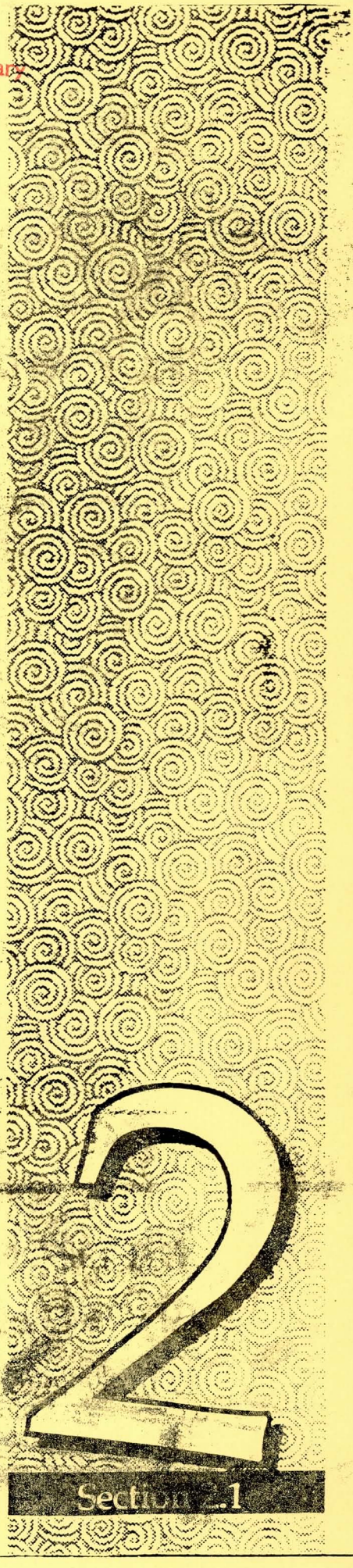
Section 2.1 Policies

Design Standards and Policies (Regarding Alluvial Fans) July 1996

Chapter 2 Drainage



City of Scottsdale, Arizona

Design Standards and Policies Manual
Chapter 2 of 7
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July 1996

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City of Scottsdale, Arizona

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July 1996

Prepared by : Drainage Planning
Transportation Planning Section
Transportation Department

City of Scottsdale, Arizona

Mayor and City Council

Sam Kathryn Campana, Mayor

Greg Bielli
Mary Manross
Robert Pettycrew
Donald Prior
Dennis Robbins
Richard Thomas

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Section 2.1

SECTION 2.1
POLICY

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POLICY

2-101. INTRODUCTION

The following are Policy Statements relative to Chapter 37 of the City of Scottsdale Code (Code 1972, § 5-611; Ord. No. 1993, 2-29-88) known as "The Floodplain and Drainage Ordinance". These policy statements are interpretations and guidance made to assist in the implementation of the requirements of the ordinance. These policies are to be followed unless adequate documentation is submitted to and approved by the City Floodplain Administrator that demonstrates that the intent and requirements of the ordinance will still be met. A copy of the Ordinance is included in the Appendix of this manual section.

Chapter 37
FLOODWAYS AND FLOODPLAINS
DIVISION 1. GENERALLY

Sec. 37-17. Definitions

Adjacent Grade: the elevation of the ground, sidewalk, patio, deck support, or basement entryway immediately next to the structure.

The 100-Year Flood: a flood with a one percent chance of being equaled or exceeded in any given year. Throughout the United States, the standard for floodplain management is protection from flooding up to and including the 100-year flood event. In hydrology the 100 year flood is determined statistically from long term records of streamflow or rainfall data. The availability of useful streamflow data for estimating the 100-year flood in most parts of Arizona is very limited. Therefore, the value is generally estimated from rainfall records. Statistical methods are used to predict the 100 year rainfall amount that is then input into hydrologic watershed models. The hydrologic model then predicts the peak rates of runoff for that amount of rainfall. This approach assumes that: the 100-year rainfall produces a 100-year flood; weather characteristics remain constant; and, the watershed and channel characteristics are correctly modeled and they remain constant.

Inherent in the statistical estimating procedure is that as additional data records become available and are added to the data base the estimated size or frequency of a specific flood can change. The often heard comment: "we have had three 100 year storms in the past two years" is statistically possible. This should be expected and is not unusual when working with a relatively short data base in the arid southwest. Rainfall and runoff events are infrequent and highly variable in the arid regions of the Southwest. Therefore, they are also more difficult to measure and predict than in the more humid regions of the country.

Division 2. Regulations

Sec. 37-42. Development Requirements to be met for Permit Issuance

(2) Drainage Characteristics

Drainage Easements:
Drainage easements should be identified as early as possible, in the planning of any development project, preferably as part of the master plan process. The City will check for and avoid discontinuous drainage easements and acquire any missing drainage easement segments as development takes place. For a variety of reasons only a small percentage of the drainage easements needed to cover all the washes and channels in the City have been dedicated and recorded. As a result, many discontinuous drainage easements exist through out the City. The protection and proper operation and maintenance of these wash corridors are greatly complicated by the lack of continuous and complete drainage easements along these corridors. Maintenance is generally the responsibility of the individual property owner or the Homeowners Association. The recorded plat and grading and drainage plan should specify maintenance responsibility.

(5) Design Procedures and Criteria

A. Drainage Policy, Downtown Scottsdale

Downtown Scottsdale refers to the study area of the Dec. 1986, Master Drainage Study by Boyle Eng. Corp. It is the policy of the COS that drainage planning for development within Downtown Scottsdale shall meet the following requirements:

1) The Property Owner shall be responsible for the cost or installation of the Lateral Storm Drain (Lateral) required to transmit runoff from the subject site. If the capacity of the Lateral must be increased to accommodate runoff from other properties, then the owner shall contribute a pro-rata share of the cost of the Lateral. Lateral refers to that part of the stormdrain system that collects surface runoff and transmits it to the Infrastructure System. This pro-rated cost shall be determined by the ratio of the Proposed Runoff divided by the total capacity of the Lateral. All Laterals shall be designed and constructed in accordance with current City of Scottsdale standards.

2) The Boyle Report is the planning guide used to determine the Baseline Runoff rate that the subject property may contribute to the Infrastructure System (System) without additional cost to the Owner. Owner refers to actual owner or the person or persons who have a financial interest in, and are responsible for, the development of the subject property. The Boyle Report refers to the "City of Scottsdale Downtown Infrastructure Master Plan" report, prepared by Boyle Engineering Corporation. Infrastructure System refers to the main trunk line of the stormdrain system that transmits the runoff to the point of outfall (e.g., the Indian School Road Stormdrain). The release of Excess Runoff from the subject property will require that the Owner participate in the cost of the System. This shall be a pro-rata cost participation, and shall be based on the ratio of the Excess Runoff divided by the capacity of the System. This shall apply the costs of the System from the point at which the Excess Runoff enters the System, to the outfall point.

If additional runoff enters the System that requires that the capacity of the System be increased, then the cost participation ratio shall be recalculated. The corresponding cost participation ratio(s) shall be applied to the respective sections of the System. The total cost participation requirement shall be the sum of these costs.

Proposed Intensity is defined as the percentage of impervious area proposed for the subject property. Boyle Report Intensity is the percentage of impervious area used in the Boyle Report for the subject property.

Proposed Runoff is the runoff calculated using the Proposed Intensity. Baseline Runoff is the runoff calculated using the Boyle Report Intensity. Excess Runoff is the Proposed Runoff, less the Baseline Runoff. If the Proposed Runoff is less than the Baseline Runoff, then the Excess Runoff shall be zero.

B. Alluvial Fan Development Policy

Introduction

The purpose of this policy statement is to clarify development issues and requirements on alluvial fans for subdivisions and single family homes. Over fourteen square miles of mostly undeveloped land North of the Central Arizona Project (CAP) Canal falls within designated special flood hazard areas. These areas were mapped by the Federal Emergency Management Agency (FEMA) and identified as alluvial fan AO Zones on Flood Insurance Rate Maps (FIRMs). Several other large, unmapped areas in north Scottsdale are also subject to similar alluvial fan flood hazards. Because, it is essential that the special requirements in alluvial fan flood zones are clearly understood and adhered to in all development projects.

Development can occur on an alluvial fan or FEMA designated AO Zone, however, development must be carefully planned, designed, and constructed in accordance with FEMA and COS regulations. This is due to the hazards associated with: the peak discharges and volumes of water; debris and sediment; potential erosion and scour; and possible relocation of the flow paths characteristic of alluvial fan flooding.

There are two primary concerns in the planning and design of any development within an alluvial fan. First is the safety and protection of the residents and property within the proposed development. Second is the potential adverse effect on adjacent and downstream residents and property owners.

Development Requirements

The following information on development requirements on Alluvial Fans is a summary of requirements. This summary is based on a review of the City's Floodplain and Drainage Ordinance; common drainage law; FEMA rules and regulations; and the City's Desert Greenbelt Project. This is not necessarily inclusive of all the requirements of applicable Federal, State or local laws or regulations. None of the following eliminates the need to comply with any laws or regulations not specifically mentioned herein. Following these requirements is also not a guarantee against flooding. Floods larger than the design flood addressed in this policy can and will occur from time to time.

There are two conditions under FEMA and COS Floodplain and Drainage Ordinance regulations in which development can occur in a mapped alluvial fan flood hazard (AO) zone. The first method is for the proposed development to remove itself entirely from the AO zone by meeting all FEMA requirements for a map revision. The second is to provide the specific flood protection measures required on alluvial fans by FEMA and COS Ordinance without revising the map and obtaining required flood insurance. The following is a summary of the requirements associated with the two conditions.

Removing the Project Area from the AO Zone, via a FEMA Map Revision:

1. The only basis for a map revision on an alluvial fan acceptable to FEMA are: "major structural flood control measures". The design and construction must be supported by sound engineering analyses that demonstrate that the measures will effectively eliminate the alluvial fan flood hazards. Revisions based on fill are not acceptable by FEMA on alluvial fans. The COS's proposed Desert Greenbelt Project (DGBP) Channels are examples of major structural flood control measures being planned and designed to meet FEMA's requirements.

2. FEMA requires engineering analyses that quantify the discharge and volume of water, debris, and sediment associated with the 100-year flood. This must be done at the alluvial fan apex under current and potential adverse watershed conditions. It must be shown that the proposed measures will effectively eliminate alluvial fan flood hazards from the fan area.

3. The standard minimum FEMA freeboard requirement for flood control structures on an alluvial fan is three to four feet, depending on the proximity to bridges, etc. The City will require engineering analysis that demonstrates to FEMA's satisfaction, that adequate protection will be provided. A lesser freeboard is possible; however, FEMA will not accept a freeboard of less than two feet.

4. Another FEMA requirement is that the City of Scottsdale must assume ultimate responsibility for all operation and maintenance activities for the flood control measures. This could be accomplished in a variety of ways, such as utility or improvement districts, homeowner's associations or contracting to the County Flood Control District.

5. The proposed development must address the impact of the project on flood hazards in the flood hazard area (other areas of the fan), as well as adjacent or downstream areas.

6. The time required for FEMA approval can be significant, depending on the complexity of the situation.

7. Homeowners would no longer be required to purchase flood insurance under this development option, once FEMA approved the map revision.

Development Without Removal from the AO Zone Designation:

1. Under this approach, homeowners are still required to buy flood insurance if they have a federally insured mortgage. They must also meet all of the criteria listed below.

2. Proposed building sites (single family residence or subdivision) must be reasonably safe from flooding from the 100 year event.

3. Residential structures must have the lowest floor (including basement) elevated above the highest adjacent grade at least as high as the depth number specified in feet on FEMA's Flood Insurance Rate Map (FIRM). If no depth is specified on the FIRM a minimum of two feet above the highest adjacent grade is required.

4. Adequate drainage paths must be provided around structures on slopes, to guide floodwaters around and away from proposed structures. Structures should not be located in natural low areas or in wash bottoms.

5. The proposed development must address the impact of their project on flood hazards in the flood area (other areas of the fan), as well as on adjacent or downstream areas beyond the mapped AO Zone.

6. Any property below an alluvial fan apex, that has not been structurally contained, must protect its upstream perimeter with structural flood control measures. These measures must be designed to withstand the entire flow quantities at the apex, plus any intervening flows, based on current existing watershed conditions. This criterion assumes that runoff from the upstream watershed will not increase in the future.

7. The design flow quantities for the perimeter protection may be adjusted if it can be demonstrated by sound engineering analyses that the actual quantities that could reach the perimeter of the development are different from those at the apex. City Drainage Planning Staff must be consulted first for guidance and approval of the approach and methodology. Some general guidelines have been developed and are available from the City's Drainage planning staff.

Property Adjacent to one of the City's proposed DGBP channels:

On property that contains any portion of one of the City's proposed DGBP channels, that develops prior to the installation of the Desert Greenbelt Project, the owner may be required to, as part of their development costs, dedicate the necessary Drainage Easement and construct the flood control structures that are a portion of the DGBP on their property.

C. Summary of Drainage Design Policy Guidelines

The following policy guidelines are based on recurring drainage and flooding problems observed in Scottsdale related to specific design or construction practices:

Subdivisions:

1. A subdivision should always have an approved subdivision-wide drainage plan. Drainage based on individual lots submitting separate grading plans as each lot is developed should be avoided.

2. Avoid design of a common drainage facility that requires maintenance by individual property owners. Put the drainage facility in a common Tract with the Homeowner's Association responsible for maintenance.

People have no awareness and/or incentive to perform the necessary maintenance unless they are directly and adversely affected.

Storm Drains

Avoid if at all possible the interception of the flow in an offsite natural wash with the intent of collecting it and putting it into a pipe or an underground storm sewer system.

Washes and even man-made channels carry a never ending supply of sediment and debris. It is almost impossible to collect and filter out this debris without a constant clogging and maintenance problem. If there is no alternative to the routing of an open channel into a piped system, water should be first routed into a sediment or debris basin. Periodic maintenance of the debris basin should be planned.

Culverts

1. Culverts should not be placed more than 0.5 feet below the natural wash invert, or the capacity must be reduced by the cross section area below this depth.

2. Culverts or homemade bridges for private driveways or walkways over washes or drainage channels whose source originates off-site or off-lot should be designed by a professional drainage designer.

Small drainage structures not designed with any hydrologic and hydraulic analysis may be OK for crossing channels originating onsite (on-lot). However, homemade drainage structures can be disastrous for the homeowner, his neighbors, and adjacent streets if installed on larger washes originating offsite (off-lot), therefore in this situation, dip crossings or free span bridges which don't constrict channel flow capacity are recommended.

Open Channels

1. Diversions of natural washes or changes in the channel's profile should be avoided whenever possible.

2. Do not permit encroachment into a drainage easement, channel, or its floodway.

3. If channel lining or landscaping material is used it must be inlaid or located below the design invert (bottom) of the channel. Do not place it on top of the designed finished grade of the channel cross section. The channel surface material (roughness coefficient) or cross sectional area shall not be changed without a plan revision and re-approval by City Staff.

This is a serious wide-spread construction and design oversight. Lining and landscaping material is commonly and incorrectly shown on plans and actually placed on top of the design channel bottom. This reduces and can eliminate a channel's conveyance capacity. This practice also makes it difficult for flow to enter such a channel, often causing ponding and backwater problems on streets and adjacent properties.

4. If only the channel banks are being lined, the lining material must extend down below the channel invert to below the anticipated scour depth.

5. Avoid designing turns in open channel conveyance systems sharper than 45 degrees, whenever possible. If curves or bends can't be avoided the run-up on the outside of curves must be calculated and incorporated into the channel design.

6. Lot lines should not extend out where they overlay or cross a drainage easement or wash. The wash area or drainage channel should be dedicated in a separate drainage easement Tract whenever possible. This will avoid "back yard to back yard" drainage channels, which can result in serious flooding problems.

Block walls or fences commonly separate lots. Channels that go under or through these walls commonly catch debris, clog, and block or divert flow. Homeowners will sometimes unknowingly and other times on purpose block off or plug these openings. There is no way for the City or a Homeowner's Association to inspect, or maintain these openings. In addition, the size of many of these openings is never actually designed or analyzed. Backyards, pools, houses, and lots can be flooded; and walls knocked over and/or undermined when these openings do not function properly.

Lot lines should end at the edge of the wash floodplain, or man-made channel, not in the middle or on the other side. Building envelopes are not recommended for delineating drainage easements. They can help but are too often misunderstood or ignored as a limit to construction of walls or structures.

Drainage Easements:

Acquire all required drainage easements as early in the planning and development process as possible. Do not allow discontinuous drainage easements. Fill in missing Drainage Easement segments in in-fill areas as development takes place.

Stormwater Detention or Retention

1. Offsite washes should not be routed into or through onsite subdivision stormwater storage basins.

Basins located on-stream interrupt the natural flow regime of the wash and can: create a continual debris and sediment maintenance problem for the property owner; affect the ability of the basin to drain within the required 36 hours; and if storage is aboveground a flood hazard is created for downstream residents.

2. Storage basins should be designed if at all possible with a gravity drain system and not rely on pumps or dry wells (see Policy Manual 2.1 Section 37-42 (12) B.).

3. All Storage basins must have an emergency spillway for flows in excess of the design as well as a safe place to overflow.

4. Above ground storage basins contained by fill, levee or berm, should be avoided whenever possible.

5. On-lot retention on single family residential lots is not permitted.

These are traditionally filled in by homeowners within several years in the process of landscaping. Runoff then ends up in their house, pool, on their neighbor's property, or in a City alley or street.

(12) Stormwater Storage Facilities

A. Stormwater Storage Policy

The current City of Scottsdale's stormwater storage requirements are contained in Section 42-(12) in Chapter 37' "Floodways and Floodplains" of the Scottsdale Revised Code, referred to as the City's Floodplain and Drainage Ordinance. This policy statement is intended to clarify the following ordinance requirement:

> *"As a minimum, all development will make provisions to store runoff from rainfall events up to and including the one-hundred-year two-hour duration event."*

The storage requirement applies to the "development". The development refers to **the area within the entire development site on which any man-made change occurs; including but not limited to: construction, mining, excavation, filling, grading, or paving.** The requirement is not applicable to undisturbed natural areas, and does not require the storage of runoff generated from these areas within the development site. The volume of storage provided onsite must equal the total runoff volume generated from all the developed areas within the entire site for fully developed conditions. Pre-development versus post development comparisons are not applicable in computing required storage volumes.

The requirement to store stormwater runoff has been in place since the adoption of COS Ordinance No. 1993, dated 2/29/88. The City of Scottsdale intends to continue to uphold its obligation and responsibility to its residents and neighboring communities by maintaining the current stormwater storage requirements. These requirements are derived from the Uniform Drainage Policies and Standards developed for use throughout Maricopa County, approved by the Maricopa County Board of Supervisors on April 20, 1987, Resolution FCD 87-7. Storage basins must have an emergency spillway that has a safe place to overflow. Above ground storage basins contained by fill, levees, or berms, should be avoided whenever possible.

This policy statement and clarification does not change any requirements or criteria contained in the above referenced City Ordinance for Floodways and Floodplains.

B. Drainage of Stormwater Storage Facilities

WATER CANNOT BE DISCHARGED ONTO A CITY STREET OR STREET GUTTER OR ALLEY

Drainage of Stormwater Storage Facilities: Storage facilities shall be drained by positive gravity outlet when at all possible. **The minimum allowable pipe size for primary outlet structures is 18 inches.** Only under special circumstances with prior city staff approval should pumps or infiltration disposal methods be used.

The following, listed in order of preference, are methods of draining storage facilities:

1.) Positive gravity outlet:

a. to an open channel either natural or man-made

b. or subsurface to a nearby storm sewer system with a maximum discharge of one cubic foot per second.

2.) Pump Station

a. to an open channel either natural or man-made

b. or subsurface directly to a nearby storm sewer system with a maximum discharge of one cubic foot per second.

c. or surface to a storm sewer system if pumped water can be discharged directly into a catch basin or other inlet.

3.) Dry wells: If allowed, dry wells must be designed per FCDMC Design Manual Vol. III design requirements.

4.) Basin Floors: Draining a basin by infiltration through the basin floor is not acceptable as the sole means of disposal.

To infiltrate properly a basin floor must be an "Engineered Basin Floor" as detailed in "UNDERGROUND DISPOSAL OF STORMWATER RUNOFF" (FHWA 1980) and per FCDMC Design Manual Vol. III design requirements. However, basin floor infiltration is not dependable, rarely are they properly designed per above reference, constructed or maintained. They are generally only landscaped and maintained for esthetic purposes.

DRAIN TIME: All storage facilities should be designed such that the stored runoff shall be discharged completely from the facility within 36 hours following the storm event. This is a City Ordinance requirement related to County Health Department Standards. Drain time should not be less than 24 hours to ensure the effectiveness of the basin, this can be regulated with a control plate over the entrance of the outlet pipe.

C. Stormwater Storage Requirements Waiver Policy:

Under the Floodplain and Drainage Ordinance, stormwater storage requirements may be waived if a project meets one or more of the specific criteria listed below. If the project meets the waiver criteria the City has the option, if it is in the best interest of the public, to grant the waiver. Meeting the waiver criteria, however, does not mean a waiver is automatically granted. Granting or denial of the waiver will only be given after formal review and processing by City staff. If a waiver is granted, the Ordinance requires payment of an in-lieu fee to be applied to the costs of installing or enlarging downstream flood control facilities necessary as a result of this waiver. The in-lieu fee will be determined by the City Staff at the time the waiver is granted.

It is not appropriate to automatically assume stormwater storage is not necessary because a project area is small relative to the entire watershed; or because a project is at the very downstream end of the watershed. The cumulative effects on the entire upstream and downstream watershed must be considered.

It is a common misconception that a small project is insignificant in a large drainage area. Typically this is only valid if the remainder of the watershed is already fully developed, and if downstream receiving channels and or storage facilities have adequate additional capacity. If not, the cumulative effects of waiving retention on many small individual projects within the same watershed can result in major downstream impacts.

If a waiver is granted:

1. All onsite storage requirements are not automatically eliminated. If the project can drain directly into an existing regional drainage system designed and constructed to contain or convey the additional runoff, all storage requirements may be waived. If not, the development must store the runoff volume necessary to maintain pre-development flow conditions.

2. Authorization is not granted by the City for the developer to increase runoff or change drainage characteristics to the detriment of any other property owner;

3. The developer is not relieved of liability if the development causes increased drainage problems or flooding on any other property.

To obtain a waiver, the developer or their engineer must submit a Request for Waiver Review form to the City. After City review, upon approval or denial, the applicant will receive a copy of the completed request form and the Waiver Review Form. A waiver approval (the completed Waiver Review Form) must be obtained prior to the processing of any proposed development plans. The results of the Waiver Review shall be included in the project stipulations and copies of both forms kept in the permanent project files.

REQUEST FOR WAIVER REVIEW FORM

(To be completed by the applicant and submitted to the City for review)

Waiver Criteria

A waiver is an intentional relinquishment of a claim or right. Before the City can waive its right to require the developer to provide some or all of the required stormwater storage at least one of the following criteria (Bolded from 37-42) must be met. The following criteria checked below apply to this project:

____1. **The runoff has been included in a storage facility at another location.** The runoff from this site must be safely conveyed to the other location through an adequately designed facility unless the other location is located upstream within the same watershed.

____2. **Application is for a building permit to construct a single family residential structure.** The development cannot increase the potential for flood damage to neighboring or downstream properties.

____3. **Development is adjacent to a watercourse or channel that has been designed and constructed to handle the additional runoff flow without increasing the potential for flood damage to any other downstream property.**
The developer must provide engineering analyses to City staff that demonstrates that the watercourse does have the additional capacity and the potential for flooding downstream properties will not be increased.

____4. **The development is for a parcel under one-half acre in an area where it can be demonstrated by engineering analysis that no significant increase in the potential for flood damage will be created by the development.**

I_____certify That:

DEVELOPER or ENGINEER DATE

the_____meets the criteria checked above.

PROJECT or DEVELOPMENT NAME

Project Location:_____

Applicant Mailing Address:_____

_____

I_____ certify that the above is correct and the project (does)/(does not) meet one or more of the waiver criteria.

PROJECT REVIEW STAFF DATE

WAIVER REVIEW FORM

(For City completion and return to applicant)

Check Appropriate Line:

_____Waiver denied, no waiver criteria met.

_____Waiver denied, insufficient data provided.

_____Waiver Criteria Met (Specify):___1;___2;___3;___4.

_____The Waiver is denied, for the following reason(s):

_____

_____

_____Waiver Granted. Explanation:

_____

_____

CONDITIONS OF WAIVER:

All storage requirements are waived_____.

Pre development conditions maintained _____.

Other
(Specify):_____

_____

_____

Above recommended by:_____

DRAINAGE PLANNER DATE

ACCEPTED BY:

_____ _____

FLOODPLAIN ADMINISTRATOR DATE PROJECT REVIEW MANAGER DATE

IN-LIEU FEES

(For City Use Only)

If a waiver is granted by the City, the developer is required to contribute the following In-Lieu Fees for the cost of drainage facilities on the basis of runoff contribution.

