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REVIEW OF THE TUCSON WATER DEPARTMENT'S ANALYSIS OF THE CAP/FLOODWATER RECHARGE ALTERNATIVE*

by
C. Brent Cluff
Associate Hydrologist
Water Resources Research Center
College of Engineering
University of Arizona
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INTRODUCTION

The analysis by the Tucson Water Department of the CAP/Floodwater Recharge Alternative was lacking in detail and justification. In the minutes of the Oct. 27, 1983 meeting of the Water Resources Coordination Committee, Steve Davis, Chief Planner of Tucson Water is quoted as saying in response to a question "recharge of CAP water has not been looked at." On July 19, 1983 at a SAWARA Board meeting Frank Brooks assured the Board that the recharge of CAP water would cost more than the use of a Treatment Plant. There has been inconsistencies in the response from Tucson Water concerning recharge of CAP. They have however been consistent in opposing the concept to the point that most people have stopped mentioning the two words CAP and recharge in the same sentence when Tucson Water representatives are around. It is not surprising therefore that the Tucson's Water Analysis of the CAP/Floodwater Recharge Alternative appeared to have been written by a group of overworked planners trying to justify political decisions that they feel are irreversible. However by law the final decision in the routing of the aqueduct must come no sooner than 30 days after the filing of an environmental impact statment.

The economical, technical and legal aspects of the CAP recharge proposal will be reaffirmed in this presentation in hopes that the benefits of the proposed recharge of CAP to the water users in the Tucson area will somehow in our democractic society be allowed to happen. There are other M&I allotments that can perhaps be recharged in the Tucson Basin. These include the Flowing Wells Water Company, the Foothills Water Company and the State Land Departments allotment scheduled to come to Pima County. These three allotments approach the 30,000 acre-feet that Tucson Water will initially contract for. Perhaps Pima County Parks and Recreation could subcontract for these allotments and recharge the water in our natural stream channels and spread the cost of the operation across the county in the name of recreation. This would buy time until a more suitable institutional arrangement could be developed.

Copies of the Tucson Water Department's Analysis can be obtained from the Tucson Water Department. The response to the Tucson Water Departments analysis will be taken in the same order and heading as is contained in their report.

FINANCIAL CONSIDERATIONS

The assumptions that Tucson Water spells out in its financial section are: (1) All pumping costs for delivery of harvested floodwater from the detention basin will be paid by Tucson Water. (2) The cost of CAP water will be the same in all alternatives. (3) All costs will be in 1984 dollars with no consideration to inflation. (4) Treatment of floodwaters to an improved quality is required. (5) Probable increase in system modifications would be required for CAP/Floodwater Recharge Alternative versus the CAP/Treatment/Transmission Alternative. (6) CAP water would require treatment prior to stream recharge.

In response to assumption 1 the distribution of costs of the floodwater harvesting part of the system would depend on how the system were built. If the floodwater harvesting features were built by the USBR as a part of CAP all costs including pumping would be paid by the USBR. Under this arrangement according to Wes Steiner (Appendix B) the extra 23,000 acre-foot of floodwater conserved by the project might have to be allocated among all CAP users.

The floodwater harvesting part of the project could be co-ventured between the USBR and Tucson Water. In that case Tucson Water could pick up the pumping costs and perhaps other costs in lieu of paying the standard charge for CAP water. This would prevent having the conserved floodwater allocated to someone else.

In response to assumption 2 at present the cost of CAP water would be the same in all alternatives. However there has been interest expressed by Mike McNulty (minutes of Oct. 27, 1983 meeting of WRCC) in having CAWCD develop a special rate for recharge. Since the recharge could be done wih surplus waters during offpeak seasons and in varying amounts the request of a special recharge rate is very reasonable and should be pursued. In addition there is always the strong possibility that allotment or surplus CAP waters now scheduled to go to agriculture could be purchased during offseason at a reduced rate for the purposes of recharge.

With regard to assumption 3 the USBR expresses its costs in 1982 dollars so a downward adjustment is required before a comparison can be made.

The fourth stated assumption that treatment of floodwaters is needed before it can be recharged to the same streams from where it was derived does not make any technical sense. There is no precedent for this requirement. It

would cause economical havoc if the same regulation was required in the Phoenix area i.e. that SRP treat floodwater from the Salt or Verde Rivers before releasing it back to the same rivers. There will be some inherent reduction of BOD, COD and sediment load in the proposed detention basin which would tend to act as a large oxidation pond. There would be further oxidation as the floodwater is exposed to air and sunlight in the process of recharge using stream channels. Requiring treatment beyond that which would occur naturally is not a realistic assumption.

The assumption that pumping and transmission costs to Tucson Water would be greater for CAP/Floodwater Recharge Alternative as compared to a CAP/Treatment Plant /Transmission system is not valid particularly when looked at a year at a time. The CAP/Floodwater Recharge System will deliver water to the South along the Santa Cruz, to the Southeast along the Pantano, to the East and Central wellfields through use of the Tanque Verde and Rillito Rivers and to the Northwest through the Canado Del Oro, Rillito and Santa Cruz rivers. Any particular area could receive additional water by making channel modifcations to increase the recharge in that particular area. The aquifer would be the transmission system to carry the water from the stream to the wells.

New wells will need to be drilled and equiped even though the CAP Treatment Plant and transmission system is built in order to provide water during CAP breakdown or drought. If the recharge system is used Tucson Water would not need a redundant water supply system. The recharge system would automatically provide the same water security as Tucson now enjoys in addition to stabilizing our water table. At the present time using our groundwater reservoir Tucson is immune from the ravishing effects of drought. For instance Tucson did not have to ration water in the drought of 1977 as did many of the western states that were dependent on surface water supplies.

The assumption (6) that CAP water would need treatment prior to open stream recharge is not valid. Treatment is not needed. This has been adequately proven in the several recharge systems in California that use the biologically pure Colorado River water without treatment for stream recharge.

The big unanswered question by the Tucson Water staff is how or why did they go from a publically stated (Ealy, SAWARA meeting, Oct 20, 1984) figure of $200 million capital cost for the first phase CAP treatment and transmission system down to a $68.84 million total capital

cost to treat and transmit their entire 151,000 acre-foot allotment! A written request for clarification was made but refused by Frank Brooks, head of Tucson Water. (See the Appendix for copies of these letters.)

