APPENDIX XIV

Sewerage System Staging

XIV SEWERAGE SYSTEM STAGING

XIV-1 STAGING

Conceptually, the approach to implementation envisions a first stage system complete by 2004, involving construction of new treatment facilities at Soapberry; early redirection of Nanse Pen sewage flows from Greenwich to Soapberry; and elimination of the Western and Greenwich plants with flow conveyed to Soapberry.

It delays improvements to service the industrial sector and accelerates the addition of new residential areas, with the following sequencing of sewering new areas:

1. Constant Spring and tributary area trunk 23.
2. Shortwood and tributary area trunk 16.
3. Billy Dunn and tributary area trunk 15.
4. Matildas Corner and remaining tributary area trunk 5 excluding Hope Pastures/Mona Heights.
5. Hope Pastures/Mona Heights
6. Havendale/Meadowbrook
7. Whitehall and remaining tributary areas trunk 3A, 3B, 4.
8. Remaining tributary area trunk 7.
9. Tributary area trunk 2.
10. Tributary area trunk 7.
11. Tributary area trunk 6 and 8.
12. Tributary area trunk 17.
13. Remaining tributary area trunk 22.
14. Whitfield Town and remaining tributary area Spanish Town Road trunk 24.
15. Kencot and tributary area trunk 14.

Note that capital costs below are totalized for each Contract, while annual O & M cost totals are a "running total", carrying the total on from each preceding Contract. Where O & M costs vary from Stage 1 to Stage 2, only the incremental cost is shown for each facility upgrade.

STAGE 1 COSTS	Capital Costs	Annual O & M Costs (Cumulative)
CONTRACT 1A (1995-1998)		
1. Construct Stage 1 of lagoons at the Soapberry site including 48" and 30" diameter to distribution structure (design treatment 34.35 Migpd required)	19,687,600	88,000
2. Extend existing 30" forcemain between Nanse Pen and Hunts Bay to the Soapberry Treatment Facility	1,125,500	
3. Refurbish Nanse Pen Pumping Station	535,000	
4. Extend 30" line (forcemain from Nanse Pen to Greenwich) as a 36" syphon from Hunts Bay to Soapberry Treatment Facility (with reversed gravity flow from Greenwich)		
5. Construct 1 - 48" syphon from Greenwich to the Soapberry Treatment Facility	5,540,000	
6. Construct Greenwich Syphon Chamber	240,000	48,200
7. Construct Greenwich Septage Treatment Revisions	75,000	
8. Extend the existing 21" forcemain between Darling Street and Western to Greenwich with a 24" main	1,125,800	
9. Construct Darling Street Pump Station Stage 1	3,627,000	55,300
10. Divert mid-level trunk from Western to Darling Street pump station	110,400	
11. Abandon the Western Treatment Plant	10,000	
12. Construct new Hunts Bay Pumping Station	598,000	11,500
13. Connect Hunts Bay pumping station forcemain to the Greenwich syphon	92,100	
14. Replace section of Upper Central Trunk #23 from West Kings House to Mannings Hill Road	630,600	
15. Refurbish existing pumping stations:		
a) Ivy Green News	23,000	1,200
b) Stadium Gardens	10,000	1,200
c) Mountain Terrace	32,000	1,600

STAGE 1 COSTS	Capital Costs	Annual O & M Costs (Cumulative)
d) Nannyville	6,000	1,200
e) Barbican Mews	6,000	1,200
f) Dunrobin Court	-	1,200
g) Hanover Street	-	14,400
h) New Haven	6,000	1,200
i) Cooreville Gardens	36,000	6,800
j) Duhaney Park	58,000	16,300
k) Eastern Industrial	408,000	9,700
l) Tunbridge	32,000	1,600
m) Queensborough	20,000	1,200
n) Queensbury	18,000	1,200
o) Glendale	18,000	1,200
* p) Calabar Mews	18,000	1,200
SUBTOTAL	35,218,000	265,400
CONTRACT 1B (1998-1999)		
1. Portmore System		
A. Hamilton Gardens System		
- Refurbish existing Hamilton Gardens Lift Station	75,000	1,000
- Extend 6" diameter forcemain from Hamilton Gardens to Caymanas Gardens	145,000	
B. Caymanas Gardens System		
- Refurbish Caymanas Gardens Lift Station	98,000	2,900
- Extend 8" diameter forcemain from Caymanas Gardens to Soapberry Lagoons	260,000	
C. Bridgeport		
- Construct new Bridgeport Lift Station	1,265,000	20,800
- Extend 18" diameter forcemain from Bridgeport to Independence City	1,958,000	
D. Independence City		
- Construct new Independence City Lift Station	2,703,000	26,100
- Extend 30" diameter forcemain from Independence City to Soapberry Lagoons	2,494,000	

STAGE 1 COSTS	Capital Costs	Annual O & M Costs (Cumulative)
E. Modifications to Existing Systems		
- Marine Park	14,000	
- Braeton	35,000	
2. Construct street sewers and laterals tributary to the Upper Central Trunk #23 to service Constant Spring Area	5,222,100	
SUBTOTAL	14,269,100	316,200
CONTRACT 1C (1999-2002)		
1. Construct Trunk #15 from the Upper Central Trunk along Gore Terrace and Old Church Roads	501,300	
2. Construct Trunk #16 along Shortwood	228,500	
3. Construct street sewers and laterals tributary to Trunk #16 to serve Shortwood area.	6,490,800	
4. Construct street sewers and laterals to serve the Billy Dunn and surrounding areas tributary to Trunk 15	17,444,700	
5. Abandon sewage pumping stations: Barbican Mews	10,000	(1,200)
6. Abandon sewage treatment plant:		
Barbican Mews	10,000	
Oakwood	10,000	
SUBTOTAL	24,695,300	315,000
CONTRACT 1D (2002-2003)		
1. Extend the existing gravity Trunk #5 along Hope Road to Hope Pastures and Mona Heights	821,900	
2. Construct street sewers and laterals for Hope Pastures and Mona Heights	10,881,400	
3. Construct remaining street sewers and laterals tributary to Trunk #5 Hope Road	2,155,000	

STAGE 1 COSTS	Capital Costs	Annual O & M Costs (Cumulative)
4. Abandon sewage treatment plant Widcome	10,000	______
SUBTOTAL	13,868,300	315,000
CONTRACT 1E (2003-2004)		
1. Construct section of Spanish Town Road Trunk #24 from Nanse Pen to Cockburn Road	1,691,300	
2. Construct Trunk #2 from Spanish Town Road to Washington Boulevard	1,767,700	
3. Construct Trunk 3A along Washington Boulevard to Molynes Road	409,600	
4. Construct Trunk #4 along Molynes Road	820,500	
5. Construction of street sewers and laterals in Havendale and Meadowbrook	7,733,200	
6. Connect Hughenden and Bay Farm Villas collection systems to Trunk #4 and Trunk #2 and abandon Hughenden and Bay Farm Villas sewage treatment	20,000	
7. Construct Central Industrial Pump Station Refurbishment Stage 1	397,000	32,900
SUBTOTAL	12,839,300	347,900
FINAL EFFLUENT DISPOSAL (2003-2004) STAGE 1		
1. Construct pumphouse, pipeline and wetlands disposal system for treated effluent (Caymanas Bay)	16,109,000	806,000
2. Construct infiltration basin system including pumping facilities and pipeline	11,773,000	720,400
SUBTOTAL	27,882,000	1,874,300
TOTAL ESTIMATED STAGE 1 CAPITAL COST	**128,772,000**	
TOTAL ESTIMATED STAGE 1 O & M COST (Cumulative)		**1,874,300**

STAGE 2 COSTS	Capital Costs	Annual O & M Costs (Cumulative)
CONTRACT 2A (2004-2006)		
1. Construct remaining treatment cells at the Soapberry lagoon facility. Includes 48" diameter to Stage 2 distribution structure (total design treatment capacity - 60.46 Migpd)	12,832,000	38,800
2. Construct 42" forcemain from Nanse Pen to the Soapberry site	2,637,100	
3. Construct new Nanse Pen Pumping Station Stage 1	3,867,000	193,100
4. Construct Trunk #3A from Molynes to Red Hills Road along Washington Boulevard	522,200	
5. Construct Trunk #3B along Savanna Road	194,500	
6. Construct street sewers and laterals to serve White Hall Gardens area	4,513,200	
7. Construct sewers and laterals for remaining areas tributary to Trunks 3A, 3B and 4. (See Figure 5.1)	10,716,000	
8. Abandon sewage pumping Stations:		
Calabar Mews	10,000	(1,200)
9. Abandon sewage treatment plants:		
Whitehall	10,000	
Grosvenor	10,000	
SUBTOTAL	35,312,000	2,105,000
CONTRACT 2B (2006-2008)		
1. Construct Stage 2 of the new Nanse Pen Pumping Station	794,000	163,000
2. Construct Trunk #1 along Henley Road	1,300,600	
3. Construct street sewers and laterals to serve the Maverly area	5,658,300	
4. Abandon sewage pumping station at Glendale	10,000	(1,200)
5. Construct street sewers and laterals for Blamagie area	4,081,900	

STAGE 2 COSTS

	Capital Costs	Annual O & M Costs (Cumulative)
6. Construct street sewers and laterals for Tower Hill and Cockburn Gardens areas	1,431,500	
7. Construct street sewers and laterals for Waltham Farm and Hyde Park area	1,908,700	
8. Construct street sewers and laterals for remaining areas tributary to Trunk 1	1,922,300	
9. Construct street sewers and laterals for remaining areas tributary to Trunk 2	8,589,200	______
SUBTOTAL	25,696,500	2,266,800
CONTRACT 2C (2008-2009)		
1. Construct Spanish Town Road Trunk #24 From Cockburn Road to Hagley Park Road	356,800	
2. Construct Trunk #6 along Hagley Park Road	772,200	
3. Construct Trunk #7 along Waltham Park Road	727,900	
4. Construct Trunk #8 along Kessing Avenue	326,300	
5. Construct street sewers and laterals in areas tributary to Trunks #6, 7 and 8	11,273,400	______
SUBTOTAL	13,456,600	2,266,800
CONTRACT 2D (2009-2010)		
1. Construct Trunk #17 along Trafalgar Road	624,700	
2. Replace existing section of Upper Central Trunk #17 along Holborn and Chelsea Road	208,200	
3. Construct street sewers and laterals tributary to Trunk #17	7,699,500	
4. Construct street sewers and laterals tributary to Trunk #22 (Slipe Road)	4,562,700	
5. Construct an additional 48" syphon from Greenwich to Soapberry	5,540,000	

