ORDINANCE ENACTED 9/11/76

§60-5 AMENDED BY COUNTY BOARD 6/12/10

ARLINGTON COUNTY CODE

Chapter 60

STORMWATER DETENTION

§ 60-1. Title.
§ 60-2. Purpose.
§ 60-3. Applicability.
§ 60-4. Manual of Operation.
§ 60-5. Criteria.
§ 60-6. Penalty.
§ 60-7. Severability.

§ 60-1. Title.

This chapter shall be known as the "Stormwater Detention Ordinance of Arlington County, Virginia."

§ 60-2. Purpose.

The purpose of this chapter is to reduce the harmful effects of stormwater runoff on streambeds, banks, parklands, private properties and other areas in Arlington County by requiring the installation of on-site stormwater detention facilities as properties are developed or redeveloped within the County.

§ 60-3. Applicability.

The provisions of this chapter shall apply to any work for which a site development plan and/or building permit is required and shall apply to any work requiring a permit for which other changes in the land use are made which change the runoff characteristics. The provisions of this chapter shall apply in all use districts under the zoning ordinance of Arlington County except for single unit residential development that occurs within the Potomac Watershed.

Potomac Watershed: The basin that drains directly into the Potomac River without passing through Four Mile Run Watershed.

Four Mile Run Watershed: The basin that drains directly into Four Mile Run, which ultimately empties into the Potomac River.

§ 60-4. Manual of operation.

The Director of the Department of Environmental Services shall prepare and set forth, in the form of a manual, guidelines for compliance of the standards of this chapter. The manual will assist those persons who are required to comply with the provisions of the stormwater detention ordinance and may be secured at the Department of Environmental Services and shall be followed unless otherwise specified. The Director of the Department of Environmental Services shall act as the County Manager's designee for control, final approval of submitted plans, and waiver of requirements.

§ 60.5. Criteria.

A. *Plan submittal and waiver of requirements*. Site, subdivision and building plans submitted to the Department of Environmental Services will include plans and design calculations for each detention facility proposed. Detention facilities shall be designed so that they do not become health or safety hazards. Whenever the benefits resulting from full compliance with this chapter are not sufficient to warrant the required detention capacity, the applicant may appeal to the county manager or his designee for a determination. Upon determination, the County Manager may waive or vary the requirements of the ordinance to the extent necessary to take account of the following factors and at the same time to maintain the maximum stormwater detention system. One (1) or more of the following factors must be found to exist in order to grant a waiver or variance of the requirements:

1. The proposed use is a temporary use, not to exceed five (5) years and not to be renewed for any combination of periods which would exceed five (5) years, unless permanent improvements are made in connection with undertaking the temporary use which are likely to outlast the period of temporary use.

2. The proposed use will have a nominal impact on the stormwater runoff characteristics and the provisions of a detention system will not produce a positive effect on the downstream storm sewer or watershed area.

3. The positive effect of the benefits on the downstream storm sewer or watershed area gained by the construction of a detention facility are slight and the cost of construction exceeds the ordinary cost of construction of detention facilities in Arlington County.

B. *Improvements on developed or undeveloped areas.*

1. Whenever any work for which a site development plan or a building permit is required is undertaken on a developed site or previously undeveloped site, then the person or persons undertaking the work shall provide stormwater detention capacity sufficient to accommodate the maximum storage required for a ten (10) year rain storm at the runoff rate on the developed site (using the applicable runoff coefficient) and a release rate which would be equivalent to that for the ten (10) year rain storm using an assumed runoff coefficient of 0.2 on the site work. Insubstantial remodeling which has no impact on stormwater runoff from the site is exempted from this chapter and shall not be considered “work” as that work is used in this chapter.

2. Whenever any said work is undertaken on a site which is located within the Four Mile Run Watershed, the following requirement shall be met in order to comply with measures authorized by the United States Congress under § 201 of the 1965 Flood Control Act (PL 89-298) and reauthorized under § 84 of the Water Resources Development Act of 1974 (PL 93-251). Within the Four Mile Run Watershed, the person or persons undertaking the said work shall provide stormwater detention capacity sufficient to accommodate the maximum storage required for a one hundred (100) year rain storm at the runoff rate on the developed site (using the applicable runoff coefficient) and a release rate which would be equivalent to that for the ten (10) year rain storm using an assumed runoff coefficient of 0.3 on the site of the work. In the event that the release rate from the site would have a negative impact and impair the effectiveness of the flood control improvement by increasing the runoff, the County Manager is vested with the authority to vary the release rate in order to comply with the aforesaid federal laws.

C. Construction and maintenance. Construction of all detention facilities shall be in conformance with approved plans. The County may require a test operation of facility during or after construction as a condition of approval. All plans submitted for stormwater detention systems shall describe an adequate procedure of normal maintenance for the detention system. It shall be the responsibility of the owner, or its successors or assigns, of the property on which the detention system is located to provide adequate maintenance for proper functioning of the detention system. The County may require periodic maintenance inspections certificates from the owner, or its successors or assigns, pursuant to schedules outlined by state or federal regulations. Periodic inspection by the Department of Environmental Services will be made to determine conformity with the chapter. The submittal of

plans for such a system or the purchase of property on which such a system is located shall be deemed an acceptance of responsibility for normal and capital maintenance of the system. Additionally, this responsibility of maintenance shall be duly recorded in the land records of Arlington County prior to the issuance of any construction permit.

§ 60-6. Penalty.

A. Any development or redevelopment in which a person, whether applicant, owner, lessee, principal, agent, employee or assigns, is required to build and maintain a stormwater detention system and fails to do so, the development or redevelopment shall be considered an unlawful use of land and the applicant shall be deemed in violation of this chapter.

B. Any person, who violates this chapter or any regulations adopted thereunder, or who fails, neglects or refuses to comply with any order of the County Manager or his designee, shall be subject to a civil penalty not to exceed thirty-two thousand five hundred dollars ($32,500.00) for each violation within the discretion of the Court. Each day of violation shall constitute a separate offense. The County Manager or his designee may issue a summons for collection of the civil penalty in the Arlington County Circuit Court. Such civil penalties shall be paid to the Treasurer of Arlington County and shall be used for the purpose of minimizing, preventing, managing or mitigating pollution of the waters.

1. A first violation under this subsection shall be subject to a civil penalty of two hundred and fifty dollars ($250.00).

2. A second violation under this subsection shall be subject to a civil penalty of five hundred dollars ($500.00).

3. A third violation or thereafter under this subsection shall be subject to a civil penalty of one thousand dollars ($1,000.00).

C. Any person who willfully and knowingly violates any provision of this chapter shall be guilty of a Class 1 misdemeanor.

D. Violations of this chapter may also be addressed in the following ways:

1. The County may apply to the Circuit Court of Arlington County for injunctive relief to enjoin a violation or threatened violation.

2. In lieu of any appropriate civil penalty that could be imposed under subsection B, the County may, with the consent and agreement of any person who has violated or failed, neglected or refused to obey with this chapter or any regulation thereunder, the County may provide, in an order issued against such person, for payment of civil charges for violations in specific sums, not to exceed thirty-two thousand five hundred dollars ($32,500.00) for each violation. Any civil charges collected shall be paid to the Treasurer of Arlington County and shall be used for the purpose of minimizing, preventing, managing, or mitigating pollution of the waters.

