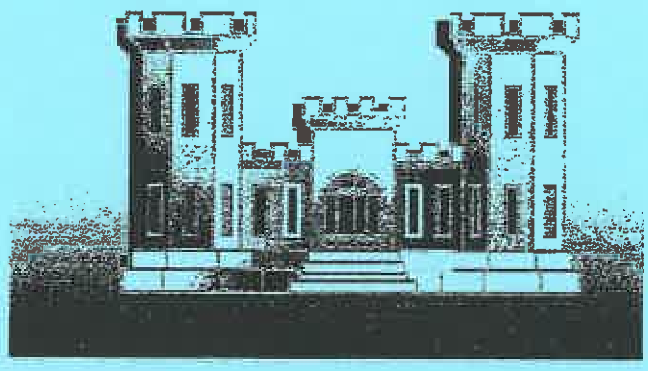
PLANNING ASSISTANCE STUDY

DRAINAGE AND FLOOD CONTROL PLAN
AIRPORT ROAD CHANNEL AND VICINITY

City of Douglas, Cochise County, Arizona



Prepared For:

U.S. ARMY CORPS OF ENGINEERS,
LOS ANGELES DISTRICT,
PLANNING SECTION B

Prepared By:

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CONTRACT DACW09-97-D0011

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Vernon Harrell, U.S.A. COE

November 1999

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I. INTRODUCTION

1.1 Purpose

The city of Douglas is currently developing plans to construct a flood control structure which will retain flows from two sub-basins on the eastern end of the city. The proposed plan consists of (1) an incised earthen channel, located along the eastern side of Airport Road, approximately between the International Border with Mexico and downstream of Geronimo Trail, which will serve also as a retention area; (2) a small below-grade retention basin at the downstream end of the channel; (3) an above-grade retention area downstream of the small retention basin, from Geronimo Trail north to approximately Rattlesnake Hill; and (4) and a second, larger, above-ground retention basin north of the first above-ground retention basin.. A spillway is proposed to connect the first above-ground retention basin to the second above-ground retention basin. A second spillway constructed along the berm of the larger, above-ground retention basin will release flows into the current channel of Palm Grove Wash, when the water surface elevation within the basin overtops the spillway. Components 1-3 above are planned to retain flows arriving from sub-basin 1; component 4 above is planned to retain combined flows arriving from sub-basins 1 and 2. The portion of the project which would retain flows from Sub-Basin 1 would be constructed on property within the City's jurisdiction, and could be implemented by the City alone. The portion of the project which would retain flows for Sub-Basin 2 would be constructed on both City and County land and would require coordination between the City and the County to implement the plan. It was not within the scope of this study to coordinate the study effort with Cochise County.

It is expected that the retention basin system will reduce flooding of Palm Grove Wash to the western part of the city by reducing the peak discharge; reduce flooding to the eastern part of the city by collecting flows that would otherwise travel westerly across Airport Road; and reduce flood flows traveling into Mexico by collecting flows diverted by berms or ditches.

To assist them in their preliminary design, the City requested under the 206 program a study to determine the time of concentration of each sub-basin, the peak flood flow from each sub-basin, and the total volume of runoff from each sub-basin. This report presents the results of hydrologic study performed to determine those quantities.

1.2 Objectives

This flood plain management study has been performed to determine the hydrologic characteristics of two sub-basins east of the city of Douglas, to assist in their preliminary design for a flood control structure. The city of Douglas was consulted at the beginning of the study effort to discuss the work to be performed, the plan of study, and the products to be provided. Based on that discussion, as well as discussions later on during the hydrologic investigations, in addition to earlier discussions with the Flood Plain Coordinator of the Los Angeles District Corps of Engineers, the following objectives were identified.

1. Research and review existing flood plain maps, topographical maps, hydrology studies, hydraulic studies, and ground survey data for the project reaches. Conduct a field investigation to document existing site conditions.

2. Develop appropriate hydrologic methodology for the study.

3. Compute the areas of the two sub-basins on the eastern end of the City.

4. Use HEC-1 to model the sub-basins with the proposed flood retention structures in place. Develop a 24-hour, 100-year peak discharge from each of the basins. Determine the 24-hour, 100-year total storm runoff volume.

5. Perform hydraulic calculations to determine the limits of flooding and the hydraulic characteristics of the flood plain of Palm Grove Wash downstream of the proposed flood retention structures to approximately State Route 80.

6. Comment upon the city's proposed plan and provide engineering recommendations for the proposed flood control structures.

7. Provide recommendations for additional studies and work efforts.

The hydrologic and hydraulic calculations performed for this study are preliminary and additional detailed studies or analysis would be necessary to establish a basis for preparing design documents.

1.3 Study Authority

This study was prepared under the authority of Section 206 of the Flood Control Act of 1960, as amended. Federal Regulation ER-1105-2-100 governs the Flood Plain Management (FPM) Program, which encourages as its objective the prudent use of the Nation's floodplains for the benefit of the national economy and the general welfare by supporting comprehensive flood plain management planning at all appropriate governmental levels.

Under Technical Services, flood and flood plain data are obtained or developed and interpreted. This includes information of flood formation and timing, flood depth or stage, floodwater velocity, obstruction to flood flows, regulatory floodways, natural and cultural resources of flood plains, and flood loss potentials before and after employment of FPM measures.

Under Planning Assistance, assistance and guidance are provided or studies are conducted on all aspects of FPM planning, including the possible impacts of off-flood plain land use changes on the physical, socioeconomic and environmental conditions of the flood plain. This can range from helping a community identify present and future flood plain areas and related problems, to a broad assessment as to which of the FPM measures, of both the flood modifying and damage modifying varieties, may be appropriate. It also includes flood warning and preparedness planning, and planning for permanent evacuation, relocation, and flood proofing.

Within personnel and funding capabilities, requests for Technical Services and Planning Assistance shall be honored from state, regional, local governments, other non-Federal public agencies, and Indian Tribes without charge. Available data shall be used whenever practical. In establishing priorities for providing services, special consideration shall be given to areas where development pressures are the most significant and where the information is most likely to be used to solve flood related problems. Services relating to flood control works and other flood damage mitigation measures shall be limited as follows: the work shall not duplicate efforts which should or are being accomplished under other Corps authorizations; detailed planning and design shall not be done; and work shall assess the likelihood of success and the identification of pros and cons of measures being considered, but shall not include detailed economic analysis.

1.4 Special Notice

Under 206 Authority, reports and studies of this type provide a variety of information to local governments; however, local, state, and Federal environmental documentation and associated permits are not a part of the program. Section 206 studies and reports are not authorized to duplicate other regulatory Authorities or programs, for example, Flood Insurance Studies or their revisions under the National Flood Insurance Program. These studies may not be used to perform detailed engineering design, nor construct flood control projects. Aerial mapping is usually not permitted. All study efforts initiated under this Authority during any given fiscal year must be completed during the fiscal year. Any assistance provided by the local government entity must be provided in a timely manner to allow for completion of the study within the allotted time.

It is intended that this study be used for planning purposes only; as a guide to assist communities in making flood plain management decisions. The conclusions presented in this report have not been developed for purposes of determining the feasibility of Federal interest in constructing a Flood Control Project along any of the watercourses investigated. The Federal interest in the construction of a flood control project is an involved process, which is conducted under one or more different Authorities (other than 206), in accordance with a specific set of planning guidelines.

1.5 Additional Information

For additional copies of this report, or for questions concerning content, please contact:

U.S. Army Corps of Engineers   Telephone (213) 452-3808
Los Angeles District   FAX (213) 452-4204
Planning Section B
911 Wilshire Boulevard
Los Angeles, California 90017-3401

II. Study Area Description

The city of Douglas lies on the United States – Mexican International Border in Cochise County, Arizona, and is located approximately 150 miles southwest of Tucson. The city of Agua Prieta, Sonora, Mexico, is located across the border and adjacent to the city of Douglas. Douglas encompasses approximately 8.5 square miles and has a current population of 14,780 people. The City is located in the High Sonora Desert near the center of the Sulphur Spring Valley, west of the Perilla Mountains. Douglas has a desert environment, typified by monsoons and flash flooding during the summer months. Figures 1 and 2 show the location, and boundaries of the City.

A physical investigation of the area was performed to document the physical description of the study area. Photographs from this visit are located in Appendix A.

2.1 Drainage Sub-Basins

Two drainage sub-basins east of the city of Douglas are the source of most of the flooding within the eastern portion of the City. The other source of flooding would be from rainfall directly overhead, which accounts for a smaller proportion of the flooding problems within the City. Portions of the two sub-basins are within the City's boundaries; the remaining portion of the sub-basins are within the boundaries of Cochise County. These two sub-basins, termed Sub-Basin 1 and Sub-Basin 2 in this report, are described in the following sections. Figure 3 shows the boundaries of Sub-Basins 1 and 2. The approximate location of the project construction is shown on Figure 3. The difference between the approximate location and the actual location of the proposed construction is not significant and does not affect the project results.

2.1.1 Sub-Basin 1

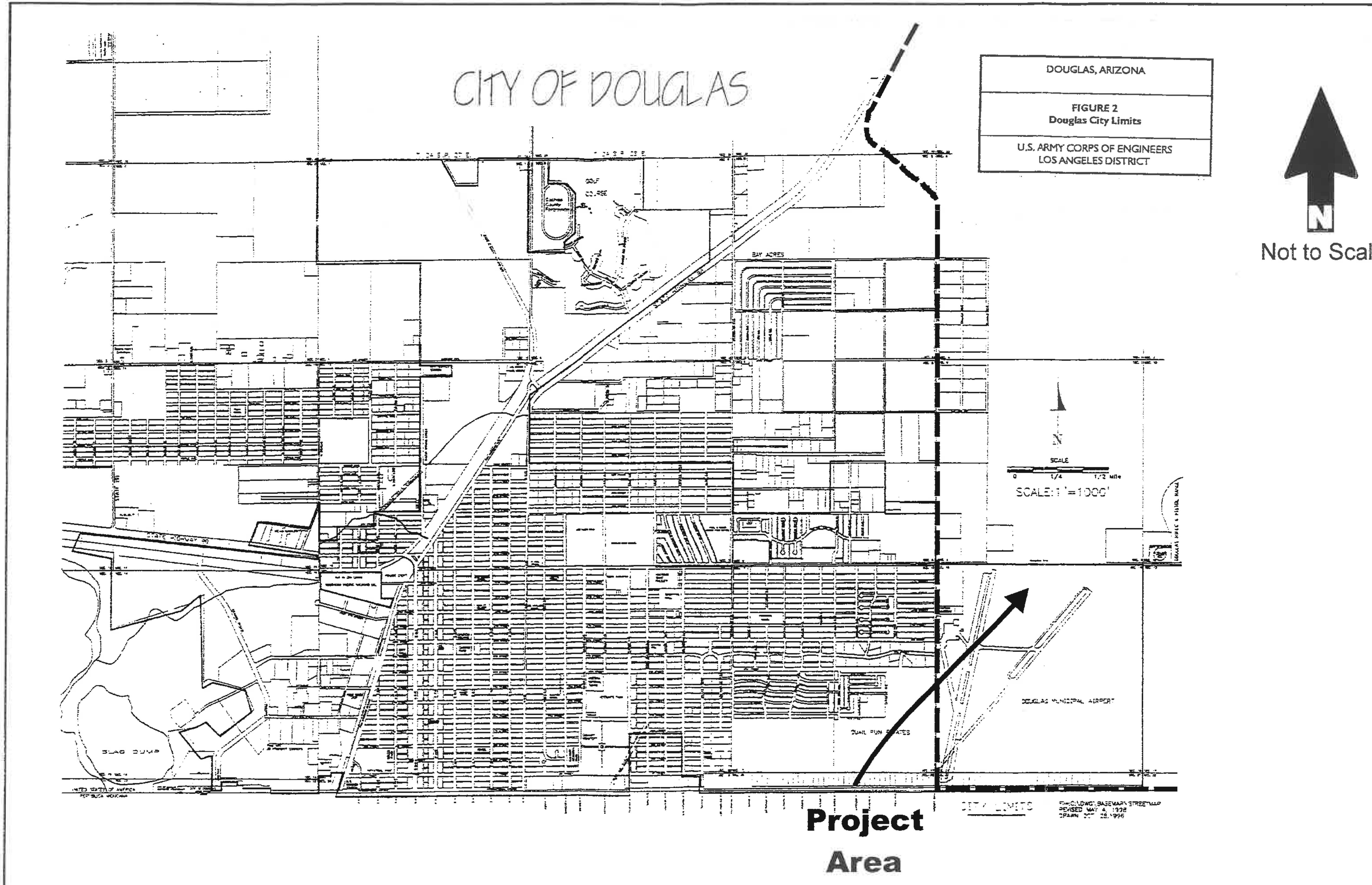
Sub-Basin 1, the smaller of the two sub-basins, is closer to Douglas Municipal Airport. The sub-basin extends west from D Hill towards the City of Douglas. Rattlesnake Hill is located at the approximate northwest corner of the sub-basin. The southernmost limit of the sub-basin is the point where Airport Road terminates at the International Border with Mexico. The southern boundary of the sub-basin does not coincide with the border, however, because flows originating from the central part of the airport have historically been conducted into Mexico. Under the City's proposed flood control plan, the flows originating east of the airport will continue to flow into Mexico after construction of the project, . Since the City has not proposed to divert these flows into Airport Road Channel, Sub-Basin 1 has been delineated to exclude this drainage area and to show only the drainage area for flood runoff between the international border to the south, and Rattlesnake Hill to the northwest and D Hill to the east, which will affect the City after the diversionary ditches are constructed. Sub-basin 1 has a total area of 1.52 square miles and, as described above, includes only that portion of the Douglas Municipal Airport which has/will have ditches diverting flows into Airport Channel Wash. The concentration point for Sub-basin 1 is at the proposed spillway connecting Sub-basin 1 to Sub-basin 2.

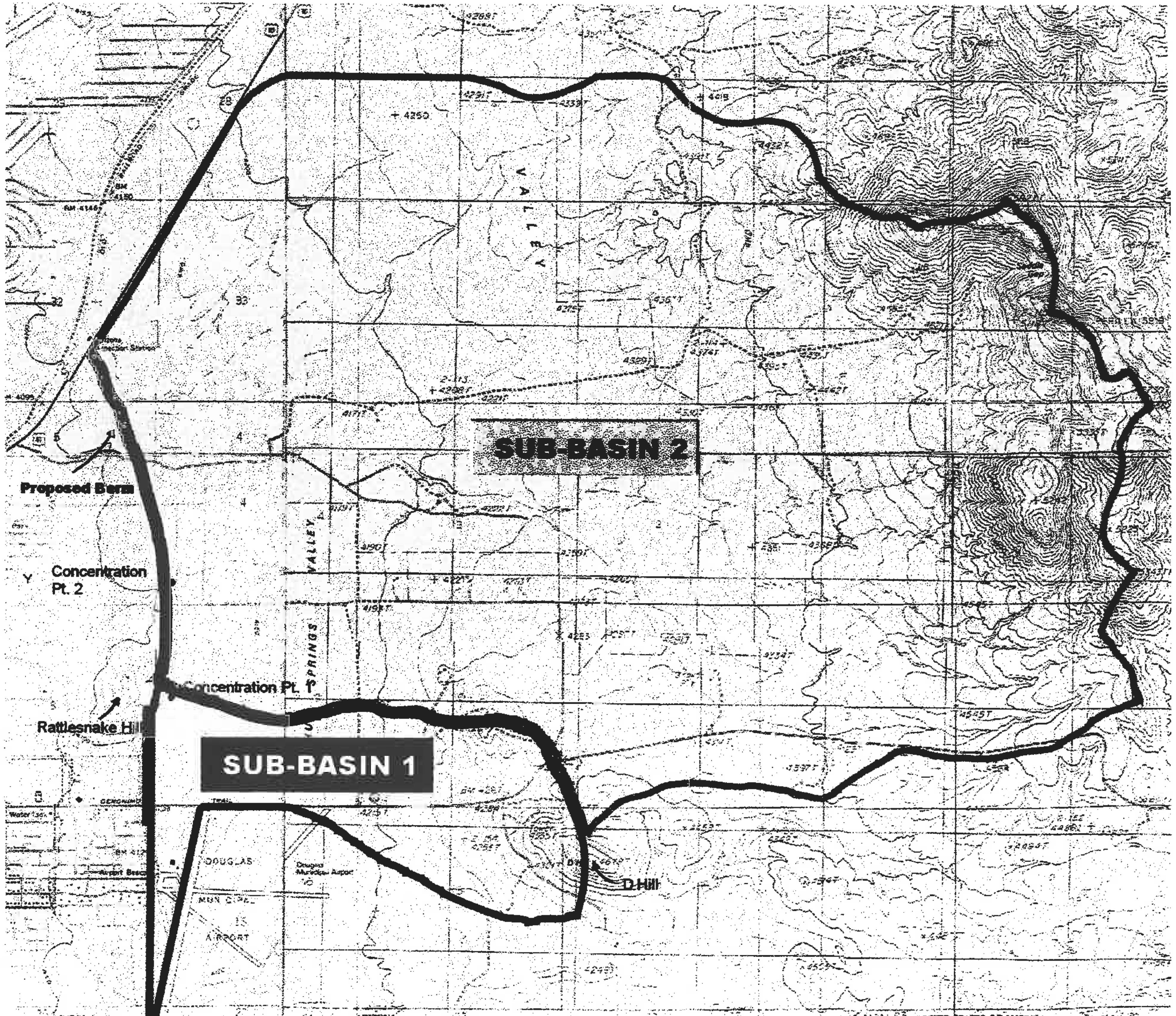
A desert terrain characterizes Sub-Basin 1 with hard, sandy soil containing shrubs and grasses. Major plants in the area include desert shrubs such as saltbush, creosotebush, and cactus, as well as other desert plants. Minimal residential development is present in the sub-basin. A small portion of the airport runway, as well as several paved roads are located within Sub-Basin 1.

