ASSESSMENT OF FLOOD DAMAGES

SALT-GILA AQUEDUCT REACH I B

JULY 17-18, 1984

BASIC ORDERING AGREEMENT

PUBLISHED BY

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BUREAU OF RECLAMATION

OCTOBER 1984

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

ASSESSMENT OF FLOOD DAMAGES SALT-GILA AQUEDUCT REACH 1B JULY 17-18, 1984

BASIC ORDERING AGREEMENT
BOA-3-PA-30-00720

0083A
3611

October 31, 1984

Bureau of Reclamation
Arizona Projects Office
23636 North 7th Street
P.O. Box 9980
Phoenix, AZ 85068

Attention: Lowell H. Heaton
Chief, Location and Surveys Branch

Subject: Assessment of Flood Flow Damage near the CAP
Salt-Gila Aqueduct Reach 1B.
July 17-18, 1984
Final Report

Gentlemen:

Transmitted herewith are twelve copies of our formal report on the assessment of flood damages that occurred near Reach 1B of the Salt-Gila Aqueduct on July 17-18, 1984.

This work was done under Basic Ordering Agreement BOA-3-PA-0720 at the request of the Arizona Projects Office of the Bureau.

Our observations, conclusions, and recommendations are given in Chapter 8 of this report.

If you have any questions, please feel free to contact me at (415) 442-7159. I may also be reached through the IECO Phoenix office at (602) 997-4050.

Very truly yours,

WG Hall

W.G. Hall
Project Manager

WGH:abm

Enclosure: a/s

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EXHIBITS

TABLES

ABBREVIATIONS

CAP	Central Arizona Project
MCFCD	Maricopa County Flood Control District
SCS	Soil Conservation Service
SGP	Salt-Gila Project
USBR	United States Bureau of Reclamation
USGS	United States Geodetic Survey

CHAPTER 1
INTRODUCTION

[illegible] requested by the Arizona Projects Office of the Bureau of [illegible] (Bureau) to provide special assistance under their ordering agreement [illegible] to assess flood damages near the Salt-Gila [illegible] Reach 16, which occurred as a result of a rainstorm on July [illegible]. Work commenced on July [illegible], 1984.

The Bureau required that the assessment include the following eight [illegible]:

1. A description of the area, including the existing Federal, State, and local structures in place now and/or currently under construction and their relationship to the damaged areas.

2. A brief function description of the in-place or proposed [illegible] (including Bureau and CAP facilities), State and local [illegible] systems, their proposed interconnects (if any) and [illegible] interim effects.

3. An analysis of the runoff flows through the existing systems [illegible] these under construction, in relation to the CAP, with particular emphasis on the CAP's Reach 16 of the Salt-Gila [illegible].

4. A statement of why the damages occurred.

5. An analysis and a delineation of areas receiving damages as a result of CAP-constructed structures which impacted the runoff [illegible] the areas in question.

CHAPTER 1
INTRODUCTION

1.1 TASK ORDER

IECO was requested by the Arizona Projects Office of the Bureau of Reclamation (Bureau) to provide special assistance under Basic Ordering Agreement BOA-3-PA-30-00720 to assess flood damages near the Salt-Gila Aqueduct Reach 1B, which occurred as a result of a rainstorm on July 17- 18, 1984. Work commenced on July 26, 1984.

The Task Order required that the assessment include the following eight sub-tasks:

1. A description of the area, including the existing Federal, State, and local structures in place now and/or currently under construction and their relationship to the damaged areas.

2. A brief function description of the in-place or proposed Federal (including Bureau and SCS facilities), State and local structural systems, their proposed intermediate (if any) and ultimate interrelationship.

3. An analysis of the runoff flows through the existing systems and/or those under construction in relation to the CAP, with particular emphasis on the CAP's Reach 1B of the Salt-Gila Aqueduct.

4. A statement of why the damages occurred.

5. An analysis and a delineation of areas receiving damages as a result of CAP-constructed structures which impacted the runoff in the areas in question.

6. Conduct a damage survey on those damaged areas impacted by the construction as defined in sub-task 5.

7. An assessment of the flooding exclusive of the CAP aqueduct (Reach 1B).

8. An analysis of the CAP design, coordination and construction implementation of Reach 1B with particular emphasis on cross drainage accommodation for the local area relative to the aqueduct.

1.2 DAMAGE ASSESSMENT

This report presents an assessment of flood damages. Each of the eight sub-tasks in Chapter 1.1 above is discussed in a chapter of the report as identified in the following table.

TABLE 1-1
LOCATION OF SUB-TASKS IN REPORT

Task Order Sub-Task	Report Chapter No.
1	2
2	2
3	4
4	5
5	5
6	3
7	6
8	7

1.3 ACKNOWLEDGEMENTS

We wish to acknowledge the special assitance given to IECO staff by the following people:

- Lowell H. Heaton
  Arizona Projects Office
  Bureau of Reclamation
  Phoenix, AZ

- Harry Millsaps
  Soil Conservation Service
  U.S. Department of Agriculture
  Phoenix, AZ

- Thomas La Marche
  Maricopa County Flood Control District
  Phoenix, AZ

- Frank Russo
  Maricopa County Department of Civil Defense
  and Emergency Services
  Phoenix, AZ

CHAPTER 2

DESCRIPTION OF AREA AND FACILITIES

2.1 STORM OF JULY 19-20, 1984

An intense rainstorm, centered on Apache Trail, between Ellsworth Street and Crismon Road in Mesa, Arizona, caused flooding in the communities of Mesa and Apache Junction during the night of July 19-20, 1984. Isohyets of the storm are shown on Exhibit 2-1. The areal extent of the storm encompassed the existing and proposed flood protection works of the Maricopa County Flood Control District, and Reaches 18 and 19 of the Salt-Gila Aqueduct of the Central Arizona Project, as shown on Exhibit 2-1.

At the time of the flood event of July 19 and 20, flood control structures of the Maricopa County Flood Control District and structures of the Salt-Gila Aqueduct were in various stages of completion. With reference to Exhibit 2-1, the Signal Butte Floodway and Retention Structure Dike were complete, the Signal Butte Floodway was almost finished, but construction of outlet drainage [illegible] had not begun. Reach 18 of the Salt-Gila Aqueduct was complete, but Reach 19 was incomplete. Construction of Apache-Crismon [illegible] drainage structure was proceeding on schedule.

Runoff from the [illegible] part of the storm in the Signal Butte Floodway which then [illegible] drainage. The excavated aqueduct prism of Reach 19 of the Salt-Gila Aqueduct intercepted and stored [illegible] together with [illegible] from the Signal Butte Floodway and runoff from tributary watersheds. Flooding developed [illegible] adjacent to the north bank of Reach 19 at three locations. [illegible] through the adjacent areas and was discharged through an opening in the south bank [illegible] and Ellsworth Road. [illegible] south of the aqueduct in the path of the [illegible] from the aqueduct [illegible] from water stored [illegible] flow and [illegible] the local drainage system.

CHAPTER 2

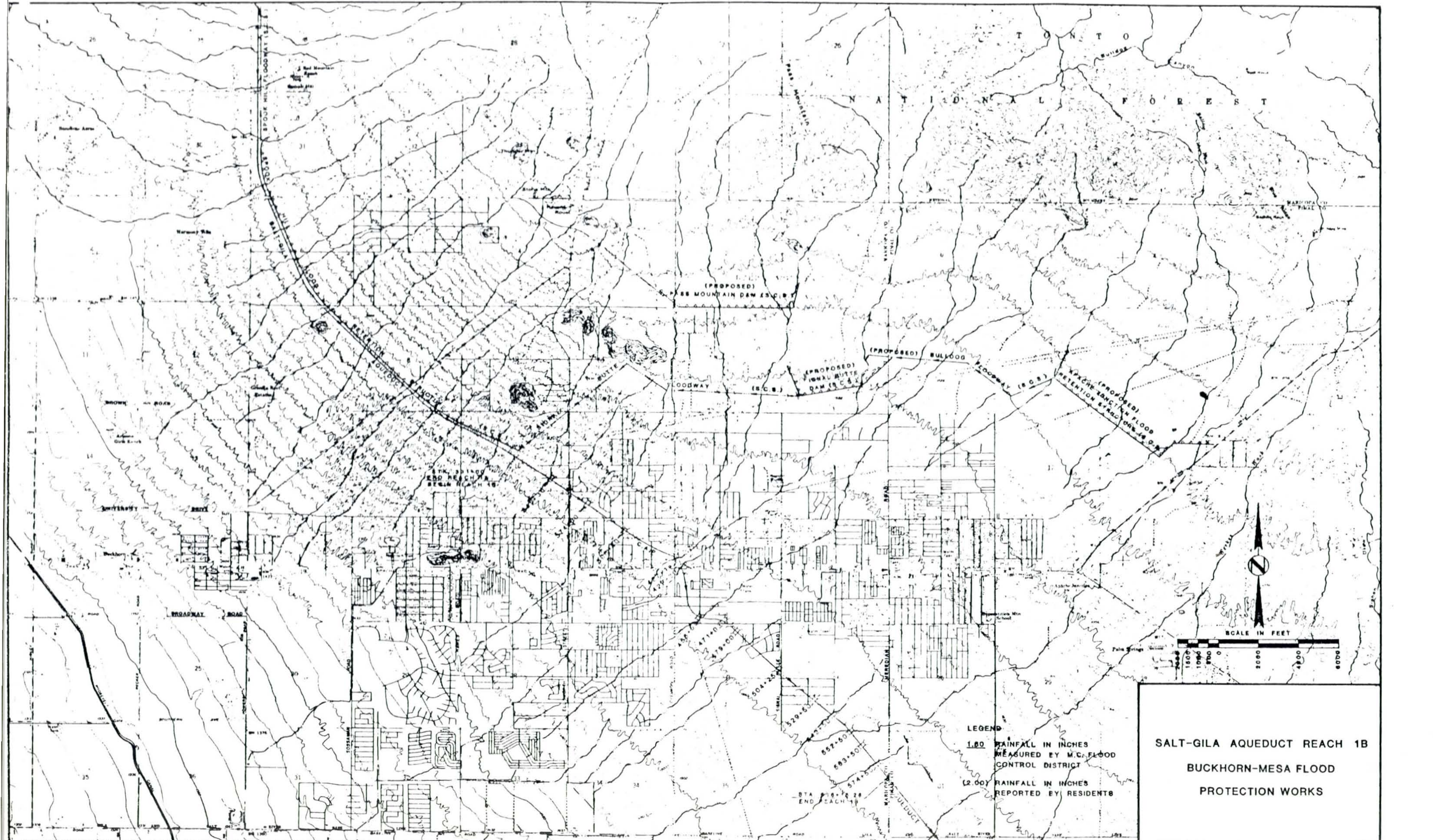
DESCRIPTION OF AREA AND FACILITIES

2.1 STORM OF JULY 17-18, 1984

An intense rainstorm, centered on Apache Trail, between Ellsworth Street and Crismon Road in Mesa, Arizona, caused flooding in the communities of Mesa and Apache Junction during the night of July 17-18, 1984. Isohyets of the storm are shown on Exhibit 4-1. The areal extent of the storm encompassed the existing and proposed flood protection works of the Maricopa County Flood Control District, and Reaches 1A and 1B of the Salt-Gila Aqueduct of the Central Arizona Project, as shown on Exhibit 2-1.

At the time of the flood event of July 17 and 18, flood control structures of the Maricopa County Flood Control District and structures of the Salt-Gila Aqueduct were in various phases of completion. With reference to Exhibit 2-1, the Spook Hill Floodway and Retention Structure were complete, the Signal Butte Floodway was almost finished, but construction of other proposed flood control works had not begun. Reach 1A of the Salt-Gila Aqueduct was complete, but Reach 1B was incomplete. Construction of Reach 1B of the aqueduct structure was proceeding on schedule.

Runoff from the rainstorm filled part of the length of the Signal Butte Floodway which then overflowed to southwest trending drainage. The excavated aqueduct prism of Reach 1B of the Salt-Gila Aqueduct intercepted and stored (together with Reach 1A) spill from the Signal Butte Floodway and runoff from tributary drainage areas. Flooding of developed land occurred adjacent to the north berm of Reach 1B in three locations. Part of the inflow was conveyed through the aqueduct prism and was discharged through an opening in the south berm at 102nd Street and Broadway Road. Developed areas south of the aqueduct in the path of the outflows from the aqueduct experienced damage from water moving in sheet flow and from overflows of the local drainage systems.



SALT-GILA AQUEDUCT REACH 1B

BUCKHORN-MESA FLOOD PROTECTION WORKS

EXHIBIT 2-1

EXHIBIT 2-1

SALT-GILA AQUEDUCT REACH 1B

BUCKHORN-MESA FLOOD PROTECTION

WORKS

(SEE ENVELOPE IN REAR OF REPORT)

2.2 DESCRIPTION OF AREA

The area under consideration consists of parts of Maricopa and Pinal Counties bounded on the west by Power Road, on the north by the Tonto National Forest and on the south by Baseline Road. The eastern boundary is about 4 miles east of Meridian Road. The generally southwest trending drainage pattern slopes from about 130 feet per mile in the north to about 65 feet per mile in the vicinity of Baseline Road. Much of the development, consisting of roads and drains in a north-south and east-west grid pattern, occurs south of University Drive and supports rapidly expanding acreages of mobile home courts. Principal water courses, initially trending more or less southwest, have been diverted, reduced or lost in the pattern of development. However, recent subdivisions are enjoined to preserve inlet and outlet positions of intercepted natural water courses. The southeast trending Reach 1B of the Salt- Gila Aqueduct passes through a suburban type development only between Quarterline Drive and Broadway Road.

2.3 SOIL CONSERVATION SERVICE (SCS) FACILITIES

The Signal Butte Floodway is part of the Maricopa County Flood Control District (MCFCD), Buckhorn-Mesa Flood Protection Facilities which, when completed, will provide flood protection to the communities located below. The facilities are being constructed under an agreement between the SCS and MCFCD. The District provides the land and agrees to operate and maintain the facilities after construction. The SCS provides design and construction supervision services to the District.

The basic watershed plan for diversion and impoundment of runoff is described in an SCS publication, "Watershed Work Plan, Buckhorn-Mesa Watershed, Maricopa and Pinal Counties, Arizona, January, 1963" (Ref. 1). The Work Plan was modified by a supplemental watershed work plan issued in 1976 (Ref. 2). The final environmental impact statement is given in Reference 3. The structures in the ultimate development, which provides protection to Reach 1B include:

- Spook Hill Floodway
- Spook Hill Retention Structure
- Signal Butte Floodway
- Signal Butte Dam
- Pass Mountain Dam
- Bulldog Floodway
- Apache Junction Flood Retention Structure

At the time of design of the Central Arizona Project all these structures were scheduled for completion by 1980. However, due to delays in funding, the only facilities that were complete as of July 17, 1984, were the Spook Hill Floodway and Spook Hill Retention Structure. The Signal Butte Floodway was under construction.

The easternmost portion of the Signal Butte Floodway is oriented approximately east-west as shown on Exhibit 2-1 and consists of a 1.4-mile-long unlined canal with above-ground berms. A collector ditch at the toe of the north berm intercepts and conveys runoff from the tributary areas above to shotcrete chutes located at intervals along the berm. Intercepted water passes over these chutes into the floodway channel for conveyance to the Salt River. Small quantities of water will be released to natural washes below the floodway through vegetative outlets. A short distance west of Crismon Road, the floodway bears northwest for a distance of about 0.4 mile and then turns sharply to the southwest for a 1.3-mile-run toward the CAP aqueduct. Near the aqueduct, the floodway again turns to the northwest and follows the aqueduct alignment.

The construction of the floodway to the east of the northernmost point was essentially complete on July 17. Immediately to the southwest of the northernmost point on the floodway, the contractor had placed an earthen plug in the channel to protect freshly placed concrete lining in the downstream channel. The top of this plug was approximately berm high, thus effectively closing the outlet to the downstream channel.

Construction of Signal Butte and Pass Mountain Dams are presently scheduled for completion in 1986. Completion of the Bulldog Floodway and the Apache Junction Flood Retention Structure is planned for 1987.

2.4 CENTRAL ARIZONA PROJECT (CAP) FACILITIES

The Salt-Gila Aqueduct, a feature of the Central Arizona Project, will convey water from the Colorado River to the Central Arizona service area in the Gila River Basin. The aqueduct begins at the Salt-Gila Pumping Plant which is the terminus of the Granite-Reef Aqueduct, and after some 6 miles (Reach 1A), achieves and maintains a course to the southeast. The aqueduct has an excavated, concrete-lined cross section with aboveground berms.

Reach 1B is approximately 5.2 miles long and extends from about a half mile west of Ellsworth Street to Meridian Road. The design incorporates collector ditches to intercept runoff at the toe of the north side berm. These lead to overchutes, which pass the collected runoff from the north side over the aqueduct into natural washes and drainage channels on the south side. Bridges cross the aqueduct at Ellsworth Street, University Drive, Crismon Road, Apache Trail, Broadway Road, Farnsworth Boulevard, Signal Butte Road, Grove Street and Meridian Road.

At the time of the storm the aqueduct cross section of Reach 1B had been excavated but not lined with concrete. The collector ditch system was generally in place. Excavation for the overchutes had been made at several locations. The University Drive, Apache Trail eastbound, Broadway Road, and Farnsworth Boulevard crossings were in place. Earth dikes, providing equipment access from the north side berm to the south side berm, were in place just upstream of the University Drive crossing and just downstream of the flume overchute at Station 396+40. Earth dikes were also placed just upstream and downstream of the Apache Trail crossing and at Signal Butte Road, the latter dike preventing any flow southeastward in the remaining part of Reach 1B. Status of completion at each of the overchute structures in Reach 1B is as follows:

Station	Berm Excavation Northside	Berm Excavation Southside	Overchute in Place	Remarks
345+30	Yes	No	No	
374+00	No	No	No	
396+40	Yes	No	Yes	South berm locally at about El. 1570
427+15	No	No	No	
429+20	No	No	No	
456+50	Yes	Yes	No	Low point of north berm and south berm access roads crossing excavation probably at El. 1563 on north and El. 1561 on south side.
471+03	Yes	Yes	No	On south berm pipes exit to pool below grade of Broadway Rd.
479+00	Yes	Yes	Yes	2 of 5 barrels in place
504+25	Yes	Yes	No	

2.5 AERIAL PHOTOGRAPHS

Aerial photographs of the entire study area were taken on July 27, 1984. There was some cloud cover, however it was deemed important to obtain a record of the damages before new storms would remove evidence of the July 17-18 storm. A severe rain storm did hit Mesa-Apache Junction on July 28. 1:12000 scale stereo-photo pairs were used extensively in the analysis and delineation of damage areas. Sediment deposits on the roads indicated paths of water and locations of ponded areas. Photo maps were made for areas of special interest. The maps of Exhibits 4-6 and 4-7 are examples.

southeastward in the remaining part of Reach 1B. Status of completion at each of the overchute structures in Reach 1B is as follows:

Station	Berm Excavation Northside	Berm Excavation Southside	Overchute in Place	Remarks
345+30	Yes	No	No	
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396+40	Yes	No	Yes	South berm locally at about El. 1570
427+15	No	No	No	
429+20	No	No	No	
456+50	Yes	Yes	No	Low point of north berm and south berm access roads crossing excavation probably at El. 1563 on north and El. 1561 on south side.
471+03	Yes	Yes	No	On south berm pipes exit to pool below grade of Broadway Rd.
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CHAPTER 3
DAMAGE SURVEY

Reports of flood damage and flooding were compiled by street address as shown in Table 3-1. The following sources were used:

IDENTIFIER SYMBOL	SOURCE
BR	Citizen damage claims filed with the Maricopa County Department of Civil Defense and Emergency Services - 225 claims had been filed as of September 20, 1984.
FC	Citizen complaints made to the Maricopa County Flood Control District on July 18, 1984.
BB	Damage claims made to the CAP Reach 1B contractors, Ball, Ball and Brosamer.
RC	Damage assessment work sheets dated July 18 to 21, 1984, prepared by the Red Cross Disaster Services.
IE	Residents interviewed by IECO Staff.

The identifier symbol is incorporated into the claim number shown in Table 3-1 and may be used to identify the source of the report. The citizen damage claims filed with the Department of Civil Defense were numbered in the order received. Many claims had accompanying photos and sketches of damage. A file of all claims together with backup material is being maintained by the Department of Civil Defense.

The location of each complaint was plotted on Exhibit 3-1 by scaling the reported address from map baselines. A different symbol for each source was used. In some of the more heavily flooded areas, distortion was necessary to show each report.

CLAIMANT LISTING
STORM/FLOOD OF JULY 17-18, 1984
DATE OF LIST - OCTOBER 3, 1984

TABLE 3-1
SHEET 1

CLAIM NO.	ADDRESS	NAME	CITY	ZIP	TELEPHONE	TYPE DAMAGE	DAMAGE EST.($)
BR204	724 N. 22nd Place	Caza, Duane E.	Mesa	85203		House	305.00
FC013	260 N. 58th Place	Kuchenbecker, Edward F	Mesa	85205		Yard	
FC014	228 S. 72nd Circle	Davidson,	Mesa	85208	985-0777	Yard	
BR206	242 S. 72nd Circle	Caron, Agnes	Mesa	85208		Yard	479.85
FC015	1056 S. 74th Place	Cheatham, Frank	Mesa	85208	981-2095	House, Yard	
BR125	1719 S. 77th Street	Nichols, Mary D.	Mesa	85208	986-0711	Yard	785.00
BR161	1720 S. 77th Street	Hendrix, Kenneth E.	Mesa	85208	986-1845	Landscaping	630.00
BR210	1744 S. 78th Place	Hadley, Holly	Mesa	85208	986-6703	Car submerged	11,818.99
BR211	1744 S. 78th Place	Von Magnus, Edward	Mesa	85208		Undermining, Flooring	1,500.00
RC012	1634 S. 78th Street		Mesa	85208			Minor
BR106	1634 S. 78th Street	Shultz, Wayne	Mesa	85208	985-4503	House, Shed	2,385.00
RC004	1635 S. 78th Street		Mesa	85208		Mobile Home	Minor
RC005	1637 S. 78th Street		Mesa	85208		Mobile Home	Major
RC002	1638 S. 78th Street	Irish, Helen	Mesa	85208			
RC006	1642 S. 78th Street	Shearer, Norma	Mesa	85208		Mobile Home	Major
RC007	1646 S. 78th Street	Hibner, C.	Mesa	85208		Mobile Home	Minor
BR006	1646 S. 78th Street	Hibner, Carol	Mesa	85208		House, Yard, Fence	
RC008	1704 S. 78th Street	Hibner, H.	Mesa	85208		Mobile Home	Minor
BR004	1704 S. 78th Street	Hibner, Harriett A.	Mesa	85208		House, Yard, Fence	
RC009	1708 S. 78th Street	Decker, B.	Mesa	85208		Mobile Home	Minor
RC011	1708 S. 78th Street	Schween, Jannett	Mesa	85208			Minor
BR005	1708 S. 78th Street	Hibner, Harold	Mesa	85208		House, Yard, Fence	
RC010	1734 S. 78th Street		Mesa	85208			Minor
BR201	1734 S. 78th Street	Phillips, Cora	Mesa	85208		Yard, Water	245.00
FC001	1922 S. 78th Street	Smith, Paul	Mesa	85208	268-6484	Undermining, Yard, Other	
BB001	502 S. 80th Place	Bowman, Clark	Mesa	85208	986-8091	House, Undermining	12,000.00
BR078	1824 S. 80th Street	Hepker, Paul	Mesa	85208	986-6328	House, Yard	2,700.00
BR079	507 S. 81st Place	Miller, R.W.	Mesa	85208	986-7659	Yard, House, Undermining	604.71
BR101	235 S. 84th Way	Robison, Clarence	Mesa	85208		Yard, Road	1,330.00
BR160	725 S. 85th Way	Gallentine, Gerald	Mesa	85208	986-6168	House, Yard	6,000.00
BR055	749 S. 85th Way	Lykes, William F.	Mesa	85208	984-3211	Yard	2,090.64
FC002	202 N. 86th Street	Roemeling, Nancy	Mesa	85208	986-8316	House, Yard	
BR060	202 N. 88th Place	Keiser, Floyd F.	Mesa	85207	986-5730	Shed, Other	652.00
BR157	101 S. 91st Street	Garcia, Katherine	Mesa	85208	984-1907	Landscaping, Yard	1,400.00
BR026	602 S. 92nd Place	Jensen, Blanche K.	Mesa	85208	986-0488	Basement, Yard	
BR025	601 S. 92nd Street	Holland, Victor	Mesa	85208	986-0917	House, Yard	50,000.00
BR164	925 S. 92nd Street	Kaminsky, Albert	Mesa	85208	986-5259	Mobile Home, Landscape	5,000.00
RC020	501 N. 94th Way	Goodwin, Bill	Mesa	85208		1/2" water in house	Minor
FC003	501 N. 94th Way	Goodwin, William C.	Mesa	85207	986-3235	House	
BR166	501 N. 94th Way	Goodwin, William	Mesa	85207	986-3235	House, Furniture	1,551.02
BR196	501 N. 94th Way	Goodwin, William	Mesa	85207		House	997.10
FC032	501 N. 94th Way	Neidhart Enterprises	Mesa	85207	277-3363	House, Yard	
FC031	502 N. 94th Way	Neidhart Enterprises	Mesa	85207	277-3363	House, Yard	
BR145	502 N. 94th Way	Shaffer, Howard A.	Mesa	85208	984-6122	House	7,593.00
BB002	502 N. 94th Way	Shaffer, Howard	Mesa	85207	984-6122	House	2,000.00

CLAIM NO.	ADDRESS		NAME	CITY	ZIP	TELEPHONE	TYPE DAMAGE	DAMAGE EST. ($)
RC019	502	N. 94th Way	Shaffer, Howard	Mesa	85208	984-6122	10" water in house	Minor
BR194	502	N. 94th Way	Shaffer, Howard	Mesa	85207		House	765.90
FC029	426	N. 95th Place	Neidhart Enterprises	Mesa	85207	277-3363	House, Yard	
BB003	426	N. 95th Place	Neidhart Enterprises	Mesa	85207	277-3363	House	500.00
BR197	426	N. 95th Place	Neidhart Investment Co.	Mesa	85207		House	5,000.00
FC030	543	N. 95th Place	Neidhart Enterprises	Mesa	85207	277-3363	House, Yard	
BR149	615	N. 95th Place	Rowlin, Kenneth L.	Mesa	85207	984-3320	Yard	452.00
BR135	505	N. 95th Street	Rodman, Joseph O. Sr.	Mesa	85207	986-8504	Yard, Day of Work	1,706.00
FC033	505	N. 95th Street	Neidhart Enterprises	Mesa	85207	277-3363	House, Yard	
FC004	505	N. 95th Street	Rodman, Joseph O.	Mesa	85207	986-8504	Yard	
BR124	843	S. 95th Street	Sims, Voris V.	Mesa	85208	986-8305	Erosion	660.00
BR083	850	S. 95th Street	O'Neill, Dale F.	Mesa	85208	984-4549	Yard	330.65
BR102	855	S. 95th Street	Vail, William L.	Mesa	85208	984-1348	Yard	600.00
BR019	901	S. 95th Street	Yezek, William A	Mesa	85208	None	Yard	485.86
BR038	907	S. 95th Street	Stevant, Sarah F.	Mesa	85208	986-5682	House, Yard	673.52
BR054	913	S. 95th Street	Day, D.L. (Marcelline)	Mesa	85208	986-0902	Yard	437.95
BR140	852	S. 95th Way	Collins, Shirley M.	Mesa	85208	984-4033	Skirting, Yard	1,600.00
RC071	852	S. 95th Way	Collins, Shirley	Mesa	85208		Landscape, Skirting	Minor
BR141	909	S. 95th Way	Molitor, Dorothy C.	Mesa	85208	984-5848	House, Erosion	1,700.00
RC069	909	S. 95th Way	Molitor, D.C.	Mesa	85208		Landscape,	Minor
BR213	915	S. 95th Way	Bronson, Ellen E.	Mesa	85208		Skirting, Yard, Sheds	1,925.40
RC070	915	S. 95th Way	Bronson, Morris	Mesa	85208		Landscape, Meter	Minor
RC068	927	S. 95th Way	Courtney	Mesa	85208		Shed, Landscape,	Major
RC067	933	S. 95th Way	Yates, Betty	Mesa	85208		Carpets, Landscape,	Major
RC066	939	S. 95th Way	Oden, L.	Mesa	85208		Landscape, Closet	Minor
BR096	951	S. 95th Way	Billington, Milliard	Mesa	85208	986-3226	House, Yard	912.06
RC080	901	S. 96th Place	Philerick, Herbert	Mesa	85208		Yard, Trailer	Minor
BR003	901	S. 96th Place	Philbrick, Herbert E.	Mesa	85208	986-9358	House, Yard, Fence	
RC079	902	S. 96th Place	Snyder, Max	Mesa	85208		Yard, Trailer	Minor
BR208	902	S. 96th Place	Snyder, Max E.	Mesa	85208	986-1874	Yard, Shed, Other	6,914.00
RC078	910	S. 96th Place	Newton, Walter	Mesa	85208		Yard	Minor
BR151	915	S. 96th Place	Woodley, Elwyn D.	Mesa	85208	986-0934	Yard, Sprinkler System	625.25
RC077	922	S. 96th Place	Trunkenboth, Bob	Mesa	85208		Yard	Minor
BR217	922	S. 96th Place	Trunkenboltz R.C.	Mesa	85208		Yard	1,800.00
BR187	946	S. 96th Place	Van Winkle, O.E.	Mesa	85208	986-9577	Yard	963.98
BR180	1021	S. 96th Place	Dynesius, Roy S.	Mesa	85208	986-8223	Home, Yard, Skirting	920.00
RC081	1064	S. 96th Place	Butterfield	Mesa	85208		Yard, Trailer	Minor
BR191	1064	S. 96th Place	Butterfield, Elmer A.	Mesa	85208	982-7097	Yard	833.75
BR059	802	S. 96th Street	Williamson, Louise	Mesa	85208	984-4239	House, yard	2,500.00
BR030	902	S. 96th Street	Robinson, Roy	Mesa	85208	986-8051	Yard	2,000.00
RC072	908	S. 96th Street	Lepire, E.H.	Mesa	85208		Landscape, Skirting	Minor
BR022	915	S. 96th Street	McGee, Edward D.	Mesa	85208	984-5177	House, Yard	1,206.00
RC073	916	S. 96th Street		Mesa	85208		Landscape, Fence	Minor
RC074	938	S. 96th Street	Fletcher	Mesa	85208		House, Yard	Major

CLAIMANT LISTING
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TABLE 3-1
SHEET 3

CLAIM NO.	ADDRESS	NAME	CITY	ZIP	TELEPHONE	TYPE DAMAGE	DAMAGE EST.($)
BR088	938 S. 96th Street	Fletcher, C.C.	Mesa	85208	986-6109	House, Undermining	6,351.61
RC075	944 S. 96th Street	Motisher, Charles	Mesa	85208		Floor, Landscape	Minor
BR203	944 S. 96th Street	Motisher, Charles	Mesa	85208		Yard	600.00
BR139	950 S. 96th Street	Valburg, Virgil W.	Mesa	85208	986-9313	Yard, Erosion, Undermining	811.50
BR138	957 S. 96th Street	Lauzon, William E.	Mesa	85208	984-1216	Erosion, Yard	2,000.00
BR113	902 S. 96th Way	Ferrill, Ara	Mesa	85208	986-4589	Yard, Basement	3,633.37
BR094	507 S. 97th Place	Adams, Jack W.	Mesa	85208	986-4186	Basement, Pool, Fence, Yard	150.00
RC038	513 S. 97th Place	Higbee, Helen	Mesa	85208		2 ft. Water, Basement	Minor
BR176	556 S. 97th Place	Millspaugh, James	Mesa	85208	986-6349	Yard, Gravel	827.34
BR205	602 S. 97th Place	Hough, Robert G. Jr.	Mesa	85208	986-8871	Yard, Undermining, Fence	2,694.84
BR126	626 S. 97th Place	Roscoe, Kelly	Mesa	85208	986-7097	Trailer Skirting, Yard	2,000.00
FC007	655 S. 97th Place	Boyer, Linda	Mesa	85207	986-6821	Yard	
BR108	661 S. 97th Place	Hensley, Della	Mesa	85208		Undermining, Yard	250.00
BR016	802 N. 97th Street	Tucker, Sigrid Ruth	Mesa	85204	986-5336	House, Pool	3,500.00
FC005	841 N. 97th Street	Trone, Guy	Mesa	85207	984-1137	House	
FC006	849 N. 97th Street	Heifler, Bob	Mesa	85207	984-1137	House	
BR008	1124 S. 97th Street	Vanzant, Charles V.	Mesa	85208	986-7948	House, Ditch, LP Tank	
BR009	1142 S. 97th Street	Timmons, Robert E.	Mesa	85208	986-2522	Yard, Ditch	
FC008	443 S. 97th Way	Leaque, Stony	Mesa	85207	986-6369	House, Yard, Other	
BB004	505 S. 97th Way	Vieth, Douglas	Mesa	85208	984-6468	Car	10,000.00
RC076	602 S. 97th Way	Dismuke	Mesa	85208		Yard, Landscape	Minor
BR219	1045 S. 97th Way	Crowley, James	Mesa	85208		Yard	400.00
BR150	420 S. 98th Place	Woods, Rose H.	Mesa	85208	986-9229	House, Yard	13,550.00
BR147	426 S. 98th Place	Crenshaw, Rudolph J.	Mesa	85208	986-7025	Yard	465.00
BR179	443 S. 98th Place	Osbourne/Murphy	Mesa	85208	986-8958	Mobile Home, Landscape	7,500.00
BR177	443 S. 98th Place	Murphy, E. Robert	Mesa	85208	986-8958	House, Appliances	2,500.00
BR136	450 S. 98th Place	Leslie, Carroll V.	Mesa	85208	986-5353	Yard, Fence, Sheds, Drive	4,350.00
BR137	458 S. 98th Place	Leslie, Kyle	Mesa	85208	984-5429	Car, Fence, Camper, Fzr.	1,192.00
BR074	68 N. 98th Street	Mihailou, William	Mesa	85207	986-0404	Fence, Erosion	1,000.00
BR075	68 N. 98th Street	Mihailou, William	Mesa	85207	986-0404	Ductwork, Insulation, Fence	3,520.00
BR034	911 S. 98th Street	Switalski, Sylvester	Mesa	85208	984-3415	Yard, Ditch	4,000.00
BR144	429 S. 98th Street	Stone, William V.	Mesa	85208	986-7025	Yard	1,100.00
BR134	437 S. 98th Street	DeLong, Marvin R.	Mesa	85208		Erosion	531.00
BR173	710 S. 98th Street	Siefker, Charles	Mesa	85208	986-4782	Yard	500.00
BR114	841 S. 98th Street	Nelson, Robert D.	Mesa	85208	984-1553	House, Yard	
BR064	847 S. 98th Street	Judy, Willard J.	Mesa	85208	986-9820	House, Yard	3,510.00
BR037	901 S. 98th Street	Wells, Wilbur	Mesa	85208		Yard, Undermining	3,500.00
BR097	915 S. 98th Street	Mills, William A.	Mesa	85208	984-3523	Yard	676.00
BR220	928 S. 98th Street	Simmons, Reed	Mesa	85208		Yard	400.00
BR040	933 S. 98th Street	Van Gaasbeck,	Mesa	85208	986-4545	Undermining, Yard	1,150.00
BR007	945 S. 98th Street	King, Doris	Mesa	85208	948-3254	Yard	825.00
BR067	952 S. 98th Street	Brown, Leata	Mesa	85208	838-0305	Modular Home, Yard	1,150.00
BR130	1002 S. 98th Street	Dangler, Frank	Mesa	85208	986-1063	Yard	740.40
RC021	414 S. 98th Way	Sims	Mesa	85208		Trailer	Minor

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TABLE 3-1
SHEET 4

CLAIM NO.	ADDRESS	NAME	CITY	ZIP	TELEPHONE	TYPE DAMAGE	DAMAGE EST.($)
RC022	419 S. 98th Way	Wilson	Mesa	85208			Minor
RC023	420 S. 98th Way	Jenkins	Mesa	85208		6" Water & Silt	Minor
RC024	425 S. 98th Way	Fredrickson	Mesa	85208			Minor
RC025	430 S. 98th Way	Robertson/Ballentine	Mesa	85208		Utility Shed Foundation	
BR110	430 S. 98th Way	Robertson, Clovis L.	Mesa	85208		House, Shed, Car, Yard	6,600.00
RC026	437 S. 98th Way		Mesa	85208			Minor
RC027	438 S. 98th Way		Mesa	85208			Minor
RC028	444 S. 98th Way	Sleighter	Mesa	85208			Minor
BR002	450 S. 98th Way	Norris, Ralph	Mesa	85208		House, Yard, Fence	50,000.00
RC029	458 S. 98th Way	Miles	Mesa	85208			Minor
BR109	458 S. 98th Way	Miles, Norman E.	Mesa	85208	984-1319	House, Driveway	1,200.00
BR215	458 S. 98th Way	Miles, Norman E.	Mesa	85208		Patio, Yard, Under Trailer	4,500.00
RC031	463 S. 98th Way	Morrison	Mesa	85208			Minor
RC030	464 S. 98th Way		Mesa	85208			Minor
RC032	502 S. 98th Way	Black	Mesa	85208		Water inside house	Minor
RC033	514 S. 98th Way		Mesa	85208			Minor
BR099	520 S. 98th Way	Lunt, Parley D.	Mesa	85208	986-6455	House, Med Supplies	715.00
BB005	544 S. 98th Way	Taft, Darell	Mesa	85208	986-9114	House, Yard, Car	20,000.00
BR071	549 S. 98th Way	Morin, George A.	Mesa	85208	986-4410	Structures, Fence, Yard	750.00
BR184	415 S. 99th Place	Markham, H.J.	Mesa	85208	986-3012	Yard, Erosion	640.00
BR186	419 S. 99th Place	Mulkey, E.R.	Mesa	85208		Yard	600.00
BR089	519 S. 99th Place	Candelaria, Tom	Mesa	85208	986-1398	House, Yard	1,120.00
BR052	538 S. 99th Place	Arment, Sidney, Sr.	Mesa	85208	984-2896	Trailer, Yard	1,376.45
BR105	543 S. 99th Place	Davis, Allan D.	Mesa	85208	986-0560	House, Workshop, Shed	1,371.00
BR042	550 S. 99th Place	Yutesler, Orval E.	Mesa	85208	984-3712	Car, Yard, Other	1,510.00
RC058	422 N. 99th Street	Byers, Scarlet	Mesa	85207	984-3678	1 inch water in House	Minor
BR046	429 S. 99th Street	McClelland, James P.	Mesa	85208	984-1840	Retaining Wall, Other	800.00
BR111	432 S. 99th Street	Squires, Cam	Mesa	85208		Lot, House	200.00
FC009	442 N. 99th Street	Byers, Scarlet	Mesa	85207	984-3678	House, Yard, Car	
010	320 N. 100th Way	Christensen, Mary	Mesa	85207	986-5742	House, Yard	
BR148	1520 N. 101st Street	Davis, Annie M.	Mesa	85207	986-0355	Yard	1,000.00
BR132	52 S. 101st Street	Frisbie, H.I.	Apache Junction	85220	984-3775	Yard	1,430.00
BR012	112 S. 101st Street	Starrett, George	Apache Junction	85220	986-2653	Driveway	500.00
BR043	420 N. 105th Street	Smith, Linda	Apache Junction	85220	984-1304	House	
BR098	336 N. 110th Street	Stevens, Marcella O.	Apache Junction	85220	986-0242	House, Yard	2,333.97
FC012	547 N. 111th Place	Wilfong, Mattie	Apache Junction	85220	986-3456	House	
FC011	110 N. 114th Street	Seeberger,	Apache Junction	85220	986-7436	House, Yard	
BR051	10013 E. Akron Street	Snyder, Royal C., Jr.	Mesa	85207	986-2154	House, Yard, Fence	548.00
FC016	9420 E. Apache Trail	Trekas, Charlie	Mesa	85207	964-7345	Yard	
RC034	10020 E. Apache Trail	Apt # 1	Apache Junction	85220		1 ft. muddy water	Minor
RC035	10020 E. Apache Trail	Apt # 2	Apache Junction	85220		1 ft. muddy water	Minor
RC036	10020 E. Apache Trail	Apt # 3	Apache Junction	85220		1 ft. muddy water	Minor
RC037	10020 E. Apache Trail	Apt # 4	Apache Junction	85220		1 ft. muddy water	Minor
BB006	10020 E. Apache Trail	Miller, Richard	Apache Junction	85220	969-6363	House, Apartments	210,000.00

