KINGMAN AREA
MASTER DRAINAGE PLAN

APPENDICES - VOLUME 2

BULL MOUNTAIN BASIN
SOUTHEAST AREA DRAINAGE

June 1988

BOYLE ENGINEERING CORPORATION
consulting engineers / architects

KINGMAN AREA
MASTER DRAINAGE PLAN

APPENDICES - VOLUME 2

BULL MOUNTAIN BASIN
SOUTHEAST AREA DRAINAGE

June 1988

BOYLE ENGINEERING CORPORATION
consulting engineers / architects

PREFACE

In March 1987 the City of Kingman contracted with Boyle Engineering Corporation to prepare a Master Drainage Plan for the greater Kingman Area. The work was to include a Drainage Design and Administrative Manual, A Master Drainage Plan, a more detailed analysis of the Bull Mountain Drainage Basin, and an Executive Summary of the entire project.

The results of the study are presented in the following documents:

Executive Summary	
Master Drainage Plan	
Appendices - Volume 1	Hydrology/Hydraulic Details
Appendices - Volume 2	Bull Mountain Basin Southeast Area Drainage
Design and Administrative Manual	

This document is **Appendices - Volume 2 Bull Mountain Basin Southeast Area Drainage.**

The reports presented in this Volume were prepared prior to the completion of the final master plan and there are elements that have since been modified in the final plan. Where there is a discrepancy, the final master plan should govern.

APPENDIX D
BULL MOUNTAIN BASIN

KINGMAN AREA
MASTER DRAINAGE STUDY

July, 1987

Table of Contents

D1. INTRODUCTION

The study of the Bull Mountain Basin is part of an overall Master Drainage Plan for the City of Kingman and surrounding environs. The limits of the basin are presented in Figure D1.1.

The Bull Mountain Basin has experienced extensive recent development resulting in a need for improvements to Stockton Hill Road. Stockton Hill Road is the major north-south arterial street on the west side of Kingman. Flooding of the street during relatively minor events has resulted in numerous traffic delays and increased maintenance.

The drainage planning of the Bull Mountain Basin is of highest priority due to the planned improvements of Stockton Hill Road between Northern Avenue and Gordon Drive. Therefore, the analysis of this basin preceeds all others and was performed prior to the completion of the Drainage Design and Administrative Manual.

The purpose of this study is to reduce the impacts of storm water runoff within the Bull Mountain Basin. This is to be achieved in a manner which balances the costs of improvements against the level of protection against flooding. Specific goals are to:

- Reduce inconvenience due to flooding.
- Reduce areal extent of flooding.
- Reduce flooding and overtopping of roadways.
- Maximize flood protection with minimum cost.

To achieve these goals, a concept was developed to provide a system of drainage improvements which controls the 100-year storm runoff. This is accomplished by eliminating flooding and street overtopping during minor storms and reducing it during major floods. Some damage may occur during the 100-year storm;

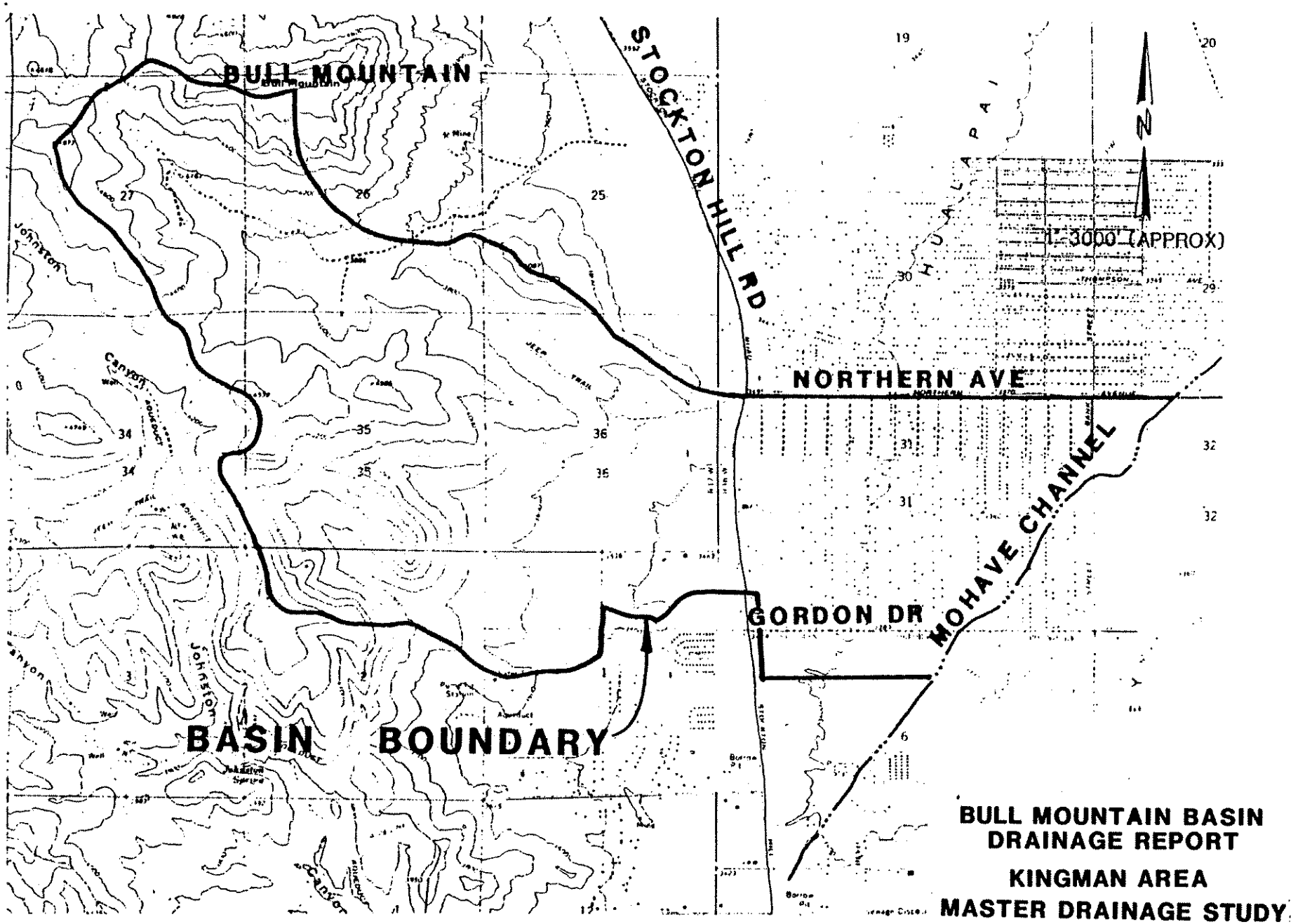


Figure D1.1 Location Map

however, catastrophic failure of the system is not anticipated and the extent of flooding is limited. Particular attention is to be paid to controlling storm flows which cross Stockton Hill Road. Because limited funds for construction and right-of-way may require phasing of the project, a phasing sequence is recommended.

In order to reduce the impacts of storm water runoff within the Bull Mountain Basin, a study consisting of the following components was performed:

- Identify existing problem areas within the basin.
- Examine existing basin characteristics.
- Quantify hydrologic and hydraulic response of the basin.
- Identify alternative solutions for the correction of drainage problems.
- Evaluate alternative solutions.
- Recommend solutions and construction phasing.
- Prepare preliminary design for recommended improvements.

D2. EXISTING CONDITIONS

The Bull Mountain Basin is located near the northwest corner of the City of Kingman. It is approximately 4 miles long and 1.5 miles wide, covering an area of nearly 6 square miles. The basin includes that portion of Bull Mountain which contributes runoff to Stockton Hill Road between Northern Avenue and Gordon Drive.

The upper reaches of the catchment are mountainous with slopes in excess of 35%. Closer to Stockton Hill Road the basin is on an alluvial fan. Slopes on the fan are about 4%, decreasing to 2% east of Stockton Hill Road to the Mohave Channel.

D2.1 Basin Development

Stockton Hill Road, Northern Avenue, Gordon Drive and Sierra Vista Avenue traverse the basin. Existing development within the Bull Mountain Basin is primarily residential, with commercial development along the major streets. A small area of low-density residential exists west of Stockton Hill Road. Residential development has taken place to a much greater extent between Stockton Hill Road and the Mohave Channel, with densities averaging about two units per acre.

Residential and commercial development is expected to continue in the basin. As shown in Figure D2.1, the ultimate land use plan for the basin is low-density residential. With the exception of the commercial strips along the major streets, existing development generally conforms to the land use plan.

D2.2 Soils

Soils within the Bull Mountain Basin can be divided into three regional groups consisting of mountains, alluvial fan and the Mohave Channel. Figure D2.2 presents the various soils classified by SCS hydrologic soil group.

