ARIZONA WATER RESOURCES NEWS BULLETIN

NEWS BULLETIN 78-1, 2 JANUARY-APRIL 1978

WATER HARVESTING AGRISYSTEM TO GROW JOJOBA ON DEVELOPED IDLE FARMLANDS

by
C. Brent Cluff and Kennith E. Foster*

Introduction

A water-harvesting agrisystem to rehabilitate abandoned farmlands in the arid Southwest has been developed by the University of Arizona Office of Arid Lands Studies (OALS) and the Water Resources Research Center (WRRC).

For descriptive purposes the agrisystem has been applied to Avra Valley idle farmland conditions with jojoba as the cash crop and vegetative dust control. Jojoba, *Simmondsia chinensis,* is a shrub native to the Sonoran Desert and requires little water once it is established. It bears a bean containing a liquid wax with chemical properties similar to oil derived from the sperm whale, an endangered species. Liquid wax extracted from jojoba beans can be used in hair oil, shampoo, machinery lubricants, paper coatings, and de-foaming agents in manufacturing pharmaceuticals. In its solid, or hydrogenated, form jojoba wax substitutes for beeswax and the expensive carnauba wax.

The system is designed to operate without groundwater, which is being overdrafted in most Arizona basins. Groundwater is the principal source of irrigation water and of ever-increasing municipal water demands in Arizona. As a result of these escalating demands, water tables are dropping rapidly. Central Arizona Project waters and reuse of treated municipal waste waters will reduce, but not eliminate, the need to shift water from agricultural uses to municipal uses as the state population continues to grow.

The Tucson area is entirely dependent on groundwater. About 11,000 acres of previously irrigated farmlands in Avra Valley, west of the Tucson Mountains, have been purchased and retired from use by the City of Tucson to secure water rights. Retired or abandoned farmlands present several problems which must be resolved.

Semiarid fragile ecosystems such as those in Avra Valley present serious rehabilitation challenges once they have been disturbed and abandoned. These lands do not revert to aesthetically pleasing desert growth without considerable passage of time, if at all, and weeds and dust become problems. Usually the dominant new growth is tumbleweed, *Salsola kali,* which has no proven economic value and is troublesome. Range grasses are established with difficulty in relatively low annual rainfall regions (11 inches or less) where evapotranspiration is relatively high. Studies indicate these grasses do not survive prolonged drought without auxiliary water, even after being established.

Sufficient commercial demand for jojoba products is developing to support establishing sizable plantations of the shrub. Maximum jojoba bean production can be maintained using harvested water from natural precipitation which offers a commercially viable solution for rehabilitating the 11,000 acres of abandoned farmland without use of groundwater.

The System

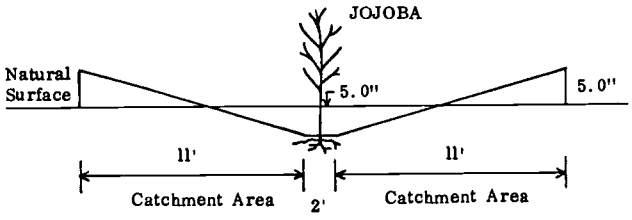
The water-harvesting agrisystem for growing jojoba on abandoned farmland was developed by WRRC in cooperation with personnel from the University of Arizona College of Agriculture Department of Soils, Water and Engineering, and Plant Sciences. OALS has practical experience in raising jojoba and WRRC has experience in designing and constructing the Compacted Earth Sodium Treated (CEST) water-harvesting and the compartmented-reservoir systems.

Field establishment of the system assumes availability of 40 acres in the Avra Valley area where there is existing but unused "pumpback" capacity to recharge the reservoir with rainwater harvested by the CEST.