2.1.2 Sub-Basin 2

Sub-Basin 2, the larger of the two sub-basins, is located north of Sub-Basin 1. Sub-basin 2 has a total area of 14.07 square miles. The northern boundary of the basin is approximately 3 miles north of the northern city limits of Douglas. The basin extends west from the Perilla Mountains, and through Sulphur Springs Valley, towards State Route 80. Rattlesnake Hill is located at approximately the southwest corner of the basin. The basin contains hard, sandy soil populated with shrubs and grasses, which is typical of desert terrain. Major plants in the area include desert shrubs, such as saltbush, creosotebush, and cactus, as well as other desert plants. Minimal residential development is present within the sub-basin. Several paved roads traverse Sub-Basin 2. The concentration point for Sub-basin 2 is at the proposed spillway along the natural channel of Palm Grove Wash.

BLACK & VEATCH PROJECT 36767.530	DOUGLAS, ARIZONA PROJECT LOCATION MAP	FIGURE 1


CITY OF DOUGLAS
DOUGLAS, ARIZONA
FIGURE 2
Douglas City Limits
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT
N
Not to Scale
SCALE: 1"=1000'
GOLF COURSE
BAY ACRES
STATE HIGHWAY 80
SLAG DUMP
DOUGLAS MUNICIPAL AIRPORT
QUAIL RUN ESTATES
Project
Area



The approximate location of the proposed berm is shown. The difference between the berm's approximate location and its proposed location is not significant and does not affect the project's results.

DOUGLAS, ARIZONA
FIGURE 3 Sub-Basin Boundaries
U.S. ARMY CORPS OF ENGINEERS LOS ANGELES DISTRICT

2.2 Washes

Flows from three washes are intercepted by the city's proposed flood control project. These washes, which are named Rattlesnake Wash, Palm Grove Wash, and Wash Z, are shown on Figure 4, as well as the flood plain overflow areas within the city which are associated with each wash. Note that the upper reaches of the washes beyond the northern and eastern boundary of the city are not shown. Figure 4 shows the flood plain as defined by the City of Douglas's Public Works Director. The figure shows the flood plain overflows before any project construction and should not be associated with flood plain overflows expected after project construction.

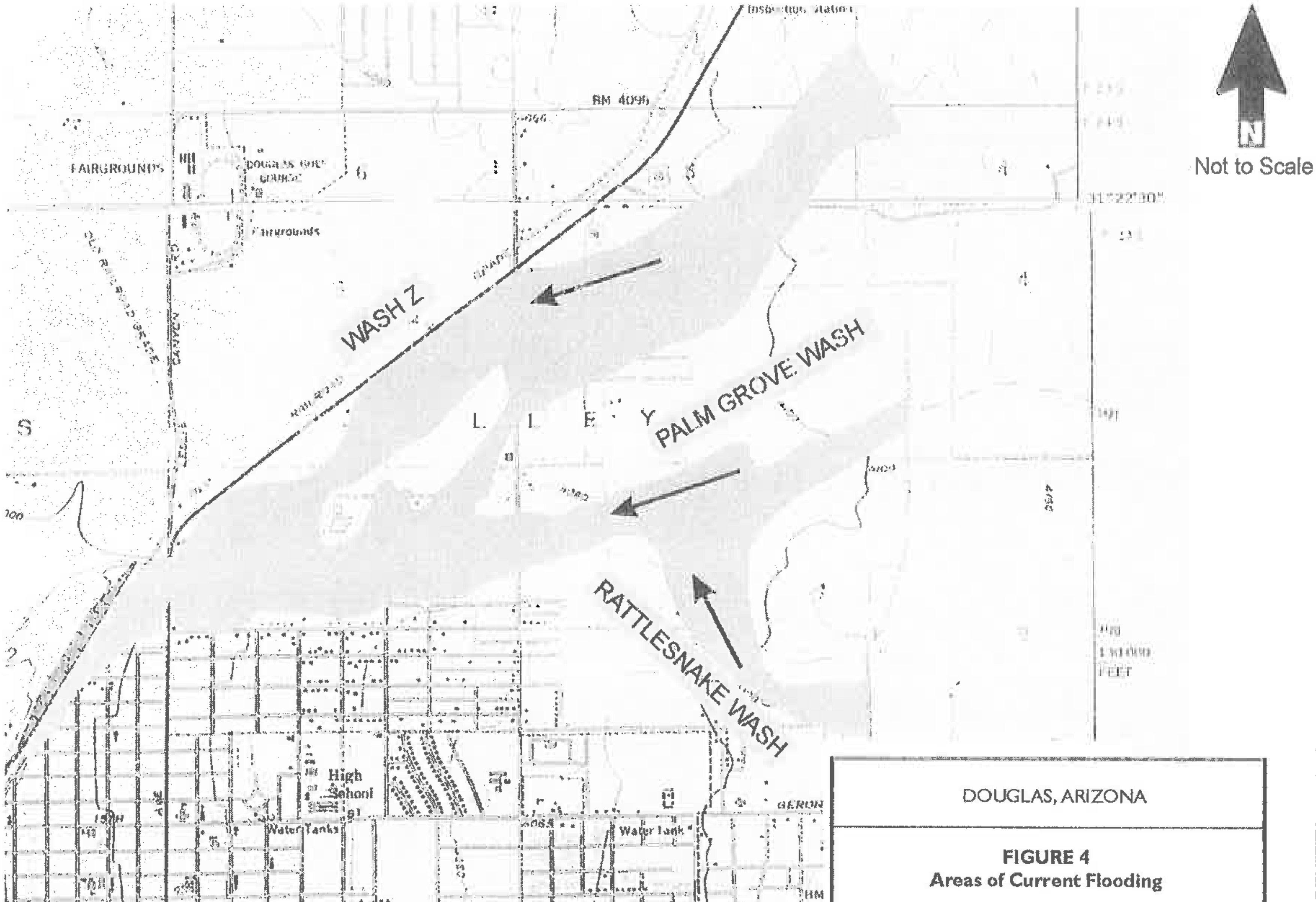
The wash begins (as a defined stream on the USGS mapping) in the southwest corner of Section 33 on the Douglas NE USGS quadrangle. Beginning at the northeast border of the City, Wash Z flows in a southwest direction to join with flows from Palm Grove Wash immediately upstream of State Route 80.

Palm Grove Wash begins as a defined stream on the USGS mapping in Section 4 of the Douglas NE USGS quadrangle. Palm Grove Wash flows in a westerly direction beginning at the eastern boundary of the City, and joins with Wash Z just before State Route 80. The third wash is Rattlesnake Wash, which begins on the southern side of Rattlesnake Hill, approximately 1500 ft north of the intersection of Airport Road and Geronimo Trail, at the eastern border of the city. The wash flows in a northwestern direction around Rattlesnake Hill before joining Palm Grove Wash.

2.3 Flooding Under Current Conditions

According to the Public Works Director for the city of Douglas, flooding to the city, from the sub-basins located to the east of the city, is caused by three conditions. The first condition that causes flooding occurs when flood flows exceed the capacity of the existing channel east of Airport Road, and then overtop the road. Runoff from Sub-Basin 1 travels west toward Airport Road, and is captured by a small channel located east of the road, identified as Airport Road Channel. The capacity of the channel is insufficient to contain any but small flows that arrive from the east, however, and flows that break out of the channel and then overtop the road proceed down gradient and flood residences in the City. According to the City, the majority of the flooding from this source occurs to residences between 5th and 13th streets. The second condition which causes flooding, occurs where flows arriving from the east of the city enter Rattlesnake Wash. According to the City, the capacity of the existing channel of Rattlesnake Wash is insufficient to carry the flood waters. Therefore, residences adjacent to the wash experience flooding. The third flooding condition occurs where runoff from Sub-Basin 2 is collected by Wash Z and Palm Grove Wash in the northeast section of the City. According to the City, Wash Z is under capacity resulting in an overtopping situation along the wash. The situation is further worsened where runoff flows from Wash Z join runoff flows from

Palm Grove Wash just east (upstream) of State Route 80. These combined flows overtop the banks of Palm Grove Wash and flood the adjacent areas. Flooding along the three natural watercourses described above currently affects developed land and severely limits development of other properties adjacent to developed land. Figure 4, shows the area of historical 100-year flooding around the washes as determined by the Public Works Director for the city of Douglas. The figure shows the flood plain overflows before any project construction and should not be associated with flood plain overflows expected after project construction.



DOUGLAS, ARIZONA

FIGURE 4
Areas of Current Flooding

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

This figure shows the current flood plain overflows as defined by the City of Douglas's Public Works Director. The figure does **not** reflect the flood plain overflows after project construction has taken place.

III. Available Studies and Mapping

The following section details hydrologic and hydraulic related studies and mapping pertaining to the study area.

3.1 Studies

3.1.1 City of Douglas Study

Mr. Lynn Kartchner, Public Works Director for the city of Douglas, has conducted an informal study to develop a conceptual solution to solve the major flooding problems within Douglas Mr. Kartchner used the Rational Method to determine a peak runoff from both drainage sub-basins east of the City. Based on the results of the initial investigations and Mr. Kartchner's knowledge of the flooding problems within the City of Douglas, three flood control structures were conceptually designed. The proposed flood control structures were mentioned earlier and are described further in Section IV. The information provided by the City prior to this study is included in Appendix G.

The objective of the flood control structures is to retain the excess runoff from Sub-Basins 1 and 2 for the 100-year interval flood. After construction of the flood retention structures, the County is planning to improve a single channel (Palm Grove Wash) to carry peak discharges from the spillway. The flood control project is expected to eliminate the wide, uncontrolled floodways along Rattlesnake Wash, Palm Grove Wash, and Wash Z, which currently extend across developed areas and severely limit development . According to the City's Public Works Director, even a partial retention of the flood flows would significantly increase the time of concentrations and reduce the resulting flood crest elevations.

3.1.2 Corps of Engineers Reports

The U.S. Army Corps of Engineers, Los Angeles District, report *"Technical Services Report, Initial Field Investigations for Airport Road Channel and International Boundary Ditch Grate"*, described the flooding problems and drainage basins in the City of Douglas. The study recommended establishing baseline hydraulics and hydrology for the area as well as developing conceptual solutions to the City's flooding problems.

3.1.3 Flood Insurance Study

The U.S. Department of Housing and Urban Development, Federal Insurance Administration published a Flood Insurance Study for the City of Douglas in March 1978. The Study investigated the existence and severity of flood hazards within the City. The report included hydrologic and hydraulic analysis to quantify the flood hazards. Results of the Flood Insurance Study are inadequate to evaluate the proposed plans for flood control, since drainage areas are different between this study and the Flood Insurance Study, and because the Flood Insurance Study did not compute flow volume for the concentration points. Additionally, flood plain overflow boundaries as depicted on the Flood Insurance Rate Map, along Airport Road Channel for example, are not considered appropriate.

3.2 Mapping

Three sources of mapping were available for the study area. These sources are 1) USGS quadrangles, 2) City of Douglas Topographical Maps, and 3) FEMA Flood Plain Maps.

The following four USGS quadrangles encompass the project area: The East of Douglas quadrangle, the College Peaks quadrangle, the Douglas NE quadrangle, and the Douglas quadrangle. Each of these quadrangles is published to a scale of 1 inch = 2,000 feet. The Douglas quadrangle has 10-foot contour intervals, the Douglas NE quadrangle has 20-foot contour intervals, and the College Peaks along with the East of Douglas quadrangles have 40-foot contour intervals.

The City of Douglas has topographical maps, which were created by the consulting firm Robert Bien, William Frost, & Associates. The mapping only covers areas within the City boundaries, however. The mapping has 5-foot contour intervals, but a scale was not provided.

IV. Proposed Flood Control Structures

Three flood control structures have been proposed by the City of Douglas to control the flooding in the eastern and northern sections of the City. These structures include the following;

- Construct an incised earthen trapezoidal channel along the eastern side of Airport Road, which has a greater capacity than the currently existing channel with its levee. The proposed channel would have a bottom width of 16 feet, and would be incised to a depth of 4 feet below the existing ground, and have side slopes of 4 H to 1 V.
- Construct a 10-acre, below grade retention basin at the intersection of Airport Road and Geronimo Trail.
- Construct an above grade retention basin north of Geronimo Trail and east of Rattlesnake Hill
- Construct an above-ground retention basin north of Rattlesnake Hill to State Route 80. This component of the project would require coordination with Cochise County.

In addition to the above, (1) some type of inlet from the proposed below-ground retention basis south of Geronimo Trail, to the above-ground retention basin north of Geronimo Trail would be provided; and (2) a spillway connecting Sub-Basins 1 and 2 would be incorporated in the plan; and (3) a spillway controlling combined outflows from Sub-Basins 1 and 2 would be provided at the location where the larger, above-ground berm intercepts Palm Grove Wash. Note that No. (3) above would require coordination with the County.

Presently, a north-south earthen channel is located along the eastern side of Airport Road. The channel is heavily vegetated and has not been maintained. Additionally, the channel has been previously graded on many occasions. According to the City of Douglas Public Works Director, the direction of flow in the channel depends on the grading. The City plans to increase the capacity of the channel by clearing out the vegetation and increasing the depth of the channel. The channel will be regraded to ensure water in the channel flows towards the 10-acre basin to the north. Peak flows occurring along this proposed channel were not developed during this analysis. No hydraulic modeling of this proposed channel to determine channel capacity was conducted during this study. The drainage area contributing to the discharges expected along this channel is approximately described by the acute triangle south of Geronimo Trail in Sub-basin 1. A 10-acre below-grade retention basin will be constructed at the southeast corner of the intersection of Airport Road and Geronimo Trail. The basin will be designed to collect flows arriving from the channel along Airport Road as well as flows arriving overland from the southeast. As currently proposed, the retention basin will be designed with an approximate bottom elevation of 4120.