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CLAIM NO.	ADDRESS	NAME	CITY	ZIP	TELEPHONE	TYPE DAMAGE	DAMAGE EST.($)
BR080	10020 E. Apache Trail	Mosher, Betty Apt#2	Apache Junction	85220	983-0525	House	580.00
BR120	10020 E. Apache Trail	RSV Enterprises	Apache Junction	85220	969-6367	Business (Rentals)	222,650.00
BR183	10020 E. Apache Trail	Swainston, James A.#2	Mesa	85208		Apartment	500.00
BR065	10104 E. Apache Trail	Josephson, George	Apache Junction	85220	986-7172	Business	53,550.00
BB007	10104 E. Apache Trail	Josephson, George	Apache Junction	85220	986-7172	Business (Steak House)	
BR045	10220 E. Apache Trail	Ambrose, Chet	Apache Junction	85220	986-3442	Yard, Shed, Other	1,136.00
BR163	10220 E. Apache Trail	Hendrickson, Frances	Apache Junction	85220	986-7390	Landscaping	1,500.00
BR162	10220 E. Apache Trail	Kehn, Dagney I. Sp.63	Apache Junction	85220	986-7390	House, Landscaping	
BR035	10444 E. Apache Trail	Crider,Painton,Bonnie	Apache Junction	85220	984-9626	Business	3,500.00
BB008	10540 E. Apache Trail	Barnum, Sue	Apache Junction	85220	832-2600	Shed, Fencing	
BR068	11198 E. Apache Trail	Parent, Evelyn L.	Apache Junction	85220		House, Gate, Ducklings	5,000.00
BR167	10153 E. Billings	Gowans, Andrew	Mesa	85207	984-1112	House, Rug	2,000.00
BR207	10043 E. Boise Street	Albrect, Fred J.	Mesa	85207		Yard, House, Other	2,000.00
BR202	10049 E. Boise Street	Secor, Violet	Mesa	85207		House, Yard	
BR062	10101 E. Boise Street	Buck, Richard	Mesa	85207	986-9545	House, Yard	540.00
BR156	9635 E. Boulder Ave.	O'Fallon, Joe	Mesa	85207	986-1872	Yard	1,000.00
BB010	9635 E. Boulder Ave.	O'Fallon, Joseph E.	Mesa		986-1872	Yard, Undermining	1,000.00
BR048	10001 E. Bramble Ave.	Perry, Rad	Apache Junction	85220	984-5451	House, Fence, Yard	
BR049	10002 E. Bramble Ave.	Scott, Sheril	Apache Junction	85220	984-6366	House, Yard, Fence	800.00
BR044	10039 E. Bramble Ave.	Tatum, Mike	Apache Junction	85220	986-3053	Fence, Car, Other	4,725.00
BR212	8001 E. Broadway Rd.	Pease, Robert	Mesa	85208		House	589.83
BB013	8001 E. Broadway Rd.	Bainum, Sue	Mesa	85208	832-2600	Fence, Other	
BR047	8001 E. Broadway Rd.	Blechschmidt, Oscar	Mesa	85208	984-1812	Lot	1,117.50
BR066	8001 E. Broadway Rd.	Ftn of the Sun Com Assoc.	Mesa	85208	832-1021	Business (Trailer Park)	1,743.12
BR129	8001 E. Broadway Rd.	Koblas, Frankling L.	Mesa	85208	986-3281	Yard, Undermining	150.00
BB011	8001 E. Broadway Rd.	Miller, R.W. (#50)	Mesa	85208		Yard, Pump, A.C.	774.00
BB012	8001 E. Broadway Rd.	Tillett, Sam	Mesa	85208	832-1021	Yard, Erosion	6,000.00
BR050	9252 E. Broadway Rd.	Bear, Fred	Mesa	85208	966-3198	Trailer Park	27,106.00
BR112	9825 E. Broadway Rd.	Vearner, Alice W.	Mesa	85208	984-2093	Erosion, Debris, Yard	1,492.40
BR152	9849 E. Broadway Rd.	Jones, Fred	Mesa	85208	984-4377	Yard, Shed, House	3,500.00
RC040	9925 E. Broadway Rd.	Bell, Harold	Mesa	85208		1 ft. water	Minor
BR142	9925 E. Broadway Rd.	Bell, Harold E.	Mesa	85208	986-6507	Yard, Fence, Skirting	2,480.00
RC039	9945 E. Broadway Rd.		Mesa	85208			Minor
BR225	9950 E. Broadway RD.	Miller, John B.	Mesa	85208		House	2,338.00
BR123	10052 E. Broadway Rd.	Martinez, Kathryn	Apache Junction	85220	986-3459	Apartment	446.00
BR189	10102 E. Broadway Rd.	Winn, Michael	Apache Junction	85220	984-4417	House, Yard, Fence, Drive	
BB014	10138 E. Broadway Rd.	Hilton, Edward	Apache Junction	85220	934-4417		
BB015	10138 E. Broadway Rd.	Hilton, Edward L.	Apache Junction	85220	984-4417	House, Fence, Other	10,000.00
BR041	10619 E. Broadway Rd.	West, Guy Michael	Apache Junction	85202	986-9442	Yard	500.00
BR181	9540 E. Brown Road	Scott, Lorrin	Mesa	85207		House, Yard, Road	50,380.00
FC017	5850 E. Butte	Butler, Bill	Mesa	85205	985-8665	Yard	
BR056	9814 E. Butte	Ferrall, Margaret	Mesa	85207	986-4416	Yard, Shed, Fish Pond	1,096.00
BR036	9822 E. Butte	Maker, Doris M.	Mesa	85207	986-4416	Yard	425.00
FC018	10106 E. Butte	Jungwirth, Karen	Mesa	85207	984-4734	House, Yard	

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CLAIM NO.	ADDRESS		NAME	CITY	ZIP	TELEPHONE	TYPE DAMAGE	DAMAGE EST.($)
FC028	9403	E. Cisco Road	Neidhart Enterprises	Mesa	85207	277-3363	House, Yard	
RC018	9403	E. Cisco Road	VACANT	Mesa	85207			Minor
FC027	9421	E. Cisco Road	Neidhart Enterprises	Mesa	85207	277-3363	House, Yard	
RC017	9421	E. Cisco Road	Shows, Denise	Mesa	85207		24" Water in House	Minor
BR143	9421	E. Cisco Road	Shows, Edward Earl	Mesa	85207	986-6162	House	30,000.00
BB018	9421	E. Cisco Road	Shows, Denise	Mesa	85207	986-6162	House, Car	15,000.00
BB022	9421	E. Cisco Road	Shows, Earl	Mesa	85207	986-6162	House, Other	30,000.00
FC026	9439	E. Cisco Road	Neidhart Enterprises	Mesa	85207	277-3363	House, Yard	
RC016	9439	E. Cisco Road	Peterson, Ron	Mesa	85207	968-4498	24" Water in House	Minor
BR193	9439	E. Cisco Road	Peterson, Ron	Mesa	85207		House	85.60
BB019	9439	E. Cisco Road	Peterson, Ronald	Mesa	85207	986-4498	House, Motorcycle, Other	20,000.00
RC015	9457	E. Cisco Road	Sparks, Wendell	Mesa	85207		20" Water in House	Minor
BR192	9457	E. Cisco Road	Sparks,, Wendell	Mesa	85207		House	96.30
BB020	9457	E. Cisco Road	Sparks, Wendell	Mesa	85207	984-5170	House, Yard, Car	
FC024	9501	E. Cisco Road	Neidhart Enterprises	Mesa	85207	277-3363	House, Yard	
RC014	9501	E. Cisco Road	Ramsey, Brad	Mesa	85207		6" Water in House	Minor
BR195	9501	E. Cisco Road	Ramsey, Brad	Mesa	85207		House	118.77
BB021	9501	E. Cisco Road	Ramsey, Bradley	Mesa	85207	986-8179	House	4,000.00
BR198	9503	E. Cisco Road	Neidhart Investment Co.	Mesa	85207		Sheetrock Walls, House	500.00
FC022	9503	E. Cisco Road	Neidhart Enterprises	Mesa	85207	277-3363	House, Yard	
BB016	9503	E. Cisco Road	Neidhart Enterprises	Mesa	85207	277-3363	House	5,000.00
RC013	9507	E. Cisco Road		Mesa	85207			Minor
FC023	9507	E. Cisco Road	Neidhart Enterprises	Mesa	85207	277-3363	House, Yard	
BR223	9507	E. Cisco Road	Sevland, Sherry	Mesa	85207		House	3,000.00
FC025	9547	E. Cisco Road	Neidhart Enterprises	Mesa	85207	277-3363	House, Yard	
BR178	7456	E. Crescent C.	Gerhard, Judith	Mesa	85208	985-6172	Property	125.00
BR090	230	N. Crismon Road	Thompson, Gilpin Renze	Mesa	85207	984-3525	Pool, Pool Filter	377.19
BR182	44	S. Crismon Road	Holien, Ray R.	Mesa	85208	986-6700	Mobile Home, Landscape	12,000.00
BR091	502	S. Crismon Road	Arnold, Robert G.	Mesa	85208	986-3287	House, Yard	2,619.60
BR128	510	S. Crismon Road	Woodard, Jim	Mesa	85208	986-0132	House, Car, TV	3,358.32
FC019	9350	E. Des Moines	Hernandez	Mesa	85207	984-3819	Yard	
FC034	9401	E. Des Moines	Neidhart Enterprises	Mesa	85207	277-3363	House, Yard	
RC082	9602	E. Edgewood		Mesa	85208		Yard, Trailer	Minor
RC085	9602	E. Edgewood	Moore, Jessie	Mesa	85208		Yard, Trailer	Major
RC083	9612	E. Edgewood	Devaux, Frank	Mesa	85208		Yard, Floor	Major
BR053	9618	E. Edgewood	Burgett, Willard D.	Mesa	85208	984-6649	Yard, Crawl Space	650.00
RC084	9624	E. Edgewood	Brown, Gale	Mesa	85208		Yard	Minor
RC086	9642	E. Edgewood	Kujacynski	Mesa	85208		Trailer	Minor
RC087	9648	E. Edgewood	Wade, Paul R.	Mesa	85208		Trailer	Minor
BR155	9655	E. Edgewood	Jamison, Elmer H.	Mesa	85208	986-9925	Yard	2,000.00
RC088	9660	E. Edgewood	Dumont, David	Mesa	85208		Yard, Trailer	Minor
BR158	9660	E. Edgewood	Dumont, David S.	Mesa	85208	986-4001	Mobile Home, Landscape	4,000.00
BR185	9701	E. Edgewood	Atlick, Ernest E.	Mesa	85208	984-5359	Yard, Insulation	
BR021	9724	E. Edgewood	McConnahan, John	Mesa	85208	986-9128	Septic Tank	210.00
BR218	9731	E. Edgewood	Salter, Donald D.	Mesa	85208		Yard	400.00

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CLAIM NO.	ADDRESS	NAME	CITY	ZIP	TELEPHONE	TYPE DAMAGE	DAMAGE EST.($)
BR224	9736 E. Edgewood	Carpenter, Jocelyne H.	Mesa	85208	986-8503	Yard, Skirting, Undermine	3,078.19
BR216	9741 E. Edgewood	Rubendell, E.L.	MEsa	85208		Yard	400.00
BR085	606 N. Ellsworth	Enfield, Alford J.	Mesa	85207	986-0789	House, Yard, Driveway	1,800.00
BR222	652 N. Elldworth	Enfield, A. Denton	Mesa	85207		Yard, Driveway	805.00
FC020	937 N. Ellsworth	Varhue, Walter	Mesa	85207	984-2423	Yard, Pool	
BR209	1452 S. Ellsworth	Valle Del Oro RV Resort	Mesa	85208		Business (RV Resort)	360,000.00
BB023	1452 S. Ellsworth	Williams, Jim	Mesa	85208	(619)481-5607	Business (Trailer Park)	250,000.00
BR214	203 S. Elmont	Brown, Ethel, J.	Mesa	85208	984-2326	Yard	500.00
BR159	7601 E. Emelita	Hazelton, Luther	Mesa	85208	986-0171	House, Carpet	461.00
FC021	7601 E. Emelita	Hazelton, Luther	Mesa	85208	986-0171	House	
BR070	9401 E. Emelila	Ocepek, Anthony	Mesa	85208	986-2660	House, Yard	6,368.11
BR113	9461 E. Emelita	Lewis, Sylvia	Mesa	85208		Erosion, Yard	300.00
BR171	9515 E. Emelita	Rawlings, Jerry	Mesa	85208		House, Yard	1,550.00
BR165	9516 E. Emelita	Steffey, Chalmer L.	Mesa	85208	986-9672	Landscape, Air Condition	1,621.00
BR018	9405 E. Escondido St.	Emmons, Leo A.	Mesa	85208	986-3770	Yard, Undermining	200.00
BR190	9436 E. Escondido	Miller, Alvin R.	Mesa	85208		Water Damage	2,950.18
BR084	846 S. Esperanza	Lee, Billy E.	Mesa	85208	986-4208	Yard	200.00
BR117	926 S. Esperanza	Bartsch, Walter	Mesa	85208		Lot	2,000.00
BR116	926 S. Esperanza	Scrutchfield, Louise	Mesa	85208		Erosion	500.00
BR115	952 S. Esperanza	Dodds, Leslie	Mesa	85208		Lot, Yard	3,000.00
FC035	8349 E. Euclid	Longstreet, Hazel	Mesa	85208	986-6334	House, Undermining	
BR100	857 S. Evangeline	Johnson, Carl	Mesa	85208	986-5408	Yard	140.00
BR153	858 S. Evangeline	Wagner, Maurice	Mesa	85208	986-5408	Yard, Patio	300.00
BR154	865 S. Evangeline	Loomer, Wayne L.	Mesa	85208	986-5408	Yard	100.00
BR069	933 S. Evangeline	Fisher, John N.	Mesa	85208	986-9266	Yard	1,315.39
BR103	943 S. Evangeline	Harriman, Earle W.	Mesa	85208	986-9770	Yard, Fence Undermining	165.00
BR027	9633 E. Frito Ave.	Pope, Vernon L., Jr.	Mesa	85208	986-4797	Yard	72.71
IE001	319 E. Glenmar	Curley	Mesa	85208		Landscape, Water in House	
BB024	201 S. Glenmar Road	Glenney	Mesa		986-3853	House	
FC036	337 S. Glenmar Road	Caza, Duane	Mesa	85208	833-4676	House	
BR092	347 S. Glenmar Road	Loveall, Lee Roy	Mesa	85208	986-1297	House, Pool, Yard	997.26
BR036	8701 E. Hazel Drive	Sischo, Stuart D.	Mesa	85208	894-2165	House, Yard	4,541.00
BR015	8733 E. Hazel Drive	Johnson, Marvin W.	Mesa	85208	986-3431	Yard	
BR082	Houston & Delaware	Junker, Robert L.	Apache Junction	85220	983-0216	House, Erosion	150,000.00
BR011	10111 E. Illini	Lynch, John L.	Apache Junction	85220	986-3387	Yard, Fence	7,500.00
FC038	10111 E. Illini	Lynch, John L.	Apache Junction	85220	986-3387	Yard	
BR029	10122 E. Illini	Hust, John O. (#5)	Apache Junction	85220	986-4004	House, Yard	145.00
BR033	10122 E. Illini	Wonders, John (#6)	Apache Junction	85220	986-4004	Yard	2,125.00
BR061	7735 E. Inverness	Miller, Robert W.	Mesa	85208	984-5013	Yard	1,400.00
BR122	7736 E. Inverness	Liarakos, Charles	Mesa	85208	986-1316	House, Yard	
BR057	7740 E. Inverness	Nichols, Don J.	Mesa	85208	986-0294	House, Yard	6,373.54
BR133	7816 E. Inverness	Wisniewski, LeRoy C.	Mesa	85208		Yard	2,950.00
BR199	7824 E. Inverness	Nobles, William H. Jr.	Mesa	85208	986-8907	House, Shed, Yard	19,400.00
BB026	7824 E. Inverness	Noble, William	Mesa	85208	986-8907	House, Other	12,000.00
RC043	7824 E. Inverness	Noble, William	Mesa	85208	986-8907	Water & Mud	Minor

CLAIMANT LISTING
STORM/FLOOD OF JULY 17-18, 1984
DATE OF LIST - OCTOBER 3, 1984

TABLE 3-1
SHEET 8

CLAIM NO.	ADDRESS	NAME	CITY	ZIP	TELEPHONE	TYPE DAMAGE	DAMAGE EST.($)
BB025	7832 E. Inverness	Smith, Edward	Mesa	85208	986-9493	House, Yard, Undermining	9,000.00
RC044	7832 E. Inverness	Smith, Edward	Mesa	85208		Water & Mud	Minor
RC003	7836 E. Inverness	Quinlan, James J.	Mesa	85208			
BR168	7836 E. Inverness	Quinlan, James J.	Mesa	85208	986-9966	Home, Furniture, Cloths	3,300.00
BR039	7839 E. Inverness	Fajardo, Cornelio	Mesa	85208	967-5456	House, Undermining	4,510.00
RC045	7840 E. Inverness	Arnold, Maureen	Mesa	85208		Water	Minor
RC046	7844 E. Inverness	Tickle, Gilbert	Mesa	85208		Water & Mud	Minor
BR032	7849 E. Inverness	Burnside, Charles	Mesa	85208	986-3992	Yard	1,200.00
RC047	7904 E. Inverness	Milaneck	Mesa	85208		Mud & Water	Minor
RC048	7908 E. Inverness		Mesa	85208		Water & Mud	Minor
RC049	7912 E. Inverness		Mesa	85208		Water & Mud	Minor
BR131	7918 E. Inverness	Gaddis, Charles A.,Jr.	Mesa	85208	984-2526	House	7,763.10
RC050	7918 E. Inverness	Gaddis, Charles	Mesa	85208		Water & Mud	Minor
RC051	7922 E. Inverness	Pikor, Charles	Mesa	85208		Water & Mud	Minor
BR076	7915 E. Javelina	Cummins, Wesley Glenn	Mesa	85208	984-4300	Yard, Undermining	1,600.00
RC056	10101 E. Jones Ave.	Watson	Apache Junction	85220		Several Inches Water	Minor
BR023	10101 E. Jones Ave.	Watson, Nathan	Apache Junction	85220	984-5408	House, Yard, Other	30,000.00
RC055	10114 E. Jones Ave.		Apache Junction	85220			Minor
RC054	10125 E. Jones Ave.	Danks	Apache Junction	85220			Minor
RC053	10144 E. Jones Ave.		Apache Junction	85220			Minor
RC052	10155 E. Jones Ave.	Garnagia	Apache Junction	85220		Muddy Water	Minor
RC001	7807 E. Juanita	Poyner, Richard	Mesa	85208			
BR107	5402 E. Main Street	Djekic, Ratibor	Mesa	85205		Business (Apts.)	
BR170	9631 E. Mason Way	Pennington, Gale	Mesa	85207	986-6437	House, Yard	2,579.68
FC041	8117 E. McDowell	Facey, Robert	Mesa	85207	986-5885	Yard, Erosion	
BR013	44 N. Mountain Rd.	Ellis, Cheryl L.	Apache Junction	85220	984-4839	Apt.	2,657.00
RC041	44 N. Mountain Rd.	Ellis, Vera	Apache Junction	85220		4 ft. Water & Mud	Minor
BR104	44 N. Mountain Rd.	Holt, Frances	Apache Junction	85220	984-5495	House	1,800.00
RC042	44 N. Mountain Rd.	Williams, Dennis	Apache Junction	85220		4 ft. Water & Mud	Minor
FC042	8701 E. Myrtle	Fuller, Chris	Mesa	85208	986-5178	House	
BR028	8701 E. Myrtle	Fuller, Chris	Mesa	85208	986-5178	Yard, Fence	3,000.00
BR121	8733 E. Myrtle	Mason, Genevieve	Mesa	85208	986-0069	Yard	125.00
BR093	8735 E. Pueblo	Robertson, Gary B.	Mesa	85208	984-2992	House, Camper, Yard	2,301.92
BR175	9307 E. Pueblo	Williams, Raymond W.	Mesa	85208	986-7861	Landscaping, Fence	700.00
BR188	9327 E. Pueblo	Posh, Michael	Mesa	85208		Yard, Air Cond., Other	
BR119	9333 E. Pueblo	Dixon, Clarence T.	Mesa	85208	1-333-4962	Yard	3,000.00
BR017	9401 E. Pueblo	Robison, Frank	Mesa	85208	986-2475	Yard, Undermining	400.00
BR014	9423 E. Pueblo	Hattley, Wiley	Mesa	85208	986-3629	House, Yard	500.00
BR058	9447 E. Pueblo	Logue, Bernice R.	Mesa	85208	986-9263	Undermining, Yard	78.00
BB027	9820 E. Pueblo	Ryan, Ed	Mesa	85208	982-3327	Grading	
BR172	9828 E. Pueblo	McMillan, John	Apache Junction	85220	982-2500	Mobile Home Park	20,000.00
IE002	10202 E. Pueblo	Archer, E.	Mesa	85208		Flooding in House	
FC043	11137 E. Pueblo	Reggle, Don	Apache Junction	85220	986-9768	Yard	
BB023	9224 E. Quarterline	Mendoza, Bridget	Mesa	85207	984-1086	House, Other	
RC061	9224 E. Quarterline	Mendoza, Benny	Mesa	85207	984-1086	10" Water in House	Minor
BB009	9234 E. Quarterline	Reece, Reuben	Mesa	85207	984-2561	House	1,500.00

CLAIMANT LISTING
STORM/FLOOD OF JULY 17-18, 1984
DATE OF LIST - OCTOBER 3, 1984

TABLE 3-1
SHEET 9

CLAIM NO.	ADDRESS	NAME	CITY	ZIP	TELEPHONE	TYPE DAMAGE	DAMAGE EST.($)
RC059	9234 E. Quarterline	Reece, Reuben	Mesa	85207	984-2561	18" Water in House	Minor
BR169	9244 E. Quarterline	Christman, Kelly	Mesa	85207	986-0394	House, Yard	923.00
RC060	9244 E. Quarterline	Christman, Kelly	Mesa	85207		2 inches Water in House	Minor
BR020	9502 E. Quarterline	Hollands, Arthur	Mesa	85207	986-9472	Yard	
RC057	9911 E. Quarterline	Levesque, Rectio	Mesa	85207		1 inch Water	Minor
BR063	9328 E. Sleepy Hollow	Timmer-Bowser, Susan	Mesa	85207	986-0116	House, yard, Shed, Fence	2,265.00
BR024	9340 E. Sleepy Hollow	Miller,Harvey L., Jr.	Mesa	85208	986-6560	House	2,000.00
BR077	1939 S. Sossamar Dr.	Puch, Norman	Mesa	85208	832-6300	House, Yard	8,000.00
BR001	9200 S. Southern	Olson, Darren F.	Mesa	85208	986-0520	Car Submerged	
BR031	9520 E. Sunland Ave.	Slate, William C.	Mesa	85208	986-5962	House, Undermining	1,800.00
BR095	9530 E. Sunland Ave.	Davis, Wilbert J.	Mesa	85208	986-8122	Equip.,Undermining, Yard	2,262.12
BR146	9613 E. Sunland Ave.	Buell, Gilbert M.	Mesa	85208	986-9830	Undermining, Yard	850.00
BR087	4065 E. University	Geis, Esther M.	Mesa	85205	830-8710	Undermining	567.03
FC040	7736 E. University	Liarakos, Charles	Mesa	85207	986-1316	House	
FC039	7840 E. University	Arnold, Maureen	Mesa	85207	984-6317	House, Yard	
BR081	9333 E. University	Turner, A.E.	Mesa	85207	986-0904	Business (Trailer Park)	9,762.00
BB029	9415 E. University	Ryan, Ed	Mesa	85207	982-3327	Grading	
RC062	9427 E. University	Bryant	Mesa	85207			Minor
BR174	9427 E. University	White, James	Mesa	85207	986-2270	Mobile Home Park,Landscape	7,500.00
BR073	9427 E. University	Jarvis, Arthur	Mesa	85207	984-5790	Business, (Trailer Park)	15,711.00
BR127	9821 E. University	Sauer, Marjorie K.	Mesa	85207	839-2952	House, Yard	645.00
BR072	11101 E. University	Timms, Margaritte	Apache Junction	85220	984-4797	Yard	800.00
BR200	15423 E. Williams Field	Dikes, Irene Bliss	Gilbert	85234	981-9577	House, Pool Motor	967.50
RC063	10112 E. Wood Avenue	Warner	Apache Junction	85220		4 to 3 Feet of Water	Major
BR010	10112 E. Wood Avenue	Warren, Reginald	Apache Junction	85220	984-6484	House, Pers Property	
RC064	10118 E. Wood Avenue	Vogt	Apache Junction	85220		1 to 3 Feet of Water	Major
BB030	10118 E. Wood Avenue	Vogt, Ed	Apache Junction	85220	986-6713	House, Other	
RC065	10126 E. Wood Avenue		Apache Junction	85220		Water	Minor

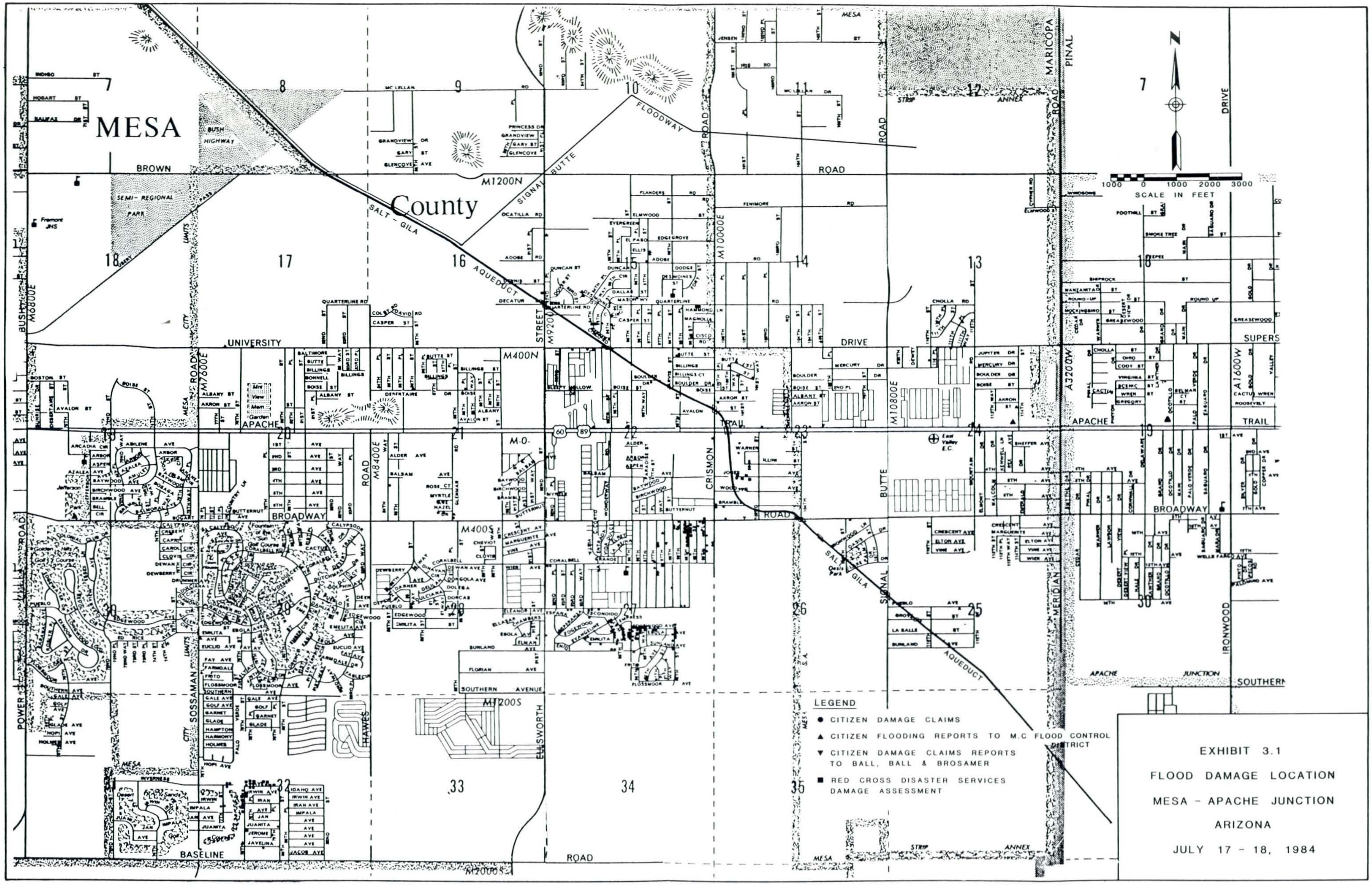


EXHIBIT 3.1

FLOOD DAMAGE LOCATION

MESA - APACHE JUNCTION

ARIZONA

JULY 17 - 18, 1984

The damages shown in Table 3-1 are those taken from the claim forms. No attempt was made to verify the amount or degree of damages.

Damages are not totalled because, in some cases, duplicate and revised claims have been submitted. An example is the property at 1452 S. Ellsworth in Table 3-1. In addition, some claims are not in the study area associated with Reach 1B. The claim at Houston and Delaware, which is associated with Reach 2, is an example.

Table 3-1 also includes duplicate reports made by the same individual to different agencies. Again, the property at 1452 S. Ellsworth is an example. In several instances both owners and tenants filed claims at the same address. The Red Cross reports classified damage as minor, major or destroyed. Minor implies that damage is such that family may have to leave the house for one or two days at most. Major implies that family may have to leave the house from 2 weeks to 2 months.

The data accumulated as part of this effort were valuable in the conduct of the study. The plot of damage locations indicated paths of flow and also areas of flooding in which investigations could be concentrated. The list in Table 3-1 provided names of witnesses who could be interviewed. Several locations for which large claims were filed were investigated to determine the cause of the flooding.

CHAPTER 4
ANALYSIS OF RUNOFF FLOWS

4.1 GENERAL

The runoff and flooding event of July 17-18, 1984 is described for the tributary drainage basin lying to the northeast of the CAP Reach 1B alignment and for the flooded areas to the southwest. A mathematical runoff model was developed for the basin northeast of the alignment. No model was formulated for the southwest area because the floodplain would be difficult to describe in mathematical terms, since natural drainage channels are interrupted by streets, developments, walls, and drainage ditches.

4.2 TRIBUTARY DRAINAGE SUB-BASINS

The terrain to the northeast of Reach 1B was divided into tributary drainage sub-basins as shown on Exhibit 4-1. The runoff from each will be conveyed over the aqueduct by one or two overchutes. Exhibit 4-1 also shows the stations of the overchute structures. The sub-basins between the Buckhorn-Mesa Flood Protection Works and the CAP alignment correspond to those used for the original design of the overchutes. Each sub-basin is oriented in a northeast-southwest direction with drainage flow toward the southwest. The boundaries of each were extended above the Flood Protection Works to the upper limits of the basin. The sub-basins between the CAP and the Flood Protection Works are numbered 1A through 10A.

The tributary sub-basins to overchutes at Stations 427+15 and 429+20 near Apache Trail crossing are areas 4A, 4B and 4D. Area 4A is the portion of the drainage area which has the Signal Butte Floodway as a northern limit. Area 4B has the proposed Signal Butte Dam as a northern limit. After construction of Signal Butte Dam, the tributary area to the two overchutes will be 4A plus 4B. A tabulation of areas and other pertinent data is given in Table 4-1.

EXHIBIT 4-1

SALT-GILA AQUEDUCT

REACH 1B TRIBUTARY DRAINAGE BASINS

JULY 17-18 STORM ISOHYETAL

(SEE ENVELOPE IN BACK OF REPORT)

TABLE 4-1

DRAINAGE SUB-BASIN CHARACTERISTICS

Sub-Basin	Drainage Area (sq. mi)	Time of Concentration (hrs)	Average Precipitation (in.) July 17, 1984 Storm	Average Precipitation (in.) Design Storm
1A	0.40	0.62	2.73	2.73
2A	0.87	0.66	2.83	2.73
2B	1.63	0.81	2.45	2.73
3A	0.76	0.69	2.34	2.73
3B	0.19	0.43	2.75	2.73
4A	0.34	0.97	2.42	2.73
4B	1.04	1.46	2.40	2.73
4C	3.81	0.87	2.61	2.73
4D	3.84	0.62	2.61	2.73
5A	1.67	1.59	2.30	2.73
5B	1.31	0.79	1.95	2.73
6A	2.28	1.32	2.20	2.73
6B	2.02	0.73	1.45	2.73
7A	3.17	1.68	2.01	2.73
7B	3.18	1.03	0.75	2.73
8A	4.06	2.40	1.84	2.73
8B	1.93	1.39	0.45	2.73
9A	0.66	1.33	1.90	2.73
10A	0.19	0.36	2.38	2.73

4.3 RAINFALL ISOHYETAL

A portion of the isohyetal of the thunderstorm that occurred during the night of July 17-18 is included on Exhibit 4-1. This isohyetal was developed by the Maricopa County Flood Control District with rain gage data from eleven stations. Gage locations and readings in inches are also shown on Exhibit 4-1. A radar observation of the storm, made at Sky Harbor Airport in Phoenix at 2250 hours on July 17, 1984, was used for orientation of the isohyetal. Two additional rain gage readings by area residents were obtained during IECO staff field trips. These are shown in brackets on Exhibit 4-1. A. E. Turner at 9333 E. University Drive reported 3.9 inches of rainfall for the storm, and R. Robinson at 902 S. 96th Street reported 2.0 inches. Neither of these readings was incorporated into the isohyetal; however, both seem reasonable and tend to verify the pattern.

The duration of the storm was approximately from 2230 hours on July 17 to 0130 hours on July 18. A mass curve developed by SCS hydrologists is shown on Exhibit 4-2.

The frequency of the July 17-18 rainstorm is not addressed in this report, since the event of primary concern is not rainfall but the peak discharge of the outflow hydrograph at the outlets of the drainage basins along the alignment of Reach 1B. Portions of drainage areas 2A, 3A, and 4D were subjected to a 3-hour rainfall greater than 2.73 inches, the 100-year, 3-hour thunderstorm precipitation used for design of the Reach 1B overchutes. This is evidenced by rain gage readings. Parts of areas 2B, 3B, 4A, and 4C may also have received more than 2.73 inches, depending on actual rainfall distribution. Table 4-1 shows average precipitation for each of the the sub-basins, based on the assumed isohyetal. In four sub-basins, 1A, 2A, 3A and 3B, the average precipitation equalled or exceeded 2.73 inches.

MASS CURVES

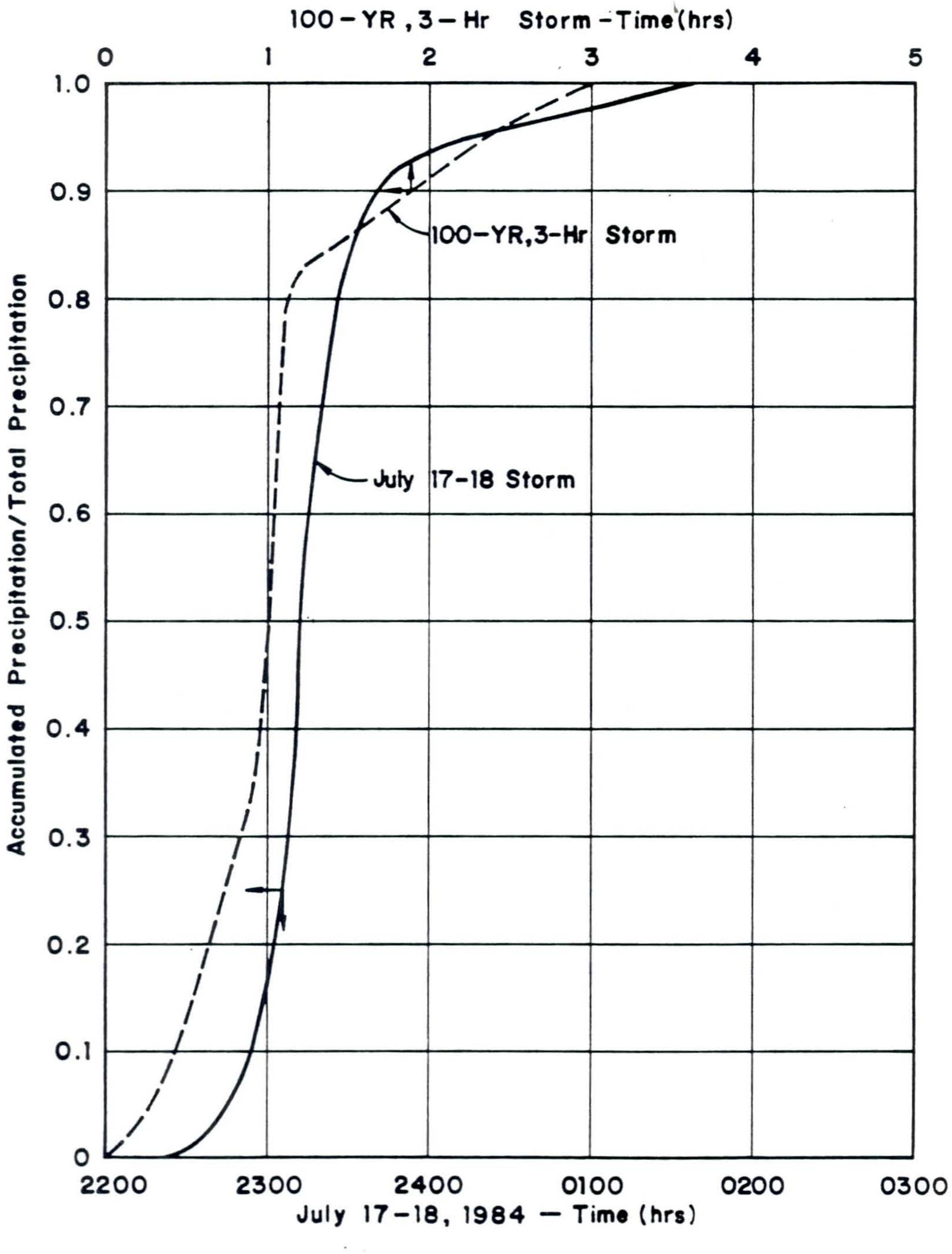


EXHIBIT 4–2

4.4 RUNOFF MODEL

The runoff model was developed to estimate discharge hydrographs at the outlets of tributary drainage basins for the four cases described below:

I) The facilities and tributary drainage basins that existed on July 17, 1984.

II) The facilities and tributary drainage basins that will exist in the interim period between completion of construction of Reach 1B and the completion of the Buckhorn-Mesa Flood Protection Works.

III) The facilities and tributary drainage basins that will exist after the completion of the Buckhorn-Mesa Flood Protection Works.

IV) The facilities and tributary drainage basins that would have existed on July 17, 1984 if Reach 1B had not been constructed.

Two storm events were considered, the one represented by the July 17-18 isohyetal and the other a 100-year, 3-hour thunderstorm that was used for design of overchutes and other drainage facilities in Reach 1B. The July storm was used for Cases I and IV, the 100-year event was used for Cases II and III.

Chapter 4 presents the description and formulation of the model and its application for Case I. The application for Cases II and III, and for Case IV will be discussed in Chapters 7 and 6, respectively, of this report.

A. Description of Model

The model used in this study is the HEC-1, Flood Hydrograph Package, developed by the U.S. Corps of Engineers Hydrologic Engineering Center. This model simulates the rainfall-runoff process for a particular watershed or stream network. Capabilities of the program include:

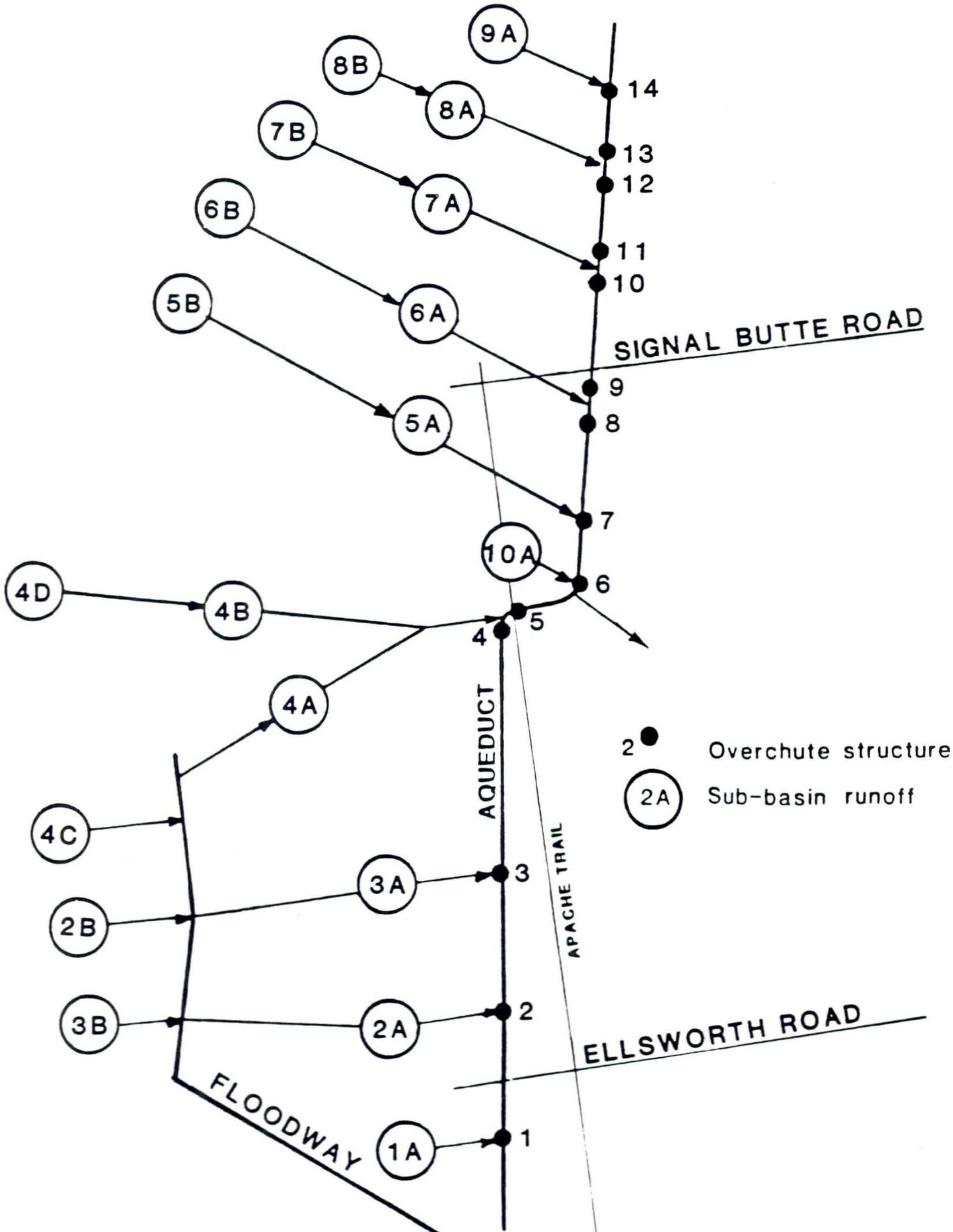
- computation of net precipitation
- derivation of unit hydrographs for each sub-basin
- computation of runoff from a rainfall event
- channel and reservoir routing
- simulation of dam breaks.

