7A BARBADOS AVENUE
KINGSTON 5
JAMAICA
TEL: 876.754.2154 -5
876.754.2158
FAX: 876.754.2156
MAIL@FCSCONSULTANTS.COM
WWW.FCSCONSULTANTS.COM

FCS CONSULTANTS LTD

PROPOSED RESIDENTIAL DEVELOPMENT,

CORAL SPRINGS TRELAWNY

FCS #: 1124/76/C

DRAINAGE DESIGN
ENGINEERING REPORT

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

MARCH 2012

TABLE OF CONTENTS

Overview ***2***

Roadway Design ***4***

Drainage Design ***5***

Design Storm Event 5

Method of Determining Design Peak Flows 6

Storm Sewers 6

Open Drains 6

Pre-Development Drainage Assessment ***7***

Post-Development Drainage Assessment 10

Depression Storage 12

Recommendation and Conclusion ***13***

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. The development will surround an existing subdivision. FCS Consultants Limited is responsible for the infrastructure designs within the project boundaries; this includes roadways, water distribution, sewage and storm water collection as well as constructed wetlands for tertiary sewage treatment.

The basis for design is guided by the local requirements for permitting and international standards with regards to similar developments. The subdivision layout as shown below will be used to develop designs and drawings for construction.

Figure 2: Coral Springs Subdivision Layout

Roadway Design

The roadways will be designed to meet a combination of the NWA and the AASHTO road design standards.

Carriageway widths will be designed based on the classification or primary use of the road such as access to housing blocks, collector road for multiple blocks or ingress egress for the subdivision.

There are three road reservations provided by the planner for this subdivision, 18m wide for the main entry road, 10m for cul de sacs, 12.2m wide for all other local streets. The road reservation provided by the planner for the entrance road to the site consists of a dual carriageway and ends at a roundabout. Throughout the subdivision the 12.2m reservation is used to provide paved carriageways of 6.0m (2x 3.00m lanes) with 3.0m available for grassed verges or sidewalks within the housing blocks. The sidewalks are proposed along the main entry road and several of the local streets.

The carriageways will be designed with a crown in the middle, such that the transverse slope will be between 1.5% and 2.5% with the channel against the kerb having a triangular section with a slope of 2.5 to 6.25%.

Internal intersections within the subdivision will be designed with a 10m radius based on recommendations by the NWA. The turning radius at curves within the subdivision will be designed with 25m minimum.

The vertical alignments of all roads will be the minimum slope of 0.5% and a maximum slope of 15% in order to meet the NWA standard. Road profiles will be designed to meet the stopping sight distance criteria for a minimum design speed of 55kmph.

The pavement structure will be guided by the geotechnical report, however at a minimum there will be 38mm of asphaltic concrete on 150mm of granular road base.

Where additional guidance is required the following manuals will be used

1. Road pavement structure will be designed to conform to AASHTO flexible pavement design method or the Asphalt Institute design method.

2. All soil gradation to be specified in the AASHTO Soil Classification system.

3. All soil strength to be specified in accordance with the ASTM 04429-04 Standard Test Method for CBR (California Bearing Ratio) of Soils in Place and 01883-07 Standard Test Method for CBR (California Bearing Ratio) of Laboratory-Compacted Soils

4. All soil compaction to be specified as a percentage of Modified Proctor Compaction ASTM 01557- 07 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort

Drainage Design

The criteria used for drainage design are determined by the GOJ Development and investment manual, the Jamaica Institution of Engineers guidelines and best practices of the industry. The storm runoff from the development will be directed toward the necessary features of the drainage system such as storm sewer and open paved drains that fall toward the main detention area, or north towards the sea.

Design Storm Event

The Jamaica Institution of Engineers recommended "Guidelines for the design and Construction of Housing Infrastructure" Vol 1: 1984 Storm Water Drainage recommends that the design storm frequency of storm sewers be 2 years and for culverts, bridges and flood control projects a minimum of 10 years. Detention/retention ponds are required to provide storage for the 100 year event. Surface drainage systems are primarily concerned with convenience and providing access to property in relatively minor storms. The criteria for the designs of drains will be as follows:

1. Lots will discharge surface flows to the roads
2. Local streets will accommodate storm flows of 1:2 years to the crown of the road and storm flows of 1:5 years to kerb height
3. Main subdivision drainage channels will be designed to accommodate storms to 1:25 year return period with a freeboard provision of 25% depth of flow. These channels will provide capacity for the 1:100 year design storm at top bank levels.
4. Flood protection will be provided for the 1:100 year event for the development, while flood levels will be maintained for existing properties within the area.

Where additional guidance is required the following manuals will be used.
The FHWA documents referenced are:

1. Hydraulic Engineering Circular No. 12 - Drainage of Highway Pavements

2. Hydraulic Engineering Circular No. 14, Hydraulic Design of Energy Dissipators for Culverts and Channels Third Edition

3. Hydraulic Engineering Circular No. 15, - Design of Roadside Channels with Flexible Linings Third Edition

4. Hydraulic Engineering Circular No. 22, URBAN DRAINAGEDESIGN MANUAL Second Edition

Method of Determining Design Peak Flows

In order to determine drain sizes the peak flow is needed. For catchment areas less than 200 acres the Rational Method (Q=CIA) will be used for determining the peak flow throughout the subdivision. The Donald Sangster IDF curves developed for the NWA bridges programme will be used. For flood routing and retention pond calculations the SCSTR20 Method will be used with the SCSUH type 3 hyetograph.

The rainfall depths for the project will be based on the gage at Duncans Trelawny.

Storm – return period	Rainfall Depth (mm)
2 yr	64
5 yr	104
10 yr	130
25 yr	164
50 yr	189
100 yr	213

Storm Sewers

The storm sewer system being the buried drainage conveyance system below the roadway pavement is designed to convey a 1:2 year storm without surcharging. The discharge of storm sewers will be to paved drains or grassed swales. Minimum cover will be as per the manufacturer's specifications. The storm sewer will be designed to ensure the carriageway can comfortably convey the 1:5 year at kerb height.

Storm sewer inlets will be placed appropriately in order to minimise the pipe runs and allow for maximum collection. A combination of kerb and grate inlets will be used as necessary.

Open Drains

Open drains will be used where possible and erosion protection using rigid linings will be used in the design. The **GOJ Development Manual**, Volume3, Section 1, Chapter 10, article 10.1.7 parts ii) and iii) recommend minimum easement and freeboard in drains are shown below:

(ii) A minimum easement of 1.22m from each side of the design water way is recommended.

(iii) Bridges and open channels should be designed with a freeboard not less than 25% of the design flow depth.

As recommended in the GOJ Development document all drains will be designed with a minimum 25% of the design depth as freeboard.

Pre-Development Drainage Assessment

The project site is a dry limestone forest on hilly terrain with 65% of the property draining into an existing central depression which contains standing water up to approximately 13m AMSL. The remaining 35% of the site drains northward overland towards the sea.

