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Concept Drainage Design Report

from

Bell Road To Skunk Creek

Sta. 811 + 00 To 1170+00

Outer Loop Highway

Section B

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Prepared For

DeLeuw, Cather & Company

Outer Loop Management Consultants

and

Arizona Department of Transportation

Prepared By

Greiner Engineering Sciences, Inc.

Phoenix, Arizona

September 1987

**Greiner
Engineering**

HYDROLOGIC MODEL DATA SHEET

Date:

By:

Area Modelled: Bell Rd to Skunk Creek (Outer Loop)

FCD File Code:

Report Title: Concept. Drg. Design Report from Bell Rd to

Author: Greiner Engr.

Date: Sept 87

Skunk Creek

Sta 311 +00 to

FCD Staff Contact:

1170+00 Outer Loop

Hwy Section B.

Hydrologic Model Summary

Computer Model Used: HEC-1

version/date:

Total Area:

No. of Subbasins:

Rainfall:

freq. & duration:

temporal dist.:

~~rainfall depth:~~

areal reduction:

Excess:

Hydrograph:

Routing:

Significant Structures

and Drainage Features:

Comments:

Objective was to develop an optimum plan for providing floodwater protection for the roadway. HEC-1 input & output not included.

CONCEPT DRAINAGE DESIGN REPORT
FROM
BELL ROAD TO SKUNK CREEK
STA. 811+00 TO STA. 1170+00
OUTER LOOP HIGHWAY

Prepared For:
DELEUW CATHER AND COMPANY
Outer Loop Management Consultants
and
ARIZONA DEPARTMENT OF TRANSPORTATION

Prepared By:
GREINER ENGINEERING SCIENCES, INC.
7310 North 16th Street, Suite 160
Phoenix, AZ 85020
(602) 275-5400

Job No. E-112-013
September 1987



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III. INTRODUCTION

Greiner Engineering Sciences, Inc. was retained as a subconsultant to DeLeuw, Cather and Company, the Outer Loop Highway Project Management Consultant for the Arizona Department of Transportation, to prepare a drainage concept plan for the segment of the Outer Loop Highway between Bell Road and the Central Arizona Project Canal (approximately 14.7 miles).

The Outer Loop Highway is a controlled access freeway which passes through rapidly developing sections of the Metropolitan Phoenix area. Due to this rapid growth, early identification of the right-of-way requirements is important. Consequently, an optimum concept drainage plan must be developed, analyzed and compared with other alternatives to limit the affect of the Outer Loop Highway on existing drainage patterns and to avoid adverse affects on adjacent areas.

The drainage concept plan (study) was prepared in two parts. A detailed hydrologic analysis titled "Hydrology Report, Off-Site Hydrology Existing Conditions" was previously submitted by Greiner Engineering Sciences on August 11, 1986. This analysis included a site investigation to identify existing drainage conditions and to determine existing drainage patterns for the 10, 50 and 100 year storm events. Flows for areas contributing to the Outer Loop Highway were calculated for the 10, 50 and 100 year storm events using the Unit Hydrograph method in conjunction with the United States Army Corps of Engineers HEC-1 computer program. The hydrology report was subsequently modified in November 1986 and April 1987 by the Project Management Consultant (Ref. 16 and 17).

The second part (Concept Drainage Design Report) was prepared in three separate reports as follows:

Bell Road to Skunk Creek, Sta. 811+00 to Sta. 1170+00
Skunk Creek to Cave Creek, Sta. 1170+00 to Sta. 1395+00
Cave Creek to the CAP Canal, Sta. 1395+00 to Sta. 1585+00

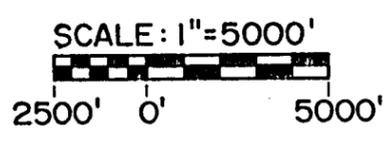
These reports were divided on the basis of major drainage areas and the division of the Outer Loop Highway segments (see Plate 1, Vicinity Map). These reports formulate various alternative drainage plans from which the proposed design plans can be selected. For each alternative, the approximate type, size and location of the drainage facilities have been determined and order of magnitude cost estimates have been developed. Each alternative has been analyzed based on their advantages and disadvantages and a concept drainage plan has been recommended by Greiner.

This report documents the development of the concept drainage plan for the Outer Loop Highway from Bell Road, Sta. 811+00 to Skunk Creek, Sta. 1170+00. This section of the highway is within construction Design Segment 5 which is scheduled for completion by 1992.

From Bell Road to Beardsley Road, the Outer Loop Highway alignment closely parallels the New River along its east bank. At Beardsley Road, the highway alignment swings to the east and follows the Beardsley Road alignment to Skunk Creek. This segment of the highway includes a full urban interchange at Bell Road and diamond interchanges at Union Hills Drive, 75th Avenue, 67th Avenue, 59th Avenue and 51st Avenue. Other features include the relocation of 83rd Avenue from the west side of the Outer Loop Highway, at a point approximately 2,600 feet north of Bell Road, to an alignment on the east side of the highway (refer to Plate 2, Aerial Map).

The watershed area contributing stormwater runoff to this section of the Outer Loop Highway is comprised of the Skunk Creek drainage area and the New River drainage area. The Skunk Creek drainage area is bound on the south by the Outer Loop Highway; on the west by a graded ridge line within the Arrowhead Ranch development that continues northward to the ridge line of Pilcher Hill and Ludden Mountain to the CAP Canal; by the CAP Canal on the north; and the Hedgpeth Hills ridge line on the east.

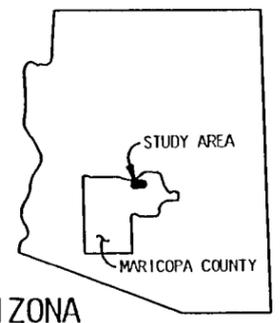
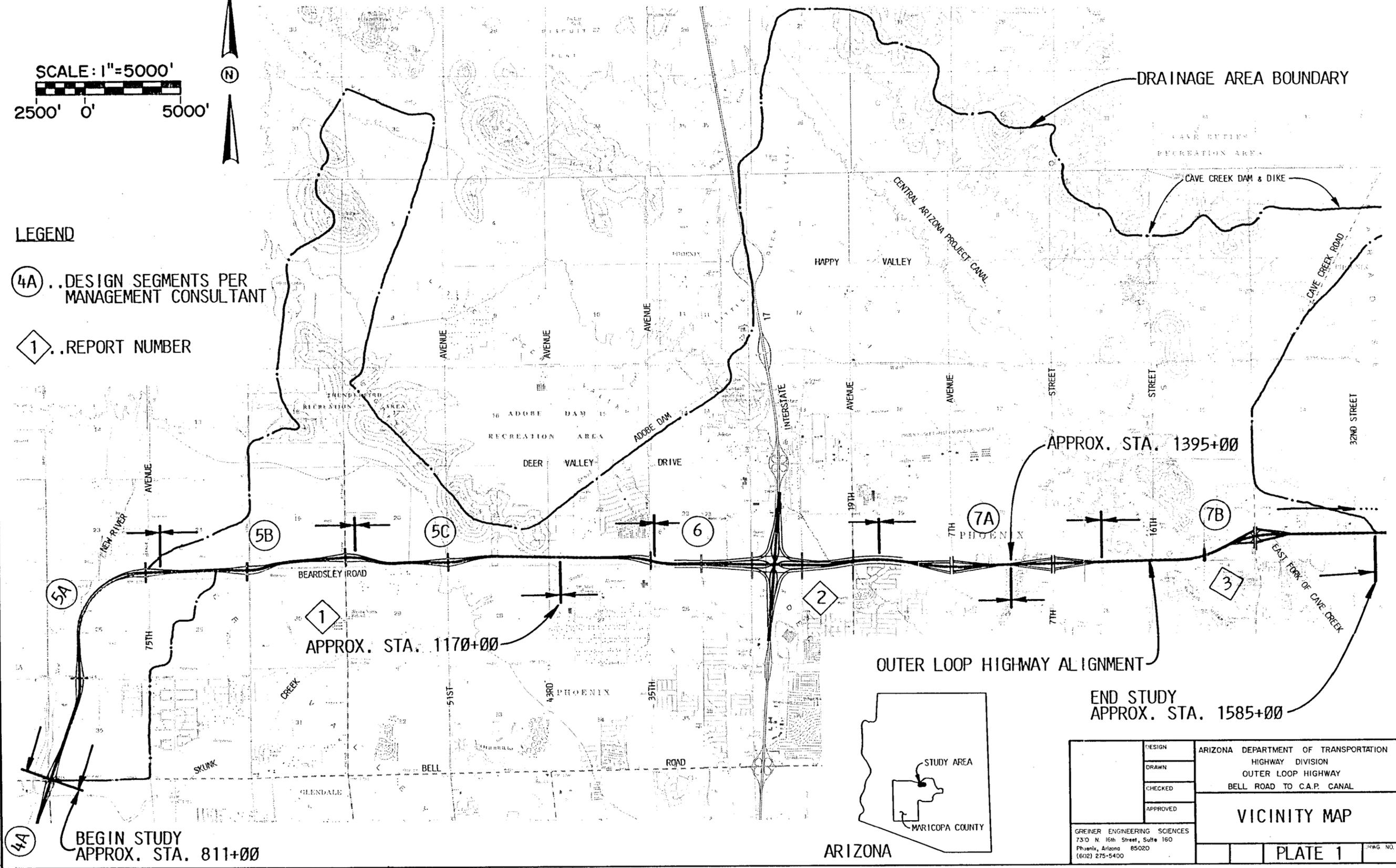
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LEGEND

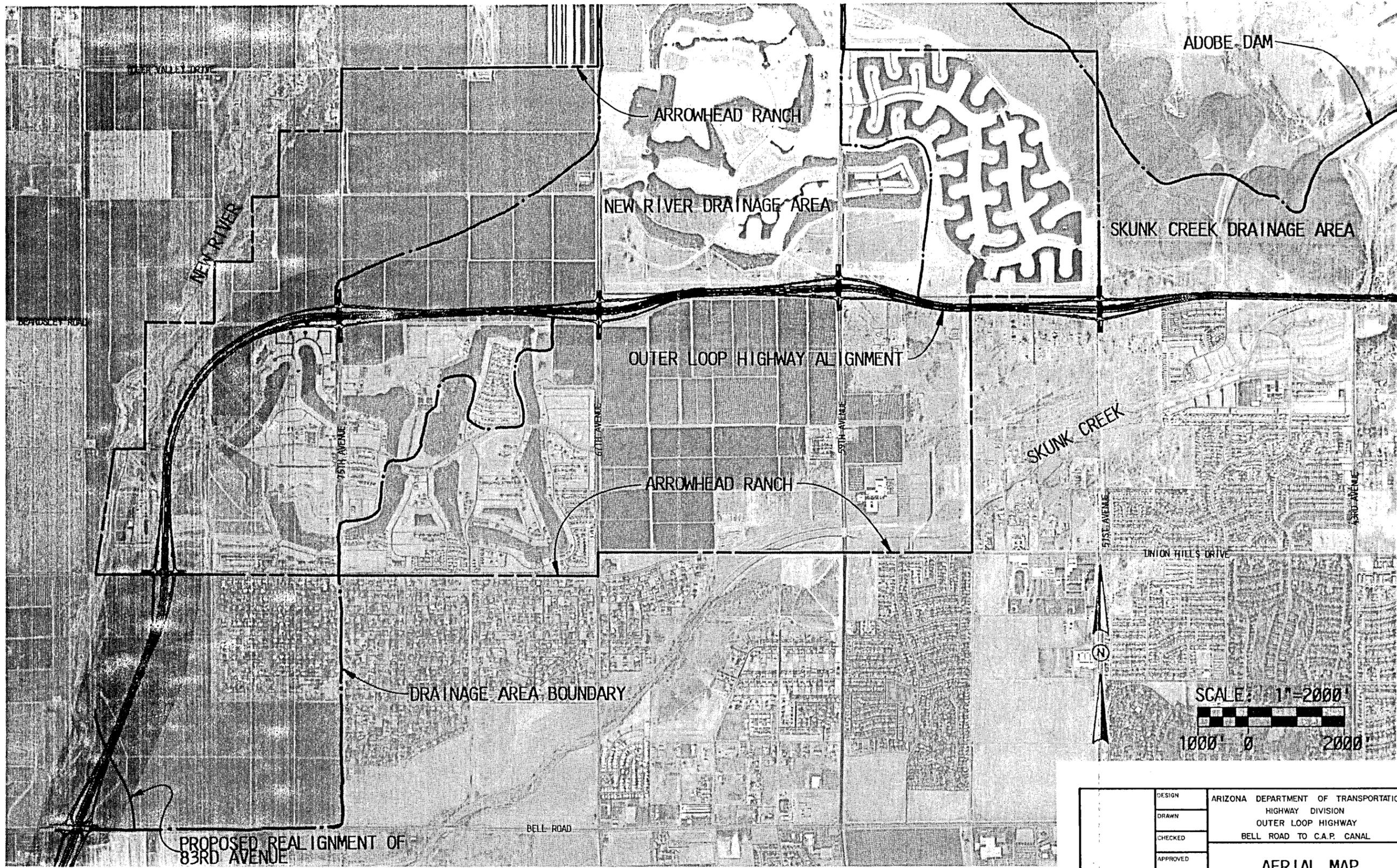
④A...DESIGN SEGMENTS PER MANAGEMENT CONSULTANT