To create an above grade retention basin north of Geronimo Trail, a berm or road grade will be constructed with a top elevation of 4125. Beginning at the intersection of Airport

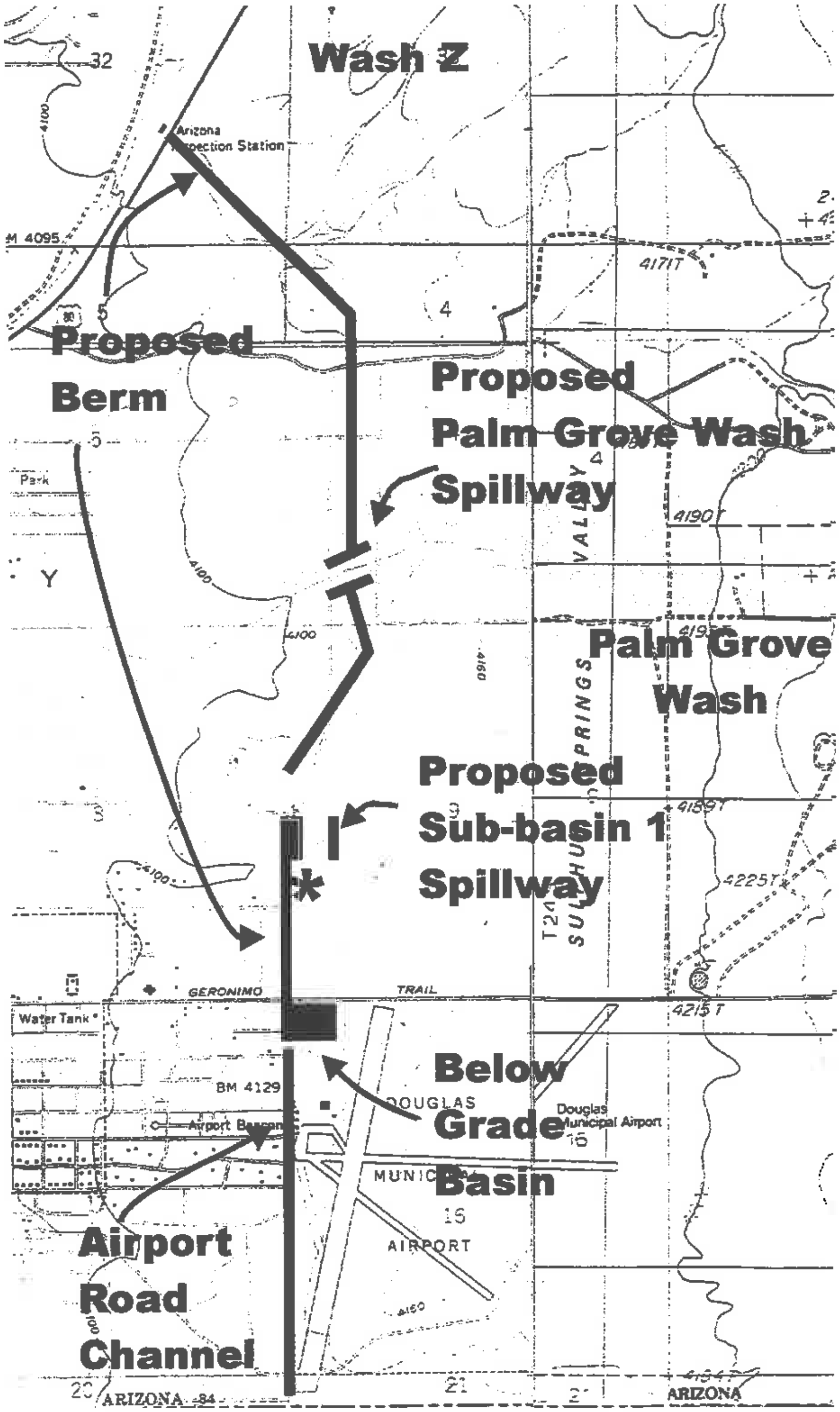
Road and Geronimo Trail, the berm will extend north to Rattlesnake Hill. This is approximately the northernmost limit of the City's jurisdiction. From Rattlesnake Hill, the berm will continue to extend north up to the State of Arizona Inspection Station on State Route 80, with the top elevation remaining at elevation 4125. According to the Public Works Director, the berm will be constructed between the 4120 and 4125 foot elevations, which will permit the berm to be less than 6 feet tall. It will not be regulated as a dam. A spillway, which currently has not been designed, will release flows from the Sub-basin #2 into Palm Grove Wash. Palm Grove Wash will be improved to increase its capacity in order to handle the increased flows.

These structures will be used to implement the following flood control plan:

The City intends to use the incised earthen channel, the below grade retention basin, and the above grade retention basin, south of Rattlesnake Hill, to contain the 100-year storm runoff volume arriving from Sub-Basin 1. The above grade retention basin, north of Rattlesnake Hill, will contain the 100-year storm runoff volume arriving from Sub-Basin 2. The incised earthen channel will direct its flow from sub-basin 1 towards the below-grade retention basin. Overflow from the below-grade retention basin will spill into the above grade retention basin south of Rattlesnake Hill. This retention basin will convey its flows via a spillway to the above-grade retention basin to the north. This retention basin shall have a spillway at the location where the proposed berm would intercept the existing channel of Palm Grove Wash. According to the Public Works Director, the spillway might be constructed such that it will have the capacity to pass the 100-year combined peak flow of Sub-Basin 1 and Sub-Basin 2 into the wash without overtopping the berm. To assist in this planning effort, the study provided the combined 100-year peak runoff flow of Sub-Basins 1 and 2. Due to study constraints under the 206 program, design level flow values were not developed in this analysis; the exact peak flow amount and spillway capacity has not been determined. Further investigation of exactly how much storage is required or available must be determined before final decisions can be made. Routing of flows through both spillways using appropriate methodology would be required as part of the analysis. This study is intended to give accurate estimates of total sub-basin peak flow values as well as total volumes to assist with the future decisions.

Figure 5 shows the location of the proposed flood control structures.

The hydrologic and hydraulic analyses in this study were performed assuming the proposed flood control structures were in place.



N

Not to Scale

* Rattlesnake Wash is not defined on topographic maps east of Airport Road

DOUGLAS, ARIZONA

FIGURE 5
Proposed Flood Control Structures

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

V. Hydrologic Analysis

Prior to the study, the City of Douglas was consulted to determine which type of methodology was preferred for the hydrologic analysis. Hydrologic investigations conducted under Section 206 authority are performed to assist local governments in their planning efforts. The methodology selected is generally based on preferences by the local entity, generally accepted engineering practices, and constraints imposed by State regulations. The City stated that a generally accepted engineering practice was to be used for the analysis. Black & Veatch recommended that a HEC-1 model be created to model the 100-year, 24-hour storm. Black & Veatch also recommended that the Graphical Peak Discharge Method from the Soil Conservation Service's TR55 Manual be used to verify the HEC-1 results. Since both HEC-1 and TR55 are generally accepted engineering modeling tools to assist in determining peak runoff, the City of Douglas agreed to the use of these models to apply the SCS methodology.

The City of Douglas recommended using rainfall intensities obtained from the National Oceanic & Atmospheric Administration (NOAA) Atlas II Rainfall Intensity-Duration-Frequency Relation curve for Douglas, Arizona. Therefore, the rainfall intensity obtained from this curve, along with an SCS Type II 24-hour rainfall distribution, was used in the model.

The following sections discuss the input and output from the HEC-1 model as well as the TR55 method calculations.

5.1 HEC-1 Input Parameters

The following discusses the HEC-1 input parameters.

5.1.1 Sub-Basins

Two basins were modeled. The basins, termed Sub-Basin 1 and Sub-Basin 2, were described in Section II of this report. The Sub-Basin areas were measured from USGS quadrangle maps. A planimeter was used to measure the sub-basin areas. These areas were compared with the City of Douglas's preliminary measurements and found to be similar. In the HEC-1 model, flow in Sub-Basin 1 was collected at a concentration point in the northwest corner of Sub-Basin 1. Flow in Sub-Basin 2 was collected at a concentration point at the proposed location of the spillway to the Palm Grove Wash. Flow from Sub-Basin 1 discharged directly into Sub-Basin 2; therefore, the runoff hydrographs of Sub-Basins 1 and 2 were combined at the concentration point of Sub-Basin 2.

5.1.2 100-Year Event Rainfall Totals and Distributions

As mentioned earlier, the City recommended using rainfall intensities obtained from the NOAA Atlas II Rainfall Intensity-Duration-Frequency Relation curve for Douglas, Arizona. The 24-hour, 100-year intensity obtained form this curve was .148 inches per hour. This translates into a 24-hour total rainfall of 3.552 inches per day. This intensity was distributed across a 24-hour period with the SCS Type II Distribution. The goal of the retention basin is to capture and retain the 100-year runoff. Flash flooding has been common within the Douglas area. A flash flood generally occurs when a short highly intensive rainstorm hits the area. This high intensity rainfall would be greater than the 24-hour rainfall intensity. However, the volume of the storm would be much smaller than the volume of the 100-year storm. Therefore, the retention basin would capture and contain the total volume of the short high intensive storm. It is an engineering judgement that the flash flooding upstream of the retention basin would be captured, and prevent downstream flash flooding as a result of the runoff that was occurring from upstream of the basin.

A copy of the NOAA Atlas Rainfall curve is located in Appendix B.

5.1.3 Runoff Curve Numbers

Curve numbers for the model were obtained from Technical Release 55 (TR-55) Urban Hydrology for Small Watersheds by the U.S. Soil Conservation Service. The curve numbers were determined in accordance with the land use and the soil type. Table 1 summarizes the development of the curve numbers.

Table 1. Curve numbers for the City of Douglas Sub-Basins

Sub-Basin #	Area (mi^2)	Land Type	% of land	CN Value	Overall CN Value
1	1.52	Desert	90	81	
		Paved roads, open ditches	10	92	
					82
2	14.07	Desert	90	81	
		Paved roads, open ditches	10	92	
					82

** CN numbers obtained from SCS TR-55 using a Soil Type of C

5.1.4 Time of Concentration and Lag Times

Sub-basin times of concentration and lag times were obtained using the SCS TR-55 method. Shallow flow and channel flow were considered where appropriate. Based on recommendations from the City of Douglas, sheet flow was not used in this analysis. According to the City's Public Works Director, flow within the two basins will be quickly concentrated into swale flow. The time of concentration for Sub-Basin 1 is approximately 22 minutes. The time of concentration for Sub-Basin 2 is approximately 31 minutes. Appendix C shows the break down of each sub-basin's time of concentration and lag times.

5.2 HEC-1 Output

The HEC-1 analysis produced the following peak flows at the concentration point of each of the sub-basins.

Table 2. HEC-1 Peak Flows

Flow Concentration Node	Peak Flow (cfs)
Sub-Basin 1	1,679
Sub-Basin 2	13,058
Combined Peak Flow (Sub-Basin 2 flow + Sub-Basin 1 flow)	14,676

Additionally, the total volume of flow from the 100-year, 24-hour storm was calculated through the HEC-1 model. The result was a total volume for the combined two sub-basins of 1,516 acre-feet. The flow volumes are summarized in the following table

Table 3. HEC-1 Storm Volumes

Basin	Storm Volumes (acre-feet)
Basin 1	148
Basin 2	1,369
Combined Volume	1,516

Hardcopy of the HEC-1 input is located in Appendix D.

The objective of the study was to provide a total volume of runoff from each sub-basin and the peak discharge of each sub-basin. While accomplishing the task the directive was to be conservative in the decision making process and the values that were chosen. The rainfall intensity selected from the graph provided by the Public Works Director was not aerial reduced. With the sub-basins not being extremely large, an engineering judgement was made to not use the reducing factor. A reduction would also go against the conservative theme of the process. It was our intention and the directive to be conservative. Rain gages and stream gages were not present in the area for a direct model calibration. A comparison was not made with USGS regional regression equations. If one were to be made it is fully expected to be on the high side for the volumes and peak flows.

A comparison was made with the TR-55 Peak Runoff method shown in the following section. It is understood that both the HEC-1 model and the TR-55 Peak Runoff methods are two different tools using basically the same methodology. Therefore, it is expected that results would be similar, however, during scope discussions with the client, it was stated that this comparison would be calculated. The comparison is also a way to check to ensure the model was coded in properly and working accordingly. As the project approaches closer to final design of the structures, it is recommended that a more detailed hydrologic and hydraulic study could be completed. This has the potential for some cost savings in the design. At that time the conservative decisions could be reduced and a more detailed verification process could be completed.

5.3 TR55 Peak Runoff

The methods for estimating total and peak runoff described in Chapters 2 and 4 of Soil Conservation Service's TR55 were used to verify the peak runoff and total volume of discharge obtained by the HEC-1 model. The following table shows the peak discharges calculated with the TR55 method.

Table 4. TR55 Peak Discharges

Basin	Peak Discharge (cfs)
Sub-Basin 1	1,660
Sub-Basin 2	13,060

Both of the TR55 peak discharge values are within 2% of the values obtained with HEC-1. This is a very good comparison between two accepted engineering practices for determining peak runoff. Additionally, the TR55 method calculated a combined storm runoff volume for the two basins of 1513 acre-feet. This volume is within 1% of the volume calculated with the HEC-1 model.

VI. Hydraulic Analysis

Normal depth calculations were used to determine the flood plain boundary of Palm Grove Wash downstream from the proposed spillway of the above grade retention basin. The Q_{100} peak flow obtained from the HEC-1 analysis was used for the calculations. The calculations assume that the above-grade retention basin is full and the 100-year peak discharge is being passed over the spillway. Four cross sections were cut from the USGS maps along Palm Grove Wash. The spillway at the beginning of Palm Grove Wash will be designed to pass the combined peak inflow from the two sub-basins upstream of the spillway. Therefore, the normal depths determined for the downstream cross sections were calculated by using the combined peak inflow. The overflow area depicted on the map is based on existing channel geometry, as defined by USGS quadrangle data using the combined peak flows of Sub-Basins 1 and 2. It is important to note that the overflow area does not define the expected flood plain subsequent to the construction of the project. A stage-storage analysis of the proposed retention structures may reduce the peak discharge significantly, and the overflow area would be reduced. If the City is planning to improve the channel in the future, the overflow areas are expected to change even if the peak discharge were to remain unchanged. Note that only the flood plain boundary of Palm Grove Wash below the proposed flood control project is shown. Flows developing as a result of local runoff within the area are not shown, and possibly sheet flow or other types of flooding might occur, especially along Wash Z upstream of the confluence with Palm Grove Wash.