A road grader could shape abandoned farmland into the initial ridge and runoff configuration shown in Figure 1. The ridged area is treated with common table salt, sodium chloride, to increase runoff and reduce weed and dust control costs. The drainage would be reshaped to form a double drainage after three or four years to increase infiltration area as plants grow

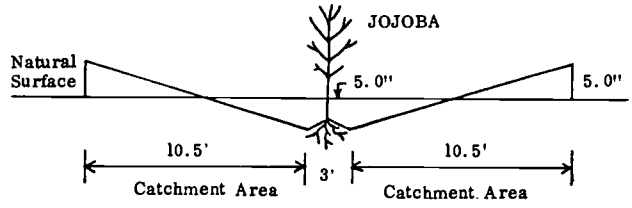
*C. Brent Cluff is Associate Hydrologist of the Water Resources Research Center and Kennith E. Foster is Associate Director of Office of Arid Lands Studies, University of Arizona.

and extend roots (see Figure 2). Rainwater would run from the ridged portion into adjacent drainages planted with jojoba (see Figure 3). Excess runoff would be collected and pumped to the compartmented reservoir for plant use as needed to maintain peak production during prolonged periods of scant precipitation and during the winter months. A compartmented reservoir is proposed to reduce evaporation losses. A reservoir is compartmented and water concentrated by pumping from one compartment to another to reduce the surface area. This method has been shown to reduce evaporation up to 45%. The use of the pump makes it possible to go to deeper above-ground compartments. When this is combined with the compartmented method savings can approach 80% (Cluff, 1978). It is proposed that each catchment would be 20 to 24 feet wide to provide sufficient runoff and adequate space for moving cultivating and harvesting equipment in the rows.



INITIAL

Figure 1



FINAL

Figure 2

The runoff efficiency of the CEST catchment is about 50%. Therefore this catchment, using a 24-foot spacing, would provide a minimum of 70% more moisture than presently is available from normal precipitation, assuming a 10-foot spacing. This means that water available to the plants in Avra Valley would increase from about 11 inches annually to about 18.7 inches. Even more important, water harvesting with surface storage would provide water to plants during the December-April period to maximize bean production.

Soil salt treatment will not degrade runoff water quality significantly, as illustrated at Page Ranch where a one-acre system has been used for the past several years to grow grapes. In addition, the salt-treated catchment was one of three treatments used on an acre water-harvesting agrisystem for growing jojoba at Sells, Arizona. Jojoba growth in the salt-treated catchment has been more vigorous than in those treated with Asphalt Plastic Asphalt Chipcoated or wax.

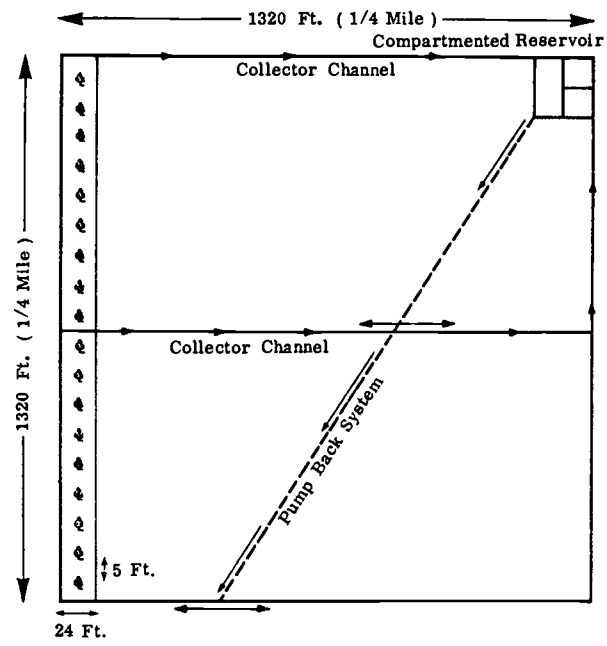


Figure 3

Five tons of salt per acre would be applied. This amount would not exceed the total dissolved solids in five acre-feet of treated municipal sewage effluent. Salt use would not prevent the treated land from being used for other purposes at a later time; the land can be reclaimed easily. Granulated salt would be applied using conventional seed drills. A large tractor-drawn roller should be used to compact catchments after the first rain of at least an inch.

