The Flood Control District
of
Maricopa County, Arizona

GLENDALE-PEORIA AREA DRAINAGE MASTER PLAN

by

CAMP DRESSER & McKEE INC.

and

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MAY 1987

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ARIZONA, U.S.A.

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NOTE: This report was completed in April 1986. During the past year, an addendum "Addendum to Glendale-Peoria Area Drainage Master Plan" was issued. Both reports were published and dated this year (May 1987).

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Executive Summary

EXECUTIVE SUMMARY

The Cities of Glendale and Peoria generally experience a dry climate with low average rainfall. However, occasional storms can produce significant stormwater runoff. Neither city has a comprehensive storm drainage system; generally runoff is carried in streets to an outlet or ponding location. Rapid urbanization in both cities has greatly increased rates of runoff from formerly agricultural lands, resulting in more inconvenience because of water in the streets and the potential for flood damage to a greater number of structures.

To respond to these needs, both Glendale and Peoria recently had separate storm drainage master plans completed by Camp Dresser & McKee, Inc. (CDM) and James M. Montgomery, Consulting Engineers, Inc. (JMM) respectively. These separate studies, which were funded in part by the Flood Control District of Maricopa County, were confined to the area within the municipal boundary of each city. However, because of the area's topography, portions of Glendale would (under normal conditions) drain to and across Peoria. Therefore, the Flood Control District initiated a Glendale-Peoria Area Drainage Master Study (ADMS) to examine the potential benefits of combining the storm drainage systems of Glendale and Peoria. The study also included some areas adjacent to Glendale and Peoria which lie within the same watershed. This report presents the results of the study and outlines the Glendale-Peoria Area Drainage Master Plan (ADMP).

The study area included the City of Glendale, the City of Peoria, and contributing drainages bounded on the west by the Agua Fria River, on the north by the Central Arizona Project (CAP) Canal and the New River Dam alignment, and on the east by the Hedgepeth Hills and Weir Valley. In order to develop the Glendale-Peoria ADMP, the study area was divided into the following subareas.

South Glendale

This area consists of the area in Glendale generally between Camelback Road and Northern Avenue. The drainage facilities selected for this area in the

"Glendale Stormwater Management Plan" could not be improved by combining with a drainage facility in Peoria. Therefore, the facilities previously selected were included in the Glendale-Peoria ADMP without change.

South Peoria/Glendale

This area consists of the portion of Glendale south of the Arizona Canal Diversion Channel (ACDC) that is not included in the South Glendale area, and the portion of Peoria east of New River and Skunk Creek. Because of the natural drainage pattern from east to west in this area, it appeared that combining the Glendale facilities in this area with Peoria facilities would be advantageous. Therefore, facilities in this area were determined by formulating and evaluating combined ADMP facilities.

North Glendale

This area consists of the portion of Glendale that is north of the ACDC. Facilities for this area were included from the "Glendale Stormwater Management Plan" without change.

North Peoria

This area consists of the area of Peoria that is north of Skunk Creek or west of New River and north of Sun City. Facilities for this area were included from the "City of Peoria Master Plan of Storm Drainage" without change.

South Peoria West of New River

This area consists of the area of Peoria that is west of New River and south of Sun City. Facilities for this area were included from the "City of Peoria Master Plan of Storm Drainage" without change.

Sun City

This area consists of the entire area of Sun City which is an unincorporated planned development. Sun City is already almost completely developed, and has an existing self-contained storm drainage system which does not affect any other subareas. There is no detailed information about the design capacity of the drainage system; however, the system has been handling the drainage flows within the area. Therefore, no improvements were recommended for this area, and the existing facilities were included in this plan for information purposes.

Several alternative drainage plans were developed for ADMP facilities in the South Peoria/Glendale area that would collect water from both cities and convey it to New River. These alternatives were then evaluated using a multi-criteria matrix procedure to determine an overall rating for each alternative. The following criteria were used for evaluation purposes: capital cost; compatibility with other projects and potential disruption; acceptability to the public; environmental factors; compatibility with major street projects scheduled for construction during the next five years; direct outlets to New River to adequately handle flows; ability to effectively use detention basins to attenuate peak flows, thereby decreasing pipe sizes downstream of basins and lowering costs; compatibility with Outer Loop Freeway; ability to effectively handle each City's individual drainage needs; and, potential for staged construction. In addition, the cost of the ADMP facilities was compared with the sum of the costs for individual Glendale and Peoria systems, in order to determine if the combined system would have any cost advantage over the individual systems.

The evaluation showed that the cost of combined ADMP facilities would be about $2.5 million less than the sum of separate systems for both Peoria and Glendale. Alternative 1 for the combined facilities was the most favorably-rated and was selected as the preliminary preferred alternative. This alternative consisted of drains along Cactus Road and Olive Avenue that would carry flow from Glendale west through Peoria. In addition, a drain along Northern Avenue in Peoria would carry flows to Orangewood Avenue in Glendale, where it would join other flows from the Glendale area. The advantages of this alternative included: it was the lowest cost option; it was well balanced in terms of avoiding major problem areas and providing a logical path for flows; and, it had three outlets to New River and would allow construction to proceed more rapidly.

The selected facilities for South Peoria/Glendale for the ADMP preferred alternative were obtained from a more detailed analysis of Alternative 1. The facilities for the other subareas were obtained directly from the "Glendale Stormwater Management Plan" and the "City of Peoria Master Plan of Storm Drainage". The locations of the ADMP facilities for the preferred alternative in South Peoria/Glendale, as well as the facilities in the other subareas, are shown on the reduced-scale figures at the end of this summary. (The full-size figures are located at the back of the report, and tables showing facility sizes, design flows, and land acquisition requirements are contained in Section 8.)

Due to the extent of the selected storm drainage facilities, the plan would be implemented in phases. The highest priority items for implementation include:

- Updating of the individual stormwater master plans for Glendale and Peoria to ensure compatibility with the ADMP, and initiation of any necessary revisions to their respective City codes.

- Acquisition of right-of-way for detention basins, since sizes of pipes downstream of these basins may be affected by decisions to change the location or size of these basins.

- Planning and construction of pipes to cross the Outer Loop Freeway.

- Implementation of the ADMP facilities which would include the Northern Avenue, Olive Avenue and Cactus Road drains in Peoria and Glendale. Construction of these facilities will relieve existing flooding problems in these areas, and will provide outlets for subsidiary drains that can be added as second priority items.

The following outline summarizes the recommended phased construction program and estimated capital costs.

I. First Priority - ADMP Facilities

Phase 1 Purchase of ADMP detention basin right-of-way	$ 13,560,000
Phase 2 Construction of ADMP drains (Olive Avenue drain, Cactus Road drain, Northern/Orangewood drain)	$ 37,010,000
Phase 3 Construction of drainage facilities connecting to ADMP drains in both Peoria and Glendale	$ 42,950,000

II. Second Priority - Individual Peoria/Glendale Facilities

A. Peoria

Phase 1 Construction of detention basin and interim ditches in Bell Road to Pinnacle Peak Road area, and of pipes under Outer Loop Freeway	$ 16,050,000
Phase 2 Completion of other drainage facilities in South Peoria	$ 13,620,000
Phase 3 Replacement of interim ditches in the Bell Road to Pinnacle Peak Road area with pipes (Some costs may be borne by developers.)	$ 24,160,000

B. Glendale

Phase 1 Construction of detention basins and interim ditches along Grand Canal and Bethany Home Road	$ 13,490,000
Phase 2 Completion of other drainage facilities in Glendale (Some costs may be borne by developers.)	$110,700,000

III. Third Priority - Individual Peoria/Glendale Facilities

A. Peoria

Phase 1 Purchase of right-of-way for channels north of Pinnacle Peak Road	$ 11,460,000
Phase 2 Construction of open channels north of Pinnacle Peak Road	$ 10,800,000

B. Glendale

None

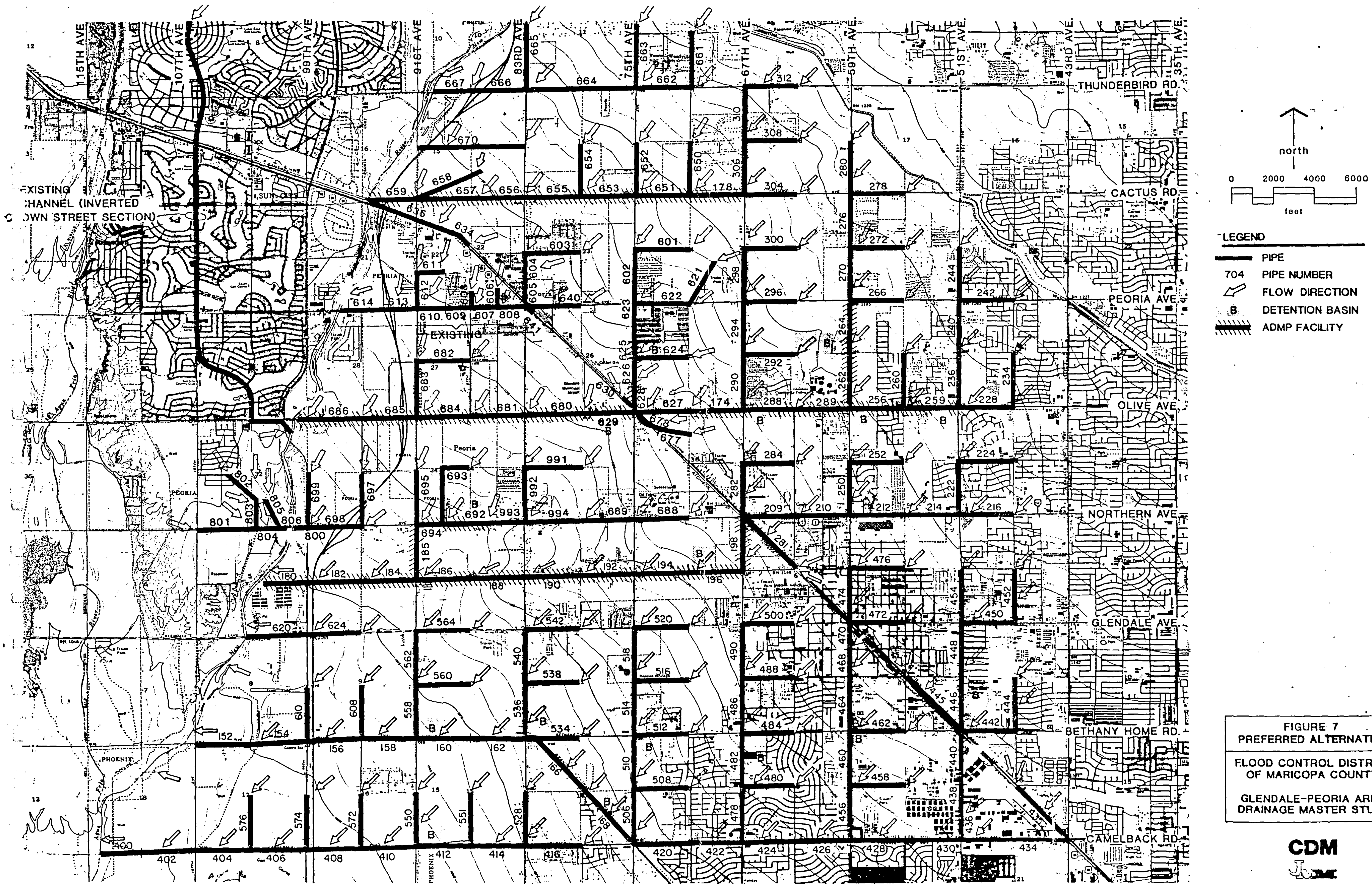

FIGURE 7
PREFERRED ALTERNATIVE

FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY

GLENDALE-PEORIA AREA
DRAINAGE MASTER STUDY

CDM

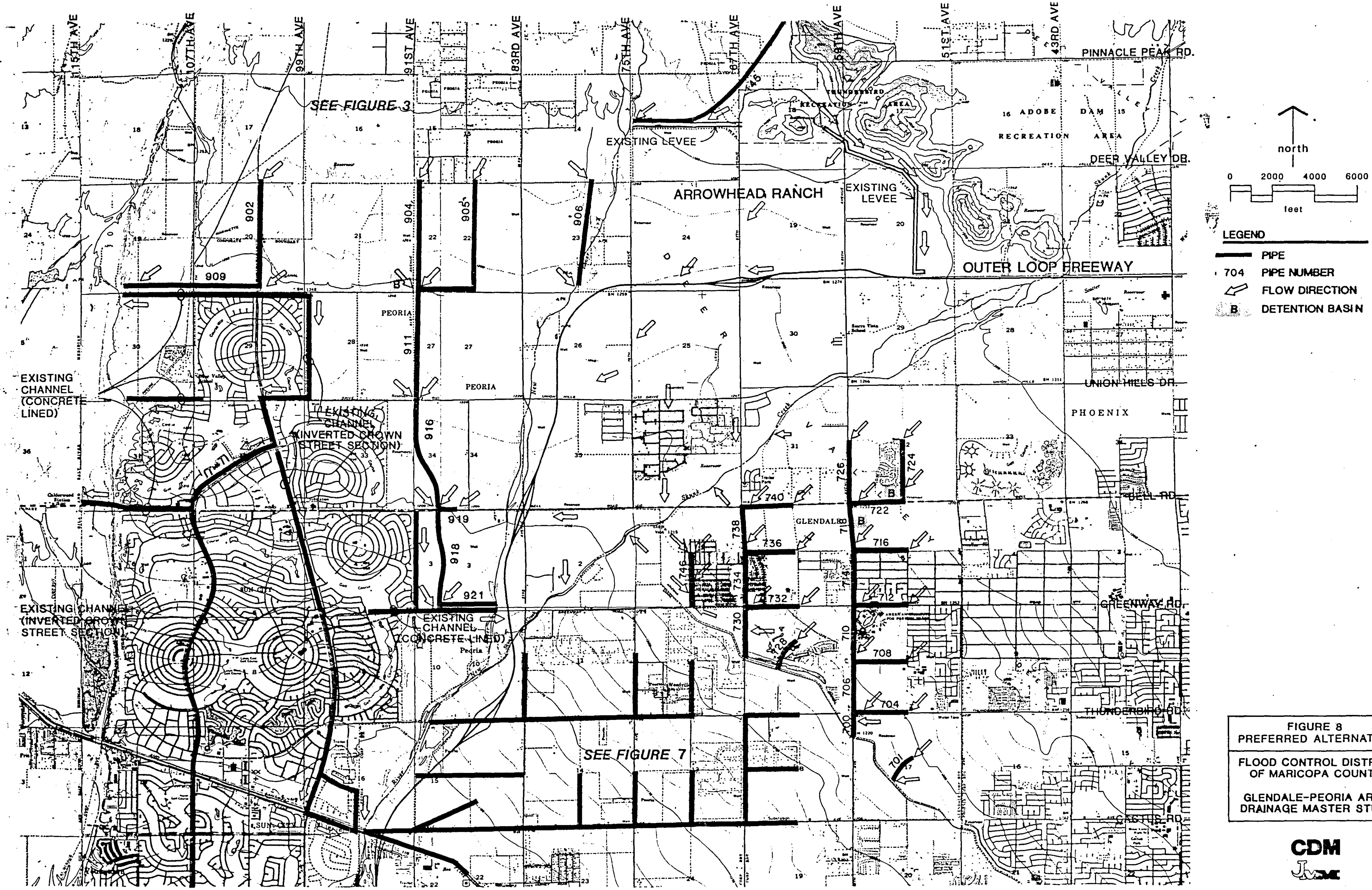

FIGURE 8
PREFERRED ALTERNATIVE

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

GLENDALE-PEORIA AREA DRAINAGE MASTER STUDY

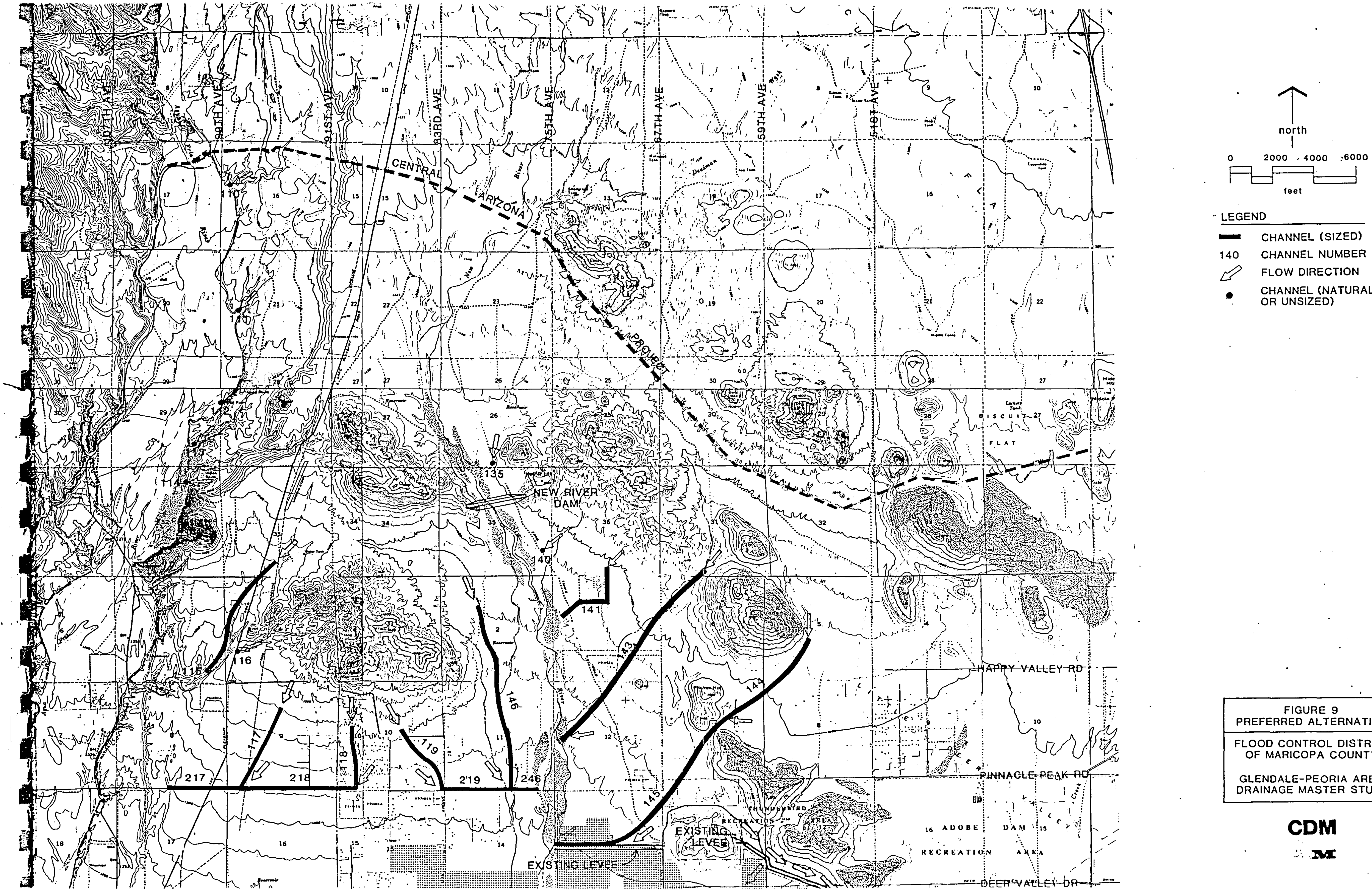

FIGURE 9
PREFERRED ALTERNATIVE

FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY

GLENDALE-PEORIA AREA
DRAINAGE MASTER STUDY

CDM

Section One

BACKGROUND

Glendale and Peoria are located in Central Arizona and experience a dry climate with a low average rainfall. In spite of the low rainfall experienced, occasional storms can produce significant stormwater runoff in both cities.