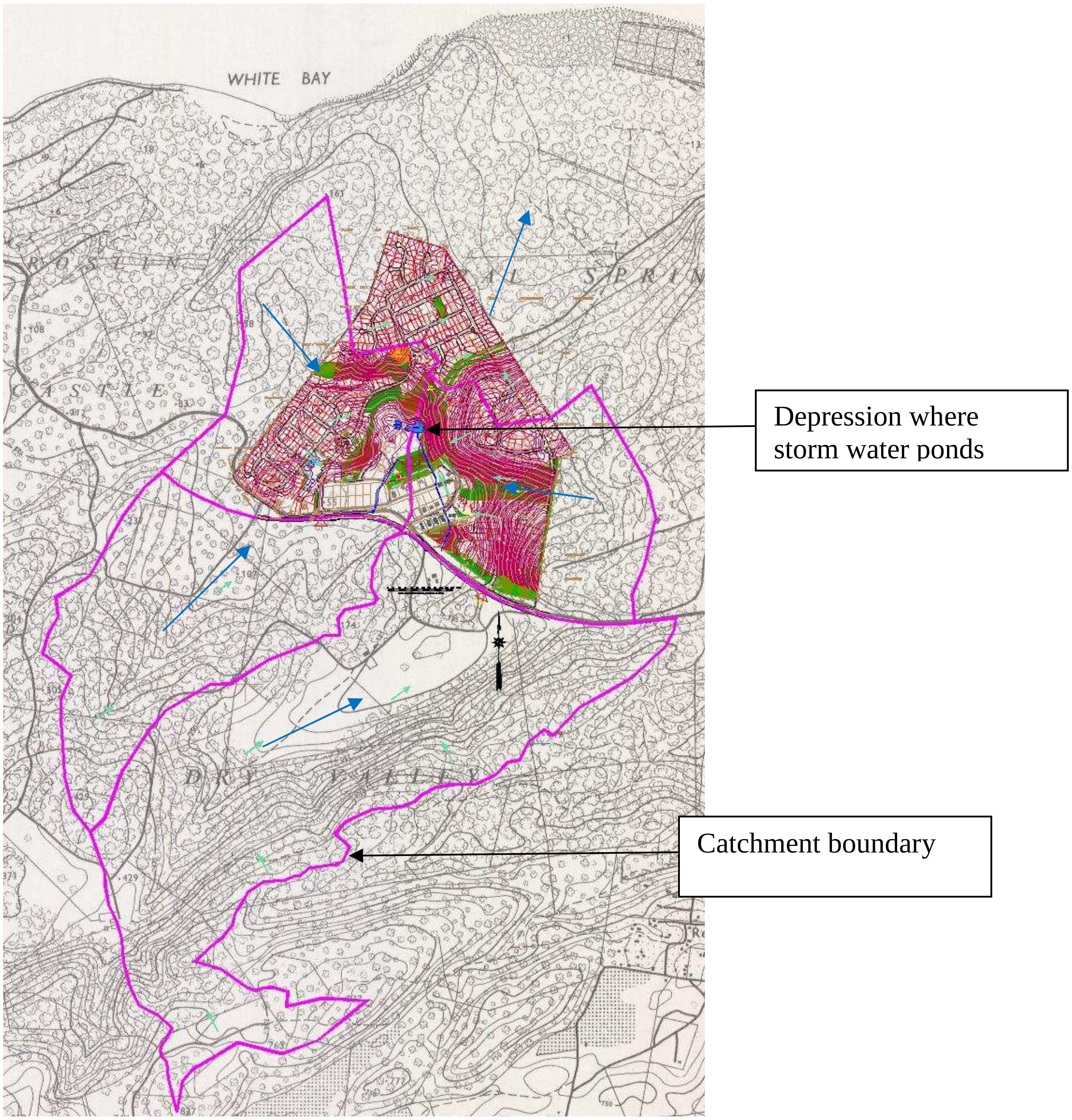


Figure 3: Catchment area for internal depression

The depression drains approximately 311 Hectares (ha), 35.4 ha of which is part of the project site. Catchment area for the depression can be divided into four (4) sub-catchments, NE - 50.5 ha, SE 139 ha, SW- 67 ha and NW - 54.3ha. The largest contributing area comes from Dry Valley south of the Highway. The Northern area flows overland to the sea.

A hydrologic model was developed for the pre development condition in order to determine the peak discharges and flood elevations in the ponding area that could be generated by various storm events. The peak discharges (m^3/s) tabulated below were developed from SCS Type III rainfall distribution.

Table 1: Pre Development catchment areas and discharge values

Catchment Name	Area (Ha)	CN	Tc	Q2	Q5	Q10	Q25	Q50	Q100
West Coral Springs	54.100	48	181.0	0.006	0.147	0.355	5.255	1.228	1.673
North Coral Springs	17.730	48	20.0	0.002	0.113	0.371	0.916	1.417	1.955
East Coral Springs	54.300	48	203.0	0.006	0.142	0.355	0.766	1.144	1.553
Dry Valley East	139.000	45	122.0	0.002	0.254	0.816	2.078	3.298	4.675
Dry Valley West	67.000	45	156.0	0.001	0.116	0.348	0.852	1.345	1.896

Figure 4: depression or ponding area

The depression or ponding area is emptied by infiltration. We assume the vegetation reduces the storage volume by 15%. The surface overflow point is at approximately 25m along the old road from Duncans to Falmouth. A conductivity rate of 5.68 mm/hr was used to determine flood potential. This is based on the soil investigation results showing hard brown clays in the low areas of the existing subdivision. It assumes that any existing sink holes or cavities are not the primary conduit for filtration from the site; but that the surface runoff percolates through the soil then the underlying limestone formation.

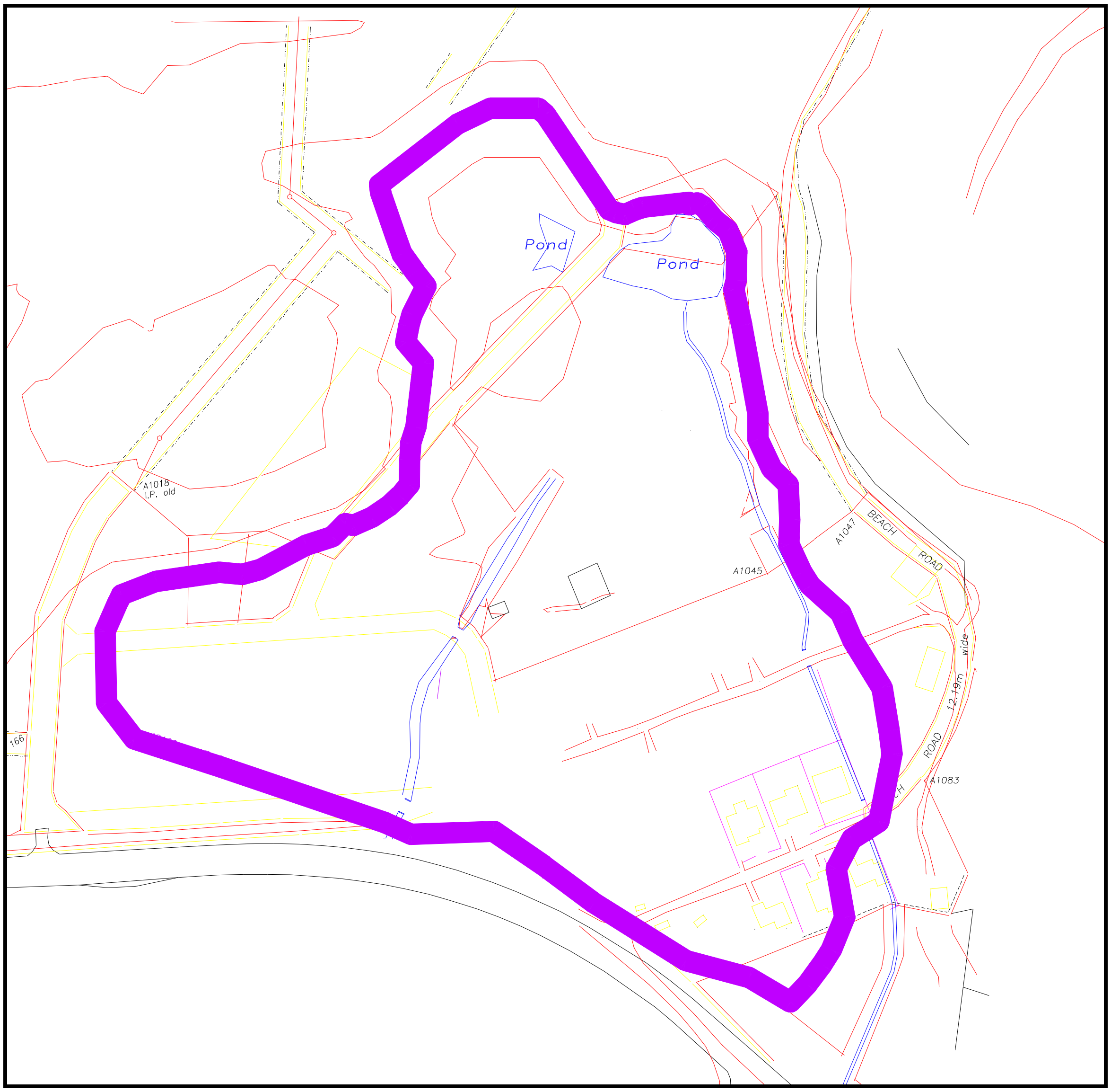


Figure 5: Demarcation of 100 year flood elevation of 17.48m

The summary of water surface elevations are tabulated below, however a full hydrologic report can be found in the appendix.

