Islamorada, Village of Islands

STORMWATER DESIGN CRITERIA TECHNICAL MANUAL

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1.0 PURPOSE AND INTENT

Pursuant to Chapter 30, Article VII, Division 8 of the Land Development Regulations (LDRs) of Islamorada, Village of Islands (the Village), Code of Ordinance (the Code), the purpose and intent of the stormwater management regulations is to provide for the safe management and disposal of stormwater runoff from developed areas, and to protect natural resources to minimize or eliminate potential adverse impacts to surface waters, shallow groundwater, and natural resources areas within the Village.

This Stormwater Design Criteria Technical Manual (Manual) has been created as a supplementary and illustrative guide to the Islamorada Village of Islands Stormwater Management Master Plan (2000). This Technical Manual contains forms and procedures, minimum design standards, details and maintenance requirements for stormwater management in order to provide technical assistance to those submitting a stormwater management plan for development and to aid and accompany the stormwater regulations.

This Manual supersedes the previous Manual dated February 2002. This update was implemented to better suit the changing needs of the Village and incorporate additional information regarding new and alternative stormwater management systems. The Manual is to be subject to future revisions, as deemed necessary by the Village to continue to meet industry standards, the needs of the citizens and the changing environment. Additionally, the information contained herein is subject to modification to assure compliance with the Village Code of Ordinances, if amended at a later time.

Future revisions to the Manual will be conducted per Section 30-1729 of the Code. The revisions may be conducted by Staff or by consultants under staff direction.

This manual is intended for use for all land use categories unless specifically exempt according to Chapter 30 LDRs. Additional requirements set forth by Chapter 30, Article VII, Division 8 of the Code must be observed as applicable. Use of this manual and compliance with the LDRs does not relieve users from compliance with other rules or regulations that apply to a project and does not supersede the need for obtaining regulatory permits from applicable permitting agencies.

Two types of Applications, found in Section 2.0, are currently compliant with the stormwater management regulations:

- Short Form Applications: Some existing single-family residential, retail facility, hotel, and motel uses
- Regular Applications: All other projects that do not fit criteria for Short Form.

2.0 APPLICATION FORMS

Applications for stormwater management plan approval shall comply with the design criteria, administrative procedures, and maintenance retrofitting requirements of Section 30-1724 of the Code. All development shall be required to manage stormwater runoff in accordance with Section 30-1727(1) of the Code for pollution abatement purposes. Note that additional information and requirements are included in Sections 30-1724 through 30-1729 of the Code.

This Manual contains examples of how the rules and technical criteria may be used during the course of designing various types of surface water management systems. What is presented does not constitute additional rule criteria, and should not be used in lieu of, or in a manner that is inconsistent with, state or federal stormwater management regulations. Additional information or permits may be required by other entities such as Monroe County, South Florida Water Management District (SFWMD), Florida Department of Environmental Protection (FDEP) and Florida Department of Transportation (FDOT). Permits must be obtained prior to the initiation of construction activities and proof of such permits must be submitted to the Village. Of particular relevance is the most recent version of the SFWMD's Applicants Handbook Volume II (including Appendices A, B, C, and D) incorporated by reference in Rule 40E-4.091(1)(a) and Chapter 62-330, Florida Administrative Code (FAC). This handbook is used as an industry standard for design of stormwater management systems in South Florida.

For all projects within the Village subject to Section 30-1724 of the Code, the stormwater management system shall limit the rate of discharge from the developed site to the rate of discharge emanating from the site prior to development, based upon a 25-year/72-hour storm event. Those sites with no positive outfall shall be required to retain total runoff from a 25-year/72-hour storm event. When pollution abatement volumes and detention volumes intended to reduce the peak rate of discharge are incorporated into one facility, the volume of water impounded to reduce peak discharges in excess of the pollution abatement volume must be evacuated by a positive, non-filtering system unless otherwise approved by the Village.

There are two types of applications for stormwater management: Short Form and Regular Applications. The following sections provide guidance information regarding the submittal of short form and regular applications. This guidance is intended to assist with and encourage the submittal of complete and correct applications. However, the applicants must not depend solely on the manual and should also review the appropriate code requirements to ensure that all criteria have been met.

2.1 Short Form Application:

The purpose of the Short Form application for a stormwater management plan is to provide ease of use and minimize the costs associated with compliance to the stormwater management regulations to the citizens of the Village.

Criteria

The following development projects qualify for Short Form Applications:

Existing single-family residential, retail facility, hotel, and motel uses qualify for the short form application under the following conditions:

- Alteration or improvement is less than 1,000 square feet and it is not adjacent to a canal or other water body.
- Alteration or improvement is less than 500 square feet and it is adjacent to a canal or other water body provided that an acceptable method of runoff retention/detention shall be provided between the development area and the adjacent canal or water body.

One short form application shall be submitted within any five-year period.

Application Requirements
For Short Form Application projects, a stormwater management system shall be designed to contain the pollution abatement volume for the new impervious area.

Short Form Application worksheets, including applicable treatment volume calculations, are provided in **Appendix A**. The following terms are used in the worksheets to assist in computing the required stormwater treatment volume:

- *Previously Unimproved Site:* Site not previously developed. Assumes 100% pervious surface.
- *Previously Improved Site*: Site with any degree of development, including but not limited to parking lots, building structures and other impervious improvements.
- *Site Area:* Total area of the lot.
- *Cubic Feet Required:* Total volume of runoff from the lot that will require retention/detention. This definition is also used for the Stormwater Treatment Volume.
- *New Impervious Area:* New impervious area that will be added to the subject lot.

Per Section 30-1724(1)d of the Code, Short Form Applications shall contain the following:

- Description of the proposed maintenance, alteration or improvement to the property.
- A site plan indicating the proposed alterations or improvements, property boundaries, buildings, landscaping features, flood prone areas and existing detention/retention areas, including drainage calculations.

2.2 Regular Applications

Criteria
All other development projects not qualified for a Short Form Application described in Section 2.1 shall submit regular applications.

Application Requirements
Regular applications shall include, but are not limited to the following:

- construction/site plans (depicting location of existing and proposed structures, including cross sections of drainage structures);
- engineering evaluation;
- drainage calculations (including supporting information);
- drainage map (depicting proposed surface elevations, drainage basins, and overland flow arrows);
- lot grading map;
- vegetation plan.

Section 30-1724(2) of the Code provides additional information regarding the submittal of Regular Applications. An example of a Regular Application is provided in **Appendix B**. Applicants are cautioned that the examples in this document are not intended for all potential design aspects of surface water management systems. Specific project variables encountered such as existing development, receiving water body location, and wetland preservation may dictate more elaborate or detailed analyses. An application checklist is provided in **Appendix B** for optional use by the applicant.

3.0 TREATMENT VOLUME CALCULATIONS

The following design methodologies apply to regular application projects. However, the applicant may elect to implement these methodologies in lieu of using the short form. This may be desirable if this information is being gathered for other purposes. Please note that pollution abatement volume requirements vary based on the selected stormwater management system. Section 4.0 provides pollution abatement volume requirements for select management systems. The following sections provide formulas to calculate treatment volume. The stormwater system shall be designed to accommodate the greater of pollution abatement or treatment volume requirements.

A common technique for estimating runoff volume (treatment volume) is NRCS equation.

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S}$$

Q= Runoff Depth (inches)
P = 25-year, 72-hour rainfall (feet) = 12 inches
S = Soil Storage (inches)

As written above, this equation assumes the following:

$I_a = 0.2*S$
S = (1000/CN) - 10
CN= Runoff Curve Number (see **Appendix C**)

Alternatively, the S value can be computed using soil moisture storage capacity based on the following values:

Depth to Water Table (feet)	Cumulative Water Storage (inches)	Compacted Water Storage (inches)
1	0.60	0.45
2	2.50	1.88
3	6.60	4.95
4	10.90	8.18

Source: August 2014 SFWMD Environmental Resource Permit Information Manual Applicant's Handbook Vol. II

Additional information regarding soil storage capacity calculations is provided in **Appendix C**.

The runoff volume can be determined from the following:

$$V = Q * A$$

V= Volume Required (acre-feet)
Q= Runoff Depth (feet)
A = Area (acre)

Using the NRCS unit hydrograph approach is also an acceptable methodology.

4.0 STORMWATER TREATMENT TECHNOLOGY ALTERNATIVES

Stormwater treatment facilities are designed to treat the pollution abatement volume or “first flush” of a rainfall event, which contains the majority of the pollutants associated with the runoff. The pollution abatement volume is dependent upon land use of the site as well as the type of stormwater management facility being utilized.

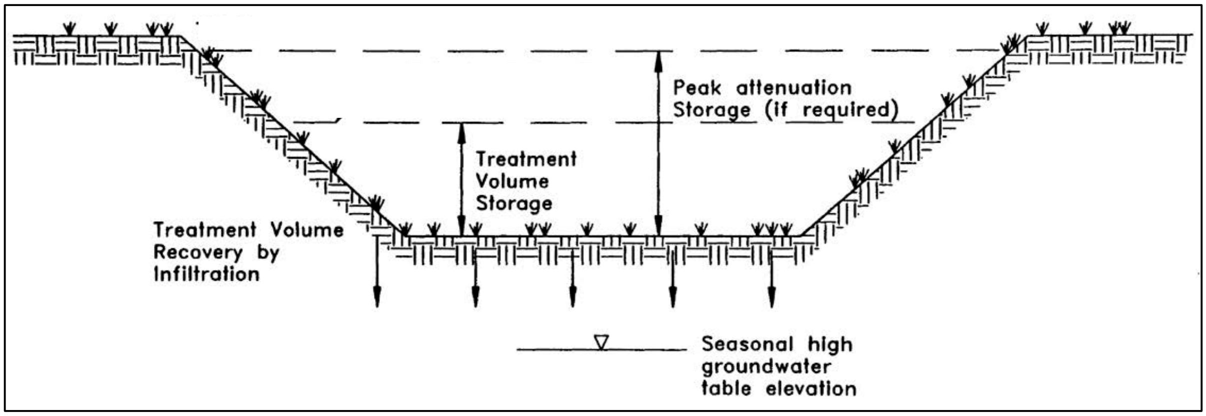
The following sections present description and design considerations for the implementation of the following stormwater management systems:

- Retention Ponds
- Dry and Wet Detention Ponds
- Exfiltration Trench System/French Drain
- Grass Swales (Interceptor Swales) and Berms
- Pervious Paving
- Permeable Paving System
- Underground Stormwater Management System
- Infiltration Swale

Please note that these are examples of typical systems and this list is not intended to provide a full list of acceptable systems.

5.0 DESIGN CRITERIA, PERFORMANCE AND MAINTENANCE

5.1 Retention Pond



Description

A retention pond is a stormwater treatment system that is defined as a storage area designed to collect a defined amount of runoff which allows the runoff to percolate through permeable soils into the shallow aquifer. The treatment volume is not discharged to surface waters. Soil characteristics and water table conditions must be such that the retention system can percolate the desired runoff amount within the specified time period following a rainfall event. Once drawdown is complete, the basin does not hold water; therefore, the system is normally dry. All retention ponds shall be designed as dry bottom ponds unless otherwise approved by the Village. Sedimentation is the primary pollutant removal process in dry retention facilities and only pollutants which are in particulate form are removed by this process.

Treatment Volume

The pollution abatement volume, or first flush of runoff, should be collected in the retention pond and infiltrated into the surrounding soil. Pollution abatement volume shall be provided for the greatest of the following:

- One-half inch of runoff over the entire project area
- One and one-quarter inches over the impervious area

For direct discharges to Class III Outstanding Florida Waters, canals or other waterways connecting to these waters, the stormwater treatment system shall provide for at least an additional fifty percent of the applicable pollution abatement volume specified above.

Runoff volume requirements shall be determined using runoff equations based on a 25-year/72-hour storm event and specific site conditions. The system shall convey the pollution abatement volume or runoff volume, whichever is greater.

Design criteria for pollution abatement utilizing retention. The design of ponds for the required retention volumes may consider separate facilities, or pollution abatement may be combined into the design of the detention pond required to reduce the peak rate of flow from the developed site, to that peak rate of flow prior to the development of the site.

Recovery Time

The retention pond shall be designed such that the maximum design discharge shall be one-half inch of the retention volume in twenty-four hours following a rainfall event assuming average antecedent moisture conditions. Antecedent moisture conditions refer to the amount of moisture and storage available in the soil prior to a rainfall event. Antecedent conditions have a significant effect on runoff rates, runoff volumes, infiltrations rates, and infiltration volumes. In general, the stormwater is drawn down in a retention pond by natural soil infiltration and dissipation processes into the groundwater table. Determining the recovery time may require the use of modeling tools.

Design

- The required retention volume is calculated based on the site conditions and a 25-year/72-hour storm event.
- Sufficient depth of filter media is required for allow filtering of the pollution abatement volume.
- The volume of stormwater impounded for pollution abatement shall be evacuated through the filter media within a seventy-two hour time period.
- A positive, nonfiltering bleed-down device with an operable gate or valve shall be installed as a backup system in the event that the filtration system fails. The gate or valve shall normally be set and locked in the closed position
- Retention areas shall be designed with side slopes no steeper than 4:l (horizontal:vertical) and to a minimum depth of two feet below the control elevation, or an equivalent substitute.
- The bottom of a required retention pond shall be a minimum of one foot above the estimated seasonal, high water table.
- A qualified engineer shall determine final design recovery rates.
- All necessary calculations to support the above shall be submitted to the Village.

Construction

The following are recommended construction procedures to avoid degradation of the retention basin infiltration capacity during construction:

- For the purposes of basin stabilization, the retention pond shall be stabilized with pervious material or permanent vegetative cover to provide proper treatment of the runoff.
- Construct retention pond to a rough grade by under excavating bottom and sides by approximately one foot. Side slopes should be sodded immediately to prevent erosion and introduction of additional sediment.
- Once drainage area contributing to the stormwater retention pond is stabilized, interior side slopes and basin bottom should be excavated to final design specifications. Undesirable material and excess soil should be excavated and removed carefully so that accumulated silts, clays, organics, and other fine sediment material are removed. Note that the excavated material should be disposed of beyond the drainage basin limits.
- The retention pond bottom should be deep raked and loosened for optimal infiltration once the facility has been excavated to final grade.

Maintenance

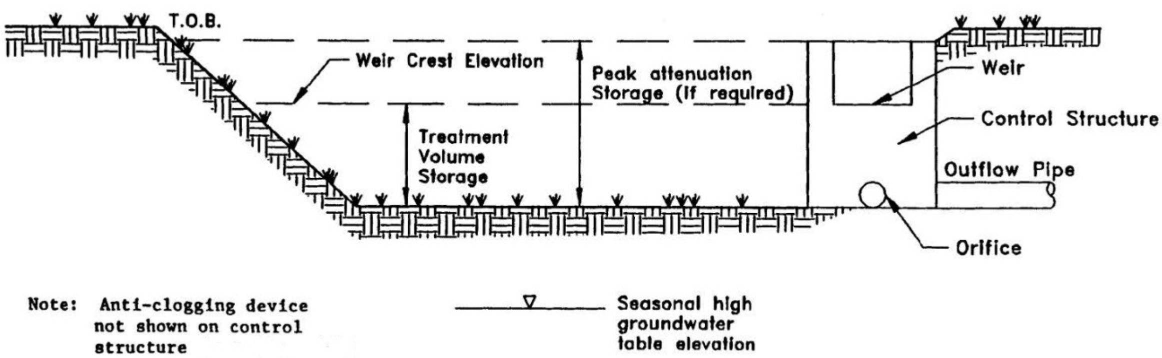
Inspection of the stormwater system should be conducted based on the following schedule:

- The stormwater system should be inspected on a routine basis to confirm that it is functioning properly
- Major inspections should be conducted on a semi-annual basis
- Brief inspections should be conducted following rainfall events greater than one inch

Cleanout frequency of ponds will depend on a number of factors including if pretreatment is utilized, vegetation, storage capacity, infiltration characteristics, volume of inflow, amount of sediment load, and type of sediment load. Maintenance should include the following:

- Typically, structures should be cleaned out when sediment levels reduce the storage volume by ten percent
- An elevation mark should be placed inside the pond indicating such elevation
- Rotary tillers or disc harrows with light tractors are recommended for scarifying pond bottoms
- After tilling, the basin floor should be level and smooth to ease future sediment removal and minimize amount of material removed during future cleaning practices

5.2 Dry Detention Pond



Description

Dry detention ponds are similar to retention systems in that the facilities are normally dry, however, the main difference is that detention systems are designed to discharge the runoff through an outlet structure to adjacent surface waters. Runoff is held for a short period and then slowly released to a receiving waterbody typically at a rate no greater than pre-development peak discharge rates. Sedimentation is the primary pollutant removal process in dry retention facilities and only pollutants which are in particulate form are removed by this process. Due to the limited pollutant removal efficiency of dry detention facilities, pollutant removal efficiency is not as great as in retention or wet detention therefore dry detention should be utilized when no other stormwater management system is feasible.

Treatment Volume

The pollution abatement volume, or first flush of runoff, should be collected in the retention pond and infiltrated into the surrounding soil. Water quality volume shall be provided for the greatest of the following:

- First three-quarter inch of runoff over the project area
- One and seven-eighths inches over the impervious area

For direct discharges to Class III Outstanding Florida Waters, canals or other waterways connecting to these waters, the stormwater treatment system shall provide for at least an additional fifty percent of the applicable pollution abatement volume specified above.

Runoff volume requirements shall be determined using runoff equations based on a 25-year/72-hour storm event and specific site conditions. The system shall convey the pollution abatement volume or runoff volume, whichever is greater.

Design criteria of detention facilities to reduce peak rate of flow: The detention pond shall be sized to limit the peak rate of discharge rate from the developed site to that discharge generated prior to development. Supporting calculations shall be submitted and contain, at a minimum, runoff hydrographs for the pre-developed site and the post-developed site, and a discharge hydrograph after routing through the proposed detention facility. All routing calculations to be submitted must consider the tailwater of the receiving facility. If the receiving facility is an existing storm drain, the hydraulic gradient line elevation (HGL) of this receiving facility can be assumed at one-half foot below its gutter line elevation, unless a detailed study of the existing system indicates otherwise. The following considerations apply to this case:

- Credit for seepage to further reduce the peak rate of discharge will not be allowed, unless accompanied by supporting documentation (infiltration studies, field permeability tests, seepage studies, etc.) prepared by a qualified engineer.
- All stormwater evacuation from detention facilities in excess of the pollution abatement volume shall be accomplished by a positive, nonfiltering discharge structure only. The use of underdrains to accomplish this required evacuation is prohibited. One foot of the freeboard is required above the design high water of the pond.
- The outlet structure shall be designed to skim floating debris, oil, and grease from an elevation six inches below the surface of the pollution abatement volume to an elevation six inches above the design high water level of the pond.

Design criteria where a positive outfall is not available: When a positive outfall is not available or discharge into a water body without a positive outfall is proposed, the pond design shall detain the 25-year/72-hour storm event. The pond shall be designed to evacuate a daily volume equivalent to one inch of runoff from the total area contributing to the pond.

Design criteria for off-site drainage: Off-street areas which drain to, or across, a site proposed for development must be accommodated in the stormwater management plans for the development. The stormwater management system for the development must be capable of transporting existing off-site flows through, or around, the development. The estimation of the off-site flows must be done separately from the estimation of on-site post-flows (i.e., separate off-site and on-site hydrographs must be computed due to the typically significant difference in land use characteristics). It is strongly recommended that the project engineer meet with the appropriate Village staff prior to generating final detailed design calculations in order to establish off-site design requirements for a particular project.

Recovery Time
An outfall structure should be designed such that the maximum design discharge following a storm event shall be one half inch of the detention volume in twenty-four hours. Determining the recovery time may require the use of modeling tools.

Outlet/Inlet Structure
The control elevation should be set at or above the design tailwater elevation. This allows the detention facility to effectively recover the treatment storage.

Inlet structures should be designed such that the energy of the water is dissipated when entering the retention pond. The outlet structure shall include a drawdown device which slowly releases the pollution abatement volume in addition to including a device which shall prevent the discharge of accumulated sediment, minimize exit velocities, and prevent clogging. Devices shall be no smaller than six square inches with a two-inch minimum cross section dimension or less than a twenty-degree "V" notch.

Design
Design considerations are recommended as follows:

- The required retention volume is calculated based on the site conditions and a 25-year/72-hour storm event.
- To ensure detention basin floor is normally dry and minimize groundwater contributions, the basin floor should be set at least one foot above the seasonal high groundwater table. The retention pond floor should be level or uniformly sloped toward the control structure.
- Control elevation shall be determined based on site conditions and provide sufficient residence time for treatment of the pollution abatement volume.
- The average length to width ratio for dry detention basins shall be at least 2:1. The inlet and outlet structures must be configured such that the residence time is maximized. This condition minimizes short circuiting and pollutant removal efficiency is maximized. If the ratio cannot be achieved, the effective flow path can be increased with the addition of diversion barriers.
- Structural elements must be designed by a Florida registered professional engineer and in accordance with acceptable engineering standards.

Construction
Construction procedures are recommended as follows during construction:

- Construct detention pond to a rough grade by under-excavating bottom and sides by approximately one foot. Side slopes should be sodded immediately to prevent erosion and introduction of additional sediment.
- The detention pond sides and bottom shall be stabilized with pervious material or permanent vegetative cover.
- Once the drainage area contributing to the stormwater detention pond is stabilized, interior side slopes and basin bottom should be excavated to final design specifications. Undesirable material and excess soil should be excavated and removed carefully so that accumulated silts, clays, organics, and other fine sediment material are removed. Note that the excavated material should be disposed of beyond the drainage basin limits.

