WATER RESOURCES EVALUATION

SUBMITTED TO:

TOWN OF PARADISE VALLEY

ARIZONA

MAY 1985

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WATER RESOURCES EVALUATION
FOR THE
TOWN OF PARADISE VALLEY, ARIZONA

EXECUTIVE SUMMARY

The Town of Paradise Valley is located in Maricopa County in central Arizona. Surrounding communities prevent area expansion by extending the Town Limits but the fixed area permits the projection of future growth and water demands within the Town of Paradise Valley. The purpose of this report is to answer water topic questions raised by the Town Council and to provide a document that can be incorporated into the long-term planning program.

PHYSICAL CHARACTERISTICS

The Town of Paradise Valley is in a semi-arid region with an average annual precipitation rate of 7.11 inches and an average evaporation rate of more than six feet per year.

The Town of Paradise Valley lies within two physiographic province basins, the Paradise Valley Basin, which is a northwest to southeast trending basin and the Salt River Basin which trends east to west. These basins are typcial of the central Arizona area, alluvium basins surrounded by rugged mountains.

The Town of Paradise Valley contains three landform regions. Mountains form the first region in the center of the Town. The second landform region is an area of sedimentary slopes that grade away from mountains in all directions. Lastly, is the main drainage channel in the area, Indian Bend Wash. This is the third landform region and it provides drainage for most of the Town of Paradise Valley.

GEOLOGY

The basins in the central Arizona area were formed by faulting which began about 20 million years ago. Some of the rock units rose and now form the mountains that ring the basins. Other portions of the rock units were lowered to form the basins. Sediments eroded in the mountain areas were transported to the basins where the alluvium was deposited.

Bedrock, which forms the mountains in the Town of Paradise Valley, consists of igneous rocks such as granite, a sedimentary rock called conglomerate and metamorphic rocks called schist, phyllite and quartzite. The water resources potential of the bedrock is very limited.

Sedimentary material in the basins has been divided into three units. These sediments contain groundwater which yields water to the wells that supply the Town of Paradise Valley and other communities.

The Upper Alluvium Unit contains clay to boulder size particles forming layers that have a total thickness of about 200 feet beneath the Town of Paradise Valley. Localized clay layers within the Upper Alluvium Unit can effect the water quality but the clay layer has a limited impact because declining water table levels have dewatered the unit. The Upper Alluvium Unit provides recharge to underlying formations.

The Middle Alluvium Unit lies beneath the Upper Alluvium Unit. Fine-grained alluvium such as clay makes up most of the sediments in the Middle Alluvium Unit. Minerals in these sediments have dissolved in the groundwater in the sediments and often the quality does not meet State drinking water standards. The Middle Alluvium Unit is thickest in the center of the basins but begins to thin beneath the Town of Paradise Valley closer to the mountains.

The poor quality groundwater and the lack of permeability of the Middle Alluvium Unit make the formation a poor source of water.

Underlying the Middle Alluvium Unit or the Upper Alluvium Unit where the Middle Alluvium Unit is not present is the Lower Conglomerate Unit. This coarse-grained sedimentary unit is the primary aquifer in the area and wells drilled into this formation have large yields.

HYDROLOGY

There are no natural surface water supplies in the Town of Paradise Valley that can be developed as a water supply. Storm runoff does recharge the groundwater but for the most part, the runoff is viewed as a potential flooding problem.

Groundwater data shows that there is at least 210,000 acre-feet of recoverable groundwater stored beneath the Town of Paradise Valley. The saturated alluvium forming the aquifer varies in thickness from less than 400 feet to more than 1,000 feet.

Pumping groundwater has resulted in alterations of the historic water table surface and subsurface flow patterns. Mining groundwater, pumping more than is replaced, has resulting in water table lowering that has exceeded 250 feet. The average water table decline rate is about 5 feet per year beneath the Town of Paradise Valley.

Central Arizona Project water has been allocated to the City of Phoenix, the Berneil Water Company and the Paradise Valley Water Company, the water companies that serve the Town of Paradise Valley. CAP water will augment the present water supplies and help to reduce the rate of water table decline. CAP water treatment costs are estimated by the City of Phoenix to be $100 per acre-foot.

LAND SUBSIDENCE

Groundwater mining results in a compaction of the alluvium and causes land subsidence. Lowering of the land surface was first documented in Arizona in the Eloy area. This condition can have serious impacts on street drainage and sewer line flow because as the land subsides, the grade of the surface changes. Land subsidence has been documented around the Town of Paradise Valley but the magnitude of the subsidence has not been quantified throughout the Town of Paradise Valley.

Earth cracks are associated with land subsidence and an earth crack has formed in the City of Phoenix north of the Town of Paradise Valley. The impacts of this geologic hazard can be minimized using good engineering designs. Earth cracks have not been reported in the Town of Paradise Valley but zones where there is a potential for earth cracks extend into the Town.

WATER QUALITY

There are no groundwater contamination problems in the Town of Paradise Valley that prevent the water from being used for domestic purposes. The Middle Alluvium Unit contains zones where the groundwater quality is poor and does not meet State standards for drinking water. These zones of poor quality groundwater can be identified and the wells can be designed to prevent that water from entering the well.

WATER REQUIREMENTS

Using a calculated dwelling density of 3.7 people and total of 4,167 lots in the Town of Paradise Valley, the projected population is about 15,500 people. The average water use is about 542 gallons per person per day in the Town of Paradise Valley, so the projected annual water demand for the 15,500 people is about 9,409 acre-feet per year.

Recharge to the aquifer beneath the Town of Paradise Valley adds about 3,375 acre-feet per year to the water supply. Central Arizona Project water will provide an additional 2,431 acre-feet for use in the Town. The tank analogy shows 210,000 acre-feet of recoverable groundwater is beneath the Town of Paradise Valley. The water sources could meet the needs of the popluation for at least 58 years based on the tank analogy.

A more accurate method to calculate the adequacy of a water supply to meet the demand is based on water table decline. This method incorporates regional pumping, regional recharge, groundwater movement and other factors into the calculations. This method of evaluation shows the water supply available for use in the Town of Paradise Valley will meet the demand for more than 100 years. A computer simulation study prepared for the Paradise Valley Water Company confirms the water supply will last in excess of 100 years.

POTENTIAL ALTERNATIVE WATER SOURCES

Central Arizona Project water, the present allocation quantities and additional water due to reallocations, presents the greatest potential for a new water supply in the Town of Paradise Valley. There are no natural surface water supplies available for development. Groundwater supplies in the area of the Town of Paradise Valley do not present a new source of water. Importing water from outside the Phoenix area using the CAP Canal to transport the water to the Town of Paradise Valley is an expensive project. Importation is not a viable source of new water.

Reuse of wastewater is an alternative water supply. This is not a new source but a method of reuse water and reducing the demand on the groundwater supply.

WATER RECYCLING

A population of 15,500 people will produce about 1,942 acre-feet of wastewater per year. Presently, 60 percent of the dwellings in the Town of Paradise Valley use septic tanks and the remaining 40 percent are connected to sewer systems.

The Town of Paradise Valley could process wastewater and use it for artificial recharge or irrigation of turf as on a golf course. The processing should be done at a water recycling plant, like the facility used at Gainey Ranch in the City of Scottsdale. There are no odors associated with the Scottsdale facility.

Artificial recharge using recycled water has only limited reuse potential at this time. Regulations have not been developed by the Arizona Department of Water Resources or by the State Legislature with regard to artificial recharge. Water quality standards for wastewater recharge have not been established.

Water recycling will reduce the demand for new water from the aquifer, provide a source of water for irrigation and reduce the money paid by the Town of Paradise Valley to the City of Scottsdale for processing wastewater. If the Town of Paradise Valley can have a developer build a water recycling facility and has a customer for the recycled water, it would be worth the time for the Town of Paradise Valley to fully investigate the proposal.

WATER CONSERVATION

Indoor water conservation devices offer only a limited potential for saving water in the Town of Paradise Valley. Maintenance of exterior and interior fixtures to eliminate leaking will save water. Modification of water using habits will also save water.

The greatest potential for water conservation in the Town of Paradise Valley is the area of outdoor water use. Controlling water applications for irrigation of landscaping, so water does not run into the streets, will save substantial water. Using drip irrigation for trees and shrubs will cut outdoor water use.

Water conservation reduces the waste of water and money. Each gallon wasted has to be treated and delivered. Water conservation reduces the need to develop additional water sources to meet future requirements because conservation reduces the demand. Water conservation should be voluntary but economic pressure could be used by the Town of Paradise Valley to encourage the residents to reduce wasting water.

WATER SYSTEM ACQUISITION

The Town of Paradise Valley could acquire the private water companies that serve the Town and that portion of the City of Phoenix water system in the Town of Paradise Valley. The cost for purchasing one or more of the water systems would not place an undue financial burden on the residents. The Town of Paradise Valley could then control water rates and monitor water use.

The Town of Paradise Valley would have to take over the operation and maintenance of a water company. CAP water would have to be purchased and treated for use in a municipal system. Current cost estimates are $160 per acre-foot for buying and treating CAP water.

The major problem facing the Town of Paradise Valley, if a water system is purchased is the water reduction goals required in the Phoenix Active Management Area. Water suppliers are required to reduce the per capita water use in their areas. If the Town of Paradise Valley owned a water system and the water use reduction goals are not achieved, the Town of Paradise Valley could face penalties up to a $10,000 per day fine.

SUMMARY

The following conclusions and recommendations are presented to the Town of Paradise Valley:

1) Complete subsidence survey work.

2) Computerize the water and sewer pipeline system layout for future planning studies.

3) Urge the water companies that supply the Town of Paradise Valley to apply for reallocations of CAP water.

4) Reduce water use by encouraging water conservation inside the home and in the yard.

5) Consider a water recycling plant to process wastewater for golf course irrigation.

6) Water companies can be purchased but regulation of water use may present problems for the Town of Paradise Valley.

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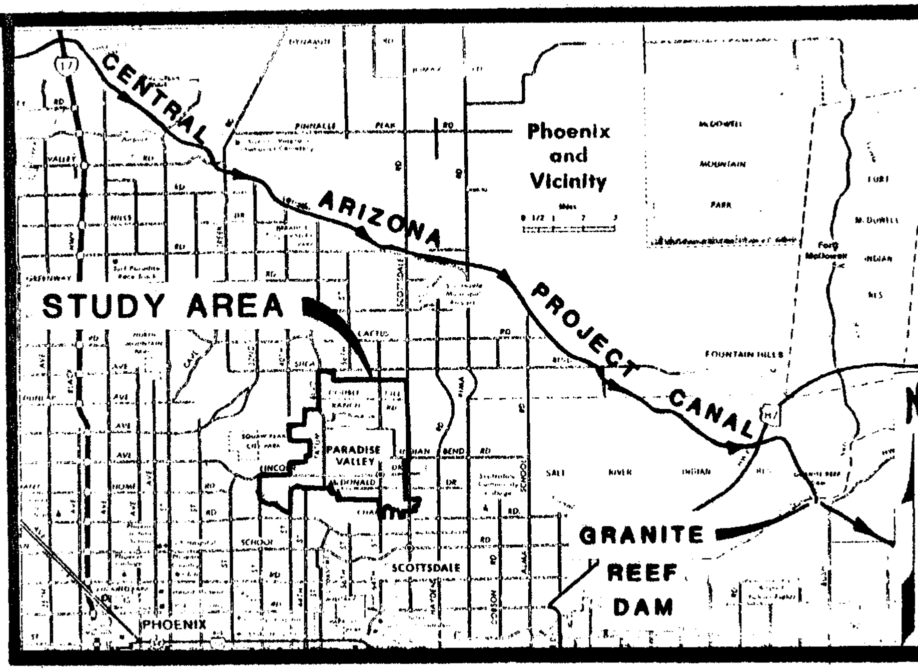
FOR THE
TOWN OF PARADISE VALLEY, ARIZONA

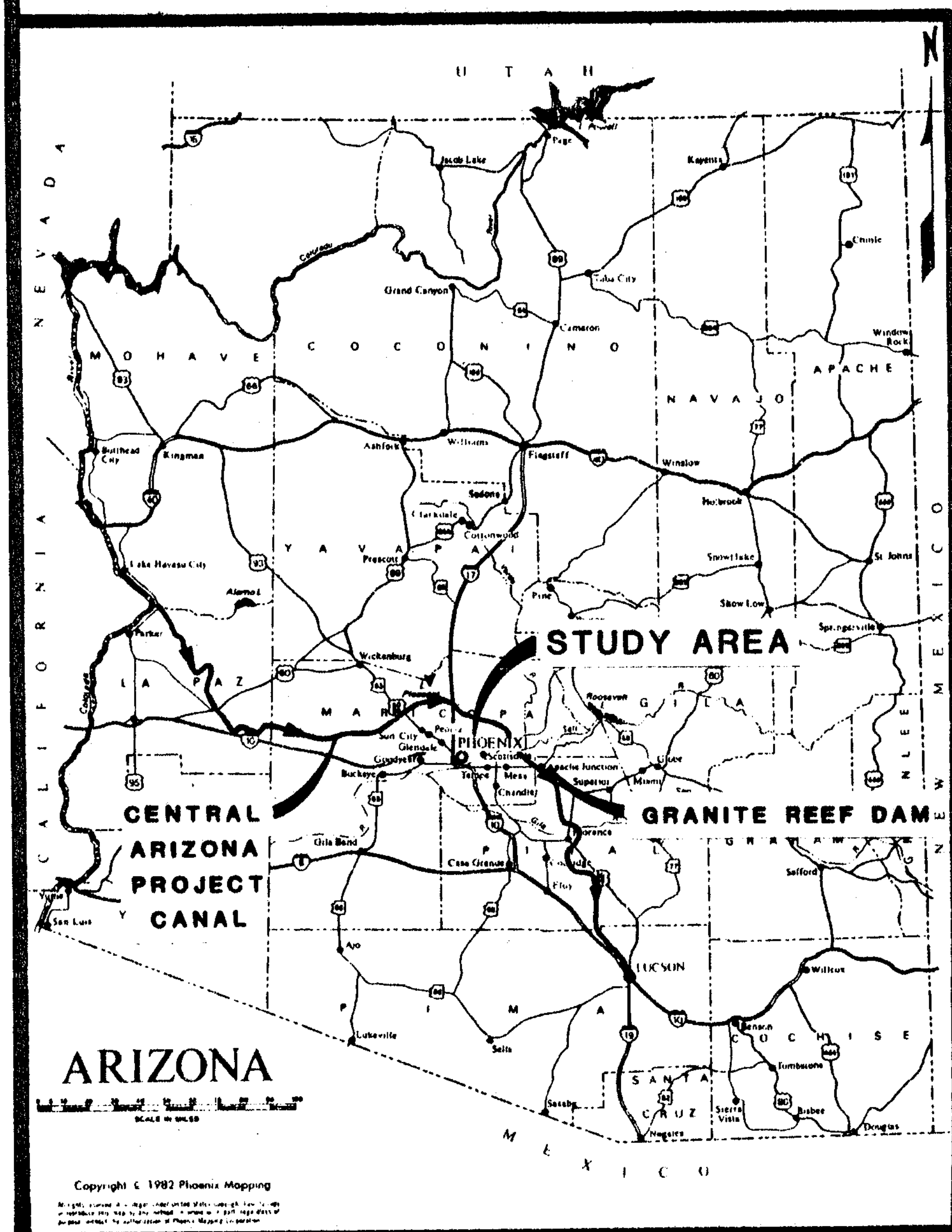
INTRODUCTION

The Town of Paradise Valley is located in central Maricopa County, Arizona, within the Phoenix metropolitan area (Figure 1). The Town of Paradise Valley contains approximately 16 square miles within its corporate limits, but the potential for expansion is limited (Figure 2). There are several islands of unincorporated land within the Town Limits and these could be annexed, but they would provide only a small increase in area. Exterior growth is prevented by the location of the city limits of other communities. The City Limits of Phoenix abut the Town of Paradise Valley to the north, west, and south, blocking growth in those directions. The City of Scottsdale borders the Town of Paradise Valley on the east and prohibits expansion in that direction.

Since the area of the Town of Paradise Valley is relatively stable, it is possible to project population growth as well as future water and sewer system demands. The Town of Paradise Valley presently does not own or operate a municipal water system or a wastewater treatment facility and, thus has no control of water use, wastewater treatment or water recycling. Knowledge of the available water supplies and the reliability of the water supplies is essential to complete any long-term development plans.

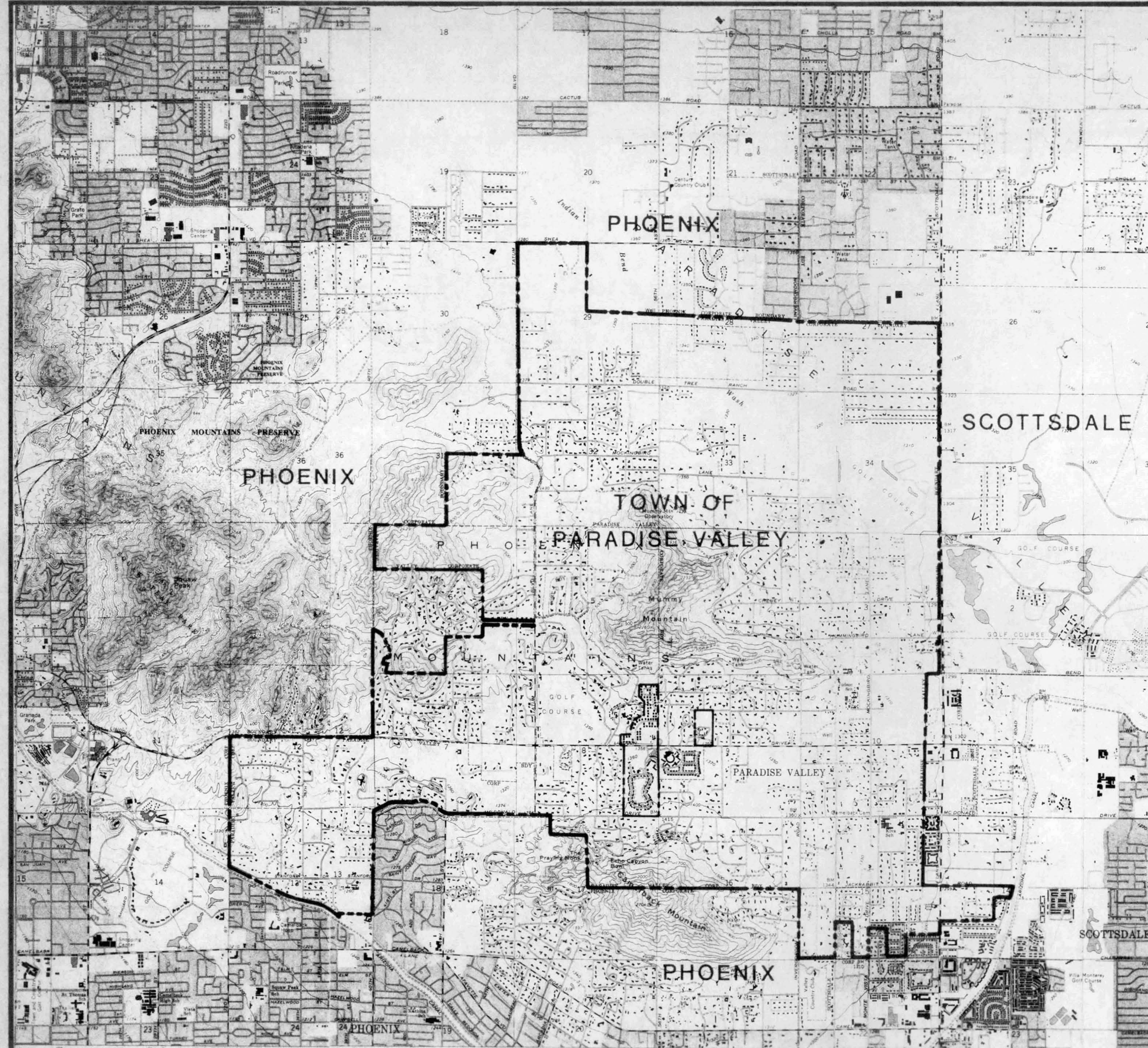
As part of a long-term planning program, the Town Council developed a list of questions and issues relating to hydrology, wastewater, geology, water supplies, and similar topics. The firm of Anderson-Nichols has been retained by the Town of Paradise Valley to complete a Water Resources Evaluation. The purpose of this report is to answer the questions originally presented by the Town Council and to identify other water related topics that should be addressed.