A. The fee is based on runoff contribution determined as follows:

_____

B. The scope and cost of drainage facilities that fees are being contributed towards include the following:

_____

_____

C. This project's In-lieu fees are: $_____ based on its proportional share, as determined in A., and identified in B.

Fees calculated by:_____ Date:_____

Approved by:_____ Date:_____

Sec. 37-43 Requirements for Certifications and Required Permits

Wall Permits: It is COS policy that requests for wall permits crossing a wash or drainage easement shall be approved by the City's Floodplain Administrator or Staff. Walls will be evaluated in relationship to the location of natural washes and the proposed drainage plan for the site as well as for compatibility with adjacent natural and manmade drainage facilities. A City 400 scale Drainage Aerial Photograph shall be submitted with any application for a wall permit.

Stormwater Storage Volume Certification: The property owner will provide the City with certified as-built dimensions of the basins and the actual volume of storage provided. This must be based on "as built" topographic surveys made by either a civil engineer or land surveyor who is registered to practice in the state of Arizona. These as-built volumes must reflect permanent finished landscaping in place. The volumes shall be certified by the Design Engineer that the volume provided meets or exceeds the required design volumes per COS Ordinance and the approved Drainage Plan. The volume of storage provided must equal or exceed the approved design volumes before the City will issue Letters of Acceptance for maintenance of any public facilities.

Sec. 37-44 Obstruction of Waterways Prohibited

Obstructions in Drainage Easements:

It is the policy of the COS that drainage easements be maintained in an open condition, free from obstructions, in order to pass the flows up to and including the 100-year event. Walls, fences, pools, landscaping, and other permanent structures should not be located in drainage easements. Even if indemnity agreements are obtained, once these types of improvements are installed, it is extremely difficult to remove such improvements. They become an obstruction to flow which can result in damage to others, as well as being damaged itself.

Section 2.1 Appendix

Chapter 37. Floodplain and Drainage Ordinance

City of Scottsdale, Arizona

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Section 2.1

Chapter 37

FLOODWAYS AND FLOODPLAINS*

*Charter reference—General power of city over floodways, etc., art. 1, § 3.

Cross references—Buildings and building regulations, Ch. 31; planning and development, Ch. 46; subdivisions, Ch. 48; basic zoning ordinance, App. B.

ARTICLE I. IN GENERAL

Secs. 37-1—37-15. Reserved.

ARTICLE II. FLOODPLAIN DEVELOPMENTS

DIVISION 1. GENERALLY

Sec. 37-16. Purpose; title.

(a) It is the purpose of this article to establish requirements and regulations pertaining to the use and development of land in the city which will minimize the occurrence of losses, hazards and conditions adversely affecting the public health, safety and general welfare which might result from flooding caused by the surface runoff of rainfall.

(b) This article may be referred to as "the floodplain and drainage ordinance."
(Code 1972, § 5-611; Ord. No. 1993, 2-29-88)

Sec. 37-17. Definitions.

Unless specifically defined below, words or phrases used in this article shall be interpreted so as to give them the meaning they have in common usage and to give this article its most reasonable application. The definitions in Arizona Revised Statutes section 48-3601 shall apply.

Appeal means a request for a review of the floodplain administrator's interpretation of any provision of this article or a request for a variance.

Area of shallow flooding means a designated AO and/or AH zone on the flood insurance rate map (FIRM). The base flood depths range from one (1) to three (3) feet, a clearly defined channel does not exist, the path of flooding is unpredictable and indeterminate, and velocity flow may be evident.

Base flood means the flood having a one-percent chance of being equalled or exceeded in any given year. This is also called a one-hundred-year flood.

Base flood water surface elevation means the following:

(1) In regulatory floodways and special flood hazard areas as shown on the FIRM or on other maps adopted by the floodplain board, the base flood water surface elevations shall be those elevations shown on the FIRM or adopted maps. For the floodways; however, when the city floodplain administrator determines that more accurate base flood water surface elevation data is available, than the data shown on the FIRM's, the more accurate data shall be used.

(2) In special flood hazard areas adopted by the floodplain board, the base flood water surface elevations shall be those elevations established in accordance with paragraph 37-18(c)(2).

(3) In a regulatory floodway not shown on the FIRM, the base flood water surface elevations shall be those elevations established in accordance with paragraph 37-18(c)(2).

(4) For those areas of the city which are not within a regulatory floodway or a special flood hazard area, the base flood water surface elevations shall be those which are established by a drainage report submitted in accordance with the criteria contained herein.

Basement means the lowest level or story of a structure which has its floor subgrade on all sides.

Breakaway wall means a wall that is not part of the structural support of the foundation and is intended through its design and construction to collapse under specific lateral loading forces, without causing damage to the elevated portion of the building support or foundation system.

Construction means new construction of or substantial improvements to a structure.

Critical feature means an integral and readily identifiable part of a flood protection system without which the flood protection provided by the entire system would be compromised.

Depressed floor area is a portion of the first floor of a residential structure, such as a sunken living room or a conversation pit, which is lower than the surrounding floor area, and which has no floor-level access to areas outside the structure. (This is not a multilevel first floor which is stepped to conform to site slope conditions).

Detention basin means a hydraulic structure similar to a reservoir that intercepts and retards or detains storm water and is specifically designed to attenuate or dampen peak discharge rates.

Development means any man-made change to improved or unimproved real estate, including, but not limited to, construction, mining, excavation, filling, grading, or paving.

Environmentally sensitive lands means environmentally sensitive lands as defined in Ordinance Numbers 1881 and 1883.*

Financial assistance means any form of loan, grant, guarantee, insurance, payment, rebate, subsidy, disaster assistance loan or grant, or any other form of direct or indirect federal assistance, other than general or special revenue sharing or formula grants made to states.

Flood or *flooding* means a general and temporary condition of partial or complete inundation of normally dry land areas from:

(1) The overflow of floodwaters;

(2) The unusual and rapid accumulation or runoff of surface waters from any source, and/or;

(3) The collapse or subsidence of land along the shore of a lake or other body of water as a result of erosion or undermining caused by waves or currents of water exceeding anticipated cyclical levels or suddenly caused by an unusually high water level in a natural body of water, accompanied by a severe storm, or by an unanticipated force of nature, such as flash flood, or by some similarly unusual and unforeseeable event which results in flooding as defined in this definition.

Flood boundary floodway map means the official map on which the Federal Insurance Administration has delineated both the areas of flood hazard and the floodway.

Flood hazard boundary map (FHBM) means an official map of a community issued by the Federal Emergency Management Agency where the boundaries of the flood, mudslide (i.e. mudflow) and related erosion areas having special hazards have been designated as zones A, M, and/or E.

Flood insurance rate map (FIRM) means the official map on which the Federal Insurance Administration has delineated both the areas of special flood hazards and the risk premium zones applicable to the community.

Flood hazard zones A, AE, AO, AH, A1-30 and, A99 are the areas shown on a FIRM which the Federal Emergency Management Agency has determined will be inundated during a one-hundred-year flood. These areas are called, collectively, "special flood hazard areas."

Flood hazard zone B or X is an area shown on a FIRM which is an area of moderate flood hazards.

Flood hazard zone C or X is an area shown on a FIRM which is an area of minimal hazards.

Flood hazard zone D is an area shown on a FIRM which has undetermined but possible flooding hazards.

Flood hazard zone E is an area of special flood-related erosion hazards.

Floodplain administrator means the city manager or designee who is authorized by this article to administer its provisions.

Floodplain or *Flood-prone area* means any land area susceptible to being inundated by water from any source (see definition of "flooding").

Floodplain board means the city council of the city at such times as they are engaged in the enforcement of this article.

Floodproofing or *floodprotection* means any combination of structural and nonstructural additions, changes, or adjustments to structures, including utility and sanitary facilities, which would preclude the entry of water. The structure must be watertight, with walls which are substantially impermeable to the passage of water. Structural components shall have the capability of resisting hydrostatic and hydrodynamic loads and the effect of buoyancy.

Floodway is the channel of a river or other watercourse and the adjacent land areas necessary in order to discharge the one-hundred-year flood without cumulatively increasing the water surface elevation.

*Editor's note—Ordinance No. 1881 is included in this Code as Ch. 46, Art. III, Div. 1, §§ 46-61—46-65; Ord. No. 1883 is included as Ch. 46, Art. III, Div. 2, §§ 46-73—46-77.

Grading is any excavation or filling of land or combination thereof.

Lowest floor means the lowest floor of the lowest enclosed area (including basement). An unfinished or flood-resistant enclosure, usable solely for parking of vehicles, building access or storage in an area other than a basement area is not considered a building's lowest floor; provided, that such enclosure is not built so as to render the structure in violation of the applicable non-elevation design requirements of this article.

Manufactured home means a structure, transportable in one (1) or more sections, which is built on a permanent chassis and designed to be used with or without a permanent foundation when connected to the required utilities. For floodplain management purposes the term "manufactured home" also includes park trailers, travel trailers and other similar vehicles placed on a site for more than one hundred eighty (180) consecutive days.

Manufactured home park (subdivision) means a parcel or contiguous parcels of land which have been divided into two (2) or more lots for rent or sale and the placement of mobile homes.

Natural areas shall mean those areas within environmentally sensitive areas which are required to be retained in a natural state, including areas stipulated as such through the zoning process. Special conditions relating to environmentally sensitive lands will apply to such "natural areas."

Regulatory base flood elevation means an elevation one (1) foot above the "base flood water surface elevation."

Regulatory floodway means the channel of a wash or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without raising the water surface elevation.

Residential structure means a place of residence and may be a single-family or multifamily dwelling.

Retention basin means an hydraulic structure similar to a reservoir that intercepts and stores stormwater and is specifically designed to be drained to the underground or to be emptied by evaporation to the atmosphere.

Special flood hazard area means an area having flood and/or flood related erosion hazards as shown on a FHBM or FIRM as zone A, AO, A1-30, AE, A99, AH, or E, and those areas identified as such by the floodplain administrator, delineated in accordance with paragraph 37-18 (b) and adopted by the floodplain board.

Start of construction, for purposes of this article only, includes substantial improvement, and means the date the building permit was issued, provided the actual start of construction, repair, reconstruction, placement, or other improvement was within one hundred eighty (180) days of the permit date. The actual start means either the first placement of permanent construction of a structure on a site, such as the pouring of slab or footings, the installation of piles, the construction of columns, or any work beyond the stage of excavation; or the placement of a manufactured home on a foundation. Permanent construction does not include land preparation, such as clearing, grading and filling; nor does it include the installation of streets and/or walkways; nor does it include excavation for a basement, footings, piers, or foundations or the erection of temporary forms; nor does it include the installation on the property of accessory buildings, such as garages or sheds not occupied as dwelling units or not part of the main structure.

Structure means a walled and roofed building or a gas or liquid storage tank that is principally above the ground. This term includes, but is not limited to, houses, commercial buildings, factories, storage buildings, mobile homes, and similar structures.

Substantial improvement means any repair, reconstruction or improvement of a structure, the cost of which equals or exceeds fifty percent of the market value of the structure either before the improvement is started or before the damage occurred, if the structure has been damaged and is being restored. For the purposes of this definition, "substantial improvement" is considered to occur when the first alteration of any wall, ceiling, floor or other structural part of the building commences, whether or not that alteration affects the external dimensions of the structure. The term "substantial improvement" does not, however, include any alteration to comply with existing state or local health, sanitary, building, or safety codes

or regulations which are solely necessary to assure safe living conditions.

Variance means a grant of relief from some of the requirements of this article which permits construction in a manner that would otherwise be prohibited by this article.

Waste disposal system means any system of disposing of worthless materials and useless by-products, either sanitary or commercial or industrial, except existing single-family septic systems and sanitary sewer pipe lines.

Watercourse means a lake, river, creek, stream, wash, arroyo, channel or other topographic feature on or over which waters flow at least periodically. Watercourses includes specifically designated areas in which substantial flood damage may occur. (Code 1972, § 5-612; Ord. No. 1993, 2-29-88)

Sec. 37-18. Basis for establishment of special flood hazard areas and regulatory floodways.

(a) The city is a participant in the National Flood Insurance Program (NFIP). The special flood hazard areas and the parts of those areas which are designated as regulatory floodways are identified and delineated by the federal emergency management agency (FEMA) in an engineering report titled "Flood Insurance Study, Scottsdale, Arizona" with accompanying flood insurance rate maps (FIRM's) and flood hazard boundary maps (FHBM's). Such studies and maps are prepared for communities participating in the NFIP. The first study and maps for Scottsdale were dated June 1972, and there have been several revisions. The current flood insurance study and flood insurance rate maps for Scottsdale are on file at the city clerk's office, and they are hereby adopted by reference and declared to be a part of this article.

(b) A special flood hazard area shall be those areas of the city identified on the FIRM's including, but not limited to, zone A, zone A1-30, zone AE, zone AH, zone A99, and zone E; and those areas which have been identified by the floodplain administrator, adopted by the floodplain board, and have been delineated in accordance with Arizona Revised Statutes, sections 48-3609 and 48-3610; and which are compatible with criteria developed by the state director of water resources for defining the extent of flooding and the base flood water surface elevations.

(c) The regulatory floodways shall be:

(1) Those areas of the city identified on the FIRM's as flood hazard zones, including, but not limited to, zone AE, and zone AO.

(2) Those other areas shown on the FIRM and those areas not shown on the FIRM which have been adopted by the floodplain board as special flood hazard areas and require the definition of regulatory floodways.

(d) If a development is proposed on land designated as a special flood hazard area, the development shall:

(1) Be designed and constructed in a manner which complies with the requirements in section 37-41, and in a manner which raises the developed land to an elevation which is at or above the regulatory base floodwater surface elevation;

(2) Upon completion of the grading and flood protection features of the development, the developer shall provide the floodplain administrator as built grading plans and other engineering data prepared and signed by a professional engineer or registered land surveyor, which demonstrates compliance with this ordinance; and

(3) If the development lies within a special flood hazard zone shown on the FIRM, the developer shall provide the floodplain administrator the appropriate engineering data and certification showing that the development no longer lies within a special flood hazard zone. The developer shall also provide to the administrator an application to the Federal Emergency Management Agency requesting a letter of map amendment or letter of map revision. The administrator will forward the application with appropriate recommendations to the federal emergency management agency for action.

(e) The requirements described in paragraph (d)(3) above, of this section do not apply to the construction of:

(1) An individual, single-family residential structure, or

(2) An individual, multifamily residential or nonresidential structure on a parcel of land under one-half acre in size, however, the community development general manager or designee will notify the property owner that appropriate insurance will be required by federally insured lending agencies.

(f) If the requirements in subsection (d), do not apply to a development, the lowest floor elevation requirements described in section 37-42 paragraphs (6) and (7) are applicable.
(Code 1972, § 5-614; Ord. No. 1993, 2-29-88)

Sec. 37-19. Floodplain administrator.

(a) *Designated.* The city manager or designee shall be the floodplain administrator.

(b) *Responsibilities.* It is the responsibility of the floodplain administrator or his authorized representative to do the following:

(1) Review all applications for development permits and insure that the requirements of this article are enforced.

(2) Provide the Federal Emergency Management Agency (FEMA) information needed to update the FIRM's and serve as the city's agent for handling revisions of the FIRM's.

(3) Coordinate the provisions of this article with all other interested and affected political subdivisions, federal and state agencies as required by Arizona Revised Statutes sections 48-3609 and 48-3610, and 44 CFR parts 60.2 (e) and 60.3 (b)(6).

(4) Make interpretations where needed as to the exact location of the flood hazard zone boundaries and, when requested, provide the public with information concerning these interpretations and the content of the FIRM's.

(5) Take action on violations of the regulations in this article.

(6) Submit an annual reports to FEMA as required by 44 CFR parts 59-77 and 60.2 (f), and the coordinating agency for the state concerning the city's management of development in special flood hazard areas.

(7) Review proposed development documents to assure that necessary permits required by section 404 of the Clean Water Act (33 USC 1344) have ben obtained for such development prior to issuance of any development permits required by the city or state statute.

(8) Notify FEMA of any annexations to the incorporated areas of the city and of any de-annexations.

(9) Maintain the following records and, upon request, provide the public with information concerning the content of these records:

a. A current copy of the FIRM's and of any letters of map amendment or any letters of map revision issued by FEMA for development in the city.
b. Certificates provided by builders pertaining to lowest floor elevations and floodproofing in the special flood hazard areas.
c. Floodplain and drainage management permits.

(10) Administer the processing of requests for a variance from the requirements of this article, maintain records of all actions taken, and report the variances that have been issued in the annual report to FEMA.

(Code 1972, § 5-616; Ord. No. 1993, 2-29-88)

Sec. 37-20. Appeals and variances.

(a) A person may appeal to the floodplain board for a variance or for a judgment on the interpretation of this article. The floodplain board may grant a variance if conditions would not be created by the variance which would result in danger or damage to persons or property and if strict application of the regulations would deprive the property owner of privileges enjoyed by similar property in the floodplain. The following subsections describe the conditions applicable to the granting of a variance.

(b) A variance shall not be granted for property within a regulatory floodway if any increase in the water surface elevation during a base flood discharge would result.

(c) A variance may be granted in conformance with subsections (d), (e) and (f) of this section for

new construction and substantial improvements to be erected on a lot of one-half acre or less in size contiguous to and surrounded by lots with existing structures with lowest floors constructed below the base flood level.

(d) A variance shall only be granted upon the determination of the following:

(1) A good and sufficient cause exists.

(2) Failure to grant the variance would result in exceptional hardship to the applicant.

(3) Granting the variance will not allow conditions to be created which result in increased floodwater heights, additional threats to public safety, extraordinary public expense, the creation of nuisances, the causing of fraud or victimization of the public, or conflict with other laws or ordinances.

(e) A variance shall only be granted upon a determination that the variance is the minimum necessary, considering the flood hazard, to afford relief for the applicant.

(f) The floodplain administrator shall notify the applicant in writing that the following conditions will exist as a result of the variance:

(1) Construction of a lowest floor below the base flood level will result in increased premium rates for flood insurance.

(2) Construction below the base flood level increases risks to life and property.

(g) While the granting of variances generally is limited to a lot size less than one-half acre, deviations from this limit may be considered by the floodplain board; however, as the lot size is increased beyond one-half acre, the technical justifications required for a variance must be more detailed and comprehensive.

(Code 1972, § 5-617; Ord. No. 1993, 2-29-88)

Sec. 37-21. Interpretation.

In the interpretation and application of this article, all provisions shall be:

(1) Considered as minimum requirements;

(2) Liberally construed in favor of the council; and

(3) Deemed neither to limit nor repeal any other powers granted under law.

(Code 1972, § 5-619; Ord. No. 1993, 2-29-88)

Sec. 37-22. Warning and disclaimer of liability.

The degree of flood protection provided by the requirements in this article is considered reasonable for regulatory purposes and is based on scientific and engineering considerations. Floods larger than the base flood can and will occur on rare occasions. Floodwater heights may be increased by manmade or natural causes. This article shall not create liability on the part of the city, any officer or employee thereof, or the federal government for any flood damages that result from reliance on this article or any administrative decision lawfully made thereunder.

(Code 1972, § 5-620; Ord. No. 1993, 2-29-88)

Secs. 37-23—37-40. Reserved.

DIVISION 2. REGULATIONS

Sec. 37-41. Prohibited development.

(a) A development is prohibited if it would create hazards to life or property by increasing the potential for flooding either on the property to be developed or on adjacent property or to any other property. Further: A watercourse may not be altered. Alteration within the meaning of this section includes, but is not limited to, encroachments, fill, new construction, substantial improvements to existing developments, and other construction within a watercourse, unless professional engineer certifies that the alterations do not increase the flood levels, and will not increase flooding hazards within, upstream or downstream of the altered portion of the watercourse.

(b) Waste disposal systems shall not be installed wholly or partially in a floodway and or a regulatory floodway. Replacement of existing systems will be reviewed on an individual basis and may be granted a variance if approved by the Arizona Department of Water Resources.

(Code 1972, § 5-615(A); Ord. No. 1993, 2-29-88)

Sec. 37-42. Development requirements to be met for permit issuance.

Prior to the issuance of a permit by the city for development on private property or for work in the public rights-of-way, the applicant for the permit shall furnish the floodplain administrator and the project review manager information as required to determine that all proposed building sites will be reasonably safe from flooding and sufficient data to enable the city staff to determine that the proposed work is not of such a scope that it would be prohibited in accordance with subparagraphs (1) and (2) of this section. Reports, construction plans, and other data submitted in support of an application for a permit shall comply with the following criteria:

(1) *Drainage reports.* When a drainage report is required, it must be prepared and sealed by a civil engineer registered as a professional engineer in the state and it must be prepared in accordance with the criteria established by the city. The purpose of the report is to analyze the effect that a proposed development would have upon the rainfall runoff in the vicinity of the development, to provide data to insure that the development is designed to be protected from flooding, to provide data to insure that the development is to be designed to minimize flooding and to provide data supporting the design of facilities to be constructed for the management of rainfall runoff. Each drainage report must consider rainfall runoff from storms with a return frequency up to and including a one-hundred-year storm. The complexity of the report depends upon the nature of the development and the site on which the development will occur. A drainage report shall be submitted by an applicant requesting one of the following:

a. Approval of a subdivision plat, condominium, townhouse, or a lot split.
b. A permit for grading, unless the requirement is waived by the floodplain administrator.
c. A permit to construct right-of-way improvements.
d. A permit to construct any structure, except that a report will not be required if the structure is to be a single-family residential structure to be built without a basement outside of a special flood hazard area and to be located at a site which the floodplain administrator has determined will not be in the vicinity of a watercourse in which the flow of rainfall runoff might be hazardous to the structure or its occupants.

(2) *Drainage characteristics.* Rainfall runoff from storms of all return frequencies should enter and depart from property after its development in substantially the same manner as under pre-development conditions. Any proposals to modify drainage characteristics must be fully justified by engineering data which shall demonstrate to the floodplain administrator that hazards to life and property will not be increased by the proposed modifications. As a minimum, drainage and flood control easements will be dedicated to the city to the extent of the estimated one-hundred-year flood for all watercourses having a capacity of twenty-five (25) cubic feet per second or greater, and the development shall be responsible for the maintenance of the watercourse. Exceptions to this regulation will be for environmentally sensitive lands covered under section 37-42 (14) and other areas covered by master drainage plans, council stipulations or other provisions of this article which insure that the standards established by this section are met. Any proposed modification must be compatible with environmentally sensitive lands criteria.

(3) *Street crossings at natural or man-made drainage channels.*

a. The crossing structure requirements listed herein will normally apply; however, the engineer may depart from these requirements if he can demonstrate to the Floodplain Administrator's satisfaction that they are inappropriate because of the type of development or the nature of the terrain or because the requirements violate environmentally sensitive land ordinances. In extreme cases it may be necessary to allow for the

entire channel flow to pass over the road.

1. Local and minor collector streets shall have a culvert or bridge which is capable of carrying all of the peak flow of runoff from a ten-year-frequency storm beneath the roadway and which is also capable of carrying enough of the peak flow of runoff from a twenty-five-year-frequency storm beneath the road so that the portion of the flow over the road is no more than six (6) inches deep.
2. Major collector and major or minor arterial streets shall have a culvert or bridge which is capable of carrying all of the peak flow of runoff from a fifty-year-frequency storm beneath the roadway and which is also capable of carrying enough of the peak flow of runoff from a one-hundred-year-frequency storm so that the portion of the flow over the road is no more than six (6) inches deep.
3. Watercourse crossings for roads shall be designed so that all lots and structures within a development will be accessible from the boundary of that development by at least one (1) route during the period of peak flow of runoff from a one-hundred-year-frequency storm. The boundary shall include any adjacent street or streets. Accessibility will be considered to exist if it can be demonstrated by the engineer that at the time of the peak flow the depth of flow over the road will be no greater than one (1) foot.

b. Regardless of the size of the culvert or bridge, the street crossing should be designed to convey the one-year storm runoff flow under and/or over the road to the area downstream of the crossing to which the flow would have gone in the absence of the street crossing. The construction of a channel crossing must not cause the diversion of drainage flows except when that diversion is part of an approved plan for modification of drainage patterns.

(4) *Streets as water carriers.* It is expected that streets will carry water from adjacent property and from local areas, but they are not to be used as major water carriers in lieu of natural washes or man-made channels. The maximum depth for water flowing in any street shall be eight (8) inches during the peak runoff from a one-hundred-year-frequency storm. The above requirements imply that in some cases water may flow deeper than a normal vertical curb height and may flow for a short distance over sidewalk or other back-of-curb areas, but the flow of the water shall always be confined to the road right-of-way or to drainage easements. Particular care must be taken in street sag locations to insure that these requirements are met. Catch basins, scuppers, or similar facilities, together with the necessary channels, must be provided at appropriate locations to remove water flowing in the streets so as not to exceed the above described depth limit.

(5) *Design procedures and criteria.* The design procedures and criteria to be used shall be in accordance with those prepared and published by the city.