E. “Person” as used in this section means any individual, partnership, co-partnership, firm, company, corporation, association, joint stock company, trust, estate, governmental entity or any other legal entity, or their legal representatives, agents, or assigns. This definition includes, without limitation, all federal, state or local government entities.

§ 60-7. Severability.

If any provision of this chapter is declared to be invalid, such declaration shall not affect, impair or invalidate the remaining provisions of this chapter.

ARLINGTON COUNTY, VIRGINIA
DEPARTMENT OF PUBLIC WORKS
COURT HOUSE
ARLINGTON, VIRGINIA 22201

H. S. HULME, JR.
DIRECTOR

W. L. JEFFERIES
DEPUTY DIRECTOR

November 29, 1979

Re: Four Mile Run Watershed
Sensitivity Study

Architects, Developers, Engineers, Surveyors:

Attached for your review and future reference is a copy of a map of the Four Mile Run Watershed showing the results of a sensitivity study. The study was performed by the Northern Virginia Planning District Commission (NVPDC) to investigate the relative sensitivity of the Four Mile Run Watershed Model to the addition of impervious cover at various points in the watershed. While the resulting lines cannot be considered conclusive, they can be used as preliminary guidelines to screen downstream impacts of projects that occur throughout the watershed.

Generally, the projects that occur in the middle and upper middle portions of the watershed seem to be most sensitive to the addition of impervious cover. (The effectiveness of detention storage revealed a similar pattern). These areas are noted by Zone A: Storage Effective. The impacts of projects in the upper most region of the Four Mile Run Watershed are usually well attenuated by the time they reach the Flood Control Project and therefore have little or no effect on the project. The area in the vicinity of the Flood Control Project also has insignificant effects and in some cases negative effects. These two areas are noted by Zone C: Storage Least Effective.

The third area is where no general trends were noted in the sensitivity study. This "gray area" is a transition between Zones A and C where impacts of development produce inconsistent results. This area being Zone B: Storage Less Effective.

In most cases, projects in Zone A will be required to have detention and projects in Zone C will be exempt from detention, unless some local problem exists or local benefits can be obtained.

But because of the ambigious results from the model for projects in Zone B, there can be no such statement regarding detention. Therefore, for Zone B detention will be required unless a separate detailed computer model run is made that has results that would exempt the site from detention.

I hope that this map will provide some help to you in preparing engineering plans for the future. As in the past, if we can be of any assistance in this matter, please call Ms. June Nakamura at 358-3653. If you would want to have the Four Mile Run Watershed Model investigate your particular site to see if detention would be required, regardless of its location in the watershed, this can be arranged with the Northern Virginia Planning District Commission. There is a fee for the computer analysis. If interested, please contact Ms. Kimberly Davis at NVPDC at 642-0700.

Sincerely,

H. S. Hulme, Jr.
Director

HSH/RLL/mh

Attachment

STORMWATER DETENTION ORDINANCE AND THE REVIEW PROCESS

COURSE OUTLINE

I. Introduction
II. Stormwater Detention Ordinance
    A. Brief History
    B. Purpose and Applicability
    C. Criteria
        1. Waivers
        2. Watershed Design Requirements
            a. Four Mile Run Sensitivity Study
        3. Construction and Maintenance
    D. Penalty
III. Waivers
    A. Submittal Process
    B. Four Mile Run Study
        1. Zone "A"
        2. Zone "B"
        3. Zone "C"
        4. Computer Model
    C. Calculations required – example
    D. Common Misconceptions
IV. Detention Facilities
    A. Submittal Process
    B. Type of Facilities
        1. Underground – vaults, enlarged pipes, etc.
        2. Surface – ponds, parking lots, roof tops, etc.
        3. Facility features
            a. Orifice
            b. Emergency overflow
            c. Storage Area
            d. Accessibility for maintenance
    C. Calculations required – example
        1. Un-detained flow
        2. Offsite flow
        3. Areas in County easements
        4. Partial waivers – existing impervious areas
        5. Volume required
        6. Sizing orifice
        7. Sizing emergency spillway
    D. Common Problems
V. Ongoing Studies/Future Changes in the Ordinance
VI. Question / Answer

WATERSHED DESIGN REQUIREMENTS

Potomac Watershed (protect local drainage system)

- Provide storage capacity to accomodate the 10-year post-development runoff and released at the 10-year pre-developed runoff rate.
- Using c = 0.2 or avg. for the pre-developed runoff rate regardless of existing site conditions.

Four Mile Run Watershed (protect Corps of Engineers Flood Control Channel capacity)

- Provide storage capacity to accomodate the 100-year post-development runoff and released at the 10-year pre-developed runoff rate.
- Using c = 0.3 or avg. for the pre-developed runoff rate regardless of existing site conditions.

WAIVER SUBMITTAL

To request a waiver of Stormwater Detention:

1) Provide a cover letter addressed to Dennis R. Johnson, Chief, Planning and Engineering Division which:

   a) States the location of the site.
   b) States the watershed and zone in which the site is located.
   c) Contains a narrative that attempts to justify the request for a waiver.

2) Provide legible plans of the site showing existing conditions and proposed work (preliminary or final plans).

3) Provide calculations which compare the predeveloped and postdeveloped runoff rates as described in the Stormwater Detention Ordinance. These calculations can be on the plan or on letter size paper attached to the waiver request.

FOUR MILE RUN WATERSHED SENSITIVITY STUDY

Zone "A" – Storage Effective – Detention Required

Zone "B" – Storage Less Effective ("gray area")

Detention Required unless separate, detailed computer model results exempts site from detention.

Zone "C" – Storage Least Effective – Exempt from Detention

WAIVER REQUIREMENTS

One or more of the following factors must be found to exist in order to grant a waiver or variance of the requirements:

1) The proposed use is a temporary use, not to exceed five(5) years...

2) The proposed use will have a nominal impact on the stormwater runoff characteristics and the provision of a detention system will not produce a positive effect on the downstream storm sewer or watershed area

3) The positive effect of the benefits on the downstream storm sewer or watershed area gained by the construction of a detention facility are slight and the cost of construction exceeds the ordinary cost of construction of detention facilities in Arlington County.

