STORMWATER DETENTION ANALYSIS

BAYFIELD
BAX PROJECT NO. 84-1200N

PREPARED FOR:

MLS INVESTMENTS COMPANY
11443 ST. CHARLES ROCK ROAD.
BRIDGETON, MISSOURI 63044

PREPARED BY:

BAX ENGINEERING COMPANY, INC.
221 POINT WEST BOULEVARD
ST.CHARLES, MO 63301
TELEPHONE: 946-6588

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Richard S. Nuster

## I. PURPOSE

The purpose of this report is to estimate the increase in the storwater runoff rate due to development of the tract of land known as "BAYFIELD" and to estimate the attenuation characteristics of the stormwater detention facility that is proposed to be constructed as part of the site improvements. Based upon such estimates, a comparison is made between the pre-developed rate of stormwater runoff and the post-developed rate of stormwater runoff.

## II. SCOPE

This report estimates the expected increase in stormwater runoff rate and attenuation characteristics during a 25 year frequency storm of 20 minutes duration, utilizing the rational method of estimating stormwater runoff to the detention facility. In addition, a storm of great intensity is checked for safe passage through the detention facility.

## III. DETENTION CONCEPT

The proposed site improvements include construction of a dry detention basin at the southwest corner of the site. The role of the detention basin is to provide attenuation for storm water runoff. The sizing of the outflow pipe will allow the peak outflow to be regulated so that the peak rate of runoff leaving the site under post-developed conditions is within range of the peak rate of runoff leaving the site under pre-developed conditions.

## IV. STORMWATER RUNOFF INFORMATION

Runoff calculations for the tract and calculations of required attenuations are shown on Exhibit 'A'.

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

## V. DETENTION BASIN CHARACTERISTICS

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

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 curves.

Exhibit 'F' displays the routing calculations.

## VII. SUMMARY

The proposed detention basin is to be designed to provide attenuation for as much of the Bayfield development as possible.

In considering a 25 year frequency storm of 20 minutes, the basin will attenuate for approximately 85% of the entire development. The pre-developed peak discharge from the entire site is 319.24 c.f.s. as compared to a post-developed peak discharge of 362.96 c.f.s.

Overflow structure calculations for a 100 year storm have also been checked and shown on Exhibit 'G'.

A breakdown of the entire attenuation and discharge is shown on Exhibit 'H'.

Graphs of the basin's inflow-time characteristics, depth-storage characteristics, depth-outflow characteristics and the design routing curve hydrograph are all shown on Exhibit 'I'.

# E X H I B I T S

# GENERAL SITE DATA & RUNOFF CALCULATIONS

When Phase I of "BAYFIELD SUBDIVISION" was approved the entire tract was governed by St. Charles County, not yet being in the City of O'fallon. At this point, a detention basin was not required. As the development progressed, St. Charles County stated that it would require detention for future development of the site, and therefore a detention basin was incorporated into the plans. The basin was to be built in the last phase of the development. As the site was being developed, it was annexxed into the City of O'fallon.

Because of the change in detention requirement, the site was not planned in a way that would drain a majority of the runoff to the basin or accomodate two or more basins. This report will show 1.) what attenuation is required using current regulations and 2.) what the detention basin actually attenuates using a 25 year 20 minute storm. An outflow pipe of 12 inch diameter will be use since this is commonly the smallest pipe requested for this size of basin.

EXHIBIT 'A'

1.) The tract of land under pre-developed conditions is generally undeveloped, and for the purpose of this analysis, assumed to be 0% to 5% impervious. The pre-developed P.I. factor is: 1.7 c.f.s./$A^c$ x 1.18 x 1.15 = 2.31 c.f.s./$A^c$.

2.) Under pre-developed conditions, peak rates of runoff tho the sub-watershed can be estimated as follows:

138.2 $A^c$ x 2.31 c.f.s./$A^c$ = 319.24 c.f.s.

(This estimated peak rate normally would be considered to be the limiting peak rate under post-developed conditions.)

3.) The tract of land under post developed conditions will be a single family residential subdivision with a post-developed P.I. factor of:

2.4 c.f.s./$A^c$ x 1.18 x 1.15 = 3.26 c.f.s./$A^c$.

4.) Under post developed conditions, peak rates of runoff from the subject tract to the subwatershed can be estimated as follows:

138.2 $A^c$ x 3.26 c.f.s/$A^c$ = 450.53 c.f.s.

5.) The attenuation normally required is therefore

450.53 c.f.s. − 319.24 = 131.29 cfs.

EXHIBIT 'A'

Sh't. 2 OF 2

## INFLOW HYDROGRAPH CALCULATIONS

1.) Of the flows that will inflow to the proposed detention basin, the most remote point of origination lies offsite approximately 700 feet offsite from the north property line where it will be picked up by an area inlet and then travel approximately 1480 feet via storm sewer. Therefore, the time of concentration can be found in the following manner.

a.) 700 feet with a difference in elevation of about 26 feet (605-579) results in a travel time of 8.4 minutes. (4.2 min. x 2 = 8.4 min. see Exhibit 'B' Sh't. 6 of 6.)

b. 1480 feet with an average velocity of 7 feet per second results in a travel time of 3.52 minutes. $\left(\frac{1480\,ft.}{1} \times \frac{1}{7\,ft/sec} \times \frac{1\,min}{60\,sec}\right)$

∴ Time of concentration = 8.4 min. + 3.52 min.
= 11.92 min ⇒ use 12 minutes.

2.) From the drainage area map
project, the estimated peak inflow to the basin is:

| | | |
|---|---|---|
| F.E.S. '646' (includes 4.98 $A^{c}$ offsite) | = | 24.95 $A^{c}$ |
| F.E.S. '627' (includes 2.49 $A^{c}$ offsite) | = | 9.56 $A^{c}$ |
| Direct into basin | = | 2.86 $A^{c}$ |
| TOTAL ACREAGE INFLOW | = | 37.37 $A^{c}$ |

Offsite flows will be considered fully developed using the appropriate P.I. factor for the zoning of surrounding property. In this case, it will be the same P.I. factor as this development which is 40 % impervious for single family residences, 10,000 square feet or less.

$\therefore$ PEAK INFLOW$_{25\ YEAR}$ = 37.37 $A^{c}$ x 3.26 c.f.s./$A^{c}$ = 121.83 c.f.s.

PEAK INFLOW$_{15\ YEAR}$ = 37.37 $A^{c}$ x 2.64 c.f.s./$A^{c}$ = 98.66 c.f.s.

PEAK INFLOW$_{100\ YEAR}$ = 37.37 $A^{c}$ x 4.17 c.f.s./$A^{c}$ = 155.83 c.f.s.

EXHIBIT 'B'

3) Inflow hydrograph for design 25 year frequency storm of 20 minutes duration with $t_c = 12$ minutes.

| TIME (minutes) | INFLOW RATE (c.f.s.) | REMARKS |
|---|---|---|
| 0 | 0 | Design Rain Begins |
| 2 | 20.31 | |
| 4 | 40.61 | |
| 6 | 60.92 | |
| 8 | 81.22 | |
| 10 | 101.53 | |
| 12 | 121.83 | All Areas Contributing Begin Peak Inflow |
| 14 | 121.83 | Inflow Rate Constant @ Peak Inflow Rate |
| 16 | 121.83 | |
| 18 | 121.83 | |
| 20 | 121.83 | Design Rain Ends |
| 22 | 101.53 | |
| 24 | 81.22 | |
| 26 | 60.92 | |
| 28 | 40.61 | |
| 30 | 20.31 | |
| 32 | 0 | Inflow Ends |
| 34 | 0 | |

EXHIBIT 'B'

Sh't 3 OF 6

4) Inflow hydrograph for 15 year frequency storm of 20 minutes duration with $t_c = 12$ minutes.

| TIME (minutes) | INFLOW RATE (c.f.s.) | REMARKS |
|---|---|---|
| 0 | 0 | Design Rain Begins |
| 2 | 16.44 | |
| 4 | 32.89 | |
| 6 | 49.33 | |
| 8 | 65.77 | |
| 10 | 82.22 | |
| 12 | 98.66 | All Areas Contributing Begin Peak Inflow |
| 14 | 98.66 | Inflow Rate Constant @ Peak Inflow Rate |
| 16 | 98.66 | |
| 18 | 98.66 | |
| 20 | 98.66 | Design Rain Ends |
| 22 | 82.22 | |
| 24 | 65.77 | |
| 26 | 49.33 | |
| 28 | 32.89 | |
| 30 | 16.44 | |
| 32 | 0 | Inflow Ends |
| 34 | 0 | |

EXHIBIT 'B'

Sh't. 4 OF 6

5.) Inflow hydrograph for 100 year frequency storm of 20 minutes duration with $t_c = 12$ minutes.

| TIME (minutes) | INFLOW RATE (c.f.s.) | REMARKS |
|---|---|---|
| 0 | 0 | Design Rain Begins |
| 2 | 25.97 | |
| 4 | 51.94 | |
| 6 | 77.92 | |
| 8 | 103.89 | |
| 10 | 129.86 | |
| 12 | 155.83 | All Areas Contributing Begin Peak Inflow |
| 14 | 155.83 | |
| 16 | 155.83 | Inflow Rate Constant @ Peak Inflow Rate |
| 18 | 155.83 | |
| 20 | 155.83 | Design Rain Ends |
| 22 | 129.86 | |
| 24 | 103.89 | |
| 26 | 77.92 | |
| 28 | 51.94 | |
| 30 | 25.97 | |
| 32 | 0 | Inflow Ends |
| 34 | 0 | |

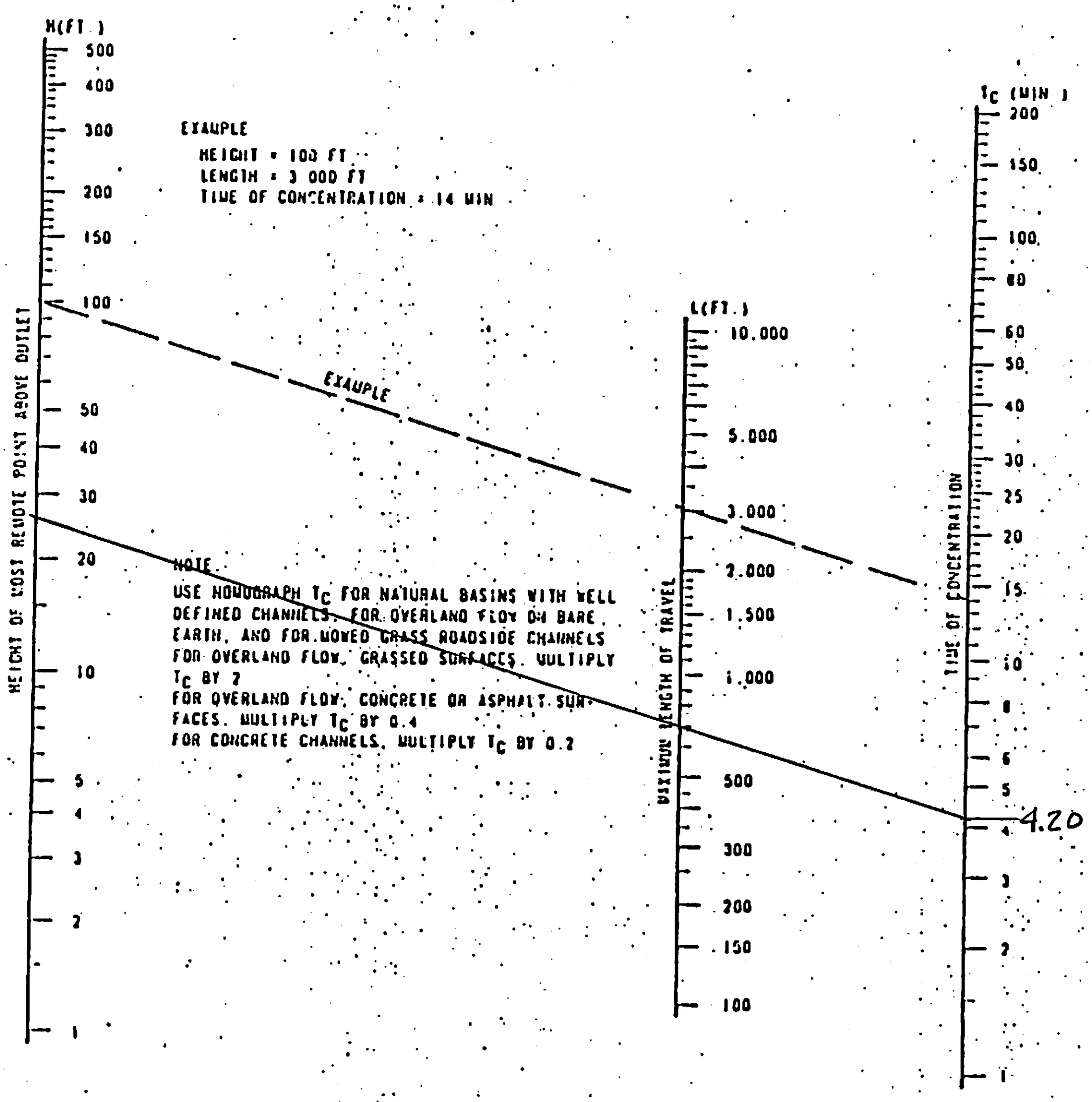


FIGURE 1

TIME OF CONCENTRATION OF SMALL DRAINAGE BASINS

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EXHIBIT 'B'

Sh't. 6 OF 6

# DEPTH STORAGE VOLUME CALCULATION

| ELEVATION | AREA (Ac) | AVERAGE AREA (Ac) | INCREMENT OF DEPTH (FT.) | INCREMENT OF VOLUME (Ac-FT) | TOTAL VOLUME (Ac-FT) |
|---|---|---|---|---|---|
| $531^{75}$ | 0 | | | | |
| | | 0.015 | 0.25 | 0.004 | |
| $532^{00}$ | 0.030 | | | | 0.004 |
| | | 0.341 | 2.00 | 0.682 | |
| $534^{00}$ | 0.651 | | | | 0.686 |
| | | 0.890 | 2.00 | 1.780 | |
| $536^{00}$ | 1.129 | | | | 2.466 |
| | | 1.199 | 2.00 | 2.398 | |
| $538^{00}$ | 1.268 | | | | 4.864 |
| | | 1.396 | 2.00 | 2.792 | |
| $540^{00}$ | 1.523 | | | | 7.656 |

EXHIBIT 'C'

Sh't. 1 OF 1

# DEPTH-OUTFLOW CALCULATIONS

1.) Outflow pipe: 12" ø R.C.P.

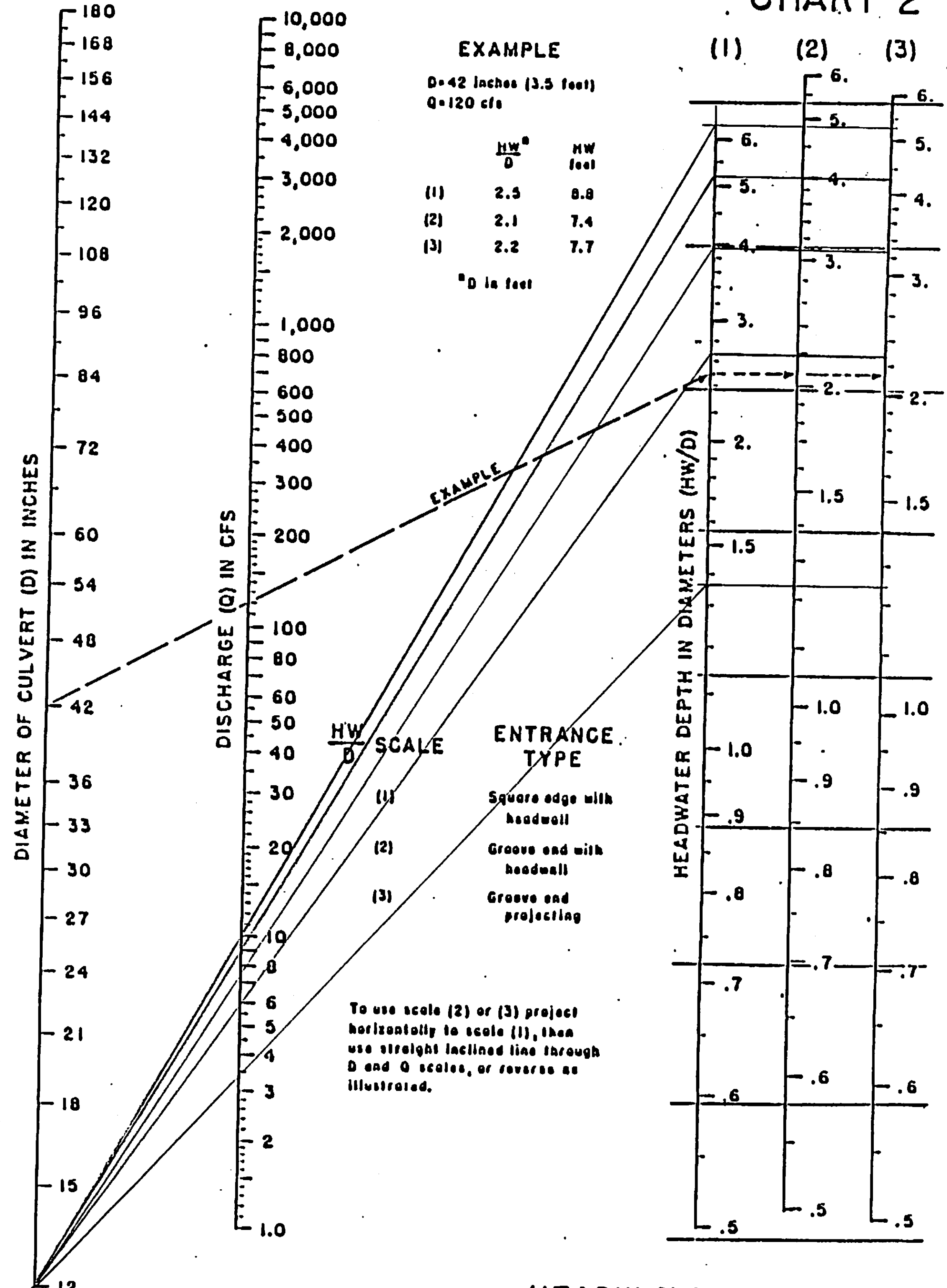
℄ ELEV. = 531.75

2.) PERFORMANCE CALCULATIONS:

| ELEVATION | H (ft.) | Hw/D | Qout (c.f.s.) |
|---|---|---|---|
| 531.75 | 0 | 0 | 0 |
| 532.00 | 0.25 | 0.25 | |
| 533.00 | 1.25 | 1.25 | 3.5 |
| 534.00 | 2.25 | 2.25 | 6.0 |
| 535.00 | 3.25 | 3.25 | 7.5 |
| 536.00 | 4.25 | 4.25 | 9.0 |
| 537.00 | 5.25 | 5.25 | 10.0 |
| 538.00 | 6.25 | 6.25 | |

EXHIBIT 'D'

CHART 2




HEADWATER SCALES 2&3
REVISED MAY 1964

BUREAU OF PUBLIC ROADS JAN. 1963

# HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

| | |
|---|---|
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## ROUTING CURVE COMPUTATIONS

Let $\Delta t$ = 2 minutes = 0.033 hours

Then $\frac{2S}{\Delta t}$ + outflow = $\frac{2S\,(\text{Ac.-Ft.})}{\Delta t\ \text{hrs.}} \times \frac{24\ \text{hrs./day}}{1.98\ (\text{Ac-Ft./c.f.s.-day})}$ + O (c.f.s.)

$\frac{2S}{\Delta t}$ + O = 727.27 S + O (c.f.s.)

| ELEVATION | S (Ac.-Ft.) | O (c.f.s.) | $\frac{2S}{\Delta t}$ + O (c.f.s.) |
|---|---|---|---|
| 531.75 | 0 | 0 | 0 |
| 532.0 | 0.004 | 0.7** | 3.61 |
| 533.0 | 0.210* | 3.5 | 156.23 |
| 534.0 | 0.686 | 6.0 | 504.91 |
| 535.0 | 1.450* | 7.5 | 1062.04 |
| 536.0 | 2.466 | 9.0 | 1802.45 |
| 537.0 | 3.600* | 10.0 | 2628.17 |

*FROM DEPTH STORAGE VOLUME CURVE

**FROM DEPTH VS. OUTFLOW CURVE

EXHIBIT 'E'

Sh't. 1 OF 1

## Design Pond Routing

| FORM 102 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| Line | Time | $I_1$ | $I_1+I_2$ | $\frac{2S_1}{\Delta t} - O_1$ | $\frac{2S_2}{t} + O_2$ | Elev | Outflow $O_2$ | Storage $S_2$ |
| 1 | 0 | 0.0 | | | 0 | | 0 | |
| 2 | 2 | 20.31 | 20.31 | 0 | 20.31 | | 1.5 | |
| 3 | 4 | 40.61 | 60.92 | 17.31 | 78.23 | | 2.5 | |
| 4 | 6 | 60.92 | 101.53 | 73.23 | 174.76 | | 3.7 | |
| 5 | 8 | 81.22 | 142.14 | 167.36 | 309.50 | | 4.8 | |
| 6 | 10 | 101.53 | 182.75 | 299.90 | 482.65 | | 5.9 | |
| 7 | 12 | 121.83 | 223.36 | 470.85 | 694.21 | | 6.6 | |
| 8 | 14 | 121.83 | 243.66 | 681.01 | 924.67 | | 7.2 | |
| 9 | 16 | 121.83 | 243.66 | 910.27 | 1153.93 | | 7.8 | |
| 10 | 18 | 121.83 | 243.66 | 1138.33 | 1381.99 | | 8.5 | |
| 11 | 20 | 121.83 | 243.66 | 1364.99 | 1608.65 | | 9.1 | |
| 12 | 22 | 101.53 | 223.36 | 1590.45 | 1813.81 | | 9.5 | |
| 13 | 24 | 81.22 | 182.75 | 1794.81 | 1977.56 | | 9.7 | |
| 14 | 26 | 60.92 | 142.14 | 1958.16 | 2100.30 | | 9.8 | |
| 15 | 28 | 40.61 | 101.53 | 2080.70 | 2182.23 | | 9.9 | |

EXHIBIT 'F'
Sh't. 1 of 2

# Design Pond Routing

| FORM 102 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| Line | Time | $I_1$ | $I_1+I_2$ | $\frac{2S_1}{\Delta t} - O_1$ | $\frac{2S_2}{t} + O_2$ | Elev | Outflow $O_2$ | Storage $S_2$ |
| 1 | 30 | 20.31 | 60.92 | 2162.43 | 2223.35 | | 9.9 | |
| 2 | 32 | 0.0 | 20.31 | 2203.55 | 2223.86 | 536.4 | 9.9 | 2.9 AC-FT.<br>126,324 Cu. Ft. |
| 3 | 34 | 0.0 | 0.0 | 2204.06 | 2204.06 | | 9.9 | |
| 4 | 36 | 0.0 | 0.0 | 2184.26 | 2184.26 | | 9.9 | |
| 5 | 38 | 0.0 | 0.0 | 2164.46 | 2164.46 | | 9.8 | |
| 6 | 40 | 0.0 | 0.0 | 2144.86 | 2144.86 | | 9.8 | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| 9 | | | | | | | | |
| 10 | | | | | | | | |
| 11 | | | | | | | | |
| 12 | | | | | | | | |
| 13 | | | | | | | | |
| 14 | | | | | | | | |
| 15 | | | | | | | | |

PEAK OUTFLOW

EXHIBIT 'F'
Sh't. 2 of 2

## OVERFLOW STRUCTURE CALCULATIONS

CONSIDER 100 YEAR STORM

$Q_{100/20} = 37.37\ A^c \times 4.17\ C.F.S./A^c = 155.83\ C.F.S.$

STRUCTURE IS TO BE A SPILLWAY.

The calculations on the following page will show that a spillway of length 300 feet will allow passage of the 100 year storm. The water will reach a depth of 0.31 feet over the spillway. The velocity of the water down the spillway will be 4.79 ft./sec. Since the velocity is under 5 ft/sec. no slope protection other than sod should be necessary.

TOP SPILLWAY ELEVATION = 539.50

TOP OF BERM ELEVATION = 540.00

15 YEAR HIGH WATER = 536.40

100 YEAR HIGH WATER OF CREEK = 539.2 ± (AT UPPER END NEAREST SPILLWAY)

EXHIBIT 'G'

Sh't. 1 OF 2

TO DETERMINE FLOW DOWN SPILLWAY.

Length of spillway = 300 ft.

$Q = CLH^{3/2}$

$155.83 = 3(300)(H^{3/2})$

$H = .3107$

$Q_i$ = Discharge /ft. of spillway

$= 155.83/300$

$= 0.5194$ c.fs.

$d_c$ = critical depth $= (.5194^2/32.2)^{.33}$

$= .2064$

$V_c$ = critical velocity $= Q_i/d_c$

$= .5194/.2064$

$= 2.52$

$S_c$ = critical slope $= K \times n^2 \times V_c^{0.33}/Q_i^{.33}$ K = 14.56 n = .04 (turf)

$= 14.56 \times .04^2 \times 2.52^{.33}/.5194^{.33}$

$= 0.0392$

$S_e$ = slope of spillway = 0.3333

$V_e$ = Velocity down spillway $= V_c\left(\frac{S_e}{S_c}\right)^{.3}$

$= 2.52\left(\frac{.3333}{0.0392}\right)^{.3}$

$= 4.79$ ft./sec.

EXHIBIT 'G'

## TOTAL ATTENUATION & DISCHARGE

25 YEAR STORM:

PEAK INFLOW = 121.83 C.F.S.

PEAK OUTFLOW = 9.9 C.F.S.

∴ ATTENUATION = 111.93 C.F.S.

ATTENUATION NORMALLY REQUIRED = 131.29

∴ THIS BASIN WILL ATTENUATE APPROXIMATELY 85% OF WHAT IS NORMALLY REQUIRED UNDER CURRENT REGULATIONS.

PEAK DISCHARGE (PRE-DEVELOPED) = 319.24 c.f.s.

PEAK DISCHARGE (POST-DEVELOPED):

ONSITE TO BASIN = 37.37 $A^c$ − 7.47 $A^c$ (offsite) = 29.90 $A^c$

∴ PEAK DISCHARGE = PEAK DISCHARGE FROM BASIN + PEAK DISCHARGE OF AREA BY-PASSING BASIN.

= 9.9 c.f.s. + ((138.2 − 29.90) × (3.26))

= 9.9 c.f.s. + 353.06

= 362.96 c.f.s.

INCREASE IN PEAK DISCHARGE

= 362.96 − 319.24 = 43.72 c.f.s.

≅ 14% INCREASE

EXHIBIT 'H'

Sh't. 1 OF 1

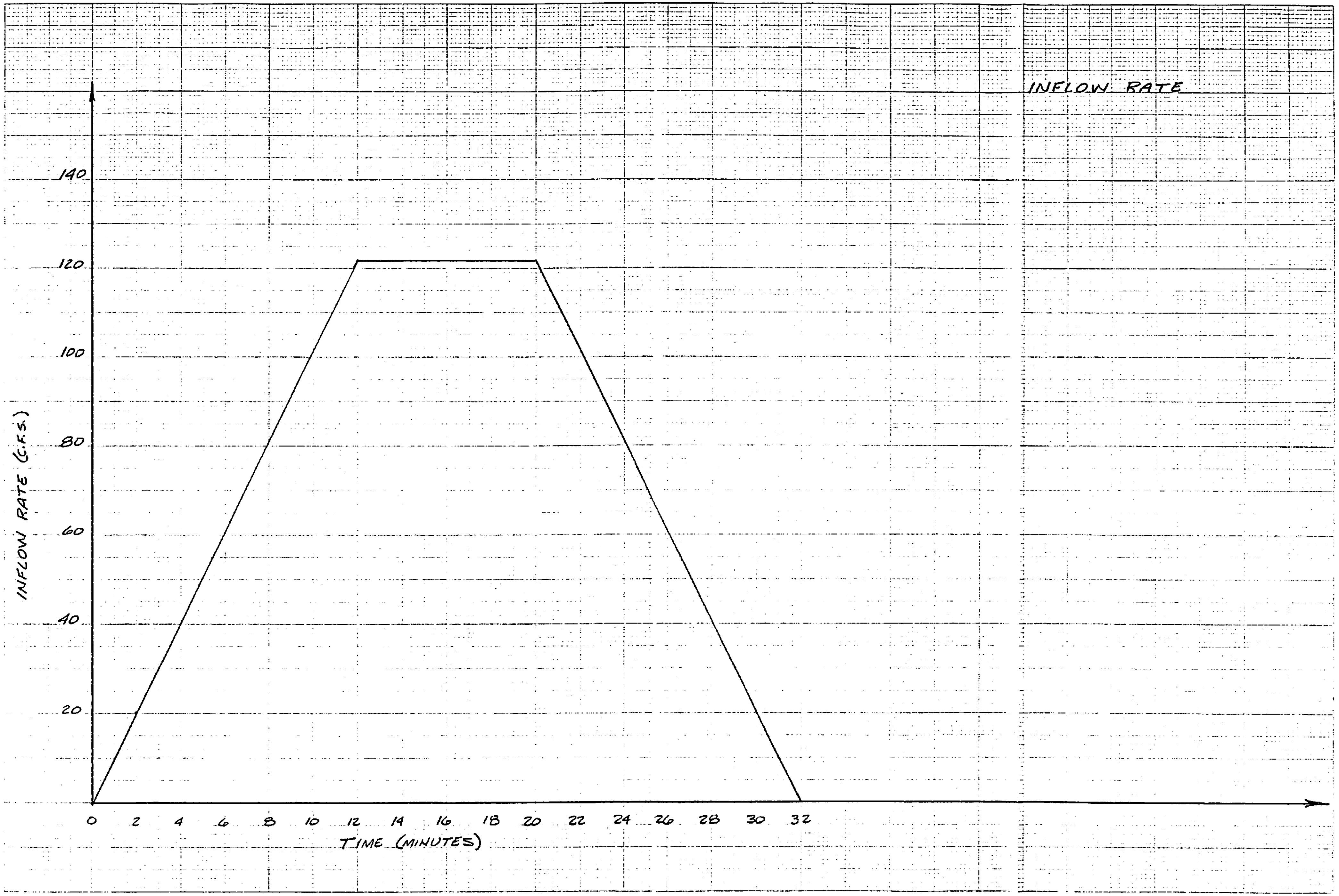
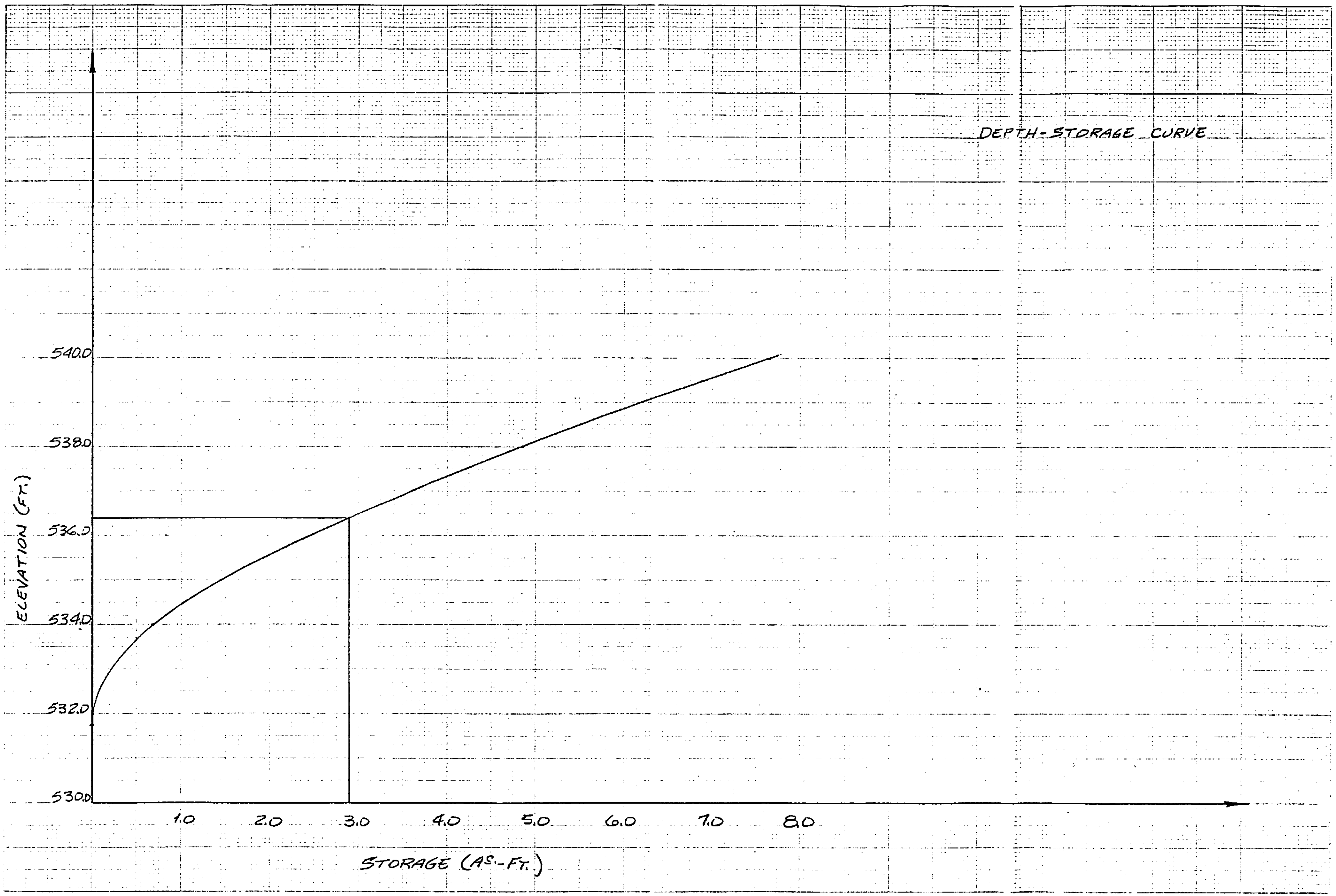



EXHIBIT 'I'
Sh't. 1 of 4

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Sht. 2 OF 4

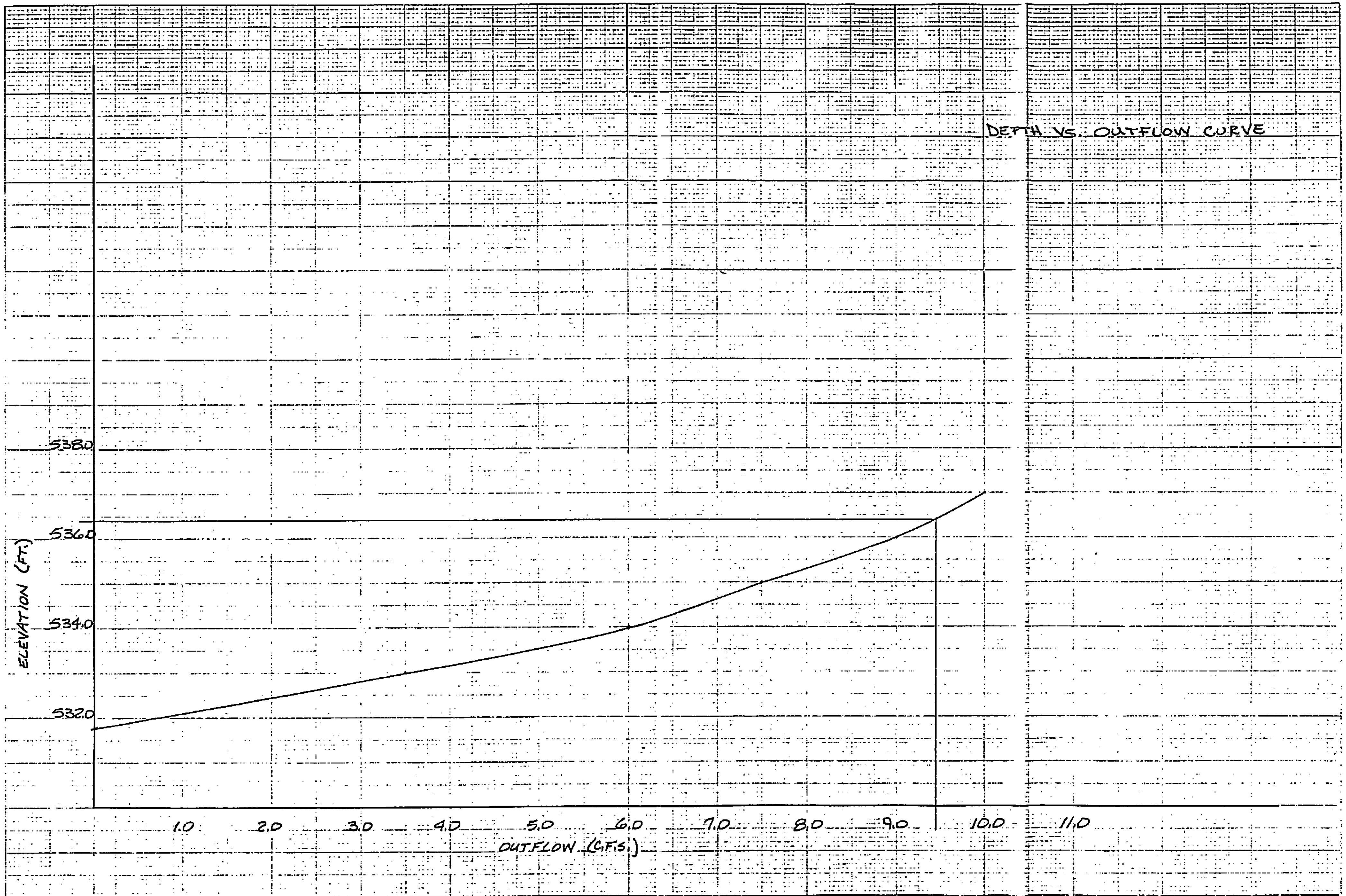



EXHIBIT 'I'
Sh't. 3 of 4

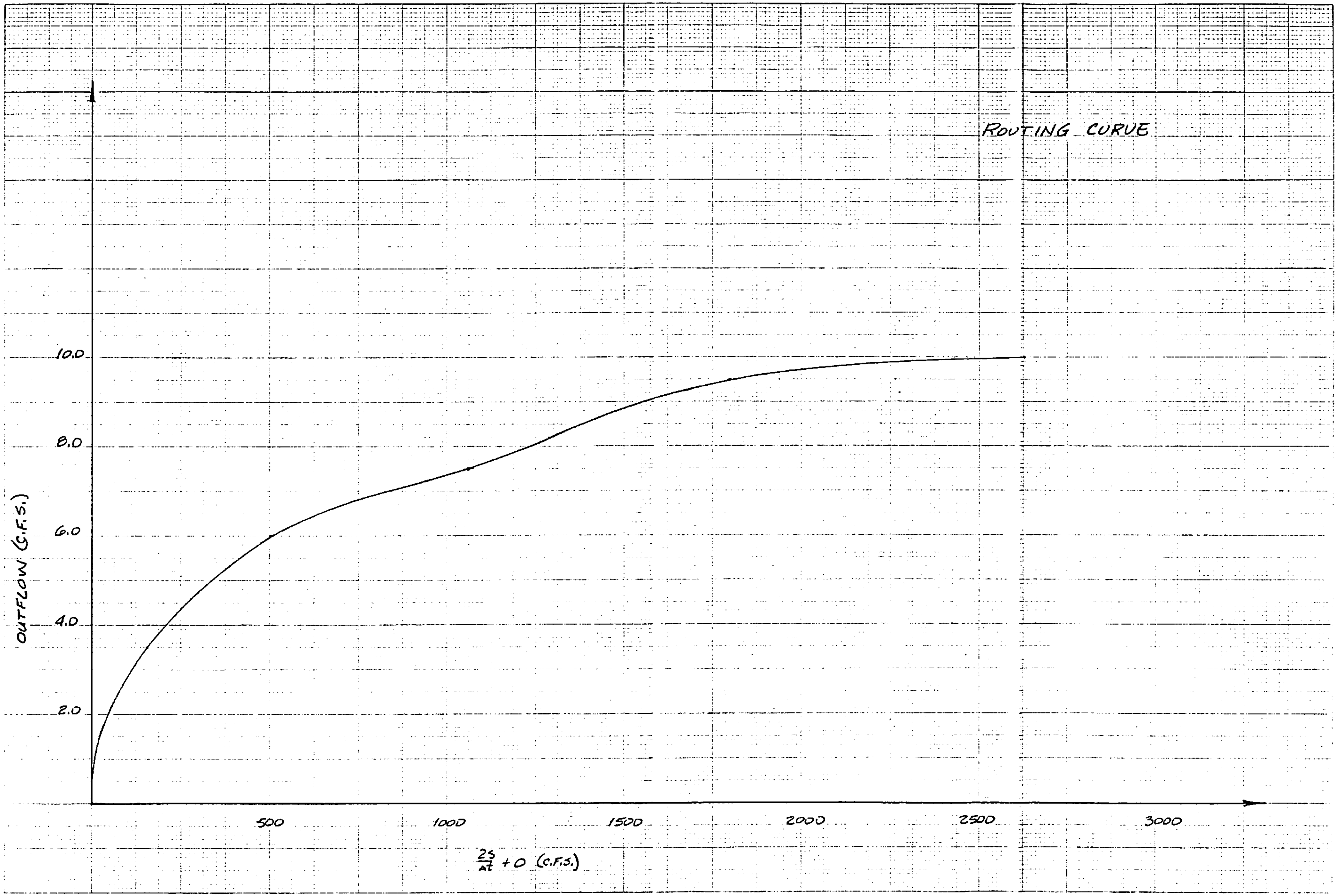
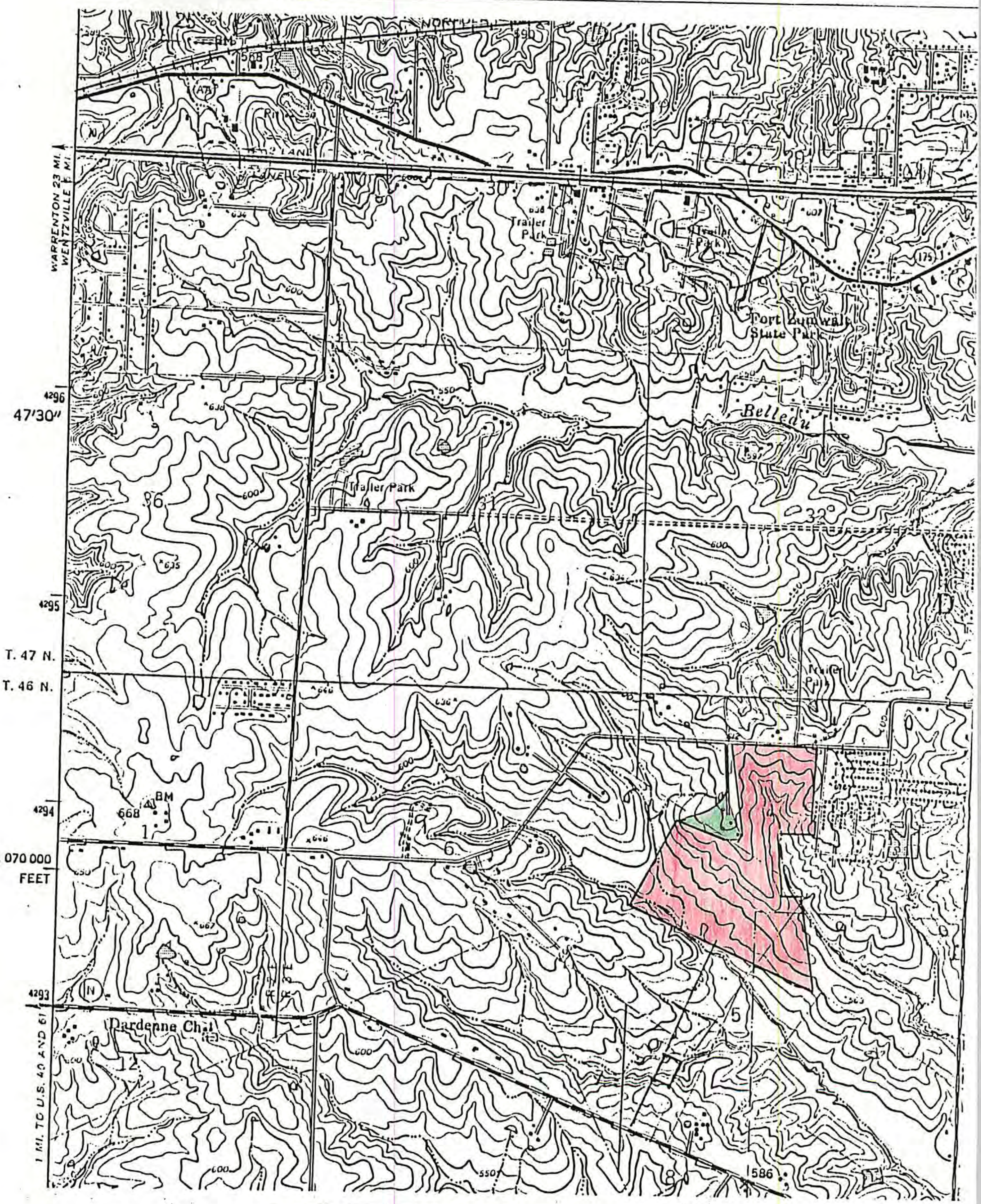





EXHIBIT 'I'
Sh't. 4 OF 4




# DRAINAGE AREA MAP

SCALE: 1" = 2000'