(6) *Lowest floor elevations in residential structures.*

a. In regulatory floodways, a new residential structure or the substantial improvement of an existing residential structure shall have its lowest floor constructed above the regulatory base flood elevation in the vicinity of the proposed construction site. In the regulatory floodway known as the Indian Bend Wash, a lowest floor elevation must also be above the water surface elevation calculated for floodwater flowing at the rate established by the U.S. Army Corps of Engineers' Indian Bend Wash Project design criteria.
b. In special flood hazard areas, a new residential structure or the substantial

improvement of an existing residential structure shall have its lowest floor constructed at least one (1) foot above the base flood elevation.

c. In flood hazard zone AO, a new residential structure or the substantial improvement of an existing residential structure shall have its lowest floor (including basement) elevated above the highest adjacent grade at least as high as the depth number specified on the FIRM (at least two (2) feet if no depth number is specified).

d. In areas outside of special flood hazard areas which are not in a regulatory floodway, a new residential structure (single- or multi-family) shall be constructed according to one (1) of the two (2) following requirements, except when the conditions in subparagraph f. apply:
   1. The lowest floor shall be constructed at an elevation which is above the base flood water surface elevation.
   2. The lowest floor may be constructed below the base flood water surface elevation, but flood proofing shall be provided for the structure to an elevation which is at least one (1) foot above the base flood water surface elevation.

e. In areas outside of special flood hazard areas those single-family residential structures which are to be built without a basement and located at a site which the floodplain administrator has determined will not be in the vicinity of a watercourse in which the flow of rainfall runoff might be hazardous to the structure or its occupants, the elevation of the lowest floor may be established by one (1) of the methods described in the following subparagraphs:
   1. If the structure is to be located in flood hazard zone B, C, D or X, the lowest floor may be set at an elevation which is fourteen (14) inches above the highest adjacent grade.
   2. The floor elevation(s) chosen for the residence may be indicated on a topographic plan of the building site parcel which shows the construction pad site and any grading proposed on the parcel. This plan must be prepared and sealed by a civil engineer or architect registered as a professional engineer or architect in the state. The floor elevation(s) indicated on the plan are to be elevations certified by the engineer or architect sufficiently high to provide protection during the base flood in the event of flooding caused by a one-hundred-year storm. This method may be appropriate for residences to be built in environmentally sensitive areas and where the floor levels are stepped to conform with natural grade conditions.

f. A residential structure to be built adjacent to but not within a regulatory floodway that will have its lowest floor at an elevation lower than the regulatory base flood elevation must be floodproofed to an elevation at least one and five-tenths (1.5) feet above the regulatory base flood elevation.

g. In regulatory floodways and in special flood hazard areas a depressed floor area shall be considered the lowest floor unless there is a basement.

h. In areas outside special flood hazard areas which are not in a regulatory floodway, a depressed floor area does not have to be considered as the lowest floor if there is no door opening directly to the outside which could admit flood water into the depressed floor area and if the depressed area walls and floor are sealed to prevent the infiltration of water into the depressed area.

(7) *Lowest floor elevations in nonresidential structures.*

a. In regulatory floodways and in special flood hazard areas a new nonresidential structure or the substantial improvement of an existing nonresidential structure shall be constructed ac-

cording to one (1) of the two (2) following requirements:

1. The lowest floor shall be constructed at an elevation which is above the regulatory base flood elevation in the vicinity of the proposed construction site. In the regulatory floodway known as the Indian Bend Wash, a lowest floor elevation must also be above the water surface elevation calculated for floodwater flowing at the rate established by the U.S. Army Corps of Engineers' Indian Bend Wash Project design criteria, or
2. The lowest floor may be constructed below the regulatory base flood elevation floodproofing shall be provided for the structure to an elevation which is at least one (1) foot above the regulatory base flood elevation, or two (2) feet above the base flood water surface elevation. In the regulatory floodway known as the Indian Bend Wash, floodproofing shall be provided for the structure to an elevation which is one (1) foot above the water surface elevation calculated for floodwater flowing at the rate established by the U.S. Army Corps of Engineers' Indian Bend Wash Project design criteria.

b. In flood hazard zone AO, a new nonresidential structure or the substantial improvement of an existing nonresidential structure shall be constructed according to one (1) of the two (2) following requirements:
   1. The lowest floor (including basement) elevated above the highest adjacent grade at least as high as the depth number shown on the FIRM (at least two (2) feet if no depth number is specified.
   2. The lowest floor may be constructed below the minimum lowest floor elevation specified in subparagraph (1), above, but floodproofing shall be provided for the structure to an elevation which is at least as high as the minimum lowest floor elevation determined by the method in subparagraph (1), above.

c. In areas outside of special flood hazard areas, new nonresidential structure or the substantial improvement of an existing nonresidential structure shall be constructed according to one (1) of the two (2) following requirements:
   1. The lowest floor shall be constructed at an elevation which is at or above the base flood water surface elevation.
   2. The lowest floor may be constructed below the elevation of the base flood water surface elevation but floodproofing shall be provided for the structure to an elevation which is at least as high as the base flood water surface elevation.

d. In flood hazard zones AH, and AO, adequate drainage paths must be constructed to guide floodwaters around and away from the structures.

(8) *Manufactured homes and manufactured home parks.*

a. The new installation of a manufactured home in an area other than a manufactured home park, the construction of a new manufactured home park, or the enlargement of an existing manufactured home park within a regulatory floodway is prohibited.

b. The new installation of a manufactured home or the replacement of an existing manufactured home outside the special flood hazard areas must be done in a manner that assures that the manufactured home is anchored to the earth so as to prevent flotation, collapse or lateral movement in the event of flooding.

c. A manufactured home to be installed in a new location or as a replacement for an existing manufactured home in a special flood hazard area and a manufactured home to be installed as a replacement for an existing manufac-

tured home located within a regulatory floodway shall be anchored to resist flotation, collapse or lateral movement by providing over-the-top and frame ties to ground anchors. The following specific requirements must be met:

1. Over-the-top ties must be provided at each of the four (4) corners of the manufactured home. Manufactured homes fifty (50) feet or more in length must have two (2) additional over-the-top ties per side at intermediate locations, and mobile manufactured homes less than fifty (50) feet in length must have one (1) additional over-the-top tie per side.
2. Frame ties must be provided at each of the four corners of the manufactured home. Manufactured homes fifty (50) feet or more in length must have five (5) additional frame ties per side, and manufactured homes less than fifty (50) feet in length must have four (4) additional frame ties per side.
3. All components of the anchoring system must be capable of resisting forces of at least four thousand eight hundred (4,800) pounds.
4. Any additions to a manufactured home must be similarly anchored.

d. The owners of manufactured home parks that are located within special flood hazard areas shall have evacuation plans prepared indicating alternate vehicular access and escape routes. These plans shall be filed with the Maricopa County Department of Civil Defense and Emergency Services and with the city's field services director.

e. If an existing manufactured home park within a regulatory floodway must undergo repair, reconstruction or improvement of the streets, utility systems and pads at a cost which equals or exceeds fifty (50) percent of the value of the streets, utility systems and pads before the repair, reconstruction, or improvement has commenced, the following requirements must be met:

1. All manufactured homes are placed on pads or lots elevated on compacted fill or on pilings so that the bottom of the structural frame or the lowest point of any attached appliances, whichever is lower, is at or above the regulatory flood elevation.
2. Adequate surface drainage and access for a hauler must be provided.
3. If the stands are elevated on pilings, the lots must be large enough to permit steps, the pilings must have foundations on stable soil and be no more than ten (10) feet apart, and reinforcement must be provided for pilings more than six (6) feet above the ground.

f. A manufactured home which is located in a regulatory floodway or in a special flood hazard area may be replaced by another manufactured home only if:

1. The manufactured home which is to be replaced was not damaged by a flood to more than fifty (50) percent of its value before the flood.
2. The replacement manufactured home is elevated so that the bottom of the structural frame or the lowest point of any attached appliances, whichever is lower, is above the regulatory base flood elevation.

(9) *Reference to regulatory base flood water surface elevations on development plans.* The grading and drainage plans for any development adjacent to a regulatory floodway and the grading and drainage plans for any development which proposes to modify an existing regulatory floodway as a part of the development must indicate the base flood water surface elevations.

(10) *Information pertaining to flood protection to be placed on building plans.* The following subparagraphs describe requirements for information which shall be placed on building plans for both residential and non-

residential structures. Depending upon the type of structure and its location, one (1) or more of the subparagraphs will apply:

a. The proposed elevation of the lowest floor must be shown, regardless of the type of structure or its location.
b. If the structure is to be built in a regulatory floodway or in a special flood hazard area, the base flood water surface elevation must be shown.
c. If the structure is to be built in flood hazard zone AO, the elevation of the highest ground adjacent to the structure and the depth number for the AO zone must be shown.
d. If the structure is to be floodproofed, the elevation to which the floodproofing will be provided must be shown.

(11) *Minimizing potential for flood damage.* Within any area of the city where the floodplain administrator determines that the land is subject to flooding, including, but not limited to, the special flood hazard areas, all development, including substantial improvements to structures, must meet the following requirements:

a. All structures shall be anchored to their foundations to prevent flotation, collapse, or lateral movement.
b. Building construction materials and utility system equipment shall be resistant to flood damage.
c. The construction methods and practices shall be those which minimize flood damage.
d. Multiple occupancy developments such as subdivisions, shopping centers, etc. shall have their public utility systems such as sewer, water, gas and electrical lines and their associated facilities located and constructed in a manner to minimize or eliminate the potential for flood damage. The developments must be constructed with drainage systems which will minimize the exposure to flood damage.
e. New and replacement water supply systems shall be designed and constructed to minimize or eliminate infiltration of floodwater into the systems.
f. New and replacement sanitary sewage systems shall be designed and constructed to minimize or eliminate infiltration of floodwaters into the systems and the discharge of sewage into the floodwaters.

(12) *Storm water storage facilities.*

a. Except as noted below, development of all land within the city must include provisions for the management of stormwater runoff from the property which is to be developed. This management shall consist of constructing storm water storage facilities, which includes detention basins. Stormwater storage facilities will provide reduced peak rates of outlet flow from the developed property onto downstream property in comparison to the peak rates of runoff flow from the same property under natural conditions with no development. As a minimum, all development will make provisions to store runoff from rainfall events up to and including the one-hundred-year two-hour duration event. If a suitable outlet for a detention basin is not available, or if engineering analysis indicates that available outlet systems would be overtaxed by a detention basin outflow, or groundwater recharge is indicated by an approved master groundwater recharge plan a retention basin shall be constructed in lieu of a detention basin.

The requirement for construction of a detention system or a retention basin all types of stormwater storage facilities may be is waived in the following cases:

1. The runoff has been included in a storage facility at another location.
2. An application for a building permit to construct a single-family residential structure.
3. Development adjacent to a floodway or a watercourse drainage channel which has been determined

by the project review manager using engineering analyses provided by the development to have been designed and constructed to handle the additional runoff flow without increasing the potential for flood damage on any other downstream property.

4. Development of a parcel under one-half acre in an area where it can be demonstrated by engineering analyses that no significant increase in the potential for flood damage will be created by the development.

If storage is waived, the development shall be required to contribute to the cost of drainage works on the basis of runoff contribution.

b. Stormwater storage facilities shall be designed and constructed according to the procedures and criteria established by the city including the following:

1. The extent of the area to be used to estimate development storage requirements is the entire proposed development including: streets, alleys, easements and rights-of-way, and one-half or other fractional parts of streets, alleys, easements and rights-of-way.
2. If possible, storage facilities are to be located so they can intercept the flow from the entire development;
3. If portions of the area cannot drain to a primary storage facility then additional facilities are to be added for these areas as approved by the director of project review;
4. Individual lot facilities are prohibited except when a clear unobstructed access from a public rights-of-way, for maintenance purposes, is conveyed by dedication or easement to the city;
5. No stormwater storage facility shall detain or retain standing water longer than thirty-six (36) hours if the basin has not been designed and constructed to be a permanent body of water with appropriate health, safety, and water quality measures for such a body of water.

c. Stormwater storage facilities are to be drained by either controlled bleed-off, discharge pump and, in limited cases, by infiltration or dry well or injection wells. Controlled bleed-off or pumping to a recognized water course is the preferred method. Methods which discharge stored stormwater to the underground must be in accordance with the approved groundwater master plan and approved by the floodplain administrator, the director of project review and the water resources director. In addition, the development must provide the director of project review the state and federal permits required to discharge stormwaters to the underground prior to the issuance of any other development permit.

(13) *Parking in flood hazard areas.* Parking areas shall be permitted within regulatory floodways and special flood hazard areas provided that there will be no overnight parking, that there will be no unattended vehicle(s), and that there will be no obstruction to the natural flow of water.

a. Overnight parking shall be considered to exist when a vehicle is left unattended during the hours from sunset to sunrise.
b. "Unattended" shall mean that the owner or authorized driver cannot reasonably be expected to be available to remove the vehicle before flooding occurs.

Whenever parking is permitted within regulatory floodways and special flood hazard areas, warning signs shall be posted by the parking area owner to indicate that the parking area is subject to flooding.

(14) *Special considerations in environmentally sensitive land areas.*

a. Existing watercourses with a capacity of fifty (50) cubic feet per second or greater, disregarding any estimated peak discharge values, shall be maintained in their natural state unless it is de-

termined that alterations are required to meet other provisions of this ordinance.

b. A drainage and flood control easement will be dedicated to the city which encompasses the area required to convey the base flood in the watercourse described in section 37-42(14)a.

c. Road-wash crossings may disrupt the natural channel beyond the right-of-way limits if engineering investigations determine the need, and are approved by the director of project review.

d. Stormwater storage facilities may not be required in areas zoned for environmentally sensitive development if the city staff determines that such facilities cannot be built without conflicting with the city's environmentally sensitive lands ordinance requirements. If on-site stormwater storage facilities requirements are waived, the development may be required to contribute to the cost of drainage works at another location on the basis of runoff contribution.

e. All drainage structures and detention facilities shall be constructed in such a manner as to minimize the impact on the natural environment, promote recharge when in conformance with the approved groundwater, recharge master plan and, when finished, shall be revegetated to be compatible with nearby natural areas.

(15) *Conformance with state law.* No construction within the limits outlined in this article shall be permitted which would violate prevailing water law of the state, whether statutory or by the courts of this state.

(Code 1972, § 5-615(B); Ord. No. 1993, 2-29-88)

Sec. 37-43. Requirement for certifications and required permits.

(a) Before the city will make a final inspection and grant a utility clearance for a single-family residential structure built in a regulatory floodway, a special flood hazard area or in flood hazard zones A or AO, or before the city will grant a certificate of occupancy for a structure other than a single-family residential structure built in a regulatory floodway, a special flood hazard zone or in flood hazard zones A or AO, the builder must submit certain certificates to the floodplain administrator. The certificates which are required pertain to lowest floor elevations, adjacent ground elevations and floodproofing. The following subparagraphs describe the required certificates.

(b) Certificates pertaining to elevations shall be made by either a civil engineer or land surveyor who is registered to practice in the state.

(c) Certificates pertaining to the adequacy of floodproofing shall be made by a civil engineer or architect who is registered to practice in the state.

(d) A certificate shall be submitted stating the "as-built" elevation (in relation to mean sea level) of the lowest floor of each new structure or substantial improvement to a structure built in a regulatory floodway or in a special flood hazard area. If the lowest floor is below grade on one (1) or more sides, the certificate must also state the elevation of the floor immediately above the lowest floor. This certificate must indicate whether the structure does or does not have a basement. If a structure has been floodproofed, a statement of the elevation to which the structure was floodproofed must be included with this certificate.

(e) For those structures which have been built in a regulatory floodway or in a special flood hazard area and have been floodproofed, a certificate shall be submitted which certifies that the floodproofing methods are adequate to withstand the flood depths, pressures, velocities, impact and uplift forces and other factors associated with the base flood conditions expected at the building site.

(f) Other permits. The city, being a participant in the National Flood Insurance Program and subject to certain federal rules associated with that program; other federal rules and directives, and; subject to the statutes of the state, establishes the following methods to manage those laws and rules when applicable:

(1) *Floodplain and drainage management permit.* Prior to issuance of a building permit, a floodplain and drainage management permit shall be obtained. The application for a permit will be on forms provided by the

floodplain administrator and must include, but not be limited to, plans drawn to scale showing the nature, location, dimensions, and elevation of the area in question; existing or proposed structures, fills and excavations, drainage facilities, and; locations of the foregoing. The following information is required to be included in the application specifically:

a. In relation to mean sea level, existing ground elevations and proposed elevation of the lowest habitable floor for all structures including basements;

b. Proposed elevation in relation to mean sea level, to which any structure will be floodproofed;

c. Description of the extent to which any watercourse will be altered or relocated as a result of proposed development; and

d. Any certifications required by this ordinance, state law and federal rules.

(2) *Evidence of state and federal permits.* Prior to start of construction the developer must submit evidence to the director of project review that necessary state and federal permits have been obtained.

(Code 1972, § 5-615(C); Ord. No. 1993, 2-29-88)

Sec. 37-44. Obstruction of waterway—Prohibited.

No person in the city shall either obstruct or reduce the capacity of a watercourse by any use or by filling, dumping, or constructing or by any other means, except as provided in this article.
(Code 1972, § 5-618(A))

Sec. 37-45. Same—Removal of obstructions.

(a) Any person who owns, occupies, or leases real property within the city and who obstructs or reduces the capacity of a watercourse other than as provided for in this article, shall be deemed to have created a public nuisance. Such persons shall be notified in writing, either personally delivered or by certified or registered mail, return receipt requested, by the floodplain administrator or his authorized representative, to remove the obstructions or the materials creating the reduction of the capacity of a watercourse within ten (10) days after receipt of said written notice. If the owner does not reside on such property, a duplicate shall also be sent to him at his last known address.

(b) If the owner, lessee, or occupant of such real property, after having been given notice as required above, does not comply and abate such conditions which constitute a public nuisance, the floodplain administrator shall be authorized to abate such condition at the expense of such owner, lessee or occupant.

(c) The floodplain administrator, or his authorized representative, shall prepare a verified statement and account of actual cost of such abatement, including inspection and other incidental costs in connection with such abatement. Said verified statement and account is hereby declared as a debt of such owner, lessee, or occupant. A copy of said statement and account shall be personally delivered or delivered by certified mail, return receipt requested, to the party served with the original notice. The city attorney may institute an action to collect the debts so created in the superior court of the county at any time after delivery of the statement and account.

(d) Within ten (10) days after receipt of the notice described in subsection (a), any person may appeal the city's request by serving written notice of appeal upon the city clerk and shall be entitled to a hearing before the floodplain board on the appeal. In the event such an appeal is filed, all proceedings shall be stayed pending disposition of the appeal. Any person may also appeal to the floodplain board within ten (10) days after the receipt of the statement and account prepared and served pursuant to subsection (c) the amount of said debt by serving written notice of appeal upon the city clerk which also shall stay all further proceedings pending disposition of the appeal.

(e) When, in the opinion of the floodplain administrator, there is immediate danger to life or property, constituting an emergency, as the result of any obstruction or reduction of the capacity of a watercourse not authorized under this article, he may order the immediate abatement of said condition notwithstanding the notice provisions provided in subsection (a) of this section.

The cost of said abatement shall be collected in the same manner as other debts, as provided for in subsection (c) of this section.
(Code 1972, § 5-618(B); Ord. No. 1993, 2-29-88)

Sec. 37-46. Penalties.

Any person, corporation, partnership or association violating or failing to comply with the provisions of this article shall, upon conviction thereof, be guilty of a class 1 misdemeanor, or appropriate actions or proceedings to prevent such acts as may be filed in a court of competent jurisdiction.
(Ord. No. 1993, 2-29-88)

Sec. 37-47. Severability.

This article and the various parts thereof are hereby declared to be severable. Should any provision of this article be declared by the courts to be unconstitutional or invalid, such decision shall not affect the validity of the article as a whole, or any portion thereof, other than the provision so declared, to be unconstitutional or invalid.
(Ord. No. 1993, 2-29-88)

Sec. 37-48. Conflict.

This article shall take precedence over any conflicting ordinance of the city.
(Ord. No. 1993, 2-29-88)

Section 2.2
Hydrology and Drainage Report Preparation

Design Standards and Policies
Revised July 1996

Chapter 2
Drainage

City of Scottsdale, Arizona

Design Standards and Policies Manual
Chapter 2 of 7
Section 2 of 3

March 1994 Revisions:
p. 10; Figure 2.2-17; Sheet 3 of 4, Appendix B
July 1996 Revisions:
Section 2-203 E added, D updated; Section 2-202 C.1.a and 2-205 updated ref. for GIS Topo Maps and Floodplain Mapping Rgmts.; and Section 2.2 Title Change

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Section 2.2

Written by Collis Lovely, Drainage Planner
Drainage Planning Section
Transportation Department

City of Scottsdale, Arizona

Mayor and City Council

Sam Kathryn Campana, Mayor

Greg Bielli
Mary Manross
Robert Pettycrew
Donald Prior
Dennis Robbins
Richard Thomas

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Section 2.2

SECTION 2.2
HYDRLOGY AND DRAINAGE REPORT PREPARATION

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SECTION 2.2
HYDROLOGY AND DRAINAGE REPORT PREPARATION

2-201 INTRODUCTION

A. General Comments

This manual section describes the City's policies concerning hydrologic analysis procedures to be used in the City of Scottsdale for the planning and design of drainage and flood control facilities and the preparation of accompanying drainage reports. This manual contains recommended procedures, equations, data and basic assumptions which the planner or designer is generally required to use. If a situation is encountered in which the use of other methods or data in addition to or instead of those presented here are believed to be more appropriate, then City Drainage Planning staff should be consulted and advance approval must be received before using them. When methods or data not described in this booklet are used, the drainage report must include enough information to enable the City Staff to fully evaluate the applicability of the methods and data. If a computer program is used that the City does not have in its software library, the consultant must provide the City with a fully usable copy of the appropriate software, or show adequate comparisons with known procedures.

For flood control projects that are cost-shared with the Flood Control District of Maricopa County, the hydrologic design procedure contained in Vol. I, Hydrology of the Drainage Design Manual for Maricopa County must be used.

B. Goals and Objectives

The following are the basic goals and objectives used as a guide in preparing this manual:

1. Reflect current requirements of the City floodplain and drainage ordinance, as well as other City ordinances and applicable County, State or Federal regulations.

2. Use the best and most current data and methods available.

3. Provide guidance for hydrologic design methods that:

   a. reflect commonly accepted state of the art procedures;

   b. produce safe, reasonable results (within an acceptable range of values);

   c. gives flexibility to the designer while at the same time maintains a reasonable level of design consistency in order to facilitate design review;

   d. are not unnecessarily complex or confusing;

   e. does not require more detailed or complex input data than is commonly available;

   f. are technically and legally defensible;

   g. provide results that are consistent with adjacent jurisdictions, primarily the City of Phoenix, the Flood Control District of Maricopa County (FCDMC) and ADOT.

Because of our efforts to meet the above goals and objectives, some options in this manual differ slightly from adjacent jurisdictions, such as the Flood Control District of Maricopa County. However, results do not differ significantly. The sensitivity analysis conducted by Ward verified that results are consistent and within acceptable ranges of seven other methods and six different envelope curves. In addition, results were found to be comparable to: an envelope curve of one hundred year frequency peak discharge values for Maricopa County, prepared by ADWR; a preliminary plot of flood frequency data for USGS streamflow data from 64 gages located in the Central Region of Arizona, obtained from ADOT; and the sample problem in the FCDMC's Hydrology Manual.

C. Application and Limitations

The purpose of this manual is to provide a means of assisting in the prediction of runoff which might result from a design storm of a given return interval. However, the sensitivity analysis by Ward and the comparisons referred to above were by no means comprehensive in testing the entire range of possible conditions that may be encountered.

Hydrology is a discipline which requires not only technical competence but also experience and good judgement. The City does not warrant or guarantee the reliability of the hydrologic methods, techniques, and/or parameter values described herein. The user of this manual is thus expected to validate the reasonableness of the predicted values by: applying alternative methods or other appropriate checks which have been developed for this area. Failure to do so may result in erroneous values.

It is not the intent nor purpose of this manual to inhibit sound innovative design or the use of new techniques. Therefore as mentioned previously, where special conditions or needs exist, other methods and procedures may be used with prior approval.

It is anticipated that, over time, as more data becomes available and/or more appropriate techniques are developed, this manual will be revised. Such revisions will probably take place annually or as needed. If any inadequacies or inaccuracies are found with any of these procedures, they should be brought to the City's attention immediately.

D. Acknowledgments

The information and procedures that are presented in this manual are mainly the result of previously published efforts of many talented individuals. The author of this manual has made every effort to cite the original authors and researchers whose contributions to this manual, and to the science of hydrology, are gratefully appreciated.

The author of this manual is indebted to the many individuals and organizations, including the staff at City of Scottsdale that have supported this effort through recommendations, technical guidance, encouragement, and review of draft sections of this manual. In particular, the following people have provided immeasurable assistance without which this manual could not have been completed in this form. Those individuals, in alphabetical order, are:

Scott Buchanan, Stanley Consultants, Inc., Phoenix, AZ.
Greg Crossman, Drainage Planner, City of Scottsdale.
Bill Erickson, Drainage Planner, City of Scottsdale.
Richard Hawkins, University of Arizona, Tucson, AZ.
Ray Jordan, ADOT, Phoenix, AZ.
George Lopez-Cepero, ADOT, Phoenix, AZ.
James R. Morris, formerly with ADWR, Phoenix, AZ.
Herbert B. Osborn, Ph.D., P.E., (retired) Arid Lands. Watershed Management Research Unit, U.S. Department of Agriculture, Tucson, AZ.
Kenneth G. Renard, Ph.D., P.E., Arid Lands Watershed Management Research Unit, U.S. Department of Agriculture, USDA, ARS, Tucson, AZ.
Marilyn Suco, formerly City of Scottsdale.
Bob Ward, Consulting Engineer, Mesa, AZ.

