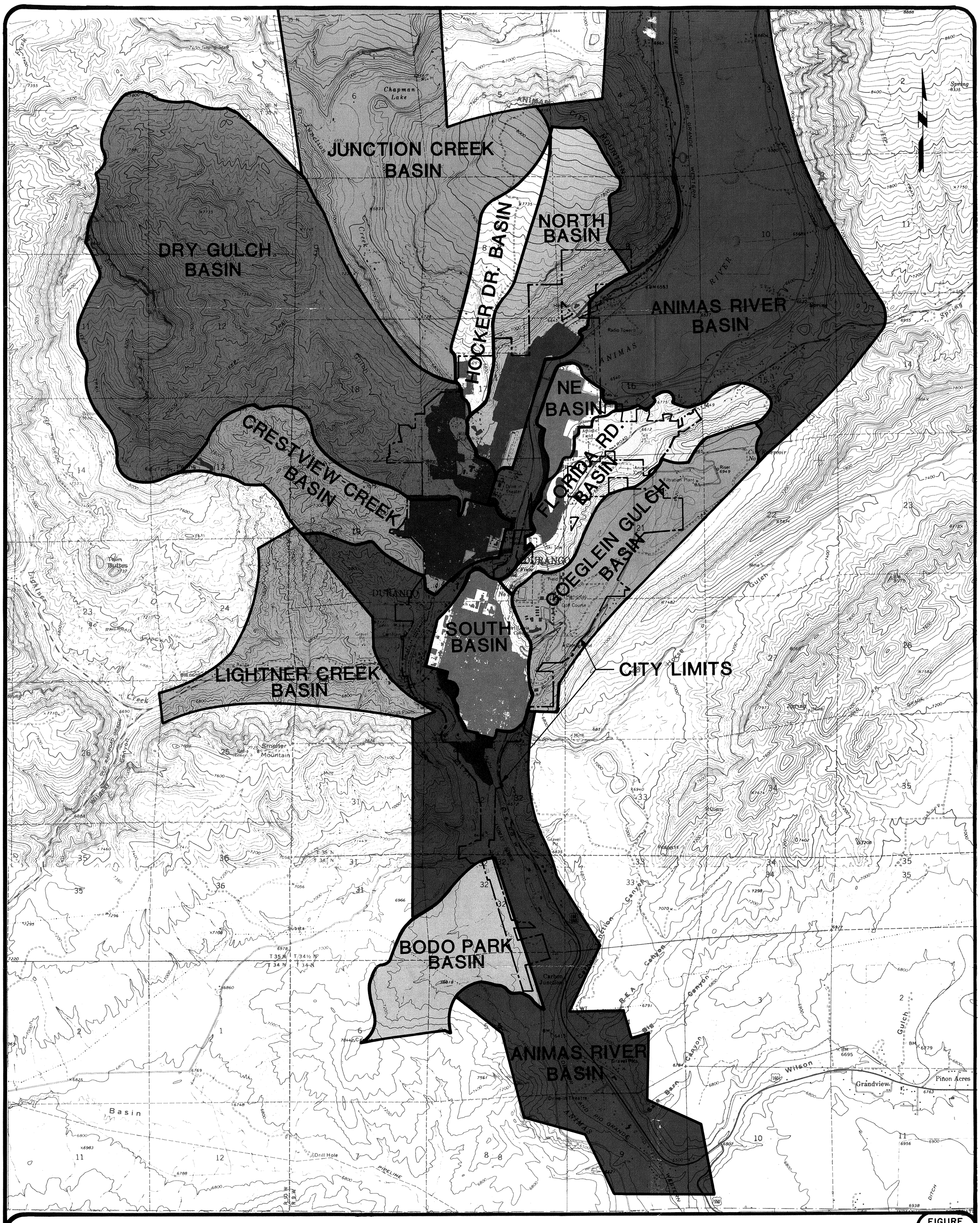

STUDY AREA

FIGURE 1

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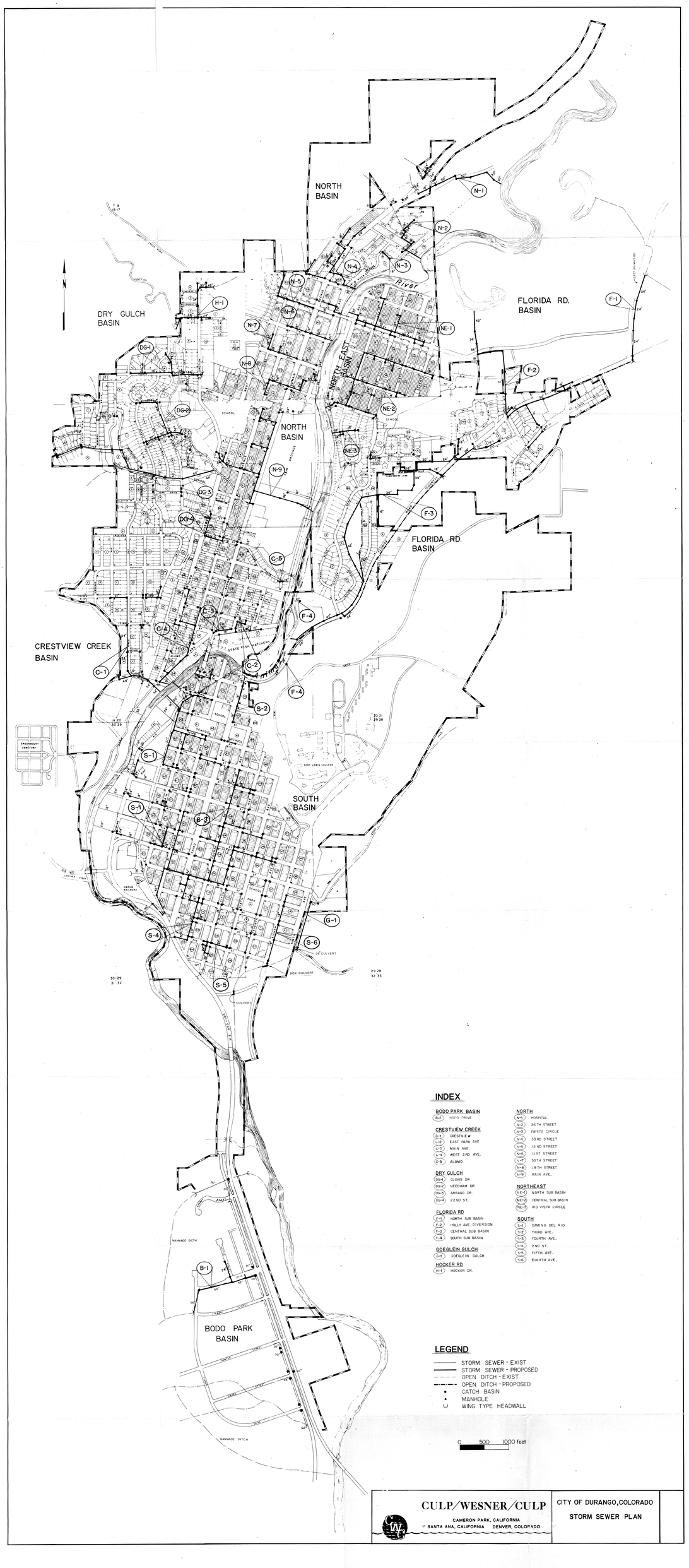
NORTH BASIN
DRY GULCH BASIN
FLORIDA RD. BASIN
NORTH EAST BASIN
NORTH BASIN
FLORIDA RD. BASIN
CRESTVIEW CREEK BASIN
SOUTH BASIN
BODO PARK BASIN
River
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N-8
N-9
H-1
DG-1
DG-2
DG-3
DG-4
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NE-2
NE-3
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CRESTVIEW CREEK
C-1 CRESTVIEW
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C-3 MAIN AVE.
C-4 WEST 3RD AVE.
C-5 ALAMO
DRY GULCH
DG-1 GLOVS DR.
DG-2 NEEDHAM DR.
DG-3 ARRAGO DR.
DG-4 22 ND ST.
FLORIDA RD
F-1 NORTH SUB BASIN
F-2 HOLLY AVE. DIVERSION
F-3 CENTRAL SUB BASIN
F-4 SOUTH SUB BASIN
GOEGLEIN GULCH
G-1 GOEGLEIN GULCH
HOCKER RD
H-1 HOCKER DR.
NORTH
N-1 HOSPITAL
N-2 36 TH STREET
N-3 FIESTA CIRCLE
N-4 33 RD STREET
N-5 32 ND STREET
N-6 31ST STREET
N-7 30TH STREET
N-8 29TH STREET
N-9 MAIN AVE.
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NE-2 CENTRAL SUB BASIN
NE-3 RIO VISTA CIRCLE
SOUTH
S-1 CAMINO DEL RIO
S-2 THIRD AVE.
S-3 FOURTH AVE.
S-4 2ND ST.
S-5 FIFTH AVE.
S-6 EIGHTH AVE.
LEGEND
STORM SEWER - EXIST
STORM SEWER - PROPOSED
OPEN DITCH - EXIST
OPEN DITCH - PROPOSED
CATCH BASIN
MANHOLE
WING TYPE HEADWALL
0 500 1000 feet
CULP/WESNER/CULP
CAMERON PARK, CALIFORNIA
SANTA ANA, CALIFORNIA DENVER, COLORADO
CITY OF DURANGO, COLORADO
STORM SEWER PLAN

Bill Casey (14)

DURANGO, COLORADO

URBAN STORM DRAINAGE MASTER PLAN

CUTP/WESNER/CUTP

NOVEMBER 1982

DENVER, COLORADO

CULP / WESNER / CULP

1777 SOUTH HARRISON, SUITE 310 DENVER, COLORADO 80210 TELEPHONE (303) 758-1721

November 15, 1982
619.1

Honorable Mayor and Council
City Hall
Durango, Colorado 81301

Gentlemen:

The enclosed report has been prepared to provide the City with a master drainage plan. The City has many drainage problems that require attention and development in and around the City is aggravating existing problems.