S A M P L E

COMPARISON OF STORMWATER RUN-OFF FOR A WAIVER CONSIDERATION

1. Site Description
   Location: Potomac Watershed or Four Mile Run Watershed
   Total area (A) = 2.4 acres
   Easement for public street and sidewalk = 0.12 ac
   Area required for detention = 2.4 - 0.12 = 2.28 ac
   Existing Condition; (see EXHIBIT 1)
   Building with asphalt parking lot
   Impervious area = 1.60 ac.
   Pervious area = 0.68 ac.
   Total 2.28 ac.

$$\text{Composite } C = \frac{1.60 \times 0.9 + 0.68 \times 0.3}{2.28} = 0.72$$

   Proposed Condition: (see EXHIBIT 2)
   Townhouse development
   Impervious area = 1.48 ac.
   Pervious area = 0.80 ac.
   Total 2.28 ac.

$$\text{Composite } C = \frac{1.48 \times 0.9 + 0.80 \times 0.3}{2.28} = 0.69$$

   Time of concentration Tc = 5 min.
   Rainfall intensity I_{10} = 7.3 in/hr
   I_{100} = 10 in/hr

IF THE SITE IS LOCATED IN THE POTOMAC WATERSHED

2. Predeveloped run-off
   Using C = 0.2 (specified by the ordinance)
   $Q_{10} = 0.2 \times 7.3 \times 2.28 = 3.33$ cfs
3. Postdeveloped run-off
   $Q_{10} = 0.69 \times 7.3 \times 2.28 = 11.48$ cfs
4. Conclusion:
   Change in run-off = + 8.15 cfs

IF THE SITE IS LOCATED IN THE POTOMAC WATERSHED AND PARTIAL WAIVER IS APPLIED

2. Predeveloped run-off
   Using $C = \frac{0.2 + 0.72}{2} = 0.46$
   $Q_{10} = 0.46 \times 7.3 \times 2.28 = 7.66$ cfs
3. Postdeveloped run-off
   $Q_{10} = 0.69 \times 7.3 \times 2.28 = 11.48$ cfs
4. Conclusion:
   Change in run-off = + 3.82 cfs

IF THE SITE IS LOCATED IN THE FOUR MILE RUN WATERSHED

2. Predeveloped run-off
   Using C = 0.3 (specified by the ordinance)
   $Q_{10} = 0.3 \times 7.3 \times 2.28 = 4.99$ cfs
3. Postdeveloped run-off
   $Q_{100} = 0.69 \times 10 \times 2.28 = 15.73$ cfs
4. Conclusion:
   Change in run-off = + 10.74 cfs

IF THE SITE IS LOCATED IN THE FOUR MILE RUN WATERSHED AND PARTIAL WAIVER IS APPLIED

2. Predeveloped run-off
   Using $C = \frac{0.3 + 0.72}{2} = 0.51$
   $Q_{10} = 0.51 \times 7.3 \times 2.28 = 8.49$ cfs
3. Postdeveloped run-off
   $Q_{100} = 0.69 \times 10 \times 2.28 = 15.73$ cfs
4. Conclusion:
   Change in run-off = + 7.24 cfs

S A M P L E 1

STORMWATER DETENTION CALCULATION
Application No. _____

1. Site Description
   Location: Potomac watershed

   Total area (A) = 2.4 Acres
   Easement for public street and sidewalk = 0.12 Ac.
   Area required for detention = 2.4 - 0.12 = 2.28 Ac.
   Existing condition : (see EXHIBIT 3)
   Building with asphalt parking lot
   Impervious area = 1.60 Ac.
   Pervious area = 0.68 Ac.
   Total 2.28 Ac.

$$\text{Composite } C = \frac{1.60 \times 0.9 + 0.68 \times 0.3}{2.28} = 0.72$$

   Proposed Condition: (see EXHIBIT 4)
   Townhouse development
   Impervious area = 1.48 Ac.
   Pervious area = 0.80 Ac.
   Total 2.28 Ac.

$$\text{Composite } C = \frac{1.48 \times 0.9 + 0.80 \times 0.3}{2.28} = 0.69$$

   Time of Consentration Tc = 5 min.
   Rainfall intensity I_{10} = 7.3 in/hr

2. Predeveloped Run-off:
   C = 0.2 (specified by the ordinance)
   $Q_{10} = 0.2 \times 7.3 \times 2.28 = 3.33$ cfs

3. Undetained Flow (see EXHIBIT 5)
   Undetained area = 0.20 Ac.
   C = 0.30 (Postdevelopment)
   $Q_{10} = 0.30 \times 7.3 \times 0.20 = 0.44$ cfs

4. Offsite Flow (see EXHIBIT 5)
   Offsite area = 0.42 Ac.
   C = 0.35
   $Q_{10} = 0.35 \times 7.3 \times 0.42 = 1.07$ cfs

5. Allowable Release Rate
   $Q_{allowable} = (Q_{10})_{pre} - (Q_{10})_{undetained}$
   $Q_{allowable} = 3.33 - 0.44 = 2.89$ cfs

6. Storage Volume Required
   Detained Area = 0.65 + 1.43 = 2.08 Ac.
   0.65Ac. @ 0.39 = 0.254 Imp. Ac.
   1.43Ac. @ 0.88 = 1.258 Imp. Ac.
   Total 1.512 Imp. Ac.

TIME (Min)	TIME (Sec)	I_{10} (in/hr)	IMP AC. (AxC)	Q_{10} (cfs)	VOL. IN (cf)	DISCHARGE RATE (cfs)	VOL. OUT (cf)	MAX. STOR. VOL. (cf)
5	300	7.3	1.512	11.038	3311	2.89	867	2444
10	600	5.9	1.512	8.921	5352	2.89	1734	3618
15	900	5.1	1.512	7.711	6940	2.89	2601	4339
20	1200	4.5	1.512	6.804	8165	2.89	3468	4697
25	1500	4.0	1.512	6.048	9072	2.89	4335	4737
30	1800	3.71	1.512	5.610	10097	2.89	5202	4895*
35	2100	3.35	1.512	5.065	10637	2.89	6069	4568

CONCLUSION: MAX. STORAGE - 10 YR @ 30 MIN.
MAX. STORAGE VOLUME = 4895 cf

7. Storage Provided
   Select and design detention facility and compute the available storage volume.

8. Orifice
   $Q = CA\ (2gH)^{1/2}$
   Size the orifice to accommodate $Q_{allowabe}$ and $Q_{offsite}$ (if applicable).

9. Emergency Spillway
   Size the emergency spillway to accommodate the postdeveloped Q_{10} , assuming that the orifice is clogged.
   For weir flow:
   $Q = CLH^{3/2}$

SAMPLE 2

STORMWATER DETENTION CALCULATION

Application No.: _____

1. Site Description
   Location: Four Mile Run Watershed
   Total area (A) = 2.4 Acres
   Easement for public street and sidewalk = 0.12 Ac.
   Area required for detention = 2.4 - 0.12 = 2.28 Ac.
   Existing Condition:
   See Sample 1.
   Proposed Condition:
   See Sample 1.
   Time of concentration Tc = 5 min.
   Rainfall intensity I_{10} = 7.3 in/hr
   I_{100} = 10 in/hr

2. Predeveloped Runoff
   c = 0.3 (specified by the ordinance)
   Q_{10} = 0.3 x 7.3 x 2.28 = 4.99 cfs

3. Undetained flow (See Exhibit 5)
   Undetained area = 0.20 Ac.
   c = 0.30 (post-development)
   Q_{100} = 0.30 x 10 x 0.20 = 0.60 cfs

4. Offsite flow (See Exhibit 5)
   Offsite area = 0.42 Ac.
   C = 0.35
   Q_{10} = 0.35 x 7.3 x 0.42 = 1.07 cfs

5. Allowable Release Rate
   Q allowable = (Q_{10}) pre - (Q_{100}) undetained
   Q allowable = 4.99 - 0.60 = 4.39 cfs

6. Storage Volume Required
   Detained Area = 0.65 + 1.43 = 2.08 Ac.
   0.65 Ac. @ 0.39 = 0.254 Imp. Ac.
   1.43 Ac. @ 0.88 = 1.258 Imp. Ac.
   Total 1.512 Imp. Ac.