◇1...REPORT NUMBER



DESIGN	ARIZONA DEPARTMENT OF TRANSPORTATION HIGHWAY DIVISION OUTER LOOP HIGHWAY BELL ROAD TO C.A.P. CANAL
DRAWN	
CHECKED	
APPROVED	
VICINITY MAP	
GREINER ENGINEERING SCIENCES 73'0 N. 16th Street, Suite 160 Phoenix, Arizona 85020 (602) 275-5400	
PLATE 1	

F.H.W.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS-BUILT
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DESIGN	ARIZONA DEPARTMENT OF TRANSPORTATION HIGHWAY DIVISION OUTER LOOP HIGHWAY BELL ROAD TO C.A.P. CANAL
DRAWN	
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APPROVED	
AERIAL MAP	
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PLATE 2	

The New River drainage area is bound on the south by Bell Road; on the west by New River between Bell Road and Beardsley Road and by a ridge line zig-zagging to the peak of a small mountain east of 67th Avenue; and on the north and east by an irregular ridge line defined by grading within Arrowhead Ranch and 75th Avenue. Skunk Creek and New River are the dominant natural topographic features which define runoff patterns within the watershed.

Land uses in the vicinity of the highway include citrus cultivation and residential. Arrowhead Ranch is a planned community development that adjoins the Outer Loop Highway between Union Hills Drive and 51st Avenue (refer to Plate 2 for the limits of Arrowhead Ranch). Portions of the development are still under citrus cultivation. A major lake system is located within Arrowhead Ranch between 59th Avenue and 51st Avenue north of Beardsley Road. The water level in the lake system is maintained by treated wastewater effluent and groundwater. A large wash enters the lake system from the north. The lake system has been designed with some storage for runoff from the wash. From the HEC-1 analysis it was determined that lake storage reduces the 100-year storm peak inflow from 3173 cfs to and outflow of 1104 cfs. A spillway and box culvert are located at the 55th Avenue alignment and Beardsley Road to permit outflows in excess of lake capacity to flow under Beardsley Road and into an improved earthen drainageway for conveyance to Skunk Creek.

Adobe Dam, constructed in 1980, is located across Skunk Creek north of Beardsley Road. The dam is designed to reduce a peak inflow rate of 66,000 cfs to an outflow rate of 1890 cfs (Ref. 8).

A stormwater/floodwater management study is currently in progress in conjunction with the proposed widening of Bell Road to a six lane urban arterial. The design level for drainage facilities proposed by this study in the vicinity of the Outer Loop Highway are for the 10-year storm event.

IV. OBJECTIVES

The objective of the Drainage Concept Plan for the Outer Loop Highway is to develop an optimum plan for providing floodwater protection for the roadway. In addition, the plan must ensure that there will be no adverse effects on adjacent areas.

The objective of this report is to develop the floodwater protection plans for the section of Outer Loop Highway extending from Bell Road to Skunk Creek. The concept plan will include the types, sizes, alignment and locations, as appropriate, for channels, culverts and detention basins. Tables and/or exhibits will be developed which document the proposed drainage system. Order of magnitude costs will be prepared. If more than one concept is developed, the advantages and disadvantages of each alternative will be analyzed and a recommendation for implementation of the optimum plan.

The need for additional rights-of-way for the drainage concept plan will be identified.

V. PROCEDURES AND METHODOLOGY

Alternative concept plans were developed for the 100 year, 24 hour storm event for existing watershed development conditions. The concept plans include the conveyance of off-site drainage impacting the highway right-of-way to alternative outfalls only. Alternative concepts studied were multiple conveyance systems versus single conveyance systems, use of multiple outfalls versus single outfalls, closed conduits versus open channel or a combination of both, and detention systems.

For each alternative concept, a HEC-1 computer model was developed and existing condition flows were routed through the alternative drainage systems. Based on the results of the hydrologic modeling of the alternative concepts, the types, sizes and locations of the proposed drainage facilities for all alternatives were identified.

Each alternative was evaluated in terms of costs, effectiveness, acceptability to municipalities, ease of maintenance, ease of construction and compatibility with other projects and plans. The alternative concept plans were reviewed by the Project Management Consultant and ADOT and their recommendations, modifications and refinements were incorporated into the selected plan development.

A. Concept Plan Development

The alternative and selected concept plans are comprised of systems of open channels, detention basins and closed conduits. The factors considered in developing the range of alternative systems are as follows:

- o Location and magnitude of runoff concentrating at the Outer Loop Highway
- o Location and adequacy of outfalls

- o Availability of and previously purchased land by ADOT along the Outer Loop Highway suitable for open channels or detention basins
- o Approved and ongoing projects and plans proposed by federal, state and local jurisdictions
- o Horizontal and vertical alignments of the proposed Outer Loop Highway

B. Hydrologic and Hydraulic Procedures

The off-site hydrologic models previously developed in the Hydrology Report 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 peak discharge values at the outfalls.

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 of flow using the Manning Equation. The Federal Highway Administration "Hydraulic Charts for the Selection of Highway Culverts" (HEC No. 5) was used for sizing culverts.

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

VI. DESIGN CRITERIA

Concept plans were developed using established design and special criteria provided by the Project Management Consultant. The following criteria was used:

- o Open Channels were sized to convey the 100-year storm runoff with an additional 20 percent added to the discharge value as freeboard per ADOT requirements.
- o The proposed off-site drainage facilities for the highway will not worsen flooding outside of the right-of-way from the 100-year storm runoff.
- o Flow velocities in concrete lined channels (trapezoidal) were kept under twelve (12) feet per second.
- o Open channels were designed using the following parameters:
 - Channel Type: Trapezoidal
 - Channel Lining: Concrete
 - Side Slope: 2:1
 - Minimum Bottom Width: 8 feet
 - Manning n Value: 0.018
- o Detention basins were designed with two feet of freeboard and with maximum side slopes of 4:1. A minimum 20 foot buffer zone was provided around the perimeter of the basin to allow for landscaping or other aesthetic treatment. Basins were designed to drain within 36 hours of peak storage.
- o Storm Sewer Pipes/Culverts were assumed to be concrete with a manning's "n" value of 0.012.

VII. ALTERNATIVE CONCEPT PLANS

Alternative off-site drainage systems were evaluated. In general, system alignments were selected to conform to topographic features of the drainage areas. The off-site drainage system may be utilized for conveyance of on-site stormwater runoff. Inverts of large drainage channels were set sufficiently deep to provide positive drainage from the highway median drains or catch basins. Grader ditches are provided where off-site stormwater runoff flowing parallel to the roadway is 25 cfs or less. At the time of final design, a hydraulic analysis should be performed to determine the extent of flow spread, and whether a collector channel is required to contain the flow so as not to adversely impact either the highway or adjacent properties.

Drainage concepts were not provided for existing or proposed frontage roads. Where necessary, the drainage facilities were extended through the frontage roads to provide the necessary protection to the highway.

The major elements of the alternative drainage systems including open channels, culverts and detention basins are described on the following pages.

Station 811 (Bell Road) to Station 893. This section of the Outer Loop Highway is mostly depressed and off-site runoff collects at the east right-of-way. From Union Hills Drive to Bell Road, an open channel will intercept off-site runoff from the east and convey it southward to the existing double 8'x6' box culvert at Bell Road. The channel will intercept runoff from Drainage Area 16A (79 cfs) and Drainage Area 19 (71 cfs). A culvert will be located under Union Hills Drive to convey runoff from D.A. 16A to the open channel and under 83rd Avenue at the channel crossing.

Runoff from D.A. 16A will be routed by the Arrowhead Ranch drainage system to the proposed culvert under Union Hills Drive. An existing 36" storm

drain located along Union Hills Drive at the Outer Loop Highway alignment may be connected to the proposed channel (refer to Plate 3 for a conceptual rendering of the drainage facilities).

Station 893 to Station 914 (Beardsley Road). Runoff from Arrowhead Ranch Drainage Areas 17 and 18 impact this section of elevated roadway. Culverts will be located at Station 895+00 and Station 908+30 to convey runoff from these drainage areas under the Outer Loop Highway for discharge into New River (refer to Plate 3 for the drainage concept). A water surface profile analysis of New River was performed by the Project Management Consultant. The results of the analysis indicated that the proposed roadway would not encroach into the 100-year floodplain. No analysis was performed to evaluate the potential for channel meandering.

Station 914 to Station 1072 (55th Avenue). This section of the highway is depressed from Station 931 to Station 1072. Runoff from Drainage Area 16C and 16E impact this section. An open channel will be located along the north right-of-way between Station 914 and Station 1045 (59th Avenue) to convey runoff to New River. Off-site runoff will be conveyed to this channel by the Arrowhead Ranch drainage system. Culverts will be required at 75th Avenue, 67th Avenue and 59th Avenue.

From Station 1045 (59th Avenue) to Station 1072 (55th Avenue) only on-site flows collect within the highway right-of-way. Off-site runoff is diverted northward and westward by the Arrowhead Ranch drainage system. A grader ditch will be provided to convey on-site flows westward to the open channel at 59th Avenue (refer to Plate 3 for a rendering of the drainage concept).