This report describes the physical facilities necessary to address these problems; however, it is not practical to construct all of these projects at once because of the high expense. It will be necessary for the City to prioritize the projects by the severity of the problem. Further, it will be necessary to finance the cost of these improvements through new charges to the citizens and fees charged to developers. A method is presented to finance costs of these projects for your consideration.

I am available to discuss this report at your convenience.

Very truly yours,

Henry Benjes

Henry H. Benjes, Jr.

HHB:jr

Enclosure

DURANGO, COLORADO

URBAN STORM DRAINAGE

MASTER PLAN

CULP/WESNER/CULP

Denver, Colorado

November, 1982

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INTRODUCTION

Urbanization results in increased impervious land which, in turn, increases sto water runoff. Development also confines the acceptable paths that the runoff m be directed. The City of Durango has some storm water drainage facilities, b most typically, drainage has been directed along streets to the natural drainag ways. This has often caused problems. Several other drainage problems occur wi new development and increased impervious areas. This study provides the City wi a master plan for an urban storm drainage system. Procedures for estimating sto water quantities are presented.

The master plan incorporates the existing drainage facilities as much as pract cal. Some existing piping and drains are plugged, broken, or otherwise ne repair. New facilities are proposed that will convey storm runoff flows throu drainagesheds that are tributary to the City. The construction costs for propos facilities are estimated and recommended procedures for implementation a presented.

This study included a survey of the existing storm drainage facilities; develo ment of rainfall intensity-duration-frequency curves; development of characteri tic runoff coefficients for various land uses; and an evaluation of the runo characteristics of surrounding areas tributary to the City. Runoff flow rat were calculated to size the drainage system.

STUDY AREA

The study area is shown in Figure 1, in the pocket at the back of this report. addition to the City limits, the study area includes Florida Road, part of Anim City Mountain, Dry Gulch Creek Basin, Crestview Basin, and the Bodo Park indu trial area. The study area is over 15,000 acres, of which 2,300 acres are in t City limits.

DRAINAGE PLAN DEVELOPMENT

The City of Durango is located in the Animas River Valley, and much of the development lies in the lowland areas adjacent to the river. The steep valley walls direct drainage to the river through the town. Mostly, the storm drainage is from local small catchment areas, although Junction Creek and Lightner Creek run through Durango to the river.

MAJOR DRAINAGE BASINS

The study area has been separated into the major drainage basins described below and shown in Figure 1.

Animas River Local Drainage: Areas in the floodway and immediately adjacent to the Animas River drain directly to the river. Riverside development is proposed in the northern portion of the study area and the storm drainage for that development is presented in reports specific to that development.

Florida Road Basin: The Florida Road Basin is composed of 522 acres located in the eastern part of the study area. Almost half of this area is outside of the City limits, and is mostly unimproved. The majority of the unimproved area is steeply sloping hillsides along the east side of Florida Road. The general slope of the Florida Road Basin is from the northeast toward the south and west, to the Animas River. The development on the west side and along North College Drive is mostly single family residential with some multi-family residential. The average runoff coefficient for the basin is 0.32.

Northeast Basin: The northeast basin has 137 acres, and is located between the Animas River and the western boundary of the Florida Road Basin. The area generally slopes gently toward the west to the Animas River. The entire area is developed with single family residential lots. The average runoff coefficient for the basin is 0.45.

South Basin: The South Basin has 366 acres. The west boundary is Camino del Rio Street. The east boundary is Rim Drive and a tributary of Horse Gulch Creek. The basin slopes generally to the west toward the Animas River.

The South Basin is the established portion of the study area containing the core City. The railroad crosses the basin on the west, where most of the commercial and industrial land use is located. The runoff coefficient is 0.56.

North Basin: The North Basin has 655 acres. About forty percent of this area is the steeply sloping Animas City Mountain. The drainage boundaries are the Animas River to the east, Junction Creek to the southwest, and the Animas City Mountain in the northwest and north. The general slope of this area is toward the south to the Animas River. Most of the developed area is single family residential. The average runoff coefficient for the area is 0.31.

Hocker Drive Basin: The Hocker Drive Basin includes 307 acres. Much of this land is the undeveloped part of Animas Mountain. The developed area is single family residential. The average runoff coefficient is 0.22.

Junction Creek Basin: Part of the Junction Creek drainageshed is in the study area; however, the developed portions have been given other names. The Junction Creek drainageshed is undeveloped.

Dry Gulch Basin: The Dry Gulch drainage area has 3,025 acres. This drainage is tributary to Junction Creek. The developed area is predominantly single family residential. The average runoff coefficient of the area is 0.22.

Crestview Creek Basin: The Crestview Creek Basin has 723 acres located in the western part of the study area. The basin slopes toward the southwest to the Animas River. A man-made ditch has been constructed that diverts drainage from areas outside the City to the Animas River. The development is mostly residential. The average runoff coefficient of the area is 0.33.

Lightner Creek Basin: Part of Lightner Creek is in the study area. Lightner Creek is almost totally undeveloped, but the small area (750 acres) in the study area

has commercial and some residential development. No structured drainage is provided in this report. Drainage goes directly to the Creek via highway ditches and culverts.

Bodo Park Basin: The Bodo Industrial Park area has 180 acres. The present drainage is natural creeks. The developed area is business and industrial. The average runoff coefficient of the area is 0.24.

Goeglein Gulch Basin: The Goeglein Gulch area is 2,700 acres. The Ft. Lewis College, Municipal Golf Course and proposed development are located in this basin.

EXISTING DRAINAGE FACILITIES

The existing drainage system in the City of Durango consists of natural creeks, man-made channels, and pipes. Pipe materials include corrugated metal (CMP), clay, and concrete. Pipe sizes above 18-inch are generally CMP. Eight to 18-inch diameter pipes are generally clay or concrete. Most of the clay pipes are in the older part of the City (South Basin) and are reported to be in poor condition. Most of the piping has been installed in shallow trenches (about 3-4 feet deep). Field observations reveal that many of the storm water catch basins and pipes (the small diameter) are plugged with silt and debris.

Florida Road Basin: The drainage facilities in this basin consist of 18-inch CMP pipe having a flow capacity of about 12 cfs. There is 2,300 feet of 20-inch CMP on Florida Road from Riverview Road to Third Avenue that has a capacity ranging from 11 to 20 cfs. The outfall is an 18-inch CMP with a free discharge capacity of about 25 cfs.

Northeast Basin: The major part of this basin is drained to the corner of Third Avenue and 29th Street, with a capacity of 20 cfs. Rio Vista Circle is drained with a 12-inch pipe having a capacity of 6 cfs, followed by an 18-inch CMP with a capacity of 12 cfs. The south part of Rio Vista Circle is drained with an 18-inch CMP having a capacity of about 15 cfs.

South Basin: The South Basin includes two major drainage subbasins. The Camino del Rio subbasin serves the majority of the downtown area. The piping on most streets is 24-inch CMP and/or 18-inch VCP. The more easterly subbasin is piped with 18-inch CMP along Fifth, Sixth, and Seventh Avenues. Tables 1 and 2 summarize the facilities of the South Basin.

North Basin: Several storm sewers provide drainage on Main Street. Inlets on the west side of Main Street are piped to the Animas River along the east-west streets. Table 3 summarizes the existing drainage sewers in the North Basin.

Dry Gulch Creek Basin: The drainage system in the Dry Gulch Creek Basin consists of ditches and a 48-inch pipe conveying drainage to Junction Creek. The 48-inch outfall has a capacity of 160 cfs. There are a few local 12-inch to 24-inch pipes along the Junction Creek with capacities of 5 to 20 cfs. At 22nd Street an 18-inch pipe followed by a 36-inch pipe has a capacity of 23 to 40 cfs.

Crestview Basin: Crestview Basin has two subbasins. These are designated as westerly and easterly subbasins. The undeveloped portion of the westerly subbasin is drained by a man-made ditch on the west boundary of the Crestview development. The ditch passes in culvert under Avenida del Sol and then across the Incline property to a 36-inch outfall culvert. Portions of the drainage from the developed Crestview area are piped to El Paso Street and the Incline property.

In the east section of this basin there are three major storm sewers described on Table 4.

Bodo Park Basin: Bodo Park is an industrial and commercial development that is largely undeveloped at present. The developer constructed interception ditches to the west of the property that divert drainage from the property. The on-site drainage is mostly directed to the streets toward the frontage road to U.S. Highway 550. Earthen roadside ditches collect the drainage and direct it toward culverts that cross the highway and direct the drainage to the river.

TABLE 1. SOUTH BASIN - CAMINO DEL RIO SUBBASIN EXISTING DRAINAGE SYSTEM - FLOW CAPACITY

Outfall Name*	Capacity at Various Locations: Section From	Section To	Pipe Diameter, inches	Flow, cfs
15th	Main Avenue	Animas River	18	6
14th	Main Avenue	**	15	4
14th	**	Animas River	18	8
13th	Main Avenue	Camino del Rio	15	9
13th	Camino del Rio	Animas River	18	13
12th	Third Avenue	Second Avenue	18	11
12th	Main Avenue	Railroad Avenue	15	11-15
12th	Camino del Rio	Animas River	24	29
10th	Second Avenue	Main Avenue	12	8
10th	Main Avenue	Railroad Avenue	12	7
10th	Camino del Rio	Animas River	24	40
9th	Second Avenue	Main Avenue	12	8
9th	Main Avenue	Camino del Rio	18	15
9th	Camino del Rio	Animas River	24	33
8th	Second Avenue	Main Avenue	12	8
8th	Main Avenue	Camino del Rio	18	16
8th	Camino del Rio	Animas River	24	26
7th	Second Avenue	Main Avenue	12	7
7th	Main Avenue	Camino del Rio	18	15
7th	Camino del Rio	Animas River	18	20
6th	Fourth Avenue	Second Avenue	12	4
6th	Main Avenue	Camino del Rio	18	15
6th	Camino del Rio	Animas River	24	26

* Name by street

** 60 ft east to river

TABLE 2. SOUTH BASIN - FIFTH AND SEVENTH AVENUES SUBBASINS EXISTING DRAINAGE SYSTEM FLOW CAPACITY

	Fifth Avenue	Sixth Avenue	Seventh Avenue
Section From - To	9th-7th	5th-4th	6th-5th
Pipe Diameter - inches	18	18	18
Flow - cfs	7	5	7
Section From - To	7th-5th	4th-3rd	5th-4th
Pipe Diameter - inches	18	18	18
Flow - cfs	3	7	8
Section From - To	5th-3rd	3rd-2nd*	4th-3rd
Pipe Diameter - inches	18	18	18
Flow - cfs	7.5	8	9
Section From - To	3rd-2nd		3rd-2nd
Pipe Diameter - inches	18		18
Flow - cfs	18		11
Section From - To	2nd-Creek		2nd-Creek
Pipe Diameter - inches	36		18
Flow - cfs	50		11-16

* Is connected to Seventh Avenue drain through 2nd Street.

