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DRAINAGE STUDY

FOR

PARADISE VALLEY/SCOTTSDALE

LINCOLN DRIVE TO CHENEY DRIVE

PREPARED FOR:

THE CITY OF SCOTTSDALE

PREPARED BY:

ERIE & ASSOCIATES, INC.

Registered Professional Engineer (Civil)
CERTIFICATE NO.
10274
LEONARD J.
ERIE II
Date Signed
ARIZONA, U.S.A.

REVISED OCTOBER 1988
REVISED JULY 1988
OCTOBER 1986

EA #1053.2

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80.0-00-9-10/86

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FLOOD CONTROL DISTRICT RECEIVED
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SECTION 1

INTRODUCTION

1.1 Objectives

This drainage study was prepared in response to the flooding problems along Scottsdale Road from Lincoln Drive to Cheney Drive. The objectives of this study were to determine the sources and extent of flooding in the study area, and evaluate and recommend alternatives for flood control.

1.2 Location

The study area includes a tributary that drains from Camelback and Mummy Mountains in Paradise Valley east towards Indian Bend Wash (see Plates 1 and 2 - Location and Tributary Maps). The study area consists of primarily one house per acre zoning, comprising a total of approximately 1600 acres. Slopes range from very steep (30% +) on Camelback Mountain to relatively flat (.5%) along the Arizona Canal. The study area involves three individual jurisdicitional agencies including the City of Scottsdale, Maricopa County, and the Town of Paradise Valley.

1.3 Past Flooding

Drainage from Mummy Mountain and Camelback Mountain naturally flow east to Indian Bend Wash. Scottsdale Road intersects the natural drainageway approximately 1/4 mile north of the Lincoln Drive intersection where the wash splits and is partially in a sheet flow condition to the outfall. As the area has developed, more storm water has been intercepted by Lincoln Drive before reaching the natural drainageway. Since the reconstruction of Lincoln Drive in the 70's, a substantial amount of Camelback Mountain drainage has been directed to the Lincoln Drive and Scottsdale Road intersection.

Reconstruction of Scottsdale Road and Lincoln Drive and urbanization of the watershed has focused continuing attention to the drainage problems. During minor storms, the Lincoln Drive and Scottsdale Road intersection experiences flooding and this continues well after rainfall has ceased due to ponding on the west side of Scottsdale Road, which has very flat slopes. A drywell was constructed on the southwest corner of Scottsdale Road and Lincoln Drive; however, its capacity is exceeded by any runoff other than that from nuisance water. During major storms, the flooding problem extends north along Scottsdale Road to approximately Cheney Drive. In addition, business and residential areas in the Lincoln and Scottsdale Road have experienced repeated flooding during even relatively minor storms.

PLATE 1

PLATE 2

SECTION 2

SUMMARY/RECOMMENDATIONS

2.1 Existing Conditions

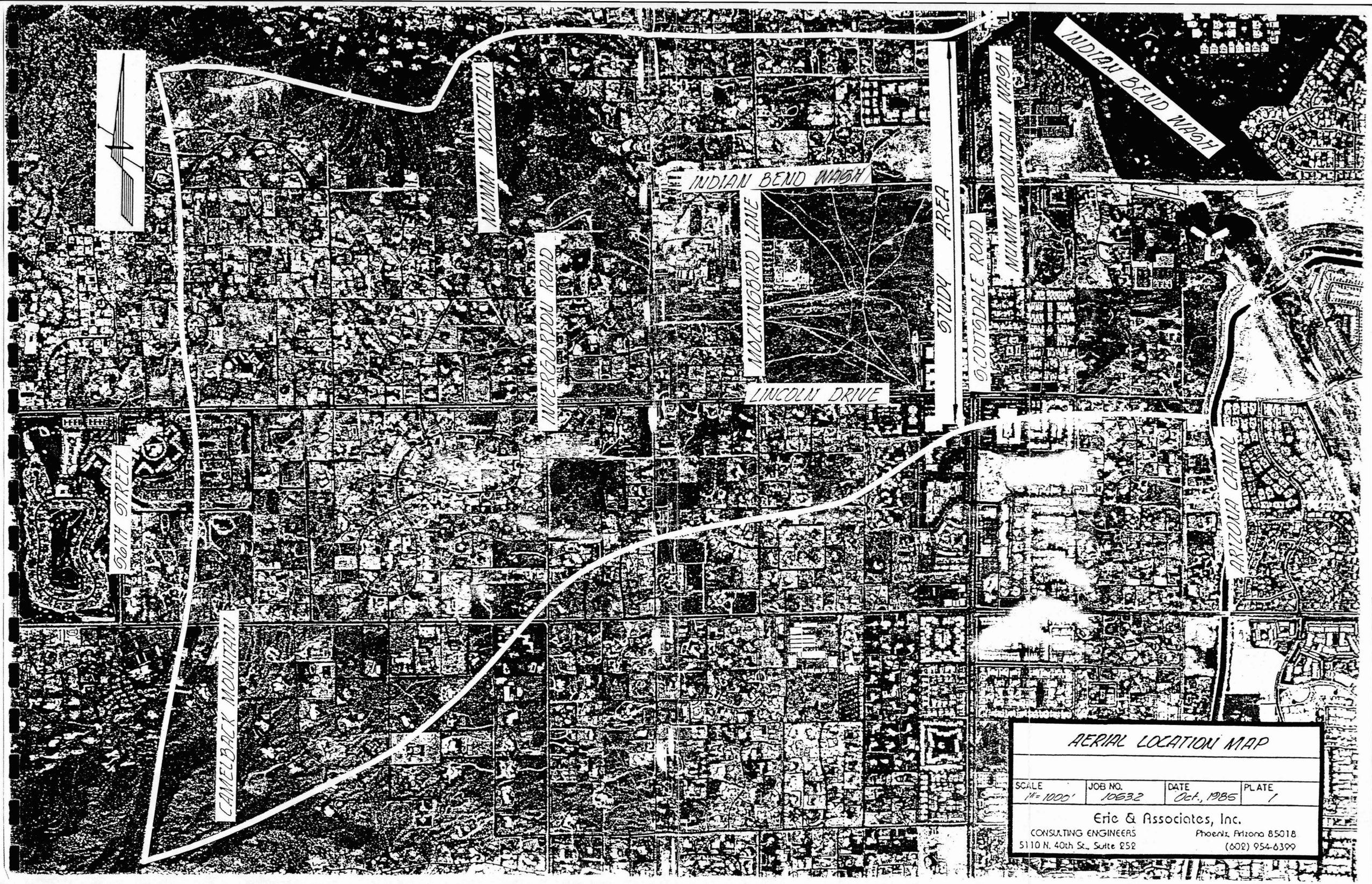
This study has been prepared in response to a regional flooding problem extending from the intersection of Lincoln Drive and Scottsdale Road to approximately one mile north of Indian Bend Road (See Plate 1 - Aerial Location Map). Historically, approximately 25 to 30 acres of desert drained to the Lincoln and Scottsdale intersection. As the area has developed, more storm water has been directed to Lincoln Drive, and as Lincoln has been reconstructed, a substantial portion of the tributary south of Lincoln from the north side of Camelback Mountain has been intercepted by the roadway and partially redirected to the Lincoln-Scottsdale intersection. The balance of the drainage continues to flow in a natural channel which runs approximately one quarter mile north of and parallel to Lincoln Drive. This natural channel turns to a sheet flow condition at Scottsdale Road and is hydraulically interconnected with the Lincoln/Scottsdale intersection.

Existing cross culverts under Scottsdale Road are not sized to handle the higher flows presently experienced at the intersection. Recent storm events have caused extensive flooding of the roadway and residential and commercial/office developments in the area. Design flow rates have been developed assuming that spill out of Lincoln Drive, across the undeveloped area east of Mockingbird, will be cut off in the future by a perimeter fence along Lincoln Drive. Therefore, existing flow rates at Lincoln Drive and Scottsdale Road are somewhat higher than could currently be expected.

2.3 Proposed Solutions

Four alternatives have been developed for both 25 and 100 year design criteria as proposed solutions to this flooding. In addition, an alternative has been added for an interim 10 year storm drain in Lincoln with the possibility of upgrading the capacity on future phases to in excess of a 100 year storm. Three of the alternatives, B, C, and D propose to redirect all or a portion of the Lincoln drive drainage back to its original course approximately a quarter mile north of Lincoln. The other alternative, Alternative A, proposes to take the water directly from the Lincoln and Indian Bend intersections to the Corps side channel project at the Arizona Canal and Indian Bend Wash. The alternative A solutions for the 25 and 100 year storms would require modification of the side channels capacity to accomodate the additional discharges at Lincoln Drive into the side channel.

A detention basin element is incorporated into two of the Alternatives (B and C). This element could be constructed as a future part of whatever development takes place on what is known as the "Little America" property. Improvements on this phased approach would be scheduled to not divert water until adequate downstream improvements are in place. However, the storm drains and channel down Lincoln Drive and Indian Bend Road would be sized for the ultimate condition (undersized for the condition without detention). Table 1 is a summary of the alternatives.


MUMMY MOUNTAIN
INDIAN BEND WASH
INDIAN BEND WASH
MACDONALD ROAD
MOCKINGBIRD LANE
STUDY AREA
SCOTTSDALE ROAD
MUMMY MOUNTAIN WASH
LINCOLN DRIVE
66TH STREET
CAMELBACK MOUNTAIN
ARIZONA CANAL
AERIAL LOCATION MAP
SCALE 1"=1000'
JOB NO. 10632
DATE Oct., 1985
PLATE 1
Eric & Associates, Inc.
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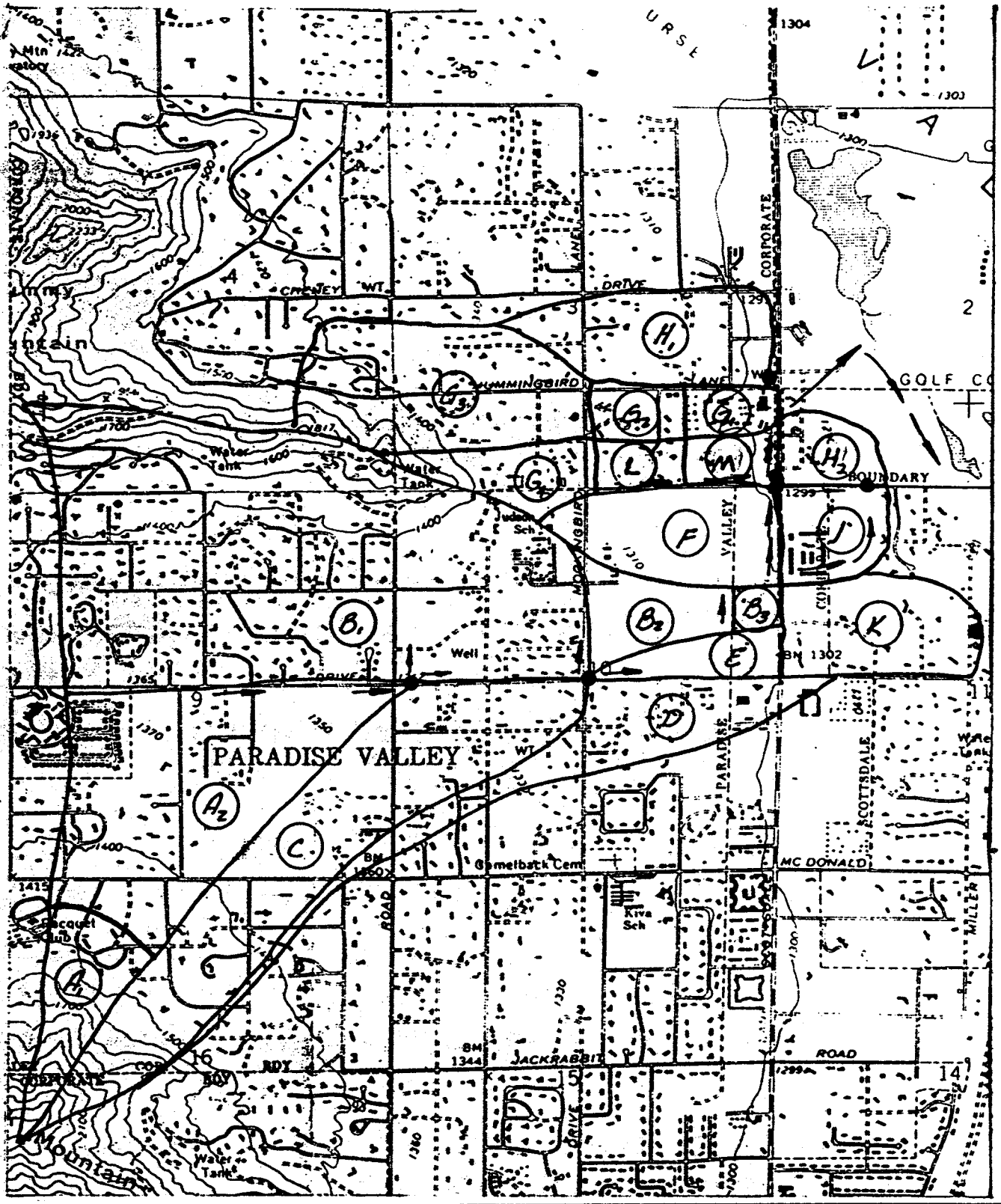

TRIBUTARY AREAS

SCALE	JOB NO.	DATE	PLATE
1"=200'	1063.2	Oct. 1985	2

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CONSULTING ENGINEERS

Phoenix, Arizona

TABLE 1

SUMMARY OF ALTERNATIVES

Alt.	Description	Estimated Construction Cost *		
		10 Yr. Linc. & 25 Yr on Balance	25 Yr**	100 Yr**
A	Pick up water west of Scottsdale Road on Lincoln Drive and Indian Bend Road with channels and culverts	1,135,000	1,550,000	1,863,000
B	Construct a basin on the natural channel west of Scottsdale Road and meter water into a diversion channel to Indian Bend Road. Develop an outfall system at Lincoln Drive and Indian Bend Road. Requires Town of Paradise Valley approval.	N/A	1,363,000	1,703,000
C	Modify Mockingbird Lane and Lincoln Drive Intersection to divert flows to a basin on the natural channel. Balance is conceptually the same as Alternative B. Requires Town of Paradise Valley approval.	N/A	1,385,000	1,691,000
D	Divert water west of Scottsdale Road or Lincoln Drive with a channel to Indian Bend Road. Construct a smaller storm drain in Lincoln Drive from the Arizona Canal to west of Scottsdale Road. Add a larger channel along Indian Bend Road to handle the increased flows. Requires Town of Paradise Valley approval.	N/A	1,862,000	2,255,000

* Alternatives B and C exclude cost of right-of-way for detention basin (2 to 8 acres). All alternatives include 30% ± for engineering and contingencies.

** Implementation of Alternative A for the 25 and 100 year storms requires that the Corps side channel be widened north of Lincoln. This cost is estimated at approximately $350,000 to 400,000 and is not included in the cost estimates.

2.2 Recommendations

Because the Town of Paradise Valley may not support the detention basin, it is recommended that the most straightforward approach, Alternative A, be implemented for a 10 year design storm on Lincoln Drive, keeping the balance of the system at a 25 year design storm. In addition, future developments west of Scottsdale Road should be encouraged to incorporate detention into the site plan as open space to ultimately upgrade the system to 100 year storm protection. If the Town of Paradise Valley supports the detention alternative, it is recommended that Alternative B be implemented at some point in the future. The proposed 72" pipe in Lincoln would then have in excess of the 100 year capacity (210 cfs) at the intersection.

