PROPOSAL OUTLINE

ON

A STUDY OF THE WATER QUALITY IMPLICATIONS OF INTERFACING THE CENTRAL ARIZONA PROJECT WITH THE MUNICIPAL WASTEWATER - IRRIGATION WATER EXCHANGE CONCEPT, PIMA COUNTY, ARIZONA.

From:

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The University of Arizona
Tucson, Arizona

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Submitted to the Pima Association of Governments for Consideration of funding under the 208 Waste Treatment Management Planning Program.

INTRODUCTION

The purposes of this tentative proposal outline are to describe the objectives of what we consider to be urgently needed research in the subject area, and to explore the possibilities for funding of said research by PAG through the 208 Waste Treatment Management Planning Program.

The following are some of the salient points of our research and related information developed during recent years:

(1) The present quantities and growing production rates of municipal effluent, well-recognized at numerous locations nationally and regionally, are in fact urgently requiring action in Pima County. The Tucson treatment plant currently yields about 40,000 acre-feet per year of secondary treated effluent, only a small fraction of which is beneficially utilized in crop production, and this rate of effluent production may be expected to double before 2000. The unused portions of these effluents are being released to the Santa Cruz River channel seepage and are contributing to excessive nitrate concentrations in the ground-water aquifers.

(2) About 40,000 acres of farmland are currently being irrigated in the Avra Valley-Marana area, cited here as setting for a Tucson case study, and the ground-water supply is being depleted at rates which indicate the imminent necessity of either curtailing water use for crop production or augmenting water supply to maintain current production, by importation of surface water or use of reclaimed effluent, or both.

(3) As shown on the attached map, a conveyance canal and some form of distribution system would be required under any proposed scheme for carrying the Tucson municipal effluent from the main treatment plant to the presently irrigated lands in the Avra Valley-Marana area. The same or

a similar conveyance and distribution system would be required and could be used for delivery of imported Colorado River water to that area, and could serve the two purposes conjunctively.

(4) Tucson presently has a well field in the upper end of Avra Valley. The City is currently under a court injunction which in effect prohibits the City's removal of water from Avra Valley without purchasing and retiring farmland on which an equivalent amount of water is presently used. An exchange of sewage effluent for irrigation water would reduce the number of acres of farmland that would need to be retired to bring the water budget in the Tucson area into balance.

(5) A preliminary economic appraisal of a proposed irrigation project to serve parts of Avra Valley indicates that effluent could be delivered for less than $15/acre-foot under the provisions of a Small Reclamation Project Loan (1971 prices escalated 10 percent annually to 1975). This would be less than the present cost to farmers for pumped irrigation water. The fertilizer or plant nutrient value of secondary effluent, which has increased by 300 percent within the past eighteen months, would tend to reduce further the net cost of utilizing effluent.

(6) Certainly, one Pima County problem is that of maintaining the capability of providing efficient management criteria for wastewater reclamation in the metropolitan area; with the advent of Colorado River M and I water deliveries through the Central Arizona Project (CAP), the dissolved salt content of municipal waste water may be increased. This is an important criterion to be considered when making the decision as to the reuse of the effluent. The use of this effluent on the farms downgradient from other M & I groundwater pumping would protect the water quality of the County.

This has not been previously studied in any detail.

(7) Moreover, additional research results are urgently needed in the field of crop irrigation efficiency in relation to treated effluent of blended effluent-well water sources. In numerous discussions with local interests, particularly farmers, the questions most frequently asked are those concerning the immediate and long-range effects of effluent use on crop response and yields, soil chemistry changes (adverse or beneficial), and fertilizer requirements. Field studies were conducted on yields of small grains by Tucker and Day in 1959 and 1962, and more recently laboratory-scale studies have been continued on soil response from effluents. Preliminary results from the Buckeye Irrigation Project indicate that the use of effluent improves the yields of all crops studied. These crops are wheat, barley, alfalfa, safflower, and cotton. More extensive field studies involving various crops and various mixes (constant or time-variant) of effluent and groundwater are needed. What is proposed under (7) is to establish an operational field experiment station, at which treated effluent would be used and its effects on soils and on various crops would be evaluated, concurrently with studies of effluent allocations. The results, in combination with other input data, will be used in the evaluation of such effluent use in total allocation schemes designed for optimal economic efficiency. The suggested research objectives are listed descriptively below, each being followed by outlines of the proposed procedures for the attainment.

In view of these and other considerations, it appears that certain extensions of research effort as set out below would provide practical and immediately applicable results for concurrent use in the areas of pollution abatement, improved management of municipal wastewaters, and increased efficiency in use of water for crop irrigation.

