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Outfall Drainage Study

Proposed Outfall Drainage Facilities
South of Cactus Road

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60th Street to Scottsdale Road

Project No. M-502-4(1)
TRACS No. 5024 MA SCT SS 249 01 C

15 NOVEMBER 1991

REGISTERED PROFESSIONAL ENGINEER
CERTIFICATE NO. 20591
RALPH C. BLUM
Date Signed 11-15-91
ARIZONA, U.S.A.

Prepared For

CITY OF SCOTTSDALE

Prepared By

BRW

PLANNING TRANSPORTATION ENGINEERING URBAN DESIGN
BRW, INC. 2700 NORTH CENTRAL AVENUE, SUITE 1000, PHOENIX, AZ 85004

31-42 to 31-44

Outfall Drainage Study

Proposed Outfall Drainage Facilities
South of Cactus Road

CACTUS ROAD:

60th Street to Scottsdale Road

Project No. M-502-4(1)
TRACS No. 5024 MA SCT SS 249 01 C

15 NOVEMBER 1991

REGISTERED PROFESSIONAL ENGINEER
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PLANNING TRANSPORTATION ENGINEERING URBAN DESIGN
BRW, INC. 2700 NORTH CENTRAL AVENUE, SUITE 1000, PHOENIX, AZ 85004

OUTFALL DRAINAGE REPORT

(Proposed Outfall Drainage Facilities South of Cactus Road)

CACTUS ROAD: 60TH STREET TO SCOTTSDALE ROAD
PROJECT NO. S0706

November 15, 1991

Prepared for:

The City of Scottsdale
3939 Civic Center Boulevard
Scottsdale, Arizona 85251

Prepared by:

BRW, Inc.
2700 North Central Avenue, Suite 1000
Phoenix, Arizona 85004

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Appendices

Appendix

A HEC–1 Model, Existing Conditions (100–Year Runoff Event)

B HEC–1 Calibration Model, Existing Conditions (100–Year Runoff Event with diversion of the 10–Year Runoff Event at the 68th Place/Cactus Road intersection)

C HEC–1 Model, Alternative #1 (10–Year Runoff Event)

D HEC–1 Model, Alternative #2 (10–Year Runoff Event)

E HEC–1 Model, Alternative #3 (10–Year Runoff Event)

F Hydraulic Calculations

Note: These appendices are too voluminous to include in this document or to bind as a separate document, and therefore, a single copy of the calculations have been delivered to the City of Scottsdale Drainage Engineer.

1.0 Introduction

This outfall drainage study was prepared to document alternative outfall schemes and the associated costs for the roadway improvement of Cactus Road. An outfall system is necessary to accept the water collected by a proposed interceptor storm drain system along Cactus Road.

1.1 Project Location

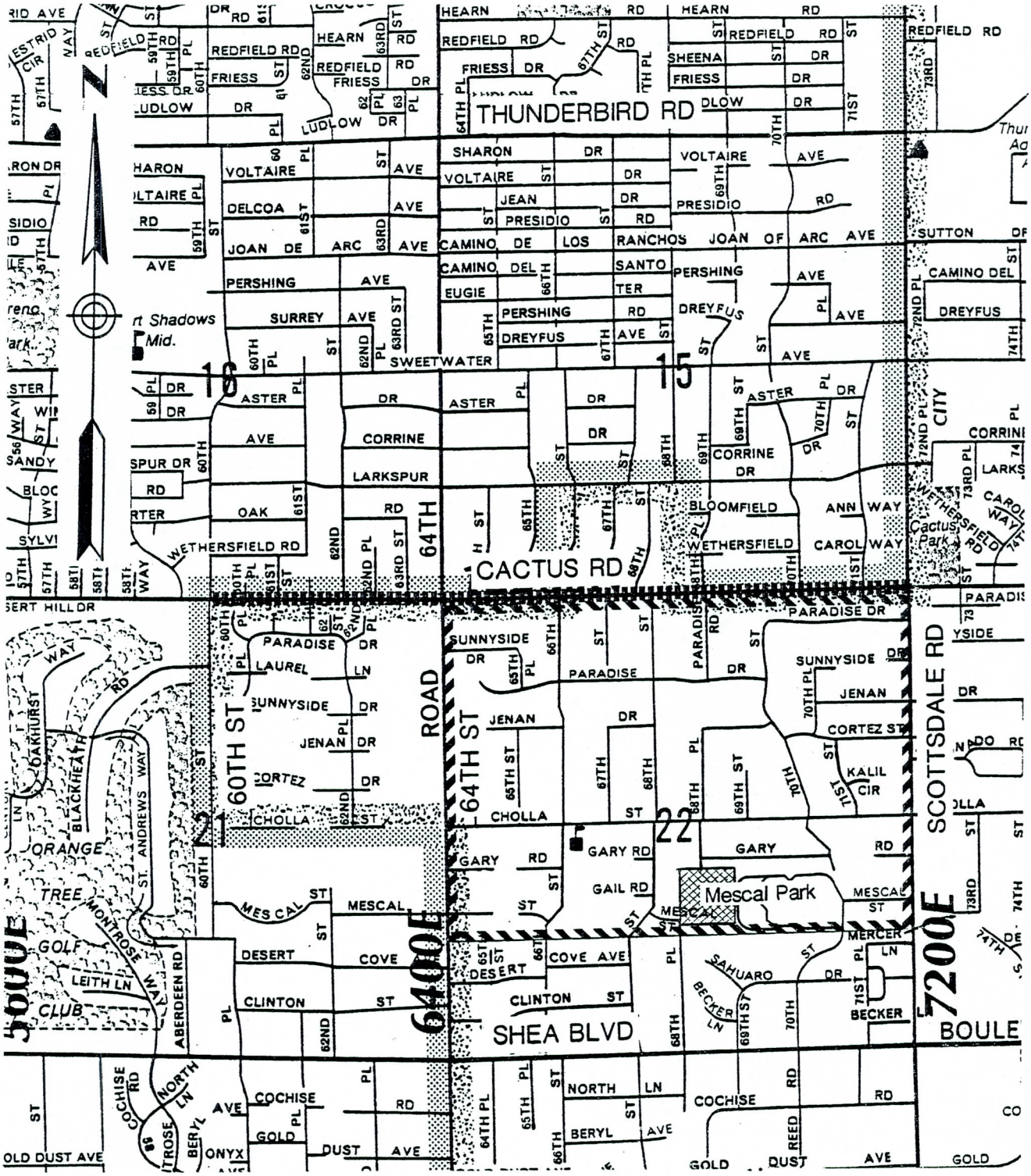
The roadway improvement of this east–west street begins at 60th Street and terminates at Scottsdale Road, a distance of one and one–half miles. The roadway segment involved in this study begins at 64th Street and terminates at Scottsdale Road. The study area of the outfall system is bounded by Cactus Road on the north, an east–west line located along the south boundary of Mescal Park, 64th Street on the west, and Scottsdale Road on the east. Figure 1 is a vicinity map showing the Cactus Road alignment in relation to the local street system. The drainage study area is also outlined on this figure.

1.2 Background

The existing roadway from 64th Street to Cactus Road is a 2–lane paved rural roadway with a profile that basically follows the natural ground contours. This segment of Cactus Road does not have an underground storm drainage system. Off–site drainage reaches Cactus Road from the north as a combination of overland sheet flow and concentrated flow within existing streets, mid–block alleys and drainage easements. Off–site runoff is conveyed over the roadway as sheet flow and at six concentration points during the 100–year flood event. Three of these concentration points are at pronounced roadway dips, which occur at 68th Street, between 68th Place and 70th Street, and between 70th Street and 71st Street. The downstream drainage system consists of concentrated flow in streets, channels, and overland flow. Figure 2, which is a drainage area map for the area north of Cactus Road, depicts these concentration points and the flow paths along the north side of Cactus Road.

This project will consist of reconstructing Cactus Road to meet Scottsdale's major collector street geometric standards. These standards require that the roadway be two lanes in each direction with a center turn lane. There will be a vertical curb on each side with 12.5–foot outside lanes, 11.0–foot inside lanes, and a 10.0–foot center turn lane. An interceptor storm drain system will be installed along Cactus Road to collect and convey the 10–year runoff to existing concentration points.

The existing outfall drainage system is inadequate to accept the flows from the proposed interceptor storm drain system along Cactus Road. The two main problems are inadequate hydraulic capacity within the streets and channels, especially just south of Cactus Road, and shallow channels that do not allow daylighting the storm drain inverts. of the proposed storm drains. Furthermore, several of the north–south streets located just south of Cactus Road have crowned rural sections, and therefore, they are not able to carry large storm flows.