Station 1072 (55th Avenue) to Station 1148). Runoff from Drainage Areas 15A, 14A, 14B and 14C impact this section of elevated roadway. Two alternative drainage concepts were evaluated as follows:

- o Alternative 1: An open channel will intercept runoff from Drainage Areas 14A, 14B and 14C and convey them to the existing drainageway at

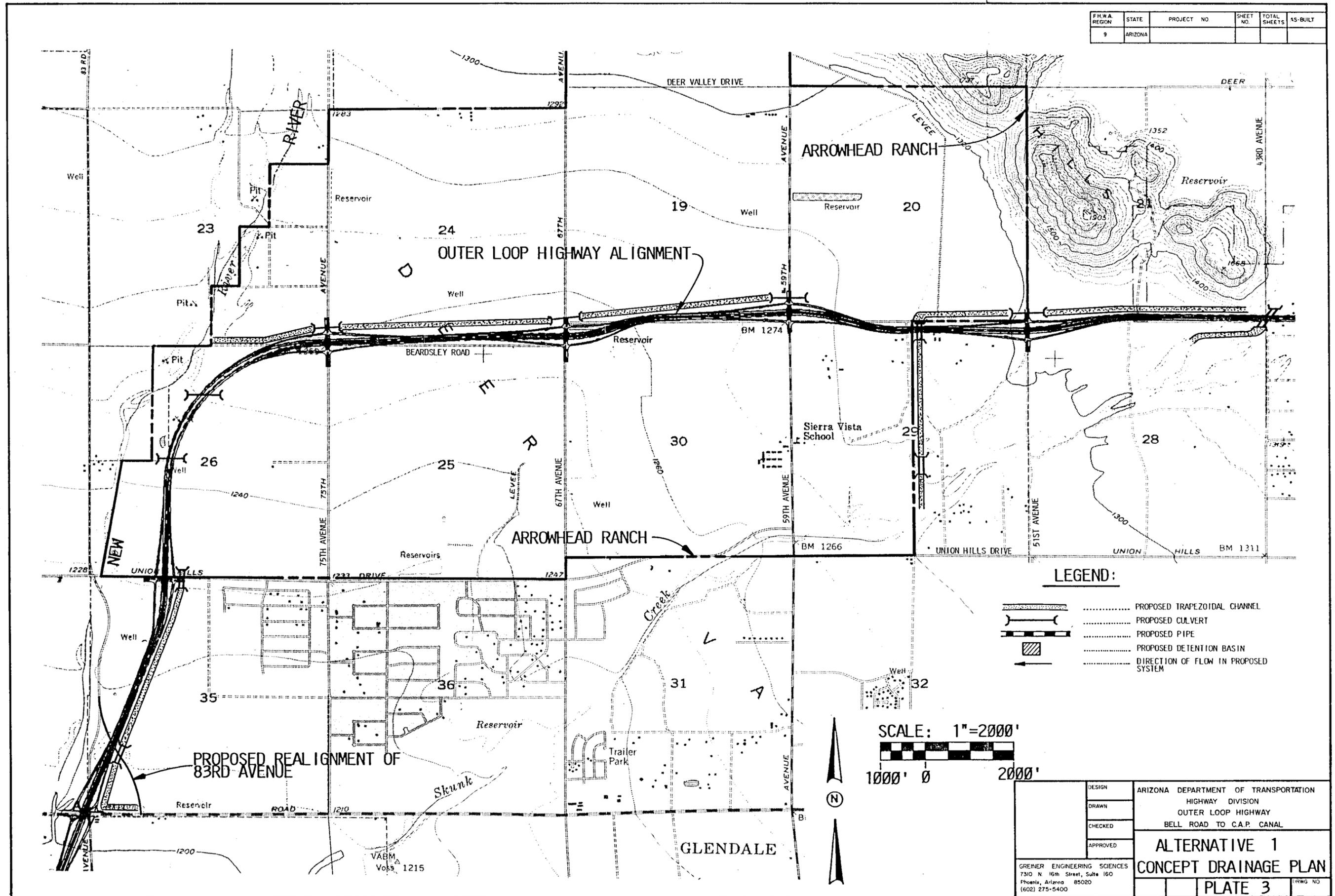
55th Avenue. This drainageway conveys overflows from the Arrowhead Ranch lake system in Drainage Area 15A along 55th Avenue to Skunk Creek. The conveyance capacity of the drainageway will be increased by lining the channel with soil cement. The existing box culvert at 55th Avenue and Utopia will have to be replaced with a bridge. A bridged crossing for the Outer Loop Highway across the 55th Avenue drainageway will also be provided (refer to Plate 1 for a rendering of Alternative 1).

- o Alternative 2: An open channel will intercept runoff from Drainage Areas 14A, 14B and 14C and convey them to a detention basin located within Drainage Area 14A east of 51st Avenue. The basin will be drained by a 24" RCP. The alignment of the 24" storm drain will be west along the north right-of-way of the highway to 51st Avenue. At that point, the 24" RCP will turn south, cross the Outer Loop Highway and follow 51st Avenue to Skunk Creek. The detention basin will be a maximum of ten feet deep. No improvements will be required to the existing 55th Avenue drainageway and a box culvert with the same capacity as the existing culvert under Beardsley Road will be provided for the highway over this drainageway (refer to Plate 4 for a rendering of Alternative 2).

Skunk Creek: The Outer Loop Highway will cross the existing Skunk Creek floodplain at approximately 1152. The 100-year design discharge for Skunk Creek is 2,600 cfs as established by the Corps of Engineers. The Outer Loop Highway Project Management Consultant developed alternative measures for crossing the floodplain. The alternative recommended by the Project Management Consultant is incorporated into this report and described as follows: Skunk Creek will be channelized in a southwesterly direction for a distance of approximately 600 feet north of the highway centerline and approximately 1,100 feet south and west of the highway centerline. A five barrel 10'x6' box culvert will be provided under the Outer Loop Highway and frontage roads at Station 1151+70. Stormwater runoff collecting along the north right-of-way between Skunk Creek and Station 1170 will be conveyed by an unlined drainage ditch to Skunk Creek.

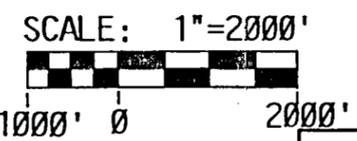
On-Site Runoff: On-site drainage from the depressed section (Bell Road to 51st Avenue) will drain by gravity storm drain to Bell Road. At Bell Road, on-site runoff and off-site runoff from the collector channel located along the east right-of-way of the Outer Loop Highway will discharge together into the existing double 8'x6' box culvert located under Bell Road.

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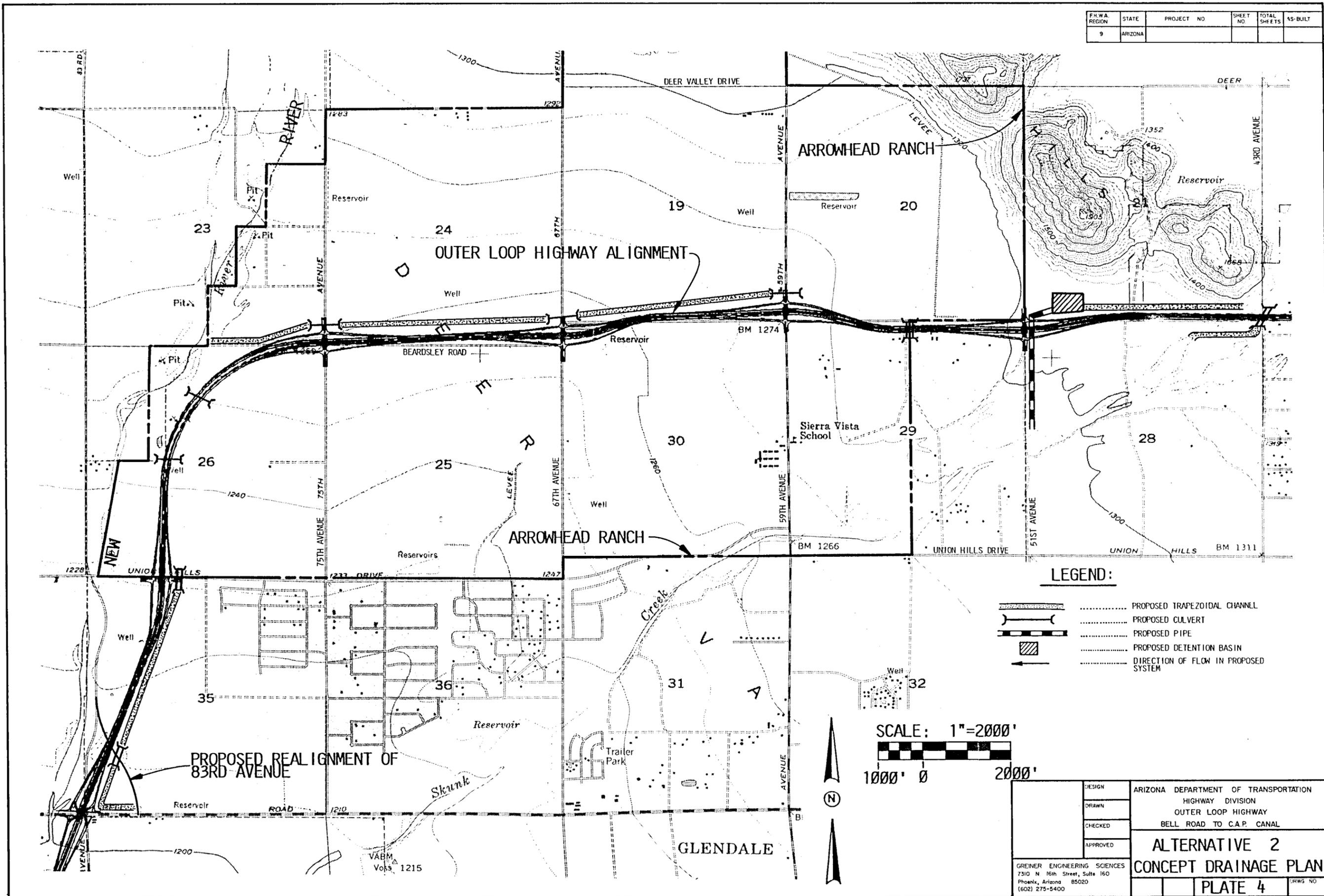
LEGEND:

-  PROPOSED TRAPEZOIDAL CHANNEL
-  PROPOSED CULVERT
-  PROPOSED PIPE
-  PROPOSED DETENTION BASIN
-  DIRECTION OF FLOW IN PROPOSED SYSTEM

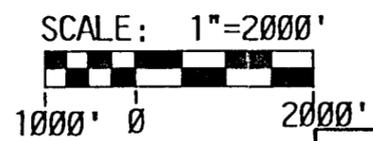


DESIGN	ARIZONA DEPARTMENT OF TRANSPORTATION HIGHWAY DIVISION OUTER LOOP HIGHWAY BELL ROAD TO C.A.P. CANAL
DRAWN	
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ALTERNATIVE 1	
CONCEPT DRAINAGE PLAN	
PLATE 3	
GREINER ENGINEERING SCIENCES 7310 N 16th Street, Suite 160 Phoenix, Arizona 85020 (602) 275-5400	
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F.H.W.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS-BUILT
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- LEGEND:**
- PROPOSED TRAPEZOIDAL CHANNEL
 - PROPOSED CULVERT
 - PROPOSED PIPE
 - PROPOSED DETENTION BASIN
 - DIRECTION OF FLOW IN PROPOSED SYSTEM



DESIGN	ARIZONA DEPARTMENT OF TRANSPORTATION HIGHWAY DIVISION OUTER LOOP HIGHWAY BELL ROAD TO C.A.P. CANAL
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ALTERNATIVE 2	
CONCEPT DRAINAGE PLAN	
PLATE 4	

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DRWG NO.

VIII. EVALUATION OF ALTERNATIVE CONCEPT PLANS

The alternative concept plans were evaluated and ranked in terms of cost, effectiveness, compatibility with other projects and plans, ease of maintenance and ease of construction. Matrices with ranking (+,0,-) were developed for comparison of the alternative concepts for each drainage area. A (+) was given for the higher ranking alternative; a neutral (0) was given to the alternatives if they ranked equally or had no negative impacts; and a (-) was given for a lower ranking.