For the purpose of the flood studies, the area north of the CAP alignment was divided into several sub-basins, as described previously. Using HEC-1, individual sub-basin unit hydrographs were developed, flood hydrographs computed and systematically combined with other appropriate sub-basin flood hydrographs to obtain the total inflow flood hydrographs at several locations along the aqueduct. These locations correspond generally to drainage overchutes that will be considered as part of the project. A schematic diagram of the model and its components is shown on Exhibit 4-3.

Recorded data, serving as a basis for derivation of unit hydrographs and time of concentration for tributary areas, were not available. Therefore, synthetic unit hydrographs for each sub-basin were derived using the U.S. Soil Conservation Service (SCS) dimensionless unit hydrograph approach. The parameters required for defining a SCS unit hydrograph for any location are time to peak and peak discharge rate.

The time to peak is a function of a basin's time of concentration and the computation interval, and is computed as:

SCHEMATIC DIAGRAM
CASE I



$$Tp = \frac{D}{2} + 0.6\ Tc$$

where Tp = time to peak in hours,
D = duration of rainfall excess in hours,
Tc = time of concentration in hours.

The time of concentration is estimated using the following equation:

$$Tc = \left(\frac{11.9\ L^3}{H}\right)^{0.385}$$

where Tc = time of concentration in hours,
L = length of longest stream in miles,
H = difference in watershed elevation in feet.

Basin characteristics such as stream lengths and elevations were measured on available USGS 7.5 minute topographic maps. The stream lengths were increased by ten percent to account for stream bends. Time of concentration for each individual sub-basin is tabulated in Table 4-1.

The peak discharge of the unit hydrograph is estimated by the SCS method using:

$$Qp = \frac{484A}{Tp}$$

where Qp = peak discharge in cfs
A = drainage area in square miles, and
Tp = time to peak in hours.

The number 484 is a constant for converting the peak discharge into cfs, assuming that the time base of the unit hydrograph is approximately 2.67 times that of the time to peak. This generalized average value is recommended by SCS for ungaged watersheds.

Rainfall excess, that portion of rainfall that becomes direct runoff, is computed by deducting the following losses from the total rainfall amount: retention losses from the soil cover, detention and evapotranspiration losses from vegetal cover, and infiltration losses into the ground. In this case study, the SCS Curve Number (CN) method was used to estimate rainfall excess. The curve number for an area reflects the hydrologic properties of the soil cover, the existing (and future, if necessary) land use and vegetal cover of the area, and the moisture condition of the soil prior to the start of the storm event. Based on aerial photographs, field reconnaissance, and engineering judgement, an average SCS Curve Number (CN = 80) was used for the tributary area.

Two rainfall events were considered: the July 17-18 storm described in Section 4.3 above, and a 100-year 3-hour storm used by the Bureau for design of the overchutes and drainage structures. The design storm was developed by the Bureau using the procedures and data presented in "NOAA Atlas 2, Precipitation-Frequency Atlas of the Western United States, Volume III - Arizona". Rainfall increments were then arranged to produce the 3-hour event. Total rainfall for the design storm is 2.73 inches and the rainfall distribution is shown on Exhibit 4-2.

4.5 MODEL FORMULATION FOR CASE I

The basic model described in Section 4.4 above is modified by incorporation of the Signal Butte Floodway and the Salt-Gila aqueduct prisms of Reaches 1A and 1B. During the July 17-18 storm, runoff from the sub-basins above the floodway entered that facility. Because the outlet was plugged, the prism filled and discharged over the south berm and through small vegetative outlets to sub-basins 2A, 3A, and 4A. Reaches 1A and 1B are included because the runoff from the entire tributary area to the north enters the prism at several locations along the aqueduct. Both reaches act as reservoirs to store runoff, and Reach 1B also acts as a conveyance.

A. Floodway

Inflow to the Signal Butte Floodway consists of flow from sub-basins 2B, 3B, and 4C. The total drainage area contributing runoff into the floodway is 5.68 square miles. Flows enter the floodway through several inlet structures along the north edge. Because of the plug located at Station 95+100, the floodway acts as a storage reservoir.

A profile of floodway south berm elevations and high-water levels is shown on Exhibit 4-4. These measurements were made by SCS staff. The high-water levels are elevations of maximum high-water marks found on the north floodway berm.

Three major outflows were assumed to have occurred, the largest occurring between the plug at Station 95+00 and Crismon Road Crossing at Station 71+69. Depth of flow ranged between 0 and 0.7 ft as shown on Exhibit 4-4.

A second outflow occurred near the east side of the Crismon Road crossing between Station 71+69 and Station 50+00. Depth of flow ranged between 0 and 0.4 feet.

A third outflow occurred between the beginning of the floodway and Station 25+00.

The peak discharge of each vegetative outlet was estimated at 8.5 cfs, and has been included in the releases to the respective sub-basins.

There were three contractor-initiated breaches in the south berm. These are not included in the model as they did not occur until the morning of July 18.

The model results indicate that the outflows from the floodway are higher than can be justified by the evidence shown on Exhibit 4-4. A total floodway peak outflow of 3458 cfs occurring at 2353 hours was

SIGNAL BUTTE FLOODWAY
BERM AND HIGHWATER ELEVATIONS
JULY 17-18, 1984

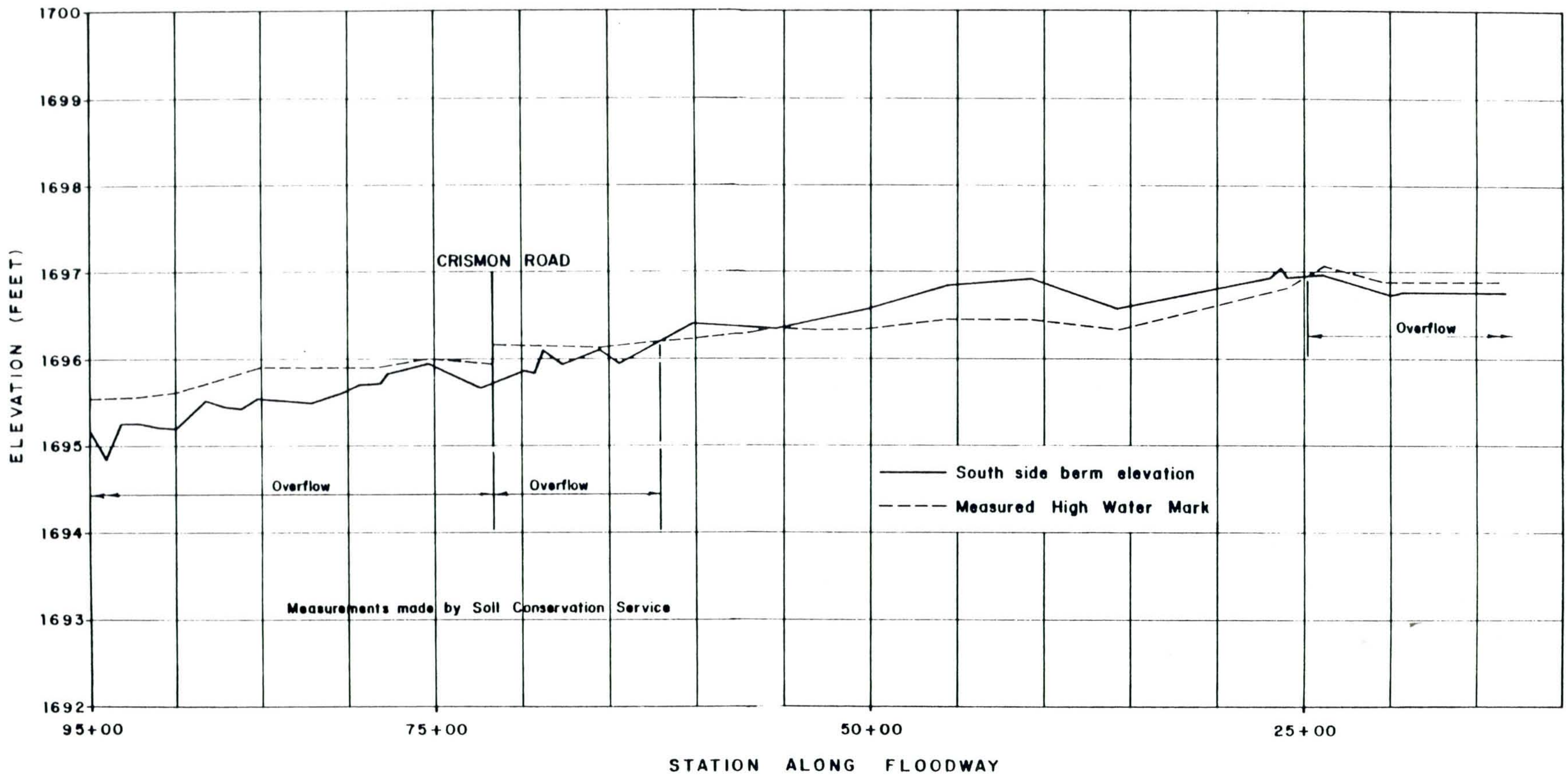


EXHIBIT 4-4

computed by the model, as shown on Table 4-2. The maximum overflow depth along the length of the berm was estimated to be approximately 0.14 feet higher than that shown on Exhibit 4-4. It should be noted that the outflow calculations are sensitive to small variations in head because of the low depths of flow over the floodway berm. The peak outflow is also directly related to the estimated peak inflow, which is highly dependent on watershed characteristics, such as time of concentration and retention loss rates. The use of the SCS dimensionless unit hydrograph is also a major factor in the determination of the inflow hydrograph.

Further investigations indicated that the model analyses were not particularly sensitive to the total outflow from the floodway. More than half of the outflow went into dead storage in Reaches 1A and 1B, and did not leave the aqueduct prism. Therefore, a reduction of estimated maximum outflow from 3458 cfs to a lesser value was not justified for Case I.

TABLE 4-2

SIGNAL BUTTE FLOODWAY OUTFLOWS

JULY 17-18

Location of Overflow	Spill Into Sub-Basin	Discharge (cfs)	Discharge (ac-ft)
95+00 - 71+59	2A	2429	144
71+59 - 50+00	3A	501	30
25+00 - end	4A	528	31

B. Conveyance and Storage in the CAP

Reach 1B served both as a regulating reservoir and as a conveyance for storm runoff. Flows entered the aqueduct at several locations. These were identified in the discussions of the separate drainage areas above. Table 4-3 summarizes the peak discharges and volumes computed for the inflow hydrographs. Points of entry are tabulated in Table 4-4 along with other pertinent information.

TABLE 4-3

CASE I

JULY 17-18, 1934

DISCHARGE HYDROGRAPHS

Drainage Area	Tributary Sub-basins	Drainage Area (sq mi)	Discharge Peak (cfs)	Discharge Volume (ac-ft)	Time of Peak (hrs)
1	1A	0.40	321	22	2342
2	*2A	0.87	1364	192	0018
3	*3A	0.76	618	77	2342
4	*4A+4B+4D	5.72	2670	320	0018
5	5A+5B	2.98	776	104	0024
6	6A+6B	4.30	757	112	0030
7	7A+7B	6.35	685	100	0024
8	8A+8B	5.99	525	100	0054
9	9A	0.66	148	13	0012
10	10A	0.19	145	3	2336

* Includes outflow from the floodway.

TABLE 4-4

RUNOFF ENTRY LOCATIONS

REACH 1B

Station or Location	Tributary Areas	Comments
345+30	1A+2A*	Flow through overchute excavation in north berm
Between 363± and 385±	2A*	See Note A below
University Dr. Crossing	2A*	Flow around abutments of crossing and entry from collector ditch
396+40	3A+4A+4B**	Flow around abutments of partially completed overchute
427+15 and 429+20	4A+4B+4D***	Flow from washes through breached contractor-placed dikes on north berm of aqueduct
456+50	4A+4B+4D+5A+5B+10A***	Flow through overchute excavation in north berm
471+03	5A+5B	Flow through partially completed overchute
479+00	6A+6B	Flow through partially completed overchutes
504+25	6A+6B	Flow through overchute excavation in north berm

NOTES:

A. It appears that elevation of top of the north berm in this area is roughly 1574 and that it probably acted as a skimming weir discharging into the aqueduct prism over a very long length but with a very small head.

* Signal Butte Floodway outflow entered sub-area 2 A.

** Signal Butte Floodway outflow entered sub-areas 3A and 4A.

*** Signal Butte Floodway outflow entered sub-area 4A.

Five contractor-built dikes had been placed in Reach 1B for construction access from one side to the other. The dikes acted as flow barriers in the reaches. Elevation of the dike tops before the storm were not available. Elevations of the tops of the dikes after the storm were estimated from photographs. A schematic showing the dike locations, assumed top elevations and estimates of high-water levels is shown on Exhibit 4-5.

The water that entered upstream of the dike at University Drive crossing went into dead storage in Reaches 1A and 1B. The maximum level upstream of the dike was at El. 1556, as evidenced by high-water marks at the pumping plant at the beginning of the reach. A maximum storage volume of 175 ac-ft was calculated. Water that entered between Stations 384+00 and 435+50 first went to filling the spaces between the four dikes. As the dikes overtopped and eroded, a surcharge was built up. Water flowed over both the upstream and downstream dikes. As the inflows decreased, the water level in the pools between the dikes dropped to an elevation equal to that of the top of the lowest of the encompassing dikes.

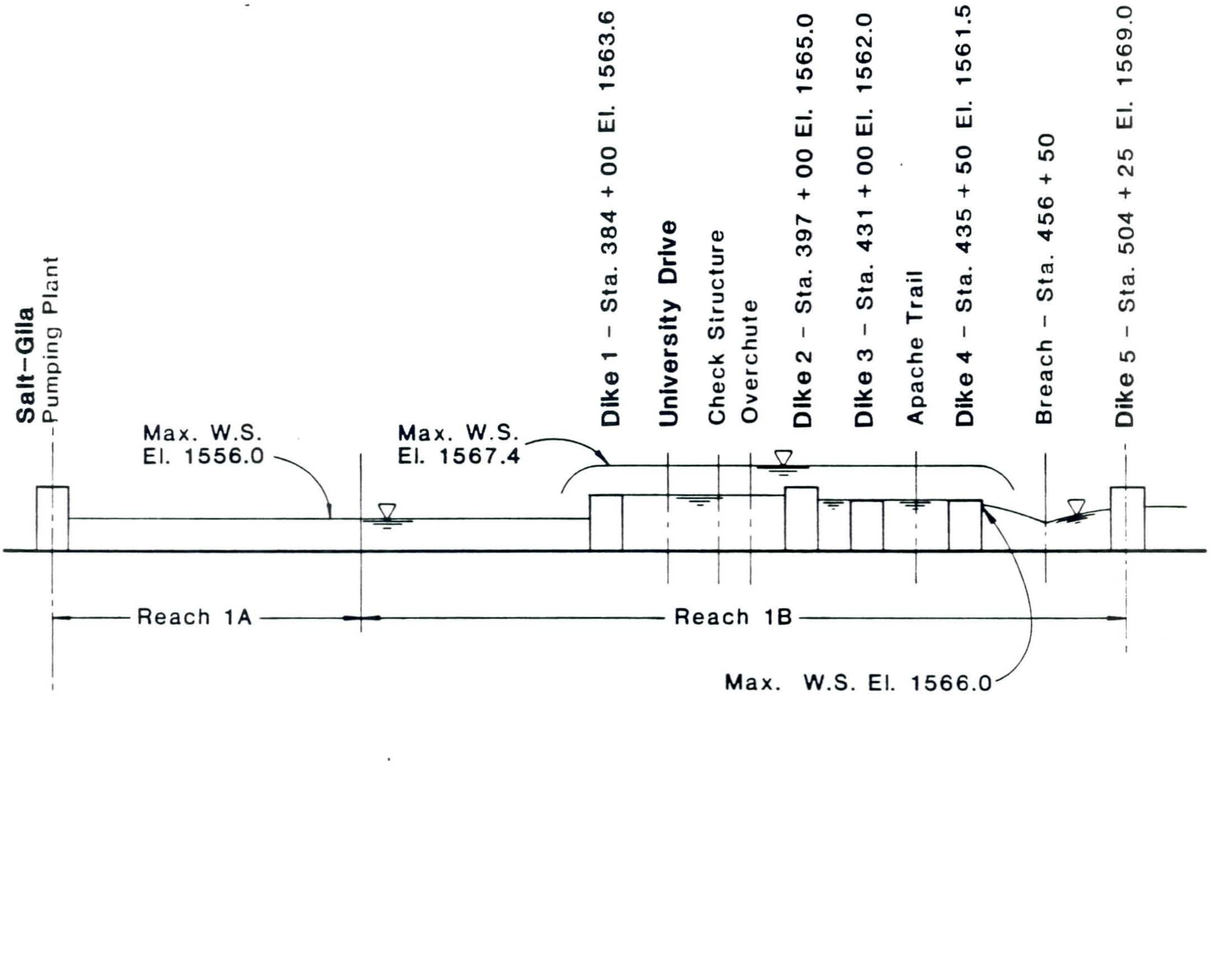
The water that flowed upstream went into dead storage in Reaches 1A and 1B, and thus did not contribute to the outflow at 102nd Street and Broadway.

The water that flowed over the downstream dike at Apache Trail, along with all inflows between Station 427+15 and the dike at Station 504+25, became part of the outflow at the overchute excavation at Station 456+50.

4.6 DESCRIPTION OF FLOODING NORTH OF REACH 1B

The flood event will be described with reference to drainage basins shown on Exhibit 4-1. The bases for the description are:

SALT-GILA AQUEDUCT
REACHES 1A AND 1B
DIKE LOCATIONS AND WATER LEVELS
JULY 17-18, 1984



1. The sequence of events at the Signal Butte Floodway on July 17-18, given by SCS staff to interested agencies on August 3, 1984.

2. Aerial photos taken on July 27, 1984.

3. Field visits and interviews by IECO staff.

4. Damage reports and claims completed by citizens and agencies.

5. The runoff model as described above for Case I.

6. The video tape taken of the canal damage on July 18, and numerous photographs taken by Bureau personnel.

7. Data supplied by SCS and Maricopa County Flood Control District staff.

A. <u>Drainage Areas 1A and 2A</u>

Peak flows and total volumes of the assumed hydrographs for the outflows from the floodway are given in Table 4-2.

The outflows tended to concentrate in two natural washes in Area 2A, shown on Exhibit 4-1, and were augmented by runoff from rain falling south of the floodway. The flow in the western wash crossed Brown Road to the west of N. 96th Street, passed in a southerly direction across Elmswood Street and was intercepted by a 1/4-mile-long ditch constructed east of Ellsworth Street along the line of Adobe Road. Streets are identified on Exhibit 3-1.

The runoff and releases were then diverted to a drainage ditch along the east side of Ellsworth Street. A major portion flowed south in the ditch, while the remainder, which exceeded the capacity of the ditch, overflowed into the road. Some of this water continued south along Ellsworth, and the rest of it flowed toward the southwest through developed and undeveloped lands. All of these flows entered a pool which formed behind the north berm of Reach 1B. The extent of this pool is shown as N-1 on Exhibit 4-6. The maximum level is El. 1574.0.

The flow in the eastern wash crossed Brown Road and Elmwood Street near N. 98th Street, entering a residential area near Edgegrove and N. 97th Street. The water then flowed south and west along the streets to pool N-1 behind the north berm.

Standard methods were used to obtain the high-water contour of the pool. A field survey party identified and confirmed the reasonableness of high-water marks found on buildings, fences, and land in each area. The contour between high-water marks was "chased out" by finding the land elevation at the elevation of high-water marks. Points were transferred to the photo map in the field, and the high-water contour sketched and reconciled with the elevations of floor slabs of residences.

High-water elevations west of Ellsworth Street were obtained at three residences by accepting each occupant's observation of the highest point reached by the water on their property. Very close agreement was achieved at two locations and reconciliation provided the elevation selected. For the area east of Ellsworth Street, excellent high-water marks were obtained on residences and fences along Quarterline Road near N. 92nd Place and all along Cisco Road.

From descriptions by others it appears that the drain on the east side of Ellsworth Street near Dennis Street did not provide sufficient waterway capacity, and diverted some flow diagonally southwest to the carport at 606 N. Ellsworth Street. This resulted in local pooling of water to about 1.5 feet above the pool established by area runoff. Pooled water west of Ellsworth apparently drained northwest, in the collector channel of the CAP aqueduct, to an excavation made in the

north berm for an overchute at Station 345+30 (Arrows B). The runoff from drainage Area 1A also entered the aqueduct through this overchute.

At maximum pool level, the collector ditch east of Ellsworth Street drained across Ellsworth to the northwest. As the pool dropped, Ellsworth became a barrier and the ditch east of Ellsworth could only drain toward the southeast.

The contour of the high-water elevation shown extending from N. 95th Place to University Drive is estimated. The pool east of 95th Place is not quiescent, since water is exiting across the University Drive crossing. Consequently, the limiting contour of the floodwater in this area is somewhat less than if the pool were quiet. A peak discharge of 594 cfs was calculated by assuming that the maximum depth of flow over the crossing was 2 ft.

The water crossing the University Drive bridge (Arrow A) continued in part on the south side of University Drive and, following the southwest trend of the topography, invaded a mobile home park. The subsequent path of the water is described in Section 4.9.

Water also entered the aqueduct prism at the University Drive crossing abutments (Arrows C).

C. Drainage Area 3A

The outflow from the floodway and the runoff from rain falling south of the floodway in Area 3A flowed southwest through natural washes and entered developed property south of Quarterline and west of Crismon. It then flowed along streets to the south and west until it was intercepted by the collector ditches behind the north berm of the aqueduct. This water entered Reach 1B at Station 396+40 through a partially completed overchute.

D. Drainage Areas 4A, 4B, 4C and 4D

The area comprised of 4A, 4B, 4C, and 4D is the largest tributary drainage area. Runoff from 4C was intercepted by the Signal Butte Floodway and a portion of this impoundment overflowed into Area 4A at the east end of the floodway. Area 4A is drained by a well-defined natural wash which terminates at the CAP alignment east of Crismon Road. Drainage areas 4B and 4D are contiguous, since the proposed Signal Butte Dam and Bulldog Floodway have not been built. These areas are drained by a large, well-defined wash terminating at the CAP alignment between the Area 4A wash and the Apache Trail crossing.

Peak flow in this wash, at a point near Signal Butte, was estimated by an indirect method outlined in the USGS publication Measurement of Peak Discharge by the Slope-Area Method (Ref. 4). The location is shown on Exhibit 4-1. Measurements were taken September 5, 1984 in the two subreaches of a 3-section reach and the respective discharges were computed as 1456 cfs and 2256 cfs. A hydrograph calculated by the runoff model for the same location had a peak discharge of 2,990 cfs. As the results obtained for the subreaches of the slope-area measurement differed by more than 25 percent, the estimate is considered poor. Yet, the mean value of about 1850 cfs establishes an order of magnitude to be compared with results obtained by other means.

Runoff from Areas 4A, 4B, 4C, and 4D gradually formed a pool adjacent to the north berm of the CAP, shown as N-2 on Exhibit 4-7. The maximum water level boundaries were defined in a manner similar to that described for the pool at University Drive and Ellsworth Street. The maximum elevation was found to be 1576.8. Excellent high-water marks were obtained, and confirmed for comparison, from several residences and land locations. Principal inflows to the area were gutter drainage (Arrow A) on the north side of the west lane of Apache Trail, and two southwest trending water courses (Arrows B).

Gutter drainage, according to bystanders at the time of the survey, occurred early in the storm and with high velocity. About 15 truckloads of fill were brought in to fill the resulting ditch on August 18th. Bureau photographs taken at about 1000 hours on July 18th show the only exit for gutter drainage to be north, behind the aqueduct stockpiles located on the north berm. Inflow from the two water courses (Arrows B) breached the north berm and entered the aqueduct (Arrow G). Inflow from Crismon Road (Arrow C) and some outflow from pooled water (Arrow F) apparently drained to the northwest in the collection channel behind the north berm, owing to the stockpiling pattern at the foot of Crismon Road. Consequently, some flow from Crismon and the pool entered the CAP at Station 396+40 through the partially completed overchute.

Bureau photographs show a swale between the unused westward lane and the diverted west lane of Apache Trail. At the western end of the swale, the elevation of the pooled water was sufficient to cause water to flow across the eastward lane of Apache Trail (Arrows D). At the same time, water was flowing into the swale and into the aqueduct just upstream of the completed east lane bridge (Arrow E).

E. Drainage Areas 5A and 5B

Areas 5A and 5B are contiguous, since the proposed Bulldog Floodway has not been built. These areas are drained by a long natural wash which crosses 104th Street near Jones Street. Floodwater flowed south on 104th Street and a portion entered the CAP through the partially completed overchute at Station 471+03. The remainder flowed west along Pueblo into Area 10A and entered a pool formed behind the north berm of the CAP.

F. Drainage Area 10A

The pool behind the north berm was defined by a survey team, as described above for the other pools north of the CAP. The location is shown as N-3 on Exhibit 4-7. The maximum level was established at El. 1564.5.

High-water marks were first taken from the residence at the corner of 102nd Street and East Pueblo Avenue. Information obtained at the next house east required a slight adjustment, which was confirmed by marks obtained by chasing out the maximum pool elevation contour.

Inflows to this pool were from the pool north of Apache Trail (Arrow D), street drainage within the area, and the part of the runoff from Areas 5A and 5B that did not pass to the aqueduct prism at Station 471+03 (Arrow J). In addition, water collecting in the swale between the east and west lanes of Apache Trail was diverted southwest, just east of 101st Street, proceeded southwest to 101st Street, south to Illini Street, then southwest to Jones Avenue and Wood Avenue to enter the floodwater pool (Arrow H).

Water from the pool entered the aqueduct at an opening excavated for an overchute at Station 456+50 (Arrow K).

G. Drainage Areas 6A and 6B

Drainage areas 6A and 6B are contiguous because the proposed Bulldog Floodway and the Apache Junction Flood Retention Structure have not been built. Runoff from these areas entered the aqueduct prism at the partially completed overchute structure at Station 479+00 and the excavation for the overchute structure at Station 504+25.

H. Drainage Areas 7A, 7B, 8A, 8B and 9A

Since the proposed Apache Junction Flood Retention Structure has not been built, Areas 7A and 7B, and 8A and 8B are contiguous. Runoff from these areas flowed into the collector ditch along the north berms and entered the aqueduct through partially completed overchutes. Most of the runoff entering the aqueduct from these drainage areas remained in the canal prism because of the contractor dikes at Signal Butte Road and Meridian Road. It is estimated that a small amount of water flowed through the uncompleted overchute openings in the south berm.

4.7 OUTFLOW AT STATION 456+50 (102nd STREET AND BROADWAY ROAD)

The inflow to, and the conveyance and storage assumptions within Reaches 1A and 1B have been described in Section 4.5.B.

Excavations for an overflow structure had been made in both north and south berms at Station 456+50. This was the only area where there was significant penetration or overtopping of the south berm of Reach 1B.

No measurements of the dimensions and elevations of the excavation outlines that existed before the storm on July 17 are available. The contractor had placed fill for access roads in the excavations in both the north and south berms. The low-point elevations of these fills are also not known but are estimated to be from 1 to 2 feet above original ground.

Water flowing in the aqueduct prism, both upstream and downstream of Station 456+50, combined with water from the pool on N-3 behind the north berm and flowed out the excavation in the south berm.

Peak discharge of the outflow hydrograph was determined from the runoff model as 3450 cfs, the volume as 620 ac-ft, and the time of peak as 0054 hours on 18 July. A sketch of the outflow hydrograph is shown on Exhibit 4-8.

4.8 DESCRIPTION OF FLOODING SOUTH OF REACH 1B

Two separate flooding events occurred in the area south of Reach 1B. The first was due to runoff from rain falling directly on the area south of Reach 1B. The second was due to the outflow from the CAP. It has proven difficult to separate the contributions of the two events, mainly due to lack of reliable reports with regard to time of occurrence versus sequence of flooding. The following descriptions refer in general to the total flood, i.e. runoff from local rainfall plus outflows from the CAP.

OUTFLOW HYDROGRAPH
102nd St. and Broadway

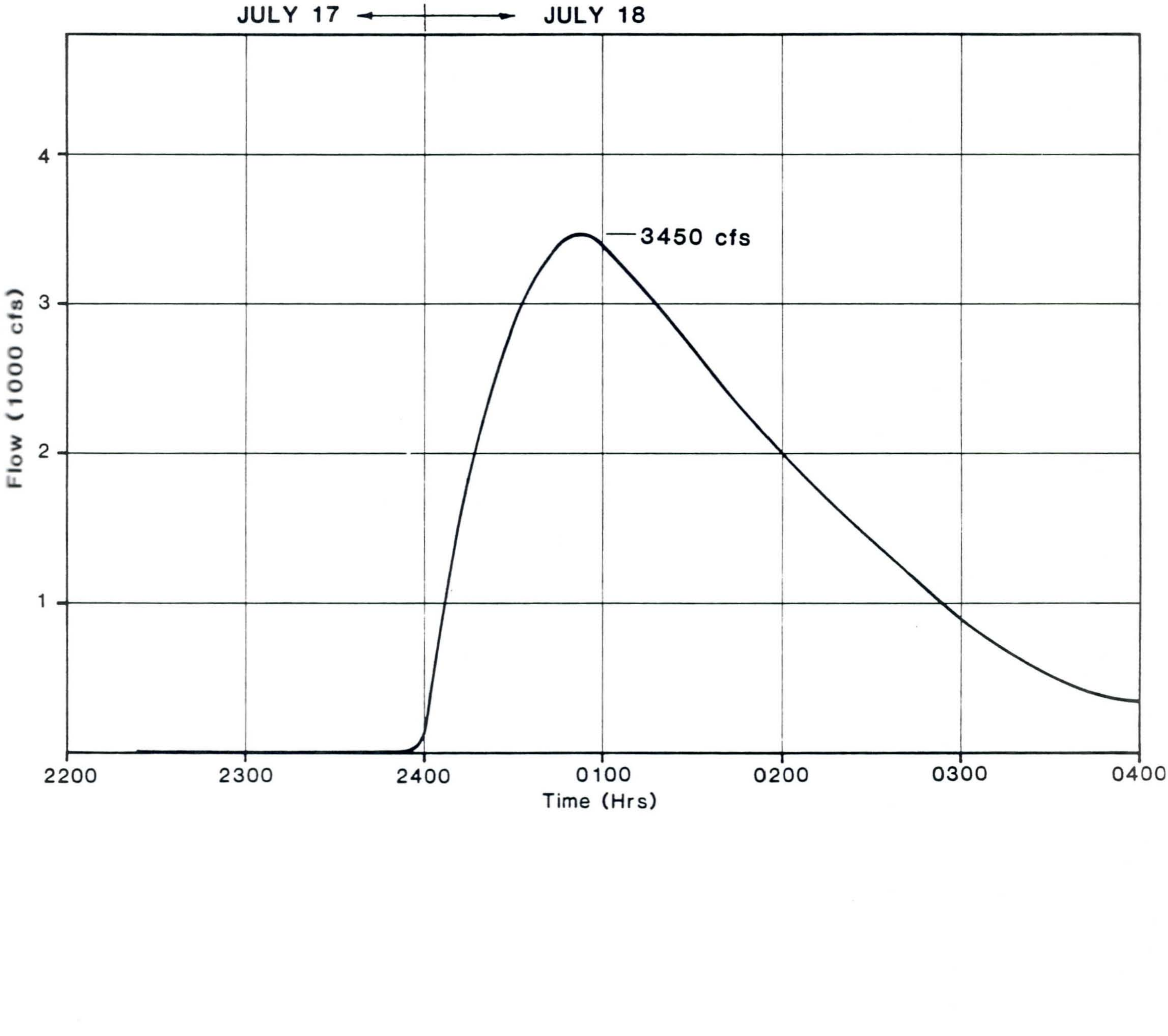


EXHIBIT 4-8

There were two principal outflows, one at University Drive crossing and one at 102nd Street and Broadway. The flooding associated with each outflow is discussed separately.

Residents and locations of flooded property are identified by street address only. Additional information, i.e., name, telephone, type of damage, etc. may be found in Table 3-1 by reference to the address.

Four areas, S-1, S-2, S-3 and S-4 are identified on Exhibit 4-9. These are the areas in which concentrations of flooding and damages were reported in Table 3-1.

4.9 CAP OUTFLOW AT UNIVERSITY DRIVE CROSSING - AREA S-1

Water from pool N-1 passed over the University Drive CAP crossing and entered Sunny Crest Mobile Home Park at 9427 E. University. The exact time of outflow is not known, however, model analysis indicates that it may have peaked at about 0020 hours. The peak flow was estimated at 594 cfs and the volume estimated to be at least 35 ac-ft. It then flowed into Silver Spur Village at 9333 E. University through the common wall between the parks. Water left the parks near Sleepy Hollow Drive and entered a natural drainage channel running in a southwest direction toward the intersection of S. Glenmar Road and Broadway Road. Some water containing CAP outflow augmented by local runoff may have flowed south, over desert land west of Sunny Crest Park, and mixed with drainage water that was flowing toward Ellsworth Street at the north side of Apache Trail.

Runoff composed of CAP outflow, and street drainage from the north side of Apache Trail, crossed the intersection at Ellsworth and Apache Trail through a culvert. At this point, most water entered a drain running parallel to Balsam Avenue. Some water also flowed south on Ellsworth and some passed on to the desert land west of Ellsworth and south of Apache Trail, to a north-south ditch located east of 91st Street

EXHIBIT 4-9

FLOOD DAMAGE AREAS

(See Envelope in Rear of Report)

between Apache Trail and Alder. This ditch carries drainage from Apache Trail and discharges into Balsam. Essentially, all runoff containing CAP outflows from the University Drive crossing was diverted into the Balsam drain before it crossed S. 90th Street.

Flooding was reported by several residents on Hazel and Myrtle Streets and on S. Glenmar Road. These reports were investigated in detail to determine if there was a connection with the CAP outflow.

A resident at 347 S. Glenmar reported water on all four sides of his house. This house, and that of a neighbor at 337 S. Glenmar, lie in a direct line with the Balsam drainage channel and were undoubtedly affected by water containing CAP outflows.

It is probable that CAP outflows reached Hazel and Myrtle Streets. Residents reported that water came from a north-south ditch running behind properties on the east side of Glenmar Road. This ditch carries runoff from desert land located south of Apache Trail and west of 90th Street, as well as drainage from Apache Trail. It is probable that overflow from the Balsam drain entered the Glenmar drain. Flows containing CAP outflows thus passed west from the Glenmar drain over Glenmar Road, into Myrtle and Hazel Streets.

The flooding situation is complicated by a drainage ditch at the west ends of Myrtle and Hazel Streets. This north-south ditch carries runoff from Apache Trail. The capacity has been restricted by a concrete block wall constructed by an adjacent landowner, and local flooding from backwater resulted.

Water containing CAP outflows from University Drive crossing could not be traced further than Glenmar and Broadway Roads, where the water joined with drainage along Broadway.

B. Flooding at Nearby Locations

Damage reports from two locations near to S-1 were examined to determine if a connection with CAP outflow existed. The Silver Sand Travel Trailer Resort at 9252 E. Broadway reported water coming from along Broadway, through a drain passing between Baywood and Birchwood Streets, and from Apache Trail to the northeast.

Water from these two sources was comprised almost completely of runoff from rain falling south of the CAP. Only a relatively small amount of water containing CAP outflows from the drainage north of Apache Trail and east of Ellsworth crossed Apache Trail and entered the desert land north of Silver Sand Resort. CAP outflows could not reach the Baywood-Birchwood ditch. Therefore, it is considered that flood damages at Silver Sand Resort were due primarily to local runoff and the contribution from CAP outflow was negligible.

Two properties on S. 85th Way near Pueblo reported flood damage. It is most probable that the floodwater came south across Broadway, passed southwest through desert land east of S. 88th Place, entered S. 86th Place and flowed west onto the two S. 85th Way properties. The water in the pool north of Broadway contained some CAP outflow from Glenmar. The damages to the S. 85th Way properties are due primarily to local runoff and the contribution from the CAP outflow was small.

4.10 CAP OUTFLOW AT CAP AQUEDUCT STATION 456+50

The approximate path of the outflow is indicated by the concentration of damage reports plotted on Exhibit 4-9. Three separate areas are identified. Area S-2 includes Broadway Road, Crismon Road, and Bramble on the north side; 102nd Street, Broadway Road, Crismon Road, Coralbelle, 96th Way, Pueblo and 98th Street on the east side; Flossmoor, 96th Street and Sunland on the south side; and Ellsworth Road, Pueblo and 97th Street on the west side. Area S-3 encompasses

Valle Del Oro Resort south of Southern Avenue and west of Ellsworth; and Area S-4, the area between Inverness Avenue and Baseline Road east of Sossaman Road and west of 82nd Street. These three areas are outlined in Exhibit 4-9.

A. Area S-2

Outflow from the CAP passed in a general southwest direction from the opening at Station 456+50 in the south berm. The opening was at the lowpoint of Reach 1B. Water passed through the portion of Area S-2 bounded by Broadway, Crismon, Bramble and 102nd Street, flooding several homes. It then flowed west on Broadway, and turned south on the north-south streets between Crismon and 96th Street. Extensive flooding was reported along Broadway between 102nd Street and Hawes Road.

A large percentage of the CAP outflow at Station 456+50 probably went south on the streets between Crismon and 96th Street. There were no reported damages along Broadway other than those in Areas S-2 and S-1 and the Silver Sands Trailer Resort at 9252 E. Broadway.

In Area S-2, water generally flowed south and west along streets and southwest on desert land. The approximate limit of flooding to the east and south was located on aerial photos and verified on the ground. The limit is shown on Exhibit 4-9. Water flowed west on Coralbelle, Pueblo, Sunland and Southern Avenue. The extent of the westward passage was not determined. Residents at 601 S. 92nd Street and 602 S. 92nd Pl. reported that a small drainage channel along Pueblo overtopped and flooded their property. The composition of this water was not determined but was probably local runoff, since the area is relatively distant from the CAP. On July 28, similar flooding was reported by the resident on 92nd Street, indicating that the contribution from the CAP was small.

Flooding was reported along Pueblo between Ellsworth and Crismon. The composition of floodwater in this area was not known, however, it is likely that more than half came from the CAP outflow. Flooding was reported at Pueblo and S. 85th Way as discussed in Section 4.9 above.

Strong evidence of the force, direction and depth of the CAP outflow was seen near 902 S. 96th Street. Grass was caught up to 1-foot-high in a steel fence on the west side of street. Scour marks on desert land and bent vegetation indicated that flood waters were moving in a southwest direction. The resident at that location told of a "wall of water" approaching from the northeast.

A resident at 950 S. 96th Street reported that at 2230 hours on July 17, the depth of rain water in the street was about three to four inches. The rain stopped at approximately 2300 hours. Around 2330 hours, the runoff began receding and electricity went off for one hour. Then between 0130 and 0200 hours on July 18, runoff increased to maximum and reached a height of three inches on his back door. The resident at number 933 S. 96th Street reported two events: the initial rain and local runoff, and the later runoff which differed from the earlier one, and was "like a roaring mountain stream."

In general, water left Area S-2 in a southwest direction. A recreational vehicle park in the Southwest corner of Area S-2 was protected by a concrete block wall. No damage report was submitted for this park. Considerable flow came down Ellsworth Street as evidenced by a damage report stating that a car at the Southern Avenue-Ellsworth intersection was flooded to headlight depth at 0030 hours on July 18.

B. Area S-3

This area encompasses the Valle del Oro recreational vehicle park for which the owner filed a large claim for damages. Some water from Area S-2 crossed Southern Avenue and Ellsworth Street and entered S-3 as shown by the arrows on Exhibit 4-9.

The following is a summary of an interview with Mr. Dean Shane, a park foreman, who was on site during the flooding:

According to Mr. Shane, who was active all that night, it started raining hard between 2000 and 2100 hours on July 17. Rain continued until approximately 0130 hours on July 18. At 2300 hours strong winds began blowing from the west and then from the east. At 2230 hours on July 17th, water was flowing in at the main gate and at two other gates on Southern Avenue. Water also entered the development from the open space south of Southern Avenue and west of Ellsworth. Some development boundary walls were broken down. Arrows showing main points of entry are shown on Exhibit 4-9. Moving water inside the park proceeded in a southwest direction from the northeast corner and combined with water coming from the gates along Southern Avenue. Mr. Shane estimates that the peak inflow occurred between 2300 and 2330 hours. The park transformer failed at 2330 hours. Water was still moving in the park until the next afternoon. The owner has a video tape of the damage.

C. Area S-4

Water leaving Areas S-2 and S-3 flowed southwestward to the drainage ditch lying to the south. In the vicinity of E. Inverness and S. 78th Street, the runoff overflowed the southern berm of the ditch and entered area S-4 causing flooding along E. Inverness and S. 78th Street. The situation was complicated by a weir structure located in the Sossaman drain near E. Juanita Avenue. It appears that this structure may have caused backwater upstream in the drain, but the weir's contribution to the flooding has not yet been determined. After passing the weir, water flowed through a culvert under Baseline Road into a Maricopa County Flood Control District drain.

A resident at 7816 E. Inverness reported that water first overtopped the berm of the ditch along Inverness at 2300 hours on July 17. After water receded, a second overflow, stronger than the first, with higher and faster flowing waters in the streets, peaked at about 0200 hours on July 18th.

There were two flood events in Area S-4. The first was due to local runoff and the second due to outflow from the CAP. Relative contributions of the two events to damages is uncertain; it appears that the second event aggravated prior damage.