- Impact of Recommended Plan on the Corps Side Channel System

  The recommended plan would pick up as much as 320 cfs (10 year storm) at the Lincoln Drive intersection and carry that flow to the Corps' side channel system at Lincoln where the design capacity is approximately 340 cfs. The storm drain would be intercepting water that previously arrived at the Corps' channel by surface drainage down Lincoln Drive. The outlet at the side channel would be turned in the pipe and designed to face downstream (north) by cutting into the bank, thereby not restricting the channel capacity to the south. It is anticipated that the final storm drain design will include a scour analysis at the outlet to determine the scope of channel protection required.

  The recommended Lincoln Drive storm drain diverts approximately 15 cfs on the 100 year storm into Lincoln from an area currently overtopping Scottsdale Road and entering the side channel system north of Lincoln. A 100 year storm currently overtaxes the Corps' system by approximately 600 cfs at the Lincoln Drive/side channel concentration point. The 15 cfs diversion is not expected to have an adverse impact with regard to the performance of the present system during a 100 year storm event. If the 15 cfs diversion is determined to be inappropriate by legal council, it is recommended that the Scottsdale Road lateral be eliminated from the proposed system. The decreased storm drain design flow would not however reduce the required size of the drain (72" line).

  The $300,000 $\pm$ cost to upgrade the Alternative B system from a 25 to 100 year design would appear to be warranted and if a 72" pipe is constructed in Lincoln Drive at this time, that system would have in excess of a 100 year capacity should Alternative B be implemented. This feature will keep approximately 10 plus dwellings and

offices from being flooded. This plan, however, requires approval and support by the Town of Paradise Valley. The Alternative B plan could be constructed as a phased project as follows.

- Phase I - Construct Lincoln storm drain (66" pipe) with capacity of 210 ± cfs (future with plan in place). The storm drain would be undersized for the existing flows now at the intersection (10 yr, 305 cfs; 25 yr, 420 cfs; 100 yr, 600 cfs).

- Phase II - Construct the Indian Bend Channel (68' top width ±) along the north side of Indian Bend Road from the wash to west of Scottsdale Road (includes culverts under Scottsdale Road) at a capacity of 1410 ± cfs. This would be oversized with respect to existing flows (100 yr, 350 cfs). This work should be coordinated to tie into development at the northeast corner of Scottsdale and Indian Bend Road.

- Phase III - Construct at or immediately following Phase II, the permanent diversion channel and structure in Lincoln at Mockingbird; and construct a temporary channel on the Scottsdale Road frontage from the natural channel to Indian Bend Road (1400 cfs ±.)

- Phase IV - Integrate 36 ac-ft of detention storage along the natural channel alignment on "Little America" property west of Scottsdale Road north of Indian Bend Road. Tie this system into the Mockingbird diversion and release flows into the Indian Bend - Scottsdale Road intersection.

This Alternative reduces the first costs (Phase I & II) by $400,000 ± over the more straightforward approach of simply picking up the water as it now enters Scottsdale Road (Alternative A) and; in addition, it provides flood protection to the existing residences and offices in the whole study area from Mockingbird to the Indian Bend Wash south of Lincoln.

SECTION 3

DATA ANALYSIS

The study area's storm-water originates from a tributary that extends west to Mummy and Camelback Mountains. The drainage areas below the mountains have developed into primarily low-density and resort type, partially-irrigated land uses. Evaluating the flow patterns and alternatives is complicated by the 17 sub-basins, four flow splits, numerous channel routings, and potential detention basin.

To accurately and efficiently assess the impacts of storage, channel routing, and flow splits, the Soil Conservation Service (SCS) TR-20 Hydrologic Computer Model was used to mathematically model the response of the tributary to various storms. The TR-20 program is a nationally accepted method used to evaluate hydrologic conditions typical of this study. The model performs hydrologic computations based on procedures presented in Section Four of the SCS National Engineering Handbook. The SCS has modified the program to use the modified Att-Kin routing procedure. The program requires, as input data, tributary areas, curve numbers, times of concentration, hydraulic rating curves at flow splits, reservoir stage-storage-outflow, channel routing cross sections, and rainfall distribution. These input data are analyzed in the model to determine volumes and flow rates that ultimately affect the study area.

3.1 TR-20 Input Definitions

Tributary Areas are delineated on Plates 1 and 2.

Curve Numbers for the tributary areas are used to compute how much rainfall will result in runoff. The curve numbers digitize the effects of soil, vegetative types, and the relative portion of impervious area on runoff. The design values in this study fall in the 88 to 85 range, depending on the terrain and land cover.

Time of Concentration is defined as the time required for runoff to travel from the most hydraulically remote part of the watershed to the point of concentration. The point of concentration is the point in the sub-basin where the sub-basin's flow (or hydrograph) is to be computed. The time of concentration is the most significant influence on the shape of the hydrograph and therefore the peak flow rate. Times of concentrations were determined using overland curves and channel and street velocities. Where the results gave low average velocities (or longer times of concentrations) the times of concentrations were modified based on hydraulic analysis of the channels or streets. On the whole, response times from the watershed are short (under an hour) causing the

resulting hydrographs to have relatively high and steep peaks that can be significantly altered by relatively small storage volumes.

Rating Curves or stage-discharge relationships were developed for the locations where flow splits occur. Flows in street and channel cross-sections were calculated using Mannings Equation. Flows across street crowns were estimated using the broad crested weir equation $Q = CLH^{3/2}$.

Routing Coefficients for the Modified Att-Kin method were estimated using Mannings Equation and typical street (or channel) cross sections.

Rainfall Data required by TR-20 includes rainfall duration, distribution, and depth. Rainfall events with durations of 24 hours and the SCS Type II distribution (summer storm) were used in this study. The rainfall depths for various return periods were based on U.S. Weather Bureau data (Technical Memorandum WBTM WR-44).

A summary of the TR-20 input parameters are given in Table 2.

3.2 TR-20 Configuration

In addition to the input data, a TR-20 model must be developed to accurately model the field and/or planned conditions. Model structuring requires the proper placement (with respect to the entire flow system) of the hydrograph generation, diversions, hydrograph routing, and alternative revisions. Schematic diagrams illustrating the TR-20 configurations for existing and design conditions are in Appendix A.

TABLE 2

SUB-BASIN CHARACTERISTICS

Sub-Basin Number	TR-20 Designation Number	Area (Sq. Mi.)	Curve Number	Time of Concentration (Hrs)
A1 & A2	10	0.44	88	0.65
C	16	0.34	87	0.35
B1	26	0.79	85	0.30
B2	28	0.07	85	0.27
B3	30	0.01	85	0.17
D	32	0.17	85	0.65
E	34	0.03	85	0.37
G3	36	0.21	88	0.16
G4	40	0.05	86	0.12
G1	46	0.03	85	0.20
K	48	0.15	85	0.31
F	58	0.11	85	0.36
J	64	0.06	85	0.20
H2	66	0.03	85	0.21
H1	72	0.14	85	0.42
L	97	0.03	85	0.22
G2	95	0.03	85	0.22
M	96	0.03	85	0.20

SECTION 5

FLOOD CONTROL MANAGEMENT ALTERNATIVES

5.1 Introduction

The purpose of this section is to present flood control management alternatives that address the problems presented in the prior section. Conceptual alternatives have been developed to intercept the Lincoln Drive and natural wash flood flows before they reach Scottsdale Road. The existing analysis showed that Lincoln Drive and the natural wash are hydraulically connected. Or, that modifying one affects the other. For ease of analysis, five structural elements were identified that would each partially solve the flooding problem. Any one portion would not solve the entire problem, however mixing the components can solve or reduce the magnitude of the flooding problems. Within each element, the level of protection can be modified to any desired level. Table 4 describes the five components and their possible impacts while Plate 4 shows their physical locations.

The flood events considered for the alternative analysis include the 10, 25 and 100 year floods. Four alternatives have been identified and these alternatives are comprised of the five elements shown in Table 4. Plate 5 shows how the components are combined to form alternatives.

SECTION 4

EXISTING CONDITIONS

Prior to any alternative analysis, the existing conditions were determined as a "base" condition upon which alternative solutions were compared.

To determine how the system reacts to different storm events, three storms were analyzed. The storm with a 10 year return frequency was chosen to represent frequent and low discharges. The storm with a 25 year return frequency was chosen to represent frequent and moderately high discharges; and the 100 year return frequency storm was chosen as an infrequent and high discharge event. Other than the Indian Bend Wash system outlet, there are no major storage or flood conveyance structures on the watershed, The 10, 25, and 100 year storms will therefore generate unimpaired runoff (no significant structured storage). Plate 3 shows the flows rates and flooded areas for the 10, 25, and 100 year floods near Scottsdale Road. Table 2 summarizes the flows shown in Plate 3.

A ten year flood causes Scottsdale Road and Lincoln Drive to carry water well over the top of the curb and traffic is impeded. The Scottsdale and Lincoln intersection is flooded and a low lying office area northwest of the intersection experiences flooding along with downstream residential areas east of Scottsdale Road.

A 100 year flood will cause extensive damage to low-lying areas east and west of Scottsdale Road. The grader ditch along the west side of Scottsdale Road acts as a channel to carry a substantial portion (60% to 70%) of the storm water entering from Lincoln Drive at the natural channel north to Indian Bend Road and Mummy Mountain Wash. This grader ditch along Scottsdale Road ultimately drains into Indian Bend Wash by Indian Bend Road and may overflow into Mummy Mountain Wash. This causes Mummy Mountain Wash to exceed its design capacity, and will subsequently create flooding problems along Scottsdale Road north of Indian Bend Road on larger storms. Flooding east of Scottsdale Road can be attributed to flows from the west on Lincoln Drive and flows crossing Scottsdale Road at the natural wash that discharge into Scottsdale Road approximately 800 feet north of Lincoln Drive. These flood waters originate from Mummy and Camelback Mountains, and, the majority of the tributary is within the Town of Paradise Valley.

Mockingbird Lane
Indian Bend Road
Lincoln Drive
Scottsdale Road
Miller Road
U.S.C.E. Side Channel
Arizona Canal
Murray Mountain Wash
10yr 747
25yr 1097
100yr 1990
10yr 101
25yr 146
100yr 218
10yr 201
25yr 279
100yr 394
10yr 90
25yr 118
100yr 161
10yr 271
25yr 371
100yr 556
10yr 561
25yr 778
100yr 1165
10yr 678
25yr 727
100yr 847
10yr 760
25yr 981
100yr 1429
10yr 112
25yr 251
100yr 388
10yr 306
25yr 419
100yr 603
10yr 403
25yr 787
100yr 1148
EXISTING FLOW RATES/ PATTERNS
SCALE 1"=400'
JOB NO. 1063.2
DATE Oct. 1985
PLATE 3
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5110 N. 40th St. Suite 252
Phoenix, Arizona 85018
(602) 954-6399

TABLE 3

SUMMARY OF FLOWS FOR EXISTING CONDITIONS *

Description	Flows 10 Year	25 Year	100 Year
Flow East along Lincoln Drive from Mockingbird Intersection	210	280	400
Flow North along Mockingbird from Lincoln Intersection	100	150	220
Flow along Lincoln Drive into Scottsdale Road Intersection	300	420	600
Flow over Mockingbird Road at Natural Wash intersection (1/2 Mile North of Lincoln Drive)	750	1060	1560
Flow into Scottsdale Road at Natural Wash	800	1125	1650
Flow North along Scottsdale Road from Natural Wash	690	880	1280
Flow East into homes from Scottsdale Road at Natural Wash	110	250	390
Intersection of Scottsdale Road and Indian Bend Road			
Flows into from South	760	980	1430
Flows into from West	90	120	160
Flows out of to East (Down Indian Bend Road)	580	730	850
Flows out of to North (To Mummy Mountain Wash)	270	370	560
Flows into Mummy Mountain Wash (Across Scottsdale Road)	560	780	1160

* Rounded to nearest 10 cfs ±

Flows from Lincoln Drive that flood the Lincoln Drive/ Scottsdale Road intersection continue north (flooding Scottsdale Road) and east (flooding Lincoln Drive). Scottsdale Road to the south of Lincoln Drive is high enough to prevent overflow to the south.

Flows from the natural drainage discharge into Scottsdale Road and splits north, east, and south. Northerly flows (60% to 70%) flood the Scottsdale Road/Indian Bend Road intersection, and split equally into both the Mummy Mountain Wash and east down Indian Bend Road on approximately an even split. The Scottsdale Road crossing of Mummy Mountian Wash is currently a dip section.

Easterly flows run toward Indian Bend Wash and flood the residential area between Scottsdale Road and the Arizona Canal. Southerly flows from the natural wash aggrevate the Lincoln Drive/Scottsdale Road intersection flooding problem.

In summary, even small storm events can cause significant traffic interuption and damage to homes and offices. Large storm events will cause area wide damage to streets, businesses, and homes.

TABLE 4

DESCRIPTION OF FLOOD CONTROL COMPONENTS

Component Description	Purpose	Other Components	Impacts to
Indian Bend Channel	Open channel that runs east from the west side of Scottsdale Road/Indian Bend Road intersection into Indian Bend Wash	To Control flooding from the natural channel north along Scottsdale Road	None
Lincoln Drive Storm Drain	Underground storm sewer that runs from Scottsdale Road/Lincoln Drive and discharges into the Indian Bend Wash side channel at the Arizona Canal	To remove surface water from Lincoln Drive and remove standing water west of the Scottsdale Road/ Lincoln Drive intersection	None
Mockingbird Lane Diversion Channel	Open Channel that starts at Lincoln Drive/Mockingbird Road intersection and connects into Indian Bend Channel or Detention Basin	To remove flow along Lincoln Drive	1) Reduces flows into Lincoln Drive Storm Drain 2) Increases flows into detention basin or Indian Bend Road Intersection
Detention Basin	A detention basin located in the middle of a parcel west of Scottsdale Road north of Lincoln Drive and connecting channel from the basin to the Indian Bend Channel	To reduce peak flows in natural wash	1) Reduces flow in Indian Bend Channel and at Lincoln Drive and at Lincoln Drive Intersection
Lincoln Drive Diversion Channel	Open channel that begins ___ approximately 1/4 mile west of Lincoln Drive/Scottsdale Road intersection and runs north to Indian Bend Channel	To remove flow along Lincoln Drive	1) Reduces flows into Lincoln Drive Storm Drain 2) Increases flows into Indian Bend Channel