Until recently, the Cities have primarily been centers for agricultural activities, with relatively low population density. In this setting, the runoff from infrequent storms could generally be handled without a formal drainage system and without causing significant damage or problems.

With the rapid residential growth of this area, the increased urbanization tended to expand the volume and rate of runoff that occurred. Also, with the larger population base, more inconvenience was experienced because of water in the streets, and the potential for flood damage increased with the greater number of structures.

As a first step in solving these drainage problems, the Cities recently had storm drainage master plans completed. The City of Glendale selected Camp Dresser & McKee Inc. (CDM) to develop their master plan, while the City of Peoria selected James M. Montgomery, Consulting Engineers, Inc. (JMM) to prepare their plan. Both studies were funded in part by the Flood Control District of Maricopa County, which is responsible for stormwater management in the county.

Because of the topography of the area, portions of the City of Glendale would (under normal conditions) drain to and across the City of Peoria. However, the Glendale Master Plan only examined alternative drainage systems that would be entirely within the Glendale city limits. Due to the potential benefits of combining the storm drainage systems of Glendale and Peoria, the Flood Control District felt that a plan not limited by municipal boundaries might best serve the needs of both Cities and the County.

Such a plan was to be formulated under the District's Area Drainage Master Study (ADMS) program which investigates stormwater management problems and jurisdictional constraints of a particular watershed or watershed cluster. Each ADMS has as its product an Area Drainage Master Plan (ADMP), adopted by the District's Board of Directors and any subsidiary jurisdictions, to provide guidelines for stormwater management as the area develops. CDM, with JMM as a subconsultant, was chosen to develop a Glendale-Peoria ADMP.

SCOPE OF WORK

The process of developing the ADMP for the Glendale-Peoria Area was divided into the following tasks:

Task 1 - Assemble and Review Basic Data

Task 2 - Compile and Evaluate Rainfall Data

Task 3 - Model the Existing Peoria Stormwater Drainage System

Task 4 - Develop Alternative Drainage Systems for Combined Glendale-Peoria Area

Task 5 - Analyze Alternative Drainage Systems

Task 6 - Estimate Alternative Costs

Task 7 - Present Alternatives to Review Committee

Task 8 - Recommend Design Criteria and Design Objectives

Task 9 - Establish Facilities for Selected Alternative

Task 10 - Recommend Phased Construction Program

Task 11 - Prepare Technical Report

Task 12 - Prepare Maps

Task 13 - Participate in Conferences

Task 14 - Provide Reports

This document represents the completion of Tasks 1 through 14 listed above.

After the ADMP had been developed, the District requested that an addendum to the initial study be undertaken which would relate costs of the Glendale-Peoria ADMP facilities to storm frequency. Specifically, additional information was requested to compare costs of varying levels of protection (2-, 5-, 10-, 25-, 50-, and 100-year storm frequencies) for joint facilities. The addendum is discussed in a separate document "Addendum to the Glendale-Peoria Area Drainage Master Plan" dated May 1987. Although the initial "Glendale-Peoria Area Drainage Master Plan" report was completed in April 1986, it was dated and published in May 1987 with the addendum report.

Section Two

LOCATION

The Cities of Glendale and Peoria are located in the center of Maricopa County, in south-central Arizona. The Cities are bounded on the south and east by the City of Phoenix and on the northeast by the Cities of El Mirage and Youngtown. The study area, as shown in Figure 1, included the City of Glendale, the City of Peoria, and contributing drainages bounded on the west by the Agua Fria River, on the north by the Central Arizona Project (CAP) Canal and the New River Dam alignment, and on the east by the Hedgepeth Hills and Weir Valley.

LAND USE

Since the distribution of land use differs between cities, this discussion will address land use in three sections: Glendale, Peoria, and Sun City.

Glendale

The City of Glendale was originally a trade and service center for the rich agricultural area lying west of the City of Phoenix. Glendale's population remained relatively constant until after World War II, at which time a large population influx occurred due to the conversion of farmland to residential tracts. Between 1970 and 1980, the population increased by 176 percent. The 1980 population of Glendale was 96,988, and the 1985 population was estimated to be 130,000. According to the City of Glendale Plan 1980-2005, additional population growth of 50 to 100 percent is expected by the year 2000.

The City of Glendale General Plan also indicates that land use in the City is distributed among the following categories, with approximate percentages for each: agriculture (48%); residential development (24%); undeveloped land (17%); schools and parks (6%); commercial enterprises (3%); and industry (2%). Growth is anticipated in residential, commercial, and industrial development while agricultural use is expected to decline.

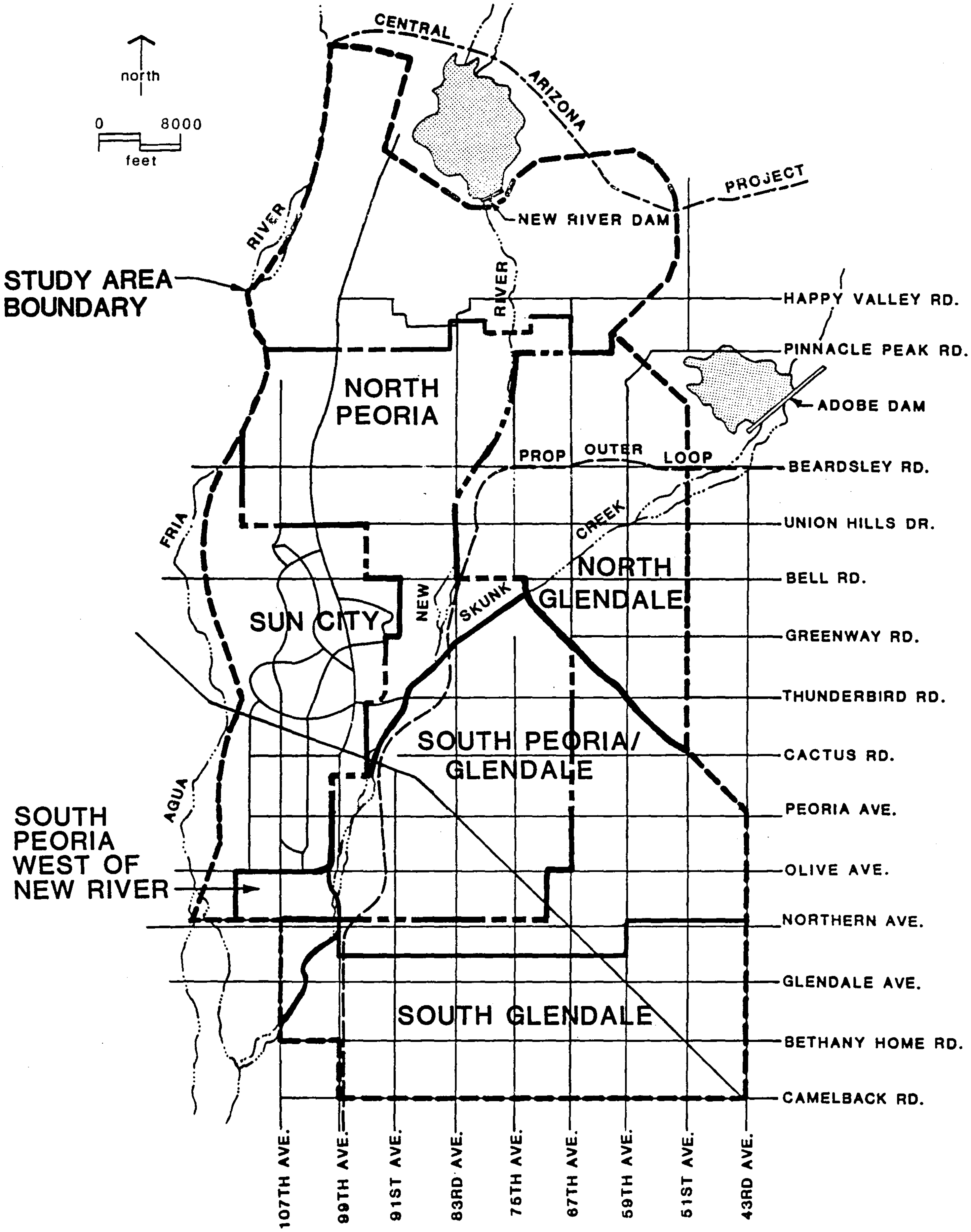

FIGURE 1
STUDY AREA

Glendale exhibits varying levels of development. The portion of the City between 67th Avenue and New River, bounded on the south by Camelback Road and on the north by Northern Avenue is primarily agricultural land with a small amount of scattered residential development. The Western Glendale Area Plan calls for residential development on much of the undeveloped farmland. Some small areas are designated for commercial and office use.

At present, the most developed area of Glendale is between 67th Avenue and 43rd Avenue, north of Camelback Road to the Arizona Canal Diversion Channel. Within this area lies the downtown portion of Glendale. Although small areas of undeveloped land exist, future changes to this part of the City will be minimal. Large amounts of undeveloped land remain in Glendale north of the Arizona Canal Diversion Channel; included is the Arrowhead Ranch, located north of Skunk Creek. Future plans for development of this area provide for mostly residential use; however some land is designated for commercial and light industrial use, as well as for floodplain allowance.

Peoria

The City of Peoria was founded in 1879 as a farming community, and historically has served as the agricultural center for the surrounding farm areas. With the rapid growth in the region, Peoria has been moving away from its agricultural origins and is shifting into a major urban center in what has now become the greater Phoenix metropolitan area. As a result of this growth, the population in Peoria increased 157% from a population of 4,753 in 1970 to 12,230 in 1980. Recent estimates put Peoria's 1985 population at approximately 27,000, with a projected population of 75,000 by the year 2000. Due to this rapid increase in population, large farming tracts are being sold to developers for conversions to subdivisions, schools, commercial centers, and industrial parks. This trend of decreasing agricultural land and increasing residential, commercial, and industrial development is expected to continue. According to the 1982 City of Peoria General Land Use Plan, the ultimate development of Peoria will be comprised of approximately 70% residential; 21% commercial and industrial; and 9% for schools, parks, floodplain, and special uses.

As in Glendale, development in Peoria varies throughout the City. The area from Northern Avenue to Bell Road is the most extensively developed part of the City. The land use here consists of residential, commercial, industrial, office, and open space. Future development of this part of Peoria is severely limited.

The portion of Peoria between Bell Road and Pinnacle Peak Road is just now beginning to be developed. Ultimate utilization is expected to occur within the next 20 years, with residential, commercial, and office use comprising the majority of the development. The region north of Pinnacle Peak Road is undeveloped and development is not planned for the foreseeable future.

Sun City

Sun City is an unincorporated large residential community. Nearly all the land in Sun City is used for residential purposes except those land areas designated for open space. The open space areas primarily consist of golf courses. Future development of Sun City will be limited due to the small amount of undeveloped land.

TOPOGRAPHY

Glendale and Peoria are situated in the basin of New River, which originates in the New River Mountains north and east of the Cities.

The primary watercourses in the area include the Agua Fria River, New River, and Skunk Creek. The Agua Fria River starts in the mountains of central Arizona near Prescott, and flows south more than 100 miles before joining the Gila River 15 miles west of Phoenix. New River, a tributary of the Agua Fria River, flows generally southwesterly until it joins the Agua Fria River west of Glendale. Skunk Creek is a major tributary of New River which starts in the New River Mountains and flows generally southwest until it joins New River west of Glendale. Apart from the major rivers in the area, natural drainage was previously provided by poorly defined washes flowing across the alluvial fan. However, when valley land was converted to agricultural uses, these small washes were generally obliterated.

The terrain in the City of Glendale is flat, with a gradual slope of about 4.5 feet per 1,000 towards the southwest and about 3 feet per 1,000 along the principal streets, which run north and south or east and west in a rectangular grid.

The City of Peoria is also located on mostly flat terrain, with slopes similar to those found in Glendale. North Peoria, however, has a considerably more uneven terrain. Several small mountains and hills can be found in North Peoria, some of which rise as much as 400 to 500 feet about the valley floor.

GEOLOGY

The geology in the Glendale-Peoria area consists of a basement complex predominantly of Precambian schistose and massive metaigneous rocks with lesser amounts of gneiss and quartzite. These are overlain with and intruded by igneous rocks consisting of granites, rhyolite, andesite, flows of vesicular basalt, tuff, and tuffaceous agglomerate. The valleys in this area are filled with alluvium derived from the same general material of which the bedrock is composed. Older alluvium is found on the side slopes of the valleys and underlying more recent deposits in the valleys, and consists of well-cemented residual soil and debris, mostly sand and silty sand. Recent alluvium is found in valley areas near streambed channels, and consists of uncemented silts, sands, gravels, cobbles, and boulders. The total depth of the alluvium is estimated to be 1,000 to 1,200 feet in the Glendale-Peoria area. The groundwater table is about 250 to 300 feet below the surface.

RAINFALL

Rain storms that occur in the Glendale-Peoria area are generally one of three types, as indicated by the U. S. Army Corps of Engineers (Design Memorandum No. 2, 1982). These storms are described below:

- General Winter Storms. These storms originate from the north Pacific Ocean, and can occur from late October through May, although they are most common from December through early March. These storms frequently last several days and spread generally light to moderate precipitation over large areas. Although these storms are generally of low intensity, combined with snowmelt from the mountains, their large areal extent and long duration, these storms can produce high peak flows on the large rivers in the area.

- General Summer Storms. These storms generally originate from the southeast or south and are often associated with tropical storms or hurricanes. The storms can occur from late June through mid-October, but are most frequent from August through early October. They usually last from 1 to 3 days, and produce locally heavy precipitation for many areas within a widespread area of light to moderate rain.

- Local Storms. These convective storms are generally referred to as thunderstorms or cloudbursts and consist of heavy downpours of rain over relatively small areas for short periods of time. They are most prevalent during the summer months of July to September. The runoff from these storms generally has a high peak and low volume, and can result in serious flash floods.

SOIL CHARACTERISTICS

Major soil types found in the study area have been mapped by the United States Department of Agriculture Soil Conservation Service (SCS). Generally, these soils are loams, sandy loams, clay loams, and clay. A hydrologic group classification has been determined for soils by the SCS to indicate the general potential of various soils to generate runoff from rainfall. The following definitions of hydrologic soil groups are used:

Group A (Low runoff potential). Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sands or gravels. These soils have a high rate of water transmission.

Group B Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well, to well-drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

Group C Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.

Group D (High runoff potential). Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

The soil types found within the Cities generally belong to the B hydrologic soil group, which have a moderately low runoff potential. Some soils belonging to the A, C, and D soil groups are also found within the Cities. For the analysis of the stormwater system, infiltration rates were used as a parameter rather than the hydrologic soil group.

Section Three

EXISTING SYSTEM

Glendale

For the most part, storm runoff in Glendale is carried in the streets themselves, and the flows generally follow the natural gradient of the land towards the south and west. For runoff originating in the northern part of the City, the railroad parallel to State Highway 93 (Grand Avenue) running northwest to southeast forms a barrier to this natural drainage pattern due to the low embankment which was created. Flows can cross the railroad at a few points, primarily at 59th Avenue and Glendale, and 51st Avenue, but the capacity of these crossings is limited.

As a part of the construction of State Highway 93 through Glendale, the Arizona Department of Transportation (ADOT) constructed a number of storm drains. These drains were installed in six different segments, extending from Thomas Road and Grand Avenue on the south to Butler Drive and Grand Avenue on the north. The drains range in size from 18- to 36-inch diameter pipe. The system was only designed to accommodate storm runoff within and adjacent to Grand Avenue, and has a relatively small capacity.

In the central downtown area, there are a number of storm drainage pipes, most of which drain to the ADOT Grand Avenue drainage system.

Other storm drain inlets in the downtown area are used to convey water to irrigation pipes and canals of the SRP system supply lines or drain lines. The City maintains these drain inlets, and in some cases also maintains drain lines where they have been abandoned by the SRP.

The Arizona Canal Diversion Channel (ACDC) is a proposed drainage structure to be located just upstream and nearly parallel to the Arizona Canal. Reach 1, from 75th Avenue and Skunk Creek to 53rd Avenue, is currently under construction. The ACDC will extend about 17.3 miles from Cudia City

Wash at the upstream end to its outlet at Skunk Creek. The channel will be concrete-lined and rectangular or trapezoidal, or unlined trapezoidal for various portions of its length. The tops of the channel walls will be at existing ground level, so that side inflow can spill directly into the channel. In areas adjacent to the channel where ponding occurs, pipe inlets will be provided.

The Grand Canal, the primary supply canal for irrigation waters in southwestern Glendale, also receives a limited amount of drainage waters. These drainage waters, which are conveyed in irrigation laterals or drainage ditches, enter the Grand Canal at locations where the Canal is below the natural ground level.

Peoria

The City of Peoria's only major underground drainage facility is the Peoria Avenue Storm Drain. This facility, constructed in 1984, is designed to carry the runoff from an area of approximately 100 acres along Peoria Avenue. The storm drain is approximately 2.5 miles in length, extending east along Peoria Avenue from the outlet point at New River to approximately Market Street (east of 83rd Avenue), and also extending north along 83rd Avenue from Peoria Avenue to Varney Road. The storm drain has pipe diameters ranging from 30- to 42-inch at the north and east upstream locations to 72-inch at the outlet structure at New River. The system includes approximately 300 feet of 48-inch diameter pipe which had to be installed beneath Grand Avenue and the Atchison Topeka and Santa Fe Railroad (ATSF) using special construction techniques.