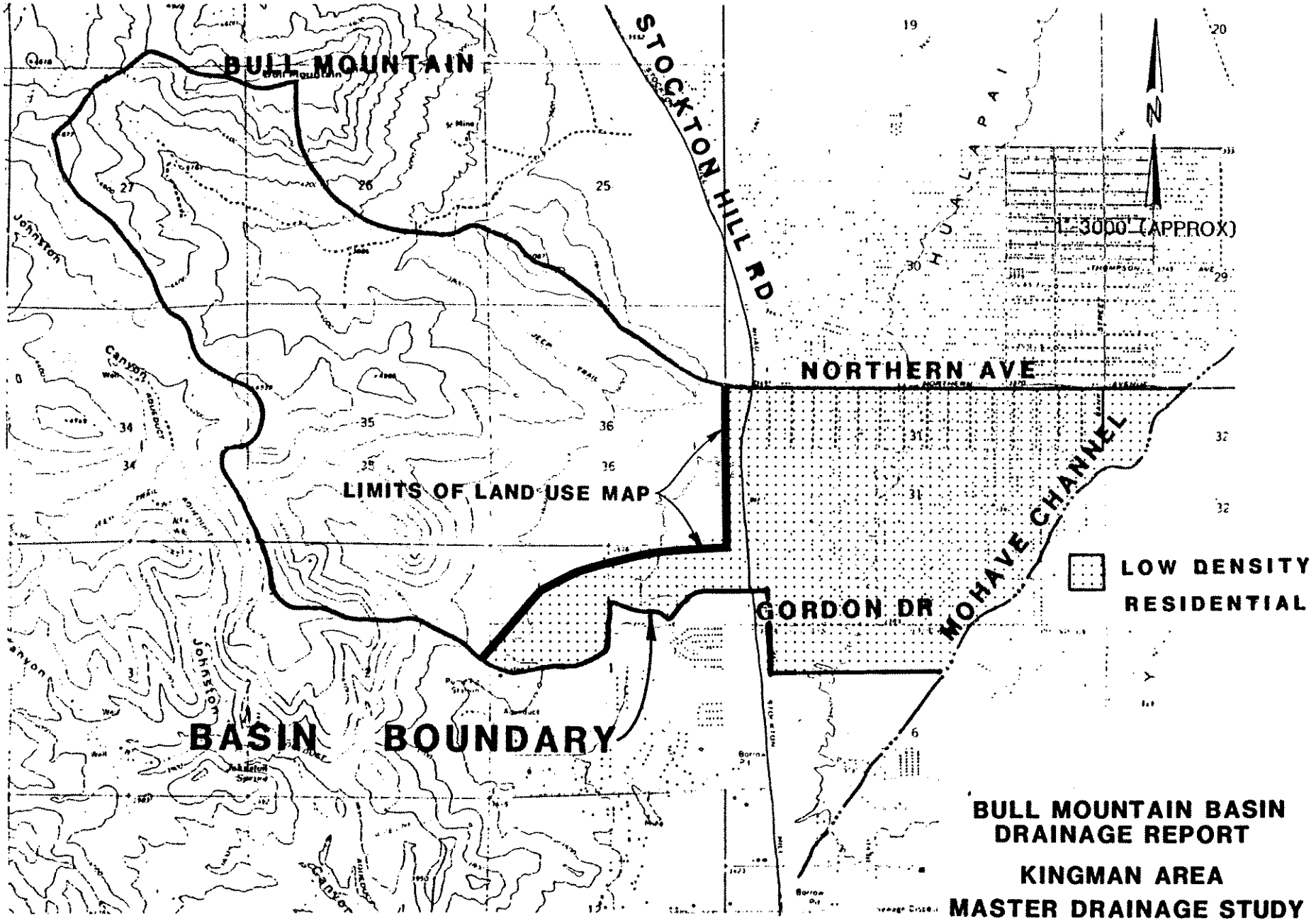


Figure D2.1 Land Use

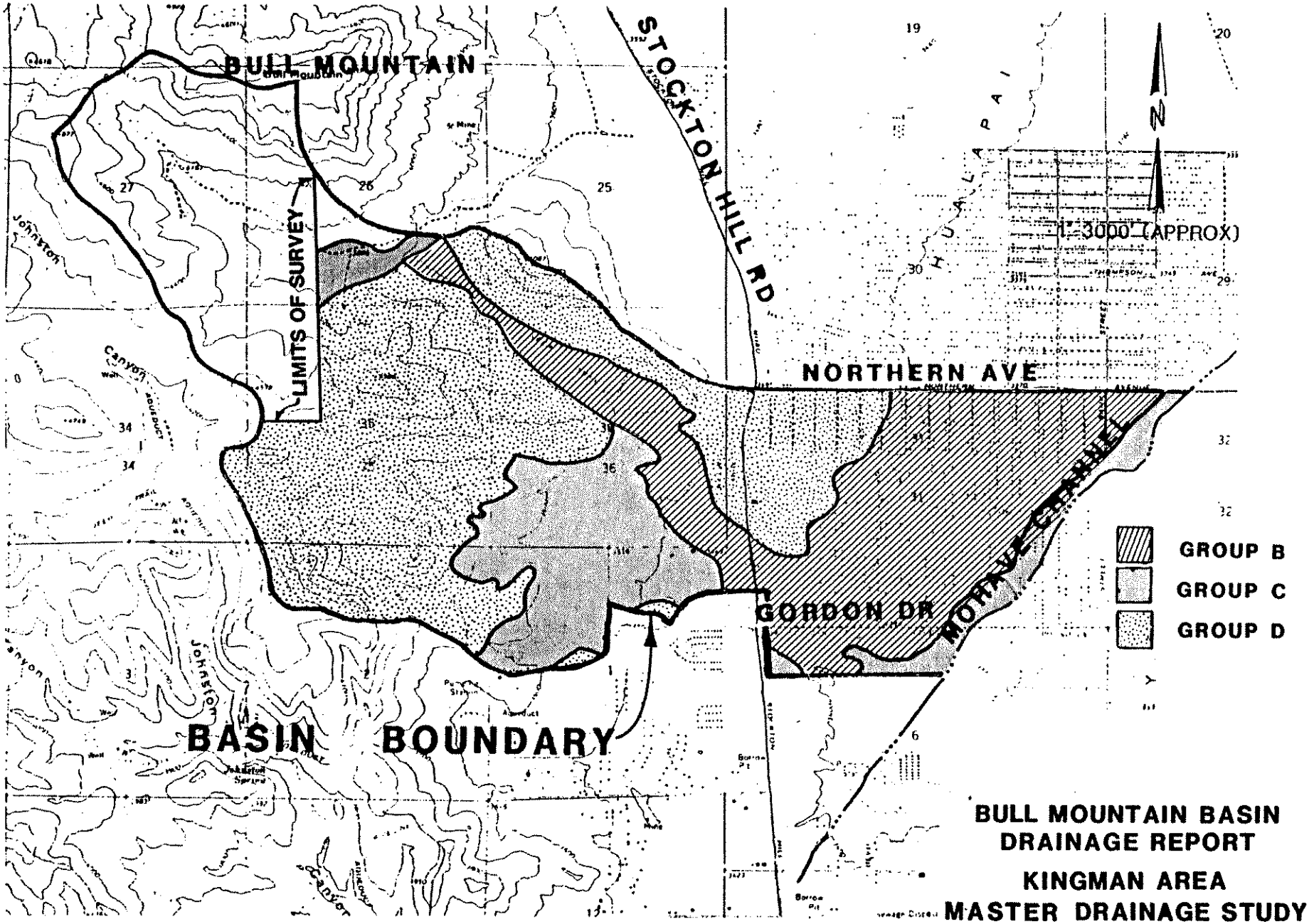


Figure D2.2 Hydrologic Soil Groups

Boyle Engineering Corporation
consulting engineers / architects

Soils in the mountains consist of rock outcrops and shallow, well-drained soils of the Akela Series. The SCS hydrologic soil classification is Group D.

Two soil types are present on the alluvial fan covering a majority of the remainder of the basin. The Whitehills Series is a moderately deep deposit of sandy and clay loam overlying hardpan at 3 to 4 feet. The hydrologic soil group is C. The Pajarito Series consists of deep, well-drained fine sandy loam with hydrologic classification of Group B.

The remaining soil type, the Glendale Series, is located in the Mohave Channel. It contains deep, well-drained soils typical of flood plains. The hydrologic soil group is C.

D2.3 Existing Drainage

Currently, there are no continuous defined channels in the basin which convey flows from the upper reaches of the catchment to the Mohave Channel. Runoff from the mountains travels swiftly, transporting sediment and boulders in defined washes. Further downstream, as the runoff flows onto the alluvial fan, velocities decrease slightly and washes tend to be laterally unstable.

At Stockton Hill Road, flatter ground slopes and recent development in the vicinity of the washes have resulted in deposition of sediment and boulders. Most of the runoff continues across Stockton Hill Road in three dipped sections between Gordon Drive and Northern Avenue.

Downstream of Stockton Hill Road, some of the flow continues overland and down streets to the Mohave Channel. The flow not crossing Stockton Hill Road in the dipped sections flows south on Stockton Hill Road to Gordon Drive and then east in a large wash south of Gordon to the Mohave Channel.

Within the Bull Mountain Basin, the Federal Emergency Management Agency (FEMA) has designated the Mohave Channel and surrounding area to be in the 100-year shallow flooding zone or Zone AH. The remainder of the alluvial fan within the Bull Mountain Basin lies in the zone of minimal flooding, or Zone C.

D2.4 Existing Problem Areas

Because drainageways are not continuous across Stockton Hill Road, frequent flooding occurs, especially in the vicinity of Gordon Drive and Stockton Hill Road. The three dipped sections on Stockton Hill Road also experience flooding problems. These problems continue downstream through the existing development to the Mohave Channel.

D3. BASIS OF DESIGN

D3.1 Available Data

Information available for this study includes:

- New aerial topographic maps from 3,000' west of Stockton Hill Road to the Mohave Channel at a scale of 1"=200' with 2 foot contour intervals.
- USGS topographic maps at a scale of 1"=2000' with 10 foot to 40 foot contour intervals. The Stockton Hill, Kingman Airport and Kingman NE quadrangles photo revised in 1980 were used.
- Existing aerial mapping furnished by City staff.
- Maps of existing right-of-way provided by City staff.
- As-built drawings of road, sewer and water improvements recorded with the City of Kingman.
- Flood Insurance Rate Maps.
- SCS Soil Survey Special Report for Parts of Mohave County, dated 1980 and extended in 1987.
- City of Kingman General Plan for 1990 (Wilsey & Ham, 1971).
- Discussions with the City staff regarding problem areas and possible relief measures.
- Field location and measurement of existing drainage structures.

- Discussions with the State Climatology Office and Arizona Department of Water Resources regarding historic rainfall in the area.

- National Oceanic and Atmospheric Administration (NOAA) Precipitation-Frequency Atlas.

D3.2 Methodology

Drainage patterns on an alluvial fan may change with each new storm. The dynamic nature of fan drainage is not consistent with the rigid boundary assumptions used in basin analysis. To allow for this, it was necessary to make certain assumptions so that the continually changing system could be modeled statically. It was assumed that the boundaries of the subcatchments and location of the conveyance channels would not shift.

The quantity of rainfall was derived from the NOAA Atlas; the rainfall distribution was taken from the Riverside County Flood Control and Water Conservation District (RCFC & WCD) rainfall patterns.

The SCS runoff estimation procedure within the HEC-1 hydrology package was chosen to estimate peak flows. The hydrograph generated is a function of basin geometry, slope and channel roughness, while the rainfall abstraction is related to the ground cover and hydrologic soil group.

Because of steep slopes and high velocities in the Bull Mountain Basin, channel routing during the hydrologic analysis was not considered necessary. To test this assumption, the effect of channel routing was investigated for critical areas in the basin. The results showed that the reduction in peak flow due to channel routing is negligible and was therefore not considered further.

D4. ALTERNATIVE PROPOSALS

Alternatives were developed to alleviate flooding problems within the Bull Mountain Basin. As stated previously, the purpose of drainage improvements is to reduce the impact of flooding and maximize the protection available while minimizing the cost. The general concept used to achieve this is to control the 100-year event through a system of structural improvements and non-structural management techniques.

In the Bull Mountain Basin non-structural management techniques are applied through the use of drainage reserves. These reserves are intended to facilitate the implementation of future improvements within the basin. The drainage reserve must be provided in the general vicinity of the existing wash. Subsequent improvements can then be made to the reserve as development dictates.

Possible structural alternatives within the Bull Mountain area include upstream detention and open channels. These can be evaluated in combination or independently. Upstream detention usually requires some level of downstream channel improvements, while channel improvements do not necessarily require any upstream detention.

D4.1 Detention

Detention facilities are designed to capture flow before it reaches critical areas and detain it so that peak flow is reduced. Detention provides for the storage of inflow and the controlled release of outflow. The location of a detention facility within the basin in part determines effectiveness and cost.

Because of the existing development in the downstream portions of the Bull Mountain Basin, detention was not considered downstream of Stockton Hill Road. Within the canyon areas at the foot of the mountains, excessive embankment heights would be required to provide useful storage volumes. This resulted in the elimination of detention facilities within the mountain canyons as a viable alternative.

Detention facilities constructed on the alluvial fan upstream of Stockton Hill Road were evaluated. A typical application of detention within this basin would require the storage of storm flows in excess of the 10-year storm. For a subcatchment area of approximately 1900 acres, a storage volume of more than 100 acre-feet would be required. Limiting the maximum embankment height to less than 10 feet and assuming an overland slope of approximately 2%, a surface area of approximately 30 acres would be required to store the volume of storm water. In addition, an embankment of approximately 2000 linear feet would be required to store 100 acre-feet of water. It was concluded that detention facilities of this magnitude were not feasible within the Bull Mountain Basin area because of their extensive land requirements and the expense associated with long embankment construction.

D4.2 Open Channels

An open channel system designed to collect and convey the flow in a controlled manner to the Mohave Channel was investigated. The purpose of these channels is to collect flows entering the developed areas by intercepting and conveying them to the Mohave Channel.

The interception and collection of flows from the mountainous regions of the basin occurs west of Stockton Hill Road and eliminates the cost of multiple channel crossings of Stockton

Hill Road. Limiting the crossing of Stockton Hill Road to one location, in addition to minimizing the cost, allows for an economical contingency in the event of flows in excess of the design.

The downstream channel from the outlet of the Stockton Hill Road crossing to the Mohave Channel follows as closely as possible the existing flow patterns. Some modification will be required to take advantage of existing undeveloped areas and to minimize right-of-way acquisition costs.