Maintenance

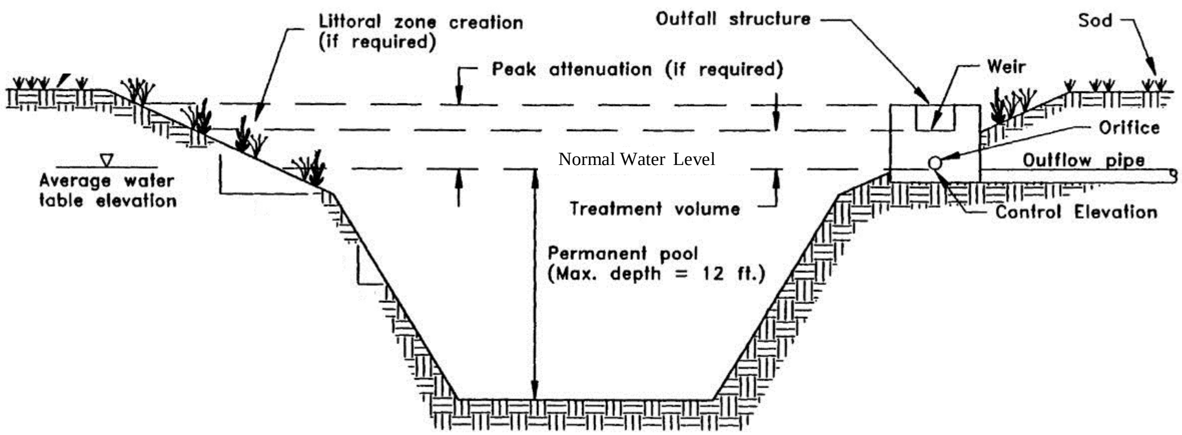
Inspection of the stormwater system should be conducted based on the following schedule:

- The stormwater system should be inspected on a routine basis to confirm that it is functioning properly.
- Major inspections should be conducted on a semi-annual basis.
- Brief inspections should be conducted following rainfall events greater than one inch.

Maintenance requirements should include the following:

- Debris removal can be accomplished with the use of trash racks or other screening devices.
- Debris should be removed following each rainfall event.
- Sediment deposition should also be monitored in the detention facility and the maintenance plan shall specify an elevation at which sediments should be removed.
- An elevation mark should be place inside the pond indicating such elevation and should be set at no greater than twenty-five percent capacity with ten percent being preferred.
- Sediment removal when a certain storage elevation is reached.

5.3 Wet Detention Pond



Description

A wet detention pond is a permanently wet pond in which runoff is held for a short period of time and then slowly released to a receiving waterbody typically at a rate no greater than pre- development peak discharge rates. Wet detention ponds are typically recommended for sites with moderate or high water table conditions. Wet detention provides for significant removal of dissolved and suspended pollutant loads via the physical, chemical and biological processes which take place within the pond. Wet detention also provides for flood detention, runoff for irrigation and aesthetic value.

Treatment Volume

The pollution abatement volume, or first flush of runoff, should be collected in the retention pond and infiltrated into the surrounding soil. Pollution abatement volume shall be provided for the greatest of the following:

- The first one inch of runoff over the project area
- Two and one-half inches over the impervious area

For direct discharges to Class III Outstanding Florida Waters, canals or other waterways connecting to these waters, the stormwater treatment system shall provide for at least an additional fifty percent of the applicable pollution abatement volume specified above.

Runoff volume requirements shall be determined using runoff equations based on a 25-year/72-hour storm event and specific site conditions.

The system shall convey the pollution abatement volume or runoff volume, whichever is greater.

Recovery Time

An outfall structure should be designed such that the maximum design discharge following a storm event is one half inch of the detention volume in twenty-four hours.

Permanent Pool Volume

The permanent pool should be sized for at least a fourteen day residence time during the wet season (June-October). The storage capacity shall be large enough to detain untreated runoff long enough for removal processes, such as uptake of nutrients by algae, adsorption of nutrients and heavy metals, biological oxidation of organic materials and sedimentation, to occur.

Outlet/Inlet Structures

Inlet structures should be designed such that the energy of the water is dissipated when entering the detention pond.

The outlet structure shall include a drawdown device which slowly releases the pollution abatement volume and a device which shall prevent the discharge of accumulated sediment, minimize exit velocities, and prevent clogging.

- The control elevation should be set at or above the design tailwater elevation. This allows the detention facility to effectively recover the treatment storage.
- Devices shall be no smaller than six square inches with a two-inch minimum cross section dimension or less than a twenty degrees “V” notch.

Littoral Zone

The littoral zone is defined as the portion of the wet detention pond which is designed to contain rooted aquatic plants. The littoral area is typically at gently sloping pond sides which extend two to three feet below the normal water level or control elevation of the pond. Littoral zones can also be located at other areas of the pond with suitable depths.

A specific vegetation establishment plan must be prepared and consider the hydroperiod of the pond and type of plants which are to be established. A layer of muck can also be incorporated into this area to promote establishment of the vegetation. Design criteria for wet detention littoral zones include the following:

- Six to one (horizontal:vertical) or flatter slope in the littoral zone and at least thirty percent of the pond surface shall consist of the littoral zone.
- The treatment volume shall not cause the water level in the pond to rise more than 18" above the established control elevation unless it is demonstrated that the vegetation in the littoral zone can survive at greater depths.
- Eighty percent coverage of the littoral zone by suitable aquatic plants is required within twenty-four months after construction of the system.
- As an alternative to the recommended planting to meet the eighty percent coverage requirement, portions of the littoral zone may be established by the introduction of wetland top soils at least four inches in depth containing a seed source of the desired wetland plants. The littoral zone must be stabilized by mulching or other means and at least the portion of the littoral zone within twenty-five feet of the inlet and outlet structures must be planted when using this alternative.

An additional fifty percent of the permanent pool volume is required in lieu of a littoral zone or pretreatment of the stormwater prior to entering the wet detention pond is required.

<u>Pre-Treatment</u>

Pre-treatment increases pollutant removal efficiency of the stormwater management system by reducing the pollutant loading which enters the wet detention pond. Pre-treatment facilities include the following:

- Retention systems that adhere to design performance criteria
- Swale systems that adhere to design performance criteria
- Exfiltration trenches that adhere to design performance criteria

Alternative pre-treatment methods, such as vegetated filter strips and infiltration swales, will be evaluated on a case-by-case basis by the Village.

<u>Design</u>

The inlet and outlet structures must be configured such that the residence time is maximized. This condition minimizes short circuiting and pollutant removal efficiency is maximized. If the ratio cannot be achieved, the effective flow path can be increased with the addition of diversion barriers to the basin. Design considerations are recommended as follows:

- The average length to width ratio for wet detention basins shall be at least 2:1.
- The pond shall be designed so that the average pond side slope measured between the control elevation and two feet below the control elevation in no steeper than 4:1 (horizontal:vertical).

- A wet detention pond shall not exceed a maximum depth of twelve feet and a mean depth (pond volume divided by pond area at control elevation) between two to eight feet. Typically, many of the nutrients and metals removed from the water column accumulate in the top inches of the pond bottom sediments. If a pond is deep enough it has a tendency to stratify creating potential for anaerobic conditions at the pond bottom. Therefore, the maximum depth criteria minimizes potential significant thermal stratification and helps maintain aerobic conditions which maximizes sediment uptake and minimizes sediment release of pollutants. Additionally, the mean minimum mean depth criteria minimize aquatic plant growth that may become excessive if the wet retention pond is too shallow.
- The control elevation should be established at or above the normal groundwater table elevation on-site to minimize groundwater contributions which may lower treatment efficiencies. The elevation is typically determined by calculating the average of the seasonal high and seasonal low groundwater elevations.
- The outfall structure shall provide for discharge of baseflow at the design normal water level and the baseflow rates must be included in drawdown calculations for the outfall structure. Baseflow should also be considered when designing the wet retention pond for permanent pool residence time.
- Structural elements must be designed by a Florida registered professional engineer and in accordance with acceptable engineering standards.

Construction

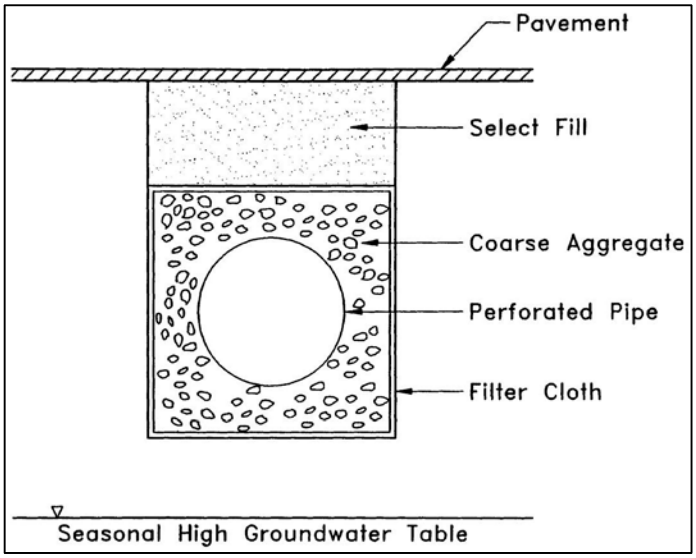
The following considerations are recommended during construction of detention ponds:

- The detention pond sides and bottom shall be stabilized with pervious material or permanent vegetative cover.
- Construct detention pond to a rough grade by under-excavating bottom and sides by approximately one foot. Side slopes should be sodded immediately to prevent erosion and introduction of additional sediment.
- Once the drainage area contributing to the stormwater detention pond is stabilized, interior side slopes and basin bottom should be excavated to final design specifications. Undesirable material and excess soil should be excavated and removed carefully so that accumulated silts, organics, and other fine sediment material are removed. Note that the excavated material should be disposed of beyond the drainage basin limits.

Maintenance

- The stormwater system should be inspected on a routine basis to confirm that it is functioning properly.
- Major inspections should be conducted on a semi-annual basis.
- Brief inspections should be conducted following rainfall events greater than one inch.
- Sediment removal when a certain storage elevation is reached.
- Debris removal can be accomplished with the use of trash racks or other screening devices.
- Debris should be removed following each rainfall event.
- Sediment deposition should be monitored in the detention facility and the maintenance plan shall specify an elevation at which sediments should be removed.
- An elevation mark should be place inside the pond indicating such elevation and should be set at no greater than twenty-five percent capacity with ten percent being preferred.

5.4 Exfiltration Trench System/French Drain



Description
An exfiltration trench is a subsurface stormwater management system consisting of a conduit such as perforated pipe which is surrounded by natural or artificial aggregate which temporarily stores and infiltrates runoff. Perforated pipe increases the storage available in the trench and helps promote infiltration. Typically, this type of system is utilized when space is limited. Like retention basins, the treatment volume is not discharged to surface waters. Exfiltration trenches are also used to promote recharge of groundwater and prevent salt water intrusion in coastal areas.

Typically, the operation life of an exfiltration trench is five to ten years. Sediment accumulation and fines reduce the life of the system and replacement may be the only alternative to restoring the treatment capacity of the system.

Treatment Volume
The pollution abatement volume, or first flush of runoff, should be collected in the trench system and infiltrated into the surrounding soil. Pollution abatement volume shall be provided for whichever is greatest from the following:

- The first one-half inch of runoff over the project area
- One and one-quarter inches over the impervious area

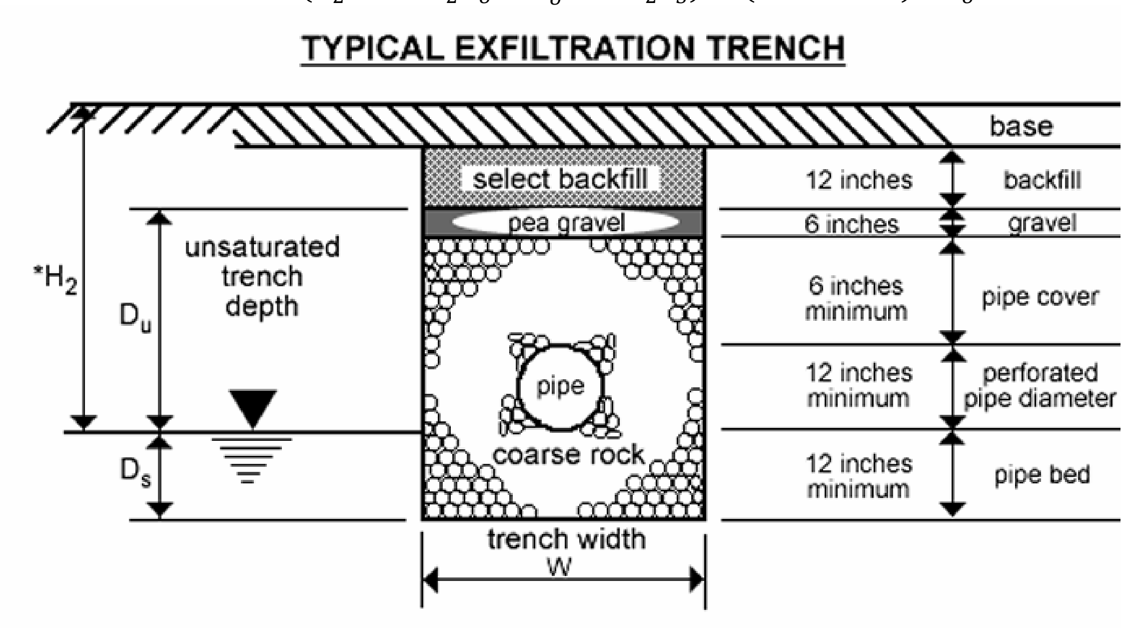
For direct discharges to Class III Outstanding Florida Waters, canals or other waterways connecting to these waters, the stormwater treatment system shall provide for at least an additional fifty percent of the applicable pollution abatement volume specified above.

Runoff volume requirements shall be determined using runoff equations based on a 25-year/72-hour storm event and specific site conditions. The system shall convey the pollution abatement volume or runoff volume, whichever is greater.

Design

The South Florida Water Management District developed an acceptable exfiltration trench design formula:

$$L = \frac{V}{K(H_2W + 2H_2D_U - D_U^2 + 2H_2D_S) + (1.39 \, x \, 10^{-4})WD_U}$$



L = Length of Trench Required (feet)

V = Volume to be Treated (acre-inches)

W = Trench Width (feet)

K = Hydraulic Conductivity (cfs/ft^2 – ft head)

*H_2 = Depth to Water Table (feet)

D_u = Non-Saturated Trench Depth (feet)

Ds = Saturated Trench Depth (feet)

* The value of H_2 to be used in the equation is the effective head on the saturated surface. A weir must be installed at the downstream end of the trench, to create true retention and to establish H_2. To achieve the design retention and exfiltration, the crest of the weir must be no lower than the top of the trench pipe.

For those situations when either: (1) the saturated depth of trench is greater than the non-saturated depth of trench; or (2) the trench width is greater than two times the total trench depth, the proportional assumptions for flow out the trench bottom are probably not valid. A conservative design formula for use in these cases would be:

$$L = \frac{V}{K(2H_2D_U - D_U^2 + 2H_2D_S) + (1.39 \, x \, 10^{-4})WD_U}$$

The following design considerations are presented for the design of exfiltration trenches:

- The stormwater system should be designed to provide for the appropriate treatment volume and contain no contiguous areas of standing or free flowing water within seventy-two hours following rainfall events assuming average antecedent moisture conditions. Antecedent moisture conditions refer to the amount of moisture and storage available in the soil prior to a rainfall event. Antecedent conditions have a significant effect on runoff rates, runoff volumes, infiltrations rates and infiltration volumes. In general, the stormwater is drawn down in an exfiltration trench by natural soil infiltration and dissipation processes into the groundwater table.
- The exfiltration trench shall be designed with a safety factor of at least two unless it can be demonstrated that a lower safety factor is appropriate for specific site conditions.
- The exfiltration trench system shall be designed with a minimum twelve inch pipe diameter and a three foot minimum trench width. The perforated pipe should be located within the trench section to minimize sediment accumulation in aggregate void storage and maximize preservation of the storage for treatment.
- The exfiltration trench should be designed so that aggregate in the trench is enclosed in filter fabric, which prevents migration of fine materials from the adjacent soil that could potentially clog the trench. Additionally, filter fabrics may be utilized directly surrounding the perforated pipe though the pipe may be more prone to clogging and capacity reduction. However, this design can be cleaned relatively simply with high-pressure hoses or vacuum systems whereas without the filter fabric surrounding the pipe, complete replacement is typically necessary when there is clogging.

Hydraulic Conductivity

The following field tests are commonly used to determine hydraulic conductivity for the design of exfiltration trenches:

- The usual constant head test. The usual test performed is an open-hole test which is either uncased or cased with fully perforated casing. The hydraulic conductivity obtained by this method may be either greater or less than the effective trench hydraulic conductivity depending upon the relative hydraulic conductivity of the surface layers.
- The falling-head test, which may be utilized in areas of excellent percolation, and when difficulty "keeping the hole filled" is encountered. The falling-head test is an open-hole test which is either uncased or cased with fully-perforated casing.
- The standard test used by the FDOT. FDOT utilizes a standard test for design of seepage trenches in conjunction with highway projects. The FDOT does not recommend utilization of seepage trenches in areas where this test yields less than 6 gallons per minute.

The engineer is cautioned that, when tests are conducted, site-specific characteristics, such as soil type, geology and hydrologic conditions must be factored into the field test methodology. Actual hydrologic conditions under which the exfiltration trench would be expected to perform must also be considered.

Inspections and Cleanout Structures

Cleanout structures, otherwise known as sediment removal devices, should be installed at the inlet of the pipe structure. Inspections and cleanout structures aid in observing how quickly the trench recovers following a storm event and how quickly the trench fills with sediment. It also allows access to the perforated pipe.

Construction

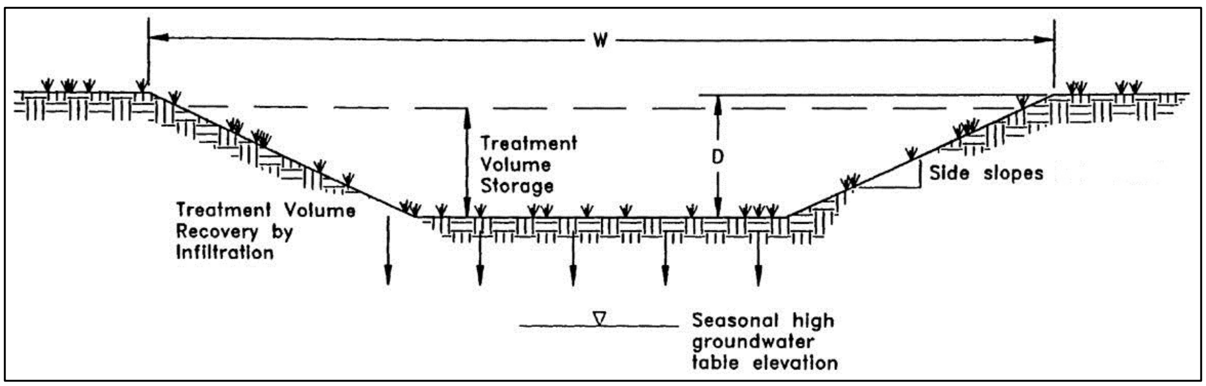
Steps should be taken to limit the parent soil and debris from entering the trench which extends the life of the exfiltration system. Diversion berms should be placed around the trench during construction and sediment and erosion control plans should be designed to keep sediment and runoff away from the trench area.

Maintenance

The stormwater system should be inspected on a routine basis to assure it is functioning properly. Route maintenance activities should include the following:

- Cleaning out the pretreatment devices such as sediment control structures periodically.
- Periodic cleaning of infiltration trench manually or by vacuum truck when ten percent or more of the available capacity is depleted.
- Major inspections should be conducted on a semi-annual basis.
- Brief inspections should be conducted following rainfall events greater than one inch.

5.5 Grass Swales (Interceptor Swales) and Berms



Description

Vegetated swales are man-made or natural systems, which are shaped or graded to specified dimensions and designed for conveyance and infiltration of stormwater runoff. Swales only hold water during and immediately following a storm event; however, unlike retention systems there are no physical barriers such as berms or check dams to impound the runoff in the swale prior to discharge. Berms are similar in nature to swales but are built up mounds of soil and vegetated materials that are typically used on or near the perimeter of a parcel to retain stormwater from exiting the parcel.

Treatment Volume

The pollution abatement volume, or first flush of runoff, should be collected in the swale and infiltrated into the surrounding soil. Pollution abatement volume shall be provided for whichever is greatest from the following:

- The first one-half inch of runoff over the project area
- One and one-quarter inches times the percent impervious surface.

For direct discharges to Class III Outstanding Florida Waters, canals or canals connected to other waterways which are approved, conditionally approved, restricted or conditionally restricted for shellfish harvesting, the stormwater treatment system shall provide for at least an additional fifty percent of the applicable pollution abatement volume specified above.

Runoff volume requirements shall be determined using runoff equations based on a 25-year/72-hour storm event and specific site conditions. The system shall convey the pollution abatement volume or runoff volume, whichever is greater.

Design

- The swale shall be designed such that the maximum design discharge shall be one half inch of the retention volume in twenty-four hours following a rainfall event (assuming average antecedent moisture conditions).
- Swales shall have side slopes equal to or greater than 4:1 (horizontal:vertical).
- Berms shall typically be no higher than three feet above natural ground surface and shall have a maximum side slope of 2:1.
- Swales and berms shall be stabilized with vegetative cover suitable for soil stabilization, stormwater treatment, and nutrient uptake. The swale and berm should be designed to take into account soil errodibility, soil percolation, slope, length, and drainage area. This allows for the reduction in pollutant loading concentrations and helps to prevent erosion.

Construction

Swales and berms shall be staked for construction. All vegetative debris including trees, stumps and brush shall be removed from the system and disposed of as not to interfere with the proper functioning of the swale or berm.

The soil removed from the swale shall be deposited beyond the drainage basin limits or where it will not interfere with flow of water into the swale system. Topsoil shall be saved and spread in the constructed soil if necessary to promote establishment of vegetative cover. The swale should be over-excavated to allow for replacement of the topsoil without encroaching of the cross section design.

Settlement of soils should be specifically considered when designing berms and proper compaction should be performed prior to stabilizing with vegetative cover.

Methods for establishing grass vegetation include:

- Seeding with straw mulch and tack coat
- Seeding with straw mulch and jute mesh or erosion netting
- Sodding

Maintenance

Inspection of the stormwater system should be conducted based on the following schedule:

- The stormwater system should be inspected on a routine basis to confirm that it is functioning properly
- Major inspections should be conducted on a semi-annual basis
- Brief inspections should be conducted following rainfall events greater than one inch
- Inspections of the swale or berm for areas of failures should be performed after each rainfall event and make any repairs or replacements when observed and re-seedings in the planting season

Routine maintenance activities should include the following:

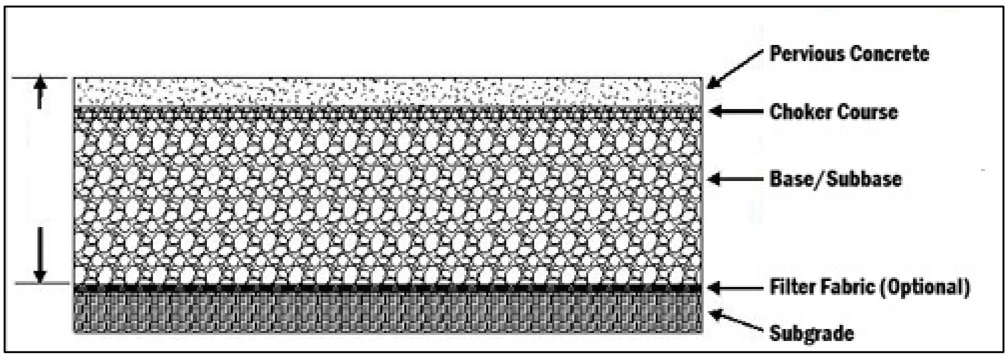
- Fertilization and mowing should be done to ensure the vegetation is in healthy condition
- Cut vegetation should be removed to prevent decaying organic litter and from adding pollutants to the swale discharge
- Vehicular traffic should be prohibited from swales and berms

5.6 Pervious Paving

Pervious paving is a generic term to describe a range of materials and techniques using permeable pavements with a base and subbase that allow the movement of stormwater through the surface. Permeable paving includes permeable concrete pavement and porous asphalt pavement. Below are examples of these types of permeable paving options.