TIME (Min)	TIME (Sec)	I_{100} (in/hr)	IMP AC. (AxC)	Q_{100} (cfs)	VOL.IN (cf)	DISCHARGE RATE (cfs)	VOL.OUT (cf)	MAX.STOR. VOL. (cf)
5	300	10.0	1.512	15.120	4536	4.39	1317	3219
10	600	8.1	1.512	12.247	7348	4.39	2634	4714
15	900	7.2	1.512	10.886	9798	4.39	3951	5847
20	1200	6.3	1.512	9.526	11431	4.39	5268	6163
25	1500	5.7	1.512	8.618	12928	4.39	6585	6343*
30	1800	5.2	1.512	7.862	14152	4.39	7902	6250

CONCLUSION: MAX. STORAGE - 100 yr @ 25 min.
MAX. STORAGE VOLUME = 6343 cf

7. Storage Provided
   Select and design detention facility and compute the available storage volume.

8. Orifice
   $Q = CA\ (2gH)^{1/2}$
   Size the orifice to accommodate Q allowable + Q offsite (if applicable).

9. Emergency Spillway
   Size the emergency spillway to accommodate the post-developed Q_{100} assuming that the orifice is clogged.
   for weir flow:
   $Q = CLH^{3/2}$

COMMON MISCONCEPTIONS

- Pre-developed runoff rate is based on "undeveloped" pasture land, using "c" factor in accordance with ordinance, regardless of existing conditions

- For Four Mile Run Watershed, comparing 10-year storm runoff with the 100-year storm.

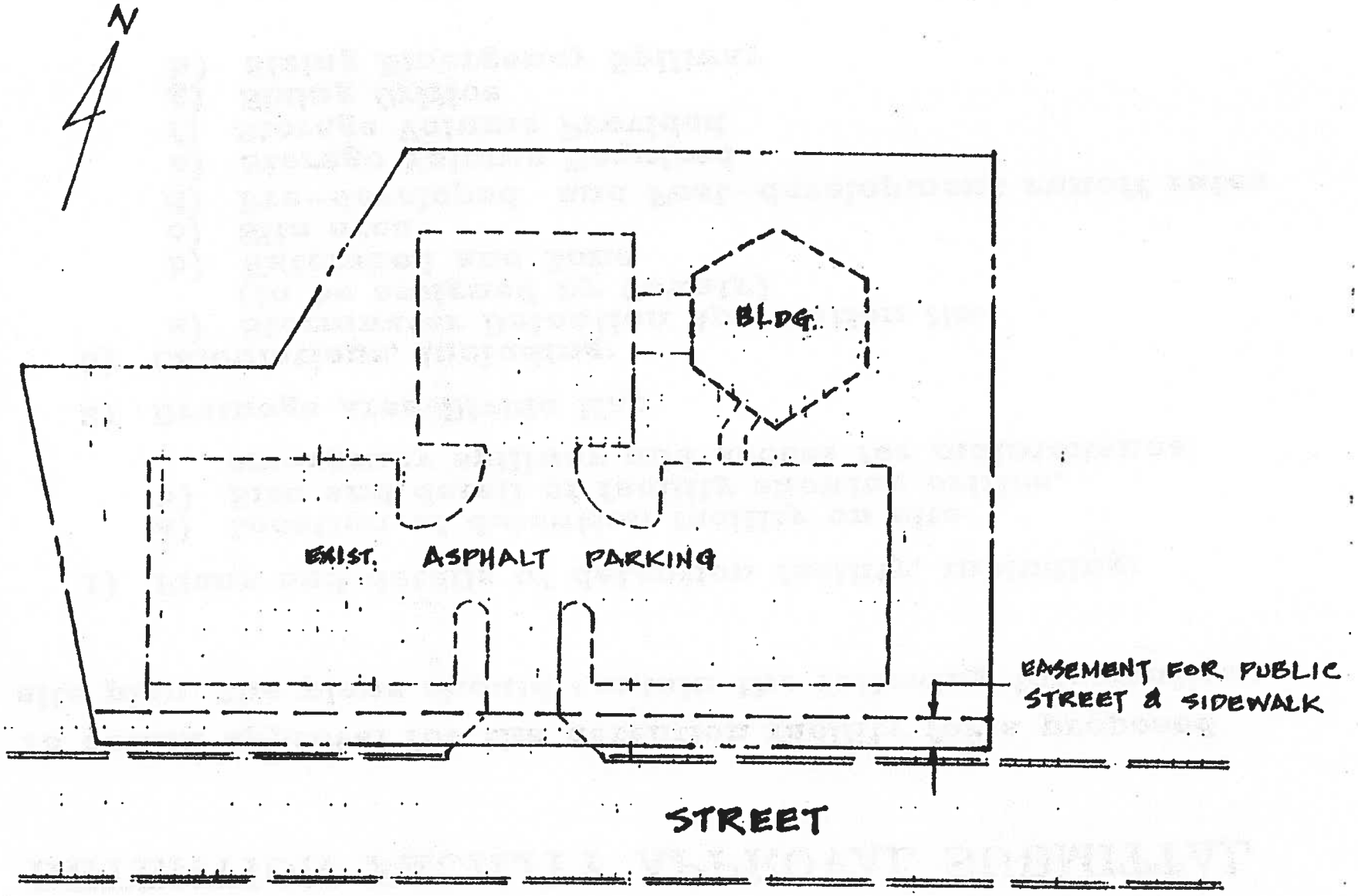
- At low points of Potomac watershed, no positive effects on storm drains or watershed.

- Zone "C" & "B" of Four Mile Run Watershed, no detention required at all. NVPDC model will exempt site from 100-year storm but detention for 10-year storm may be required to protect local drainage systems.

