

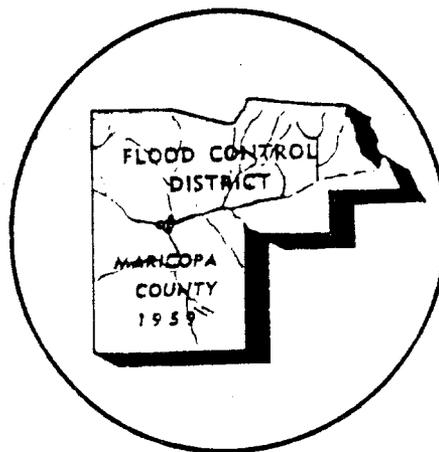
BELL ROAD PROJECT DRAINAGE STUDY

Volume III

**ALTERNATE STORMWATER / FLOOD WATER
MANAGEMENT CONCEPT PLANS**

FOR

MARICOPA COUNTY FLOOD CONTROL DISTRICT



PREPARED BY

GREINER ENGINEERING SCIENCES, INC.

PHOENIX, ARIZONA

October, 1987

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**BELL ROAD PROJECT DRAINAGE STUDY
VOLUME III
ALTERNATE STORMWATER/FLOODWATER MANAGEMENT
CONCEPT PLANS**

Prepared For:
MARICOPA COUNTY FLOOD CONTROL DISTRICT
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Phoenix, AZ 85009

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IV. INTRODUCTION

The purpose of the Bell Road Project Drainage Study is to develop a stormwater/floodwater management master plan for the expansion of Bell Road to a divided six-lane major urban arterial street.

This report documents the procedures, methodology, objectives and criteria used to develop, evaluate and rank alternative stormwater/floodwater management concept plans for Bell Road. The Bell Road drainage study is located between Grand Avenue and Scottsdale Road and has been divided into ten major drainage areas. These areas are briefly described as follows:

Area 1: Bound by Bell Road on the south, Grand Avenue on the west, McMicken Dam Outlet Channel on the north and the west boundary of Sun City West on the east.

Area 2: Bound by Bell Road on the south, Agua Fria River on the west, the ridge on the mountain in Section 4, Township 4 north, Range 1 East on the north and the New River on the east.

Area 3: Bound by Bell Road on the south, New River on the west, Skunk Creek on the east and Union Hills Drive on the north.

Area 4: Bound by Bell Road on the south, Skunk Creek on the west, Beardsley Road on the north and Interstate-17 (I-17) on the east.

Area 5: Bound by Bell Road on the south, Interstate-17 on the west, the ridge line of the Union Hills on the north and Cave Creek on the east.

Area 6: Bound by Bell Road on the south, Cave Creek on the west, a ridge line just north of Beardsley Road on the north and East Fork of Cave Creek on the east.

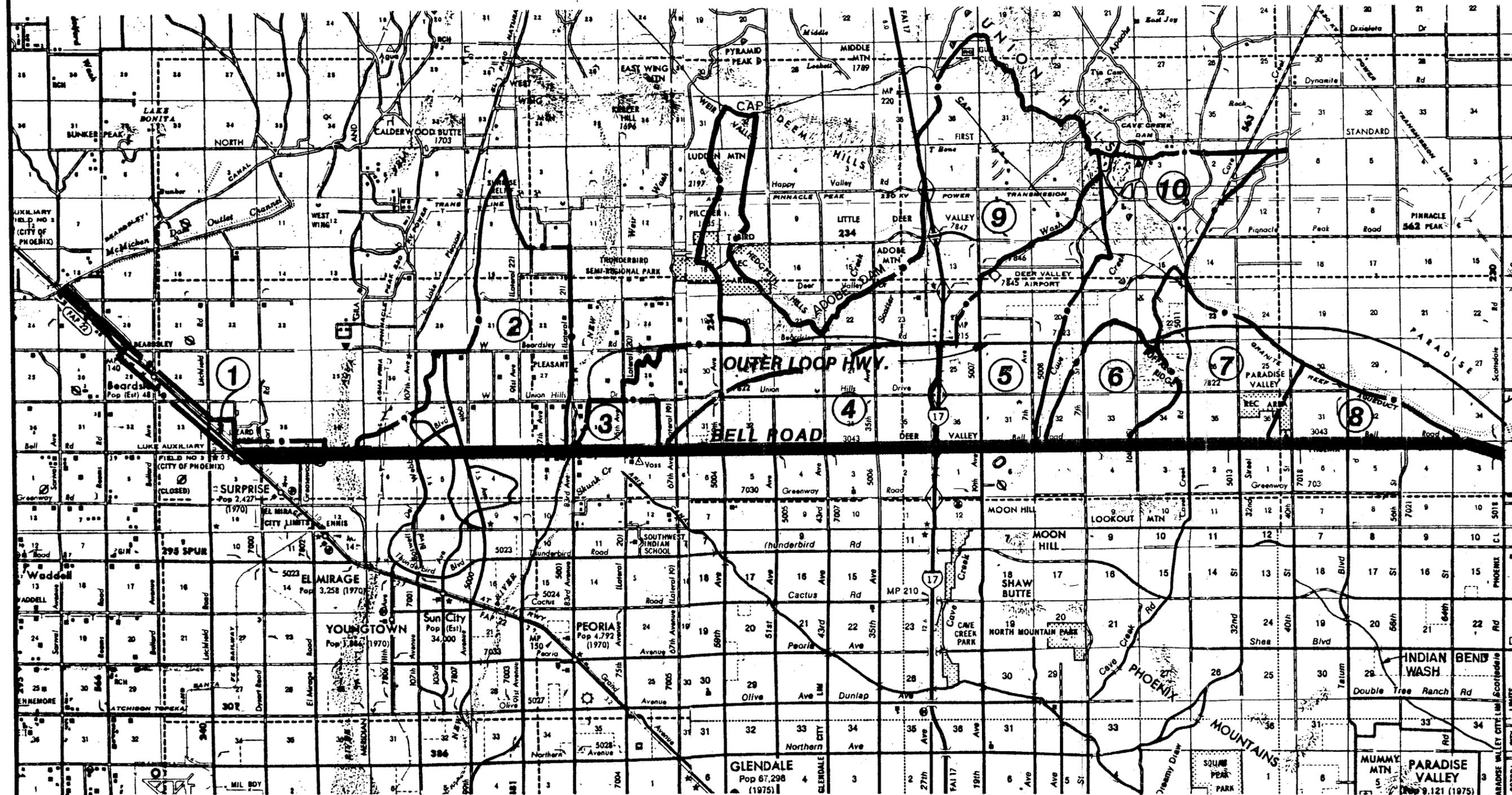
Area 7: East Fork of Cave Creek watershed.

Area 8: Bound by Bell Road on the south, East Fork of Cave Creek drainage divide on the west, and the Central Arizona Project on the north and east.

Area 9: Skunk Creek Watershed.

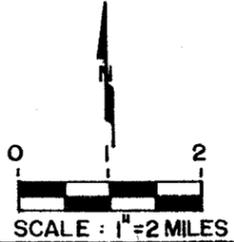
Area 10: Cave Creek Watershed.

The limits of all drainage areas are shown on Exhibit 1.



LEGEND

- MAJOR DRAINAGE AREA BOUNDARIES
- 1, MAJOR DRAINAGE AREA NUMBERS



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 A Greiner Engineering, Inc. Company
 Greiner Engineering, Inc.
 7310 N. 16th Street, Suite 160 Phoenix, Arizona 85020-6020 275-5400
 2650 North American Way, Tucson, Arizona 85712 802-207-9413

Design: M.C./R.B./G.S./M.O.
 Drawn: FC
 Check: M.S.S.
 Scale: 1" = 2 Mi.

BELL ROAD PROJECT
 DRAINAGE STUDY
 MAJOR DRAINAGE AREAS

Date: JAN. 1987
 Job No: E 123061
 Sheet: 1 of 1

V. OBJECTIVES

The objective of the overall study is to develop a stormwater/floodwater management plan for the expansion of Bell Road from Grand Avenue to Scottsdale Road which includes a cost-effective method of handling drainage as well as to provide flood protection for the roadway. In addition, the plan will ensure that downstream drainage facilities can handle discharged flows or that new facilities can be provided to an adequate outfall. Upstream properties will not be adversely impacted by the construction of the roadway or drainage facilities.

The objective of this report is to develop alternative stormwater/floodwater management concept plans for the 100-year and 10-year storm events for the drainage areas affecting the proposed roadway. The goal of the alternative concept plans is to allow travel on the proposed Bell Road expansion during the design storm event, as well as to ensure that downstream and upstream conditions will not be worsened in the 100-year event. At a minimum, four lanes of Bell Road will remain open during the 100-year and/or the 10-year design storm events, respectively. Alternative concept plans will be developed and evaluated for both the 100-year and the 10-year storm events

Each alternative will be evaluated at a preliminary study level in terms of capital costs, effectiveness, environmental impacts, potential for staged construction, acceptability to municipalities and compatibility with other projects and plans. A general working matrix for ranked comparisons of alternative plans will be prepared.

VI. PROCEDURES AND METHODOLOGY

Separate alternative stormwater/floodwater management concept plans were developed for the 100-year and the 10-year storm events. The alternative concept plans included collection points for on-site drainage of the roadway and conveyance of off-site and on-site drainage to the alternative outfalls. Alternative concepts studied were multiple conveyance systems versus single conveyance system, use of multiple outfalls versus single outfall, closed conduits versus open channel or a combination of both, and detention systems.

Based on the alternative concepts developed, a HEC-1 computer model was developed for each alternative and post-development (future) flows were routed through the alternative drainage systems. From the results of the hydrologic modeling of the alternative concepts, the types, sizes and locations of the proposed drainage facilities were identified.

Each alternative was evaluated in terms of capital costs, effectiveness, environmental impacts, potential for staged construction, acceptability to municipalities and compatibility with other projects and plans. Matrixs for ranked comparison of alternative concepts were prepared.

A. Concept Plan Development

The alternative stormwater/floodwater management concept plans evaluated are comprised of interconnected systems of open channels, detention basins and closed conduits. A number of factors were considered in developing the range of alternative systems for each drainage area. These factors are:

- o Location and magnitude of runoff concentrating at Bell Road.
- o Location and adequacy of outfalls

- o Availability of vacant land along Bell Road or in the upper watershed suitable for open channels or detention basins
- o Approved and ongoing storm drainage plans proposed by Federal, state and local jurisdictions

The location and types of alternative systems evaluated are shown in Plates 1 through 56 found in Sections VIII and X.

B. Hydrologic and Hydraulic Procedures

The off-site hydrology is summarized in the "Hydrologic Modeling" report first submitted on September 17, 1986. The design storms used for this report are the 100-year 24-hour storm and the 10-year, 24-hour storm. Discharge values were determined by utilizing the HEC-1 computer program. The hydrologic modeling used to develop alternative concept plans was performed for post-development (future) watershed conditions.

The off-site hydrologic models previously developed were re-analyzed wherever runoff was diverted from its existing flow path into a proposed collection system. The HEC-1 program was used to route flows through the alternative concept drainage systems and to calculate the new 100-year and 10-year peak discharge values at the outfalls. The peak discharge values routed through the components of the alternative concept drainage systems are shown on Plates 1 through 56.

Preliminary structure sizes were assumed and incorporated into the hydrologic models. The resultant calculated peak discharges were then used to resize the drainage structures. Open channels were sized for normal depth flow using the Manning Equation. The Federal Highway Administration's "Hydraulic Charts for the Selection of Highway Culverts" (HEC No. 5) was used for sizing closed conduits.

The calculated drainage structure sizes were re-input to the hydrologic model. If the resultant peak discharges were significantly different from the previously calculated discharge values the structure sizes were recalculated again.

The following criteria and procedures were followed in sizing and analyzing the alternative drainage systems.

- o A Manning's Roughness Coefficient (n) of 0.027 was used for earthen channels. A value of 0.012 was used for concrete culverts.
- o A.D.O.T. standard box culverts were used.
- o Storm drain culvert slopes were approximate to the existing ground slope, as determined from 7.5 minute quadrangle maps and City of Phoenix AP #40 maps.
- o Storm drain inverts were assumed to be at a depth of ten (10) feet below existing ground.
- o The outfall structures were sized to convey runoff concentrating at Bell Road only. Additional flows that may enter the system between Bell Road and the outfall were not taken into consideration.

Potential impacts on downstream facilities or watercourses have not been evaluated. This issue will be addressed during the development and analysis of the recommended plan.

On-site runoff, generated within the Bell Road right-of-way width of 110 feet was calculated using the HEC-1 model. It was determined that 19 cfs of runoff is generated per 0.5 miles of roadway for the 100-year storm and 12 cfs for the 10-year storm. It was determined that these minor flows would peak earlier than off-site runoff concentrating at Bell Road. For the purpose of storm drain sizing, on-site runoff was, therefore, not combined with the significantly larger off-site flows.

VII. DESIGN CRITERIA

Alternative stormwater/floodwater concept plans were developed using established design and special criteria provided by the Flood Control District of Maricopa County (FCD). The drainage design criteria and standards of state and local municipalities and organizations were reviewed for the purpose of developing the criteria utilized in this report. A listing of the source material used can be found in References, Section XIII.

The design criteria utilized for the development of the alternative concept plans are interim standards only. Design criteria to be applied during implementation of the selected drainage plan will be recommended by Greiner and submitted to the FCD for review and approval. The approved design criteria will be utilized to develop the drainage master plan to preliminary plan level.

The following criteria were used:

- o The proposed drainage facilities for Bell Road not worsen downstream and upstream conditions during the 100-year storm event.
- o Both storm drains and open channels were evaluated. Open channels, however, were evaluated only in undeveloped areas or in areas with low density development.
- o Flow velocities in earthen channels were kept to approximately five feet per second to minimize the potential for erosion.
- o Maximum side slopes of 4:1 were utilized for earthen channels to allow for landscaping or other aesthetic treatments. Channel depths were set to accept future storm drain facilities.

- o Detention basins were designed with 1.5 feet of freeboard and with maximum side slopes of 4:1. A 20 foot buffer zone was provided around the perimeter of the basin to allow for landscaping or safety features. The maximum depth of the basins is 10 feet.
- o Minimum size for pipes is 18 inches and 6' x 3' for box culverts.
- o In keeping with the urban arterial design concept for the Bell Road improvement project, cross-culverts that would collect runoff at the north right-of-way, then convey it underneath Bell Road for discharge at the south right-of-way, were generally not considered as viable alternatives unless an adequate drainageway exists downstream.

VIII. ALTERNATE STORMWATER/FLOODWATER MANAGEMENT CONCEPT PLANS, 100-YEAR STORM EVENT

A minimum of three alternative stormwater/floodwater management systems were evaluated for most of the drainage areas investigated. In general, system alignments were selected to conform to topographic features of the drainage areas. To achieve the design objective of 100 percent interception of off-site runoff at the Bell Road right-of-way, it was often necessary to evaluate trunk storm drains, open channels or detention basins in the upper watershed along the section-line and half-section line streets. These alignments were generally followed because of right-of-way availability, minimal utility conflicts and minimal disruption of residential areas. Also, the general trend for urban development in the study area is based a grid pattern. Smaller laterals or runoff collection systems which would connect to the main system were not included in the analyses.

The major elements of the alternative drainage systems, including trunk lines, on-site storm drains, detention basins and open channels are described in the following pages. Refer to Section IV for descriptions of each of the drainage areas.

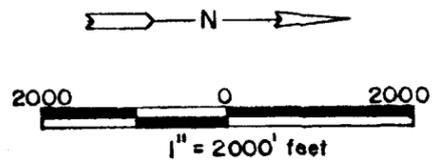
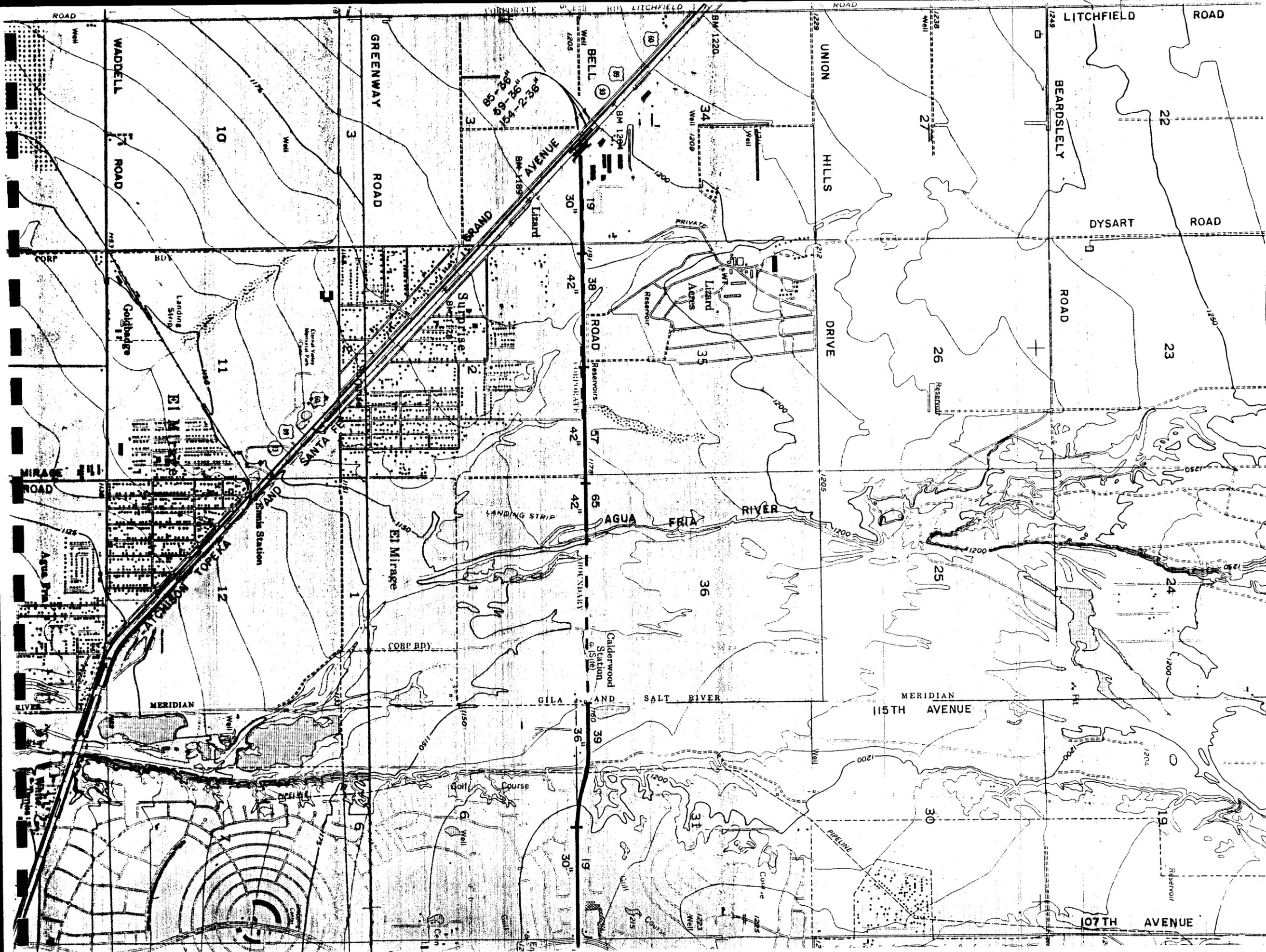
Drainage Area 1: Off-site runoff concentrates at Bell Road along the Grand Avenue and Atchison-Topeka & Santa Fe (A.T. & S.F.) Railroad right-of-way. Drainage from Sun City West is diverted to the Agua Fria River north of Bell Road.

It is proposed that the existing culverts under Bell Road be upgraded to convey the 100-year discharge. A 36-inch culvert will be required between Grand Avenue and the railroad. Discharges will continue downstream in their present flow path between Grand Avenue and the railroad embankment. A second 36-inch culvert will be required to convey runoff under Bell Road just east of the railroad embankment. A double 36-inch culvert would be required for convey runoff under Bell Road from the Sun City West construction yard facility. The single and

double 36-inch culverts would discharge into the gunite channel proposed by the Grand Avenue Corridor Study. This channel will convey runoff to the Agua Fria River along the northern right-of-way of the railroad.

On-Site Runoff: On-site runoff from the Bell Road right-of-way will be conveyed by storm drain from Grand Avenue eastward to the Agua Fria River. Storm drain sizes range from a 30-inch pipe to a 42-inch pipe.

Refer to Plate 1 for a schematic of the proposed off-site and on-site drainage facilities for Drainage Area 1.



- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - ▨ DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS

OPEN CHANNELS

TW = 60' TOP WIDTH
 D = 5' DEPTH

100 YEAR FREQUENCY STORM
 PLATE I
 ALTERNATE I
 DRAINAGE AREA 1
 BELL ROAD PROJECT
 DRAINAGE STUDY

**Greiner
 Engineering**

Drainage Area 2: Seven alternative concept designs were developed and evaluated for Drainage Area 2. Relatively large flows concentrate at Bell Road and 91st Avenue (2,413 cfs) and 87th Avenue (1,404 cfs). To achieve 100 percent interception of the 100-year storm runoff, the concept designs for all alternatives were extended three miles north of Bell Road to Deer Valley Road. Off-site runoff generated in Sun City is managed by drainage systems constructed as part of that development.

Alternative 1: Two open channels are proposed to intercept runoff from the areas north of Beardsley Road. One channel would be located along 91st Avenue between Deer Valley Road and Beardsley Road to intercept runoff from areas to the west and north. A second channel would be located along the 87th Avenue alignment from Deer Valley Road to Beardsley Road then turning westward to 91st Avenue. This channel would intercept runoff generated in the area bounded by Beardsley Road on the south, 91st Avenue on the west, Pinnacle Peak Road on the north and 83rd Avenue on the east. The two channels would discharge into a storm drain at 91st Avenue and Beardsley Road. The storm drain would head southward along 91st Avenue to Bell Road. The storm drain would then discharge into an open channel that would continue south of Bell Road to Greenway Road then eastward to its outfall at the New River. Storm drain laterals will extend along Bell Road east and west of 91st Avenue to collect off-site runoff concentrating along Bell Road. An open channel along the north side of Bell Road will convey both on-site and off-site runoff concentrating along Bell Road east of 87th Avenue to the New River at Bell Road.

The 100-year peak discharge at the New River and Greenway Road outfall would be 3,905 cfs. Channel sizes range from 3 to 8 feet deep and 37 to 247 feet in top width. Storm drains would range in size from a single 8' x 5' to 8-10' x 5' box culverts. Future development of the area will determine the final location of the storm drain trunk alignment and the location of all inlet structures.

Refer to Plate 2 for a schematic representation of the storm drainage facilities proposed in Alternative 1.

Alternative 2: Alternative 2 is similar to Alternative 1 with the addition of a detention basin located at the northeast corner of 91st Avenue and Beardsley Road intercepting discharges from the open channels along 91st Avenue and Beardsley Road. The purpose of the detention basin will be to decrease the size of downstream structures. The peak discharge for Alternative 2 at the New River outfall would be 2,886 cfs. Open channels would range in depth from 3 to 8 feet deep and 37 to 192 feet in top width. Storm drains would be comprised of box culverts ranging from a single 8' x 5' to 6-10' x 5' in size. The shape and size of the detention basin can be varied to meet the needs of future development in the surrounding area.

Refer to Plate 3 for a schematic of Alternative 2.

Alternative 3: Alternative 3 is similar to Alternative 2 with the addition of a second detention basin to further downsize downstream structures. This basin would be located at the northeast corner of Union Hills Drive and 91st Avenue. The 100-year discharge at the New River outfall would be reduced to 1,999 cfs. Open channels would be 3 to 8 feet deep and 37 to 149 feet in top width. Storm drains range in size from a single 8' x 5' to 4-10' x 5' box culverts.

Refer to Plate 4 for a schematic of Alternative 3.

Alternative 4: Parallel drainage systems on 91st Avenue and 87th Avenue between Deer Valley Road and Bell Road were evaluated as an alternative to a single system on 91st Avenue as described in Alternatives 1 through 3.

The parallel systems are comprised of open channels between Deer Valley Road and Beardsley Road and storm drains to Bell Road. The 91st Avenue system would outfall to the New River via open channel as in Alternatives 1 through 3. The 87th Avenue system would outfall at the New River and Bell Road via a storm drain. The alignment of the 87th Avenue system may be affected by future development of the area.

The 100-year peak discharge for the 91st Avenue system would be 2,413 cfs and 1,768 cfs for the 87th Avenue system. Open channels would be 3 to 8 feet deep and 37 to 171 feet in top width. Storm drains range in size from 2-10' x 5' to 5-10' x 5' box culverts.

Refer to Plate 5 for a schematic of the proposed storm drainage facilities for Alternative 4.

Alternative 5: Alternative 5 is similar to Alternative 4 with the addition of a detention basin located at the northeast corner of 91st Avenue and Beardsley Road and at the northeast corner of 87th Avenue and Union Hills Drive. The 100-year peak discharge for the 91st Avenue system would be 1,455 cfs and 117 cfs for the 87th Avenue system. Open channels would be 3 to 8 feet deep and 37 to 100 feet in top width. Storm drains would range in size from 2-8' x 4' to 4-8' x 4' box culverts.

Refer to Plate 6 for a schematic of Alternative 5.

Alternative 6: Alternative 6 is similar to Alternative 4 with the exception that the 87th Avenue storm drain will outfall to the New River at Union Hills Drive. This will eliminate the need for a major storm drain between Union Hills Drive and Bell Road. A smaller storm drain will convey on-site and off-site runoff along Bell Road from east of 87th Avenue to the New River. The 100-year peak discharge at the Union Hills Drive outfall would be 1,407 cfs

and 447 cfs at the Bell Road outfall. Open channels would be 3 to 8 feet deep and range from 37 to 171 feet in top width. Storm drains would range in size from 2-8' x 3' to 4-10' x 5' box culverts.

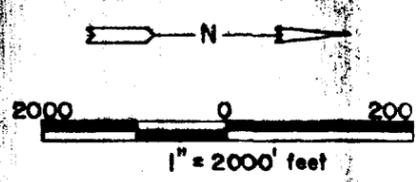
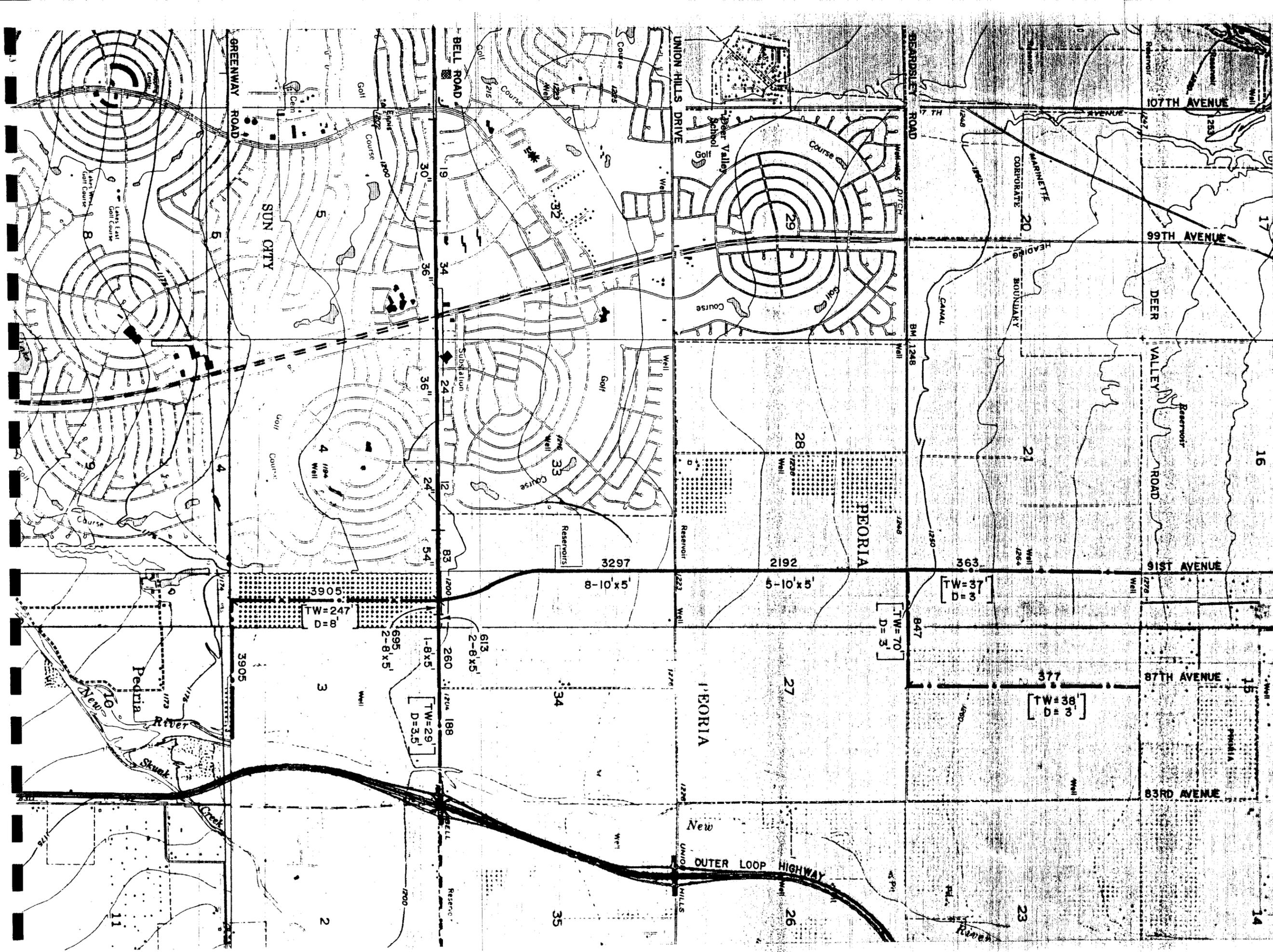
Refer to Plate 7 for a schematic of the proposed drainage facilities for Alternative 6.

Alternative 7: Alternative 7 is similar to Alternative 6 with the addition of detention basins at the northeast corner of 91st Avenue and Beardsley Road and at the northeast corner of 87th Avenue and Union Hills Drive. The 100-year peak discharge at Union Hills Drive and the New River would be 503 cfs and 1,455 cfs at the New River outfall for the 91st Avenue storm drain. Open channels would be 3 to 8 feet deep and range from 37 to 100 feet in top width. Storm drains range in size from 2-8' x 5' to 4-8' x 4' box culverts.

Refer to Plate 8 for a schematic of the proposed drainage facilities for Alternative 7.

On-site Runoff: On-site runoff from the Bell Road right-of-way in Drainage Area 2 (Agua Fria River to the New River) will be conveyed via open channels or storm drains. Open channels or storm drains may be utilized between the Agua Fria River and 115th Avenue alignment and also for the section of Bell Road between 87th Avenue and the New River. Storm drains will be utilized for all other areas. An outfall will be located at the existing Sun City drainage way at 99th Avenue for runoff generated between Dell Webb Boulevard and Burns Drive (located approximately 3,000 feet west of 91st Avenue). Runoff west of Dell Webb Boulevard will discharge into the structure at Bell Road and the 115th Avenue alignment. Runoff from east of Burns Drive would be picked up by the off-site drainage facilities at 91st Avenue.

Refer to Plates 2 through 8 for a schematic representation of the on-site storm drainage system along Bell Road.



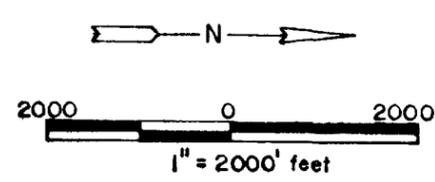
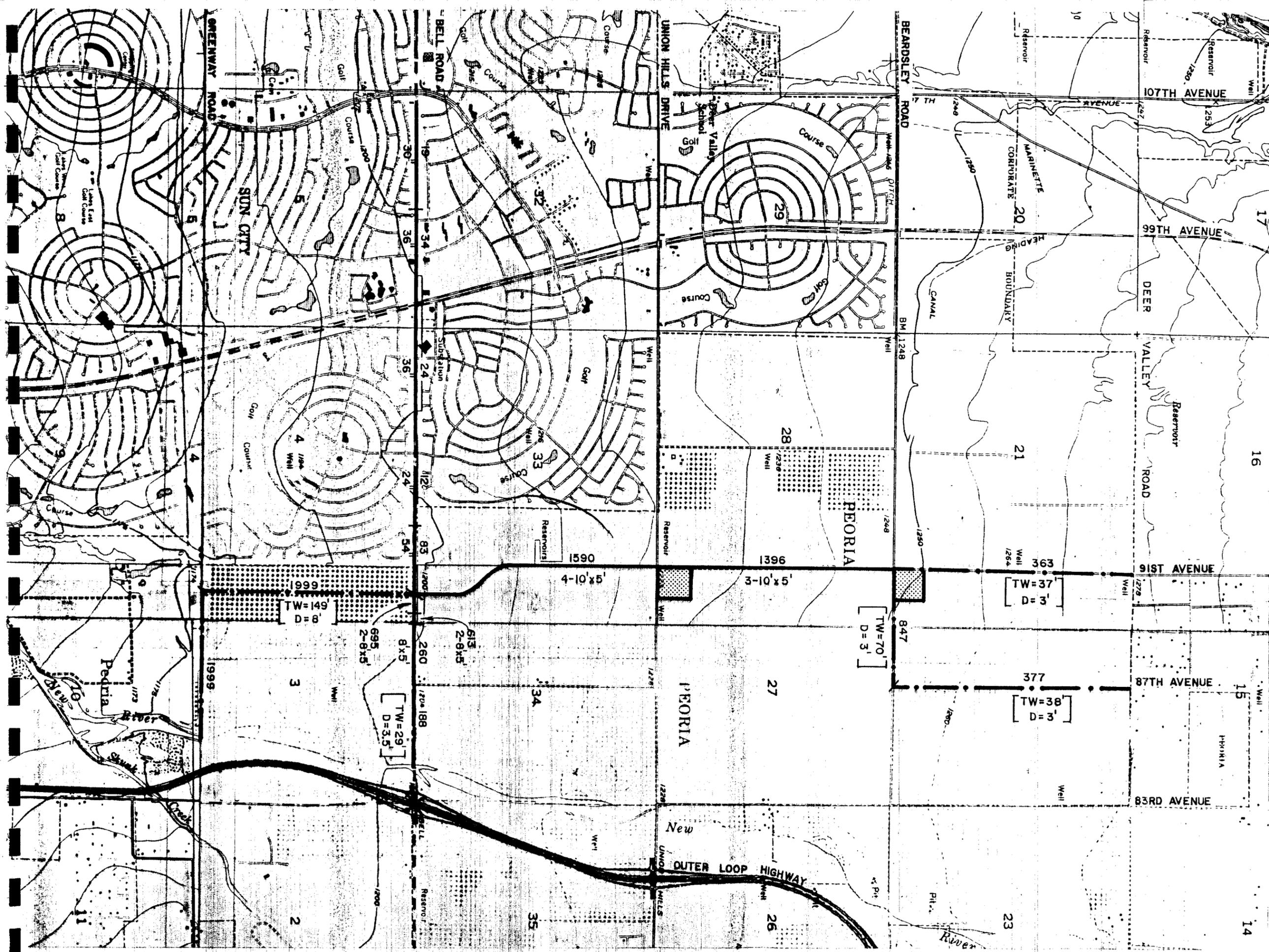
- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS

OPEN CHANNELS

[TW=60'] TOP WIDTH
[D=5'] DEPTH

100 YEAR FREQUENCY STORM
 PLATE 2
 ALTERNATE 1
 DRAINAGE AREA 2
 BELL ROAD PROJECT
 DRAINAGE STUDY

**Greiner
 Engineering**



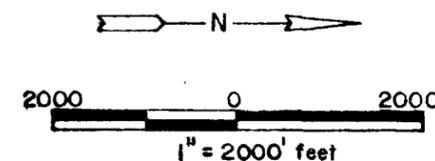
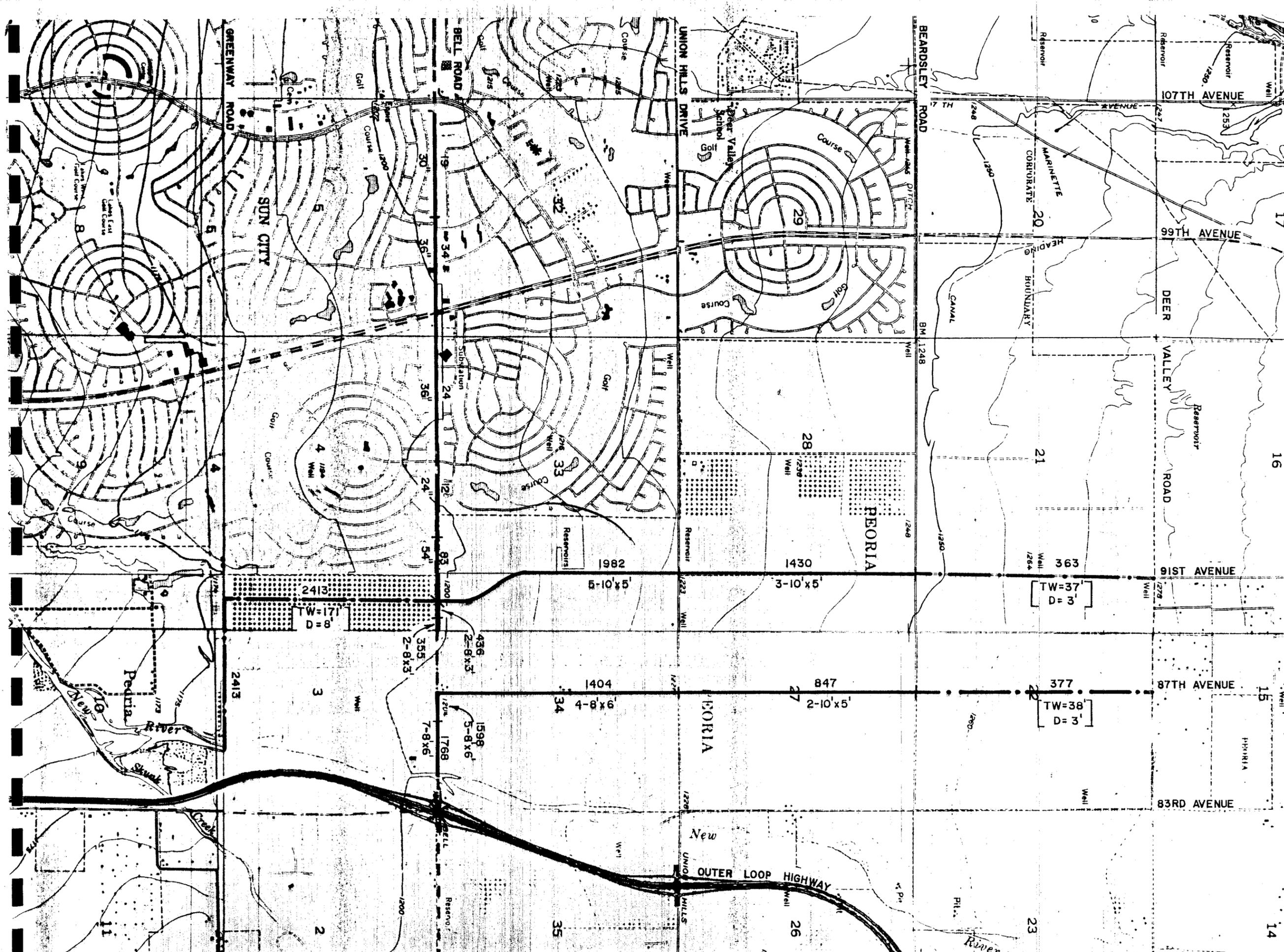
- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - ▒ DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS

OPEN CHANNELS

[TW=60'] TOP WIDTH
[D = 5'] DEPTH

100 YEAR FREQUENCY STORM
 PLATE 4
 ALTERNATE 3
 DRAINAGE AREA 2
 BELL ROAD PROJECT
 DRAINAGE STUDY

**Greiner
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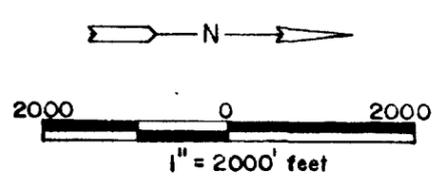
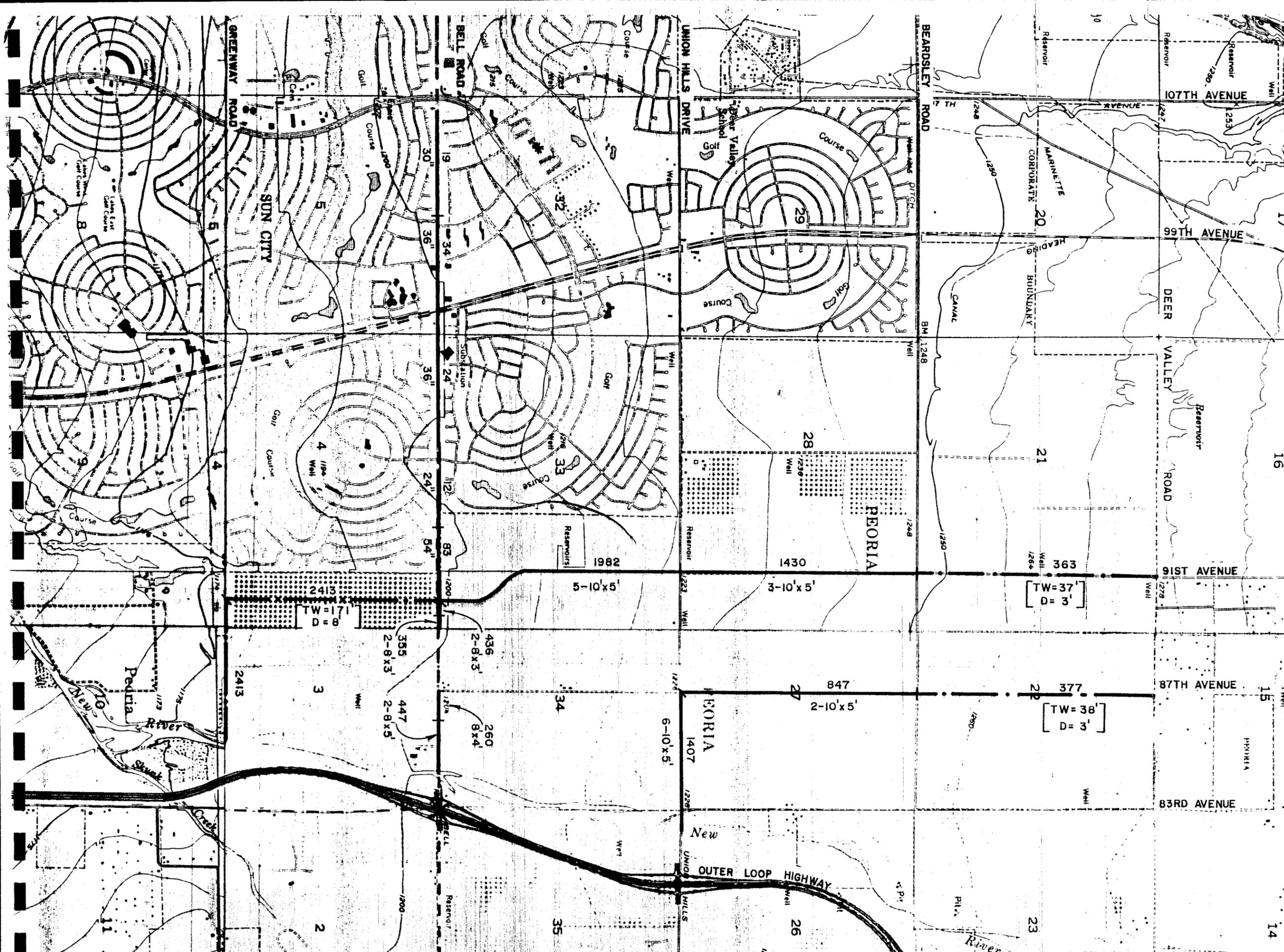
- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - ▒ DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS

OPEN CHANNELS

[TW=60'] TOP WIDTH
 [D = 5'] DEPTH

100 YEAR FREQUENCY STORM
 PLATE 5
 ALTERNATE 4
 DRAINAGE AREA 2
 BELL ROAD PROJECT
 DRAINAGE STUDY

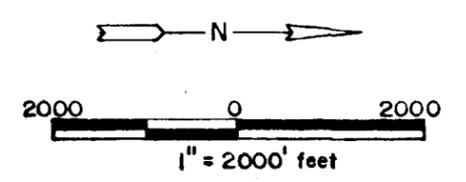
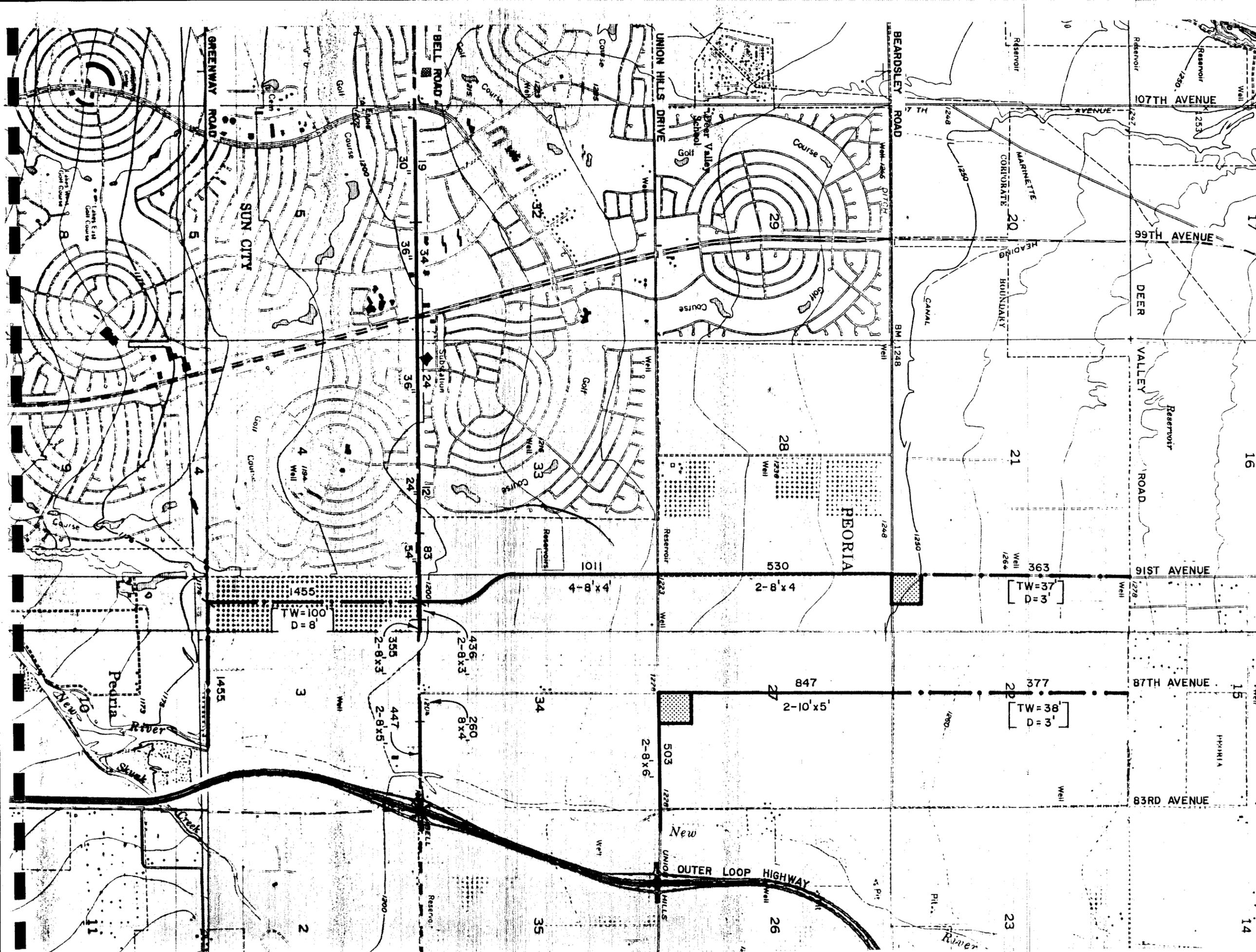
**Greiner
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- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - ▒ DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS
- OPEN CHANNELS**
- [TW=60'] TOP WIDTH
[D = 5'] DEPTH

100 YEAR FREQUENCY STORM
 PLATE 7
 ALTERNATE 6
 DRAINAGE AREA 2
 BELL ROAD PROJECT
 DRAINAGE STUDY

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LEGEND

- CONDUIT
- - - OPEN CHANNEL
- ▒ DETENTION BASIN
- 690 PEAK FLOW IN CFS
- 2-8'x3' STRUCTURE SIZE
- 72" FOR CONDUITS

OPEN CHANNELS

TW=60' TOP WIDTH
D = 5' DEPTH

100 YEAR FREQUENCY STORM

PLATE 8
ALTERNATE 7
DRAINAGE AREA 2
BELL ROAD PROJECT
DRAINAGE STUDY

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Drainage Area 3: Off-site runoff in Drainage Area 3 concentrates at Bell Road and 77th Avenue and Bell Road and 75th Avenue. Three alternative drainage concepts were evaluated for intercepting the 100-year runoff impacting Bell Road.

