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Drainage Improvement in Northern Hong Kong Island -
Hong Kong West Drainage Tunnel

Hong Kong West Drainage Tunnel
Pollutants and Sediment Load
Final Report

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1. INTRODUCTION

1.1 The operation of the proposed drainage tunnel will result in a reduction of pollution loads to the existing downstream watercourses/drainage systems, and Victoria Harbour. Consequently, pollution loads will be transported to the Western Portal at Pok Fu Lam. The pollutant loads and flows during dry and wet seasons have been estimated in the present paper.

1.2 This paper is divided into two parts:
- Part A) Estimation of pollutant loads
- Part B) Estimation of sediment loads

PART A) ESTIMATION ON POLLUTANT LOADS FROM PROPOSED INTAKE SHAFTS TO WESTERN PORTAL

2. BACKGROUND

2.1 The objective of this paper is to quantify of the potential pollutant loading on the receiving waters from the new discharge portal at Pokfulam. It is important to note that the proposed scheme does not introduce additional stormwater and pollutants into the marine environment. It only diverts existing stormwater discharges and pollutants to an alternative discharge point.

2.2 This paper describes how sampling was carried out to characterise the stream flows; how this sampling was applied to the estimated intercepted storm flows; and how the pollutant loadings to western side of Hong Kong Island are derived. This will reduce the flows in the lower catchment and Victoria Harbour and reduce flooding frequency in the urban area.

2.3 The sampling identified that there were pollutants present in the stream courses. The presence of *E. coli* was particularly surprising as the catchments above the interception points are largely undeveloped, primarily being Country Parks. There was no opportunity to determine the source of the pollution but over time we would anticipate that the pollution sources would be detected and steps taken to remove them.

3. SAMPLING LOCATION

3.1 Thirteen streams were selected out of the thirty-five streams that are proposed to be intercepted by intake shafts identified in this project. The sampling locations are at intake shafts E4(P), W1, W5, W10, E5(B)(P), W11(P), PFLR1(P), W3(P), TP789(P), THR2(P), W8, P5(P) and W12 (Figure 1).

3.2 The aim of the sampling is to characterize the water quality of the streams in order to make a preliminary estimation on the pollutant loading that will discharge from the downstream outfall (the Western Portal at Pokfulam). Sampling points were selected based on flow proportion of the steams entering the intake shafts. Those sampling points represent about 65% of the likely diverted flow and include the largest catchment in the project area (Eastern Portal (E4P) – 17% of total catchment area of the western portal).

4. SELECTED PARAMETERS

4.1 In order to determine the pollutant loading to the Western Portal during dry and wet seasons, a range of parameters were selected:

- Physical (pH, temperature, turbidity, water depth, salinity, flow, dissolved oxygen (DO));
- Aggregate organics (BOD_5, COD, oil and grease);
- Nutrients (nitrogen and phosphorus);
- Algal biomass (chlorophyll a); and
- Faecal bacteria (*E. coli*).
- Suspended Solids

4.2 Sampling was conducted in the field and analysed by a HOKLAS laboratory, and both the laboratories of the government and the EPD.

5. PRELIMINARY DESIGN OF THE INTAKE STRUCTURES

5.1 Figure 2 (plan and side view) shows the preliminary design of the intake structures and a detail diagram of the bypass facility is shown in Figure 3. Upstream of the intakes the low flows will be collected into either a 150 mm pipe or open U-shape channel (this option is preferred since it is unlikely to be obstructed from potential debris blockage). This will convey all low flow past the diversion intakes and discharge to existing downstream watercourses. The maximum capacity of the bypass is about 20 L/s. When the capacity of the by-passes is exceeded during rainfall events, the excess flow will enter the diversion intakes.

5.2 The catchments in the project area are a mixture of ephemeral and perennial watercourses and owing to the steep nature of the catchments they are very responsive to storm runoff with very 'peaky' and quickly receding hydrographs. After storm events, baseflows will continue within the watercourses as groundwater levels further recede. The magnitudes of the baseflows are dependant on the temporal proximity of antecedent storm events, the areal extent of the catchment and the geology of the catchment. Combined these features are complex and typically in-stream continuous flow monitoring is necessary to estimate stream baseflows. This information is not available to the present study so judgment has been used to define the amount of baseflow that should bypass the intake structures.

5.3 Stream flows at 13 intake sites were gauged on three separate occasions. There was no rainfall on any of the occasions and flows within the streams could be considered as baseflows. The flows observed during the wet season were generally greater than those for the dry season most likely owing to elevated groundwater level associated with the wet season. The observed flows ranged from about 0.l/s to 25 l/s and a regression of the data shows that a reasonable trend is evident between catchment size and baseflow for the wet season gauging (Chart 1).

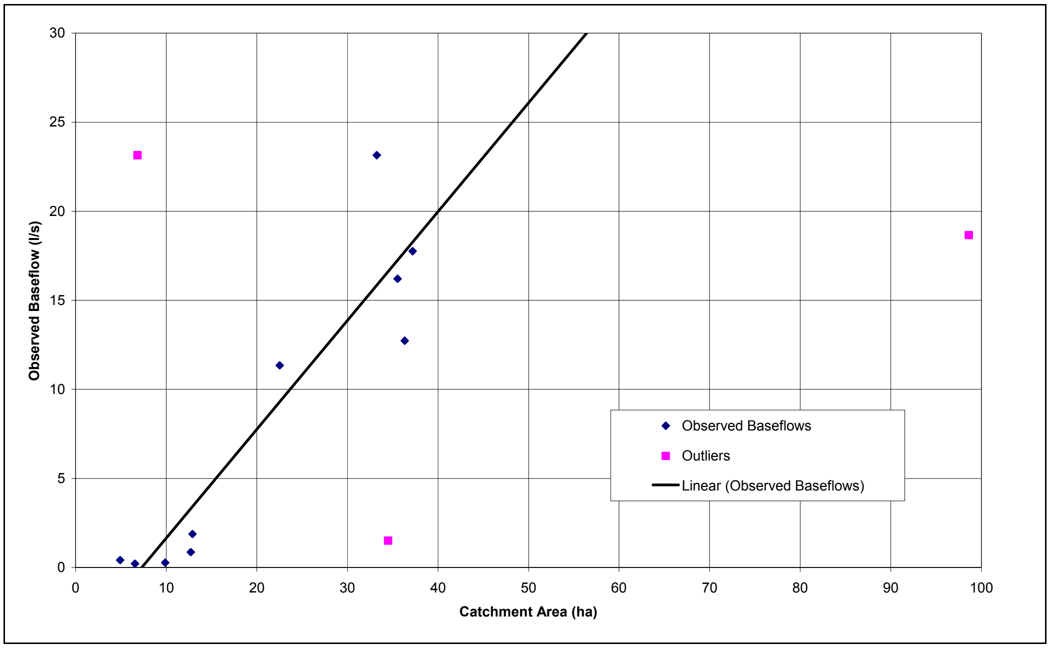

Chart 1: Baseflow and Catchment Area Regression

5.4 Based on this data, it is considered satisfactory to adopt 20 l/s as a minimum bypass flow since the majority of observed flows were in fact less than this amount and all catchments, except the Eastern Portal catchment, are less than 40 hectares in areal extent (from the regression a catchment area of 40 hectares approximates a 20 l/s baseflow). Catchment areas of intakes are shown in Appendix A. From an engineering perspective, it would be difficult to construct and maintain a channel that would guarantee conveyance of flows less than 20 l/s.

5.5 Because the intake structures have bypass facilities, it is expected that flows will only be diverted and discharged to the Western Portal during rainfall events. However, during storm events flows will also continue to be conveyed to the lower catchment by the bypass channels.

6. FIELD SAMPLING

6.1 Timing of Sampling Events: The objective was to characterize the stream water quality for both the wet and dry seasons. The rainy season in Hong Kong is considered to last from April to September each year. Sampling was carried out on three occasions, with one replicate, on 10 March, 25 March and 5 May 2004. Details of results are shown in Tables 1a and 1b (10 March 04), Table 2 (25 March 04) and Tables 3a and 3b (5 May 04). Based on the rainfall recorded by Hong Kong Observatory, trace amounts of rainfall were observed during the period from 1st January to 25 March 2004. Therefore the first two sampling episodes are considered representative of the dry season for pollutant load assessment. For the sampling on 5 May 2004, a storm event with comparatively higher rainfall (potentially the first flush of rain for the season) was recorded on 30 March 2004. This sample episode is regarded as being representative of the wet season for the pollutant load assessment.

6.2 The average concentrations of tested parameters for the dry and wet season samples have been calculated and are shown in Tables 4a and 4b respectively.

7. FLOW MEASUREMENT

7.1 In order to determine pollutant loading it was necessary to establish the water flowing in the streams on the sampling day. Different flow measurement methods were used including tracer method, volumetric method and different flow ranges of flowmeter/propeller. A limiting factor was the extremely low flows in the streams during the sampling period. The shallow depth of water prevented the housing of the flowmeter / propeller to be completely submerged to comply with the standard operating procedure. Therefore the flow rates recorded using the flowmeter have been ignored.

7.2 Tracer and volumetric methods rely on physically collecting volumes over a set period and are considered to be more representative for the current site conditions. Therefore average values measured by the tracer method and volumetric method have been adopted for estimation of flow rates for the pollutant load assessment. Average flow values for dry and wet season are shown in Table 5a and 5b, respectively.

7.3 It is important to note that due to the extremely low water flows in the streams (with depths of approximately 0.02m for all of sampled streams except the Eastern Portal at 0.16m) during sampling, unrealistically high pollutant concentrations could have been recorded due to collection of settled and batch samples in the stream. Therefore, it is perceived that the pollutant loadings estimated in the present study are conservative.

8. POLLUTANT CONCENTRATIONS ESTIMATION

8.1 For design purposes the 2, 10, 50 and 200-year design flows are derived. The design flow for each of the thirty-five intake shafts is presented in Table 6a, the contribution of the thirteen intake shafts where sampling was carried out is also highlighted in Table 6a. Table 6b identifies the particular intake's overall contribution to the total discharge at the Western Portal. The thirteen sampling locations represent 65% of total flow to the drainage tunnel. It also shows the flow proportion of thirteen intake shafts which were sampled and actual flow rate during sampling.

Table 6b Flow Proportion of Intake Shafts and Actual Flow during Sampling to Drainage Tunnel

Catchment	Proposed Intake Shafts	% of flow to proposed drainage channel	Average value during March sampling	Average value during May sampling
C17	Eastern Portal	17.1	17.8 L/s	18.7 L/s
C16	E5B	2.3	4.1 L/s	23.1 L/s
C15	THR2	7.9	19 L/s	18 L/s
C14	W1	5.9	0.3 L/s	12.7 L/s
C13	W3	7.1	14.1 L/s	23.1 L/s
C12	TP789	3.1	0.5 L/s	1.9 L/s
VC	W5	5.9	6.3 L/s	11.3 L/s
C4	W10	3.2	0.2 L/s	0.86 L/s

Catchment	**Proposed Intake Shafts**	**% of flow to proposed drainage channel**	**Average value during March sampling**	**Average value during May sampling**
C6	W8	1.8	1.4 L/s	0.41 L/s
C5	P5	1.5	0.04 L/s	0.27 L/s
C3	W11	3.2	6.3 L/s	16.2 L/s
C240	PFLR1	1.1	0.2 L/s	0.21 L/s
C240	W12	4.9	2.4 L/s	1.5 L/s
	Total	64.8	72 L/s	128 L/s

9. PREDICTION OF ANNUAL FLOW TO ALL INTAKES

9.1 In order to estimate the discharge volume at the intake shafts to the proposed tunnel during the dry and wet seasons, recorded rainfall data for the past 3 years (2001-2004), obtained from the Hong Kong Observatory was used. Based on this data, it is observed that the rainfall volume increases and decreases significantly during April and October, respectively (Figure 4). Therefore, for the pollutant load assessment, May to September (5 months) and October to April (7 months) are regarded as the wet season and dry season, respectively.

9.2 Figure 5 shows the total monthly rainfall from January to May 2004. Daily observed rainfall data confirmed that the samples collected in March are representative dry season samples while the sampling carried out in May is representative of a wet season sample after the first flush of rain (Figure 6).

9.3 Based on the past rainfall record data since 1884 (Appendix B), it is calculated that rainfall between May and September contributes 78.5% of total rainfall per year (wet season) while the remaining 21.5% of rainfall occurs between October and April (dry season) (Table 7).

Table 7 Annual Rainfall Volume to All Intakes during Wet and Dry seasons

Month	Rainfall flows to all intakes from catchment area
January	58,703 m³
February	96,539 m³
March	140,900 m³
April	300,348 m³
May	595,033 m³
June	803,648 m³
July	734,806 m³
August	783,811 m³
September	573,901 m³
October	230,989 m³
November	79,131 m³
December	52,388 m³

9.4 Even though the intake structures are designed with bypass facilities, to assess the pollutant loading to the Western Portal it is assumed that all stream flows will be diverted to the tunnel and therefore no bypass flows will occur during rain storm events. Note that this assumption is only to simplify the calculations and does not mean no bypass flows will occur in the prototype. Furthermore, for the purpose of estimating the pollutant loading to the Western Portal this assumption can be considered conservative.

10. POLLUTANT CONCENTRATIONS TO WESTERN PORTAL

10.1 Table 8 shows the estimated pollutant concentrations during the wet and dry seasons based on the actual flow and sampled pollutant concentrations. The thirteen sampling locations represent 65% of the total inflows to the tunnel and the water quality characteristics at the remaining unsampled intake shafts is assumed to be similar to the sampled streams. The rationale for this is that all interception points are in similar geographical locations on the upper edge of the urban area. The catchments above the interception / sampling points are Country Park areas with similar characteristics and negligible contributing urban populations.

10.2 Based on the sampling results taken at dry and wet seasons, estimated pollutant concentrations from all intakes during the dry and wet seasons based on average annual rainfall are estimated and shown in Table 9.

Table 9 Predicted pollutants concentration from all intakes

	Dry Season	Wet Season
Suspended Solids (mg/L)	17 mg/L	14 mg/L
Oil & Grease (mg/L)	2.5 mg/L	2.0 mg/L
BOD_5 (mg/L)	6.0 mg/L	3.1 mg/L
Total Organic Carbon (mg/L)	2.3 mg/L	4.0 mg/L
TKN (mg/L)	1.3 mg/L	1.0 mg/L
Nitrate-N (mg/L)	0.6 mg/L	0.7 mg/L
Nitrite-N (mg/L)	0.3 mg/L	0.1 mg/L
Ammonia-N (mg/L)	0.3 mg/L	0.4 mg/L
Total Phosphorus (mg/L)	0.3 mg/L	0.2 mg/L
Orthophosphorus (mg/L)	0.2 mg/L	0.2 mg/L
E.coli (cfu/100mL)	9,279 cfu/100mL	40,676 cfu/100mL
Chlorophyll-a (mg/m^3)	4.9 mg/m^3	2.5 mg/m^3
TIN (mg/L)	1.22 mg/L	1.13 mg/L

10.3 The storm volumes for the 1 in 2 year's, 1 in 10 year's, 1 in 50 year's and 1 in 200 year's (4 hours duration) are presented in Table 10.

Table 10 Predicted discharge volume to western portal for different magnitude rain storms

	Volume for 4 hours rain (m³)
1 in 2 years	273,345
1 in 10 years	551,750
1 in 50 years	844,752
1 in 200 years	1,046,675

10.4 Prediction of pollutant discharge concentrations for the storm events (1 in 2 years and 1 in 50 years) are calculated and shown in Table 11. The effects on the receiving marine environment by the increased flow during storm events at the Western Portal and pollutant loads on water quality will be quantified using a Water Quality Model. The 1 in 2 year and 1 in 50 year storm events will be chosen as the hydraulic load scenarios:

- The 1 in 2 year storm events is a regular event with relatively high concentrations of pollutants
- The 1 in 50 year event has smaller discharge volume (80.7% of 1 in 200 years) than 1 in 200 years but this significant event is more likely to occur during the design life of the scheme and has higher estimated concentrations than 1 in 200 year return storm.
- The 1 in 200 year event has the largest discharge volume and hence plume size but it also has the weakest concentrations. Therefore, 1 in 200 year storm event has not been selected for water quality model run.