Pervious Concrete Pavement

Pervious concrete, also known as porous, gap-graded, or enhanced porosity concrete, is concrete with reduced sand or fines and allows water to drain through it. Pervious concrete over an aggregate storage bed will reduce stormwater runoff volume, rate, and pollutants. The reduced fines leave stable air pockets in the concrete and a total void space of between 15 and 35 percent, with an average of 20 percent. The void space allows stormwater to flow through the concrete as shown in the figure below, and enter a crushed stone aggregate bedding layer, and base that supports the concrete while providing storage and runoff treatment. When properly constructed, pervious concrete is durable, low maintenance, and has a low life cycle cost.



Pervious concrete comprises the surface layer of the permeable pavement structure and consists of Portland cement, open-graded coarse aggregate (typically 5/8 to 3/8 inch), and water. Admixtures can be added to the concrete mixture to enhance strength, increase setting time, or add other properties. The thickness of pervious concrete ranges from 4 to 8 inches depending on the expected traffic loads. Additional subsurface components of this treatment practice are detailed below.

- *Choke course*: This permeable layer is typically 1 - 2 inches thick and provides a level bed for the pervious concrete. It consists of small-sized, open-graded aggregate.
- *Open-graded base reservoir*: This aggregate layer is immediately beneath the choke layer. The base is typically 3 - 4 inches thick and consists of crushed stones typically 3/4 to 3/16 inch in size. Besides storing water, this high infiltration rate layer provides a transition between the bedding and subbase layers.
- *Open-graded subbase reservoir*: The stone sizes are larger than the base, typically 2½ to ¾ inch stone. Like the base layer, water is stored in the spaces among the stones. The subbase layer thickness depends on water storage requirements and traffic loads. A subbase layer may not be

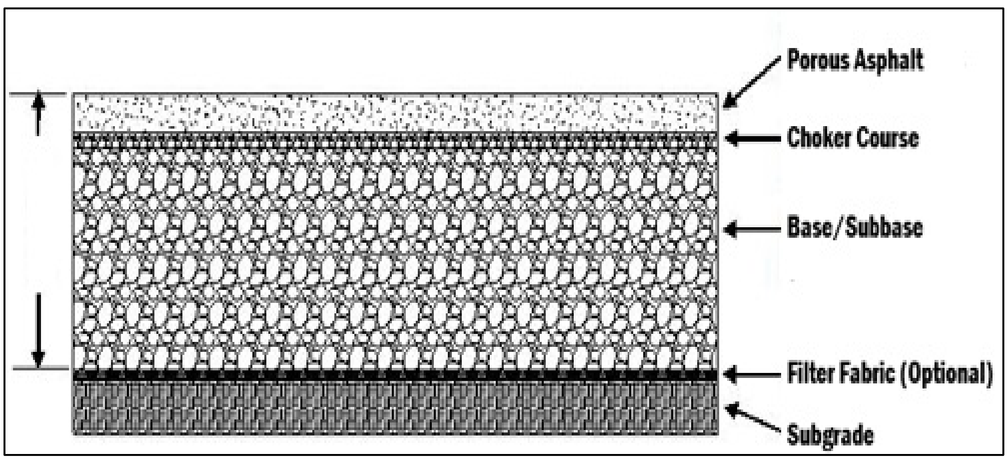
required in pedestrian or residential driveway applications. In such instances, the base layer is increased to provide water storage and support.

- *Underdrain (optional)*: In instances where pervious concrete is installed over low-infiltration rate soils, an underdrain facilitates water removal from the base and subbase. The underdrain is perforated pipe, open or modular structure that ties into an outlet structure. Supplemental storage can be achieved by using a system of underdrains in the aggregate layers.
- *Filter Media/Geotextile (optional*): This can be used to separate the subbase from the subgrade and prevent the migration of soil into the aggregate subbase or base.
- *Subgrade*: The layer of soil immediately beneath the aggregate base or subbase. The infiltration capacity of the subgrade determines how much water can exfiltrate from the aggregate into the surrounding soils. The subgrade soil is generally not compacted.

Consult with manufacturers and Village staff prior to selecting a system to ensure pervious concrete is compatible with land use.

Porous Asphalt Pavement

Porous asphalt, also known as pervious, permeable, "popcorn," or open-graded asphalt, is standard hot-mix asphalt with reduced sand or fines and allows water to penetrate and drain through it. Porous asphalt over an aggregate storage bed will reduce stormwater runoff volume, rate, and pollutants. The reduced fines leave stable air pockets in the asphalt. The interconnected void space allows stormwater to flow through the asphalt, and enter a crushed stone aggregate bedding layer and base that supports the asphalt while providing storage and runoff treatment. When properly constructed, porous asphalt is a durable and cost competitive alternative to conventional asphalt.



Porous asphalt comprises the surface layer of the permeable pavement structure and consists of open-graded coarse aggregate, bonded together by bituminous asphalt. Polymers can also be added to the mix to increase strength for heavy load applications. The thickness of porous asphalt ranges from 2 to 4 inches depending on the expected traffic loads. For adequate permeability, the porous asphalt should have a minimum of 16% air voids. Additional subsurface components of this treatment practice are detailed below.

- *Choke course*: This permeable layer is typically 1 - 2 inches thick and provides a level and stabilized bed surface for the porous asphalt. It consists of small-sized, open-graded aggregate.
- *Open-graded base reservoir*: This aggregate layer is immediately beneath the choke layer. The base is typically 3 - 4 inches thick and consists of crushed stones typically 3/4 to 3/16 inch. Besides storing water, this high infiltration rate layer provides a transition between the bedding and subbase layers.
- *Open-graded subbase reservoir*: The stone sizes are larger than the base, typically 3/4 to 2 1/2-inch stone. Like the base layer, water is stored in the spaces among the stones. The subbase layer thickness depends on water storage requirements and traffic loads. A subbase layer may not be required in pedestrian or residential driveway applications. In such instances, the base layer is increased to provide water storage and support.
- *Underdrain (optional)*: In instances where porous asphalt is installed over low-infiltration rate soils, an underdrain facilitates water removal from the base and subbase. The underdrain is a perforated pipe with open or modular structures that tie into an outlet structure. Supplemental storage can be achieved by using a system of underdrains in the aggregate layers.
- *Filter Fabric/Geotextile (optional)*: This can be used to separate the subbase from the subgrade and prevent the migration of soil into the aggregate subbase or base.
- *Subgrade*: The layer of soil immediately beneath the aggregate base or subbase. The infiltration capacity of the subgrade determines how much water can exfiltrate from the aggregate into the surrounding soils. The subgrade soil is generally not compacted.

Treatment Volume

This type of system shall be considered as a retention system for design purposes. Therefore, treatment volumes outlined above for retention systems shall be evaluated for the design of this management system.

Consult with manufacturer and Village staff prior to selecting a system to ensure installation of permeable pavement is compatible with land use.

Maintenance

The most prevalent maintenance concern among pervious pavements is the potential clogging of the pavement by sediment accumulation. This consists of clogging of pervious concrete pores in permeable concrete pavement, and porous asphalt pavement. Routine maintenance should be conducted to allow for proper infiltration through the systems.

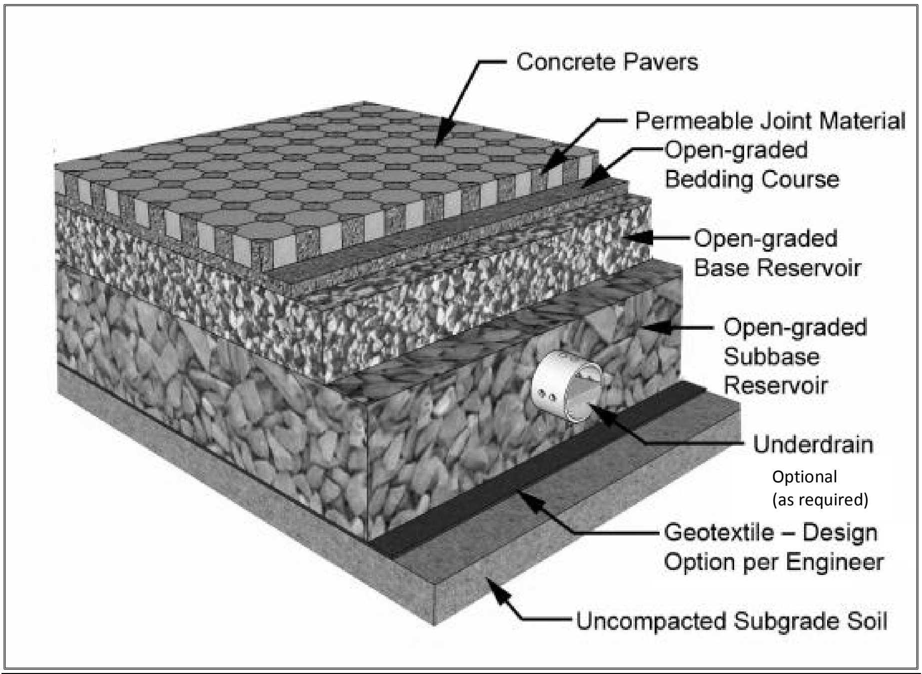
5.7 Permeable Paving System

Permeable interlocking concrete pavement consists of manufactured concrete units that reduce stormwater runoff volume, rate, and pollutants. The impervious units are designed with small openings between permeable joints. The openings typically comprise 5% to 15% of the paver surface area and are filled with highly permeable, small-sized aggregates. The joints allow stormwater to enter a crushed stone aggregate bedding layer and base that supports the pavers while providing storage and runoff treatment. Permeable interlocking concrete pavements are attractive, durable, easily repaired, require low maintenance, and can withstand heavy vehicle loads if properly constructed.

The concrete pavers with permeable joint material comprise the surface layer of permeable pavements. Typical paver sizes are:

- 80 mm (3 1/8 in.) thick for vehicular areas
- 60 mm (2 3/8 in.) thick for pedestrian areas

Additional subsurface components listed in the permeable pavements cross-section figure are defined below.



Permeable Pavements Cross-Section, source US EPA.

- *Open-graded bedding course*: This permeable layer is typically 50 mm (2 in.) thick and provides a level bed for the pavers. It consists of small-sized, open-graded aggregate.
- *Open-graded base reservoir*: An aggregate layer immediately beneath the bedding layer. The base is typically 75 to 100 mm (3 - 4 in.) thick and consists of crushed stones typically from 5 mm down to 20 mm (3/16 in to 3/4 in.). Besides storing water, this high infiltration rate layer provides a transition between the bedding and subbase layers.
- *Open-graded subbase reservoir*: The stone sizes are larger than the base, typically from 20 mm down to 65 mm (3/4 in. to 2½ in.) stone. Like the base layer, water is stored in the spaces among the stones. The subbase layer thickness depends on water storage requirements and traffic loads. A subbase layer may not be required in pedestrian or residential driveway applications. In such instances, the base layer is increased to provide water storage and support.
- *Underdrain (optional)*: In instances where porous asphalt is installed over low-infiltration rate soils, an underdrain facilitates water removal from the base and subbase. The underdrain is a perforated pipe, with open or modular structures that tie into an outlet structure. Supplemental storage can be achieved by using a system of underdrains in the aggregate layers.
- *Geotextile (optional)*: This can be used to separate the subbase from the subgrade and prevent the migration of soil into the aggregate subbase or base.
- *Subgrade*: The layer of soil immediately beneath the aggregate base or subbase. The infiltration capacity of the subgrade determines how much water can exfiltrate from the aggregate into the surrounding soils. The subgrade soil is generally not compacted.

Treatment Volume

This type of system shall be considered as a retention system for design purposes. Therefore, treatment volumes outline above for retention system shall be evaluate for the design of this management systems.

Consult with the manufacturer and Village staff prior to selecting a system to ensure installation of permeable pavement is compatible with land use.

Maintenance

Maintenance of the system is necessary to remediate clogging of sediment in the openings and joints between pavers in permeable interlocking concrete pavement.

5.8 Underground Stormwater Management System

Description

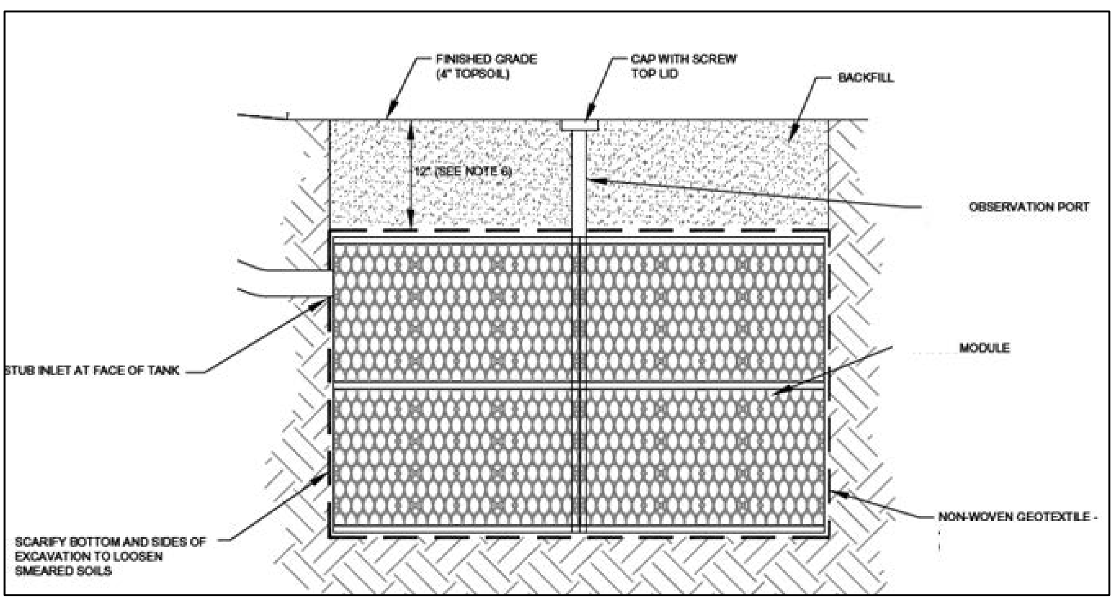
On-site underground retention/detention systems are designed to provide a predetermined amount of storage volume within a specified area. They essentially consist of storage chambers or pipes accompanied with access points and inlets. These systems allow stormwater to be stored within the void volume until it can infiltrate into the ground. The systems can utilize a variety of industry available materials based on project conditions and needs. These systems can be installed below parking lots, streets, driveways, or other surfaces as well as below porous pavement areas to maximize land use. The storage chambers can be installed in trench or bed configurations depending on the area available.

Treatment Volume

Pollution abatement volume and runoff volume considerations for detention and retention as described in the sections above are applicable to these stormwater management systems.

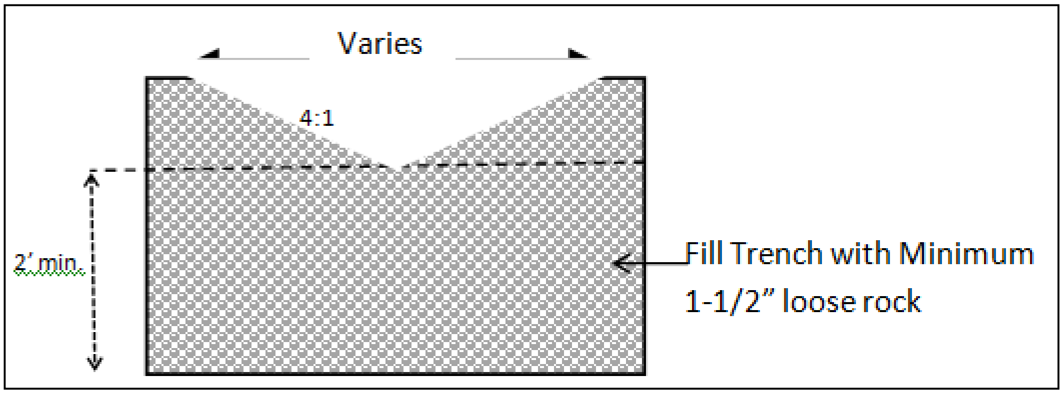
Design and Construction

Design and construction shall be provided by the system provider and are dependent upon site conditions. It is standard that each system shall have an inlet and an access point. It is important to note that a cover layer suitable to endure traffic, or similar effect based on the site use and system location, is necessary to prevent damage to the underground system.



Factors such as depth to water table, bedrock, and available area affect the design and installation consideration. The depth to water table must be observed when designing these systems. The systems shall be installed one foot above the seasonal high water level or as recommended by the manufacturer.

5.9 Infiltration Swale



Description

Infiltration swales are stormwater conveyance systems designed to enhance the infiltration of runoff. A vegetated infiltration swale can be a natural elongated depression or a constructed channel. A vegetated infiltration swale differs from a conventional drainage channel or ditch in that it is constructed specifically to promote infiltration. The primary purpose of the infiltration swale is to infiltrate stormwater, while limiting groundwater contamination by providing filtering of pollutants. This practice is believed to have high pollutant removal efficiency and can also help recharge the groundwater.

Treatment Volume

Infiltration swales need to be located carefully. In particular, designers need to ensure that the soils on the site are appropriate for infiltration, and the design minimizes the potential for groundwater contamination and long-term maintenance problems. Consequently, consult with Village staff prior to selecting this type of system.

Design

When designing infiltration swales, designers need to carefully consider both the restrictions on the site and design features to improve the long-term performance.

- *Drainage Area*: In general, vegetated infiltration swales are best applied to relatively small drainage areas.
- *Location*: The swale shall not be located in traffic areas or areas subject to surface disturbance.
- *Slope*: Swales shall have side slopes equal to or greater than 4:1 (horizontal:vertical).
- *Soils/Topography*: Soils and topography are limiting factors when locating infiltration swales. Soils must be significantly permeable to ensure that the practice can infiltrate quickly enough to reduce the potential for clogging, and soils that infiltrate too rapidly may not provide sufficient treatment, creating the potential for groundwater contamination. The infiltration rate should range between 0.5 and 3 inches per hour. In addition, the soils should have no greater than 20 percent clay content, and less than 40 percent silt/clay content. Finally, infiltration swales may not be used in regions of karst topography, due to the potential for sinkhole formation or ground water contamination.

- *Groundwater*: Designers always need to provide significant separation distance (2 to 5 feet) from the bottom of the infiltration basin and the seasonally high ground water table, to reduce the risk of contamination. Infiltration practices should also be separated from drinking water wells.

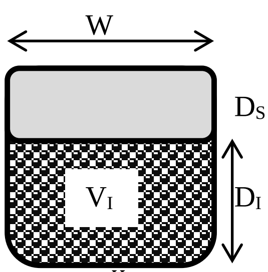
Specific designs may vary considerably, depending on site constraints or preferences of the designer or community. There are some features, however, that should be incorporated into most infiltration swale designs.

- Treatment design features enhance the pollutant removal of a practice. For infiltration practices, designers need to stabilize upland soils to ensure that the basin does not become clogged with sediment. In addition, the facility needs to be sized so that the volume of water to be treated infiltrates through the bottom in a given amount of time. Because infiltration swales are designed in this manner, infiltration swales designed on less permeable soils should be significantly larger than those designed on more permeable soils.
- Landscaping can enhance the aesthetic value of stormwater practices or improve their function. In infiltration swales, the most important purpose of vegetation is to reduce the tendency of the swale to clog. Upland drainage needs to be properly stabilized with a thick layer of vegetation, particularly immediately following construction.

The following sample calculations are applicable to the cross section presented below:

V_s = Swale Volume
$V_s = SA_s * L$
SA_s = Surface Areas of Swale section (in this case = $W * D_s/2$)
V_I = Infiltration Volume
$V_I = [(W*D) - SA_s] * L * n$
V_T = Total Treatment Volume provided = $V_I + V_S$
A_I = Surface area of the infiltration
n = % porosity of the infiltration aggregate
L = Length of the swale
W = Width of the swale

$$L = \frac{V_T}{SA_S + \{[(W*D) - SA_S]*n\}}$$



$$L = \frac{V_T}{D * W * n}$$

Vs = Swale Volume
V_I = Infiltration Volume
V_T = Total Treatment Volume provided = $V_I + V_S$
D = Total Depth = $D_s + D_I$
A_I = Surface area of the infiltration
n = % porosity of the infiltration aggregate
L = Length of the swale
W = Width of the swale

Maintenance

Regular maintenance is critical to the successful operation of infiltration basins. Inspection of the stormwater system should be conducted based on the following schedule:

- Standard maintenance (as needed):
    - Mow and remove litter and debris
    - Stabilize eroded banks.
    - Repair undercut and eroded areas at inflow and outflow structures

- Semi-annual inspection:
    - Inspect facility for signs of wetness or damage to structures
    - Note eroded areas.
    - Check to ensure that water percolates within 2-3 days following storms.
    - Note signs of petroleum hydrocarbon contamination or other.

- Annual maintenance:
    - Disc or otherwise aerate bottom.
    - Dethatch swale bottom.

- 5-year maintenance:
    - Scrape bottom and remove sediment.
    - Restore original cross-section and infiltration rate.
    - Restore ground cover.

6.0 REFERENCES

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- St. Johns River Water Management District (October 1, 2013). *Permit Information Manual*.

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- Mississippi Department of Environmental Quality (2011). *Erosion Control, Sediment Control and Stormwater Management on Construction Sites and Urban Areas, Volume 2 Stormwater Management*.

- New Jersey Department of Environmental Protection (February 2004). *StormwaterBest Management Practices Manual*.

- Wisconsin Department of Natural Resources (May 2007). *Conservation Practice Standard, Vegetated Infiltration Swale, Interim Technical Standard*.