4.11 ANALYSIS OF RUNOFF AND FLOODING

Several observations and comments were formulated during the field surveys, data analysis and runoff model development.

1. Flood damages attributable to CAP facilities are of two types, depending on whether the damage location is north or south of Reach 1B. On the north side, damages are due to ponding against the aqueduct berm. Damages on the south side are due to moving water.

2. There is insufficient evidence to precisely differentiate between the flooding due to runoff from rain falling south of Reach 1B, and the flooding attributable to outflows from the CAP.

3. Many locations in the area were subjected to annual flooding before construction of the CAP. For example, a storm in August 1983 caused severe flooding along Broadway between Crismon and Hawes, and along Crismon north of Broadway. Rainfall data were available, but sufficient information on depths of flooding and associated damage was not. An analysis was attempted but later abandoned.

4. Accurate and reliable information on such factors as time, depth, direction of flow, and sequence of events was lacking chiefly because (a) that the storm occurred at night, when few witnesses were around; and (b) that involved citizens were concerned about their own property and did not notice the time nor the outside events. There are considerable time-of-event data available from citizens' damage reports. However, the

times reported for flooding in Area S-2 range from 2130 hours on July 17th (one hour before the rain actually started) to 0300 hours on July 18th.

Selected times for six locations are tabulated in Table 4-5. Times calculated by the runoff model are shown for comparison. Rural/Metro Fire Department log times are included, as these indicate the exact time that a citizen became concerned enough to call the Department. The citizen report ranges are taken from the damage claims that were filed with the Maricopa County Department of Civil Defense. It is difficult to tie the citizen time data to sequence of events since information on depth, direction of flow at the time of observation, etc. is lacking.

The model results and the Rural Metro data present times that can be used for comparison of the citizen report ranges. For example, at Broadway near Crismon, the CAP outflow started at 0000 and peaked at 0054 hours. This indicates that the early citizen reports were for local flooding, and those made after midnight were for CAP outflow flooding.

5. A reasonable estimate of flow peaks and volumes for the aqueduct prism and the area to the north of Reach 1B was made with the assistance of the runoff model. This was not possible for the area south of the CAP. The paths of the outflows were traced with reasonable accuracy; however, no estimate of flow parameters was possible within the scope of the study. The area to the south would be extremely difficult to model because of the effects of walls, constructed ditches, street patterns, etc. The natural drainage to the southwest has been interrupted by extensive development. A reliable model could be formulated only after an extensive data gathering operation undertaken immediately after the event.

TABLE 4-5

TIME OF EVENT COMPARISON

JULY 17-18, 1984

Location	Time (Hrs) Citizen Report Range	Model Start	Model Peak	Rural/Metro Fire Dept.
Floodway at Crismon	-	2346	2353	-
Ellsworth and CAP	0000-0100	2306	0018	2337-2350
Apache Trail near Crismon	2300*	2300	0018	-
Broadway near Crismon	2230-0100	0000	0054	0011-0018
S. 96th Street between Sunland and Coralbell	2230-0300	-	-	0104*
S. Ellsworth and Southern	0030*	-	-	-
E. Inverness near S. 78th Street	2230-0200	-	-	0200*

* One report

6. Apparently, the runoff from local rainfall followed the street pattern in Area S-2 in the sense that when street capacity was exceeded, sidewalks and lawns were encroached upon, but the direction of flow was still determined by the streets and drains.

The character of the progress of the CAP outflow from 102nd Street and Broadway through Area S-2 was radically different. The central fast-moving part of the sheet flow ignored streets and persisted in maintaining a southwest direction, crossed streets, ran through yards and eroded earth areas and home foundations along its way until its force was diffused.

CHAPTER 5
DELINEATION OF DAMAGE AREAS

Seven different CAP structure-related damage areas were identified. These were generally found to be of two different types, depending on the location north or south of the Reach 1B alignment. Three CAP structure-related damage areas north of Reach 1B are adjacent to the north berm of the aqueduct. Damages in these areas were caused by ponded water. Damages in four areas south of the aqueduct were more widespread and were caused by rushing water.

Rushing water in streets and over developed property and desert land north of Reach 1B can be attributed to either rainfall runoff or outflows from the Signal Butte Floodway. South of the CAP there was relatively little ponding of water except on and along east-west streets such as Broadway Road and Apache Trail.

5.1 DAMAGE AREAS NORTH OF REACH 1B

There are three CAP structure-related damage areas adjacent to the north berm. These are the ponded areas identified as N-1, N-2 and N-3 on Exhibits 4-6 and 4-7. Based on the evidence at hand, flooding at other discrete locations north of Reach 1B outside the boundaries of the three areas is not attributable to CAP facilities. Damages may be claimed for locations where flooding of property occurred close to, but outside, the boundaries of Areas N-1, N-2 and N-3. Claims for these sites will have to be examined on a case by case basis.

The delineation of these areas, described in Chapter 4, Section 4.6, is sufficiently detailed on Exhibits 4-6 and 4-7 to identify impacted property. A brief description of each damage area follows. In each description, note is made of damage claims within the areas by street or address. These are not intended to be inclusive.

A. Damage Area N-1

The flooding in Area N-1 was attributable to ponding behind the north berm of Reach 1B. Water ponded to an elevation of 1574.0. The sources of water were outflow from the Signal Butte Floodway and runoff from rain falling on sub-basin 2A. The outlets for N-1 were at the excavation in the aqueduct north berm for the overchute at Station 345+30 and at the University Drive crossing. There is an overchute planned at aqueduct Station 374+00, however construction had not been started on July 17.

Area N-1 contains Cisco Road, where several residents and a contractor filed claims and reported damages as shown in Table 3-1.

B. Damage Area N-2

The flooding in Area N-2 was attributable to runoff carried by two large washes draining sub-basins 4A, 4B and 4D and from outflow from the Signal Butte Floodway. Water ponded to a maximum level of El. 1576.8 behind the north berm of the CAP at this location. There were also inflows to the pool from street drainage along Crismon and Apache Trail.

Area N-2 contains the property at 10020 E. Apache Trail, for which damage reports and claims have been made as shown in Table 3-1.

C. Damage Area N-3

Flooding in Area N-3 was caused by street runoff from Apache Trail, 102nd Street, 104th Street, outflows from pool N-2, and part of the runoff from sub-basin 5A. Ponding to an elevation of 1564.5 occurred behind the north berm of the aqueduct. The only outlet was through the opening in the north berm at Station 456+50.

Several damage reports and claims were filed for the portion of Wood Avenue in Area N-3 as listed in Table 3-1. During the field investigations it was noted that flood water had entered the residence at 10202 E. Pueblo and that no damage claim had been filed by the owner. This property was therefore added to Table 3-1.

5.2 DAMAGE AREAS SOUTH OF CAP

The CAP structure-related damage areas are associated in general with Areas S-1, S-2, S-3 and S-4 which are identified on Exhibit 4-9. The paths of CAP outflows through these areas were described in Chapter 4, Section 4.9. The boundaries shown on Exhibit 4-9 delineate the general areas in which flood damages can be attributed, at least in part, to CAP outflows. This differs from Areas N-1, N-2 and N-3, in which all CAP-related damages were located within well-defined boundaries.

The delineation of damage areas south of the CAP is primarily based on judgment. The areas encompass most of the individual locations for which damage reports or claims were submitted.

A. Damage Area S-1

The delineation of Damage Area S-1 is discussed in terms of sub-areas. The sub-area defined by University Drive, S. 95th Street, Sleepy Hollow and S. 93rd Street was flooded by CAP outflows from the University Drive crossing. Trailer parks at 9333 and 9427 E. University and residents on Sleepy Hollow submitted damage claims as shown in Table 3-1.

CAP outflows passed into and through trailer parks located in the sub-area defined by Sleepy Hollow, S. 95th Street, Apache Trail and S. 93rd Street. For this reason, the sub-area was included in Damage Area S-1 although no damage was reported by residents in these parks. The streets and diagonal drainage channel were apparently able to carry the flows. Yard flooding was reported at 9420 E. Apache Trail. Some CAP-affected water could have reached this property, however, it is likely that flooding at this site was caused primarily by local runoff.

One damage claim was located at 101 S. 91st St. This claim is associated with a north-south drainage channel running between Apache Trail and Alder, carrying local runoff that may have been augmented with some outflow from the University Drive crossing. The relative contributions to damage of the runoff and outflow are uncertain, however, it is likely that the CAP outflow aggravated the flooding, and therefore the residence is included in Area S-1.

Residents in the sub-area delineated by Myrtle Avenue, Glenmar Road, Broadway Road and the drainage ditch located at the west ends of Hazel and Myrtle Streets submitted several damage reports and claims, as shown in Table 3-1. Runoff entered this sub-area from a north-south drainage ditch located to the rear of houses on the east side of Glenmar, and from a natural wash running south-west across desert land, north of Broadway between Glenmar Road and S. 90th St. The wash was carrying outflow from the University Drive crossing augmented with local runoff.

CAP outflows entering the sub-area along with the local runoff aggravated the flooding, and therefore this sub-area is considered part of the CAP structure-related Damage Area S-1. The flooding condition on Hazel and Myrtle Streets was aggravated by a restriction in the drain at the west ends of the two streets, caused by a concrete block wall. This restriction may have been a contributing cause to the flood damage on Hazel and Myrtle.

Two flooding locations close to Damage Area S-1 are the trailer park at 9252 E. Broadway and the two residences on S. 85th Street near Pueblo. These were discussed in Chapter 4, Section 4.9.

The trailer park appears to have been flooded by local runoff coming from the northeast. The relatively small amount of CAP outflows that could have reached the park would have been greatly diluted by runoff from rain falling south of the CAP. A similar statement may be made for the properties at S. 85th Street. CAP outflows reaching these houses would also have been greatly diluted by local runoff. Consequently, neither the 9252 E. Broadway nor the S. 85th Street properties were included in the CAP structure-related damage area.

A damage claim made by the resident at 9635 E. Boulder Drive was investigated. It was found that the reported yard damage was due to contractor pumping operations undertaken to empty the aqueduct prism, and thus not CAP structure-related flooding directly related to the storm event.

B. Damage Area S-2

Damage Area S-2 is delineated as shown on Exhibit 4-9 and described in Chapter 4, Section 4-9. Flooding damage in this area is associated with moving water comprised of mixtures of local rainfall runoff and outflow from the CAP at 102nd and Broadway. There is evidence from which to conclude that there were two separate flooding events in the area. The first event was due to local runoff alone, and the second was due to a mixture of local runoff and CAP outflows. Historically, before construction of Reach 1B, this area has been subject to flooding from rainfall runoff. Crismon and Broadway Roads have frequently been flooded, and water from these two streets has often entered the area.

Many of the damage report claims from Area S-2 shown in Table 3-1 report flooding before 0000 hours on July 18th, when the CAP outflow began according to Exhibit 4-8. Other damage reports from Area S-2 give times of damage between 0100 and 0300 hours, during which time CAP outflows would be moving through the area according to Exhibit 4-8. Since it has not been possible to separate damage caused by local runoff from damage caused by CAP outflows, it must therefore be concluded that Area S-2 is a CAP structure-related damage area.

There is a possibility, however, that a few properties in Area S-2, particularly to the west of Evangeline, were flooded only by local runoff. The only way this may be determined is on a case-by-case basis, considering past records to determine historical flooding patterns.

C. <u>Damage Area S-3</u>

Area S-3 encompasses the entire Valle Del Oro Recreational Vehicle Park at 1452 S. Ellsworth. Water coming from the northeast entered the north and east sides of the park.

As shown on Exhibit 4-8, the CAP outflow at Broadway and 102nd Street started at about 0000 on July 18th and peaked at 0054 hours. According to a park employee, there was a peak inflow into the park between 2300 and 2330 hours. This indicates that flooding was caused by two separate events as described for Damage Area S-2. The relative contributions to damages caused by CAP outflows and those caused by local runoff alone is uncertain; it is likely that the CAP outflow aggravated the prior damage. It has therefore been concluded that Area S-3 is a CAP structure-related damage area.

D. <u>Damage Area S-4</u>

Damage Area S-4 is bounded by Inverness, S. 80th Street, Baseline and S. 78th Street. Flooding was caused by water overtopping a drainage ditch located just north of Inverness. This ditch had captured water leaving Area S-3. As discussed previously, this water at first contained all local runoff and then became a mixture of CAP outflows and local runoff. Damages from local runoff cannot be separated from those caused by a mixture of the two. According to a witness, flooding from the second event was more severe than the first. Therefore, it has been concluded that Area S-4 is a CAP structure-related damage area.

The situation was complicated by a weir structure located in the Sossaman drain near Juanita Avenue. It appears that this structure may have caused backwater upstream in the drain, and thus aggravated the flooding damages. The weir contribution to damages was not determined.

5.3 REASONS FOR CAP STRUCTURE-RELATED FLOOD DAMAGES

The scope of sub-task 4 of this study was to determine the reasons for the flood damages, and to prepare a statement to this effect.

Seven CAP structure-related flood damage areas were identified. Three of these areas are north of Reach 1B, and four are to the south of said Reach, as shown on Exhibit 4-9.

A. Damage Areas North of Reach 1B

Runoff pooled behind the north berms of the aqueduct in three ponded areas:

- N-1 in the vicinity of University Drive and Ellsworth.
- N-2 in the vicinity of Crismon Road and Apache Trail.
- N-3 in the vicinity of S. 102nd Street and Pueblo.

Each of the three areas differed in details of how runoff entered and left the pools. However, in each area, the north berms of the aqueduct were a barrier to runoff from the north and northeast. Water ponded until sufficient head was available to move the water into the aqueduct prism either along collector ditches into partially completed over-chutes, or through breaches in berms and dikes, or in the particular case of pool N-1, across the University Drive crossing.

It has been concluded that the only CAP structure-related flooding damages on the north side were associated with water ponding against the aqueduct berms. The ponding was due to insufficient outlet flow area, causing the water to rise, and thus providing the required head to pass the particular inflow either into the aqueduct prism or out of the area.

B. Damage Areas South of Reach 1B

Areas in which CAP outflows were considered to contribute to damage were designated as CAP structure-related damage areas. The delineation of the damage areas involved a judgement decision in estimating the probable contributions of the local runoff and CAP outflows to the total damage.

Three areas situated to the southwest of Crismon Road and Broadway, S-2, S-3 and S-4, were impacted by CAP outflow from an opening in the aqueduct at S. 102nd Street and Broadway. A fourth area, S-1, received damages from CAP outflow over the University Drive crossing from pool N-1.

At several locations in the damage areas, witnesses identified two different flooding events separated by a definite period of time. The first event was due solely to local runoff and arrived shortly after the storm began. The water of the second event was composed of CAP outflow augmented with local runoff. The further the point of observation was from the point of outflow, the greater the time difference between the two events.

The outflow at Broadway and S. 102nd Street was estimated to start at 0000 hours and peaked at 0054 hours on July 18, therefore flooding before that time was due to local runoff alone. There were numerous reports of flooding throughout areas S-2, S-3 and S-4 which occurred earlier than midnight, indicating that local flooding was severe enough to make an impression on the observer.

There is also evidence that the farther away the location from the CAP outlet, the greater the effect of the local runoff with respect to the CAP contribution. For example, a witness near Ellsworth Road and Southern Avenue reported that there were damages associated with a peak inflow at 2330 hours, which was earlier than the estimated start of the CAP outflow at Broadway.

Sequence of event data is generally lacking. There are few reliable observations of time, depth and direction of flow during the flood. Therefore, correlations of damage with sequence of flooding events are not possible and the two events could not be separated.

CHAPTER 6
FLOODING ASSESSMENT WITHOUT CAP FACILITIES

6.1 GENERAL

Case IV is the assessment of flooding that would have occurred if the Salt-Gila Aqueduct Reach 1B had not been in place during the July 17-18 storm. The assessment uses hydrographs that were developed for Case I in Chapter 4. Peak discharges and volume of these hydrographs, for the tributary sub-basins delineated on Exhibit 4-1, are listed in Table 4-3. Case IV differs from Case I primarily in that, in the former, consideration is given to the location and the manner in which runoff crosses the line of Reach 1B. In Case I, the aqueduct was considered a reservoir and the specific location of each inflow was not necessary for analysis. The runoff from each sub-basin simply accreted to the reservoir along a discrete length of reach.

For Case IV, runoff would cross the Reach 1B alignment in drainage channels, along streets and gutters, in natural washes, and by sheet flow on open land. In some of the sub-basins, there is a pattern of predominant quasi-parallel natural drainage channels oriented toward the southwest. A few of these channels are larger than others and thus carry a larger part of the basin runoff. Some sub-basins have no dominant channel and the outflow would be distributed with relative uniformity across the width of the sub-basin. Each sub-basin along the alignment of Reach 1B is discussed, together with its tributary sub-basins, with respect to the likely paths that would have been taken by the runoff if Reach 1B had not been present on July 17-18.

The dominant channels in each sub-basin are shown on Exhibit 4-1. Principal streets are also shown on Exhibit 4-1 but not identified due to space limitations. Reference may be made to Exhibit 4-9 or Exhibit 3-1 for identification of streets mentioned in the following text.

As the runoff from each sub-basin moves south of the line of Reach 1B, it would be augmented by local runoff from rain falling south of the aqueduct. In this analysis estimates of the contribution of local runoff to the total volume of water were made, where feasible, as noted below.

6.2 SUB-BASIN 1A

The dominant channel in this basin crosses the line of Reach 1B at aqueduct Station 345+30. It is estimated that, at this point, peak flow in the channel would be about 200 cfs. The peak would travel with little change southwest to University Drive near N. 88th Street.

After crossing University Drive, the sub-basin 1A runoff, augmented by local runoff from rain falling south of the 1B alignment, would move south along the street pattern and southwest through desert land to Apache Trail. At this point it would join street drainage and cross Apache Trail through culverts.

A subjective evaluation indicates that without Reach 1B, residents in the vicinity of N. 88th Street between University Drive and Apache Trail might have experienced more water in local streets. There is also a good possibility that some of the runoff from 1A would have entered the drainage channel that runs between Apache Trail and Broadway, parallel to Glenmar, at the west ends of Myrtle Avenue and Hazel Drive, thereby increasing the possibility of flooding on these two streets.

6.3 SUB-BASIN 2A

The peak runoff of 1864 cfs from sub-basin 2A, shown in Table 4-3, includes the major component of the Signal Butte Floodway outflow. There are two dominant natural washes in the sub-basin, as shown on

Exhibit 4-1, which share the discharge. The peak discharge of the floodway overflow when routed down to the line of the aqueduct is 1617 cfs. This becomes about 1700 cfs when the recession flow from the local runoff is added. This peak would be largely concentrated in the east side drain along Ellsworth Street. A small portion would be deflected west across Ellsworth by the partial blockage caused by the drain at Dennis Street. This would cause local flooding of the residences on the west side of Ellsworth as was described in Chapter 4, Section 4.6. At present, the Ellsworth drain terminates at the collector ditch along the north berm of the CAP. Without the CAP, the ditch would probably have been continued along Ellsworth to Apache Trail.

Therefore, it is presumed that the majority of the outflow from the floodway would have passed south along Ellsworth Street to University Drive and Apache Trail.

Most likely the street capacity would have been exceeded and water would have entered onto desert land to the west of Ellsworth between University and Apache Trail. The water would have flowed southwest to Apache Trail. Some runoff would have continued south on Ellsworth; however, the largest portion would have flowed across desert land south of Apache Trail and west of Ellsworth, to the Balsam Avenue drain and its southwest extension toward Glenmar and Broadway, and the northsouth drain lying to the rear of the properties on the east side of Glenmar.

There would also be a contribution from the eastern portion of subbasin 2A, which would pass from the eastern wash through the streets of the developed areas between Quarterline Road and N. 96th Place. This runoff would be diffused along the entire line of the aqueduct between Ellsworth Street and 96th Place, and would be composed of runoff from rain falling between the floodway and Reach 1B. The peak of 400 cfs would occur earlier than the 1700 cfs peak containing floodway outflows. Some concentration would be expected along Cisco Road and the adjoining streets.

It is likely that some of the runoff from sub-basin 2A would have passed through the trailer parks, located between Sleepy Hollow and University Drive, to the drain running from the vicinity of Sleepy Hollow and Boise Streets to the intersection of Ellsworth Street and Apache Trail. At this point it would have combined with the flow coming south along Ellsworth. The combined runoff would have crossed Apache Trail through culverts, and possibly as street flow, and either entered the Balsam Avenue drain or continued south on Ellsworth.

It is pertinent to note that without the floodway outflow, the peak outflow from Basin 2A would have been about 700 cfs instead of the 1864 cfs shown in Table 4.3. A peak of about 300 cfs from the western wash would have crossed the aqueduct alignment at Ellsworth Street, and about 400 cfs would have been dispersed along Reach 1B between Ellsworth and N. 96th Place. Runoff from the western wash would have continued south on Ellsworth as described above for the larger flow containing the floodway outflow.

A subjective evaluation of the flooding that would have occurred without the CAP is as follows:

1. Compared to the actual July 17-18 event there would have been more water passing south on Ellsworth Street between Quarterline Road and Apache Trail and over the desert land to the west of Ellsworth. Some water might have entered the trailer park, located on Ellsworth between University and Sleepy Hollow, and the development west of 90th Street between University and Apache Trail; however, the amounts were not determined. It is likely that some flooding damage would have occurred in these two areas if Reach 1B had not been under construction.

2. The Balsam Avenue drain, its extension through the desert land to Glenmar and Broadway, and the north-south ditch to the east of Glenmar would probably have been carrying additional water

compared to the actual July 17-18 event. The ditch at the west ends of Myrtle Avenue and Hazel Drive might also have been carrying more runoff. Consequently, the lower Glenmar area could have experienced more flooding. In addition, the developed area in the vicinity of Balsam Avenue might have been flooded if the capacity of the Balsam ditch had been exceeded by greater flows.

3. There would probably have been more water flowing west along Broadway, between Ellsworth and Hawes Road, with consequential flooding in the developed area to the south of Broadway.

4. The two trailer parks on University Drive near the CAP alignment most likely would have received some water from the Cisco Road and N. 95th Place area. However, since the outflow from the eastern part of the sub-basin would be diffused along University between Ellsworth and 95th Place, the peak passing through the trailer parks would have been much less than that experienced on July 17-18.

6.4 SUB-BASIN 3A

The peak discharge from sub-basin 3A at the line of Reach 1B is shown as 618 cfs in Table 4-3. There is no clearly defined dominant watercourse in this sub-basin. There were flooding reports from several locations just northeast of the Reach 1B alignment, and it would be reasonable to expect some similar local flooding as the runoff moved south of the alignment through developed areas to Apache Trail. Sub-basin 3A runoff, augmented by street drainage, would then move west to culverts which pass under Apache Trail. The runoff from sub-basin 3A would augment the flows through developed areas and desert land that were actually experienced during the July 17-18 storm. A subjective evaluation of flooding without Reach 1B due to runoff from sub-basin 3A is as follows:

1. There might have been flooding in the developed area west of Crismon and north of Apache Trail.

2. The runoff from 3A that crosses Apache Trail combines with the runoff from sub-basins 4A, 4B and 4D. The effects of the runoff from sub-basin 3A cannot be separated from the 4A, 4B and 4D runoff and will, therefore, be discussed in the following section.

6.5 SUB-BASINS 4A + 4B + 4D

Two washes crossing the aqueduct alignment at Station 427+15 and 429+20 convey the total peak flow of 2670 cfs, estimated at 1670 and 1000 cfs, respectively, in each wash. The upper wash continues westsouthwest and meets Apache Trail near N. 98th Street. Runoff in this wash would join with Apache Trail drainage and pass through culverts and street flow to the desert land south of Apache Trail and west of Crismon. It would then flow to the southwest to Balsam Avenue and the Baywood- Birchwood drain. This drain passes to Broadway, west of Ellsworth, through the trailer parks located on Broadway between Wonderway Road and Ellsworth. Flows from the upper wash would combine with runoff from sub-basin 3A. Ultimately, there would have been additional water on Broadway, between Ellsworth and Hawes, due to the combined flows.

Most of the runoff in the lower wash would cross under Apache Trail and Crismon Road and head south and west, cross Balsam, and join the flows from 3A and the upper wash in the drain between Baywood and Birchwood. A portion of the flow from the lower wash would continue south as street flow on Crismon Road.

Most of the water in the Baywood-Birchwood drain would probably reach S. Ellsworth Street near Broadway. A portion would pass south on Ellsworth and the remainder east on Broadway. The relative split was not estimated; however, it is quite likely that there would be considerable flow on both Broadway and Ellsworth from the 3A, 4A, 4B, and 4D sub-basins.

The flows on Broadway would continue west and southwest through the developed areas and desert lands south of Broadway, to the Hawes Road drainage. The flows on Ellsworth would continue south, and would probably also flow west on cross streets including Coralbell, Pueblo, Sunland Avenue, and Southern Avenue. Water flowing along Ellsworth south of Southern Avenue could also enter the Valle del Sol development in Damage Area S-3, shown on Exhibit 4-9, in a manner similar to that actually experienced during the July 17-18 storm.

Ultimately, the runoff from sub-basins 3A and 4A, 4B and 4D will pass into the Hawes Road, Inverness Avenue, and Sossaman Road drains, and exit the study area under Baseline Road.

A subjective evaluation of the flooding caused by runoff from Areas 3A and 4A, 4B and 4D is as follows:

1. The runoff from sub-basin 3A and the upper wash of sub-basins 4A, 4B, and 4D would likely cause flooding along the east side of S. 98th Street and along Balsam Avenue.

2. The runoff from the lower wash of 4A, 4B and 4D would likely combine with the water in the upper wash to cause flooding in the developed areas adjacent to the Baywood-Birchwood drain.

3. There would probably have been additional flooding along Broadway, east of Ellsworth Street, above that experienced in the July 17-13 storm.

4. There would most likely have been flooding in the developed areas south of Broadway between Ellsworth Street and Hawes Road, due to the additional water on Broadway and to the

increased flows south on Ellsworth and east on Coralbell, Pueblo, and Sunland Avenue.

5. It is very likely that large flows on Ellsworth would have reached the Valle del Sol development in Damage Area S-3, south of Southern Avenue. No calculations were made; however, the possibility that the development would have incurred similar damage to that experienced during the July 17-18 storm cannot be overlooked. The runoff from Areas 3A, 4A, 4B and 4D, without Reach 1B in place, would have followed similar paths to those of the local runoff which flooded the development before the arrival of the CAP overflow. Refer to Chapter 4, Section 4.10, for additional information.

6. It is probable that the flow peak in the Inverness Avenue drain would have been similar to the actual peaks experienced during the July 17-18 storm. Approximately the same tributary drainage area would be contributory to the runoff in the Inverness drain. Consequently, it is likely that similar flooding and damage would have been experienced in damage Areas S-4 shown on Exhibit 4-9. Refer to Chapter 4, Section 4.10 for more information.

6.6 SUB-BASINS 5A + 5B

Sub-basins 5A and 5B are drained by a natural wash which intersects S. 104th Street north of Wood Street. Flow from the wash would then proceed south on 104th Street to Broadway Road. Runoff from the sub-basins would have a peak of 776 cfs at the line of Reach 1B, as shown in Table 4-3. Part of the runoff would flow directly west along Broadway Road; however, the bulk would probably cross desert land southwest to the junction of S. 98th Street and Edgewood Avenue. It would then follow a drain through developed areas to Flossmoor and Southern Avenue. Continuing southwest across desert land, the runoff would flow into the north-south drain just east of S. Ellsworth Street. At this junction, the flows from sub-basins 5A and 5B, augmented with local runoff, would combine with part of the runoff from sub-basins 3A, 4A, 4B and 4D, similarly augmented with local runoff, flowing south on Ellsworth.

The portion of the runoff from 5A and 5B that flowed west on Broadway would join water flowing down Crismon containing runoff from the lower wash of sub-basins 4A, 4B and 4D. A portion of the combined flows would continue south across Broadway along the extension of Crismon, to join with other runoff from 5A and 5B that passed southwest through desert land to S. 98th Street and Edgewood. The remainder of the Crismon-5A-5B runoff would probably join the flow of water on and along Broadway. It is likely that some of this water would enter the north-south streets between S. 99th Place and S. 96th Street. Flow on these streets would proceed south, to east-west streets such as Coralbell, Pueblo and Sunland Avenue, where it would join runoff from other sub-basins.

The following is a subjective evaluation of the flooding:

It is difficult to estimate the extent of flooding in the developed area south of Broadway Road, between Ellsworth Street and Crismon Road, shown on Exhibit 4-9 as Damage Area S-2. Many of the streets which experienced extensive flooding drainage in the July 17-18 storm would also be flooded by the runoff that would have occurred without Reach 1B. The developments, however, would not be subjected to the concentrated outflow from the CAP at 102nd Street and Broadway. Runoff flows would be more diffuse. Much of the runoff from sub-basins 3A, 4A, 4B and 4D would pass to the north and west of the streets most severely affected by the July 17-18 storm event. The net effect would be that flooding in Area S-2 would probably have been somewhat less than that experienced in the July 17-18 event.

6.7 SUB-BASINS 6A + 6B

The peak flow from sub-basins 6A and 6B at the line of Reach 1B is shown as 757 cfs in Table 4-3. Approximately half of the runoff would follow a natural wash running to the southwest toward S. 98th Street and Flossmoor. Continuing in a drain, the flow would be directed across Southern Avenue southwest to desert lands east of Ellsworth Road. The remaining half of the runoff would follow a parallel path to the south, also trending southwest and passing over desert lands and reaching Baseline Road.

A subjective assessment of the flooding potential indicates that runoff from basins 6A and 6B would cause little flooding in developed areas.

6.8 SUB-BASINS 7A + 7B, 8A + 8B, and 9A

Runoff from these basins proceeds in a southwest direction over desert land. No flooding in developments would be expected.

6.9 SUB-BASIN 10A

Runoff having a peak flow of 145 cfs at the line of Reach 1B would pass southwest to Crismon Road and Broadway, where it would join other water from sub-areas 4A, 4B, 4D, 5A and 5B.

CHAPTER 7
ANALYSIS OF CAP DESIGN
AND
CONSTRUCTION IMPLEMENTATION

7.1 ANALYSIS OF CAP DESIGN OF CROSS-DRAINAGE FACILITIES

Three cases were considered in the analysis of the CAP design of the cross-drainage facilities of Reach 1B. Case I concerns the drainage condition at the time of the July 17-18, 1984 thunderstorm and is discussed in Chapter 4; Case II is the drainage condition during the interim between completion of Reach 1B and before completion of the proposed SCS flood protection facilities; and Case III represents the drainage condition after completion of the proposed SCS facilities. The 100-year, 3-hour thunderstorm is the design event for Case II and Case III.

7.2 CASE II

This analysis considers drainage conditions along Reach 1B, during the interim period after completion of the Salt-Gila Aqueduct and before completion of the proposed SCS flood protection works to the north. The basic runoff model described in Chapter 4 was modified as shown on Exhibit 7-1. The hydrograph characteristics for this case are shown on Table 7-1.

In addition to determining the adequacy of the overchute structures for the 100-year, 3-hour storm runoff, the capability of the aqueduct* to intercept the flows, should the capacity of the cross-drainage structures be exceeded, was analyzed.

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* There is a discrepancy in the left bank O&M road elevations. The table on Drawing 344-D-8355 shows the height above invert to vary between 26 and 32.1 feet, whereas the plan and profile drawings show 23 to 32 feet.

SCHEMATIC DIAGRAM
CASE II

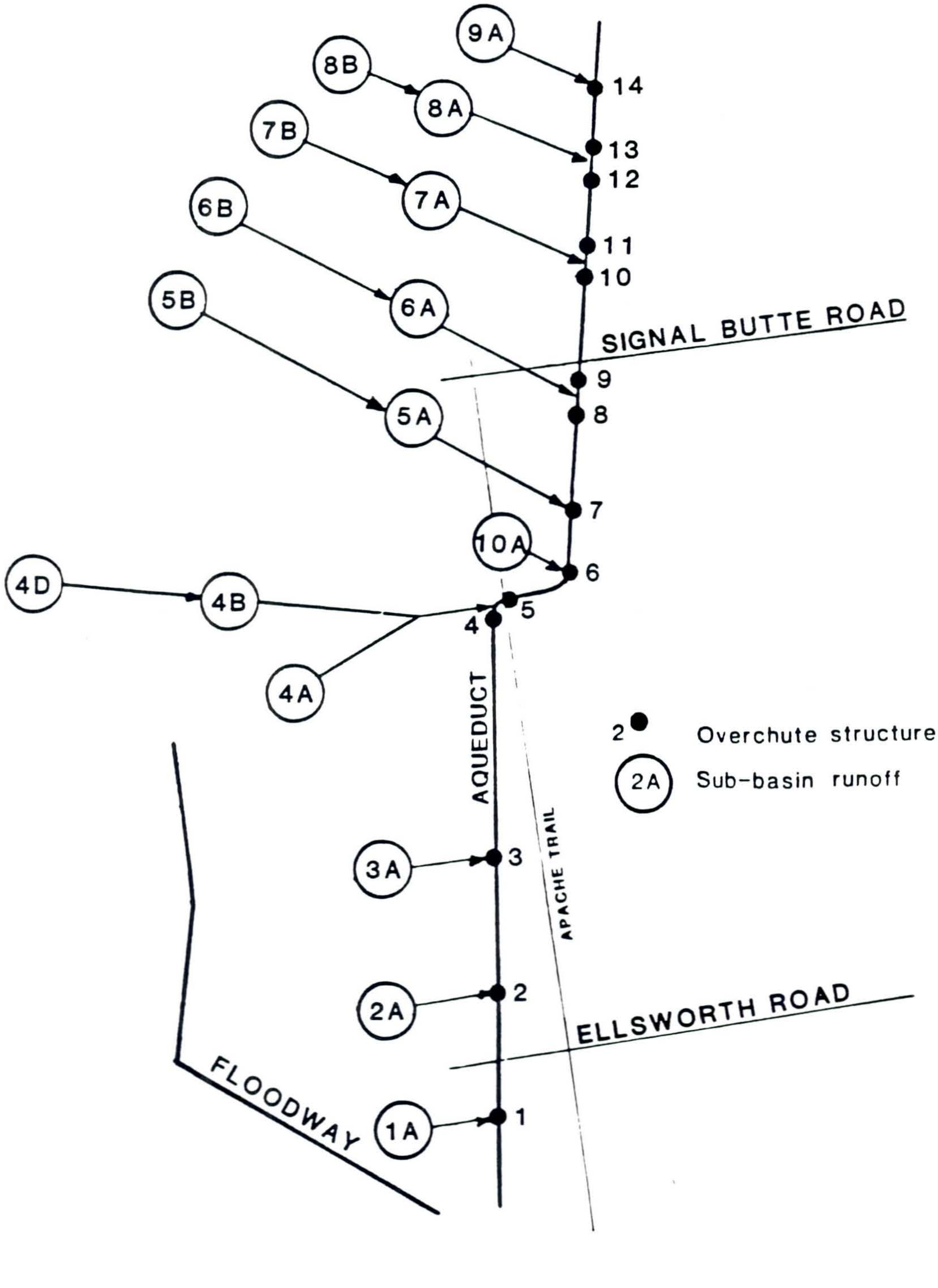


EXHIBIT 7-1

TABLE 7-1

CASE II

DISCHARGE HYDROGRAPHS

Structure		Drainage Area		Discharge	
No.	Station	Designation	Area (sq mi)	Peak (cfs)	Volume (ac-ft)
1	345+30	1A	0.40	436	31
2	374+00	2A	0.87	887	67
3	396+40	3A	0.76	762	58
4	427+15	4A+4B+4D	5.72	2320*	219*
5	429+20				
6	456+50	10A	0.19	286	15
7	471+03	5A+5B	2.98	1765	228
8	479+00	6A+6B	4.30	1201*	165*
9	504+25				
10	529+50	7A+7B	6.35	1821*	243*
11	542+50				
12	552+50	8A+8B	5.99	1190*	228*
13	563+50				
14	574+50	9A	0.66	401	50

* per each structure

Table 7-2 shows the computed inlet water surface elevation for each of the cross drainage structures for design peak discharges, provided by the Bureau, and the peak discharges computed by the runoff model under Case II conditions. Ground elevations are given for the natural ground at the toe of the north berm of the aqueduct. Computations for each overchute, considered to act independently, are in Appendix A.

A comparison of Case II inlet water surface elevations computed for the structures at and between Stations 479+00 and 563+50, with the natural ground elevations indicates that local flooding or ponding will occur near the north berm of the aqueduct. Topographic maps show that the ponding between these stations will not encroach on developed property.

At Station 471+03, a similar analysis shows that considerable flooding of developed property will occur adjacent to the north berm of the aqueduct, even though the theoretical inlet water surface elevation of 1572 may not be achieved due to diversion of flows to other drainage structures. There seems to be little inducement for runoff to the southeast, along the toe of the north berm, as the low point of Broadway Road is Elevation 1570 east of the aqueduct. More likely a good part of the runoff will proceed west along Bramble to the overchute at Station 456+50, where the ground elevation is about 1562, and form a pool.

At Stations 427+15 and 429+20 the 100-year, 3-hour thunderstorm peak runoff is 2320 cfs at each overchute structure, about four times more than the design value. In this very local area, the upslope berm elevation is 1577.9 which returns to about Elevation 1574 via 20:1 ramps before meeting Crismon Road or Apache Trail. The theoretical head to obtain these discharges through the overchutes greatly exceeds the berm elevations. Upon reaching Elevation 1574 backwater simply spills into the aqueduct at the ends of the ramps near Crismon Road and Apache Trail and, with increasing head, crosses Apache Trail and flows

TABLE 7-2

CASE II CROSS-DRAINAGE INLET WATER SURFACE ELEVATIONS

Aqueduct Station	Overchute Type	Bureau Design Discharge (cfs)	Bureau Inlet Water Surface Elev. (ft)	Ground Elevation (ft)	Case II Peak Discharge (cfs)	Case II Inlet Water Surface Elev. (ft)
345+30	3 - 54"	460	1572.39	1573	436	1572.3
347+00	40' wide	870	1569.93	1570	887	1569.92
396+40	40' wide	800	1569.45	1571	762	1569.3
427+15	3 - 72"	565	1573.96	1575	2320	1649.0
429+20	3 - 72"	565	1576.46	1575	2320	1711.0
456+50	2 - 60"	270	1561.65	1561.8	286	1561.94
471+03	3 - 72"	910	1566.64	1569	1765	1572.0
479+00	5 - 72"	575	1566.79	1567	1201	1569.37
504+25	5 - 72"	575	1566.79	1569	1201	1569.37
529+50	5 - 72"	840	1568.28	1569	1821	1571.75
542+50	5 - 72"	840	1568.28	1569	1821	1571.75
552+50	5 - 72"	760	1569.13	1570	1190	1571.0
563+50	5 - 72"	760	1569.13	1570	1190	1571.0
574+50	3 - 54"	400	1571.9	1574	401	1572.0

south to the overchute at Station 456+50 in a manner similar to the flooding which occurred in this locale during the July 17-18, 1984 storm, which pooled at Elevation 1576.8.

To achieve the discharge of 2320 cfs the theoretical inlet water surface elevation required at Stations 427+15 and 429+20 are 1649 and 1711, respectively. The higher head required at Station 429+20 is partly due to the abrupt transition from invert elevation 1563.37 to 1565.5 at the extension of the drainage way and the smaller capacity of four 48-inch pipes as shown on Exhibit 7-2.

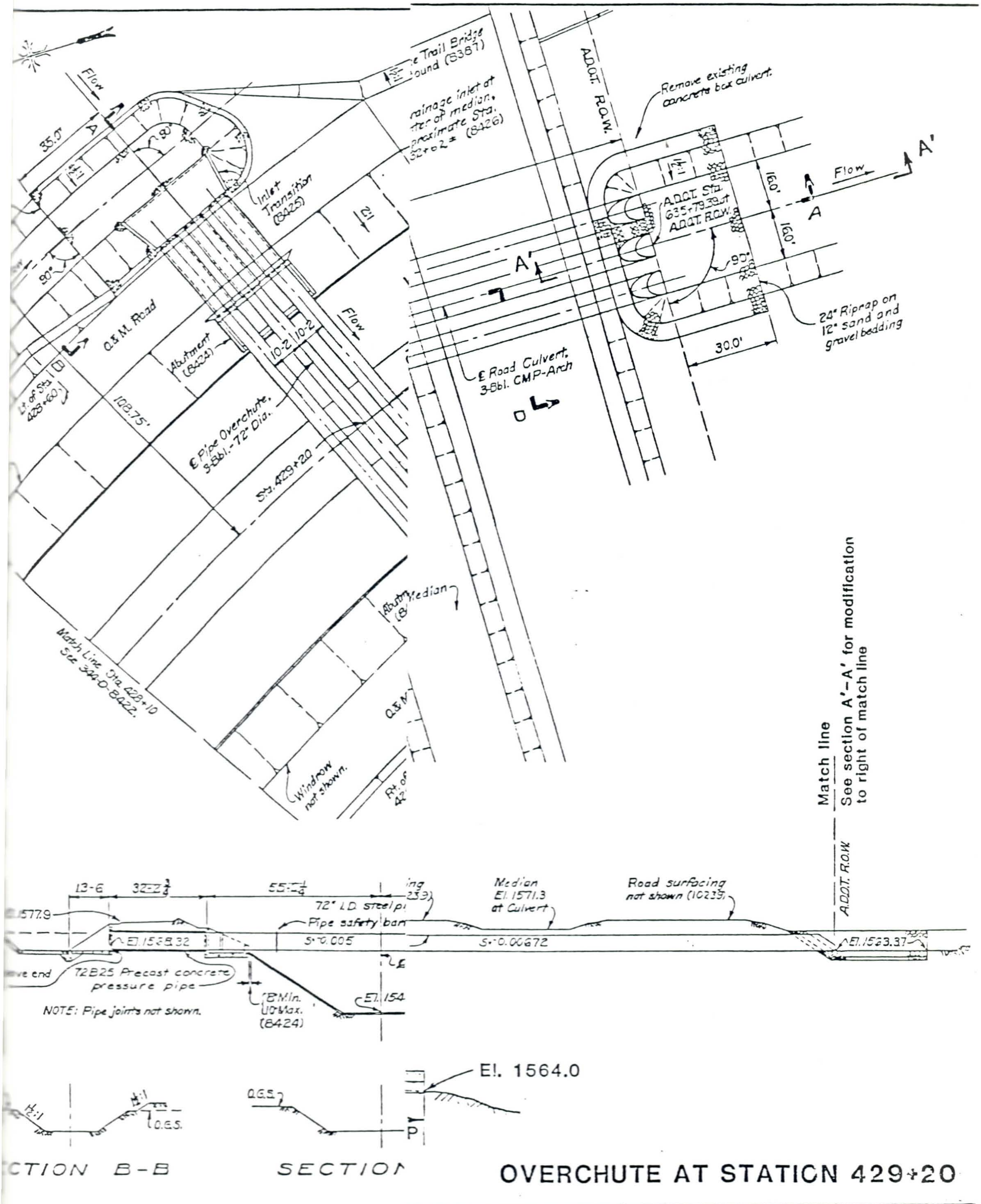
The analysis discounts the effect of sediment buildup during low flows, as, once the larger flows occur and velocities reach 4 feet-per-second or more, the sediment will be picked up and carried with the discharge. See Exhibit 7-3.