Table 11 Predicted concentrations at the Western Portal during rain storms events

	1 in 2 years		**1 in 50 years**	
	Dry season	Wet season	Dry season	Wet season
BOD_5 (mg/L)	0.035	0.032	0.011	0.010
Nitrate (mg/L)	0.003	0.007	0.001	0.002
Nitrite (mg/L)	0.002	0.001	0.001	0.000
Ammonia-N (mg/L)	0.002	0.004	0.001	0.001
TIN (mg/L)	0.007	0.012	0.002	0.004
Total Phosphorus (mg/L)	0.002	0.003	0.001	0.001
Chlorophyll-a (mg/m³)	0.029	0.026	0.009	0.009
TKN (mg/L)	0.008	0.011	0.002	0.003
Orthophosphorus (mg/L)	0.001	0.002	0.000	0.001
Total Organic Carbon (mg/L)	0.014	0.042	0.004	0.014
Oil & Grease (mg/L)	0.015	0.021	0.005	0.007
E-coli (cfu/100ml)	54	422	17	137
Suspended Solids (mg/L)	0.101	0.144	0.033	0.047

Remarks:

Calculation assumption:

(i) The pollutant load to intakes remains unchanged during the rainstorm events;

(ii) The pollutant will be diluted by the severe rainstorm events.

Sampling calculation:

E. coli discharge concentration at Western Portal during wet season 1 in 2 years and 1 in 50 years storm events:

Wet season flow to Western Portal = 17,029 m^3/d = 2,838 m^3 per 4 hrs

E. coli concentration (wet season) = 40,676 cfu/100mL = 406,760,000 cfu/m^3

Total cfu to western portal in 4 hours = 406,760,000 cfu/m^3 x 2,838 m^3 per 4 hrs = 1.15 x 10^{12} cfu

Total volume of 2 yrs 4 hours storm = 273,345 m^3

Total volume of 50 yrs 4 hours storm = 844,752 m^3

Average 2 yr storm E. coli concentration = 1.15 x 10^{12} cfu / 273,345 m^3 = 4,223,427 cfu/m^3 = 422 cfu/100mL.

Average 50 yr storm E. coli concentration = 1.15 x 10^{12} cfu / 844,752 m^3 = 1,366,617 cfu/m^3 = 136 cfu/100mL.

10.5 The water quality recorded at the WM1 (nearest EPD marine water monitoring station to the Cyberport STWs) from 1998 – 2005 (wet season). Table 16 shows that there are no significant changes in on Salinity (Chart 1), *E. coli* concentration (Chart 2) and Suspended Solids concentrations (Chart 3) (surface, middle and bottom) before and after commissioning (2002) of the Cyberport Sewage treatment works.

10.6 The pre-project baseline scenario (2002-2005) for the proposed drainage tunnel will be used. For the present study, the best representative as the baseline condition is after the commissioning of the Cyberport in 2002 to up to date record (May 2005). WM1 is the nearest EPD monitoring locations to the Cyberport STW. Table 12 shows the average water quality during wet seasons.

Table 12 Average Water Quality at EPD monitoring station WM1 Wet seasons over years (1998-2005)

		Salinity	SD	***E. coli***	SD	**SS**	SD
Bottom	1998	**33.44**	0.91	**41.14**	9.62	**4.89**	2.44
	1999	**33.50**	1.14	**20.57**	23.65	**10.21**	7.75
	2000	**33.03**	0.89	**154.86**	259.62	**9.14**	5.81
	2001	**33.04**	0.83	**39.57**	48.69	**13.96**	8.87
	2002	**33.67**	0.62	**43.71**	21.80	**12.44**	5.59
	2003	**34.25**	0.62	**209.20**	296.94	**8.74**	5.73
	2004	**33.76**	0.49	**111.00**	217.03	**6.73**	2.83
	2005	**33.88***	0.29	**20.00***	-	**3.60***	-
Middle	1998	**32.86**	0.81	**85.57**	69.51	**3.24**	1.71
	1999	**32.96**	1.42	**379.86**	761.22	**4.70**	4.62
	2000	**32.39**	1.27	**502.29**	887.04	**4.94**	3.71
	2001	**32.54**	0.93	**80.00**	52.07	**7.99**	3.91

		Salinity	SD	*E. coli*	SD	SS	SD
	2002	**33.07**	0.96	**148.86**	224.45	**6.17**	3.07
	2003	**33.48**	0.82	**194.75**	161.63	**5.29**	2.06
	2004	**31.91**	2.18	**199.71**	294.15	**4.06**	1.07
	2005	**33.54***	0.13	**75.00***	-	**1.10***	-
Surface	1998	**27.29**	5.13	**52.14**	38.00	**2.66**	1.39
	1999	**28.84**	4.30	**306.86**	333.69	**4.04**	3.66
	2000	**29.00**	3.92	**1240.71**	2518.81	**2.70**	1.02
	2001	**28.03**	4.48	**136.00**	121.13	**4.26**	1.92
	2002	**30.10**	3.34	**1590.00**	2552.14	**4.66**	2.75
	2003	**29.10**	5.11	**224.63**	477.10	**3.20**	1.50
	2004	**30.43**	2.79	**561.14**	931.48	**3.04**	1.15
	2005	**30.77***	3.08	**120.00***	-	**2.10***	-

Remarks: * Available data for Apr and May 2005 only.

Table 13 90th percentile (depth average) at EPD monitoring locations (1998-2005)

EPD marine monitoring location	Salinity (ppt)	*E. coli* (cfu/100mL)	Suspended Solids (mg/L)
WM1	**34.0**	**650**	**13.5**
Min	19.0	2	0.7
Max	34.9	6900	53
WM2	**33.36**	**2400**	**16**
Min	18.1	4	1
Max	33.9	9400	28
SM3	**33.9**	**148**	**10.6**
Min	20.4	1	0.7
Max	34.6	920	34
SM4	**33.58**	**92.4**	**8.37**
Min	21.9	1	0.8
Max	33.15	17500	13
VM8	**33.15**	**17500**	**13**
Min	18.6	47	0.8
Max	33.9	100000	32

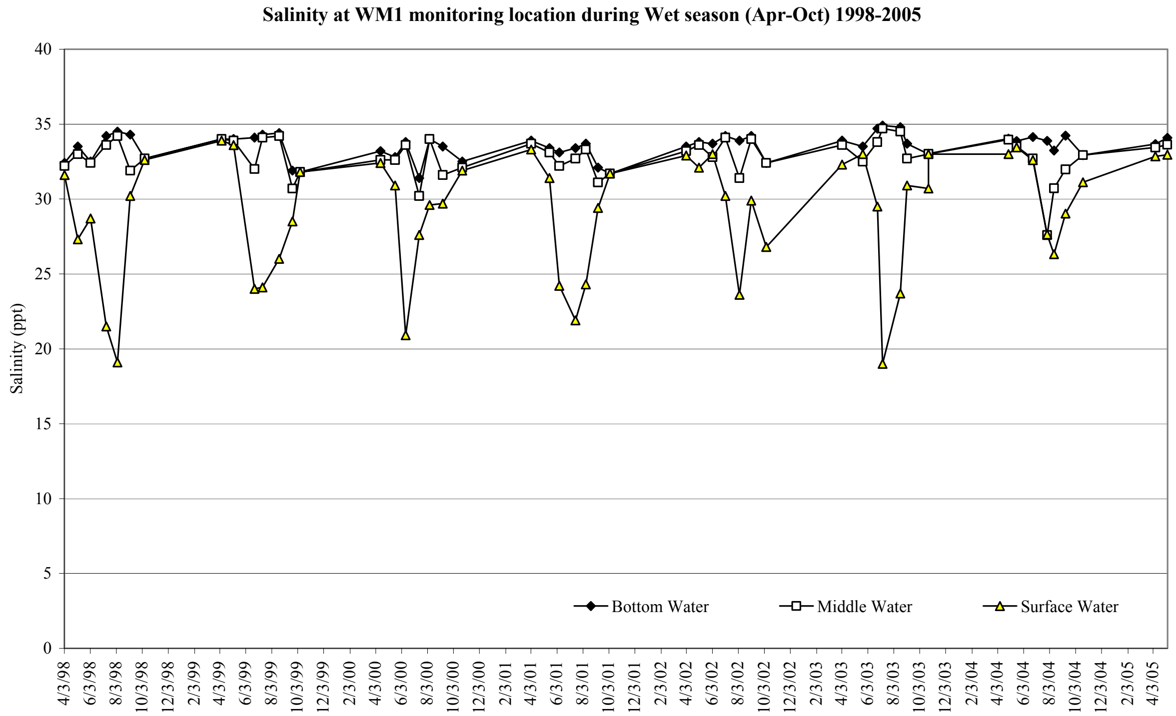

Chart 2 Salinity at WM1 monitoring location – Wet seasons (1998-2005)

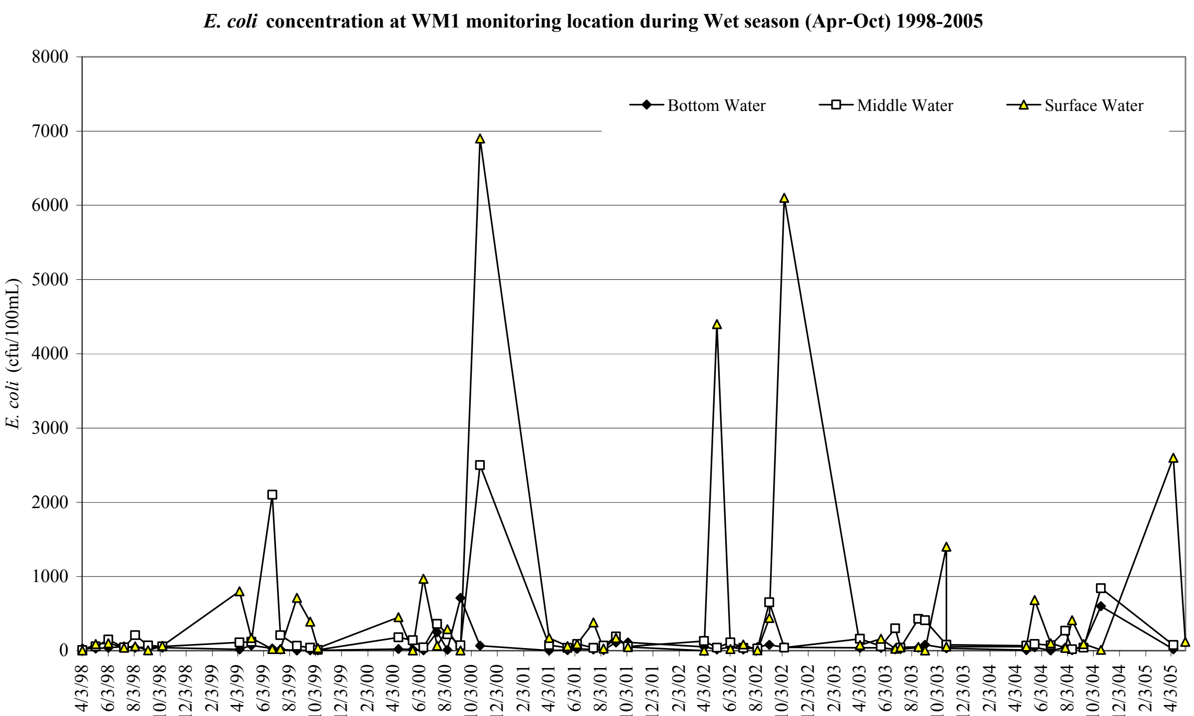

Chart 3 *E. coli* concentrations at WM1 monitoring location – Wet seasons (1998-2005)

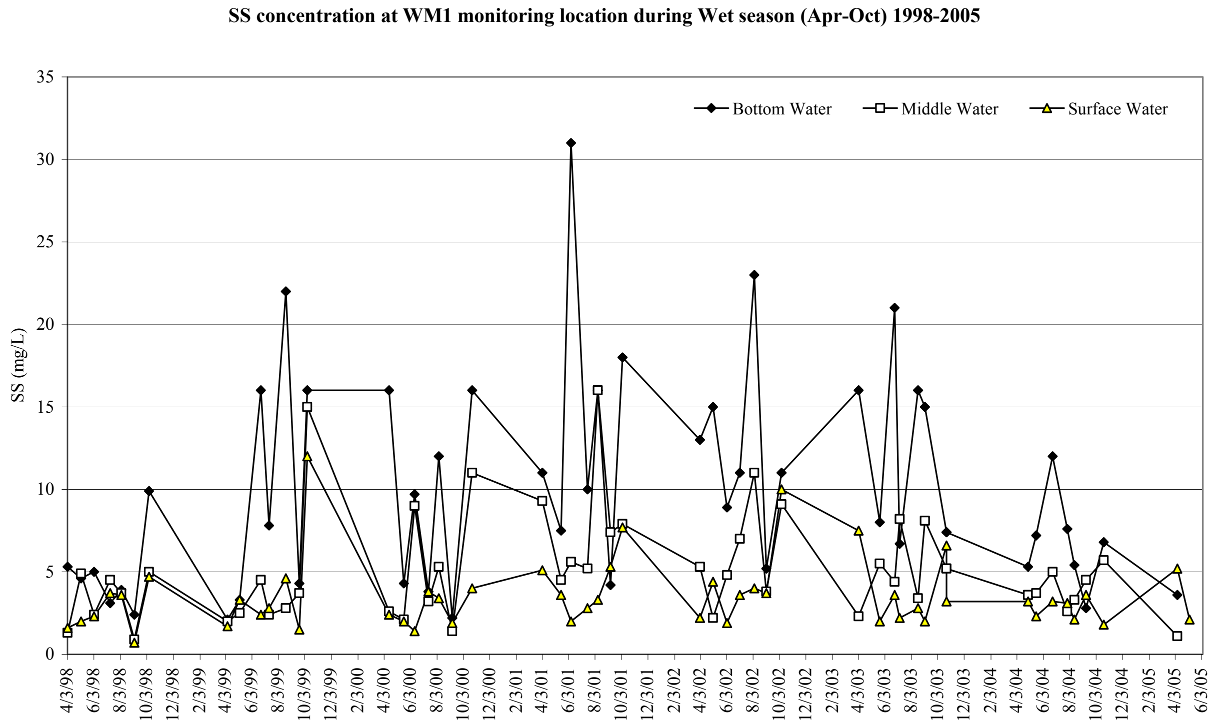

Chart 4 SS concentrations at WM1 monitoring location – Wet seasons (1998-2005)

11. CONCLUSION

11.1 The concentrations of pollutants that may discharge at the Western Portal are considered to be highly conservative for the reasons discussed earlier in the present report.

11.2 The Water Pollution Control Ordinance (Cap. 358) provides the major statutory framework for the protection and control of water quality in Hong Kong. Under the WPCO, Hong Kong marine waters are divided into 10 Water Control Zones (WCZs). Each WCZ has a designated set of statutory Water Quality Objectives (WQOs). The proposed drainage tunnel outfall falls within the Western Buffer WCZ which has declared in June 1993. During operation, pollutant plumes generated from outfall may impact the Western Buffer WCZ. The WQOs set limits for different parameters that should be achieved in order to maintain the water quality within the Western Buffer and Southern WCZs.

11.3 Table 14 presents the estimate pollutants concentrations discharge at the Western Portal during 1 in 2 years and 1 in 50 years event which compares against the Western Buffer WQOs. Table 14 shows the summary water quality (1998-2005) at the nearest EPD monitoring location (WM1) to the Western Portal. Based on the results of the present study the following parameters will be investigated in the Water Quality Model – salinity, *E. coli* and suspended solids.

Table 14 Discharge Concentrations at Western Portal comparing with WQO

	1 in 2 years		**1 in 50 years**		Western Buffer WQOs
	Dry season	Wet season	Dry season	Wet season	-
BOD_5 (mg/L)	0.035	0.032	0.011	0.010	-
Nitrate (mg/L)	0.003	0.007	0.001	0.002	-
Nitrite (mg/L)	0.002	0.001	0.001	0.000	-
Ammonia-N (mg/L)	0.002	0.004	0.001	0.001	-
TIN (mg/L)	0.007	0.012	0.002	0.004	Annual mean depth-averaged inorganic nitrogen not to exceed 0.4 mg/L
Total Phosphorus (mg/L)	0.002	0.003	0.001	0.001	
Chlorophyll-a (mg/m^3)	0.029	0.026	0.009	0.009	-
TKN (mg/L)	0.008	0.011	0.002	0.003	
Orthophosphorus (mg/L)	0.001	0.002	0.000	0.001	-
Total Organic Carbon (mg/L)	0.014	0.042	0.004	0.014	-
Oil & Grease (mg/L)	0.015	0.021	0.005	0.007	-
E-coli (cfu/100ml)	54	422	17	137	< 610 cfu/100mL (secondary contact/FCZ)
Suspended Solids* (mg/L)	-	-	-	-	< natural ambient level + 30%

Remarks: The predicted suspended solids concentration (first flush) during the operation phase of the proposed project is shown in Part B of this report and more discussion is at the Chapter 7 of the EIA report.

PART B) ESTIMATION OF SEDIMENT LOADS FROM PROPOSED INTAKE SHAFTS TO WESTERN PORTAL

1. SEDIMENT ANALYSIS

1.1 Consideration of sediment yield is required as part of the Hong Kong West Drainage Tunnel Investigation to investigate both the transport efficiency of the tunnel and the impact of the downstream receiving water quality of Western Portal at Pok Fu Lam.