No other major drainage facilities have been constructed in Peoria to date. Because of the lack of existing storm drains, the remainder of the storm runoff in the City occurs as overland flow and is carried primarily in the streets, in roadside ditches, or to the irrigation pipes or canals of the SRP system supply lines or drain lines.

EXISTING DRAINAGE PROBLEMS

The inadequacy of the current drainage system causes a number of problems under existing conditions during intense storms. These problems consist primarily of flooding of streets and intersections and subsequent traffic disruption, as well as ponding of water in ditches and gutters at many locations in the study area.

The flooding problems are most severe where the shallow flood flows are interrupted by natural or manmade barriers, which cause ponding of water. This occurs on the north side of Grand Avenue, where the downtown commercial district is particularly affected, and on the north side of the Grand Canal.

A number of intersections in the study area also have dip crossings where a shallow gutter along one street extends across an intersecting street to allow passage of stormwater. The flow of traffic at these crossings can be restricted when stormwater flow is high.

With increased development, street flooding has worsened to the point where it is a severe nuisance on the threshold of causing damage to structures and their contents in some areas.

Some flooding occurs because of water that enters Glendale from surrounding areas. In the northern part of Glendale, stormwater enters the City from Phoenix along 51st Avenue. Most of this water flows west on Thunderbird Road and into the ACDC. This is a severe problem making Thunderbird Road impassable, causing property damage, and critically reducing access to the Thunderbird Samaritan Hospital. The remaining stormwater continues south on 51st Avenue and enters the ACDC at Cactus Road.

A similar problem occurs in Peoria as it receives excess runoff from Glendale along its eastern boundary. This additional runoff compounds flooding problems already occurring at the Grand Avenue-ATSF Railroad flow barrier.

The most serious flooding in Peoria has occurred in the Olive Avenue and 75th Avenue areas near Grand Avenue, as stormwater ponds along the north side of the highway and railroad and floods adjacent property.

Arizona Department of Transportation (ADOT) projects, particularly the Outer Loop Freeway and Grand Avenue improvements, will potentially affect drainage in the study area. Cooperation with ADOT would be beneficial to assess possible effects on the existing drainage situation and planned drainage improvements, as well as to explore the possibility of joint facilities.

Flooding problems have also occurred along the Grand Canal, which causes water to pond where the canal is higher than the surrounding ground. Stormwater entering the canal can also cause the canal to overflow.

In the past, considerable water has entered the Arizona Canal during storm periods, causing it to overflow in the study area. When the adjoining drainage channel (ACDC) is completed, overflows from the canal will be greatly reduced. The drainage channel has been designed to intercept the estimated 100-year future peak storm flow that would otherwise enter the canal between Skunk Creek and 40th Street. Storm runoff could still enter the canal east of 40th Street.

There are several rivers within the study area that experience periodic flooding. Skunk Creek and New River flow directly through the study area while the Agua Fria River forms the western boundary of the study area. In addition, flooding has been experienced along the Arizona Canal and along Grand Canal. In September 1981 a flood insurance study for the City of Glendale was completed by Harris-Toups Associates under the direction of the Federal Emergency Management Agency. This study provides the basis for the following discussion.

The hydrologic analysis of the three rivers within the study area established the peak discharges for the 10-, 50-, 100-, and 500-year storms. These peak discharges for New River and Skunk Creek are shown in Table 1. It was also determined that the capacity of the Arizona and Grand Canals

TABLE 1

SUMMARY OF DISCHARGES

	PEAK DISCHARGES (cfs)			
River	10-Year	50-Year	100-Year	500-Year
New River Confluence of Skunk Creek	17,000	44,000	58,000	86,000
Skunk Creek 59th Avenue	13,000	26,000	37,000	58,000

are 800 and 600 cfs, respectively. Although the Arizona and Grand Canals are primarily irrigation canals they do provide a limited amount of flood protection by intercepting overland flows. However, during periods of large runoff, the channels are often breached.

As mentioned above, the flooding along the Arizona Canal will be greatly reduced with the construction of the Arizona Canal Diversion Channel. The areas flooded by Skunk Creek and New River during the 100-year flood were obtained from the U.S. Army Corps of Engineers and are shown on Figure 2; floodplain widths are listed in Table 2.

As can be seen in Figure 2, the problem areas of flooding by Skunk Creek and New River are near Thunderbird Road and Union Hills Drive. The anticipated construction of stormwater facilities within the study area is not expected to significantly change the flooding of these rivers during periods of peak runoff. The facilities will, however, aid in the reduction of flood damage outside of the floodplain and will assist in the removal of standing water within the floodplain once the peak discharge has passed.

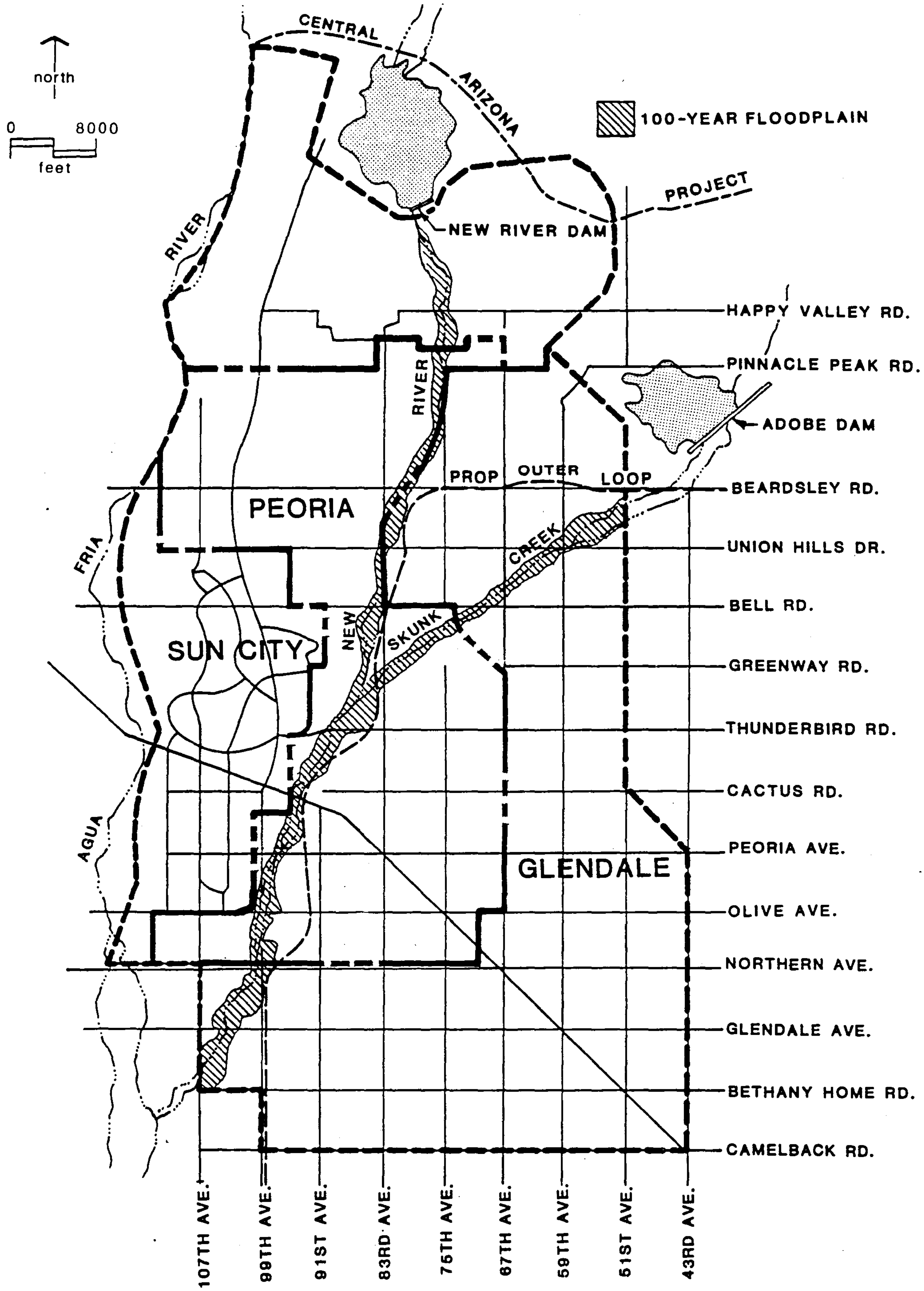

FIGURE 2
100-YEAR FLOOD BOUNDARY

TABLE 2

SUMMARY OF 100-YEAR FLOODPLAIN
WIDTHS AND ELEVATIONS

Stream	Cross Street	Floodplain Width (ft)	Water Surface Elevation (ft)
New River:			
	Glendale Ave.	2400	1060
	Olive Ave.	1900	1096
	Peoria Ave.	350	1113
	Grand Ave.	2100	1133
	Thunderbird Rd.*	4500	1166
	Bell Rd.	270	1200
	Beardsley Rd.	1050	1256
	Pinnacle Peak Rd.	400	1308
	Happy Valley Rd.	550	1330
Skunk Creek:			
	83rd Ave.	200	1172
	Bell Rd.	300	1217
	59th Ave./Union Hills Dr.*	160	1266
	51st Ave.	350	1295

*Requests for Letter of Map Adjustment (LOMA) have or soon will be made to FEMA. Each LOMA is expected to result in a reduction in floodplain width.

RETENTION AND DETENTION BASINS

Retention and detention basins are devices that can be used to reduce the peak storm runoff from urban areas; both types of facilities can store runoff during storms and then release the runoff gradually after the storm passes. Retention basins differ from detention basins as follows: The retention basin has no outlet, and water leaves only by evaporation or percolation into the ground. Stormwater entering the retention basin does not normally enter the storm drain system unless the retention basin overflows. The detention basin, on the other hand, has a small outlet, and flow returns to the downstream drainage system at a low rate. The size of the downstream pipes and ditches can be reduced below what would be required without detention.

The use of retention/detention basins is a relatively new concept for the City of Glendale, having been used only within the last 2 or 3 years. Glendale now owns and maintains several retention basins, and some of them are used as city parks. Two of these basins are located at Montarra Park, near Peoria and 65th Avenues, and at Sunnyside Park, at 63rd Avenue and Cholla Street. The City has found that water in these basins tends to percolate very slowly, allowing standing water to remain in the basin for long periods. Occasionally, the City has used portable pumps to drain the basins by pumping water into the street; dry wells are planned to facilitate percolation and reduce retention time in parks.

In addition to the City operated retention basins in Glendale, there are a number of privately owned retention basins. The current City regulations specify that new development retain on site all flow from a 10-year storm. At the present time, developers in Glendale are required to install retention basins for new development. Parking lots have typically been used as retention facilities for commercial developments. Problems have been experienced with landscaping and filling activities in these areas with small retention basins, thereby reducing or eliminating the retention storage. The present policy is to use larger retention sites that serve all or major portions of developments.

The City of Peoria, like the City of Glendale, does not have extensive experience with retention/detention basins. Presently there are no City operated retention/detention facilities within the City of Peoria. Private retention basins do, however, exist within Peoria.

According to the current administration of the City of Peoria Code, all new developments are to provide on-site storage for the difference in runoff between the 2-year storm and the 10-year storm; additional runoff must be conveyed safely to the nearest major mile street. The intent of these regulations is to minimize nuisance flooding allowing normal traffic flow. The provision requiring excess runoff to be routed to major mile streets foresees the construction of a stormwater network along the major arterial routes.

On-site retention of runoff in Peoria may be achieved in two ways: one, by constructing a common retention site which is required for multi-family residential, commercial, and industrial developments; or two, by constructing a depressed rear yard for single family residential areas. The combined storage of the depressed rear yards should provide the same amount of storage as a common retention area. The City's policies have been effective where common retention basins have been provided (often a parking lot is used), but have been less effective for single family residential areas. This lack of effectiveness stems from homeowners regrading or filling in their rear yards to prevent ponding of stormwater. The resulting lack of runoff storage compounds flooding problems in downstream developments and on the major arterial streets where the anticipated stormwater system has yet to be implemented.

Section Four

PURPOSE OF MODELING

Because of the complexity of storm runoff, and the difficulty of measuring actual peak flows in small urban watersheds, modeling of watersheds using computer simulation techniques is necessary to develop a reliable stormwater plan. Computer models also have the advantage of being able to predict flows under a variety of physical conditions (including existing and future land use conditions), and different storm conditions. The effect of various stormwater facilities can also be studied with the use of the models.

The methods used by these models is to take the physical parameters of the watershed that normally affect the runoff process, such as slope, roughness, and infiltration, and use mathematical equations to predict the runoff hydrograph that will be produced on the watershed by a given rainfall pattern.

Because of the need to divide the watershed into a relatively small number of segments, and the need to use an average value for the parameters in each segment, the models can only approximate the runoff hydrograph that will actually occur. However, if the values of the parameters chosen for the watershed are truly representative of actual conditions, the approximation can be quite close, and well within the limits of accuracy required for planning drainage facilities.

MODELS USED

A number of the runoff simulation models in general use were considered for the Glendale Stormwater Management Plan, the Peoria Master Plan of Storm Drainage and the Glendale-Peoria ADMP. These included the Storm Water Management Model (SWMM) developed by the Environmental Protection Agency, the Illinois Urban Drainage Area Simulator (ILLUDAS) model developed by the Illinois State Water Survey, and the HEC-1 Flood Hydrograph Package developed by the U. S. Army Corps of Engineers.

The SWMM model was used for developing the Glendale Stormwater Management Plan, the portion of the Peoria Master Plan of Storm Drainage south of Pinnacle Peak Road, and the Glendale-Peoria ADMP. The area north of Pinnacle Peak Road in Peoria was originally modeled using the HEC-1 model because of that model's suitability to less developed areas. However, in order to make it compatible with the remainder of the Glendale-Peoria study area, the area was converted to the SWMM model.

HYDROLOGIC CRITERIA

In order to assure the validity of the results obtained with the stormwater model, the input parameters used must be obtained in a consistent and reasonable manner, and must agree with the objectives of the stormwater plan.

The simulation done by the SWMM model is divided into two phases. The watershed to be simulated is divided into catchments, and the overland flow hydrograph is computed for each catchment. The input parameters required for each catchment include the drainage area, land slope, overland flow length, overland flow roughness, infiltration parameters, infiltration decay rate, and depression storage depth.

After the individual runoff hydrographs for each catchment are computed, these hydrographs are combined and routed through the stormwater system. For modeling purposes, the drain system is divided into reaches, with each reach having a constant channel section and slope. Input parameters for the model include the channel shape and dimensions (diameter if a pipe, or bottom width and side slope if an open channel), the slope, and the roughness coefficient.

Detention basins are modeled in SWMM by including, downstream of the proposed basin location, a pipe whose capacity equals the outlet capacity from the basin. When inflow to the basin exceeds the capacity of this pipe, the excess is stored in the model as surcharge. The surcharge represents the stormwater storage volume needed at that basin location. When inflow equals the specified basin outlet capacity, the surcharge (storage) has reached its maximum volume. As inflow drops below the basin outlet capacity, the model allows the surcharge back into the system. The volume of water detained in the basin can be adjusted by changing the size of the basin outlet pipe.

The criteria used for the Glendale Plan was that a 10-year storm should be carried by the storm drainage system. It was assumed that new development in Glendale would retain on site all flow from a 10-year storm, as specified by the current City regulations. This was simulated by decreasing the contributing drainage areas for those catchments that would be developed in the future. Fifteen percent of the area to be developed was included in the model to represent roads and other areas for which retention would not be feasible.

The criteria used for the Peoria Plan was that a 2-year storm would be carried by the storm drainage system. It was assumed that the difference between the 10-year storm and the 2-year storm would be stored in on-site retention areas. The 2-year storm was used in the SWMM model to determine the required storm drainage system.

The criteria used for the Glendale-Peoria ADMP was that the 10-year storm would be carried by the storm drainage system. The 10-year storm with reduced contributing areas for new development was used for those portions of the study area in Glendale. For those portions of the study area in Peoria, all runoff from the 10-year storm from existing developed areas was considered to enter the combined Glendale-Peoria trunk drains. As mentioned above, it was assumed that the difference in runoff from the 10-year and 2-year storms for new developments would be retained on site.

The land use conditions assumed for the Glendale-Peoria ADMP were future conditions, based on ultimate development with the current city land use plans.

Rainfall Patterns

The SWMM Model requires input of an entire rainfall pattern for a storm rather than just a peak rainfall intensity or a total precipitation amount. The rainfall pattern chosen can greatly affect the calculated flows. The relative placement of the peak rainfall within a storm is an important factor. In order to locate the peak rainfall, actual rainfall records for a number of major storms in the Phoenix area were plotted. It was observed that the most intense rainfall occurred fairly consistently within the first hour of the storm. Therefore, to best represent this condition, it was determined that the idealized pattern should have the peak rainfall at the beginning of the storm. This situation simulates the local thunderstorm which produces high peak runoff rates.

An idealized synthetic rainfall pattern showing rainfall intensities at 15-minute increments over a 6-hour period was constructed for each return period analyzed in this task. The rainfall intensity-duration-frequency curves developed for the City of Phoenix (based on methods of U.S. Weather Bureau Technical Papers Nos. 28, 40 and 44) were used to obtain rainfall intensities at 15-minute intervals. These intensities were then converted to incremental rainfall amounts, adjusted to reflect the total precipitation amount that would fall in the specified design storm, and then converted back to rainfall intensities. The total precipitation amount in the Glendale-Peoria area for each design storm was obtained from U.S. Weather Bureau isopluvial maps. The rainfall patterns constructed using this procedure are shown in the Appendix.

Section Five

STUDY AREAS

For the purposes of developing the Glendale-Peoria ADMP facilities, the study area was divided into a number of subareas as shown in Figure 1. These subareas and the procedure used for developing the drainage facilities for each area are described below.

South Glendale

This area consists of the area in Glendale generally between Camelback Road and Northern Avenue. The drainage facilities selected for this area in the "Glendale Stormwater Management Plan" could not be improved by combining with a drainage facility in Peoria. Therefore, the facilities previously selected have been included in the Glendale-Peoria ADMP without change.

South Peoria/Glendale

This area consists of the portion of Glendale south of the ACDC that is not included in the South Glendale area, and the portion of Peoria east of New River and Skunk Creek. Because of the natural drainage pattern from east to west in this area, it appeared that combining the Glendale facilities in this area with Peoria facilities would be advantageous. Therefore, facilities in this area were determined by choosing the best set of combined facilities. The process for this selection is described in more detail in this section.