Table 2: Expected Water Surface Elevations prior to proposed development

Storm – return period	Pre development Water surface elevation
25 yr	16.44 m
50 yr	16.98m
100 yr	17.48m

Post-Development Drainage Assessment

Following the predevelopment assessment the project area was then analyzed based on the proposed subdivision layout in order to create a drainage model for the post development stage of the project. The entire site area was divided in the areas shown in Figure 5 below. In order to get the storm water off the roads a system of kerb inlets and pipes under the road will be used. Small open U drains will be used where required due to cover limitations.

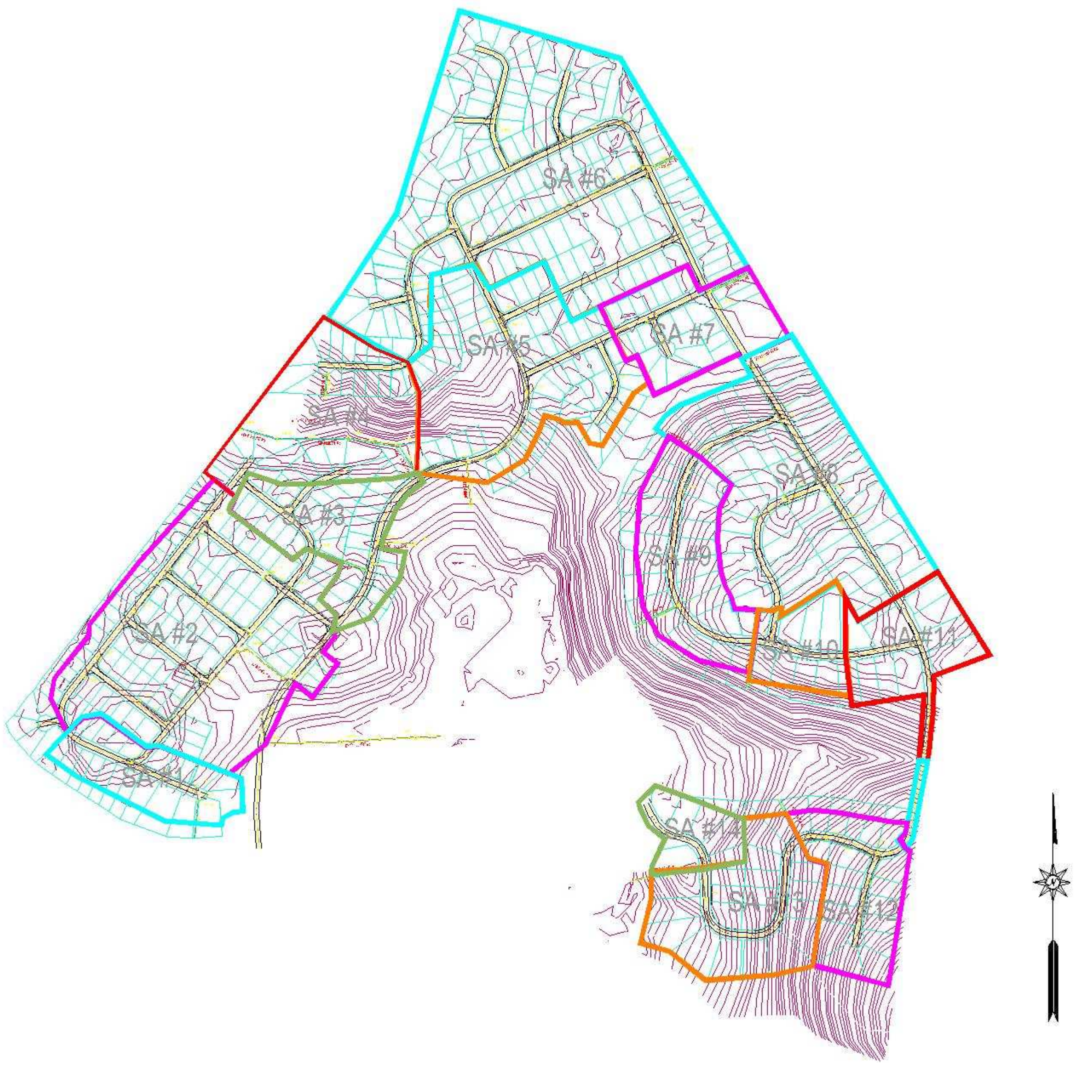


Figure 6: Internal Drainage Sub-catchments

Sub-catchments SA#1 to SA# 5 from part of the 54.3 ha NW drainage area and flows to the depression in a series of 600 to 900 mm diameter storm sewer and covered U drains

Sub-catchments SA#6 to SA# 8 are the ones that flow north towards the sea. They leave the subdivision at three exit points to meet natural channels in 600 mm to 900mm wide open U drains.

Sub-catchments SA#9 to SA# 14 form part of the 50.5 ha NE drainage area. These flow into the existing channels via several 600mm drains.

The discharges from each internal sub catchment are tabulated below.