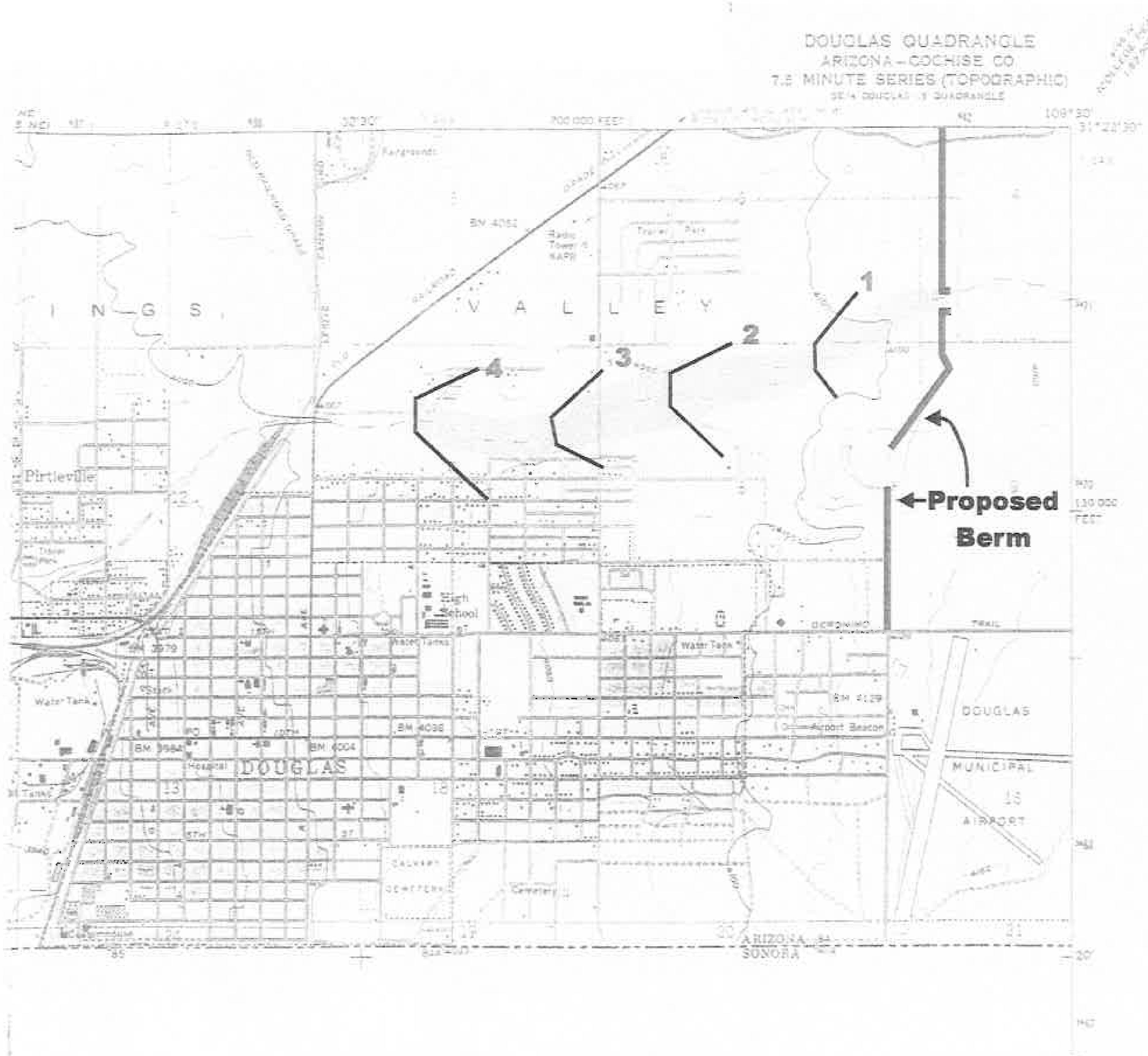
Table 5 shows the calculated normal depths for each of the cross sections. The normal depth analysis was performed assuming the proposed flood control structures have been previously constructed.

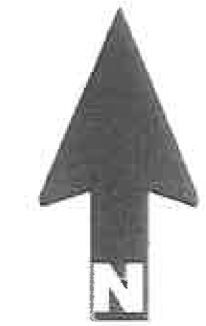
Table 5. Calculated Normal Depths

Cross Section	W.S. Elevation (ft)	Normal Depth (ft)	Velocity (ft/s)	Top Width (ft)
1 (River Station 7200)	4083.0	5.02	7.98	636.6
2 (River Station 4900)	4062.4	2.42	6.50	1066.3
3 (River Station 2700)	4042.0	6.01	7.91	650.9
4 (River Station 0)	4022.3	6.30	7.58	723.8

The normal depth calculation spreadsheets are located in Appendix E.

Figure 6 shows results of the normal depth analysis.





Legend:

Cross Section	W.S. Elevation (ft)	Normal Depth (ft)	Velocity (ft/s)	Top Width (ft)
1 (River Station 7200)	4083.0	5.02	7.98	636.6
2 (River Station 4900)	4062.4	2.42	6.50	1066.3
3 (River Station 2700)	4042.0	6.01	7.91	650.9
4 (River Station 0)	4022.3	6.30	7.58	723.8

DOUGLAS, ARIZONA

FIGURE 6
Normal Depth Analysis

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

VII. Conclusions and Recommendations

The following table highlights the findings of this 206 flood plain management study.

Table 6. 206 Study Results

Time of Concentration, Sub-Basin 1 =	**22 minutes**
Time of Concentration Sub-Basin 2 =	**31 minutes**
Combined 100-year Peak Runoff Flow (Sub-Basin 1 + Sub-Basin 2) =	**14,676 cfs**
Combined Total 100-year, 24-hour Runoff Volume (Sub-Basin 1 + Sub-Basin 2) =	**1,516 acre-feet**

This study is a preliminary analysis for determining time of concentrations, peak runoff flows, and total storm runoff volumes for the two sub-basins east of the City of Douglas. These values can be used to help determine the required storage volume and spillway length required for flood control structures that would be constructed and not overtopped by a 100-year flood. Additionally, peak inflow values were used as peak outflow values from the sub-basin for predicting normal depths downstream. This 206 study was not conducted to a level of detail suitable for construction and design. The output data from this study should be used for planning purposes only. Future studies would be recommended for detailed design and detailed flood mapping.

For design information, a more detailed HEC-1 study or HEC-HMS study should be conducted. One of the additions to the model would be the interaction of the proposed basins with the inflow and outflow hydrographs. Stage-Storage curves would be used in conjunction with Stage-Discharge curves to determine the effects of storage on the inflow hydrograph. If the entire storm is to be retained then only total runoff volume is needed. However, if this assumption is too conservative, and there is not enough storage space available to contain the complete runoff volume, then a dynamic model could be used for adequately sizing the retention basins. This study provides the total runoff volumes for the 100-year storm for each sub-basin.

The water surface elevations along Palm Grove Wash downstream of the proposed flood retention structures were determined from the normal depth calculations for cross sections taken from a USGS map with 20-foot contour intervals. The normal depth calculations do not take into account any backwater conditions that may exist downstream at State Route 80. A recommended future study would be to model the downstream conditions with HEC-RAS. Since detailed mapping of the area is not available, surveyed cross sections could be used to model the channel and overbanks, if feasible. The more detailed the cross sections, the more accurate the model's results. A HEC-RAS model would also take into account the backwater that may be generated by bridge crossings along the channel. Where flooding of homes is an issue, the lowest opening of the structure should be surveyed for reference when computing water surface elevations. Accurate representation of the spillway structure would also be beneficial to determine if the structure becomes submerged. HEC-RAS can be used when developing the Stage-Discharge curve for HEC-1.

Because this study is only to be used for preliminary analysis, some “general” guidelines are given for compaction standards, acceptable side-slopes, and cross section dimensions for the proposed berm. The use of onsite material for the berm is subject to the amount of caliche present. If a high content of calcium carbonate is present then the soil should not be used for the berm unless an impermeable layer is placed on the upstream side of the berm. This impermeable layer could be, but is not limited to, a fabric, soil cement, or clay liner. If a soil with a high clay content were used, then an impermeable liner may not be needed. The compaction standard recommended is 95% standard ASTMD698, +3 to –3% above optimum. The length of time that the water remains in the basin is a factor for deciding if an impermeable boundary layer is required.

Additionally, the amount of time the stagnant water resides in the basin may present a health issue (i.e., vectors, mosquitoes etc.). This depends primarily on the length of retention time of the flood control structure. If health issues are a concern, a small low level outlet pipe could be installed to allow the basin to drain slowly over a period of time.

A recommended side-slope for the berm would be 3:1. The top width would be 10 feet wide. Therefore, on a 3:1 side slope, with a 5 ft berm, the bottom width would be 40 feet wide. With the 3:1 side slope, and the berm only being 5 feet tall a fence would not be required.

The City of Douglas plans to construct flood control structures to retain and combine flood runoffs from sub-basins east of the City. This 206 study has provided hydrology and hydraulic data that can be utilized to assess the feasibility of these flood control structures.

VIII. Computer Files Generated

File Name	Format or Program	Description	Report Contents not captured on disk
100%a.doc	Word 97	Report Text for Douglas	Appendix B
Toc100.doc	Word 97	Table of Contents	
Title100.doc	Word 97	Title Sheet	
Mfr1.doc	Word 97	Memorandum For Record	
Mfr2.doc	Word 97	Project File	
Tccalcs.xls	Excel 97	Time of Concentration Calcs.	
Ndepths.xls	Excel 97	Normal Depths Calcs.	
Doug2.dat	HEC-1 Version 2.1	Input File	
Doug2.out	HEC-1 Version 2.1	Output File	
Cover.doc	Word 97	Report Cover	
Pictures.doc	Word 97	Appendix A Site Photos	
Divider.doc	Word 97	Report Dividers	
Figure1.cdr	Corel Draw 8	Figure 1	
Figure2.cdr	Corel Draw 8	Figure 2	
Figure3a.cdr	Corel Draw 8	Figure 3	
Figure4.cdr	Corel Draw 8	Figure 4	
Figure5.cdr	Corel Draw 8	Figure 5	
Figure6.cdr	Corel Draw 8	Figure 6	

IX. References

1. "Technical Services Report, Initial Field Investigations for Airport Channel Road and International Boundary Ditch Grate", U.S. Army Corps of Engineers, Los Angeles District; November 1997.

2. "Flood Insurance Study, City of Douglas, Arizona"; U.S. Department of Housing and Urban Development; March 1978.

3. "Urban Hydrology for Small Watersheds, Technical Paper 55"; U.S. Soil Conservation Service; 2nd Edition, June 1986.

4. Mays, Larry W.; Water Resources Handbook; McGraw Hill Co., 1996.

5. Franzini, Joseph B. and Linsley, Ray K.; Water Resources Engineering; McGraw Hill Co., 1964.

6. "Flood Hydrograph Package [HEC-1], Version 4.0"; Hydrologic Engineering Center, U.S. Army Corps of Engineers, September 1990.

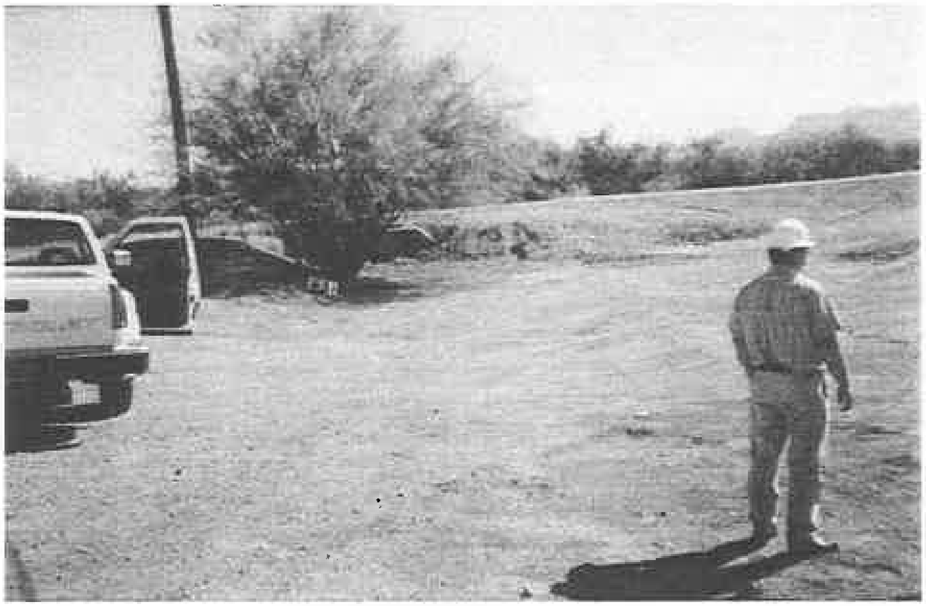
Appendix A
Site Visit Photographs

1	Looking northwest from the southern end of the Airport Road Channel.

2	Looking south down the east side of Airport Road.

3	Looking south from the corner of Airport Road and Geronimo Trail (15th Street).

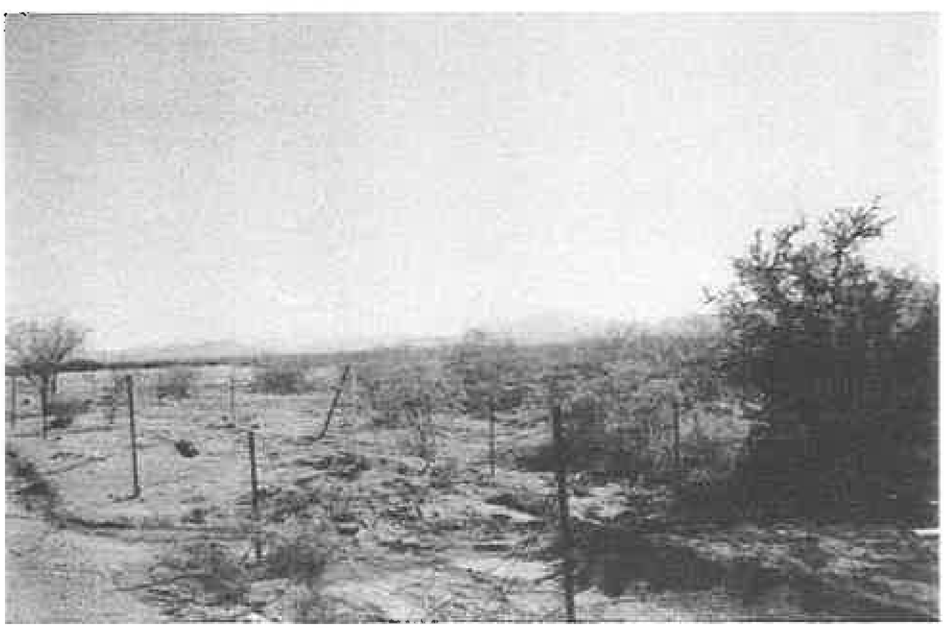
4	Looking east from the corner of Airport Road and Geronimo Trail (15th Street).



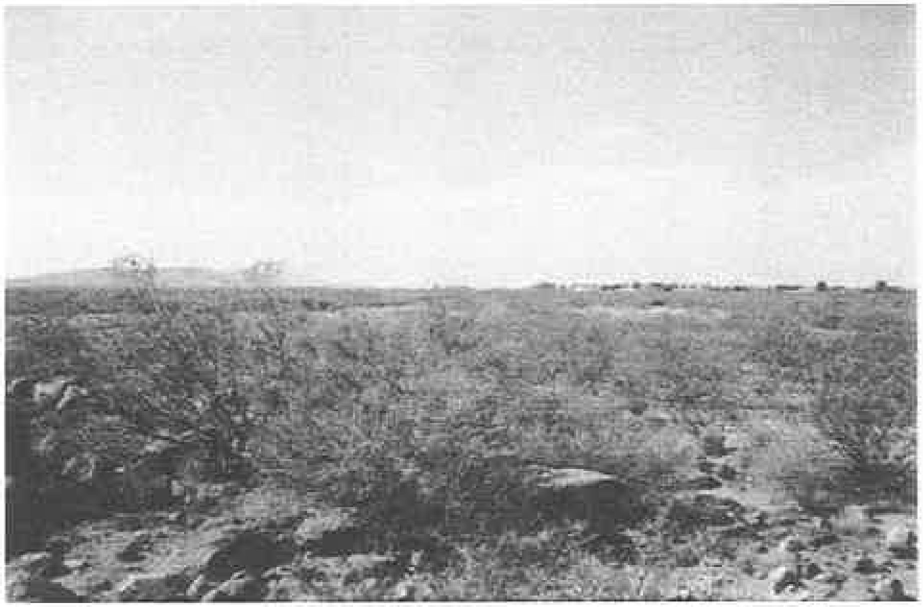
5	Looking northwest from the corner of Airport Road and Geronimo Trail (15th Street).

6	Looking north from the beginning of Rattlesnake Wash.

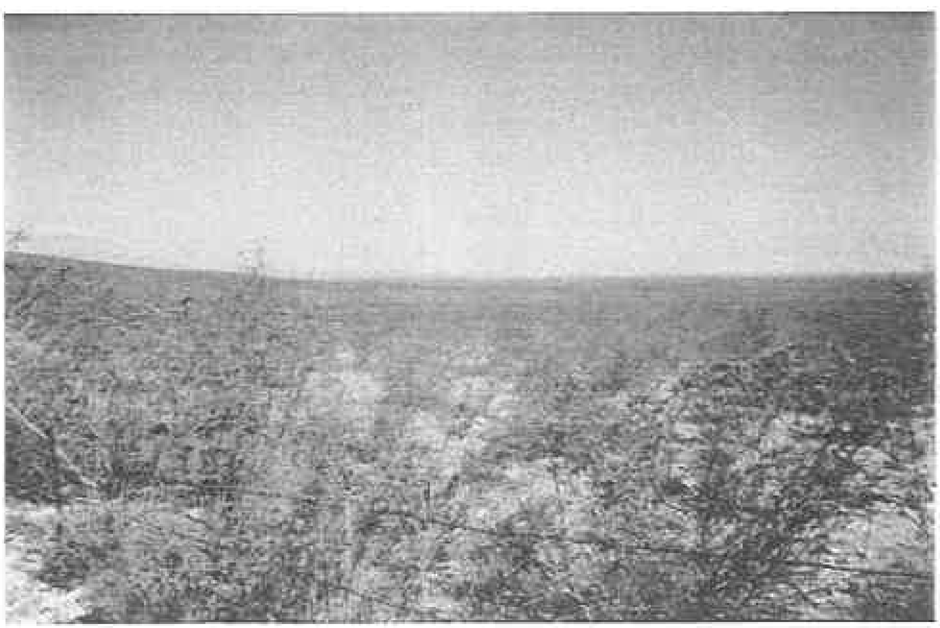
7	Looking west at the beginning of Rattlesnake Wash.