D5. PROPOSED SYSTEM

D5.1 Constraints

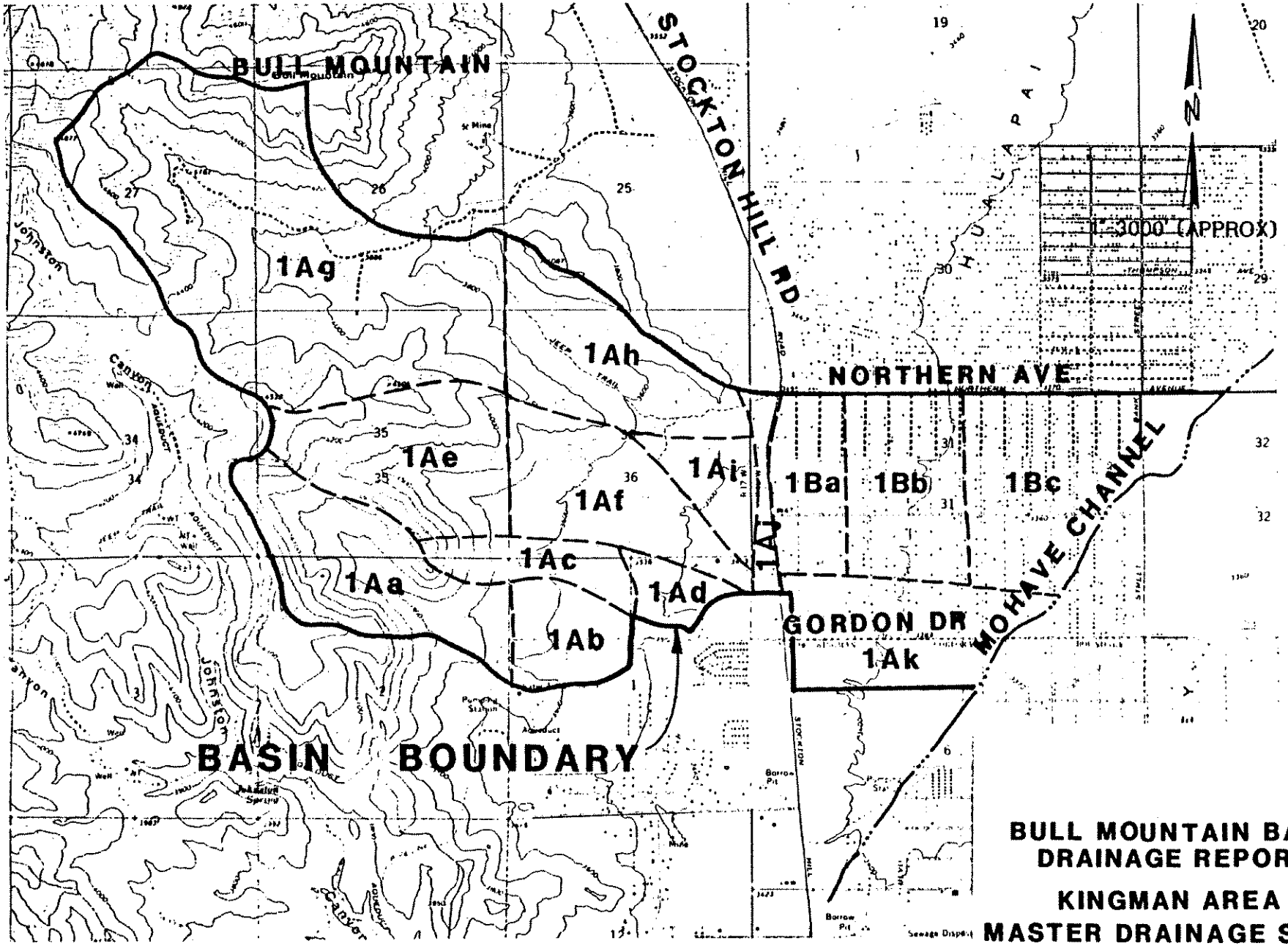
Numerous physical and technical constraints dictate the final proposed alignment. The most obvious physical constraints are Stockton Hill Road and development within the basin. The nature and extent of the existing development limits the potential channel and crossing locations. An existing coal slurry pipeline crossing Stockton Hill Road in the vicinity of Gordon Drive imposes a further constraint on potential alignment.

In addition to the physical constraints, technical constraints impact the selection of the alignment. Because of the high channel velocities and steep overall basin gradient, changes in direction of flow within the channel were kept to a minimum. The possibility that all improvements would not be constructed simultaneously was also considered during the selection of the recommended alignment.

The concept of collecting flows upstream of Stockton Hill Road, providing one crossing of Stockton Hill Road and constructing downstream improvements to convey flow to the Mohave Channel was presented to the Kingman Council. The concept was accepted. Hydrologic and hydraulic analyses were then undertaken to finalize the sizing and location of the plan components.

D5.2 Hydrology

The drainage basin was subdivided into 14 subbasins ranging in size from 80 to 1000 acres. These subbasins were delineated to reflect homogeneous land use and hydrologic characteristics. Figure D5.1 presents the subbasin delineation and identification. The delineation and linking of the basins is consistent with the alternative selected. The results of the hydrologic analysis for the 10-year and the 100-year events are presented in Table D5.1.



BULL MOUNTAIN BASIN DRAINAGE REPORT

KINGMAN AREA MASTER DRAINAGE STUDY

Figure D5.1 Subbasin Delineation

Boyle Engineering Corporation
consulting engineers / architects

Table D5.1 Hydrologic Data Summary

Sub-basin	Area (sq mi)	Tc (hr)	CN	Runoff (in) 10y	Runoff (in) 100y	Qp (cfs) 10y	Qp (cfs) 100y
1Aa	.50	.22	84	.59	1.38	270	550
1Ab	.20	.13	84	.59	1.38	120	240
1Ac	.15	.17	82	.51	1.25	80	160
1Ad	.12	.14	81	.47	1.18	60	130
1Ae	.45	.14	84	.59	1.38	260	530
1Af	.39	.22	82	.51	1.25	190	400
1Ag	1.57	.30	90	.91	1.82	1030	1880
1Ah	.43	.23	81	.47	1.18	190	420
1Ai	.13	.18	75	.28	.85	40	110
1Aj	.13	.23	80	.44	1.12	50	120
1Ak	.38	.25	73	.23	.76	100	270
1Ba	.21	.13	85	.64	1.45	130	260
1Bb	.34	.18	77	.34	.96	130	300
1Bc	.50	.20	73	.23	.76	140	370

D5.3 Hydraulics

Using the discharge rates developed in the hydrologic analysis and the conceptual plan developed in the Alternative Proposal section, a hydraulic analysis was performed to determine required channel size, depth of flow and velocity. Table D5.2 presents the results of the hydraulic analysis of the channels. Exhibit D1 presents the hydraulic linking and node numbers.

Table D5.2 Hydraulic Data Summary

Reach	Runoff (cfs)	Slope (%)	Base Width (ft)	Depth (ft)
1A13 - 1A14	1880	1.0	30	5
1A12 - 1A19	530	1.0	10	4
1A16 - 1A18	160	1.0	10	2
1A16 - 1A21	770	1.0	10	5
1A11 - 1A16	930	1.0	10	5
1A12 - 1A13	2290	1.8	30	4
1A11 - 1A12	3280	1.8	40	5
1A10 - 1A11	4330	1.5	70	4
1A10	4330	1.5	70	5
1A 8 - 1A10	4450	1.5	80	4
1A 8	4450	1.5	70	5
1A 1 - 1A8	4450	1.1	70	5

The crossing of Stockton Hill Road includes an estimate of the headwater depth and velocities through the culvert. To convey the 100-year flood flows of approximately 4330 cfs, a headwater depth of approximately 9 feet is required.

Because of the high velocities and the abrupt discontinuities in channel horizontal alignment, special structures to dissipate energy are required. These structures were analyzed assuming concrete-lined sections with the ability to withstand high turbulence and high velocities.

D5.4 Proposed System

The proposed alternative consists of a combination of structural improvements and the identification of drainage reserves as shown on Exhibit D1. Improvements include interceptor and collector channels, a crossing at Stockton Hill Road, and a downstream channel which conveys flows from the Stockton Hill Road crossing to the Mohave Channel.

The upstream portions of the proposed alternative consist of the identification of drainage reserves to provide a specified right-of-way width for flood flows in areas which currently experience little or no flood damage. Future development may require the conversion of these drainage reserves into formalized drainage channels which convey flows to the downstream system. The exact location and improvements to these reserves are left to the discretion of the developer, subject to the approval by the City or County.

An interceptor channel, Section 1A11-1A13, is proposed west of Stockton Hill Road. The alignment will approximately parallel Stockton Hill Road, 500 feet to the west. The interceptor channel has a slope about equal to the existing ground slope to minimize required excavation. Due to high velocities, channel lining will be provided. Flow in this channel reach will be

supercritical and, because of the location, will be subject to large rocks entering the system. The resulting possibility of a hydraulic jump occuring has been mitigated by increasing the channel lining freeboard. The channel invert will be constructed on the existing hardpan materials with no additional stabilization anticipated. A geotechnical investigation will be needed prior to detailed design to confirm bed material.

The Stockton Hill Road and Gordon Drive crossings will be a series of 7-5'x10'concrete box culverts.

Reach 1A8-1A11 will be fully lined up to the 10-year flow depth to protect against erosion. An integral part of Reach 1A7-1A11 are the energy dissipators.

The downstream channel improvements, Reach 1A1-1A7, will provide a conveyance system for flows from the Gordon Drive crossing to the Mohave Channel. Velocities in Reach 1A1-1A7 are still high; however, the absence of adjacent developments and critical facilities reduces the hazards associated with excessive erosion. No major inflows are expected in the reach and no significant accumulations of debris are anticipated. For these reasons, no channel lining is proposed in this section. The channel bottom will be constructed on hardpan.

Table D5.3 presents a summary of components of the proposed system. The various reaches are identified along with the corresponding type of proposed improvements, the required right-of-way and the design discharges.

Cost estimates for the proposed system have been based on unit rates presented in Table D5.4. The unit rates were developed from recent bids, estimating manuals and comparison to other similar jobs.

Table D5.3 Components of Proposed Alternative

Reach	Type	Length (ft)	Base Width (ft)	ROW (ft)	10 YEAR Q (cfs)	10 YEAR D (ft)	10 YEAR V (f/s)	100 YEAR Q (cfs)	100 YEAR D (f/s)	100 YEAR V (f/s)
1A1 - 1A	I	3,845	70	150	2,250	2.6	11.5	4,450	3.9	14.7
1A7	Structure	146	Varies	Varies	2,250	4.5	6.3	4,450	6.9	7.7
1A7 - 1A	II	534	70	142	2,250	2.8	10.6	4,450	4.4	12.8
1A8	III	60	7-5x10	-	2,250	4.5	7.1	4,450	5.0	12.7
1A8 - 1A	II	664	70	142	2,250	2.7	11.0	4,450	7.5	7.0
1A9	Structure	131	Varies	Varies	2,250	4.9	5.8	4,450	7.9	6.7
1A9 - 1A	II	450	70	142	2,250	2.2	13.1	4,450	3.3	17.0
1A10	III	100	7-5x10	-	2,190	4.9	6.6	4,330	5.0	12.4
1A10 - 1A	IV	614	28	100	2,190	3.5	17.9	4,330	5.1	22.2
1A11	Structure	70	Varies	Varies	Varies	5.1	6.3	Varies	7.9	8.1
1A11 - 1A	V	861	40	104	1,680	3.4	10.6	3,280	5.0	13.1
1A12 - 1A	V	2,725	30	94	1,220	2.4	14.6	2,290	3.5	17.7
1A13 - 1A	VI	6,080		100	1,030			1,880		
1A12 - 1A	VI	5,760		75	260			530		
1A16 - 1A	VI	3,440		75	75			160		
1A16 - 1A	VI	3,520		75	380			770		
1A11 - 1A	VI	2,560		75	450			930		

Table D5.4 Unit Cost Estimates

Item	Unit Rate
Land	$25,000 Per Acre
Common Excavation	$3 Per CY
Hardpan Excavation	$5 Per CY
Embankment	$5 Per CY
Concrete Lining	$4 Per Sq. Ft.
Concrete Wall	$10 Per Sq. Ft.
Concrete Slab	$4 Per Sq. Ft.
Box Culvert	$1,500 Per Foot

No allowance is made for utility relocation or other related construction. Channel design and associated construction costs are based on the assumption that hardpan materials exist approximately four feet below the existing ground. Actual costs will vary based on actual field conditions. A summary of the costs by reach and structure is given in Table D5.5.