A. Estimated Costs

Construction costs for all alternative concept plans and the selected concept plan were estimated. Unit costs for reinforced concrete pipe (RCP), box culverts (RCBC) and excavation and concrete lining were obtained from the Project Management Consultant.

Thirty (30) percent was added to the estimated construction costs for the drainage facilities to include associated appurtenances and contingencies. Appurtenance include the cost of outlet or inlet works, junction structures, manholes, laterals, catch basins, erosion protection, bank stabilization, minor street reconstruction, minor utility relocation and conflicts resolution.

The size of the necessary bridges were evaluated based on the preliminary hydraulic and highway geometric information. Square footage deck costs were estimated based on the number of spans, the length of the spans, the size and number of beams, size and number of columns and caps, lineal footage of barrier and the quantity of deck and approach slab.

Costs did not include right-of-way acquisition, any major utility relocations, street reconstruction, landscaping, maintenance,

administration and engineering to cover survey, design, contract administration, field engineering and inspection services.

The estimated construction costs of each of the alternatives are found in Tables 1 and 2.

B. Effectiveness

Effectiveness is defined as the ability of the alternative concepts to meet the objective of the Drainage Concept Plan. The objective of the plan is to protect the Outer Loop Highway during the 100-year storm event, while ensuring that upstream and downstream conditions will not be worsened. To achieve this, both alternative concept plans were developed for the 100-year storm event. Therefore, both alternatives meet the effectiveness criteria and received a (0) ranking.

C. 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. A higher ranking was given if utility conflicts and street reconstruction were minor in comparison with other alternatives.

Alternative 1 will require reconstruction of the 55th Avenue drainage-way and replacement of the existing box culvert at Utopia with a bridge. Alternative 1 was, therefore, given a negative (-) ranking.

D. Ease of Construction and Maintenance

Ease of construction and maintenance is a measure of the overall complexity of the structures to be constructed including the use of special or non-standard structures and the degree of frequency and intensity of maintenance during the life of the project.

Table 1
Estimated Costs

Alternative 1

<u>Location (Station-Station)</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
813-866 (right)	Channel: Excavation	12,560 C.Y.	\$ 2.50	\$ 31,000
	Concrete	15,250 S.Y.	35.00	534,000
830 (right)	8'x4' R.C.B.C.	60 L.F.	225.00	14,000
867 (right)	60" R.C.P.	110 L.F.	140.00	15,000
895 (right)	36" R.C.P.	560 L.F.	69.00	39,000
908+30	36" R.C.P.	600 L.F.	69.00	41,000
920 - 941 (left)	Channel: Excavation	8,560 C.Y.	2.50	21,000
	Concrete	8,020 S.Y.	35.00	281,000
942+70 (left)	2-8'x5' R.C.B.C.'s	180 L.F.	400.00	72,000
943+50 - 994+90 (left)	Channel: Excavation	19,070 C.Y.	2.50	48,000
	Concrete	18,480 S.Y.	35.00	647,000
995+60 (left)	8'x5' R.C.B.C.	120 L.F.	250.00	30,000
996+10 - 1045+10 (left)	Channel: Excavation	7,620 C.Y.	2.50	19,000
	Concrete	11,660 S.Y.	35.00	408,000
1045+70 (left)	48" R.C.P.	120 L.F.	98.00	12,000
55th Avenue Drainageway	Soil Cement Lining	18,130 C.Y.	22.00	479,000
	Bridge at Highway	25,280 S.F.	37.00	1,122,000
	Bridge at Utopia	7,200 S.F.	37.00	320,000
1075 - 1122 (left)	Channel: Excavation	16,710 C.Y.	2.50	42,000
	Concrete	17,700 S.Y.	35.00	620,000
1099+30 (left)	4-6'x6' R.C.B.C.	90 L.F.	580.00	52,000
1122 - 1137 (left)	Channel: Excavation	6,160 C.Y.	2.50	15,000
	Concrete	7,500 S.Y.	35.00	263,000

Sub-Total				\$ 5,125,000
30% Appurtenances and Contingencies				\$ 1,538,000

Sub-Total				\$ 6,663,000
Skunk Creek Crossing*				\$ 1,978,000

TOTAL ESTIMATED COST				\$ 8,641,000

*Cost provided by Project Management Consultant

Table 2
Estimated Costs

Alternative 2

<u>Location (Station-Station)</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
813-866 (right)	Channel: Excavation	12,560 C.Y.	\$ 2.50	\$ 31,000
	Concrete	15,250 S.Y.	35.00	534,000
830 (right)	8'x4' R.C.B.C.	60 L.F.	225.00	14,000
867 (right)	60" R.C.P.	110 L.F.	140.00	15,000
895 (right)	36" R.C.P.	560 L.F.	69.00	39,000
903+30	36" R.C.P.	600 L.F.	69.00	41,000
920 - 941 (left)	Channel: Excavation	8,560 C.Y.	2.50	21,000
	Concrete	8,020 S.Y.	35.00	281,000
942+70 (left)	2-8'x5' R.C.B.C.'s	180 L.F.	400.00	72,000
943+50 - 994+90 (left)	Channel: Excavation	19,070 C.Y.	2.50	48,000
	Concrete	18,480 S.Y.	35.00	647,000
995+60 (left)	8'x5' R.C.B.C.	120 L.F.	250.00	30,000
996+10 - 1045+10 (left)	Channel: Excavation	7,620 C.Y.	2.50	19,000
	Concrete	11,660 S.Y.	35.00	408,000
1045+70 (left)	48" R.C.P.	120 L.F.	98.00	12,000
1072+20	6-10'x6' R.C.B.C.	160 L.F.	1,800.00	288,000
1106 - 1114 (left)	Detention Basin	95,190 C.Y.	2.50	238,000
1106 - Skunk Creek	24" R.C.P.	8,000 L.F.	39.00	312,000
1114 - 1122 (left)	Channel: Excavation	2,840 C.Y.	2.50	7,000
	Concrete	3,010 S.Y.	35.00	105,000
1122 - 1137 (left)	Channel: Excavation	6,160 C.Y.	2.50	15,000
	Concrete	7,500 S.Y.	35.00	263,000

Sub-Total				\$ 3,440,000
30% Appurtenances and Contingencies				\$ 1,032,000

Sub-Total				\$ 4,472,000
Skunk Creek Crossing*				\$ 1,978,000

TOTAL ESTIMATED COST				\$ 6,450,000

*Cost provided by Project Management Consultant

Neither alternative requires the use of special structures. Alternative 2 will require more maintenance because of the use of a detention basin. The 24" outlet storm drain from the basin will also require more maintenance than the improved 55th Avenue drainageway. Alternative 2 is, therefore, given a negative (-) ranking.

E. Evaluation Matrices

Table 3
Evaluation Matrix

	<u>Capital Costs</u>	<u>Effectiveness</u>	<u>Compatibility with other Project & Plans</u>	<u>Ease of Construction and Maintenance</u>	<u>Net Score</u>
Alternative 1	-	0	-	0	-2
Alternative 2	+	0	0	-	0

On the basis of the above evaluation, Alternative 2 will comprise the recommended concept drainage plan.

IX. PRELIMINARY DRAINAGE PLANS

Preliminary plans of the selected facilities for the Outer Loop Highway were developed. The plans include sizes, profiles, alignments and locations as appropriate for channels, pipes, trunk mains, culverts and detention basins. The plans were prepared initially on 1"=200' scale plan and profile sheets prior to reduction for inclusion in this report. The plan sheets are found at the end of this section.

The plan portion depicts drainage area divides; subarea numbers adjacent to the Outer Loop Highway with their respective 100-year peak discharge values; the proposed right-of-way; the highway alignment including interchanges, ramps and frontage roads; topographic features with two foot contour intervals; 100-year floodplain limits for major rivers, creeks and washes, street names, highway stationing and station ticks every 100 feet. Design discharges used for the 100-year drainage facilities are also shown. These values do not include the 20 percent freeboard factor. The location of grader ditches is not shown but should be assumed to be located within the highway right-of-way.

Proposed right-of-way limits were obtained from ADOT right-of-way maps. Existing drainage facilities were inventoried in the field and verified with as-built plans.

One hundred year floodplain limits were obtained from the current FEMA and FIRM maps or from more recent floodplain work maps obtained from the Flood Control District of Maricopa County.

Shown in the profile is the existing ground profile, major street crossings, the cross-section and location of existing crossing drainage structures, the cross-section and location of existing and planned major utilities crossing the Outer Loop Highway and the profiles of the proposed drainage facilities.

The existing ground profile was plotted from the topographic aerial base maps provided by the Project Management Consultant. The current centerline (vertical alignment) of the Outer Loop Highway has also been shown in the profile. Quarter section maps for water, sanitary sewer, gas, buried and overhead electric lines and cable TV were used. The as-built plans for storm drains and critical utilities were also used wherever they were available. Shown in cross-section are water lines 8 inches in diameter and larger, sanitary sewers, major electric lines, gas lines and high pressure gas lines crossing the Outer Loop Highway.

The stationing is based on the stationing proposed by the Project Management Consultant.

The horizontal alignments of the drainage facilities were set to conform to the proposed Outer Loop Highway alignment and geometrics including interchanges, ramps, cut/fill slopes, structures, frontage roads and right-of-way.

The vertical profiles of the proposed drainage facilities were established to provide adequate cover for the structure; ensure positive drainage to the outfalls; ensure that the hydraulic grade line of the drainage facilities will be within the freeboard requirements of tributary laterals and catch basins; avoid conflict with utilities, particularly sanitary sewers and large water distribution pipes; and match existing or proposed drainage facilities by others.

Table 4 is a channel and detention basin summary which identifies the channels by location with respect to highway stationing, structure type, design discharge or volume, slope, channel characteristics [depth and top width (TW)] and length. Table 5 is a culvert summary (refer to Plate 5 for a hydrologic summary of the recommended plan).