LOCATION MAP

FIGURE 1



EXPLANATION

CORPORATE LIMIT

TOWN OF PARADISE VALLEY
CORPORATE LIMITS

WATER RESOURCES EVALUATION
TOWN OF PARADISE VALLEY
MARICOPA COUNTY, ARIZONA

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PHOENIX, ARIZONA

FIGURE 2

PHYSICAL CHARACTERISTICS

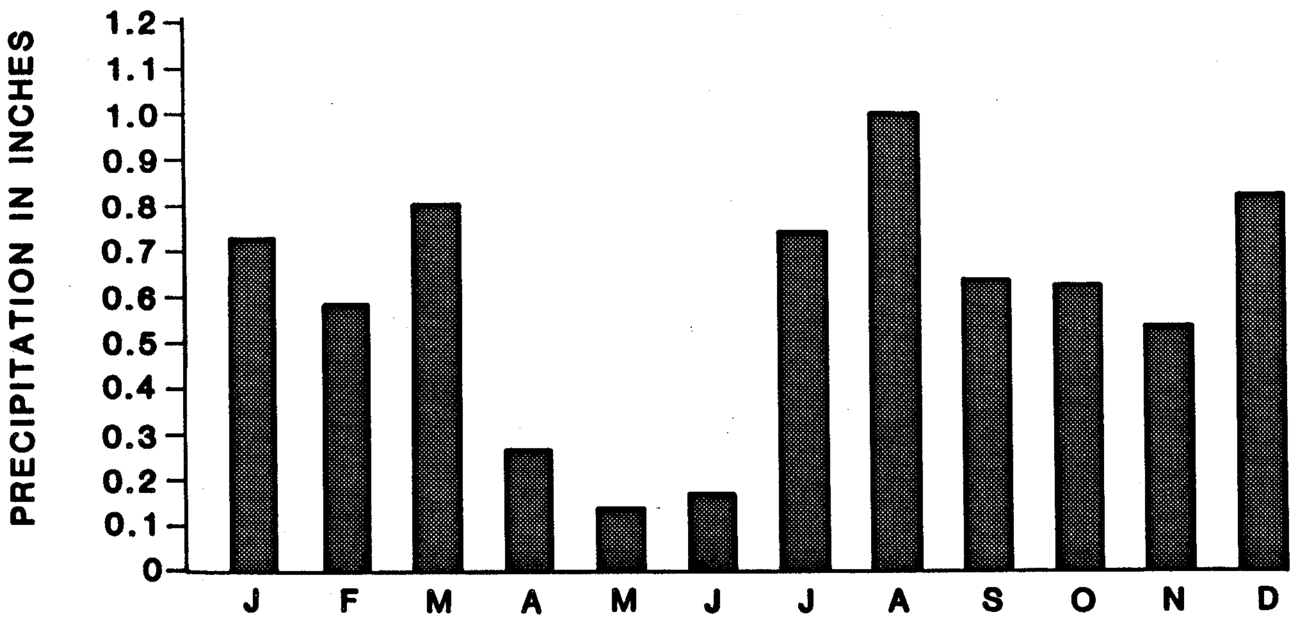
The Town of Paradise Valley is located in a region with a semi-arid climate characterized by hot summers and cool winters as is typical of Southwest deserts. The evaporation rate in the Phoenix area is more than six feet per year and the average humidity is low. Precipitation averages about 7.11 inches per year in Phoenix and occurs in two principal seasons(Figure 3). Rains in the winter season are generally gentle and of long duration. In the summer season, thunderstorms provide rainfall for short duration periods, but with high intensity. Summer storms often result in flooding because of the local intensity of the storms. Climate conditions in the Phoenix area are summarized on Table 1.

The State of Arizona has been divided into three major physiographic provinces. The Town of Paradise Valley is within the Basin and Range Physiographic Province which is characterized by alluvium basins surrounded by mountain ranges. The Town of Paradise Valley is partly within two of these physiographic province basins, the Paradise Valley Basin and the Salt River Basin.

The Paradise Valley Basin is a northwest to southeast trending valley that is about 27.5 miles long and 5 to 12 miles wide. The Cave Creek area is the northern limit of this basin and the Salt River is the southern boundary. The Salt River Basin has more of an east to west orientation. The Phoenix Mountain and Camelback Mountain area marks the northern limit of the Salt River Basin in the Town of Paradise Valley.

The topography and landforms within the Town of Paradise Valley can be separated into three general landform categories. The first landform region contains the rugged mountain areas. The Phoenix Mountains and Mummy Mountain form the core of this region in the center of the Town. A portion of Camelback Mountain and some isolated outcrops of rock along the south boundary of the Town of Paradise Valley are also in this region.

Landslopes in the mountain areas are quite steep. These rugged areas have a high precipitation runoff potential due to the nature of the rock units forming



AVERAGE MONTHLY PRECIPITATION

WATER RESOURCES EVALUATION
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FIGURE 3

TABLE 1

CLIMATE CONDITIONS IN THE PHOENIX AREA

MONTH	AVERAGE PRECIPITATION (INCHES)
January	0.73
February	0.59
March	0.81
April	0.27
May	0.14
June	0.17
July	0.74
August	1.02
September	0.64
October	0.63
November	0.54
December	0.83

Average = 7.11 inches

Evaporation = 80.27 inches (6.69 feet) per year

Average Daily Humidity

5 a.m.	52 percent
11 a.m.	32 percent
5 p.m.	23 percent
11 p.m.	40 percent

the mountains and the steep slopes. The rocks are hard and do not allow rainfall to soak into the ground. The water drains rapidly from the rock and gathers in channels which transport the water downslope. The mountain areas separate the Paradise Valley Basin to the north and east from the Salt River Basin to the south.

The second landform region contains the areas of slopes that grade away from the mountain areas in all directions. These slopes consist of sedimentary materials which control the surface configuration and drainage patterns. Most of the development in the Town of Paradise Valley has occurred on these slopes.

The third major landform region is the channel of Indian Bend Wash which flows in a northwest to southeast direction through the northeast area of the Town. The gentle slopes of the second landform region grade toward this wash. Lands lying south of the wash slope to the northeast and those lands lying north of the wash slope to the southwest. Indian Bend Wash drains most of the Town. Surface drainage from the northern, eastern, and part of the central area of the Town of Paradise Valley flows directly into Indian Bend Wash or via a subchannel into the Wash. A second wash, Echo Canyon Wash (also known as Cudia City Wash), flows to the southwest into the Salt River Basin. This wash drains the central and southwest parts of the Town of Paradise Valley.

GEOLOGY

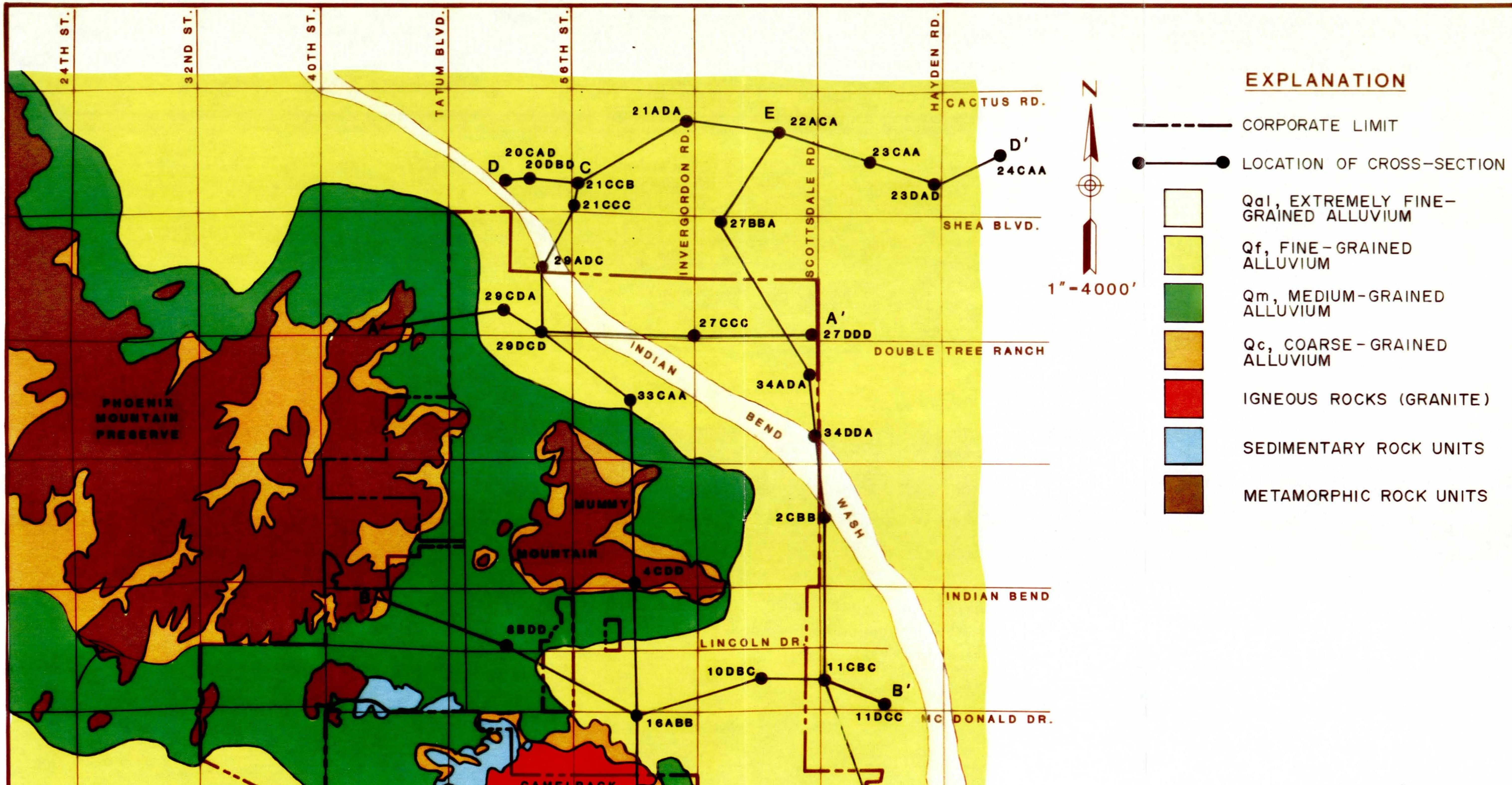
General:

The geology of the Paradise Valley Basin area has been studied by other authors. The general geology of the surface materials can be interpreted from the basic data on the geologic map of Maricopa County (Wilson, et.al., 1957). That map provides a broad scale overview of the area, but by using field data and other references, a more detailed evaluation of the geology can be completed. The local geology of the Town of Paradise Valley area is shown on Figure 4.

The regional geologic history of the Paradise Valley Basin is related to faulting which formed the mountains and sediment filled basins. This geologic area is dominated by northwest-southeast fault block mountains separated by broad valleys partially filled with sediments.

During the period of regional warping and tensional faulting which began 20 million years ago, some of the rock units were uplifted forming the present mountain ranges. Other blocks of rock were down dropped and became the floors of the present valleys. The faulting was not a sudden event, but a long, gradual occurence. This geologic process spanned millions of years during which erosion and weathering of the uplifted rock created sediments which were transported to the basin.

Deposition of the sediments occurred as washes and channels developed and transported the sedimentary material downslope. At the head of the washes the channel slopes were steep resulting in fast moving water currents with enough energy to transport sediments as large as boulders. As the channel slopes flattened, the water lost energy and the larger rocks and boulders were deposited. Medium-grained sediments were deposited farther away from the mountains. This depositions process continued down the wash channels until the flow had decreased to a level where the fine-grained sediments were deposited. Figure 4 illustrates this natural distribution of sediments; i.e. the coarse-grained alluvium is near the mountains and the fine-grained alluvium in Indian Bend Wash is farther away from the mountains.



SURFACE GEOLOGY OF THE TOWN OF PARADISE VALLEY

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TOWN OF PARADISE VALLEY
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FIGURE 4

Climate variations have resulted in different sedimentation conditions and changed drainage paths for the channels. During wet cycles, higher precipitation rates increased the runoff flow in washes resulting in greater erosion potential and a greater transportation of the sediments. The boulders and coarse-grained material were deposited farther down slope from the head of the washes. During dry cycles and low flow periods, less erosion occurred and the sediment was deposited closer to the mountains. The thickness of alluvium layers, grain size within the layers, and lateral extent of the layers within the basin are functions of these historic climate variations, depositional environments, and the magnitude of structural movement. The present land surface and underlying rock units are the result of millions of years of development, all controlled by the geology of the area.

Bedrock Geology:

Bedrock is exposed in the mountains in the Town of Paradise Valley. The formations consist of igneous, metamorphic, and sedimentary rocks. The rock outcrops were mapped by Shank (1973) and Holway (1977). Figure 4 illustrates the bedrock outcrops and rock types within the study area.

The water resources potential of the bedrock units is quite limited. These rocks are hard and dense, and thus have almost no value as a source of groundwater. Occasionaly, the rock is fractured which increases the porosity (void space) and permeablity (ability to transmit water) of the rock. However, subsurface fractures are difficult to map and wells drilled into fractures usually do not yield sufficient quantities of water for municipal use. The bedrock unit is also a poor surface water source. The unit does have a high runoff coefficient and low infiltration rate, but runoff is not perennial or dependable.

The Phoenix Mountains and Mummy Mountain are formed by erosion resistant metamorphic rocks. The rock units consist of schists, phyllite, and quartzite that is of Early Precambrian Age. Metamorphic rocks are formed due to great heat and/or pressure acting on existing rock units. These forces change the characteristics of the rocks creating the metamorphic rocks. The tilted layers of different colored rock units in these mountains owe their origin to the metamorphosed rocks that were later tilted by faulting. The area has been mineralized and, in the past, a series of mercury (cinnibar) mines were developed in the Phoenix Mountains.

Camelback Mountain is a bedrock outcrop consisting mostly of granite, but the area of the camel's head consists of sedimentary rock. The granite is from the Late Precambrian Age. Granite forms when a magma is intruded into surrounding rocks and slowly cools. The rock that forms is a hard, coarse-grained, igneous rock that is erosion resistant.

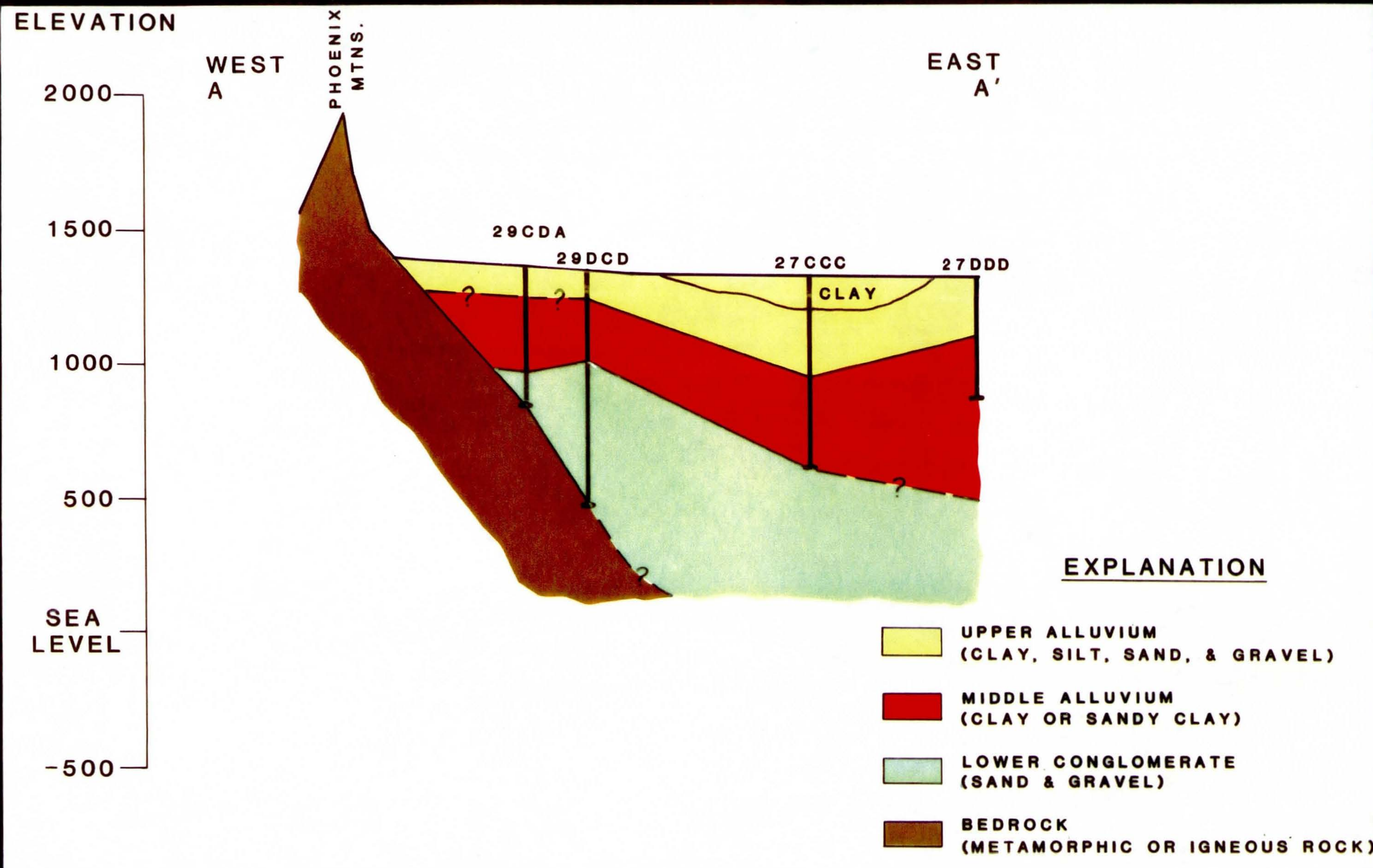
The sedimentary bedrock unit was formed by the lithification (cementing) of an alluvial fan deposited a high energy environment. This environment consisted of steep washes which deposited the coarse-grained sediments. These alluvial fan sediments were lithified by natural cementing agents deposited in the pore spaces. The sedimentary bedrock unit, therefore, is made of a well cemented coarse-grained sandstone and conglomerate.

Alluvial Sediments:

Materials eroded from the mountains are transported into the basin where they are deposited. During this erosion and deposition cycle, the sediments are naturally sorted resulting in the larger and heavier sediments being deposited near the mountains with the fine-grained sediments being deposited toward the center of the basin.

Surface geology reflects the most recent depositional environment conditions in the area. The climate and related depositional environments have changed throughout the period alluvium has been accumulating in the basin. The subsurface geology of the area also reflects these changed conditions as evidenced by and interpreted from water well driller's logs that are on file at the Arizona Department of Water Resources (ADWR). Because each driller describes the well cuttings differently, the local geologic history must be anlyzed in conjunction with the well logs in order to construct subsurface geologic cross-sections. The well logs are used to reinforce the local geology and as a result, the locations of the cross-sections are dependent on the driller's logs. Three geologic cross-sections were developed within the Town of Paradise Valley. These include west-east cross-sections near Double Tree Ranch Road and Lincoln Drive (Figures 5 & 6) and a north-south cross-section through Mummy Mountain and Camelback Mountain (Figure 7).

In order to show regional geologic trends within the Paradise Valley Basin, cross-sections were included near Shea Boulevard to the north of the Town of Paradise Valley (Figure 8) and near Scottsdale Road to the east of the Town (Figure 9). Locations of the geologic cross-sections are shown on Figure 4.