TABLE 3. NORTH BASIN EXISTING DRAINAGE SYSTEM FLOW CAPACITY

Location Street	From	To	Pipe Diameter inches	Flow cfs
North to Hospital	U.S. 550	County Road*†	24	26
North to Hospital	U.S. 550	County Road*†	24	20-30
South to Hospital	U.S. 550	County Road*†	24	20-30
South to Hospital	U.S. 550	Silverton St.*	36	100
33rd Street	35th & Main	Animas River	24-30	20-45
32nd Street	Main	Animas River	18-24	18
30th Street	Main	Animas River	18-24	16-30
29th Street	Main	Animas River	18-24	9-30
North to Fairground	Main	Animas River	18-24	7-30

* This overland flow eventually is drained to Animas River, through open ditches and culverts.
† A road south to U.S. 550.

TABLE 4. CRESTVIEW CREEK BASIN EXISTING DRAINAGE CAPACITY

	West Second & West Third	Main	Park Ave.
From - To	20th-18th	20th-19th	18th-Second
Diameter - inches	18	18	15
Flow - cfs	13	11	3-4
From - To	18th-16th	19th-18th	Second-Main
Diameter - inches	18	18	18
Flow - cfs	13	11	9
From - To	17th-Park Ave.	18th-17th	Main-River
Diameter - inches	18	18	18
Flow - cfs	13	14	10-20
From - To	Park Ave.-Ditch	17th-Animas River	
Diameter - inches	15	18	
Flow - cfs	13	24-30	

DESIGN APPROACH

This study proposes a drainage system that collects and conveys storm water runoff from a rainfall that occurs on the average of once every ten years. This is referred to as a "ten-year frequency storm". Surface runoff of rainfall varies with the nature of the surface that the rain falls upon and the preceding rainfall or moisture conditions. Runoff will be a fractional part of the rainfall volume; the balance of the rain that does not run off, percolates in the soil, is retained in surface depressions, or evaporates. Runoff can be related to rainfall by the following equation; this equation is called the Rational Method.

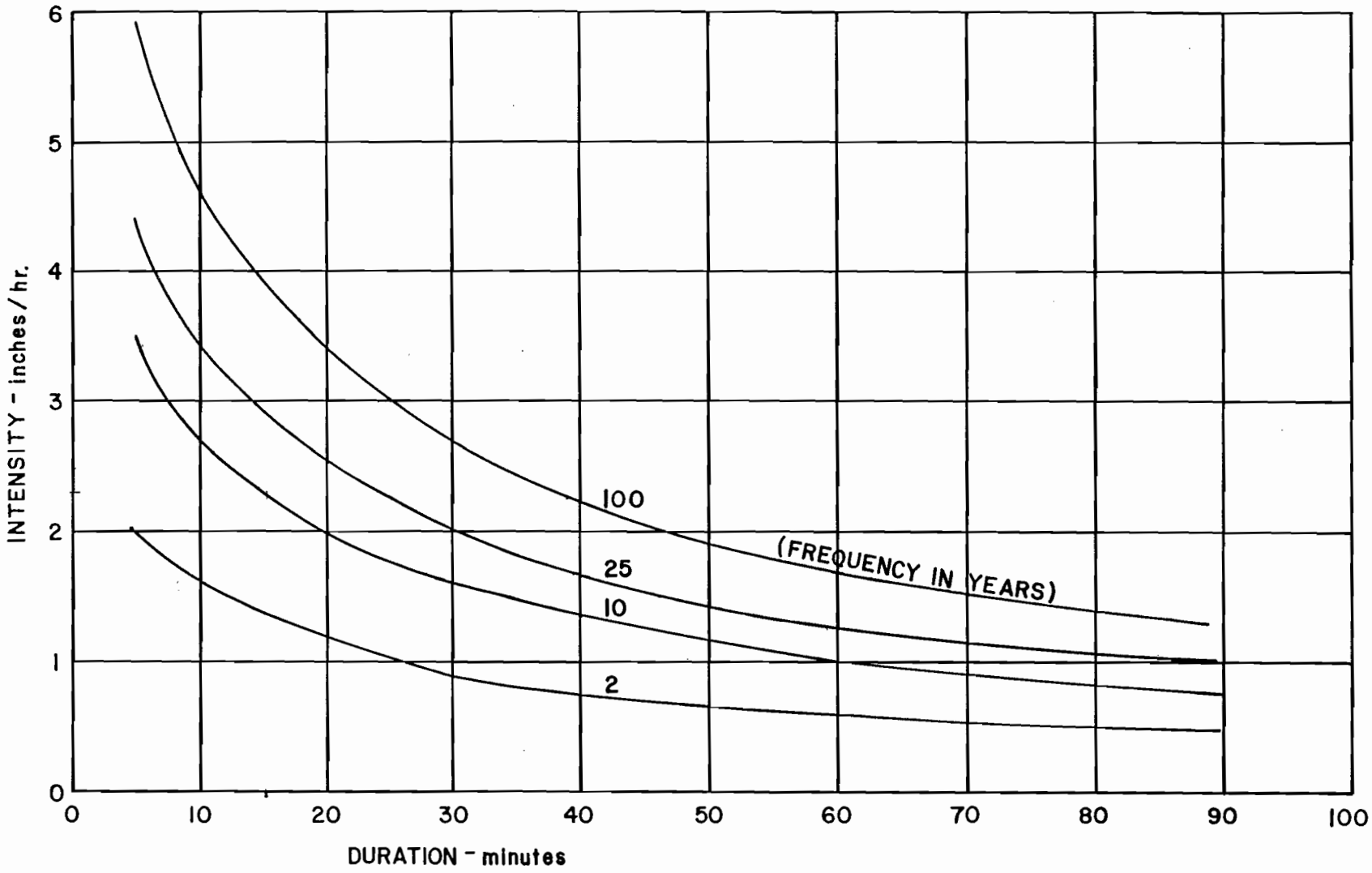
$$Q = CiA$$

Where:
- Q - Runoff, cfs
- i - Rainfall intensity, in/hr
- C - Runoff coefficient
- A - Drainage area, acres

Rainfall intensity varies with the duration of the rainfall. Average rainfall intensity during short periods will be greater than during longer periods. The time required for rainfall that begins at the remote point in the drainageshed to travel to the point under consideration is termed the "time of concentration". The time of concentration is used synonymously with the rainfall duration. Therefore, in the Rational Method, the average rainfall intensity for the time of runoff travel is used.

The rainfall intensity-duration-frequency curves for Durango, Colorado, are shown in Figure 2. Appendix A summarizes the methodology used in development of these curves. The ten-year frequency was selected for a design base to provide adequate drainage for most storms. Storms of greater intensity will be carried in the drainage system, as well as across the surface.

From aerial maps (scale of 1" = 100'), representative blocks of Durango have been analyzed to determine the relative distribution of pervious and impervious areas. Characteristic runoff coefficients were developed for various land uses. For



INTENSITY-DURATION RAINFALL CURVES, DURANGO, COLORADO

FIGURE 2

drainage areas consisting of several land uses, a composite coefficient was applied based on the relative distribution of each category of land use. Table 5 summarizes the runoff coefficients for the specific land uses in the City of Durango.

TABLE 5. CHARACTERISTIC RUNOFF COEFFICIENTS

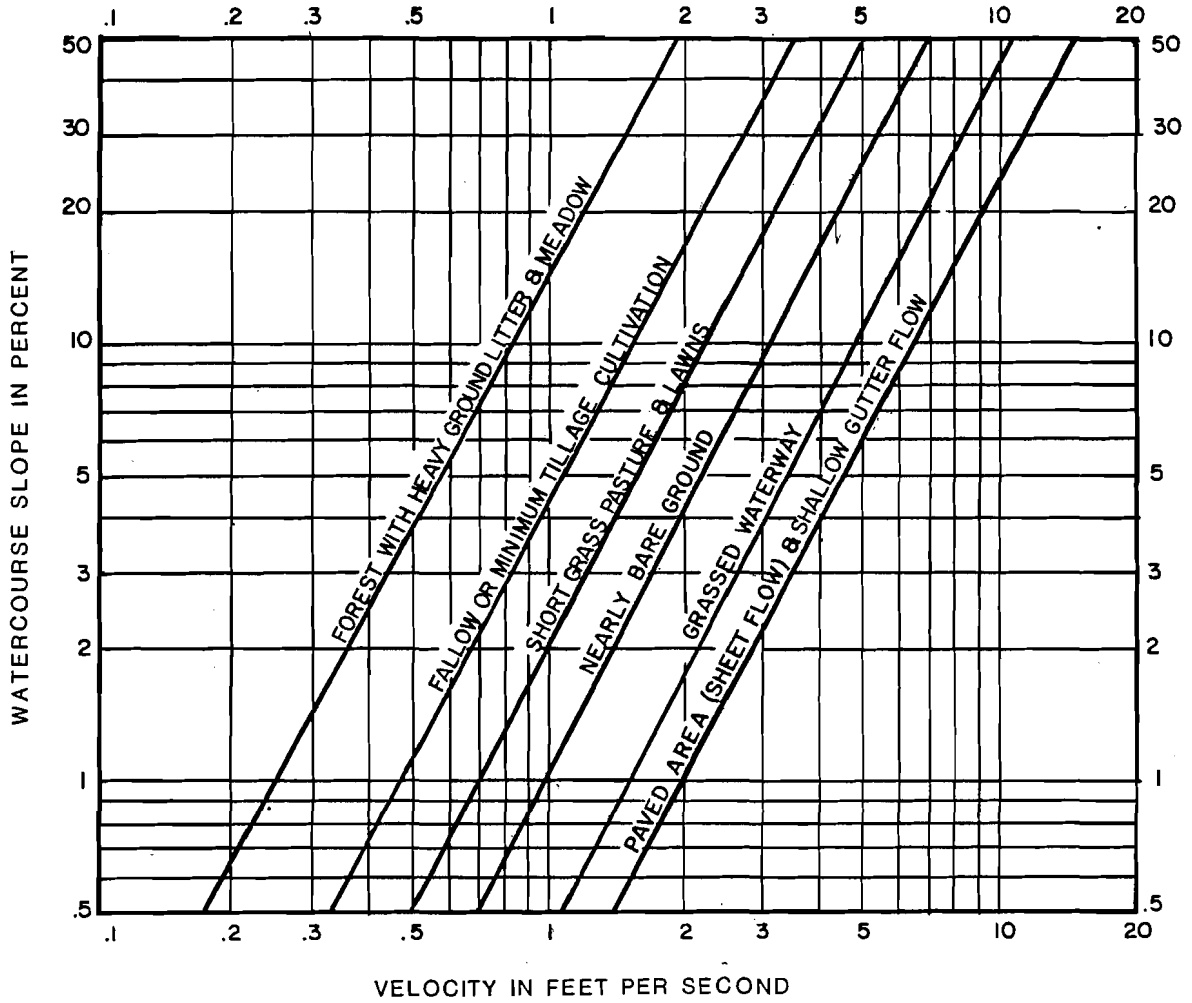
LAND USE	RUNOFF COEFFICIENT
Unimproved Areas	0.2-0.25
Parks	0.2-0.25
Agricultural	0.3
Single Family	0.45-0.50
Multi-Family (attached units)	0.60-0.65
Business	0.6-0.90