I. WATER MANAGEMENT STUDIES

General Objectives:

1. To study the use of an expanded Cortaro-Marana Irrigation District and a joint use of treated sewage effluent with CAP water and salvaged flood waters.

2. To study the possible future extension of the exchange concept to the Redrock-Eloy area in Pinal County as the Avra-Marana Valleys become urbanized, and/or additional water is needed in Pima County.

3. To study the related water quality aspects both on a regional and local basis related to reuse of treated effluent for irrigation in the Avra-Marana area.

General Procedure:

A sample calculation has been made* in terms of comparative cost analysis for delivery of effluent versus groundwater for irrigation in Avra Valley. It is proposed to expand the cost analysis to minimize net cost under various delivery systems criteria, thence to a determination of the optimal combination of size of irrigated service area, cropping patterns therein, design of delivery system, quantity of effluent delivered, and dilution of effluent with pumped groundwater, CAP water and salvaged flood waters. If sufficient financial support is available, this analysis will be extended to include a maximization of net benefit under varying allocations of effluent to irrigation use.

*Cluff, C.B., K.J. DeCook and W.G. Matlock, "Technical, Economic and Legal Aspects Involved in the Exchange of Sewage Effluent for Municipal Use - Case Study - City of Tucson", Completion Report for Office of Water Research and Technology, Dec. 1972.

Mathematical programming models available for such problems include linear or quadratic programming procedures for allocation under large numbers of variables, and dynamic programming for multistage, sequential delivery schemes. Solutions for operation will necessarily be bounded by recent court decisions on local water use, the recent Mines, FICO, City of Tucson and Pima County Letters of Intent for CAP water, the objectives of community planning, and State and Federal administrative regulations.

Preliminary conversations with the Cortaro-Marana Irrigation District have indicated an interest in expanding to include some of the lands now irrigated in Avra Valley for possible contracting for CAP project water. They have also indicated an interest in obtaining municipal effluent (see Appendix I). A possible extension of the district might be made to include all the lands in the Consolidated Irrigation District-Metropolitan Operated (CIDMO) Phase 3 plan as outlined in Appendix I. This area contains approximately 15,500 acres of irrigated farmland which would bring the total irrigated land in the expanded district to 28,000 acres.

This is the approximate size of district needed to properly utilize effluent through 1995. Beyond that time other irrigated lands would be needed if the full nutrient value of the effluent were to be utilized. Groundwater and salvaged flood flows could be used for blending until CAP is available in 1985. This part of the proposal would be completed within a six-month period to allow time for the district to contract (or write a Letter of Intent) for CAP water within the time allotted for agricultural users. An extended Cortaro-Marana District would greatly enhance the water management in Avra-

Marana. The present district is one of the most efficient in terms of water used per acre, of any in the State. The use of effluent and priorities with regard to existing water to protect existing members of the district, are essential elements that will be studied in the proposed expansion of the district.

Water quality aspects of use of municipal wastewater on Avra-Marana farmlands will be studied using computer models. Existing water quality models will be modified and expanded to cover the Tucson region.

Budget:

In order to accomplish the research outlined in this part of the proposal it is estimated to require a funding of $57,910 for the first year and $48,050 for the succeeding year. The breakdown on this proposed budget is given in Appendix II.

Principal Investigators:

C. B. Cluff, Associate Hydrologist; K. J. DeCook, Associate Hydrologist; and E. S. Simpson, Professor of Hydrology and Water Resources.

Cooperating Personnel:

Lucien Duckstein, Professor of Systems and Industrial Engineering; and V. J. Gupta, Assistant Professor of Hydrology and Water Resources.

II. POLLUTION ABATEMENT: EFFLUENT RECHARGE

General Objective:

To formulate operational procedures for recharge of effluent through water-spreading of effluent and recovery for agricultural use or other compatible uses, to minimize the potential pollution to ground waters otherwise suitable for general municipal and industrial use.

General Procedure:

Facilities for controlled recharge, storage, and pumpback will be necessitated under most effluent irrigation schemes, by reason of time differences between schedules of irrigation demand and effluent supply. The effluent could be given a tertiary treatment in this manner and would then be suitable for use on lettuce, a major vegetable crop in the Cortaro-Marana Irrigation District. During the off-lettuce period, April 15-Aug. 15, the secondary treated effluent could be used.