Alternative 1: To intercept the large flow concentrating at Bell Road and 75th Avenue (605 cfs) a storm drain will be located along 75th Avenue, extending from Bell Road northward for three-quarters of a mile. The storm drain will outlet into an open channel south of Bell Road discharging into Skunk Creek. An open channel located along the north right-of-way of Bell Road will convey runoff concentrating at the 77th Avenue alignment to the New River. Structures will be provided by the Arizona Department of Transportation to convey this discharge through the realigned 83rd Avenue and the Outer Loop Highway. The 100-year discharge to Skunk Creek at 75th Avenue would be 605 cfs. The discharge to the New River would be 1,157 cfs. Open channels would be from 3 to 8 feet deep and range from 47 to 84 feet in top width. Storm drain sizes would vary from 66-inch pipe to 2-8' x 5' box culverts.

Refer to Plate 9 for a schematic of the drainage facilities proposed Alternative 1.

Alternative 2: Alternative 2 is comprised of the same storm drain along 75th Avenue as proposed for Alternative 1. Under alternative 2, this storm drain will discharge into a detention basin located at the northeast corner of 75th Avenue and Bell Road. The basin will drain via pipe to Skunk Creek south of Bell Road. A second basin located at 77th Avenue and adjacent to the north right-of-way of Bell Road would detain off-site flows from the area north of Bell Road and west of 75th Avenue. The basin would drain to the New River via a pipe located along Bell Road. The 100-year peak discharge into Skunk Creek at 75th Avenue would be 125 cfs. The discharge into the New River at Bell Road would be 111 cfs. Storm drain sizes range from a 48-inch pipe to a 10' x 5' box culvert.

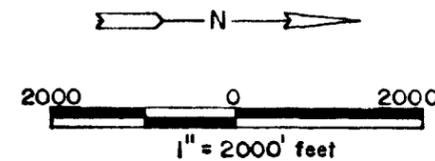
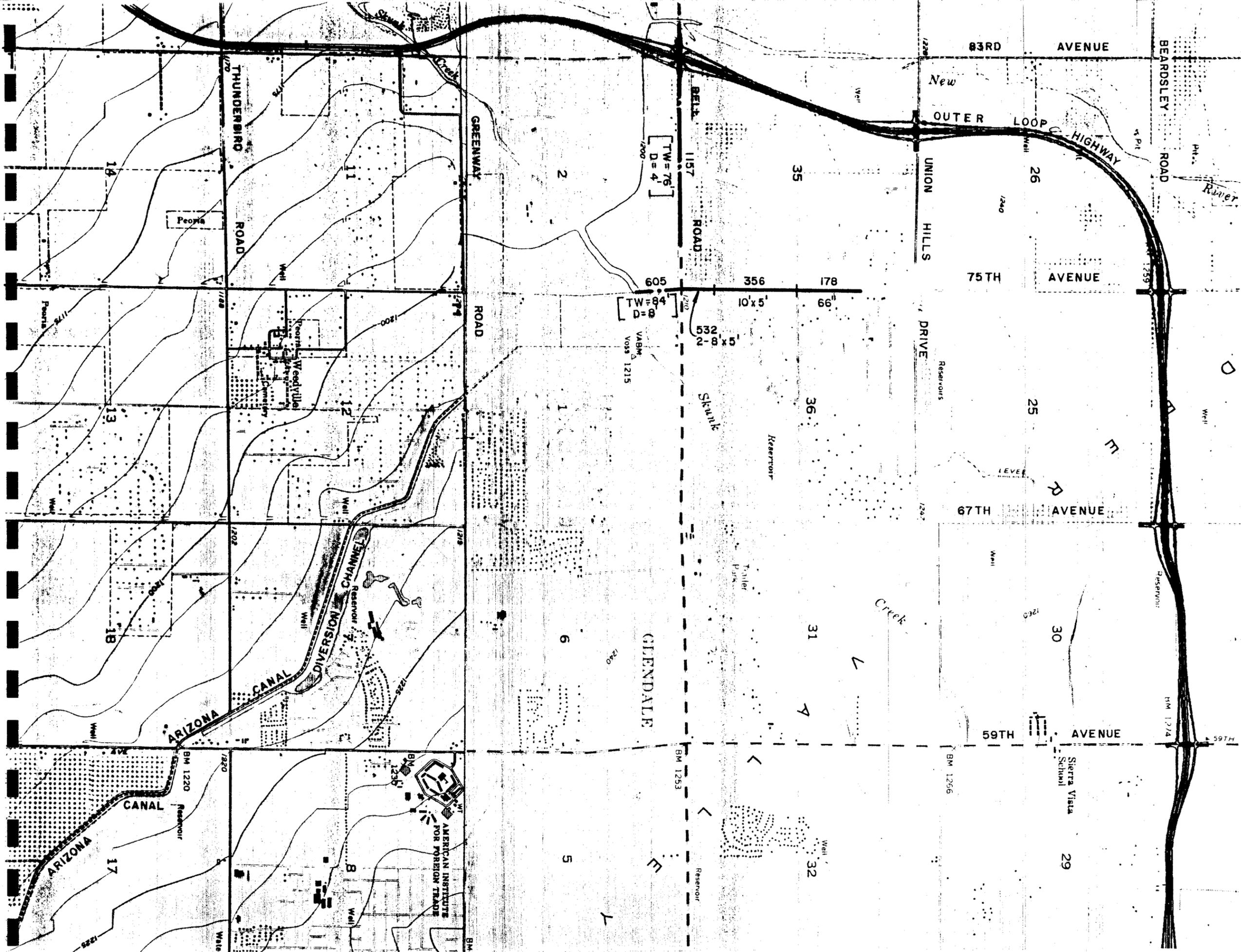
The shape of the detention basin can vary to meet local aesthetic requirements and the needs of future development in the area.

Refer to Plate 10 for a schematic of the drainage facilities proposed for Alternative 2.

Alternative 3: Alternative 3 is similar to Alternative 2 except that a detention basin will be located only at Bell Road and 77th Avenue as described in Alternative 2. Discharge at Skunk Creek would be 605 cfs and 111 cfs into the New River.

Refer to Plate 11 for a schematic of the drainage facilities for Alternative 3.

On-site Runoff: On-site runoff from the Bell Road right-of-way in Drainage Area 3 (New River to Skunk Creek) will be conveyed via storm drain or open channel to outfalls in Skunk Creek or the New River. For Alternative 1, the open channel along Bell Road from the New River to 77th Avenue would convey on-site runoff. On-site runoff from Bell Road east of 77th Avenue would be conveyed via storm drain to the proposed facility at 75th Avenue.



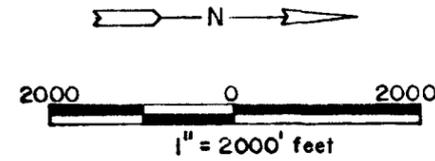
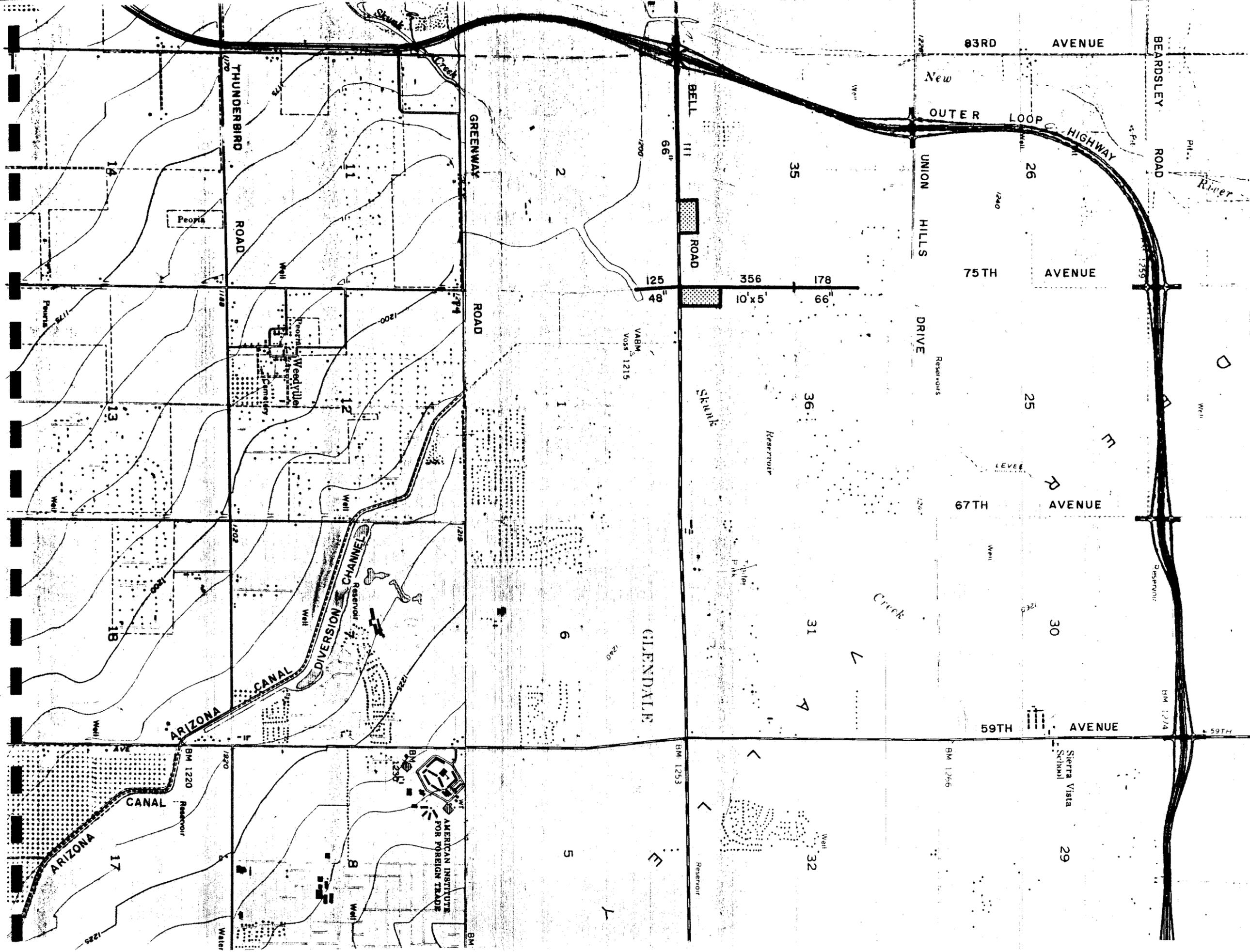
- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8' x 3' STRUCTURE SIZE
 - 72" FOR CONDUITS

OPEN CHANNELS

[TW = 60'] TOP WIDTH
 [D = 5'] DEPTH

100 YEAR FREQUENCY STORM
 PLATE 9
 ALTERNATE 1
 DRAINAGE AREA 3
 BELL ROAD PROJECT
 DRAINAGE STUDY

**Greiner
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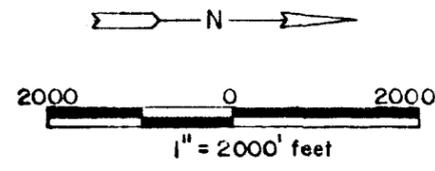
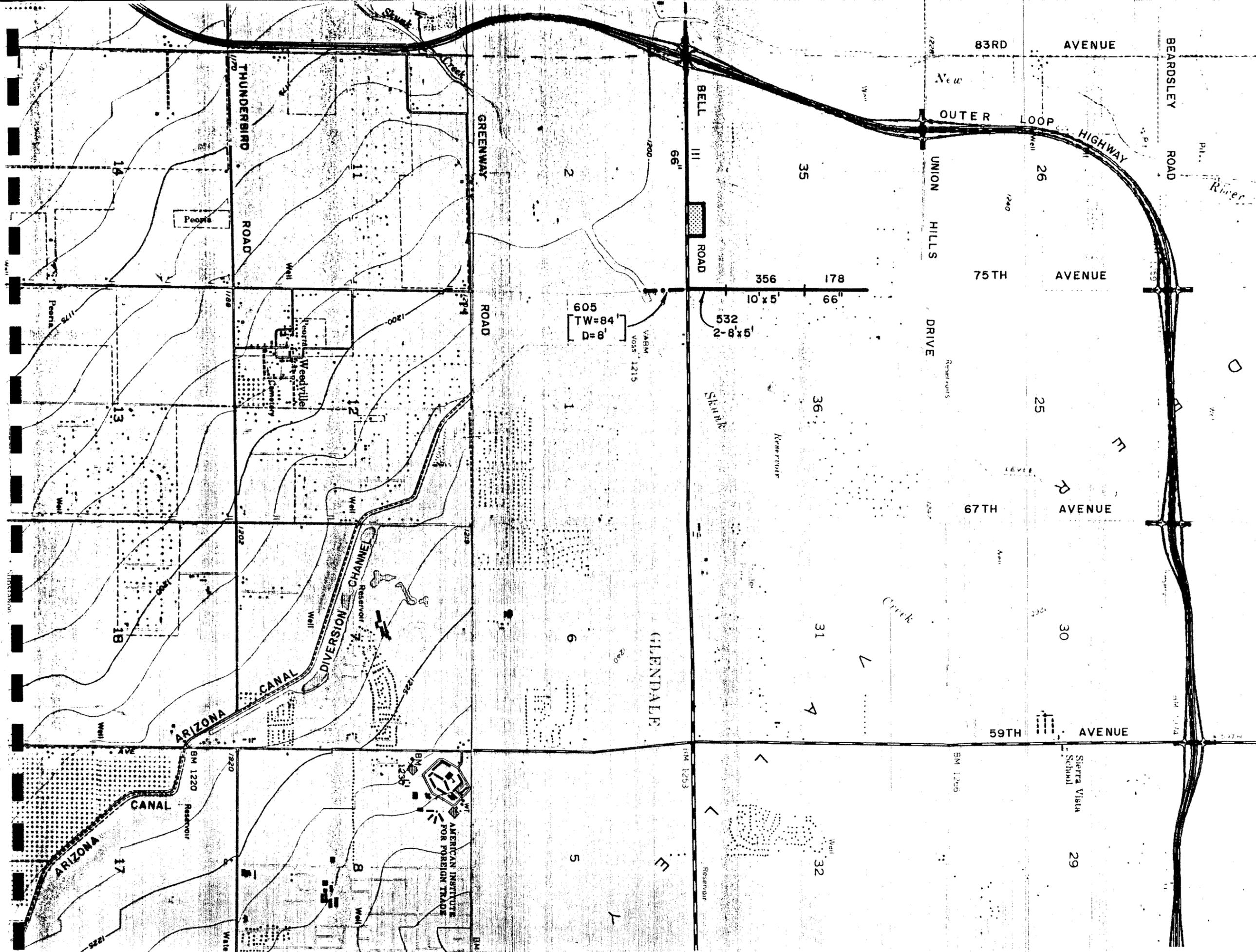
- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - ▨ DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS

OPEN CHANNELS

[TW=60'] TOP WIDTH
 [D = 5'] DEPTH

100 YEAR FREQUENCY STORM
 PLATE 10
 ALTERNATE 2
 DRAINAGE AREA 3
 BELL ROAD PROJECT
 DRAINAGE STUDY

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- LEGEND**
- CONDUIT
 - OPEN CHANNEL
 - DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8x3' STRUCTURE SIZE
 - 72" FOR CONDUITS

OPEN CHANNELS

TW=60' TOP WIDTH
D = 5' DEPTH

100 YEAR FREQUENCY STORM
 PLATE 11
 ALTERNATE 3
 DRAINAGE AREA 3
 BELL ROAD PROJECT
 DRAINAGE STUDY

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Drainage Area 4: Major concentration points for off-site runoff in Drainage Area 4 along Bell Road are at 67th Avenue, 59th Avenue, 51st Avenue, 43rd Avenue and 35th Avenue. Additional flows to Bell Road at 27th Avenue are diverted from Drainage Area 5 (east of I-17) via a proposed culvert. Three alternative concepts were evaluated. For all concept plans, the storm drainage systems may need to be extended north of Bell Road along both section-line and minor streets to assure 100 percent interception at Bell Road. No adequate drainage outfalls exist immediately south of Bell Road, therefore, all alternatives outlet either at the Arizona Canal Diversion Channel (ACDC) or Skunk Creek.

Alternative 1: Alternative 1 is comprised of five separate systems of box culvert storm drains that would convey off-site runoff to the ACDC along the section-line streets. Where necessary the trunk lines were extended eastward along Bell Road and/or north of Bell Road along the section-line streets to achieve full interception of the 100-year runoff. The box culvert along Bell Road from 35th Avenue was extended to the proposed culvert at I-17 discharging flows from Drainage Area 5. A detention basin recommended by the Glendale Storm Water Management Plan, to be located along the northern right-of-way of Bell Road between 57th and 55th Avenues, was incorporated into the drainage system. The proposed basin would retain the 10-year runoff.

The 100-year peak discharges to the ACDC vary from 350 cfs (67th Avenue) to 2,020 cfs (35th Avenue). Structure sizes range from a single 8' x 4' box culvert to 6-8' x 6' box culverts.

Refer to Plates 12 and 13 for schematics of the drainage facilities proposed for Alternative 1.

Alternative 2: Alternative 2 is similar to Alternative 1 with the exception that runoff concentrating from 59th Avenue west to 67th Avenue is conveyed westward along Bell Road to Skunk Creek rather than southward along the section-line streets to the ACDC.

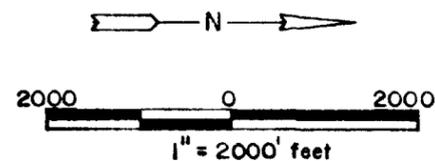
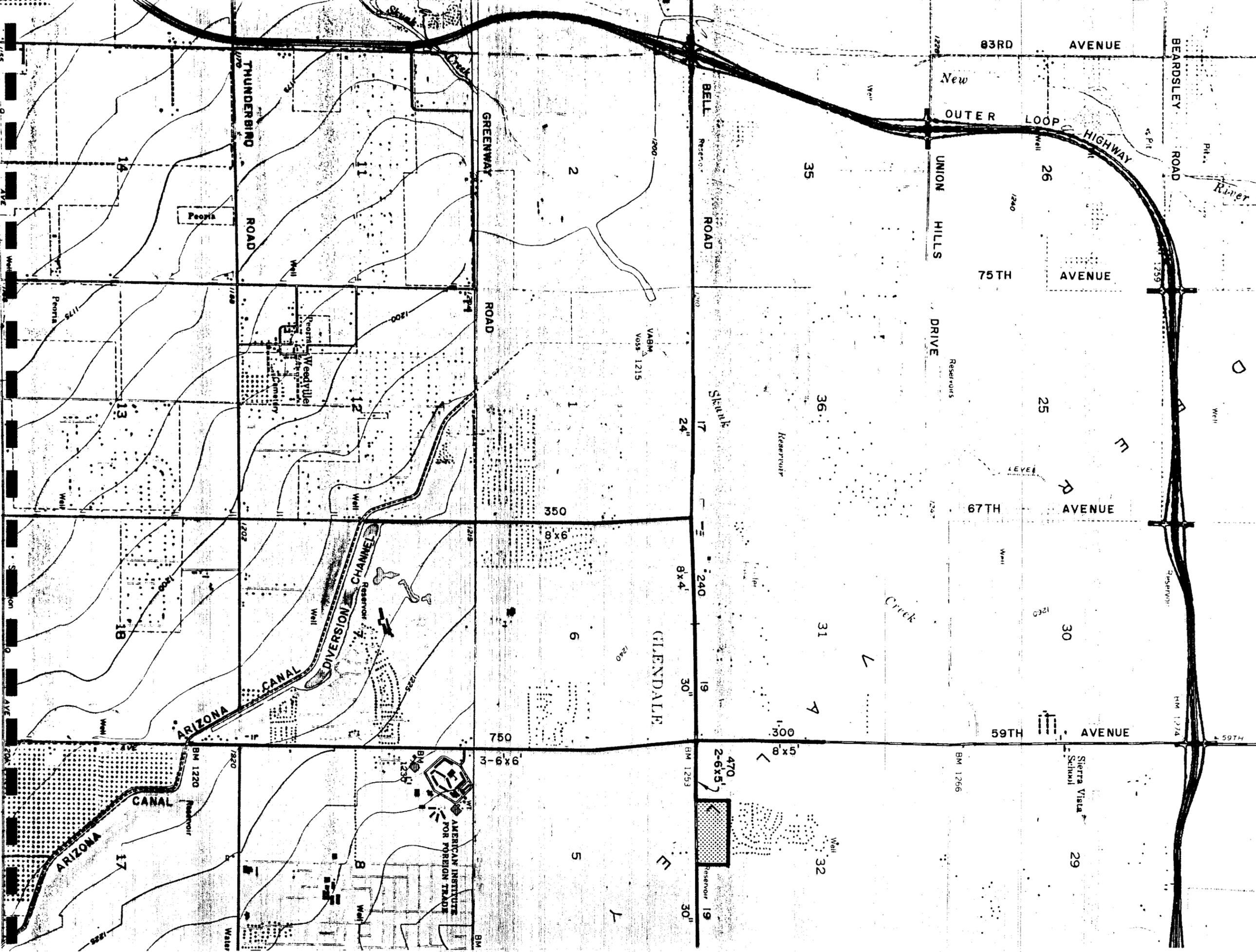
Refer to Plates 13 and 14 for schematics of the drainage facilities proposed for Alternative 2.

Alternative 3: Alternative 3 is comprised of two separate drainage systems. Drainage concentrating at Bell Road and 35th Avenue is conveyed along 35th Avenue to the ACDC. All drainage concentrating west of 35th Avenue is conveyed along Bell Road to Skunk Creek. The 100-year discharge at Skunk Creek would be 2,890 cfs. Storm drain structures would range in size from a single 10' x 6' box culvert to 6-10' x 7' box culverts.

Refer to Plate 16 and 17 for schematics of the drainage alternatives proposed for Alternative 3.

On-site Runoff: Minor off-site and on-site runoff from the Bell Road right-of-way in Drainage Area 4 (Skunk Creek to I-17) will be intercepted by storm drains that will tie into the off-site storm drain trunk lines.

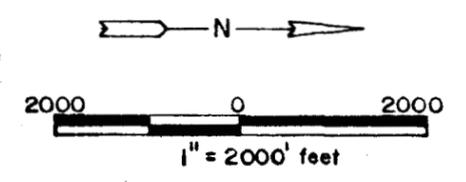
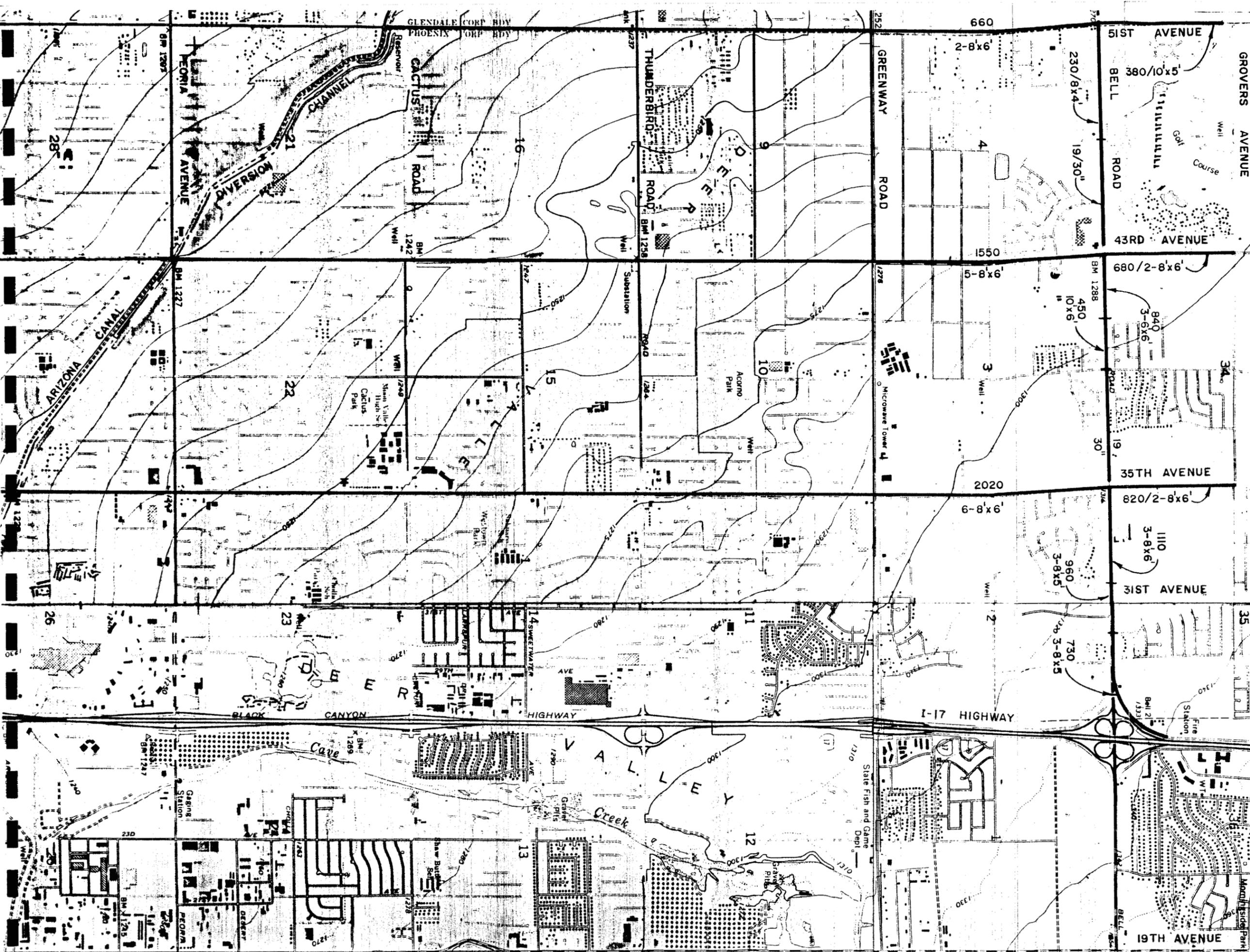
Refer to Plates 12 through 17 for schematics of the on-site drainage facilities.



- LEGEND**
- CONDUIT
 - OPEN CHANNEL
 - DETENTION BASIN
- 690 PEAK FLOW IN CFS
 2-8'x3' STRUCTURE SIZE
 72" FOR CONDUITS
- OPEN CHANNELS**
- TW=60' TOP WIDTH
 D = 5' DEPTH

100 YEAR FREQUENCY STORM
 PLATE 12
 ALTERNATE 1
 DRAINAGE AREA 4 (1 OF 2)
 BELL ROAD PROJECT
 DRAINAGE STUDY

**Greiner
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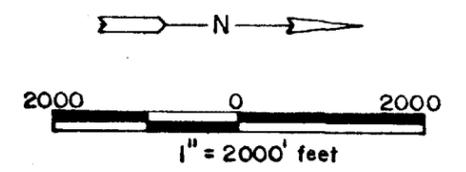
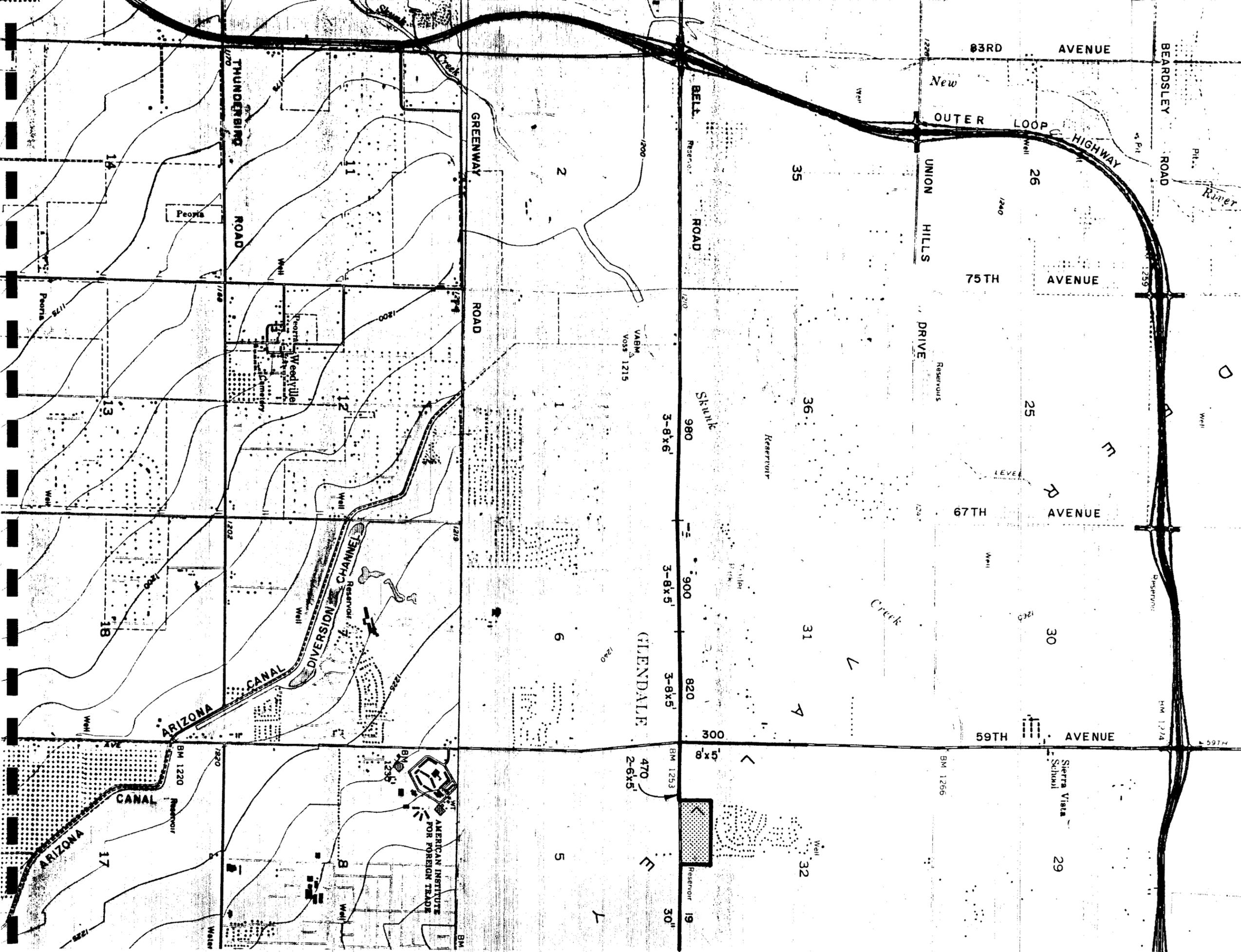
- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - ▨ DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8x3' STRUCTURE SIZE
 - 72" FOR CONDUITS

OPEN CHANNELS

[TW=60'] TOP WIDTH
[D = 5'] DEPTH

100 YEAR FREQUENCY STORM
 PLATE 13
 ALTERNATE 1
 DRAINAGE AREA 4 (2 OF 2)
 BELL ROAD PROJECT
 DRAINAGE STUDY

**Greiner
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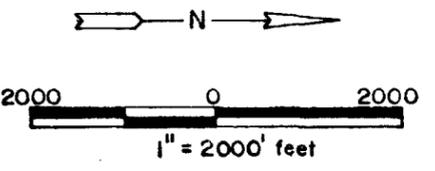
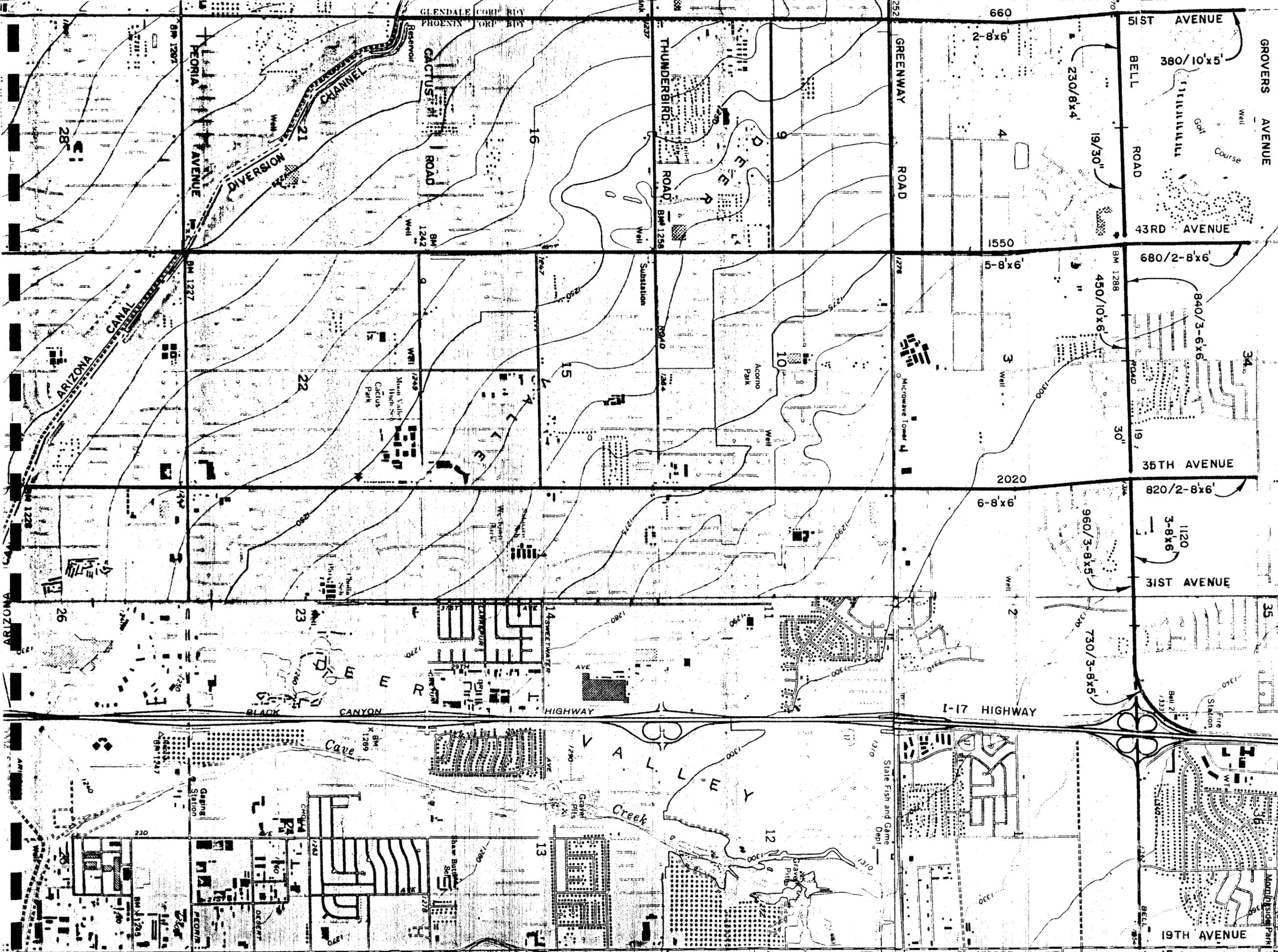
- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - ▨ DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS

OPEN CHANNELS

TW = 60' TOP WIDTH
 D = 5' DEPTH

100 YEAR FREQUENCY STORM
 PLATE 14
 ALTERNATE 2
 DRAINAGE AREA 4 (1 OF 2)
 BELL ROAD PROJECT
 DRAINAGE STUDY

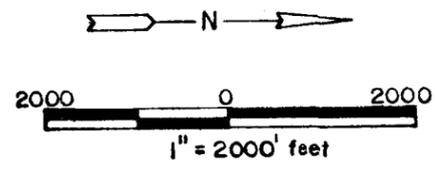
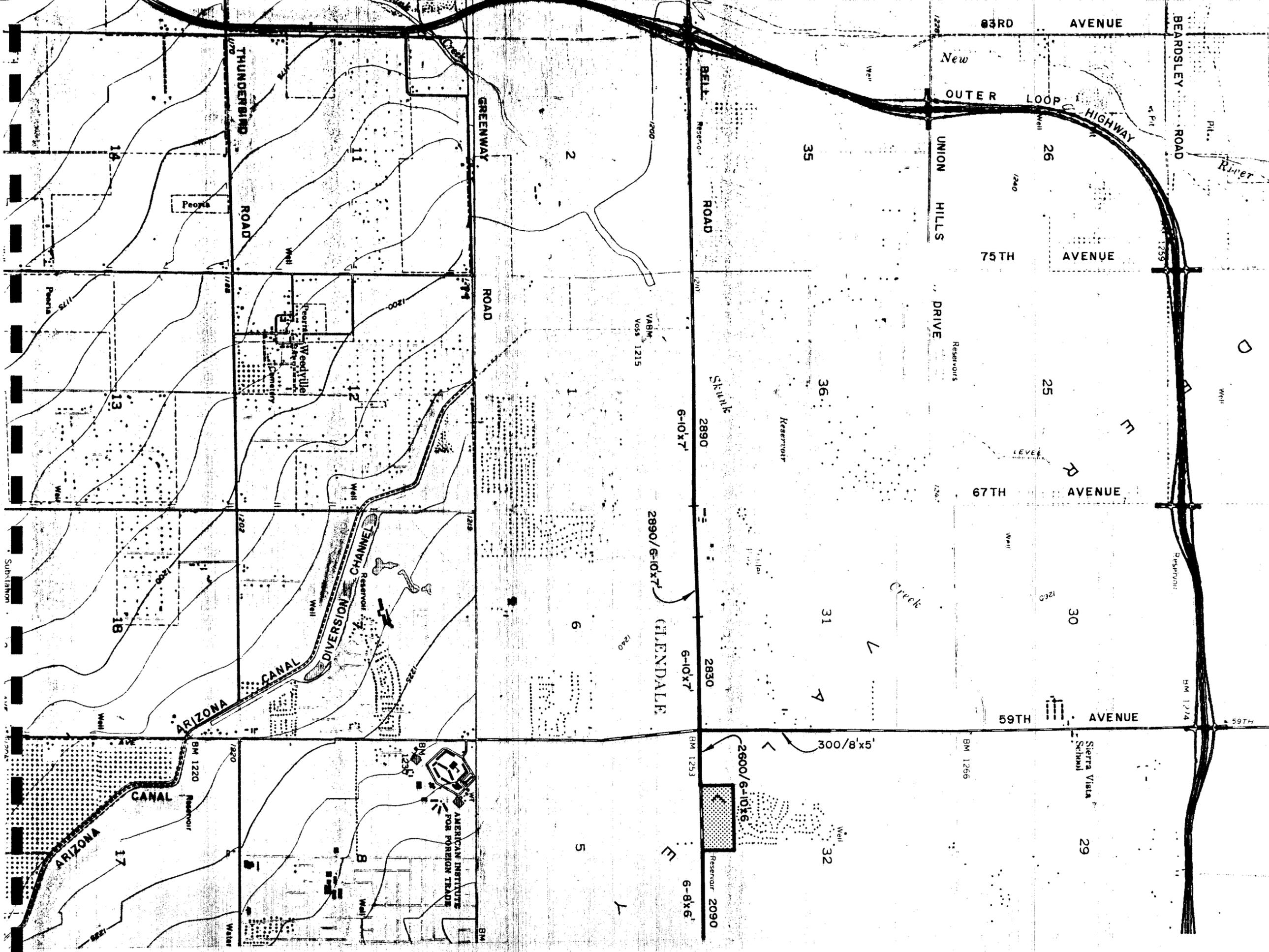
**Greiner
 Engineering**



- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - ▨ DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8x3' STRUCTURE SIZE
 - 72" FOR CONDUITS
- OPEN CHANNELS**
- [TW = 60'] TOP WIDTH
 [D = 5'] DEPTH

100 YEAR FREQUENCY STORM
 PLATE 15
 ALTERNATE 2
 DRAINAGE AREA 4 (2 OF 2)
 BELL ROAD PROJECT
 DRAINAGE STUDY

**Greiner
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LEGEND

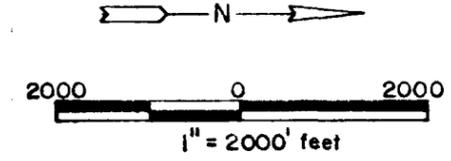
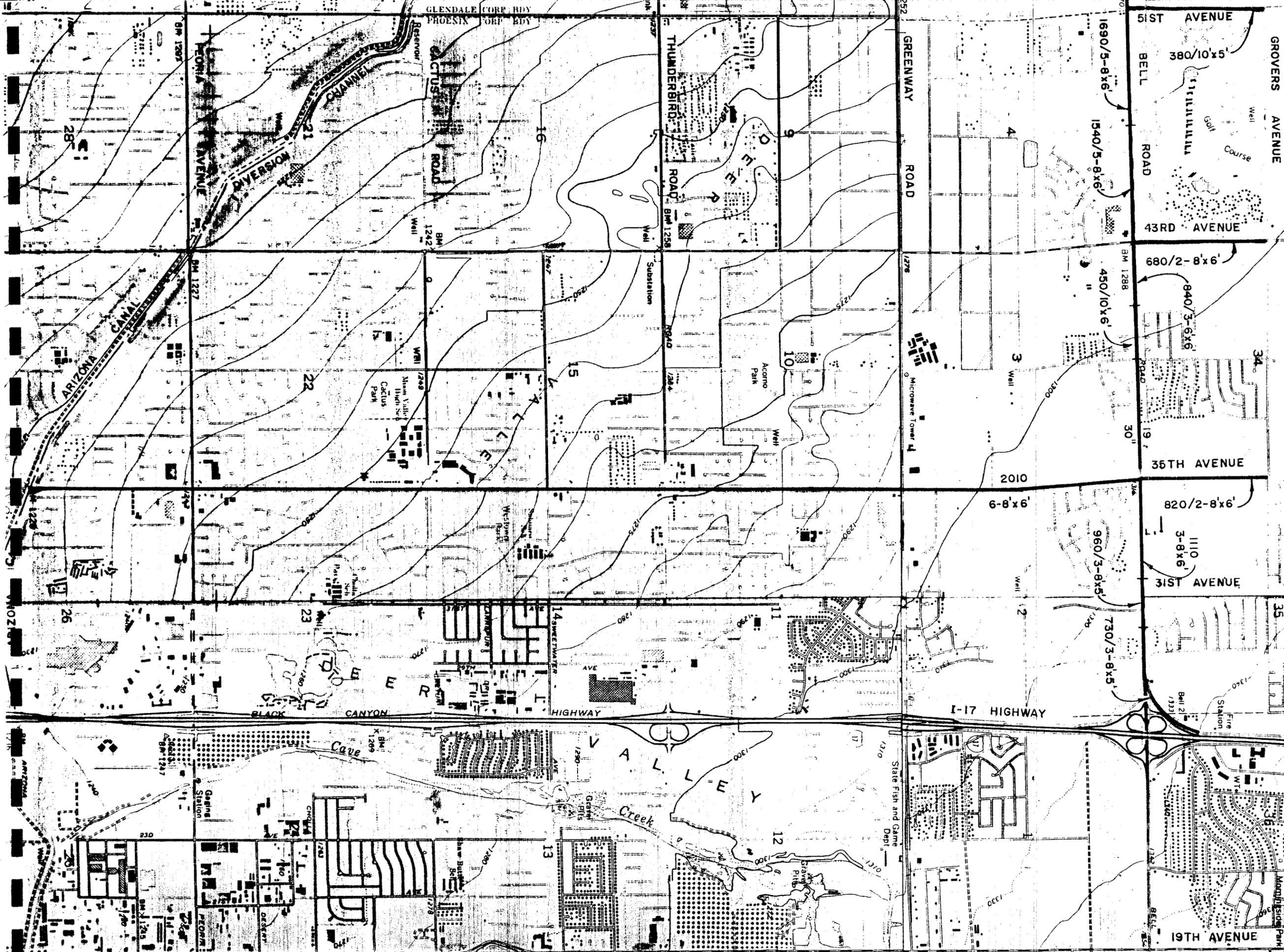
- CONDUIT
- OPEN CHANNEL
- DETENTION BASIN
- 690 PEAK FLOW IN CFS
- 2-8'x3' STRUCTURE SIZE
- 72" FOR CONDUITS

OPEN CHANNELS

[TW=60] TOP WIDTH
[D = 5'] DEPTH

100 YEAR FREQUENCY STORM
 PLATE 16
 ALTERNATE 3
 DRAINAGE AREA 4 (1 OF 2)
 BELL ROAD PROJECT
 DRAINAGE STUDY

**Greiner
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- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - ▨ DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS
- OPEN CHANNELS**
- [TW=60'] TOP WIDTH
[D = 5'] DEPTH

100 YEAR FREQUENCY STORM

PLATE 17

ALTERNATE 3

DRAINAGE AREA 4 (2 OF 2)

BELL ROAD PROJECT

DRAINAGE STUDY

Greiner Engineering

Drainage Area 5: Off-site runoff in Drainage Area 5 concentrates at Bell Road and 19th Avenue (2,090 cfs) and along Bell Road between I-17 and 21st Avenue (730 cfs). Two alternative drainage systems were evaluated.