Table D5.5 Estimated Cost Summary

Reach	Type	Length (ft)	Base Width (ft)	ROW (ft)	ESTIMATED COST ROW ($)	Channel ($)	Structure ($)	Total ($)
1A1 - 1A7	I	3,845	70	150	331,000	270,000		601,000
1A7	Structure	146	Varies	Varies	12,000		62,000	74,000
1A7 - 1A8	II	534	70	142	44,000	74,000		118,000
1A8	III	60	7-5x10	-			90,000	90,000
1A8 - 1A9	II	664	70	142	54,000	141,000		195,000
1A9	Structure	131	Varies	Varies	10,000		61,000	71,000
1A9 - 1A10	II	450	70	142	37,000	95,000		132,000
1A10	III	100	7-5x10	-			150,000	150,000
1A10 - 1A11	IV	614	28	100	35,000	75,000		110,000
1A11	Structure	70	Varies	Varies	4,000		60,000	64,000
1A11 - 1A12	V	861	40	104	51,000	78,000		129,000
1A12 - 1A13	V	2,725	30	94	147,000	243,000		390,000
					$725,000	$976,000	$423,000	$2,124,000

D5.5 Phasing

Because of the time process associated with establishing the required right-of-way for this project, and the desire to improve Stockton Hill Road from Gordon Drive to Northern Avenue, the necessary drainage improvements will need to be constructed in phases. A recommended phasing of work is presented below:

Phase 1
- o 7-5'x10' box culverts at 1A10 to be constructed together with Stockton Hill Road improvements.
- o Block off the 5'x10' box culverts under Stockton Hill Road.

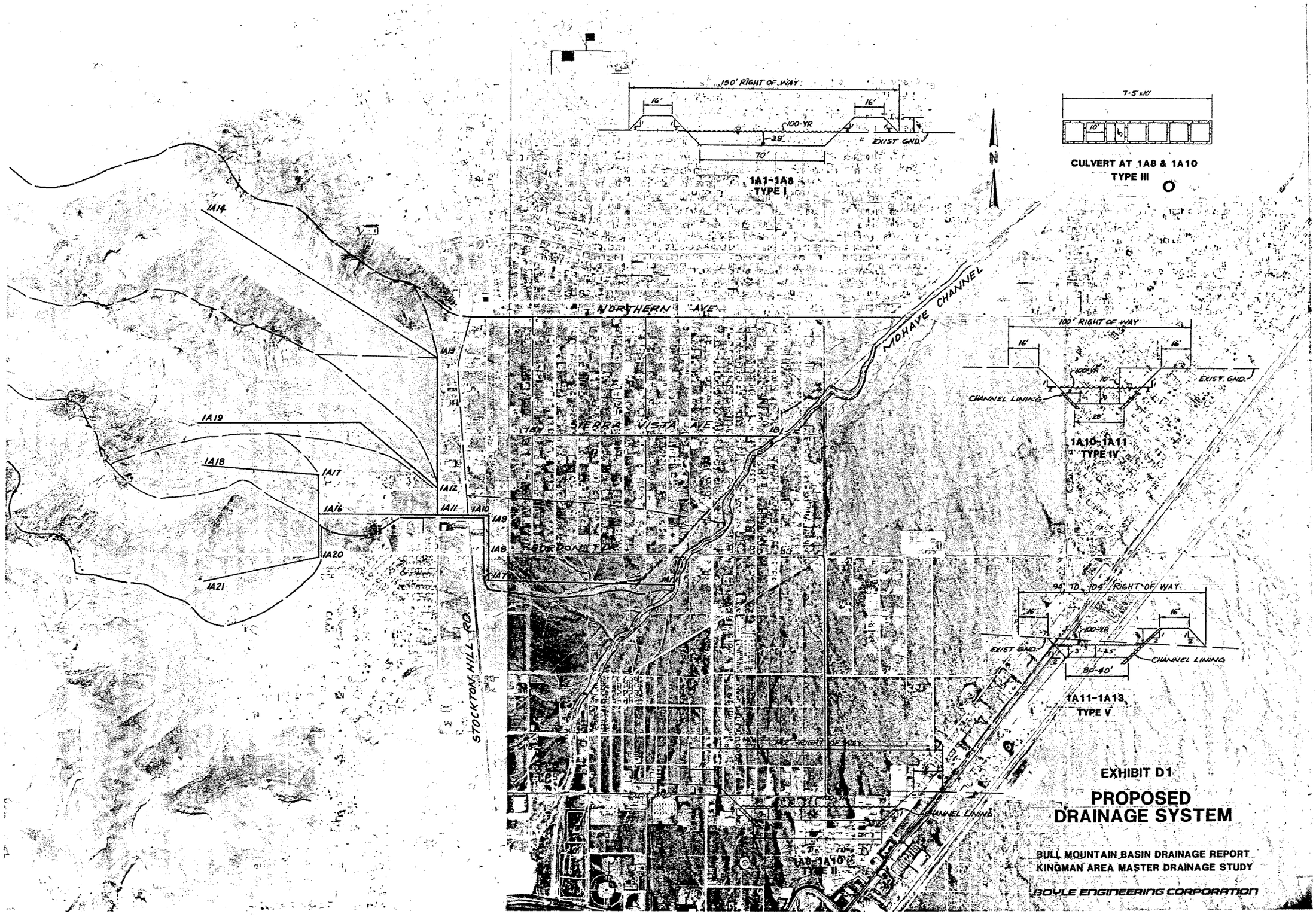
Phase 2
- o Construct Channels 1A7 - 1A10 and 1A10 - 1A13.

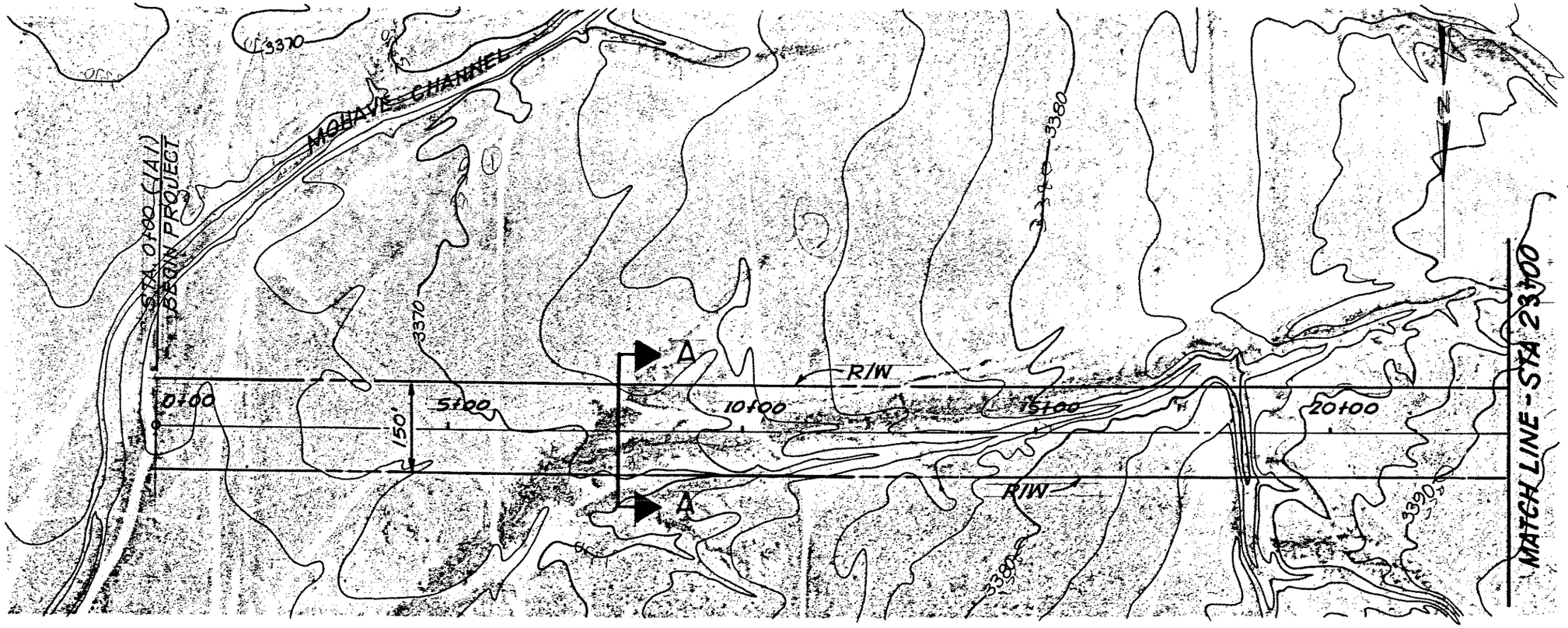
Phase 3
- o Construct Channel 1A1 to 1A7.

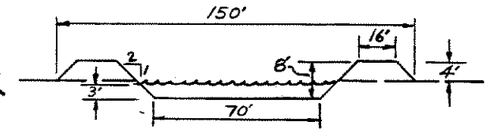
Phase 4
- o Remaining work west of Stockton Hill Road as development takes place.

D6. PRELIMINARY DESIGN

The preliminary design of the upstream interceptor, the crossings of Stockton Hill Road and Gordon Drive and the downstream channel improvements to the Mohave Channel are presented in Plates D1-D7. The Plates present a plan and profile of the proposed improvements, as well as a typical cross section of the channel, the channel lining and special structures. The intent of these drawings is to direct the planning and subsequent final design of improvements within the Bull Mountain Basin.


150' RIGHT OF WAY
16'
16'
100-YR
3'
EXIST GND.
70'
1A1-1A8
TYPE I
7-5'x10'
10'
CULVERT AT 1A8 & 1A10
TYPE III
N
1A14
1A13
1A19
1A18
1A17
1A12
1A16
1A11
1A10
1A9
1A8
1A20
1A7
1A21
NORTHERN AVE
MOHAVE CHANNEL
SIERRA VISTA AVE
1B1
100' RIGHT OF WAY
16'
16'
100-YR
10'
EXIST. GND.
CHANNEL LINING
25'
1A10-1A11
TYPE IV
STOCKTON HILL RD.
90' TO 104' RIGHT OF WAY
16'
100-YR
EXIST GND.
3'
25'
CHANNEL LINING
30'-40'
1A11-1A13
TYPE V
EXHIBIT D1
PROPOSED
DRAINAGE SYSTEM
BULL MOUNTAIN BASIN DRAINAGE REPORT
KINGMAN AREA MASTER DRAINAGE STUDY
BOYLE ENGINEERING CORPORATION





$Q_{100} = 4450$ cfs

SECTION A-A
STA. 0+00 TO STA. 38+45

SCALE 1"=200' HORIZ.
1"=20' VERT.