The agrisystem design was fed into a computer program having 31 years daily rainfall data to simulate runoff. Findings were compressed into a weekly array. With these data the size of the compartmented reservoir was optimized so that adequate soil moisture could be maintained. The simulation indicated that a three-compartment reservoir with a surface area of about one acre and holding 11.35 acre-feet of water would assure water for maximum jojoba growth and production for the 40-acre system. The simulation also indicated that a cover would be needed on the "last" compartment to increase evaporation control efficiency beginning in the third or fourth year of use. The "last" compartment is the one containing water all the time, thus it makes effective use of a floating cover. This cover would be constructed out of wax impregnated foam also developed at the University of Arizona.

Three simulations were made using different root-depth and infiltration-width data. The analysis showed that as jojoba plants grow larger amounts of water can be stored in the soil and lesser amounts in the compartmented reservoir. However, the reservoir appears to be essential to maximize production. Jojoba shrubs cannot grow where water ponding around the base of the plant occurs. Thus, the pumpback and reservoir system is essential to capture excess runoff and move the water to the plants as needed.

Approximately 42,000 jojoba seedlings would be needed to plant a 40-acre area. Usually each seedling is grown in a test-tube container. These would be transplanted in late April, with

"RESHAPING" NATIONAL WATER POLICY ADDRESSED BY INTERIOR SECRETARY ANDRUS*

There will be no federal pre-emption of state water rights in "reshaping" national water policy, according to a statement made by Secretary of the Interior Cecil Andrus before a recent meeting of the National Conference of State Legislatures' State-Federal Assembly.

Andrus acknowledged that the lack of water will be the next resource crisis, but "if together we can recognize the problems and plan for them now, we won't be in a crunch. We must have a national water policy to better determine our water resources and calculate our needs; at the same time regional water needs must be accommodated," he said.

Reshaping water policy is necessary because of water supply problems in the West, particularly groundwater overdrafts in Arizona, Nebraska and western Kansas, Andrus said. An effective groundwater management act should be a priority, he added. Energy producers will be able to pay more for groundwater, Andrus said, and agricultural and irrigation interests could lose use of groundwater to energy demands, Andrus warned.

Environmental considerations must be part of a national water policy, Andrus said, adding that stream flows must be maintained for fish and wildlife habitats and to prevent fertilizer and salt buildup from irrigation return flow.

The National Conference of State Legislatures (NCSL) Natural Resources Committee met with officials from the Department of the Interior, Council on Environmental Quality and Office of Management and Budget in October, November, January and March to discuss the proposed water policy. NCSL policy developed during those meetings states that "the overall federal policy should be that water policy can and must be developed at the state level, and that the appropriate role of the federal government is to provide technical, research and financial assistance to the states at their requests."

NCSL policy further states that state legislatures are willing to show commitment to sound state water management by identifying long-term state water policy needs, beginning development or review of policies to meet identified needs, analyzing the impacts of state water policy on neighboring states, and preparing an annual report of activities which should be used by involved federal agencies when reporting to Congress.

The "Dateline Washington" article points out that "a national water policy with water conservation as a key element could seriously affect the western states' water laws. In most of the western states, the right to claim water rests on putting it to beneficial use. The Administration holds that this is no longer a useful concept as water becomes more scarce."

President Carter has said that he will announce his proposals for a national water policy sometime this spring, according to "Dateline Washington." Because of suggestions from various states and associated national organizations, the timetable has been pushed back several times.

"Whatever the Administration's proposals, Congress will have the final say on much of the policy," the article concludes.

*Excerpted from Dataline Washington III (3):1, 12, National Conference of State Legislatures, 444 North Capitol Street, NW, Washington, DC 20001.

ARIZONA SECTION, AMERICAN WATER RESOURCES ASSOCIATION ANNOUNCEMENTS

Thirty-four papers were presented to the "Water for Cities in an Arid Environment: Demand Management" Symposium held during the Joint Session of the Arizona Section, American Water Resources Association (AWRA), and the Hydrology Section, Arizona-Nevada Academy of Science, April 14-15, 1978, at Northern Arizona University, Flagstaff.