North Glendale

This area consists of the portion of Glendale that is north of the ACDC. Facilities for this area were included from the "Glendale Stormwater Management Plan" without change.

North Peoria

This area consists of the area of Peoria that is north of Skunk Creek or west of New River and north of Sun City. Facilities for this area were included from the "City of Peoria Master Plan of Storm Drainage" without change.

South Peoria West of New River

This area consists of the area of Peoria that is west of New River and south of Sun City. Facilities for this area were included from the "City of Peoria Master Plan of Storm Drainage" without change.

Sun City

This area consists of the entire area of Sun City which is an unincorporated planned development. Sun City is already almost completely developed, and has an existing self-contained storm drainage system which does not affect any other subareas. There is no detailed information about the design capacity of the drainage system; however, the system has been handling the drainage flows within the area. Therefore, no improvements are recommended for this area, and the existing facilities are included in this plan for information purposes.

ALTERNATIVE PLANS FOR THE SOUTH PEORIA/GLENDALE COMBINED SYSTEM

Four major alternative drainage plans were developed for ADMP facilities in the South Peoria/Glendale area that would collect water from both cities and convey it to New River. These alternatives are described as follows:

Alternative 1

This alternative is shown in Figure 3 and consists of drains (trunk mains) along Cactus Road and Olive Avenue that would carry flow from Glendale west through Peoria. In addition, a drain along Northern Avenue in Peoria would carry flows to Orangewood Avenue in Glendale, where it would join other flows from the Glendale area.

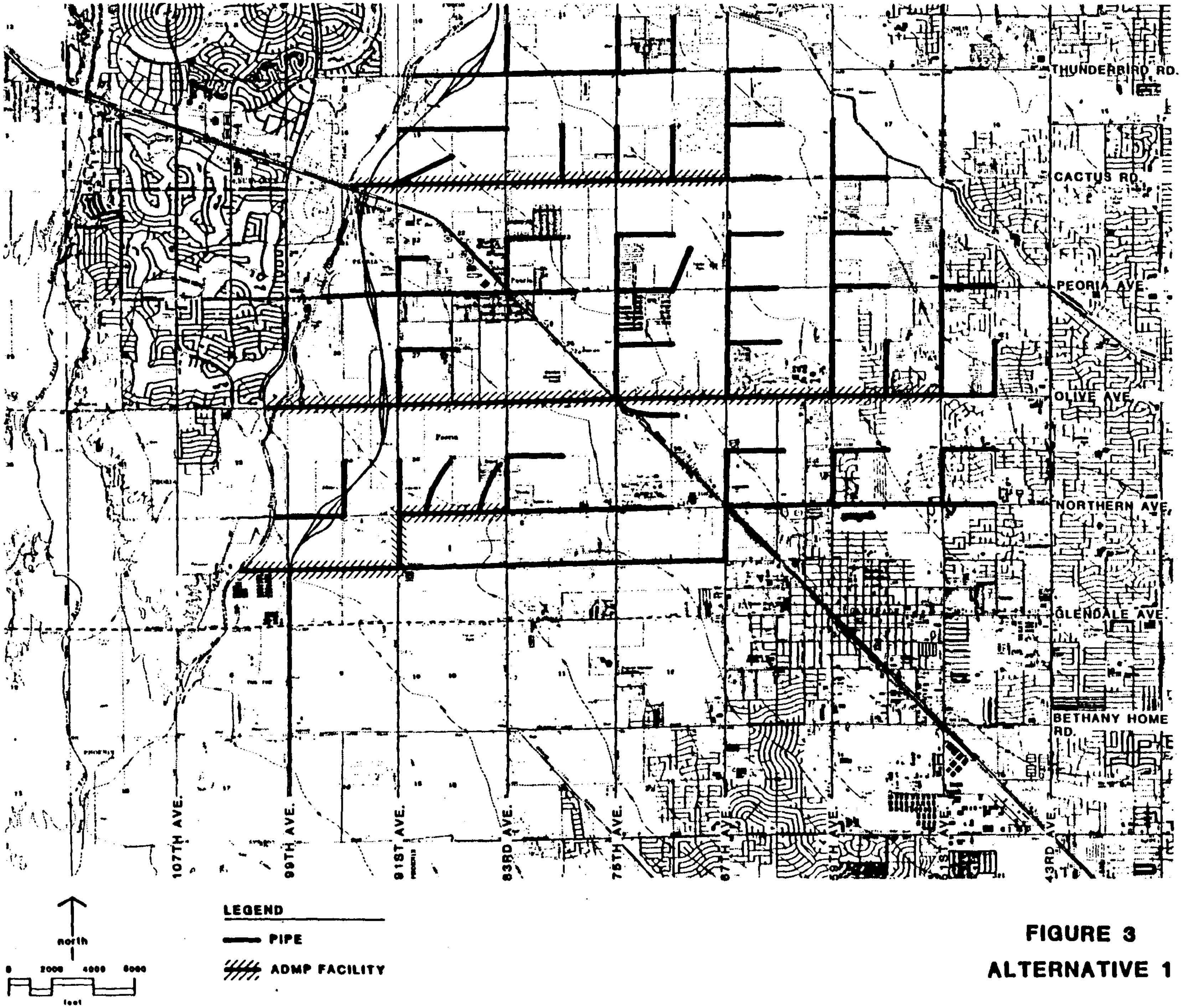

FIGURE 3
ALTERNATIVE 1

Alternative 2

This alternative is shown in Figure 4 and consists of a drain flowing west along Cactus Road, and another drain flowing west along Peoria Avenue, south along 75th Avenue, and then west along Orangewood Avenue.

Alternative 3

This alternative is shown in Figure 5 and consists of a drain flowing west along Cactus Road, and another drain flowing west along Mt. View Road, south on 75th Avenue, and then west along Butler Drive.

Alternative 4

This alternative is shown in Figure 6 and consists of a drain flowing west along Cactus Road, and a drain flowing west along Northern Avenue, south on 67th Avenue, and west along Orangewood Avenue. Another drain flowing west on Olive Avenue and south on 83rd Avenue would join the Orangewood Avenue trunk.

The locations of the drains in these alternatives were chosen based on a general evaluation of conditions in the area and discussions with Peoria and Glendale staffs.

The following factors were felt to be important in developing the alternatives and in their subsequent evaluation:

In the northern part of the Glendale-Peoria area, a drain along Cactus Road was felt to be the best alignment. An alignment one-half mile north of Cactus Road would be a problem because the street has not yet been constructed. An alignment farther north along Thunderbird Road would drain such a small area that it would be impractical as an ADMP facility. An alignment farther south than Cactus Road would interfere with existing improvements in Central Peoria.

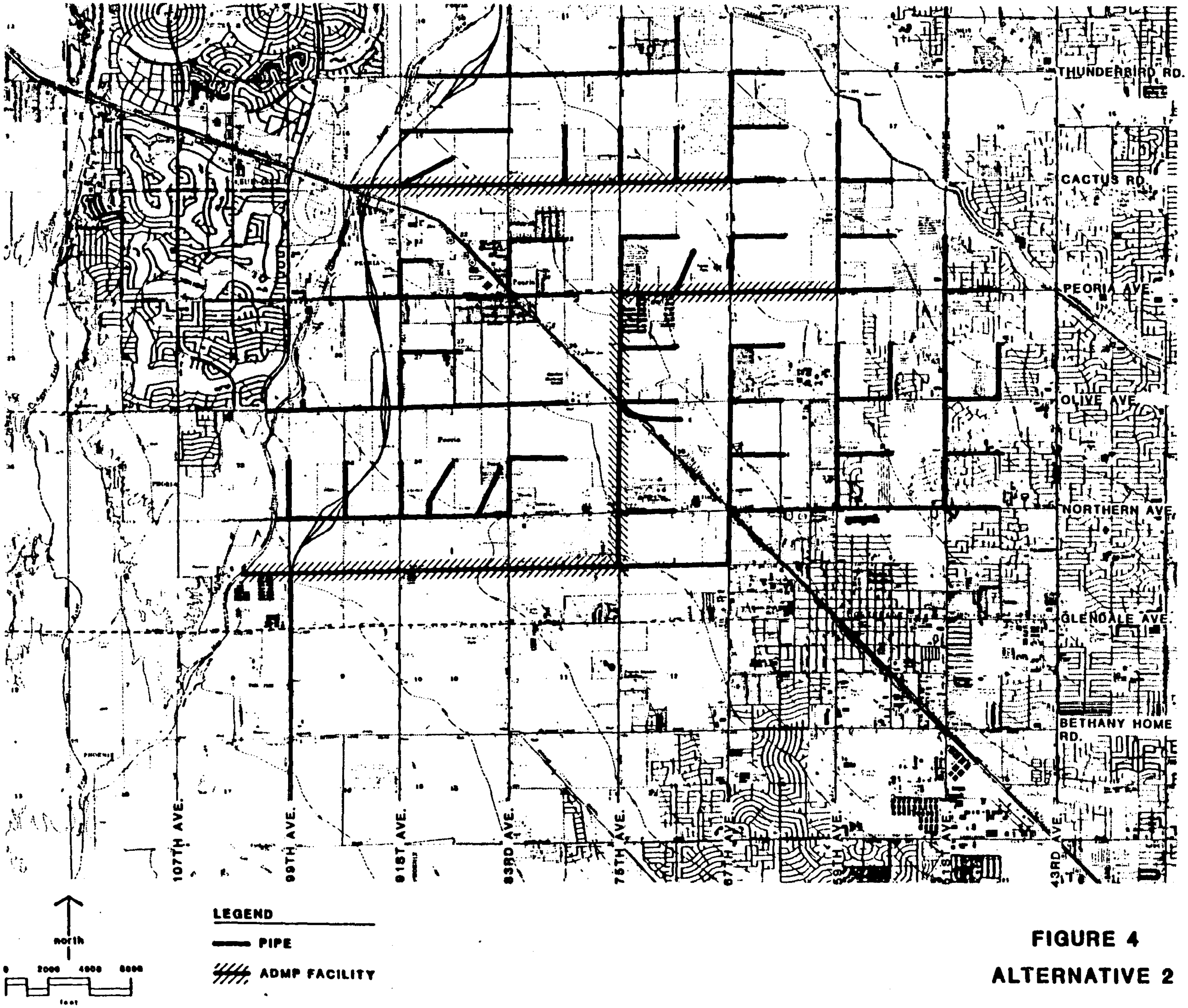

FIGURE 4

ALTERNATIVE 2

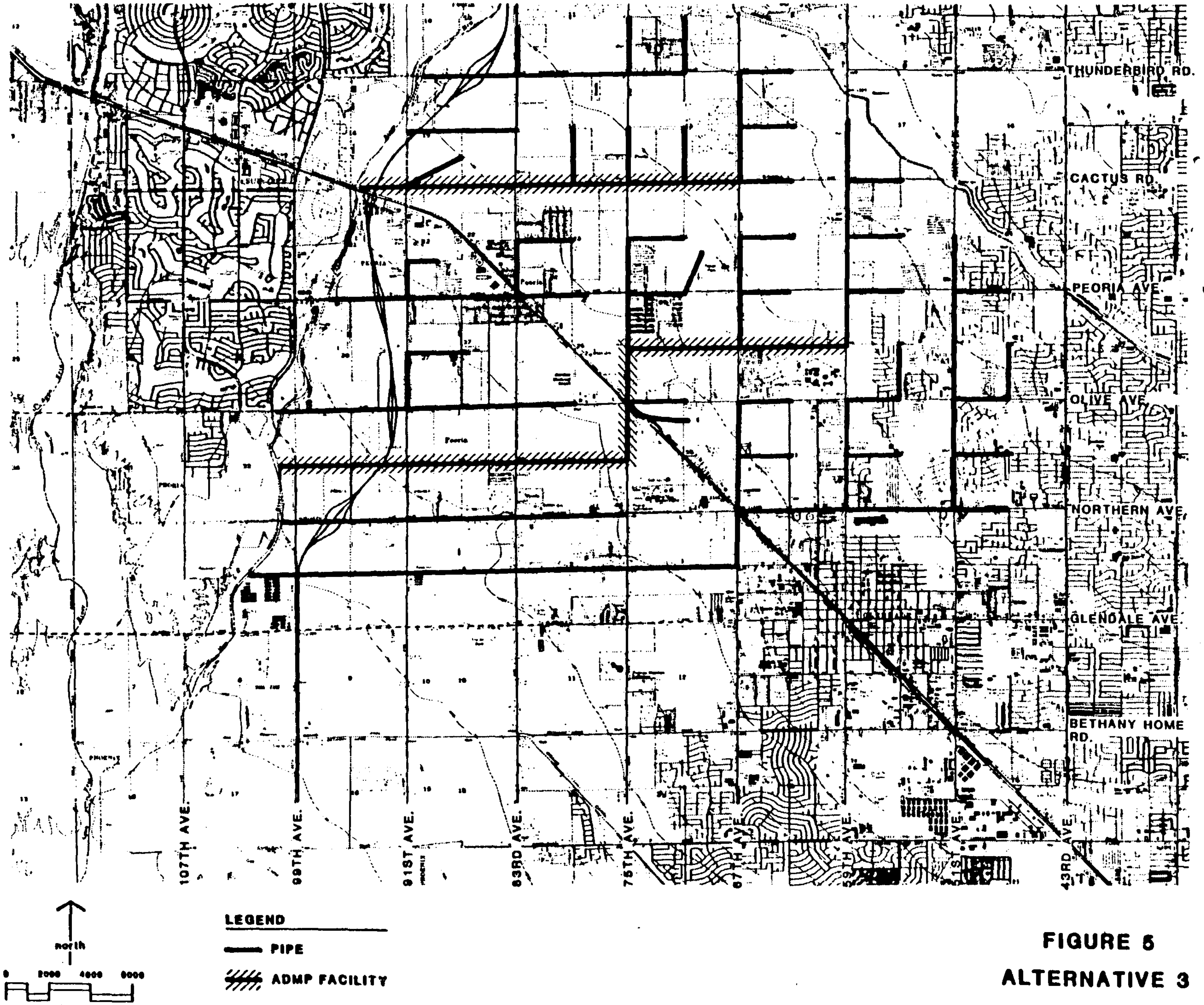

FIGURE 5

ALTERNATIVE 3

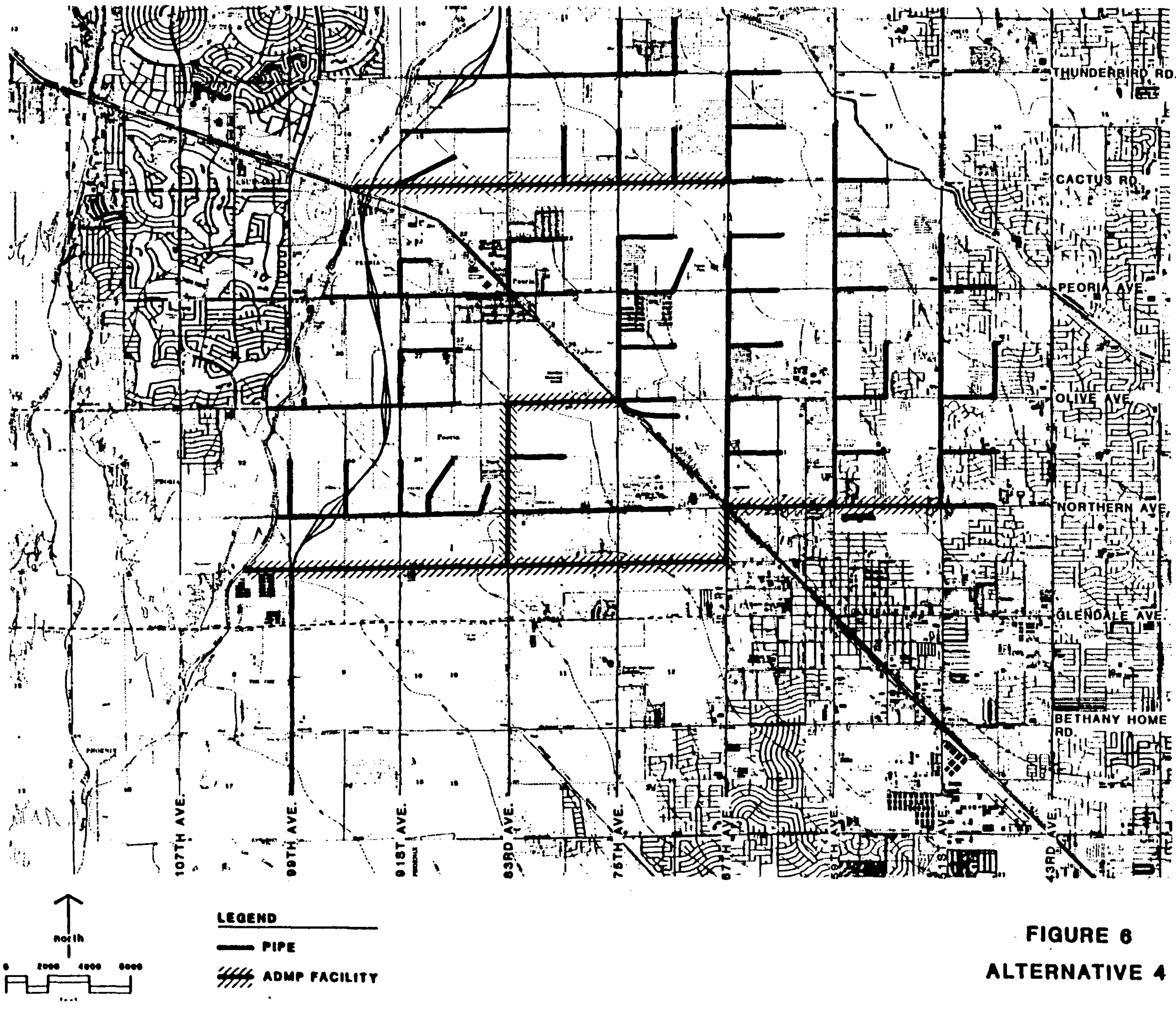

FIGURE 6

ALTERNATIVE 4

In the central part of the Glendale-Peoria area, it was recommended that the alignment avoid drains which would pass through the central Peoria area, because of the resulting congestion and interference problems with utilities in this area. The use of Olive Avenue was felt to be a desirable alignment because both Peoria and Glendale are planning to make major improvements to this street in the near future, and this would tie in well with the installation of a storm drain system.