WEST-EAST CROSS-SECTION
NEAR DOUBLE TREE RANCH ROAD
VIEW TO NORTH

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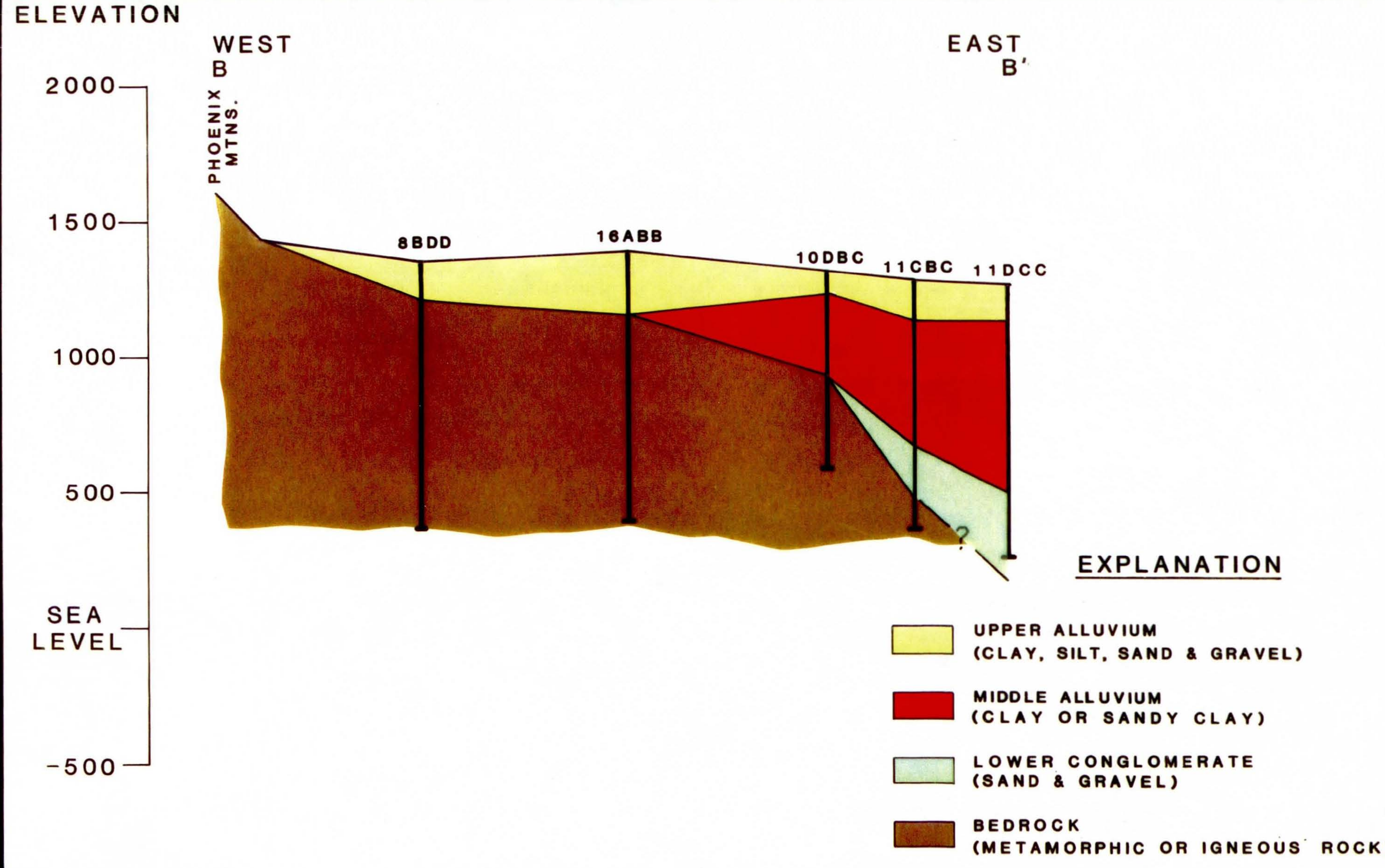
FIGURE 5



WEST-EAST CROSS-SECTION
NEAR LINCOLN DRIVE
VIEW TO NORTH

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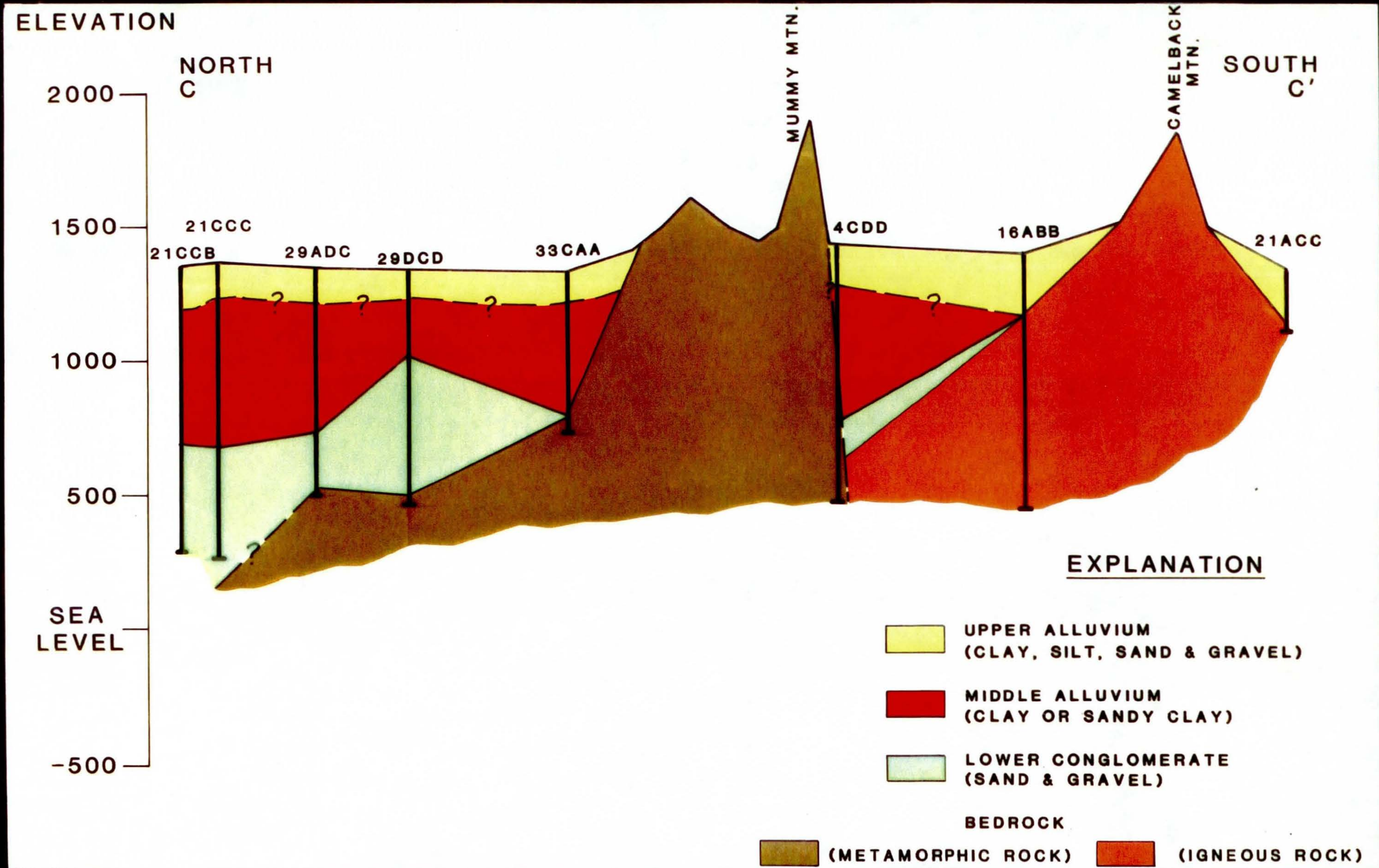
FIGURE 6



NORTH-SOUTH CROSS-SECTION
THROUGH MUMMY MTN. AND CAMELBACK MTN.
VIEW TO EAST

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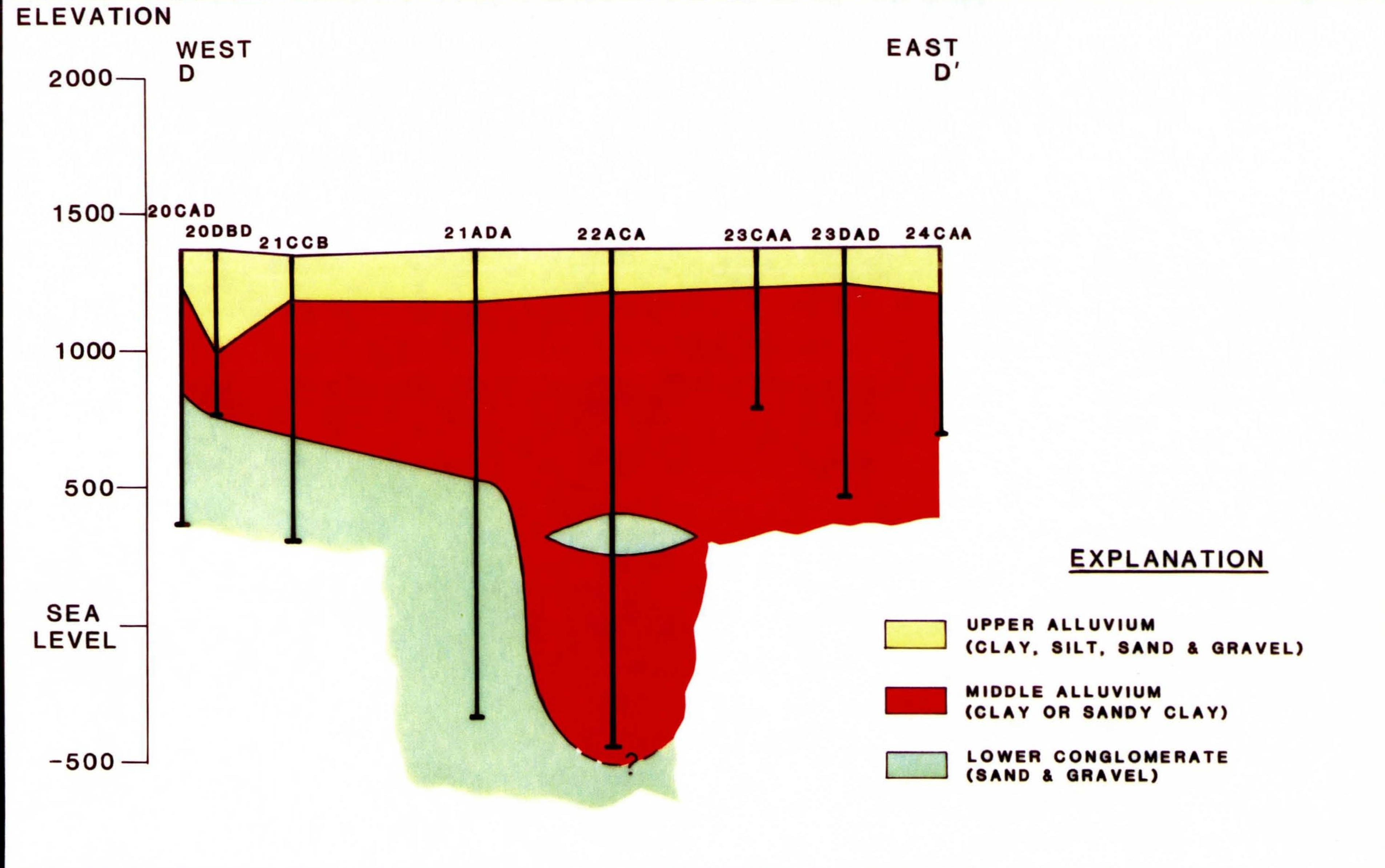
FIGURE 7



WEST-EAST CROSS-SECTION
NEAR SHEA BOULEVARD
VIEW TO NORTH

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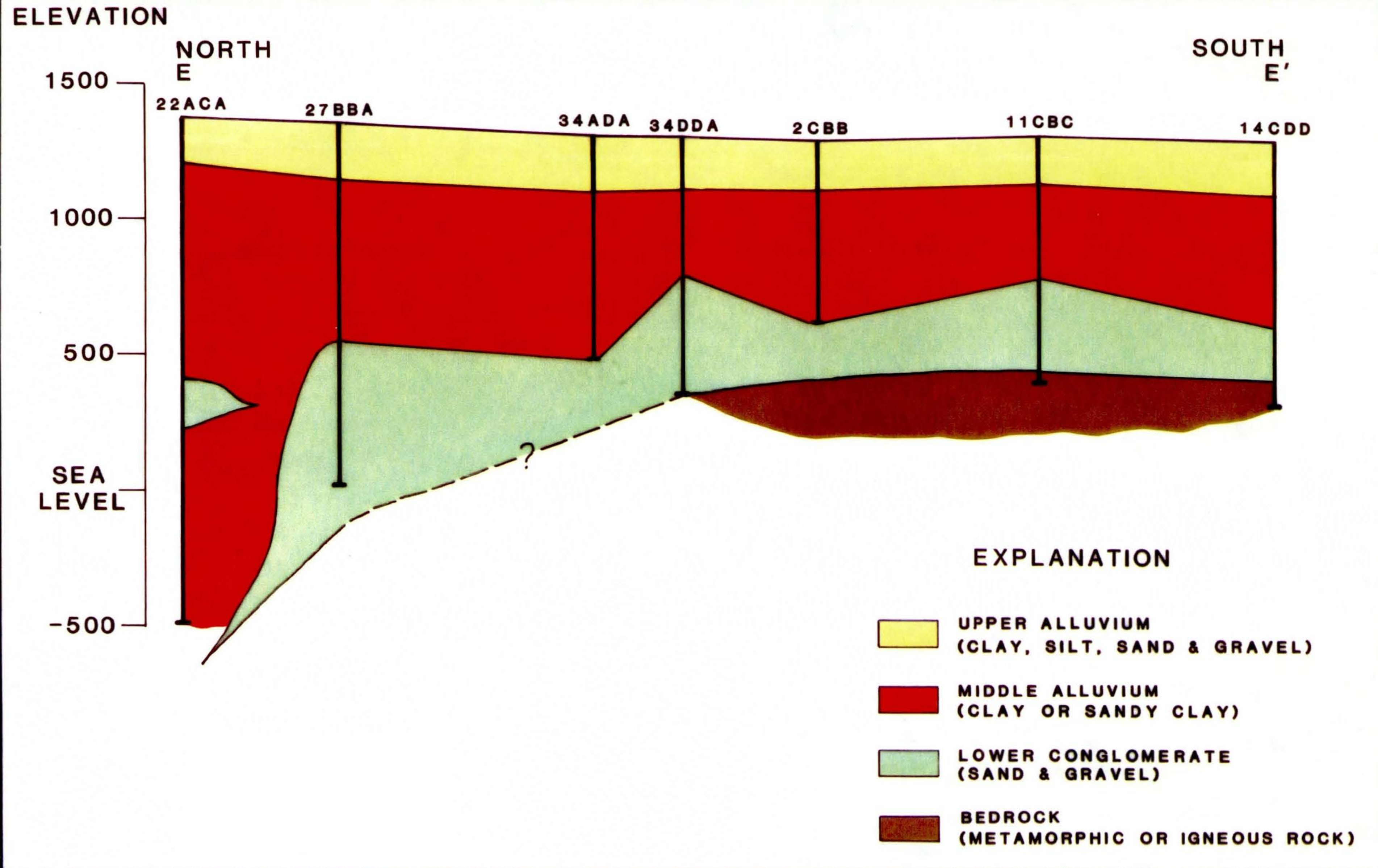
FIGURE 8



NORTH–SOUTH CROSS–SECTION
NEAR SCOTTSDALE ROAD
VIEW TO EAST

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FIGURE 9

The sediments have been subdivided into three formations which are consistently found in this area: the Upper Alluvium Unit, the Middle Alluvium Unit, and the Lower Conglomerate Unit (Arteaga et.al., 1968). These three formations have been identified in other basins in central Arizona and are typical of the region.

Upper Alluvium Unit:

The Upper Alluvium Unit consists of clay to boulder size particles. This unit is the surface alluvium unit illustrated on Figure 4. In the Paradise Valley Basin, the Upper Alluvium Unit can range in thickness from a few feet near the mountains to more than 1,000 feet in the central part of the basin. The thickness of this unit beneath the Town of Paradise Valley can be seen on Figures 5, 6, and 7. This formation can reach a thickness of 200 feet in the northeast portion of the Town of Paradise Valley. Within the northeast portion of the area on Figure 4 and near Scotsdale Airport, there are localized clay units in the Upper Alluvium Unit. These clay units were deposited in a playa lake environment, an extremely low energy environment, in which conditions resemble those in Death Valley, California. The cross-section shown on Figure 5 identifies the clay unit within the Upper Alluvium Unit.

This formation has a high potential for water well development. The coarse-grained areas near the mountains are primary areas for water recharge. From 1946 to the present, the Upper Alluvium Unit provided significant quantities of water to wells in the area. This resulted in lowering the water table and has dewatered most of this formation in many areas of the Paradise Valley Basin. In the areas where the water level is near the bottom of the formation, the hydrologic potential of the formation is limited. However, this upper unit still provides recharge to the formations that lie beneath it.

Middle Alluvium Unit:

The Middle Alluvium Unit consists of fine-grained sediments, mainly clay and silt. The formation can exceed 2,000 feet in thickness in the center of the valley, but thins toward the basin margin. These clays were deposited in a playa lake depositional environment (U.S.B.R., 1976). Evidence of this environment is the presence of gypsum in the clays recovered during well drilling. The Middle Alluvium Unit is overlain by the Upper Alluvium Unit and is shown on the geologic cross-sections (Figures 5, 6, and 7).

This unit has a very limited hydrologic potential for two reasons. First, the fine-grained sediments do not yield water to wells at a rate sufficient to meet municipal needs. This is due to the low permeability within this unit. The low permeability, or ability to transmit water, in the Middle Alluvium Unit retards the downward percolation of water from the overlying formation. In hydrology, this type of formation is called an aquiclude or an aquitard, depending upon the degree to which it prevents percolation.

The second reason that the Middle Alluvium Unit has limited well potential is due to the minerals dissolved in the water in the formation. The playa depositional environment in which drainage had no exit, caused many minerals such as chromium, fluoride, arsenic, iron, and salts to become concentrated in the sediments and in the water contained in those sediments. These waters generally will not meet the State standards for potable water and municipal wells must usually be designed to prevent water from the Middle Alluvium Unit from entering the well by providing blank casing in these sections.

Lower Conglomerate Unit:

The third formation is the Lower Conglomerate Unit which is a coarse-grained sedimentary formation. This unit was deposited directly over the basement complex in a high energy environment. The alluvium contains gravel- to sand-sized particles for the most part, but there are some local fine-grained strata contained within it. The Middle Alluvium Unit thins and pinches out prior to reaching the mountain areas. Where the Middle Alluvium Unit is present, it overlies the Lower Conglomerate Unit. In areas where the Middle Alluvium Unit is not present, the upper contact of the Lower Conglomerate Unit is the base of the Upper Alluvium Unit. This is illustrated on Figures 8 and 9. Well log data shows that the Middle Alluvium Unit is absent west of Camelback Mountain within the Town of Paradise Valley.

The hydrologic potential of the Lower Conglomerate Unit is quite good due to the particle size in this unit. Gravel to sand size particles result in high porosities and permeability. It is one of the primary aquifer units in the area and wells that penetrate it have high yields. This fact is confirmed by well data provided by the Paradise Valley Water Company because wells that penetrate this unit have specific capacities in excess of 100 gallons per minute per foot of drawdown. The Lower Conglomerate Unit is recharged by water percolating into it from the Upper Alluvium Unit.

The total thickness of the three formations is not known in many areas of the Paradise Valley Basin because very few wells have been drilled to bedrock in the center of the Paradise Valley Basin. Along the margins of the basin where bedrock is relatively shallow (1,000 to 1,500 feet), wells have penetrated the full thickness of the formations. The U.S. Geological Survey (USGS) (1973) published a map that shows estimated alluvium thickness in central Arizona. However, this map illustrates regional trends only and is not site specific. The estimated alluvium thicknesses shown on the USGS map is not considered definitive for specific locations and must be correlated with other published data and substantiated by driller's logs in the area. The thick areas of alluvium in the central part of the Paradise Valley Basin are only shown to be more than 1,200 feet thick on the USGS maps. Other studies in the area estimate that the sediments in this basin could be 5,100 feet thick or as much as 7,000 feet thick.

The thickness of the alluvium beneath the Town of Paradise Valley varies from a thin veneer of sediments a few feet thick near the mountains to more than 1,200 feet thick in the northeast part of the Town. A large part of the Town overlies areas where the average thickness of the alluvium is from 0 to 400 feet thick (USGS, 1973).

HYDROLOGY

Surface Water:

There are no natural surface water sources in the Town of Paradise Valley. The drainage channels flow in direct response to precipitation but these flows are not usable for a water supply. Storm runoff can total substantial quantites of water but the runoff will usually occur over a short time period that can vary from a few hours to a few days. An impoundment is needed to trap and store the runoff to save the water so it can be used during the no flow periods. There are no sites in the Town of Paradise Valley where a reservoir could be located to store the runoff and put it to beneficial use, other than for groundwater recharge, due to the topography. A lake could be sited in the Indian Bend Wash floodplain as it is in McCormick Ranch, but it would be shallow and wide. This configuration would cause the lake to lose about 6.7 feet of water per year due to evaporation. The McCormick Ranch lake, and other similar lakes in the Phoenix metropolitan area, have been designed for some recreational use and to provide some flood control, but are there primarily for aesthetic purposes. These urban lakes are not used to store runoff for later use as an urban water supply.

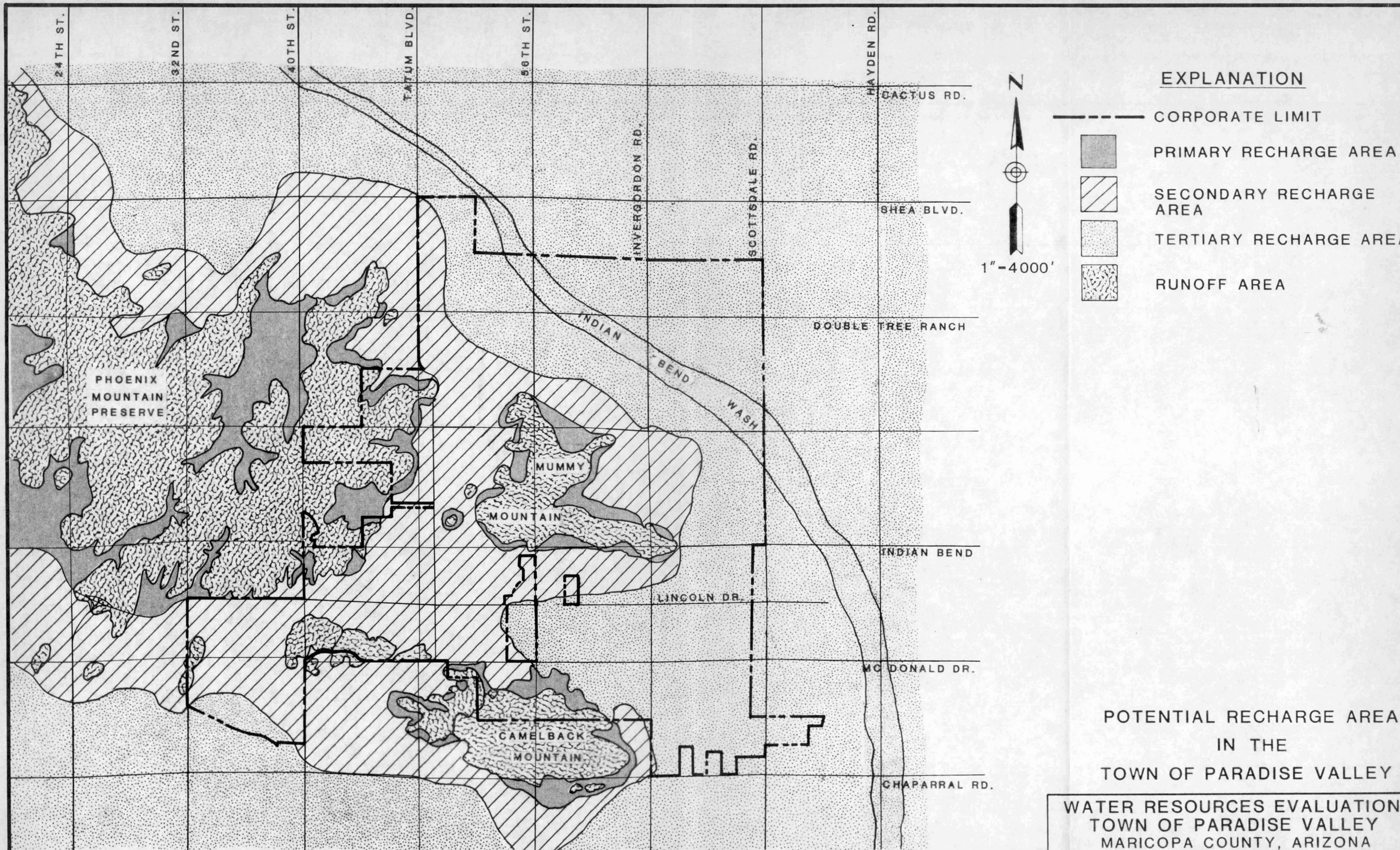
In most cases, the surface water is viewed as a problem in urban areas. Storm runoff can fill the small- and medium-sized drainage channels and that results in street flooding. Large storms can fill Indian Bend Wash and that causes major flooding and street closures. Channelization of Indian Bend Wash was required in order to control the flow and reduce the flood hazard.