Titled "Hydrology and Water Resources in Arizona and the Southwest," the Proceedings will be the eighth in a series of volumes developed from the joint meeting. It will be published in July 1978.

Proceedings include papers addressing general hydrology; water quality, recycling, reuse; land use planning; recreation; energy generation; agriculture; mining; Indian water claims; socioeconomic, political and psychological research; and technology transfer.

Copies of the Proceedings will be available for $10 through either K.J. DeCook, Executive Secretary, Arizona Section, American Water Resources Association, c/o the University of Arizona Water Resources Research Center or Tika Verma, Proceedings Editor, School of Renewable Natural Resources, College of Agriculture, University of Arizona, Tucson 85721. Members of the AWRA Arizona Section are entitled to a $2 discount on Proceedings purchase.

. . . Reprints of papers given at the Symposium will be available. Order information is available from Messrs. DeCook and Verma.

. . . Copies of earlier Proceedings also can be ordered from Messrs. DeCook and Verma. Volume 1 is out of print. Volumes 2 and 3 cost $8; Volumes 4 through 7 cost $10. AWRA Arizona Section members are entitled to a $1 discount on purchases of the earlier volumes.

. . . AWRA Arizona Section memberships cost $1 annually and cover the period April 1 through March 31. Dues should be mailed to DeCook at the address given above.

. . . All checks for purchases and memberships should be made payable to the Arizona Section, AWRA.

CONFERENCES

Two courses about the systems approach to water resources management will be held July 5-14, 1978, at Colorado State University (CSU), Fort Collins.

Course A will be held July 5-7 and is a 30-lecture, full color videotape program developed at CSU. Each lecture is followed by discussion and workshop sessions using computer programs and numerical examples. The course is designed to be of interest to water managers seeking education in some of the broader aspects of water management systems analysis.

Course B will be held July 5-14 and includes the Course A material but delves more deeply into technical aspects and computer models.

For more information, contact the course manager, J.W. Labadie, Engineering Research Center, Colorado State University, Fort Collins, Colorado 80523, phone (303) 491-8596.

each seedling cluster of three plants placed in hills five feet apart in the row. The hills would be thinned as the plants mature.

It should be noted that at least two irrigations supplemental to rainfall will be required when the plants are transplanted to assure seedling survival. And additional watering may be necessary during July if precipitation is negligible. After the first year water held in storage in the compartmented reservoir will be adequate for supplemental irrigation.

Agronomic Potential

Estimated 1978 costs to establish and maintain one plantation acre of jojoba for three years before bean yield are shown in Table 1. Total costs of $1,638 per acre are assumed amortized over a 10-year period beginning in the fourth year when production begins.

Estimated 1978 costs to produce jojoba using mechanical harvest methods beginning in the fourth year are shown in Table 2. The yearly break-even price incorporates cost of paying off the first three-year crop establishment expenses, prorated over the next 10 years, plus yearly production costs during the fourth through the tenth years.

When a hydraulic expeller is used for extraction, liquid wax yield from jojoba beans is about 40% and costs $.25 per pound. If it costs $.67 to produce a pound of beans and liquid wax yield is about 40%, the break-even price for liquid wax is $1.97 per pound. Liquid jojoba wax currently sells for between $5.50 and $6.00 per pound.

Several budget details should be noted. Layout and planting costs are $142 per acre, including materials and labor for seedling production and transportation to the site. Supervision and management costs of $365 per acre include all salary and fringe benefits. For a 1,000-acre plantation, management costs would drop to $20 per acre, assuming an annual salary of $20,000.