8	Looking northeast from the beginning of Rattlesnake Wash.



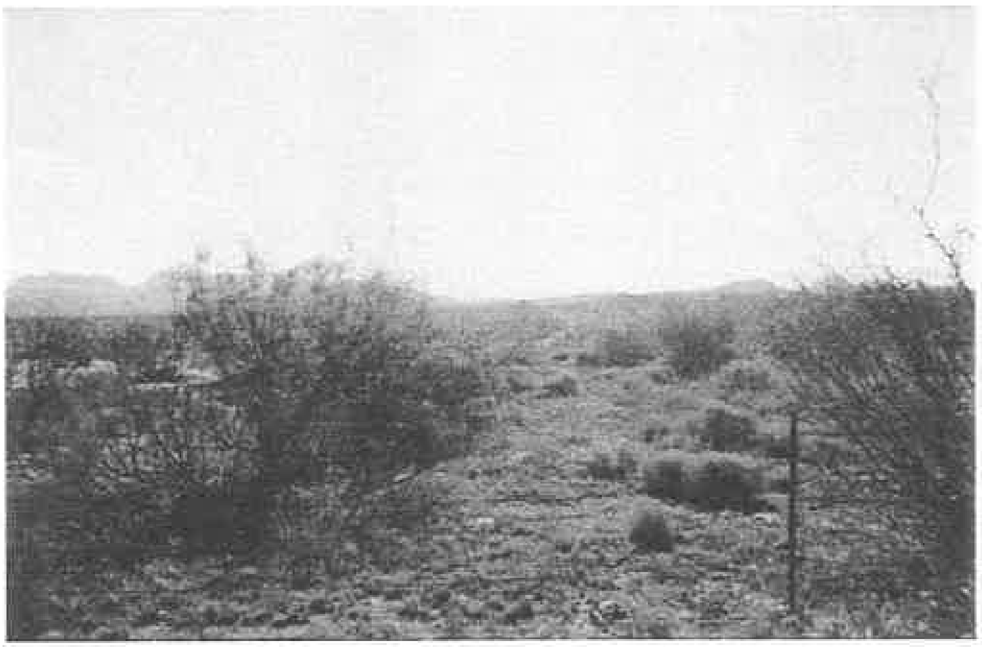
9	Looking south from the estimated 1425 elevation.



10	Looking northwest at the Sub-basin 2.

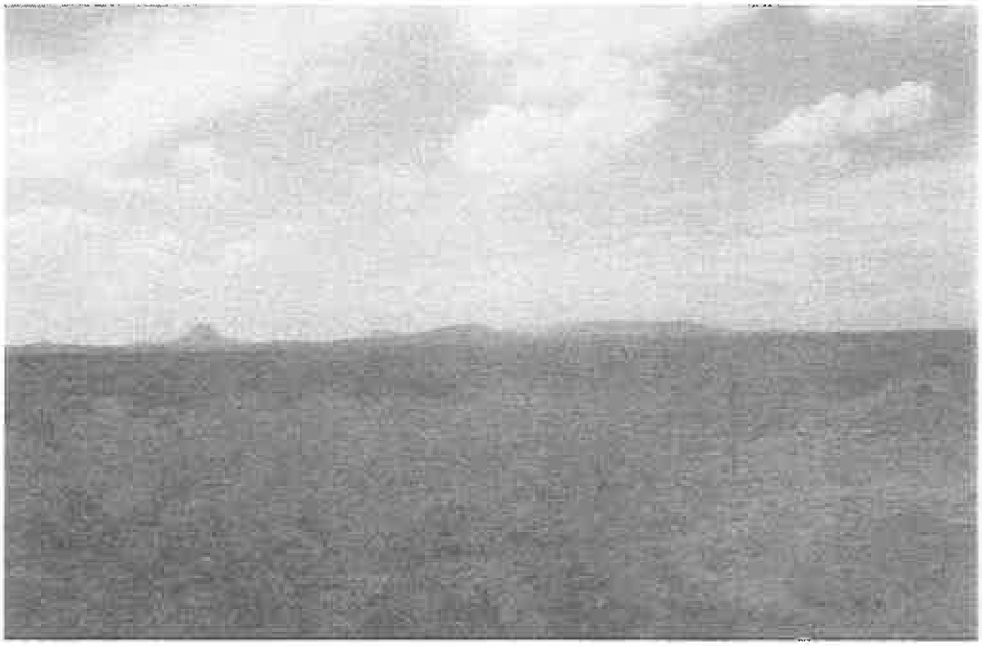
11	Looking northeast at the Sub-basin 2.

12	Looking west at Pacific Grove Wash.

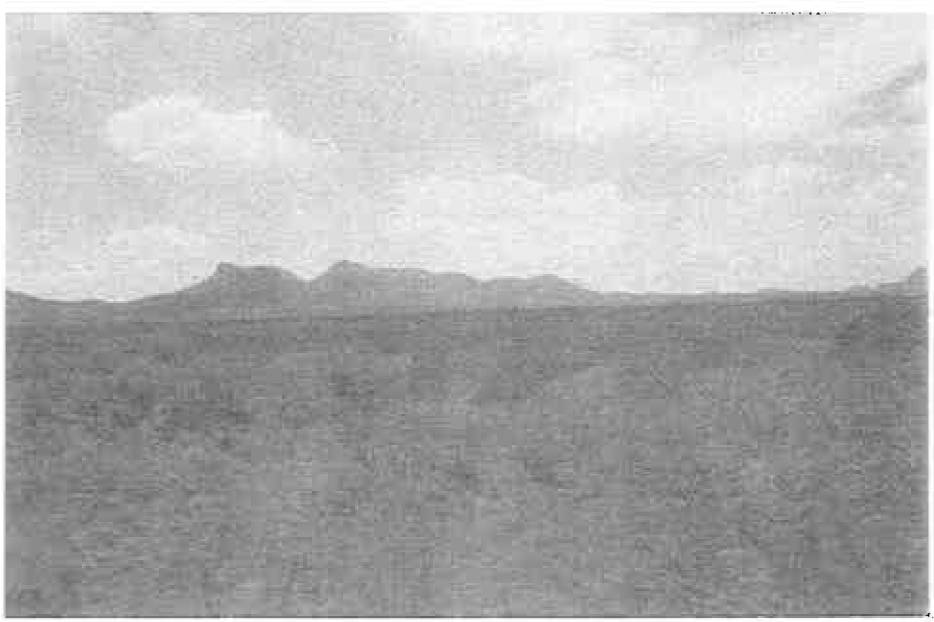


13	Looking east at the Pacific Grove Wash.

14	Typical ground cover in the project area.

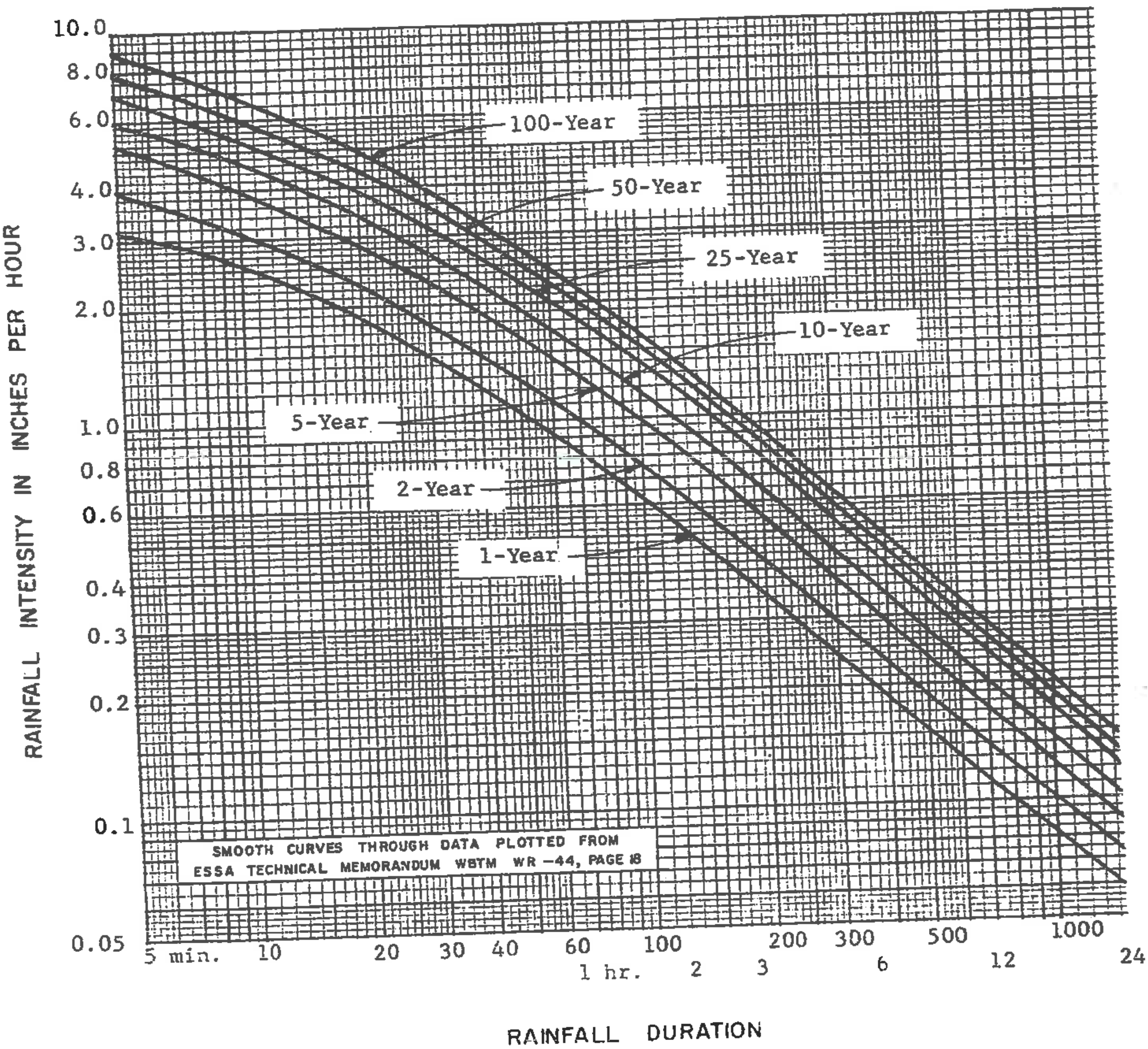


15	Looking south at the top of the Sub-basin 2.



16	Looking southeast at the top of Sub-basin 2.

Appendix B
NOAA Atlas Rainfall Curve



RAINFALL INTENSITY - DURATION - FREQUENCY RELATION FOR DOUGLAS, ARIZONA

(PARTIAL DURATION SERIES)

FIGURE 2

Appendix C
Time of Concentration Calculations

Time of Concentration Calculations

	SubBasin 1
Sheet Flow	N/A
Tc for Sheet Flow	**0.000**
Swale Flow	
Swale Flow (Section 1)	
L (ft)	1200
S	0.065
V (ft/sec) Fig. 3-1 in TR 55	4.75
Tt (hr)	**0.070**
Swale Flow (Section 2)	
L (ft)	750
S	0.267
V (ft/sec) Fig. 3-1 in TR 55	8.50
Tt (hr)	**0.025**
Swale Flow (Section 3)	
L (ft)	1100
S	0.109
V (ft/sec) Fig. 3-1 in TR 55	5.6
Tt (hr)	**0.055**
Tc for Swale Flow	**0.149**
Channel Flow	
Channel Flow (Section 4)	
Length (ft)	8850
Channel Trap. Base (ft)	25
Channel Side Slope(z:1)	2
Estimated Channel Depth (ft)	4
Cross Sect. Area (ft^2)	132.0
Wetted Perimeter (ft)	42.9
R=A/PW	3.078
S	0.016
N	0.035
V (ft/s)	11.322
Q(ft^3/s)	1494.545
Tt (hr)	**0.217**
Tc for Channel Flow	**0.217**
Tc Total (hr)	0.366
Tlag (hr)	0.220

Time of Concentration Calculations

	SubBasin 2
Sheet Flow	N/A
Tc for Sheet Flow	**0.000**
Swale Flow	
Swale Flow (Section 1A)	
L (ft)	1000
S	0.202
V (ft/sec) Fig. 3-1 in TR 55	7.25
Tt (hr)	**0.038**
Tc for Swale Flow	**0.038**
Channel Flow	
Channel Flow (Section 1B)	
Length (ft)	3500
Channel Trap. Base (ft)	80
Channel Side Slope(z:1)	4
Estimated Channel Depth (ft)	1
Cross Sect. Area (ft^2)	84.0
Wetted Perimeter (ft)	88.2
R=A/PW	0.952
S	0.202
N	0.035
V (ft/s)	18.515
Q(ft^3/s)	1555.233
Tt (hr)	**0.053**
Channel Flow (Section 2)	
Length (ft)	4000
Channel Trap. Base (ft)	90
Channel Side Slope(z:1)	3
Estimated Channel Depth (ft)	3
Cross Sect. Area (ft^2)	297.0
Wetted Perimeter (ft)	109.0
R=A/PW	2.725
S	0.090
N	0.040
V (ft/s)	21.804
Q(ft^3/s)	6475.807
Tt (hr)	**0.051**
Channel Flow (Section 3)	
Length (ft)	12700
Channel Trap. Base (ft)	110
Channel Side Slope(z:1)	2
Estimated Channel Depth (ft)	5
Cross Sect. Area (ft^2)	600.0
Wetted Perimeter (ft)	132.4
R=A/PW	4.533
S	0.019
N	0.035
V (ft/s)	16.073
Q(ft^3/s)	9643.643
Tt (hr)	**0.219**
Channel Flow (Section 4)	
Length (ft)	7700
Channel Trap. Base (ft)	140
Channel Side Slope(z:1)	2
Estimated Channel Depth (ft)	6.0
Cross Sect. Area (ft^2)	912.0
Wetted Perimeter (ft)	166.8
R=A/PW	5.467
S	0.010
N	0.035
V (ft/s)	13.472
Q(ft^3/s)	12286.796
Tt (hr)	**0.159**
Tc for Channel Flow	**0.482**
Tc Total (hr)	**0.520**
Tlag (hr)	**0.312**