- United States Environmental Protection Agency. *National Pollutant Discharge Elimination System, National Menu of Best Management Practices*.

Appendix A

SHORT FORM APPLICATION

December 20, 2013

Planning & Development Services Department
Islamorada, Village of Islands
86800 Overseas Highway
Islamorada, Florida 33036

Subject: Short Form Application for Stormwater Management System
Lot 57, Block 2, Subdivision Venetian Shores
123 Conch Way
Islamorada, Florida
Owner Name: Ralph Jones

To Whom It May Concern:

Please accept the attached Short Form Application for a Stormwater Management System for 123 Conch Way, Islamorada, Florida for your review and approval. Enclosed with this application are a written description of the site alterations, a Stormwater Retention Pond and Swale Worksheet (Short Form), applicable stormwater calculations, and a site sketch of the proposed site alterations and stormwater management system.

The project consists of the addition of a 250 square-foot brick paver patio on the north side of the existing building structure. The project site is located adjacent to a canal in the Venetian Shores development; however, there will be no direct discharge from the proposed site alterations to the adjacent canal. The project is designed with a 17-foot vegetative buffer consisting of St. Augustine grass and native vegetation between the proposed patio and canal seawall. Additionally, a dry retention pond has a storage capacity of approximately 27 cubic feet has been designed to retain the required stormwater runoff from the proposed addition.

Please review the attached information at your earliest convenience. If you have any questions regarding the information provided, please contact me at (305) 555-1212.

Sincerely,

Joe Smith, P.E.

attachments

STORMWATER RETENTION POND AND SWALE WORKSHEET "SHORT FORM"

LOT: __________ BLOCK: _______ SUBDIVISON: _________________________________

PHYSICAL ADDRESS: _________________________OWNER NAME: ___________________

Calculate Treatment Volume Required

Previously Unimproved Site

<u>Original Pre Development Conditions</u>

(A) Rainfall = 0.5 in

(B) Site Area _________ft^2

(C) Cubic Feet Required = $\frac{\text{Site Area x Rainfall}}{12} = \frac{\text{B x A}}{12}$ = __________ft^3

<u>Improved Post Development Conditions</u>

(D) Rainfall = 1.25 in

(E) Proposed Impervious Area __________ft^2

(F) Cubic Feet Required = $\frac{\text{Impervious Area x Rainfall}}{12} = \frac{\text{E x D}}{12}$ = ________ft^3

(G) Stormwater Treatment Volume (greater of C or F) = _________ft^3

(H) Stormwater treatment discharge facilities which discharge directly to sensitive receiving waters including Class III Outstanding Florida Waters, or canals or other waterways connecting these with these waters shall provide additional retention pretreatment equal to fifty (50) percent of the total required volume, depending on the arrangement of on-site facilities.

Total Cubic Feet Required = G x 1.5 = ___________ft^3

Previously Improved Site

<u>Improved Post Development Conditions</u>

(I) New Impervious Area _________ft^2

(J) Rainfall = 1.25 in

(K) Cubic Feet Required = $\frac{\text{Impervious Area x Rainfall}}{12} = \frac{\text{I x J}}{12}$ = _______ft^3

(L) Stormwater treatment discharge facilities which discharge directly to sensitive receiving waters including Class III Outstanding Florida Waters, or canals or other waterways connecting these with these waters shall provide additional retention pretreatment equal to fifty (50) percent of the total required volume, depending on the arrangement of on-site facilities.

Total Cubic Feet Required = K x 1.5 = ____________ft^3

STORMWATER RETENTION POND AND SWALE WORKSHEET "SHORT FORM" (Cont.)

Calculate Swale Length (if applicable)

(M) Cubic Feet Required _________ft^3

(N) Square Feet Cross Sectional Area _________ft^2

Note: A swale with 4:1 slopes and 1 foot depth has a 4 ft^2 of Cross Sectional Area.

(O) Swale Length = $\frac{\text{Cubic ft. Required}}{\text{Square Feet Cross Sectional Area}} = \frac{M}{N}$ = _________ft

MUST PROVIDE CROSS SECTIONAL DETAIL OF SWALE, BERM, OR OTHER STORMWATER RETENTION OR DETENTION STRUCTURE

STORMWATER DRY DETENTION POND WORKSHEET "SHORT FORM"

LOT: __________ BLOCK: _______ SUBDIVISON: ________________________________

PHYSICAL ADDRESS: ________________________OWNER NAME: __________________

____

Calculate Treatment Volume Required

Previously Unimproved Site

Original Pre Development Conditions

(A) Rainfall = 0.75 in

(B) Site Area _________ft^2

(C) Cubic Feet Required = $\frac{\text{Site Area x Rainfall}}{12} = \frac{\text{B x A}}{12}$ = _________ft^3

Improved Post Development Conditions

(D) Rainfall = 1.875 in

(E) Impervious Area _________ft^2

(F) Cubic Feet Required = $\frac{\text{Impervious Area x Rainfall}}{12} = \frac{\text{E x D}}{12}$ = _________ ft^3

(G) Stormwater Treatment Volume (greater of C or F) = _________ft^3

(H) Stormwater treatment discharge facilities which discharge directly to sensitive receiving waters including Class III Outstanding Florida Waters, or canals or other waterways connecting these with these waters shall provide additional retention pretreatment equal to fifty (50) percent of the total required volume, depending on the arrangement of on-site facilities.

Total Cubic Feet Required = G x 1.5 = ___________ft^3

Previously Improved Site

Improved Post Development Conditions

(I) New Impervious Area _________ft^2

(J) Rainfall = 1.875 in

(K) Cubic Feet Required = $\frac{\text{Impervious Area x Rainfall}}{12} = \frac{\text{I x J}}{12}$ =________ft^3

(L) Stormwater treatment discharge facilities which discharge directly to sensitive receiving waters including Class III Outstanding Florida Waters, or canals or other waterways connecting these with these waters shall provide additional retention pretreatment equal to fifty (50) percent of the total required volume, depending on the arrangement of on-site facilities.

Total Cubic Feet Required = K x 1.5 = ___________ft^3

MUST PROVIDE CROSS SECTIONAL DETAIL OF SWALE, BERM, OR OTHER STORMWATER RETENTION OR DETENTION STRUCTURE

STORMWATER WET DETENTION POND WORKSHEET "SHORT FORM"

LOT: __________ BLOCK: _______ SUBDIVISON: _________________________________

PHYSICAL ADDRESS: _________________________OWNER NAME: ___________________

____

Calculate Treatment Volume Required

Previously Unimproved Site

Original Pre Development Conditions

(A) Rainfall = 1 in

(B) Site Area _________ft^2

(C) Cubic Feet Required = $\frac{\text{Site Area x Rainfall}}{12} = \frac{\text{B x A}}{12}$ =________ft^3

Improved Post Development Conditions

(D) Rainfall = 2.5 in

(E) Impervious Area _________ft^2

(F) Cubic Feet Required = $\frac{\text{Impervious Area x Rainfall}}{12} = \frac{\text{E x D}}{12}$ = _________ ft^3

(G) Stormwater Treatment Volume (greater of C or F) = __________ft^3

(H) Stormwater treatment discharge facilities which discharge directly to sensitive receiving waters including Class III Outstanding Florida Waters, or canals or other waterways connecting these with these waters shall provide additional retention pretreatment equal to fifty (50) percent of the total required volume, depending on the arrangement of on-site facilities.

Total Cubic Feet Required = G x 1.5 = ____________ft^3

Previously Improved Site

Improved Post Development Conditions

(I) New Impervious Area _________ft^2

(J) Rainfall = 2.5"

(K) Cubic Feet Required = $\frac{\text{Impervious Area x Rainfall}}{12} = \frac{\text{I x J}}{12}$ =______ft^3

(L) Stormwater treatment discharge facilities which discharge directly to sensitive receiving waters including Class III Outstanding Florida Waters, or canals or other waterways connecting these with these waters shall provide additional retention pretreatment equal to fifty (50) percent of the total required volume, depending on the arrangement of on-site facilities.

Total Cubic Feet Required = K x 1.5 = _____________ft^3

MUST PROVIDE CROSS SECTIONAL DETAIL OF SWALE, BERM, OR OTHER STORMWATER RETENTION OR DETENTION STRUCTURE

STORMWATER EXFILTRATION TRENCH SYSTEM WORKSHEET "SHORT FORM"

LOT: __________ BLOCK: _______ SUBDIVISON: _________________________________

PHYSICAL ADDRESS: _________________________OWNER NAME: ___________________

____

Calculate Treatment Volume Required

Previously Unimproved Site

Original Pre Development Conditions

(A) Rainfall = 0.5 in

(B) Site Area _________ft^2

(C) Cubic Feet Required = $\frac{\text{Site Area x Rainfall}}{12} = \frac{\text{B x A}}{12}$ =________ft^3

Improved Post Development Conditions

(D) Rainfall = 1.25 in

(E) Impervious Area _________ft^2

(F) Cubic Feet Required = $\frac{\text{Impervious Area x Rainfall}}{12} = \frac{\text{E x D}}{12}$ = _________ft^3

(G) Stormwater Treatment Volume (greater of C or F) = ____ft^3

(H) Stormwater treatment discharge facilities which discharge directly to sensitive receiving waters including Class III Outstanding Florida Waters, or canals or other waterways connecting these with these waters shall provide additional retention pretreatment equal to fifty (50) percent of the total required volume, depending on the arrangement of on-site facilities.

Total Cubic Feet Required = G x 1.5 = ____________ft^3

Previously Improved Site

Improved Post Development Conditions

(I) New Impervious Area _________ft^2

(J) Rainfall = 1.25 in

(K) Cubic Feet Required = $\frac{\text{Impervious Area x Rainfall}}{12} = \frac{\text{I x J}}{12}$ =_______ft^3

(L) Stormwater treatment discharge facilities which discharge directly to sensitive receiving waters including Class III Outstanding Florida Waters, or canals or other waterways connecting these with these waters shall provide additional retention pretreatment equal to fifty (50) percent of the total required volume, depending on the arrangement of on-site facilities.

Total Cubic Feet Required = K x 1.5 = _________________ft^3

MUST PROVIDE CROSS SECTIONAL DETAIL OF SWALE, BERM, OR OTHER STORMWATER RETENTION OR DETENTION STRUCTURE

Appendix B

- EXAMPLE REGULAR APPLICATION

- CHECKLIST FOR STORMWATER MANAGEMENT PLAN APPLICATION

December 20, 2013

Planning & Development Services Department
Islamorada, Village of Islands
86800 Overseas Highway
Islamorada, Florida 33036

Subject: Application for Stormwater Management System
Lot 36 - Block 6 - Subdivision Williams Tract
Snapper Street Resort
123 Snapper Street
Islamorada, FL
Owner Name: Mary Williams

To Whom It May Concern:

Please accept the attached Application for a Stormwater Management System for 123 Snapper Street, Islamorada, Florida for your review and approval. Enclosed with this application are a written description of the site alterations, stormwater calculations and stormwater system design, and site design drawings.

Proposed Site Alterations

The project generally consists of redevelopment of the existing Snapper Street Resort Complex with the addition of new parking areas, re-vegetation, façade and interior renovations and stormwater improvements. An additional impervious area of approximately 2,200 square feet is proposed for the site.

Stormwater Management Plan

As indicated on the attached site plan, the stormwater management plan consists of redirecting stormwater from the impervious areas of the site to three retention ponds that are to be constructed on the site. Drainage calculations indicate that the ponds are required to treat 1,234 cubic feet of runoff and have been designed according to the criteria set forth in Chapter 30, Article VII, Division 8, *Stormwater Management*, of the Village Code and the supplementary Stormwater Design Criteria Technical Manual.

Drainage Map

See Drainage Plan

Lot Grading Map
See Drainage Plan

Vegetation Plan
The vegetation plan generally consists of the addition of new native plants around the perimeter of the project area. The Landscape Architect specifically selected the vegetation in general accordance with locally-accepted criteria for native vegetation, minimal watering requirements and aesthetic value. The attached Drainage Plan specifies the location and layout of the proposed vegetative areas.

Stormwater System Maintenance and Operation
The owner, Ms. Mary Williams, will conduct the stormwater system maintenance and operation according to the frequencies specified in the Stormwater Design Criteria Technical Manual.

Please review the attached information at your earliest convenience. If you have any questions regarding the information provided, please contact me at (305) 555-1212.

Sincerely,

Joe Smith, P.E.

attachments

Islamorada, Village of Islands
86800 Overseas Highway, 2nd Floor
Islamorada, Florida 33036
Phone: (305) 664-6400 – Fax: (305) 664-6467

CHECKLIST FOR SURFACE WATER MANAGEMENT PLAN APPLICATIONS

GENERAL DEISGN AND PREFORMANCE REQUIREMENTS

	The stormwater management system shall be designed to meet pollution abatement requirements, rate of discharge limitations, finished floor elevations, and protection from flooding.
	A stormwater management system shall be required to limit peak discharge of a developed site to the discharge from the site in the pre-development condition during a 72-hour/25-year frequency storm event unless otherwise specified by the director of planning and development.
	Stormwater management systems shall be located between the development and the receiving water body where appropriate.
	Engineering features to minimize the transport of floating debris, oil, and grease from the detention system must be incorporated into the design of the outlet control structure.
	Surface waters may be deducted from site areas for water quality pervious/impervious calculations.
	Discharged stormwater runoff shall not degrade receiving surface water bodies below the minimum conditions established by state water quality standards.
	Utilize the stormwater design criteria technical manual for standards and minimum requirements.

SHORT FORM APPLICATION REQUIREMENTS

	Description of proposed maintenance, alteration or improvement to the property.
	Site plan indicating the proposed alterations or improvements, property boundaries, buildings, landscaping features, and existing stormwater structures and facilities at a minimum.
	Short Form Application Worksheet with complete calculations.
	Cross-Sections and pertinent proposed elevations of proposed structures must be submitted and supporting volume calculations.
	Supporting data: general type of soil, percolation test data for soil conductivity value, and depth to water considerations.
	Statement confirming that the site and proposed development meet the Short Form Application Criteria.

STANDARD APPLICATION REQUIREMENTS

	Drainage calculations for both pre- and post-development conditions per drainage basin.
	Water Quality Calculations per drainage basin.
	Supporting data: general type of soil, percolation test data for soil conductivity value, and depth to water considerations.
	Proposed construction drawings signed and sealed by a professional engineer or architect.
	Stormwater management plan signed and sealed by a state registered engineer or architect.
	Drainage map showing all existing and proposed drainage features. Drainage map shall include drainage boundaries; delineation of drainage basins; proposed ground elevations and description of all existing and proposed ground cover. Drainage maps shall depict overland runoff flow pattern (i.e. runoff flow arrows).
	Cross sections of retention/detention facilities, typical swale or ditch sections, and drainage right-of-ways. Cross-sections of drainage structures including proposed structure elevations.

Appendix C

DESIGN SUPPORT INFORMATION

MOISTURE STORAGE INFROMATION
(as provided in the South Florida Water Management Basis of Review 2012)

The moisture storage capability of the soil profile has been estimated by the Soil Conservation Service for the normal sandy soils found within the South Florida Water Management District boundaries. The total amount of water which can be stored in the soil profile expressed as a function of the depth to the water table for these soils is:

Depth to Water Table (feet)	Cumulative Water Storage (inches)	Compacted Water Storage (inches)
1	0.60	0.45
2	2.50	1.88
3	6.60	4.95
4	10.90	8.18

The values in the third column represent the estimated amount of water which can be stored under pervious areas after development. These values represent the cumulative water storage values reduced by 25 percent to account for the reduction in void spaces due to the compaction which occurs incidental to earthwork operations.

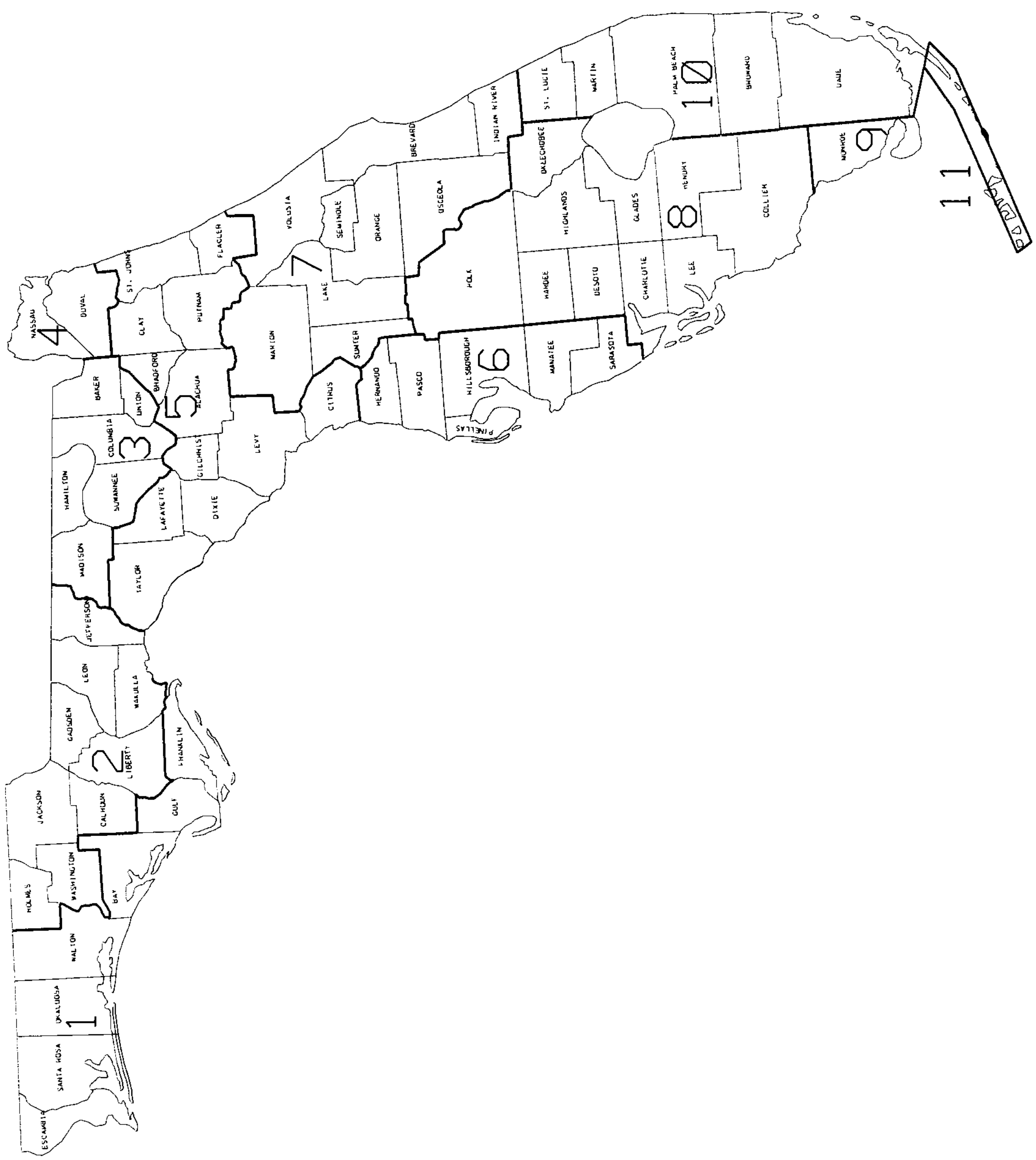
Example Calculations:

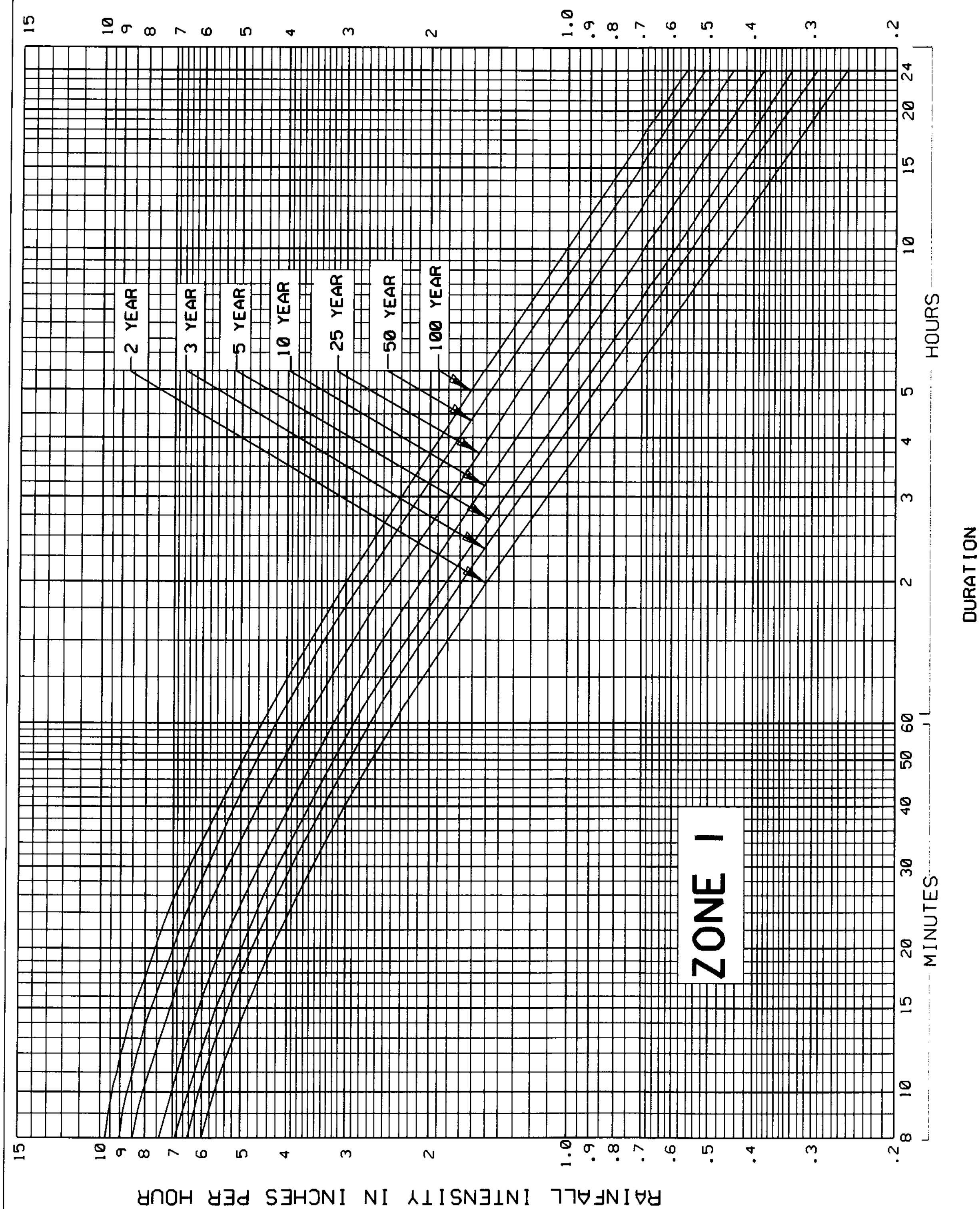
Assume the following:
Average Finished Grade = 17.0 feet NGVD Average Ground Water* Level = 14.0 feet NGVD Percent of Project in Lakes = 15%
Percent of Project Impervious = 35%

