AMM ✓

CITY OF PHOENIX

STREET TRANSPORTATION DEPARTMENT

FLOOD PLAIN MANAGEMENT

WORK SESSION ISSUE LOWER CAVE CREEK FLOOD PLAIN CONCEPT STUDY

Z & H ENGINEERING, INC.
717 WEST DUNLAP AVE.
PHOENIX AZ 85021
602-997-7536

MEMO January 12, 1996

TO: Invited participants COP, SRP, FCDMC, ADOT, McGuckin, & Z&H

FROM: Jim Barr, Sr Engr, Z&H Engineering Inc

RE: Lower Cave Creek Flood Study Work Session
09:00 to 11:30, January 24,1996 in the West Conference Room, 5th Floor, Phoenix City Hall

The attached preliminary outline report on the subject study is for your detailed review prior to the work session. Please be prepared to discuss not only the engineering, but the practical and political aspects of the report in detail. This preliminary report reflects the author's current opinions and is subject to significant revision, primarily as a result of the work session. It does not at this time represent nor reflect official policy of any agency involved. It is our desire to identify and remedy the criticisms and weak points of the study now, not after completion. It should be noted that the recommended flood control method resulting from the study was not contemplated at the outset and your initial contact probably was oriented in an entirely different direction.

The report presents an innovative concept for reduction or effective elimination of flooding from less than 100 year events in a maturally developed area of the City. An open, receptive but skeptical mind is requested of the reader. The traditional storm drain solutions are so expensive and disruptive to a fully developed area, that there is much justified opposition to the construction of what should be a very beneficial development for the protection of the area's infrastructure and the lives of the residents. The recommended system is much less expensive and perhaps more importantly will result in very little disruption to the City or neighborhood, either during construction or later.

Very basically the suggested solution consists of modified recharge wells or infusers that remove only the short term peak flow from a flood while allowing the flow equal to a 1-2 year flood to continue using the existing storm drain system of gutters, pipes and channels. This allows the contaminated first flush of storm water from all storms to be carried away in the traditional manner, while capturing the short duration, high intensity peak of the large storms. This peak flow would be skimmed off the gutter flow and then receive primary treatment prior to infiltration and recharge of the ground water. Treatment consists of retention of floating material, settling of suspended material and absorption of floating hydrocarbons. The result is that scarce water is saved by recharging relatively unpolluted rainwater at approximately one fifth the cost of a storm drain system large enough to handle the very large short term peak flows. Maintenance of the system will be extremely minimumal since it will only be used less than 2 hours per year on the average and to capacity only once every hundred years. (Where did we come up w/ this?)

We are excited about being involved in an opportunity to bring effective flood control to developed areas of our City at a reasonable cost. We have appreciated the cooperation received to date and look forward to your further constructive comments and suggestions.

C:\PHXF\PRELCLTR.WP6

LOWER CAVE CREEK WASH FLOOD STUDY

DRAFT EXECUTIVE SUMMARY January 12,1996

Cave Creek Wash continues to represent a serious flooding threat to central Phoenix despite the diversion of the 100 year Cave Creek flood by the Arizona Canal Diversion Channel (ACDC) Project. This project reduced the ~~flooded area~~ below the ACDC from 16 square miles to 7, but the remaining area is still subject to flooding up to 10 feet deep from local runoff in the 25 square mile drainage basin. The present storm drain system was designed and will only control approximately a one to two year storm. The City of Phoenix instituted this project to identify means of effectively eliminating the flooding in the Lower Cave Creek Wash from the ACDC at Dunlap Avenue south to the Salt River and East from I-17 to approximately Central Avenue.

The annual cost of flood damage in the study area is difficult to assess, and the cost of lives lost is usually not even attempted. The U.S. Corps of Engineers estimated that the costs were $14,953,000 before the ACDC and $2,763,000 afterwards. Of this remaining portion, Lower Cave Creek probably represents more than 50% or over $1.4 million dollars. A second method of evaluation is the savings in flood insurance which would be approximately $2.7 million *** annually in the study area. This represents only the savings that could be realized in the FEMA designated flood plain where flood insurance is mandatory. These two approaches have provided a comparison and $1.1 million has been used as the annual savings that could be accomplished, with the remaining amount being considered essentially uneconomical to reduce further. At 5% interest and a 20 year life to the project this sets an economic cap on the project of about $20 million.

Meetings have been held with interested agencies and individuals to identify all feasible flood control methods for the area. Each method was analyzed for possible innovations and the best alternative methods compared first on the basis of construction costs including right of way, but not disruption to traffic, business or personal lives. Clearly only two of the principal alternatives can be justified economically as demonstrated by the results summarized in the following table:

	MILLIONS	
STORM DRAIN STANDARD PIPE	$59.22	Parallel pipes to limit size
STORM DRAIN CBC UTILIDOR	$55.14	Utilities accessible inside
GRAND CANAL USED JOINTLY	$54.09	Separate Irrigation and Storm Channels
DETENTION STORAGE BASINS	$35.59	With gathering storm drains
INFUSION WELLS FOR INFILTRATION	$18.40	No new storm drains required

The recommended solution is to install approximately 4000, one cfs, improved infusion wells at carefully selected locations to infiltrate the excess runoff. They are designed to complement the existing system and have the following advantages and characteristics:

1. similar "dry" wells have been successfully used for over 20 years throughout Arizona
2. they are completely unobtrusive, being primarily under sidewalks with only a curb inlet
3. they recharge our aquifer rather than wasting it, a much needed activity in a desert city
4. the initial flush of contaminated water, silt and debris flows on by down the gutters
5. water is treated before infiltration, by screening, settling, and adsorption of hydrocarbons
6. the first wells provide immediate benefit, versus the need to complete most projects
7. the project can be staged as funds become available
8. construction is localized and relatively unobtrusive and non-disruptive
9. destruction of existing infrastructure is very minor

Detention basins at Encanto Park and areas south of Dunlap along 19th Avenue are recommended as complements to the flood wells where extensive storm drain gathering lines are not required.

CITY OF PHOENIX

STREET TRANSPORTATION DEPARTMENT

FLOOD PLAIN MANAGEMENT

WORK SESSION ISSUE LOWER CAVE CREEK FLOOD PLAIN CONCEPT STUDY

Z & H ENGINEERING, INC.
717 WEST DUNLAP AVE.
PHOENIX AZ 85021
602-997-7536

LOWER CAVE CREEK WASH FLOOD STUDY
MITIGATION: ARIZONA CANAL TO SALT RIVER

JANUARY 12, 1996

Note: This preliminary outline report reflects the author's current opinions and is subject to revision. It does not reflect official policy of any agencies. Items needing further confirmation, references or refinement are marked ***. All amplifications, comments, corrections, suggested modifications or information would be appreciated.

DISCUSSION OUTLINE

For Work Session involving COP, FCDMC, SRP, ADOT, McGuckin and Z&H

A. PURPOSE OF THE STUDY (IDENTIFY AND DEFINE THE PROBLEM)

1. Cave Creek presented a serious flooding hazard to the inhabitants of its floodplain in the City of Phoenix. This threat has been largely eliminated by construction of the Arizona Canal Diversion Channel (ACDC) and upstream flood control dams, but the continued designation as a flood zone of a considerable portion of the original flood plain and flooding from local storm runoff, is seriously hindering development in the area. The City of Phoenix would like to remove the threat of flooding in this area if it can be accomplished within a reasonable budget.

2. The project area is shown on the Project Map (page 2). It involves the area south from the ACDC to the Salt River channel and from I-17 to Central Avenue; plus the area from I-10 south to the Salt River from Central Avenue to The Squaw Peak Parkway; and an area southwest of the Durango Curve on I-17 to 53rd Avenue.

3. Conversion of irrigated farmland to urban development, without construction of the infrastructure to support the change, has caused many problems.

4. The ACDC and existing storm drains have reduced but not eliminated flooding.

5. Cave Creek Wash downstream of the Arizona Canal (AC) has been developed with only minor (2 year or less) storm drain facilities, subjecting it to both local and stream flow flooding. Flooding south of the Grand Canal will vary in the designated flood plain from 0 to 10 feet in depth for a 100 year recurrence interval flood.

6. Flood Insurance is mandatory in areas designated on published Flood Insurance Rate Maps (FIRM's) by the Federal Emergency Management Administration (FEMA) as subject to flooding. FEMA uses as the basis of their designation a recurrence interval of 100 years; or more accurately, a 1 percent probability of a flood of that magnitude occurring each year. It should be noted that weather is cyclic, not random, and therefore large events are most likely to occur in groups rather than nicely spread at the statistical intervals. In addition, the Salt River Project reports that their tree ring studies indicate the last 70 years have been the

wettest in the last 700 years. (?)

7. Flood insurance payments could be better used to prevent flooding than repairing flood damage on structures still in the flood plain.

8. In desert areas with long intervals between major floods, deaths, serious damage or lawsuits usually must occur before flood control is taken seriously. By who, public or govmnt?

9. Serious flooding occurs when depths exceed 3 feet, since lives and most buildings are threatened at this depth. (flowing water, depth/velocity is important. Ponded water, even less than 3 ft).

B. HISTORY OF FLOODING & CONTROL MEASURES

1. Minor flooding occurs due to local runoff in the study area after almost all ~~storms~~ rainfall events. Refer to the frequency of flooding complaints tabulation in the appendix.** The study area although in the heart of the City, is not a minor drainage basin, but at nearly 25 square miles must be considered seriously.

2. Serious flooding has happened many times in the past with the most recent being in 1963 Maryvale 1972 and 1992. (See report excerpts).

3. Three major canals cross the study area. These canals were ~~built~~ re-built (Hohokam Canal alignments) over the last century to provide irrigation water for the farm lands laying west of the intake areas on the Salt River. As the area has developed, they continue to be used, but for slightly different purposes. In addition to agricultural use, they now supply water for residential and commercial irrigation and provide a substantial portion of the area's drinking water. The ~~RID~~ Roosevelt Irrigation District (RID) canal provides conveyance for treated wastewater to be used for irrigation in the Buckeye area. The necessity of maintaining grade for proper water flow results in the canals intercepting ~~all~~ most drainage channels along their routes. Except for those few channels that are bypassed under or over the canals, flood waters pond north of the canal berms and, after overtopping, pour into the canal. This large influx of water during major floods far surpasses the canal's capacity and results in a "dam break" event when the south bank is overtopped. This may occur directly opposite the inflow from the north, but storm inflow into the canals can cause overflows at locations often some distance downstream. In the 1972 storm, inflow was chiefly at Indian Bend Wash, but major flooding from the AC occurred west to I-17. ? It often results in more flood damage than if the canal had not been there. This chain of events places the canal operators, particularly SRP, in the unwanted business of storm drainage.

No necessarily, it could be argued that @ some specific frequencies, Canals may help reduce the flooding.

4. The flooding from a 100 year event would be substantially greater than any flood in recent years. (See FEMA FIRM's). in the study area.

5. The ACDC project reduced average flood depths to under 1 foot upstream of the Grand Canal, but even there depths of 3 feet or more can be expected in the worst locations.

6. FEMA reclassified the area (which area) as Zone AH, after a long series of letters and reports. They agreed that their interpretation of shallow flooding was incorrect as it included average depth areas between 0.51 and 1.00 feet and the area was reclassified as Zone X. This did not reduce flooding, only the requirement for mandatory flood insurance.

7. The area south of the Grand Canal is subject to flooding up to 10 feet in depth from canal failures and local runoff south of the ACDC.

8. Several suggestions have been made that the FEMA floods are too large and overstate the seriousness of the flooding. However, review of the Cella Barr study for the FEMA classification of Cave Creek south of the ACDC indicates that if not for the allowance made for on-site storage and the existing storm drain system (basically a 1 year storm system), the runoff from the 24.65 square mile basin would be 3-4 times as large as computed. In addition, recent storms indicate that the rainfall intensities that have been used are probably less than 100 year values. This is apparently being confirmed in the new precipitation-frequency values being developed by the National Weather Service.

9. Complaints and lawsuits have been filed in the past and all of the agencies involved would like to eliminate or reduce the problem prior to a serious event.

C. CANAL WATER SOURCES AND OPERATION

1. Summary of SRP Canal flows. The canals have been considered as desirable and convenient storm drains by those outside of the Salt River Valley Water Users' Association (SRP) and conversely as not involved at all in storm drainage or flood control by many within SRP. As in most such situations, neither view is correct nor universally held. The canals by their construction and location are directly involved in runoff. All water that flows from upstream down to the canals finds its passage blocked by the canals since they basically run perpendicular to the drainage ways. Unless the water is conveyed over or under the canal in a drain, it has only two choices; infiltrate upstream of the canal or flow into the canal. During our summer thunderstorms, the runoff hydrographs are so steep and short that most of the runoff now ends up in the canal. SRP does not want it there since it introduces contaminates, trash and weeds to the irrigation water, it damages the canal and increases maintenance, and most importantly it causes overflows and washouts. A brief study of the pipes and spillways entering both the AC and the GC as shown in the SRP Water Transmission System 1995 Water Operations booklet, demonstrates that the storm water that can enter the canals through actual storm drain outlets to the canals significantly exceeds the canals' capacity. Pipe flow into the Grand Canal from the OCC to I-17 will equal 250 cfs, and the 10 spillways will easily exceed the remaining 500 cfs capacity. This is without even considering sheet flow and spillage into the canals for the balance of their length.

   a. Arizona Canal. Peak flow capacity of the canal in the study area is 650 cfs from the Squaw Peak Treatment Plant to I-17.
   Storage Volume in the canal will almost certainly be utilized by upstream inflow from areas to the east of 40th Street.
   Inflow into the canal is quite well controlled in the study area due to construction of the ACDC immediately upstream (north) of the AC. However east of 40th Street, this is not true with the entire Arcadia area largely discharging into the canal. This large runoff poses a serious hazard to the balance of the canal system. A design project for the FCDMC is currently underway to provide a solution to this drainage problem.
   Inflows from storm drains and sheet flow from the study area are impractical because it would have to be gathered and pumped up into the canal even if it had the capacity.

b. Grand Canal Overflow.
Peak flow- The capacity of the canal in the study area is 750 cfs from the Old Cross Cut Canal east of 44th Street to I-17.
Volume- The capacity of this canal also will be greatly exceeded by the storm drain inflow pipes discharging into it during a 100 year storm.
Inflow from upstream storm drains, AC overflow and sheet flow in the study area is a serious problem. Many of the storm drains need to be carried across the canal and connected to storm drain trunks downstream to prevent overtopping and failure of the canal banks unless a better solution is found.

2. Normal SRP Canal Operation

a. The Arizona Canal is fed "ordered water" from Granite Reef Dam and in turn supplies the Grand Canal (GC) chiefly through the Crosscut Canal (CCC).

b. The Grand receives a small percentage of its flow from the Indian Bend Pump Ditch (1400 miner's inches = 35 cfs).

c. Maintenance is currently performed primarily in the dry during annual dryup periods in the winter months. Maintenance in the wet will be used more in the future, but there will probably always be a requirement for dryup periods.

d. The Old Crosscut Canal (OCC) automatically bypasses flow under the GC but some flow can be manually diverted into the GC (100 cfs).

3. Operation during flooding conditions.

a. Currently flood operations are controlled from the central office with most gates having both remote and manual operation capability.

b. The Meteorology Section monitors conditions, ~~such as hurricanes~~, and alerts Operations with recommendations. Interties with FCDMC's flood warning system will increase in the future. If Sky Harbor reports more than 1/4" of rain, Operations calls in personnel and takes the actions required by the storms severity.

c. Much of the western part of the system is supplied with electricity by APS. When power is lost during a storm both SRP and APS could be liable for damages , so SRP must continue to plan for manual operation. Since it takes a minimum of 30 minutes before a full crew is available and another 4 hours (10 miles) of water travel time from CCC to the project area, a different system would be required for effective flood control.

d. The Crosscut Canal is about 18 canal miles from the Granite Reef Intake, so water discharged into the AC system will take 6-12 hours to reach the CCC. Response time is therefore too great for inlet control to be effective in flood control, at least for summer storms. Anticipation of a storm based on forecasting could, however, reduce wasted spill water.

e. The design capacity of the AC, which includes all ordered water for the AC, can be spilled at the CCC (automatic Joint Head Drain Gates) and OCC (manual gates at present). The AC capacity is 1600 cfs, with the CCC capacity at 650 cfs and the OCC at 1000 cfs. No water from the AC is currently spilled into the ACDC expect at the outlet works. Some water can be discharged from the GC into City storm drains such as at 32nd Street (50-75 cfs), but this must be done prior to or after the local runoff peak or flooding may be increased in the area drained by the storm drain. ✓

f. Spillways are spaced along both canals that should bleed off flood water ~~in~~ from the canal prior to overtopping and washout of the canal bank. These spillways have caused local flooding downstream in the past and were not effective in stopping overtopping and washout during the two big storms., but may have somewhat controlled overtopping.

g. Except for the ACDC area, the areas north of each canal discharge into the canals either by sheet flow or from the many storm drains that are connected. Only small amounts are conveyed under or over the canal. (IBW?) , IBW collector channels

h. This brings first flush water into the canals, which is objectional for irrigation. This first flush water contains hydrocarbons and other pollutants that the water users do not want on their property. The Clean Water Act also objects to this practice because of ground water contamination.

i. A court decision in the early 1970's*** determined that the canal served as a dam, ponding water on the upstream side and providing protection for the downstream properties. (This has precluded using over or undershoots without storm drains to convey the flow downstream, even though this would reduce the damage to the property south of the canals during very large storms.) Does not make sense!

j. Some areas north of the canals are lower than the flood WS in the canal, so during flooding, water can back up onto these properties through storm drains or bank cuts. ✓
from the canals

k. At 75th Ave. and Camelback, large local runoff inflows have been observed during storms. (out of the study area)

3. Proposed Changes or Improvements in Operation

a. The new OCC is being designed to handle an additional 990 cfs at Indian School Road to handle the storm flow from the Arcadia area. A larger capacity is needed.
SRP has always had the right to dump 1000 cfs, increase to 1990.

b. The AC discharges a maximum of 625 cfs into the ACDC near 75th Avenue.

c. The GC discharges up to 288 cfs into the New River at about 100th Avenue.

d. The October 1995 storm effectively reached the capacity of the AC & GC. They were within inches of overflowing. This was only a 5*** year storm. (where, southwest Scottsdale?)

e. FCDMC through Amir Motamedi and Don Rerick have opened discussions with the USCE regarding dumping of AC excess into ACDC. Current indications are that the

ACDC is designed for 6700 cfs @ Cudia City Basin. Flows from the Cudia City wash @ Q_{100} is 6700 cfs. FCD asked to use the excess capacity when flows are less than 5700.

USCE would allow dumping only under conditions that would not adversely effect the operation of the ACDC. The main topic of discussion was regarding outflow from the Arcadia area however. The USCE indicated that the ACDC was designed for 6700 cfs at the entrance near 40th Street, but that the peak flow from the Cudia City Wash area (Paradise Valley) was about 5700 cfs. The FCDMC wanted to use this 1000 cfs for Arcadia. The USCE indicated that this capacity was needed downstream for other inflows, but if the FCDMC could demonstrate that there was excess capacity at some point, it could be used.

wrong!

f. SRP would like to change to as much wet maintenance as possible.

4. RID Canal

The RID canal presents the same type of situation as the SRP canals except that because of its location near the downstream end of the flooded area it's impact is much less. The entire flow of the Cave Creek wash basin less the amount handled by the storm drain system must cross or flow down the RID canal. Because the flow is intercepted by I-17 and only very large floods impact the canal, very little attention has been focused on the problem. The relatively small size and rural orientation of the RID has also resulted in only a minimum amount of study being focused on the problems involved. The problem of upstream inflows of runoff into the canal does not exist for the Cave Creek area since the canal originates in the study area. The impact of Cave Creek storm flows on areas downstream is serious, however, because of the large peak flow involved. More attention needs to be given to control of storm inflows into and along the canal by RID as a general procedure.

