REPORT

# INVESTIGATION OF NORTH PHOENIX MOUNTAINS

# FLOOD DETENTION BASINS

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July 27, 1972

Engineering Department
City of Phoenix
700 Municipal Building
251 West Washington
Phoenix, Arizona 85003

Attention: Mr. J. E. Attebery, City Engineer

Re: Job No. ST 71185.00

Gentlemen:

We submit herewith our Report on Investigation of North Phoenix Mountains Flood Detention Basins in accordance with Contract No. 12860 dated December 14, 1971.

We wish to thank you and the City's staff for the assistance and cooperation given in conference and the preparation of this Report.

Respectfully submitted,

JOHN CAROLLO ENGINEERS

Donald R. Preisler

Donald R. Preisler, Partner
Arizona Registration No. 2501

John H. Shannon

John H. Shannon, Engineer
Arizona Registration No. 2930

DRP/lc

REPORT

# INVESTIGATION OF NORTH PHOENIX MOUNTAINS FLOOD DETENTION BASINS

CITY OF PHOENIX, ARIZONA

1972

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Registered Professional Engineer (Mechanical)
CONRAD R. FREISLER
Date Signed 6/1/72
ARIZONA, U.S.A.

# REPORT

# INVESTIGATION OF NORTH PHOENIX MOUNTAINS FLOOD DETENTION BASINS

## CITY OF PHOENIX, ARIZONA

1972

## SCOPE OF REPORT

The purpose of this Report is to locate flood detention basins for regulation of surface runoff from the higher elevations in the Phoenix Mountains due to a 100-year design storm. Release of impounded water is to be controlled by fixed openings at outlets from each basin for discharge at rates suitable to existing downstream channel capacity. For storms greater than the 100-year recurrence, an emergency spillway is to be provided with freeboard capacity sufficient to pass the maximum probable storm runoff. Sites for flood detention basins are to be selected by field reconnaissance in conjunction with aerial pictures and the use of two-foot contour topography maps at the scale of one inch equals 100 feet. Landscaping is to be considered in each plan of improvement. Reservoir ponding areas are to be defined and the land areas required for each project determined. Estimates of cost will be prepared for each basin and shall include the costs for land, construction, and landscaping.

## DETENTION BASIN LOCATIONS

Investigations for detention basins in the Phoenix Mountains have been made at the following locations:

| | |
|---|---|
| Basin No. 2a | 7th Street south of Thunderbird Road |
| Basin No. 2b | Thunderbird Road east of 7th Street |
| Basin No. 3 | 16th Street Wash east of Cave Creek Road |

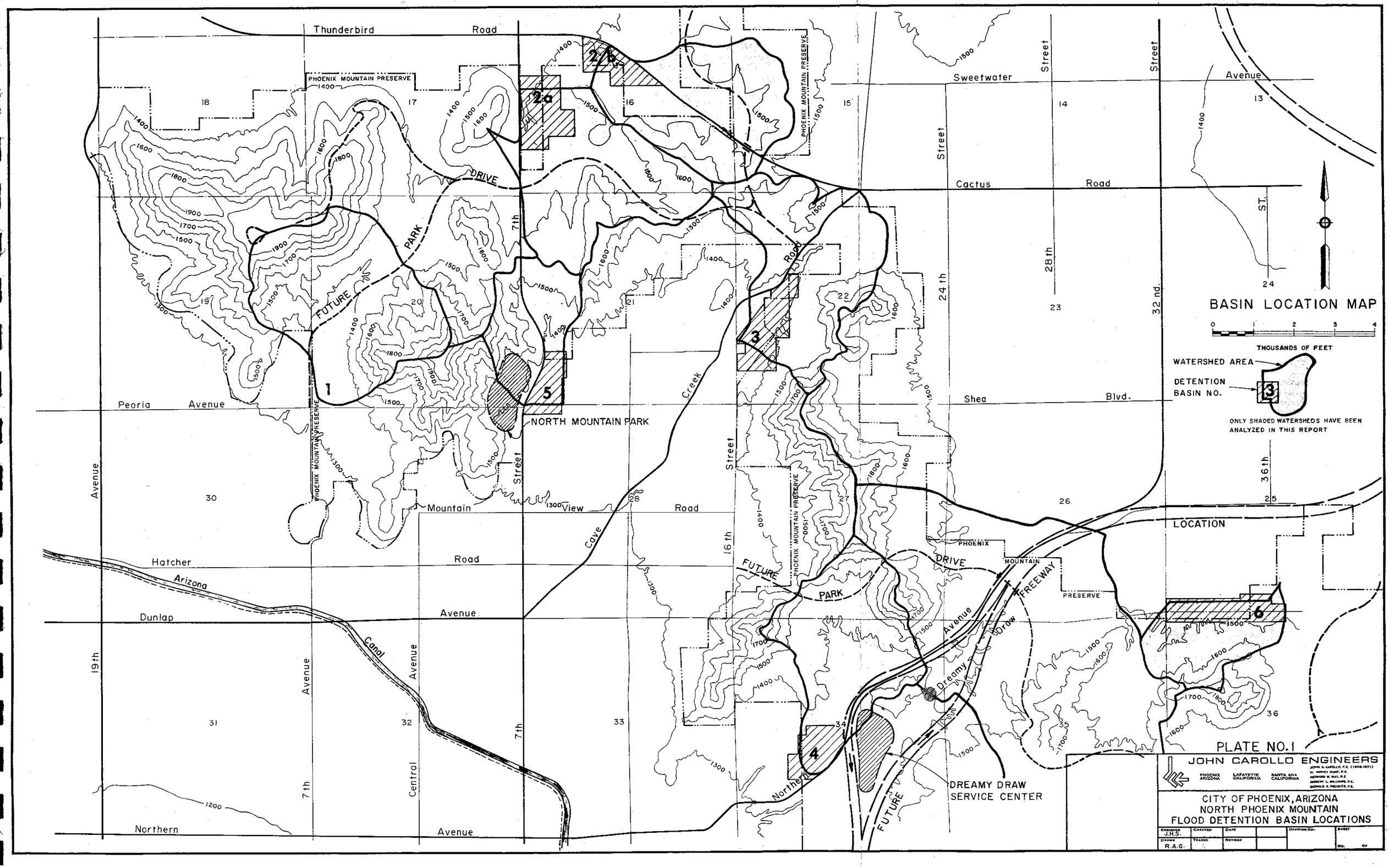
| | |
|---|---|
| Basin No. 4 | 18th Street north of Northern Avenue |
| Basin No. 5 | 7th Street and Peoria Avenue |
| Basin No. 6 | 36th Street south of Mountain View Road |

The various watersheds have been indicated on a map of the North Phoenix Mountains area included on the following page as Plate No. 1 of this Report. Also shown are the watershed locations of City of Phoenix Basin No. 1 and Dreamy Draw Detention Basin, both in the designed-awaiting-construction-funds status.

## CRITERIA FOR DESIGN

Soil Conservation Service criteria and procedure are to be applied in the design of each detention basin. Where failure of an earth dam could result in loss of human life or serious damage to buildings and important public utilities, the Soil Conservation Service has set down in memorandum form the following requirements:

| Basin Design Feature | Requirement |
|---|---|
| a. Sediment storage | Provide for 100-year accumulation below the principal spillway |
| b. Storage capacity and principal spillway | Regulate 6-hour 100-year storm runoff |
| c. Emergency spillway | Provide for peak flow from 6-hour precipitation determined by formula $P = P_{100} + 0.26\ (PMP - P_{100})$ |
| d. Emergency spillway freeboard | Provide for peak flow from 6-hour probable maximum precipitation |


Thunderbird Road
PHOENIX MOUNTAIN PRESERVE
Sweetwater Avenue
Cactus Road
Shea Blvd.
Peoria Avenue
Hatcher Road
Dunlap Avenue
Northern Avenue
Mountain View Road
Cave Creek Road
7th Street
16th Street
24th Street
28th Street
32nd Street
36th Street
19th Avenue
7th Avenue
Central Avenue
Arizona Canal
FUTURE PARK DRIVE
NORTH MOUNTAIN PARK
PHOENIX MOUNTAIN PRESERVE
Dreamy Draw Avenue
FREEWAY
DREAMY DRAW SERVICE CENTER
1
2a
2b
3
4
5
6
BASIN LOCATION MAP
THOUSANDS OF FEET
WATERSHED AREA
DETENTION BASIN NO.
ONLY SHADED WATERSHEDS HAVE BEEN ANALYZED IN THIS REPORT
LOCATION
PLATE NO. 1
JOHN CAROLLO ENGINEERS
PHOENIX ARIZONA
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SANTA ANA CALIFORNIA
CITY OF PHOENIX, ARIZONA
NORTH PHOENIX MOUNTAIN
FLOOD DETENTION BASIN LOCATIONS
DESIGNED J.H.S.
DRAWN R.A.G.
CHECKED
TRACED
DATE
REVISED
DRAWING NO.
SHEET
NO.
OF

For design of the basins in this study, no sediment storage has been provided below the principal spillway. This step avoids extended ponding of water which can be an attractive nuisance. A surveillance and maintenance program will be required to ascertain and remove any excess accumulation of sediments.

The Los Angeles County Flood Control District has planned and developed a notable flood control system over the past forty years. Detention dams and major channels were designed to handle the runoff from a storm equivalent to a fifty-year frequency while the local storm drain network was designed for the runoff from a ten-year frequency storm. These design criteria were established to achieve a balance between the necessity of flood protection works and their considerable cost.

## HYDROLOGICAL DATA

Since stream flow measurements are not available for these small desert watersheds, dependence for runoff will be upon rainfall determined from U. S. Weather Bureau Precipitation Records and Maps. The following table summarizes in brief the general relation of precipitation magnitude for the area of study versus frequency of occurrence for storms of various duration.

PHOENIX MOUNTAINS PRECIPITATION - INCHES

| Storm Duration | Recurrence Interval 10 Years | 25 Years | 50 Years | 100 Years | Observed Maximum | Probable Maximum |
|---|---|---|---|---|---|---|
| 1-Hour(1) | 1.6 | 1.9 | 2.2 | 2.4 | 3.0(2) | 13.0(3) |
| 3-Hour(4) | 1.8 | 2.1 | 2.5 | 2.7 | 3.5(4) | 15.3(4) |
| 6-Hour(5) | 2.0 | 2.4 | 2.8 | 3.1 | 4.0(4) | 18.0(3) |
| 24-Hr(5) | 2.4 | 2.9 | 3.4 | 3.8 | 5.0(3) | 23.0(3) |
| 10-Day(6) | 5.4 | 7.0 | 7.8 | 8.3 | - | - |

(1) Technical Paper No. 40 - U.S. Weather Bureau, 1961
(2) U.S. Weather Bureau, Tempe, Arizona, Sept. 14, 1969
(3) Technical Paper No. 38 - U.S. Weather Bureau, 1960
(4) J.C.E. interpolation - T.P. No. 40 U.S. Weather Bureau
(5) Precipitation Maps - U.S. Weather Bureau, SCS (AHD Rev. 1970)
(6) Technical Paper No. 49 - U.S. Weather Bureau, 1964

## SURFACE RUNOFF

Examination of the Phoenix Mountains watersheds reveal the upper slopes and hills to be steep and rocky while the lower slopes and valleys are caliche cemented talus through which drainage channels are deeply cut. Reference to the Soil Conservation Service "General Soil Map of Maricopa County" indicates the watersheds to be rock outcroppings, stony mountainous soils on steep slopes, and recent alluvial soil with conservative infiltration rates of 0.05 to 0.15 inch per hour. For this study a surface runoff factor (SCS - curve number) of 91 has been selected after consideration of the slopes, soil types, and ground cover.

## SEDIMENT

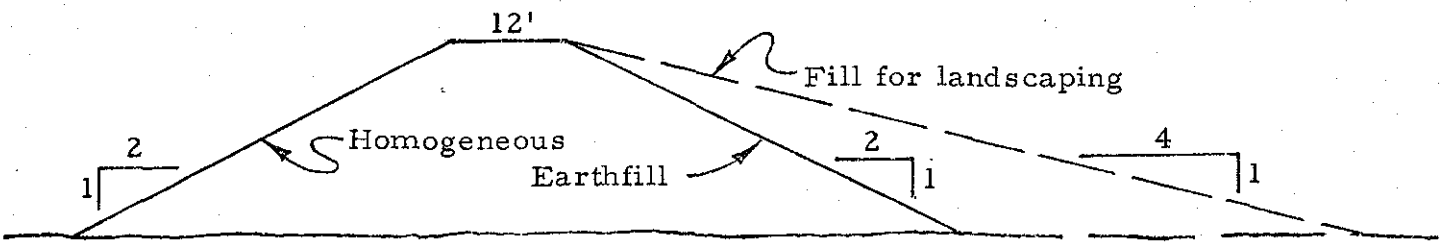
Investigations of silt accumulation have been made for several reservoirs in Arizona. Results of these studies are noted below in terms of average accumulation per year. Also included are average sediment accumulation values applied in designated project design reports.

### SEDIMENT ACCUMULATION TABLE

| Location | Period | Rate A-F per Sq Mile per Year |
|---|---|---|
| 1. San Carlos Reservoir - Gila River | 1928-37 | 0.18 |
| | 1937-47 | 0.37 |
| 2. Roosevelt Lake - Salt River | 1925-35 | 0.15 |
| | 1935-39 | 0.85 |
| | 1939-46 | 0.42 |
| 3. Little Box Canyon Reservoir - Mineral Creek | 1952-67 | 0.27 |
| 4. Magma No. 1 near Florence | 1948-59 | 0.15 |
| Magma No. 2 near Florence | 1954-59 | 0.15 |
| Magma No. 3 near Florence | 1949-59 | 0.03 |
| 5. Big Horn Mountain Tank No. 1 near Tonopah | 1960-64 | 0.11 |
| Big Horn Mountain Tank No. 2 near Tonopah | 1960-64 | 0.11 |
| 6. Guadalupe south of Tempe | Design Report | 0.13 |
| 7. Trilby Wash near Beardsley | Design Report | 0.20 |
| 8. Santa Rosa Wash near Casa Grande | Design Report | 0.20 |
| 9. Sands Draw Detention Dam near Safford | Design Report | 0.15 |

## STANDARD SECTION FOR FLOOD DETENTION DAM

In this study the typical cross section illustrated below summarizes simply the results of preliminary design for development of cost estimates. In general, the crest of an earth dam acts as a single lane roadway and for ease of construction with power equipment should be not less than twelve feet in width. The upstream and downstream slopes of 2:1 are typical of small homogeneous flood control dams on an impervious foundation. To permit landscaping, the downstream slope has been modified to 4:1 and the cost thereof included as a separate item. The total height of embankment includes the ponding depth resulting from routing of the 100-year, 6-hour storm runoff, plus 3 feet for the emergency spillway hydrograph peak discharge plus 3 feet for freeboard in the spillway channel.




EMBANKMENT SECTION

## LANDSCAPING

Considering the location of these detention basins in a water deficient area adjacent to the Phoenix Mountain Preserve where mountain forms and desert vistas are to be preserved, we recommend that desert landscaping be adopted. This can be achieved through the protection,

salvage, and relocation of existing desert plants with some supplemental planting during construction. Natural revegetation can be expected to complete restoration of desert cover.

Placement of additional uncompacted fill on the downstream slope as a landscaping measure could lessen the public awareness of detention basin embankments. Modification of the slope increases the embankment volume and area requiring landscape treatment. A policy will have to be established regarding landscape fill placement. In this Report for estimating purposes a uniform fill to a 1:4 slope has been used. Should exotic landscaping be considered, costs of various elements are approximated as follows:

| | |
|---|---|
| Nursery stock and planting | $2,500 per acre |
| Water distribution system | $7,500 per acre |
| Maintenance and water | $1,000 per acre per year |

DOWNSTREAM CHANNELS

Field inspection was made of the existing downstream flood channels. Typically these are irregular desert shrub lined, sand, rock, and caliche bottom courses encroached upon by some structures, fill material, and trash. In one subdivision the street has been constructed with an inverted crown on the general channel alignment to carry the desert runoff and surface flow from subdivision lots. The capacity of the channels all considerably exceed 30 cubic feet per second except in one case where property owners in a subdivision have reduced the runoff channel section to a capacity of about 25 cubic feet per second. Principal spillways have been considered individually in this Report and their capacities range from about 20 to 35 cubic feet per second.

## SOIL CONSERVATION SERVICE DESIGN PROCEDURE

For orderly computation a hydraulic design data sheet was prepared for tabulation of watershed physical and computed characteristics. This form and a copy of the Soil Conservation Service Design Hydrograph Computation Sheet used in computing Principal Spillway, Emergency Spillway, and Emergency Spillway Freeboard Hydrographs are included in the Appendix.

The Principal Spillway Hydrograph for this study has been computed for a six-hour 100-year storm runoff utilizing the Soil Conservation Service Emergency Spillway dimensionless hydrograph procedure outlined in Chapter 21, Section 4, Hydrology of the National Engineering Handbook. The capacity of the reservoir was then determined by routing the hydrograph flow through the reservoir and orifice controlled outlet to ascertain the storage and emergency spillway level and time required for the reservoir to drain. Orifice size was selected after field inspection of the downstream channel and consideration of the orifice head-discharge capacity.

Design of the emergency spillway is based upon the peak discharge of the Emergency Spillway Hydrograph computed by Soil Conservation Service procedure and the six-hour design minimum precipitation computed by the formula:

$$P = P_{100} - 0.26\,(PMP - P_{100})$$

Width of the spillway is determined assuming three feet of available head at the channel inlet and computing the width for critical depth at the control section. In this design since the channels are not overly long, the grade of the spillway can be level.

The Emergency Spillway Freeboard Hydrograph is also constructed following the Soil Conservation Service dimensionless hydrograph procedure by utilizing the Probable Maximum Precipitation. From the peak hydrograph discharge and the width of the spillway, total depth of flow is computed as the minimum height of the detention dam embankment above the spillway channel.

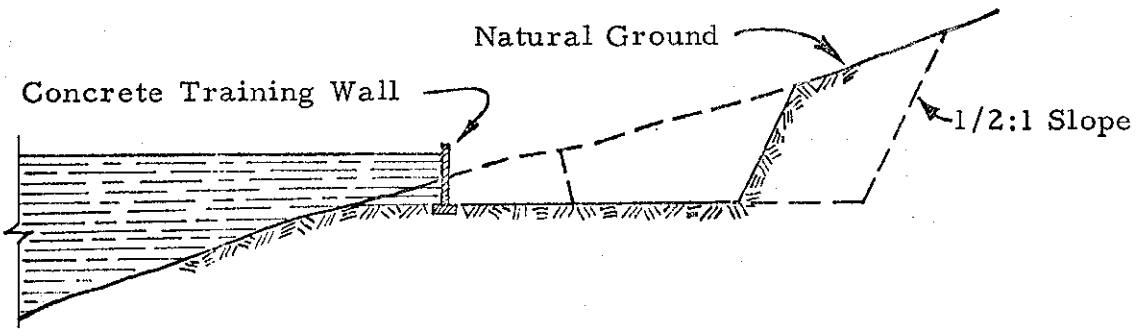
A summary of references, applicable design curves, and six-hour precipitation maps utilized in design of detention basins in this Report appear in the Appendix.

## PRINCIPAL SPILLWAY — CONTROLLED OUTLET

This structure is composed of three elements: a large trash rack surrounding a rectangular steel orifice plate bolted to the inlet headwall for a 27-inch outlet pipe laid to a grade greater than critical slope at maximum head. Advantages include the generally vandal-proof system, orifice control independent of pipe length which can be altered, and a discharge pipe suitable for inspection and repair. This system was devised for use at the Shaw Butte Detention Dams (Basin No. 1) and has been adopted in this Report.