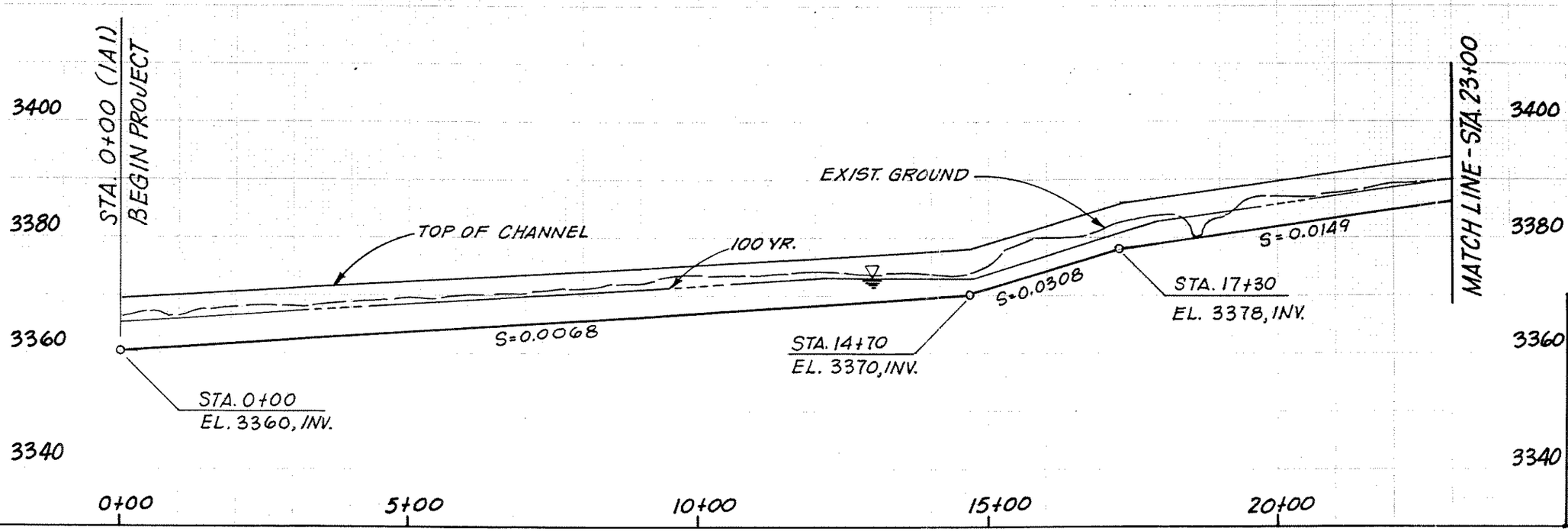
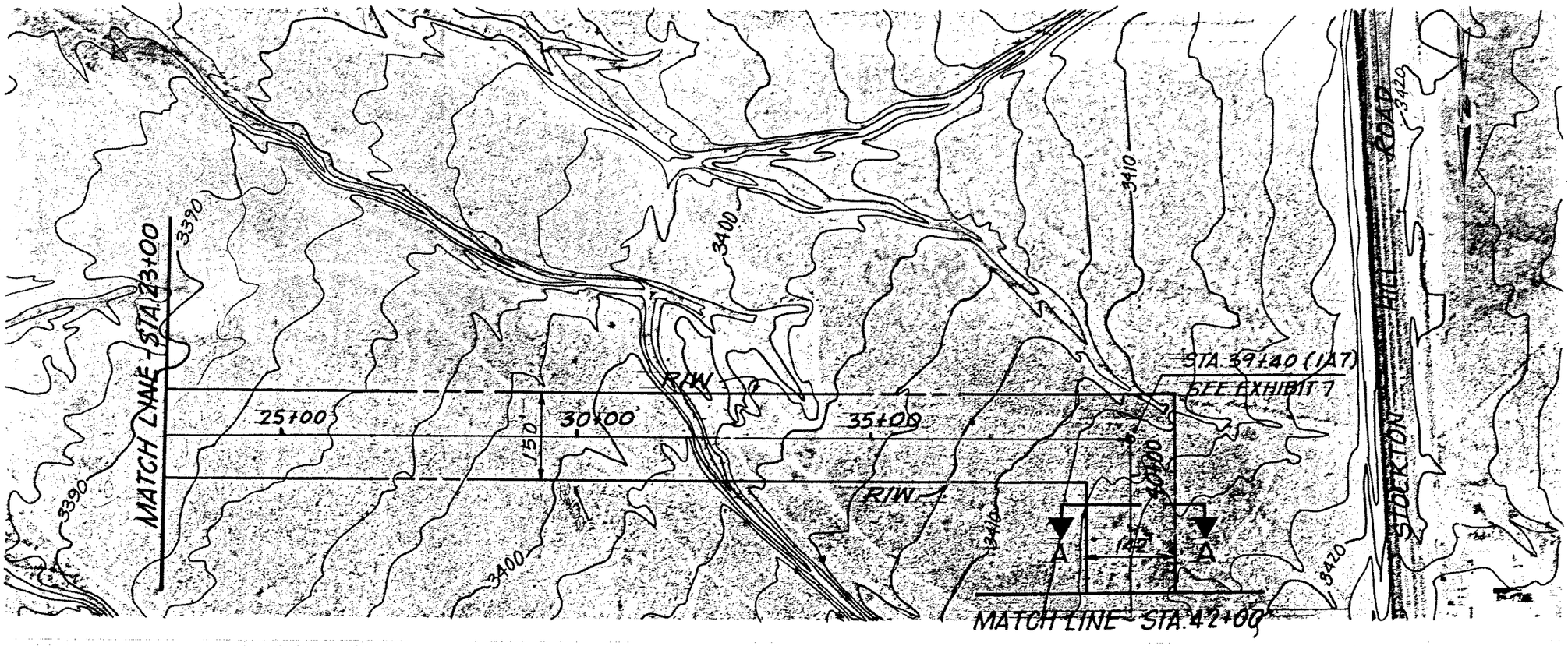
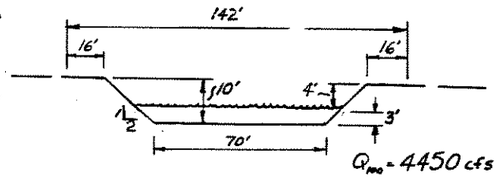


PLATE D1
PLAN & PROFILE
BULL MOUNTAIN BASIN DRAINAGE REPORT
KINGMAN AREA MASTER DRAINAGE STUDY

Boyle Engineering Corporation
consulting engineers / architects





SECTION A-A

STA. 39+91 TO STA. 44+65

SCALE: 1" = 200' HORIZ.
1" = 20' VERT.

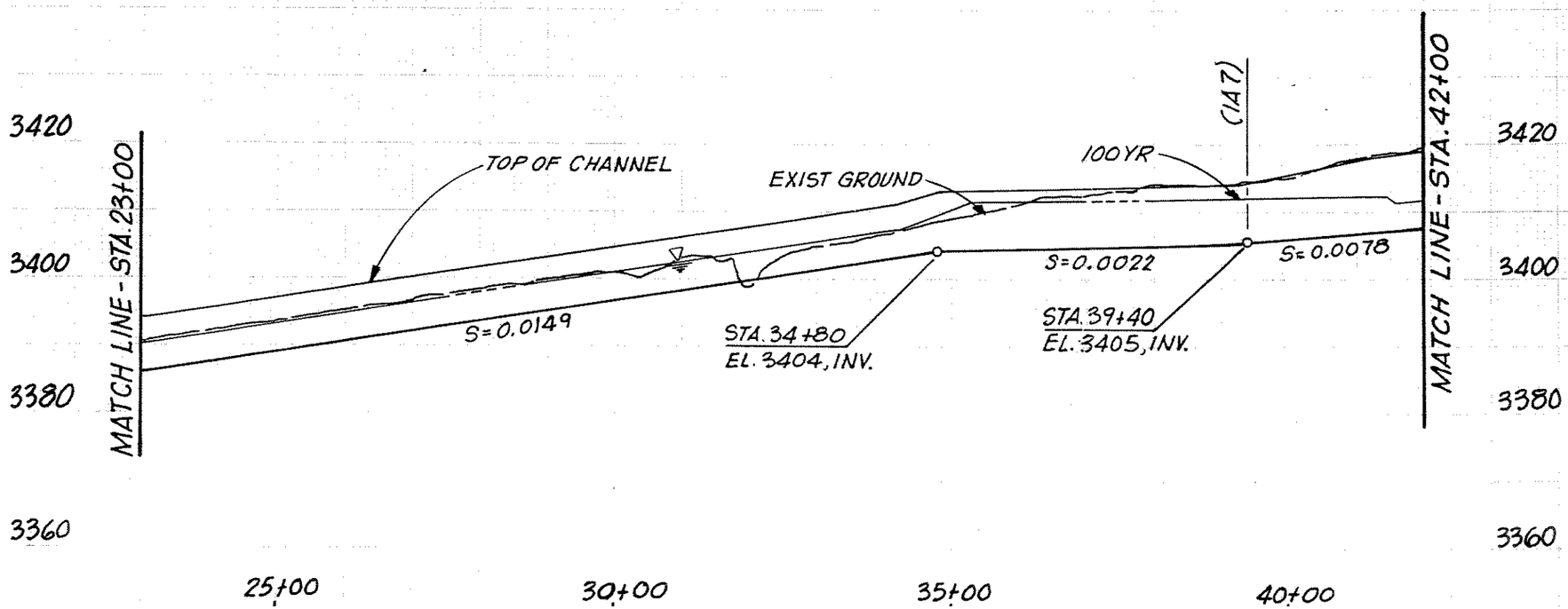


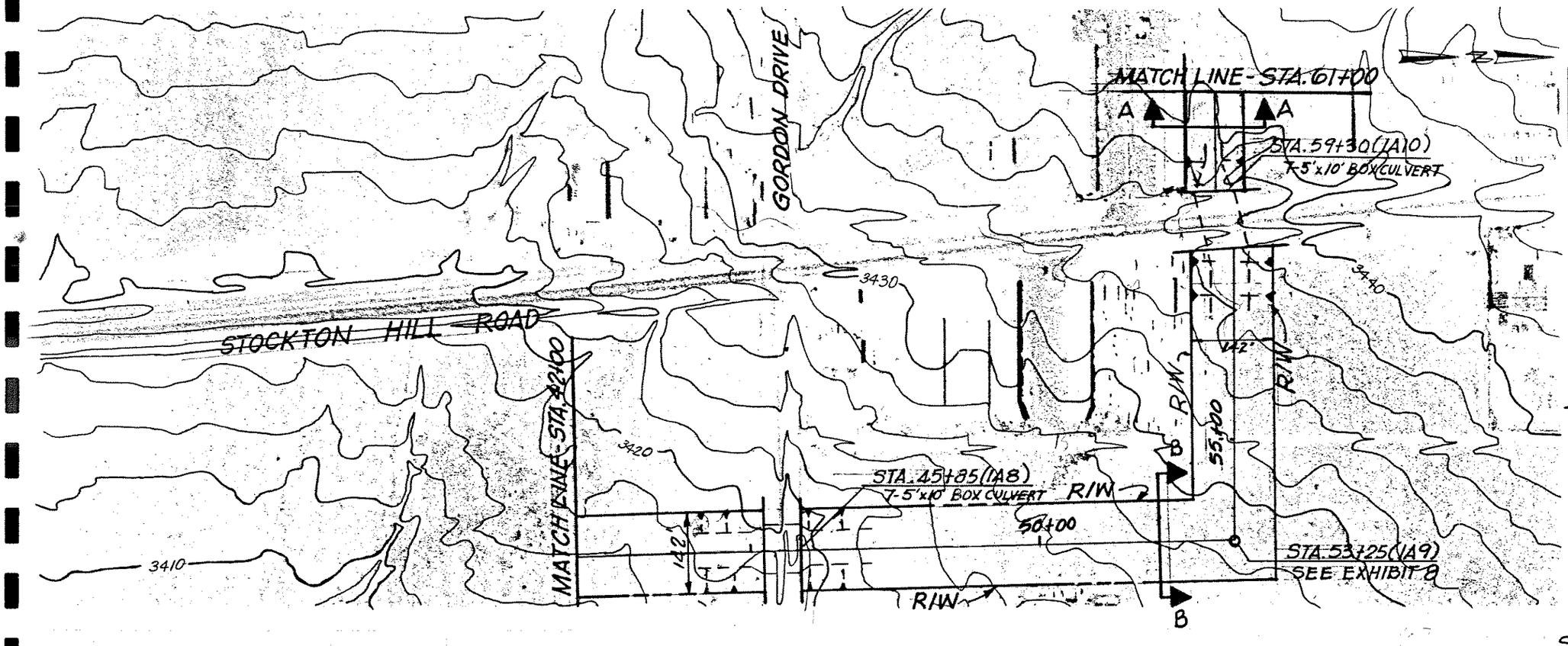
PLATE D2

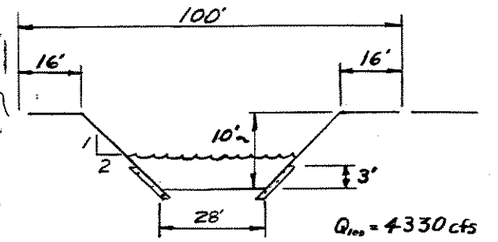
PLAN & PROFILE

BULL MOUNTAIN BASIN DRAINAGE REPORT

KINGMAN AREA MASTER DRAINAGE STUDY

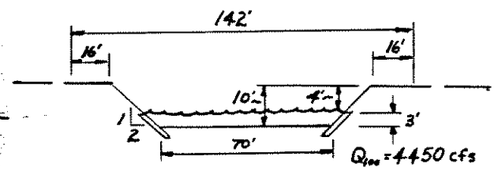
Boyle Engineering Corporation
consulting engineers / architects





SECTION A-A

STA. 59+30 TO STA. 65+44



SECTION B-B

STA. 45+85 TO STA. 58+30

SCALE: 1"=200' HORIZ.
1"=20' VERT.