Cactus Road

CITY OF SCOTTSDALE

FIGURE 1

BRW

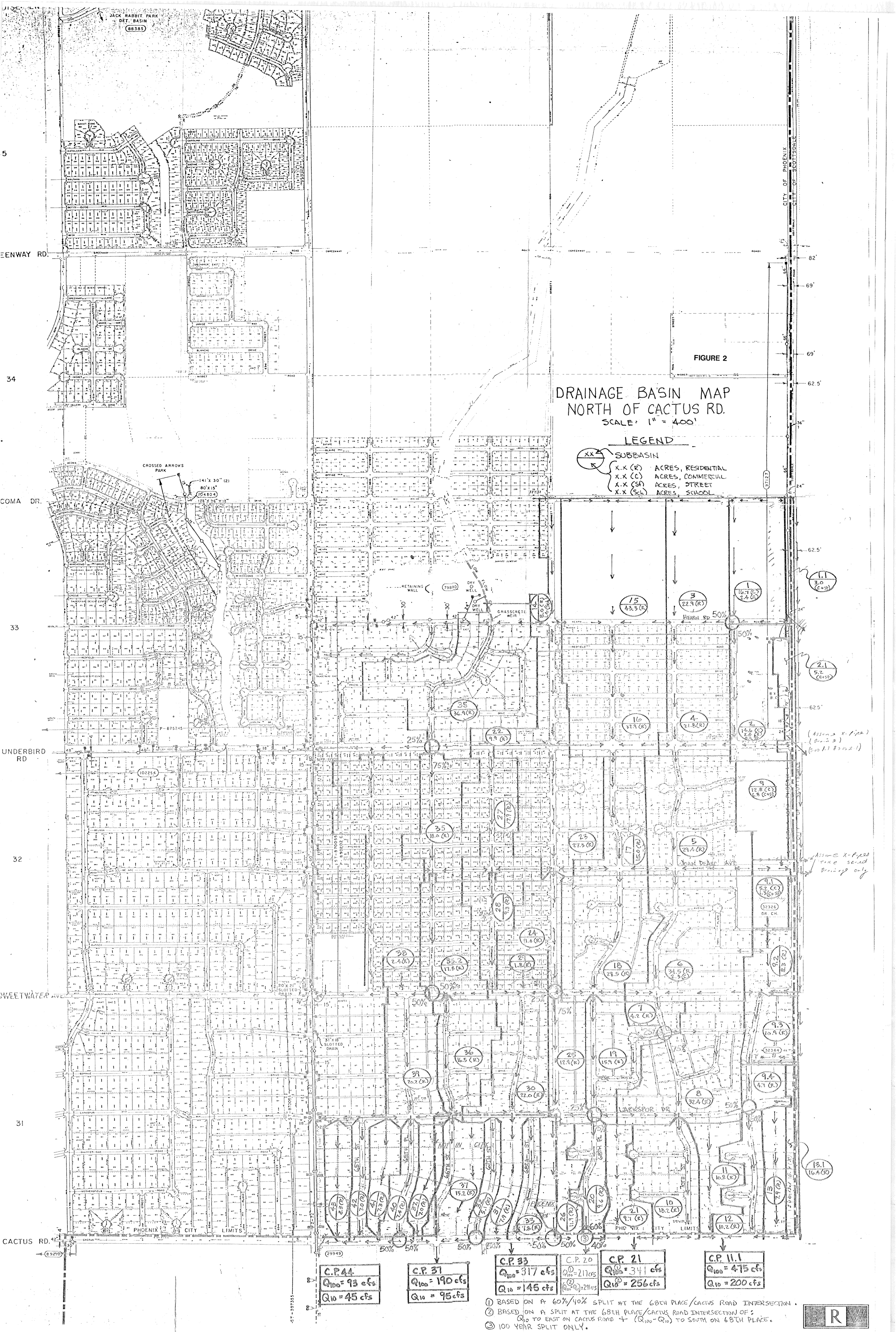


FIGURE 2
DRAINAGE BASIN MAP
NORTH OF CACTUS RD.
SCALE: 1" = 400'
LEGEND
SUBBASIN
X.X (R) ACRES, RESIDENTIAL
X.X (C) ACRES, COMMERCIAL
X.X (St) ACRES, STREET
X.X (Sch) ACRES, SCHOOL
JACK RABBIT PARK DET. BASIN
CROSSED ARROWS PARK
GREENWAY RD.
COMA DR.
UNDERBIRD RD
SWEETWATER AVE
CACTUS RD.
HEARN RD
JOAN DE ARC AVE
LARKSPUR DR
CITY OF PHOENIX
CITY OF SCOTTSDALE
PHOENIX CITY LIMITS
NOT IN CITY
RETAINING WALL
DRY WELL
GRASSCRETE WEIR
LOW FLOW
20'X21' SLOTTED DRAIN
31'X18' SLOTTED DRAIN
DR. CH.
C.P. 44
Q100 = 93 cfs
Q10 = 45 cfs
C.P. 37
Q100 = 190 cfs
Q10 = 95 cfs
C.P. 33
Q100 = 317 cfs
Q10 = 145 cfs
C.P. 20
Q100 (1) = 217 cfs
(Q100 (2) - Q10) = 291 cfs
C.P. 21
Q100 (1) = 341 cfs
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C.P. 11.1
Q100 = 475 cfs
Q10 = 200 cfs
(1) BASED ON A 60%/40% SPLIT AT THE 68TH PLACE/CACTUS ROAD INTERSECTION.
(2) BASED ON A SPLIT AT THE 68TH PLACE/CACTUS ROAD INTERSECTION OF: Q10 TO EAST ON CACTUS ROAD + (Q100 - Q10) TO SOUTH ON 68TH PLACE.
(3) 100 YEAR SPLIT ONLY.
BRW

It has been decided that an improved outfall system is required to accept the off-site flows collected by the proposed interceptor storm drain. This system could be an underground storm drain system and/or improvements to the north-south streets and channels just south of Cactus Road.

1.3 Scope of Work

The purpose of this drainage study is to determine the most acceptable outfall system to convey the off-site storm drainage from Cactus Road southerly to existing outfall locations. The Scope of Work is as follows:

Task 1: Perform field survey to determine actual dimensions and elevation of the Mescal Park detention basin. Included, would be top of berm, bottom of basin, slopes, elevation of inflow and discharge devices and elevations at the Stilling Basin at the Berniel Channel (this channel is called the 71st Street Channel).

Task 2: Route the 50-year and 100-year discharge flows from 66th Street, 68th Street and Paradise to the detention basin. [On November 8, 1991, this sentence was revised to read: Route the 10-year discharge flows from 66th Street, 68th Street and Paradise Drive; and the 100-year discharge flow from 68th Place to the detention basin.] Determine the required conduit sizes and preliminary construction quantities.

Task 3: Calculate the construction cost of the storm drain systems described in Task 2 for both the 50-year and the 100-year discharge conditions. [On November 8, 1991, this sentence was revised to read: Calculate the construction cost of the storm drain systems described in Task 2 for the 10-year discharge conditions.]

Task 4: Calculate what "level of protection" would then be provided by the existing Mescal Park detention basin, i.e., at what re-occurrence interval would the basin overflow.

Task 5: Determine if and how additional capacity could be developed in the detention basin. Prepare construction cost estimates of feasible options. Estimate the resulting re-occurrence interval at overflow.

Task 6: Calculate and compare the construction cost of the following options for handling the off-site discharge from Cactus Road.

A. Carrying the discharges southerly from Cactus Road in a combination of paved channels and reconstructed streets with inverted crowns at each of the three locations.

B. The options discussed in Task 3.

Prepare a summary report (5 copies) of the study including recommendations.

2.0 Existing Hydrology

The existing hydrologic conditions need to be quantified to establish a base condition from which to undertake design investigations. This chapter will describe the existing drainage system downstream of Cactus Road, the design methodology, the existing detention basin at Mescal Park, and the existing hydrology. A brief description of the existing system on Cactus Road is contained in subsection 1.2 of this report.

2.1 Existing Drainage System

During large storm events, flow crosses Cactus Road as both sheet flow and as concentrated flow at six points. These six concentration points are located at 64th Street, 66th Street, 68th Street (roadway dip) 68th Place, a location between 68th Place and 70th Street (roadway dip), and a location between 70th Street and 71st Street (roadway dip). Flows reach these concentration points by flowing in a shallow swale along the north side of Cactus Road. During large storm events, the shallow swale can not contain the flow and sheet flow to the south over Cactus Road will also occur. It should be noted that small storm events will produce concentrated flow only at the three major dip sections. However, during every storm event, this segment of Cactus Road is flooded and several areas have ponded water including the six concentration points. Figure 3, which is a drainage area map for the area north of Cactus Road, depicts these concentration points, the flow paths along Cactus Road, and the existing downstream outfall system.

