Table C4: Results of the Effluent Grab Sample

Parameter	Result	Standard A	Effluent Limit**
pH	7.2	6.0-9.0	6.0-9.0
BOD_5, mg/L	3	20	10
COD, mg/L	6	50	30
Total Suspended Solids, mg/L	18	50	50
Mercury, mg/L	ND	0.005	0.001
Cadmium, mg/L	ND	0.01	0.01
Chromium (hexavalent), mg/L	ND	0.05	0.05
Arsenic, mg/L	ND	0.05	0.05
Cyanide, mg/L	ND	0.05	0.02
Lead, mg/L	ND	0.10	0.05
Chromium (trivalent), mg/L	ND	0.20	0.20
Copper, mg/L	ND	0.20	0.10
Manganese, mg/L	1.14*	0.20	0.20
Nickel, mg/L	ND	0.20	0.20
Tin, mg/L	ND	0.20	0.20
Zinc, mg/L	0.03	1	1
Boron, mg/L	ND	1	1
Iron, mg/L	1.23*	1	1
Phenol, mg/L	ND	0.001	0.001
Free chlorine, mg/L	0.02	1	1
Sulphide, mg/L	ND	0.50	0.50
Oil & grease, mg/L	1	ND	ND
Ammoniacal nitrogen, mg/L	1.91	-	1
E. coli, MPN/100 mL	ND	-	2,000

*- Exceeded all limits

**- Environmental Quality (Perbadanan Putrajaya) (Water Pollution Control) Regulations, 1998 (Effluent Standard for discharge onto land).

N.D.-Not detected

Source : Consolidated Laboratory (M) Sdn. Bhd., 2000

Table C5: Water Quality of a Grab Sample from Sg. Langat

Parameter	Grab Sample	Class IV Limit
Ammoniacal nitrogen, mg/L	0.43	2.7
Biochemical oxygen demand, mg/L	6.2	12
Chemical oxygen demand, mg/L	15.6	100
Chloride, mg/L	11.4	80
Nitrate, mg/L	0.45	5
Iron, mg/L	**16.8**	1.0
Manganese, mg/L	0.11	0.2
Mercury, mg/L	0.001	0.002
Cadmium, mg/L	0.002	0.01
Arsenic, mg/L	0.005	0.10
Cyanide, mg/L	0.01	-
Lead, mg/L	<0.04	5
Zinc, mg/L	0.04	2
Orthophosphate, mg/L	<0.01	-
Oil and grease, mg/L	<0.1	-
Total coliform, MPN/100 mL	**300,000**	50,000
E. coli, MPN/100 mL	**17,000**	5,000

Note : Parameters which exceeded the Class IV limits are indicated in bold.

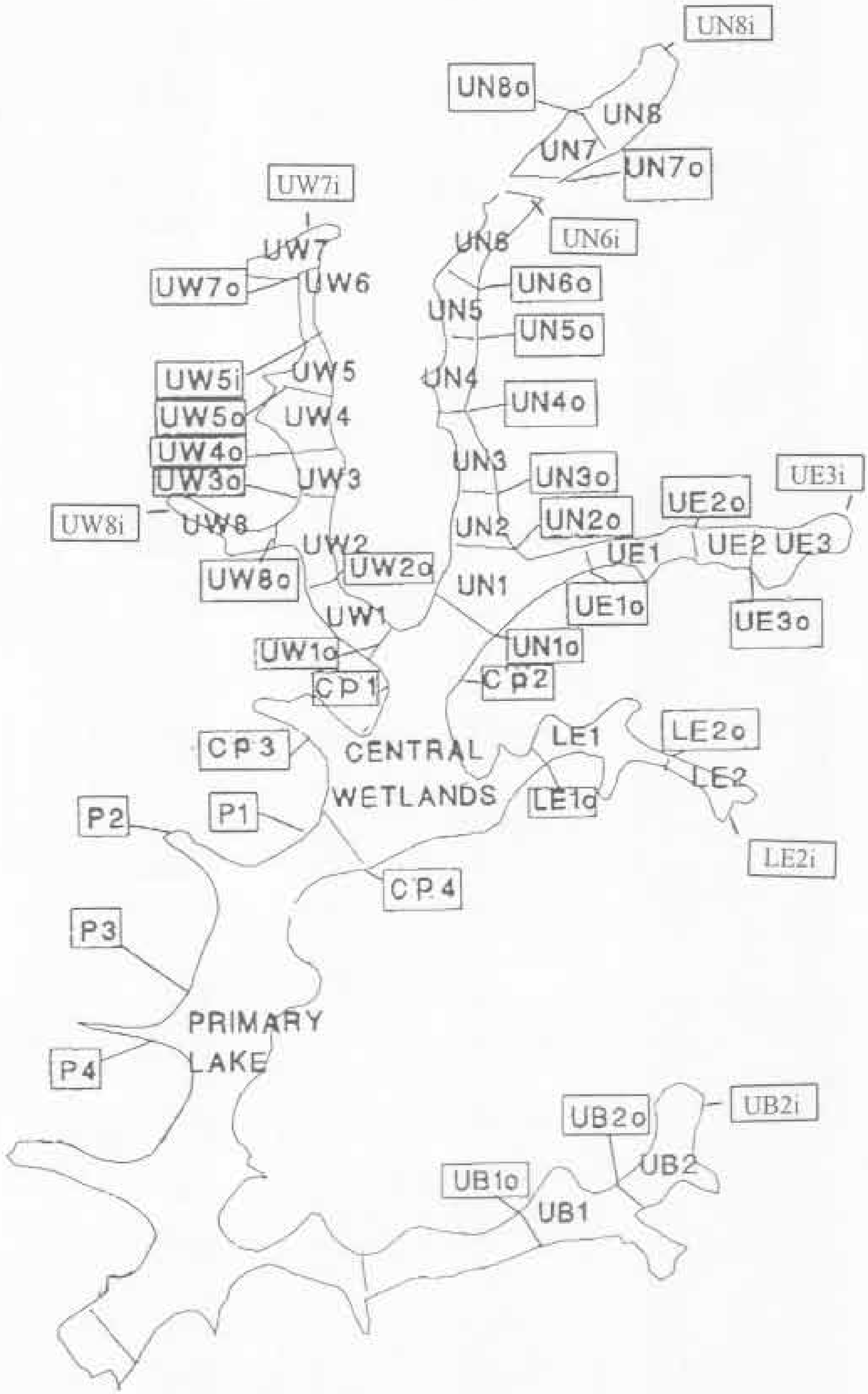
Source : Permulab Sdn. Bhd., 1999

Table C6 : Water Quality of Grab Samples from the Pond

Parameter	P1	P2
PH	2.5	2.5
BOD, mg/L	2	2
COD, mg/L	13	10
TSS, mg/L	16	20
Mercury, mg/L	ND	ND
Cadmium, mg/L	0.018	0.018
Chromium (Hexavalent), mg/L	ND	ND
Arsenic, mg/L	ND	ND
Cyanide, mg/L	ND	ND
Lead, mg/L	0.04	0.04
Chromium (Trivalent), mg/L	0.03	0.05
Copper, mg/L	0.80	0.78
Manganese, mg/L	3.25	3.15
Nickel, mg/L	0.23	0.20
Tin, mg/L	ND	ND
Zinc, mg/L	1.68	1.59
Boron, mg/L	ND	ND
Iron, mg/L	98.26	97.80
Phenol, mg/L	0.012	0.005
Free Chlorine, mg/L	ND	ND
Sulphide, mg/L	ND	ND
Oil and grease, mg/L	ND	ND

ND-Not Detected

Source : PAG Consult Sdn. Bhd., 1998



IRRIGATION MASTER PLAN FOR PUTRAJAYA

SAMPLING POINTS IN THE PUTRAJAYA LAKE (PHASE 1A)

APPENDIX C1

:I

pH

SE	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	Mean
n	6.6	6.5	6.0	6.5	5.7	6.5	6.5	6.3
ion*	6.7	6.7	6.2	6.3	6.5	6.6	-	6.5
tion*	7.4	6.8	6.2	6.3	6.5	7.6	6.7	6.8
on*	7.4	7.8	7.1	7.1	7.2	7.4	7.3	7.3
g	6.9	7.0	6.8	6.7	7.2	7.1	7.3	7.0
ing	6.4	6.6	6.3	6.5	6.8	6.5	6.6	6.5
:	6.3	6.4	6.3	3.4	7.1	6.4	6.9	6.1
	5.9	6.1	5.5	6.1	6.6	6.2	6.5	6.1

he construction of artificial wetlands

t arm B-Bisa arm UN-Upper-north arm LE-Lower-east arm

UE-Upper-east arm PL-Primary lake

anan Putrajaya, 1999

TURBIDITY (FTU)

PHASE	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	Mean
Pre-construction	11.6	21.5	19.3	8.2	11.7	8.2	8.2	12.7
Early construction* (3/97-5/97)	118.4	107.2	162.1	401.3	291.5	120.1	-	200.1
Heavy construction* (6/97-8/97)	261.3	192.5	872.4	273.1	439.0	277.3	206.7	360.3
Late construction* (9/97-3/98)	227.9	928.9	339.9	204.6	1880.4	760.9	532.9	696.5
Early monitoring (4/98-9/98)	36.1	30.1	23.0	17.2	1263.2	164.0	441.6	282.2
Middle monitoring (10/98-3/99)	28.3	22.9	20.5	12.1	151.4	25.0	229.0	69.9
Late monitoring (4/99-9/99)	16.8	21.3	17.2	9.3	13.8	11.9	16.3	15.2
Maintenance (from 10/99)	30.3	26.3	30.5	39.7	5.0	10.8	12.0	24.0

* in relation to the construction of artificial wetlands

UW-Upper-west arm B-Bisa arm UN-Upper-north arm LE-Lower-east arm

CL-Central lake UE-Upper-east arm PL-Primary lake

Source : Perbadanan Putrajaya, 1999

TSS (mg/L)

PHASE	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	Mean
Preconstruction	43.0	23.0	21.0	14.0	14.0	14.0	14.0	20.4
Early construction* (3/97-5/97)	88.2	46.5	97.0	88.2	61.2	62.3	-	73.9
Heavy construction* (6/97-8/97)	243.3	175.7	433.6	212.4	226.9	219.0	137.2	235.4
Late construction* (9/97-3/98)	130.8	659.1	165.5	166.5	1402.3	670.9	375.2	510.0
Early monitoring (4/98-9/98)	26.1	25.4	18.0	20.8	992.2	148.5	352.2	226.2
Middle monitoring (10/98-3/99)	17.2	17.0	15.1	11.3	71.2	15.7	43.1	27.2
Late monitoring (4/99-9/99)	15.4	16.3	12.7	13.3	18.9	18.5	13.9	15.6
Maintenance (from 10/99)	15.1	17.9	21.5	28.3	6.3	6.3	7.3	15.1