Alternative 1: Alternative 1 is comprised of two separate drainage systems. Runoff concentrating along 19th Avenue between Grovers Avenue and Bell Road is conveyed via box culvert storm drains to Cave Creek at 19th Avenue, south of Bell Road. No other adequate outfalls exist south of Bell Road within this drainage area. A trunk storm drain would extend east along Bell Road from 19th Avenue to 15th Avenue. Runoff concentrating at Bell Road between 21st Avenue and I-17 will be conveyed via box culvert storm drains west across I-17 to the 35th Avenue storm drain described under the Drainage Area 4 alternatives. This system will prevent off-site drainage from entering the depressed section of Bell Road under I-17. The proposed culvert will be located north of and parallel to the existing 2-6' x 3' box culverts. The 100-year discharge at the 19th Avenue outfall would be 2,090 cfs. The system conveying runoff west across I-17 would discharge at 730 cfs. Culverts would range in size from 2-6' x 6' to 6-8' x 6'.

Refer to Plates 18 and 19 for schematics of the drainage facilities proposed for Alternative 1.

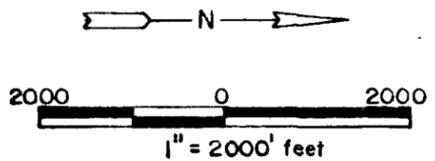
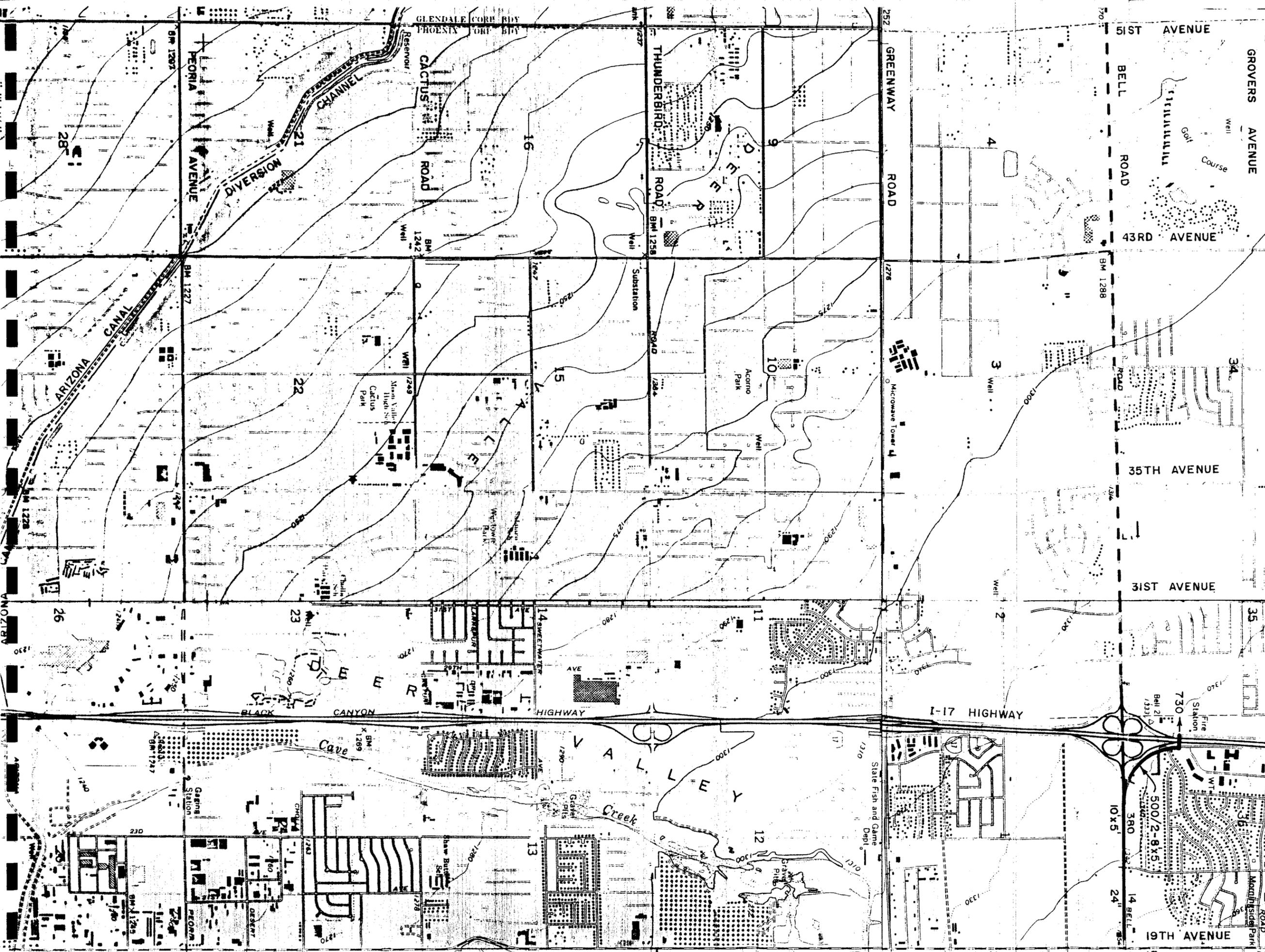
Alternative 2: A storm system parallel to the system proposed for 19th Avenue in Alternative 1, is proposed for 15th Avenue. This will reduce the size of the storm drain needed for 19th Avenue. Both storm drains will join at 19th Avenue and Bell Road and outlet at Cave Creek and 19th Avenue south of Bell Road as in Alternative 1. Runoff from areas west of 19th Avenue will be conveyed across I-17 as in Alternative 1. The 100-year peak discharge at 19th Avenue and Cave Creek would be 2,110 cfs. Storm drain culverts range in size from a single 8' x 5' to 6-6' x 6'.

Refer to Plates 18 and 20 for schematics of the drainage facilities proposed for Alternative 2.

On-site Runoff: Minor off-site and on-site runoff from the Bell Road right-of-way in Drainage Area 5 (I-17 to Cave Creek) will be conveyed by storm drains to either the proposed off-site storm drainage systems or to Cave Creek, as in the case for Bell Road east of 15th Avenue.

The system proposed by PRC Engineering for draining the depressed section of Bell Road under I-17 is designed for the 25-year storm event only. The pumps will have to be upgraded to discharge at the 100-year storm inflow rate.

Refer to Plates 18 through 20 for schematics of the on-site drainage facilities.



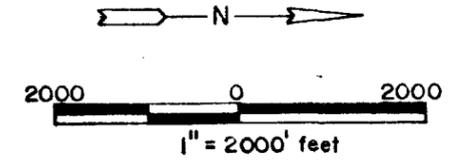
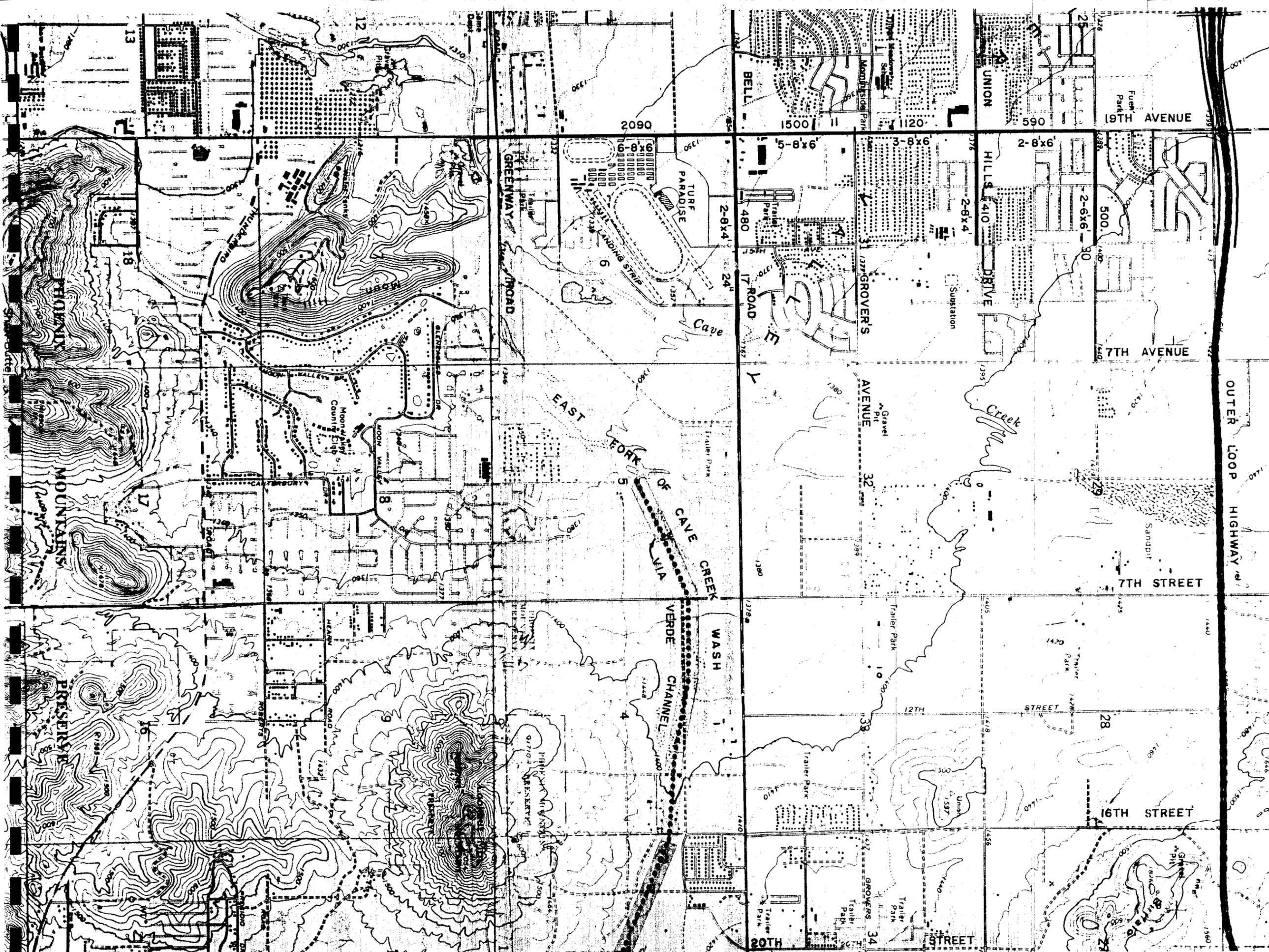
- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - ▒ DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS

OPEN CHANNELS

[TW=60'] TOP WIDTH
[D = 5'] DEPTH

100 YEAR FREQUENCY STORM
 PLATE 18
 ALTERNATE 1 & 2
 DRAINAGE AREA 5 (1 OF 3)
 BELL ROAD PROJECT
 DRAINAGE STUDY

**Greiner
 Engineering**



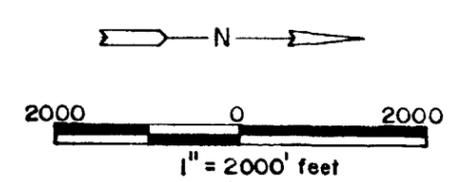
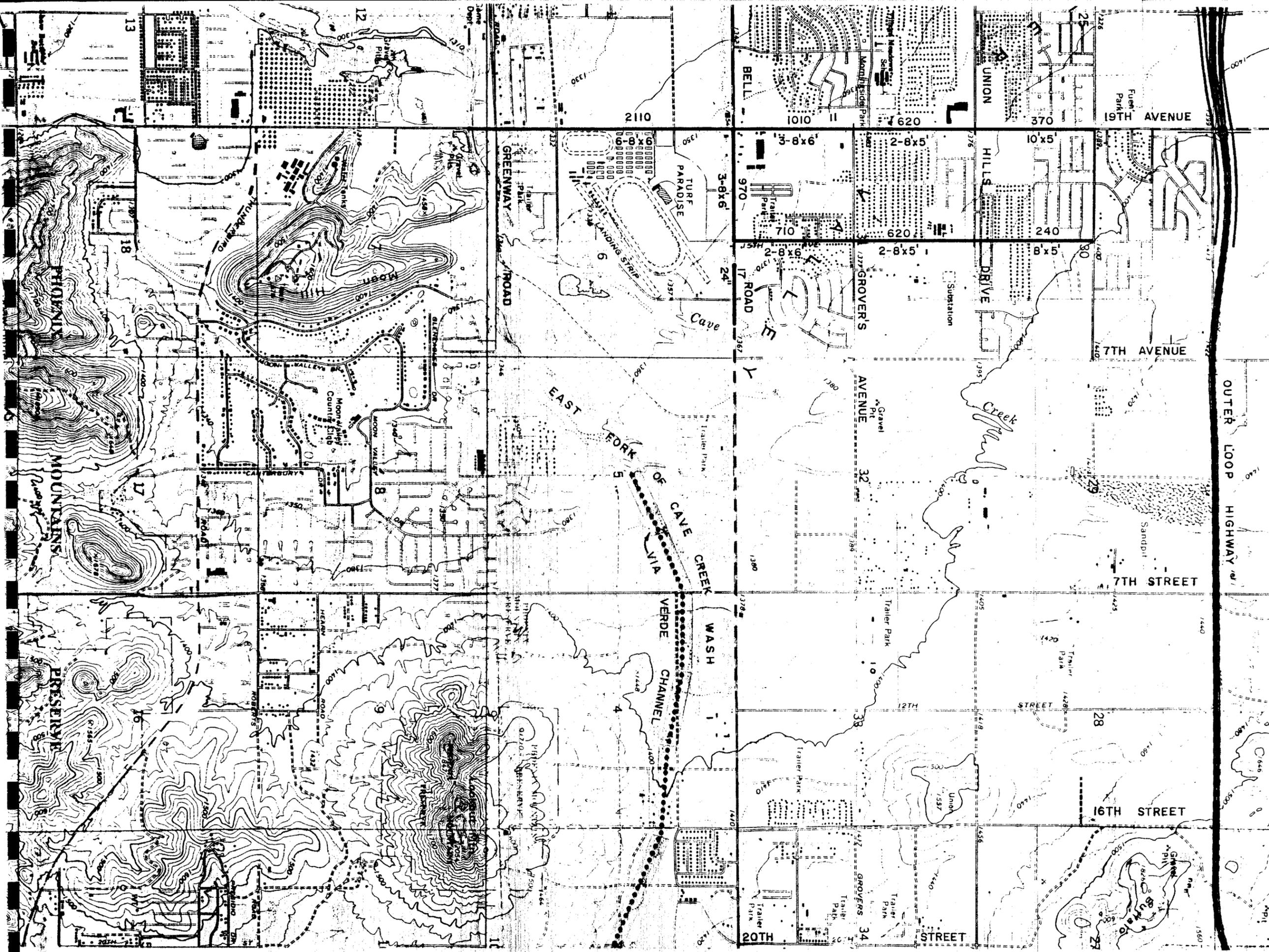
- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - ▨ DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS

OPEN CHANNELS

[TW=60'] TOP WIDTH
 [D = 5'] DEPTH

100 YEAR FREQUENCY
 PLATE 19
 ALTERNATE 1
 DRAINAGE AREA 5 (2 OF 3)
 BELL ROAD PROJECT
 DRAINAGE STUDY

**Greiner
 Engineering**



- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - ▒ DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS
- OPEN CHANNELS**
- [TW=60] TOP WIDTH
 [D = 5'] DEPTH

100 YEAR FREQUENCY STORM
 PLATE 20
 ALTERNATE 2
 DRAINAGE AREA 5 (3 OF 3)
 BELL ROAD PROJECT
 DRAINAGE STUDY

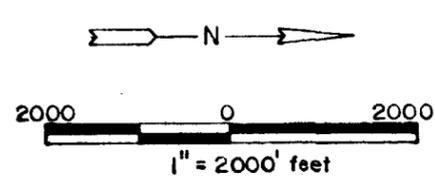
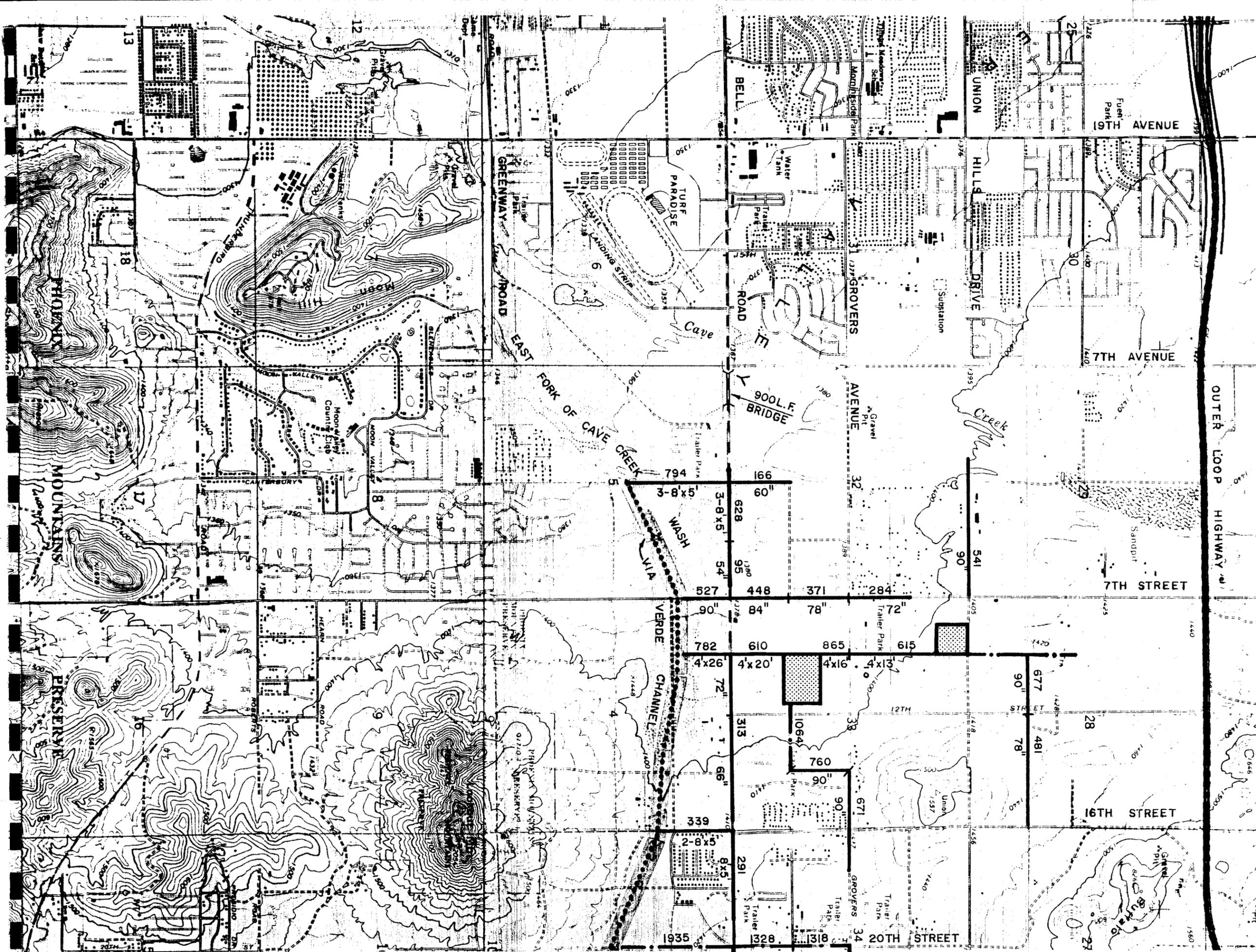
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Drainage Area 6: Drainage Area 6 is the western portion of the East Fork of Cave Creek Wash watershed. Major flows concentrate at Bell Road and Central Avenue, 7th Street, 9th Street and 16th Street. A current study by NBS/Lowry Engineers, "Upper East Fork Cave Creek Area Drainage Master Studyk," has developed a drainage and flood control master plan for the 100-year, 24-hour storm runoff in this area. Per the FCD's guidance, Greiner has incorporated the NBS/Lowry proposal into the Bell Road study. Additional drainage facilities were evaluated by Greiner where it was required to protect Bell Road from off-site drainage not intercepted by the NBS/Lowry system. From the hydrologic modeling it was determined that additional storm drainage systems will be required on Central Avenue and 16th Street. Only one alternative system was evaluated for Drainage Area 6.

Alternative 1: The drainage and flood control facilities developed by NBS/Lowry and Greiner are comprised of four (4) independent systems draining to the proposed Greenway Parkway flood control channel located south of Bell Road between Cave Creek Road and Cave Creek. Storm drain systems would be located north of Bell Road on Central Avenue, 7th Street and 16th Street. A combination storm drain detention basin system is proposed for 9th Street. Discharges to the Greenway Parkway channel range from 339 cfs (16th Street) to 794 cfs (Central Avenue). Storm drain structures range in size from a 54- inch pipe to a single 4' x 26' box culvert. The detention basins will be located on the northeast corner of 9th Street and Campobello Street and on the southwest corner of Union Hills Drive and 9th Street.

On-Site Runoff: On-site runoff from the Bell Road right-of-way in Drainage Area 6 (Cave Creek to 19th Street) will be conveyed by the storm drain systems for off-site drainage to either the Greenway Parkway channel or Cave Creek.

Refer to Plate 21 for a schematic of the drainage facilities proposed by both Greiner and NBS/Lowry for Drainage Area 6.



- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - ▨ DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8x3' STRUCTURE SIZE
 - 72" FOR CONDUITS

OPEN CHANNELS

[TW=60] TOP WIDTH
[D = 5'] DEPTH

100 YEAR FREQUENCY STORM

PLATE 21

ALTERNATE 1

DRAINAGE AREA 6, 7

BELL ROAD PROJECT

DRAINAGE STUDY

Greiner Engineering

Drainage Area 7: Drainage Area 7 is the eastern portion of the East Fork of Cave Creek Wash watershed. Drainage and flood control facilities proposed by NBS/Lowry Engineers were incorporated by Greiner for this area. Only the NBS/Lowry system was evaluated as per the FCD's guidance.

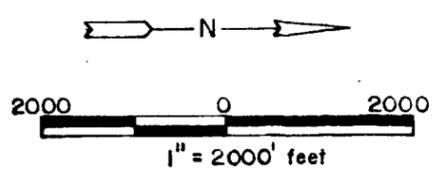
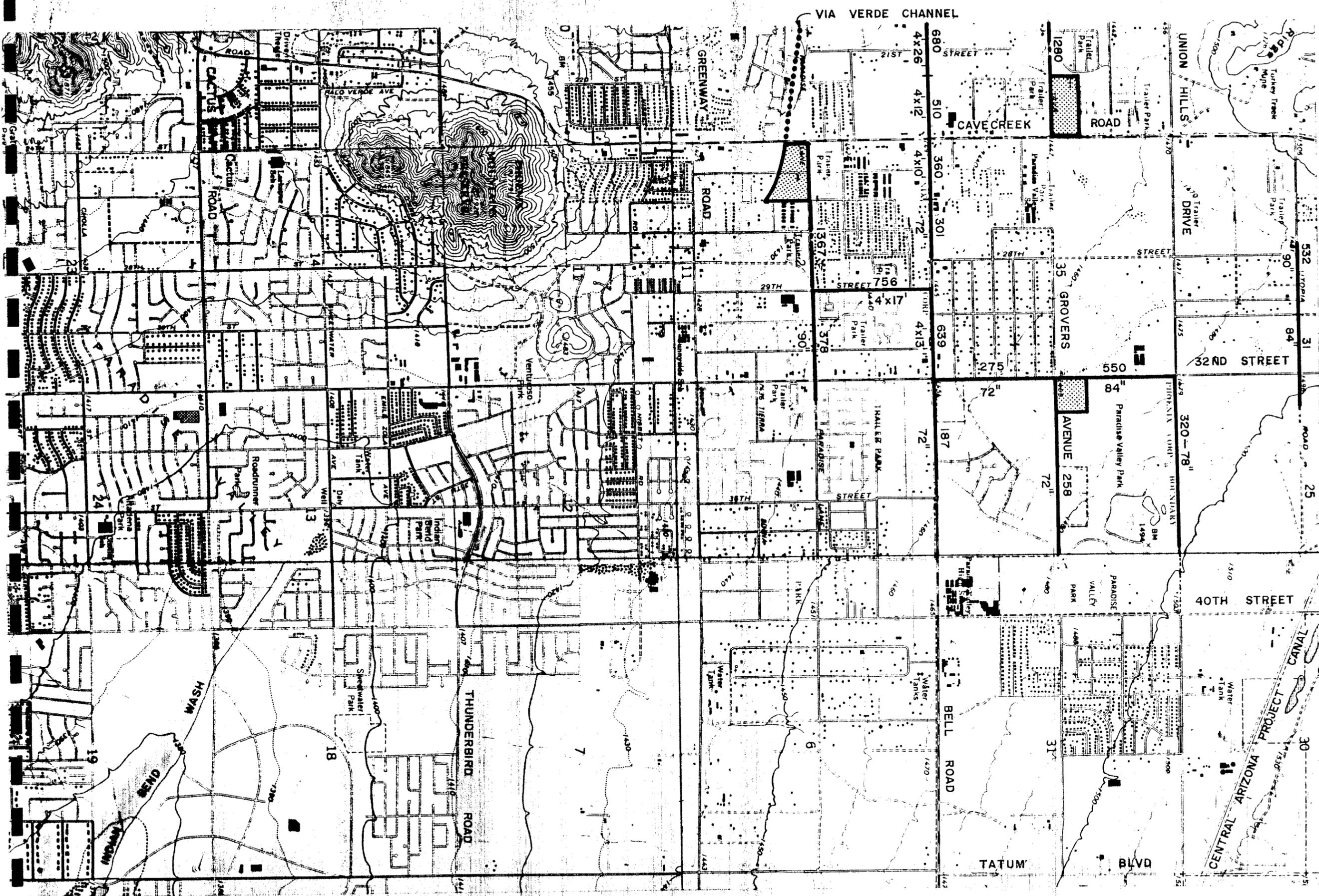
Alternative 1: The drainage and flood control facilities developed by NBS/Lowry are comprised of two separate drainage systems conveying runoff to the proposed Greenway Parkway flood control channel located south of Bell Road between Cave Creek Road and Cave Creek.

One system intercepts flows in the primary floodplain of the East Fork of Cave Creek Wash. The system consists of a detention basin located along the northern right-of-way of Beardsley Road at 26th Street (not shown on Plate 18) and a basin located at the northwest corner of Grovers Avenue and Cave Creek Road. The latter basin discharges into an open channel which conveys flows along 20th Street to the Greenway Parkway channel. A storm drain extending from 28th Street to 20th Street along Bell Road discharges flows into a channel at 20th Street. The peak discharge into the Greenway Parkway channel was estimated by NBS/Lowry to be 1,935 cfs.

The second system, comprised of storm drains along Union Hills Drive, Grovers Avenue, Bell Road and Paradise Lane that conveys runoff to a storm drain along 32nd Street. A detention basin will be located at the northeast corner of Grovers Avenue and 32nd Street. A second basin will be located south of Paradise Lane between Cave Creek Road and 26th Street. Outflows from this basin would discharge into the Greenway Parkway channel. NBS/Lowry estimated the discharge of the 100-year peak flow into the Via Verde channel to be 756 cfs.

On-Site Runoff: On-site runoff from Bell Road in Drainage Area 7 (20th Street to 35th Street) will be conveyed by the off-site drainage system for discharge into the Via Verde channel.

Refer to Plates 21 and 22 for schematics of the drainage facilities proposed for Drainage Area 7.



- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - ▨ DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS
- OPEN CHANNELS**
- [TW=60'] TOP WIDTH
[D = 5'] DEPTH

100 YEAR FREQUENCY STORM
 PLATE 22
 ALTERNATE 1
 DRAINAGE AREA 7
 BELL ROAD PROJECT
 DRAINAGE STUDY

**Greiner
 Engineering**

Drainage Area 8: Major off-site flows concentrate along Bell Road in Drainage Area 8 at 36th Street, 40th Street, 44th Street, Tatum Boulevard and 56th Street. No adequate outfalls exist immediately south of Bell Road. All alternatives, therefore, outlet at the Indian Bend Wash (IBW). Three (3) alternative drainage concepts were evaluated.

Alternative 1: Alternative 1 is comprised of five storm drain trunk systems extending from Bell Road to the IBW along 36th Street, 40th Street, 44th Street, Tatum Boulevard and 56th Street. The storm drain systems extend along Bell Road and/or north of Bell Road as necessary to intercept off-site flows. Some improvements to the natural channel at 36th Street just north of Bell Road will be required to divert flows into the proposed 36th Street storm drain.

The 100-year peak discharges at the IBW range from 550 cfs (44th Street) to 1,076 cfs (40th Street). Storm drain sizes range from a 36 inch pipe to 3-8' x 6' box culverts.

Refer to Plates 23 and 24 for schematics of the drainage facilities proposed for Alternative 1.

Alternative 2: Alternative 2 is similar to Alternative 1 with the exception that open channels are utilized wherever open space along Bell Road is available rather than using storm drains. Open channels were evaluated from 40th Street to 42nd Street, 44th Street to 47th Street and 55th Street to 63rd Street. Channels range from 4.5 to 8 feet in depth and from 36 to 94 feet in top width.

Refer to Plates 25 and 26 for schematics of the drainage facilities proposed for Alternative 2.

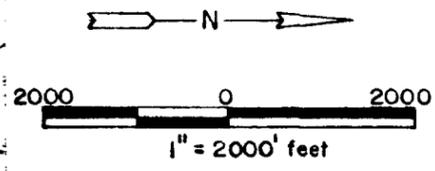
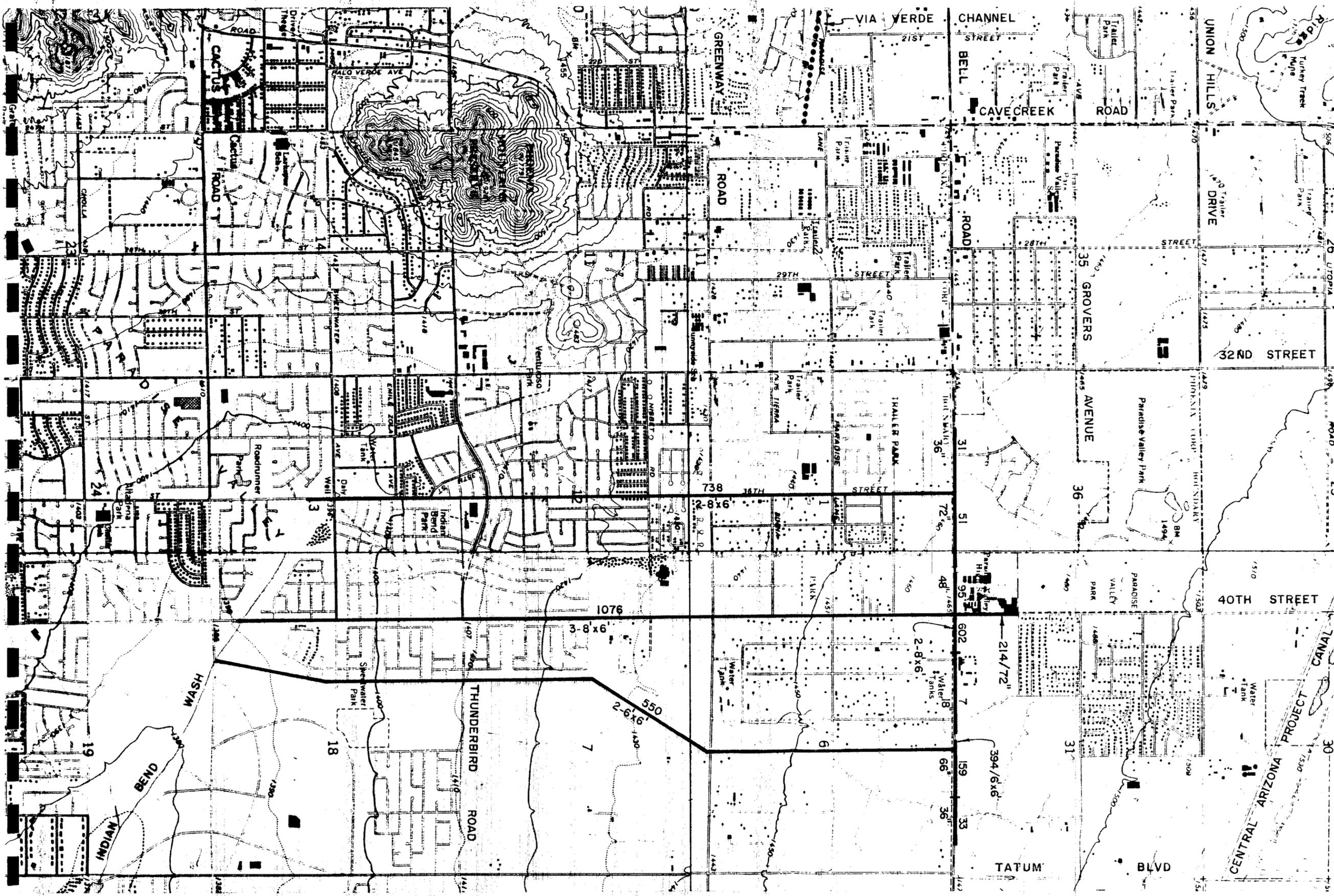
Alternative 3: Alternative 3 is similar to Alternative 2 with the addition of detention facilities north of Grovers Avenue on the 38th Street alignment (Paradise Valley Park) and on the southwest corner

of Tatum Boulevard and Bell Road. Detention would reduce the peak discharge at the 36th Street system from 740 cfs to 419 cfs. The 56th Street system was replaced with a system along 52nd Street to avoid crossing into the Town of Paradise Valley. Detention would reduce the peak discharge at the Tatum Boulevard system from 531 cfs to 140 cfs. The detention basin on the 38th Street alignment will discharge directly into the existing natural drainageway that will then be intercepted at 36th Street and Bell Road as described in Alternative 1. The basin on Tatum Boulevard will discharge directly into the proposed Tatum Boulevard storm drain.

Refer to Plates 27 and 28 for schematics of the drainage facilities proposed for Alternative 3.

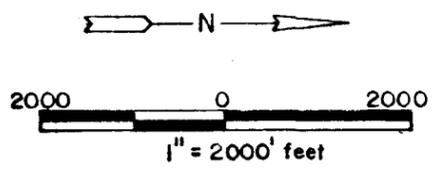
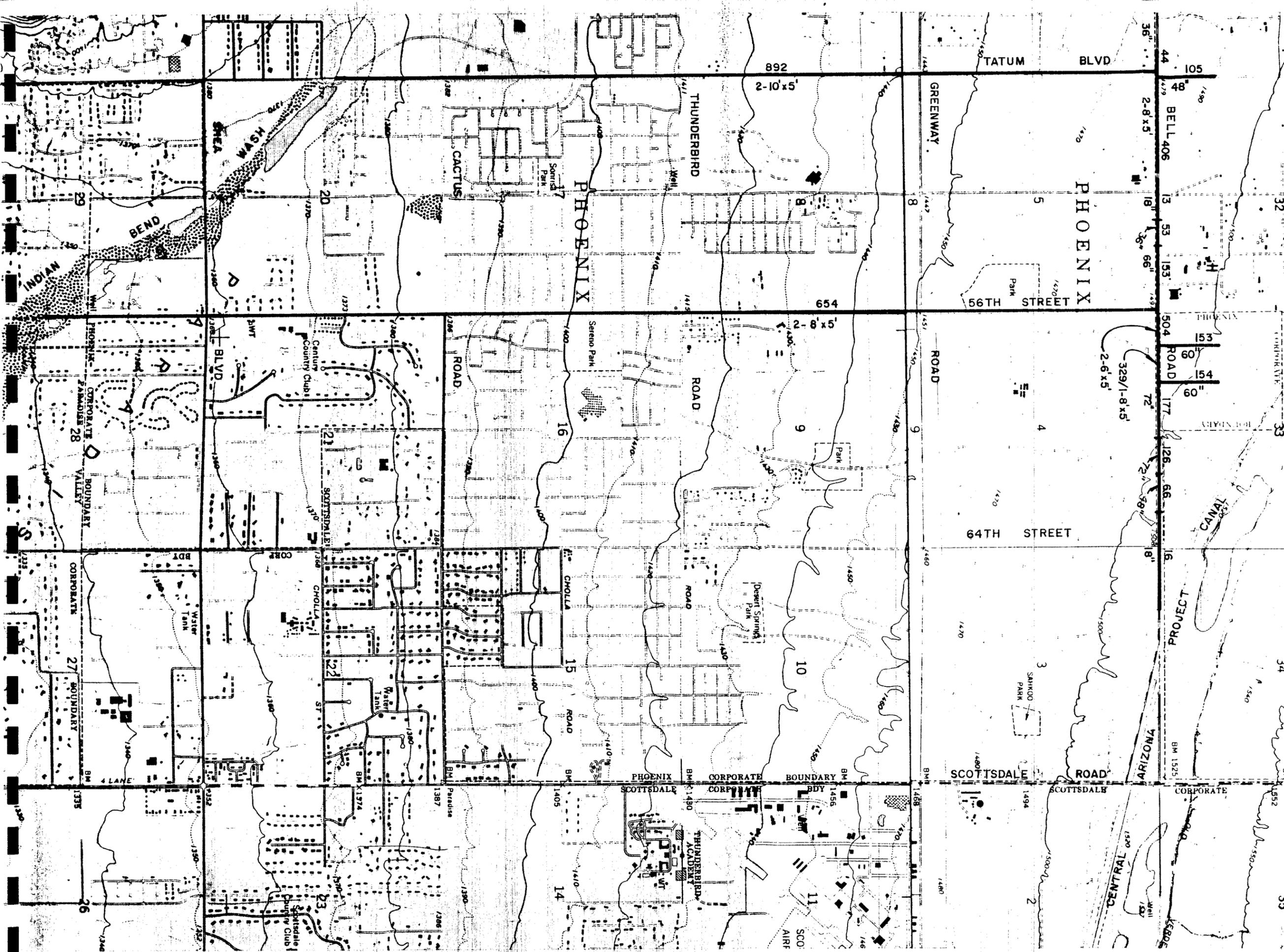
On-Site Runoff: On-site runoff from the Bell Road right-of-way in Drainage Area 8 (32nd Street to Scottsdale Road) will be collected by storm drain pipe and discharged either into the off-site storm drain trunk system (Alternative 1) or the open channels (Alternatives 2 and 3).

Refer to Plates 23 through 28 for schematics of the on-site drainage system for Drainage Area 8.



- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8x3' STRUCTURE SIZE
 - 72" FOR CONDUITS
- OPEN CHANNELS**
- [TW=60'] TOP WIDTH
- [D = 5'] DEPTH

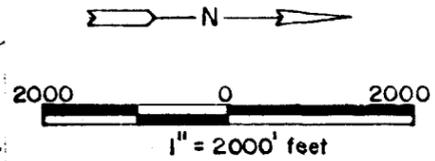
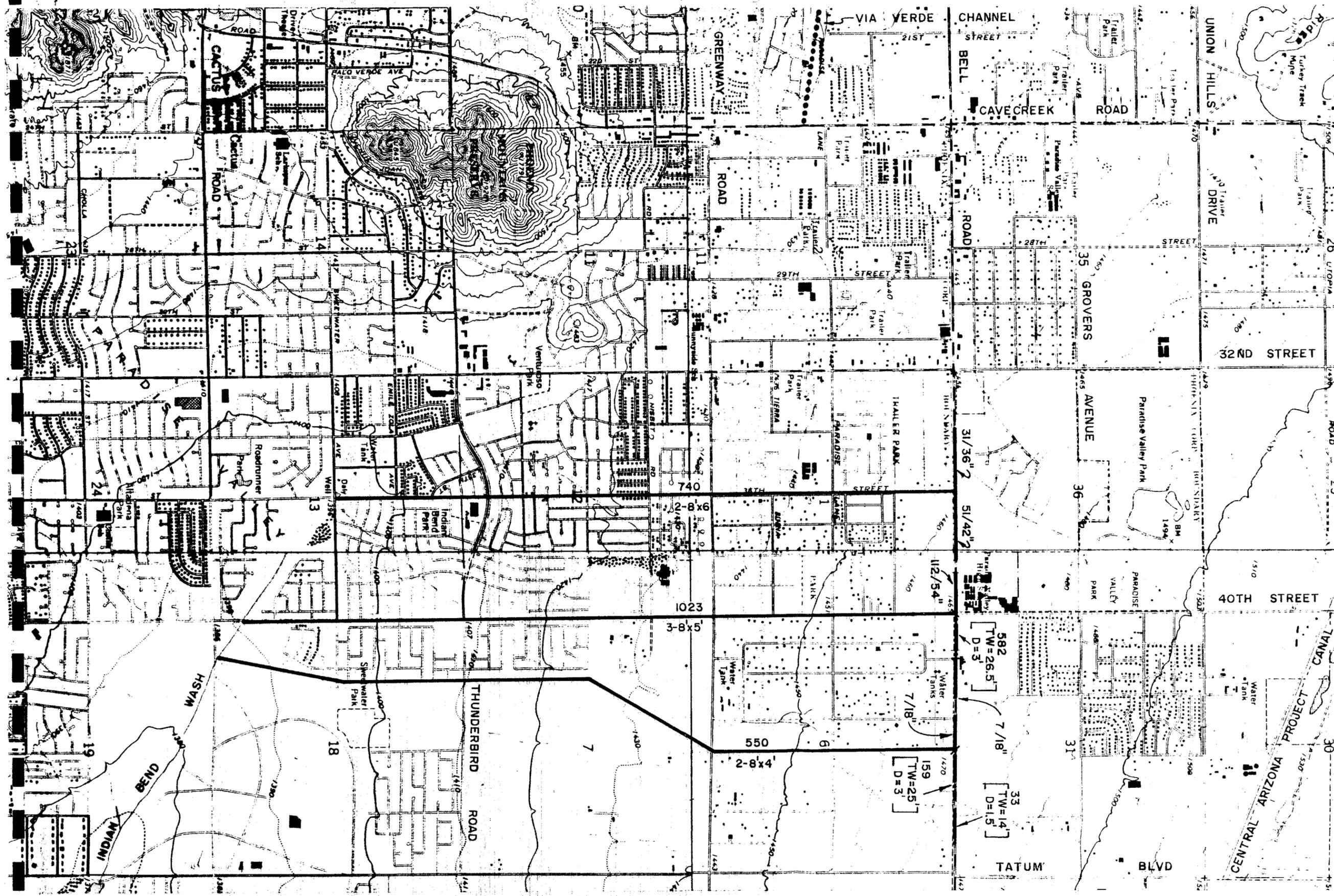
100 YEAR FREQUENCY STORM
 PLATE 23
 ALTERNATE 1
 DRAINAGE AREA 8 (1 OF 2)
 BELL ROAD PROJECT
 DRAINAGE STUDY



- LEGEND**
- CONDUIT
 - OPEN CHANNEL
 - DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS
- OPEN CHANNELS**
- [TW=60'] TOP WIDTH
[D = 5'] DEPTH

100 YEAR FREQUENCY STORM
PLATE 24
 ALTERNATE 1
 DRAINAGE AREA 8 (2 OF 2)
 BELL ROAD PROJECT
 DRAINAGE STUDY

**Greiner
 Engineering**



- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - ▨ DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8x3' STRUCTURE SIZE
 - 72" FOR CONDUITS
- OPEN CHANNELS**
- [TW=60'] TOP WIDTH
D = 5' DEPTH

100 YEAR FREQUENCY STORM

PLATE 25

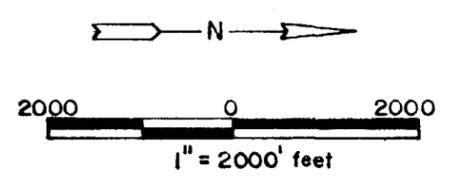
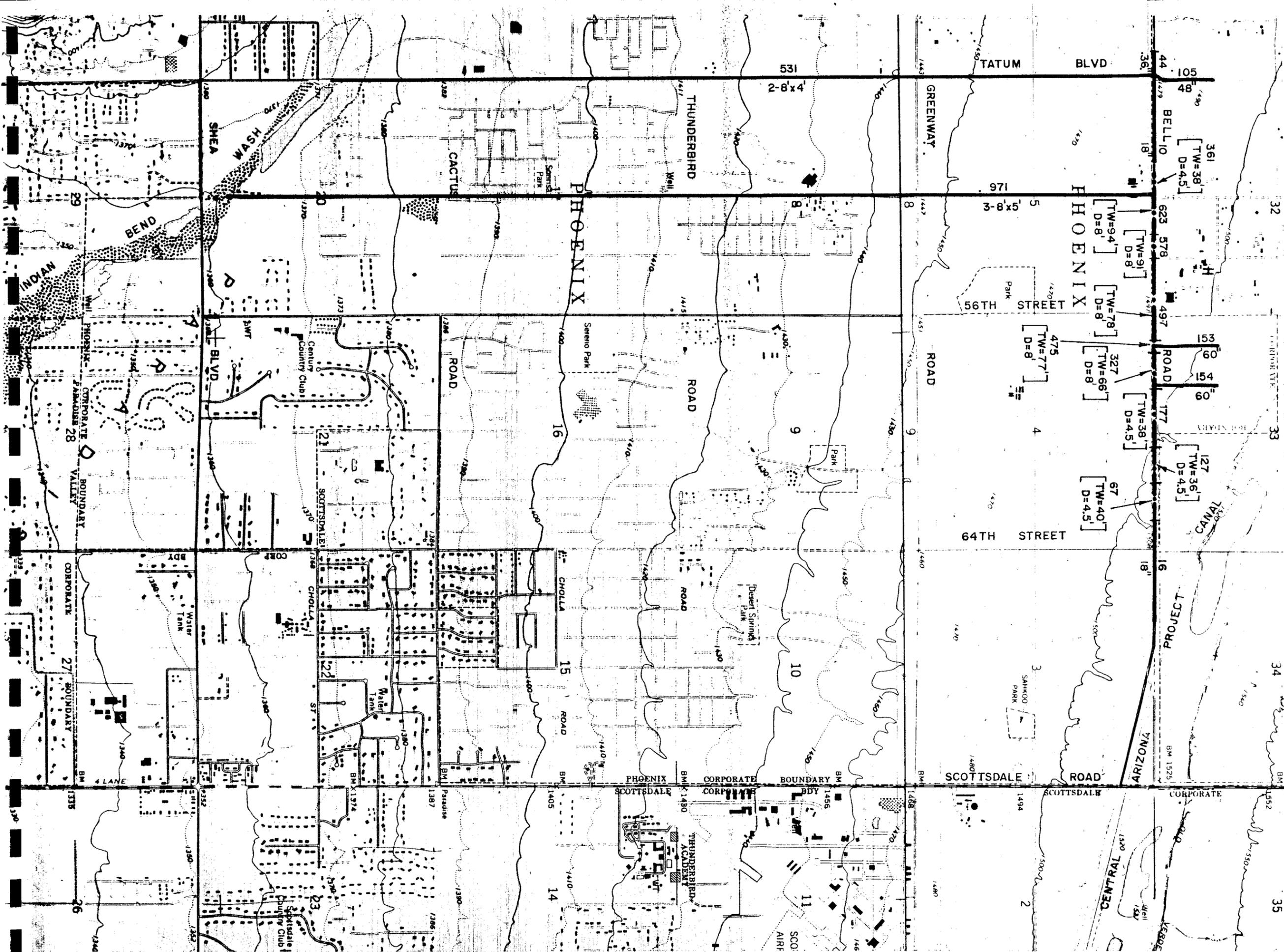
ALTERNATE 2

DRAINAGE AREA 8 (1 OF 2)

BELL ROAD PROJECT

DRAINAGE STUDY

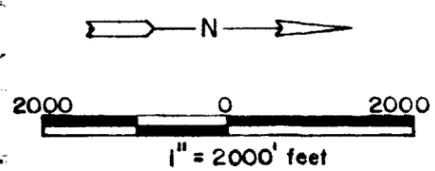
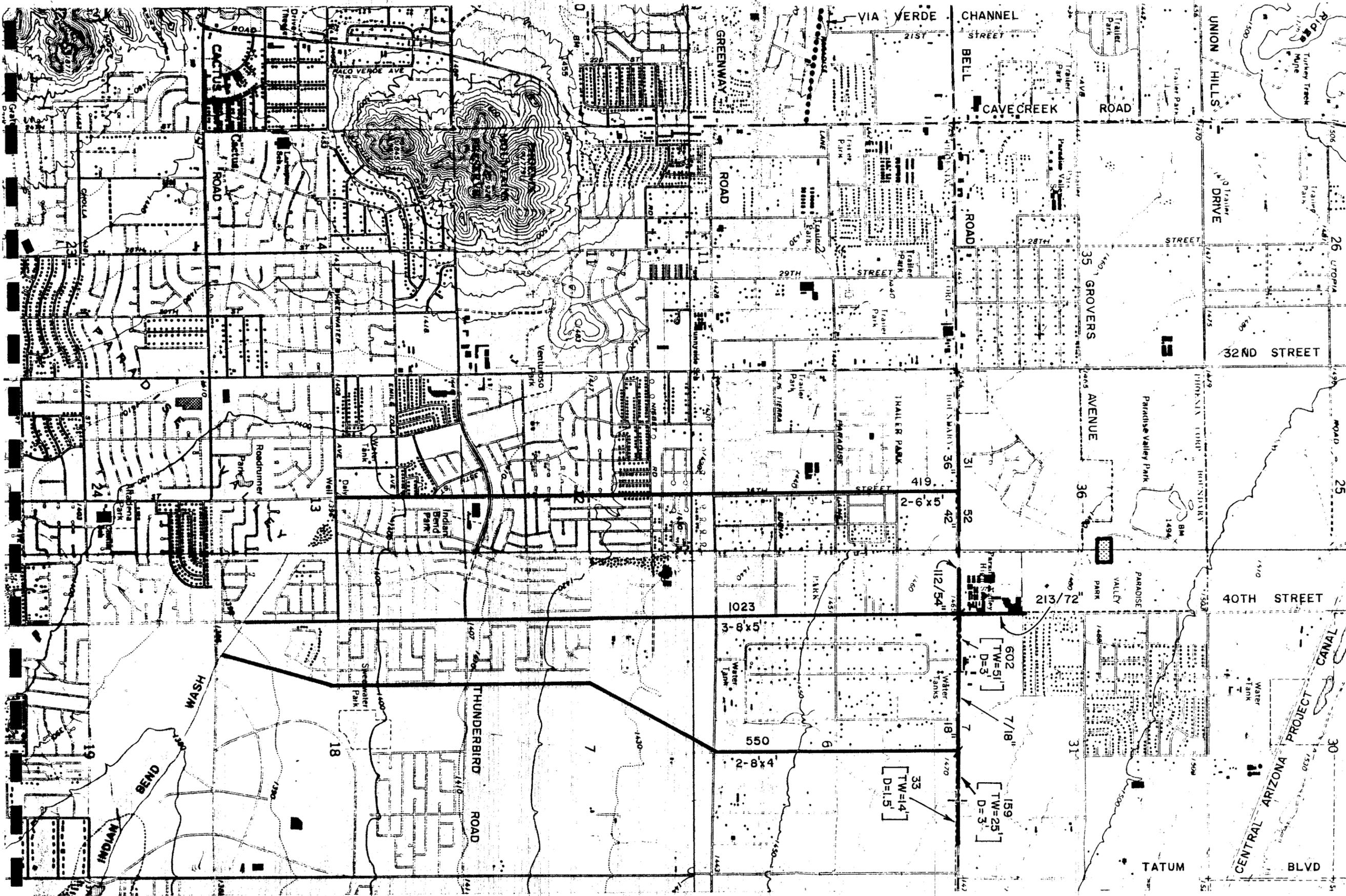
**Greiner
Engineering**



- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8x3' STRUCTURE SIZE
 - 72" FOR CONDUITS
- OPEN CHANNELS**
- TW=60' TOP WIDTH
D = 5' DEPTH

100 YEAR FREQUENCY STORM
PLATE 26
 ALTERNATE 2
 DRAINAGE AREA 8 (2 OF 2)
 BELL ROAD PROJECT
 DRAINAGE STUDY

**Greiner
 Engineering**

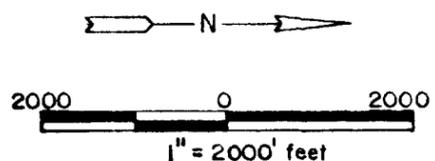
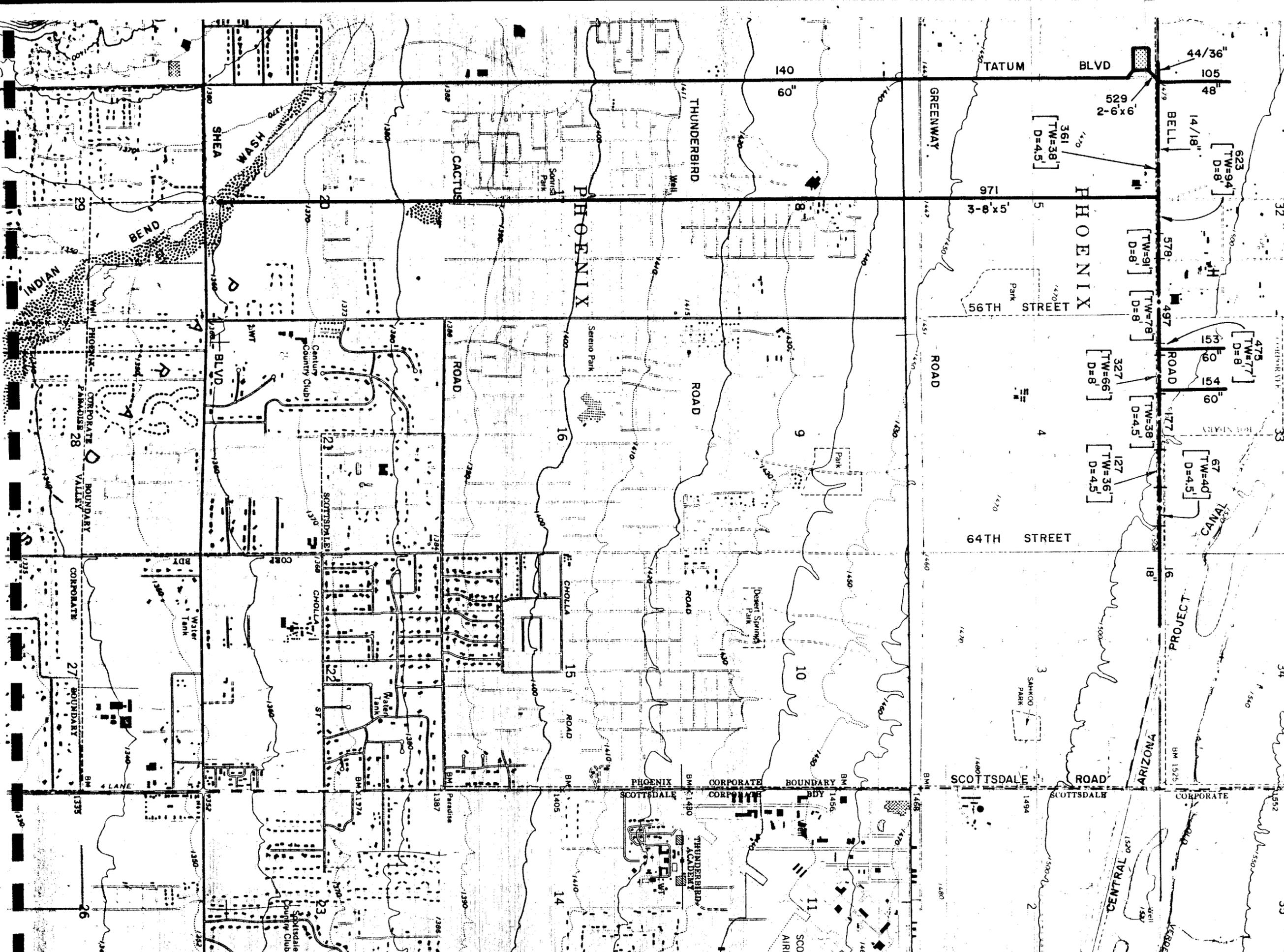


- LEGEND**
- CONDUIT
 - OPEN CHANNEL
 - DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS

OPEN CHANNELS

[TW=60'] TOP WIDTH
 [D=5'] DEPTH

100 YEAR FREQUENCY STORI
 PLATE 27
 ALTERNATE 3
 DRAINAGE AREA 8 (1 OF 2)
 BELL ROAD PROJECT
 DRAINAGE STUDY



- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS
- OPEN CHANNELS**
- [TW=60'] TOP WIDTH
[D = 5'] DEPTH

100 YEAR FREQUENCY STORM
PLATE 28
 ALTERNATE 3
 DRAINAGE AREA 8 (2 OF 2)
 BELL ROAD PROJECT
 DRAINAGE STUDY

Drainage Area 9: Drainage Area 9 is the Skunk Creek channel and floodplain. It was determined from the most current flood boundary maps, dated 1983, that the 100-year flood is contained within Skunk Creek at Bell Road.

On-Site Runoff: On-site runoff will be conveyed from 73rd Avenue to Skunk Creek via a 24 inch storm drain. If either Alternatives 2 or 3 are implemented for Drainage Area 4 the on-site runoff within Drainage Area 9 will be conveyed in the off-site drainage system for Drainage Area 4. Refer to Plates 12 through 17.

Drainage Area 10: Drainage Area 10 is the Cave Creek channel and floodplain. According to the floodplain maps, dated April 25, 1978, the floodplain is approximately 900 feet wide at Bell Road. The existing structure at Bell Road and Cave Creek is inadequate to protect Bell Road from the 100-year flood. A 900 foot long bridge was evaluated to span the floodplain (see Plate 21).

New River and Agua Fria River: It was determined from current flood boundary maps that the 100-year floods on the New River and the Agua fria river will be conveyed under Bell Road within the existing bridges.

IX. EVALUATION OF ALTERNATE STORMWATER/FLOODWATER MANAGEMENT CONCEPTS PLANS, 100-YEAR STORM EVENT

The alternative concept plans were evaluated and ranked in terms of capital costs, effectiveness, environmental impacts, potential for staged construction, acceptability to municipalities and compatibility with other projects and plans. Matrix tables with numerical ranking from one to ten were developed for comparison of the alternative concepts for each drainage area. These tables are found on pages 85 through 90.

A. Capital Costs

Costs for all alternative concept plans were developed for construction, engineering, administration and land acquisition. Construction costs for the on-site and off-site drainage systems included the costs for storm drain trunkline conduit (concrete pipe or box culvert) and excavation (channels and detention basins). Unit costs for concrete pipe, box culverts and excavation were derived from unit costs recently developed for preliminary cost estimates for the Outer Loop Highway. The unit costs for conduit include the cost of installation. All costs are in 1986 dollars.

Thirty percent was added to the estimated construction costs for the on-site and off-site drainage facilities. These include costs associated with appurtenances to the trunk system such as minor utility relocation and conflict resolutions, cost of outlet or inlet works, junction structures, manholes, laterals, catch basins, erosion protection, bank stabilization, minor street reconstruction, etc. This cost was estimated on the basis of recently completed roadway drainage and flood control design projects.

Twenty percent of the estimated construction costs was added for engineering and administration to cover the costs for survey, design, contract administration, field engineering and inspection services. This fee was added to the construction cost.

Land acquisition costs for additional right-of-way for open channels and detention basins were based on per acre values derived from either current County Assessors records and/or information recently developed by the City of Glendale for the "Glendale Storm Water Management Plan."

A factor of twenty percent was then added for contingency costs to reflect the effects of unknown potential difficulties or changes during final design and construction. Estimated costs did not include the following:

- o Major utility relocation
- o Pumping stations
- o Major street reconstruction
- o Landscaping and maintenance

A rank of ten was given to the most cost effective alternative for each drainage area. Rankings for the other alternatives within each drainage area were based on their cost ratio to the most cost effective alternative. The costs for each alternative concept plan for each of the drainage areas are summarized in the following pages.

TABLE 1
ESTIMATED COSTS
DRAINAGE AREA 1
100-YEAR FREQUENCY STORM

	<u>Alt. 1</u>
On-Site Drainage Facilities	\$ 680,000
Off-Site Drainage Facilities	40,000
30% Appurtenances	220,000
20% Engineering & Administration	190,000
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Sub-Total	\$1,130,000
Land Acquisition	Ø
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Sub-Total	\$1,130,000
20% Contingency	230,000
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Total Estimated Cost	\$1,360,000

TABLE 2
ESTIMATED COSTS
DRAINAGE AREA 2
100-YEAR FREQUENCY STORM

	<u>Alt. 1</u>	<u>Alt. 2</u>	<u>Alt. 3</u>	<u>Alt. 4</u>	<u>Alt. 5</u>	<u>Alt. 6</u>	<u>Alt. 7</u>
On-Site Drainage Facilities	\$ 910,000	\$ 910,000	\$ 910,000	\$ 910,000	\$ 910,000	\$ 910,000	\$ 910,000
Off-Site Drainage Facilities	20,240,000	14,800,000	11,980,000	22,100,000	13,020,000	20,380,000	12,470,000
30% Appurtenances	6,350,000	4,710,000	3,870,000	6,900,000	4,180,000	6,390,000	4,010,000
20% Engineering & Administration	5,500,000	4,080,000	3,350,000	5,980,000	3,620,000	5,540,000	3,480,000
Sub-Total	\$33,000,000	\$24,500,000	\$20,110,000	\$35,890,000	\$21,730,000	\$33,220,000	\$20,870,000
Land Acquisition	4,910,000	5,090,000	6,610,000	3,210,000	4,190,000	3,210,000	4,190,000
Sub-Total	\$37,910,000	\$29,590,000	\$26,720,000	\$39,100,000	\$25,920,000	\$36,430,000	\$25,060,000
20% Contingency	7,580,000	5,920,000	5,340,000	7,820,000	5,180,000	7,290,000	5,010,000
Total Estimated Cost	\$45,490,000	\$35,510,000	\$32,060,000	\$46,920,000	\$31,100,000	\$43,720,000	\$30,070,000

TABLE 3
ESTIMATED COSTS
DRAINAGE AREA 3

100-YEAR FREQUENCY STORM

	<u>Alt. 1</u>	<u>Alt. 2</u>	<u>Alt.3</u>
On-Site Drainage Facilities	*	*	*
Off-Site Drainage Facilities	\$1,140,000	\$1,790,000	\$1,840,000
30% Appurtenances	340,000	540,000	550,000
20% Engineering & Administration	300,000	470,000	480,000
Sub-Total	\$1,780,000	\$2,800,000	\$2,870,000
Land Acquisition	2,170,000	1,580,000	1,500,000
Sub-Total	\$3,950,000	\$4,380,000	\$4,370,000
20% Contingency	790,000	880,000	870,000
Total Estimated Cost	\$4,740,000	\$5,260,000	\$5,240,000

*On-site drainage is conveyed by the off-site facilities.

TABLE 4
ESTIMATED COSTS
DRAINAGE AREA 4
100-YEAR FREQUENCY STORM

	<u>Alt. 1</u>	<u>Alt. 2</u>	<u>Alt. 3</u>
On-Site Drainage Facilities	\$ 80,000*	**	**
Off-Site Drainage Facilities	75,960,000	\$ 73,440,000	\$ 65,120,000
30% Appurtenances	22,810,000	22,030,000	19,540,000
20% Engineering & Administration	19,770,000	19,090,000	16,930,000
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Sub-Total	\$118,620,000	\$114,560,000	\$101,590,000
Land Acquisition	Ø	Ø	Ø
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Sub-Total	\$118,620,000	\$114,560,000	\$101,590,000
20% Contingency	23,720,000	22,910,000	20,320,000
<hr/>			
Total Estimated Cost	\$142,340,000	\$137,470,000	\$121,910,000

*On-site drainage from Drainage Area 9 conveyed to Skunk Creek.

**On-site drainage is conveyed by the off-site facilities.

TABLE 5
ESTIMATED COSTS
DRAINAGE AREA 5
100-YEAR FREQUENCY STORM

	<u>Alt. 1</u>	<u>Alt. 2</u>
On-Site Drainage Facilities	*	*
Off-Site Drainage Facilities	\$16,860,000	\$16,450,000
30% Appurtenances	5,060,000	4,940,000
20% Engineering & Administration	4,380,000	4,280,000
<hr/>		
Sub-Total	\$26,300,000	\$25,670,000
Land Acquisition	Ø	Ø
<hr/>		
Sub-Total	\$26,300,000	\$25,670,000
20% Contingency	5,260,000	5,130,000
<hr/>		
Total Estimated Cost	\$31,560,000	\$30,800,000

*On-site drainage is conveyed by the off-site facilities.

TABLE 6
ESTIMATED COSTS
DRAINAGE AREA 6*
100-YEAR FREQUENCY STORM

	<u>Alt. 1</u>
On-Site Drainage Facilities	**
Off-Site Drainage Facilities	\$10,380,000
30% Appurtenances	3,110,000
20% Engineering & Administration	2,700,000
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Sub-Total	\$16,190,000
Land Acquisition	3,520,000
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Sub-Total	\$19,710,000
20% Contingency	3,940,000
<hr/>	
Total Estimated Cost	\$23,650,000

*Includes cost of facilities proposed by NBS/Lowry.

**On-site drainage is conveyed by the off-site facilities.

TABLE 7
 ESTIMATED COSTS
DRAINAGE AREA 7*
 100-YEAR FREQUENCY STORM

	<u>Alt. 1</u>
On-Site Drainage Facilities	**
Off-Site Drainage Facilities	\$ 9,390,000
30% Appurtenances	2,820,000
20% Engineering & Administration	2,440,000
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Sub-Total	\$14,650,000
Land Acquisition	3,760,000
<hr/>	
Sub-Total	\$18,410,000
20% Contingency	3,680,000
<hr/>	
Total Estimated Cost	\$22,090,000

*Includes cost of facilities proposed by NBS/Lowry.

**On-site drainage is conveyed by the off-site facilities.

TABLE 8
ESTIMATED COSTS
DRAINAGE AREA 8
100-YEAR FREQUENCY STORM

	<u>Alt. 1</u>	<u>Alt. 2</u>	<u>Alt. 3</u>
On-Site Drainage Facilities	\$ 260,000	\$ 270,000	\$ 270,000
Off-Site Drainage Facilities	44,880,000	42,500,000	38,090,000
30% Appurtenances	13,540,000	12,830,000	11,510,000
20% Engineering & Administration	11,740,000	11,120,000	9,970,000
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Sub-Total	\$70,420,000	\$66,720,000	\$59,840,000
Land Acquisition	Ø	1,370,000	2,600,000
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Sub-Total	\$70,420,000	\$68,090,000	\$62,440,000
20% Contingency	14,080,000	13,620,000	12,490,000
<hr/>			
Total Estimated Cost	\$84,500,000	\$81,710,000	\$74,930,000

TABLE 9

ESTIMATED COSTS

DRAINAGE AREA 10 (CAVE CREEK BRIDGE)

100-YEAR FREQUENCY STORM

900 L.F. New Bridge	\$3,810,000
Spur Dikes and Appurtenances	1,140,000
20% Engineering & Administration	990,000
<hr/>	
Sub-Total	\$5,940,000
20% Contingency	1,190,000
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Total Estimated Cost	\$7,130,000

B. Effectiveness

Effectiveness is defined as the ability of the alternative concepts to meet the objective of the Bell Road Project Drainage Study. The objective of the alternative plans is to allow travel on four lanes of Bell Road during the 100-year storm event, while ensuring that upstream and downstream conditions will not be worsened in the 100-year storm event. To achieve this, all alternative concept plans were developed for the 100-year storm event. Therefore, all alternatives meet the effectiveness criteria and received a ranked value of ten.

C. Environmental Impacts

An environmental assessment was conducted for each alternative design concept to determine what impacts might occur. A detailed field reconnaissance was performed in each of the drainage areas for each alternative design concept for the study area. The environmental impacts assessed included socio/economic, natural resources, cultural resources and farmlands.

As part of the environmental evaluation, the appropriate agencies were informed of the objectives of the study and comments concerning the study solicited. The following agencies were contacted:

Arizona Commission of Agriculture and Horticulture
Arizona Department of Health Services Bureau of Water Quality
Arizona Game and Fish Department
ADOT Environment Planning
Arizona State Parks Department
ADOT Roadside Development Services
State Historic Preservation Society
Maricopa County Parks Department
Arizona State Museum--Historic and Archaeologic Division
Pueblo Grande Museum
United States Army Corps of Engineers

All pertinent environmental regulations were obtained from each agency and any particular concern was noted. Refer to References, Section XIII, for documents obtained from these agencies.

Rankings of zero to ten were used in the evaluation of each alternative, with zero representing severe long-term environmental impacts and ten representing minimal, short-term impacts.

All proposed concepts will impact the surrounding areas during construction, but with appropriate construction techniques, these impacts can be minimized. Long term impacts will occur only when additional right-of-way is required. Generally, if facilities are constructed within the existing right-of-way, no significant long term impacts occur unless otherwise noted in the following analysis.

Drainage Area 1: Existing drainage facilities will be upgraded, therefore, no significant impacts will occur other than temporary construction impacts.

Drainage Area 2: The seven alternative concepts were proposed in areas which have either undergone development or are zoned for development. There are viable citrus groves between Deer Valley Road and Beardsley Road and Bell Road and Greenway Road, but these areas are zoned for future development. However, the assessment was performed for existing conditions.

Alternative 1: The open channel extending north of Beardsley Road approximately one-half mile along the 87th Avenue alignment will impact existing farmland through either right-of-way acquisitions or disruptions of irrigation and maintenance facilities.

Right-of-way is required for the open channel on the north side of Bell Road from 87th Avenue to the New River. This area is improved

with paving and parking. Acquisition of right-of-way and construction of the channel will impact local business through loss of parking space or disruption of access during construction.

Alternative 2: The same impacts as in Alternative 1 would occur. The use of detention basins to downsize downstream facilities may lessen the severity of some of the temporary construction impacts to 91st Avenue south of Beardsley Road. However, the withdrawal of this land for use as a detention basin may result in economic losses to future development.

Alternative 3: The same impacts as for Alternative 2.

Alternative 4: Impacts to the existing farmland north of Beardsley Road would occur as described in Alternative 1.

Alternative 5: The locating of detention basins on prime development property may have an adverse economic impact. There will be impacts to the farmland north of Beardsley Road as previously described in Alternative 1.

Alternative 6: There will be impacts only to active farmland north of Beardsley Road as previously described in ~~Alternative 1~~.

Alternative 7: Locating detention basins on prime development property may have an adverse economic impact. There would be impacts to the farmland north of Beardsley Road as previously described in Alternative 1.

Drainage Area 3: This drainage area is in transition. Currently this area consists of citrus groves which are being developed. Proposed facilities built within the existing right-of-way will not impact the area other than during construction.

Alternative 1: Disruption of access may occur during construction to the residential areas on the east side of 75th Avenue between Bell Road and Grovers Avenue.

The church on the east side of 75th Avenue north of Bell Road may be impacted by noise during construction.

The proposed channel located along the north side of Bell Road between 83rd Avenue and 77th Avenue will not significantly impact existing citrus groves, but additional right-of-way will be required. The loss of developable land due to right-of-way acquisition may have an adverse economic impact on future development.

The open channel located along 75th Avenue south of Bell Road will require additional right-of-way. This is vacant flood prone land and no impacts other than construction impacts will occur.

Alternative 2: Environmental impacts will be similar to those for Alternative 1 except that the channel along Bell Road will be replaced by a storm drain. However, the loss of developable land for use as detention basins will have an economic impact on development potential.

Alternative 3: Same potential impacts as in Alternative 2.

Drainage Area 4: Major developments from 67th Avenue to 59th Avenue may be affected by noise, dust and limited access to business and residential areas during construction.

The churches on the east side of 51st Avenue and on 43rd Avenue, one-quarter mile south of Bell Road, may be impacted by noise during construction.

On 43rd Avenue north of Bell Road, access to the pedestrian walkway on the east side will be disrupted during construction.

The park at 35th Avenue and Beverly Street may be impacted if construction is not maintained within the existing right-of-way.

On the east side of 35th Avenue north of Bell Road, access to the sidewalks may be limited during construction.

Drainage Area 5: This area is densely populated and there is a high concentration of commercial development. Substantial impacts to access will occur during construction but only of a temporary nature.

Alternative 1: This alternative will have no significant impacts to the area adjacent to the proposed facilities.

Alternative 2: On 15th Avenue from Bell Road to Grovers Avenue, there is minimal right-of-way and the residences are very close to the street. Maintaining access during construction may be difficult.

Drainage Area 6: Environmental impacts were evaluated only for the drainage facilities proposed by Greiner at Central Avenue and 16th Street. Per guidance from the FCD, the facilities proposed by NBS/Lowry were not evaluated for environmental impacts.

There is an existing archaeological site which surrounds the intersection of Central Avenue and Bell Road. The Pueblo Grande Museum staff verified that this site is Hohokam culture from the late sedentary through classic period (A.D. 1050-1400). This is an extensive shard (pottery) area. Numerous lava boulder concentrations were noted which suggest possible structures. Monitoring will probably be required during construction.

On 16th Street north and south of Bell Road, there will be no impacts if the facilities are constructed within the existing right-of-way.

Drainage Area 7: Per guidance from the FCD, the facilities proposed by NBS/Lowry were not evaluated for environmental impacts.

Drainage Area 8: For all alternatives, the drainage facilities that were proposed south of Bell Road will not cause any significant long term impacts if they are constructed within the existing rights-of-way.

Alternative 1: The Humana Hospital at 40th Street and Bell Road may be impacted by dirt and noise during construction.

Indian Bend Elementary School at 36th Street and Thunderbird Road may be impacted by dirt and noise during construction.

Alternative 2: In addition to impacts similar to those in Alternative 1, construction of the open channel along Bell Road in the vicinity of 40th Street will require destruction or relocation of native plants, particularly desert broom. The open channel may also pose a hazard to students from Paradise Valley High School.

The construction of the open channel along Bell Road in the vicinity of Tatum Boulevard may destroy native plants in some areas. Right-of-way acquisition may impact Arabian horse ranches through loss of pasture or potentially developable land.

The parcel proposed for a detention basin at the southwest corner of Tatum Boulevard and Bell Road may be subject to development. The proposed detention basin could have an adverse economic impact on this development.

The church on the east side of Tatum Boulevard, north of Paradise Valley Lane, may be affected by noise during construction.

Two hawks were noted in the area along Bell Road between 43rd Street and Tatum Boulevard. The Bell Road improvements may disturb their habitat or nesting site.

Alternative 3: Impacts are similar to those in Alternative 2.

Drainage Area 9: No plans.

Drainage Area 10: The construction of the proposed bridge will impact native vegetation (paloverde and desert broom).

D. Potential for Staged Construction

The potential for staged construction is a measure of plan flexibility for implementation or modification in response to different urbanization patterns from those assumed in this study. The analysis pertains to the ability of the plan's response to the needs of local jurisdictions in meeting their construction goals for roadway improvement along Bell Road. The lower the ranking the more difficulties are anticipated with staged construction.

Drainage Area 1: Installation of the proposed culverts could be undertaken either as part of the Bell Road improvement project or the Grand Avenue Expressway project.

Drainage Area 2: The implementation of all alternatives may be staged from downstream to upstream to meet both the Bell Road improvement schedule and the trend of urbanization north of Bell Road. As development plans are proposed for the undeveloped land north of Bell Road, the location and geometry of the proposed detention facilities may be changed and incorporated into the development plans. The open channels proposed may be an interim measure only. As the area develops, open channels may be replaced by underground conduits or incorporated into the site development scheme.

Drainage Area 3: The location of proposed channels, storm drains or runoff interception points may be changed to accommodate the development of the currently abandoned citrus orchard located north of Bell Road and west of 75th Avenue. The facilities along Bell Road may be staged to accommodate the construction schedule of the Outer Loop Highway and the realignment of 83rd Avenue.

Drainage Area 4: The proposed storm drain systems for Alternatives 1 and 2 have the greatest flexibility for staged construction. The trunk system of each mile street is independent, and each may be constructed to meet the Bell Road construction schedule established by either the City of Glendale or the City of Phoenix. Alternative 3 has only one discharge outlet for all runoff collected west of 35th Avenue. The system could, therefore, only be constructed from downstream to upstream regardless of drainage priorities further east. The proposed system for Alternative 3 from 35th Avenue to Skunk Creek crosses the jurisdictional boundary line between the City of Phoenix and the City of Glendale. Planning, design, capital expenditure and construction scheduling will have to be coordinated with both cities. The construction of all alternatives will have to be phased with the construction schedule of the ACDC.

Drainage Area 5: Construction of the facilities west of 19th Avenue will have to be coordinated with proposed improvements to the I-17 drainage facilities and construction of the storm drain on 35th Avenue (Drainage Area 4). The facilities west of I-17 will have to be constructed prior to construction of the system between 19th Avenue and I-17.

Drainage Areas 6 and 7: Coordination will be required between the Bell Road Project, the Upper East Fork of the Cave Creek flood control project and the Via Verde channel project. Flexibility in staging will be limited for any given element of the Bell Road project.

Drainage Area 8: The north-south mile street drainage systems proposed in Drainage Area 8 are independent and may be implemented in stages as desired by the affected jurisdictions. The storm drain along 56th Street in Alternative 1, however, outfalls into Indian Bend Wash within Paradise Valley. This will require inter city coordination and agreement.

Until the final alignment of the Squaw Peak Parkway has been selected it is not possible to determine the impacts on scheduling and phasing for the Bell Road project.

Drainage Area 9 (Skunk Creek): No plans.

Drainage Area 10: The proposed bridge at Cave Creek may be constructed independently of the drainage alternatives for Bell Road.

E. Acceptability to Municipalities

Acceptability to municipalities has been defined for the purpose of this study as the compatibility of drainage design criteria utilized in the Bell Road study to current drainage design criteria applied by the affected jurisdiction. Overall, the proposed alternative concepts conform to current design standards for the Town of Surprise, the Cities of Peoria, Glendale and Phoenix and Maricopa County. In general, storm drains are preferred to open channels for reasons of right-of-way impacts, safety, aesthetics and maintenance. Therefore, alternatives with open channels are not as acceptable as those with only storm drains. However, earthen channels are preferred to concrete-lined channels. Detention basins excavated to a depth of ten feet may also be unacceptable to some jurisdictions which normally may allow basin with depths ranging from three to four feet.

A rank of ten was given if the alternative meets all current design criteria. Lesser rankings were given if non-standard features have been included.

F. Compatibility with Other Projects and Plans

The compatibility of the proposed alternative concept plans with other projects and plans including existing and proposed drainage and flood control projects, existing roadways, utilities and bike paths were evaluated. Higher rankings were given if utility conflicts and street reconstruction were minor in comparison with other alternatives, or if the alternative is similar in layout to current drainage master plans.

Drainage Area 1: The proposed culverts are compatible with the proposed Grand Avenue Expressway plans.

Drainage Area 2:

Alternative 1: Conflicts will occur between the proposed storm drain and utilities at Bell Road and 91st Avenue. Existing utilities at this location include a 12 inch water line, 15 inch and 27 inch sanitary sewer lines and an underground electrical line.

Alternative 2: The same potential for conflicts between the proposed storm drain and utilities at Bell Road and 91st Avenue may occur as in alternative 1. The reduction in storm drain size, however, may reduce the potential for disruption of the utilities.

Alternative 2 is the most similar to the current City of Peoria Master Plan for Storm Drainage.

Alternative 3: The potential for utility conflicts may be further limited by the use of two detention basins to reduce the size of downstream storm drains.

Alternative 4: By using parallel systems, the potential for utility conflicts at Bell Road and 91st Avenue is decreased due to the

downsized structure required at that location. The storm drain along Bell Road from 87th Avenue to the New River, however, may conflict with underground electrical lines. The 87th Avenue storm drain is not compatible with the City of Peoria Master Plan for Storm Drainage and may not be compatible with future development of the area.

Alternative 5: Impacts on utilities at Bell Road and 91st Avenue may be further reduced by use of upstream detention to reduce storm drain sizes. The 87th Avenue storm drain is not compatible with the City of Peoria Master Plan for Storm Drainage and may not be compatible with future development of the area.

Alternative 6: The potential for utility conflicts along Bell Road between 87th Avenue and the New River was eliminated by diverting the storm drain to the New River at Union Hills Drive. The 87th Avenue storm drain is also not compatible with the City of Peoria Master Storm Drainage plan and may not be compatible with future development of the area.

Alternative 7: Alternative 7 has the same potential for impacts at Bell Road and 91st Avenue as in Alternative 5. The 87th Avenue storm drain is not compatible with the City of Peoria Master Plan for Storm Drainage and may not be compatible with future development of the area.

Drainage Area 3:

Alternative 1: Potential utility conflicts may occur between the proposed open channel along Bell Road and a 69 KV overhead electrical distribution line and an underground electrical line.

The open channel will be compatible with the proposed culverts under the realigned 83rd Avenue and the Outer Loop Highway.

Alternative 2: The potential for conflict with the electrical lines along Bell Road has been eliminated by the use of storm drains rather than open channels. The storm drain along Bell Road will bypass the culverts proposed for off-site drainage concentrating at Bell Road and the Outer Loop Highway. This alternative is, therefore, not compatible with the Outer Loop Highway plans for off-site drainage.

Alternative 3: Alternative 3 has the same potential for utility conflicts as with Alternative 2. It will also be incompatible with off-site drainage plans for the Outer Loop Highway.

Drainage Area 4: For all alternatives, the proposed box culvert from I-17 to 35th Avenue along Bell Road may conflict with utilities including a 12-inch water line, a 12 inch sanitary sewer line, a gas line and electrical lines.

Alternative 1: The proposed storm drain along 35th Avenue between Bell Road and the ACDC may conflict with a 12 inch water line and a 12-inch sewer line. The proposed culverts along 43rd Avenue and 51st Avenue from Bell Road to the ACDC may conflict with water lines, sanitary sewer lines and gas lines. The implementation of the plan for 51st Avenue will require reconstruction of the outlet to the ACDC which was sized for the 2-year storm discharge only.

Alternative 1 will require construction on approximately 20.5 miles of street. Alternative 1 is similar in layout to the current City of Phoenix and City of Glendale stormwater management plans.

Alternative 2: The proposed storm drain along 35th Avenue between Bell Road and the ACDC may conflict with a 12 inch water line and a 12 inch sewer line. The proposed culverts along 43rd Avenue and 51st Avenue from Bell Road to the ACDC may conflict with a water

line, a sanitary sewer line and a gas line. The storm drain outlet at 51st Avenue and the ACDC will have to be reconstructed as described for Alternative 1.

Alternative 3: The proposed storm drain along Bell Road may conflict with utilities crossing Bell Road at 43rd, 51st, 55th and 59th Avenues.

Alternative 3 is the least compatible with current City of Phoenix and City of Glendale stormwater management plans. The storm drains proposed by these plans for 41st, 51st and 59th Avenues could be reduced in size if Alternative 3 is implemented because flows will be diverted west along Bell Road. Alternative 3 will require construction on approximately 12 miles of street.

Drainage Area 5:

Alternative 1: The proposed storm drain along 19th Avenue may conflict with a new 60-inch water line, a 12 inch water line and gas and electrical lines. The existing 90 inch storm drain may have to be removed. The proposed culvert crossing I-17 along Bell Road may conflict with a 12-inch water line, an 8 inch sanitary sewer line and gas and electrical lines. A construction method that minimizes or eliminates any impact to traffic on I-17 is necessary. Alternative 1 is the most compatible with the current City of Phoenix drainage master plan.

Alternative 2: Utilities and traffic along 15th Avenue will be disrupted in addition to those on 19th Avenue.

Drainage Area 6: The compatibility of the drainage facilities proposed by NBS/Lowry was not evaluated. The drainage systems proposed by Greiner along Central Avenue and 16th Street were evaluated and are compatible with both the NBS/Lowry system and the proposed Greenway Parkway channel project.

Utility conflicts may occur with a 12 inch sanitary sewer line and an 8-inch water line along Central Avenue, as well as a 12 inch sanitary sewer line and a 20 inch water line along 16th street.

Drainage Area 7: Per guidance from the FCD, the drainage facilities recommended by NBS/Lowry were not evaluated.

Drainage Area 8: Until the final alignment of the Squaw Peak Parkway has been selected, it is not possible to evaluate its impact on the proposed Bell Road project drainage facilities.

Alternative 1: Utilities along 36th Street, 40th Street and 44th Street, Tatum Boulevard and 56th Street may be impacted by the proposed storm drains along these streets between Bell Road and the Indian Bend Wash. A 48 inch water line along Bell Road between 32nd Street and 52nd Street may also be affected.

Alternative 1 is the most compatible alternative with the current City of Phoenix's Master Storm Drainage Study for the area.

Alternative 2: Most storm drains along Bell Road were substituted with open channels in this alternative. This may reduce impacts on utilities beneath the roadway along Bell Road. Underground or overhead electrical along the northside of Bell Road, however, will be affected.