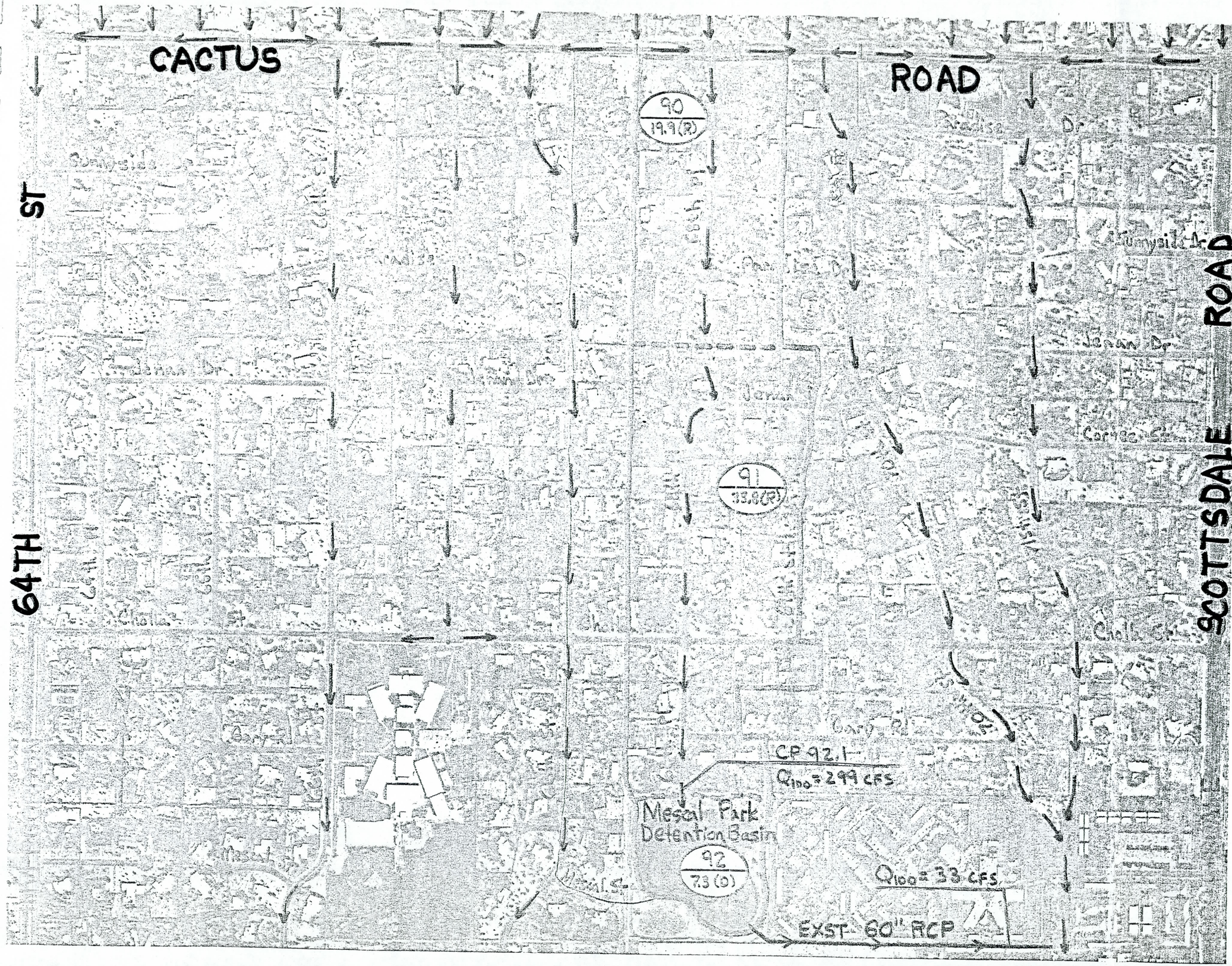
Downstream of Cactus Road, the existing drainage system consists of concentrated flow within the streets, channels, and overland sheet flow. A field review of the project indicates that the flow crossing Cactus at the six concentration points follows six separate flow paths to a location just south of Cholla Street. At that location, the three easterly flow paths discharge to a single open channel (the 71st Street Channel) that continues along the east side of 71st Street. From west-to-east, these six flow paths are located on 64th Street, 66th Street, 68th Street, 68th Place, Paradise Drive – 70th Street, and 71st Street. A description of each flow path between Cactus Road and Shea Boulevard follows:

- *64th Street:* An open-channel exists along the east side of 64th Street between Cactus Road and Shea Boulevard. Three private drives and two streets cross this open-channel with drainage structures. Flow enters this channel just south of Cactus Road from a 72" RCP in 64th Street to the north and from a swale along the north side of Cactus Road to the east. Under another contract, an underground conduit is being designed to replace the open-channel from Cactus Road south to Cholla Street.

DRAINAGE BASIN MAP

SOUTH OF CACTUS RD

SCALE 1" = 400'



LEGEND

XX — SUBBASIN

X.X (R) ACRES, RESIDENTIAL

X.X (D) ACRES, DETENTION BASIN

FIGURE 3

Cactus Road

CITY OF SCOTTSDALE

- *66th Street:* The sixty–sixth Street drainage path consists of a narrow, crowned, rural road with no side ditches from Cactus Road to Paradise Drive (0.2 miles) and an inverted crown, urban Street from Paradise Drive to Shea Boulevard (0.8 miles). The curb is mountable from Paradise Drive to Cholla Street and vertical from Cholla Street to Shea Boulevard. The profile of the narrow, rural road segment follows approximately the contours of the adjacent ground and therefore, the roadway does not function as a well–defined drainage channel.

- *68th Street:* The sixty–eighth Street drainage path consists of a narrow, crowned, rural road from Cactus Road to a point one lot north of Jenan Drive (.25 miles) and an inverted crown, urban street with vertical curb from one lot north of Jenan Drive to Shea Boulevard (0.75 miles). At Cactus Road, 68th Street is a dog–legged intersection with the north leg located approximately 200 feet west of the south leg. During small storm events flow on the north leg of 68th Street will cross Cactus Road, flow into a very shallow swale, and rejoin the south leg of 68th Street approximately 600 feet south of Cactus Road. During large storm events, the flow will follow both the channel and the south leg of 68th Street.

- *68th Place:* The sixty–eighth Place drainage path consists of a narrow, crowned, rural road from Cactus Road to Paradise Drive, (0.2 miles) a channel from Paradise Drive to Jenan Drive (0.1 miles) and an inverted crown, urban street with vertical curb from Jenan Drive to the Mescal Park Detention basin (0.35 miles). A 60" RG/RCP (1376 feet) discharges the detention basin east into a north–south channel located along the east side of 71st Street.

- *Paradise Drive – 70th Street:* The Paradise Drive – 70th Street drainage path consists of a shallow V–shaped channel from Cactus Road to Paradise Drive (0.1 miles), a narrow, crowned, rural road along Paradise Drive to a point one lot north of Jenan Drive (0.2 miles), an inverted crown, urban street with vertical curb from one lot north of Jenan Drive to the dead–end of 70th Street located 250–feet south of Gary Road (0.1 miles), and a lined channel from the dead–end to the north–south 71st Street drainage channel (.05 miles).

- *71st Street:* The seventy–first Street drainage path consists of an earthen channel from Cactus Road to a point 300–feet south of Paradise Drive (0.1 miles), a bituminous–lined channel from a point 300–feet south of Paradise Drive to Cortez Drive (0.2 miles), an inverted crown, urban street with vertical curb from Cortez Drive to Cholla Street (0.2 miles), and a concrete–lined channel from Cholla Street to a north–south 71st Street (0.1 miles) drainage channel.

2.2 Methodology

The Hydrologic Engineering Circular Number 1 (HEC–1) computer model developed by the US Army Corps of Engineers was used to calculate the 10–year and 100–year, 24–hour storm water peak discharges and hydrographs for select concentration points. The HEC–1 model was chosen due to the large urban drainage basins and in accordance with policies for both the City of Scottsdale and the Arizona Department of Transportation. The City of Scottsdale provided hydrologic parameter design data that was developed specifically for the City. These parameters are as follows:

- 24–Hour Type IIA Rainfall Distribution
- CN of 74 for a 24–hour storm and Hydrologic Soil Group B (study area soil type).
- Percent of Impervious Area Versus Dwelling Units/Acre design figure.

The precipitation amounts for the 10–year and 100–year, 24–hour rainfalls were determined by the ADOT methodology as stated in their publication entitled, "Hydrologic and Hydraulic Training Session Manual," October 16–18, 1972, revised December 1973. These valves are shown in Table 1.

TABLE 1

24–Hour Rainfall Depths Versus Recurrence Interval

Recurrence Interval (Years)	Rainfall Depth (Inches)
10	2.46
100	3.90

Sub–basin runoff was determined by the kinematic wave excess transformation method. Both kinematic overland flow parameters and sub–catchment kinematic wave collector/main channel parameters were required. Rainfall loss rate was determined based on the Soil Conservation Service (SCS) curve number method. Reservoir routing was accomplished with the modified Puls method.

2.3 Mescal Park Detention Basin

The PVSP Drainage Study, completed and approved by the PVSP committee in 1978, recommended the construction of a detention basin in Mescal Park. This City of Scottsdale park is located just south of the 68th Place/Gary Road intersection. It was recommended that the detention basin be sized to a capacity of 42 acre–feet with an average discharge of 150 cfs for 4–hours duration. As part of the Agua Caliente development, off–site grading and drainage plans were produced for the construction of

the Mescal Park detention basin. The plans were completed in late 1986 and construction has subsequently been completed by the Agua Caliente developer.

As part of this drainage study, BRW performed a field survey to determine actual dimensions and elevations of the Mescal Park detention basin and discharge pipe. The length of discharge pipe was determined from the construction plans. These data are:

Storage Volume = 37.94 Acre–Feet
Berm Elevation = 1361.7
Bottom Elevation of Basin @ Inflow Flume = 1354.0
Bottom Elevation of Basin @ Discharge Pipe = 1353.0
Inlet Elevation, 60" RG/RCP = 1352.75
Outlet Elevation, 60" RG/RCP = 1350.71
Length of 60" RG/RCP = 1376 feet

The actual elevations are fairly close to the elevations shown on the construction plans. The actual storage volume of 37.94 acre–feet is approximately 4.1 acre–feet less than the recommended 42 acre–feet. Figure 4 is a plan view of the actual detention basin.

2.4 Hydrology Discussion

This study was prompted by the idea that the Mescal Park detention basin has excess storage capacity. If that idea is correct, then additional water could be discharged to the basin by an underground storm drain system. To determine the required 100–year storage volume based on existing drainage patterns, a HEC–1 model was developed. This model is contained in Appendix A of this report.

A field review of the existing flow patterns indicates that currently only the runoff reaching 68th Place will be captured by the Mescal Park detention basin at the Cactus Road/68th Place intersection. A 60%/40% flow split is assumed, with 60% flowing east along Cactus Road and 40% flowing south along 68th Place. Between Cactus Road and the detention basin discharge pipe, additional runoff is contributed by 53.7 acres of residential land and 7.3 acres of park land. A depiction of these drainage characteristics is shown on Figure 3.

A stage–storage–discharge curve was developed for the existing detention basin as input to the HEC–1 reservoir routing routine. The stage–storage volume relationship was determined from the actual field survey data depicted in Figure 4. The stage–discharge relationship was computed with the FHWA culvert analysis computer program, HY–8 (Version 3.2). It was assumed that the tailwater in the discharge channel would rise as the water surface rises in the detention basin. Tailwater versus stage elevations are: zero feet, stage of 1352.75 to 1355.0; 2.5 feet, stage of 1356.0; 4.0 feet, stage of 1357.0; 5.0 feet, stage of 1358.0; and 6.0 feet, stage of 1359.0 to 1361.7. The stage–storage–discharge curve for existing conditions and Alternative No. 1 is shown in Table 2. Alternative No. 1 will be discussed under Section 3.0 of this report.