Table 1

Estimated 1978 Costs for Establishing One Acre of Jojoba on Retired Agricultural Lands: Years One-Three

Operation	First Year	Second Year	Third Year
Land Preparation (shaping, salt, etc.)	$403	–	–
Grow, Layout and Plant (seedlings)	142	–	–
Chemical Weed Control @ $5 /application	10	10	10
Cultivation @ $5 /cultivation	15	10	10
Fertilizer and Application ($.25/Unit of N)	12	12	12
Plant Replacement	10	5	5
Roguing-Pruning-Disposal	–	45	45
Supervision and Management	365	227	230
Variable Farm Overhead	10	10	10
Subtotal	967	319	322
Accumulated Subtotal		967	1,286
Total Establishing Costs	967	1,286	1,608
Costs to be Carried Forward	967	1,286	

Establishing costs are to be allocated equally over a 10-year period = $1,608/10 = $161/year.

Table 2

Estimated 1978 Costs for Producing One Acre of Jojoba on Retired Agricultural Lands: Years Four-Ten

Operation	Fourth Year	Fifth Year	Sixth Year	Seventh Year	Eighth Year	Ninth Year	Tenth Year
Chemical Weed Control @ $5/application	$ 10	$ 10	$ 10	$ 10	$ 10	$ 10	$ 10
Cultivation @ $5/cultivation	10	10	10	10	10	10	10
Fertilizer and Application @ $.25/Unit of N	12	12	12	12	12	12	12
Plant Replacement @ $.75/plant	10	10	10	10	10	10	10
Roguing-Pruning-Disposal	50	50	50	50	50	50	50
Supervision and Management	90	91	92	93	94	95	96
Variable Farm Overhead	12	12	12	12	12	12	12
Subtotal	194	195	196	197	198	199	200
Machine Harvest @ $200/acre	200	200	200	200	200	200	200
Clean Seed Harvested (*)	225	360	720	900	900	900	900
Clean and Handle Seed @ $.05/lb.	10	18	37	45	45	45	45
Subtotal	404	413	433	442	443	444	445
Establishing Stand Costs (Prorated over 10 years)	161	161	161	161	161	161	161
Total Producing Costs	565	574	594	603	604	605	606
Break-even Price/lb. seed	2.51	1.59	.82	.67	.67	.67	.68

*(300 producing plants—machine pick—900 lbs./acre—idle land)

☆ ☆ ☆

An American Water Resources Association symposium on "Establishment of Water Quality Monitoring Programs" will be held June 12-14, 1978, in San Francisco, California.

Symposium session topics include surface water monitoring, soil-water monitoring, groundwater monitoring, waste water and pollutant source monitoring, and institutional needs of monitoring.

General chairman of the symposium is Kenneth D. Schmidt, 1111 Fulton Mall, Suite 306, Fresno, California 93721, phone (209) 268-0059. Technical program chairman is Lorne G. Everett, General Electric–TEMPO, Center for Advanced Studies, P.O. Drawer QQ, Santa Barbara, California 93102, phone (805) 965-0551.

☆ ☆ ☆

A special "Management of Groundwater Resources" summer program will be conducted by the Massachusetts Institute of Technology Department of Civil Engineering July 10-21, 1978.

The program is designed for civil and agricultural engineers, geologists, hydrologists and planners.

Based on the underlying concepts of groundwater hydraulics, the program addresses development of a conceptual model of the groundwater forecasting problem for water quantity and quality. Through numerical finite difference and finite element techniques this model is translated into expected effects which are used in management models to suggest optimal decision strategies. Monitoring strategies and parameter identification are examined also.

For further information, contact Director of the Summer Session, Room No. 19-356, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139.

PUBLICATIONS

"A Methodology for Municipal Water Supply Planning in Water-Short Metropolitan Areas" is a planning guide prepared by the University of Denver Research Institute, Industrial Economics Division. For illustrative purposes, the methodology is applied to Denver, Colorado.

Ten alternatives for coping with municipal water shortages are presented. Eight address increasing water supplies and two focus on reducing water demands.

Techniques to increase supplies include water system management; diverting additional water to the municipal area; reallocating agricultural water supplies; using groundwater; watershed land management; augmenting precipitation (weather modification); desalting brackish or salt water; and reusing municipal waste waters.

Water-demand reduction techniques are water conservation and water pricing.