2-202 DRAINAGE REPORT PREPARATION

A. Requirements for a Drainage Report

A drainage report is required by the City Floodplain and Drainage Ordinance to document the effect that a proposed project would have upon stormwater runoff in the vicinity of the project; to provide data to insure that the project is designed to be protected from flooding; and to provide data supporting the design of facilities to be constructed for the management of stormwater runoff. Each drainage report must consider runoff from storms with a return frequency up to and including a 100-year storm. The complexity of the report depends upon the nature of the project and the site on which the project will occur.

A drainage report must be prepared by a qualified professional drainage designer and sealed by a professional Civil Engineer registered in the State of Arizona. The design and drainage report must be prepared in accordance with the City's current Floodplain and Drainage Ordinance; the criteria and direction contained within Sections 2.1 - 2.3 of the Drainage Design Manual; and other applicable City policies and criteria. A drainage report shall be submitted by an applicant requesting one of the following:

- Approval of a subdivision plat (preliminary and final).
- A permit for grading, unless the requirement is waived by the Floodplain Administrator.
- A permit to construct right-of-way improvements.
- A permit to construct any structure, unless the structure is to be a single family residential structure without a basement in Flood Hazard Zones X, B, C, or D and is to be located at a site which the Floodplain Administrator has determined will not be in the vicinity of a watercourse in which the flow of rainfall runoff might be hazardous to the structure or its occupants.
- Zoning case approval.
- Development review case approval.

B. The Purpose of a Drainage Report

The purpose of a drainage report is to document that stormwater runoff has been considered in the planning of each project and that the public and its property will be protected from damage by runoff flows and flooding. The requirement for this protection not only applies to those who will own and/or use a proposed project but also to those who own or occupy property adjacent to or near enough upstream or downstream to be affected by the proposed project.

C. Six Elements of a Drainage Report

There are six elements of a drainage report which normally must be present to demonstrate that the effects of stormwater runoff have been considered and that the runoff will be properly managed by the project. Subparagraphs 1, 2, 3 and 6, below, are elements found in "conceptual" or "master reports;" and subparagraphs 4 and 5, below, could be submitted as supplemental reports to support design choices shown on construction plans. There will, of course, be cases when one or more of these elements would not be applicable, and there could be special projects requiring analysis or information not covered in these six elements. The six elements are described in the following subparagraphs. In addition, refer to the Drainage Report Outline Checklist in section 2-205 for specific items that might be included within a drainage report; and section 2-206 for Master Drainage Plan Requirements.

1. Description of the Property and the Watersheds:
   Each drainage report must have a section which includes a narrative, topographic maps and aerial photographs that describes the location and condition of the property the project is located on (on-site conditions) and the upstream (off-site) watersheds as well as any downstream constraints which affect the property.

   a. On-site Conditions: An essential part of each report is a topographic map which shows the location of the project area. As a minimum the City GIS quarter-section topographic maps with either a 1 foot or 2 foot contour interval must be used as the base map. The map need not be elaborate, but it must show the location of the property with respect to the street system and other features such as the Arizona Canal or the CAP Aqueduct. A City of Scottsdale 400 scale Existing Drainage Network aerial photograph (the most current available) must accompany each drainage report which shows existing on-site drainage conditions on the property. The narrative description should include the following basic information about the property, as applicable:

      - Description of existing drainage patterns including natural and man-made channels and watershed boundaries on the property.

      - Mapping of the 100 year floodplain for washes with a capacity of 50 cfs or greater in ESL areas of the City and 25 cfs in the remainder of the City.

      - Description of the existing ground cover conditions and the identification of the SCS hydrologic soil group(s) or appropriate Green-Amp soil characteristics found on the property.

      - Description of how existing development located on the property affects drainage.

      - Description of how existing and/or proposed developments on adjacent properties affect drainage on the project area.

b. Off-site Watershed Conditions: Watersheds above the project area from which stormwater runoff enters or affects the project's property must be delineated on topographic maps. These maps should be prepared at a scale which will clearly show the drainage areas so that the watershed boundaries can be drawn with accuracy. Contour lines should be shown on the maps at an interval appropriate to the ground slope and complexity of the terrain. Recent aerial photographs of every part of the City are available at scales 1 inch = 100; 400; and 800 feet. An aerial photograph(s) of appropriate scale, the most current available, must be included in each drainage report which shows the off-site watershed areas and adjacent properties in relation to the project site.

The narrative description should include the following things:

- Existing upstream and downstream drainage patterns on the watersheds.
- The natural ground cover and the SCS hydrologic soil group(s) or Green Ampt soil classes found on the watersheds.
- Existing development on the watersheds and how this affects drainage.
- The location and type of development that would exist on the watersheds if the land were developed in accordance with the Land Use Element of the current General Plan for Scottsdale as approved by the City Council, and the probable effect of this project on drainage.
- Any condition which would significantly affect the way the runoff from the watershed would be analyzed.

2. Estimation of Stormwater Runoff:
The report must provide estimates for selected storm return frequencies of peak stormwater runoff rates at concentration points entering and leaving the property, or site, from on-site, as well as Off-site, watershed areas. (See paragraphs under 2-203.) In addition, the report must include estimates of stormwater runoff volumes from the project area or development site that are required to be stored on-site in accordance with City Ordinance requirements. (See paragraphs 2-203)

3. Evaluation of the Effects of The Project:
The report must show how stormwater runoff will be handled when the project has been completed and how the project will affect stormwater runoff.

Depicting Pre- and Post-Project Topography: Prior to the project or development of a piece of property, topographic conditions exist on the property which will influence and direct the flow of drainage water which enters the property from watersheds above it or which originates on the property. When the project has been completed, certain topographic changes will have occurred which influence the drainage flows and resulting time of concentration. It is necessary that the drainage report include sufficient pre- and post-project topographic information to demonstrate the effects of the project. This information should be depicted on contour maps. In addition to showing the developer's property, these maps should also show enough of the adjacent property to give a clear picture of what exists, what will affect drainage, and what will be affected by drainage on the property being developed. Information about adjacent property, such as significant differences in elevation, walls, drainage structures, buildings with their floor elevations, etc. must be included.

Pre- and Post-Project Stormwater Runoff: The amount and type of stormwater runoff that would exit the property prior to the project and after the project must be depicted for a 2-year, a 10-year and a 100-year storm. If, as a result of the project, drainage flows will be reduced by facilities such as retention or detention basins, the effect of these facilities on flows exiting the property should be described and depicted on appropriate maps. Construction of roads, parking areas, roofs, channels, and other project features generally increases the runoff volume and peak discharge and reduces the time of concentration.

4. Presentation of the Basis for Design of Facilities to Manage Runoff:
   This presentation includes a summary of the design criteria used, a brief description of the design approach and methods used. The sketches, data, and calculations which support the selection of materials, the locations, and design of facilities should be included in the Appendix. (See Section 2.1 for design criteria and policy guidance and Section 2.3, Hydraulics, for design guidance of the specific drainage facility.)

5. Presentation of the Basis for Selecting Elevations for the Lowest Floor:
   Elevations must be selected to provide protection from flooding. The basis for the selection of a floor elevation or the design of protection for the interior of the building must be presented. (See Manual Sections 2.1 and 2.3)

6. Description of the Provisions for Project Phasing:
   Any project, particularly a large one, may have stormwater runoff, flooding, and erosion problems during the construction phases which would not exist after the project has been completed. The report must indicate how the phasing will occur, what interim drainage problems are anticipated, and what must be done to alleviate these problems.

   As of October 1, 1992, the National Pollutant Discharge Elimination System (NPDES) General Permit for stormwater discharges requires all owners/operators of construction projects disturbing five or more acres to prepare a Storm Water Pollution Prevention Plan (SWPPP) and file a Notice of Intent (NOI). The NOI must be sent to the United States Environmental Protection Agency with a copy to the city of Scottsdale 48 hours before construction begins (The city must have evidence of this permit before a development permit will be issued). The goal of this NPDES storm water permit for construction activities is to reduce erosion potential, minimize sedimentation, and to eliminate non-stormwater discharges for construction sites.

2-203 METHODS FOR ESTIMATING PEAK DISCHARGE

A. Introduction

Two methods are defined for the determination of peak discharges: the Rational Method, and rainfall-runoff modeling using the U.S. Army Corps of Engineers' HEC-1 Flood Hydrograph Package. For small watersheds, less than 160 acres the Rational Method is acceptable. For smaller watersheds that are non-uniform, irregular in shape, or when routing of flows are necessary, or for areas larger than 160 acres, HEC-1 modeling is required.

The City's procedures parallel those contained in the FCDMC's Hydrology Manual for Maricopa County. Scottsdale uses a six hour duration storm event. However, Scottsdale uses the original source data, NOAA Atlas II for precipitation data, and the storm distribution pattern built in HEC-1. A detailed analysis of various methodologies conducted by Robert L. Ward tested and verified that the results using the following HEC-1 methods are comparable to those of the FCDMC and others.

B. Watershed Conditions

When a peak runoff flow rate is to be used in determining the size of a drainage management facility (culverts, channels, etc.) or in determining the protection to be provided from possible flooding (lowest floor elevation, flood-proofing, etc.), the flow rate must be estimated by considering the watershed to be at a state of development which would produce the greatest peak flow rate. Usually a watershed which is fully developed in accordance with the City's General Plan Land Use Element will produce such conditions but other interim conditions such as the watershed's current state or its development in accordance with existing zoning may produce a greater peak flow rate and must be considered. Comments should be included in the report indicating the conditions considered and the choice of the watershed conditions used to calculate the peak flow rates.

C. The Rational Method

The Rational Method is limited to use on small, uniform, regularly shaped watersheds less than or equal to 160 acres in size.

$Q=C\ I\ A\ F$

Q = the peak discharge rate in cubic feet per second;
C = a dimensionless runoff coefficient (Figure 2.2-17);
I = the rainfall intensity in inches per hour;
A = the watershed area in acres.
F = a frequency adjustment factor (per FCDMC, Hydrology Manual, 6-92)

The Rational Method generates an instantaneous peak discharge rate in cubic feet per second. It does not generate a runoff hydrograph and cannot be used to determine runoff volumes. Calculations must be submitted on figure 2.2-18 or a similar form containing the same data and information. Frequency adjustment factors are included in Figure 2.2-18.

PRECIPITATION: precipitation data is not required; rainfall intensity (I) is obtained directly from Figure 2.2-13, which applies Citywide. The time of concentration (Tc), which is assumed to equal "Duration" in the rational method, is all that is required to determine "I" from Figure 2.2-13.

TIME OF CONCENTRATION (Tc): Time of concentration is the total time of travel from the most hydraulically remote part of the watershed to the concentration point of interest. Figures 2.2-14 and 2.2-15 can be used to estimate flow velocity for calculating the time of travel. Procedures from Chapter 3 of SCS's TR-55, contained in Appendix B, are recommended for determining Tc. The minimum time of concentration that should be used is five minutes.

CAUTION: Natural land slopes are too steep and variable in Scottsdale to add a set amount of time for lot runoff. Analyze delays from lot runoff as overland flow or sheet flow. Use the lot's size and slope to determine the actual time of travel across the lot. **Do not automatically add an additional set amount of time to the estimated TC for lot runoff delay (such as 5 or 10 minutes).**

RUNOFF COEFFICIENTS: Figure 2.2-17 must be used to obtain "C" values. Composite "C" values for the appropriate zoning category or weighted average values calculated for the specific site, are both acceptable approaches.

CAUTION: HEC-1 procedures (which are required on areas greater than 160 acres in size) instead of the Rational Method are recommended on areas between 40 and 160 acres in size if the watershed is non-uniform, irregular in shape, or if routing of flows is necessary.

D. The Corps of Engineer's HEC-1 Computer Model

HEC-1 procedures are applicable for any watershed area over 40 acres and up to 100 square miles in size; and is required for analyzing drainage areas over 160 acres in size. Minimum required submittals if using HEC-1 is a printout of: the input data; a schematic diagram of the stream network; the runoff summary output table; and a diskette with the input file(s).

PRECIPITATION: The required precipitation input is the six hour duration storm using the model's built in hypothetical storm distribution pattern input using the PH record.

Precipitation values are to be obtained from the Isopluvial maps (figures 2.2-1 through 12) for the specific frequency desired. The 5, 15, 60 120,180, and 360 (6 hour) minute duration rainfall amounts should be calculated per the formulae and procedures in Appendix A.

INFILTRATION: Infiltration or Soil losses can be determined using SCS Runoff Curve Numbers (Use Figures 2.2-19 and 2.2-20) or Green and Ampt (G&A) procedures per FCDMC Hydrology Manual. Use the most recent published SCS soil survey maps of the area to determine the hydrologic soil group or surface soil texture for the G&A procedures. Use USDA Soil Conservation Services maps, Soil Survey of Aquila-Carefree Area, Parts of Maricopa and Pinal Counties, or the Soil Survey of Eastern Maricopa and Northern Pinal Counties, Arizona depending on what part of the City you are located in. The simplified map on Figure 2-14 of the old City manual is not sufficiently detailed and is superceded by the above soil maps.

RUNOFF CURVE NUMBERS: When using runoff curve numbers (ROCN) within the City of Scottsdale one must:

- Assume poor hydrologic condition and desert shrub cover type for natural undisturbed desert conditions in Figure 2.2-20.
- For lawns, golf courses, and other grassed open space areas, assume good condition in Figure 2.2-19 to determine the ROCN, then adjust the ROCN to antecedent moisture condition III (use Figure 2.2-21).

- For developed conditions, increase the percent impervious on the LS card without changing the ROCN (except in the case of grassed areas, in which the curve number should be adjusted up according to the above). Obtain the percent impervious from Figure 2.2-16 for residential districts or use actual amount. For commercial or industrial districts use the actual or estimated percent impervious. A minimum of 85 percent for commercial and 72 percent industrial must be used.

HYDROGRAPH GENERATION: Small basin or sub-watershed hydrographs can be generated using the SCS dimensionless unit hydrograph procedure or kinematic wave method as described in the HEC-1 Users Manual. Computation time interval should generally range from 5 to 1 minute.

TIME OF CONCENTRATION (Tc): Use the estimated time of travel, from the most hydraulically remote part of the watershed to the concentration point. The procedures from Chapter 3 of SCS's TR-55 (contained in Appendix B) are recommended for obtaining Tc. **CAUTION:** For the SCS method, remember TLAG on the UD input card is equal to .6(Tc), not Tc.

CHANNEL ROUTING: Channel routing should use the Normal Depth (Modified Puls), eight point routing procedure as described in the HEC-1 Users Manual.

CAUTIONS: For the 1990 version of the HEC-1 program do not use the Kinematic wave method with the multi-ratio JR cards, hydrographs do not combine properly. For the 1988 version don't use JD cards with the Green-Ampt method, as errors will result. HEC-1 versions prior to the 1988 version are unacceptable.

E. Pre versus Post Development Discharge Analysis Procedures

The following HEC-1 analysis procedures must be used when it is necessary to establish a comparison of pre development to post development discharge (runoff) conditions.

1. HEC-1 modeling procedures already described in Section 2-203 must be followed.

2. Reflect fully developed conditions per section 2-203C.3, by:

   a. Increasing the percent impervious on the LS card to reflect the amount of impervious surfaces that will exist under fully developed conditions.

   b. Recalculate the time of concentration (Tc) based on the proposed drainage system, after full development. (There should be a reduction in Tc.)

3. The existing condition model must be sub-divided, as necessary, to create concentration points which will match the subwatershed areas above each proposed storage facility under fully developed conditions.

4. Each separate storage facility proposed must be modeled as it will physically exist under fully developed conditions with appropriate routing and combining operations through each basin and through the entire watershed. Modeling of storage capacity provided, as one hypothetical reservoir at the outlet with all the upstream storage arbitrarily combined at this one location is not acceptable.

5. As a minimum the 2, 10 and 100 year frequency events should be analyzed.

6. Comparison of discharge values for existing and post development conditions must be made at concentration points just downstream from each proposed storage facility; other critical locations such as road crossings; and at points where flows exit the proposed development.

2-204 CALCULATION OF RUNOFF VOLUMES

The only method for the determination of the required volume of stormwater storage is the standard formula in 2-204-A. HEC-1 modeling can be used for storage basin design and analysis (2-204-B) or if a pre-versus post volume difference is needed. The current citywide ordinance requirement is to provide on-site storage for runoff from the 2-hour 100-year frequency event, as described below, and in Section 2.1 of the City of Scottsdale Drainage Design manual.

A. The Standard Formula

$$Vr=(P/12)\,AC$$

Vr = Storage volume in acre feet.

P = Precipitation Depth = 2.82 inches, the 100 year 2 hour duration rainfall depth in inches (applies citywide).

A = Area in acres; the developed portion of the entire site in acres, to the centerline of adjacent streets, on which any man-made change is planned, including, but not limited to: construction, excavation, filling, grading, paving, or mining. See the Stormwater Storage Policy Statement in Section 2.1.

C = Runoff Coefficient; rational method values from Figure 2.2-17, either composite or weighted.

B. HEC-1 Computer Modeling

The HEC-1 model is not to be used to determine the ordinance required 2-hour 100-year stormwater storage runoff volumes. The HEC-1 model is, however, recommended for use in storage routing for storage basin design and analysis purposes; or for a pre versus post analysis (which must use a six hour storm and procedures described under Section 203). Use modified Puls level pool routing option in HEC-1 for hydrograph routing through storage basins and lakes. For permanent lakes, assume no available storage below the normal water surface.

CAUTION: do not use the built in orifice equation in the HEC-1 model, errors can result. Build your own stage discharge table and input to the model.

2-205 GENERAL OUTLINE CHECKLIST FOR DRAINAGE REPORTS

Title: Preliminary or Final Drainage Report or Master Drainage Plan

1. Introduction
   - Project Name
   - Project Type
   - Size
   - Location

   - Exhibit: Vicinity Map.

2. Objectives
   - Describe the type of report and purpose: Preliminary, Final, Master Plan.

3. Description of Drainage Characteristics
   - On-site Property.
     -Existing drainage network, patterns, and watershed and floodplain boundaries.
   - Off-site Watersheds.
     -Existing conditions and characteristics.
     -Future planned conditions if different from existing.
   - Off-site drainage network entering and leaving the project site.
   - Relation to existing Master Plans and adjacent drainage plans above and below the project.
   - Classification by the FIRM maps.

   - Exhibits:
     Off-site Watershed Map:
     -USGS 7.5 min. quads and city 800 scale aerial photos.
     Existing On-site Drainage Map including Mapped 100 year Floodplains:
     -Include as a minimum City's existing drainage network 400 scale aerials and G.I.S. 100 scale 1ft. or 2ft. contour interval topographic quarter section maps.

4. Proposed Drainage Plan
   - General description of proposed drainage system and components, including design criteria and probable effect on the existing upstream and downstream drainage system.
   - Pre and post runoff characteristics at key concentration points.
   - Stormwater storage requirements, volume required, volume provided, and location.
   - Major drainage structures or special drainage facilities needed.
   - Exhibits: Proposed On-site Drainage Plan:
     -Scale appropriate to type of drainage report and size of the project.
   - Tables: Pre vs Post Development Peak Flows and Retention Volumes.

5. Data Analysis Methods
   - Hydrologic procedures and assumptions.
   - Hydraulic procedures, methods, and assumptions.
   - Stormwater storage calculation methods and assumptions.

6. Summary and Recommendations (Optional)

7. References or Bibliography (Optional)

Appendix

Data and Calculations (as applicable)
- Peak Flow Calculations (figure 2.2-18 data records; or HEC-1 printouts)
- Channel Design Calculations
- Culvert Design Calculations
- Floodplain Calculations (Manning's or HEC-2 printouts)
- Storage Volume Calculations
- Retention/Detention Basin Inflow-Outflow Analysis and Design Calculations
- Street Capacity Calculations
- Curb Opening, Catch Basin Calculations
- Storm Drain Calculations
- Special Problem Calculations
- Sediment and Scour Calculations

Where applicable these additional sections may be required:
- Finished Floor Elevations
  -In relation to designated floodplains
  -In relation to natural ground elevation if not in floodplain
  -Basis for setting elevations
- Special Interim Measures
  -Construction Phasing
  -Erosion/Sediment Control Plan
- Discharge and Fill Permit Requirements
  (COE 404 Permit if filling or cutting below normal high water mark)

2-206 MASTER DRAINAGE PLAN CHECK LIST (Page 1 of 2)

This checklist is to assist in submitting a complete and successful Master Drainage Plan to the City of Scottsdale. The following items on this list are required with your submittal.

Master Plan#_____-MP-_____ Title_____

PART I - GENERAL REQUIREMENTS

_____1. Master Drainage Plan Check List (this list).

_____2. Master Plan Review Fee $_____.

_____3. Six (6) copies of the approved Master Drainage Plan Report, two (2) copies to initiate the review process.

PART II - REQUIRED PLANS AND RELATED DATA

Each Master Drainage Plan Report submittal shall include the following items:

DESCRIPTION OF PROJECT

_____1. Project Name.

_____2. Location.

_____3. Description of the type and scope of project.

_____4. Size.

_____5. Vicinity Map.

DESCRIPTION OF ON-SITE DRAINAGE CHARACTERISTICS

_____1. COS Drainage Aerial Photograph 400 scale, (clearly identifying project location) - 30" x 30".

_____2. Topographic Map, 100 scale 1 foot contour interval, 24" x 36".

_____3. Show key concentration points with Q100 year peak discharges.

_____4. Show watershed boundaries.

_____5. Show floodplain boundaries for all washes were Q100 year is 250 cfs or greater.

_____6. Describe existing onsite drainage characteristics.

DESCRIPTION OF OFF-SITE WATERSHED CONDITIONS

_____1. City 800 scale aerial photos.

_____2. City G.I.S. 2 ft. contour interval topographic maps, if available, otherwise USGS 7.5 quads.

_____3. Show drainage concentration points entering and leaving the project site.

_____4. Describe existing drainage conditions and characteristics and any future planned projects.

_____5. Describe relation to existing Master Plans and adjacent drainage plans.

PROPOSED MASTER DRAINAGE PLAN (Page 2 of 2)

_____1. Proposed on-site drainage plan: Scale 1 inch equals 100 feet, one foot contour intervals, 24" x 36".

_____2. Site development plan 24" x 36".

_____3. Show peak discharge values Q100 year at key concentration points.

_____4. Show and describe major drainage structures or special drainage facilities needed.

_____5. Describe proposed drainage system and components, including design criteria and probable effect on the existing upstream and downstream drainage system.

_____6. Describe ordinance stormwater requirements, volume required, volume provided, and location.

DATA ANALYSIS METHODS

_____1. Describe hydrologic procedures and assumptions.

_____2. Describe hydraulic procedures, and assumptions.

_____3. Describe stormwater storage calculation methods and assumptions.

DATA AND CALCULATIONS

_____1. Peak flow calculations (Figure 2.2-18 data records; or HEC-1 printouts).

_____2. Channel design calculations.

_____3. Culvert design calculations.

_____4. Floodplain calculations (Manning's or HEC-2 printouts).

_____5. Storage volume calculations.

_____6. Retention / detention basin inflow-outflow analysis and design calculations.

PART III - MASTER DRAINAGE PLAN REPORT FORMAT

The following chapters should include the data and exhibits listed above in Part II. See 2-202 and 2-205 in section 2.2 of the City's Design Standards and Policies Manual for additional guidance for Report Preparation.