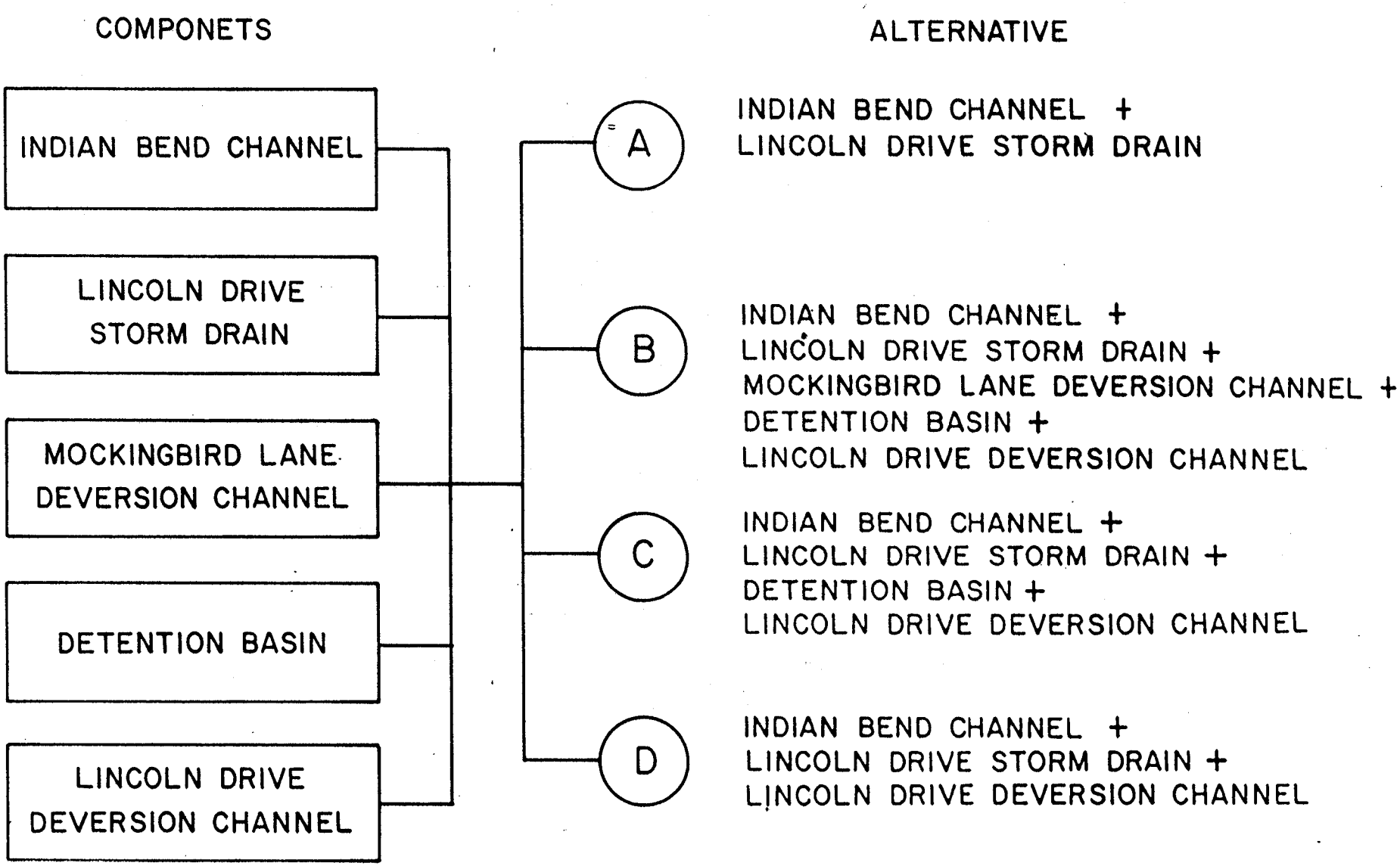

PLATE 5

CONCEPTUAL ALTERNATIVE DEVELOPMENT

The following is a summary of the alternatives.

5.2 Alternative A

Alternative A (shown on Plate 6) is the most straightforward approach and, includes the Indian Bend Channel and the Lincoln Drive Storm Drain with no diversions. Alternative A eliminates (up to the design flood) the flooding at the intersection of Scottsdale Road at Lincoln Drive and the flooding along Lincoln Drive East of Scottsdale Road. Flooding of Scottsdale Road at Indian Bend Road is eliminated, and this in turn solves the capacity problems at Mummy Mountain Wash. However, until upstream development occurs, waters from the natural wash would still flow uncontrolled along Scottsdale Road from the natural wash to Indian Bend Road; and, businesses and homes on greater than the design storm in the natural wash/Scottsdale Road intersection would, in the interim period, be subject to flooding. The estimated Alternative A cost to protect for the 25 and 100 year floods are $1,550,000.00 and $1,863,000.00, respectively. In addition, an alternative is included for construction of a 10 year Lincoln Drive storm drain with a 25 year capacity on the balance of the alternatives. The total cost of this alternative is $1,135,000.

5.3 Alternative B

Alternative B (Shown on Plate 7) uses the Indian Bend Channel, a reduced Lincoln Drive Storm Drain, Mockingbird Lane Diversion Channel, and Detention Basin components. Alternative B controls the flows from Lincoln Drive and the natural wash and eliminates flooding problems along the east side of Scottsdale Road. The precise location for the detention basin has not been determined, however it is likely that it would lie in whole or partly within the Town of Paradise Valley.

Detention basin sizes could range from 29 to 36 acre-feet covering 5 to 8 acres (5 to 10 foot depth). It is anticipated that any detention basin alternative in Paradise Valley would incorporate a storm water recharge system and would require Town approval. The cost of this alternative, exclusive of land costs, is $1,363,000.00 and $1,703,000.00 for the 25 and 100 year floods.

5.4 Alternative C

Alternative C (Shown on Plate 8) is comprised of the Indian Bend Channel, Lincoln Drive Storm Drain, Lincoln Drive Diversion Channel and detention basin. Alternative C controls the flows from Lincoln Drive and the natural wash and eliminates flooding problems along and east of Scottsdale Road. This alternative is similar to Alternative B except the Lincoln Drive flows are not routed through the detention basin.

Consequently, the size (and cost) of the Indian Bend Channel is increased and the detention basin size (and cost) is decreased. Detention basin capacities range from 17 to 27 acre-feet covering 2 to 5 acres (5 to 10 foot depth). This is equivalent to approximately 75% of the detention basin capacity in Alternative B. As in Alternative B, the location of the detention basin would lie in whole or partly within Paradise Valley. The cost to protect for the 25 and 100 year floods, exclusive of land costs, are $1,385,000.00 and $1,691,000.00, respectively.

5.5 Alternative D

Alternative D (Shown as Plate 9) uses the Lincoln Drive Storm Drain, Lincoln Drive Diversion Channel, and the Indian Bend Channel components. This alternative, like Alternatives B and C, controls the flows from Lincoln Drive and the natural wash and eliminates flooding along and east of Scottsdale Road. Because detention basins are not used, the Indian Bend Channel's capacity is increased. The Lincoln Drive diversion channel could act as a buffer area between the higher density to lower density land uses along the Scottsdale - Paradise Valley Border. The cost of this alternative is $1,862,000.00 and $2,255,000.00 for the 25 and 100 year storm designs.

5.6 Alternative Comparison

Alternative A controls the water as it now arrives at Scottsdale Road while Alternatives B, C, and D all control the flooding at Lincoln Drive by diverting water from Lincoln Drive to Indian Bend. Alternatives B and C incorporate a detention basin in the upstream system. Table 5 summarizes the cost and engineering data for the 25 and 100 year floods and Table 6 summarizes the same information for the Alternative A system with a 10 year Lincoln Drive Storm drain and 25 year system on the balance.

FLOOD CONTROL COMPONETS

SCALE	JOB NO.	DATE	PLATE
1"=100'	10632	Oct. 1985	4

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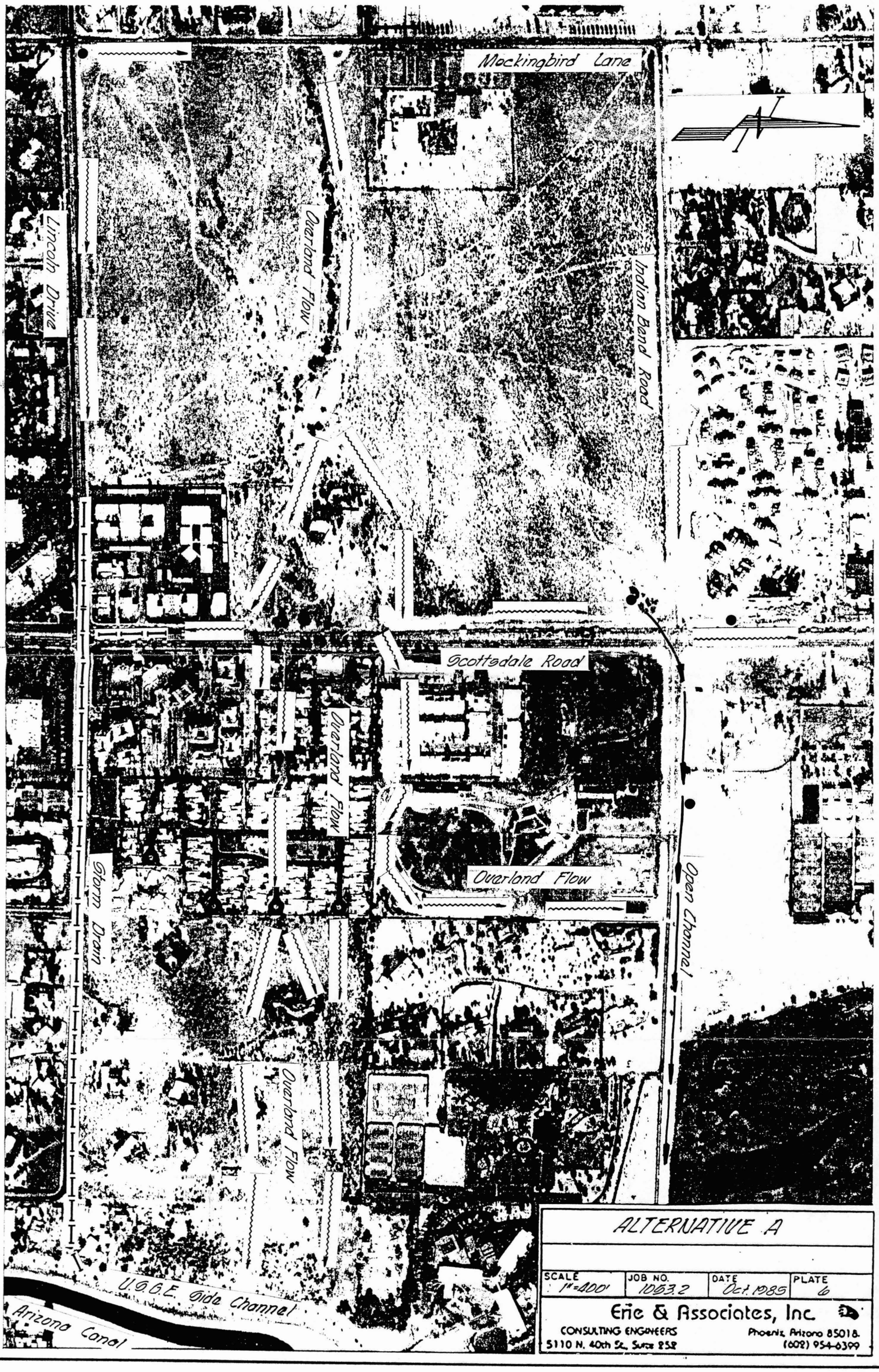
Mockingbird Lane
Lincoln Drive
Overland Flow
Indian Bend Road
Scottsdale Road
Overland Flow
Storm Drain
Overland Flow
Open Channel
Overland Flow
U.S.G.E. Side Channel
Arizona Canal
ALTERNATIVE A
SCALE 1"=400'
JOB NO. 1053.2
DATE Oct. 1985
PLATE 6
Erie & Associates, Inc.
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(602) 954-6399

ALTERNATIVE B

SCALE	JOB NO.	DATE	PLATE
1" = 400'	1053.2	Oct. 1985	7

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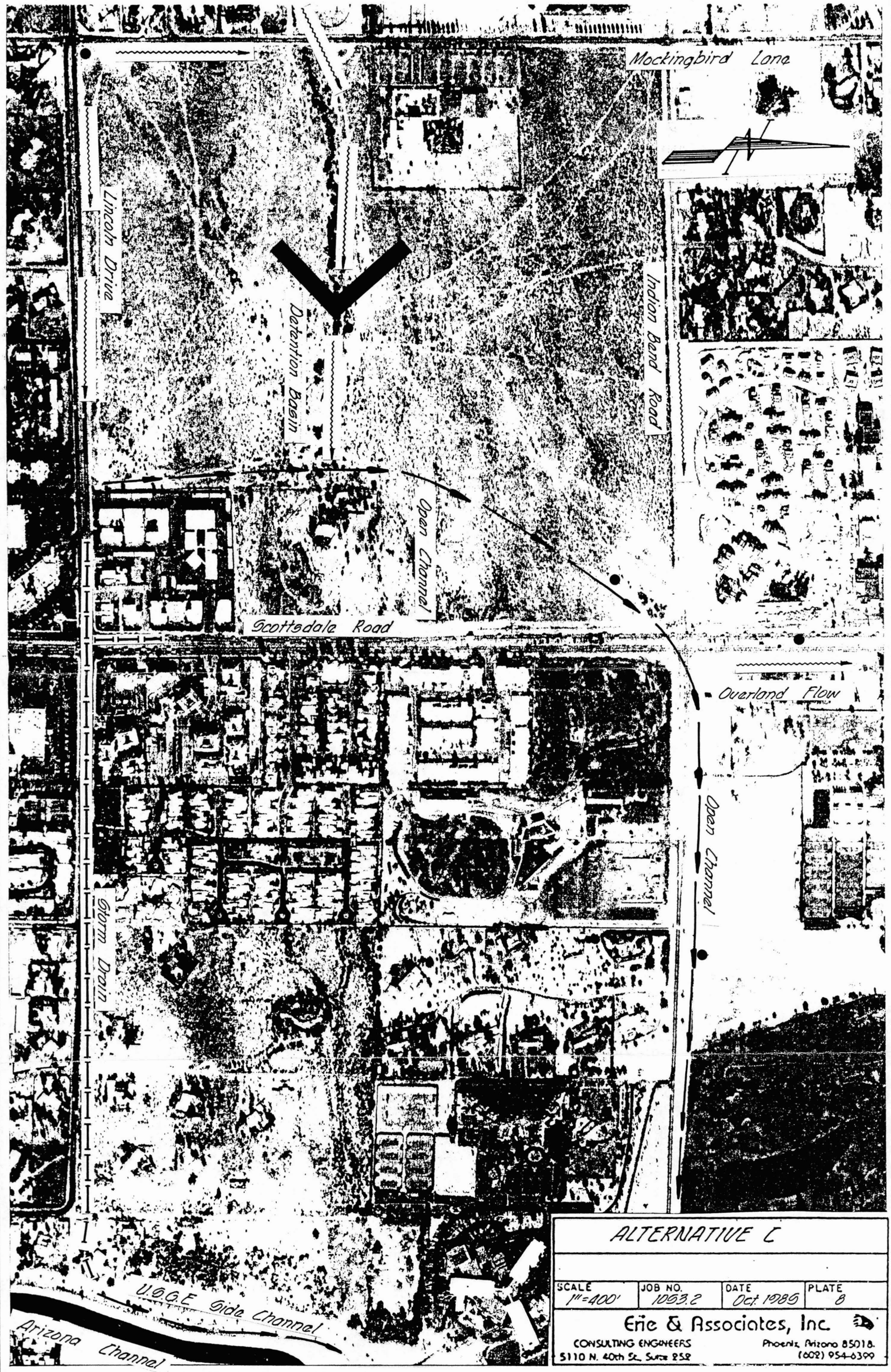
Phoenix, Arizona 85018
(602) 954-6399



ALTERNATIVE C

SCALE	JOB NO.	DATE	PLATE
1"=400'	1053.2	Oct. 1986	8

Erie & Associates, Inc.