DETENTION FACILITY APPROVAL SUBMITTAL

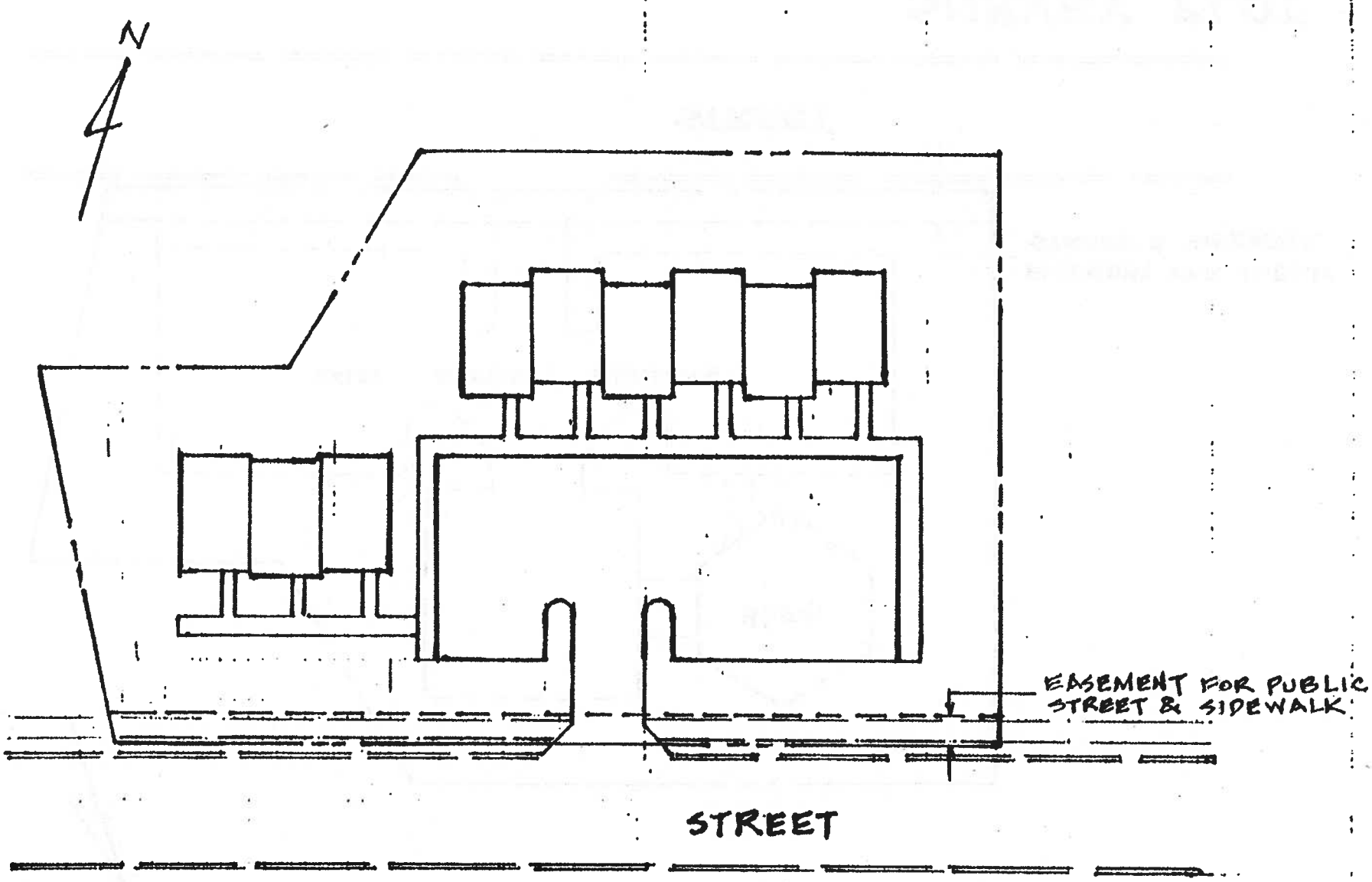
To obtain approval for the detention facility for a proposed site plan, the plans should contain the following information:

1) **Plans and details of detention facility, including:**
   a) **Location of detention facility on site**
   b) **Size and detail of facility showing orifice, emergency spillway and access for maintenance.**
2) **Drainage Area Divide Map**
3) **Calculations, including:**
   a) **Stormwater Detention Application No. (to be assigned by County)**
   b) **Watershed and Zone**
   c) **Site area**
   d) **Pre-developed and Post-development runoff rates**
   e) **Storage Volume Required**
   f) **Storage Volume Provided**
   g) **Sizing Orifice**
   h) **Sizing Emergency Spillway**



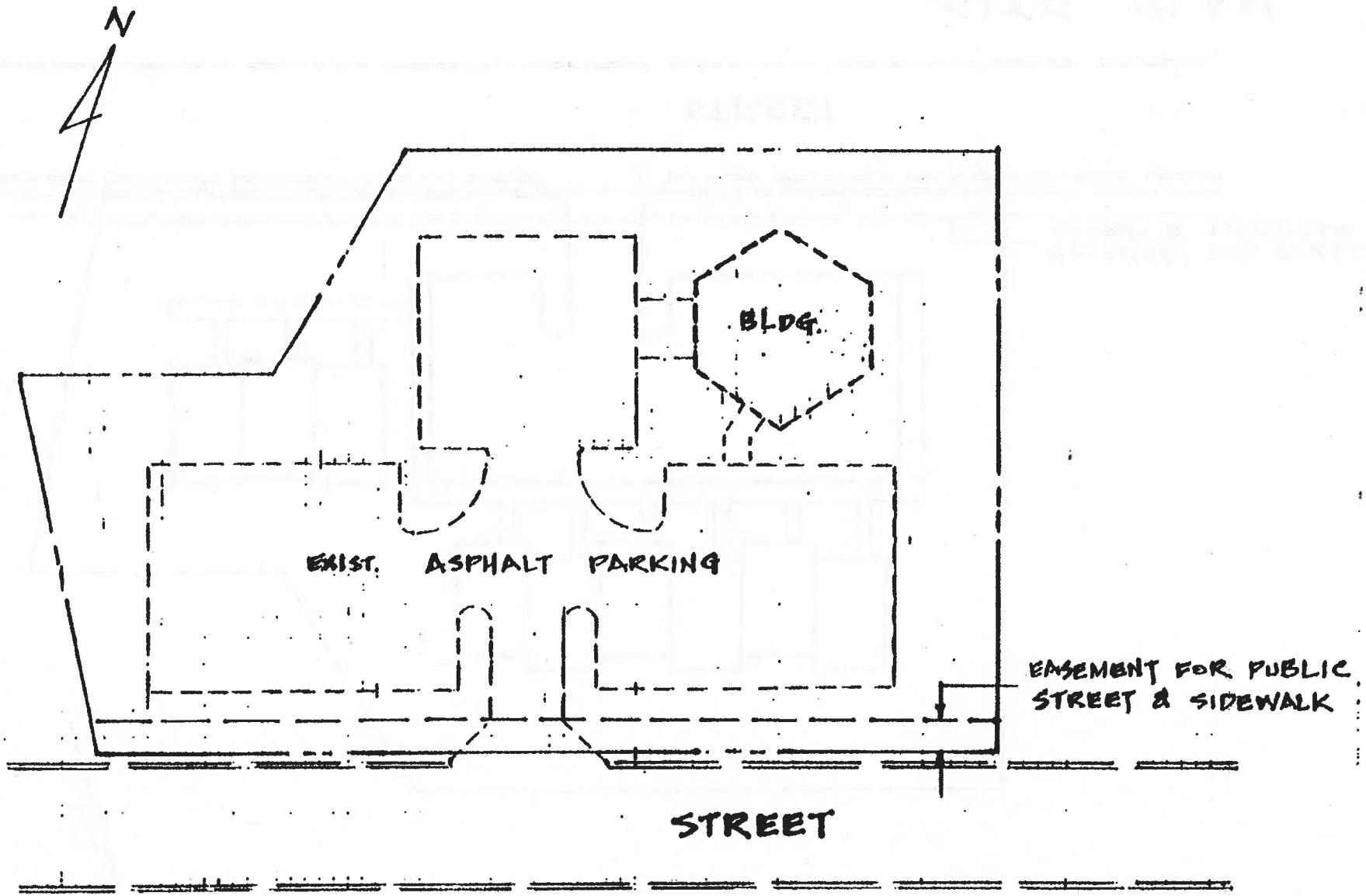
SURVEY PLOT
(EXISTING CONDITION)

