

# FINAL STORM DRAINAGE ANALYSIS

## WATERFORD PLACE SUBDIVISION SECTION 2

*Bounded by Vogel Road to the north; Columbia Street to the South;  
Stockfleith Ditch to the West; & Tutor Lane to the East  
BLA Project No. 194-0021-OPD*

**RECEIVED**

**JUL 15 2008**

Vanderburgh County Engineering

Prepared for:

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&  
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March 13, 2008

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## INTRODUCTION

Decem Investments, Inc. and Waterford Commons, LLP have plans to further subdivide the remainder of this tract of land. The subject tract contains 11 lots. The preliminary design assumption shall be made to perform the necessary preliminary hydraulics as part of the primary plat approval process:

- That nearly all of the stormwater runoff within the overall drainage area made up of lots 3, 4, 5, 6 and 7 will be directed and routed through a new lake to be constructed near the southwest corner of this watershed area (total contributory area = 12.19 acres (531,037 square feet)).
- That nearly all of the stormwater runoff within the overall drainage area made up of Lots 8, 9, 10 & 11 and the adjoining section of Waterford Boulevard and will be divided and routed through an existing lake situated on the east end of Lots 8 and 9 (total contributory area = 8.76 acres (381,558 square feet)).
- That the stormwater storage for the Raffi development, located on Lot 5 of the original Waterford plat located east of Tutor Lane will be accounted for in the storage requirement for the existing lake described above (total contributory area = 0.96 acres (41,772 square feet)).
- That the stormwater storage for the Realty Group parcel, located on Lot 10 of this plat and to the south of the existing lake described above, will be accounted for in the storage requirement for the existing lake described above (total contributory area = 0.678 acres (29,568 square feet)—which is included in 8.76 acreage noted above).
- That the stormwater storage requirement for the Evansville Clinic development be accounted for in the same existing lake (total contributory area = 1.13 acres (49,145 square feet)—which is included in 8.76 acreage noted above).
- That the existing lake that lies between the Waterford Commons/Geiger Minerals, LLC tract (Lots 9A and 9B) of the Replat of Lot 9 of Waterford Place and both the Sweet Investments LLC (Lot 7 of Waterford Place) and the Sugarbakers/Ken & Ann Pate property (Lot 8 of Waterford Place will be enlarged to accommodate the development of Lots 1 and 2 of this plat (total contributory area = 6.41 acres (279,379 square feet)).

Based on the redefined watershed area described above, the stormwater storage requirement for each watershed will be re-analyzed and the results compared to those previously reported and/or the existing facilities as previously constructed. If the existing basins have adequate capacity, no suggested changes to the lakes will be made. Should the existing lakes be undersized and not have adequate storage capacity, a plan for expansion of these lake areas will be shown. The amount of additional cubic footage of storage volume required will be quantified.

In addition, the existing outlet structures for the two existing lakes will be re-analyzed and, if necessary, modifications to these structures will be made. The existing outlet structures are possibly undersized for the additional growth programmed into these existing lakes and will consequently further reduce the allowable outflow for these basins beyond that required by the stormwater ordinance. This will result in higher storage volumes required for each pond and will only yield a more conservative value. Should the outfalls prove to be oversized, further restriction will be designed and built into the lake outfall structures.

For the new lake to be constructed as part of the development of Lots 3, 4, 5, 6 and 7, a lake meeting the requirements for stormwater storage will be shown that meets the intended parameters. An outlet control structure will also be determined. The developer of these lots may wish to reconfigure or relocate the lake and, if so desired, will need to resubmit a new plan for this site that meets or exceeds the parameters established herein.

The compilation of this report and statement of its findings shall serve to fulfill the developer's previous agreement that if any owner/developer of the Waterford Place did not fulfill their drainage obligation, this plan, when implemented, will satisfy those requirements for the previously approved drainage plans contained in the following paragraph:

*"As previously agreed, if any owner/developer of this remaining portion of the Replat of Waterford Place fails to fulfill this drainage obligation, East Park Development/Decem Investments will construct a basin on the remaining undeveloped real estate sized to handle the storm water detention requirements for any lot found to be deficient and/or not in accordance with a particular lots approved drainage plan."*

## **METHOD**

The Rational Method ( $Q = CIA$ ) will form the basis for this analysis. The inflow/outflow analysis will be calculated to determine the storage requirements needed to preserve the runoff rate from the existing 10 year storm and store the additional runoff generated by the developed 25 year, 50 year and 100 year storms. A larger Time of Concentration resulting in reduced allowable outflow rates will also be considered if it is necessary to match the existing allowable outflow rates made available by the existing outlet control structures.

At present, a roadside ditch along Columbia Street drains the south end of the property and the lake constructed on Lots 8 and 9 to the Stockfleith Ditch which lies west of the subject property. This was the outlet ditch assumed in the original plan approval. Since that time, an outlet pipe and swale have been run west and south to this ditch. The Owner will pipe the remainder of this swale which will tie into the drainage facilities to be located in Kimber Lane.

For this final drainage submittal, the required storage previously committed to for Lots 1, 2, 3, 4, 6 and 12 (developments to the east of this project) is considered satisfactory and therefore is not being addressed in this report. However, Lot 5 (Raffi's) is being addressed in this report because of some concern about available retention. In addition, Lot 9D (Hooks Apothecary) and Lot 9C (Evansville Federal Credit Union) have been built as approved by the drainage board and are, therefore, not being considered a part of this plan. Even though Sugarbakers, Stephen Libbs and Village Commons drainage have also been previously approved, we are going to share their facility with Lots 1 and 2 of this development and these developments, therefore, will be included in this analysis.

A plan submitted for The Realty Group was approved, but due to its proximity to Lake No. 1, we are asking that the original plan be considered null and void and that the drainage requirement for said parcel be made a part of this plan. Also shown on the drainage plan is an additional building west of The Realty Group (The Evansville Clinic) that will be addressed in this plan and report.

A value of 0.2 will be used for the undeveloped runoff coefficient ("c"). This is a value that has been accepted by the local authority to best describe those drainage characteristics for that portion of the east side of Evansville from Green River Road east to the Vanderburgh/Warrick county line and from the Lloyd Expressway north to Morgan Avenue.

The developed weighted runoff coefficient of 0.70 will be utilized for the proposed final development plan. This value takes into account all of the existing development including the buildings shown on the plan and anticipated buildings on the remaining lots.

## RESULTS

The allowable outflow rate of 6.87 cfs was calculated for the 12.19 acre development area (shown in red on drainage plan) using a 30 minute Time of Concentration. This 6.87 cfs outflow will be used to size the primary outlet. A 15 inch diameter pipe will be used to control this release rate.

The allowable outfall rate of 5.20 cfs was calculated for the 9.72 acre development area (shown in green on the drainage plan) using a 32 minutes Time of Concentration. This allowable rate is nearly equal to that rate made available by the existing structure, being 5.21 cfs at 1.6 foot of head.

The allowable outflow rate of 4.76 cfs was calculated for the 6.41 acre development area (shown in orange on the drainage plan). This allowable outfall rate is nearly equal to that rate made available by the existing structure, being 4.76 cfs at 1.9 foot of head.

The required stormwater storage required for the 12.19 acre development (**red**) is:

		Cubic Feet	Acre-Feet
Q <sub>100</sub>	=	74,468	1.71
Q <sub>50</sub>	=	59,771	1.37
Q <sub>25</sub>	=	47,722	1.10

based on a theoretical outflow rate of 6.87 cfs.

**NOTE: Basin 1 (red)** available storage to elevation 385.00 = 2.05 acre-feet (exceeds 100 year requirement).

The required stormwater storage required for the 9.72 acre development (**green**) is:

		Cubic Feet	Acre-Feet
Q <sub>100</sub>	=	60,301	1.38
Q <sub>50</sub>	=	48,450	1.11
Q <sub>25</sub>	=	38,711	0.89

based on the allowable rate of 5.20 cfs—attainable through the existing outfall structure

**NOTE: Basin 2 (green)** available storage to elevation 385.00 = 2.03 acre-feet (exceeds 100 year requirement).

The required stormwater storage required for the 6.41 acre development (**orange**) is:

		Cubic Feet	Acre-Feet
Q <sub>100</sub>	=	35,964	0.83
Q <sub>50</sub>	=	28,695	0.66
Q <sub>25</sub>	=	22,482	0.52

based on the allowable rate of 4.76 cfs—attainable through the existing outfall structure

**NOTE: Basin 3 (orange)** available storage to elevation 385.00 = 0.70 acre-feet (exceeds 50 year requirement).

**(Orange Enlarged** as shown on plan) available storage to elevation 385 = 0.92 acre-feet (exceeds 100 year requirement).

## SUMMARY

The drainage parameters established modifications to existing facilities, construction of new facilities as presented herein, if adhered to, shall serve as final drainage approval. Any proposed changes or alterations to said plans will require an amended plan and approval prior to issuance of building permits for these sites.

The final result will produce very attractive stormwater retention facilities, able to satisfy the drainage from this development. They are, for the most part, removed from any right-of-way or peripheral area that would need to be utilized in the future for road widening or other purposes. All maintenance of these facilities will become the responsibility of the developer/owner of the adjoining complex.

That portion of entrance road lining up with Waterford Boulevard that lies west of Tutor Lane is to become a public roadway in a perpetual roadway easement. Any drainage and storm sewers necessary to properly drain said roadway will be contained within easements for access is not needed.

All maintenance of the drainage facilities will be the responsibility of the individual land owners who abut these facilities.

## APPENDICES INDEX

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Appendix B	-	Runoff Coefficients
Appendix C	-	Time of Concentration
Appendix D	-	Storage Volume Data
Appendix E	-	Outlet Control Structure
Appendix F	-	Basin Volume

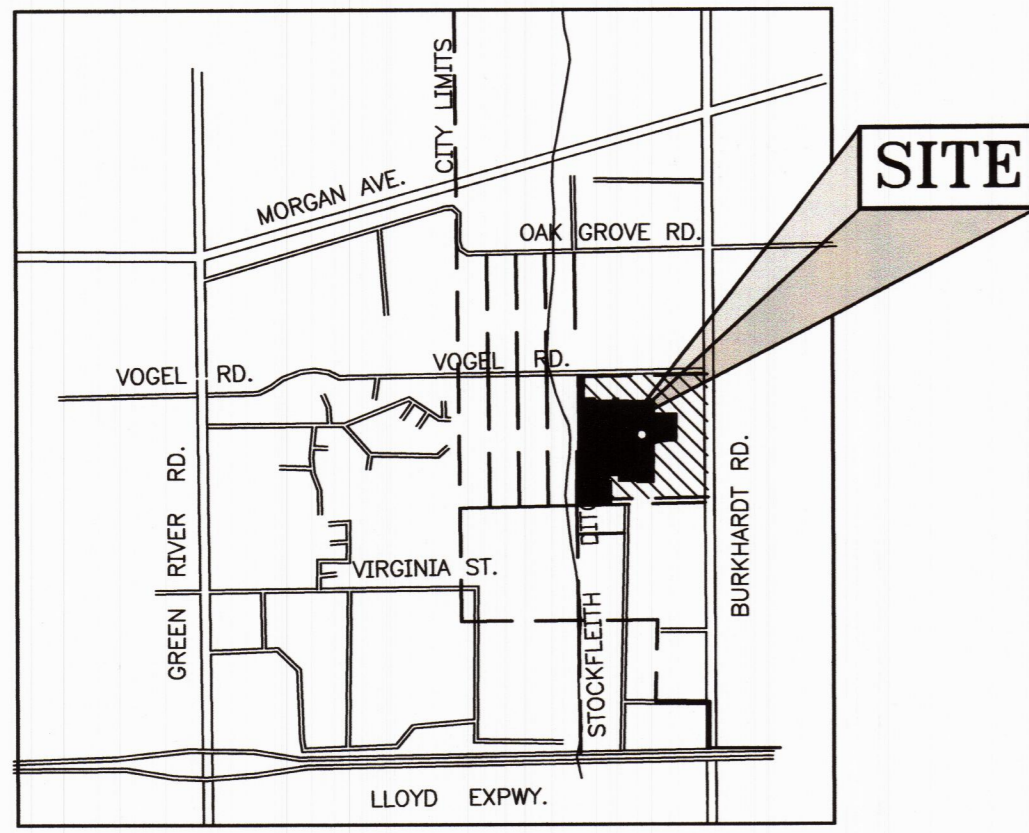
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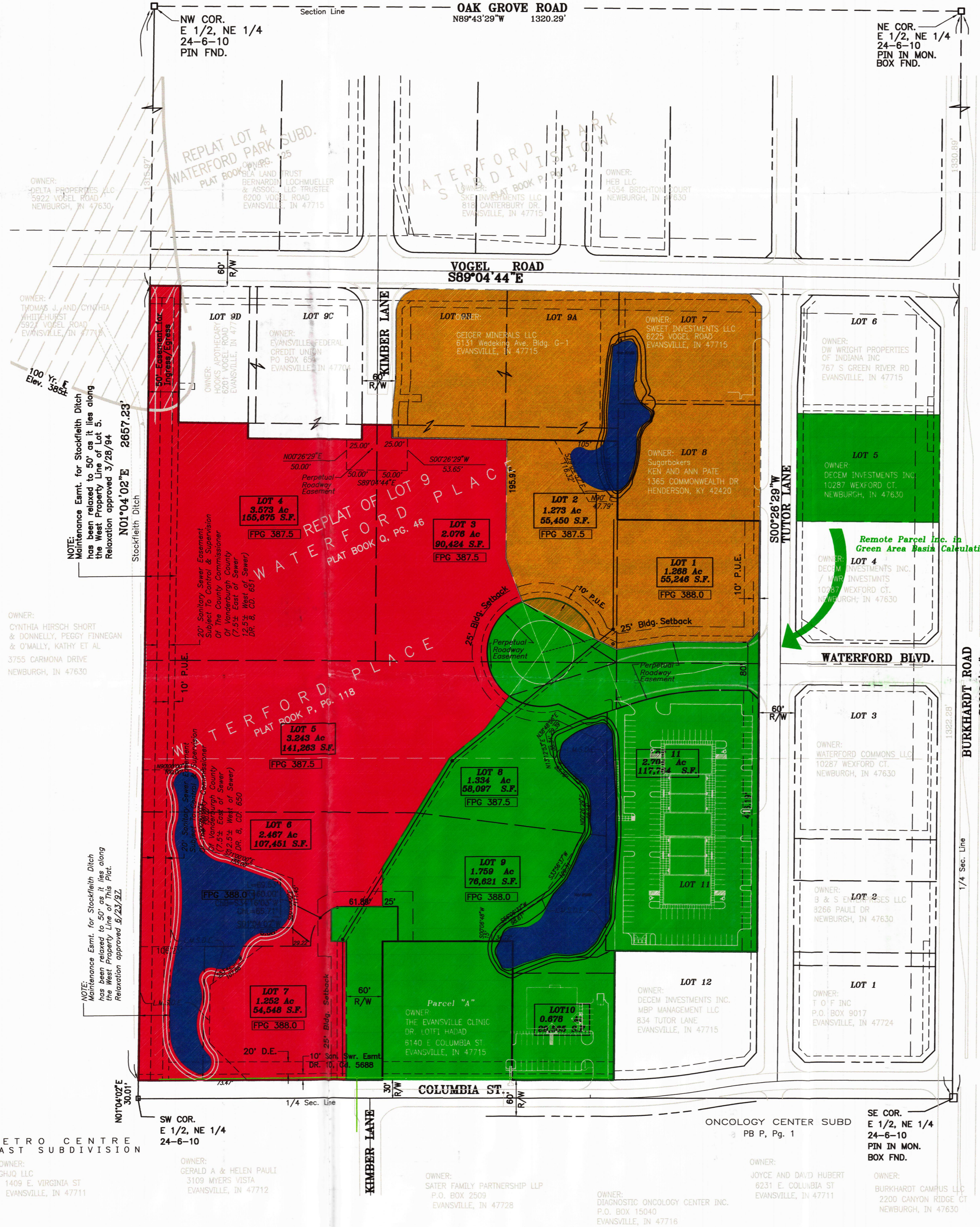
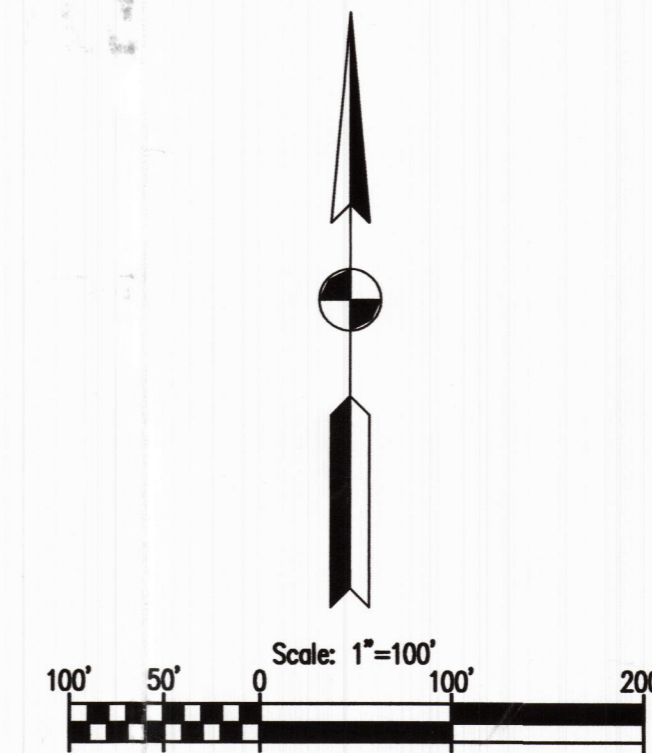
**APPENDIX "A"**  
**DRAINAGE PLAN**

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# WATERFORD PLACE SUBDIVISION DRAINAGE PLAN



**LOCATION MAP**  
KNIGHT TWP.  
VANDERBURGH CO.  
SEC. 24, T 6 S - R 10 W



**Red Area Summary**  
Proposed Lake Shown  
100 Year Proposed Lake Capacity 89,317 cft  
100 Year Storage Requirement 74,468 cft


**Green Area Summary**  
Existing Lake Shown  
100 Year Existing Lake Capacity 88,272 cft  
100 Year Storage Requirement 60,301 cft

**Brown Area Summary**  
Expanded Lake Shown  
100 Year Existing Lake Capacity 30,442 cft  
100 Year Expanded Lake Capacity 40,137 cft  
100 Year Storage Requirement 35,964 cft

**Rational Method Q=cia**  
"C" undeveloped = 0.20  
"C" developed = 0.70  
T<sub>c</sub> = 30 Min/ i<sub>10</sub> = 2.818  
Allowable Release Rate = 6.87 cfs

**Rational Method Q=cia**  
"C" undeveloped = 0.20  
"C" developed = 0.70  
T<sub>c</sub> = 32 Min/ i<sub>10</sub> = 2.673  
Allowable Release Rate = 5.20 cfs

**Rational Method Q=cia**  
"C" undeveloped = 0.20  
"C" developed = 0.70  
T<sub>c</sub> = 20.5 Min/ i<sub>10</sub> = 3.715  
Allowable Release Rate = 4.76 cfs

 JAMES A. FARN REGISTERED No. 20434 STATE OF INDIANA PROFESSIONAL ENGINEER	<b>DRAINAGE PLAN</b> FOR <b>WATERFORD PLACE SUBDIVISION</b> SECTION 2 VANDERBURGH COUNTY, INDIANA		Prepared By <b>BERNARDIN LOCHMUELLER &amp; ASSOC., INC.</b> Planners - Engineers - Surveyors <small>2208 Lloyd Blvd. Evansville, IN 47715 (812) 439-0200</small>	DATE: 3/13/08 PROJECT NO.: 194-0021 OPD ISSUED: 3/13/08	1
Num. Description Date					

**APPENDIX "B"**  
**RUNOFF COEFFICIENTS**

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**UNDEVELOPED "c" FACTOR = 0.20 (TABLE 803)  
Cultivated Fields (Less than 2%)**

*NOTE: This is a value used extensively throughout the area that lies between the Lloyd Expressway and Morgan Avenue, and between Green River Road and I-164.*

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**DEVELOPED WEIGHTED "C" FACTOR**

**(As previously reported for other adjoining developments)**

**"c" = 0.70**

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**APPENDIX "C"**  
**TIME OF CONCENTRATION**

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TIME OF CONCENTRATIONSHEET FLOW

(Kirby's Formula)

$$TC = .827 \left[ \frac{(N)(L)}{\sqrt{S}} \right]^{.467}$$

N = 0.4 Coefficient Pasture/Grass

L = Length = 250'

H = 384.00 - 383.35 = 0.5

S = Slope = .0022

$$TC = .827 \left[ \frac{(0.4)(225)}{\sqrt{.0022}} \right]^{.467} = 30 \text{ minutes}$$

(T/c of 30 min. used for undeveloped area (Red))

(T/c of 32 min. used to match existing outlet flow (Green))

(T/c of 20.5 min. used to match existing outlet flow (Orange))

INTENSITY

$$I = \frac{C(T)^\alpha}{(Tc+d)^\beta}$$

Factors for Evansville / Newburgh Area

C = 1.9533

T = duration

 $\alpha = 0.1747$ 

Tc = Time of Concentration (10 yr. undeveloped)

d = 0.522

 $\beta = 1.6408$ 

$$I_{10} \text{ (red)} = \frac{1.9533(10)^{0.1747}}{(30/60+0.522)^{1.6408}} = \frac{2.9206}{1.036} = 2.818$$

$$I_{10} \text{ (green)} = \frac{1.9533(10)^{0.1747}}{(32/60+0.522)^{1.6408}} = \frac{2.9206}{1.0924} = 2.673$$

$$I_{10} \text{ (orange)} = \frac{1.9533(10)^{0.1747}}{(20.5/60+0.522)^{1.6408}} = \frac{2.9206}{0.7862} = 3.715$$

TABLE 803  
UNDEVELOPED RUNOFF COEFFICIENTS ("C")  
SURFACE TYPE:

WOODLAND, TURFED MEADOWS  
ROUGH PASTURE, FALLOW BRUSH:

## SLOPE:

Less than	2%	C = 0.12
2% to	5%	C = 0.24
5 + % to	10%	C = 0.36
Over	10%	C = 0.48

## CULTIVATED FIELDS:

Less than	2%	C = 0.20
2% to	5%	C = 0.35
5 + % to	10%	C = 0.50
Over	10%	C = 0.65

TABLE 804  
DEVELOPED RUNOFF COEFFICIENTS ( $C_d$ )  
SURFACE TYPE:

PAVEMENT, ROOFTOP  
OTHER IMPERVIOUS SURFACES:

## SLOPE

Less than	2%	C = 0.92
2% to	5%	C = 0.94
5 + % to	10%	C = 0.96
Over	10%	C = 0.98

## LAWNS WITH TURF

Less than	2%	C = 0.15
2% to	5%	C = 0.25
5 + % to	10%	C = 0.40
Over	10%	C = 0.55

ALL WATER SURFACES  
BASINS, PONDS & LAKES

C = 1.00

**TABLE 807**  
**RAINFALL INTENSITY-DURATION-FREQUENCY TABLE FOR EVANSVILLE**

<b>INTENSITY IN INCHES PER HOUR</b>					
<b>STORM DURATION</b>	<b>STORM RETURN PERIOD IN YEARS</b>				
	<b>5</b>	<b>10</b>	<b>25</b>	<b>50</b>	<b>100</b>
<b>5 MIN</b>	6.063	6.625	7.208	7.936	8.469
<b>10 MIN</b>	4.863	5.380	5.925	6.616	7.126
<b>15 MIN</b>	4.029	4.515	5.033	5.697	6.194
<b>30 MIN</b>	2.837	3.226	3.646	4.194	4.608
<b>60 MIN</b>	1.549	1.819	2.078	2.412	2.663
<b>2.0 HRS</b>	1.053	1.230	1.400	1.620	1.785
<b>3.0 HRS</b>	0.774	0.899	1.019	1.175	1.291
<b>4.0 HRS</b>	0.632	0.736	0.836	0.965	1.062
<b>5.0 HRS</b>	0.524	0.606	0.684	0.785	0.861
<b>6.0 HRS</b>	0.453	0.522	0.589	0.676	0.741
<b>7.0 HRS</b>	0.399	0.459	0.516	0.591	0.647
<b>8.0 HRS</b>	0.358	0.412	0.463	0.530	0.581
<b>9.0 HRS</b>	0.323	0.370	0.415	0.472	0.516
<b>10 HRS</b>	0.297	0.339	0.379	0.431	0.470
<b>11 HRS</b>	0.276	0.314	0.351	0.399	0.435
<b>12 HRS</b>	0.259	0.296	0.331	0.376	0.410
<b>13 HRS</b>	0.245	0.280	0.314	0.357	0.390
<b>14 HRS</b>	0.233	0.267	0.299	0.341	0.372
<b>15 HRS</b>	0.220	0.252	0.281	0.320	0.349
<b>16 HRS</b>	0.209	0.238	0.266	0.302	0.329
<b>17 HRS</b>	0.198	0.225	0.251	0.284	0.310



**APPENDIX "D"**  
**STORAGE VOLUME DATA**

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PROJECT: WATERFORD PLACR RUN1 (RED)  
 ENGINEER: BERNARDIN, LOCHMUELLER & ASSOCIATES

DATE: 03/12/08

RELEASE RATE PERIOD: 5\10\25\100  
 WATERSHED AREA (ACRES): 5\10\25\100 12.19  
 TIME OF CONCENTRATION UNDEV. (min): 30  
 RAINFALL INTENSITY (INCHES/HR): 100.00 2.8181358 2.2797042  
 UNDEVELOPED RUNOFF COEFFICIENT: 0.20  
 UNDEVELOPED RUNOFF RATE (CFS): 6.87  
 DEVELOPED RUNOFF COEFFICIENT: 0.7

25 Year Storm

STORM DURATION (HRS)	RAINFALL INTENSITY (INCH/HR)	INFLOW RATE (CFS)	OUTFLOW RATE (CFS)	STORAGE RATE (CFS)	REQUIRED STORAGE (ACRE-FT)
0.08	7.88	67.26	6.87	60.39	0.403
0.17	6.27	53.51	6.87	46.64	0.661
0.25	5.24	44.72	6.87	37.85	0.789
0.33	4.46	38.04	6.87	31.17	0.857
0.42	3.78	32.26	6.87	25.39	0.889
0.50	3.31	28.22	6.87	21.35	0.890
0.58	2.92	24.94	6.87	18.07	0.873
0.67	2.57	21.92	6.87	15.05	0.841
0.75	2.31	19.71	6.87	12.84	0.802
0.83	2.09	17.83	6.87	10.96	0.758
0.92	1.88	16.04	6.87	9.17	0.703
1.00	1.72	14.68	5.56	9.12	0.760
1.25	1.88	16.08	5.56	10.52	1.096
1.50	1.67	14.23	5.56	8.67	1.084
1.75	1.50	12.80	5.56	7.24	1.056
2.00	1.37	11.65	5.56	6.09	1.016
2.50	1.16	9.93	5.56	4.37	0.910
3.00	1.02	8.68	5.56	3.12	0.781
4.00	0.82	7.00	5.56	1.44	0.479
6.00	0.60	5.12	5.56	-0.43	-0.217
10.00	0.40	3.43	5.56	-2.13	-1.772

STORAGE (ACRE/FT): 1.10  
 STORAGE (CUBIC FT): 47,722.81

PROJECT: WATERFORD PLACR RUN1 (RED)  
 ENGINEER: BERNARDIN, LOCHMUELLER & ASSOCIATES

DATE: 03/12/08

RELEASE RATE PERIOD: 5\10\25\100  
 WATERSHED AREA (ACRES): 12.19  
 TIME OF CONCENTRATION UNDEV. (min): 30  
 RAINFALL INTENSITY (INCHES/HR): 100.00 2.8181358 2.2797042  
 UNDEVELOPED RUNOFF COEFFICIENT: 0.20  
 UNDEVELOPED RUNOFF RATE (CFS): 6.87  
 DEVELOPED RUNOFF COEFFICIENT: 0.7

**100 Year Storm**

STORM DURATION (HRS)	RAINFALL INTENSITY (INCH/HR)	INFLOW RATE (CFS)	OUTFLOW RATE (CFS)	STORAGE RATE (CFS)	REQUIRED STORAGE (ACRE-FT)
0.08	10.04	85.69	6.87	78.82	0.525
0.17	7.99	68.17	6.87	61.30	0.868
0.25	6.68	56.97	6.87	50.10	1.044
0.33	5.68	48.46	6.87	41.59	1.144
0.42	4.82	41.10	6.87	34.23	1.198
0.50	4.21	35.96	6.87	29.08	1.212
0.58	3.72	31.77	6.87	24.90	1.204
0.67	3.27	27.93	6.87	21.06	1.176
0.75	2.94	25.11	6.87	18.24	1.140
0.83	2.66	22.72	6.87	15.85	1.096
0.92	2.40	20.44	6.87	13.57	1.040
1.00	2.19	18.71	5.56	13.15	1.096
1.25	2.54	21.71	5.56	16.15	1.682
1.50	2.25	19.21	5.56	13.66	1.707
1.75	2.03	17.28	5.56	11.72	1.710
2.00	1.84	15.73	5.56	10.18	1.696
2.50	1.57	13.40	5.56	7.84	1.634
3.00	1.37	11.72	5.56	6.16	1.541
4.00	1.11	9.45	5.56	3.89	1.296
6.00	0.81	6.92	5.56	1.36	0.680
10.00	0.54	4.63	5.56	-0.92	-0.770

STORAGE (ACRE/FT): 1.71  
 STORAGE (CUBIC FT): 74,468.33

PROJECT: WATERFORD PLACR RUN1 (RED)  
 ENGINEER: BERNARDIN, LOCHMUELLER & ASSOCIATES

DATE: 03/12/08

RELEASE RATE PERIOD: 5\10\25\100  
 WATERSHED AREA (ACRES): 5\10\25\100 12.19  
 TIME OF CONCENTRATION UNDEV. (min): 30  
 RAINFALL INTENSITY (INCHES/HR): 100.00 2.8181358 2.2797042  
 UNDEVELOPED RUNOFF COEFFICIENT: 0.20  
 UNDEVELOPED RUNOFF RATE (CFS): 6.87  
 DEVELOPED RUNOFF COEFFICIENT: 0.7

50 Year Storm

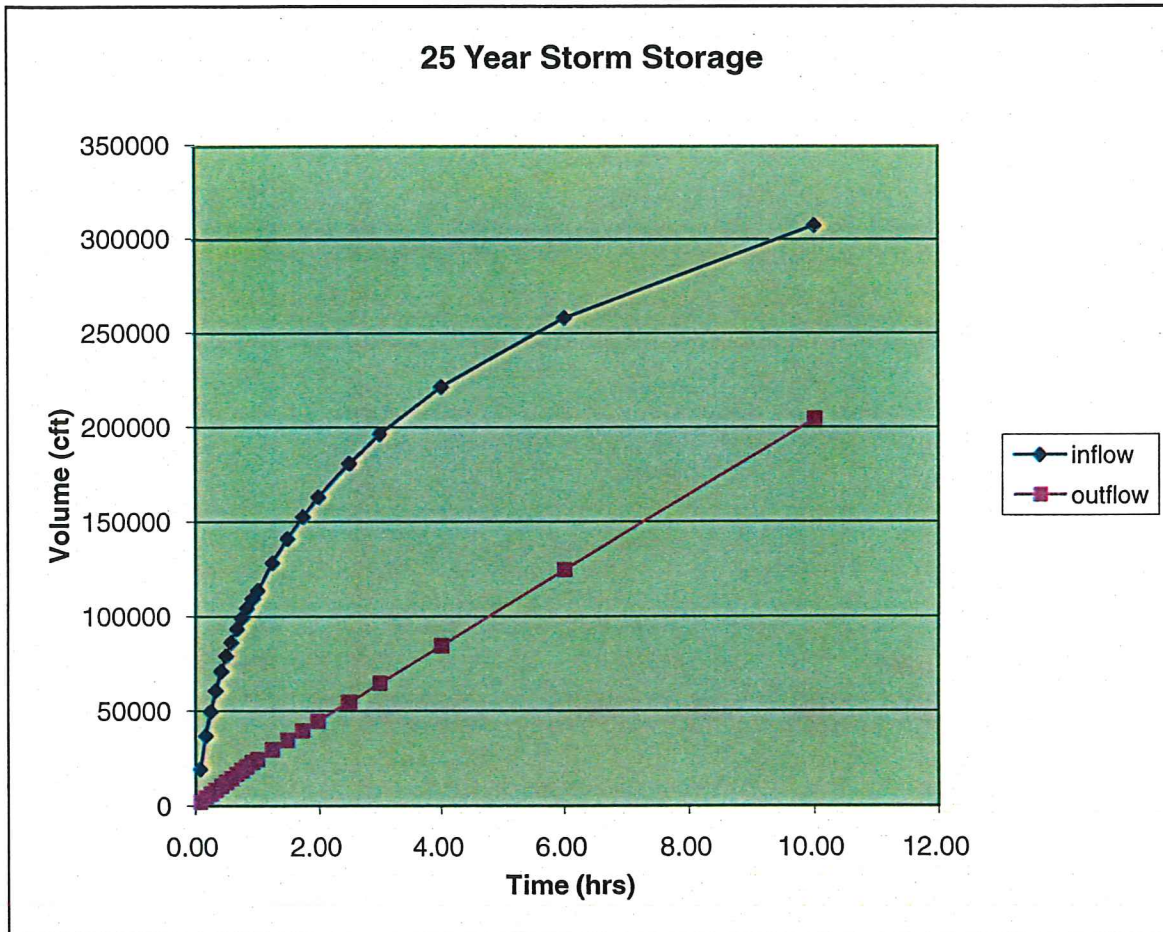
STORM DURATION (HRS)	RAINFALL INTENSITY (INCH/HR)	INFLOW RATE (CFS)	OUTFLOW RATE (CFS)	STORAGE RATE (CFS)	REQUIRED STORAGE (ACRE-FT)
0.08	8.90	75.91	6.87	69.04	0.460
0.17	7.08	60.40	6.87	53.53	0.758
0.25	5.92	50.48	6.87	43.60	0.908
0.33	5.03	42.94	6.87	36.06	0.992
0.42	4.27	36.41	6.87	29.54	1.034
0.50	3.73	31.85	6.87	24.98	1.041
0.58	3.30	28.15	6.87	21.28	1.028
0.67	2.90	24.75	6.87	17.88	0.998
0.75	2.61	22.25	6.87	15.37	0.961
0.83	2.36	20.13	6.87	13.26	0.917
0.92	2.12	18.11	6.87	11.24	0.861
1.00	1.94	16.57	5.56	11.01	0.918
1.25	2.19	18.68	5.56	13.12	1.367
1.50	1.94	16.54	5.56	10.98	1.372
1.75	1.74	14.87	5.56	9.31	1.358
2.00	1.59	13.54	5.56	7.98	1.330
2.50	1.35	11.53	5.56	5.98	1.245
3.00	1.18	10.09	5.56	4.53	1.132
4.00	0.95	8.13	5.56	2.57	0.857
6.00	0.70	5.95	5.56	0.40	0.198
10.00	0.47	3.99	5.56	-1.57	-1.309

PEAK STORAGE (ACRE/FT): 1.37  
 PEAK STORAGE (CUBIC FT): 59,771.54

PROJECT: WATERFORD PLACR RUN1 (RED)  
 ENGINEER: BERNARDIN, LOCHMUELLER & ASSOCIATES

DATE: 03/12/08

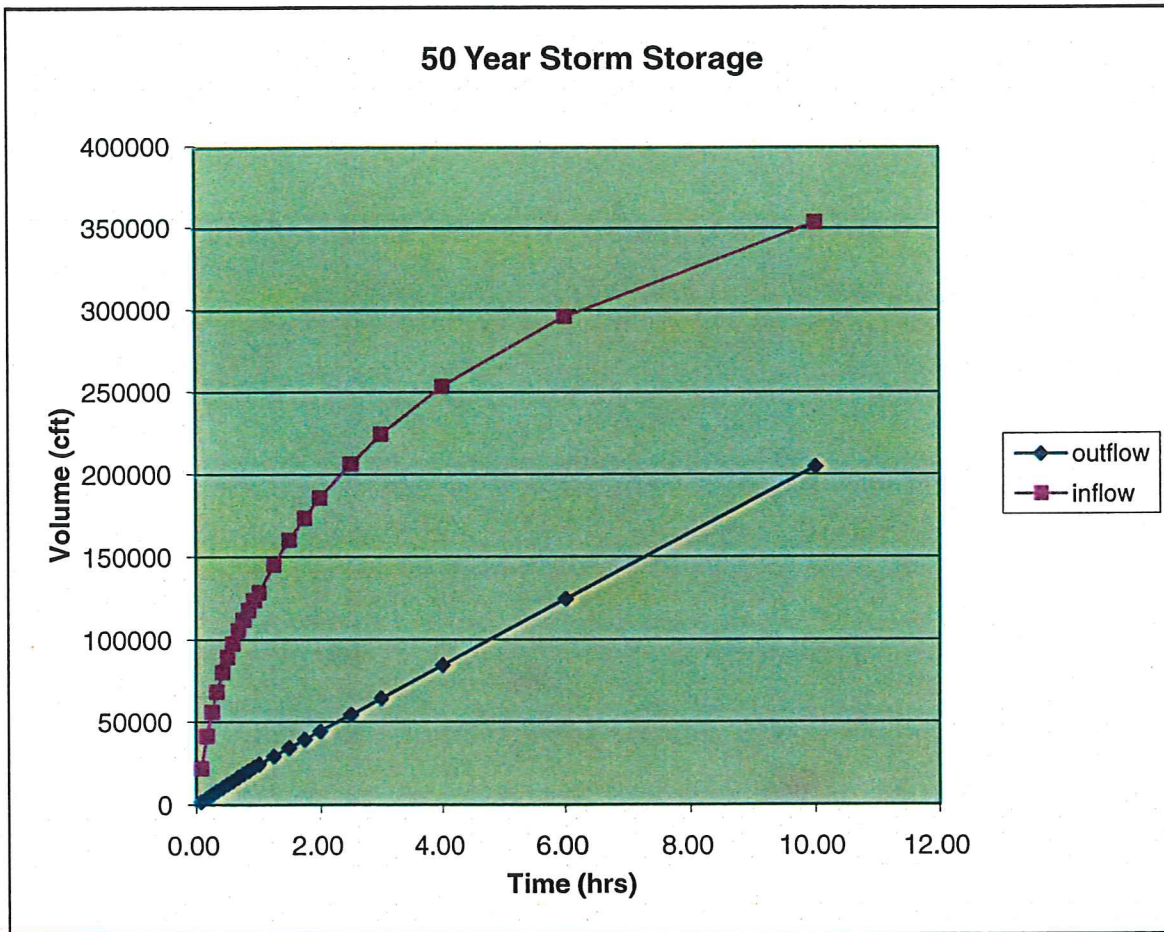
5\10\25\100  
 5\10\25\100  
 RELEASE RATE PERIOD: 12.19  
 WATERSHED AREA (ACRES): 30  
 TIME OF CONCENTRATION UNDEV. (min): 100.00 2.8181358 2.2797042  
 RAINFALL INTENSITY (INCHES/HR): 0.20  
 UNDEVELOPED RUNOFF COEFFICIENT: 6.87  
 UNDEVELOPED RUNOFF RATE (CFS): 0.7  
 DEVELOPED RUNOFF COEFFICIENT:



PROJECT: WATERFORD PLACR RUN1 (RED)  
 ENGINEER: BERNARDIN, LOCHMUELLER & ASSOCIATES

DATE: 03/12/08

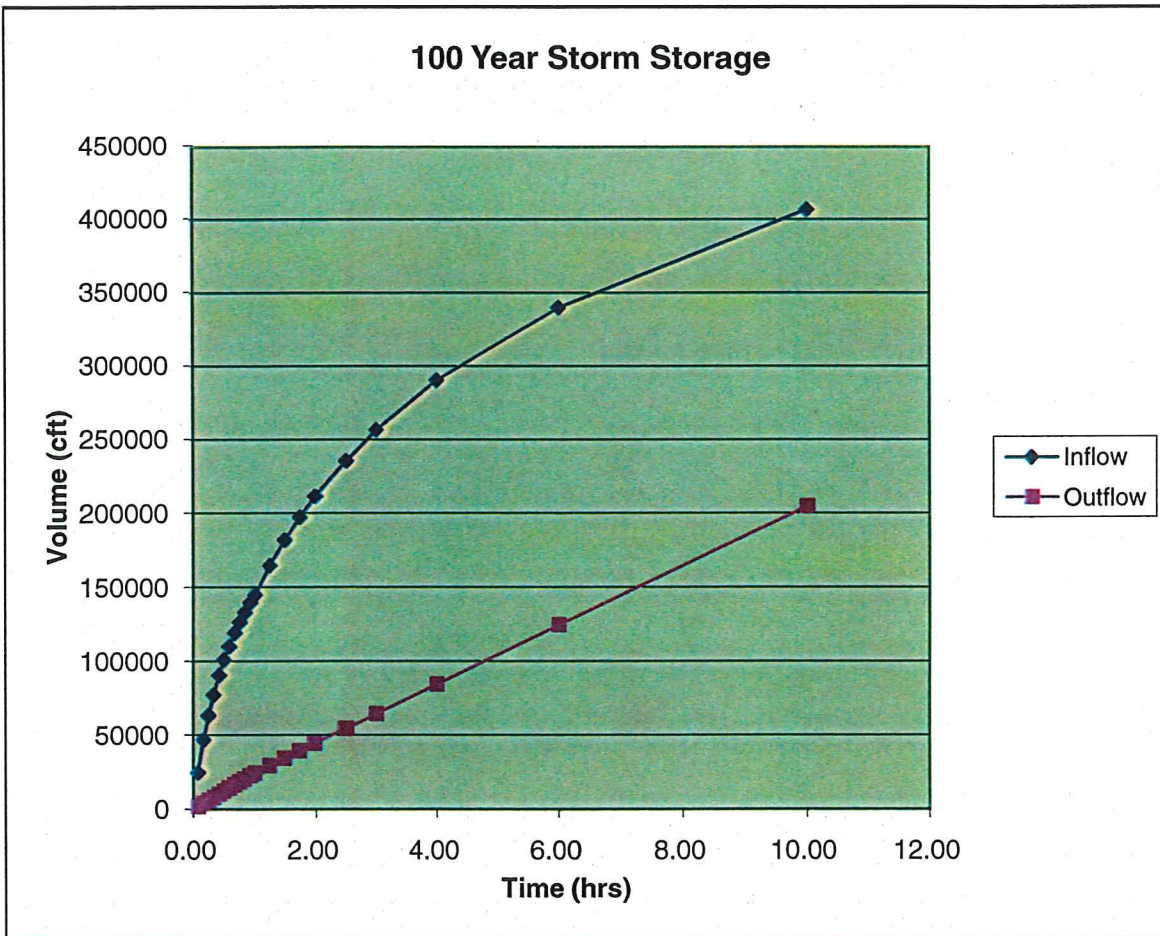
RELEASE RATE PERIOD: 5\10\25\100  
 WATERSHED AREA (ACRES): 12.19  
 TIME OF CONCENTRATION UNDEV. (min): 30  
 RAINFALL INTENSITY (INCHES/HR): 100.00 2.8181358 2.2797042  
 UNDEVELOPED RUNOFF COEFFICIENT: 0.20  
 UNDEVELOPED RUNOFF RATE (CFS): 6.87  
 DEVELOPED RUNOFF COEFFICIENT: 0.7



PROJECT: WATERFORD PLACR RUN1 (RED)  
 ENGINEER: BERNARDIN, LOCHMUELLER & ASSOCIATES

DATE: 03/12/08

RELEASE RATE PERIOD: 5\10\25\100  
 5\10\25\100  
 WATERSHED AREA (ACRES): 12.19  
 TIME OF CONCENTRATION UNDEV. (min): 30  
 RAINFALL INTENSITY (INCHES/HR): 100.00 2.8181358 2.2797042  
 UNDEVELOPED RUNOFF COEFFICIENT: 0.20  
 UNDEVELOPED RUNOFF RATE (CFS): 6.87  
 DEVELOPED RUNOFF COEFFICIENT: 0.7



PROJECT: WATERFORD PLACR RUN2 (GREEN)  
 ENGINEER: BERNARDIN, LOCHMUELLER & ASSOCIATES

DATE: 03/12/08

RELEASE RATE PERIOD: 5\10\25\100  
 WATERSHED AREA (ACRES): 9.72  
 TIME OF CONCENTRATION UNDEV. (min): 32  
 RAINFALL INTENSITY (INCHES/HR): 100.00 2.6735678 2.2050704  
 UNDEVELOPED RUNOFF COEFFICIENT: 0.20  
 UNDEVELOPED RUNOFF RATE (CFS): 5.20  
 DEVELOPED RUNOFF COEFFICIENT: 0.7

### 25 Year Storm

STORM DURATION (HRS)	RAINFALL INTENSITY (INCH/HR)	INFLOW RATE (CFS)	OUTFLOW RATE (CFS)	STORAGE RATE (CFS)	REQUIRED STORAGE (ACRE-FT)
0.08	7.88	53.63	5.20	48.43	0.323
0.17	6.27	42.67	5.20	37.47	0.531
0.25	5.24	35.66	5.20	30.46	0.635
0.33	4.46	30.33	5.20	25.13	0.691
0.42	3.78	25.72	5.20	20.53	0.718
0.50	3.31	22.50	5.20	17.31	0.721
0.58	2.92	19.89	5.20	14.69	0.710
0.67	2.57	17.48	5.20	12.28	0.686
0.75	2.31	15.71	5.20	10.52	0.657
0.83	2.09	14.22	5.20	9.02	0.624
0.92	1.88	12.79	5.20	7.59	0.582
1.00	1.72	11.71	4.29	7.42	0.618
1.25	1.88	12.82	4.29	8.53	0.889
1.50	1.67	11.35	4.29	7.06	0.883
1.75	1.50	10.21	4.29	5.92	0.863
2.00	1.37	9.29	4.29	5.00	0.834
2.50	1.16	7.91	4.29	3.63	0.756
3.00	1.02	6.92	4.29	2.64	0.659
4.00	0.82	5.58	4.29	1.29	0.430
6.00	0.60	4.09	4.29	-0.20	-0.101
10.00	0.40	2.74	4.29	-1.55	-1.292

STORAGE (ACRE/FT): 0.89  
 STORAGE (CUBIC FT): 38,711.31



PROJECT: WATERFORD PLACR RUN2 (GREEN)  
 ENGINEER: BERNARDIN, LOCHMUELLER & ASSOCIATES

DATE: 03/12/08

RELEASE RATE PERIOD: 5\10\25\100  
 WATERSHED AREA (ACRES): 5\10\25\100 9.72  
 TIME OF CONCENTRATION UNDEV. (min): 32  
 RAINFALL INTENSITY (INCHES/HR): 100.00 2.6735678 2.2050704  
 UNDEVELOPED RUNOFF COEFFICIENT: 0.20  
 UNDEVELOPED RUNOFF RATE (CFS): 5.20  
 DEVELOPED RUNOFF COEFFICIENT: 0.7

100 Year Storm

STORM DURATION (HRS)	RAINFALL INTENSITY (INCH/HR)	INFLOW RATE (CFS)	OUTFLOW RATE (CFS)	STORAGE RATE (CFS)	REQUIRED STORAGE (ACRE-FT)
0.08	10.04	68.32	5.20	63.13	0.421
0.17	7.99	54.36	5.20	49.16	0.696
0.25	6.68	45.43	5.20	40.23	0.838
0.33	5.68	38.64	5.20	33.45	0.920
0.42	4.82	32.77	5.20	27.58	0.965
0.50	4.21	28.67	5.20	23.47	0.978
0.58	3.72	25.34	5.20	20.14	0.973
0.67	3.27	22.27	5.20	17.08	0.953
0.75	2.94	20.02	5.20	14.82	0.926
0.83	2.66	18.11	5.20	12.92	0.893
0.92	2.40	16.30	5.20	11.10	0.851
1.00	2.19	14.92	4.29	10.63	0.886
1.25	2.54	17.31	4.29	13.02	1.356
1.50	2.25	15.32	4.29	11.03	1.379
1.75	2.03	13.78	4.29	9.49	1.384
2.00	1.84	12.55	4.29	8.26	1.376
2.50	1.57	10.69	4.29	6.40	1.333
3.00	1.37	9.35	4.29	5.06	1.265
4.00	1.11	7.53	4.29	3.25	1.082
6.00	0.81	5.52	4.29	1.23	0.615
10.00	0.54	3.69	4.29	-0.59	-0.493

STORAGE (ACRE/FT): 1.38  
 STORAGE (CUBIC FT): 60,300.85

PROJECT: WATERFORD PLACR RUN2 (GREEN)  
 ENGINEER: BERNARDIN, LOCHMUELLER & ASSOCIATES

DATE: 03/12/08

RELEASE RATE PERIOD: 5\10\25\100  
 WATERSHED AREA (ACRES): 5\10\25\100 9.72  
 TIME OF CONCENTRATION UNDEV. (min): 32  
 RAINFALL INTENSITY (INCHES/HR): 100.00 2.6735678 2.2050704  
 UNDEVELOPED RUNOFF COEFFICIENT: 0.20  
 UNDEVELOPED RUNOFF RATE (CFS): 5.20  
 DEVELOPED RUNOFF COEFFICIENT: 0.7

### 50 Year Storm

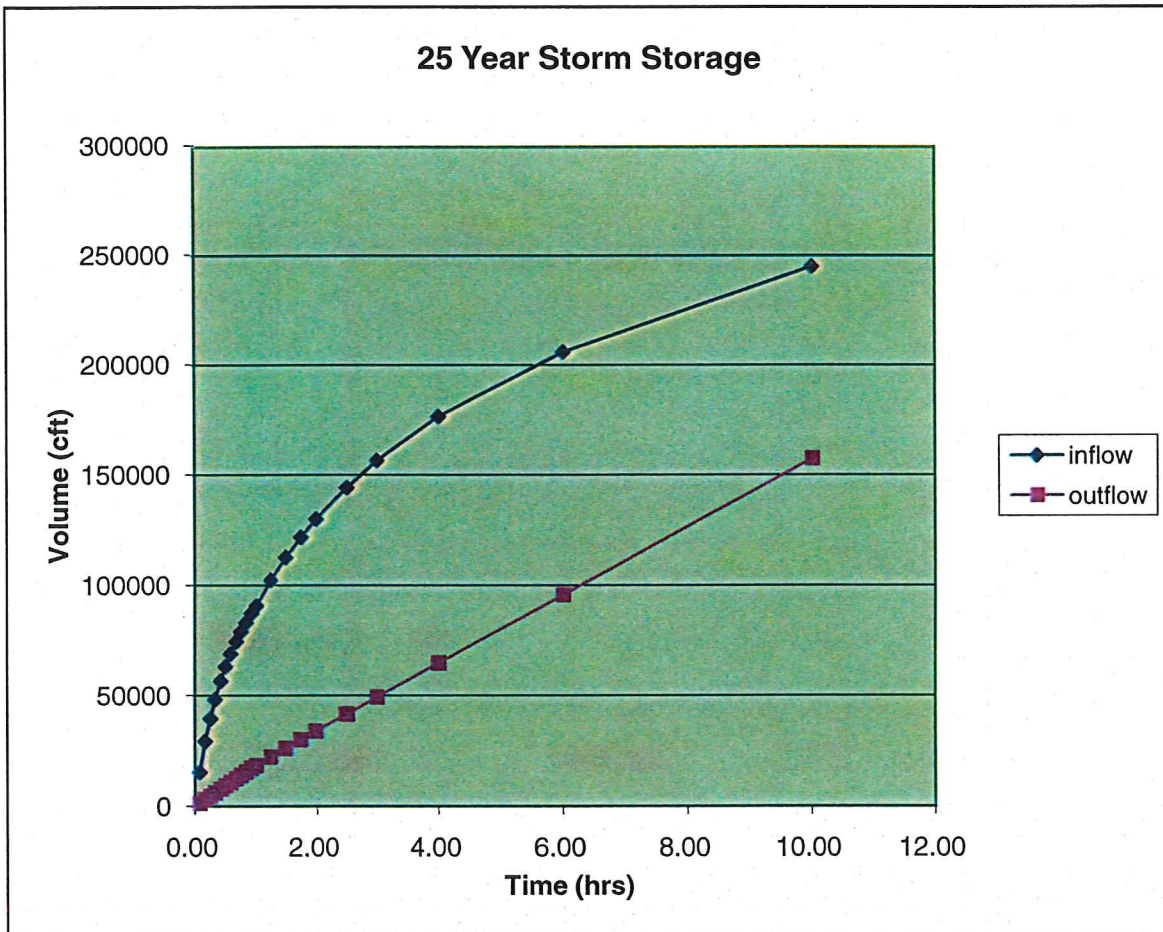
STORM DURATION (HRS)	RAINFALL INTENSITY (INCH/HR)	INFLOW RATE (CFS)	OUTFLOW RATE (CFS)	STORAGE RATE (CFS)	REQUIRED STORAGE (ACRE-FT)
0.08	8.90	60.53	5.20	55.33	0.369
0.17	7.08	48.16	5.20	42.96	0.609
0.25	5.92	40.25	5.20	35.05	0.730
0.33	5.03	34.24	5.20	29.04	0.799
0.42	4.27	29.03	5.20	23.84	0.834
0.50	3.73	25.40	5.20	20.20	0.842
0.58	3.30	22.45	5.20	17.25	0.834
0.67	2.90	19.73	5.20	14.54	0.812
0.75	2.61	17.74	5.20	12.54	0.784
0.83	2.36	16.05	5.20	10.85	0.751
0.92	2.12	14.44	5.20	9.24	0.708
1.00	1.94	13.21	4.29	8.93	0.744
1.25	2.19	14.89	4.29	10.61	1.105
1.50	1.94	13.18	4.29	8.90	1.112
1.75	1.74	11.86	4.29	7.57	1.104
2.00	1.59	10.80	4.29	6.51	1.085
2.50	1.35	9.20	4.29	4.91	1.023
3.00	1.18	8.04	4.29	3.76	0.939
4.00	0.95	6.48	4.29	2.20	0.732
6.00	0.70	4.75	4.29	0.46	0.230
10.00	0.47	3.18	4.29	-1.11	-0.923

PEAK STORAGE (ACRE/FT): 1.11  
 PEAK STORAGE (CUBIC FT): 48,450.33

PROJECT: WATERFORD PLACR RUN2 (GREEN)  
 ENGINEER: BERNARDIN, LOCHMUELLER & ASSOCIATES

DATE: 03/12/08

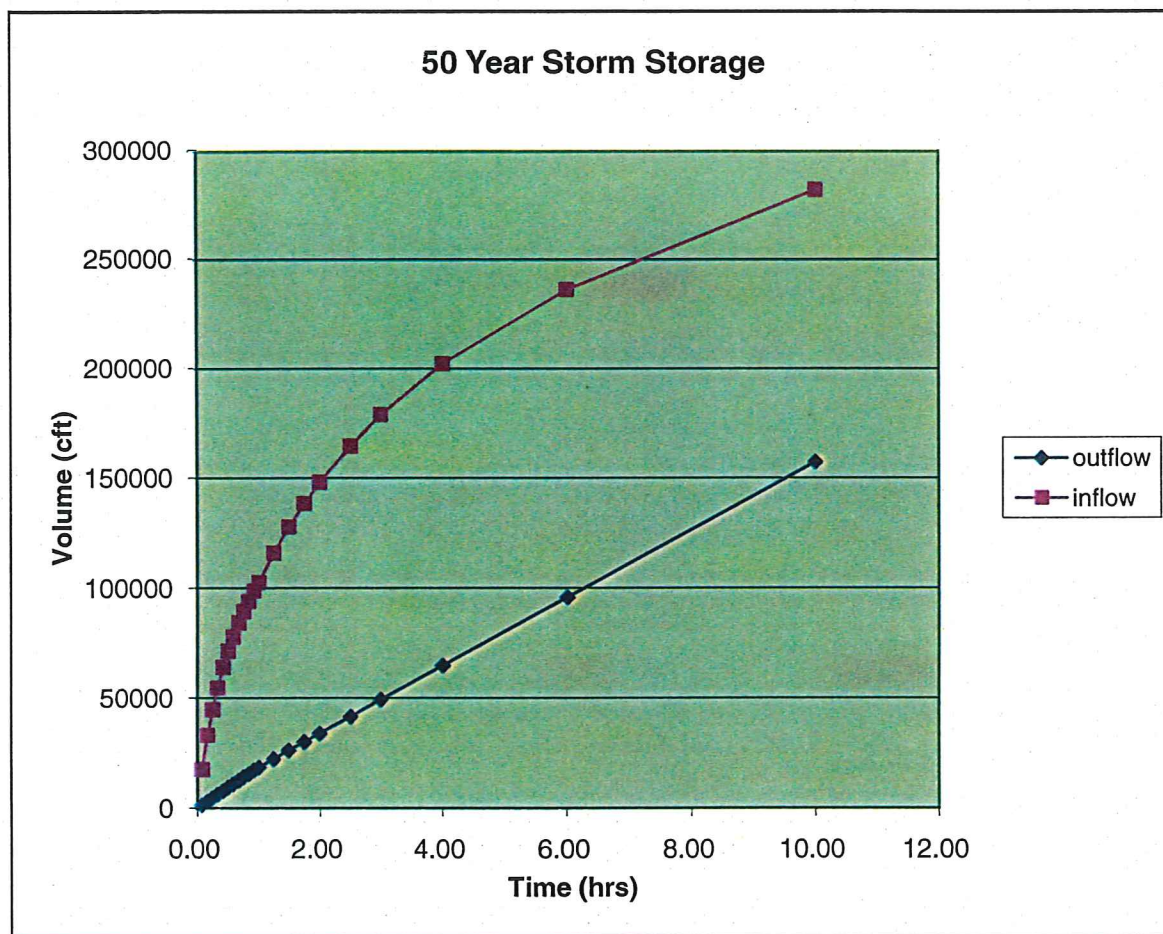
RELEASE RATE PERIOD:	5\10\25\100
WATERSHED AREA (ACRES):	9.72
TIME OF CONCENTRATION UNDEV. (min):	32
RAINFALL INTENSITY (INCHES/HR):	100.00 2.6735678 2.2050704
UNDEVELOPED RUNOFF COEFFICIENT:	0.20
UNDEVELOPED RUNOFF RATE (CFS):	5.20
DEVELOPED RUNOFF COEFFICIENT:	0.7



PROJECT: WATERFORD PLACR RUN2 (GREEN)  
 ENGINEER: BERNARDIN, LOCHMUELLER & ASSOCIATES

DATE: 03/12/08

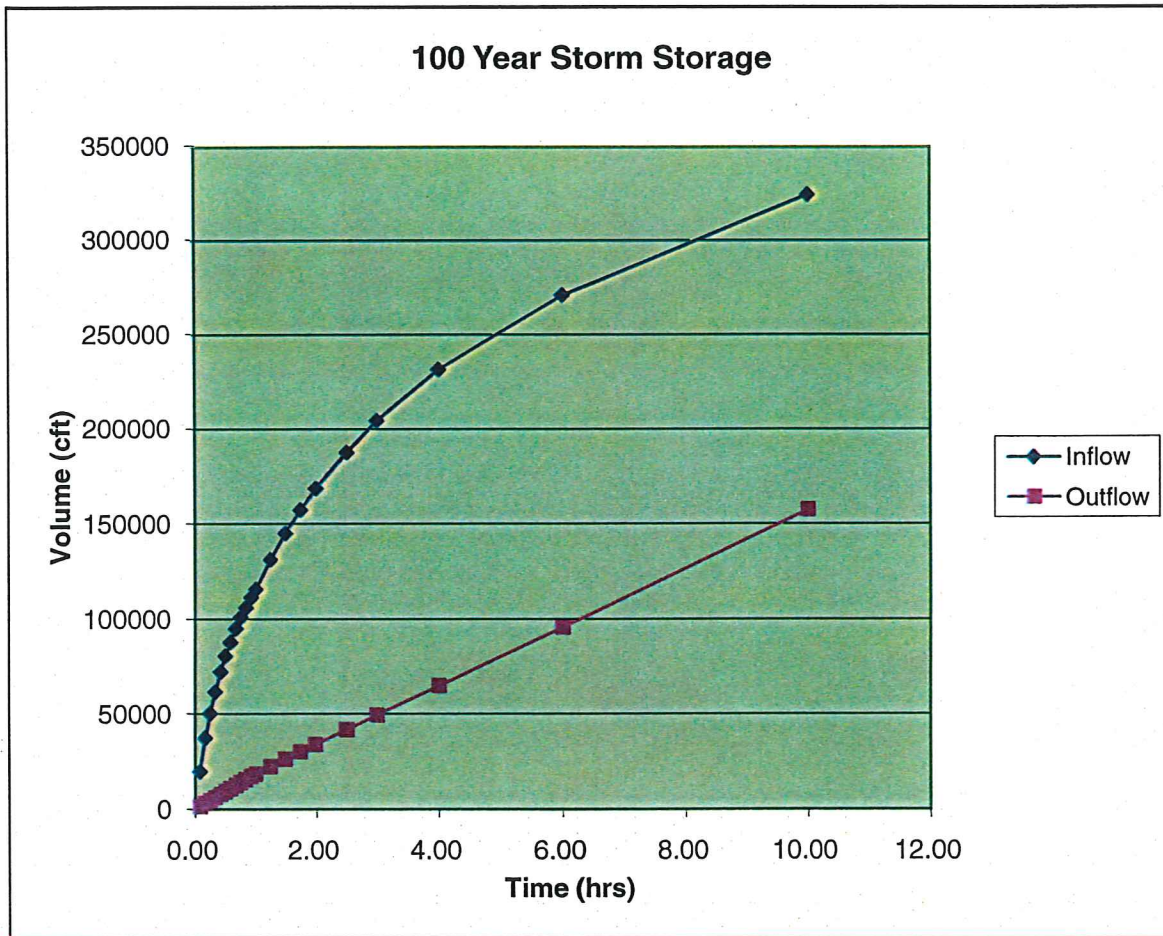
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 WATERSHED AREA (ACRES): 9.72  
 TIME OF CONCENTRATION UNDEV. (min): 32  
 RAINFALL INTENSITY (INCHES/HR): 100.00 2.6735678 2.2050704  
 UNDEVELOPED RUNOFF COEFFICIENT: 0.20  
 UNDEVELOPED RUNOFF RATE (CFS): 5.20  
 DEVELOPED RUNOFF COEFFICIENT: 0.7



PROJECT: WATERFORD PLACR RUN2 (GREEN)  
 ENGINEER: BERNARDIN, LOCHMUELLER & ASSOCIATES

DATE: 03/12/08

RELEASE RATE PERIOD: 5\10\25\100  
 WATERSHED AREA (ACRES): 9.72  
 TIME OF CONCENTRATION UNDEV. (min): 32  
 RAINFALL INTENSITY (INCHES/HR): 100.00 2.6735678 2.2050704  
 UNDEVELOPED RUNOFF COEFFICIENT: 0.20  
 UNDEVELOPED RUNOFF RATE (CFS): 5.20  
 DEVELOPED RUNOFF COEFFICIENT: 0.7



PROJECT: WATERFORD PLACE RUN3 (ORANGE)  
 ENGINEER: BERNARDIN, LOCHMUELLER & ASSOCIATES

DATE: 03/14/08

RELEASE RATE PERIOD: 5\10\25\100  
 5\10\25\100  
 WATERSHED AREA (ACRES): 6.41  
 TIME OF CONCENTRATION UNDEV. (min): 20.5  
 RAINFALL INTENSITY (INCHES/HR): 100.00 3.714601 2.728839  
 UNDEVELOPED RUNOFF COEFFICIENT: 0.20  
 UNDEVELOPED RUNOFF RATE (CFS): 4.76  
 DEVELOPED RUNOFF COEFFICIENT: 0.7

### 25 Year Storm

STORM DURATION (HRS)	RAINFALL INTENSITY (INCH/HR)	INFLOW RATE (CFS)	OUTFLOW RATE (CFS)	STORAGE RATE (CFS)	REQUIRED STORAGE (ACRE-FT)
0.08	7.88	35.37	4.76	30.60	0.204
0.17	6.27	28.14	4.76	23.38	0.331
0.25	5.24	23.51	4.76	18.75	0.391
0.33	4.46	20.00	4.76	15.24	0.419
0.42	3.78	16.96	4.76	12.20	0.427
0.50	3.31	14.84	4.76	10.08	0.420
0.58	2.92	13.11	4.76	8.35	0.404
0.67	2.57	11.53	4.76	6.77	0.378
0.75	2.31	10.36	4.76	5.60	0.350
0.83	2.09	9.38	4.76	4.61	0.319
0.92	1.88	8.44	4.76	3.67	0.282
1.00	1.72	7.72	3.50	4.22	0.352
1.25	1.88	8.45	3.50	4.95	0.516
1.50	1.67	7.48	3.50	3.98	0.498
1.75	1.50	6.73	3.50	3.23	0.471
2.00	1.37	6.13	3.50	2.63	0.438
2.50	1.16	5.22	3.50	1.72	0.358
3.00	1.02	4.56	3.50	1.07	0.267
4.00	0.82	3.68	3.50	0.18	0.060
6.00	0.60	2.69	3.50	-0.80	-0.402
10.00	0.40	1.80	3.50	-1.69	-1.412

STORAGE (ACRE/FT): 0.52

STORAGE (CUBIC FT):

22,481.95

PROJECT: WATERFORD PLACE RUN3 (ORANGE)  
 ENGINEER: BERNARDIN, LOCHMUELLER & ASSOCIATES

DATE: 03/14/08

RELEASE RATE PERIOD: 5\10\25\100  
 WATERSHED AREA (ACRES): 5\10\25\100 6.41  
 TIME OF CONCENTRATION UNDEV. (min): 20.5  
 RAINFALL INTENSITY (INCHES/HR): 100.00 3.714601 2.728839  
 UNDEVELOPED RUNOFF COEFFICIENT: 0.20  
 UNDEVELOPED RUNOFF RATE (CFS): 4.76  
 DEVELOPED RUNOFF COEFFICIENT: 0.7

100 Year Storm

STORM DURATION (HRS)	RAINFALL INTENSITY (INCH/HR)	INFLOW RATE (CFS)	OUTFLOW RATE (CFS)	STORAGE RATE (CFS)	REQUIRED STORAGE (ACRE-FT)
0.08	10.04	45.06	4.76	40.29	0.269
0.17	7.99	35.85	4.76	31.09	0.440
0.25	6.68	29.96	4.76	25.20	0.525
0.33	5.68	25.48	4.76	20.72	0.570
0.42	4.82	21.61	4.76	16.85	0.590
0.50	4.21	18.91	4.76	14.14	0.589
0.58	3.72	16.71	4.76	11.95	0.577
0.67	3.27	14.69	4.76	9.93	0.554
0.75	2.94	13.20	4.76	8.44	0.528
0.83	2.66	11.95	4.76	7.18	0.497
0.92	2.40	10.75	4.76	5.99	0.459
1.00	2.19	9.84	3.50	6.34	0.528
1.25	2.54	11.41	3.50	7.92	0.824
1.50	2.25	10.10	3.50	6.61	0.826
1.75	2.03	9.09	3.50	5.59	0.815
2.00	1.84	8.27	3.50	4.77	0.796
2.50	1.57	7.05	3.50	3.55	0.739
3.00	1.37	6.16	3.50	2.67	0.666
4.00	1.11	4.97	3.50	1.47	0.490
6.00	0.81	3.64	3.50	0.14	0.070
10.00	0.54	2.44	3.50	-1.06	-0.885

STORAGE (ACRE/FT): 0.83  
 STORAGE (CUBIC FT): 35,964.44

PROJECT: WATERFORD PLACE RUN3 (ORANGE)  
 ENGINEER: BERNARDIN, LOCHMUELLER & ASSOCIATES

DATE: 03/14/08

RELEASE RATE PERIOD: 5\10\25\100  
 WATERSHED AREA (ACRES): 5\10\25\100  
 TIME OF CONCENTRATION UNDEV. (min): 6.41  
 RAINFALL INTENSITY (INCHES/HR): 20.5  
 UNDEVELOPED RUNOFF COEFFICIENT: 100.00 3.714601 2.728839  
 UNDEVELOPED RUNOFF RATE (CFS): 0.20  
 DEVELOPED RUNOFF COEFFICIENT: 4.76  
 DEVELOPED RUNOFF RATE (CFS): 0.7

### 50 Year Storm

STORM DURATION (HRS)	RAINFALL INTENSITY (INCH/HR)	INFLOW RATE (CFS)	OUTFLOW RATE (CFS)	STORAGE RATE (CFS)	REQUIRED STORAGE (ACRE-FT)
0.08	8.90	39.92	4.76	35.16	0.234
0.17	7.08	31.76	4.76	27.00	0.382
0.25	5.92	26.54	4.76	21.78	0.454
0.33	5.03	22.58	4.76	17.82	0.490
0.42	4.27	19.15	4.76	14.39	0.503
0.50	3.73	16.75	4.76	11.99	0.500
0.58	3.30	14.80	4.76	10.04	0.485
0.67	2.90	13.01	4.76	8.25	0.461
0.75	2.61	11.70	4.76	6.94	0.433
0.83	2.36	10.58	4.76	5.82	0.403
0.92	2.12	9.52	4.76	4.76	0.365
1.00	1.94	8.71	3.50	5.22	0.435
1.25	2.19	9.82	3.50	6.32	0.659
1.50	1.94	8.69	3.50	5.20	0.650
1.75	1.74	7.82	3.50	4.32	0.630
2.00	1.59	7.12	3.50	3.62	0.604
2.50	1.35	6.06	3.50	2.57	0.535
3.00	1.18	5.30	3.50	1.81	0.451
4.00	0.95	4.27	3.50	0.78	0.259
6.00	0.70	3.13	3.50	-0.37	-0.184
10.00	0.47	2.10	3.50	-1.40	-1.168

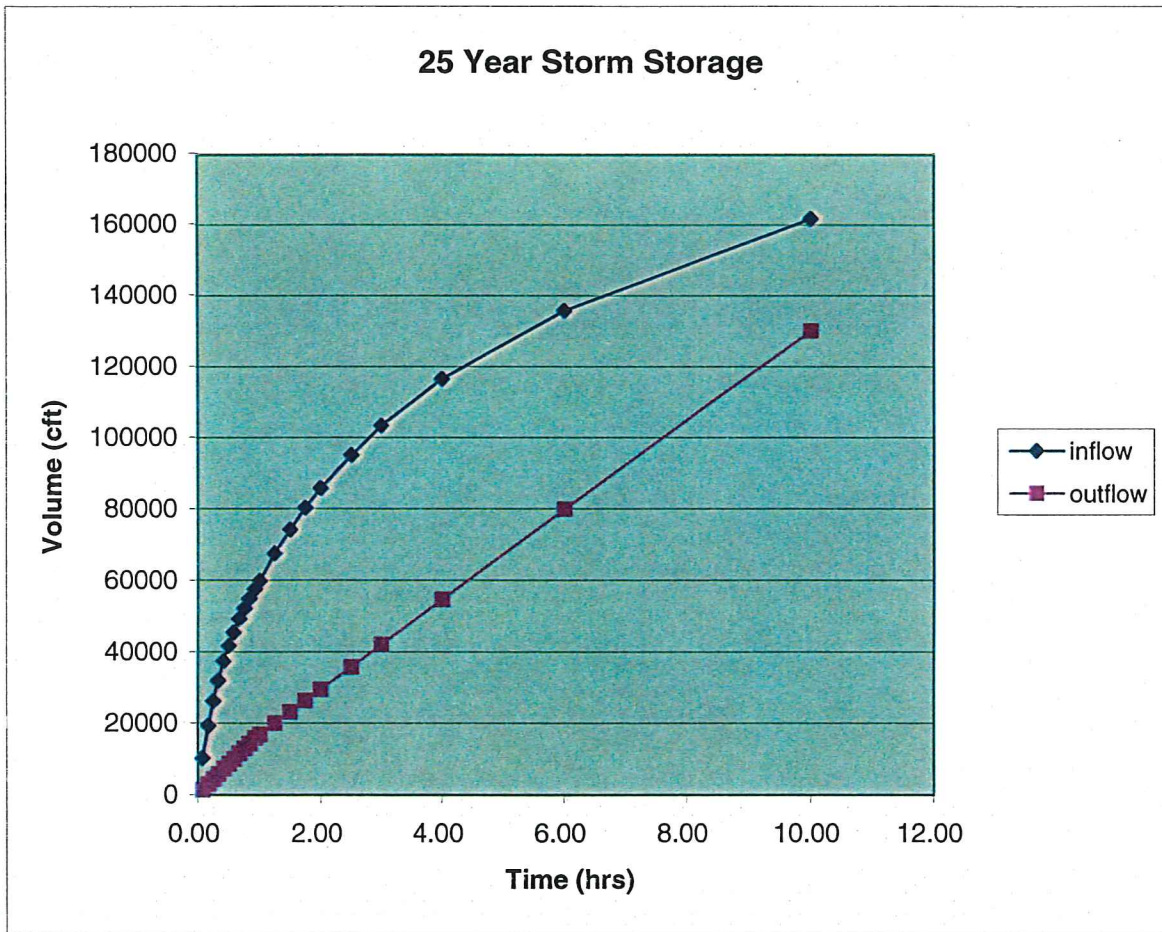
PEAK STORAGE (ACRE/FT): 0.66  
 PEAK STORAGE (CUBIC FT): 28,695.28



PROJECT: WATERFORD PLACE RUN3 (ORANGE)  
 ENGINEER: BERNARDIN, LOCHMUELLER & ASSOCIATES

DATE: 03/14/08

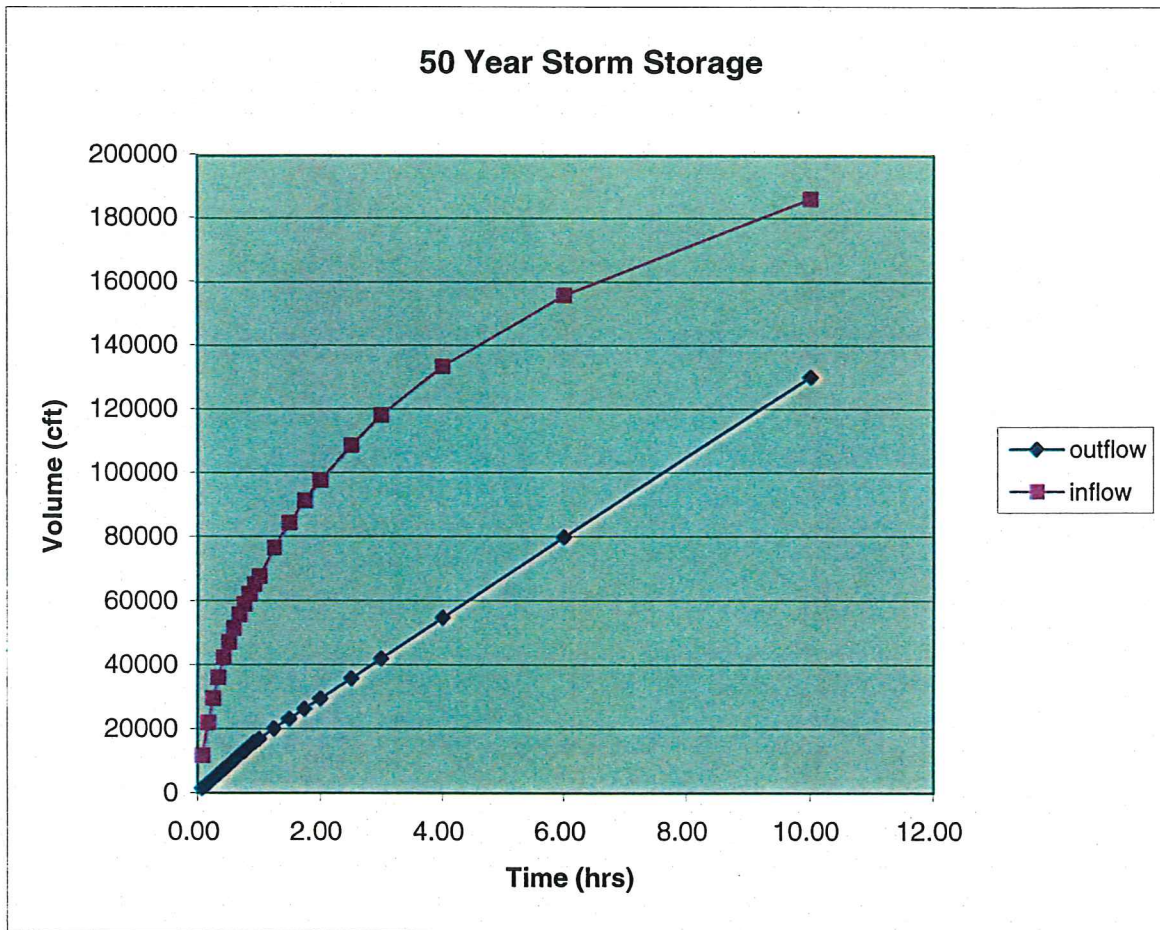
RELEASE RATE PERIOD:	5\10\25\100		
WATERSHED AREA (ACRES):	5\10\25\100		
TIME OF CONCENTRATION UNDEV. (min):	6.41		
RAINFALL INTENSITY (INCHES/HR):	20.5		
UNDEVELOPED RUNOFF COEFFICIENT:	100.00	3.714601	2.728839
UNDEVELOPED RUNOFF RATE (CFS):	0.20		
DEVELOPED RUNOFF COEFFICIENT:	4.76		
	0.7		



PROJECT: WATERFORD PLACE RUN3 (ORANGE)  
 ENGINEER: BERNARDIN, LOCHMUELLER & ASSOCIATES

DATE: 03/14/08

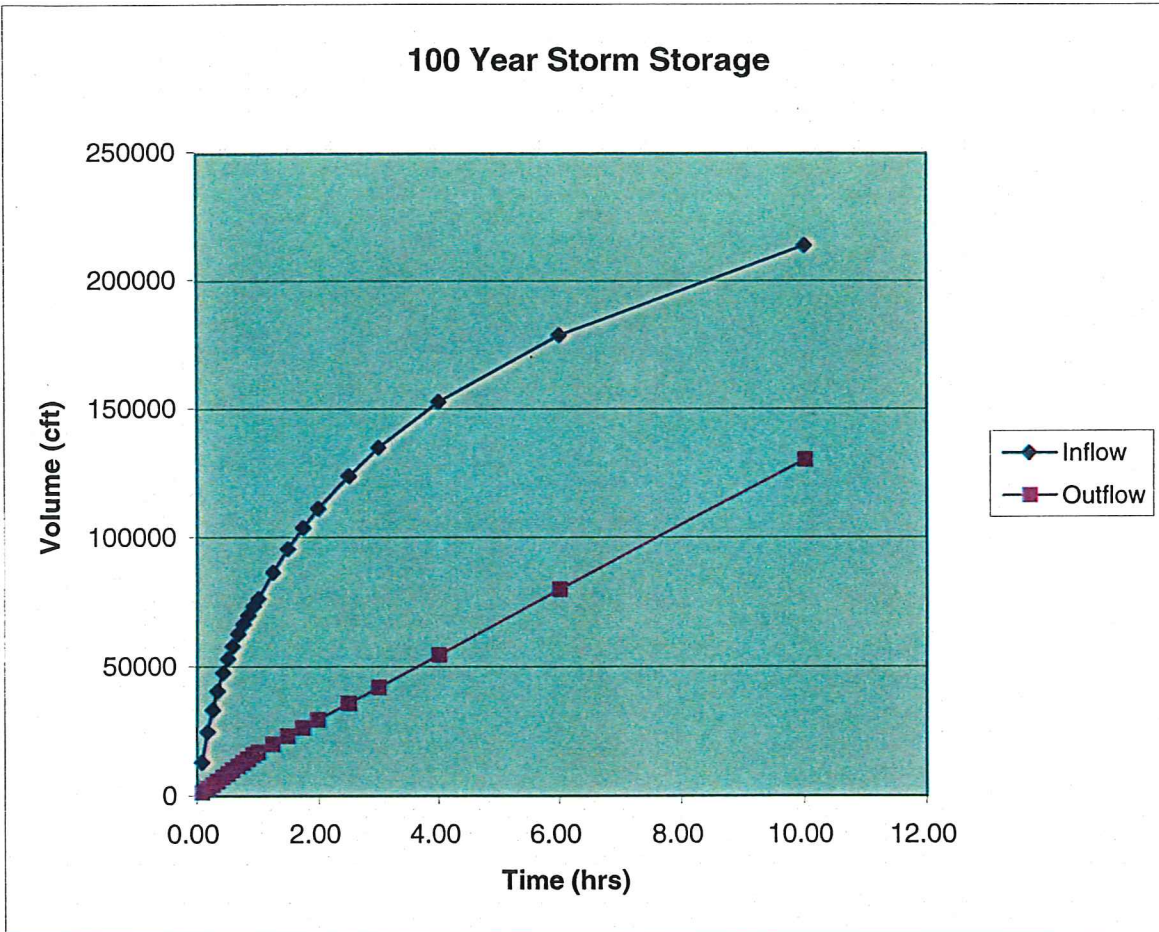
RELEASE RATE PERIOD: 5\10\25\100  
 WATERSHED AREA (ACRES): 6.41  
 TIME OF CONCENTRATION UNDEV. (min): 20.5  
 RAINFALL INTENSITY (INCHES/HR): 100.00 3.714601 2.728839  
 UNDEVELOPED RUNOFF COEFFICIENT: 0.20  
 UNDEVELOPED RUNOFF RATE (CFS): 4.76  
 DEVELOPED RUNOFF COEFFICIENT: 0.7



PROJECT: WATERFORD PLACE RUN3 (ORANGE)  
 ENGINEER: BERNARDIN, LOCHMUELLER & ASSOCIATES

DATE: 03/14/08

RELEASE RATE PERIOD:	5\10\25\100		
WATERSHED AREA (ACRES):	5\10\25\100		
TIME OF CONCENTRATION UNDEV. (min):	6.41		
RAINFALL INTENSITY (INCHES/HR):	20.5		
UNDEVELOPED RUNOFF COEFFICIENT:	100.00	3.714601	2.728839
UNDEVELOPED RUNOFF RATE (CFS):	0.20		
DEVELOPED RUNOFF COEFFICIENT:	4.76		
	0.7		



**APPENDIX E**  
**OUTLET CONTROL STRUCTURE**

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OUTLET CONTROL STRUCTURE**ORIFICE EQUATION**Red Area - New Structure

$$cd = C_c \times C_v = (.62)(.97) = .60$$

$$Q = cdA \sqrt{2gh}$$

$$\text{Allowable Outflow } Q = cia = (0.2)(2.818)(12.19) = 6.87 \text{ cfs}$$

$$c = 0.2$$

$$i = 2.818 / T_c = 30 \text{ min.}$$

$$A = 12.19$$

$$\text{Allowable HW} = 385 - 383 - 0.5 = 1.5$$

$$(6.87) = Q = (.60)(A) \sqrt{2(32.2)} (1.5)$$

$$A = \frac{6.87}{5.8971} = 1.1650 = \frac{\Pi d^2}{4}$$

$$d = 1.21 \cong 15'' \text{ dia. pipe}$$

**ORIFICE EQUATION**Green Area - Existing Structure

$$cd = C_c \times C_v = (.62)(.97) = .60$$

$$Q = cdA \sqrt{2gh}$$

$$\text{Allowable Outflow } Q = cia = (0.2)(2.673)(9.72) = 5.20 \text{ cfs}$$

$$c = 0.2$$

$$i = 2.673 / T_c = 32 \text{ min.}$$

$$A = 9.72$$

$$\text{Allowable HW} = 385 - 382.60 - 0.5 = 1.9$$

$$(5.20) = Q = (.60)(A) \sqrt{2(32.2)} (1.9)$$

$$A = \frac{5.20}{6.637} = 0.7835 = \frac{\Pi d^2}{4}$$

$$d = 0.99 = 12'' \text{ dia. pipe (agrees with existing } \cong 12'' \text{ pipe)}$$

**ORIFICE EQUATION**Orange Area - Existing Structure

$$cd = C_c \times C_v = (.62)(.97) = .60$$

$$Q = cdA \sqrt{2gh}$$

$$\text{Allowable Outflow } Q = cia = (0.2)(3.715)(6.41) = 4.76 \text{ cfs}$$

$$c = 0.2$$

$$i = 3.715 / T_c = 20.5 \text{ min.}$$

$$A = 6.41$$

$$\text{Allowable HW} = 385 - 382.90 - 0.5 = 1.6$$

$$(4.76) = Q = (.60)(A) \sqrt{2(32.2)(1.6)}$$

$$A = \frac{4.76}{6.0905} = 0.7815 \frac{\pi d^2}{4}$$

$$d = 0.9975 = 12'' \text{ dia. pipe (agrees with existing } \cong 12'' \text{ pipe)}$$


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**APPENDIX F  
BASIN VOLUME**

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**BASIN VOLUME****Project:** WATERFORD RUN1 (RED)**Date:** 3/12/2008

<b>ELEVATION</b>	<b>SURFACE AREA (square feet)</b>	<b>Incremental Volume (cubic feet)</b>	<b>Accumulated Volume (cubic feet)</b>	<b>Accumulated Volume (acre/feet)</b>
433.00	36,971	0	0	0
434.00	44,598	40,785	40,785	0.94
435.00	52,467	48,533	89,317	2.05
				#VALUE!



**BASIN VOLUME****Project: WATERFORD RUN2 (GREEN)****Date: 3/12/2008**

<b>ELEVATION</b>	<b>SURFACE AREA (square feet)</b>	<b>Incremental Volume (cubic feet)</b>	<b>Accumulated Volume (cubic feet)</b>	<b>Accumulated Volume (acre/feet)</b>
382.60	30,043	0	0	0
383.00	32,001	12,409	12,409	0.28
384.00	37,643	34,822	47,231	1.08
385.00	44,439	41,041	88,272	2.03

**BASIN VOLUME****Project: WATERFORD RUN3 (ORANGE)****Date: 3/14/2008**

<b>ELEVATION</b>	<b>SURFACE AREA (square feet)</b>	<b>Incremental Volume (cubic feet)</b>	<b>Accumulated Volume (cubic feet)</b>	<b>Accumulated Volume (acre/feet)</b>
382.90	10,672	0	0	0
383.00	11,908	1,129	1,129	0.03
384.00	14,450	13,179	14,308	0.33
385.00	17,818	16,134	30,442	0.70

**Project: WATERFORD RUN3 ENL (ORANGE)****Date: 3/14/2008**

<b>ELEVATION</b>	<b>SURFACE AREA (square feet)</b>	<b>Incremental Volume (cubic feet)</b>	<b>Accumulated Volume (cubic feet)</b>	<b>Accumulated Volume (acre/feet)</b>
382.90	14,084	0	0	0
383.00	16,049	1,507	1,507	0.03
384.00	19,219	17,634	19,141	0.44
385.00	22,774	20,997	40,137	0.92