Alternative 2 is least compatible with the City of Phoenix Master Storm Drainage Study for the area.

Alternative 3: The use of detention basins to reduce downstream storm drain sizes may reduce impacts on utilities along 56th Street and Tatum Boulevard.

Drainage Area 9: No plans.

Drainage Area 10: Construction of the new bridge may temporarily disrupt services along Bell Road.

G. Evaluation Matrices

TABLE 10
EVALUATION MATRIX
DRAINAGE AREA 1

100-YEAR FREQUENCY STORM

	CAPITAL COSTS	EFFECTIVENESS	ENVIRONMENTAL IMPACTS	POTENTIAL FOR STAGED CONSTRUCTION	ACCEPTABILITY TO MUNICIPALITIES	COMPATIBILITY WITH OTHER PROJECTS & PLANS	TOTAL
Alternative 1	N/A	10	9	10	10	10	49

TABLE 11
EVALUATION MATRIX
DRAINAGE AREA 2

100-YEAR FREQUENCY STORM

	CAPITAL COSTS	EFFECTIVENESS	ENVIRONMENTAL IMPACTS	POTENTIAL FOR STAGED CONSTRUCTION	ACCEPTABILITY TO MUNICIPALITIES	COMPATIBILITY WITH OTHER PROJECTS & PLANS	TOTAL
Alternative 1	6.6	10	8.4	10	10	8	53.0
Alternative 2	8.5	10	8.4	10	10	9	55.9
Alternative 3	9.4	10	8.2	10	10	9	56.6
Alternative 4	6.4	10	8.0	10	10	5	49.4
Alternative 5	9.7	10	7.6	10	10	5	52.3
Alternative 6	6.9	10	8.6	10	10	5	50.5
Alternative 7	10.0	10	8.6	10	10	5	53.6

TABLE 12

EVALUATION MATRIX

DRAINAGE AREA 3

100-YEAR FREQUENCY STORM

	CAPITAL COSTS	EFFECTIVENESS	ENVIRONMENTAL IMPACTS	POTENTIAL FOR STAGED CONSTRUCTION	ACCEPTABILITY TO MUNICIPALITIES	COMPATIBILITY WITH OTHER PROJECTS & PLANS	TOTAL
Alternative 1	10.0	10	8.6	8	7	7	50.6
Alternative 2	9.0	10	8.6	8	8	8	51.6
Alternative 3	9.0	10	9.0	8	9	8	53.0

TABLE 13

EVALUATION MATRIX

DRAINAGE AREA 4

100-YEAR FREQUENCY STORM

	CAPITAL COSTS	EFFECTIVENESS	ENVIRONMENTAL IMPACTS	POTENTIAL FOR STAGED CONSTRUCTION	ACCEPTABILITY TO MUNICIPALITIES	COMPATIBILITY WITH OTHER PROJECTS & PLANS	TOTAL
Alternative 1	8.6	10	7.8	9	10	5	50.4
Alternative 2	8.9	10	8.0	9	10	4	49.9
Alternative 3	10.0	10	8.8	5	10	7	50.8

TABLE 14

EVALUATION MATRIX

DRAINAGE AREA 5

100-YEAR FREQUENCY STORM

	CAPITAL COSTS	EFFECTIVENESS	ENVIRONMENTAL IMPACTS	POTENTIAL FOR STAGED CONSTRUCTION	ACCEPTABILITY TO MUNICIPALITIES	COMPATIBILITY WITH OTHER PROJECTS & PLANS	TOTAL
Alternative 1	9.8	10	8.6	5	10	7	50.4
Alternative 2	10.0	10	7.8	5	10	5	47.8

TABLE 15

EVALUATION MATRIX

DRAINAGE AREA 6

100-YEAR FREQUENCY STORM

	CAPITAL COSTS	EFFECTIVENESS	ENVIRONMENTAL IMPACTS*	POTENTIAL FOR STAGED CONSTRUCTION	ACCEPTABILITY TO MUNICIPALITIES	COMPATIBILITY WITH OTHER PROJECTS & PLANS	TOTAL
Alternative 1	N/A	10	7	5	10	N/A	32

*Impacts of Greiner proposed facilities only (Central Avenue, 16th Street).

TABLE 16

EVALUATION MATRIX

DRAINAGE AREA 7

100-YEAR FREQUENCY STORM

	CAPITAL COSTS	EFFECTIVENESS	ENVIRONMENTAL IMPACTS	POTENTIAL FOR STAGED CONSTRUCTION	ACCEPTABILITY TO MUNICIPALITIES	COMPATIBILITY WITH OTHER PROJECTS & PLANS	TOTAL
Alternative 1	N/A	10	N/A	7	10	N/A	27

TABLE 17

EVALUATION MATRIX

DRAINAGE AREA 8

100-YEAR FREQUENCY STORM

	CAPITAL COSTS	EFFECTIVENESS	ENVIRONMENTAL IMPACTS	POTENTIAL FOR STAGED CONSTRUCTION	ACCEPTABILITY TO MUNICIPALITIES	COMPATIBILITY WITH OTHER PROJECTS & PLANS	TOTAL
Alternative 1	8.9	10	9	8	10	8	53.9
Alternative 2	9.2	10	7.4	10	5	5	46.6
Alternative 3	10.0	10	7.2	10	5	7	49.2

TABLE 18

EVALUATION MATRIX

DRAINAGE AREA 10

100-YEAR FREQUENCY STORM

	CAPITAL COSTS	EFFECTIVENESS	ENVIRONMENTAL IMPACTS	POTENTIAL FOR STAGED CONSTRUCTION	ACCEPTABILITY TO MUNICIPALITIES	COMPATIBILITY WITH OTHER PROJECTS & PLANS	TOTAL
Alternative 1	N/A	10	9	10	10	10	49

X. ALTERNATE STORMWATER/FLOODWATER MANAGEMENT CONCEPT PLANS, 10-YEAR STORM EVENT

A minimum of three alternative stormwater/floodwater management plans were evaluated for most of the drainage areas investigated. In general, system alignments were selected to conform to topographic features of the drainage areas. To achieve the design objective of 100 percent interception of off-site runoff at the Bell Road right-of-way, it was often necessary to evaluate trunk storm drains, open channels or detention basins in the upper watershed along the section-line and half-section line streets. These alignments were followed because of right-of-way availability, minimal utility conflicts and minimal disruption of residential areas. Also, the general trend for urban development in the study area is based on a grid pattern. Smaller laterals or runoff collection systems which would connect to the main system were not included in the analyses.

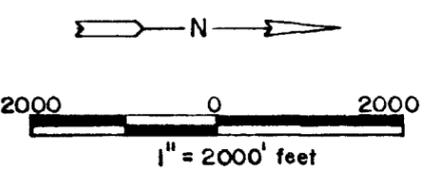
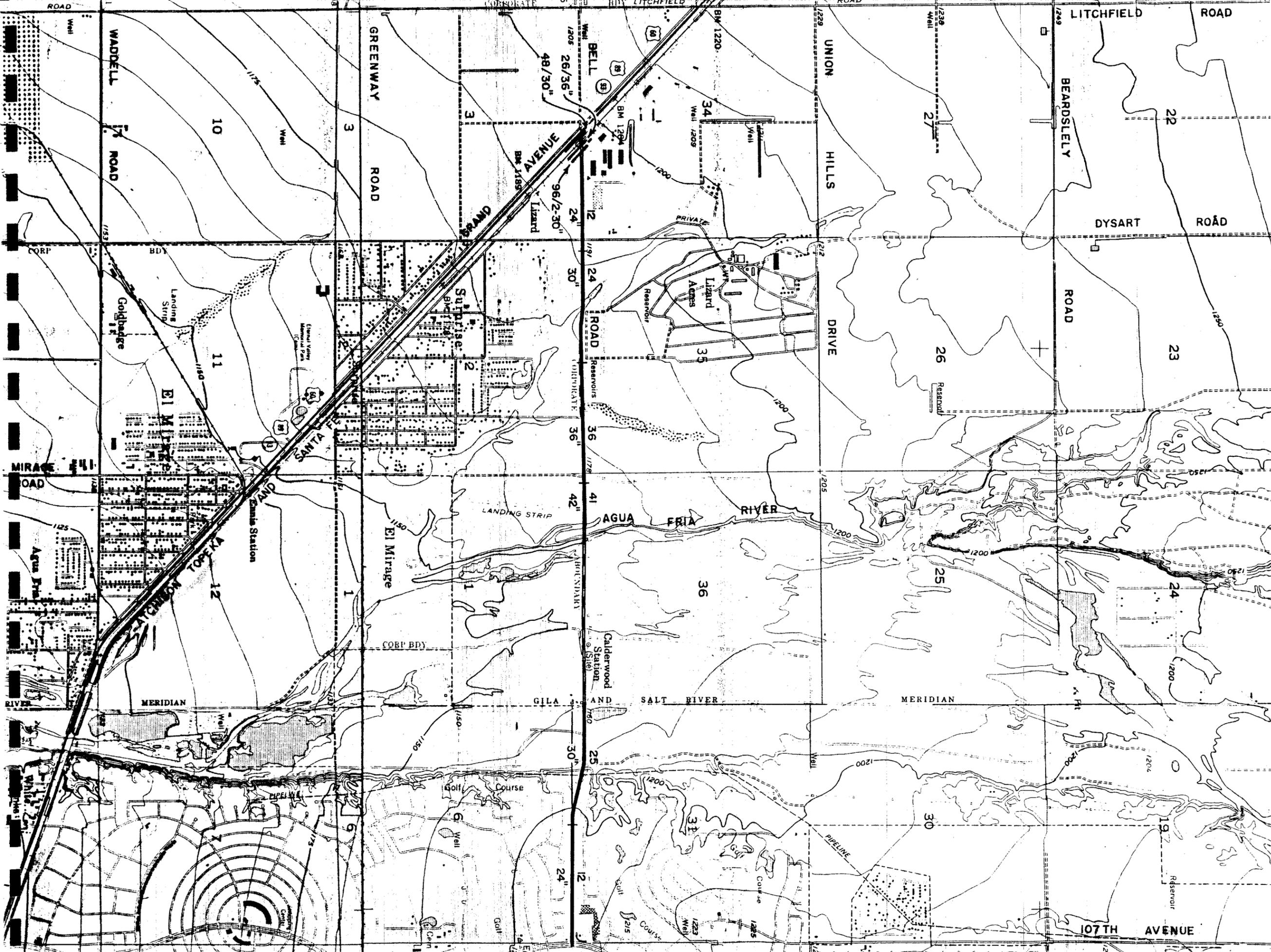
Concepts developed for the 10-year storm event are for the most part, similar in layout to concepts developed for the 100-year storm event. The major elements of the alternative drainage systems, including trunk lines, on-site storm drains, detention basins and open channels are described in the following pages. Refer to Section IV for descriptions of each of the drainage areas.

Drainage Area 1: Off-site runoff impacts Bell Road along the Grand Avenue and A.T. & S.F. Railroad rights-of-way. Drainage from Sun City West is diverted to the Agua Fria River north of Bell Road. To convey the 10-year peak discharge under Bell Road, it would be necessary to upgrade or replace the existing culverts. A 30 inch culvert is required between Grand Avenue and the railroad embankment. The 36 inch culvert located just east of the railroad embankment may need to be lengthened or replaced to conform to the proposed roadway geometry. Two 30 inch culverts are required for conveying discharges from the Sun City West construction yard area.

The 36-inch and double 30-inch culverts will discharge into a gunitite channel east of the railroad embankment as proposed by the Grand Avenue Corridor Study. This channel terminates at the Agua Fria River.

On-site runoff for Bell Road in Drainage Area 1 (Grand Avenue to the Agua Fria River) will be conveyed to the Agua Fria River by storm drains ranging in size from 24 inch to 36 inch pipe.

Refer to Plate 29 for a schematic of drainage facilities proposed for Drainage Area 1.



- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - ▨ DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS

OPEN CHANNELS

TW = 60' TOP WIDTH
 D = 5' DEPTH

10 YEAR FREQUENCY STORM
 PLATE 29
 ALTERNATE 1
 DRAINAGE AREA 1
 BELL ROAD PROJECT
 DRAINAGE STUDY

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 Engineering**

Drainage Area 2: Off-site runoff in Drainage Area 2 concentrates along Bell Road at 91st Avenue and 87th Avenue. Off-site runoff generated in Sun City is managed by drainage systems constructed as part of that development.

Four alternative concept plans were evaluated for Drainage Area 2. For all alternatives the storm drainage facilities were extended to Deer Valley Road to insure complete interception at Bell Road. Final alignment of all facilities and the location of inlet structures will be affected by future development of the area.

Alternative 1: Alternative 1 facilities consist of an open channel from Deer Valley Road to Beardsley Road along 91st Avenue and an open channel along 87th Avenue from Deer Valley Road to Beardsley Road and then turn westward along Beardsley Road to 91st Avenue. The two channels discharge into a storm drain system at 91st Avenue and Beardsley Road which then continues southward along 91st Avenue to Bell Road. This system discharges into an open channel south of Bell Road at 91st Avenue and continues south along 91st Avenue to Greenway Road where it turns east to its outfall at the New River.

The 10-year peak discharge at the New River outfall would be 1,636 cfs. Channel sizes range from 3 to 7 feet deep and from 26 to 134 feet in top width. Storm drains vary from a 36 inch pipe to 4-10' x 5' box culverts.

Refer to Plate 30 for a schematic of the drainage facilities proposed for Alternative 1.

Alternative 2: Alternative 2 is similar to Alternative 1 with the addition of a detention basin located at the northeast corner of 91st Avenue and Beardsley Road. This detention basin reduces the peak discharge at the New River outfall to 965 cfs. Open channels range in depth from 3 to 7 feet and from 26 to 98 feet in top width.

Storm drains range in size from a 36-inch pipe to 2-8' x 6' box culverts.

Refer to Plate 31 for a schematic of the drainage facilities proposed for Alternative 2.

Alternative 3: Alternative 3 consists of parallel drainage systems along 91st Avenue and 87th Avenue. The 91st Avenue system is comprised of an open channel from Deer Valley Road to Beardsley Road and a storm drain system between Beardsley Road and Bell Road. South of Bell Road, the storm drain system discharges into a channel with its outfall to the New River at Greenway Road.

The 87th Avenue system consists of an open channel from Deer Valley Road to Beardsley Road and a storm drain system along 87th Avenue between Beardsley Road and Union Hills Drive. At Union Hills Drive, the system heads eastward along Union Hills Drive to its outfall at the New River near 83rd Avenue.

Peak discharge for the 91st Avenue system at Greenway Road and the New River is 1,030 cfs. Peak discharge for the 87th Avenue system at the New River and Union Hills Drive is 585 cfs. Channel sizes range from 3 to 7 feet deep and 26 to 102 feet in top width. Storm drains vary in size from a 36-inch pipe to 2-10' x 5' box culverts.

Refer to Plate 32 for a schematic of the drainage facilities proposed for Alternative 3.

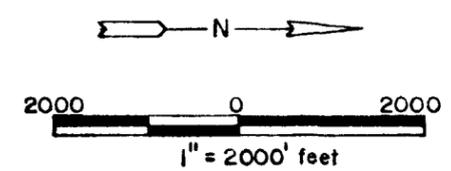
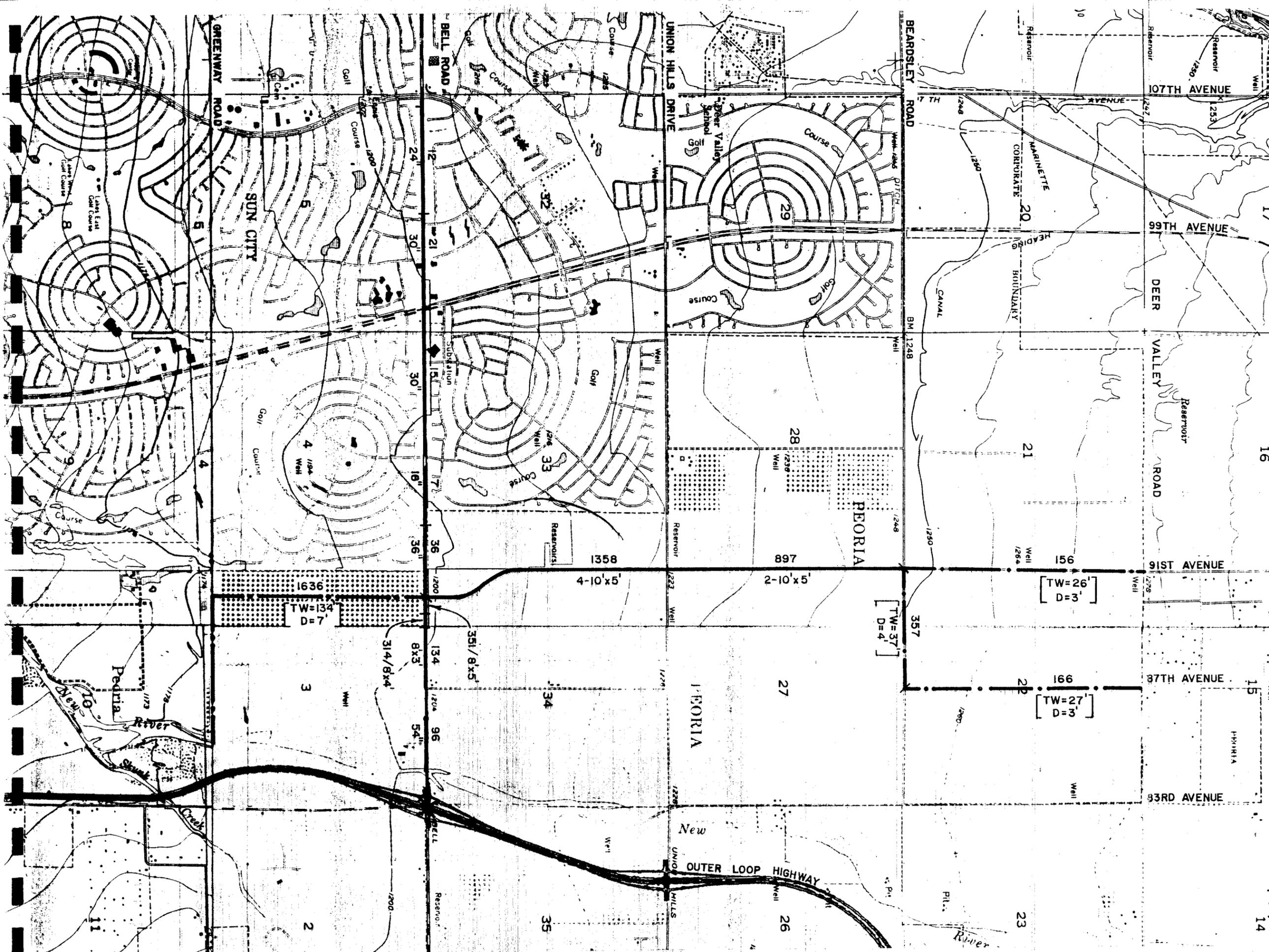
Alternative 4: Alternative 4 is similar to alternative 3 with the addition of one detention basin to each system. A detention basin located at the northeast corner of 91st Avenue and Beardsley Road would reduce the peak discharge at Greenway Road and the New River to 557 cfs. A detention basin located at the northeast corner of Union Hills Drive and 87th Avenue would reduce the peak discharge at Union Hills Drive and the New River to 109 cfs. Channel sizes range from 3 to 7 feet deep and from 26 to 76 feet in top width. Storm

drains vary in size from a 36-inch pipe to 2-6' x 6' box culverts.

Refer to Plate 33 for a schematic of the drainage facilities proposed for Alternative 4.

On-site Runoff: On-site runoff for Bell Road in Drainage Area 2 (Agua Fria River to the New River) will be conveyed via open channels or storm drains. Open channels or storm drains may be utilized between the Agua Fria River and 115th Avenue alignment and for the section of Bell Road between 87th Avenue and the New River. Storm drains will be utilized for all other areas. An outfall would be located at the existing Sun City drainageway at 99th Avenue for runoff generated between Del Webb Boulevard and Burns Drive (located approximately 3,000 feet west of 91st Avenue). Drainage west of Del Webb Boulevard will discharge into the existing box culvert at Bell Road and the 115th Avenue alignment. Runoff east of Burns Drive will be picked up by the off-site drainage facilities at 91st Avenue.

Refer to Plates 29 and 30 for schematics of the on-site facilities proposed for Drainage Area 2.



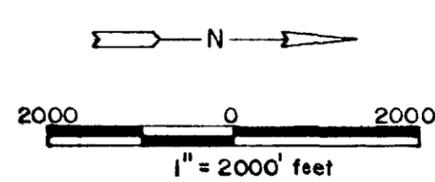
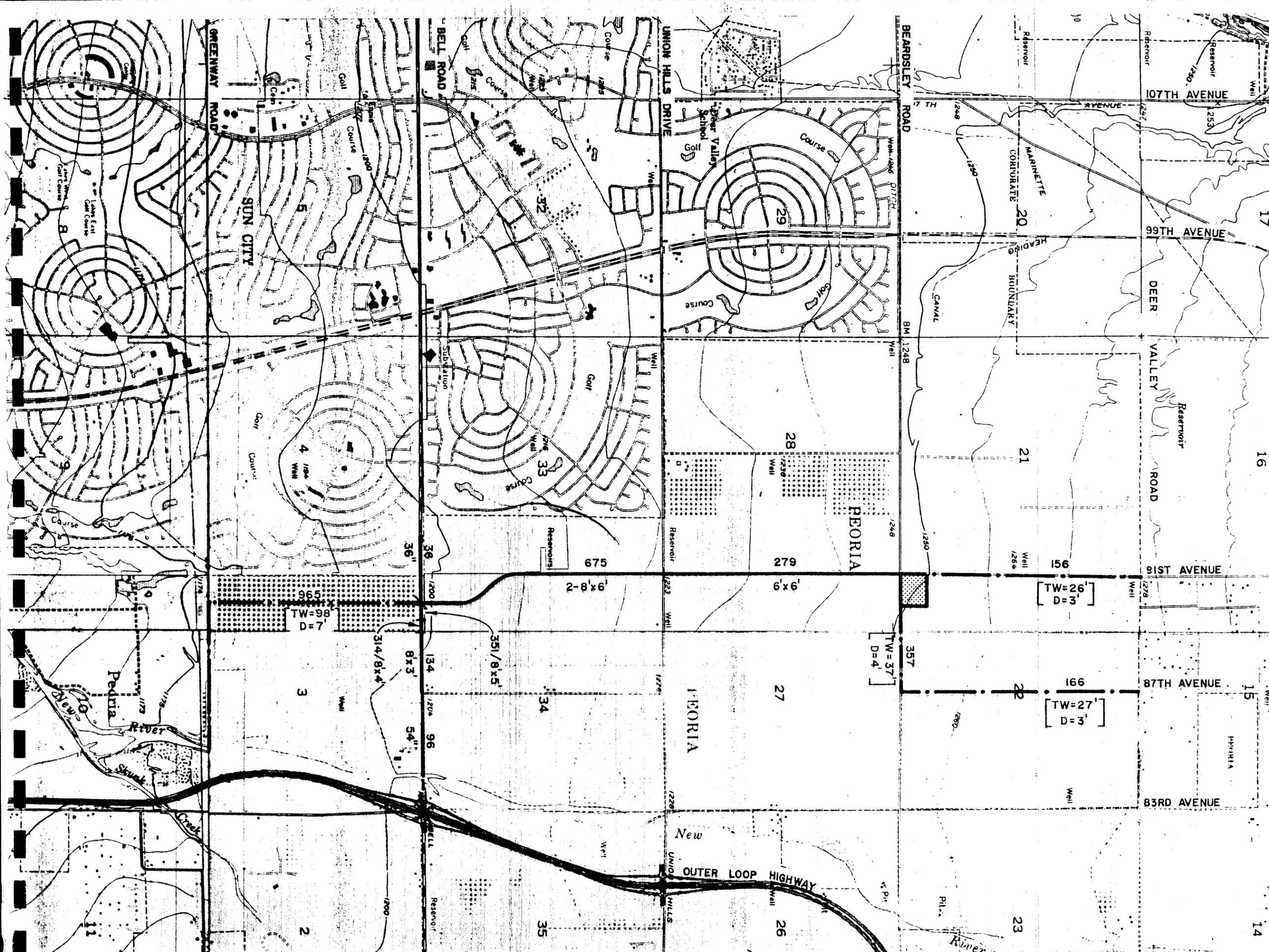
- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - ▒ DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS

OPEN CHANNELS

[TW=60'] TOP WIDTH
[D = 5'] DEPTH

10 YEAR FREQUENCY STORM
PLATE 30
 ALTERNATE 1, WITH ONSITE
 DRAINAGE AREA 2
 BELL ROAD PROJECT
 DRAINAGE STUDY

**Greiner
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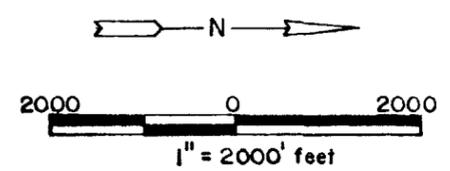
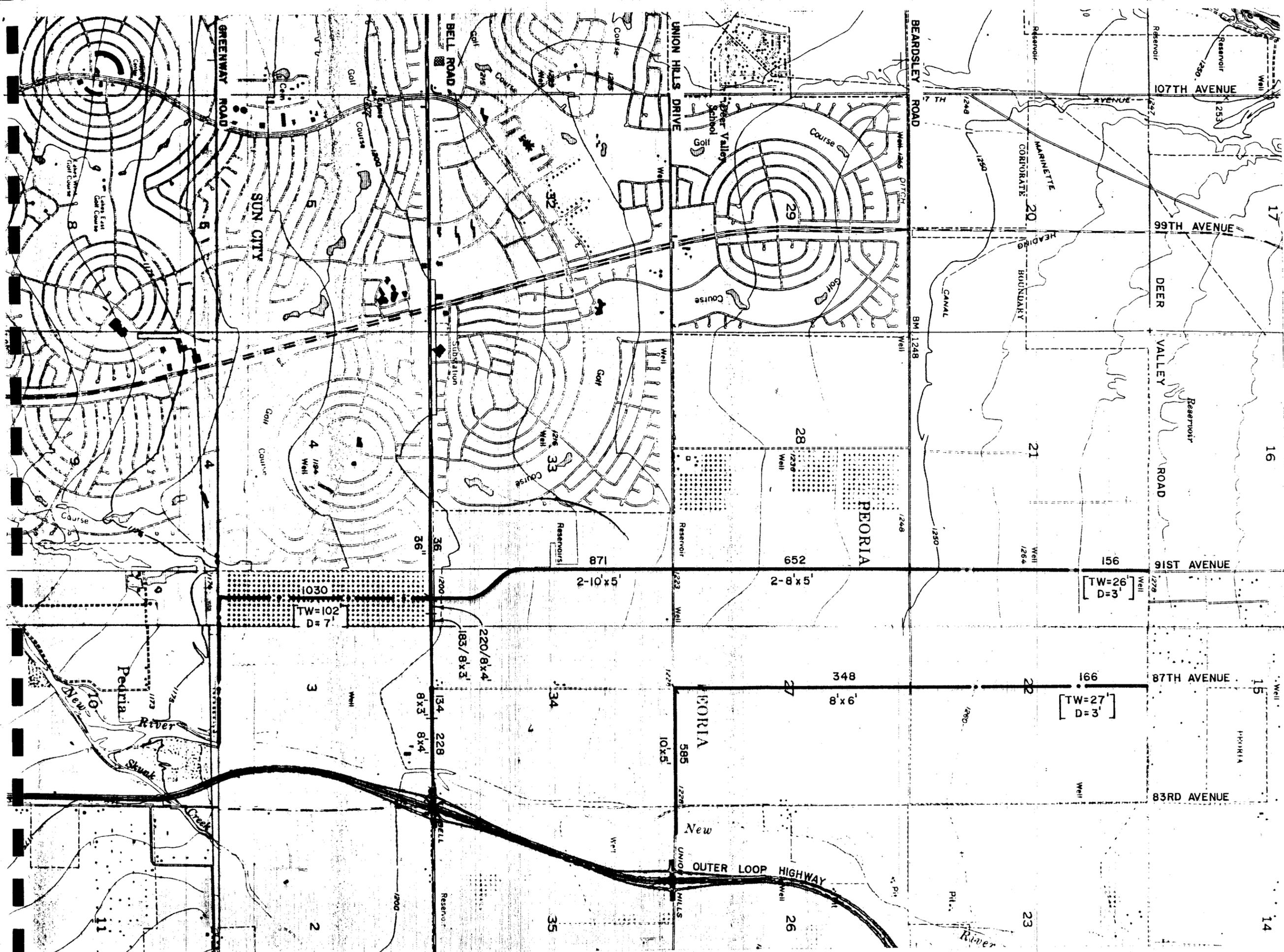


- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - ▒ DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8x3' STRUCTURE SIZE
 - 72" FOR CONDUITS

OPEN CHANNELS

TW=60' TOP WIDTH
D=5' DEPTH

10 YEAR FREQUENCY STORM
 PLATE 31
 ALTERNATE 2
 DRAINAGE AREA 2
 BELL ROAD PROJECT
 DRAINAGE STUDY



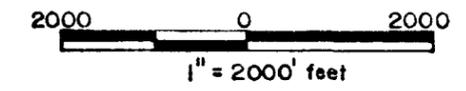
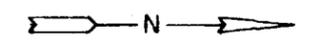
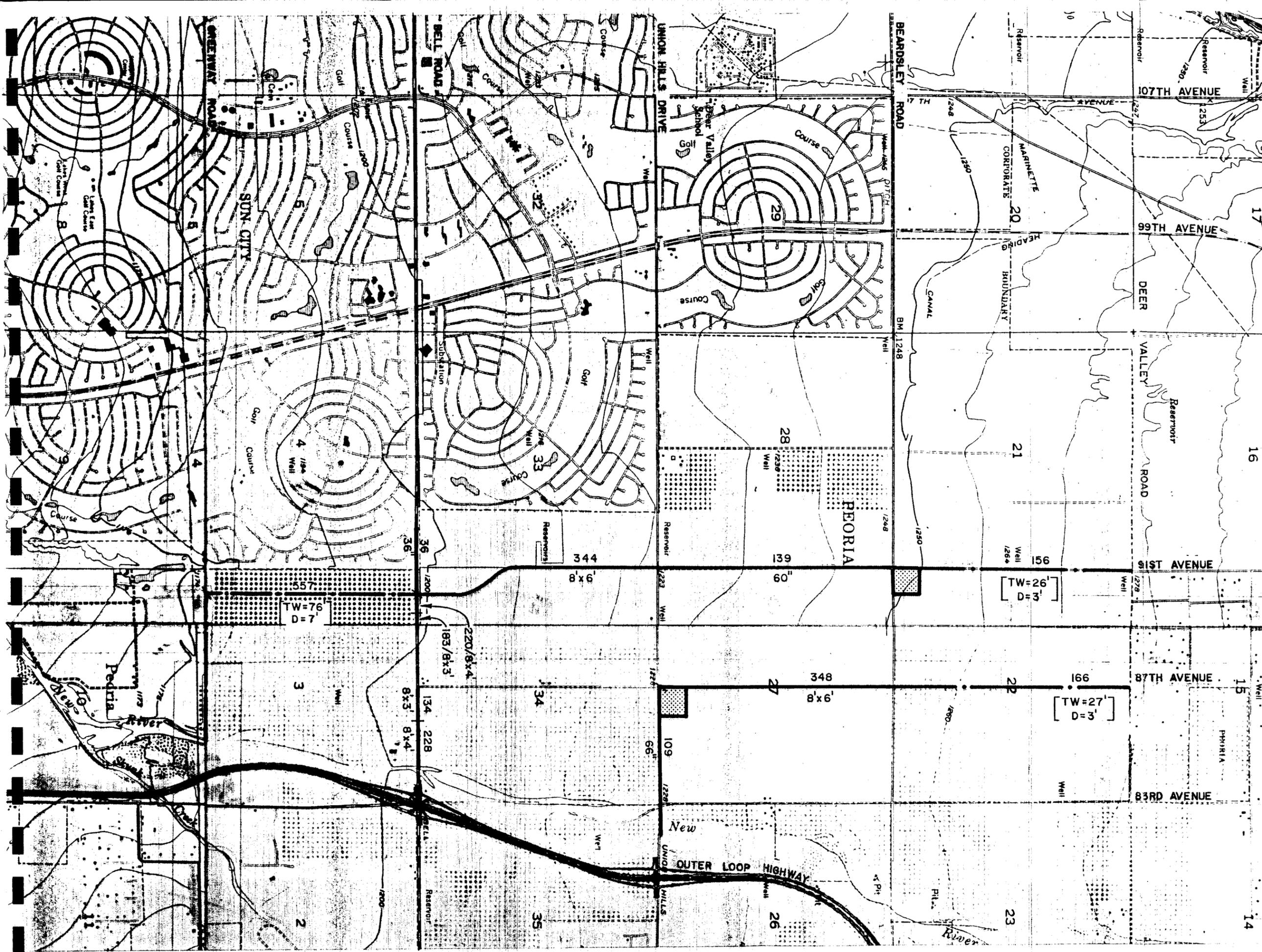
- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - ▒ DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS

OPEN CHANNELS

[TW=60] TOP WIDTH
 [D = 5'] DEPTH

10 YEAR FREQUENCY STORM
 PLATE 32
 ALTERNATE 3
 DRAINAGE AREA 2
 BELL ROAD PROJECT
 DRAINAGE STUDY

**Greiner
 Engineering**



LEGEND

- CONDUIT
- OPEN CHANNEL
- DETENTION BASIN
- 690 PEAK FLOW IN CFS
- 2-8'x3' STRUCTURE SIZE
- 72" FOR CONDUITS

OPEN CHANNELS

[TW=60] TOP WIDTH
[D = 5'] DEPTH

10 YEAR FREQUENCY STORM

PLATE 33

ALTERNATE 4

DRAINAGE AREA 2

BELL ROAD PROJECT

DRAINAGE STUDY

**Greiner
Engineering**

Drainage Area 3: Off-site runoff in Drainage Area 3 concentrates at Bell Road and 77th Avenue and Bell road and 75th Avenue. Five (5) alternative drainage concepts were evaluated for intercepting the 10-year runoff impacting Bell Road. Detention basins were not evaluated in any of the alternatives because discharges were relatively small.

Alternative 1: A storm drain will be located along 75th Avenue, extending from Bell Road northward for approximately three-quarters of a mile. The storm drain will outlet into Skunk Creek south of Bell Road at 75th Avenue. A second storm drain will be located along Bell Road to convey runoff concentrating at 77th Avenue to the New River. The 10-year discharge to Skunk Creek would be 274 cfs. The discharge to the New River would be 160 cfs. Storm drain pipe sizes vary from 48-inch to 72-inch.

Refer to Plate 34 for a schematic of the drainage facilities proposed for Alternative 1.

Alternative 2: Alternative 2 is similar to Alternative 1 with the exception that the 75th Avenue system will be comprised of an open channel located between Bell Road and Skunk Creek and the system along Bell Road would be comprised of an open channel from 77th Avenue to the New River. Channel sizes range from 3.5 to 9 feet deep and 28 to 83 feet in top width.

Refer to Plate 35 for a schematic of the drainage facilities proposed for Alternative 2.

Alternative 3: Alternative 3 is comprised of a single storm drain extending from approximately one-quarter mile north of Grovers Avenue on 75th Avenue to Bell Road and then heading westward along Bell Road to its outfall at the New River. The 10-year discharge into the New River would be 434 cfs. Storm drains vary from a 48-inch pipe to 2-8' x 5' box culverts.

Refer to Plate 36 for a schematic of the drainage facilities proposed for Alternative 3.

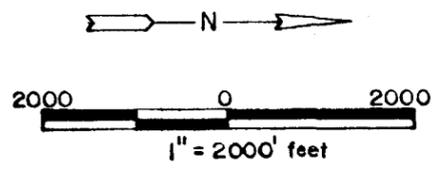
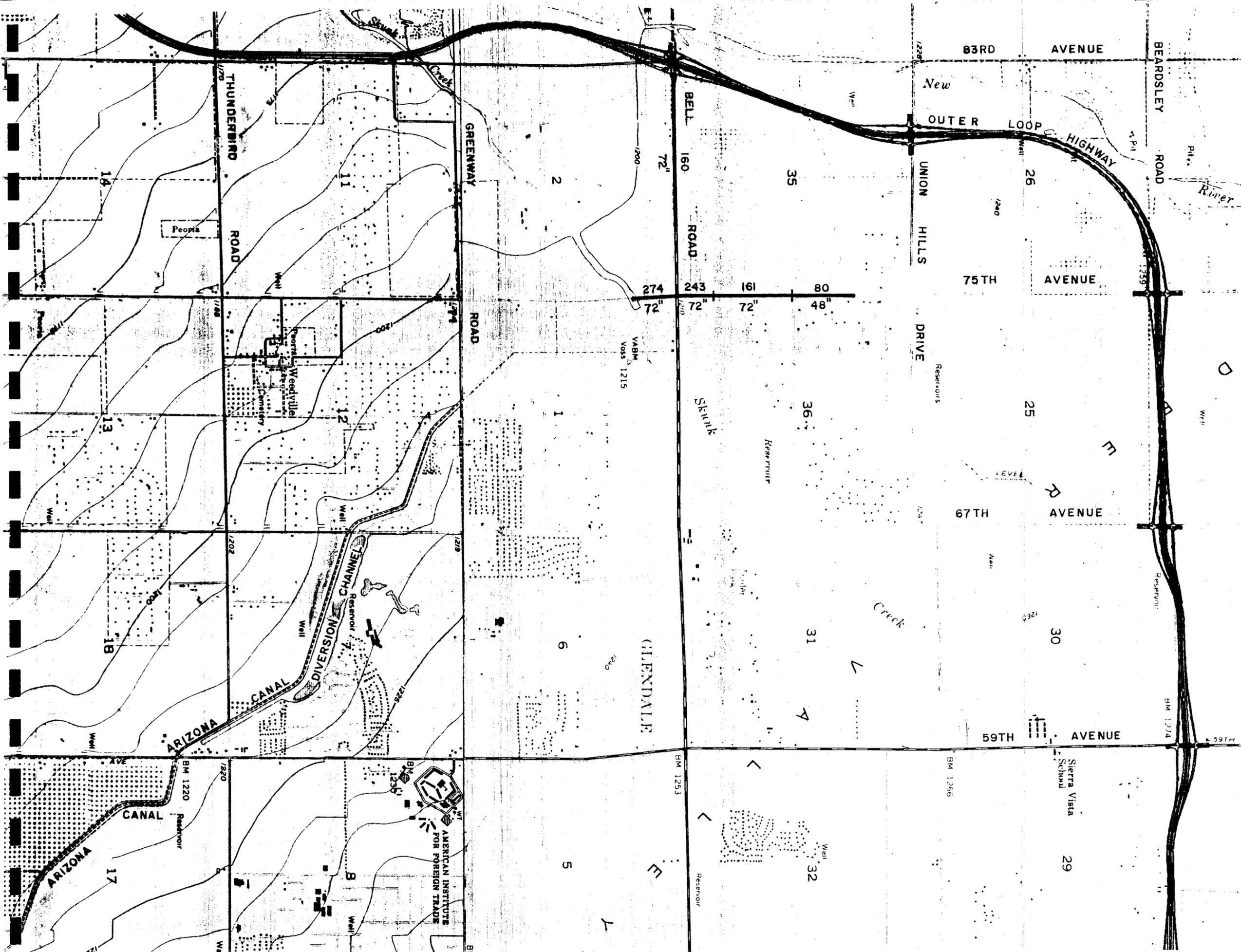
Alternative 4: Alternative 4 is similar to Alternative 3 with the exception that the system along Bell Road will be comprised of an open channel. The channel would be 8 feet deep and range from 32 to 74 feet in top width.

Refer to Plate 37 for a schematic of the drainage facilities proposed for Alternative 4.

Alternative 5: Alternative 5 is comprised of a single storm drain outletting into Skunk Creek at 75th Avenue. The storm drain will extend northward on 75th Avenue to approximately one-quarter mile north of Grovers Avenue. A trunk line will also be extended west on Bell Road to 77th Avenue.

Refer to Plate 38 for a schematic of the drainage facilities proposed for Alternative 5.

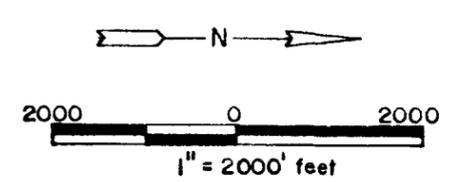
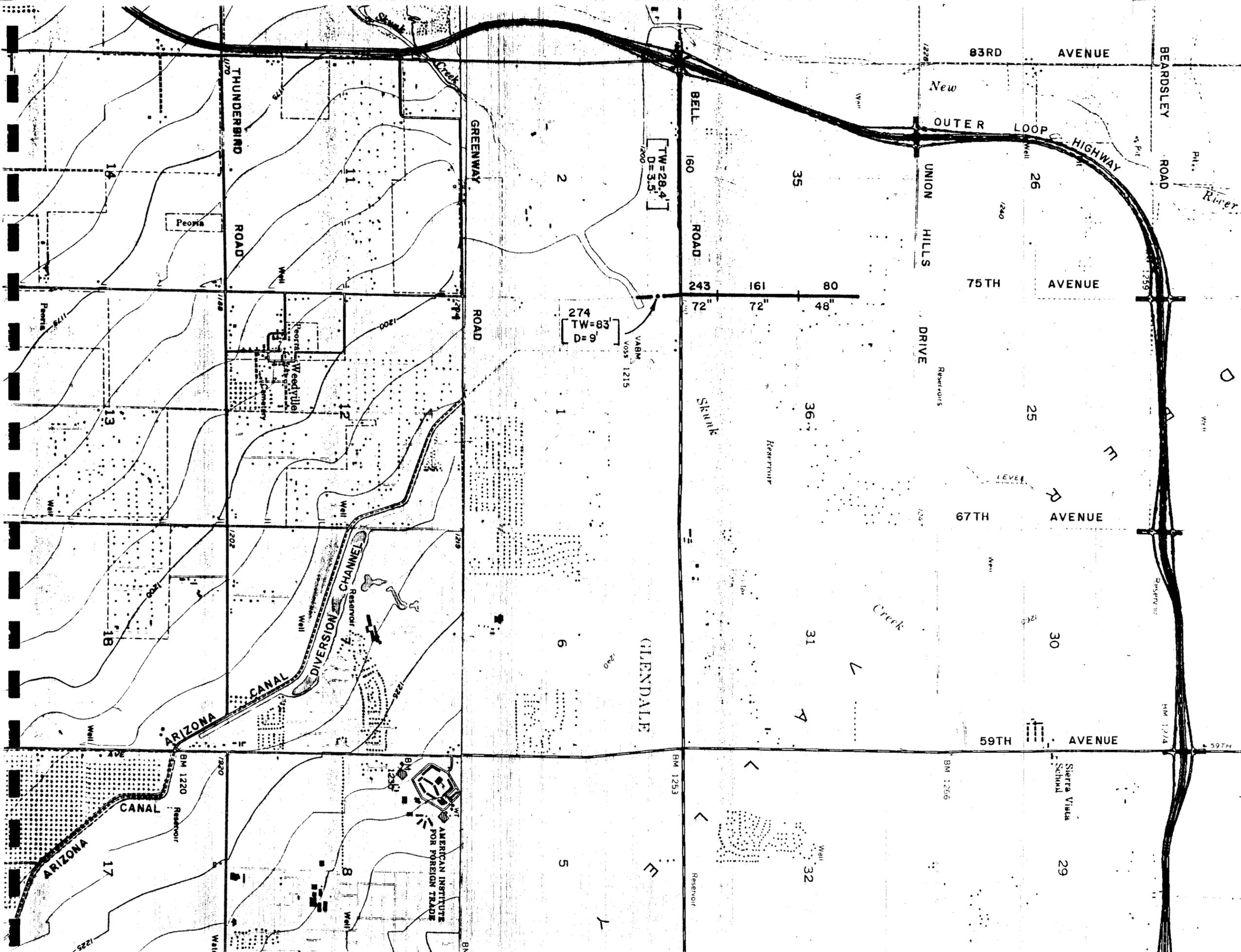
On-site Runoff: On-site runoff for Bell Road in Drainage Area 3 (New River to Skunk Creek) will be conveyed via storm drains or open channel to outfalls in Skunk Creek or the New River. For Alternatives 1 through 4, the off-site drainage system will also convey on-site runoff. An additional storm drain along Bell Road extending west of 77th Avenue will be required for Alternative 5. (Plate 38).