The next step is to compute the project-specific S-value to use for deter-mining the runoff volume which will be discharged from the site. The depth to the water table will be 3 feet (17.0 - 14.0 = 3.0), consequently the total amount of water which can be stored under pervious surfaces will be 4.95 inches. If 15% of the project will be in lakes and 35% will be covered by impervious surfaces, then the remainder, or 50% will be pervious areas and the appropriate weighted S-value will be:

4.95" x (1 - (.15+.35)) = 2.48" = S

ZONES FOR PRECIPITATION IDF CURVES DEVELOPED BY THE DEPARTMENT





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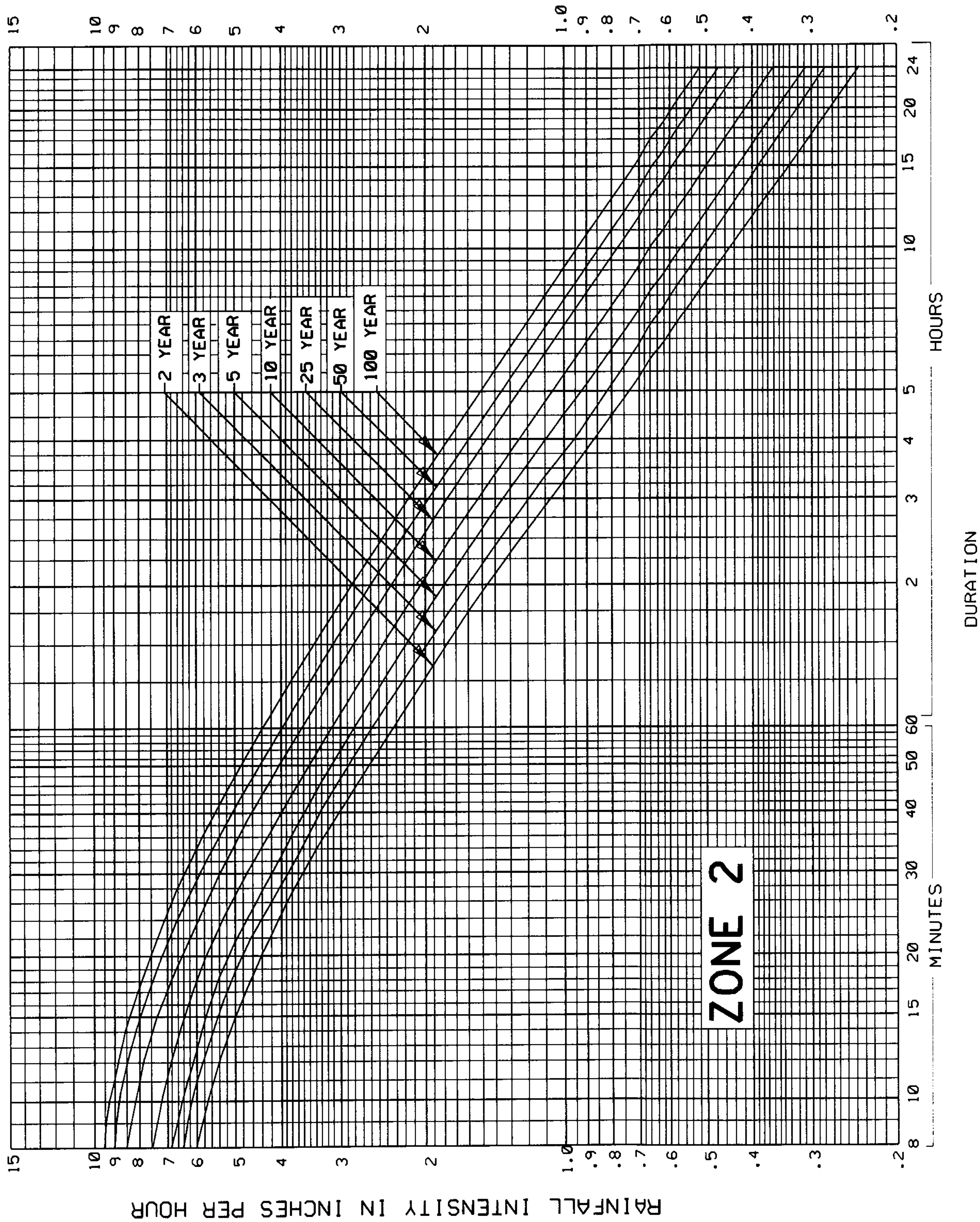
ZONE 1



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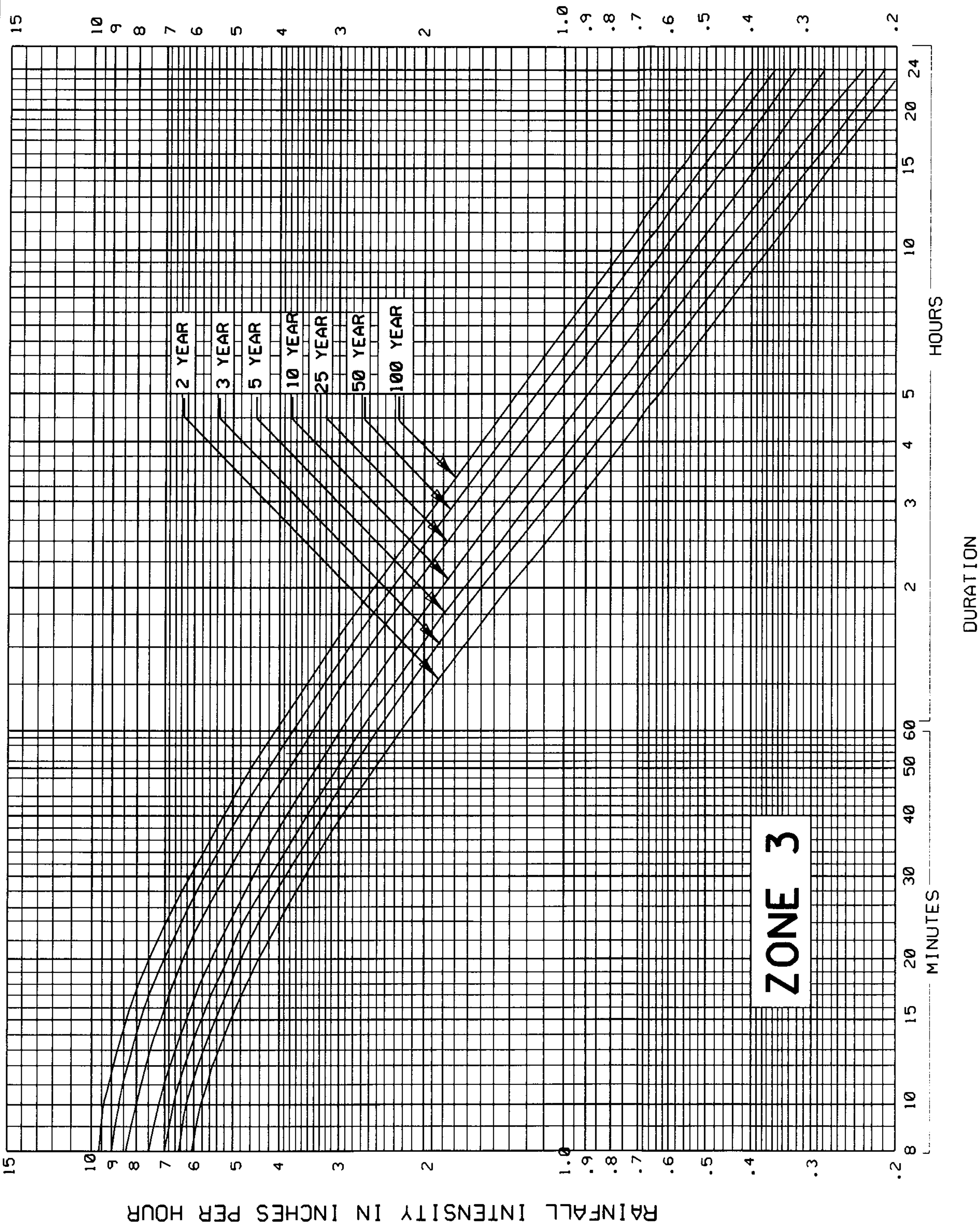

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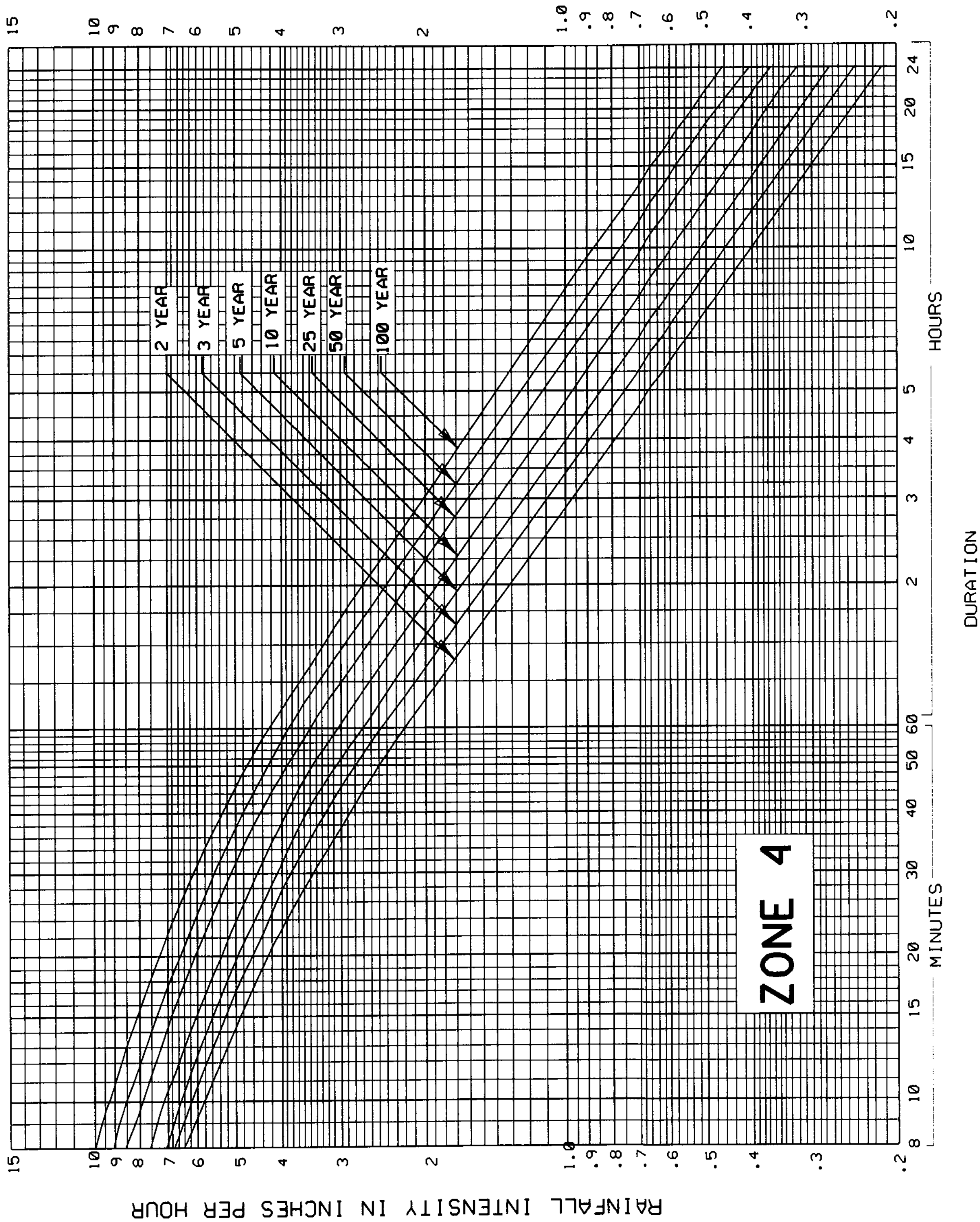
ZONE 3



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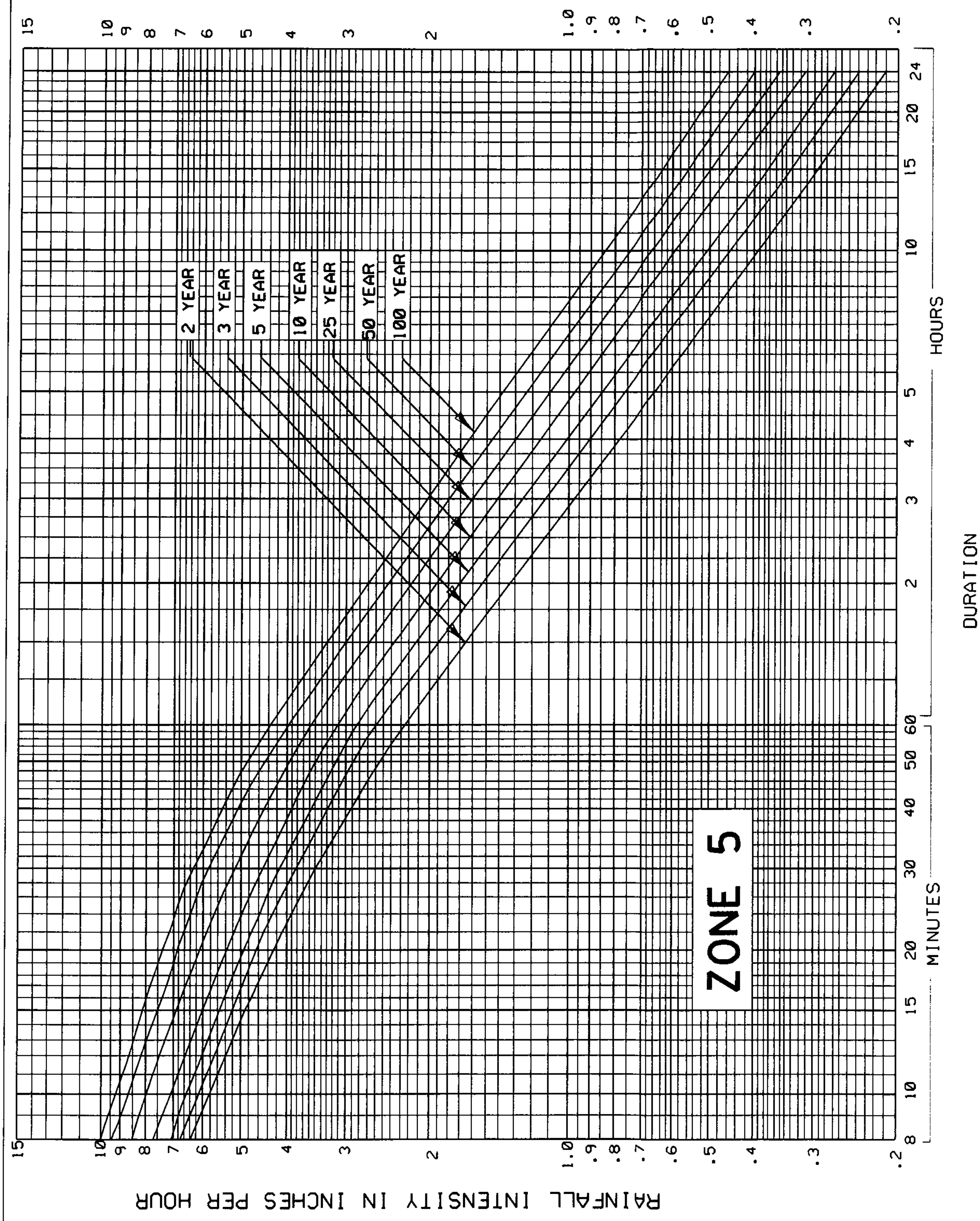

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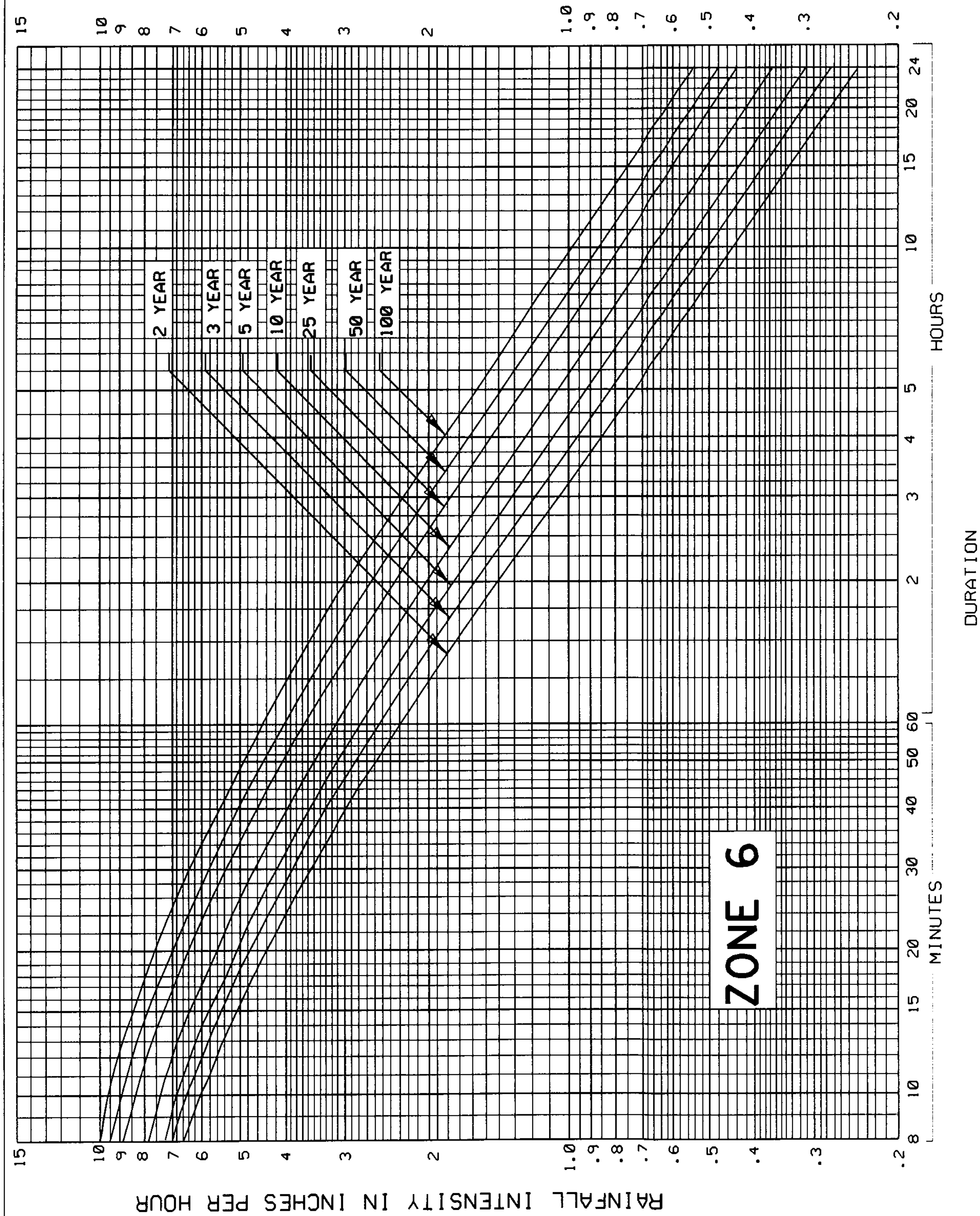
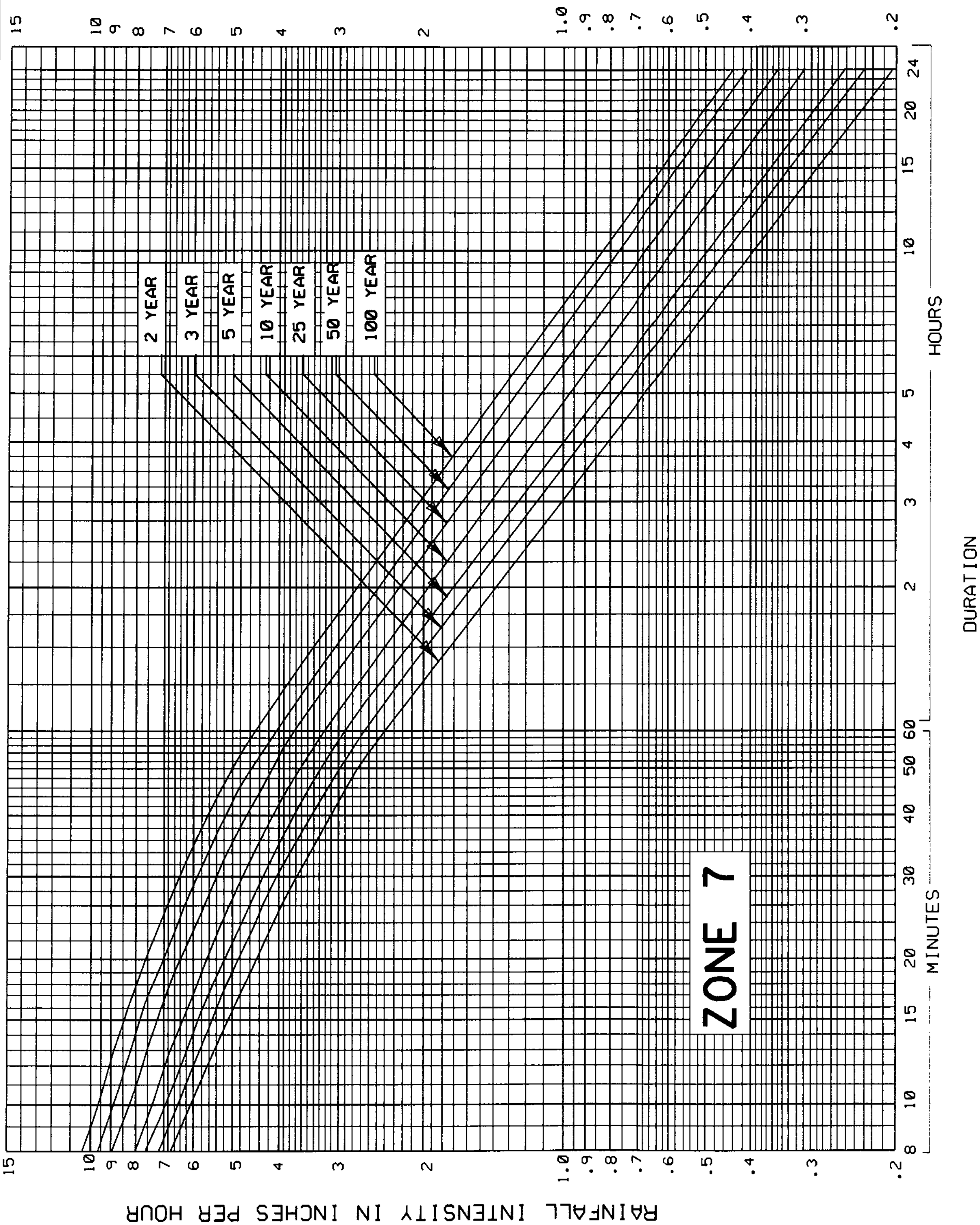