The USBR financial analysis, also given in the Appendix of this report, was heavily dependent on these reduced costs provided by Tucson Water. The USBR economical analysis was based on using a generalized costing procedure for the floodwater detention basin that did not take into consideration its unique features. No recreational or flood control benefits were included. Finally the value of the water produced by the system was placed at $200/acre-foot which is below the $425/acre-foot value of alternative water used in earlier studies to justify the importation of CAP water to the Tucson area. It is well below the actual cost of importation of CAP water. The whole concept of floodwater detention near the narrows developed after seeing the large costs the USBR was projecting in sealing the proposed pit storage plans for CAP water. The Santa Cruz floodwater will seal the CAP storage and conserve floodwater at the same time. When the USBR (1) separated the CAP water storage from the floodwater storage (2) used costing proceedures that did not account for the unique cost-saving features of the reservoir site (3) neglected to include the value of recreation and flood control and (4) priced the value of the water conserved at only $200 it is not surprising that the floodwater harvesting feature does not have a positive benefit cost ratio. This part of the system will have to be built by someone else or wait until the USBR is ready to build, as promised, the CAP terminal storage reservoir.

When the flood conservation features are left off the USBR'S cost analysis and the previously announced CAP integration costs of $200 million is used the capital cost comparison looks entirely different as indicated in Table 2 in the Appendix. This Table shows that either recharge plan is more cost effective than the proposed Westside/Water Treatment/Transmission System.

With regard to operation costs the USBR has clarified that they used a much higher energy rate (67 mills/KW) for the recharge projects as they did for the Westside Plan (43

mills/KW) (Disansa, Jan., 1984). This increase in rates was based on a integrated pumping scheme whereby Tucson Water would be required to pay for power used in the pipeline extentions to Canado Del Oro and Pantano/Tanque Verde/Rillito. The USBR assumed that under the integreted puimping that offpeak power could not be used because Tucson Water might not be able to obtain power when the USBR was pumping. This possibility could be handled with the construction of small regulatory reservoirs 100 acre-feet at the Canado Del Oro and 400 acre-feet at the Pantano/Tanque Verde pipeline. A similar sized reservoir is planned at the Tucson Water turnout from the Westside Aqueduct. The cost of this reservoir has not been added to the cost estimate for the westside aqueduct.

There does not seem to be any defensible justification to use different energy rates in the two schemes. If the USBR and CAWCD have agreed to furnish water to Tucson at the 2800 foot elevation in the CAP/Treatment Plant/Transmission System scheme why can't it also do the same in the recharge alternatives? The USBR not only applied a higher energy rate they also assumed a different average annual delivery on which they based their total energy cost. Mr D. Hagstrom of the USBR in a telephone conversation in February, 1984 indicated that 89,000 acre-foot average flow was used for the recharge scheme but apparently did not know what the average flow for the westside aqueduct/ treatment plant scheme was. As a result of this unethical comparison the energy cost of operating the Pantano Recharge Pipeline (200 cfs capacity) lifting 71,200 acre-feet of water 399 feet was given at $2.88 million or $0.10/acre-foot/foot of dynamic head. In the USBR favored westside alignment the total cost of lifting the average Tucson Water allotment 319 feet was listed in the support data as only $0.87 million. If the same flow of 89,000 acre-feet is assumed this would be $0.0306/acre-foot/foot of dynamic head. Thus the energy costs in the recharge system ended up being charged at a overall rate almost 3 time what was charged in the favored westside/treatment plant system!

If the same energy rate and average delivery is applied the energy cost of the Westside Recharge Alternative (Plan B) drops to within 5% of the Westside Plan. Since under Plan B the water is lifted to the same elevation as the Westside

Plan the difference is made up of the friction head required for the additional pipeline going to Canado Del Oro and the Pantano/Tanque Verde/ Rillito streams. This friction head amounts to 112.6 feet for the 50 cfs Canado Del Oro Pipeline and 71 feet for the 200 cfs Pantano/Tanque Verde/ Rillito Pipeline. This compares with the more than 800 foot total head for the 550 cfs Phase B Westside Aqueduct as now planned.

Under the Eastside Recharge Alternative (Plan A) as the USBR perceived it most of Tucsons allotment would be pumped to an elevation of only 2550 feet. In addition the friction head would be 94.6 feet for the 50 cfs line from Canado Del Oro. There was no friction head or static head data given in the USBR's information sent down for the Pantano/Tanque Verde/Rillito Pipeline but there was a $62.7 thousand dollar cost for a pumping plant and a $1.056 million dollar energy charge even though the preceeding reach of the aqueduct (2a) will according to the USBR's data lift all the water in the main stem to a elevation of 2560 feet. This analysis needs to also be further clarified. In any event there would be a significant drop in energy costs under the Eastside Recharge Alternative (Plan A) as compared with the USBR's Westside Plan if the same energy rate and average water delivery were used.

For some reason the USBR used only $1.500 million Tucson Water operation cost for the CAP treatment plant ($8/acre-foot) and transmission system. In checking with the Phoenix Water Department they projected a $40/acre-foot cost (excluding energy costs) of operating their 80 mgd Union Hills Water Treatment Plant. (Steve Bonteger, Phoenix Water Department, Tele. Conservation, Feb. 6, 1984) With this cost the operation costs should be $3.56 million if a average delivery of 89,000 acre-feet is assumed. This does not include any OM&R for the large transmission lines whereas in the USBR analysis of the recharge alternatives these costs were charged. It also does not include any maintenance of the redundant water supply source (wells) that would have to be kept ready to provide emergency water under the CAP Treatment Plant/Transmission Alternative.

In Orange County the average cost of operating their 200,000 acre-foot recharge system over the past several years was given by Mr. Fairchild in a visit in November, 1983 as approximately $250,000 or $1.25/acre-foot. In January, 1984 Mr. Fairchild was asked to send written verification of their costs. This letter which is included in the Appendix lists their 1983 costs at $850,000 or $4.50/acre-foot. Using this higher Orange County figure for a average delivery of 89,000 acre-feet of CAP water the operating cost is $0.4 million.