- LEGEND**
- CONDUIT
 - OPEN CHANNEL
 - DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS
- OPEN CHANNELS**
- TOP WIDTH
DEPTH

10 YEAR FREQUENCY STORM
 PLATE 34
 ALTERNATE 1
 DRAINAGE AREA 3
 BELL ROAD PROJECT
 DRAINAGE STUDY

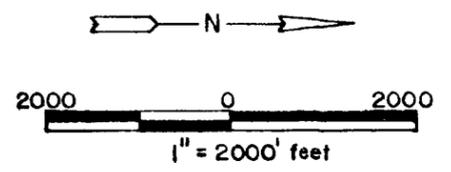
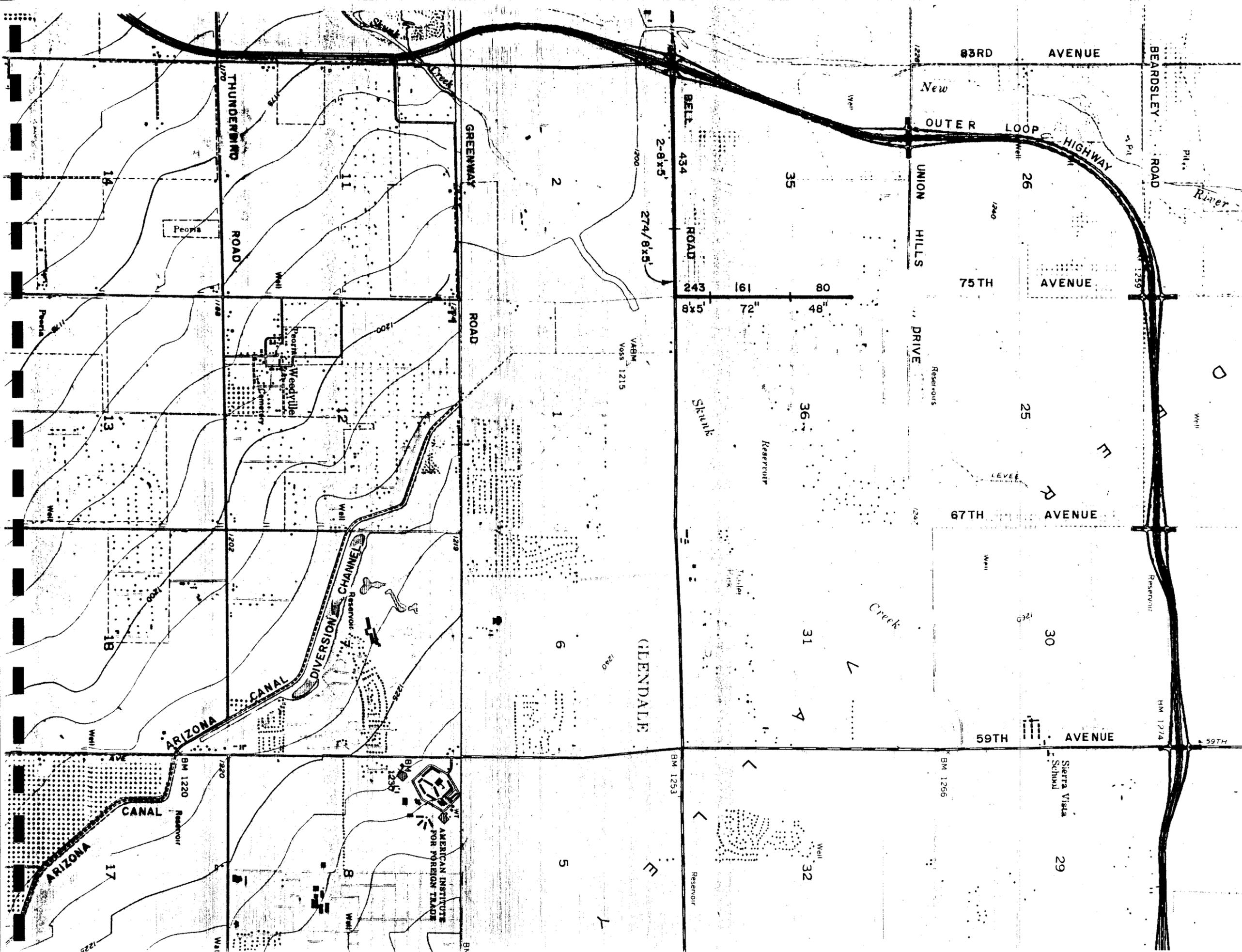
**Greiner
 Engineering**



- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS
- OPEN CHANNELS**
- [TW=60'] TOP WIDTH
 [D = 5'] DEPTH

10 YEAR FREQUENCY STORM
 PLATE 35
 ALTERNATE 2
 DRAINAGE AREA 3
 BELL ROAD PROJECT
 DRAINAGE STUDY

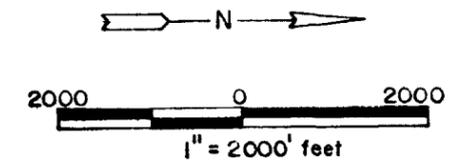
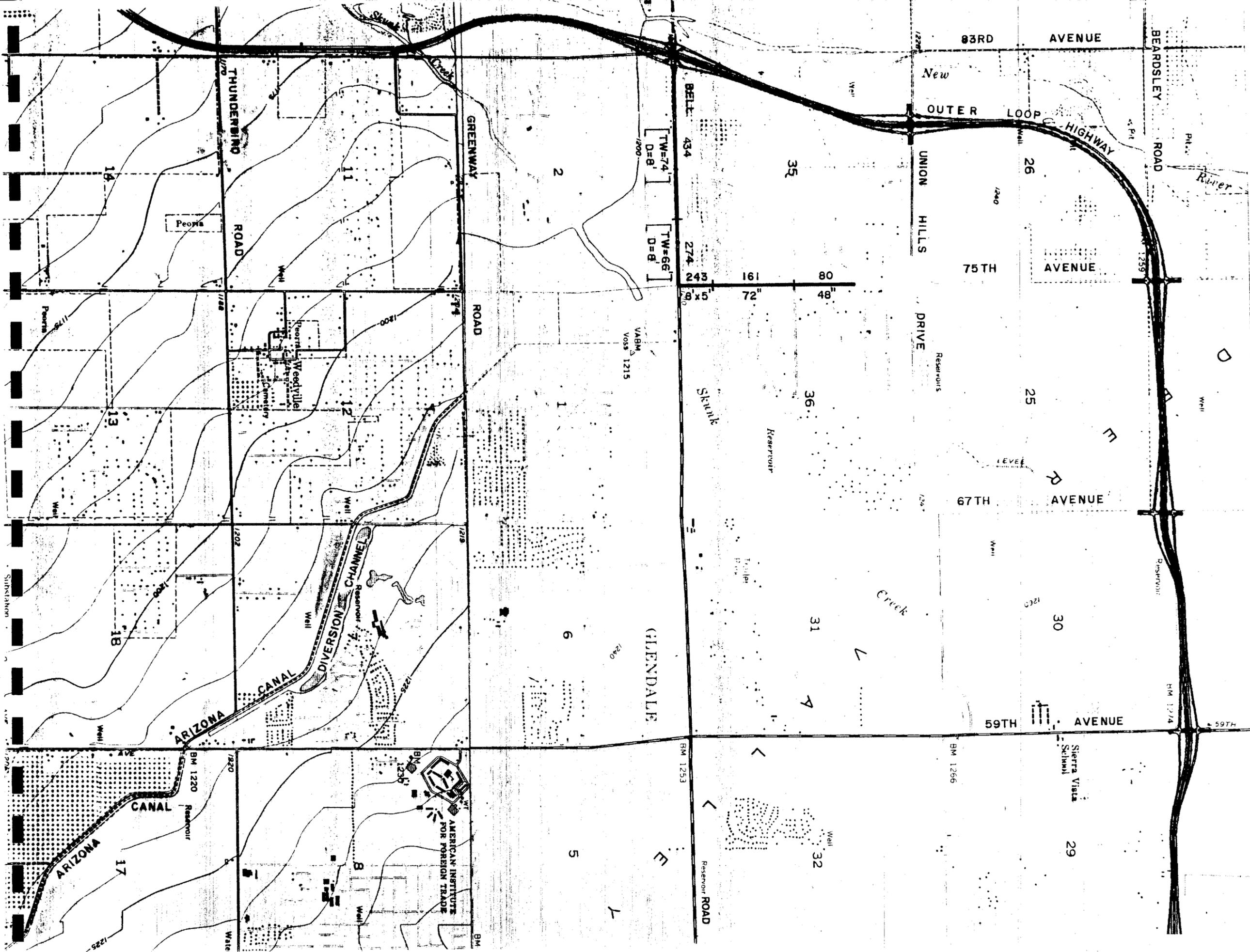
**Greiner
 Engineering**



- LEGEND**
- CONDUIT
 - OPEN CHANNEL
 - DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS
- OPEN CHANNELS**
- [TW = 60'] TOP WIDTH
 [D = 5'] DEPTH

10 YEAR FREQUENCY STORM
 PLATE 36
 ALTERNATE 3
 DRAINAGE AREA 3
 BELL ROAD PROJECT
 DRAINAGE STUDY

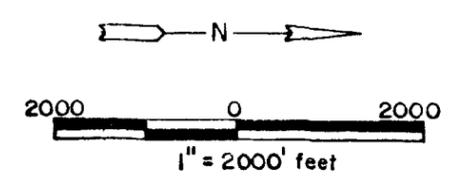
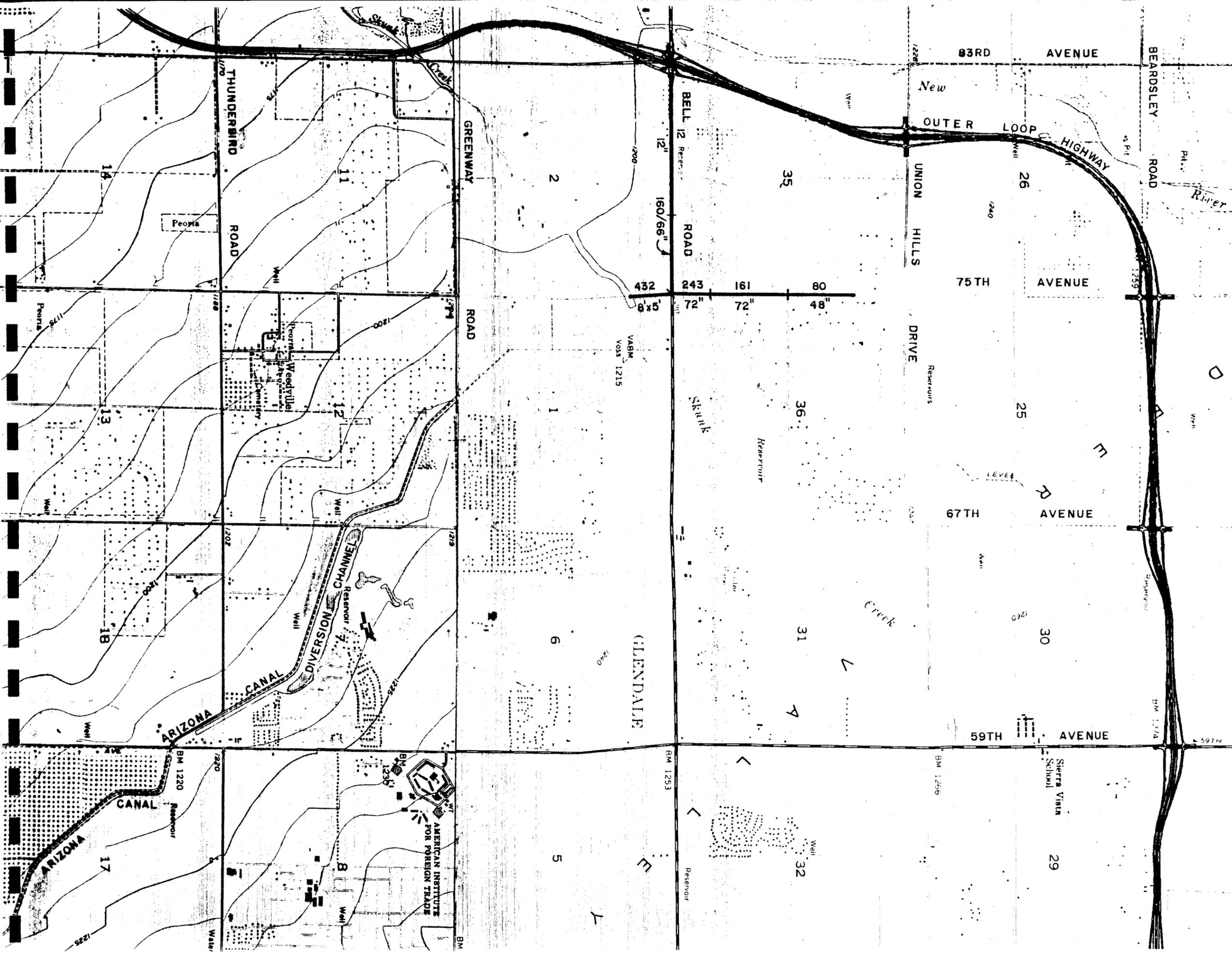
**Greiner
 Engineering**



- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS
- OPEN CHANNELS**
- [TW=60] TOP WIDTH
[D = 5'] DEPTH

10 YEAR FREQUENCY STORM
 PLATE 37
 ALTERNATE 4
 DRAINAGE AREA 3
 BELL ROAD PROJECT
 DRAINAGE STUDY

**Greiner
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- LEGEND**
- CONDUIT
 - OPEN CHANNEL
 - DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS
- OPEN CHANNELS**
- [TW=60'] TOP WIDTH
 [D = 5'] DEPTH

10 YEAR FREQUENCY STORM

PLATE 38

ALTERNATE 5

DRAINAGE AREA 3

BELL ROAD PROJECT

DRAINAGE STUDY

Greiner
 Engineering

Drainage Area 4

Alternative 1: Alternative 1 is comprised of five separate systems of box culvert storm drains that will convey off-site drainage to the Arizona Canal Diversion Channel (ACDC) along the section-line streets. Where necessary, the trunk lines were extended eastward along Bell Road and/or north of Bell Road along the section-line streets to achieve full interception of the 10-year runoff. The box culvert along Bell Road from 35th Avenue was extended to the proposed culvert at I-17 discharging flows from Drainage Area 5. A detention basin recommended by the City of Glendale Storm Water Management Plan, to be located at Bell Road between 57th and 55th Avenues, was also incorporated. The proposed basin will retain the 10-year runoff.

The 10-year peak discharges to the ACDC vary from 160 cfs (67th Avenue) to 890 cfs (35th Avenue). Structure sizes range from a 54 inch pipe to 3-8' x 6' box culverts.

Refer to Plates 39 and 40 for schematics of the drainage facilities proposed for Alternative 1.

Alternative 2: Alternative 2 is similar to Alternative 1 with the exception that outfalls will be located at 35th, 51st and 67th Avenues along Bell Road to the ACDC rather than at all the section-line streets along Bell Road between I-17 and 59th Avenue.

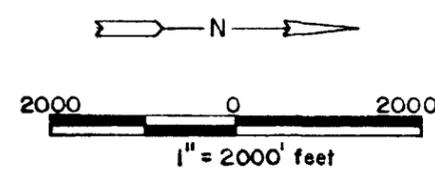
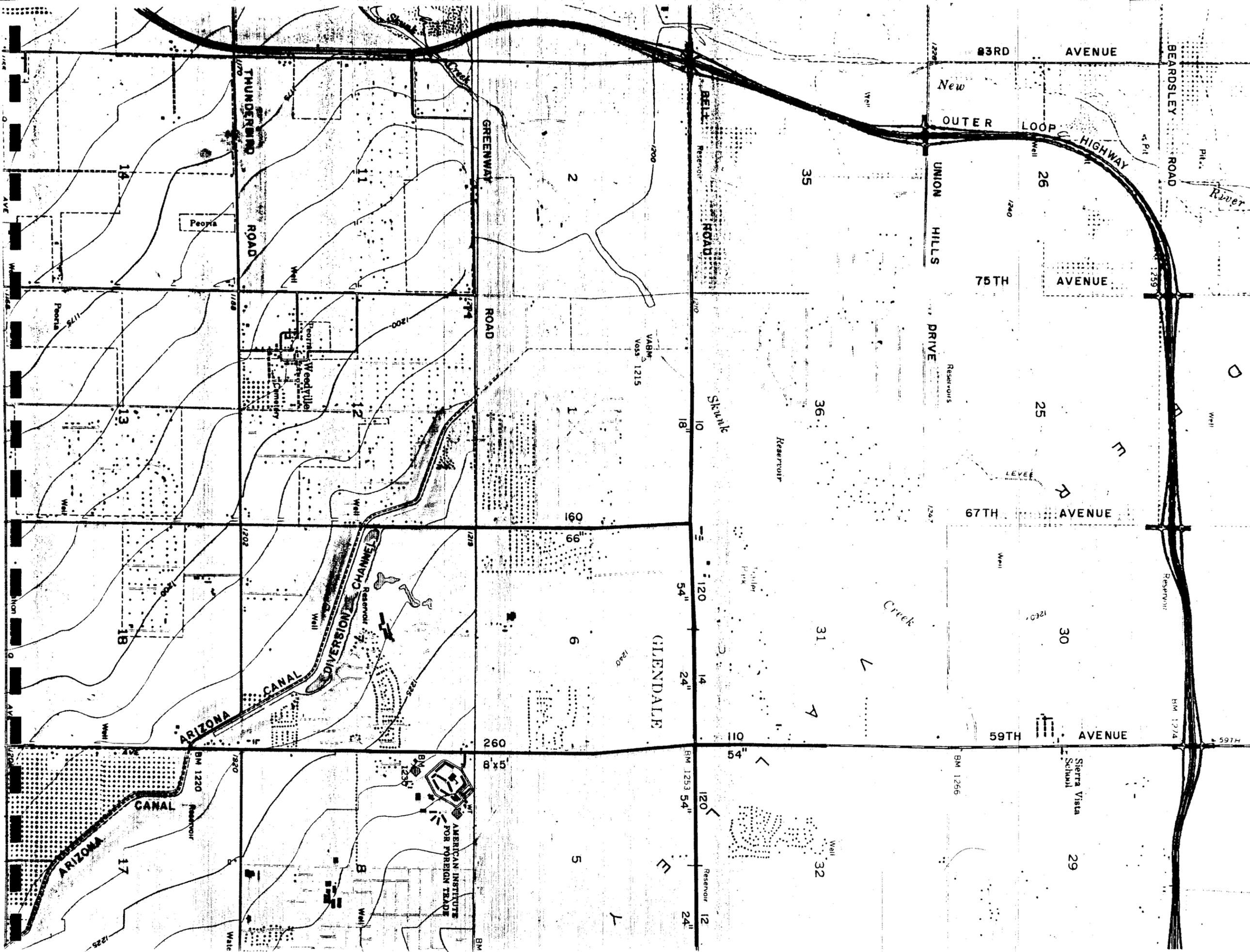
The 10-year peak discharges to the ACDC vary from 370 cfs (67th Avenue) to 890 cfs (35th Avenue). Structure sizes range from a 54-inch pipe to 3-8' x 6' box culverts.

Refer to Plates 41 and 42 for schematics of the drainage facilities proposed for Alternative 2.

Alternative 3: Alternative 3 is a storm drain system that conveys off-site drainage to Skunk Creek along Bell Road. The 10-year discharge at Skunk Creek would be 1,820 cfs. Storm drain structures range in size from a 54-inch pipe to 6-8' x 6' box culverts.

Refer to Plates 43 and 44 for schematics of the drainage facilities proposed for Alternative 3.

On-site Runoff: Minor off-site and on-site runoff for Bell Road in Drainage Area 4 (Skunk Creek to I-17) will be intercepted by storm drains that tie into the off-site drainage storm drain trunk lines.



- LEGEND**
- CONDUIT
 - OPEN CHANNEL
 - DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8x3' STRUCTURE SIZE
 - 72" FOR CONDUITS
- OPEN CHANNELS**
- [TW = 60'] TOP WIDTH
 - [D = 5'] DEPTH

10 YEAR FREQUENCY STORM

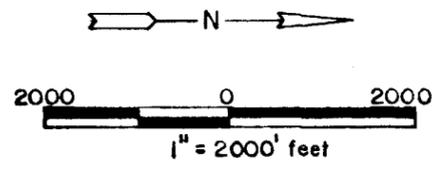
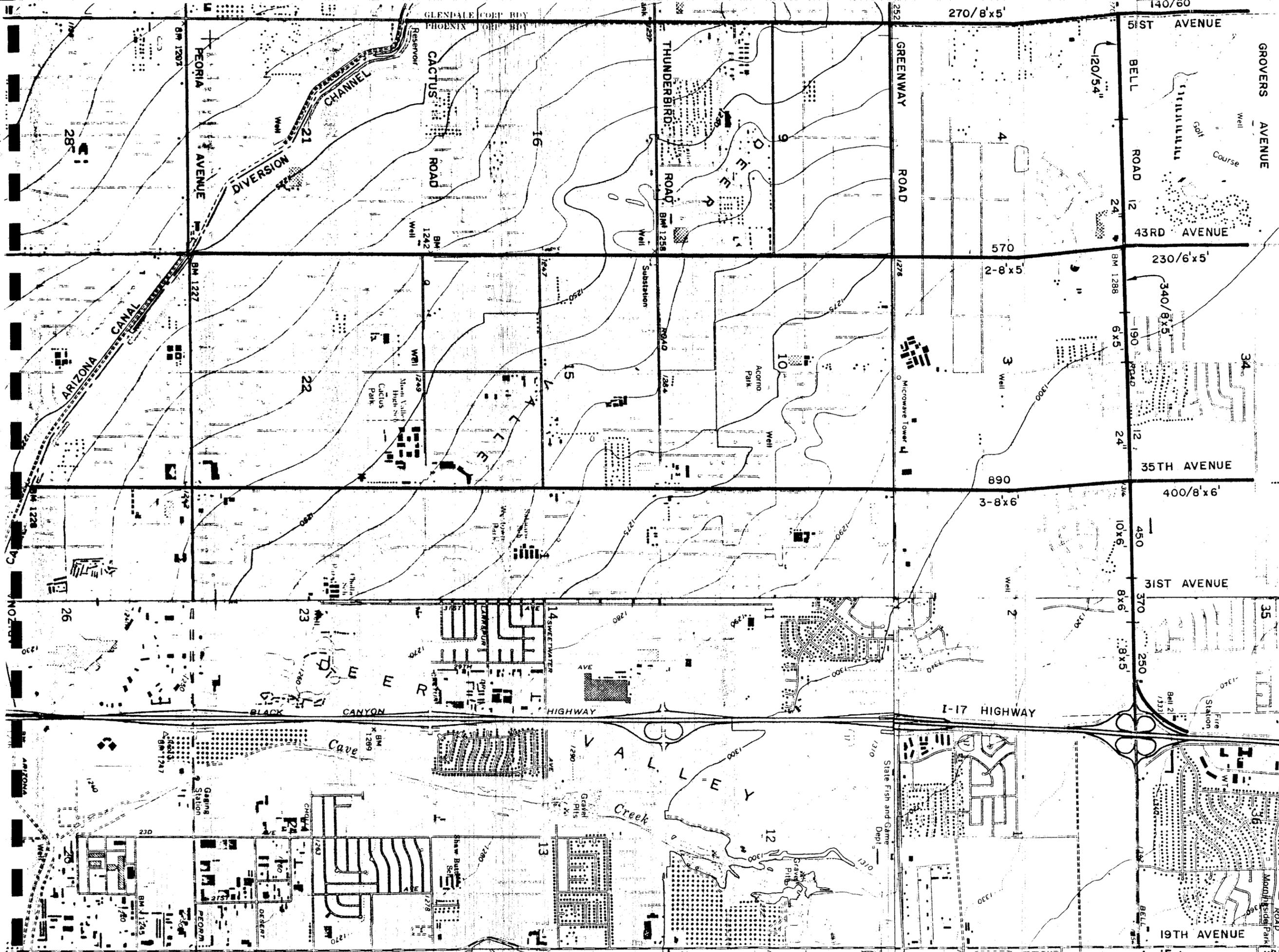
PLATE 39

ALTERNATE I

DRAINAGE AREA 4 (1 OF 2)

BELL ROAD PROJECT

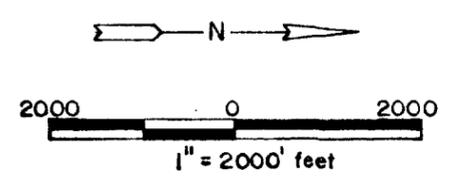
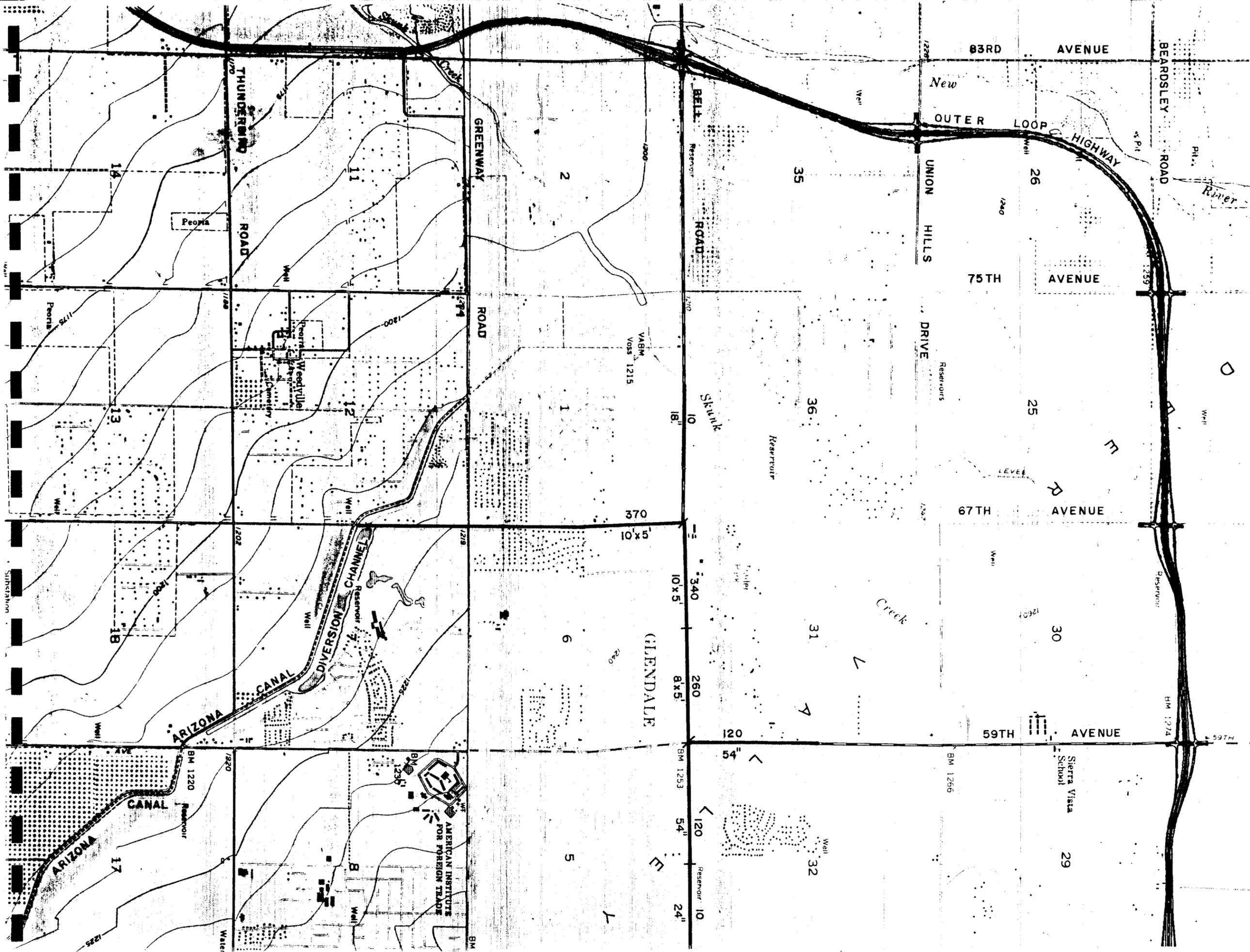
DRAINAGE STUDY



- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - ▒ DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS
- OPEN CHANNELS**
- [TW=60'] TOP WIDTH
[D = 5'] DEPTH

10 YEAR FREQUENCY STORM
 PLATE 40
 ALTERNATE 1
 DRAINAGE AREA 4 (2 OF 2)
 BELL ROAD PROJECT
 DRAINAGE STUDY

**Greiner
 Engineering**



- LEGEND**
- CONDUIT
 - OPEN CHANNEL
 - DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS

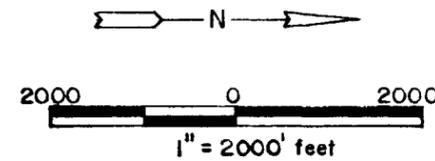
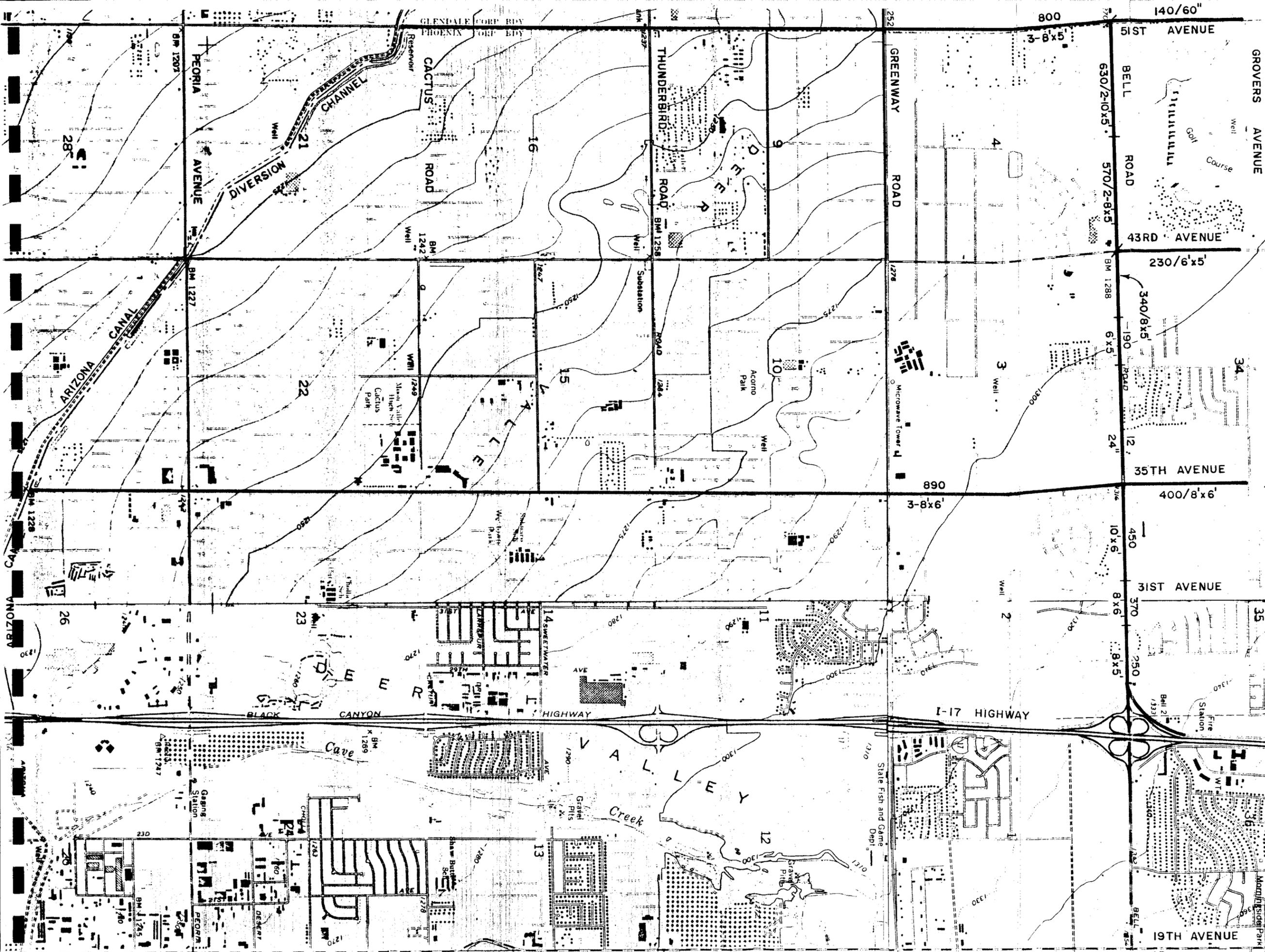
OPEN CHANNELS

[TW = 60'] TOP WIDTH
 [D = 5'] DEPTH

10 YEAR FREQUENCY STORM

PLATE 41
 ALTERNATE 2
 DRAINAGE AREA 4 (1 OF 2)
 BELL ROAD PROJECT
 DRAINAGE STUDY

**Greiner
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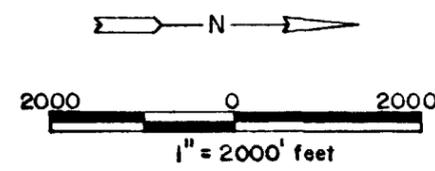
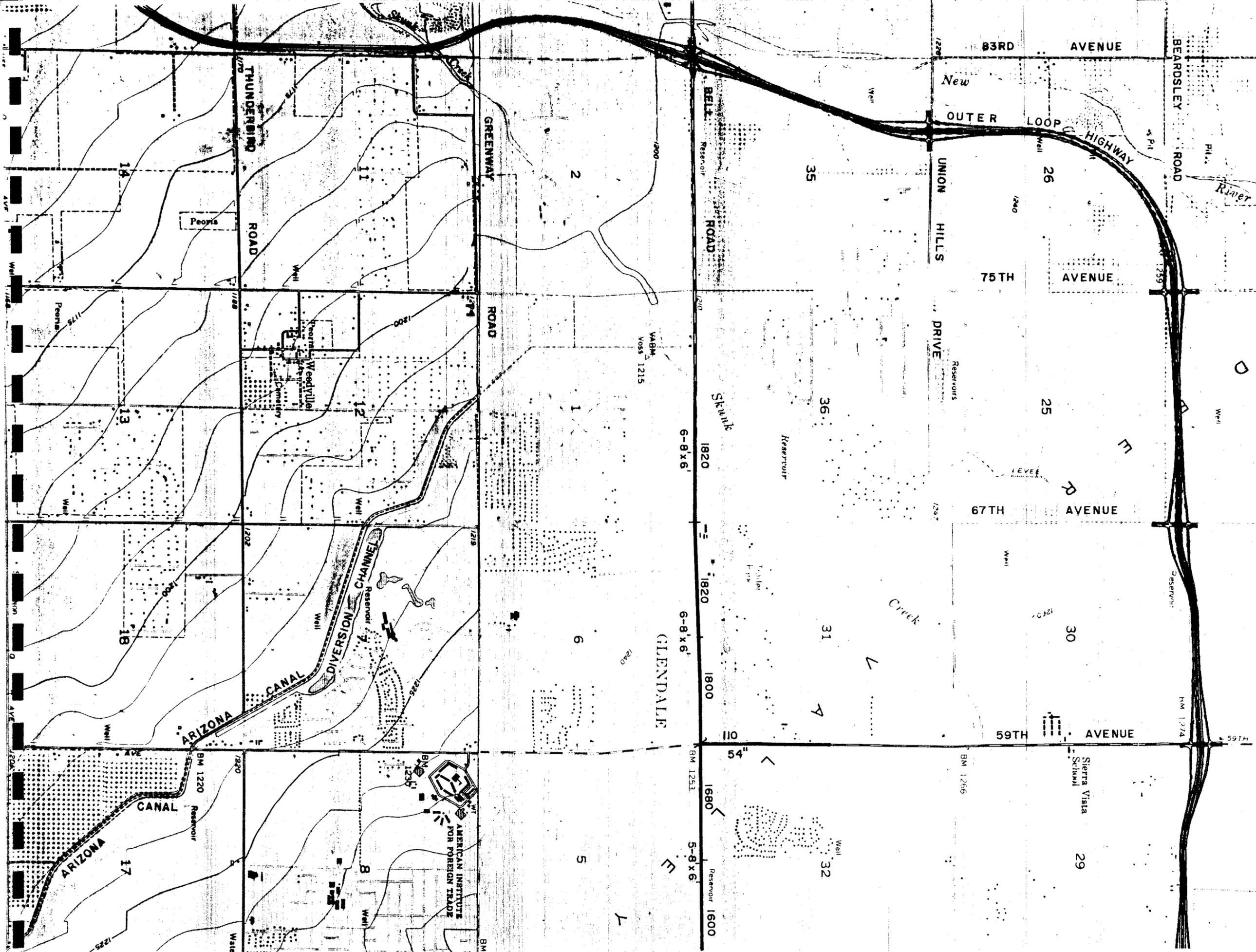
- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - ▨ DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS

OPEN CHANNELS

TW=60' TOP WIDTH
 D = 5' DEPTH

10 YEAR FREQUENCY STORM
 PLATE 42
 ALTERNATE 2
 DRAINAGE AREA 4 (2 OF 2)
 BELL ROAD PROJECT
 DRAINAGE STUDY

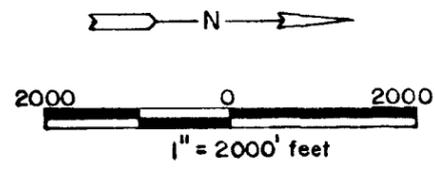
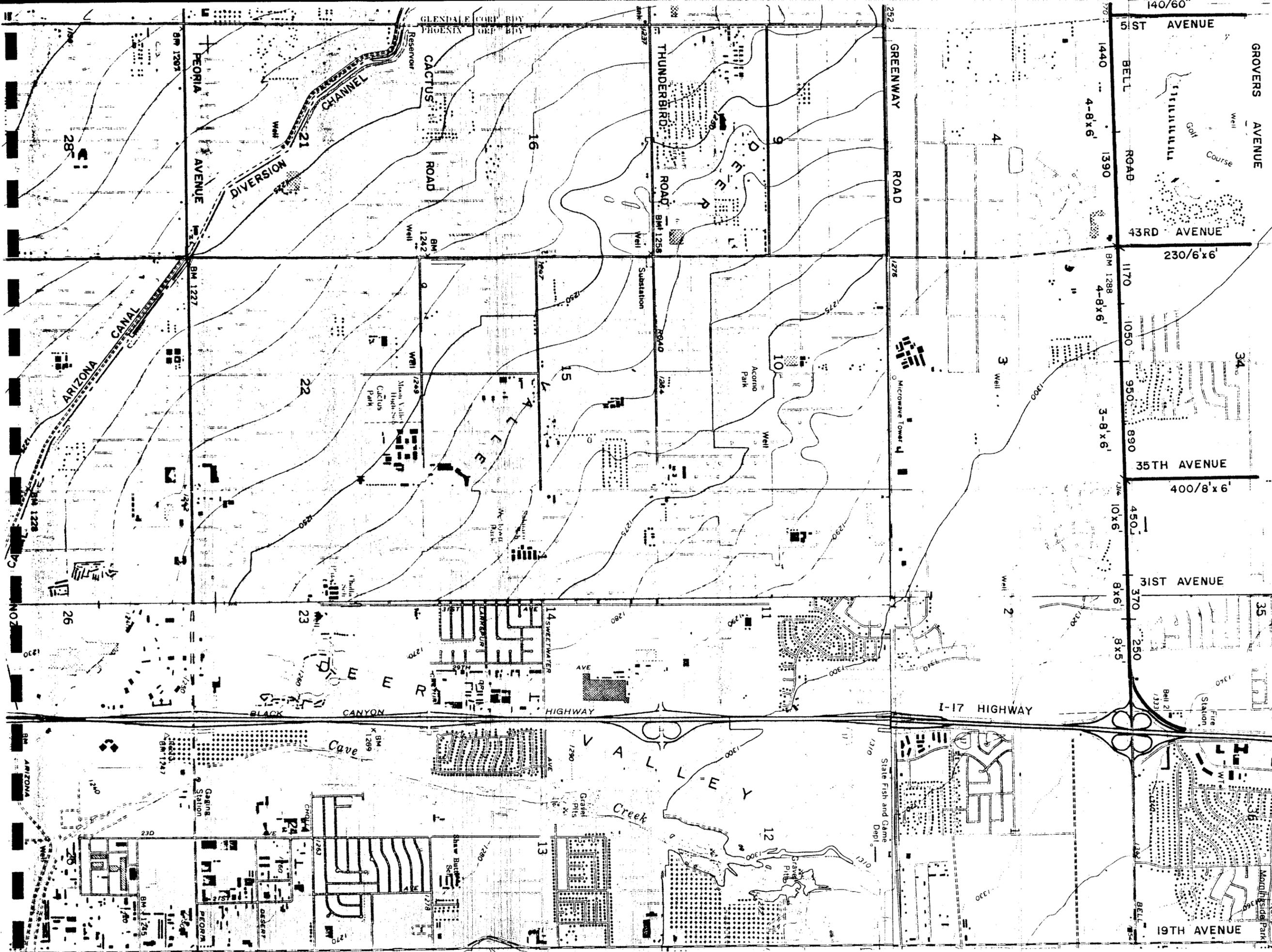
**Greiner
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- LEGEND**
- CONDUIT
 - OPEN CHANNEL
 - DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS
- OPEN CHANNELS**
- [TW=60] TOP WIDTH
[D = 5'] DEPTH

10 YEAR FREQUENCY STORM
 PLATE 43
 ALTERNATE 3
 DRAINAGE AREA 4 (1 OF 2)
 BELL ROAD PROJECT
 DRAINAGE STUDY

**Greiner
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- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - ▨ DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS

OPEN CHANNELS

[TW=60'] TOP WIDTH
 [D = 5'] DEPTH

10 YEAR FREQUENCY STORM
 PLATE 44
 ALTERNATE 3
 DRAINAGE AREA 4 (2 OF 2)
 BELL ROAD PROJECT
 DRAINAGE STUDY

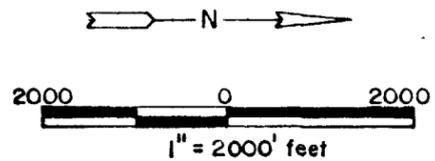
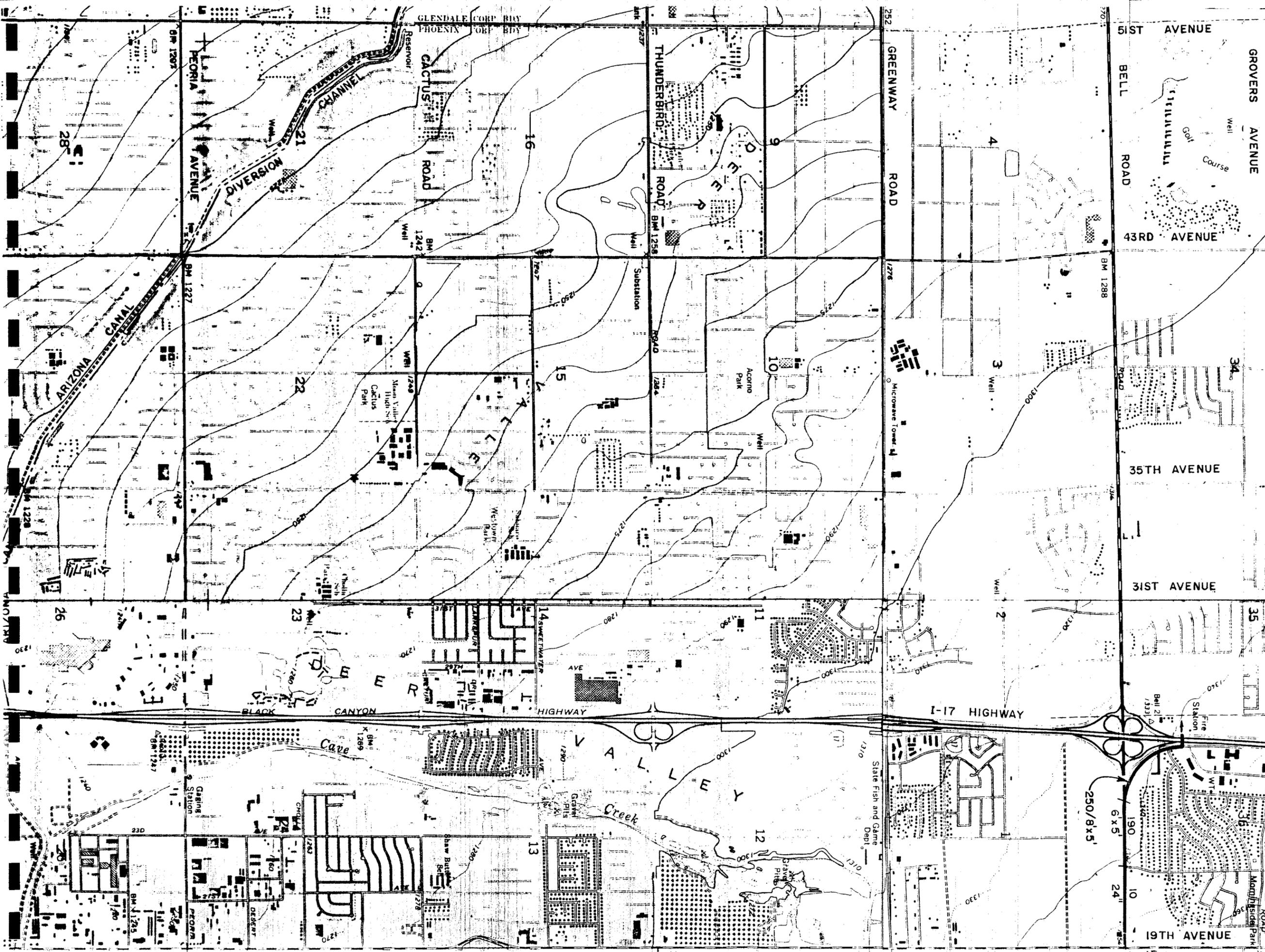
**Greiner
 Engineering**

Drainage Area 5: Off-site runoff in Drainage Area 5 concentrates at Bell Road and 19th Avenue and along Bell Road between I-17 and 21st Avenue. Only one concept plan was evaluated as it had been determined from the 100-year storm concept plan analysis that no other alternatives appeared feasible.