Appendix D
HEC-1 Input

```
ID      Douglas
ID      Project No. 36767.530 Date: 1999
ID      By: F. Means & P. Molloy
* *****
*       File name: doug2.dat
* *****
*       Storm Frequency: 100 years
*       100 Year Existing Conditions
* *****
*       Time interval of model
IT    5 29OCT99   0100    300
*       Output controls
IO    0     1
* *****
*   Precipitation distribution time interval of 15 minutes
IN    15
* *****
*       - NOAA Atlas II Rainfall Intensity-Dur.- Freq. Relation
*   Intensity    Duration    Frequency    P_ card
*     in/hr         hr          years       in/day
*                   24          100
* *****
KK  Sub1 COLLECT SOUTH SUBBASIN & ROUTE
* *****
* ******
* *****
* *****
*   Precipitation distribution
PC 0.000  0.010  0.020  0.030  0.040  0.050  0.060  0.070  0.080  0.090
PC 0.100  0.110  0.120  0.140  0.150  0.160  0.170  0.180  0.200  0.210
PC 0.230  0.240  0.260  0.270  0.280  0.300  0.320  0.340  0.360  0.370
PC 0.390  0.410  0.430  0.450  0.470  0.500  0.520  0.550  0.580  0.610
PC 0.640  0.680  0.720  0.780  0.830  0.920  1.000  1.370  2.350  2.480
PC 2.610  2.670  2.740  2.790  2.840  2.870  2.910  2.940  2.960  2.990
PC 3.020  3.040  3.070  3.100  3.120  3.140  3.160  3.170  3.190  3.200
PC 3.220  3.240  3.250  3.270  3.280  3.300  3.320  3.330  3.350  3.360
PC 3.380  3.390  3.400  3.410  3.420  3.430  3.440  3.450  3.460  3.480
PC 3.490  3.500  3.510  3.520  3.530  3.540  3.550
*
* *****
* Modeling of Douglas
* *****
* SUBBASIN 01
BA  1.52
LS    0    82     0
UD  0.22
*
KK Sub02 COLLECT SUBBASIN & ROUTE
* SUBBASIN 02
BA 14.07
LS    0    82     0
UD  0.31
*
KKND02-1
* COMBINE (CH01,BAS2)
HC    2
*
*
*
*
ZZ
```

Appendix E
Normal Depth Calculation Spreadsheets

Cross Section 1 (River Station 7200)- Palm Grove Wash

Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Max Chl Dp (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Palm Grove	7200	14676	4078	4083.02	5.02		4084.01	0.0086	7.98	1838.37	636.62	0.83
Palm Grove	7190.*	14676	4077.91	4082.93	5.02		4083.92	0.008564	7.97	1841.16	637.04	0.83
Palm Grove	7180.*	14676	4077.83	4082.85	5.02		4083.84	0.008617	7.99	1837.12	636.44	0.83
Palm Grove	7170.*	14676	4077.74	4082.76	5.02		4083.75	0.008582	7.98	1839.76	636.83	0.83
Palm Grove	7160.*	14676	4077.66	4082.67	5.01		4083.67	0.008635	7.99	1835.72	636.23	0.83
Palm Grove	7150.*	14676	4077.57	4082.59	5.02		4083.58	0.008602	7.98	1838.22	636.6	0.83
Palm Grove	7140.*	14676	4077.48	4082.5	5.02		4083.49	0.008566	7.97	1841.01	637.02	0.83
Palm Grove	7130.*	14676	4077.4	4082.42	5.02		4083.41	0.008617	7.99	1837.12	636.44	0.83
Palm Grove	7120.*	14676	4077.31	4082.33	5.02		4083.32	0.008584	7.98	1839.61	636.81	0.83
Palm Grove	7110.*	14676	4077.23	4082.24	5.01		4083.24	0.008637	8	1835.57	636.21	0.83
Palm Grove	7100	14676	4077.14	4082.16	5.02	4081.75	4083.15	0.008602	7.98	1838.21	636.6	0.83

Cross Section 2 (River Station 4900)- Palm Grove Wash

Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Max Chl Dp (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Palm Grove	4900	14676	4060	4062.42	2.42		4063.08	0.008609	6.5	2258.8	1066.27	0.79
Palm Grove	4890.*	14676	4059.91	4062.34	2.43		4062.99	0.008552	6.48	2263.75	1066.78	0.78
Palm Grove	4880.*	14676	4059.83	4062.25	2.42		4062.91	0.00863	6.5	2256.98	1066.08	0.79
Palm Grove	4870.*	14676	4059.74	4062.16	2.42		4062.82	0.008576	6.49	2261.66	1066.57	0.79
Palm Grove	4860.*	14676	4059.66	4062.08	2.42		4062.73	0.008654	6.51	2254.9	1065.87	0.79
Palm Grove	4850.*	14676	4059.57	4061.99	2.42		4062.65	0.008609	6.5	2258.8	1066.27	0.79
Palm Grove	4840.*	14676	4059.48	4061.91	2.43		4062.56	0.008552	6.48	2263.75	1066.78	0.78
Palm Grove	4830.*	14676	4059.4	4061.82	2.42		4062.48	0.008627	6.5	2257.24	1066.11	0.79
Palm Grove	4820.*	14676	4059.31	4061.73	2.42		4062.39	0.008576	6.49	2261.66	1066.57	0.79
Palm Grove	4810.*	14676	4059.23	4061.65	2.42		4062.3	0.008657	6.51	2254.64	1065.84	0.79
Palm Grove	4800	14676	4059.14	4061.56	2.42	4061.21	4062.22	0.008606	6.5	2259.06	1066.3	0.79

Cross Section 3 (River Station 2700)- Palm Grove Wash

Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Max Chl Dp (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Palm Grove	2700	14676	4036	4042.01	6.01		4042.98	0.008603	7.91	1854.61	650.89	0.83
Palm Grove	2690.*	14676	4035.91	4041.92	6.01		4042.89	0.008568	7.9	1857.47	651.43	0.82
Palm Grove	2680.*	14676	4035.83	4041.84	6.01		4042.81	0.008618	7.92	1853.33	650.64	0.83
Palm Grove	2670.*	14676	4035.74	4041.75	6.01		4042.72	0.008585	7.91	1856.04	651.16	0.83
Palm Grove	2660.*	14676	4035.66	4041.66	6		4042.64	0.008635	7.92	1851.9	650.37	0.83
Palm Grove	2650.*	14676	4035.57	4041.58	6.01		4042.55	0.008605	7.91	1854.45	650.85	0.83
Palm Grove	2640.*	14676	4035.48	4041.49	6.01		4042.46	0.00857	7.9	1857.31	651.4	0.82
Palm Grove	2630.*	14676	4035.4	4041.41	6.01		4042.38	0.008618	7.92	1853.33	650.64	0.83
Palm Grove	2620.*	14676	4035.31	4041.32	6.01		4042.29	0.008587	7.91	1855.88	651.13	0.83
Palm Grove	2610.*	14676	4035.23	4041.23	6		4042.21	0.008637	7.93	1851.75	650.34	0.83
Palm Grove	2600	14676	4035.14	4041.15	6.01	4040.71	4042.12	0.008605	7.91	1854.45	650.85	0.83

Cross Section 4 (River Station 0)- Palm Grove Wash

Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Max Chl Dpth (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Palm Grove	0	14676	4016	4022.3	6.30		4023.19	0.008603	7.58	1935.02	723.8	0.82
Palm Grove	-10.*	14676	4015.91	4022.21	6.30		4023.1	0.008568	7.57	1938.21	724.51	0.82
Palm Grove	-20.*	14676	4015.83	4022.13	6.30		4023.02	0.008619	7.59	1933.61	723.48	0.82
Palm Grove	-30.*	14676	4015.74	4022.04	6.30		4022.93	0.008586	7.58	1936.62	724.15	0.82
Palm Grove	-40.*	14676	4015.66	4021.96	6.30		4022.85	0.008637	7.6	1932.02	723.12	0.82
Palm Grove	-50.*	14676	4015.57	4021.87	6.30		4022.76	0.008605	7.59	1934.85	723.76	0.82
Palm Grove	-60.*	14676	4015.48	4021.78	6.30		4022.67	0.00857	7.57	1938.03	724.47	0.82
Palm Grove	-70.*	14676	4015.4	4021.7	6.30		4022.59	0.008619	7.59	1933.61	723.48	0.82
Palm Grove	-80.*	14676	4015.31	4021.61	6.30		4022.5	0.008588	7.58	1936.44	724.11	0.82
Palm Grove	-90.*	14676	4015.23	4021.53	6.30		4022.42	0.008639	7.6	1931.85	723.08	0.82
Palm Grove	-100	14676	4015.14	4021.44	6.30	4020.99	4022.33	0.008605	7.59	1934.85	723.76	0.82

Appendix F
Memorandums for Record

Black & Veatch

Memorandum For Record (MFR)
Douglas, Arizona
Flood Plain Management Study
Field Investigation

B&V Project 36767.530
B&V File B
July 14, 1999

Recorded By: Patrick Molloy, Black & Veatch

Attendees: Lynn Kartchner, Public Works Director, City of Douglas
Frank Means, Black & Veatch
Patrick Molloy, Black & Veatch

On July 9, 1999 a site visit and field investigation were performed in the City of Douglas in Arizona. The purpose of the visit was the City of Douglas Flood Plain Management Study being performed by Black & Veatch for the U.S. Army Corps of Engineers.

The visit started with a brief meeting in Lynn Kartchner's office. The main components of the proposed project were discussed. These components are 1) an incised earthen channel, 2) a small below grade retention basin downstream of the channel, and 3) an above grade retention basin downstream of the retention basin. Following this meeting a field investigation was performed on the study area. The site visit began at the southern end of the Airport Channel Road, near the United States-Mexican Border. The following locations were viewed during the site visit:

- Airport Road Channel
- Airport Road and Geronimo Trail Intersection (location of the below ground retention basin)
- Rattlesnake Wash and Rattlesnake Hill
- Palm Grove Wash
- Wash Z
- Overview of the entire study area

Additionally, the area downstream from the study area was investigated to gain an idea of the big picture involved with the project.

Throughout the site visit the physical description of the study area was recorded, pictures of the area were taken, and possible runoff coefficients were estimated. In general, the study area was characterized by hard sandy soil with shrubs and grasses. Lynn stated that C values for the area were very high. He suggested using C values in the nineties for modeling. Lynn stated that times of concentration would be very short in the area. He suggested using very minimal lengths of sheet and swale flow. He stated that the flow channelized very quickly in the study area. The locations of the two detention basins were discussed. Lynn stated that no spillway widths had been designed for both basins. Lynn described the calculations he had performed on the study area. His calculations used the Rational Method and employed a conservative approach. Lynn was unable to locate a hardcopy of his calculations.

Hydraulic Methodology

The hydraulic methodology for the study was discussed. It was agreed that a 100-year, 24 hour rainfall intensity for the City of Douglas from NOAA Atlas II would be used. Time of Concentration values would be determined through the SCS TR-55 method. It was agreed that HEC-1 would be used to determine the peak flows.

Lynn provided Black & Veatch with a copy of the Maricopa County Hydraulic and Hydrology Standards. He said he was not bound to following the standards but that Black & Veatch could use the standards as a reference. Lynne provided Black & Veatch with mapping of the study area and a drawing of the proposed cross section for Airport Road Channel.

Primary Concerns

Lynn stated that his primary concerns with the project were, time of concentration values, the peak runoff for the 100-year 24-hour storm, and the total runoff volume for sizing the retention basin. The peak 100-year runoff would be used for sizing the spillways and the total runoff volume would be used for sizing the retention basins. The volume of the 100-year storm would be completely retained in the basins.

Distribution

- Attendees
- Vernon Harrell, U.S. Corps of Engineers
- Sam Abi-Samra, Project Manager, Black & Veatch
  Telephone # - (213) 312-3321

Black & Veatch

Memorandum For Record #2(MFR2)
Douglas, Arizona
Flood Plain Management Study

B&V Project 36767.530
B&V File B
August 11, 1999

To: Vernon Harrell, U.S. Corps of Engineers

From: Sam Abi-Samra, Black & Veatch

This memorandum documents the progress on the Douglas Flood Plain Management Study.

The project is approximately 60% complete. A site visit has been performed to document site conditions. A HEC-1 model has been created to model the 100-year, 24-hour storm. The Graphical Peak Discharge method from the Soil Conservation Service's TR55 manual was used to verify the HEC-1 results.

The City of Douglas's Public Works Director agreed to the methodology used for this project. The methodology was required to be a generally accepted engineering practice. Both HEC-1 and TR55 are generally accepted engineering practices for determining peak runoff. Rainfall intensities were obtained from the NOAA Atlas II Rainfall Intensity-Duration-Frequency Relation curve for Douglas, Arizona. The SCS type II 24-hour rainfall distribution was used. Basin areas were measured off USGS quadrangle maps. The curve number was determined in accordance with the land use and the soil type. Time of concentration values for the basins were calculated using the Soil Conservation Service's TR55 method. The methods for estimating total and peak runoff described in Chapters 2 and 4 of TR55 were used to verify the peak runoff and total volume of discharge obtained by the HEC-1 model. Normal depth was determined for four cross sections downstream of the proposed spillway location along Palm Grove Wash. Currently it is understood that the spillway will be designed to pass the combined peak inflow from the two subwatersheds upstream of the spillway. Therefore, the normal depths determined for the downstream cross sections were calculated by using the combined peak inflow.

Previously, the City of Douglas's Public Works Director had stated that his primary concerns with the project were, time of concentration values, the peak runoff for the 100-year 24-hour storm, and the total runoff volume for sizing the retention basin. The peak 100-year runoff would be used for sizing the spillways and the total runoff volume would be used for sizing the retention basins. The runoff volume of the 100-year storm would be completely retained in the basins.

Appendix G
Correspondence

THE CITY OF DOUGLAS

425 TENTH STREET, DOUGLAS, ARIZONA 85607 — *TELEPHONE (520)364-7501* *FAX (520)364-7507*

Michael J. Ortega, P.E.
City Manager

August 12, 1997

Colonel Robert L. Davis
District Engineer
U.S. Army Corps of Engineers
Los Angeles District
Post Office Box 532711
Los Angeles, CA 90053-2325

Attention: Mr. Robert S. Joe
Chief, Planning Division

Re: Request for assistance/206 Program

Dear Colonel Davis:

As you may be aware the City of Douglas recently received heavy rains and corresponding flooding. In speaking to Vernon Harrell, of your staff, some assistance may be available in reviewing our situation. I realize that the 206 Program deals with feasibility studies and very preliminary engineering; however, at this point we are unsure as to the appropriate solution to our particular problem.

I have asked Mr. Harrell to set up a meeting for September 4, 1997 at your offices to discuss this matter in more detail. I would appreciate appropriate staff from your office in attendance.

Please feel free to contact me if you would like additional information or more detail on our request. I look forward to hearing from you or your Staff on the feasibility of meeting on September 4, 1997. As always I look forward to working with you and your Staff on this potential project.

Sincerely,

Michael J. Ortega, P.E.
City Manager

MJO:rl

cc: Barry K. Dauphinee, Executive Officer
Mayor and Council
Richard Thomas, P.W. Director
✓Vernon E. Harrell

THE CITY OF DOUGLAS
425 TENTH STREET, DOUGLAS, ARIZONA 85607
TELEPHONE (520)364-7501
FAX (520)364-7507

Michael J. Ortega, P.E.
City Manager

August 19, 1997

Vernon Harrell
U.S. Army Corps of Engineers
Los Angeles District
Post Office Box 532711
Los Angeles, CA 90053-2325

Re: Flooding in Douglas/Assistance from the Corps of Engineers

Dear Vernon:

Per our discussion, you are aware the City of Douglas received heavy rains on August 5, and 6, 1997, causing flooding in the vicinity of the Port of Entry on August 6, 1997. The flooding in the area caused the tragic death of eight Mexican Nationals trying to cross into the United States. Subsequent to the flooding, we had a meeting with the General Services Administration to discuss possible solutions to our flooding problem, since we beleive the port expansion improvements may have caused some of the flooding. They believe a more global solution to this problem is warranted and suggested we look further upstream for possible solutions. Part of the issues surrounding this situation involve a grate which was installed by GSA and the size of culverts implemented as a part of the port expansion.

Other areas of the city received flooding, particularly along the east side. Apparently, a dike breached and at least two homes were flooded.

I am attaching a map showing the affected areas. You may want to review the Rose Avenue Channel and International Wash studies previously performed by the Corps of Engineers.

I trust this gives you adequate information about the flooding which ocurred here on August 6, 1997. Please feel free to contact me if you need additional information.