STAGE 2 COSTS	Capital Costs	Annual O & M Costs (Cumulative)
6. Greenwich Syphon Chamber - Stage 2	35,000	24,500
SUBTOTAL	18,670,100	2,291,300
CONTRACT 2E (2010-2011)		
1. Extend the Spanish Town Road Trunk #24 from Hagley Park Road to the Greenwich transfer site	939,700	
2. Construct street sewers and laterals to serve Whitfield Town	1,059,100	
3. Construct remaining street sewers and laterals tributary to the Spanish Town Road Trunk #24	11,794,700	______
SUBTOTAL	13,793,500	2,291,300
CONTRACT 2F (2011-2012)		
1. Construct Trunk #14 along Greenwich Road from the Upper Central Trunk	418,400	
2. Construct street sewers and laterals to serve the Kencott area	2,826,500	
3. Construct remaining street sewers and laterals tributary to Trunk #14	2,428,700	
4. Abandon sewage pumping stations:		
Ivy Green News	10,000	(1,200)
Stadium Gardens	10,000	(1,200)
Mountain Terrace	10,000	(1,200)
Nannyville	10,000	(1,200)
5. Replace the section of the High Level Trunk #20 between Mayfield and Greenwich along Spanish Town Road	398,300	
6. Construct street sewers and laterals tributary to the High Level Trunk #20	2,042,100	
7. Construct a second forcemain from Darling Street to Greenwich 24" in diameter	1,592,100	

STAGE 2 COSTS	Capital Costs	Annual O & M Costs (Cumulative)
8. Construct Southcamp Road Trunk #11	305,000	
9. Construct street sewers and laterals tributary to the Southcamp Road Trunk #11	4,480,800	
10. Construct Stage 2 of Darling Street Pumping Station	291,000	72,000
SUBTOTAL	14,822,900	2,358,100
CONTRACT 2G (2012-2013)		
1. Construct Portland and Wild Street Trunks #12 and #13	658,900	
2. Construct street sewers and laterals tributary to Trunk #12 and #13	6,862,900	
3. Construct the Mountain View Trunk #10	197,200	
4. Construct street sewers and laterals tributary to the Mountain View Trunk #10	2,699,100	
5. Construct street sewers and laterals tributary to Trunk #19	7,485,800	
6. Construct the Eastern Trunk #19 from Greenwich to Southcamp Road	447,800	
7. Construct the Eastern Trunk #19 from Southcamp to Portland Road	2,093,400	
8. Construct Eastern Trunk #19 from Portland to Mountain View	673,000	______
SUBTOTAL	21,118,100	2,358,100
CONTRACT 2H (2013-2014)		
1. Construct Riverton East Forcemain to Greenwich syphon	295,000	
2. Construct the Riverton Trunk	1,657,700	
3. Construct laterals and street sewers to sever the Riverton area	11,736,000	
4. Construct Riverton Pump Station	1,150,000	22,800

STAGE 2 COSTS	Capital Costs	Annual O & M Costs (Cumulative)
5. Construct refurbishment of Rae Town Pumping Station	115,000	8,900
SUBTOTAL	14,953,700	2,389,800
CONTRACT 2J (2014)		
1. Construct the Western Industrial Pumping Station	920,000	12,700
2. Construct the Western Industrial forcemain to Central Industrial	209,200	
3. Construct street sewers and laterals tributary to the Western Industrial Station	8,234,700	______
SUBTOTAL	9,363,900	2,402,500
CONTRACT 2K (2015)		
1. Construct Barned's Pump Station	552,000	5,400
2. Construct the Barned's forcemain	211,700	
3. Construct street sewers and laterals tributary to the Barned's Station	2,204,000	
4. Construct street sewers and laterals tributary to the Rae Tow Station	1,431,100	
5. Construct street sewers and laterals tributary to the Central Industrial Station	5,914,900	
6. Construct street sewers and laterals tributary to the Eastern Industrial Station	2,172,000	
7. Construct Stage 2 of Central Industrial Pumping Station	1,553,000	39,500
SUBTOTAL	14,038,700	2,447,400

STAGE 2 COSTS	Capital Costs	Annual O & M Costs (Cumulative)
FINAL EFFLUENT DISPOSAL (2014-2015) STAGE 2		
1. Construct pumphouse, pipeline and wetlands disposal system for treated effluent (North Soapberry)	10,666,000	426,000
2. Construct infiltration basin system, including pumping facilities and pipeline	10,253,000	590,000
SUBTOTAL	20,919,000	3,463,400
TOTAL ESTIMATED STAGE 2 CAPITAL COST	**202,145,000**	
TOTAL STAGE 1 and STAGE 2 (including Wetlands Disposal)	**330,917,000**	
TOTAL STAGE 1 AND STAGE 2 O & M (Cumulative)		**3,463,400**

APPENDIX XV

Downtown Sewerage System Upgrading Cost Estimate

(Letter of July 1, 1993 from Fisher Pryce & Associates)

FISHER PRYCE & ASSOCIATES
CONSULTING ENGINEERS

26 HAINING ROAD,
KINGSTON 5,
JAMAICA, W.I.
TELEPHONE: 926-8961 . 926-8858

July 1, 1993

Sentar Consultants Limited
231a Old Hope Road
Kingston 6

Attention: Mr. Horace Beckford

Sirs,

DOWNTOWN KINGSTON REDEVELOPMENT
UPGRADING OF SEWERAGE FACILITIES

As requested by you in your letter May 19, 1993, we have determined and costed the section of Downtown sewers which require upgrading and are not included in the Urban Development Corporation's programme of upgrading.

The area is generally bounded by the following streets:-

- the the north by West Queen Street/East Queen Street/Victoria Avenue
- to the west by Pechon Street
- to the east by Paradise Street
- to the south by Harbour Street.

The actual areas involved are denoted as A to I on the attached area map. The division into the respective areas is basically for the convenience of calculating cost which has been determined on a unit area basis, relative to the estimated cost (based on Preliminary Engineering Design) of sewer upgrading presently being implemented by the UDC.

...../2

The estimates provided do not include surveys, engineering and contingency.

It will be noted that the U.D.C. did not include any area between South Camp Road and Paradise Street. They have, however, replaced some sewers in Area I, as a result of which only 50% of Area I has been included in the estimate.

The attached table sets out the total estimated cost (J$) for the upgrading of the relevant area.

Yours faithfully,

R. C. Fisher

FISHER PRYCE & ASSOCIATES
CONSULTING ENGINEERS

26 HAINING ROAD,
KINGSTON 5,
JAMAICA, W.I.
TELEPHONE: 926-8961 . 926-8858

July 1, 1993

DOWNTOWN KINGSTON SEWERAGE

COSTS

	$
SECTION A	6,500,000.00
SECTION B	6,800,000.00
SECTION C	1,250,000.00
SECTION D	13,900,000.00
SECTION E	12,900,000.00
SECTION F	5,100,000.00
SECTION G	30,702,000.00
SECTION H	4,644,000.00
SECTION I	3,250,000.00
TOTAL	$ 85,046,000.00

SENTAR

FIGURE XV.1

KINGSTON HARBOUR ENVIRONMENTAL PROJECT

Location of Areas Shown in Downtown Kingston Sewer Upgrading Cost Estimate

CHARACTERISTICS PROFILE OF RAW AND TREATED SEWAGE

Kingston Metropolitan Area + S.E. St. Catherine Sewage

KINGSTON HARBOUR ENVIRONMENTAL PROJECT

Stage	BOD5	COD	Total - N	Total - P	F/C - Coli
	mg/L	mg/L	mg/L	mg/L	MPN / 100 ml
Raw Sewage	150	200	25	5	5.00E+05
Retention, days	20	20	20	20	20
Removal Efficiency	95%	90%	80%	55%	99.96%
Secondary Effluent (AIPS)	7.5	20	5	2.25	200
Removal Efficiency	0%	0%	0%	0%	0.00%
Influent to Constructed Wetlands	7.5	20	5	2.25	200
Retention, days	2	2	2	2	2
Removal Efficiency	50%	45%	75%	20%	90.00%
Tertiary Effluent (Constructed Wetlands)	3.75	11	1.25	1.8	20

Estimated loads based on design flow for Stage 1 tertiary treatment

35 MiGD

Stage	BOD5	COD	Total - N	Total - P	F/C - Coli
	Kg/d	Kg/d	Kg/d	Kg/d	MPN / 100 ml
Raw Sewage	23845.5	31794	3974.25	794.85	5.00E+05
Retention, days	20	20	20	20	20
Removal Efficiency	95%	90%	80%	55%	99.96%
Secondary Effluent (AIPS)	1192.3	3179.4	794.9	357.7	200
Removal Efficiency	0%	0%	0%	0%	0.00%
Influent to Constructed Wetlands	1192.3	3179.4	794.9	357.7	200
Retention, days	2	2	2	2	2
Removal Efficiency	50%	45%	75%	20%	90.00%
Tertiary Effluent (Constructed Wetlands)	596.1	1748.7	198.7	286.1	20

XVI.3.3 Design Philosophy Constructed Wetlands

Background

Constructed wetlands have come to the attention of the designers of sewage treatment systems throughout the world particularly over the past fifteen years.

This is especially so as the need for robust, technologically simple and inexpensive systems to operate and maintain becomes more urgent worldwide.

Overland flow sewage treatment systems have been used for centuries, and have had a recent revival of interest where large land area is available. Natural wetlands have also been used for sewage treatment but suffered from overloading with contingent offensive odors, and their eventual decline into anaerobic swamps. Some use is again being made of natural wetlands for sewage treatment but only for tertiary treatment of relatively small secondary flows.

With the recognition of the very high productivity of natural wetlands and their ability to assimilate a large variety of pollutants, the concept of a controlled treatment environment using plant and animal species common to locally occurring wetlands brings "constructed wetlands" as a new player in waste treatment systems.

Types of Constructed Wetlands

Constructed wetlands can be generally classified into two types of reactors, i.e. surface flow and subsurface flow systems. Many different names are being used to describe these systems i.e.,

- reed bed treatment systems
- root zone method treatment
- gravel bed hydroponic treatment
- soil filter trench, marsh beds
- biological - macrophytic systems

Surface Flow Systems

These constructed wetlands feature a substrate of native soil or sandy silt having a relatively low hydraulic conductivity i.e. less than 10^{-4} m/s suitable to support emergent vegetation. The reed beds are designed to have shallow water, evenly distributed across the width flowing through the reactors, usually at a depth not exceeding 100 - 150 mm. The main mechanism for aeration is through re-aeration at the water surface. Anoxic conditions can develop during summer periods due to reduced re-aeration and oxygen solubilities coupled with increased oxygen demand by the biological systems operating at higher rates.