Alternative 1: Alternative 1 is comprised of two separate systems. Runoff concentrating along 19th Avenue between Utopia Drive and Bell Road is conveyed via box culvert storm drains to Cave Creek at 19th Avenue. A trunk storm drain will also extend east on Bell Road from 19th Avenue to 15th Avenue. Drainage concentrating at Bell Road between 21st Avenue and I-17 will be conveyed via box culvert storm drains west across I-17 to the storm drain systems described under Drainage Area 4 alternatives. The system will prevent off-site flows from flooding the depressed sections of Bell Road under I-17. The 10-year peak discharge west across I-17 would be 250 cfs. Culverts range in size from a single 6' x 4' box culvert to 3-8' x 6' box culverts.

On-site Runoff: Minor off-site and on-site runoff for Bell Road in Drainage Area 5 (I-17 to Cave Creek) will be conveyed by storm drains to the proposed off-site storm drainage systems to Cave Creek for Bell Road east of 15th Avenue. Flows entering the depressed section under I-17 will be pumped out by pumps sized for the 25-year storm event as proposed by PRC Engineering.

Refer to Plates 45 and 46 for schematics of the drainage facilities proposed for Drainage Area 5.



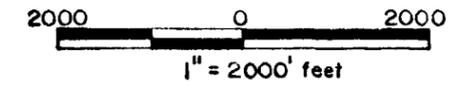
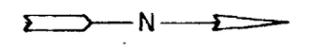
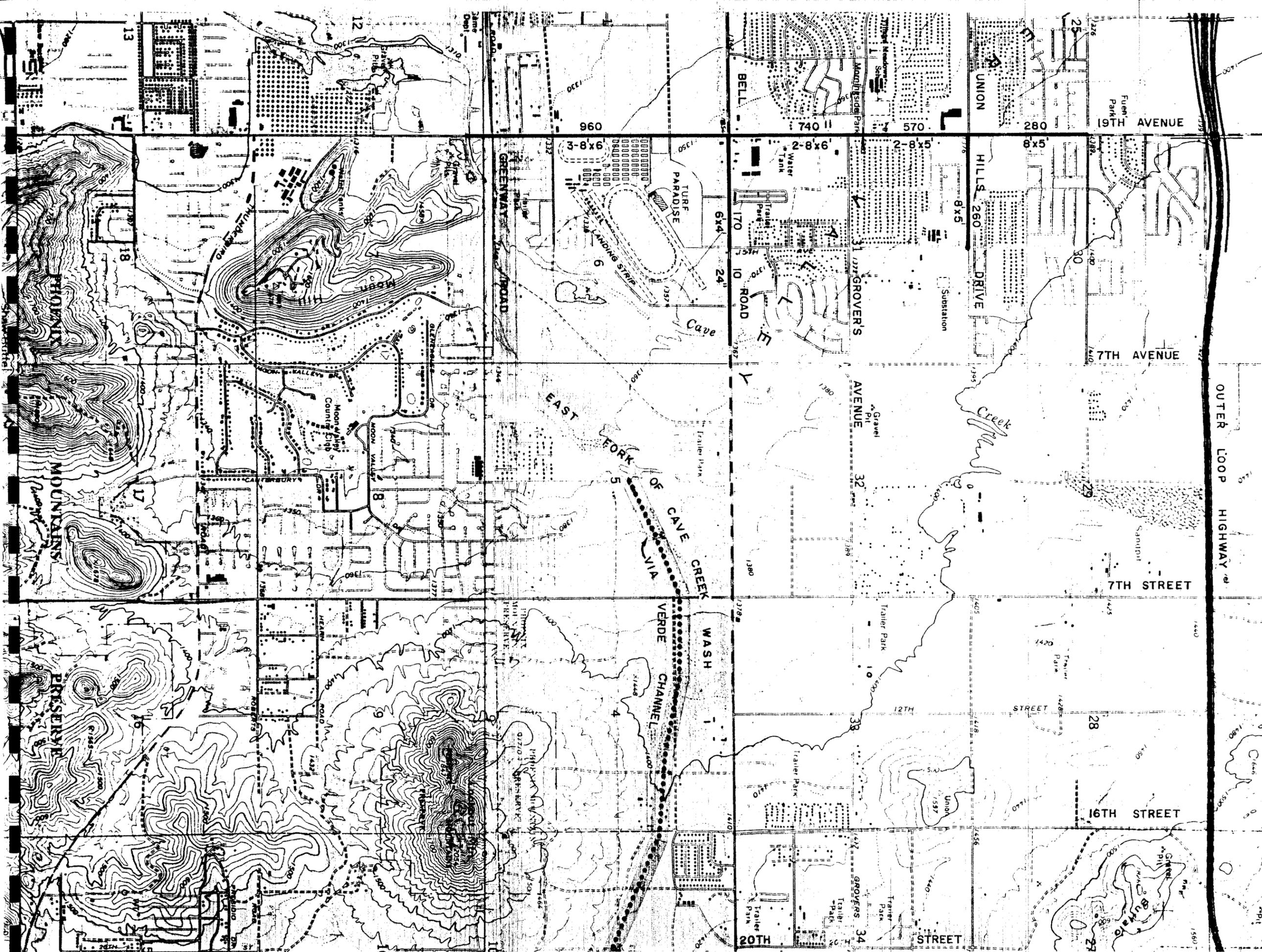
- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - ▒ DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS

OPEN CHANNELS

[TW=60'] TOP WIDTH
[D = 5'] DEPTH

10 YEAR FREQUENCY STORM
 PLATE 45
 ALTERNATE I
 DRAINAGE AREA 5 (1 OF 2)
 BELL ROAD PROJECT
 DRAINAGE STUDY

**Greiner
 Engineering**



- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - ▒ DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS

OPEN CHANNELS

[TW=60'] TOP WIDTH
 [D = 5'] DEPTH

10 YEAR FREQUENCY STORM
 PLATE 46
 ALTERNATE 1
 DRAINAGE AREA 5 (2 OF 2)
 BELL ROAD PROJECT
 DRAINAGE STUDY

**Greiner
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Drainage Area 6: Drainage Area 6 is the western portion of the East Fork of Cave Creek Wash watershed. A current study by NBS/Lowry Engineers, "Upper East Fork Cave Creek Area Drainage Master Study", has developed a drainage and flood control master plan for the 100-year storm event in this area. Per the FCD's guidance, Greiner has incorporated the NBS/Lowry proposal into the Bell Road study. Additional drainage facilities were evaluated only where required to protect Bell Road from off-site drainage not intercepted by the NBS/Lowry System. From the hydrologic modeling it was determined that drainage systems will have to be added on Central Avenue and 16th Street. Only one concept plan was evaluated for Drainage Area 6.

Alternative 1: The drainage and flood control facilities developed by NBS/Lowry and Greiner is comprised of four (4) independent systems draining to the proposed Via Verde Channel located south of Bell Road. A storm drain system will be located on Central Avenue, 7th Street and 16th Street. A combination storm drain detention basin system is proposed for 9th Street. Discharges to the Greenway Parkway channel range from 117 cfs (16th Street) to 418 cfs (9th Street). Storm drain structures range from a 54-inch pipe to a 4' x 26' box culvert. The detention basins will be located on 9th Street at Campobello Drive and Union Hills Drive.

On-Site Runoff: On-site runoff for Bell Road in Drainage Area 6 (Cave Creek to 19th Street) will be conveyed by the storm drain systems for off-site drainage to either the Greenway Parkway channel or Cave Creek.

Refer to Plate 47 for a schematic of the drainage facilities proposed for Drainage Area 6.

Drainage Area 7: Drainage Area 7 is the eastern portion of the East Fork of Cave Creek Wash watershed. Drainage and flood control facilities proposed by NBS/Lowry were also incorporated by Greiner in this area. Three alternative plans were evaluated.

Alternative 1: The drainage facilities developed by NBS/Lowry were adopted with no modifications. Two separate systems conveying runoff to the proposed Greenway Parkway Channel comprise this alternative.

One system intercepts flows in the primary flood plain of the East Fork of Cave Creek Wash. This system consists of a detention basin located along the northern right-of-way of Beardsley Road and 26th Street (not shown on Plate 47) and a basin located at the northwest corner of Grovers Avenue and Cave Creek Road. The basin at Grovers Avenue discharges into an open channel which conveys flows along 20th Street to the Greenway Parkway channel. A storm drain extending from 28th Street to 20th Street along Bell Road discharges flows into the channel along 20th Street. The peak discharge into the Greenway Parkway channel would be 1.125 cfs.

The second system is comprised of storm drains along Union Hills Drive, Grovers Avenue, Bell Road and Paradise Lane that conveys runoff to a storm drain along 32nd Street. A detention basin will be located at the northeast corner of Grovers Avenue and 32nd Street. A second basin will be located south of Paradise Lane between Cave Creek Road and 26th Street. Outflows from the latter basin will discharge into the Greenway Parkway channel. The 10-year peak discharge at Bell road and 29th street would be 199 cfs.

Refer to plates 47 and 48 for schematics of the drainage facilities proposed for alternative 1.

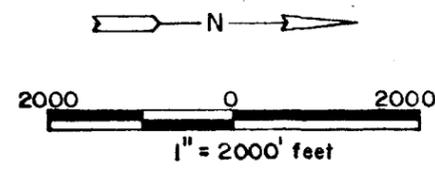
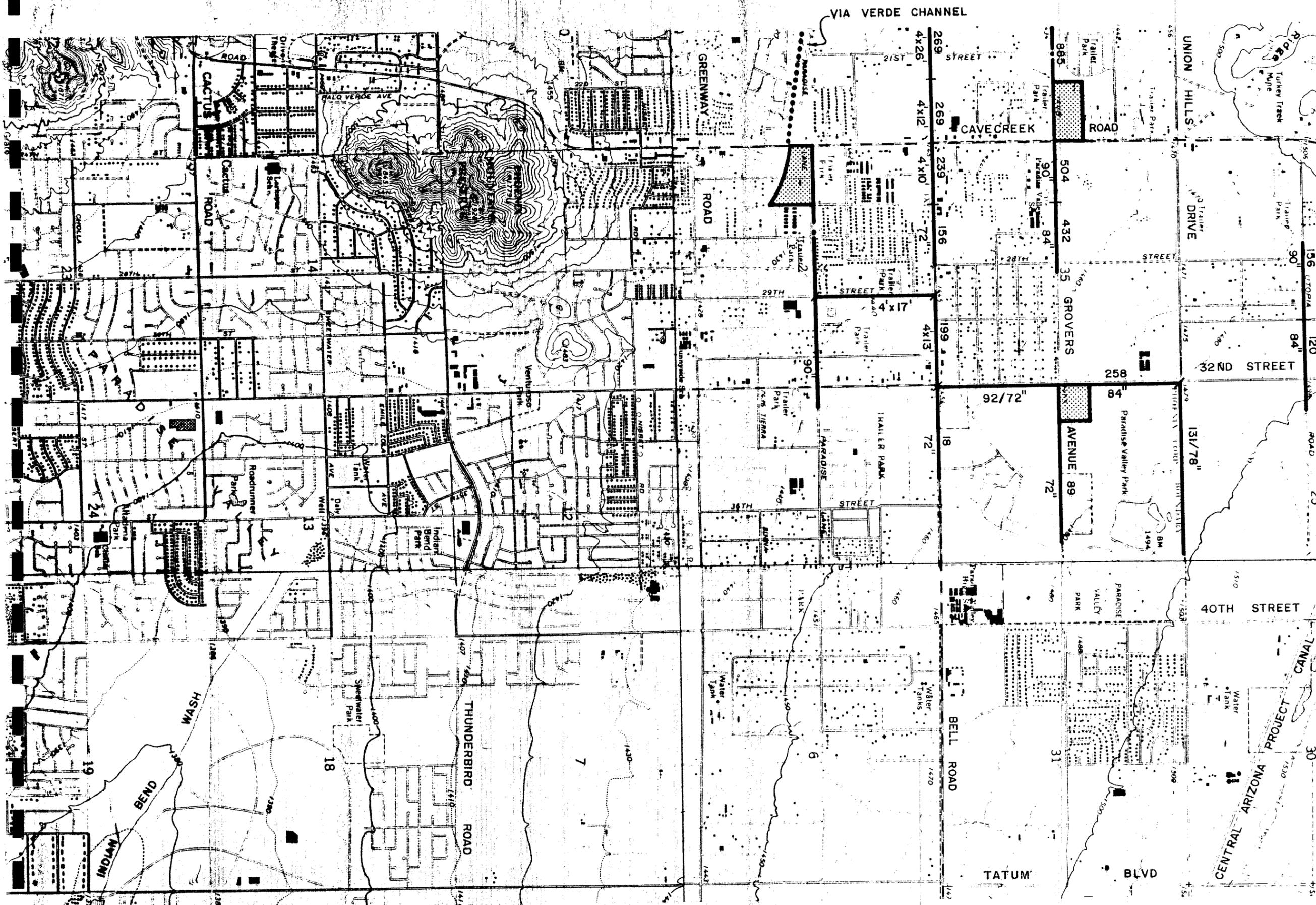
Alternative 2: Alternative 2 is similar to Alternative 1 with an extension added to the NBS/Lowry storm drain along Bell Road from 35th Street to just west of 40th Street. This extension will replace the storm drain along 36th Street from Bell Road to the Indian Bend Wash proposed in the Drainage Area 8 alternatives (see the following pages). The 10-year peak discharge at Bell Road and 29th Street would be 578 cfs.

Refer to Plate 49 for a schematic of the drainage facilities proposed for Alternative 2.

Alternative 3: Alternative 3 is similar to Alternative 2 with the addition of a detention basin located north of Grovers Avenue on the 38th Street alignment (Paradise Valley Park). The 10-year peak discharge at Bell Road and 29th Street would be 343 cfs.

Refer to Plate 50 for a schematic of the drainage facilities proposed for Alternative 3.

On-site Runoff: On-site runoff from Bell Road in Drainage Area 7 (20th Street to 35th Street) will be conveyed by the off-site drainage system for discharge into the Greenway Parkway channel.



- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - ▨ DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8x3' STRUCTURE SIZE
 - 72" FOR CONDUITS

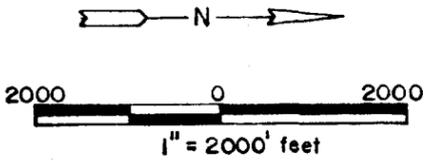
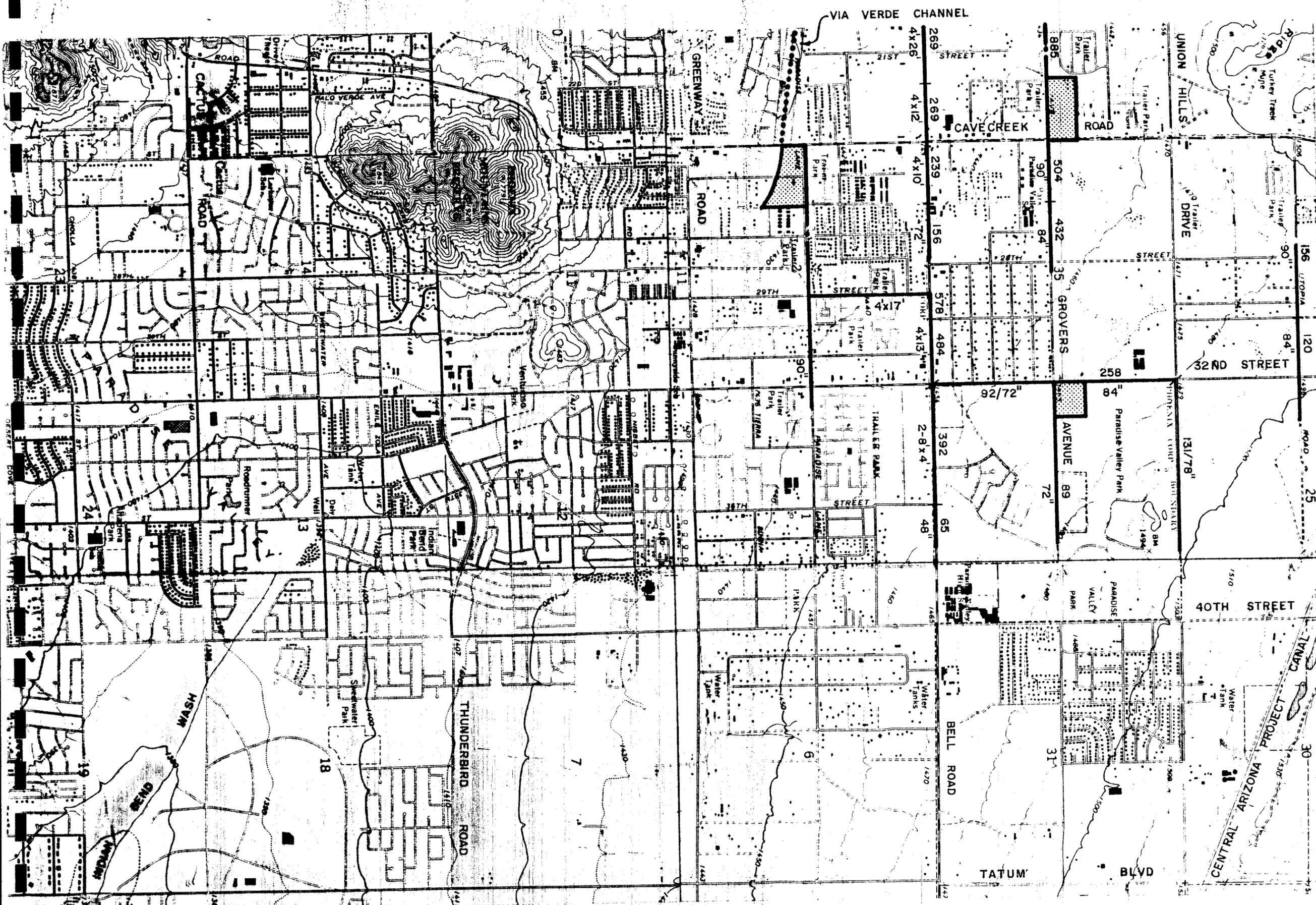
OPEN CHANNELS

[TW = 60] TOP WIDTH
 [D = 5'] DEPTH

10 YEAR FREQUENCY STORM

PLATE 48
 ALTERNATE 1
 DRAINAGE AREA 7
 BELL ROAD PROJECT
 DRAINAGE STUDY

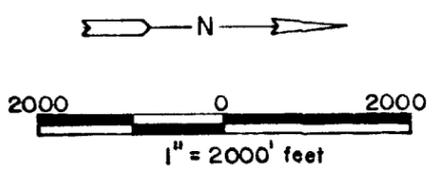
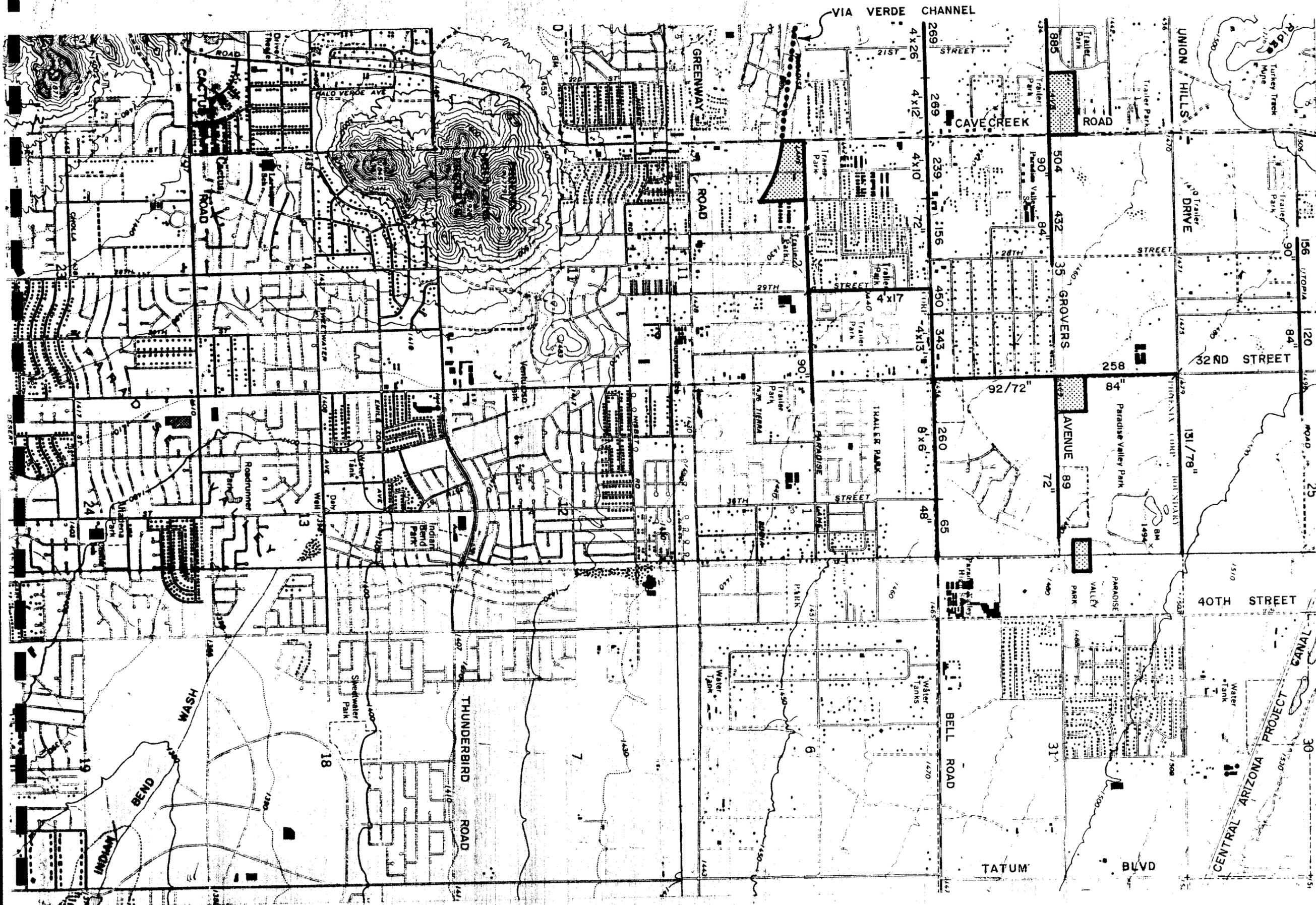
**Greiner
 Engineering**



- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - ▒ DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS
- OPEN CHANNELS**
- [TW=60'] TOP WIDTH
[D = 5'] DEPTH

10 YEAR FREQUENCY STORM
 PLATE 49
 ALTERNATE 2
 DRAINAGE AREA 7
 BELL ROAD PROJECT
 DRAINAGE STUDY

**Greiner
 Engineering**



- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - ▨ DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS

OPEN CHANNELS

[TW=60'] TOP WIDTH
 [D = 5'] DEPTH

10 YEAR FREQUENCY STORM
 PLATE 50
 ALTERNATE 3
 DRAINAGE AREA 7
 BELL ROAD PROJECT
 DRAINAGE STUDY

**Greiner
 Engineering**

Drainage Area 8: Major off-site flows concentrate along Bell Road in Drainage Area 8 at 36th Street, 40 Street, 44th Street, Tatum Boulevard and 56th Street. Five alternative drainage concepts were evaluated.

Alternative 1: Alternative 1 is comprised of four storm drain systems with outfalls to the Indian Bend Wash (IBW). Systems are proposed for 36th Street, 40th Street, Tatum Boulevard and 52nd Street. Trunk lines will extend along Bell Road and/or to the north of Bell Road as required to intercept off-site drainage. The 10-year peak discharges to the IBW range from 245 cfs (Tatum Boulevard) to 742 cfs (40th Street). Storm drain sizes range from a 24-inch pipe to 2-10' x 5' box culverts.

Refer to Plates 51 and 52 for schematics of the drainage facilities proposed for Alternative 1.

Alternative 2: Alternative 2 is similar to Alternative 1 with the addition of a detention basin at the southwest corner of Tatum Boulevard and Bell Road and a basin north of Grovers Avenue on the 38th Street alignment (Paradise Valley Park). The detention basin at Tatum Boulevard reduces the 10-year discharge from 245 cfs to 39 cfs. The basin on 38th Street reduces the peak discharge at Bell Road and 36th Street from 322 cfs to 52 cfs.

Refer to Plates 53 and 54 for schematics of the drainage facilities proposed for Alternative 2.

Alternative 3: Alternative 3 is similar to Alternative 1 except that open channels rather than storm drains have been utilized to intercept off-site runoff along Bell Road. Channel sizes will range from 2 to 7 feet in depth and from 20 to 58 feet in top width.

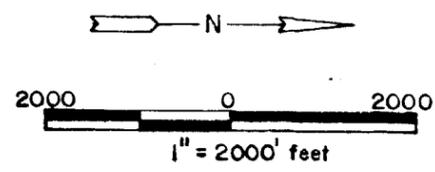
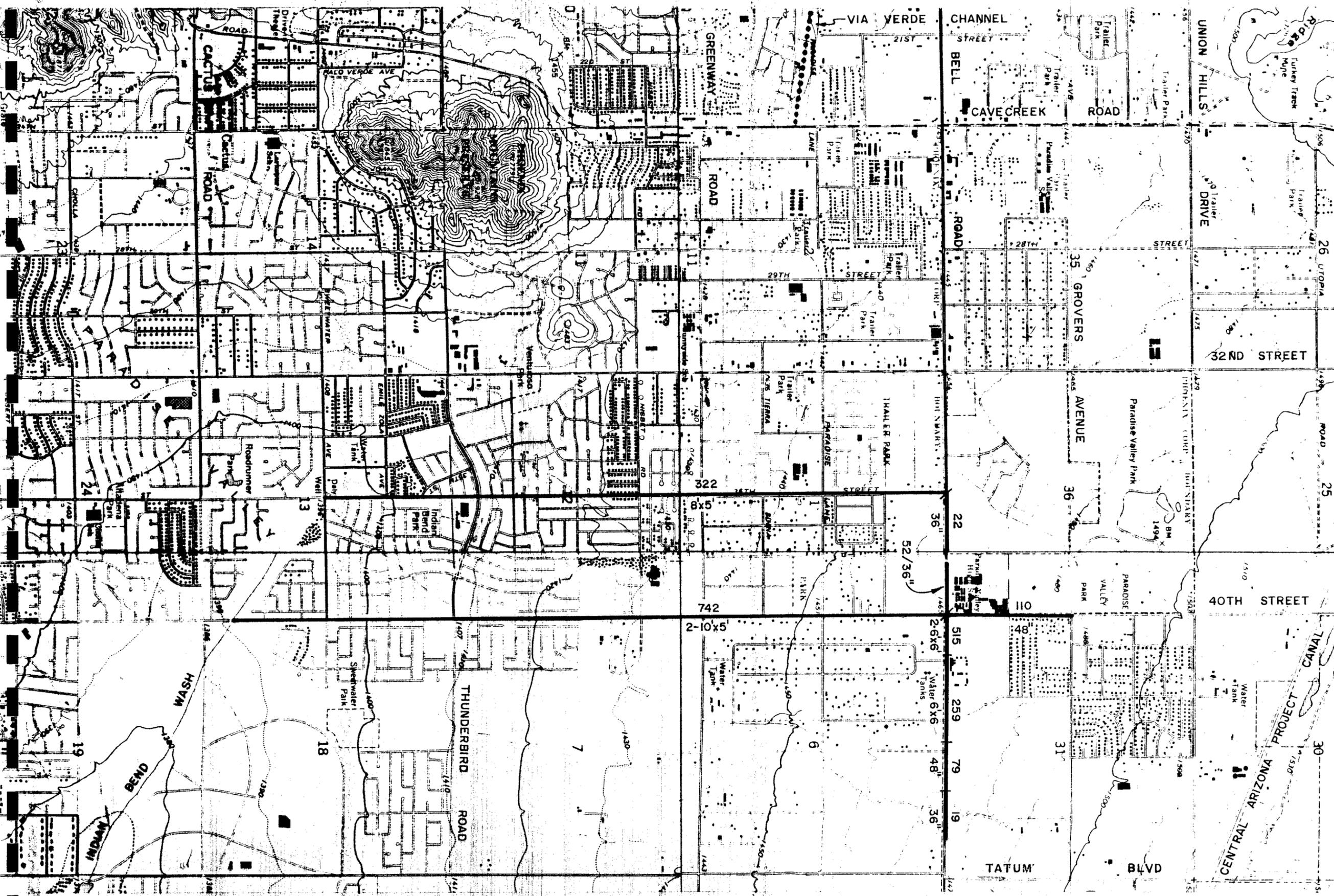
Refer to Plates 55 and 56 for schematics of the drainage facilities proposed for Alternative 3.

Alternative 4: Alternative 4 is similar to Alternatives 1 and 3 except that all off-site drainage concentrating along Bell Road west of 40th Street is conveyed to the 32nd Street storm drain system proposed by NBS/Lowry. This alternative has also been described under Alternative 2 for Drainage Area 7.

Refer to Plate 49 for a schematic of the drainage facilities proposed for Alternative 4.

Alternative 5: Alternative 5 is similar to Alternative 2 except that all off-site drainage concentrating along Bell Road west of 40th Street is conveyed to the 32nd Street storm drain system proposed by NBS/ Lowry. This alternative has also been described under Alternative 3 for Drainage Area 7.

Refer to Plate 50 for a schematic of the drainage facilities proposed for Alternative 5.



- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - ▒ DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS
- OPEN CHANNELS**
- [TW=60'] TOP WIDTH
 - [D = 5'] DEPTH

10 YEAR FREQUENCY STORM

PLATE 51

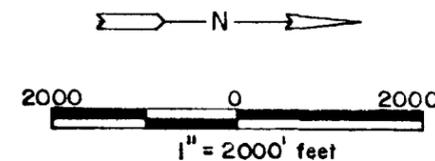
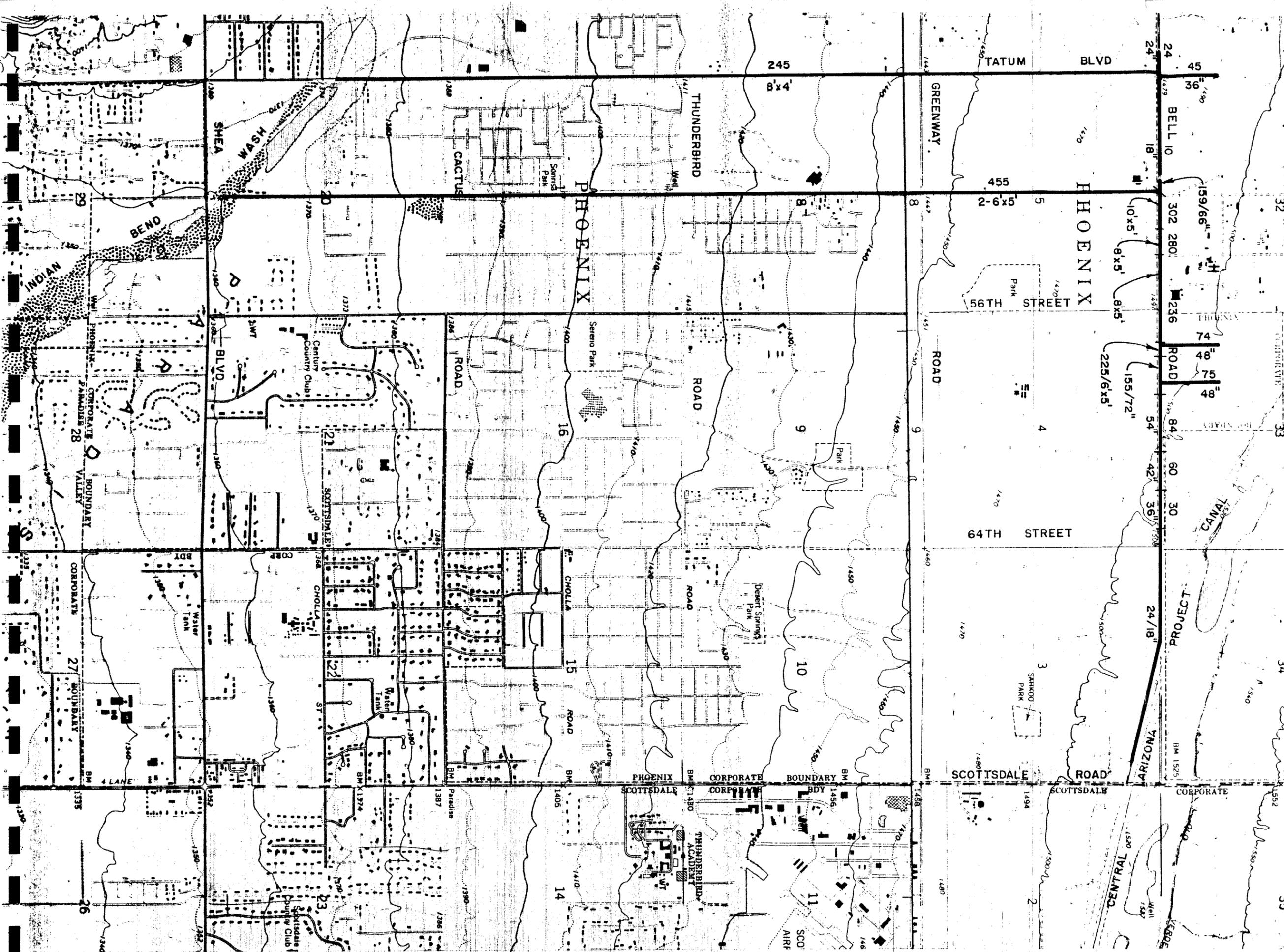
ALTERNATE 1

DRAINAGE AREA 8 (1 OF 2)

BELL ROAD PROJECT

DRAINAGE STUDY

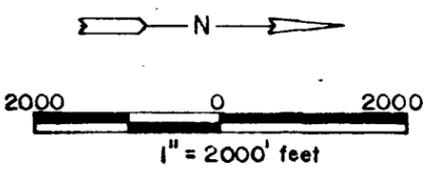
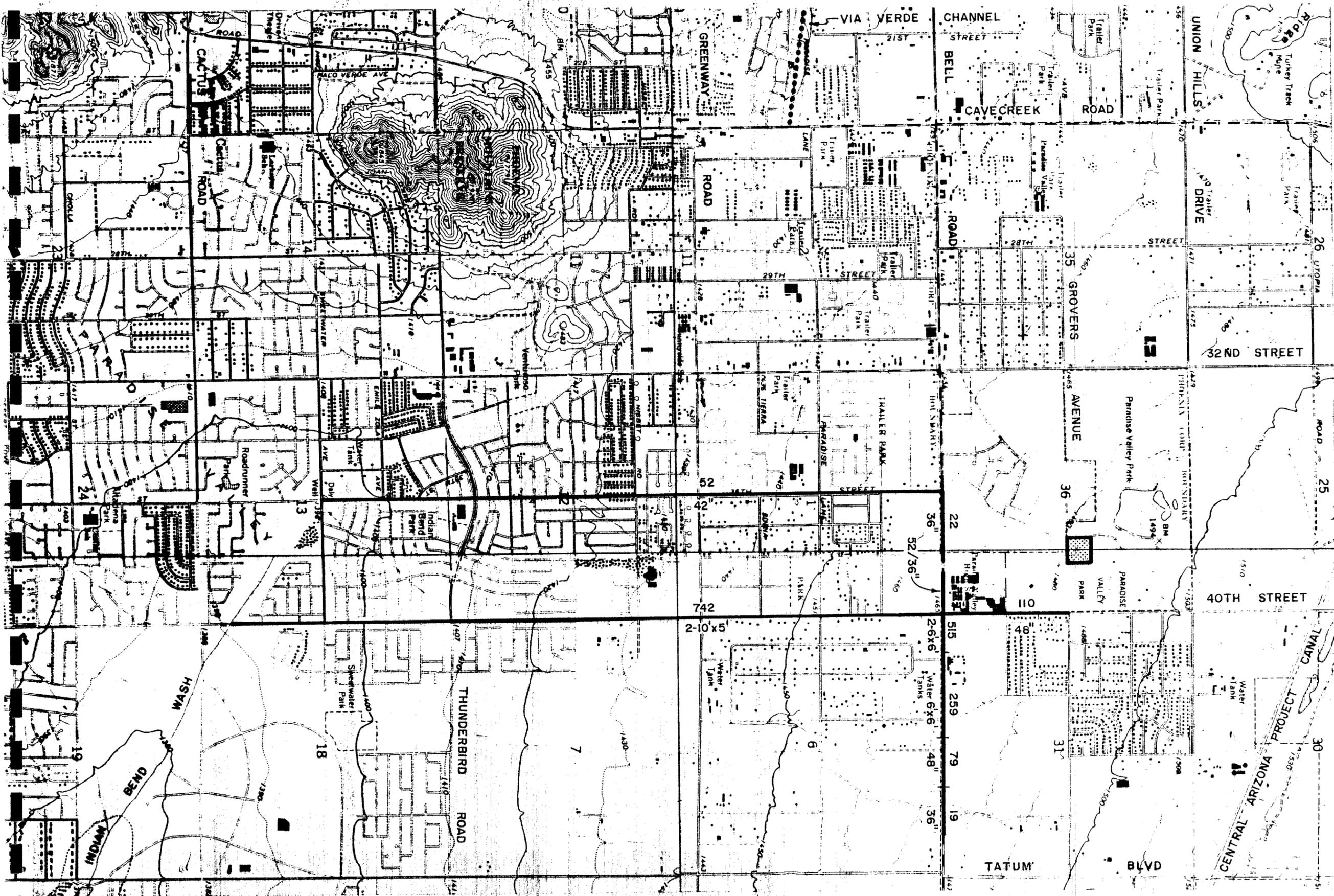
Greiner Engineering



- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - ▨ DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS
- OPEN CHANNELS**
- [TW=60'] TOP WIDTH
 [D = 5'] DEPTH

10 YEAR FREQUENCY STORM
 PLATE 52
 ALTERNATE 1
 DRAINAGE AREA 8 (2 OF 2)
 BELL ROAD PROJECT
 DRAINAGE STUDY

**Greiner
 Engineering**



- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - ▒ DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8x3' STRUCTURE SIZE
 - 72" FOR CONDUITS

OPEN CHANNELS

[TW=60'] TOP WIDTH
[D = 5'] DEPTH

10 YEAR FREQUENCY STORM

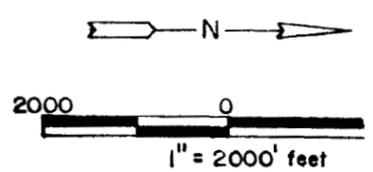
PLATE 53

ALTERNATE 2

DRAINAGE AREA 8 (1 OF 2)

BELL ROAD PROJECT

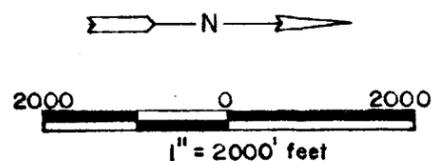
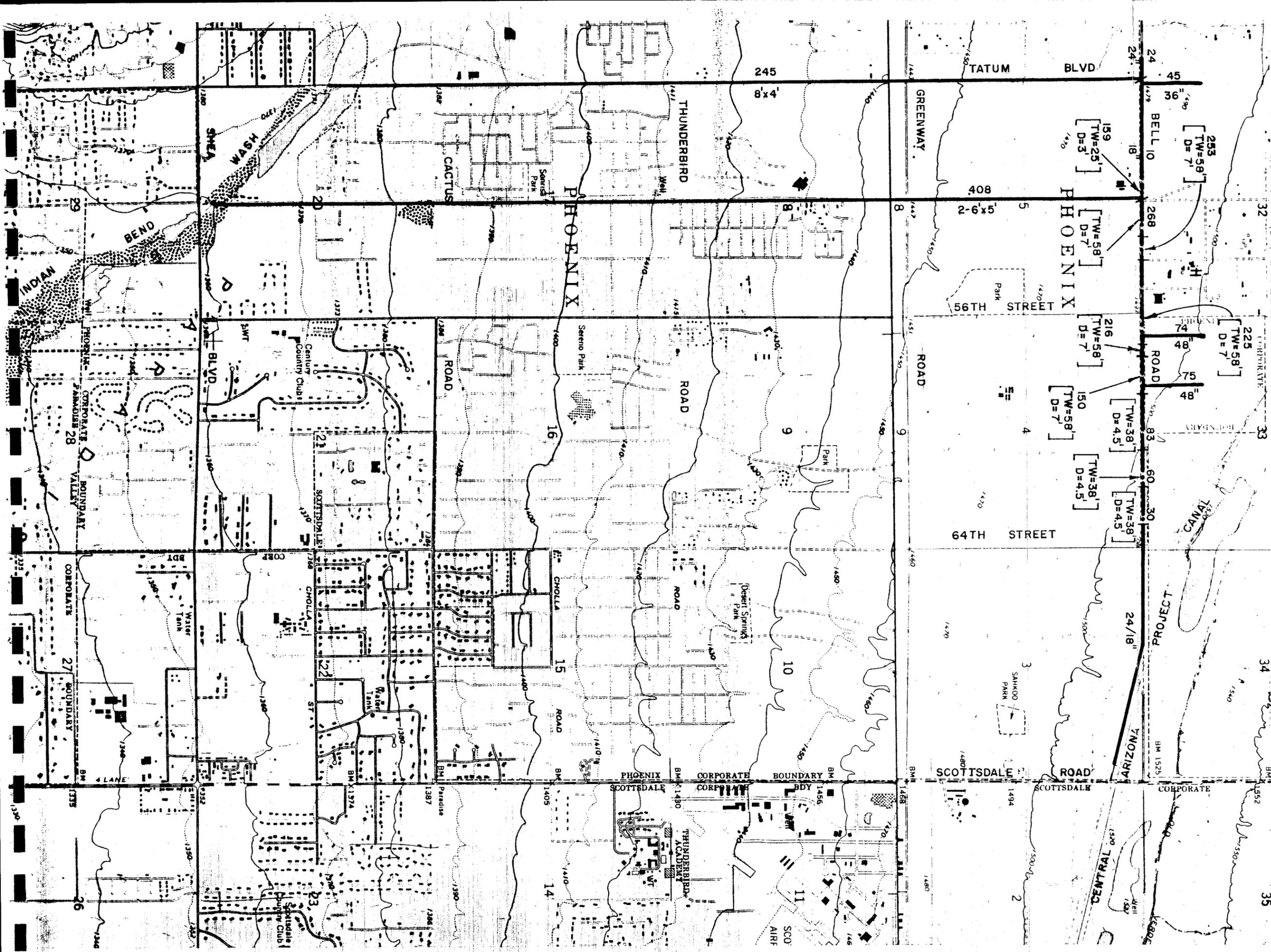
DRAINAGE STUDY



- LEGEND**
- CONDUIT
 - - - OPEN CHANNEL
 - ▨ DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS
- OPEN CHANNELS**
- [TW=60'] TOP WIDTH
[D = 5'] DEPTH

10 YEAR FREQUENCY STO
 PLATE 54
 ALTERNATE 2
 DRAINAGE AREA 8 (2 OF
 BELL ROAD PROJECT
 DRAINAGE STUDY

**Greiner
 Engineering**



- LEGEND**
- CONDUIT
 - OPEN CHANNEL
 - DETENTION BASIN
 - 690 PEAK FLOW IN CFS
 - 2-8'x3' STRUCTURE SIZE
 - 72" FOR CONDUITS
- OPEN CHANNELS**
- [TW=60'] TOP WIDTH
 - [D = 5'] DEPTH

10' YEAR FREQUENCY STORM
 PLATE 56
 ALTERNATE 3
 DRAINAGE AREA 8 (2 OF 2)
 BELL ROAD PROJECT
 DRAINAGE STUDY

**Greiner
 Engineering**

Drainage Area 9: Drainage Area 9 is the Skunk Creek channel and floodplain. It was determined from the most current flood boundary maps, dated 1983, that the 100-year flood is contained within Skunk Creek at Bell Road.