In the southern part of the Glendale-Peoria area, an alignment for a drain along Northern Avenue was considered but was felt to present a number of construction difficulties due to the number of utilities located in this street. Therefore, an alignment one-half mile south along Orangewood Avenue was chosen in this area.

The advantages and disadvantages of the alternatives that were considered are as follows:

Alternative 1

This alternative is well balanced in terms of avoiding the major problem areas and providing a logical path for flows. It has three outlets to New River and would allow construction to proceed more rapidly.

Alternative 2

This alternative avoids the major problem areas but combines most of the flow from Glendale and some of the flow from Peoria into one drain along 75th Avenue then along Orangewood Avenue that would have to be very large. This would cause extra construction difficulties, and could require a large initial expenditure for the first phase of the plan.

Alternative 3

This alternative has the disadvantage of having all of the ADMP drains located in Peoria. In addition, the drain along Butler Drive is located too far north to effectively carry runoff from Glendale.

Alternative 4

This alternative combines most of the flow from Glendale and Peoria into a single drain that would have to be very large. This could have the same disadvantages as Alternative 2 of construction difficulties and large required initial expenditures.

Because of the disadvantages of Alternative 3, and because it did not seem to provide any distinct advantage over the other alternatives, it was dropped from further consideration.

Section Six

EVALUATION PROCEDURE

In order to compare and evaluate the alternatives described in Section 5, an evaluation matrix procedure was used. With this procedure, a number of criteria important to the project were established. These criteria were then evaluated to determine an overall rating for each alternative.

The following criteria were established for evaluation purposes.

1. Capital Cost

   An estimate of capital cost was made for each drainage system configuration.

2. Compatibility and Disruption

   An estimate was made of the compatibility of the drainage system configuration with other projects and plans. The factors considered were disruption of existing roads and utilities during construction of the system.

3. Acceptability to the Public

   An assessment was made of how the public would react to each drainage system configuration.

4. Environmental Factors

   The relative impact that implementation of the drainage system configuration would have on the quantity and quality of water in the receiving channel, as well as the effects on wildlife, aquatic life, and vegetation, were evaluated.

5. Compatibility with Major Street Projects Scheduled for Construction During Next 5 Years

   An assessment was made of the compatibility of the proposed drainage system with planned major street improvements to minimize construction costs and public inconvenience.

6. Direct Outlets to New River

   This criterion evaluated the ability of each alternative to provide an adequate major drain system to handle ADMP flows and meet each City's individual needs.

7. <u>Effective Use of Detention Basins</u>

An assessment was made of the use of detention basins in the drainage system configuration to reduce required pipe sizes downstream of the basins, and the availability of the City-owned or vacant land for construction of the basins.

8. <u>Compatibility with Outer Loop Freeway</u>

The impact of the Outer Loop Freeway on the alternatives was evaluated in terms of the effect on pipe and channel alignments, compatibility with the ADOT drainage system, and effective functioning of the regional drainage system.

9. <u>Benefits to Glendale Versus Benefits to Peoria</u>

An assessment was made of the ability of each alternative to effectively handle each City's individual drainage needs compared to implementation of a completely separate system for each city.

10. <u>Potential for Staged Construction</u>

Each alternative was assessed to determine its potential for a phased implementation of the proposed drainage system that would allow the system to be constructed in reasonable, well-defined segments to meet immediate drainage needs while allowing implementation of the remaining portions to be spread over a number of years.

The evaluation of each criterion, as it applied to the various drainage system configurations, was done on the basis of a positive, negative, or neutral rating. Positive (+) indicates that the alternative would have a favorable (least negative) impact upon the element. Negative (-) indicates that the alternative would have an unfavorable (most negative) impact upon the element, and neutral (0) indicates that the alternative would not significantly affect the element. This rating was intended to evaluate each project only in relation to the other alternative projects. The rating factor is not intended to have a meaning in relation to projects in other locations.

The cost of Alternatives 1, 2, and 4 were determined by using the SWMM model to estimate the pipe sizes and detention basin sizes required to handle the storm flow.

Alternative detention basin sites and sizes were considered in the SWMM analysis. Basin sites were chosen based on areas that are presently vacant or devoted to open space uses such as parks or recreation areas. Sites and the maximum amount of space that could be devoted to detention at each site were confirmed with City staff.

Because of the many different combinations of pipe sizes and detention basin sizes and locations, it was not possible to evaluate all combinations and determine an optimal set of facilities for each alternative. However, based on a number of simulations for each alternative, it is believed that the results obtained were approaching an optimum solution. In general, it was found that increasing the volume of detention storage available would decrease the total construction cost of the storm drainage facilities.

The cost of the ADMP facilities was compared with the sum of the costs for the individual Glendale and Peoria systems in order to determine if the combined system would have any cost advantage over the individual systems.

EVALUATION RESULTS

The results of the cost analysis showed that the cost of each of the combined alternatives would be about $2.5 million less than the sum of separate systems for both Peoria and Glendale.

In addition, it appears that Alternative 1 would be the lowest cost option, although all three alternatives were very close in cost.

Table 3 shows a summary of the estimated costs.

The results of the evaluation procedure for the three drainage system configurations (Alternatives 1, 2 and 4) are presented in Table 4. Alternative 1 received an overall positive rating, while the other two alternatives received an overall neutral rating. Therefore, Alternative 1 was chosen as the preferred alternative.

TABLE 3

ALTERNATIVE COST SUMMARY

Alternative	Cost of Drains $ Million	Cost of Detention Basins $ Million	Total $ Million
Separate Systems:			
Peoria	30.8	0	30.8
Glendale	32.9	9.3	42.2
			73.0
Combined Systems:			
Alternative 1	59.9	10.6	70.5
Alternative 2	60.9	9.9	70.8
Alternative 4	61.4	10.2	71.6

TABLE 4

EVALUATION MATRIX

	Alternative		
Evaluation Criteria	1	2	4
Capital Cost	+	0	0
Compatibility and Disruption	0	0	0
Acceptability to the Public	+	0	0
Environmental Factors	0	0	0
Compatibility with Major Street Projects Scheduled for Construction During Next 5 Years	+	0	0
Direct Outlets to New River	+	-	-
Effective Use of Detention Basins	0	0	0
Compatibility with Outer Loop Freeway	0	0	0
Benefits to Glendale Versus Benefits to Peoria	0	-	0
Potential for Staged Construction	0	0	0
OVERALL EVALUATION	+	0	0

+ = Favorable

0 = Neutral

- = Unfavorable

Section Seven

7. DESIGN CRITERIA AND DESIGN OBJECTIVES

INTRODUCTION

In order to ensure that the Glendale-Peoria ADMP facilities will provide the desired protection for the communities, it is necessary to clearly define the design objectives to be met and the design criteria to be used. This will ensure that

- All parts of the drainage facilities will be compatible with other parts;
- The facilities will carry the desired flows;
- They will not interfere with other services in the community; and
- They will have a normal service life.

Unless otherwise noted, it is expected that the criteria and objectives established for this study area would be compatible with the Drainage Policies and Standards currently under development by Maricopa County. The items discussed in the following sections are intended to supplement the Maricopa County general criteria and cover conditions special to the Glendale-Peoria study area.

DESIGN OBJECTIVES

The objectives of the stormwater drainage system for the Glendale-Peoria study area will be to safely store and convey the runoff during the 10-year storm without causing flood damage or inconvenience. In addition, the flow during the 100-year storm in excess of the design capacity should be carried along streets and other pathways without causing damage to structures.

The major storm drainage conveyance facilities will be planned ultimately to be an underground system. In some cases, an open channel or other temporary facility can be installed where existing land use cannot justify the immediate cost of an underground pipe system. However, the temporary facility should be compatible with the eventual installation of an underground pipe system. If an interim channel is in place prior to development, the developers may be required to pay for the pipe installation as part of their street and other improvements.

DESIGN CRITERIA

For open channels constructed in natural material, the design velocities during the 10-year storm should be limited to non-eroding velocities for the soil material in which the channel is constructed. The maximum allowable mean channel velocities for various natural materials are shown in Table 5 as adapted from the Corps of Engineers Hydraulic Design of Flood Control Channels.

TABLE 5

SUGGESTED MAXIMUM PERMISSIBLE MEAN CHANNEL VELOCITIES

Channel Material	Mean Channel Velocity, fps
Fine sand	2.0
Coarse sand	4.0
Fine gravel	6.0
Earth	
Sandy silt	2.0
Silt clay	3.5
Clay	6.0
Rock	10 to 20

Most soil types in the study area would be classified in the silt-clay category.

If design velocities exceed the allowable non-eroding velocity, erosion protection should be provided along the sides and invert of the channel, or drop structures should be provided to reduce channel velocities. If drop structures are used, they should be located wherever possible at planned road crossing structures. The vertical drop at each structure should not exceed one half of the normal design flow depth in the channel. Based on ground slopes in the study area, the distance between successive drop structures should not exceed 1/4 mile. The design of the drop structure should provide sufficient measures for dissipation of energy at the structure. Channel areas just upstream and downstream of drop structures should be provided with erosion protection measures consistent with the velocities to be expected in these areas.

The radius of curved sections of channels as measured at the channel centerline should be at least three times the top width of the channel. At curved sections, the superelevation of the design water surface should be accounted for in determining the required height of the channel.

Where major channels join, they should enter as nearly parallel to each other as possible.

Although conveyance facilities in the recommended plan are indicated as pipes, for sizes larger than 7 to 8 feet in diameter, box culverts of equivalent capacity will probably be less costly to construct. Pipe sizes will be chosen so that the pipes flow full or nearly full under design flow conditions. In certain cases, pipes can flow under pressure if the hydraulic grade line at the adjacent inlets is 0.5 feet or more below the gutter inlet. Where there are no stormwater inlets, the entrance to side streets should be slightly humped so that stormwater flowing in gutters on mile and one-half mile streets will not enter the side streets.

In preparing this plan, it was assumed that the current on-site retention regulations imposed on new development would be continued and facilities were sized accordingly. If basins for on-site retention are allowed to drain into the system, stormwater should be held a minimum of two hours or the basin outlet should have a low capacity so that peak flows are not affected.

The drainage system configuration outlined in this plan makes use of detention basins to allow further reductions in pipe sizes. Design criteria for detention basins include:

- Maximum water depth of 3 feet.
- Maximum embankment height around the basin of 2 feet.
- Basin should have an uncontrolled overpour spillway to keep stormwater from overtopping the banks. The top of the embankment should be 1 foot above the 10-year maximum water surface elevation.
- A surface route for the 100-year flood flow through and downstream from the basin should be provided, so that no more than nuisance damage to adjacent and downstream facilities can occur.
- Outlets should be provided to release incoming flows to downstream facilities at retarded rates, but not greater than the capacity of the downstream facilities.

Provision should be made for storm flows in excess of the 10-year design capacity of the storm drainage system up to the 100-year storm flow. Wherever possible, the excess flow should be confined to the street or areas immediately adjacent to the street. However, major roads should maintain one flood-free lane in each direction. Excess flow should be directed along routes that have surface outlets to watercourses, rather than to areas that will cause water to pond and flood structures. The general pattern of flows should maintain the natural runoff pattern, rather than be re-directed to other drainage basins. Flooding of structures should be avoided, and access to community facilities such as fire stations, schools, and hospitals should be maintained during the 100-year storm.

Section Eight

GENERAL CHARACTERISTICS OF PREFERRED ALTERNATIVE

The selected facilities for South Peoria/Glendale for the ADMP preferred alternative were obtained from a more detailed analysis of the preliminary preferred regional alternative, Alternative 1, that was performed to obtain more precise alignments and sizes for pipes and detention basins. The other facilities were obtained directly from the "Glendale Stormwater Management Plan" and the "City of Peoria Master Plan of Storm Drainage". The locations of the ADMP facilities are shown on Figures 7 through 9, inserted at the back of this report. The selected facilities are listed by subarea as shown on Figure 1. (Note that Figure 7 is more detailed and the ADMP alignments are slightly different than Figure 3. Alternative 1 shown in Figure 3 considered only preliminary alignments for regional facilities; while the Preferred Alternative shown in Figure 7 was derived from a more detailed analysis of Alternative 1.)

Information on the selected facilities for all subareas except Sun City are contained in this section. Sun City is a planned area development, and takes care of its own drainage with an existing system. The existing system in Sun City is shown on Figures 7 and 8. An unlined ditch along Beardsley to the Agua Fria protects Sun City against flows that might enter from Peoria. Several other concrete-lined ditches run east-west to carry flow to either the Agua Fria or New River. Two major north-south channels are along approximately the 99th Avenue and 107th Avenue alignments. The north-south flow is carried in the street, by means of an inverted crown street section, to New River. Two driving lanes on either side of the central channel are open during storms for traffic. Since this system is adequate to handle drainage needs and the subarea is already almost completely developed, no new facilities were recommended for Sun City.

Recommended Facility Sizes

Pipes

The details of the pipe sizes required to carry the applicable design storm flows (as set forth in Chapter 4) under future land use conditions, as well as their length, approximate slope, and estimated design flow are shown in Tables 6 through 10. These tables also show the areas where utility crossings, special factors, and difficult areas of construction may need to be considered for administration and implementation of the storm drainage system.

Channels

There are two different types of channels: permanent and interim. Permanent channels are those in North Peoria as shown in Table 9. Interim channels or ditches are those included as a temporary measure to provide an outlet for runoff from upstream improvements before pipes are installed.

In Glendale, interim ditches along Camelback Road, Grand Canal and Bethany Home Road would provide an outlet for runoff from the more developed area to the east. Interim ditches in Peoria are planned for the area between Greenway Road and Deer Valley Drive. It would not be necessary to construct the interim ditches to meet the ultimate required capacity, since they would not be serving the entire developed contributing area. The interim capacity should be evaluated on a case-by-case basis as interim ditches are constructed. The interim ditches would be replaced by the recommended pipe improvements as future conditions warranted.

Another goal behind the construction of interim ditches is to have a drainage channel in place prior to development of the respective areas so that developers will pay for pipe installation as road and other improvements are constructed in their developments.

Land Acquisition Requirements

The land acquisition requirements for detention basins and for pipes that will not be located in existing public rights-of-way are shown for each subarea in Tables 11 through 15. Basin locations are generalized and can be within 1/4 mile of the specified location.

Critical Conflicts

Of the potential conflicts between proposed storm drain pipes and other utilities and facilities shown in Tables 6 through 10, most can be satisfactorily resolved during the design process by carefully choosing the storm drain profile to cross under or over utilities, by altering the drainage structure cross-section to a low profile shape, or by rerouting utility lines.

Some conflicts could prove to be more difficult to resolve, and additional planning may be required to resolve them. Critical conflicts are defined as those that occur where proposed drains cross 48-inch or larger existing utility lines. Critical conflicts also occur where the proposed drains cross utility lines smaller than 48-inch at the same location as a railroad or freeway crossing. Pipes that would have to cross the railroad tracks along Grand Avenue would require special construction methods to install without interrupting rail traffic. Construction access areas that will not interfere with road or railroad traffic will have to be identified. Pipes that will cross the path of the proposed Outer Loop Freeway could also be a critical conflict and should be planned in advance. Planning and construction of these crossings should be coordinated with the construction of the freeway.

The areas shown in Table 16 were identified as locations where conflicts may exist that will require more than the normal design and planning procedures.

All conveyance facilities in the preferred alternative are indicated as pipes. However, for pipes larger than 7 to 8 feet in diameter, box culverts of equivalent capacity will probably be less costly to construct.

TABLE 6

SELECTED FACILITIES FOR SOUTH GLENDALE

Pipe Number	Length (ft)	Design Flow (cfs)	Approximate Slope	Equivalent Pipe Size (ft)	Potential Conflicts
152	2640	1000	.0030	10.0	
154	2640	1000	.0034	10.0	Crosses 42" sanitary sewer at 99th Ave. and crosses Freeway
156	2640	970	.0015	11.0	
158	2640	860	.0023	10.0	
160	2640	1230	.0019	12.0	
162	2640	1200	.0042	11.0	
166	3800	1170	.0016	12.0	Crosses 27" sanitary sewer and Grand Ave.
168	3820	1050	.0013	12.0	
400	1900	210	.0016	6.5	
402	2500	220	.0016	6.0	
404	2640	230	.0011	7.0	
406	2640	180	.0023	6.0	Crosses Freeway
408	2640	130	.0019	5.5	Crosses 42" sanitary sewer at 99th Ave.
410	2640	6	.0030	1.5	Crosses 24" sanitary sewer at 91st Ave.
412	2640	240	.0030	6.0	
414	2640	200	.0045	5.5	
416	2640	60	.0030	4.0	
420	2640	2490	.0023	15.0	Crosses 48" sanitary sewer
422	2640	2480	.0027	15.0	
424	2640	2160	.0016	16.0	
426	2640	2100	.0030	14.0	
428	2640	1520	.0019	13.0	
430	2640	1440	.0027	12.0	
434	5280	480	.0011	10.0	Crosses railroad
435	3800	310	.0018	8.0	
436	1320	860	.0023	10.0	
438	1320	860	.0030	10.0	
440	2640	760	.0038	9.0	Crosses 36" water at 51st Ave. and crosses railroad

TABLE 6

SELECTED FACILITIES FOR SOUTH GLENDALE
(continued)

Pipe Number	Length (ft)	Design Flow (cfs)	Approximate Slope	Equivalent Pipe Size (ft)	Potential Conflicts
442	2640	360	.0011	9.0	
444	2640	270	.0023	7.0	
445	3800	310	.0005	10.0	
446	2640	90	.0019	4.5	
448	2640	490	.0042	8.0	
450	2640	320	.0011	8.0	
452	2640	250	.0030	6.0	
454	2640	120	.0023	5.0	
456	2640	580	.0030	9.0	
458	2640	270	.0023	6.5	
460	2640	310	.0030	6.5	Crosses 30" water at 59th Ave.
462	2640	250	.0023	6.5	
464	2640	710	.0023	10.0	
468	1320	700	.0038	9.0	
470	1320	640	.0015	10.0	Crosses railroad at Glendale Ave.
472	2640	230	.0034	6.0	
474	2640	390	.0023	8.0	
476	2640	240	.0030	6.0	
478	2640	380	.0023	8.0	
480	2460	260	.0024	7.0	
482	2640	150	.0030	5.0	Crosses 30" water at 67th Ave.
484	2460	150	.0024	5.5	
486	2640	590	.0011	10.0	
488	2460	160	.0041	5.0	
490	2640	370	.0015	8.0	Crosses 27" sanitary sewer
500	2460	280	.0045	6.0	
506	2640	220	.0011	7.0	
508	2640	130	.0034	5.0	Crosses 48" sanitary sewer
510	2640	5	.0019	1.5	
512	2640	110	.0030	4.5	
514	2640	240	.0015	7.0	