1.2 The following methodology has been devised to estimate the annual sediment yield of the study's catchments using available information.

2. METHODOLOGY AND CONCLUSIONS

2.1 In May 1997, the third report associated with "Territorial Land Drainage and Flood Control Strategy Study" (TELADFLOCOSS III) was published and it considered sedimentation issues within main water courses mostly located in the New Territories. As part of the TELADFLOCOSS III study sediment sampling was carried out within each watercourse over an extended period. Methods were devised and used to estimate the annual sediment yield of the catchments.

2.2 The TELADFLOCOSS III did not focus on any watercourses in the present project area. Therefore, this methodology has been devised to use the information within the TELADFLOCOSS III and apply its results.

2.3 The TELADFLOCOSS III study indicated that erosion rates for varying land uses were approximately those shown in Table B1.

Table B1 Typical Erosion Rates

Land Use	**Erosion Rate**	**Range %**	
	(tonnes/km^2/year)	**Lower**	**Upper**
Urban	50	-10	+10
Woodland	350	-20	+20
Agriculture/Grasslands	750	-20	+20
Ponds	100	-10	+10
Bare Soil	2,000	-10	+10
Construction/Quarry	4,000	-20	+20

2.4 To estimate the sediment yields for each catchment the TELADFLOCOSS III study then considered the sediment delivery ratios based on sampling the suspended sediments in each stream. This is shown in Table B2 with their associated geology, erosion rates, and sediment yields. The TELADFLOCOSS III report does not discuss whether the bed load was also monitored, however the present paper assumes it was in order to derive the delivery ratios.

Table B2 Sediment Yield Values from TELADFLOCOSS III and Catchment Geology

Location	Catchment Geology	Natural Erosion ($tonne/km^2/yr$)	Sediment Delivery Ratio	Effective Sediment Yield ($tonne/km^2/yr$)
Silver River	Alluvium, Colluvium, Granite, Volcanic	624	0.26	162
Staunton Creek*	Volcanic	364	0.34	124
Kai Tak Nullah	Alluvium, Colluvium, Granite	286	0.23	66
Shing Mun River	Granite	460	0.27	124
Tai Po / Lam Tsuen	Volcanic, Alluvium	398	0.29	116
River Indus*	Alluvium, Volcanic	438	0.25	109
San Tin*	Alluvium	248	0.28	69
Yuen Long / Kam Tin/ Ngau Tam Mei	Alluvium	439	0.26	114
Tin Shui Wai	Alluvium	286	0.2	57
Tuen Mun	Alluvium, Colluvium, Granite	405	0.2	81
So Kwun Wat	Alluvium, Granite	897	0.27	242
Tai Lam Chung*	Alluvium, Granite	604	0.31	187
Sham Tseng*	Granite	524	0.38	199
Average Value		**459**	**0.27**	**127**

Note: '*' denotes catchments that receive sediments mainly from the natural catchment as opposed to quarry and construction work.

2.5 The sediments entering the Staunton Creek, River Indus, San Tin, Tai Lam Chung and Sham Tseng watercourses are mostly derived from the natural catchment. This represents the likely situation for the watercourses in the present study since new developments and quarry work in the catchments is extremely unlikely owing to their predominately country park status. The San Tin catchments however are located in low lying areas and the channels are surrounded by fish ponds that may influence the observed sedimentation rates and therefore are excluded from the present study. The remaining river channels receive their runoff from steep catchments that have gradients ranging from 0.10 m/m to 0.70 m/m which are similar to the gradients of the catchments in the present study (0.15m/m to 0.70m/m)), likewise they have similar land uses and geology.

2.6 A simple approach to transferring the TELADFLOCOSS III data to the catchments of the present study is to derive the erosion rates for the catchments based on Table 1 and to use the average of the sediment delivery ratios for the Staunton Creek, River Indus, San Tin, Tai Lam Chung and Sham Tseng catchments shown in Table B2. The results are shown in Table B3.

Table B3 Average Total Annual Sediment

Total Catchment Area	$5.3\ km^2$
Catchment Area – Urban	$1.0\ km^2$
Catchment Area – Woodland	$4.3\ km^2$
Average Annual Erosion Rate	$294\ tonnes/km^2$
Average Sediment Delivery Ratio	0.32
Average Annual Sediment Yield	$94\ tonnes/km^2$
Average Total Annual Sediment	498 tonnes

3. MASS CONCENTRATION

3.1 The total mean annual runoff to the tunnel intakes is estimated to be about 4,450,000 m^3 based on observed long-term rainfall data and typical volumetric runoff coefficients (BV, 2004). Sediments are likely to be transported downstream during runoff events and rainfall records indicate that 90% of the annual rainfall falls during the months of April to October (inclusive). Therefore, as a conservative measure, the average annual mass concentration is derived using the runoff volume that occurs during the wet season.

3.2 The average annual concentration of sediment runoff is therefore estimated in Table B4.

Table B4 Average Annual Mass Concentration

Average Annual Total Sediment Yield	498,000 kg
Average Annual Total Runoff	4,450,000 m^3
Average Wet Season Runoff	4,005,000 m^3
Average Annual Mass Concentration	124 mg/l

3.3 This value is relatively low compared to typical values (50mg/l to 1,000mg/l) used when assessing sediment concentrations in stormwater reticulation systems in the United Kingdom (CIRIA, 1996). But considering that the value of 124 mg/l is derived from HK data; the catchments draining to the proposed tunnel scheme are very well protected by mature and well-established, dense vegetation; and there is very limited potential for development on the steep slopes, it is expected that the sediment runoff would be reasonably low. Therefore, an average concentration of 124 mg/l is considered acceptable for the present study and this concentration is recommended to be used in the Water Quality Model.

3.4 The 'first flush' principal relating to suspended solids is not considered by the present study because this phenomenon does not affect sediment loadings from natural catchments. This is supported by the Australian New South Wales Environment Protection Agency (Internet Reference 1) who say that the "first flush may not be observed for one or more of the following reasons:

1. Bare soils or vegetated surfaces are generally not 'cleansed' as easily or effectively as sealed surfaces.
2. Pollutant sources that are effectively continuous may exist within the catchment. First flush is generally seen only where the supply of pollutants is limited. Sediment washing off from soil erosion, for example, will not give a first flush because the supply of soil particles is (for all practical purposes) unlimited. In cases like this, on-line, flow-through pollution controls will be needed."

3.5 In extreme circumstances landslides and slips do occur and these will generate significantly higher concentrations of sediments. This phenomenon is not considered in the present paper.

3.6 Based on the present analysis the total mass of sediments discharged to the Western Portal during storm events is shown in Table B5.

Table B5 Total Sediment Discharge During Storm Events

Storm Event	Total Runoff Volume (m^3)	Total Sediment Runoff Volume (tonnes)
2-year	273,345	33.9
10-year	551,750	68.4
50-year	844,752	104.8
200-year	1,046,675	129.8

3.7 The sediment will discharge form the Western Portal as a plume and will eventually settle onto the seafloor over a large distributed area. The advection and dispersion of the sediment plume and the rate of settlement at key sites is investigated by the water quality model.

4. SEDIMENT SIZE AND WEIGHT

4.1 A soil study conducted in the Mid-Levels during the seventies (GCO, c1980) investigated the soil properties in some of the catchments that drain to the proposed tunnel. Since the remaining catchments have both similar geology (Allen and Stephens, 1971) and soils (Grant, 1960) it can be assumed that the information collected in the Mid Levels study is applicable to those remaining catchments. It was found that the soils generally were colluviums derived from the underlying volcanic or granite parent material. They generally consist of sandy loams, loams and clay loams and have a specific gravity of about 2.65. Based on this information it is expected that the size of most soil particles ranges from 2μm to 1mm (Raudkivi, 1993).

4.2 It was found that in some places the colluvium consists of up to 75% cobbles and boulders of varying sizes.

REFERENCES

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Internet Reference 1: *http://www.epa.nsw.gov.au/mao/stormwater.htm*
Raudkivi (1993). *Sedimentation – Exclusion and Removal of Sediment from Diverted Water*.

Table 1a. In-situ measurement and laboratory analysis at proposed Eastern portal and selected intake shafts (10 March 2004).

Test	Unit	Method Used	E4(P)	E4(P)-D	W1	W1-D	W5	W5-D	W10	W10-D	E5(B)(P)	E5(B)(P)-D	W11(P)	W11(P)-D	PFLR1(P)	PFLR1(P)-D
In-situ Measurement																
Water Depth	m	In house method by using water depth meter	0.160		0.002		0.030		0.005		0.020		0.020		0.020	
Water Flow	m^3 / day	In house method by using water flow meter	3.9		6.2		2808		138		482		1673		9.6	
pH	at 25^oC	In house method by using potable pH meter	7.54	7.55	7.75	7.72	8.19	8.22	8.09	8.06	7.98	8	7.88	7.9	7.73	7.71
Turbidity	NTU	In house method by using potable turbidimeter	3.1	3.02	6.37	5.98	31.61	31.25	21.12	21.04	9.61	10.82	11.38	11.04	12.37	12.29
Temperature	^oC	APHA 19ed 2550B	16.1	16	17.3	17.3	20	20	18.9	19	19.6	19.8	19.4	19.5	20.4	20.5
DO	mg/L	APHA 19ed 4500-O G	10.1	10.11	6.64	6.62	7.86	7.81	8.74	9.71	7.85	7.88	8.8	8.82	8.64	8.62
Salinity	ppt	APHA 19ed 2520B	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4	0.4	0.1	0.1
Laborary analysis																
Suspended Solids	mg/L	In house method TPE/006/W	5	5	5	5	23	24	13	12	12	11	5	5	5	5
Oil & Grease	mg/L	APHA 19ed 5520B	5	5	5	5	9.9	10	6.4	6.7	5	5	5	5	5	5
BOD_5	mg/L	In house method TPE/001/W	2	2	2.6	2.7	38	38	31	31	25	25	3.8	3.8	4.4	4.4
Total Organic Carbon	mg/L	APHA 19ed 5310B	3	2	2	2	10	8	9	8	4	3	2	2	1	1
TKN	mgN/L	In house method TPE/017/W	0.6	0.5	0.6	0.50	8.2	8.0	1.7	1.6	4.2	4.1	1.2	1.2	1.2	1.1
Nitrate	$mgNO_3^-$-N/L	In house method TPE/010/W	0.1	0.2	1.6	0.8	0.9	1.1	0.6	0.7	1.2	1.6	0.3	0.2	0.3	0.3
Nitrite	$mgNO_2^-$-N/L	In house method TPE/011/W	1.3	1.3	4.8	5.2	1.9	1.9	1.3	1.4	3.0	2.8	0.81	0.78	1.1	1.1
Ammonia-N	$mgNH_3^-$-N/L	In house method TPE/016/W	0.025	0.025	0.052	0.053	0.37	0.36	0.15	0.14	2.7	2.7	0.025	0.025	0.087	0.080
Total Phosphorus	mgP/L	In house method TPE/019/W	0.07	0.09	0.07	0.07	2.2	2.2	0.87	0.85	1.5	1.5	0.60	0.60	0.34	0.35
Orthophosphorus	mgP/L	In house method TPE/020/W	0.041	0.042	0.069	0.065	1.0	1.0	0.33	0.34	0.68	0.67	0.24	0.24	0.19	0.18
E-coli	cfu/100ml	DoE 7.8 & 7.9 plus in-situ urese test	30	20	2300	1700	19000	30000	1500	2800	54000	48000	70	74	100000	120000
Chlorophyll-a	mg/L	APHA 19ed 10200H	1.1	0.5	0.5	0.5	9.1	8.5	6.4	5.3	5.9	6.4	0.5	1.1	1.1	0.5

(to be continued)

Table 1a. In-situ measurement and laborary analysis at proposed Eastern portal and selected intake shafts (10 March 2004).

Test	Unit	Method Used	W3(P)	W3(P)-D	TP789(P)	TP789(P)-D	THR2(P)	THR2(P)-D	W8	W8-D	P5(P)	P5(P)-D	W12	W12-D
In-situ Measurement														
Water Depth	m	In house method by using water depth meter	0.020		0.030		0.030		0.003		0.002		0.025	
Water Flow	m^3 / day	In house method by using water flow meter	886		399		5550		57		27		640	
pH	at 25^oC	In house method by using potable pH meter	11.6	11.59	8.28	8.26	7.25	7.22	8.23	8.25	7.6	7.59	7.68	7.66
Turbidity	NTU	In house method by using potable turbidimeter	46.17	45.93	7.02	7.2	0.77	0.86	8.77	8.63	3.57	3.49	13.15	12.99
Temperature	^oC	APHA 19ed 2550B	19.3	19.2	17.5	17.3	21.6	21.7	19	19	21.5	21.5	19	19
DO	mg/L	APHA 19ed 4500-O G	7.9	7.85	9.33	9.31	8.92	8.93	8.72	8.7	7.89	7.86	7.69	7.72
Salinity	ppt	APHA 19ed 2520B	0.4	0.4	0.1	0.1	0.1	0.1	0.5	0.5	0	0	0.1	0.1
Laborary analysis														
Suspended Solids	mg/L	In house method TPE/006/W	120	120	5	5	5	5	5	5	5	5	15	16
Oil & Grease	mg/L	APHA 19ed 5520B	7.0	6.8	5	5	5	5	5	5	5	5	11	12
BOD_5	mg/L	In house method TPE/001/W	34	34	2	2	2	2	5.8	5.8	4.8	4.8	41	41
Total Organic Carbon	mg/L	APHA 19ed 5310B	9	8	1	1	1	1	4	3	1	1	10	8
TKN	mgN/L	In house method TPE/017/W	4.2	4.1	1.2	1.0	1.0	0.7	2.8	2.7	1.4	1.3	3.9	3.8
Nitrate	$mgNO_3^-$-N/L	In house method TPE/010/W	0.6	0.7	1.2	1.4	0.1	0.1	0.5	0.5	0.2	0.1	0.3	0.4
Nitrite	$mgNO_2^-$-N/L	In house method TPE/011/W	1.8	1.9	2.7	2.6	0.33	0.33	1.3	1.2	0.65	0.66	0.82	0.77
Ammonia-N	$mgNH_3^-$-N/L	In house method TPE/016/W	0.049	0.046	0.092	0.092	0.025	0.025	0.29	0.29	0.025	0.025	0.025	0.025
Total Phosphorus	mgP/L	In house method TPE/019/W	0.31	0.29	0.39	0.39	0.18	0.18	0.62	0.61	0.51	0.51	2.0	2.0
Orthophosphorus	mgP/L	In house method TPE/020/W	0.16	0.17	0.22	0.21	0.036	0.038	0.47	0.51	0.46	0.45	1.1	1.1
E-coli	cfu/100ml	DoE 7.8 & 7.9 plus in-situ urese test	1	1	1100	1100	57	10	5100	5700	63	60	180000	140000
Chlorophyll-a	mg/m^3	APHA 19ed 10200H	32	34	1.1	0.5	4.8	6.4	1.6	1.1	1.1	0.5	4.3	4.3

Remarks: Data are analyzed by ETL laborary.

Table 1b. In-situ measurement and laborary analysis at proposed Eastern portal and selected intake shafts (10 March 2004).

Test	Unit	Method Used	E4(P)	E4(P)-D	W1	W1-D	W5	W5-D	W10	W10-D	E5(B)(P)	E5(B)(P)-D	W11(P)	W11(P)-D	PFLR1(P)	PFLR1(P)-D
Laborary analysis																
Suspended Solids	mg/L	In house method TPE/006/W	1.5	1.3	3.6		18	59	22	12	11	11	3.6	22	6.2	20
Oil & Grease	mg/L	APHA 19ed 5520B	0.5	0.5	0.5	0.5	1.95	2.1	0.75	1.05	0.5	0.5	0.5	0.5	0.5	0.5
BOD_5	mg/L	In house method TPE/001/W	25		1.1		1.8	1.7	18	19	3.5	3.8	4.3	2.5	2.5	3
Total Organic Carbon	mg/L	APHA 19ed 5310B	1	1	1.8		12	12	9	9	5	5	3	2	3	3
TKN	mgN/L	In house method TPE/017/W	0.09	0.12	0.1		7.6	8.3	0.64	0.58	3.2	3.3	0.15	0.18	0.24	0.28
Nitrate	$mgNO_3^-$-N/L	In house method TPE/010/W	0.9	0.89	4		0.94	1.4	1.4	1.3	2.1	2.3	0.36	0.38	1.1	0.99
Nitrite	$mgNO_2^-$-N/L	In house method TPE/011/W	0.004	0.004	0.025		0.48	0.23	0.073	0.064	0.59	0.47	0.013	0.012	0.045	0.058
Ammonia-N	$mgNH_3^-$-N/L	In house method TPE/016/W	0.039	0.024	0.08		4	4.6	0.13	0.13	2.4	2.3	0.032	0.042	0.085	0.1
Total Phosphorus	mgP/L	In house method TPE/019/W	0.024	0.0235	0.07		1.8	1.8	0.67	0.67	1.2	1.3	0.22	0.14	0.21	0.22
Orthophosphorus	mgP/L	In house method TPE/020/W	0.024	0.022	0.062		1.2	1.4	0.38	0.36	1	0.98	0.12	0.11	0.18	0.18
E-coli	cfu/100ml	DoE 7.8 & 7.9 plus in-situ urese test	130	52	4400	6100	34000	32000	8000	8000	34000	32000	110	470	39000	53000
Chlorophyll-a	mg/m^3	APHA 19ed 10200H	0.5	0.3	0.6		1.7	2.2	0.8	0.8	1.5	4.1	0.5	0.3	3.8	11
Faecal coli count	cfu/100ml		370	140	12000	15000	56000	59000	140000	140000	56000	59000	7200	11000	330000	380000

(to be continued)

Table 1b. In-situ measurement and laborary analysis at proposed Eastern portal and selected intake shafts (10 March 2004).