* in relation to the construction of artificial wetlands

UW-Upper-west arm　B-Bisa arm　UN-Upper-north arm　LE-Lower-east arm

CL-Central lake　UE-Upper-east arm　PL-Primary lake

Source : Perbadanan Putrajaya, 1999

CONDUCTIVITY (μmhos/cm)

PHASE	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	Mean
Pre-construction	NOT SAMPLED							
Early construction* (3/97-5/97)	47.7	73.2	28.7	47.5	27.8	46.3	-	45.2
Heavy construction* (6/97-8/97)	86.8	122.1	53.6	70.0	59.0	86.6	105.4	83.4
Late construction* (9/97-3/98)	83.4	132.4	81.3	113.3	69.3	84.5	121.0	97.9
Early monitoring (4/98-9/98)	167.1	91.7	66.0	113.5	105.6	97.5	108.0	107.1
Middle monitoring (10/98-3/99)	70.3	84.5	50.8	104.2	187.0	86.0	117.4	100.0
Late monitoring (4/99-9/99)	75.7	81.7	49.8	102.3	124.4	76.4	103.8	87.7
Maintenance (from 10/99)	90.5	87.5	53.3	104.7	131.3	79.8	97.5	89.7

* in relation to the construction of artificial wetlands

UW-Upper-west arm B-Bisa arm UN-Upper-north arm LE-Lower-east arm

CL-Central lake UE-Upper-east arm PL-Primary lake

Source : Perbadanan Putrajaya, 1999

AMMONIACAL NITROGEN (mg/L)

PHASE	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	Mean
Pre-construction	0.30	0.40	0.10	0.30	0.30	0.30	0.30	0.30
Early construction* (3/97-5/97)	0.57	0.59	0.30	0.39	0.31	0.40	-	0.43
Heavy construction* (6/97-8/97)	0.13	1.98	0.69	0.57	0.67	1.07	1.03	0.88
Late construction* (9/97-3/98)	0.83	1.28	0.83	1.03	0.85	1.07	1.09	1.00
Early monitoring (4/98-9/98)	0.34	0.35	0.27	0.91	0.56	0.38	0.49	0.47
Middle monitoring (10/98-3/99)	0.25	0.29	0.25	0.28	0.38	0.23	0.38	0.29
Late monitoring (4/99-9/99)	0.30	0.34	0.34	0.30	0.29	0.24	0.23	0.29
Maintenance (from 10/99)	0.44	0.56	0.47	0.46	0.63	0.58	0.49	0.51

* in relation to the construction of artificial wetlands

UW-Upper-west arm B-Bisa arm UN-Upper-north arm LE-Lower-east arm

CL-Central lake UE-Upper-east arm PL-Primary lake

Source : Perbadanan Putrajaya, 1999

NITRATE (mg/L)

PHASE	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	Mean
Pre-construction	1.90	2.20	1.40	2.00	1.20	2.00	2.00	1.80
Early construction* (3/97-5/97)	1.18	3.15	1.66	1.31	1.41	2.03	-	1.18
Heavy construction* (6/97-8/97)	1.62	2.74	1.71	2.04	1.87	2.68	3.92	1.62
Late construction* (9/97-3/98)	1.49	7.94	1.37	1.31	1.61	2.15	2.38	1.66
Early monitoring (4/98-9/98)	12.02	1.77	1.50	2.26	1.71	2.05	2.26	4.37
Middle monitoring (10/98-3/99)	1.67	1.75	0.82	1.19	2.24	0.86	1.30	1.52
Late monitoring (4/99-9/99)	0.86	2.01	1.48	1.40	1.35	1.39	0.97	1.35
Maintenance (from 10/99)	3.26	3.24	2.12	4.50	1.79	2.17	1.62	2.83

* in relation to the construction of artificial wetlands

UW-Upper-west arm B-Bisa arm UN-Upper-north arm LE-Lower-east arm

CL-Central lake UE-Upper-east arm PL-Primary lake

Source : Perbadanan Putrajaya, 1999

PHOSPHORUS (mg/L)

PHASE	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	Mean
Pre-construction	0.010	0.030	0.010	0.010	0.030	0.010	0.010	0.020
Early construction* (3/97-5/97)	0.030	0.030	0.030	0.030	0.030	0.030	-	0.030
Heavy construction* (6/97-8/97)	0.167	0.167	0.167	0.167	0.167	0.167	0.090	0.156
Late construction* (9/97-3/98)	0.012	0.107	0.024	0.021	0.021	0.021	0.045	0.036
Early monitoring (4/98-9/98)	0.021	0.010	0.010	0.010	0.010	0.010	0.010	0.012
Middle monitoring (10/98-3/99)	0.015	0.014	0.010	0.010	0.010	0.010	0.010	0.011
Late monitoring (4/99-9/99)	0.027	0.014	0.011	0.012	0.024	0.016	0.103	0.030
Maintenance (from 10/99)	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010

* in relation to the construction of artificial wetlands

UW-Upper-west arm B-Bisa arm UN-Upper-north arm LE-Lower-east arm

CL-Central lake UE-Upper-east arm PL-Primary lake

Source : Perbadanan Putrajaya, 1999

POTASSIUM (mg/L)

PHASE	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	Mean
Pre-construction	NOT SAMPLED							
Early construction* (3/97-5/97)	1.74	2.18	1.22	2.27	1.28	1.45	-	1.69
Heavy construction* (6/97-8/97)	2.69	2.38	3.21	5.04	2.60	2.97	5.28	3.45
Late construction* (9/97-3/98)	2.47	2.31	5.01	4.73	2.98	2.48	3.54	3.36
Early monitoring (4/98-9/98)	1.47	1.38	1.25	3.15	3.07	2.01	2.55	2.13
Middle monitoring (10/98-3/99)	1.12	1.18	0.88	1.98	4.72	1.40	2.25	1.93
Late monitoring (4/99-9/99)	1.68	1.33	1.02	1.75	2.74	1.79	2.24	1.79
Maintenance (from 10/99)	3.74	2.44	1.81	2.39	3.68	2.32	2.88	2.92

* in relation to the construction of artificial wetlands

UW-Upper-west arm B-Bisa arm UN-Upper-north arm LE-Lower-east arm
CL-Central lake UE-Upper-east arm PL-Primary lake

Source : Perbadanan Putrajaya, 1999

MAGNESIUM (mg/L)

PHASE	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	Mean
Pre-construction	NOT SAMPLED							
Early construction* (3/97-5/97)	0.91	1.21	0.76	0.97	0.44	0.85	-	0.86
Heavy construction* (6/97-8/97)	1.29	1.75	1.20	1.63	0.98	1.52	1.78	1.45
Late construction* (9/97-3/98)	1.30	1.81	1.57	1.59	0.90	1.36	1.43	1.42
Early monitoring (4/98-9/98)	0.22	0.32	0.28	1.01	0.39	0.56	0.51	0.47
Middle monitoring (10/98-3/99)	0.22	0.50	0.21	1.10	0.69	0.72	0.86	0.62
Late monitoring (4/99-9/99)	0.13	0.18	0.11	0.27	0.17	0.15	0.13	0.16
Maintenance (from 10/99)	1.61	1.38	1.03	1.87	1.12	1.32	1.32	1.41

* in relation to the construction of artificial wetlands

UW-Upper-west arm　B-Bisa arm　UN-Upper-north arm　LE-Lower-east arm

CL-Central lake　UE-Upper-east arm　PL-Primary lake

Source : Perbadanan Putrajaya, 1999

IRON (mg/L)

PHASE	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	Mean
Pre-construction	0.90	1.00	0.80	1.20	1.40	1.20	1.20	1.10
Early construction* (3/97-5/97)	1.33	1.07	0.80	1.71	0.70	1.02	-	1.10
Heavy construction* (6/97-8/97)	1.88	0.94	1.44	2.41	1.70	1.72	2.08	1.74
Late construction* (9/97-3/98)	1.44	1.78	1.99	3.42	1.88	1.82	2.00	2.05
Early monitoring (4/98-9/98)	0.06	0.05	0.04	0.64	0.24	0.11	0.08	0.17
Middle monitoring (10/98-3/99)	0.04	0.03	0.04	0.14	0.005	0.008	0.002	0.04
Late monitoring (4/99-9/99)	0.03	0.03	0.05	0.004	0.002	0.005	0.002	0.02
Maintenance (from 10/99)	0.22	0.24	0.32	0.002	0.002	0.002	0.002	0.11

* in relation to the construction of artificial wetlands

UW-Upper-west arm B-Bisa arm UN-Upper-north arm LE-Lower-east arm

CL-Central lake UE-Upper-east arm PL-Primary lake

Source : Perbadanan Putrajaya, 1999

MERCURY (mg/L)

PHASE	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	Mean
Pre-construction	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Early construction* (3/97-5/97)	0.001	0.001	0.001	0.002	0.001	0.001	-	0.001
Heavy construction* (6/97-8/97)	0.001	0.001	0.001	0.004	0.001	0.001	0.001	0.001
Late construction* (9/97-3/98)	0.001	0.001	0.001	0.003	0.003	0.002	0.002	0.002
Early monitoring (4/98-9/98)	0.001	0.001	0.002	0.002	0.001	0.001	0.001	0.001
Middle monitoring (10/98-3/99)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Late monitoring (4/99-9/99)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Maintenance (from 10/99)	0.001	0.001	0.001	0.002	0.002	0.001	0.001	0.001

* in relation to the construction of artificial wetlands

UW-Upper-west arm B-Bisa arm UN-Upper-north arm LE-Lower-east arm

CL-Central lake UE-Upper-east arm PL-Primary lake

Source : Perbadanan Putrajaya, 1999

LEAD (mg/L)

PHASE	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	Mean
Pre-construction	0.070	0.030	0.030	0.030	0.030	0.030	0.030	0.040
Early construction* (3/97-5/97)	0.110	0.080	0.062	0.030	0.032	0.045	-	0.060
Heavy construction* (6/97-8/97)	0.115	0.098	0.108	0.094	0.107	0.133	0.125	0.111
Late construction* (9/97-3/98)	0.034	0.030	0.037	0.054	0.041	0.029	0.034	0.037
Early monitoring (4/98-9/98)	0.013	0.011	0.013	0.014	0.027	0.014	0.018	0.016
Middle monitoring (10/98-3/99)	0.007	0.006	0.008	0.006	0.006	0.006	0.006	0.006
Late monitoring (4/99-9/99)	0.018	0.018	0.018	0.020	0.018	0.025	0.018	0.019
Maintenance (from 10/99)	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006