TABLE 6

SELECTED FACILITIES FOR SOUTH GLENDALE
(continued)

Pipe Number	Length (ft)	Design Flow (cfs)	Approximate Slope	Equivalent Pipe Size (ft)	Potential Conflicts
516	2640	60	.0030	4.0	
518	2640	170	.0023	5.5	
520	2640	180	.0027	5.5	
528	2640	120	.0015	5.5	
534	2640	70	.0034	4.0	
536	2640	4	.0011	1.5	
538	2640	100	.0038	4.5	
540	2640	240	.0034	6.0	
542	2640	210	.0038	5.5	
550	2640	150	.0019	5.5	
551	2640	70	.0019	4.0	
558	2640	210	.0023	6.0	
560	2640	70	.0019	4.5	
562	2640	200	.0011	7.0	
564	2640	150	.0049	5.0	
572	2640	80	.0027	4.5	
574	2640	70	.0015	4.5	
576	2640	70	.0023	4.0	
608	2640	70	.0027	4.0	
610	2700	70	.0004	5.5	
620	2700	110	.0037	4.0	Crosses Freeway
624	2640	150	.0017	5.5	

TABLE 7

SELECTED FACILITIES FOR SOUTH PEORIA/GLENDALE

Pipe Number	Length (ft)	Design Flow (cfs)	Approximate Slope	Equivalent Pipe Size (ft)	Potential Conflicts
174	2640	140	.0045	4.5	
178	2640	340	.0025	7.0	
180	1960	630	.0013	8.5	Crosses 39" sanitary sewer at 99th Ave. and crosses Freeway
182	2640	640	.0027	9.0	
184	2640	620	.0019	9.5	
185	2640	250	.0038	6.0	
186	2640	360	.0019	7.5	
188	2640	340	.0064	6.0	
190	2640	320	.0034	6.5	
192	2640	280	.0023	7.0	
194	2640	180	.0015	6.0	Crosses 39" sanitary sewer
196	2640	1610	.0034	12.0	
198	2640	1520	.0034	12.0	
209	2460	780	.0020	10.0	
210	2640	780	.0038	9.0	
212	2640	490	.0038	7.5	
214	2640	510	.0045	7.5	
216	2640	250	.0019	7.0	
222	2640	220	.0011	7.0	
224	2640	130	.0038	4.5	
228	2640	350	.0027	7.0	
234	2640	300	.0025	7.0	
236	2640	240	.0030	6.0	
240	2640	240	.0030	6.0	
242	2640	50	.0030	3.5	
244	2640	160	.0019	5.5	
250	2640	300	.0027	6.5	
252	2640	110	.0034	4.5	
256	2640	270	.0027	6.5	
259	2640	45	.0038	3.0	

TABLE 7

SELECTED FACILITIES FOR SOUTH PEORIA/GLENDALE
(continued)

Pipe Number	Length (ft)	Design Flow (cfs)	Approximate Slope	Equivalent Pipe Size (ft)	Potential Conflicts
260	2640	270	.0030	6.5	
262	2640	130	.0023	5.0	
264	2640	10	.0019	2.0	
266	2640	120	.0042	4.5	
270	2640	320	.0038	6.5	
272	2640	230	.0023	6.5	
276	2640	80	.0034	4.0	
278	2640	15	.0027	2.5	
280	2150	80	.0028	4.5	
281	3700	340	.0008	9.0	
282	2640	550	.0011	10.0	
284	2460	150	.0028	5.0	
288	2460	220	.0028	6.0	
289	2640	60	.0034	3.5	
290	2640	510	.0027	8.0	Crosses 33" sanitary sewer at 67th Ave.
292	2460	60	.0028	3.5	
294	2640	380	.0038	7.0	
296	2460	70	.0037	4.0	
298	2640	330	.0019	7.5	
300	2460	110	.0045	4.5	
304	2460	90	.0037	4.0	
306	2640	270	.0034	6.0	
308	2460	100	.0024	4.5	
310	2640	150	.0034	5.0	
312	2460	90	.0024	4.5	
601	2640	70	.0023	4.0	
602	2640	110	.0039	4.5	
603	2640	140	.0034	5.0	
604	1260	170	.0016	6.5	
605	910	190	.0016	6.5	Crosses 48" storm sewer at Peoria Ave.
606	700	40	.0037	3.5	

TABLE 7

SELECTED FACILITIES FOR SOUTH PEORIA/GLENDALE
(continued)

Pipe Number	Length (ft)	Design Flow (cfs)	Approximate Slope	Equivalent Pipe Size (ft)	Potential Conflicts
607	1300	250	.0040	6.0	
608	800	40	.0031	3.5	
609	1100	280	.0029	7.0	
610	1520	330	.0028	7.5	
611	850	60	.0018	4.5	
612	1700	100	.0035	4.5	
613	1800	150	.0017	6.0	Crosses Freeway
614	1530	50	.0016	4.0	
621	2550	20	.0035	2.5	
622	2640	100	.0021	4.5	
623	1950	240	.0043	6.0	
624	2640	70	.0047	3.5	
625	690	60	.0032	3.5	
626	1510	260	.0026	6.5	
627	2640	330	.0036	6.5	
628	1030	290	.0042	6.0	
629	2700	270	.0019	6.5	Crosses Grand Ave., 75th Ave., and Olive Ave.
630	350	50	.0042	3.5	
634	2000	120	.0019	5.5	
635	3000	230	.0018	7.0	
640	2730	100	.0029	4.5	
641	140	70	.0028	4.0	
650	2640	70	.0034	4.0	
651	2640	470	.0040	7.5	
652	2640	70	.0027	4.0	Crosses 24" electrical duct feeder at Cactus Road
653	2640	600	.0036	8.0	
654	2640	70	.0036	4.0	
655	2640	780	.0019	10.0	
656	2640	860	.0029	10.0	
657	2640	880	.0032	9.5	Crosses Freeway
658	3850	15	.0028	2.5	Crosses Freeway

TABLE 7

SELECTED FACILITIES FOR SOUTH PEORIA/GLENDALE
(continued)

Pipe Number	Length (ft)	Design Flow (cfs)	Approximate Slope	Equivalent Pipe Size (ft)	Potential Conflicts
659	2150	970	.0027	9.5	
661	2640	30	.0035	3.0	
662	2640	90	.0033	4.5	
663	2640	90	.0033	4.5	
664	5280	180	.0034	5.5	
665	2640	110	.0029	5.0	Crosses Freeway
666	2640	230	.0033	6.0	Crosses Freeway
667	1510	290	.0081	5.5	
670	4600	180	.0027	6.0	Crosses Freeway
677	1800	30	.0040	3.0	
678	1150	80	.0030	4.0	
680	2640	320	.0022	7.0	
681	2640	430	.0021	8.0	
682	2640	70	.0038	4.0	
683	2640	130	.0017	5.5	
684	2640	470	.0029	8.0	
685	2640	670	.0032	9.0	Crosses 36" sanitary sewer at 95th Ave. and Crosses Freeway
686	2200	740	.0038	9.0	Crosses 36" sanitary sewer at 99th Ave.
688	2640	50	.0030	3.5	
689	2640	160	.0044	5.0	
692	2640	70	.0009	4.5	
693	3900	50	.0026	3.5	
694	1320	150	.0033	5.0	
695	2640	60	.0032	4.0	Crosses 36" sanitary sewer at 91st Ave.
697	2640	60	.0029	4.0	
698	2640	90	.0038	4.0	Crosses Freeway
699	2970	50	.0041	3.5	
800	550	170	.0038	5.0	Crosses 36" sanitary sewer at 99th Ave.
808	1590	270	.0042	6.5	
991	2640	100	.0031	4.5	

TABLE 7

SELECTED FACILITIES FOR SOUTH PEORIA/GLENDALE
(continued)

Pipe Number	Length (ft)	Design Flow (cfs)	Approximate Slope	Equivalent Pipe Size (ft)	Potential Conflicts
992	2640	200	.0037	5.5	
993	1320	520	.0009	10.0	
994	2640	240	.0048	5.5	

TABLE 8

SELECTED FACILITIES FOR NORTH GLENDALE

Pipe Number	Length (ft)	Design Flow (cfs)	Approximate Slope	Equivalent Pipe Size (ft)	Potential Conflicts
700	1900	420	.0025	8.0	
701	1300	120	.0030	5.0	
704	2640	270	.0023	7.0	Crosses 30" water at 59th Ave.
706	2640	120	.0019	5.0	
708	2640	120	.0045	4.5	Crosses 30" water at 59th Ave.
710	2640	340	.0034	2.0	
712	2640	210	.0034	6.0	
714	2640	120	.0034	4.5	
716	2640	140	.0034	5.0	
718	2400	140	.0042	1.5	
722	2640	240	.0027	1.5	
724	3000	210	.0020	7.0	
726	3000	90	.0030	4.5	
728	1300	220	.0030	6.0	
730	2500	500	.0016	9.0	
732	2640	220	.0027	6.0	
734	2640	310	.0030	7.0	
736	2640	110	.0034	4.5	
738	2200	250	.0027	6.0	
740	2400	210	.0038	5.5	
746	2700	260	.0022	7.0	

TABLE 9

SELECTED FACILITIES FOR NORTH PEORIA

Pipe Number	Length (ft)	Design Flow (cfs)	Approximate Slope	Equivalent Pipe Size (ft)	Potential Conflicts
110	(1)				
111	(1)				
112	(2)				
113	(1)				
114	(1)				
115	6070	1100	.0150	14.8/32.8/4.5(3)	
116	(2)				
117	4220	1110	.0340	8.9/26.9/4.5(3)	
118	3170	530	.0600	4.0/19.2/3.8(3)	
119	4220	1020	.0460	6.2/24.2/4.5(3)	
135	(2)				
140	(2)				
141	3170	600	.0450	4.0/20.8/4.2(3)	
142	(2)				
143	11090	2160	.0150	31.9/49.9/4.5(3)	
144	8450	1270	.0210	14.2/32.2/4.5(3)	
145	8710	1510	.0320	13.5/31.5/4.5(3)	
146	8180	1410	.0059	32.7/50.7/4.5(3)	
217	3960	1640	.0013	158.0/194.0/4.5(4)	
218	1320	530	.0013	50.0/86.0/4.5(4)	
219	2640	1020	.0013	96.0/132.0/4.5(4)	
246	2640	2430	.0013	235.0/271.0/4.5(4)	
902*	5280	270	.0049	6.0	
904*	5220	150	.0068	4.5	
905*	7820	160	.0040	5.5	
906*	5400	270	.0064	6.0	
909*	5680	490	.0048	7.5	
911*	5280	890	.0048	9.5	
916*	5500	1260	.0047	11.0	
918*	5250	1450	.0043	11.5	

TABLE 9

SELECTED FACILITIES FOR NORTH PEORIA
(continued)

Pipe Number	Length (ft)	Design Flow (cfs)	Approximate Slope	Equivalent Pipe Size (ft)	Potential Conflicts
919*	600	290	.0020	7.5	Crosses 24" sanitary sewer at 91st Ave.
921	3000	1400	.0017	2-10.5	

(1) Existing Natural Channel
(2) 90-100% Open land under Ultimate Development (no channel sized)
(3) Bottom width/top width/channel depth with 1.5-foot freeboard, assuming 2:1 side slopes, unless otherwise noted (lined channel)
(4) 4:1 side slopes (unlined channel)

*Denotes ditch included in interim plan but will ultimately be replaced with a pipe.

TABLE 10

SELECTED FACILITIES FOR SOUTH PEORIA WEST OF NEW RIVER

Pipe Number	Length (ft)	Design Flow (cfs)	Approximate Slope	Equivalent Pipe Size (ft)	Potential Conflicts
801	2640	180	.0044	5.5	
802	1050	170	.0037	5.5	
803	1400	270	.0037	6.5	
804	800	490	.0043	7.0	
805	1600	90	.0020	5.0	
806	960	530	.0091	7.0	

TABLE 11

RIGHT-OF-WAY LAND ACQUISITION REQUIREMENTS FOR
SOUTH GLENDALE

Location of Detention Basin	Area (acres)	Future Use
SE Corner of Bethany Home Rd. and 75th Ave.	10.4	Medium Density Resid.
NE Corner of Bethany Home Rd. and 83rd Ave.	8.4	Medium Density Resid.
NE Corner of Camelback Rd. and 91st Ave.	9.2	Medium Density Resid.
51st Ave. North of Bethany Home Rd.	8.4	Agricultural
SE Corner of Bethany Home Rd. and 59th Ave.	10.8	Agricultural
67th Ave. South of Bethany Home Rd.	10.0	Medium Density Resid.
NW Corner of Cactus Rd. and 75th Ave.	38.8	Medium Density Resid.
NE Corner of 91st Ave. and Bethany Home Rd.	34.8	Medium Density Resid.

TABLE 12

RIGHT-OF-WAY LAND ACQUISITION REQUIREMENTS FOR
SOUTH PEORIA/GLENDALE

Location of Detention Basin or Pipe Number	Area (acres)	Future Use
658	0.4	Garden Industrial
634	0.5	Garden Industrial
635	1.0	Garden Industrial
621	0.4	Manufact. Housing
677	0.3	Industrial
678	0.3	Industrial
SW Corner of Olive Ave. and 51st Ave.	12.8	Medium Density Resid.
SE Corner of Olive Ave. and 59th Ave.	7.2	Industrial
59th Ave. South of Peoria Ave.	12.0	Agricultural
SE Corner of Olive Ave. and 67th Ave.	10.4	Medium Density Resid.
SW Corner of Northern Ave. and 67th Ave.	39.2	Industrial
Olive Ave. West of 75th Ave.	13.2	Industrial
75th Ave. North of Olive Ave.	8.8	Medium Density Resid.
Northern Ave. West of 83rd Ave.	18.0	Park

TABLE 13

RIGHT-OF-WAY LAND ACQUISITION REQUIREMENTS FOR NORTH GLENDALE

Location of Detention Basin	Area (acres)	Future Use
North of Bell Rd. Between 51st Ave. and 59th Ave.	5.2	Medium Density Resid.
59th Ave. South of Bell Rd.	2.8	Industrial
59th Ave. South of Greenway Rd.	8.8	Public Facilities

TABLE 14

RIGHT-OF-WAY LAND ACQUISITION REQUIREMENTS FOR NORTH PEORIA

Location of Detention Basin or Channel Number	Area (acres)	Future Use
115	5.9	Low Density Resid.
	1.5	Open
117	3.6	Medium Density Resid.
	0.9	Open
118	2.3	Medium Density Resid.
	0.6	Open
119	3.0	Medium Density Resid.
	1.3	Open
141	1.5	Medium Density Resid.
	1.5	Open
143	16.0	Medium Density Resid.
	1.8	Open
144	5.0	Low Density Resid.
	5.0	Open
145	6.2	Medium Density Resid.
	4.2	Open
146	10.7	Medium Density Resid.
	2.7	Open
217	15.6	Medium Density Resid.
	3.9	Open
218	2.6	Medium Density Resid.
	0.6	Open
219	6.5	Medium Density Resid.
	2.8	Open
246	14.1	Medium Density Resid.
	3.5	Open
902*	3.6	Commercial
	1.2	Medium Density Resid.

TABLE 14

RIGHT-OF-WAY LAND ACQUISTION REQUIREMENTS FOR
NORTH PEORIA
(continued)

Location of Detention Basin or Channel Number	Area (acres)	Future Use
904*	0.8	Commercial
	1.9	Medium Density Resid.
	1.5	High Density Resid.
905*	0.4	Commercial
	5.8	Medium Density Resid.
	0.4	High Density Resid.
906*	4.6	Medium Density Resid.
909*	2.8	Commercial
	2.6	Medium Density Resid.
	0.5	High Density Resid.
911*	1.3	Commercial
	2.0	Office
	3.6	High Density Resid.
916*	2.3	Commercial
	6.1	Office
918*	4.5	Garden Industrial
	4.5	High Density Resid.
919*	0.6	High Density Resid.
91st Ave. and Beardsley Rd.	18.4	Medium Density Resid.

*Denotes channel included in interim plan but will ultimately be replaced with a pipe.

TABLE 15

RIGHT-OF-WAY LAND ACQUISITION REQUIREMENTS FOR
SOUTH PEORIA WEST OF NEW RIVER

Pipe Number	Area (acres)	Future Use
802	0.3	Commercial
805	0.2	Commercial
	0.2	Manufact. Housing

TABLE 16

CRITICAL UTILITY INTERFERENCES

Pipe Number	Description
154	Crosses 42" sanitary sewer at 99th Ave. and crosses Freeway
166	Crosses Grand Ave. and 27" sanitary sewer
180	Crosses 39" sanitary sewer at 99th Ave. and crosses Freeway
406	Crosses Freeway
420	Crosses 48" sanitary sewer
440	Crosses 36" water line at 51st Ave. and crosses AT & SF R.R.
508	Crosses 48" sanitary sewer
605	Crosses 48" storm sewer at Peoria Ave.
613	Crosses Freeway
620	Crosses Freeway
629	Crosses Grand Ave., 75th Ave., and Olive Ave. (significant crossing due to intersection)
657	Crosses Freeway
658	Crosses Freeway
665	Crosses Freeway
666	Crosses Freeway
670	Crosses Freeway
685	Crosses 36" sanitary sewer at 95th Ave. and crosses Freeway
698	Crosses Freeway

Section Nine

9. COSTS OF THE PREFERRED ALTERNATIVE

The estimated construction costs and land costs for the selected facilities in the five subareas are shown in Tables 17 to 26. The costs are based upon July 1985 construction costs in Maricopa County. The costs include 20 percent for engineering, legal, and administration, plus 20 percent for contingencies, including relocation of utilities.

A discussion of the derivation of the construction unit costs used for this analysis is contained in the Appendix.