Test	Unit	Method Used	W3(P)	W3(P)-D	TP789(P)	TP789(P)-D	THR2(P)	THR2(P)-D	W8	W8-D	P5(P)	P5(P)-D	W12	W12-D
Laborary analysis														
Suspended Solids	mg/L	In house method TPE/006/W	140	140	3.8	6.9	0.8	0.5	3.4	3.6	5.4	2.4	12	10
Oil & Grease	mg/L	APHA 19ed 5520B	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.7	1.95
BOD_5	mg/L	In house method TPE/001/W	14	9.4	0.72	0.64	2.2	1.5	4.6	5.1	6.6	7.7		
Total Organic Carbon	mg/L	APHA 19ed 5310B	7	7	1	1	1	1	4	4	2	2	11	10
TKN	mgN/L	In house method TPE/017/W	2.7	2.4	0.05	0.05	0.06	0.09	0.89	0.9	0.4	0.33	2	2
Nitrate	$mgNO_3^-$-N/L	In house method TPE/010/W	1.8	2	2.6	2.7	0.3	0.3	1.4	1.4	0.38	0.35	0.6	0.63
Nitrite	$mgNO_2^-$-N/L	In house method TPE/011/W	0.27	0.23	0.004	0.006	0.002	0.002	0.03	0.031	0.01	0.009	0.05	0.053
Ammonia-N	$mgNH_3^-$-N/L	In house method TPE/016/W	0.13	0.14	0.024	0.021	0.03	0.043	0.21	0.21	0.037	0.06	0.69	0.74
Total Phosphorus	mgP/L	In house method TPE/019/W	0.4	0.42	0.02	0.02	0.02	0.02	0.45	0.47	0.47	0.44	1.9	1.8
Orthophosphorus	mgP/L	In house method TPE/020/W	0.037	0.032	0.013	0.012	0.019	0.019	0.39	0.4	0.44	0.43	1.3	1.3
E-coli	cfu/100ml	DoE 7.8 & 7.9 plus in-situ urese test	1	1	900	3200	64	59	3300	4100	270	160	210000	160000
Chlorophyll-a	mg/m^3	APHA 19ed 10200H	24	24	4.6	3.6	1.8	0.4	0.8	0.7	1.4	0.5	0.5	0.6
Faecal coli count	cfu/100ml		2	1	1000	3200	910	600	87000	63000	2500	1600	240000	160000

Remarks: Data are provided by EPD (analyzed by the government laboratory)

Table 2. In-situ measurement and laboratory analysis at proposed Eastern portal and selected intake shafts (25 March 2004).

Test	Unit	Method Used	E4(P)	E4(P)-D	W1	W1-D	W5	W5-D	W10	W10-D	E5(B)(P)	E5(B)(P)-D	W11(P)	W11(P)-D	PFLR1(P)
In-situ Measurement															
Water Depth	m	In house method by using water depth meter	0.11		0.005		0.03		0.03		0.02		0.015		0.[illegible]
Water Flow	m^3 / day	In house method by using water flow meter	2611		39.6		499		7.0		288		538		14.8
pH	at 25^{o}C	In house method by using potable pH meter	7.28	7.25	7.76	7.77	8.07	8.1	7.81	7.79	7.93	7.92	8.05	8.07	7.57
Turbidity	NTU	In house method by using potable turbidimeter	4.75	4.79	8.22	8.09	20.58	21.24	17.4	17.32	5.86	5.91	12.9	13.14	4.56
Temperature	^{o}C	APHA 19ed 2550B	17.8	17.9	18.8	18.8	19.8	19.8	18.3	18.3	20	20	18.7	18.7	18.7
DO	mg/L	APHA 19ed 4500-O G	7.22	7.2	7.42	7.33	6.67	6.69	6.9	6.92	7.28	7.31	7.69	7.66	7.24
Salinity	ppt	APHA 19ed 2520B	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.1
Laborary analysis															
Suspended Solids	mg/L	In house method TPE/006/W	5.0	5.0	6.2	6.4	22	21	8.5	9.0	6.0	6.2	16	15	5
Oil & Grease	mg/L	APHA 19ed 5520B	5	5	5	5	5	5	5	5	5	5	5	5	5
BOD$_5$	mg/L	In house method TPE/001/W	2	2	2	2	20	20	12	12	12	12	4.6	4.6	2.9
Total Organic Carbon	mg/L	APHA 19ed 5310B	2	2	2	1	8	8	7	7	1	1	2	2	5
TKN	mgN/L	In house method TPE/017/W	0.7	0.7	0.6	0.6	10	10	2.0	2.1	1.8	1.7	2.5	2.4	1.8
Nitrate	mgNO$_3^-$-N/L	In house method TPE/010/W	0.6	0.6	5.1	5.0	0.4	0.5	0.8	0.7	4.2	4.1	0.7	0.8	0.6
Nitrite	mgNO$_2^-$-N/L	In house method TPE/011/W	0.31	0.30	0.10	0.11	0.80	0.84	0.05	0.05	0.01	0.01	0.09	0.08	0.01
Ammonia-N	mgNH$_3^-$-N/L	In house method TPE/016/W	0.028	0.083	0.038	0.038	5.3	5.3	0.35	0.41	1.6	1.4	0.15	0.18	0.061
Total Phosphorus	mgP/L	In house method TPE/019/W	0.03	0.03	0.16	0.16	3.8	3.8	0.36	0.36	0.89	0.92	0.26	0.27	0.07
Orthophosphorus	mgP/L	In house method TPE/020/W	0.017	0.017	0.13	0.11	2.3	2.2	0.22	0.21	0.66	0.66	0.14	0.14	0.053
E-coli	cfu/100ml	DoE 7.8 & 7.9 plus in-situ urese test	100	96	1400	460	61000	42000	340000	360000	16000	14000	1000	22000	13000
Chlorophyll-a	mg/m³	APHA 19ed 10200H	8.5	6.9	18	17	4.8	4.8	8.0	7.5	6.4	7.5	12	11	10

(to be continued)

Table 2. In-situ measurement and laboratory analysis at proposed Eastern portal and selected intake shafts (25 March 2004).

Test	Unit	Method Used	W3(P)	W3(P)-D	TP789(P)	TP789(P)-D	THR2(P)	THR2(P)-D	W8	W8-D	P5(P)	P5(P)-D	W12	W12-D
In-situ Measurement														
Water Depth	m	In house method by using water depth meter	0.02		0.025		0.025		0.005		0.005		0.025	
Water Flow	m^3 / day	In house method by using water flow meter	1390		35.7		2972		155		3.0		204	
pH	at 25^{o}C	In house method by using potable pH meter	9.06	9.08	8.04	8.01	8.42	8.38	7.5	7.48	7.75	7.74	7.56	7.54
Turbidity	NTU	In house method by using potable turbidimeter	5.63	5.8	1.86	1.79	34.87	35.11	56.04	57.19	3.49	3.55	13.15	13
Temperature	^{o}C	APHA 19ed 2550B	19.4	19.5	17.1	17.1	21.6	21.6	18.6	18.5	18	17.9	18.9	19
DO	mg/L	APHA 19ed 4500-O G	8.2	8.17	9.07	9.1	7.9	7.88	7.22	7.2	7.24	7.21	6.67	6.69
Salinity	ppt	APHA 19ed 2520B	0.1	0.1	0.1	0.1	0.1	0.1	1	1	0	0	0.1	0.1
Laborary analysis														
Suspended Solids	mg/L	In house method TPE/006/W	7.6	7.4	5	5	30	32	63	64	5	5	14	15
Oil & Grease	mg/L	APHA 19ed 5520B	5	5	5	5	5	5	5	5	5	5	5	5
BOD$_5$	mg/L	In house method TPE/001/W	2.0	2.0	2.0	2.0	2.0	2.0	23	23	2	2	12	12
Total Organic Carbon	mg/L	APHA 19ed 5310B	1	1	1	1	1	1	28	22	1	1	7	8
TKN	mgN/L	In house method TPE/017/W	0.7	0.7	0.1	0.1	1.0	1.0	7.2	7.8	0.8	0.8	3.4	3.3
Nitrate	mgNO$_3^-$-N/L	In house method TPE/010/W	2.3	2.2	1.2	1.1	0.1	0.1	7.6	7.0	0.5	0.5	1.3	1.3
Nitrite	mgNO$_2^-$-N/L	In house method TPE/011/W	0.01	0.01	0.66	0.63	0.05	0.05	0.14	0.15	0.01	0.01	0.01	0.01
Ammonia-N	mgNH$_3^-$-N/L	In house method TPE/016/W	0.028	0.025	0.045	0.039	0.010	0.019	0.56	0.50	0.12	0.10	0.61	0.61
Total Phosphorus	mgP/L	In house method TPE/019/W	0.21	0.19	0.06	0.05	0.16	0.15	1.5	1.5	0.25	0.25	0.91	0.88
Orthophosphorus	mgP/L	In house method TPE/020/W	0.15	0.15	0.032	0.033	0.11	0.11	0.65	0.72	0.11	0.11	0.50	0.40
E-coli	cfu/100ml	DoE 7.8 & 7.9 plus in-situ urese test	4200	2400	3500	3100	1000	2800	30000	20000	260	80	720000	770000
Chlorophyll-a	mg/L	APHA 19ed 10200H	10	11	11	12	2.7	3.7	1.6	1.6	2.1	2.1	21	21

Table 2. In-situ measurement and laboratory analysis at proposed Eastern portal anc

Test	Unit	Method Used	PFLR1(P)-D
In-situ Measurement			
Water Depth	m	In house method by using water depth meter	02
Water Flow	m^3 / day	In house method by using water flow meter	868
pH	at 25^{o}C	In house method by using potable pH meter	7.6
Turbidity	NTU	In house method by using potable turbidimeter	4.7
Temperature	^{o}C	APHA 19ed 2550B	18.7
DO	mg/L	APHA 19ed 4500-O G	7.21
Salinity	ppt	APHA 19ed 2520B	0.1
Laborary analysis			
Suspended Solids	mg/L	In house method TPE/006/W	5
Oil & Grease	mg/L	APHA 19ed 5520B	5
BOD_5	mg/L	In house method TPE/001/W	2.9
Total Organic Carbon	mg/L	APHA 19ed 5310B	4
TKN	mgN/L	In house method TPE/017/W	1.8
Nitrate	$mgNO_3^-$-N/L	In house method TPE/010/W	0.6
Nitrite	$mgNO_2^-$-N/L	In house method TPE/011/W	0.01
Ammonia-N	$mgNH_3^-$-N/L	In house method TPE/016/W	0.083
Total Phosphorus	mgP/L	In house method TPE/019/W	0.07
Orthophosphorus	mgP/L	In house method TPE/020/W	0.052
E-coli	cfu/100ml	DoE 7.8 & 7.9 plus in-situ urese test	18000
Chlorophyll-a	mg/m³	APHA 19ed 10200H	12

Table 2. In-situ measurement and laboratory analysis at proposed Eastern portal anc

Test	Unit	Method Used
In-situ Measurement		
Water Depth	m	In house method by using water depth meter
Water Flow	m^3 / day	In house method by using water flow meter
pH	at 25^{o}C	In house method by using potable pH meter
Turbidity	NTU	In house method by using potable turbidimeter
Temperature	^{o}C	APHA 19ed 2550B
DO	mg/L	APHA 19ed 4500-O G
Salinity	ppt	APHA 19ed 2520B
Laborary analysis		
Suspended Solids	mg/L	In house method TPE/006/W
Oil & Grease	mg/L	APHA 19ed 5520B
BOD_5	mg/L	In house method TPE/001/W
Total Organic Carbon	mg/L	APHA 19ed 5310B
TKN	mgN/L	In house method TPE/017/W
Nitrate	$mgNO_3^-$-N/L	In house method TPE/010/W
Nitrite	$mgNO_2^-$-N/L	In house method TPE/011/W
Ammonia-N	$mgNH_3^-$-N/L	In house method TPE/016/W
Total Phosphorus	mgP/L	In house method TPE/019/W
Orthophosphorus	mgP/L	In house method TPE/020/W
E-coli	cfu/100ml	DoE 7.8 & 7.9 plus in-situ urese test
Chlorophyll-a	mg/L	APHA 19ed 10200H

Table 3a. In-situ measurement and laboratory analysis at proposed Eastern portal and selected intake shafts (5 May 2004).

Test	Unit	Method Used	E4(P)	E4(P)-D	W1	W1-D	W5	W5-D	W10	W10-D	E5(B)(P)	E5(B)(P)-D	W11(P)	W11(P)-D	PFLR1(P)	PFLR1(P)-D
In-situ Measurement																
Water Depth	m	In house method by using water depth meter	0.18		0.03		0.02		0.03		0.03		0.02		0.05	
Water Flow	m^3 / day	In house method by using water flow meter	13200		1100		980		41		2000		1400		17	
pH	at 25^{o}C	In house method by using potable pH meter	7.51	7.53	8.11	8.10	8.23	8.20	8.42	8.44	7.69	7.66	8.62	8.66	7.63	7.61
Turbidity	NTU	In house method by using potable turbidimeter	4.57	4.6	8.61	8.44	21.6	21.8	23.9	24.1	20.4	19.7	216	223	3.86	3.82
Temperature	^{o}C	APHA 19ed 2550B	21.6	21.7	21.2	21.3	22.5	22.6	21.8	21.8	21.6	21.8	22.4	22.4	22.3	22.3
DO	mg/L	APHA 19ed 4500-O G	7.69	7.65	8.09	8.02	6.87	6.92	7.36	7.40	6.59	6.62	7.26	7.18	6.84	6.92
Salinity	ppt	APHA 19ed 2520B	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Laborary analysis																
Suspended Solids	mg/L	In house method TPE/006/W	5	5	7.5	8.5	22	18	7.5	15	5	18	59	110	5	5
Oil & Grease	mg/L	APHA 19ed 5520B	5	5	5	5	5.5	5.9	5	5	5	5	6.6	6.4	5	5
BOD$_5$	mg/L	In house method TPE/001/W	2	2	2	2	9.1	9.1	9.1	9.1	9.0	9.0	2	2	2	2
Total Organic Carbon	mg/L	APHA 19ed 5310B	1	1	3	3	11	7	4	4	4	4	3	3	2	2
TKN	mgN/L	In house method TPE/017/W	0.5	0.5	0.6	0.5	8.6	8.7	0.8	0.8	1.2	1.2	1.6	1.6	0.6	0.7
Nitrate	mgNO$_3^-$-N/L	In house method TPE/010/W	0.36	0.31	1.3	1.3	0.004	0.013	0.49	0.50	1.1	1.0	0.43	0.42	0.35	0.30
Nitrite	mgNO$_2^-$-N/L	In house method TPE/011/W	0.006	0.006	0.004	0.003	0.004	0.004	0.073	0.070	0.32	0.32	0.010	0.010	0.030	0.030
Ammonia-N	mgNH$_3^-$-N/L	In house method TPE/016/W	0.025	0.025	0.025	0.025	3.7	3.7	0.025	0.025	0.49	0.49	0.025	0.025	0.13	0.13
Total Phosphorus	mgP/L	In house method TPE/019/W	0.04	0.04	0.25	0.25	0.29	0.30	0.30	0.32	0.29	0.28	0.16	0.16	0.06	0.06
Orthophosphorus	mgP/L	In house method TPE/020/W	0.029	0.030	0.15	0.14	0.24	0.23	0.17	0.17	0.27	0.27	0.16	0.16	0.045	0.045
E-coli	cfu/100ml	DoE 7.8 & 7.9 plus in-situ urese test	2500	1800	6100	5300	230000	250000	320	420	100000	110000	63	130	10000	10000
Chlorophyll-a	mg/m³	APHA 19ed 10200H	1.1	1.1	2.1	2.1	24	23	8.5	8.5	4.3	4.3	10	10	3.2	3.2

(to be continued)

Table 3a. In-situ measurement and laboratory analysis at proposed Eastern portal and selected intake shafts (5 May 2004).