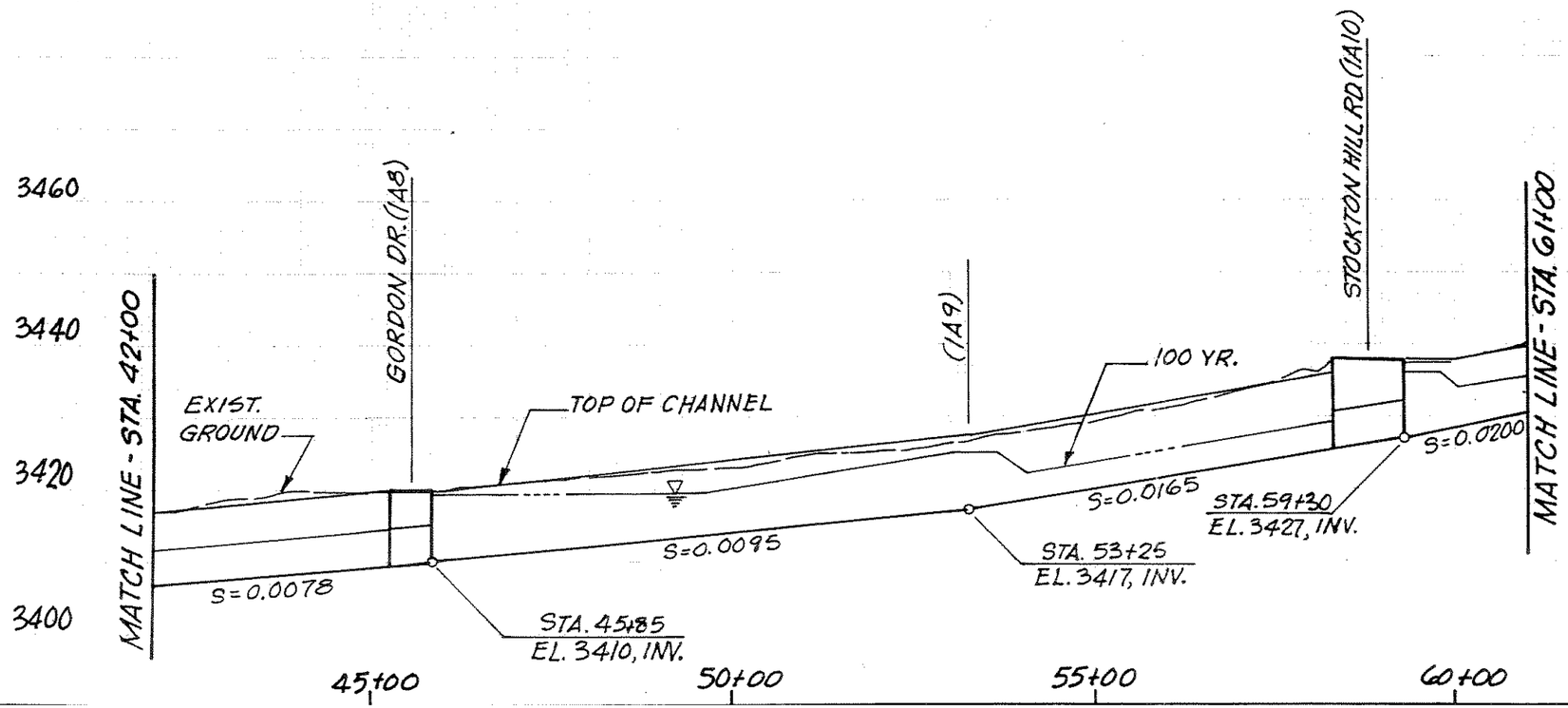


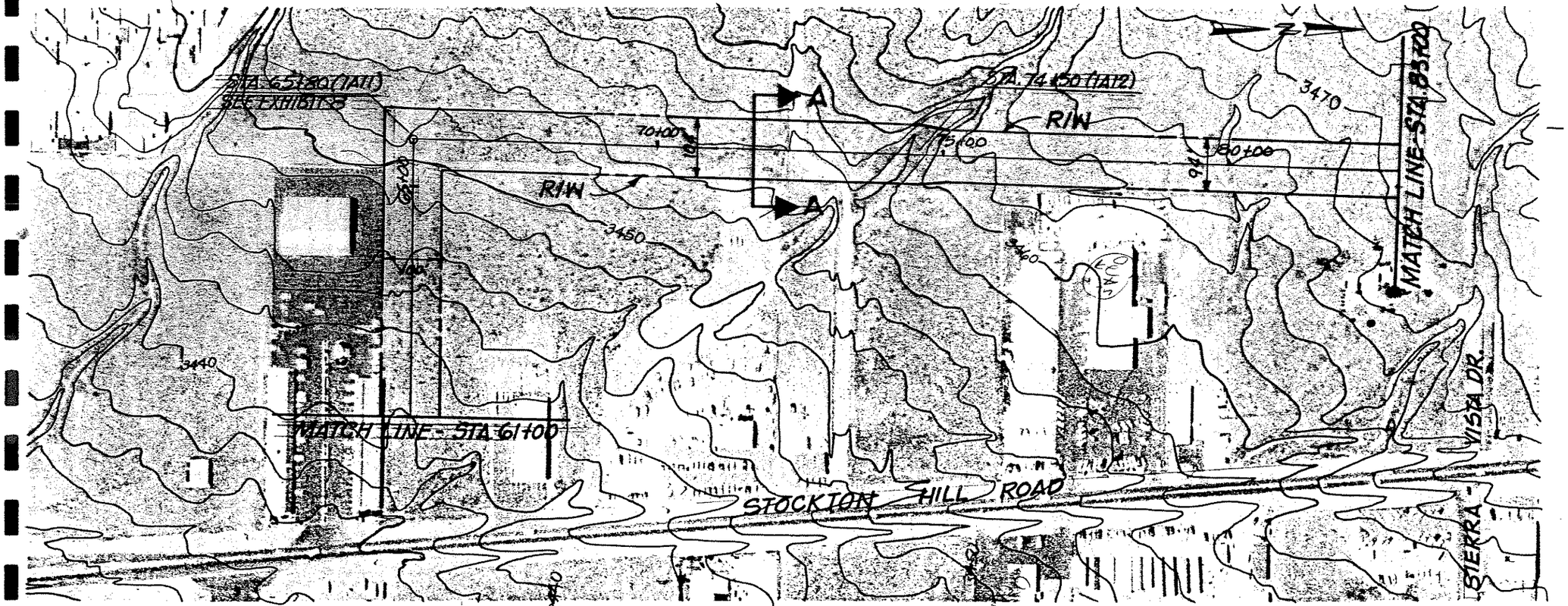
PLATE D3

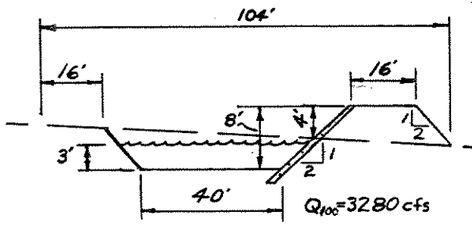
PLAN & PROFILE

BULL MOUNTAIN BASIN DRAINAGE REPORT

KINGMAN AREA MASTER DRAINAGE STUDY

Boyle Engineering Corporation
consulting engineers / architects





SECTION A-A
STA. 66+14 TO STA. 74+50

SCALE: 1"=200' HORIZ.
1"= 20' VERT.

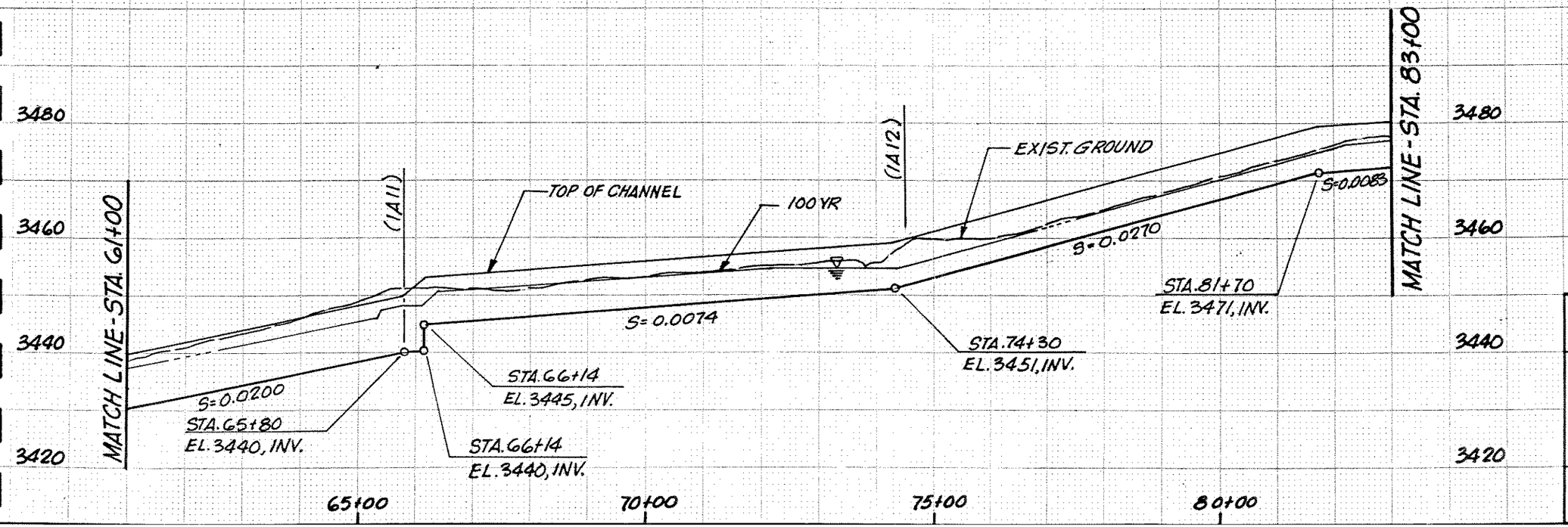
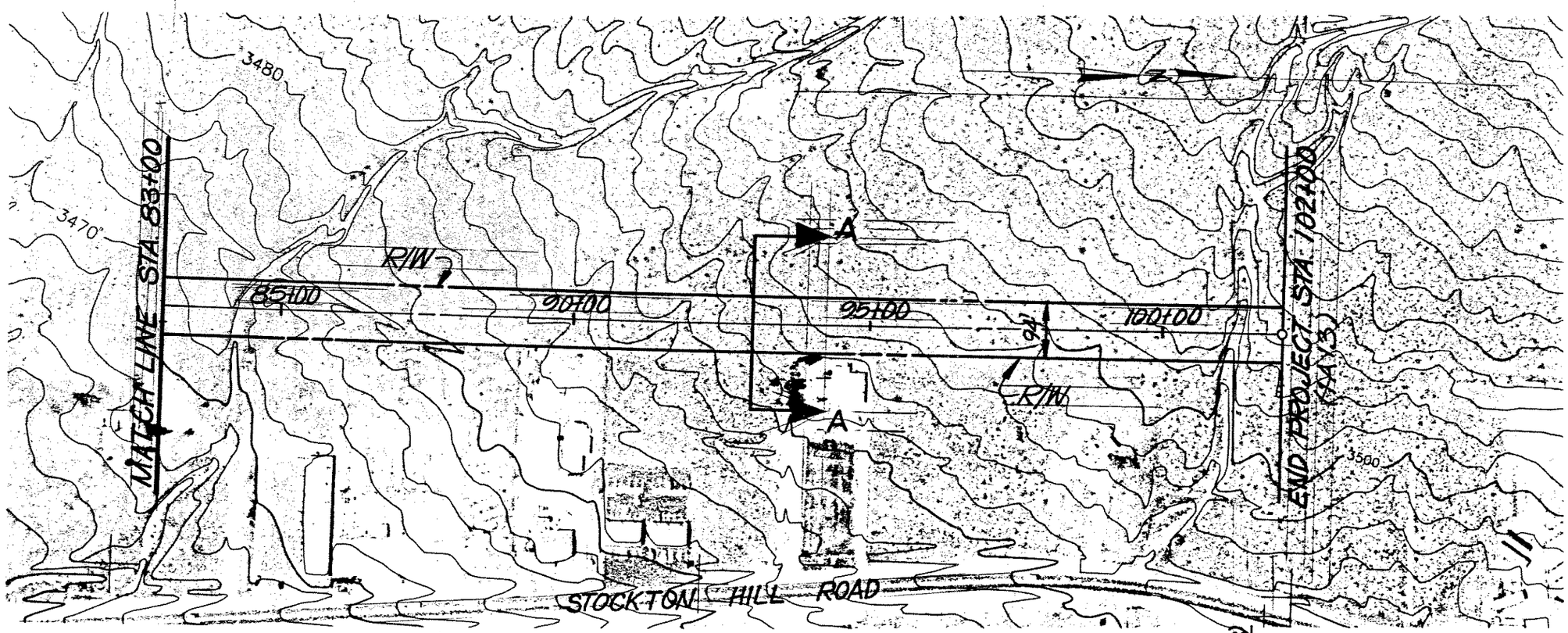
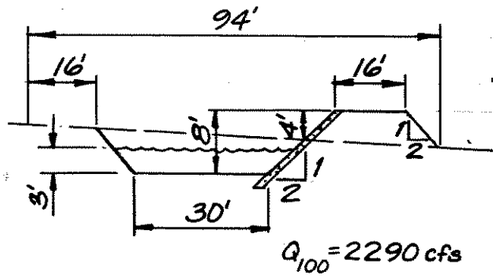