D. RUNOFF FROM LOCAL RAINFALL

1. Peak flow in cfs

From actual storms the rainfall was higher than used in the FEMA study.

March 1978 flood - 15" in 7 days

June 22, 1972 flood - 5" in 6 hours (ref 7)

July 24, 1992 flood - peak 6.25" in 12 hours

Runoff was ***.

The FEMA study was based on a maximum rainfall of 4.04 inches in 24 hours. Almost all of this rainfall (75%) was computed to occur in 3 hours at the peak of the storm. This resulted in computed runoffs of 2230 cfs downstream of I-17, 2500 cfs upstream of I-17 and about 2200 cfs between Jackson Street and the Grand Canal at Indian School.

2. The volume of flood water represented by the runoff excess to the storm drains, is difficult to represent with a single number because of the attenuation caused by storage and travel time. For this study, (using) we have used a rate of 2400 cfs, which is near the maximum rate for the area times a two hour period or a total of about 400 acre feet. This is only 7.5% of the total rainfall for ~~the study~~ area. The balance is infiltrated, carried by the storm drain system, evaporated or attenuated by channel storage and travel time. Disagree strongly!!!

Volume is measured in in, ft³, Ac-ft, do we mean peak?

3. The storage volume required to reduce the flooding to streets and yards only will be assumed to be equal to the 400 acre feet because the small amount (200-600 cfs) that can be carried by the streets alone is a small safety factor.

4. Existing flooding problems

   a. Local rainfall related

      1). All neighborhoods in the study area have poorly drained local areas where flooding has repeatedly been reported. (ref to flooding reports***) Most of these areas are the result of runoff from upstream areas, so individual field investigation is necessary to determine the best solution for each location.

   b. Canal related

      1). SRP has had flooding problems near 27th Avenue and Camelback and would like the area from I-17 to 27th Avenue included in the study.

      2). The '92 storm washed the north bank of the AC into the canal. This type of failure results in a large surge of water from the storage area on the upstream bank and will usually cause overtopping of the south bank and subsequent flooding of downstream areas. Both banks of the canals need to be stabilized with spillways at strategic locations to prevent washouts

      3). The GC has problems from 16th Street to 27th Avenue, with heavy inflow that will greatly exceed its capacity during major storms and unstable banks.

   c. Runoff related

      1). The lowest areas through out the study area are inundated during even annual storms with depths from 1 to 3 feet. Some locations have relatively steep upstream street slopes changing to flatter slopes downstream. The deceleration of the water in the gutter at these locations causes it to jump over the curb and flood the property to the south. These specific locations need local storm drainage protection.

      2). The lowest areas of the east-west cross sections north and south of the GC and particularly those immediately north of the canal berm are flooded during moderate sized storms. Maximum depths of 3 feet in the low areas to 4 feet immediately north of the GC can be expected. These areas need general storm drainage to intersect the runoff upstream before it exceeds the carrying capacity of the gutters and existing storm drain system (if it exists at all in their area)

      3). The area along 19th Avenue between the GC and Durango is threatened with serious flooding during major storms. When the capacity of the GC is exceeded and it overflows the water will concentrate around 19th Avenue with maximum depths to about 4 *** feet. Major effort is required to protect these areas. Primarily the runoff north of the GC, including overflow from the AC, must be diverted into a storm system before it enters the GC. Other areas that inflow into the GC east of Central must be controlled so the capacity of the canal is not exceeded. Complete stoppage of flow down the GC at the CCC and OCC will also be required during all floods that exceed approximately the one year size.

4). The Durango curve area on the north and east sides of I-17 and including the depressed portion of I-17 represent a dangerous situation during very large storms (exceeding 50 years). During these storms when the GC is overtopped, the runoff backs up in the low area north of the freeway and spills into the freeway. When the capacity of the ADOT pumps is exceeded water ponds both on the freeway and to the north and east. This ponding will be approximately 8 to 10 feet deep and endangers lives of the occupants of the property and motorists on the freeways and streets. In addition, the property damage during such an event would be very substantial. This area needs both to have the upstream inflow reduced and controlled, and for the private property, a larger more clog proof storm drain outlet.

5). The area downstream of I-17 to the Salt River has a double problem. It is in both the Cave Creek Wash and Salt River floodplains. If drainage improvements are made in the study area that reduce the inflow to the Durango Curve area to significantly under the 50 year runoff value, this area will no longer be subject to Cave Creek flooding. It will then be evaluated as part of the Salt River flood plain, which although lower than the Cave Creek flood plain water surface, is still important. The raising of Roosevelt Dam and changes to the Salt River channel will result in lowering of the floodway water surface elevations for the Salt River flood plain. A study is currently under way by Michael Baker Jr. Engineering for FEMA to redelineate the Salt River floodplain. An unofficial approximate flood plain boundary is included in the appendix based on preliminary data from this study. **

E. FLOODING CONTROLS

1. Administrative & legal changes required for coordination or to eliminate insurance

   a. The correct definition for shallow flooding for FEMA flood plains has been agreed to between FEMA and the City of Phoenix in a previous study for the area between the AC and the GC. In simple terms, FEMA has agreed that the definition of shallow flooding is from 0.95 to 3.05 feet average depth for a cross section rather than 0.50 to 3.50 as was being used. In the area south of the GC, this means that mandatory insurance requirements could be lifted with less than full storm drain control. Probably most of the area could be removed, if there was no overflow at the GC.

   b. Local enforcement changes not taken into account by agreement for the Cella-Barr study could be enforced & flow reduction accounted for, but this would require lengthy and quite possibly non-productive negotiations with FEMA. Past experience indicates that this is not a productive approach.

   what are local Enforcement changes?

   c. Reduction of the drainage basin area because of diversion or storage changes in the upstream watershed due to construction has been suggested. No significant changes have been identified.

   d. Comparison of FEMA and ADOT hydrology was suggested, but no hydrology has been found for I-17. A general check against other hydrologic methods, including rational and envelope curves indicates that the FEMA runoff peak is only about one quarter of the total runoff peak if ponding, infiltration and the existing storm drains were not considered. This low percentage would indicate that little or no further reduction could be expected in the FEMA data. From an engineering standpoint, the probability of higher rainfall rates for small storms being suggested by the US Weather Service indicates that a restudy would show increases in maximum runoff rates, rather than a reduction. FEMA's policy is that the values resulting from a flood study become legal values when published and unless significant mistakes can be demonstrated in the original data, they will not normally revise the study without physical changes being made.

e. Limit control measures to those that cost less than the cost of damage as measured by the cost of insurance at present worth. The estimated annual expenditure for flood insurance in the study area is about $2,700,000***. For this report, a more conservative value of $1,100,000 has been used. At 5% interest, the present worth of these payments made over the next 20 years (minimum projected life of a drainage system) is about $20,000,000. The other inconveniences and damages associated with flooding would increase this amount, but for the purposes of this study the present worth of the insurance premiums has been used as the amount available for construction of drainage improvements to at least stop flooding of off street areas.

f. Assure that the method used by FEMA, SRP and the City for canal overtopping flow is realistic. Historical events must be considered in light of the changes that have occurred since the original study was made. Primarily these are the construction of the ACDC and Indian Bend Wash facilities and changes in the operating procedures of SRP on the canals. Future changes should include improvements in the Arcadia area and flood control works such as those recommended in this study.

g. FEMA is considering forcing all mortgage holders to carry insurance, if in a flood plain. This will force more owners to pay premiums than at present and increase the political pressure to take flood control measures. Changes in the tax structure to collect the costs of flood control and damages from the beneficiaries could have the same effect.

h. Cooperative use and funding from ADOT requires staff concurrence, district engineer support and ADOT board approval. For SRP, the concurrence for desirable well thought out proposals will probably be positive, but legal aspects may present serious problems.

i. Liability for flood damage is a serious problem for all of the agencies involved. They are considered to have "deep pockets" and there are many precedents on which to base a suit. The law suit of ***vs SRP in 19**, for instance, established a precedent that the landowners downstream of a canal had a right to expect the berm on the upstream side to serve as a dam backing up inflow and reducing the threat of their being flooded. In would appear that the court felt that the purchasers of property upstream that get flooded should have anticipated this, but the downstream owners can expect to be protected by a berm that was not designed as a dam.

2. Flood proofing of individual properties usually makes flooding of other areas worse.

   a. Raising or flood proofing buildings or lots is the most common approach and is recognized by FEMA as an acceptable solution. Generally all that is required is to raise the effected property 1 foot or more above the 100 year flood water surface. This obviously removes this area from the flood plain and thereby raises the water level in the balance of the flooded area and may flood areas that were not previously flooded. This is only a viable alternative from the individual's viewpoint, but not from the community's.

   b. Creating dikes to limit the flood runoff area would reduce the number of properties affected, but increase the severity of flood damage on those within the dikes. Practical problems of streets crossing the dikes also make this an unacceptable option from the standpoint of political fairness.

   c. Providing incentives for raising buildings to allow flood flow under them would be a feasible alternative if a large amount of new construction were planned. In this rather well developed area, that is unlikely in the foreseeable future.

   d. Provide assistance for flood damaged property could take several forms. FEMA has some programs that at least partially fund the purchase and removal of flood damaged buildings. These pieces of property then could be utilized for flood control measures rather than paying insurance for flood damage repairs over and over. Other options are largely local programs and work much better in areas where regular flooding occurs.

3. Lower the flood water surface elevation due to the Salt River

   Not enough effect to even mention

   a. A current FEMA study will calculate new flood zones due to Roosevelt Dam improvements. Flow reductions are expected to result in a 100 year flow of about 175,000 cfs at Granite Reef.

   b. This study will also determine the effects of channel improvements downstream of and adjacent to the study area. A preliminary copy of the Michael Baker Jr. topography for the river and approximate flows to be used by FEMA were obtained and approximate water surface elevations determined. (see map p.*** (not included)).

   c. Raising other dams and increasing storage would further decrease the water surface elevations, but significant changes in dam storage are not currently anticipated.

   d. Rio Salado projects and other channel improvements are very likely to effect water surface levels from the Salt River. Gravel removal from the effective river channel is the most economical method of flood control available. The cost to the community is limited to planning, permits, control and inspection, since the commercial companies provide all of the investment required. The community gets an additional benefit in lower prices for aggregate than would be required if obtained from other sources. Esthetics and environmental problems from dust, noise and visual aspects could be reduced at the expense of higher aggregate prices. Rio Salado type projects require that planning be thorough in advance so that the grading can be done prior to the scenic improvements. Both solutions could be combined at less cost for the Rio Salado, if a long term construction period would be acceptable.

e. The flood events of the Salt River & Cave Creek can be considered separately. They have different peaks both in the time to peak for a particular storm and to the time of year and type of storm. The lower Cave Creek watershed will be primarily effected by intense local summer thunder storms with very high peak runoff rapidly attenuated over distance. This type of storm affects the Salt River only slightly. The Salt River is primarily effected by large area winter storms that are remnants of hurricanes, with the worst storms those that drop warm rain on deep snow packs in the mountains. The large drainage area of the Salt requires a correspondingly large storm to create a major flood. Therefore the starting water surface for Cave Creek should be a dry channel in the Salt River. The FEMA study utilized a starting water surface elevation of 1011.3 or about 11 feet above the bed. However this only affects the Cave Creek water surface for less than 0.2 mi upstream. When changes are made and a new Cave Creek FEMA study is undertaken, the starting water surface should be revised. If the Cave Creek flood plain is eliminated of course this problem will no longer exist.

4. Reduce or eliminate Canal overflow from Arizona, Grand and RID canals. This is a necessity for all areas of the City downstream (south) of any of these canals. Local flood control measures are prohibitively expensive if each has to be designed to handle a major canal bank failure in addition to the drainage from the local area. Ignoring the danger merely places all of these residents in jeopardy.

a. SRP and RID canal management

1). Velocities in the irrigation canals are relatively low and the distances involved relatively high resulting in long delays between decisions and field effects. If closing the gates occurs after the rainfall has neared its peak, the response will be too late to assist in flood control. Therefore gates must be controlled based on storm predictions; an art more than a science. With the volumes of water involved and the need for water at downstream sites such as water treatment plants and crucial irrigation sites, over cautious operation can be nearly as expensive as no operation. Spillage of water (even if stored and repumped into the system) is expensive and often wasteful siiice many anticipated storms never materialize. If the community desires that irrigation canals be operated for flood control, then they have to accept the costs of wasted water.

2). SRP currently has in operation a storm alert diversion program. Reduction of irrigation water flow in the canals must occur early in a storm to be effective. They respond when either a major storm is predicted or when Sky Harbor weather reports more than 1/2 inch of rainfall. This system needs to be further improved, if it is to be successful in preventing overtopping of canals. Early response prior to the storm's occurrence is necessary. This requires improved forecasting either by the weather service or other entity. Additional use of the FCDMC's rain gages to provide immediate notice of rainfalls and tracking of storms through their system as well as by Weather Service radar tracking will be required. RID needs to implement a similar emergency system.

thought it was 1/4 inch

3). Automated gate control is already in use by SRP. RID needs to improve its system and additional safety needs to be built into both systems. One weak aspect that has been identified is the operating power and control system. In past floods these have failed and gates had to be opened manually. The time involved from identification of the storm to actual opening of the gate is almost always longer than the time for passage of the peak flow, thereby rendering the effort nearly worthless. Most of SRP's gates are currently dependant upon use of primarily APS overhead power. This power source is subject to interruption during major thunder storms as are phone control lines. Consideration needs to be given to a dual system with phone/radio control and power line/battery power for at least the CCC gate at the AC, the OCC gate at the AC, the Joint Head drain gates on the GC and the GC gate and sluice at the OCC. RID's system is much less automated and sophisticated than SRP's and response times are therefore much longer and consequently less effective. Although this doesn't materially affect flooding in the study area, it does increase the City's exposure to liability since the flood effects may be carried a considerable distance downstream in the DIR canal before overtopping and flooding other areas.

b. Eliminate storm water from the canals.

1). ACDC eliminated several major sources of storm water including Cave Creek and Cudia City Wash (Camelback Mountain and Paradise Valley) plus many smaller drainages that affected the study area.

2). The Indian Bend Project effectively eliminated that flow from the canal system.

3). That has left only the Arcadia area drainage as a major uncontrolled source of storm water that affects the Cave Creek area. Even this drainage could be largely controlled if the OCC was fully opened to take all of the water in the canal from the east. However, it should be noted that the OCC's capacity is not this large, so it would flood areas along it, particularly in the lower and flatter reaches. A strong argument can be made that this is the traditional path for this flood water and that it must be discharged there.

4). Flood water could be passed over or under the canals, but the threat of liability probably would require that storm drain capacity below the canal be at least equal to the overshoot capacity to comply with the court order.

5). Detention basins could serve to replace the upstream storage created by the canal banks.

6). In the RID canal, the problem is to eliminate Cave Creek flows. This study represents the next logical step in this process after completion of the ACDC.

c. Enlarging the canals downstream to serve as storm drains is viable since sufficient ROW exists. This is possible because the volume of storm water and size of channel required increases as more flow is continuously added downstream while the size of the irrigation canals decreases downstream as water is removed for irrigation and treatment plants along the way. However, canals are constructed to retain as much elevation as possible, while storm drains are most economical if the grade is as steep as practical. Joint use is also a problem because of trash and contaminates in storm water and differing priorities. For instance a severe storm restricted to the eastern system does not reduce the need for irrigation water in the western portion of the system. Joint use of the ROW in separate canals is covered under the next section.

d. A cursory comparison of available capacity with current needs quickly indicates that economics has already sized the demand to that available. What little excess capacity is available in some areas has already been far exceeded by the incoming storm drains and bank overflow.

e. Dumping of the excess flow from the AC into ACDC is being discussed by the FCDMC with the USCE. The talks were primarily oriented to Arcadia drainage. These talks should be continued but oriented to emergency overflow into the ACDC rather than south into developed areas. The evidence seems convincing that no allowance was made for additional drainage areas. A detailed analysis would be required, but if only emergency overflow of canal water were allowed it is likely that peaks would not coincide and the ACDC could be safely used.

f. Measures instituted should improve the canal water quality not degrade it. First flush storm water or approximately one year storm volumes should be carried off in storm drains and only larger amounts introduced into the canals. At present most of the drainage into the canals includes first flush.

5. Dual use of the canals or the ROW

a. SRP attorneys must approve any use of their system or property for storm drains to assure that their liability is not increased. A desirable project would result in decreasing their liability.

b. The canals could be widened or deepened, but water losses through evaporation or infiltration must be factored in.

Note: c. The ROW for the Maricopa Canal still exists along much of the GC east of 16th Street and could provide width for creating a Grand Canal Diversion Channel (GCDC) to a channel running south or continuing to the west. Explain

d. Utilize old irrigation systems of SRP and COP Irrigation Dept. including the Maricopa and Little Maricopa. Most of the Little Maricopa Canal ROW along Oak Street is unusable because many parcels have reverted to private ownership with buildings on them.

e. Vertical walled channels have proven to be easier to clean than sloping walled channels, in addition to having higher capacity in a given ROW, but involve a substantially higher first cost.

f. Enlarge and manage the Grand and RID canals to be storm channels. Consideration has been given to dual channels, combined single irrigation type channel or a combination storm drain channel with pumps for irrigation water removal. All are possible in the existing ROW. A pipe or pipes could be used for irrigation with an access road/bike trail over it. A diversion channel with vertical sides or a deep channel, would require fencing to limit liability from people falling into it. Sections of the DC could be used as a temporary channel to carry irrigation water while adjoining sections of the GC was being maintained (dryup). The water could then be pumped back into the GC downstream for continuous irrigation use resulting in some benefit to SRP. In addition, the DC could be used as equalizing operational storage rather than wasting water or acquiring storage area. The size of the pipe and open channel for both the GC and the GCDC would vary. The DC could start in a relatively small pipe or channel and then increase in size downstream; vertical walled initially, then sloping as ROW became less expensive. The GC could start as an open channel then change to a pipe or small channel as the capacity required decreased. In this report, the capacity of such a drainage project has been limited to that necessary to serve only the study area to permit comparison with other alternatives. If a GCDC were to be built, it should serve all areas to the west that have inadequate drainage, since additions to the capacity would almost certainly be less expensive than an alternate individual system.

g. Provision should be made for recapture of unused water from the irrigation tailwater system. Since the DC would probably be upstream of the GC to capture runoff, the tailwater would need to be conveyed over (or through) the DC to the GC.

h. Maintenance of a closed pipe system is generally less than for an open canal system. For example, maintenance has not been a serious problem in two large storm drain pipes in Tempe. They drive a golf cart through them for inspection while diverting all of the flow into the other pipe. Losses are reduced as well as algae and weed growth. The construction cost of equal capacity in pipes is much more expensive than open channels, whereas the ROW costs are just the opposite..

i. Lined canals of the AC & GC size have roughly cost SRP $1 million per mile to build which compares closely with the estimates used herein. ROW cost is not included in either figure.

j. Recreational use of the canal should be considered in conjunction with any use for flood control. This could include not only parallel trails for walking, biking and horseback riding, but possibly such rather exotic uses as canoeing, water skiing and boating as commercial or public park ventures.