The two-volume, 760-page guide costs $30 and is available from Industrial Economics Division, Denver Research Institute, University of Denver, Denver, Colorado 80208.

☆ ☆ ☆

Water resources planning, water law, and the economic and social impacts of water shortages are discussed in "Climate, Climatic Change, and Water Supply." An overview and some recommendations introduce the eight papers in the three-part report. The paperback, 132-page publication costs $7.75 and is available from the Printing and Publishing Office, National Academy of Sciences, 2101 Constitution Ave., Washington, DC 20418.

☆ ☆ ☆

"Western Energy Resources and the Environment: Geothermal Energy" gives the reader a comprehensive understanding of developing geothermal energy. Geothermal resource potentials, development technologies and environmental considerations are discussed. Research and development efforts being conducted by various federal agencies are highlighted. A balanced review of the problems and prospects for developing geothermal energy in the United States is provided by the report.

Published by the Office of Energy, Minerals and Industry, the report, EPA-600/9-77-010, PDS No. 3869, is free from Energy Publications, U.S. Environmental Protection Agency, RD-681, Washington, DC 20460.

☆ ☆ ☆

Proceedings of the Irrigation Association 1977 technical conference are available. Topics include soil properties and irrigation; drip application as supplemental irrigation; land treatment and Environmental Protection Agency policies and guidelines; applying waste water to land; and groundwater management policies.

Also discussed are the views of the populace; the impacts of current social attitudes on water supplies and management; practical groundwater management; using infrared photography in scheduling and monitoring irrigation; and irrigation technology and agricultural production.

Copies of "1977 Annual Technical Conference Proceedings: Irrigation for All Reasons" are available from the Irrigation Association, 13975 Connecticut Ave., Silver Spring, Maryland 20906.

☆ ☆ ☆

"Deserts of the World," by M.P. Petrov, focuses on the similarities of deserts including geological structure, surface sediment characteristics, geomorphological processes and climatic peculiarities.

The author describes flora and fauna differences; specific desert environments; and desert natural resources and means of developing the resources.

The 447-page, illustrated publication costs $57.50 and is available from Halsted Press, 605 3rd Ave., New York, New York 10016.

☆ ☆ ☆

"Nutrient, Bacterial, and Virus Control as Related to Groundwater Contamination," was written by J.F. McNabb, W.J. Dunlap and J.W. Keeley. The authors present the history of groundwater, present uses and how it becomes contaminated. Contaminants in four U.S. geographic areas are listed.

Topics include the fate of phosphorus in soil systems, and sorption and biological use and degradation of organic and inorganic nitrogen compounds. Data on survival and transport of bacteria and viruses and indicator organisms in the sub-surface environment are included.

Order information about the publication, EPA-600/8-77-010, is available from the Robert S. Kerr Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Ada, Oklahoma 74820.

☆ ☆ ☆

"Procedures Manual for Ground-Water Monitoring at Solid Waste Disposal Facilities," by Dennis Fenn, et al, is a comprehensive publication which may be particularly interesting to regulatory agency personnel, engineers, or other persons who have no prior knowledge or training in groundwater monitoring techniques.

Monitoring fundamentals are described. The manual guides the reader in establishing a need for monitoring; assigning priorities to facilities to be monitored; and implementing and directing cost-effective, ongoing monitoring programs.

Single copies of the manual, EPA/530/SW-611, are free. Write to Solid Waste Information, U.S. Environmental Protection Agency, Cincinnati, Ohio 45268.

☆ ☆ ☆

Please address your news items or comments on the News Bulletin to any of the three editors:

Phil Briggs, Arizona Water Commission, Suite 800, 222 North Central Avenue, Phoenix, Arizona 85004.

Jim DeCook, Water Resources Research Center, University of Arizona, Tucson, Arizona 85721.

Ken Foster, Office of Arid Lands Studies, University of Arizona, Tucson, Arizona 85721.

UNIVERSITY OF ARIZONA
WATER RESOURCES RESEARCH CENTER
WATER INFORMATION SECTION
TUCSON, ARIZONA 85721