Sincerely,

Michael J. Ortega, P.E.
City Manager

MJO:cg

cc: Barry K. Dauphinee, GSA
Richard Thomas, Public Works Director

THE CITY OF DOUGLAS

425 TENTH STREET, DOUGLAS, ARIZONA 85607

TELEPHONE (520)364-7501
FAX (520) 364-7507

Michael J. Ortega, P.E.
City Manager

December 28, 1998

Vernon E. Harell, Flood Plain Coordinator
U.S. Army Corps of Engineers,
Los Angeles District, Planning Section B
911 Wilshire Boulevard
Los Angeles, CA 90017-3401

Re: Your faxed dated December 15, 1998/City of Douglas flood control improvements

Dear Vernon:

Thank you, for informing us of the status of the 206 studies. As I mentioned the grate at the U.S. /Mexico Port of Entry has been removed by General Services Administration. Although we have requested that it stay removed I do not believe we have received final word on its ultimate status. I am reasonably sure it will not be replaced.

With respect to the Airport Road Wash Project I am enclosing information developed by our new Public Works Director Lynn Kartchner. Please note that the thought centers on a more comprehensive approach to addressing this situation.

Once you have had an opportunity to review the attached information please contact me, so that we can meet to discuss this project in more detail. Again thank you for keeping the City of Douglas in mind.

Sincerely,

Michael J. Ortega, P.E.
City Manager

MJO/cm

cc: Lynn Kartchner, Public Works Director

THE CITY OF DOUGLAS

CITY OF DOUGLAS ARIZONA INCORPORATED MAY 15 1905

425 TENTH STREET, DOUGLAS, ARIZONA 85607 *TELEPHONE (520)805-4077*
FAX (520)364-7507

PUBLIC WORKS DEPARTMENT
Lynn Kartchner, P.E.
Public Works Director/City Engineer

January 14, 1999

U. S. Army Corps of Engineers
Los Angeles District
911 Wilshire Blvd.
Los Angeles, CA 90017
ATT: Mr. Vernon Harrell
RE: City of Douglas Airport Road Drainage and Retention Project

Dear Mr. Harrell:

I am enclosing a merged copy of the RBF topo map for the above-referenced project, along with a pasted-up basin delineation taken from the current USGS quadrangle maps. Also, please find a copy of the current Intensity-Duration-Frequency curve derived from the NOAA Atlas II, which is the most recent data I have available. A 100-year one hour storm is just under 2.5 inches, while a 100-year 24 hour storm is about 3.6 inches. Also, I have enclosed a graphic depicting the precipitation variation by month.

As you can see, the subbasin contributing all flows between the international boundary and Rattlesnake Hill amounts to something less than 2 square miles, with the total subbasin contributing to Palm Grove Wash amounting to approximately 15.5 square miles. The project scheduled to be constructed next fiscal year (the 10-acre retention basin and Airport Road and channel improvements) can conceivably retain the full runoff from a 100-year 24 hour storm in the small subbasin. Also, some flows diverted southward from the subbasin along the airport runway can be returned to the original pattern to the west, somewhat reducing flows into Mexico, where even minor events cause considerable damage due to the dense development of the floodplain in Agua Prieta immediately downstream from the airport. From the topo map, the natural breakout would be at about 1421' elevation east of Rattlesnake Hill, which would put spilled water directly into Palm Grove Wash north of Rattlesnake Hill. Even partial retention would significantly increase the time of concentration, and hence reduce crest elevations, in Palm Grove Wash compared to existing conditions. The larger subbasin would be largely a Cochise County FCDproject, and need not be tied to the Airport Road project, but does appear to be a natural extension. Any flows not retained would be discharged into Palm Grove Wash, which is the existing main drainage channel.

I hope that you can assist us in refining the hydrology to verify the efficacy of this project in protecting property and reducing the size of the floodplain. I am aware that structural flood control measures are usually the least desirable, but in this case the topography allows a very synergetic small project to provide large benefits. The City would anticipate applying for a LOMR after completion of the proposed project to allow development of lands both east and west of the project.

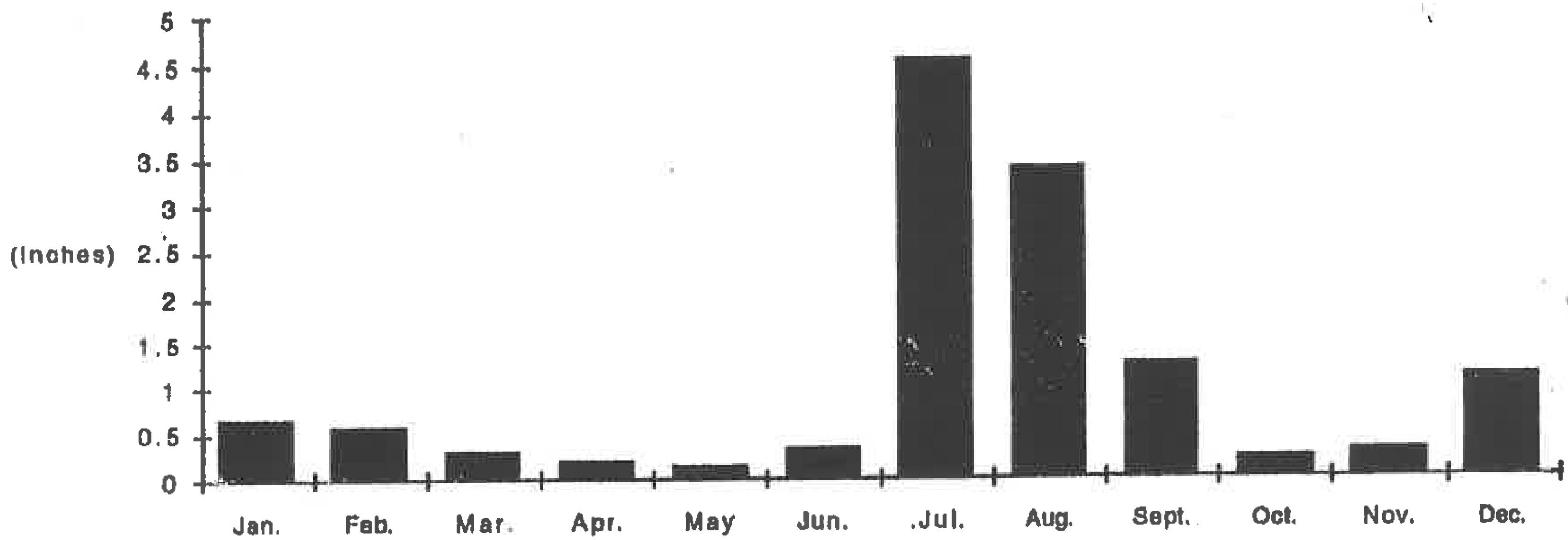
Please keep in contact with my office and call me for any information or field support you may need.

Respectfully,

Lynn Kartchner
City Engineer

FIGURE 1.2

PRECIPTATION VARIATION (BY MONTH) IN DOUGLAS



Appendix H
Proposed Project Data
Provided by the City

THE CITY OF DOUGLAS

425 TENTH STREET, DOUGLAS, ARIZONA 85607

TELEPHONE (520)364-7501
FAX (520) 364-7507

Michael J. Ortega, P.E.
City Manager

December 28, 1998

Vernon E. Harell, Flood Plain Coordinator
U.S. Army Corps of Engineers,
Los Angeles District, Planning Section B
911 Wilshire Boulevard
Los Angeles, CA 90017-3401

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With respect to the Airport Road Wash Project I am enclosing information developed by our new Public Works Director Lynn Kartchner. Please note that the thought centers on a more comprehensive approach to addressing this situation.

Once you have had an opportunity to review the attached information please contact me, so that we can meet to discuss this project in more detail. Again thank you for keeping the City of Douglas in mind.

Sincerely,

Michael J. Ortega, P.E.
City Manager

MJO/cm

cc: Lynn Kartchner, Public Works Director

THE CITY OF DOUGLAS

425 TENTH STREET, DOUGLAS, ARIZONA 85607 *TELEPHONE (520)805-4077*
FAX (520)364-7507

PUBLIC WORKS DEPARTMENT
Lynn Kartchner, P.E.
Public Works Director/City Engineer

MEMORANDUM

DATE: January 6, 1999

TO: Michael J. Ortega, City Manager

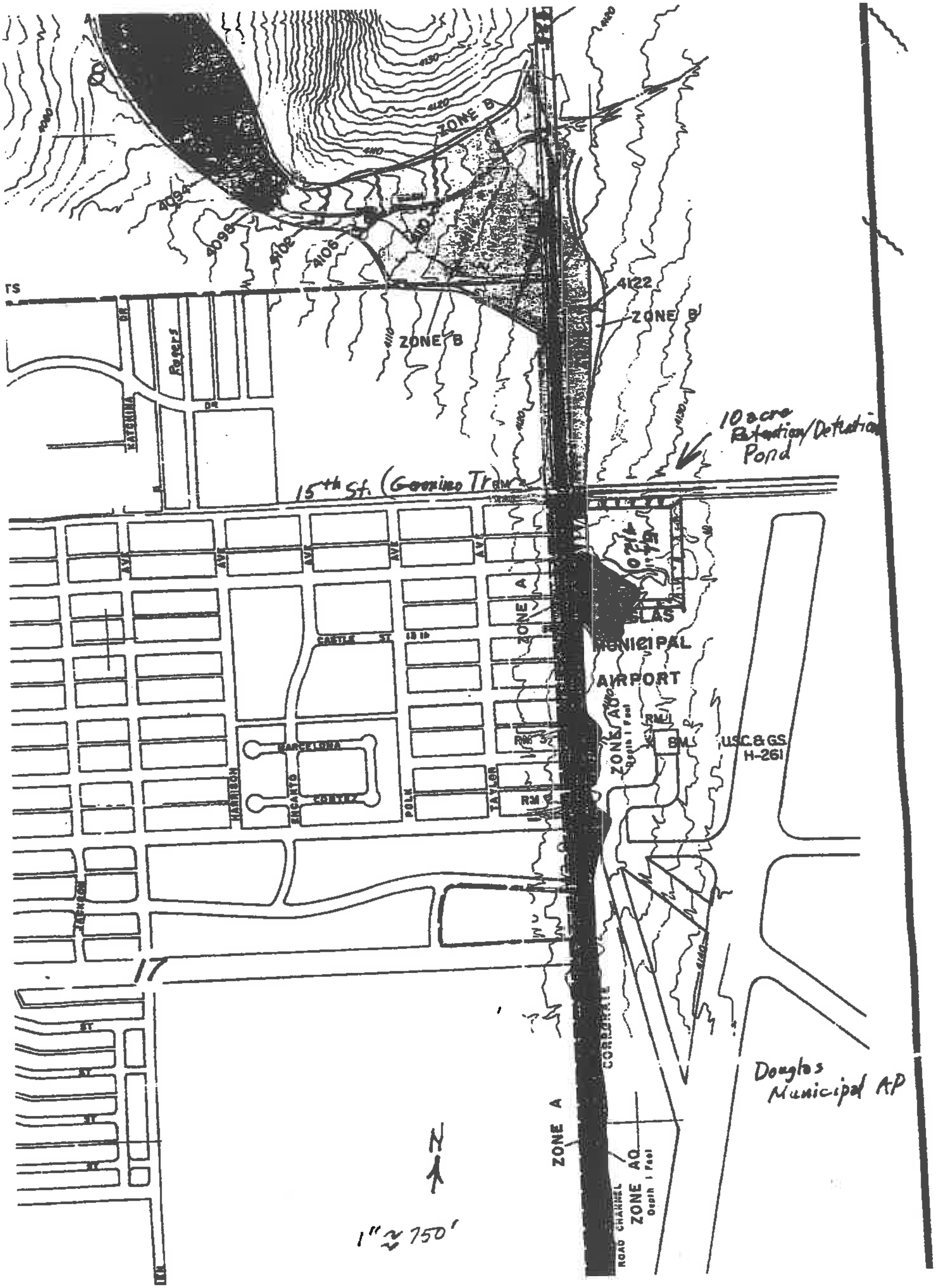
FROM: Lynn Kartchner, City Engineer

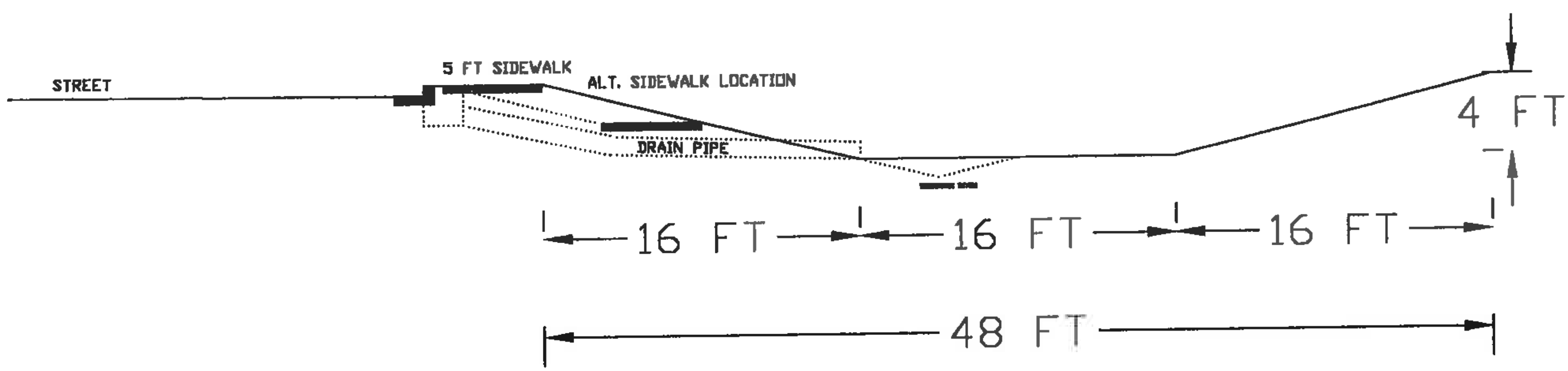
RE: **Airport Road flood control and Park Improvements for FY 99-00**

Attached are the preliminary engineering sketches showing the general location of the Airport Road project, together with the Project Submittal which has been approved by the County Flood Control District. Assistance requested is limited to earthwork, amounting to approximately 200,000 cubic yards. Engineering and control will be the responsibility of the City. Other improvements, including fencing, landscaping, culvert crossings, and road work will also be the responsibility of the City, although none of these are essential to the flood control function. Approved FCD funding is $263,000.