If the aqueduct were to act as interceptor canal, utilizing the storage between normal depth of 15.74 feet and bank height of approximately 26 feet, it could convey 5300 cfs operating unchecked at bankfull conditions. The rating curve for the aqueduct is shown on Exhibit 7-4.However, if the design discharge of 2750 cfs was being conveyed, only 2330 cfs could be allocated to flood inflows.

7.3 CASE III

This analysis considers the adequacy of cross-drainage facilities after completion of construction of the Salt-Gila Aqueduct and the proposed SCS facilities.

The model schematic for this case is shown on Exhibit 7-5, and the hydrograph characteristics are shown in Table 7-3, together with the original design values. Comparison shows that Case III peak discharges are in substantial agreement with the original Bureau design.



OVERCHUTE AT STATION 429+20

EXHIBIT 7-2

SEDIMENT TRANSPORT DIAGRAM

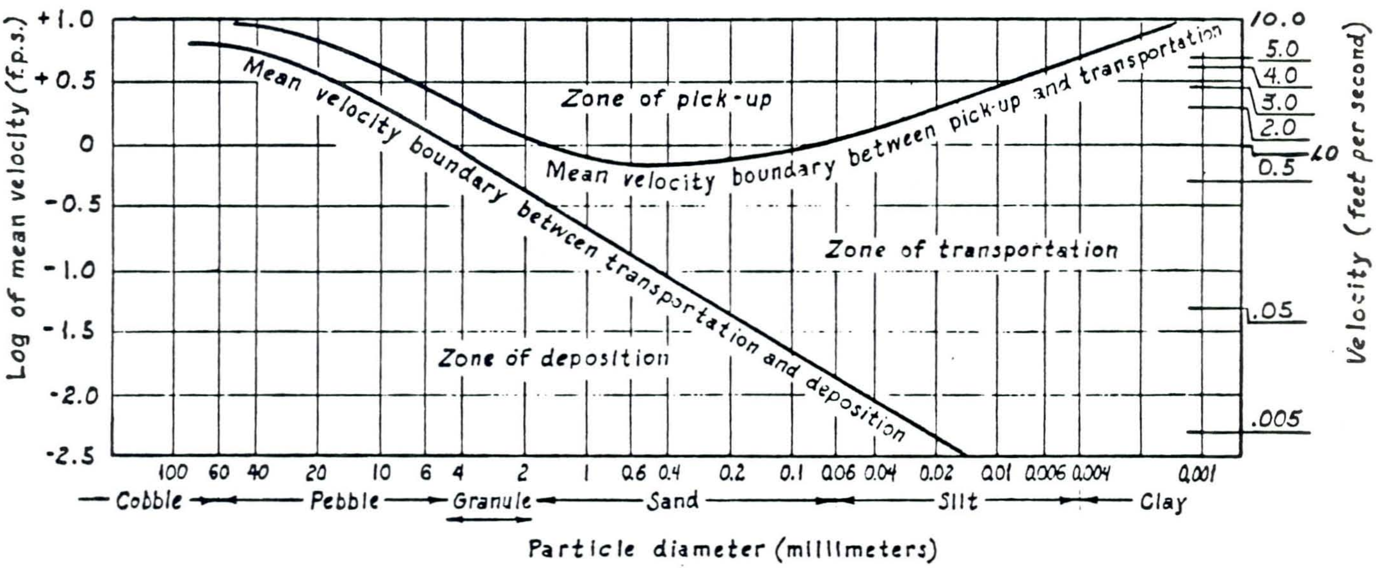
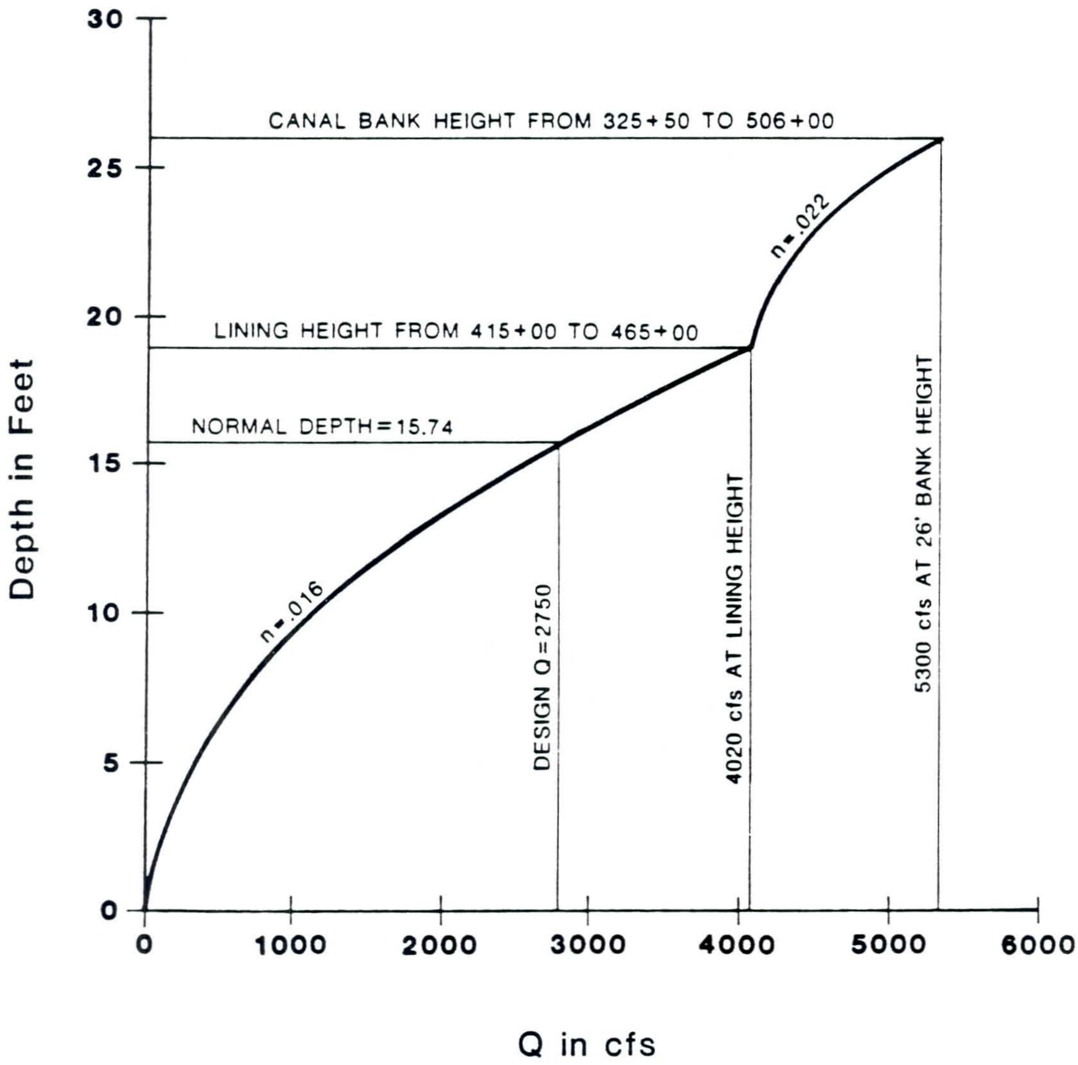


Fig. 7.22 Hjulstrom's diagram, somewhat simplified, showing the relationship between the average stream velocity and the movement of particles of specified size. The field of deposition indicates that below the boundary line current velocities are insufficient to propel particles downstream. In the field of transportation velocities are great enough to keep the specified particle in motion. Above the line marking the upper limit of the field of transportation, particles may be picked from the stream bed in accordance with the velocities indicated. Note that particles of medium sand size are caused to move at lowest velocities and that velocities needed to pick up clay (from a clay layer) are as great as those for pebble size. (Hjulstrom, Recent Marine Sediments, Am. Assoc. Petrol. Geologists.)

AQUEDUCT RATING CURVE



SCHEMATIC DIAGRAM
CASE III

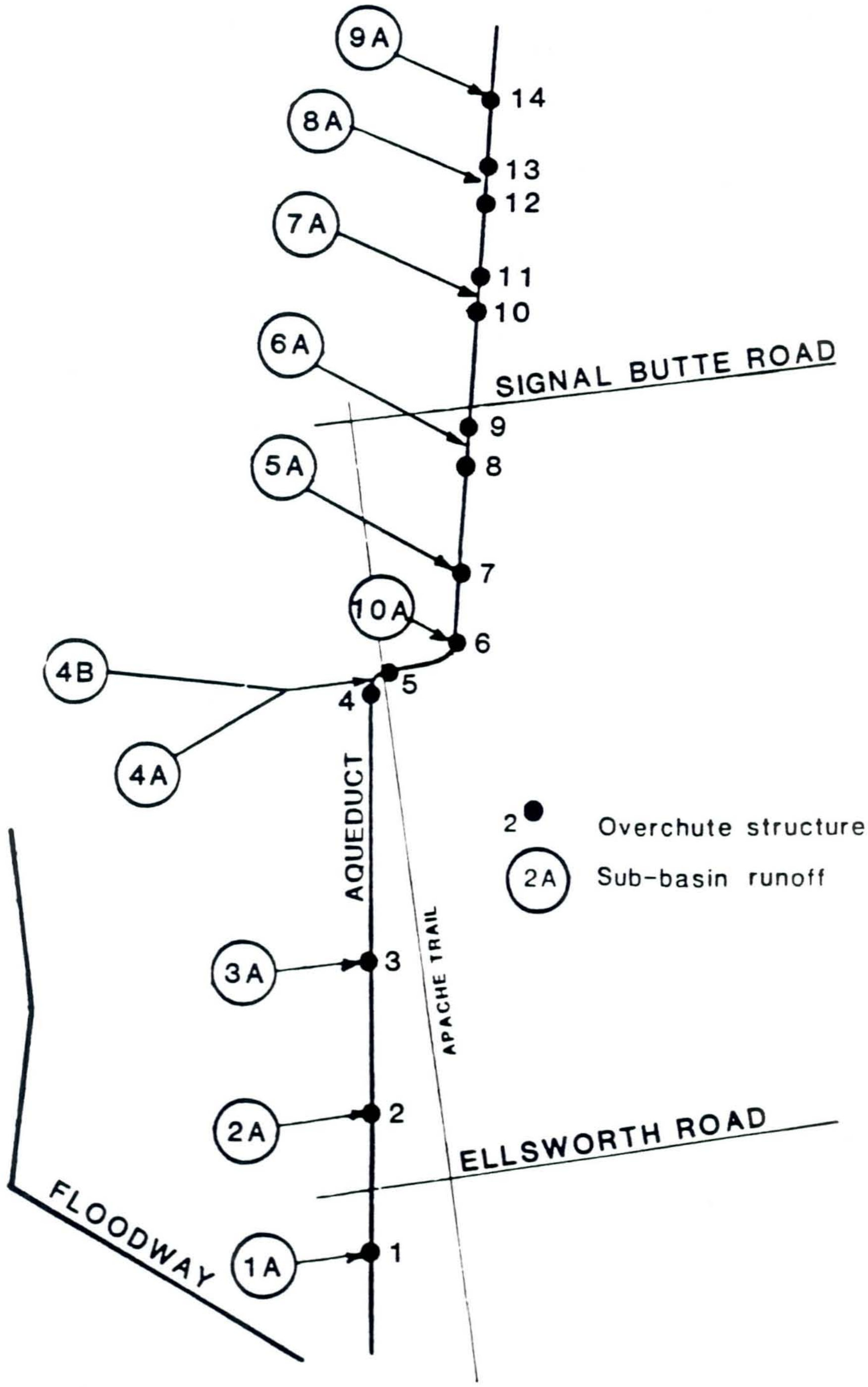


TABLE 7-3

CASE III

DISCHARGE HYDROGRAPHS

Structure		Case III				Bureau(1) Original Design		
		Drainage Area		Discharge		Drainage Area	Discharge	
No.	Station	Designation	Area (sq mi)	Peak (cfs)	Volume (ac-ft)	(sq mi)	Peak (cfs)	Volume (ac-ft)
1	345+30	1A	0.40	436	31	0.40	460	27
2	374+00	2A	0.87	887	67	0.82	870	60
3	396+40	3A	0.76	762	58	0.76	800	51
4	427+15	4A+4B+4D	1.88	530*	72*	1.73	565*	59*
5	429+20							
6	456+50	10A	0.19	286	15	0.19	270	13
7	471+03	5A	1.67	889	128	1.67	910	113
8	479+00	6A	2.28	543*	87*	2.26	575*	52*
9	504+25							
10	529+50	7A	3.17	803*	121*	3.10	840*	105*
11	542+50							
12	552+50	8A	4.06	778*	154*	3.99	760*	135*
13	563+50							
14	574+50	9A	0.66	401	50	0.62	400	42

(1) Reference 7

* per each structure

It has been shown in Table 7-2 that the inlet water surface elevations for the Bureau design peak discharges were below the ground elevations for all structures but the one at Station 429+20. The reduced capacity of four 48-inch pipes at this location as discussed above creates a 1.46-foot backwater.

Since the Case III peak discharges are similar to the Bureau design peak discharges we conclude that the design capacities of the overchute structures are acceptable for the 100-year 3-hour storm.

7.4 COORDINATION OF DESIGN AND CONSTRUCTION

A. Design Coordination

Design efforts of the Bureau and the SCS were extremely well-coordinated; in fact, the SCS Planned Project was part of the design data submitted for this portion of the Central Arizona Project.

As a result of the contemplated construction of the SCS facilities the need for cross-drainage structures between Stations 14+95 and 345+00 was eliminated, as all runoff not exceeding the 100-year frequency was to enter the Spook Hill flood retarding structure that also shared a common right-of-way with Reach 1A of the Salt-Gila Aqueduct.

The proposed SCS designs were also used as a basis for intercepting runoff for the Bureau sizing of cross-drainage structures from Stations 345+00 to 588+00. The proposed SCS structures have the effect of reducing the peak flows to the extent that the concentration of runoff, necessary for economical design, will not exceed the present conditions. This eliminates the need for detention ponds and resulting backwater conditions on the uphill side of the canal.

B. Construction Coordination

Construction coordination was also necessary, since both the SCS and the Bureau had simultaneous construction contracts. One result of the coordination is construction of the SCS Spook Hill flood retarding structure with excavated material from the Salt-Gila Aqueduct. The Bureau specifications for Reach 1B of the Salt-Gila Aqueduct (Reference 5) explicitly state that the contractor will cooperate fully with other contractors or government employees. During the progress of the work under this contract, additional work may be performed concurrently by other contractors under specifications 3D-C7501 and 3D-C7518, and by the Government, in the vicinity of Stations 331+00 and 558+00 of the Salt-Gila Aqueduct. Under these specifications, the contractor will fully cooperate with such other contractors and government employees as stipulated in the clause entitled "Other Contracts".

When working space is limited, its use will be subject to the approval of the contracting officer.

C. Bureau Construction Schedule

Examination of the construction schedule for the Salt-Gila Aqueduct, compared with visual observation, shows that construction was approximately on schedule and that cross-drainage structures were scheduled for completion in December 1984. The schedule shows that canal excavation was to be complete on June 1 and that structural earthwork would have been approximately 50 percent complete at the time of the flood.

The major part of the overchute construction is scheduled for the period between August 1984 and January 1985. The only other items affecting runoff are the detours and access roads; these facilities were scheduled for completion on 1 May 1984.

The contractor's construction program shows a completion date of January 1, 1985.

D. SCS Construction Schedule

A review of the construction schedule for the SCS Buckhorn-Mesa Watershed shows that:

1. Spook Hill was completed in 1980.

2. Signal Butte Floodway was completed in September 1984.

3. Pass Mountain Dam and Signal Butte Dam designs are completed and will go out for bids under one contract. Construction will start in July 1985 and take from nine months to one year to complete.

4. Bulldog Floodway and Apache Junction Flood Retention Structure have not yet been designed. SCS will advertise for an A&E design firm in October 1984. Designs will be completed in time to award a construction contract at the termination of the Pass Mountain-Signal Butte Dam contract. Completion will be sometime in 1987.

7.5 CARE OF WATER DURING CONSTRUCTION

The responsibility for care of water during construction by the Bureau contractor for Salt-Gila Aqueduct, as per the specifications, is as follows:

A. Bureau Contract

Care of the water during construction is described in paragraph 1.3.8 - Construction at Existing Watercourses and Utilities - and paragraph

2.4.1 - Cross Drainage - of the specifications for construction of Salt-Gila Aqueduct (Ref. 5). Extracts are shown on Exhibit 7-6.

B. <u>SCS Contract</u>

Responsibility for care of water during construction by the SCS contractors for the Signal Butte Floodway is described in Section 11, paragraph 2 of the specifications (Ref. 6) as shown on Exhibit 7-6.

EXCERPTS FROM CONSTRUCTION SPECIFICATIONS

SALT-GILA AQUEDUCT-REACH 1B

1.3.8 CONSTRUCTION AT EXISTING WATERCOURSES AND UTILITIES

Where the work to be performed under these specifications crosses or otherwise interferes with water, sewer, gas, or oil pipelines; buried cable; or other public or private utilities, or with artificial or natural watercourses, the Contractor shall provide for such utilities and watercourses, and shall perform such construction during the progress of the work so that no damage will result to either public or private interests. The term "watercourses" includes ditches, terraces, furrows, or other features of surface irrigation systems. The Government does not represent that the locations of watercourses and utilities shown on the drawings are exact. It shall be the responsibility of the Contractor to determine the actual locations of and make provision for all watercourses and utilities. The Contractor shall coordinate and verify all utility locations with the various utility companies.

Before any watercourse or utility is taken out of service, permission shall be obtained from the owners. The Contractor shall be liable for all damage that may result from failure to provide for watercourses or utilities during the progress of the work and the Contractor shall indemnify and hold harmless the Government from claims of whatsoever nature or kind arising out of or connected with damage to watercourses or utilities encountered during construction, damages resulting from disruption of service, and injury to persons or damage to property resulting from the negligent, accidental, or intentional breaching of watercourses or utilities.

Irrigation systems disturbed by the work shall be restored in the location and in as good condition as found, except as otherwise approved.

If the Contractor does not maintain the existing watercourses and utilities in such condition that no damage will result to either public or private interests, the Government will cause the necessary repairs to be made and backcharge the Contractor for such work.

Except as otherwise provided below, the cost of all work described in this paragraph shall be included in the prices bid in the schedule for other items of work.

Where construction of new structures or modifications of existing structures are required in order to continue a watercourse or utility in operation beyond the period of the contract, the Contractor shall notify the Contracting Officer so that arrangements can be made with the owners for the construction or modifications required. When it is determined that such work is to be performed by the Contractor and such items of work are not provided for in the schedule, the Contractor shall perform the necessary work in accordance with clause No. 3 of the General Provisions.

Where watercourses or utilities are encountered but are not shown on the drawings or otherwise provided for in these specifications, all additional work required to be performed by the Contractor as a result of encountering the watercourses or utilities shall be performed in accordance with clause No. 3 of the General Provisions.

2.4.1 CROSS DRAINAGE

The Contractor shall handle all flows from natural drainage channels intercepted by the work under these specifications, perform any additional ditching and grading for drainage as directed, provide and maintain any temporary construction required to bypass or otherwise cause the flows to be harmless to the work, property, and other ongoing contracts. When the temporary construction is no longer needed and prior to acceptance of the work, the Contractor shall remove the temporary construction and restore the site to its original condition as approved by the Contracting Officer. The cost of all work and materials required by this paragraph shall be included in the prices bid in the schedule for other items of work.

SIGNAL BUTTE FLOODWAY

SECTION II - PARAGRAPH 2

Diverting Surface Water
The Contractor shall build, maintain, and operate all cofferdams, channels, flumes, sumps, and other temporary diversion and protective works needed to divert streamflow and other surface water through or around the construction site and away from the construction work while construction is in progress. Unless otherwise specified, a diversion must discharge into the same natural drainageway in which its headworks are located.

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CHAPTER 8

OBSERVATIONS, CONCLUSIONS AND RECOMMENDATIONS

A summary of the sequence of events is presented below to provide a common understanding of how the runoff moved through the area with respect to the Salt-Gila Aqueduct Reach 1B.

8.1 SEQUENCE OF EVENTS

A severe thunderstorm, centered on Reach 1B, started at about 2230 hours on July 17, 1984. Near midnight the Signal Butte Floodway, in the watershed above the reach, filled and overflowed its south berm. The outflows, augmented by runoff from rain falling between the floodway and the aqueduct, formed three pools adjacent to the north berms of the aqueduct. Water from the pools entered the aqueduct prism through excavations and breaches in the north berms.

Two major outflows to areas south of Reach 1B occurred: one over the University Drive crossing, and the other through an opening in the aqueduct south berm near 102nd Street and Broadway. The University outflow was estimated to have a volume of more than 35 ac-ft and a peak of 594 cfs that occurred at about 0020 hours. It was estimated that the Broadway outflow started at about 0000 hours, had a volume of 620 ac-ft and a peak flow of 3459 cfs, which occurred at about 0054 hours on July 18.

The portion of the Reach 1B aqueduct prism, which extends from just upstream of the University Drive crossing to just downstream of the Apache Trail crossing, contained four dikes that acted as partial barriers to flow in the prism. The dikes are shown schematically on Exhibit 4-5. Water that entered the aqueduct above the University Drive crossing remained in the aqueduct. The volume in Reaches 1A and 1B on July 18, after the storm, was estimated at 175 ac-ft.

Runoff, which entered between the upstream dike at University Drive crossing and the dike just downstream of Apache Trail, formed a surcharged pool above the dikes and was thus able to flow both upstream to dead storage and downstream across the barrier dikes.

Runoff entering the aqueduct between the downstream dike at Apache Trail and the dike at Signal Butte Road became part of the outflow at the Broadway outlet, along with the water that flowed downstream over the barrier dikes.

Outflows from the opening at S. 102nd Street and Broadway, augmented by local runoff, flowed to the southwest through developed areas to a drainage channel located halfway between Southern Avenue and Baseline Road. Water from this ditch overflowed its banks near Inverness Avenue and 78th Street, and then flowed through a developed area into a drainage channel exiting south of Baseline Road.

8.2 OBSERVATIONS AND CONCLUSIONS

The following observations and conclusions were formulated during the investigations. The first 8 observations and conclusions are based on Chapter 7. Numbers 9 through 12 are taken from Chapters 4 and 5 and Number 13 is derived from Chapter 6.

1. Cross-drainage facilities, to carry runoff from natural drainage channels interrupted by the construction of Reach 1B, were not developed for the care of water during construction as required by the Bureau specifications. There were no indications that the contractor had a plan for handling large storm flows.

2. No hydrographs for areas tributary to Reach 1B were given in the Salt-Gila Aqueduct specifications. The hydrographs presented are for a gaging station for a tributary to the Salt River somewhat removed from Reach 1B. The applicability of

these hydrographs for construction planning in Reach 1B to determine the probability of major flooding is questionable.

3. Drainage channels and collection ditches along the toe of the north berm of the aqueduct were not fully developed on July 17, and thus caused backwater and flooding due to ponding against the berms. In particular, the area northeast of the Apache Trail-Crismon Road intersection was inundated because the water had no place to go until it broke through the berm of the aqueduct.

4. SCS specifications for the Signal Butte floodway required the contractor to divert surface water through or around the construction site, and away from the construction work while construction is in progress. The diversion must discharge into the same natural drainageways in which its headworks are located. Neither the diversion nor the discharge requirements were met.

5. The plug construction in the Signal Butte floodway by the SCS contractor prevented intercepted flows during the July 17-18 storm from entering the concrete portion of the floodway and thus caused overtopping of the south access road. This overtopping resulted in a surcharge to the runoff from the sub-basins south of the floodway and an additional 205 acre-feet that had to be handled by aqueduct facilities.

6. Aqueduct cross-drainage structures will carry Bureau design flows without causing upstream flooding due to impounded water, provided downstream controls do not cause a higher backwater condition.

7. During the interim period between the completion of Reach 1B and the completion of SCS flood protection works:

- Inlet water surface elevations computed for the cross-over structures at and between Stations 479+00 and 563+50 indicate that ponding will occur on undeveloped land near the north berm for the 100-year, 3-hour storm. The pool will not encroach on developed land for the present stage of development.

- At Station 471+03 the inlet water surface elevation at the overchute structure, calculated for the 100-year, 3-hour storm, indicated that flooding of developed land will occur adjacent to the north berm.

- The 100-year, 3-hour storm peak discharge from the tributary areas to drainage structures at 427+15 and 429+20 during the interim period exceeds the Bureau design discharge by about four times. This will cause considerable backwater and flooding northeast of the Apache Trail-Crismon Road inter- section. There is also potential danger of flooding in this area after the flood protection works are complete, as there is a downstream control at the exit of the three 87-inch by 63-inch pipe arches that cross under Apache Trail. Also, the channel downstream of the pipe arches under Crismon Road does not appear to have the capacity to carry the Bureau design flow of 565 cfs.

8. After construction of the SCS flood protection works, flooding south of Reach 1B will not be greater than that which would have occurred under pre-aqueduct conditions. The flooding in general will be mitigated due to the construction of the protection works. There may, however, be local flooding along drainage channels on the south side of the aqueduct, which receives the outflows from the drainage structures, particularly for the 100-year, 3-hour event.

9. Flooding damages north of Reach 1B attributable to CAP structure-impacted water were due to ponding against the north berm of the aqueduct. Reported damages elsewhere north of Reach 1B were due to running water either from local runoff or Signal Butte Floodway outflows and are thus not attributable to CAP facilities.

10. Flooding damage south of Reach 1B attributable to CAP structure-impacted water were due to running water from two outflows from the reach, one at University Drive crossing and the other at S. 102nd Street and Broadway.

11. There is clear evidence that two separate flooding events occurred south of Reach 1B. The first was due to local runoff, and the second to CAP releases augmented by local runoff. It has not been possible to determine the relative contributions to flooding by the two events.

12. The major CAP outflow at Broadway and S. 102nd Street was estimated to have begun at 0000 hrs and to have peaked at 0054 hours on July 18. This event, adjusted for time of travel, seperates flood damages attributable to local runoff from CAP structure-impacted water. The application of this concept is difficult, however, since relative time and sequence of event data from witnesses is generally lacking.

    There is also clear evidence that the farther away the point of flooding was from the CAP the greater the time difference between the two flood events, and the greater the effect on flooding of the local runoff with respect to the CAP contribution.

13. A subjective analysis of the flooding that would have occurred if Reach 1B had not been in place resulted in the following:

- Ponding north of the aqueduct would not have occurred as there would have been no aboveground berms to interrupt the flow.

- The aqueduct prism provided dead storage for 175 ac-ft of runoff upstream of University Drive, much of which was outflow from the Signal Butte Floodway. This large, concentrated flow would have caused additional flooding along Ellsworth and in the developed area southwest of the Apache Trail-Ellsworth intersection.

- In general, the areas between Crismon and Ellsworth, and between the Reach 1B alignment and Apache Trail, would have experienced more flooding in the vicinity of drainage channels and along principal streets. Runoff from the north of the Reach 1B line would have been distributed along the line of the reach, instead of going into dead storage in the prism or becoming part of the outflows at University Drive crossing and at Broadway and 102nd Street.

- In Damage Area S-1, southwest of the University Crossing outflow, the trailer parks at 9333 and 9427 E. University would most likely have received less inflow without Reach 1B.

- Damage Area S-2, the area in the path of the CAP outflow at Broadway and 102nd Street, would have received less total runoff without Reach 1B in place. The degree of flooding cannot, however, be determined from the available evidence. Much of the water that passed through the most heavily affected areas on July 17-18 would probably have passed through streets to the northwest. Flooding during the earlier part of the storm might have been more severe without Reach 1B, as there would have been more water on Crismon and Broadway from the large, concentrated flows to the Crismon Road-Apache Trail intersection which would not have been intercepted by the aqueduct.

- It is likely that damages similar to those incurred on July 17-18 would have been sustained in Damage Areas S-3 and S-4 if Reach 1B had not been in place. Both areas are distant from the CAP and would have been subjected to runoff from approximately the same tributary drainage areas, with or without the aqueduct.

8.3 RECOMMENDATIONS

1. The construction program for Reach 1B indicates that 87 percent of the overchute construction work remains to be completed. Temporary wasteways or overchutes should be constructed to discharge runoff into channels that are capable of handling predetermined discharge. Consideration should be given to making some of these wasteways permanent.

2. In conjunction with the above, temporary drainage inlets to the aqueduct prism should be constructed, to allow the aqueduct prism to act as a temporary reservoir for the storage of runoff to avoid ponding against the north berm in case the capacity of the temporary wasteways is exceeded.

3. The SCS and the Bureau should enter into negotiations at the highest level necessary for the purpose of expediting completion of the SCS facilities.

4. The Bureau and the entities responsible for drainage south of Reach 1B should decide on a course of cooperative action to assure that the drainage channels downstream of the overchute drainage structures have sufficient capacity to carry the design outflow plus the increment from local runoff. The basis for this recommendation is that the Salt-Gila aqueduct is a highly visible facility in the area. Future flooding, in developed areas receiving outflow from the overchute

structures operating as designed, will likely be attributed directly to the aqueduct without consideration of other, more significant causative factors such as poorly maintained, restricted, or non-existent drainage channels of insufficient capacity to carry storm runoff.

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[illegible]

[illegible]

REFERENCES

1. Soil Conservation Service, U.S. Department of Agriculture, Watershed Work Plan, Buckhorn-Mesa Watershed, Maricopa and Pinal Counties, Arizona, January 1963.

2. Soil Conservation Service, U.S. Department of Agriculture, Buckhorn-Mesa Watershed, Arizona, Final Supplemental Watershed Work Plan; Agreement No. 1 and Supplemental Watershed Work Plan No. 1, July 1976.

3. Soil Conservation Service, U.S. Department of Agriculture, Final Environmental Impact Statement, Buckhorn-Mesa Watershed, Arizona, June 1976.

4. U.S. Geological Survey, U.S. Department of the Interior, TWRI, Book 3, Chapter A2 Measurement of Peak Discharge by the Slope Area Method, Washington D.C. 1967.

5. Bureau of Reclamation, United States Department of the Interior, Salt-Gila Aqueduct, Reach 1B, Central Arizona Project, Arizona, Solicitation/Specifications 3-SB-30-00500/DC-7557.

6. Soil Conservation Service, U.S. Department of Agriculture, Specifications, Signal Butte Floodway, Buckhorn-Mesa Watershed, Maricopa and Pinal Counties, Arizona.

7. Bureau of Reclamation, United States Department of the Interior, Memorandum to Chief, Division of Design, from Chief, Division of Planning Technical Services. Subject: Review of Specifications Design Data for Reach 1 - Salt-Gila Aqueduct - Central Arizona Project, Arizona; Denver, Colorado, May 27, 1980.

APPENDIX A

Computations to determine the adequacy of the cross drainage facilities were originally based on three discharge conditions: (1) Design flow, (2) July 17 and 18 storm, and (3) the 100-year 3-hour storm. Subsequently, it was decided that the July 17-18 storm should not be a consideration.

The hydraulic cases of the cross drainage are shown on the accompanying sketch. In some cases, where the outlet pond submerged portions of the pipe, it was necessary to balance the energy (Bernoulli) to determine which case controlled.

The analysis of structure at 429+20 also considered the effect of the private drainage structure which is an extension of the CAP cross drainage. The water surface elevations determined for the 100-year 3-hour storm are theoretical, and based on a hypothetical condition that the embankments would be high enough to contain the discharge. The actual condition is discussed in Chapter 7.

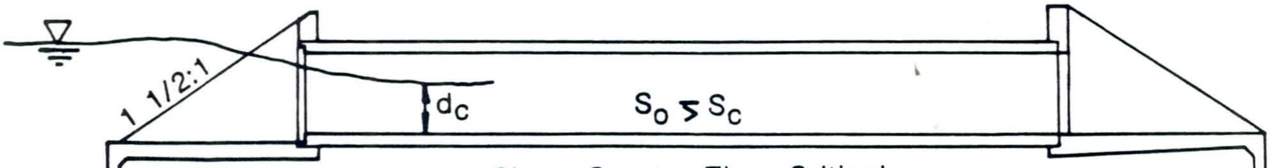
Maximum discharges were based on an impoundment elevation of 1574.5, the approximate elevation of the O&M road on the left bank.

Exit losses were based on sudden expansion, and equal one pipe velocity head (hv). Entrance losses were based on convergence from ponded water, and were equal to one half of the pipe velocity head (.5 hv). Friction losses were based on Manning's n=.012 for both steel and concrete pipe, and .027 for the CMP arches, which have 1" corrugation. Full pipe conditions were based on

$$\frac{Qn}{D^{8/3}\,S^{1/2}} = .5$$

rather than .463, as flow is unstable due to the rapid change in hydraulic radius between .463 and .498.

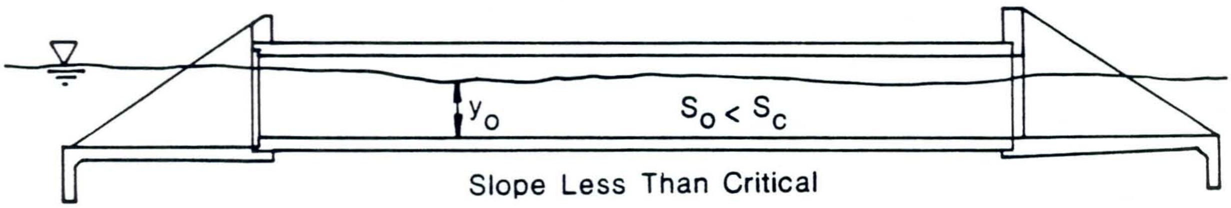
CASE I



Slope Greater Than Critical

Inlet w.s. = d_c + 1.5hvc + Invert El. at Inlet

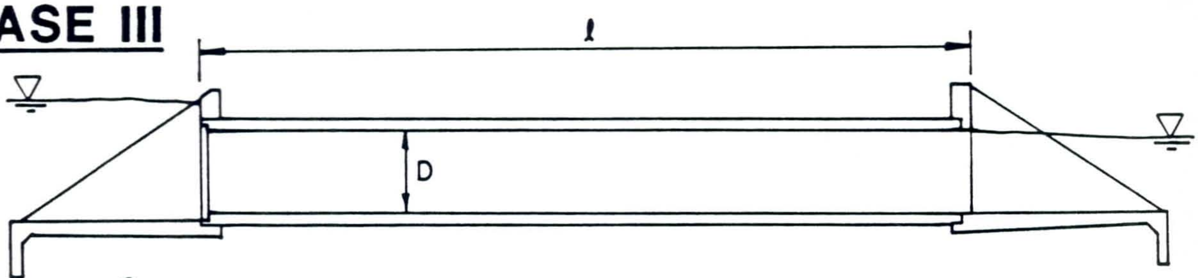
CASE II



Slope Less Than Critical

Inlet w.s. = y_o + 1.5hv + Invert El. at Inlet

CASE III

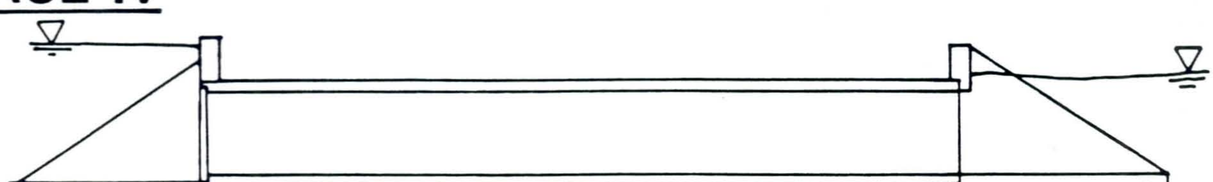


$\frac{Qn}{D^{8/3}\ S^{1/2}} > .50$ Full Pipe - Under Pressure - Outlet Unsubmerged

Inlet w.s. = Exit Loss + Pipe Friction + Entrance Loss + D + Invert El. at Outlet = 1.5hv + $S\ell$ + D + Invert El.

$$S = \left(\frac{Qn}{D^{8/3}\ .463}\right)^2$$

CASE IV


Full Pipe Outlet Submerged

Inlet w.s. = w.s. El. at Outlet + 1.5hv + $S\ell$

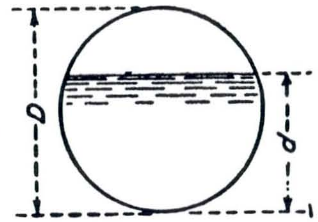
Table 21.—*Uniform flow in circular sections flowing partly full*

d = Depth of flow
D = Diameter of pipe
A = Area of flow
R = Hydraulic radius
Q = Discharge in second-feet by Manning's formula
n = Manning's coefficient
S = Slope of the channel bottom and of the water surface

$\frac{d}{D}$	$\frac{A}{D^2}$	$\frac{R}{D}$	$\frac{Qn}{D^{8/3}S^{1/2}}$	$\frac{Qn}{d^{8/3}S^{1/2}}$	$\frac{d}{D}$	$\frac{A}{D^2}$	$\frac{R}{D}$	$\frac{Qn}{D^{8/3}S^{1/2}}$	$\frac{Qn}{d^{8/3}S^{1/2}}$
0.01	0.0013	0.0066	0.00007	15.04	0.51	0.4027	0.2531	0.239	1.442
0.02	0.0037	0.0132	0.00031	10.57	0.52	0.4127	0.2562	0.247	1.415
0.03	0.0069	0.0197	0.00074	8.56	0.53	0.4227	0.2592	0.255	1.388
0.04	0.0105	0.0262	0.00138	7.38	0.54	0.4327	0.2621	0.263	1.362
0.05	0.0147	0.0325	0.00222	6.55	0.55	0.4426	0.2649	0.271	1.336
0.06	0.0192	0.0389	0.00328	5.95	0.56	0.4526	0.2676	0.279	1.311
0.07	0.0242	0.0451	0.00455	5.47	0.57	0.4625	0.2703	0.287	1.286
0.08	0.0294	0.0513	0.00604	5.09	0.58	0.4724	0.2728	0.295	1.262
0.09	0.0350	0.0575	0.00775	4.76	0.59	0.4822	0.2753	0.303	1.238
0.10	0.0409	0.0635	0.00967	4.49	0.60	0.4920	0.2776	0.311	1.215
0.11	0.0470	0.0695	0.01181	4.25	0.61	0.5018	0.2799	0.319	1.192
0.12	0.0534	0.0755	0.01417	4.04	0.62	0.5115	0.2821	0.327	1.170
0.13	0.0600	0.0813	0.01674	3.86	0.63	0.5212	0.2842	0.335	1.148
0.14	0.0668	0.0871	0.01952	3.69	0.64	0.5308	0.2862	0.343	1.126
0.15	0.0739	0.0929	0.0225	3.54	0.65	0.5404	0.2882	0.350	1.105
0.16	0.0811	0.0985	0.0257	3.41	0.66	0.5499	0.2900	0.358	1.084
0.17	0.0885	0.1042	0.0291	3.28	0.67	0.5594	0.2917	0.366	1.064
0.18	0.0961	0.1097	0.0327	3.17	0.68	0.5687	0.2933	0.373	1.044
0.19	0.1039	0.1152	0.0365	3.06	0.69	0.5780	0.2948	0.380	1.024
0.20	0.1118	0.1206	0.0406	2.96	0.70	0.5872	0.2962	0.388	1.004
0.21	0.1199	0.1259	0.0448	2.87	0.71	0.5964	0.2975	0.395	0.985
0.22	0.1281	0.1312	0.0492	2.79	0.72	0.6054	0.2987	0.402	0.965
0.23	0.1365	0.1364	0.0537	2.71	0.73	0.6143	0.2998	0.409	0.947
0.24	0.1449	0.1416	0.0585	2.63	0.74	0.6231	0.3008	0.416	0.928
0.25	0.1535	0.1466	0.0634	2.56	0.75	0.6319	0.3017	0.422	0.910
0.26	0.1623	0.1516	0.0686	2.49	0.76	0.6405	0.3024	0.429	0.891
0.27	0.1711	0.1566	0.0739	2.42	0.77	0.6489	0.3031	0.435	0.873
0.28	0.1800	0.1614	0.0793	2.36	0.78	0.6573	0.3036	0.441	0.856
0.29	0.1890	0.1662	0.0849	2.30	0.79	0.6655	0.3039	0.447	0.838
0.30	0.1982	0.1709	0.0907	2.25	0.80	0.6736	0.3042	0.453	0.821
0.31	0.2074	0.1756	0.0966	2.20	0.81	0.6815	0.3043	0.458	0.804
0.32	0.2167	0.1802	0.1027	2.14	0.82	0.6893	0.3043	0.463	0.787
0.33	0.2260	0.1847	0.1089	2.09	0.83	0.6969	0.3041	0.468	0.770
0.34	0.2355	0.1891	0.1153	2.05	0.84	0.7043	0.3038	0.473	0.753
0.35	0.2450	0.1935	0.1218	2.00	0.85	0.7115	0.3033	0.477	0.736
0.36	0.2546	0.1978	0.1284	1.958	0.86	0.7186	0.3026	0.481	0.720
0.37	0.2642	0.2020	0.1351	1.915	0.87	0.7254	0.3018	0.485	0.703
0.38	0.2739	0.2062	0.1420	1.875	0.88	0.7320	0.3007	0.488	0.687
0.39	0.2836	0.2102	0.1490	1.835	0.89	0.7384	0.2995	0.491	0.670
0.40	0.2934	0.2142	0.1561	1.797	0.90	0.7445	0.2980	0.494	0.654
0.41	0.3032	0.2182	0.1633	1.760	0.91	0.7504	0.2963	0.496	0.637
0.42	0.3130	0.2220	0.1705	1.724	0.92	0.7560	0.2944	0.497	0.621
0.43	0.3229	0.2258	0.1779	1.689	0.93	0.7612	0.2921	0.498	0.604
0.44	0.3328	0.2295	0.1854	1.655	0.94	0.7662	0.2895	0.498	0.588
0.45	0.3428	0.2331	0.1929	1.622	0.95	0.7707	0.2865	0.498	0.571
0.46	0.3527	0.2366	0.201	1.590	0.96	0.7749	0.2829	0.496	0.553
0.47	0.3627	0.2401	0.208	1.559	0.97	0.7785	0.2787	0.491	0.535
0.48	0.3727	0.2435	0.216	1.530	0.98	0.7817	0.2735	0.489	0.517
0.49	0.3827	0.2468	0.224	1.500	0.99	0.7841	0.2666	0.483	0.496
0.50	0.3927	0.2500	0.232	1.471	1.00	0.7854	0.2500	0.463	0.463

Table 22.—*Velocity head and discharge at critical depths and static pressures in circular conduits partly full*

D=Diameter of circle.
d=Depth of water.
h_v=Velocity head for a critical depth of d.
Q=Discharge when the critical depth is d.
P=Pressure on cross section of water prism in cubic units of water. To get P in pounds, when d and D are in feet, multiply by 62.5.