TABLE 17

CAPITAL COSTS FOR SOUTH GLENDALE PIPES

Pipe Size (ft)	Unit Price (dollars)	Total Length (ft)	Amount (dollars)
1.5	58	7920	459,000
4.0	120	18540	2,225,000
4.5	140	15840	2,218,000
5.0	160	13020	2,083,000
5.5	185	26280	4,862,000
6.0	210	23440	4,922,000
6.5	235	9820	2,308,000
7.0	260	15660	4,072,000
8.0	320	17000	5,440,000
9.0	390	9240	3,604,000
10.0	450	26240	11,808,000
11.0	530	5280	2,798,000
12.0	600	12900	7,740,000
13.0	680	2640	1,795,000
14.0	760	2640	2,006,000
15.0	850	5280	4,488,000
16.0	940	2640	2,482,000
Subtotal			65,310,000
Engineering, legal, administration (20%)			13,062,000
Contingencies (20%)			13,062,000
TOTAL			91,434,000

TABLE 18

CAPITAL COSTS FOR SOUTH GLENDALE
DETENTION BASINS

Location of Detention Basin	Area (acres)	Land Purchase and Construction (dollars/acre)	Amount (dollars)
SE Corner of Bethany Home Rd. & 75th Ave.	10.4	90,000	936,000
NE Corner of Bethany Home Rd. & 83rd Ave.	8.4	90,000	756,000
NE Corner of Camelback Rd. and 91st Ave.	9.2	90,000	828,000
51st Ave. North of Bethany Home Rd.	8.4	48,000	403,000
SE Corner of Bethany Home Rd. & 59th Ave.	10.8	48,000	518,000
67th Ave. South of Bethany Home Rd.	10.0	90,000	900,000
NW Corner of Cactus Rd. and 75th Ave.	38.8	90,000	3,492,000
NE Corner of 91st Ave. and Bethany Home Rd.	34.8	90,000	3,132,000
Subtotal			10,965,000
Engineering, legal, administration (20%)			2,193,000
Contingencies (20%)			2,193,000
TOTAL			15,351,000

TABLE 19

CAPITAL COSTS FOR SOUTH PEORIA/GLENDALE PIPES

Pipe Size (ft)	Unit Price (dollars)	Total Length (ft)	Amount (dollars)
2.0	63	2640	166,000
2.5	71	9040	642,000
3.0	84	7080	595,000
3.5	100	22430	2,243,000
4.0	120	31500	3,780,000
4.5	140	41210	5,769,000
5.0	160	17530	2,805,000
5.5	185	19350	3,580,000
6.0	210	31620	6,640,000
6.5	235	26450	6,216,000
7.0	260	25220	6,557,000
7.5	290	14720	4,269,000
8.0	320	10560	3,379,000
8.5	360	1960	706,000
9.0	390	13820	5,390,000
9.5	420	7430	3,121,000
10.0	450	11700	5,265,000
12.0	600	5280	3,168,000
Subtotal			64,291,000
Engineering, legal, administration	(20%)		12,858,200
Contingencies	(20%)		12,858,200
TOTAL			90,007,400

TABLE 20

CAPITAL COSTS FOR SOUTH PEORIA/GLENDALE
DETENTION BASINS AND PIPE RIGHT-OF-WAY

Location of Detention Basin or Pipe Number	Area (acres)	Land Purchase and Construction* (dollars/acre)	Amount (dollars)
SW Corner of Olive Ave. and 51st Ave.	12.8	90,000	1,152,000
SE Corner of Olive Ave. and 59th Ave.	7.2	120,000	864,000
59th Ave. North of Olive Ave.	12.0	48,000	576,000
SE Corner of Olive Ave. and 67th Ave.	10.4	90,000	936,000
Orangewood Ave. West of 67th Ave.	39.2	120,000	4,704,000
SW Corner of Olive Ave. and 75th Ave.	13.2	120,000	1,584,000
Northern Ave. West of 83rd Ave.	18.0	48,000	864,000
75th Ave. North of Olive Ave.	8.8	90,000	792,000
658	0.4	100,000	40,000
634	0.5	100,000	50,000
635	1.0	100,000	100,000
621	0.4	75,000	30,000
677	0.3	100,000	30,000
678	0.3	100,000	30,000
Subtotal			11,752,000
Engineering, legal, administration (20%)			2,350,400
Contingencies (20%)			2,350,400
TOTAL			16,452,800

* Unit costs shown for pipe right-of-way acquisition are for land purchase only.

TABLE 21

CAPITAL COSTS FOR NORTH GLENDALE PIPES

Pipe Size (ft)	Unit Price (dollars)	Total Length (ft)	Amount (dollars)
1.5	58	5040	292,000
2.0	63	2640	166,000
4.5	140	10920	1,529,000
5.0	160	6580	1,053,000
5.5	185	2400	444,000
6.0	210	8780	1,844,000
7.0	260	10980	2,855,000
8.0	320	1900	608,000
9.0	390	2500	975,000
Subtotal			9,766,000
Engineering, legal, administration (20%)			1,953,200
Contingencies (20%)			1,953,200
TOTAL			13,672,400

TABLE 22

CAPITAL COSTS FOR NORTH GLENDALE DETENTION BASINS

Location of Detention Basin	Area (acres)	Land Purchase and Construction (dollars/acre)	Amount (dollars)
Bell Rd. East of 59th Ave.	5.0	90,000	450,000
South of Bell Rd. on 59th Ave.	3.0	120,000	360,000
South of Greenway Rd. on 59th Ave.	9.0	48,000	432,000
Subtotal			1,242,000
Engineering, legal, administration (20%)			248,400
Contingencies (20%)			248,400
TOTAL			1,738,800

TABLE 23

CAPITAL COSTS FOR NORTH PEORIA PIPES AND CHANNELS

Pipe Size (ft)	Unit Price (dollars)	Total Length (ft)	Amount (dollars)
4.5	140	5220	731,000
5.5	185	7820	1,447,000
6.0	210	10680	2,243,000
7.5	290	6280	1,821,000
9.5	420	5280	2,218,000
10.5	490	6000	2,940,000
11.0	530	5500	2,915,000
11.5	560	5250	2,940,000
Pipe Subtotal			17,255,000

Channel Number	Excavation Volume (cy)	Excavation Cost* (dollars)	Lining Area (sy)	Lining Cost* (dollars)
115	24086	169,000	23562	377,000
117	12602	88,000	13622	218,000
118	5172	36,000	7390	118,000
119	10701	75,000	12355	198,000
141	6111	43,000	8020	128,000
143	75583	529,000	64094	1,026,000
144	32666	229,000	32219	515,000
145	32670	229,000	32549	521,000
146	56879	398,000	48035	769,000
217	116160	813,000	-	-
218	14960	105,000	-	-
219	50160	351,000	-	-
246	111320	779,000	-	-
Channel Subtotals		3,844,000		3,870,000
Subtotal				24,969,000
Engineering, legal, administration (20%)				4,993,800
Contingencies (20%)				4,993,800
TOTAL				34,956,600

*Excavation cost at $7/cy and Lining cost at $16/sy

TABLE 24

CAPITAL COSTS FOR NORTH PEORIA
DETENTION BASINS AND CHANNEL RIGHT-OF-WAY

Location of Detention Basin or Channel Number	Area (acres)	Land Purchase (dollars/acre)	Amount (dollars)
115	5.9	75,000	442,000
	1.5	40,000	60,000
117	3.6	75,000	270,000
	0.9	40,000	36,000
118	2.3	75,000	172,000
	0.6	40,000	24,000
119	3.0	75,000	225,000
	1.3	40,000	52,000
141	1.5	75,000	112,000
	1.5	40,000	60,000
143	16.0	75,000	1,200,000
	1.8	40,000	72,000
144	5.0	75,000	375,000
	5.0	40,000	200,000
145	6.2	75,000	465,000
	4.2	40,000	168,000
146	10.7	75,000	802,000
	2.7	40,000	108,000
217	15.6	75,000	1,170,000
	3.9	40,000	156,000
218	2.6	75,000	195,000
	0.6	40,000	24,000
219	6.5	75,000	488,000
	2.8	40,000	112,000
246	14.1	75,000	1,058,000
	3.5	40,000	140,000
902*	3.6	175,000	630,000
	1.2	75,000	90,000

TABLE 24

CAPITAL COSTS FOR NORTH PEORIA
DETENTION BASINS AND CHANNEL RIGHT-OF-WAY
(continued)

Location of Detention Basin Channel Number	Area (acres)	Land Purchase (dollars/acre)	Amount (dollars)
904*	0.8	175,000	140,000
	3.4	75,000	255,000
905*	0.4	175,000	70,000
	6.2	75,000	465,000
906*	4.6	75,000	345,000
909*	2.8	175,000	490,000
	3.1	75,000	232,000
911*	1.3	175,000	228,000
	2.0	100,000	200,000
	3.6	75,000	270,000
916*	2.3	175,000	402,000
	6.1	100,000	610,000
918*	4.5	100,000	450,000
	4.5	75,000	338,000
919*	0.6	75,000	45,000
91st Ave. and Beardsley Rd.	18.4	90,000 **	1,656,000
Subtotal			15,102,000
Engineering, legal, administration (20%)			3,020,400
Contingencies (20%)			3,020,400
TOTAL			21,142,800

Note: Different land purchase prices within the same right-of-way are due to different land uses within the right-of-way.

* Denotes ditch included in interim plan but will ultimately be replaced with a pipe.

** Unit cost for detention basin includes construction costs.

TABLE 25

CAPITAL COSTS FOR SOUTH PEORIA
WEST OF NEW RIVER PIPES

Pipe Size (ft)	Unit Price (dollars)	Total Length (ft)	Amount (dollars)
5.0	160	1600	256,000
5.5	185	3690	683,000
6.5	235	1400	329,000
7.0	260	3850	1,001,000
Subtotal			2,269,000
Engineering, legal, administration	(20%)		453,800
Contingencies	(20%)		453,800
TOTAL			3,176,600

TABLE 26

CAPITAL COSTS FOR SOUTH PEORIA WEST
OF NEW RIVER PIPE RIGHT-OF-WAY

Pipe Number		Area (acres)	Land Purchase (dollars/acre)	Amount (dollars)
802		0.3	175,000	53,000
805		0.2	175,000	35,000
		0.2	75,000	15,000

Subtotal				103,000
Engineering, legal, administration	(20%)			20,600
Contingencies	(20%)			20,600
TOTAL				144,200

Section Ten

10. IMPLEMENTATION AND CONSTRUCTION PHASING

ADOPTION OF THE PREFERRED ALTERNATIVE

It is recommended that the Flood Control District review and adopt this plan as the Glendale-Peoria Area Drainage Master Plan. The District should work with the Cities of Glendale and Peoria to prevent development of declared detention basins sites prior to their acquisition and to establish alignments for trunk stormwater facilities. This action will strengthen the policies concerning stormwater and drainage in the City of Glendale, the City of Peoria, and in Maricopa County, and will require new stormwater facilities to be in conformance with the ADMP.

INTERAGENCY COOPERATION

The Cities of Glendale and Peoria have stormwater interfaces with Maricopa County, the Arizona Department of Transportation, the Corps of Engineers, and the Salt River Project. Because of these conditions, interagency cooperation in the management of stormwater is recommended.

Interagency agreements might address the following subjects:

1. Control of stormwater overflows;
2. Closing of certain streets during periods of heavy runoff;
3. Improvement of existing stormwater facilities;
4. Construction of new stormwater facilities (interim and/or permanent);
5. Runoff controls; and/or
6. Emergency operations plan during flood conditions.

Glendale, Peoria and the Flood Control District should cooperate with the Arizona Department of Tranportation as the Outer Loop Freeway and Grand Avenue Improvements are designed and constructed.

SUGGESTED PHASING

Due to extent of the selected storm drainage facilities, it will not be practical or feasible to implement the entire system at one time. These facilities should, therefore, be installed in planned phases.

The highest priority items for implementation should include:

- Updating of individual stormwater master plans for Glendale and Peoria to ensure compatibility with the ADMP, and initiation of any necessary revisions to their respective city codes.
- Acquisition of right-of-way for the detention basins, since the sizes of pipes downstream of these basins may be affected by decisions to change the location or size of these basins.
- Planning and construction of pipes to cross the Outer Loop Freeway.
- Implementation of the ADMP facilities which would include the Northern Avenue, Olive Avenue, and Cactus Road drains in Peoria and Glendale. Construction of these facilities will relieve existing flooding problems in these areas, and will provide proper outlets for subsidiary drains that can be added as second priority items.

The following outline summarizes the recommended phased construction program.

I. First Priority - ADMP Facilities

- Phase 1

  Purchase all detention basin right-of-way, since pipe sizing is based on having these basins in place.

Estimated Costs	
Peoria Basins	$3,960,000
Glendale Basins	9,600,000
Total Cost of Phase 1	$13,560,000

. Phase 2

Construction of drains and associated detention areas.

Item 1 - Olive Avenue drain

Estimated Cost	$11,890,000

Item 2a - Cactus Road drain

Estimated Cost	$9,360,000

Item 2b - Northern/Orangewood drain

Estimated Cost	$15,760,000
Total Cost of Phase 2	$37,010,000

. Phase 3

Construction of drainage facilities connecting to the ADMP facilities in both Peoria and Glendale

Item 1 - Pipes connecting to Olive Avenue drain

Estimated Costs

Peoria Pipes	$5,150,000
Glendale Pipes	$14,060,000
Subtotal	$19,210,000

Item 2a - Pipes connecting to Cactus Road drain

Estimated Costs

Peoria Pipes	$1,710,000
Glendale Pipes	$2,750,000
Subtotal	$4,460,000

Item 2b - Pipes connecting to Northern/Orangewood Avenue drain

Estimated Costs

Peoria Pipes	$6,090,000
Glendale Pipes	$13,190,000
Subtotal	$19,280,000

Total Cost of Phase 3	$42,950,000

II. Second Priority - Individual Peoria/Glendale Facilities

A. Peoria

. Phase 1

Item 1 - Construct detention basin and interim ditches in the Bell Road to Pinnacle Peak Road area, including right-of-way purchase if necessary. The goal is to have the drainage channel in place prior to development, so that developers will pay for pipe installation as the road and other improvements are constructed for their developments.

Estimated Right-of-Way Costs	$9,681,000
Estimated Facilities Costs	$3,969,000

Item 2 - Pipes under Outer Loop Freeway

Estimated Cost	$2,400,000

Total Cost of Phase 1	$16,050,000

. Phase 2 - Complete other drainage facilities in South Peoria

Item 1 - Thunderbird Road drain

Estimated Cost	$3,680,000

Item 2 - Northern Avenue drains west of New River

Estimated Cost	$3,320,000

Item 3 - Minor drains near Grand Avenue

Estimated Cost	$1,870,000

Item 4 - Parallel Peoria Avenue drain (if necessary)

Estimated Cost	$4,750,000

Total Cost of Phase 2	$13,620,000

. Phase 3 - Replacement of interim ditches in the area from Bell Road to Pinnacle Peak Road with pipes, concurrent with development or road-improvement projects. (Some costs may be borne by developers in the area).

Estimated Cost	$24,160,000

B. Glendale

. Phase 1 - Construct detention basins and interim ditches along Grand Canal and Bethany Home Road, including right-of-way purchase if necessary. The goal is to have the drainage channel in place prior to development so that developers will pay for pipe installation as the road and other improvements are constructed for their developments.

Estimated Right-of-Way Costs	$11,490,000
Estimated Facility Costs	$2,000,000
Total Cost of Phase 1	$13,490,000

- Phase 2 - Complete detention basins and other drainage facilities in Glendale including interim ditch along Camelback Road from 79th Avenue to New River. (Some costs may be borne by developers in the area.)

Estimated Right-of-Way Costs	$5,600,000
Estimated Facility Costs	$105,100,000
Total Cost of Phase 2	$110,700,000

III. <u>Third Priority - Individual Peoria/Glendale Facilities</u>

A. Peoria

- Phase 1 - Purchase right-of-way for channels in North Peoria north of Pinnacle Peak Road, provided that a land use plan for the area has been developed.

Estimated Cost $11,460,000

- Phase 2 - Construction of open channels in North Peoria north of Pinnacle Peak Road, as development warrants

Estimated Cost $10,800,000

B. Glendale

None

Section Eleven

INTRODUCTION

An important part of developing a stormwater drainage system for the Glendale-Peoria study area will be the determination of a satisfactory method of obtaining funds for the initial construction of the facilities, and for the yearly operation and maintenance costs that will be needed to keep the system functioning properly.

There are a number of methods that could be used for obtaining financing that will be equitable and acceptable to the public. It will be possible to use different methods for construction funding, and for operation and maintenance costs. A combination of funding methods could also be used for any of the financial requirements of the drainage plan.

The following sections describe the possible financing methods which could be used by the cooperators for implementing and maintaining the selected facilities. The key features, advantages, and disadvantages of these methods are shown in Table 27.

CAPITAL REQUIREMENTS

Federal Loans/Grants

A number of federal programs exist that relate to funding for drainage and flood control activities. These are initiated through the Department of Agriculture, the Department of Interior, the Environmental Protection Agency, the Department of Commerce, and the Army Corps of Engineers. Most of the specific programs are structured in a manner that requires lengthy study, planning, design, and construction staging. The funding of all such programs is uncertain due to the need for executive branch budget approval in concert with legislative branch appropriation.

TABLE 27

FUNDING SOURCES
AVAILABILITY AND APPLICABILITY

Source of Funds	Availability	Applicability	Advantages	Disadvantages
Federal Loans/Grants	Unlikely	Construction	Low Financing Costs	Competition w/Other Agencies
State & County Loans/Grants	Probable	Construction	Low Financing Costs	Competition w/Other Agencies
Bonds:				
Assessment Bonds	Possible	Construction	No Direct City Debt	Special Engineering Report Needed
Revenue Bonds	Possible	Construction	User/Benefit Relationships	Voters Must Approve
General Obligation Bonds	Unlikely	Construction	Large Bond Market	Voters Must Approve
Non-Profit Corporation	Probable	Construction	Recognized Method	Complex to Set Up
Reserve Funds	Possible	Construction and O&M	No Interest Costs	Uneven Cash Flow
Taxation	Probable Difficult	Construction O&M	Implementable by Zones Costs are Widely Spread	Has never applied Difficult to Obtain Public Acceptance
Developer Fees:				
Zone Fees	Probable	Construction	Easily Administered	Dependent on Growth
Acreage Fees	Probable	Construction	Easily Explained	Unrelated to Land Use
Trunk Fees	Probable	Construction	Provides Advance Funding	Possible Imbalance Between Developers
User Fees:				
Uniform Service Charge	Probable	O&M	Understandable	May Lack Equitability
Variable Service Charge/ Drainage Contribution	Probable	O&M	Considers Runoff Factors	Requires Engineering Analysis
Variable Service Charge/ Zoning Drainage	Possible	O&M	Recognizes Land Use	Relatively Complex

State Cost-Sharing

Drainage and flood control funding administered by the State of Arizona is handled through the Department of Water Resources. State funding mechanisms are well defined, but availability of funds is uncertain due to the impact of future budget and appropriation decisions.

