SECTION G

STORM DRAINAGE STUDY

The following storm water drainage study has been prepared with regard to on-site storm water retention for the proposed development of the three-story office addition and parking area.

The design procedure as outlined in ordinance no. 1978-47, exhibit A has been used for the basis of this report. The type of discharge control employed in this study is for off-stream retention basins. The discharge curve of the hydrograph is horizontal throughout the duration of the storm and run-off. The required retention volume will be provided on the surface of the parking lot at an average depth of four inches (4”). This impoundment of water will result due to the use of flow control device placed in the last down stream manhole.

SUMMARY OF DRAINAGE PARCEL REQUIREMENTS

Existing Drainage Parcel

The existing drainage parcel as defined on plan 0883-5 contains an area of 2.649 acres of land. The existing one story office building was built in 1970, prior to the existence of ordinance 1978-08 (Storm Drainage) and has been determined to be exempt from the Storm Water Retention Requirements for the proposed office addition.

DRAINAGE PARCEL #1

Drainage parcel #1 contains 1.201 acres of land of which 0.747 acres is pervious and 0.454 acres is impervious. **The Allowable Discharge (Qa) = 0.259 CFS**, Required Retention Volume = 4,163 CF, and the Design Retention Volume = 6,700 CF.

DRAINAGE PARCEL #2

Drainage parcel #2 contains 2.957 acres of land of which 1.133 acres is pervious and 1.824 acres is impervious. **The Allowable Discharge (Qa) = 0.680 CFS**, Required Retention Volume = 11,190 CF, and the Design Retention Volume = 14,476.

DRAINAGE PARCEL #3

Drainage parcel #3 contains 2.567 acres of land of which 0.764 acres is pervious and 1.803 acres is impervious. **The Allowable Discharge (Qa) = 0.524 CFS**, Required Retention Volume = 10,320 CF, and the Design Retention Volume = 14,802 CF.

FUTURE (PHASE II) DRAINAGE PARCEL

The future (Phase II) drainage parcel contains 5.055 acres of land, which will remain un-developed. Storm water retention must be provided within this 5.055 acre parcel when it is developed.

SUMMARY OF EXISTING AND PROPOSED LAND USE FOR THE VARIOUS DRAINAGE PARCELS

DRAINAGE PARCEL #1

	Existing Land Use	Proposed Land Use
Pervious Area C = .3	1.163 ac	0.747 ac
Impervious Area C = .84	0.038 ac	0.454 ac
Total Area	1.201 ac	1.201 ac

DRAINAGE PARCEL #2

	Existing Land Use	Proposed Land Use
Pervious Area C = .3	2.746 ac	1.133 ac
Impervious Area C = .84	0.211 ac	1.824 ac
Total Area	2.957 ac	2.957 ac

DRAINAGE PARCEL #3

	Existing Land Use	Proposed Land Use
Pervious Area C = .3	2.567 ac	0.764 ac
Impervious Area C = .84	0 ac	1.803 ac
Total Area	2.567 ac	2.567 ac

NOTE:

A drainage charge of $1,100.00 per acre will be assessed on the area to be improved within the development. Namely, the sum of the acreage of drainage parcel #1, #2 and #3 or 6.725 ac.

The following assumptions have been incorporated into the calculations of ref-stream retarding basin volumes.

1.) Time of concentration (Tc) = 15 min
2.) The shape of the area under the discharge curve is rectangular
3.) Rate of infiltration = 0.5 in/hr
4.) Run-off from a developed site cannot exceed 2/3 of the existing storm water run-off based on a 10 year rainfall intensity curve

EQUATIONS

Qa = 2/3 Ce I A

Allowable Discharge = two-thirds of the existing run-off co-efficient, times the intensity of a 2 hour storm, times the area in acres.

Q10 = Cp I10 A

Peak Inflow Rate = the proposed land use run-off co-efficient, times the intensity of the 10 year storm at various storm durations, times the area in acres.

I 1 = (.25 x I10) + .75 (I10 – 0.5)

Run-Off Rate = 25% of the 10 year intensity plus 75% of the 10 year intensity less the infiltration rate.