Surface flow systems are typically loaded less than subsurface flow systems with a breakline being about 4 cm/day or 25 ac/mgd.

Sub-surface Flow Systems

These reed beds have a substrate of gravel and or sand having high hydraulic conductivity i.e., greater than 10^{-2} m/s. The general intention of these reactors is to have the water just below the surface of the substrate. They consist of a trench or bed containing substrate (planting medium) which supports the growth of the emergent vegetation. Gravel bed hydroponic systems are typical subsurface flow reactors.

The systems are usually lined with impervious material to prevent seepage and to ensure that water levels can be controlled through the reactor. Physical, chemical and biological processes contribute to the stabilization of organics and the removal of nutrient through the reactor. Wastewater flows laterally through the substrate and organics are removed by contact with substrate surfaces and the root systems of the emergent plants.

The subsurface zone is generally saturated and anaerobic. In and around the root and rhizome zones however, there are 'aerobic microsites' supported by excess oxygen conveyed through the plants root system.

BOD Removal

Constructed wetland systems are primarily attached-growth biological reactors. The performance of such systems are generally described with first order, plug flow kinetics where steady state conditions exist.

Organic reduction (BOD_5), nitrification, disinfection and absorption all follow first order kinetics.

The reaction rate kinetic constants are determined experimentally for varying situations of organic loading, substrate plant material and hydraulic retention. Information particularly from the U.S.A., Canada, Europe and South Africa is available for rates for BOD_5 removal.

Constructed wetland systems are however, never simple plug flow suspended growth systems, as each application has its own unique feature. A fully developed constructed wetland has many micro-environments interacting throughout. These may behave either positively or negatively toward the overall goal of reducing organic load, nutrient content of the waste flows and disinfection.

Kickuth developed a model for sizing reed beds which has been used extensively in Europe and the U.K.

The measure of loading is usually expressed in population equivalents (p.e.) of 56g BOD_5/person/day and 170 L/person/day.

Land area requirements of 2 - 7.5 m^2/p.e. are generally yielded. For tertiary treatment and polishing systems, the hydraulic loading is typically higher.

THE APPROACH MAKES NO PROVISION FOR TEMPERATURE, SUBSTRATE TYPE OR PLANT MATERIAL.

Several modifications of the basic first order model have been developed by "Reed" and "Kadlec". Some of these models, set out in the attached Table XVI.2, make provision for BOD_5 loss by settlement, substrate type, geometry of the reactor and substrate porosity.

Apparent system performance and hence derived rate constants are affected by precipitation, evaporation, infiltration, BOD_5 loss by settlement, substrate type, geometry of the reactor and substrate porosity. Reed and Kadlec made provisions in refinement of the equation for such influences.

Typical loading and removal efficiency parameters for various systems currently treating secondary effluent are shown in Table XVI.3.

<u>Nitrogen Removal</u>

Reed beds can be particularly efficient in removing nitrates. The removal is primarily by nitrification/denitrification. In subsurface flow systems, oxygen is supplied to nitrifying bacteria in the root zone by plant root biomass. The depth of the reed bed and the type of plant can make a significant difference to the systems efficacy.

Nitrification requires adequate alkalinity. Marl substrate can be used to supply additional alkalinity if required. Other factors which affect nitrification are carbonaceous oxygen demand which limits nitrifiers, pH within the range of 7 to 8, and retention time.

Denitrification occurs readily in wetland systems where sufficient dissolved carbon is available. The process occurs in the anoxic zones of the reedbed system. Nitrate removal efficiency of 90% is attainable in wetland systems.

TABLE XVI.2

DESIGN MODELS FOR CONSTRUCTED WETLANDS

	Source	Process	Model		Parameters	Loading	Comments
1.	Kickuth	BOD_5 reduction	$A_h = 5.2\ Qd(\ln Co - \ln Ct)$	A_h Qd Co Ct	surface area of bed m^2 avg. sewage flow m^3/d Influent BOD - mg/L Effluent BOD - mg/L	2.2 to 7.5 m^2/p.e.	Sub-surface flow, plug flow
2.		BOD_5 reduction	$Ce = \exp[-K_T(Vv/Q)]Co$	K_T t Vv	first order coefficient hydraulic retention voids vol. = LWdn	110 kg/ha/day	Sub-surface flow, plug flow
3.		BOD_5 reduction	$Ce = \exp[-K_T A_s d_n/Q]Co$	K_T t As	first order coefficient hydraulic retention saturated x-sectional area	110 kg/ha/day	Sub-surface flow, plug flow
			$K_T = K_{20}(1.1)^{(T-20)}$	K_{20}			
	Reed		$K_{20} = K_0(37.31n)^{4.172}$	K_0	K_o = the optimum rate constant for a medium with a fully developed root zone, 1.839 d^{-1} for typical municipal wastewaters.		
		Available O_2	Available $O_2 = (TrO_2)(As)/(1000)$ g/kg	TrO_2	oxygen transfer rate for vegetation = 20 $g/m^2/day$		
4.	Kadlec	BOD_5 reduction	$Ce = \exp[-K_T t]Co$	K_T t	1st order rate constant hydraulic retention	50 kg/ha/day	Surface flow, plug flow
5.	Kadlec	BOD_5 reduction	$Ce = Co.[1-a(x/L)]^{(K_T t/a-1)}$	a x/L	fractional augmentation fractional distance to outlet	50 kg/ha/day	Surface flow with precipitation and evapouration
6.	Kadlec	BOD_5 reduction	$Ce = Co.[1-a(x/L)]^{(K_T t/a)}$	a x/L	fractional augmentation fractional distance to outlet	50 kg/ha/day	Surface flow with infiltration
7.	Reed	BOD_5 reduction	$Ce = CoA'\exp[-C'K_T(A_v)^{1.75}LWdn/Q]$	A' C' A_v K_T L W d n Q	BOD not removed by settle medium constant (.7) $K_T = .0057(1.1)^{(T-20)}$ length of sys // to flow path width of system design depth of bed porosity of system avg. hydraulic loading m^3/d		Surface flow
8.	Reed	BOD_5 reduction	$Ce = .52Co\ \exp[-C'K_T(A_v)^{1.75}LWdn/4.63S^{0.33}Q]$	S	bed slope or hydraulic gradient		Surface flow For application when bed slope or the hydraulic gradient is equal to or greater than 1%

TABLE XVI.2 (CONTINUED)

DESIGN MODELS FOR CONSTRUCTED WETLANDS

	Source	Process	Model		Parameters	Loading	Comments
1.	Darcy	Hydraulic regime	$Q = k_s AS$	k_s A S	hydraulic conductivity saturated x-sectional area hydraulic gradient	low 3.9 cm/d or 25 ac/mgd high 62 cm/d. or 1.6 ac/mgd	Sub-surface flow
2.		Hydraulic regime	for full secondary treatment			1.2 to 4.7 cm/d. i.e. 75 to 20 ac/mgd	Surface flow - secondary
3.		Hydraulic regime	polishing for secondary level discharges			1.9 to 9.4 cm/d. i.e. 50 to 10 ac/mgd	Surface flow - polishing
4.		Hydraulic regime	polishing for advanced level discharges			>3.1 cm/d. i.e. >30 ac/mgd	Surface flow - advanced

Phosphorus Removal

Wetland systems remove phosphorus primarily by adsorption, absorption and precipitation. The presence of clay, iron, aluminum or calcium in the substrate will enhance the removal efficiency of the system. Plants absorb limited amounts of phosphorus.

Surface flow systems because of limited soil contact are less effective in removing phosphates than subsurface flow systems. For surface flow systems phosphorus removal of more than 20% is not typical.

Pathogen Removal

Wetland treatment systems are very effective in the removal of pathogens. The normally expected removal is 80 to 90%.

XVI.3.4 Design Requirements

The following are generally accepted parameters and plant requirements;

a) The beds should have adequate site drainage to prevent surface flows from entering them.

b) There should be provision for instantaneous flow measurement at the inlet and outlet of each bed.

A "V-notch" weir set in a fibre-glass box is recommended.

c) Bed depth should be 0.5 to 0.6 m and should have where possible, a free board of 0.3 - 0.5 m to accommodate the expected accumulation of plant material for several years.

APPENDIX XVI

Constructed Wetlands Disposal System and Cost Estimate

XVI. WETLANDS DISPOSAL OPTION FOR LAGOON TREATED SEWAGE EFFLUENT

XVI.1 INTRODUCTION

The optimum Harbour benefit would be achieved with a land disposal system following treatment. It would result in virtually a total elimination of loadings from sewage, an opportunity to re-use a relatively scarce water resource, and to take some advantage of the fertilizer value of nutrients in the sewage. The system proposed is a wetlands facility for effluent polishing, especially for nitrogen removal, followed by ground disposal to sequester phosphorus through soil adsorption.

This facility can be supplemented by irrigation use but is not reliant on irrigation. It will also be complemented by an emergency overflow from the treatment system to Hunts Bay for periods when storm or weather conditions may preclude use of the wetlands or infiltration system. This overflow will also permit a staged development of the land-based disposal facilities, using the overflow as an interim period discharge from the treatment works.

Infiltration basins were addressed in the Phase 1 Working Document 1 and those costs have been used in developing estimates for the land disposal option.

Two potential wetlands sites have been considered:

- Site 1, in the vicinity of the abandoned experimental freshwater removal pond at Caymanas Bay.

- Site 2, north of the proposed Soapberry Lagoon site, between the Fresh River and the railway line.

Both sites also merge with existing adjacent natural wetlands which make them marginal for other useful development. Both sites are under the jurisdiction of the Urban Development Corporation. Since UDC is a Government agency, the cost of the land has not been factored into the project costs.

The sites have been considered for constructed wetlands development since they have a limited assimilative capacity for natural wetlands disposal. The adjacent marginal land is not suitable for constructed wetlands.

The proximity of Site 2 to the proposed Soapberry Lagoon site would provide an economic advantage because of a shorter pipeline; however, the site is also limited by the Riverton Landfill to the east, the Fresh River to the north and the railway line to the south, and a preliminary 35 Migd layout shown on Figure XVI.1 indicates that there would be encroachment into the existing sugar cane lands to the west to develop the site. To receive 35 Migd, further site investigations at the design stage would be necessary to confirm land availability, consequently it has been considered adequate for only 26 Migd for the second stage expansion, with use of the 35 Migd capacity available at Caymanas Bay planned for first stage use.