EMERGENCY SPILLWAY

Each basin must have an emergency spillway to prevent overtopping and failure of the embankment section due to runoff from the maximum probable storm. The structure is generally an excavated section all in natural ground. However, at the Phoenix Mountains sites studied in this Report, a concrete training wall has been included as a means of reducing the spillway cut and protecting the earthfill embankment.




EMERGENCY SPILLWAY SECTION

## DETENTION BASIN ANALYSIS

### BASIN NO. 2: 7th Street and Thunderbird Road

Field investigation and study of this basin indicates that by dividing the watershed in two and accepting surface runoff on the streets at the northwest corner an economy will result through reduction of embankment and use of lower valued land. This solution also permits the continued use of existing street drainage structures. Relative to land area, 91 percent of the surface runoff can be controlled by the basins designated as Basin No. 2a and Basin No. 2b.

### Basin No. 2a: 7th Street south of Thunderbird Road

Control of this portion of the watershed can be accomplished with an embankment along 7th Street and across the existing drainage channel to the hill approximately 500 feet to the east as shown on Plate No. 2. Material for embankment should be obtained from the reservoir area above the principal spillway invert and an adjustment made for the increase in reservoir storage capacity. This basin site is located outside the Phoenix Mountains Preserve on land owned by private individuals and the State of Arizona.

### Basin No. 2b: Thunderbird Road east of 7th Street

Development of this basin requires an embankment running north from the high ground across the natural drainage channel to Thunderbird Road and thence east along the right-of-way. Insufficient storage capacity was available above the natural contours so excavation and disposal of excess material has been employed to develop the basin indicated on Plate No. 3. Disposal of excess material at some designated location or

elsewhere at a contractor's option would permit bid pricing for the work. Land for this basin site outside the Phoenix Mountains Preserve is indicated by the Maricopa County Assessor to be owned by the State of Arizona.

BASIN NO. 3: 16th Street Wash east of Cave Creek Road

Field reconnaissance of this basin revealed three possible detention basin sites. One site north of Cave Creek Road at approximately 19th Street was eliminated on account of the small watershed which could be controlled. The basin site selected on the main wash north of Desert Cove Road lies east of 16th Street and Cave Creek Road. Analysis indicates this detention basin illustrated on Plate No. 4 would have a greater storage capacity, require dikes of lesser height, and make relocation of existing streets unnecessary when comparison is made with a basin located 500 feet upstream. Acquisition of land in addition to that now held by the City of Phoenix for a park will be necessary. The main embankment is located across the Santa Rosa Mining Claim, and final location of the long auxiliary dike on the north may require commercial frontage on Cave Creek Road.

BASIN NO. 4: 18th Street north of Northern Avenue

Only one site is possible for a detention basin on this watershed. A problem in priority and design exists between present and future streets and drainage channels adjacent to the proposed freeway and Dreamy Draw Service Center to the east of the basin site. Within the watershed an amphitheater, picnic area, equestrian center, and a recreation area represent improvements planned for the future in this sector of the Phoenix Mountains Preserve. The detention basin developed on Plate No. 5 utilizes the natural contour of the site. In a final design, integrated with access

streets and freeway location, excavation can be employed to conform with structures and embankments to provide the required detention storage capacity. The land for this detention basin site is privately owned.

BASIN NO. 5: 7th Street and Peoria Avenue

Field reconnaissance indicated two possible detention basin sites available, but in subsequent discussion the northerly site was selected for investigation. The basin illustrated on Plate No. 6 is formed by an embankment commencing at the diversion point of the easterly drainage channel which runs southward to parallel a fenced property. The embankment then curves westerly along the line of peoria Avenue to higher ground near 7th Street. The natural contours enclosed by the embankment provide the necessary storage to control runoff from the six-hour 100-year storm. Land required for this improvement is privately owned.

BASIN NO. 6: 36th Street south of Mountain View Road

Past flooding in this area has resulted in damage to individual homes where subdivision street drainage capacity was exceeded. With expanded subdivision development, flooding can be expected to occur with greater frequency due to increased volume of runoff and more rapid accumulation of flow. Some alleviation of the problem can be effected by the construction of storm drains and channels of limited capacity to improved natural courses of surface drainage. Consideration of the future freeway along Mountain View Road and the moderate slope of lands south of the existing subdivisions has resulted after several trials in location of this detention basin along the foot of the Phoenix Mountains as shown on Plate No. 7 of this Report.

Some consideration was given to excavation of an emergency spillway channel easterly into the next natural surface drainage. However, for the height of embankment determined, a long concrete lined channel would have been required, and this was judged to be uneconomical.

On the following pages are included design data summary, estimate of costs, and preliminary design drawing of each detention basin in numerical order. The basin designated No. 1, not a part of this Report, has been investigated and designed by the City of Phoenix. Approval to construct the two detention basins has been received from the Arizona Water Commission.

# DESIGN DATA SUMMARY

DETENTION BASIN NO. 2a, 7th Street south of Thunderbird Road

| Item | Unit | Total |
|---|---|---|
| Class of Structure | - | C |
| Drainage Area | Sq Mi | 0.54 |
| Average Area Slope | % | 6.6 |
| Width Factor | - | 0.89 |
| Curve No. (1-day) (AMC II) | - | 91 |
| $T_c$ | Hrs | 0.39 |
| Elevation: Top of Dam | Ft | 1,414 |
| Crest Emergency Spillway | Ft | 1,408 |
| Invert Principal Spillway | Ft | 1,391 |
| Maximum Height of Dam | Ft | 23 |
| Crest Width | Ft | 12 |
| Volume of Embankment 2:1 Slopes | Cu Yds | 28,000 |
| Volume of Landscape Fill to 4:1 Slope | Cu Yds | 10,000 |
| Capacity | | |
| Sediment - 100 Yrs @ 0.15 A-F/SM/Yr | Ac-Ft | 8.1 |
| Retarding Storage | Ac-Ft | 51.6 |
| Crest Contour | Ac-Ft | 148.0 |
| Surface Area | | |
| Sediment Pool | Acres | 0 |
| Retarding Pool | Acres | 10.3 |
| Crest Contour | Acres | 19.8 |
| Principal Spillway | | |
| Rainfall Volume (PSH) (areal) | In. | 3.1 |
| Runoff Volume (PSH) | In. | 2.2 |
| Capacity at Emergency Spillway Crest | cfs | 27 |
| Size of Orifice | In. | 14x14 |
| Size of Conduit | Diam - In. | 27 |
| Minimum Slope of Conduit | Ft/Ft | 0.006 |
| Emergency Spillway | | |
| Rainfall Volume (ESH) (areal) | In. | 7.0 |
| Runoff Volume (ESH) | In. | 6.0 |
| Soil Type | - | Caliche |
| Bottom Width | Ft | 100 |
| Velocity of Flow ($V_e$) | Ft/Sec | 8 |
| Slope of Exit Channel | Ft/Ft | Level |
| Maximum Water Surface Elevation | Ft | 1,411 |
| Freeboard | | |
| Rainfall Volume (FH) (areal) | In. | 18 |
| Runoff Volume (FH) | In. | 17 |
| Maximum Water Surface Elevation | Ft | 1,414 |

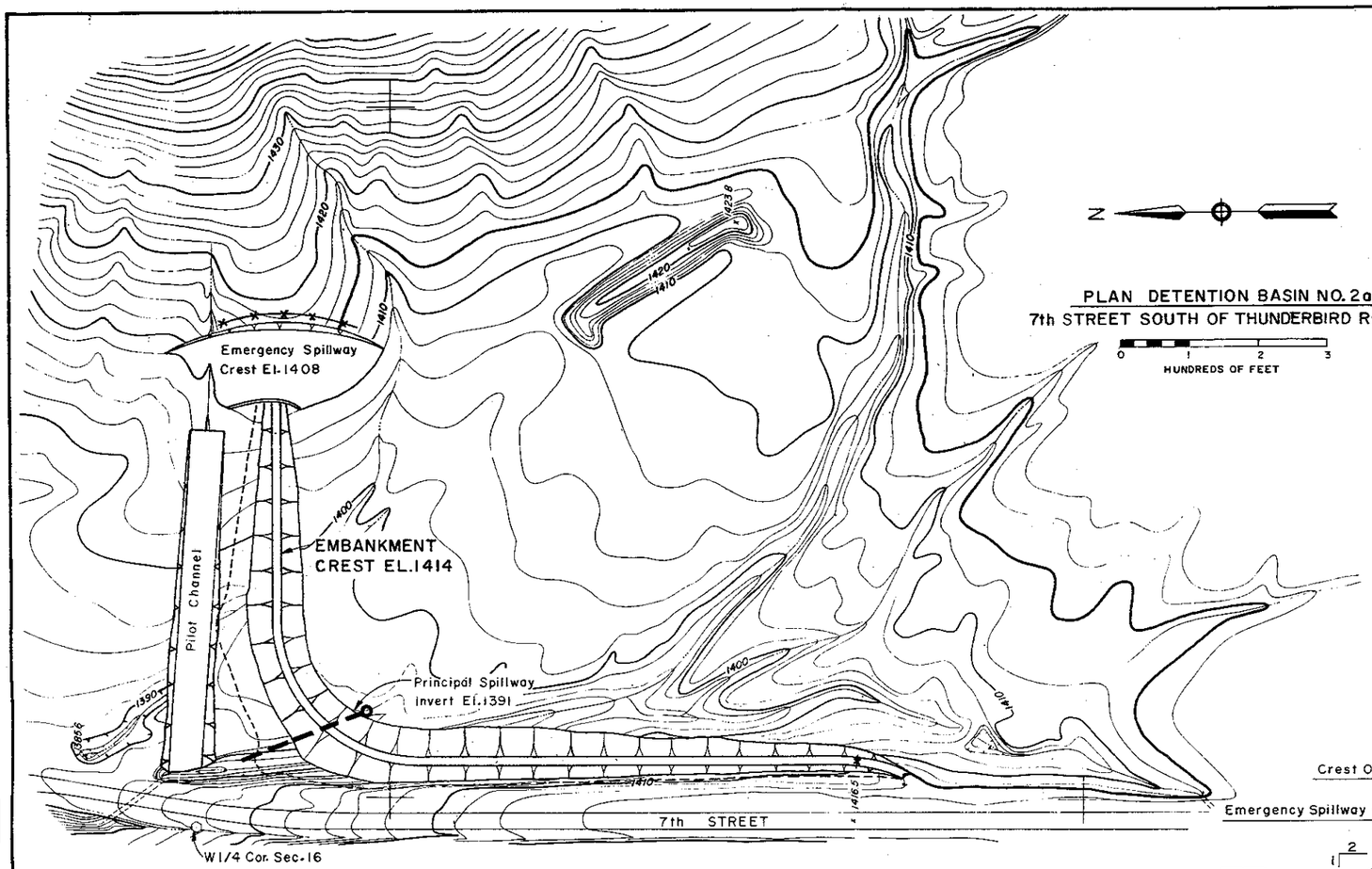
# ESTIMATE OF COST - 1972

DETENTION BASIN NO. 2a

7th Street south of Thunderbird Road

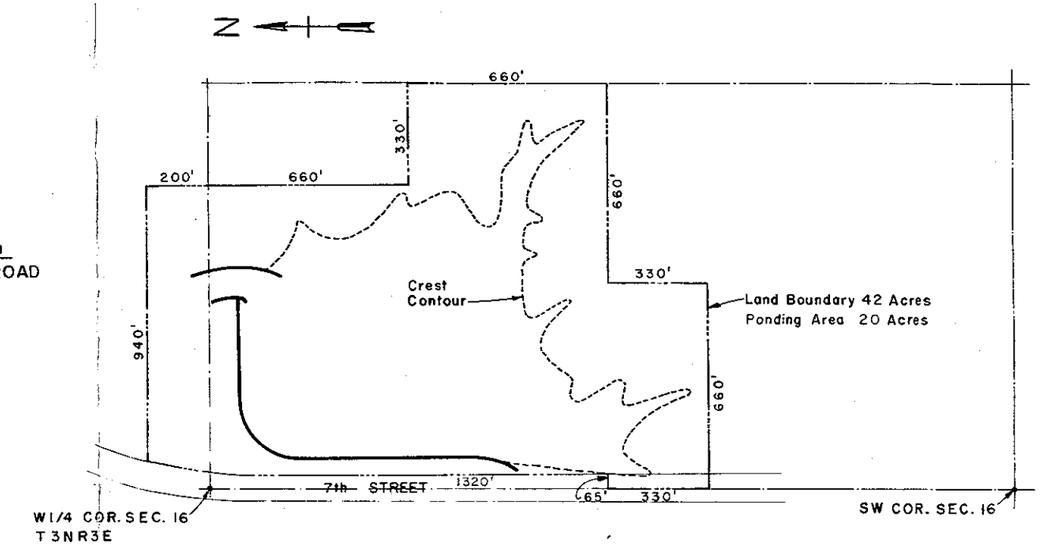
| No. | Item | Unit | Quantity | Unit Price | Cost * |
|---|---|---|---|---|---|
| 1 | Embankment | CY | 28,000 | $ 2.00 | $ 56,000 |
| 2 | Spillway Excavation | CY | 4,000 | 3.00 | 12,000 |
| 3 | Concrete Wall | LF | 100 | 60.00 | 6,000 |
| 4 | Outlet Works | LS | 1 | 8,000.00 | 8,000 |
| 5 | Fencing | LF | 225 | 4.00 | 900 |
| | Basin Construction Cost | | | | $ 82,900 |
| 6 | Landscape Fill | CY | 10,000 | 1.50 | 15,000 |
| 7 | Desert Landscaping | Ac | 2 | 1,000.00 | 2,000 |
| 8 | Land Purchase | Ac | 42 | 6,000.00 | 252,000 |
| 9 | Engr. Design & Insp. (12% of Constr. Cost) | | | | 12,000 |
| 10 | Admin., Legal, etc. ( 8% of Constr. Cost) | | | | 8,000 |
| | Total Project Cost | | | | $371,900 |

* Figures are rounded



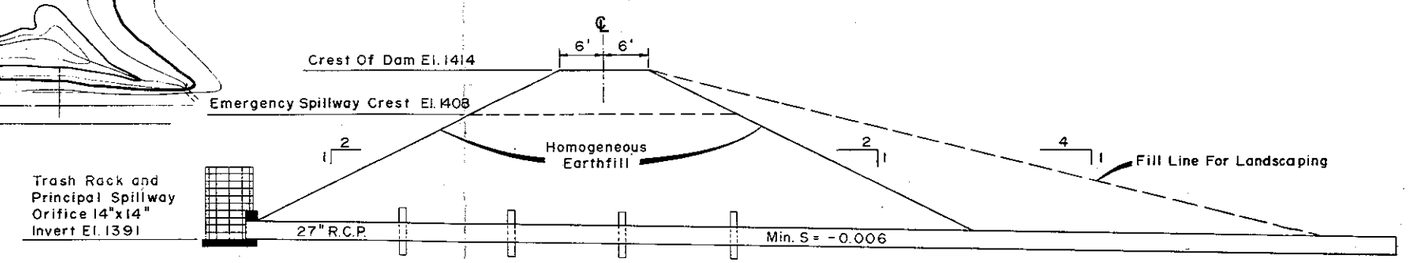

PLAN DETENTION BASIN NO. 2a
7th STREET SOUTH OF THUNDERBIRD ROAD

0 1 2 3
HUNDREDS OF FEET

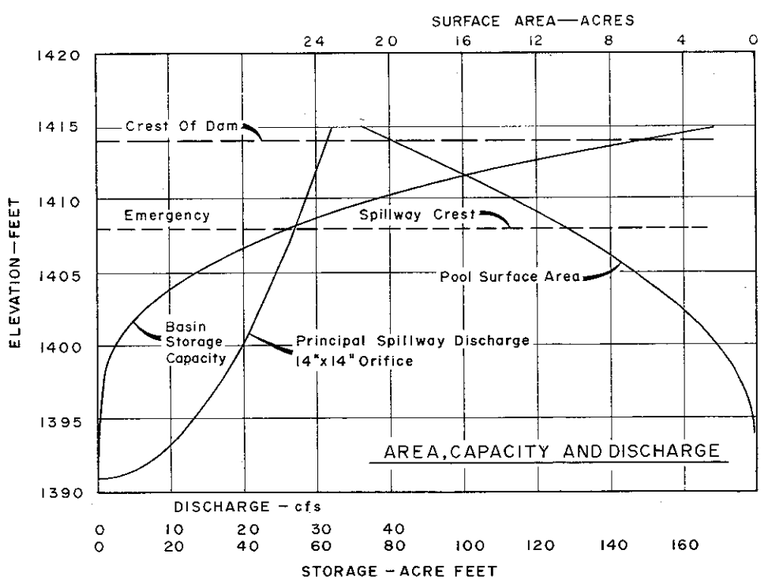



LAND ACQUISITION MAP

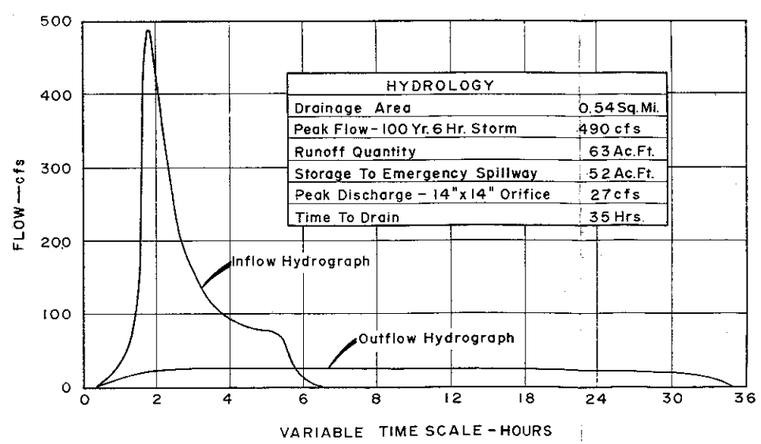
0 1 2 3 4 5
HUNDREDS OF FEET




SECTION-EARTHFILL AND PRINCIPAL SPILLWAY




AREA, CAPACITY AND DISCHARGE




| HYDROLOGY | |
|---|---|
| Drainage Area | 0.54 Sq. Mi. |
| Peak Flow - 100 Yr. 6 Hr. Storm | 490 cfs |
| Runoff Quantity | 63 Ac. Ft. |
| Storage To Emergency Spillway | 52 Ac. Ft. |
| Peak Discharge - 14"x14" Orifice | 27 cfs |
| Time To Drain | 35 Hrs. |

PLATE NO. 2

JOHN CAROLLO ENGINEERS
PHOENIX ARIZONA · LAFAYETTE CALIFORNIA · SANTA ANA CALIFORNIA

CITY OF PHOENIX, ARIZONA
NORTH PHOENIX MOUNTAIN
FLOOD DETENTION BASIN NO. 2a

| Designed | Checked | Date | | Drawing No. | Sheet |
|---|---|---|---|---|---|
| B.W. | | | | | No. of |
| Drawn | Traced | Revised | | | |
| R.A.G. | | | | | |