The time of concentration to the point under consideration is calculated by adding the incremental periods of time that water flows from the most remote part of drainage area. The water may flow by overland flow, gutter flow, channel flow, pipe flow, or combination of these. The time for overland flow in unimproved areas is calculated based on the relationship shown in Figure 3. The time for overland flow in urban sections of the study was estimated using the relationship shown on Figure 4. The time of flow in pipes and ditches was estimated from velocity and length. Velocities in pipes and ditches were calculated. The time of flow in street gutters was based upon a velocity of 3 feet per second.

The following parameters were used in planning storm sewers.

- Pipe slopes were used that result in a minimum velocity of 3 feet per second (in a few cases, a minimum velocity of 2.5 feet per second was used). Lower pipe velocities could be used in detailed design, should they be required.

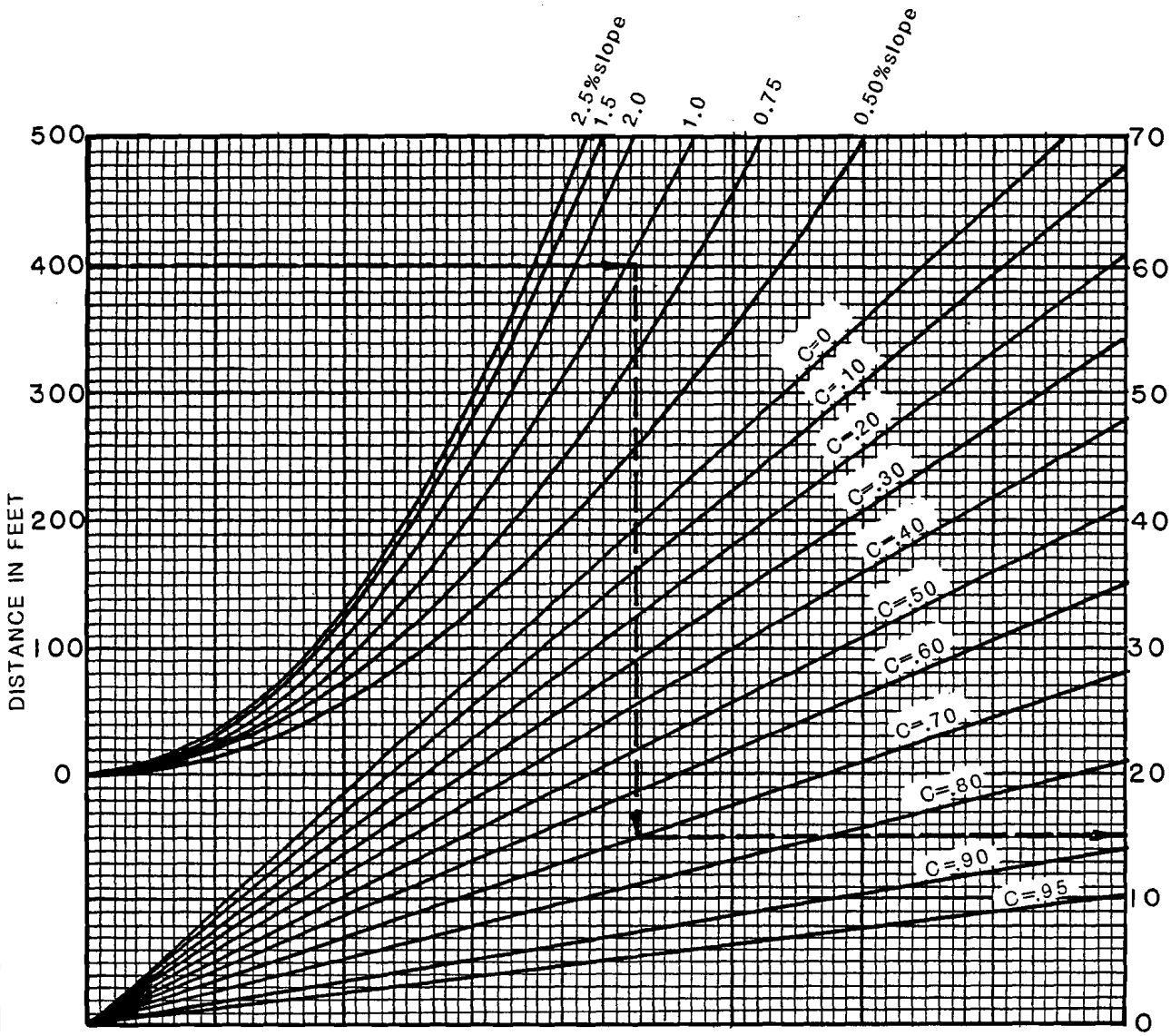
- The crown of the pipe has been limited to more than 4 feet below the ground (in a few cases this rule couldn't be applied, especially where existing



OVERLAND FLOW-VELOCITY CURVES (3)

FIGURE 3

CULP / WESNER / CULP



(4)

TIME OF CONCENTRATION CURVES

FIGURE 4

piping was incorporated in the design). Piping has been set below the frost level for structural reasons and to minimize freezing of melting snow in the pipe. The City has used shallower depths but the condition of the pipe is not well known. Where storm drains conflict with water or sewer piping, the least potential problems will result if the storm drains are constructed at a shallower depth.

- Crown of different pipe sizes have been set at same elevation.

- Provide manholes at each change in pipe direction and at a maximum interval of 500 feet.

- All new pipe has been based on using corrugated metal pipe.

- The outfall piping to the Animas River and Junction Creek have been set at or higher than the 10-year flood frequency(1) for those streams.

- Pipe friction factor (n) using Mannings Formula
  Corrugated Metal Pipe - n = 0.021
  Concrete Pipe or Vitrified Clay Pipe - n = 0.013
  Man-made Channels, Ditches - n = 0.03

DRAINAGE IMPROVEMENTS

Drainage in urban areas generally uses the streets and curbs for conveyance, so long as there is adequate capacity. Streets should be able to carry traffic during all but the more intense storms. Where the capacity of the gutter is exceeded, piped systems are required. The drainage improvements have incorporated existing piping where practical. The improvements are shown on Figure 5 (at the back of this report), and are described in the following.

FLORIDA ROAD BASIN

The basin is divided into four drainage subbasins:

- North Subbasin
- Holly Avenue Diversion
- Central Subbasin
- South Subbasin

Table 6 summarizes the flow characteristics of each subbasin and the proposed piping system.

TABLE 6. FLORIDA ROAD DRAINAGE PLAN

Subbasin	Area ac	Runoff Coeff.	T_c min	Rainfall in/hr	Flow cfs	New Piping Ft 18"	24"	30"	36"	42"
North	64.0	0.27	63	1.0	17.3	-	1,720	-	-	-
Holly Ave.[1]	157.2	0.34	75	0.9	48.1	1,630	60	830	2,750	540
Central[2]	246.0	0.33	78	0.9	73.1	2,740	1,490	520	1,220	4,140
South - 24"	47.8	0.25	47	1.2	14.3	-	-	-	-	-
South - 12"	6.9	0.5	25	1.8	6.2	-	-	-	-	-
TOTAL	521.9	0.32			159.0	4,370	3,270	1,350	3,770	4,680

1) Includes 1,400 ft of roadside ditch.
2) Includes 3,570 ft of roadside ditch.

North Subbasin: The runoff from the mountains at the northeastern part of this basin is proposed to be intercepted with a 24-inch pipe, which intercepts the flow and pipes it northerly on East Animas Road to a natural creek.

Holly Avenue Diversion: The proposed drainage system consists of a roadside ditch along Florida Road to a new piped system at North College Drive. The drainage is piped along Holly Avenue to the Animas River floodplain. Hilltop Circle and a portion of 31st Street are also served by this line.

Central Subbasin: The Central Subbasin system starts at Aspen Drive on the north side of Florida Road and at Oak Drive on the south side of Florida Road. The 24-inch pipe gradually increases to 42 inches near Folsom Place. The 42-inch line extends back to Florida Road and terminates at the Animas River. Alternatively, the 42-inch line could be piped in tunnel from Folsom Park under Riverview Drive to the Animas River. This potentially will be more economical than the conventional construction of the 42-inch line as shown in this report. However, inadequate geological information is available at this time to assess the feasibility of the tunnel. Where the detailed design of this alternative is authorized, this alternative should be investigated and evaluated.