This Site 1 would involve a long pipeline from Soapberry; however, it offers the best alternative and advantages at this time, including the following:

- Better physical arrangement of land, providing more accessible space.
- Easy access for investigations and development.
- Distance from Hunts Bay and the existing natural downstream wetlands offers Natural Wetlands treatment of discharge to the fresh river if pumping facilities to the infiltration basins were out of order.
- Proximity to irrigation users, should they develop this potential opportunity.

For the purpose of this report, the stage 1 project development of wetlands requirements for 35 Migd has been based on Site 1.

XVI.2 WETLANDS DEVELOPMENT AT CAYMANAS BAY (35 Migd)

Activities carried out relative to the consideration of this site include the following:

a) Preliminary site visit,

b) Discussions with the Urban Development Corporation (owners of the site),

XVI4.5.3 Grand Totals with Caymanas Bay Disposal

a) Capital Costs

i)	Effluent from ponds to Wetlands			16,109,000
ii)	Effluent from Wetlands to Infiltration Basin			11,773,000
	Grand Total (Capital Cost)	**US**	**$**	**27,882,000**

b) Annual O&M Costs

i)	Effluent from ponds to Wetlands			806,000
ii)	Effluent from Wetlands to Infiltration Basin			720,400
	Grand Total (O&M Costs)	**US**	**$**	**1,526,400**

XVI.4.6 Estimates - North Soapberry Wetlands and Infiltration Basin (US$)

XVI.4.6.1 Effluent to Wetlands

a) Capital Costs

i) Effluent Pump Station (26.0 Migd) at Soapberry Pond Site

. Structure		$	93,100
. Pumps			217,300
. Motor Controls			43,300
. Station Pipework			78,000
. Level Controls and Flow Recorder			23,000
. Power Supply			59,000
		$	513,700
Contingency 20%			102,700
		$	616,800
Engineering 15%			92,500
Sub Total	U.S.	$	708,900

ii) Pipeline from Soapberry Ponds to North Soapberry Wetlands

. 13,333 ft of 48" dia. + fittings	$	3,654,000
Contingency 20%		731,000
	$	4,385,000

	Engineering 15%			658,000
	Sub Total	U.S.	$	5,043,000
iii)	Constructed Wetlands			
	. Cost estimate is proportioned (26/35 X 6,615,000) based on Caymanas Bay Wetlands costs	US	$	4,914,000
	Total Capital Cost (North Soapberry Wetlands Disposal)	**US**	**$**	**10,665,900**

b) **Annual Operating & Maintenance Costs**

i)	Effluent Pump Station			
	. Power costs		$	296,000
	. Parts and general repairs			112,000
	. Personnel			5,000
	Sub Total	U.S.	$	413,000
ii)	Wetlands, as for Caymanas Bay		$	13,000
	Total Annual O&M Cost (North Soapberry Wetlands Disposal)	**U.S.**	**$**	**426,000**

XVI.4.6.2 Effluent to Infiltration Basin

a) **Capital Costs**

. Pump station		$	1,650,000
. Power supply to pump station			20,000
. 42" forcemain			1,596,000
. Infiltration basins			4,164,000
		$	7,430,000
Contingency 20%			1,486,000
			8,916,000
Engineering 15%			1,337,000
Total Capital Cost (Infiltration Basin Disposal)	**U.S.**	**$**	**10,253,000**

b) Annual Operation & Maintenance Costs

. Power costs		$	499,500
. Parts and general repairs			83,000
. Pump station personnel			5,000
. Infiltration Basin Personnel			2,500
Total O&M Cost (Infiltration Basin Disposal)	**U.S.**	**$**	**590,000**

XVI.4.6.3 Grand Totals with North Soapberry Disposal

a) Capital Costs

i)	Effluent from pnds to Wetlands	US	$	10,665,900
ii)	Effluent from Wetlands to Infiltration Basin			10,253,000
	Grand Total (Capital Cost)	**US**	**$**	**20,918,900**

b) O&M Costs

i)	Effluent from ponds to Wetlands			426,000
ii)	Effluent from Wetlands to Infiltration Basin			590,000
	Grand Total (O&M Cost)	**US**	**$**	**1,016,000**

c) Map Preparation for site,

d) Preliminary evaluation of the hydraulic impact on the Fresh River (carried out by Underground Water Authority),

e) Development of the design requirements and concept for a constructed wetlands (prepared with the assistance of our Sub-Consultant Fluid Systems Engineering Ltd.),

f) preparation of cost estimates.

XV1.2.I The Site

The site was visited on May 10, 1993 at which time the existing dyked area had been drained except for some isolated ponding and the normally wet northern area extending to the adjacent Fresh River.

The area is generally covered with grass, shrub type vegetation and scattered trees. Based on our visit and aerial photographs, it was determined that the constructed wetlands facilities would have to be located along the southern side of the dyked area and extending to the east outside the dyked area, in order to avoid the unsuitable wet areas. Figure XVI.1 shows the proposed reedbed layout.

XVI.2.2 Discussions With The Urban Development Corporation

On July 27, 1993, a meeting was held with the General Manager of the Urban Development Corporation to discuss the proposed use of the site, and the following was determined:

a) Interest has been expressed by private sources in the development of water recreation facilities at the site; however, no firm planning or commitment has been made.

b) The height to which the water level is raised within the dyked area is critical to the groundwater elevation in the adjacent sugar cane fields. However, it is not expected that water levels for the proposed "Wetlands" development for the sewage project would present a problem.

c) The Urban Development Corporation expressed interest in possible use of water from the system, if developed.

d) The Urban Development Corporation would like to be consulted further when the project report is completed.

XVI.2.3 Impact On The Fresh River

At the request of SENTAR Consultants Ltd., the Underground Water Authority has carried out a preliminary assessment of the likely impact of Wetlands effluent on the Fresh River. The assessment assumes the worse case of a fully developed sewerage system generating 61 Migd in addition to high river flow and high tidal effect.

Since the preparation of this assessment it has been determined that wetlands treatment at this site, is unlikely to exceed 35 Migd,. and would therefore greatly reduce any impact on the adjacent environment.

It is recommended that prior to development in the future, further environmental impact assessment be carried out on the relevant area from Caymanas Bay to Hunts Bay.

The preliminary report by the Underground Water Authority is included at the end of this Appendix as Annex 1.

XVI.3 DEVELOPMENT OF WETLAND TREATMENT SYSTEM DESIGN

XVI.3.1 Hydraulic, Organic and Nutrient Loads

Hydraulic Loads

The scope of this project element seeks to address the tertiary treatment of sewage from Kingston, St. Andrew and partially from S.E. St. Catherine. The daily total sewage flow over the study period i.e. 1994 - 2015 is expected to reach 61 Migd. There has been some debate as to whether or not this level of hydraulic load will in fact be experienced during the study period based on feedback from the NWC. Possible reasons for likely change are;

a) The extension of the central collection system is likely to be prioritized based on revenue potential. The entire contributing area to generate 61 Migd may not therefore be serviced within the near future as presently envisaged.

b) There are some concerns as reflected in the Underground Water Authority's Liguanea Aquifer recharge assessment about the reduced effect of aquifer recharge with the implementation of a central collection system throughout the Liguanea Plains. The potential impact of reducing the available groundwater, could result in a decision to further contract the area to be sewered.

Provisions for flows have however, been based on a staged future full sewerage development as follows:

1.	Stage I Kingston Metropolitan Area and S.E. St. Catherine	35 Migd
2.	Stage II flows	26 Migd
	TOTAL	61 Migd

Discussion of the provision of a tertiary treatment systems will therefore be restricted to an initial 35 Migd hydraulic load capability. (Requirements for a Stage 2 of 26 Migd will be proportioned to the requirements for 35 Migd.)

These initial flows are likely to be generated from the following sewage generating areas;

1. Greenwich WWTP
2. Western WWTP
3. Nance Pen Pump Station
4. Independence City
5. Bridgeport

XVI.3.2 Estimated Organic and Nutrient Loads

The proposed secondary treatment system for the sewage is an Advanced Integrated Pond System (AIPS).

From past performances of existing AIPS which are mainly situated in sub-tropical California, raw wastewater can be reduced as follows:

BOD_5	-	95 - 97%
COD	-	90 - 95%
Total Nitrogen	-	80 - 90%
Total Phosphorus	-	55 - 60%
E. Coli	-	99.99%

The mechanisms for reduction have been discussed previously by the designers of the AIPS at Appendix XII.

Based on the above minimum performances which are expected to be achieved from the AIPS in a Jamaican application, the following effluent characteristics are expected from the proposed secondary treatment system.

<u>Note</u>:

The general characteristics of the raw sewage applied to the North American AIPS was not provided, but it is not expected to be significantly different from the raw sewage characteristics for KMA.

Based on the above flows and organic loads measured as BOD_5 taken in recent months at the Western and Greenwich WWTP's, organic and nutrient loads to and from the 35 Migd AIPS treatment facility are estimated as set out in the following Table XVI.1:

Costs have been developed for pumping and transmission of treated effluent from the Soapberry ponds, and for pumping and transmission from the Wetlands to the infiltration basins.

Previous infiltration basin costs developed in Phase 1, Working Document 1, have been used as a basis for developing corresponding costs relevant to the North Soapberry site.

The following design basis has been used to estimate costs of pumping and transmission from the Soapberry ponds to the North Soapberry Wetlands.

- Capacity 26.0 Migd (ave.)
- 13,333 ft (4,065 m) of 48" forcemain
- Estimated total dynamic lead of 45 ft.
- Energy output of 410 HP (306 KW)

The following design basis has been used to estimate costs of the pumping and transmission from the North Soapberry Wetlands to the infiltration basin.

- Capacity 26.0 Migd (ave.)
- 7,000 ft. (2134 m) 42" force main
- Estimated total dynamic lead of 95 ft.
- Energy output of 693 HP (517 KW)

XVI.4.4 Staging of Wetlands Disposal Development

It will be necessary to conduct extensive preliminary investigations with regards to the development of Constructed Wetlands and infiltration basin facilities, prior to carrying out actual designs and implementation.

It is recommended that these investigations commence as soon as the first phase of Soapberry Ponds are in service. In order to facilitate these investigations and also avoid a delay in general project implementation, it is proposed that initial pond treated effluent be discharged to the Hunts Bay. Programmed long term monitoring of pond effluent and receiving waters would be implemented and the results used to assist in the development of wetlands and infiltration basin criteria and also general environment monitoring. Timing of implementation of the final effluent disposal facilities will also be dependent on the extent of the observed environmental stress due to pond effluent, during the period of monitoring, also the availability of funding.