# DESIGN DATA SUMMARY

DETENTION BASIN NO. 2b, Thunderbird Road east of 7th Street

| Item | Unit | Total |
|---|---|---|
| Class of Structure | - | C |
| Drainage Area | Sq Mi | 0.48 |
| Average Area Slope | % | 4.5 |
| Width Factor | - | 1.0 |
| Curve No. (1-day) (AMC II) | - | 91 |
| $T_c$ | Hrs | 0.53 |
| Elevation: Top of Dam | Ft | 1,418 |
| Crest Emergency Spillway | Ft | 1,412 |
| Invert Principal Spillway | Ft | 1,396 |
| Maximum Height of Dam | Ft | 22 |
| Crest Width | Ft | 12 |
| Volume of Embankment 2:1 Slopes | Cu Yds | 17,000 |
| Volume of Landscape Fill to 4:1 Slope | Cu Yds | 6,000 |
| Capacity | | |
| Sediment - 100 Yrs @ 0.15 A-F/SM/Yr | Ac-Ft | 7.2 |
| Retarding Storage | Ac-Ft | 47.9 |
| Crest Contour | Ac-Ft | 85.0 |
| Surface Area | | |
| Sediment Pool | Acres | 0 |
| Retarding Pool | Acres | 6.0 |
| Crest Contour | Acres | 11.3 |
| Principal Spillway | | |
| Rainfall Volume (PSH) (areal) | In. | 3.1 |
| Runoff Volume (PSH) | In. | 2.2 |
| Capacity at Emergency Spillway Crest | cfs | 34 |
| Size of Orifice | In. | 16 x 16 |
| Size of Conduit | Diam - In. | 27 |
| Minimum Slope of Conduit | Ft/Ft | 0.009 |
| Emergency Spillway | | |
| Rainfall Volume (ESH) (areal) | In. | 7.0 |
| Runoff Volume (ESH) | In. | 6.0 |
| Soil Type | - | Caliche |
| Bottom Width | Ft | 80 |
| Velocity of Flow ($V_e$) | Ft/Sec | 8 |
| Slope of Exit Channel | Ft/Ft | Level |
| Maximum Water Surface Elevation | Ft | 1,415 |
| Freeboard | | |
| Rainfall Volume (FH) (areal) | In. | 18 |
| Runoff Volume (FH) | In. | 17 |
| Maximum Water Surface Elevation | Ft | 1,418 |

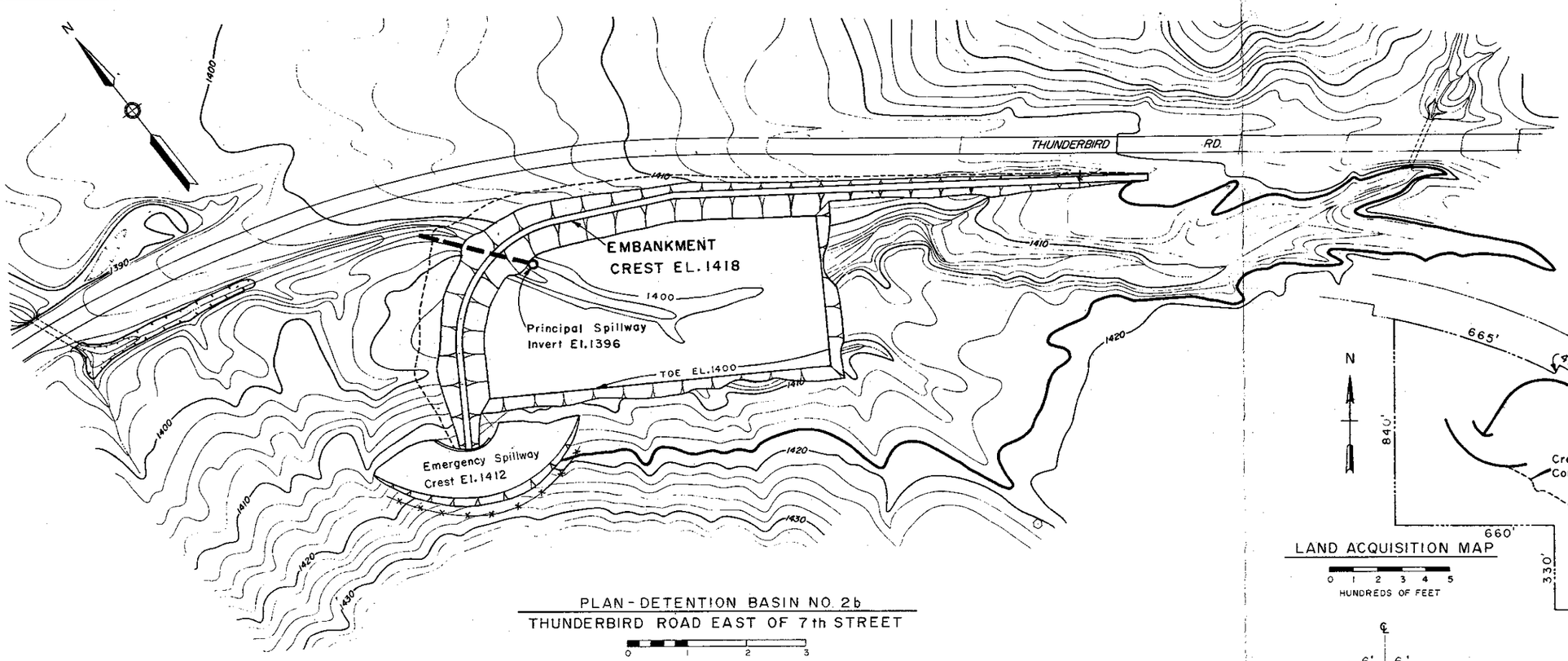
# ESTIMATE OF COST - 1972

DETENTION BASIN NO. 2b

Thunderbird Road east of 7th Street

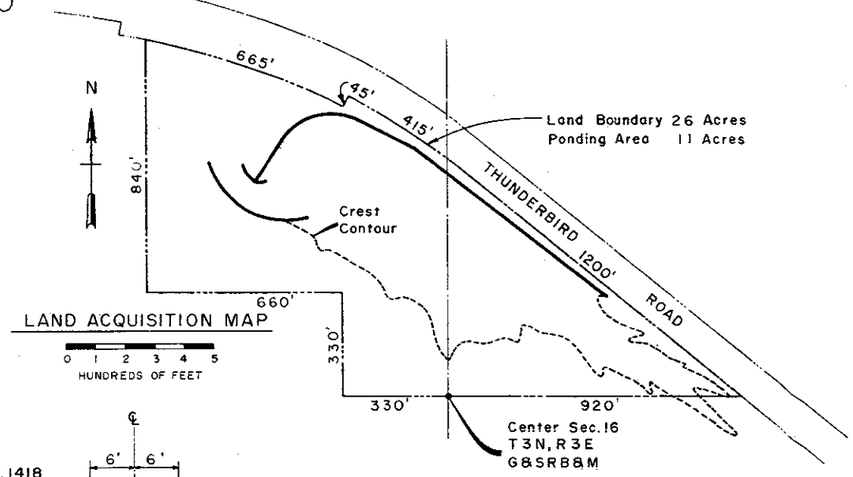
| No. | Item | Unit | Quantity | Unit Price | Cost* |
|---|---|---|---|---|---|
| 1 | Embankment | CY | 17,000 | $ 2.00 | $ 34,000 |
| 2 | Spillway Excavation | CY | 6,000 | 3.00 | 18,000 |
| 3 | Basin Excavation | CY | 5,000 | 1.50 | 7,500 |
| 4 | Concrete Wall | LF | 100 | 60.00 | 6,000 |
| 5 | Outlet Works | LS | 1 | 8,000.00 | 8,000 |
| 6 | Fencing | LF | 400 | 4.00 | 1,600 |
| | Basin Construction Cost | | | | $ 75,100 |
| 7 | Landscape Fill | CY | 6,000 | 1.50 | 9,000 |
| 8 | Desert Landscaping | Ac | 1.3 | 1,000.00 | 1,300 |
| 9 | Land Purchase | Ac | 26 | 6,000.00 | 156,000 |
| 10 | Engr. Design & Insp. (12% of Constr. Cost) | | | | 10,250 |
| 11 | Admin., Legal, etc. ( 8% of Constr. Cost) | | | | 6,850 |
| | Total Project Cost | | | | $258,500 |

* Figures are rounded



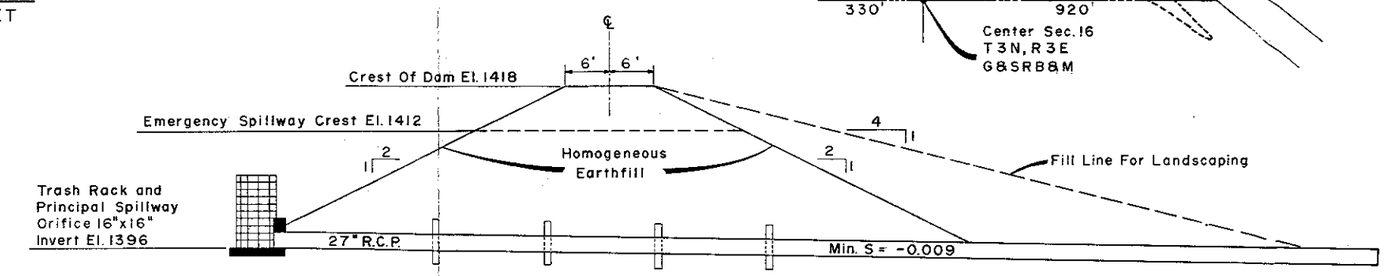

PLAN - DETENTION BASIN NO. 2b
THUNDERBIRD ROAD EAST OF 7th STREET

0 1 2 3
HUNDREDS OF FEET

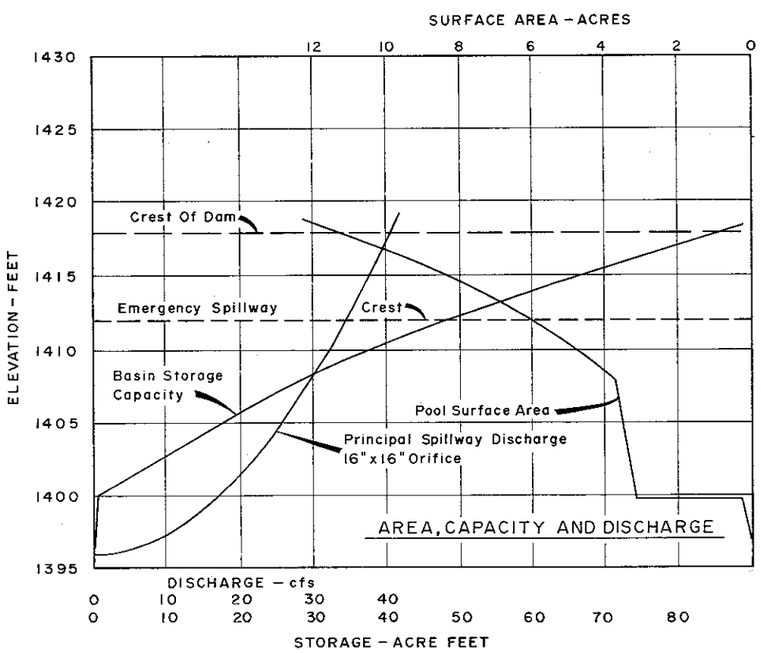



LAND ACQUISITION MAP

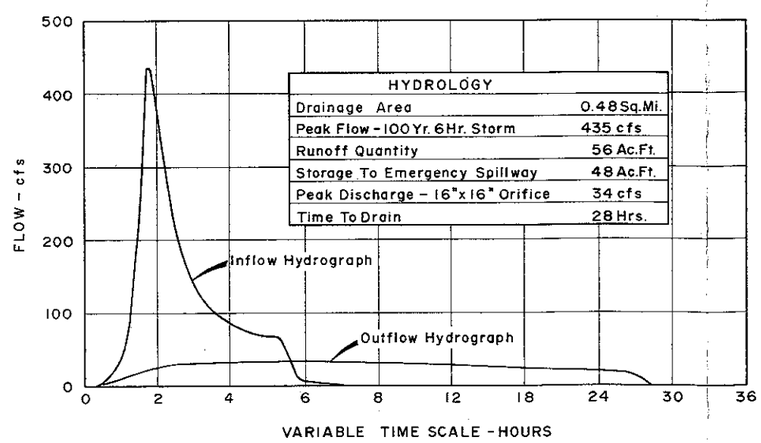
0 1 2 3 4 5
HUNDREDS OF FEET




SECTION - EARTHFILL AND PRINCIPAL SPILLWAY




AREA, CAPACITY AND DISCHARGE




| HYDROLOGY | |
|---|---|
| Drainage Area | 0.48 Sq.Mi. |
| Peak Flow - 100 Yr. 6 Hr. Storm | 435 cfs |
| Runoff Quantity | 56 Ac.Ft. |
| Storage To Emergency Spillway | 48 Ac.Ft. |
| Peak Discharge - 16"x16" Orifice | 34 cfs |
| Time To Drain | 28 Hrs. |

PLATE NO. 3

JOHN CAROLLO ENGINEERS
PHOENIX ARIZONA · LAFAYETTE CALIFORNIA · SANTA ANA CALIFORNIA

CITY OF PHOENIX, ARIZONA
NORTH PHOENIX MOUNTAIN
FLOOD DETENTION BASIN NO. 2b

| Designed | Checked | Date | | Drawing No. | Sheet |
|---|---|---|---|---|---|
| J.H.S. | | | | | |
| Drawn | Traced | Revised | | | No. of |
| R.A.G. | | | | | |

# DESIGN DATA SUMMARY

DETENTION BASIN NO. 3, 16th Street Wash east of Cave Creek Road

| Item | Unit | Total |
|---|---|---|
| Class of Structure | - | C |
| Drainage Area | Sq Mi | 0.48 |
| Average Area Slope | % | 4.2 |
| Width Factor | - | 1.0 |
| Curve No. (1-day) (AMC II) | - | 91 |
| $T_c$ | Hrs | 0.56 |
| Elevation: Top of Dam | Ft | 1,391 |
| Crest Emergency Spillway | Ft | 1,385 |
| Invert Principal Spillway | Ft | 1,363 |
| Maximum Height of Dam | Ft | 28 |
| Crest Width | Ft | 12 |
| Volume of Embankment 2:1 Slopes | Cu Yds | 24,000 |
| Volume of Landscape Fill to 4:1 Slope | Cu Yds | 8,000 |
| Capacity | | |
| Sediment - 100 Yrs @ 0.15 A-F/SM/Yr | Ac-Ft | 7.2 |
| Retarding Storage | Ac-Ft | 54.0 |
| Crest Contour | Ac-Ft | 137.6 |
| Surface Area | | |
| Sediment Pool | Acres | 0 |
| Retarding Pool | Acres | 9.4 |
| Crest Contour | Acres | 18.6 |
| Principal Spillway | | |
| Rainfall Volume (PSH) (areal) | In. | 3.1 |
| Runoff Volume (PSH) | In. | 2.2 |
| Capacity at Emergency Spillway Crest | cfs | 30 |
| Size of Orifice | In. | 14x14 |
| Size of Conduit | Diam - In. | 27 |
| Minimum Slope of Conduit | Ft/Ft | 0.008 |
| Emergency Spillway | | |
| Rainfall Volume (ESH) (areal) | In. | 8.0 |
| Runoff Volume (ESH) | In. | 7.0 |
| Soil Type | - | Caliche |
| Bottom Width | Ft | 80 |
| Velocity of Flow ($V_e$) | Ft/Sec | 8 |
| Slope of Exit Channel | Ft/Ft | Level |
| Maximum Water Surface Elevation | Ft | 1,388 |
| Freeboard | | |
| Rainfall Volume (FH) (areal) | In. | 18 |
| Runoff Volume (FH) | In. | 17 |
| Maximum Water Surface Elevation | Ft | 1,391 |

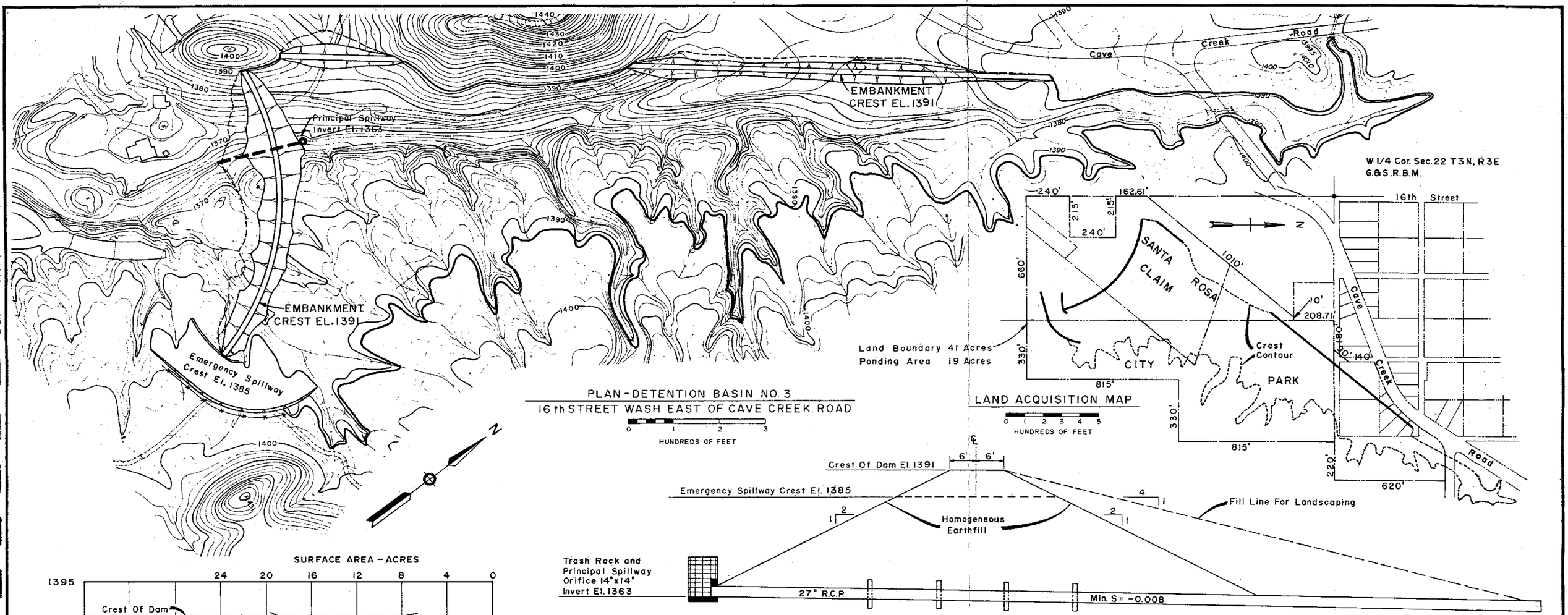
# ESTIMATE OF COST - 1972

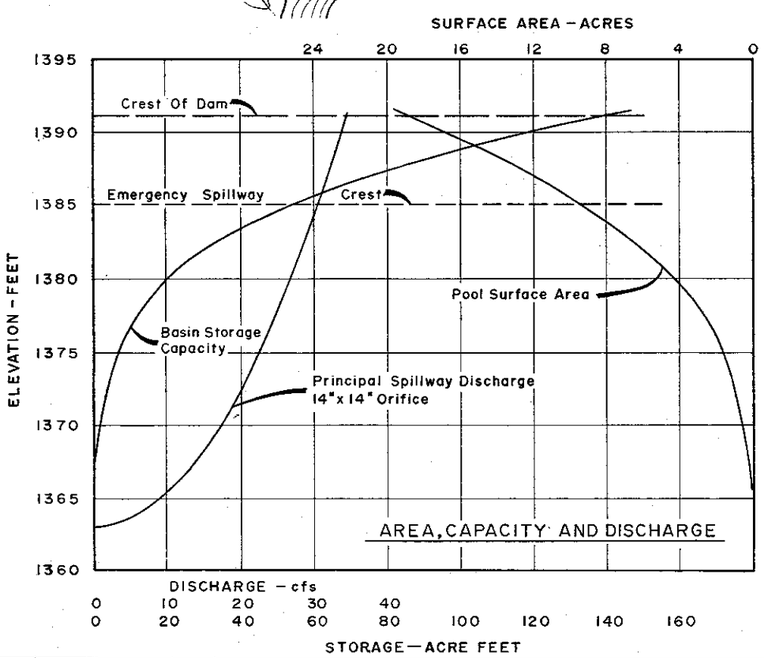
DETENTION BASIN NO. 3

16th Street Wash east of Cave Creek Road

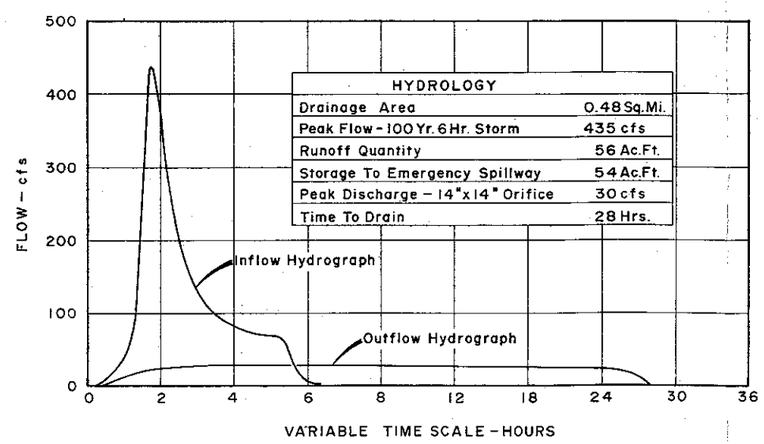
| No. | Item | Unit | Quantity | Unit Price | Cost* |
|---|---|---|---|---|---|
| 1 | Embankment | CY | 24,000 | $ 2.00 | $ 48,000 |
| 2 | Spillway Excavation | CY | 5,000 | 3.00 | 15,000 |
| 3 | Concrete Wall | LF | 150 | 60.00 | 9,000 |
| 4 | Outlet Works | LS | 1 | 8,000.00 | 8,000 |
| 5 | Fencing | LF | 350 | 4.00 | 1,400 |
| | Basin Construction Cost | | | | $ 81,400 |
| 6 | Landscape Fill | CY | 8,000 | 1.50 | 12,000 |
| 7 | Desert Landscaping | Ac | 1.5 | 1,000.00 | 1,500 |
| 8 | Land Purchase | Ac | 22 | 5,000.00 | 110,000 |
| 9 | Engr. Design & Insp. (12% of Constr. Cost) | | | | 11,400 |
| 10 | Admin., Legal, etc. ( 8% of Constr. Cost) | | | | 7,600 |
| | Total Project Cost | | | | $223,900 |