5. Channelize the flow

a. Increasing the N-S street flow capacity by lowering the grade either uniformly or with an inverted crown has been considered both previously and in this study. There is strong objection to this from many aspects. The entire utility system within the streets would have to be reconstructed. Water depths would exceed the one foot that automobiles can drive through and therefore the City would be cut into sections with no east-west travel in the study area. Deep water at these streets could represent serious safety hazards to motorists and pedestrians trying to cross them during flooding.

Connection to cross streets becomes increasingly difficult as the flow is concentrated into fewer streets thereby requiring additional lowering to handle the flow. If only one street such as 19th Avenue were used it would require approximately an average depth of 5 feet. If there were a need for another north-south separated freeway, it could be lowered further and cross streets carried on overpasses. The cost of interchanges with these cross streets raises the project cost well above that for the other alternatives and no detailed estimate was prepared.

b. Use of I-17 as a storm channel has been suggested by several on the basis that at the 50 year flood level it already becomes a flood channel. Obviously, it is not the purpose of a freeway that is our major link through the city to be a storm channel. A quick look however indicates that the depressed section of I-17 is only about one half the distance to the GC. I-17 could have a box culvert built under one lane without disrupting many utilities as a better solution. SRP has about 6 inverted siphons south of the GC, but several of them are inactive and could be abandoned. Disruption of traffic would still be a problem, but should be considered if ADOT plans a new widening. The construction cost of the main trunk line would be approximately the same as the cost of the storm drain trunk line in the City streets since they are essentially the same length. Longer lengths of each larger size of pipe would be required for gathering lines, however because it would be on one side of the area. This increased cost would be offset by the reduced cost of utility replacement.

A joint outlet to the Salt River bed downstream should be considered to save costs while keeping I-17 open even at the 100 year flood level. It is possible to drain the freeway south to the river. I-17's low pt is at elevation 1047.5, with overtopping into Durango Street at 1057.5 whereas the Salt River bed is at 1040± two miles south and of course lower if the discharge point is downstream. If gravity flow is considered, back flow prevention of some kind will be necessary to prevent flooding of the freeway from a Salt River flood. The current water surface elevation at 19th Avenue for the 100 year flood is 1052.0 or 4.5' above the low point. This problem can be avoided, however by discharging downstream of 22nd Avenue where the 100 year Salt River water surface will be below the low point.

c. Enlarging and managing the Grand and RID canals as combination irrigation and storm drains is discussed above under canals. They could be dual channels, combined single at grade irrigation type channel or a storm channel type with pumps for withdrawing irrigation water.

d. Sharing of storm drains with ADOT for I-17 and/or I-10 would be a possibility except that the existing systems are already under sized for the 100 year flood. The I-17 system was designed for 250 cfs in a 108" pipe along the freeway to Salt River by pumping. I-17 has only been closed 4 times since it opened and last overflowed in 1972, but none of these storms were 100 year events. I-10's deep tunnel system was designed to handle up to a 50 year event by gravity flow. The deep tunnel system was chosen to avoid disrupting traffic on downtown streets. It uses helicoil drop shafts to dissipate the energy in the drop based on a design by Dr. Kennedy from the University of Iowa. They cost about $250,000 each, require less area than drop structures and have functioned well to date. Other possibilities that were considered include; the

South Mountain freeway which is not currently planned to connect in the study area, Grand Avenue elevated way is not likely to be funded soon. Increased flow through the existing system on I-17 by high pressure pumping was considered, but the current redesign of the system is already considering that for ADOT's use. Additional pressure pumping is probably not a feasible alternative for significant increases in the I-10 system capacity.*** ADOT probably would seriously consider use of either system for off peak discharge as long as their system was not degraded.

e. Construct a shallow channel from Durango to the Salt River along 27th or 35th Avenue. Both of these locations have lightly developed areas that could be used. This would effectively eliminate flooding from Cave Creek in the area to the west of the channel. Unless there are serious problems with the 27th Avenue alignment it would protect a larger area than the 35th Avenue alignment at about the same cost. The channel should be carried north to gather essentially all of the overflow from I-17. A more comprehensive alternative would be to drain the area northeast of the Durango Curve, but it has the problem of back flow since the ground is 1052.5 or only 0.5 feet above the maximum Salt River flood level at 19th Avenue. This could be controlled with a tide gate arrangement that only allows flow in one direction. The most maintenance free and least likely to fail are rubber Tideflex valves produced by Red Valves. They are however, very expensive, in the large sizes required here. A more economical solution would be to discharge downstream of 22nd Avenue where the water surface is less than 1047' in a manner that prevents the water at 19th Avenue from entering the channel.

f. Build a large storm drain system centered on 19th Avenue. The Salt River/Pima Indian Community is utilizing twin 10' diameter cast in place concrete pipes on 96th Street because of economy. The construction of such a system would highly disrupt the downtown for at least one to two years. Traffic would essentially be cutoff both along the route and across it. In addition, the utilities in the street would have to be moved and reconstructed and those crossing the street would require rerouting over or under the pipes. The inverted siphons required for sewer and irrigation lines always require increased maintenance. This is the conventional solution and has been used successfully both locally and throughout the nation.

g. ADOT used a deep tunnel for I-10 because of the economy of not disrupting traffic and utilities. It could be used for this system, since the scale of this project is large enough to justify the mobilization costs. The need for multiple inlets is a serious economical detriment at the estimated cost of $250,000 each.

h. An open channel is an obvious solution that is the normal one used for most drainage. However in an highly developed area such as this the cost of ROW becomes prohibitive. The estimated cost of $100,000*** per acre plus improvements and partial taking problems, results in a total of at least $500,000 per acre. With a width of roughly 100 feet and a length of 35,000 feet, the $40 million dollar ROW cost alone exceeds several of the other alternatives. Construction costs plus disruption of traffic, utilities and neighborhoods rules this alternative out unless there is a strong desire for a linear park similar to Indian Bend Wash.

i. Construct a major utilidor for use as SD, water, sewer, electrical, phone and communication in a half street section 20 feet wide by 10-12 feet high. This could be an attractive alternative if there was a need for major new utilities in the area. At this time the City has no indicated needs for any. The alternative must therefore compete on price alone against the pipe alternative. Pricing was based on standard ADOT concrete double box culverts to assure a close estimate. In practice the construction would probably be a single span either slip formed in place or prefabbed Utility Vaults for better utility. Total costs would be within a few percentage points of the standard box culvert for either of these alternatives with the prefab savings partially balanced by the extra cost of the clear span.

6. Storing and infiltrating rainwater has two major advantages in developed areas. Disruption of the general public is decreased and the aquifer can be recharged by using the water rather than wasting it. The disadvantages have been the need for land to store the water while it awaits discharge or infiltration and contamination of the ground water. Local storm runoff currently flows with no treatment directly into the Salt River where most of it is infiltrated into the local aquifers.

   a. Enforcing the retention ordinance to store all off street water is the least expensive alternative for the general public. Runoff would be limited to about 950 cfs which the existing storm drain system and the gutters could handle. Legally and politically there is serious question if the City government has the will required to enforce this regardless of the benefits. Never-the-less it is a factor that must be considered and even partial enforcement will reduce the flooding with no other construction and, as a complement to any of the other alternatives, it will reduce the required size and cost. The practical difficulty faced by FEMA in its study and by any other study is to make a realistic evaluation of such a policy's long term effect. The method used by Cella Barr and Howard Needles Tammen and Bergendorf for the I-10 drain was to survey the existing condition and use that for a prediction of the future. If that is applied in this case, it would require that actual field changes occur before changes in runoff estimates are formulated or accepted by FEMA.

   b. Storage due to existing control sections with outflow limited by street capacity has largely been incorporated into the FEMA study. A more detailed study probably would identify additional areas that will be flooded during a 100 year event and if so the maximum outflow and therefore the flooded area at the lower end of the area would be reduced. The net result would probably be only a slight reduction in total flooded area.

   c. Detention basins are a very viable alternative, if the storm drain must be built through developed areas, provided that there are areas that can be utilized for detention. In inner city areas, this mandates joint use; as open space, parking lots, parks, play fields, golf courses or other uses that can be disrupted for one to two days every few years. A map survey of the study area produced the list of large open areas attached in the appendix (Open Spaces in the Study Area p.**). There are probably others that are not obvious that could be used if innovation was applied. Of these, ten are particularly attractive because of their location: Park Central Mall parking lot, Encanto Park, the Coliseum parking, the area under the elevated portion of I-10 (ADOT already uses a small portion east of 19th Avenue for detention, but with increased use a geotechnical check would need to be made of column stability), El Caro Golf Course, three City Parks, Ottawa University and the areas subject to serious flooding north of the GC and I-17's Durango curve. The City could also buy and use flood damaged property such as 24th Avenue & Camelback, 26th Avenue & Verde Lane and north of the Grand Canal and Durango curve or other vacant property to create parks and storage basins. The City Parks and Police Departments have not been in favor of this, because of increased operational and enforcement problems. Continued decay of the area may create more problems however. The total area that could be utilized in these identified properties is about 14 times what is required. Therefore only a few or a portion of each would be required. Some thoughts on how different uses could be accommodated: mall parking lots are notoriously unfilled during and immediately after major storms. If compensating payments were made to the owners for 25 to 33% of their parking, open space and existing retainage area and the improvements made at public expense, mall owners may be surprisingly interested in a solution that removes the flooding from their access streets. Golf courses can have the rough and fairways lowered while leaving the greens (the most expensive portion) in place, The area under I-10 could be utilized for event and short term parking even if depressed for storage. The stability of the columns would have to be checked. The use of parks for dual use has been adequately considered and accomplished and should be utilized.

d. Infuser wells or super dry wells to replenish ground water. Contamination of the aquifer has been the main argument against dry wells in the past. If the dry well is properly located and designed as an improved version of the Maxwell or Stormceptor systems, it will provide both settling and retention of floating materials. Proper siting and design can bypass a one year storm (first flush) in the existing storm drain system and gutters and retain and infiltrate only the balance to maintain water quality. These dry wells could be located both on street and off as required to solve local problems. No payment for ROW is anticipated because the only off-street locations would be those that have been requested and ROW furnished by the owner. Objections are often based on reports of projects such as one by the U of A in conjunction with Pima County tried large dry wells 15 years ago at Ina Road in Tucson. They reported loss of infiltration, but these wells were operated using poorer quality water on a continuous basis with much higher rates than the proposed wells. The proposed infuser wells would only be used for about 2 hours per year on average. The resulting resting period provides a nearly full recovery of infiltration rates. This type of dry well has been in use for almost 20 years with very few failures even though most of them take all the runoff from the area served in every storm. Although we have had a report involving the raising of the water table at Central and Camelback, this is either a perched water lens or a unique problem. The basement of the building has been having trouble with a rising ground water table. It was 110' deep when built, but now is only about 45' or less. This appears to have been caused by a reduction in pumping from SRP and COP wells in the area combined with a wet period***. SRP meteorologists believe that the last 70 years have been the wettest period in the last 700 years based on tree ring studies. This indicates that the long term water table will continue to drop in the future as long as we continue to pump water at near current rates and don't recharge at greatly increased rates.

G. COMPARISON OF ALTERNATIVES

The five principal alternatives can be compared on the basis of cost, disruption, partial completion benefits and reliability. Cost of construction and right-of-way is compared in the following summary table. For more detail, refer to the individual alternative estimate sheets and the cost calculations in the addendum.

ALTERNATIVE PROJECT	COST $ MILLIONS	COMMENTS
STANDARD STORM DRAIN PIPE ALTERNATIVE	$59.22	Parallel pipes to limit size
CBC UTILIDOR STORM DRAIN ALTERNATIVE	$55.14	Utilities accessible inside
GRAND CANAL USED JOINTLY	$54.09	Separate Irrigation and Storm Channels
DETENTION STORAGE ON LARGE TRACTS	$35.55	With gathering storm drains
INFUSER WELLS DESIGNED FOR INFILTRATION	$18.40	No new storm drains required

On the basis of cost alone, it is clear that the Infuser well solution is the only alternative that has a likelihood of being funded. A comparison with the FCDMC budget for last year with a total of $45 Million and only $24 Million for construction out of $37 Million for the entire County's flood control Capitol Improvement budget indicates the scale of the projects.

The two storm drain projects would cause serious disruption in the central City for their entire construction period. The Grand Canal and detention projects would cause significantly less disruption because of smaller pipes and much of the work being done off-street. The Infuser wells represent the least disruption with only the drill and hauling equipment required at each site, many of which would not be on main streets.

The three storm drain alternatives would not produce significant benefits until they were completed to the north bank of the Grand Canal at 19th Avenue. The majority of the funds would be expended in this effort. Detention storage provides partial completion benefits as soon as the first (northernmost) storage is completed and local feeder lines installed. Each addition has additive benefits, not only locally, but on downstream to the River. The Infuser wells have a similar effect. The first Infuser well will provide some protection for the adjacent property as well as reducing the downstream flow. By selective location, the dry wells can be added to provide protection from any desired storm size with further protection added later.

All of the alternatives have proven to be reliable during substantial field experience. The least known solution is use of Infuser wells. These wells, however, have been in use since 1974 with over 17,000 constructed. They have been continuously improved, but we still recommend that a pilot project of 4-5 wells be undertaken to make further improvements and, most importantly, some cost reductions.

F. RECOMMENDATIONS.

Combination - subject to concurrence of FEMA

1. increase enforcement of the retention ordinance
2. make minor improvements to the storm drain system to handle 2 year storms
3. divert storm drain inflow over or under the canals wherever possible
4. agree with SRP and RID on improved operation of the canals for flood control
5. divert the Arcadia area storm flow into the OCC as soon as possible
6. coordinate all improvements with ADOT for both City & ADOT systems
7. reach agreement with the USCE on emergency overflow of the AC into ACDC
8. identify and proceed on the most feasible detention basins
9. immediately start a pilot Infuser well project of 4-5 wells
10. if pilot program is successful, install 3-4000 Infuser wells throughout the area

Where did this # come from?

REFERENCES

Other studies or reports referenced herein

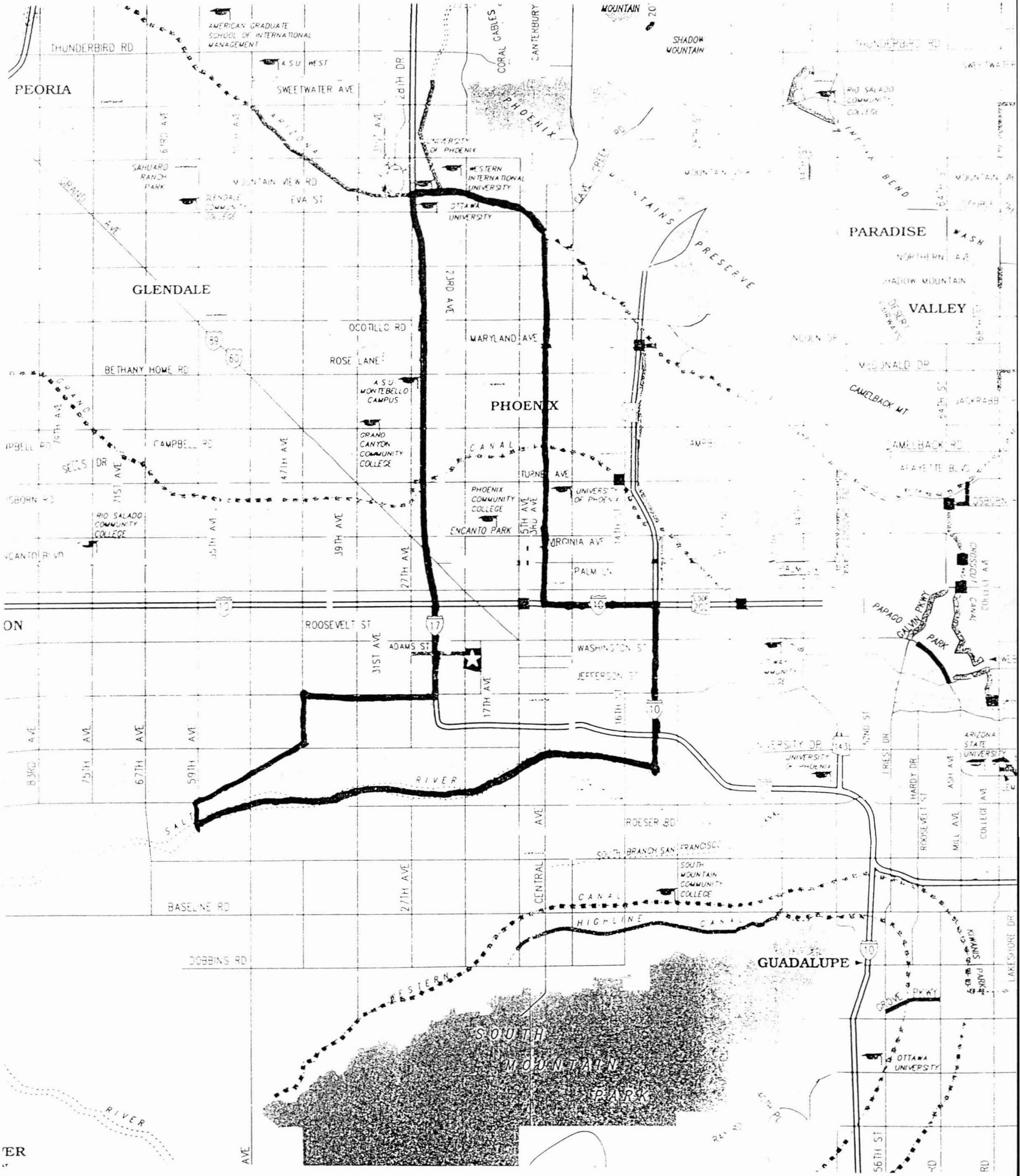
1. Proposed Metro Area Drainage Master Study, FCDMC
2. Cave Creek Wash Flood Insurance Studies 3 volumes, Cella Barr for FEMA
3. FCDMC annual report 1993/1994 and 1994/1995
4. Christown Mall Area Floodplain Study
5. 23rd Ave Storm Drain Route Study Report
6. February 1979 Flood Damage Report
7. Report On Flood of 22 June 1972
8. Preliminary Physical Suitability Study Solid Waste Landfill
9. System Maps by Salt River Valley Water User's Association
   1995 Water Transmission System
   1994 Zanjero Area Maps
10. Storm Drainage Report for Maricopa Association of Governments 1970 by Yost & Gardner Engineers
11. The Maxwell IV by McGuckin Drilling

A pilot project is recommended to refine the concept design of the infusion wells from the adaption of dry wells as currently used. A four well project is recommended with each well incorporating improvements identified in construction and testing of the previous well. The project should identify and refine methods for controlling the input quantity, limiting input of debris, silt and floating hydrocarbons; settling of sediment, screening of floating debris, removal of hydrocarbons and other contaminants, detection or bypassing of spills, cleaning of debris and sediment, location of individual wells, reduction of traffic obstruction including hauling of removed soil and materials to be installed, construction materials, construction methods, design details, efficient sizes, identification of experience and equipment required for the highest quality infiltration, qualification of the factors involved in determining the depth required for maximum infiltration efficiency, analysis of the most practical hydraulic analysis for locating and assessing the effects of individual flood wells, agreement with FEMA on the requirements to gain revision of the flood plain designation, coordination with ADEQ and thus NPDS to assure acceptance of infiltration through the final designed wells and preparation of construction specifications. DWR approval?