Potential sites for artificial recharge will be evaluated in the vicinity of the Santa Cruz River and Rillito Narrows. Stratigraphic cross-sections will be obtained by drilling several test wells and obtaining drill cuttings for sieve analysis. Trends in groundwater quality and water levels in the area will be characterized by examining records available in the Dept. of Soils, Water and Engineering, and by initiating a monitoring program. A number of small basins will be constructed at potential sites. Representative wet-dry flooding cycles, with municipal effluent pumped from the Santa Cruz River will be implemented and evaluated with respect to intake rates, near-surface transformations in quality, etc. Based on results from these basins, one or two Parger basins will be constructed in the most promising

recharge site as a pilot project to provide data for a 10-20 million gallons per day enlargement. Neutron probe access wells will be installed to permit monitoring the subsurface movement of recharged effluent. These access wells will be situated wherever possible to allow for enlargement of the basin. The program to monitor local groundwater levels and quality in the vicinity of these basins will be intensified.

Although the technique will be used in this study for tertiary treatment of water to be used in agriculture, it could also be used to supply tertiary treated waste water to the mines, (if this proves to be feasible), or other compatible industrial uses.

Budget:

The required financial assistance needed to perform the outlined research is $61,150 for the first and $56,300 for the second year. A budget breakdown is in Appendix II.

Principal Investigators:

R. A. Phillips, Professor of Civil Engineering; E. S. Simpson, Professor of Hydrology and Water Resources; and L. G. Wilson, Hydrologist.

Cooperating Personnel:

K. J. DeCook, Associate Hydrologist, C. B. Cluff, Associate Hydrologist, and V. J. Gupta, Assistant Professor of Hydrology and Water Resources.

III. WATER-USE EFFICIENCY: CROPS AND SOILS

General Objectives:

1. To determine the optimum use of sewage effluent as a source of irrigation water and plant nutrients for selected crops.

2. To determine the effects of treated municipal wastewater on physical and chemical properties of soil.

General Procedure:

Cotton, alfalfa, sorghum, barley, and wheat will be grown using treated municipal wastewater under field conditions in individual basins for each treatment. Controlled application of various proportions of sewage effluent and/or well water can be accomplished through gated pipe to each plot. Approximately five treatments are anticipated to include variations in proportions of sewage effluent and well water applications and frequency of sewage effluent use. Treatments will be designed in consideration of the nutritional needs of each crop. Yield and quality data will be obtained on the fiber, feed, and food crops produced. Effects of sewage effluent on soil reactions and plant behavior will be studied under controlled environmental and laboratory conditions.

Budget and Duration:

The required budget is $75,250 for the first year and $68,300 for the second of the two-year period.

Principal Investigators:

A. D. Day, Agronomist; and T. C. Tucker, Soil Scientist.

Cooperating Personnel:

K. J. DeCook, Associate Hydrologist; and C. B. Cluff, Associate Hydrologist.

FACILITIES AND SUPPORTING ACTIVITIES

(1) For Objective I, the University Computer Center facility is available as needed, and Prof. Lucien Duckstein of the Department of Systems and Industrial Engineering has agreed to provide assistance in programming and economic analysis through the auspices of the Engineering Experiment Station;

(2) Much background data has already been collected. The low-water measuring flume has been recording recharge rates of effluent in the Santa Cruz River. Some water quality data relating thereto is being collected.

(3) Relative to Objective III, supporting research is now being done in monitoring the use of effluent in the Buckeye area. The necessary land for field studies will be obtained, if possible, near the river in Avra-Marana Valley in the vicinity of the Avra Valley and Sandario Roads.

RELEVANCY

The research efforts outlined above, performed in the Tucson region, would also substantially benefit water resource planning throughout the State, Region, and Nation. As an example of the effect of the exchange principle on regional water management, it is not unreasonable to foresee the possibility of transporting sewage effluent to the Imperial Valley from the municipalities of southern California. This effluent could be exchanged for Colorado River water, now used for irrigation, which could be transported to the coastal citites in the existing Colorado Aqueduct, or to Arizona cities through the

Central Arizona Project. This is perhaps the most inexpensive way to augment the Colorado River water. The amount of water exchanged in such a proposal could exceed one million acre-feet per year. The water quality of the exchanged effluent, having originated from multiple sources, may be better than that of the Colorado River water presently used on farms in Imperial Valley.