South Subbasin: The existing 24-inch and 18-inch pipe on the east side of Florida Road provide drainage from the undeveloped hillside. An existing 12-inch outfall south of Animas Place drains the local area.

NORTHEAST BASIN

The basin is divided into three drainage subbasins:

- North Subbasin
- Central Subbasin
- Rio Vista Circle

Table 7 summarizes the flows and the proposed piping system.

TABLE 7. NORTHEAST DRAINAGE PLAN

Subbasin	Area ac	Runoff Coeff.	T_c min	Rainfall in/hr	Flow cfs	New Piping Ft 18"	24"	30"	36"
North	34.8	0.47	25	1.8	29.4	1,610	430	1,070	-
Central (New)[1]	73.1	0.43	46	1.2	37.7	2,870	1,960	750	340
Central (Exist)	7.9	0.47	15	2.3	8.5	-	-	-	-
Rio Vista Cr. (New)	9.1	0.47	16	2.2	9.4	650	-	-	-
Rio Vista Cr. (Exist)	11.8	0.47	10	2.7	14.7	-	-	-	-
TOTAL	136.7	0.45			99.7	5,130	2,390	1,820	340

1) Includes 450 ft of roadside ditch.

North Subbasin: Runoff from this residential area is collected along 32nd Street and discharged to the Animas River.

Central Subbasin: The Central Subbasin is drained with piping along 31st, 30th, and 29th Streets; the 29th Street drain intercepts flows from the ditch along Riverview Drive. The existing outfalls at the corner of Third Avenue and 29th Street drain the runoff from a portion of Third Avenue.

Rio Vista Circle: The 12-inch pipe from the east loop to the west loop is replaced with a new 18-inch pipe. The existing outfalls remain, intercepting the runoff from the south section of this subbasin.

SOUTH BASIN

Generally, the drainage system in the Camino del Rio subbasin requires upgrading to adequately convey the design year drainage. Runoff east of the railroad from 10th Street to 14th Street is collected at 13th Street where a railroad and highway crossing are provided. Also a new 18-inch drain is added along Third Avenue from 13th Street north to the Animas River.

A major new pipe is proposed on Fourth Avenue. This area is fairly flat and has poor drainage. Sections of the existing 18-inch line along Fifth Avenue and others are incorporated in this interceptor. The incorporated portions are old and may require replacement or major renovation. The Fourth Avenue sewer is located along 5th Street and then south on Second Avenue to the Animas River. The highway crossing is by way of the existing 36-inch culvert. A second interceptor is proposed to drain the south part of Fourth Avenue. It also terminates at an existing 36-inch culvert.

The existing Fifth Avenue, Sixth Avenue, and Seventh Avenue drains remain with a few additions. A new 18-inch drain is added along Eighth Avenue from Fifth to the Horse Gulch drainage swale.

Table 8 summarizes the flows, the characteristics of each subbasin, and the piping system.

TABLE 8. SOUTH BASIN DRAINAGE PLAN

Subbasin	Area ac	Runoff Coeff.	T_c min	Rainfall in/hr	Flow cfs	New Piping Ft 12"	18"	21"	24"	30"	36"	42"
Camino Del Rio Subbasin												
15th St. (New)	9.1	0.67	11	2.6	15.9	-	90	-	40	400	-	-
15th St. (Exist)	2.9	0.66	11	2.6	5.0	-	-	-	-	-	-	-
14th St.	4.3	0.74	15	2.3	7.3	-	-	-	-	-	-	-
13th St. (Exist)	8.1	0.67	16	2.2	11.9	-	-	-	-	-	-	-
Railroad Ave.	47.3	0.61	36	1.5	43.3	390	1,200	-	780	2,010	-	-
10th St.	3.5	0.90	5	3.5	11.0	-	-	-	-	-	-	-
9th St.	17.8	0.80	17	2.1	29.9	-	-	-	370	-	-	-
8th St.	11.5	0.84	12	2.5	24.2	-	60	-	30	-	-	-
7th St.	9.6	0.85	12	2.5	20.4	-	-	-	-	-	-	-
6th St.	13.9	0.84	16	2.2	25.7	-	640	-	170	-	-	-
SUBTOTAL	128.0	0.72			194.6	390	1,990	-	1,390	2,410	-	-

TABLE 8. (Continued)

Easterly Subbasin						12"	18"	21"	24"	30"	36"	42"
Third Ave.	9.7	0.42	31	1.6	6.5	-	950	-	-	-	-	-
Fourth Ave.	144.7	0.47	46	1.2	81.6	-	3,660	760	540	410	1,960	3,190
2nd St.	18.7	0.47	21	1.9	16.7	-	680	350	-	680	-	-
Fifth Ave.	32.3	0.45	30	1.6	23.3	-	170	420	260	-	-	-
Seventh Ave.	18.5	0.47	21	1.9	16.5	-	-	-	-	-	-	-
Eighth Ave.	13.7	0.47	15	2.3	14.8	-	1,480	-	-	-	-	-
SUBTOTAL	237.6	0.47			159.4	-	6,940	1,530	800	1,090	1,960	3,190
TOTAL SOUTH	365.6	0.56			358	390	8,930	1,530	2,190	4,200	1,960	3,190

NORTH BASIN

A new 36-inch sewer is proposed at the Fairgrounds and will serve the area west of Main Avenue from 24th Street to 28th Street. Additional new outfalls are planned east of the hospital area and at several of the east-west streets. The existing piping is incorporated with new piping. Table 9 summarizes the drainage system for the North Basin.

TABLE 9. NORTH BASIN DRAINAGE PLAN

Subbasin	Area ac	Runoff Coeff.	T_c min	Rainfall in/hr	Flow cfs	New Piping Ft 18"	21"	24"	30"	36"
Hospital	204	0.21	90	0.75	32.9	390	-	50	1,220	-
36th	41.7	0.38	13	2.4	38.0	400	-	30	450	580
Fiesta Cr.	12.4	0.50	24	1.8	11.2	200	-	-	-	-
33rd (Exist)	47.8	0.24	32	1.55	17.8	650	-	-	-	-
33rd (New)	140.1	0.25	46	1.2	42.0	760	160	820	940	-
Alley 32nd	14.6	0.67	17	2.1	20.5	170	-	250	-	-
32nd	36.5	0.32	33	1.5	17.5	1,200	-	-	-	-
31st	17.9	0.56	17	2.1	21.0	470	500	-	-	-
30th	23.4	0.46	22	1.9	20.5	1,160	-	-	-	-
North Fair-ground	17.6	0.50	21	1.9	16.7	-	-	-	-	-
South Fair-ground	6.5	0.50	15	2.3	7.5	-	-	-	-	-
29th	23.9	0.44	24	1.8	18.9	400	-	870	-	-
Main Ave.	63.1	0.43	41	1.3	35.3	1,370	-	1,170	1,100	1,740
TOTAL	654.5	0.31			299.8	7,170	660	3,190	3,710	2,320

HOCKER DRIVE BASIN

The Hocker Drive Basin receives water from the Animas Mountain. A new storm sewer is proposed along Junction Street and Hocker Drive to Junction Creek. The Hocker Drive sewers are described in Table 10.

TABLE 10. HOCKER DRIVE BASIN DRAINAGE PLAN

Subbasin	Area ac	Runoff Coeff.	T_c min	Rainfall in/hr	Flow cfs	New Piping, ft 18"	21"	24"	30"	36"
Hocker Dr.	154.9	0.23	51	1.15	41	260	190	770	-	480
TOTAL	154.9	0.23			41	260	190	770		480

DRY GULCH BASIN

This basin is divided into four small subbasins:

- Clovis Drive
- Needham Drive
- Arroyo Drive
- 22nd Street

The drainage basin characteristics and proposed piping are described in Table 11.

TABLE 11. DRY GULCH DRAINAGE PLAN

Subbasin	Area ac	Runoff Coeff.	T_c min	Rainfall in/hr	Flow cfs	New Piping Ft 18"	21"	24"	30"	36"	60"
Hocker Dr.	154.9	0.23	51	1.15	41	260	190	770	-	480	-
Clovis Dr. E	22.7	0.36	22	1.9	15.5	60	50	380	-	-	-
Clovis Dr. W	33.2	0.34	21	1.9	21.5	1,110	-	-	200	-	-
Needham Dr. (New)	46.5	0.47	20	2.0	43.7	170	-	1,120	510	220	-
Needham Dr. (Exist)	4.3	0.47	10	2.7	5.5	-	-	-	-	-	-
Arroyo Dr.	2,862	0.21	93	0.73	439	-	-	-	1,350	-	1,970
22nd	32	0.51	30	1.6	26.1	40	-	860	-	-	-
TOTAL	3,155.6	0.22			592.3	1,640	240	3,130	2,060	700	1,970

Clovis Drive: New piping is provided to drain the Clovis Drive area to Junction Creek with 30-inch sewer to Junction Creek on the west side and a 24-inch sewer on the east side.

Needham Drive: The Needham Drive, Butte Drive, and Columbine Avenue area is drained to Junction Creek.

Arroyo Drive: The drainage upstream from Columbine Avenue and San Juan Drive is mostly intercepted with the existing 48-inch drain and the addition of a new 60-inch drain that extends up Hidden Valley Circle to intercept the drainage from the mountain.

22nd Street: The existing 36-inch outfall is extended up 22nd and Third Avenue.

CRESTVIEW CREEK BASIN

The basin is divided into 5 subbasins:

- Crestview Subbasin
- East Park Avenue Subbasin
- Main Avenue Subbasin
- W. Third Avenue
- Local Basins (Incline and Alamo)

Table 12 presents the subbasin description and proposed piping summary.