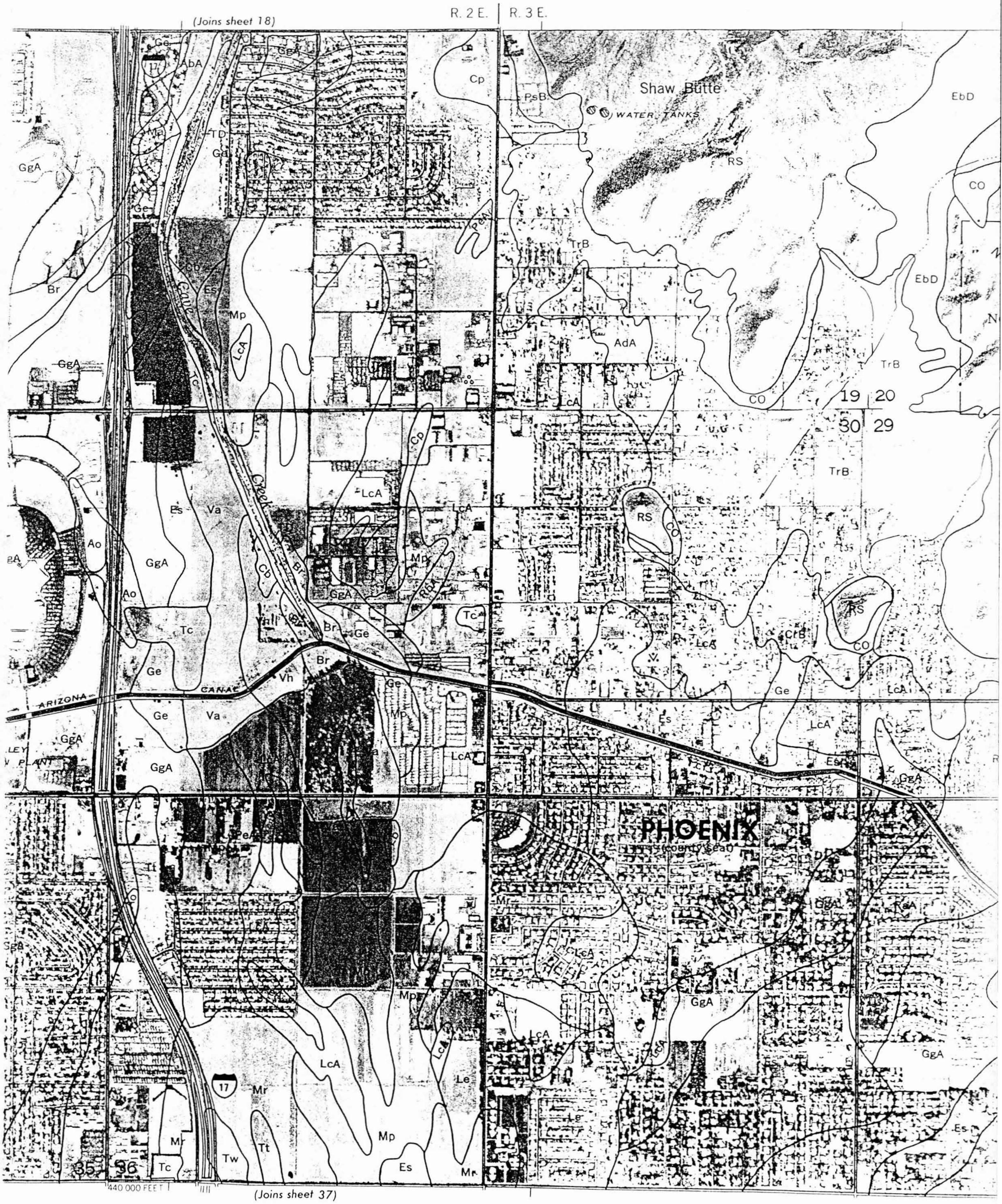
ESTIMATED UNIT COSTS PER WELL

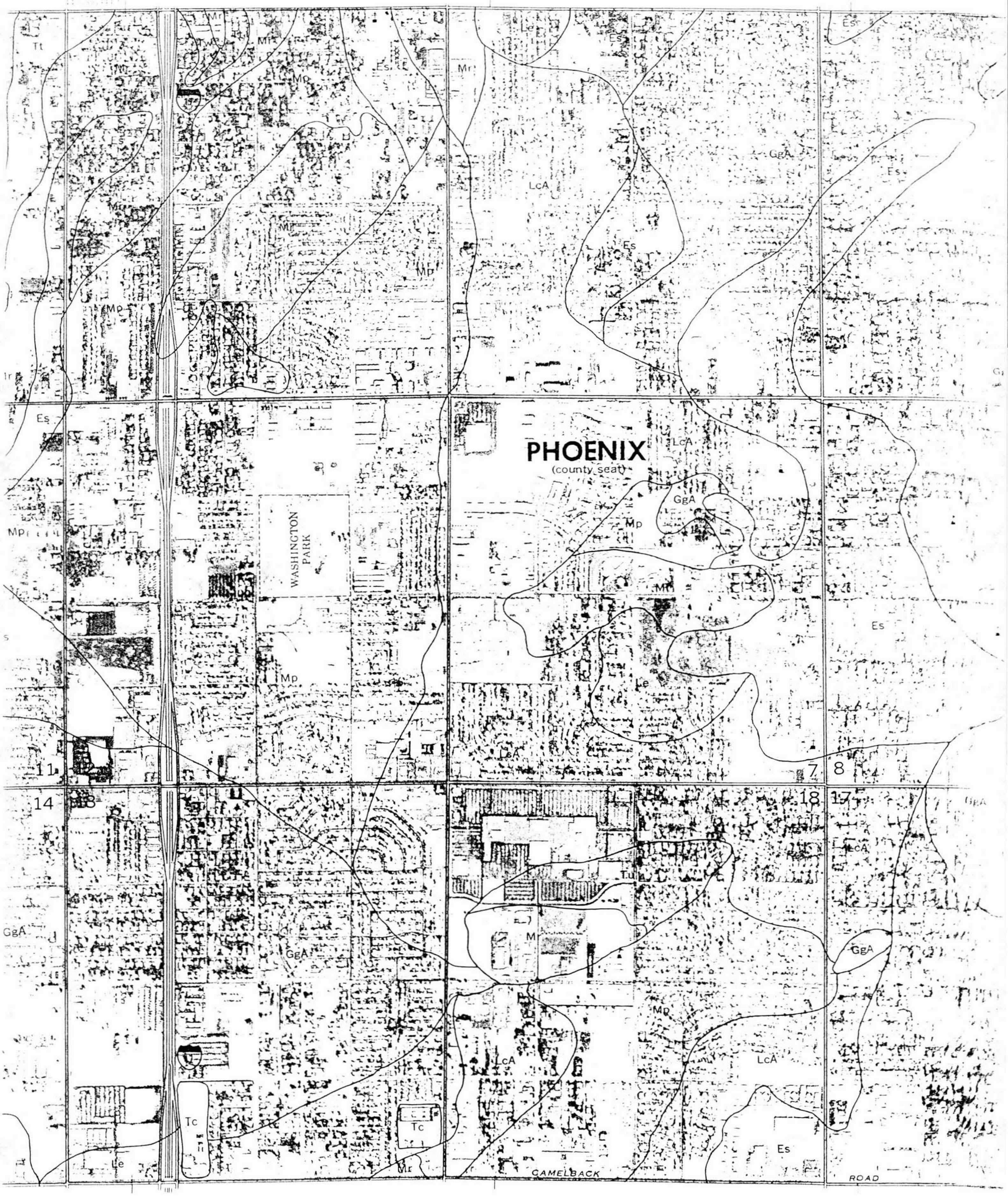
ITEM	DESIGN	CONSTRUCTION	TOTAL
test flood well	$4000	$6000	$10000
Final design & location	$175		
Specifications	$125		
Construction & inspection	$200	$3500	$4000

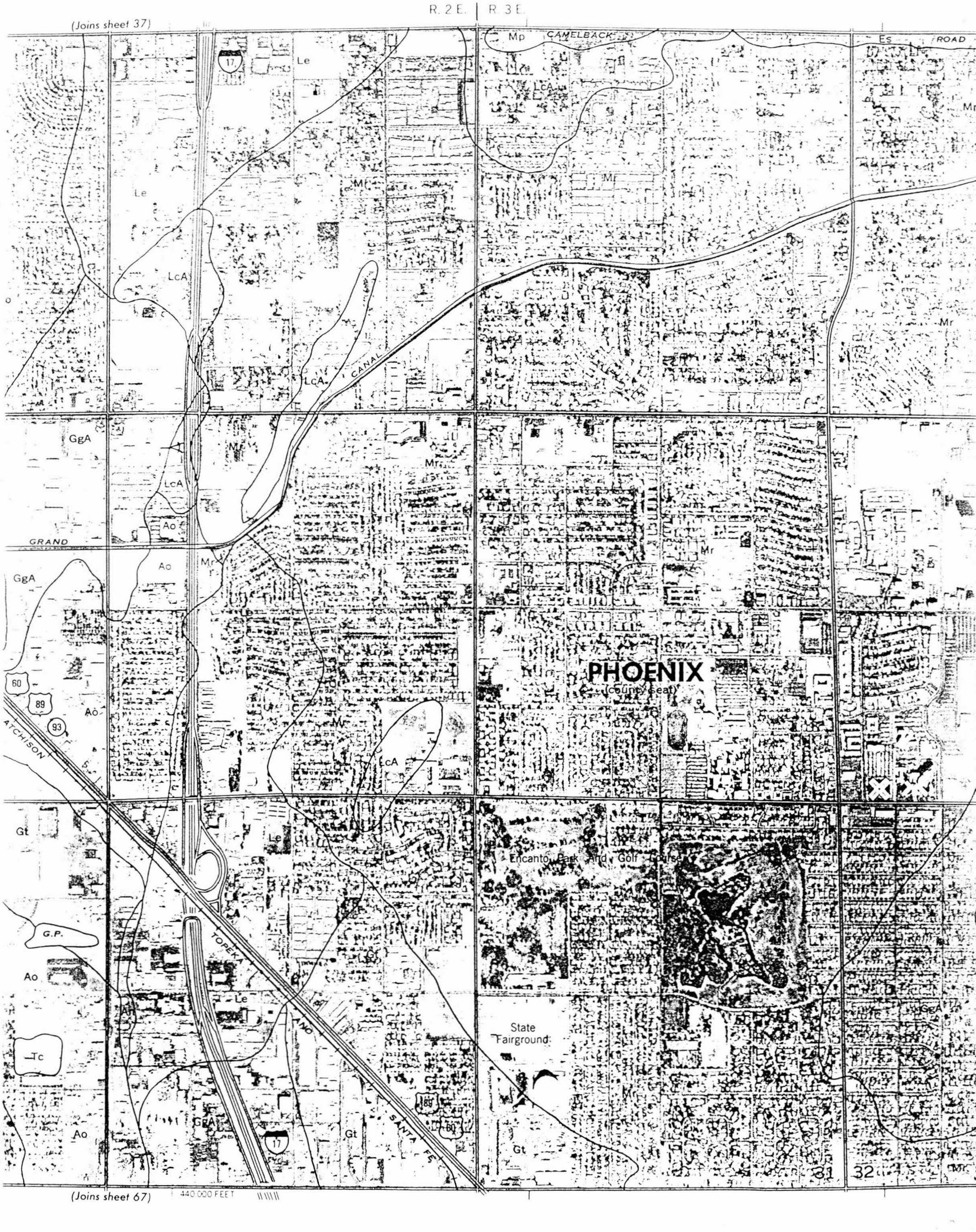
maintenance cost?

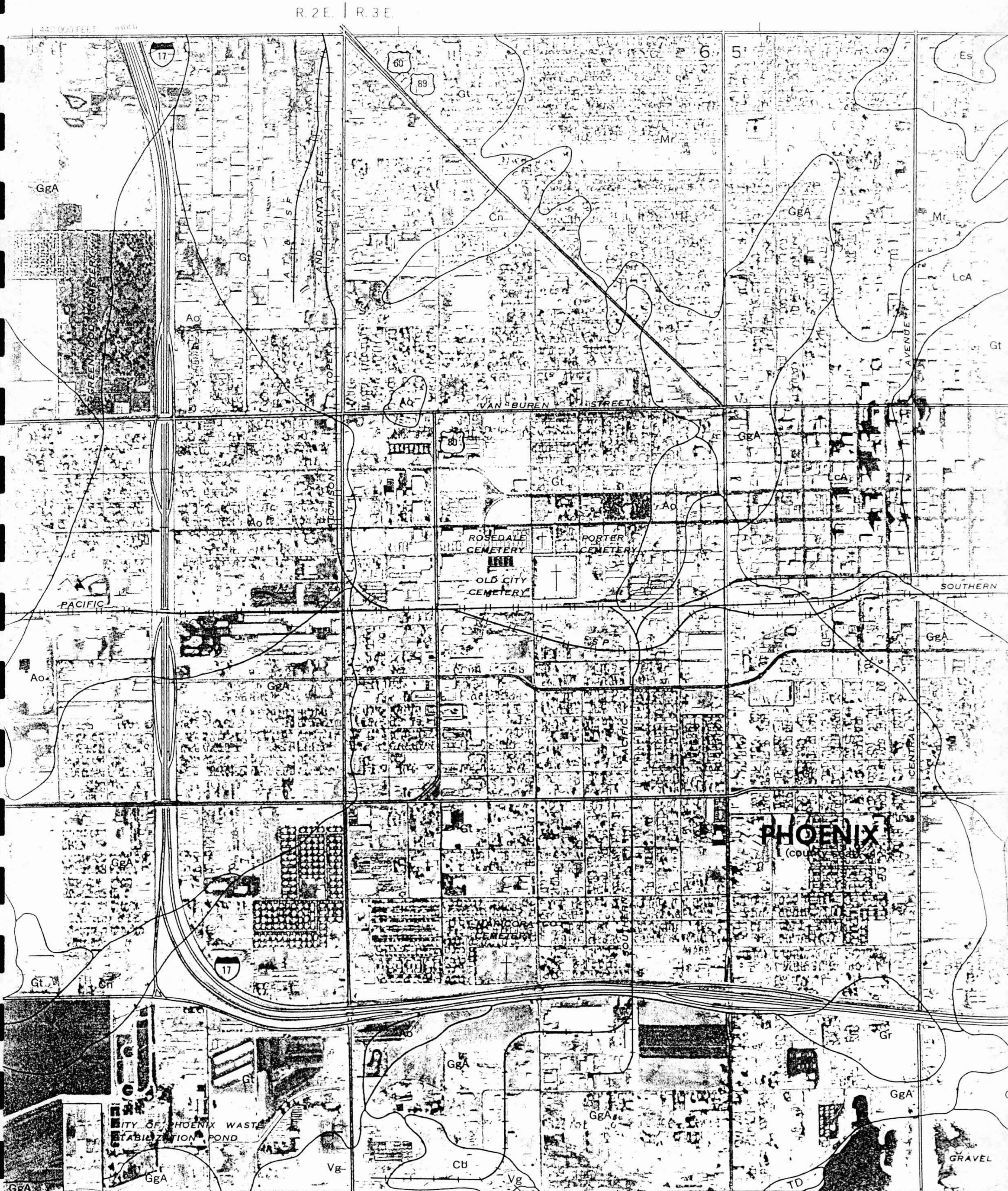


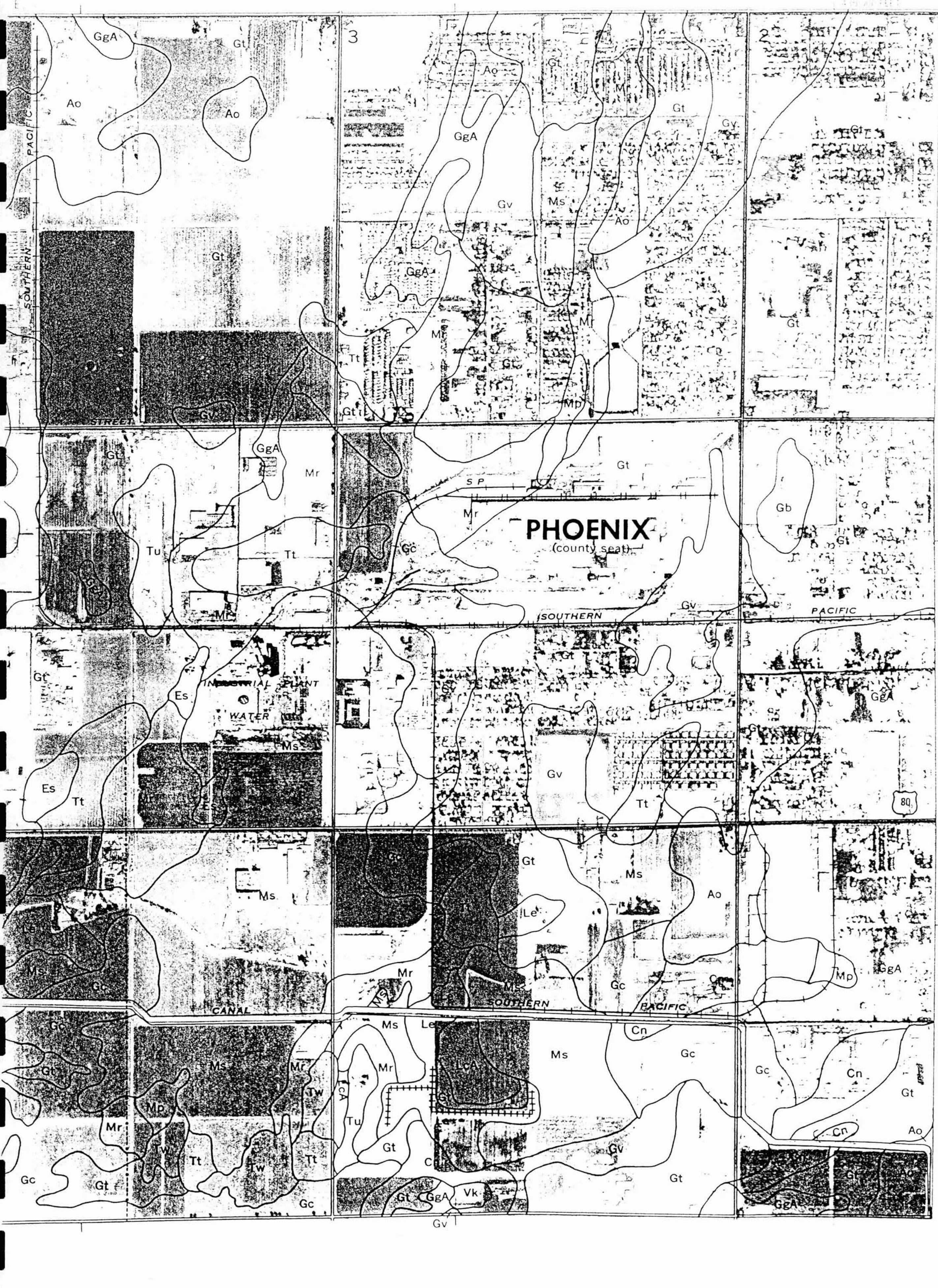
LOWER CAVE CREEK WASH FLOOD STUDY AREA


(Joins sheet 18)
R. 2 E.
R. 3 E.
Shaw Butte
WATER TANKS
Cave Creek
ARIZONA CANAL
PHOENIX
(county seat)
19
20
30
29
35
36
440 000 FEET
(Joins sheet 37)
17
Ge
AbA
GgA
TD
Cp
PsB
EbD
RS
CO
PeA
TrB
Br
Cb
Es
Mp
LcA
Tc
AdA
Va
Ao
Vh
Mr
Tt
Tw
Le
CrB


R.2E.
R.3E.
PHOENIX
(county seat)
WASHINGTON PARK
CAMELBACK
ROAD
Tt
Mr
Mp
Es
LcA
GgA
Le
Tu
Tc
M
11
14
7
8
18
17