CONSULTING ENGINEERS
5110 N. 40th St. Suite 252
Phoenix, Arizona 85018
(602) 954-6399

Mockingbird Lane
Indian Band Road
Open Channel
Lincoln Drive
Overland Flow
Storm Drain
Open Channel
U.S.G.E. Side Channel
Arizona Channel
ALTERNATIVE D
SCALE 1"=400'
JOB NO. 1053.2
DATE Oct. 1985
PLATE 9
Eric & Associates, Inc.
CONSULTING ENGINEERS
5110 N. 40th St. Suite 252
Phoenix, Arizona 85018
(602) 954-0399

TABLE 5

ENGINEERING AND COST SUMMARY

Component	Alternatives for 25 Year Flood Protection				Alternatives for 100 Year Flood Protection			
	A	B	C	D	A	B	C	D
Indian Bend Channel and Culvert								
Box Culvert	10' x 8'	10' x 8'	2(10' x 8')	2(10' x 8')	2(10' x 8')	2(10' x 8')	3(10' x 8')	3(10'x 8'
Length (ft)	150	150	150	150	150	150	150	150
Top Width (ft)	53	53	63	73	63	68	78	88
Length (ft)	1600	1600	1600	1600	1600	1600	1600	1600
Capacity (cfs)	730	760	1200	1490	1150	1410	1690	2200
Cost ($)	298,600	298,600	392,500	443,500	392,500	417,000	510,800	559,700
Lincoln Drive Storm Drain								
Length (Main and Laterals) (ft)	4150	4150	4150	4150	4150	4150	4150	4150
Diameter (Main In)	2 -66"	60"	60"	60"	2 - 72"	66"	66"	66"
Main Capacity (cfs)	450	140	120	120	650	210	180	180
Cost ($)	792,000	411,300	411,300	411,300	891,000	429,300	429,300	429,300
Mockingbird Lane Diversion Channel								
Length (ft)		1500				1500		
Capacity (cfs)		420				620		
Cost ($)	N/A	20,800	N/A	N/A	N/A	29,200	N/A	N/A
Detention Basin								
Capacity (AF)		29	17			36	27	
Outlet Channel Length		2000	1800			2000	1800	
Outlet Channel Capacity (cfs)		600	790			1300	1100	
Land Requirements (Ac)		5	2			8	5	
Cost ($) *	N/A	261,500	172,000	N/A	N/A	332,600	244,800	N/A
Lincoln Drive Diversion Channel								
Length (ft)			1000	2800			1000	2800
Capacity (cfs)			300	300 - 1410			430	430 - 2060
Cost ($)	N/A	N/A	12,200	500,000			13,900	636,400
Mummy Mountain Wash Crossing								
Capacity (cfs)	780	510	510	510	1160	740	740	740
Cost ($)	101,600	77,400	77,400	77,400	149,800	101,600	101,600	101,600

TABLE 5 (Con't)

ENGINEERING AND COST SUMMARY

Component	Alternatives for 25 Year Flood Protection				Alternatives for 100 Year Flood Protection			
	A	B	C	D	A	B	C	D
Subtotal Cost ($)	1,192,200	1,048,800	1,065,400	1,432,200	1,433,300	1,309,700	1,300,400	1,727,000
** (Subtotal Cost)	1,192,200	787,300	893,400	1,432,200	1,433,300	977,100	1,055,600	1,727,000
Engr. Legal, Admin. & Contingincies @ 30% ± ($)	357,800	314,200	319,600	428,700	429,700	393,300	390,600	528,100
Total Cost ($) *	1,550,000	1,363,000	1,385,000	1,862,000	1,863,000	1,703,000	1,691,000	2,255,000

* Does not include detention basin land costs

** Subtotal Costs - Excluding Detention Basin and assuming Mockingbird Diversion costs are reallocated to a tempora channel along Scottsdale Road from the natural wash.

TABLE 6

ENGINEERING AND COST SUMMARY

Alternatives for 10 Year Flood Protection Lincoln Drive Storm Drain and 25 Year or 100 Year on Balance

Component	A
Lincoln Drive Storm Drain	
Length (main & laterals)	4150
Diameter (main, in.)	72
Main capacity (cfs)	320
Cost ($)	472,150

Note: Balance of componets are designed for a 25 year storm.

Subtotal Cost ($)	872,350
Engineering, Legal, Administrative & Contingincies @ 30% ± ($)	262,650
Total Cost ($)	1,135,000

APPENDIX A

ENGINEERING COMPUTATIONS AND CONCEPT DRAWINGS

A-1 Hydrology Computation Sheets

i) Basin Characteristics

ii) TR-20 Schematic Existing Conditions

111) Rainfall/Precipitation Data

A-2 Hydraulic Computation Sheets

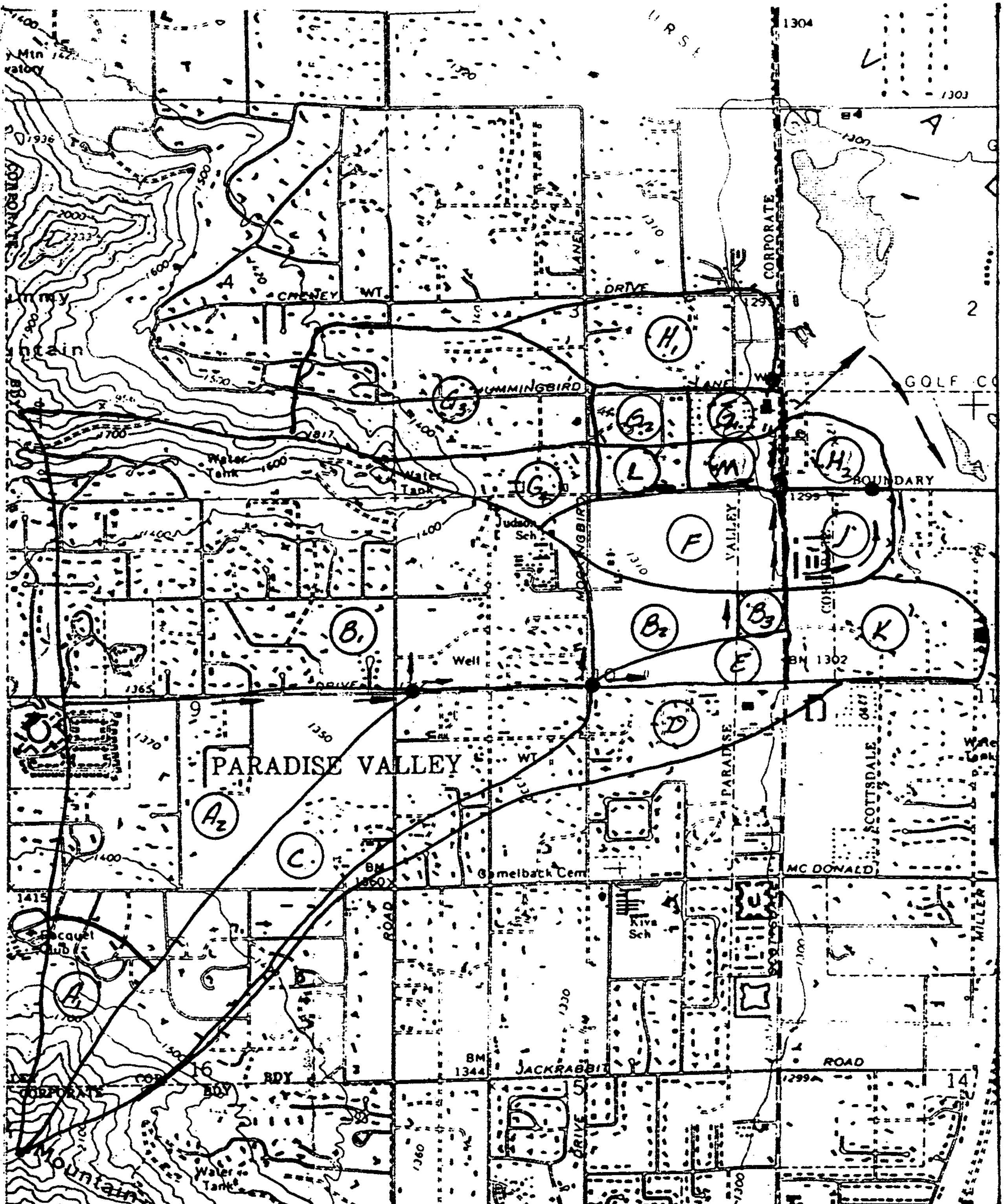
i) "Cross Section" Computation Sheets

ii) Routing Coefficient Computations

A-3 Cost Estimates for Alternatives

APPENDIX A

A-1) HYDROLOGIC COMPUTATION SHEETS



TRIBUTARY AREAS

SCALE	JOB NO.	DATE	PLATE
1"=200'	1063.2	Oct. 1985	2

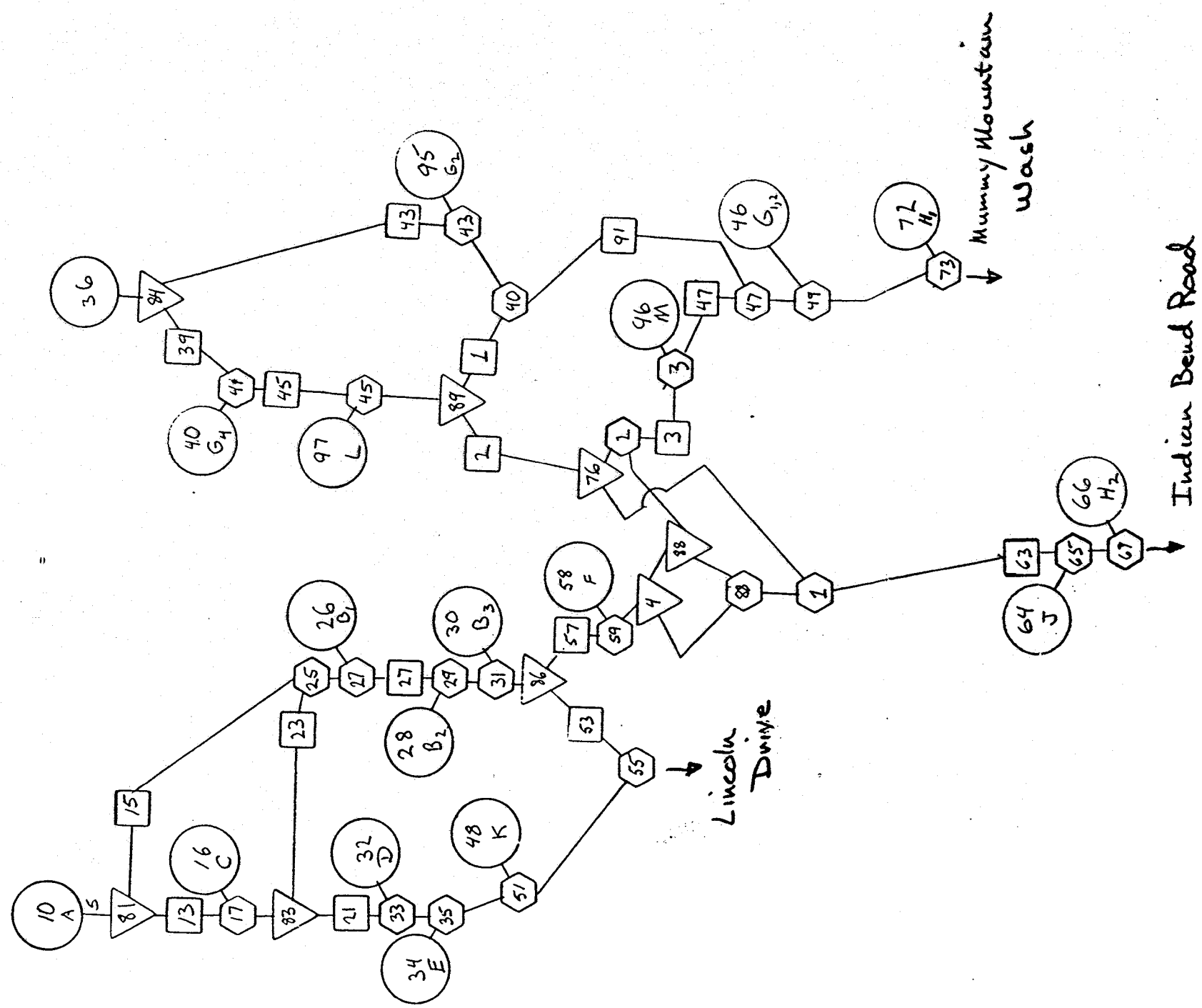
Erie & Associates, Inc.

CONSULTING ENGINEERS — Phoeni. Arizona

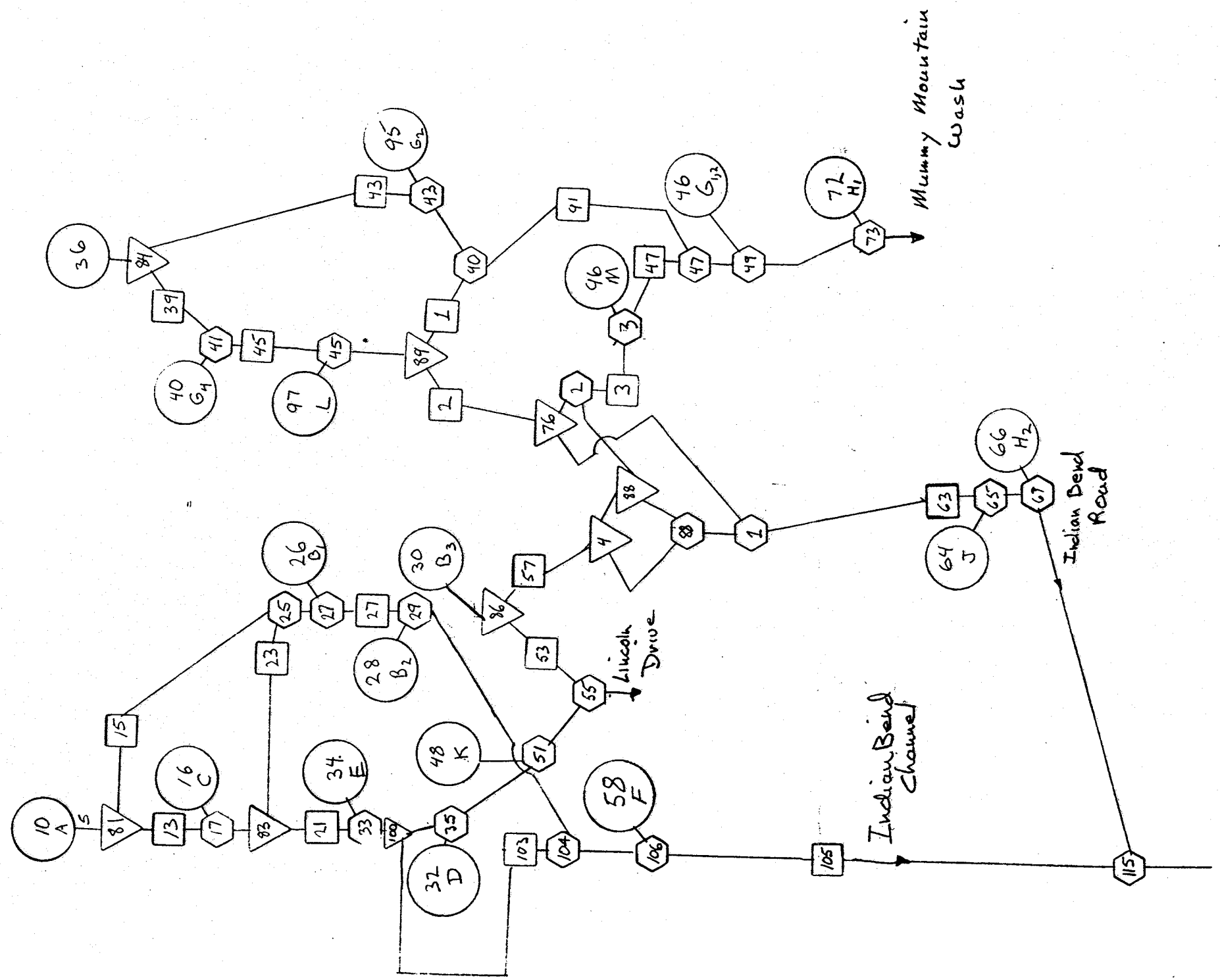
TABLE A-2

SUB-BASIN CHARACTERISTICS

Sub-Basin ID	TR-20 Designation Number	Area (Sq. Mi.)	Curve Number	Time of Concentration (Hrs)	Length (ft)	delta H (ft)
A1 & A2	10	0.44	88	0.65	9000	1158
C	16	0.34	87	0.35	10000	1180
B1	26	0.79	85	0.30	7200	680
B2	28	0.07	85	0.27	2000	20
B3	30	0.01	85	0.17	650	5
D	32	0.17	85	0.65	6600	68
E	34	0.03	85	0.37	2600	28
G3	36	0.21	88	0.16	4000	500
G4	40	0.05	86	0.12	2650	385
G1	46	0.03	85	0.20	1200	9
K	48	0.15	85	0.31	2600	30
F	58	0.11	85	0.36	3400	40
J	64	0.06	85	0.20	1500	16
H2	66	0.03	85	0.21	1500	14
H1	72	0.14	85	0.42	3800	40
L	97	0.03	85	0.22	1400	10
G2	95	0.03	85	0.22	1400	10
M	96	0.03	85	0.20	1200	10