Test	Unit	Method Used	W3(P)	W3(P)-D	TP789(P)	TP789(P)-D	THR2(P)	THR2(P)-D	W8	W8-D	P5(P)	P5(P)-D	W12	W12-D
In-situ Measurement														
Water Depth	m	In house method by using water depth meter	0.02		0.02		0.02		0.05		0.02		0.02	
Water Flow	m^3 / day	In house method by using water flow meter	2000		73		1700		32		23		130	
pH	at 25^{o}C	In house method by using potable pH meter	8.55	8.54	8.15	8.21	8.25	8.23	8.24	8.23	7.73	7.75	7.50	7.45
Turbidity	NTU	In house method by using potable turbidimeter	4.38	4.42	6.17	6.05	19.2	18.9	26.1	26.0	1.86	1.79	94.0	95.7
Temperature	^{o}C	APHA 19ed 2550B	22.2	22.2	20.6	20.6	21.7	21.7	22.6	22.6	21.4	21.5	22.2	22.3
DO	mg/L	APHA 19ed 4500-O G	8.30	8.36	8.94	9.03	8.47	8.45	7.91	7.85	9.18	9.1	6.96	6.90
Salinity	ppt	APHA 19ed 2520B	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Laborary analysis														
Suspended Solids	mg/L	In house method TPE/006/W	5	5	5	5	7.0	14	13	11	5	5	55	63
Oil & Grease	mg/L	APHA 19ed 5520B	5	5	5	5	5	5	5	5	5	5	14	15
BOD$_5$	mg/L	In house method TPE/001/W	2	2	2	2	3.5	3.5	8.9	8.9	2	2	7.0	7.0
Total Organic Carbon	mg/L	APHA 19ed 5310B	2	2	2	2	3	3	3	4	1	1	3	3
TKN	mgN/L	In house method TPE/017/W	0.7	0.7	0.6	0.7	0.8	0.8	0.9	0.9	5	5	1.0	1.0
Nitrate	mgNO$_3^-$-N/L	In house method TPE/010/W	1.2	1.1	2.3	2.4	0.56	0.48	1.0	1.0	0.29	0.36	0.52	0.52
Nitrite	mgNO$_2^-$-N/L	In house method TPE/011/W	0.070	0.071	0.005	0.005	0.054	0.054	0.021	0.021	0.002	0.002	0.014	0.014
Ammonia-N	mgNH$_3^-$-N/L	In house method TPE/016/W	0.14	0.13	0.025	0.025	0.25	0.25	0.14	0.15	0.025	0.025	0.059	0.062
Total Phosphorus	mgP/L	In house method TPE/019/W	0.13	0.13	0.02	0.02	0.05	0.05	0.40	0.41	0.09	0.09	0.65	0.48
Orthophosphorus	mgP/L	In house method TPE/020/W	0.042	0.041	0.017	0.019	0.021	0.020	0.19	0.19	0.060	0.061	0.31	0.27
E-coli	cfu/100ml	DoE 7.8 & 7.9 plus in-situ urese test	12000	18000	8400	12000	48000	37000	13000	16000	390	320	32000	35000
Chlorophyll-a	mg/m³	APHA 19ed 10200H	5.3	5.3	1.6	1.6	2.7	2.7	1.1	1.1	2.2	2.7	7.5	6.9

Remarks: Data are analyzed by ETL laborary.

Table 3b. In-situ measurement and laboratory analysis at proposed Eastern portal and selected intake shafts (5 May 2004).

Test	Unit	Method Used	E4(P)	E4(P)-D	W1	W1-D	W5	W5-D	W10	W10-D	E5(B)(P)	E5(B)(P)-D	W11(P)	W11(P)-D	PFLR1(P)	PFLR1(P)-D
Laboratory analysis																
Suspended Solids	mg/L	In house method TPE/006/W	3.1	3.2	8.3	9.8	34	27	9.6	8.7	15	19	96	97	2.4	1.9
Oil & Grease	mg/L	APHA 19ed 5520B	0.5	0.5	0.5	0.5	1.3	1.2	2.5	2.6	0.5	0.5	0.6	0.7	0.5	0.5
BOD_5	mg/L	In house method TPE/001/W	0.1	0.1	1.3	1		25	6.1	6.2	7.9	8.1	7.7	2.5	0.9	0.95
Total Organic Carbon	mg/L	APHA 19ed 5310B	1	1	4	4	20	17	7	7	5	6	4	71	2	2
TKN	mgN/L	In house method TPE/017/W	0.11	0.1	0.45	0.54	7.1	8.3	0.56	0.63	1.7	1.8	0.38	4.2	0.42	0.36
Nitrate	$mgNO_3^-$-N/L	In house method TPE/010/W	0.67	0.66	2.3	2.3	0.041	1.1	0.52	0.42	1.8	1.8	0.53	0.55	0.61	0.6
Nitrite	$mgNO_2^-$-N/L	In house method TPE/011/W	0.004	0.004	0.013	0.012	0.062	0.34	0.056	0.063	0.18	0.17	0.002	0.005	0.013	0.014
Ammonia-N	$mgNH_3^-$-N/L	In house method TPE/016/W	0.036	0.022	0.033	0.028	3.9	4.7	0.046	0.058	0.92	0.94	0.05	0.076	0.16	0.16
Total Phosphorus	mgP/L	In house method TPE/019/W	0.03	0.04	0.16	0.17	2.8	2.7	0.31	0.35	0.44	0.46	0.35	1.3	0.06	0.06
Orthophosphorus	mgP/L	In house method TPE/020/W	0.027	0.027	0.14	0.14	1.8	1.9	0.21	0.23	0.27	0.28	0.13	0.09	0.038	0.028
E-coli	cfu/100ml	DoE 7.8 & 7.9 plus in-situ urese test	1300	1300	6000	7100	520000	340000	170	130	210000	220000	390	570	10000	13000
Chlorophyll-a	mg/m^3	APHA 19ed 10200H	0.8	0.8	2.7	2.6	1	1.6	1.4	1.7	2.8	2.9	0.6	6.2	0.8	0.7
Faecal coli count	cfu/100ml		13000	20000	24000	34000	1200000	770000	690	260	460000	350000	3600	3700	15000	15000

(to be continued)

Table 3b. In-situ measurement and laboratory analysis at proposed Eastern portal and selected intake shafts (5 May 2004).

Test	Unit	Method Used	W3(P)	W3(P)-D	TP789(P)	TP789(P)-D	THR2(P)	THR2(P)-D	W8	W8-D	P5(P)	P5(P)-D	W12	W12-D
Laboratory analysis														
Suspended Solids	mg/L	In house method TPE/006/W	4.8	5.1	1.7	2.6	13	12	14	18	1.4	1.5	110	95
Oil & Grease	mg/L	APHA 19ed 5520B	0.5	0.5	0.5	0.5	0.5	0.5	0.9	1	0.5	0.5	0.5	
BOD_5	mg/L	In house method TPE/001/W	0.97	0.55	0.47	0.39	5.7	5.9	21	21	0.1	0.13	10	11
Total Organic Carbon	mg/L	APHA 19ed 5310B	2	2	2	2	5	5	8	8	1	1	3	3
TKN	mgN/L	In house method TPE/017/W	0.12	0.23	0.05	0.05	0.97	0.9	0.83	1	0.05	0.09	0.92	0.97
Nitrate	$mgNO_3^-$-N/L	In house method TPE/010/W	2.6	2.4	2.4	2.4	0.87	0.85	0.17	0.18	0.71	0.75	0.66	0.77
Nitrite	$mgNO_2^-$-N/L	In house method TPE/011/W	0.054	0.052	0.003	0.003	0.044	0.043	0.027	0.023	0.002	0.002	0.005	0.008
Ammonia-N	$mgNH_3^-$-N/L	In house method TPE/016/W	0.037	0.038	0.031	0.03	0.24	0.23	0.094	0.062	0.047	0.038	0.08	0.072
Total Phosphorus	mgP/L	In house method TPE/019/W	0.32	0.26	0.03	0.03	0.17	0.16	0.66	0.68	0.08	0.1	0.57	0.6
Orthophosphorus	mgP/L	In house method TPE/020/W	0.31	0.25	0.023	0.024	0.11	0.11	0.15	0.15	0.076	0.076	0.29	0.31
E-coli	cfu/100ml	DoE 7.8 & 7.9 plus in-situ urese test	16000	18000	9000	8000	10000	14000	8600	12000	460	480	20000	23000
Chlorophyll-a	mg/m^3	APHA 19ed 10200H	1.7	1.4	1	1	0.8	0.9	0.8	0.7	1.1	2.1	0.4	0.3
Faecal coli count	cfu/100ml		28000	39000	16000	19000	120000	210000	96000	95000	10000	7900	86000	59000

Remarks: Data are provided by EPD (analyzed by the government laboratory)

Table 4a. Average concentration among the 2 samplings during March 2004 (representative for dry season)

Test	Unit	Method Used	Detection limit	E4(P)	W1	W5	W10	E5(B)(P)	W11(P)	PFLR1(P)	W3(P)	TP789(P)	THR2(P)	W8	P5(P)	W12
In-situ Measurement																
Water Depth	m	In house method by using water depth meter	0.01 m	0.135	0.004	0.020	0.018	0.020	0.018	0.020	0.020	0.028	0.028	0.004	0.004	0.025
pH	at 25°C	In house method by using potable pH meter	0.1 pH	7.41	7.75	8.15	7.94	7.96	7.98	7.65	10.33	8.15	7.82	7.87	7.67	7.61
Turbidity	NTU	In house method by using potable turbidimeter	1 NTU	3.9	7.2	26.2	19.2	8.1	12.1	8.5	25.9	4.5	17.9	32.7	3.5	13.1
Temperature	°C	APHA 19ed 2550B	0.5 °C	16.95	18.05	19.90	18.63	19.85	19.08	19.58	19.35	17.25	21.63	18.78	19.73	18.98
DO	mg/L	APHA 19ed 4500-O G	1 mg/l	8.66	7.00	7.26	8.07	7.58	8.24	7.93	8.03	9.20	8.41	7.96	7.55	7.19
Salinity	ppt	APHA 19ed 2520B	1 ppt	0.10	0.10	0.10	0.10	0.15	0.25	0.10	0.25	0.10	0.10	0.75	0.00	0.10
Laborary analysis																
Suspended Solids	mg/L	In house method TPE/006/W	2 mg/l	3.8	5.2	27.8	12.8	9.5	11.1	7.7	89.2	5.1	12.2	24.0	4.6	13.7
Oil & Grease	mg/L	APHA 19ed 5520B	2 mg/l	3.5	3.5	5.7	4.2	3.5	3.5	3.5	4.1	3.5	3.5	3.5	3.5	6.1
BOD5	mg/L	In house method TPE/001/W	3 mg/l	6.6	2.1	19.9	20.5	13.6	3.9	3.4	15.9	1.6	2.0	11.2	4.7	26.5
Total Organic Carbon	mg/L	APHA 19ed 5310B	5 mg/l	1.8	1.8	9.7	8.2	3.2	2.2	2.8	5.5	1.0	1.0	10.8	1.3	9.0
TKN	mgN/L	In house method TPE/017/W	5 mg/l	0.5	0.5	8.8	1.4	3.0	1.3	1.1	2.5	0.4	0.6	3.7	0.8	3.1
Nitrate	mgNO_3^--N/L	In house method TPE/010/W	0.01 mg/l	0.557	3.288	0.874	0.917	2.581	0.452	0.657	1.599	1.673	0.184	3.053	0.353	0.755
Nitrite	mgNO_2^--N/L	In house method TPE/011/W	0.005 mg/l	0.525	2.043	1.016	0.492	1.141	0.297	0.382	0.710	1.100	0.127	0.464	0.225	0.286
Ammonia-N	mgNH_3^--N/L	In house method TPE/016/W	0.05 mg/l	0.037	0.052	3.320	0.217	2.189	0.075	0.083	0.070	0.052	0.025	0.344	0.060	0.450
Total Phosphorus	mgP/L	In house method TPE/019/W	0.05 mg/l	0.045	0.102	2.592	0.630	1.226	0.348	0.211	0.302	0.155	0.117	0.864	0.404	1.572
Orthophosphorus	mgP/L	In house method TPE/020/W	0.05 mg/l	0.027	0.086	1.541	0.306	0.774	0.165	0.139	0.117	0.087	0.055	0.521	0.333	0.954
E-coli	cfu/100ml	DoE 7.8 & 7.9 plus in-situ urese test	< 1 cfu	58	2,018	34,160	17,901	29,292	425	42,393	15	1,832	135	7,861	123	278,779
Chlorophyll-a	mg/m³	APHA 19ed 10200H	1 ug/l	3.0	7.3	5.2	4.8	5.3	4.2	6.4	22.5	5.5	3.3	1.2	1.3	8.6
Faecal coli count	cfu/100ml	EPD Laboratory	< 1 cfu	228	13,416	57,480	140,000	57,480	8,899	354,119	1	1,789	739	74,034	2,000	195,959

Remarks:

1) If the value is less than the detection limit, the concentration used for calculation is equal to the detection limit concentration due to the worse scenario (highest concentration) to Western portal.

2) Due to the inaccurate flow measurment by ETL, flow rate will be based on other flow measurement suggested by EPD (Tracer study, volumetric method, flowmate2000 and HKU propeller) instead.

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Table 4b. Average concentration among the 1 sampling during May 2004 (representative for wet season)

Test	Unit	Method Used	Detection limit	E4(P)	W1	W5	W10	E5(B)(P)	W11(P)	PFLR1(P)	W3(P)	TP789(P)	THR2(P)	W8	P5(P)	W12
In-situ Measurement																
Water Depth	m	In house method by using water depth meter	0.01 m	0.180	0.030	0.020	0.030	0.030	0.020	0.050	0.020	0.020	0.020	0.050	0.020	0.020
pH	at 25°C	In house method by using potable pH meter	0.1 pH	7.52	8.11	8.22	8.43	7.68	8.64	7.62	8.55	8.18	8.24	8.24	7.74	7.48
Turbidity	NTU	In house method by using potable turbidimeter	1 NTU	4.6	8.53	21.70	24.00	20.05	219.50	3.84	4.40	6.11	19.05	26.05	1.83	94.85
Temperature	°C	APHA 19ed 2550B	0.5 °C	21.65	21.25	22.55	21.80	21.70	22.40	22.30	22.20	20.60	21.70	22.60	21.45	22.25
DO	mg/L	APHA 19ed 4500-O G	1 mg/l	7.67	8.06	6.90	7.38	6.61	7.22	6.88	8.33	8.99	8.46	7.88	9.14	6.93
Salinity	ppt	APHA 19ed 2520B	1 ppt	0.10	0.10	0.20	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Laborary analysis																
Suspended Solids	mg/L	In house method TPE/006/W	2 mg/l	4.1	8.5	25.3	8.8	14.3	90.5	3.6	5.0	3.6	11.5	14.0	3.2	80.8
Oil & Grease	mg/L	APHA 19ed 5520B	2 mg/l	2.8	2.8	3.5	13.3	2.8	3.6	2.8	2.8	2.8	2.8	3.0	2.8	9.8
BOD5	mg/L	In house method TPE/001/W	3 mg/l	1.1	1.6	14.4	14.0	8.5	3.6	1.5	1.4	1.2	4.7	15.0	1.1	8.8
Total Organic Carbon	mg/L	APHA 19ed 5310B	5 mg/l	1.0	3.5	13.8	7.2	4.8	20.3	2.0	2.0	2.0	4.0	5.8	1.0	3.0
TKN	mgN/L	In house method TPE/017/W	5 mg/l	0.3	0.5	8.2	0.3	1.5	1.9	0.5	0.4	0.4	0.9	0.9	2.5	1.0
Nitrate	$mgNO_3^-$-N/L	In house method TPE/010/W	0.01 mg/l	0.500	1.800	0.290	0.470	1.425	0.483	0.465	1.825	2.375	0.690	0.588	0.528	0.618
Nitrite	$mgNO_2^-$-N/L	In house method TPE/011/W	0.005 mg/l	0.005	0.008	0.103	5.655	0.248	0.007	0.022	0.062	0.004	0.049	0.023	0.002	0.010
Ammonia-N	$mgNH_3^-$-N/L	In house method TPE/016/W	0.05 mg/l	0.027	0.028	4.000	2.526	0.710	0.044	0.145	0.086	0.028	0.243	0.112	0.034	0.068
Total Phosphorus	mgP/L	In house method TPE/019/W	0.05 mg/l	0.038	0.208	1.523	4.715	0.368	0.493	0.060	0.210	0.025	0.108	0.538	0.090	0.575
Orthophosphorus	mgP/L	In house method TPE/020/W	0.05 mg/l	0.028	0.143	1.043	2.110	0.273	0.135	0.039	0.161	0.021	0.065	0.170	0.068	0.295
E-coli	cfu/100ml	DoE 7.8 & 7.9 plus in-situ urese test	< 1 cfu	1,661	6,092	317,532	11	150,144	207	10,678	15,793	9,230	22,330	12,104	407	26,791
Chlorophyll-a	mg/m^3	APHA 19ed 10200H	1 ug/l	1.0	2.4	12.4	1.0	3.6	6.7	2.0	3.4	1.3	1.8	0.9	2.0	3.8
Faecal coli count	cfu/100ml	EPD Laboratory	< 1 cfu	16,125	28,566	961,249	424	401,248	3,650	15,000	33,045	17,436	158,745	95,499	8,888	71,232

Remarks:

1) If the value is less than the detection limit, the concentration used for calculation is equal to the detection limit concentration due to the worse scenario (highest concentration) to Western portal.