R. 2 E.
R. 3 E.
(Joins sheet 37)
CAMELBACK
ROAD
Mp
Es
Le
LcA
Mr
CANAL
GgA
GRAND
Ao
PHOENIX
(county seat)
ATCHISON
TOPEKA
AND
SANTA FE
Gt
Encanto Park And Golf Course
G.P.
Tc
State
Fairground
31
32
(Joins sheet 67)
440 000 FEET


R. 2 E.
R. 3 E.
440 000 FEET
17
60
89
6
5
Es
Gt
Mr
GgA
Cn
Mr
LcA
Gt
Ao
Gt
GREENWOOD CEMETERY
A. T. & S. F.
AND SANTA FE
TOPEKA
ATCHISON
AVENUE
Ao
VAN BUREN STREET
80
GgA
Gt
LcA
Ao
Ao
ROSEDALE CEMETERY
PORTER CEMETERY
OLD CITY CEMETERY
SOUTHERN
PACIFIC
GgA
Ao
GgA
S. P.
PACIFIC
SOUTHERN
CENTRAL
PHOENIX
(county seat)
Gt
GgA
MARICOPA CEMETERY
17
Gt
Gr
Ao
Gr
GgA
Gt
GgA
GgA
CITY OF PHOENIX WASTE STABILIZATION POND
Vg
Cb
Vg
GgA
GgA
TD
GRAVEL



(Joins sheet 67)

ALTERNATIVE PROJECT COST SUMMARY

96-01-16

cst-sum.wq1

PROJECT	COST $ MILLIONS	COMMENTS
STANDARD STORM DRAIN PIPE ALTERNATIVE	$58.79	Parallel pipes to limit size
CBC UTILIDOR STORM DRAIN ALTERNATIVE	$55.14	Utilities accesssible inside
GRAND CANAL USED JOINTLY	$54.09	Separate Irrigation and Storm Channels
DETENTION STORAGE ON LARGE TRACTS	$35.59	With gathering storm drains
INFUSER WELLS DESIGNED FOR INFILTRATION	$18.40	No new storm drains required

COST ESTIMATE TABULATION FOR TRUNK STORM DRAINS

Pipe I.D. Ft	Wall Thick In	Pipe O.D. Ft	Trench Width Ft	Trench Depth Ft	Exc CY/Ft	Cost Exc /LF	Cost Pipe /LF	Cost Inst /LF	Cost MH /LF	Cost SD /LF	Cost Pave /LF	Cost Util /LF	Cost Inlets /LF	Cost Total /LF
2.0	2.5	2.4	4.4	8.0	1.31	7.85	10.71	3.68	12.86	35.09	0.98	2.64	18.00	$57
2.5	2.8	3.0	5.0	8.5	1.56	9.37	14.55	4.80	14.37	43.10	1.10	2.92	18.00	$65
3.0	3.0	3.5	5.5	9.0	1.83	11.00	18.91	5.98	15.75	51.63	1.22	3.18	18.00	$74
3.5	3.5	4.1	6.1	9.5	2.14	12.84	25.74	7.19	17.01	62.78	1.35	3.44	18.00	$86
4.0	4.0	4.7	7.7	10.0	2.84	17.04	33.61	8.44	12.12	71.22	1.70	3.67	18.00	$95
4.5	4.5	5.3	8.3	10.5	3.21	19.25	42.54	9.73	12.86	84.38	1.83	3.90	18.00	$108
5.0	5.0	5.8	8.8	11.0	3.60	21.59	52.52	11.04	13.55	98.70	1.96	4.11	18.00	$123
5.5	5.5	6.4	9.4	11.5	4.01	24.06	63.55	12.38	14.21	114.20	2.09	4.31	18.00	$139
6.0	6.0	7.0	10.0	12.0	4.44	26.67	75.63	13.74	14.85	130.88	2.22	4.50	18.00	$156
6.5	6.5	7.6	10.6	12.5	4.90	29.40	88.76	15.12	15.45	148.73	2.35	4.68	18.00	$174
7.0	7.0	8.2	11.2	13.0	5.38	32.26	102.94	16.53	16.03	167.77	2.48	4.86	18.00	$193
7.5	7.5	8.8	11.8	13.5	5.88	35.25	118.17	17.96	16.60	187.98	2.61	5.03	18.00	$214
8.0	8.0	9.3	12.3	14.0	6.40	38.37	134.46	19.40	17.14	209.37	2.74	5.19	18.00	$235
8.5	8.5	9.9	12.9	14.5	6.94	41.62	151.79	20.87	17.67	231.94	2.87	5.35	18.00	$258
9.0	9.0	10.5	13.5	15.0	7.50	45.00	170.17	22.35	18.18	255.70	3.00	5.51	18.00	$282
9.5	9.5	11.1	14.1	15.5	8.08	48.51	189.60	23.84	18.68	280.64	3.13	5.66	18.00	$307
10.0	10.0	11.7	14.7	16.0	8.69	52.15	210.09	25.36	19.17	306.76	3.26	5.81	18.00	$334
10.5	10.5	12.3	15.3	16.5	9.32	55.92	231.62	26.89	19.64	334.06	3.39	5.95	18.00	$361
11.0	11.0	12.8	15.8	17.0	9.97	59.81	254.20	28.43	20.10	362.55	3.52	6.09	18.00	$390
12.0	11.5	13.9	16.9	18.0	11.28	67.67	301.99	31.56	20.99	422.21	3.76	6.34	18.00	$450
13.0	12.0	15.0	18.0	19.0	12.67	76.00	990.00	34.74	21.85	1122.59	4.00	6.58	18.00	$1,151
14.0	12.5	16.1	19.1	20.0	14.14	84.81	1076.27	37.97	22.68	1221.74	4.24	6.82	18.00	$1,251
15.0	13.0	17.2	20.2	21.0	15.69	94.11	1168.93	41.25	23.47	1327.77	4.48	7.04	18.00	$1,357
16.0	13.5	18.3	21.3	22.0	17.31	103.89	1267.99	44.57	24.24	1440.69	4.72	7.26	18.00	$1,471
17.0	14.0	19.3	22.3	23.0	19.02	114.15	1373.43	47.94	24.99	1560.50	4.96	7.47	18.00	$1,591
18.0	14.5	20.4	23.4	24.0	20.81	124.89	1485.27	51.34	25.71	1687.21	5.20	7.68	18.00	$1,718

EQUATIONS

PIPE TABLES

C	D	E	F	G	H	I	J	K	L	M	N	O
(A1+2*B1)/12	C1+2	6+A1/12	(D1*E1)/27	F1*C$41	(0.7854*(C1^2-(A1/12)^2)/27)*C$42	((A1/12)^1.2)*C$43/10	(A1/12)^0.5*C$45/H$45	G1+H1+I1+J1	(D1/9)*C$47	C1^0.5*C$46	C$44/E$44	K1+L1+M1+N1

VARIABLE COSTS

33	Item	Cost	Per				
34	Exc	$6	CY				
35	Conc	$200	CY				
36	Inst	16	Install factor				
37	CB	$3,600	Ea	200	Ft Spacing	20' wings	
38	MH	$4,000	Ea	660	Ft Spacing	440	Ft spacing for dia<48"
39	Util	$1.70	Factor				
40	Pave	$2	SY				

NOTE: Pipe larger than 12' dia is not moveable on the streets
Larger sizes must be mad in an on-site plant.
Use two parallel smaller pipes instead.

LOWER CAVE CREEK FLOOD STUDY

96-01-16
est-sd.wq1

STANDARD STORM DRAIN PIPE ALTERNATIVE

FROM	TO	PIPES #	CFS EA	LENGTH FT	SLOPE FT/FT	ID FT	COST /FT	TOTAL MILLION $
Dunlap	Glendale	7	200	10700	0.0043	5	$123	$9.20
Glendale	Grand C	7	300	16000	0.0035	6	$156	$17.43
Grand C	McDowell	2	2400	11500	0.0027	10.5	$361	$8.31
McDowell	VanBurean	2	2400	5820	0.0022	11	$390	$4.54
VanBurean	I-17	2	2400	8600	0.0014	12	$450	$7.75
I-17(19th)	Durango	2	2800	3300	0.00105	12	$450	$2.97
Durango	Salt Rvr	Chan	2800	6000	0.001	28	$61	$0.00
	SUBTOTAL IN $ MILLION FOR TRUNK LINES							$50.19
Feeder lines @ 1 mi		10	110	4000	0.0045	4	$95	$3.78
		10	50	6000	0.0042	3	$74	$4.44
	SUBTOTAL IN $ MILLION FOR CONSTRUCTION							$58.42
TOTAL WITH 15% CONTINGENCIES IN $ MILLIONS								$67.18

ALTERNATE SOLUTION WITH SINGLE TRUNK

FROM	TO	PIPES #	CFS EA	LENGTH FT	SLOPE FT/FT	ID FT	COST /FT	TOTAL MILLION $
Dunlap	Glendale	1	1000	10700	0.0047	9	$307	$3.29
Glendale	Grand C	1	1800	16000	0.0033	12	$450	$7.20
Grand C	McDowell	2	2400	11500	0.0027	10.5	$361	$8.31
McDowell	VanBurean	2	2400	5820	0.0022	11	$390	$4.54
VanBurean	I-17	2	2400	8600	0.0014	12	$450	$7.75
I-17(19th)	Durango	2	2800	3300	0.00105	12	$450	$2.97
Durango	Salt Rvr	Chan	2800	6000	0.001	28	$61	$0.00
	SUBTOTAL IN $ MILLIONS FOR TRUNK LINES							$34.07
Feeder lines @ 1 mi		10	600	4000	0.0045	7	$193	$7.72
		10	350	6000	0.0042	6	$156	$9.34
	SUBTOTAL IN MILLIONS FOR CONSTRUCTION							$51.13
TOTAL WITH 15% CONTINGENCIES IN $ MILLIONS								$58.79

COST ESTIMATE TABULATION FOR CBC UTILIDORS

96-01-15

COST-CBC.WQ1

SIZE #	R	S	CONC CY/LF	STEEL #/LF	CONC $/LF	STEEL $/LF	CBC $/LF	EXC CY/LF	EXC $/LF	PAVE $/LF	UTIL $/LF	TOTAL $/LF
1	8	8	1.180	183	189	82	271	5.93	17.78	3.11	4.81	$297
1	9	12	1.942	363	311	163	474	8.81	26.44	4.00	5.10	$509
1	10	10	1.622	206	260	93	352	8.00	24.00	3.56	5.38	$385
2	10	10	2.678	410	428	185	613	8.67	26.00	3.56	5.38	$648
2	10	11	3.101	438	496	197	693	9.33	28.00	3.78	5.38	$730
A	B	C	D	E	F	G	H	I	J	K	L	M

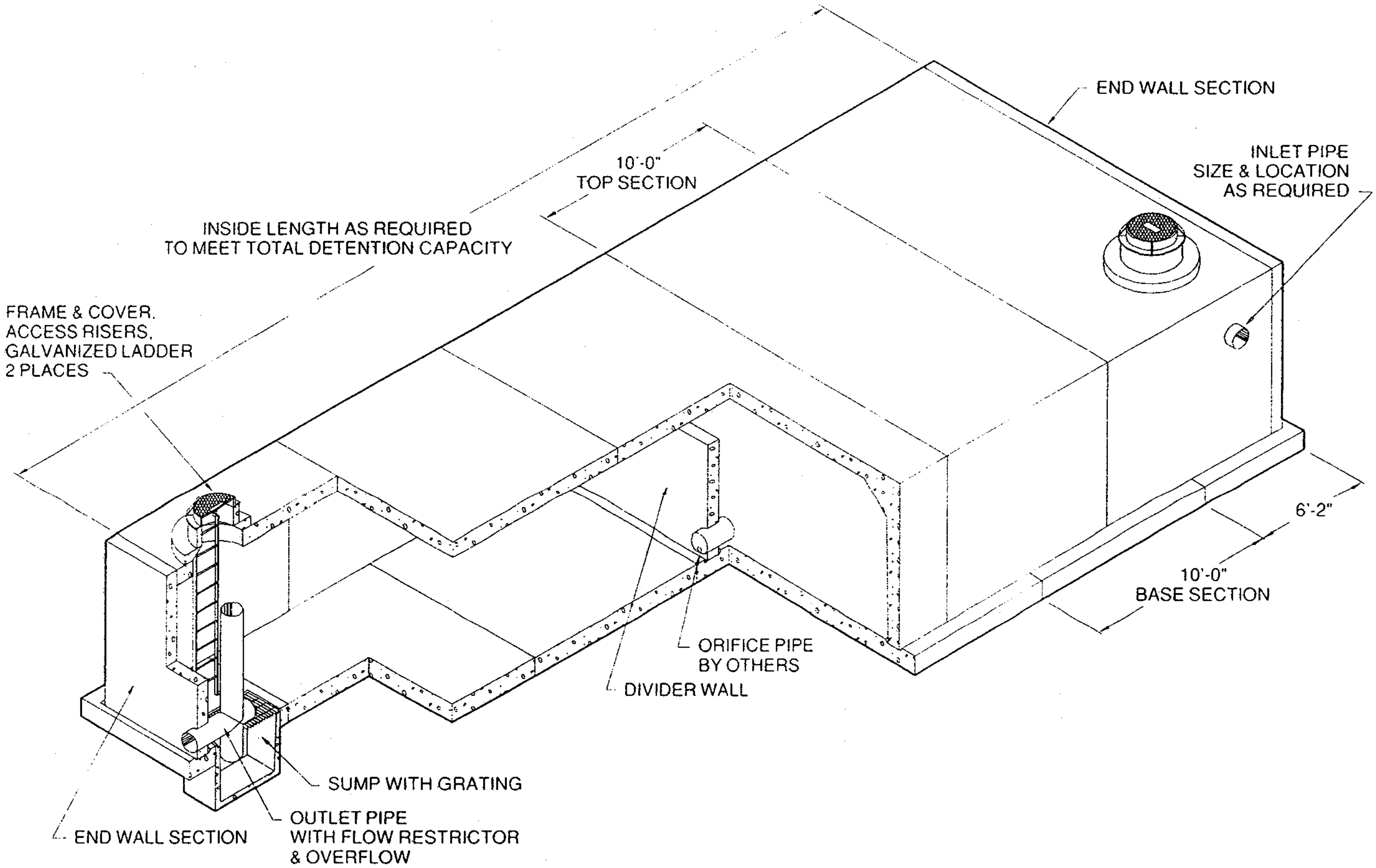
EQUATIONS

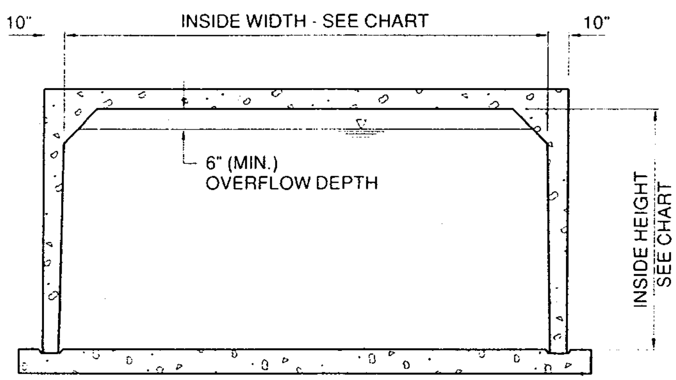
D	E	F	G	H	I	J	K	L	M
ADOT	TABLES	D1*D$21	E1*D$22	F1+G1	(C1+1+A1)*(B1+F$20+2)/27	I1*D$20	(C1+6)*D$27/9	(B1^0.5)*D$26	H1+J1+K1+L1

VARIABLE COSTS

19	Item	Cost	Per				
20	Exc	$3	CY	6	Ft Cover		
21	Conc	$160	CY				
22	Steel	$0.45	#				
23	Inst	12	Hr factor				
24	CB	$4,000	Ea	200	Ft Spacing	20' wings	
25	MH	$2,000	Ea	660	Ft Spacing	440	Ft spacing dia<48"
26	Util	$1.70	Factor				
27	Pave	$2	SY				

DETENTION VAULTS
3-SIDED BOX SYSTEM





SECTION VIEW

		INSIDE HEIGHT					
		3'-0"	4'-0"	5'-0"	6'-0"	7'-0"	8'-0"
INSIDE WIDTH	12'-0"	218	309	400	491	582	673
	13'-0"	237	335	433	532	631	729
	14'-0"	256	361	467	573	679	785
	15'-0"	275	387	501	614	728	842
	16'-0"	293	414	534	655	776	898
	17'-0"	312	440	568	696	825	954
	18'-0"	331	466	601	737	873	1,010
	19'-0"	349	492	635	778	922	1,066
	20'-0"	368	518	669	820	971	1,122

DETENTION VAULT SIZING CHART

GALLONS PER LINEAR FT.

UTILITY VAULT COMPANY

PHONE (602) 963-2678

FAX (602) 899-1937

Each Detention Vault Is Custom Designed And Produced To Meet Project And Jobsite Requirements.

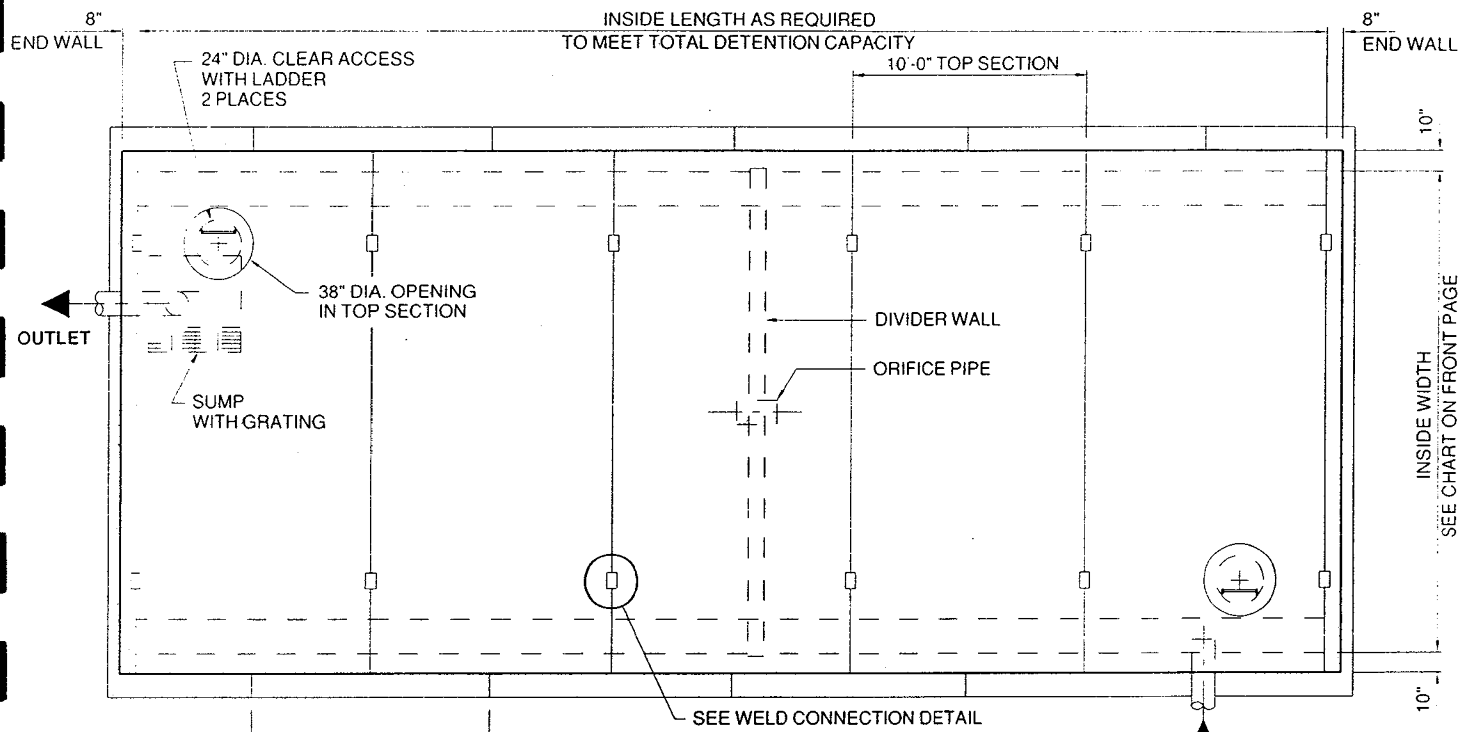
Contact Utility Vault Representative For Details.