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES
ZONE 6



RAINFALL INTENSITY-DURATION-FREQUENCY CURVES
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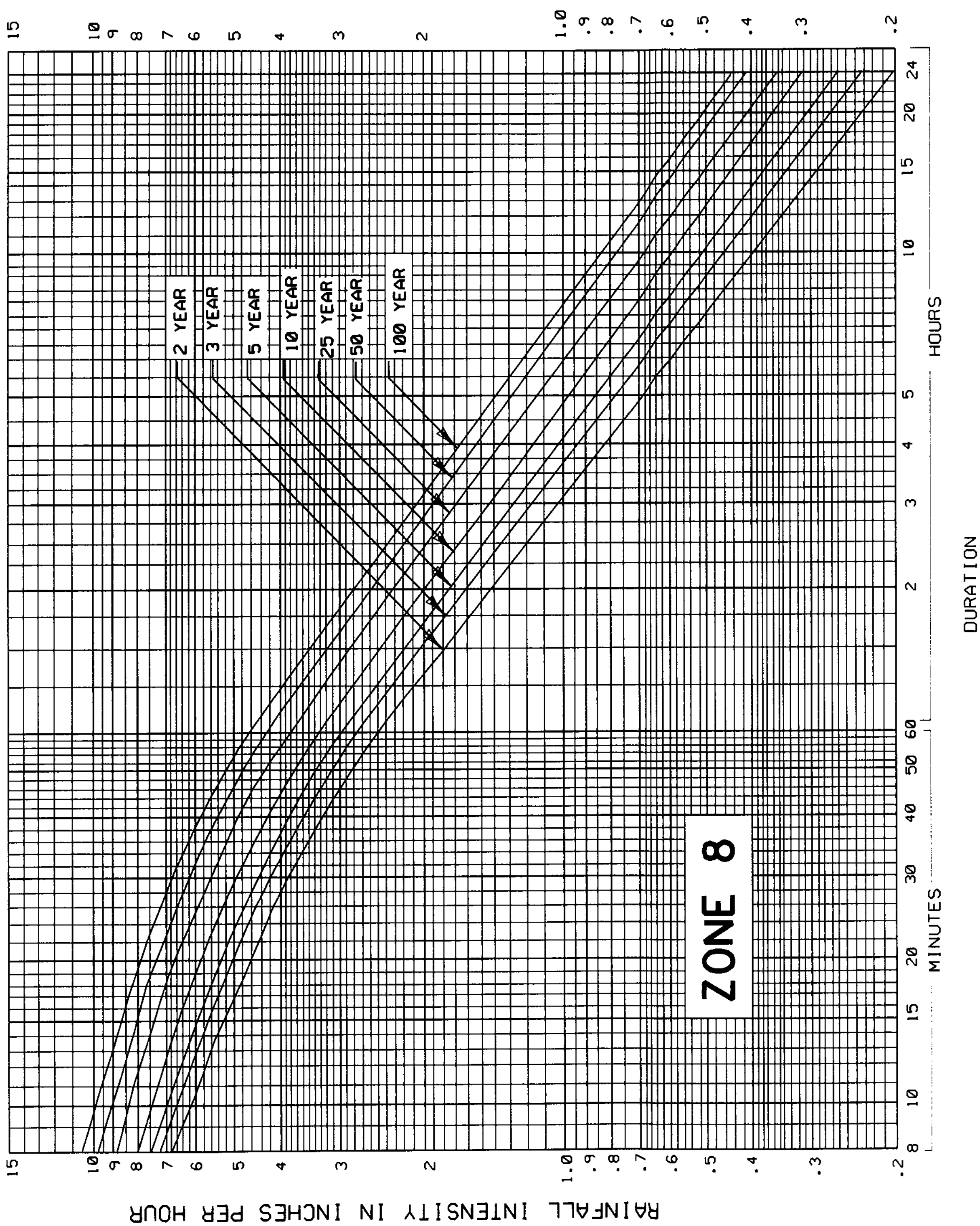

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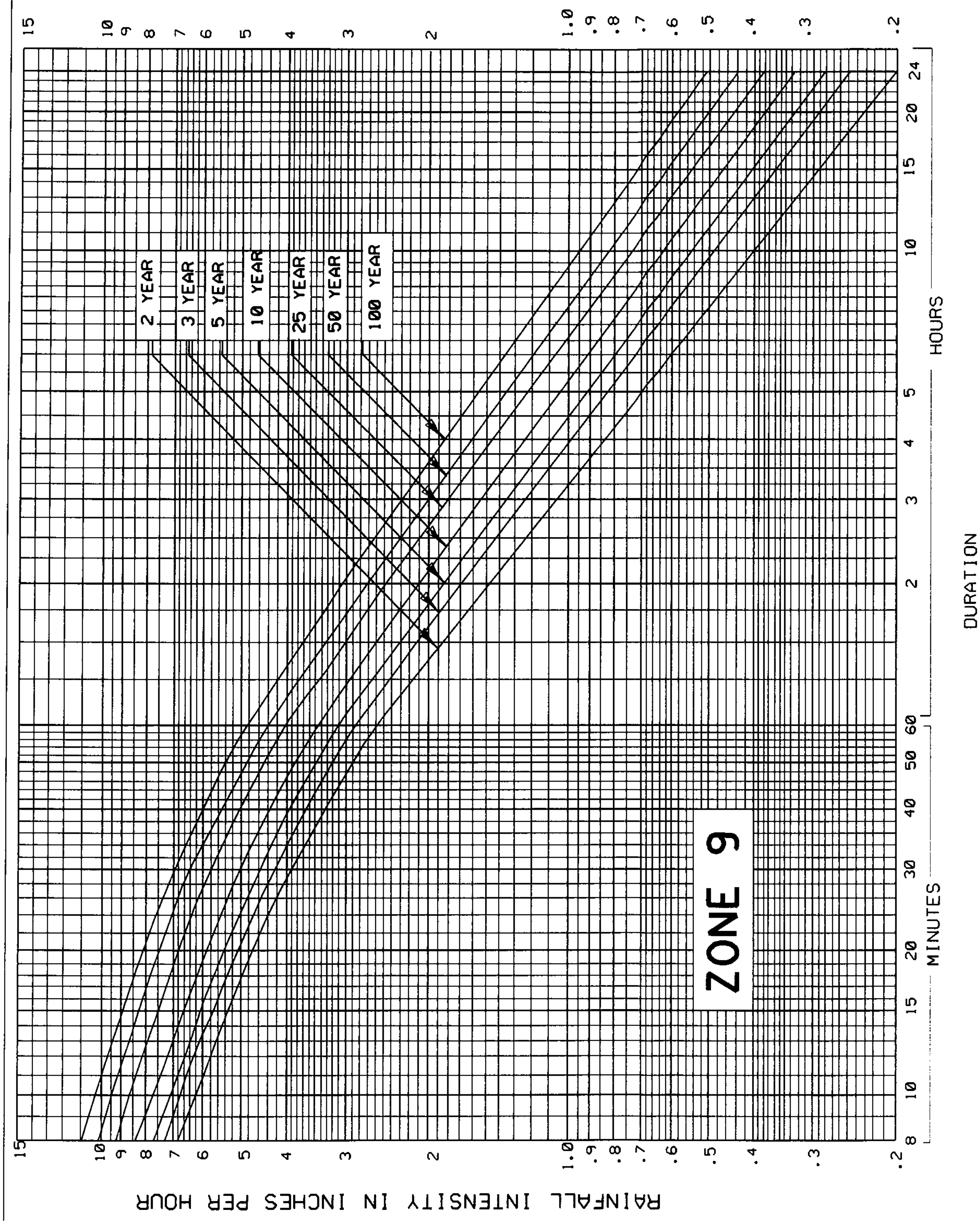

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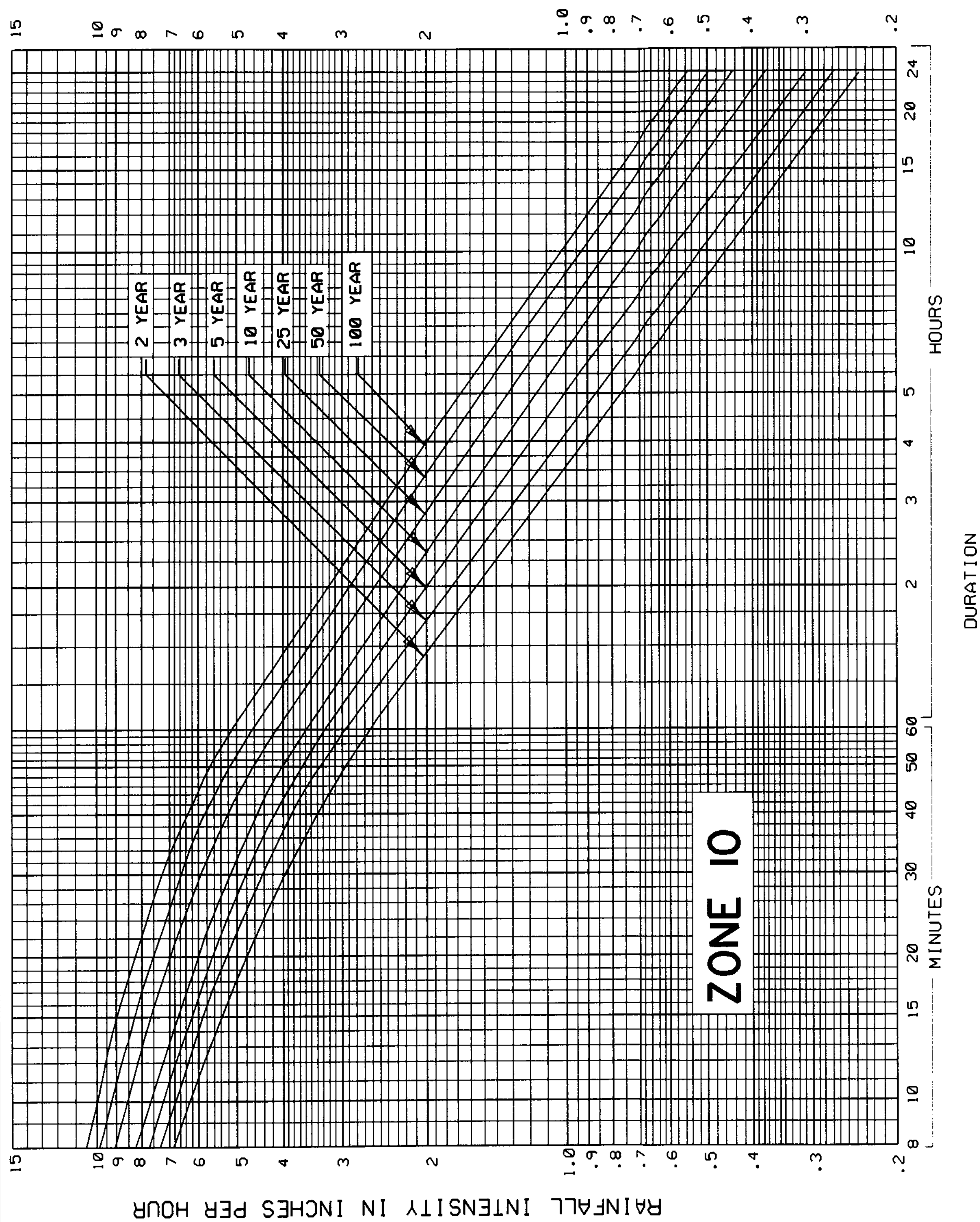
ZONE 9



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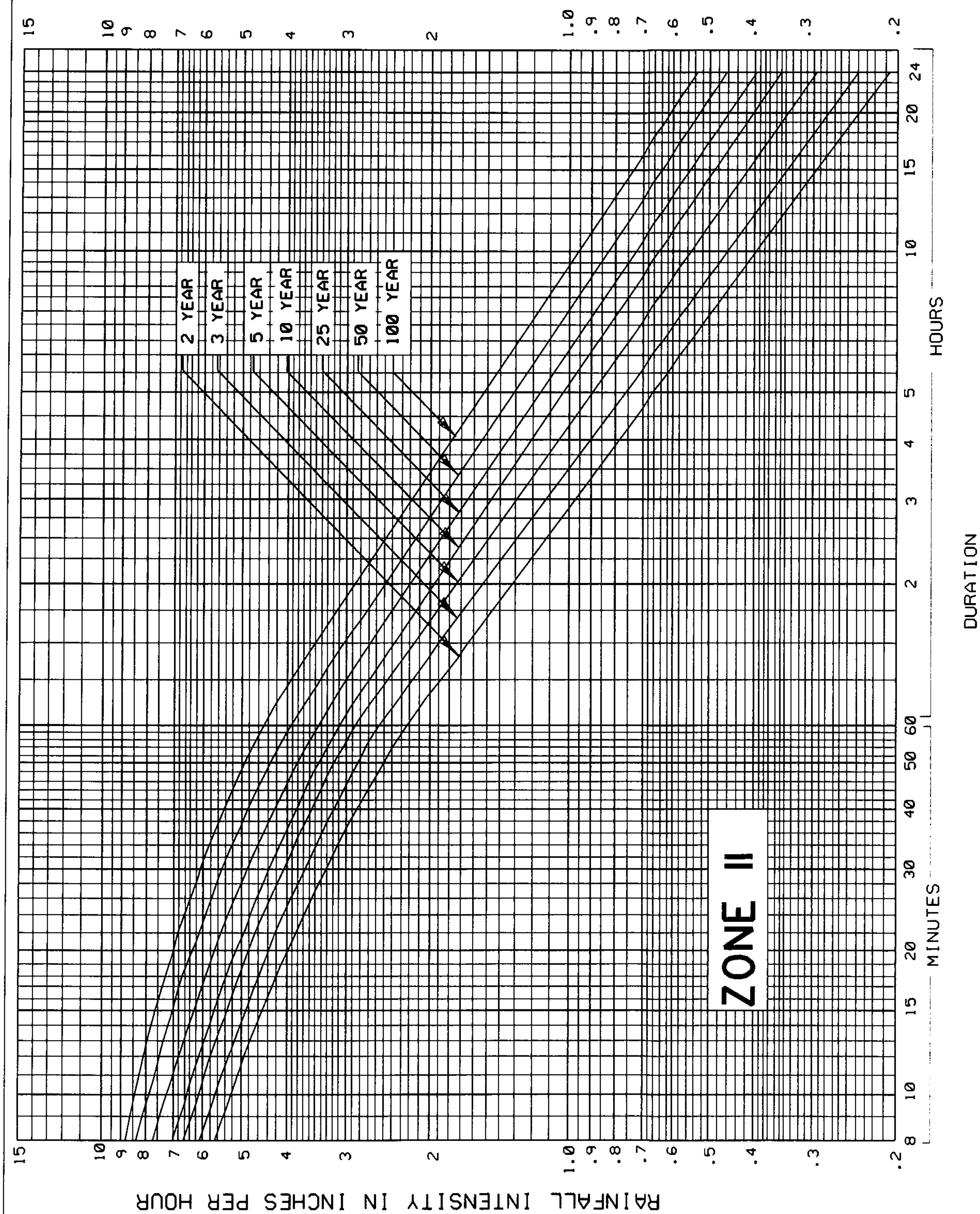
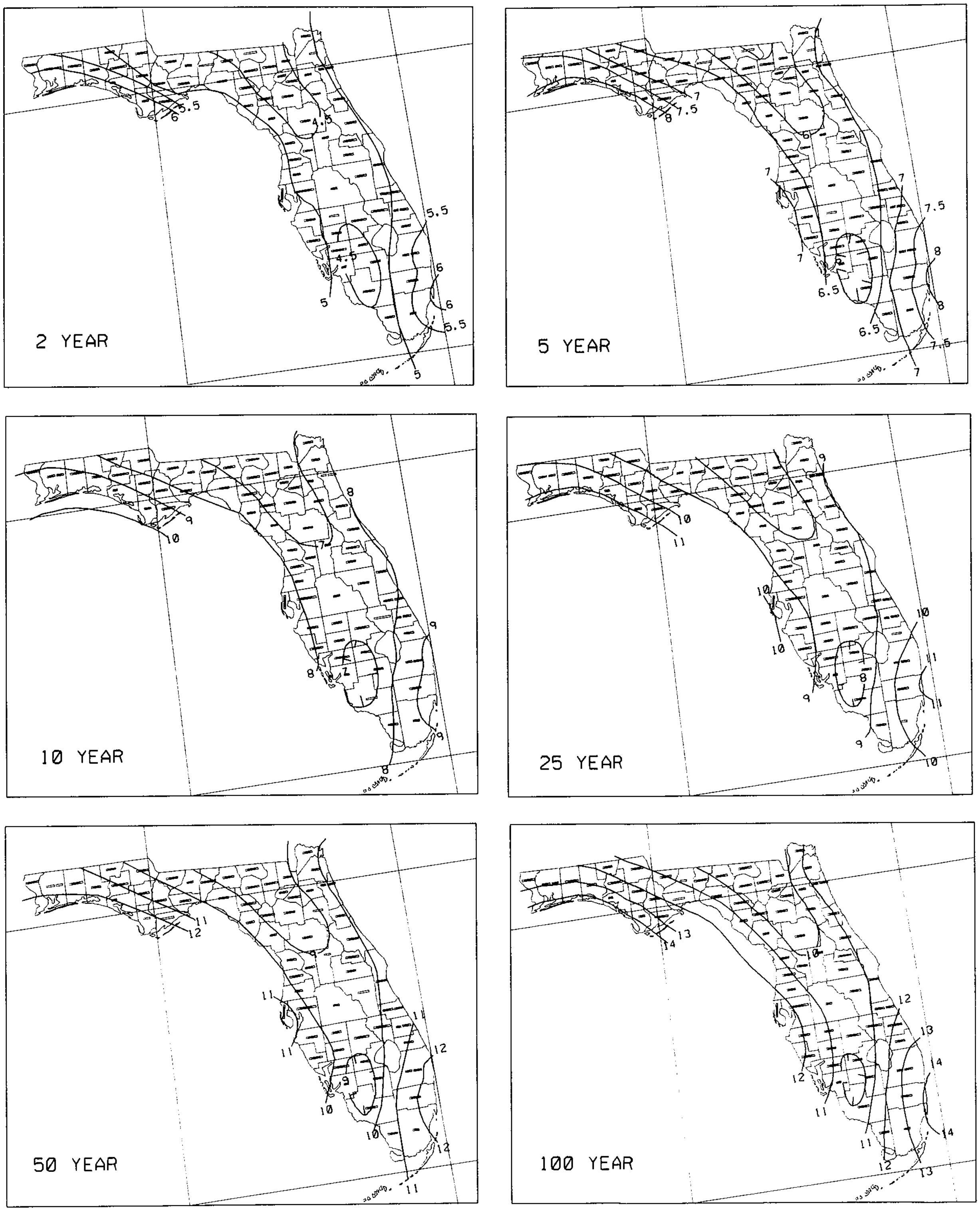
ZONE 10