TR-20 Schematic			
Existing Conditions			
SCALE NTS	JOB NO. 1053.2	DATE Sept. 86	PLATE B-1
Erie & Associates, Inc.			
CONSULTING ENGINEERS			Phoenix, Arizona



TR-20 Schematic			
Design Conditions			
SCALE NTS	JOB NO. 1053.2	DATE Sept. 86	PLATE B3
Erie & Associates, Inc.			
CONSULTING ENGINEERS		Phoenix, Arizona	

ERIE & ASSOCIATES, INC.
CONSULTING ENGINEERS

JOB NO. 1053.2 SHEET ____ OF ____

PROJECT Drainage Study CALC. ____ DATE ____

SUBJECT Precipitation Data CHKD. ____ DATE ____

FROM: US Weather Bureau (WR-44) 1975 (page 37)

ESTIMATED RETURN PERIODS FOR SHORT-DURATION PRECIPITATION IN ARIZONA
(Inches)

Station: Phoenix WBO

Latitude: 33° 26'

Longitude: 112° 01'

Elevation (feet): 1117

RETURN PERIOD (YEARS)

DURATION	1	2	5	10	25	50	100
5 min.	0.17	0.26	0.38	0.47	0.59	0.68	0.77
10 min.	0.27	0.40	0.59	0.72	0.91	1.06	1.20
15 min.	0.34	0.50	0.74	0.92	1.15	1.34	1.52
30 min.	0.47	0.70	1.03	1.27	1.60	1.86	2.10
1 hr.	0.60	0.88	1.30	1.61	2.02	2.35	2.66
2 hr.	0.65	0.94	1.39	1.72	2.15	2.49	2.82
3 hr.	0.69	1.01	1.48	1.82	2.27	2.62	2.97
6 hr.	0.81	1.16	1.70	2.07	2.57	2.96	3.35
12 hr.	0.91	1.30	1.90	2.30	2.84	3.26	3.69
24 hr.	1.02	1.44	2.10	2.53	3.12	3.57	4.04

APPENDIX A

A-2) HYDRAULIC COMPUTATION SHEETS

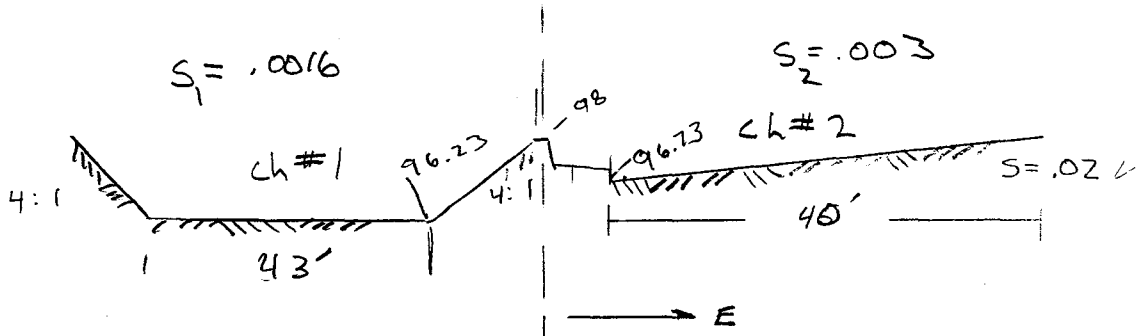
ERIE & ASSOCIATES, INC.
CONSULTING ENGINEERS

JOB NO. 1053.2 SHEET ____ OF ____

PROJECT Drainage Study CALC. DWD DATE 6/4/86

SUBJECT Rating Curve Data CHKD. ____ DATE ____

Scottsdale Rd. Cross Section at Indian Bend Road



Characteristics:

S = .0016
n = 0.02

S = .003
n = .02

Stage (ft)	D_1	A_1	Q_1	H_2	A_2	Q_2	A	Q
0	0	0	0	0	0	0	0	0
.25	.25	11	12.8	0	0	0	11	13
.50	.50	22.5	41.0	0	0	0	22.5	41
1.00	1.0	47	132.0	.5	6.25	10.1	53	142
1.50	1.5	73.5	264.0	1.0	16.8	35.5	90.3	300
2.00	2.0	102.	434.0	1.5	39.3	146.1	141	480

xsect 5
xsect 6

XSECT 77

ERIE & ASSOCIATES, INC.
CONSULTING ENGINEERS

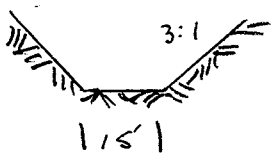
JOB NO. 1053.2 SHEET ____ OF ____

PROJECT Drainage Study CALC. DWD DATE 6/4/85

SUBJECT Rating Curve Data CHKD. ____ DATE ____

- Location: Channel that flows North from diversion #89

- Characteristics:
  - $n = .02$
  - $B = 15'$
  - $z = 3$
  - $S = .0040$



Stage (ft)	Q (cfs)	A (ft^2)
0	0	0
.25	7.1	3.9
.50	22.9	8.3
.75	45.9	12.9
1.00	75.6	18.0
1.50	154.7	29.3
2.00	260.8	42.0

xSect 75

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JOB NO. 1053.2 SHEET ____ OF ____

PROJECT Drainage Study CALC. DWD DATE 6/4/86

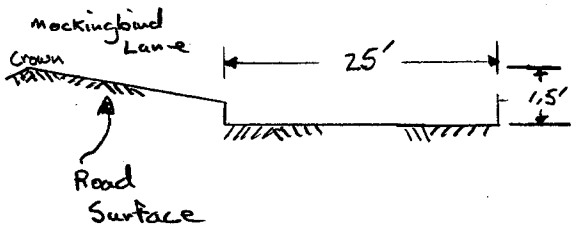
SUBJECT Rating Curve Data CHKD. ____ DATE ____

Diversion #84:

Location: near intersection of Mockingbird Lane & Hummingbird Lane

Mockingbird Cross-section Capacity (South)

Cross-section



Characteristics

- $n \cong 0.02$
- Slope (med) $\cong .003$ from USGS, Paradise Valley, Quadrangle:

Stage (ft)	Depth ft	Area ft²	Perim ft	V ft/s	Q cfs
0	0	0	0	0	0
.25	.25	6.25	25.5	1.60	10.0
.5	.5	12.5	26.0	2.50	31.2
.75	.75	18.75	26.5	3.23	60.6
1.0	1.0	25.0	27.0	3.87	96.7
1.5	1.5	37.5	28.0	4.95	185.4
2.0	2.0	50.0	29.0	5.90	292.6

xsect. #84

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JOB NO. 1053.2 SHEET ____ OF ____

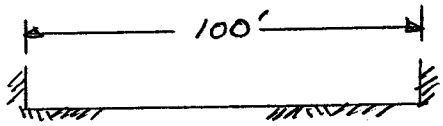
PROJECT Drainage Study CALC. DWD DATE 6/5/85

SUBJECT Rating Curve Data CHKD. ____ DATE ____

Diversion #84 (contin)

Cross Flow - over Mockingbird Lane - Capacity:

Cross-Section:



Characteristics

- Depth-Flow relationship approximated with broad crested weir eq:

$$Q = CLD^{3/2}$$

- $C \approx 2.70$
- $L \cong 100'$

Stage (ft)	Depth (ft)	Area (ft^2)	Q (cfs)
0	0	0	0
.5	0	0	0
.75	.25	25.0	33.8
1.0	.50	50.0	96.
1.25	.75	75.0	175.
1.50	1.00	100.0	270.

xsect #85

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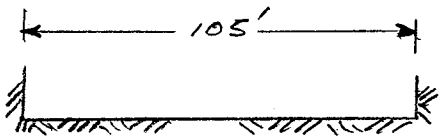
JOB NO. 1053.2 SHEET ____ OF ____

PROJECT Drainage Study CALC. DWD DATE 6/4/85

SUBJECT Rating Curve Data CHKD. ____ DATE ____

Cross section Computations:

- Flow over crown of Scottsdale Rd. at intersection with Indian Bend Rd.



Characteristics

- $Q = CLH^{3/2}$
- $L = 105'$
- $C \approx 3.0$

Stage (ft)	H (ft)	A (ft^2)	Q (cfs)
0	0	0	0
.5	0	0	0
1.0	.2	21.0	28.
1.5	.7	73.5	185.
2.0	1.2	126.0	414.

xsect: 88

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JOB NO. 1053.2 SHEET ____ OF ____

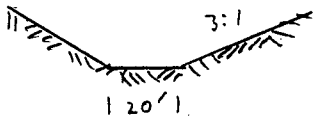
PROJECT Drainage Study CALC. DWD DATE 6/4/86

SUBJECT Rating Curve Data CHKD. ____ DATE ____

Cross Section: Trap Channel on South side

- Location: Channel that heads south from diversion #89

- Characteristics
  - n = .020
  - B = 20'
  - z = 3
  - S = .44% = .0044



Stage (ft)	Q (cfs)	A (ft²)
0	0	0
.25	9.9	5.2
.50	31.8	10.8
.75	63.3	16.7
1.00	103.6	23.0
1.50	209.8	36.8
2.00	349.5	52.0

xsect: 89

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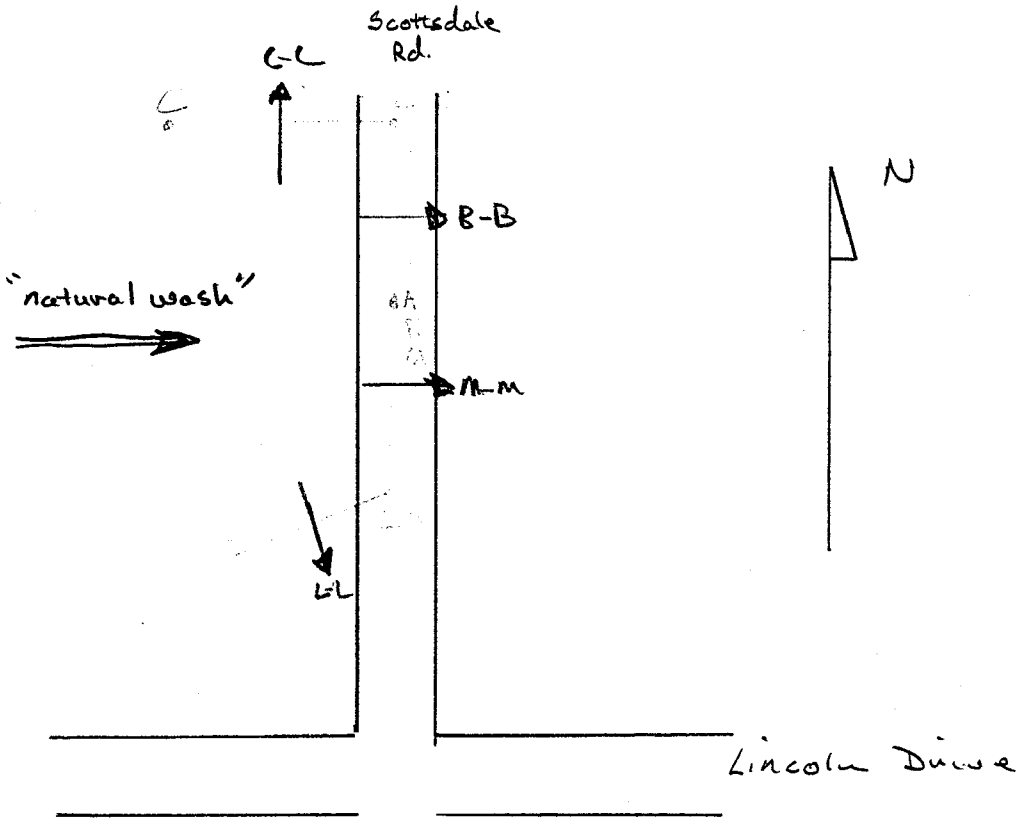
JOB NO. 1053.2 SHEET ____ OF ____

PROJECT ____ CALC. DWD DATE 6-7-85

SUBJECT ____ CHKD. ____ DATE ____

Schematic of Flow split at
Intersection of "natural wash" and Scottsdale Rd.



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JOB NO. 1053.2 SHEET ____ OF ____

PROJECT Drainage Study CALC. DWD DATE 6/4/86

SUBJECT Rating Curve Data CHKD. ____ DATE ____

Cross Section: Diversion #86

Location: Scottsdale Rd. north of the intersection of Scottsdale Rd. & Lincoln Drive

---

Section 99 — Flow north, based on previous study: (see attachment, section C-C): #1097.4

Elevation:	Q (cfs)	A (ft²)
1299	0	0
1300	32.2	15.
1301.	330.8	140.3
1301.6	944.4	323.2
1302.	2115.1	523.7

Section 86 — Flow southand East: based on previous study: (combination of Sections B-B, M-M, & L-L) #1097.4

Elv. (ft)	Q (cfs)	A (ft²)
1301.2	0	0
1301.7	371	173.
1302.	821	416.
1302.5	2440	1003.