Surface water flows resulting from storm runoff do provide a beneficial service. The wash channels transport runoff water from the relatively impervious mountain areas to the alluvium of the valley. The coarse-grained areas of the Upper Alluvium Unit on the surface near the mountains (Figure 4) have the highest permeability and water can percolate into the alluvium from the washes. Permeability is a measurement of the capacity of a material to transmit a fluid such as water. The greater the permeability of the material, the more water it can transmit. A portion of the water that percolates into the ground will continue to infiltrate down below the surface and will recharge the aquifer unit. Not all of the water entering the ground will recharge the underlying sediments because a portion of the water will be used by the vegetation of the area and some will evaporate directly from the soil or sediments before the water can penetrate to any significant depth.

Recent urbanization trends have resulted in the channelization of washes to expedite water flows from specific areas or to control the surface flow. Many natural channels are modified or lined to help control runoff. This practice does help to remove water from areas faster, but it decreases the potential for recharging the aquifer beneath the Town of Paradise Valley.
Water infiltration into the ground is controlled by the permeability of the material in the channel and the amount of time that the water is in contact with the material. When a channel in an alluvium area is lined, usually with concrete, it greatly reduces the permeability of the bed of the channel. Channelization often increases the rate of flow in the channel. This reduces the contact time of the water with the channel bed. These two conditions can reduce the groundwater recharge resulting from storm runoff.

In many cases, it would be better to design floodwater retention basins to provide short-term storage of runoff water and allow the water to percolate into the ground. These retention basins would be most efficient in areas where the coarse-grained alluvium of the Upper Alluvium Unit is present. Such basins would provide dual benefits; one, to help control storm runoff and two, recharging of the aquifer units beneath the Town of Paradise Valley.

Locations of potential recharge are based on the surface geology in the Town of Paradise Valley are illustrated on Figure 10. These recharge area zone classifications are based on regional surface geology and soil conditions. Experience has shown that the surface materials can exhibit a variety of conditions over short distances. This regional data should be supplemented by local on-site soil tests to verfiy the specific permeability and percolation rates that are valid at each specific site. Figure 10 is a regional planning map for the Town of Paradise Valley. Primary recharge areas are where the surface materials are coarse-grained and allow relatively rapid infiltration of water into the alluvium. Secondary recharge areas are where the surface materials are medium-grained in size. The secondary areas have permeability rates that are slightly less than in the primary areas but water can still percolate into the ground. Tertiary recharge areas contain the fine-grained to very fine-grained surface materials. Permeablity and percolation rates are



POTENTIAL RECHARGE AREAS
IN THE
TOWN OF PARADISE VALLEY

WATER RESOURCES EVALUATION
TOWN OF PARADISE VALLEY
MARICOPA COUNTY, ARIZONA

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PHOENIX, ARIZONA

FIGURE 10

slower than in the other two areas but artifical recharge basins could still be used.

Groundwater:

There are less total groundwater resources beneath the Town of Paradise Valley than beneath the surrounding communities because a large portion of the Town of Paradise Valley contains mountainous areas or regions where bedrock is relatively close to the surface. In areas where the alluvium is thin, there are less saturated sediments and thus less groundwater in storage than in areas where the alluvium is thick.

One method of calculating the amount of groundwater in an area is the "tank analogy". The amount of water in storage beneath the Town of Paradise Valley can be calculated using this analogy, assuming that the groundwater is static and the Town Limits form a wall that extends down into the ground. The amount of groundwater within the tank formed by those limits can be calculated. Osterkamp (1976) estimated the amount of groundwater in storage to a depth of 1,200 feet in the basins and subbasins of central Arizona on a regional basis. The 1,200 foot depth is commonly used as the lower limit in groundwater evaluations because of State regulations in the Groundwater Code even if the bottom of the saturated sediments is more than 1,200 feet below the surface. State regulations have established 1,200 feet as the maximum projected water table depth permitted for use in calculations relating to an application for a certificate of adequacy for a 100-year water supply. The data developed by Osterkamp can be used to estimate the amount of recoverable groundwater per square mile of surface area when the data is adjusted to reflect the local conditions beneath the Town of Paradise Valley. Not all of the groundwater contained in the aquifer can be removed from storage. A portion of the groundwater always remains as retention water in the aquifer, adhered by molecular forces to the sediment particles (Bouwer, 1978). Groundwater that can be removed from the aquifer is the recoverable groundwater.

Regional groundwater projections show that the aquifer beneath the Town of Paradise Valley contains an average of 30,000 acre-feet of recoverable groundwater per square mile. The term acre-feet is used when dealing with large volumes of water. The resulting numbers when using acre-feet are much more manageable than gallons. An acre-foot of water is about equal in volume to a layer of water one foot deep covering a football field. There are 325,851 gallons in an acre-foot of water and that quantity could supply six people for one year based on the water use limits set by the Arizona Department of Water Resources. The area of the Town of Paradise Valley with sufficient alluvium for consideration as an aquifer is about seven square miles. The tank analogy method shows a recoverable groundwater supply of about 210,000 acre-feet of water exists beneath the Town of Paradise Valley down to 1,200 feet or bedrock, whichever is higher.

Using the tank analogy on a much larger scale, an estimate can be made of the amount of groundwater in storage in entire groundwater basins. It can be calculated that 9.8 million acre-feet of recoverable groundwater is stored to a depth of 1,200 feet in the Paradise Valley Basin.

Southwest of the Town of Paradise Valley is the Salt River Basin, an area with greater groundwater reserves than the Paradise Valley Basin. However, the portion of the Salt River Basin in the area adjacent to the Town of Paradise Valley is estimated to contain approximately 22,000 acre-feet per square mile. The majority of the groundwater in the Salt River Basin is stored in the sediments toward the center of the valley and not in areas near the mountains where the alluvium is relatively thin.

However, groundwater is not static. It flows from areas of high water table elevation to areas of low water table elevation just as surface water flows follow the land surface elevations downslope, but groundwater flows at a much slower rate. As groundwater is used in one area, it can be replaced by recharge from the surface and also by groundwater flow into the depleted areas from other areas. The tank analogy is only a rough estimate of the groundwater reserves because it assumes that groundwater is fixed in one place and does not incorporate groundwater movement into the calculations.

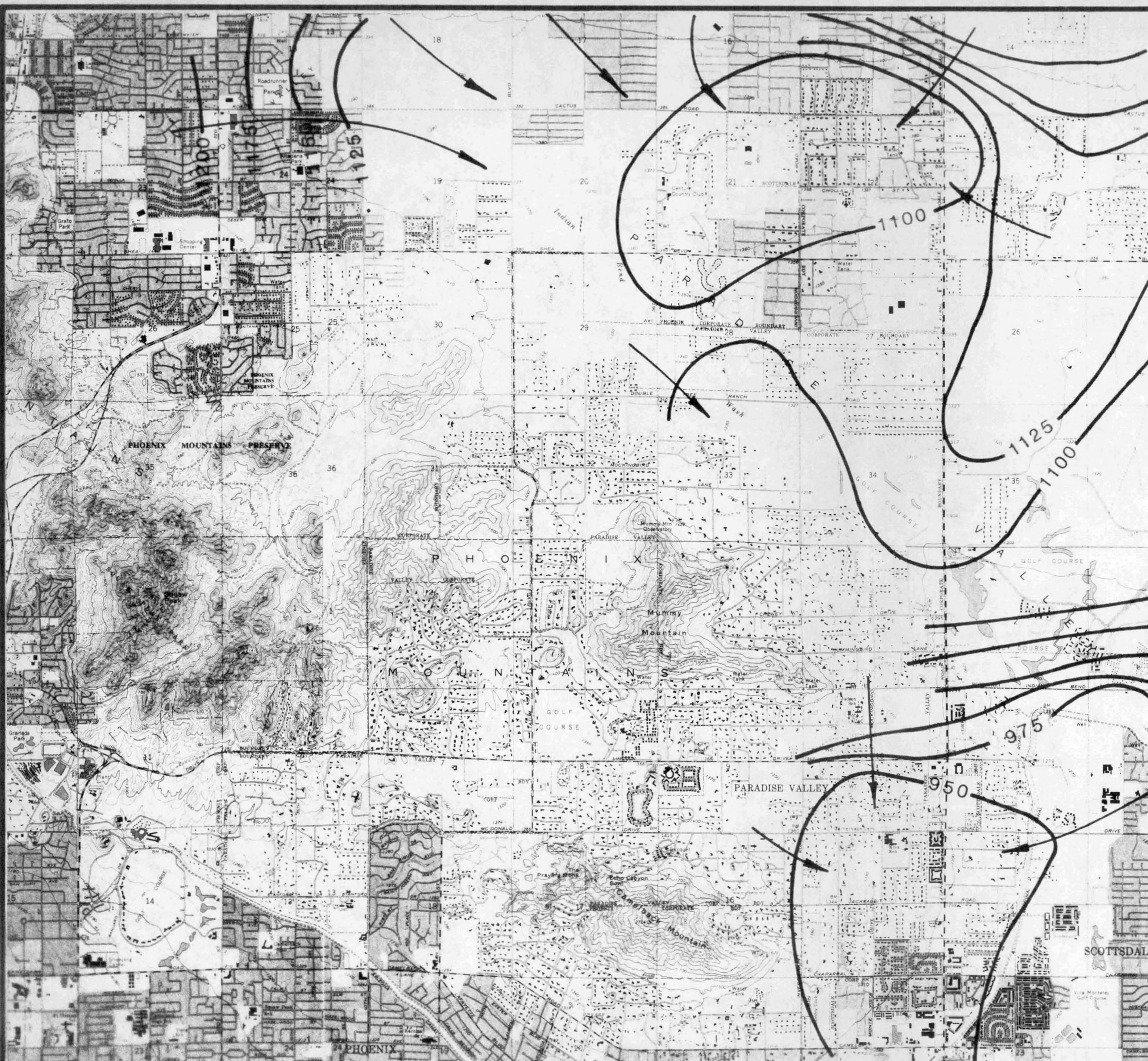
Groundwater reservoir conditions, recharge, and pumping stresses do have local impacts on the aquifer, but they are controlled by regional conditions. Historic data can be used to compile water table contour maps which show the elevation of the water table and the direction of flow of groundwater at different points in time. Water table contour maps show the top of the water table so that it looks like a land surface topographic map. Areas where there are groundwater mounds have higher elevations than groundwater depressions can be identified on these maps. In most undeveloped areas, the water table surface mirrors the land surface. When groundwater pumping is initiated, the subsurface conditions are altered and the water table will acquire different configurations.

The 1966 groundwater table conditions in the Paradise Valley Basin (Figure 11) are projected for this study based on data compiled from published records and well data on file at the ADWR. The 1966 water table map shows two areas of water table depressions caused by pumping. The first depression is located in Phoenix, northeast of the Town of Paradise Valley and includes the southeast area of the Town of Paradise Valley and part of the City of Scottsdale. Original regional groundwater flow patterns are altered and the groundwater is flowing into the two depressions. Groundwater flows into the northern depression from the northwest, north, and east. Groundwater flows into the southern depression from the west, north, and east.

Groundwater flow in the southwest area of Figure 11 would be from the mountain region toward the southwest where development in the Salt River Valley Basin required the water. The historic flow directions are still evident in 1966. Groundwater movement in the Paradise Valley Basin is from the northern area illustrated on Figure 10 where the elevation of the water table is about 1,200 feet above sea level toward the south along the east side of the mountainous region. The water table elevation in the southeast area on Figure 10 is about 950 feet above sea level.

By 1977, the water table conditions in the Paradise Valley Basin had been altered even more (Figure 12). The southern groundwater depression that included part of the Town of Paradise Valley and part of the City of Scottsdale has an enlarged area of impact since 1966 and groundwater was now flowing into the depression from all directions. Groundwater beneath the southeast portion of the Town of Paradise Valley was flowing toward the depression. That is an expected condition because the aquifers receive recharge from the mountainous region.

The northern groundwater depression that was identified in 1966 had been changed by 1977. The area was no longer a circular depression, but had formed a northwest to southeast trending trough that directed groundwater flow toward the southern depression.



EXPLANATION

→ GENERALIZED GROUNDWATER FLOW PATTERN

—975— WATER LEVEL CONTOUR ELEVATIONS ABOVE MEAN SEA LEVEL (INTERVAL-25 FEET)

GROUNDWATER CONTOURS & GENERALIZED FLOW PATTERNS, 1966

WATER RESOURCES EVALUATION
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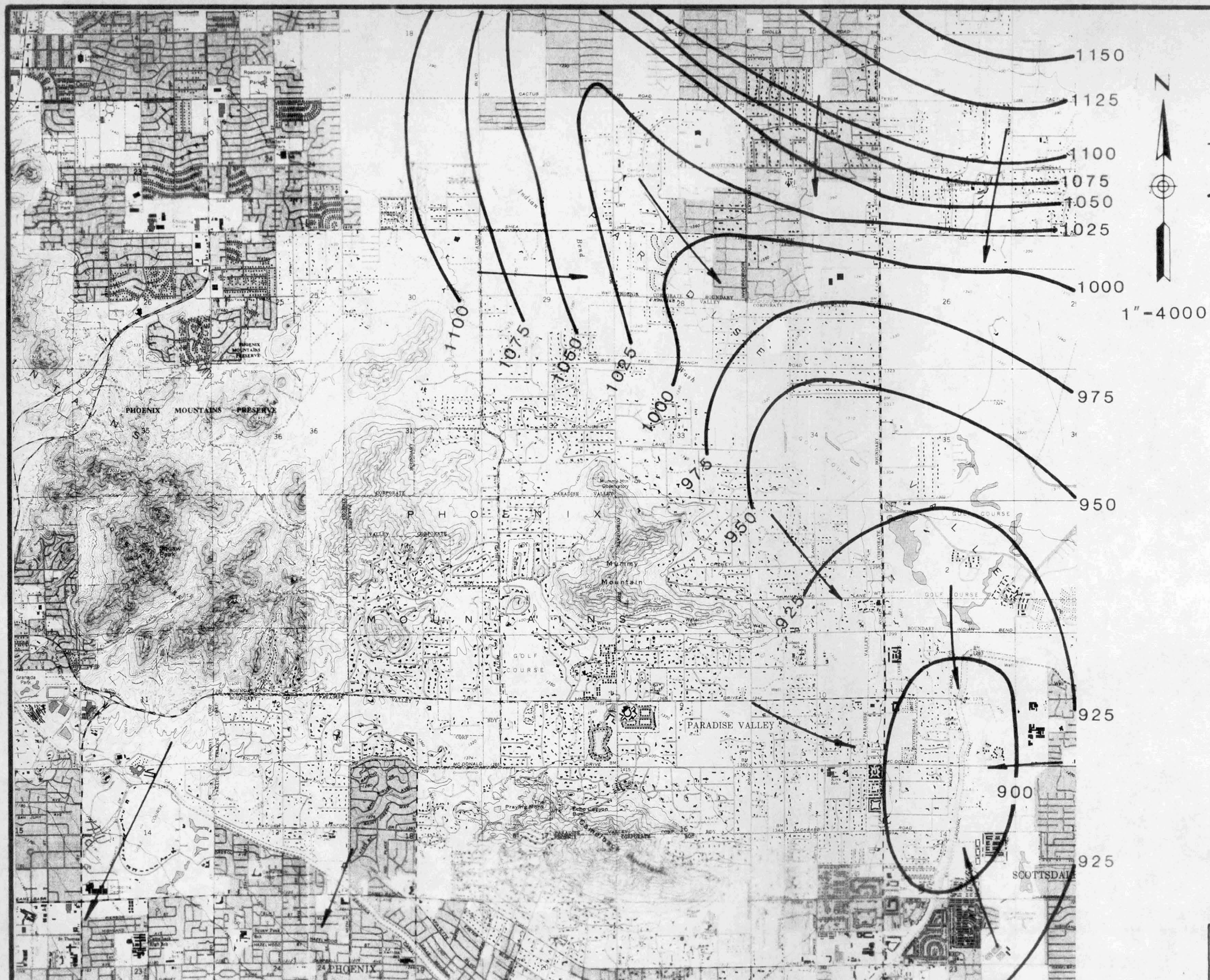
FIGURE 11



GROUNDWATER CONTOURS & GENERALIZED FLOW PATTERNS, 1977

WATER RESOURCES EVALUATION
TOWN OF PARADISE VALLEY
MARICOPA COUNTY, ARIZONA

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PHOENIX, ARIZONA

FIGURE 12

Groundwater flow in the southwest area of Figure 12 is from the mountain region toward the southwest and the areas of major groundwater use in the Salt River Valley Basin.

The Town of Paradise Valley overlies an area of somewhat limited groundwater in storage when compared to some other areas in the Phoenix metropolitan area. Fortunately, this factor is offset by the local geologic conditions that form the primary recharge areas for the aquifers. Wells of various ownership within the Town of Paradise Valley have access to the recharge before it can flow into other areas. When the Paradise Valley Basin is viewed in a regional context, pumping greatly exceeds the natural recharge, but on a local scale in the Town of Paradise Valley the impact is less.

Due to the imbalance between the amount of pumping and the quantity of recharge, there has been a regional decline or lowering of the water table caused by the mining of groundwater in storage. Mining groundwater is like mining any other resource. Groundwater can be removed from storage and if it is not replaced, the effect is the same as mining a metal such as copper, the amount of the resource in reserve for future use is reduced. In the Paradise Valley Basin for the period 1946 to 1966, groundwater declines averaged about 5 feet per year north of the Arizona Canal and 11 feet per year between that canal and the Salt River. During the period 1966 to 1977, the annual rate of groundwater decline decreased, but did not stop. The primary reason for this decrease in the decline rate can be attributed, in part, to a series of wet years. Increased rainfall has provided additional recharge to the aquifers. Since 1977, there have been more wet years and, consequently, more recharge. The USGS (1984) data shows that these more recent wet years have had a great impact on the water table in the Paradise Valley Basin. During the period from 1978 to 1983, the water levels in many wells in the Paradise Valley Basin stabilized or even increased in elevation. The same conditions occurred in the Salt River Basin near the Phoenix Mountains and Camelback Mountain.

The change in the water table decline rates will probably be a short-lived phenomenom. Population increases in areas of the Paradise Valley Basin that were previously undeveloped have resulted in increased groundwater demands. When the present wet cycle ends, water tables will again decline and, perhaps, decline at a faster rate because of the increasing groundwater demand.

Groundwater declines in the Town of Paradise Valley have followed the regional pattern (Figure 13). In the southeastern portion of the Town near the intersection of Scottsdale Road and McDonald Drive, the rate of decline from 1946 to 1966 averaged about 11 feet per year. Water table declines in this area were in the range of 220 feet for this twenty-year period. For the years between 1966 and 1977, the rate of decline decreased to 5 feet per year and totaled 55 feet during that period.