* Figures are rounded




AREA, CAPACITY AND DISCHARGE




| HYDROLOGY | |
|---|---|
| Drainage Area | 0.48 Sq.Mi. |
| Peak Flow - 100 Yr. 6 Hr. Storm | 435 cfs |
| Runoff Quantity | 56 Ac.Ft. |
| Storage To Emergency Spillway | 54 Ac.Ft. |
| Peak Discharge - 14"x14" Orifice | 30 cfs |
| Time To Drain | 28 Hrs. |

PLATE NO. 4

JOHN CAROLLO ENGINEERS
PHOENIX ARIZONA · LAFAYETTE CALIFORNIA · SANTA ANA CALIFORNIA

CITY OF PHOENIX, ARIZONA
NORTH PHOENIX MOUNTAIN
FLOOD DETENTION BASIN NO.3

Designed B.W. · Checked · Date · Drawing No. · Sheet · Drawn R.A.G. · Traced · Revised

# DESIGN DATA SUMMARY

DETENTION BASIN NO. 4, 18th Street north of Northern Avenue

| Item | Unit | Total |
|---|---|---|
| Class of Structure | - | C |
| Drainage Area | Sq Mi | 0.44 |
| Average Area Slope | % | 4.2 |
| Width Factor | - | 1.0 |
| Curve No. (1-day) (AMC II) | - | 91 |
| $T_c$ | Hrs | 0.55 |
| Elevation: Top of Dam | Ft | 1,338 |
| Crest Emergency Spillway | Ft | 1,332 |
| Invert Principal Spillway | Ft | 1,317 |
| Maximum Height of Dam | Ft | 21 |
| Crest Width | Ft | 12 |
| Volume of Embankment 2:1 Slopes | Cu Yds | 26,000 |
| Volume of Landscape Fill to 4:1 Slope | Cu Yds | 9,000 |
| Capacity | | |
| Sediment - 100 Yrs @ 0.15 A-F/SM/Yr | Ac-Ft | 6.6 |
| Retarding Storage | Ac-Ft | 44.2 |
| Crest Contour | Ac-Ft | 124.7 |
| Surface Area | | |
| Sediment Pool | Acres | 0 |
| Retarding Pool | Acres | 9.7 |
| Crest Contour | Acres | 16.7 |
| Principal Spillway | | |
| Rainfall Volume (PSH) (areal) | In. | 3.1 |
| Runoff Volume (PSH) | In. | 2.2 |
| Capacity at Emergency Spillway Crest | cfs | 33.5 |
| Size of Orifice | In. | 16 x 16 |
| Size of Conduit | Diam - In. | 27 |
| Minimum Slope of Conduit | Ft/Ft | 0.009 |
| Emergency Spillway | | |
| Rainfall Volume (ESH) (areal) | In. | 7.0 |
| Runoff Volume (ESH) | In. | 6.0 |
| Soil Type | - | Caliche |
| Bottom Width | Ft | 75 |
| Velocity of Flow ($V_e$) | Ft/Sec | 8 |
| Slope of Exit Channel | Ft/Ft | Level |
| Maximum Water Surface Elevation | Ft | 1,335 |
| Freeboard | | |
| Rainfall Volume (FH) (areal) | In. | 18 |
| Runoff Volume (FH) | In. | 17 |
| Maximum Water Surface Elevation | Ft | 1,338 |

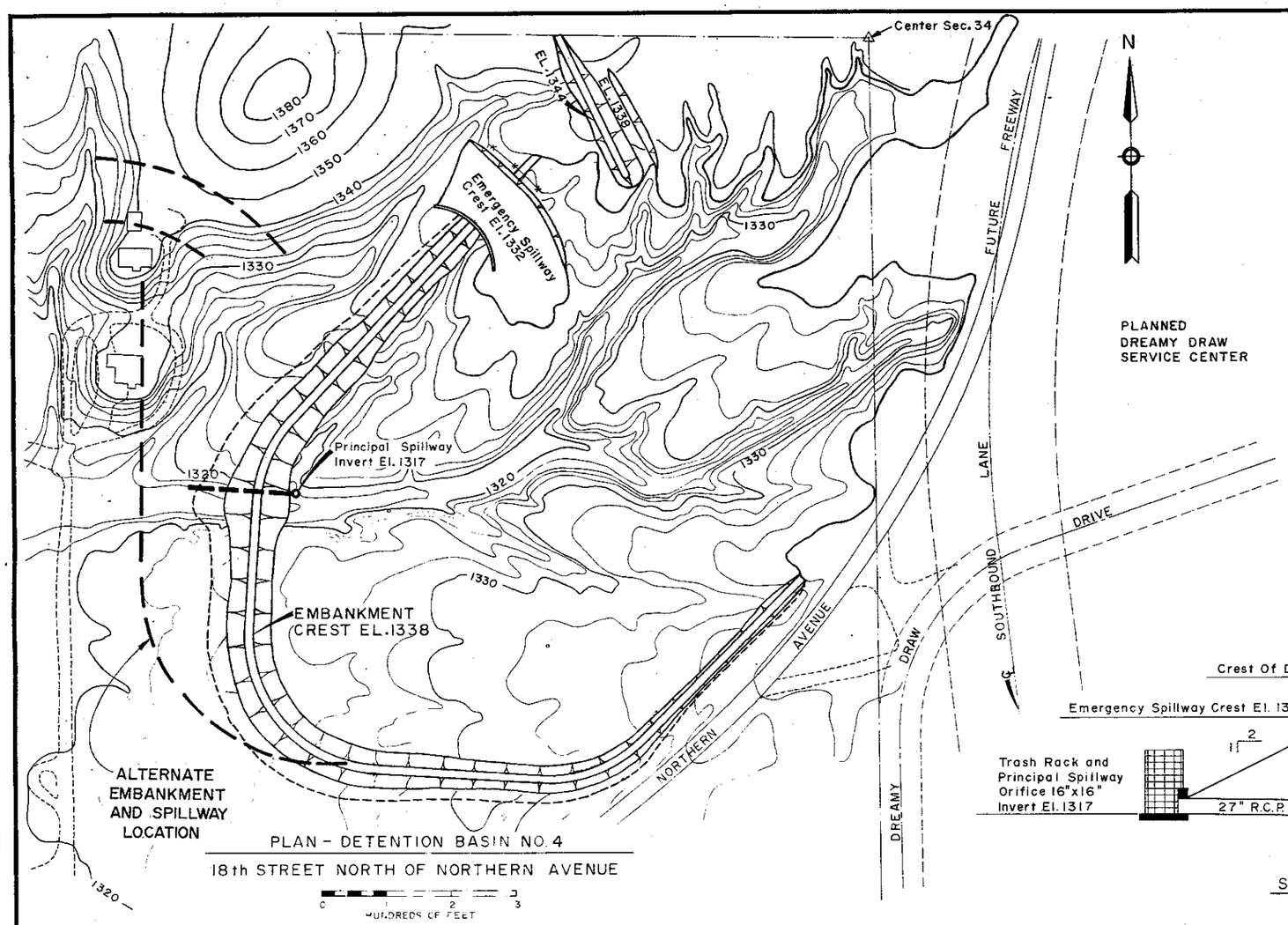
# ESTIMATE OF COST - 1972

DETENTION BASIN NO. 4

18th Street north of Northern Avenue

| No. | Item | Unit | Quantity | Unit Price | Cost* |
|---|---|---|---|---|---|
| 1 | Embankment | CY | 26,000 | $ 2.00 | $ 52,000 |
| 2 | Spillway Excavation | CY | 2,000 | 3.00 | 6,000 |
| 3 | Concrete Wall | LF | 150 | 60.00 | 9,000 |
| 4 | Outlet Works | LS | 1 | 8,000.00 | 8,000 |
| 5 | Fencing | LF | 150 | 4.00 | 600 |
| | Basin Construction Cost | | | | $ 75,600 |
| 6 | Landscape Fill | CY | 9,000 | 1.50 | 13,500 |
| 7 | Desert Landscaping | Ac | 2.0 | 1,000.00 | 2,000 |
| 8 | Land Purchase | Ac | 33 | 5,500.00 | 181,500 |
| 9 | Engr. Design & Insp. | (12% of Constr. Cost) | | | 10,900 |
| 10 | Admin., Legal, etc. | ( 8% of Constr. Cost) | | | 7,300 |
| | Total Project Cost | | | | $290,800 |

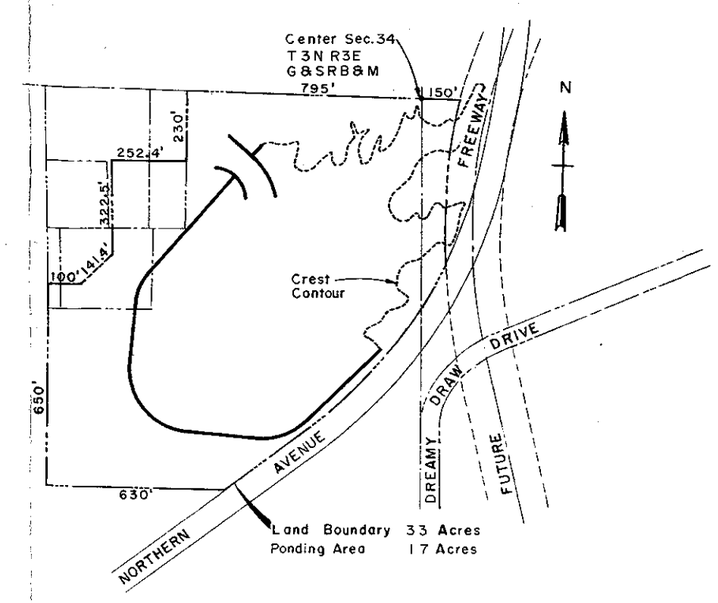
* Figures are rounded




PLAN - DETENTION BASIN NO. 4

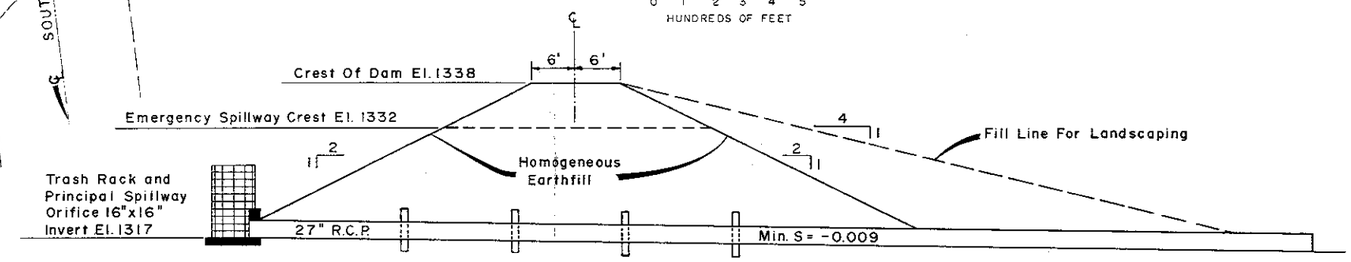
18th STREET NORTH OF NORTHERN AVENUE

0 1 2 3 HUNDREDS OF FEET

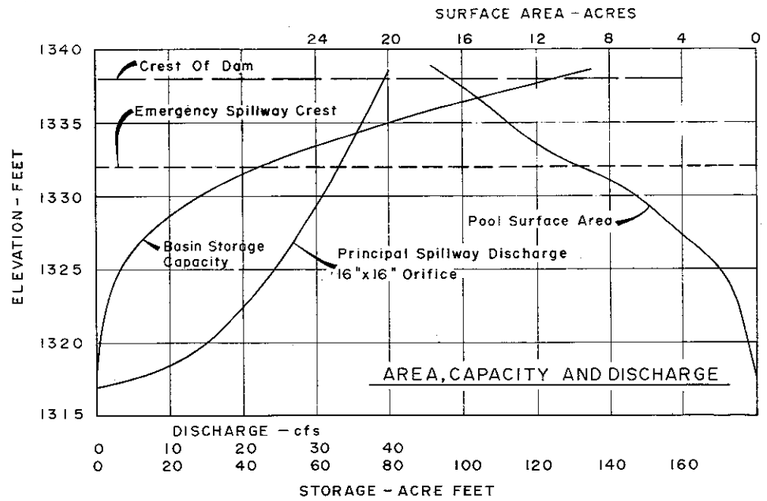



LAND ACQUISITION MAP

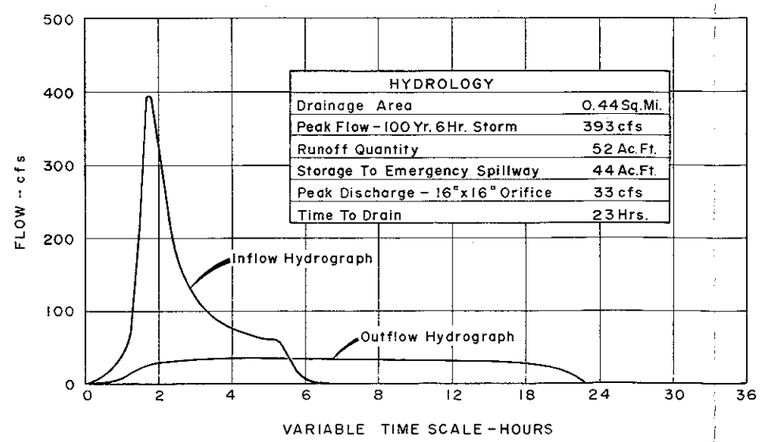
0 1 2 3 4 5 HUNDREDS OF FEET




SECTION - EARTHFILL AND PRINCIPAL SPILLWAY




AREA, CAPACITY AND DISCHARGE




| HYDROLOGY | |
|---|---|
| Drainage Area | 0.44 Sq. Mi. |
| Peak Flow - 100 Yr. 6 Hr. Storm | 393 cfs |
| Runoff Quantity | 52 Ac. Ft. |
| Storage To Emergency Spillway | 44 Ac. Ft. |
| Peak Discharge - 16"x16" Orifice | 33 cfs |
| Time To Drain | 23 Hrs. |

PLATE NO. 5

JOHN CAROLLO ENGINEERS

PHOENIX ARIZONA · SANTA ANA CALIFORNIA · LAFAYETTE CALIFORNIA

CITY OF PHOENIX, ARIZONA
NORTH PHOENIX MOUNTAIN
FLOOD DETENTION BASIN NO. 4

| Designed | Checked | Date | | Drawing No. | Sheet |
|---|---|---|---|---|---|
| B.W. | | | | | |
| Drawn | Traced | Revised | | | No. of |
| R.A.G. | | | | | |

# DESIGN DATA SUMMARY

DETENTION BASIN NO. 5, 7th Street and Peoria Road

| Item | Unit | Total |
|---|---|---|
| Class of Structure | - | C |
| Drainage Area | Sq Mi | 0.23 |
| Average Area Slope | % | 9.2 |
| Width Factor | - | 1.0 |
| Curve No. (1-day) (AMC II) | - | 91 |
| Tc | Hrs | 0.31 |
| Elevation: Top of Dam | Ft | 1,371 |
| Crest Emergency Spillway | Ft | 1,365 |
| Invert Principal Spillway | Ft | 1,348 |
| Maximum Height of Dam | Ft | 23 |
| Crest Width | Ft | 12 |
| Volume of Embankment 2:1 Slopes | Cu Yds | 20,000 |
| Volume of Landscape Fill to 4:1 Slope | Cu Yds | 7,000 |
| Capacity | | |
| Sediment - 100 Yrs @ 0.15 A-F/SM/Yr | Ac-Ft | 3.5 |
| Retarding Storage | Ac-Ft | 25.0 |
| Crest Contour | Ac-Ft | 65.0 |
| Surface Area | | |
| Sediment Pool | Acres | 0 |
| Retarding Pool | Acres | 4.6 |
| Crest Contour | Acres | 8.9 |
| Principal Spillway | | |
| Rainfall Volume (PSH) (areal) | In. | 3.1 |
| Runoff Volume (PSH) | In. | 2.2 |
| Capacity at Emergency Spillway Crest | cfs | 20 |
| Size of Orifice | In. | 14 x 14 |
| Size of Conduit | Diam - In. | 27 |
| Minimum Slope of Conduit | Ft/Ft | 0.004 |
| Emergency Spillway | | |
| Rainfall Volume (ESH) (areal) | In. | 7.0 |
| Runoff Volume (ESH) | In. | 6.0 |
| Soil Type | - | Caliche |
| Bottom Width | Ft | 45 |
| Velocity of Flow ($V_e$) | Ft/Sec | 8 |
| Slope of Exit Channel | Ft/Ft | Level |
| Maximum Water Surface Elevation | Ft | 1,368 |
| Freeboard | | |
| Rainfall Volume (FH) (areal) | In. | 18 |
| Runoff Volume (FH) | In. | 17 |
| Maximum Water Surface Elevation | Ft | 1,371 |