_____1. Project Description.

_____2. On-site Drainage Characteristics.

_____3. Off-site Watershed Conditions.

_____4. Proposed Master Drainage Plan.

_____5. Project Phasing Plan.

_____6. Data and Calculations (Appendixes).

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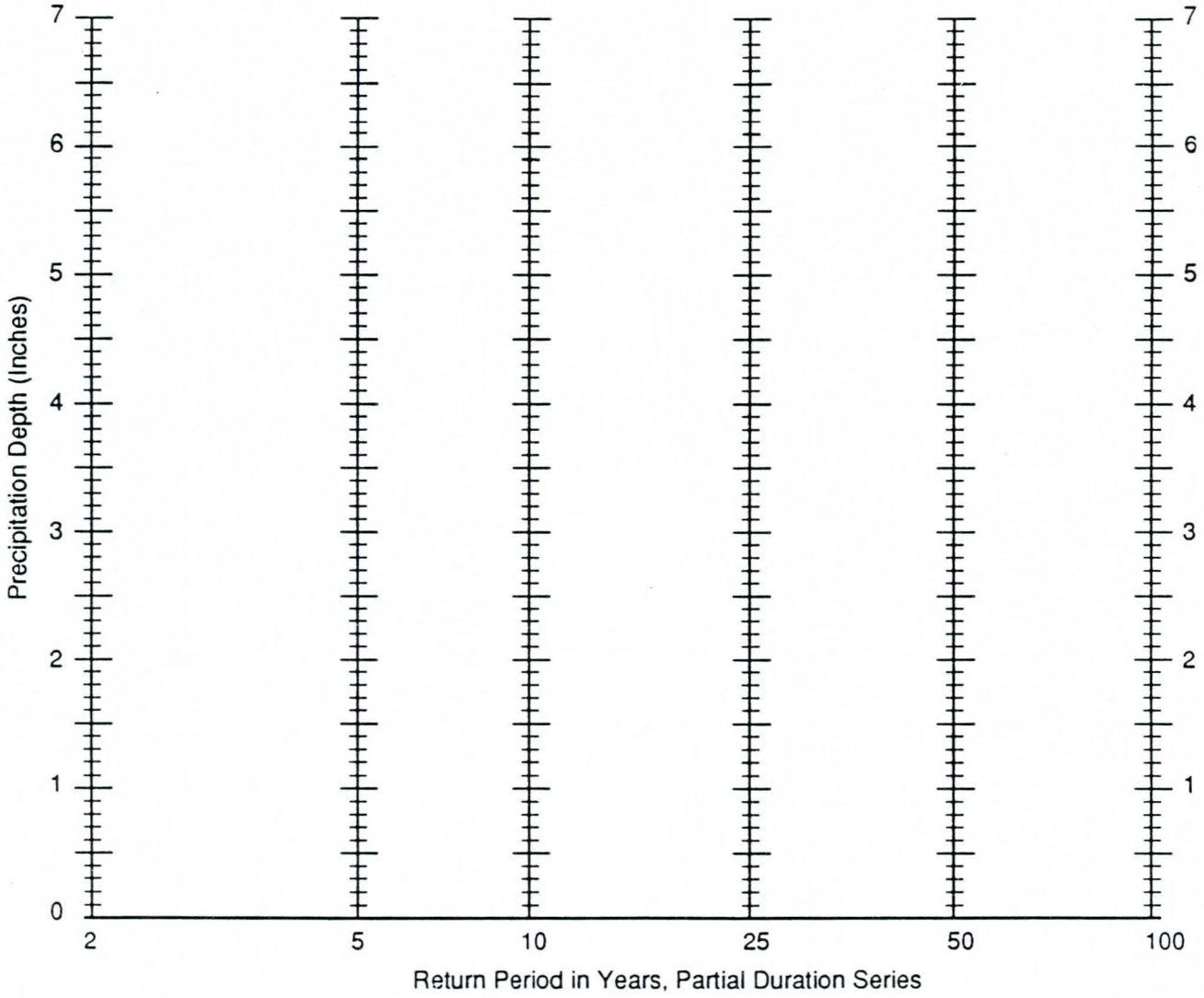
APPENDIX A

Figure 1
Precipitation Depth Versus Return Period for Partial - Duration Series
Sheet 2 of 3
(Source: Addendum to "Hydrologic Design for Highway Drainage in Arizona," April 1975)



Project: _____ Station: _____

APPENDIX A

Steps for Determination of Precipitation Values for Various Durations and Return Periods.

Sheet 3 of 3

(Source: Addendum to "Hydrologic Design for Highway Drainage in Arizona," April 1975, and ADOT April 17, 1987)

Step 5: Using the 6 and 24 hour values for the 2 year and 100 year return periods, from Table 1 (corrected values), solve the following equations to determine the 1 hour values:

$$Y_2 = -0.011 + 0.942(X_1^2 / X_2)$$

$$Y_{100} = 0.494 + 0.755(X_3^2 / X_4)$$

Where: Y_2 = 2 year 1 hour value
Y_{100} = 100 year 1 hour value
X_1 = 2 year 6 hour value from Table 1
X_2 = 2 year 24 hour value from Table 1
X_3 = 100 year 6 hour value from Table 1
X_4 = 100 year 24 hour value from Table 1

Step 6: To determine 1 hour precipitation values for the other return periods, first plot the 2 year 1 hour value and the 100 year 1 hour value on Figure 1. Connect the two points by a straight line. The values on this line will give the 1 hour precipitation values for the various return periods.

Step 7: To determine the 2 and 3 hour precipitation values, use the following formula with data far the appropriate return period from Table 1 (corrected values):

$$P_{2\ hour} = 0.341\ (P_{6\ hour}) + 0.659\ (P_{1\ hour})$$
$$P_{3\ hour} = 0.569\ (P_{6\ hour}) + 0.431\ (P_{1\ hour})$$

Step 8: The 12 hour precipitation value for any return period is determined by the following equation:

$$P_{12hr} = 0.49\ P_{24\ hour} + 0.51\ P_{6\ hour}$$

Step 9: To determine precipitation values for durations less than 1 hour for any return period, multiply the 1 hour depth by the following ration:

Duration (minutes) :	5	10	15	30
Ratio to one hour*:	.34	.51	.62	.82

*From Arkell and Richards (1986) per FCDMC's Hydrology Manual (9-90)

APPENDIX B

SCS TR55's Time of Concentration and Travel Time.
Sheet 1 of 4

Introduction

Travel time (T_t) is the time it takes water to travel from one location to another in a watershed. T_t is a component of time of concentration (T_c), which is the time for runoff to travel from the hydraulically most distant point of the watershed to a point of interest within the watershed. T_c is computed by summing all the travel times for consecutive components of the drainage conveyance system.

T_c influences the shape and peak of the runoff hydrograph. Urbanization usually decreases T_c, thereby increasing the peak discharge. But T_c can be increased as a result of (a) ponding behind small or inadequate drainage systems, including storm drain inlets and road culverts, or (b) reduction of land slope through grading.

Factors affecting time of concentration and travel time

Suface roughness

One of the most significant effects of urban development on flow velocity is less retardance to flow. That is, undeveloped areas with very slow and shallow overland flow through vegetation becomemodified by urban development: the flow is then delivered to streets, gutters, and storm sewers that transport runoff downstream more rapidly. Travel time through the watershed is generally decreased.

Channel shape and flow patterns

In small non-urban watersheds, much of the travel time results from overland flow in upstream areas. Typically, urbanization reduces overland flow lengths by conveying storm runoff into a channel as soon as possible. Since channel designs have efficient hydraulic characteristics, runoff flow velocity increases and travel time decreases.

Slope

Slopes may be increased or decreased by urbanization, depending on the extent of site grading or the extent to which storm sewers and street ditches are used in the design of the water management system. Slope will tend to increase when channels are straightened and decreased when overland flow is directed through storm sewers, street gutters, and diversions.

Computation of travel time and time of concentration

Water moves though a watershed as sheet flow, shallow concentrated flow, open channel flow, or some combination of these. The type that occurs is a function of the conveyance system and is best determined by field inspection.

Travel time (T_t) is the ratio of flow length to flow velocity:

$$T_t = \frac{L}{3600\ V} \quad \text{(Eq. \#1)}$$

Where:
T_t = travel time (hr.),
L = flow length (ft.),
V = average velocity (ft/s), and
3600 = coversion factor from seconds to hours.

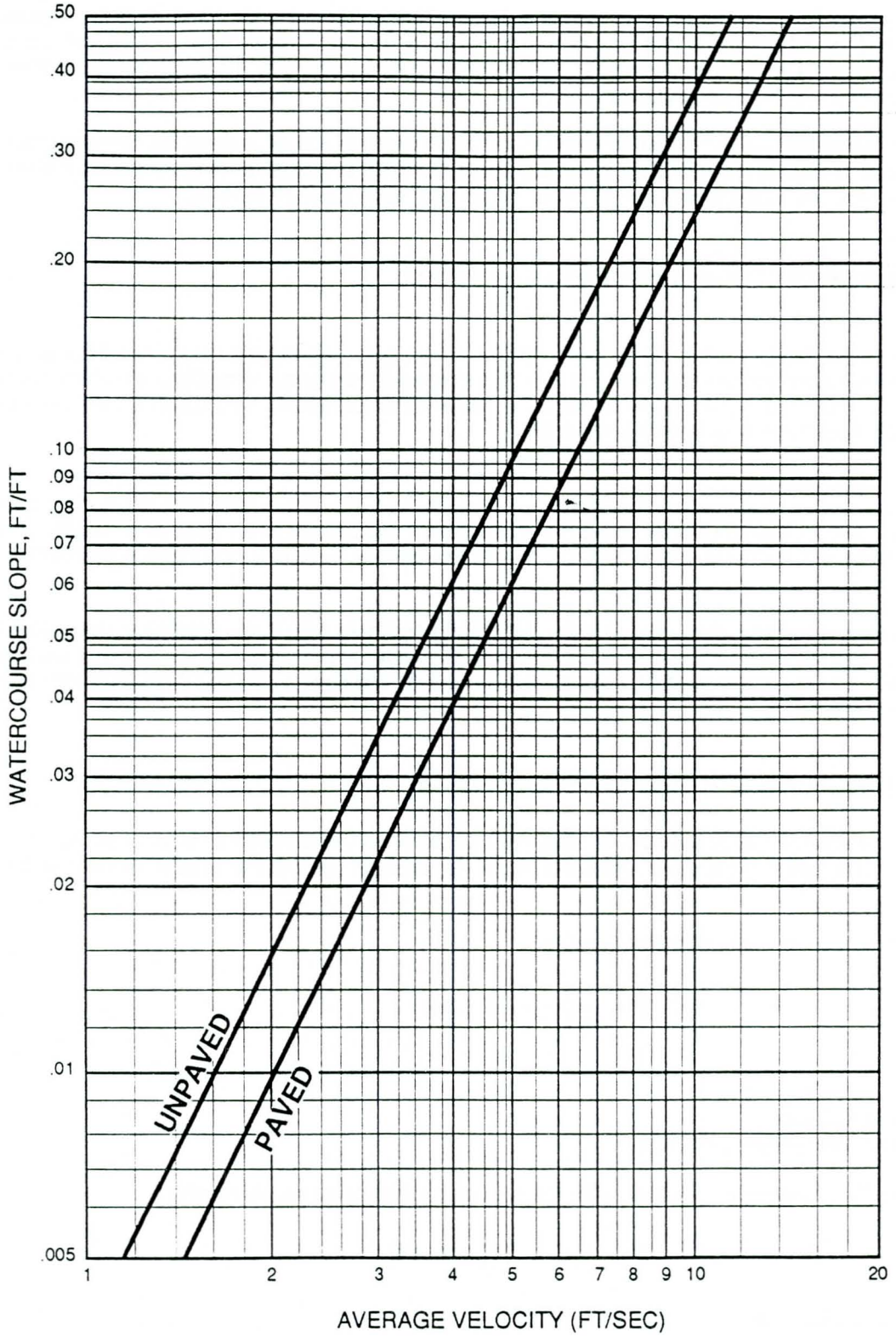
Time of concentration (T_c) is the sum ot T_t values for the various consecutive flow segments:

$$Tc = T_{t1} + T_{t2} + \ldots T_{tm} \quad \text{(Eq. \#2)}$$

Where:
T_c = time of concentration (hr) and
m = number of flow segments.

APPENDIX B

Figure B-1
Average Velocity for Estimating Travel Time for shallow Concentrated Flow
Sheet 2 of 4



Source: TR-55, Fig. 3-1

APPENDIX B

SCS TR55's Time of Concentration and Travel Time.
Sheet 3 of 4

Sheet Flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. The following table gives Manning's n values for sheet flow for various surface conditions.

Table B-1
Roughness coefficients (Manning's n) for sheet flow:

Surface Description	n[1]	Surface Description	n[1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011	Grass:	
Fallow (no residue)	0.05	Short grass prairie	0.15
Cultivated soils:		Dense grasses[2]	0.24
Residue cover ≤20%	0.06	Bermudagrass	0.41
Residue cover >20%	0.17	Woods[3]:	
Range (natural)	0.13	Light underbrush	0.40
		Dense underbrush	0.80

[1]The n values are a composit of information compiled by Engman (1976)
[2]Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures
[3]When selecting n, consider cover to a height of about 0.1ft. This is the only part of the plant cover that will obstruct sheet flow.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overton and Meadows 1976) to compute T_t:

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P_{10})^{0.5}\,(S)^{0.4}} \quad \text{(Eq. \#3)}$$

Where:
T_t = travel time (hr),
n = Manning's roughness coefficient (from Table B-1)
L = flow length (ft)
P_{10} = 10-year, 6 hour rainfall (in), and
S = slope of hydraulic grade line (land slope, ft/ft)

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. (The above formula and assumptions were modified for use in Scottsdale based on: rainfall duration is 6 hours; and bankfull flow is a 10 year frequency event.)

Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from Figure B-1, in which average velocity is a function of watercourse slope and type of channel. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in Figure B-1, use equation #1 to estimate travel time for the shallow concentrated flow segment.

Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usally determined for bank-full elevation (assume 10 year frequency event in Arizona desert).

APPENDIX B

SCS TR55's Time of Concentration and Travel Time.
Sheet 4 of 4

Manning's equation is:

$$V = \frac{1.49 r^{2/3} s^{1/2}}{n} \quad \text{(Eq.\#4)}$$

Where:
V = average velocity (ft/s)
r = hydraulic radius (ft) and is equal to a/p_w
a = cross sectional flow area (ft^2)
p_w = wetted perimeter (ft)
s = slope of the hydraulic grade line (channel slope, ft/ft)
n = Manning's roughness coefficient for open channel flow

Manning's n values for open channel flow can be obtained from standard textbooks such as Chow (1959) or Linsley et al. (1982). After average velocity is computed using equation #4, T_t for the channel segment can be estimated using equation #1.

Reservoirs or lakes

Sometimes it is necessary to estimate the velocity of flow through a reservoir or lake at the outlet of a watershed. This travel time is normally very small and can be assumed as zero.

Limitations

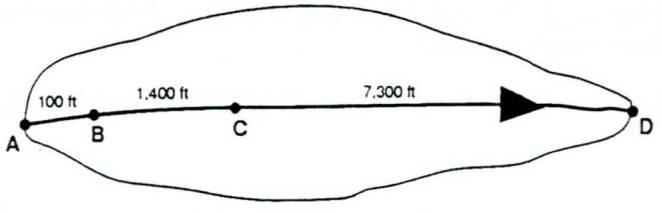
- Manning's kinematic solution should not be used for sheet flow longer than 300 feet. Equation #3 was developed for use with the four standard rainfall intensity-duration relationships (used in TR-55).

- In watersheds with storm sewers, carefully identify the appropriate hydraulic flow path to estimate T_c. Storm sewers generally handle only a small portion of a large event. The rest of the peak flow travels by streets, lawns, and so on, to the outlet. Consult a standard hydraulics textbook to determine average velocity in pipes for either pressure or nonpressure flow.

- The minimum T_c used in TR-55 is 0.1 hour.

Example

The sketch below shows a sample watershed. The problem is to compute T_c at the outlet of the watershed (point D). All three types of flow (overland sheet flow, shallow concentrated flow, and channel flow) occur from the hydraulically most distant point (A) to the point of interest (D). To compute T_c, first determine T_t for each segment, then sum all three T_t's to obtain the watershed or sub-area T_c.