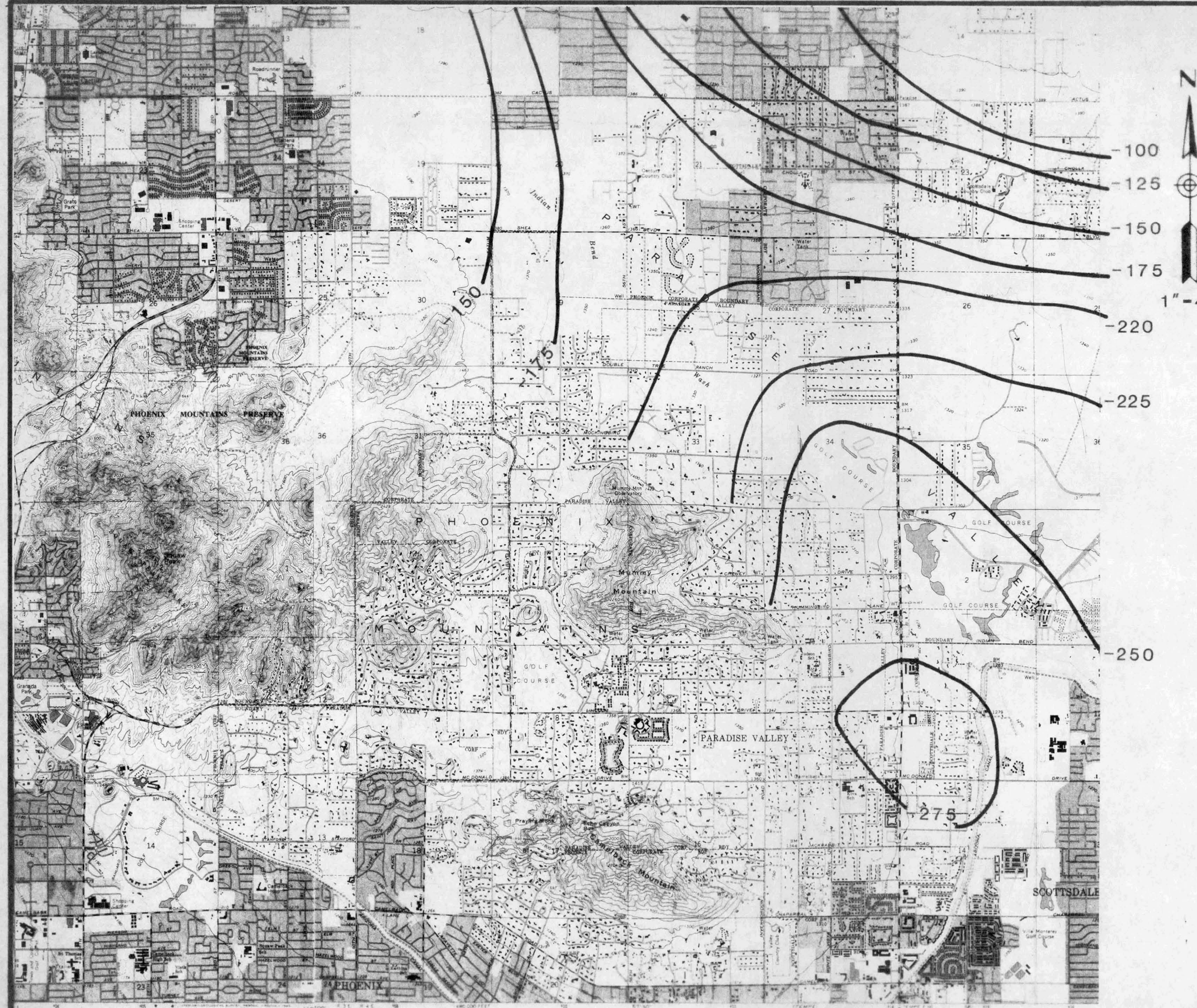
North of this area, where development occurred during the 1970's, groundwater decline rates have increased. In the vicinity of Doubletree Ranch Road and Scottsdale Road, decline rates of four feet per year from 1946 to 1966 have increased to as much as 12 feet per year for the period from 1966 to 1977. The overall decline of the water table in this area since 1946 has been approximately 200 to 225 feet with 140 feet of the decline occurring since 1966.

In the northern part of the Town of Paradise Valley and north of the corporate limits, the rate of decline has remained fairly constant since 1946. The rate of decline has averaged about 5 feet per year resulting in a total decline of 100 to 150 feet from 1946 to 1977. A long-term decline of 250 feet was calculated by Péwé (1982) for the area near Shea Boulevard and Tatum Boulevard, but this was for the period 1915 to 1979.

Wells in the Town of Paradise Valley have shown a rise in water levels in recent years (USGS, 1984). This is also considered to be a short-term condition caused by increased rainfall and recharge.

Data provided by the Paradise Valley Water Company from a well southeast of the Town of Paradise Valley documents water table decline rates in the groundwater depression illustrated on Figures 11 and 12. Water levels have been collected in that well since 1961 and the average annual decline rate for the period 1961 to 1984 is 5.35 feet per year.

Groundwater decline patterns in the Town of Paradise Valley have reflected the degree of development in specific areas both inside the Town Limits and in surrounding communities. Water levels in the southern portion of the Town have exhibited the greatest historic decline being about 275 feet of decline centered around McDonald Drive and Scottsdale Road. However, the rate of decline has been decreasing. An increased groundwater decline rate has shifted



EXPLANATION

-125 LINES OF EQUAL CHANGE IN WATER LEVEL (INTERVAL-25 FEET)

CHANGE IN GROUNDWATER LEVELS FROM SPRING 1946 TO SPRING 1977

WATER RESOURCES EVALUATION
TOWN OF PARADISE VALLEY
MARICOPA COUNTY, ARIZONA

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FIGURE 13

to the central portion of the Town extending from Indian Bend Road to Shea Boulevard. This reflects increased water use and development not only within the Town of Paradise Valley, but also in the neighboring community of Scottsdale.

Central Arizona Project:

Groundwater mining and water table declines measured throughout Arizona have shown that the water resources of the area are being depleted faster than the water can be replaced. The State Legislature passed a Groundwater Code in 1980 to allow groundwater use to be regulated and to force conservation of this resource. In addition, Colorado River water will be imported to the central Arizona area via the Central Arizona Project (CAP). The CAP aqueduct system is shown on Figure 1. This imported water will be used for agricultural, municipal, mining, and related purposes to reduce the amount of groundwater pumped to meet those needs at the present time.

Future water table declines in central Arizona will occur with or without the importation and use of CAP water. Water demands exceed the safe yield (pumped water quantities equal the recharge to the aquifers) of groundwater, local surface water supplies plus the CAP water. Groundwater mining will continue to meet the demand. CAP water should relieve some of the stress placed on the aquifers, but will not eliminate the stress. The average water table decline rate will be reduced when CAP water is used, but the regional water table will continue to be lowered.

Current projections show that approximately 1.5 million acre-feet of Colorado River water will be imported to central Arizona each year in the CAP system. This water has been allocated for agricultural use in irrigation districts; municipal use by cities, towns, and private water companies; use on several Indian reservations; use by the mining industry; power generation use; and some recreation purposes.

Deliveries of CAP water will follow two patterns. Demand will control deliveries if New Waddell Dam is not available on the Agua Fria River to regulate deliveries. In this case, the CAP water deliveries will be at the peak during the periods of greatest water demand from April through September each year and there will be much less flow in the aqueduct during the remaining months. New Waddall Dam will permit regulation of flow during the year. Maximum pumping in the CAP will occur from October to February each year when the demand is low, but electricity costs less. The water transported from the Colorado River in excess of the demand will be stored in the reservoir impounded by New Waddell Dam. When the peak use period occurs, water will be released from the reservoir into the aqueduct system to meet the demand, but pumping from the Colorado River and the electricity bill during the summer will be reduced.

CAP allocations are recommended by the ADWR and the Arizona Water Commission to the Secretary of the Interior who then makes the actual allocations. Water users contract for CAP water and to pay water costs to the Central Arizona Water Conservation District (CAWCD), the link between the water users and the Federal government. Water users do not have to accept the allocations and, in fact, many water users have chosen not to sign contracts for CAP water. That water will be reallocated by the Secretary of Interior to other water users, but the reallocation is not expected this year.

CAP water costs will vary depending upon the use. Municipal CAP water costs are currently projected to be about $60.00 per acre-foot. This cost includes an annual operation and maintenance charge of $55.00 per acre-foot, plus a $5.00 per acre-foot capital payment charge. The operation and maintenance charge will be adjusted to reflect actual costs during CAP deliveries. The capital payment charge will also increase through the year 2024 according to the schedule from the Bureau of Reclamation from $5.00 to $40.00 per acre-foot (Table 2).

Treatment will be required for CAP water used for municipal or urban purposes. Treatment costs per gallon will vary depending upon the size of the facility. Current cost estimates for the City of Phoenix CAP water treatment facility are $100.00 per acre-foot. That can be subdivided into $50.00 per acre-foot for treatment including operation and maintenance of the facility and $50.00 per acre-foot for capital costs to build the treatment facility.

TABLE 2

CAP CAPITAL PAYMENT CHARGES

Payment year	Payment per acre-foot of CAP
1988-1993	$ 5
1994	6
1995	8
1996	10
1997	12
1998	14
1999	15
2000	16
2001	17
2002	18
2003	19
2004	20
2005	21
2006	22
2007	23
2008	24
2009	25
2010	26
2011	27
2012	28
2013	29
2014	30
2015	31
2016	32
2017	33
2018	34
2019	35
2020	36
2021	37
2022	38
2023	39
2024	40

LAND SUBSIDENCE

When groundwater is mined and the aquifer sediments are dewatered, the sedimentary material begins to compact. This is caused, in part, by the reduction of fluids in the pore spaces between the sedimentary particles and a loss of the buoyancy provided by these fluids. Fine-grained sediments have more total pore space than coarse-grained sediments even though the pores are larger in coarse-grained materials. Thus, fine-grained materials have a greater subsidence potential. Groundwater pumping allows compaction to take place by reducing the amount of pore space. The result is land subsidence, which is a lowering of the surface of the ground.

The rate of land subsidence is influenced by factors such as groundwater pumping rates, the composition of the sediments being dewatered, water table decline rates, and the amount of effective stress on the sediments. There is a time lag factor that relates to land subsidence. The lowering of the surface does not begin as soon as sediments are dewatered. It often takes several years for subsidence to occur in a magnitude great enough to be measured.

Once land subsidence has begun, it is a long-term condition. The time lag related to the initiation of subsidence also impacts the duration of subsidence. Even if groundwater pumping and water mining is stopped today, the compaction of sediments will continue into the future until equilibrium is reached. Land subsidence will also continue to that point.

Land subsidence is a regional condition and should not be confused with shallow soil compaction. This condition (hydrocompaction) is caused by wetting a collapsing soil structure. The unstable soil particles begin to move when wet and compact to reduce the spaces between the soil grains. This condition is a local condition and is not related to water table decline.

Land subsidence was first documented in agricultural areas around Eloy, Arizona where large quantities of groundwater were pumped for irrigation. Once the large areas of subsidence were identified, studies were initiated to calculate the magnitude of the subsidence problem in the central Arizona area. These studies were needed because land subsidence alters the surface slope of the land. Changes in slope and gravity have a great impact on sewer flows, street drainage, and canal systems which depend on slope to cause the fluids to move. In some cases, the slope has or will soon be at a point which is insufficient to permit fluid movement. In other cases, the opposite occurs and the slope increases. That causes an increase in the rate of fluid movement and may result in unstable flows and pipe degradation.

Initial projections of land subsidence in the Town of Paradise Valley and the areas surrounding the Town were estimated to be up to 1 foot of subsidence (Schumann, 1974). These estimates were for the period 1948 to 1967. Land subsidence occurs only in the areas of sedimentary material because the bedrock areas in the mountain region are stable. Later work by Holway (1977) documented the potential for subsidence and related impacts in the area of the Town of Paradise Valley on a more local scale.

In January, 1980 an earth crack was discovered near 40th Street and Lupine Avenue in northeast Phoenix (Harmon, 1982). The formation of earth cracks is directly related to water table declines, land subsidence, and the subsurface bedrock configuration. The formation of this earth crack initiated research into the magnitude of the subsidence problem in that area of Phoenix.

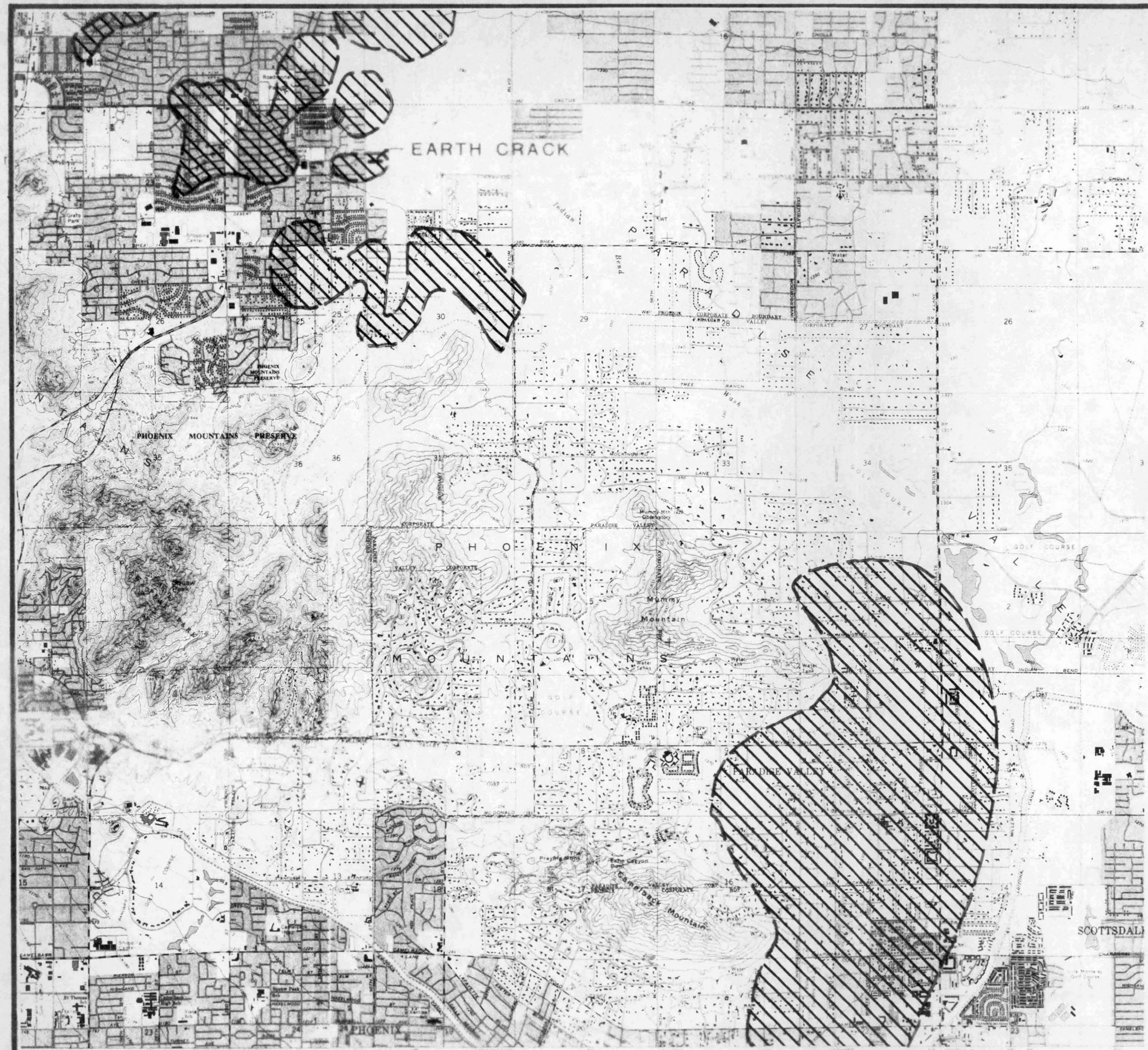
Earth cracks appear as a small break, usually less than one inch wide, on the surface after a period of rainfall. Earth cracks begin to form below the surface at some depth and work their way up toward the land surface. Rainfall erodes the sediments that cover the crack when the crack reaches near the surface. When the sediment cover is eroded, the crack appears at the surface. The huge fissures shown by the media are fissure gullies formed by erosion of the alluvium around an earth crack. Sediments on each side of the crack are eroded and washed into the crack by runoff. This erosion widens the crack to form the large fissures. Earth cracks are not like earthquake fissures. There is very little, if any, vertical movement between the sides of an earth crack and there is no violent earth-shaking associated with their formation. The formation of fissure gullies along an earth crack can be controlled through proper site engineering and design work. The area along each side of the crack should be excavated. The material that is removed should be replaced with compacted fill. The fill is more dense than the native material and, thus, more erosion resistant. Surface drainage must be channeled away from the earth crack site to prevent runoff from causing erosion of the fill and resulting in the formation of a fissure.

Earth cracks are a geologic hazard that requires monitoring. Once they have been identified at a site, it is possible to control erosion and reduce the impacts.

There are two major areas of subsidence in northeast Phoenix, one near 56th Street and Thunderbird Road, and the other major area is between Bell Road and Greenway Road along 44th Street (Harmon, 1982). The amount of subsidence measured from 1962 to 1982 has been about 5 feet in the 56th Street and Thunderbird Road area (Péwé and Larson, 1982). The amount of land subsidence in the Town of Paradise Valley is not documented. The Town Engineer is beginning a survey program to identify areas of subsidence within the Town of Paradise Valley and to quantify the amount of subsidence that has occurred. This study will start in the northeast portion of the Town of Paradise Valley where the alluvium beneath the area is the thickest and the potential for subsidence is the greatest.

Most of the Town of Paradise Valley is either built on bedrock or located where bedrock is at a relatively shallow depth. Those areas have a very low potential for land subsidence and earth cracks. Holway (1977) and Péwé (1982) identified potential areas where it is possible for earth cracks to form (Figure 14). These are only potential crack zones. It is not possible to identify any specific sites where earth fissures will occur. Once the new survey data to be collected by the Town of Paradise Valley has been analyzed, it may be possible to define the subsidence and earth fissure zones with much greater preciseness.

Another factor important to the Town of Paradise Valley is the subsidence impact on sewer and drainage lines. These drainage and sewer line paths follow the slopes down away from the mountains. Land subsidence will increase the capacity of flow by increasing the slope of the land. In areas where the sewer lines or street drainage in potential subsidence areas is parallel to the land slope, survey data is needed to determine the direction the surface will follow toward potential subsidence areas. This will allow the designs of the systems to account for the impacts of subsidence.



EXPLANATION

POSSIBLE EARTH CRACK AREAS

POSSIBLE EARTH CRACK AREAS

WATER RESOURCES EVALUATION
TOWN OF PARADISE VALLEY
MARICOPA COUNTY, ARIZONA

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FIGURE 14

WATER QUALITY

Only the quality of groundwater available for use in the Town of Paradise Valley will be discussed. Since there are no local surface water sources available for use by the Town of Paradise Valley there is no need to evaluate surface water quality.

Groundwater quality changes laterally throughout the central Arizona area and it has been documented that the quality can also change with depth. In the Phoenix metropolitan area, there are several common groundwater quality problems including excessive nitrates, total dissolved solids, hardness, fluoride, and chromium. The State of Arizona has set concentration limits for many inorganic and organic constituents identified in drinking water (Table 3). These limits are the maximum concentrations allowed in the water.

Excessive nitrates in water can be a problem to young infants (less than four months old) because it can be absorbed into their blood and result in methemoglobinemia commonly called blue baby disease. The nitrates alter the hemoglobin in the blood so that it cannot absorb oxygen.

Two sources are believed to be responsible for the nitrates in the groundwater in the Phoenix area; nitrate fertilizers applied in agricultural areas, and naturally occurring organic material in the alluvial deposits. Nitrate levels in the Paradise Valley Basin are low due to the limited agricultural activity. The acceptable concentration for nitrates in groundwater is 45 milligrams per liter (mg/l) measured as nitrates or 10 mg/l when measured as nitrogen. Investigations of nitrate levels in the Paradise Valley Basin including the southeast portions of the Town of Paradise Valley were conducted between 1974 and 1977 and indicated an average nitrate level of 8 mg/l measured as nitrate (Silver and Fielden, 1980). Several wells within the southern third of the Paradise Valley Basin, but outside of the Town of Paradise Valley, were found to exceed legal nitrate levels, but nitrates present no groundwater quality problems in the Town of Paradise Valley.

Total dissolved solids (TDS) concentrations, the amount of salt and mineral constituents in the groundwater, have been regionally documented in the Phoenix

TABLE 3

WATER QUALITY CRITERIA

CONSTITUENT (INORGANIC)	STATE CONCENTRATION LIMIT (mg/l)
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium	0.05
Fluoride (Phoenix area)	1.4
Lead	0.05
Mercury	0.002
Nitrate (as N)	10.0
(as NO3)	45.0
Selenium	0.01
Silver	0.05
(ORGANIC)	
Endrin	0.0002
Lindane	0.004
Methoxychlor	0.1
Toxaphene	0.0005
2,4-D	0.1
2,4-5-TP Silvex	0.01

mg/l = milligrams per liter

area by the USGS (Kister, 1974). A concentration of 1,000 mg/l of dissolved solids is the preferred maximum for public water supply without treatment (U.S. Public Health Service, 1962). However, a State legal concentration limit does not exist because the TDS does not present a general health hazard. High TDS concentrations give drinking water a salty taste. In general, total dissolved solids concentrations range from 1,000 to 3,000 mg/l south of the Salt River and in some places exceed 3,000 mg/l. North of the Salt River and south of the Arizona Canal in east Phoenix, dissolved solids range from 500 to 1,000 mg/l. In the Paradise Valley Basin, groundwater generally contains less than 500 mg/l of total dissolved solids.

Hardness of water is related to the minerals, primarily calcium carbonate ($CaCO_3$), found in the water. Groundwater in the Paradise Valley Basin is hard water and this is evident by the scale that forms as the calcium minerals precipitate out of the water in pots, water heaters, and almost everywhere water is used. Hardness is not a general health hazard, so there are no State water quality limits for hardness.

Fluoride is a common mineral in drinking water and in low concentrations it is beneficial in preventing tooth decay. When fluoride concentrations get high, the mineral can cause fluorosis or mottling of the teeth. State fluoride concentration limits are based on mean air temperatures which is related to how much water is consumed. In the Phoenix area, the State fluoride concentration limit is 1.4 milligrams per liter.

Fluoride is a major problem in areas west and south of Phoenix. In the Paradise Valley Basin fluoride is found in specific geologic units, in particular, the Middle Alluvium Unit has a major adverse effect on the concentrations quality of groundwater. The Middle Alluvium Unit contains high concentration levels of chromium, arsenic, salts, and iron. Areas with thick layers of the Middle Alluvium Unit such as the northeast portion of Paradise Valley Basin, consequently exhibit high mineral concentrations.

In areas near Scottsdale Airport, there is a second clay layer at a depth of about 500 feet. This layer exhibits depositional and sedimentary characteristics similar to the Middle Alluvium Unit and contains water with high mineral concentrations. Groundwater from this clay layer and the Middle Alluvium Unit almost always exceeds the legal limit in one or more of the elements of arsenic, fluoride, chromium, or iron.