$\frac{d}{D}$	$\frac{h_v}{D}$	$\frac{Q}{D^{5/2}}$	$\frac{P}{D^3}$	$\frac{d}{D}$	$\frac{h_v}{D}$	$\frac{Q}{D^{5/2}}$	$\frac{P}{D^3}$	$\frac{d}{D}$	$\frac{h_v}{D}$	$\frac{Q}{D^{5/2}}$	$\frac{P}{D^3}$
1	2	3	4	1	2	3	4	1	2	3	4
.01	.0033	.0006	.0000	.34	.1243	.6657	.0332	.67	.2974	2.4464	.1644
.02	.0067	.0025	.0000	.35	.1284	.7040	.0356	.68	.3048	2.5182	.1700
.03	.0101	.0055	.0001	.36	.1326	.7433	.0381	.69	.3125	2.5912	.1758
.04	.0134	.0098	.0002	.37	.1368	.7836	.0407	.70	.3204	2.6656	.1816
.05	.0168	.0153	.0003	.38	.1411	.8249	.0434	.71	.3286	2.7414	.1875
.06	.0203	.0220	.0005	.39	.1454	.8671	.0462	.72	.3371	2.8188	.1935
.07	.0237	.0298	.0007	.40	.1497	.9103	.0491	.73	.3459	2.8977	.1996
.08	.0271	.0389	.0010	.41	.1541	.9545	.0520	.74	.3552	2.9783	.2058
.09	.0306	.0491	.0013	.42	.1586	.9996	.0551	.75	.3648	3.0607	.2121
.10	.0341	.0605	.0017	.43	.1631	1.0458	.0583	.76	.3749	3.1450	.2185
.11	.0376	.0731	.0021	.44	.1676	1.0929	.0616	.77	.3855	3.2314	.2249
.12	.0411	.0868	.0026	.45	.1723	1.1410	.0650	.78	.3967	3.3200	.2314
.13	.0446	.1016	.0032	.46	.1769	1.1899	.0684	.79	.4085	3.4112	.2380
.14	.0482	.1176	.0038	.47	.1817	1.2399	.0720	.80	.4210	3.5050	.2447
.15	.0517	.1347	.0045	.48	.1865	1.2908	.0757	.81	.4343	3.6019	.2515
.16	.0553	.1530	.0053	.49	.1914	1.3427	.0795	.82	.4485	3.7021	.2584
.17	.0589	.1724	.0061	.50	.1964	1.3955	.0833	.83	.4638	3.8061	.2653
.18	.0626	.1928	.0070	.51	.2014	1.4493	.0873	.84	.4803	3.9144	.2723
.19	.0662	.2144	.0080	.52	.2065	1.5041	.0914	.85	.4982	4.0276	.2794
.20	.0699	.2371	.0091	.53	.2117	1.5598	.0956	.86	.5177	4.1465	.2865
.21	.0736	.2609	.0103	.54	.2170	1.6164	.0998	.87	.5392	4.2721	.2938
.22	.0773	.2857	.0115	.55	.2224	1.6735	.1042	.88	.5632	4.4056	.3011
.23	.0811	.3116	.0128	.56	.2279	1.7327	.1067	.89	.5900	4.5486	.3084
.24	.0848	.3386	.0143	.57	.2335	1.7923	.1133	.90	.6204	4.7033	.3158
.25	.0887	.3667	.0157	.58	.2393	1.8530	.1179	.91	.6555	4.8725	.3233
.26	.0925	.3957	.0173	.59	.2451	1.9146	.1227	.92	.6966	5.0603	.3308
.27	.0963	.4259	.0190	.60	.2511	1.9773	.1276	.93	.7459	5.2726	.3384
.28	.1002	.4571	.0207	.61	.2572	2.0409	.1326	.94	.8065	5.5183	.3460
.29	.1042	.4893	.0226	.62	.2635	2.1057	.1376	.95	.8841	5.8118	.3537
.30	.1081	.5225	.0255	.63	.2699	2.1716	.1428	.96	.9885	6.1787	.3615
.31	.1121	.5568	.0266	.64	.2765	2.2386	.1481	.97	1.1410	6.6692	.3692
.32	.1161	.5921	.0287	.65	.2833	2.3067	.1534	.98	1.3958	7.4063	.3770
.33	.1202	.6284	.0309	.66	.2902	2.3760	.1589	.99	1.9700	8.8263	.3848
								1.00	------	------	.3927

A-4

Waterway Areas for Standard Sizes of Corrugated Steel Conduits

Round Pipe

Diameter (Inches)	Area Square Feet
12	.785
15	1.227
18	1.767
21	2.405
24	3.142
30	4.909
36	7.069
42	9.621
48	12.566
54	15.904
60	19.635
66	23.758
72	28.27
78	33.18
84	38.49
90	44.18
96	50.27
108	63.62
114	70.88
120	78.54
126	86.59
132	95.03
138	103.87
144	113.10
150	122.7
156	132.7
162	143.1
168	153.9
174	165.1
180	176.7
186	188.7
192	201.1
198	213.8
204	227.0
210	240.5
216	254.5
222	268.8
228	283.5
234	298.6
240	314.2
246	330.1
252	346.4
258	363.1
264	380.1
270	397.6
276	415.5
282	433.7
288	452.4
294	471.4
300	490.9

Pipe-Arch (½ in Corrugation)

Size	Area
17 x 13	1.1
21 x 15	1.6
24 x 18	2.2
28 x 20	2.9
35 x 24	4.5
42 x 29	6.5
49 x 33	8.9
57 x 38	11.6
64 x 43	14.7
71 x 47	18.1
77 x 52	21.9
83 x 57	26.0

Pipe-Arch (1 in Corrugation)

Size	Area
60 x 46	15.6
66 x 51	19.3
73 x 55	23.2
81 x 59	27.4
87 x 63	32.1
95 x 67	37.0
103 x 71	42.4
112 x 75	48.0
117 x 79	54.2
128 x 83	60.5
137 x 87	67.4
142 x 91	74.5

Structural Plate Arch

Size Feet Inches	Area Square Feet
6.0 x 3-2	15
7.0 x 3-8	20
8.0 x 4-2	26
9.0 x 4-8½	33
10.0 x 5-3	41
11.0 x 5-9	50
12.0 x 6-3	59
13.0 x 6-9	70
14.0 x 7-3	80
15.0 x 7-9	92
16.0 x 8-3	105
17.0 x 8-10	119
18.0 x 8-11	126
19.0 x 9-5½	140
20.0 x 10-0	157
21.0 x 10-6	172
22.0 x 11-0	190
23.0 x 11-6	172
24.0 x 12-0	226
25.0 x 12-6	247

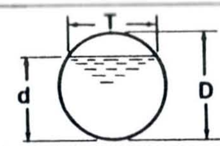
Structural Plate Pipe-Arch

Size Feet Inches	Area Square Feet
18-inch Corner Radius R_c	
6-1 x 4-7	22
6-4 x 4-9	24
6-9 x 4-11	26
7-0 x 5-1	28
7-3 x 5-3	31
7-8 x 5-5	33
7-11 x 5-7	35
8-2 x 5-9	38
8-7 x 5-11	40
8-10 x 6-1	43
9-4 x 6-3	46
9-6 x 6-5	49
9-9 x 6-7	52
10-3 x 6-9	55
10-8 x 6-11	58
10-11 x 7-1	61
11-5 x 7-3	64
11-7 x 7-5	67
11-10 x 7-7	71
12-4 x 7-9	74
12-6 x 7-11	78
12-8 x 8-1	81
12-10 x 8-4	85
13-5 x 8-5	89
13-11 x 8-7	93
14-1 x 8-9	97
14-3 x 8-11	101
14-10 x 9-1	105
15-4 x 9-3	109
15-6 x 9-5	113
15-8 x 9-7	118
15-10 x 9-10	122
16-5 x 9-11	126
16-7 x 10-1	131
31 inch Corner Radius R_c	
13-3 x 9-4	97
13-6 x 9-6	102
14-0 x 9-8	105
14-2 x 9-10	109
14-5 x 10-0	114
14-11 x 10-2	118
15-4 x 10-4	123
15-7 x 10-6	127
15-10 x 10-8	132
16-3 x 10-10	137
16-6 x 11-0	142
17-0 x 11-2	146
17-2 x 11-4	151
17-5 x 11-6	157
17-11 x 11-8	161
18-1 x 11-10	167
18-7 x 12-0	172
18-0 x 12-2	177
19-3 x 12-4	182
19-6 x 12-6	188
19-8 x 12-8	194
19-11 x 12-10	200
20-5 x 13-0	205
20-7 x 13-2	211

Hydraulic Properties of Circular Conduits Flowing Partly Full

d = Depth of Flow
d_c = Critical depth
d_m = Mean depth

D = Diameter of pipe
A = Area of flow
R = Hydraulic radius
T = Top width of flow

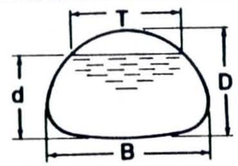


$\frac{d}{D}$ or $\frac{d_c}{D}$	$\frac{A}{D^2}$	$\frac{R}{D}$	$\frac{T}{D}$	$\frac{d_m}{D}$
1.00	0.7854	0.2500	—	—
0.95	0.7707	0.2865	0.4359	1.7681
0.90	0.7445	0.2980	0.6000	1.2408
0.85	0.7115	0.3033	0.7142	0.9962
0.80	0.6736	0.3042	0.8000	0.8420
0.75	0.6319	0.3017	0.8660	0.7297
0.70	0.5872	0.2962	0.9165	0.6407
0.65	0.5404	0.2882	0.9539	0.5665
0.60	0.4920	0.2776	0.9798	0.5021
0.55	0.4426	0.2649	0.9950	0.4448
0.50	0.3927	0.2500	1.0000	0.3927
0.45	0.3428	0.2331	0.9950	0.3445
.040	0.2934	0.2142	0.9798	0.2994
0.35	0.2450	0.1935	0.9539	0.2568
0.30	0.1982	0.1709	0.9165	0.2163
0.25	0.1535	0.1466	0.8660	0.1773
0.20	0.1118	0.1206	0.8000	0.1397
0.15	0.0739	0.0929	0.7142	0.1035

Hydraulic Properties of Pipe Arch Conduits Flowing Partly Full

d = Depth of flow
d_c = Critical depth
d_m = Mean depth

D = Diameter of pipe
A = Area of flow
R = Hydraulic radius
T = Top width of flow



$\frac{d}{D}$ or $\frac{d_c}{D}$	$\frac{A}{D^2}$	$\frac{R}{D}$	$\frac{T}{D}$	$\frac{d_m}{D}$
1.00	0.7879	0.2991	—	—
0.95	0.7762	0.3408	0.3489	2.225
0.90	0.7552	0.3549	0.4855	1.555
0.85	0.7283	0.3622	0.5848	1.245
0.80	0.6970	0.3649	0.6637	1.0503
0.75	0.6621	0.3639	0.7288	0.9085
0.70	0.6243	0.3595	0.7837	0.7966
0.65	0.5839	0.3520	0.8303	0.7033
0.60	0.5414	0.3415	0.8700	0.6223
0.55	0.4970	0.3282	0.9037	0.5500
0.50	0.4511	0.3120	0.9320	0.4840
0.45	0.4039	0.2928	0.9555	0.4227
0.40	0.3556	0.2705	0.9755	0.3646
0.35	0.3065	0.2451	0.9889	0.3100
0.30	0.2568	0.2162	0.9967	0.2577
0.25	0.2069	0.1839	0.9967	0.2076
0.20	0.1574	0.1484	0.9815	0.1603
0.15	0.10908	0.11022	0.9477	0.11505

$1.486 AR^{2/3} = \frac{Qn}{S^{1/2}}$

STA ~~345~~ 354+30

3- 54" Dia - Free discharge at outlet

Design Q = 460 = 153.33/pipe n=.012

So = .005 Sc = .00536

Normal depth yo = 3.76'

V = ~~10.8~~ hv = ~~…~~ 1.82

Inlet W.S = 1565.90 + 3.76 + 1.5 × 1.82 = 1572.39

July 17-18 Q = 321 = 107 cfs/pipe n = .012

Inlet W.S = 1565.90 + yo + 1.5 hv = 1565.9 + 2.79 + 1.65

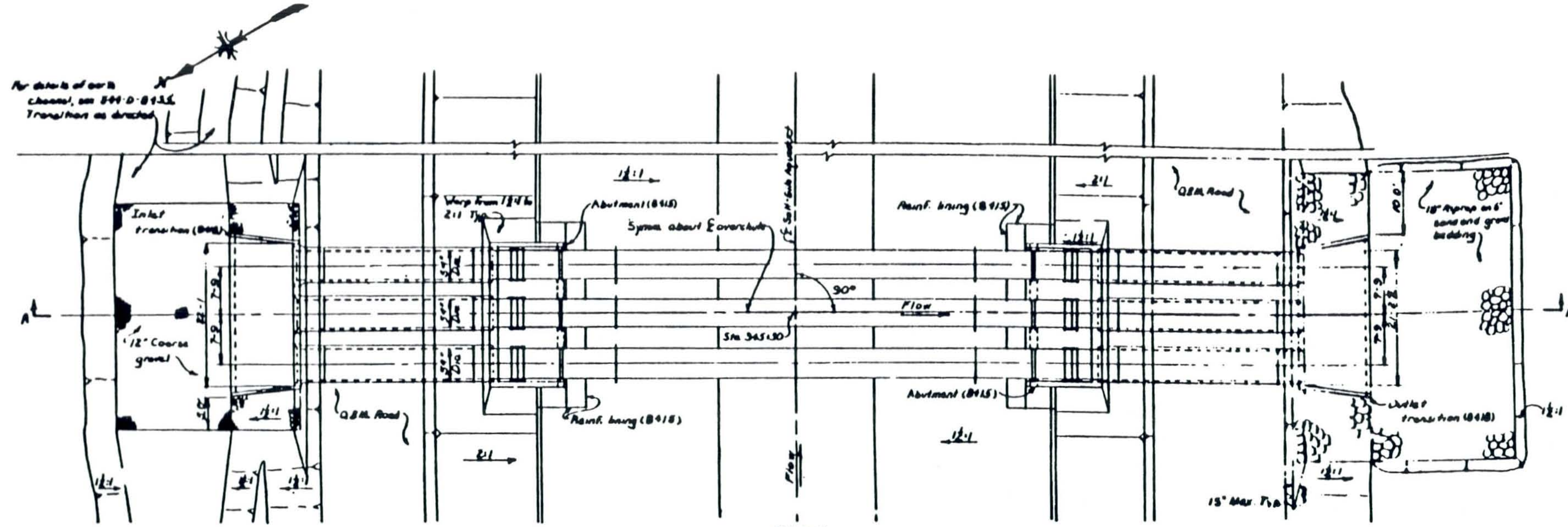
= 1570.34

100 yr 3hr essentially same as Design Q

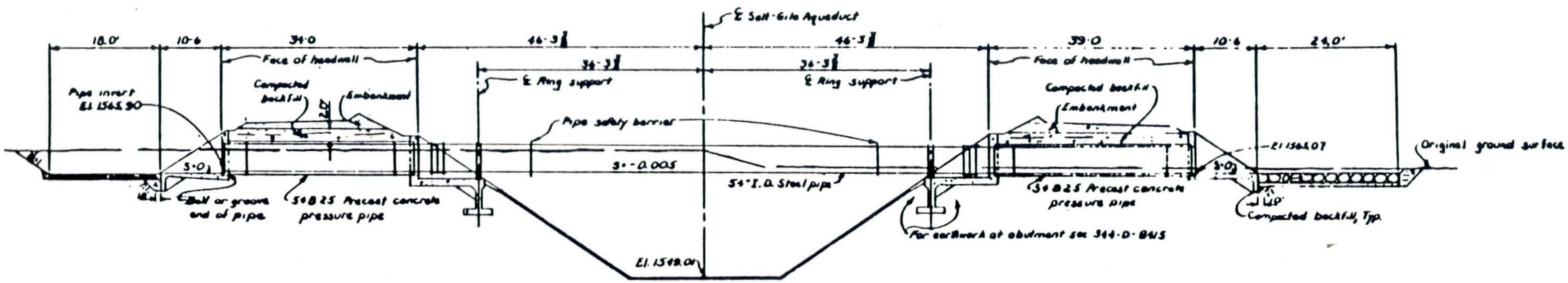
MAX Q | H = 5 l = 166'

MAX Q = 233/pipe = 699 cfs

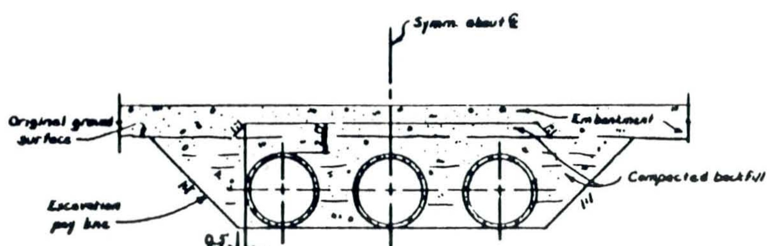
A-6



PLAN



SECTION A-A



TYPICAL EARTHWORK DETAIL

374+00

4 open chutes Design Q = 870 = 217.5/chute

From topography water spreads out all over at outlet use critical depth at outlet d_c = 2.68 h_{vc} 1.34 H_c = 4.02

S_c = ~~.00476~~ .00328 ✓

l = ~~175~~ 150 per plan

$l = \frac{H_e'' - H_e'}{S - S_{ave}}$ = ~~178~~ 150 = $\frac{4.02 - H_e}{S_c}$

✓ H_e' = 4.72

Try d =	3.0	3.5	4.0
A =	26.25	30.625	35
V =	8.28	7.10	6.21
h_v	1.06	.78	.60
d+h =	4.06	4.28	4.6
S		.0016	.0011
l =	~~246~~		176 > 175

$F = \frac{Q n}{d^{8/3} S^{1/2}}$

d =	3.9	3.8
A	34.125	33.25
V	6.37	6.54
h_v	.63	.66
d+h	4.53	4.46
S =	.0012	.00126
l	172 < 175 OK	A_{ces} = .0022 l = 200 OK

W.S El. = 1565.08 + 3.8 + ~~1.0~~ = 1569.93
+1.5 h_v

Project CAP	Contract No.	File No.
Feature Cross Drainage Analysis	Designed RF	Date 10/8/84
Item Chutes @ Sta 374+00	Checked	Date

STA 374+00

July 17-18 Q = 707 = 176.75 cfs/chute

b = 8.75' q = 20.2' dc 2.33' hv_c 1.17'

He = 3.5' n = .013

Sc = .00346 l = 175

Trial	d =	3.4
	A	29.75
	V	5.94
	hv	.55
	d+hv	3.95
	S	.0011
	Ave S	= .00228
	l =	197 ≈ 175 OK

W.S. El. = 1565.08 + 3.4 + .83 = 1569.31

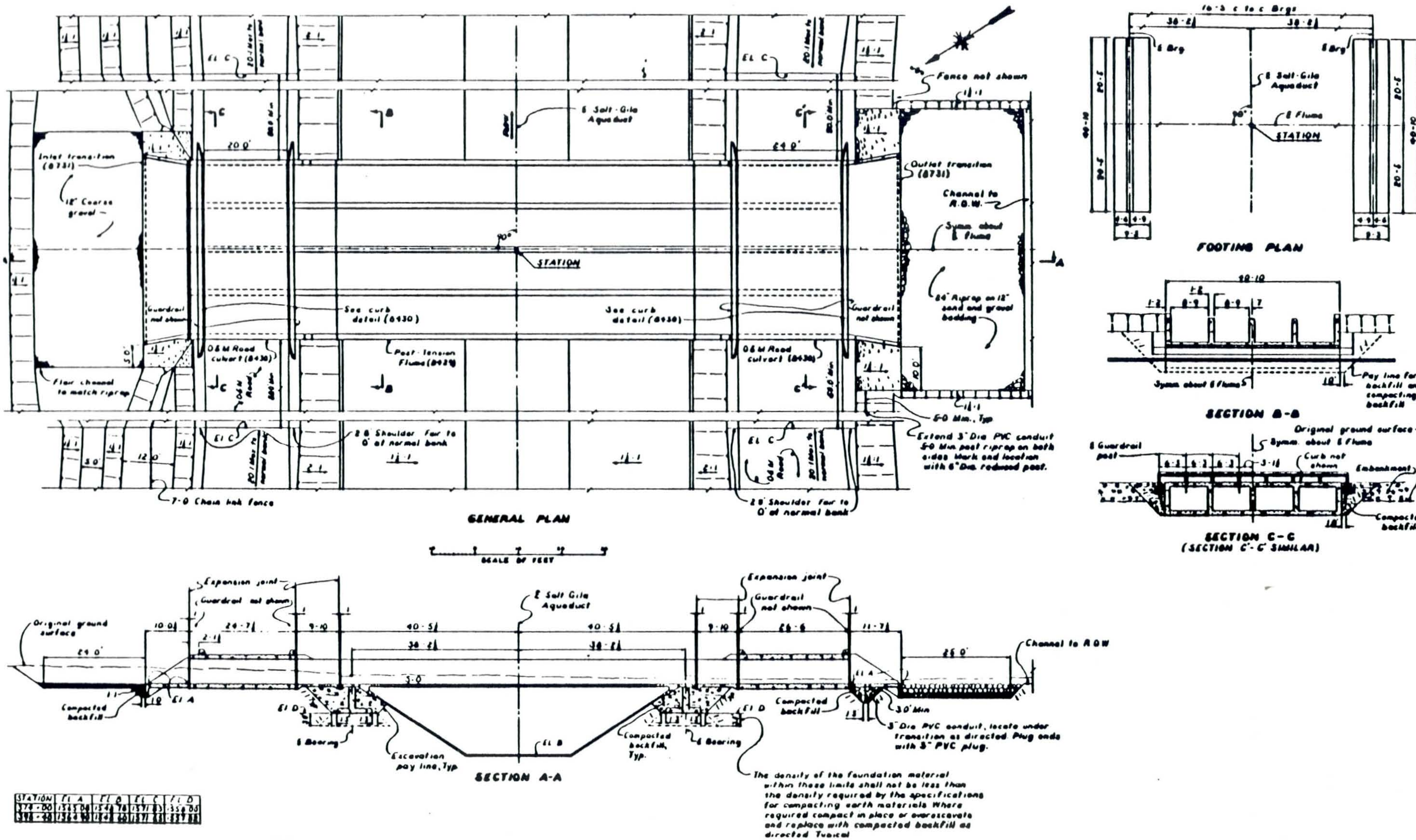
100yr 3hr Q = 887 = 221.75 cfs/chute

q = 25.34 dc 2.71 hvc 1.36 He = 4.07

Sc = .00336 l = 175

Trial	d =	4.0	3.9	3.8
	A	35	34.125	33.25
	V :	6.33	6.50	6.67
	hv	.62	hv = .66	.69
	d+hv	4.62	4.56	4.49
	s =	.00116	.001256	.00135
	Ave S =	.00226	.00236	.00235
	l =	243 > 175	207 > 175	178 ≈ 175 OK

W.S. El. = 1565.08 + 3.8 + 1.04 = 1569.92


GENERAL PLAN
SCALE OF FEET
Fence not shown
Salt-Gila Aqueduct
STATION
Inlet transition (8731)
12" Coarse gravel
Outlet transition (8731)
Channel to R.O.W.
Symm. about Flume
24" Riprap on 12" sand and gravel bedding
Guardrail not shown
See curb detail (8430)
O&M Road culvert (8430)
Post-tension Flume (8429)
Flair channel to match riprap
2:1 Shoulder flair to 0' at normal bank
7-0 Chain link fence
Extend 3" Dia PVC conduit 5-0 Min past riprap on both sides. Mark end location with 6" Dia. redwood post.
FOOTING PLAN
Brg
Flume
SECTION B-B
Pay line for backfill and compacting backfill
Symm. about Flume
SECTION C-C
(SECTION C'-C' SIMILAR)
Original ground surface
Guardrail post
Curb not shown
Embankment
Compacted backfill
SECTION A-A
Expansion joint
Guardrail not shown
Original ground surface
Channel to R.O.W.
Compacted backfill
Bearing
Excavation pay line, Typ
Compacted backfill, Typ.
3" Dia PVC conduit, locate under transition as directed. Plug ends with 3" PVC plug.
The density of the foundation material within these limits shall not be less than the density required by the specifications for compacting earth materials. Where required compact in place or overexcavate and replace with compacted backfill as directed. Typical

STA 396+40

4 - open chutes   Design Q = 800 cfs = 200/chute

s = 0, n = .013, no ponded outlet - b = 8.75'

l = 175' ±

outlet channel spreads out therefore assume

critical depth control at beginning of outlet transition

$d_c = .3143 q^{2/3} = (.3143)\left(\frac{200}{8.75}\right)^{2/3} = 2.53$

$H_e = 3.80'$ $s = \left(\frac{(200)(.013)}{8.25^{5/3}(1.39)}\right)^2 = .0033$

$l = \frac{H_e' - H_e''}{S_o - S_{ave}} = \frac{3.80 - H_e}{-S(ave)}$

Trial

d =	3.0	3.5	3.7	3.6 ✓
A =	26.25	30.625	32.375	31.5
V =	7.62	6.53	6.18	6.34
h_v =	.90	.66	.59	.63
d+h =	3.9	4.16	4.29	4.23
S =	-.002	-.0013	-.0012	.0013
Sav =	-.0027	-.0023	-.0022	.0023
l =	37 < 173	113 < 173	222 > 173	186 ok

Inlet W.S = 1564.96 + 3.6 + 1.5 hv = 1569.45

STA 396+40

July 17-18 Q = 614 = 153.5 /chute

b = 8.75 q = 17.54 dc = 2.12 hvc = 1.06 He = 3.19

n = .013

Sc = .00322 l = 175

Trial d (inlet)

d =	3.15	3.1
A =	27.56	27.125
V =	5.57	5.65
hv =	.48	.50
d+hv =	3.63	
S =	.00104	
Ave S =	.00213	
l =	206 ≈ 175	d about 3.1

W.S at inlet = 1564.9 + 3.1 + .75 = 1568.75

100 yr 3 hr Q = 762 ≈ 190.5 /chute

dc = 2.45 hvc = 1.22 He = 3.68

Sc = .00327

d =	3.6	3.5
A =	31.5	30.625
V =	6.0476	6.22
hv	.57	.60
d+hv =	4.17	4.10
S =	.0011	.0012
Ave S =	.0022	.00224
l =	222 > 175	187.5 ≈ 175 ok

W.S at inlet = 1564.9 + 3.5 + .90 = 1569.3

INTERNATIONAL ENGINEERING COMPANY, INC.

Project CAP | Contract No. | Sheet
Feature Cross Drainage Analysis | Designed RF | File No.
Item Conduit @ Sta 427+15 | Checked | Date 10/8/84 | Date

STA 427+15

From visual observation, there does not seem to be any downstream control that would cause backwater - Therefore system will be analyzed for a free discharge condition - that is, water surface and hydraulic gradient equal to pipe crown at outlet when Q is enough for full pipe

1. Design Q = 565
2. July 17-18 Q = 1597 CASE II
3. July 17-18 Q = 327 CASE III
4. 100yr 3hr Q = 2320 CASE II
5. 100yr 3hr Q = 530 CASE III

Exit loss $= \frac{Q^2}{A^2 2g}$ CMP ARCHES $A = 32.1^{\square'}$ periphery = 20.42'

$R = \frac{32.1}{20.42} = 1.57$ $R^{2/3} = 1.35$ (Full Arch)

$1.486 A R^{2/3} = \frac{Qn}{S^{1/2}}$ $Q = \frac{(1.486)(32.1)(1.35)\sqrt{.0069}}{.027}$

$Q = 195.5 \times 3 = 586^{\pm}$

Pipe will flow full for 1, 2, 4

System Hydraulics for full pipe

Arch Exit loss $\frac{Q^2}{A_c^2 2g}$ + Entr. loss $\frac{.5Q^2}{A^2 2g}$ + $S\ell$ + pipe exit loss

+ pipe $S\ell$ + Entrance loss

$1.5 \frac{Q^2}{32.1^2 2g} = .0000226 Q^2$

INTERNATIONAL ENGINEERING COMPANY, INC.

Project ______ Contract No. ______ Sheet ______
Feature ______ Designed RF File No. ______ Date 10/8/84
Item Conduit @ Sta 427+15 Checked ______ Date ______

$$S = \left(\frac{Qn}{1.486AR^{2/3}}\right)^2 \quad \frac{Q^2 .000729}{(2.208)32.1^2 1.33^2}$$

$Q \frac{565}{3} = 188.33$

$S = .000000\ 175\ Q^2$ (~~185~~)

$l = 200$

water surface between structures

$= 156~~9~~ +5.25 + .0000226\,Q^2 + .000035\,Q^2 = 1569.25 + 5.8 \times 10^{-5} Q^2$

Pipe overchutes - 3-82"
n = .012   l = 180'

Losses = Exit + entrance + pipe friction $S = \left(\frac{Qn}{D^{8/3}.46}\right)^2$

$= \frac{1.5\,Q^2}{A^2 2g} + S\,l = .000029Q^2 + .000085\,Q^2$

System loss = .0001328 Q^2 (~~.000075 Q~~)   WS El. = 1569.25 + .0001328 Q^2 (~~.000085~~)

	~~INLET W.S~~	~~INLET W.S~~	INLET WS
DESIGN Q = 565/3		~~1572.62~~	1573.96
July 17-18 Q = 1547/3		~~1594.55~~	1604.57
100 yr 3hr Q = 2320/3		~~1626.15~~	1648.68 ✓

July 17-18 Q = 327 = 109/unit
Page 167 of Modern Sewer Design AISI

$S = \left(\frac{Qn}{1.486AR^{2/3}}\right)$

Trial		
d =	.70	.65 D = 3.41' = yo
A =	17.21	16
V =	6.33	6.77
hv	.62	.71
R =	1.89	1.85
$R^{2/3}$	1.53	1.51
S =	.00568 < .00672	.006719 ✓

INTERNATIONAL ENGINEERING COMPANY, INC.

Project ____ Contract No. ____ Sheet ____
Feature ____ Designed RF File No. ____ Date 10/8/84
Item Conduit @ Sta 427+15 Checked ____ Date ____

water surface between structures

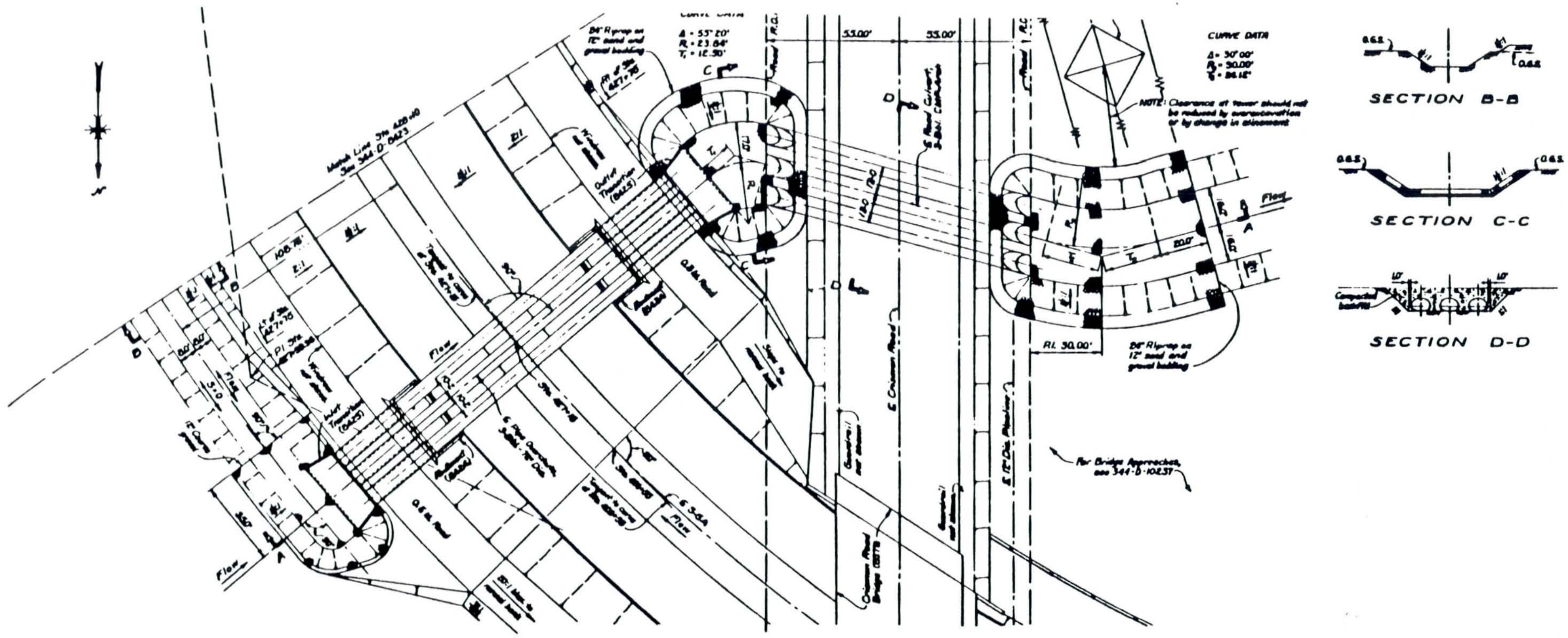
= 1564.77 + 3.41 + 1.5 hv = 1569.25

Pipe crown is 1570.33 but pipe has a steep slope for 27 1/2 ft. Therefore control is ~~normal~~ depth on .005 + entrance loss

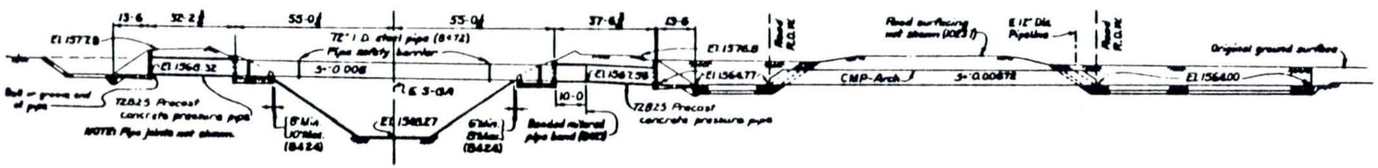
y_0 = normal depth = .395×6 = 2.37 He = 4.06
y_c = critical depth = .465×6 = 2.79 He = ~~4.0~~ 3.86
Mild slope < Critical slope

Inlet W.S = 1568.32 + 2.37 + 1.5(1.69) = 1573.22

Max Q = 600 cfs



PLAN



SECTION A-A

STA 429+20

Control for major discharges is Young's pipes

4-48" 190' in length $S = .00789$

Full pipe $Q = \dfrac{\sqrt{.00789}\,(D)^{8/3}(.463)}{n}$

n for Young's pipes seems about .014

Q for full pipe = 118.5

Total Q = 4 x 118.5 = 474

System Hydraulics in terms of Q for all discharges greater than 474 is as follows

Water Surface at inlet to overchutes = Exit loss for Young's pipes + Friction loss for Youngs Pipes + Entrance loss for Young's pipes + exit loss for Arches + friction loss for Arches + entrance loss for Arches + exit loss for overchute pipes + Friction loss for overchute pipes + entrance loss for overchute pipes.

$$W.S \text{ at inlet} = \frac{1.5\,Q_1^2}{\left(\frac{\pi\,16}{4}\right)^2 2g} + \left(\frac{Q_1 n_1}{D_1^{8/3}\,.463}\right)^2 \ell_1 + \frac{1.5\,Q_2^2}{(32.1)^2\,2g} + \left(\frac{Q n_2}{1.486\,AR^{2/3}}\right)^2 \ell_2$$

$$+ \frac{1.5\,Q_2^2}{\left(\frac{\pi\,36}{4}\right)^2 2g} + \left(\frac{Q_2 n}{D_2^{8/3}\,.463}\right)^2 \ell_3 + 1568.0$$

Project	Contract No.	File No.
Feature	Designed RJ	Date
Item	Checked	Date

where $Q_1 = \frac{Q_t}{4}$, $Q_2 = \frac{Q_t}{3}$

$D_1 = 4'$, $n_1 = .014$ $l_1 = 190'$, Arch area $= 32.1^{\square'}$

Arch $n_2 = .027$, Arch hydraulic radius $= R = 1.57$

$l_2 = 200$, $D_2 = 6'$, $n_3 = .012$, $l_3 = 180'$

For purpose of computation 4' Q = .75Q

$$\text{Water Surface at inlet} = \underset{48''}{\frac{(1.5)(.75Q_1)^2}{\left(\frac{\pi 4^2}{4}\right)^2 2g}} + \underset{48}{\left(\frac{.75Qn_1}{D_1^{8/3}\,.463}\right)^2} l_1$$

(s beneath the second term)

$$+ \underset{\text{Arch}}{\frac{1.5\,Q_1^2}{(32.1)^2 2g}} + \underset{\text{Arch}}{\left(\frac{Q_1 n_2}{1.486AR^{2/3}}\right)^2} l + \underset{72''}{\frac{1.5\,Q^2}{\left(\frac{\pi 6^2}{4}\right)^2 2g}} + \underset{72''}{\left(\frac{Qn}{D_2^{8/3}\,.463}\right)^2} l_3 + 1568$$

(s beneath the Arch friction term and the 72" friction term)

$$W.S = Q^2(8.307\times10^{-5} + 6.006\times10^{-5} + 2.26\times10^{-5} + 3.51\times10^{-5}$$
$$+ 2.92\times10^{-5} + .855\times10^{-5}) + 1568 = 23.86\times10^{-5}Q^2$$
$$+1568$$

Q		INLET WS
Design	565/3	1576.46
July 17-18 II	1547/3	1631.44
July 17-18 III	seperate computation Q < 474	
100 yr 3hr II	2320/3	1710.68
100 yr 3hr III	530/3	1575.45

July 17-18 storm CASE III

Normal depth y_o in 48" pipes

$Q = 327/4 = 81.75$ $n = .014$

$\frac{Qn}{D^{8/3} S^{1/2}} = \frac{81.75 \times .014}{40.336 \sqrt{.00789}} = .32$

$y_o = .61 D = 2.44$

$A = 8.03$ $V = 10.18$ $h_v = 1.61$

Water surface between outlet of Arches and inlet to 48" pipes = 1565.5 + 2.44 + 1.5(1.61)

= 1570.35 which submerges the CMP Arches. $Q = 329/3 = 109$

From previous sheet

Inlet W.S = $.00009545 Q^2 + 1570.35 = 1571.48$

STA 429+20

The previous computations ~~were~~ based on a theoretical condition of complete containment of flood flows by dikes high enough to prevent overtopping. A ~~more~~ realistic approach is to compute the head required based on overbank conditions

(1) Young's pipes $Q = 2320$ $Q_{pipe} = 580$

Approximate El. of parking lot is 1573

Exit loss $= h_v = \frac{V^2}{2g} = \left(\frac{580}{7.85 \times 10^2}\right)^2 / 2g = \frac{46^2}{2g} = 33'$

Friction loss $= 36'$

Entrance loss $= 16'$

Σ losses $= 85$ - not possible - water will flow over parking lot at El 1573

Perimeter of basin between Youngs pipes and CMP Arches is about 100'

Flow through Youngs Pipe based on Elevation 1575

$H = 1575 - 1568 = 7$ $Q = 166/\text{pipe} = 664$ cfs

Overbank at ~~...~~ 1575 = 2' assume as d_c

$q = 16$ $Q = 16 \times 100 = 1600$

$\Sigma Q = 2264 \approx 2320$ OK

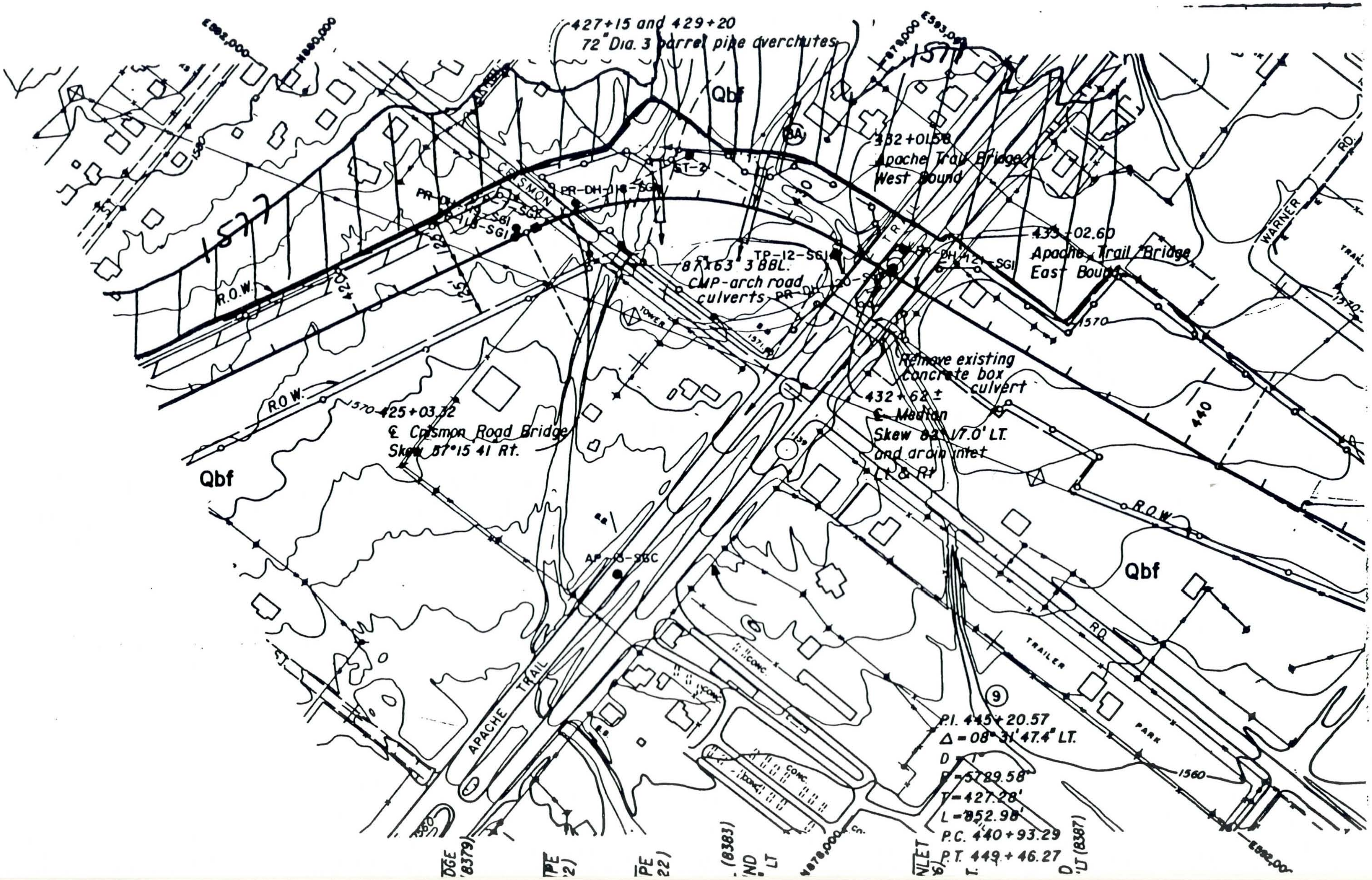
INTERNATIONAL ENGINEERING COMPANY, INC.