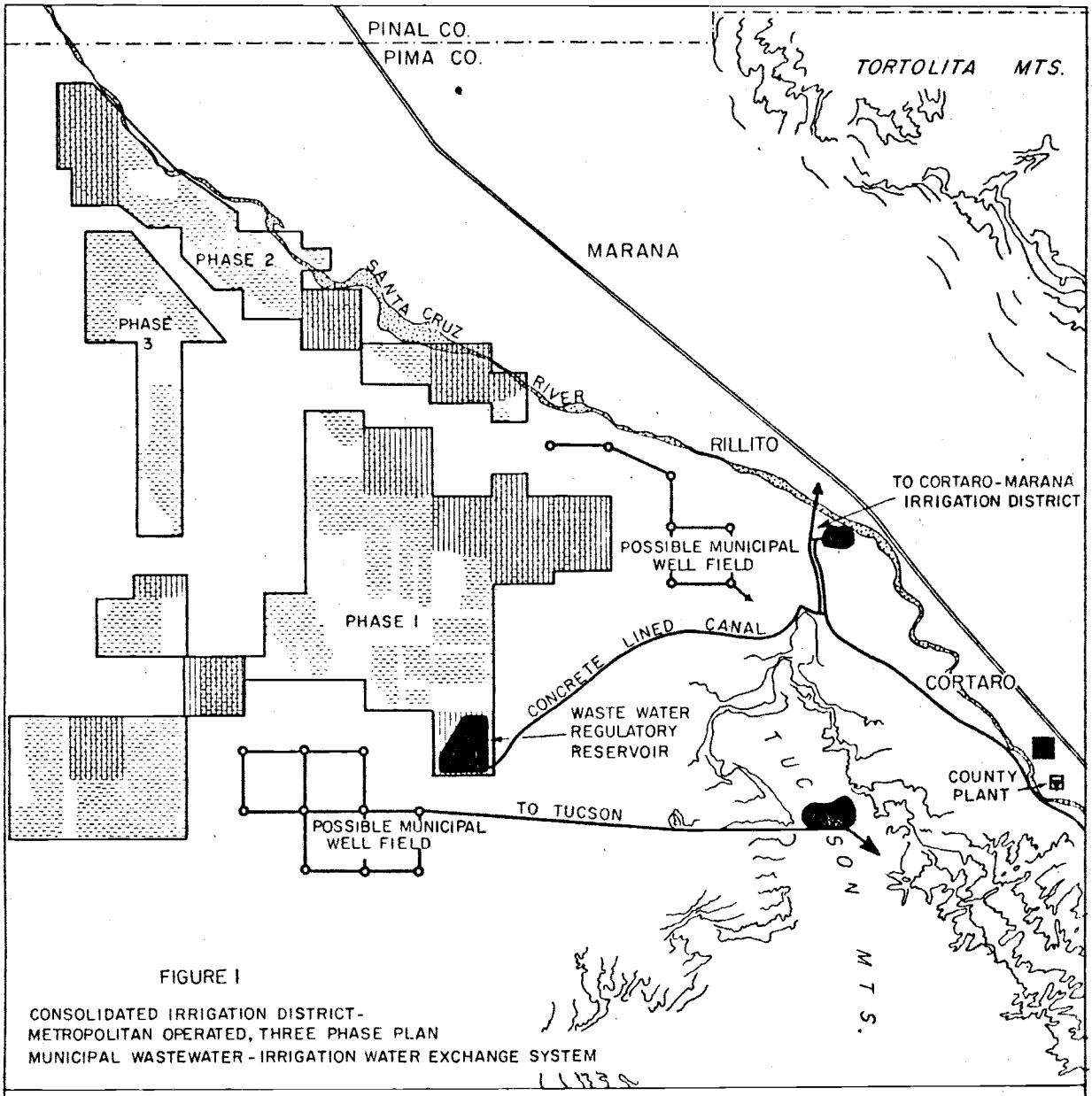

FIGURE I

CONSOLIDATED IRRIGATION DISTRICT-
METROPOLITAN OPERATED, THREE PHASE PLAN
MUNICIPAL WASTEWATER - IRRIGATION WATER EXCHANGE SYSTEM

11139

AVRA VALLEY - MARANA REGION NEAR TUCSON, ARIZONA. .

WATER RESOURCES RESEARCH CENTER

THE UNIVERSITY OF ARIZONA - 1974

EXPLANATION

STATE OWNED LANDS GROUNDWATER IRRIGATED LANDS WASTEWATER TREATMENT PLANT

APPENDIX I

CORTARO-MARANA IRRIGATION DISTRICT
13864 B N. Sandario Road
Marana, Arizona 85238

Statement Concerning: The Central Arizona Project and ground water in general for the hearings held in Tucson, Arizona, January 9, 1975.