In staging of the development of these Wetlands and infiltration basin facilities it has been assumed that implementation for both Stage 1 and Stage 2 will take place at the end of the respective stages:

- Stage 1 Year 2002 - 2004
- Stage 2 Year 2014 - 2015

XVI.4.5 Estimates - Caymanas Bay Wetlands and Infiltration Basin (US$)

XVI.4.5.1 Effluent to Wetlands

(a) **Capital Costs**

i) Effluent Pump Station (35 Migd) at Soapberry Pond Site

. Structure		$	93,000
. Pumps			497,000
. Motor Control Center			99,000
. Station Pipework			78,000
. Level Controls and Flow Recorder			23,000
Stage 1 (35 Mig) Pump Station		$	790,000
Contingency 20%			158,000
			948,000
Engineering 15%			142,000
Sub Total	US	$	1,090,000

TABLE XVI.3

TYPICAL LOADINGS AND REMOVAL EFFICIENCIES FOR REED BEDS

Application	Organic loading			Hydraulic loading			Removal efficiency		
Ref:	m^2/p.e.	kg/ha/day	lbs/ac/day	cm/day	ac/i-mgd	Retention	BOD_5	SS	NO_3 - N
Kickuth/Mannersdorf	3.00	186.67	166.57	5.7	19.8				
settled sewage	5.00	112.00	99.94	3.4	33.0				
design									
Middleton	1.92	58.49	52.19	8.9	12.6		73%	73%	28%
Severn - Trent									
humus tank effluent									
Greater Portmore	1.00	112.00	99.94	17.0	6.6				
Design									
stabilization pond effluent									
Arcata, California	0.76	146.79	130.99	22.3	5.0		51%	85%	23%
surface	1.52	73.68	65.75	11.2	10.0		49%	85%	9%
stabilization pond effluent	3.04	36.84	32.88	5.6	20.1		59%	84%	25%
Haughton, Louisiana	0.78	143.59	128.13	21.8	5.1		82%	94%	
sub-surface									
stabilization pond effluent									
Benton, Kentucky	4.10	27.32	24.38	4.1	27.1		57%	75%	26%
surface	3.95	28.35	25.30	4.3	26.1		52%	67%	37%
South Africa	2.03	55.31	49.36	8.4	13.4		54%		76%
stabilization pond effluent									

KINGSTON METROPOLITAN AREA - CONSTRUCTED WETLANDS

Design of Reed Beds - Surface/Subsurface Flow System

Design Parameters		Imperial		S.I.	
Flow - Q	"Surface"	10.35	MiGD	46,996	m^3/d
No. of Beds		50	No.	50	No.
Reed bed length - L		160.45	ft.	50.00	m
Reed bed width - W		962.70	ft.	300.00	m
Total Reed bed width - W		48135.00	ft.	15000.00	m
Headloss redq along bed		0.06	ft.	0.02	m
Bed Surface Slope - S		0.0004	ft/ft	0.0004	m/m
Retention (t) = Ln/{a^(1/b) x [Q/W]^(1-1/b) x S^(c/b)}		1.00	days	1.00	days
Porosity - n	thru' reeds	0.5		0.5	
Empirical constant - a		4.00E+06		4.00E+06	
Empirical constant - b		3		3	
Empirical constant - c		1.00		1.00	
Area of Reed Bed reqd		177	acres	75	hectare
Flow - Q = ksWdS	"Sub-surface"	24.65	MiGD	77,760	m^3/d
Typical bed depth		1.93	ft.	0.6	m
Bed Bottom Slope - S		0.01	ft/ft	0.01	m/m
ks - Hydraulic Conductivity	quarry run	3.12E-03	ft/s	1.00E-02	m/s
Porosity - n	thru' substrate	0.3		0.3	
Retention		2.87	days	2.87	days
SYSTEM LOADING					
Hydraulic loading		5.1	ac/i-mgd	22.1	cm/day
Flow to each bed		0.70	MiGD	2,495	m^3/d
Effective retention		2.32	days	2.32	days
SYSTEM GEOMETRY		172.5	ft.	62.0	m
Length including access + drainage		962.70	ft.	300.00	m
Reed bed width - W		191	acres	93	hectare
Total area of treatment system					
		0.20	ft^2.	2.0	m^2.
Plant density		1,500,000	No.	1,500,000	No.
No. of Plants Required					

For the specific sites at Caymanas Bay and North Soapberry, site preparation requires regrading to create 100 m wide ridges, 1 m high at the centre.

Materials

The reedbeds are to be constructed from silty clay native soil which is readily available in the area.

It is proposed that substrate for the beds be quarry run material taken from limestone quarries to the north and east of the Caymanas Bat site. The volume of the material required would justify purchasing a substantial quarry site from the Government of Jamaica and making arrangements within the project for the mining.

Cost Estimates

Estimates have been prepared on the basis of current construction and material rates in Jamaican dollars and converted to U. S. dollars. The estimated cost for developing the Caymanas Bay site is presented in Table XVI.5.

The present cost for developing the North Soapberry site can be taken as the same as for the Caymanas Bay site. Haulage distances for substrate will be longer to this site, but the site will only be required to handle 26 Migd and will therefore only require 75% of the acreage.

An overall layout of the project area showing both proposed sites, the general layout of the proposed reedbeds and the pipeline route to deliver the secondary effluent to tertiary treatment sites, is shown in Figure XVI.1.

XVI.4 COST ESTIMATES FOR CONSTRUCTED WETLANDS DISPOSAL OF POND TREATED EFFLUENT (CAYMANAS BAY 35 Migd, AND NORTH SOAPBERRY 26 Migd) WITH FINAL DISCHARGE TO INFILTRATION BASIN

XVI.4.1 General

The following main elements are required for a land disposal option involving constructed wetlands and final disposal to infiltration basin:

- Effluent pump station at the proposed Soapberry Lagoon site.
- Transmission pipeline from the pump station to the wetlands site at Caymanas Bay, or North Soapberry.
- The constructed wetlands excluding the cost of land.
- Pumping facilities and transmission main to discharge from the wetlands site to the infiltration basin.
- Infiltration basin facility.

XVI.4.2 Caymanas Bay Wetlands (35 Migd)

Effluent Pump Station at Soapberry Ponds

The pumpstation which will discharge a daily average of 35 Migd would consist of four (4) duty pumps and two standby pumps. Estimates are based on submersible type pumps.

The pump station would be located in the lagoon embankment to enable suspension of the pumps directly in the lagoon and ensure reliable suction for the four high capacity pumps.

The structure would provide enclosed space for the motor control centers and other sensitive equipment such as flow recorder. Elements would consist of a reinforced block wall superstructure with reinforced concrete framework, mounted on a pile cap supported by reinforced concrete piles.

TABLE XVI.5

KINGSTON HARBOUR ENVIRONMENTAL PROJECT

Cost estimate for tertiary treatment system - Reed beds

Item	Description	Quantity	Unit	Rate	Amount
1	Shrubing + clearance				
	General shrubbing	95	ha	$12,100.00	$1,149,500
	Remove 150mm top soil and stockpile	95	ha	$48,400.00	$4,598,000
2	Earthworks				
	Site grading cut	1,875	m^3	$38.89	$72,917
	Site grading fill	1,875	m^3	$45.37	$85,069
	Clay seal	4,500	m^3	$194.44	$875,000
	Embankments - main access	62,400	m^3	$51.85	$3,235,556
	Embankments - sides	34,800	m^3	$51.85	$1,804,444
	Inlet zone, 75 to 100mm river shingle	22,500	m^3	$162.04	$3,645,833
	Outlet zone, 75 to 100mm river shingle	31,200	m^3	$162.04	$5,055,556
	Substrate, quarry run material	517,500	m^3	$129.63	$67,083,333
	Marl all weather access surface	7,500	m^3	$155.56	$1,166,667
3	Slope protection				
	Grassing, embankments, sides	11,600	m^2	$42.69	$495,213
	Splash, scour protection	150	m^3	$162.04	$24,306
4	Pipeworks, PVC C-900 DR25 Class				
	Main header 600mm	1,250	m	$2,900.16	$3,625,200
	Main header 450mm	1,250	m	$1,873.02	$2,341,275
	Distribution to ponds 300mm	3,750	m	$1,208.40	$4,531,500
	Distribution to ponds 200mm	3,750	m	$671.84	$2,519,400
	Flow application at ponds 200mm	750	m	$671.84	$503,880
	Flow application at ponds 150mm, perforated	13,500	m	$574.56	$7,756,560
5	Valves and appurtenances				
	Main header 600mm	14	ea.	$139,125.00	$1,947,750
	Main header 450mm	12	ea.	$99,375.00	$1,192,500
	Distribution to ponds 300mm	24	ea.	$49,687.50	$1,192,500
	Distribution to ponds 200mm	152	ea.	$21,531.25	$3,272,750
6	Sourcing and establishing plants				
	Source plants	1,500,000	ea.	$0.65	$975,000
	Establish plants	1,500,000	ea.	$0.45	$675,000
	SUB TOTAL				$119,824,708
7	Design, Supervision and Profit				
	Engineering @ 5%	1	ea.	$5,991,235.41	$5,991,235
	Supervision @ 10%	1	ea.	$11,982,470.82	$11,982,471
	Contingency @ 15%	1	ea.	$20,669,762.17	$20,669,762
	TOTAL - Ja$				$158,468,176.64
	TOTAL - US$				$5,979,931.19
J$ = US$	26.5				

Pumping Facilities and Transmission Main to Wetlands

The following preliminary requirements have been used for estimating the cost for these facilities:

- 35 Migd average discharge
- 22,222 ft (6,775 m) 48" forcemain
- Estimated total dynamic pumping head of 95 ft
- Energy output of 938 H.P. (700 KW)

Constructed Wetlands

This element is fully discussed at Section XVI.6 and would consist of thirty (30) constructed reed beds occupying approximately 222 acres (550 ha).

Pumping Facilities and Transmission to Infiltration Basin

The following preliminary requirements have been used for purposes of estimating costs for these facilities:

- 35 Migd average discharge
- 11,000 ft. (3354 m) of 42" forcemain
- Estimated total dynamic pumping head of 85 ft.
- Energy output of 835 HP (623 kw)

Costs for infiltration basin, pumping and transmission facilities are estimated based on original estimates in Working Document 1 involving infiltration basin disposal shown on Page VII.9 of Appendix VII of that document.