Chromium is also a common contaminant in groundwater. This mineral has been found associated with the fine-grained sediments in the Paradise Valley Basin. Hexavalent chromium in high concentrations can be toxic. The State limit for chromium concentration in drinking water is 0.05 milligrams per liter.

The groundwater quality problems in the Paradise Valley Basin are localized and usually restricted to the fine-grained clay layers in the alluvium. Wells can be designed to prevent water from these strata from entering the well. Analysis of the formation material by a geologist and a water sampling program during well construction permits the identification of fine-grained layers containing poor quality water. The well can then be designed to tap aquifer units with acceptable quality water. This technique usually allows a municipal water supply to be developed in the areas with known groundwater quality problems.

Contamination of groundwater by the activities of man have been documented throughout the Phoenix metropolitan area. A report prepared by the Arizona Department of Health Services (1984) inventoried wells contaminated by herbicides, solvents, pesticides, and other industrial chemicals. According to that report, no such contaminated wells have been located within the corporate limits of the Town of Paradise Valley.

Groundwater used in the Town of Paradise Valley is within legal limits for inorganic and organic compounds. However, there is a potential for poor quality groundwater in the north and east sections of Town where the Middle Alluvium Unit is present. Proper well design and groundwater testing during drilling allows wells to be constructed such that the poor quality layers are eliminated from the water production zone. There are no present groundwater hazards in the water supply.

WATER REQUIREMENTS

General:

Water use is influenced by factors such as climate, lifestyle, economics, and water availability. The total amount of water required in an area is related to population and water using businesses.

It is essential to know the present and projected population of an area in order to compute the future water demand. The Town of Paradise Valley has limits that are fixed, thus it is possible to estimate future population growth with a reasonable degree of accuracy.

Population:

Population data for the Town of Paradise Valley from several sources is presented on Table 4. Historic population information is from U.S. Census data for 1960, 1970, and 1980. That data shows that the population of the Town of Paradise Valley increased by 4,546 from 1960 to 1970, and increased by 4,428 from 1970 to 1980. Population increases were almost equal in those two decades.

Planning estimates of population growth for the Town of Paradise Valley for the first few years of the 1980's project only a modest increase in population (Table 4). Population projections prepared by the Maricopa County Planning Department forecast a population increase until the year 2010 when they project a population of 23,173. That group then projects a small decrease in population in the year 2015 to 22,977.

In 1980, when the population was 11,085, there were 2,966 residences in the Town of Paradise Valley. That equals a population density of 3.7 people per dwelling unit. In 1985, there are 3,399 dwelling units and using the density factor of 3.7 people per unit as a multiplier that equals a 1985 population of 12,576.

Since the Town of Paradise Valley has a relatively fixed area, the future population can be calculated by counting the available lots and multiplying by the dwelling unit factor. Within the Town Limits, 338 lots have been recorded

TABLE 4

POPULATION PROJECTION

SOURCE	POPULATION
1960 Census	2,091
1970 Census	6,637
1980 Census	11,085
1983 Planning Estimate	12,290
1984 Planning Estimate	12,640
1984 Police Department Estimate	12,941
Maricopa County Planning Department:	
1985	15,173
1990	18,295
1995	22,203
2000	23,075
2005	23,310
2010	23,173
2015	22,977

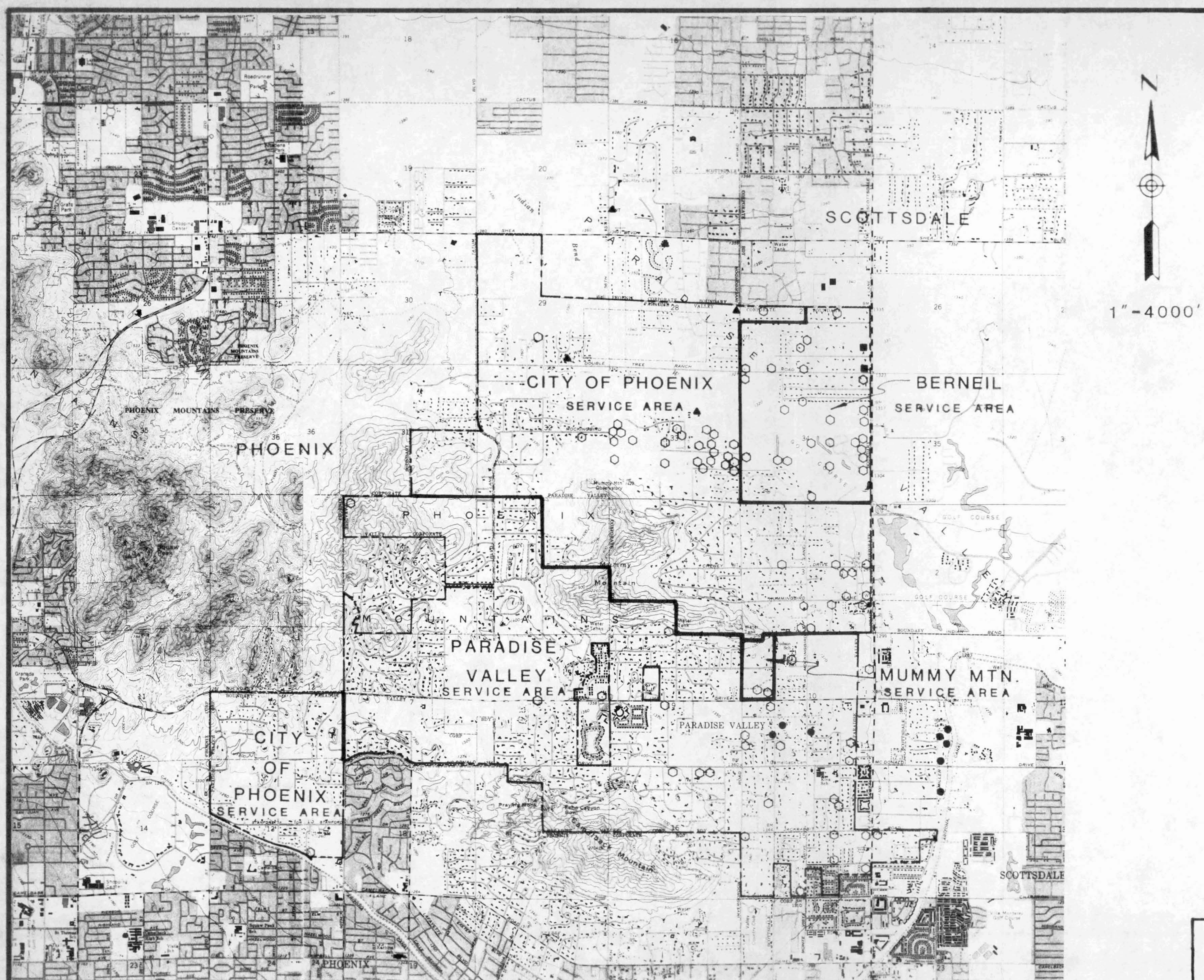
which do not yet have dwelling units on them. There are about 500 acres of undeveloped land which could be subdivided into an additional 430 lots. The projected increase is equal to 768 dwelling units times the density factor of 3.7 or 2,842 people. Then, the future population of the Town of Paradise Valley based on lots or dwelling units is 15,418. In this study, we will use the population of 15,500 to project water demands. (Table 5)

Water Demand:

Four distinct water systems currently supply the water needs of the Town of Paradise Valley (Figure 15). The Arizona Department of Water Resources (1984) calculated the 1980 per capita water use for water systems in the Phoenix Active Management Area. The ADWR calculates per capita water use by dividing the amount of groundwater pumped by the population. The ADWR data for the water companies serving the Town of Paradise Valley is presented on Table 6. The ADWR does not make any allowances for golf course use, resort use, or industrial use in the calculations. They simply divide water production by the population. Water deliveries by the City of Phoenix to the Town of Paradise Valley are not separated from the overall City deliveries in the ADWR report. Water delivered by the Mummy Mountain Water Company is supplied from the Paradise Valley Water Company system, thus, water use for the Paradise Valley Water Company reflects Mummy Mountain Water Company use.

The ADWR 1980 data shows a use of 422 gallons per day (gpd) per person for the Berneil Water Company and a use of 884 gpd per person served by the Paradise Valley Water Company. The average for the Phoenix AMA in 1980 was 257 gpd per person. The City of Phoenix has high water consumption uses such as golf courses, but that City has a large population which diffuses the impact of the large water users.

The water demand in 1984 can be calculated based on the total water supplied and the number of connections to the system. The Berneil Water Company supplied 154 million gallons of water to 349 connections in 1984, which averages 1,209 gpd per dwelling. If there is an average of 3.7 people per dwelling unit, the calculated use was 327 gpd per person which is a 95 gpd reduction from the 1980 use. The AMA goals call for an 11 percent use reduction from the 1980 water use starting in 1986 for the Berneil Water Company, that would be 46 gpd per person. It appears that the Berneil Water Company has exceeded the AMA goal but the final determination of that fact will be made by the ADWR.



EXPLANATION

- CORPORATE LIMIT
- WATER COMPANY SERVICE AREA BOUNDARY
- ▲ CITY OF PHOENIX WELL
- ■ BERNEIL WATER COMPANY WELL
- ● PARADISE VALLEY WATER COMPANY WELL
- ○ PRIVATE OWNERSHIP WELL

WATER COMPANIES AND WELLS
IN THE
TOWN OF PARADISE VALLEY

WATER RESOURCES EVALUATION
TOWN OF PARADISE VALLEY
MARICOPA COUNTY, ARIZONA

Anderson-Nichols & Co., Inc.
CONSULTING ENGINEERS
PHOENIX, ARIZONA

FIGURE 15

TABLE 5

TOWN OF PARADISE VALLEY FORECAST POPULATION

Based on a dwelling unit factor of 3.7 people per dwelling.

1980 = 11,085 people, 2,966 dwellings density is 3.7 peolpe per dwelling

		POPULATION
1985	3,399 dwellings	12,576
	388 recorded lots	1,251
	430 potential lots	1,591
	4,167 dwellings	15,418

TABLE 6

ADWR CALCULATED WATER USE
(1980 data)

WATER COMPANY	ACRE-FEET WITHDRAWALS	GALLONS PER DAY	POPULATION	DAILY PER CAPITA USE
Berneil	522	466,012	1,105	422
Paradise Valley	7,077	6,317,938	7,146	884
City of Phoenix	248,034	221,430,485	830,712	267

The Paradise Valley Water Company served 1.001 billion gallons of water in 1984 to 1,552 connections which equals 1,767 gpd per connection and a demand of 478 gpd per person. The use reduction required by the AMA for the Paradise Valley Water Company is 97 gpd per person down to 787 from 884 gpd per person.

The City of Phoenix supplied 1.663 billion gallons of water to 1,498 connections in the Town of Paradise Valley which represents a 1984 dwelling use of 3,042 gpd and a per capita use of 822 gpd. The City of Phoenix had an annual average use of 267 gpd per person in 1980 in its entire service area. The water use per person in the Town of Paradise Valley appears to exceed the City of Phoenix average, but this is due in part to the method of calculation used by the ADWR which averages water use over the entire population.

To project the future demand, the average 1984 demand for the three water companies was averaged and then multiplied by the projected population. The average equals 542 gpd per person. As a comparison, the average daily demand calculated from the 1980 ADWR data is 524 gpd per person. That calculation is 542 gpd per person times 15,500 people for an average demand of 8.4 million gpd. The annual consumption would be 9,409 acre-feet.

Water Supply Adequacy:

Often, when the adequacy of a water supply is compared to the demand, the tank analogy evaluation of the groundwater resources is used to quantify the amount of groundwater available to supply the demand. As was previously explained, that tank analogy method does not provide a true representation of the available groundwater supply becuase it does not consider recharge and groundwater movement but it can provide a quick estimate.

The Berneil Water Company obtains its water from the groundwater beneath the Town of Paradise Valley. The City of Phoenix and the Paradise Valley Water Company have service areas that extend beyond the Town Limits and thus, these water companies can obtain groundwater from beyond the boundary of the Town of Paradise Valley.

The service area of the Paradise Valley Water Company extends into the City of Scottsdale. The tank analogy of the amount of groundwater beneath the Town of Paradise Valley does not include the groundwater available to the Paradise

Valley Water Company outside the Town of Paradise Valley that can be pumped and transported into the Town of Paradise Valley.

The City of Phoenix has a large service area in the Paradise Valley Basin and, thus, the City has access to extensive groundwater reserves. Phoenix also has gatewater credits in the Verde River reservoir system that allows it to use surface water. The City of Phoenix can develop water supplies and transport the water to its customers within the Town of Paradise Valley.

The tank analogy only estimates the amount of groundwater fixed beneath an area and does not account for additions to the groundwater supply caused by recharge. The Town of Paradise Valley surrounds the mountain regions with a high precipitation runoff potential and contains surface deposits of coarse-grained sediments near the mountains which are primary recharge zones (Figure 10). The Town of Paradise Valley is in an area for optimum recharge. An estimate of the amount of natural recharge that occurs in the Town of Paradise Valley can be made by adapting data from other areas where recharge studies have been calculated.

The USGS (Osterkamp, 1973) calculated recharge rates in the Tucson area, estimating 100 to 400 acre-feet of recharge per year per mile of mountain front. Tucson receives a little more rainfall than the Phoenix area, so the average of the recharge quantity estimates equal to 250 acre-feet per year will be used in this study. There are aproximately 13.5 miles of mountain front (bedrock of the mountain region in contact with alluvium sediments) in the Town of Paradise Valley. Multiplying the recharge rate (250 acre-feet per mile) by the miles of mountain front (13.5 miles) yields an annual recharge rate estimate of 3,375 acre-feet per year.

An estimate of the adequacy of the groundwater beneath the Town of Paradise Valley to meet the future demand can be made using the following data. The tank analogy results in an estimated groundwater quantity of 210,000 acre-feet in storage. The projected demand for a population of 15,500 people using a consumption of 542 gpd per person is about 9,409 acre-feet per year. If the average recharge quantity of 3,375 acre-feet per year is incorporated into the calculations, the quantity of recharge reduces the demand placed on the groundwater in storage. When the recharge quantity is deducted from the water supply required to meet future needs, the demand on the groundwater system is reduced 6,034 acre-feet per year. That estimate shows that using the tank analogy, the groundwater would provide a water supply for about 35 years, but planning must not be based on that data because it is only a rough estimate and does not incorporate regional conditions such as groundwater movement or water supplies that can be transported into the Town of Paradise Valley from other areas.

An alternate method can be used to estimate the adequacy of the water supply and this method is based on the local water table decline rate. A water table decline rate of 5 feet per year is an average annual decline rate for the water table beneath the Town of Paradise Valley. The regional decline rate is influenced by factors inside and outside of the Town of Paradise Valley including pumping, recharge, groundwater in storage, and groundwater movement. The average depth to water in 1972 was 200 to 400 feet below the surface in the north and east sections of the Town of Paradise Valley and the water table was 100 to 200 feet in the southwest section of Town (Osterkamp, 1973). The thickness of alluvium in those areas (Cooley, 1973) minus the depth to water shows a zone of saturated alluvium that averages 400 to 500 feet thick exists beneath the Town of Paradise Valley. Based on the average thickness of saturated alluvium equal to 400 to 500 feet and a decline rate of 5 feet per year, the groundwater supply can be estimated to be adequate for 80 to 100 years.

These calculations do not include the addition of new water into the hydrologic system. Central Arizona Project water is scheduled for delivery in the Phoenix metropolitan area starting in December, 1985. The City of Phoenix, the Berneil Water Company, and the Paradise Valley Water Company all have been allocated CAP water. The Berneil Water Company has been allocated 432 acre-feet per year and all of that water will be used within the Town of Paradise Valley. The Paradise Valley Water Company has been allocated 3,231 acre-feet per year and the City of Phoenix has been allocated 113,882 acre-feet per year but their service areas extend beyond the Town of Paradise Valley. The City of Phoenix and Paradise Valley Water Company allocations of CAP water will be distributed throughout the systems, but the Berneil Water Company allocation of 432 acre-feet per year will be used only within the Town of Paradise Valley.

CAP allocations are based on a use of 140 gpd per person. The projected population for the Town of Paradise Valley is 15,500, thus the CAP water allocated for use in the water systems that serve the Town of Paradise Valley is 15,500 people multiplied by 140 gpd per person. The CAP water available equals about 2,431 acre-feet per year.

CAP water will have a significant impact on the adequacy of the groundwater supply. Using the tank analogy amount of 210,000 acre-feet, a recharge rate of 3,375 acre-feet per year, a demand of 9,409 acre-feet per year and the combined CAP allocation of 2,431 acre-feet per year, the longevity of the supply can be calculated. The demand on the groundwater reservoir equals the annual demand minus recharge and now minus CAP for a total of 3,603 acre-feet per year. This results in an adequate supply for 58 years using the crude estimate of a tank analogy. The following table summarizes this approach:

Water Consumption, 15,500 people @ 542 gpd/person	9,409 acre-feet/year
Groundwater Recharge (credit)	(3,375) acre-feet/year
CAP Water Supply (credit)	(2,431) acre-feet/year
Net Demand on Aquifer	3,603 acre-feet/year

Longevity of Aquifer: $\frac{210{,}000 \text{ acre-feet}}{3{,}603 \text{ acre-feet/year}}$ = 58 years

The impact that the use of CAP water will have on regional and local decline rates can only be estimated. If it is assumed that the use of CAP reduces the annual groundwater mining by about 40 percent and, if this has the long-term effect of reducing the decline rate by 40 percent, the long-term water table decline rate will be 3 feet per year. Based on a saturated alluvium thickness of 400 to 500 feet, the groundwater supply will last 133 to 166 years. Based on these two approaches to the calculation, it is safe to say that the Town's groundwater supply will last more than 100 years.

Mr. O'Leary of the Paradise Valley Water Company has water table decline projections for his water company's area. The projections do not include the impacts of CAP water or water conservation. The data used in the Paradise Valley Water Company projections are water level measurements collected from 1961 through 1984.

The projections were made using water table decline rates based on 5-year, 10-year, 15-year, and 20-year moving averages. In this technique a five year average is based on the 1961 to 1966 data. The next five year average deletes the first number in the sequence (1961) and adds a new number at the end (1967) so the average is calculated using 1962 to 1967 data. This progresses until the final sequence 1979 to 1984 is used. A similar technique is used for the 10, 15, and 20-year averages.

Paradise Valley Water Company projections estimate that in the year 2080 the water table will be 734 feet to 888 feet below the surface and that shows the water supply is sufficient to meet the demand for more than 100 years.

The Town of Paradise Valley, the water companies in the area and all of the Phoenix Active Management Area can be shown to have an adequate water supply using a literal interpretation of the State Groundwater Code. The Phoenix AMA was created by the Groundwater Code as an initial active management area (45-411). Management goals for the Phoenix AMA are specified in Article 9 of the Groundwater Code which states that the management goal for the Phoenix AMA is safe-yield by the year 2025 or earlier (ARS 45-562). Safe-yield is defined in the Groundwater Code as follows (ARS 45-561).

> "Safe-yield" means a groundwater management goal which attempts to achieve and thereafter maintain a long-term balance between the annual amount of groundwater withdrawn in an active management area and the annual amount of natural and artificial groundwater recharge in the active management area.

Under safe-yield conditions, groundwater withdrawals should equal recharge so there will be no groundwater mining and water tables will stabilize. The director will establish management plans to achieve the goals required by the Groundwater Code. When safe-yield conditions are achieved and the water table is stabilized, presumably at a depth shallower then 1,200 feet, there will be sufficient water to meet the demand. Safe-yield means an assured water supply for all permitted uses, thus an adequate water supply is required pursuant to the Groundwater Code.

POTENTIAL ALTERNATIVE WATER SOURCES

The Town of Paradise Valley does not own a water supply system. Therefore, the Town cannot obtain alternative water sources because it has no way of directly using or distributing the water. The water companies serving the Town of Paradise Valley could seek out and develop water from sources other than the local groundwater resources.

One potential source of water is additional CAP water to increase the original allocation. It now is apparent that many of the small water companies, the water users that would require exchange water agreements, and many of the mines will not be contracting for their CAP water allocations.

Many of the small water companies who received small allocations of CAP can not afford to build a system to transport CAP water from the main CAP aqueduct to the point of use or can not afford the expense to build a CAP water treatment plant. They will not contract for their CAP water and the water will go into a general pool for reallocation.

Recent economic trends have forced the copper mines in Arizona to curtail operations and even to shut down. The mines were allocated a total of 60,784 acre-feet of CAP water per year. The mines will not need CAP water under current mine operating conditions and can not afford to contract and pay for the CAP water each year to reserve it for future use. A large portion of the allocations made to the copper mines will not be taken and that CAP water will also be placed in the general reallocation pool.

Some allocations of CAP water were made to water users that have no direct access to the CAP aqueduct system. These water users will need to exchange their CAP water. In most cases, the outlying water users are along or have access to a surface water source. The water users have to exchange water rights with a downstream water user that has access to CAP water and a right to use the surface water. The exchange water user who received the CAP allocation can then use the surface water at their location and the downstream water user will have the surface water replaced with CAP water. This is a complicated and costly contracting process. Many of the smaller exchange water allocations will not be taken and that CAP will go into the general reallocation pool.

This CAP water will be reallocated to water users that submit requests for additional CAP water to the ADWR. Reallocations will follow the procedure developed for the original allocations. Reallocations will be recommended by the ADWR to the U.S. Secretary of Interior for hearings and final approval. This process is not expected to be completed in the near future and the present time frame estimate is at least one year. The Town Council should urge the water companies that supply the Town of Paradise Valley to apply for additional CAP water through the reallocation process. The Town Council should offer to help the water companies with the application process for additional water. This could provide additional CAP water for use in the Town of Paradise Valley and further reduce the demand on the groundwater system.