ERIE & ASSOCIATES, INC.
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PROJECT Drainage Study
SUBJECT Natural wash @ Scottsdale Rd.
JOB NO. 10532 SHEET ___ OF ___
CALC. ___ DATE 6/7/86
CHKD. ___ DATE ___

TABLE 1 Calculations

Hydraulic Rating Curves

$Q_{weir} = CLH^{3/2}$ & C=3.0

$Q_{manning} = \frac{1.486}{n} AR^{2/3} S^{1/2}$

Section	Elevation	Depth	Area	W.P.	R	V	Q	S	N
A-A	1301.60	0.00	----		----	----	0.00	----	W eq
	1301.70	0.10	----	L=445'	----	----	40.00	----	" "
	1302.00	0.40	----	Weir	----	----	340.00	----	" "
	1302.50	0.90	----		----	----	1140.00	----	" "
B-B	1301.2	0.00	----		----	----	0.00	----	W eq
	1301.7	0.50	----	L=320'	----	----	340.00	----	" "
	1302.0	0.80	----	Weir	----	----	690.00	----	" "
	1302.5	1.30	----		----	----	1420.00	----	" "
C-C	1299.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00833	0.04
	1300.00	1.00	15.00	30.00	0.50	2.14	32.04	"	"
	1301.00	2.00	140.30	243.00	0.58	2.36	330.84	"	"
	1301.60	2.60	323.20	404.00	0.80	2.92	944.38	"	"
	1302.00	3.00	523.70	404.00	1.30	4.04	2115.08	"	"
D-D	1303.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00667	"
	1305.00	1.20	25.30	39.00	0.65	2.28	57.60	"	"
	1305.50	1.70	72.00	128.00	0.56	2.06	148.42	"	"
	1306.00	2.20	163.50	298.00	0.55	2.04	333.00	"	"
	1306.50	2.70	351.00	340.00	1.03	3.09	1086.14	"	"
E-E	1303.80	0.00	0.00	0.00	0.00	0.00	0.00	0.010	"
	1305.00	1.20	18.56	24.00	0.77	3.12	57.92	"	"
	1305.50	1.70	79.36	143.00	0.55	2.49	197.91	"	"
	1306.00	2.20	174.08	202.00	0.86	3.36	584.84	"	"
	1306.50	2.70	484.48	318.00	1.52	4.91	2379.38	"	"
F-F	1304.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00833	"
	1305.00	0.50	5.12	22.00	0.23	1.27	6.52	"	"
	1305.50	1.00	54.08	118.00	0.46	2.02	109.27	"	"
	1306.00	1.50	133.44	155.00	0.86	3.07	409.17	"	"

ERIE & ASSOCIATES, INC.
CONSULTING ENGINEERS

PROJECT Drainage Study
SUBJECT Table #1 continued

JOB NO. 1053.2 SHEET ___ OF ___
CALC. ___ DATE ___
CHKD. ___ DATE ___

Section	Elevation	Depth	Area	W.P.	R	V	Q	S	N
G-G	1301.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00667	0.04
	1301.70	0.70	29.44	70.00	0.42	1.70	50.09	"	"
	1302.00	1.00	74.88	104.00	1.07	3.17	237.67	"	"
	1302.50	1.50	127.04	104.00	1.81	4.48	596.45	"	"
H-H	1300.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00833	"
	1301.00	0.80	12.16	32.00	0.38	1.78	21.63	"	"
	1301.30	1.10	46.40	137.00	0.34	1.65	76.64	"	"
	1302.00	1.80	190.08	256.00	0.74	2.77	527.28	"	"
	1302.50	2.30	307.52	250.00	1.20	3.83	1177.45	"	"
I-I	1305.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00667	"
	1306.00	0.50	6.08	30.00	0.20	1.04	6.31	"	"
	1306.50	1.00	35.84	30.00	1.19	3.41	122.11	"	"
J-J	1303.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00667	"
	1305.00	1.20	25.30	39.00	0.65	2.28	57.60	"	"
	1305.50	1.70	67.80	125.00	0.54	2.00	135.00	"	"
	1306.00	2.20	150.00	180.00	0.84	2.70	405.00	"	"
	1306.50	2.70	240.00	180.00	1.33	3.50	840.00	"	"
K-K	1303.80	0.00	0.00	0.00	0.00	0.00	0.00	0.010	"
	1305.00	1.20	18.56	24.00	0.77	3.12	57.92	"	"
	1305.50	1.70	70.08	228.00	0.31	1.70	119.25	"	"
	1306.00	2.20	231.04	252.00	0.92	3.51	811.90	"	"
L-L	1301.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00667	"
	1302.00	1.00	13.12	19.00	0.69	2.37	31.08	"	"
	1302.50	1.50	171.20	166.00	1.03	3.09	529.77	"	"
	1303.00	2.00	228.80	174.00	1.31	3.63	831.11	"	"
	1303.50	2.50	315.80	174.00	1.81	4.51	1423.05	"	"
M-M	1301.70	0.00	0.00	0.00	0.00	----	0.00	----	W eq
	1302.50	0.80	----	227.00	----	----	490.00	----	"
	1303.00	1.30	----	227.00	----	----	1010.00	----	"

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PROJECT Drainage Study
SUBJECT Table #1 Continued

JOB NO. 1053.2
CALC.
CHKD.

SHEET ___ OF ___
DATE 4/7/86
DATE

Section	Elevation	Depth	Area	W.P.	R	V	Q	S	N
N-N	1305.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00667	W eq
	1306.00	0.30	11.20	100.00	0.11	0.70	7.80	"	" "
	1306.50	0.80	221.60	503.00	0.42	1.70	377.07	"	" "
	1307.00	1.30	535.60	628.00	0.85	2.72	1458.17	"	"
O-O	1306.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0067	.04
	1306.50	0.50	120.00	240.00	0.50	1.90	230.00	"	"

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JOB NO. 1053.2 SHEET ____ OF ____

PROJECT Drainage Study CALC. DWD DATE 6/4/85

SUBJECT Rating Curve Data CHKD. ____ DATE ____

Cross Sectional Data:

- Flow in Culverts (East) at intersection of Indian Bend Rd & Scottsdale Rd:

- Culvert Characteristics:

  - Standard Corr. Metal Pipe-Arch 36"x22"

Culverts on south side of intersection

- Twin 36"x22" pipe-arch
- $L = 137'$
- $S \cong 0.01$

$$\Rightarrow \frac{L}{100 S_0} = 137 \times 150$$

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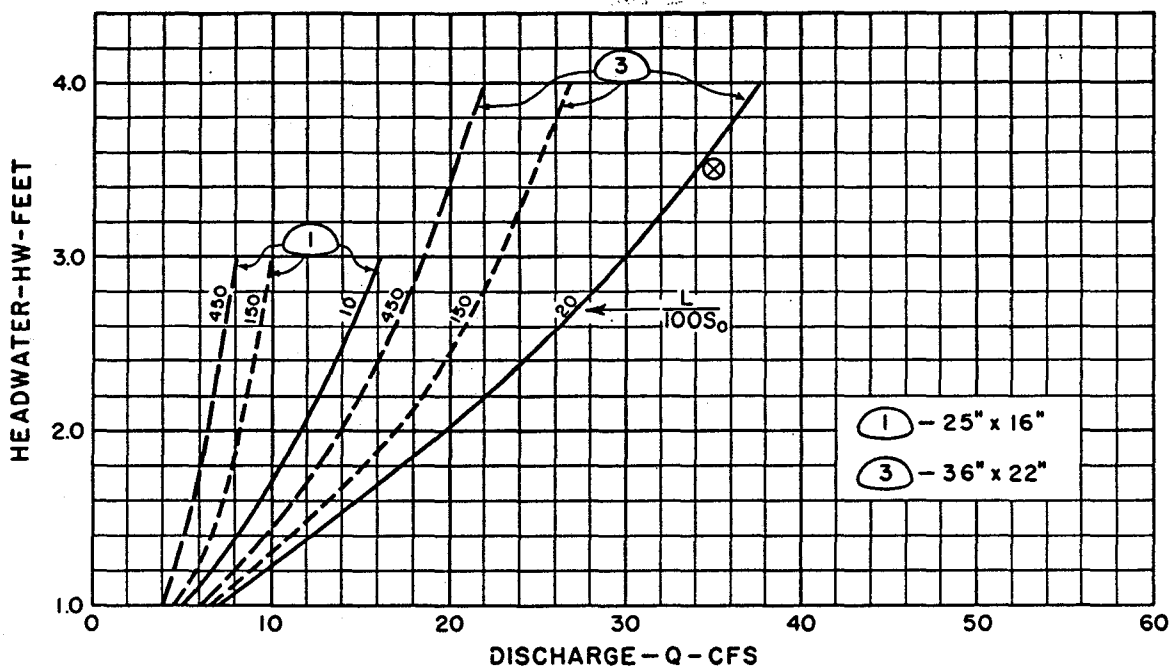
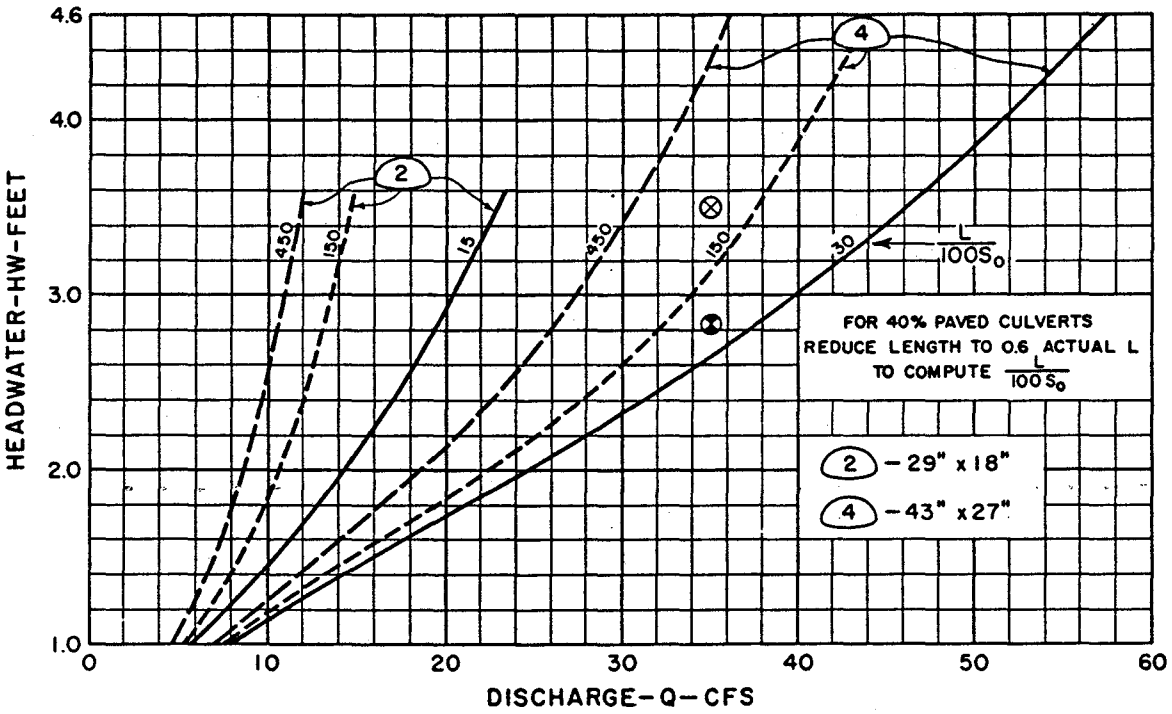
JOB NO. 1053.2 SHEET ____ OF ____

PROJECT Drainage Study CALC. ____ DATE ____

SUBJECT Rating Curve Data CHKD. ____ DATE ____

CHART 27





EXAMPLE

⊗ GIVEN:
35 CFS; AHW = 3.5 FT.
L = 145 FT.; S_0 = 0.020

⊗ SELECT NO.4, 43" x 27"
HW = 2.8 FT.
UNPAVED INVERT

BUREAU OF PUBLIC ROADS JAN. 1963

CULVERT CAPACITY
STANDARD CORR. METAL PIPE-ARCH
HEADWALL ENTRANCE
25" x 16" TO 43" x 27"

ERIE & ASSOCIATES, INC.
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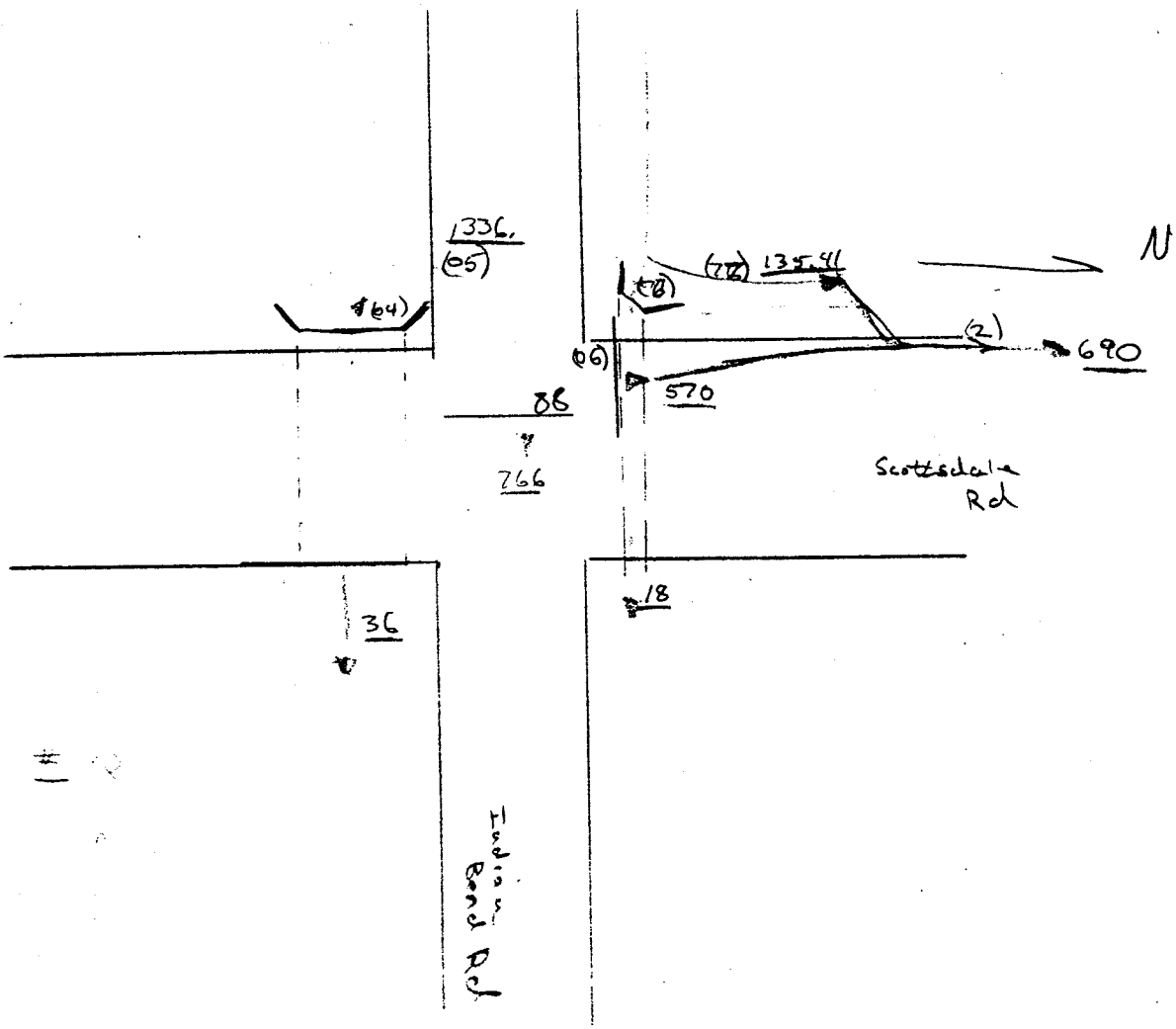
JOB NO. 1053.2 SHEET ____ OF ____

PROJECT Drainage Study CALC. DWD DATE 6/7/85

SUBJECT Flow Splits CHKD. ____ DATE ____

Cross-sectional data for flow over crown of Scottsdale Rd. at intersection with Indian Bend Rd.

Width: median to median: 105'



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JOB NO. 1053.2 SHEET ____ OF ____

PROJECT Drainage Study CALC. DWD DATE 5-29-86

SUBJECT ____ CHKD. ____ DATE ____

- Nomographs and worksheets for estimating "Routing Coefficients" (x and m) for Att-Kin Routing Method (SCS)

- Governing Eq. $Q = XA^m$

  A = area (ft^2)

  Q = discharge (cfs).