* **ITEMS SHOWN ARE SUBJECT TO CHANGE WITHOUT NOTICE.**

FOR DETAILS SEE REVERSE SIDE.

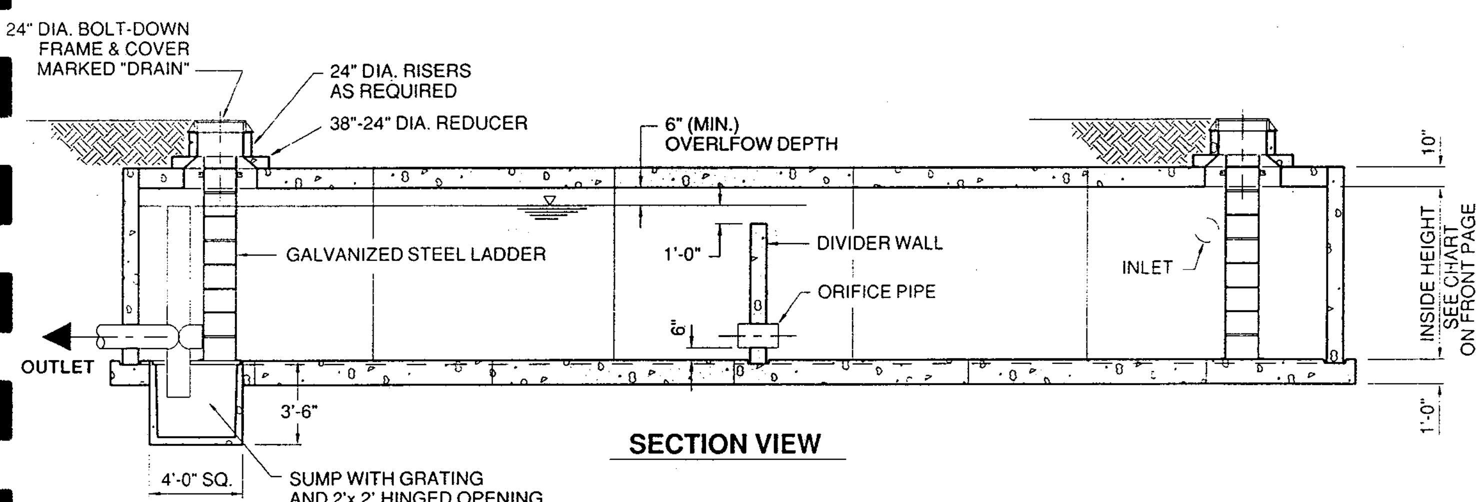
Issue: January 1993

DETENTION VAULTS
3-SIDED BOX SYSTEM

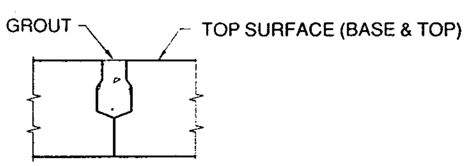


PLAN VIEW

FRAMES & COVERS, ACCESS RISERS NOT SHOWN

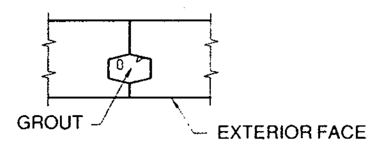


SECTION VIEW



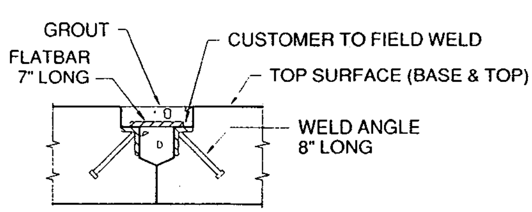
DECK, BASE KEY DETAIL

TYPICAL BETWEEN TOP SECTIONS
AND BETWEEN BASE SECTIONS



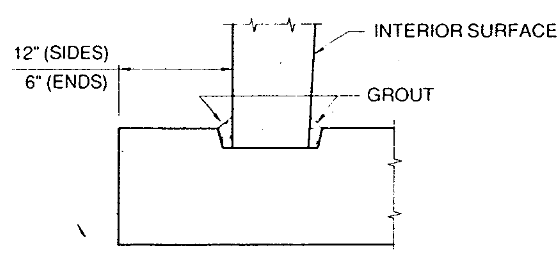
VERTICAL KEY DETAIL

TYPICAL BETWEEN TOP SECTION



WELD CONNECTION

TYPICAL BETWEEN TOP SECTIONS
AND BETWEEN BASE SECTIONS



FOOTING KEY DETAIL

LOWER CAVE CREEK FLOOD STUDY

96-01-16
est-cbc.wq1

CBC UTILIDOR STORM DRAIN ALTERNATIVE

FROM	TO	PIPES #	CFS EA	LENGTH FT	SLOPE FT/FT	SIZE FT	COST /FT	TOTAL MILLION $
Dunlap	Glendale	1	1000	10700	0.0047	8x8	$297	$3.17
Glendale	Grand C	1	1800	16000	0.0033	9x12	$509	$8.15
Grand C	I-17	2	2400	25900	0.0027	10x10	$648	$16.78
I-17(19th)	Durango	2	2800	3300	0.00105	9x12	$730	$2.41
Durango	Salt Rvr	Chan	2800	6000	0.001	28	$61	$0.37
				SUBTOTAL TRUNK LINES				$30.88
Feeder lines @ 1 mi		10	600	4000	0.0045	7	$193	$7.72
		10	350	6000	0.0042	6	$156	$9.34
				SUBTOTAL CONSTRUCTION				$47.94
TOTAL WITH 15% CONTINGENCIES								$55.14

COST ESTIMATE TABULATION 96-01-16

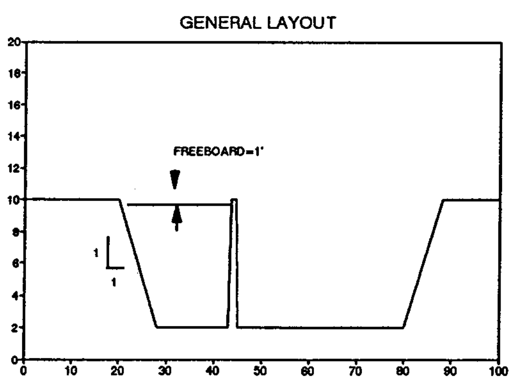
FOR OPEN STORM DRAIN CHANNELS COSTCHAN.WQ1

BOTTOM SD	IRRIG	WIDTH TOTA	DEPTH FT	EXC CY/LF	LINING SY/LF	WALL CY/LF	EXC $/LF	LINING $/LF	WALL $/LF	TOTAL $/LF
28		28	8	10.67	4.4	0	32.00	29.18	0	$61
17	2	20	8	8.30	3.5	0.619	24.89	23.24	74.28	$122
21	2	24	8	9.48	3.9	0.619	28.44	26.21	74.28	$129
31	11	43	8	15.11	6.0	0.619	45.33	40.31	74.28	$160
46	11	58	8	19.56	7.7	0.619	58.67	51.44	74.28	$184

EQUATION	C	D	E	F	G	H	I		
# #			(A1+B1)*B1/27			C1*C$21			F1+G1+H1
	A1+B1+1			(A1+1.414*B1)/9			D1*C$24		
		8			0.619			E1*C$22	

VARIABLE COSTS

20	Item	Cost	Per
21	Exc	$3	CY
22	Conc	$120	CY
23	Thickness	0.167	FT
24	Lining	$6.68	SY



LOWER CAVE CREEK FLOOD STUDY 96-01-16

est-gc.wq1

GRAND CANAL USED JOINTLY SEPARATE CHANNELS FOR IRRIGATION & STORM DRAINS

FROM	TO	IRRIG CFS	SD CFS	LENGTH FT	SLOPE FT/FT	SIZE FT	COST /FT	TOTAL MILLION $
7 St	59 Ave	750	2400	37300	0.0008	58	$184	$6.88
59 Ave	83 Ave	550	2400	20900	0.0004	43	$160	$3.34
83 Ave	99 Ave	360	2400	10600	0.0025	24	$129	$1.37
99 Ave	New Rvr	280	2400	5500	0.0035	20	$122	$0.67
		SUBTOTAL IN $ MILLION FOR GRAND CANAL CONVER						$12.26

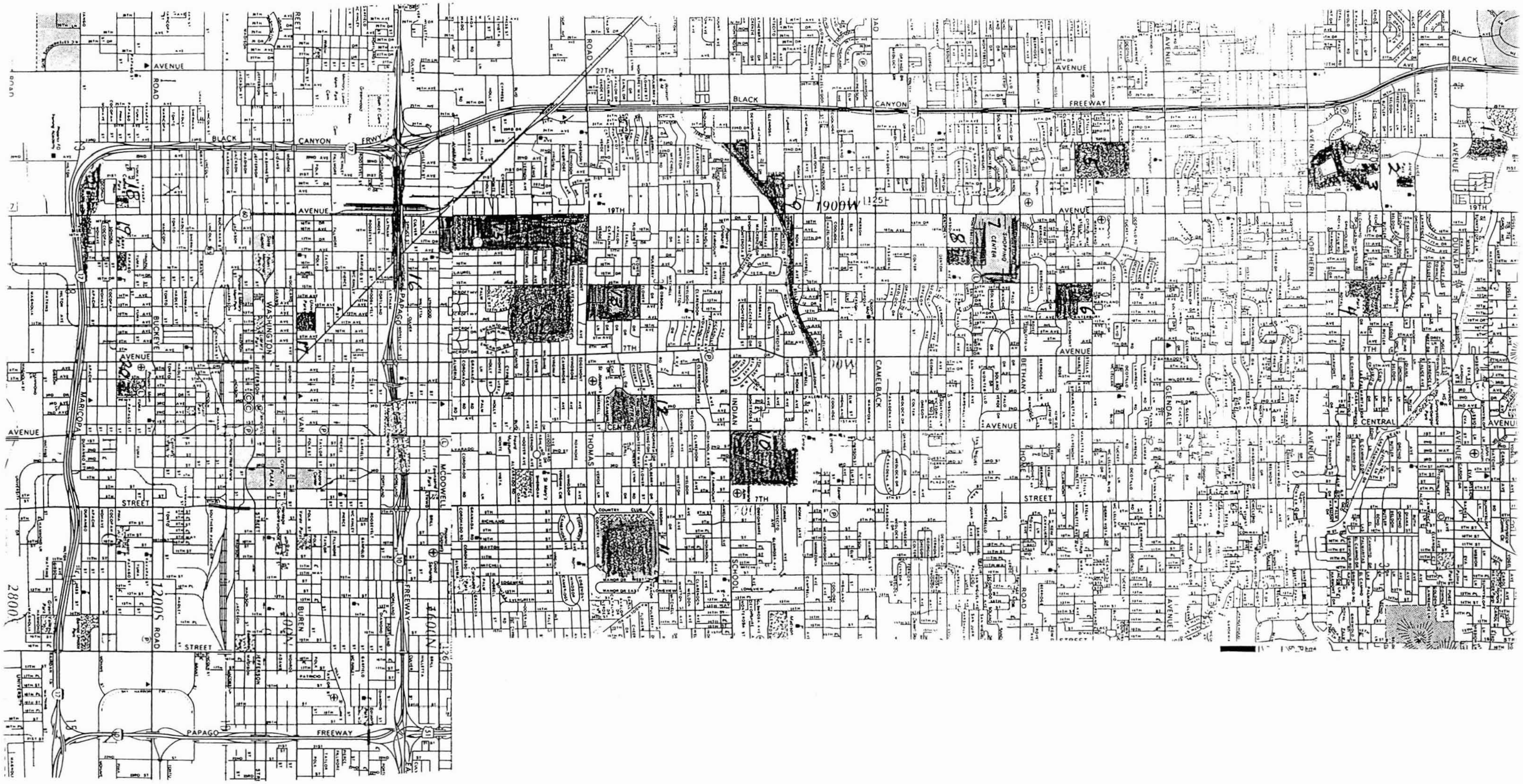
SOLUTION WITH SINGLE TRUNK

FROM	TO	IRRIG CFS	SD CFS	LENGTH FT	SLOPE FT/FT	SIZE FT	COST /FT	TOTAL MILLION $
Dunlap	Glendale	1	1000	10700	0.0047	9	$282	$3.02
Glendale	Grand C	1	1800	16000	0.0033	12	$450	$7.20
Grand C	McDowell	1	400	11500	0.0027	7	$193	$2.22
McDowell	VanBurean	1	600	5820	0.0022	8	$235	$1.37
VanBurean	I-17	1	800	8600	0.0014	9	$282	$2.43
I-17(19th)	Durango	1	1000	3300	0.00105	10	$334	$1.10
Durango	Salt Rvr	1	1000	6000	0.001	28	$61	$0.37
		SUBTOTAL IN $ MILLION FOR TRUNK LINES						$17.71
Feeder lines @ 1 mi		10	600	4000	0.0045	7	$193	$7.72
		10	350	6000	0.0042	6	$156	$9.34
		SUBTOTAL IN $ MILLION FOR FEEDER LINES						$17.06
		TOTAL CONSTRUCTION IN $ MILLIONS						$47.03
	TOTAL WITH 15% CONTINGENCIES IN $ MILLIONS							$54.09

LOWER CAVE CREEK WASH FLOOD STUDY Job 95123
OPEN AREAS IN THE STUDY AREA

	AREA	E-W STREETS S	E-W STREETS N	N-S AVENUES W	N-S AVENUES E	AREA ACRE	OWNER
1	Ottawa University	Mission	A Canal	34	32	130	Univ
2	Alicia Park	Butler	Alice	21	20	23	City
3	El Caro Golf C	Northern	Butler	23	20	230	Dev
4	Royal Palm Park	El Camino	Butler	15	12	100	City
5	Washington Park	Maryland	Ocotilla	23	21	150	City
6	Palo Verde Golf C	Rose	Maryland	15	11	100	Priv
7	Christown Mall	Montebello	Bethany	19	15	70	Mall
8	Solano Park	Missouri	San Miguel	17	15	20	City
* 9	N Bank Grand Canal	Grand C	varies	24	C	90	Priv
10	Phoenix Indian School	Ind Sch	Turney	C	4St	80	USBIA
11	Phx Crty Club	Thomas	Osborn	7St	12St	25	Club
12	Park Central Mall	Catalina	Osborn	3	C	40	Mall
13	Phoenix College	Thomas	Flower	15	11	10	Univ
14	Encanto Park	Encanto	Thomas	19	9	850	City
15	Fairgrounds	Encanto	McDowell	19	17	100	State
16	I-10 Elevated	Lathum	Spruce	24	11	130	ADOT
17	University Park	Van Burean	Polk	12	10	20	City
18	Coffelt Park	Pima	Papago	20	19	6	City
19	Alkire Park	Pima	Papago	17	16	10	City
20	Harmon Park	Pima	Yavapai	5	3	20	City
21	Durango Bend Area	I-17	Pima	I-17	19	60	Priv

REQUIRED AREA 160 TOTAL OPEN AREA 2264 ACRES



BLACK CANYON FREEWAY
BLACK CANYON FRWY
PAPAGO FREEWAY
MARICOPA FREEWAY
CAMELBACK ROAD
INDIAN SCHOOL ROAD
THOMAS ROAD
MCDOWELL
WASHINGTON STREET
VAN BUREN STREET
BUCKEYE ROAD
NORTHERN AVENUE
GLENDALE AVENUE
BETHANY HOME ROAD
DUNLAP AVENUE
CENTRAL AVENUE
7TH AVENUE
19TH AVENUE
27TH AVENUE
7TH STREET
SHOPPING CENTER

LOWER CAVE CREEK FLOOD STUDY 96-01-16

est-stor.wq1

DETENTION STORAGE ON LARGE TRACTS (SEE MAP # ***)

TOTAL VOLUME TO BE STORED

2400 CFS x 2 HRS x 3600 SEC/HR x 0.5 FOR TRIANGULAR PEAK
x 2 NON-ATTENUATION / 43560 SF/ACRE = 397 ACRE FEET

much too little

AT AN AVERAGE OF 2.5' DEEP, THIS REQUIRES 159 ACRES OF STORAGE

ITEM			QUANTIT	UNITS	UNIT $	TOTAL MILLION $
Excavation	17280000	cf	640000	CY	4	2.56
Surface replacement	6912000	sf	768000	SY	20	15.36
ROW	160	acres	160	ACRE	25000	4.00

SUBTOTAL in $ MILLION FOR DETENTION AREAS 21.92

How do we get water to this Basins?

