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FCS CONSULTANTS LTD

PROPOSED RESIDENTIAL DEVELOPMENT,

CORAL SPRINGS TRELAWNY

FCS #: 1124/76/C

SEWAGE TREATMENT
ENGINEERING REPORT

PREPARED FOR
Gore Developments Limited
2c Braemar Ave,
Kingston 10

March 2, 2012

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1.0 OVERVIEW

Gore Developments Limited proposes to develop part of Coral Springs lands for housing. This particular parcel of land is north of the North Coast highway between White Bay and Duncans in Trelawny as shown in the figure below.

Figure 1 : Location of project site

The 169 acre parcel of land will be developed into 400 two bedroom homes and 142 larger service lots with the required open spaces, commercial area, and basic school. FCS Consultants Limited is responsible for the infrastructure designs within the project boundaries; this includes roadways, water distribution, and sewage and storm water collection as well as constructed wetlands for tertiary sewage treatment.

2.0 SEWERAGE TREATMENT DESIGN

The design for this project provides septic tanks in each lot with 2 day capacity capable of providing primary treatment for an average of 4.5 people per lot. The sewerage collection designs include four (4) street main collection systems (and sewage pump station design where required) each terminating in a separate constructed wetland. Effluent from the wetlands will be disinfected and directed to a central depression/pond onsite via an existing or newly constructed drainage channel.

Septic Tanks

The on lot septic tanks will have a minimum hydraulic retention time of 1.5 days; during which the COD and BOD will be reduced to 300 and 150 mg/l respectively. The septic tanks will also remove the majority of the TSS and fecal coli form by about 1 log. The tanks proposed for this project are detailed in the construction drawings

Sewerage Effluent

The sewage effluent to be generated by the development will be treated in four separate constructed wetlands. The largest wetland will serve the northern lots and the smallest will serve the south eastern lots.

Table 1: Sewage Generation Estimate

Gore Coral springs Sewage Generation Estimate			
Item	**Description**	**Qty**	**Unit**
1	**SW residential lots**	167	No
2	Estimate of the number of persons per lot	4.50	No
3	Population Estimate	752	No
4	Water for commercial and light Industry	125,501	L
5	**Average Sewage Generation**	178	**m^3/d**
6			
7	**North residential lots**	229	No
8	Estimate of the number of persons per lot	4.50	No
9	Population Estimate	1,031	No
10	Estimate of Basic School demand	570	Liters/day
11	**Average Sewage Generation**	222	**m^3/d**
12			
13	**E residential lots**	87	No
14	Estimate of the number of persons per lot	4.50	No
15	Population Estimate	392	No
16	**Average Sewage Generation**	84	**m^3/d**
17			
18	**SE residential lots**	47	No
17	Estimate of the number of persons per lot	4.50	No
18	Population Estimate	212	No
19	**Average Sewage Generation**	45	**m^3/d**

The level of sewage treatment being provided for this development is tertiary. The expected influent and effluent quality is described in Table 2.

Table 2: Constructed Wetland Wastewater characteristics.

Parameter	Units	Influent	Effluent
COD	mg/l	300	100
BOD	mg/l	150	20
TSS	mg/l	50	20
TKN	mg/l	35	10
P	mg/l	8	4
FC	MPN/100ml	10^5 -10^6	200

Constructed Wetlands

Constructed wetlands are engineered systems designed and constructed to utilise wetland vegetation to assist in treating wastewater in a more controlled environment than occurs in natural wetlands. The type of wetland chosen for sewage treatment at this site is subsurface flow. In subsurface flow systems, water flows though a porous media such as gravels or aggregates, in which the plants are rooted

Subsurface flow systems are most appropriate for treating primary wastewater, because there is no direct contact between the water column and the atmosphere. There is no opportunity for vermin to breed, and the system is safer from a public health perspective. The environment within the subsurface flow bed is mostly either anoxic or anaerobic. Oxygen is supplied by the roots of the emergent plants and is used up in the biofilm growing directly on the roots and rhizomes, being unlikely to penetrate very far into the water column itself. Subsurface flow systems are good for nitrate removal (de-nitrification), but not for ammonia oxidation (nitrification), since oxygen availability is the limiting step in nitrification.