Table 4
Channel and Detention Basin
Summary

<u>Location (Station to Station)</u>	<u>Structure Type</u>	<u>Design Discharge/ Volume (20% Freeboard Included)</u>	<u>Slope (ft./ft.)</u>	<u>Channel Depth/TW (ft.)</u>	<u>Channel Bottom Width (ft.)</u>	<u>Velocity (fps)</u>	<u>Depth of Flow (ft)</u>
813 - 866	Channel	137 cfs*	0.0046	4/24	8	6.7	1.8
920 - 941	Channel	554 cfs	0.0009	5/32	12	5.3	4.8
943+50 - 994+90	Channel	290 cfs	0.0009	5/30	10	4.5	3.7
996+10 - 1045+10	Channel	60 cfs	0.0033	3/20	8	4.6	1.2
1106 - 1114	Detention Basin	33 A.F.	N/A	10/-	N/A	N/A	N/A
1114 - 1122	Channel	781 cfs	0.0053	4/32	16	10.7	3.2
1122-1137	Channel	235 cfs	0.0032	4/24	8	15.4	1.4

*Design discharge provided by Project Management Consultant

Table 5
Culvert Summary

<u>Location (Station)</u>	<u>Structure Type</u>	<u>Design Discharge (20% Freeboard Included)</u>	<u>Length (ft.)</u>
830 (right)	8'x4' R.C.B.C.	137 cfs*	60
867 (right)	60' R.C.P.	95 cfs*	110
895	2-36" R.C.P.	65 cfs	280
908+30	2-36" R.C.P.	65 cfs	300
942+70 (left)	2-8'x5' R.C.B.C.'s	494 cfs	180
995+60 (left)	8'x5' R.C.B.C.	230 cfs	120
1045+70 (left)	48" R.C.P.	60 cfs	120
1072+20	6-10'x6' R.C.B.C.'s	2,520 cfs*	160

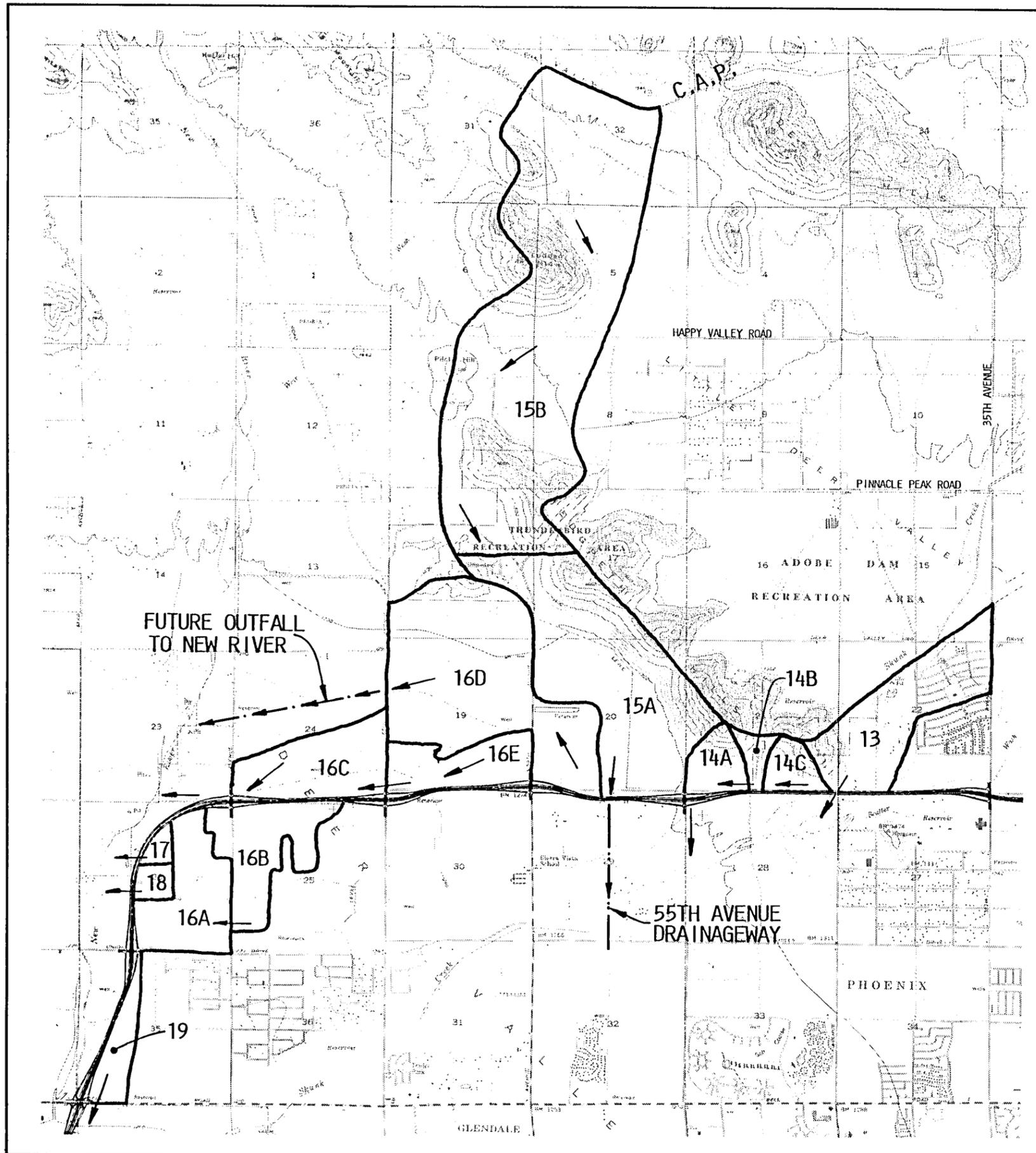
*Design discharge provided by Project Management Consultant

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9	ARIZONA				

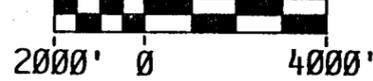
OUTER LOOP HIGHWAY
 BELL ROAD TO SKUNK CREEK
 100-YEAR, 24-HOUR STORM
 RUNOFF SUMMARY - HIGHWAY CONDITIONS
 FLOW IN CUBIC FEET PER SECOND
 TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	BASIN	BASIN AREA	CURVE NUMBER	LAG TIME	PEAK FLOW	TIME OF PEAK	VOLUME (AC-FT)
Hydrograph At	15B*	2.73	86	0.84	2506	12.92	379
Routed To	15A*	----	----	----	2447	13.08	379
Hydrograph At	15A*	1.22	94	0.35	2408	12.42	213
2 Combined At	15A*	3.95	----	----	3173	12.50	592
Routed To	Wet*	3.95	----	----	1104	14.00	551
Hydrograph At	14C	0.06	93	**	196	12.33	10
Cum Hydrograph At	14B	0.20	93	**	651	12.33	34
Cum Hydrograph At	14A	0.32	85	**	837	12.33	49
Routed To	Det. Basin	----	----	----	42	13.50	49
2 Combined At	15A	4.27	----	----	3699	12.50	641
Hydrograph At	16E	0.27	88	1.73	142	13.83	39
Routed To	16C	----	----	----	141	14.00	39
Hydrograph At	16C	0.33	83	1.00	223	13.17	39
2 Combined At	16C	0.60	----	----	312	13.33	78
Routed to New River	---	----	----	----	311	13.50	78
Hydrograph At	16B	0.60	84	1.65	276	13.83	73
Routed To	16A	----	----	----	275	13.83	73
Hydrograph At	16A	0.66	83	1.25	363	13.33	77
2 Combined At	16A	1.26	----	----	614	13.50	150
Hydrograph At	17	0.06	87	0.79	54	12.83	8
Hydrograph At	18	0.05	87	0.60	54	12.67	7
Hydrograph At	19*	0.09	80	0.65	71	9.00	8

* Peak Flow Provided by Project Management Consultant
 ** Kinematic Wave Model Used



SCALE: 1"=4000'



LEGEND:

- 15A WATERSHED AREA I.D.
- WATERSHED AREA BOUNDARY
- DIRECTION OF FLOW



DESIGN	ARIZONA DEPARTMENT OF TRANSPORTATION HIGHWAY DIVISION OUTER LOOP HIGHWAY BELL ROAD TO C.A.P. CANAL
DRAWN	
CHECKED	
APPROVED	
HYDROLOGIC SUMMARY	
RECOMMENDED	
PLATE 5	
GREINER ENGINEERING SCIENCES 7310 N. 16th Street, Suite 160 Phoenix, Arizona 85020 (602) 275-5400	DRWG. NO.

X. **ADDITIONAL RIGHT-OF-WAY REQUIREMENTS**

Additional rights-of-way requirements are identified in areas where the existing or proposed right-of-way, as provided to Greiner Engineering by the Project Management Consultant, are insufficient to accommodate the recommended drainage facilities. At a number of locations, the need for additional right-of-way is directly dependent on the highway's vertical and horizontal geometry, use of retaining walls, piers and embankment fill for elevation. For these locations, the design assumptions made by Greiner are identified. Minimum right-of-way requirements for open channels were defined by the Project Management Consultant as the required channel top width, plus an additional 30 feet for buffer. Locations and descriptions of additional rights-of-way required are as follows.

Station 908+30: A 40 foot wide by 350' long strip of land is required for an outlet grader ditch to convey culvert discharges to New River (refer to Plan Sheet 3 for the location of this area).

XI. CONCLUSIONS AND RECOMMENDATIONS

An optimum drainage concept plan has been developed that will provide flood-water protection to the Outer Loop Highway between Bell Road and Skunk Creek. The plan ensures that there will be no adverse affects on adjacent areas and that downstream drainage receiving facilities or natural water-courses have the adequate capacity to handle off-site stormwater flows from the Outer Loop Highway.

The drainage scheme developed by Arrowhead Ranch was carefully reviewed. All drainage outfalls proposed by the Arrowhead Master drainage plan that impact the Outer Loop Highway were incorporated into the highway drainage system.

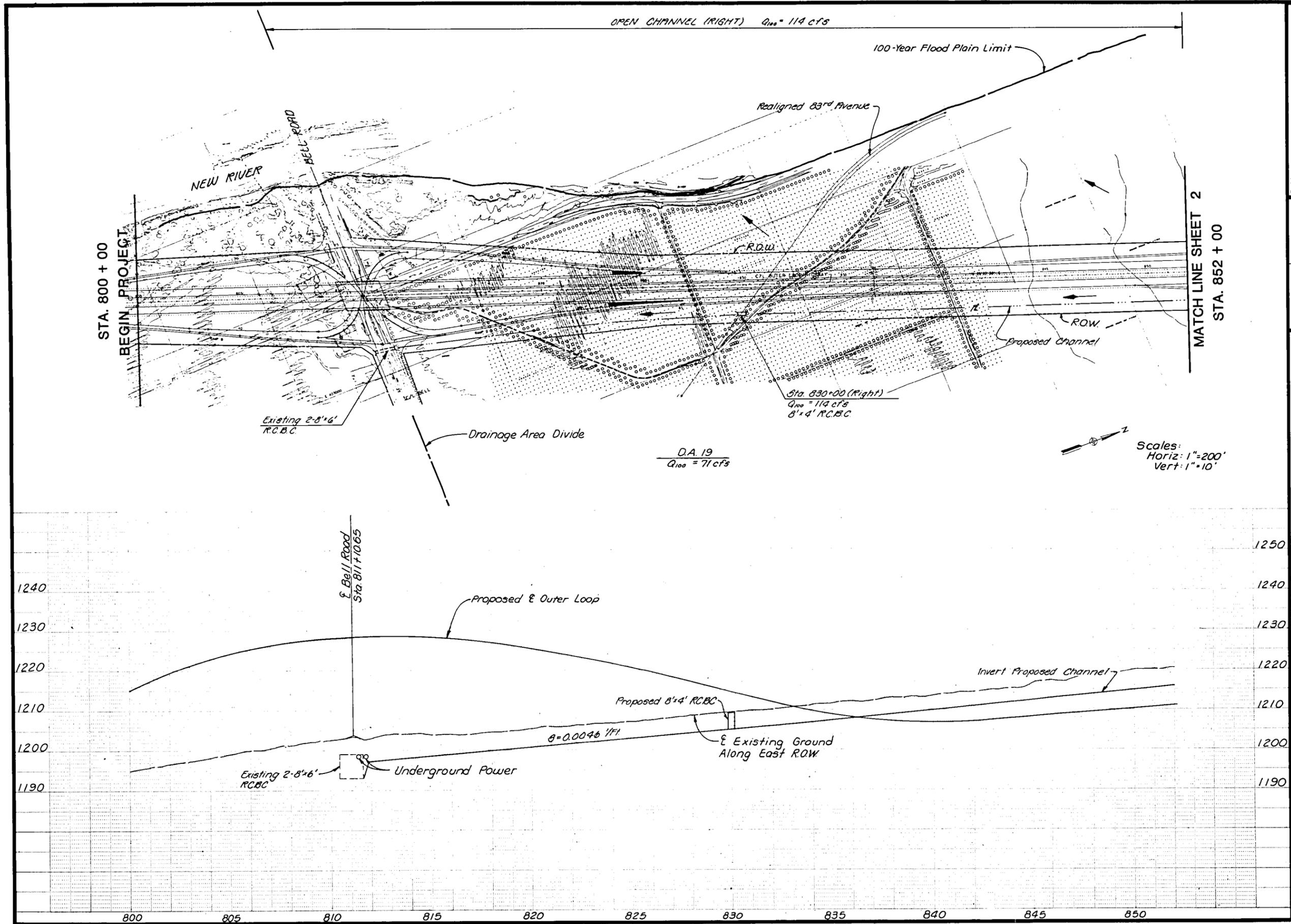
Additional right-of-way needs were identified at one location only, Station 908+30.