TABLE 12. CRESTVIEW CREEK BASIN DRAINAGE PLAN

Subbasin	Area ac	Runoff Coeff.	T_c min	Rainfall in/hr	Flow cfs	New Piping Ft 18"	21"	24"	30"	48"	54"
Crestview	617	0.3	30	1.6	296.0	480	900	1,080	-	280	760
East Park Ave.	9.6	0.59	24	1.8	10.2	440	-	-	-	-	-
Main Ave.	24	0.56	24	1.8	24.2	380	-	-	-	-	-
W. Third Ave.	51.5	0.46	24	1.8	42.6	910	-	350	1,630	-	-
Alamo Dr.	12.9	0.48	20	2.0	12.4	-	-	-	-	-	-
Incline	7.5	0.6	15	2.3	10.4	-	-	-	-	-	-
TOTAL	722.5	0.33			395.8	2,210	900	1,430	1,630	280	760

Crestview Subbasin: A new 24-inch pipe is proposed along Forest Avenue from Leyden to El Paso Street. The ditch from the Vandenberg Dalla property is intercepted with 48-inch pipe at El Paso Street. The new drain at Forest and the existing drain at Eastlawn are connected to the 48-inch pipe, which has a 54-inch outfall to Animas River.

East Park Avenue Subbasin: The existing drainage is modified by reconnecting the East Second Avenue drain to the Main Street drain and adding supplemental drainage piping on 18th Street.

Main Avenue Subbasin: The existing lower Main Street drain to the Animas River remains unchanged, except the change made by reconnecting the Second Avenue drain described above.

West Third Avenue: Sections of existing drains along W. Third and W. Second Avenues are incorporated with a proposed 30-inch outfall.

Local Basins: The Alamo Drive are at the north end of the basin and the Incline property and Greenmont Cemetery at the south end of the basin are drained with the existing culverts and outfalls.

LIGHTNER CREEK BASIN

The drainage in the Lightner Creek Subbasin does not affect urban drainage within the City limits.

BODO PARK BASIN

The drainage improvements proposed in Bodo Park use the 36-inch sewer along Bodo Drive and Suttle Street. The effectiveness of the cutoff ditch upstream of the park is unknown. Table 13 summarizes the proposed piping.

TABLE 13. BODO PARK DRAINAGE PLAN

Subbasin	Area ac	Runoff Coeff.	T_c min	Rainfall in/hr	Flow cfs	New Piping Ft 24"	36"	42"
Bodo Dr.	180.0	0.24	30	1.6	69.1	450	1,200	500
TOTAL	180.0	0.24			69.1	450	1,200	500

GOEGLEIN GULCH BASIN

There is development proposed near Goeglein Gulch Road that will drain along the roadside ditch to the lumber yard at 6th Street and Ninth Avenue. The area around the college drains into a gully that eventually combines with the gully near 6th Street and Ninth Avenue. Nearly 200 cfs of storm flow converges at this point during a 10-year storm. Presently, the drainage runs in a bermed channel adjacent to Ninth Avenue. A 72-inch sewer is proposed to replace the bermed channel and to pick up drainage along Ninth Avenue. This drainage discharges to Horse Gulch. Horse Gulch brings large quantities of drainage (300 cfs) through existing drainage facilities to the Animas River. Table 14 summarizes the new piping and drainage basin characteristics.

TABLE 14. GOEGLEIN GULCH DRAINAGE PLAN

Subbasin	Area ac	Runoff Coeff.	T_c min	Rainfall in/hr	Flow cfs	New Piping Ft 72"
College	186	0.4	60	1.0	74	-
Goeglein Gulch	860	0.2	80	0.8	137	1,500
Horse Gulch	1,825	0.2	90	0.75	274	-
TOTAL	2,871	.2			485	1,500

IMPLEMENTATION

PRIORITIES

The drainage facilities recommended in this study represent major capital improvement costs. Portions of the facilities and costs are attributable to development as it occurs, but much of the recommended improvements are associated with existing drainage problems.

The estimated construction and project costs for proposed facilities described previously are summarized in Table 15. The unit costs are listed in Appendix B. Estimated construction costs include piping, manholes, inlets, and paving replacement. Total estimated project costs include a 25 percent allowance for engineering and contingencies. Costs are based on the mid-1982 value of the dollar. The overall project costs to improve the drainage system are obviously more than the City can finance, especially since major projects are underway with water and sewage utilities. Therefore, it is necessary to phase the storm drainage facilities by first constructing the items having greatest priority and postponing less critical items. Establishing projects with greater priority than others will be difficult, since there are many critical drainage problems and obviously important projects will be delayed while other projects are financed. It is important to construct the improvements in a sound manner in order to eventually result in workable facilities.

The basis for establishing priorities should be as objective as possible. Objectively, it is more important to construct projects that, for the cost, will protect the greatest value of property; that is, the projects with the greatest benefit to cost should be constructed first. There is some subjective judgment to the value of property being protected and the degree of harm that might accrue to various frequency storms. The local subjective knowledge of problems will be of greater benefit than can be provided in this study. It is recommended that the projects be prioritized by the City staff with input from the community.

TABLE 15. ESTIMATED COSTS OF PROPOSED IMPROVEMENTS

Basin - Subbasin	Estimated Construction Cost	Estimated Project Cost
1. Florida Rd. Basin		
North Subbasin	$ 118,150	$ 147,700
Holly Ave. Diversion	467,840	584,800
Central Subbasin	928,950	1,161,200
South Subbasin	--	--
SUBTOTAL	1,514,940	1,893,700
2. North East Basin		
North Subbasin	$247,480	$309,400
Central Subbasin	442,520	553,100
Rio Vista Circle	35,900	44,900
SUBTOTAL	$725,900	$907,400
3. South Basin		
Camino del Rio	528,430	660,500
Third Ave.	53,620	67,000
Fourth Ave.	963,390	1,204,200
2nd St.	138,520	173,150
Fifth Ave.	72,580	90,700
Eighth Ave.	92,070	115,100
SUBTOTAL	1,848,610	2,310,650
4. North Basin		
Hospital	134,840	168,500
36th St.	135,750	169,700
Fiesta Cir.	10,360	13,000
33rd St.	233,410	291,800
32nd St.	98,800	123,500
31st St.	66,330	82,900
30th St.	61,930	77,400
29th St.	88,860	111,000
Main Ave.	432,680	540,900
SUBTOTAL	1,262,960	1,578,700
5. Hocker Drive Basin		
Hocker Drive	124,500	155,600
6. Dry Gulch Basin		
Clovis Dr.	115,970	145,000
Needham Dr.	148,590	185,700
Arroyo Dr.	406,000	507,500
22nd St.	64,390	80,500
SUBTOTAL	$ 734,950	$ 918,700

TABLE 15 (Continued)

Basin - Subbasin	Estimated Construction Cost	Estimated Project Cost
7. Crestview Basin		
Crestview	$ 310,180	$ 387,700
East Park Ave.	21,840	27,300
Main Ave.	20,000	25,000
W. Third Ave.	211,510	264,400
SUBTOTAL	563,530	704,400
8. Bodo Park		
Bodo Dr.	172,190	215,200
9. Goeglein Gulch		
Goeglein Gulch	260,220	325,250
TOTAL	$7,207,800	$8,854,000

FINANCING

The financing of drainage projects in the past has been from the general fund and from local improvement districts when street paving has also been involved. The financial responsibility for drainage improvements is not clearly defined, especially when new development and existing problems are comingled in a single project. To further complicate matters, the City may have a different priority for City funding of storm water projects than projects that may be required for new development.

When new development requires drainage, the City must look to the developer for a fair share of the costs for drainage facilities. The sharing of costs is only possible when there are adequate monies available from the City and the developer. The City should plan the course of action for financing drainage of proposed development early in the project. If the project associated with a new development is a high priority, the project might move ahead on a timely basis. If the project is a lower priority project and partial financing by the City would delay a higher priority project, it may be necessary to require the developer to finance the entire project. Or, it may be appropriate to collect a fee

for future drainage facility construction from the developer and not construct the associated project until it comes up on the priority list. It may be appropriate to adjust the priorities, if projects are nearly as important and the development offers the opportunity to adequately finance a high priority existing drainage problem.

When a project does involve new development and resolution of an existing problem, the sharing of costs can be complicated.

A policy that proposes each development take care of its own drainage, including that drainage that enters the property from upstream has been discussed previously and is attached as Appendix D. This policy has created considerable confusion and a reaction that it may not be practical. A second proposal has been made that a residential unit fee be charged. The simplicity of this method is appealing except there are also opportunities for inequities.

Presently, the capital improvements proposed are estimated to cost $8,854,000. If the costs were spread over a 20-year period, it would be necessary to generate about $450,000 per year to continue working at the proposed plan, exclusive of existing operating maintenance and replacement costs. Based on a total 6,000 equivalent residential units in the next 20 years that may be subject to financial responsibility for the drainage system, each unit would be responsible for 1,500. If the growth were 125 units per year, the annual income from new units would be $187,500. The City would need to generate the balance from other sources.

SUMMARY AND RECOMMENDATIONS

This study provides a master plan for storm drainage system. Improvements are estimated to cost $8.9 million. The proposed drainage system modifies and incorporates the existing facilities to convey the design flow to the Animas River and Junction Creek.

It is only practical to construct the recommended improvements over a period of years. As a general concept, it is proposed that a 20-year plan be used over which the recommended improvements described herein are constructed.

The sequence of construction requires each project be prioritized, constructing the most needed projects first. The projects with the greatest need should be selected on the basis of a carefully considered priority system. The prioritization of projects should be by the City with an opportunity to gain input from citizens.

The financing of projects is recommended to be through a fund established for drainage projects. The source of revenue for the fund is from developers and from charges made to existing property. The method of allocating costs to new development will be most easily administered if a uniform charge is made. The charge may be on the basis of acreage or equivalent residential units.

The existing property could either be charged a drainage service charge per month, or property tax, or some other method. The revenue from existing property needs to be $250,000-$300,000 per year.

As funds accumulate in the drainage fund, projects could be financed in order of their priority.

APPENDIX A

INTENSITY DURATION CURVES FOR THE CITY OF DURANGO

The rainfall intensity-duration curves developed for Durango are based on the isopluvial maps and the equations presented in the Precipitation Frequency Atlas of U.S. for Colorado (2).