EXHIBIT 1



SITE PLAN

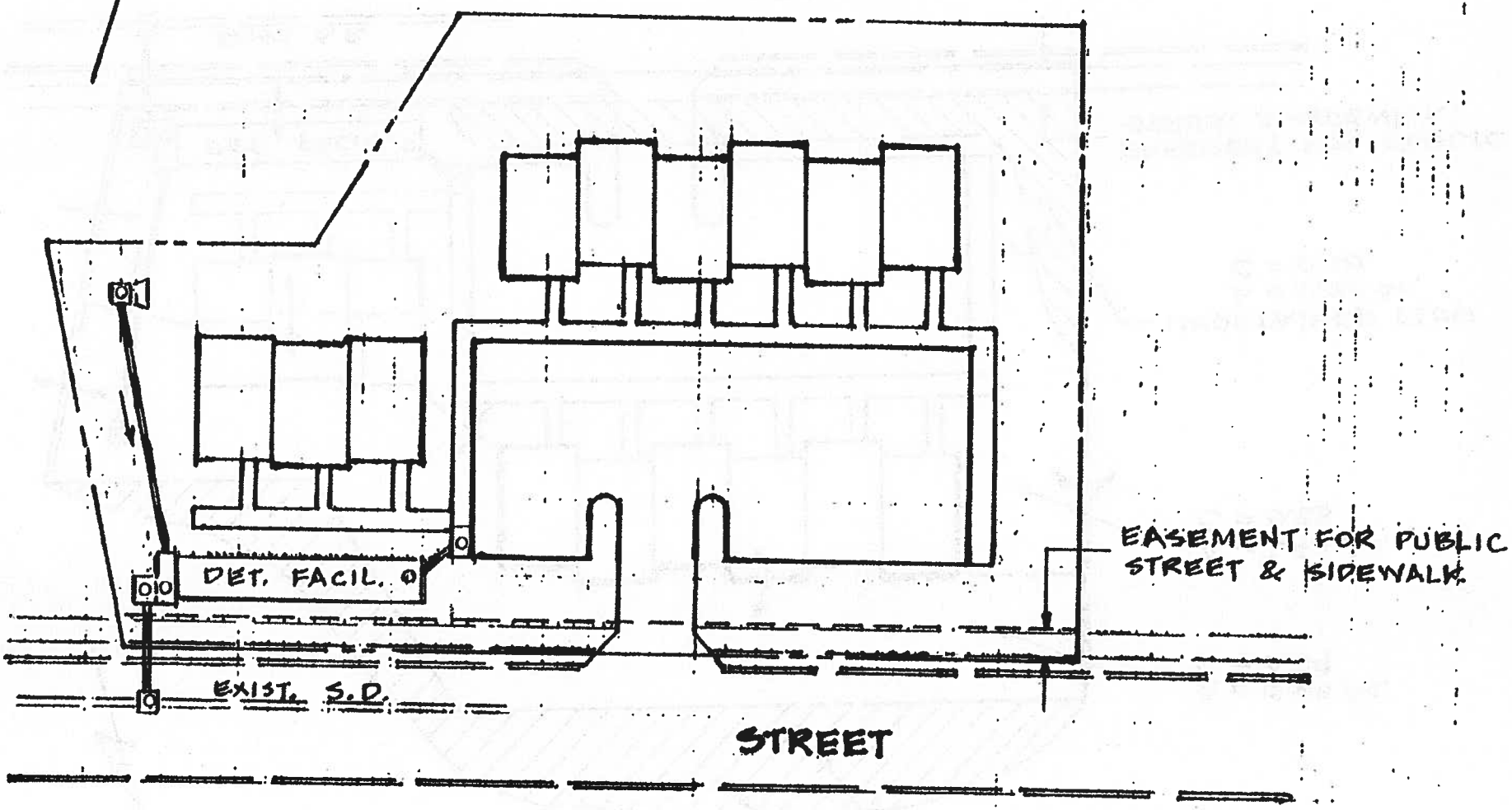
EXHIBIT 2



SURVEY PLOT
(EXISTING CONDITION)