To the cost of operating the recharge system must be added the cost of repumping which has been estimated to be $45/acre-foot. The total operation cost of the recharge/repump system for the average 89,000 acre-foot delivery would be $4.00 million.

The total operational costs of the two systems when fully operational would be similar. The main difference in operation costs of the two systems is that in the intervening years when the amount of water going through the treatment plant is relatively small there would be a higher unit operation cost due to maintenance on features of the treatment plant and transmission system that were built but not yet needed.

The over-riding economic issue as indicated in the Position Paper (Cluff, 1983) will be in the capital recovery costs of Tucson Water which will have to pay in advance for facilities that will not be fully utilized for many years. As alluded to in the above referenced paper if a 8% bond rate is used with a 20 year payoff, the capital recovery charge on a $200 million dollar (first phase) treatment and transmission system would be $20 million per year. This is $660/acre-foot for the 30,000 acre-feet of water initially delivered.

The Tucson Water analysis did not address this issue of high intermediate costs. In contrast the costs of the recharge system with the exception of the two pipeline extentions would be incurred gradually. Construction of the pipeline extentions could be phased. The $67 million dollar Pantano/Tanque Verde/Rillito Pipeline should be built first to assure stability of the water table in the central wellfield. The $17 million pipeline to the Canado Del Oro might be built later. Recharge of the initial amounts of CAP water could also be easily made down the Santa Cruz River with little expense particularly if the eastside alignment were selected by the USBR.

HYDROLOGIC IMPACTS

1. Most of the concerns stated on page 5 of the Tucson Water Analysis of the proposed CAP/Floodwater Alternative were covered in the final September 27, 1983 report. Evidently the Tucson Water Staff used a earlier version of the report for their review. In the September 27 report the advantages of intermittant operation were discussed. There was sufficient capacity built in to the proposed aqueducts to leave any one stream dry and only utilize the other three. Also releveling and channel scarification to maintain satisfactory infiltration rates were mentioned as operational proceedures that could be done if necessary. It was also pointed out in the final report that floodflows would tend to clean out deposited sediment reducing the need of scarification or wet/dry cycle operation.

In the Orange County, California recharge system the stream channel of the Santa Ana River is devided. On one side of the channel holding ponds or recharge pits were created, on the other side the natural stream channel is used with sand dikes to spread the water over the bottom of the channel. Every time a natural flow occurs greater than 500 to 1000 cfs the sand dikes are washed out. However during these events sediment is removed. On the side of the channel where holding ponds are installed the sediment has to be removed using heavy equipment. In talking with James. B. Fairchild, the Water Conservation Projects Manager of the Orange County Water District he stated that it would have been better to have constructed their system to operate both sides of the channel in such a way that the floodwaters could alternately be directed down first one side and then the other. This would allow the natural floodflows to remove any deposited sediment and thereby restore the initial infiltration rates. In spite of sediment removal costs overall recharge costs are relatively low. The average costs over the past several years was reported by Mr. Fairchild to be $250,000 to recharge 200,000 acre-feet per year. The cost in 1983 was

approximately $850,000 including salaries, deisel etc to recharge 200,000 acre-feet. During this year there was additional cleaning expense of a large recharge pit that is normally cleaned every 2 or 3 years. However even for this relatively expensive year the cost per acre-foot recharged was only $4.25/acre-foot. See the Appendix for a verification of these costs in a letter from Mr. Fairchild.

Orange County has successfully recharged an average of 200,000 acre-feet per year primarily using a modified 8-mile stretch of the Santa Ana River. The recharge rates suggested for the CAP/Floodwater Recharge Alternative were based on a 50 foot wide strip over 68 miles of available stream channel. If additional recharge capacity is needed in particular upstream areas this width can be increased by simple furrowing or building low profile sand dikes. The Orange County experience shows that the cost of doing this is relatively inexpensive.

2. The hydraulics of groundwater flow do not "dictate that it would take years to infiltrate the vadose zone sediments to a degree sufficient to allow recovery of recharged water through properly designed and located wells." The process of recharge is already occuring along the streams. At the Water Resource Research Center Field Laboratory there is a cascading well that responds within hours to stream flow down the adjacent Santa Cruz River.

According to Steve Davis of the Tucson Water at a SAWARA meeting on January 18, 1984 the central well field of the city has already responded to the large amounts of natural recharge from the floods that have occured the past two years. There would be a similar response from recharging CAP water down the same streams. There is no need to saturate any more vadose sediments for recharging CAP water than were saturated during the "flood of 1983" last October. That is the advantage of using natural streams versus using "dry wells" where natural recharge is not occurring and the saturation claim might have some validity. It would be impossible in the Tucson Basin to saturate the volume of sediment up to the bottom of the stream channel with a total flow of only 250 cfs to be distributed into four streams. Why would it be impossible? Because hydraulics of groundwater flow dictate that the

water would flow into the "holes" or depressions in the water table caused by pumping at a rate faster than the infiltration rate. In most of the beds of the major streams in the Tucson Basin the infiltration rate is controled primarily by the rate of surface entry into the sediments not by any underground restrictions. That is why the Tucson Water's recharge system along the Santa Cruz in Northwest Tucson has never completely saturated the vadose zone although 30,000 acre feet per year have been run down the river over the past several years. That is why dangerous "quicksand" conditions have not developed.

In Orange County, according to James B. Fairchild, the water table has never been closer to the surface than 40 feet below the bottom of the stream even though the recharge system is operated at a relatively high continous rate. As proof that they have never developed "quick sand" conditions Orange County routinely use dozers in the stream channels while recharge is taking place.

3. The indications that recharge of CAP water through the use of a 50 foot wide strip in the stream channels would prevent any natural recharge to occur is rediculous. The floodflows occupy a much wider width of stream channel than the proposed CAP recharge ever would unless intensive recharge methods used by Orange County were employed here. If these intensive recharge methods were used it wouldn't be necessary to utilize the full 68 miles of stream available. As indicated above the streambeds cannot become saturated with a 250 cfs stream that is distributed in the Canado Del Oro, Santa Cruz River, Tanque Verde/Rillito and the Pantano. There would still be ample infiltration capacity for natural recharge to occur.

