joints shall be provided in accordance with the latest amendment of General Specification for Civil Engineering Works 2006 Edition Volume 1 Clause 5.71 – Connections to structures in providing the flexible joints to structures.
- Pipeline Structural Design: The structural checking and bedding design should in accordance with Section 6 of Sewerage Manual Part 1.

6.7.1.3 Manholes Design

The design of manholes should be in accordance with Section 7 of Sewerage Manual Part 1.

- Location: Manholes should be provided at all changes in direction, at intersections and to suit property connections. The maximum spacing between manholes should be as follows:

Diameter of Pipe (mm)	Maximum Intervals (m)
Smaller than 600	40
Between 600 – 1050	80
Larger than 1050	120

- Access Openings/Shafts: Desilting opening should not be smaller than 750mm by 900mm and should be placed in the line of the sewer. The man access opening with minimum size of 675mm x 750mm should be provided at manholes. Man access openings should be placed off the line of the sewer for deep manhole and along the line of the sewer for manholes shallower than 1.2m.
- Working Chambers: Working Chambers should be provided to manholes deeper than 1.2m.
- Intermediate Platforms: When the invert of a manhole is more than 4.25m from the cover level, intermediate platforms should be provided at regular intervals. The headroom between platforms should not be less than 2m nor greater than 4m. Hand railing and safety chains should be provided at the edge of platform to protect persons from falling down. The minimum size of platform should is 800mm by 1350mm.
- Covers: The manhole cover should be designed strong enough to take the design loading and should not rock when initially placed in position or develop a rock with wear. The design of manhole covers should make reference to DSD standard drawings.
- Backdrop Manhole: When the level difference between the inlet pipe and the invert level of manhole is greater than 600mm, backdrop manhole should be used. The design of backdrop manhole should follow guidelines under Section 7.1.9 in Sewerage Manual Part 1.
- Step-irons/Cat Ladder: Step-irons should be securely fixed in position and should be equally spaced and staggered about a vertical line at 300mm centres. Cat ladders should be used in manholes deeper than 4.25m or where manholes are frequently entered. Set-irons and ladders should be start at not more than 600mm below the cover level and continue to the platform or benching. Corrosion

resistance materials should be used if step-irons and ladders are constantly in a damp atmosphere and prone to corrosion.

6.7.1.4 Sump Pumps Design

The design of sewage sump pumps should follow the requirements stipulated in the Sewerage Manual Part 2.

The number of pumps to be installed depends on the sump capacity. Standby pumps should be provided to ensure the operation can still be maintained during maintenance or mechanical failure.

The selected electrical equipment shall be suitable to operate under high humidity, high temperature and presence of corrosive gases.

Appropriate mitigation measures to control noise and odour problems should be designed under detailed design stage. The typical methods for noise and odour control could refer to the Seweage Manual Part 2.

In order to control the septicity of sewage due to operation of sewage pumping facilities, the retention time of sewage should be minimized. Pumps with different small rate should be considered for reducing the time of retention of sewage. Direct injection of oxygen could also be used to control septicity. The mitigation methods should be considered under detailed design stage.

Fresh water should be provided for the operation and maintenance staff for hygienic reasons.

6.7.1.5 Rising Mains Design

The design of rising main should follow the requirement stipulated in the Sewerage Manual Part 2.

Twin rising mains should be provided as far as possible because of the following reasons:

- To accommodate a wide range of flow conditions such that the velocity in the mains can be kept within acceptable limits;
- To provide continued operation when one of the mains is damaged; and
- To facilities future inspection and maintenance while the normal sewage flow can be maintained.

The maximum velocity at peak flow should not exceed 3m/s. The desirable range of velocity should be 1m/s to 2m/s with due consideration given to the various combinations of number of duty pumps in operation.

Air relief valves, check valves, isolating valves and discharge sumps shall be provided in accordance to the Sewerage Manual Part 2.

Septicity control methods for rising mains, such as oxygen injection and reducing retention time of sewage, should be designed under detailed design stage.

6.7.1.6 Thrust Blocks for Rising Mains

Thrust blocks should be provided to rising mains to prevent pipes from being moved by forces exerted within the pipe by the flow of water hitting bends, tapers, and closed or partially closed valves. The size of a thrust block is dependent upon the deflection of the flow and the head of water inside the pipe. Design of thrust block should refer to DSD Sewerage Manual Part 2.

6.7.1.7 Inspection and General Maintenance Operations

All gravity sewers and rising mains shall be tested in accordance with relevant GS sections as appropriate in the presence and to the satisfaction of the staff of DSD upon completion of the installation.

Records of satisfactory testing on the completed works shall be submitted to DSD after the testing. CCTV survey records, as-built drawings and hydraulic and structural design calculations should be submitted to DSD for records.

6.8 Environmental Monitoring and Audit

With the implementation of the proposed sewerage system according to the specifications stated in **Section 6.7**, no sewerage or sewage treatment implications are anticipated. No specific sewerage monitoring programme is thus required for the WKCD Development.

6.9 Conclusion

EPD has completed the WK&TW SMP Review study to identify the performance of the existing sewerage systems. The SMP Review allows provision for sewage flows from WKCD. Comparing the latest estimated sewage flows from the WKCD development plan and the sewage flows allowed in the SMP Review, the existing sewer system in West Kowloon has sufficient capacity to cater for the sewage generated from the proposed development of WKCD. The peak sewage flow generated from WKCD is estimated to be 157.50 L/s, which is less than 210 L/s allowed in the SMP Review.

The sewage generated from the sub-catchments S1 to S7 will be discharged to the branch sewer at Austin Road West that to be upgraded under West Kowloon Terminus development and further conveyed to the existing 1350mm diameter trunk sewer. From the hydraulic capacity checking shown in **Appendix 6.1**, the upgraded branch sewer has sufficient capacity to cater for the sewage from the WKCD development and the utilization of the existing 1350mm diameter trunk sewer will be around 58%.

The sewage generated from sub-catchment S8 will be discharged to the existing sewer at Canton Road and there is only 1.8% of addition utilization to the existing sewer. The maximum utilization of the existing sewer will become about 94.1%. There should be no adverse impact to the existing sewer.

A sewerage system is proposed to collect the sewage from WKCD and convey the sewage to the upgraded branch sewer at Austin Road West. A sewerage system is proposed in the Park for collecting the sewage generated from different venues and buildings and conveying to the proposed pumping facilities at the Freespace venue. The impact assessment shows that the proposed sewerage system has sufficient capacity to cater for the sewage flow from WKCD.

Based on the above, it is concluded that no adverse sewage impact would be anticipated resulting from the development of WKCD.