The following table summarizes the isopluvial readings for several return periods.

TABLE A-1. PRECIPITATION AT DURANGO, INCHES

Return Period (Years)	Duration, Hrs. 6	24
2	1.00	1.58
5	1.30	2.00
10	1.58	2.30
25	1.94	2.76
50	2.16	3.20
100	2.36	3.50

Precipitation of 1 hr. duration is determined according to the following equations(2).

(2) $Y_2 = 0.011 + 0.942\ (X_1)\ (X_1/X_2)$

(3) $Y_{100} = 0.494 + 0.755\ (X_3)\ (X_3/X_4)$

Where:

X_1 - 2 yr. and 6 hr. duration, precipitation, inches

X_2 - 2 yr. and 24 hr. duration, precipitation, inches

X_3 - 100 yr. and 6 hr. duration, precipitation, inches
X_4 - 100 yr. and 24 hr. duration, precipitation, inches
Y_2 - 2 yr. and 1 hr. duration, precipitation, inches
Y_{100} - 100 yr. and 1 hr. duration, precipitation, inches

For return periods between 2 years and 100 years a nomogram* is used, to calculate the precipitation for 1 hour duration.

Precipitation for shorter duration than an hour is determined by applying the proper factor to the 1 hour duration storm.

Duration, minutes -	5	10	15	30
Factor	0.29	0.45	0.57	0.79

Precipitation for 2 hours and 3 hours is estimated using the following equations (2).

(4) $I_2 = 0.341\ I_6 + 0.659\ I_1$
(5) $I_3 = 0.569\ I_6 + 0.431\ I_1$

Where:

I_1, I_2, I_3, I_6, - Precipitation at 1, 2, 3, and 6 hour duration, respectively.

The following table summarizes the intensity duration relationship used in developing the curves.

---

* The nomogram presented in the Atlas (2) was adapted from the Weather Bureau Technical Paper 40.

TABLE A-2. INTENSITY DURATION RELATIONSHIP

Return Period (Years)	Intensity in Inches Per Hour Duration, Minutes 5	10	15	30	60	120
2	2.0	1.6	1.4	0.9	0.6	0.4
5	3.0	2.3	2.0	1.4	0.9	0.5
10	3.5	2.7	2.3	1.6	1.0	0.6
25	4.4	3.4	2.9	2.0	1.3	0.8
50	5.2	4.0	3.4	2.3	1.5	0.9
100	5.9	4.6	3.9	2.7	1.7	1.0

APPENDIX B

COST DATA

1. Piping Cost,* $/lf

Trench Depth ft	Pipe Diameter, Inches 18	21	24	30	36	42
5	37.8	42.2	44.8	56.4	64.0	70.3
6	40.9	45.5	48.2	60.2	68.0	75.5
7	44.0	48.8	51.7	64.0	72.1	80.0
8	47.2	52.1	55.2	67.6	76.1	84.3
9	50.3	55.4	58.5	71.4	80.2	88.5
10	53.0	58.2	61.5	74.7	83.6	92.5
11	56.6	62.0	65.4	78.8	88.2	97.3
12	60.2	65.8	69.3	83.1	92.7	102
13	63.9	69.6	73.3	87.4	97.3	107
14	67.5	73.2	77.1	91.5	102	112
15	70.5	76.5	81.3	95.3	106	116

* Includes: Excavation cost at $4/cy, backfill at $12.40/cy, shoring and sheeting cost at $10 to $21.50/lf for 5 to 15 ft deep trenches respectively, and corrugated metal piping cost at $18/lf for 18" diameter pipe, $22/lf for 21", $24/lf for 24", $35/lf for 30", $42/lf for 36" and $49/lf for 42" diameter pipe.

2. Catch Basins and Precast Manholes Cost

Depth ft	Catch Basin	Precast Manhole 48" Diameter	60" Diameter
4	1600	1300	2600
6	2800	1400	2700

2. Catch Basins and Precast Manholes Cost (Continued)

Depth ft	Catch Basin	Precast Manhole 48" Diameter	Precast Manhole 60" Diameter
8	3900	1500	2800
10	4900	1550	2900
12	5900	1600	3000
14	6900	1650	3100

3. Wing Type Head Walls

Pipe Diameter Inches	Cost $
18	700
21	800
24	950
30	1300
36	1650
42	1900
48	2500
54	3000
60	3500

4. Miscellaneous Cost Data

Pavement Replacement	$12/sy
Road Side Ditch	$7/ft
Tunnel	24" Diameter - $500/ft
	36" Diameter - $560/ft
	48" Diameter - $660/ft

APPENDIX C

REFERENCES

Corps of Engineers, "Flood Hazard Information, Durango, Colorado", Department of the Army, Sacramento, CA, May 1977.

T.F. Miller, R.H. Hederick, and R.J. Tracey, "Precipitation Frequency Atlas of U.S., NOAA Atlas 2, Vol. III Colorado", U.S. Department of Commerce, National Oceanic and Atmospheric Administration. National Weather Service Office, Silver Spring, MD, 1973.

Urban Hydrology for Small Watersheds, Technical Release No. 55, Engineering Div. Soil Conservation Services, U.S. Dept. of Agriculture, Jan. 1975.

Airport Drainage Federal Aviation Agency, Washington, D.C., 1965.

APPENDIX D

ALTERNATIVE PROPOSED FINANCIAL RESPONSIBILITY

1. Proposed developments are responsible to provide facilities that will adequately convey storm water entering their property and originating on their property to natural drainage courses in a manner that will not affect downstream property.

2. The basis for design of storm drainage facilities will be to consider that surface drainage and piped drainage of flows that result from a 100-year return frequency rainfall will not cause flooding of surface structures. In no event shall piped drainage facilities be designed for less than the flows that result from a 10-year return frequency rainfall.

3. In the event owners of property in the same drainageshed elect jointly to construct storm drainage facilities, the responsibility for cost sharing will be determined as follows:

   a. Upstream property owners will participate in project costs for facilities downstream from their property on the basis of the incremental increase in flow over that which would result from the undeveloped property in proportion to the total design flow.

   b. Where the existing storm drainage crosses property proposed for development, the property owner will participate in project costs for facilities from their property line to the ultimate discharge location in proportion to the total upstream drainage basin storm flow, based upon existing conditions, and all flow generated from the subject property.

   c. Downstream property owners located where existing storm drainage currently flows will participate in costs in proportion to the total upstream drainage basin storm flow based upon existing conditions and all flow generated from their property.

4. In the event owners of propety in the same drainageshed do not develop simultaneously and elect not to construct storm drainage facilities jointly, the responsibility for cost sharing and subsequent planning for facilities will be determined as follows:

   a. Upstream property owners who currently are not submitting development proposals will be required to construct storm water retention facilities to limit storm flow rates downstream from their property to that rate which would result from undeveloped property, should they submit plans for development of their property in the future.

   b. Downstream property owners who currently are not submitting development proposals will be required to construct storm water conveyance facilities separate from existing facilities.

STORM DRAIN IMPACT FEES.

Storm Drainage Facilities
Statement of Policy
City of Durango
January, 1984

Section 1

General

The provision of adequate drainage for urban areas is necessary to preserve and promote the general health, welfare and economic well-being of the urbanized area. Drainage is a phenomenon which traverses political boundaries and affects all governmental subdivision. Planning of facilities must be provided by all governmental agencies involved and is primarily a governmental function. Funding of construction of storm drainage projects is a responsibility of all entities contributing to storm water runoff. Developers must share with government in the construction costs of needed improvements. Developer costs are passed on to the new residents of the community while city and county costs are paid for by local taxpayers. The value of all properties is likely to increase as a result of proper drainage in the community. The equitable distribution of costs is the subject of the policies which follow.

Section 2

Developer Responsibility for Off-Site Drainage

Developers are responsible for damage to downstream and/or upstream properties where drainage facilities are omitted when needed, or where inadequate when flood flows are increased or diverted from their natural drainage course as a result of the development. City requirements are that:

1. Developers must calculate historic and developed flood flows from the ten year and 100 year flood at each point within the development where flows enter, leave, or are concentrated within the development. The flows calculated must be based upon the Rational Method and must use criteria (C,I,t) established in the City's Urban Storm Drainage Master Plan except when subbasin areas exceed 200 acres in area. In subbasins of greater than 200 acres, the Soil Conservation Service, Technical Release 55 Method of Determining Peak Flows shall be used.
2. Developers must show the path of storm runoff from the project to the nearest major natural drainage course and must demonstrate that no property damage occurs downstream as a result of the 10 year flood. If property damage would occur or if allowable uses of streets for drainage as defined in the Development Standards for Public Improvements, City of Durango, 1984 are exceeded as a result of the 10 year flood, then the developer must take measures to relieve the situation. This may include either of the following:
   a. On site flood detention so as to relieve the downstream property from damage and to confine flows to allowable uses of streets for drainage at all places downstream from the development. In addition, storm water runoff shall not be released from a development at a rate greater than the 10-year historic runoff. The amount of runoff to be detained on-site shall be the difference between the 100-year runoff under developed conditions and the 10-year historic runoff.
   b. Construction of downstream facilities at the point necessary to prevent property damage or adverse effect on streets. The facilities shall be designed based on flows from the fully developed subbasin. The construction of facilities may include surface or subsurface drainage devices and must include obtaining easements or rights-of-way as necessary for construction.
3. Developers must demonstrate that the impact of the development on the 100 year flood does not increase property damage to

downstream property owners or cause the allowable uses of streets for drainage to be exceeded. When development will cause such adverse effect, then facilities must be installed to mitigate those adverse effects from the point the condition occurs to a point on a natural drainage course.

Section 3

Developer Responsibility for On-Site Drainage

Drainage facilities on site will be required in accordance with the City's Development Standards where the capacity of streets to carry storm runoff is exceeded. Storm sewers shall be sized so as to carry the 10 year flood and the design of all development shall be such that no building structure shall be subject to damage from the 100 year flood.

Developers are responsible to provide easements and rights-of-way for storm drainage facilities as identified in the Urban Storm Drain Master Plan, where such facilities traverse the development. In addition, where possible, all Master Plan facilities adjacent to or traversing the property shall be installed by the developer. Provision of easements, rights-of-way, and on-site construction of facilities does not relieve the developer from addressing downstream needs as described in Section 2.