4. Channel infiltration has very little effect on the peaks of damage producing floods. The fact that a 50 foot wide streambed was previously wetted would not have affected the damage that was done in the "Flood of 1983" How could a flow of 250 cfs affect a flood peak of 60,000 cfs. If it could, the City is already in trouble since they have previously wetted 28 miles of streambed with their sewage effluent releases into the Santa Cruz River. How many suites has that recharge project created?

The low sand dams and furrows envisioned to enhance recharge in selected areas could be built without impeding major flood flows. All of these temporary dikes would be leveled by the rising water long before any damage producing peak is reached. This has been well demonstrated by the operation of the recharge system in Orange County.

5. Intercepter wells were included in the CAP/Floodwater Recharge Alternative only because some staff members of the City Water were fearful that the recharged water would not reach existing wells. If the intercepter wells would isolate "interior wells from a primary recharge source they depend upon" then don't drill the interceptor wells!

6. Again the recommendation to drill additional wells in the vicinity of Rillito Narrows was made to allay fears expressed by some members of the Tucson Water staff that we would not be able to capture the water that was recharged. It is doubtful that these wells would be needed particularly if recharge was enhanced in the upper reaches of the streams. However if they are needed there are areas near the narrows where water quality is as good or better than CAP water. Wells could be drilled in these areas to serve the growing water demand in the northwest rather than run expensive transmission pipelines from the central treatment plant near Ajo Road in Avra Valley. Under the proposed CAP/Floodwater Recharge Scheme municipal wastewater now being recharged in the Santa Cruz River beginning at the Roger Road Plant would be diverted and put in the streambed below the floodwater diversion point near Cortaro Road bridge. This diversion over time would improve the water quality above Cortaro Road Bridge.

7. The flood control benefits would accrue to downstream users principally in the Marana, Redrock, Casa Grande and Maricopa areas. If the USBR built the floodwater detention reservoir as a part of CAP project the costs and benefits of the flood control portion of this project would be spread out over the state and nation in accordance to USBR costing policy. These benefits would help compensate for reduction of the sporadic streamflow in the Santa Cruz River. The flood control benefits would be greater if the reservoir was built upstream. However this would require reservoirs on Canado Del Oro, Pantano/Rillito and main stem of the Santa Cruz to get an equivalent amount of flood protection downstream as the proposed reservoir would provide. Other issues would be involved as discussed in

the the CAP/Floodwater Recharge Alternative Report. There does not appear to be any cost effective flood control reservoir site unless both the real value of conserved water and flood control benefits are considered together. When this is done it would not be difficult to show that the offstream Rillito Narrows site as well as pit excavation using strip mining techniques near tributary streams to be cost effective. It appears that the offstream Rillito Narrows site if developed in conjunction with CAP storage would be the most cost effective floodwater storage alternative. The Corps of Army Engineers had not previously looked at the site. Prior to the "flood of 1983" a request had been made to the Corps of Army Engineers to provide flood benefits of the proposed reservoir. This data needs to be developed before a final cost benefit assessment of the proposed site can be made.

8. The claim that turbulent flow breaks up and resuspends the deposited fines, restoring streambed infiltration capacity "after passage of the initial salt laden flow" may appear reasonable when conceptualized but in reality does not necessarily happen due to the cellular nature of our flood producing rainfall. Salt laden flow, if it occurs, can be carried to a stream that is already turbulent from a flood flow that occured somewhere else on the watershed. Rainfall does not add salts to our system. As any farmer who has alkalai soil can attest you do not get rid of salts by running water over the surface of the soil. Deep plowing and percolation of water through the soil is needed. Therefore our floodflows contain relatively few dissolved solids. The real danger to our long term water quality will not come from the recharging of this relatively salt free water rather it will come from importation of CAP water and recycling the resultant muncipal wastewater with a relatively high salt content up gradient to use for irrigation of golf courses etc. This will further concentrate the dissolved solids to eventually pollute our ground water.

ENVIRONMENTAL CONSIDERATIONS

On January 8, 1984 the recharge operation located west of Palm Springs, California was visited. Colorado River Water was being released to a otherwise dry streambed. The rate of release was in the 100 to 200 cfs range. There were

several hundred people wading, riding their ATC's and other offroad vehicles and in general just watching and enjoying running water in the desert. If the water wasn't there the people wouldn't have been there. Knotts Berry Farm and Disneyland were also visited. Most of the popular attractions at these facilities are based on runing water. It is a basic characteristic that humans enjoy being around water, particularly runing water. Where do people from Tucson go when they go on vacation? To the ocean, to the lakes, to the Colorado River, to go tubing on the Salt and Gila Rivers, and to the mountain streams. No amount of meetings by SAWARA or any other group is going to change this basic human characteristic.

With regard to the liability of a 50 foot wide stream of flowing water there is no need to look any farther than the inadvertant recharge project that Tucson Water has been operating over the past several years. Under this project streamflow has occurred on a daily basis over some 28 miles of stream channel in the area northwest of Tucson. This water is at times poorly treated and would have to be fenced if it were applied on Golf Courses. However when placed in the river there are no fences, there are in fact few signs posted warning people of the poor quality water. Dangerous quick sand conditions have not occured. This indicates that the underlying sediments are not saturated even though the daily flow has approached or exceeded 100 cfs over the past 10 to 15 years. How many lawsuits has this caused the city? The city seems willing to accept this liability risk. In view of this comparison the labeling of a proposed CAP recharge system as an unacceptable risk needs to be reconsidered.

The proposed CAP/Floodwater Recharge system can be modified to reduce energy requirements. It was suggested that 68 miles of streams could be used to recharge the 151,000 acre-foot allotment plus the approximately 23,000 acre-foot of salvaged floodwater. This length of streams were used to emphasize the recharge potential that is available. As stated earlier in Orange County only 8 miles of modified streambed is needed. By modifying the stream channels all of the CAP water could be recharged in the upper reaches of the streams reducing the energy requirement. With a modified east side alignment for the Phase B Aqueduct lower elevation release points could be made to the Canada Del Oro, Rillito and Santa Cruz to further reduce the energy requirements of getting the CAP water to the streams.