COLLECTION LINES FOR BASINS

FROM	TO	CFS	LENGTH FT	ID FT	UNIT $	TOTAL MILLION $	
BUTLER							
I-17	23 Ave	250	1600	5	$123	0.20	
17 Ave	22 Ave	500	2600	7	$193	0.50	
17 Ave	15 Ave	80	1000	3.5	$86	0.09	
Central	12 Ave	60	4100	3	$74	0.30	
MARYLAND (OCTATILLO)							
I-17	23 Ave	80	800	3	$74	0.06	
19 Ave	21 Ave	200	1300	5	$123	0.16	
7 St	12 Ave	300	7000	6	$156	1.09	
GRAND CANAL							
7 St	7 Ave	250	3700	5.5	$139	0.51	
ENCANTO							
I-17	19 Ave	250	3500	5	$123	0.43	
7 St	10 Ave	400	5800	7	$193	1.12	
UNDER I-10							
Gathering Lines		60	1000	3	$74	0.07	
DURANGO CURVE							
3 Ave	19 Ave	1000	7600	11	$390	2.97	adjust slopes
19 Ave	23 Ave	1200	3000	12	$450	1.35	very flat
Channel		1200	6000	20	$31	0.18	no ROW includ

SUBTOTAL in $ MILLION FOR GATHERING LINES 9.03

SUBTOTAL IN $ MILLION FOR CONSTRUCTION $30.95

TOTAL WITH 15% CONTINGENCIES IN $ MILLIONS $35.59

LOWER CAVE CREEK FLOOD STUDY

96-01-16

est-well.wq1

INFUSER WELLS DESIGNED FOR INFILTRATION

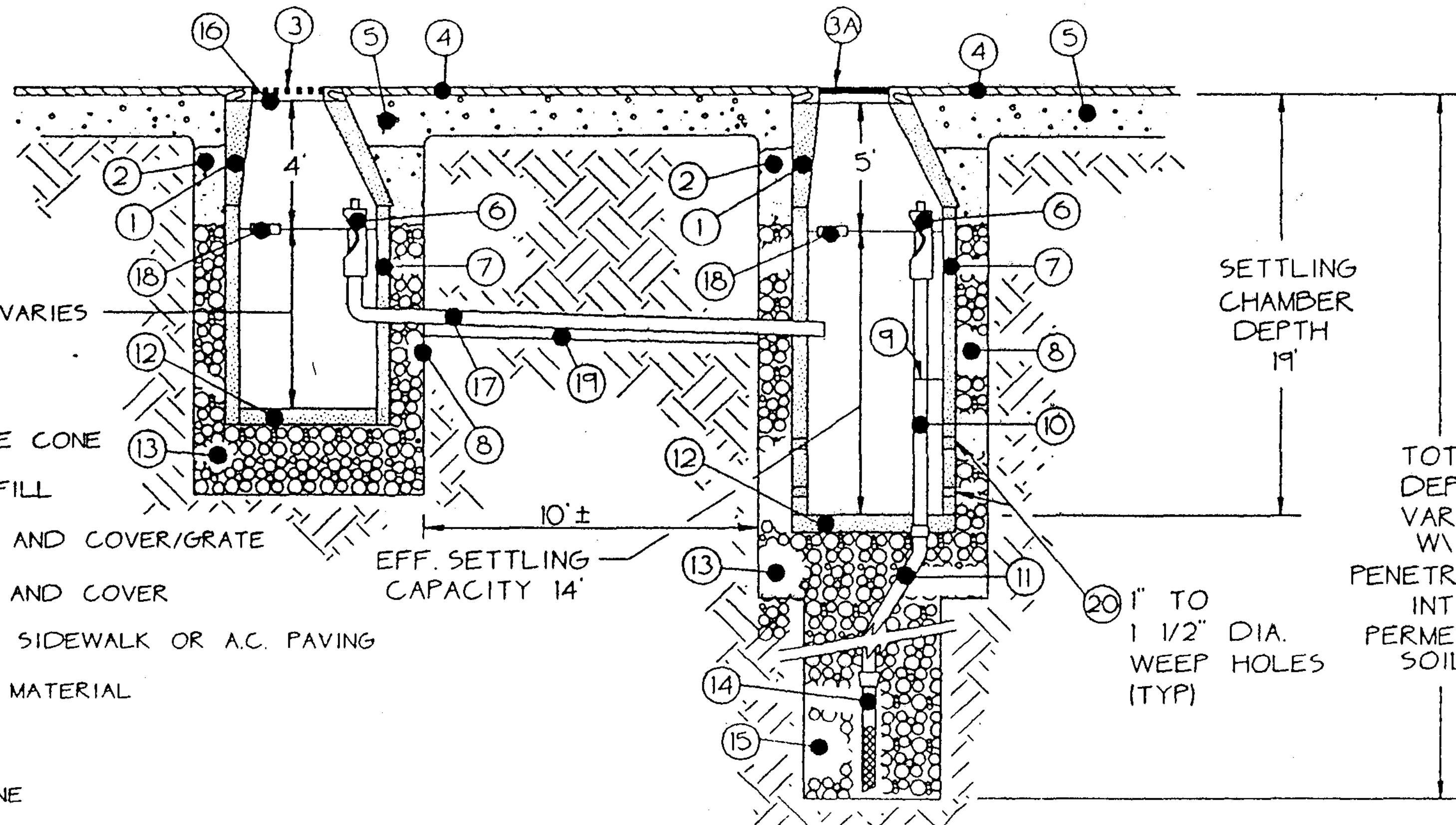
TOTAL FLOW RATE TO BE INFILTRATED

BASED ON THE FEMA REPORT, 2400 CFS PEAK FLOW MUST BE DISPOSED OF

EXACT NUMBER TO BE DETERMINED BY TESTING AND HEC-1 DETAILED ANALYSIS

PER DISCUSSION IN THE REPORT COST ON THE BASIS OF 4000 INFUSER WELLS

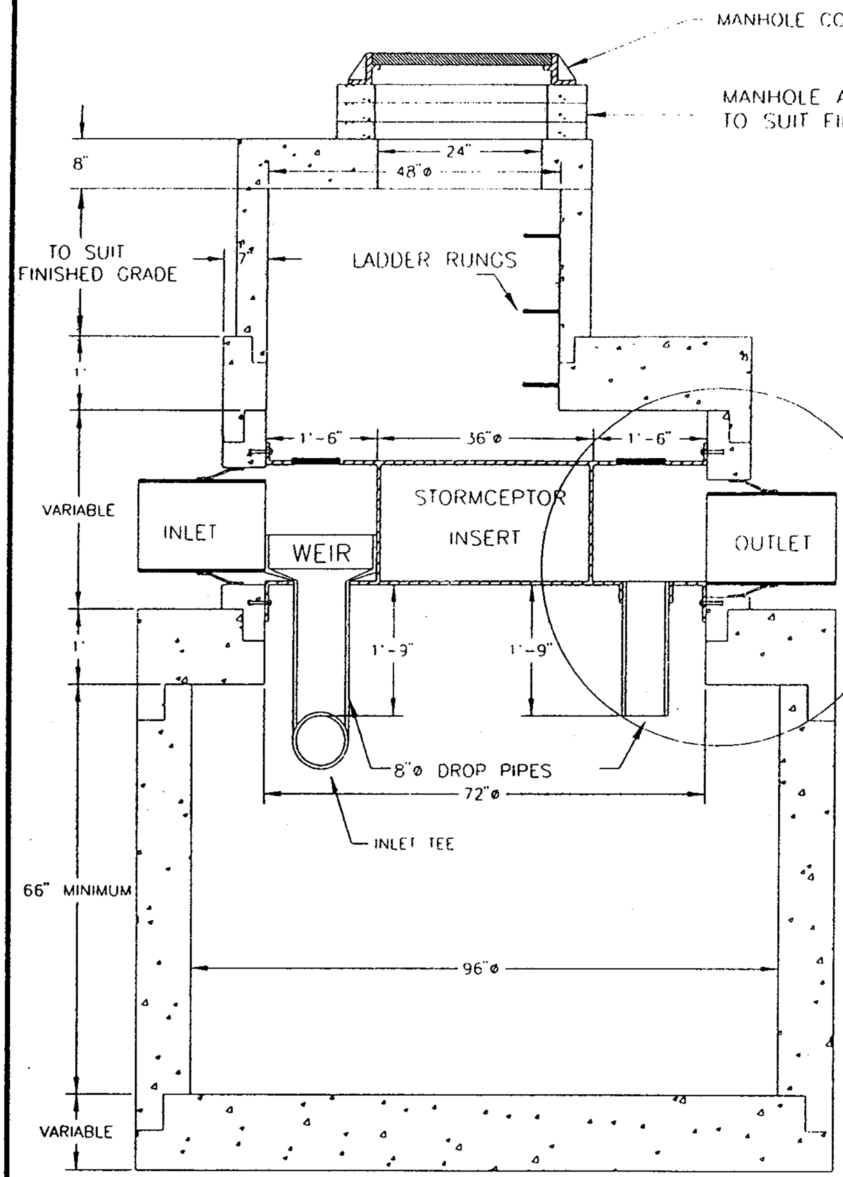
ITEM	QUANTI	UNITS	UNIT $	TOTAL MILLION $
INFUSER WELLS COMPLETE @ 1 CFS E	4000	ea	$4,000	$16.00
SUBTOTAL IN $ MILLIONS FOR DRYWELLS				$16.00
TOTAL WITH 15% CONTINGENCIES IN $ MILLIONS				$18.40



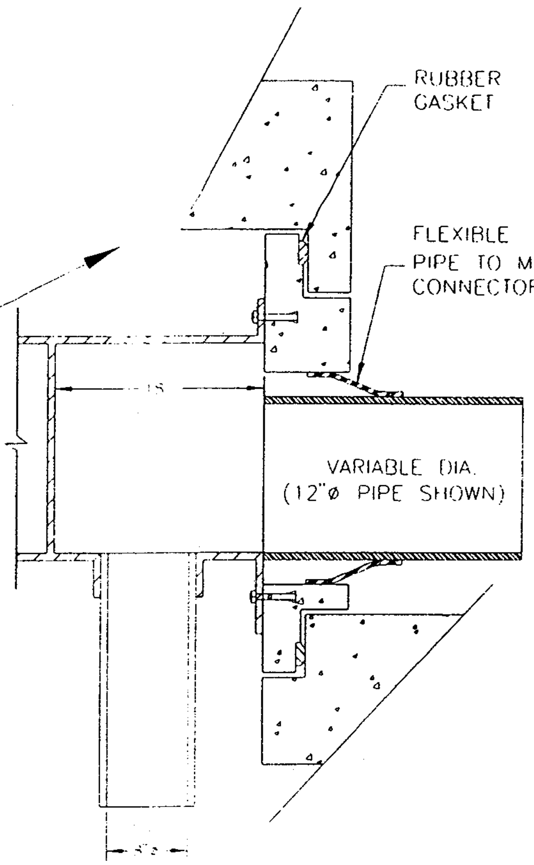
(1) MODIFIED MANHOLE CONE
(2) STABILIZED BACKFILL
(3) BOLTED C.I. RING AND COVER/GRATE
(3A) BOLTED C.I. RING AND COVER
(4) GRADED PARKWAY, SIDEWALK OR A.C. PAVING
(5) COMPACTED BASE MATERIAL
(6) DEBRIS SHIELD
(7) 4' ID PRECAST LINE
(8) MIN. 6' DIA. DRILLED SHAFT
(9) SUPPORT BRACKET
(10) 6" DIA. SCHEDULE 40 PVC OVERFLOW PIPE
(11) 6" DIA. DRAIN PIPE
(12) 4" THICK CONCRETE BASE
(13) 3/4" TO 1-1/2" WASHED ROCK
(14) SCREEN
(15) MIN. 4' DRILLED SHAFT
(16) FABRIC SEAL
(17) 4" DIA. CONNECTOR PIPE W/ FLOW REGULATOR
(18) MIN. 4 QUART CAPACITY ABSORBENT
(19) SLURRY BACKFILL
(20) 8 PERFORATIONS PER LINEAR FOOT FOR BOTTOM 3 FEET OF CHAMBER.

DETAIL NO. 43 NTS	CITY OF CHANDLER STANDARD DETAIL JULY 1994	DRY WELL SYSTEM DETAIL AND SPECIFICATIONS	APPROVED: [signature] CITY ENGINEER DATE: 11/22/94	DETAIL NO. 43 NTS

Hydro Conduit



SECTION
SCALE 1:30

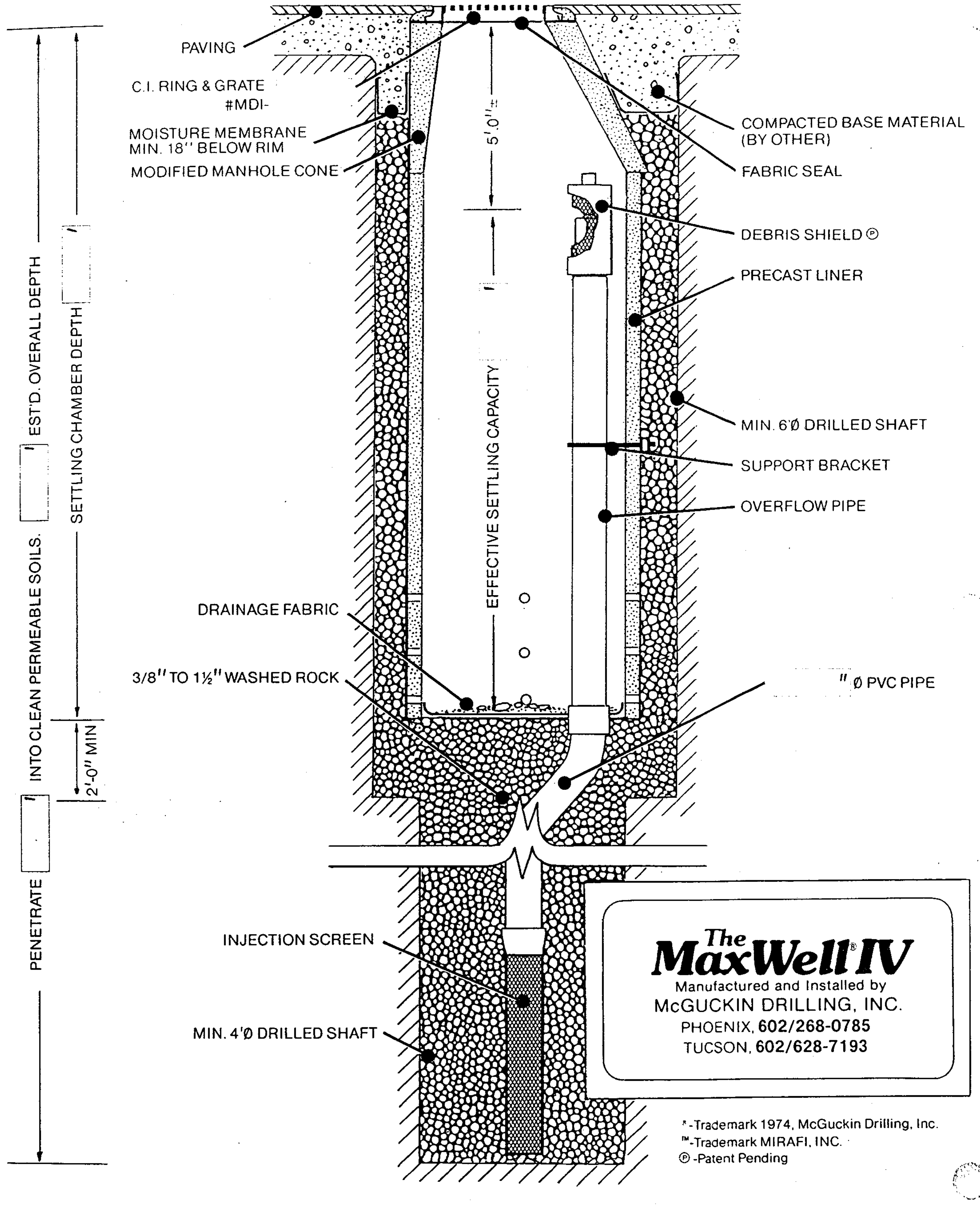


ENLARGED OUTLET CONNECTION DETAIL
SCALE 1:15

Design Specifications:

1. ASTM C 478

REV.	D.B J.G.B.	S.B	STC 2400 PRECAST CONCRETE STORMCEPTOR 2400 US GALLON CAPACITY
DATE 12/15/95	SCALE 1:30	UNITS Imperial	



The MaxWell® IV

Manufactured and Installed by
McGUCKIN DRILLING, INC.
PHOENIX, 602/268-0785
TUCSON, 602/628-7193

®-Trademark 1974, McGuckin Drilling, Inc.
™-Trademark MIRAFI, INC.
Ⓟ-Patent Pending

The above drawing and specification are available in reduced scale, printed on inkable self-adhesive matte acetate. Ask for drawing MDI-880 IV. All material in this bulletin is copyrighted, but may be used in construction plans without further release.

The MaxWell Idea

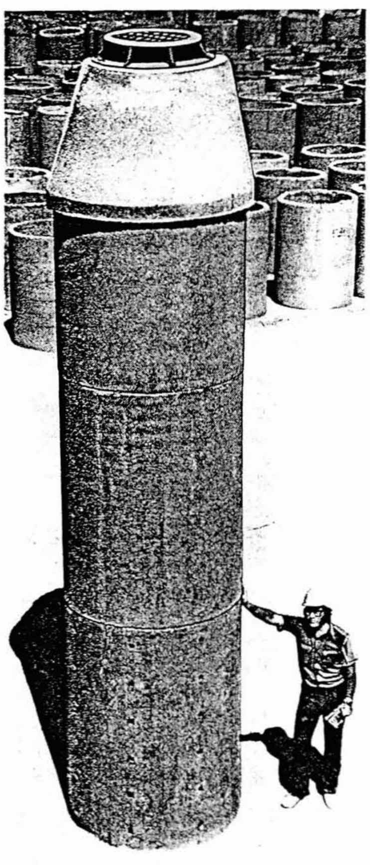
The silt and debris that flow into a conventional storm water drywell can quickly cut short its life by clogging the soils meant to transmit the water. In addition, pavement sediment can contribute to these problems further restricting long-term performance.

Since 1974, engineers have been specifying the ***MaxWell*** to bring an end to all these life-expectancy problems and provide a practical solution to today's drainage needs. The ***MaxWell® IV*** takes the drywell one step further by virtually eliminating problems associated with all floating debris.

What's the secret? Common to all ***MaxWells*** is a deep settling chamber that removes most of the silt and other heavy particles carried by the incoming storm water. A tall overflow pipe in this chamber is topped by a two foot long debris shield, which effectively stops all floating material. An internal screen traps suspended debris. The filtered water is then carried to the permeable soils below by the overflow pipe.

Equally important to long life is the care taken in drilling the drywell and installing the components. At least ten feet of penetration with a large 4 foot diameter hole into the permeable clay-free, sand, gravel, and cobbles is vital. McGuckin Drilling's specialized "crowd" equipped rigs get through the difficult cemented soils to reach clean drainage soils at depths up to 180 feet. Techniques we developed assure that those soils will stay clean too, until the well structure is installed and is put to use.

Now, the ***MaxWell® IV*** brings the drywell to a new level of performance and effectiveness, and with no increase in cost.



The MaxWell® IV
18 foot settling chamber gives over 200 cubic feet of capacity and a settling time of 13.3 minutes at .25cfs inflow.

The rugged FloFast® Injection screen provides maximum transmissibility. It assures consistent performance and high flow rates.

All floating debris is effectively removed by the PureFlo® Debris Shield in the new MaxWell® IV making it our best drywell ever.

MaxWell®IV

...The Best!

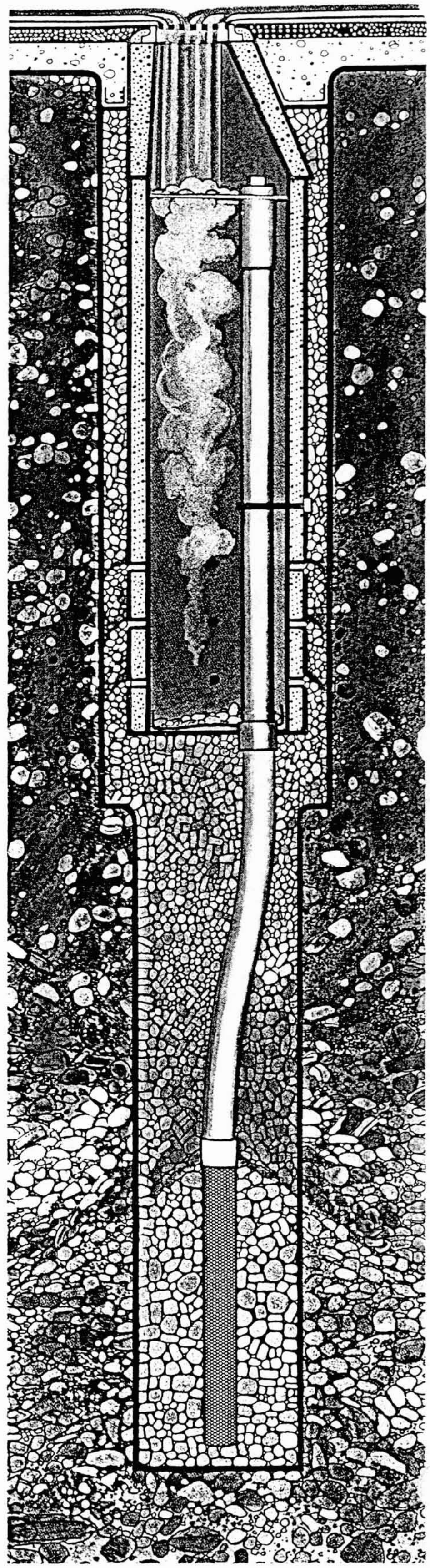
More than 99% of the 7000-plus ***MaxWells*** ever made are still doing their job . . . solid proof of the performance possible with quality product design, manufacture, application engineering and installation.