- Theoretical Values for "regular channels"

  $x \cong 1.5$

  $m \cong 5/3 \cong 1.6$

  - assumed for xsect's 13, 15, 21, 23, 27, 39, 45, 43, 53, 57, and 63

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JOB NO. 10532 SHEET ____ OF ____

PROJECT Drainage Study CALC. DWD DATE 5-29-86

SUBJECT Routing Coef's CHKD. ____ DATE ____

— Reach 01: S = .001 B = 15' Z = SS = 3:1 L = 1050' D* ~ 3.5' D/B ~ .23 A = 89 ft²	assume n = .015 from Nomograph TR 20 user's manual X = .43 M = 1.54
— Reach 02: L = 1300' S = .005 B = 5 ~ 6' Z = 3.5:1 D = 3.5' D/B = 0.70 A = 60.4 n = .015	X = 1.6 M = 1.38
— Reach 91: L = 1100' B ≅ 60' S ≅ .004 Z ≅ 3:1 D ≅ 2.5' D/B = .04 A = 169 n = .015	X = .50 M = 1.65
— Reach 03 L = 500' S = .0016 Z = 4:1 D ≅ 1.7' B ≅ 75 D/B ≅ .02 A = 139 n = .015	X = .19 M = 1.70

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JOB NO. 1053.2 SHEET ____ OF ____

PROJECT Drainage Study CALC. DWD DATE 5-29-86

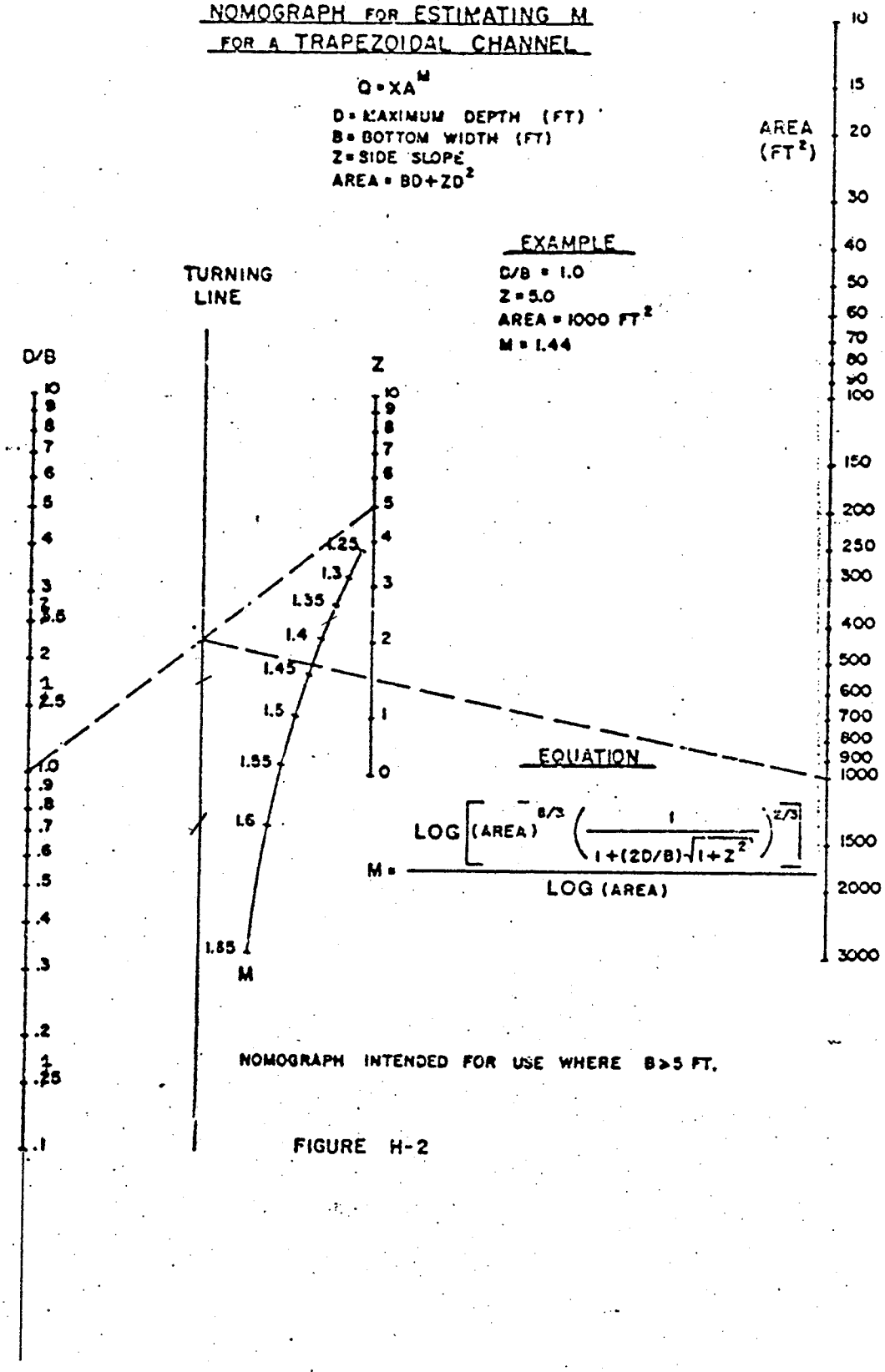
SUBJECT Routing Coef's CHKD. ____ DATE ____

- Reach 47 L = 800' B = 40' S = .0016 Z = 10:1 D = 1.0' D/B = .03 A = 50 ft² n = .015	X = .43 M = 1.56
Reach 103 - Lincoln Diversion First leg -	X = 1.0 m = 1.38
Reach 104 - Lincoln Div. 2nd Leg -	X = 0.5 m = 1.57
Reach 105 - Indian Bend Rd. Channel	X = 0.4 m = 1.58

NOMOGRAPH FOR ESTIMATING M FOR A TRAPEZOIDAL CHANNEL

$Q = XA^M$

D = MAXIMUM DEPTH (FT)
B = BOTTOM WIDTH (FT)
Z = SIDE SLOPE
AREA = $BD + ZD^2$



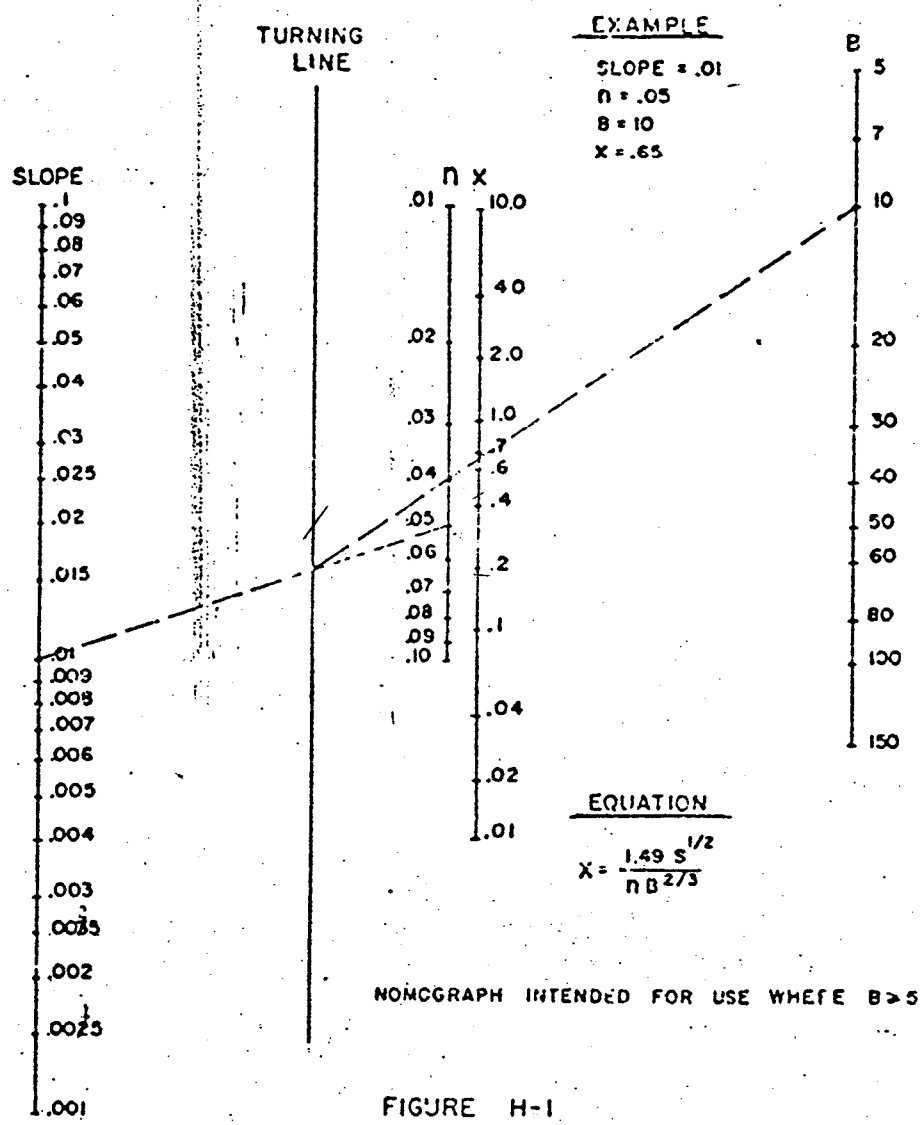
NOMOGRAPH INTENDED FOR USE WHERE B>5 FT.

FIGURE H-2

NOMOGRAPH FOR ESTIMATING X FOR A TRAPEZOIDAL CHANNEL

$Q = XA^M$

SLOPE = BOTTOM SLOPE (FT/FT)
n = MANNING'S n
B = BOTTOM WIDTH (FT)



EXAMPLE

SLOPE = .01
n = .05
B = 10
X = .65

EQUATION

$$X = \frac{1.49\, S^{1/2}}{n\, B^{2/3}}$$

NOMOGRAPH INTENDED FOR USE WHERE B > 5 FT.

FIGURE H-1

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JOB NO. 10 SHEET ____ OF ____

PROJECT Drainage Study CALC. DWD DATE 8-13-85

SUBJECT Rating Curves - Structure 08 CHKD. ____ DATE ____

Detention Basin outlet:

- Select culvert size such that:

  $Q \cong 100$ cfs with $HW = 8'$

  Trial and Error Solution using chart 5 (attached)

  (Entrance Type 1)

Diameter	Discharge (cfs)
48"	140.
42"	110.
36"	89.

- Rating Curve for the 42" culvert:

Stage* (Elev)	Q (cfs)	(DB#1) 4Q (cfs)	(DB#2) 6Q (cfs)	(DB#3) 8Q (cfs)
0	0	0	0	0
2	22	88	132	176
4	60	240	360	480
6	90	360	540	720
8	110	440	660	880
10	130	520	780	1040
12	150.	600	900	1200
14	160.	640	960	1280
16	180.	720	1080	1440
18	190.	760	1140	1520

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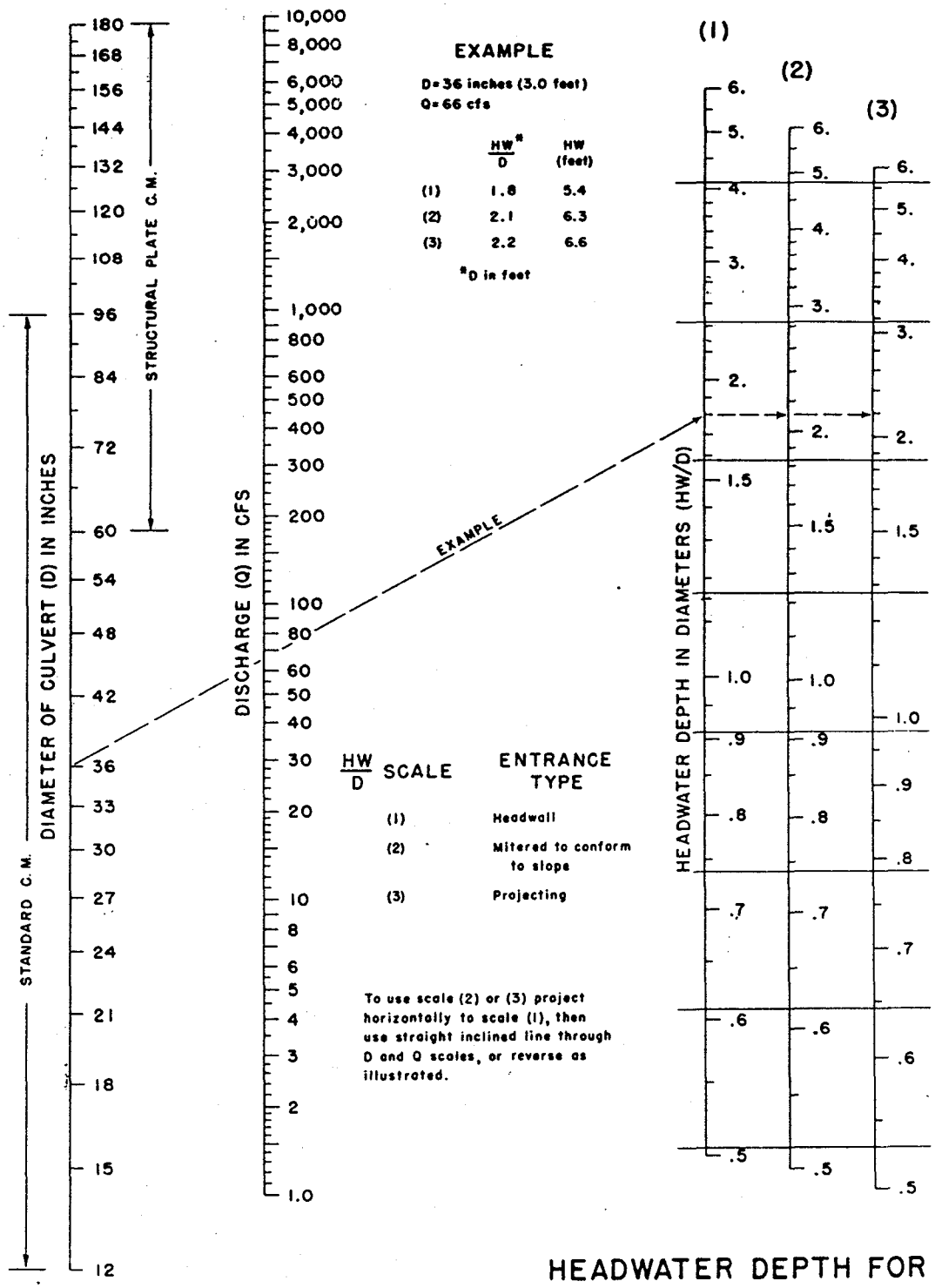
JOB NO. 1053.2 SHEET ____ OF ____

PROJECT Drainage Study CALC. ____ DATE ____

SUBJECT Structure 08 CHKD. ____ DATE ____

CHART 5



HEADWATER DEPTH FOR
C. M. PIPE CULVERTS
WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

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JOB NO. 1053.2 SHEET ____ OF ____

PROJECT Drainage Study CALC. DWD DATE 8-13-85

SUBJECT Structure 08 CHKD. ____ DATE ____

Storage vs stage Info For detention basin

3:1 : side slope

$$Vol \cong L \cdot W \cdot D + \frac{3}{2} D^2 (2(W+L))$$

- For L (length) $= W$ (width) $= X$

$$Vol \approx X^2 \cdot D + 6 D^2 (X)$$

- For $D = 8'$

Vol (AF)	X (ft)	release rate Q cfs
49	493	~400
33	401	~600
19	299	~800

For $L = W = 493$

Stage	#1 x = 493 AF	#2 x = 401 AF	#3 x = 299 AF
0	0	0	0
2	11.4	7.6	4.3
4	23.4	15.7	8.9
6	35.9	24.1	13.8
8	49.0	33.1	19.1
10	62.6	42.4	24.6

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JOB NO. 1053.2 SHEET ____ OF ____

PROJECT Drainage Study CALC. DWD DATE 9-5-85

SUBJECT Design Channel Characteristics CHKD. ____ DATE ____

Channel Characteristics for Open channel
East of Scottsdale Road - North of Indian Bend Rd.

Design Depth = 5, n = .025 Length 1,200'
1' F.B.