On-Site Runoff: On-site runoff will be conveyed from 73rd Avenue to Skunk Creek via an 18-inch storm drain. If Alternative 3 is implemented for Drainage Area 4 the off-site drainage system for Drainage Area 4 will convey on-site runoff for Drainage Area 9. Refer to Plates 39, 41 and 43.

Drainage Area 10: Drainage Area 10 is the Cave Creek channel and floodplain. According to the floodplain maps, dated April 25, 1978, the 100-year floodplain is approximately 900 feet wide at Bell Road. The existing structure at Bell Road and Cave Creek is inadequate to protect Bell Road from the 100-year flood. A 900 foot long bridge was evaluated to span the floodplain (see Plate 47).

New River and Agua Fria River: It was determined from current flood boundary maps that the 100-year floods on the New River and the Agua Fria River will be conveyed under Bell Road within the existing bridges.

XI. EVALUATION OF ALTERNATE STORMWATER/FLOODWATER MANAGEMENT CONCEPTS PLANS, 10-YEAR STORM EVENT

The alternative concept plans were evaluated and ranked in terms of capital costs, effectiveness, environmental impacts, potential for staged construction, acceptability to municipalities and compatibility with other projects and plans. Matrix tables with numerical ranking from one to ten were developed for comparisons of the alternative concepts for each drainage area. These tables are found on pages 160 through 167.

A. Capital Costs

Costs for all alternative concept plans were developed for construction, engineering, administration and land acquisition. Construction costs for the on-site and off-site drainage systems included the costs for storm drain trunkline conduit (concrete pipe or box culvert) and excavation (channels and detention basins).

Unit costs for concrete pipe, box culverts and excavation were derived from unit costs recently developed for preliminary cost estimates for the Outer Loop Highway. The unit costs for conduit include the cost of installation. All costs are in 1986 dollars.

Thirty percent was added to the estimated construction costs for the on-site and off-site drainage facilities to include costs associated with appurtenances to the trunk system such as outlet or inlet works, junction structures, manholes, laterals, catch basins, erosion protection, bank stabilization, minor street reconstruction, minor utility relocation, conflict resolutions, etc. This fee was estimated on the basis of recently completed roadway drainage and flood control design projects.

Twenty percent of the construction costs was added for engineering and administration to cover the costs for survey, design, contract administration, field engineering and inspection services.

Land acquisition costs for additional right-of-way for open channels and detention basins were based on per acre values derived from either current County Assesors records and/or information recently developed by the City of Glendale for the "Glendale Storm Water Management Plan."

A factor of twenty percent was then added for contingency costs to reflect the effects of unknown potential difficulties or changes during final design and construction. This cost was added to the above mentioned costs. Estimated costs did not include the following:

- o Major utility relocations
- o Major street reconstruction
- o Landscaping and maintenance

A rank of ten was given to the most cost effective alternative for each drainage area. Rankings for the other alternatives within each drainage area were based on their cost ratio to the most cost effective alternative. The costs for each alternative concept plan for each of the drainage areas are summarized in the following pages.

TABLE 19
 ESTIMATED COSTS
DRAINAGE AREA 1
 10-YEAR FREQUENCY STORM

	<u>Alt. 1</u>
On-Site Drainage Facilities	\$ 510,000
Off-Site Drainage Facilities	40,000
30% Appurtenances	170,000
20% Engineering & Administration	140,000
<hr/>	
Sub-Total	\$ 860,000
Land Acquisition	Ø
<hr/>	
Sub-Total	\$ 860,000
20% Contingency	170,000
<hr/>	
Total Estimated Cost	\$1,030,000

TABLE 20
ESTIMATED COSTS
DRAINAGE AREA 2
10-YEAR FREQUENCY STORM

	<u>Alt. 1</u>	<u>Alt. 2</u>	<u>Alt. 3</u>	<u>Alt. 4</u>
On-Site Drainage Facilities	\$ 700,000	\$ 700,000	\$ 700,000	\$ 700,000
Off-Site Drainage Facilities	9,860,000	4,730,000	8,150,000	4,980,000
30% Appurtenances	3,170,000	1,630,000	2,660,000	1,700,000
20% Engineering & Administration	2,750,000	1,410,000	2,300,000	1,480,000
Sub-Total	\$16,480,000	\$ 8,470,000	\$13,810,000	\$ 8,860,000
Land Acquisition	2,830,000	3,360,000	1,360,000	2,380,000
Sub-Total	\$19,310,000	\$11,830,000	\$15,170,000	\$11,240,000
20% Contingency	3,860,000	2,370,000	3,030,000	2,250,000
Total Estimated Cost	\$23,170,000	\$14,200,000	\$18,200,000	\$13,490,000

TABLE 21
ESTIMATED COSTS
DRAINAGE AREA 3
10-YEAR FREQUENCY STORM

	<u>Alt. 1</u>	<u>Alt. 2</u>	<u>Alt. 3</u>	<u>Alt. 4</u>	<u>Alt. 5</u>
On-Site Drainage Facilities	\$ *	\$ *	\$ *	\$ *	\$ 110,000
Off-Site Drainage Facilities	1,270,000	550,000	2,640,000	620,000	1,010,000
30% Appurtenances	380,000	170,000	790,000	190,000	340,000
20% Engineering & Administration	330,000	140,000	690,000	160,000	290,000
Sub-Total	\$1,980,000	\$ 860,000	\$4,120,000	\$ 970,000	\$1,750,000
Land Acquisition	Ø	1,200,000	Ø	2,400,000	Ø
Sub-Total	\$1,980,000	\$2,060,000	\$4,120,000	\$3,370,000	\$1,750,000
20% Contingency	400,000	410,000	820,000	670,000	350,000
Total Estimated Cost	\$2,380,000	\$2,470,000	\$4,940,000	\$4,040,000	\$2,100,000

*On-site drainage is conveyed by the off-site facilities.

TABLE 22
ESTIMATED COSTS
DRAINAGE AREA 4
10-YEAR FREQUENCY STORM

	<u>Alt. 1</u>	<u>Alt. 2</u>	<u>Alt. 3</u>
On-Site Drainage Facilities	\$ 470,000*	\$ 260,000*	\$ 0
Off-Site Drainage Facilities	36,080,000	35,480,000	24,230,000
30% Appurtenances	10,970,000	10,720,000	7,270,000
20% Engineering & Administration	9,500,000	9,290,000	6,300,000
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Sub-Total	\$57,020,000	\$55,750,000	\$37,800,000
Land Acquisition	0	0	0
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Sub-Total	\$57,020,000	\$55,750,000	\$37,800,000
20% Contingency	11,400,000	11,150,000	7,560,000
<hr/>			
Total Estimated Cost	\$68,420,000	\$66,900,000	\$45,360,000

*Includes cost for conveyance of on-site runoff from Drainage Area 9 to Skunk Creek.

TABLE 23
 ESTIMATED COSTS
DRAINAGE AREA 5
 10-YEAR FREQUENCY STORM

	<u>Alt. 1</u>
On-Site Drainage Facilities	\$ 150,000
Off-Site Drainage Facilities	8,160,000
30% Appurtenances	2,490,000
20% Engineering & Administration	2,160,000
<hr/>	
Sub-Total	\$12,960,000
Land Acquisition	Ø
<hr/>	
Sub-Total	\$12,960,000
20% Contingency	2,590,000
<hr/>	
Total Estimated Cost	\$15,550,000

TABLE 24
ESTIMATED COSTS
DRAINAGE AREA 6*
10-YEAR FREQUENCY STORM

	<u>Alt. 1</u>
On-Site Drainage Facilities	\$ **
Off-Site Drainage Facilities	8,380,000
30% Appurtenances	2,510,000
20% Engineering & Administration	2,180,000
<hr/>	
Sub-Total	\$13,070,000
Land Acquisition	3,520,000
<hr/>	
Sub-Total	\$16,590,000
20% Contingency	3,320,000
<hr/>	
Total Estimated Cost	\$19,910,000

*Includes cost of facilities proposed by NBS/Lowry.

**On-site drainage conveyed by the off-site facilities.

TABLE 25
ESTIMATED COSTS
DRAINAGE AREA 7*
10-YEAR FREQUENCY STORM

	<u>Alt. 1</u>	<u>Alt. 2</u>	<u>Alt. 3</u>
On-Site Drainage Facilities	\$ **	\$ **	\$ **
Off-Site Drainage Facilities	9,390,000	10,930,000	9,920,000
30% Appurtenances	2,820,000	3,280,000	2,980,000
20% Engineering & Administration	2,440,000	2,840,000	2,580,000
<hr/>			
Sub-Total	\$14,650,000	\$17,050,000	\$15,480,000
Land Acquisition	3,760,000	3,760,000	3,760,000
<hr/>			
Sub-Total	\$18,410,000	\$20,810,000	\$19,240,000
20% Contingency	3,680,000	4,160,000	3,850,000
<hr/>			
Total Estimated Cost	\$22,090,000	\$24,970,000	\$23,090,000

*Includes cost of facilities proposed by NBS/Lowry.

**On-site drainage conveyed by the off-site facilities.

TABLE 26
ESTIMATED COSTS
DRAINAGE AREA 8
10-YEAR FREQUENCY STORM

	<u>Alt. 1</u>	<u>Alt. 2</u>	<u>Alt. 3</u>	<u>Alt. 4</u>	<u>Alt. 5</u>
On-Site Drainage Facilities	\$ 230,000	\$ 230,000	\$ 230,000	\$ 230,000	\$ 230,000
Off-Site Drainage Facilities	24,430,000	20,200,000	21,330,000	21,350,000	18,980,000
30% Appurtenances	7,400,000	6,130,000	6,470,000	6,470,000	5,760,000
20% Engineering & Administration	6,410,000	5,310,000	5,610,000	5,610,000	4,990,000
<hr/> Sub-Total	<hr/> \$38,470,000	<hr/> \$31,870,000	<hr/> \$33,640,000	<hr/> \$33,660,000	<hr/> \$29,960,000
Land Acquisition	Ø	1,230,000	790,000	Ø	1,230,000
<hr/> Sub-Total	<hr/> \$38,470,000	<hr/> \$33,100,000	<hr/> \$34,430,000	<hr/> \$33,660,000	<hr/> \$31,190,000
20% Contingency	7,690,000	6,620,000	6,890,000	6,730,000	6,240,000
<hr/> Total Estimated Cost	<hr/> \$46,160,000	<hr/> \$39,720,000	<hr/> \$41,320,000	<hr/> \$40,390,000	<hr/> \$37,430,000

TABLE 27

ESTIMATED COSTS

DRAINAGE AREA 10 (CAVE CREEK BRIDGE)

10-YEAR FREQUENCY STORM

900 L.F. New Bridge	\$3,810,000
Spur Dikes and Appurtenances	1,140,000
20% Engineering & Administration	990,000
<hr/>	
Sub-Total	\$5,940,000
20% Contingency	1,190,000
<hr/>	
Total Estimated Cost	\$7,130,000

B. Effectiveness

Effectiveness is defined as the ability of the alternative concepts to meet the objective of the Bell Road Project Drainage Study. The objective of the alternative plans is to allow travel on four lanes of Bell Road during the 10-year storm event, while ensuring that upstream and downstream conditions will not be worsened in the 100-year storm event. To achieve this, all alternative concept plans were developed for the 10-year storm event. Therefore all alternatives meet the effectiveness criteria and received a ranked value of ten.

C. Environmental Impacts

An environmental assessment was conducted for each alternative design concept to determine what impacts might occur. A detailed field reconnaissance was performed in each of the drainage areas for each alternative design concept for the study area. The environmental impacts assessed included socio/economic, natural resources, cultural resources and farmlands.

As part of the environmental evaluation, the appropriate agencies were contacted to inform each agency of the objectives of the study and to solicit comments concerning the study. The following agencies were contacted:

- Arizona Commission of Agriculture and Horticulture
- Arizona Department of Health Services Bureau of Water Quality
- Arizona Game and Fish Department
- ADOT Environment Planning
- Arizona State Parks Department
- ADOT Roadside Development Services
- State Historic Preservation Society
- Maricopa County Parks Department
- Arizona State Museum--Historic and Archaeologic Division

Pueblo Grande Museum
United States Army Corps of Engineers

All pertinent environmental regulations were obtained from each agency and any particular concern was noted. Refer to References, Section XIII, for documents obtained from these agencies.

Rankings of zero to ten were used in the evaluation of each alternative, with zero representing severe long-term environmental impacts and ten representing minimal, short-term impacts.

All proposed concepts will impact the surrounding areas during construction, but with appropriate construction techniques, these impacts can be minimized. Long term impacts will occur only when additional right-of-way is required. Generally, if facilities are constructed within the existing right-of-way, no significant long term impacts will occur unless otherwise noted in the following analysis.

Drainage Area 1: Existing drainage facilities will be upgraded, therefore, no significant impacts will occur other than temporary construction impacts.

Drainage Area 2: The four alternative concepts were proposed in areas which have either undergone development or are zoned for development. There are viable citrus groves between Deer Valley Road and Beardsley Road and Bell Road and Greenway Road, but these areas are zoned for future development. However, the assessment was performed for existing conditions.

Alternative 1: The open channel extending north of Beardsley Road approximately one-half mile along the 87th Avenue alignment will impact existing farmland through either right-of-way acquisitions or disruptions of irrigation and maintenance facilities.

Alternative 2: The same impacts as in Alternative 1 would occur. The use of a detention basin to downsize downstream facilities may lessen the severity of some of the temporary construction impacts to 91st Avenue south of Beardsley Road.

Alternative 3: There would be impacts to active farmland north of Beardsley Road as previously described.

Alternative 4: Locating detention basins on prime development property may have an adverse economic impact. There would be impacts to the farmland north of Beardsley Road as previously described in Alternative 1.

Drainage Area 3: This drainage area is in transition. Currently this area consists of citrus groves which are being developed. Proposed facilities built within the existing right-of-way will not impact the area other than during construction.

Alternative 1: Disruption of access may occur during construction to the residential areas on the east side of 75th Avenue between Bell Road and Grovers Avenue.

The church on the east side of 75th Avenue north of Bell Road may experience dust and noise impacts during construction.

Alternative 2: The same impacts will occur for Alternative 2 as described for Alternative 1. Construction of the proposed channel located along the north side of Bell Road between 83rd Avenue and 77th Avenue will not significantly impact existing citrus groves, but additional right-of-way will be required. The loss of developable land due to right-of-way acquisition may have an adverse economic impact on future development.

The open channel south from Bell Road to Skunk Creek on 75th Avenue will require additional right-of-way. This is vacant flood prone land and no impacts other than those from construction will occur.

Alternative 3: Alternative 3 has the same impacts as in Alternative 1.

Alternative 4: Alternative 4 has the same impacts as Alternative 2 except that no channel is proposed from Bell Road to Skunk Creek on 75th Avenue.

Alternative 5: Alternative 5 has the same potential impacts as in Alternative 1.

Drainage Area 4:

Alternative 1: Major developments from 67th Avenue to 59th Avenue may be affected by noise, dust and limited access to business and residential areas during construction.

The churches on the east side of 51st Avenue and on 43rd Avenue, approximately one-quarter mile south of Bell Road, may experience negative impacts from dust and noise during construction.

On 43rd Avenue north of Bell Road, access to the pedestrian walkway on the east side will be disrupted during construction.

The park at 35th Avenue and Beverly Street may be impacted if construction is not maintained within the existing right-of-way.

On the east side of 35th Avenue north of Bell Road, access to the sidewalks may be limited during construction.

Alternative 2: Alternative 2 has the same impacts as in Alternative 1 except that no impacts would occur on 43rd Avenue south of Bell Road.

Alternative 3: Impacts will be limited to areas along Bell Road and north of Bell Road only.

Drainage Area 5:

Alternative 1: This area is densely populated and there is a high concentration of commercial development. Substantial impacts to access will occur during construction but only of a temporary nature.

Drainage Area 6: Per guidance from the FCD, environmental impacts were evaluated only for the drainage facilities proposed by Greiner at Central Avenue and 16th Street.

There is an existing archaeological site which surrounds the intersection of Central Avenue and Bell Road. The Pueblo Grande Museum staff verified that this site is Hohokam culture from the late sedentary through classic period (A.D. 1050-1400). This is an extensive shard (pottery) area. Numerous lava boulder concentrations were noted which suggest possible structures. Monitoring may be required during construction.

On 16th Street, north and south of Bell Road, there will be no impacts if the facilities are constructed within the existing right-of-way.

Drainage Area 7: Per guidance from the FCD, the facilities proposed by NBS/Lowry were not evaluated for environmental impacts.

Drainage Area 8: For all alternatives, the drainage facilities that were proposed south of Bell Road will not cause any significant long term impacts if they are constructed within the existing rights-of-way.

Alternative 1: The Humana Hospital at 40th Street and Bell Road may be impacted by dust and noise during construction.

Indian Bend Elementary School at 36th Street and Thunderbird Road may be impacted by dust and noise during construction.

Alternative 2: Alternative 2 has the same impacts as in Alternative 1.

The parcel proposed for a detention basin at the southwest corner of Tatum Boulevard and Bell Road may be subject to development. The proposed detention basin could have an adverse economic impact on this development by the removal of developable land.

Alternative 3: In addition to impacts similar to those in Alternative 1, construction of the open channel along Bell Road in the vicinity of 40th Street will require destruction or relocation of native plants, particularly desert broom. The open channel may also pose a hazard to students from Paradise Valley High School.

Construction of the open channel along Bell Road in the vicinity of Tatum Boulevard may require the relocation or destruction of native plants in some areas. Right-of-way acquisition may impact Arabian horse ranches through loss of pasture or potential developable land.

The church on the east side of Tatum Boulevard, north of Paradise Valley Lane, may be affected by dust and noise during construction.

Two hawks were noted in the area along Bell Road between 43rd Street and Tatum Boulevard. Construction of the open channels may disturb their habitat or nesting site.

Alternative 4: Impacts are similar to those in Alternative 1 except that no impacts will occur on 36th Street south of Bell Road.

Alternative 5: Impacts are similar to those in Alternative 2 except that no impacts will occur on 36th Street south of Bell Road.

Drainage Area 9: No plans.

Drainage Area 10: The construction of the proposed bridge will impact native vegetation (paloverde and desert broom).

D. Potential for Staged Construction

The potential for staged construction is a measure of plan flexibility for staged implementation or modification in response to different urbanization patterns from those assumed in this study. The analysis pertains to the ability of the plan's response to the needs of local jurisdictions in meeting their construction goals for roadway improvement along Bell Road. The lower the ranking the more difficulties anticipated in construction phasing.

Drainage Area 1: Installation of the proposed culverts could be undertaken either as part of the Bell Road improvement project or the Grand Avenue Expressway project.

Drainage Area 2: The implementation of all alternatives may be staged from downstream to upstream to meet both the Bell Road improvement schedule and the trend of urbanization north of Bell Road. As development plans are proposed for the undeveloped land north of Bell Road, the location and geometry of the proposed detention facilities may be

changed and incorporated into the development plans. The open channels proposed may be an interim measure only. As the area develops, open channels may be replaced by underground conduits, or incorporated into the site development scheme.

Drainage Area 3: The location of proposed channels, storm drains or runoff interception points may be changed to accommodate the development of the currently abandoned citrus orchard located north of Bell Road and west of 75th Avenue. The facilities along Bell Road may be staged to accommodate the construction schedule of the Outer Loop Highway and the realignment of 83rd Avenue. Alternative 5 has the best potential for staged construction because none of the proposed facilities cross 83rd Avenue and the Outer Loop Highway.

Drainage Area 4: The proposed storm drain systems for Alternatives 1 and 2 have the greatest flexibility for staged construction. Each section-line trunk system is independent of the other, and each may be constructed to meet the Bell Road construction schedule established by either the City of Glendale or the City of Phoenix. Alternative 3 has only one discharge outlet for all runoff collecting west of I-17. The system could, therefore, only be constructed from downstream to upstream regardless of drainage priorities further east. Alternative 3 has less flexibility because the proposed system from I-17 to Skunk Creek crosses the jurisdictional boundary line between the City of Phoenix and the City of Glendale. Coordination of planning, design, capital expenditure and construction scheduling will therefore be required. The construction of Alternatives 1 and 2 will have to be phased with the construction schedule of the ACDC.

Drainage Area 5: Construction of the facilities west of 19th Avenue will have to be coordinated with proposed improvements to the I-17 drainage facilities and implementation of the storm drain on 35th Avenue (Drainage Area 4).

Drainage Areas 6 and 7: Coordination will be required between the Bell Road Project, the Upper East Fork of Cave Creek flood control project and the Greenway Parkway channel project. Flexibility in staging will be limited for any given element of the Bell Road project.

Drainage Area 8: The various elements or drainage systems proposed for Alternatives 1 through 3 are independent and may be implemented in stages as desired by the affected jurisdictions. Alternatives 4 and 5 (drainage facilities west of 40th Street) will have to be phased with the Upper East Fork of Cave Creek project.

Until the final alignment for the Squaw Peak Parkway is selected, it is not possible to determine how the Bell Road drainage project construction schedule will be affected.

Drainage Area 9 (Skunk Creek): No plans.

Drainage Area 10: The proposed bridge at Cave Creek may be constructed independently of any of the drainage alternatives for Bell Road.

E. Acceptability to Municipalities

Acceptability to municipalities has been defined, for the purpose of this study, as the compatibility of drainage design criteria utilized in the Bell Road study to current drainage design criteria applied by the affected jurisdiction. Overall, the proposed alternative concepts conform to current design standards for the Town of Surprise, the Cities of Peoria, Glendale and Phoenix and Maricopa County. In general, storm drains are preferred to open channels for both safety, aesthetics and maintenance reasons. Therefore, alternatives with open channels may not be as acceptable as those alternatives with only storm drains. However, earthen channels are preferred to concrete-lined channels. Detention basins excavated to a depth of ten feet may also be unacceptable to some jurisdictions.

A rank of ten was given if the alternative meets all current design criteria. Lesser rankings were given if non-standard features have been included.

F. Compatibility with Other Projects and Plans

The compatibility of the proposed alternative concept plans with other projects and plans including existing and proposed drainage and flood control projects and existing roadways and utilities were evaluated. Higher rankings were given if utility conflicts and street reconstruction were minor in comparison with other alternatives, or if the alternative is similar in layout to current drainage master plans.

Drainage Area 1: The proposed culverts are compatible with the proposed Grand Avenue Expressway plans.

Drainage Area 2:

Alternative 1: Conflicts will occur between the proposed storm drain and utilities at Bell Road and 91st Avenue. Existing utilities at this location include a 12-inch water line, 15-inch and 27-inch sanitary sewer lines and an underground electrical line.

Alternative 2: The same potential conflicts between the proposed storm drain and utilities at Bell Road and 91st Avenue may occur. The reduction in storm drain size, however, may reduce the potential for disruption of the utilities.

Alternative 2 is the most similar to the current City of Peoria Master Plan for Storm Drainage.

Alternative 3: By using parallel systems, the potential for utility conflicts at Bell Road and 91st Avenue is decreased due to the

downsized structure required at that location. However, there is the potential for the disruption of future development along 87th Avenue.

Alternative 4: Impacts on utilities at Bell Road and 91st Avenue may be further reduced by use of upstream detention to reduce storm drain sizes. Disruption of future development along 87th Avenue may still occur.

Drainage Area 3:

Alternative 1: No significant impacts on existing utilities are anticipated. The proposed storm drain along Bell Road between 77th Avenue and the New River should not be adversely affected by the realignment of 83rd Avenue or the Outer Loop Highway.

Alternative 2: Potential utility conflicts may occur between the proposed open channel along Bell Road and a 69 KV overhead electrical distribution line and an underground electrical line.

The open channel will be compatible with the proposed culverts under the realigned 83rd Avenue and the Outer Loop Highway.

Alternative 3: No significant impacts on existing utilities are anticipated. The proposed storm drain along Bell Road between 77th Avenue and the New River should not be adversely affected by the realignment of 83rd Avenue or the Outer Loop Highway.

Alternative 4: Alternative 4 has the same impacts as Alternative 2.

Alternative 5: No conflicts with utilities or other roadway and drainage projects are anticipated.

Drainage Area 4: For all alternatives, the proposed box culvert from I-17 to 35th Avenue along Bell Road may conflict with utilities including a 12 inch water line, a 12 inch sanitary sewer line, a gas line and electrical lines.

Alternative 1: The proposed storm drain along 35th Avenue between Bell Road and the ACDC may conflict with a 12-inch water line and a 12-inch sanitary sewer line. The proposed culverts along 43rd Avenue and 51st Avenue from Bell Road to the ACDC may conflict with water lines, sanitary sewer lines and gas lines. The existing storm drain outlet at 51st Avenue and the ACDC will have to be reconstructed to accommodate the 10-year frequency discharges.

Alternative 1 will require construction on approximately 20.5 miles of street.

It is similar to current City of Phoenix's and City of Glendale's stormwater management plans.

Alternative 2: The proposed storm drain along 35th Avenue between Bell Road and the ACDC may conflict with a 12 inch water line and a 12 inch sanitary sewer line. The proposed culverts along 51st Avenue and 67th Avenue from Bell Road to the ACDC may conflict with a water line, a sanitary sewer line and a gas line. Construction will be required on approximately 16 miles of street. The storm drain outlet at 51st Avenue and the ACDC will have to be reconstructed.

Alternative 3: The proposed storm drain along Bell Road may conflict with utilities crossing Bell Road at 43rd, 51st, 55th and 59th Avenues.

Alternative 3 is the least disruptive to the existing utilities and is the least compatible with the current City of Phoenix's and City

of Glendale's storm drainage plans. The storm drains proposed by these plans for 41st, 51st and 59th Avenues could be reduced in size if Alternative 3 is implemented because flows would be diverted west along Bell Road. Alternative 3 will require construction on only 7.5 miles of street.

Drainage Area 5:

Alternative 1: The proposed storm drain along 19th Avenue may conflict with a new 60 inch water line, a 12 inch water line and gas and electrical lines. The existing 90 inch storm drain may have to be removed. The proposed culvert crossing I-17 along Bell Road may conflict with a 12 inch water line, an 8 inch sanitary sewer line and gas and electrical lines. A construction method that minimizes or avoids impacts to traffic on I-17 must be implemented.

Drainage Area 6: The drainage facilities proposed by NBS/Lowry were not evaluated. The drainage systems proposed by Greiner along Central Avenue and 16th Street were evaluated and are compatible with both the NBS/Lowry system and the proposed Greenway Parkway channel project.

Utility conflicts may occur with a sanitary sewer line and a water line along both Central Avenue and 16th Street.

Drainage Area 7:

Alternative 1: The drainage facilities recommended by NBS/Lowry were not evaluated.

Alternative 2: The extension to the NBS/Lowry storm drain along Bell Road between 35th Street and 40th Street may only have a minor impact on existing utilities. The proposed extension will not introduce flows into the storm drain recommended by NBS/Lowry in excess of its design capacity.

Alternative 3: The use of upstream detention to reduce the size of downstream storm drains may reduce the potential for utility conflicts along Bell Road between 35th Street and 40th Street.

Drainage Area 8: Until the final alignment of the Squaw Peak Parkway is selected, it is not possible to determine any significant conflicts with the Bell Road drainage project facilities.

Alternative 1: Utilities along 36th Street, 40th Street, Tatum Boulevard and 52nd Street may be impacted by the proposed storm drains along these streets between Bell Road and the Indian Bend Wash. Alternative 1 is the most compatible with the current City of Phoenix's area drainage plan.

Alternative 2: The use of detention basins to reduce downstream storm drain sizes may reduce impacts on utilities along 36th Street and Tatum Boulevard.

Alternative 3: The use of open channels along Bell Road may disrupt overhead and buried electrical lines.

Alternatives 4 and 5: The diversion of flows from Bell Road between 36th Street and 40th Street to the storm drain proposed by NBS/Lowry in Drainage Area 7 will eliminate the need for a storm drain along 36th Street between Bell Road and the Indian Bend Wash.

Drainage Area 9: No plans.

Drainage Area 10: Construction of the new bridge may temporarily disrupt service along Bell Road in this area.

G. Evaluation Matrices

TABLE 28

EVALUATION MATRIX

DRAINAGE AREA 1

10-YEAR FREQUENCY STORM

	CAPITAL COSTS	EFFECTIVENESS	ENVIRONMENTAL IMPACTS	POTENTIAL FOR STAGED CONSTRUCTION	ACCEPTABILITY TO MUNICIPALITIES	COMPATIBILITY WITH OTHER PROJECTS & PLANS	TOTAL
Alternative 1	N/A	10	9	10	10	10	49.0

TABLE 29

EVALUATION MATRIX

DRAINAGE AREA 2

10-YEAR FREQUENCY STORM

	CAPITAL COSTS	EFFECTIVENESS	ENVIRONMENTAL IMPACTS	POTENTIAL FOR STAGED CONSTRUCTION	ACCEPTABILITY TO MUNICIPALITIES	COMPATIBILITY WITH OTHER PROJECTS & PLANS	TOTAL
Alternative 1	5.8	10	8.4	10	10	8	52.2
Alternative 2	9.5	10	8.4	10	10	9	56.9
Alternative 3	7.4	10	7.8	10	10	5	50.2
Alternative 4	10.0	10	7.8	10	10	5	52.8

TABLE 30

EVALUATION MATRIX

DRAINAGE AREA 3

10-YEAR FREQUENCY STORM

	CAPITAL COSTS	EFFECTIVENESS	ENVIRONMENTAL IMPACTS	POTENTIAL FOR STAGED CONSTRUCTION	ACCEPTABILITY TO MUNICIPALITIES	COMPATIBILITY WITH OTHER PROJECTS & PLANS	TOTAL
Alternative 1	8.8	10	8.8	8	10	8	52.6
Alternative 2	8.5	10	7.6	8	7	8	49.1
Alternative 3	4.3	10	8.8	8	10	7	48.7
Alternative 4	5.2	10	7.6	8	7	8	45.8
Alternative 5	10.0	10	8.8	10	10	8	56.8

TABLE 31

EVALUATION MATRIX

DRAINAGE AREA 4

10-YEAR FREQUENCY STORM

	CAPITAL COSTS	EFFECTIVENESS	ENVIRONMENTAL IMPACTS	POTENTIAL FOR STAGED CONSTRUCTION	ACCEPTABILITY TO MUNICIPALITIES	COMPATIBILITY WITH OTHER PROJECTS & PLANS	TOTAL
Alternative 1	6.6	10	8.4	9	10	6	50.0
Alternative 2	6.8	10	8.6	9	10	6	50.4
Alternative 3	10.0	10	8.6	8	10	7	53.6

TABLE 32

EVALUATION MATRIX

DRAINAGE AREA 5

10-YEAR FREQUENCY STORM

	CAPITAL COSTS	EFFECTIVENESS	ENVIRONMENTAL IMPACTS	POTENTIAL FOR STAGED CONSTRUCTION	ACCEPTABILITY TO MUNICIPALITIES	COMPATIBILITY WITH OTHER PROJECTS & PLANS	TOTAL
Alternative 1	N/A	10	8.6	7	10	8	43.6

TABLE 33

EVALUATION MATRIX

DRAINAGE AREA 6

10-YEAR FREQUENCY STORM

	CAPITAL COSTS	EFFECTIVENESS	ENVIRONMENTAL IMPACTS	POTENTIAL FOR STAGED CONSTRUCTION	ACCEPTABILITY TO MUNICIPALITIES	COMPATIBILITY WITH OTHER PROJECTS & PLANS	TOTAL
Alternative 1	N/A	10	7	7	10	N/A	34

TABLE 34
EVALUATION MATRIX
DRAINAGE AREA 7

10-YEAR FREQUENCY STORM

	CAPITAL COSTS	EFFECTIVENESS	ENVIRONMENTAL IMPACTS	POTENTIAL FOR STAGED CONSTRUCTION	ACCEPTABILITY TO MUNICIPALITIES	COMPATIBILITY WITH OTHER PROJECTS & PLANS	TOTAL
Alternative 1	10.0	10	7.0	7	10	N/A	44.0
Alternative 2	8.8*	10	7.0	6	10	N/A	41.8
Alternative 3	9.6*	10	6.6	6	10	N/A	42.2

*Includes cost of the storm drain that diverts flows from Drainage Area 8. Refer to Table 36.

TABLE 35
EVALUATION MATRIX
DRAINAGE AREA 8

10-YEAR FREQUENCY STORM

	CAPITAL COSTS	EFFECTIVENESS	ENVIRONMENTAL IMPACTS	POTENTIAL FOR STAGED CONSTRUCTION	ACCEPTABILITY TO MUNICIPALITIES	COMPATIBILITY WITH OTHER PROJECTS & PLANS	TOTAL
Alternative 1	8.1	10	9.0	10	10	9	56.1
Alternative 2	9.4	10	8.2	10	10	7	54.6
Alternative 3	9.1	10	7.2	10	7	7	49.3
Alternative 4	9.3*	10	9.0	9	10	9	56.3
Alternative 5	10.0*	10	8.2	9	10	9	56.2

*Cost for storm drain diverting flows to Drainage Area 7 are not included. Refer to Table 36.

TABLE 36

EVALUATION MATRIX

DRAINAGE AREAS 7 AND 8

10-YEAR FREQUENCY STORM

D.A.7/D.A.8 (ALT.) (ALT.)	CAPITAL COSTS	EFFECTIVENESS	ENVIRONMENTAL IMPACTS	POTENTIAL FOR STAGED CONSTRUCTION	ACCEPTABILITY TO MUNICIPALITIES	COMPATIBILITY WITH OTHER PROJECTS & PLANS	TOTAL
Alternative 1 1/1	9.1	10	8.0	8.5	10	9	54.6
Alternative 2 1/2	10.0	10	7.6	8.5	10	7	53.1
Alternative 3 1/3	9.7	10	7.1	8.5	8.5	7	50.8
Alternative 4 2/4	9.5	10	8.0	7.5	10	9	54.0
Alternative 5 2/5	9.9	10	7.6	7.5	10	9	54.0
Alternative 6 3/4	9.5	10	7.8	7.5	10	9	53.8
Alternative 7 3/5	10.0	10	7.4	7.5	10	9	53.9

Note: Since Alternatives 2 and 3 for Drainage Area 7 used the NBS/Lowry system with an extension along Bell Road, eliminating the need for a storm drain along 36th Street proposed in Alternatives 1 through 3 in Drainage Area 8, it was necessary to combine Drainage Areas 7 and 8 and develop a ranking system for all the possible combinations between the alternates in Drainage Areas 7 and 8.

TABLE 37

EVALUATION MATRIX

DRAINAGE AREA 10

10-YEAR FREQUENCY STORM

	CAPITAL COSTS	EFFECTIVENESS	ENVIRONMENTAL IMPACTS	POTENTIAL FOR STAGED CONSTRUCTION	ACCEPTABILITY TO MUNICIPALITIES	COMPATIBILITY WITH OTHER PROJECTS & PLANS	TOTAL
Alternative 1	N/A	10	9	10	10	10	49

XII. RECOMMENDED CONCEPT PLANS

Based on the matrix tables developed, ranking each alternative stormwater/floodwater management concept plan for each drainage area in terms of capital cost, effectiveness, environmental impacts, potential for staged construction, acceptability to municipalities and compatibility with other projects and plans, Greiner is making the following recommendations.

A. 100-Year Stormwater/Floodwater Concept Plans

Drainage Area 1: Alternative 1 is the selected plan having a total estimated capital cost of approximately \$1.4 million. This plan will have minimal environmental impacts, a great potential for staged construction, is acceptable to municipalities and is compatible with the proposed Grand Avenue Expressway plans. Refer to Plate 1.

Drainage Area 2: Out of the seven alternative plans developed Alternative 3 ranked the highest in the overall evaluation. Although this alternative ranked third in capital costs, this alternative is one of the most compatible with other projects and plans. It limits the potential for utility conflicts by using two detention basins at the northeast corner of the intersection of 91st Avenue and Beardsley Road and 91st Avenue and Union Hills Drive to reduce the size of downstream storm drains. The total estimated capital cost for this plan is approximately \$32 million. Refer to Plate 4.

Drainage Area 3: Alternative 3 ranked highest in the overall evaluation and is the recommended plan of the three developed. Although this alternative ranked second in capital cost, it has the least environmental impacts, good potential for staged construction, the greatest acceptability to municipalities, due to the system being mostly closed conduits, and is the most compatible with other projects and plans. The total estimated capital cost for this alternative plan is approximately \$5 million. Refer to Plate 11.

Drainage Area 4: Alternative 3 ranked highest in the overall evaluation and is the recommended plan of the three developed. This alternative is the most cost effective, having a total estimated capital cost of approximately \$122 million. It has the least environmental impacts. It ranked the lowest for the potential for staged construction because it has only one discharge outlet for all the drainage collected west of 35th Avenue to Skunk Creek and it crosses jurisdictional boundaries.

Although this alternative is the least compatible with the current City of Phoenix and the City of Glendale storm water management plans, it could reduce the size of the proposed storm drains south of Bell Road for these plans. This alternative will cause less disruption of streets and utilities than the other two. The other two alternatives propose tying into the ACDC on 43rd Avenue, 51st Avenue and 59th Avenue. The ACDC has been designed to capture the 100-year flood peak discharge where most side inflow will flow into the channel over the channel wall. Concentrating these flows in closed conduits at 43rd Avenue, 51st Avenue and 59th Avenue at the ACDC may cause a significant re-design of the ACDC and, therefore, is considered to not be compatible. The City of Phoenix is designing a storm drain trunk line down 51st Avenue for the 2-year storm event; therefore the 100-year facility will not be compatible with this system. With these factors in mind, Alternative 3 is the most compatible with other projects and plans. Refer to Plates 16 and 17.

Drainage Area 5: Alternative 1 ranked highest in the overall evaluation and is the recommended plan of the two developed. Although it is not as cost effective as Alternative 2, there is only a \$750,000 difference between the two. The total estimated capital cost for Alternative 1 is \$32 million.

Alternative 1 has considerably less environmental impacts, is less disruptive to existing neighborhoods and is more compatible with other projects and plans. Refer to Plates 18 and 19.

Drainage Areas 6 and 7: Only one plan was developed for these drainage areas. Additional drainage facilities were evaluated where it was required to protect Bell Road from off-site drainage not intercepted by the recommended NBS/Lowry systems. The total estimated capital costs for Drainage Area 6 and Drainage Area 7 including the costs for facilities proposed by NBS/Lowry is approximately \$24 million and \$22 million, respectively. Refer to Plates 21 and 22.

Drainage Area 8: Alternative 1 ranked highest in the overall evaluation and is the recommended plan of the three developed. Although it is the least cost effective of the three plans evaluated, other factors dominated in the overall analysis. Alternative 1 has considerably less environmental impacts and is more acceptable to municipalities, due to the fact that this alternative is a closed conduit system and can be constructed completely within the existing rights-of-way. This alternative is also the most compatible with the current City of Phoenix storm drainage study. The total estimated capital cost is approximately \$85 million. Refer to Plates 23 and 24.

Drainage Area 9: No plans were developed for this area. Drainage Area 9 is the Skunk Creek channel and floodplain and it was determined that the 100-year flood is contained within Skunk Creek at Bell Road. On-site drainage will be intercepted by the recommended plan for Drainage Area 4.

Drainage Area 10: A 900-foot long bridge is recommended to span the Cave Creek floodplain at Bell Road. The total estimated capital costs are approximately \$7 million. Refer to Plate 21.

B. 10-Year Stormwater/Floodwater Concept Plan

Drainage Area 1: Alternative 1 is the selected plan, having a total estimated capital cost of approximately \$1 million. This plan will have minimal environmental impacts, a great potential for staged construction, is acceptable to municipalities and compatible with the proposed Grand Avenue Expressway plans. Refer to Plate 29.

Drainage Area 2: Alternative 2 ranked highest in the overall evaluation and is the recommended plan of the four developed. Although it ranked second in capital costs, it will have minimal environmental impacts and is the most compatible plan with other projects and plans, including the current City of Peoria Master Plan for Storm Drainage. The total estimated capital cost for this plan is approximately \$14 million. Refer to Plate 31.

Drainage Area 3: Alternative 5 ranked highest in the overall evaluation and is the recommended plan of the five developed. It is the most cost effective, having a total estimated cost of \$2.1 million. Alternative 5, being a closed conduit system and having approximately ninety percent of the system proposed within existing right-of-way, has the least environmental impacts and is the most acceptable to municipalities. It also ranked the highest in its potential for staged construction and its compatibility with other projects and plans. Refer to Plate 38.

Drainage Area 4: Alternative 3 ranked highest in the overall evaluation and is the recommended plan of the three developed. It is the most cost effective, having a total estimated capital cost of approximately \$45 million. Alternative 3 ranked the lowest in its potential for staged construction because it has only one discharge outlet for the runoff collecting west of I-17 to Skunk Creek and it also crosses jurisdictional boundaries. It has minimal environmental impacts, is acceptable to municipalities and is the most compatible with other projects and plans. Although Alternative 3 is the least compatible with

the current City of Phoenix and City of Glendale storm water management plans, it could reduce the size of the proposed storm drains south of Bell Road. This alternative will cause less disruption of streets and utilities. The City of Phoenix is designing a storm drain trunk line down 51st Avenue, designed for the 2-year storm event; therefore, a 10-year facility will not be compatible with this system. Refer to Plates 43 and 44.

Drainage Area 5: Alternative 1 is the selected plan, having a total estimated capital cost of approximately \$16 million. This plan will have minimal environmental impacts and is acceptable to municipalities. Refer to Plates 45 and 46.

Drainage Area 6: Only one plan was developed for this drainage area. Additional drainage facilities were evaluated where it was required to protect Bell Road from off-site drainage not intercepted by the NBS/Lowry systems. The total estimated capital cost including the costs for the facilities proposed by NBS/Lowry, is approximately \$20 million. Refer to Plate 47.

Drainage Areas 7 and 8: Three alternatives were evaluated for Drainage Area 7. Alternative 1 used the drainage facilities developed by NBS/Lowry with no modifications. Alternatives 2 and 3 used the NBS/Lowry system with an extension of their facility along Bell Road from 35th Street to just west of 40th Street. This extension will eliminate the storm drain along 36th Street from Bell Road to the Indian Bend Wash proposed in the Drainage Area 8 plans for Alternative 1 through 3. Five alternatives were evaluated for Drainage Area 8. Alternatives 1 through 3 are independent of the facilities proposed for Alternative 1 in Drainage Area 7, while Alternatives 4 and 5 are dependent on the storm drain extension proposed for Alternatives 2 and 3 in Drainage Area 7.

Although individual rankings were performed to evaluate both drainage areas, it was necessary to combine Drainage Areas 7 and 8 and develop a ranking system for all of the possible combinations between the alternatives in Drainage Areas 7 and 8. Seven were evaluated as follows:

Alternative 1: Alternative 1 from Drainage Area 7 with Alternative 1 from Drainage Area 8.

Alternative 2: Alternative 1 from Drainage Area 7 with Alternative 2 from Drainage Area 8.

Alternative 3: Alternative 1 from Drainage Area 7 with Alternative 3 from Drainage Area 8.

Alternative 4: Alternative 2 from Drainage Area 7 with Alternative 4 from Drainage Area 8.

Alternative 5: Alternative 2 from Drainage Area 7 with Alternative 5 from Drainage Area 8.

Alternative 6: Alternative 3 from Drainage Area 7 with Alternative 4 from Drainage Area 8.

Alternative 7: Alternative 3 from Drainage Area 7 with Alternative 5 from Drainage Area 8.

Alternative 1 ranked highest in the overall evaluation and is the recommended plan. Although it is the least cost effective of the seven evaluated, other factors dominated in the overall analysis. This alternative has the least environmental impacts, is the most acceptable to municipalities and is the most compatible with other projects and plans. Another vital factor is that this alternative, along with Alternatives 2 and 3, has more flexibility because it is independent of

the drainage facilities proposed by NBS/Lowry giving it a greater potential for staged construction. The total estimated capital cost for Alternative 1 including the cost for the facilities proposed by NBS/Lowry is approximately \$68 million. Refer to Plates 22, 23 and 24.

Drainage Area 9: No plans were developed for this area. Drainage Area 9 is the Skunk Creek channel and floodplain and it was determined that the 100-year flood is contained within Skunk Creek at Bell Road. On-site drainage will be intercepted by the recommended plan for Drainage Area 4.

Drainage Area 10: A 900-foot long bridge is recommended to span the Cave Creek floodplain at Bell Road. The total estimated capital cost is approximately \$7 million. Refer to Plate 47.

In summary, the total estimated capital costs for the recommended alternative plans for the 100-year and 10-year are approximately \$330 million and \$174 million, respectively.

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16. Interstate-17 As-Builts from South of Bell Road to Union hills.
17. General Plan of Phoenix 1985/2000, City of Phoenix Planning Department, 1985.