Each constructed wetland is designed based on an application rate of 90 l/m^2 to have a minimum hydraulic retention time of 4 days; this is required to reduce the oxygen demand and nutrient levels to NEPA standards. The reeds in the constructed wetland should be planted with one reed per square foot to ensure an adequate plant density.

Nitrogen removal by wetland plants ranges from 0.2 to 2.25 $g/(m^2.day)$. Using a removal rate of 1.1 $g/(m^2.day)$ over the total area (49 m^2) the Total Nitrogen in the effluent concentration will be below 10mg/l.

Phosphorous removal by wetland plants ranges from 0.05 to 0.5 $g/m^2/day$. Using an average of 0.15$g/m^2/day$, the phosphorous will be below acceptable levels within the 4 days of retention. Phosphorous reduction will occur via plant uptake and sedimentation of PO4.

Fecal coliform levels are expected to be reduced by an additional 2 logs in the constructed wetland. Chlorination is required as disposal is to open water.

The four (4) constructed wetlands are all of varying sizes treating different amounts of effluent.

Table 3: Required Constructed Wetland sizes

1	**Coral Springs Sewage Treatment Wetlands**		
2		**Qty**	**Unit**
3	**SW residential lots**		
4	Average Flow into wetland beds	178.12	m^3/d
5	Reed bed loading	90	L/m^2
6	Min wetland size required	1,979.10	m^2
7	Contact Chlorine chamber HRT	30	min
8	Contact Chlorine chamber	3.71	m^3
9			
10	**North residential lots**		
11	Average Flow into wetland beds	221.57	m^3/d
12	Reed bed loading	90	L/m^2
13	Min wetland size required	2,461.90	m^2
14			
15	**East residential lots**		
16	Average Flow into wetland beds	83.98	m^3/d
17	Reed bed loading	90	L/m^2
18	Min wetland size required	933.14	m^2
19	Contact Chlorine chamber HRT	30	min
20	Contact Chlorine chamber	6.37	m^3
21			
22	**South East residential lots**		
23	Average Flow into wetland beds	45.37	m^3/d
24	Reed bed loading	90	L/m^2
25	Min wetland size required	504.11	m^2
26	Contact Chlorine chamber HRT	30	min
27	Contact Chlorine chamber	0.95	m^3

The calculations for the sizing of the each sewage treatment wetland are included in the appendix of this report.

3.0 CONCLUSIONS

Based on our calculations, the minimum required size for the on lot septic tank with 2 days retention is 2.05m^3 (540 US gallons). The Constructed Wetlands will have a minimum area 4.0 days retention. The Wetland areas will range from 500 to 2900 m^2. There will be three chlorination chambers. The northern and eastern lots wetland effluent will be chlorinated together.

These sewage treatment wetlands combined with on lot septic tanks should provide an effluent which meets NEPA 2004 standards.

Prepared by:

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Managing Director

APPENDIX

DETERMINATION OF DESIGN FLOW & SIZING OF SEPTIC TANK

Design Flow for The Residential Development:

Select Income range of residents:	Low Middle Income	
Daily water usage per person =	60	USG/day
Enter number of bedrooms:	2	
Number of persons per bedroom:		
Total number of persons for design:	4.5	
Design flow in US Gallons per day:	270	USG/day

Sizing of Septic Tank

Enter daily sewage flow from above (or otherwise) 270 USG/day
[1022 liters]

Retention time = 2 days
Design septic tank with capacity of 540 US Gallons

540 gallons = 2.04 m^3

Use tank depth of : 2.40 m
Required Area = 0.85 m^2

Dimensions of tank required to give 2:1 ratio for Length:Width

Length (m) 1.31 **Width (m) 0.65**

NOTE: Dimensions shown are internal dimensions so wall thickness should be added to get overall size of septic tank