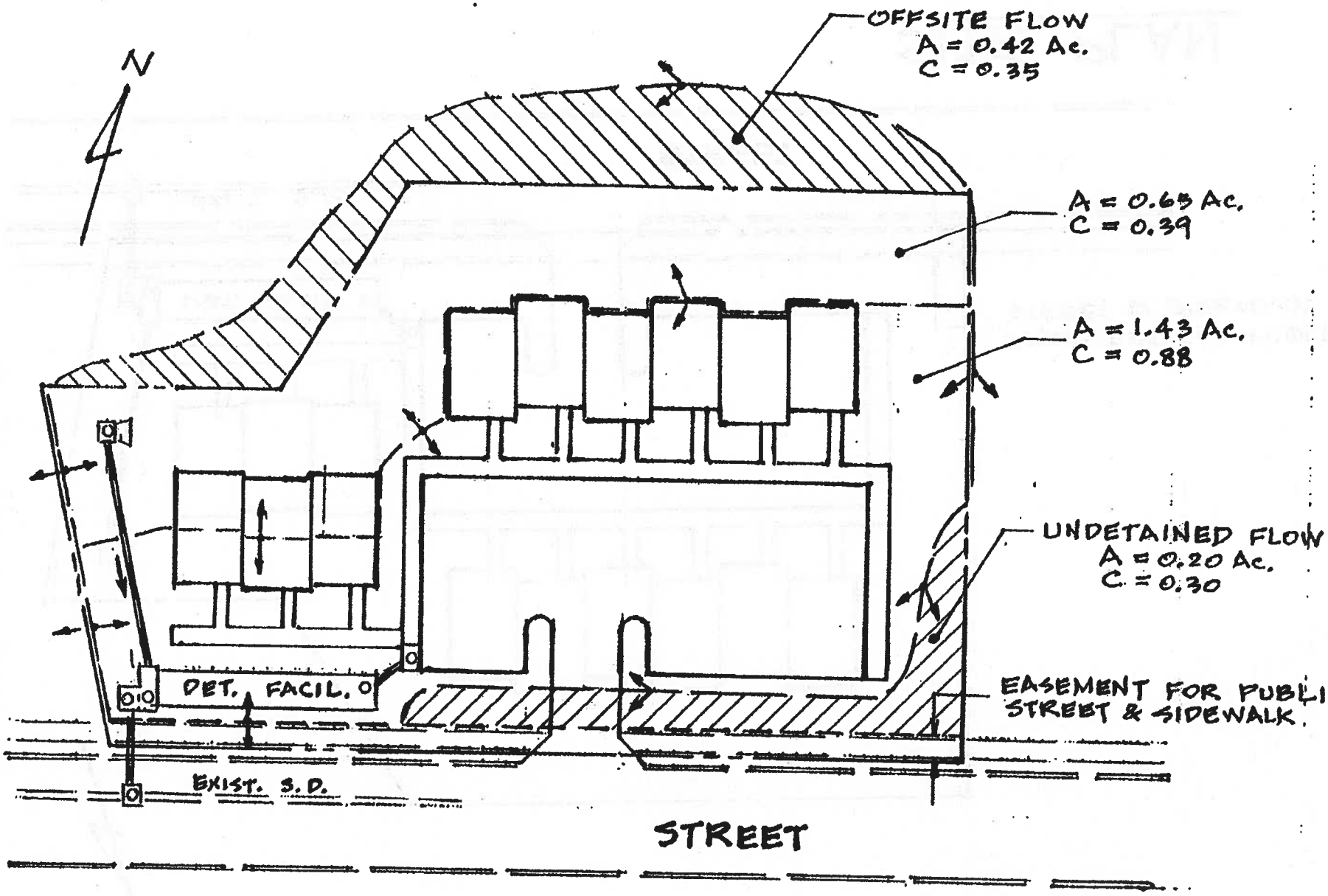
EXHIBIT 3

4



SITE PLAN

EXHIBIT 4



DRAINAGE AREA MAP

EXHIBIT 5

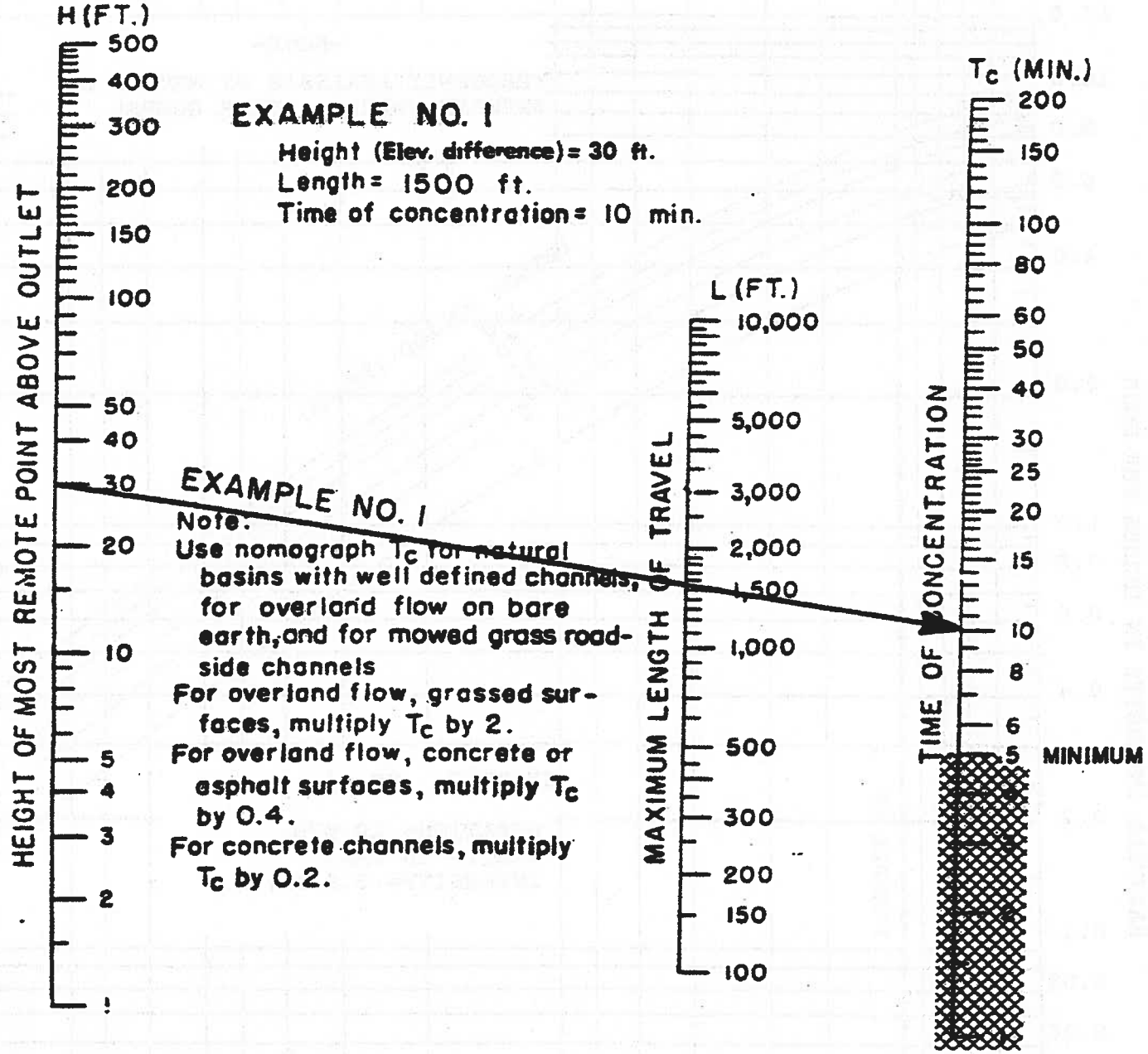


Figure 2. TIME OF CONCENTRATION OF SMALL DRAINAGE BASINS

Source: Virginia Department of Highways and Transportation "Drainage Manual," 1972, p. 69, Appendix B