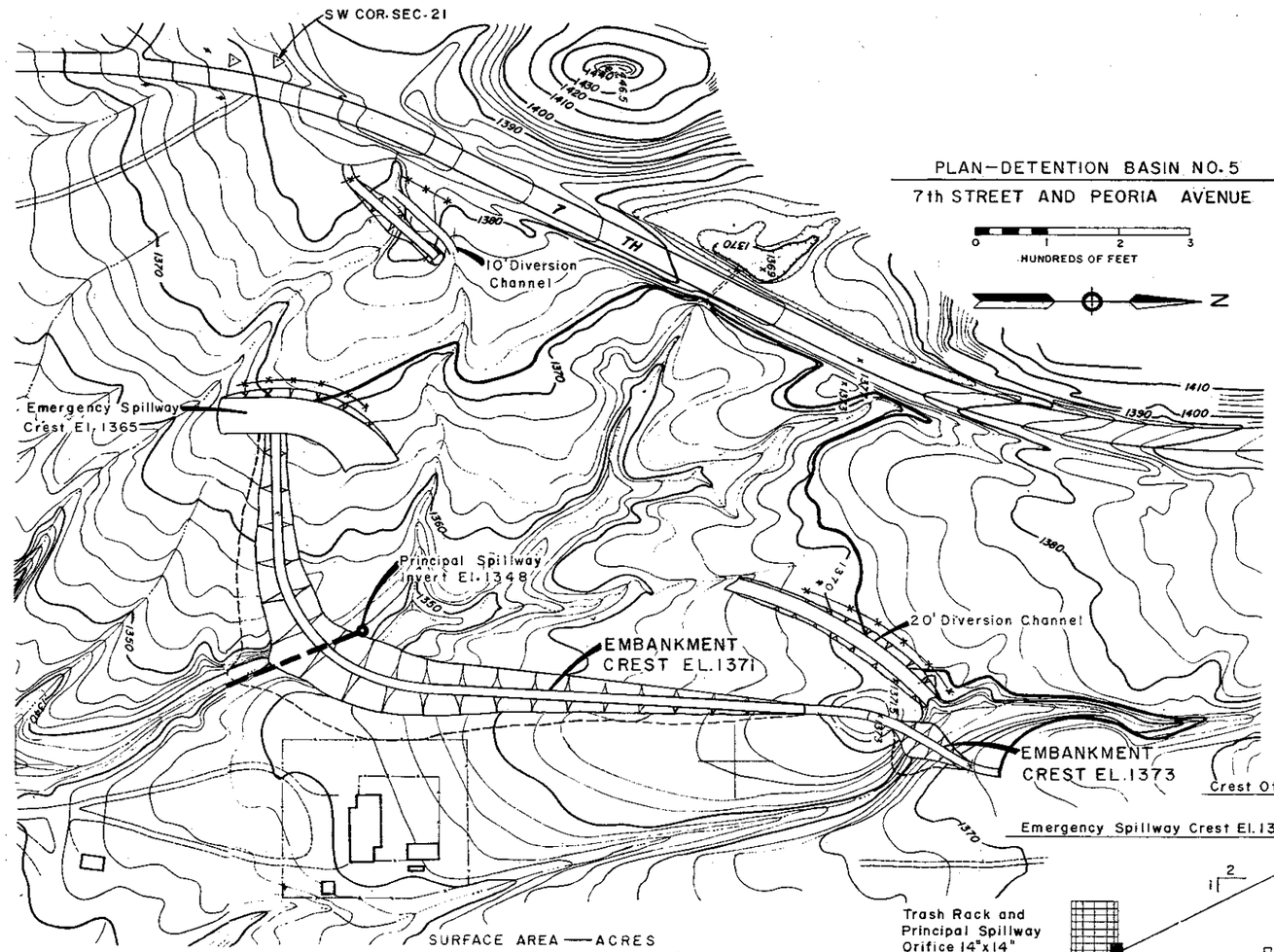
# ESTIMATE OF COST - 1972

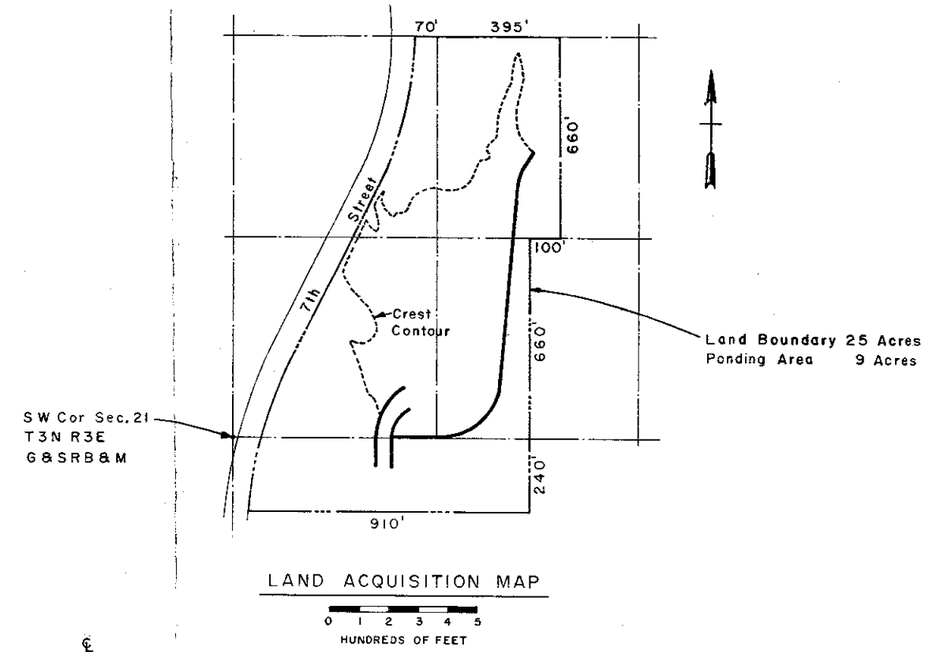
DETENTION BASIN NO. 5

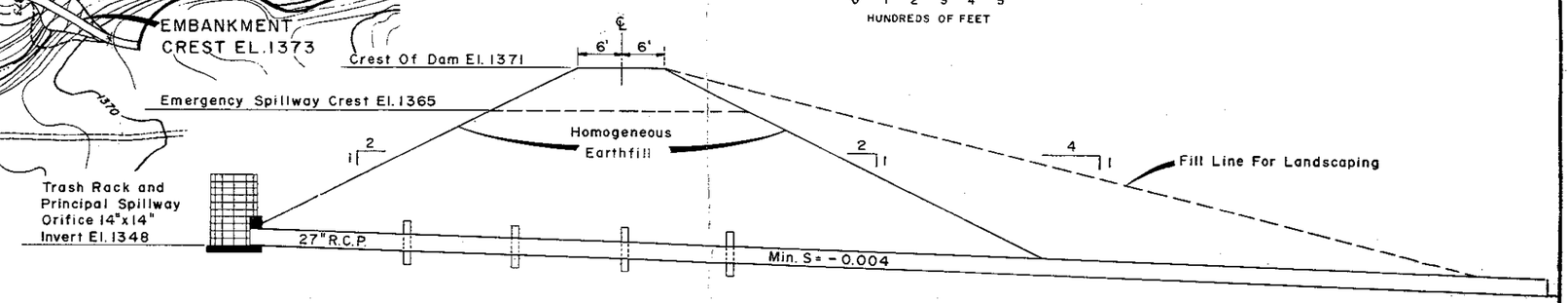
7th Street and Peoria Avenue

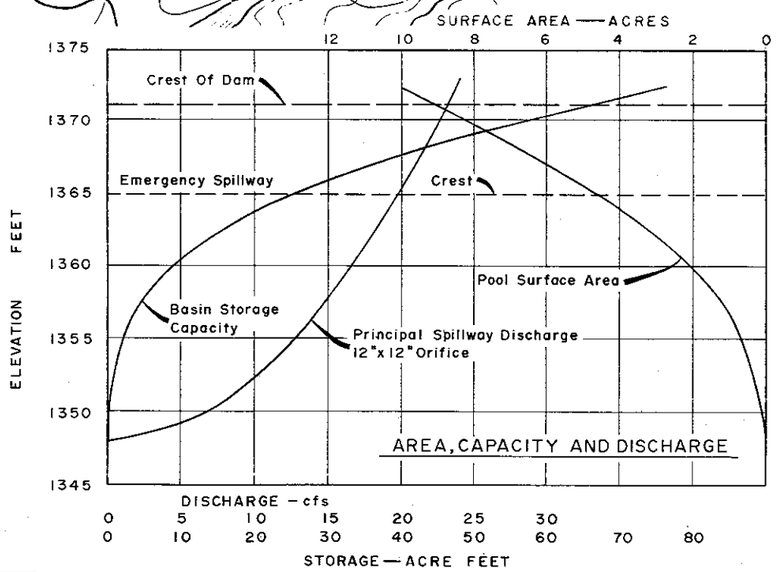
| No. | Item | Unit | Quantity | Unit Price | Cost * |
|---|---|---|---|---|---|
| 1 | Embankment | CY | 20,000 | $ 2.00 | $ 40,000 |
| 2 | Spillway Excavation | CY | 2,000 | 3.00 | 6,000 |
| 3 | Concrete Wall | LF | 100 | 60.00 | 6,000 |
| 4 | Outlet Works | LS | 1 | 8,000.00 | 8,000 |
| 5 | Fencing | LF | 175 | 4.00 | 700 |
| | Basin Construction Cost | | | | $ 60,700 |
| 6 | Landscape Fill | CY | 7,000 | 1.50 | 10,500 |
| 7 | Desert Landscaping | Ac | 1.5 | 1,000.00 | 1,500 |
| 8 | Land Purchase | Ac | 20 | 5,000.00 | 100,000 |
| 9 | Engr. Design & Insp. (12% of Constr. Cost) | | | | 8,700 |
| 10 | Admin., Legal, etc. ( 8% of Constr. Cost) | | | | 5,800 |
| | Total Project Cost | | | | $187,200 |

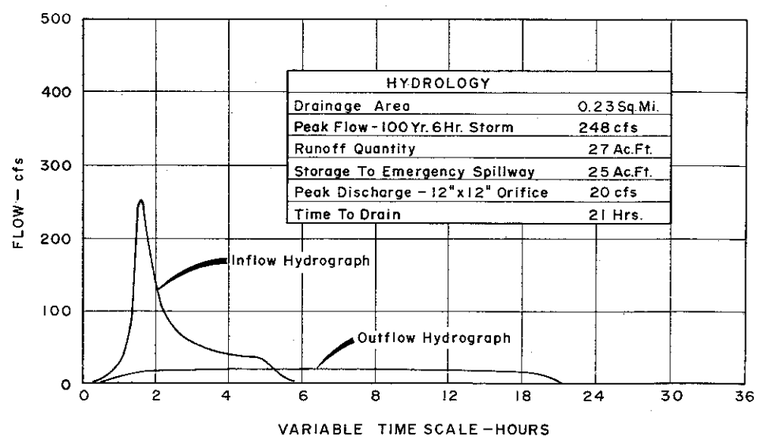
* Figures are rounded




| HYDROLOGY | |
|---|---|
| Drainage Area | 0.23 Sq. Mi. |
| Peak Flow - 100 Yr. 6 Hr. Storm | 248 cfs |
| Runoff Quantity | 27 Ac.Ft. |
| Storage To Emergency Spillway | 25 Ac.Ft. |
| Peak Discharge - 12"x12" Orifice | 20 cfs |
| Time To Drain | 21 Hrs. |

PLATE NO. 6

JOHN CAROLLO ENGINEERS
PHOENIX ARIZONA · LAFAYETTE CALIFORNIA · SANTA ANA CALIFORNIA

CITY OF PHOENIX, ARIZONA
NORTH PHOENIX MOUNTAIN
FLOOD DETENTION BASIN NO. 5

| Designed | Checked | Date | | Drawing No. | Sheet |
|---|---|---|---|---|---|
| J.H.S. | | | | | |
| Drawn | Traced | Revised | | | No. |
| G.N.M. | | | | | |

# DESIGN DATA SUMMARY

DETENTION BASIN NO. 6, 36th Street south of Mountain View

| Item | Unit | Total |
|---|---|---|
| Class of Structure | - | C |
| Drainage Area | Sq Mi | 0.21 |
| Average Area Slope | % | 18.7 |
| Width Factor | - | 1.0 |
| Curve No. (1-day) (AMC II) | - | 91 |
| $T_c$ | Hrs | 0.20 |
| Elevation: Top of Dam | Ft | 1,486 |
| Crest Emergency Spillway | Ft | 1,480 |
| Invert Principal Spillway | Ft | 1,468 |
| Maximum Height of Dam | Ft | 16 |
| Crest Width | Ft | 12 |
| Volume of Embankment 2:1 Slopes | Cu Yds | 29,000 |
| Volume of Landscape Fill to 4:1 Slope | Cu Yds | 10,000 |
| Capacity | | |
| Sediment - 100 Yrs @ 0.15 A-F/SM/Yr | Ac-Ft | 3.0 |
| Retarding Storage | Ac-Ft | 26.9 |
| Crest Contour | Ac-Ft | 91.0 |
| Surface Area | | |
| Sediment Pool | Acres | 0 |
| Retarding Pool | Acres | 6.2 |
| Crest Contour | Acres | 15.5 |
| Principal Spillway | | |
| Rainfall Volume (PSH) (areal) | In. | 3.1 |
| Runoff Volume (PSH) | In. | 2.2 |
| Capacity at Emergency Spillway Crest | cfs | 21 |
| Size of Orifice | In. | 14x14 |
| Size of Conduit | Diam - In. | 27 |
| Minimum Slope of Conduit | Ft/Ft | 0.014 |
| Emergency Spillway | | |
| Rainfall Volume (ESH) (areal) | In. | 7.0 |
| Runoff Volume (ESH) | In. | 6.0 |
| Soil Type | - | Caliche |
| Bottom Width | Ft | 45 |
| Velocity of Flow ($V_e$) | Ft/Sec | 8 |
| Slope of Exit Channel | Ft/Ft | Level |
| Maximum Water Surface Elevation | Ft | 1,483 |
| Freeboard | | |
| Rainfall Volume (FH) (areal) | In. | 18 |
| Runoff Volume (FH) | In. | 17 |
| Maximum Water Surface Elevation | Ft | 1,486 |

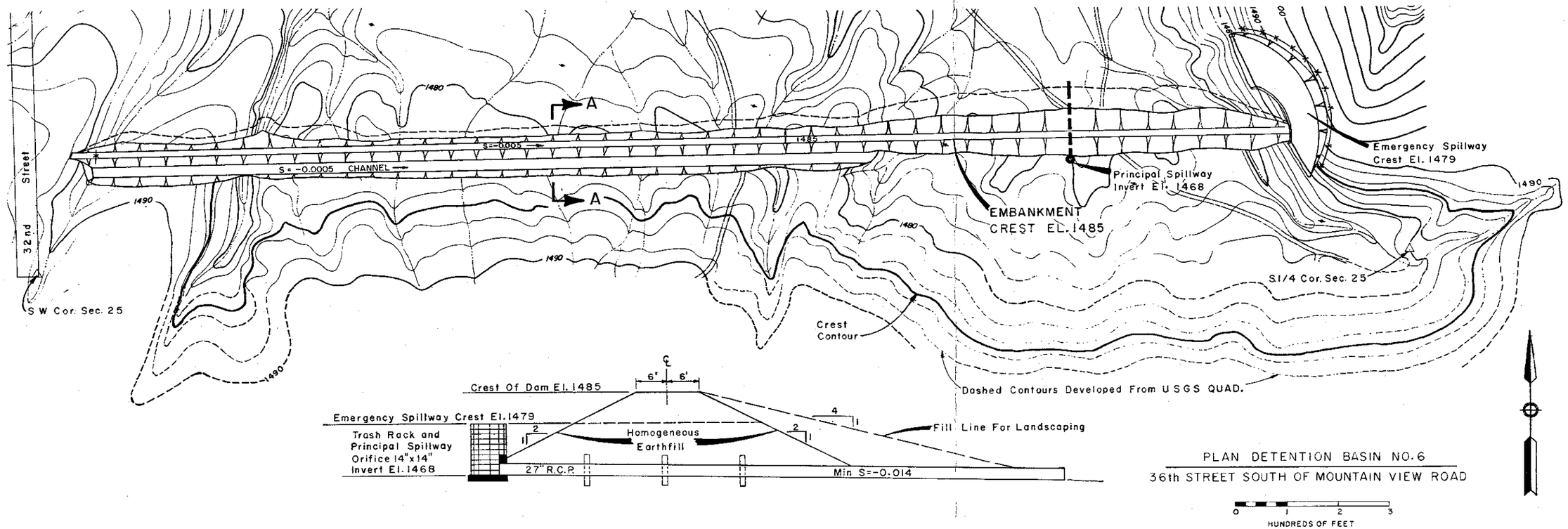
# ESTIMATE OF COST - 1972

## DETENTION BASIN NO. 6

36th Street south of Mountain View Road

| No. | Item | Unit | Quantity | Unit Price | Cost* |
|---|---|---|---|---|---|
| 1 | Embankment | CY | 29,000 | $ 2.00 | $ 58,000 |
| 2 | Spillway Excavation | CY | 6,400 | 1.50 | 9,600 |
| 3 | Concrete Wall | LF | 150 | 60.00 | 9,000 |
| 4 | Outlet Works | LS | 1 | 8,000.00 | 8,000 |
| 5 | Fencing | LF | 600 | 4.00 | 2,400 |
| | Basin Construction Cost | | | | $ 87,000 |
| 6 | Landscape Fill | CY | 10,000 | 1.50 | 15,000 |
| 7 | Desert Landscaping | Ac | 2.5 | 1,000.00 | 2,500 |
| 8 | Land Purchase | Ac | 41 | 5,000.00 | 205,000 |
| 9 | Engr. Design & Insp. (12% of Constr. Cost) | | | | 12,900 |
| 10 | Admin., Legal, etc. ( 8% of Constr. Cost) | | | | 8,600 |
| | Total Project Cost | | | | $331,000 |

*Figures are rounded





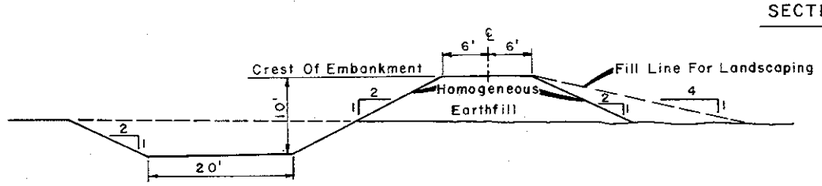


SECTION — EARTHFILL AND PRINCIPAL SPILLWAY

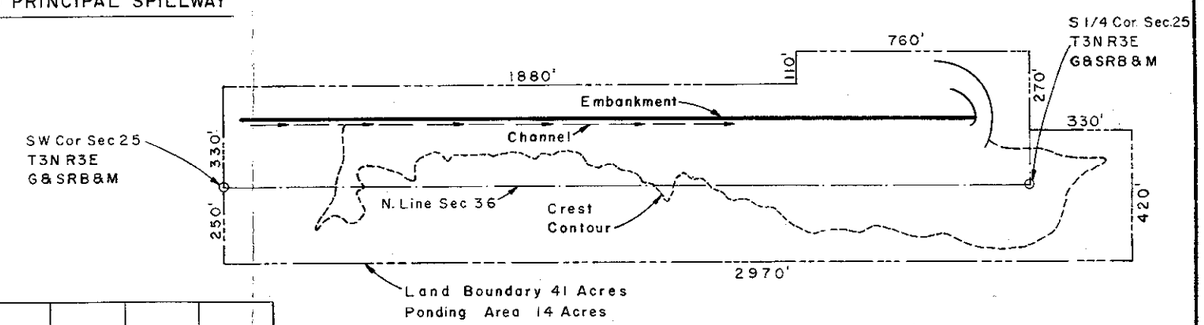
PLAN DETENTION BASIN NO. 6

36th STREET SOUTH OF MOUNTAIN VIEW ROAD

0 1 2 3
HUNDREDS OF FEET

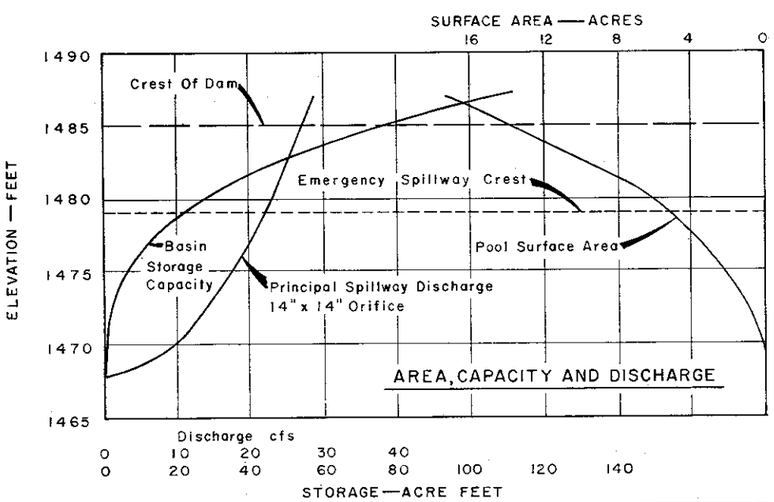



SECTION A-A CHANNEL AND EMBANKMENT

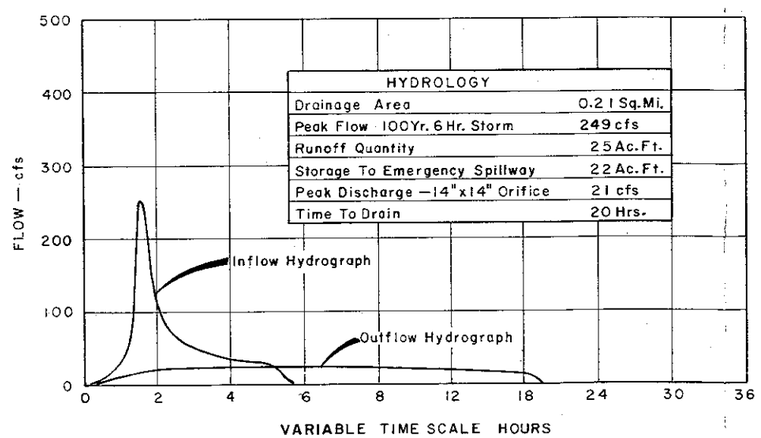



LAND ACQUISITION MAP

0 1 2 3 4 5
HUNDREDS OF FEET




AREA, CAPACITY AND DISCHARGE




| HYDROLOGY | |
|---|---|
| Drainage Area | 0.21 Sq.Mi. |
| Peak Flow 100Yr. 6 Hr. Storm | 249 cfs |
| Runoff Quantity | 25 Ac.Ft. |
| Storage To Emergency Spillway | 22 Ac.Ft. |
| Peak Discharge — 14"x14" Orifice | 21 cfs |
| Time To Drain | 20 Hrs. |