More than 20 years ago hearings were held in Marana in order that the State Land Department could decide whether or not to declare the area a critical ground water area. The results were that the area was subsequently declared critical and no additional wells would be drilled for irrigation and no new land would be put into cultivation. Most of the farmers who testified at those hearings were in favor of this decision even though many of them owned lands which were physically suitable in every way for irrigation. To our knowledge, there has been no new land brought into cultivation since the enactment of this legislation. One farmer in Avra Valley tested the "teeth of the law" and the State of Arizona siezed his well immediately after it was placed into production.

Even with the closing down of additional pumping in 1954, we have seen the water levels in our wells in the Marana area recede. This has generally meant less production of water at the discharge pipe and more horsepower requirements at higher costs.

The Board of Directors of our irrigation district is vitally concerned about the present but more importantly the future of our water supply. Water is now and always has been our number one priority of concern.

During the past 20 years, we have spent thousands of dollars toward water conservation. Today, we have no non-cemented canals and we have designed our system to enable us to recapture and re-use vertually all of the run-off from fields within the system. However, we realize that we must do everything possible which might enhance and protect our underground supply of water.

We have decided that there two courses of action which we will pursue in order to try to maintain at least a status quo of our present supply. Number one--we have decided to try to enter into some kind of agreement with the City of Tucson which will permit us to contract for and use the city sewage effluent for irrigation purposes. Mr. Pat Garrett, our project manager, and I met with Mr. Frank Brooks in November to exchange views on this plan Mr. Brooks told us that he would do some preliminary work on the plan and be back in touch with us. The use of effluent in our system has many problems--One being the State Health Regulations which preclude the use of effluent on certain edible crops. However, we are looking forward to an opportunity to discuss it further. We feel that if we could use any amount of effluent we could reduce our ground water pumping by the same amount and by so doing we would conserve that amount in the underground.

The second thing which we have decided to do is to contract for Central Arizona Project water--that is if there is any available to us after thr top priority contracts for municipal and industrial

uses are filled. We are fully aware that for every acre foot of C.A.P. water which we use we will have to decrease our ground water pumping by the same amount. We are also aware of the fact that we will have many problems to overcome in order to become eligible to receive this water. However, with the very serious water problems which is prevalent in all of Pima County, we are willing to contract for this water in spite of the fact that the tentative cost is more than three times our cost of pumping ground water today.

We feel that we would be most irresponsible as a Board if we did not take advantage of the opportunity to import water in order to supplement- in any degree- the dwindling supply.

The C.A.P. concept has been in congress and the courts for most of this century and we should all realize that this is a one and only opportunity to help alleviate our very major problem. We fail to see how any responsible person in this area could have a different view point.

Ludd M. Payne-President
Cortaro-Marana Irrigation District

APPENDIX II

REQUIRED FINANCIAL SUPPORT:
Part I - Water Management Studies

Salaries and Wages:	First Year	Second Year
Principal Investigators:	No Charge	No Charge
Research Assistant III	$12,500	$13,750
Research Assistant III (1/2 time)	6,250	-
Graduate Assistants (2)	10,000	10,000
Student Assistants	4,000	3,000
	$32,750	$26,750
Employee Benefits:	3,600	3,000
Indirect Costs:	15,060	12,300
Operations:		
Expendable supplies	1,000	1,000
Travel	1,500	1,000
Publications	1,000	1,000
Computer	3,000	3,000
	$ 6,500	$ 6,000
	$57,910	$48,050

REQUIRED FINANCIAL SUPPORT:
Part II - Pollution Abatement: Effluent Recharge Studies

Salaries and Wages:	First Year	Second Year
Principal Investigators:	No Charge	No Charge
Research Assistant III	$12,500	$13,750
Research Assistant II	10,000	11,000
Research Assistant*	6,000	6,600
	$28,500	$31,350
Employee Benefits:	3,135	3,450
Indirect Costs:	9,700	10,700
Capital:	2,000	
Expendable:	17,815	10,800
	$61,150	$56,300

*Some of this work will probably be performed by Dr. R. A. Phillips.

REQUIRED FINANCIAL SUPPORT:
Part III - Water Use Efficiency: Crops and Soils

	First Year	Second Year
Salaries and Wages:	$25,000	$30,000
Employee Benefits:	2,750	3,300
Indirect Costs:	7,500	9,000
Capital:	25,100	10,000
Operations:	14,900	16,000
	$75,250	$68,300

FINANCIAL SUMMARY

	First Year	Second Year	Total
I Water Management Studies:	$57,910	$48,050	$105,960
II Pollution Abatement: Effluent Recharge	61,150	56,300	117,450
III Water Use Efficiency: Crops and Soils	75,250	68,300	143,550
	$194,310	$172,650	$366,960