* in relation to the construction of artificial wetlands

UW-Upper-west arm B-Bisa arm UN-Upper-north arm LE-Lower-east arm

CL-Central lake UE-Upper-east arm PL-Primary lake

Source : Perbadanan Putrajaya, 1999

DISSOLVED OXYGEN (mg/L)

E	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	Mean
	7.3	7.2	7.2	7.2	7.0	7.2	7.2	7.2
on*	4.9	5.0	5.6	5.2	6.1	5.8	-	5.4
ion*	4.1	4.0	4.5	4.1	5.1	4.8	4.4	4.4
n*	6.4	6.6	6.3	6.6	6.4	6.6	6.5	6.5
g	6.0	6.2	6.1	6.0	5.8	6.0	5.9	6.0
ing	6.0	5.8	5.8	5.9	5.9	6.2	6.1	6.0
	6.0	5.9	6.1	6.4	6.8	6.4	6.5	6.3
	6.1	6.1	5.7	6.0	6.3	6.7	6.7	6.2

he construction of artificial wetlands

t arm B-Bisa arm UN-Upper-north arm LE-Lower-east arm

UE-Upper-east arm PL-Primary lake

anan Putrajaya, 1999

CHEMICAL OXYGEN DEMAND (mg/L)

PHASE	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	Mean
Pre-construction	4.0	6.0	7.0	3.0	10.0	3.0	3.0	5.1
Early construction* (3/97-5/97)	14.5	11.3	10.4	4.7	8.7	6.1	-	9.3
Heavy construction* (6/97-8/97)	26.9	20.2	36.9	14.6	16.2	16.4	24.1	22.2
Late construction* (9/97-3/98)	10.4	8.7	8.2	12.4	12.2	10.3	8.8	10.1
Early monitoring (4/98-9/98)	5.10	6.3	6.1	11.3	6.1	5.9	7.8	6.9
Middle monitoring (10/98-3/99)	8.90	8.4	7.1	12.3	9.9	8.9	7.8	9.0
Late monitoring (4/99-9/99)	8.30	9.1	7.7	10.7	10.5	9.3	9.7	8.9
Maintenance (from 10/99)	3.90	7.9	5.3	1.0	1.0	1.0	1.5	4.5

* in relation to the construction of artificial wetlands

UW-Upper-west arm B-Bisa arm UN-Upper-north arm LE-Lower-east arm

CL-Central lake UE-Upper-east arm PL-Primary lake

Source : Perbadanan Putrajaya, 1999

BIOCHEMICAL OXYGEN DEMAND (mg/L)

PHASE	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	Mean
Pre-construction	0.8	0.9	0.7	0.8	0.5	0.8	0.8	0.8
Early construction* (3/97-5/97)	4.6	3.7	4.0	2.0	3.2	1.8	-	3.2
Heavy construction* (6/97-8/97)	8.3	7.4	4.5	4.6	5.0	4.2	7.7	5.9
Late construction* (9/97-3/98)	3.8	3.7	3.1	6.1	3.8	4.5	3.9	4.1
Early monitoring (4/98-9/98)	2.0	2.1	2.1	2.3	2.2	2.2	2.8	2.2
Middle monitoring (10/98-3/99)	3.1	3.0	2.5	4.1	3.4	3.5	3.5	3.3
Late monitoring (4/99-9/99)	2.1	2.1	2.1	2.2	2.4	2.2	2.2	2.2
Maintenance (from 10/99)	2.1	2.0	2.0	2.0	2.0	2.0	2.0	2.0

* in relation to the construction of artificial wetlands

UW-Upper-west arm B-Bisa arm UN-Upper-north arm LE-Lower-east arm

CL-Central lake UE-Upper-east arm PL-Primary lake

Source : Perbadanan Putrajaya, 1999

FAECAL COLIFORM (MPN/100 mL)

PHASE	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	Mean
Pre-construction	300	5,000	500	500	500	3,000	3,000	1,829
Early construction* (3/97-5/97)	1,300	1,661	315	212	567	498	-	759
Heavy construction* (6/97-8/97)	10,946	8,793	608	1,569	1,545	3,268	1,919	4,093
Late construction* (9/97-3/98)	18,483	4,564	10,680	4,779	18,874	9,579	2,033	9,856
Early monitoring (4/98-9/98)	1,217	2,584	1,202	2,992	6,578	1,488	2,886	2,707
Middle monitoring (10/98-3/99)	2,179	2,099	889	408	1,145	1,308	475	1,215
Late monitoring (4/99-9/99)	29,887	21,823	5,881	2,667	23,338	17,908	8,779	15,755
Maintenance (from 10/99)	7,080	6,330	8,425	2,663	4,167	5,400	3,150	5,853

* in relation to the construction of artificial wetlands

UW-Upper-west arm B-Bisa arm UN-Upper-north arm LE-Lower-east arm

CL-Central lake UE-Upper-east arm PL-Primary lake

Source : Perbadanan Putrajaya, 1999

APPENDIX C2

PHASE	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	MEAN
Pre-Construction	-	-	-	-	-	-	-	88.6 (II)
Early construction* (3/97-5/97)	75.7 (III)	79.8 (II)	81.5 (II)	80.8 (II)	83.9 (II)	84.2 (II)	-	81.0 (II)
Heavy construction* (6/97-8/97)	62.3 (III)	62.6 (III)	67.4 (III)	68.4 (III)	71.6 (III)	69.6 (III)	63.8 (III)	66.5 (III)
Late construction* (9/97-3/98)	78.9 (II)	75.3 (III)	79.3 (II)	45.5 (IV)	71.1 (III)	75.7 (III)	76.2 (III)	71.7 (III)
Early monitoring (4/98-9/98)	86.4 (II)	87.1 (II)	87.5 (II)	84.0 (II)	78.5 (II)	82.1 (II)	79.3 (II)	83.6 (II)
Middle monitoring (10/98-3/99)	86.1 (II)	85.5 (II)	85.9 (II)	84.4 (II)	81.3 (II)	87.0 (II)	84.9 (II)	85.0 (II)
Late monitoring (4/99-9/99)	86.7 (II)	86.1 (II)	87.4 (II)	87.6 (II)	88.7 (II)	88.3 (II)	89.0 (II)	87.7 (II)
Maintenance (from 10/99)	85.8 (II)	84.7 (II)	82.0 (II)	86.0 (II)	88.0 (II)	87.7 (II)	89.2 (II)	86.2 (II)

* in relation to the construction of artificial wetlands

UW-Upper-west arm   B-Bisa arm   UN-Upper-north arm   LE-Lower-east arm

CL-Central lake   UE-Upper-east arm   PL-Primary lake

Source : Perbadanan Putrajaya, 1999

APPENDIX D

INTAKE AND PUMPHOUSE DESIGN

1 Intake Design

2 Pumphouse Design

FIGURE

Figure D1	General Arrangement Of Pumphouse Plan For Submersible Multistaged Pump (Borehole Type, Vertically Mounted)
Figure D2	General Arrangement Of Pumphouse Plan For Vertical Turbine Pump
Figure D3	General Arrangement Of Pumphouse Plan For Vertical Multistaged Centrifugal Pump
Figure D4	General Arrangement Of Pumphouse Plan For Submersible Multistaged Pump (Encapsulated and Horizontally Mounted)

INTAKE AND PUMPHOUSE DESIGN

1. INTAKE DESIGN

Two options of intake design (see Figure D1a) are proposed as follows:-

a) Option I – Piped Intake

An intake pipe of suitable diameter is connected from the pump sump which is located below the pumphouse, to a strainer at the end of the pipe which extends into the lake.

A sectional view of this option is shown in Figure D1b.

b) Option II – Channelled Intake

In this design, box culverts are used to provide a channel for water to flow from the lake to the pump sump located below the pumphouse.

A sectional view of this option is shown in Figure D1c.

2. PUMPHOUSE DESIGN

Two basic types of pumphouses are proposed, one which is underground, i.e. concealed type and the other which is above ground i.e. exposed type.

For both types of pumphouses, provision is made for a removal screen which is proposed to be located before the inlet to the pump sump. The purpose of the screen is to trap and remove any debris found in the lake water and also to prevent the debris from entering the pump sump. In order to minimize space usage, the pump sump is proposed to be located directly below the pumphouse.

Due to the relatively high delivery heads required that range from about 6 bar to 12 bar for the pumping plants under consideration, the selection of pumps is limited to the following types :-

(i) Submersible multistaged (borehole type, vertically mounted)

(ii) Vertical turbine

(iii) Vertical multistaged centrifugal

(iv) Submersible multistaged (encapsuled and horizontally mounted)

Type (i) has the advantage of the motor being submersible but the disadvantage is that a building is required to house the pumps for normal operation and maintenance.

Type (ii) is suitable for high capacity and high head applications but a superstructure is required to house the pumps for normal operation and maintenance and also the motor is not submersible.

Type (iii) has the advantage of being smaller in physical dimensions and the pumps can be accommodated in an underground pumphouse. However, this type of pump is limited to capacity of about 50 m^3/h and about 100m head. Also, the motor is not submersible.

Type (iv) is basically similar to type (i) except that it has a wider pump capacity range coverage and can be installed vertically or horizontally in-line in a pipe. However the cost of the pump is generally higher than the other types by about 30%.

2.1 Option of Pumphouse

In consideration of the above, the following options have been proposed:-

Option A

Type (i) or Type (ii) pumps for all 9 nos pumphouses. All the pumphouses are above ground i.e. exposed type.

The general arrangement of Type (i) pumps is shown in Figure D1a – 1c whereas the general arrangement of Type (ii) pumps is shown in Figure D2a and D2b.

Option B

Type (iii) pumps of lower capacity range for 7 nos pumphouses which are underground (concealed type), Type (iii) pump of lower capacity range for 1 nos pumphouse which is aboveground and Type (ii) pumps of larger capacity range for 1 nos pumphouse which is above ground (exposed type).

The general arrangement of Type (iii) pumps is shown in Figure D3a and D3b.

Option C

Type (iv) pumps which are installed horizontally for all 9 nos pumphouses which are underground (concealed type)

The general arrangement of Type (iv) pumps is shown in Figure D4a and D4b.

2.2 Evaluation of Option

For Option A, all the pumphouses will be above ground and exposed. The advantages of this option are as follows:-

(a) All the control and starterboards will be above the flood level and hence there is no danger of ingress of water into the boards.