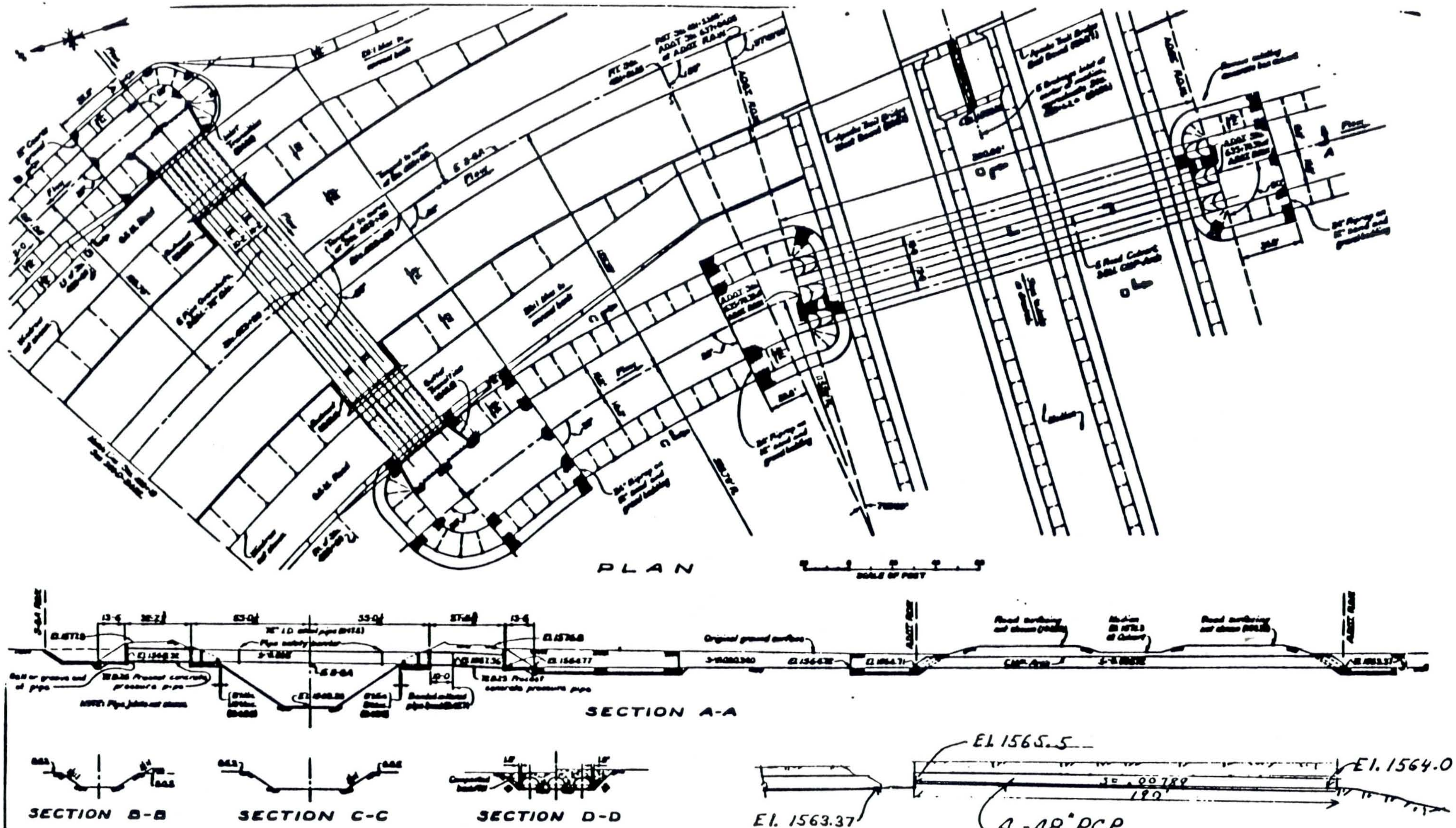
Project ______ Contract No. ______ Sheet ______ File No. ______
Feature ______ Designed ______ Date ______
Item ______ Checked ______ Date ______

Water surface between overchutes and CMP Arches

= 1575 + 34' - not possible as water will overflow the area between the structures - into the canal, down Appache Trail and Crismon Road.

A-21


427+15 and 429+20
72" Dia. 3 barrel pipe overchutes
Qbf
1577
R.O.W.
CRISMON
432+01.58
Apache Trail Bridge
West Bound
433+02.60
Apache Trail Bridge
East Bound
87"X63" 3 BBL.
CMP-arch road
culverts
Remove existing
concrete box
culvert
432+62±
℄ Median
and drain inlet
425+03.32
℄ Crismon Road Bridge
Skew 57°15 41 Rt.
Qbf
Qbf
R.O.W
APACHE TRAIL
TRAILER PARK RD.
WARNER RD.
440
1560
1570
P.I. 445+20.57
P.C. 440+93.29
P.T. 449+46.27


PLAN
SECTION A-A
SECTION B-B
SECTION C-C
SECTION D-D
El. 1565.5
El. 1564.0
El. 1563.37
4-48" PCP
180'

456+50

2-60" pipes Q=270 Q per pipe = 135

outlet ponds ~~don't~~ do not submerge pipe

l = 190' S = .005

Normal depth = .6 x 5 = 3.0

critical depth = .665 x 5 = 3.25

steep slope critical depth at inlet

Inlet ws = 1556.16 + 3.25 + 2.25 (1.5 hv) = 1561.65

100yr 3hr Q = 286 Q per pipe ~ 143

dc = .685 x 5 = 3.43

Inlet ws = 1556.16 + 3.43 + 2.35 = 1561.94

STA 456+50

2- 60" Pipe overchutes - Ponded outlet

B_2 = Crest length = 48
Crest Elevation = 1558
Pipe invert = 1555.21

Check to see if pipe outlet is submerged

for Q of 145 - July 17-18 storm

q = 145/48 = 3.02
d_c = .66
h_{vc} = .33

Water surface El. = 1558+.99 = 1558.99 < 1560.21

Normal depth in pipe = y_o S = .005

$$\frac{Qn}{D^{8/3} S^{1/2}} = \frac{(72.5)(.012)}{5^{8/3}\sqrt{.005}} = .17$$

y_o = .42×5 = 2.1

Critical depth = .48×5 = 2.4   Flow is at y_o

but critical depth controls at inlet. A = 9.32, V = 7.78

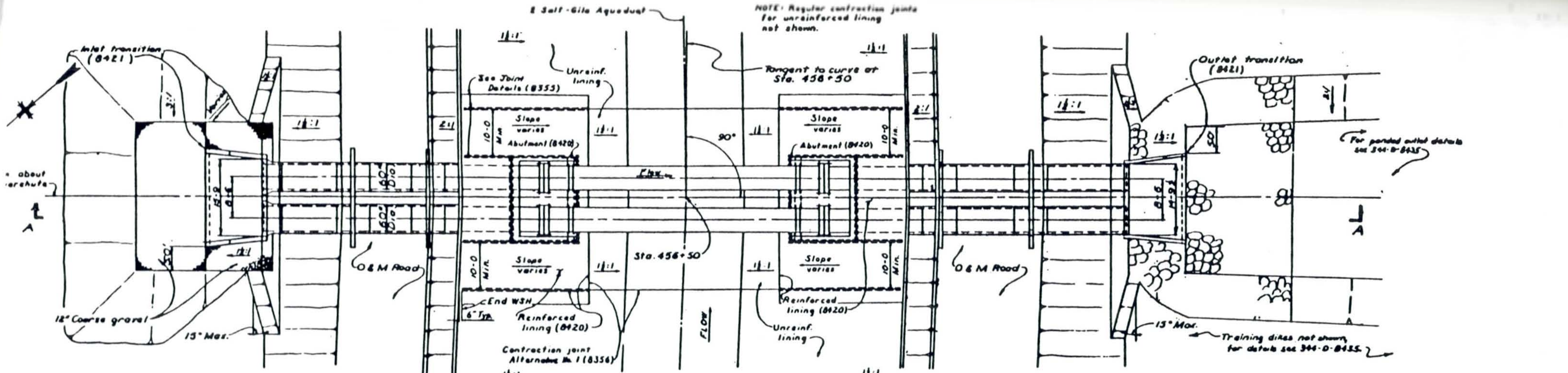
h_{vc} = .94

Inlet W.S = 1556.16 + 2.4 + (1.5×.94) = 1559.98

Max Q

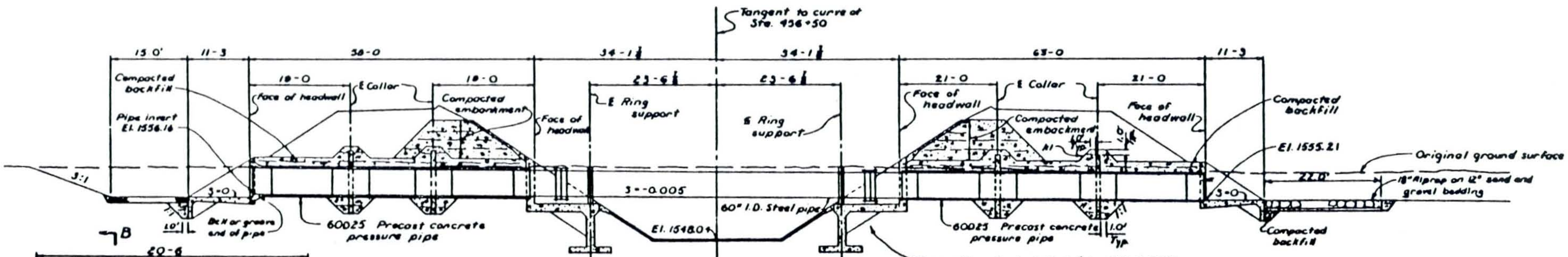
H = 1560.5 + 1574.5 = 14

MAX Q = 407/pipe = 814

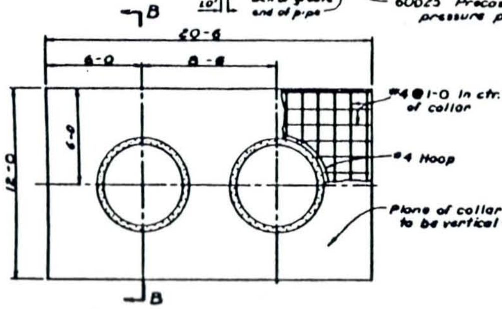


PLAN

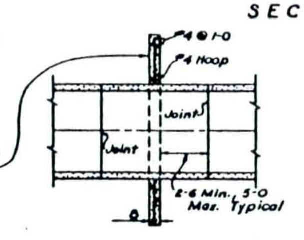
SCALE OF FEET



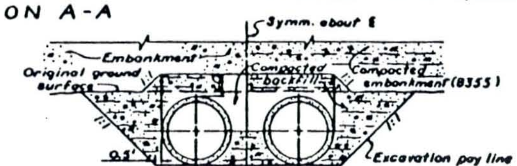
SECTION A-A



COLLAR DETAIL



SECTION B-B



TYPICAL EARTHWORK DETAIL

471+03

5 - 72" Dia There is no outlet pond for this structure

Design Q = 910 = 182 cfs/barrell n = .012

Normal depth yo = 3.25'

Critical depth dc = 3.69 steep slope

Inlet w.s = 1560.62 + 3.69 + 1.5(1.56) = 1566.64

July 17-18 CASE II Q = 806 = 161.2/barrell n = .012

Normal depth = 3.0'

Critical depth = ~~1.97~~ 3.45

Inlet w.s = 1560.62 + 3.45 + 2.14 = 1566.21

100yr 3hr CASE II Q = 1765 Q per barrell = 353

$\frac{Qn}{D^{8/3}\sqrt{.005}}$ = .57 .463 pipe runs full

V = 12.48
hv 2.42
ℓ = 169'

Inlet ws = ~~1561.36~~ 1557.75 + 6 + 1.5(2.42) + $\left(\frac{Qn}{D^{8/3} .463}\right)^2$ 169 = ~~1571.49~~ 1570.18

July 17-18 CASE III Q = 497 = 99.4

Normal depth = 2.28
Critical depth = 2.65 hvc = 1.0649

Inlet ws = 1560.62 + 2.65 1564.87

100yr 3hr CASE III Q = 889
Close enough to Design Q

Canal bank El. 1574± Max discharge H = 1574.0 - 1565.75

$$H = \frac{Q^2}{A^2 2g}(1.5) + S\ell \qquad S = \left(\frac{Qn}{D^{4/3}\,.463}\right)^2 = .00000047Q^2$$

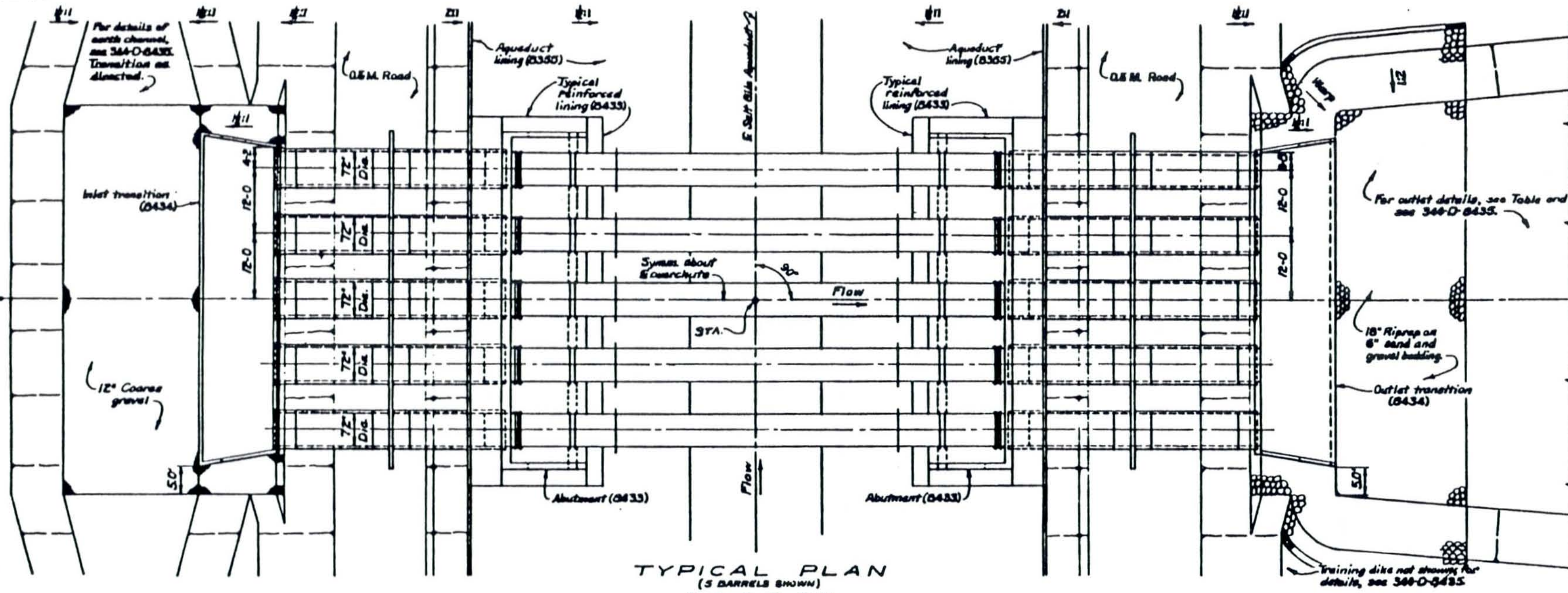
$H = 8.25 \quad \ell = 169$

$8.75 = .000029Q^2 + 0000080Q^2$

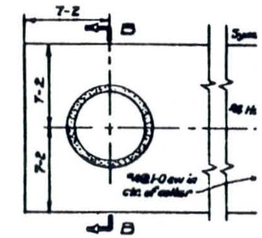
$Q = \sqrt{\frac{8.75}{.0000370}}$ = ~~472~~ 478 cfs per barrell

= ~~2832~~ 2390

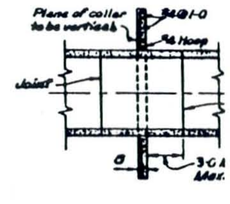
A-28



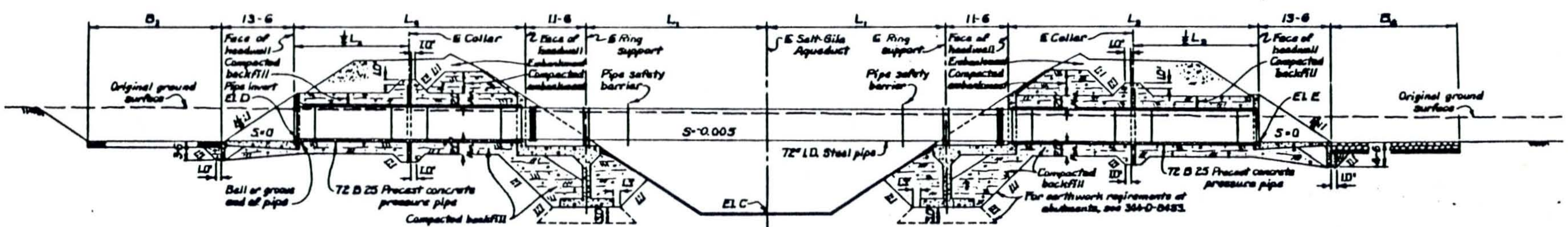
TYPICAL PLAN
(5 BARRELS SHOWN)



COLLAR DETAIL



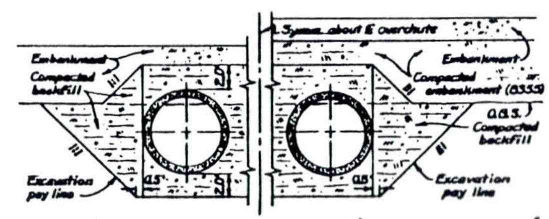
SECTION B-B



SECTION A-A

TABLE OF DATA

STA.	EL. C	EL. D	EL. E	L_1	L_2	L_3	B_1	OUTLET	B_2	NO. BBLS.	DESIGN FLOW
471+03.12	1542.92	1560.62	1559.75	31-4	42-0	47-0	26.0'	Riprap	26.0'	5	910 cfs
479+00	1547.06	1562.20	1561.38	33-9	37-0	41-0	22.0'	Pond	22.0'	5	575 cfs
504+25	1547.48	1562.20	1561.36	34-0	36-0	41-0	22.0'	Pond	22.0'	5	575 cfs
529+50	1547.45	1562.53	1561.70	34-10	40-5	44-11	25.0'	Pond	25.0'	5	840 cfs
542+50	1547.35	1562.50	1561.66	34-11	44-0	48-2	25.0'	Pond	25.0'	6	840 cfs
552+60	1547.27	1563.76	1562.84	36-10	40-11	45-5	24.0'	Pond	24.0'	6	760 cfs
583+50	1547.18	1563.78	1562.85	37-0	40-8	45-2	24.0'	Pond	24.0'	6	760 cfs



TYPICAL EARTHWORK DETAILS

479+00

5-72" Pipes, Outlet pond B_2= 100, crest = 1563.9

Pipe invert = 1561.36, Crown = 1567.36 n = .012

Discharge over crest for w.s at 1567.36

$= CLH^{3/2} = (3.087)(100)3.46^{3/2} = 1987$ cfs

Discharge will not submerge pipes for all Q: under consideration

Q for full pipe $= \frac{(.463)D^{8/3}\sqrt{S}}{n} = 324.5$

324.5 x 5 = 1622 cfs > all Qs under consideration

Design Q = 575 Q per pipe = 115

Normal depth = .41 x 6 = 2.46
Critical depth = .48 x 6 = 2.88 h_{vc} = 1.14
S_c = .0029

Depth at outlet = 1563.9 + 1.5 - 1561.36 = 4.04'
F_r = .51
ℓ = 169' s = .061

$\ell = \frac{H_e' - H_e''}{S_o - S_{ave}} = \frac{4.55 - 4.02}{.005 - .00195} = 173$ ok

Inlet control
ws = 1562.20 + 2.88 + 1.5(1.14) = 1566.79

July 18-48 CASE D Q = 353 = 70.6 per pipe

Normal depth = .32 x 6 = 1.92
Critical depth = .375 x 6 = 2.25

Inlet w.s = 1562.2 + 2.25 + 1.5(.82) = 1565.68

100 yr 3 hr CASE III Q = 1200 Q per pipe = 240

Pond w.s = 1566.37
Depth = 1566.37 - 1561.36 = 5.0

V = 9.52
hv = 1.41
He = 6.41
S = .0027

critical depth = .71 × D = 4.26
A = 21.47
V = 11.17
hv 1.94
Hc = 6.20
Sc = .00375

$$l = \frac{6.41 - 6.20}{.005 - .0032} = \frac{.21}{.0018} = 116'$$

critical depth control

Inlet WS = 1562.2 + 4.26 + 1.5(1.94) = 1569.37

July 17-18 case III < CASE II

100 yr 3 hr CASE III approximates Design Q

Max Discharge

Canal Bank El. = 1573.8

water surface in pond = $1563.9 + \left(\frac{Q_T}{100}\right)^{2/3} .31433 \times 1.5$

$.02185\, Q^{2/3} + 1563.9$

$H = 1573.8 - 1563.9 + .02185\, Q_T^{2/3}$

$\doteq 1.5 \frac{Q^2}{A^2 2g} + \left(\frac{Q\,n}{D^{8/3}\,.463}\right)^2 169$

$= .000029 Q_p^2 + .000008 Q_p^2 = .000037 Q_p^2$

$H = 1573.8 - 1563.9 + .02185 Q^{2/3} = .000037 Q^2$

$9.9 = .000037 Q^2 - .02185 Q_T^{2/3}$

Try $Q_T = 2000$ $Q_p = 400$

9.9 = 5.92 +

Try Q_T = 4000 Q_p = 800

9.9 ≈ 23.68 − 5.52

Try Q = 3000 Q_p = 600

9.9 = 13.32 − 4.56

9.9 ≈ 8.76

Try Q_T = 3200 Q_p = 640

9.9 = 15.15 − 4.74 = 10.4

Try Q_T = 3100 Q_p = 620

9.9 14.22 − 4.64 = 9.57

Q approx 3100 cfs

Revise maximum discharge based on upstream W.S El = 1574.5 − pond water surface elevation equal 1563.9+2.5 = 8.1 ft

Max Q = 460 × 5 = 2302 cfs

504+25

Same as 479+00 - outlet weir crest is 0.7' higher and submerges exit for the 1200 cfs discharge, but backwater effect does extend to the inlet.

Max Q changes as H = 7.4'

~~H = ... 0.0000 ... Q^2 ... Q_T^{2/3}~~

~~Q between 3000 and 7100~~

Max Q = 440 x 5 = 2200 cfs

529+50 - Design Q = 840 = 168 cfs per pipe

5 - 72" Dia with outlet pond

Outlet pond
$B_2 = 150'$
$q = 5.6$
$dc = 1.0$
Crest El. = 1564.0
Water surface El. = 1565.5
Pipe invert = 1561.66
d = 3.84 He = 5.04

Pipe is not submerged

Normal Depth in pipe yo = .51×6 = 3.06 He 5.14

Critical Depth dc = .595×6 = 3.57 · 4.98
slope is steeper than critical

Control is critical dept

Inlet w.s. = 1562.59 + ~~El~~ 3.57 + 2.12 = 1568.28

100 yr 3hr CASE II = 1821 cfs = 364.2/pipe

outlet pond w.s ~~is higher than the 2.5'~~

~~Training dike~~

q = 1821/150 = ~~12~~ 12.14

dc 1.66'
hvc .83

Water Surface = 1564 + = 1566.49
Pipe invert = 1561.66
4.83

~~Pipe will run just full~~

~~Critical depth = .86×6 = 5.16~~
~~Normal depth = full pipe~~

$\frac{Qn}{D^{8/3}\sqrt{S}}$ = .527 > .463 pipe Flows Full

INTERNATIONAL ENGINEERING COMPANY, INC.

Project ____ Contract No. ____ Sheet ____ File No. ____

Feature ____ Designed RF Date 10/8/84

Item Conduit @ Sta 529+50 Checked ____ Date ____

$V = \frac{364.2}{.7854 D^2} = 12.88$

h_v 2.57

Slope of H.G $= \left(\frac{(364.2)(.012)}{6^{8/3} \; .463} \right)^2 = .0063$

$l = 190$

Inlet w.s = 1561.70 + 5 + 1.5(2.57) + .0063 × 190

= 1571.75

Max Q

H = 1574.5 − 1566.5 = 8

Q = 458/pipe = 2290

INTERNATIONAL ENGINEERING COMPANY, INC.

Project CAP
Feature Cross Drainage Analysis
Item Conduit @ Sta 542+50

Sheet
Contract No.
File No.
Designed RF
Date 10/8/84
Checked
Date

542+50

Same conditions as 524+50

INTERNATIONAL ENGINEERING COMPANY, INC.

Project: CAP | Sheet:
Feature: Cross Drainage Analysis | Contract No.: | File No.:
Item: Conduit @ Sta 552+40 | Designed: RF | Date: 10/8/84
Checked: | Date:

Sta 552+50 . Design Q= 760 cfs = 152 cfs/~~barrel~~ pipe

5-72" Dia. Pipes discharging into an outlet pond

Outlet Pond

$B_2 = 134'$
$q = 5.67$
$d_c = 1.0$

Crest El = 1566.8
W.S. El = 1568.3
Pipe invert = 1562.85

d ~ 5.45

Pipe is unsubmerged

$$\frac{Qn}{D^{8/3} S^{1/2}} = \frac{(152)(.012)}{6^{8/3} \sqrt{.005}} = .217$$

$y_o = .48 \times 6 = 2.88$ $H_e = 4.88$

$d_c = .555 \times 6 = 3.33$ $H_e = 4.69$
Steep slope

~~tail~~ Critical depth control

W.S = 1563.76 + 3.33 + 2.04 = 1569.13

100yr 3hr Q= 1190 cfs = 238/pipe

d_c at outlet $= \left(\frac{1190}{134}\right)^{2/3} .31433 = 1.34$

water surface = 1566.8 + 2.02 = 1568.82
pipe invert = 1562.85
5.97

Pipe just full at outlet

$$\frac{Qn}{D^{8/3} S^{1/2}} = .34$$

$y_o = .64 \times 6 = 3.84$ 2.4
$d_c = .705 \times 6 = 4.23$ 1.95

Bernouli to determine inlet condition

	d	hv	He	S
Full pipe	6	1.10	7.7	.00269
Normal depth	3.84	2.4	6.24	.005
Critical depth	4.23	1.95	6.18	.00374

$$l_c = \frac{He' - He''}{S_o - S_{ave}} = \frac{-7.7 + 6.18}{.005 - .00324} = 864'$$ critical not reached

$$l_T = \frac{-7.7 + 6.24}{.005 - .00384} = 1264$$ normal not reached

Full pipe

Inlet W.S = 1568.84 + 1.5 (1.1) + (.00269)(190)

= 1571.00

~~Maximum discharge is~~

Same conditions for 563+50

Max discharge ~~[illegible]~~ is

552+50 H = 1574.5 − 1567.5 = 7

Q = 428 × 5 = 2140

563+50 H = 1574.5 − 1569.3 = 5.2

Q = 369 × 5 = 1845

INTERNATIONAL ENGINEERING COMPANY, INC.

Project: CAP
Feature: Cross Drainage Analysis
Item: Conduit @ Sta 574+50
Contract No.:
Designed: RF
Checked:
Sheet:
File No.:
Date: 10/8/84
Date:

STA 574+50

3-54" Dia, n=.012, A per pipe = 15.90 ft^2, l = 190'

Outlet pond - Crest El. 1568 - Crest length = 70

Outlet pond water surface = 1.5 dc + 1568

Pipe invert at outlet = 1565.13

Design Q	= 400	W.S. El. in Pond
CASE II July 17 & 18	= 148	El. 1568.78
CASE II 100 yr 3 hr	= 407	El. 1569.52
CASE III July 17 & 18	= 148	El. 1568.78
CASE IV 100 yr 3 hr	= 401	El. 1568.78
CASE I	=	

Design Q and 100 yr 3 hr will submerge outlet

Inlet water surface = 1568 + 1.5 dc + 1.5 hv + Sl

$1.5 dc = \left(\frac{Q}{70}\right)^{2/3} .31433 = .0185 \times 1.5 = .0278 Q^{2/3}$

$1.5 hv = \frac{Q_p^2}{A^2 2g}$ = where $Q_p = 1/3\, Q$

$= .000092\, Q_p^2$

$Sl = \left(\frac{Qn}{D^{8/3}\, .463}\right)^2 l = .000042\, Q^2$

Inlet W.S. = $1568 + .0278 Q^{2/3} + .000092\, Q_p^2 + .000042\, Q_p^2$

Design Q = 1568 + 1.5 + 1.64 + .74 = 1571.9

CASE II 100 yr 3 hr = 1568 + 1.52 + 1.69 + .77 = 1572.0

Bank El. = 1574 ± OK

July 17 & 18 storm

Pond WS = 1568.78
Pipe invert = 1565.13
3.65 < 4.5

INTERNATIONAL ENGINEERING COMPANY, INC.

Project ____ Contract No. ____ Sheet ____

Feature ____ Designed RF File No. ____

Item Conduit @ Sta 574+50 Checked ____ Date 10/8/84 Date ____

Bernouli for pipe depth - include exit loss of hv

$d_{pipe} + 2hv = 3.65 + hv_p$ $Q = 49.333$

$d + hv_p = 3.65 + hv_p$

$d_p = 3.65 = He''$

Trial

d =	3.5	3.45
A =	13.26	13.08
V =	3.72	3.77
hv =	.21	.22
d+hv =	3.71 > 3.65	3.67 > 3.65

d in pipe = 3.43' $s = \left(\frac{Qn}{D^{8/3} .424}\right)^2 = .0006 < .005$

$l = \frac{He' - Ha''}{S_o - S_{ave}} = 190$

Approx inlet depth = 3.43 - 190 x .0006 = 3.32

$l = \frac{He' - 3.65}{.005 - .0006+}$

$l = \frac{3.65 - 3.56}{.005 - .00063} = 21$

Trial

d =	3.0	2.5	2.3
A =	11.32	9.15	8.15
V =	4.36	5.38	6.05
hv =	.29	.45	.57
d+hv =	3.29	2.95	2.87
s =	.00085	.00018	.0020
Ave s =	.00073	.00010	.0013
l =	84 < 190	142 < 190	210 > 190

depth = 2.4

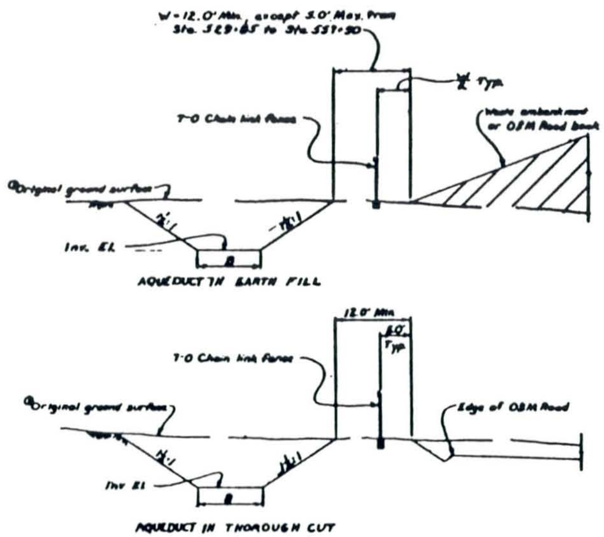
inlet w.s = pipe invert + 1.5 hv + d = invert + 3.07'

= 1566.08 + 3.07 = 1569.15

MAX Q

H = 1574.5 - 1570.5 = 4

Q = 173/pipe = 519



COLLECTOR CHANNEL SECTIONS
(LEFT SIDE OF CANAL LOOKING DOWNSTREAM)

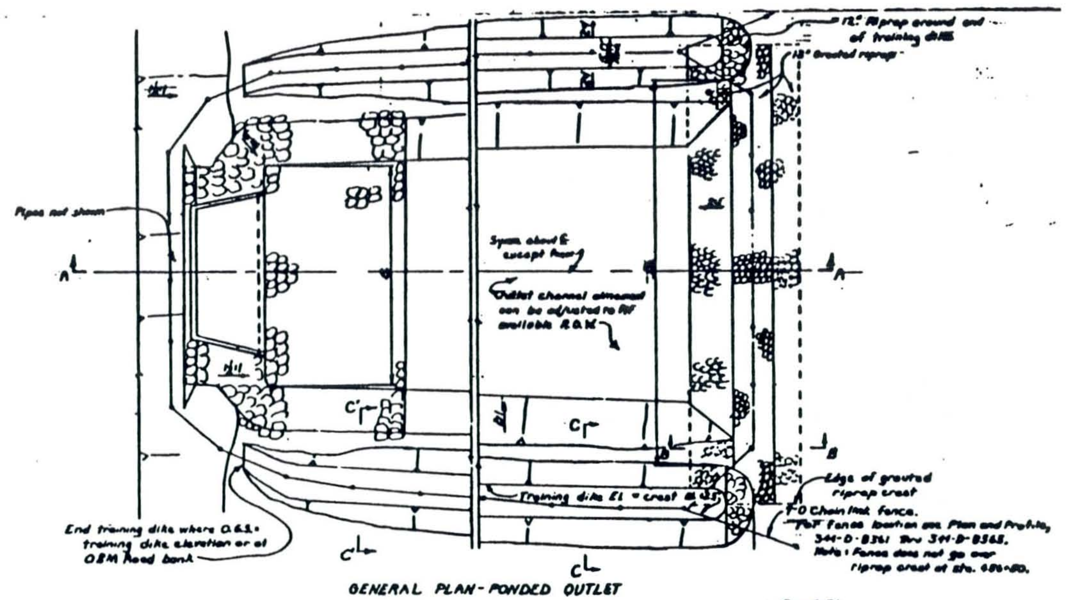
SCALE OF FEET

TABLE OF DIMENSIONS

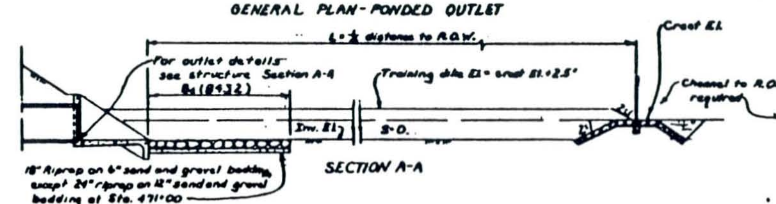
STATION	B	INV. EL.	TO	STATION	B	INV. EL.
331+00	5.0'	[a] O.G.S.		345+12	5.0'	1565.7
345+18	5.0'	1565.7		360+00	5.0'	[a] O.G.S.
347+00	5.0'	1565.1		373+70	5.0'	1565.1
374+30	5.0'	[a] 1565.1		385+00	5.0'	1565.1
388+00	5.0'	1564.9		396+10	5.0'	1564.9
396+70	5.0'	1564.9		424+00	5.0'	1564.9
427+50	16.0'	1568.6		428+85	16.0'	1568.6
475+50	5.0'	1562.0		478+61	5.0'	1562.0
479+36	12.0'	1562.0		483+75	12.0'	1562.0
483+75	2 BBL. 58" x 36" CMP-ARCH ROAD CULVERT					
484+40	12.0'	1562.0		506+64	12.0'	1562.0
509+50	8.0'	1562.4		520+00	8.0'	1562.4
520+00	2 BBL. 72" x 44" CMP-ARCH ROAD CULVERT					
521+00	18.0'	1562.4		542+14	18.0'	1562.4
542+[illegible]	5.0'	1562.4		547+00	5.0'	1562.4
548+00	5.0'	1563.6		552+14	5.0'	1563.6
552+[illegible]	16.0'	1563.6		563+14	16.0'	1563.6
563+06	10.0'	1563.6		571+30	10.0'	1563.6
572+00	5.0'	[a] O.G.S.		574+32	5.0'	1565.9
574+68	5.0'	1565.9		582+60	5.0'	[a] O.G.S.

COLLECTOR CHANNEL NOTES

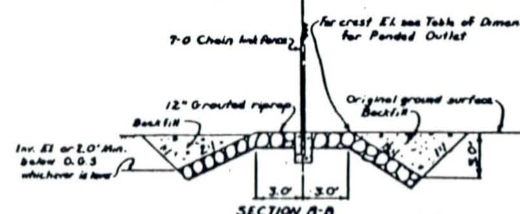
End waste embankments at overchutes.
Channel to overchutes as shown on overchute plan.
Vary dimensions of collector channels uniformly between the stations shown.



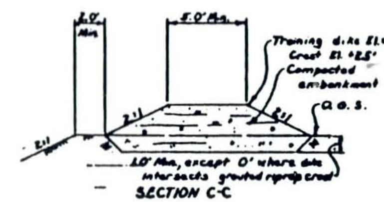
GENERAL PLAN - PONDED OUTLET



SECTION A-A



SECTION B-B



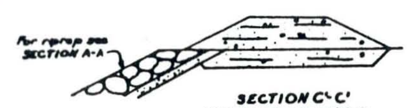
SECTION C-C

SCALE OF FEET

TABLE OF DIMENSIONS FOR PONDED OUTLET

STATION	B_1	B_2	APPROX. L	INV. EL.	MAX. CREST ELEVATION [a]
456+50	30'	48'	80'	1555.4	1558.0
471+03.12 [b]	47'	—	—	1553.9	—
479+00	71'	100'	78'	1561.4	1563.9
504+25	71'	100'	32'	1561.4	1564.6
529+50	71'	150'	75'	1561.7	1564.0
542+50	71'	150'	70'	1561.7	1564.0
552+50	71'	134'	71'	1562.8	1565.0
563+50	71'	134'	71'	1562.8	1566.8
574+50	36'	70'	71'	1565.1	1568.0

[a] Use Max. crest El. or O.G.S. whichever is lower
[b] Sta. 471+03.12: No 12" grouted riprap crest and training dikes are required. Channel to daylight as shown on 344-D-10240



SECTION C'-C'
(SIMILAR TO SECTION C-C EXCEPT RIPRAP)

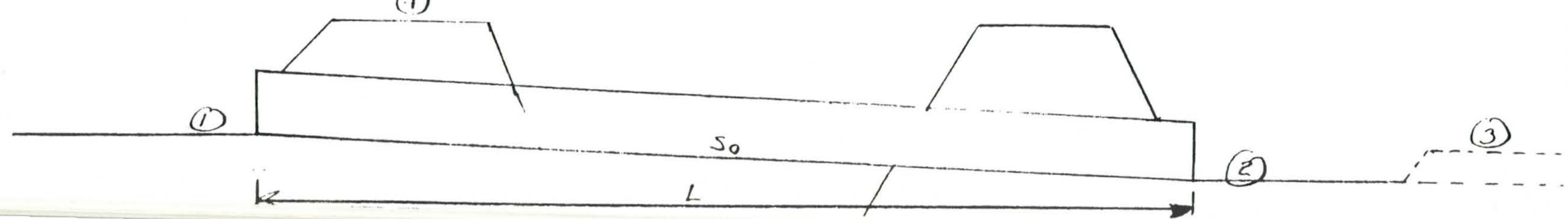
CHECKER'S COMPUTATIONS

INTERNATIONAL ENGINEERING COMPANY, INC.