Additional groundwater reserves are available to the City of Phoenix because of the current size of its service area and the fact that the City can continue to expand and increase the size of its service area. The Berneil Water Company and the Paradise Valley Water Company cannot go beyond their certificated areas to drill new wells without entering another water utility's service area. Even if these private water companies were to be purchased by the Town of Paradise Valley, they would still have a groundwater resource limited by the size of the certificate area. If the Cities of Phoenix or Scottsdale were to purchase the water companies, they would be incorporated into the City's water system and have a much larger area from which to obtain groundwater or other water supplies. Groundwater does not offer a potential alternative water source for new supplies at this time.

Another water source alternative could be importation of surface water or groundwater from a water farm located outside of the Phoenix area using the CAP canal to transport the water into the metropolitan area. This is an option that the City of Scottsdale recently undertook with their purchase of the Planet Ranch. This option is very expensive and, while it could be accomplished by the City of Phoenix, it is most likely outside the financial capabilities of the private water companies that serve the Town of Paradise Valley. Therefore, this option is not considered reasonable for the Town of Paradise Valley.

The final water source alternative is recycled wastewater. This is not a source of new water but provides a method to reuse water to meet specific water demands. This is a viable option and will be discussed in detail in the following chapter.

WATER RECYCLING

General:

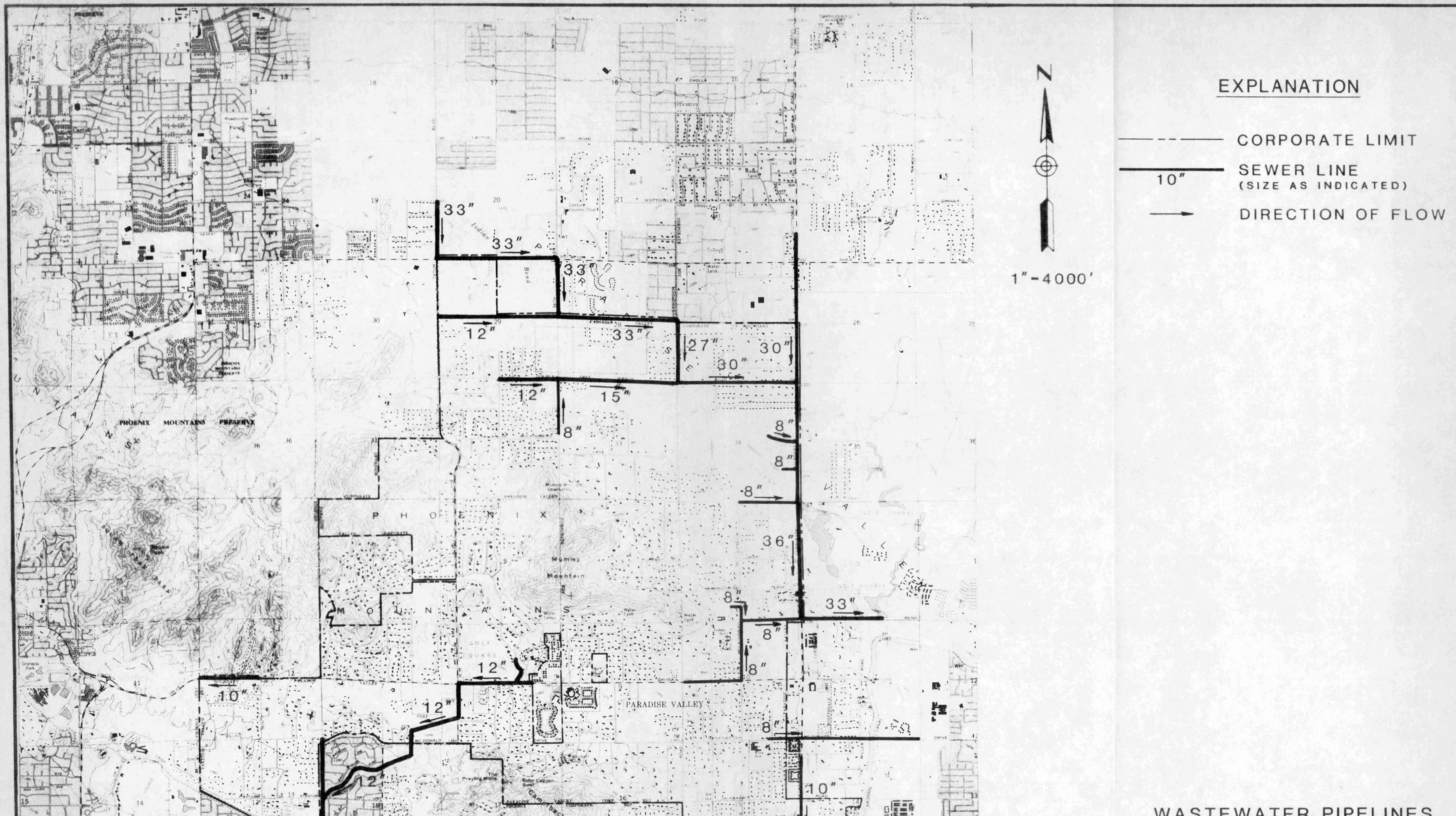
The Town of Paradise Valley does not own a wastewater treatment facility. A portion of the wastewater generated within the Town of Pardise Valley enters the Scottsdale sewer system while the remainder enters the City of Phoenix sewer system (Figure 16). Not all of the residences in the Town of Paradise Valley are connected to sewer systems. Most of the homes in the Town of Paradise Valley use septic tank systems to dispose of wastewater.

Septic tank systems can process household wastewater providing that the soil has sufficient porosity and permeability to permit infiltration of water into the ground. Biodegradeable solids in the wastewater are digested by bacteria in the septic tank. The liquids percolate into the ground where the purification action of the soil provides further processing. Bouwer (1968) showed, at a demonstration facility in Phoenix, the soil lowered the concentrations of nitrates and phosphates in the wastewater, removed the bacteria and that there were no detectable viruses in the wastewater that passed through the soil. Domestic septic tank sytems do not present a hazard to groundwater resources in the Town of Paradise Valley.

There are 616 residences connected to the City of Phoenix sewer system and 730 dwellings connected to the City of Scottsdale system. The Town of Paradise Valley contains 3,399 residences, thus 2,053 residences, about 60 percent of the homes, use septic tank systems.

Wastewater Quantities:

The Town of Paradise Valley has studies which evaluate the historic quantity of wastewater flows based on water meter readings (Malcolm Pirnie, 1984). The flow of wastewater per dwelling connected to the Scottsdale system was calculated to average 416 gpd or 116 gpd per person during the period 1982 to 1985 (International Engineering, 1983). The flows of wastewater into the City of Phoenix should be similar for the 616 residences connected to that system. The total wastewater flows into sewer systems are estimated to be 0.560 million gpd or 627.2 acre-feet per year for 1985. That can be subdivided into .256 million gpd or 286.8 acre-feet per year to the City of Phoenix and .304 million gpd or 340.5 acre-feet per year to the City of Scottsdale.



WASTEWATER PIPELINES

WATER RESOURCES EVALUATION
TOWN OF PARADISE VALLEY
MARICOPA COUNTY, ARIZONA

Anderson-Nichols & Co., Inc.
CONSULTING ENGINEERS
PHOENIX, ARIZONA

FIGURE 16

There are 2,053 residences in the Town of Paradise Valley using septic tank systems which produce an estimated 0.854 million gpd of wastewater. That wastewater does not enter a sewer system at this time. The 768 potential lots in the Town of Paradise Valley will generate an additional 0.391 million gpd of wastewater. When the Town of Paradise Valley is fully developed at 4,167 residences, the total daily wastewater production will be an estimated 1,733 million gpd or 1,942 acre-feet of wastewater per year. Projections show that when fully developed approximately .4 million gpd or 23 percent of the daily flow will enter the City of Phoenix system, .5 million gpd or 29 percent will enter the City of Scottsdale system and .898 million gpd or 48 percent will be in the septic system at each dwelling. If the septic system dwellings are connected to a sewer system, they are in locations that will be added to the City of Scottsdale system.

Residences in the City of Phoenix sewer system areas are billed $36.00 per month for wastewater removal. Residences in the City of Scottsdale are billed $12.00 per month. The Town of Paradise Valley has to pay the City of Scottsdale to accept the wastewater. The fee charged the dwellings is a flat fee not adjusted for the amount of wastewater entering the system. The Town of Paradise Valley has to pay the City of Scottsdale $3.00 per gallon times a multiplyer as the flows increase for each gallon of wastewater entering the Scottsdale system from the Town of Paradise Valley. This charge is based on a 24-hour flow reading and is charged for the amount of wastewater flow in gallons that is more than the previous years 24-hour reading. As the flows increase, so do the fees paid by the Town of Paradise Valley.

Continued population growth within the Town of Paradise Valley and the potential for connecting additional areas to the City of Scottsdale sewer system that are currently using spetic tanks presents an economic problem to the Town of Paradise Valley. The costs paid by the Town of Paradise Valley for wastewater delivered to the City of Scottsdale can be lowered by two methods, increased residence cost or reduced wastewater flows.

One method to reduce the amount of money paid by the Town of Paradise Valley is to adopt an adjustable monthly wastewater billing rate rather than a flat fee. The monthly sewer fee could be calculated based on a percentage of the water delivered to the dwelling. It would allow the Town of Paradise Valley to charge large water users and therefore, large wastewater producers, a monthly sewer fee that represents the amount of wastewater generated. The Town could collect the additional wastewater revenues from the dwellings to help pay the fee to the City of Scottsdale.

The other method is to reduce the quantity of wastewater entering the City of Scottsdale system. One possiblity is through water conservation in the home. If less water is used, then less wastewater will be produced. The other possiblity is to recycle a part of all of the wastewater so that less wastewater enters the City of Scottsdale system. Wastewater reuse and water conservation will be investigated in additional detail in following sections of this report.

Wastewater Reuse:

Uses for recycled wastewater vary depending upon the degree of treatment. The most common wastewater reuse alternative is irrigation of turf or crops. Since there are no large farms within the Town of Paradise Valley, agricultural reuse is not a viable alternative. The Town of Paradise Valley does not own any parks or golf courses, so it does not have any municipal reuse options.

One reuse alternative is to recycle wastewater and use it for artificial recharge of the aquifer. Potential recharge sites close to the mountains (Figure 10) could be used as recycled water injection points. This alternative would be beneficial to the area because water would be added to the underground system. Wells that supply the Town of Paradise Valley would be in the most beneficial location for making use of the artificial recharge.

Artificial groundwater recharge legislation is currently being considered by the State of Arizona. One form of the legislation may provide groundwater credits for artificial recharge equal to some percentage of the amount of artifical recharge. These credits could then be applied to current groundwater pumping amounts to reduce the quantity of groundwater in the consumptive use calculations. This bookkeeping process will result in a reduced per capita water use for a water supplier and, thus, help a water system achieve the reduction goals mandated by the Phoenix AMA.

The ADWR also has artifical recharge legislation relating to wastewater recharge. There are many unanswered questions in the bill relating to recharge ownership, pumping rights, water quality requirements for recharge, and many other topics. Groundwater recharge legislation for recycled wastewater may be approved in the next year, but until that time, the impacts and benefits can not be evaulated.

Since the Town of Paradise Valley does not own a water system it can not use any recharge credits in order to reduce the Town's total water use as calculated by the ADWR. The credits would present no direct benefit to the Town of Paradise Valley, but it may be possible to transfer these recharge credits to one or more of the water systems that supply water to the Town of Paradise Valley, this would represent an indirect benefit.

Another alternative would be to use the recycled water to irrigate golf courses. The Town of Paradise Valley does not own a golf course, but, if recycled wastewater is used to irrigate the turf, it will reduce the demand for groundwater. An existing course is limited to using 5 acre-feet of groundwater per acre of turf by Phoenix AMA regulations. Paradise Valley Country Club has 130 acres of turf and thus, they will be restricted to a use of 650 acre-feet per year for irrigation. Camelback Country Club has about 400 acres of turf and will be allowed to use 2,000 acre-feet per year for irrigation.

If all the residences in the Town of Paradise Valley are connected to sewers the projected wastewater quantity is 1,942 acre-feet per year. In theory all of the wastewater generated by the Town of Paradise Valley could be used to irrigate the two golf courses in the Town. The Town of Paradise Valley would have to sell recycled water to the golf courses at an economical rate that is competitive with current groundwater pumping costs. Using recycled wastewater for golf course irrigation will become more important in the future as potable water costs increase, pumping costs increase and additional water conservation is required by AMA rules.

Water recycling will provide economic benefits to the Town of Paradise Valley. The sale of recycled wastewater will provide income to pay for the operation of a treatment and also reduce the money paid to the City of Scottsdale for accepting the Town of Paradise Valley°s wastewater.

<u>Wastewater Treatment Plants:</u>
If the Town of Paradise Valley elects to develop a wastewater recycling program, then a decision must be made to build either a wastewater treatment plant or a water recycling plant.

A wastewater treatment plant is a facility that treats wastewater for the purpose of discharging it into a river or lake with the degree of treatment determined by the State Health Department depending on the nature of the receiving stream or lake. A wastewater treatment plant processes the solid and liquid components of wastewater. A water recycling plant is a facility designed to treat wastewater to the degree required for reuse of the water for a specific purpose. Again, the degree of treatment is set by the Health Department depending on the planned use of the treated wastewater. Odor potential, land requirements, solids disposal, and other aspects of the treatment processes are common to wastewater treatment plants to varying degrees.

If the Town of Paradise Valley decides that it wants to process wastewater to reduce groundwater demand, reduce payments to the City of Scottsdale and sell recycled water, it would be better to build a water recycling plant similar to the facility now in operation at the Gainey Ranch in the City of Scottsdale than to build a wastewater treatment plant. Water recycling plants are planned for construction at the Boulders development in Carefree and at the Desert Highlands development near Pinnacle Peak.

At the Gainey Ranch plant, untreated wastewater is taken from the main sewer line and transported to the plant for processing. The first step is to separate the large solid material from liquid wastes. The liquid wastewater is processed through a series of chambers that digest and remove the fine solids in the liquid. The resulting liquid is then treated with ultraviolet light to kill any viruses and bacteria in the liquid. The solid wastes separated during treatment are returned to the main sewer line for transportation to a wastewater treatment plant. Recycled water from the Gainey Ranch facility is used for golf course irrigation.

The Gainey Ranch water recycling plant is enclosed, the screen room, the chambers and the other components are sealed to prevent the escape of any odors. The air used in the plant is circulated in a closed system and processed prior to release. There is no odor associated with the discharged air. The facility is built close to the ground and much of the equipment is below the surface. There is very little visual impact. The lack of odor and low profile make the Gainey Ranch facility a very descrete facility. People driving past the water recycling plant on Scottsdale Road would not be aware of its existence unless they knew it was there.

If the Town of Paradise Valley does want to own and operate a water recycling plant, it first has to decide if the water will be used for artificial recharge or for golf course irrigation.

It would be difficult to construct a water recycling plant to process water for groundwater recharge. There is insufficient sewer flow near the mountain region where the recharge potnetial is the greatest to allow a plant in those areas to be feasible. A long pipeline would be required to transport recycled water from a treatment site to a recharge site. In addition, the treatment required for recycling water for artificial recharge would have to produce water of drinking quality prior to recharge. That would be expensive.

The Town of Paradise Valley will have to select and purchase a site for a recharge well or wells to inject the recycled water into an aquifer. A pipeline from a recycling plant to the point of artificial recharge will also be needed.

There would be no direct benefit for the Town of Paradise Valley to own or operate a water recycling plant unless the Town of Paradise Valley has a place for direct reuse of the water. If the Town of Paradise Valley elects to build such a facility, the best location would be where Indian Bend Wash crosses Scottsdale Road, between the Camelback Country Club golf course and the road. Recycled water could then be sold for use on a golf course.

A customer will be needed if the Town of Paradise Valley is going to sell recycled water for golf course irrigation. The Paradise Valley Country Club has offered to buy all the recycled water it can use and to pay for a pipeline to transport the recycled water from the plant to the golf course. Negotiations for the cost of the water and a commitment to purchase the water should be obtained prior to building any plant.

The next step would be to select the site for a water recycling plant and to purchase the land. The Gainey Ranch water recycling plant and the short term water storage reservoir is built on 6 acres. It is easy to place a recycling plant in a new development because no one lives there. Building a water recycling plant in a developed area, especially in an area of lifestyles such as those that exist in the Town of Paradise Valley, could be an unpopular idea at first, because of a lack of understanding. There would be opposition to the water recycling plant because no one would want a wastewater treatment plant in their backyard, but a water recycling plant is not a wastewater treatment plant. There are no odors at the recycling plant and the facility can be designed so that there are limited esthetic impacts. Opposition to a water recycling plant can be eliminated or reduced by taking a tour of the Gainey Ranch facility.

The Town of Paradise Valley could have to fund the design, construction, and operation of the facility, but this is a large expense project. It would be better if the Town of Paradise Valley let a private firm build the water recycling plant and give it to the Town of Paradise Valley. Operation coiuld be done via privatization.

It is probably not necessary for the Town of Paradise Valley to build and fund a water recycling facility. The Town of Paradise Valley should encourage large developers or perhaps a private corporation to build and operate a water recycling facility. The Town of Paradise Valley will then receive indirect benefits from water reuse in the form of reduced demands on the groundwater, a direct economic benefit by reducing the amount of money paid to the City of Scottsdale to receive the Town of Paradise Valley's wastewater and possible an economic benefit from the sale of recycled water. If the facility is built as a part of a development and given to the Town of Paradsie Valley, then the Town of Paradise Valley can recover the benefits without having the responsibility and expense of building a water recycling plant.

WATER CONSERVATION

Reducing water use to extend the production life of the groundwater and other water supplies is a worthwhile goal for the Town of Paradise Valley because water conservation benefits everyone in the area. Individual water conservation efforts are voluntary at the present time, but indoor and outdoor water use can be reduced. New water sources can be developed, more groundwater can be pumped, and wastewater can be recycled to help meet future water demands but water conservation is an essential part of a water planning program. Every gallon of water that is wasted has to be pumped and treated and that costs money, wasting water also wastes money. It does not make economic or hydrologic sense to recharge the aquifer with recycled water to replace the water that is being wasted throughout the system. Water conservation reduces the water demand so that groundwater does not have to be pumped from the aquifer to provide waste and thus it will not have to be replaced.

Desert landscaping and the use of drip irrigation for watering will reduce outdoor water use. Everyone has seen examples of wasting water outdoors at their own residence and throughout the area. A dripping faucet around the home can waste 170 gallons in a 24-hour period. Lawn watering practices often waste water. When sprinkler systems are set on timers, they water the turf regardless of the weather. Many times sprinklers can be seen in operation during a thunderstorm and the excess water flows down the street. In other cases, the sprinklers are not properly set and the system waters not only the turf, but also sidewalks and streets.

Water in the streets is an annoying waste of water. It forms puddles that can over a long period, deteriorate the pavement. One method to reduce outdoor water waste is to fine people who allow water to run into the streets. The City of Phoenix is considering this at the present time. A ticket, much like a traffic ticket, will be issued to anyone who wastes water and allows the water to flow into the street. The proposed fine is small, around ten dollars, but it is designed to encourage water conservation.

Interior water use can be reduced through the intallation of water conservation devices such as low flow showerheads, flow reducers on indoor faucets, and water conserving toilets. Current estimates of water savings are 10 to 18 percent toilet water savings, 9 to 12 percent shower water savings, and a maximum of 2 percent faucet water use. The Town may adopt an ordinance requiring all new construction to use water conserving fixtures.

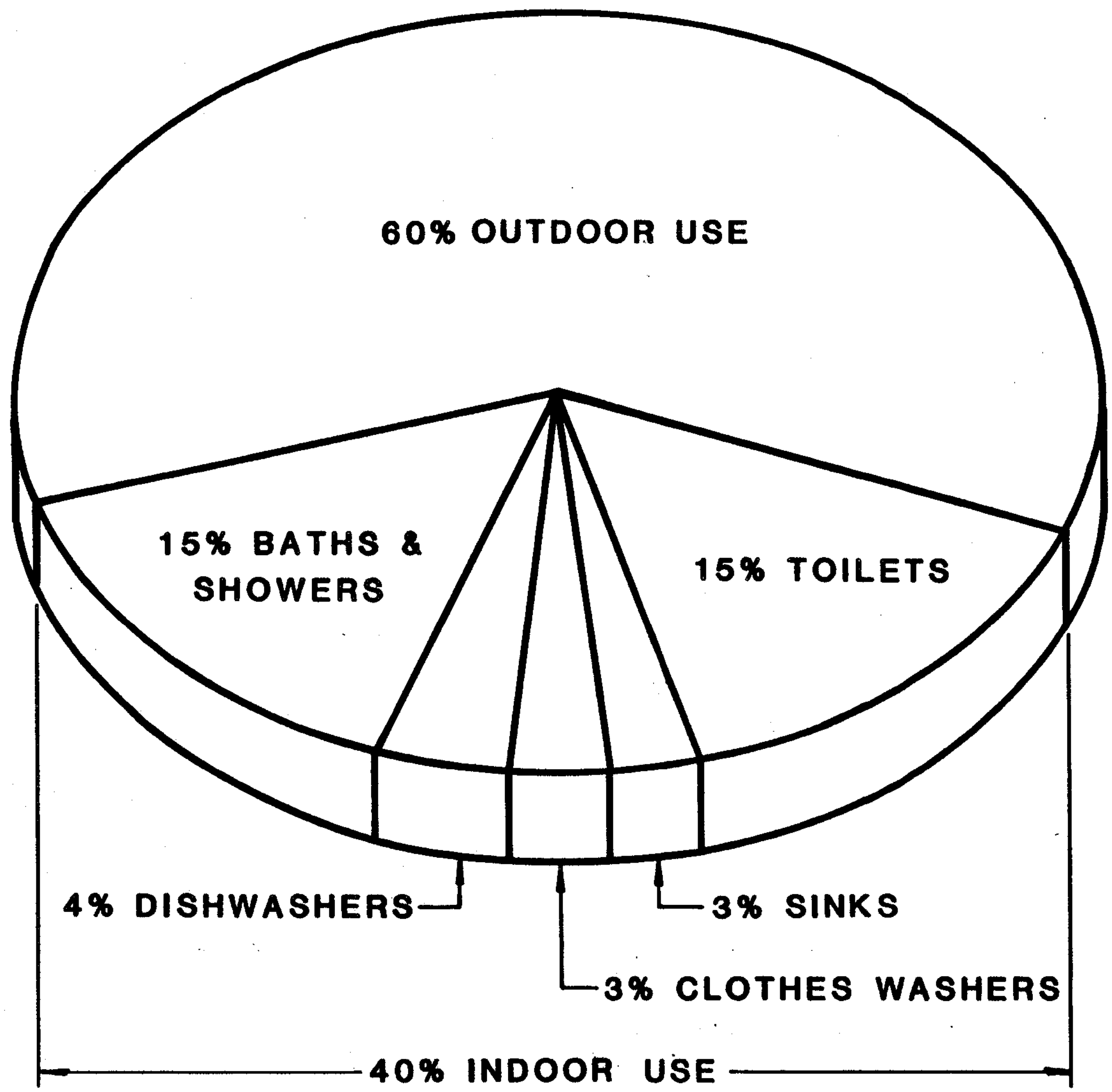
Indoor water conservation can be achieved by a variety of methods. Repairng leaking faucets can save 170 gallons per day and a leaking toilet can waste hundreds of gallons of water per day. Changing the way water is used in the home can also conserve water. Some use practices that conserve water include:

> Run dishwashers only when full. This saves 14 gallons per cycle in the dishwasher.
>
> Take shorter showers. A five-minute shower use 45 gallons less than a ten-minute shower.
>
> Do not run water continuously while brushing teeth, shaving, washing hands or washing foods.
>
> Keep water in the refrigerator for a cold drink. Do not run the water faucet to get cool water.

The City of Phoenix Office of Water Conservation has a presentation relating to water conservation that it can give to interested groups. The Town of Paradise Valley should schedule the presentation for public seminars to make the general public aware of what can be done to conserve water.

The City of Phoenix estimates that 40 percent of the water delivered to each dwelling is used indoors and the remaining 60 percent is used outdoors (Figure 17). If the average water demand for the Town of Paradise Valley is 542 gpd per person as calculated previously in this report is used as a water delivery total, then the indoor use is 217 gpd per person and the outdoor use equals 325 gpd per person.

The City of Phoenix further breaks down the indoor use into 15 percent for toilets, 15 percent for baths or showers, 3 percent is sink use, 3 percent for clotheswashers, and 4 percent for dishwashers (Figure 17). This would equal 83.6 gpd per person for showers, 83.6 gpd for toilet use, 17 gpd for sinks and clotheswashers, and 22 gpd for dishwashers in the Town of Paradise Valley. It



AVERAGE RESIDENTIAL WATER USE
IN THE CITY OF PHOENIX

WATER RESOURCES EVALUATION
TOWN OF PARADISE VALLEY
MARICOPA COUNTY, ARIZONA
ANDERSON-NICHOLS & CO., INC.

FIGURE 17

is obvious that a simple equation of the average City of Phoenix water use and the average Town of Paradise Valley water use can not be made. Even if 40 percent of the water used per person per day is for indoor use (217 gallons), it is not logical to assume that almost 84 gallons is used to flush the toilets. The average toilet uses 5 to 9 gallons per flush and 84 gallons would equal 9 to 17 flushes per person per day.

Water conservation devices could reduce the indoor use by an estimated of 25 gpd per person. The average daily use would be reduced from 542 gpd to 517 gpd, which is not a significant amount. The greatest potential for water conservation areas relate to outdoor water use and changing water use habits.

Water conservation will not be voluntary in the near future. The ADWR has a proposed a management plan for the Phoenix AMA that requires water use reductions for almost all municipal and private water systems (ADWR, 1984). Water reduction goals set for the water companies that serve the Town of Paradise Valley are based on 1980 water use totals previously described in this study. The Berneil Water Company and the Paradise Valley Water Company are both required to reduce system water use by 11 percent. The City of Phoenix has a 6 percent water use reduction goal. These are the goals of the first management plan for the 1980 to 1990 period. The water reduction goals are required for the year 1985.

If a water supplier does not meet the water reduction goals set for the AMA by the ADWR, they could face fines. Goals for the subsequent management periods will most likely require even more strict controls on water use and require more water conservation. Fines are an economic incentive for water conservation. A hearing by the Arizona Corporation Commission would probably be required to determine if a water company could incorporate the payment of these fines into their water rates and pass the costs to the large quantity water users.

In other areas of the country during periods of drought, maximum water use allocations for each dwelling were established. When water use exceeded the allocation, substantial fines were levied against the offenders. This economic pressure forced individuals to conserve water.

Water conservation required to reduce water use in an AMA is one of the impacts of the State Groundwater Code. The Town of Paradise Valley will not be directly affected by the Code because it does not own or operate a water system. The water companies in the Town of Paradise Valley will be affected and that will have an impact on the people served by those companies.

In addition to the Phoenix AMA first management period goals, it will be more difficult for water companies to drill new water wells due to the Groundwater Code. Well impact studies are required for wells with a planned yield greater than 500 gallons per minute. This allows the ADWR to evaluate the impact that a new well will have on surrounding wells. The ADWR can prevent the drilling of the new well if the impact is considered too severe.

The Groundwater Code requires in Arizona Revised Statutes (ARS) 45-576 that an assured water supply be established for an area before subdivision development can proceed. Pursuant to ARS 45-576(I), when a municipality such as the City of Phoenix receives an allocation of CAP water and signs a notice of intent to contract for CAP water, the service area and extensions of the service area are deemed to have an assured water supply until December 31, 2000. Starting on January 1, 2001, the water supply of the municipality, such as the City of Phoenix, is subject to review by the director of the ADWR to determine if the municipality still has an adequate water supply within its service area. The City of Phoenix has contracted for CAP water thus the areas within the Town of Paradise Valley served water by the City have an assured water supply pursuant to the Groundwater Code.

The assured water supply criteria for a private water company are different from the criteria applied to a municipality. If a private water company has made an unconditional offer to enter into a contract for its CAP allocation, and if the CAP water is sufficient to supply the intended use of the water and if the private water company is proceeding to develop the delivery system and treatment facilities for CAP water, then the ADWR director can find that the private water company is deemed a presumption of an assured water supply exists for the private water company (ARS 45-576 D).

The key differences between a private water company and municipality CAP designation is the "unconditional offer" and "deemed a presumption" of an assured water supply. The assured water supply is a presumption for a private water company and deemed for a municipality. A private water company has to demonstrate that the CAP water is sufficient to supply the "intended use" but the term intended use is not defined. Since the Town of Paradise Valley does not own a water system, it cannot get an assured water supply certificate. This is the responsibility of the water utilities serving the Town of Paradise Valley.

That portion of the Town of Paradise Valley that is served by the City of Phoenix has an assured supply since Phoenix has already contracted for CAP water. Neither the Berneil Water Company or the Paradise Valley Water Company currently has an assured water supply certificate issued by the ADWR. The Berneil Water Company has signed a contract with the CAWCD but still has to submit documents to the ADWR for issuance of the certificate. The Paradise Valley Water Company is currently negotiating the CAP contract for delivery and treatment of CAP water. Once the subcontracts for CAP water have been approved and the Berneil Water Company and the Paradise Valley Water Company demonstrate how they will treat the CAP water, both water companies have been discussing a treatment agreement with the City of Phoenix, they can apply for a certificate of adequacy. The ADWR was contacted on that subject and the ADWR claims that should be no problem issuing the certificates once the CAP conditions are verified.

WATER SYSTEM ACQUISITION

General

Except for that portion served by the City of Phoenix, the Town of Paradise Valley lies within the franchise areas of the two private water companies. The Town of Paradise Valley cannot begin a new water company within the Town Limits, but would have to purchase an existing water company. Legally, the Town of Paradise Valley can acquire one or both of the private water companies. This process, either through mutual agreement or condemnation in the courts, has been used by cities and towns in the Phoenix area for years as the urban area grows and overtakes the rural areas served by the private water companies. The acquisition of a private water company by a city or town is not unique, but the decision to do so should be thoroughly considered because of the potential costs involved.

The Town of Paradise Valley should consider many factors before deciding to purchase one or both of the water companies. The first question should be, "Will the purchase of a water company benefit the Town?" In order to answer that question, the Town Council must evaluate the quality of service presently provided to the Town of Paradise Valley residents and decide if it could be improved; the cost of purchasing or condemning a water system including the wells, pipelines, meters, and other equipment; the cost to operate a water company including salaries, insurance, and equipment maintenance; could the Town of Paradise Valley make a profit selling water; and could a better source of water be developed. Furthermore, the Town of Paradise Valley must decide if it wants the added responsibility.

Purchase Cost Estimate

The first criteria that should be considered is the cost to purchase a water system. The City of Phoenix did not have a general method of calculating water company value due to a variation in private water company values. The City of Scottsdale purchased the Ironwood Water Company for $2 million. The Ironwood Water Company has 500 connections, so the purchase price was $4,000 per connection.

The Town of Apache Junction considered purchasing the water system that provides service to its area. The cost of the water system was equal to $1,565 per connection. A review of other private water companies in the general Phoenix area shows a value of about $1,650 per connection.

The Town of Paradise Valley is in an area of valuable land but a cost of $4,000 per meter did not seem appropriate. The other per connection costs were in areas of lesser land values than the Town of Paradise Valley. The average of $4,000 per connection and $1,650 per connection is $2,825 ($2,800 rounded) and that value will be used in cost evaluations.

Possible purchase costs for each of the four water companies that serve the Town of Paradise Valley have been calculated the average and high per connection cost. Calculations using the average connection cost ($2,800 each) are presented on Table 7. The calculations assume that 10.5 percent bonds or loans will be used to fund the purchase and three payout periods (10, 15, and 20 years) assess the economic impact.

The monthly cost per connection is constsant for each payout option for each water company. That is because the cost per connection in each water company calculation is constant ($2,800). The cost per connection is the same as if the landowner obtained a loan for $2,800 at a 10.5 percent interest rate for a given period.

The monthly payment per connection based on a $2,800 per connection cost varies from $27.95 per connection using a 20 year repayment period to $37.78 per connection with a 10 year repayment period. These monthly fees would not place an undue financial burden on the households in the Town of Paradise Valley.

A similar set of calculations are given on Table 8 using a per connection cost of $4,000. These data show that the monthly payment per connection varies from $39.94 with a 20 year repayment period to $53.97 using a 10 year payment period. These costs are not considered excessive for the households in the Town of Paradise Valley.

These purchase cost estimates do not purport to be the asking price of any of the water companies that serve the Town of Paradise Valley. The economic

TABLE 7

WATER SYSTEM PURCHASE

(AVERAGE CONNECTION COST)

ITEM	BERNEIL WATER COMPANY	CITY OF PHOENIX	PARADISE VALLEY WATER COMPANY	MUMMY MT. WATER COMPANY
No. of 1984 Connections	349	1,498	1,539	13
Cost @ $2,800 per connection	977,200	4,194,400	4,309,200	36,400
10½% Interest	**10 year payout**	**120 months**		
Monthly Cost	13,185.88	56,597.28	58,146.34	491.16
Total Cost	1,582,305.60	6,791,673.60	6,977,560.80	58,939.20
Monthly Cost per connection	37.78	37.78	37.83	37.38
10½% Interest	**15 year payout**	**180 months**		
Monthly Cost	10,801.98	46,364.94	47,633.94	402.37
Total Cost	1,944,356.40	8,345,689.20	8,574,109.20	72,426.60
Monthly Cost per connection	30.95	30.95	30.95	30.95
10½% Interest	**15 year payout**	**240 months**		
Monthly Cost	9,756.18	41,876.10	43,022.24	363.41
Total Cost	2,341,483.20	10,050,264.00	10,325,337.60	87,218.40
Monthly Cost per connection	27.95	27.95	27.95	27.95

TABLE 8
WATER SYSTEM PURCHASE
(HIGH CONNECTION COST)

ITEM	BERNEIL WATER COMPANY	CITY OF PHOENIX	PARADISE VALLEY WATER COMPANY	MUMMY MT. WATER COMPANY
No. of 1984 Connections	349	1,498	1,539	13
Cost @ $4,000 per connection	1,396,000	5,992,000	6,156,000	52,000
10½% Interest	**10 year payout**	**120 months**		
Monthly Cost	18,836.97	80,853.25	83,066.19	701.66
Total Cost	2,260,436.40	9,702,390.00	9,967,942.28	84,199.20
Monthly Cost per connection	53.97	53.97	53.97	53.97
10½% Interest	**15 year payout**	**180 months**		
Monthly Cost	15,431.41	66,235.63	68,048.48	574.81
Total Cost	2,777,653.80	11,922,413.40	12,248,726.40	103,465.80
Monthly Cost per connection	44.22	44.22	44.22	44.22
10½% Interest	**20 year payout**	**240 months**		
Monthly Cost	13,937.40	59,823.00	61,460.35	519.16
Total Cost	3,344,976.00	14,357,520.00	14,750,484.00	124,598.40
Monthly Cost per connection	39.94	39.94	39.94	39.94

estimate is presented to give a magnitude of cost that the purchase of a water company would add to the monthly bill per connection.

Water Rates

The Town of Paradise Valley could set water rates for the customers if a water system is purchased. A municipality can change water rates without having a rate adjustment hearing before the Arizona Corporation Commission. The hearing process is required for private water company rate adjustment requests.

Monthly water costs have been calculated for Berneil Water Company, Paradise Valley Water Company, and City of Phoenix (winter and summer rates) customers. The calculation includes several per capita water consumption rates, 140 gpd as required by the ADWR, 267 gpd the average use in Phoenix, 542 gpd the average used in this study, and 884 gpd, the use calculated by the ADWR in 1980 for the Paradise Valley Water Company. The monthly costs for water are summarized on Table 9.

The Town of Paradise Valley could adjust water rates as needed to reflect economic conditions of production and treatment costs and also to encourage water conservation. The City of Phoenix water costs for the residents in the Town of Paradise Valley may change due to pending litigation relating to inside of the City versus outside of the City water rate differentials. The outcome of the litigation and the impacts that it will have on the City of Phoenix water rates can not be predicted.

New Water Sources

If the Town of Paradise Valley purchases a water company or part of the City of Phoenix system, the CAP allocation that corresponds to that area must be transferred to the Town of Paradise Valley. As was explained previously in this study, the potential for new alternative water sources is quite limited and CAP water is the only potential source of new water. Water recycling reuses existing water.

CAP water will cost approximately $100 per acre-foot to treat for municipal use and the current estimated cost for the water is $60.00 at the CAP aqueduct. If the Town of Paradise Valley purchases a water system and contracts with the City of Phoenix to process the water, the cost will be $160 per acre-foot which is equal to about $0.50 per 1,000 gallons. The cost does not include

TABLE 9
WATER COST COMPARISON

Monthly Water Use
Per Capita Use Rate

ITEM	140 gpd	267 gpd	542 gpd	888 gpd
Daily Dwelling Use (gallons)	518	988	2,005	3,286
Monthly Dwelling Use (gallons)	15,540	29,640	60,150	98,580
Monthly Dwelling Use (cubic feet)	2,078	3,963	8,041	13,179
Cost				
Berenil Water Company	$16.00	$32.00	$63.00	$121.26
Paradise Valley Water Company	14.96	29.90	76.78	85.54
City of Phoenix				
Winter	24.55	47.25	99.44	165.21
Summer	26.28	56.67	128.44	222.07

distribution system costs for pumping, operation, maintenance, and overhead that the Town of Paradise Valley would have to charge.

AMA Regulations

Water use reduction goals have been set for municipalities and private water companies in the Phoenix AMA. These goals have to be achieved by January 1, 1987 or the water company, including cities, could be penalized. The ADWR has not established the penalty for not meeting the goal and the Groundwater Code does not specify any penalties. The ADWR feels that the penalty for not achieving the required water use reduction will be influenced by how far off the goal the water user is, if an effort was made to reduce water use and similar factors. The penalty could range from no action to a $10,00 per day fine.

If the Town of Paradise Valley purchases a water company, the Town or an employee of the Town would be responsible to assure that water reduction goals are achieved. The Town of Paradise Valley would then be faced with the problem of enforcing water use reduction or being subjected to penalties. Water use reductions could be through voluntary conservation, economic pressure by raising water rates, or physical restriction of water flow to mention a few alternatives.

Jurisdiction

Another factor that should be evaluated if the Paradise Valley Water Company is considered for purchase is that company's service area. If the Town of Paradise Valley purchases the Paradise Valley Water Company water system, it may have to serve residents in the City of Scottsdale.

The water company could be divided so that the City of Scottsdale purchases the sections within its limits. That would be a problem for the Town of Paradise Valley because several of the wells that provide water for delivery in the Town of Paradise Valley are located within the City of Scottsdale. These jurisdiction problems would have to be solved prior to finalizing any pruchase agreement.

If the Town of Paradise Valley desires to own and operate a water system, it would have to purchase one or more of the systems within the Town Limits. A friendly purchase would have the Town of Paradise Valley and the water system owner negotiate a price. The system could then be purchased. If the Town of Paradise Valley wants a system, but the owner does not want to sell, then the Town of Paradise Valley must condemn the system and acquire it through a legal process.

In the latter case, a detailed appraisal study is required to evaluate the condition of the water company's system and establish its worth and the cost of the evaluation would add to the pruchase price.

Purchasing a water company is an expensive process. The Town of Paradise Valley must evaluate the alternatives and requirements of owning and operating a water company and decide if the cost for the system is justified.

SUMMARY

The Town of Paradise Valley is projected to have 15,500 people when fully developed. This figure is based on an average occupancy of 3.7 people per dwelling on the 4,167 lots within the Town of Paradise Valley and the projected water demand will be 9,409 acre-feet per year based on present use rates. The Town of Paradise Valley does not own a water system but water is supplied water by the Berneil Water Company, the Paradise Valley Water Company, the Mummy Mountain Water Company, and the City of Phoenix.

Groundwater currently supplies the needs of the Town of Paradise Valley residents. Geologic and hydrologic information indicates that the groundwater supply when used in conjunction with the Central Arizona Project water allocations is adequate to meet the water demand for more than 100 years. There are no groundwater quality problems that would prevent its use in the future.

Throughout the course of this study, alternatives were considered in order to determine if any topics not included in the original scope of work needed to be addressed. It was found that the items originally proposed by the Town Council were quite detailed. The issues facing the Town of Paradise Valley that should be addressed are as follows:

1. Completion of subsidence survey work. The Town Engineer has begun this study. Land subsidence has been documented in the area and could impact street drainage and sewer flows. A thorough knowledge of subsidence areas within the Town of Paradise Valley and the long range impact that it will have on the slope of the ground surface is essential to design of gravity flow systems.

2. Computer studies of the water and sewer system. The Town of Paradise Valley will continue to add water and sewer pipelines in its area. This may or may not be done by the Town of Paradise Valley itself. A computer analysis of the water distribution systems for each water company should be completed. This data should be prepared in a format that allows the Town Engineer to review the water system periodically to evaluate the impact new

homes will have on the water deliveries. A similar study should be done for the existing and planned sewer system.

A computer system will allow the Town Engineer to monitor the capcity of the water and wastewater system pipelines. This will allow projections to be made based on the water and sewer system demands so that additions to the systems will be adequate to provide service. The computer programs can caluclate the diameter of the pipeline required to deliver water at an adequate pressure throughout the system. The computer can show areas in the system where problems may result due to increased demands and then the problems can be solved before they actually occur.

The sewer system will probably expand to include the areas in the Town of Paradise Valley that are presently using septic tanks. A computer program can be used to design the pipelines in the area to assure that the system will have the capcity to transport the predicted wastewater quantities.

3. CAP allocations. The Town of Paradise Valley should encourage the water companies to apply for a reallocation of CAP water and should also support their efforts to obtain additional CAP supplies. This will reduce the groundwater demand and further preserve the groundwater resources.

4. Reduce water use. Residents in the Town of Paradise Valley use large quantities of water and the Town of Paradise Valley has no real method control of the amount of water used by its residents because it does not supply the water. It would be to everyone's benefit if the Town of Paradise Valley actively encouraged water conservation through public awareness and public spirit rather than using economic pressure.

5. Water Recycling. The Town of Paradise Valley has been offered a water recycling plant that will provide water for golf course and landscape irrigation. The Paradise Valley Country Club has offered to buy and transport recycled water for use on its golf course. The Town of Paradise Valley can own a water recycling facility for a minimal amount of expense and will have a customer for the water. The Town Council should carefully evaluate the proposal for building the facility because it will allow water companies to reduce the amount of groundwater pumped to provide irrigation water and to conserve groundwater for other uses.

6. Water Company Purchase. The water customers in the Town of Paradise Valley would not have an unreasonable economic burden to fund the purchase of a water company. The potential for penalities, including fines, if water use reduction goals are not achieved could be severe.

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