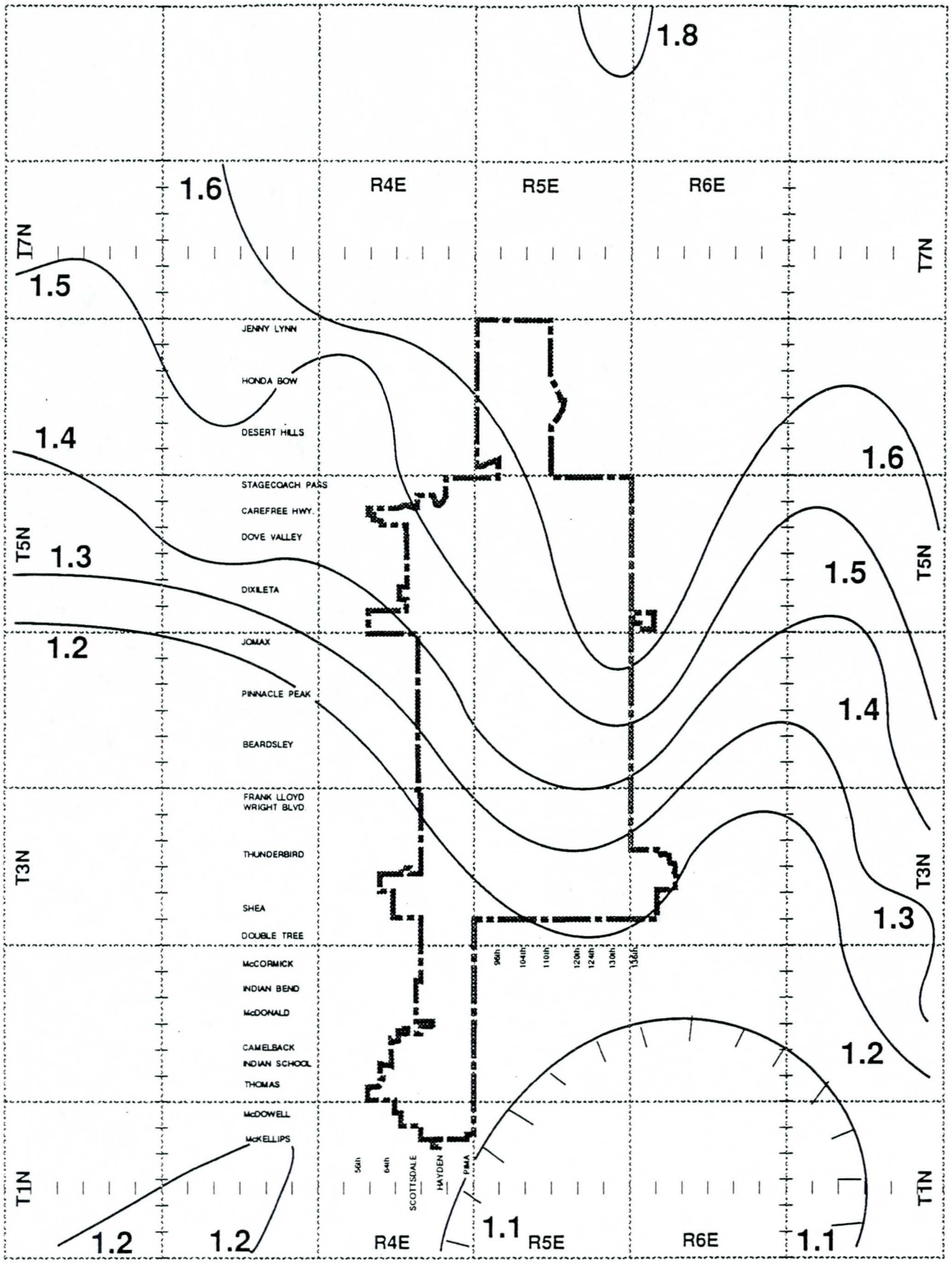


FIGURE 2.2-1

Isopluvials 2 Year 6 Hour Precipitation in Inches

Rainfall Data From NOAA Atlas 2, Vol. VIII

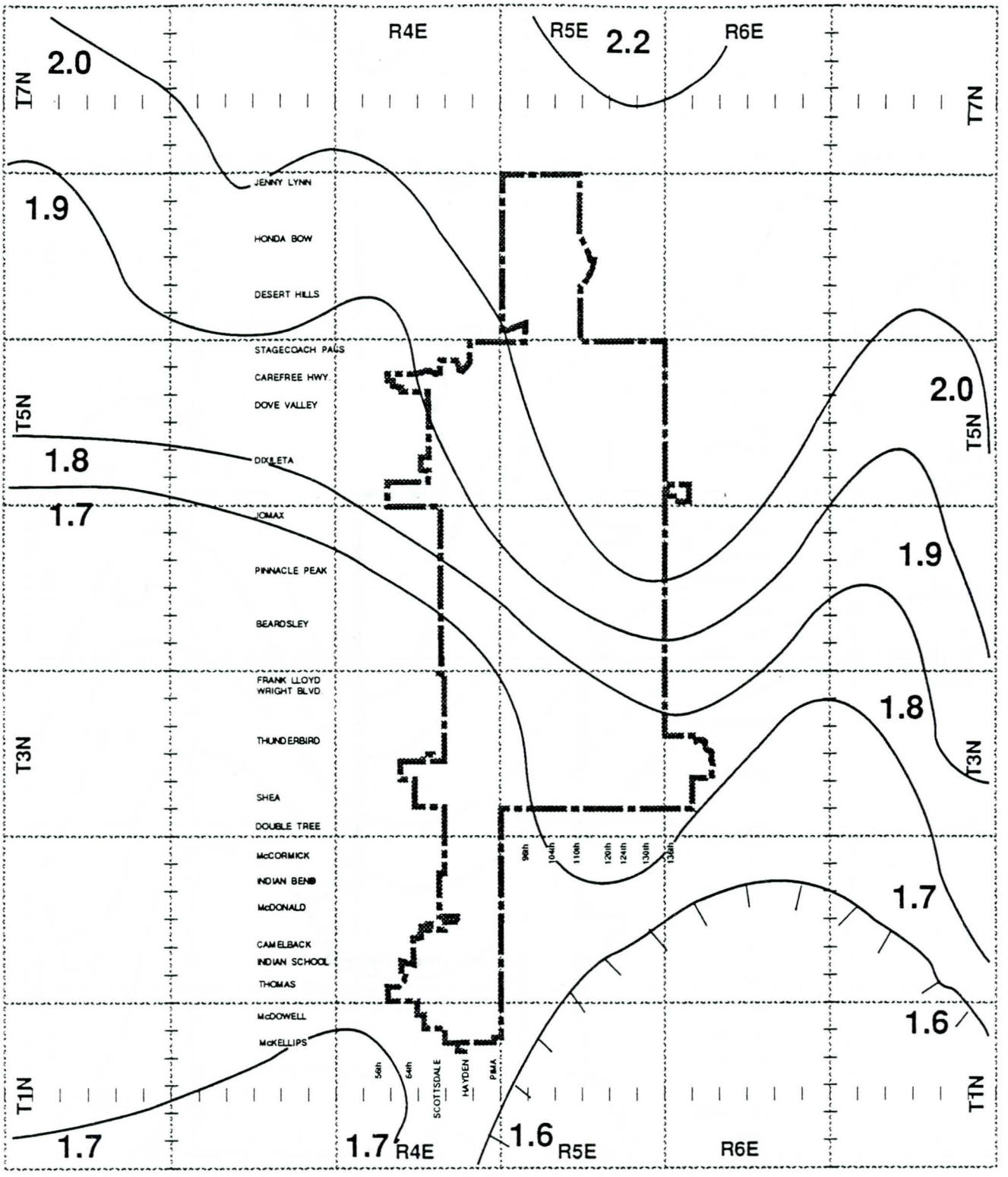


FIGURE 2.2-2

Isopluvials 5 Year 6 Hour Precipitation in Inches

Rainfall Data From NOAA Atlas 2, Vol. VIII

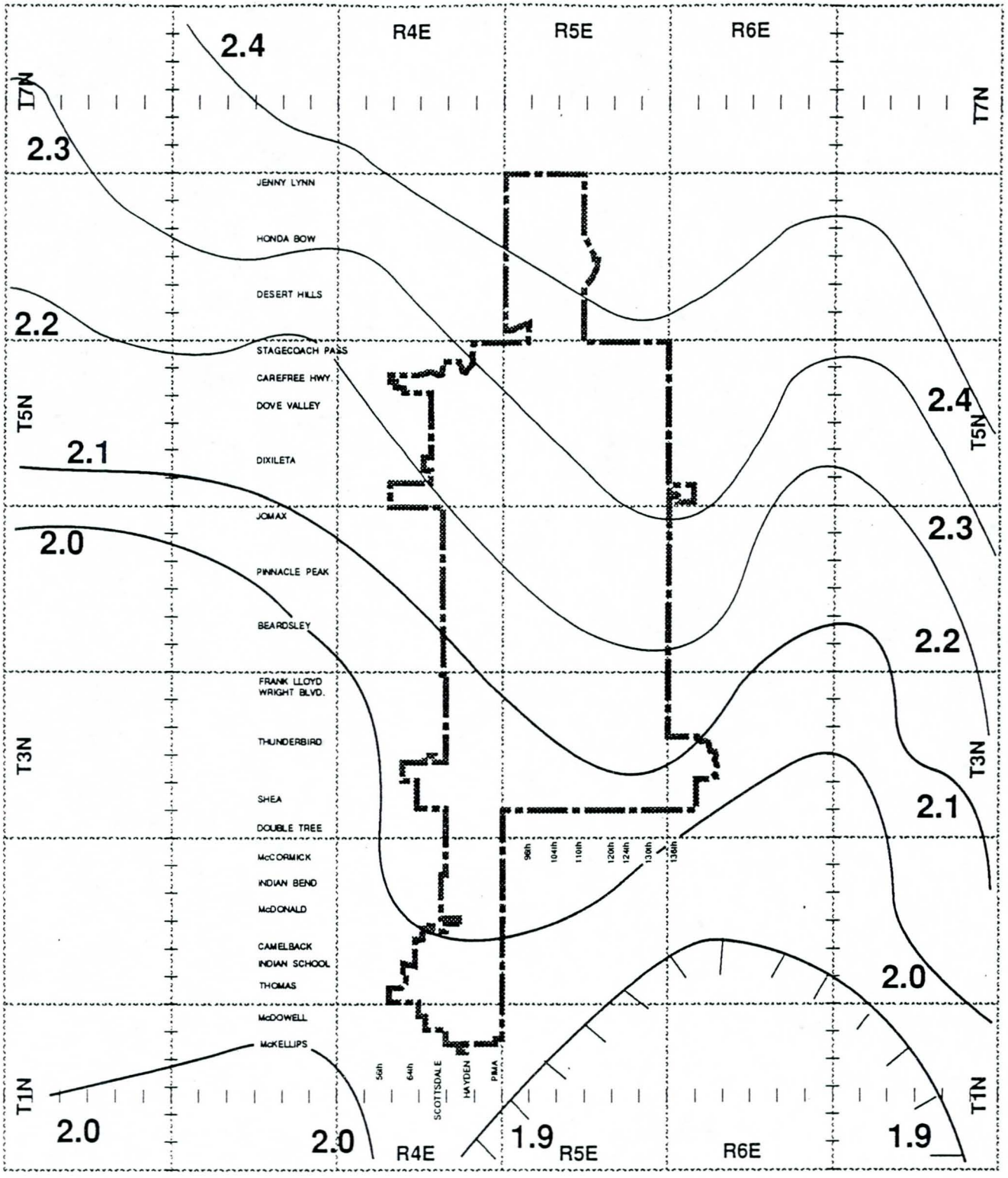


FIGURE 2.2-3

Isopluvials 10 Year 6 Hour Precipitation in Inches

Rainfall Data From NOAA Atlas 2, Vol. VIII

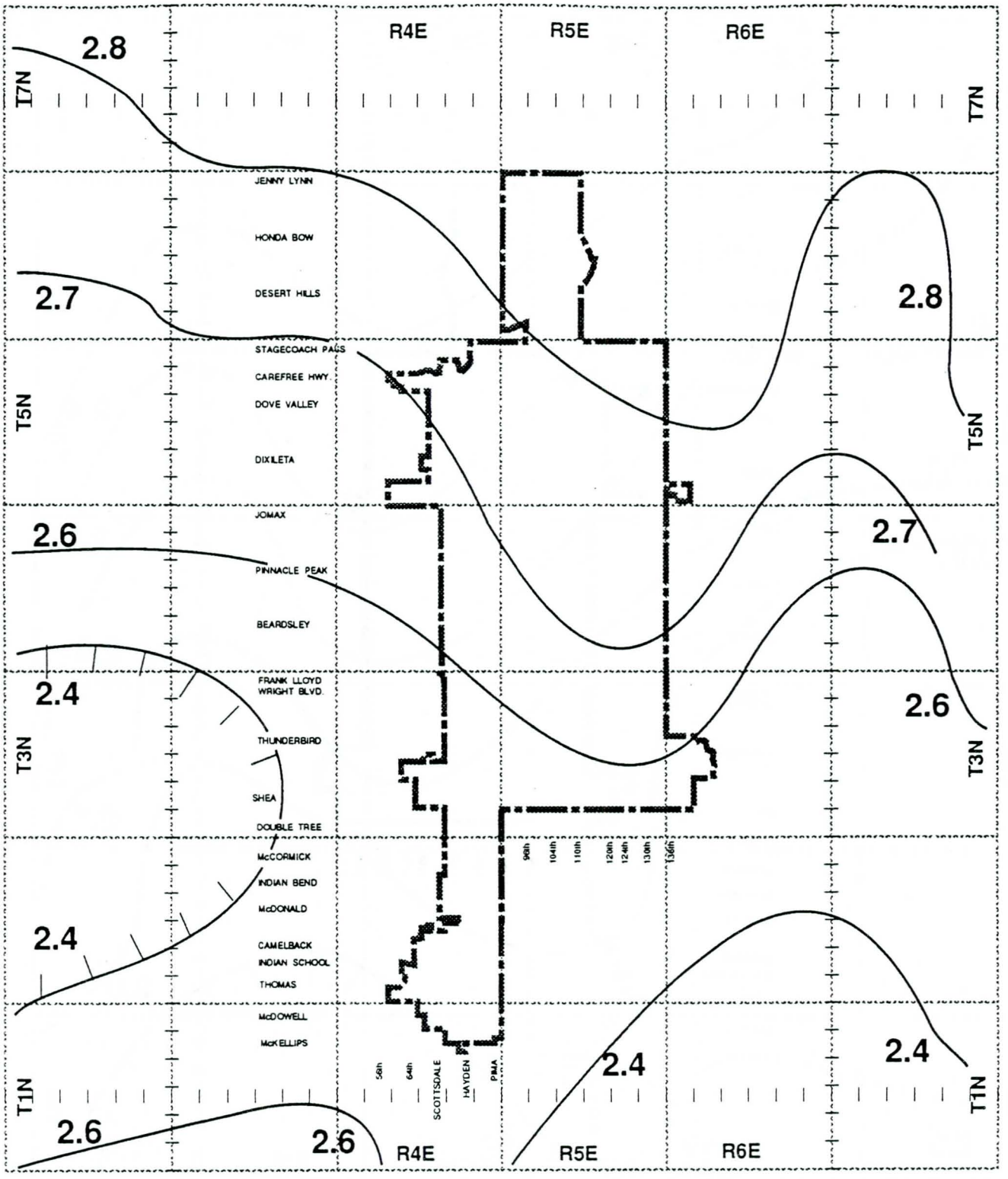


FIGURE 2.2-4

Isopluvials 25 Year 6 Hour Precipitation in Inches

Rainfall Data From NOAA Atlas 2, Vol. VIII

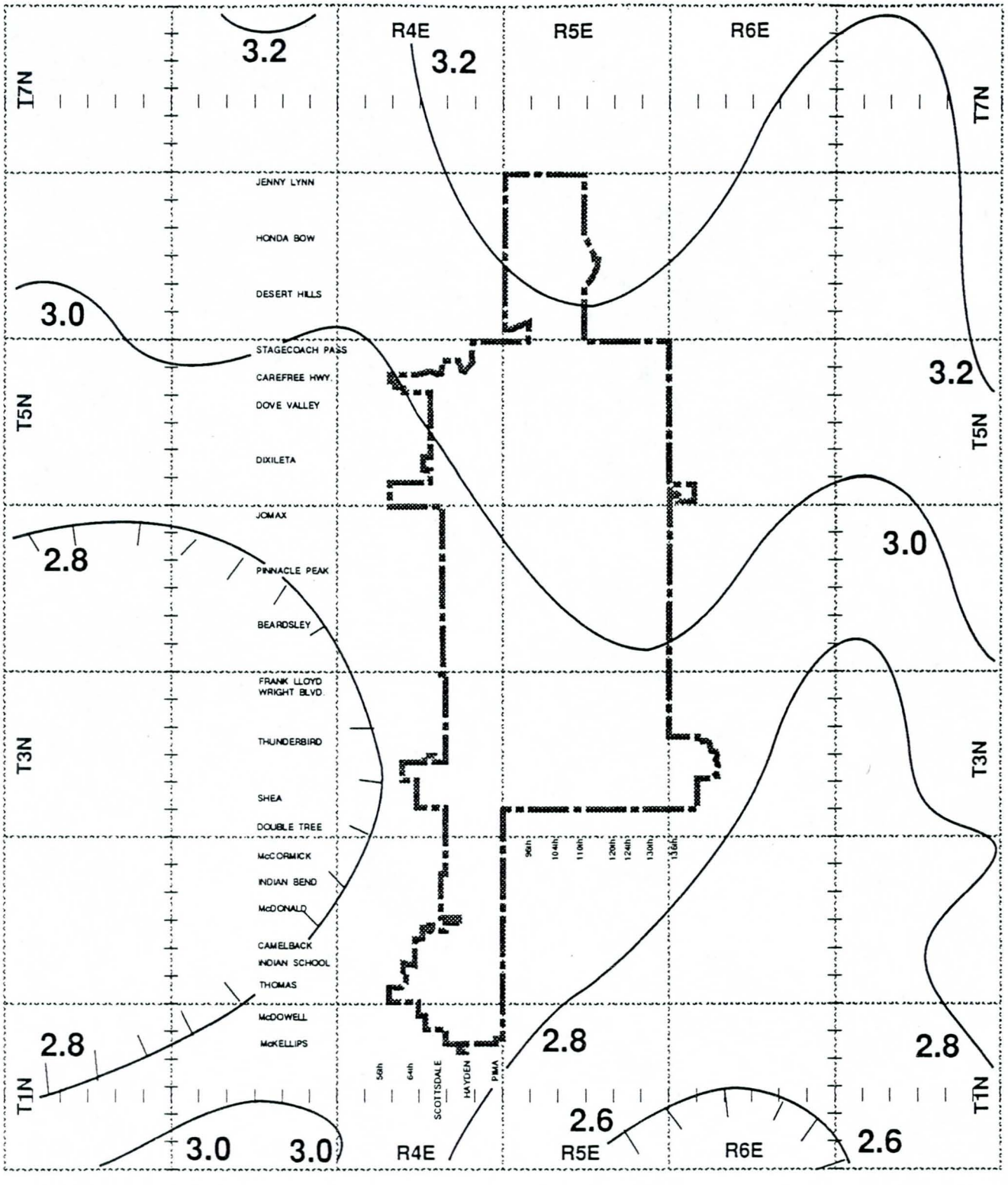


FIGURE 2.2-5

Isopluvials 50 Year 6 Hour Precipitation in Inches

Rainfall Data From NOAA Atlas 2, Vol. VIII

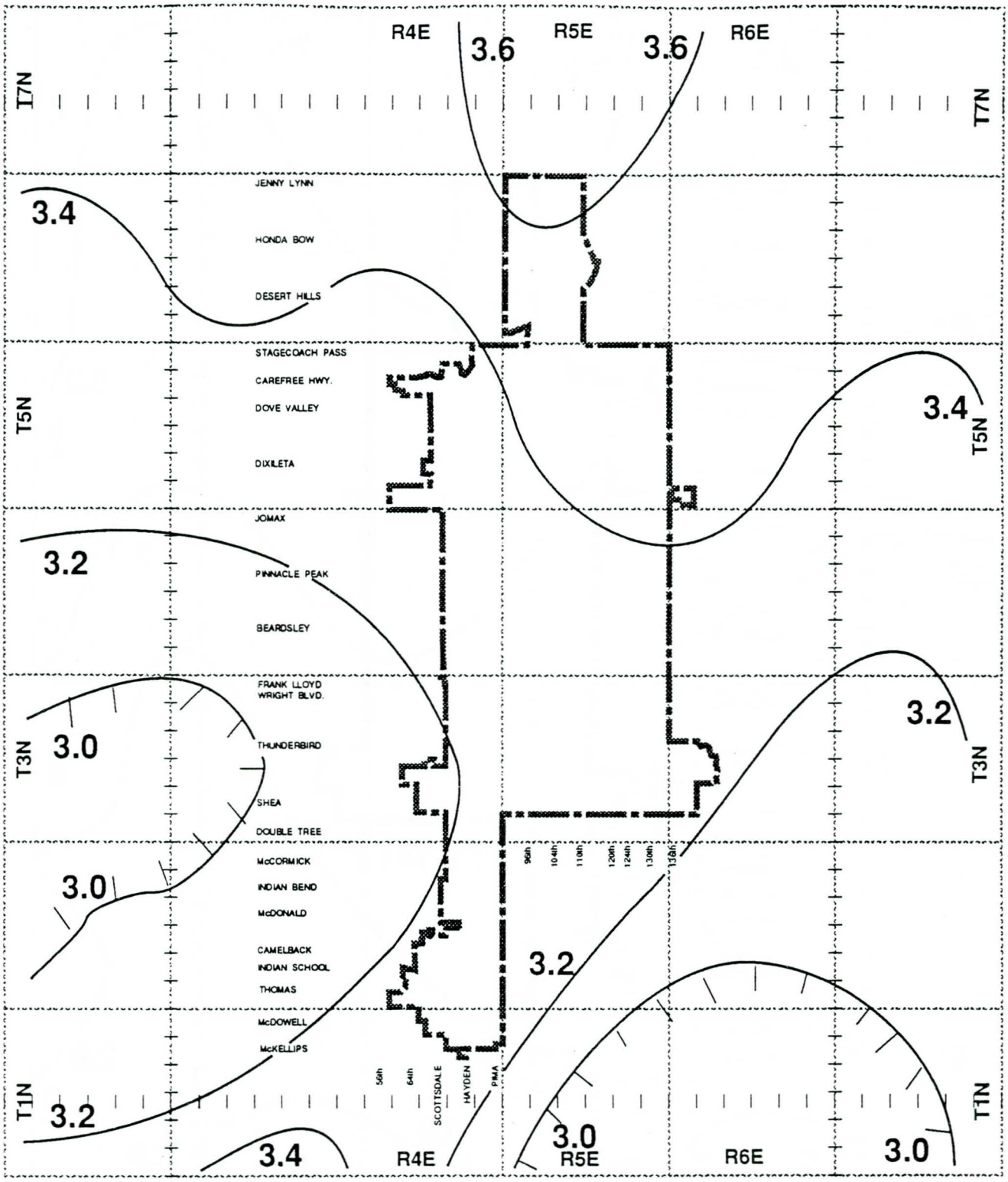


FIGURE 2.2-6

Isopluvials 100 Year 6 Hour Precipitation in Inches

Rainfall Data From NOAA Atlas 2, Vol. VIII

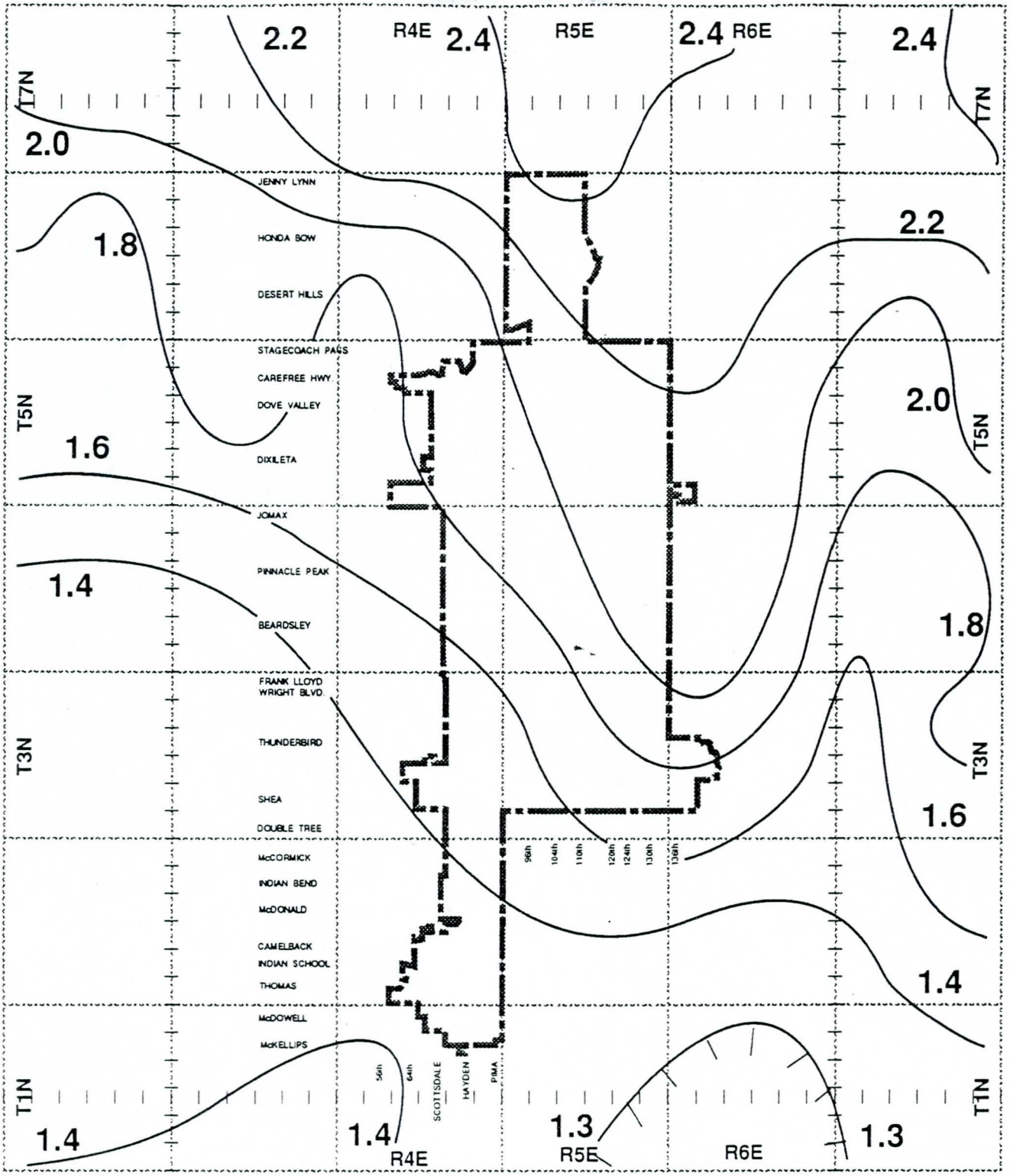


FIGURE 2.2-7

Isopluvials 2 Year 24 Hour Precipitation in Inches

Rainfall Data From NOAA Atlas 2, Vol. VIII

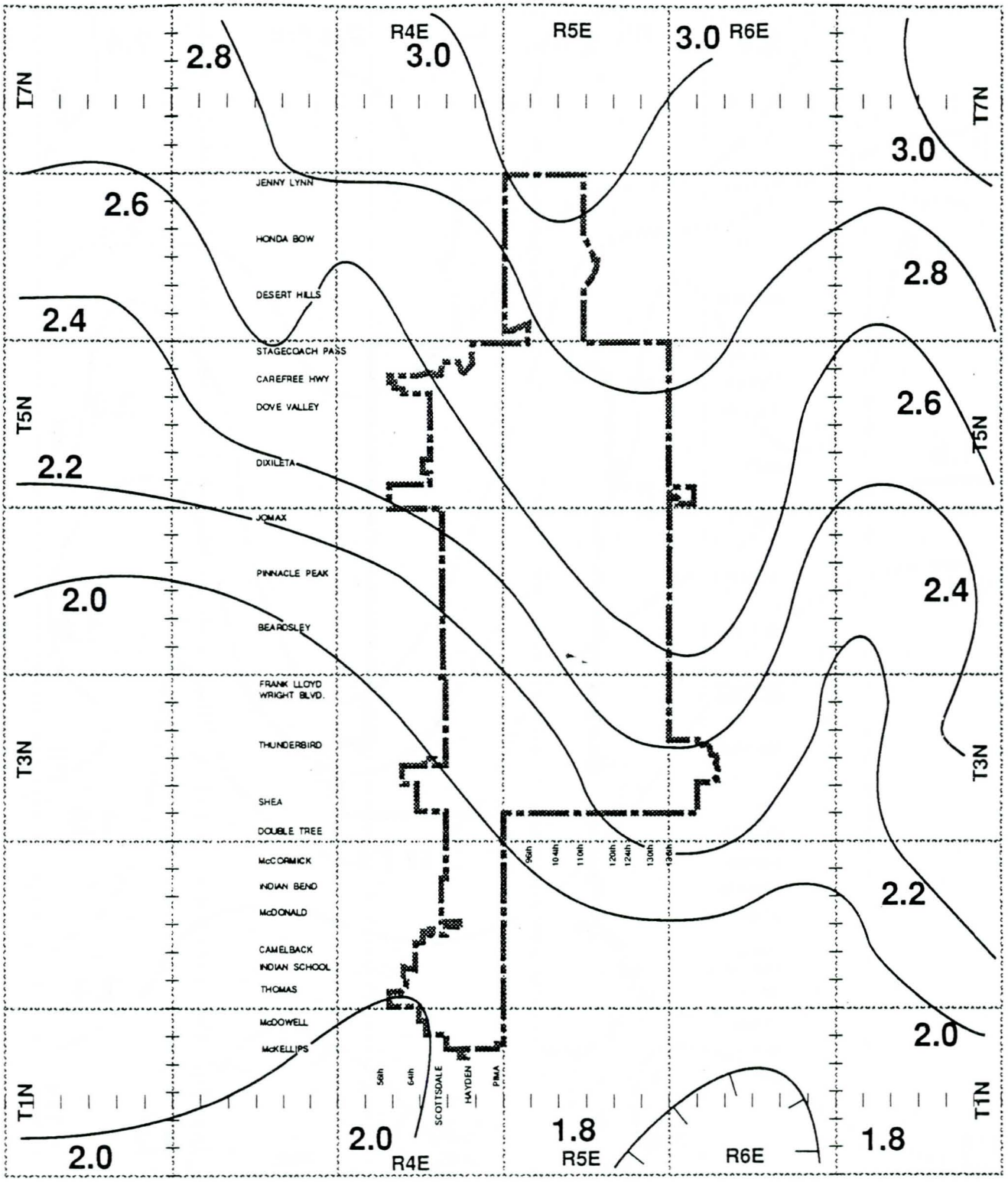


FIGURE 2.2-8

Isopluvials 5 Year 24 Hour Precipitation in Inches

Rainfall Data From NOAA Atlas 2, Vol. VIII

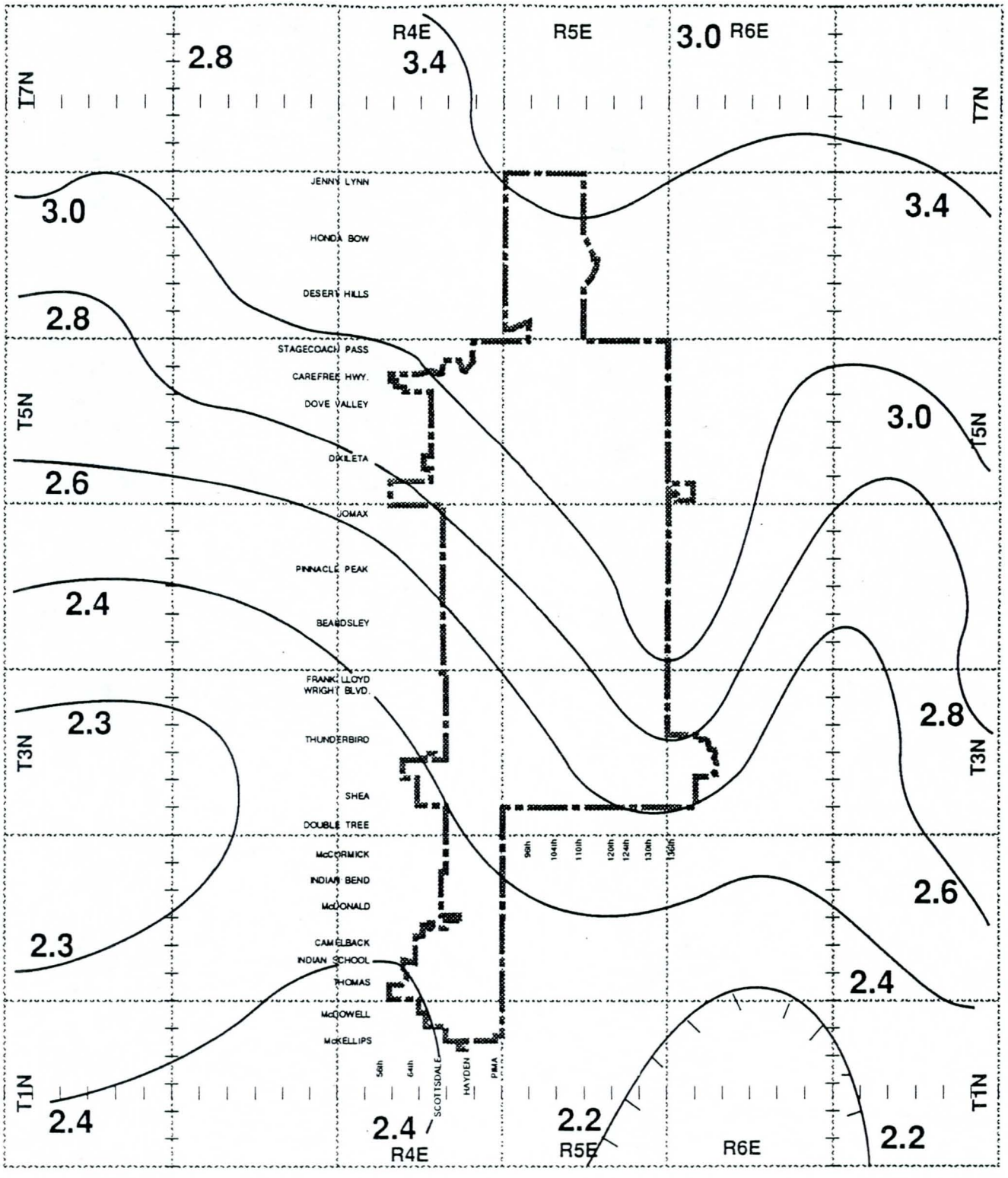


FIGURE 2.2-9

Isopluvials 10 Year 24 Hour Precipitation in Inches

Rainfall Data From NOAA Atlas 2, Vol. VIII

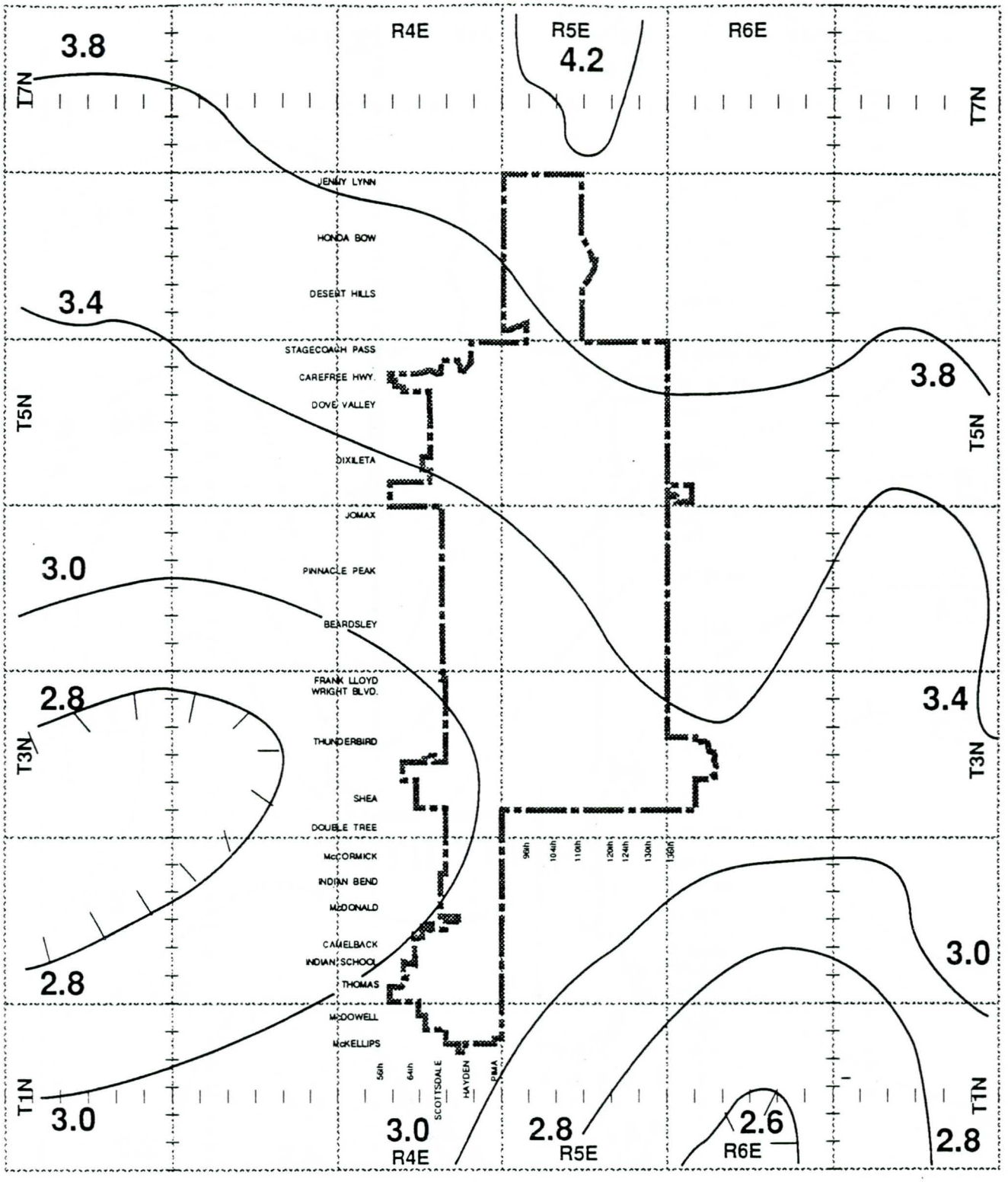


FIGURE 2.2-10

Isopluvials 25 Year 24 Hour Precipitation in Inches

Rainfall Data From NOAA Atlas 2, Vol. VIII

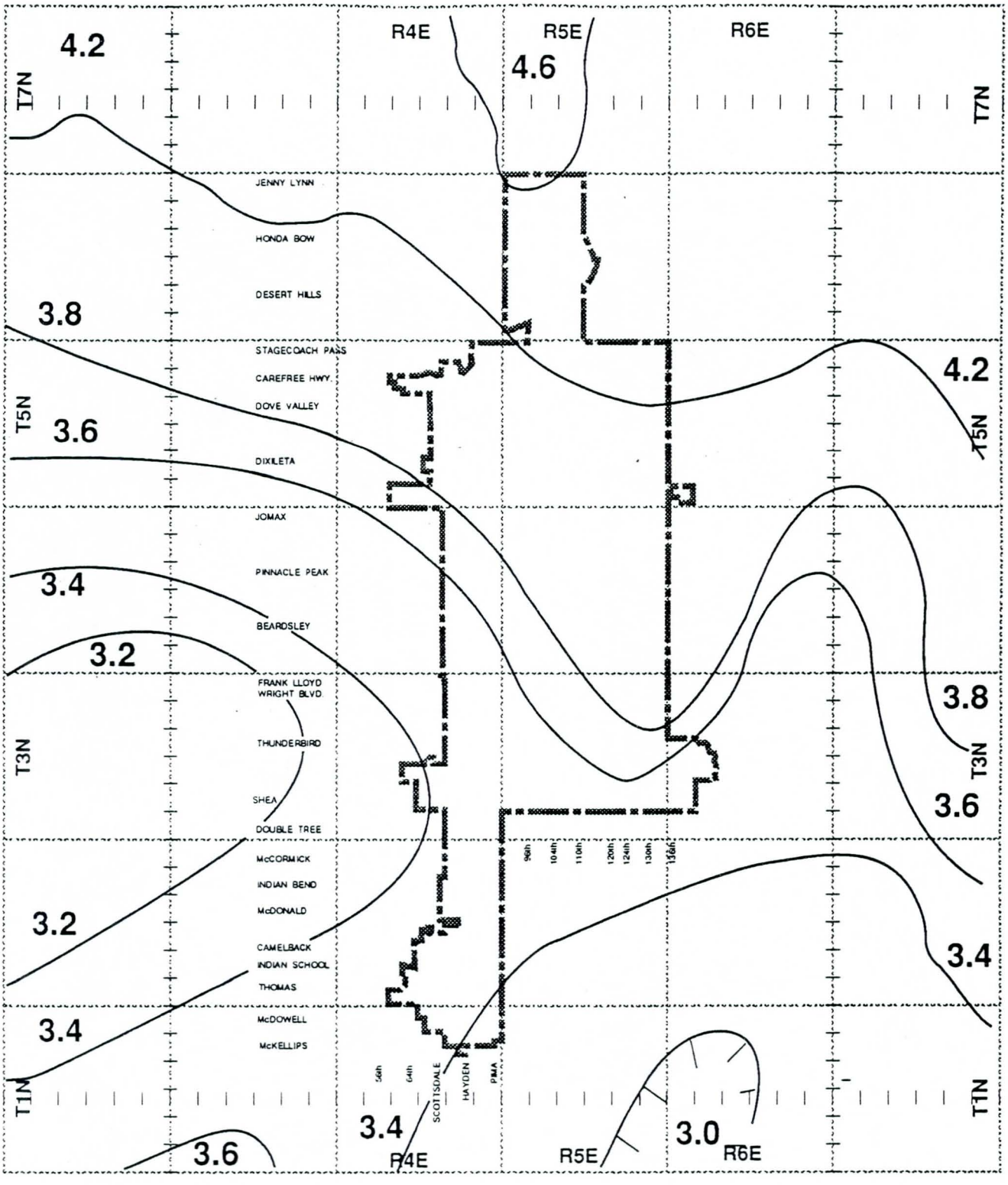


FIGURE 2.2-11

Isopluvials 50 Year 24 Hour Precipitation in Inches

Rainfall Data From NOAA Atlas 2, Vol. VIII

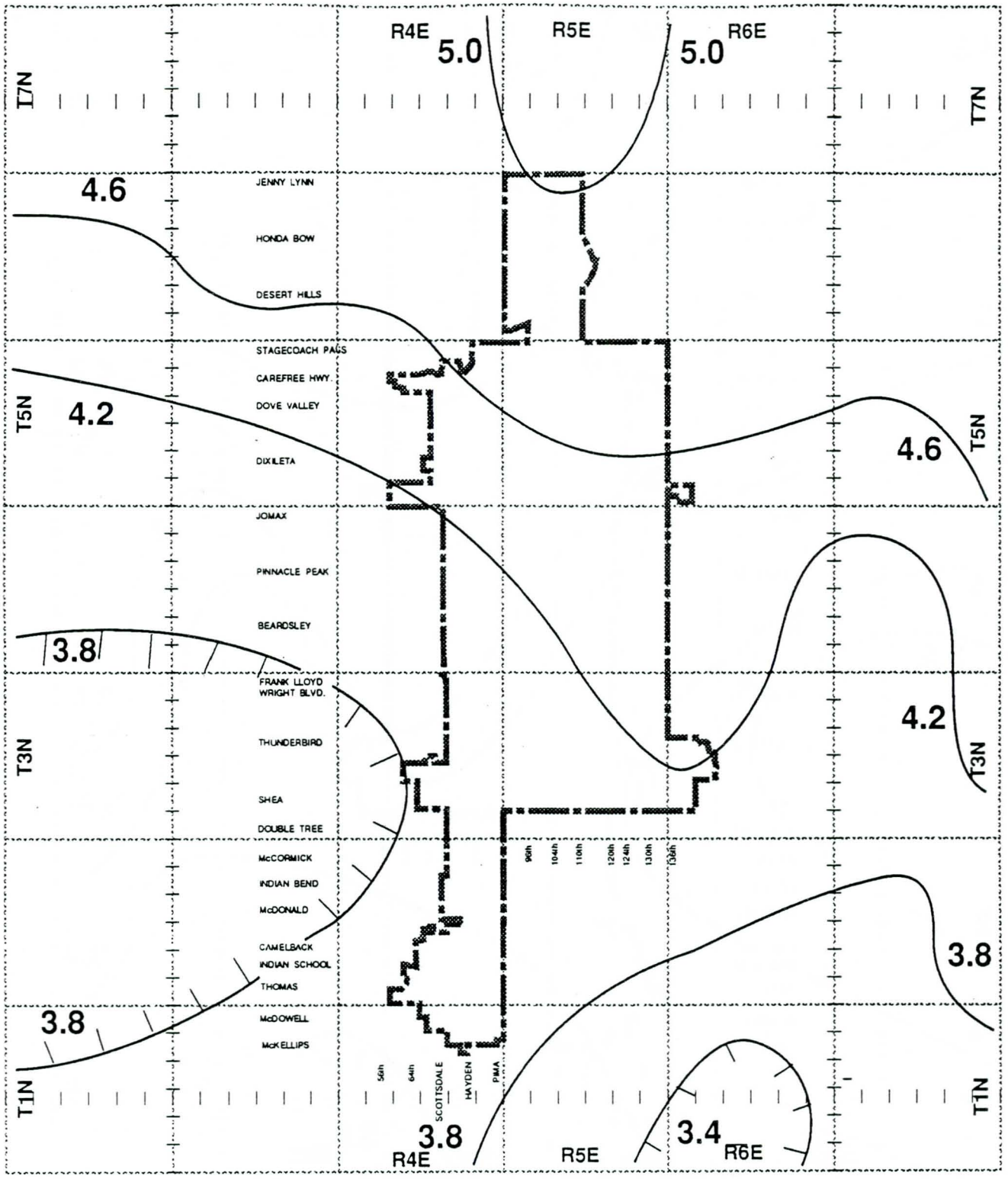


FIGURE 2.2-12

Isopluvials 100 Year 24 Hour Precipitation in Inches

Rainfall Data From NOAA Atlas 2, Vol. VIII