Any time natural drainage courses are interrupted as a result of development, surface drainage easements shall be maintained through the natural drainage course of sufficient width to carry the difference between the 100 year flood and the 10 year flood where diversion of the 10 year flood is part of the development plan. Where diversion of natural drainage courses is not planned, an easement of sufficient width to encompass the 100 year flood shall be granted to the City.

The formula is based on the Rational Method for calculating peak flow for the 10 year flood, and a distribution of cost based upon contribution of flow. The formula is as follows:

Section 4

Determining Drainage Improvements Participation

The cost of providing storm drainage facilities can reasonably be shared by developers and the government in a number of ways. The method presented here offers a definitive means of determining the cost to any developer and is a method which, when combined with other sources of funding, will provide the City with sufficient capital to proceed with a Capital Improvements Program for storm drain construction.

Section 4.1

Participation Formula

The formula is based on the Rational Method for calculating peak flow for the 10 year flood, and a distribution of cost based upon contribution of flow. The formula is as follows:

$$\$D = \sum_{n=1}^{i} \frac{q_{D10}}{q_{n10}} \$n$$

Where

$\$D$ is the developer contribution (dollars)

q_{D10} is the 10 year flood flow originating on the developed parcel

q_{n10} is the 10 year flood flow from the subbasin at various reaches within the subbasin

$\$n$ is the total estimated (or actual) cost (dollars) of the construction of reach n

n is the number of reaches of storm sewer between the major drainage course and the uppermost part of the development

i is the reach of the storm drainage facility to the uppermost reach of development

Example 1

SUBBASIN DATA

Reach	q_{10} Flow (cfs)	Estimated Cost	Drainage area (acres)	C	$\bar{I}_{10}$ (in/hr)
AB	40	$80,000	50	.5	1.6
BC	28	50,000	35	.5	1.6
CD	18	30,000	18.75	.6	1.6
DE	12	24,000	15	.5	1.6
BB_1	10	30,000	13.89	.45	1.6
Total Subbasin	40	214,000	50	.5	1.6

Development wxyz

Area = 3.0 acres
Density = 6 units/acres which is multi-family; $C_{wxyz} = .60$

$$q_{wxya\ 10} = C_{wxyz} I_{10} A_{wxyz}$$
$$= (0.6)(1.6)(3.0)$$
$$= 2.88 \text{ cfs}$$

$$\$_{wxyz} = \frac{q_{wxyz}}{q_{AB}} (\$_{AB}) \quad \frac{q_{wxyz}}{q_{BC}} (\$_{BC})$$

$$+ \frac{q_{wxyz}}{q_{CD}} (\$_{CD})$$

$$\$_{wxyz} = \frac{2.88}{40} (80,000) + \frac{2.28}{28} (50,000) + \frac{2.28}{18.0} (30,000)$$
$$= 5,760 + 5,143 + 4,608$$
$$= \$15,511$$

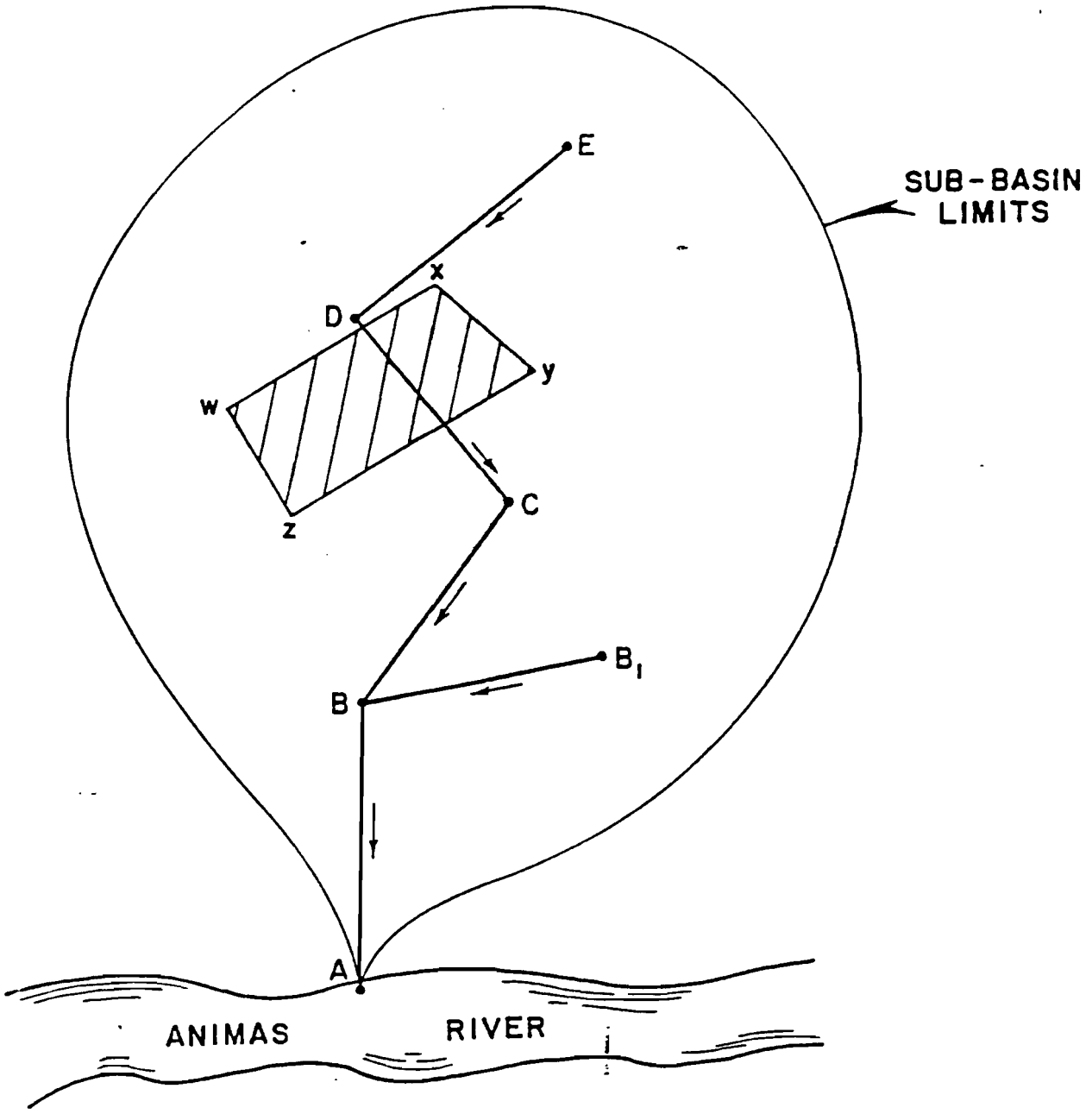
Example 2

The same conditions as Example 1 except that development is now planned for single family residential.

Area = 3.0 acres

Density = 3 units/acre which is single family; $C_{wxyz} = .45$

$$\$_{wxyz} = C_{wxyz} I_{10} A_{wxyz}$$
$$= (0.45)(1.6)(3.0)$$
$$= 2.16 \text{ cfs}$$
$$\$_{wxyz} = \frac{2.16}{40} (80,000) + \frac{2.16}{28} (50,000) + \frac{2.16}{18.75} (30,000)$$
$$= 4,320 + 3,857 + 3,456$$
$$= \$11,633$$



STORM DRAINAGE FACILITIES

STATEMENT OF POLICY

EXAMPLE I

Coefficient runoff (C) and intensity (I) for each subbasin given in the Master Plan are average values for the subbasin. The coefficient of runoff and intensity for each development will be evaluated based upon type of development, slope and extent of the development. Values obtained for use in formula application shall be approved by the City Engineer.

Section 4.2

Application of Formula to Various Developments

The application of the Storm Drainage Formula will apply to developments where the development is within a subbasin identified in the Master Storm Drain Plan and where the storm drainage facilities are recommended in the Master Plan.

Where on-site and off-site facilities recommended in the Master Plan are installed by the developer, the estimated cost of those facilities shall be subtracted from that amount calculated as the developer contribution in the participation formula. The remainder shall be the fee assessed to the developer by the City. Where the cost of on-site and off-site facilities recommended in the Master Plan are installed by the developer, and the estimated cost of those facilities is greater than that amount calculated as the developer contribution in the participation formula, then no reimbursement will be made to the developer.

Where no Master Storm Drain Facilities are installed by the developer, then the developer shall pay the entire amount as calculated in the participation formula. However, this amount shall, in no event, be less than the amount required under calculation of the storm drainage fee established through Section 5.

There will be situations where development occurs ~~where~~ outside the subbasins identified in the Master Plan, the developer must identify the limits of the subbasin(s) within which the development lies. The developer will be required to provide a plan up to and including his development for the subbasin(s). The plan will be used to calculate developer contribution in accordance with the formula in Section 4.1

Section 4.3

Application of Storm Drain Fee

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There will be situations in the City where development occurs where existing storm drains are sufficient or where no storm drains are needed. In such cases, a fixed fee per equivalent residential unit will be assessed. The amount of the fee will be adopted by Resolution of the City Council. The determination of the equivalent residential unit shall be made by the City Engineer and shall be based upon fixture units as established in the Uniform Plumbing Code.

Section 5

Use of Storm Drain Funds

All monies collected in the storm sewer improvements fund shall only be used for capital improvements to storm sewer facilities. The order of construction of facilities shall be based upon a priority listing of projects approved by the City Council.

Section 6.

Applicability of Storm Drainage Facilities Policy

Section 11-18-12-(A) of the Durango City Code states, in part:

> "provision shall be made for the improvements required, including . . . culverts, drainage facilities . . ."

This policy document shall be used in conjunction with that Code provision by way of delineating responsibilities for on and off site improvements, the methodology for determining participation, the applicability of the participation formula to various developments and application of a storm drainage in-lieu fee.

The policy shall apply to any and all development which is subject to the provisions of Chapter 18, Title XI of the City Code.