TABLE 2

Mescal Park Stage-Storage-Discharge Curve (Existing Conditions and Alternative No. 1)

Stage (feet)	Storage (acre feet)	Discharge (cfs)
1352.75	0	0
1353.0	0.10	3
1353.5	1.01	10
1354.0	2.67	17
1355.0	6.55	31
1356.0	10.64	33
1357.0	14.94	33
1358.0	19.45	33
1359.0	24.17	33
1360.0	29.09	74
1361.0	37.94	101
1361.7	37.94	116

Based on these parameters, reservoir routing was performed on the Mescal Park detention basin for the 100-year, 24-hour runoff event. The peak inflow and outflow are 299 cfs and 33 cfs, respectively. The water surface elevation will reach 1356.78 with a peak volume requirement of 14.0 acre feet. The available volume is 37.9 acre feet, and hence, this basin has 23.9 acre feet of excess storage volume available during the 100-year, 24-hour runoff event. It is concluded that additional water can be directed into the Mescal Park detention basin.

3.0 Design Investigations

3.1 Alternatives

Alternative designs have been investigated for each of these drainage system components—the Cactus Road storm drain interceptor, the outfall system, and the Mescal Park detention basin. The alternatives for each system component are:

- **Storm Drain Interceptor**
  - Shallow depth box culverts
  - Circular pipes (RG/RCP)

- **Outfall System**
  - Channel/street system
  - Circular pipes (RG/RCP)

- **Mescal Park Detention Basin**
  - Current volume of 37.9 acre feet
  - Increase volume to 43.0 acre feet
  - Increase volume to 49.5 acre feet

Combining the alternatives of these three drainage system components into practicable arrangements has resulted in four alternative drainage schemes for the present. The practicable arrangements were developed based on the following physical constraints:

- The circular pipe storm drain interceptor system will only work with the circular pipe outfall system. The circular storm drain interceptor is too deep to meet the flow lines of the channel/street outfall system.

- The shallow depth box culvert storm drain interceptor is required to meet the flow lines of the channel/street outfall system. It is more expensive than the circular pipe storm drain interceptor system, and therefore, it was not combined with the circular pipe outfall system.

- Increasing the storage volume of the Mescal Park detention basin is only considered with drainage schemes that will add more water to the basin. This will occur only with the circular pipe outfall system.

The four alternative drainage schemes for the Cactus Road project are:

Alternative 1:
- Circular pipe storm drain interceptor.
- Circular pipe outfall system.
- Existing storage volume of Mescal Park detention basin to remain at 37.9 acre feet.

Alternative 2:
- Circular pipe storm drain interceptor.
- Circular pipe outfall system.
- Storage volume of Mescal Park detention basin increased to 43.0 acre feet.

Alternative 3:
- Circular pipe storm drain interceptor.
- Circular pipe outfall system.
- Storage volume of Mescal Park detention basin increased to 49.5 acre feet.

Alternative 4:
- Shallow depth box culvert storm drain interceptor.
- Channel/street outfall system
- Storage volume of Mescal Park to remain at 37.9 acre feet.

A channel improvement on the 71st Street drainage path is required on all the alternatives.

3.2 Mescal Park Detention Basin

As part of these design investigations, it was determined that additional storage volume may be required in the Mescal Park detention basin. Preliminary design indicated that basin enlargement could be undertaken by expanding the entire basin perimeter. However, the greatest additional volume can be attained by expanding into the horse arena located in the southwest corner, and by expanding into the picnic area located at the north park boundary. Expanding into the horse arena would increase the storage volume by 5.1 acre feet and expanding into the picnic area would increase the storage volume by 6.5 acre feet. It was decided that Alternative 2 would investigate increasing the storage volume by 5.1 acre feet (Total = 43.0 acre feet) and that Alternative 3 would investigate increasing the storage volume by 11.6 acre feet (Total = 49.5 acre feet). Alternative 1 would investigate the existing storage volume of 37.9 acre feet. Figure 4 is a plan scale drawing of the three schemes for the Mescal Park detention basin.

The horse arena and picnic area would be salvaged by placing these facilities within the detention basin. They would be constructed at an elevation of 1356.0, which is 2 to 3 feet above the elevation of the basin bottom. This elevation difference should assure that these areas would remain dry during nuisance runoff events. Moreover, landscaping of the picnic area could include trees and shrubs without affecting the basin storage volume.

3.3 Hydrologic/Hydraulic Performance of Outfall Drainage Facilities

The outfall systems were sized to handle the 10–year peak runoff. The circular pipe outfall system was sized based on assumptions of rubber gasket reinforced concrete pipe (RG/RCP), full flow, no tailwater, low energy loss at bends, and 2–foot minimum cover above inside pipe crown. The trapezoidal channel improvements were sized based on lined–concrete, one foot of freeboard, and low energy loss at bends. The street