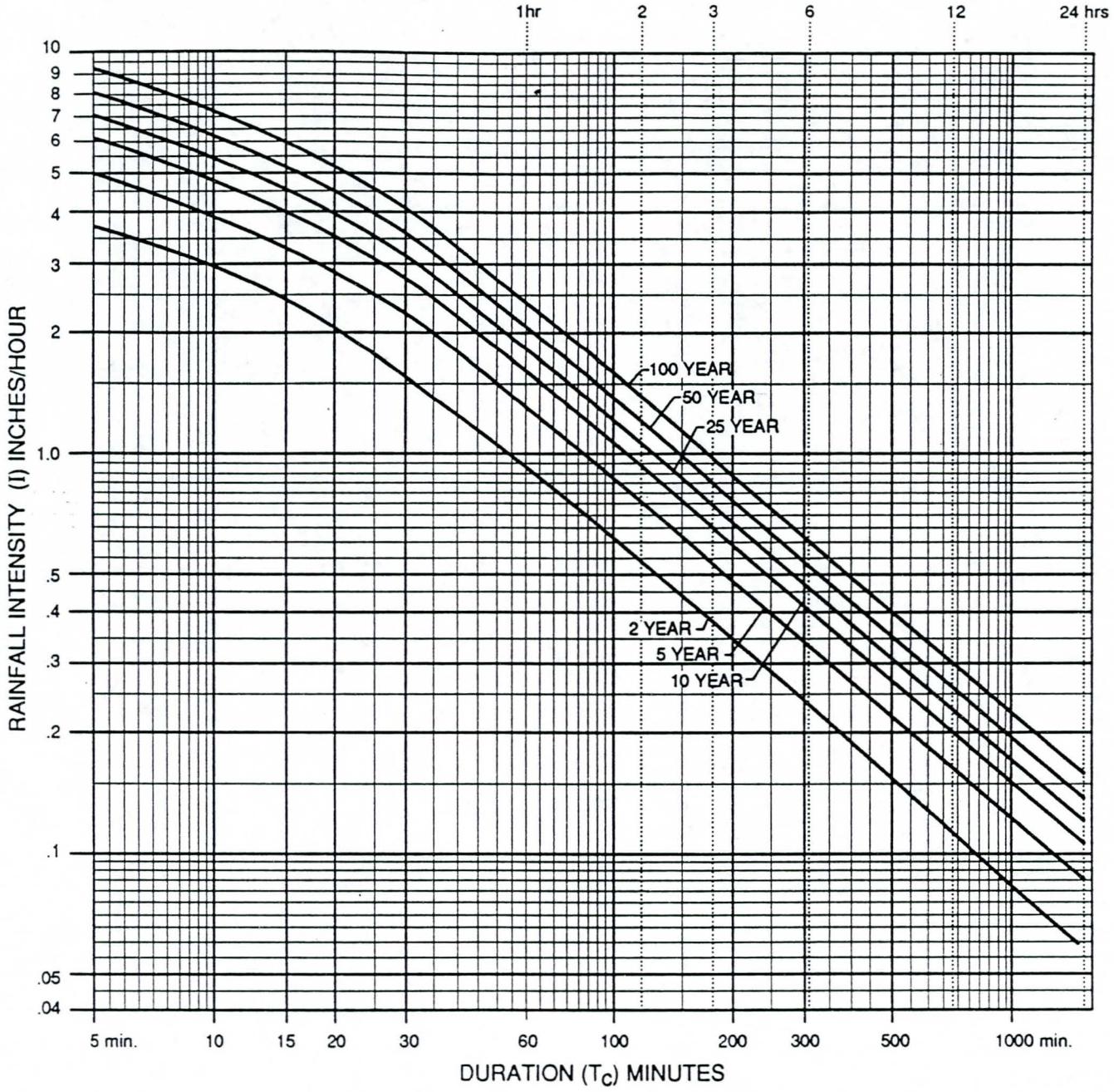
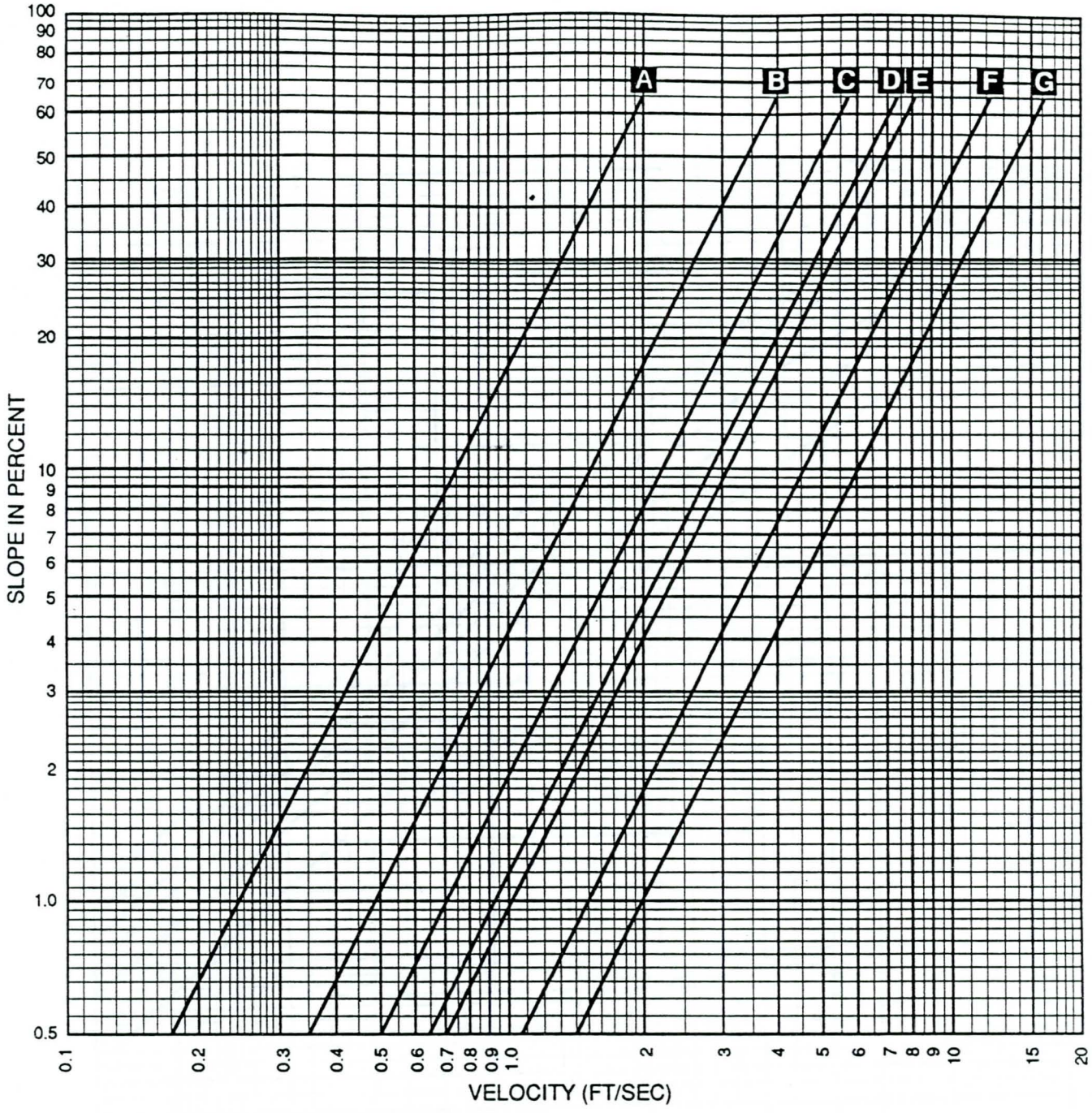


FIGURE 2.2-13

Rainfall Intensity (I) Values for Use in Rational Method

Source: Hydrologic Design Manual for Maricopa County



A Forest with heavy ground litter & hay meadow (overland flow)

B Trash fallow or minimum tillage cultivation; contour or strip cropped & woodland (overland flow)

C Short grass pasture (overland flow)

D Cultivated, straight row (overland flow)

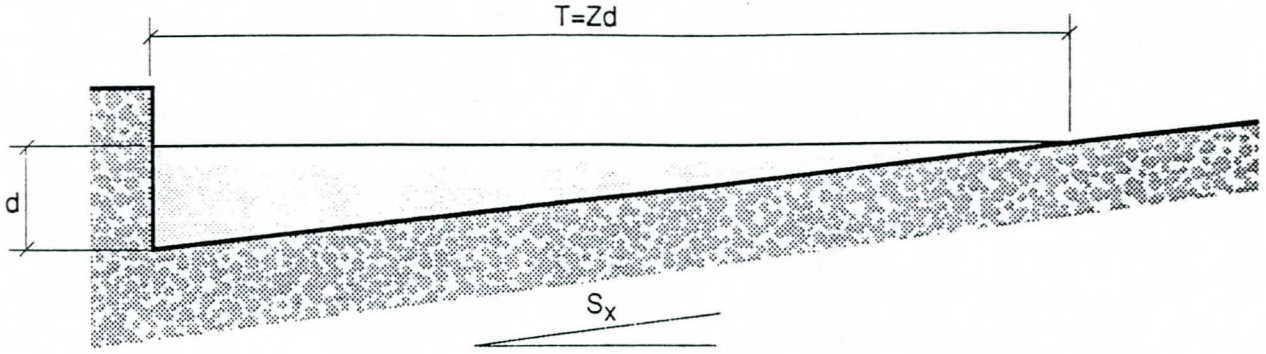
E Nearly bare and untilled (overland flow); alluvial fans western mountain regions

F Grassed waterway

G Paved area (sheet flow); small upland gullies

FIGURE 2.2-14

Overland Flow Velocities for Upland Method of Estimating T_c



$$Q=\left(\frac{0.56}{n}\right)S_x^{1.67}S^{0.5}T^{2.67}*$$

Where:

Q = Rate of discharge in cubic feet per second.

n = Manning's channel roughness coefficient.

S_x = Cross slope of gutter.

S = Longitudinal slope of gutter in feet per second.

T = Top width of water surface in feet.

d = depth of flow at curb in feet.

Z = Reciprocal of the cross slope T/d.

Since $V=Q/A$ and $A=\frac{Zd^2}{2}$:

$$V=\left(\frac{1.12}{n}\right)S^{0.5}d^{0.67}\ fps*$$

If n=0.013 (which is typical for concrete gutters):

$$V=\ 86\ S^{0.5}d^{0.67}*$$

If d=6" (0.5') when n=0.013:

$$V=\ 54\ S^{0.5}*$$

If d=4" (0.33') when n=0.013:

$$V=\ 41\ S^{0.5}*$$

*Does not apply when depth of water is above the top of curb

FIGURE 2.2-15

Flow Velocities in Street Gutters

(Source: Hydraulic Engineering Circular No. 12, U.S. Department of Transportation)

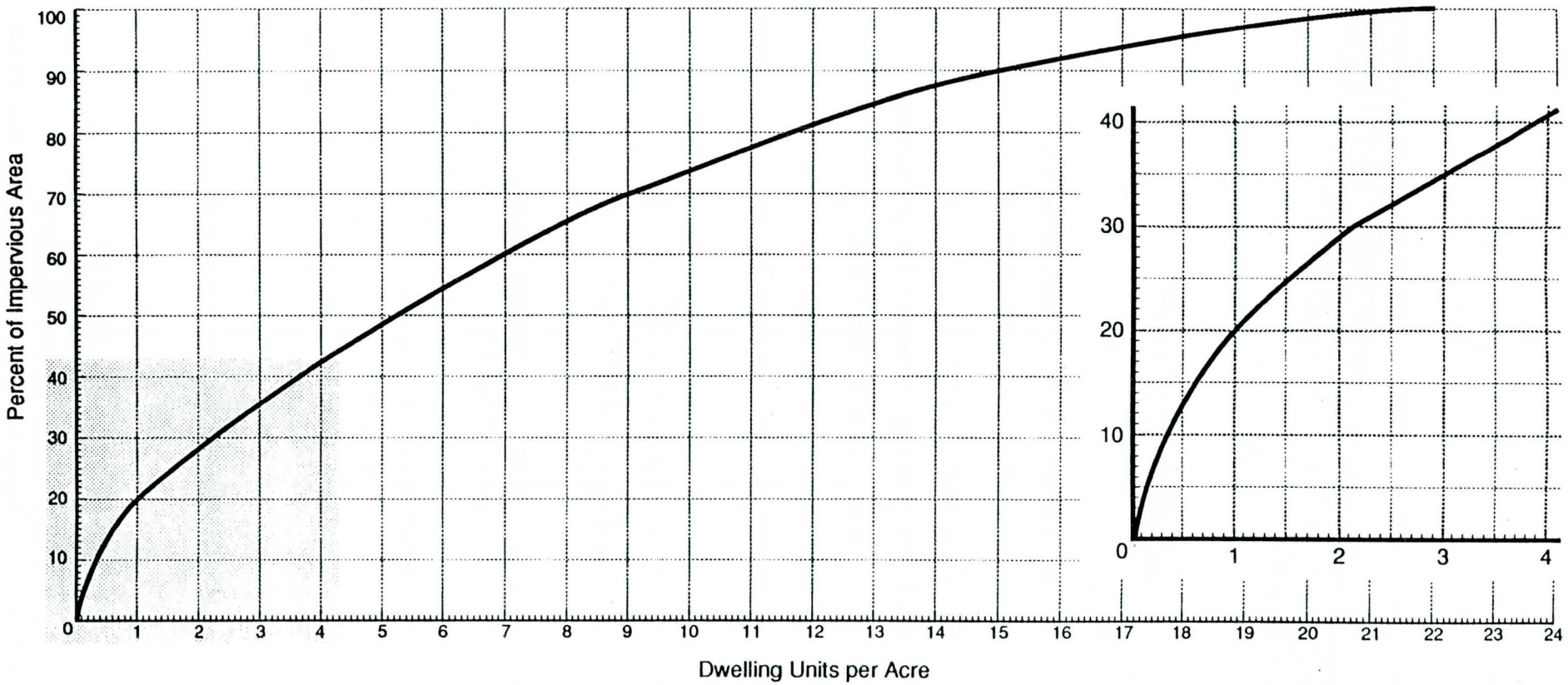


FIGURE 2.2-16

Percent of Impervious Area vs. Dwelling Density

eveloped by Water Resources Associates, Inc. from data in Table 2.2a of TR-55 n Hydrology For Small Watersheds, and from discussions with Scottsdale city s