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References: *- Standard Handbook of environmentl Engineering. Table 5.2*
- JIE Recommended Guidelines for Design & Construction of Housing infrastructure - SEWERAGE SYSTEMS

Project: Coral Springs
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SW WETLAND DESIGN

Input Data:

Design Flow Rate,Q: **47054.17 GPD** (6290.23) $ft.^3$ (178.053) m^3

Req'd BOD_5 Removal (%): **86**

Depth of Wetland, d: **3 ft**
Type of soil in wetland: **Medium Gravel**
Gradation of particles: **35mm - 75mm**
Porosity of gravel/stones, n: **40 %**
Slope of bottom of wetland: **1 %**

Calculate Temperature Dependent Rate Constant

Enter Avg. Temperature of location: **21** °

K_T = Rate Constant at Temperature T
= $K_{20}\,\Theta^{(T-20)}$

where K_{20} = Rate Constant at 20° C = 1.104
Θ = 1.06

→ K_T = 1.104 x $(1.06)^{1}$
= 1.17

Calculate Area of Reed Bed required for BOD removal

$$A = \frac{Q\,[\ln(C_o/C_e)]}{K_T d n}$$

where C_o = Influent BOD_5 (150mg/l)
C_e = Effluent BOD_5 (<20mg/l)
so C_o/C_e = Ratio of Influent:Effluent = 150 ÷ (150 - % Reduction)
= 7.14

Area = [6290.23 x ln (7.14)] ÷ [1.17 x 3 x 0.4]
= 8806.81 sq. ft

Calculate Hydraulic Retention Time Required for BOD Removal

From the equation : $C_e/C_o = e^{(K_T t)}$
Hydraulic retention time, t = $[\ln(C_e/C_o)] \div K_T$
= 1.680094 days

Calculate Area of Reed Bed required for Nitrogen removal

Parameters	Amount	Units
Daily flow rate	178.053	m3
Area needed for Nitrogen removal	1543.701	m2
Hydraulic retention time	3.121	days
Nitrogen concentration	40	g/m3
Total daily nitrogen load	2281.880	g
Removal by plant uptake	1698.071	g/day
Effluent concentration	10.234	g/m3

Calculate Area of Reed Bed required for Phosphorus removal

Parameters	Amount	Units
Daily flow rate	178.053	m3
Area provided for removal	1543.701	m2
Hydraulic retention time	3.121	days
Phosphorus concentration	8	g/m3
Total daily phosphorus load	456.376	g
Removal by plant uptake	231.555	g/day
Effluent concentration	3.941	g/m3

Calculate Total Area and Retention time

TOTAL AREA REQUIRED = 8806.81 + ##### = 25423.1 sq.ft
= 2362 sq.m

Using a 2:1 Length to Width ratio, Dimensions are:

Length = 225.49 ft Width = 112.75 ft Depth = 3 ft
= 68.73 m = 34.36 m = 0.91 m

Total HRT = 1.68 + 3.12
= 4.8 days

References: - EPA Technology Assessment: Subsurface Flow - Constructed Wetlands for Wastewater Treatment - EPA/832-R-93-008

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N WETLAND DESIGN

Input Data:

Design Flow Rate,Q: **58532.8 GPD** (7824.70) $ft.^3$ (221.488) m^3

Req'd BOD_5 Removal (%): **86**

Depth of Wetland, d: **3 ft**
Type of soil in wetland: **Medium Gravel**
Gradation of particles: **35mm - 75mm**
Porosity of gravel/stones, n: **40 %**
Slope of bottom of wetland: **1 %**

Calculate Temperature Dependent Rate Constant

Enter Avg. Temperature of location: **21** ^{o}

K_T = Rate Constant at Temperature T
= $K_{20}\,\Theta^{(T-20)}$

where K_{20} = Rate Constant at 20^o C = 1.104
Θ = 1.06

$\rightarrow K_T$ = 1.104 x $(1.06)^{1}$
= 1.17

Calculate Area of Reed Bed required for BOD removal

$$A = \frac{Q\,[\ln(C_o/C_e)]}{K_T d n}$$

where C_o = Influent BOD_5 (150mg/l)
C_e = Effluent BOD_5 (<20mg/l)
so C_o/C_e = Ratio of Influent:Effluent = 150 ÷ (150 - % Reduction)
= 7.14