XVI.4.3 North Soapberry Constructed Wetlands (26.0 Migd)

Development at this site is limited to 26 Migd at this time as previously noted. Costs have been estimated by proportion to those estimated for the 35 Migd system.

ii) Pipeline from Soapberry to Wetlands at Caymanas Bay (capacity 35 Migd)

. 48" Diameter pipeline installed including fittings 22,222 ft (6773 m)		$	6,090,000
. Contingency 20%			1,218,000
			7,308,000
. Engineering 15%			1,096,000
Sub-Total	U.S.	$	8,404,000

iii) Constructed Wetlands (35 Migd Capacity)

Siteworks and Reed Bed Construction		$	3,572,000
Pipework, valves and appurtenances			1,155,000
Source and establish plants			66,000
		$	4,793,000
. Contingency 20%			959,000
			5,752,000
. Engineering 15%			863,000
Sub Total	U.S.	$	6,615,000
Total Capital Cost (Caymanas Bay Wetlands Disposal)	**U.S.**	**$**	**16,109,000**

b) **Annual Operation And Maintenance Cost**

i) Effluent Pump Station

. 4 pumps @ 175 kw - continuous		$	676,000
. parts and general station repairs			112,000
. personnel			5,000
Sub Total	U.S. $		793,000

ii) Wetlands

. 222 acres @ 2 man weeks/acre/year			
Sub Total	U.S.	$	13,000
Total Annual O&M (Caymanas Bay Wetlands disposal)	**U.S.**	**$**	**806,000**

XVI.4.5.2 Effluent to Infiltration Basin

a) Capital Costs

. Pump Station at Caymanas Bay			1,800,000
. Power supply to Pump Station			59,000
. 42" Forcemain to infiltration basin			2,508,000
. Infiltration Basin			4,164,000
		$	8,531,000
Contingency 20%			1,706,200
			10,237,200
Engineering 15%			1,535,580
Total Capital Cost (Infiltration Basin Disposal)	**U.S.**	**$**	**11,773,000**

b) Annual Operation & Maintenance Costs

. Power costs		$	600,900
. Parts and general repairs			112,000
. Pump Station personnel			5,000
. Infiltration Basin Personnel			2,500
Total Annual O&M (Infiltration Basin Disposal)	**U.S.**	**$**	**720,400**

d) The slope of the bottom of the beds should be 1 - 5% and the surface of the substrate relatively flat for sub-surface flow systems.

For surface flow systems, the substrate surface should have a slope not greater than 1% to reduce the chances of channeling and erosion.

e) Where ponds are to be sealed with clay lining, the material should have a coefficient of permeability after compaction of $< 10^{-7}$ m/s.

f) Depending on the flow regime of the beds being designed, the substrate should have hydraulic conductivity of; i) 0.4 to 0.06 m/s for surface flow systems (gravel or coarse sands) and ii) 0.06 or less m/s for sub-surface flow systems (fine sands or soils).

g) Signs should be posted indicating that beds are for wastewater treatment.

h) Plants recommended are Scirpus (bulrush), Phragmites (common reed), Typha (reedmace), napier grass.

i) Driving access to the beds should be an all weather surface. Roads without a granular base should be adequately drained to prevent saturation.

j) Weed control can be achieved by flooding but a level bed surface is required and water depths of .05 to .15 m.

k) Inlet distribution should be through 0.5 m wide zones filled with coarse gravels and stones 30 to 100 mm. Perforated pipes or a header with several connections is preferred for applying the influent to the zone.

l) Outlet collection should be from 0.5 m wide zones filled with coarse gravels and stones 30 to 100 mm. For the outlet, a slotted pipe at the base of the zone is recommended. Provision for raising or lowering the water level in the bed with an adjustable height outlet is essential.

System Design

A basic design has been developed for the reed beds which are proposed as a tertiary treatment facility for the effluent from the secondary treatment (AIPS) to be provided for KMA sewage.

The design establishes the hydraulic loading for the system and is set out in Table 4. As there will be the need to develop reaction rate coefficients and physical parameters relating to climate and infiltration for the particular application, no attempt was made to model organic or nutrient reduction through the proposed system. The possible reductions expected, can however, be estimated from Table 3 where existing systems with similar hydraulic loading and flow regime are listed.

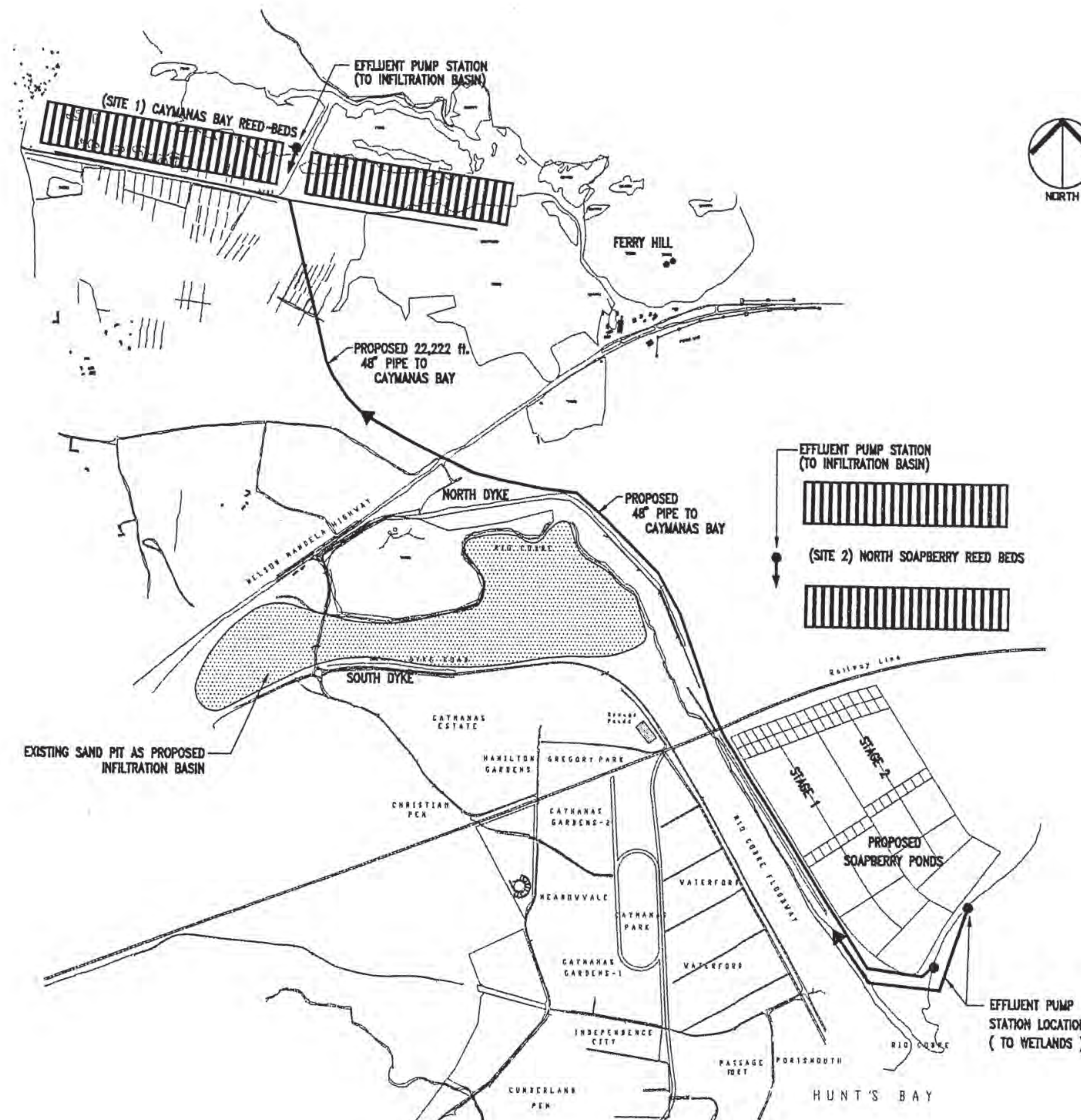
The physical features of the proposed reedbeds are as follows:

1.	No. of beds	50
2.	Length of beds	50 m
3.	Width of beds	300 m
4.	Substrate depth	0.6 m
5.	Retention	2.32 days
6.	Substrate	quarry run (marl)
7.	Conductivity of substrate	0.01 m/s
8.	Porosity of substrate	30%
9	Hydraulic loading	22.1 cm/day
10.	Reed bed embankments	imported clay

Layout

From the general design requirements for the reedbeds set out in Table 4, a configuration has been developed for a typical reactor which is detailed in Figures XVI.2 and XVI.3.

This arrangement is well suited to sites with relatively flat ground conditions, that is, with slopes less than 1:500.



SENTAR

SITE 1 - CAYMANAS BAY REED BEDS

SITE 2 - NORTH SOAPBERRY REED BEDS

FIGURE XVI.1
KINGSTON HARBOUR ENVIRONMENTAL PROJECT
Layout of Proposed Tertiary Treatment System

ACAD F:\C9341\FIGXVI-1

SENTAR

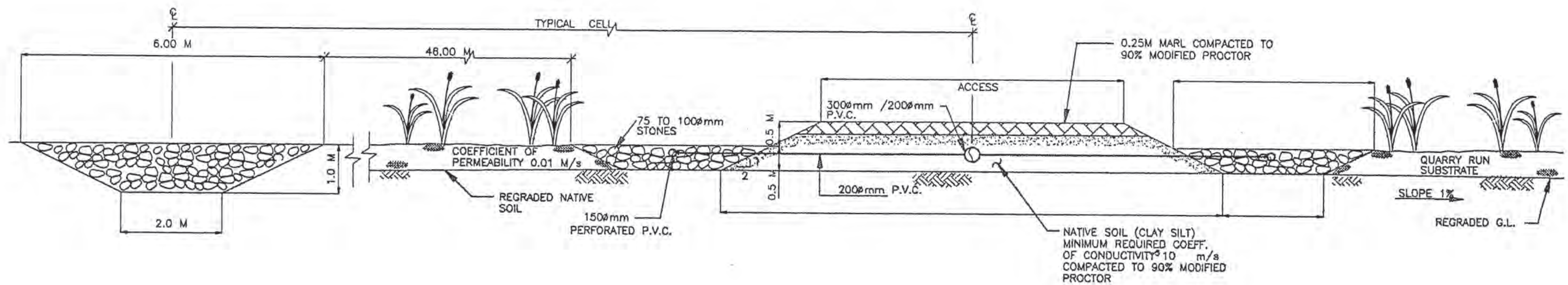


FIGURE XVI.3

KINGSTON HARBOUR ENVIRONMENTAL PROJECT

Typical Reed Bed Section, A-A (Fluid Systems Eng. Ltd.)