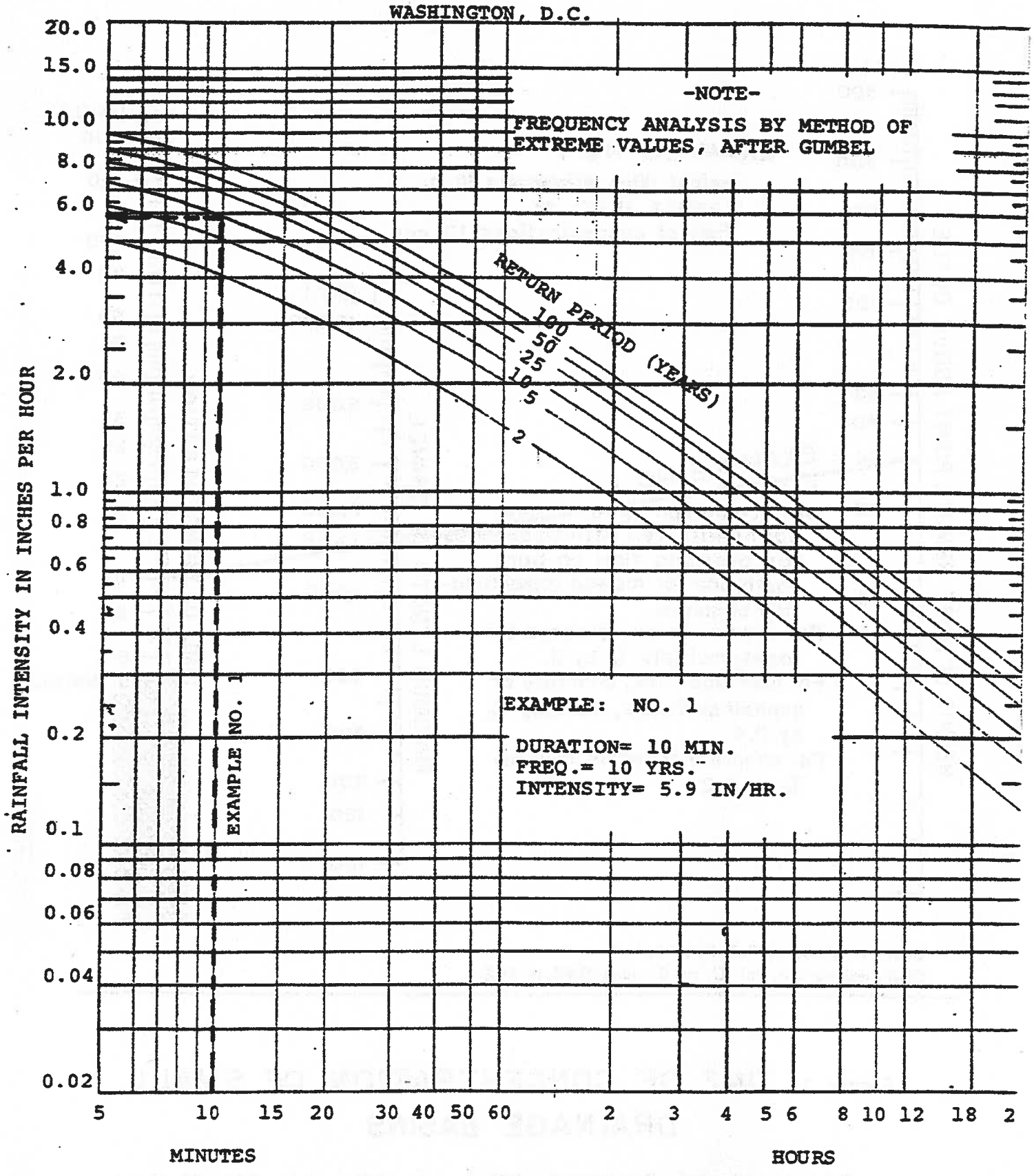


FIGURE 3 RAINFALL INTENSITY DURATION FREQUENCY CURVES

SOURCE: U.S. DEPARTMENT OF COMMERCE WEATHER BUREAU

RAINFALL INTENSITY DURATION

TIME	INTENSITY* 10-YEAR	100-YEAR
5 minutes	7.3	10.0
10 minutes	5.9	8.1
15 minutes	5.1	7.2
20 minutes	4.5	6.3
30 minutes	3.71	5.2
40 minutes	3.15	4.3
50 minutes	2.73	3.7
60 minutes	2.3	3.5
1 hr 30 min	1.9	2.65
2 hours	1.48	2.3
3 hours	1.1	1.65

* Based on rainfall intensity duration frequency curves of the Washington D.C. area, from the U.S. Department of Commerce Weather Bureau.

Example No. 1, for a particular land area found in the Potomac Watershed, the following calculations are needed to determine the capacity that must be met by detention storage systems on the site to meet the requirements of the Ordinance.

Given:

Location: Potomac Watershed

Length= 1,500 feet

Height= 30 feet

Area (A)= 2.5 acres

Runoff Coefficient (C)= 0.2

Intensity (I)= 5.9 in/hr 10 yr. 10 min. from Figures 2 and 3.

Total flow (Q)= 2.95 cfs used as max. discharge rate

C= 0.2 undeveloped

C= 0.9 max. developed

TIME	SECS	100-yr. I-in/hr.	C=0.9 AxC	Q cfs	RAINFALL VOL. cf.	2.95 cfs. DISCHARGE VOL.cf.	MAX. STORAGE VOL.cf.
15 min.	900	5.1	2.25	11.48	10,332	2,655	7,677
20 min.	1200	4.5	2.25	10.13	12,150	3,540	8,610
30 min.	1800	3.71	2.25	8.35	15,030	5,310	9,720
45 min.	2700	2.9	2.25	6.53	17,631	7,965	9,666
1 hour	3600	2.5	2.25	5.63	20,268	10,620	9,648
1 hr. & 30 min.	5400	1.90	2.25	4.28	23,085	15,930	7,155
2 hour	7200	1.48	2.25	3.33	23,976	21,240	2,736
3 hour	10800	1.1	2.25	2.48	26,784	31,860	0

CONCLUSION:

MAX. STORAGE= 10 yr. 30 min.

MAX. STORAGE VOLUME= 9720 c.f.

In Example No. 4, for a particular land area found in the Four Mile Run Watershed, the following calculations are needed to determine the capacity that must be met by detention storage systems on the site to meet the requirements of the Ordinance.

Given:

Location: Four Mile Run Watershed

Area (A)= 2 acres

Runoff Coefficient (C)= ~~0.2~~ 0.3

Intensity (I)=

(a) discharges= 5.9 in/hr. 10 yr. 10 min. from Figures 2 and 3.

(b) rainfall volume= 100 yr. storm "I" in/hr. at duration times.

Total flow (Q)= ~~2.36~~ 3.54 cfs. used as maximum discharge

C= 0.2 undeveloped

C= 0.9 developed

TIME	SECS	100-yr. I-in/hr.	C=0.9 AxC	Q cfs	RAINFALL VOL. cf.	~~2.36~~ 3.54 cfs. DISCHARGE VOL.cf.	MAX. STORAGE VOL.cf.
15 min.	900	7.2	1.8	12.96	11,664	2,124	9,540
30 min.	1800	5.2	1.8	9.36	16,848	4,248	12,600
45 min.	2700	4.0	1.8	7.2	19,440	6,372	13,068
1 hour	3600	3.5	1.8	6.3	22,680	8,496	14,184
1 hr. & 30 min.	5400	2.65	1.8	4.77	25,758	12,744	13,014
2 hour	7200	2.3	1.8	4.14	29,808	16,992	12,816
3 hour	10800	1.65	1.8	2.97	32,076	25,488	6,588
4 hour	14400	1.3	1.8	2.34	33,696	33,984	0

CONCLUSION:

Maximum storage at 1 hour.

MAXIMUM STORAGE VOLUME= 14,184 c.f.

ONGOING STUDIES/FUTURE CHANGES

- **NVPDC in process of updating sensitivity study**
- **"Combining" public & private water for detention**
- **Detention in public facilities for single family subdivision**
- **Modeling Potomac Watershed**
- **Excluding more types of developments from ordinance**

COMMON PROBLEMS

- Missing information – especially drainage area divide map.
- Use of offsite runoff to compensate for uncollected runoff on site
- Identifying and reducing allowable release rate by undetained flow
- Using correct I, intensity rates on storage volume required chart
- Need to address safety measures and provide adequate access to detention facilities
- Landscaping consideration on surface ponds