Area = [7824.70 x ln (7.14)] ÷ [1.17 x 3 x 0.4]
= 10955.19 sq. ft

Calculate Hydraulic Retention Time Required for BOD Removal

From the equation : $C_e/C_o = e^{(K_T t)}$
Hydraulic retention time, t = $[\ln(C_e/C_o)] \div K_T$
= 1.680094 days

N WETLAND DESIGN Cont.

Calculate Area of Reed Bed required for Nitrogen removal

Parameters	Amount	Units
Daily flow rate	221.488	m3
Area needed for Nitrogen removal	1920.279	m2
Hydraulic retention time	3.121	days
Nitrogen concentration	40	g/m3
Total daily nitrogen load	2838.533	g
Removal by plant uptake	2112.307	g/day
Effluent concentration	10.234	g/m3

Calculate Area of Reed Bed required for Phosphorus removal

Parameters	Amount	Units
Daily flow rate	221.488	m3
Area provided for removal	1920.279	m2
Hydraulic retention time	3.121	days
Phosphorus concentration	8	g/m3
Total daily phosphorus load	567.707	g
Removal by plant uptake	288.042	g/day
Effluent concentration	3.941	g/m3

Calculate Total Area and Retention time

TOTAL AREA REQUIRED = 10955.19 + ##### = 31624.9 sq.ft
= 2938 sq.m

Using a 2:1 Length to Width ratio, Dimensions are:

Length = 251.50 ft Width = 125.75 ft Depth = 3 ft
= 76.66 m = 38.33 m = 0.91 m

Total HRT = 1.68 + 3.12
= 4.8 days

References: - EPA Technology Assessment: Subsurface Flow - Constructed Wetlands for Wastewater Treatment - EPA/832-R-93-008

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Project: Coral Springs
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E WETLAND DESIGN

Input Data:

Design Flow Rate,Q:	**22185.87 GPD**	(2965.82) $ft.^3$ (83.951) m^3
Req'd BOD_5 Removal (%):	**86**	
Depth of Wetland, d:	**3**	**ft**
Type of soil in wetland:	**Medium Gravel**	
Gradation of particles:	**35mm - 75mm**	
Porosity of gravel/stones, n:	**40**	**%**
Slope of bottom of wetland:	**1**	**%**

Calculate Temperature Dependent Rate Constant

Enter Avg. Temperature of location: **21** °

K_T = Rate Constant at Temperature T

= $K_{20}\,\Theta^{(T-20)}$

where K_{20} = Rate Constant at 20^o C = 1.104

Θ = 1.06

$\rightarrow K_T$ = 1.104 x $(1.06)^1$

= 1.17

Calculate Area of Reed Bed required for BOD removal

$$A = \frac{Q\,[\ln(C_o/C_e)}{K_T d n}$$

where C_o = Influent BOD_5 (150mg/l)

C_e = Effluent BOD_5 (<20mg/l)

so C_o/C_e = Ratio of Influent:Effluent = 150 ÷ (150 - % Reduction)

= 7.14

Area = [2965.82 x ln (7.14)] ÷ [1.17 x 3 x 0.4]

= 4152.38 sq. ft

Calculate Hydraulic Retention Time Required for BOD Removal

From the equation : $C_e/C_o = e^{(K_T t)}$

Hydraulic retention time, t = $[\ln(C_e/C_o)] \div K_T$

= 1.680094 days

E WETLAND DESIGN Cont.