PLATE D4
PLAN & PROFILE
BULL MOUNTAIN BASIN DRAINAGE REPORT
KINGMAN AREA MASTER DRAINAGE STUDY

Boyle Engineering Corporation
consulting engineers / architects





SECTION A-A
STA. 75+00 TO STA. 102+00

SCALE: 1"=200' HORIZ.
1"= 20' VERT.

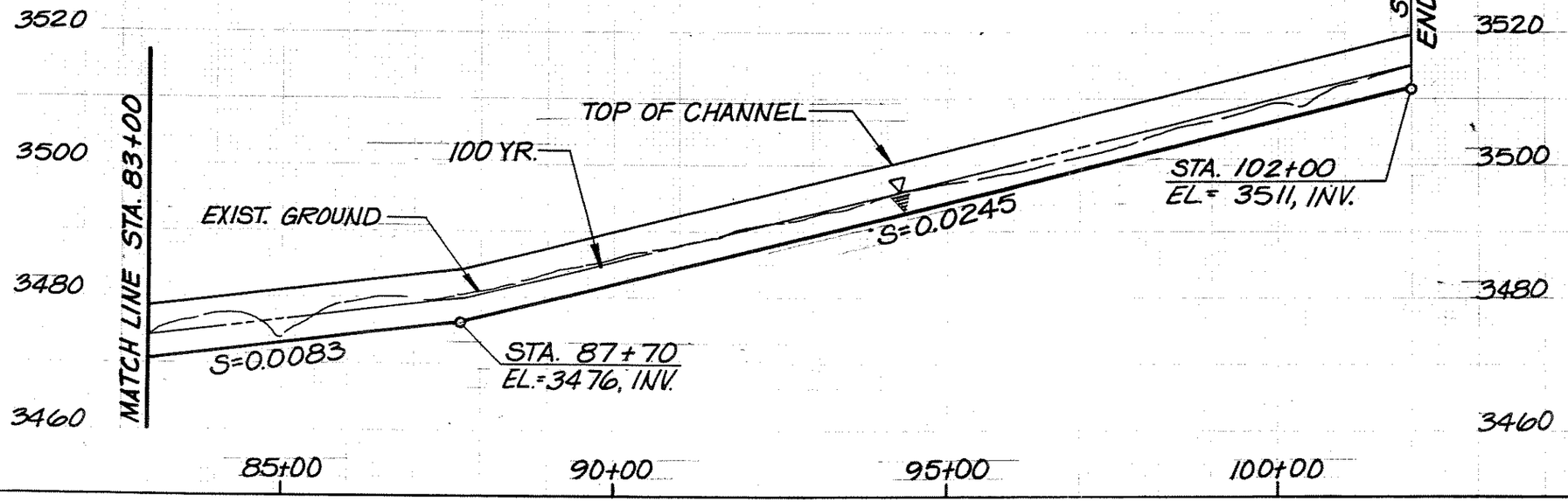


PLATE D5
PLAN & PROFILE
BULL MOUNTAIN BASIN DRAINAGE REPORT
KINGMAN AREA MASTER DRAINAGE STUDY

Boyle Engineering Corporation
consulting engineers / architects

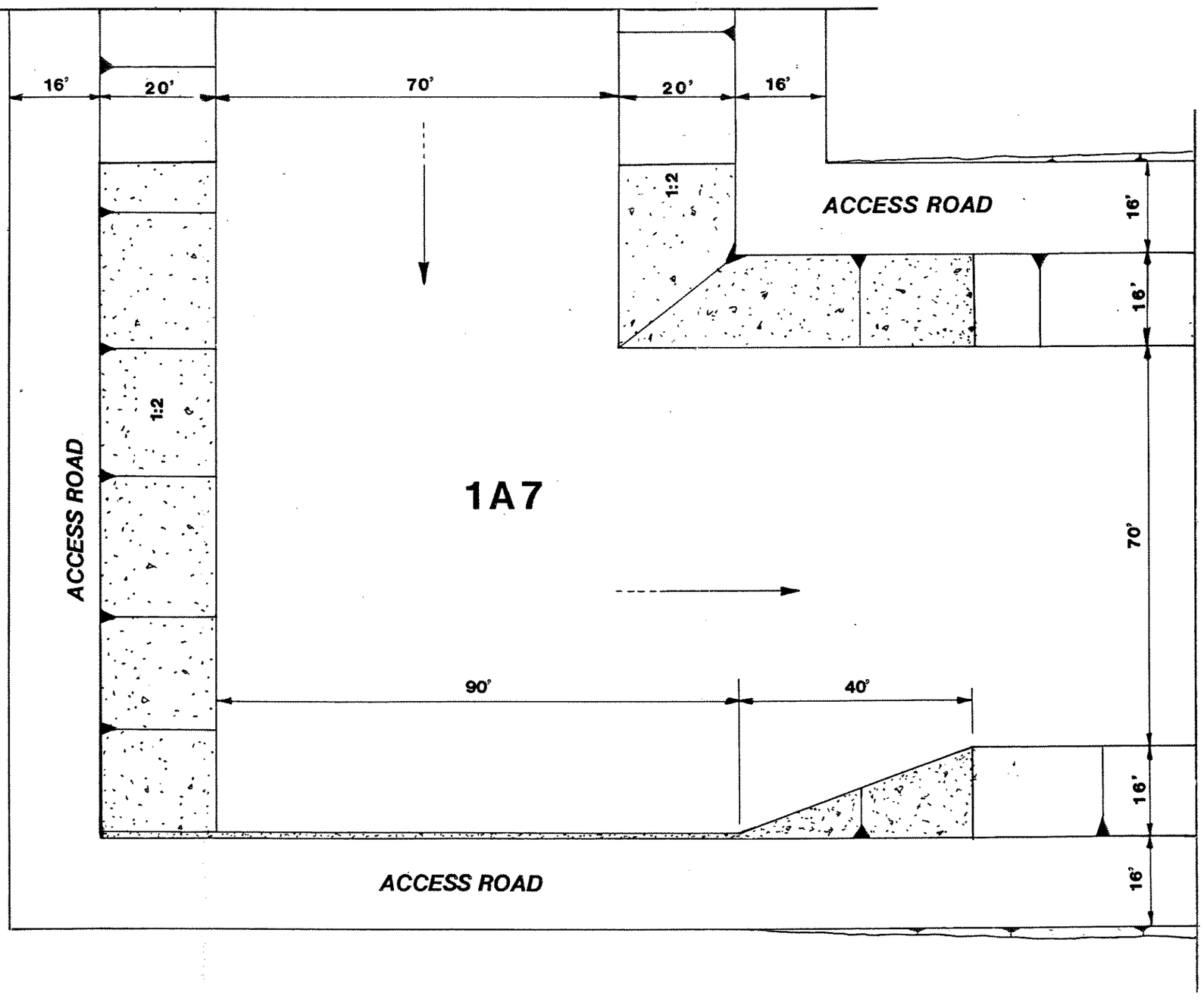
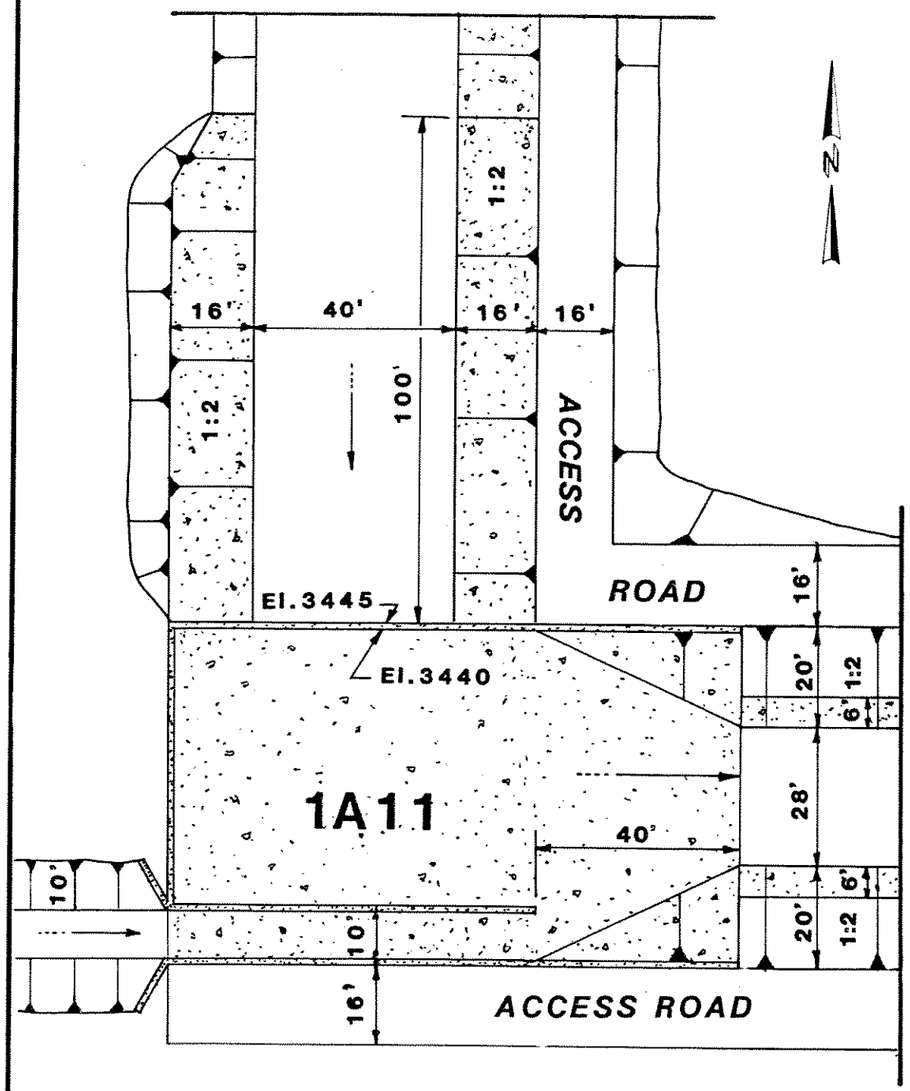