Under the proposed Westside Alignment using a central treatment plant all CAP water would be pumped to the 2800 foot elevation even though the average surface elevation for utilization is only 2467 feet. This appears to be a unconscionable waste of energy. There are modifications that can rather easily be made to reduce the energy requirements of the CAP/Floodwater Recharge Alternative but there does not appear to be much that can be done to reduce the energy waste in the Westside Alignment/Central Treatment Plant Scheme.

LEGAL CONSIDERATIONS

(1) Existing Surface Water Appropriations.
No new information was presented by the Tucson Water's staff analysis with regard to surface water appropriations that was not covered in the CAP/Floodwater Recharge Alternative report. Obtaining a clear title to excess floodwaters on the Santa Cruz will take considerable effort. The amount of time it will take depends on the approach that is used. If every effort is made to educate the general population of the wasted resource that could be better utilized and the resulting flood benefits that would result from the utilization it would reduce the time involved. If any benefit from the present use of floodwater of the Santa Cruz can be demonstrated then some type of payment or tradeoff would need to be arranged. Now is the time to get started in view of the heavy flood damage recently suffered by downstream users and the availability of CAP water beginning in 1985 in the Phoenix area to make trade offs as necessary.

The CAP/Floodwater Recharge Alternative report did not argue against the policy of purchasing farmland to obtain a water supply. However the consequences of those purchases as compared to letting the farms proceed with plans for using CAP water need to be thoroughly examined. The purchase of additional farmland in Avra Valley to slow down the rate at which the aquifer there is being drained should not be equated with obtaining rights to the renewable floodwaters which will be available long after the Avra Valley aquifer is exhausted. Furthermore groundwater hydraulics dictate that subsurface water will continue to

move downgradient to the wells of agricultural pumpers in Pinal County. The rate of movement now is estimated to be 16,000 acre-feet per year. Since this rate is directly proportional to the gradient it will increase as the Pinal County farmers continue to pump and Tucson Water retires additional farmland in an attempt to save the Avra Valley Aquifer for the future. The Pinal AMA have adopted a policy that permits complete aquifer depletion. Under this policy the pumpers in the Pinal AMA could very well drain a significant quantity of water from the Avra Valley aquifer as the water table drops in Pinal County and the gradient increases.

As the urban area grows and increasing percentages of the desert is paved the amount of floodwater will increase. Even after all the farmland in Pima County is retired and all the water available to Tucson from the CAP is utilized Tucson will need additional water. This water can be developed by a better utilization of the more than 300,000 gallons of rainfall that is received per acre of land in an average year. Obtaining rights to the floodwater of the Santa Cruz will make the task of better utilization of rainfall much easier.

2. Effluent Recharge.
This section was difficult to understand in light of the fact that Tucson Water has been operating an "inadvertant" effluent recharge system over the past several years without the apparent need for prior tertiary treatment and with the Arizona Department of Health Services approval. In the CAP/Floodwater Recharge Report it was suggested that the river channel north of Cortaro could be used to intensify the reacharge that is already taking place. This would minimize downstream losses and reduce the amount of effluent flowing out of the county.

3. Surface Water Quality Regulations.
If this regulation applied to the CAP/Floodwater Recharge Alternative on the Santa Cruz it would also have to be applied to any floodwater the Salt River Project released to the Salt River streambed. To require treatment of floodwaters before the water could be returned to the same

streams from which they were obtained does not make sense. If the Arizona Department of Health Services is proposing this regulation they have not fully considered its consequences. If it is administered statewide it would create economic havoc in the Salt River Basin and other parts of the state. There are no examples I know of where treatment of natural floodflows are required before those flows can be released to the same streams that produced the water.

4. Farmland Retirement.
This policy has dominated the water planning activities of Tucson Water for the past decade. With the advent of CAP this policy needs to be carefully reviewed. The continuation of the policy could jeopordize the entire importation of CAP water into the Tucson area. The announcement that Tucson Water is going to buy out Avra Valley Irrigation District has already eliminated any economic justification of the westside alignment over the eastside alignment. See Table 3 in the Appendix for a cost comparison of the old Eastside and Westside alignment versus a updated Eastside alignment with no Avra Valley Irrigation canal. The sizing of the CAP aqueduct to Tucson may have to be reduced. There does not appear to be any justification for Tucson Water to retire farmland that plans to use CAP water that otherwise will be used on a farm in some other county. When the farmland starts using CAP water they have to stop using ground water. In addition there will be some deep percolation that will eventually recharge the groundwater table. The farms can be used to provide a place for CAP water to be used until it is needed by the expanding urban community.

5. No legal changes are needed in the groundwater law for the Tucson Water to recharge the aquifer in which the City pumps 85% of the water. Existing pumpers will continue to withdraw water that Tucson Water could have used with the advent of CAP. This will happen whether CAP water is recharged or not. Using a expensive central treatment plant and distribution system rather than the recharge method not only penalizes the city water consumer economically it also penalizes the city water consumer with poorer quality water while the remaining pumpers enjoy better quality ground water. Recharging of CAP water would eventually cause all pumpers in the basin to share in the water quality degredation caused by importation of CAP. This degredation would be more gradual uder the CAP recharge scheme than with the use of a treatment plant.

APPENDIX

THE UNIVERSITY OF ARIZONA
TUCSON, ARIZONA 85721

COLLEGE OF ENGINEERING
WATER RESOURCES RESEARCH CENTER
A.E. DOUGLASS BUILDING 28

Jan. 17, 1984

Memorandum To: Frank Brooks
From: C. Brent Cluff CBC

Subject: Response to Tucson Water's Staff review of CAP/Floodwater Recharge Alternative.