The costs to construct the Outer Loop Highway drainage facilities for off-site runoff were also evaluated. Total estimated costs for the plan, not including right-of-way acquisition, is 5.5 million dollars.

XII. REFERENCES

1. U.S. Department of Agriculture, Soil Conservation Service General Soil Map, Maricopa County, Arizona, 1973.
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3. National Oceanic and Atmospheric Administration, Atlas 2, Volume VIII - Arizona, Precipitation Frequency Atlas of the Western United States, Washington, D.C., 1973.
4. U.S. Department of Agriculture, Soil Conservation Service, Urban Hydrology for Small Watersheds, T.R. No. 55, 1975.
5. U.S. Department of Agriculture, Soil Conservation Service, National Engineering Handbook, Section 4, Hydrology, 1972.
6. U.S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-1, Flood Hydrograph Package Users Manual, September 1981, Revised 1983.
7. Brater and King, Handbook of Hydraulics, Sixth Edition, 1976.
8. U.S. Army Corps of Engineers, Adobe Dam Design Memorandum No. 3, Phase II, Part 2.
9. U.S. Army Corps of Engineers, Cave Buttes Dam Design Memorandum No. 3, Phase II, Part 1.
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11. Bureau of Reclamation, Central Arizona Project, GRA, Reach 10 Hydrology (unpublished calculations).
12. Topographic and Highway Geometric and Layout Plans for the Outer Loop Highway; DeLeuw, Cather and Company.
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14. Arrowhead Ranch Infrastructure, 55th Avenue Drainage Channel Project No. A845035; Moore, Knickerbocker and Associates; Carollo/Swengel-Robbins, July 1984.
15. Floodplain Delineation Maps for New River, Skunk Creek, Scatter Wash and Cave Creek U.S.C.O.E./ F.E.M.A.
16. Arrowhead Ranch Lake Outfall at 55th Avenue Analysis by DCCO, Memorandum of November 18, 1986; Deleuw Cather & Company.
17. Section 5A Drainage, memorandum of April 24, 1987; Deleuw Cather & Company.



Revisions

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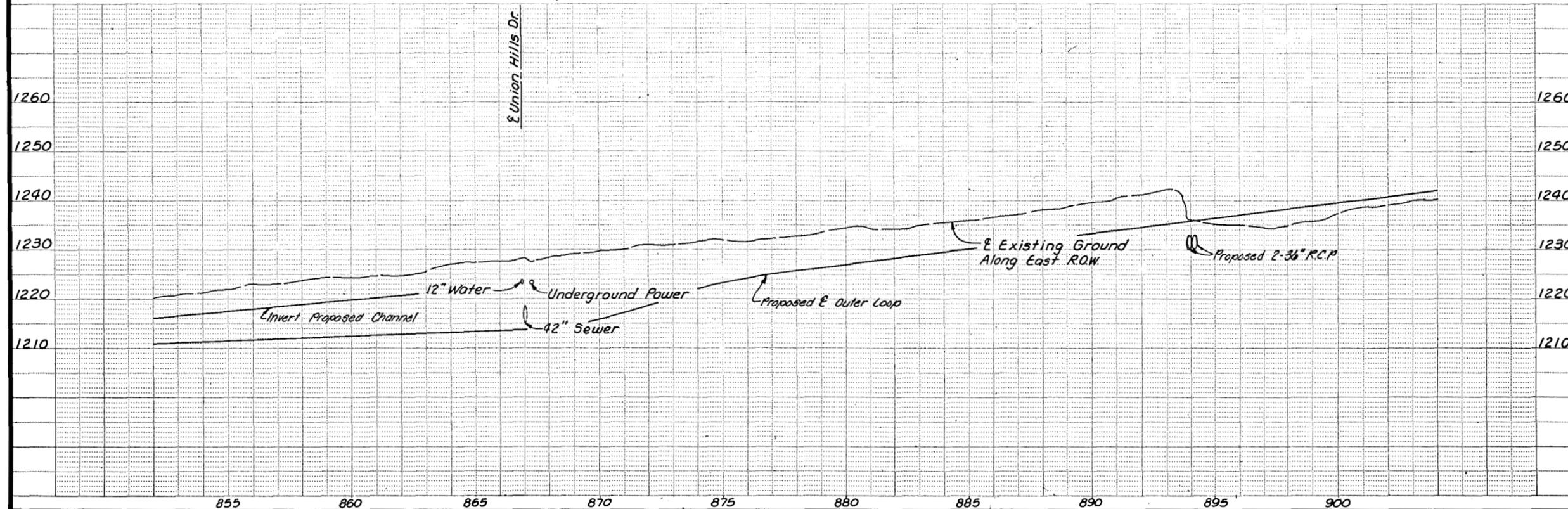
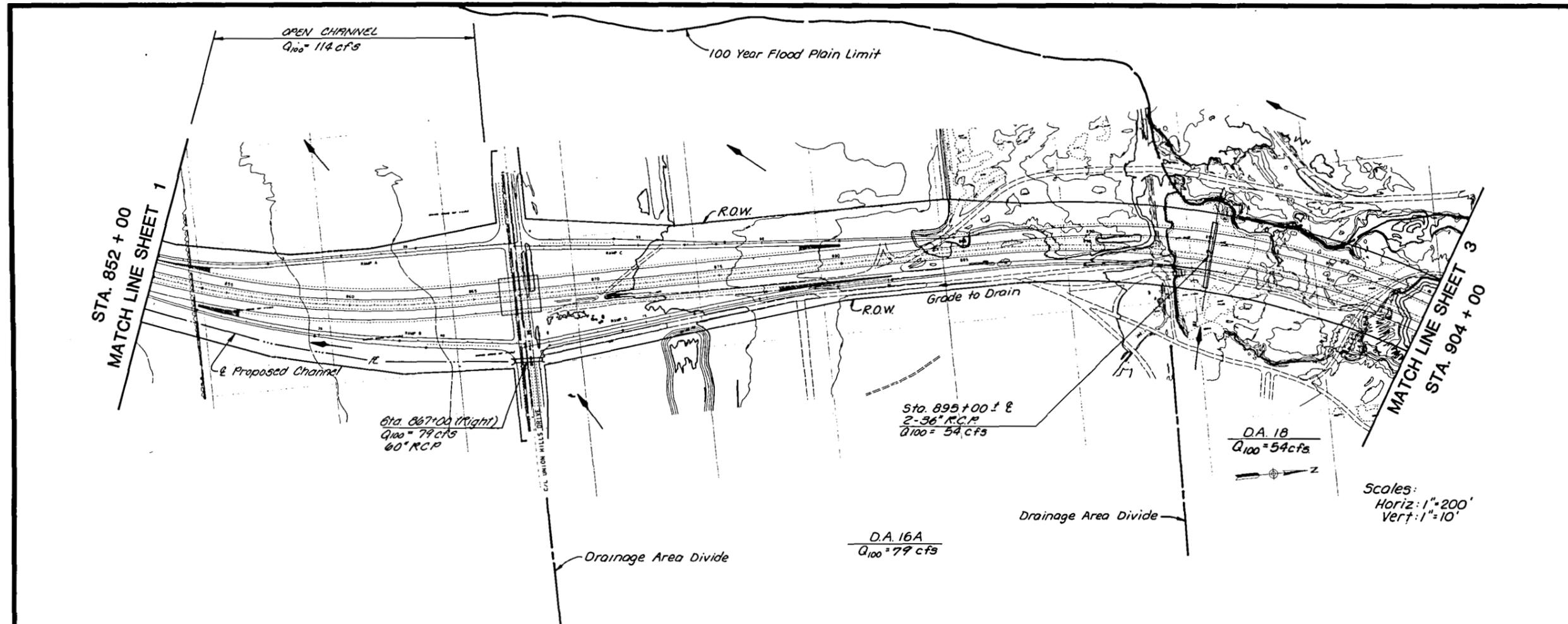
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**OUTER LOOP HIGHWAY
BELL ROAD TO C.A.P. CANAL
CONCEPT DRAINAGE PLANS**

Date SEPTEMBER 1987
Job No. E112013

Sheet 1 of 1



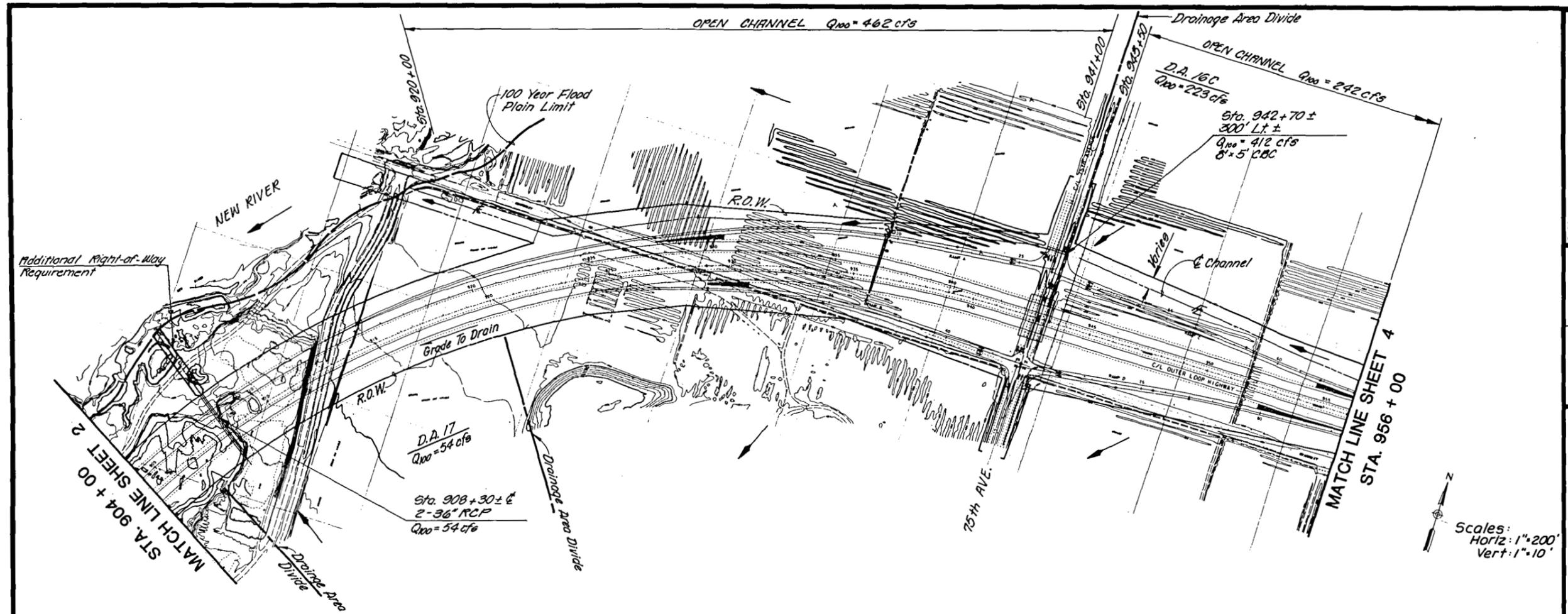
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 CONCEPT DRAINAGE PLANS**