PLATE D6

STRUCTURE A7

KINGMAN AREA
MASTER DRAINAGE STUDY

Boyle Engineering Corporation
consulting engineers / architects



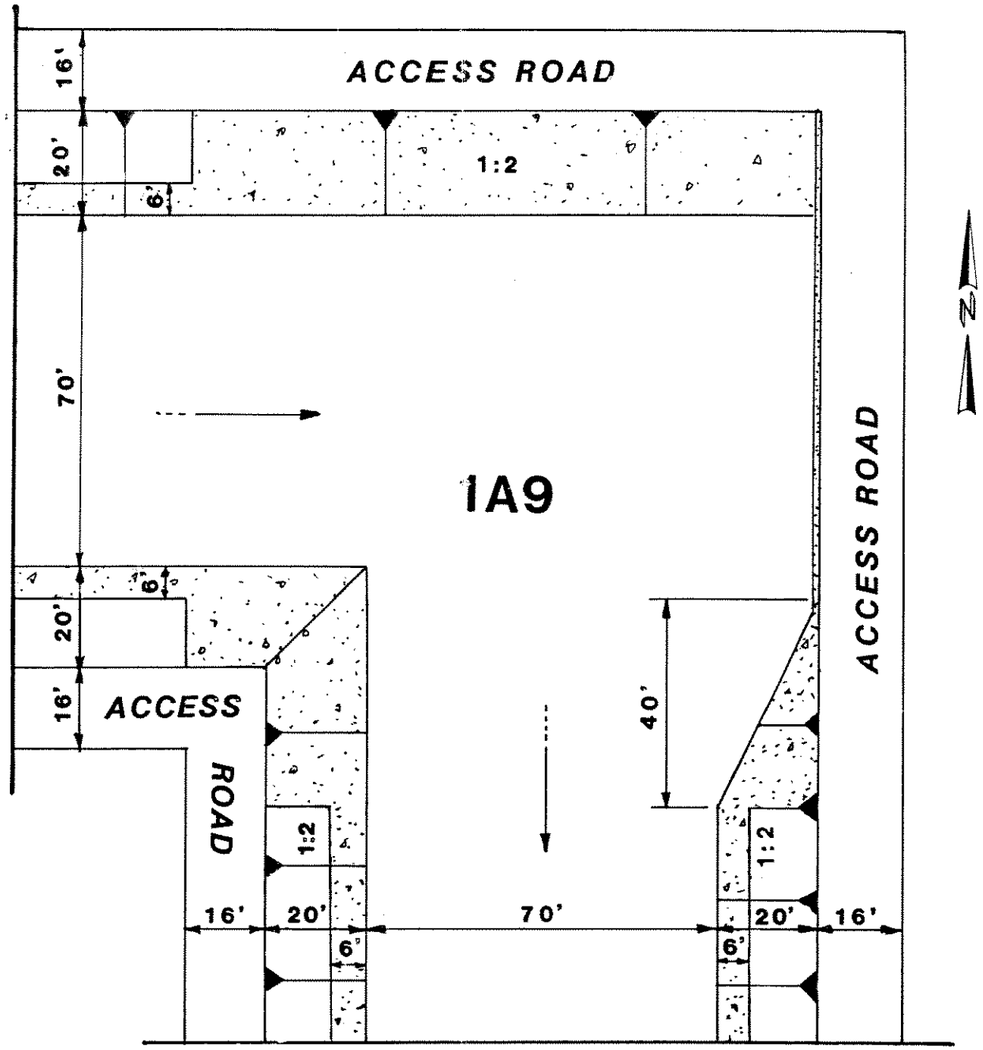


PLATE D7

STRUCTURE 1A11, 1A9

KINGMAN AREA
MASTER DRAINAGE STUDY

Boyle Engineering Corporation
consulting engineers / architects

APPENDIX E
SOUTHEAST AREA DRAINAGE

KINGMAN AREA
MASTER DRAINAGE STUDY

Sepember 4, 1987

E1. INTRODUCTION

The southeast area drainage basin consists of 120 square miles of area bounded by the Hualapai Mountains on the south and east, the northern study limit on the north and the Atchison, Topeka and Santa Fe Railroad on the west. Flows generated in the Hualapai Mountains enter the downstream alluvial fan and flow in a general northwesterly direction. The railroad acts as a barrier to flow and creates concentrated points of flow at culvert locations. These flows pass under the railroad and U.S. Highway 66 and discharge into downstream developed areas which have non-existent or undersized conveyance facilities.

E2. HYDROLOGY

Preliminary hydrologic calculations were performed to determine flow rates for basins tributary to the railroad. Flows at various points are summarized in the following table:

Location	Area (mi^2)	Q_{10}(cfs)	Q_{100}(cfs)
RR @ I-40	4	800	2100
RR @ Mallard	10	1400	4100
RR @ Airport (S)	14	1900	5100
RR @ Frees Wash	30	4000	12000
RR @ North Study Limit	60	5000	16000
I-40 @ Frees Wash	16	3000	7000

E3. ALTERNATIVES

Several alternatives were evaluated to mitigate drainage problems which exist or are anticipated. All involve some means of reducing flows crossing the railroad and entering the developed areas of Kingman. The various alternatives can be categorized as follows:

1. Diversion of flows generated south of I-40 to the south.

2. Diversion of flows along the railroad to the north and south.

3. Diversion of flows along the railroad to the north.

The diversion of flows generated south of I-40 to the south into Slaughterhouse Canyon was eliminated as a practical alternative for two principal reasons:

1. The flows contributing to developed downstream portions of the basin generally are generated north of I-40; and

2. The basin topography at the west end of the diversion is not conducive to inexpensive diversion.

Diversions along the railroad are feasible in both directions. Some additional excavation is anticipated if diversions to the south into Slaughterhouse Canyon are proposed and this, in combination with the undesirable nature of transbasin diversions, resulted in the emphasis being put on diversions to the north (Alternative 3).

E4 PROPOSED ALTERNATIVE

The proposed alternative includes:

1. Construction of a diversion channel along the railroad from Louise Street to the south airport culvert.

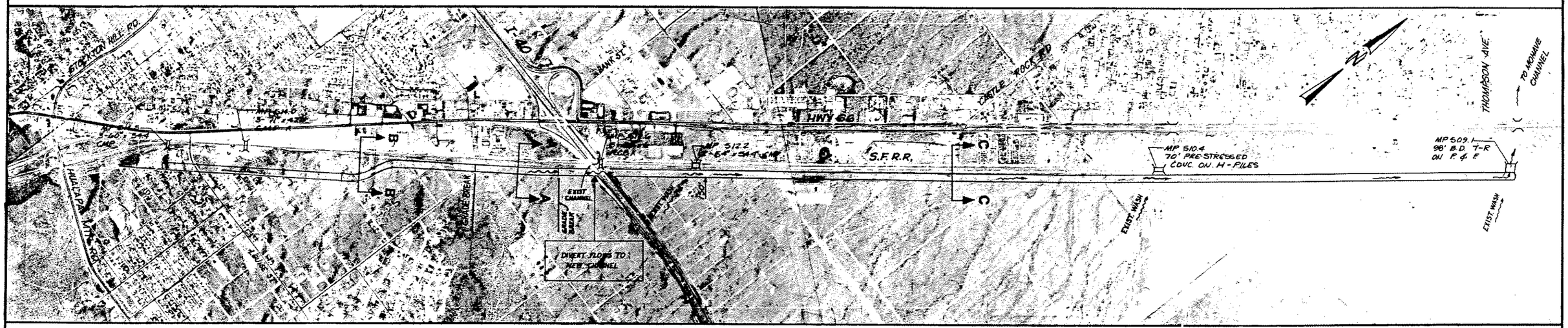
2. Elimination of railroad crossing culverts along the diversion.

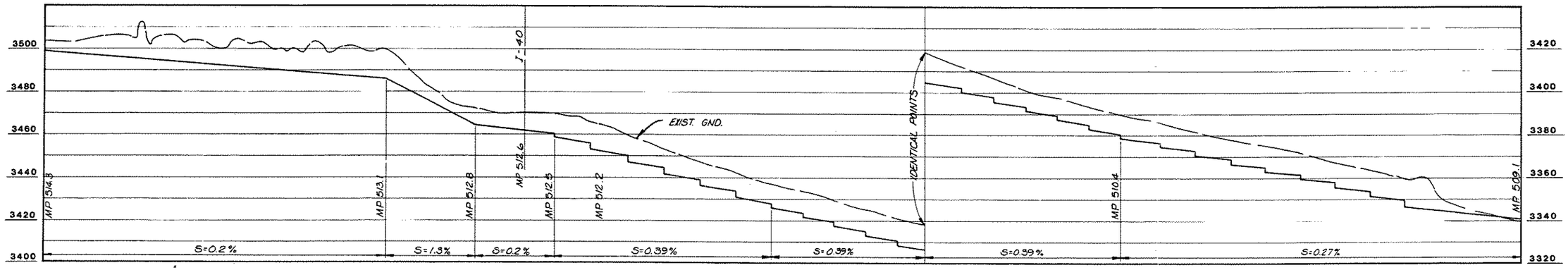
3. Providing drainage reserves in upstream areas which are currently undeveloped.

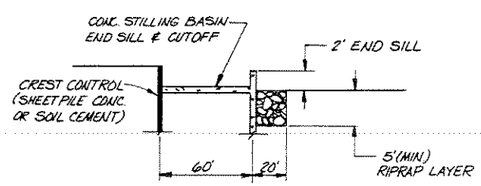
The railroad acts as a barrier and provides a logical location to construct a diversion channel. Adjacent development to the east of the railroad has been minimal; thereby, reducing right-of-way acquisition costs and impacts. The attached plan and profile sheet shows the proposed channel alignment, grades and typical cross sections. The extent of channel excavation and lining has been minimized through the use of grade breaks and drop structures.

The elimination of the railroad crossing culverts reduces flows entering the developed areas of Kingman and limits flow to those generated north and west of the railroad. A large crossing structure will be provided south of the airport. This crossing is coincident with the location of the existing airport diversion structure. The outfall of this facility is downstream of most developed areas of Kingman and will flow to the Mohave Channel through a designated drainage reserve.

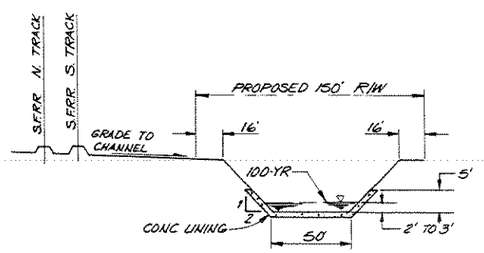
Areas to the north and east of the diversion are generally undeveloped and are subject to limited damage. In these areas, drainage reserves will be identified which will designate proposed right-of-way for channels in anticipation of future development.



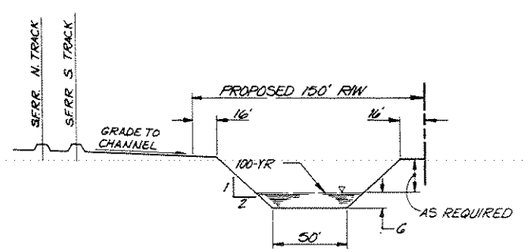




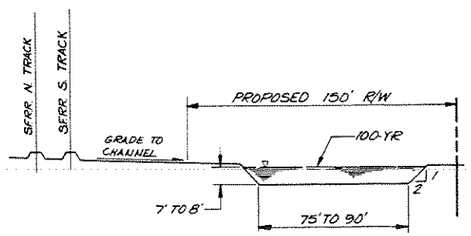
DETAIL



SECTION A-A
CONCRETE LINED CHANNEL



SECTION B-B
LOUISE ST. I-40



SECTION C-C
I-40 TO AIRPORT

PLATE E1

EAST AREA
PROPOSED DRAINAGE AREA

Boyle Engineering Corporation
consulting engineers / architects