2) Due to the inaccurate flow measurment by ETL, flow rate will be based on other flow measurement suggested by EPD (Tracer study, volumetric method, flowmate2000 and HKU propeller) instead.

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Table 5a. Summary stream flow of measued flow by various methods during March 04 (Dry season)

		Dry season representative samples											
Samping Date		10-Mar-04			25-Mar-04								
Station		ETS Flow meter	Surface flow (leaves)	Volumetric volume	ETS Flow meter	Surface flow (leaves)	Volumetric volume	Flowmate 2000	Propeller from HKU	Tracer Method	Selected average flow (L/s)	Water depth (10 March 2004)	Water depth (25 March 2004)
E4	虎豹別墅	0.045 L/s			30.2 L/s			39.7 L/s	5.3 L/s		17.8 L/s	0.160 m	0.110 m
W1	聖雅各小學		0.1 L/s				0.46 L/s			0.5 L/s	0.3 L/s	0.002 m	0.005 m
W5	高主教中學		32.5 L/s			5.8 L/s				6.9 L/s	6.3 L/s	0.030 m	0.030 m
W10	干德道	2.9 L/s					0.14 L/s			0.2 L/s	0.2 L/s	0.005 m	0.030 m
E5B	大坑道嘉雲臺		5.6 L/s			3.3 L/s				3.3 L/s	4.1 L/s	0.020 m	0.020 m
W11	旭龢消防局	19.4 L/s				6.2 L/s				6.4 L/s	6.3 L/s	0.020 m	0.015 m
PFLR1	薄扶林道樸園			0.12 L/s			0.29 L/s			0.2 L/s	0.2 L/s	0.020 m	0.020 m
W3	港燈	10.3 L/s				16.1 L/s				16.1 L/s	14.1 L/s	0.020 m	0.020 m
TP789	地利根德里	10.3 L/s					0.49 L/s			0.5 L/s	0.5 L/s	0.030 m	0.025 m
THR2	藍塘道日本人學校)	64.2 L/s				34.4 L/s		12.9 L/s	9.3 L/s	17 L/s	19 L/s	0.030 m	0.025 m
W8	卑利士道	0.73 L/s				1.8 L/s				1.8 L/s	1.4 L/s	0.003 m	0.005 m
P5	寶珊道		0.3 L/s				0.04 L/s			0.04 L/s	0.04 L/s	0.002 m	0.005 m
W12	薄扶林道林泉	7.4 L/s				2.4 L/s				2.4 L/s	2.4 L/s	0.025 m	0.025 m

Table 5b. Summary stream flow of measued flow by various methods during May 04 (after 1 flush of rain)

		Wet season representative samples						
Samping Date		05-May-04						
Station		ETS Flow meter	Surface flow (leaves)	Volumetric volume	FlowMate 2000	Propeller from HKU	Selected average flow (L/s)	Water depth (5 May 2004)
E4	虎豹別墅	152.8 L/s			23.5 L/s	13.8 L/s	18.7 L/s	0.180 m
W1	聖雅各小學		12.7 L/s				12.7 L/s	0.030 m
W5	高主教中學		11.3 L/s				11.3 L/s	0.020 m
W10	干德道			0.86 L/s			0.86 L/s	0.030 m
E5B	大坑道嘉雲臺		23.1 L/s				23.1 L/s	0.030 m
W11	旭龢消防局		16.2 L/s				16.2 L/s	0.020 m
PFLR1	薄扶林道樸園			0.21 L/s			0.21 L/s	0.050 m
W3	港燈		23.1 L/s				23.1 L/s	0.020 m
TP789	地利根德里			1.88 L/s			1.9 L/s	0.020 m
THR2	藍塘道日本人學校)		19.7 L/s		24.6 L/s	9.0 L/s	18 L/s	0.020 m
W8	卑利士道			0.41 L/s			0.41 L/s	0.050 m
P5	寶珊道		0.3 L/s				0.27 L/s	0.020 m
W12	薄扶林道林泉		1.5 L/s				1.5 L/s	0.020 m

Table 6a. Estimated Maximum Intake Flows for 2, 10, 50 and 200 years storm to the Western Portal

		Intake Peak Flow (m³/s) from HydroWorks Model				
Catchment	Intake shafts	2 year	10 years	50 years	200 years	% of flow
C17	Eastern Portal*	13.3	23.7	35.5	42.3	17.1
C16	E5A	1.9	3.1	4.3	5.0	2.5
	E5B*	1.8	2.8	3.9	4.5	2.3
	MB16	0.5	1.0	1.5	1.8	0.7
C15	MBD2	0.7	1.3	1.9	2.3	0.9
	E7	1.3	2.5	3.7	4.4	1.7
	THR2*	6.2	10.5	15.3	18.2	7.9
	HR1	2.8	4.7	6.8	8.0	3.5
	GL1	1.3	2.1	4.1	4.8	1.6
	DG1	2.3	4.0	5.8	7.0	2.9
	W0	4.1	7.3	10.6	12.6	5.3
	BR3	0.9	1.3	2.9	3.4	1.1
	BR4	0.4	0.7	1.0	1.1	0.5
C14	W1*	4.6	8.2	12.5	14.6	5.9
C13	BR5	0.6	0.9	1.3	1.6	0.7
	BR6	0.5	0.9	1.2	1.5	0.7
	BR7	0.6	1.1	1.5	1.8	0.7
	W3*	5.5	9.4	13.7	16.3	7.1
C12	B2	0.4	0.7	0.9	1.1	0.5
	MA13	0.4	0.6	1.2	1.6	0.5
	MA14	0.2	0.3	1.4	1.7	0.2
	MA15	1.0	1.7	2.4	2.9	1.2
	MA17	2.4	3.9	5.6	6.6	3.0
	M3	1.5	2.4	3.3	3.9	1.9
	TP789*	2.4	4.0	5.8	6.8	3.1
	TP5	0.8	1.5	2.1	2.6	1.1
	TP4	1.0	1.9	2.8	3.3	1.3
VC	W5*	4.5	7.4	10.7	12.7	5.9
C6	RR1	1.5	2.5	3.6	4.3	1.9
	W8*	1.4	2.2	3.0	3.6	1.8
C5	P5*	1.2	2.2	3.3	4.0	1.5
C4	W10*	2.5	4.0	5.8	6.8	3.2
C3	HKU1	0.4	0.8	1.2	1.4	0.6
	W11*	2.5	7.9	11.7	13.8	3.2
C240	PFLR1*	0.8	1.5	2.2	2.7	1.1
	W12*	3.8	7.3	11.2	13.4	4.9
	Total Intake Flow (m^3/s)	**77.7**	**138.2**	**205.8**	**244.4**	**100**

* For those selected stream for in-situ flow measurement.

Appendix A Catchment Area of Inakes

Intakes	Area (Ha)
Eastern Portal	98.6
E5A	7.7
E5B	6.8
MB16	4.9
MBD2	6.2
E7	11.6
THR2	37.2
GL1	11.2
HR1	15.9
DG1	14.9
W0	28.5
BR3	8.7
BR4	2.8
W1	36.3
BR5	3.5
BR6	3.4
BR7	4.7
W3	33.2
B2	2.0
MA13	1.0
MA14	3.1
MA15	6.2
MA17	11.8
M3	6.4
TP789	12.9
TP5	5.6
TP4	7.9
W5	22.5
RR1	8.1
W8	4.9
P5	9.9
W10	12.7
W11	35.5
HKU1	3.7
PFLR1	6.6
W12	34.5

Appendix B - Details Calculation on Annual Discharge Flow to Western Portal

Monthly Total Rainfall at the Hong Kong Observatory (1884 - Present) Units : mm

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1884	Trace	87.1	148.2	134.3	229.5	280.5	332.3	275.0	314.5	78.6	38.0	Trace	1918.0
1885	22.4	68.9	62.6	378.0	123.1	797.3	344.7	708.4	148.8	63.7	19.4	31.8	2769.1
1886	51.2	38.5	65.5	144.2	44.9	270.4	717.7	230.7	76.1	71.5	1.1	45.1	1756.9
1887	214.3	47.9	74.7	143.5	52.1	139.5	307.3	334.2	278.2	51.7	19.9	21.7	1685.0
1888	4.6	100.8	265.0	176.7	495.7	605.9	268.3	337.7	162.7	114.9	19.7	104.2	2656.2
1889	18.5	18.2	63.4	311.9	1241.1	247.2	116.7	460.4	299.6	221.4	39.0	4.4	3041.8
1890	61.2	37.6	105.4	49.3	285.5	377.3	573.9	227.7	49.2	0.3	0.2	34.7	1802.3
1891	1.0	6.3	65.0	80.3	711.1	541.3	587.2	425.9	290.5	158.0	58.5	49.4	2974.5
1892	13.0	31.6	98.8	294.0	217.8	873.1	274.2	307.5	178.0	0.4	8.5	12.8	2309.7
1893	38.4	11.3	85.8	213.8	409.5	180.3	539.4	222.1	382.4	454.1	0.8	1.2	2539.1
1894	22.4	14.8	6.7	63.1	508.4	420.0	240.6	420.2	485.4	446.2	0.8	19.0	2647.6
1895	10.1	21.0	35.2	65.9	143.0	126.2	479.9	156.0	101.2	12.6	8.1	5.0	1164.2
1896	43.7	201.4	36.4	53.3	28.9	473.4	316.0	132.5	254.0	200.8	75.6	32.6	1848.6
1897	57.6	45.7	20.2	82.5	377.3	593.0	141.6	649.5	211.5	163.9	185.9	11.9	2540.6
1898	29.3	63.7	4.1	87.2	144.6	362.2	179.2	251.8	134.3	170.5	20.1	0.7	1447.7
1899	4.6	55.9	8.0	79.7	181.8	482.3	257.6	507.4	160.2	22.5	41.7	45.5	1847.2
1900	19.6	67.1	77.2	70.4	236.2	673.9	257.5	170.2	109.4	41.1	146.9	4.0	1873.5
1901	17.4	19.7	32.4	229.3	358.3	59.7	142.0	356.0	98.9	63.8	19.9	21.4	1418.8
1902	7.2	0.5	12.1	46.6	678.9	392.8	413.4	673.3	16.3	23.9	136.9	75.3	2477.2
1903	34.4	5.2	67.0	119.8	354.8	640.6	283.7	380.5	420.0	42.4	27.9	2.2	2378.5
1904	3.1	5.1	95.0	48.3	196.3	499.2	183.6	702.1	248.1	51.1	5.4	6.0	2043.3
1905	45.6	28.0	291.5	31.4	173.6	500.5	228.5	308.0	80.9	46.6	7.3	60.0	1801.9
1906	50.6	56.9	66.6	248.6	294.3	149.7	176.9	101.1	777.9	33.5	4.3	16.9	1977.3
1907	87.9	4.1	8.5	298.4	286.4	334.5	187.4	377.9	494.9	228.1	32.3	37.3	2377.7
1908	67.4	72.2	19.2	283.5	33.6	387.5	565.5	307.1	348.6	138.5	3.9	108.9	2335.9
1909	37.0	42.5	59.3	62.1	170.5	188.0	326.8	212.3	216.4	609.7	1.6	0.0	1926.2
1910	22.7	10.5	14.7	94.3	49.5	462.1	353.1	283.6	405.4	1.2	65.0	20.2	1782.3
1911	18.7	0.0	97.4	150.5	563.6	129.0	205.1	763.4	158.2	144.5	69.2	2.5	2302.1
1912	68.4	62.3	110.4	101.2	100.3	359.9	191.8	399.6	98.5	0.4	7.4	125.0	1625.2
1913	26.1	60.7	177.5	55.0	237.0	407.2	382.2	268.6	370.4	90.2	18.7	35.5	2129.1
1914	0.0	82.4	29.9	113.6	320.3	310.7	668.6	106.5	507.5	163.8	224.2	18.3	2545.8
1915	8.8	12.9	66.7	45.8	324.4	303.7	391.1	267.0	145.3	297.0	48.2	19.6	1930.5
1916	103.3	33.3	8.9	109.0	327.8	816.8	211.0	128.0	267.2	18.6	1.9	1.3	2027.1
1917	8.6	10.3	67.4	133.2	246.3	292.5	763.8	303.5	123.6	88.1	2.4	28.8	2068.5
1918	0.2	0.3	28.0	112.5	168.8	629.5	296.2	742.8	468.6	1.2	128.9	3.3	2580.3
1919	15.8	38.2	44.7	112.4	176.3	274.2	492.7	499.3	67.4	119.5	73.7	18.3	1932.5
1920	1.6	67.1	35.1	209.7	461.3	395.4	610.9	278.6	298.2	157.3	178.8	45.6	2739.6

1921	4.8	26.3	114.8	71.7	858.4	374.3	301.5	392.6	307.6	10.0	5.7	5.5	2473.2
1922	67.3	139.3	93.0	51.3	139.3	165.6	325.5	445.6	252.6	51.6	13.8	18.7	1763.6
1923	3.3	9.9	16.7	212.3	96.1	399.1	470.7	872.2	159.8	453.4	10.2	8.0	2711.7
1924	27.2	114.5	4.7	157.6	428.6	588.1	501.0	271.6	164.0	230.7	Trace	17.9	2505.9
1925	110.2	10.0	210.8	201.8	65.6	594.5	525.1	143.3	253.0	80.4	27.6	5.9	2228.2
1926	5.7	60.8	122.9	436.5	145.7	168.2	757.2	203.9	439.0	83.0	126.4	11.5	2560.8
1927	8.0	110.3	115.2	180.9	646.2	296.3	476.0	530.8	157.1	137.6	46.3	35.0	2739.7
1928	47.8	90.7	131.9	104.4	468.0	384.5	121.4	327.7	99.8	11.1	20.8	0.5	1808.6
1929	23.2	14.8	12.8	39.2	168.5	107.1	578.2	509.1	274.0	3.8	35.0	10.8	1776.5
1930	57.9	35.1	183.8	53.1	157.6	311.2	737.5	154.2	717.9	10.4	0.9	22.7	2442.3
1931	8.4	13.8	81.0	227.0	304.9	294.4	251.0	362.3	341.5	18.5	24.7	116.0	2043.5
1932	Trace	64.9	56.0	93.8	63.9	643.1	653.6	531.1	110.2	2.2	2.5	104.6	2325.9
1933	12.3	2.7	25.9	48.8	114.7	417.6	363.9	44.2	319.4	95.2	105.4	35.1	1585.2
1934	12.1	38.4	44.3	62.4	222.2	637.5	493.8	618.9	272.9	56.3	10.3	13.8	2482.9
1935	28.0	28.7	118.8	62.0	120.4	367.2	565.4	153.1	188.1	147.6	9.3	26.5	1815.1
1936	14.8	85.1	11.8	117.1	258.5	144.9	224.0	541.2	314.3	48.0	4.2	9.8	1773.7
1937	70.4	8.2	87.6	57.7	282.6	337.1	490.4	365.0	317.9	38.2	26.3	15.2	2096.6
1938	9.0	118.9	145.9	47.1	221.0	76.1	310.8	200.1	108.9	154.2	13.6	0.2	1405.8
1939	28.2	0.5	90.1	401.3	532.8	219.1	322.7	325.8	123.9	35.7	122.6	Trace	2202.7
1947	66.1	13.0	72.4	60.4	185.2	549.5	579.6	574.7	449.5	17.9	14.3	8.9	2591.5
1948	31.6	4.3	20.2	154.0	232.3	435.9	607.0	313.4	580.5	79.5	3.9	20.2	2482.8
1949	2.0	126.0	4.2	132.2	116.0	543.5	170.3	357.4	432.3	77.8	129.3	10.2	2101.2
1950	39.4	32.0	36.4	166.3	390.6	272.4	343.5	296.9	252.6	182.6	58.8	4.0	2075.5
1951	32.1	24.4	96.1	172.5	553.8	560.9	209.4	480.5	69.9	82.7	69.6	12.0	2363.9
1952	23.9	30.1	36.4	194.2	184.4	596.6	187.3	410.8	844.2	13.0	8.4	15.0	2544.3
1953	29.9	56.5	133.2	113.0	364.3	405.4	150.2	349.2	583.6	43.4	53.3	78.2	2360.2
1954	49.1	29.9	49.3	156.1	78.9	218.6	157.7	265.4	223.3	24.7	113.0	1.0	1367.0
1955	3.7	0.1	52.6	173.6	440.9	293.9	619.0	547.9	142.8	6.2	45.4	24.1	2350.2
1956	77.1	65.6	8.7	69.7	239.7	413.8	145.9	388.6	161.9	37.4	33.6	7.3	1649.3
1957	15.6	99.3	97.2	71.9	894.2	462.3	395.2	387.5	469.6	47.3	2.2	8.0	2950.3
1958	54.0	87.8	118.0	48.0	225.5	243.6	479.1	174.6	549.8	47.6	0.7	4.9	2033.6
1959	1.2	210.2	44.4	294.0	90.1	913.7	352.5	603.8	281.0	1.0	0.1	5.4	2797.4
1960	15.0	Trace	64.5	41.6	245.4	676.6	160.6	544.9	311.0	26.1	138.0	13.3	2237.0
1961	3.9	46.2	51.2	172.3	213.9	121.0	492.1	462.0	535.0	31.2	91.5	12.1	2232.4
1962	7.2	82.5	10.4	50.6	184.7	504.9	157.8	84.8	456.0	168.3	33.8	Trace	1741.0
1963	9.8	1.5	9.2	13.6	6.0	204.7	323.6	182.1	83.0	35.1	31.6	0.9	901.1
1964	100.6	11.1	37.0	17.3	413.1	263.9	103.6	445.1	518.5	514.8	4.1	3.0	2432.1
1965	13.5	16.3	9.0	253.2	163.7	330.7	342.7	170.3	798.4	156.3	96.7	1.8	2352.6
1966	Trace	100.4	116.1	337.0	140.4	962.9	473.7	218.3	24.1	9.5	11.1	4.7	2398.2
1967	8.3	38.4	2.5	243.8	28.7	357.1	154.1	556.7	117.5	26.0	37.0	0.5	1570.6
1968	5.5	101.9	140.7	6.9	265.0	647.8	272.1	682.2	80.9	53.4	7.0	24.8	2288.2
1969	68.3	24.2	86.7	150.4	209.8	400.7	434.8	338.9	105.5	75.7	0.5	Trace	1895.5
1970	28.7	3.0	43.3	14.7	531.8	409.3	151.3	410.5	509.6	143.6	0.1	70.4	2316.3

1971	18.0	14.1	1.1	17.9	172.7	434.5	324.4	525.5	194.5	26.0	Trace	175.1	1903.8
1972	46.5	22.0	1.8	134.8	654.5	799.8	191.0	556.8	239.7	36.4	109.0	15.0	2807.3
1973	57.8	21.7	13.3	104.3	516.6	373.7	696.6	826.4	476.0	4.7	9.3	Trace	3100.4
1974	3.9	37.0	31.7	231.1	203.7	323.3	184.2	226.6	131.2	718.4	24.9	206.9	2322.9
1975	35.8	35.7	81.5	345.0	571.5	579.6	292.4	458.9	96.0	465.6	17.4	49.3	3028.7
1976	5.8	13.1	11.2	117.3	162.1	424.9	426.8	765.3	204.7	64.1	0.8	1.1	2197.2
1977	20.1	3.2	4.0	46.7	296.1	258.4	276.1	149.7	415.9	195.8	6.1	7.9	1680.0
1978	22.9	16.2	143.8	237.0	300.4	242.4	555.2	230.8	271.8	501.4	55.8	15.3	2593.0
1979	45.1	9.4	71.9	234.5	311.6	378.2	339.4	706.9	506.3	0.0	11.2	0.2	2614.7
1980	4.3	54.5	76.9	120.1	278.2	150.9	454.4	250.0	211.6	80.8	28.2	0.7	1710.6
1981	Trace	11.8	123.9	94.2	336.1	106.4	317.2	101.2	381.9	111.6	69.8	5.4	1659.5
1982	16.0	23.1	30.6	310.0	767.4	205.9	296.2	872.0	466.8	163.7	95.8	Trace	3247.5
1983	76.3	241.0	428.0	171.1	372.5	445.8	131.2	345.7	447.4	227.4	Trace	7.4	2893.8
1984	3.5	2.7	13.6	215.0	468.2	445.7	125.9	348.8	211.3	167.1	4.5	10.7	2017.0
1985	13.8	218.8	64.2	271.3	103.3	378.4	189.8	501.4	335.5	56.1	45.9	12.9	2191.4
1986	Trace	68.8	51.8	115.7	378.7	415.9	547.3	274.9	264.7	61.3	112.6	46.6	2338.3
1987	12.5	11.2	234.0	277.8	460.2	231.2	618.1	176.3	158.3	72.7	66.6	0.4	2319.3
1988	1.0	11.9	40.6	82.4	115.2	296.9	327.4	505.7	109.9	61.8	25.6	106.6	1685.0
1989	23.9	2.7	47.8	201.1	771.9	137.5	237.9	218.0	228.1	15.2	20.3	40.2	1944.6
1990	47.5	195.7	29.9	257.6	102.4	448.1	268.0	150.1	409.9	100.7	36.9	0.1	2046.9
1991	28.7	8.2	51.5	34.7	60.9	371.7	293.6	302.3	178.7	294.3	2.7	11.8	1639.1
1992	40.0	142.8	242.4	492.2	602.3	532.8	358.1	97.7	63.1	30.9	10.1	66.4	2678.8
1993	33.5	1.0	49.0	136.3	338.4	485.2	213.7	182.8	655.9	87.8	144.6	15.7	2343.9
1994	Trace	50.5	26.5	6.0	183.7	290.2	1147.2	597.6	298.9	2.2	0.2	122.6	2725.6
1995	21.1	33.1	32.4	76.3	20.8	243.9	668.7	1090.1	81.4	476.9	1.8	7.9	2754.4
1996	1.3	27.2	83.1	228.7	313.9	404.0	230.3	308.3	604.0	44.8	3.5	Trace	2249.1
1997	44.6	111.7	34.8	133.2	300.8	783.6	746.0	829.0	232.9	112.8	7.1	6.5	3343.0
1998	48.9	153.7	55.3	237.1	335.2	814.5	267.2	245.4	230.9	133.9	28.8	13.7	2564.6
1999	4.5	Trace	23.6	176.9	177.8	197.4	203.8	892.0	365.7	38.8	15.7	32.9	2129.1
2000	70.3	27.6	40.9	547.7	208.3	443.3	304.0	600.7	152.6				

20 percentile	5.8	10.1	16.3	54.7	136.1	240.2	190.8	210.6	122.4	20.9	4.1	4.1	1015.9
80 percentile	49.7	82.5	106.4	231.8	444.8	551.8	541.0	549.7	447.8	163.8	69.6	39.6	3278.4

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Normal[61-90]	23.4	48.0	66.9	161.5	316.7	376.0	323.5	391.4	299.7	144.8	35.1	27.3	2214.3
Mean	29.2	48.0	70.0	149.3	295.7	399.4	365.2	389.6	285.2	114.8	39.3	26.0	2208.5
Maximum	214.3	241.0	428.0	547.7	1241.1	962.9	1147.2	1090.1	844.2	718.4	224.2	206.9	3343.0
Minimum	0.0	0.0	1.1	6.0	6.0	59.7	103.6	44.2	16.3	0.0	0.1	0.0	901.1

Urban	21240	34931	50982	108675	215300	290783	265874	283606	207654	83578	28632	18955	1610210
Rural	37462	61609	89919	191673	379732	512865	468932	500206	366247	147410	50499	33432	2839986
Total (m3/mth)	58,703	96,539	140,900	300,348	595,033	803,648	734,806	783,811	573,901	230,989	79,131	52,388	4,450,196

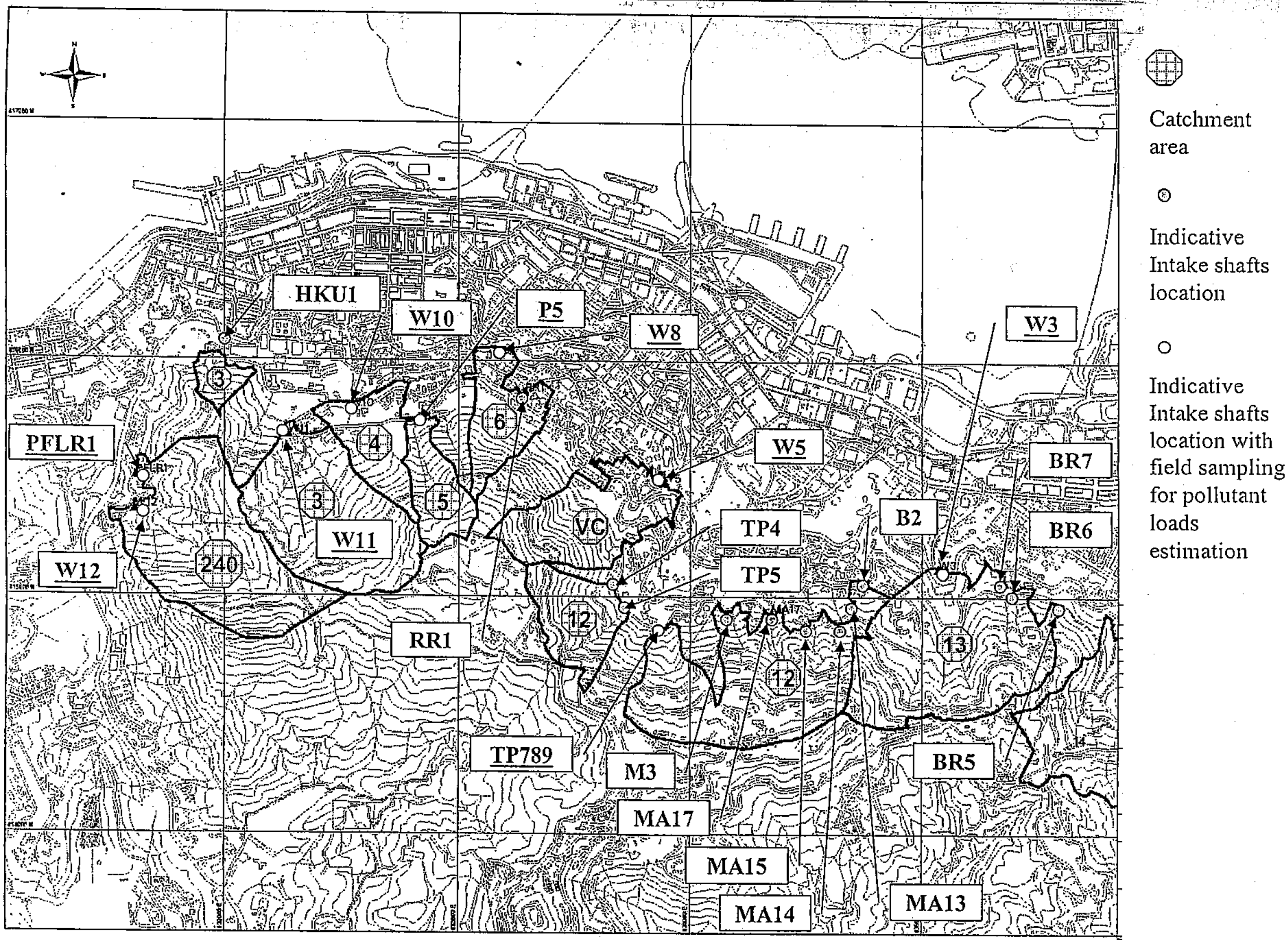


Figure 1 Catchment area for the proposed drainage channel (Part 1 of 2)

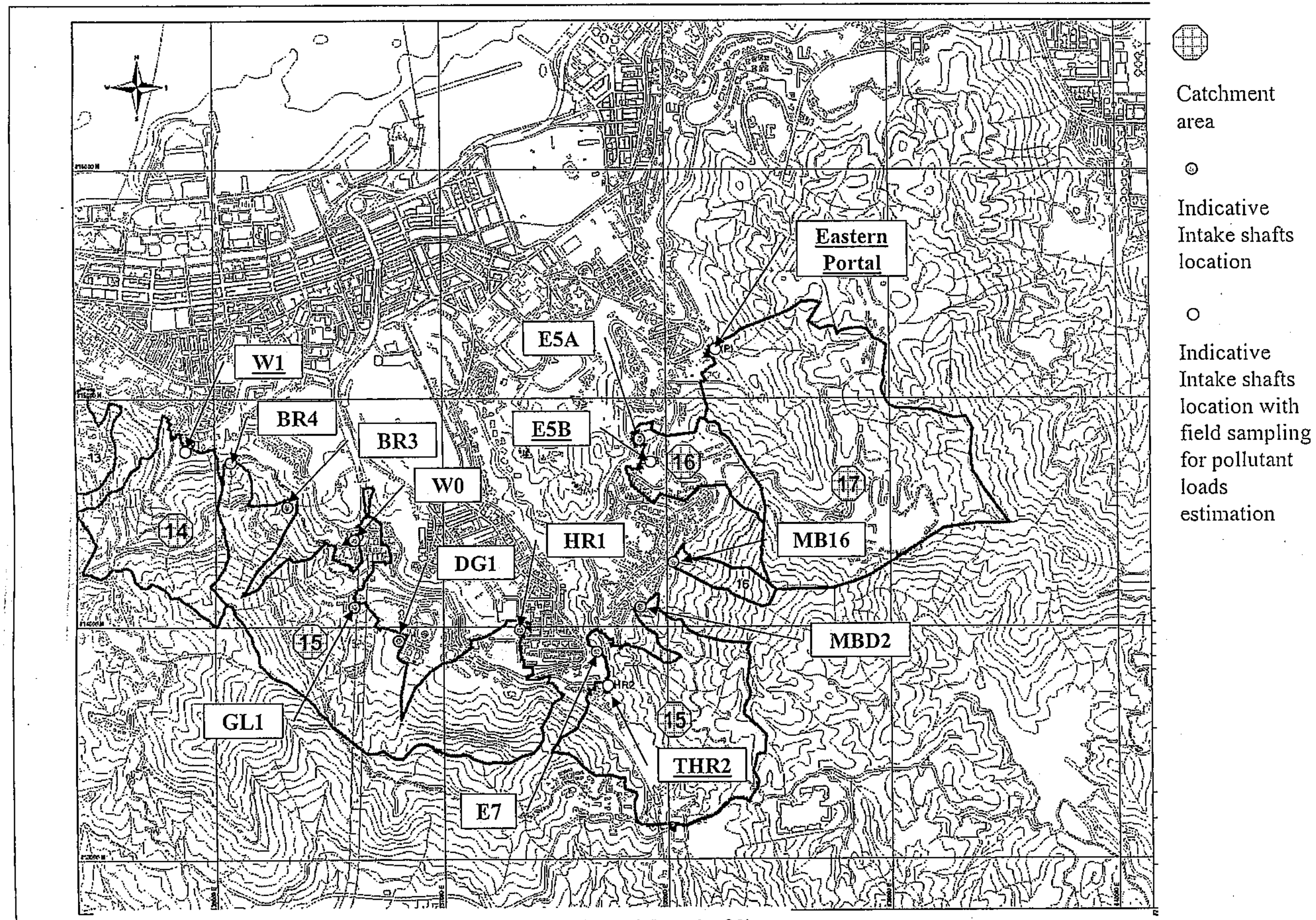
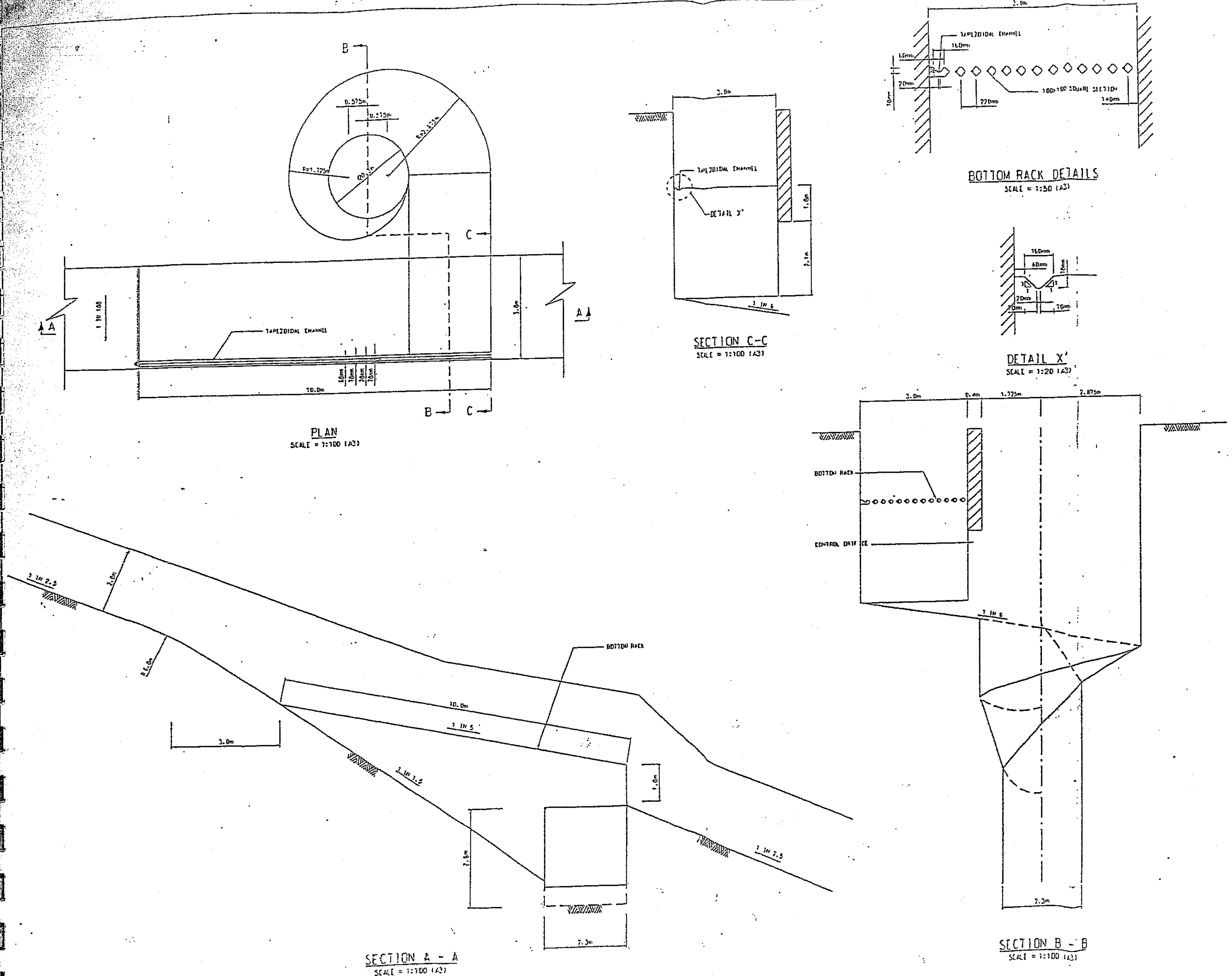


Figure 1 Catchment area for the proposed drainage channel (Part 2 of 2)



Revision	Date	Description		Initial
	Designed	Checked	Drawn	Checked
Initial	LWG	DCA	JT	LWG
Date	07/04	07/04	07/04	07/04

Approved

Agreement no.
CE 25/2002 (DS)

Contract title
DRAINAGE IMPROVEMENT IN NORTHERN HONG KONG ISLAND - HONG KONG WEST DRAINAGE TUNNEL AND LOWER CATCHMENT IMPROVEMENT - INVESTIGATION

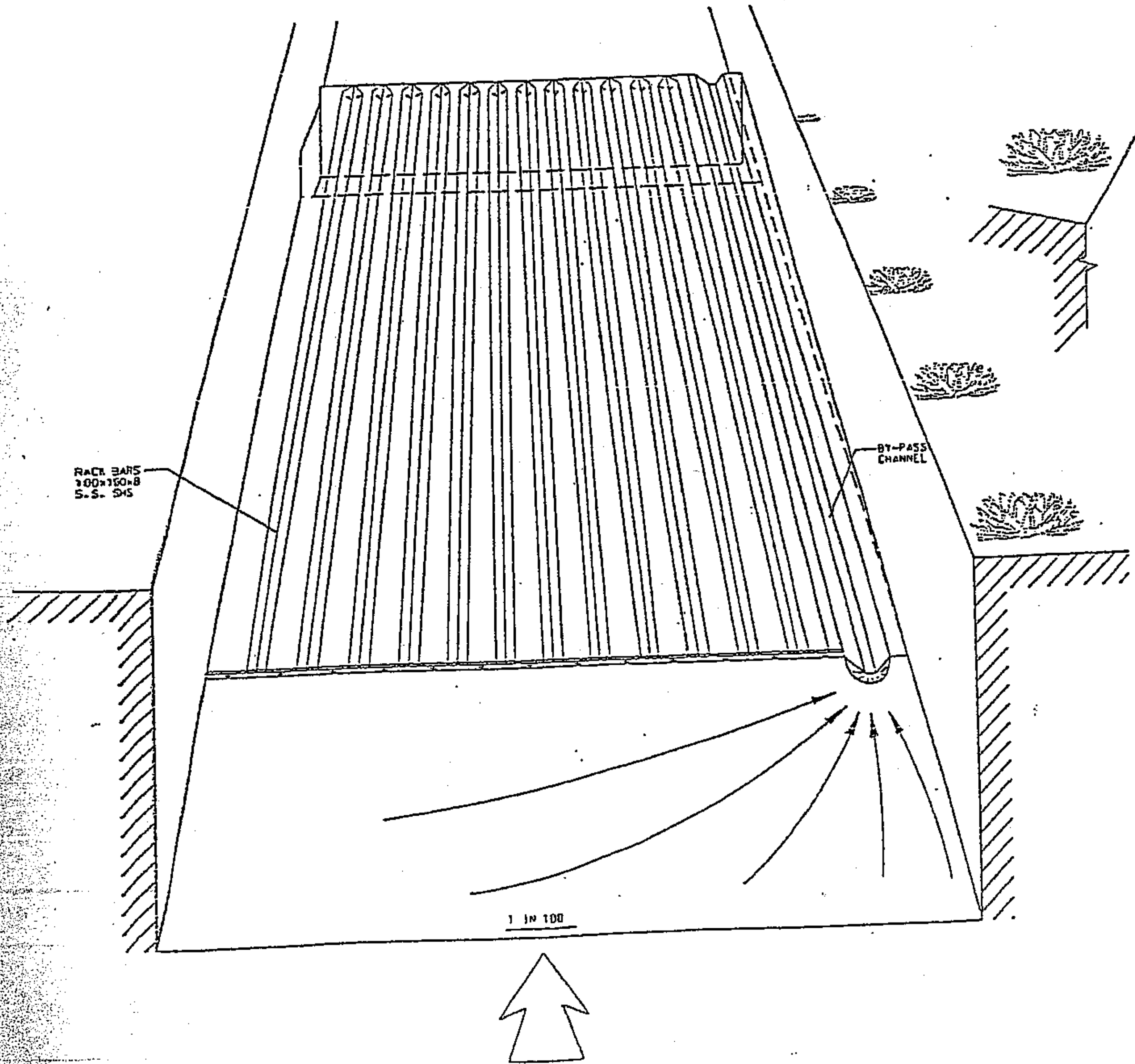
Figure title
PRELIMINARY DESIGN OF TYPICAL STRUCTURE FOR PHYSICAL MODEL TESTING

Figure no.
FIGURE 2

Scale
AS SHOWN

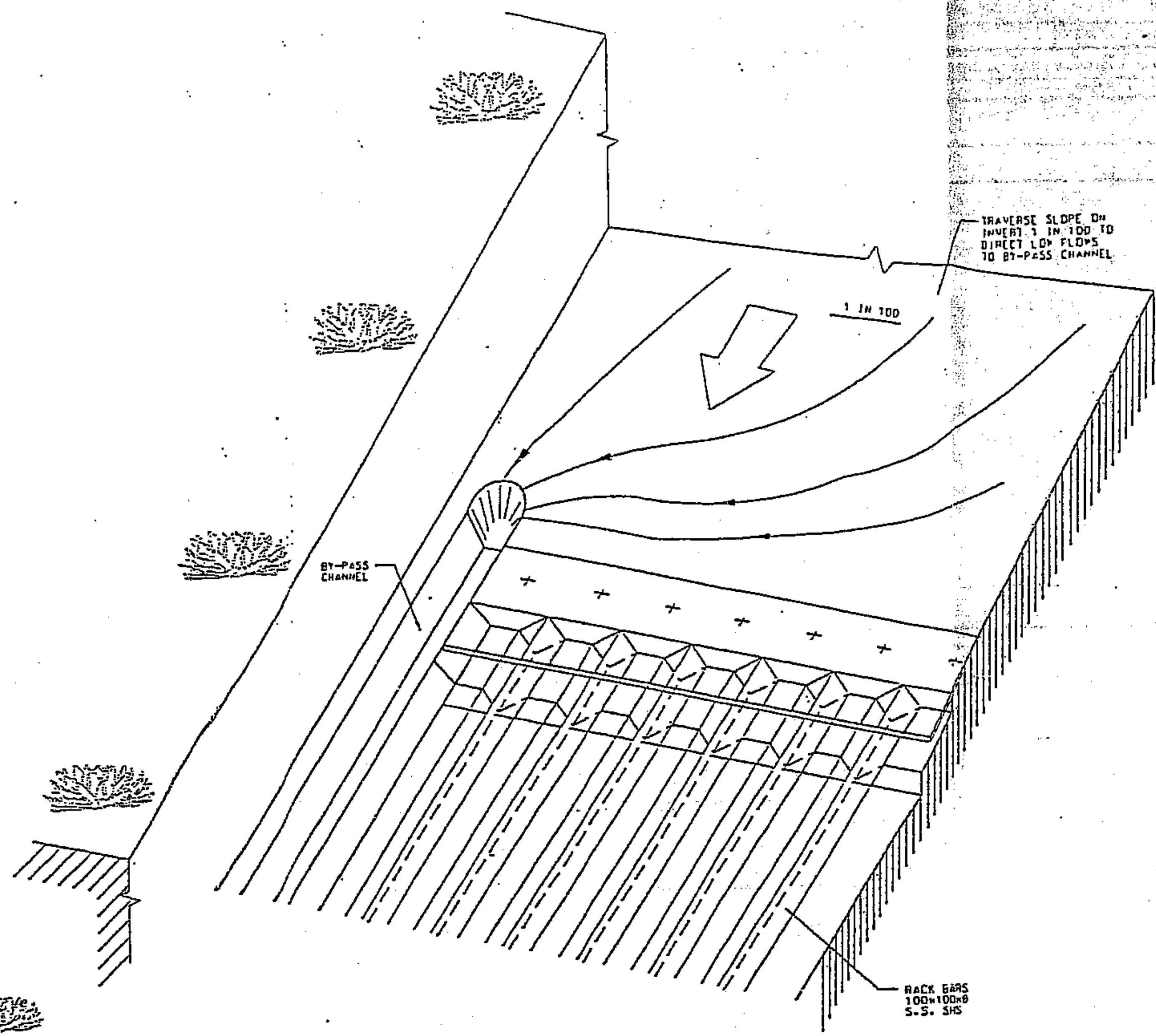
香港特別行政區政府渠務署
THE GOVERNMENT OF THE HONG KONG SPECIAL ADMINISTRATIVE REGION DRAINAGE SERVICES DEPARTMENT

BLACK & VEATCH HONG KONG LIMITED



PERSPECTIVE VIEW 1

NO SCALE



PERSPECTIVE VIEW 2

NO SCALE

Revision	Date	Description			Initial
	Designed	Checked	Drawn	Checked	
Initial	CHH	LWG	PJL	LWG	
Date	07/04	07/04	07/04	07/04	

Approved

Agreement no.
CE 25/2002 (DS)

Contract title
DRAINAGE IMPROVEMENT IN NORTHERN HONG KONG ISLAND - HONG KONG WEST DRAINAGE TUNNEL AND LOWER CATCHMENT IMPROVEMENT - INVESTIGATION

Figure title
PERSPECTIVE VIEW OF BY-PASS FACILITY ON INTAKE STRUCTURES

Figure no.	Scale
FIGURE 3	AS SHOWN

香港特別行政區政府渠務署
THE GOVERNMENT OF THE HONG KONG SPECIAL ADMINISTRATIVE REGION DRAINAGE SERVICES DEPARTMENT

BLACK & VEATCH HONG KONG LIMITED
博威工程顧問有限公司

Figure 4. Total rainfall in Hong Kong during 2001-2004

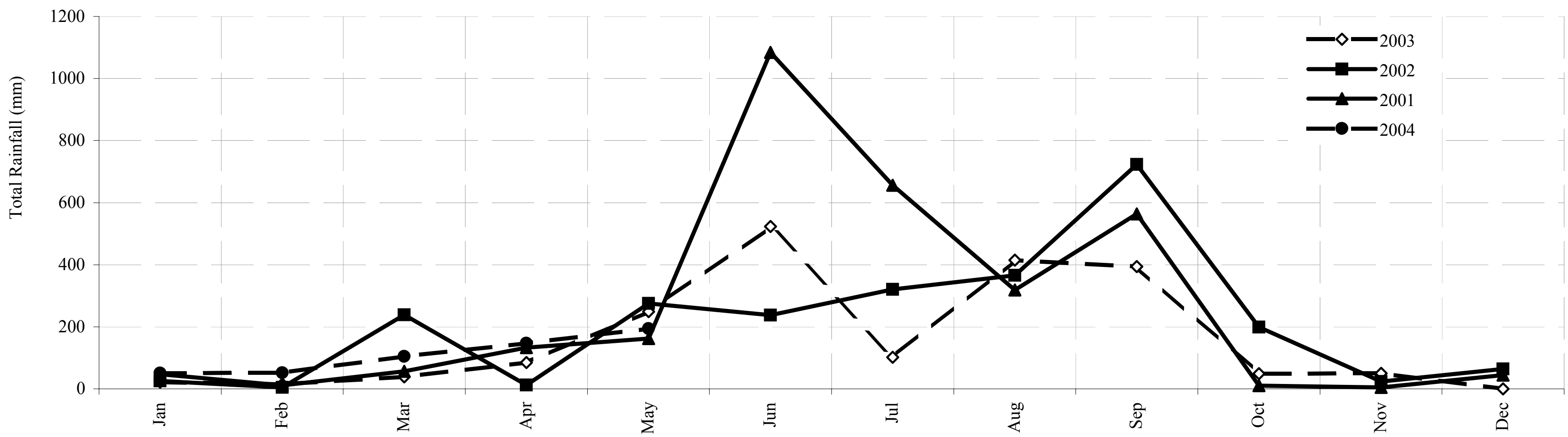


Figure 5. Total rainfall recorded from January to May 2004

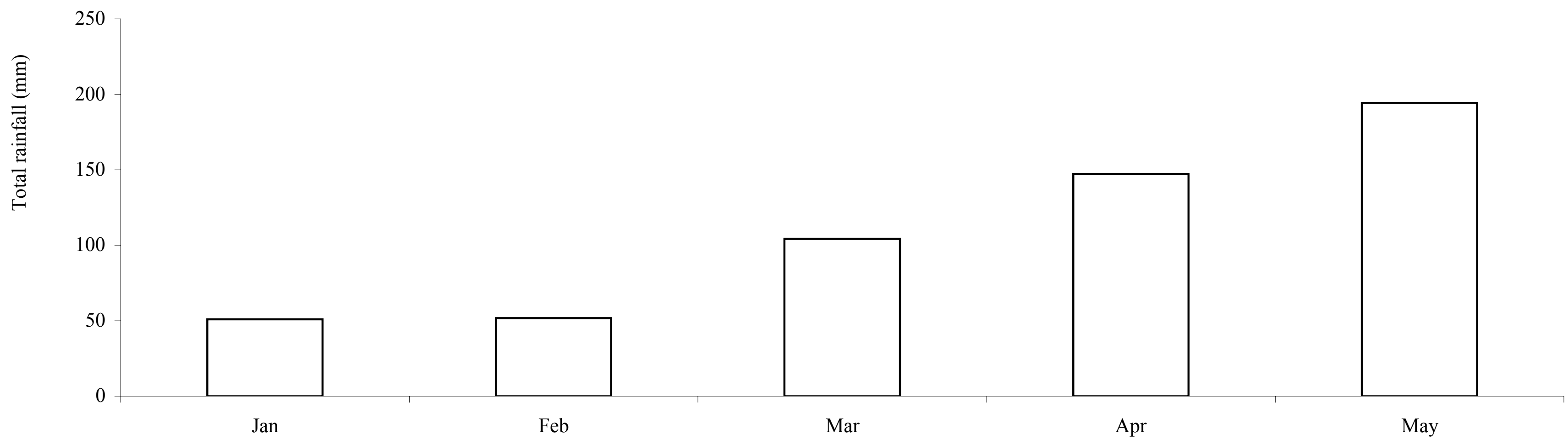


Figure 6. Detail rainfall even during January to June 2004
(Water quality sampling data were 10 Mar, 25 Mar and 5 May 2004)