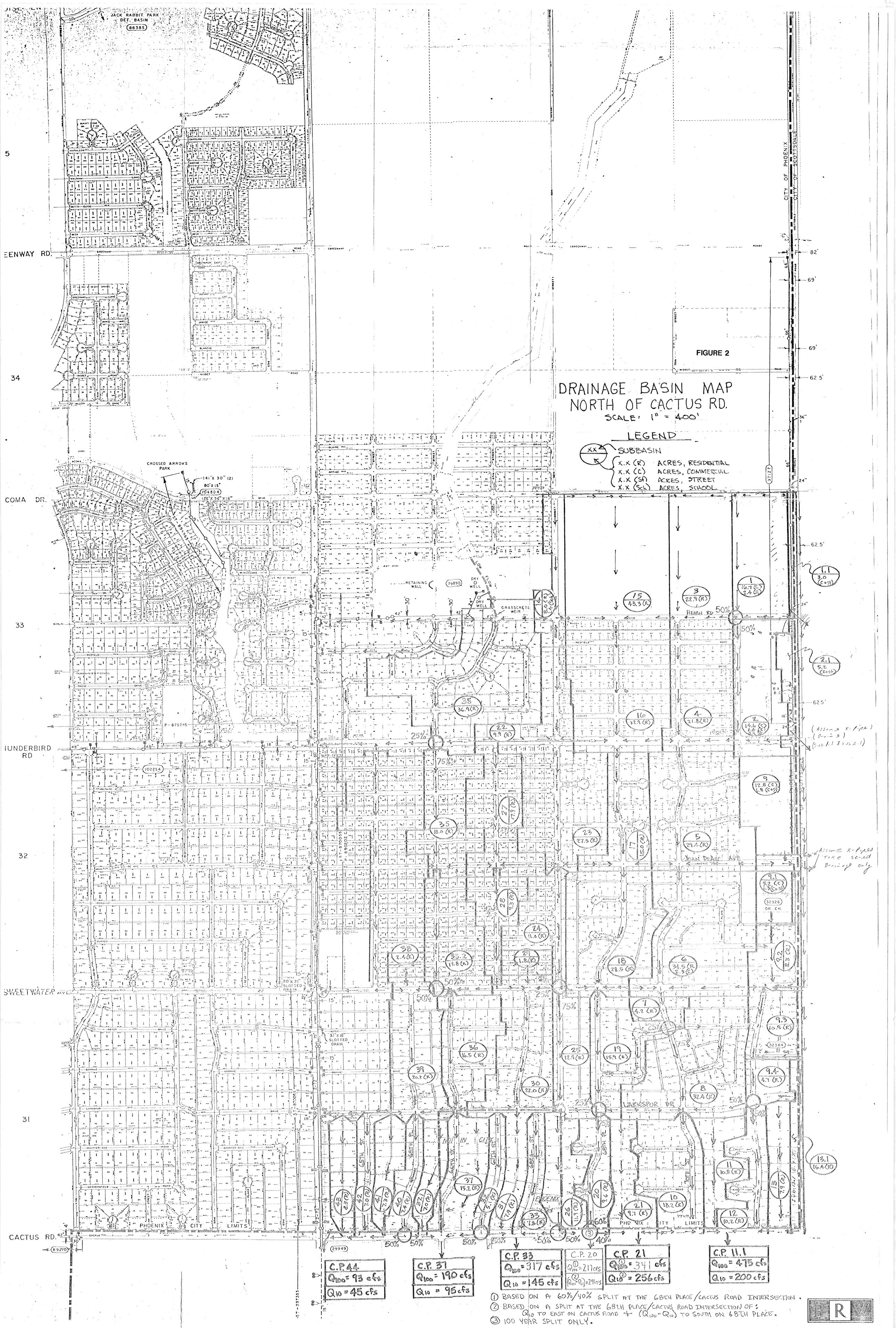


FIGURE 2
DRAINAGE BASIN MAP
NORTH OF CACTUS RD.
SCALE: 1" = 400'
LEGEND
SUBBASIN
X.X (R) ACRES, RESIDENTIAL
X.X (C) ACRES, COMMERCIAL
X.X (St) ACRES, STREET
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Q100 = 475 cfs
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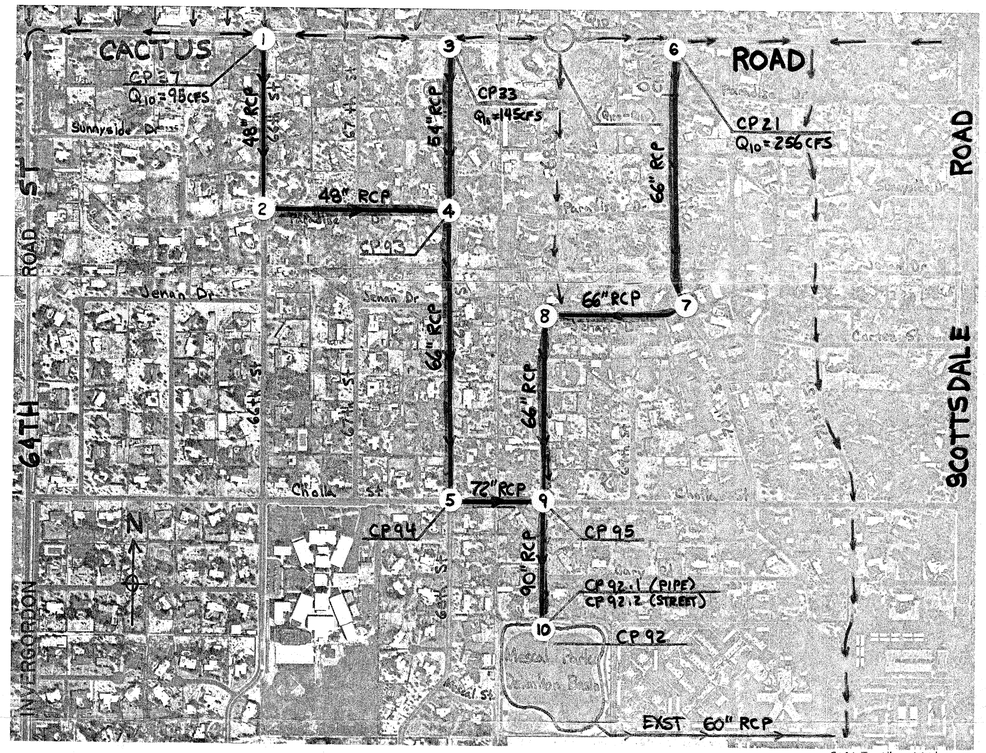
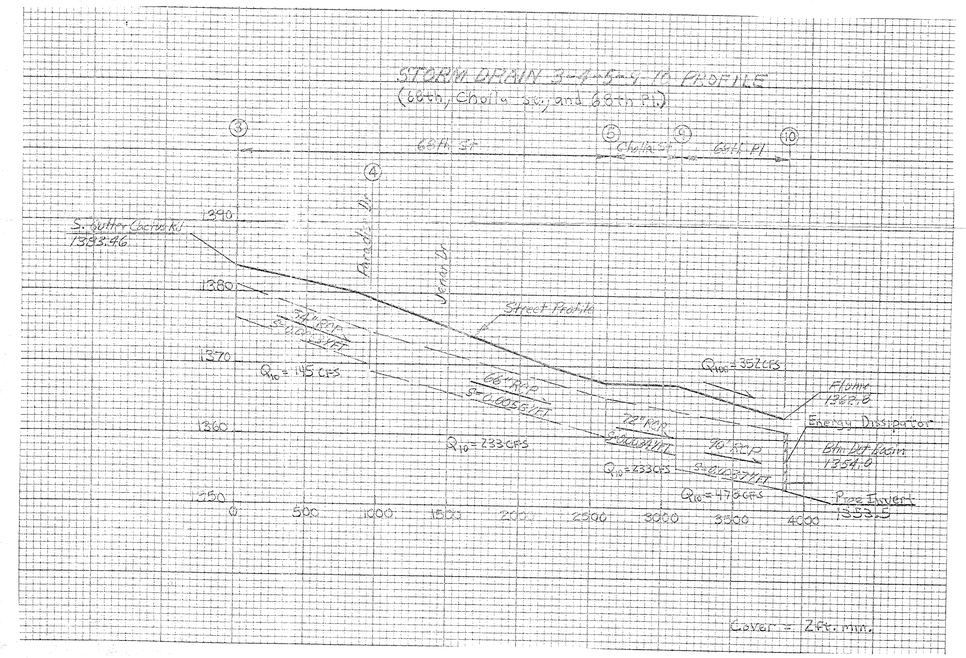
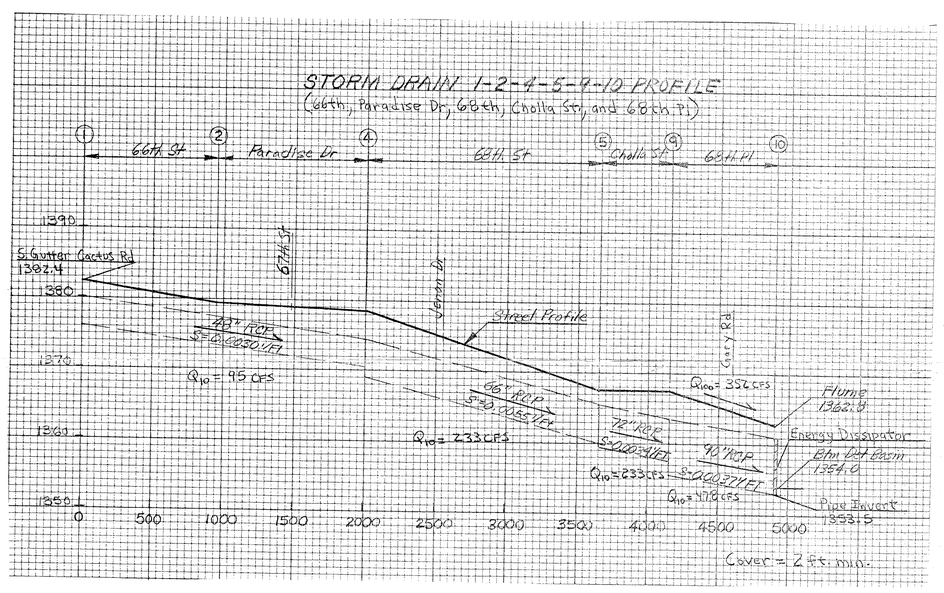
(2) BASED ON A SPLIT AT THE 68TH PLACE/CACTUS ROAD INTERSECTION OF: Q10 TO EAST ON CACTUS ROAD + (Q100 - Q10) TO SOUTH ON 68TH PLACE.
(3) 100 YEAR SPLIT ONLY.
BRW



SCALE 1" = 400'





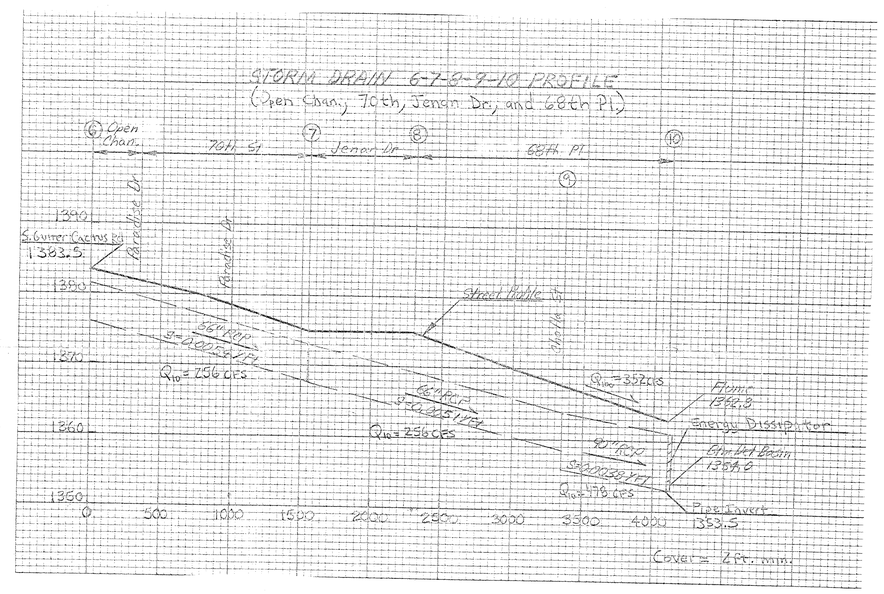


FIGURE 5

OUTFALL STORM DRAIN LAYOUT AND PROFILES, Alternatives 1, 2 and 3

improvements were not sized based on peak runoff, but instead they were selected based on City of Scottsdale street standards for local residential, local collector, and by matching existing downstream improved urban sections.

The circular pipe outfall system was used for Alternatives 1, 2 and 3, and the channel/street outfall system was used for Alternative 4. Figure 5 shows the storm drain layout and profiles for the circular pipe outfall system. Figure 6 shows the drainage layout and profiles for the channel/street outfall system.

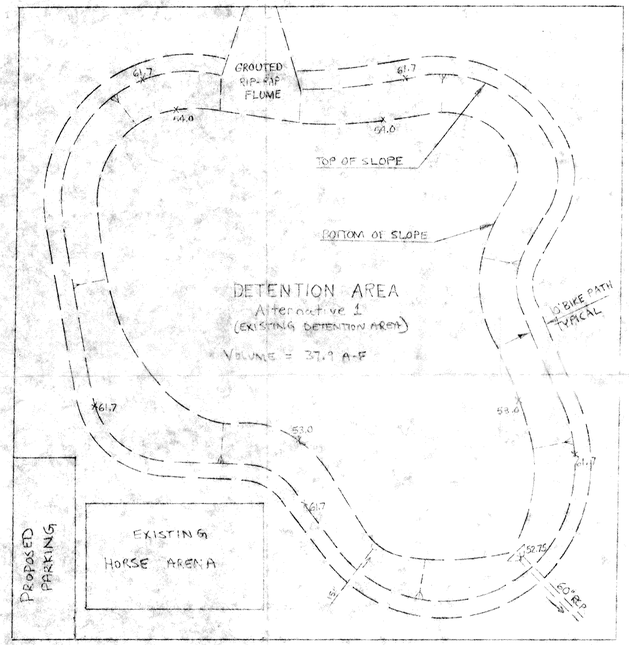
The circular pipe outfall system will convey to the detention basin the 10–year peak flows collected along Cactus Road at three concentration points; 66th Street, 68th Street and a location between 70th Street and 71st Street. Furthermore, the 100–year flow minus the 10–year peak flow will cross Cactus Road at 68th Place and flow south along 68th Place into the detention basin. No other flows will reach the detention basin. Flow at the concentration point located between 70th Street and 71st Street will continue to flow along the 71st Street drainage path, and therefore, a channel improvement will be required. This channel improvement will be required on all alternatives.