RAINFALL INTENSITY-DURATION-FREQUENCY CURVES
ZONE 11

PRECIPITATION DEPTH DATA FOR 2-,5-,10-,25-, 50-, AND 100-YEAR FREQUENCIES

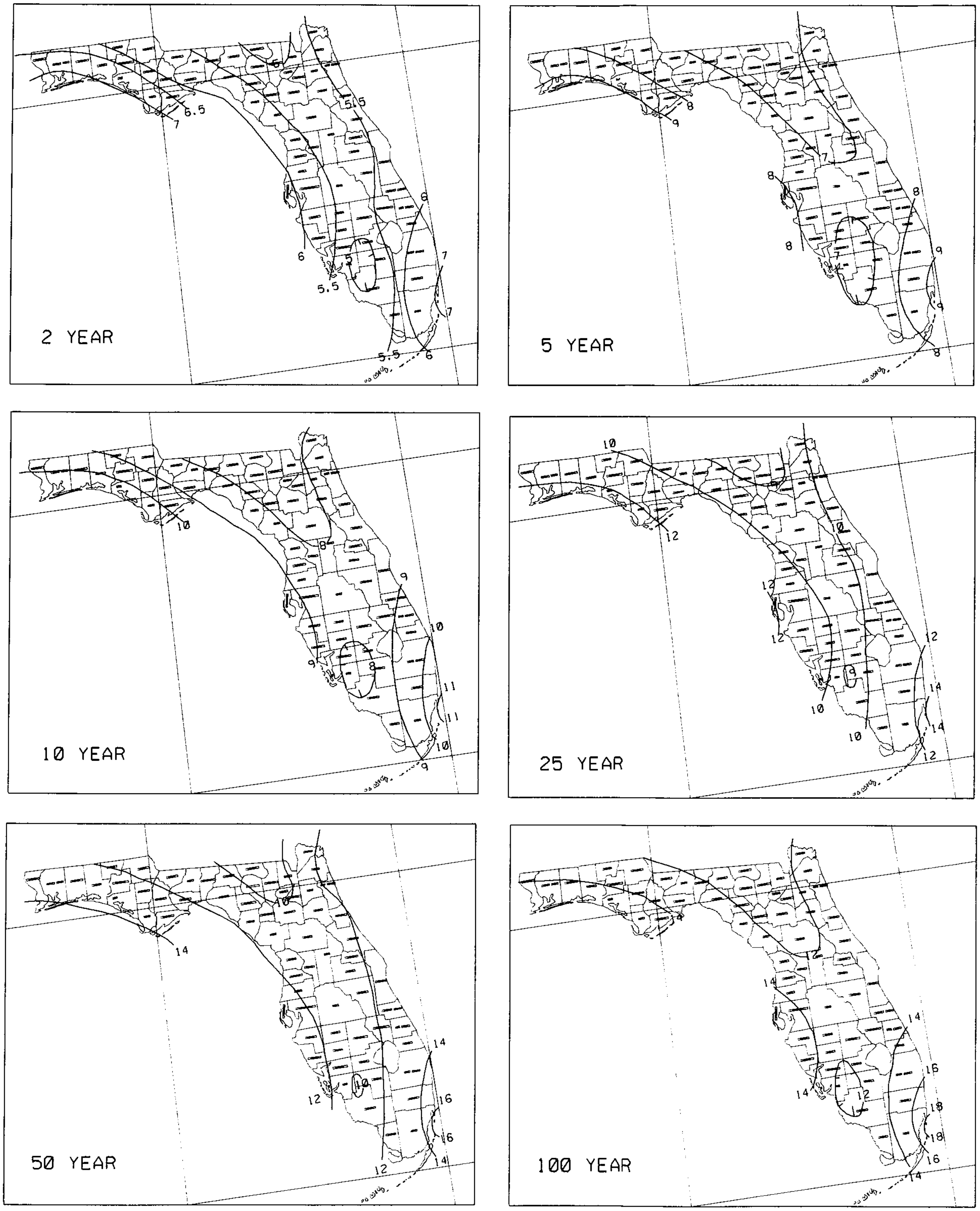
1 DAY



ALL DEPTH CONTOURS IN INCHES

PRECIPITATION DEPTH DATA FOR 2-,5-,10-,25-, 50-, AND 100-YEAR FREQUENCIES

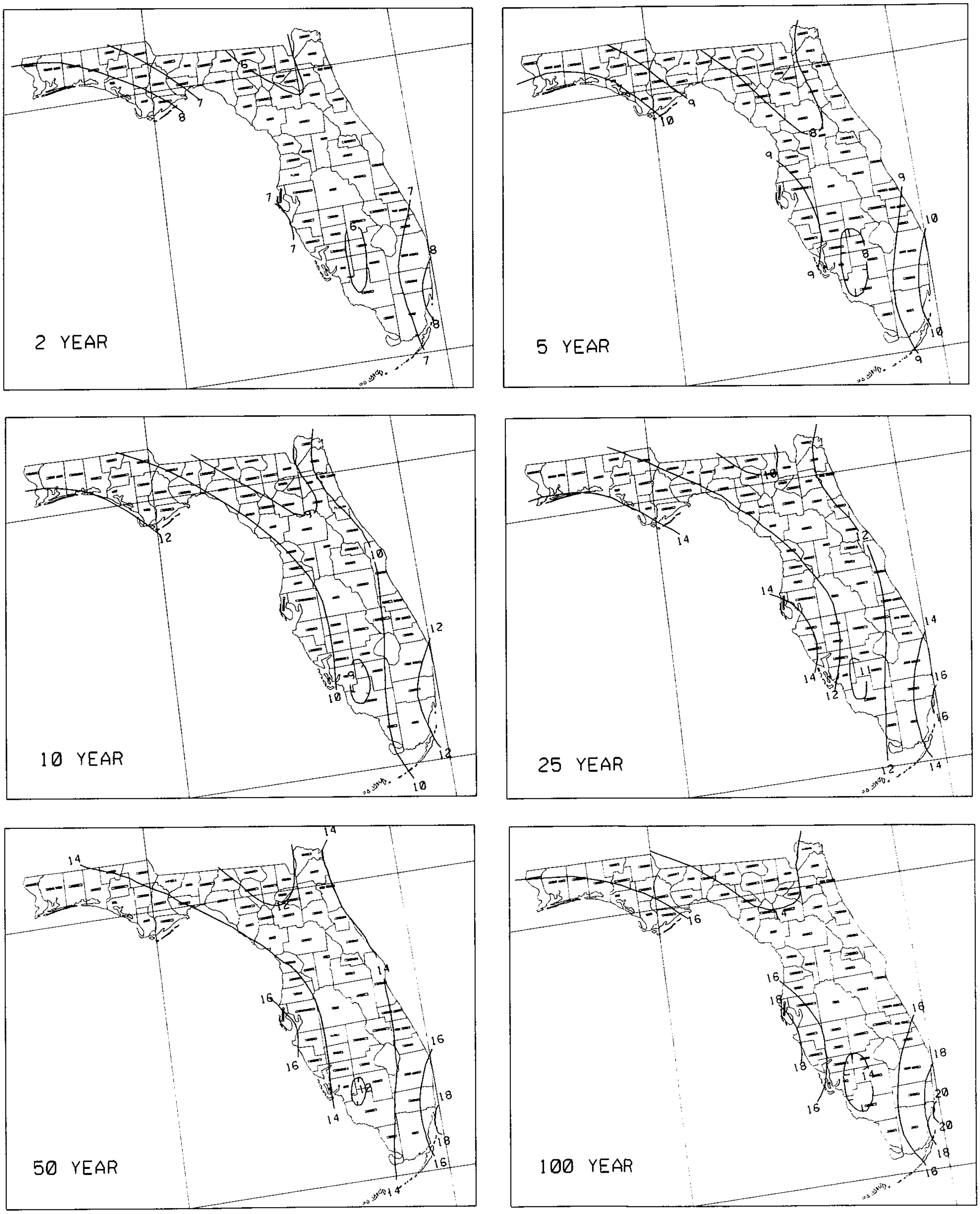
2 DAY



ALL DEPTH CONTOURS IN INCHES

PRECIPITATION DEPTH DATA FOR 2-,5-,10-,25-, 50-, AND 100-YEAR FREQUENCIES

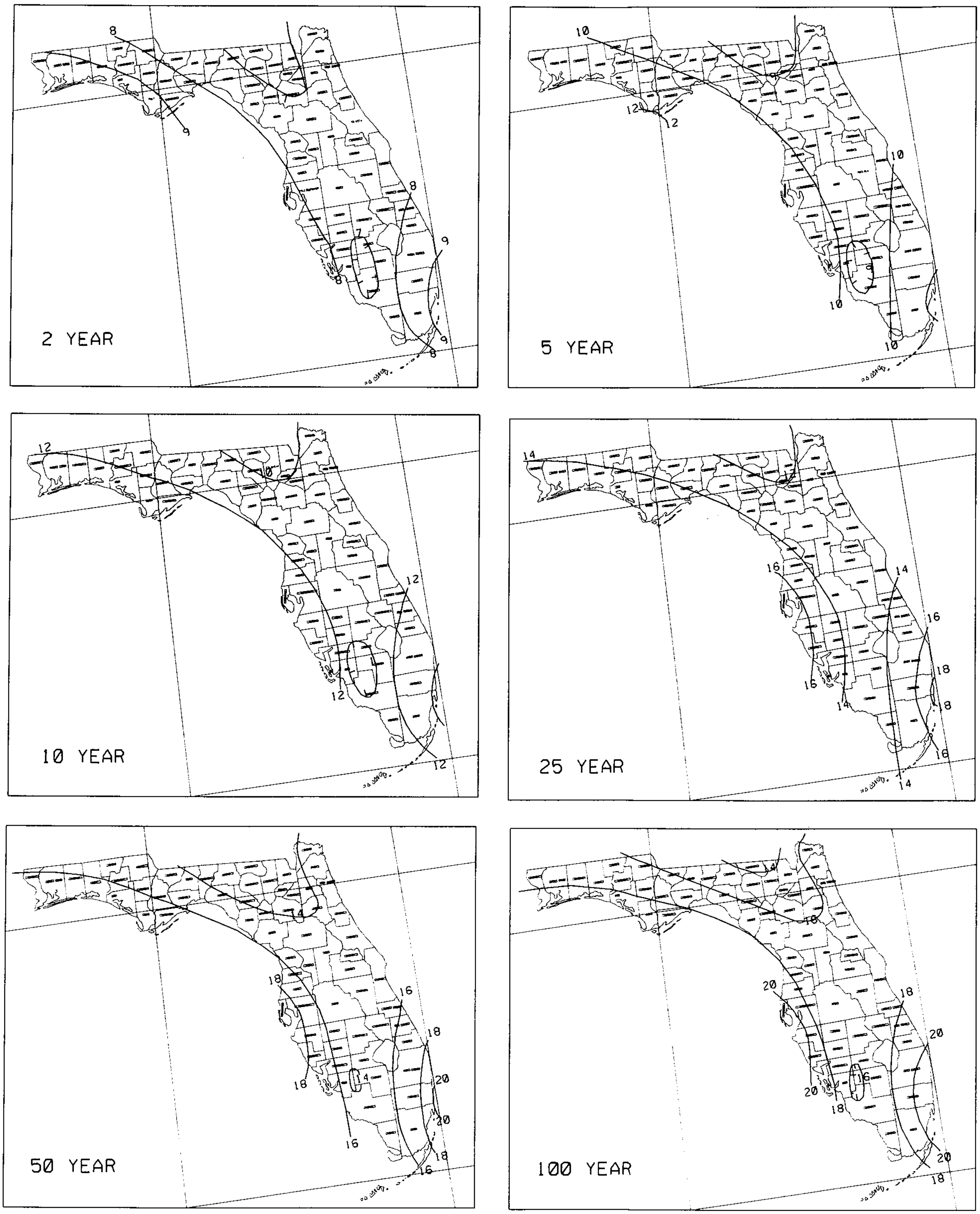
4 DAY



ALL DEPTH CONTOURS IN INCHES

PRECIPITATION DEPTH DATA FOR 2-,5-,10-,25-, 50-, AND 100-YEAR FREQUENCIES

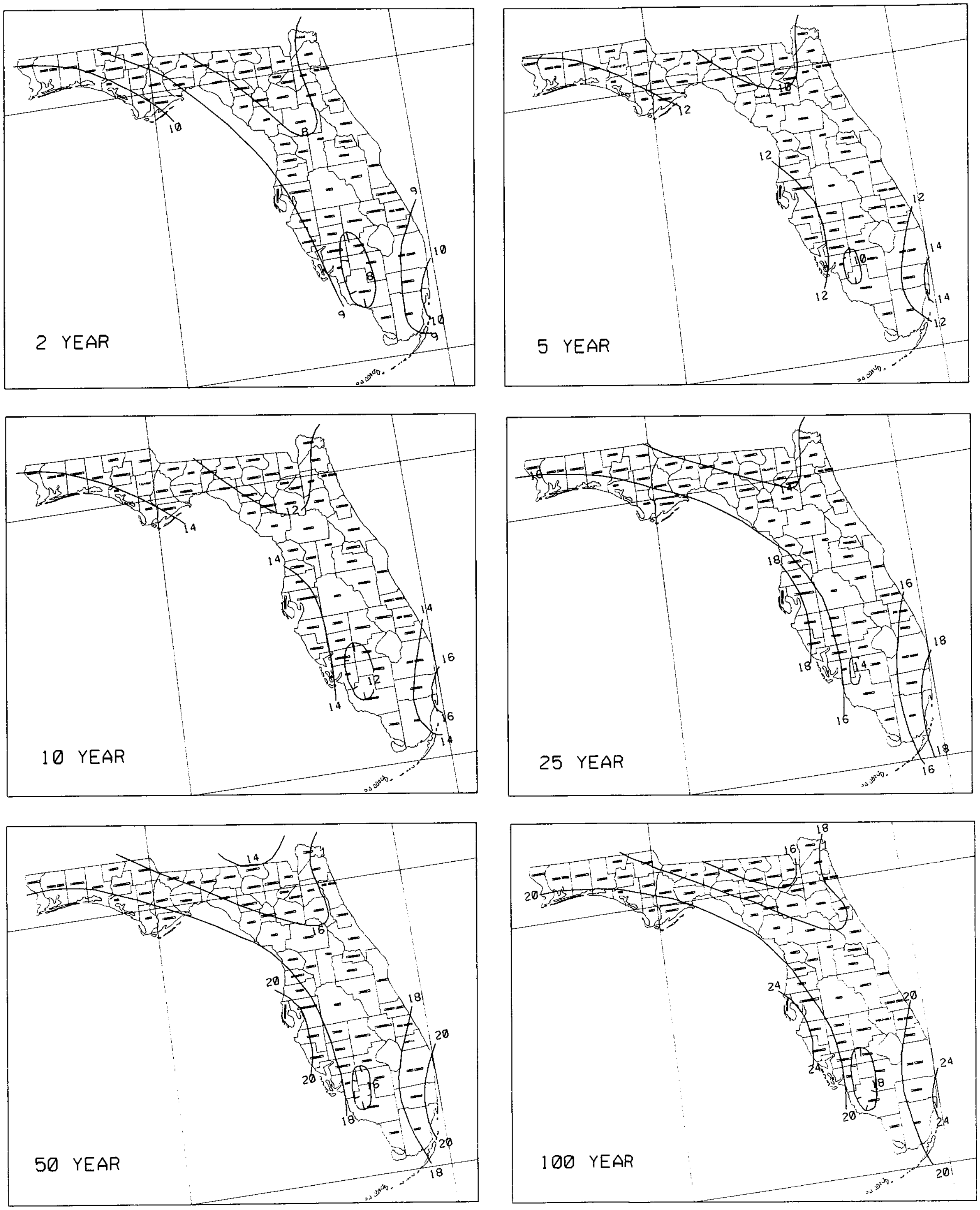
7 DAY



ALL DEPTH CONTOURS IN INCHES

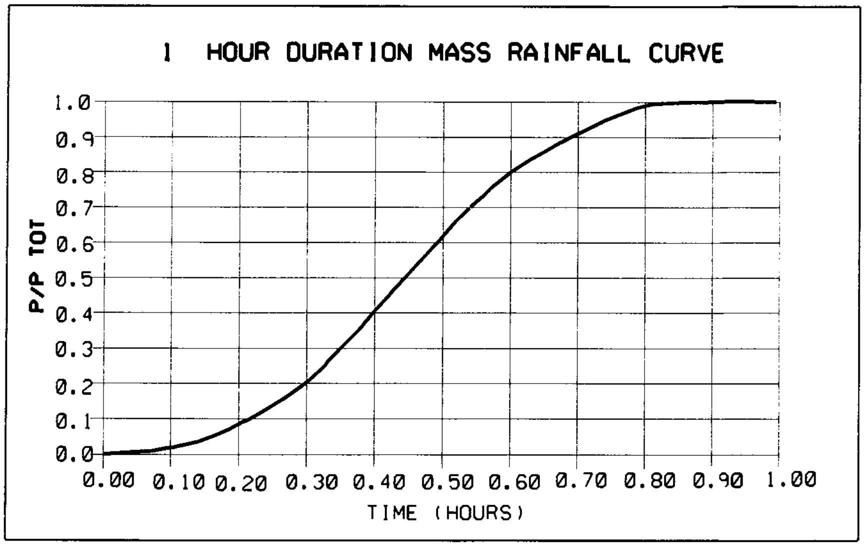
PRECIPITATION DEPTH DATA FOR 2-,5-,10-,25-, 50-, AND 100-YEAR FREQUENCIES

10 DAY

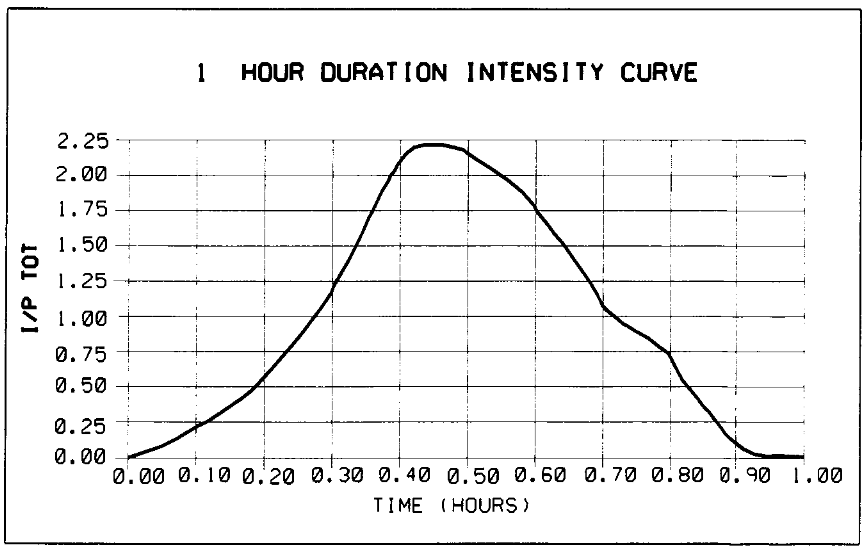


ALL DEPTH CONTOURS IN INCHES

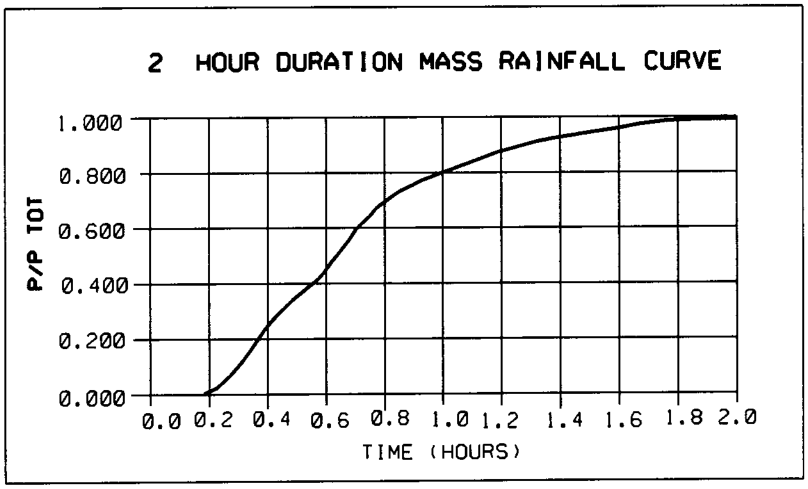
RAINFALL DISTRIBUTION CURVES
1 HOUR DURATION

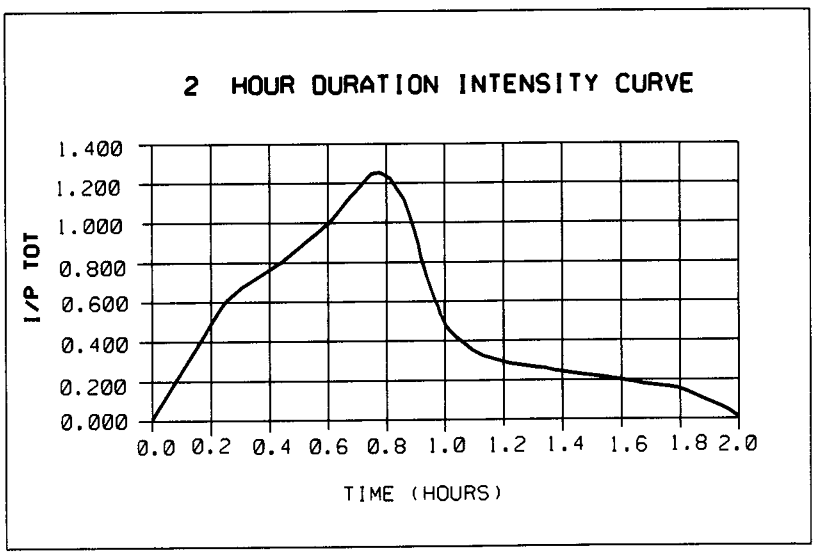


T(HRS.)	P/P TOT	I/PTOT
0.00	0.000	0.00
0.10	0.020	0.20
0.20	0.080	0.60
0.30	0.200	1.20
0.40	0.410	2.10
0.50	0.625	2.15
0.60	0.805	1.80
0.70	0.915	1.10
0.80	0.985	0.70
0.90	0.995	0.10
1.00	1.000	0.00



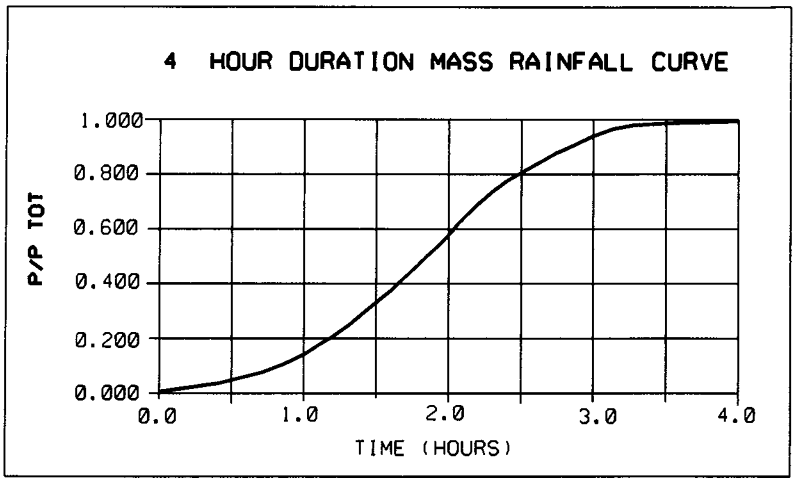
RAINFALL DISTRIBUTION CURVES
2 HOUR DURATION

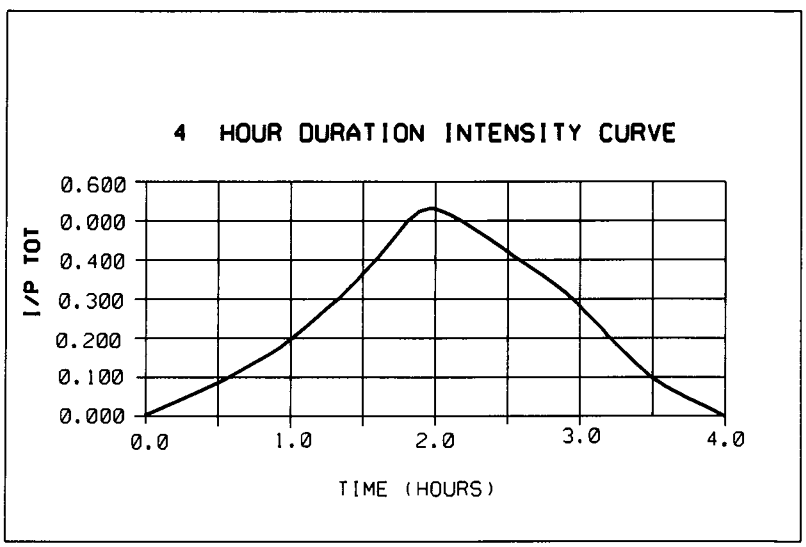




T(HRS.)	P/P TOT	I/PTOT
0.0	0.000	0.000
0.2	0.010	0.500
0.4	0.250	0.750
0.6	0.450	1.000
0.8	0.700	1.250
1.0	0.800	0.500
1.2	0.860	0.300
1.4	0.910	0.250
1.6	0.950	0.200
1.8	0.980	0.150
2.0	1.000	0.000