In going over your analysis I find that the cost comparison you made on the first page is lacking in detail. I need some expanation as to how you went from a publically announced figure of $200 million on Oct 20, 1983 down to a figure of $68 million on Jan 11, 1984. Futhermore the $200 million dollar estimate was for the first phase (10 year needs) and would treat up to 60,000 acre-feet per year. Some of the transmission system would be sized to transport your entire allotment but there would be other major transmission mains that would have to be installed. Your $68 million dollar figure you claimed would not only treat but would transmit your entire allotment over your service area! Please break down your $68 million dollar estimate. How much of this is allocated for the treatment plant? How much is allocated for transmission?

I also need an explanation of the $71,089,000 capital investment needed by Tucson water for the CAP/Floodwater Alternative. Do these costs include capital expenditures for treating CAP and floodwater before it can be recharged? Your explanation of these costs are not clear. You mention on page 5 that you utilized $161 million but this amount is not in your table on page 1, please explain.

I would also like a breakdown of your annual costs on both plans. How much of these costs were due to energy etc? What discount rate did you use?

I do wish to apologise for laughing during your staffs presentation of your analysis. I should have kept myself under better control. Self control would have been easier if I had been permitted to see an advanced copy of your analysis.

I appreciated seeing the April 27 memo written by Sol since I had not previously seen a copy. Evidently the memo was written for your benefit not mine. In any event the subject of the memo had nothing to do with the CAP/Floodwater recharge project therefore this memo should be deleted from future distributions of your analysis. As referenced in my final report dated September 27, 1983 Sol Resnick, Jim DeCook and Grey Wilson of the WRRC endorsed the concept of CAP recharge in a report written for the Army Corps of Engineers in 1981.

I don't know of any groundwater hydrologist on campus that doesn't support the general concept of using our natural stream channels to recharge CAP. My report was formally reviewed by Grey Wilson, Nathan Buras, Gene Simpson, Jerry Matlock, Emmett Laursen, Bill Martin and Terry Triffet. Dr. Terry Triffet, Associate Dean of the College of Engineering approved the publication and distribution of the final report.

Dr. John Harshbarger is presently reviewing both my report and your response. John has been a strong advocate of recharge particularly along the Rillito River. In fact he related to me that some officials of the City went to Pres. Harvill to try to get him fired for reccommnding that the city recharge floodwaters along the Rillito rather than develop groundwater along the San Pedro. It is fortunate that the City officials were unsuccessful.

cc: Tom Volgy
Frank DiSansa
Bill Ealy

United States Department of the Interior

BUREAU OF RECLAMATION
ARIZONA PROJECTS OFFICE
SUITE 2200 VALLEY CENTER
201 NORTH CENTRAL AVENUE
PHOENIX, ARIZONA 85073

IN REPLY REFER TO: 330-700
500.

JAN. 5,1984

Dr. C.B. Cluff
Water Resources Research Center
College of Earth Sciences
A.E. Douglass Building No. 28
University of Arizona
Tucson, Arizona 85721

Dear Dr. Cluff:

On behalf of Regional Director Plummer, we are providing you the following information in response to your November 22, 1983, memorandum and report regarding the Central Arizona Project/Floodwater Recharge Alternative. This information is intended to supplement our initial findings that were provided to you by letter dated June 14, 1983.

In summary, we do not feel the recharge alternative is feasible as proposed (see June 14, 1983, letter) and as such is not a viable alternative to the Tucson Aqueduct-Phase B plans presently under consideration. Therefore, we intend to only discuss the recharge alternative in the Tucson Aqueduct-Phase B draft environmental impact statement as an alternative considered but eliminated.

To demonstrate the high costs associated with the recharge alternative, we have prepared the enclosed table that compares the Tucson Aqueduct-Phase B West Side Plan with two versions of the recharge alternative. The costs used in the enclosed table are based on appraisal level estimates and should be used for comparison purposes only.

Although our analysis shows the recharge alternative is not feasible, we believe that a ground water recharge project in the Tucson area could be beneficial. Therefore, the Arizona Projects Office supports the evaluation of projects such as the City of Tucson's effluent recharge demonstration project and the recharge demonstration projects contained in House Report 71 (H.R. 71). Furthermore, we have recommended that a Santa Cruz River project be one of the demonstration projects evaluated under H.R. 71.

Sincerely yours,

Edward M. Hallenbeck
Project Manager

Enclosure

Table 3*
Regional Cost Summary[1/]
Tucson Aqueduct-Phase B
(All Cost are in Thousands of Dollars)
(January 1982 Price Levels)

	East Side		West Side
	Old	New**	Old
Aqueduct	231,541	231,541	188,810
Indian Delivery Line	8,250	8,250	1,750
Avra Valley Delivery Line	25,041	0	0
Treatment Plant Pipeline and Pumping Plant	0	0	40,369
TOTAL FIELD COST	264,832	239,791	230,929
Noncontract (25%)	66,208	59,947	57,732
TOTAL CONSTRUCTION COST	331,040	299,738	288,661
Interest During Construction[2/]	63,436	57,437	55,315
Mitigation - Biological[3/]	3,063	3,063	5,062
- Cultural Resources[3/]	1,000	1,000	2,500
TOTAL CAPITAL COST	398,539	361,238	351,538
OM&R - Aqueduct	987	987	1,287
- Indian Delivery Line	20	20	48
- Avra Valley Delivery Line	304	0	0
- Treatment Plant Pipeline and Pumping Plant	0	0	178
Energy - Aqueduct	7,063	7,063	4,379
- Indian Delivery Line	0	0	0
- Avra Valley Delivery Line	26	0	0
- Treatment Plant Pipeline and Pumping Plant	0	0	1,544
TOTAL OM&R COST	8,400	8,070	7,436
ANNUAL EQUIVALENT OF CAPITAL COST[4/]	30,408	27,562	26,822
TOTAL OM&R COST	8,400	8,070	7,436
VALUE OF ADDITIONAL WATER LOSSES IN WEST VERSUS EAST ALIGNMENT ($520 x 2620)	0	0	1,374***
TOTAL ANNUAL COST	38,808	35,632	35,632

1/ Labels used in this table relate to function and not to funding responsibility.
2/ Interest during construction is based on a 5-year construction period and an interest rate of 7.625 percent.
3/ Worst case conditions based on available information.
4/ Formulated based on 100-year project life and an interest rate of 7.625 percent.