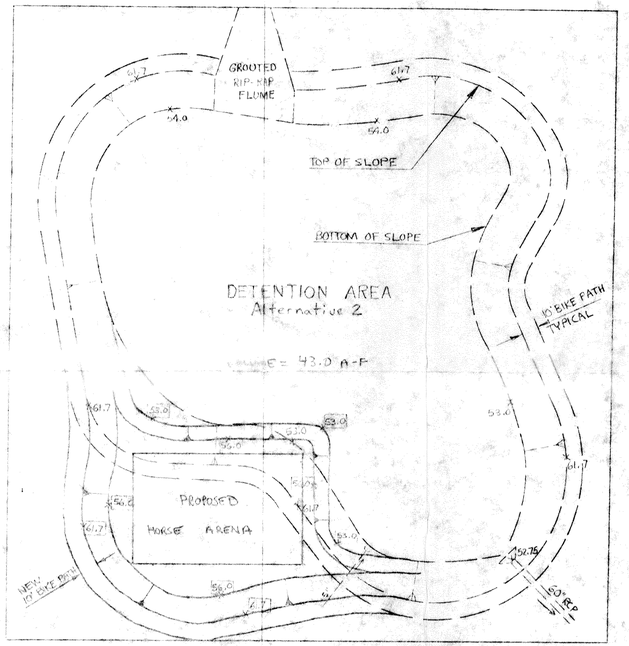
The channel/street outfall system will continue to use existing streets and channels to convey the runoff south away from Cactus Road. Improvements are required just south of Cactus Road along four drainage paths; 66th Street, 68th Street, Paradise Drive–70th Street and 71st Street.

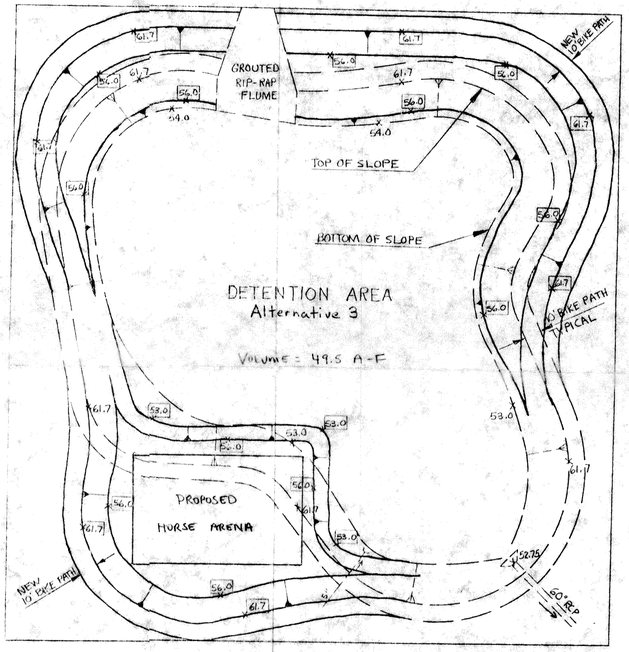
The street sections were not designed to convey the 10–year peak flow, but instead were selected based on City of Scottsdale standards. Hydraulic calculations, assuming 6–inch curb height, indicate that the street sections will not be able to convey the 10–year flow without overflow onto the terraces. The actual capacities (flow at top of curb) and the required capacities (10–year runoff) are as follows:

- **66th Street:** Actual Capacity = 66 cfs, velocity = 2.8 fps
  Required Capacity = 95 cfs, velocity = 3.2 fps, dn = 1.0'
- **68th Street:** Actual Capacity = 138 cfs, velocity = 5.0 fps
  Required Capacity = 145 cfs, velocity = 5.1 fps, dn = 0.9'
- **Paradise Drive/70th Street:** Actual Capacity = 68 cfs, velocity = 3.4 fps
  Required Capacity = 256 cfs, velocity = 5.4, dn = 1.5'

The storage volume of the Mescal Park detention basin will be increased to 43.0 acre feet for Alternative 2 and to 49.5 acre feet for Alternative 3. New stage–storage–discharge curves for those two alternatives are contained in Tables 3 and 4, respectively.







LEGEND

x 61.7 EXISTING ELEVATION

x 61.7 PROPOSED ELEVATION

N

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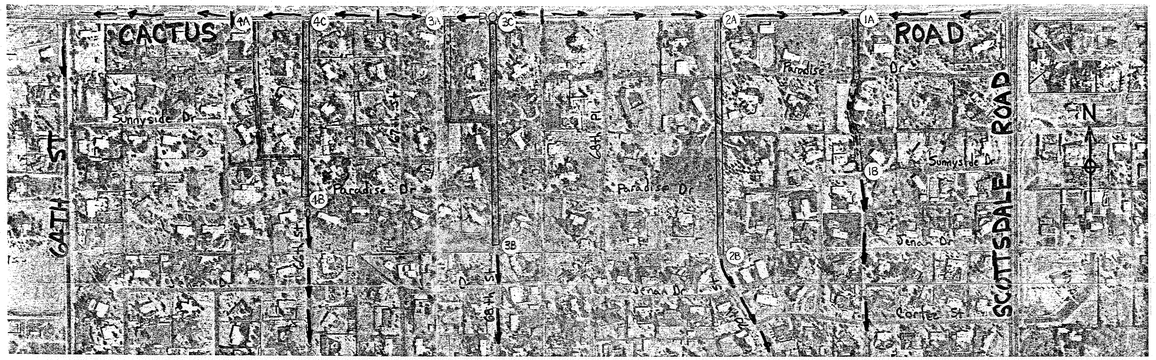
FIGURE 4

MESCAL PARK DETETION BASIN
Alternatives 1, 2 and 3

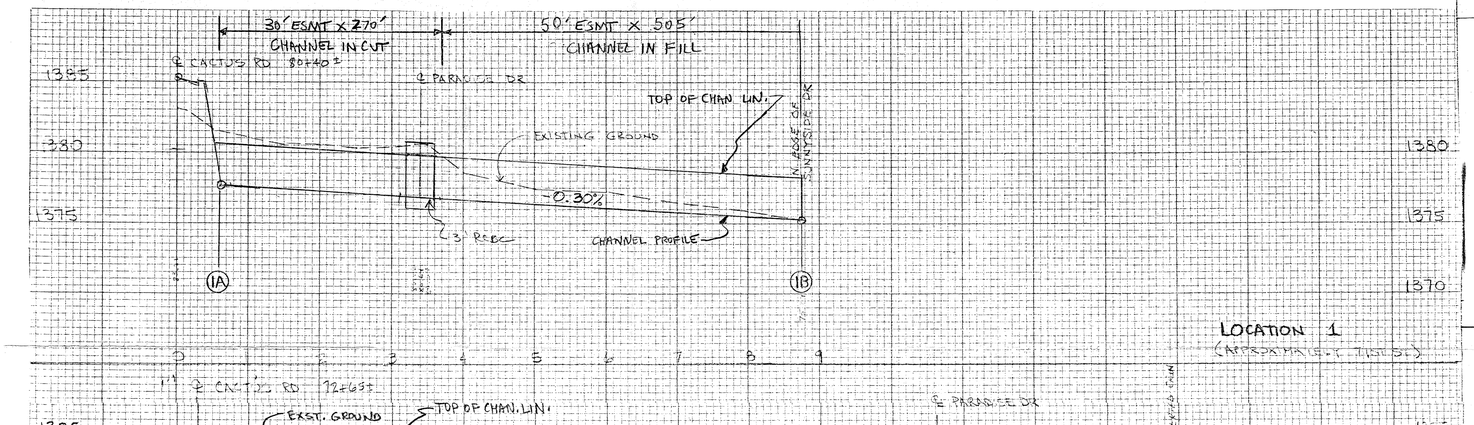


SCALE 1" = 400'