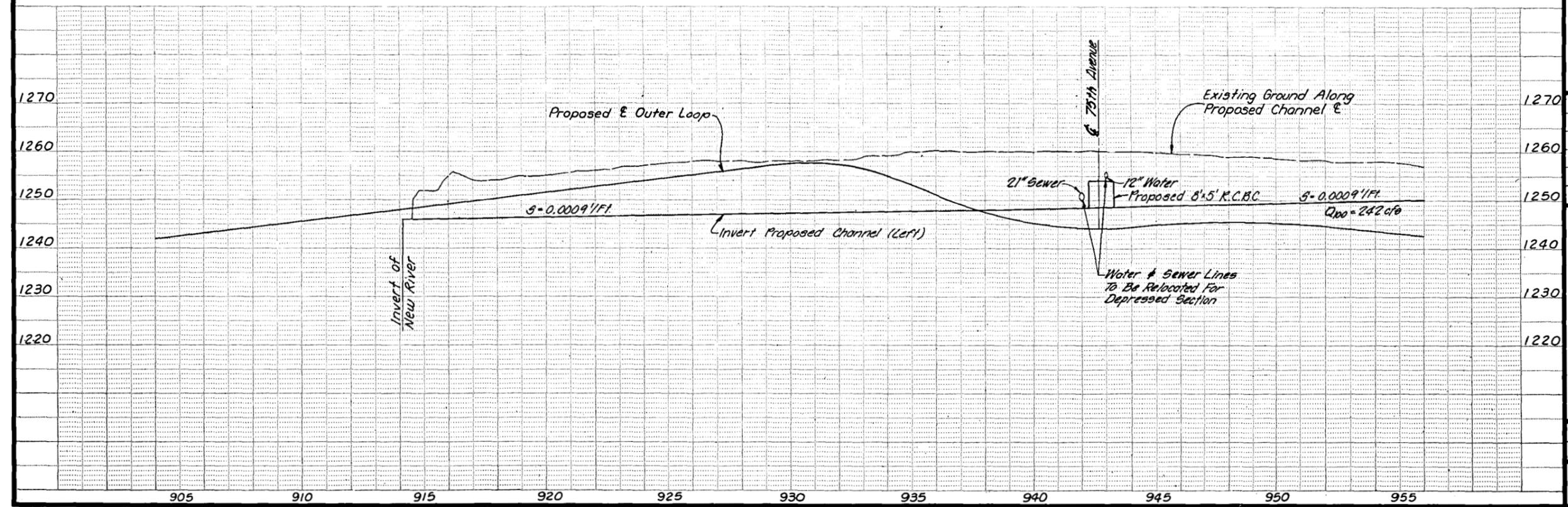
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Sheet 2 of 4



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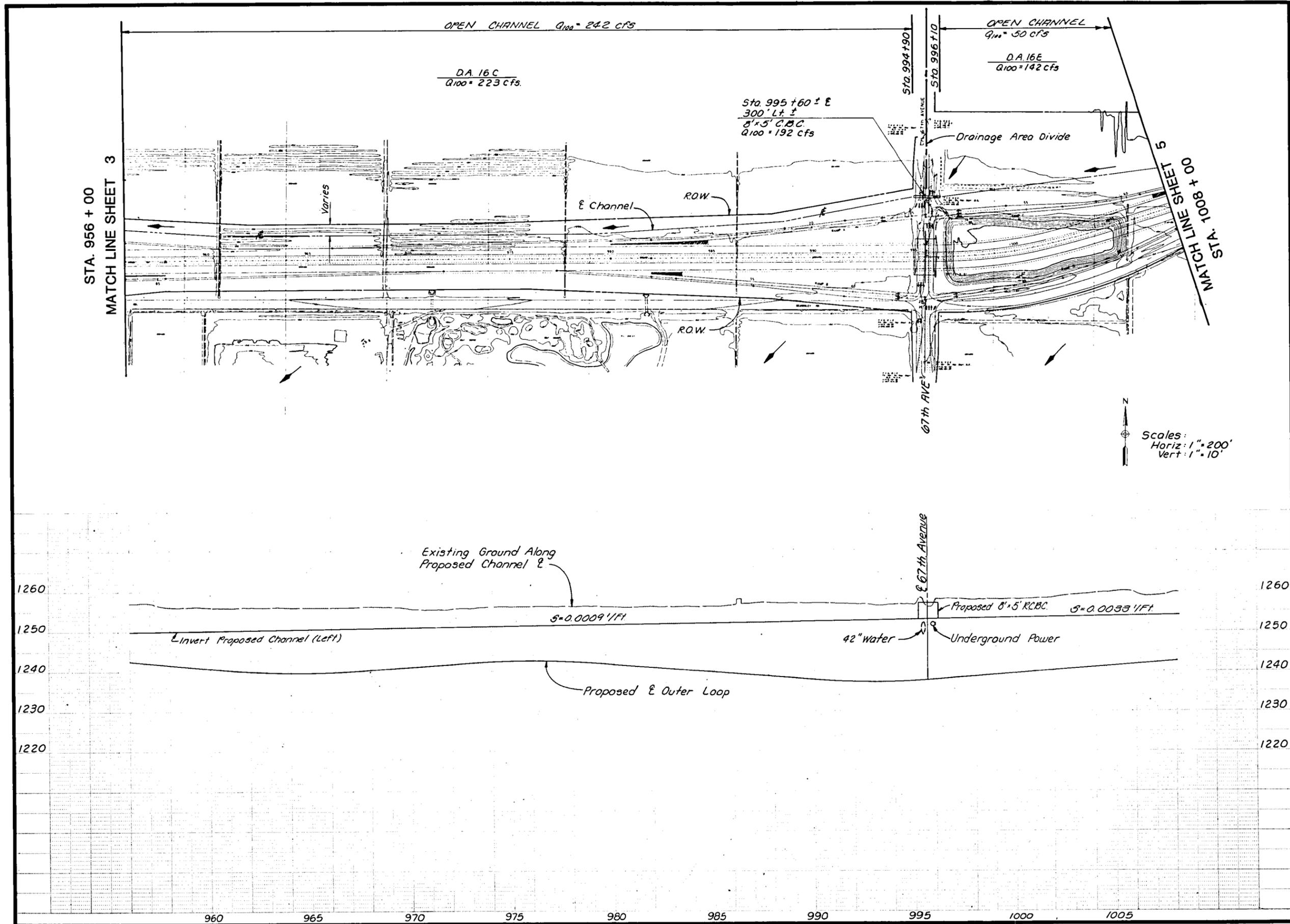
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OUTER LOOP HIGHWAY
BELL ROAD TO C.A.P. CANAL
CONCEPT DRAINAGE PLANS

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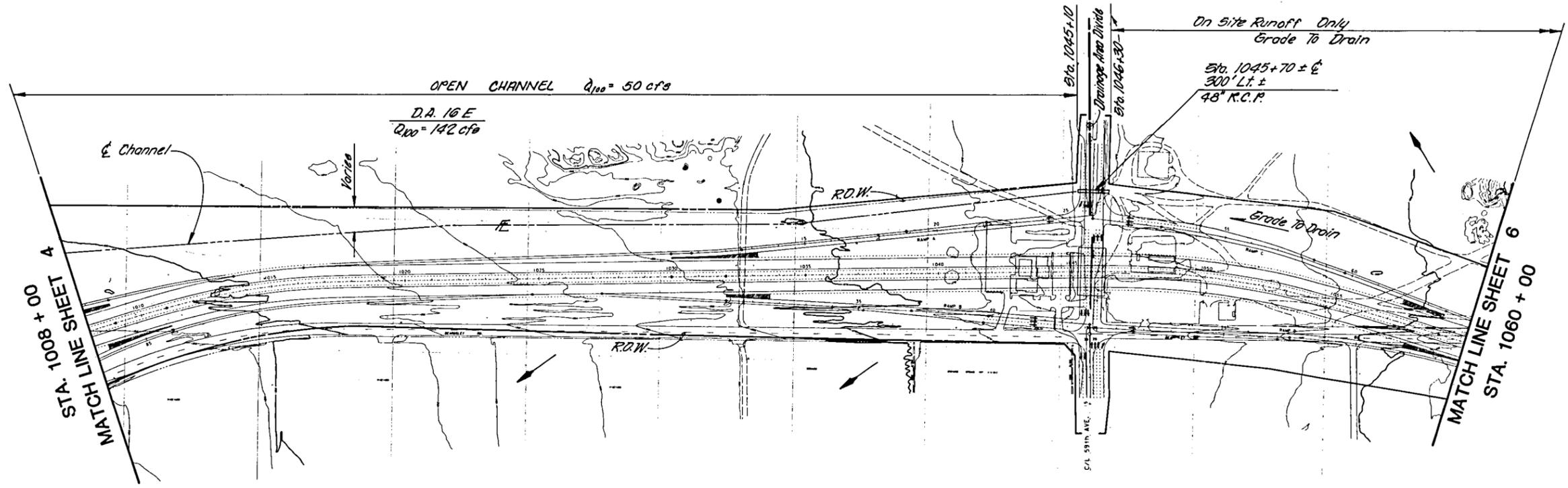
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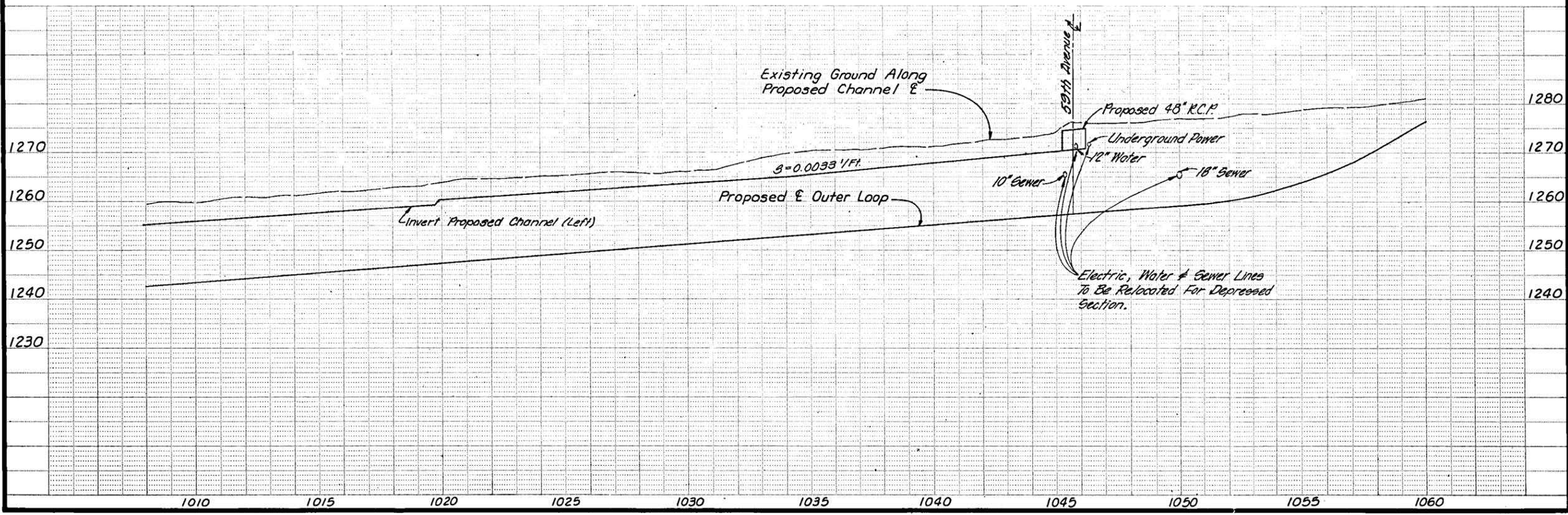
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CONCEPT DRAINAGE PLANS