PLATE NO. 7

JOHN CAROLLO ENGINEERS

PHOENIX ARIZONA · LAFAYETTE CALIFORNIA · SANTA ANA CALIFORNIA

CITY OF PHOENIX, ARIZONA
NORTH PHOENIX MOUNTAIN
FLOOD DETENTION BASIN NO. 6

| DESIGNED | CHECKED | DATE | | DRAWING NO. | SHEET |
|---|---|---|---|---|---|
| B.W.-J.H.S. | | | | | NO. OF |
| DRAWN G.N.M. | TRACED | REVISED | | | |

## REPORT CONCLUSION

No cost benefit ratios have been determined in this study of detention basins located above developing residential and commercial properties in the City of Phoenix. Total costs for land, detention basin construction, and overall project including landscaping, engineering, and administration are summarized as follows:

| Detention Basin No. | Watershed Area Acres | Ponding Area Acres | Land Cost | Construction Cost | Project Cost |
|---|---|---|---|---|---|
| | | | $ | $ | $ |
| 2a | 346 | 20 | 252,000 | 82,900 | 371,900 |
| 2b | 307 | 11 | 156,000 | 75,100 | 258,500 |
| 3 | 307 | 19 | 110,000* | 81,400 | 223,900 |
| 4 | 282 | 17 | 181,500 | 75,600 | 290,800 |
| 5 | 147 | 9 | 100,000 | 60,700 | 187,200 |
| 6 | 135 | 16 | 205,000 | 87,000 | 331,000 |

Examination of the cost tabulation indicates land to be the major cost item and that the utilization thereof should be increased. This was done in the solution for Detention Basin No. 2b by excavating material from the retarding basin area in excess of the requirement for embankment. Cost reduction may result from a decrease in the land area and quantity of embankment required, but design is dependent upon the determination of adequate quantities of material suitable for embankment within the retarding basin area.

* Portion of required land owned by City of Phoenix

## ALTERNATE SPILLWAY ESTIMATES

Further scrutiny as requested of the topography at each site for natural ground features favorable to spillway construction reveals one possibility at Detention Basin Site No. 4. Redesign of the dam to align with the ridge upon which two houses stand would provide the most favorable embankment and spillway relation as outlined on Plate 5.

Estimates of an alternate spillway at each site excavated completely in natural ground (concrete training wall eliminated) with a minimum 30 foot distance between end of embankment and spillway channel are as follows:

ESTIMATED ADDITIONAL DETENTION BASIN COST

| Detention Basin No. | Quantity cu. yds. | Alternate Spillway @$3.00/cu. yd. * $ | Plan Spillway Excav. + Conc. $ | Additional Cost of Alternate $ |
|---|---|---|---|---|
| 2a | 14,000 | 42,000 | 18,000 | 24,000 |
| 2b | 25,000 | 75,000 | 25,500 | 49,500 |
| 3 | 10,000 | 30,000 | 24,000 | 6,000 |
| 4 | 16,000 | 48,000 | 15,000 | 33,000 |
| 5 | 5,000 | 15,000 | 12,000 | 3,000 |
| 6 | 18,000 | 54,000 | 18,600 | 36,600 |

*For ripping caliche cemented talus. Unit cost will be higher where sound rock requiring blasting is encountered.

# APPENDIX


| | Page |
|---|---|
| References | A-1 |
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| Design Hydrograph Computation | A-3 |
| Time of Concentration for Drainage Areas Less than 10 Sq. Miles | A-4 |
| Hydrology: Criteria for Design Storms Used in Developing Emergency Spillway Design and Freeboard Hydrographs | A-5 |
| Hydrology: Solution of Runoff Equation, Sheet 1 | A-6 |
| Hydrology: Solution of Runoff Equation, Sheet 2 | A-7 |
| Chart for Selecting a Hydrograph Family for a 6-Hour Rainfall | A-8 |
| Duration of Excess Rainfall for Runoff Curve | A-9 |
| Arizona Precipitation Map 1 | A-10 |
| Arizona Precipitation Map 3 | A-11 |
| Arizona Precipitation Map 5 | A-12 |
| Arizona Precipitation May 7 | A-13 |

# REFERENCES


1. National Engineering Handbook, Soil Conservation Service. Section 4, Hydrology, January 1971

2. U.S. Weather Bureau, Precipitation Maps Prepared for Soil Conservation Service, 1967, Revised 1970, obtained from reference No. 6 below

3. U.S. Weather Bureau, Technical Paper No. 38, Generalized Estimates of Probable Maximum Precipitation for the United States West of the 105th Meridian

4. Storm Drainage Report for Maricopa Association of Governments, 1970, Yost and Gardner Engineers.

5. Design of Small Dams, U.S. Bureau of Reclamation, First Edition, 1960

6. Hydrologic Design for Highway Drainage, Arizona Highway Department, Bridge Division, including 1970 Revised Weather Bureau Precipitation Maps

7. Hydrology of Spillway Design, Journal of Hydraulic Division, ASCE, May 1964, p. 235

8. Los Angeles County Flood Control System,Civil Engineering, ASCE, January 1970

9. Flood Control Planning in Arizona, 14th Annual Arizona Watershed Symposium, Proceedings September 1970

# HYDROLOGIC DESIGN DATA SHEET

## SOIL CONSERVATION SERVICE METHOD

LOCATION DATA:

Place _____ County _____

Location _____

Project No. _____

Watershed _____

DESIGN DATA:

| | | |
|---|---|---|
| Design Storm | _____ | year |
| Drainage Area | _____ | square miles |
| Drainage Length | _____ | feet |
| Average Area Width | _____ | feet |
| Width Factor | _____ | |
| Elevation | | |
| Top of Drainage Area | _____ | feet |
| At Structure | _____ | feet |
| Drainage Area Slope | _____ | percent |
| Time of Concentration | _____ | hour |
| Vegetative Cover Type | _____ | |
| Vegetative Cover Density | _____ | percent |
| Soil Group | _____ | |
| Curve Number | _____ | |
| Antecedent Moisture Condition | _____ | |
| Precipitation | | |
| P = 6-hour 100-year | _____ | inches |
| $P = P_{100} + 0.26(PMP - P_{100})$ | _____ | inches |
| P = 6-hr Probable maximum | _____ | inches |

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Rev. (2 - 66)



# DESIGN HYDROGRAPH COMPUTATION

DATE _____
COMPUTED BY _____
CHECKED BY _____

WATERSHED OR PROJECT _____

STATE _____

STRUCTURE SITE OR SUBAREA _____

DR. AREA _____ SQ. MI. STRUCTURE CLASS _____

$T_c$ _____ HR. STORM DURATION _____ HR.

POINT RAINFALL _____ IN.

ADJUSTED RAINFALL:

AREAL : FACTOR _____ IN. _____

DURATION : FACTOR _____ IN. _____

RUNOFF CURVE NO. _____

Q _____ IN.

HYDROGRAPH FAMILY NO. _____

COMPUTED $T_p$ _____ HR.

$T_o$ _____ HR.

$(T_o / T_p)$:

COMPUTED _____ ; USED _____

REVISED $T_p$ _____

$q_p = \frac{484A}{\text{REV. } T_p}$ = _____ CFS.

$(Q \times q_p)$ = _____ CFS.

t(COLUMN) = $(t / T_p)$ REV. $T_p$ q(COLUMN) = $(q_c / q_p) \times Q \times q_p$

Q(COLUMN) = $(Q_t / Q) Q$

| | $t = (t/T_p)$ Rev. $T_p$ | $q = (q_c/q_p) \times Q \times q_p$ | $Q_t = Q_t/Q \times Q$ |
|---|---|---|---|
| | t HOURS | q CFS | Q INCHES |
| 1 | 0 | 0 | 0 |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | | | |
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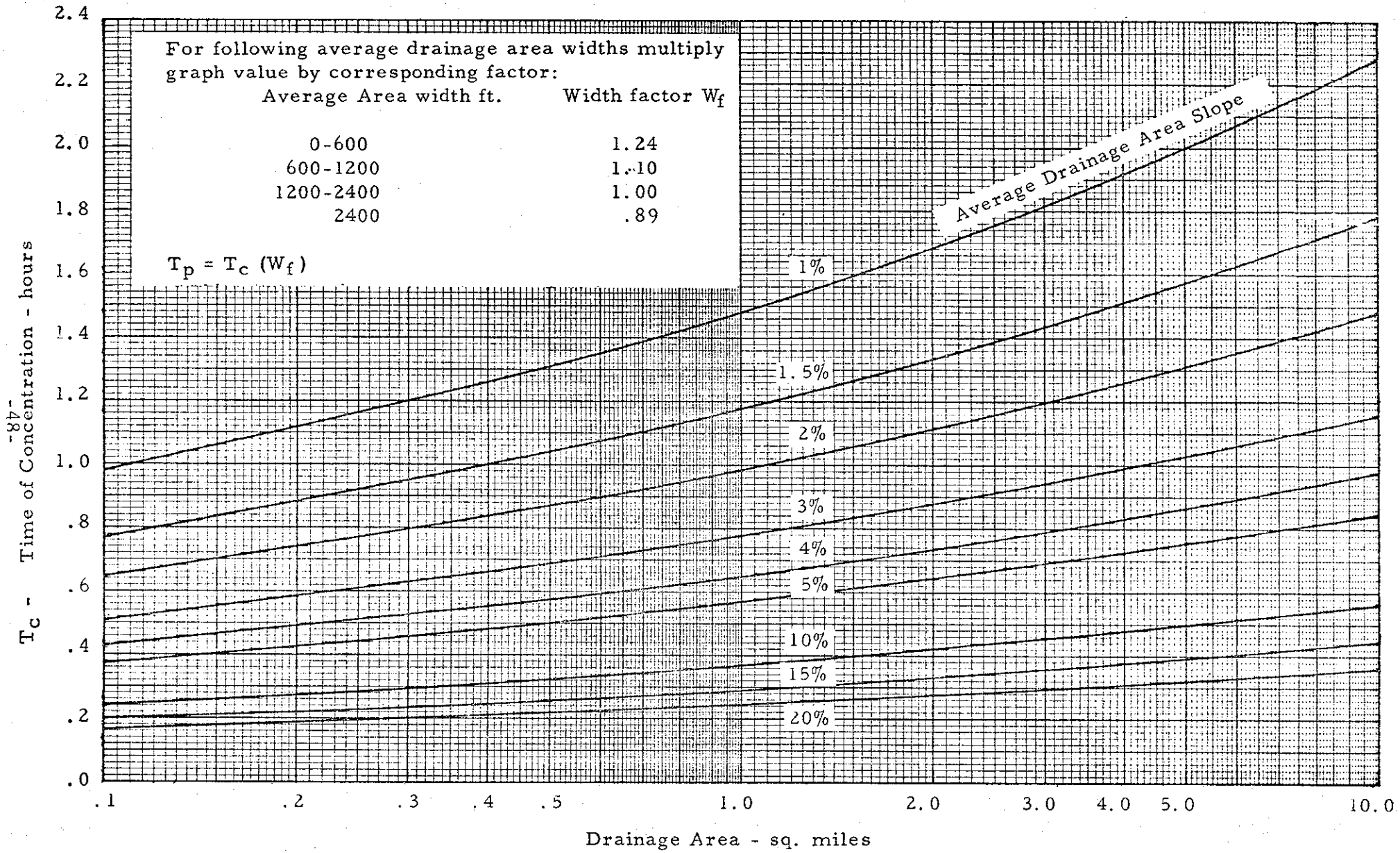


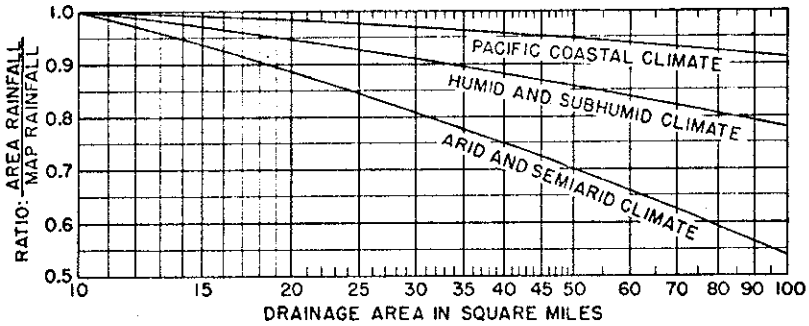

Fig. 2-5

TIME OF CONCENTRATION
FOR
DRAINAGE AREAS LESS THAN 10 SQ. MILES

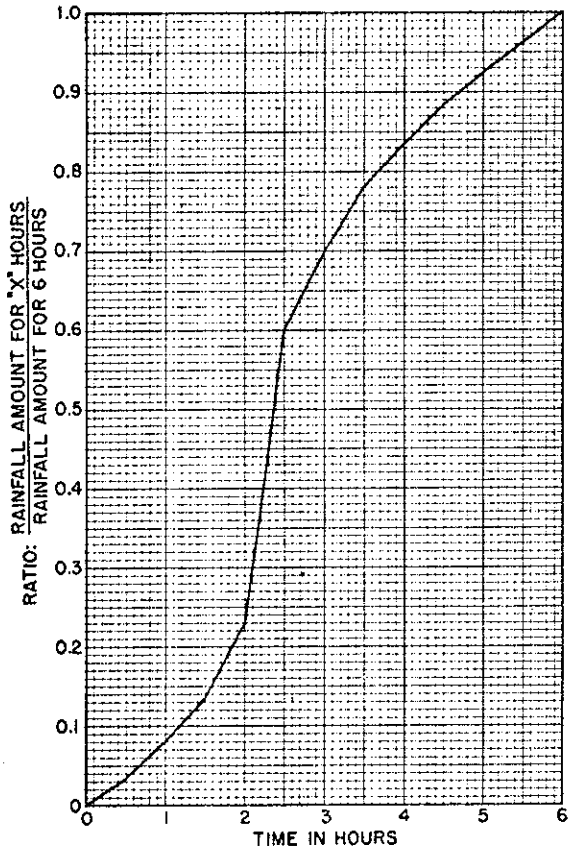
Soil Conservation Service
AHD Hydraulic Design

A-4

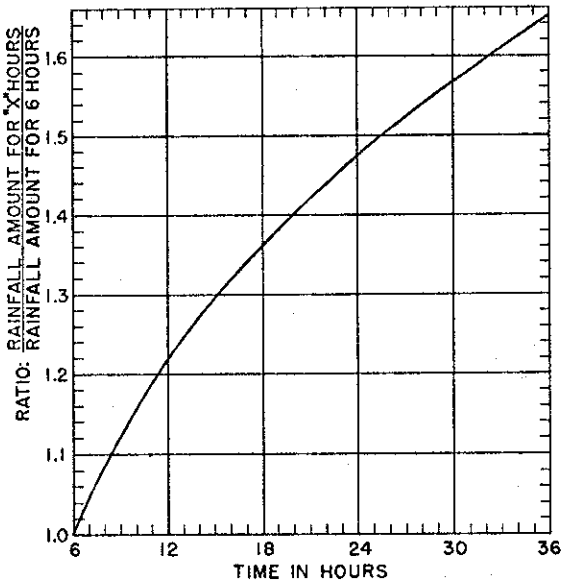
# HYDROLOGY: CRITERIA FOR DESIGN STORMS USED IN DEVELOPING EMERGENCY SPILLWAY DESIGN AND FREEBOARD HYDROGRAPHS




(a) RAINFALL RATIOS FOR DRAINAGE AREAS OF 10 TO 100 SQUARE MILES




(b) SIX HOUR DESIGN STORM DISTRIBUTION



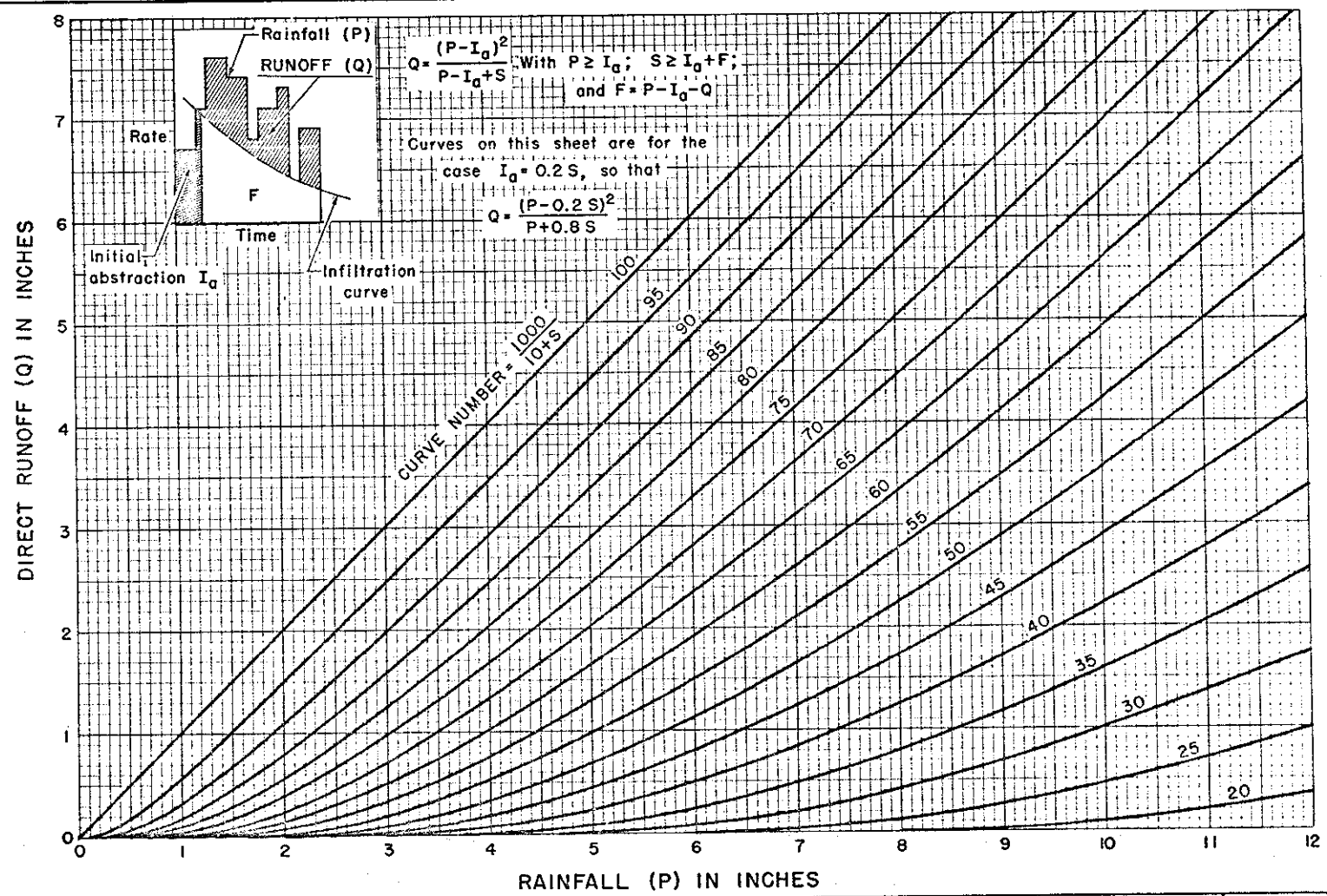

(c) RELATIVE INCREASE IN RAINFALL AMOUNT FOR STORM DURATIONS OVER SIX HOURS

FIGURE 21.2

| REFERENCE | U. S. DEPARTMENT OF AGRICULTURE<br>SOIL CONSERVATION SERVICE<br>ENGINEERING DIVISION - CENTRAL TECHNICAL UNIT | STANDARD DWG. NO.<br>ES-1003<br>SHEET 1 OF 1<br>DATE 7-2-56<br>REVISED 9-10-63 |
|---|---|---|