Bonds

Three basic types of bond financing are recognized by the State of Arizona: Assessment Bonds, Revenue Bonds, and General Obligation Bonds. Assessment bond costs are those associated with public works, and represent an unpaid assessment levied against the property owners who benefit from the facilities constructed. This type of bond is also referred to as an "Improvement Act" bond and can be issued under either of two formats. In one case, the issuing agency assumes a contingent liability, and, in the case of delinquency, can advance the amount due or can establish a limited tax that applies only to the delinquent area. In the other, and more commonly used form, the issuing agency has no obligation to the bondholder other than to forward payments made by property owners.

Improvement district bonds relate to a debt obligation of an area that is less than district-wide. Debt service costs may be met through property taxes or assessments but only against the specific property contained within the improvement district.

Revenue bonds require both the demonstration of adequate revenues and the pledge to create and maintain a reserve fund.

General obligation bonds rely on their security through the taxing powers of the issuing agency. This form of financing is usually, though not necessarily, associated with property taxation.

Non-Profit Corporations

Initially, non-profit corporations were used in connection with the funding of a specific facility, frequently a municipal building. More recently, they have been used in relation to multiple projects or to improvements of various facilities. The essential features of a non-profit corporation are that it can be created by a public agency, that it be truly non-profit, that it act as the landlord during the term of the bond, and that the facilities become the property of the public agency at the time the debt obligation is retired.

Reserve Funds

The use of reserve funds by a public agency for capital improvements or for operation and maintenance is limited to critical situations -- those in which no other funding source is appropriate. Obviously, the legal constraints that apply to existing reserve funds must be known and followed. In addition, suitable mechanisms must be developed so that reserve funds used in this way can be replaced in a timely manner.

Taxation

Recent flood control legislation by the State allows flood control districts to designate zones for the purpose of special levies. Property owners within each zone may be taxed based on the benefits they obtain from special flood control projects.

OPERATION AND MAINTENANCE REQUIREMENTS

Taxation

A public agency can apply a general tax against property for a demonstrated revenue need. Taxation would be an appropriate financing device where the public need is apparent to the electorate. Special taxes may be per house, per lot, per lot size or other method.

Developer Fees

When an area is being developed for residential, commercial, or industrial purposes, it is sometimes appropriate to levy a fee against the developer to offset the capital costs of storm drainage facilities. These costs are then, clearly, passed along to the eventual owner or user of the property. This transfer of costs may be at cross purposes with agency goals in terms of growth or expansion. Developer fees may also create some problems when analyzed in relation to earlier development practices or in relation to the fee to be charged to some future developer. Three types of developer fees are possible. One is a drainage improvement zone fee that is tailored to the costs associated with a specific location, usually an identifiable drainage area or basin. Another is commonly referred to as an acreage fee and is uniformly applied. The third is a trunk facilities fee whose revenues are used to construct major conveyance facilities.

User Fees

The concept of a user fee for drainage and flood control purposes is relatively well established in many parts of the country. By its nature, it resolves the issue that those who use or benefit from a public utility system should also pay the associated costs. In some cases, the technical issues relating to how much rainfall is absorbed into the ground, how much evaporates, or how much runs off from a given user's land can be of considerable concern. Nevertheless, there are accepted methods for making these determinations and producing user fees that are equitable between users or between user classes.

Reserve Funds

As stated above, the use of reserve funds for operation and maintenance costs is limited to critical situations. Where no alternative source is available or appropriate, reserves can be utilized; however, their replacement must be planned accordingly.

Other Methods

In those cases where a municipality or an existing drainage and flood control agency chooses to modify or add to its current facilities, a financial restructuring is sometimes appropriate. One method of accomplishing this is under a "redevelopment program." The basic premise of this type of program assumes that redeveloped areas will exhibit an increase in assessed valuation and that the incremental increase in property tax revenue can be used to fund redevelopment work.

Section Twelve

12. INSTITUTIONAL CONSIDERATIONS AND INFRASTRUCTURE IMPROVEMENTS

INSTITUTIONAL CONSIDERATIONS

The actual implementation of the stormwater plan and the maintenance of the stormwater drainage facilities will require actions by political institutions. In addition, planning and coordination with other institutions that may have jurisdiction over some portion of the facilities will be required.

In addition to the Flood Control District of Maricopa County, there are a number of other institutions that could play a part in the implementation of the plan.

Federal

The U.S. Army Corps of Engineers has traditionally been responsible for flood control planning and construction on major river systems. The Corps also issues permits for construction over navigable waters. More recently, the Corps has also devoted some attention to urban flood control with the funding of a number of urban studies. The Corps emphasizes the use of structural solutions, with the justification of these solutions based on a favorable benefit/cost ratio. The Arizona Canal Diversion Channel is a Corps project.

The Soil Conservation Service (SCS) of the U.S. Department of Agriculture is involved with planning and funding of watershed management and floodplain management programs. Traditionally, the SCS has worked with local soil and water conservation districts in rural areas to provide technical and financial assistance to local landowners, occupants, and other local agencies. However, the SCS has recently expanded its program to provide similar assistance in urban areas. There are no current SCS projects in Glendale.

The Federal Emergency Management Agency (FEMA) is responsible for administering the National Flood Insurance Act, which makes flood insurance available to property owners living on flood-prone lands. To be a part of the program, a community must meet certain requirements, including implementation of floodplain land use control measures. FEMA develops maps showing the location of the floodplain and the magnitude of flood hazards within the community.

In 1981 FEMA completed flood insurance studies for Peoria and Glendale. These studies indicate flood levels in the Agua Fria River, New River, and Skunk Creek, as well as the areas of the cities which will be flooded during the 100-year and 500-year floods.

As part of the Central Arizona Project, the Corps of Engineers has built the Adobe Dam and New River Dam facilities. Because of the effect these facilities have on flood conditions in Peoria and Glendale, FEMA is considering modifying the previous flood insurance studies for these cities.

The Environmental Protection Agency (EPA) is responsible for enforcing federal water pollution laws. Although these laws area generally concerned with point sources of pollution such as sanitary sewage outfalls and industrial outfalls, they are also concerned with non-point sources of pollution that would be associated with storm runoff.

State

In the State of Arizona, the Department of Water Resources is responsible for drainage and flood control. The Department is generally concerned with problems of a regional or statewide nature.

County

Within Maricopa County, the Flood Control District of Maricopa County is generally concerned with drainage and flood control problems of an inter-jurisdictional nature, and shares costs for design and construction of necessary improvements in cooperation with other jurisdictions.

The Maricopa County Highway Department is generally concerned with drainage affecting their road improvements, particularly the construction of cross-drainage structures.

Municipal

Because the drainage plan will most affect the Cities of Peoria and Glendale, close coordination with these cities will be required for implementation of the selected plan.

INFRASTRUCTURE IMPROVEMENTS

The installation of the complete storm drainage system will be a large undertaking which will have to be done over a period of many years.

In order to eliminate unnecessary disruption, the storm drainage system should be coordinated with other planned infrastructure improvements in the cities. When major reconstructon of streets is planned, the stormwater system should be installed at the same time. If downstream portions of the stormwater system are not ready, the pipe can be blocked at each end and connected at a later time.

The details of the stormwater system should be coordinated with other major utilities such as water and sewer lines. Advance planning of the locations of pipes and utilities can reduce problems that could occur at a later time. During construction of facilities, sleeves should be installed at proposed crossings so that pipes can later be inserted without relocating or extensively modifying the existing facility.

In all developing areas south of the Arizona Canal that are currently used for agriculture, coordination with the Salt River Project over the existing irrigation canals will be required.

The recommended plan calls for the use of detention facilities to reduce the cost of the system. Detention facilities would be located in city parks or vacant space wherever possible. Due to the multipurpose use of these areas, the use as a detention facility must be carefully coordinated to avoid unnecessary disruption, inconvenience, and maintenance problems. The detention basins, wherever possible, should have water enter the basin only when the capacity of the downstream drain is exceeded. This would keep the basin dry during very small storms, and would reduce the interference with other uses of the site.

In planning the detention facilities, it will be necessary to ensure that no flooding or damage will occur to buildings and structures. It may be desirable to grade or build compartments in the facility so that some unflooded space will remain after frequent, small storms. Complete inundation would occur only during major storms.

The length of time that water would be stored in the detention facility would depend on the size of the storm and the design of the facility's outlet structure. However, it is anticipated that during major storms, park facilities would drain in 2 hours and other facilities would be emptied within 1 day after the end of the storm.

Section Thirteen

13. CONDITIONS AND LIMITATIONS

In the development of the recommended plan, certain conditions and limitations have been imposed or applied. These include:

1. The ADMP has been based upon information about the existing stormwater system obtained from the City of Glendale, the City of Peoria, the Arizona Department of Transportation, and other agencies. No field surveys were performed.

2. Stormwater runoff rates and volumes for the preferred alternative have been calculated with the information in 1. There are no measurements of stormwater runoff rates. Any physical changes in the stormwater system will modify the runoff rates presented herein.

3. It was assumed that all existing stormwater system components will be adequately maintained so that their existing flow carrying capacity will not be diminished.

4. It was assumed that inlet grates are capable of allowing stormwaters to enter the inlets and that manholes and inlets along pipelines do not restrict flow.

5. The recommended ADMP is based on the land use projections presented in the City of Peoria General Land Use Plan, 1982, City of Glendale General Plan 1980-2005, and the two supplements: Western Glendale Community Plan and the West Glendale Area Plan.

6. The recommended ADMP is a first step toward orderly stormwater management. Prior to the next step, preliminary designs and field surveys will be needed to verify pipe sizes, elevations, and other details about the overall stormwater system and areas tributary to the system.

7. Studies in regard to structural adequacy of the existing stormwater facilities and water quality are beyond the scope of this ADMP.

Section Fourteen

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Appendix A

TABLE A-1

DESIGN RAINFALL

Time (hours and minutes)	Rainfall Intensity (inches per hour)			
	2 Year	5 Year	10 Year	100 Year
0-0:15	2.0	2.85	3.25	4.80
0:15-0:30	0.70	0.95	1.15	1.92
0:30-0:45	0.40	0.56	0.72	1.14
0:45-1:00	0.24	0.38	0.48	0.66
1:00-1:15	0.14	0.22	0.32	0.55
1:15-1:30	0.11	0.18	0.22	0.45
1:30-1:45	0.10	0.15	0.18	0.36
1:45-2:00	0.084	0.12	0.17	0.30
2:00-2:15	0.080	0.11	0.15	0.24
2:15-2:30	0.080	0.10	0.14	0.20
2:30-2:45	0.080	0.10	0.13	0.18
2:45-3:00	0.076	0.096	0.12	0.16
3:00-3:15	0.076	0.092	0.12	0.15
3:15-3:30	0.072	0.088	0.12	0.15
3:30-3:45	0.068	0.084	0.11	0.14
3:45-4:00	0.064	0.080	0.10	0.14
4:00-4:15	0.060	0.080	0.10	0.13
4:15-4:30	0.060	0.076	0.10	0.13
4:30-4:45	0.056	0.072	0.096	0.13
4:45-5:00	0.052	0.068	0.092	0.12
5:00-5:15	0.048	0.064	0.092	0.12
5:15-5:30	0.048	0.060	0.088	0.12
5:30-5:45	0.044	0.056	0.084	0.12
5:45-6:00	0.044	0.056	0.080	0.12

CONSTRUCTION UNIT COSTS

The unit price costs for storm sewer construction presented in Tables 17, 19, 21, 23, and 25 are based on nine storm sewer projects which bid within the 2-year period from mid-1983 to mid-1985. Two of the projects were constructed in the City of Peoria, while the remaining seven projects were constructed within the City of Phoenix. Each of the nine projects utilized reinforced concrete pipe as the primary pipe material.

To analyze the bid data, weighted pipe installation costs from the three low bids of each of the nine projects were calculated. These average costs were weighted based on lineal footage installed, so that costs obtained from projects which utilized greater quantities of a given pipe diameter were more representative of the average costs. The pipe installation costs obtained from these projects included the cost of the pipe, as well as costs for trench excavation and backfill. A cost estimation curve was then generated from these average costs, relating installation cost per foot of pipe to pipe diameter. The use of the curve allowed estimation of pipe installation costs for a wide range of pipe diameters, including those for which no bid data could be obtained.

Because the costs obtained were for pipe installation only and did not include other items associated with storm sewer projects, such as manholes, catch basins, pavement replacement, etc., an estimate of the total project cost was needed. To develop this estimate, ratios of the total project cost to the pipe installation cost for the nine storm sewer projects were calculated. The nine ratios averaged approximately 1.37. Thus, once the pipe installation cost per foot of pipe for a given pipe diameter was obtained from the cost estimation curve, an estimate of the total construction cost associated with that pipe was calculated by multiplying the installation cost by a factor of 1.37. The unit prices shown in Tables 17, 19, 21, 23, and 25 include the 1.37 factor, and therefore yield the total construction costs to be expected for a storm sewer project when multiplied by the length of pipe required.

In addition to underground pipes, the Glendale-Peoria ADMP also includes open channel conveyance systems. Thus, cost estimates for construction of this type of structure were required. To calculate channel construction costs, ADOT was contacted to obtain cost data for the open channel constructed adjacent to the newly completed sections of the Papago (I-10) Freeway in Phoenix. This channel has a minimum bottom width of 12 feet, and side slopes of 2:1 (horizontal:vertical), which is similar in shape to the channels proposed for the Glendale-Peoria ADMP. The primary costs in construction of the Papago Freeway Drainage Channel were for excavation and lining. For the three low bids received, excavation costs averaged $3.00 per cubic yard of earth, and lining costs averaged $16.00 per square yard of 6-inch thick concrete lining.

As the Papago Freeway Drainage Channel represented only one source of cost data, a local construction company was contacted to determine estimates for excavation costs. Their estimates ranged from $2.00 to $6.00 per cubic yard of excavation, depending on conditions such as haul length and type of equipment used. Thus, to provide a conservative estimate for channel construction costs, a cost of $5.00 per cubic yard of excavation was selected. The total excavation cost for a given channel was then increased by 40 percent to account for any other facilities required, such as culverts at road crossings, or inlet/outlet structures.

NORTHERN/ORANGEWOOD ADMP FACILITY

PIPE PROFILE
ORANGEWOOD AVENUE

Pipe Number	Location	Exist. Ground Elev.	Pipe Invert Elev.	Equiv. Pipe Size (ft)	Pipe Length (ft)	Pipe Slope
	New River	1066.0	1058.0			
180				8.5	1960	.0020
	99th Avenue	1074.0	1062.0			
182				9.0	2640	.0027
	1/2 mile west of 91st Avenue	1081.0	1069.0			
184				9.5	2640	.0019
	91st Avenue	1086.0	1074.0			
186				7.5	2640	.0019
	1/2 mile west of 83rd Avenue	1091.0	1079.0			
188				6.0	2640	.0064
	83rd Avenue	1108.5	1096.0			
190				6.5	2640	.0034
	1/2 mile west of 75th Avenue	1117.5	1105.0			
192				7.0	2640	.0023
	75th Avenue	1123.0	1111.0			
194				6.0	2640	.0015
	1/2 mile west of 67th Avenue	1218.0	1115.0			
196				12.0	2640	.0034
	67th Avenue	1135.0	1124.0			
	67th Avenue Profile					
	Orangewood Ave	1135.0	1124.0			
198				12.0	2640	.0034
	Northern Avenue	1142.0	1133.0			
	91st Avenue Profile					
	Orangewood Ave	1086.0	1076.0			
185				6.0	2640	.0038
	Northern Avenue	1095.5	1086.0			
	Northern Avenue Profile					
	91st Avenue	1095.5	1087.0			
694				5.0	1320	.0033
	3/4 mile west of 83rd Avenue	1097.5	1091.5			
692				4.5	2640	.0009
	1/4 mile west of 83rd Avenue	1100.0	1094.0			

OLIVE AVENUE ADMP FACILITY

PIPE PROFILE
OLIVE AVENUE

Pipe Number	Location	Exist. Ground Elev.	Pipe Invert Elev.	Equiv. Pipe Size (ft)	Pipe Length (ft)	Pipe Slope
	New River	1090.0	1080.0			
686				9.0	2200	.0038
	1/2 mile west of 91st Avenue	1102.5	1088.4			
685				9.0	2640	.0032
	91st Avenue	1111.0	1098.0			
684				8.0	2640	.0029
	1/2 mile west of 83rd Avenue	1117.5	1105.7			
681				8.0	2640	.0021
	83rd Avenue	1124.0	1112.0			
680				7.0	2640	.0022
	1/2 mile west of 75th Avenue	1130.0	1118.5			
629				6.5	2700	.0019
	75th Avenue	1135.0	1123.6			
627				6.5	2640	.0036
	1/2 mile west of 67th Avenue	1145.0	1135.0			
174				4.5	2640	.0045
	67th Avenue	1155.0	1147.0			
288				6.0	2460	.0028
	1/2 mile west of 59th Avenue	1164.0	1154.5			
289				3.5	2640	.0034
	59th Avenue	1173.0	1165.5			
256				6.5	2640	.0027
	1/2 mile west of 51st Avenue	1181.0	1176.0			
259				3.0	2640	.0038
	51st Avenue	1191.0	1186.0			
		<u>75th Avenue Profile</u>				
	Olive Avenue	1135.0	1124.0			
628				6.0	1030	.0042
	1/5 mile north of Olive Avenue	1140.0	1128.5			
626				6.5	1510	.0026
	1/2 mile north of Olive Avenue	1143.0	1132.5			
		<u>59th Avenue Profile</u>				
	Olive Avenue	1173.0	1165.5			
262				5.0	2640	.0023
	1/2 mile north of Olive Avenue	1180.0	1171.5			

CACTUS ROAD ADMP FACILITY

PIPE PROFILE
CACTUS ROAD

Pipe Number	Location	Exist. Ground Elev.	Pipe Invert Elev.	Equiv. Pipe Size (ft)	Pipe Length (ft)	Pipe Slope
	New River	1129.0	1117.0			
659				9.5	2150	.0033
	91st Avenue	1138.0	1124.0			
657				9.5	2640	.0032
	1/2 mile west of 83rd Avenue	1146.0	1132.4			
656				10.0	2640	.0029
	83rd Avenue	1153.0	1140.0			
655				10.0	2640	.0019
	1/2 mile west of 75th Avenue	1158.0	1145.0			
653				8.0	2640	.0036
	75th Avenue	1166.0	1154.4			
651				7.5	2640	.0040
	1/2 mile west of 67th Avenue	1172.5	1165.0			
178				7.0	2640	.0027
	67th Avenue	1182.0	1172.0			