Runoff Coefficients

Land Use	"C" Value Hydrologic Soil Group B	C	D
Composite Area-wide Values			
Commercial and industrial areas:	0.90		
Residential areas-single family (average lot size):			
R1-1-190:	0.33	0.50	0.58
R1-130:	0.35	0.51	0.59
R1- 70:	0.37	0.52	0.60
R1-43:	0.38	0.55	0.61
R1-35 (35,000 sq. ft./lot):	0.40	0.56	0.62
R1-18 (18,000 sq. ft./lot):	0.43	0.58	0.64
R1-10 (10,000 sq. ft./lot):	0.47	0.62	0.67
R1-7 (7,000 sq. ft./lot):	0.51	0.64	0.70
Townhouses (R-2, R-4):	0.63	0.74	0.78
Apartments and condominiums (R-3, R-5):	0.76	0.83	0.87
Specific Surface Type Values			
Paved streets or parking lot (concrete or asphalt), roofs, dirveways, etc.	0.95		
Lawns, golf courses, and parks (grassed areas):	0.33	0.56	0.66
Undisturbed natural desert or desert landscaping (no impervious weed barrier):	0.31	0.48	0.56
Desert landscaping (with impervious weed barrier)	0.83	0.83	0.83
Mountain terrain - slopes greater than 10%:	0.70	0.70	0.70
Agricultural areas (Flood Irrigated Fields):	0.20	0.20	0.20

FIGURE 2.2-17

Runoff Coefficients (C) for use with the Rational Formula

CITY OF SCOTTSDALE

HYDROLOGIC DESIGN DATA RECORD
RATIONAL METHOD

LOCATION DATA

PROJECT: _____ CONCENTRATION POINT: _____

LOCATION: _____

PROJECT NO.: _____ STATION: _____

NAME OF STREAM/WATERSHED: _____

DESIGN DATA

DESIGN FREQUENCY:		2	5	10	25	50	100	YEARS
DRAINAGE AREA:	A1							ACRES
	A2							ACRES
	A3							ACRES
	TOTAL (A)							ACRES
DRAINAGE LENGTH:								FEET
ELEVATION:								
TOP OF DRAINAGE AREA:								FEET
AT STRUCTURE								FEET
DRAINAGE AREA SLOPE:								PERCENT
HYDROLOGIC SOIL GROUP:								

DESIGN COMPUTATIONS

FREQUENCY FACTOR (F):		1.00	1.00	1.00	1.10	1.20	1.25	
TIME OF CONCENTRATION:	T_c							MINUTES
RAINFALL INTENSITY (I):								INCHES/HOUR (Figure 2.2-13)
RUNOFF COEFFICIENT (C):	C1							
	C2							
	C3							
WEIGHTED RUNOFF COEFFICIENT (C_w):	C_w							
PEAK DISCHARGE $Q_p = C_wIA(F)$:								cfs

COMPUTED BY: _____ DATE: _____

CHECKED BY: _____ DATE: _____

FIGURE 2.2-18
Hydrologic Design Data Record

Runoff Curve Numbers for Urban Areas[1]

Cover type and hydrologic condition	Average % Impervious Area[2]	Curve numbers for hydrologic soil group A	B	C	D
Fully developed urban areas with vegetation established					
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]:					
Poor condition (grass cover less that 50%)		68	79	86	89
Fair condition (grass cover 50-75%)		49	69	79	84
Good condition (grass cover greater than 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roads, driveways, etc. (excld. right-of-way)		98	98	98	98
Steets and roads:					
Paved; curbs and storm sewer (excld. right-of-way)		98	98	98	98
Paved; open dithces (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				
Industrial	85				
Townhouse, duplexes	65	Not Applicable in Scottsdale			
Multi-Family	85				
Residential districts by average lot size: (See Figure 2.2-16)					
Developing Urban Areas					
Newly graded areas (pervious areas only, no vegetation)[5]:		77	86	91	94

[1]Average runoff condition, and I_a = 0.2S; Table 2-2a, 210-VI-TR55, Second Ed., June 1986.
[2]The average percent impervious area shown was used to develop the compsite 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 (not applicable in Scottsdale).
[3]CN's shown are equaivalent 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 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 shoud be computed based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

FIGURE 2.2-19

Runoff Curve Numbers for Urban Areas[1]

Runoff Curve Numbers for Arid and Semiarid Rangelands[1]

Cover type and hydrologic condition	Hydrologic Condition[2]	Curve numbers for hydrologic soil group			
		A	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, mequite, 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; Table 2-2d, 210-VI-TR55, Second Ed., June 1986.
[2]Poor: <30% ground cover (litter, grass, and brush overstory).
Fair: 30 to 70% ground cover (not applicable in Scottsdale)
Good: >70% ground cover (not applicable in Scottsdale).
[3]Curve Numbers for group A have been developed only for desert shrub.

FIGURE 2.2-20

Runoff Curve Numbers for Arid and Semiarid Rangelands[1]

CN for Condition II	CN for Condition I	CN for Condition III	CN for Condition II	CN for Condition I	CN for Condition III
100	100	100	54	34	73
99	97	100	53	33	72
98	94	99	52	32	71
97	91	99	51	31	70
96	89	99	50	31	70
95	87	98	49	30	69
94	85	98	48	29	68
93	83	98	47	28	67
92	81	97	46	27	66
91	81	97	45	26	65
90	78	96	44	25	64
89	76	96	43	25	63
88	75	95	42	24	62
87	73	95	41	23	61
86	72	94	40	22	60
85	70	94	39	21	59
84	68	93	38	21	58
83	67	93	37	20	57
82	66	92	36	19	56
81	64	92	35	18	55
80	63	91	34	18	54
79	62	91	33	17	53
78	60	90	32	16	52
77	59	89	31	16	51
76	58	89	30	15	50
75	57	88			
74	55	88	25	12	43
73	54	87	20	9	37
72	53	87	15	6	30
71	52	86	10	4	22
70	51	86	5	2	13
69	50	85	0	0	0
68	48	84			
67	47	84			
66	46	83			
65	45	82			
64	44	82			
63	43	81			
62	42	80			
61	41	79			
60	40	78			
59	39	78			
58	38	77			
57	37	76			
56	36	75			
55	35	75			

FIGURE 2.2-21

Curve Numbers (CN) for Antecedent Moisture Conditions I, II, and III

Section 2.3
Hydraulics

Design Standards and Policies
July 1996

Chapter 2
Drainage

2

Section 2.3

City of Scottsdale,
Arizona

Design Standards and Policies Manual
Chapter 2 of 7
Section 3 of 3

July 1996

Prepared by : Drainage Planning
Transportation Planning Section
Transportation Department

City of Scottsdale, Arizona

Mayor and City Council

Sam Kathryn Campana, Mayor

Greg Bielli
Mary Manross
Robert Pettycrew
Donald Prior
Dennis Robbins
Richard Thomas

2

Section 2.3

SECTION 2.3
HYDRAULICS

TABLE OF CONTENT PAGE

SECTION 2.3
HYDRAULICS

TABLE OF CONTENT (continued) PAGE

SECTION 2.3
HYDRAULICS

2-301 INTRODUCTION

The design of drainage and flood control facilities in the City of Scottsdale shall follow the current Drainage Design Manual of the Flood Control District of Maricopa County (FCDMC), Volume II, Hydraulics, as supplemented by this manual section. This manual contains clarifications or modifications applicable to the design of facilities within the City of Scottsdale (C.O.S.). Specific C.O.S. requirements in the following subsections correspond to the appropriate FCDMC Drainage Design Manual paragraph numbers (per the new revised chapters of Vol. II of FCD Manual scheduled for release July-August of 1996). (Example COS 2-302 equals FCD Chapter 2). Entries exist only where guidance or design criteria differ from the FCDMC Manual.

2-302 HYDROLOGY

The determination of flood hydrology for designing stormwater facilities in the City of Scottsdale shall be performed according to the procedures set forth in the City Design Standards Manual, Section 2.2. The following Table 2.1 outlines the minimum hydrology design criteria for stormwater management and drainage facilities within the City of Scottsdale.

Table 2.1
Hydrology Design Criteria

	Peak Frequencies		
Drainage Feature	10 Year	50 Year	100 Year
Street With Curb & Gutter	Runoff (the flow of water) contained within street curbs. For major collector and all arterial streets one 12-foot dry lane must be maintained in each direction.	N/A	*Runoff to be confined to road right of way or to drainage easements.* [37-42, (4)] Maximum depth for water (d_{max}) d_{max}=8 inches above (low spot) the street. [37-42, (4)] Runoff to be contained below the finished floor of adjacent buildings.
Street Without Curb & Gutter	N/A	N/A	Same as Street with Curb and Gutter.
Street with Storm Drain System	Pipes or roadway channels are added if the 10-year runoff exceeds street capacity.	N/A	Storm drain systems are used if 100-year runoff inundates the building's first floor. Storm drain systems: *catch basins, scuppers, etc. to be provided to remove water so as not to exceed dmax=8".* [37-42, (4)]
Cross Road Culvert *or Bridge* for *Major* Collector & Arterial Streets	N/A	Runoff to be conveyed by culvert *or bridge* under road with no flow overtopping the road. [37-42, (3)a.2]	Runoff to be conveyed by culvert and by flow over the road with maximum 6-inch flow depth over the road. [37-42, (3)a.2] Minimum Freeboard for Bridges 2.0 ft.
Cross Road Culvert or Bridges for Local and Minor Collector Streets	*Runoff to be conveyed by culvert or bridge under road with no flow overtopping the road.* [37-42, (3)a.1]	*For a 25 year frequency storm* runoff to be conveyed by culvert *or bridge* and by flow over the road with maximum 6-inch flow depth over the road. [37-42, (3)a.1]	Maximum depth flow over road 12 inches.
Any street crossing a water course that provides the only access to residential areas	N/A	N/A	All lots and structures must be accessible by at least one route with the depth of flow no greater than one foot over the road during the 100 year run off event.
FEMA Floodplain Channel	N/A	N/A	100-year peak discharge.
Channel to Convey Offsite Flow Through Development	N/A	N/A	100-year peak discharge.
Stormwater Storage	N/A	N/A	100-year 2-hour runoff for determining on-site storage volume.

2-303 STREET DRAINAGE

3.2.1 Design Criteria for Streets and Gutters
3.2.1.2 Pavement Encroachment

Typical street sections used in City of Scottsdale are in Section 3.1, Geometrics, of the City's Design Standards and Policies Manual. See Figures 3.1-2 through 3.1-7, in Section 3.1.

3.2.1.3 Theoretical Capacity

A Manning's "n" value of 0.015 (normal asphalt) or .016 (rough asphalt) shall be used for street flow unless special conditions exist which then must be clearly documented in the Drainage Design Report.

3.2.1.6 Longitudinal Street Grades

The desirable minimum longitudinal street grade is 0.4% to ensure good gutter drainage. Wherever possible, longitudinal street grades greater than or equal to the desirable minimum grade shall be provided. It is recognized that this desirable grade is not always attainable, particularly with projects involving existing streets. Therefore, the absolute minimum longitudinal street grade is 0.2%.

Any slope less than 0.4% needs specific review and approval by City. Longitudinal grades lower than 0.4% may only be used with written approval from City Staff.

3.2.2 Design Criteria for Intersections

Valley gutters may be used to transport runoff across local streets when a storm drain system is not required. However, valley gutters are generally not acceptable for collector or arterial streets.

In unusual cases, valley gutters may be required to cross collector streets in which case a wider eight foot design width should be used. Mid-block valley gutters should be avoided.

3.2.3 Design Criteria for Roadside Ditches
3.2.3.3 Geometry

Trapezoidal channel bottoms should be a minimum of 8 feet wide for maintenance purposes. V-shaped channels are not allowed because of the difficulty of maintenance. Shallow swales of less than 1 foot depth are generally acceptable.

3.3 Catch Basins

MAG, ADOT, and City of Phoenix catch basin details are acceptable if modified to be "bicycle friendly" (wheel can't drop into space between bars on the grates).

SCUPPERS: MAG Standard Detail 206 shall be used as basis of scupper design unless prior approval of another design is obtained from City Staff.

3.3.2.3 Shallow Sheet Flow Condition

The use of slotted drains for shallow sheet flow conditions is permitted in the City of Scottsdale. Slotted drains may also be used in other situations with City Staff approval.

2-304 STORM DRAINS

4.2.2.10 Separation of Storm Drain from Water and Sewer Lines

Horizontal separation of storm drains and water or sewer lines shall be a minimum of 6 feet. Vertical separation of storm drains and sewers should be 2 feet (sewer below) unless the sewer line is manufactured from ductile iron with mechanical joints or equal. Vertical separation of storm drain and water line (water line below) shall be 3 feet clear. Separation is measured from the outside of the two pipes.

4.2.3.5 Sizing

Minimum Pipe Size: The minimum pipe size of the main is 24 inches and the lateral collector pipe shall be 18 inches unless staff approval is obtained for smaller diameters. In situations where debris is expected, the City's Drainage Planning staff should be consulted for applicable debris criteria.

2-305 CULVERTS AND BRIDGES

5.3 Inverted Siphons

5.3.1 General

Inverted siphons shall be used only when no other solution is available to the designer. Prior City staff approval is required.

2-306 OPEN CHANNELS

6.2 General

6.2.2 Floodplains

The City of Scottsdale is a member of the National Flood Insurance Program and administers floodplain use in accordance with the Federal Program requirements. Within the City of Scottsdale, County Floodplain use permits or drainage permits are not required. In Scottsdale, floodplains and drainageways, including FEMA designated floodplains, are regulated through site development plan requirements. This is done as part of the standard building permits application process; or by Right-of-Way Encroachment Permit. Encroachment Permits are required to enter and use any portion of a designated drainage easement.

6.3.2.4 Safety

The City of Scottsdale requires fencing (railing) at vertical drops of two feet or greater around an inlet or outlet works. Access for maintenance should be maintained to the extent practical.

6.4 Natural Channels

6.4.1. Analysis of Natural Channels

6.4.1.1 Requirements for Natural Channels

Floodplain Delineation:

The 100 year floodplain limits must be delineated for all watercourses having a capacity of: 25 (cfs) cubic feet per second or greater; or in Environmentally Sensitive Land (ESL) areas, a capacity of 50 cfs or greater (C.O.S. Ordinance Sec. 37-42.(2)). These floodplain limits must be delineated on all site development plans.

Drainage Easements:

Drainage easements will be dedicated to the City to the extent of the 100 year floodplain for all water courses having: 50 cubic feet per second (cfs) capacity or greater in ESL areas; and 25 cfs or greater throughout the rest of the City. Maintenance of drainage easements is generally the responsibility of the individual property owner or Homeowner's Association. Responsibilities should be recorded on the Subdivision Plat and Grading and Drainage Plan.

6.4.1.4 Related Issues:

Maintenance:

Access: Open channels to be properly maintained should provide reasonable access for maintenance. Minimum width of access should be 8 feet. Spacing between vehicular access points should be a maximum of 1/2 mile. A minimum of one access point per subdivision is required. Non-vehicular access points shall be provided every 660 foot maximum. If the facility is to be City maintained the above minimum requirements are mandatory.

Responsible Party: Maintenance of drainage facilities within the City of Scottsdale is usually the responsibility of the property owner or the Subdivision's Homeowners Association. Specific maintenance responsibilities should be called out on the Recorded Plat and the Grading and Drainage Plan.

2-307 HYDRAULIC STRUCTURES

No changes.

2-308 DETENTION OR RETENTION

8.2 Introduction

8.2.1 Interaction with other Components of a Drainage System

Do not assume retention can be waived just because an area is small relative to the entire watershed; or because the project is at the very downstream end of the watershed. The cumulative effects on the entire upstream as well as the downstream watershed must be evaluated.

These are common arguments for waivers, however they are only valid if the remainder of the entire watershed is already fully developed, and if downstream receiving channels and or storage facilities have adequate capacity. If downstream facilities do not have adequate capacity the cumulative effects of waiving retention on many small individual projects within the same watershed can result in major downstream problems.

8.3 Design Criteria

8.3.1.1 Design Frequency

In C.O.S., development must store runoff from rainfall events up to and including the one-hundred year, two-hour duration event.

Multi-frequency storm control must be incorporated into basin design. Rainfall runoff from storms of all frequencies should enter and depart from property in substantially the same manner as under pre-development conditions (C.O.S. Sec: 37-42). As a minimum the 2, 10, 50, and 100 year events should be analyzed.

8.3.1.2 Hydrology: *The Uniform Drainage Policies and Standards for Maricopa County, Arizona* (February 25, 1987), states that: "all development shall make provisions to retain the peak flow and volume of runoff from rainfall events up to and including the 100-year, 2-hour duration storm falling within the boundaries of the proposed development". The procedure for determining the volume of runoff from the 2-hour storm is provided in Section 2.2 Hydrology, Chapter 2-204 of the City of Scottsdale Design Standards and Policy Manual. Also see Section 2.1 for additional guidance.

Volume Certification: The property owner will provide the City with certified as-built dimensions of the basins and the actual volume of storage provided. This must be based on "as-built" topographic surveys made by either a civil engineer or land surveyor who is registered to practice in the State of Arizona. These as-built volumes must reflect permanent finished landscaping in place. The volumes shall be certified by the Design Engineer that the volumes provided meets or exceeds the required design volumes per COS Ordinance and the approved Drainage Plan. The volume of storage provided must equal or exceed the approved design volumes before the City will issue Letters of Acceptance for maintenance of any public facilities.

8.3.1.8 Detention or Retention Facility Inlet and Outlet Structures

Drainage of Stormwater Storage Facilities:
Storage facilities shall be drained by positive gravity outlet. Only under special circumstances with prior city staff approval should pumps or infiltration disposal methods be used.

The minimum allowable pipe size for primary outlet structures is 18 inches.

The preferred methods of draining stormwater storage facilities are:

1.) Positive gravity outlet:

a. to an open channel either natural or man-made

b. or subsurface to a nearby storm sewer system with a maximum discharge of one cubic foot per second.

2.) Pump Station

a. to an open channel either natural or man-made

b. or subsurface directly to a nearby storm sewer system with a maximum discharge of one cubic foot per second.

c. or surface to a storm sewer system if pumped water can be discharged directly into a catch basin or other inlet.

WATER CANNOT BE DISCHARGED INTO A CITY: STREET, GUTTER, OR ALLEY.

3.) Dry wells

If allowed, dry wells must be designed per FCDMC Design Manual Vol. III design requirements.

4.) Basin Floors

Draining a basin by infiltration through the basin floor as the sole means of draining is not acceptable. The basin floor to infiltrate properly must be an "Engineered Basin Floor" as detailed in "UNDERGROUND DISPOSAL OF STORMWATER RUNOFF" (FHWA 1980) and per FCDMC Design Manual Vol. III design requirements. However, basin floor infiltration is not dependable, rarely are they properly designed (per above reference) or maintained. They are generally landscaped and maintained for looks only.

DRAIN TIME: All storage facilities should be designed such that the stored runoff shall be discharged completely from the facility within 36 hours following the storm event. This is a City Ordinance requirement related to County Health Department Standards. Drain time should not be less than 24 hours to ensure the effectiveness of the basin.

8.3.1.9 Subsurface Disposal:

Dry Wells: Dry wells are only permitted as a last resort and need prior City Staff approval. Dry wells are not appropriate for use in flow-through systems or in facilities receiving offsite flow.

8.3.2.4 Parking Lot Storage

1. Before final plan approval an approved Drainage Report must show the calculated stormwater storage volume based on runoff from the 100 year , 2-hour storm.

2. Up to 50% of the required storage volume may be provided in parking areas if the following conditions are met:

a. Storage system shall be designed to store the first 30% of the required runoff volume off paved areas (to avoid nuisance water constantly ponding on the pavement).

b. Interference with pedestrian traffic will be minimized in the design of the storage facility.

c. Depth of water shall not exceed six inches within the parking area.

8.3.3 Embankment Design Criteria

Detention or Retention facilities should be constructed below the natural ground surface. The use of embankments to impound stormwater runoff requires prior approval by City staff. Embankments become small dams that can be a serious potential downstream flood hazard. If approval is obtained, all the design requirements contained in the FCDMC Manual Sec. 8.3.3 must be completely and thoroughly followed. The owner/developer must provide the City as-built certification by a registered Geotechnical or Civil Engineer, experienced in dam technology, that the embankment was designed, and constructed properly, is stable, and will safely impound the design volumes of water.

8.5 Operation and Maintenance

Maintenance of Detention or Retention facilities within the City of Scottsdale is usually the responsibility of the property owner or the Subdivision's Homeowners Association.

2-309 PUMP STATIONS

No Changes

2-310 SUMMARY OF DRAINAGE DESIGN GUIDELINES

The following **guidelines** are based on recurring drainage and flooding problems observed in Scottsdale related to specific design or construction practices:

Subdivisions:

1. A subdivision should always have an approved subdivision-wide drainage plan. Drainage based on individual lots submitting separate grading plans as each lot is developed should be avoided.

2. Avoid design of a common drainage facility that requires maintenance by individual property owners. Put the drainage facility in a common Tract with the Homeowner's Association responsible for maintenance.

People have no awareness and/or incentive to perform the necessary maintenance unless they are directly and adversely affected.

Storm Drains

Avoid if at all possible the interception of an offsite natural wash with the intent of collecting it and putting it into a pipe or an underground storm sewer system.

Washes and even man-made channels carry a never ending supply of sediment and debris. It is almost impossible to collect and filter out this debris without a constant clogging and maintenance problem. If there is no alternative to the routing of an open channel into a piped system, water should be first routed into a sediment or debris basin. Periodic maintenance of the debris basin should be planned.

Culverts

1. Culverts should not be placed more than 0.5 feet below the natural wash invert, or the capacity must be reduced by the cross section area below this depth.

2. Culverts or homemade bridges for private driveways or walkways over washes or drainage channels whose source originates off-site or off-lot should generally be designed by a professional civil engineer/drainage designer.

For small private driveways or walkways, dip crossings or free span bridges that won't constrict the flow capacity of the channel, are recommended. Small drainage structures not designed with any hydrologic and hydraulic analysis may be OK for crossing channels originating onsite (on-lot). Homemade drainage structures can be disastrous for the homeowner, his neighbors, and adjacent streets if installed on larger washes originating offsite (off-lot) without the help of a professional.

Open Channels

1. Diversions of natural washes or changes in the channel's profile should be avoided whenever possible.

2. Do not permit encroachment into a drainage easement, channel, or its floodway.

3. If channel lining or landscaping material is used it must be inlaid or located below the design invert (bottom) of the channel. Do not place it on top of the designed finished grade of the channel cross section. The channel surface material (roughness coefficient) or cross sectional area shall not be changed without a plan revision and re-approval by City Staff.

This is a serious wide-spread construction and design oversight. Lining and landscaping material is commonly and incorrectly shown on plans and actually placed on top of the design channel bottom. This reduces and can eliminate a channel's conveyance capacity. This practice also makes it difficult for flow to enter such a channel, often causing ponding and backwater problems on streets and adjacent properties.

4. If only the channel banks are being lined, the lining material must extend down below the channel invert to below the anticipated scour depth.

5. Avoid designing turns in open channel conveyance systems sharper than 45 degrees, whenever possible. If curves or bends can't be avoided the run-up on the outside of curves must be calculated and incorporated into the channel design.

6. Lot lines should not extend out where they overlay or cross a drainage easement or wash. The wash area or drainage channel should be dedicated in a separate drainage easement Tract whenever possible. This will avoid "back yard to back yard" drainage channels, which can result in serious flooding problems.

Block walls or fences commonly separate lots. Channels that go under or through these walls commonly catch debris, clog, and block or divert flow. Homeowners will sometimes unknowingly and other times on purpose block off or plug these openings. There is no way for the City or a Homeowner's Association to inspect, or maintain these openings. In addition, the size of many of these openings is never actually designed or analyzed. Backyards, pools, houses, and lots can be flooded; and walls knocked over and/or undermined when these openings do not function properly.

Lot lines should end at the edge of the wash floodplain, or man-made channel, not in the middle or on the other side. Building envelopes are not recommended for delineating drainage easements. They can help but are too often misunderstood or ignored as a limit to construction of walls or structures.

Drainage Easement:

Record all required drainage easements as early in the planning and development process as possible. Discontinuous drainage easements for channels are not permitted. Missing drainage easement segments must be dedicated as development takes place.

Detention or Retention

1. Routing of offsite washes into or through onsite subdivision stormwater storage basins should be avoided whenever possible. Prior staff approval must be obtained and maintenance responsibilities clearly stated on the recorded plat and grading and drainage plan.

2. Storage basins should be designed if at all possible with a gravity drain system and not rely on pumps or dry wells (see Policy Manual 2.1 Section 37-42 (12) B.).

3. All Storage basins must have an emergency spillway for flows in excess of the design as well as a safe place to overflow.

4. Above ground storage basins contained by fill, levee or berm, should be avoided whenever possible see 2-308 8.3.3.

5. On-lot retention on individual single family residential lots is not permitted as a solution to subdivision retention requirements.

On-lot retention is normally filled in by homeowners within several years. Runoff then ends up in flooding their house, pool, their neighbor's property, or the alley or street.