ACAD F:\C9341\FIGXVI-3

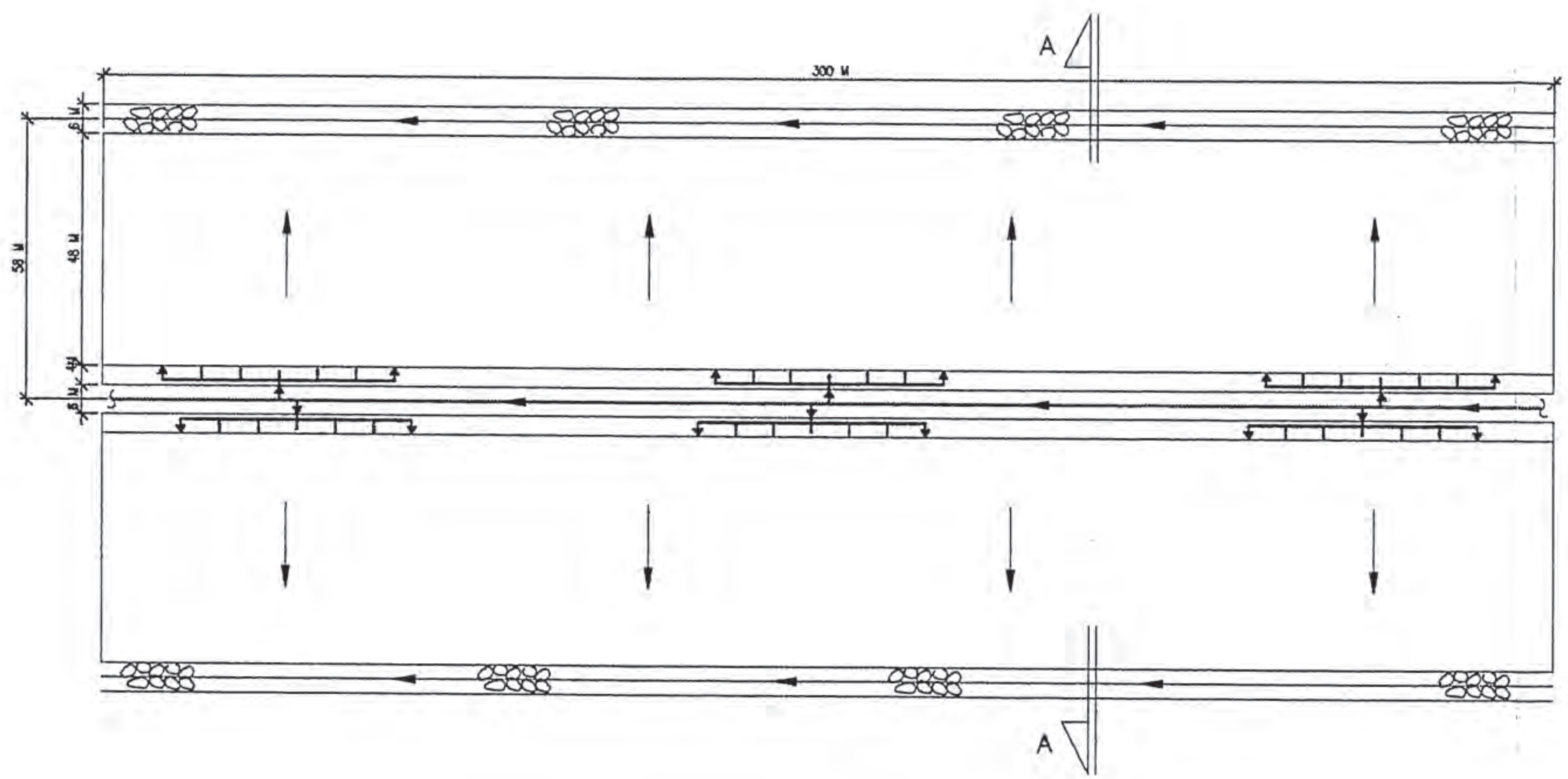


FIGURE XVI.2
KINGSTON HARBOUR ENVIRONMENTAL PROJECT
Typical Reed Bed Section, Plan Layout (Fluid Systems Eng. Ltd.)
ACAD F:\C9341\FIGXVI-2

Alternative 2	Stage 1	Stage 2
Scenario 1 (incremental tariffs)	0.1% - 2.1 %	2.2 $ - 4.1 %
Scenario 3 (total monthly bill)	0.4 % - 6.8 %	6.8 % - 13.9 %

Analysis of the affordability in the case of Alternative 2 leads to the same conclusions as that one for the Alternative 1. The only difference is that, in absolute terms, incremental tariffs required under Alternative 2, under the most favorable financing terms analyzed, are at the same level as the incremental tariffs required under Alternative 1, but under the least favorable financing terms.

9.0 RECOMMENDATIONS FOR THE IMPROVEMENT OF FINANCIAL PERFORMANCE

Based on SENTAR's review, a number of recommendations have been formulated which are intended to improve the financial performance of the NWC and, thus, ensure that it can operate as a financially stable and health commercial entity. These recommendations are presented in the following paragraphs.

Significant Tariff Increases are Required Over the 1993-2015 Period

Given the Assumptions underlying the financial projections presented, tariffs must be increased significantly over the 1993-2015 period. Depending on the specific scenario considered, the average annual increase in average water and sewerage tariffs ranges from a low of 6.9 % (Scenario 3) to a high of 24.1 % (Scenario 1) over the same period.

A Study of Existing Water and Sewerage Tariff Structure Should be Undertaken

The existing water and sewerage tariff structure should be reviewed and implementation of an alternative tariff structure should be initiated in order to improve cash flow stability. The NWC should continue to focus on improving billings and collections and the financial management system.

Implementation Annual Increases in Tariffs

As was discussed in previous sections, there is presently a need to significantly increase water and sewerage tariffs in order to offset the impact of past inflation on operating and maintenance. it is estimated that tariffs would need to be increased by over 50% in order to achieve full cost recovery and generate an acceptable return on assets by 1998. Regular tariff increases, implemented on an annual basis, would spread tariff increases over a longer period, and, therefore be more acceptable to consumers.

Reduce the Number of Disconnected Water Connections

The NWC needs to undertake measures which will encourage prompt payment without the need for disconnection. This could be achieved by pursuing large water consumers as soon as arrears appear. In the past, the NWC often allowed arrears to accumulate to levels beyond the customer's ability to pay before actively attempting to collect such arrears.

A second method for improving collections and reducing the need to disconnect is increased public education. The NWC's recent advertisements designed to provide information to the public on the need for prompt payment is a positive step in increasing the level of public education.

Modify the Financial Management System

The NWC needs to place a greater emphasis on the generation of regular financial information which can play a valuable role in the ongoing management and operation of the NWC. In order to achieve such an objective, the information must be timely, reliable, meaningful and presented in a format which can be easily utilized by management and senior operations staff. The financial information could be incorporated into a monthly report which also includes key operating data. Such a monthly report should focus on a limited number of efficiency, performance and customer service indicators and provide comparisons between districts. It is expected that implementation of the new information management system, currently underway, should provide the NWC with ability to achieve these objectives.

Establish a Formal System for Accessing Funds from the National Government

The lack of a formalized system for accessing funds from the Government required to undertake capital works projects limits the ability of the NWC to undertake necessary capital works and tariff planning. The development of a system for providing grant and/or loan funds to the NWC would allow it to operate within a more stable and predictable financial environment in which meaningful financial performance objectives can be established.

Reduce NRW Levels

NRW levels are not at acceptable levels. Since NRW is often the lowest cost source of additional water supplies, greater efforts to reduce NRW should be undertaken.

NATIONAL WATER COMMISSION

STATEMENT OF SOURCES & APPLICATION OF FUNDS

(J Dollars Million)

Alternative 1
Scenario 3/ Table 3

FISCAL YEAR ENDING MARCH 31st	ACTUAL 1988	1989	1990	1991	1992	PROJECTED 1993	1994	1995	1996	1997	1998	1999	2000	2001
SOURCES OF FUNDS:														
OPERATING INCOME	44.6	31.1	(102.3)	(93.6)	(76.9)	83.0	170.6	102.2	227.1	260.8	128.1	148.3	226.1	306.9
ADD: DEPRECIATION	4.7	4.6	9.6	18.0	47.2	50.0	49.2	69.0	90.1	112.8	148.6	181.2	200.4	221.0
DISPOSAL OF FIXED ASSETS	3.0	0.1												
LESS: TAXES ON INCOME														
TOTAL INTERNAL FUNDS GENERATION	52.3	35.8	(92.7)	(75.6)	(29.7)	133.0	219.8	171.2	317.2	373.6	276.7	329.5	426.5	527.8
GOVERNMENT GRANTS	8.0	30.2	46.3	57.9	130.0	160.0	90.0	208.3	122.4	126.7	333.7	336.5	131.2	135.8
WORLD BANK LOAN								118.3	122.4	126.7	333.7	336.5	131.2	135.8
LONG-TERMS LOANS		53.9	61.1	58.3	148.6	208.0	190.0	190.0						
TOTAL EXTERNAL SOURCE OF FUNDS	8.0	84.1	107.4	116.2	278.6	368.0	280.0	516.5	244.8	253.3	667.4	673.0	262.5	271.6
TOTAL SOURCES OF FUNDS:	60.3	119.9	14.7	40.6	248.9	501.0	499.8	687.7	562.0	626.9	944.2	1,002.4	689.0	799.5
APPLICATION OF FUNDS:														
CAPITAL EXPENDITURE-BANK PROJECT								236.5	244.8	253.3	667.4	673.0	262.5	271.6
-OTHER	22.5	108.6	65.9	117.6	204.8	429.0	270.0	270.0						
TOTAL CAPITAL EXPENDITURE	22.5	108.6	65.9	117.6	204.8	429.0	270.0	506.5	244.8	253.3	667.4	673.0	262.5	271.6
LOAN INTEREST CHARGED TO INCOME	30.9	36.7	35.6	39.8	69.1	83.0	83.2	100.2	115.8	114.2	120.7	135.2	133.7	121.2
REPAYMENT OF LONG-TERM LOAN PRINCIPAL	11.7	5.7	15.8	6.9	13.8	20.7	76.7	95.7	151.6	151.6	151.6	151.6	325.6	325.6
DEBT SERVICE	42.6	42.4	51.4	46.7	82.9	103.7	159.9	195.9	267.4	265.8	272.3	286.8	459.3	446.8
SHORT-TERM DEPOSITS														
OTHER CURRENT ASSETS	27.7	54.4	(15.2)	44.1	531.2	205.9	57.5	(71.5)	(22.0)	5.6	(124.4)	(72.3)	(177.5)	65.5
SHORT-TERM LOANS	5.0	(5.9)	(4.5)	(4.7)	(21.1)	(50.7)		8.7	8.7	8.7	8.7	8.7	8.7	8.7
OTHER CURRENT LIABILITIES	(35.8)	(76.5)	(86.8)	(155.1)	(541.2)	(223.9)	(10.1)	(3.1)	1.7	17.3	16.5	20.0	97.2	(35.0)
CHANGE IN WORKING CAPITAL-INCR/(DECR)	(3.1)	(28.0)	(106.5)	(115.7)	(31.1)	(68.8)	47.4	(65.9)	(11.6)	31.7	(99.2)	(43.6)	(71.6)	39.2
LONG-TERM DEPOSITS/INVESTMENTS-INCR/(DECR)							(0.8)							
OTHER LONG-TERM LIABILITIES-INCR/(DECR)														
DIRECT TRANSACTIONS TO EQUITY FUNDS														
TOTAL APPLICATION OF FUNDS	62.0	123.0	10.8	48.6	256.6	463.9	476.6	636.4	500.5	550.9	840.6	916.2	650.2	757.6
CASH INCREASE/DECREASE	(1.7)	(3.1)	3.9	(8.0)	(7.8)	37.0	23.3	51.3	61.4	76.1	103.5	86.2	38.9	41.8
CASH BALANCE, BEGINNING	24.4	22.7	19.6	23.5	15.5	7.8	44.8	68.1	119.3	180.8	256.8	360.3	446.5	485.4
CASH BALANCE, ENDING	22.7	19.6	23.5	15.5	7.8	44.8	68.1	119.3	180.8	256.8	360.3	446.5	485.4	527.2