Base Width (ft)	Side slope	slope	FL Elev	TW ft	A	Q cfs	V fps	Fr
2	3			38	85	513	6.0	.48
2	4	"	"	50	110	667	6.1	.48
5	4:1	.003	1288	53	125	790	6.3	.50
7				55	135	870	6.5	.51
10	4	.003	1288	58	150	1000	6.7	.53
15	4	.003	1288	63	175	1220	6.9	.55
20	"	"	"	68	200	1430	7.2	.56
25		"		73	225	1660	7.4	.58
30	"	"	"	78	250	1880	7.5	.60
35	"	"	"	83	275	2100	7.7	.60
40				88	300	2330	7.8	.61

$WP = 2((2.5)^2 + 6^2)^{1/2} + B$

Z4 $WP = 50 + B$

$W = 38 + B$

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JOB NO. 1053.2 SHEET ____ OF ____

PROJECT Drainage Study CALC. DWD DATE 9-5-85

SUBJECT Design Channel Characteristics CHKD. ____ DATE ____

West of Scotsdale Rd.: Diversion Channels

assume Design Depth = 5', n = .035, $S = \frac{1306 - 1300}{2800'} = .0021$

Base width	side slope	Slope	TW 1'FB	A	Q	V	FR
2	4	.002	50	110	390	3.5	.28
5	"	"	53	125	460	3.7	.29
10			58	150	580	3.9	.31
15			63	175	710	4.1	.31
20			68	200	840	4.2	.32
30			78	250	1100	4.4	.35
40			88	300	1360	4.5	.36
50			98	350	1630	4.7	.37
60			110	400	1900	4.8	.37
65			115	425	2030	4.8	.38

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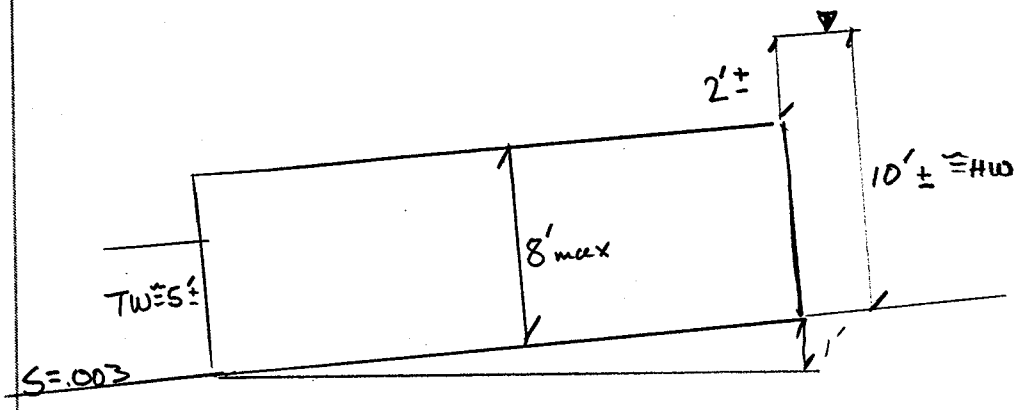
JOB NO. 1053.2 SHEET ____ OF ____

PROJECT Drainage Study CALC. DWD DATE 5-9-85

SUBJECT Scottsdale Rd. Culvert @ I.B. Rd. CHKD. ____ DATE ____

Scottsdale RD Underpass @ Indian Bend Rd.

10'x8' Box Culvert: Inlet Control



Headwater HW	HW (D=10')	Q/B	Q cfs
8'	1.0	55	550
10'	1.25	75	750

Q	CY* Per linear ft	($300/CY L=150') Cost
750	1.3	58,500
1500	2.3	103,500
2250	3.3	148,500

From ADOT Standard Details

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JOB NO. 1053.2 SHEET ____ OF ____

PROJECT ____ CALC. DWD DATE 10-30-85

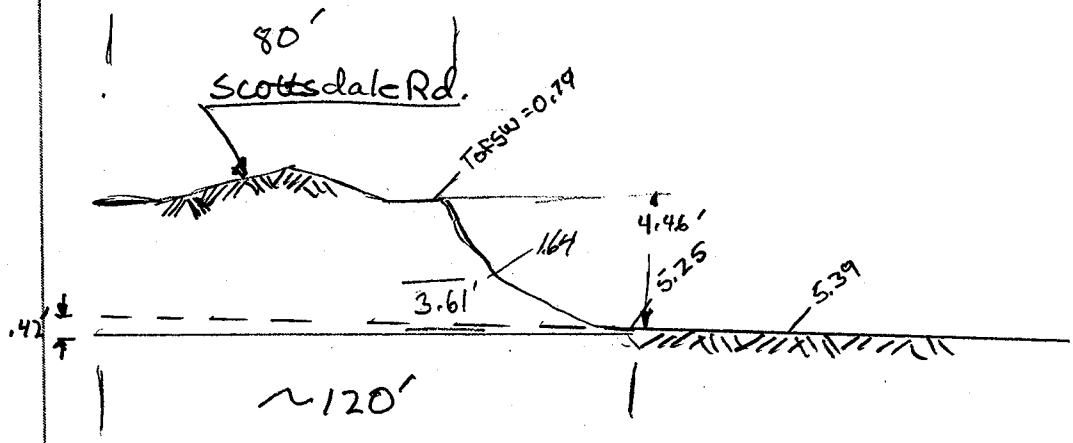
SUBJECT Mummy Mountain Wash Culverts CHKD. ____ DATE ____

Mummy Mountain Wash: Box Culverts For Scottsdale Road

assumptions:

1) Inlet Control

2) Bed slope $= \frac{.14'}{40'} = 0.0035$



∴ ~4.0' from invert to top of sidewalk at west side of Scottsdale Rd.

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JOB NO. 1053.2 SHEET ____ OF ____

PROJECT Drainage Study CALC. DWD DATE 10-30-85

SUBJECT Mummy Mountain Wash CHKD. ____ DATE ____

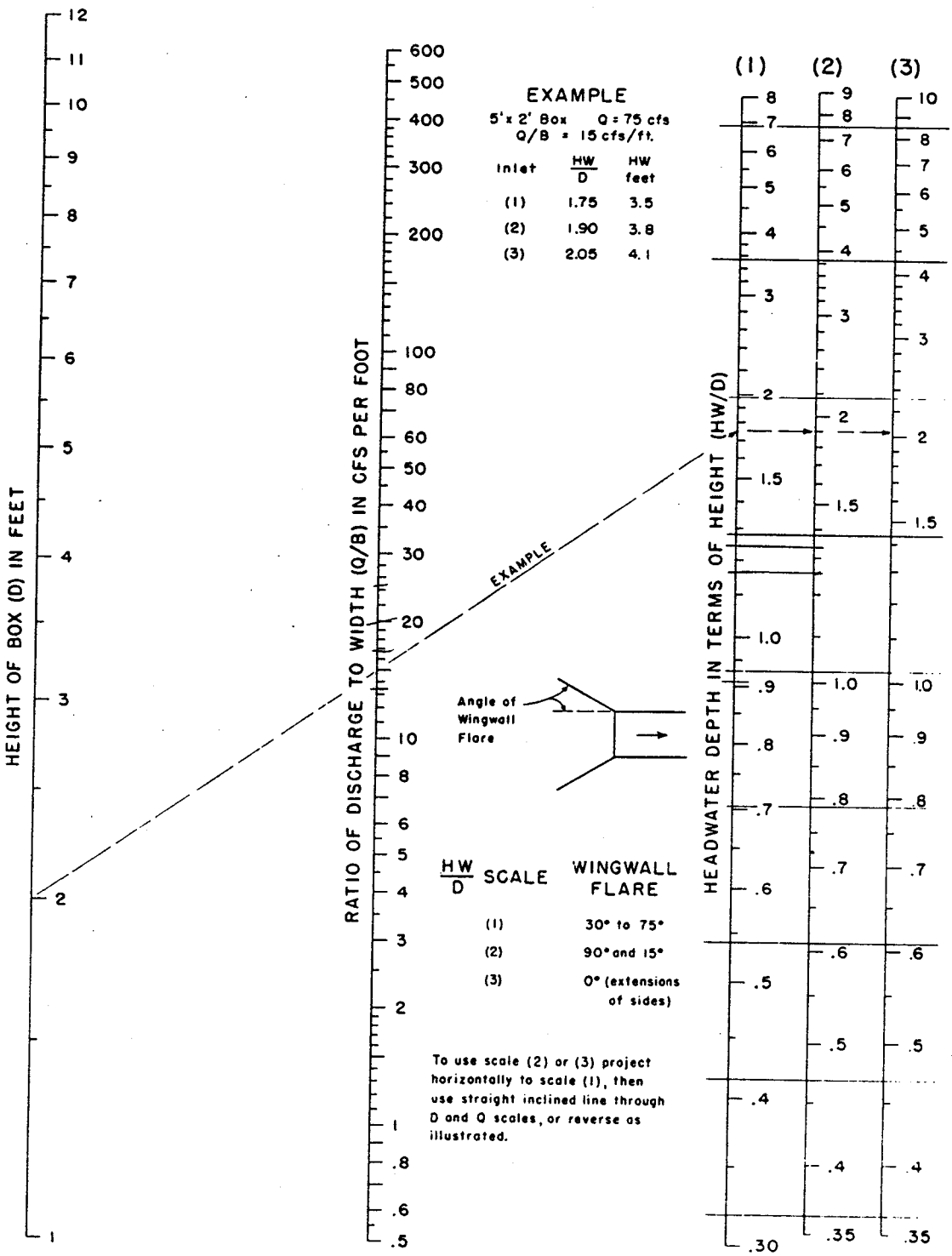
• Box Culvert Capacities: Inlet Control
• assuming Inlet (2)

Height of Box	HW/D	Q/B $\frac{cfs}{ft}$
3'	3'/3' = 1	13.5
3'	4'/3' =	20 ——— *
3.5'	1	16.5
3.5'	4.5/3.5	25.0
4'	1	21.0
4'	5'/4'	28.0

Discharges at Culvert
Existing Conditions

Event	Q (cfs)	Width of Culvert (3' x W)
10yr	560.	28'
25yr	780.	39'
100yr	1160.	58'

CHART I



HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

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JOB NO. 1053.2 SHEET ____ OF ____

PROJECT Drainage Study CALC. DWD DATE 11-6-85

SUBJECT ____ CHKD. ____ DATE ____

Mummy Mountain Wash Culvert Costs

- Computed Capacity of 3' high Culvert: $\frac{Q}{B} = 20 \frac{cfs}{ft}$
- Considering sets of 3' x 10' Culverts
- Concrete $300.00 per CY • length = ~100'

Capacity	CY of Concrete (ADOT 1983)	Amount
200 cfs	.899/LF	26,970.00
400 cfs	1.777/LF	53,100.00
600 cfs	2.581/LF	77,430.00
800 cfs	3.385/LF	101,550.00
1000 cfs	4.189/LF	125,670.00
1200 cfs	4.993/LF	149,790.00

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JOB NO. 1053.2 SHEET ____ OF ____

PROJECT Drainage Study CALC. DWD DATE 7-17-85

SUBJECT ____ CHKD. ____ DATE ____

- Pipe Size Required for Lincoln Rd. Storm Drain:

Return Period	Existing Q (cfs)	Existing Concrete Pipe Size (in)	Pipe Sizes; If Diversion Channel (100%, 100yr) is adopted: Q (cfs)	Concrete Pipe Size (in)
2	135	54"	26	24"
10	320	72"	83	42"
25	445	2(66")	119	54"
100	640	2(72")	192	60"

- Scottsdale Rd. Lateral:

Return Period	Q (cfs)	Concrete Pipe Size (in)	Q (cfs)	Pipe
2	10	24"	0	—
10	15	24"	0	—
25	25	30"	0	—
100	40	36"	15	24"

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PROJECT Drainage Study
SUBJECT Summary Sheet

JOB NO. 1053.2
CALC. DWD
CHKD.
DATE 8-19-85
SHEET ___ OF ___
DATE

DISCHARGES AT REACH 105: Scottsdale Rd. at Indian Bend Rd.

Return Period	ALT. A Existing Cond. (cfs)	ALT. D Diversion at Lincoln (only, no DB) (cfs)	ALTERNATIVE C Div. at Lincoln W. of Scottsdale Rd. + DB #1 4 outlet culverts (cfs)	+ DB #2 6 outlet cul. (cfs)	+ DB #3 8 outlet cul. (cfs)	ALTERNATIVE B Diversion at Lincoln & Mockingbird + DB #1 4 outl. cul. (cfs)	+ DB #2 6 outlet cul. (cfs)	+ DB #3 8 outlet cul. (cfs)
10	580	1030.	520	700	870	390	590	800
25	730	1490.	730	960	1200	500	760	1050.
100	~~850~~ 1150	2200.	1040	1320	1690	680	1030	1410
• Peak Q (at D.B.) (cfs)	~	~	520	790	1100	610	930	1270.
• VOL. of DB. (AF)	~	~	62	43	27	81	57	36
Corresponding Flows at Lincoln & Scottsdale Rd. (Add hyd 35)								
10	300	80	80			100		
25	420	120	120			140		
100	600	180	180			210		
Corresponding Flows at Mockingbird & wash (Add hyd 27)								
10	750	750	750			950		
25	1060	1060	1060			1340		
100	1560	1560	1560			1950		

APPENDIX A

A-3) COST ESTIMATES FOR ALTERNATIVES

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JOB NO. 1053.2 SHEET ____ OF ____

PROJECT Drainage Study CALC. DWD DATE 9-10-86

SUBJECT Cost Estimate Assumptions CHKD. ____ DATE ____

Parameters

VOL = Required Capacity of Detention Basin (AF)
B = Bottom width
V = vol. cy
A_F = Cross sectional Flow Area of Channel
TW = top width of trapezoidal channel 6' deep
L = Length of channel LF
A = area of land required
Z:1 = Z' horiz. to 1' vert.
SA = lined surface area of channel

- Excavation Estimates for Channels

- $V = (L \cdot A_F)/27$; $\$V = V \cdot \$3.00$ per c.y.
- $A = TW \cdot L$ (Ft^2)

$$= \frac{TW \cdot L}{43{,}560} \quad (Ac)$$

- Lining Estimates for Channels

- $SA = \left[2 \cdot (36 + (6Z)^2)^{1/2} + B\right] \cdot L$ (s.f.) ; $\$SA = SA \cdot \$2.50$ per s.f.

- Excavation Estimates for Detent. Basins

- $V = \dfrac{(1+.30) \cdot VOL \cdot 43{,}560}{27}$ (CY)

- $\$V = V \cdot \$3.00$ per c.y.

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JOB NO. 1053.2 SHEET ____ OF ____

PROJECT Drainage CALC. DWD DATE 9-10-85

SUBJECT Unit Costs (Estimates) CHKD. ____ DATE ____

Item	Unit Cost	Unit	Comment
• Storm Drains:			
24"	$35.00	LF	
30"	40.00	LF	
36"	50.00	LF	
42"	80.00	LF	
54"	90.00	LF	
60"	95.00	LF	
66"	100.00	LF	
72"	113.00	LF	
• Inlet/Outlet Works Lincoln Drive Storm Drain:	$50,000.00	(Total)	
• Land	Public	—	Assumed to be located under roadway.
• Open Channels:			
Earthwork	$3.00	C.Y.	$V = \frac{VOL \cdot 43,560}{27}$ (C.Y.)
Lining	$2.50	S.F.	$SA = \left[2 \cdot (36 + (6z)^2)^{1/2} + B\right] \cdot L$ (s.f.)
• Detention Basins:			
Spillway Lining	25,000.00	(total)	
Outlet Pipes	Same as Storm Drains	LF	Assumed pipe length of 20'
• Box Culvert			
Concrete	300.00	CY	Volumes obtained from ADOT standard Drawings, 1983

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JOB NO. 1053.2 SHEET ____ OF ____

PROJECT Drainage Study CALC. DWD DATE ____

SUBJECT Note CHKD. ____ DATE ____

Note: See Proceeding Section For Cost Estimates For Specific Hydraulic Structures – such as culverts etc....