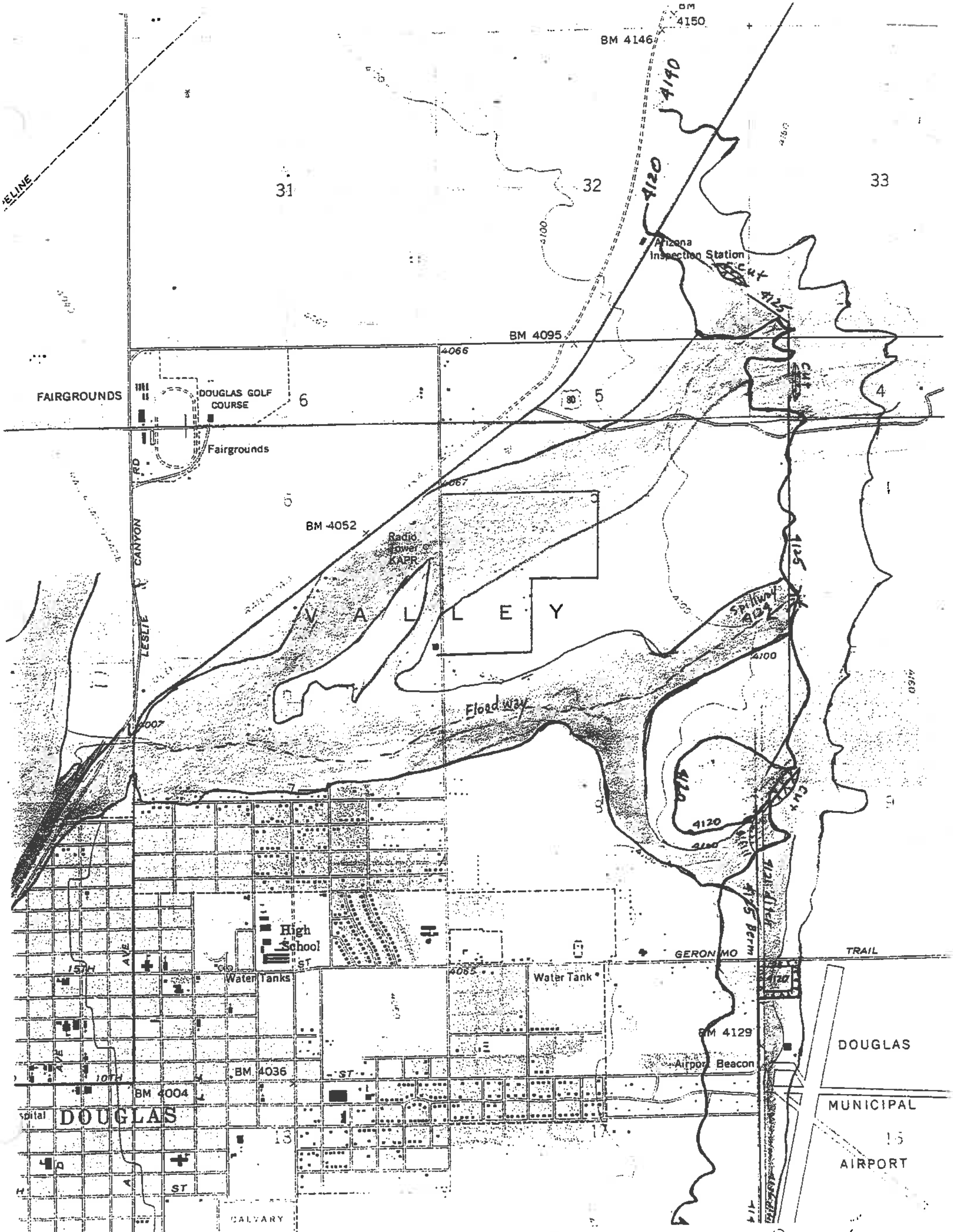
The County has a project for FY 2000-01 to do some work on their own to protect Bay Acres. I have included maps depicting the planned before- and after locations of the floodplains which could be achieved by integrating our project with a long-range plan to protect the entire east side, and improve a single channel for carrying all the excess runoff, rather than the present multiple, wide, uncontrolled floodways which cut across already developed land, and severely limit development on much more property. Virtually all the work can be done between the 4120 foot and 4125 foot contours, which run from the Inspection Station on SR 80 to Geronimo Trail, behind Rattlesnake Hill. The proposed 10 acre retention basin in the southeast corner of Geronimo Trail and Airport Road will have a flat bottom, excavated down to 4120 elevation. The southerly leg of Airport Road Channel from the international boundary to the retention basin will be graded to the north and will be widened to 48 feet at the top, 16 feet at the bottom, with 4:1 sideslopes. New culverts will be constructed to accommodate the full flow capacity.

All earthworks will be designed to allow construction of ball fields and linear and conventional parks. I have included a schematic cross section of a typical linear park/floodway to show locations of sidewalks and the method of draining adjacent streets. The floodways are excellent corridors for underground utilities, as well.

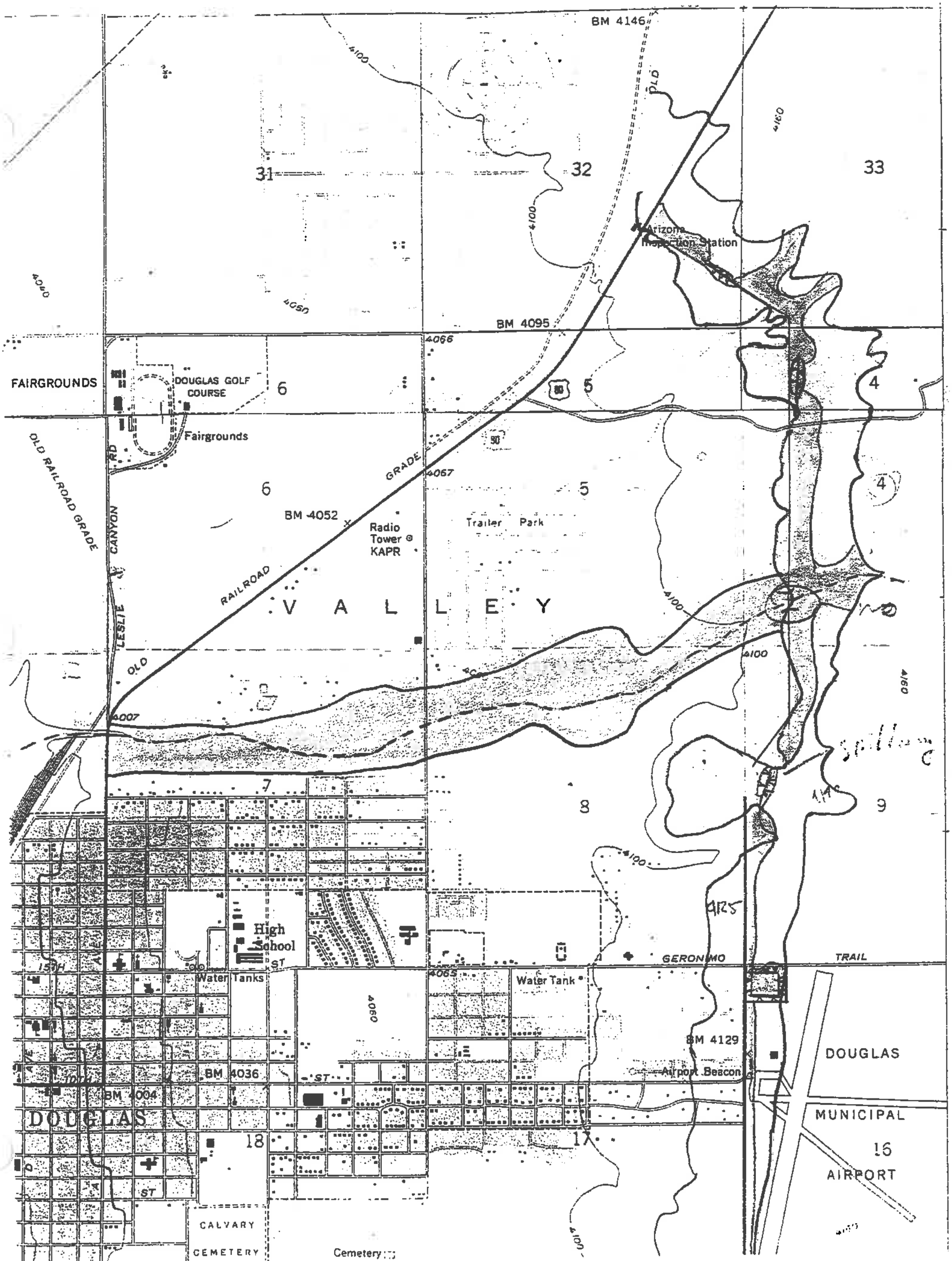

ZONE B
4122
ZONE B
ZONE B
Rogers
10 acre Retention/Detention Pond
15th St. (Geronimo Trail)
ZONE A
MUNICIPAL
AIRPORT
ZONE AO
Depth 1 Foot
BM
USC&GS
H-261
CASTLE ST
BARCELONA
CORTEZ
HARRISON
ENCANTO
POLK
TAYLOR
17
CORPORATE
Douglas Municipal AP
ZONE A
N
ROAD CHANNEL
ZONE AO
Depth 1 Foot
1" ≈ 750'



LINEAR PARK CHANNEL
TYPICAL SECTION
SCALE: 1/8 IN = 1 FT
1/4/99 I K



Before Project



BM 4146
OLD
4100
31
32
33
4160
Arizona Inspection Station
4040
4050
BM 4095
4066
FAIRGROUNDS
DOUGLAS GOLF COURSE
6
5
4
Fairgrounds
OLD RAILROAD GRADE
LESLIE CANYON RD
GRADE
4067
BM 4052
Radio Tower KAPR
Trailer Park
RAILROAD
VALLEY
OLD
4007
4100
7
8
9
High School
15TH
ST
Water Tanks
4065
Water Tank
GERONIMO TRAIL
4060
BM 4129
Airport Beacon
DOUGLAS MUNICIPAL AIRPORT
16
BM 4036
BM 4004
DOUGLAS
18
17
CALVARY CEMETERY
Cemetery

Cochise County Flood Control District
Project Submitals
August 11, 1998

Location	Description	Total Project Cost	Total Funding Requested	CCFCD Cost Benefit Ratio
	Fiscal Year 1998/1999			
Buena #3 Drainageway @ Busby Dr., Sierra Vista	Clear debris &weeds 200'. Repair existing concrete on E side & install 200' gabions W side	$ 7,242.00	$ 5,985.00	46.2
S. Coronado Dr. @ Town & Country, Sierra Vista	Repair existing and install new gabions 700' on both sides	$ 48,681.00	$ 40,232.00	13.82
El Camino Real @ Town & Country Drainageway, Sierra Vista	Regrade channel cross section , install gabion bank protection on both sides for 475' & install gabion grade control every 70'	$ 92,434.00	$ 76,391.00	5.9
	Total	$ 148,357.00	$ 122,608.00	
	Fiscal Year 1999/2000			
Geronimo Tr @ Airport Rd., Douglas	Excavate 1.5 mile channel, Excavate 10 acre retention/detention basin @ SE corner. Improve culvert crossing. Landscape & fence	$ 378,000.00	$ 263,000.00	2.06
	Total	$ 378,000.00	$ 263,000.00	
	Fiscal Year 2000/2001			
Beginning behind lot #35, Buckhorn Dr. E, Sierra Vista (Catalina Wash)	Regrade channel cross section and install gabion grade control every 85' (for 600' length)	$ 150,881.00	$ 124,695.00	2.05
Bay Acres outside of City limits of Douglas	Repair/ install berms to the east & north of trailer park	$58,374.72	$58,374.72	3.6
	Total	$ 209,255.72	$ 183,069.72	

SUMMARY

COCHISE COUNTY FLOOD CONTROL DISTRICT

PROJECT PROPOSAL SUMMARY

APPLICANT: **CITY OF DOUGLAS** FISCAL YEAR **98/99**

PROJECT DESCRIPTION: Excavate 1.5 mile channel along Airport Road; excavate 10-acre retention/detention basin at SE comer of Geronimo Trail at Airport Road, improve culvert crossing Geronimo, landscape, fence

ESTIMATED COSTS	line no.	EST. COST
TOTAL PROJECT COST from Attachment A	1	**$ 378,000**
LOCAL MATCH AND IN-KIND from Attachment B	2	$ 115,000
OTHER MATCH from Attachment C	3	
CCFCD FUNDING REQUESTED (line 1-line 2- line 3)	4	$ 263,000
CAPITALIZED MAINTENANCE from Attachment D	5	$ 30,000
LOCAL CAPITALIZED MAINT. from Attachment B	6	$ 30,000
TOTAL CCFCD CAPITAL COST (line 4+line 5-line 6)	7	**$ 263,000**
PUBLIC BENEFIT, protection of property, Att. E	8	$ 25,000
PUBLIC BENEFIT, increased property value, Att. E	9	$ 187,000
PRIVATE BENEFIT, protection of property, Att. F	10	$ 90,000
PRIVATE BENEFIT, increased property value, Att. F	11	$ 240,000
TOTAL BENEFIT (line 7+line 8+line 9+line 10)	12	**$ 542,000**
BENEFIT/COST, TOTAL COST BASIS (line 12/line 1)	13	1.43
BENEFIT/COST, CCFCD COST BASIS (line 12/line 7)	14	2.06

	TOTAL PROJECT COST ESTIMATE	
	COST:	LINE DESCRIPTION:
ADMINISTRATION	$ 25,000	advertize, report, process payment, secure funds
ENGINEERING	$ 50,000	hydrology, hydraulics, soils testing, design of earthworks and structures
INSPECTION	$ 3,000	on-site inspection by project engineer for owner
RIGHT-OF-WAY	$ 40,000	purchase of setbacks, channel, slope, and access
EARTHWORK	$200,000	clear, grub, excavate, place, compact suitable soils, cut channels
STRUCTURAL WORK	$ 50,000	culverts, headwalls, fences
SPECIAL FEATURES	$ 5,000	landscape of slopes for natural stabilization
MISC. COSTS	$ 5,000	construction traffic control
TOTAL COST	**$378,000**	
CAPITALIZED MAINT.*	$ 30,000	
*see Attachment D		

PROJECT DESCRIPTION: Purchase right-of-way, design, build, and maintain 10-acre retention/detention basin with approximately 1.5 mile of channel, berm and structural improvements to intercept 1.5 miles of overland flow along the uphill (east) side of the City of Dougla. This will greatly improve the existing Airport Road Channel. This project will protect the whole of the built-up portions of Douglas, and will control flows across the International Boundary into Agua Prieta, Sonora, making the project of international importance, and eligible for federal funding.

			LOCAL MATCHING AND IN-KIND FUNDING				
ADMINISTRATION	$ 20,000						
ENGINEERING	$ 10,000						
INSPECTION	$ 3,000						
RIGHT-OF-WAY	$ 40,000	all construction in City ROW or on City-owned property					
EARTHWORK	$ 10,000						
STRUCTURAL WORK	$ 25,000						
SPECIAL FEATURES	$ 5,000						
MISC. COSTS	$ 2,000						
TOTAL COSTS	**$115,000**						
CAPITALIZED MAINT:*	**$ 30,000**						
*see Attachment D							
DESCRIPTION OF LOCAL MATCHING AND IN-KIND FUNDING:							

		OTHER MATCHING FUNDS					
ADMINISTRATION							
ENGINEERING							
INSPECTION							
RIGHT-OF-WAY							
EARTHWORK							
STRUCTURAL WORK							
SPECIAL FEATURES							
MISC. COSTS							
TOTAL COSTS							
DESCRIPTION OF OTHER MATCHING FUNDS:				Federal and/or state grants to offset costs			

	CAPITALIZED MAINTENANCE COSTS FOR CCFCD						
ANNUAL MAINTENANCE COST:							
LIST MAINT. ITEMS:							
Clean culverts	$ 500						
Trim brush below flowline	$ 1,000						
Remove debris after flood event	$ 500						
Maintain fences and access	$ 1,000						
TOTAL ANNUAL COST:	$ 3,000						
X 10 = **CAPITALIZED COST:**	**$ 30,000**						
THE PURPOSE OF CAPITALIZING MAINTENANCE COSTS IS TO PREVENT CONSTRUCTING AN UNMAINTAINABLE ARRAY OF PROJECTS. LOCAL ASSUMPTION OF THIS CAPITALIZED COST IS A SIGNIFICANT MATCH WHICH DOES NOT REQUIRE IMMEDIATE INVESTMENT BY THE SPONSOR.							

	PUBLIC BENEFITS OF PROJECT				
PROTECTION OF PUBLIC PROPERTY	NUMBER	UNIT VALUE	DEPTH	% DAMAGE	LINE VALUE
Airport buildings	3	$ 50,000	1 FT	10%	$ 15,000
Airport Road, one mile segment	1	$ 100,000	1 FT	10%	$ 10,000
		SUBTOTAL:			**$ 25,000**
INCREASE OF VALUE OF PUBLIC PROPERTY					
10 acre basin, raw land to recreational fields	10	$ 10,000			$ 100,000
8.7 acres channel, raw land to recreational path	8.7	$ 10,000			$ 87,000
		SUBTOTAL:			**$ 187,000**
TOTAL PUBLIC BENEFIT ATTRIBUTABLE TO PROPOSED PROJECT:					**$ 212,000**

	PRIVATE BENEFITS OF PROJECT				
PROTECTION OF PRIVATE PROPERTY	NUMBER	UNIT VALUE	DEPTH	% DAMAGE	LINE VALUE
Existing private residences in City Limits	10	$ 90,000	1 FT	10%	$ 90,000
		SUBTOTAL:			**$ 90,000**
INCREASE OF VALUE OF PRIVATE PROPERTY					
Vacant lots along Airport Road in floodplain	20	$ 2,000			$ 40,000
Land removed from floodplain	100	2000			$ 200,000
		SUBTOTAL:			**$ 240,000**
TOTAL PRIVATE BENEFIT ATTRIBUTABLE TO PROPOSED PROJECT:					**$ 330,000**