FISCAL YEAR ENDING MARCH 31st	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	201!
SOURCES OF FUNDS:														
OPERATING INCOME	252.3	255.4	157.5	181.6	204.5	211.5	458.6	299.3	239.8	160.1	145.3	156.6	170.9	165.2
ADD: DEPRECIATION	254.3	304.4	365.4	404.5	465.4	509.7	572.8	636.3	704.4	776.7	859.8	944.9	1,028.5	1,111.7
DISPOSAL OF FIXED ASSETS														
LESS: TAXES ON INCOME														
TOTAL INTERNAL FUNDS GENERATION	506.6	559.8	523.0	586.1	670.0	721.2	1,031.4	935.6	944.3	936.8	1,005.1	1,101.5	1,199.4	1,276.9
GOVERNMENT GRANTS	294.5	498.1	611.1	269.5	538.0	268.2	493.0	452.3	469.8	477.3	573.5	540.1	459.5	395.2
WORLD BANK LOAN	294.5	498.1	611.1	269.5	538.0	268.2	493.0	452.3	469.8	477.3	573.5	540.1	459.5	395.2
LONG-TERMS LOANS														
TOTAL EXTERNAL SOURCE OF FUNDS	588.9	996.3	1,222.2	539.0	1,076.0	536.3	986.1	904.7	939.6	954.5	1,147.0	1,080.2	919.0	790.3
TOTAL SOURCES OF FUNDS:	1,095.5	1,556.0	1,745.1	1,125.1	1,746.0	1,257.5	2,017.5	1,840.3	1,883.9	1,891.3	2,152.1	2,181.7	2,118.4	2,067.2
APPLICATION OF FUNDS:														
CAPITAL EXPENDITURE-BANK PROJECT	588.9	996.3	1,222.2	539.0	1,076.0	536.3	986.1	904.7	939.6	954.5	1,147.0	1,080.2	919.0	790.3
-OTHER														
TOTAL CAPITAL EXPENDITURE	588.9	996.3	1,222.2	539.0	1,076.0	536.3	986.1	904.7	939.6	954.5	1,147.0	1,080.2	919.0	790.3
LOAN INTEREST CHARGED TO INCOME	114.7	133.2	150.7	166.6	177.7	193.3	187.8	166.3	152.8	139.4	135.9	141.4	142.9	138.5
REPAYMENT OF LONG-TERM LOAN PRINCIPAL	325.6	325.6	248.9	230.3	210.9	210.9	673.9	673.9	673.9	675.5	499.9	499.9	499.9	499.5
DEBT SERVICE	440.3	458.8	399.6	396.9	388.6	404.2	861.7	840.2	826.7	814.9	635.8	641.3	642.8	638.0
SHORT-TERM DEPOSITS														
OTHER CURRENT ASSETS	57.2	93.2	90.3	92.0	125.0	101.3	177.9	98.4	127.3	131.7	162.5	173.4	175.2	174.2
SHORT-TERM LOANS	8.7	8.7	8.6											
OTHER CURRENT LIABILITIES	(47.9)	(64.7)	(77.0)	(61.8)	(85.1)	(71.1)	(90.5)	(92.6)	(98.8)	(104.9)	(117.2)	(121.3)	(122.3)	(124.6
CHANGE IN WORKING CAPITAL-INCR/(DECR)	18.0	37.2	21.9	30.2	39.9	30.2	87.3	5.8	28.5	26.9	45.3	52.1	52.9	49.6
LONG-TERM DEPOSITS/INVESTMENTS-INCR/(DECR)														
OTHER LONG-TERM LIABILITIES-INCR/(DECR)														
DIRECT TRANSACTIONS TO EQUITY FUNDS														
TOTAL APPLICATION OF FUNDS	1,047.3	1,492.3	1,643.7	966.0	1,504.6	970.7	1,935.1	1,750.7	1,794.9	1,796.3	1,828.1	1,773.7	1,614.8	1,477.8
CASH INCREASE/DECREASE	48.2	63.7	101.5	159.0	241.4	286.8	82.4	89.6	89.0	95.0	324.1	408.0	503.6	589.3
CASH BALANCE, BEGINNING	527.2	575.4	639.1	740.6	899.6	1,141.1	1,427.8	1,510.3	1,599.9	1,688.9	1,783.8	2,107.9	2,515.9	3,019.5
CASH BALANCE, ENDING	575.4	639.1	740.6	899.6	1,141.1	1,427.8	1,510.3	1,599.9	1,688.9	1,783.8	2,107.9	2,515.9	3,019.5	3,608.8

SUMMARY FINANCIAL ANALYSIS

Alternative 1
Scenario 3/ Table 4

	ACTUAL					PROJECTED																						
FISCAL YEAR ENDING MARCH 31st	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
FINANCIAL RATIOS:																												
OPERATING RATIO	85.4%	88.1%	111.7%	114.5%	94.1%	82.1%	81.0%	87.5%	85.4%	87.1%	94.0%	94.7%	93.1%	91.6%	93.6%	94.2%	96.8%	96.6%	96.6%	96.7%	93.8%	96.2%	97.2%	98.2%	98.5%	98.6%	98.5%	98.7%
DEPRECIATION (%)	1.8%	1.7%	1.8%	3.3%	5.0%	4.7%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%
RATE OF RETURN ON NET FIXED ASSETS	45.4%	15.2%	-30.0%	-20.1%	-12.2%	9.9%	16.8%	7.3%	12.1%	10.9%	4.2%	3.9%	5.2%	6.6%	4.9%	4.3%	2.2%	2.3%	2.3%	2.2%	4.4%	2.6%	1.9%	1.2%	1.0%	1.0%	1.1%	1.5%
DEBT SERVICE COVERAGE- (TIMES)	1.2	0.8	(1.8)	(1.6)	(0.4)	1.3	1.4	0.9	1.2	1.4	1.0	1.1	0.9	1.2	1.2	1.2	1.3	1.5	1.7	1.8	1.2	1.1	1.1	1.1	1.6	1.7	1.9	2.0
SELF-FINANCING RATIO (%):(3-YEAR AVERAGE)	19.5%	32.6%	-38.6%	-5.1%	-32.5%	32.5%	3.1%	12.1%	18.3%	19.6%	19.5%	16.1%	9.7%	11.2%	7.8%	6.8%	11.0%	16.8%	33.7%	33.1%	10.2%	9.5%	9.5%	9.4%	30.6%	38.9%	54.2%	69.0%
SELF-FINANCING RATIO (%):(YEAR)	56.9%	19.7%	-57.1%	-5.6%	-39.8%	22.8%	4.6%	8.2%	25.1%	30.0%	15.5%	12.8%	14.8%	15.4%	8.2%	6.4%	8.3%	29.5%	22.4%	53.5%	8.4%	9.9%	9.5%	10.0%	28.2%	37.8%	54.8%	74.6%
% LONG-TERM DEBT, TO L-TERM DEBT + EQUITY	53.2%	54.0%	67.8%	80.0%	85.9%	73.3%	58.4%	52.6%	44.0%	37.2%	35.5%	31.2%	25.4%	20.0%	17.5%	18.5%	20.3%	19.5%	20.3%	16.1%	13.3%	10.8%	8.8%	8.2%	8.1%	7.9%	7.3%	7.8%
CURRENT RATIO - (CURR.ASSETS/CURR.LIAB'S)	1.2	1.0	0.8	0.6	0.8	0.8	0.8	0.8	0.8	0.9	1.0	0.9	0.9	1.0	1.1	1.2	1.4	1.6	1.8	1.5	1.6	1.6	1.7	1.9	2.1	2.3	2.5	3.2
QUICK RATIO - (QUICK ASSETS/CURR.LIAB'S))	1.1	0.9	0.7	0.6	0.7	0.7	0.7	0.7	0.8	0.8	0.9	0.8	0.8	0.8	0.9	1.1	1.2	1.4	1.6	1.3	1.4	1.5	1.5	1.7	1.9	2.1	2.3	2.9
ACCOUNTS RECEIVABLE- AVER.NO.MONTHS SALES	10.1	11.3	9.4	9.3	9.3	8.5	7.2	6.2	5.1	4.5	3.6	2.8	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Acc. Rec. - No of days worth of water & sewerage billings	310.8	345.1	289.4	284.7	285.4	270.8	228.3	194.9	159.5	141.7	113.8	88.5	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
Acc. Payable/ Cash Expenditures - No of days	30	55	94	150	230	200	180	160	140	120	100	80	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
Doubtfull Allowance/ Water and Sewerage Billings	9.3%	5.4%	13.3%	12.1%	4.4%	5.0%	9.9%	12.2%	11.2%	11.3%	10.7%	6.7%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%
Other Accounts Receivable/ Other Income	344	1,971	730	1,253	659	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Inventories/Materials, chemicals etc.	445	599	995	466	228	200	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
Cash & Bank	36	28	25	14	3	15	20	31	42	52	63	64	64	64	64	63	65	73	83	95	91	89	86	83	90	99	110	122