Vt = I1, Td A (60.5)

Total Inflow Volume = Run-off rate, times the time of duration, times the area, times a conversion factor of 60.5.

$$\frac{Vt \times 2}{Q10 \times 60} - (Td - Tc)$$

End of Run-Off Time = Total inflow volume times two divided by the peak inflow rate times a conversion factor of 60, minus the difference between the time of duration and the time of concentration.

Volume of Store Required= Total inflow volume (Vt) less the total discharge of (Qa) (Te) (60)

Drainage Parcel #1

Design of off stream retarding basins.

Area = 1.201 ac
Tc = 15 min
Infiltration = 0.5 in/hr

$Cp = 0.747 \times .3 = 0.224$
$\quad\; 0.454 \times .84 = \underline{0.381}$
$\quad\quad\quad\quad\quad\quad\; 0.605$

$Cp = \frac{0.605}{1.201} = 0.504$

$Ce = 1.163 \times .3 = 0.3489$
$\quad\; \underline{0.038} \times .84 = \underline{0.0319}$
$\quad\; 1.201 \quad\quad\; 0.3808$

$Ce = \frac{0.3808}{1.201} = 0.317$

Qa = 2/3 Ce I A = 2/3 (0.317) (1.02) (1.201) = 0.259 CFS

(1) Td = 15 min
I10 = 4.21 in/hr
Qa = 0.259 CFS
A = 1.201 ac
Cp = 0.504

Peak Flow Rate

Q10 = Cp I10 A = 0.504 (4.21) 1.201 = 2.55 CFS

Run-Off Rate

I1 = (.25 x I10) + .75 (I10 – 0.5) = (.25 x 4.21) + .75 (4.21 – 0.5) = 3.83 in/hr

Total Inflow Volume

Vt = I1 Td A (60.5) = 3.83 (15) (1.201) 60.5 = 4.174 CF

End of Run-Off Time

$Te = \frac{Vt \times 2}{Q10 \times 60} - (Td - Tc) = \frac{4.174 \times 2}{2.55 \times 60} - 0 = 54.56 \text{ min}$

Volume of Storage Required

Total Inflow (Yt)	= 4,174
Total discharge (Qa) (Te) (60) = 0.259 (54.56) (60) =	848
	3,326 CF

(2) Td = 30 min
I10 = 2.91 in/hr
Qa = 0.259 CFS
A = 1.201 AC
Cp = 0.504

Peak Inflow Rate

Q10 = 0.504 (2.91) (1.201) = 1.76 CFS

Run-Off Rate

I1 = .25 (2.91) = .75 (2.91 - 0.5) = 2.54 in/hr

Total Inflow Volume

Vt = 2.54 (30) (1.201) (60.5) = 5,537 CF

End of Run-Off Time

$$Te = \frac{5{,}537 \times 2}{1.76 \times 60} - 15 = 89.87 \text{ min}$$

Volume of Storage Required

Total Inflow (Vt)	5,537
Total Discharge (0.259) 89.87 (60) =	1,397
	4,140 CF

(3) Td = 45 min
- I10 = 2.22 in/hr
- Qa = 0.259 CFS
- A = 1.201 Ac
- Cp = 0.504

Peak Inflow Rate

Q10 = 0.504 (2.22) (1.201) = 1.344 CFS

Run-Off Rate

I1 = .25 (2.22) + .75 (2.22 – 0.5) = 1.84 in/hr

Total Inflow Volume

Vt = 1.84 (45) (1.201) (60.5) = 6,016 CF

End of Run-Off Time

$$Te = \frac{6{,}016 \times 2}{1.344 \times 60} - 30 = 119.21 \text{ min}$$

Volume of Storage Required

Total Inflow	6,016
Total Discharge (0.259) (119.21) (60)	1,853
	4,163 CF *max

(4) Td = 60min
- I10 = 1.80 in/hr
- Qa = 0.259 CFS
- A = 1.201 ac
- Cp = 0.504

Peak Inflow Rate
Q10 = 0.504 (1.80) (1.201) = 1,090 CFS

Run-Off Rate
I1 = (.25 x 1.80) + .75 (1.80 – 0.5) = 1.42 in/hr

Total Inflow Volume
Vt = 1.42 (60) (1.201) (60.5) = 6,191 CF

End of Run-Off Time

$$Te = \frac{6,191 \times 2}{1.09 \times 60} - 45 = 144.33 \text{ min}$$

Volume of Storage Required

Total Inflow	6,191
Total Discharge (0.259) (144.33) (60)	2,243
	3,948 CF

Design of Off-Stream Retarding Basin

Area	=	2.957 ac
Tc	=	15 min
Infiltration Rate	=	0.5 in/hr

$$Cp = \frac{\begin{matrix}1.133 \times .3 = 0.3393 \\ 1.824 \times .84 = 1.5322\end{matrix}}{2.957} \quad \underline{1.8715}$$

Cp = 1.133 x .3 = 0.3393
1.824 x .84 = 1.5322
2.957 1.8715

$$Cp = \frac{1.8715}{2.957} = 0.633$$

Ce = 2.746 x .3 = 0.8238
0.211 x .84 = 0.1772
2.957 1.0010

$$Ce = \frac{1.001}{2.957} = 0.338$$

Qa = 2/3 Ce I A = 2/3 (0.338) (1.02) (2.957) = 0.680 CFS

(1) Td = 15 min
I10 = 4.21 in/hr
Qa = 0.680 CFS
A = 2.957 Ac.
Cp = 0.633

Peak Inflow Rate
Q10 = Cp I10 A = 0.633 (4.21) (2.957) = 7.88 CFS

Run Off Rate
I1 = (.25 x I10) = .75 (I10 -0.5) = (.25 x 4.21) = .75 (4.21 – 0.5) = 3.83 in/hr

Total Inflow Volume

Vt = I1 Td A (60.5) = 3.83 (15) (2.957) (60.5) = 10.278 CF

End of Run-Off Time

$$Te = \frac{Vt \times 2}{Q10 \times 60} - (Td - Tc) = \frac{10.278 \times 2}{7.88 \times 60} - 0 = 43.48 \text{ min}$$

Volume of Storage Required

Total Inflow (Vt)	10,278
Total Discharge (Qa) Te (60) = 0.680 (43.48) 60	1,774
	8,504 CF

(2) Td = 30 min

I10 = 2.91 in/hr

Qa = 0.680 CFS

A = 2.957 Ac

Cp = 0.633

Peak Inflow Rate

Q10 = 0.633 (2.91) (2.957) = 5.45 CFS

Run-Off Rate

I1 = .25 (2.91) + .75 (2.91- 0.5) = 2.54 in/hr

Total Inflow Volume

Vt = 2.54 (30) (2.957) (60.5) = 13,632 CF

End of Run-Off Time

$$Te = \frac{13{,}632 \times 2}{5.45 \times 60} - 15 = 68.38 \text{ min}$$

Volume of Storage Required

Total Inflow (Vt)	13,632
Total Discharge (0.580) 68.38 (60) =	2.790
	10,842 CF

(3) Td = 45 min

I10 = 2.22 in/hr

Qa = 0.680 CFS

A = 2.957

Cp = 0.633

Peak Inflow Rate

Q10 = 0.633 (2.22) 2.957 = 4.155 CFS

Run-Off Rate

I1 = .25 (2.22) + .75 (2.22 – 0.5) = 1.84 in/hr

Total Inflow Volume

Vt = 1.84 (45) (2.957) 60.5 = 14.813 CF

End of Run Time

$$Te = \frac{14.813 \times 2}{4.155 \times 60} - 30 = 88.8 \text{ Min.}$$

Volume of Storage Required

Total Inflow	14,813
Total Discharge (0.680) (88.8) (60) =	3,623
	11,190 CF *Max.

(4) Td = 60 min
I10 = 1.80 in/hr
Qa = 0.680 CFS
A = 2.957 ac
Cp = 0.633

Peak Inflow Rate

Q10 = 0.633 (1.80) (2.957) = 3.369 CFS

Run-Off Rate

I1 = .25 (1.80) + .75 (1.80-0.5) = 1.42 in/hr

Total Inflow Volume

Vt = 1.42 (60) (2.957) 60.5 = 15,242 CF

End of Run-Off Time

$$Te = \frac{15{,}242 \times 2}{3{,}369 \times 60} - 45 = 105.81 \text{ min}$$

Volume of Storage Required

Total Inflow	15,242
Total Discharge (0.680) (105.81) (60) =	4,317
	10,925

(2) Td = 30 min
I10 = 2.91 in/hr
Qa = 0.524 CFS
A = 2.567 ac
Cp = 0.679

Peak Inflow Rate

Q10 = 0.679 (2.91) (2.567) = 5.07 CFS

Run-Off Rate

I1 = .25 (2.91) + .75 (2.91-0.5) = 2.54 in/hr

Total Inflow Volume

Vt = 2.54 (30) (2.567) (60.5) = 11,834 CF

End of Run-Off Rate

$$Te = \frac{11,834 \times 2}{5.07 \times 60} - 15 = 62.80 \text{ min}$$

Volume of Storage Required

Total Inflow	11,834
Total Discharge (0.524) (62.8) (60)	1,974
	9,860 CF

(3) Td = 45 min
I10 = 2.22 in/hr
Qa = 0.524 CFS
A = 2.567 ac
Cp = 0.679

Peak Inflow Rate

Q10 = 0.679 (2.22) (2.567) = 3.87CFS

Run-Off Rate

I1 = .25 (2.22) + .75 (2.22 - 0.5) = 1.84 in/hr

Total Inflow Volume

Vt = 1.84 (45) (2.567) 60.5 = 12,859 CF

End of Run-Off Time

$$Te = \frac{12,859 \times 2}{3.87 \times 60} - 30 = 80.76 \text{ min}$$

Volume of Storage Required

Total Inflow	12,859
Total Discharge (0.524) (80.76) 60	2,539
	10,320 CF *Max

(4) Td = 60min
I10 = 1.80 in/hr
Qa = 0.524 CFS
A = 2.567 ac
Cp = 0.679

Peak Inflow Rate
Q10 = 0.679 (1.80) (2.567) = 3.14 CFS

Run-Off Rate
I1 = .25 (1.80) + .75 (1.80 – 0.5) = 1.42 in/hr

Total Inflow Volume
Vt = 1.42 (60) (2.567) (60.5) = 13,232 CF

End of Run-Off Time
$$Te = \frac{13,232 \times 2}{3.14 \times 60} - 45 = 95.47 \text{ min}$$

Volume of Storage Required

Total Inflow	13,232
Total Discharge (0.524) (95.47) (60) =	3,002
	10,230 CF

SUMMARY

DRAINAGE PARCEL #1

Duration	Peak Inflow Rate	Volume of Inflow	Volume of Discharge	Storage Required	
15 min	2.55 CFS	4,174 CF	848 CF	3,326 CF	
30 min	1.76 CFS	5,537 CF	1,397 CF	4,140 CF	
45 min	1.34 CFS	6,016 CF	1,853 CF	4,163 CF	*Max
60 min	1.09 CFS	6,191 CF	2,243 CF	3,948 CF	

The maximum storage volume for this off-stream retarding basin with a controlled discharge of 0.259 CFS is 4,163 CF.

DRAINAGE PARCEL #2

Duration	Peak Inflow Rate	Volume of Inflow	Volume of Discharge	Storage Required	
15 min	7.88 CFS	10,278 CF	1,774 CF	8,504 CF	
30 min	5.45 CFS	13,632 CF	2,790 CF	10,842 CF	
45 min	4.16 CFS	14,813 CF	3,623 CF	11,190 CF	*Max
60 min	3.37 CFS	15,242 CF	4,317 CF	10,925 CF	

The maximum storage volume for this off-stream retarding basin with a controlled discharge of 0.680 CFS is 11,190 CF.

DRAINAGE PARCEL #3

Duration	Peak Inflow Rate	Volume of Inflow	Volume of Discharge	Storage Required	
15 min	7.34 CFS	8,922 CF	1,274 CF	7,648 CF	
30 min	5.07 CFS	11,834 CF	1,974 CF	9,860 CF	
45 min	3.87 CFS	12,859 CF	2,539 CF	10,320 CF	*Max
60 min	3.14 CFS	13,232 CF	3,002 CF	10,230 CF	

The maximum storage volume for this off-stream retarding basin with a controlled discharge of 0.524 CFS is 10,320 CF.