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* Bureau of Reclamation Report, Central Arizona Project RE:CAP Tucson Division, INFORMATION PACKET TUCSON AQUEDUCT-PHASE B ALTERNATIVE PLANS, May 1983.

** The costs in this column are based on the elimination of the Avra Valley Delivery line.

*** Not included in original table.

(5) Avra Valley Delivery is no longer applicable to any delivery plan since the City of Tucson's announced intention of purchase of farmlands belonging to the AVRA Valley Irrigation District.

(6) Santa Cruz Canal will deliver water from the upper end of Aqueduct to Santa Cruz River for the purposes of recharge.

(7) The Water Treatment Plant is to be built in three stages each of which will have a capacity of approximately 50,000 acre-feet. The cost of the second and third phases has not been announced.

(8) The distribution system to move water from the treatment plant to the existing distribution system will also be built in stages however some portions of the first stage will be designed to carry the full capacity of the final treatment plant so that the cost of subsequent stages should be less than the first stage. The costs of the second and third stages needed for the treatment plant have not been announced. Similarly the costs of the connecting new wells to the existing system have not been determined.

(9) The Tucson Water Department has on several occasions announced that wells would continue to be used if CAP water was not available because of drought. Thus a large well field will have to built and maintained even with the advent of CAP water. The City has sufficient well capacity for the near future particularly if the aquifer is recharged and the drop in water tables is reduced. However in the future additional wells will be needed for a emergency source of water. For this reason the 26,000,000 estimated cost by the City Water Department was applied to all Alternatives.

(10) Environmental mitigation costs were left the same as the USBR estimated they would be if the recharge project included a surface storage reservoir for Floodwater. This is described in the USBR memo of Jan. 5, 1984. Without the floodwater storage these costs would be less.

(11) These costs were reduced substantially from the USBR Jan. 5, 1984 memo due to a dropping of the surface storage reservoir and the use of the same energy rate and pumping amounts as the proposed Westside Alignment/Treatment Plant. A energy cost 5% less than the proposed Westside Plan was used for Plan A and 5% more was used for Plan B. See text for full explanation.

(12) The costs of operating the recharge system is based on 1983 costs of a similar system in Orange County.

(13) This is the value of the maximum expected evaporation and seepage from aqueducts @ $200 per acre-foot.

(14) Tucson Water estimates they can only recover about 70% of the water recharged in their wells. The other 30% would be recovered by private pumpers and water companies. Therefore this would be considered a loss by Tucson Water.

(15) This represents the value to private pumpers and water companies of the 30% of the water that they will pump with or without the recharge alternative. However with the recharge alternative the water not recovered directly by Tucson water will reduce the overdraft if the Tucson Basin and thereby also benefit Tucson Water Department. Many of the largest private pumpers already have agreed to take delivery and pay for their CAP water through Tucson Water.It is expected that the use by the City of Tucson of the recharge alternative will not affect these basic agreements.

(16) With the West Side Plan and Treatment Plants there will be no opportunity for the Tucson Basin to take advantage of available surplus waters from the Colorado River. At the present time all such waters will go to agriculture contractors which are contracting for a percentage of all waters remaining after the Urban and Indian allotments are met. With the purchase of the Avra Valley farmlands the opportunity to bring surplus water to Pima county will be greatly reduced unless CAP contract proceedures can be modified. There is the possibility that in the case of a wet year such as we have had this year and last year the agricultural contractors will not be able to use the 1,000,000 acre feet of surplus water that will be available to the CAP. In these years Tucson could obtain these surplus waters if the recharge alternative was adapted. There is also the possibility that surplus water could be obtained from the Salt and Gila Rivers which have had over 6,000,000 acre-feet of surplus water since 1978.

(17) The recreational benefit of using live streams to recharge the Tucson Basin should be substantial but as yet has not been determined. In a desert area just west of Palm Springs, California where a live stream is used to recharge the aquifer with surplus Colorado River Water there is considerable recreational activity surrounding the running water. Tucson would be no different.

State of Arizona

DEPARTMENT OF WATER RESOURCES

99 E. Virginia Avenue, Phoenix, Arizona 85004

BRUCE BABBITT, Governor
WESLEY E. STEINER, Director

November 30, 1983

Dr. C. Brent Cluff
Associate Hydrologist
College of Engineering
Water Resources Research Center
A.E. Douglas Building 28
University of Arizona
Tucson, Arizona 85721

Dear Brent:

Thenk you for your letter of October 25, 1983, and for the opportunity to review your report.

Groundwater recharge is a very important concept that could provide substantial benefits to the Santa Cruz Basin. Your plan appears reasonable in concept but I believe requires extensive evaluation in order to determine feasibility.

As you are aware the Bureau's studies to determine the most cost effective plan to deliver CAP water to users in the Tucson area indicated that regulatory storage is not necessary at this time and was, therefore, not included in the base recommendation. The Bureau's plan also does not include features for water treatment since these costs would be the responsibility of the designated water users. In your plan both conservation and regulation storage and water treatment considerations are included while the Bureau's plan provides only the minimum facilities required to deliver CAP water to designated users.

While I believe that your proposal deserves further attention, I do not feel it should be incorporated with the Central Arizona Project facilities at this time for several reasons. First, the Colorado River Basin Project Act which authorizes the CAP does not give the Bureau authority to develop conservation storage facilities on the Santa Cruz River. Additional legislation would be necessary to accomplish this. Secondly, should conservation storage and groundwater recharge on the Santa Cruz River become a part of the CAP the newly developed water would be Project water and must be made available to all users. This would require an allocation of the newly developed supplies, and would in effect be taking water which could be conserved for future use in the Tucson area and distributing it to the entire CAP service area.

Office of Director 255-1554
Administration 255-1550, Water Resources and Flood Control Planning 255-1566, Dam Safety 255-1541,
Flood Warning Office 255-1548, Water Rights Administration 255-1581, Hydrology 255-1586.