Project CAP
Feature Cross Drainage Analysis
Item Physical Features of each unit
Contract No.
Designed RKM
Checked
File No.
Date 10/9/84
Date

STA	NO, SIZE & TYPE	LENGTH FT (L)	PIPE SLOPE (So)	① INLET I.E. ELEV.	② OUTLET I.E. ELEV.	④ EMBANKMENT ELEV.		DESIGN Q cfs	OUTLET POND CREST LENGTH FT	OUTLET POND CREST ELEV ③
345+30	3-54"Ø CONDUIT	165.5	0.005	1565.90	1565.07	1572.8		460	—	
374+00	4-8.75'X5.75' BOX FLUME	151.7	0.00	1565.08	SAME	1571.4 1571.8*		870	—	
396+40	4-8.75'X5.75' BOX FLUME	151.7	0.00	1564.90	SAME	1571.4 1570.8*		800	—	
427+15	3-72"Ø + ARCH CONDUIT	179.83 110.0	0.005 0.00672	1568.32 1564.77	1564.77 1564.00	1577.9		565	—	
429+20	3-72"Ø + 78" ARCH CONDUIT	179.83 200.0	0.005 0.00034	1568.32 1564.77	1564.77 1563.37	1577.9		565	—	
456+50	2-60"Ø CONDUIT	189.25	0.005	1556.15	1555.21	1571.4		270	50	1558.0
471+03	5-72"Ø CONDUIT	174.75	0.005	1560.62	1559.75			910	—	
479+00	5-72"Ø CONDUIT	168.5	"	1562.20	1561.36			575	100	1563.9
504+25	5-72"Ø CONDUIT	168.0	"	1562.20	1561.36			575	100	1564.6
529+50	"	178.0	"	1562.59	1561.70			840	150	1564.0
542+50	"	187.0	"	1562.59	1561.66			840	150	1564.0
552+50	"	183.0	"	1563.76	1562.84			760	134	1565.0
563+50	"	182.8	"	1563.76	1562.85			760	134	1566.8
574+50	3-54"Ø CONDUIT	189.5	0.005	1566.08	1565.13	1579.17		400	70	1568.0

* TOP OF CONC BOX @ FLUMES - NO FILL MATERIAL ON BOX



INTERNATIONAL ENGINEERING COMPANY, INC.

Project Salt-Gila Aqueduct — Contract No. ____ — Sheet ____
Feature Runoff Facility Analysis — Designed RKM — File No. ____
Item Open Canal @ Sta 374+00 — Checked ____ — Date 10/3/84 — Date ____

4 - CONCRETE FLUME 8'-9"W X 5'-9"H
152 LENGTH
0.0 SLOPE
ELEVATION OF INVERT 1565.08

ASSUME NO TAILWATER AT CULVERT AS THE FLOW WILL FAN OUT

CHECK

DESIGN Q = 870 cfs

JULY 17-18 Q = 707 cfs

MAX Q BEFORE FLOW INTO DITCH

CASE I

$Q = 870$ cfs or $\frac{870}{4}$ 217.50 cfs/FLUME

$Q = \sqrt{g}\, b\, D_c^{3/2}$

$Q = 217.5$
$g = 32.2$
$b = 8.75$

$\frac{Q}{\sqrt{g}\, b} = D_c^{3/2}$

or $D_c = .315 \sqrt[3]{(Q/b)^2}$

$D_c = 2.68'$

$S = 0.00 \therefore S_c > S$

AND OUTLET CONTROLS

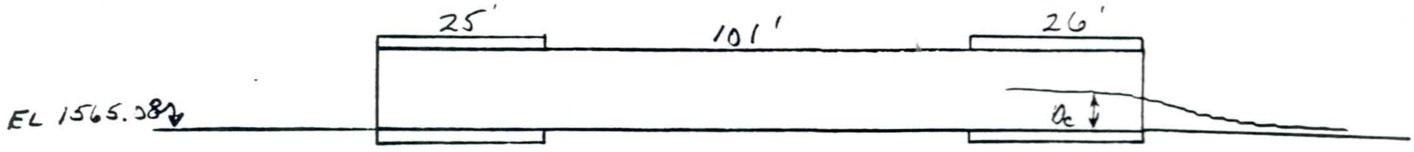
INTERNATIONAL ENGINEERING COMPANY, INC.

Project ______ Contract No. ______ Sheet ______ File No. ______

Feature ______ Designed ______ Date ______

Item *Open Canal @ Sta 374+00* Checked ______ Date ______

$Q = 217.5$ cfs / FLUME



0.00 SLOPE

@ Pt 4 $\quad D_c = 2.68$

$$V_c = \frac{217.50}{2.68 \times 8.75} = 9.275$$

$$V_c = \frac{1.486}{n} R^{2/3} S^{1/2}$$

$S_c = 0.0034$

$n = 0.013$

$\frac{D_c}{b} = 0.306$

∴ TABLE 7-1

$C_r = 0.620$

$R = C_r D$

$= 2.68(.620)$

$h_{v_c} = 1.33'$

$H_e' = d_c + h_{vc} = 4.01$

$$l = \frac{H_e'' - H_e'}{S_o - S_c}$$

$l = 152$

$H_e' = 4.01$

$S_o = 0$

$S_c = 0.0034$

$H_e'' = 4.52'$

Try

d =	3.2	3.5
A =	28	30.625
V =	7.77	7.1
hv =	0.94	0.78
d+h	4.14	4.28
s =	0.0021	s = 0.0016
l =	50	= 108

$$s = \left(\frac{Qn}{b^{8/3} \text{(TABLE 18 VALUE)}} \right)^2$$

$$\frac{Qn}{b^{8/3}} = 0.008697$$

try

d =	3.6	3.7
A =	31.5	32.38
V =	6.9	6.72
hv =	0.74	0.70
d+h =	4.34	3.40
s =	0.0015	.0014
SAVE	.0024	.0024
	l = 135	l = 163 ≈ 152

W.S. ELEV = 1565.08 + 3.70 + 1.5 h_v

= **1569.83** ←

CASE II - JULY 17-18 FLOOD

$Q = 707 \text{ cfs} \div 4 = 176.75 \text{ cfs}/\text{FLUME}$

$b = 8.75$

$d_c = .315 \sqrt[3]{(Q/b)^2} = 2.33'$

$V_c = 8.67$ fps

$S_c = 0.0033$

$\frac{Qn}{b^{8/3}} = 0.037068$

$h_{v_c} = 1.17$

$H_e = d_c + h_{v_c} = 3.50'$

$l = 152'$

Try

d =	3.4	3.3
A =	29.75	28.88
V =	5.94	6.12
h_v =	0.55	0.58
$d + h_v$ =	3.95	3.88
s =	0.00114	0.0013
SAVE	.00222	.00232
	$l = 203$	$l = 164 \cong 155$

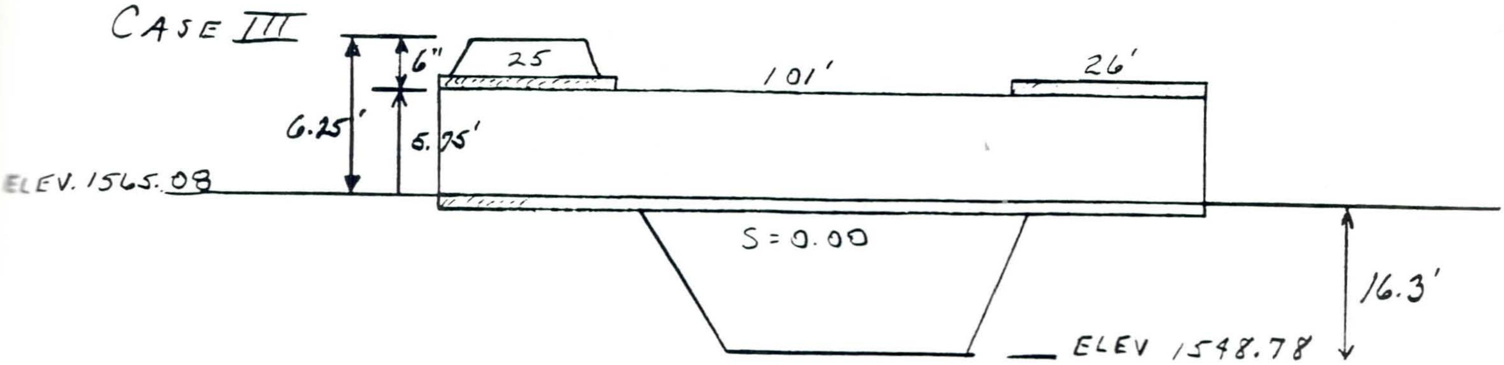
TABLE 18 = $\frac{Qn}{b^{8/3} S^{1/2}}$ from D/b

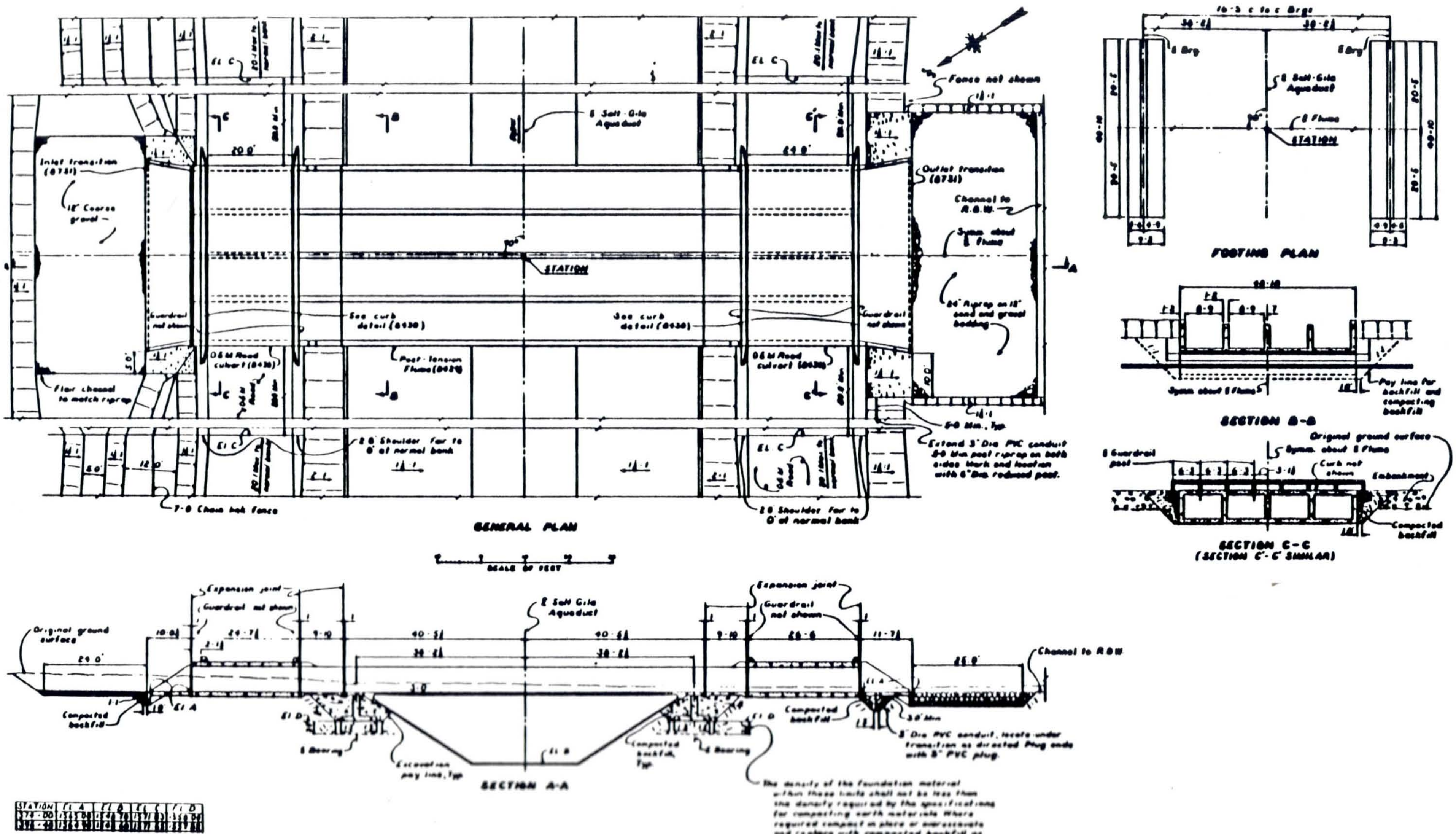
WS ELEVATION = $1565.08 + 3.3 + 1.5 h_v$

1569.25

Project ______ Contract No. ______ File No. ______
Feature ______ Designed ______ Date ______
Item Open Canal @ Sta 374+00 Checked ______ Date ______

CASE III




Fence not shown
℄ Salt Gila Aqueduct
Inlet transition (B731)
12" Coarse gravel
Outlet transition (B731)
Channel to R.O.W.
Symm. about ℄ Flume
STATION
24" Riprap on 12" sand and gravel bedding
Guardrail not shown
See curb detail (B430)
Post-tension Flume (B429)
O&M Road culvert (B430)
Flow channel to match riprap
2-8 Shoulder flair to 0' at normal bank
7-0 Chain link fence
Extend 3" Dia PVC conduit 5-0 Min. past riprap on both sides. Mark end location with 6" Dia. reduced post.
5-0 Min., Typ.
GENERAL PLAN
SCALE OF FEET
FOOTING PLAN
℄ Brg
℄ Flume
SECTION B-B
Pay line for backfill and compacting backfill
Symm. about ℄ Flume
Original ground surface
℄ Guardrail post
Curb not shown
Embankment
Compacted backfill
SECTION C-C
(SECTION C'-C' SIMILAR)
Expansion joint
Guardrail not shown
Original ground surface
Compacted backfill
Channel to R.O.W.
℄ Bearing
Excavation pay line, Typ.
Compacted backfill, Typ.
3" Dia PVC conduit, locate under transition as directed. Plug ends with 3" PVC plug.
SECTION A-A
The density of the foundation material within these limits shall not be less than the density required by the specifications for compacting earth materials. Where required compact in place or overexcavate and replace with compacted backfill as directed. Typical.

3 - 54" DIA CONC PIPE -
165.5 FT LENGTH
0.005 FT/FT SLOPE
CONC PIPE
PIPE IE. @ OUTLET = ELEV 1565.07
PIPE IE @ INLET = ELEV 1565.90

CHECK.

Q OF JULY EVENT = 321 cfs ÷ 3 = 107 cfs / PIPE
Q OF 100 YR = 460 cfs ÷ 3 153.3 cfs / PIPE

FIRST CASE
FLOW = 107 cfs

$$\frac{Q}{D^{5/2}} = 2.4909$$

FROM HYDRAULIC AND EXCAVATION TABLE 22

$$d/D = 0.6762$$

$$D_c = .6762(4.5) = 3.04'$$

TABLE 21

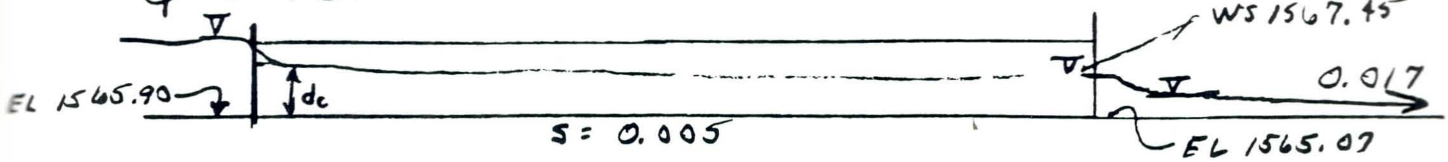
$$\frac{Qn}{D^{8/3} S^{1/2}} = 0.3703$$

$$\frac{107(.012)}{(4.5)^{8/3} .3703} = S_c^{1/2} = 0.003947$$

$$S = 0.005$$

$S > S_c$ THEREFORE UPSTREAM (ENTRANCE) CONTROLS

Q = 107 cfs



ASSUME MINIMUM WS @ OUTLET BECAUSE CONDUITS DISCHARGE TO A FLAT SURFACE @ A SLOPE OF 0.017

$d_c = 3.043$ $\quad$ $.5622 \times D^2$

AREA = 11.385 □
Q = 107 cfs

$V = \frac{Q}{A} = 9.4$ fps.

$H = (1.5)\frac{V^2}{2g} + d_c$

$(1.5)\,1.37 + 3.043$

$= 5.10'$

UPSTREAM W.S. = EL 1565.90
+ 5.10
1571.00 ←

DOWNSTREAM WS @ OUTLET

EL = 3.043 − (.003747 × 165.5') + EL 1565.07

= ELEV 1567.45 ←

SECOND CASE
FLOW = 153.33

$Q/D^{5/2} = 3.5694$

$d/D = .8066$

$d_c = .8066 \times 4.5 = 3.63'$

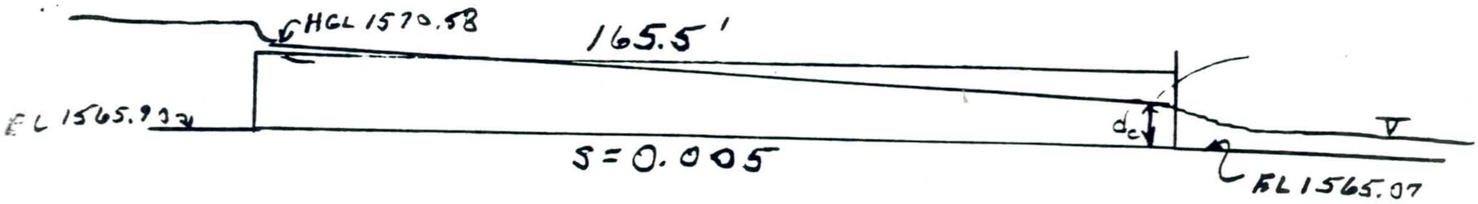
$\frac{Qn}{D^{8/3} S^{1/2}} = 0.4563$

$\frac{153.33(0.012)}{(4.5)^{8/3}\ 0.4563} = S^{1/2}$

$S_c = 0.00534$
$S = 0.005$

THEREFORE OUTLET CONTROLS

Q = 153.33 cfs



ASSUME MINIMUM WS AFTER OUTLET

W.S. @ OUTLET

= EL 1565.07 + dc (3.63')

= ELEVATATION 1569.70 ←

W.S. @ INLET

$= ELEV\ 1569.70 + (0.00534 \times 165.5) + (1.5)\frac{V^2}{2g}$

$= 1569.7 + 0.88 + 2.16$

BECAUSE HGL ABOVE PIPE @ ENTRANCE

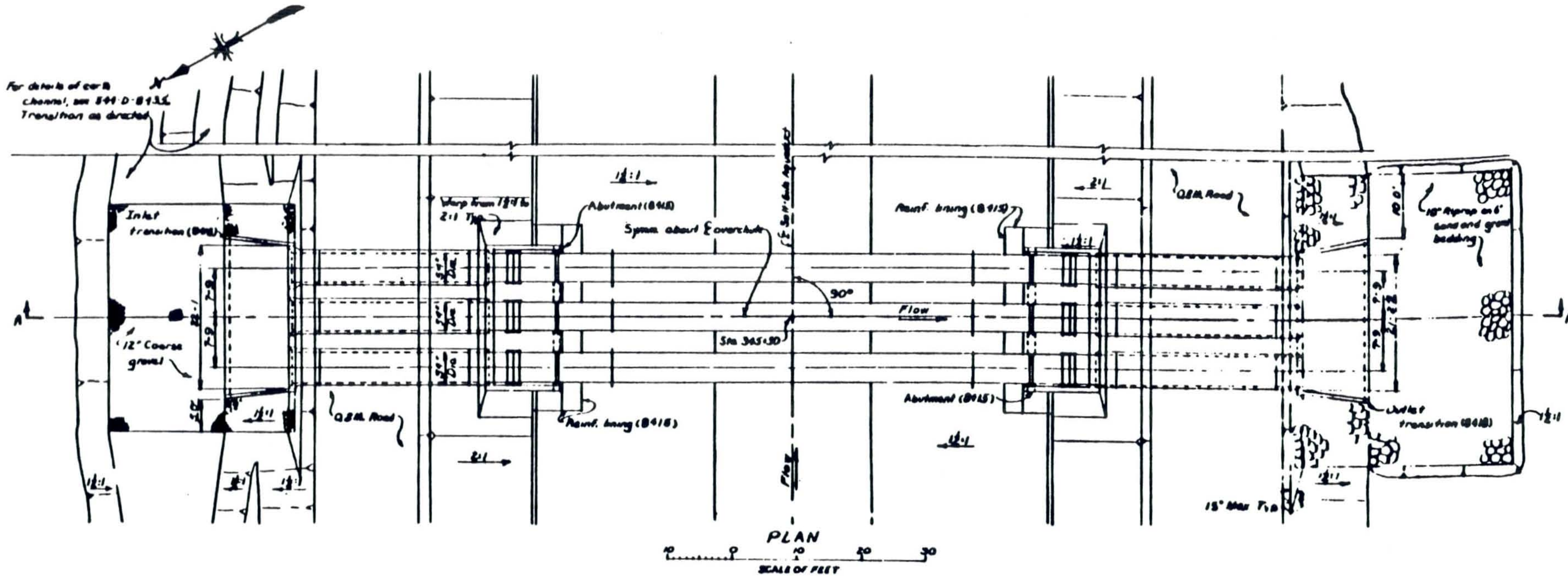
$V = \frac{Q}{A}$ $Q = 153.33$ cfs

$A = \pi\left(\frac{4.5}{2}\right)^2 = 15.904$ ft²

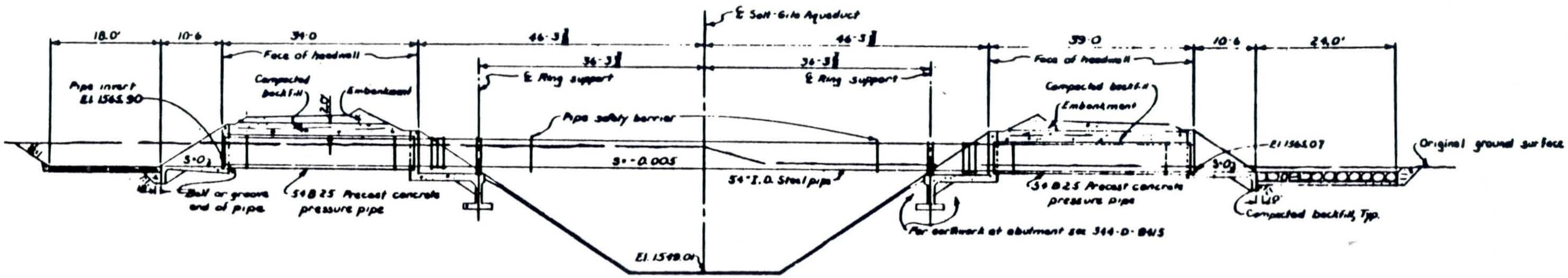
V = 9.64 fps.

WS = ELEVATION 1572.74 ←

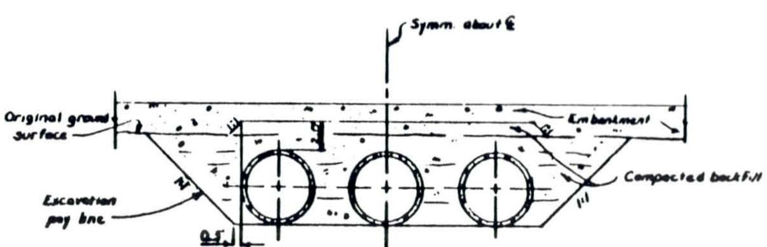
NOTE: WS ≅ ROAD GRADE
ANY EXCESS FLOW WOULD
RUN INTO THE CANAL



PLAN



SECTION A-A



TYPICAL EARTHWORK DETAIL

INTERNATIONAL ENGINEERING COMPANY, INC.

Project Salt - Gila Aqueduct
Feature Runoff Facility Analysis
Item Open Channel @ Sta 396+40
Contract No.
Designed RKM
Checked
Sheet
File No.
Date 10/4/84
Date

4 - CONCRETE FLUMES - 8'9" W X 5'-9" H
152' LENGTH
0.00 SLOPE
ELEV. OF INVERT 1564.90

ASSUME NO TAILWATER AT CULVERT AS THE FLOW WILL FAN OUT

CHECK

DESIGN Q = 800 cfs

JULY 17-18 Q = 814 cfs

MAXIMUM Q BEFORE RUNOFF FLOWS INTO THE [illegible]

CASE I

Q = 800 cfs ÷ 4 FLUMES = 200 cfs/FLUME

$D_c = 0.315 \sqrt[3]{(Q/b)^2}$

$= 2.53'$

$S_c > S_o$

∴ OUTLET CONTROL

$V_c = 9.03$ fps

$S_c = \left(\frac{Qn}{b^{8/3} \text{ FACTOR}} \right)^2$

$\frac{D_c}{d} = 0.287$

$\frac{Qn}{b^{8/3}} = 0.00777$

$S_c = 0.0033$

$h_{v_c} = 1.27'$

$H_{e_c} = 3.80'$

Try

d =	3.6	3.5
A =	31.5	30.625
V =	6.35	6.53
h_v =	.63	.66
$d + h_v$ =	4.23	4.16
s =	0.00125	0.00135
s_{AVE} =	0.0023	.0023
l =	188.9'	155.0' ≅ 152'

$$S = \left(\frac{Qn}{b^{8/3}} \text{ (TABLE)} \right)^2$$

W.S. ELEV. - 1564.90 + 3.5 + 1.5 h_v

1569.39

CASE II

$Q = 614 \text{ cfs} \div 4 = 153.5 \text{ cfs.}$

$D_c = 2.12'$

$V_c = 8.27$ fps

$h_{v_c} = 1.06$

$H_{e_c} = 3.18'$

$S_c = 0.0032$

$\frac{Qn}{b^{8/3}} = 0.00\ldots$

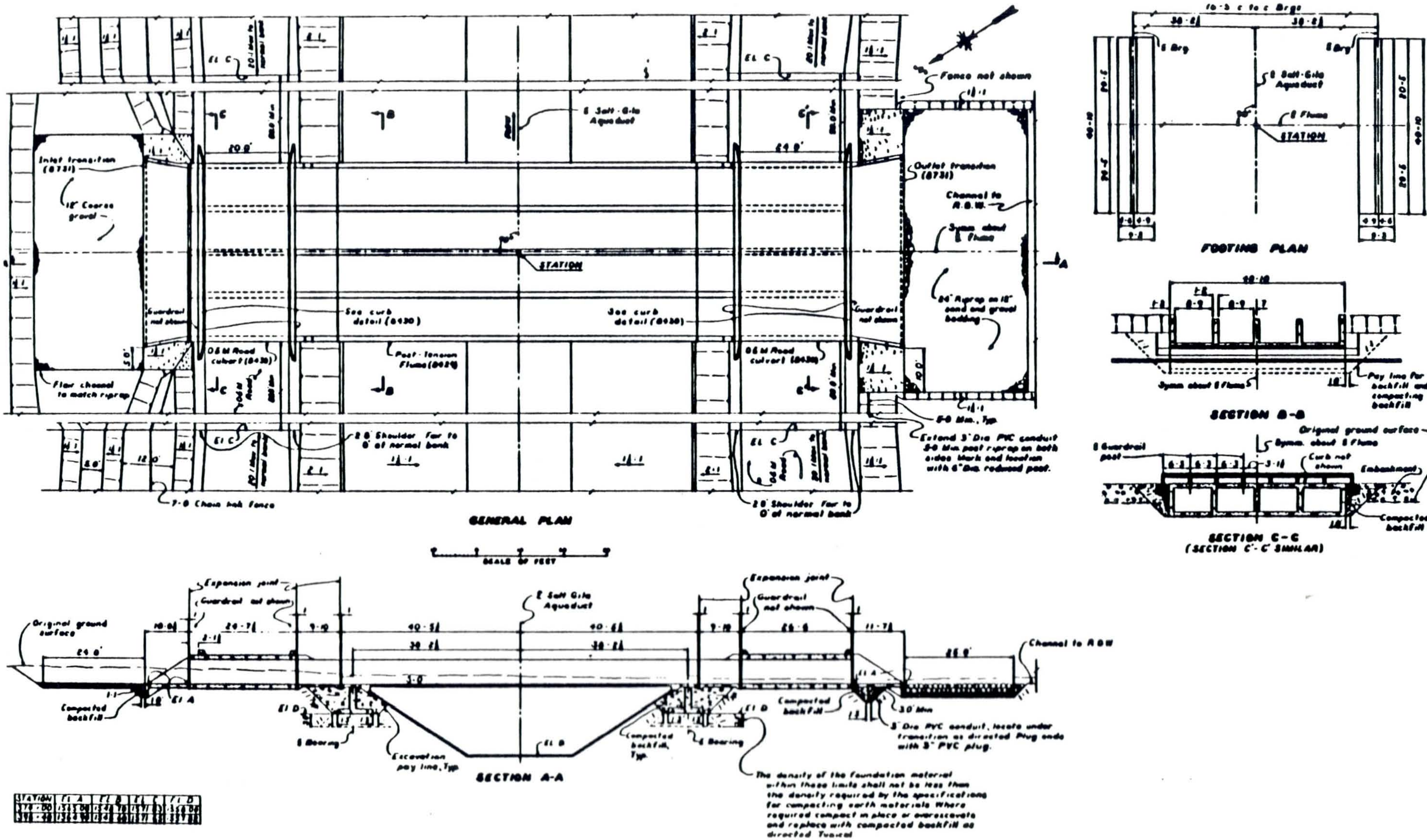
Try

d =	3.2	3.1
A =	28	27.13
V =	5.48	5.66
h_v =	0.47	.50
$d + h_v$ =	3.67	3.51
S =	0.0010	0.0011
S_{AVE} =	0.0021	.0022
ℓ =	232	ℓ = 153.5 ≅ 152

W.S. ELEV = 1564.90 + 3.1 + 1.5 h_v

= 1568.75

A-57


GENERAL PLAN
FOOTING PLAN
SECTION B-B
SECTION C-C
(SECTION C'-C' SIMILAR)
SECTION A-A
SCALE OF FEET
℄ Salt-Gila Aqueduct
℄ Flume
STATION
Fence not shown
Inlet transition (8731)
Outlet transition (8731)
12" Coarse gravel
Channel to R.O.W.
Symm. about ℄ Flume
24" Riprap on 12" sand and gravel bedding
Guardrail not shown
See curb detail (8430)
Post-tension Flume (8429)
O&M Road culvert (8430)
Flair channel to match riprap
2.0' Shoulder flair to 0' at normal bank
7-0 Chain link fence
5-0 Min., Typ.
Extend 3" Dia PVC conduit 5-0 Min. past riprap on both sides. Mark end location with 6" Dia. redwood post.
℄ Brg
Pay line for backfill and compacting backfill
Original ground surface
Curb not shown
Embankment
Compacted backfill
℄ Guardrail post
Expansion joint
Channel to R.O.W.
Compacted backfill
Excavation pay line, Typ.
℄ Bearing
3" Dia PVC conduit, locate under transition as directed. Plug ends with 3" PVC plug.
The density of the foundation material within these limits shall not be less than the density required by the specifications for compacting earth materials. Where required compact in place or overexcavate and replace with compacted backfill as directed. Typical

2 - 60" CONDUIT
SLOPE = 0.005
ELEV @ OUTLET 1555.21
ELEV @ INLET 1556.16
LENGTH 190.0'

POND @ OUTLET = 48' CREST
CREST ELEV 1558.00

EVALUATE AT

DESIGN Q = 270 cfs

100 YR Q = 286 cfs

MAXIMUM Q = ?

Q = 286 ÷ 2 = 143 cfs/PIPE

@ OUTLET POND - TREAT AS BROAD CRESTED WEIR

$Q = CLH^{3/2}$ | L = 48'
C = 2.63
Q = 286

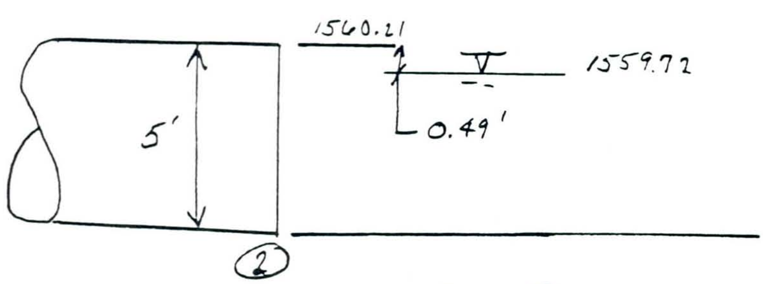
H = 1.72'

W.S. = 1558.00 +
+ 1.72' (H)
= 1559.72

$A/D^2 = .7445$ A = 18.61 #

V = 7.68

$h_{v_2} = 0.92'$



INTERNATIONAL ENGINEERING COMPANY, INC.

Sheet ______
Project ______ Contract No. ______ File No. ______
Feature ______ Designed RKM Date 10/9/84
Item Conduit @ Sta 456+50 Checked ______ Date ______

CHECK S_c

$Q/D^{5/2} = \frac{143}{5^{5/2}}$ 2.558

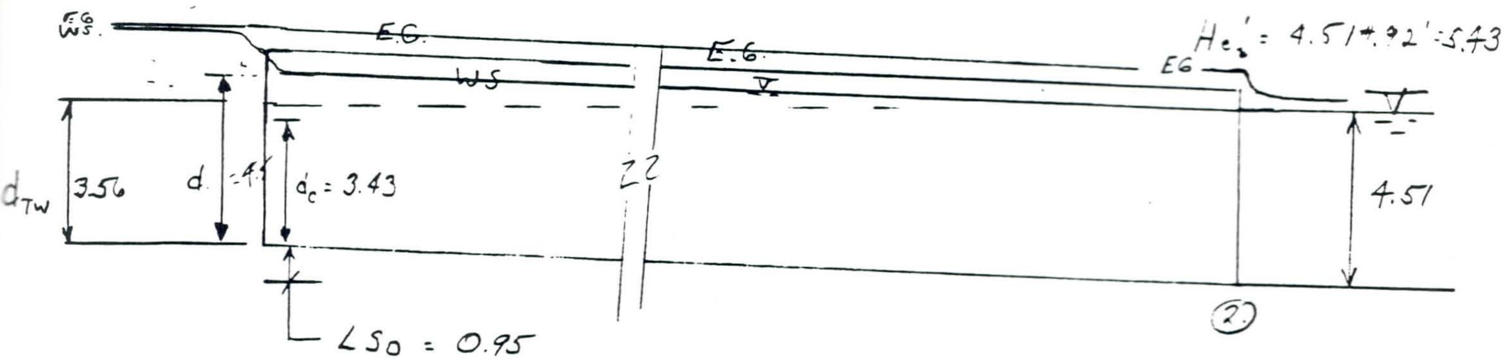
$d_c/D = 0.686$ $d_c = 3.43$

$\frac{Qn}{D^{8/3} S^{1/2}} = 0.377$ $S_c = 0.0045$

$A/D^2 = 0.5720$ $A = 14.3^{\square}$ $V_c = \frac{143}{14.3} = 10.0$ fps

$h_{vc} = 1.55$

$S_c > S_o$



$d_{TW} = 4.51 - 0.95 = 3.56$

$l = \frac{H_e'' - H_e}{S_o - S_{AVE}}$ $190[(0.005) - (0.0045)] + 5.43$

$H_e'' = 5.33$

Try					
d =	4.0	4.2	4.4	4.6	4.5
A =	16.8	17.6	18.3	18.9	18.6
V =	8.49	8.12	7.81	7.57	7.68
h_{v1} =	1.12	1.02	0.95	.89	0.92
$d + h_v + LS_o$ =	6.07	6.17	6.30	6.44	6.37
S =	0.00607		.0052	.0050	.0051
S_{AVE}	.00529	.0050			
l =	121	146.9	179.3	211.6' ≅	195.7' ≅ 190

$\frac{Qn}{D^{8/3}}$:

W.S. = 1556.16 + 4.5' + 1.5 (.92)

= 1562.04

INTERNATIONAL ENGINEERING COMPANY, INC.

Project: CAP Project | Contract No. | Sheet | File No.
Feature: Cross Drainage Analysis | Designed: RKM | Date
Item: Conduit @ Sta 47+03 | Checked | Date

5 - 72" DIA PIPES
SLOPE = 0.005
INLET ELEV. 1560.62
OUTLET ELEV. 1559.75
LENGTH - 174.0'

EVALUATE AT

DESIGN Q = 910 cfs

100 YR Q = 1765 cfs

---

910 cfs ÷ 5 = 182.0 cfs / pipe.

OUTLET TO CHANNEL
ASSUMED WS IN CHANNEL WILL NOT EFFECT PIPEFLOW

$Q / D^{5/2} = 2.0639$

2.0409 = .61
2.0639 = .614
2.1057 = .62

TABLE 22

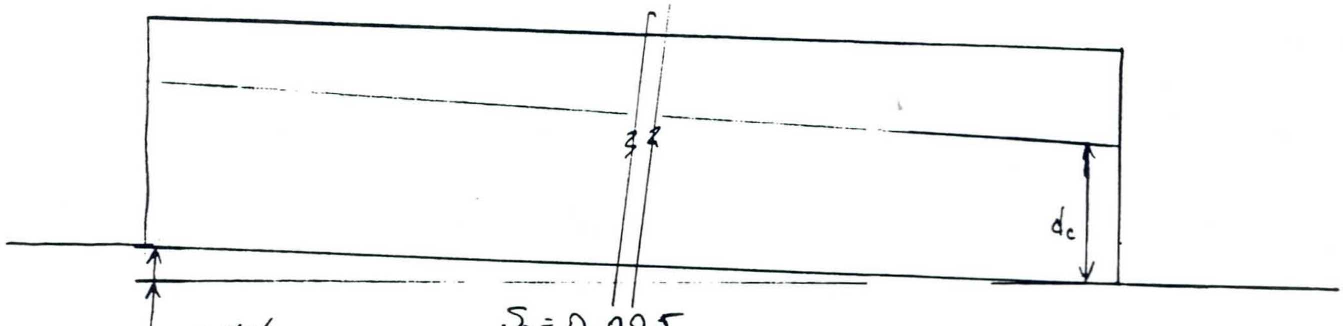
$d_c / D =$ $d_c = 3.68'$

$\frac{Qn}{D^{8/3} S^{1/2}} = .321$

Q = 182
n = 0.013
D = 6'

$\therefore S_c = 0.0623$

$S_c > S_o$



$A/D^2 = .504$ $A = 18.14^{ft}$

$V_c = 10.03$

$h_{v_c} = 1.56$

$He_c' = d_c + h_{vc}$
$= 3.68 + 1.56$
$= 5.24$

$$l = \frac{He'' - He}{S_o - S_{AVE}}$$

$174(.005 - 0.00623) + 5.24 = He'' = 5.45'$

Try

d	= 5.0	4.0	3.7
A	= 25.09	20.2	18.06
V	7.3	9.88	10.13
h_v	= 0.83	1.28	1.59
$d_1 + h_{v_1} + \Delta h$	= 6.7	6.15	6.16
s	= .001846	.00302	.00397
S_{AVE}	.00438	.00462	.005102
l	= 361	196.	180 ≅ 174

$$\frac{Qn}{D^{8/3}} = 0.0201$$

WS = EL 1560.62 + 3.7 + 1.5(1.59)

<u>ELEV. 1566.71</u>

INTERNATIONAL ENGINEERING COMPANY, INC.

Project ______ Contract No. ______ Sheet ______ File No. ______

Feature ______ Designed ______ Date ______

Item ______ Checked ______ Date ______

$Q = 1765 \div 5 = 353$ cfs / PIPE

$Q/D^{5/2} = 4.003$ $\quad d_c/D = .85$

CHECK FULL PIPE

@ Full Pipe $\frac{Qn}{D^{8/3} S^{1/2}} = 0.463$ $\quad n = 0.013$, $D = 6$, $S = 0.005$

$Q = 299$ cfs (PIPE FULL)

$Q_{90\%}$ $1.075(299) = 321$ cfs

THEREFORE PIPE WILL FLOW FULL

$$d_1 + \frac{V^2}{2g} + L S_o = d_2 + H_v + H_e + H_f$$

$$d_1 + 0 + 0.87 = 6.0 + 2.42 + 1.41 + 1.20'$$

$d_1 = 10.17'$

+ EL 1559.75

1569.92

$H_f = \frac{29 n^2 l}{R^{1.33}} \left(\frac{V^2}{2g}\right)$

$= 0.497(2.42) = 1.20'$

$d_2 = 6.0'$

$L S_o = .87'$