(b) This arrangement provides better access to the pumping equipment for the purpose of installation, operation and maintenance.

However, the disadvantages are :-

(a) Being above ground and exposed, the pumphouses will be aesthetically obtrusive.

For Option B, 7 of the 9 proposed pumphouses will be underground and 2 other above ground. The advantages are :-

(a) The aesthetic impact is less profound as 7 of the pumphouses will be underground. 2 of above ground pumphouses are located at the sewerage treatment plants (most of the structures are already aboveground) and require no consideration on the aesthetics aspect.

However, the disadvantages are :-

(a) There is a possibility of flooding of the underground pumphouse and cause damage to the pump motors which are not submersible and electrical boards.

(b) Access for maintenance is difficult and inconvenient.

For Option C, all the 9 pumphouses will be underground and concealed. The main advantages of this option are :-

(a) The pumps are submersible and can still operate in the unlikely event of flooding in the pumphouse. However the electrical boards are still susceptible to flooding.

(b) Minimal space is required for installation of the pumps.

(c) The noise levels of the pumps are comparatively lower.

However, the disadvantage of this option is :-

(a) The pumps are generally about 20 – 30% more expensive than the other types of pumps.

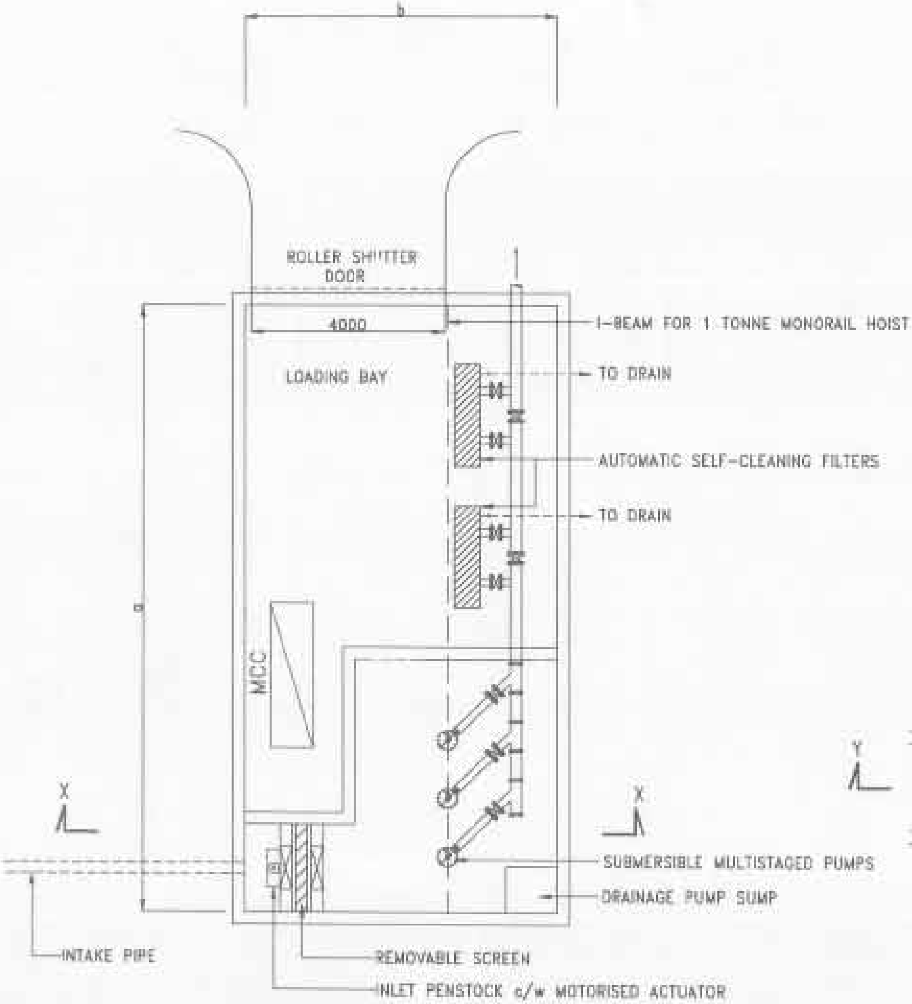
2.3 Recommendation

We would like to recommend that Option A which all the pumphouses to be above ground and exposed be adopted for the following reasons:-

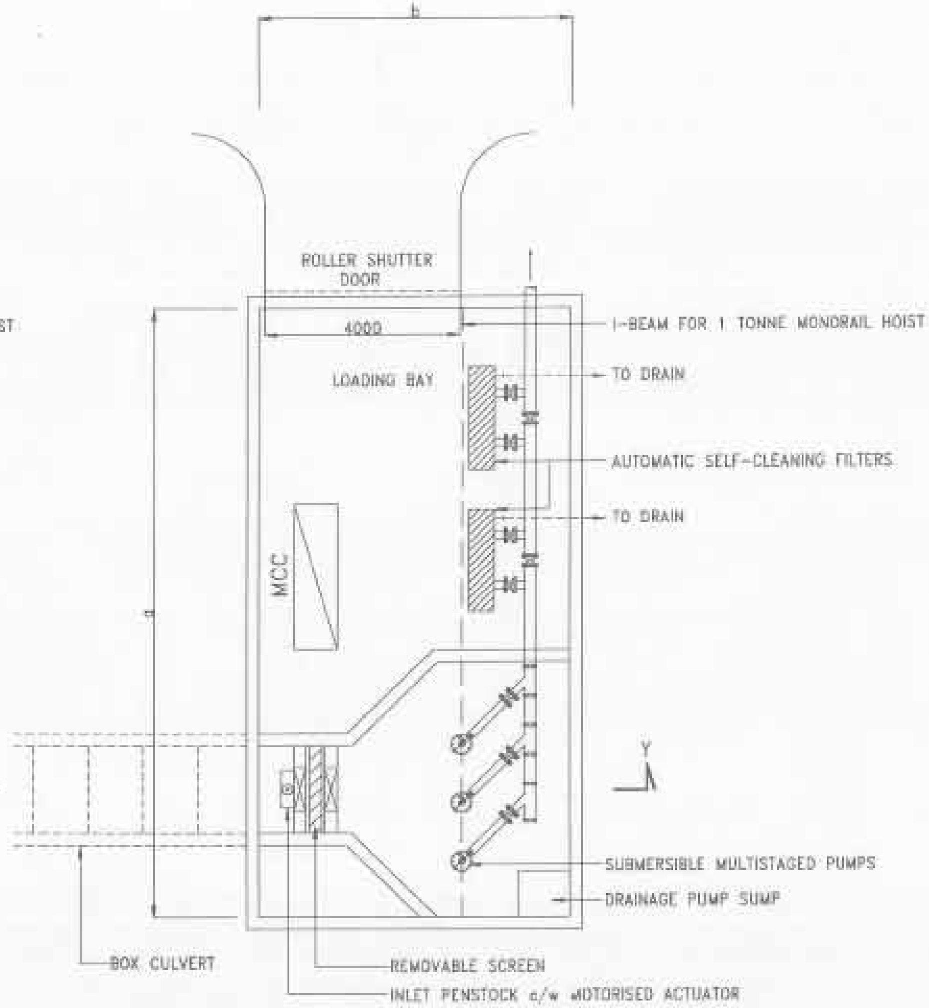
(i) Aboveground pumphouse provides better access for installation, operation and maintenance works.

(ii) There is no chance of the electrical switchboards and pump motors being flooded.

(iii) Artificial rocks and vegetation can be used to camouflage the pumphouses.



OPTION I (PIPED INTAKE)



OPTION II (CHANNELED INTAKE)

GENERAL ARRANGEMENT OF PUMPHOUSE PLAN

TOTAL FLOW (cu.m/h)	'a' (mm)	'b' (mm)	NO OF PUMPHOUSE
< 15	7000	5000	0
15 to 510	10,000	6000	8
> 510	12,000	8000	1

Figure D1a

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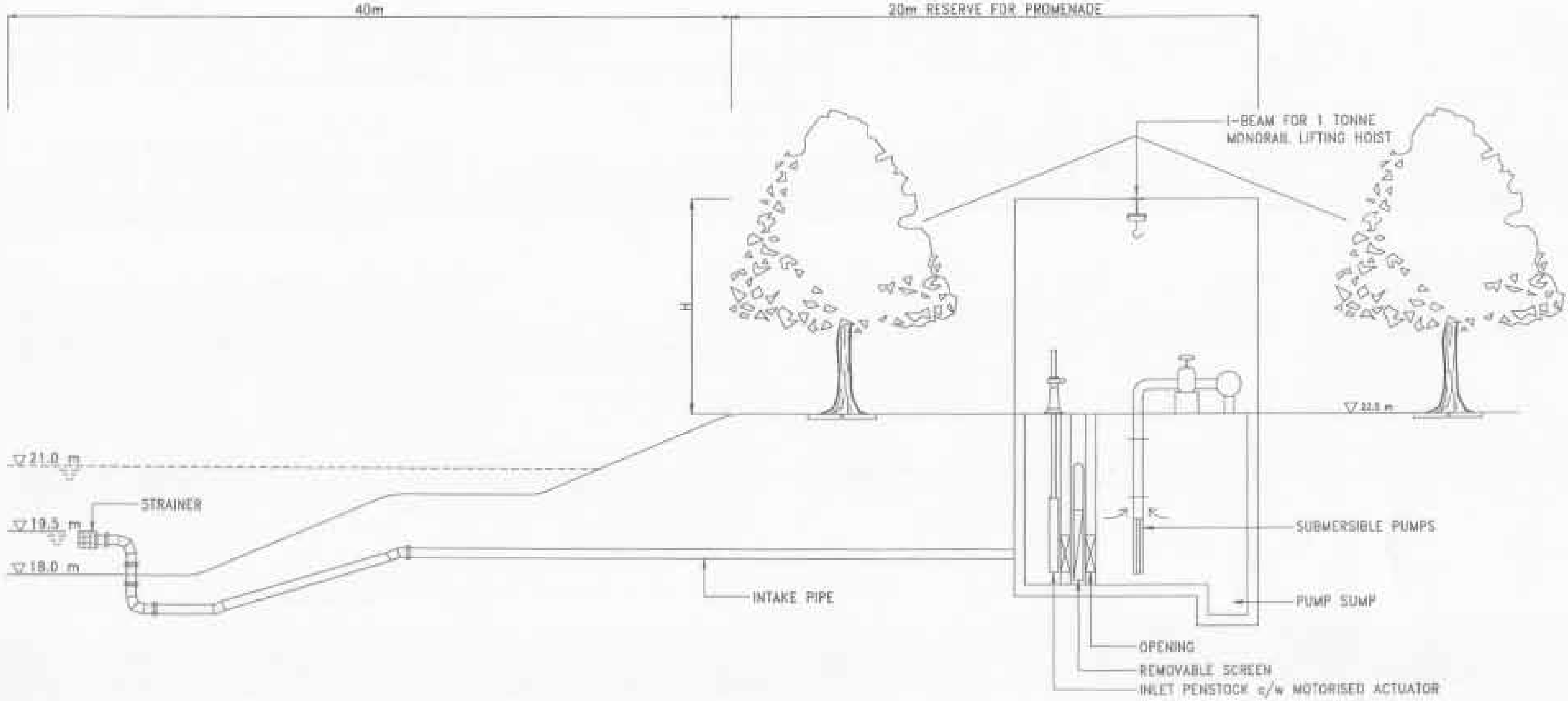

SECTION X–X

OPTION I : PIPED INTAKE

ARTIFICIAL ROCKS OR VEGETATION TO LANDSCAPE ARCHITECT DETAILS FOR CAMOUFLAGING THE PUMPHOUSE

NOTES:

1. DIMENSION 'H' SHALL VARY FROM 3.5m TO 5.0m TO SUIT THE PUMP DIMENSIONS

Figure D1b

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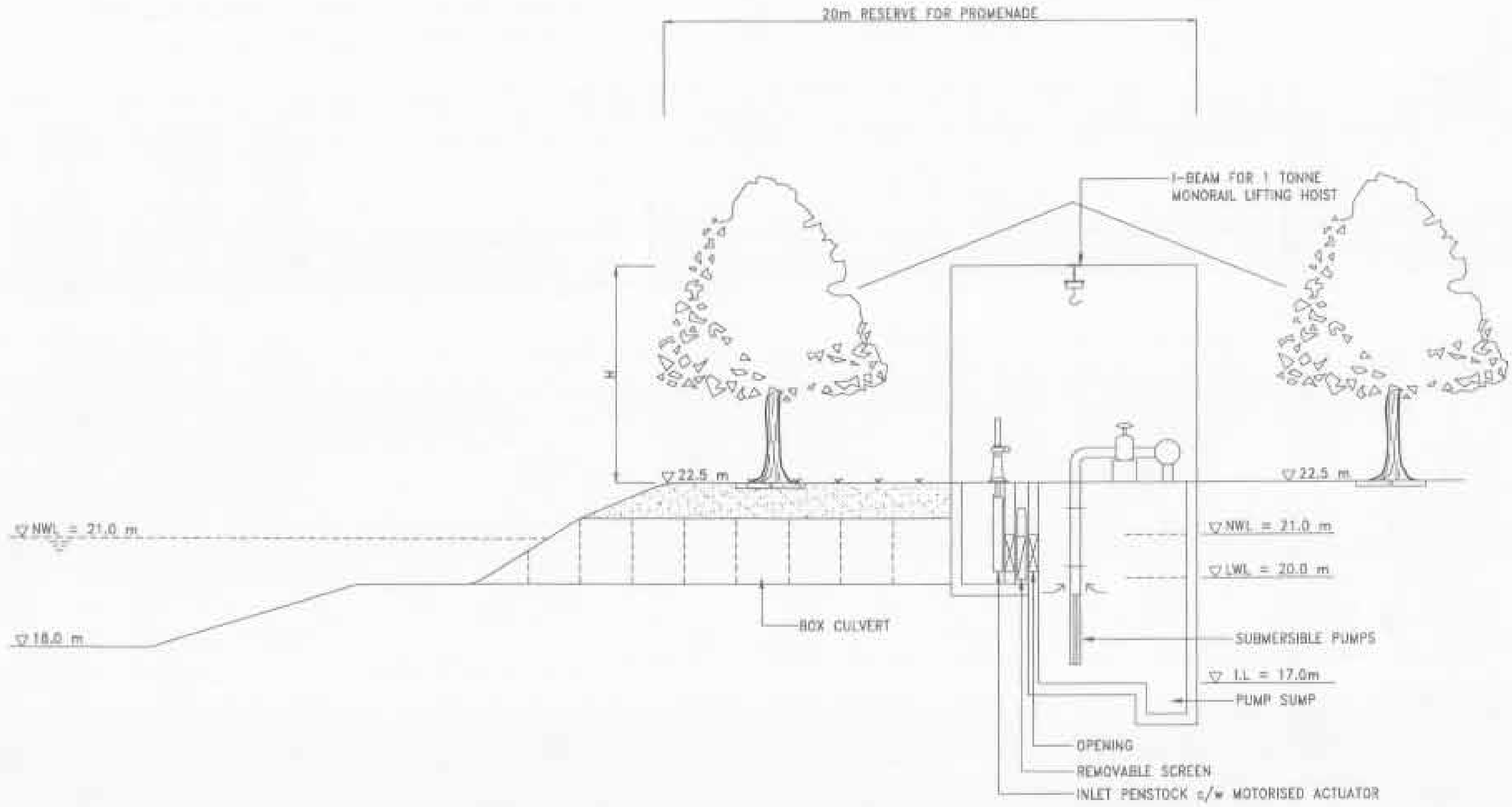

SECTION Y–Y

OPTION II : CHANNELLED INTAKE

ARTIFICIAL ROCKS OR VEGETATION TO LANDSCAPE ARCHITECT DETAILS FOR CAMOUFLAGING THE PUMPHOUSE

NOTES:

1. THE I.L OF THE PUMP SUMP SHALL VARY TO SUIT THE PUMP SIZE.
2. A NOMINAL I.L IS 17.0m
3. DIMENSION 'H' SHALL VARY FROM 3.5m TO 5.0m TO SUIT THE PUMP DIMENSIONS

Figure D1c

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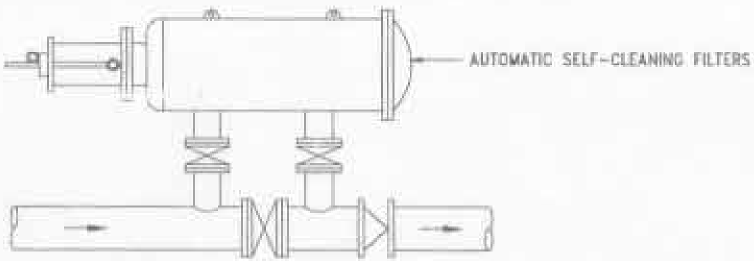
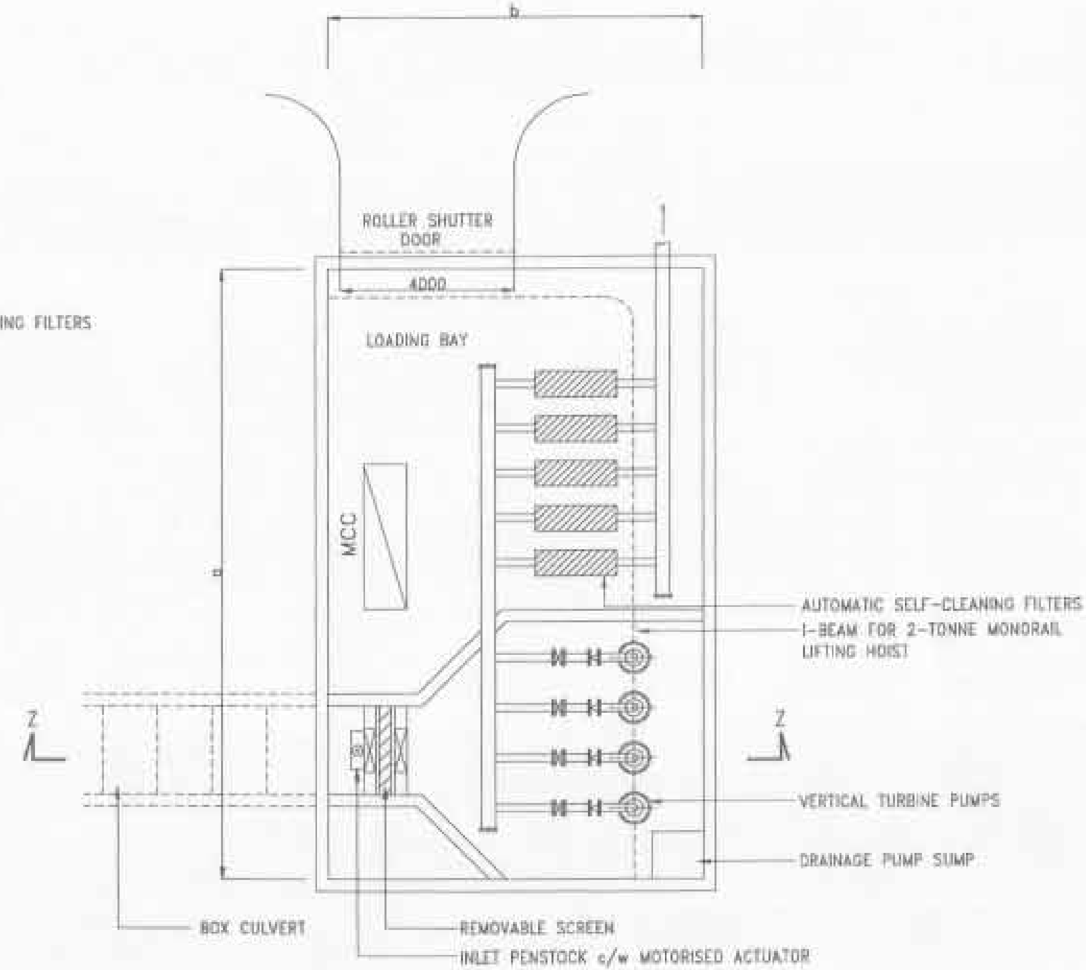
NOTES:

1. THIS ARRANGEMENT IS APPLICABLE TO ONLY ONE OF THE 13 nos OF PUMPHOUSE PROPOSED.



TYPICAL PIPEWORK ARRANGEMENT FOR AUTOMATIC SELF-CLEANING FILTER



TOTAL FLOW (cu.m/h)	'a' (mm)	'b' (mm)	NO OF PUMPHOUSE
< 15	7000	5000	0
15 to 510	10,000	6000	6
> 510	12,000	8000	1

GENERAL ARRANGEMENT OF PUMPHOUSE PLAN

Figure D2a

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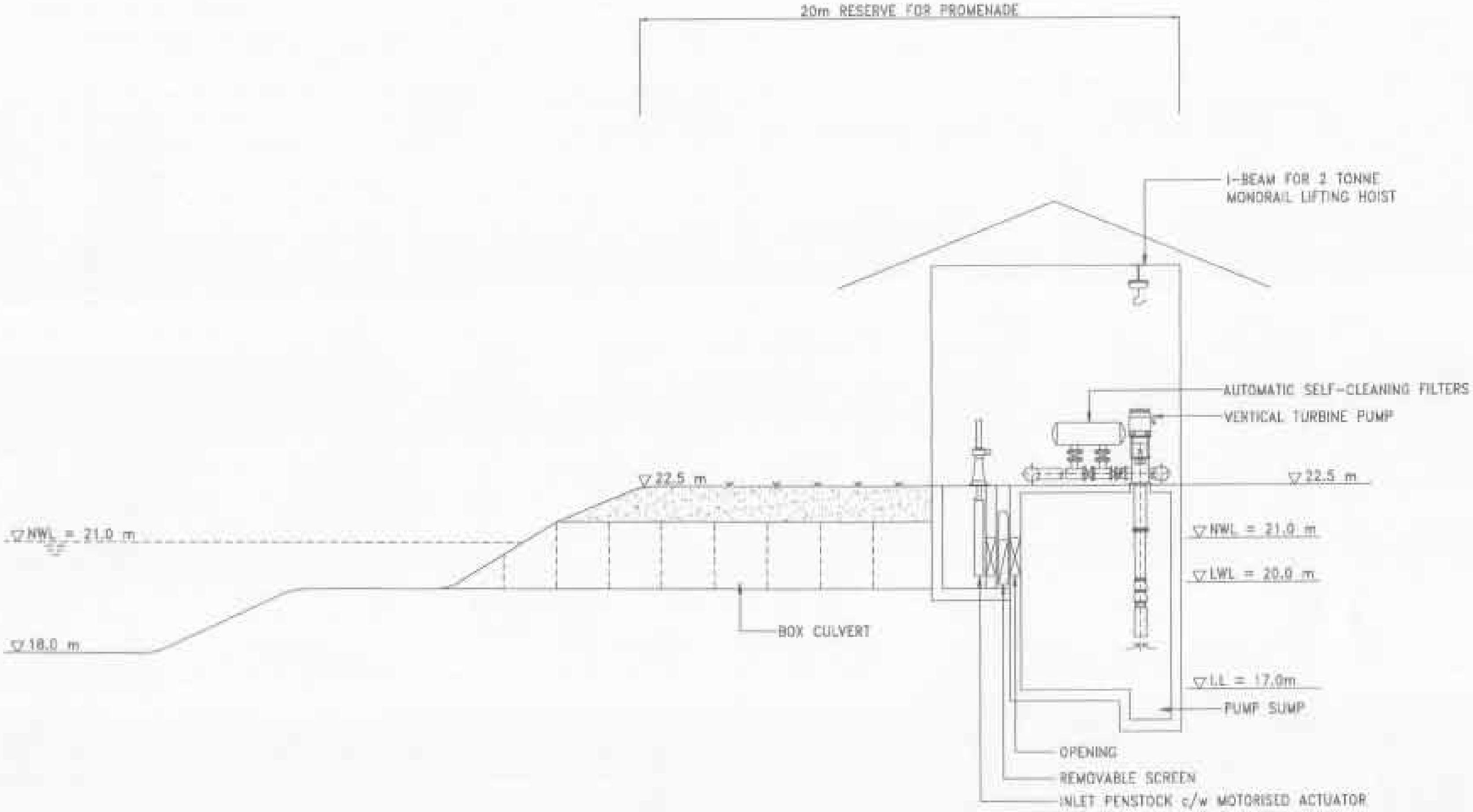

SECTION Z-Z

OPTION II : CHANNELLED INTAKE

NOTES:

1. THE I.L OF THE PUMP SUMP SHALL VARY TO SUIT THE PUMP SIZE.
2. A NOMINAL I.L IS 17.0m

Figure D2b

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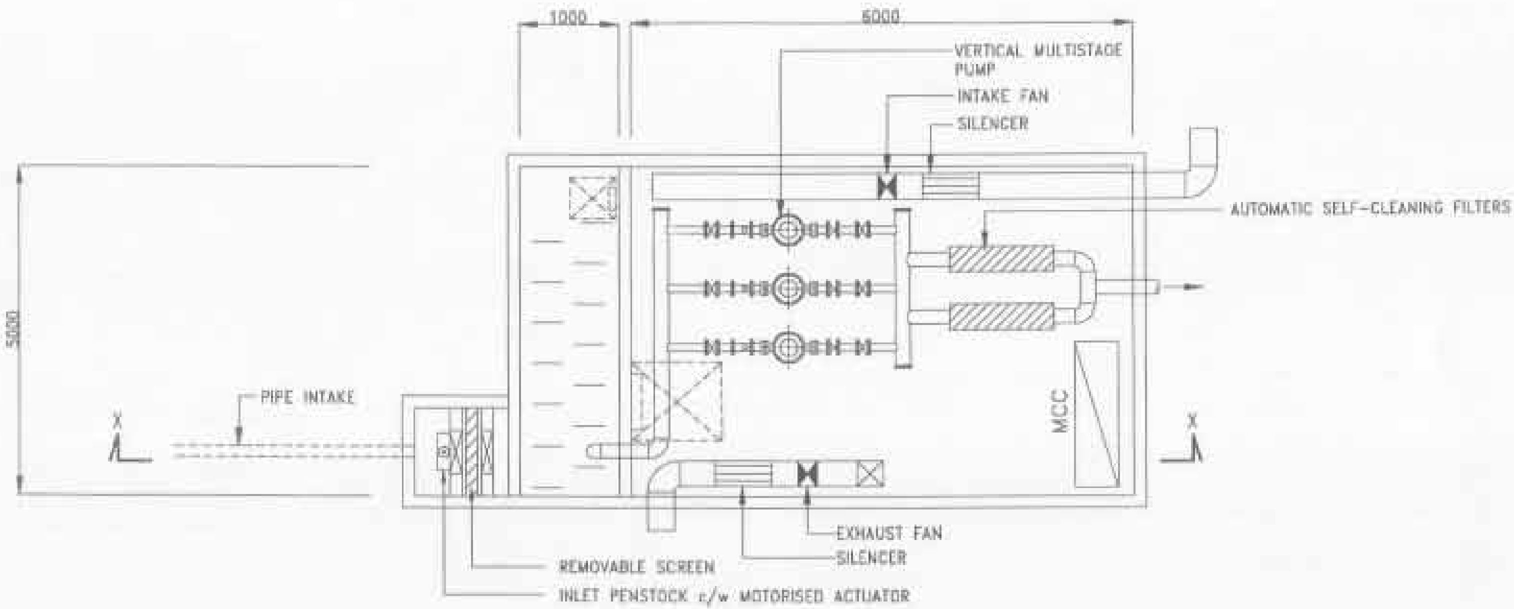
ALTERNATIVE PUMPHOUSE DESIGN - OPTION (B)

(FOR TOTAL FLOW LESS THAN 150 cu.m/h AND TOTAL HEAD LESS THAN 90m)



GENERAL ARRANGEMENT OF PUMPHOUSE PLAN (PIPED INTAKE)

Figure D3a

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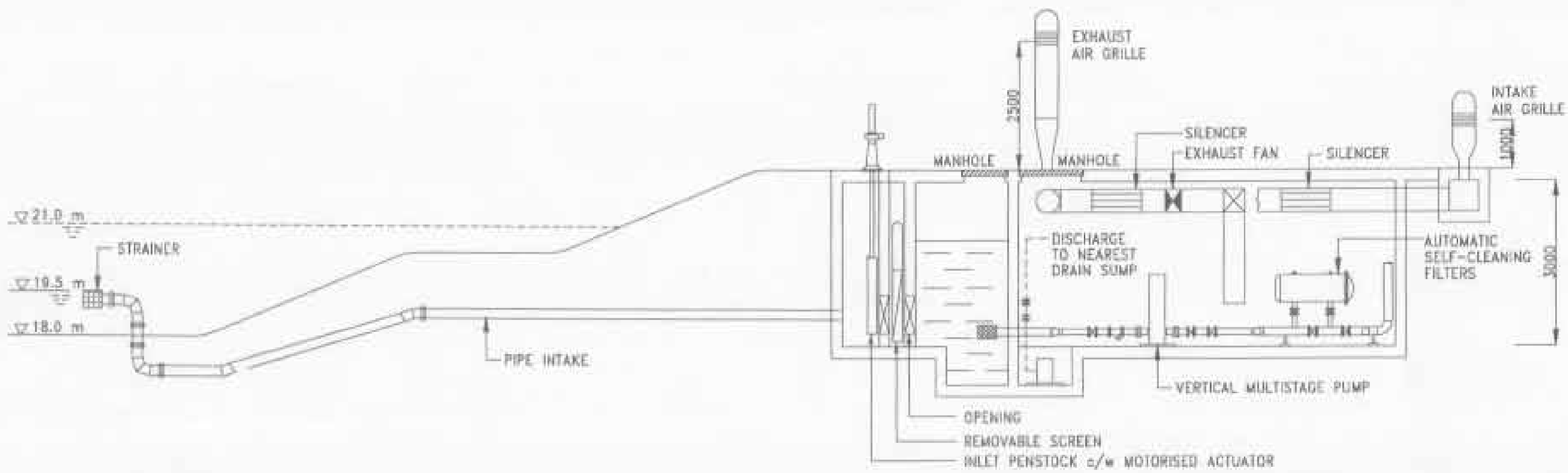
ALTERNATIVE PUMPHOUSE DESIGN – OPTION (B)

(FOR TOTAL FLOW LESS THAN 150 cu.m/h AND TOTAL HEAD LESS THAN 90m)



SECTION X–X

Figure D3b

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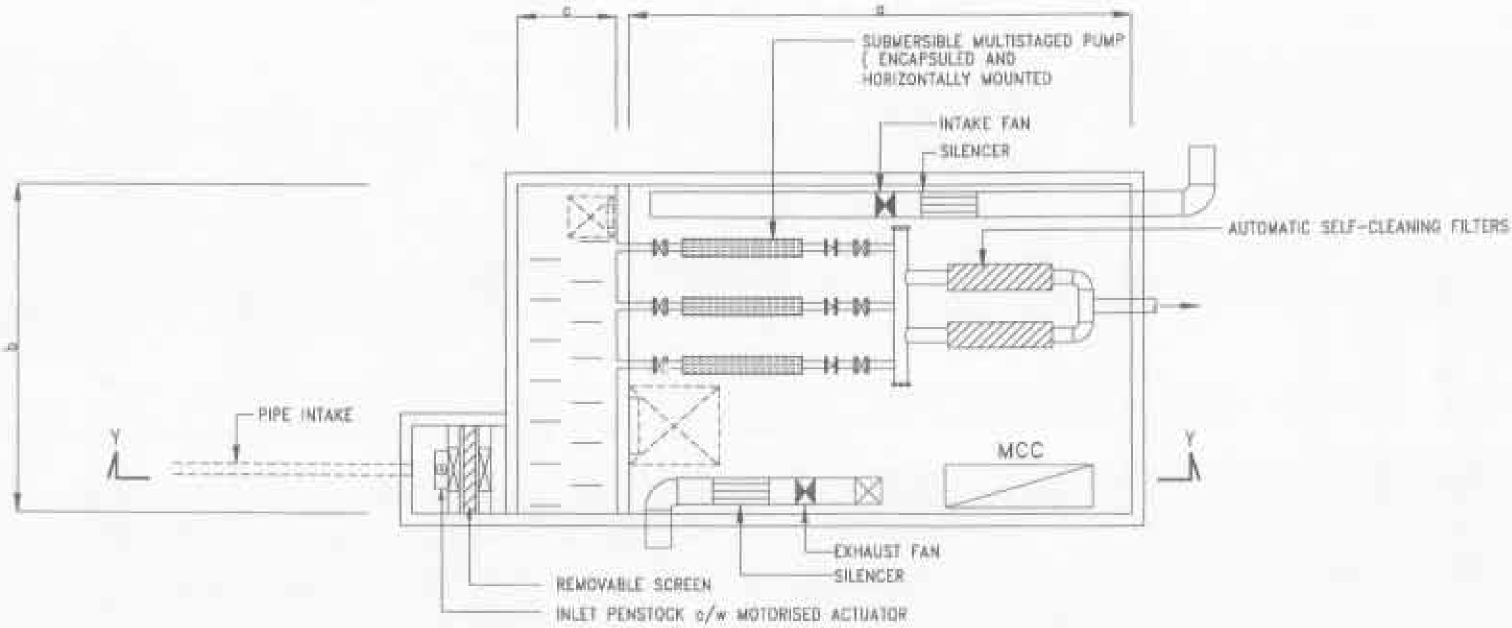
ALTERNATIVE PUMPHOUSE DESIGN – OPTION (C)

TOTAL FLOW (cu.m/h)	'a' (mm)	'b' (mm)	'c' (mm)	NO OF PUMPHOUSE
< 160	6000	5000	1000	8
200 to 510	7000	5000	1500	0
> 510	12,000	7000	3000	1



GENERAL ARRANGEMENT OF PUMPHOUSE PLAN (PIPED INTAKE)

Figure D4a

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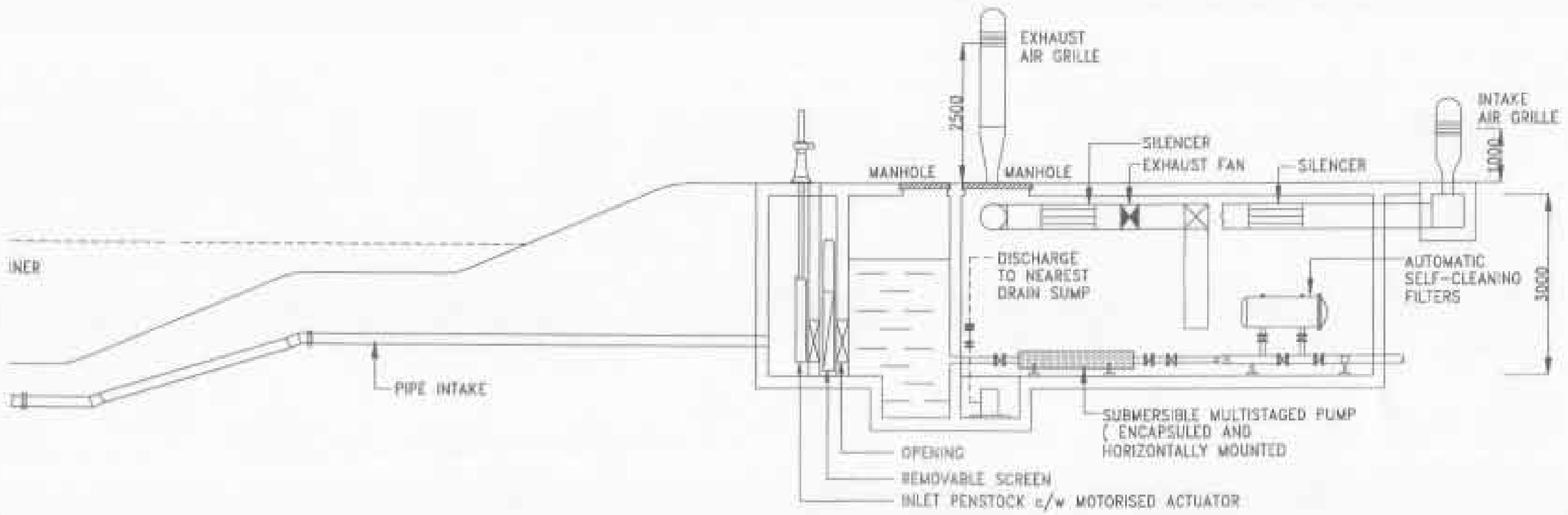
TIVE PUMPHOUSE DESIGN – OPTION (C)



SECTION Y–Y

Figure D4b

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APPENDIX E

LOCATIONAL AND DESIGN CRITERIA FOR IRRIGATION FACILITIES

1 Introduction

TABLE

Table E1 Locational And Design Criteria For Pump House

Table E2 Locational And Design Criteria For Pump House For Storage Pond

Table E3 Locational And Design Criteria For Truck Depot

Table E4 Locational And Design Criteria For Truck Refilling Kiosk

Table E5 Locational And Design Criteria For Holding Pond (Storage, Disinfection and Treatment)

APPENDIX E

LOCATIONAL AND DESIGN CRITERIA FOR IRRIGATION FACILITIES

1. INTRODUCTION

Site identification and selection for pump houses, truck depots (for overnight parking and repairs), water filling stations (for trucks) and ponds for storage and disinfection (of treated water from the sewage treatment plants) are to be undertaken by the respective planners or designers for the precinct.

However, the following locational and design criteria given in Table E1 – E5 are to be used as guidelines in site selection and planning and design of these facilities i.e.,

a) Table E1 Locational And Design Criteria For Pump House

b) Table E2 Locational And Design Criteria For Pump House For Storage Pond

c) Table E3 Locational And Design Criteria For Truck Depot

d) Table E4 Locational And Design Criteria For Truck Refilling Kiosk

e) Table E5 Locational And Design Criteria For Holding Pond (Storage, Disinfection and Treatment)

Table E1 Locational And Design Criteria For Pump House – 1/4

Pump Houses	Land Area (sqm)	Locational Criteria	Design Criteria
PH1 (Zone 1/ PjP 2, 3 & 18)	16x12	1. The facility may be located along a green connector or promenade; and adjacent to or in close proximity to an existing or proposed vehicular maintenance reserve. 2. The facility is to be setback at least 3m from private property line; 3m from the water's edge and away from major activity areas. 3. A reserve of at least 3.5m along the promenade or green connector is to be maintained for pedestrian and bicycle circulation. 4. The facility may not be positioned or located in a way that it hinders pedestrian circulation or safety.	1. Design of the facility must be consistent with the overall landscape design concept of the promenade or green connector. 2. Security fencing must adopt a soft fencing approach. 3. The site must be adequately landscaped; and security signs kept to a minimum. 4. Building, preferably, should be set below grade to minimize visibility.
PH2 (Zone 2/ PjP 3 & 4)	16x12	1. The facility may be located along a green connector, linear park or promenade; and adjacent to or in close proximity to an existing or proposed vehicular maintenance reserve. 2. The facility is to be setback at least 3m from private property line; 3m from the water's edge and away from major activity areas. 3. A reserve of at least 3.5m along the promenade or green connector is to be maintained for pedestrian and bicycle circulation. 4. The facility may not be positioned or located in a way that it hinders pedestrian circulation or safety.	1. Design of the facility must be consistent with the overall landscape design concept of the promenade or green connector. 2. Security fencing must adopt a soft fencing approach. 3. The site must be adequately landscaped; and security signs kept to a minimum. 4. Building, preferably, should be set below grade to minimize visibility.

Table E1 Locational And Design Criteria For Pump House (Cont'd) – 2/4

Pump Houses	Land Area (sqm)	Locational Criteria	Design Criteria
PH3 (Zone 3/ PjP 16, 17 & 19)	16x12	1. The facility may be located along a green connector or promenade; and adjacent to or in close proximity to an existing or proposed vehicular maintenance reserve. 2. The facility is to be setback at least 3m from private property line; 3m from the water's edge and away from major activity areas. 3. A reserve of at least 3.5m along the promenade or green connector is to be maintained for pedestrian and bicycle circulation. 4. The facility may not be positioned or located in a way that it hinders pedestrian circulation or safety.	1. Design of the facility must be consistent with the overall landscape design concept of the promenade or green connector. 2. Security fencing must adopt a soft fencing approach. 3. The site must be adequately landscaped; and security signs kept to a minimum. 4. Building, preferably, should be set below grade to minimize visibility.
PH4 (Zone 4/ PjP7, 8, 9 & 10)	16x12	1. The facility may be located along a green connector, linear park or promenade; and adjacent to or in close proximity to an existing or proposed vehicular maintenance reserve. 2. The facility is to be setback at least 3m from private property line; 3m from the water's edge and away from major activity areas. 3. A reserve of at least 3.5m along the promenade or green connector is to be maintained for pedestrian and bicycle circulation. 4. The facility may not be positioned or located in a way that it hinders pedestrian circulation or safety.	1. Design of the facility must be consistent with the overall landscape design concept of the promenade or green connector. 2. Security fencing must adopt a soft fencing approach. 3. The site must be adequately landscaped; and security signs kept to a minimum. 4. Building, preferably, should be set below grade to minimize visibility.

Table E1 Locational And Design Criteria For Pump House (Cont'd) – 3/4

Pump Houses	Land Area (sqm)	Locational Criteria	Design Criteria
PH5 (Zone 5/ PjP 5,6, & 20)	16x12	1. The facility may be located along a green connector, linear park or promenade; and adjacent to or in close proximity to an existing or proposed vehicular maintenance reserve. 2. The facility is to be setback at least 3m from private property line and 3m from the water's edge. 3. The facility is to be located away from major public activity and residential areas. 4. A reserve of at least 3.5m along the promenade or green connector is to be maintained for pedestrian and bicycle circulation. 5. The facility may not be positioned or located in a way that it hinders pedestrian circulation or safety.	1. Design of the facility must be consistent with the overall landscape design concept of the promenade or green connector. 2. Security fencing must adopt a soft fencing approach. 3. The site must be adequately landscaped; and security signs kept to a minimum. 4. Building, preferably, should be set below grade to minimize visibility.

Table E1 Locational And Design Criteria For Pump House (Cont'd) – 4/4

Pump Houses	Land Area (sqm)	Locational Criteria	Design Criteria
PH6 (Zone 6/ PjP 12)	16x12	1. The facility may be located along a green connector, linear park or promenade; adjacent to or in close proximity to an existing or proposed vehicular maintenance reserve; and accessible to the open pond of Lower East 1. 2. The facility may not be located along the wetlands maintenance reserve, inside the zone of intermittent inundation (ZII) or wetland zone. 3. The facility is to be setback at least 3m from private property line and 3m from the top of the ZII. 4. The facility is to be located away from major public activity and residential areas. 5. A reserve of at least 3.5m along the promenade or green connector is to be maintained for pedestrian and bicycle circulation. 6. The facility may not be positioned or located in a way that it hinders pedestrian circulation or safety.	1. Design of the facility must be consistent with the overall landscape design concept of the promenade or green connector. 2. Security fencing must adopt a soft fencing approach. 3. The site must be adequately landscaped; and security signs kept to a minimum. 4. Building, preferably, should be set below grade to minimize visibility.
PH7 (Zone 7/ PjP 13)	16x12	1. The facility may not be located along the wetlands maintenance reserve, inside the zone of intermittent inundation (ZII) or wetland zone. 2. Extraction is confined to the open ponds in Upper West 4 or Upper West 5.	1. Design of the facility must be consistent with the overall landscape design concept of the wetlands.

Table E? Locational And Design Criteria For Pump House At Storage Pond

Storage Ponds	Land Area (sqm)	Locational Criteria	Design Criteria
SP1 (Zone 9/ PjP14, 15 & DE)	16x12	1. The pump house is to be located within the compound of the sewerage treatment plant (STP1).	
SP2 (Zone 10/ PjP 5, 19 & 20)	18x14	1. The pump house is to be located adjacent to the compound of the sewerage treatment plant (STP2).	

Refer Table 9.3, Map 2 and Map 2a – 2h.

Table E3 Locational And Design Criteria For Truck Depot

Depot	Land Area (sqm)	Locational Criteria	Design Criteria
Precinct 16	25 x25	1. Truck depots are to be located in the vicinity of utility reserves and away from main activity and residential areas. 2. Vehicular parking areas inside Metropolitan parks (Taman Jati, Taman Rimba Alam, Taman Wetland) may be considered for overnight truck parking.	1. The depot must be adequately landscaped, screened and signed for safety and security reasons.
Precincts 11	35 x35	1. Truck depots are to be located in the vicinity of utility reserves and away from main activity and residential areas. 2. Reserves outside Putrajaya are recommended.	1. The depot must be adequately landscaped, screened and signed for safety and security reasons.

Refer Table 9.3 and Map 4.

Table E4 Locational And Design Criteria For Truck Refilling Kiosk – 1/2

Refilling Kiosk	Land Area (sqm)	Locational Criteria	Design Criteria
Precincts 16	1 nos x 20 x 40	1. The facility may be located along a green connector, linear park, promenade, road (as layby) or sewerage treatment plant (STP1); and adjacent to or in close proximity to an existing or proposed vehicular maintenance reserve. 2. The facility is to be setback at least 3m from private property line; 3m from the water's edge and away from major activity areas. 3. A reserve of at least 3.5m along the promenade or green connector is to be maintained for pedestrian and bicycle circulation. 4. The facility may not be positioned or located in a way that it hinders pedestrian circulation or safety.	1. Design of the facility must be consistent with the overall landscape design concept of the promenade or green connector. 2. Security fencing must adopt a soft fencing approach. 3. The site must be adequately landscaped and signed for safety reasons.
Precincts 11	1 nos x 20 x 40	1. The facility may be located along a green connector, linear park, promenade or road (as layby); and adjacent to or in close proximity to an existing or proposed vehicular maintenance reserve. 2. The facility is to be setback at least 3m from private property line; 3m from the water's edge and away from major activity areas. 3. A reserve of at least 3.5m along the promenade or green connector is to be maintained for pedestrian and bicycle circulation. 4. The facility may not be positioned or located in a way that it hinders pedestrian circulation or safety.	1. Design of the facility must be consistent with the overall landscape design concept of the promenade or green connector. 2. Security fencing must adopt a soft fencing approach. 3. The site must be adequately landscaped and signed for safety reasons.

Refer Table 9.3 and Map 4.

Table E5 **Locational And Design Criteria For Holding Pond (Storage, Disinfection and Treatment)**

Holding Ponds	Land Area (sqm)	Locational Criteria	Design Criteria
SP1 (STP1) • Storage • Disin-fection	• 40x40 • 10x15	1. The facility is to be located adjacent to the compound of the sewerage treatment plant (STP1).	1. The pond must be adequately landscaped and signed for safety reasons.
SP2 (STP2) • Storage • Disin-ection	• 70x70 • 10x15	1. The facility is to be located adjacent to the compound of the sewerage treatment plant (STP2).	1. The pond must be adequately landscaped and signed for safety reasons.

Refer Table 9.3, Map 2 and Map 2a – 2h.

APPENDIX F

IRRIGATION APPLICATION SYSTEM, SCHEDULING CONCEPT AND CENTRALISED CONTROL SYSTEM

1 Irrigation Application System

2 Irrigation Scheduling Concept

3 Irrigation Centralised Control System

TABLE

Table F1	Application System For Each Plant Group
Table F2	Adjustment In Head Spacing For Wind Conditions
Table F3	Maximum Precipitation Rate Based On Soil and Slope Type
Table F4	Emitter Flow Rate With Proper Emitter And Lateral Spacing For Different Soil And Plant Types
Table F5	Recommended Maximum Concentrations Of Trace Element In Irrigation Water

FIGURE

Figure F1	Schematic Diagram Of Block System
Figure F2	Schematic Diagram Of Valve-In-Head System
Figure F3	Irrigation Centralised Control System Layout

APPENDIX F

IRRIGATION APPLICATION SYSTEM, SCHEDULING CONCEPT AND CENTRALISED CONTROL SYSTEM

1. Irrigation Application System

1.1 Watering System

Two types of watering system which are commonly used are the Spray System and Drip System. These systems are preferred as they are more suitable in its application at Putrajaya which could cover large lawn areas as well as landscape areas. The spray system is generally used for the grass areas, groundcovers, low shrubs and short species herbaceous plants; whereas drip system is utilized for the shrubs, seedlings and saplings, trees and palms. The system generally used for the various plant types are as tabulated in Table F1.

1.1.1 Spray System

Sprinkler or spray system refers to the system which accomplishes water distribution in a form of stream or fine spray by forcing water flowing through sprinklers having a nozzle orifice. There are many types of sprinklers available for different areas of coverage and rates of application. Two types of sprinklers that are suitable for Putrajaya applications are: 1) spray sprinkler; 2) rotary sprinkler.

Both the spray and rotary sprinkler systems are much the same in its basic design, but varying primarily in size and type of equipment and piping used, spacing of the sprinklers, and the methods of operation control.

Sprinkler Head

Sprinkler head is used to direct water to a specified area. Two types of sprinklers head identified are *Spray Head* and *Rotary Head*.

Spray heads are stationary and discharge water continuously in the form of a fine, uniform spray that resembles small droplets or individual jets. The heads are popped out of the ground by water pressure and spray water in pattern of nozzle selected. When the pressure stops, the heads retract back to grade level and do not provide any obstructions. A spray head is limited as to the distance it can throw a circle of water, usually up to a maximum radius of from 2 to 5 m.

Rotary heads utilise slow-rotating, high velocity streams to distribute water over relatively large circular or part circular areas. The heads rotate to throw water evenly over the distribution area, and the arc can be adjusted. Because rotary heads throw water in a concentrated stream(s), they can throw water greater distances than spray heads. Diameter of coverage ranges from 10 m to over 60 m.

Generally, the following specifications of sprinkler heads shall be considered:

- Non-metalline material to be used for body and riser. Non-corrodible heavy-duty plastic is recommended.
- Pop up feature to be incorporated.
- Low head drainage prevention check valve to be used.
- Non-portable alert covers to be provided. "Purple" is the standard colour code used for indicating the use of non-portable water.

Design Considerations

The design considerations are as follows:

i) *Sprinklers selection*

The sprinkler heads are the most visible and critical of the components making up the irrigation system. Selection of sprinkler heads to be used depends upon the following criteria:

- Size and shape of the area to be irrigated.
- Types of plants to be irrigated.
- Water pressure and flow availability.
- Required rate of head discharge.
- Compatibility of sprinkler type with others in area.
- Obstructions preventing proper distribution of water.
- Serviceability and dependability.
- Client preferences.

ii) *Distribution uniformity*

Distribution of water to each area of coverage should be as uniform in application as possible. A coefficient is used to measure the uniformity of coverage. This coefficient is designated as the Christiansen Coefficient or Uniformity Coefficient (C_u) and is defined by the equation,

$$C_u = 100 \times (1.0 - \frac{\Sigma x}{m\,n})$$

In which **x** is the deviation of individual observations from the mean value **m** and **n** is the number of observations. Σ**x** is the sum of the deviations of the individual observations from the mean value.

An absolutely uniform application is represented by a uniformity coefficient of 100 percent; a less uniform application by some lower percentage.

This coefficient is more important for large spray sprinklers of radius more than 15 m. A uniformity coefficient of 80% and above is recommended.

iii) *Spacing patterns and distances*

The amount of water applied to an area decreases as the distance from sprinkler increases. In order to obtain a reasonable uniformity of application, sprinkler heads should be placed so that adjacent sprinklers overlap each other and the end of the spray radius of one head hits the adjacent head's spray. The overlapped spacings are based on a percentage of sprinklers' measurable wetted diameter. Sprinkler heads can be located in either a square or triangular pattern. The triangular method results in wider spacing and is usually better for irregular boundaries.

Table F2 shows the adjustment spacing recommended for estimated wind conditions.

iv) *Precipitation rate*

The precipitation rate (PR) of individual sprinkler operating zones is an important factor for design and system operation. Precipitation rate describes the length of time required to deposit a given depth of water on an area. PR is normally measured in inches per hour .