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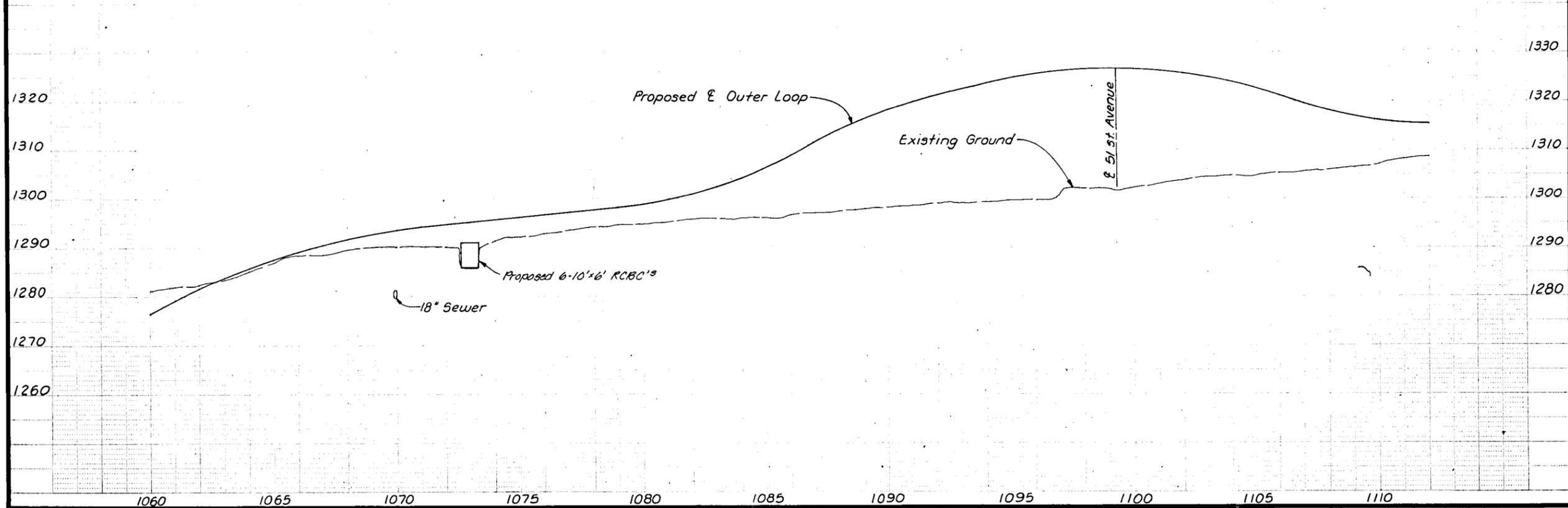
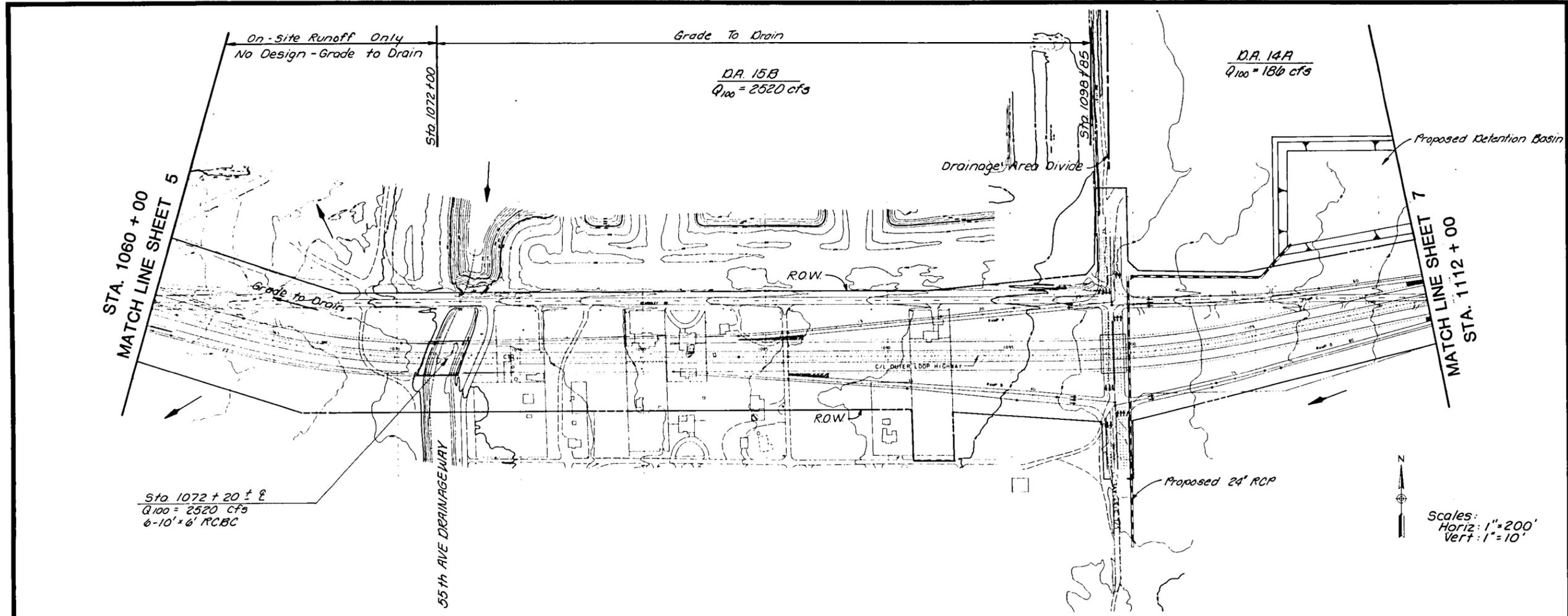
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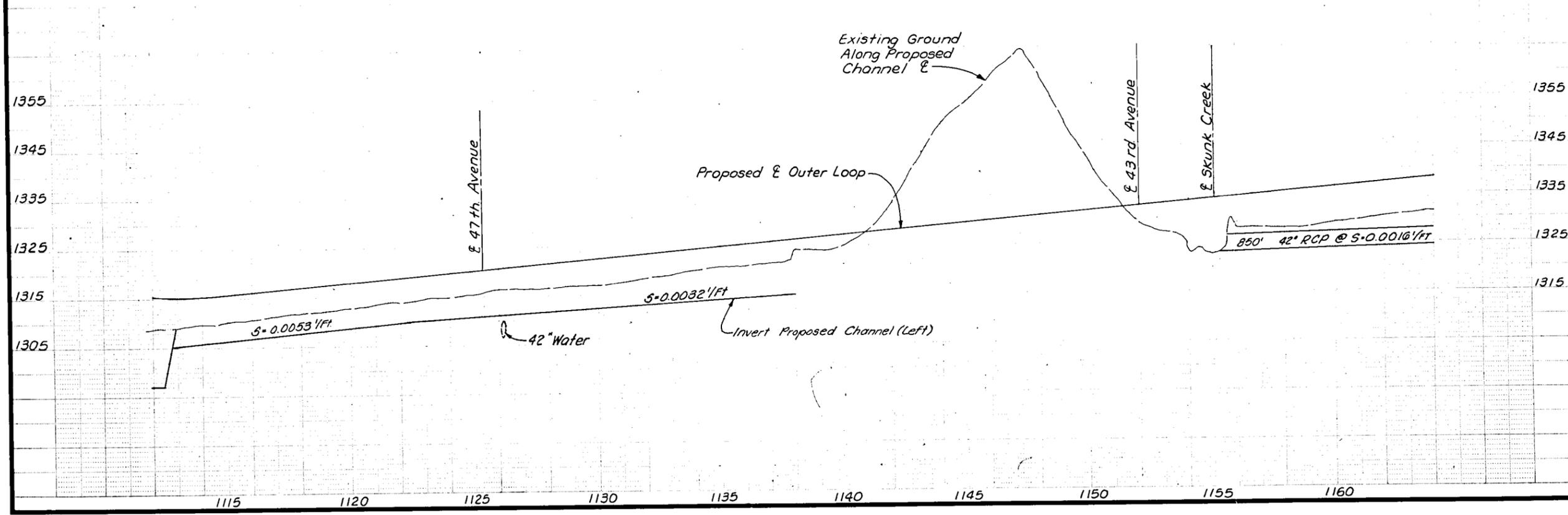
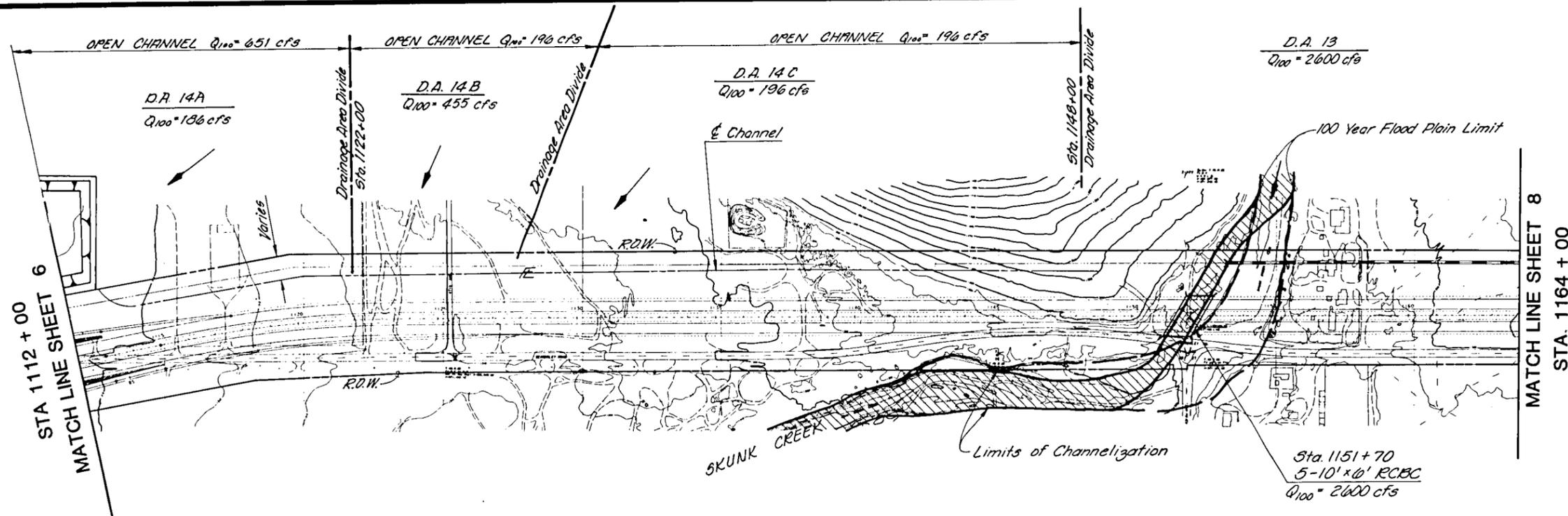
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OUTER LOOP HIGHWAY
BELL ROAD TO C.A.P. CANAL
CONCEPT DRAINAGE PLANS

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Sheet of 6



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Sheet 7 of 7