Because your proposal is one which will basically provide conservation of a local supply and will provide a mechanism for treatment, it seems that the concept should be evaluated as a local project with these objectives in mind. There is currently legislation under consideration by Congress to develop demonstration groundwater recharge projects in the west. We are hopeful that we will be able to develop two demonstration projects in Arizona under this program. If Arizona is successful in obtaining funds for demonstration projects, your proposal could be considered as forming the basis for one of the projects.

I appreciate the opportunity to review and comment on your report and your continued efforts in behalf of Arizona's water future.

Sincerely,

Wesley E. Steiner
Director

ORANGE COUNTY WATER DISTRICT

February 23, 1984

Dr. Brent Cluff
WRRC
University of Arizona
Tucson, Arizona 85721

Dear Dr. Cluff:

I've finally located some aerial photos of our water spreading operations in the Santa Ana River and I apologize for the delay in answering your request. The portion of the river that has the small sand dikes is the flood channel and these dikes wash out whenever we have an excessive rate of flow down the river. The other portion of the river is dedicated to large spreading basins through which the rate of flow can be controlled. To maintain the dikes and clean accumulated silt from the ponds, we have four D-8 size tractors, two scrapers and a dragline.

The cost for our water recharge operations for this year is approximately $844,000. This includes payroll costs, equipment repair, fuel, facilities maintenance, landscape maintenance and utilities. During this fiscal year we percolated approximately 200,000 acre-feet of water. The annual cost that I related to you during your visit must have been memories of the good old days.

You asked if we ever experienced any quicksand conditions in the river and the answer is no. Quicksand requires some rising water and we have never been able to raise the water table all the way to ground surface.

I must ask that the slides be returned eventually but feel free to have duplicates made if you desire. Again, I apologize for being so late with them.

Sincerely,

Jim Fairchild

James B. Fairchild
District Geologist

Enclosures

JBF:dao

10500 ELLIS AVENUE • P.O. BOX 8300 FOUNTAIN VALLEY, CALIFORNIA 92728-0300 TELEPHONE (714) 963-5661/556-8260

Recharge can make water work if we rock CAP boat now

By C. BRENT CLUFF

A few weeks ago, Diane Culbertson, editorial writer of the Tucson Citizen, issued a request that the responsible officials of the city, county, state and federal governments sit down and seriously consider the merits of recharging Central Arizona Project water in the Tucson area.

If these officials are really interested in recharging CAP water, the first thing that needs to be done is to change the alignment of the Phase-B Aqueduct. As far as can be determined, the West Side alignment through Avra Valley was selected with total disregard for the effect it will have on recharging of CAP water in stream channels in the Tucson basin. There has been no response from a request to the U.S. Bureau of Reclamation to give evidence of consideration of recharge prior to selection of the preferred route.

Since the West Side alignment was selected, the City of Tucson has announced plans to buy out most of the remaining farmland in Avra Valley. Thus, Avra Valley Irrigation District will not contract for CAP water. This removes the major advantage and economic benefit of the West Side alignment. It also generates additional reasons to recharge CAP water.

In order to justify the large expense of building the Phase-B Aqueduct, the Bureau of Reclamation, through the Central Arizona Water Conservancy District, needs to deliver more water, particularly in the early years of the project. Tucson Water Department has only recently begun to talk about recharging its unused allotment. This would amount to 90,000 acre feet per year in 1992. The cost of recharging this amount of water with the present alignment, in addition to building and operating a water treatment plant, will be excessive.

In contrast, studies have been made which show that with an East Side alignment, the Tucson Water Department could purchase and recharge its entire CAP allotment of 150,000 acre-feet, using the stream bed of the Canada del Oro, Rillito and Santa Cruz, for less cost than purchasing, treating and distributing 60,000 acre-feet.

This past spring, one of the longest base-flow natural recharge demonstrations in over 50 years occurred in the Tucson basin. Base flow in the Santa Cruz and the Rillito, exceeding 1,000 acre-feet per day, was recharged for several weeks. This event clearly showed our stream beds have sufficient capacity to recharge the entire allotment of Pima County.

What are the advantages of recharge over direct use through a treatment plant? There are many:

- It is less expensive even when groundwater repumping costs are included.
- It is safer. Tucson will not be dependent on day-to-day delivery from a fluctuating water source 350 miles away.
- By using the sands and gravels in our streams to purify the water, Tucson will avoid expensive treatment and chlorination.
- Power costs will be reduced because most of the pumping from the Colorado River to Tucson (2,400 feet elevation difference) could be done in the winter when energy costs are low. Excess summer energy could be sold for a profit.
- With recharge, all of our allotment can be used to replenish the groundwater table. Excess water from both the Colorado and Salt River systems can be stored during years of surplus to be available during years of drought.
- With recharge, there will be many recreational opportunities, such as stream-side lakes and water flowing in our major streams. These lakes will be needed for temporary storage of CAP water whenever there is a natural flood. In contrast, the treatment plant method of utilization of CAP water will not have any recreational use of the water.
- By using recharge as a means of introducing CAP into the Tucson basin, the change in drinking-water quality will be much more gradual than with the treatment plant method.
- Recharge of CAP water in our stream beds will enhance the recharge of floodwaters.
- The East Side alignment is shorter, with most of the aqueduct constructed as buried pipeline. This is more environmentally acceptable than the open canal planned for the West Side alignment.

With all of the evidence that supports CAP recharge, why does the Bureau of Reclamation insist on the West Side alignment? There are two possible reasons: The bureau already has spent $2 to $3 million more on the West Side alignment than it has on the East Side alignment; and bureaucracies are very reluctant to change their minds unless forced to do so.

Why doesn't one of the "checks" in our checks-and-balances democratic system do something? It seems that everyone is afraid to "rock the boat" for fear Tucson will not get the CAP aqueduct at all. This fear is going to cost Tucson a lot more money plus lost opportunities for a more secure water supply.

Is this fear justified? I have enough confidence in the U.S. Congress to feel that if the matter were explained by our capable Arizona delegation, Congress would support Tucson's change in plans. One reason Congress would support it is that the plan could become the nation's most spectacular example of designing a system to fit the natural environment rather than forcing conventional approaches on that environment. It would provide answers that could be used in other water-short areas across the nation and around the world.

C. Brent Cluff is an engineer at the University of Arizona's Water Resources Research Center.