STORMWATER DETENTION ANALYSIS
PARKVIEW PLACE II SUBDIVISION
BAX PROJECT NO. 84-1473

PREPARED FOR:

BLUE RIBBON HOMES, INC.
3877 HIGHWAY 70
SAINT CHARLES, MISSOURI 63303

PREPARED BY:

BAX ENGINEERING COMPANY, INC.
530 MADISON STREET
SAINT CHARLES, MISSOURI 63301
TELEPHONE: 946-6588

AUGUST 07, 1986

I. PURPOSE:

The purpose of this report is to estimate the attenuation characteristics of the detention facility that is proposed to be constructed as part of the subdivision improvements of the 18.88 Acre tract of land known as "Parkview Place II" Subdivision, and to establish the amount of money to be contributed to the City of O'Fallon's Stormwater Management Fund.

II. SCOPE:

This report estimates the expected attenuation characteristics during the 15, 25 and 100 year frequency storms of 20 minutes duration, utilizing the rational method of estimating storm runoff to the detention facility.

III. DETENTION CONCEPT:

The proposed site improvements include construction of a detention basin at a low point of the subdivision. The basin will be utilized as a stormwater detention facility, and outflow will discharge to the adjacent creek. The storage volume and outflow rates have been analyzed to determine the peak rate of runoff leaving the detention facility, and hence the attenuation provided by the detention facility for the design storms.

IV. STORMWATER RUNOFF INFORMATION:

Runoff considerations for the subdivision are shown on Exhibit 'A'.

Estimated Inflow Hydrograph calculations for the design storm are shown on Exhibit 'B'.

V. DETENTION BASIN CHARACTERISTICS:

The depth-storage characteristics of the proposed basin are shown on Exhibit 'C'.

The selection of an outlfow pipe size and outflow pipe performance calculations are shown on Exhibit 'D'.

VI. ROUTING PROCEDURE:

The modified Puls routing procedure was used to estimate the effects of storage volume on outflow rate.

Exhibit 'E' details the development of the routing curve.

Exhibit 'F' displays the routing calculations.

VII. SUMMARY:

The proposed detention facility will attenuate the design 15 year frequency storm by 7.02 cfs, the design 25 year frequency storm by 8.31 cfs, and the design 100 year storm by 11.96 cfs.

Using the design 25 year storm as the basis for establishing the amount of money to be contributed to the City's Stormwater Management fund, the amount is established at $9,540.00 as detailed in Exhibit 'G'.

Graph's of the detention basin's depth-storage characteristics, depth-outflow characteristics and the design routing curve are all shown on Exhibit 'H'.

EXHIBITS

RUNOFF CONSIDERATIONS

1. Overall Considerations:

(a.) In accordance with the proposal made by letter to the City Engineer, signed by R. Musler of Bax Engineering Co., Inc. and dated July 18, 1986; which proposal was accepted by the City Engineer by letter, signed by Gerald R. Hurlbert, P.E. and dated July 30, 1986; copies of which are included in this exhibit; the proposed detention facility shall be designed to achieve the maximum attenuation possible.

(b.) The final achieved reduction in peak rate of runoff shall be used as a means of calculating the acreage that attenuation is provided for. The remaining acreage will then be known, for which a contribution of #1,000 per acre will be made. For these purposes, the ordinance required 25 year frequency storm shall be used.

(c.) As detailed in calculations made and submitted to the City Engineer previously, the design storm duration of 20 minutes is selected as being the most critical storm duration, as such duration has the largest difference in peak rates as well as being a duration that closely coincides with the time of concentration of the receiving stream at the point in the watershed that the proposed basin lies.

2. Runoff Considerations

(a.) For the purposes of this detention analysis, all flow to the detention basin will be assumed to inflow in an efficient manner, regardless of storm frequency.

(b.) For the purposes of estimating runoff, the following rational method factors will be used:

PRE-DEVELOPED CONDITIONS :	0% - 5% Impervious
	15 Year, 20 Min. P.I. = 1.87 cfs/AC
	25 Year, 20 Min. P.I. = 2.15 cfs/AC
	100 Year, 20 Min. P.I. = 2.95 cfs/AC
POST-DEVELOPED CONDITIONS :	40% Impervious
	15 Year, 20 Min. P.I. = 2.64 cfs/AC
	25 Year, 20 Min. P.I. = 3.04 cfs/AC
	100 Year, 20 Min. P.I. = 4.17 cfs/AC

(c.) For the purposes of sizing and calculating ordinance requirements, the 25 year 20 Min. PI factors will be used. Differential rate = 3.04 cfs/AC - 2.15 cfs/AC = 0.89 cfs/AC

GEORGE BUTLER ASSOCIATES, INC
Engineers / Architects / Landscape Architects / Planners
Suite 200 / 225 South Main Street / O'Fallon, Missouri 63366
Telephone (314) 272-2444

July 30, 1986

Richard S. Musler, P.E.
Bax Engineering Co., Inc.
530 Madison Street
St. Charles, Mo. 63301

Re: Parkview Place II
Detention Versus Contribution to Storm
Water Fund.

Dear Rich:

Please be advised that what you proposed in your letter dated July 18, 1986 is acceptable to the City of O'Fallon. The final determination of your contribution will be based on your approved final detention calculations upon your submittal.

Very truly yours,

GEORGE BUTLER ASSOCIATES, INC.

Gerald R. Hurlbert

Gerald R. Hurlbert, P.E.

cc: Jerry Schoenherr
John Griesenauer
Wilber Copenhafer

GRH/mbs

EXHIBIT 'A'
Sh't. 3 of 5

BAX ENGINEERING CO., INC.
530 Madison Street
St. Charles, Missouri 63301
946-6588 724-3330

July 18, 1986

Mr. Gerald R. Hurlbert, P.E.
GEORGE BUTLER ASSOCIATES, INC.
225 South Main Street, Suite 225
O'Fallon, MO 63366

RE: Parkview Place II Subdivision
Proposal to Contribute to City Storm Water Fund
Bax Project No. 84-1473

Dear Gerry,

I thought that I would confirm in writing the proposal that we made to you in our telephone conversation today, concerning a contribution to the City's Storm Water Fund.

We propose to construct the detention basin as depicted in our grading plan. Such basin is sized to have sufficient volume to store the differential runoff of our entire tract for the 25 year, 20 minute design storm, and contain approximately 30,000 cubic feet storage volume.

From our grading plan, we will have approximately 3.36 acres tributary to the basin without any unusual storm sewer alignment. Consequently, peak inflow to the basin will be approximately 10.2 cfs for the design 25 year, 20 minute storm. (Q= 3.36 A$\underline{C}$ x 3.04 cfs/A$\underline{C}$ = 10.2 cfs.) We propose to attenuate such flow in the proposed basin to perhaps 3.0 cfs outflow, thereby detaining some 7.2 cfs. (Final routing calculations will determine peak outflow and attenuation.)

If 7.2 cfs is detained, such attenuation would provide for storage of the differential runoff for some 8.0 acres. This is arrived at by the following calculation:

Detention = 7.2 cfs
Differential Rate = 3.04 cfs/A$\underline{C}$ - 2.15 cfs/A$\underline{C}$
= 0.89 cfs/A$\underline{C}$
Acres provided for = 7.2 cfs/0.89 cfs/A$\underline{C}$ = 8.0 A$\underline{C}$

Such detention will not provide sufficient attenuation for our entire 18.88 acre tract. Consequently, we would also propose to contribute $1,000 per acre for the remaining 11.0 acres for a total contribution of approximately $11,000.

EXHIBIT 'A'
Sh't. 4 of 5

As I also mentioned, flow rates to the other two sub-watersheds will remain as previously estimated.

Although the numbers above are estimates at this point, we ask for your review and approval of the concept of our proposal as stated herein. Upon yur conconcurrence, we will finalize storm sewer design and detention basin routing calculations.

Sincerely,

Richard S. Musler

Richard S. Musler, P.E.

RSM/bas

EXHIBIT 'A'
Sht. 5 of 5

INFLOW HYDROGRAPH CALCULATIONS

1. Of the flows that will inflow to the proposed detention basin, the most remote point is on West Park Drive.

The travel time on the left side of Ft. Zumwalt Dr. is:

Overland Flow (Hi Point W. Park Dr. to CI 125)

length ≅ 520'

Avg. slope ≅ $598 - 583 / 520$ ≅ 3%

velocity ≅ 3.5 ft/sec

travel time ≅ 520 ÷ 3.5 ft/sec = 149 secs

Pipe flow (CI 125 → FE 122)

length = 503'

velocity ≅ 7.0 ft/sec

travel time ≅ 503 ft ÷ 7.0 ft/sec = 72 secs

total travel time ≅ 149 + 72 = 221 secs ≅ 3.7 min.

The travel time on the right side of Ft. Zumwalt Dr. is:

Overland Flow (W. Park Dr. to CI 124)

length ≅ 800'

Avg. slope ≅ $597 - 578.5 / 800$ = 2.3 %

velocity ≅ 3.0 ft/sec

travel time ≅ 800 ft ÷ 3.0 ft/sec = 267 secs

Pipe flow (CI 124 → FE 122)

length = 172'

velocity ≅ 7.0 ft/sec

travel time ≅ 172 ft ÷ 7.0 ft/sec = 25 secs

total travel time ≅ 267 + 25 = 292 secs ≅ 4.8 min.

2. For inflow hydrograph purposes, use T_c = 4.0 minutes

3. From the Drainage Area Maps, peak inflow to the basin for 15 year, 20 minute storm is as follows:

Pipe Flow :	2.13 Ac @ 2.64 cfs/Ac	=	5.62 cfs
Direct Flow :	1.23 Ac @ 2.64 cfs/Ac	=	3.25 cfs
TOTALS	3.36 Ac		8.87 cfs

4. Inflow Hydrograph, 15 Year 20 Minute Storm, T_c = 4 minutes

TIME (minutes)	INFLOW RATE (cfs)	REMARKS
0	0	Design Rain Begins
		↕ Inflow rate increasing
2	4.44	
4	8.87	Begin Peak Inflow
6	8.87	↕ Inflow rate constant @ Peak rate
⌇	⌇	
20	8.87	Design Rain Ends
		↕ Inflow rate decreasing
22	4.44	
24	0	Inflow Ends

5. For a 25 Year, 20 Minute storm,

Peak Inflow Rate = 3.36 Ac @ 3.04 cfs/Ac = 10.21 cfs

6. Inflow Hydrograph, 25 Year 20 Minute Storm, T_c = 4 minutes

TIME (minutes)	INFLOW RATE (cfs)	REMARKS
0	0	Design Rain Begins
2	5.11	Inflow rate increasing
4	10.21	Begin Peak Inflow
6	10.21	Inflow rate constant @ Peak rate
⌇	⌇	
20	10.21	Design Rain Ends
22	5.11	Inflow rate decreasing
24	0	Inflow Ends

7. For 100 Year, 20 Minute Storm

Peak Inflow Rate = 3.36 Ac @ 4.17 cfs/Ac = 14.01 cfs

8. Inflow Hydrograph, 100 Year 20 Minute Storm, T_c = 4 minutes

TIME (minutes)	INFLOW RATE (cfs)	REMARKS
0	0	Design Rain Begins
2	7.01	Inflow rate increasing
4	14.01	Begin Peak Inflow

8. cont'd.

TIME (minutes)	INFLOW RATE (cfs)	REMARKS
4	14.01	Begin Peak Inflow
6	14.01	↕ Inflow rate constant @ peak rate
⋮	⋮	
20	14.01	Design Rain Ends
22	7.01	↕ Inflow rate decreasing
24	0	Inflow Ends

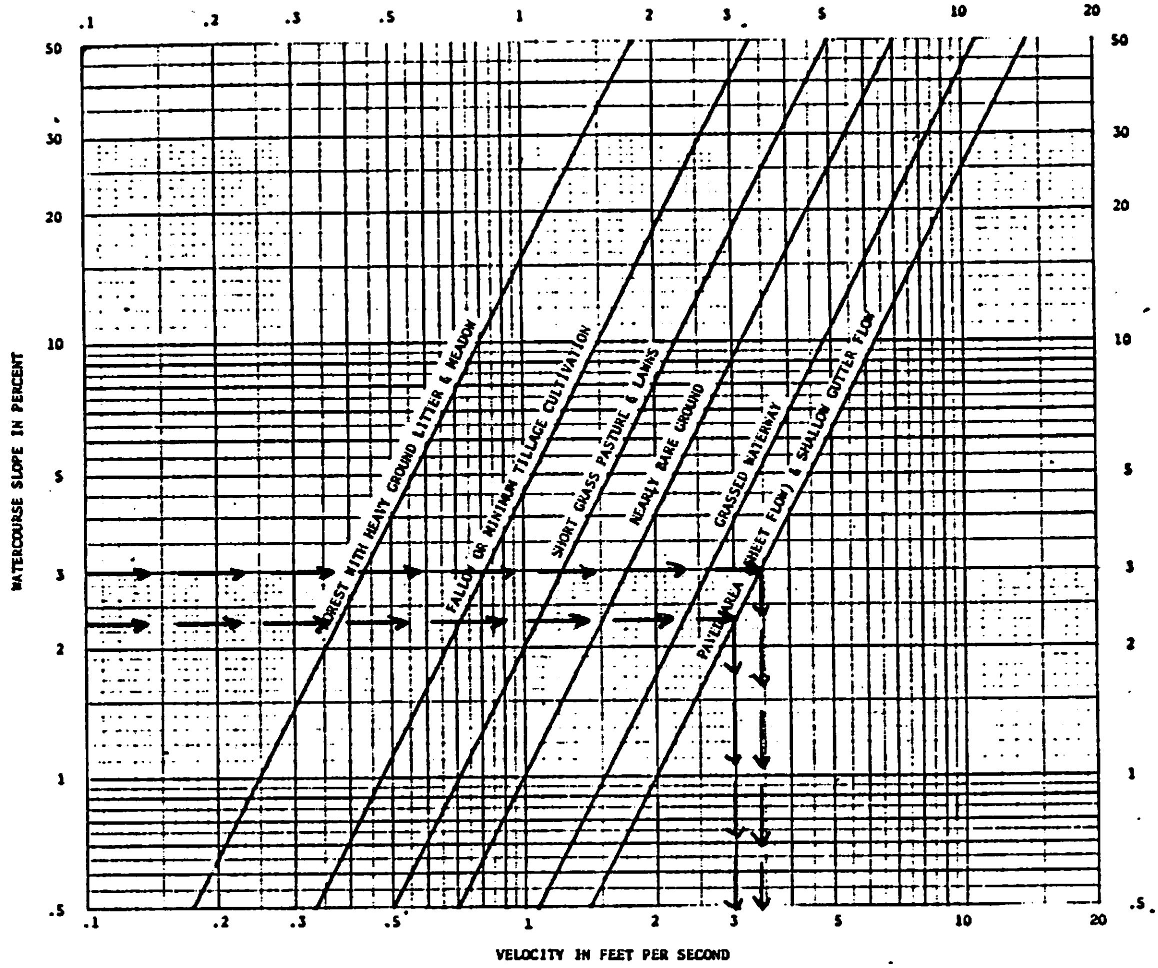

Figure 3-1.--Average velocities for estimating travel time for overland flow.

BAX ENGINEERING CO., INC.

LAND PLANNING — LAND SURVEYING — SITE ENGINEERING

EXHIBIT 'B'
Sh't. 5 of 5

DEPTH · STORAGE VOLUME CALCULATIONS

ELEVATION	AREA (A.C.)	AVERAGE AREA (A.C.)	INCREMENT OF DEPTH (FT.)	INCREMENT OF VOLUME (A.C. FT.)	TOTAL VOLUME (A.C. FT.)
558.0 (FL out)	0				0
		0.014	2.0	0.028	
560.0	0.028				0.028
		0.083	2.0	0.166	
562.0	0.138				0.194
		0.1675	2.0	0.335	
564.0	0.197				0.529
		0.2315	2.0	0.463	
566.0	0.266				0.992
		0.3095	2.0	0.619	
568.0 (Top Berm)	0.353				1.611

EXHIBIT 'C'
Sht. 1 of 1

SELECTION OF OUTFLOW STRUCTURE

1. As detailed in EXHIBIT 'A', the detention facility is desired to achieve the maximum attenuation possible. In order to minimize maintenance needs and clogging potential of the outflow pipe, a six (6) inch diameter pipe has been selected as the smallest pipe size to reasonably use.

2. The overflow structure proposed is an area inlet open on three sides, with a sill elevation of 566.00 and a top elevation of 566.92.

3. Outflow rates are estimated by use of the following equations:

6" ø PIPE : $Q_{out} = Ca\sqrt{2gH}$ (orifice equation)

AREA INLET : $Q_{out} = CLH^{3/2}$ (weir equation)

or

$Q_{out} = Ca\sqrt{2gH}$ (orifice equation)

A. Outflow Performance Calculations:

ELEVATION	6" ϕ PIPE H	6" ϕ PIPE Qout	A.I. OPEN 3 SIDES H	Qout	H	Qout	Controlling Qout	TOTAL Qout
558.0	0	0						0
559.0	0.75	0.82						0.82
560.0	1.75	1.25						1.25
561.0	2.75	1.57						1.57
562.0	3.75	1.83						1.83
563.0	4.75	2.06						2.06
564.0	5.75	2.26						2.26
565.0	6.75	2.45						2.45
566.0	7.75	2.63	0	0	0	0	0	2.63
566.5	8.25	2.71	0.5	9.55	0.25	10.83	9.55	12.26
567.0	8.75	2.79	1.0	27.00	0.75	18.76	18.76	21.55
568.0	9.75	2.95	2.0	76.37	1.75	28.66	28.66	31.66

6" ϕ PIPE : $Q_{out} = C a \sqrt{2gH}$

$= .60 \times .196 \sqrt{2gH}$

$= .1176 \sqrt{2gH}$

$a = 0.196 \text{ ft}^2$

℄ Elev = 558.25

H = Elev − 558.25

C = 0.60

A.I. : $Q_{out} = CLH^{3/2}$

C = 3.0

L = 38" + 38" + 32" = 108" = 9'

H = Elev − 566.0

$Q_{out} = C a \sqrt{2gH}$

C = 0.60

$a = 9' \times 0.5' = 4.5 \text{ ft}^2$

H = Elev − 566.25

EXHIBIT 'D'

Sht. 2 of 2

Routing Curve Calculations

Let Δt = 2 minutes = $0.03\dot{3}$ hours

Then $$2S/\Delta t + \text{Outflow} = \frac{2S \ (\text{Ac Ft.})}{0.03\dot{3} \ (\text{hrs.})} \times \frac{24 \ (\text{hours/day})}{1.98 \ (\text{Ac Ft./cfs-day})} + O \ (\text{cfs})$$

$$2S/\Delta t + \text{Outflow} = 727.27 \, S + O \quad (\text{cfs})$$

ELEVATION	S (Ac Ft)	O (cfs)	$2S/\Delta t + O$ (cfs)
558.0	0	0	0
559.0	0.010*	0.82	8.1
560.0	0.028	1.25	21.6
561.0	0.080*	1.57	59.8
562.0	0.194	1.83	142.9
563.0	0.348*	2.06	255.1
564.0	0.529	2.26	387.0
565.0	0.750*	2.45	547.9
566.0	0.992	2.63	724.1
567.0	1.260*	21.55	937.9
568.0	1.611	31.66	1,203.3
566.5	1.120*	12.26	826.3

* - From DEPTH-STORAGE VOLUME CURVE

EXHIBIT 'E'
Sht. 1 of 1

15 Year, 20 Minute Storm
T_c = 4 minutes

Design Pond Routing

FORM 102	0	1	2	3	4	5	6	7	
Line	Time (minutes)	I_1 (cfs)	I_1+I_2 (cfs)	$\frac{2S_1}{\Delta t} - O_1$	$\frac{2S_2}{\Delta t} + O_2$	Elev	Outflow O_2 (cfs)	Storage S_2	
1	0	0			0		0		
2	2	4.44	4.44	0	4.44		0.45		
3	4	8.87	13.31	3.54	16.85		1.1		
4	6	8.87	17.74	14.65	32.39		1.35		
5	8	8.87	17.74	29.69	47.43		1.45		
6	10	8.87	17.74	44.53	62.27		1.58		
7	12	8.87	17.74	59.11	76.85		1.6		
8	14	8.87	17.74	73.65	91.39		1.63		
9	16	8.87	17.74	88.13	105.87		1.7		
10	18	8.87	17.74	102.47	120.21		1.75		
11	20	8.87	17.74	116.71	134.45		1.79		
12	22	4.44	13.31	130.87	144.18		1.84		
13	24	0	4.44	140.50	144.94	562.10	1.85	0.208 Ac Ft. 9,060 Cu Ft.	PEAK OUTFLOW
14	26	0	0	141.24	141.24		1.82		
15									

EXHIBIT 'F', Sht. 1 of 4

25 Year, 20 Minute Storm
T_c = 4 minutes

Design Pond Routing

FORM 102	0	1	2	3	4	5	6	7
Line	Time (minutes)	I_1 (cfs)	I_1+I_2 (cfs)	$\frac{2S_1}{\Delta t} - O_1$	$\frac{2S_2}{\Delta t} + O_2$	Elev	Outflow O_2 (cfs)	Storage S_2
1	0	0			0		0	
2	2	5.11	5.11	0	5.11		0.5	
3	4	10.21	15.32	4.11	19.43		1.2	
4	6	10.21	20.42	17.03	37.45		1.4	
5	8	10.21	20.42	34.65	55.07		1.5	
6	10	10.21	20.42	52.07	72.49		1.55	
7	12	10.21	20.42	69.39	89.81		1.6	
8	14	10.21	20.42	86.61	107.03		1.7	
9	16	10.21	20.42	103.63	124.05		1.75	
10	18	10.21	20.42	120.55	140.97		1.8	
11	20	10.21	20.42	137.37	157.79		1.85	
12	22	5.11	15.32	154.09	169.41		1.88	
13	24	0	5.11	165.55	170.76	562.30	1.9	0.235 AF Ft. 10,237 Cu. Ft.
14	26	0	0	166.96	166.96		1.86	
15								

PEAK OUTFLOW

EXHIBIT 'E'
Sht. 2 of 4

100 Year, 20 Minute Storm

T_c = 4 minutes

Design Pond Routing

FORM 102	0	1	2	3	4	5	6	7
Line	Time (minutes)	I_1 (cfs)	I_1+I_2 (cfs)	$\frac{2S_1}{\Delta t} - O_1$	$\frac{2S_2}{\Delta t} + O_2$	Elev	Outflow O_2 (cfs)	Storage S_2
1	0	0			0		0	
2	2	7.01	7.01	0	7.01		0.65	
3	4	14.01	21.02	5.71	26.73		1.35	
4	6	14.01	28.02	24.03	52.05		1.45	
5	8	14.01	28.02	49.15	77.17		1.6	
6	10	14.01	28.02	73.97	101.99		1.65	
7	12	14.01	28.02	98.69	126.71		1.75	
8	14	14.01	28.02	123.21	151.23		1.85	
9	16	14.01	28.02	147.53	175.55		1.9	
10	18	14.01	28.02	171.75	199.77		1.95	
11	20	14.01	28.02	195.87	223.89		2.0	
12	22	7.01	21.02	219.89	240.90		2.02	
13	24	0	7.01	236.86	243.87	562.95	2.05	0.340 Ac Ft. 14,810 Cu. Ft.
14	26	0	0	239.77	239.77		2.02	
15								

PEAK OUTFLOW

EXHIBIT 'F'
Sht. 3 of 4

SUMMARY OF ROUTING CALCULATIONS

1. 15 Year 20 Minute Storm

   PEAK INFLOW RATE = 8.87 cfs

   PEAK OUTFLOW RATE = 1.85 cfs

   ATTENUATION = 7.02 cfs

   HIGH WATER ELEVATION = 562.10

   OVERFLOW SILL ELEVATION = 566.00

   FREEBOARD = 3.90 ft.

2. 25 Year 20 Minute Storm

   PEAK INFLOW RATE = 10.21 cfs

   PEAK OUTFLOW RATE = 1.90 cfs

   ATTENUATION = 8.31 cfs

   HIGH WATER ELEVATION = 562.30

   FREEBOARD TO OVERFLOW SILL = 3.70 ft.

3. 100 YEAR, 20 Minute Storm

   PEAK INFLOW RATE = 14.01 cfs

   PEAK OUTFLOW RATE = 2.05 cfs

   ATTENUATION = 11.96 cfs

   HIGH WATER ELEVATION = 562.95

   FREEBOARD TO OVERFLOW SILL = 3.05 ft.

   CAPACITY OF OVERFLOW STRUCTURE = 31.66 cfs AT TOP OF BERM ELEV.

CALCULATION OF MONETARY CONTRIBUTION TO BE MADE TO CITY'S STORMWATER MANAGEMENT FUND

1. Basis of contribution amount to be attenuation provided in 25 Year 20 Minute Storm. Attenuation provided during such storm ≅ 8.31 cfs.

2. Differential Runoff Rate = 0.89 cfs/Ac

3. Attenuation provided accounts for the following acreage:

   Acres = 8.31 cfs ÷ 0.89 cfs/Ac
   = 9.34 Acres

4. Overall Tract Size = 18.88 Acres
   Acres provided for = 9.34 Acres
   Acres NOT provided for = 18.88 - 9.34 = 9.54 Ac

5. Monetary Contribution Amount = 9.54 Ac × $1,000 / Ac

   = $9,540.00

EXHIBIT 'G'
Sh't. 1 of 1

K+E 20 x 20 TO THE INCH • 10 x 15 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

47 1242

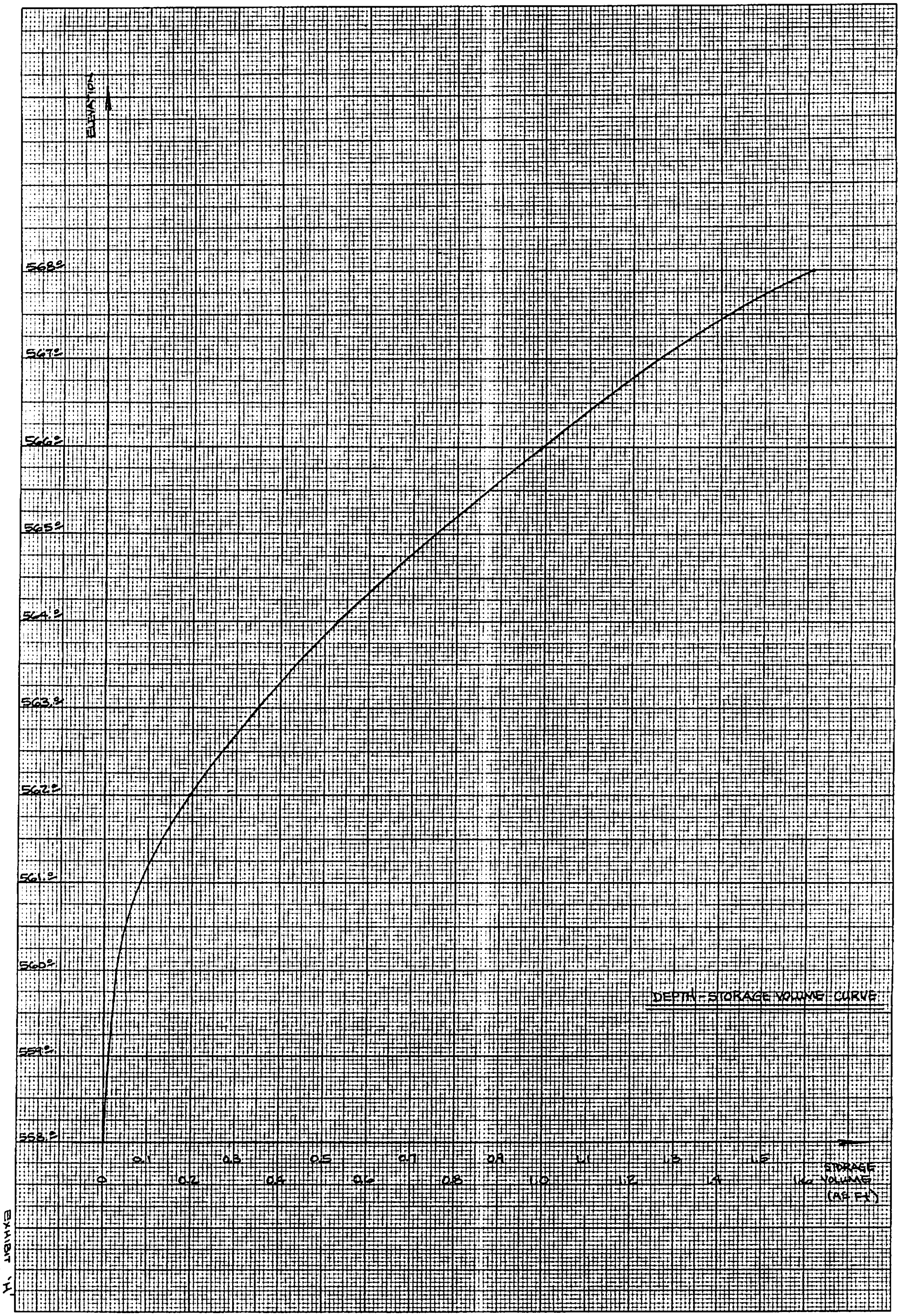

EXHIBIT 'H'
Sht. 1 of 3

K+E 20 x 20 TO THE INCH • 10 x 15 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

47 1242

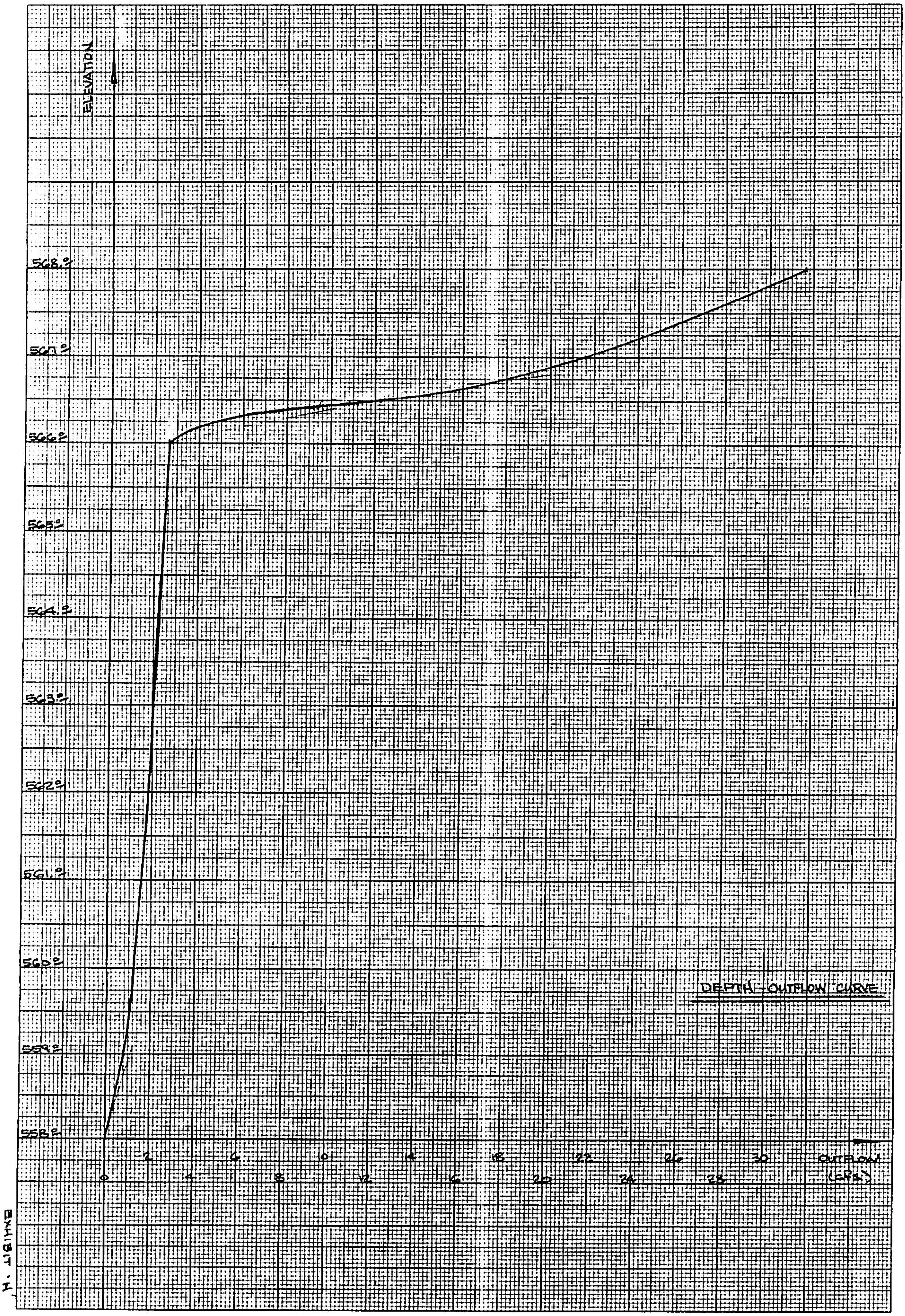

EXHIBIT 'H'
Sht. 2 of 3

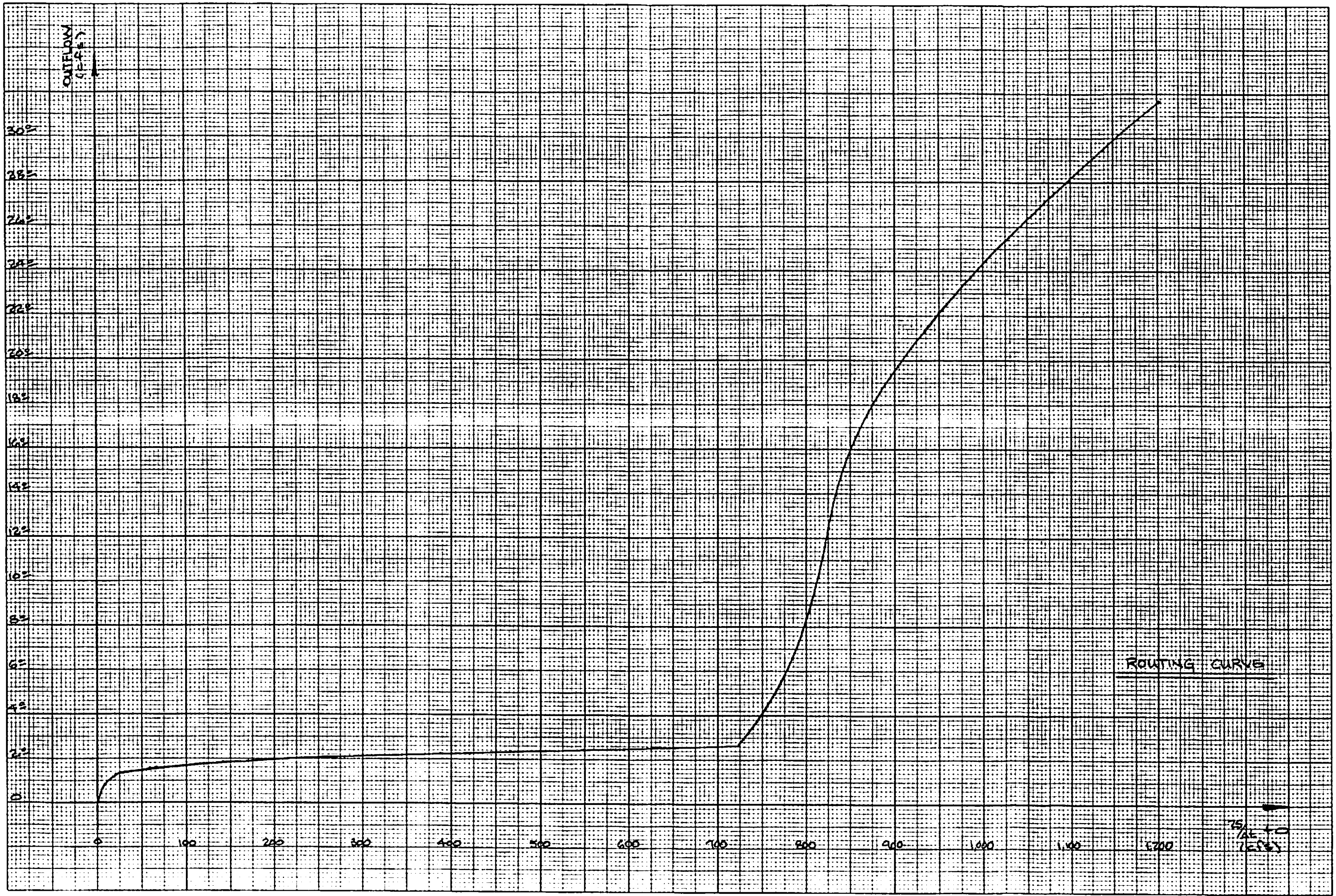

EXHIBIT 'H'
Sh't. 3 of 3