Table 3: Post Development discharges

Coral Springs Subdivision Post Development Design								
Catchment Name	Return period	mm/day	Tc	Area m^2	c	I mm/hr	Q cfs	cms
SA #1	1 in 2 yr	64	**6**	**15,764.54**	**0.75**	143.32	16.48	0.47
	1 in 5 yr	104	6	15,764.54	0.75	242.3459	27.88	0.79
	1 in 25 yr	164	6	15,764.54	0.75	391.99903	45.09	1.28
SA #2	1 in 2 yr	64	**15**	**67,514.00**	**0.75**	89.23	43.96	1.24
	1 in 5 yr	104	15	67,514.00	0.75	143.698	70.79	2.00
	1 in 25 yr	164	15	67,514.00	0.75	225.24267	110.96	3.14
SA #3	1 in 2 yr	64	**6**	**20,636.71**	**0.75**	143.32	21.58	0.61
	1 in 5 yr	104	6	20,636.71	0.75	242.3459	36.49	1.03
	1 in 25 yr	164	6	20,636.71	0.75	391.99903	59.02	1.67
SA #4	1 in 2 yr	64	**15**	**31,938.61**	**0.6**	89.23	16.64	0.47
	1 in 5 yr	104	15	31,938.61	0.6	143.698	26.79	0.76
	1 in 25 yr	164	15	31,938.61	0.6	225.24267	41.99	1.19
SA #5	1 in 2 yr	64	**6**	**48,085.00**	**0.75**	143.32	50.28	1.42
	1 in 5 yr	104	6	48,085.00	0.75	242.3459	85.03	2.41
	1 in 25 yr	164	6	48,085.00	0.75	391.99903	137.53	3.89
SA #6	1 in 2 yr	64	**6**	**100,870.00**	**0.75**	143.32	105.48	2.99
	1 in 5 yr	104	6	100,870.00	0.75	242.3459	178.36	5.05
	1 in 25 yr	164	6	100,870.00	0.75	391.99903	288.51	8.17
SA #7	1 in 2 yr	64	**6**	**19,185.03**	**0.75**	143.32	20.06	0.57
	1 in 5 yr	104	6	19,185.03	0.75	242.3459	33.92	0.96
	1 in 25 yr	164	6	19,185.03	0.75	391.99903	54.87	1.55
SA #8	1 in 2 yr	64	**6**	**57,242.48**	**0.75**	143.32	59.86	1.70
	1 in 5 yr	104	6	57,242.48	0.75	242.3459	101.22	2.87
	1 in 25 yr	164	6	57,242.48	0.75	391.99903	163.72	4.64
SA #9	1 in 2 yr	64	**6**	**24,221.61**	**0.75**	143.32	25.33	0.72
	1 in 5 yr	104	6	24,221.61	0.75	242.3459	42.83	1.21
	1 in 25 yr	164	6	24,221.61	0.75	391.99903	69.28	1.96
SA #10	1 in 2 yr	64	**6**	**11,280.28**	**0.75**	143.32	11.80	0.33
	1 in 5 yr	104	6	11,280.28	0.75	242.3459	19.95	0.56
	1 in 25 yr	164	6	11,280.28	0.75	391.99903	32.26	0.91
SA #11	1 in 2 yr	64	**6**	**17,166.12**	**0.75**	143.32	17.95	0.51
	1 in 5 yr	104	6	17,166.12	0.75	242.3459	30.35	0.86
	1 in 25 yr	164	6	17,166.12	0.75	391.99903	49.10	1.39
SA #12	1 in 2 yr	64	**6**	**19,326.08**	**0.75**	143.32	20.21	0.57
	1 in 5 yr	104	6	19,326.08	0.75	242.3459	34.17	0.97
	1 in 25 yr	164	6	19,326.08	0.75	391.99903	55.28	1.57
SA #13	1 in 2 yr	64	**6**	**28,232.93**	**0.75**	143.32	29.52	0.84
	1 in 5 yr	104	6	28,232.93	0.75	242.3459	49.92	1.41
	1 in 25 yr	164	6	28,232.93	0.75	391.99903	80.75	2.29
SA #14	1 in 2 yr	64	**6**	**8,630.37**	**0.75**	143.32	9.02	0.26
	1 in 5 yr	104	6	8,630.37	0.75	242.3459	15.26	0.43
	1 in 25 yr	164	6	8,630.37	0.75	391.99903	24.68	0.70
Average Residential Lot	1 in 5 yr	104	**6**	**238.95**	**0.75**	242.3459	0.42	0.01

Depression Storage

As the depression is the primary outlet for rainfall runoff from this area a hydrologic model was developed to determine what the potential water surface elevations would be due to additional runoff after the Coral Springs Housing development is constructed and to determine the required building limits for Coral Springs. The lands being developed by Gore Developments that contribute runoff to the depression were modeled with an increased Curve Number (CN 48 increased to CN 77 and CN 82). The results are detailed in the appendix and summarized in the tables below.

Table 4: Expected Water Surface Elevations with proposed development and no mitigation

Storm – return period	Post development water surface elevation
25 yr	17.04 m
50 yr	17.57 m
100 yr	18.08 m

Due to the potential increase in water surface elevations with the additional runoff from the proposed Coral Springs housing development; it has been determined that the best way to mitigate against additional flooding is to expand the storage capacity of the depression and its infiltration potential.

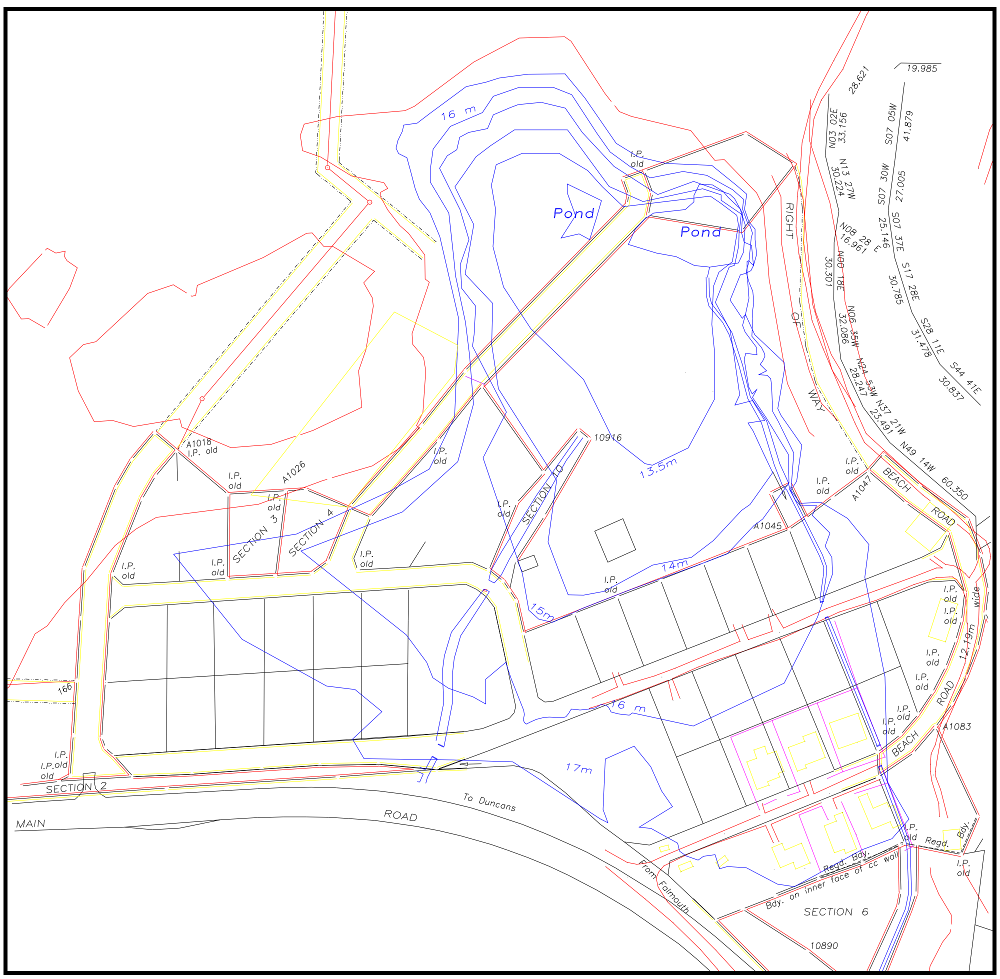


Figure 7: Contours after regrading

This will be done by re-grading a part of the depression area above the standing water elevation (13.3); excavating between the 13.5 contour and the 14.2 contour and removing the hard brown clay and filling with compacted gravel and crushed limestone. It will then be vegetated for use as a park. The conductivity rate estimated for the area between 13.5 and 14.2 is 460 mm/hr. This is within the percolation range for a gravel stratum. When used to develop the HydroCad model the predicted water surface elevations are improved by these changes to the area.

Table 5: Expected Water Surface elevations with proposed development and grading of depression

Storm – return period	Post development water surface elevation – with grading
25 yr	15.46 m
50 yr	16.13 m
100 yr	16.70 m

This re-grading exercise is to ensure that the Post Development flood elevation is no more than the Pre Development after construction of the housing development. The results actually show the re-grading and removal of the clay layer in the park location will reduce the flood levels by approximately 0.78m in the 100yr storm and therefore reduce the threat to existing properties.

The figure below shows the proposed 13.5 to 17m contours after the re-grading exercise is completed. The re-grading on the north side of the pond is between 13.5 and 17m. To the west and south regarding is between 13.5 and 15m, only in properties owned by the developer.

Recommendation and Conclusion

The drainage system for the Coral Springs Development has been designed according to best practices. The streets and storm sewer will provide conveyance of peak discharges for the 10yr event. All storm sewer will empty into existing drains leading to the depression or natural gullies.

If no mitigation measures are taken the proposed Coral Spring housing development will impact the depression ponding area by raising the water surface elevation a total of 0.6m. This can be mitigated by re-grading above the standing water line to expand the pond as well as replacing the soil in a section of the proposed park in order to improve the percolation of storm water and achieve less than the same elevation as existed before the development. The current re-grading plan will reduce the post development water surface level to 0.78m below pre development level.

All subdivision lots and services are set above the proposed 100 yr flood limit of 16.7m.

Prepared by: **Checked by:**

Lise Walter, PE
Senior Civil Engineer

David Chung, PE
Director

APPENDIX

Appendix 1: IDF equations (Jamaica Bridges Programme- Hydraulics Guide 2009) 15
Appendix 2: Pre Development HydroCad Diagram...16
Appendix 3: Pre Development HydroCad results for 2 and 25 yr storms................................17
Appendix 4: Pre Development HydroCad results for 50 and 100 yr storms............................18
Appendix 5: Post Development Model 19
Appendix 6: Post Development HydroCad results for 2 and 25 yr storms 20
Appendix 7: Post Development HydroCad results for 50 and 100 yr storms 21

Table 2-1: Norman Manley International Airport

Return Period (years)	Rainfall Intensity in i.p.h. or mm/hr	
	t < 60 min	t > 60 min
2	$i = 2.6125 \ P \times t^{-0.4814}$	$i = 5.9487 \ P \times t^{-0.6822}$
5	$i = 2.5444 \ P \times t^{-0.5119}$	$i = 4.2020 \ P \times t^{-0.6344}$
10	$i = 2.4944 \ P \times t^{-0.5218}$	$i = 3.6597 \ P \times t^{-0.6154}$
25	$i = 2.4556 \ P \times t^{-0.5300}$	$i = 3.2696 \ P \times t^{-0.5999}$
50	$i = 2.4377 \ P \times t^{-0.5343}$	$i = 3.0870 \ P \times t^{-0.5920}$
100	$i = 2.4230 \ P \times t^{-0.5375}$	$i = 2.9552 \ P \times t^{-0.5860}$

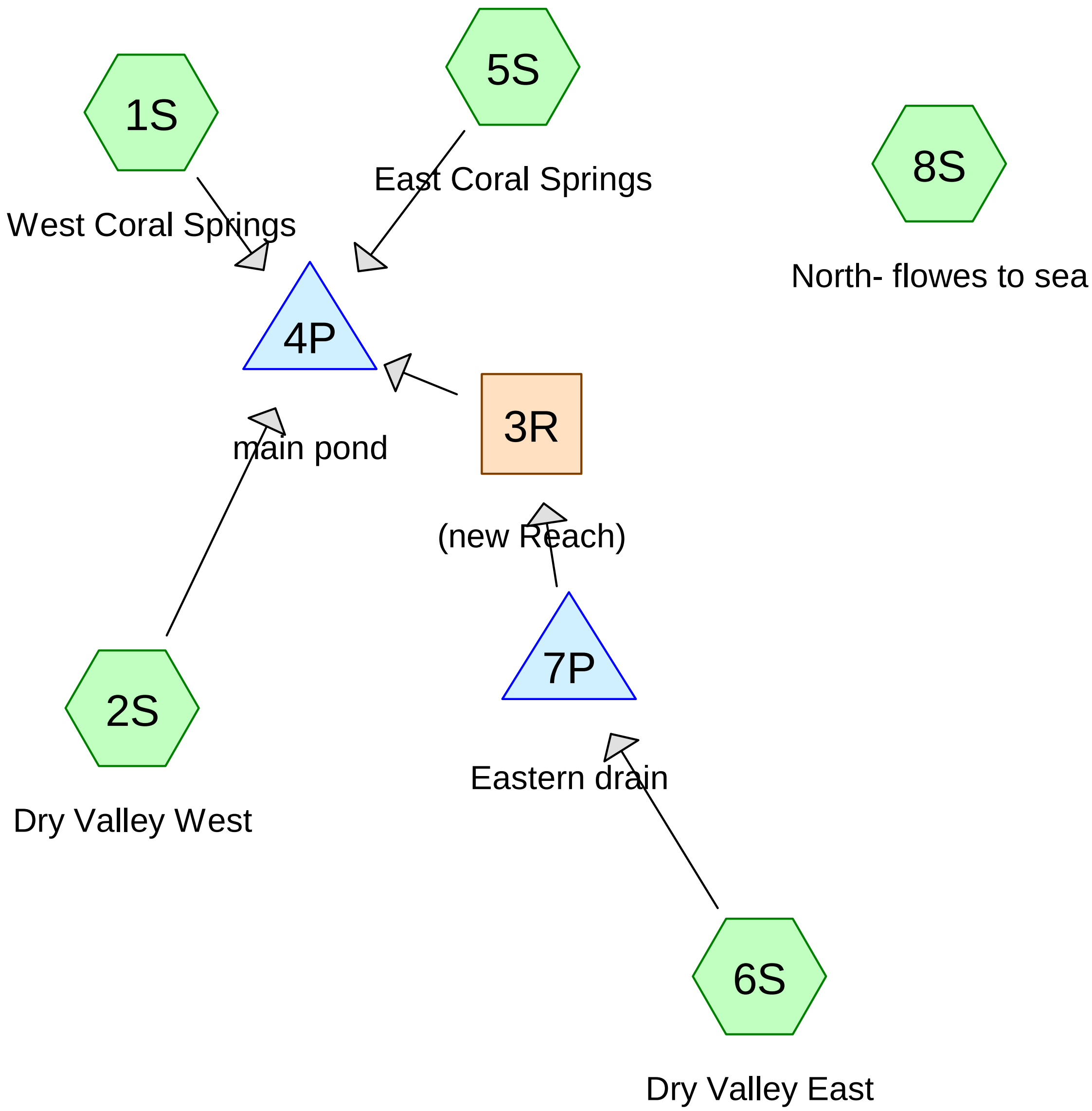
i = Rainfall intensity in inches per hour (inch/hour) or millimeters per hour (mm/hr)
P = 24-hour rainfall in inches or mm
t = rainfall duration in minutes

Table 2-2: Sangster International Airport

Return Period (years)	Rainfall Intensity in i.p.h. or mm/hr	
	t < 60 min	t > 60 min
2	$i = 5.6559 \ P \times t^{-0.5171}$	$i = 24.8880 \ P \times t^{-0.8790}$
5	$i = 6.4753 \ P \times t^{-0.5704}$	$i = 20.5852 \ P \times t^{-0.8529}$
10	$i = 6.7976 \ P \times t^{-0.5893}$	$i = 19.2810 \ P \times t^{-0.8439}$
25	$i = 7.0630 \ P \times t^{-0.6047}$	$i = 18.2178 \ P \times t^{-0.8361}$
50	$i = 7.1972 \ P \times t^{-0.6123}$	$i = 17.6826 \ P \times t^{-0.8320}$
100	$i = 7.2901 \ P \times t^{-0.6181}$	$i = 17.2759 \ P \times t^{-0.8288}$

i = Rainfall intensity in inches per hour (inch/hour) or millimeters per hour (mm/hr).
P = 24-hour rainfall in inches or mm
t = rainfall duration in minutes

Appendix 1: IDF equations (Jamaica Bridges Programme- Hydraulics Guide 2009)



Appendix 2: Pre Development HydroCad Diagram

Pre Development 2yr storm

Time span=5.00-72.00 hrs, dt=0.05 hrs, 1341 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: West Coral Springs Runoff Area=54.1700 ha 0.00% Impervious Runoff Depth=0 mm
Flow Length=1,429.0 m Slope=0.0200 m/m Tc=181.4 min CN=48 Runoff=0.0055 m^3/s 0.153 Ml

Subcatchment 2S: Dry Valley West Runoff Area=66.9989 ha 0.00% Impervious Runoff Depth=0 mm
Flow Length=2,546.0 m Slope=0.0800 m/m Tc=155.6 min CN=45 Runoff=0.0007 m^3/s 0.008 Ml

Subcatchment 5S: East Coral Springs Runoff Area=54.3000 ha 0.00% Impervious Runoff Depth=0 mm
Flow Length=1,050.0 m Tc=203.1 min CN=48 Runoff=0.0055 m^3/s 0.154 Ml

Subcatchment 6S: Dry Valley East Runoff Area=139.2947 ha 0.00% Impervious Runoff Depth=0 mm
Flow Length=2,166.0 m Slope=0.1000 m/m Tc=122.3 min CN=45 Runoff=0.0017 m^3/s 0.016 Ml

Subcatchment 8S: North- flowes to sea Runoff Area=17.7300 ha 0.00% Impervious Runoff Depth=0 mm
Tc=21.0 min CN=48 Runoff=0.0018 m^3/s 0.050 Ml

Reach 3R: (new Reach) Avg. Depth=0.01 m Max Vel=0.70 m/s Inflow=0.0097 m^3/s 1.947 Ml
n=0.013 L=340.00 m S=0.0162 m/m Capacity=10.6285 m^3/s Outflow=0.0097 m^3/s 1.939 Ml

Pond 4P: main pond Peak Elev=13.225 m Storage=0.573 Ml Inflow=0.0211 m^3/s 2.254 Ml
Outflow=0.0101 m^3/s 1.790 Ml

Pond 7P: Eastern drain Peak Elev=20.003 m Storage=0.000 Ml Inflow=0.0017 m^3/s 0.016 Ml
Outflow=0.0017 m^3/s 0.016 Ml

Total Runoff Area = 332.4936 ha Runoff Volume = 0.381 Ml Average Runoff Depth = 0 mm
100.00% Pervious = 332.4936 ha 0.00% Impervious = 0.0000 ha

Pre Development 25yr storm

Time span=5.00-72.00 hrs, dt=0.05 hrs, 1341 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: West Coral Springs Runoff Area=54.1700 ha 0.00% Impervious Runoff Depth=31 mm
Flow Length=1,429.0 m Slope=0.0200 m/m Tc=181.4 min CN=48 Runoff=0.8171 m^3/s 16.744 Ml

Subcatchment 2S: Dry Valley West Runoff Area=66.9989 ha 0.00% Impervious Runoff Depth=25 mm
Flow Length=2,546.0 m Slope=0.0800 m/m Tc=155.6 min CN=45 Runoff=0.8517 m^3/s 16.875 Ml

Subcatchment 5S: East Coral Springs Runoff Area=54.3000 ha 0.00% Impervious Runoff Depth=31 mm
Flow Length=1,050.0 m Tc=203.1 min CN=48 Runoff=0.7661 m^3/s 16.784 Ml

Subcatchment 6S: Dry Valley East Runoff Area=139.2947 ha 0.00% Impervious Runoff Depth=25 mm
Flow Length=2,166.0 m Slope=0.1000 m/m Tc=122.3 min CN=45 Runoff=2.0776 m^3/s 35.084 Ml

Subcatchment 8S: North- flowes to sea Runoff Area=17.7300 ha 0.00% Impervious Runoff Depth=31 mm
Tc=21.0 min CN=48 Runoff=0.9158 m^3/s 5.480 Ml

Reach 3R: (new Reach) Avg. Depth=0.53 m Max Vel=3.95 m/s Inflow=2.0748 m^3/s 37.015 Ml
n=0.013 L=340.00 m S=0.0162 m/m Capacity=10.6285 m^3/s Outflow=2.0737 m^3/s 37.009 Ml

Pond 4P: main pond Peak Elev=16.437 m Storage=76.248 Ml Inflow=4.2822 m^3/s 87.413 Ml
Outflow=0.2296 m^3/s 39.965 Ml

Pond 7P: Eastern drain Peak Elev=20.846 m Storage=0.495 Ml Inflow=2.0776 m^3/s 35.084 Ml
Outflow=2.0668 m^3/s 35.084 Ml

Total Runoff Area = 332.4936 ha Runoff Volume = 90.968 Ml Average Runoff Depth = 27 mm
100.00% Pervious = 332.4936 ha 0.00% Impervious = 0.0000 ha

Appendix 3: Pre Development HydroCad results for 2 and 25 yr storms

Pre Development 50yr storm

Time span=5.00-72.00 hrs, dt=0.05 hrs, 1341 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: West Coral Springs Runoff Area=54.1700 ha 0.00% Impervious Runoff Depth=44 mm
Flow Length=1,429.0 m Slope=0.0200 m/m Tc=181.4 min CN=48 Runoff=1.2282 m³/s 23.762 Ml

Subcatchment 2S: Dry Valley West Runoff Area=66.9989 ha 0.00% Impervious Runoff Depth=37 mm
Flow Length=2,546.0 m Slope=0.0800 m/m Tc=155.6 min CN=45 Runoff=1.3452 m³/s 24.674 Ml

Subcatchment 5S: East Coral Springs Runoff Area=54.3000 ha 0.00% Impervious Runoff Depth=44 mm
Flow Length=1,050.0 m Tc=203.1 min CN=48 Runoff=1.1443 m³/s 23.819 Ml

Subcatchment 6S: Dry Valley East Runoff Area=139.2947 ha 0.00% Impervious Runoff Depth=37 mm
Flow Length=2,166.0 m Slope=0.1000 m/m Tc=122.3 min CN=45 Runoff=3.2981 m³/s 51.298 Ml

Subcatchment 8S: North- flowes to sea Runoff Area=17.7300 ha 0.00% Impervious Runoff Depth=44 mm
Tc=21.0 min CN=48 Runoff=1.4171 m³/s 7.777 Ml

Reach 3R: (new Reach) Avg. Depth=0.75 m Max Vel=4.39 m/s Inflow=3.2885 m³/s 53.229 Ml
n=0.013 L=340.00 m S=0.0162 m/m Capacity=10.6285 m³/s Outflow=3.2868 m³/s 53.224 Ml

Pond 4P: main pond Peak Elev=16.981 m Storage=110.810 Ml Inflow=6.6663 m³/s 125.479 Ml
Outflow=0.3182 m³/s 55.340 Ml

Pond 7P: Eastern drain Peak Elev=21.151 m Storage=0.921 Ml Inflow=3.2981 m³/s 51.298 Ml
Outflow=3.2805 m³/s 51.298 Ml

Total Runoff Area = 332.4936 ha Runoff Volume = 131.330 Ml Average Runoff Depth = 39 mm
100.00% Pervious = 332.4936 ha 0.00% Impervious = 0.0000 ha

Pre Development 100 yr storm

Time span=5.00-72.00 hrs, dt=0.05 hrs, 1341 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: West Coral Springs Runoff Area=54.1700 ha 0.00% Impervious Runoff Depth=58 mm
Flow Length=1,429.0 m Slope=0.0200 m/m Tc=181.4 min CN=48 Runoff=1.6734 m³/s 31.208 Ml

Subcatchment 2S: Dry Valley West Runoff Area=66.9989 ha 0.00% Impervious Runoff Depth=49 mm
Flow Length=2,546.0 m Slope=0.0800 m/m Tc=155.6 min CN=45 Runoff=1.8962 m³/s 33.073 Ml

Subcatchment 5S: East Coral Springs Runoff Area=54.3000 ha 0.00% Impervious Runoff Depth=58 mm
Flow Length=1,050.0 m Tc=203.1 min CN=48 Runoff=1.5533 m³/s 31.283 Ml

Subcatchment 6S: Dry Valley East Runoff Area=139.2947 ha 0.00% Impervious Runoff Depth=49 mm
Flow Length=2,166.0 m Slope=0.1000 m/m Tc=122.3 min CN=45 Runoff=4.6750 m³/s 68.761 Ml

Subcatchment 8S: North- flowes to sea Runoff Area=17.7300 ha 0.00% Impervious Runoff Depth=58 mm
Tc=21.0 min CN=48 Runoff=1.9546 m³/s 10.215 Ml

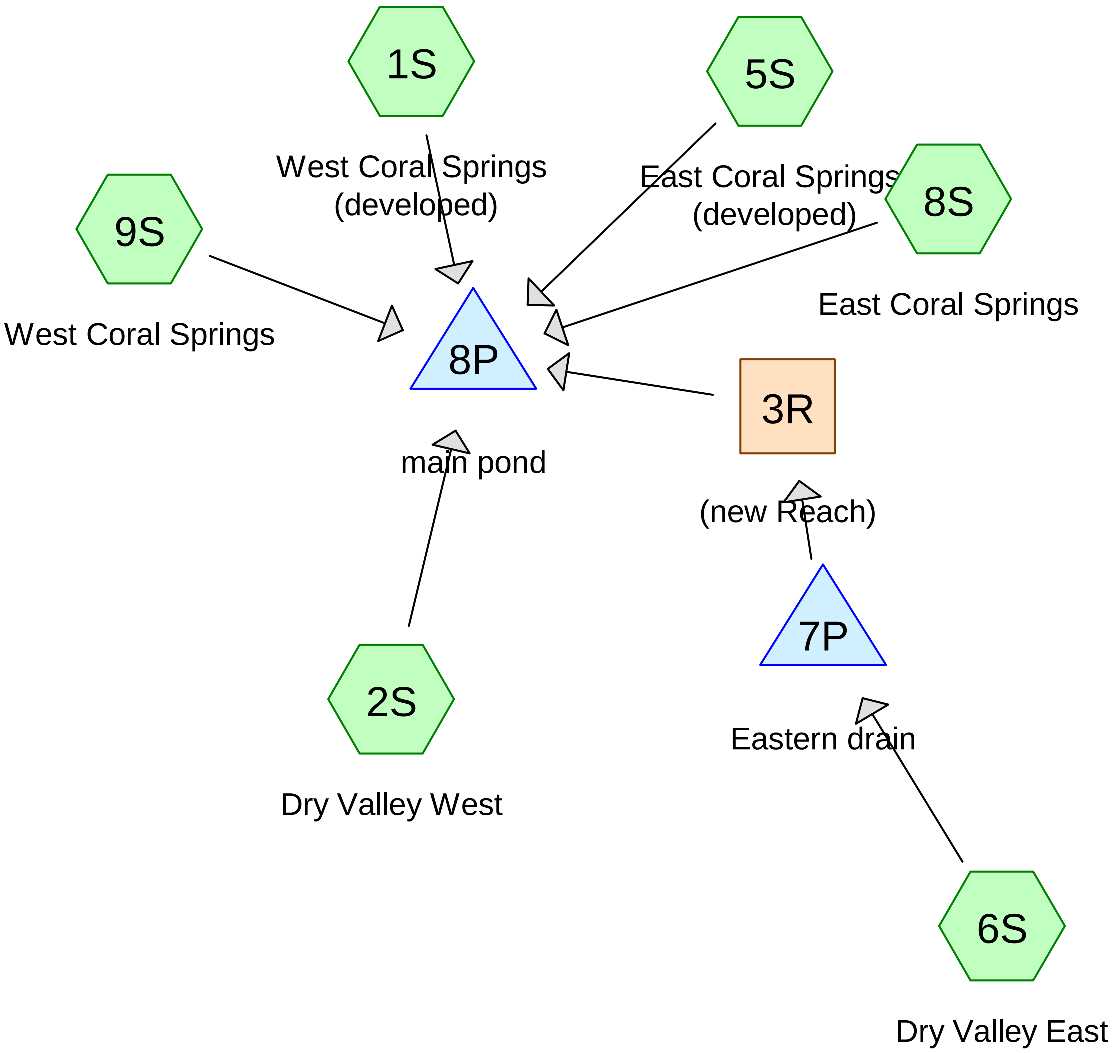
Reach 3R: (new Reach) Avg. Depth=0.99 m Max Vel=4.69 m/s Inflow=4.6366 m³/s 70.692 Ml
n=0.013 L=340.00 m S=0.0162 m/m Capacity=10.6285 m³/s Outflow=4.6343 m³/s 70.687 Ml

Pond 4P: main pond Peak Elev=17.483 m Storage=148.986 Ml Inflow=9.3129 m³/s 166.251 Ml
Outflow=0.3510 m³/s 67.964 Ml

Pond 7P: Eastern drain Peak Elev=21.448 m Storage=1.506 Ml Inflow=4.6750 m³/s 68.761 Ml
Outflow=4.6286 m³/s 68.761 Ml

Total Runoff Area = 332.4936 ha Runoff Volume = 174.540 Ml Average Runoff Depth = 52 mm
100.00% Pervious = 332.4936 ha 0.00% Impervious = 0.0000 ha

Appendix 4: Pre Development HydroCad results for 50 and 100 yr storms



Appendix 5: Post Development Model

Post Development 2yr storm

Time span=5.00-48.00 hrs, dt=0.05 hrs, 861 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: West Coral Springs (developed) Runoff Area=26.1334 ha 0.00% Impervious Runoff Depth=26 mm
Flow Length=592.0 m Tc=18.3 min CN=82 Runoff=1.4774 m³/s 6.721 Ml

Subcatchment 2S: Dry Valley West Runoff Area=66.9989 ha 0.00% Impervious Runoff Depth=0 mm
Flow Length=2,546.0 m Slope=0.0800 m/m Tc=155.6 min CN=45 Runoff=0.0007 m³/s 0.008 Ml

Subcatchment 5S: East Coral Springs (developed) Runoff Area=29.3600 ha 38.00% Impervious Runoff Depth=19 mm
Flow Length=435.0 m Tc=59.9 min CN=77 Runoff=0.6587 m³/s 5.613 Ml

Subcatchment 6S: Dry Valley East Runoff Area=139.2947 ha 0.00% Impervious Runoff Depth=0 mm
Flow Length=2,166.0 m Slope=0.1000 m/m Tc=122.3 min CN=45 Runoff=0.0017 m³/s 0.016 Ml

Subcatchment 8S: East Coral Springs Runoff Area=24.9400 ha 0.00% Impervious Runoff Depth=2 mm
Flow Length=1,050.0 m Tc=203.1 min CN=55 Runoff=0.0170 m³/s 0.545 Ml

Subcatchment 9S: West Coral Springs Runoff Area=28.0400 ha 0.00% Impervious Runoff Depth=0 mm
Flow Length=1,429.0 m Slope=0.0200 m/m Tc=181.4 min CN=48 Runoff=0.0028 m³/s 0.079 Ml

Reach 3R: (new Reach) Avg. Depth=0.01 m Max Vel=0.70 m/s Inflow=0.0097 m³/s 1.256 Ml
n=0.013 L=340.00 m S=0.0162 m/m Capacity=10.6285 m³/s Outflow=0.0097 m³/s 1.248 Ml

Pond 7P: Eastern drain Peak Elev=20.003 m Storage=0.000 Ml Inflow=0.0017 m³/s 0.016 Ml
Outflow=0.0017 m³/s 0.016 Ml

Pond 8P: main pond Peak Elev=13.710 m Storage=4.137 Ml Inflow=1.6502 m³/s 14.214 Ml
Outflow=0.6599 m³/s 13.422 Ml

Total Runoff Area = 314.7670 ha Runoff Volume = 12.983 Ml Average Runoff Depth = 4 mm
96.46% Pervious = 303.6102 ha 3.54% Impervious = 11.1568 ha

Post Development 25yr storm

Time span=5.00-48.00 hrs, dt=0.05 hrs, 861 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: West Coral Springs (developed) Runoff Area=26.1334 ha 0.00% Impervious Runoff Depth=112 mm
Flow Length=592.0 m Tc=18.3 min CN=82 Runoff=6.5330 m³/s 29.268 Ml

Subcatchment 2S: Dry Valley West Runoff Area=66.9989 ha 0.00% Impervious Runoff Depth=25 mm
Flow Length=2,546.0 m Slope=0.0800 m/m Tc=155.6 min CN=45 Runoff=0.8517 m³/s 16.875 Ml

Subcatchment 5S: East Coral Springs (developed) Runoff Area=29.3600 ha 38.00% Impervious Runoff Depth=99 mm
Flow Length=435.0 m Tc=59.9 min CN=77 Runoff=3.6790 m³/s 28.941 Ml

Subcatchment 6S: Dry Valley East Runoff Area=139.2947 ha 0.00% Impervious Runoff Depth=25 mm
Flow Length=2,166.0 m Slope=0.1000 m/m Tc=122.3 min CN=45 Runoff=2.0776 m³/s 35.084 Ml

Subcatchment 8S: East Coral Springs Runoff Area=24.9400 ha 0.00% Impervious Runoff Depth=45 mm
Flow Length=1,050.0 m Tc=203.1 min CN=55 Runoff=0.5647 m³/s 11.321 Ml

Subcatchment 9S: West Coral Springs Runoff Area=28.0400 ha 0.00% Impervious Runoff Depth=31 mm
Flow Length=1,429.0 m Slope=0.0200 m/m Tc=181.4 min CN=48 Runoff=0.4230 m³/s 8.667 Ml

Reach 3R: (new Reach) Avg. Depth=0.53 m Max Vel=3.95 m/s Inflow=2.0748 m³/s 36.324 Ml
n=0.013 L=340.00 m S=0.0162 m/m Capacity=10.6285 m³/s Outflow=2.0737 m³/s 36.318 Ml

Pond 7P: Eastern drain Peak Elev=20.846 m Storage=0.495 Ml Inflow=2.0776 m³/s 35.084 Ml
Outflow=2.0668 m³/s 35.084 Ml

Pond 8P: main pond Peak Elev=15.459 m Storage=50.139 Ml Inflow=8.0126 m³/s 131.390 Ml
Outflow=2.3838 m³/s 130.508 Ml

Total Runoff Area = 314.7670 ha Runoff Volume = 130.156 Ml Average Runoff Depth = 41 mm
96.46% Pervious = 303.6102 ha 3.54% Impervious = 11.1568 ha

Appendix 6: Post Development HydroCad results for 2 and 25 yr storms

Post Development 50yr storm

Time span=5.00-48.00 hrs, dt=0.05 hrs, 861 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: West Coral Springs (developed) Runoff Area=26.1334 ha 0.00% Impervious Runoff Depth=135 mm
Flow Length=592.0 m Tc=18.3 min CN=82 Runoff=7.8497 m³/s 35.385 Ml

Subcatchment 2S: Dry Valley West Runoff Area=66.9989 ha 0.00% Impervious Runoff Depth=37 mm
Flow Length=2,546.0 m Slope=0.0800 m/m Tc=155.6 min CN=45 Runoff=1.3452 m³/s 24.674 Ml

Subcatchment 5S: East Coral Springs (developed) Runoff Area=29.3600 ha 38.00% Impervious Runoff Depth=121 mm
Flow Length=435.0 m Tc=59.9 min CN=77 Runoff=4.5077 m³/s 35.528 Ml

Subcatchment 6S: Dry Valley East Runoff Area=139.2947 ha 0.00% Impervious Runoff Depth=37 mm
Flow Length=2,166.0 m Slope=0.1000 m/m Tc=122.3 min CN=45 Runoff=3.2981 m³/s 51.298 Ml

Subcatchment 8S: East Coral Springs Runoff Area=24.9400 ha 0.00% Impervious Runoff Depth=61 mm
Flow Length=1,050.0 m Tc=203.1 min CN=55 Runoff=0.7851 m³/s 15.260 Ml

Subcatchment 9S: West Coral Springs Runoff Area=28.0400 ha 0.00% Impervious Runoff Depth=44 mm
Flow Length=1,429.0 m Slope=0.0200 m/m Tc=181.4 min CN=48 Runoff=0.6357 m³/s 12.300 Ml

Reach 3R: (new Reach) Avg. Depth=0.75 m Max Vel=4.39 m/s Inflow=3.2885 m³/s 52.538 Ml
n=0.013 L=340.00 m S=0.0162 m/m Capacity=10.6285 m³/s Outflow=3.2868 m³/s 52.532 Ml

Pond 7P: Eastern drain Peak Elev=21.151 m Storage=0.921 Ml Inflow=3.2981 m³/s 51.298 Ml
Outflow=3.2805 m³/s 51.298 Ml

Pond 8P: main pond Peak Elev=16.134 m Storage=79.578 Ml Inflow=9.7446 m³/s 175.679 Ml
Outflow=2.6267 m³/s 174.721 Ml

Total Runoff Area = 314.7670 ha Runoff Volume = 174.445 Ml Average Runoff Depth = 55 mm
96.46% Pervious = 303.6102 ha 3.54% Impervious = 11.1568 ha

Post Development 100yr storm

Time span=5.00-48.00 hrs, dt=0.05 hrs, 861 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: West Coral Springs (developed) Runoff Area=26.1334 ha 0.00% Impervious Runoff Depth>158 mm
Flow Length=592.0 m Tc=18.3 min CN=82 Runoff=9.1140 m³/s 41.332 Ml

Subcatchment 2S: Dry Valley West Runoff Area=66.9989 ha 0.00% Impervious Runoff Depth=49 mm
Flow Length=2,546.0 m Slope=0.0800 m/m Tc=155.6 min CN=45 Runoff=1.8962 m³/s 33.073 Ml

Subcatchment 5S: East Coral Springs (developed) Runoff Area=29.3600 ha 38.00% Impervious Runoff Depth=143 mm
Flow Length=435.0 m Tc=59.9 min CN=77 Runoff=5.3109 m³/s 41.981 Ml

Subcatchment 6S: Dry Valley East Runoff Area=139.2947 ha 0.00% Impervious Runoff Depth=49 mm
Flow Length=2,166.0 m Slope=0.1000 m/m Tc=122.3 min CN=45 Runoff=4.6750 m³/s 68.761 Ml

Subcatchment 8S: East Coral Springs Runoff Area=24.9400 ha 0.00% Impervious Runoff Depth=77 mm
Flow Length=1,050.0 m Tc=203.1 min CN=55 Runoff=1.0151 m³/s 19.327 Ml

Subcatchment 9S: West Coral Springs Runoff Area=28.0400 ha 0.00% Impervious Runoff Depth=58 mm
Flow Length=1,429.0 m Slope=0.0200 m/m Tc=181.4 min CN=48 Runoff=0.8662 m³/s 16.154 Ml

Reach 3R: (new Reach) Avg. Depth=0.99 m Max Vel=4.69 m/s Inflow=4.6366 m³/s 70.001 Ml
n=0.013 L=340.00 m S=0.0162 m/m Capacity=10.6285 m³/s Outflow=4.6343 m³/s 69.996 Ml

Pond 7P: Eastern drain Peak Elev=21.448 m Storage=1.506 Ml Inflow=4.6750 m³/s 68.761 Ml
Outflow=4.6286 m³/s 68.761 Ml

Pond 8P: main pond Peak Elev=16.700 m Storage=112.284 Ml Inflow=11.4544 m³/s 221.864 Ml
Outflow=2.8363 m³/s 220.813 Ml

Total Runoff Area = 314.7670 ha Runoff Volume = 220.629 Ml Average Runoff Depth = 70 mm
96.46% Pervious = 303.6102 ha 3.54% Impervious = 11.1568 ha

Appendix 7: Post Development HydroCad results for 50 and 100 yr storms