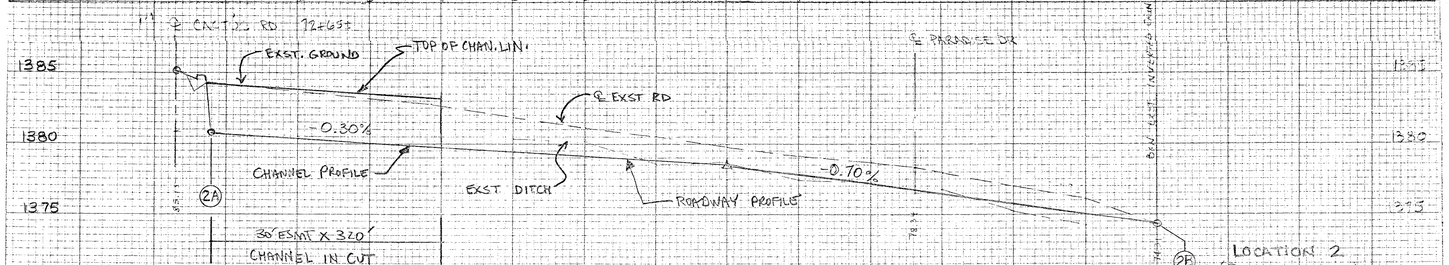
LEGEND

Channel Improvement

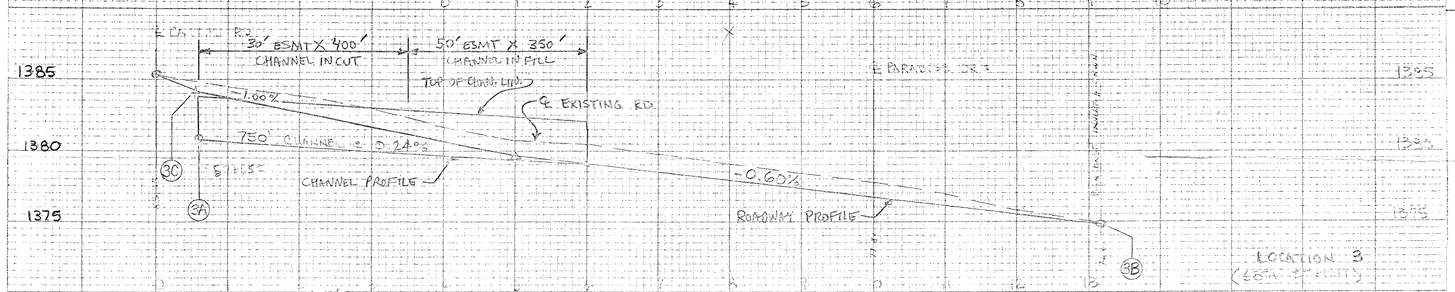
Street Improvement



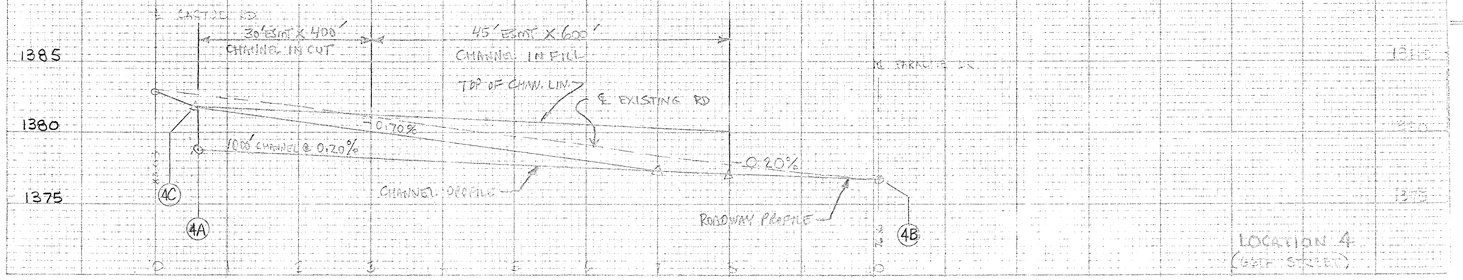
LOCATION 1
(APPROXIMATELY 71ST ST)



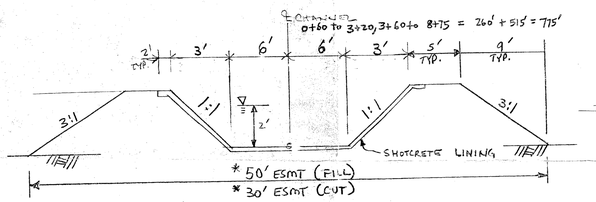
LOCATION 2
(PARADISE DRIVE)

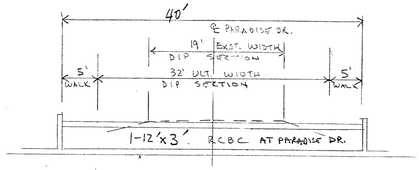


LOCATION 3
(68TH STREET)



LOCATION 4
(66TH STREET)





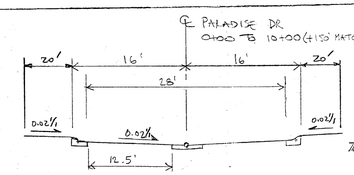
$Q_{10\,CHAN}$ = 200 CFS
$d_{n\,CHAN}$ = 2.0'
V_{CHAN} = 6 FPS

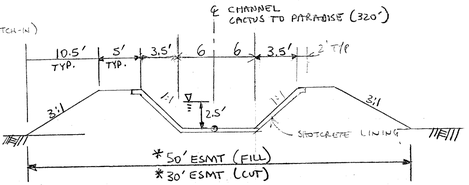
100' OF SHOTCRETE LINING = 200 S.Y. { 22 TON +1 50# AC, 35 C.Y. AB

* SEE PROFILE FOR FILL & CUT LOCATIONS

LOCATION 1
(APPROXIMATELY 71ST ST)

$Q_{10\,ROAD}$ = 256 CFS
$d_{n\,ROAD}$ = 1.5' @ ℄
V_{ROAD} = 5.4 FPS



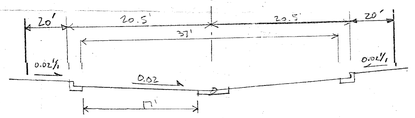


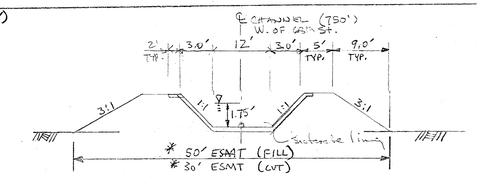
(2 x 12.5') 1150' ÷ 9 = 319 S.Y.
(INT) + (25' x 150') ÷ 9 = 416 S.Y.
3610 S.Y. AC x 2" x .055 TONS/INCH = 397 TONS ASPHALT CONC.
5% x 397 = 19.9 TONS ASPH. CEMENT
3610 ÷ 6 = 601 C.Y. AB.
32' x 1300' ÷ 9 = 4622 S.Y. GRADING ROWY
(1150' + 150') 2 = 2600' CSG TYPE C
1150+150 = 1300' VALLEY GUTTER

* SEE PROFILE FOR FILL & CUT LOCATIONS
$Q_{10\,CHAN}$ = 256 CFS
$d_{n\,CHAN}$ = 2.5'
V_{CHAN} = 7 FPS

LOCATION 2
(PARADISE DRIVE)

$Q_{10\,ROAD}$ = 145 CFS
$d_{n\,ROAD}$ = 0.9' @ ℄
V_{ROAD} = 5.1 FPS



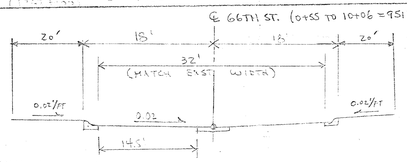


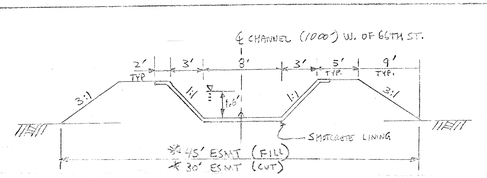
(2 x 17') 1262' ÷ 9 = 4768 S.Y.
(INT) + (30' x 100') ÷ 9 = 333 S.Y.
5% S.Y. AC x 2" x .055 TONS/INCH = 237 TONS ASPH. CONC.
5% x 237 = 11.8 TONS ASPH. CEMENT
850 C.Y. AB.
41' x 1362' ÷ 9 = 6204 S.Y. GRADING ROWY
(1262') 2 = 2524' CSG TYPE A
(100') 2 = 200' CSG TYPE C
1362 VALLEY GUTTER

* SEE PROFILE FOR FILL & CUT LOCATIONS
$Q_{10\,CHAN}$ = 145 CFS
$d_{n\,CHAN}$ = 1.75'
V_{CHAN} = 5.5 FPS

LOCATION 3
(68TH STREET)

$Q_{10\,ROAD}$ = 95 CFS
$d_{n\,ROAD}$ = 1.0' @ ℄
V_{ROAD} = 3.3 FPS

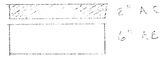




(2 x 14.5) 951' ÷ 9 = 3064 S.Y. x 2" x .055 TONS/IN = 337 TONS ASPH. CONC.
337 x 5% = 16.9 TONS ASPH. CEMENT
3064 ÷ 6 = 511 C.Y. AB
(30' x 951') ÷ 9 = 3304 S.Y. GRADING ROWY
15' x 2 = 1902' CSG TYPE C
95' VALLEY GUTTER

* SEE PROFILE FOR FILL & CUT LOCATIONS
$Q_{10\,CHAN}$ = 95 CFS
$d_{n\,CHAN}$ = 1.8'
V_{CHAN} = 4.5 FPS

LOCATION 4
(66TH STREET)



PVMT STRUCTURAL SECTION

FIGURE 6

OUTFALL DRAINAGE CHANNEL / STREET LAYOUT AND PROFILES, Alternative 4

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TABLE 3

Mescal Park Stage–Storage–Discharge Curve, Alternative No. 2

Stage (feet)	Storage (acre feet)	Discharge (cfs)
1352.75	0	0
1353.0	0.10	3
1353.5	1.04	10
1354.0	2.75	17
1355.0	6.75	31
1356.0	10.95	33
1357.0	15.75	33
1358.0	21.16	33
1359.0	26.77	33
1360.0	32.59	74
1361.0	38.62	101
1361.7	42.97	116

TABLE 4

Mescal Park Stage–Storage–Discharge Curve, Alternative No. 3

Stage (feet)	Storage (acre feet)	Discharge (cfs)
1352.75	0	0
1353.0	0.10	3
1353.5	1.04	10
1354.0	2.75	17
1355.0	6.75	31
1356.0	10.95	33
1357.0	17.21	33
1358.0	23.68	33
1359.0	30.37	33
1360.0	37.28	74
1361.0	44.40	101
1361.7	49.51	116

Based on these parameters, reservoir routing was performed on the Mescal Park detention basin for the 100–year, 24–hour rainfall event. This would result in the 100–year, 24–hour runoff event flowing down 68th Place and the 10–year, 24–hour runoff event flowing in the proposed storm drain. Both the storm drain sizes and the catch basin capacities would be selected to prevent peak flows greater than the 10–year, 24–hour runoff from entering the storm drain system. The hydrologic/hydraulic performance data is listed in Table 5.