Calculate Area of Reed Bed required for Nitrogen removal

Parameters	Amount	Units
Daily flow rate	83.951	m3
Area needed for Nitrogen removal	727.849	m2
Hydraulic retention time	3.121	days
Nitrogen concentration	40	g/m3
Total daily nitrogen load	1075.898	g
Removal by plant uptake	800.634	g/day
Effluent concentration	10.234	g/m3

Calculate Area of Reed Bed required for Phosphorus removal

Parameters	Amount	Units
Daily flow rate	83.951	m3
Area provided for removal	727.849	m2
Hydraulic retention time	3.121	days
Phosphorus concentration	8	g/m3
Total daily phosphorus load	215.180	g
Removal by plant uptake	109.177	g/day
Effluent concentration	3.941	g/m3

Calculate Total Area and Retention time

TOTAL AREA REQUIRED = 4152.38 + ##### = 11986.9 sq.ft
= 1114 sq.m

Using a 2:1 Length to Width ratio, Dimensions are:

Length = 154.83 ft Width = 77.42 ft Depth = 3 ft
= 47.19 m = 23.60 m = 0.91 m

Total HRT = 1.68 + 3.12
= 4.8 days

References: - EPA Technology Assessment: Subsurface Flow - Constructed Wetlands for Wastewater Treatment - EPA/832-R-93-008

Project: Coral Springs
Project No. 1124/76/C

SE WETLAND DESIGN

Input Data:

Design Flow Rate,Q: **22185.87 GPD** (2965.82) $ft.^3$ (83.951) m^3

Req'd BOD_5 Removal (%): **86**

Depth of Wetland, d: **3 ft**
Type of soil in wetland: **Medium Gravel**
Gradation of particles: **35mm - 75mm**
Porosity of gravel/stones, n: **40 %**
Slope of bottom of wetland: **1 %**

Calculate Temperature Dependent Rate Constant

Enter Avg. Temperature of location: **21** **°**

K_T = Rate Constant at Temperature T
= $K_{20}\,\Theta^{(T-20)}$

where K_{20} = Rate Constant at 20° C = 1.104
Θ = 1.06

→ K_T = 1.104 x $(1.06)^{1}$
= 1.17

Calculate Area of Reed Bed required for BOD removal

$$A = \frac{Q\,[\ln(C_o/C_e)]}{K_T d n}$$

where C_o = Influent BOD_5 (150mg/l)
C_e = Effluent BOD_5 (<20mg/l)
so C_o/C_e = Ratio of Influent:Effluent = 150 ÷ (150 - % Reduction)
= 7.14

Area = [2965.82 x ln (7.14)] ÷ [1.17 x 3 x 0.4]
= 4152.38 sq. ft

Calculate Hydraulic Retention Time Required for BOD Removal

From the equation : $C_e/C_o = e^{(K_T t)}$
Hydraulic retention time, t = $[\ln(C_e/C_o)] \div K_T$
= 1.680094 days

SE WETLAND DESIGN Cont.

Calculate Area of Reed Bed required for Nitrogen removal

Parameters	Amount	Units
Daily flow rate	83.951	m3
Area needed for Nitrogen removal	727.849	m2
Hydraulic retention time	3.121	days
Nitrogen concentration	40	g/m3
Total daily nitrogen load	1075.898	g
Removal by plant uptake	800.634	g/day
Effluent concentration	10.234	g/m3

Calculate Area of Reed Bed required for Phosphorus removal

Parameters	Amount	Units
Daily flow rate	83.951	m3
Area provided for removal	727.849	m2
Hydraulic retention time	3.121	days
Phosphorus concentration	8	g/m3
Total daily phosphorus load	215.180	g
Removal by plant uptake	109.177	g/day
Effluent concentration	3.941	g/m3

Calculate Total Area and Retention time

TOTAL AREA REQUIRED = 4152.38 + ##### = 11986.9 sq.ft
= 1114 sq.m

Using a 2:1 Length to Width ratio, Dimensions are:

Length =	**154.83**	**ft**	**Width =**	**77.42**	**ft**	**Depth =**	**3 ft**
=	**47.19**	**m**	**=**	**23.60**	**m**	**=**	**0.91 m**

Total HRT = 1.68 + 3.12
= 4.8 days

References: - EPA Technology Assessment: Subsurface Flow - Constructed Wetlands for Wastewater Treatment - EPA/832-R-93-008