Now, the ***MaxWell®IV*** maintains the high flow rates of the over 5000 proven ***Maxwell®III*** models, while improving efficiency and extending life . . . all at no increase in cost.

This performance is made possible by a unique PureFlo® debris shield at the top of the well. The PureFlo shield is composed of an outer vented, solid casing that effectively traps all floating debris, including pavement sediment, in the well's cleanable settling chamber. An internal screen that is up to 6 times more effective than previous models, efficiently filters incoming suspended matter.

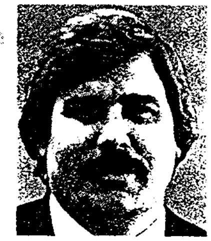
The large volume of the ***Maxwell®III*** settling chamber is retained. The debris shield, overflow pipe and FloFast® injection screen are available in 6'', 8'' and 12'' diameters to meet specific load requirements. Mirafi™ filtration fabric across the bottom of the settling chamber assures post-storm dry-up without silt infiltration.

MaxWell®IV drywells are recommended for most medium to high volume storm water applications where permeable soils are more than 20 feet below finished grade. Designs for other applications are described on pages 6-7.



DESIGN SUGGESTIONS FOR RETENTION + DRYWELL SYSTEMS

by S.C. De Tommaso and P.R. Le Blanc, McGuckin Drilling, Inc.



Designing the Retention Facility

The retention volume for a given property should be calculated according to the requirements of the city or other jurisdiction. Generally, any rainfall in excess of these requirements is allowed to overflow to the streets or storm sewers.

Since no allowance is made for soil or drywell transmissibility, the retention facility must be designed to retain 100% of the calculated rainfall volume. Most retention is achieved using parking lots and/or landscaped areas.

Parking Lots - The most important design factor is **user convenience.** Some engineers design parking lot retention so that most or all of the water is stored in deep sections remote from the project's buildings. This keeps paving near the building useable in light storms, but cars in the deep area may be endangered in a heavy storm.

In an effort to protect all cars in the lot, some engineers design for a more even storage, but at the possible expense of frequent pedestrian inconvenience. Such decisions should consider parking lot size and loading, kind of business, major storm frequency, and the facilities installed for disposing of the retained water.

The speed with which water is removed, and thus the number of **hours acceptable** for disposal, is determined by the number of **MaxWells** and their transmissibility. See "Calculating the Drywell Requirements."

Landscaped Areas - There are many landscaped retention areas that contribute to the aesthetic, and even functional quality of the property they protect. Where space permits, landscaped retention has many benefits, whether in the form of a depressed grass area, rockscape, a playground, sidewalk park or putting green.

Unlandscaped retention ponds are definitely not recommended, since their silt is very hard on drywells. Landscaped retention should be designed to drain quickly so that plants or grass are not damaged.

Calculating The Drywell Requirements

1. Determine the total cubic feet of retention needed to meet code.
2. Determine the number of **hours acceptable** for disposal of water retained.
3. Determine total cfs of disposal needed to drain retention in the hours acceptable:

$$\text{TOTAL CFS} = \frac{\text{Required Retention in Ft}}{\text{Hours Acceptable} \times 3600}$$

4. Determine approximate individual well CFS:
   a. For non-critical applications, known soil data can be the basis for estimated percolation rates. McGuckin Drilling, Inc., maintains extensive maps, records and drilling logs on its work in Arizona. From this data, our personnel can quickly determine likely soil conditions and percolation rates for most sites requiring drywells.
   b. For large projects, ones with critical drainage problems, or to verify well performance, a percolation test may be in order. It is common procedure to build one drywell in a location where one will be needed and to then test the completed well. In a finished well, silt cannot wash into the good drainage soils, so performance is optimized and the number of wells required is minimized. Over $135,000 was saved for a major electronics plant through this testing method. Because MaxWells will often take test water faster than a water truck or firehose can provide it, McGuckin Drilling utilizes a percolation testing apparatus that can bring water to the well from a fire hydrant ½ mile or more away, through large diameter lines. Flow rates up to 3.2 cfs are measured by precision totalizing flow-meters. Tests are usually monitored and reported by a soils laboratory.

For assistance in estimating percolation rates or arranging a percolation test, contact our Design Staff.

5. Calculate the number of drywells required.

$$\text{Number of Wells} = \frac{\text{TOTAL CFS} \times 2^{*}}{\text{Individual Well CFS}}$$

*Derating factor for well aging. Fine soils may require higher factor.

6. Select and specify the desired drywell. For drawings, specifications and instructions, see pages 4 to 7. Contact our Design Staff for no-charge assistance in any phase of your planning.

DRYWELL SPECIFICATIONS

PRECAST LINER - REINFORCED 4000 PSI CONCRETE. 48" ID, 54" OD. 8 1¼"Ø HOLES/FOOT.

MANHOLE CONE - STANDARD UTILITY CONSTRUCTION, EXCEPT FLAT BOTTOM.

OVERFLOW PIPE - SCHEDULE 40 PVC MATED TO DRAINAGE PIPE BELOW ROCK.

BRACKETS - FORMED 12 GA. STEEL. COAL TAR EPOXY COATED.

DEBRIS SHIELD - ROLLED 16 GA. STEEL X 36" LENGTH WITH ROLLED 16 GA. X .265" MAX SWO FLATTENED EXPANDED STEEL SCREEN X 12" LENGTH, COAL TAR EPOXY COATED.

DRAINAGE PIPE - 100 PSI MIN. PVC PIPE OR EQUAL.

RINGS AND GRATES - CLEAN CAST-IRON WITH WORDING "**STORM WATER ONLY**" IN RAISED LETTERS. MACHINED MATING SURFACES.

ROCK - CLEAN WASHED ROCK - BETWEEN ⅜" and 1½", SIZED TO COMPLIMENT SOIL CONDITIONS.

MOISTURE MEMBRANE - 6 MIL PLASTIC. **PLACE SECURELY AGAINST CONE AND HOLE SIDEWALL.**

DRAINAGE FABRIC - MIRAFI™ 140N FABRIC. PLACE FABRIC TIGHTLY AGAINST LINER AND PIPE.

INJECTION SCREENS - ROLLED 10 GA. X .625" MAX. SWO FLATTENED EXPANDED STEEL, COAL TAR EPOXY COATED. 96" OVERALL LENGTH WITH MDI-B COUPLER OR EQUAL.

HOLES ARE TO BE DRILLED IN A MANNER TO PREVENT CONTAMINATION OF PERMEABLE SOILS. **HOLE SHAFT TO BE A MINIMUM OF 4'Ø** TO MAXIMIZE SURFACE WALL AREA.

PVC PIPE SHALL BE SUSPENDED DURING BACKFILL OPERATIONS TO PREVENT BUCKLING OR BREAKAGE.

CENTER PRECAST LINER IN HOLE AND ALIGN SECTIONS TO MAXIMIZE BEARING SURFACE.

SECURE RING AND GRATE TO CONE WITH MORTAR. RIM ELEVATION ±0.02' OF PLANS.

DRYWELL MANUFACTURER IS TO INSTALL TWO LAYERS OF MIRAFI 100X FABRIC BENEATH GRATE. GENERAL CONTRACTOR TO REMOVE AT END OF PROJECT, AFTER PAVING AND LANDSCAPING ARE COMPLETE.

COMPLETING THE MAXWELL IV DRAWING

To apply the **MaxWell IV** *drawing to your specific project, simply fill in the blue boxes per instructions below.*

PENETRATE ['] INTO CLEAN PERMEABLE SOILS

Most cities require at least 10 feet. In most cases we recommend a minimum of 10 feet and in very high-load applications, 15 feet or more. At small cost, this added depth can greatly increase both the absorption rate and drywell life.

['] EST'D OVERALL DEPTH

Generally used only as a basis for quoting, with add or deduct figures, used to determine final cost to penetrate permeable soils, as specified above. McGuckin Drilling's extensive drilling logs and maps are available to use as a basis for estimated Overall Depth.

SETTLING CHAMBER DEPTH [']

On ***MaxWell***® ***IV***'s of over 30 feet overall depth and up to .25cfs drywell flow rate, the standard settling chamber depth is **18 feet**. For higher flow rates or greater peak loads, depths up to 25' are recommended.

EFFECTIVE SETTLING CAPACITY [']

The effective settling capacity is determined by the height of the overflow pipe. The greater the overflow pipe height, the more effective the settling process. An o'flow height of **13 feet** is used with the standard settling chamber. Also consider amount of water born debris and maintenance scheduling. For assistance please consult our design staff.

["] PVC PIPE

This dimension also applies to the **PureFlo** debris shield, couplers, brackets, and **FloFast** screen. Choices are 6", 8", or 12". Selection is arbitrary based on need for rapid absorption and venting. Again, our design staff can assist you in a final determination.

C.I. RING & GRATE #MDI [ ]

Select to match PVC PIPE diameter:

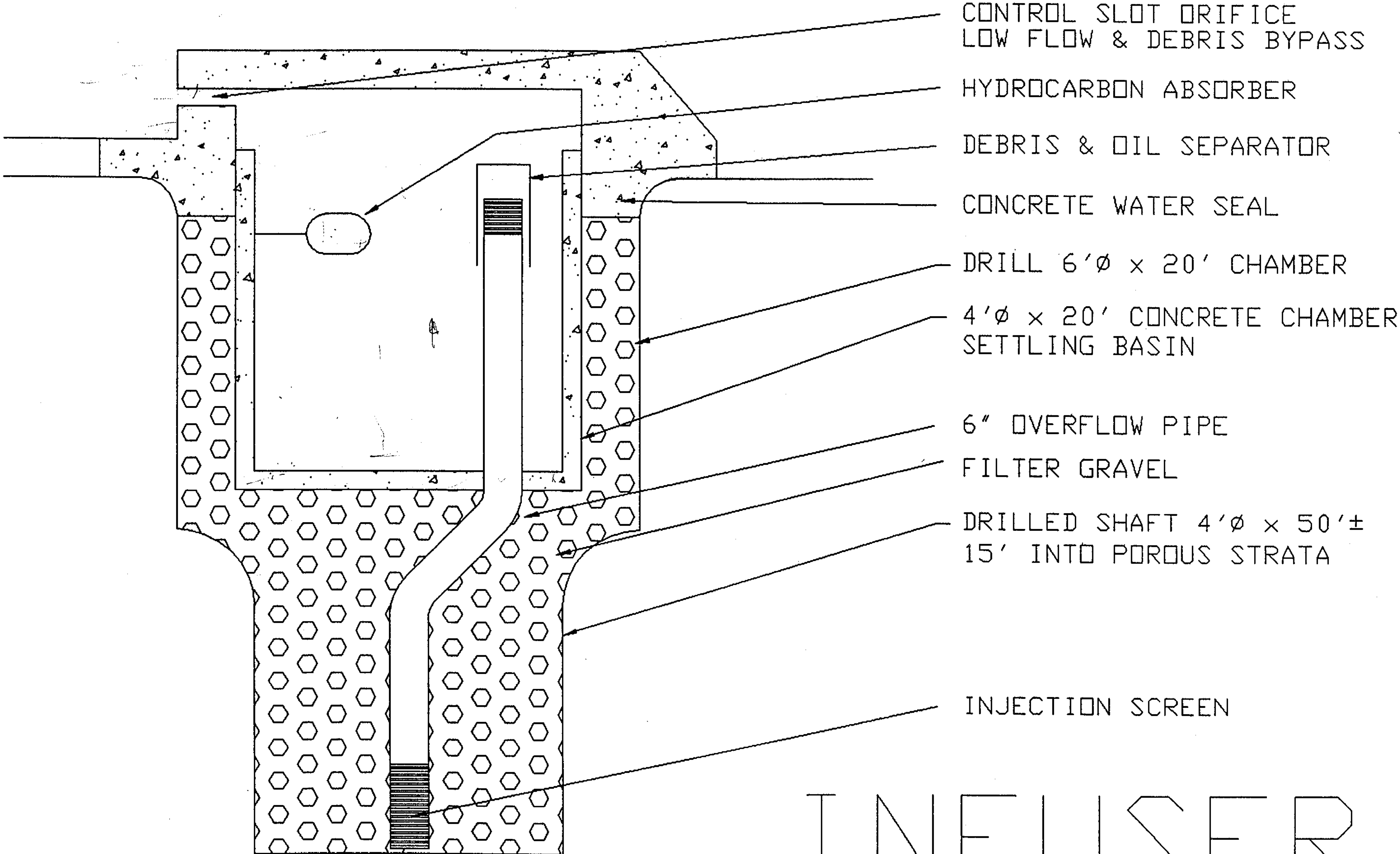
PART NUMBER	CLEAR-OPENING Ø	MATCHES PIPE Ø
MDI - 2024	24", traffic	6"
MDI - 2124B	24", non-traffic, bolted	6"
MDI - 2030	30", traffic	8"
MDI - 2130	30", non-traffic	8"
MDI - 2036	36", traffic or non-traffic	12"

Add a "B" to Part Number for bolted, theft-resistant option.

For various SURFACE TREATMENTS that may be specified, **See Following Page.**

IMPORTANT:

Specifications should be included in plans. Imitation is the sincerest form of flattery, but there have been many failures in imitations of the MaxWell due to inferior materials, inadequat protected steel parts or careless drilling and installation.



INFUSER

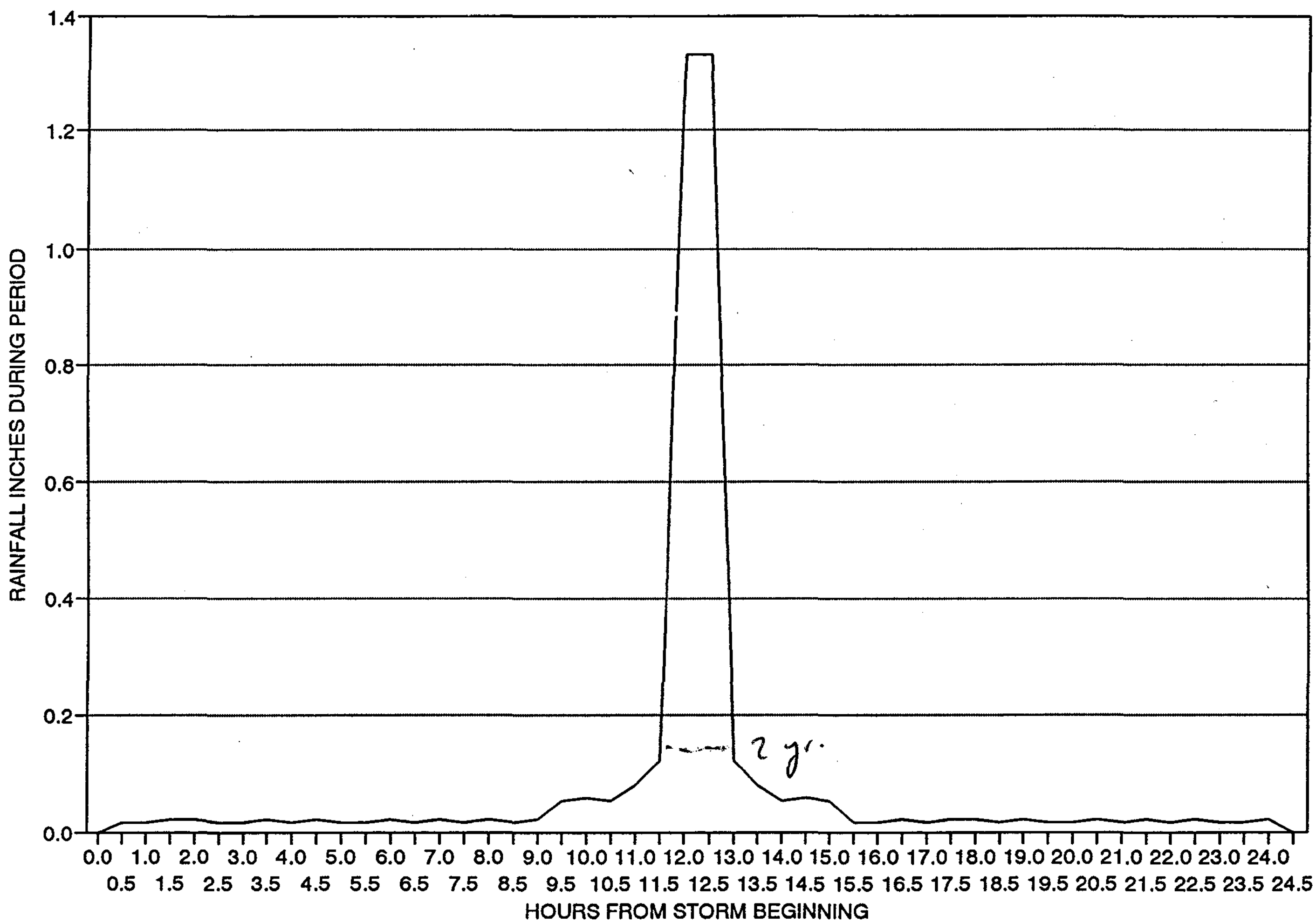
N.T.S.

SECTION A-A

¼ cfs

Probably better to show runoff hydrograph instead.

PHOENIX 100 YEAR RAINFALL HYETOGRAPH USED FOR THE FEMA CAVE CREEK WASH STUDY



- Dead Storage / bypass, can this be damaging
- if 2 year system still is needed, costs should be adjusted.
- problems with # of drywells needed.
(
- see pg. 7., comments on Coolidge City Wash Q_{100}.
- 2 yr. Runoff longer in duration than 2 yr. Storm
- solvents / etc. float on top of water, not sink.
- proximity of injection wells, all working at the same time, what effect does it have on cfs recharge.
- 1/2 cfs to 1/4 cfs, then quadruple the #'s?

1000 gal capacity

FLOOD CONTROL DISTRICT
OF
MARICOPA COUNTY
Flood Damage Form

Staff/Observer: ______________________ ______ am pm
Name Phone Ext Division Date Time

Location: 4238 W. Burgess Ln Phoenix
Street Number (mile post, station, etc.) Street/Route (structure, etc) City

T ____ R ____ S ____ Type of Structure: ____________ Ownership: ____________
(road, culvert, house,...)

Type of Damage: (circle one) ~~Inundation~~ (circled: Inundation) Erosion Sedimentation Structural Failure Other ________

Event Date: 7-14-99 Time: ________ am pm

Eye Witness: ~~[illegible]~~ Raul Martinez (602) 237-3521
(person who observed damage occurring) Phone #:
4238 W. Burgess Phoenix
Address City

Narrative Description of the Damage/Problem

We've been living in this vicinity for 21 years and every year we go through the same mess. When we have alot of rain the canals fill up and go straight to our neighborhood. It's like we live in a ditch. The water went up about 1/2 a foot and not even the sand bags could stop the water from coming in the house. All we could do is mop it up and drain it outside. We

Sketch of the Area Showing Flow Directions

repeated this same process for 6 hours and we couldn't even get out of our house.

Referrals/Notification: ______________________
Ref. : File: ________ Photo: ________ Video: ________ Other: ________ FORM LAST REVISED 1-17-95

To be filled by Data Base Manager

Date/Duration of Damage:____________________

Action Taken/Status:____________________

Frequency of the Event:____________________ Estimated By:__________

Cost of Damage:____________________ Estimated By:__________

Extent of the Damage (area):____________________

B.O.D. Dist. #:__________ Jurisdiction:__________ Verif. of Ownership:__________

Date of Report(input):__________ Staff:__________

Accuracy/Reliability of Data (1=not reliable, 2=reliable 3=very reliable): Reason for rating:__________

Source of Data (other than the FCD):

Special Notes: