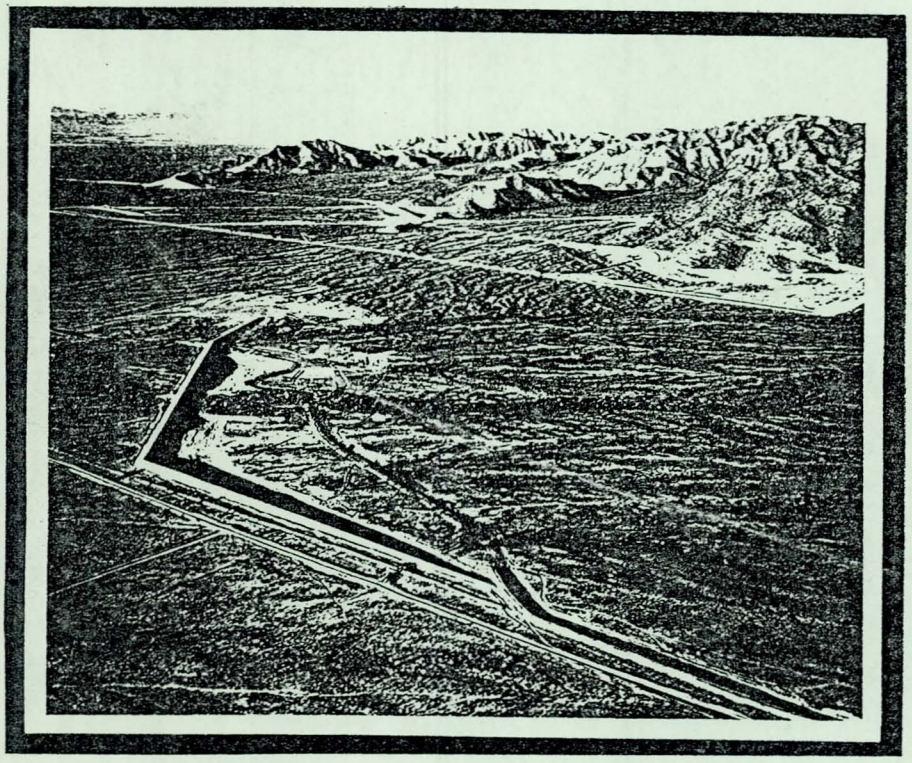
PROPOSAL FOR REHABILITATION

WHITE TANK MOUNTAINS FLOOD RETARDING STRUCTURES #3 AND #4

PILOT WATERSHED PROJECT
MARICOPA COUNTY, ARIZONA



UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
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WHITE TANKS REPORT

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WHITE TANKS #3 AND #4

I. BACKGROUND

The White Tanks drainage area includes the easterly watershed of the White Tanks Mountains and the northerly Trilby Wash Watershed. McMicken Dam (Initially designed as White Tanks Units #1 and #2 but later designed and constructed by the Army Corps of Engineers), was constructed to collect runoff from the 223 sq. mi. Trilby Wash Watershed. White Tanks #3 and #4 were built to collect the runoff from 24 sq. mi. and 10 sq. mi. watershed areas, respectively, of the easterly portion of the watershed.

McMicken Dam was constructed in 1955 by the Corps of Engineers and remains under the purview of the Maricopa County Flood Control District and the Corps. Accordingly, McMicken Dam is not included in this report, we are addressing White Tanks Dams #3 and #4 only.

White Tanks #3 and #4 were designed and constructed by the Soil Conservation Service (SCS) in 1954. Their purpose was to protect farmland and irrigation facilities which had sustained severe storm damage. A detailed engineering report of the proposed projects dated 2/27/53, is in Appendix 1.

A. Sponsors

The sponsor for White Tanks #3 and #4 at the time of planning and installation was the Aqua Fria Soil Conservation District. The SCD participated in accordance with the work plan prepared by SCS, dated April 1954 (see Appendix 2). Please note that the work plan was prepared under authority of the Soil Conservation Act of 1935 (Public Law No. 46, 74th Congress).

With the construction plans completed and landrights acquired, the sponsors awaited an opportunity for funds to construct the dams while the work plan was being formalized. In the spring of 1953 the 83rd Congress passed the Pilot Watershed Protection Program. This became the resource for funds and in February 1954 a contract for construction was awarded. The construction was completed by July 1954. We understand this was the first Pilot Project completed in the Nation.

B. Construction Cost

The construction of structures #3 and #4 was accomplished under a construction contract for $163,334. The Condensed Cost Summary, prepared following installation of the projects is found in Table 1 - Appendix 3. The table shows the total project cost to be $395,145. The engineering and other cost information are also provided.

C. O&M Agreements

Annual operation and maintenance costs were paid by the Agua Fria SCD. At the time of construction an agreement was formed between Agua Fria SCD and the Maricopa County Municipal Water Conservation District Number One (Beardsly Project) wherein the Water Conservation District would perform the annual O&M works and receive an annual payment from Agua Fria SCD. (See Appendix 4.)

In 1966 the responsibility for O&M shifted to the Flood Control District of Maricopa County (FCDMC) which in turn also paid The Beardsly Project to perform the work in accordance with their agreement. The agreement was terminated on June 30, 1975 and the FCDMC has since performed all routine O&M activities.

D. Project Life

The amortized life of the structure was 50 years. The benefit-cost ratio was estimated to be 1.7 to 1 (see Table 1 - Appendix 3). Please note however that the reservoir was designed to contain the 100 year frequency storm to the emergency spillway elevation.

II. ORIGINAL DESIGN

The planning and design of structures #3 and #4 were performed by SCS in October 1952. Those records are no longer available. From Table 1 - Appendix 3 the designed spillway capacities were 11,750 cfs and 4400 cfs, respectively, and the reservoir capacities 2655 AF and 1036AF, respectively for structures 3 and 4. These capacities are based on the following design elevations:

	Dam #3	Dam #4
Dam Crest Elevation	1216	1056
Max Water Surface Elevation	1213	1053
Spillway Elevation	1210	1050

A. 1983 Review of Structure #3 Hydrologic Study

In 1983 the FCDMC reviewed a 1981 study prepared by Ertec Western, Inc. The study showed that the Probable Maximum Flood (PMF) would result in overtopping of the dam by 1.12 feet if the reservoir was initially full, or 1.01 feet if the reservoir was initially empty. The structure would not be overtopped by a one-half PMF. The study was based on the original design elevations of the structure (see Appendix 5).

B. 1983 Hydrologic Study of Structure #4

The FCDMC prepared a preliminary study in 1983 which showed Structure #4 would be overtopped by the PMF. It also showed that a one-half PMF could overtop the dam by 0.34 foot if the dam's reservoir was initially full (see Appendix 5). The study was based on original as-built structure elevations. The Arizona Department of Water Resources - Dam Safety Branch has classified this structure as unsafe due to the questionable spillway adequacy.

C. 1955 Photos

Copies of photos taken in 1955 show the structures and vicinity shortly after construction in 1954 (see Appendix 6).

III. 1982 REPAIR PROJECT

In 1979 an SCS Crack Study Team conducted an investigation and prepared a report on "Cracking of Dams in Arizona". Their work found that White Tanks #3 and #4 had sustained extensive cracking and they proposed further investigation.

In 1979 Furgo, Inc., Consulting Engineers and Geologists were retained by SCS to perform a "Crack Location Investigation" on several cracked embankments that included White Tanks Structures #3 and #4. Both dams were found to have severe and extensive cracking. Corrective measures were proposed.

Corrective measures were designed that included excavating a centerline trench and eradicating the larger cracks found. A contract for the repairs to both #3 and #4 was completed in 1982, at a cost of $709,066. White Tanks #3 repair included the breach of approximately 400 feet of dam and replacement with new materials, including a vertical filter.

IV. CURRENT CONDITIONS

A. Area Subsidence

The vicinity easterly and southerly of the dams has long been in intensive cultivation with irrigation by use of groundwater. Long term pumping has caused mining of the resource and steady lowering of groundwater levels, resulting in general subsidence of the earth surface above the aquifer system. The constructed Central Arizona Project (CAP) has supplemented the Arizona water supply such that the amount of ground water withdrawal is greatly reduced. However, the area subsidence is still continuing at a reduced rate.

1. Effect on Structure #3

When Structure #3 was repaired in 1982 it was discovered that the crest of the dam had declined in elevation. Subsidence monuments were installed in 1984 to monitor further decline. Several surveys have since been conducted along the crest.

A centerline survey with elevation readings at 100 feet intervals was conducted in 1990. It was confirmed that the northerly end of the dam had subsided up to 4.4 feet since 1954. The southerly end had almost negligible subsidence. The differential subsidence was attributed to the northerly end being located over the dewatered aquifer while the southerly end was near or over bedrock. Hydrologic analyses of the dam have all been based on the original crest elevation of 1216 feet and at that elevation the dam could safely withstand approximately the 0.6 PMF. However, with the actual minimum crest elevation around 1211.6 feet the dam can be expected to fail under a much less intense storm.

2. Effect on Structure #4

Structure #4 was constructed with a crest elevation of 1056 feet. The most recent survey of the seven subsidence monuments along the dam centerline showed the lowest monument to have an elevation of 1054.791 feet. The average crest elevation is about 0.6 feet below the design level.

B. Dam Breach Study

A "Dam Breach Study" was performed by AGK Engineering, Inc., in January 1991 under contract with FCDMC. The study considered dam breaks at three locations on each dam. The design flows were one

PMF and one-half PMF for structure #3 and #4, respectively, as directed by ADWR and FCDMC. The results are summarized below:

Description	White Tanks FRS No.3	White Tanks FRS No. 4
Size Designation	Medium	Small
Hazard Designation	High	High
Design Inflow Magnitude	PMF	1/2 PMF
Peak Design Inflow (CFS)	41,554	22,820
Spillway Crest Elevation	1209.0	1048.5

1. Dam #3 Results

Highlights of the results are shown in Table 1 of Appendix 7. Included are velocities and water depths at the following major public facilities along the path of the flood: Perryville Prison, Interstate Highway 10, Roosevelt Canal, Southern Pacific Railroad.

Not addressed in the table are the heavy damages which would be caused to the Town of Goodyear, the trotting park, agricultural lands and roads along the way, as well as individual dwellings. Boundaries of the path are shown on the enclosed maps of the downstream area.

2. Dam #4 Results

Highlights of the results are shown in Table 2 of Appendix 7. Included are velocities and water depths at the following major facilities along the path of the flood: Roosevelt Canal, Southern Pacific Railroad, and the Town of Liberty.

Not addressed in the table are damages which would be caused to agricultural lands, roads and individual dewellings.

V. IMPROVEMENTS REQUIRED

A. Structure #3

The condition of Structure #3, wherein the dam crest has subsided as much as 4.4 feet, presents a serious threat to downstream development. Improvements are needed to enable the dam to withstand the full PMF. The following are items which should be included in design considerations:

1. Raise the dam crest to the elevation required to pass the full PMF without failure.

2. Enlarge the emergency spillway to pass the required design flow through the structure. Note, a mechanical spillway may be required due to the highly erosive soils present at the site.

3. Raise the height of the crest elevation to accommodate future subsidence.

4. Extend the dam as needed for catch point to reach the elevation of top of crest.

5. Provide gravel surface to embankment slopes to prevent rilling, gullying, and crack protection.

B. Structure #4

Structure #4 has been little affected by subsidence. However, there is some settlement of the crest of the dam which causes a 0.34 foot overflow of crest by the, one-half PMF. The crest of the dam needs to be raised to a uniform elevation to allow the freeboard storm to pass safely through the emergency spillways without overtopping.

C. Estimated Cost

Preliminary estimates of repair works were prepared for budgetary purposes. The cost estimate to make structure #3 safe under a full PMF design flow is much greater than that required to upgrade Structure #4 to withstand a one-half PMF flow. The costs for Structure #3 include raising the dam crest, and constructing a reinforced concrete spillway structure. The estimates are as follows:

	TA Design	TA Inspection	FA
Structure #3	$210,000	$300,000	$2,000,000
Structure #4	10,000	10,000	30,000
Totals	$220,000	$310,000	$2,030,000

APPENDIX 1

DETAILED ENGINEERING REPORT

FEBRUARY 1953

DETAILED ENGINEERING REPORT

White Tanks Erosion Control Project

The history of the White Tanks Erosion Control Project is so well known to all personnel, both in the State and Regional Offices, that a brief summary should suffice for the engineering narrative.

The White Tanks area includes the Trilby Wash Watershed and the east watershed of the White Tanks Mountains in Maricopa County, Arizona. Runoff from the storms originating in the upper watershed has caused extensive damage to irrigated lands, highways, railroads, armed forces installations and other public and private property. Interest has been active for many years in the construction of some type of works to alleviate this damage, but until the severe floods of 1951 the various groups concerned could never agree on a comprehensive plan.

The Agua Fria Soil Conservation District, which includes all of the irrigated lands in the White Tanks area, was organized in 1946. Commencing in 1946, at the request of the Agua Fria Soil Conservation District, Service technicians began work on the development of a plan for the protection of the farm land and irrigation facilities. In 1947 the design of one detention structure was completed and submitted to the Agua Fria Soil Conservation District, but no construction was undertaken because of financing difficulties.

Severe damage resulted from a storm in January, 1951, and agitation for protection became active. Additional storms during July and August of 1951 emphasized the necessity for immediate construction of adequate protection works. A base line was established from a point about one-half mile northwest of the Beardsley Canal, and permanent points were set approximately every 500 feet. All pertinent items in the structures as designed are referred to the permanent points previously mentioned. Topographic mapping of a strip approximately 4,000 feet in width and 18½ miles in length was started during August, 1951, and completed late in December. After a thorough study of the base map and considerable field reconnaissance, it was decided that a system of four detention dams with controlled outlets or "bleeders" could adequately control runoff. The structures have been located so that the flow from the watershed will run directly into the reservoirs. This provides for a minimum use of training dikes and channels and decreases the maintenance problem considerably.

Structures Numbers 1 and 2 have been designed to function as a unit. A large outlet has been provided to discharge stored water from Number 1 to Number 2, in order to utilize the maximum capacity of the main canal and all laterals in evacuating both reservoirs in a minimum length of time. Because of the interdependence of these two structures, they should be constructed as a unit. The outlets or "bleeders" will be sliding headgates and specially treated corrugated metal pipe. They will discharge stored water directly into the main Beardsley Canal for

distribution into the laterals and wasteways. In case of large storms and increased runoff, additional "bleeders" will discharge small quantities over the present concrete siphons and into established channels.

No structures are to be built between laterals 8½ and 10½. The Irrigation District has agreed to strengthen a dike presently located just west of the Beardsley Canal, and in this manner train runoff into Structure Number 3. The present overshot at Lateral 10½ will consequently be blocked.

Structure Number 4 is located at the extreme southern end of the project and is the smallest of the series. After thorough field reconnaissance, it was decided that with minor modifications in the presently existing structures on the Caterpillar proving grounds that they could easily be incorporated into the overall plan. It was on this basis that the design for Structure Number 4 was made.

Agreement exists between the Irrigation District and the Agua Fria Soil Conservation District for the operation and maintenance of the structures after they have been completed. Necessary water distribution plans will be made and personnel will be trained in the operation of the control gates. Both the Agua Fria Soil Conservation District and the Irrigation District have given assurances that the reservoirs will always be evacuated in the shortest possible time and that water will never be stored for irrigation purposes.

George Sohn

George Sohn
Engineering Specialist
February 27, 1953

APPENDIX 2

WORK PLAN, APRIL 1954

AND

LETTERS OF ACCEPTANCE

WORK PLAN

WHITE TANK WATERSHED PROTECTION PROJECT
Agua Fria River Watershed
Maricopa County, Arizona

Participating Agencies

Agua Fria Soil Conservation District
Maricopa County Municipal Water Conservation District
Soil Conservation Service, USDA

Prepared by
Soil Conservation Service
United States Department of Agriculture
April 1954

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WORK PLAN
WHITE TANK WATERSHED PROTECTION PROJECT
AGUA FRIA RIVER WATERSHED
MARICOPA COUNTY, ARIZONA.

INTRODUCTION

Authority - The Federal participation outlined in this work plan is expected to be performed under the authority of the Soil Conservation Act of 1935 (Public Law No. 46 74th Congress) and other authorities of the national programs of concerned agencies.

Purpose and Scope of the Plan - The purpose of this plan is to state specifically the practices and measures required and feasible and how they will be carried out to achieve the maximum practicable reduction of erosion, floodwater and sediment damages. Application of this mutually developed plan will provide protection and improvement of land and water resources which it has been agreed can be undertaken at this time with the combined facilities of local interests, State and Federal agencies. Upon completion and continued maintenance of the measures set forth in this plan, agricultural production will be sustained at a level corresponding to the capability of the land, and the welfare of the landowners and operators, the community, and State and the Nation will be promoted thereby. The area in the subwatershed is entirely in Maricopa County and contains 59,136 acres, or 92.4 square miles.

SUMMARY OF PLAN

This plan is a combination of land treatment practices and measures used for the conservation of water and watershed lands which contribute directly to flood prevention, and of measures primarily for flood prevention. The works of improvement as listed in combined Tables 1 and 2 are planned to be completed entirely during calendar year 1954, at an estimated total cost of $417,375, said cost to be shared $218,287, by the non-Federal interests and $199,088 by the Federal Government. These estimates include the current costs of local interests and Federal agencies under the going national programs pertaining to the objectives of this plan.

The Agua Fria Soil Conservation District hereafter referred to as the "District" will assume overall responsibility for future operation and maintenance of this project. This District has arranged with the Maricopa County Municipal Water Conservation District #1 (Locally known and hereinafter referred to as the Beardsley Project) an irrigation district organized under laws of Arizona to assume specific responsibility for overall periodic inspection of the measures primarily for flood prevention and for maintenance of the floodwater retarding structures and directly associated measures at an estimated annual cost of $3,750.

Comparison of Benefit and Cost - When the works of improvement are applied and operating at full effectiveness, the ratio of the estimated average annual benefit ($35,350) to the estimated average annual value of the cost $20,860 is 1.7 to 1 based on current price levels for costs and long term prices for benefits.

DESCRIPTION OF THE WATERSHED PROTECTION PROJECT AREA

The White Tank Mountains generally form the western edge of the Agua Fria River Watershed near its confluence with the Gila River. Drainage from the eastern face of the White Tank Mountains is divided between Trilby Wash on the north, tributary to the Agua Fria River, and an intermittent stream locally known as Avondale Wash, tributary to the Gila River on the south. It is this southern portion of the White Tank Mountain drainage area that comprises the subwatershed area covered by this plan. The watershed has a gross area of 59,136 acres, of which 25,024 acres are mountain and foothill slopes comprising the drainage area and flood source. The remaining 34,112 acres are intensively irrigated land lying on a broad, gently sloping alluvial fan and terrace which have an average slope to the southeast of about 0.4 percent. Channels are very poorly defined or even non-existent through the cultivated areas, making the construction of floodways through the farmland to the Gila River impractical.

Following the disastrous floods of 1951, the Agua Fria Soil Conservation District with the technical assistance of the Soil Conservation Service prepared plans designed to reduce the damages caused by flash runoffs from the White Tank - Trilby Wash watersheds. Construction of a series of four primary detention structures numbered (1) to (4) respectively were planned, near the mouths of Trilby and Avondale Washes. Damage to military and national defense installations in the area, however, led to the initiation by the Corps of Engineers of plans for the protection of these installations from water originating in the Trilby Wash drainage. These plans of the Corps of Engineers also protect the irrigated lands from floods from Trilby Wash so no further

consideration was given by the Soil Conservation Service for structures (1) and (2) of their original plan.

The Avondale Wash watershed has no protection and therefore active interest in watershed protection has been maintained in this area. The necessity for structures 3 and 4 remains, if adequate protection to farm lands is to be obtained. Since the numerical designation has become recognized through usage, it has been retained throughout this report. Costs of original planning on these four structures have been prorated and those applying to structures 3 and 4 are charged as a portion of the engineering costs incident to this plan.

The soils of the area comprise recent alluvial soils along the Gila River, the moderately developed fan soils of the intermediate slopes and the shallow soil materials and rocks in the White Tank Mountains. The soils of the intermediate slopes, including the bulk of the cultivated lands, are moderately deep, deep or very deep, calcareous, moderately developed fan soils. They are derived principally from granites and schists.

Soils derived from these parent materials compact badly as a rule and as a result water penetrates slowly and they are highly susceptible to erosion. The organic matter content is low but the general fertility level is good with the possible exception of nitrogen.

The soils of the area have been classified according to their permanent limitations and hazards into five capability classes. The non-arable lands fall into classes VI, VII and VIII, whereas the cultivated lands fall into classes I and II. See Map 2. Irrigation is required for successful crop production. Water for irrigation is available and exceptionally high crop yields are obtained.

Class I lands are productive farm lands with very few or no permanent hazards or limitations. These lands are subject to a moderate overflow hazard at the present time. The proposed program will greatly reduce this hazard. Class II lands have a few recognized limitations and under the conservation farming being practiced in this area safe and continuing production is assured. The limitation which places these lands in Class II is the greater slope which creates an erosion hazard. Land leveling and adjustment of length of irrigation runs keep erosion at a minimum. Class II lands are also subject to a moderate overflow hazard which will be greatly reduced by this project works. Good land management, including the use of fertilizers and crop rotations to improve soil structure, is essential to keep the soils of both classes I and II productive.

Class VI lands consist of desert bottom intermingled with rolling desert plain. The soils are medium textured and subject to gullying when the vegetative cover is depleted. The dominant climax vegetation is sacaton and big galleta. Class VI lands have moderate rates of runoff.

Class VII lands consist of medium textured soils of varying depth with plane to slightly rolling topography. The climax vegetation is mixed desert grass and shrub. Class VII lands have high rates of runoff

The upper portion of the watershed is mapped as desert mountains and includes capability classes VII and VIII. These lands consist of bare rock or rough, stony, mostly shallow soils. Vegetation consists of desert shrubs such as encelia, bursage, cactus cholla, lycium, mariola and grasses such as bush muhly, tobosa, Arizona Cotton grass and black grama. Runoff rates are very high. Infiltration rates for

classes VI, VII and VIII vary from .10 inches per hour on the less permeable shallow soils to .60 inches per hour for the desert bottoms. Sediment production rates are relatively low in this area.

The elevation of the watershed varies from about 950 feet above sea level at its confluence with the Gila River to 3,500 feet at the crest of the White Tank Mountains. Mean temperatures range from 50 degrees Fahrenheit in winter to 91 degrees in summer, with recorded extreme temperatures ranging from a low of 17 degrees to a high of 117 degrees. The average date of the last killing frost is March 3 and that of the first killing frost is November 22, or a normal frost free period of 264 days. The mean annual precipitation is 8.04 inches, which generally occurs in two well defined rainy seasons. The winter rainy season usually extends through December, January and February, while the summer season includes July and August and early September. During the summer flood season the damage potential is very high due to the fact that crops, especially cotton which is the staple crop in the area, are very susceptible to damage. In contrast, during the winter flood season the value of crops is much lower. Most of the cotton has been harvested at this time and the growing crops consist of alfalfa, small grain and a small acreage of winter vegetables. Offsetting the lower crop values during the winter rainy season, to some extent, is the higher damage that land sustains due to the fact that it is not so well protected. Other direct flood damages are not usually affected by the season in which the flood occurs.

The range land in the upper, mountainous part of this watershed has sparse vegetation of the desert grassland type. Forage production is low and generally grazing occurs only after periods of unusually high precipitation. Because of the low precipitation, difficulty of

access, and scarce watering facilities, grazing use has not significar ly affected the vegetative cover in the upper portion of this watershed.

The cultivated land is highly productive under irrigation and is intensively farmed with cotton being the principal cash crop. Alfalfa barley and various varieties of sorghums are the principal feed crops. Some winter vegetables are grown on the less calcareous soils. Double cropping is practiced to some extent, but not to the degree found in the Salt River Valley to the east. Farm units vary from small family-size farms of forty to eighty acres to large commercial farms covering several thousand acres. The value of crop production in the watershed is estimated at seven million dollars annually.

The White Tank Watershed includes parts of three soil conservation districts, the Agua Fria, Roosevelt and Buckeye. Because of the nature of the enabling legislation prior to an amendment adopted by the legislature in 1954 soil conservation districts in Arizona are limited to areas used primarily for crop production. The non-arable flood producing portion of the watershed is, therefore, not included within the boundaries of any district. The Agua Fria Soil Conservation district sponsored this project as major structures and principal damage areas are in this district.

Approximately 53 percent of the land in the watershed is privately owned. Ownership of the remainder is about equally divided between the State of Arizona and the Federal Government. The Federal land is all included in Arizona Grazing District Number 3 and is administered by the Bureau of Land Management. Most of the high runoff producing portion of the watershed is publicly owned, whereas the flood plain is

privately owned. See map 3.

The watershed is adequately served by a network of county roads aggregating 62 miles. U. S. Highway No. 80 crosses the lower portion of the flood plain for a distance of four miles. Drainage ways are poorly defined or non-existent in the flood plain, so destruction of bridges does not constitute an important part of highway damage. The Southern Pacific railroad crosses the lower portion of the flood plain, generally paralleling U. S. Highway No. 80. In addition, the Santa Fe Railway has a branch line from Ennis extending about 2½ miles into the flood plain from the north. Portions of the supply canals of the Beardsley, Roosevelt, Goodyear and Buckeye Irrigation Districts lie within the flood plain. All are subject to damage by floods. Many miles of farm laterals serve the farm land in the watershed.

There are no incorporated towns within the watershed. Phoenix, within 20 miles of the watershed, is the trade center for this part of Arizona. The small unincorporated villages of Liberty and Perryville are in the lower end of the watershed. Cotton gins are located at various places throughout the farming area. The Caterpillar Tractor Company has a proving ground for testing various types of earth moving equipment near the central part of the watershed.

FLOOD AND EROSION PROBLEMS AND DAMAGES

Storm runoff from the White Tank Mountains and intervening foothill areas strike the Beardsley Canal at the western edge of the flood plain. Siphons have been installed along this canal at natural drainageways so that floodwater may pass over without damage. However, past experience has shown that these siphons are inadequate both as to capacity or number

to handle anything but small flows. Occasionally even small flows damage the canal because aggradation causes shifts in the channels above the canal and floodwater may strike a section of the canal where there is no siphon. After the water passes over the Beardsley Canal it tends to spread out because of the flat terrain and absence of defined channels. This sheet flow is, however, modified by roads and irrigation ditches which tend to concentrate the water until sufficient volume is attained to cause it to break over into adjoining fields. Improved roads have eroded in some cases to depths of 3 to 4 feet. Ponding usually occurs in the lower ends of flooded fields until water over-tops and breaches the irrigation lateral that has caused the ponding. Other obstructions such as railroad grades or flood dikes may shift the area of overflow but seldom reduce it. Attempts to control floodwater, once it has crossed the Beardsley Canal, have not been successful. Farm property incurs the greatest damage of any type of property within the flood plain. Crop yields are reduced by scouring of soil from the plant roots, ponding and scalding due to high temperatures. Irrigation furrows and field laterals may be so badly damaged late in the irrigation season that it is not possible to make the final irrigation needed to develop a profitable yield. In many cases where land damage is severe the land cannot be cultivated until it has been releveled. Growing alfalfa usually is not seriously damaged, but hay that has been cut is a complete loss. Land damage is greatest where water concentrates and flows with considerable velocity as it does below breaks in irrigation laterals, road fills, or other obstructions and where there is no protective cover from growing crops or crop stubble.

Farm irrigation systems are damaged by even relatively small floods. Earthen ditches generally require rebuilding after a flood, and the case of ditches formed above the ground surface considerable dirt has to be hauled in to build a new ditch. Concrete lined ditches generally withstand small floods, but scouring of the soil away from the lining causes structural failures that are expensive to repair. Occasionally pump motors are fouled by sediment and have to be repaired before they can be used. In a few cases, irrigation wells have caved in and have been abandoned. Farm improvements are frequently damaged, though not seriously because water does not attain great depths. Farm machinery is damaged if the water reached sufficient depth to deposit mud on moving parts. Stored crops and supplies sustain damages. The lower tiers of stacked baled hay that are flooded usually rot and this also requires the rebuilding of the stack.

Flood flows from the upper watershed first strike the Beardsley Canal with sufficient force to breach it in many places. Larger floods also damage other canals. Siphons and unloaders to spill floodwater that gets into canals have been installed, but these measures have been of only minor benefit. The floods of 1951 breached canals in many places and tore out many sections of canal lining, ruined two irrigation wells and washed out training dikes. In some places the canal embankments have been washed out so many times that it is becoming increasingly difficult to secure earth within reasonable distances to patch them. The Beardsley District has been forced to defer replacing some canal lining until the flood hazard is reduced except where the canal gradient is so steep that lining is necessary to prevent damaging erosion. As a result, water losses from seepage have increased. County roads are

very susceptible to damage by floodwater. This is due primarily to two reasons: first, road beds have eroded below ground level and now serve as channelways, and second, the location of irrigation laterals on the downstream side of east and west roads provide a natural barrier to prevent water from draining off the road. As a result, most roads are sub-standard and until such time as the flood hazard is reduced, permanent road improvements are not practicable.

Railroads in the flood plain experience some damage in each flood. The principal damage is loss of ballast where floodwaters over-top the roadbed. Occasionally, the roadbed is washed out and requires major repair work before trains can again move over the line.

Damage to power and telephone lines is usually limited to undermining a few poles, thereby necessitating resetting or straightening. The cost associated with this type of damage in this area is comparatively small.

The true value of property subject to damage in the flood plain is estimated at $23,900,000, distributed as follows (1951 prices):

Agricultural	$22,110,000.00
Irrigation Works	1,320,000.00
Transportation Facilities . . .	370,000.00
Rural Non-Farm	100,000.00

Flood records of the past 25 years indicate that damaging floods occur once in two years on the average. Analysis of high intensity storms and examination of past flood records show that fully 85 percent of the floods can be expected during the summer months when crops are most susceptible to damage. The most damaging recent flood year was 1951 when floods in January, July and two in August occurred. The flood of August 28, 1951, caused direct damage of more than $200,000.

The total primary direct floodwater damage is estimated to average $28,220 annually, of which 47 percent is crop damage. About 23 percent is irrigation system damage including farm laterals, 15 percent is land damage and the remainder consists of damage to transportation facilities and farm improvements. None of this floodwater damage occurs in the area which will be inundated by proposed detention structures. These figures are based on all floods up to and including those of 100-year frequency. In addition, there are important indirect primary damages such as the reduction in crop yields arising from interruption of irrigation schedules, travel interruptions or detouring costs, losses of income to cotton gins and reduction of income to cotton workers. The estimated annual value of these indirect primary damages is $7,000. See Table 4.

Erosion Damage - Soil erosion, exclusive of flood plain scour, is a factor only on the upper desert portion of the watershed. In this part of the watershed sheet erosion has progressed to the point where the soil surface consists principally of desert pavement. Gully erosion is confined chiefly to the rough mountainous part of the watershed and the alluvial outwash at the base of the mountains. Because of watershed characteristics, it is not considered feasible to apply a program designed primarily to reduce the present rate of erosion. There is little likelihood that the present rate of erosion will change under existing use and management practices. Erosion damage of watershed land has not been evaluated for the reason that erosion has not seriously impaired the productivity of these lands, and it is apparent that a program which would significantly reduce the rate of erosion is not practical.

Sedimentation Damage - Deposition of sediment has caused considerable channel changes above works that have been installed to protect irrigation canals. As a result, each successive flow may strike canals or other property at unprotected places. Sediment deposition on farm land makes more frequent leveling necessary to maintain the precise grade of irrigated land. Both of these types of sediment damage are closely associated with floodwater damage and have been evaluated as floodwater damage. None of the sediment from this watershed reaches irrigation reservoirs.

EXISTING OR PROPOSED WATER MANAGEMENT PROJECTS

Efforts to control high runoff in the White Tank-Trilby Wash watersheds date back at least to 1939. At that time efforts were made by local interested groups to establish a soil erosion demonstration project. In 1945 the Agua Fria Soil Conservation District was organized for the express purpose of unifying flood control efforts. At various times plans to alleviate the flood problem have been prepared, but inability to finance delayed construction. For practical purposes work being done by local interests is continuous. Some structures have been completed recently and others are being built concurrently with work being done by the Federal Government (See combined Table 1 and 2 attached).

Measures Primarily for Flood Prevention - Engineering and hydrologic studies show that the most effective method of controlling surface runoff from the watershed of Avondale Wash above the Beardsley Canal is by the construction of two retarding structures and 11 miles of diversions. The diversions will divert runoff from small subwatersheds into retarding structures numbers 3 and 4, located in the larger drainage channels. Eight small stabilizing and sediment control structures

in the upper watershed will provide sediment storage and desilting basins and thereby lengthen the effective life of the retarding structures. The total cost of these measures is shown in combined Table 1 and 2 attached. The location of these structures is shown on map 2. These measures are located on nonarable land.

For design purposes, the area-depth-duration relationship for storm rainfall was developed from a number of high intensity storms which have occurred in central and southern Arizona. For reservoir design a storm of four-inch center was used. This is estimated to have a recurrence interval of more than 100 years. Retarding structure Number 3 will discharge into the Beardsley Canal. Retarding Structure Number 4 will discharge into existing waterways at a safe rate. Maximum evacuation time for the detention reservoirs will not exceed five days. The spillway design storm selected was one of six-inch rainfall center. The frequency of such a storm is estimated to substantially exceed the 100-year expectancy. Reservoir and spillway designs are based on the occurrence of design storms centered over each watershed so that the maximum runoff would occur at the structure. Because adequate detention storage is developed at each structure paved emergency spillways are unnecessary. Sediment capacity has been provided in the design of the retarding structures for 50 years of sedimentation without encroachment on the effective detention capacity.

Measures for Conservation of Water and Watershed Lands Which Contribute Directly to Flood Prevention - Sixty-four hundred acres of private and state range land are being retired permanently from grazing. The lands retired from grazing include those areas immediately above the retarding structures and any improvement in cover will reduce reservoir sedimentation.

Measures for Evaluating the Effects of the Program - The hydrologic, economic and other effects of this watershed program will be measured in the future. A plan for the installations and procedures required to evaluate these results is now being developed in cooperation with other interested fact-finding agencies. This plan will be distributed later as a supplement to this work plan.

Effect of These Measures on Damages and Benefits - The measures described above will prevent damage from all floods of the size used in the damage evaluation series. Hence, the floodwater damage reduction benefit is equal to the average annual damage under present conditions or $35,220 in Table 4.

Approximately 79 percent of the flood damage reduction benefit is credited to the two retarding structures and 18 percent is credited to the diversions. The remainder is credited to the stabilization and sediment control structures and the range improvement program. The flood prevention benefit is distributed by measures in Table 5.

It is not believed that any significant land use changes will occur from the measures described above. An examination of land use in the flood plain indicates that the presence of a flood hazard is not a primary determinant of land use. This conclusion is confirmed by local people. Hence, no land enhancement benefit is expected to accrue from these measures.

Range forage production on the watershed is extremely limited. Hence, the conservation benefit is insignificant and only $130.00 per year is credited to range improvement in Table 5. As previously mentioned, about one-third of the total watershed above the structures has been retired from grazing use. The remaining area consisting of steep rocky desert mountains is under adequate management by the Bureau of Land

Management. The program is not expected to improve ground or surface water supply significantly and no water conservation benefit is credited to it.

Comparison of Costs and Benefits - The ratio of the average annual benefit from measures primarily for flood prevention ($35,100) to the average annual cost of the measures ($20,730) is 1.7 to 1. The ratio of the average annual benefit ($250) from the range improvement measure to the average annual cost ($130) is about 1.9 to 1. The ratio of total average annual benefits ($35,350) to total average annual value of costs ($20,860) is 1.7 to 1. See Table 5.

ACCOMPLISHING THE PLAN

The sponsoring agency, the Agua Fria Soil Conservation District, and the Soil Conservation Service have mutually agreed to the sharing of costs set forth in combined Table 1 and 2. Specifically, the Soil Conservation District (or the Beardsley Irrigation District or others in behalf of the Agua Fria Soil Conservation District) will:

1. Acquire all lands, easements and rights of way needed for the floodwater retarding structures. This has been done.
2. Purchase and install all outlet pipes in the retarding structures together with gates and appurtenant works. The pipe and gates have been ordered.
3. Clear, strip and excavate the sites for the retarding structures. This has been done.
4. Excavate 300 feet of the spillway on Structure Number 3. Arrangements for accomplishing this are now being negotiated.
5. Arrange to complete the installation of all stabilization and sediment control structures and diversions by December 31, 1954.

6. Provide for periodic inspection of the measures to insure that they are maintained in a satisfactory manner.

7. Bring about the retirement from grazing use of 6,400 acres (about one-third) of watershed above the Structures 3 and 4.

The above items of local contribution are valued at $218,287.

The sponsoring agency has sufficient funds or commitments to meet its obligations within the specified time.

The Soil Conservation Service will:

1. Contract for the earth work for Structures 3 and 4, except for Item 4 above.

2. Design Structures 3 and 4 with appurtenances and will provide engineering supervision and inspection during construction.

3. Transfer to the Agua Fria District the sum of $14,000 to help defray costs of the Districts' portion of the work.

The above items of Federal contribution, plus Program evaluation and development of the work plan are valued at $199,088.

PROVISIONS FOR MAINTENANCE

Executed agreements provide for adequate future maintenance by assuring that periodic inspections, at least annually, will be made by a responsible local agency with representatives of the Soil Conservation Service, annual levies will be made for maintenance purposes and repairs will be made promptly when needed.

COMBINED TABLE 1 & TABLE 2 *

ESTIMATED INSTALLATION COST ** - TOTAL NEEDED PROGRAM

MEASURES	UNIT	NO. TO BE APPLIED	ESTIMATED TOTAL COSTS		
			Federal	Private ***	Total
A-Measures Primarily for Flood Protection					
Floodwater Retarding Structures	No.	2	192,088	119,664	311,752
Stabilization and Sediment Control Measures					
Diversion Dykes & Ditches	Mile	11		77,805	77,805
Debris & Desilting Basins	No.	8		18,068	18,068
SUB TOTAL			192,088	215,537	407,625
B-Measures					
Range Improvement	Ac.	6400		2,750	2,750
TOTAL A & B MEASURES			192,088	218,287	410,375
Facilitating Measures					
SCS					
Program Evaluation			2,000		2,000
Work Plan Development			5,000		5,000
TOTAL SOIL CONSERVATION SERVICE			7,000		7,000
GRAND TOTAL			199,088	218,287	417,375

* For practical purposes, the work being done by local interests is a continuous job. Some items have been completed recently and others are now being constructed concurrently with the work being done by the Federal Government. For convenience, all parts of the program are shown in combined Table 1 and 2.

** All items to be installed during calendar year 1954.

*** It is impractical to distinguish between contributions from Maricopa County and the Beardsley project, which are local units of government, and from strictly private sources. Hence, no separate column has been shown for Non-Federal Gov't costs and these items are included in Private costs.

TABLE 3

ANNUAL COSTS

MEASURES	AMORTIZATION OF INSTALLATION COSTS			OPERATION AND MAINTENANCE			OTHER ECONOMIC COSTS	GRAND TOTAL
	FEDERAL	PRIVATE	TOTAL	FEDERAL	PRIVATE	TOTAL		
A MEASURES	(1)	(2)						
Floodwater Retarding Structures	$6,950	$5,570	$12,520	--	$2,950	$2,950	--	$15,470
Stabilization and Sediment Control Measures								
Debris & Desilting Basins	--	840	840	--	150	150	--	990
Diversion Dikes & Ditches	--	3,620	3,620	--	650	650	--	4,270
SUB TOTAL	$6,950	$10,030	$16,980	--	$3,750	$3,750	--	$20,730
B MEASURES								
Range Improvement	--	$ 130	$ 130	--	--	--	--	$ 130
TOTAL A & B	$6,950	$10,160	$17,110	--	$3,750	$3,750	--	$20,860

(1) Amortization factor .035258 (50 yrs. @ 2½% interest).
(2) Amortization factor .04655 (50 yrs. @ 4% interest).

TABLE 4

SUMMARY OF AVERAGE ANNUAL MONETARY FLOODWATER AND SEDIMENT DAMAGE AND FLOOD PREVENTION BENEFIT FROM THE PLAN
(LONG TERM PRICES)

MAGES	AVERAGE ANNUAL DAMAGE			AVERAGE ANNUAL BENEFIT		
	PRESENT CONDITION	B-MEASURES ONLY	A and B MEASURES	B-MEASURES ONLY	A-MEASURES ONLY	TOTAL FLOOD BENEFIT FROM A & B MEASURES
	DOLLARS	DOLLARS	DOLLARS	DOLLARS	DOLLARS	DOLLARS
OODWATER & SEDIMENT DAMAGE						
CROP	$13,260	$13,140	0	$ 120	$13,140	$13,260
LAND	4,380	4,380	0	0	4,380	4,380
IMPROVEMENTS	1,310	1,310	0	0	1,310	1,310
TRANSPORTATION FACILITIES	2,790	2,790	0	0	2,790	2,790
DITCH SYSTEMS	6,480	6,480	0	0	6,480	6,480
POWER & PHONE ETC.	--	--	--	--	--	--
INDIRECT DAMAGE	7,000	7,000	0	0	7,000	7,000
TOTAL DAMAGE	$35,220	$35,100	0	XXX	XXXXX	XXXXX
BENEFIT FROM REDUCTION OF DAMAGE	XXXXX	XXXXX	XXXXX	$ 120	$35,100	$35,220
BENEFIT FROM MORE INTENSIVE USE OF FLOOD PLAIN	XXXXX	XXXXX	XXXXX	0	0	0
TOTAL FLOOD PREVENTION BENEFIT	XX	XXXXX	XXXXX	$ 120	$35,100	$35,220

TABLE 6

FLOODWATER RETARDING STRUCTURE DATA

SITE NO.	DRAINAGE AREA SQ. MI.	STORAGE CAPACITY			SURFACE AREA						FLOOD PLAIN AREA INUNDATED			VOL. OF FILL	DRAW DOWN RATE	TYPE OF SPILL-WAY	EST. TOTAL COST
		SEDIMENT POOL	DETENTION POOL	TOTAL	SEDIMENT POOL	DETENTION POOL	TOTAL	TOP OF SED. POOL	TOP OF DET. POOL	MAXIMUM HT. OF DAM	UNDER SED. POOL	UNDER DET. POOL	TOTAL				
		AC.FT.	AC.FT.	AC.FT.	INCHES OF RUNOFF			ACRES		FEET	ACRES			C.Y.	CFS		
3*	24.1	193	2,462	2,655	.14	1.92	2.06	30	384	30	---	---	---	375,000	375	Earth	$229,500
4*	10.3	72	964	1,036	.13	1.76	1.89	14	221	20	---	---	---	175,000	100	Earth	$124,159

Sediment Storage based on 50 Year estimated accumulation (including structures on Drainage Area).

*Note discussion of numerical designations in narrative portion of report.

TABLE 7

SUMMARY OF PROGRAM DATA

ITEM	UNIT	QUANTITY
YEARS TO COMPLETE PROGRAM	YEAR	1
TOTAL INSTALLATION COST		
FEDERAL	DOLLARS	199,088
NON-FEDERAL	DOLLARS	218,287
ANNUAL O & M COST		
FEDERAL	DOLLARS	---
NON-FEDERAL	DOLLARS	3,750
ANNUAL BENEFITS	DOLLARS	35,350
FLOODWATER RETARDING STRUCTURES	EACH	2
AREA INUNDATED BY STRUCTURES		
FLOODPLAIN	ACRES	0
UPLAND	ACRES	605
WATERSHED AREA ABOVE STRUCTURES	ACRES	22,000
REDUCTION IN FLOODWATER AND SEDIMENT DAMAGE		
A MEASURES	PERCENT	99.7
B MEASURES	PERCENT	0.3
REDUCTION OF EROSION DAMAGE		
A MEASURES	PERCENT	---
B MEASURES	PERCENT	---
OTHER BENEFITS		
A MEASURES	DOLLARS	---
B MEASURES	DOLLARS	130

TABLE 8

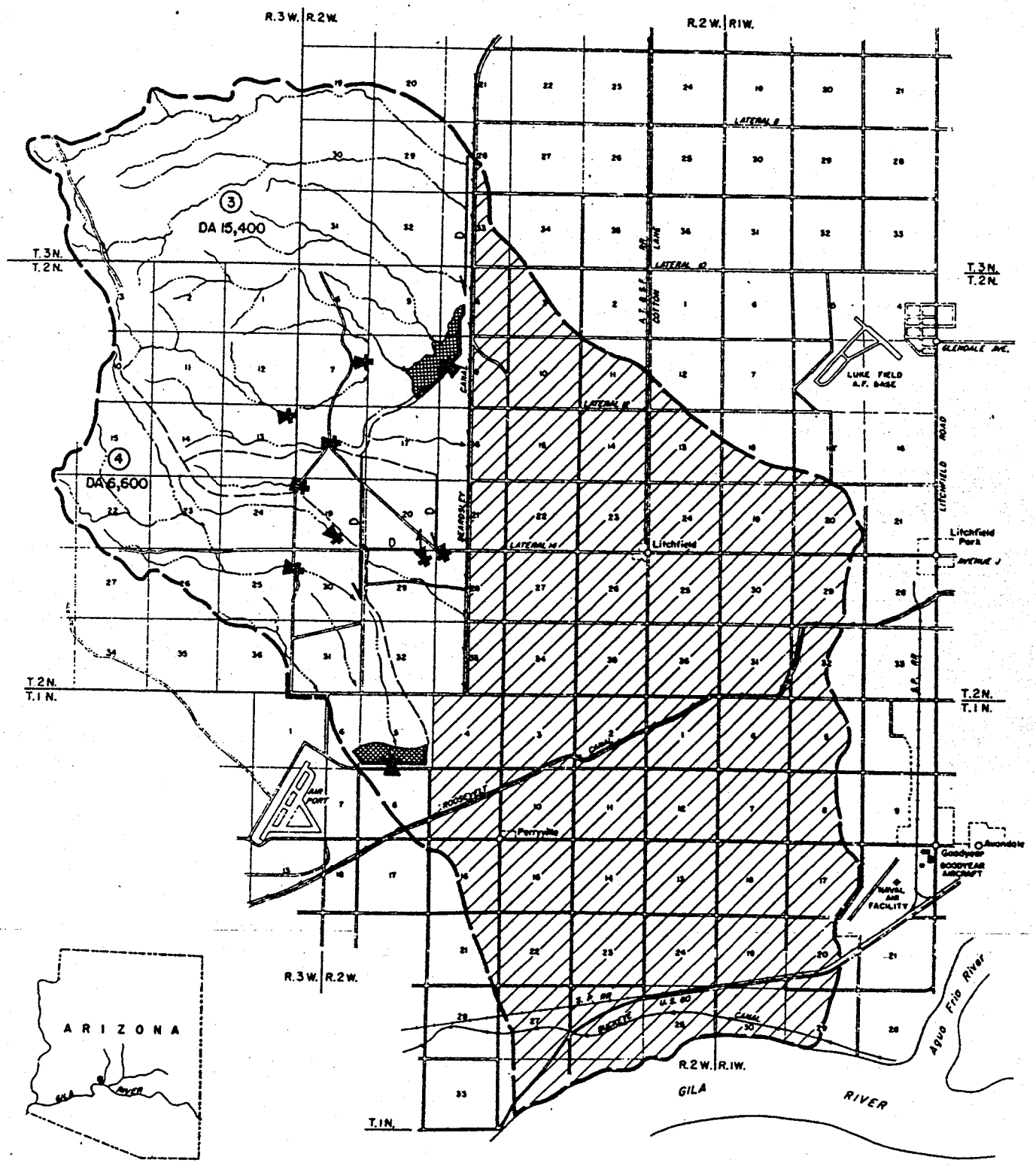
SUMMARY OF PHYSICAL DATA

ITEM	UNIT	QUANTITY WITHOUT PROGRAM	QUANTITY WITH PROGRAM
WATERSHED AREA	SQ. MI.	92.4	92.4
WATERSHED AREA	ACRES	59,136	59,136
AREA OF CROPLAND	ACRES	34,112	34,112
AREA OF GRASSLAND	ACRES	25,024	25,024
AREA OF WOODLAND	ACRES	---	---
FLOODPLAIN SUBJECT TO DAMAGE BY DESIGNATED STORM	ACRES	4,800	0
ANNUAL RATE OF EROSION (FLOOD PRODUCING PORTION)			
SHEET	TONS/YR)	33,900	31,900
GULLY	TONS/YR)		
STREAMBANK	TONS/YR)		
SCOUR	TONS/YR)		
AREA DAMAGED ANNUALLY BY:			
SEDIMENT	ACRES)	660	0
FLOODPLAIN SCOUR	ACRES)		
SWAMPING	ACRES	---	---
STREAMBANK EROSION	ACRES	---	---
SHEET EROSION	ACRES	Not determined	
SEDIMENT PRODUCTION (FLOOD PRODUCING PORTION)	TONS/AC/YR	.77	1/
SEDIMENT ACCUMULATION IN RESERVOIRS	AC/FT/YR	---	---
FREQUENCY OF FLOODING	EVENTS/YR	.5	0
AVERAGE ANNUAL RAINFALL	INCHES	8	8
AVERAGE ANNUAL RUNOFF	INCHES	.3	.3

1/ Amount depends on trap efficiency of retarding structures. No basis for accurate estimate at this time.

Encls. File

WORK PLAN
WHITE TANKS WATERSHED
ARIZONA



PREPARED BY
SOIL CONSERVATION SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE
APRIL, 1954

M-514

AGUA FRIA SOIL CONSERVATION DISTRICT

P. O. BOX 578, WE 5-9251
PEORIA • ARIZONA

June 3, 1954

Mr. Lucien Hill,
Area Soil Conservationist,
Soil Conservation Service,
United States Department of Agriculture,
39 N. 6th Ave.
Phoenix, Arizona.

Dear Mr. Hill;

The Supervisors of the Agua Fria Soil Conservation District have reviewed the Work Plan for the White Tanks Watershed as prepared by the Soil Conservation Service.

We whole heartedly subscribe to the plan and will do our part in effecting its completion and successful operation.

Very truly yours,

H. S. Raymond, Secretary

MARICOPA COUNTY MUNICIPAL WATER CONSERVATION
DISTRICT NUMBER ONE

P. O. BOX 807
PEORIA, ARIZONA

June 3, 1954

Mr. Lucien Hill,
Area Soil Conservationist,
Soil Conservation Service,
United States Department of Agriculture,
39 N. 6th Ave.
Phoenix, Arizona.

Dear Mr. Hill;

We have reviewed the Work Plan for the White Tanks Watershed as prepared and presented by the Soil Conservation Service. We are in agreement with the plan and pledge our continued participation in the construction, maintenance, and operation of the project.

Very truly yours,

H. S. Raymond, District Engineer.

APPENDIX 3

TABLE 1

CONDENSED COST SUMMARY

TABLE 1

Condensed Summary

WHITE TANK AND TRILBY WASH PROJECTS
ARIZONA

	Structure No.3	Structure No.4	McMicken Dam
Cooperating Federal Agency	1954, SCS	1954, SCS	1956, C of E
Length	1.5 Mi.	1.3 Mi.	9.3 Mi.
Drainage Area	24 sq. mi.	10 sq. mi.	223 sq. mi.
Max. Fill height	30 ft.	20 ft.	38 ft.
Spillway Size	800 ft.	2 @ 165 ft.	2,000 ft.
Spillway Capacity	11,750 cfs.	4400 cfs.	60,000 cfs.
Reservoir Capacity in A.F.	2655 AF	1036 AF	19,000 AF
Reservoir Capacity in inches of runoff	2.1	1.9	1.6
Crest Width	10'	10'	12'
Side slope	2½:1 & 2:1	2:1 & 2:1	2½:1 & 2:1
No. of outlets	3 pipes	2 pipes	1 box
Size of outlets	48",48" & 24"	30" & 36"	11' x 20'
Max. Discharge through outlets	- - - -	- - - -	4400 cfs.
Evacuation time	80 hrs.	118 hrs.	- - - -
Sediment Production: Ac.Ft.Per sq.mi.per yr.est.	.3	.3	.25
Total cost of Project		$395,145.00	$2,180,000.00
Private Contributions		196,057.00	180,000.00
Public Contributions		199,088.00	2,000,000.00
Annual O & M cost(Non-Federal)		3,750.00	17,000.00
Estimated annual cost of project (50 yr. amortization)		20,860.00	115,000.00
Estimated annual benefits (50 yr. amortization)		35,220.00	200,000.00

Benefit - cost ratio 1.7 to 1

APPENDIX 4

O&M DOCUMENTS

FLOOD CONTROL DISTRICT of Maricopa County

3325 West Durango Street • Phoenix, Arizona 85009 • Telephone (602) 262-3630/262-3639

November 4, 1975

United States Department of Agriculture
Soil Conservation Service
3556 West Buckeye Road
Phoenix, Arizona 85009

ATTENTION: Mr. Terence E. Taylor

Dear Mr. Taylor:

We acknowledge receipt of your letter dated September 30, 1975, regarding Operations and Maintenance agreements between Soil Conservation Service and the Flood Control District of Maricopa County.

It is assumed the structures on the White Tanks Watershed you are concerned with are the White Tanks retarding structures #3 and #4.

A review of Operation and Maintenance agreement records in this office indicate that he last agreement entered into relative to these structures was one for Operations and Maintenance, dated November 28, 1966, between the Flood Control District of Maricopa County and the Maricopa County Municipal Water Conservation District No. 1. This agreement provided for the Maricopa County Municipal Water Conservation District No. 1 to do maintenance work on the structures and to be reimbursed for this work by the Flood Control District. This agreement was terminated by mutual consent of both parties on June 30, 1975. Thus, the Flood Control District of Maricopa County is now responsible for the Operation and Maintenance of the above structures.

The agreement referred to above is the only agreement of record involving the Flood Control District of Maricopa County and there appears to be no provision in the agreement for Operation and Maintenance reports to the Soil Conservation Service. There appears to be no record of a formal Operations and Maintenance agreement or official legal transfer of responsibility of these structures from the Soil Conservation Service to the Flood Control District.

In view of the fact that District and Soil Conservation Service personnel are meeting this week to discuss Operations and Maintenance procedures, any further discussion of this matter could be continued at this time.

Sincerely,

Herbert P. Donald, P.E.
Chief Engineer and General Manager

PD/WAA/ly

6029 Federal Building, Phoenix, Arizona 85025

Jan. 4, 1972

Colonel John C. Lowry
Chief Engineer and General Manager
Flood Control District of Maricopa County
3325 West Durango
Phoenix, Arizona 85009

Dear Colonel Lowry:

Attached for your file are the following operation and maintenance agreements for the White Tanks Pilot Watershed Project:

1. Agreement - Between Agua Fria Soil Conservation District and the Soil Conservation Service - dated November 30, 1953. (See Item 2, page 1 and the first paragraph of page 3 covering O & M).

2. Agreement - Amendment No. 2 dated October 15, 1957 - change in spillway design and costs.

3. Letter - from Robert V. Boyle to K. B. McMicken dated January 28, 1955 advising Service acceptance and outlining O & M responsibilities.

4. Letter - H. S. Raymond to Robert Boyle dated August 31, 1959 confirming O & M responsibilities of Agua Fria SCD.

5. Cooperative agreement - Agua Fria SCD and Maricopa County Water Conservation Dist. No. 1 (Beardsly Project) dated December 3, 1953 giving O & M responsibilities to Beardsly Project.

6. Agreement - Flood Control District of Maricopa County and Maricopa County Municipal Water District No. 1 dated Nov. 28, 1966. Outlines O & M responsibilities of FCDMC for White Tanks structures and provides for the irrigation district to perform this work for a certain fee (See Item 2, page 2).

Sincerely,

Cliffton A. Maguire
Asst. State Conservationist (Acting)

Attachments/6

CAMaguire:as

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE Room 6029 Federal Bldg., Phoenix, AZ 85025

JECT: MGT - Program Inspection
October 4-7, 1971

DATE: December 16, 1971

TO:
Chris Williams, DC
SCS, Phoenix

Attached for your use and file are the following operation and maintenance agreements for the White Tanks Pilot Watershed Project:

1. Agreement - Between Agua Fria Soil Conservation District and the Soil Conservation Service - dated November 30, 1953. (See Item 2, page 1 and the first paragraph of page 3 covering O & M).

2. Agreement - Amendment No. 2 dated October 15, 1957 - change in spillway design and costs.

3. Letter - from Robert V. Boyle to K. B. McMicken dated January 28, 1955 advising Service acceptance and outlining O & M responsibilities.

4. Letter - H. S. Raymond to Robert Boyle dated August 31, 1959 confirming O & M responsibilities of Agua Fria SCD.

5. Cooperative agreement - Agua Fria SCD and Maricopa County Water Conservation Dist. No. 1 (Beardsly Project) dated December 3, 1953 giving O & M responsibilities to Beardsly Project.

6. Agreement - Flood Control District of Maricopa County and Maricopa County Municipal Water District No. 1 dated November 28, 1966. Outlines O & M responsibilities of FCDMC for White Tanks structures and provides for the irrigation district to perform this work for a certain fee (See Item 2, page 2).

This transmittal completes agreed-to item 18 of the program inspection report.

Ralph M. Cunningham Acting
J. J. Turner
State Conservation Engineer

cc: D. Swenson w/o attachment
G. Welsh w/ attachment

Gerry - We are attaching a copy for your transmittal to the FCDMC to assure they have these documents in their office.

Tussmans File

AGUA FRIA SOIL CONSERVATION DISTRICT

P. O. BOX 578. WE 5-9251
PEORIA • ARIZONA

August 31, 1959

Mr. Robert V. Boyle, State Conservationist
Soil Conservation Service
106 East Roosevelt
Phoenix, Arizona

Dear Bob,

By action taken by the Board of Supervisors on August 24, 1959, the Agua Fria Soil Conservation District assumed, as a matter of record, full responsibility for the operation and maintenance of the White Tanks Project. The District has, however, actually operated and maintained the project since its completion in 1954.

Sincerely yours,

H. S. Raymond, Secretary
AGUA FRIA SOIL CONSERVATION DISTRICT

HSR/po

A G R E E M E N T

THIS AGREEMENT, made and entered into this 30th day of November, 1953, by and between Agua Fria Soil Conservation District, State of Arizona, hereinafter called the DISTRICT and the Soil Conservation Service, Region 6, of the Department of Agriculture, hereinafter called the SERVICE.

OBJECT - The object of this agreement is to coordinate the activities and efficient use of the resources of the two parties in carrying out and maintaining watershed protection needed on watershed lands, and the installation of such measures in the District as are needed and practicable for the reduction of flood water and sediment damages, such as waterflow-retarding dams, channel improvements, streambank stabilization, major gully control, and related measures.

Specifically this agreement covers the construction of White Tanks Project retarding structures No. 3 and No. 4 as planned by the Soil Conservation Service, along with any appurtenances that may be required. All located about 8 miles west of Goodyear, Arizona, immediately above the main canal of the Maricopa Municipal Water Conservation District No. 1 (Beardsley).

AUTHORITY - Public Law 156, 83rd. Congress, 1st. Session, approved July 28, 1953.

W I T N E S S E T H

A. The District, for and in consideration of the benefits to be derived in the carrying out of this agreement and to accomplish the object herein set forth, does hereby represent, promise and agree as follows:

(1) The District represents that past non-federal contributions, including engineering, securing rights-of-way and easements, and other costs associated with retarding structures No. 3 and No. 4, have a value of $145,046.00 (See attached itemization of expenditures).

(2) To arrange for such easements for rights-of-way as may be required by the parties to facilitate, perform and maintain the watershed protection measures set forth herein, record in the county where the land is situated and furnish evidence to the Service that the foregoing has been accomplished.

(3) To contribute future measures as listed below:

(a) Approximately 50% of required engineering services.

(b) Necessary labor and equipment for clearing and stripping site for structure No. 4

(c) Water required for performance of the work.

(d) Necessary labor, materials and equipment for constructing two-diversion dykes.

(e) Necessary labor, materials and equipment for excavating and sealing a channel.

(f) Furnish and install 511 linear feet of corrugated metal pipe and gates for structures No. 3 & 4 together with appurtenances.

(g) Necessary labor and equipment for completion of spillway excavation. Structure #3.

(h) Completion and/or modification of existing dykes on caterpillar proving ground to insure their functioning as planned with relation to completed project.

It is estimated that cost of the above contributions will amount to $80,412.00 (See attached itemization of estimated costs).

(4) The contributions listed under 3 above shall be timed and performed so as to coordinate with the construction program of the Service's contribution, in order that a minimum of friction and delay will be caused.

B. The Service, in consideration of the representations, promises, and agreements made on the part of the District herein set forth, agrees as follows:

(1) To furnish approximately 50% of required engineering services for surveys, designs and specifications for the construction of two earth filled dams. Structures No. 3 and No. 4.

(2) To circulate invitations for bids and award a contract to the lowest qualified bidder for furnishing necessary materials, equipment and labor, and performing the proposed construction work, except as otherwise provided herein.

(3) To supervise, inspect and make final acceptance of the completed work.

It is estimated that the contribution to be made on the part of the Service as described above will amount to approximately $219,074.00.

IT IS FURTHER UNDERSTOOD AND AGREED

That contributions of the District toward completion of the watershed protection project, both past and future shall equal or exceed Federal Watershed protection funds expended on the project. On the basis of the estimates included in this agreement, the value of the District's contributions, past and future, amounts to $225,458.00. The estimated cost of project work to be financed with Federal watershed protection funds is $219,074.00.

That the District will assume responsibility for operation and proper maintenance of the completed work.

That the responsibility of the Service under this agreement shall terminate upon completion and acceptance of the work as provided under Paragraph B(1)(2)(3), and all interests in ownership and operation shall at that time be relinquished.

That the Service will, upon request from the District, furnish technical assistance to the extent available to aid in inspection and to advise local interests with respect to maintenance needed.

That the District will hold and save the United States Government free from all claims for damages that may arise from construction or operation of the work installed under this agreement.

That determinations will be made jointly by the District and the Service that proposed structures are in conformity with State laws, before construction is started.

No Member of or Delegate to Congress or Resident Commissioner shall be admitted to any share or part of this agreement or to any benefit that may arise therefrom unless it be made with a corporation for its general benefit.

IN WITNESS WHEREOF, the parties hereto have hereunder subscribed their names as of the date first above written.

U. S. DEPARTMENT OF AGRICULTURE
Soil Conservation Service

By Cyril Luker

Title Regional Director
January 11, 1954

AGUA FRIA SOIL CONSERVATION DISTRICT

By /s/ K. B. McMicken

Title Chairman, Agua Fria Soil Conservat District

The signing of this agreement on behalf of the Agua Fria Soil Conservation District Governing Body adopted at a meeting held on 30th day of November, 1953.

/s/ H. S. Raymond
Secretary, District Governing Board

COOPERATIVE AGREEMENT
AGUA FRIA SOIL CONSERVATION DISTRICT

STATE OF ARIZONA

THIS AGREEMENT is entered into by the AGUA FRIA Soil Conservation District, hereafter referred to as the "District" and MARICOPA COUNTY MUNICIPAL WATER CONSERVATION DISTRICT NUMBER ONE, locally known and hereafter referred to as the Beardsley Project
(Name of company, enterprise, municipality or other legally organized group)

THIS AGREEMENT is for the purpose of setting forth an understanding of how the two parties will install certain prescribed watershed structures or measures within the boundaries of the District.

THE DISTRICT AGREES TO:

1. Furnish technical assistance and supervision for surveys, designs, and construction as required to the extent that these services are available to the District at the time they are scheduled to be furnished.
2. Arrange for funds to be provided by the Soil Conservation Service to install the structures and measures in addition to that supplied by the Beardsley Project and others.
3. Will allow credit to the Beardsley Project for contributions supplied by them, such as easements, labor, materials or installations as agreed upon and set forth in the attached plan.
4. Provide assistance to make inspections by qualified people of all structures and measures installed under this agreement to determine maintenance needs and a schedule for the conduct of maintenance.

THE BEARDSLEY PROJECT AGREES TO:

1. Obtain easements and right of ways for the construction, operation, and maintenance structures and measures installed under this agreement and to pay its proportionate share of the costs of such easements and right of ways as provided for in the attached plans.

2. To provide labor, materials or installations as provided for in the attached plan.

3. Operate and maintain the structures and measures as provided in the attached plan.

4. Hold and save the District free from all claims that may arise from the costs of construction and operation of the work.

IT IS MUTUALLY AGREED THAT:

1. Each party to this Agreement will encourage the adoption and maintenance of conservation measures on the watershed above the works installed under this Agreement.

2. This Agreement will take effect on the date of the last signature to it and will remain in effect for the period of the normal life of the structures or measures installed under this Agreement.

APPROVED:

MARICOPA COUNTY MUNICIPAL WATER CONSERVATION DISTRICT NUMBER ONE

By Scott L. Libby (Name) President (Title) 12-2-53 (Date)

By [signature] (Name) [illegible] (Title) 12-2-53 (Date)

AGUA FRIA SOIL CONSERVATION DISTRICT

By [signature] (Supervisor) CHAIRMAN (Title) 12/3/53 (Date)

By [signature] (Supervisor) SECRETARY (Title) 12/3/53 (Date)

(Seal)

UNITED STATES DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

~~Washington, D. C. 20250~~ Arizona State Office, Phoenix, Arizona

SUBJECT: WATERSHEDS - White Tanks Project - Report on Flood of September 5, 1970

DATE: November 12, 1970

TO: M. E. Strong, State Conservationist
SCS, Phoenix, Arizona

1. In the summer of 1954 two flood control structures, identified as White Tanks No. 3 and No. 4, were built by the Soil Conservation Service in cooperation with the County of Maricopa, the Municipal Water Conservation District No. 1, and the Agua Fria-New River Soil Conservation District.

2. The project was known as the White Tanks Erosion Control Project and SCS participation was under the Pilot Watershed Program.

3. It is reported that 4.5" of precipitation were recorded in a gauge near the intersection of Jackrabbit Road (195th Avenue) and West Indian School Road. (See attached map.) This is believed to have been near the center of maximum rainfall with somewhat lesser intensity near the summit of the White Tanks Mountains about five miles to the west.

4. The rain is reported to have started about midafternoon on Saturday, September 5, 1970. The maximum intensity is believed to have occurred between 6:00 and 8:00 p.m. It was reported that water started flowing across Jackrabbit Road in the vicinity of Thomas Road about 7:00 p.m. and ceased to flow across the road about 9:00 p.m.

5. The elevation of the high point of the watershed is 3671'. The spillways of Structure No. 4 are at elevation 1050' with the top of the structure at 1056'. The elevation of the rain gauge is approximately 1165'.

6. Structure No. 4 was designed to impound 1036 acre-feet from a drainage area of 10.3 square miles.

7. Since 1954 developments north of Indian School Road and west of Tuthill Road have caused four square miles of watershed originally designed to flow into Structure No. 3, and an additional 1.8 square miles of watershed to flow into Structure No. 4 along Tuthill Road. Additional land developments between Jackrabbit Road and Tuthill Road plus improvement of Jackrabbit Road divert still another 2.7 square miles of watershed into the north end of Structure No. 4 along Jackrabbit Road.

8. Thus at the time of the storm there was a total of 18.8 square miles of watershed contributing to Structure No. 4. This is 8.5 square miles more than the 10.3 square miles for which the structure was designed.

9. It should be noted that chronic deposition of coarse sands in the borrow channel on the west side of Jackrabbit Road limits the flow of water diverted into Structure No. 4. Excess flood waters flowing south along Jackrabbit Road overflowed the pavement in the vicinity of Thomas and McDowell Roads causing damage to an unknown number of homes in the subdivisions east of Jackrabbit Road.

10. High water marks indicate that the Structure No. 4 filled and the 165' wide Tuthill Road (west) emergency earth spillway flowed for a short period at a depth averaging about 0.8'. There was no erosion in the channel except for a small 1' deep headcut at the extreme south end where it emptied into a flood channel along the north side of an auxiliary Air Force landing field that appeared to have been carrying 10 to 20 times the spillway flow.

11. Flow through the Jackrabbit Road (north) emergency earth spillway, also 165' wide, averaged about 1.6' in depth. Surveys after the flood indicate that the crest of this spillway is now about 0.4' below the elevation at the time of completion. It is believed that most of the lowering of the earth spillway crest resulted from wind erosion and from use of the cleared spillway crest area as a driveway for vehicles and as a practice ground for horsemen and motorcyclists during the 16 years since its construction. The high water marks indicate that the water surface was 0.4' higher at the Jackrabbit Road spillway than at the Tuthill Road (west) spillway. This could have been the result of wave action or a west wind across the one-mile reach of the reservoir. Erosion in this spillway from this storm was negligible. Floodwater through the spillway crossed unimproved desert for one-half mile before co-mingling with larger onslaughts of water flowing from the north and west.

12. The two principal spillways equipped with gates remained closed during the storm. Had they been open they would have had little effect upon the reservoir hydrograph because of the intense short-period of runoff. The reservoir was emptied in a matter of a few days through seepage into the ground.

13. Structure No. 3 with a capacity of 2655 acre-feet and a designed watershed area of 24.1 square miles, received an inflow of approximately 350 acre-feet. The rainfall was less intense on this watershed than on the watershed of Structure No. 4 and as mentioned in paragraph seven above. As mentioned above, four square miles of this watershed has been diverted into the watershed of Structure No. 4. Runoff from this four-square mile area was quite heavy.

It is recommended that consideration be given to correcting the overloading of Structure No. 4 by combinations of the following alternatives:

A. Redesign the roadway fills and channels in Sections 18 and 13 so as to permit the four-square-mile area in parts of Sections 2, 3, 10, 11, 12, 13, and 14 to drain into Structure No. 3 as originally planned. (See map attached.)

B. Construct one or more small retarding structures north of Indian School Road to control runoff from all or parts of Sections 13, 14, 17, 18, 19, and 20. (Structure No. 4 was not designed to receive runoff from this area but since 1954 the runoff has been directed into Structure No. 4.)

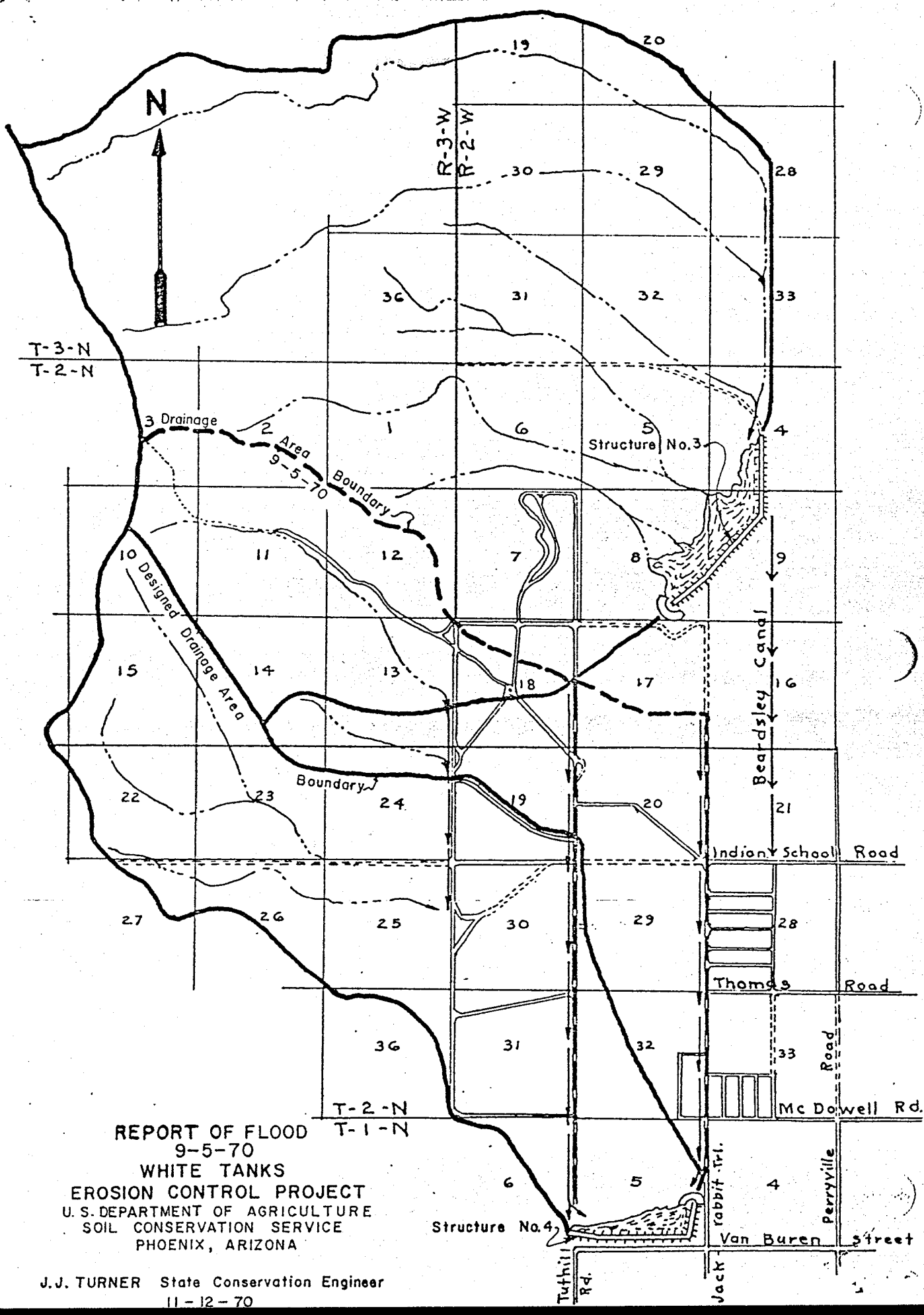
C. Enlarge Structure No. 4 to enable it to safely accommodate runoff from Section 29 and that part of Section 32 that was not originally designed to contribute to Structure No. 4.

D. If it is not practical to materially increase the capacity of Structure No. 4 additional structures should be built upstream, possibly in Sections 23 and 25.

J. J. Turner
State Conservation Engineer

Attachment

cc to:
E. J. Core, Head, E&WP Unit, SCS, Portland, Oregon
Kenneth E. Grant, Administrator, SCS, Washington, D. C.



REPORT OF FLOOD
9-5-70
WHITE TANKS
EROSION CONTROL PROJECT
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
PHOENIX, ARIZONA

J. J. TURNER State Conservation Engineer
11 - 12 - 70

Gerald Welsh 1 112

AGREEMENT

THIS AGREEMENT made and entered into at Phoenix, Arizona, on this, the 23rd day of November, 1966, by and between the FLOOD CONTROL DISTRICT OF MARICOPA COUNTY, ARIZONA, a Flood Control District organized under and pursuant to the laws of the State of Arizona, hereinafter designated "Flood Control District", and the MARICOPA COUNTY MUNICIPAL WATER CONSERVATION DISTRICT NO. 1 an Irrigation Distfict organized under and pursuant to the laws of the State of Arizona, hereinafter designated "Irrigation District".

W I T N E S S E T H :

THAT, WHEREAS, Flood Control District has the responsibility of operating and maintaining certain flood control works, consisting in the main of McMicken Dam and outlet channel, S.C.S. Dams No. 3 and No. 4, and interconnecting dikes and channels and related and adjoining flood control works, all located within the County of Maricopa, State of Arizona, and desires that said flood control works be maintained in proper working condition, and operated in a good and workmanlike manner; and

WHEREAS, Irrigation District has available and is able forthwith to secure the necessary labor, materials, equipment and supervisory personnel necessary and required for the proper maintenance and operation of said flood control works.

NOW, THEREFORE, for and in consideration of the mutual covenants and agreements hereinafter set forth and contained on the part of the parties hereto to be by them respectively kept and performed, said parties hereto agree as follows:

1. That the Irrigation District shall, for the period beginning as of the 1st day of July, 1966, and ending on the 30th day of June, 1967, and from year to year thereafter, in a good and workmanlike manner, keep, maintain and operate said flood control works in a proper condition and manner and

in accordance with instructions and procedures given by the Flood Control District, provided, however, that the Irrigation District shall not be required to do or perform any work in relation to keeping, maintaining and operating said flood control works in a proper condition and manner, the cost of which shall be in excess of the amount which the Flood Control District shall theretofor have obligated itself to pay to the Irrigation District for such work.

2. That for the period beginning as of the 1st day of July, 1966, and ending on the 30th day of June, 1967, the Flood Control District shall pay to the Irrigation District a sum not in excess of FOUR THOUSAND ($4,000.00) DOLLARS for keeping, maintaining and operating said flood control works in a proper condition and manner.

3. That the Flood Control District shall, prior to the 1st day of June of each and every year beginning on the 1st day of June, 1967, estimate the amount that the Flood Control District shall provide for keeping, maintaining and operating said flood control works in a proper condition and manner during the period of each year, respectively, beginning on said 1st day of June, 1967. The Irrigation District shall not, during any such period, be required to do and perform any work upon said flood control works, the cost of which shall be in excess of said estimated amount, nor shall it perform any work upon or in relation to the maintenance and operation of said flood control works not previously authorized in writing by the Flood Control District. That in the event that the Irrigation District shall, at any time, by notice in writing given to the Flood Control District, advise the Flood Control District that the cost of doing the work done or to be done and performed by the Irrigation District during the period then in effect will be in excess of the amount estimated by the Flood Control District to cover the cost of such work, then and in such event the Flood Control District shall forthwith give notice in writing to the Irrigation District of its approval for the performance of the work to be done, the cost

of which will be in excess of said estimated amount for such work, and in the further event that such notice shall not be received by the Irrigation District within fifteen (15) days from and after the giving of said notice by the Irrigation District to the Flood Control District, then and in such events the Irrigation District shall have no further obligation to do and perform any further or additional work in relation to the maintenance and operation of said works, the cost of which will be in excess of the amount estimated by the Flood Control District to cover the cost of such work.

4. That the Irrigation District shall, from time to time, as it shall determine, present to the Flood Control District a detailed and itemized statement, with supporting invoices, of the cost of the work performed by the Irrigation District in relation to the maintenance and operation of said flood control works, including among other things, that part of the Irrigation District's general administrative and overhead expenses which are attributable to the maintenance and operation of said flood control works, provided, however, that in no event shall the amount of the Irrigation District's general administrative and over-head expenses exceed twenty per cent (20%) of the total cost to the Irrigation District of performing said work of maintaining and operating said flood control works, and notwithstanding anything herein to the contrary, any and all withholding, social security and other taxes and expenses of any and all employees engaged in the performance of the work of maintaining and operating said flood control works shall be the sole and exclusive responsibility of and shall be paid by the Irrigation District.

5. That the parties hereto recognize and agree that from time to time as a result of accidental, natural or other causes, and through no fault of the parties hereto, or either of them, there may be unusual damage to said flood control works requiring repairs and maintenance thereto exceeding normal repairs and maintenance, and in the event of any such eventuality the parties hereto shall determine and

agree upon the amount of the additional costs and expenses to be incurred as the result of such extraordinary causes, and in the event that the parties hereto shall agree upon the amount of said additional costs and expenses resulting from such extraordinary causes, then and in such event the Irrigation District shall proceed to do and perform the additional work made necessary by such extraordinary causes, and upon the completion thereof the Flood Control District shall pay to the Irrigation District the cost to the Irrigation District of performing such work, together with that part of the Irrigation District's general administrative and over-head expenses which are attributable to the performance of such extraordinary work.

6. That this Agreement shall be automatically renewed from year to year from and after the 1st day of July, 1967, unless the Flood Control District or the Irrigation District shall serve notice in writing, upon the other of them within thirty (30) days prior to the end of the period then in effect of its desire to terminate this Agreement at the end of said period, and upon the giving of such notice this Agreement shall terminate and end on the 30th day of June following the date on which such notice was given.

IN WITNESS WHEREOF, the parties hereto have caused their respective names to be hereto subscribed and their respective corporate seals to be hereto affixed on this, the 24th day of December, 1966.

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY, ARIZONA

By _____

MARICOPA COUNTY MUNICIPAL WATER CONSERVATION DISTRICT NO. 1

By _____

STATE OF ARIZONA)
) ss.
County of Maricopa)

On this, the 24th day of December, 1966, before me, the undersigned Notary Public, personally appeared _____, who acknowledged

APPENDIX 5

COMMENTS ON 1981 HYDROLOGIC STUDIES

13 JAN 1984

FLOOD CONTROL DISTRICT of MARICOPA COUNTY 1959

FLOOD CONTROL DISTRICT of Maricopa County

3335 West Durango Street • Phoenix, Arizona 85009
Telephone (602) 262-1501

D. E. Sagramoso, P.E., Chief Engineer and General Manager

JAN 12 1984

Mr. Dan Lawrence
Arizona Department of Water Resources - Dam Safety
99 East Virginia Avenue
Phoenix, Arizona 85004

Dear Mr. Lawrence:

The Flood Control District recently completed a review of the hydrology study conducted by Ertec Western, Inc. in August 1981 as part of the Phase I Inspection Report for White Tanks Retarding Dam No. 3. We investigated the hydrologic and hydraulic assumptions used by Ertec Western and restructured the input data used in the HEC - 1 model developed by them so that the model would run on the most recent version of HEC - 1. A copy of the output listing is attached. In general, our study agrees with the Ertec Western study. The important results are summarized as follows:

1) The structure would be overtopped 1.12 feet during a Probable Maximum Flood if the structure were initially full.

2) The structure would be overtopped 1.01 feet during a PMF if the structure were initially empty.

3) The structure would not be overtopped during a ½ PMF event.

I recommend that we plan a meeting to discuss possible remedies to the dam safety concerns. If you have any questions regarding the hydrology study, please contact Tom LaMarche of my staff.

Sincerely,

...ted – Dan Sagramoso

D. E. Sagramoso, P. E.

Enclosures

Copy to: Verne M. Bathurst, State Conservationist
with Enclosures

SUMMARY OF DAM OVERTOPPING/BREACH ANALYSIS FOR STATION WT3

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1210.00	1210.00	1216.00
STORAGE	2655.	2655.	4802.
OUTFLOW	0.	0.	48000.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.25	1211.89	.00	3277.	7960.	.00	5.00	.00
.50	1213.16	.00	3696.	17235.	.00	4.75	.00
.75	1214.39	.00	4095.	27767.	.00	4.75	.00
1.00	1215.13	.00	4366.	38005.	.00	4.75	.00

PLAN 2 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1190.00	1210.00	1216.00
STORAGE	0.	2655.	4802.
OUTFLOW	0.	0.	48000.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.25	1207.14	.00	1909.	0.	.00	.00	.00
.50	1211.42	.00	3123.	5245.	.00	6.25	.00
.75	1212.97	.00	3633.	15981.	.00	5.50	.00
1.00	1214.35	.00	4095.	27760.	.00	5.00	.00

*** NORMAL END OF HEC-1 ***
TOP 101

END OF FILE
OS/VS CLI TERMINATING 21-MAR-84 13:14:10

PROCESS 36 TERMINATED
ELAPSED TIME 0:00:38
(OTHER JOBS/ SAME USERNAME)
USER 'FCD' LOGGED OFF 21-MAR-84 13:14:10

***
LIST FILE EMPTY, WILL NOT BE PRINTED
***

30 SEP 1983

FLOOD CONTROL DISTRICT
of
Maricopa County

3335 West Durango Street • Phoenix, Arizona 85009
Telephone (602) 262-1501

D. E. Sagramoso, P.E., Chief Engineer and General Manager

mtg w/ FCD 2-23-84

Sep. 28, 1983

Mr. Verne M. Bathurst, State Conservationist
Soil Conservation Service
230 North First Avenue
Phoenix, Arizona 85025

Dear Mr. Bathurst: Verne,

My staff recently completed a draft report on the effect of a probable maximum flood on the White Tanks #4 floodwater retarding structure. The report concludes that the structure would be overtopped and presumably fail in that flood event.

I am forwarding a copy of this report to you for your comments and recommendations about the report and about possible remedial action that could be taken to ensure the integrity of the structure in a probable maximum flood. I suggest that a meeting be arranged to discuss this topic after you have completed your review.

Sincerely,

D. E. Sagramoso, P.E.

Enclosure

Table 1

Top of Dam Elevation	1,056 m.s.l.
Spillway Capacity at stage 1056	13,125 cfs
PMF Inflow	42,400 cfs
PMF Outflow	
Reservoir empty	40,100 cfs
Reservoir full	42,400 cfs
PMF Maximum Stage	
Reservoir empty	1,057.3
Reservoir full	1,057.4
PMF Flow Diverted Past Reservoir	19,132 cfs
1/2 PMF Outflow	
Reservoir empty	10,309 cfs
Reservoir full	16,990 cfs
1/2 PMF Maximum Stage	
Reservoir empty	1,054.98
Reservoir full	1,056.34
1/2 PMF Flow Diverted Past Reservoir	8,959 cfs

WT #4

SUMMARY OF DAM OVERTOPPING/BREACH ANALYSIS FOR STATION DAM

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1050.00	1050.00	1056.00
STORAGE	1407.	1407.	2613.
OUTFLOW	0.	0.	13125.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.25	1054.10	.00	2198.	7918.	.00	4.75	.00
.50	1056.34	.34	2694.	16990.	.75	4.75	.00
1.00	1057.42	1.42	2956.	42400.	2.25	4.25	.00

PLAN 2 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	991.00	1050.00	1056.00
STORAGE	0.	1407.	2613.
OUTFLOW	0.	0.	13125.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.25	1051.55	.00	1725.	1999.	.00	6.25	.00
.50	1054.98	.00	2366.	10309.	.00	5.25	.00
1.00	1057.34	1.34	2938.	40186.	1.75	4.50	.00

*** NORMAL END OF HEC-1 ***

WT4

APPENDIX 6

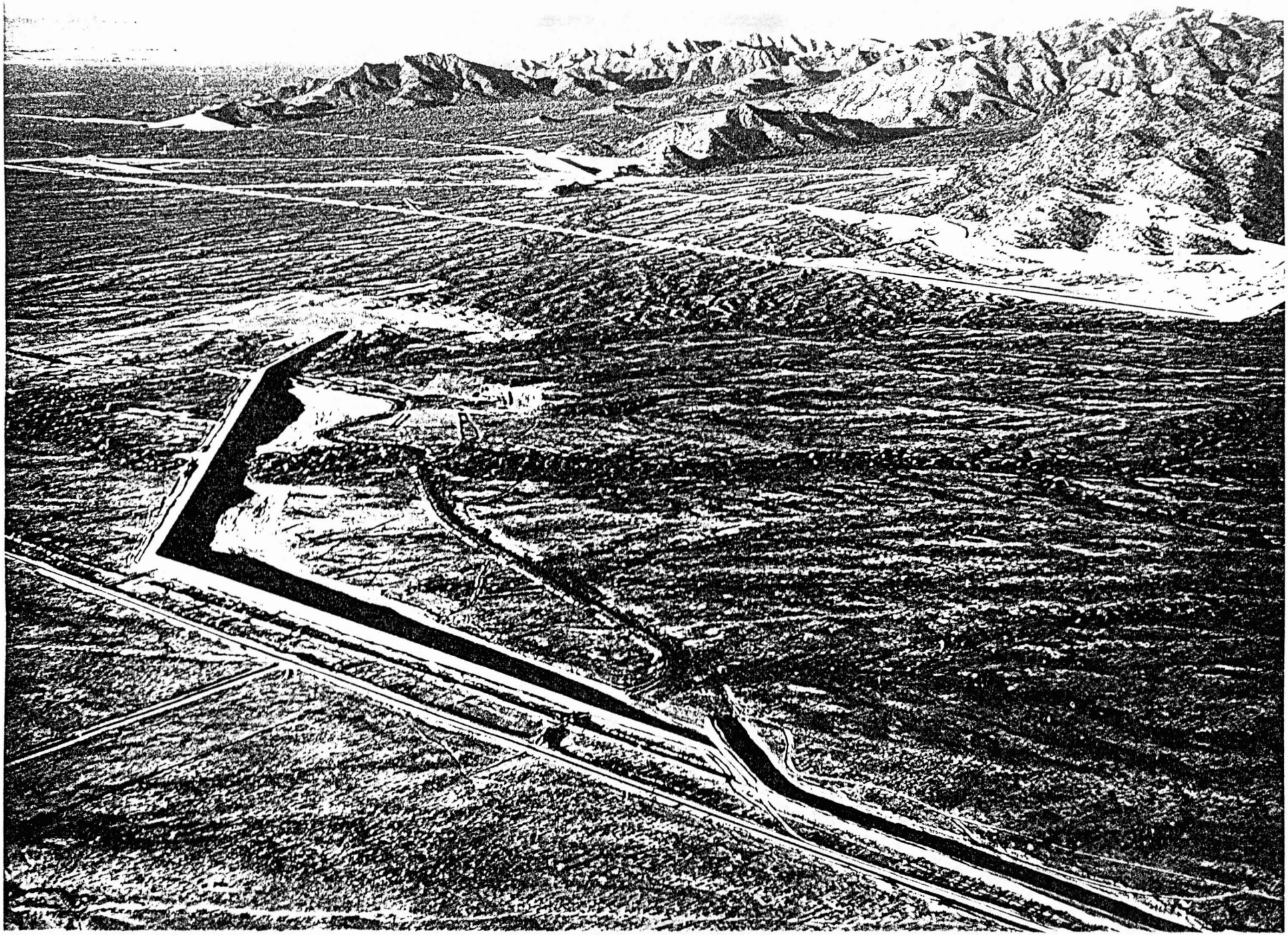
1955 PHOTOS OF

COMPLETED PROJECT

AZ-5294

White Tanks Project Structure #3
and diversion dikes in foreground,
White Tank Mountain in background.
View facing southwest.

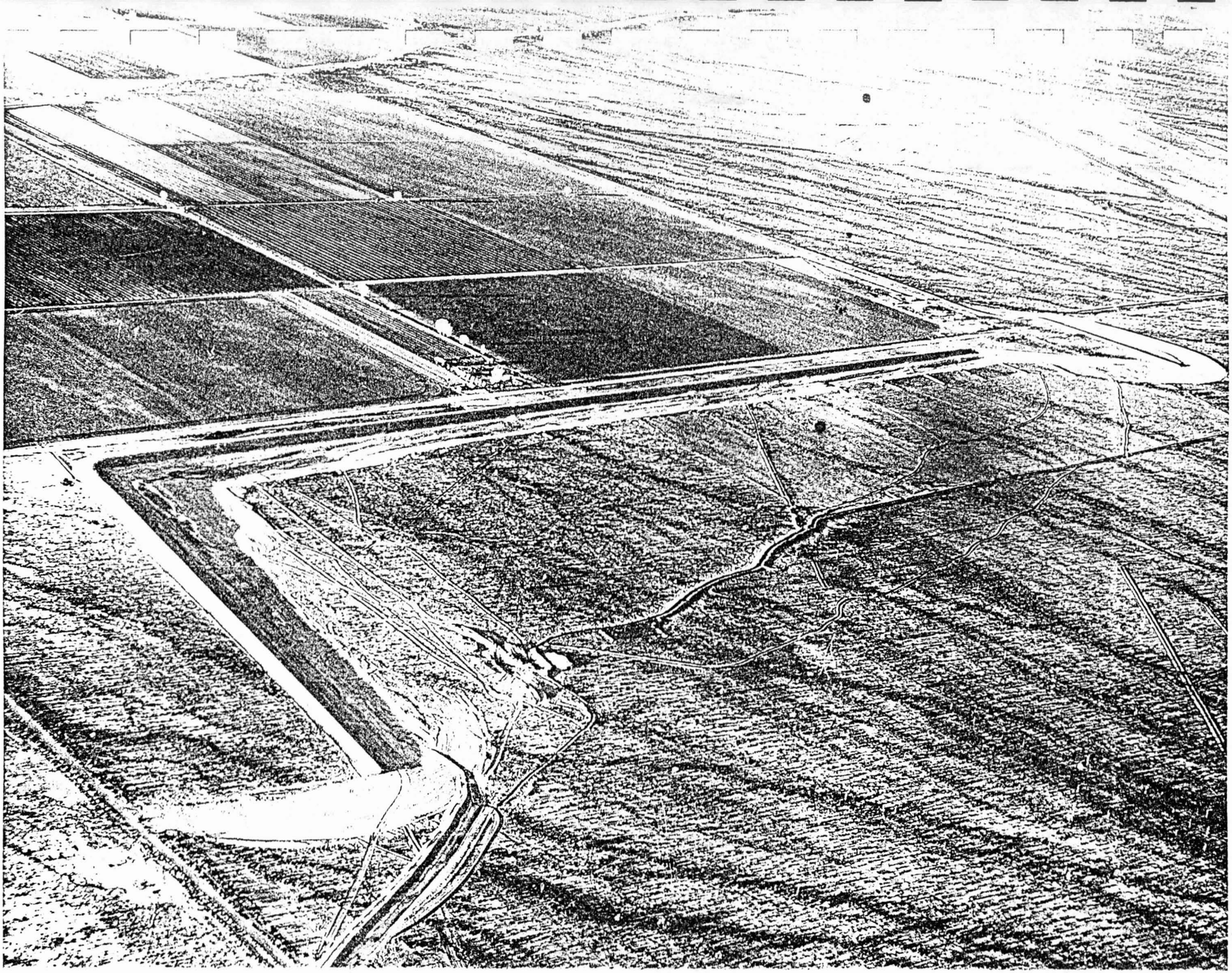
Photogtraphed by Edward D. Neville on March 2, 1955.



AZ-5318

White Tanks Structure #4.
View facing southwest, showing farm
lands protected. Diversion dike into
flood retarding basin in center foreground.

Photographed by Edward D. Neville on March 2, 1955.



APPENDIX 7

HIGHLIGHTS OF DAMBRK MODELING,

STRUCTURES #3 AND #4

JANUARY 1991

TABLE 1

Highlights of Results for DAMBRK Modeling at White Tanks FRS No. 3

Description	Breach Location No. 1	Breach Location No. 2	Breach Location No. 3
Water Surface Elev. at Beginning of Breach	1209.0	1209.0	1209.0
Peak Outflow at Dam (cfs)	76,292	97,378	73,977
Perryville Prison - Mile 4.25			
Maximum Flow (cfs)	68,650	85,632	67,861
Maximum Depth (feet)	3.76	4.00	3.71
Travel Time (hours)	1.80	1.80	1.84
Maximum Velocity (fps)	4.74	5.17	4.91
Interstate Highway 10 - Mile 5.45			
Maximum Flow (cfs)	45,217	54,716	47,757
Maximum Depth (feet)	10.65	11.16	10.81
Travel Time (hours)	2.70	2.52	2.72
Maximum Velocity (fps)	8.41	8.25	12.39
Roosevelt Canal - Mile 5.75			
Maximum Flow (cfs)	45,217	54,167	47,757
Maximum Depth (feet)	3.64	3.98	3.74
Travel Time (hours)	2.70	2.60	2.72
Maximum Velocity (fps)	5.65	6.04	5.84
Southern Pacific Railroad - Mile 9.25			
Maximum Flow (cfs)	45,303	52,971	46,306
Maximum Depth (feet)	3.91	4.17	3.98
Travel Time (hours)	3.61	3.50	3.68
Maximum Velocity (fps)	3.54	3.77	3.63
Gila River - Mile 11.25			
Maximum Flow (cfs)	37,353	42,100	39,935
Maximum Depth (feet)	4.37	4.59	4.54
Travel Time (hours)	4.70	4.50	4.72
Maximum Velocity (fps)	3.69	3.81	3.76

TABLE 2

Highlights of Results for DAMBRK Modeling at White Tanks FRS No. 4

Description	Breach Location No. 1	Breach Location No. 2	Breach Location No. 3
Water Surface Elev. at Beginning of Breach	1053.0	1053.0	1053.0
Peak Outflow at Dam (cfs)	58,513	37,263	38,197
Roosevelt Canal - Mile 0.80			
Maximum Flow (cfs)	49,081	30,845	32,248
Maximum Depth (feet)	1.78	1.28	1.32
Travel Time (hours)	0.50	0.55	0.55
Maximum Velocity (fps)	4.78	4.54	4.60
Southern Pacific Railroad - Mile 3.62			
Maximum Flow (cfs)	36,105	24,580	24,325
Maximum Depth (feet)	3.63	3.16	3.16
Travel Time (hours)	1.45	1.60	1.59
Maximum Velocity (fps)	3.63	3.33	3.42
Town of Liberty - Mile 5.3			
Maximum Flow (cfs)	24,008	16,554	16,467
Maximum Depth (feet)	2.82	2.36	2.36
Travel Time (hours)	2.40	2.80	2.83
Maximum Velocity (fps)	2.48	2.20	2.22
Gila River - Mile 5.5			
Maximum Flow (cfs)	23,124	16,033	15,944
Maximum Depth (feet)	1.53	1.11	1.17
Travel Time (hours)	2.55	3.00	3.01
Maximum Velocity (fps)	2.57	2.27	2.20

APPENDIX 8

ENGINEERING REPORT

WHITE TANKS #3

DRAFT

WHITE TANKS No. 3

DECLINING ELEVATIONS ALONG

DAM CREST

Report of Investigator
May 17, 1991

CONTENTS

LIST OF FIGURES

LIST OF APPENDICES

WHITE TANKS NO. 3

DECLINE IN CREST ELEVATION

I. AUTHORITY

An investigation was ordered by the Arizona State Conservationist on February 6, 1991 to study the cause of differential elevations along the crest of White Tanks No. 3 Flood Retarding Structure. The investigator appointed was William A. McFerrin, Civil Engineer with the Flood Control District of Maricopa County, assigned to the design section at SCS (see Appendix A).

Specifically, the duties include an engineering investigation to determine the facts and prepare a report to document the findings. A report of "Preliminary Findings" was prepared to organize the relative documents and information for developing this report.

II. OBJECTIVES

The basic purpose of the study is to determine the cause of differential elevation of over 3.5 ft. along the dam crest, with the lowest point being 4.4 ft. below design elevation. It is also necessary to assess the potential problems which could result from the anomaly, and discuss methods of resolving them.

In connection with potential repairs, the existence and ownership of right-of-way around the site is to be reviewed. Right-of-way will be needed to provide access and construction/borrow sites as determined through the design procedure.

III. SUMMARY OF FINDINGS

A. 1978 Report on Cracking of Earth Dams

An investigating team was appointed to study cracking of earth dams in Arizona. They presented an interim report on July 21, 1977 and a final report on April 27, 1978 (Stearns et al). The 1978 report contained the following observations:

1. Under VII. Causes of Cracking:

"Certainly, the movement associated with subsidence as a result of ground water removal may well have aggravated the

cracking in some areas. No evidence has been collected to indicate that subsidence cracks occur in any of the dams' foundations."

2. Under VIII. Summary of Findings:

"A. The principal cause of the transverse cracking is tension released because of shrinkage as the embankments dry from placement moisture content in the severely hot, arid climatic conditions in the area.

B. Secondary causes of cracking are:

1. Tension zones resulting from differential settlement because of shallow foundation compression. This is the primary cause of the longitudinal cracks investigated.

2. Tension zones resulting from stress differences caused by regional subsidence associated with groundwater withdrawal.

3. Tension zones caused by stress differences resulting from variations in type of material, degree of compaction of moisture content in fill materials as placed.

4. Stresses induced by tremors and earthquakes."

The report also discussed the effect of subsidence on dams, together with planning and design concepts to prevent cracking. A system of monuments was recommended to monitor movements of dams in subsiding areas.

B. 1979 Crack Location Investigation

Fugro, Inc., Consulting Engineers and Geologists, under contract to SCS, performed a crack location investigation (Fugro, Inc.,1979) on White Tanks No. 3. The work included digging with trencher and backhoe to locate and assess cracks. The findings, dated April 16, 1979 were as follows:

"4.1 Conclusions

a. The maximum depth of cracking below crest grade is eight feet as determined by Ditch Witch trenching and flooding.

b. The deepest crack in the backhoe trenches extends to 21.9 feet.

c. The dominant mode of cracking is of the transverse type, however, a single longitudinal crack was observed from Station 25+36 to 26+18.

d. "Healing" or filling of cracks has occurred along some of the cracks investigated in the backhoe trenches. The filling material is most commonly loose, fine to coarse, well sorted sand.

e. Six pipe outlets were observed to discharge water as a result of Ditch Witch trench flooding.

f. Two reaches of severe cracking were encountered. One is from Station 28+50 to 29+00 and the other is from Station 57+90 to 58+40 (see Appendix C).

g. No cracking was encountered from Station 0+00 to 13+30 and from Station 69+65 to the end of structure 76+67.

h. Based upon our investigation, it is estimated that 60 percent of the FRS has experienced no cracking to date, 34 percent has a low degree of cracking and six percent has a moderate to severe degree of cracking.

i. White Tanks No. 3 FRS will require the implementation of remedial action to mitigate the potential problems due to cracking and piping of the embankment."

Subsequent to receiving the Fugro report, Stanley N. Hobson, Head, Engineering Staff, WNTC, sent a memorandum dated June 20, 1979 to Ralph Arrington, State Conservation Engineer, with the following recommendations regarding White Tanks No. 3 repair design (see Appendix B):

"White Tanks No. 3 (White Tanks Watershed)

The pattern of cracking at this site departs significantly from the pattern at the other sites. We are particularly concerned about the deep crack at Station 58+50. It is recommended that the original geology and other investigations data be studied to see if this crack may be explained by discontinuities in the foundation. It may be necessary to do more investigations to better define the cause of this deep crack. Seismic study may be helpful. Borings to check foundation conditions may be required.

We believe it necessary to know more about the cause of this crack before a design of corrective measures is completed."

C. 1981 Phase I Inspection

Ertec Western, Inc. (1981) was contracted by the Arizona Department of Water Resources to perform a phase I inspection

under the authority of the National Dam Inspection Act. The following Section 6.0 Conclusions and Recommendations is from the inspection report:

"Corps of Engineers guidelines indicate that White Tanks Retarding Dam No. 3 is a high hazard dam because of downstream development; storage criteria indicate that it is intermediate in size. Because of the high hazard and intermediate size classification, the guidelines also indicate that the emergency spillway should have the capability to safely pass the PMF. Results of this investigation indicate that the spillway can only accommodate 60 percent of the PMF, and the dam would experience a maximum overtopping across the entire dam crest of up to 1.12 feet for approximately 1.25 hours, during a PMF. It is probable that the dam would fail in the event of such overtopping. Results of the existing data evaluation indicate the internal structural integrity is also questionable because of embankment cracking known to affect the structure.

Results of this Phase I inspection and technical evaluation indicate corrective actions must be implemented during regular maintenance of the structure and that Phase II studies must be implemented to evaluate and ultimately correct apparent hydraulic and structural deficiencies. Specific recommendations are as follows:

1. The dam and emergency spillways should be fenced to prevent trail bikes and off-road vehicles from using them as a playground.

2. Because of the known embankment cracking inadequate emergency spillway, a warning system and evacuation plan should be developed and implemented in the event of a possible dam failure.

3. Brush and sediment deposition should be cleaned from the outlet structures.

4. The dam embankment should be inspected at least annually to observe the occurrence of embankment cracking.

5. The population of burrowing animals on the embankment should be controlled by either periodically grading the surface to fill in burrows, or by covering the slope surfaces with a rock or gravel blanket (see report in Appendix D).

6. Plans for any remedial construction should be reviewed with respect to the existing geotechnical conditions.

7. The crest of the dam should be traversed by a level survey to determine the magnitude, if any. of any settlement since completion of construction. This should consist of determining ground surface elevations along the center of the crest at 20-foot intervals.

8. A Phase II investigation should be completed to further evaluate the embankment and foundation conditions and their stability, to characterize the cause(s) of recent cracking, and to provide a plan of action to correct the deficiencies in the embankment. Results of the level survey should be used to re-evaluate adequacy of the spillway, and means for modifying the spillway to accommodate the PMF should be investigated."

D. Phase II Flood Study

A phase II study was conducted (date unavailable) by the FCD (see Appendix C). The study included a review of watershed boundaries which resulted in a reduction of watershed area. The following results were obtained with the assumption that the reservoir was full at the beginning of the storm.

PMF Ratio	Maximum Water Surface Elev.	Freeboard (ft.)
0.5	1212.69	3.31
0.75	1213.74	2.26
1.00	1214.58	1.42

E. Repair Works Accomplished

The dam was repaired in 1982. The project design report described the work as follows:

"The project consists of the removal of 200 feet of embankment at Station 58+00 and replacement to its original exterior dimensions. An embankment drain shall be excavated along the centerline at Stations 18+00, 29+00, and 42+00, for 200 feet each to depths of 7.5, 12.0, and 10.0 feet respectively. Each trench shall be excavated approximately three (3) feet below the maximum depth of crack observed as recommended. Each trench shall be graded to its individual outlet. The trenches and outlets shall be filled with well-graded drain fill material of maximum size passing the 1-1/2 inch sieve."

F. Discovery of Decreasing Elevation of Dam Crest

During the construction of repair works in 1982 an apparent anomaly was found in the elevation of the crest. A survey was ordered and a differential elevation problem was confirmed (see

Appendix D). Elevations were taken at 250' intervals. The lowest elevation recorded was 1213.5 at Station 10+00. while the highest was 1216.9 at Station 75+00. The maximum differential settlement measured was 3.4 feet. The as-built dam elevation was 1216.

G. Subsidence Monuments

A system of subsidence monuments was established in 1984. Seven bench marks were placed at 1000 ft. spacing from Station 10+00 to 70+00 along the centerline of the dam. They were numbered A-1 through A-7. Correspondingly, seven existing benchmarks located at the downstream toe of slope, with the same stationing, were numbered B-1 through B-7.

Surveys of the monuments were conducted in 1984, 1986, 1990 and 1991. The "B" monuments were also surveyed in 1982.

H. Updated Hydrologic/Hydraulic Analysis

In 1981 Ertec performed the hydrologic investigation of White Tanks No. 3, described hereinbefore in paragraph C. In 1983 the Flood Control District confirmed the results. The conclusion was that a probable maximum flood would overtop the original design dam height by over one foot, even with the reservoir initially empty.

Additional studies have been prepared by the Flood Control District, with the latest being A Hydrology Analysis of the White Tanks Flood Retarding Structure No. 3 and No. 4, dated October 1989. These need to be reviewed during the planning stage for repair of the dam.

I. This Study

At the time of construction in 1954, the datum used for construction was the 1948 elevation of USC&GS BM H265. No allowance for subsidence was made, whereas the subsidence rate was estimated by the ADOT in 1967 to be approximately 0.1 ft. per year. Since the dam was constructed six years after the original survey, the BM elevation was probably about 0.6 ft. lower then when set, and the crest of the dam was probably built 0.6 ft. lower than design, or elevation 1215.4.

The difference in elevation between the lowest subsidence monument on dam centerline (Sta. 10+00; elevation. 1211.56) and the highest subsidence monument (Sta. 70+00; elevation. 1215.10) was 3.53 ft. at the time of the latest survey on 07/91. This represents the accumulation of differential settlement since construction of the dam in 1954.

The northerly end of the dam is close (several hundred feet) to C&GS bench mark H265. The southerly end is near bedrock. The differential settlement between the ends of dam is nearly the same as the subsidence of H265. The historical rates in ft/year, of differential settlement and subsidence are also similar. The total subsidence of the dam since construction is estimated to be 3.8' at station 10+00, which is 4.4' below crest design. The southerly end has experienced little subsidence while the northerly end has subsided about the same as H265.

Structure No. 3 lies on the westerly limits of a groundwater basin. Drawdown records from 1923 to 1977 show a steep decline in the water surface from west to east across the dam. The differential groundwater decline would influence differential subsidence.

Analyses of subsidence surveys for 1982 through 1990 show the ends of the dam have subsided somewhat as blocks, while the central portion has sustained the strain of differential subsidence. On the southerly end, this can be explained by relatively low total subsidence from approximately Station 60+00 to Station 75+00. On the northerly end the section of dam between 0+00 and 30+00 is parallel with the lines of equal groundwater surface decline, so the subsidence along that reach of the dam would be expected to be nearly uniform.

IV. SUBSIDENCE IN AREA OF DAM

Bench marks were installed along Beardsley Canal by the Coast & Geodetic Survey in 1948, at one mile intervals, at each major street intersection. The closest one to White Tanks No. 3 is BM H265 at Glendale Avenue. It is several hundred feet east of approximate Station 17+00 (see Figure 1).

Conversations were held with Mr. Carl C. Winikka, Asst. State Engineer (retired) from ADOT. He provided subsidence information for four bench marks along Beardsley Canal at Camelback, Bethany Home, Glendale, and Northern (see Figure 1). The information is tabulated below.

Street Crossing	Bench Mark	Subsidence (ft.) 1948-81	Subsidence Rates (ft./yr.) 1948-67	1967-81
Camelback	F265	2.781	0.1133	0.0452
Bethany Home	G265	1.902	0.0754	0.0849
Glendale	H265	3.256	0.1088	0.0849
Northern	J265	2.548	0.0655	0.0931

Rates of subsidence have decreased except at Northern Avenue. Decreases would be expected as use of the groundwater system naturally

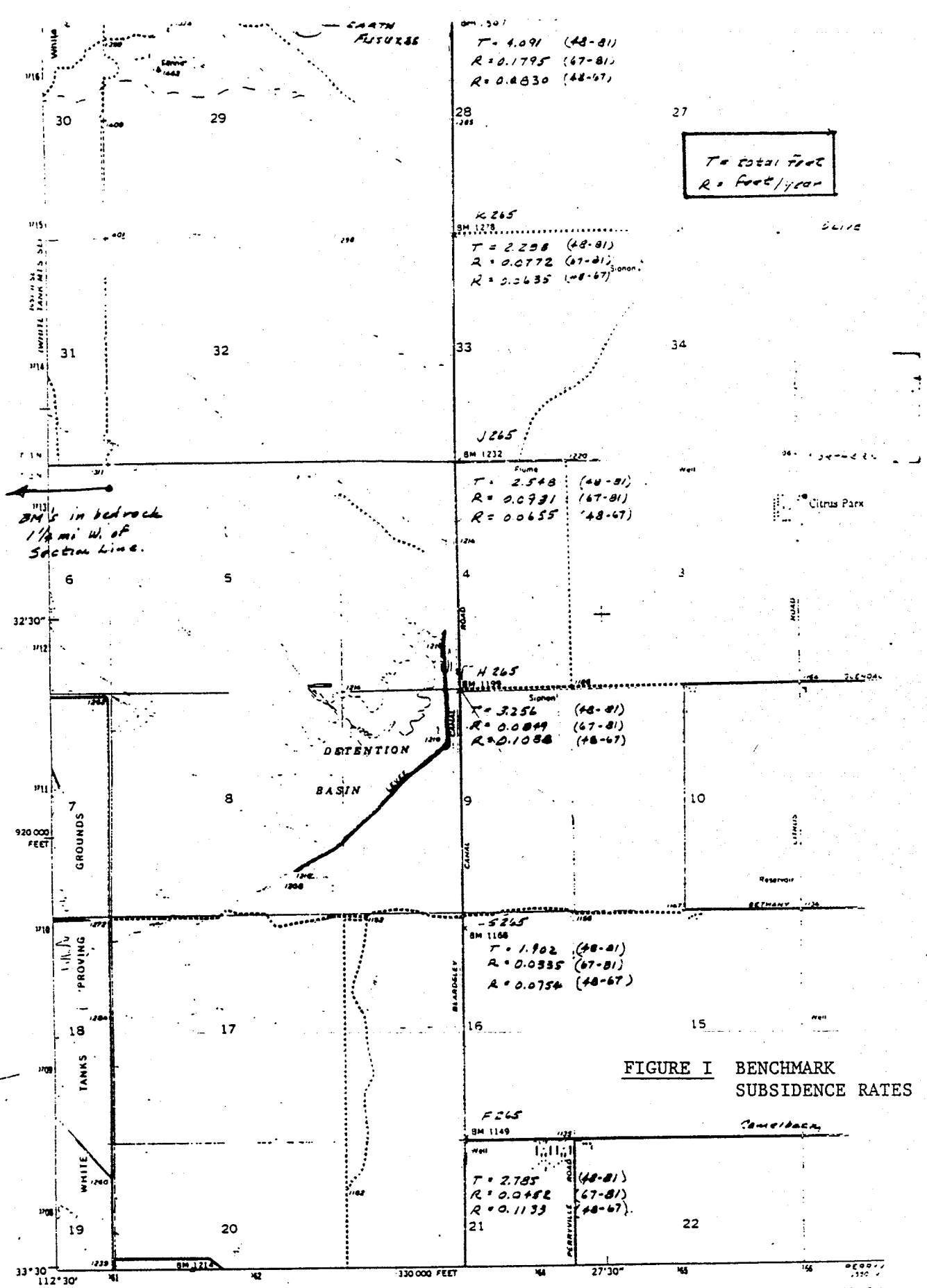


FIGURE I BENCHMARK SUBSIDENCE RATES

Mapped, edited and published by the Geological Survey

Control by USGS and USC&GS

Topography from aerial photographs by photogrammetric methods and by planetable surveys 1957. Aerial photograpons taken 1954

Polyconic projection. 1927 North American datum
10,000-foot grid based on Arizona coordinate system, central zone
1000-metre Universal Transverse Mercator grid ticks, zone 12, shown in blue

UTM GRID AND 1971 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE

CONTOUR INTERVAL

DASHED LINES REPRESENT NATIONAL GEODETIC

changes from mining of the water toward lesser use and stable relationship between extraction and recharge. The increase at Northern could be caused by increased extraction or diminution of volume of the water bearing strata without decreased extraction.

A survey performed in July 1991, for the Flood Control District showed the elevation of H265 to be 1195.691 (adjusted). The subsidence of the BM since the previous survey in 1981 was 0.444 ft.. indicating a rate of 0.0444 ft/yr. for the latest 10 years.

V. DIFFERENTIAL ELEVATIONS OF DAM CREST

A. Discovery

A contract was awarded to G.R.L. Construction on September 16, 1981 for repair of cracked areas of structures No. 3 & 4. The project was completed in August 1982.

On December 10, 1981 the project survey crew ran a level survey along the centerline of the dam, taking shots at 250 feet intervals (see Appendix D). The elevation at station 0 + 00, the north end of the dam, was 1213.9. At station 76 + 65, the southerly end of the dam, the elevation was 1216.4,or 2.5 feet higher than the other end. The difference in elevation between the highest and lowest points was 3.4 feet between elevation 1213.5 at station 10+00 and elevation 1216.9 at station 75+00. This survey marked the discovery of the declining elevation of the dam crest.

B. Possible Causes

Four possible causes for decrease in the crest elevation are:

-- initial construction error;

-- consolidation of the dam fill;

-- consolidation of the alluvial foundation material under the dam fill;

-- general subsidence caused by mining of groundwater.

1. Initial Construction Error

Sufficient survey data were not found in the files to show that final survey of the top of dam verified it was constructed to the design level. However, plotted final cross sections for Stations 30+00, 39+00, 63+00 and 73+00 indicated the structure was properly completed. Furthermore, the survey data required to prepare earthwork quantities for payment should leave little chance for a large error in final finished grade.

The construction survey for the dam, dated 3/31/54, was based on the 1948 elevation of USC&GS bench mark H265 (elevation 1199.391), located at Glendale Avenue and Beardsley Canal. No correction was made for subsidence during the six-year interval. The 1967 elevation of H265 was 1197.32, and the average annual subsidence for the BM was 0.109 ft./year for the period 1948-67. The actual elevation of BM H265 was probably about 1198.8 in 1954. The dam crest would have been constructed about 0.6' lower than design.

2. Consolidation of Dam Fill

The dam construction specifications required fill to be compacted to 95% of Standard Proctor Density, with a maximum depth fill of about 29 feet. Consolidation after this level of compaction should be negligible.

3. Consolidation of Alluvial Foundation Material Under the Dam

Consolidation of the foundation material due to the weight of the dam can be expected, but cannot be readily quantified without bench marks designed specifically for measuring consolidation. Furthermore, it is difficult to differentiate between consolidation due to the weight of the dam and consolidation (subsidence) due to lowering of groundwater level.

An indicator of foundation consolidation due to the weight of the dam may be the change in differences between subsidence monument elevations on the top of dam and those at the left toe of slope. Surveys conducted in February 1984 and July 1990 indicated consolidation of the dam foundation during those 6.5 years was as follows: (see Appendix E):

Bench Marks	Station	2/84 to 9/90 "Apparent" Consolidation (ft.)
A1 - B1	10+00	0.025
A2 - B2	20+00	0.045
A3 - B3	30+00	0.051
A4 - B4	40+10	0.026
A5 - B5	50+00	0.025
A6 - B6	60+00	0.050
A7 - B7	70+00	---*---
		0.037 (average)

* BM A7 was reset, making A7 - B7 irrelevant.

The magnitude of the rate of consolidation during the period 2/84 to 8/90 was about 0.0057 ft/year. This compares with the calculated rate of subsidence 0.0849 ft/year at C&GS bench mark H 265, located near BM A2 and B2, during the same period. The estimate was based on the assumption that the subsidence rate continued to be the same during 81 - 90 as it was during 67 - 81.

There are several points to be made from the above results which indicate consolidation due to dam weight is not an important factor in the differential settlement along the structure. First, a relatively high "apparent" consolidation (0.050 ft.) occurred at Station 60+00 of the structure where settlement was low. Secondly, there is no clear pattern of differential consolidation which relates to the differential elevation measurements. Furthermore, the rate of "apparent" consolidation (0.0057 ft/yr) is very small compared to the estimated rate of regional subsidence (0.0849 ft/yr).

It should be pointed out that the above conclusions are only indicated. The movement of monuments at the toe of slope can be misleading because they might move in an unpredicted direction, depending on settlement conditions.

4. General Subsidence Caused by Mining of Groundwater

General subsidence due to lowering of groundwater levels is clearly the major contributor to settlement of the dam. Figure 2 shows how the dam is located along the westerly boundary of a groundwater basin, and how groundwater levels changed during 1923 to 1977. It also indicates why the structure has been subject to differential settlement:

a. The proximity of bedrock near the southerly end would reduce settlement there, while the northerly end would be expected to settle at approximately the same rate as the nearby bench mark H265 at Glendale and Beardsley Canal.

b. The gradient of the groundwater surface at the structure indicates that soil moisture conditions help cause differential settlement in the manner it has occurred. Lesser subsidence would be expected where the change in the groundwater surface elevation is less.

Surveys conducted during 1982 to 1990 show that the ends of the dam tend to subside as blocks. The approximate stationing of these blocks is from 0+00 to 30+00 on the northerly end and 60+00 to 75+00 on the southerly end. The northerly block movement can be explained by the fact that it parallels a line of equal

groundwater level decline along which subsidence would be expected to be nearly uniform. The southerly block is located over or near bedrock where subsidence should be minimal.

Since subsidence monuments were installed in 1984, surveys have shown the lowest monument to be A-1, located at Sta. 10+00, and the highest to be A-7, located at Sta. 70+00. For the July 1991 survey the calculated elevations were 1211.561 and 1215.091, respectively. The difference between the two was 3.53 feet. The original design elevation was 1216.0, about 4.4 feet above monument A-1.

C. Subsidence Analysis

Bench mark H265 subsided 3.256' during the period 1948 - 1981 (33 years). The differences between elevations of bench marks A1 and A7, located on the centerline of structure, was 3.529 feet in July 1991, 36 years after the dam was constructed with uniform crest elevation. The rate of subsidence for H265 during 1948 - 1981 was 0.0987 ft/yr, while the rate of differential subsidence between Stations 10+00 and 70+00 was 0.0954 ft/yr. The implication is that the southerly end of the structure sustained little subsidence and the northerly end subsided about the same as BM H265.

Total differential subsidence between BM A1 and other 'A' BM's is plotted in Figure 3. Analysis of the difference between A1 and A7 shows differential subsidence between the two points occurred at the following rates:

Period	Rate of Differential Subsidence
1954 - 1984	0.0843 ft/yr
2/84 - 7/86	0.0579
7/86 - 8/90*	0.0354

*Based on estimated elevations of A7 in 1990 after reset of BM A7.

The figures indicate the rate of differential subsidence is decreasing. By comparison, the most recent data available for subsidence of H265, showed subsidence rates of 0.1088 ft/yr for 1948 - 67, 0.0849 ft/yr for 1967 - 81, and 0.0444 ft/yr. for 1981 - 1991.

The most recent survey of dam centerline was taken December 17, 1990. Figure 4 is a plot of that survey, and shows the current relationship between the spillway and the dam. The approximate average elevation of the spillway is 1.9 ft below the lowest point surveyed on the dam. The design maximum water surface was 3 ft above the spillway demonstrating that the dam could not withstand such an event.

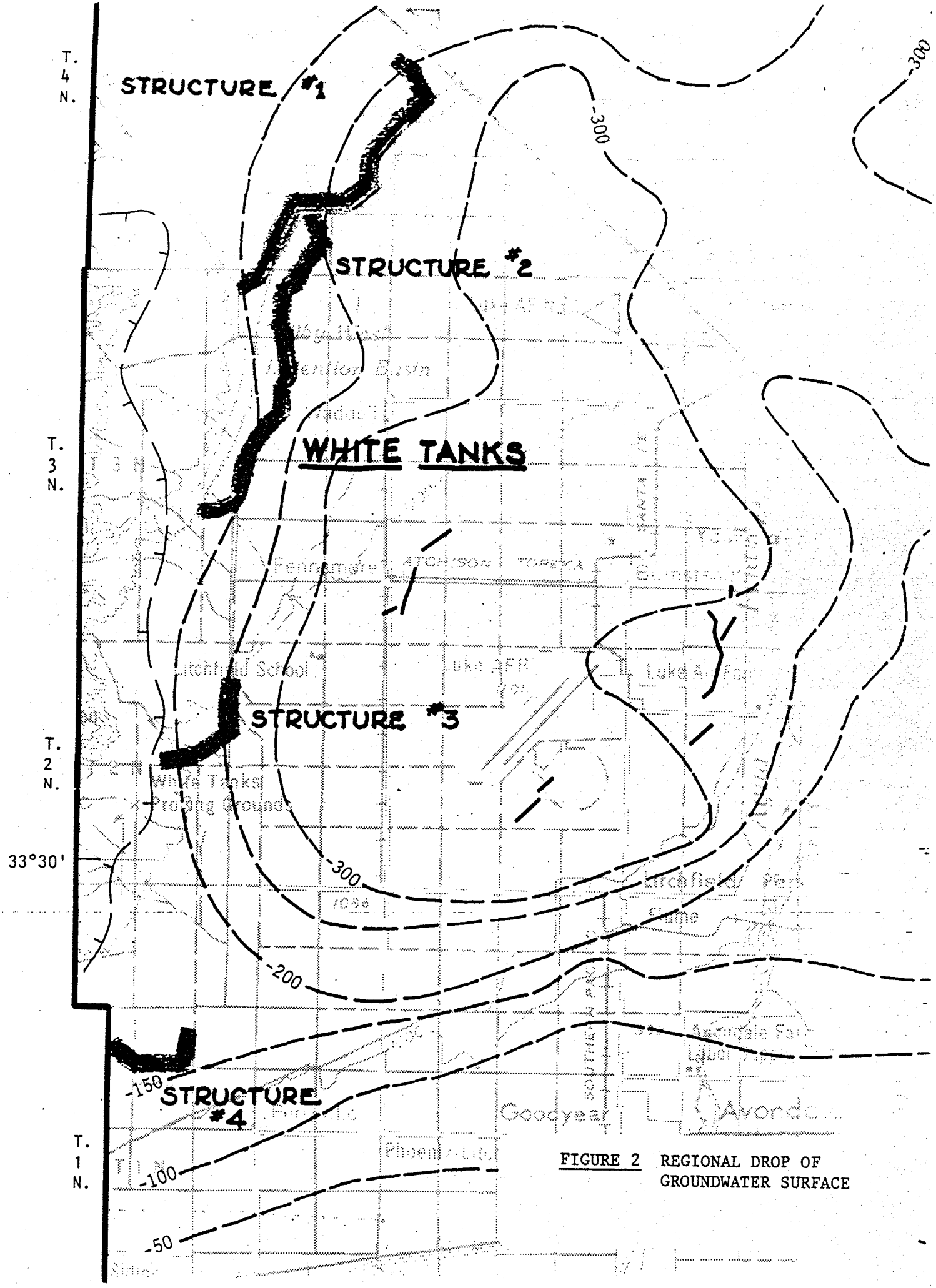


FIGURE 2 REGIONAL DROP OF GROUNDWATER SURFACE

Figures 3 and 4 also demonstrate that little differential subsidence took place between Stations 0+00 and 30+00 on the northerly end, and between 60+00 and 75+00 on the southerly end as previously discussed. The elevation of subsidence monument A-1 was 1207.883 in July 1991, based on BM 8-90. Ties to USC&GS monuments showed the correct elevation to be 1211.561 in accordance with BM Q475. The original design called for a crest elevation of 1216.0, so the lowest existing crest elevation is 4.439' below design level.

VI. SUBSIDENCE RELATED TO CRACKING

Considering the scope of differential subsidence along the dam crest, it might be a much greater contributor to cracking than was previously assumed. The crack team and Fugro studies assumed that desiccation was the main problem causing transverse cracking, and the shallow foundation consolidation was the main contributor to longitudinal cracks. However, there were no survey data available for those studies to specifically assess subsidence of the structure.

Analysis of the surveys taken in 1982, 1984, 1986 and 1990 were made based on the assumption that upon completion of the dam in 1954 the crest was level at the design elevation.

Figure 3 shows overall differential subsidence between subsidence monument A-1 and the other "A" monuments, based on surveys in 1984, 1986 and 1990.

Figure 5 shows rates of differential subsidence (ft/yr) for The "A" monuments during the time periods 1954-1984, 2/84-7/86 and 7/86-8/90. The significance of the curves is that the first shows a high rate of strain between Stations 30+00 and 50+00 during the 30 year period 1954-1984. In more recent years, the area of maximum strain has moved to Station 50+00 to 70+00.

Figure 6 is a plot of the rate of differential subsidence between subsidence monument B1 and the other "B" monuments for the periods 5/82-2/84, 2/84-7/86 and 7/86-8/90. The rates of subsidence for the 5/82-2/84 period are similar to those for the 30 year period for the "A" monuments, while the rates for the later periods again are less and indicative of higher strain in the area of Station 60+00.

All the rate curves indicate a slowing in differential subsidence in recent years. However, the area of maximum strain, or the maximum relative subsidence between two consecutive subsidence monuments, has apparently moved from the central portion of the dam (stations 30+00 to 50+00) to the southerly portion (stations 50+00 to 70+00). This could be explained by recent stabilization in groundwater levels at the center section, while the water bearing strata below the southerly end continues to dewater.

Figure 7 shows a family of plots of differential subsidence for "A" and "B" monuments. These curves clearly show the maximum strain in

DIFFERENTIAL SUBSIDENCE WAS DETERMINED BY SUBTRACTING THE ELEVATION OF A-1 FROM THE ELEVATION OF A-1 THRU A-7.

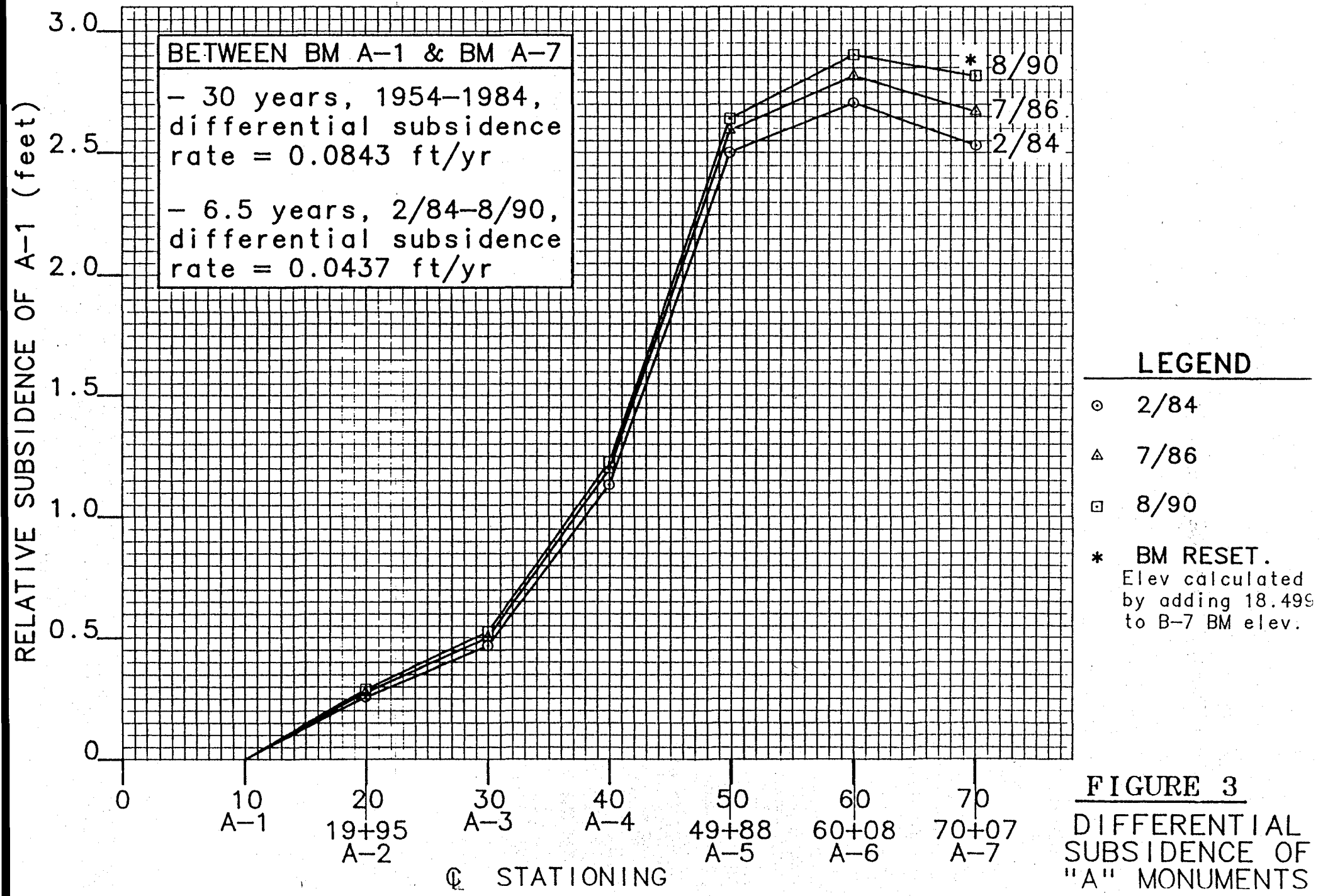
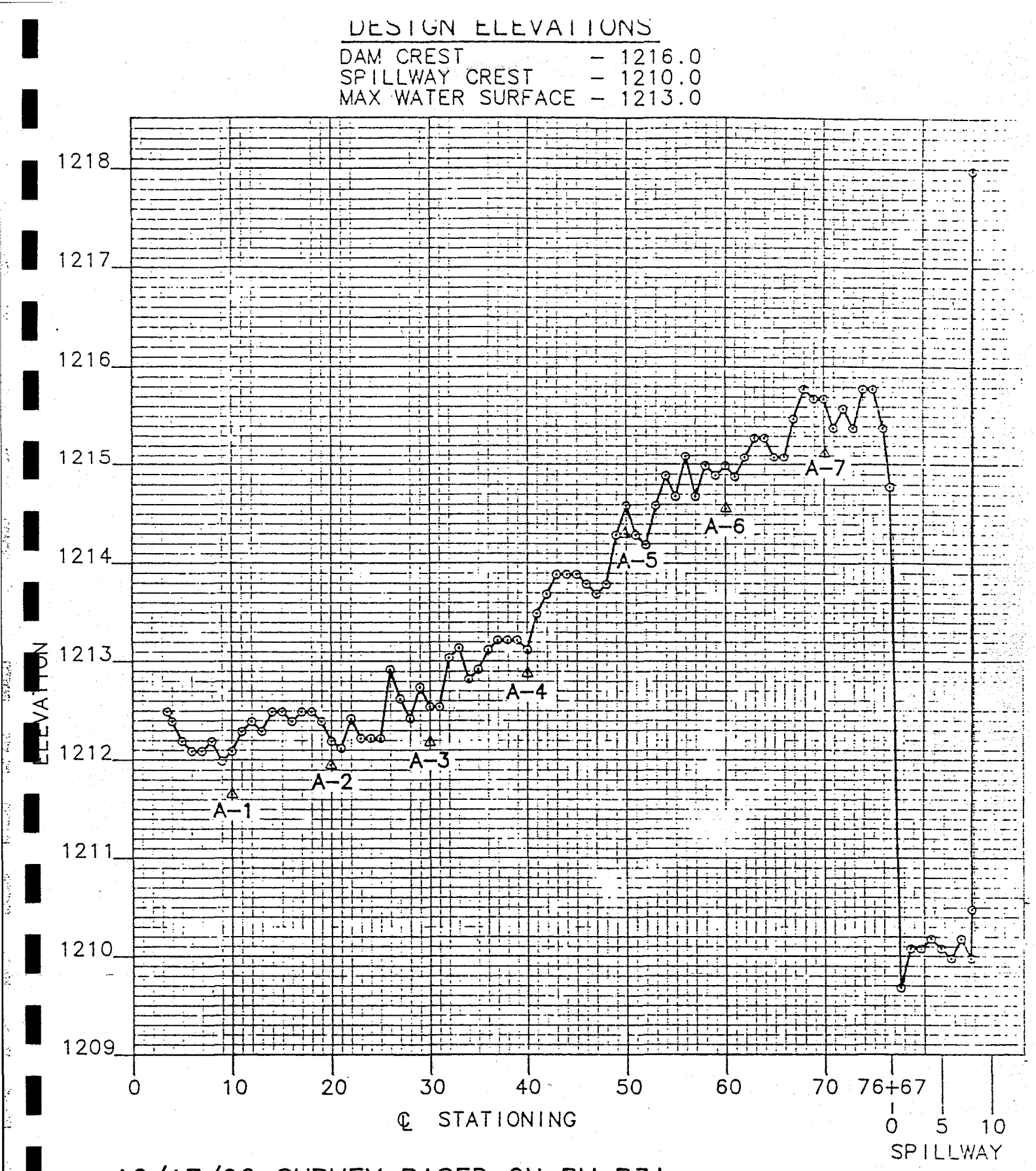


FIGURE 3

DIFFERENTIAL SUBSIDENCE OF "A" MONUMENTS



12/17/90 SURVEY BASED ON BM R3A,
ADJUSTED BY +3.68' TO MATCH BM Q475.

FIGURE 4

WHITE TANKS #3
1990 CENTERLINE SURVEY

POINTS ON CURVES REPRESENT RATES OF DIFFERENTIAL SUBSIDENCE
OF BENCH MARK A-1 WITH RESPECT TO OTHER "A" BENCH MARKS.

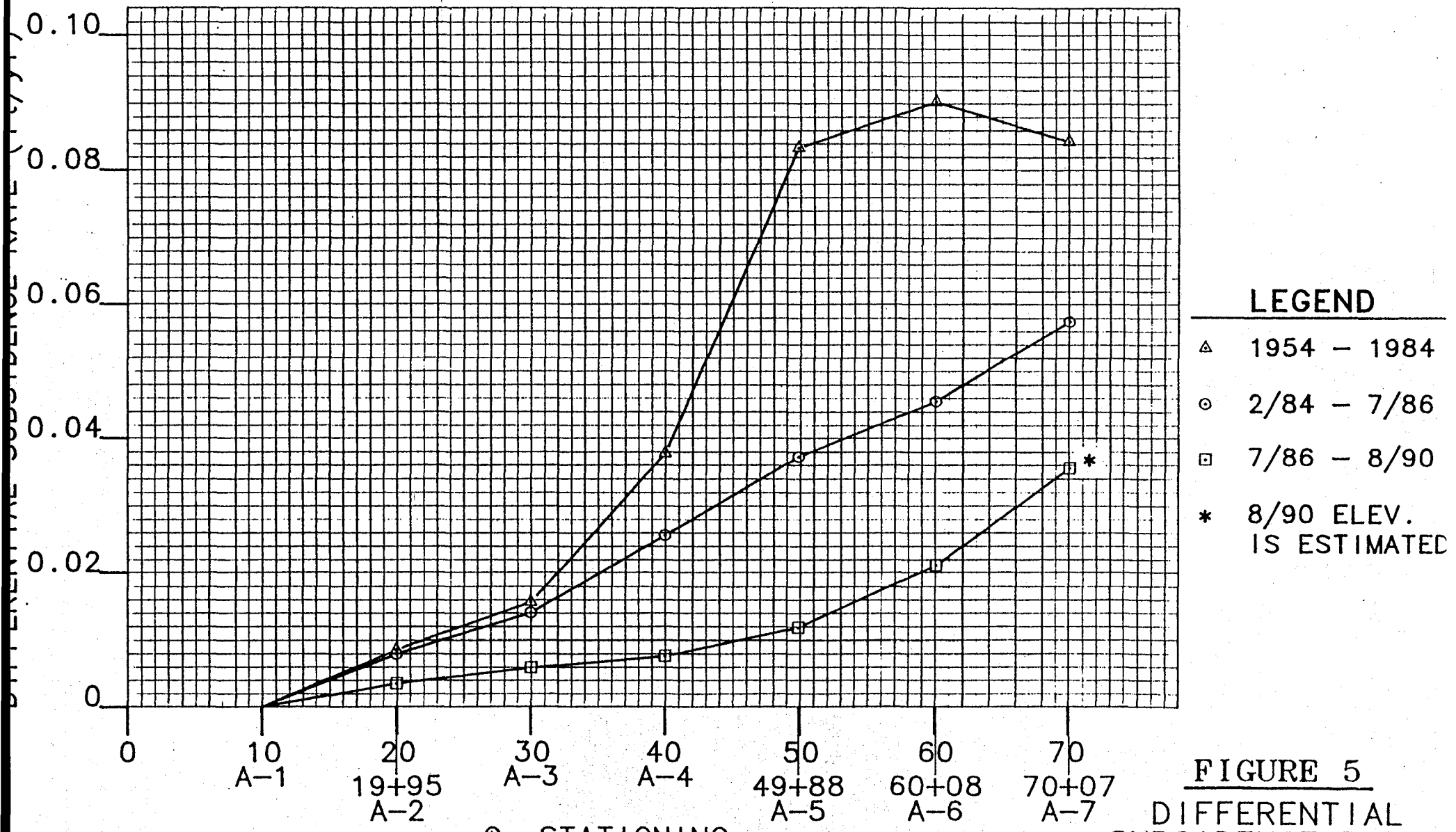


FIGURE 5
DIFFERENTIAL SUBSIDENCE RATES OF "A" MONUMENTS

the dam fill has been in the area of stations 50+00 to 70+00 during the most recent years.

In the memo from Hobson to Arrington dated June 20, 1979, concern was expressed about the cracking pattern of white Tanks No. 3 being different from those of other dams. An explanation could not be made at that time. There is no direct proof that differential subsidence was the cause of the large crack, or unusual cracking pattern but the survey analyses strongly suggest that it may be at least partially responsible.

VII. UPDATED HYDROLOGIC/HYDRAULIC ANALYSES

A. Phase I

In 1981, Ertec Western, Inc. performed a hydrologic/hydraulic investigation as part of a Phase 1 inspection report for White Tanks Retarding Dam No. 3. The analysis was made with a HEC-1 model.

The Flood Control District, in 1983, updated the analysis with use of the latest version of HEC-1. The District concurred with the earlier analysis and the results were summarized as follows:

a. The structure would be overtopped 1.12 feet during a Probable Maximum Flood (PMF) if the structure were initially full.

b. The structure would be overtopped by 1.02 feet during a PMF if the structure were intially empty.

c. The structure would not be overtopped during a 1/2 PMF event. The analysis was based on the assumption that the crest elevation of the dam was the same as as-built, 1216 feet. No allowance was made for subsidence of the crest by approximately 4.0 feet relative to the spillway. The dam would therefore be overtopped sooner than the study indicated.

B. Phase II

According to the 1984 dam inspection report (Appendix C), White Tanks No. 3 is rated a small dam in a high hazard location. The standard design flood criteria for this rating is normally 0.5 PMF.

The Flood Control District submitted a Phase II flood study to the ADWR (apparently early 1984, date not available). The study included a field review of the watershed boundary contributing runoff to the dam. The report indicated portions of the watershed were lost through avulsion caused by training dikes and diversion channels north of Northern, and flows from the Caterpillar Test Grounds. The reduced watershed area input yielded the following results through HEC-1 analysis:

POINTS ON CURVES REPRESENT RATES OF DIFFERENTIAL SUBSIDENCE
OF BENCH MARK B-1 WITH RESPECT TO OTHER "B" BENCH MARKS.

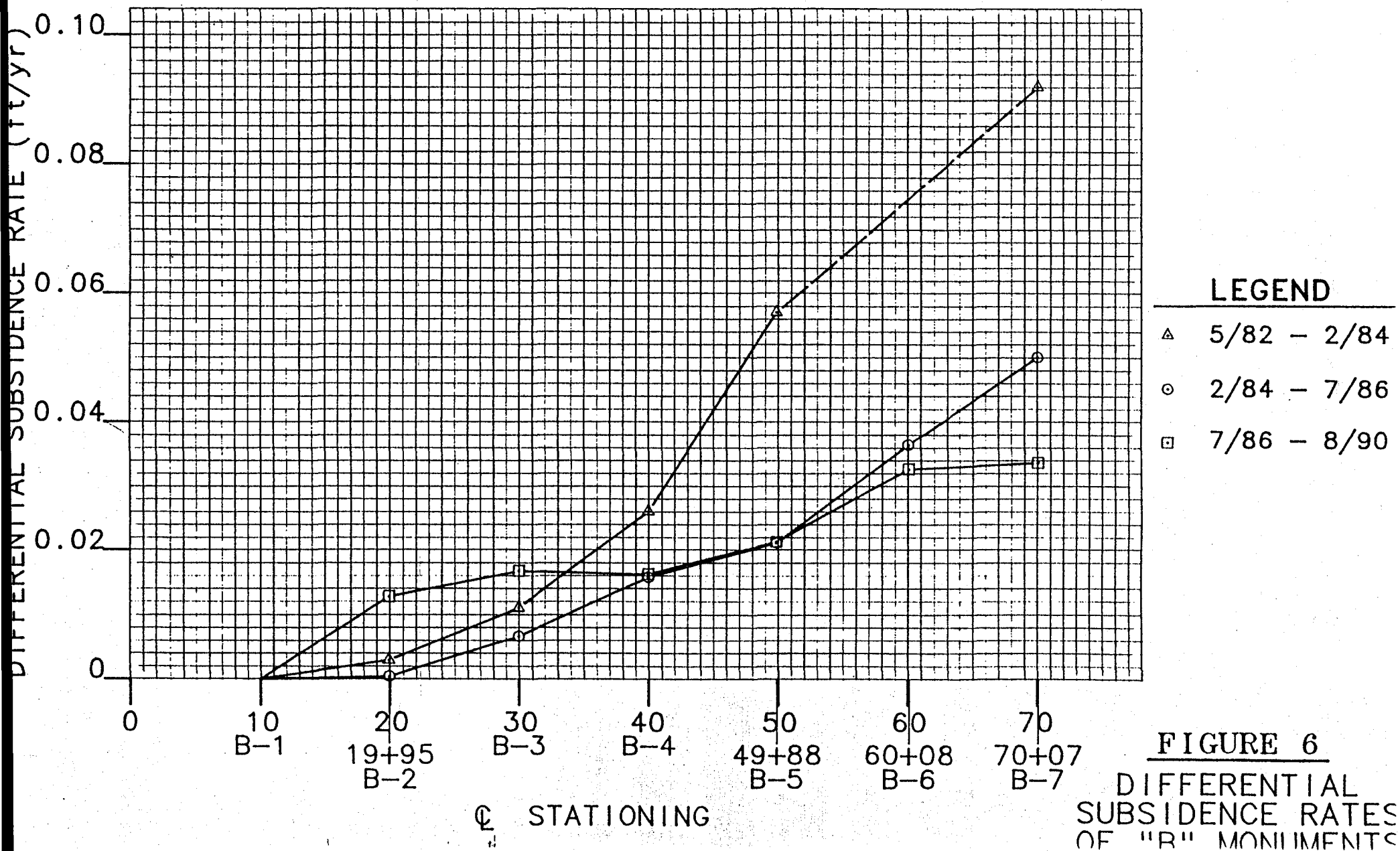


FIGURE 6

DIFFERENTIAL SUBSIDENCE RATES OF "B" MONUMENTS

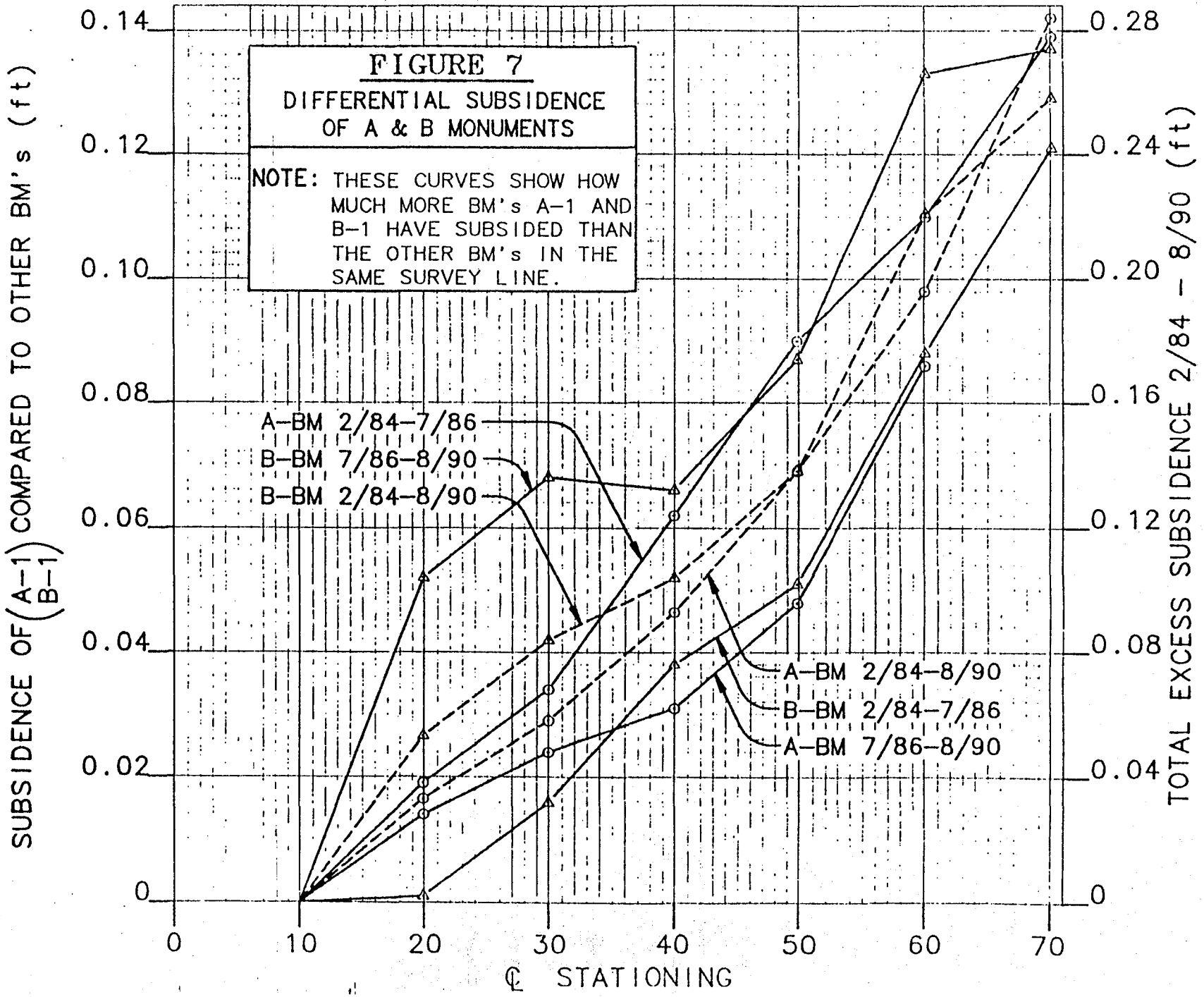


FIGURE 7
DIFFERENTIAL SUBSIDENCE OF A & B MONUMENTS
NOTE: THESE CURVES SHOW HOW MUCH MORE BM's A-1 AND B-1 HAVE SUBSIDED THAN THE OTHER BM's IN THE SAME SURVEY LINE.
SUBSIDENCE OF (A-1 / B-1) COMPARED TO OTHER BM's (ft)
TOTAL EXCESS SUBSIDENCE 2/84 - 8/90 (ft)
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0
0.28
0.24
0.20
0.16
0.12
0.08
0.04
0
0
10
20
30
40
50
60
70
℄ STATIONING
A-BM 2/84-7/86
B-BM 7/86-8/90
B-BM 2/84-8/90
A-BM 2/84-8/90
B-BM 2/84-7/86
A-BM 7/86-8/90

PMF Ratio	Maximum Water Surface Elev.	Freeboard Ft.
0.5	1212.69	3.31
0.75	1213.74	2.26
1.00	1214.58	1.42

The available freeboard (assuming the crest is at design elevation 1216) exceeded the 1984 requirement.

VIII. ADDITIONAL INFORMATION NEEDED

A. Short Term

The subsidence surveys for White Tanks and Buckeye structures have been based on the bench mark "DEAD", and have varied from other USC&GS monuments about 3.7 feet. In order to achieve direct comparison with design and as-built data, all subsidence surveys should be tied into a grid of USC&GS monuments established in rock. Future subsidence surveys would then be more easily analyzed to determine actual subsidence and to perform hydrologic/hydraulic reviews.

B. Long Term

Subsidence surveys should be performed every two or three years, and should always be based on a bench mark in rock. The frequency of survey might be reduced to once every five years if the rate of subsidence decreases significantly. Water levels should also be determined for wells in the vicinity, preferably at timing close to that of the surveys. Subsidence changes and water level changes can be determined and compared. Water level information is available at the Arizona Department of Water Resources, Basic Data Section. It can also be found at the Maricopa County Water District No. 1 Office, which monitors water levels in the area.

IX. DESIGN PROBLEMS

Original and Repair

There is little information available regarding the original design of the structure. However, it is likely that the problem of subsidence in the area had not yet been observed, and was therefore not considered.

When studies were performed in 1978 and 1979 to determine the cause of cracks in the dam, subsidence was discussed, but no attempt was made to determine if it would be a causative factor. Available information therefore led to the conclusion that transverse cracking was mostly a result of desiccation.

X. EXISTING RIGHT-OF-WAY

The dam and reservoir are on Flood Control District right-of-way. Assessor's parcel numbers and maps are provided in Appendix F. The right-of-way perimeter follows the high water line.

The property south of the central section of the dam is owned by Maricopa Water District.

XI. RECOMMENDATIONS FOR REPAIR

A. Determine Existing Conditions

Total subsidence along the dam centerline needs to be determined at 100 ft. intervals. The reservoir floor elevation also needs to be surveyed and the volume of existing reservoir verified. The watershed boundary determined in Phase II should be confirmed.

B. Estimate Future Subsidence

Future subsidence of the dam and reservoir needs to be estimated. The information will be used for design of repairs to maintain sufficient freeboard even after projected subsidence has been achieved.

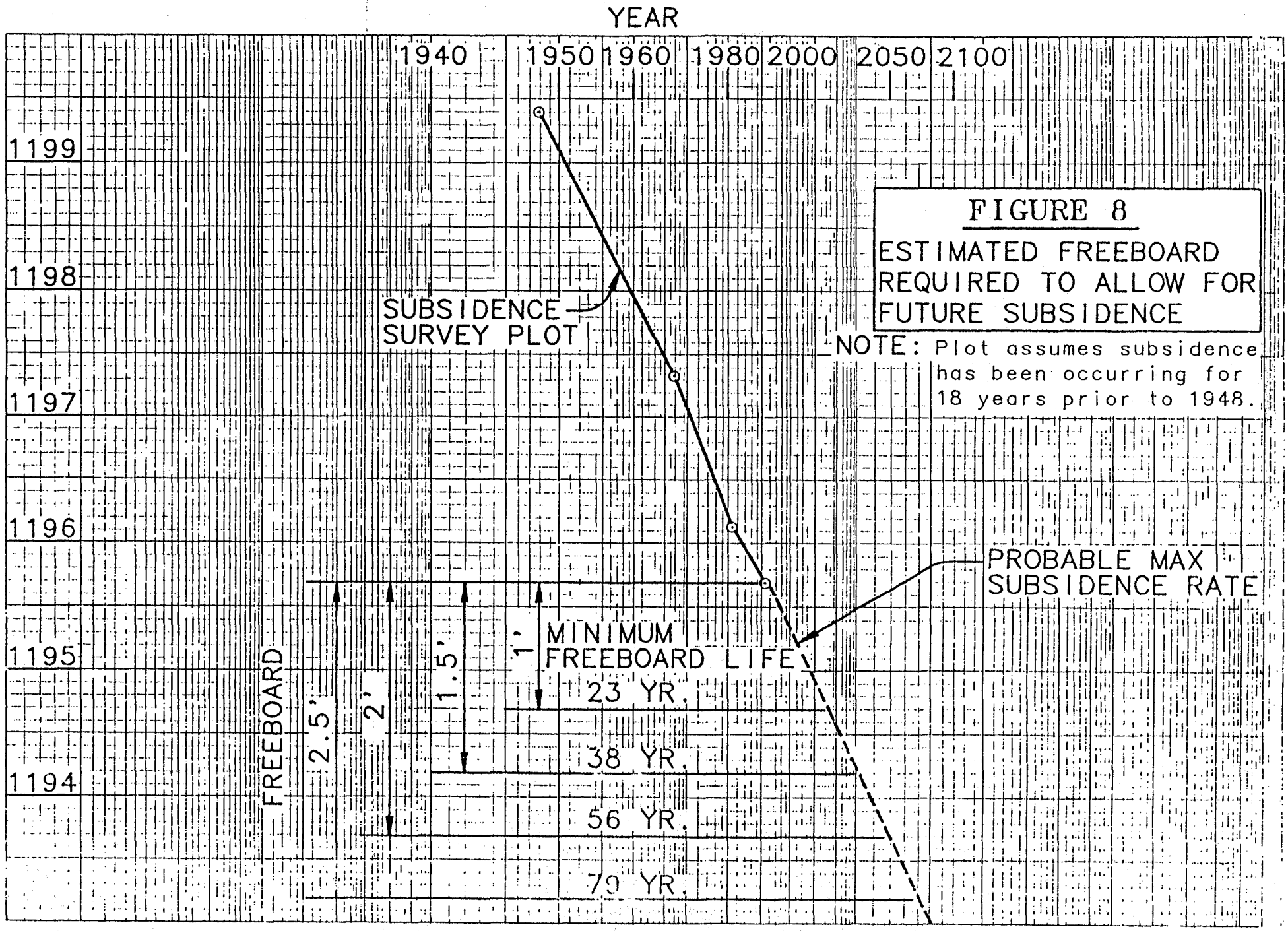
A preliminary estimate of future subsidence was made by plotting the survey year versus the elevations of BM H265 (Figure 8). As an approximation, it was assumed that the first survey year (1948) occurred 18 years after the beginning of subsidence. A line was extended to demonstrate the minimum apparent life of the structure before subsiding a given amount. For example, 2' of fill would compensate for the subsidence which would occur in the next 56 or more years.

C. Verify Hydrologic/Hydraulic Conditions

Review Phase II studies/reports prepared by the Flood Control District. Review the latest District report titled "A HYDROLOGIC ANALYSIS OF THE WHITE TANKS FLOOD RETARDING STRUCTURES No. 3 AND No. 4" dated October 1989. Perform a new hydrologic/hydraulic analysis as necessary to determine the options for repair to make the structure safe under conditions of the appropriate storm event (100-yr, 1/2 PMF or PMF). Options will include increasing the reservoir capacity, increasing the spillway capacity, breaching the dam, construction of an additional spillway or other improvements arrived at through the design procedure.

D. Design Repair Works

Actions A, B, and C above are necessary for preliminary planning of a repair project. However, no detailed recommendations are made herein as to how to design and construct the repairs.


YEAR
1940
1950
1960
1980
2000
2050
2100
Elevation (BM H265)
1199
1198
1197
1196
1195
1194
SUBSIDENCE SURVEY PLOT
PROBABLE MAX SUBSIDENCE RATE
FREEBOARD
2.5'
2'
1.5'
1'
MINIMUM FREEBOARD LIFE
23 YR.
38 YR.
56 YR.
79 YR.
FIGURE 8
ESTIMATED FREEBOARD REQUIRED TO ALLOW FOR FUTURE SUBSIDENCE
NOTE: Plot assumes subsidence has been occurring for 18 years prior to 1948.

By: _____
William A. McFerrin

Reviewed By: _____
John Harrington, State Design Engineer

Approved By: _____
Ralph M. Arrington, State Conservation Engineer

BIBLIOGRAPHY

STEARNS, C. E., SMITH. R. J., and STEVENSON, J. C., 1977; Cracking of Dams in Arizona Interim Report of SCS Study Team for USDA Soil Conservation Service, Phoenix, Arizona, 17 p. with figures.

STEARNS, C. E., SMITH, R. J., and STEVENSON, J. C., 1978; Cracking of Dams in Arizona Report of the Crack Study Team for USDA Soil Conservation Service, Phoenix, Arizona, 31 p. with figures.

FUGRO, INC., Consulting Engineers and Geologist, 1979; Crack Location Investigation White Tanks No. 3 Flood Retarding Structures Maricopa County, Arizona, for Soil Conservation Service, 16 p. with Appendices.

ERTEC WESTERN, INC., 1981; Phase I Inspection Report for White Tanks Retarding Dam No. 3, for Department of Water Resources, 39 p. with figures.

APPENDIX A

Investigation Authorization

United States Department of Agriculture
Soil Conservation Service
201 E. Indianola Avenue
Suite 200
Phoenix, Arizona 85012

Subject: ENG - White Tanks #3 Investigative Committee

Date: February 6, 1991

To: William McFerrin
Design Engineer

File Code: 210

Recent top of dam surveys for the White Tanks #3 FRS shows that the crest has sustained significant decrease in elevation in a south to north direction. Maximum difference in elevation is approximately 3.8 ft. This means that the hydraulic freeboard value for the spillway design hydrograph is inadequate for this existing high hazard Class "c" dam.

It is necessary to conduct an engineering investigation to determine the facts and prepare an engineering report to document the findings. After consultation with Richard Van Klaveren, Head, Engineering staff, WNTC, you are hereby appointed as investigating engineer for this job. Follow the policy, procedures and guidelines, as appropriate, contained in the NEM Item 504.04 page 504-3.

Please schedule your work so as to complete a draft of the report by May 3 1991. Please keep the State Conservation Engineer appraised of your progress.

Donald W. Gohmert

DONALD W. GOHMERT
State Conservationist

cc:
Richard Van Klaveren, Head, Engineering Staff, WNTC, Portland, OR
Bart Ambrose, ASTC (P), Phoenix
Ralph Arrington, SCE, Phoenix
Jon Hall, DC, Phoenix FO
Joe Knisley Jr., AC, Tucson
John Harrington State Design Engineer, Phoenix

APPENDIX B

Hobson Memo Regarding

Arizona Dams Investigation Reports

Paul Mamulis
Copy

United States Department of Agriculture
Soil Conservation Service
West Technical Service Center
511 NW Broadway, Rm. 510
Portland, Oregon 97209

SUBJECT: EN - Arizona Dams - Crack Location
A&E Investigation Reports

DATE: June 20, 1979

TO: Ralph Arrington, State Conservation Engineer
SCS, Phoenix, Arizona

The reports prepared by Fugro, Inc. of their findings and recommendations for the Buckeye #1, White Tanks #3 and #4, Magma and Vineyard Road Dams, have been reviewed with much interest. The reports are well prepared. Data is presented in a logical, easy-to-use manner.

Analysis of their data verifies that repair work is necessary at all five structures. With the possible exceptions of White Tanks #3, it appears sufficient investigations have been made to obtain data to determine the extent and magnitude of needed repairs.

In the recommendations section of the reports, the consultant refers to proposed drain-filled trenches as cutoffs. Such terminology is not consistent with earth dam nomenclature where cutoff normally signifies an impervious barrier. We suggest that the terminology in the reports be changed.

Buckeye #1 (Buckeye Watershed)

Alternate "a" is an interesting concept and upon further study may prove to be a viable solution. You may want to have your designers check it out.

Alternate "b" is favored by our staff to repair this structure. If you select this alternate, it is suggested that in preparing the designs, you insure that:

1. The drain trenches extend well into uncracked areas at each end.

2. Detail the outlets similar to those installed at the Rittenhouse Dam.

3. Apply any lessons learned at Rittenhouse to improving the design concept and specifications.

4. Install repair measures in questionable areas as well as demonstrated distress areas.

Ralph Arrington
6/20/79

White Tanks #3 (White Tanks Watershed)

The pattern of cracking at this site departs significantly from the pattern at the other sites. We are particularly concerned about the deep crack at station 58+05. It is recommended that the original geology and other investigations data be studied to see if this crack may be explained by discontinuities in the foundation. It may be necessary to do more investigations to better define the cause of this deep crack. Seismic study may be helpful. Borings to check foundation conditions may be required.

We believe it necessary to know more about the cause of this crack before a design of corrective measures is completed.

White Tanks #4

Alternate "a" presents a real possibility to solve the potential problems at this site. It is suggested that this possibility be fully evaluated in selecting repair measures.

From the standpoint of evaluating the overall condition of the dam, alternate "b" provides the opportunity to observe and log all the cracks.

Vineyard Road Dam (Apache Junction Gilbert Watershed)

The data collected show this structure to be badly in need of repair. We do not look at alternate "e" as a viable solution. It appears that alternate "a" is the best choice for long-term correction of the problem. The suggestions enumerated for the Buckeye #1 repair should be considered in the design of repair measures for the Vineyard Road Dam.

Magma Dam (Magma Watershed)

Data collected indicate this structure has serious problems. The extent can better be evaluated after completion of the Fugro investigations of earth crack potential and the USGS bedrock profile study that is planned.

STANLEY N. HOBSON
Head, Engineering Staff

cc:
Thomas G. Rockenbaugh, State Conservationist, SCS, Phoenix, Arizona

APPENDIX C

Phase II Studies

ARIZONA DEPARTMENT OF WATER RESOURCES

15 South 15th Avenue, Phoenix, Arizona 85007
Telephone (602) 542-1553
Fax (602 256-0506

FIFE SYMINGTON
Governor

ELIZABETH ANN RIEKE
Director

DATE: 9-17-1991

TO: Bill McFerrin

SCS - Phoenix

FROM: Ken Hussain

AZ DEPARTMENT OF WATER RESOURCES

3 PAGES TO FOLLOW

MESSAGE:

TELEPHONE: (602) 542-1541 EXT.

TELEFAX TELEPHONE NUMBER: (602) 256-0506

STATE OF ARIZONA
DEPARTMENT OF WATER RESOURCES
DIVISION OF SAFETY OF DAMS

SCS Fax # 640-5137

INSPECTION OF OPERATIONAL DAM

NAME OF DAM White Tanks No. 3 FRS DAM NO. 07.28

TYPE OF DAM Earthfill FREEBOARD _____ FT.

STORAGE LEVEL Dry FT. ( ) ABOVE (XXX) BELOW SPILLWAY CREST

CONTACTS Paul DiPierro, Earl Kirby, Flood Control District of Maricopa County

Smith Covey, SCS, Phoenix

DAM

1. The embankment shows some rilling in the soft fill of the upstream slope where material excavated from the filter trench was spread.

2. The downstream and upstream embankment slopes have some desert species vegetation in different densities along the length of the dam.

3. No apparent cracks or sinkholes were noticeable.

4. The historic sinkhole near the upstream toe near outlet "L" (station 46+00 (1954) and Phase I) has been covered by maintenance dressing of the channel along the upstream toe of the dam.

5. The effect of the 1981 repairs has not been altered by evidence of new cracking activity in the embankment.

OUTLET WORKS

1. The outlet at station 63+80 was opened to allow light thru. The tube appeared clear. Extensive spider webs were noticed. No unusual change in grade or line was apparent although basin subsidence may have occurred. The gate was clean and functioned smoothly. The outlet cobble rubble outlet basin was clean.

2. The outlets at station 46+00 and 29+00 were also in satisfactory condition.

SPILLWAY

1. The spillway channel has a light to moderate cover of desert habitat vegetation over a soil generally having a gravel surface texture. The extent of vegetation will have a minor retarding effect on flows during low stages of discharge for storms greater than the assumed 100-year frequency.

INSPECTED BY: D.E. Creighton, Jr. DEC DATE OF INSPECTION: June 13, 1984

PHOTOS: YES XX NO _____ DATE OF REPORT: June 18, 1984

DISCUSSION

1. The cracking problem has had a remedial treatment of a gravel filter core drain with outlets installed in 1981-1982 and a breach and embankment replacement at station 58 (station 56+10 to station 59+90).

2. The Phase I Report indicated that the partial PMF capacity for this structure was about 0.6 PMF (0.8 ft. freeboard at 0.5 PMF, 0.50 ft. overtop at 0.75 PMF).

3. White Tanks Dam is rated as a high hazard location structure with a small size rating. The normal SDF criteria for this structure is ½ PMF. R. 1/2 per discussion w/ Karl Dist.

4. The FCDMC has submitted a revised Phase II flood study for this structure. The study included further field review of watershed boundary conditions for determining the watershed area contributing to inflow. The study indicates that with the shedding of watershed area by avulsive breaches of the training dikes and diversion channels north of Northern Avenue, and flows from the Caterpillar Test grounds, and with a full reservoir at the start of the storm the maximum water surface elevations and freeboards would be as shown below for full and partial PMF flows.

PMF Ratio	Max. Water Surface Elev.	Freeboard
0.5	1212.69	3.31
0.75	1213.74	2.26
1.00	1214.58	1.42

This exceeds the criteria for freeboard at the current level of flood diversion channelization of the watershed generally lying north of Northern Avenue and south of the control exercised by McMicken Dam.

5. A 100-year current criteria routing for the 23.69 sm watershed may be near the 0.25 PMF Phase I results. This would indicate a 2.82 ft. freeboard. The results from a specific 100-year precipitation would be expected to be somewhat different. Whether the difference would be significant for meeting freeboard criteria would be problematic. For a 100-year frequency analysis it may be appropriate to include the area between the McMicken Dam and the Beardsley Canal dike in the gross watershed area with the northern subarea still subject to possible dike breaching. This area may become particularly critical for a more secure level of local development flood protection in view of the increasing subdivision development being experienced under the Beardsley Canal.

6. As-built drawings and the affidavit of total cost have not been received to date for the drain repairs to White Tanks No. 3 FRS. The as-built drawing should include the location and current elevation data for outlet works "K", "L" & "M". It is procedurally inappropriate to issue an updating license for White Tanks No. 3 until the final fee determination has been satisfied and as-built drawings are on file. Minimum pool elevation license restriction should be based on lip elevation of outlet "L" instead of outlet "K" (1952 data, unless changed by 1984 data). The status of the upstream seeding is also uncertain.

7. Bids are scheduled to be opened June 27 for a contract to put granular dam crest plating on White Tanks #3, White Tanks #4, and that portion of Buckeye No. 1 not showing cracks.

RECOMMENDATIONS

With the increasing housing being located below the Beardsley Canal between Northern Avenue and Beardsley Road an upgrading of the storm diversion reliability along the Beardsley Canal to a 100-year level should be the criteria for checking the comparative White Tanks No. 3 reservoir performance under 100-year or ½ PMF storm criteria for free-board.

An emergency action plan should be prepared, submitted for review and approval and kept current.

An updated license of approval for White Tanks No. 3 should be issued following receipt of the as-built drawings including current outlet works elevations, and the affidavit of final costs for the repair construction. These items should be received by December 31, 1984.

This high hazard location dam should be inspected annually.

Special effort will be required to detect probable future cracking evidence after the placement of surface plating gravel on the dam crest.

The settlement point survey data should be obtained and reviewed.

APPENDIX D

February 1982 Memo Regarding

Survey and Discovery of Problem

ted States
partment of
riculture

Soil
Conservation
Service

Room 3008 Federal Bldg., Phoenix, AZ 85025

ENG 210-12 Construction Progress
February 1, 1982
White Tanks No. 3 and 4 Repair

Date: February 9, 1982

Ralph M. Arrington
State Conservation Engineer

I visited the White Tanks repair Monday, February 1, 1982 to check the construction progress. The only work being performed was the placing of the fill in the section that was removed. The contractor has completed approximately 1300 feet of the drain trench, but was not working on these items this day.

I was discussing the job with Mark Eddington and he informed me that they ran a level circuit along the centerline of White Tanks No. 3 which showed the north end of the dam being 2.5 feet lower than the design elevation of 1216.1.

The following are the elevations at 250 foot intervals.

Station	Top Elevation	Station	Top Elevation
0+00	1213.9	42+50	1215.0
2+50	1214.6	45+00	1215.2
5+00	1213.8	47+50	1215.0
7+50	1213.6	50+00	1215.9
10+00	1213.5	52+50	1215.4
12+50	1213.8	55+00	1216.1
15+00	1213.8	57+50	1215.7
17+50	1213.8	60+00	1216.3
20+00	1213.8	62+50	1216.2
22+50	1214.0	65+00	1216.1
25+00	1213.8	67+50	1216.6
27+50	1214.0	70+00	1216.4
30+00	1213.6	72+50	1216.5
32+50	1214.0	75+00	1216.9
35+00	1214.2	76+50	1216.5
37+50	1214.6	76+65	1216.4
40+00	1214.7		

John L. Sullivan
Construction Engineer

cc: Mark Eddington, Project Engineer, Chandler Construction Office

APPENDIX E

Subsidence Survey Data

and

Consolidation Estimate

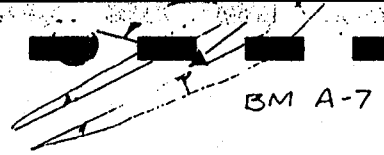
APPENDIX E

Subsidence Survey Data
and
Consolidation Estimate

The following data are from subsidence surveys taken February 1984 and July 1990. The change in the difference between "A" monument and "B" monument is calculated and may represent consolidation during the period between surveys.

Monument Number	2/84 Survey A - B	7/90 Survey A - B	"Apparent" Consolidation
1	10.097	10.072	0.025
2	18.920	18.875	0.045
3	21.584	21.533	0.051
4	20.181	20.155	0.026
5	23.080	23.055	0.025
6	24.434	24.384	0.050
7	18.498	*	*

*Monument A-7 reset.



Benchmark location
BM B-90
Basis for 1990 elevations
on WHITE TANKS No. 3
Elev. = 1280.682

WHITE TANKS SITE No. 3, 1990

A-1	1207.979
A-2	1208.267
A-3	1208.504
A-4	1209.204
A-5	1210.618
A-6	1210.880
A-7	1211.445 ← Reset 9/90

B-1	1197.907
B-2	1139.392
B-3	1186.971
B-4	1189.049
B-5	1187.563
B-6	1186.916
B-7	1192.294

1

12

13

24

SUBSIDENCE SURVEY

WHITE TANKS FRS, MARICOPA COUNTY, ARIZONA

JULY 1986

WHITE TANKS SITE NO. 3

No.	2/84	07/86	Sta.	No.	2/84	07/86
A-1	1207.397	1208.348	10+00	B-1	1197.300	1198.268
A-2	1207.652	1208.622	19+95	B-2	1188.732	1189.701
A-3	1207.864	1208.849	30+00	B-3	1186.280	1187.264
A-4	1208.529	1209.542	40+00	B-4	1188.348	1189.354
A-5	1209.898	1210.939	49+88	B-5	1186.818	1187.837
A-6	1210.102	1211.163	60+08	B-6	1185.668	1186.724
A-7	1209.927	1211.017	70+07	B-7	1191.429	1192.518

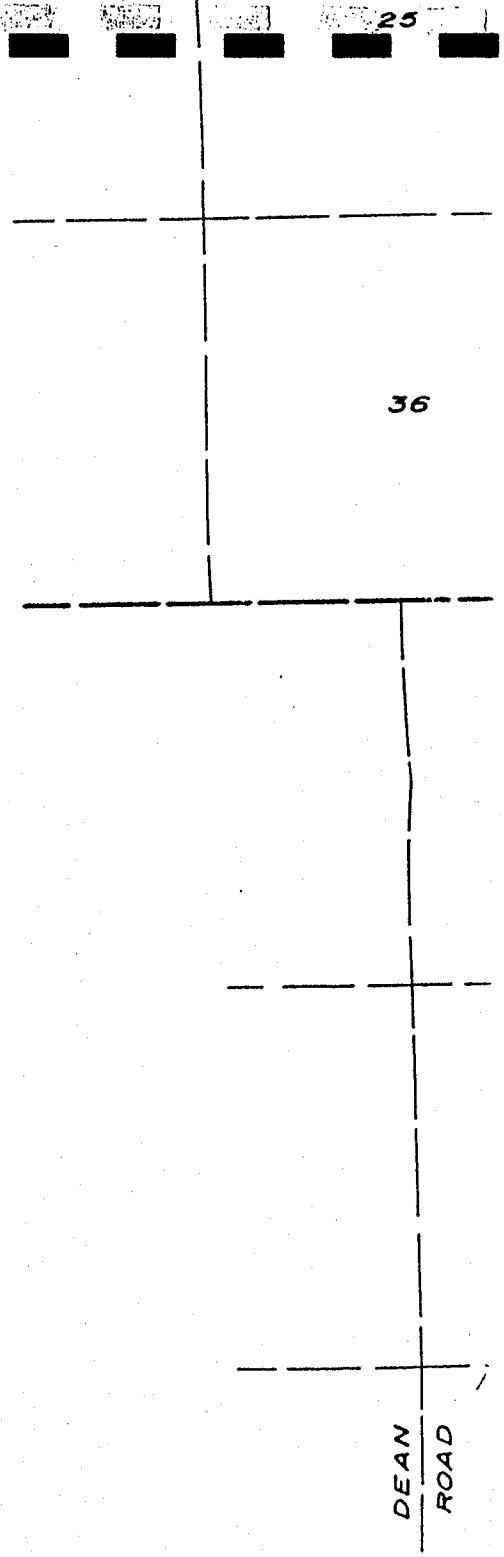
WHITE TANKS SITE NO. 4

No.	2/84	07/86	Sta.	No.	2/84	07/86
C-1	1050.766	1051.059	00+47	D-1	REPLACED	1046.492
C-2	1051.395	1051.666	10+00	D-2	1037.665	1037.935
C-3	1051.300	1051.596	19+62	D-3	1032.758	1033.022
C-4	1051.359	1051.642	29+59	D-4	1032.361	1032.609
C-5	1051.909	1052.182	39+64	D-5	1034.868	1035.132
C-6	1051.773	1052.045	49+68	D-6	1035.910	1036.165
C-7	1051.248	1051.498	59+87	D-7	1039.496	1039.749

	7/90
C-1	1051.112
C-2	1051.732
C-3	1051.649
C-4	1051.688
C-5	1052.243
C-6	1052.106
C-7	1051.570

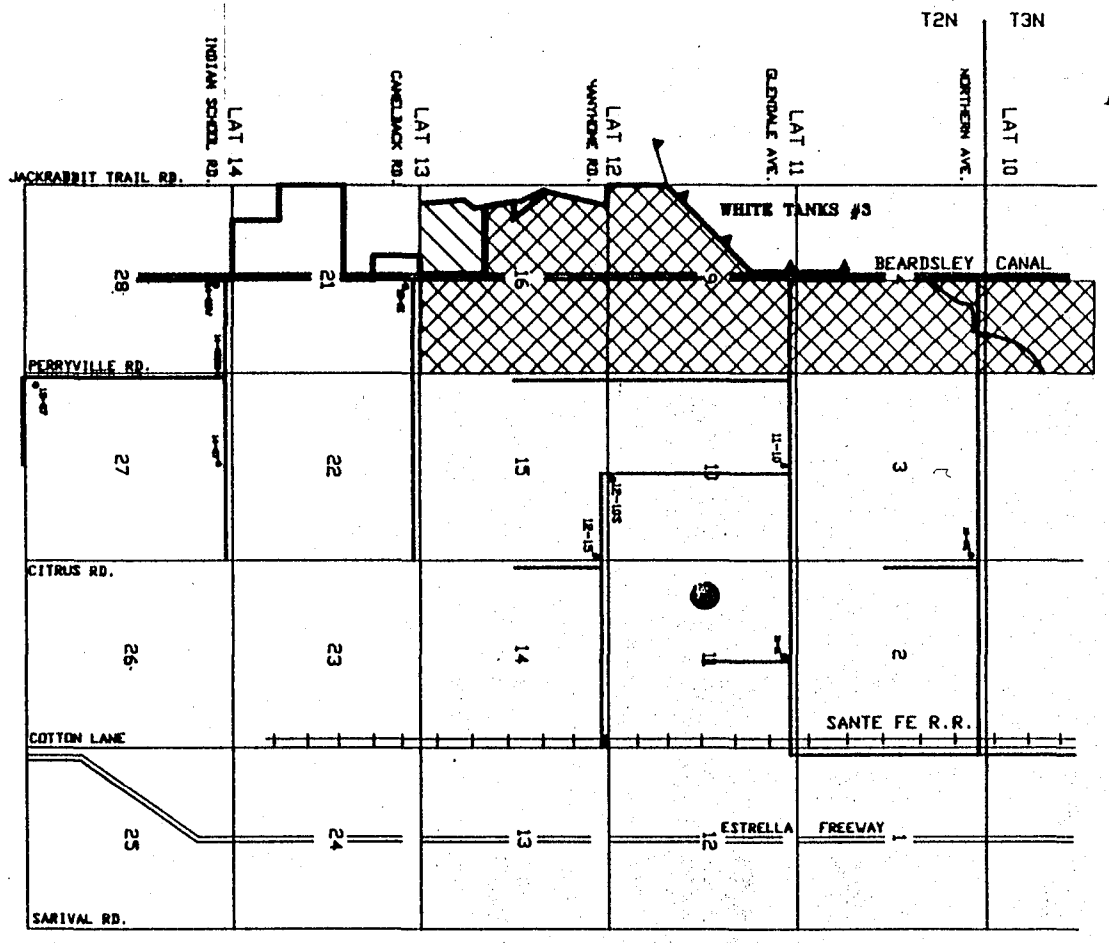
	7/90
D-1	1046.583
D-2	1038.022
D-3	1033.130
D-4	1032.714
D-5	1035.224
D-6	1036.262
D-7	1039.837

CTS ENGINEERING, INC.



APPENDIX F

Property Ownership

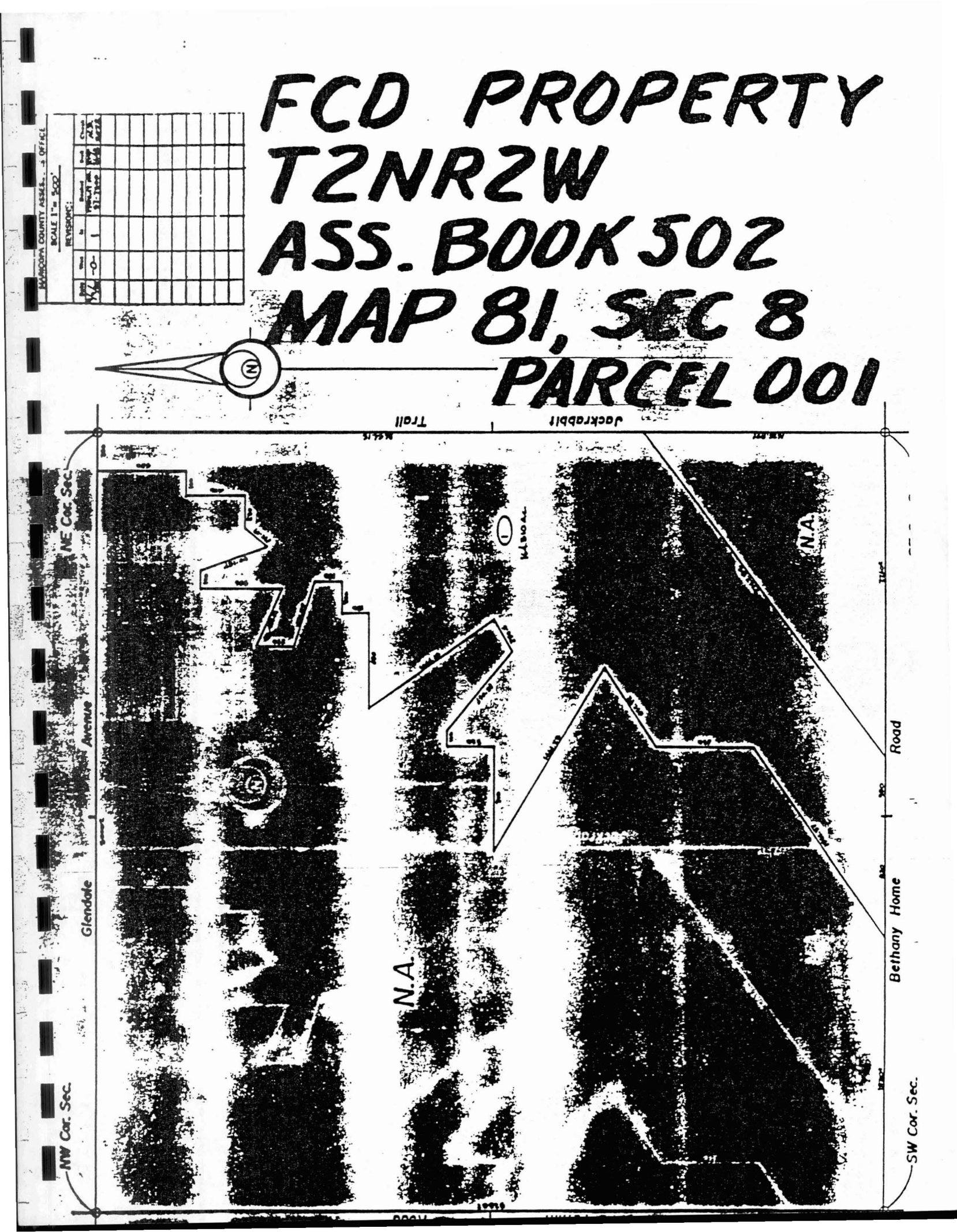


MARICOPA WATER DISTRICT LANDS

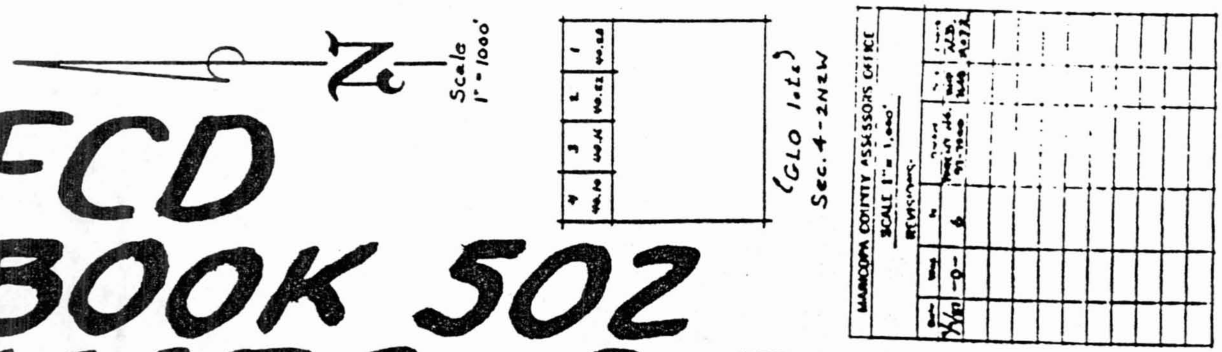
MARICOPA WATER DISTRICT LATERALS

MARICOPA WATER DISTRICT			
	NAME	DATE	SCALE: NTS
DESIGN:	GLV	6-4-91	DESCRIPTION: WHITE TANKS #3
DRAWN:	DLJ	6-5-91	
CHECKED:			DWG. NO. 1 OF 1

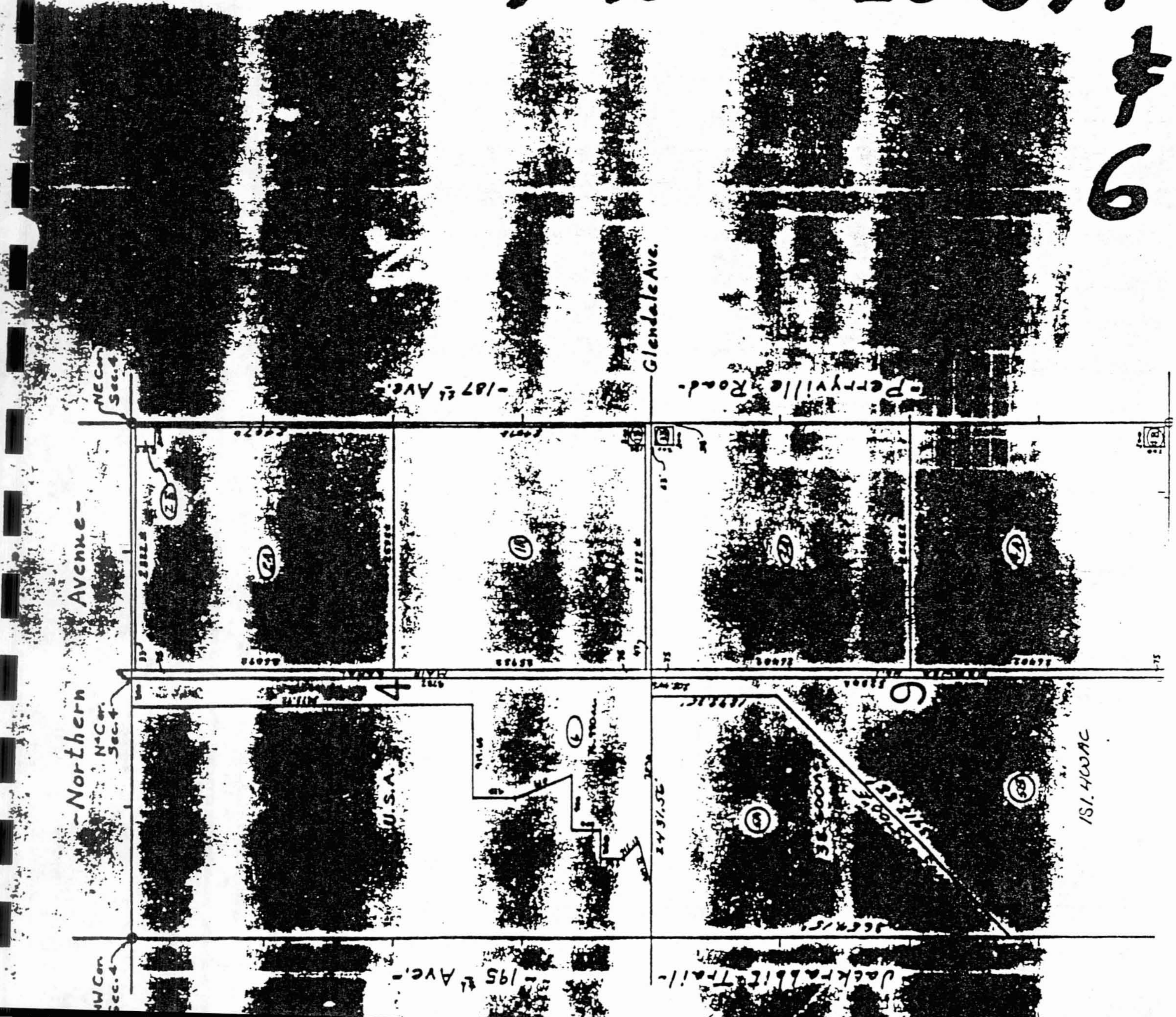
FCD PROPERTY
T2NR2W
ASS. BOOK 502
MAP 81, SEC 8
PARCEL 001



T2N R2W
SEC 4 & 9



FCD
BOOK 502
MAP 22, PARCELS 5A & 6



-22-00[redacted]	[redacted] PO BOX 730 PEORIA AZ85345				$0			.53[redacted]	317,[redacted]
	PROPERTY ADDRESS NOT AVAILABLE FROM ASSESSOR				$0			16.0%	$2,317,.
	M C M W C D I	4739- 093			$196,035	STATE		7900	$0
					$370,870	95 00		$0.00 90	$0
	9 2N 2W	(9 2N 2W) SE4 EX W 75' FOR CANAL & EX N 200' OF S 233' OF W 200' OF E 233' OF SE4 154. 53 AC							
-22-004B	PO BOX 730 PEORIA AZ85345				$0			.920 AC	$500
	PROPERTY ADDRESS NOT AVAILABLE FROM ASSESSOR				$0			16.0%	$500
	MARICOPA CO MUN WATER CON DIST NO 1	9072- 253	11-17-71		$80	VCT LTD OR NO DEV PT		7900	$0
					$80	00 85		$0.00 90	$0
	9 2N 2W	(9 2N 2W) N 200' OF S 233' OF W 200' OF E 233' OF SE4 .92 AC							
-22-005A	3325 W DURANGO PHOENIX AZ85009				$0			138.600 AC	$2,079,000
	PROPERTY ADDRESS NOT AVAILABLE FROM ASSESSOR				$0			16.0%	$2,079,000
	MARICOPA CO FLOOD CONTROL DISTRICT	10822- 9	09-10-74		$175,830	STATE		7900	$0
					$332,640	95 00		$0.00 90	$0
	9 2N 2W	(9 2N 2W) BEG NW COR SD SEC TH S 3654.15F TH N 45D 45M E 34 12.88F TH N 1293.35F TO PT ON N LN SD SEC TH W 24 31.56F TO POB							

K01

02-22-005 MARICOPA 1991

PARCEL	OWNER MAILING ADDRESS			SALE PRICE / DATE TI VC	PCL SIZE	TOTAL FCV
PROPERTY ADDRESS				PRIOR SALE / DATE TI VC	ASMT%	LAND- FCV
TITLEHOLDER		DKT-PG	REC-DATE	PRIM ASSESS LCIC DESCRIPTION	TAX AREA	IMPR- FCV
CONTRACT PURCHASER		DKT-PG	REC-DATE	SEC ASSESS LC IC	PROP TAX YR	TOTAL LIM
SEC TWN RNG GRID CENSUS ZONE	LEGAL DESCRIPTION					
-22-005B	PO BOX 730 PEORIA AZ85345			$0	181.400 AC	$2,721,000
	PROPERTY ADDRESS NOT AVAILABLE FROM ASSESSOR			$0	16.0%	$2,721,000
	MARICOPA CO MUN WATER CON DIST NO 1			$230,120 STATE	7900	$0
				$435,360 95 00	$0.00 90	$0
9 2N 2W	(9 2N 2W) W2 SD SEC EX BEG NW COR TH S 3654.15F TH N 45D 45 M E 3412.88F TH N 1293.35F TO PT ON N LN SD SEC T H W 2431.56F TO POB					
-22-006	3335 W DURANGO PHOENIX AZ85009			$0	76.990 AC	$1,154,850
	PROPERTY ADDRESS NOT AVAILABLE FROM ASSESSOR			$0	16.0%	$1,154,850
	MARICOPA COUNTY FLOOD CONTROL DIST	87-624561	10-08-87	$103,340 STATE	7900	$0
				$184,775 95 00	$0.00 90	$0
4 2N 2W	(4 2N 2W) BEG S4 COR SEC 4 W 2090F N 73D 10M E 449.22F N 45D W 212.13F N 230F E 280F N 300F E 580F N 21D 06M W 610F N 430F E 919.65F N 3472.92F E 250F S 5282F POB					
-23-001	111 W MONROE PHOENIX AZ85003			$1,915,250 08-01-85 WD	.000 AC	$50,000
	PROPERTY ADDRESS NOT AVAILABLE FROM ASSESSOR			$880,000 03-05-81 WD 03	16.0%	$50,000
	FIRST AMERICAN TITLE INS CO AZ TR 7221	85-360530	08-01-85	$6,190 VACANT, UNDETERMINED	7903	$0
				$8,000 00 04	$764.98 90	$0
	(L 4900) ROMOLA OF ARIZ 46 LOT 4900 A B C D E					
-23-002	111 W MONROE PHOENIX AZ85003			$1,915,250 08-01-85 WD	.000 AC	$50,000
	PROPERTY ADDRESS NOT AVAILABLE FROM ASSESSOR			$880,000 02-19-81 WD 03	16.0%	$50,000
	FIRST AMERICAN TITLE INS CO AZ TR 7221	85-360530	08-01-85	$6,190 VACANT, UNDETERMINED	7903	$0
				$8,000 00 04	$764.98 90	$0

SEC	TWN	RNG	CL	LEGAL DESCRIPTION						
502-80-001A				100 NE ADAMS ST ATTN TAX DEPT PEORIA IL61602		$0			200 AC	$1,600
	PROPERTY ADDRESS NOT AVAILABLE FROM ASSESSOR					$0			16.0%	$1,600
	CATERPILLAR INC			13003- 204	06-30-78	$169,600	VACANT, UNDETERMINED		9000	$0
						$256,000	00 04		$6,941.32 90	$0
	3	2N	3W	(3 2N 3W) SECS 3 10 11 12 13 ALL						
502-81-001				3335 W DURANGO PHOENIX AZ85009		$0			164.310 AC	$82,155
[redacted]	PROPERTY ADDRESS NOT AVAILABLE FROM ASSESSOR					$0			16.0%	$82,155
	MARICOPA COUNTY FLOOD CONTROL DIST			87-024561	10-08-87	$13,145	STATE		9000	$0
	FLOOD CONTROL DIST PATENT 57-7300					$13,145	95 00		$0.00 90	$0
	8	2N	2W	(8 2N 2W) BEG NE COR SEC 8 S 3654.15F S 54D 01M W 2767.85F W 1200F N 55D 41M E 1561.57 F N 650F N 57D 31M E 651.92F N 59D 34M W 1461.23F E 710F N 320F E 110F S 51D 28M E 690 .29F N 61D 23M E 250.60F N 36D 25M W 1044.03F E 650F N 180F E 220F N 180F TH N 72D 43M W 471.27F N 250F S 66D 15M E 437.01F N 556F E 120F S 20D 41M E 481.04F N 38D 39M E 19 2.09F E 230F N 400F E 160F N 580F E 280F POB				
[redacted]										
502-82-001				3335 W DURANGO ST PHOENIX AZ85009		$0			129.270 AC	$64,635
	PROPERTY ADDRESS NOT AVAILABLE FROM ASSESSOR					$0			16.0%	$64,635
	FLOOD CONTROL DIST OF MARICOPA COUNTY			89-475019	10-13-89	$9,410	COUNTY		8900	$0
						$10,340	96 00		$0.00 90	$0
	20	3N	2W	(20 3N 2W) PT SEC 20 KNOWN AS TR 2C & 2F PER MCR 63-31 DAF BEG NE COR SEC 20 S 674.41F TO NLY COR TR 2F & TPOB S 4049.09F TO COR TR 2C TH S 49D 44M W 852.94F TO S SEC LN TH W 1917.36F N 32D 29M E 633.76F TO NW COR TR 2C N 29D E 4648.43F TO TPOB					
502-99-001				2020 N CENTRAL AVE STE 170 PHOENIX AZ85004		$3,190,000	11-10-88 SD		319.000 AC	$15,950
	PROPERTY ADDRESS NOT AVAILABLE FROM ASSESSOR					$3,190,000	07-11-86 SD		16.0%	$15,950
	PIONEER TRUST CO TR 20797			89-320771	07-13-89	$2,550	VCT LTD OR NO DEV PT		9000	$0
						$2,550	00 85		$92.72 90	$0
	35	2N	3W	(35 2N 3W) /CLAIMS/ LUKE AUXILIARY 6 GROUP 2 CLAIMS EMBRACING SEC 35 2N 3W SE4 NE4 SW4 W2 NE4 SW4 NW4 SW4 LOTS 1 & 2 & LUKE AUXILIARY 6 GROUP 7 CLAIMS EMBRACING SEC 34 2N 3 W N2 SE4 LOTS 3 & 4 UNKNOWN DIST 319.00 AC					
503-01-001E				P O BOX 20790 WICKENBURG AZ85358		$0			46.440 AC	$46,440
	PROPERTY ADDRESS NOT AVAILABLE FROM ASSESSOR					$0			16.0%	$46,440
	R & B ENTERPRISES LTD PRTNRSP			87-030587	01-16-87	$7,430	VACANT, UNDETERMINED		0950	$0
						$7,430	00 04		$690.10 90	$0
	7	7N	4W	(7 7N 4W) BEG SW COR SE4 NW4 SEC 7 TH N 890.66F TO TPOB TH CONT W 435F TO SW COR NE4 N W4 SEC 7 N 1D 1326.40F TO NW COR NE4 NW4 SEC 7 E 1317.24F TO N4 COR SEC 7 S 1D W 1173. 12F W 76F S 56D 151.14F W 141F N 57 D W 130F N 82D W 34.15F S 61D 29.33F S 34D W 80F S 55D E 80F S 3D E 100F S 79D W 33F N 22D W 80F S 67D W 100F S 22D E 78F S 67D W 95F N 22D W 30F N 53D W 81F N 16D W 115F N 50D W 64.54F W 72F S 52D W 73.03F S 19D W 90F S 2 1D E 93F S 37D E 191.10F TH ARD CUR TO LT 132.65F S 22D 49M W 201.14F N 50D W TH ARD C UR TO RT 40.11F N 50D 13M W 358.42F W 114.06 TO TPOB					
503-01-001F				BOX 20790 WICKENBURG AZ85358		$0			29.934 AC	$29,934
	PROPERTY ADDRESS NOT AVAILABLE FROM ASSESSOR					$0			16.0%	$29,934
	SUN PARK CORP			85-477882	10-08-85	$4,790	VACANT, UNDETERMINED		0950	$0
						$4,790	00 04		$444.90 90	$0
	7	7N	4W	(7 7N 4W) E2 NW4 EX BEG SW COR SD E2 N 498F TPOB N 125F E 348.4F S 125F W 348.4F TPOB & EX DKTS 85-595733 & 87-030587 PAR A & EX PAR DAF COM NW COR NE4 SW4 SEC 7 TH S 240.4 3F TPOB N 56D 25M W 96.08F N 39D 47M E 330.11F N 36D 19M E 213.71F S 14D 57M E 275 .35 F S 100.30F S 39D 56M W 278.21F N 56D 25M W 182.03F TPOB					

[redacted]

TRW - REAL ESTATE INFORMATION SERVICES -

503-01-001

MARICOPA 1991