TABLE 5

Hydrologic/Hydraulic Performance of the Mescal Park Detention Basin

Alternative No.	Storage Volume		Peak Stage (feet)	Freeboard (feet)	Peak Flows	
	Available (acre feet)	Required (acre feet)			Inflow[1] (cfs)	Outflow (cfs)
1	37.9	36.0	1361.26	0.44	799	107
2	43.0	37.0	1360.72	0.98	799	93
3	49.5	38.0	1360.17	1.53	799	79

1. Peak inflow results from combining the 10–year hydrograph for the 90" storm drain discharge and the 100–year hydrograph for the 68th Place runoff. The 90" storm drain and 68th Place have peak runoffs of 352 cfs and 478 cfs, respectively. The sum of these peak flows does not equal 799 cfs, because they occur at different times.

All alternatives studied will hold these runoff events (100–year, 24–hour rainfall event) while providing some freeboard. The freeboards are 0.5 feet, 1.0 feet and 1.5 feet for Alternatives 1, 2 and 3 respectively. The peak inflow is 799 cfs for all alternatives and the peak outflows are 107 cfs, 93 cfs, and 79 cfs for Alternatives 1, 2 and 3, respectively. It should be noted that the freeboards shown will occur during the 100–year, 24–hour rainfall event, and therefore, all of these alternative basins will provide protection for storm events with recurrence intervals greater than 100–years. Furthermore, all basins will be completely discharged in less than 36–hours, which meets City of Scottsdale code.

3.4 Cost Analysis

A detailed cost estimate was prepared for the four alternatives discussed in Section 3.1 of this report. Each estimate was prepared to a level commensurate with preliminary design. Table 6 summarizes the estimated construction costs (including right–of–way) for a 10–year recurrence interval drainage outfall system south of Cactus Road.

TABLE 6

Estimated Cost of Outfall System for Alternatives Studied

Alternative	Total Costs	COS Participation	Federal Participation
1	$1,840,000	$1,840,000	$0.00
2	$1,890,000	$1,890,000	$0.00
3	$1,990,000	$1,990,000	$0.00
4	$690,000	$690,000	$0.00

Table 7 summarizes the estimated drainage construction costs on Cactus Road only for a 10–year recurrence interval. Note that the outfall system costs are not included.

TABLE 7

Estimated Cost of Cactus Road Interceptor for Alternatives Studied

Alternative	Total Costs	COS Participation	Federal Participation
1	$1,590,000	$1,320,000	$270,000
2	$1,590,000	$1,320,000	$270,000
3	$1,590,000	$1,320,000	$270,000
4	$2,440,000	$2,110,000	$330,000

Table 8 summarizes the estimated total roadway, drainage, outfall system and right–of–way costs for a 10–year recurrence interval. It should be noted that selecting the storm drain outfall system will result in a $850,000 savings for the Cactus Road Interceptor System. This savings is realized by using circular pipes in place of shallow, wide box culverts.

TABLE 8

Estimated Total Cost of Project Including Drainage System for Alternatives Studied

Alternative	Total Costs[1]	COS Participation	Federal Participation
1	$4,860,000	$3,335,000	$1,525,000
2	$4,910,000	$3,385,000	$1,525,000
3	$5,010,000	$3,485,000	$1,525,000
4	$4,560,000	$2,975,000	$1,585,000

1. Cactus Road construction cost of $1,430,000 ($1,255,000 Federal Participation) is included in all alternatives.

Examination of the estimated costs tabulated above reveals that Alternative 4 (channel/roadway outfall system) will cost between $300,000 and $450,000 less than Alternatives 1, 2 and 3.

The cost of the outfall storm drain system was estimated based on the assumption that rubber gasket reinforced concrete pipe would be installed. It is our opinion that some savings could be realized by allowing the contractor the option of installing cast-in-place non-reinforced concrete pipe. The cast-in-place contractor's maintain that they are able to install cast-in-place pipe for the cost of reinforced concrete pipe delivered to the site. The data we have does not verify these claims.

3.5 Additional Considerations

Selecting an alternative for a drainage project of this magnitude requires considering several items in addition to the hydrologic/hydraulic performance and construction cost. These items for consideration are:

- *Maintenance* – The channel/street outfall system would be a continuing maintenance problem requiring the periodic removal of silt and debris after rainfall events. The storm drain outfall system has enough gradient to maintain a clean pipe.
- *Safety* – Deep flowing water within inverted crown streets can prevent emergency vehicle access to homes during large storm events. Increased flow depths in the streets could be a hazard to small children.
- *Public Acceptance* – The public may not accept the improvement of streets to convey storm waters past their homes. They may feel that improving the streets means additional storm water will be diverted to their streets.

Furthermore, the people living in these neighborhoods may prefer the rural character produced by their existing rural roads.

- *Aesthetics* – The proposed channels would be constructed on new and/or existing drainage easements along residential lot lines. In several segments of the channel, especially the transition segment prior to entering the street, the channel banks would need to be elevated above the elevations of the adjacent residential lots. These types of channels are not aesthetically pleasing, especially a raised channel in residential front yards.
- *Hydraulic Features* – Some of the proposed channels discharge to downstream streets at right angles to those streets. The flowing water would need to be diverted by a right angle deflector. These deflectors are not very effective during large runoffs and damage to vehicles and properties across the street could occur.
- *Flooding Considerations* – Installing a storm drain outfall system would provide more flood protection for the cost than the channel/street outfall system. The storm drain would carry the 10–year peak flows and additional flows larger than the 10–year would be carried by the existing channel/street system.
- *Legal Considerations* – There may be an increased potential for property owner drainage claims by constructing improved drainage channels on easements through residential property.

4.0 Recommendations

The City of Scottsdale Stormwater Management policy is to use a combination of streets, channels and underground storm drains to provide a cost effective system to dispose of stormwater runoff. During the design development of a project, informal value engineering is performed to select the best solution for each drainage problem. In our judgement, and based on value engineering, we recommend the construction of the storm drains, where possible, for the Cactus Road outfall system. We also recommend that the Mescal Park Detention Basin not be enlarged at this time. Furthermore, we recommend that the 71st Street drainage path be improved south of Cactus Road. Stormwater runoff in 71st Street cannot be diverted to the basin because of limited basin capacity.

For the recommended storm drain outfall system (Alternative No. 1), the estimated cost of the project, including the complete drainage system is $4,860,000. For the channel/street outfall system (Alternative No. 4), the estimated cost of the project, including the complete drainage system is $4,560,000. The recommended storm drain outfall system would cost $300,000 more than the channel/street outfall system. We believe the cost of the storm drain system can be reduced by allowing the use of cast-in-place concrete pipe. Our estimate was based on the more expensive rubber gasket reinforced concrete pipe.

Additional reasons to select the storm drain outfall system are:

- *Maintenance* – Lower long-term cost because silt and debris would not have to be removed after rainfall events.
- *Safety* – Emergency vehicles could get to the homes during large storm events. Potential hazard to children would be eliminated by removing water from the street.
- *Public Acceptance* – The property owners downstream of Cactus Road would appreciate the dry streets during rainfall events. They may not agree to signing easements for the construction of channels along their lot lines.
- *Aesthetics* – The underground storm drain system would not change the character of the neighborhood. Open channels, especially when their banks need to be raised above the surrounding ground elevations, are very unsightly.
- *Hydraulic Features* – The hydraulic operation of an underground storm drain system has less potential for damage to existing properties than the channel/street system.
- *Legal Considerations* – Under current conditions, the property owners have limited access to the legal system for flood damages. However, the construction of improved drainage channels on easements may give property owners access to the legal system for future flood damage.
- *Flooding Considerations* – Installation of an underground storm drain outfall system would provide more flood protection for each dollar spent than the channel/street outfall system. A dual drainage system would be created with the 10-year flow

handled by the storm drains and the larger flows handled by the existing channel/street system.

- *Interceptor Storm Drains* – The majority of interceptor storm drains along Cactus Road would consist of circular pipes, instead of shallow depth box culverts. The circular pipes could be installed with 3 feet of cover, allowing the installation of utilities over the pipes. Energy loss considerations would also be less critical. We also anticipate less construction time to install the circular pipes, and therefore, traffic control would be improved.

5.0 References

1. *PVSP Drainage Study, Phase III,* Prepared for Town of Paradise Valley, City of Scottsdale, City of Phoenix and the Flood Control District of Maricopa County, Collar, Williams and White Engineering, Inc. 1978.

2. U.S. Department of Transportation, Federal Highway Administration, *HY8 Culvert Analysis Microcomputer Program Applications Guide,* May, 1987

3. U.S. Department of Transportation, Federal Highway Administration, *Hydraulic Design of Highway Culverts,* Hydraulic Design Series No. 5, September, 1985.

4. Arizona Highway Department, Structures Section, *Hydrologic and Hydraulic Training Session Manual* October 16–18, 1972, revised December, 1973.

5. City of Scottsdale, Community Development Department, Design Procedures and Criteria, Section 2, *Drainage Report Preparation,* revised July 1975.

6. City of Scottsdale, Community Development Department, Design Procedures and Criteria, Section 3, *Design of Facilities to Manage Stormwater Runoff,* Reprinted June 1988.

7. Computational Hydrology Institute, *HEC–1 Flood Hydrology Applications of HEC–1 in Watershed and Flood Studies.*

8. U.S. Department of Commerce, Bureau of Public Roads, *Design Charts for Open–Channel Flow, Hydraulic* Design Series No. 3, August 1961.