HYDROLOGY: SOLUTION OF RUNOFF EQUATION $Q = \frac{(P-0.2S)^2}{P+0.8S}$

P = 0 to 12 inches
Q = 0 to 8 inches




REFERENCE
Mockus, Victor; Estimating direct runoff amounts from storm rainfall: Central Technical Unit, October 1955

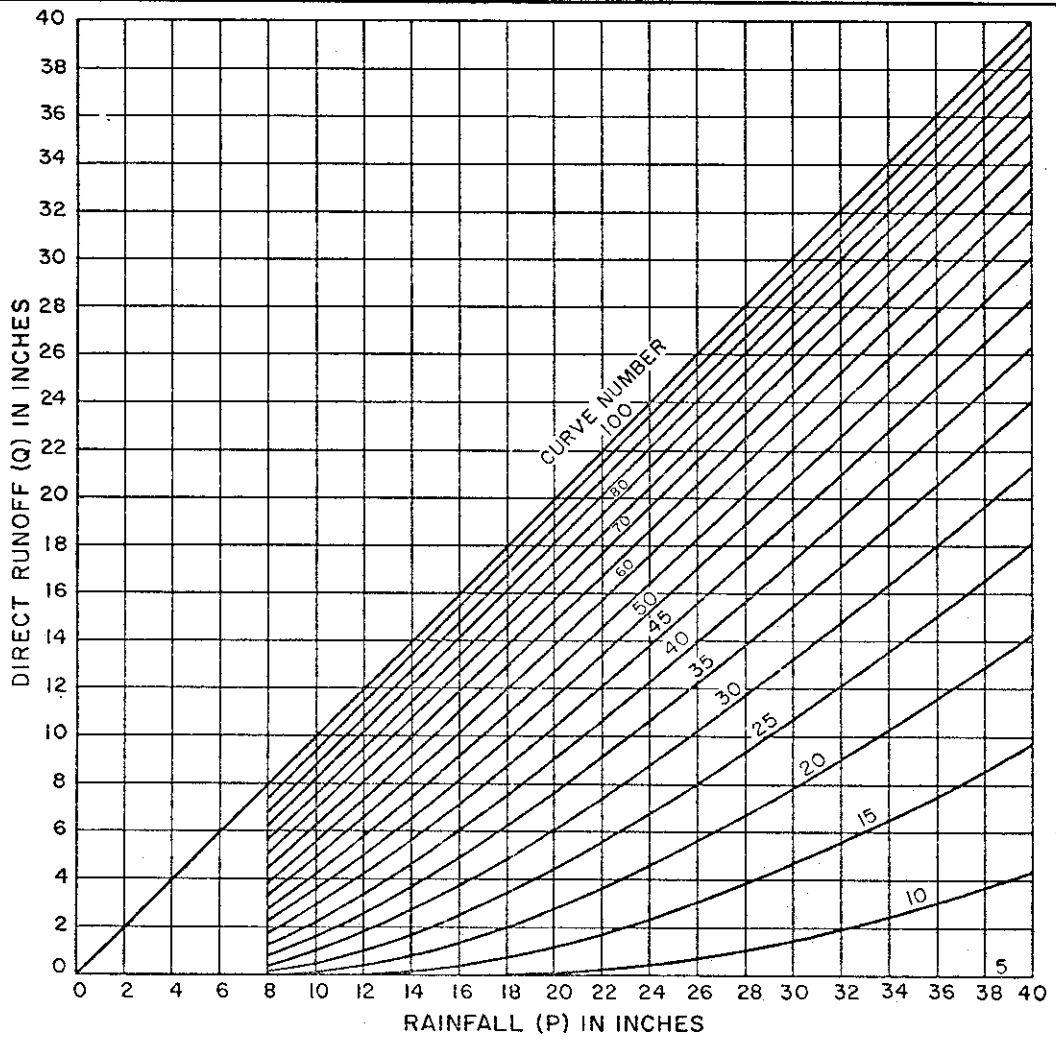
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ENGINEERING DIVISION – HYDROLOGY BRANCH

STANDARD DWG. NO.
ES- 1001
SHEET 1 OF 2
DATE 6-29-56
REVISED 10-1-64

Figure – 10.1 (1 of 2)

HYDROLOGY: SOLUTION OF RUNOFF EQUATION $Q=\frac{(P-0.2S)^2}{(P+0.8S)}$

P=8 to 40 inches
Q=0. to 40 inches



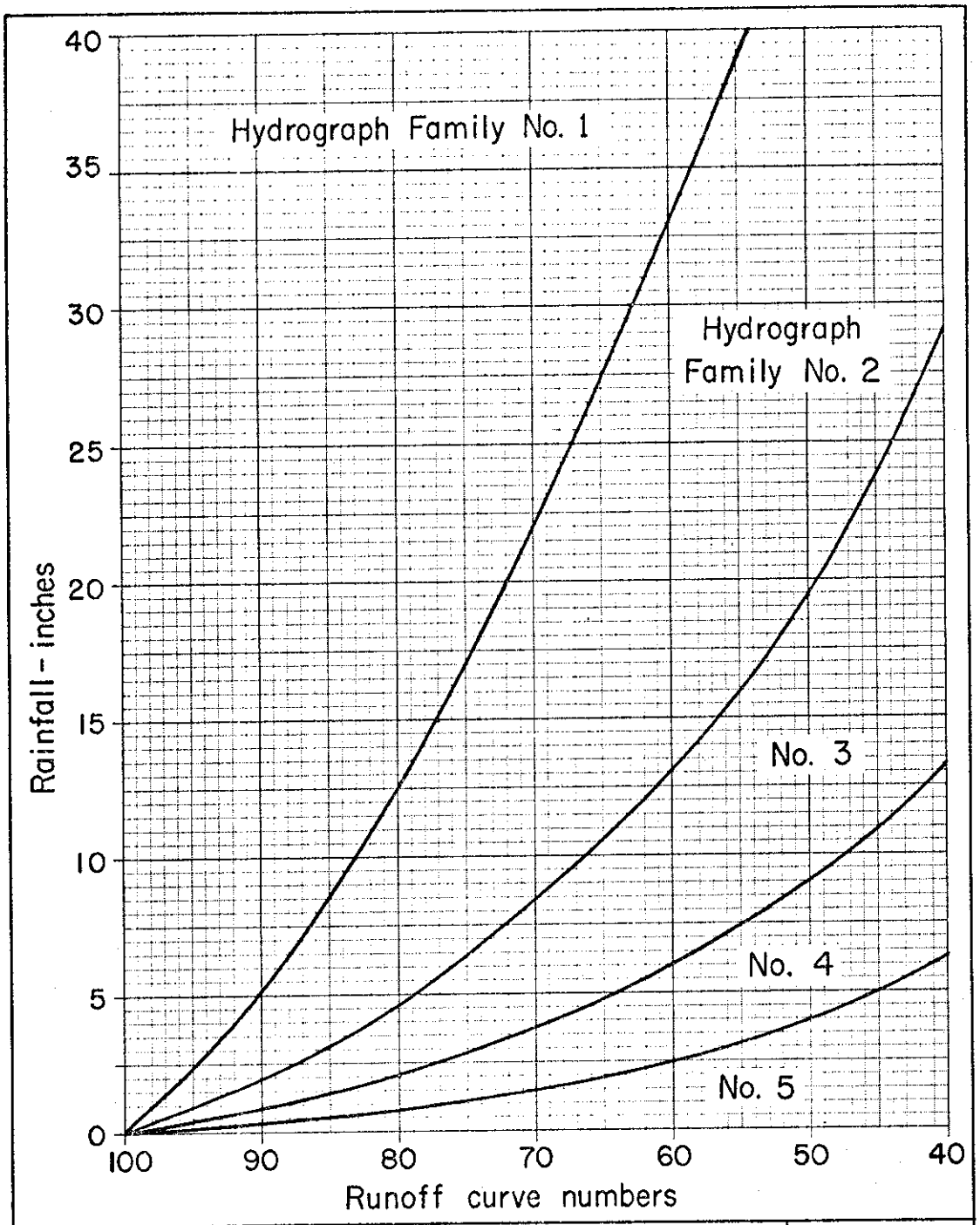

REFERENCE

Mockus, Victor; Estimating direct runoff amounts from storm rainfall: Central Technical Unit, October 1955.

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ENGINEERING DIVISION – HYDROLOGY BRANCH

STANDARD DWG. NO. ES- 1001
SHEET 2 OF 2
DATE 6-27-56

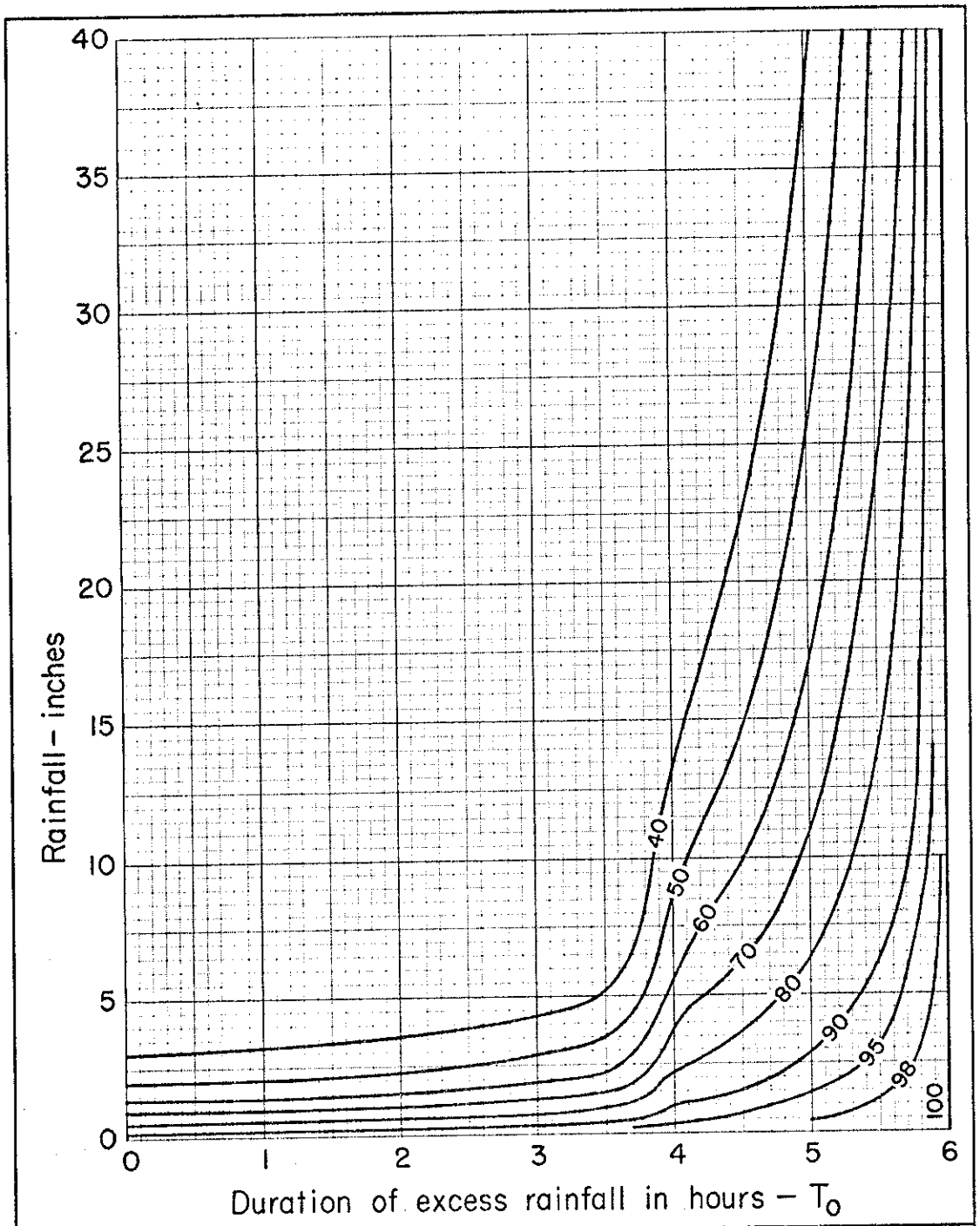
Figure 10.1 (2 of 2)




| REFERENCE | U. S. DEPARTMENT OF AGRICULTURE | STANDARD DWG. NO. |
|---|---|---|
| CENTRAL TECHNICAL UNIT | SOIL CONSERVATION SERVICE<br>ENGINEERING DIVISION - HYDROLOGY BRANCH | ES- 1011<br>SHEET 1 OF 1<br>DATE 2-14-58 |

REVISED 10-12-64

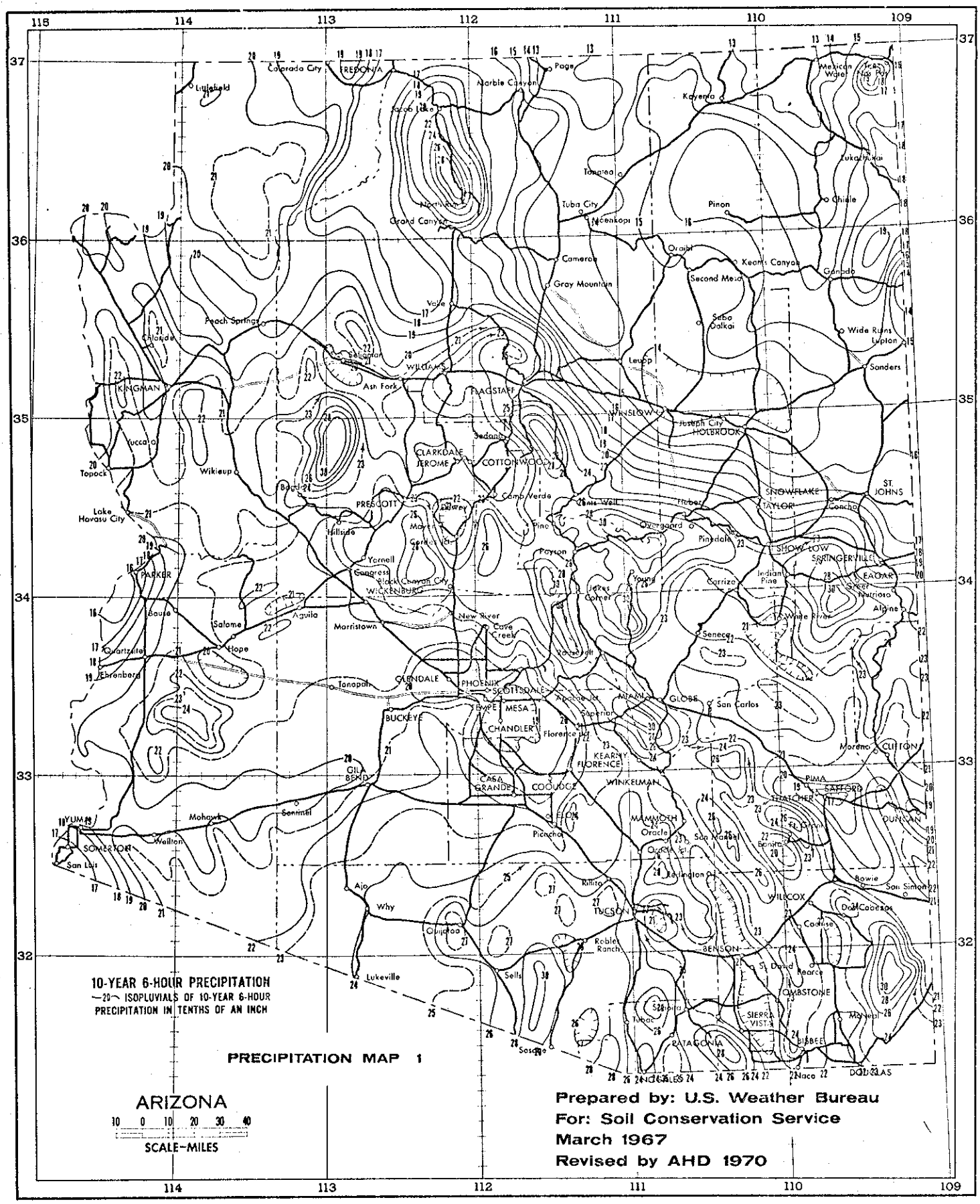
FIGURE 21.3 — Chart for selecting a hydrograph family for a given 6-hour rainfall and runoff curve number.