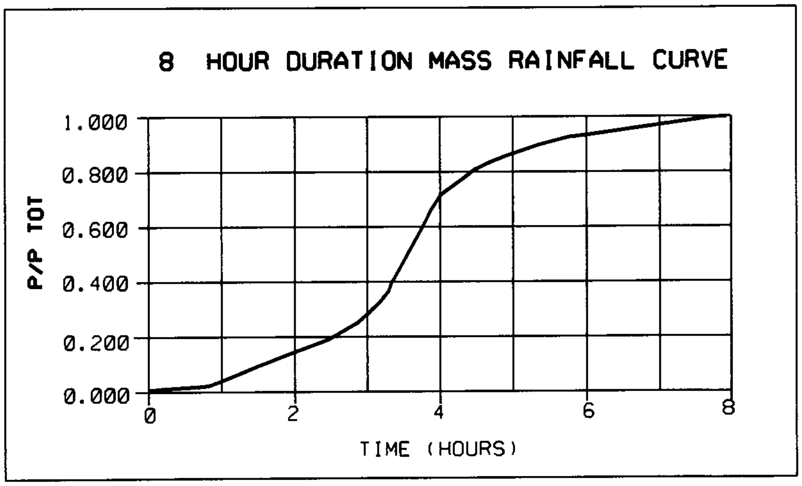
RAINFALL DISTRIBUTION CURVES
4 HOUR DURATION

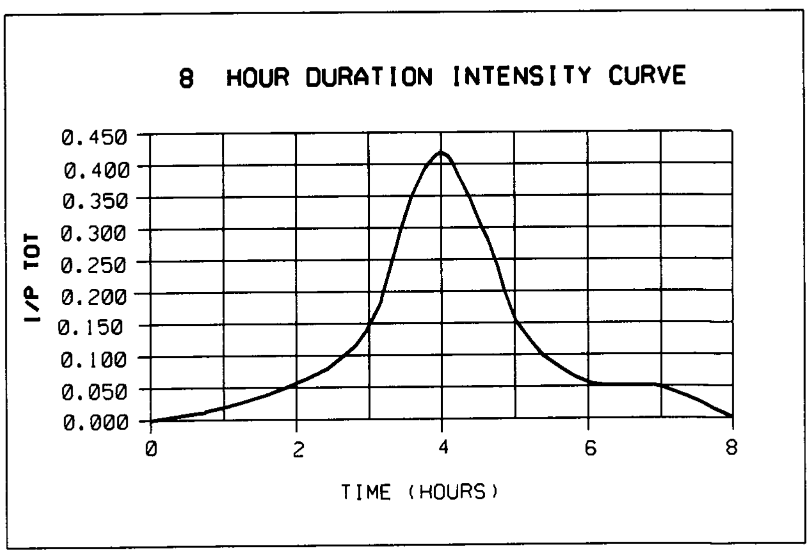




T(HRS.)	P/P TOT	I/PTOT
0.0	0.000	0.000
0.5	0.040	0.080
1.0	0.140	0.200
1.5	0.320	0.360
2.0	0.580	0.520
2.5	0.790	0.420
3.0	0.930	0.280
3.5	0.980	0.100
4.0	1.000	0.000

RAINFALL DISTRIBUTION CURVES
8 HOUR DURATION

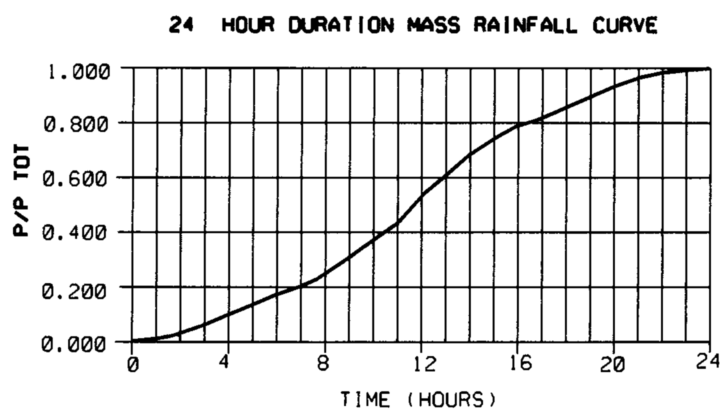


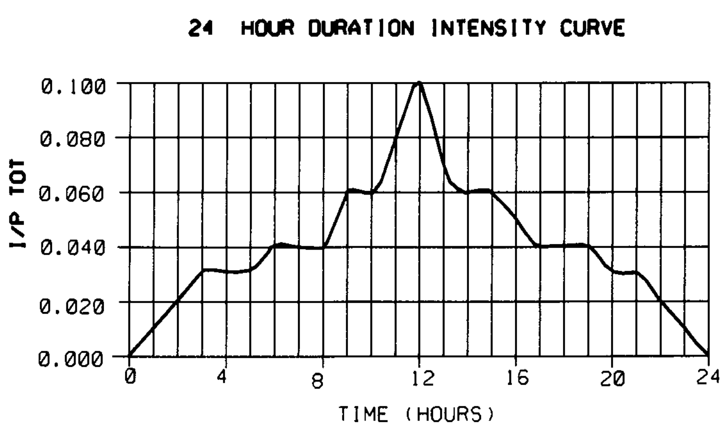


T(HRS.)	P/P TOT	I/PTOT
0	0.000	0.000
1	0.020	0.020
2	0.130	0.060
3	0.280	0.150
4	0.700	0.420
5	0.860	0.160
6	0.920	0.060
7	0.970	0.050
8	1.000	0.000

RAINFALL DISTRIBUTION CURVES

24 HOUR DURATION





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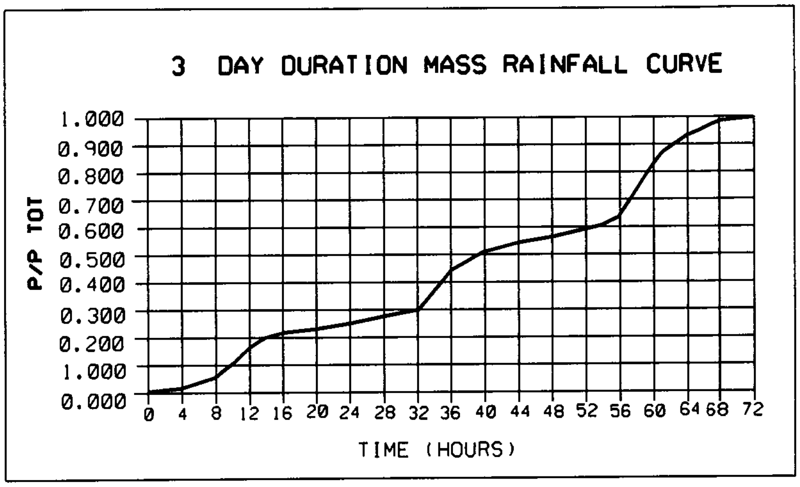
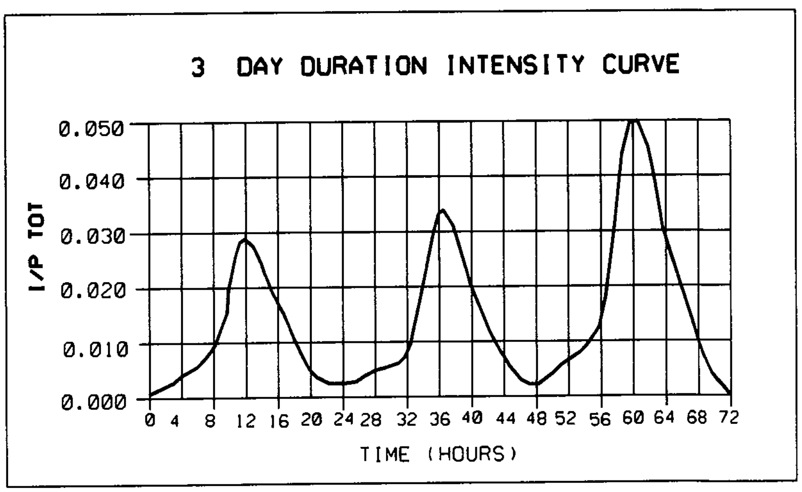
0	0.000	0.000
1	0.010	0.010
2	0.030	0.020
3	0.060	0.030
4	0.090	0.030
5	0.120	0.030
6	0.160	0.040
7	0.200	0.040
8	0.240	0.040
9	0.300	0.060
10	0.360	0.060
11	0.440	0.080
12	0.540	0.100
13	0.610	0.070
14	0.670	0.060
15	0.730	0.060
16	0.780	0.050
17	0.820	0.040
18	0.860	0.040
19	0.900	0.040
20	0.930	0.030
21	0.960	0.030
22	0.980	0.020
23	0.990	0.010
24	1.000	0.000

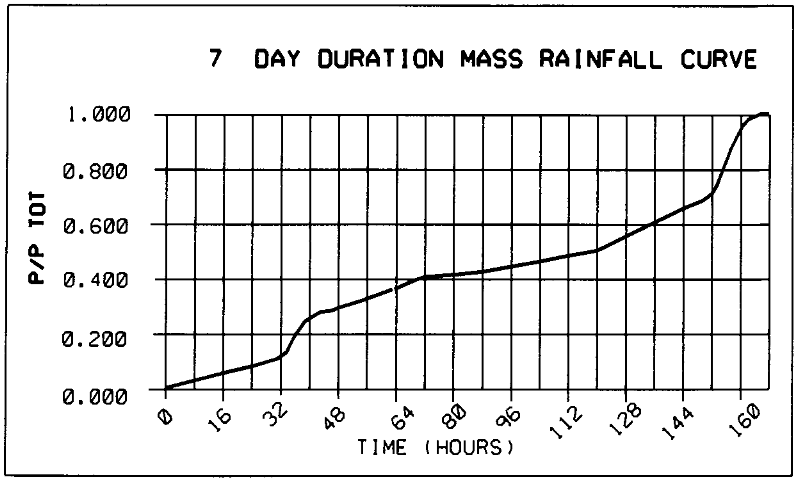
RAINFALL DISTRIBUTION CURVES
3 DAY DURATION

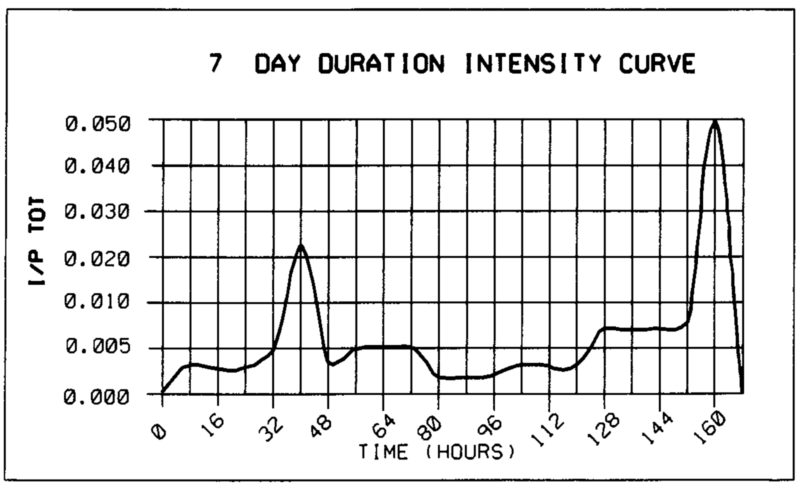


T(HRS.)	P/P TOT	I/PTOT
0	0.000	0.000
4	0.010	0.003
8	0.045	0.009
12	0.155	0.028
16	0.218	0.016
20	0.240	0.006
24	0.250	0.003
28	0.268	0.005
32	0.304	0.009
36	0.436	0.033
40	0.511	0.019
44	0.538	0.007
48	0.550	0.003
52	0.577	0.007
56	0.631	0.014
60	0.829	0.050
64	0.942	0.028
68	0.982	0.010
72	1.000	0.000



RAINFALL DISTRIBUTION CURVES
7 DAY DURATION

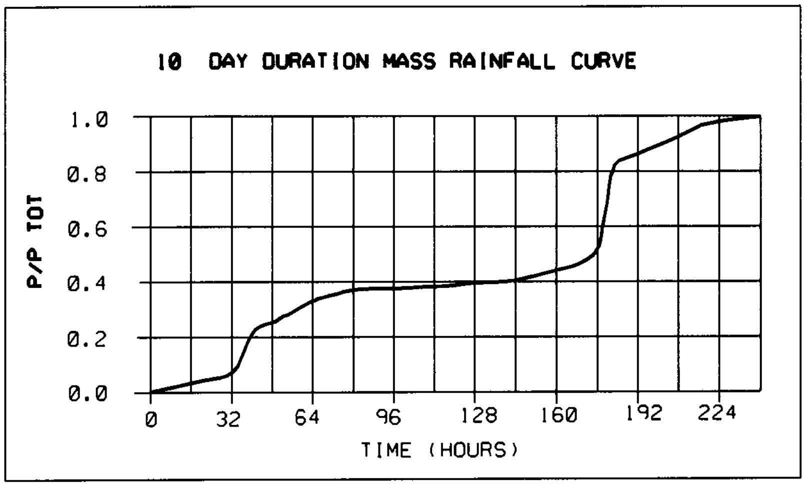


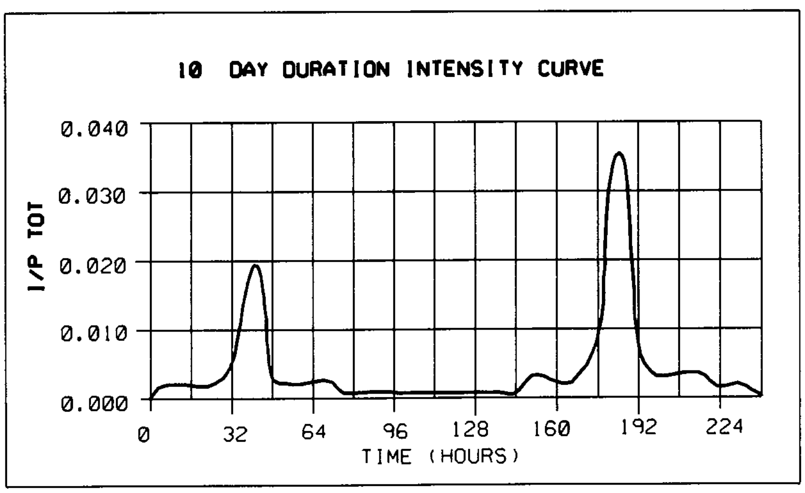


T(HRS.)	P/P TOT	I/PTOT
0	0.000	0.000
8	0.027	0.003
16	0.053	0.003
24	0.080	0.003
32	0.116	0.005
40	0.254	0.017
48	0.280	0.003
56	0.320	0.005
64	0.360	0.005
72	0.400	0.005
80	0.413	0.002
88	0.427	0.002
96	0.440	0.002
104	0.460	0.003
112	0.480	0.003
120	0.500	0.003
128	0.553	0.007
136	0.607	0.007
144	0.660	0.007
152	0.721	0.008
160	0.956	0.029
168	1.000	0.000

RAINFALL DISTRIBUTION CURVES

10 DAY DURATION





T(HRS.)	P/P TOT	I/PTOT
0	0.000	0.000
8	0.013	0.002
16	0.027	0.002
24	0.040	0.002
32	0.080	0.005
40	0.229	0.019
48	0.260	0.004
56	0.287	0.003
64	0.313	0.003
72	0.340	0.003
80	0.347	0.001
88	0.353	0.001
96	0.360	0.001
104	0.367	0.001
112	0.373	0.001
120	0.380	0.001
128	0.387	0.001
136	0.393	0.001
144	0.400	0.001
152	0.420	0.003
160	0.440	0.003
168	0.460	0.003
176	0.532	0.009
184	0.808	0.035
192	0.860	0.007
200	0.893	0.004
208	0.926	0.004
216	0.960	0.004
224	0.973	0.002
232	0.986	0.002
240	1.000	0.000

Table T-4
Runoff Coefficients for a Design Storm Return Period of 10 Years or Less[a]

Slope	Land Use	Sandy Soils Min.	Sandy Soils Max.	Clay Soils Min.	Clay Soils Max.
Flat (0-2%)	Woodlands	0.10	0.15	0.15	0.20
	Pasture, grass, and farmland [b]	0.15	0.20	0.20	0.25
	Bare Earth	0.30	0.50	0.50	0.60
	Rooftops and pavement	0.95	0.95	0.95	0.95
	Pervious pavements [c]	0.75	0.95	0.90	0.95
	SFR: 1/2-acre lots and larger	0.30	0.35	0.35	0.45
	Smaller lots	0.35	0.45	0.40	0.50
	Duplexes	0.35	0.45	0.40	0.50
	MFR: Apartments, townhouses, and condominiums	0.45	0.60	0.50	0.70
	Commercial and Industrial	0.50	0.95	0.50	0.95
Rolling (2-7%)	Woodlands	0.15	0.20	0.20	0.25
	Pasture, grass, and farmland [b]	0.20	0.25	0.25	0.30
	Bare Earth	0.40	0.60	0.60	0.70
	Rooftops and pavement	0.95	0.95	0.95	0.95
	Pervious pavements [c]	0.80	0.95	0.90	0.95
	SFR: 1/2-acre lots and larger	0.35	0.50	0.40	0.55
	Smaller lots	0.40	0.55	0.45	0.60
	Duplexes	0.40	0.55	0.45	0.60
	MFR: Apartments, townhouses, and condominiums	0.50	0.70	0.60	0.80
	Commercial and Industrial	0.50	0.95	0.50	0.95
Steep (7%+)	Woodlands	0.20	0.25	0.25	0.30
	Pasture, grass, and farmland [b]	0.25	0.35	0.30	0.40
	Bare Earth	0.50	0.70	0.70	0.80
	Rooftops and pavement	0.95	0.95	0.95	0.95
	Pervious pavements [c]	0.85	0.95	0.90	0.95
	SFR: 1/2-acre lots and larger	0.40	0.55	0.50	0.65
	Smaller lots	0.45	0.60	0.55	0.70
	Duplexes	0.45	0.60	0.55	0.70
	MFR: Apartments, townhouses, and condominiums	0.60	0.75	0.65	0.85
	Commercial and Industrial	0.60	0.95	0.65	0.95

[a] Weighted coefficient based on percentage of impervious surfaces and green areas must be selected for each site.

[b] Coefficients assume good ground cover and conservation treatment.

[c] Depends on depth and degree of permeability of underlying strata.

Note: SFR = Single Family Residential
MFR = Multi-Family Residential

Table T-5
Design Storm Frequency Factors for Pervious Area Runoff Coefficients *

Return Period (years)	Design Storm Frequency Factor, X_T
2 to 10	1.0
25	1.1
50	1.2
100	1.25

Reference: Wright-McLaughlin Engineers (1969).

* DUE TO THE INCREASE IN THE DURATION TIME THAT THE PEAK OR NEAR PEAK DISCHARGE RATE IS RELEASED FROM STORMWATER MANAGEMENT SYSTEMS, THE USE OF THESE SHORT DURATION PEAK RATE DISCHARGE ADJUSTMENT FACTORS IS NOT APPROPRIATE FOR FLOOD ROUTING COMPUTATIONS.

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Description	"C" Value	Adjustment	Adjusted C	Area	$C_i A_i$
Park	0.20	1.1	0.22	53.9	11.9
Commercial Development	0.95	N/A	0.95	3.7	3.5
Single Family	0.40	1.1	0.44	50.5	22.2
	TOTALS			108.1	37.6

$$Weighted\ C = \frac{\Sigma C_i A_i}{A} = \frac{37.60}{108.1} = 0.35$$

Table 2-2a Runoff curve numbers for urban areas [1/]

Cover description: Cover type and hydrologic condition	Average percent impervious area [2/]	Curve numbers for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3/]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4/]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5/]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

1 Average runoff condition, and I_a = 0.2S.
2 The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.
3 CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.
4 Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.
5 Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Table 2-2b Runoff curve numbers for cultivated agricultural lands [1/]

Cover description			Curve numbers for hydrologic soil group			
Cover type	Treatment [2/]	Hydrologic condition [3/]	A	B	C	D
Fallow	Bare soil	—	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T+ CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T+ CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

1 Average runoff condition, and I_a=0.2S
2 Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.
3 Hydraulic condition is based on combination factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes, (d) percent of residue cover on the land surface (good ≥ 20%), and (e) degree of surface roughness.

Poor: Factors impair infiltration and tend to increase runoff.

Good: Factors encourage average and better than average infiltration and tend to decrease runoff.

Table 2-2c Runoff curve numbers for other agricultural lands [1/]

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing. [2/]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element. [3/]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30 [4/]	48	65	73
Woods—grass combination (orchard or tree farm). [5/]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods. [6/]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 [4/]	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

1 Average runoff condition, and $I_a = 0.2S$.
2 *Poor:* <50%) ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: > 75% ground cover and lightly or only occasionally grazed.
3 *Poor:* <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.
4 Actual curve number is less than 30; use CN = 30 for runoff computations.
5 CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.
6 *Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Table 2-2d Runoff curve numbers for arid and semiarid rangelands [1/]

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition [2/]	A [3/]	B	C	D
Herbaceous—mixture of grass, weeds, and low-growing brush, with brush the minor element.	Poor		80	87	93
	Fair		71	81	89
	Good		62	74	85
Oak-aspen—mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush.	Poor		66	74	79
	Fair		48	57	63
	Good		30	41	48
Pinyon-juniper—pinyon, juniper, or both; grass understory.	Poor		75	85	89
	Fair		58	73	80
	Good		41	61	71
Sagebrush with grass understory.	Poor		67	80	85
	Fair		51	63	70
	Good		35	47	55
Desert shrub—major plants include saltbush, greasewood, creosotebush, blackbrush, bursage, palo verde, mesquite, and cactus.	Poor	63	77	85	88
	Fair	55	72	81	86
	Good	49	68	79	84

1 Average runoff condition, and I_a, = 0.2S. For range in humid regions, use table 2-2c.
2 Poor: <30% ground cover (litter, grass, and brush overstory).
Fair: 30 to 70% ground cover.
Good: > 70% ground cover.
3 Curve numbers for group A have been developed only for desert shrub.