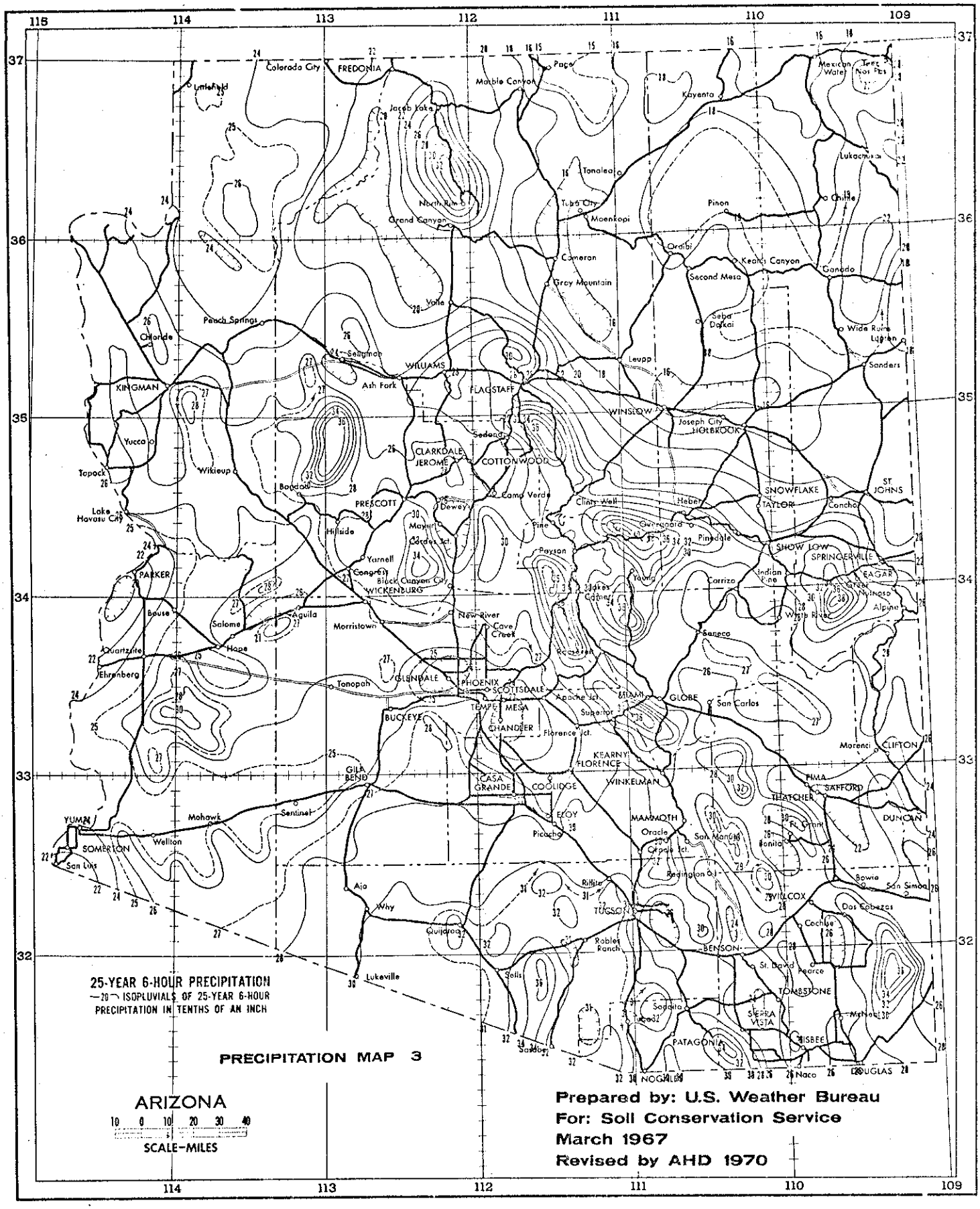



| REFERENCE<br>CENTRAL TECHNICAL UNIT | U. S. DEPARTMENT OF AGRICULTURE<br>SOIL CONSERVATION SERVICE<br>ENGINEERING DIVISION · HYDROLOGY BRANCH | STANDARD DWG. NO.<br>ES- 1012<br>SHEET 1 OF 1<br>DATE 2-14-58 |
|---|---|---|

REVISED 10-12-64

FIGURE 21.4 – Duration of excess rainfall for runoff curve numbers 40 to 100


10-YEAR 6-HOUR PRECIPITATION
—20— ISOPLUVIALS OF 10-YEAR 6-HOUR PRECIPITATION IN TENTHS OF AN INCH
PRECIPITATION MAP 1
ARIZONA
SCALE-MILES
Prepared by: U.S. Weather Bureau
For: Soil Conservation Service
March 1967
Revised by AHD 1970
FREDONIA
Colorado City
Page
Marble Canyon
Kayenta
Tonalea
Tuba City
Moenkopi
Pinon
Chinle
Grand Canyon
Cameron
Gray Mountain
Oraibi
Keams Canyon
Second Mesa
Ganado
Vale
Peach Springs
Chloride
Seligman
WILLIAMS
Ash Fork
FLAGSTAFF
Leupp
Wide Ruins
Lupton
Sanders
KINGMAN
WINSLOW
Joseph City
HOLBROOK
Yucca
Topock
Wikieup
Sedona
CLARKDALE
JEROME
COTTONWOOD
Camp Verde
Bagdad
PRESCOTT
Hillside
Mayer
Pine
Overgaard
Pinedale
SNOWFLAKE
TAYLOR
ST. JOHNS
Concho
Lake Havasu City
Payson
SHOW LOW
SPRINGERVILLE
EAGAR
Yarnell
Congress
Black Canyon City
WICKENBURG
Young
Carrizo
Indian Pine
Nutrioso
Alpine
PARKER
Bouse
Salome
Aguila
Morristown
New River
Cave Creek
Seneca
White River
Quartzsite
Hope
Ehrenberg
Tonopah
GLENDALE
PHOENIX
SCOTTSDALE
MIAMI
GLOBE
San Carlos
BUCKEYE
TEMPE
MESA
CHANDLER
Florence Jct.
Superior
KEARNY
FLORENCE
Morenci
CLIFTON
GILA BEND
CASA GRANDE
COOLIDGE
WINKELMAN
PIMA
SAFFORD
THATCHER
DUNCAN
YUMA
Mohawk
Sentinel
ELOY
MAMMOTH
Oracle
San Manuel
Ft. Grant
Benita
SOMERTON
Wellton
San Luis
Picacho
Redington
Bowie
San Simon
Ajo
Why
Rillito
TUCSON
WILLCOX
Dos Cabezas
Quijotoa
Robles Ranch
BENSON
Coalise
Lukeville
Sells
St. David
Pearce
TOMBSTONE
Sonoita
Tubac
SIERRA VISTA
Mc Neal
PATAGONIA
BISBEE
Sasabe
NOGALES
Naco
DOUGLAS


25-YEAR 6-HOUR PRECIPITATION
—20— ISOPLUVIALS OF 25-YEAR 6-HOUR PRECIPITATION IN TENTHS OF AN INCH
PRECIPITATION MAP 3
ARIZONA
10 0 10 20 30 40
SCALE-MILES
Prepared by: U.S. Weather Bureau
For: Soil Conservation Service
March 1967
Revised by AHD 1970
FREDONIA
Colorado City
Marble Canyon
Page
Kayenta
Jacob Lake
North Rim
Grand Canyon
Tonalea
Tuba City
Moenkopi
Pinon
Oraibi
Cameron
Gray Mountain
Second Mesa
Keams Canyon
Ganado
Seba Dalkai
Wide Ruins
Lupton
Sanders
Valle
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Seligman
WILLIAMS
Ash Fork
FLAGSTAFF
Leupp
KINGMAN
WINSLOW
Joseph City
HOLBROOK
Yucca
Topock
Wikieup
Sedona
CLARKDALE
JEROME
COTTONWOOD
Bagdad
PRESCOTT
Camp Verde
Dewey
Clints Well
Heber
SNOWFLAKE
TAYLOR
Concho
ST. JOHNS
Lake Havasu City
Hillside
Mayer
Cordes Jct.
Pine
Overgaard
Pinedale
SHOW LOW
SPRINGERVILLE
EAGAR
Yarnell
Congress
Black Canyon City
WICKENBURG
Payson
Young
Carrizo
Indian Pine
Greer
Nutrioso
Alpine
PARKER
Bouse
Salome
Aguila
Morristown
New River
Cave Creek
Seneca
Quartzsite
Hope
Ehrenberg
Tonopah
GLENDALE
PHOENIX
SCOTTSDALE
Apache Jct.
MIAMI
GLOBE
San Carlos
BUCKEYE
TEMPE
MESA
CHANDLER
Superior
Florence Jct.
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CLIFTON
KEARNY
FLORENCE
GILA BEND
CASA GRANDE
COOLIDGE
WINKELMAN
FIMA
SAFFORD
THATCHER
DUNCAN
YUMA
Mohawk
Sentinel
ELOY
Picacho
MAMMOTH
Oracle
San Manuel
Ft. Grant
Bonita
SOMERTON
Wellton
San Luis
Redington
Bowie
San Simon
Aja
Why
Rillito
TUCSON
WILLCOX
Dos Cabezas
Quijotoa
Robles Ranch
Cochise
BENSON
St. David
Pearce
Lukeville
Sells
TOMBSTONE
Sonoita
SIERRA VISTA
McNeal
PATAGONIA
BISBEE
Sasabe
NOGALES
Naco
DOUGLAS
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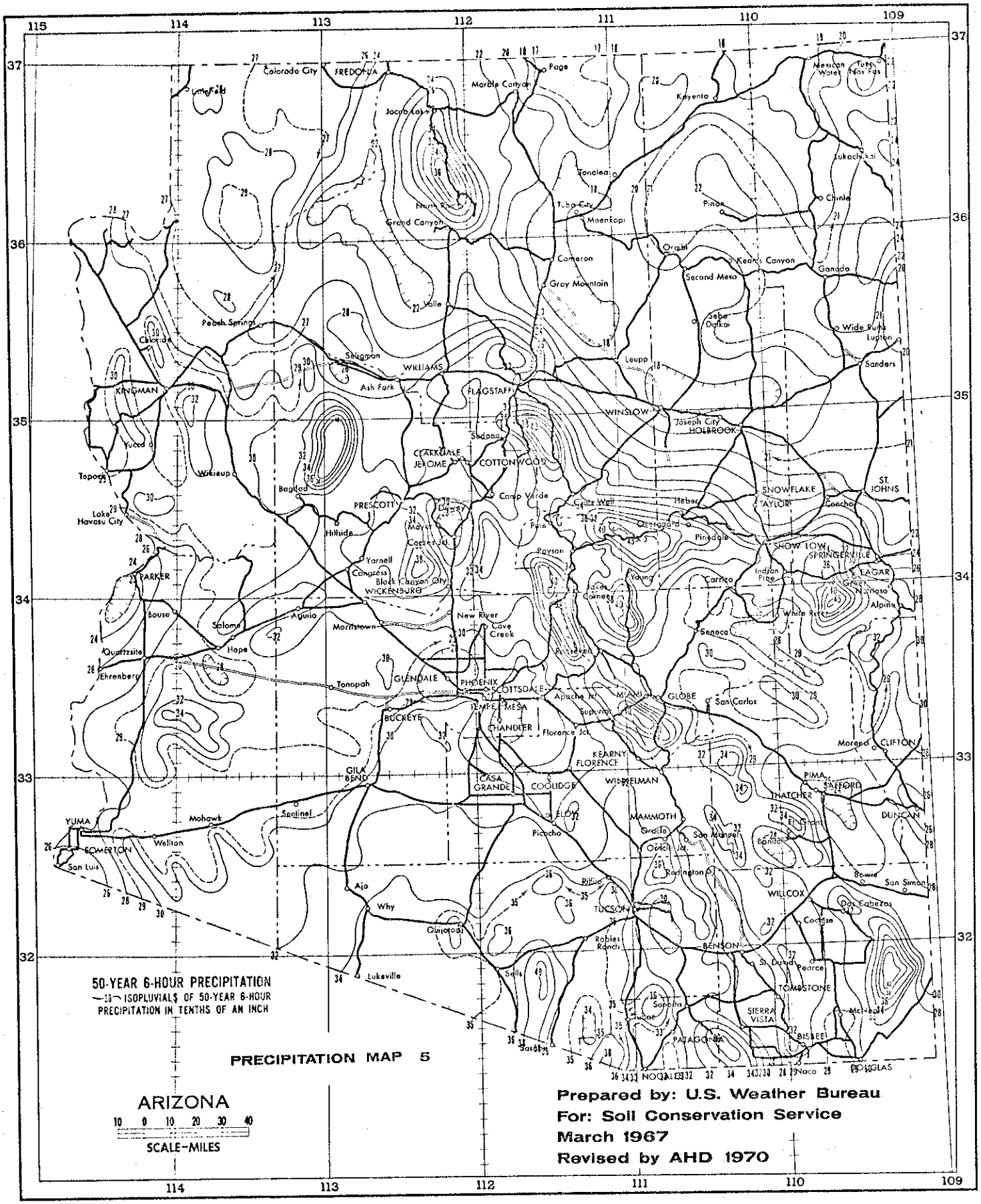
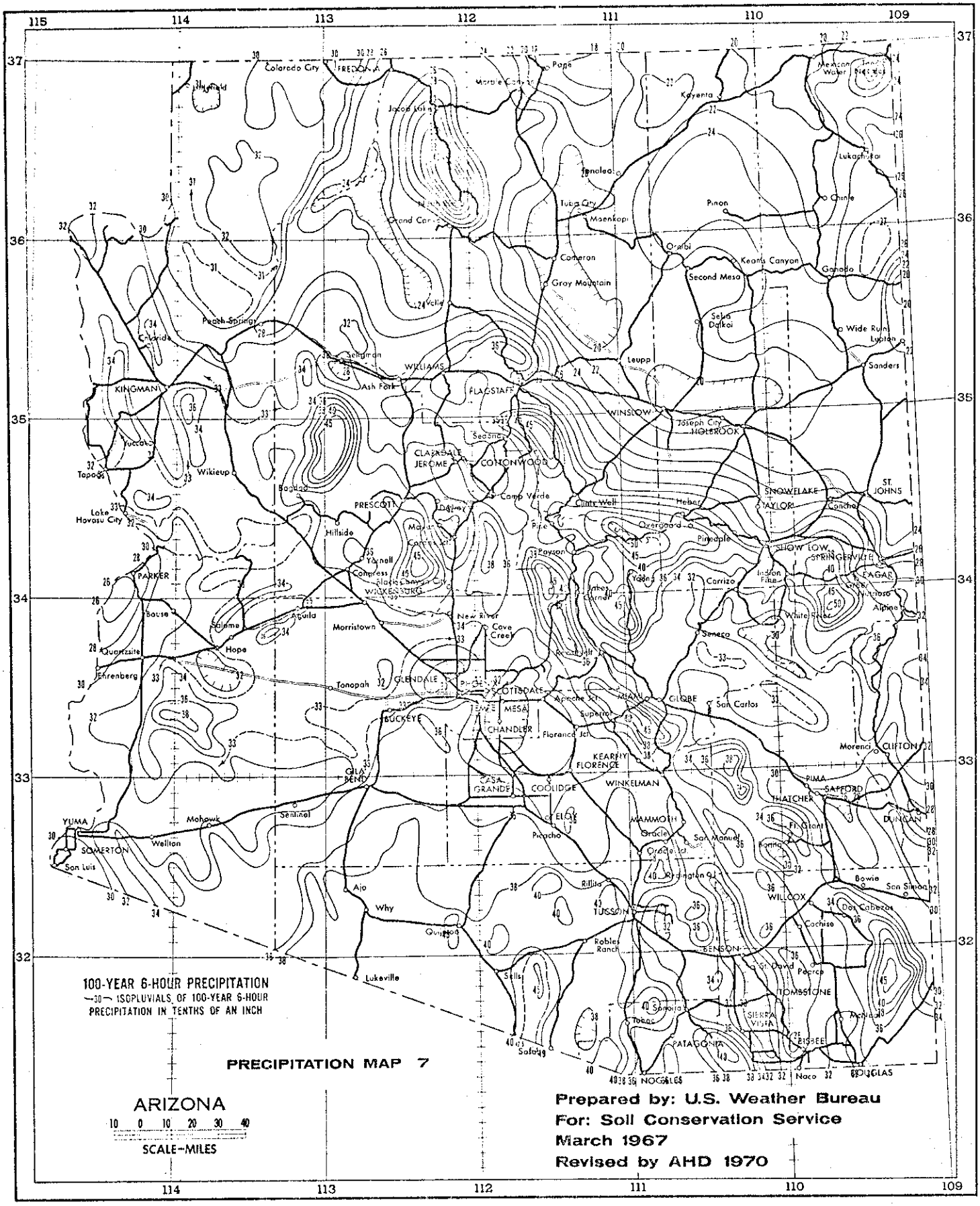

50-YEAR 6-HOUR PRECIPITATION
ISOPLUVIALS OF 50-YEAR 6-HOUR PRECIPITATION IN TENTHS OF AN INCH
PRECIPITATION MAP 5
ARIZONA
SCALE-MILES
Prepared by: U.S. Weather Bureau
For: Soil Conservation Service
March 1967
Revised by AHD 1970
FREDONIA
Colorado City
Page
Marble Canyon
Kayenta
Jacob Lake
Tonalea
Tuba City
Moenkopi
Pinon
Chinle
Grand Canyon
Cameron
Gray Mountain
Orgibi
Keam's Canyon
Second Mesa
Ganado
Valle
Peach Springs
Seligman
WILLIAMS
Ash Fork
FLAGSTAFF
Leupp
Wide Ruins
Lupton
Sanders
KINGMAN
WINSLOW
Joseph City
HOLBROOK
Sedona
CLARKDALE
JEROME
COTTONWOOD
Camp Verde
Topock
Wikieup
Bagdad
PRESCOTT
Dewey
Mayer
Cottonwood
Cliffs Wall
Heber
SNOWFLAKE
TAYLOR
ST. JOHNS
Concho
Lake Havasu City
Hillside
Pine
Overgaard
Pinedale
SHOW LOW
SPRINGERVILLE
EAGAR
Yarnell
Congress
Black Canyon City
WICKENBURG
Payson
Young
Carrizo
Indian Pine
Alpine
PARKER
Bouse
Salome
Aguila
Morristown
New River
Cave Creek
Senoca
White River
Quartzsite
Hope
Ehrenberg
Tonopah
GLENDALE
PHOENIX
SCOTTSDALE
Apache Jct.
MIAMI
GLOBE
San Carlos
BUCKEYE
TEMPE
MESA
CHANDLER
Florence Jct.
Superior
Morenci
CLIFTON
KEARNY
FLORENCE
GILA BEND
CASA GRANDE
COOLIDGE
WINKELMAN
PIMA
SAFFORD
THATCHER
DUNCAN
YUMA
Mohawk
Sentinel
ELOY
MAMMOTH
Oracle
San Manuel
Bonita
SOMERTON
Wellton
San Luis
Picacho
Oracle Jct.
Redington
Bowie
San Simon
Aja
Why
Rillito
TUCSON
WILLCOX
Dos Cabezas
Quijotoa
Robles Ranch
Cochise
BENSON
Lukeville
Sells
St. David
Pearce
TOMBSTONE
Sonoita
SIERRA VISTA
McNeal
Tubac
PATAGONIA
BISBEE
Sasabe
NOGALES
Naco
DOUGLAS


100-YEAR 6-HOUR PRECIPITATION
—30— ISOPLUVIALS OF 100-YEAR 6-HOUR PRECIPITATION IN TENTHS OF AN INCH
PRECIPITATION MAP 7
ARIZONA
10 0 10 20 30 40
SCALE-MILES
Prepared by: U.S. Weather Bureau
For: Soil Conservation Service
March 1967
Revised by AHD 1970
Colorado City
FREDONIA
Page
Kayenta
Tuba City
Moenkopi
Pinon
Chinle
Lukachukai
Ganado
Keams Canyon
Second Mesa
Oraibi
Cameron
Gray Mountain
Grand Canyon
Peach Springs
Seligman
Ash Fork
WILLIAMS
FLAGSTAFF
KINGMAN
Yucca
Topock
Wikieup
Lake Havasu City
WINSLOW
Joseph City
HOLBROOK
Leupp
Sanders
Wide Ruin
Lupton
CLARKDALE
JEROME
COTTONWOOD
Sedona
Camp Verde
Cottonwood
Cliff
Hebron
Heber
Overgaard
Pinedale
SNOWFLAKE
TAYLOR
Concho
ST. JOHNS
SHOW LOW
SPRINGERVILLE
EAGAR
Alpine
Carrizo
Indian Flat
White River
Seneca
Pine
Payson
Tonto Basin
Roosevelt
PRESCOTT
Dewey
Mayer
Yarnell
Congress
Stanton
WICKENBURG
Hillside
PARKER
Bouse
Salome
Aguila
Morristown
New River
Cave Creek
Hope
Quartzsite
Ehrenberg
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GLENDALE
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BUCKEYE
Apache Jct.
Superior
MIAMI
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KEARNY
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COOLIDGE
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Lukeville
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TOMBSTONE
Sonoita
Tubac
SIERRA VISTA
Mexican Water
PATAGONIA
BISBEE
Safford
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Naco
DOUGLAS