FINAL REPORT:

Rainwater Harvesting in Tucson, Arizona: A Pilot Study on Increasing Practice

Submitted to:

DR. DIANE AUSTIN

ANTH 595F Special Topics in Applied Anthropology:
Applying Anthropology in Environmental Research and Decision Making
University of Arizona

Submitted by:

Lisa Gavioli
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1.0 Introduction

The goal of this pilot study was to generate strategies for increasing rainwater harvesting in Tucson, Arizona. The study was exploratory in nature and focused on two areas of research: (1) an evaluation of a community within Tucson that is currently implementing rainwater harvesting activities by the community members themselves, as a case study with applications to the greater Tucson community; and (2) solicitation of information and ideas from outside experts and key informants regarding the present and future status of rainwater harvesting in Tucson. Through a mixed methodology, the research team was able to achieve these goals and accomplish the following objectives:

Objectives

1. **Identify parties concerned with rainwater harvesting in the greater Tucson community (hereafter called *stakeholder groups*);**

2. **Better understand the *awareness* of rainwater harvesting principles, methods, and resources among stakeholder groups;**

3. **Determine *impediments* to change and *incentives* for growth with regard to the current level of rainwater harvesting in Tucson;**

4. **Evaluate the awareness and effectiveness of water harvesting as a water conservation strategy in a *case study* community within Tucson; and,**

5. **Generate *recommendations* for increasing rainwater harvesting based on the findings of the research.**

2.0 Methodology

The study employed a set of mixed methods that included secondary data gathering, focus group discussions, short survey-like interviews, longer structured interviews, participation in public meetings and participant observation at rainwater harvesting workshops. The research focus encompassed two distinct scales: (1) the macro-community of Tucson, in which emphasis was placed on water problems in Tucson and perceptions of public awareness and

behavior regarding water conservation; and, (2) the micro-community of Civano, a planned sustainable living community in southeast Tucson, in which knowledge and practice regarding water conservation were evaluated among residents in a "best case scenario" environment, a point that will be elaborated below.

Initially, the research team identified eight-(8) stakeholder groups as potential participants in the proposed research. These groups were defined as community groups with vested interest in rainwater harvesting and included the following:

1. Landscape Architects;
2. Landscaping Companies and Nurseries;
3. Civil Engineers and Builders;
4. Experts/Consultants in Hydrology (Hydrologists);
5. City, County and State Officials;
6. Water Harvesting Activist Organizations;
7. Water Harvesting Businesses/Companies; and,
8. General public (including interested individuals and community representatives).

During the course of the research and analysis, these eight groups were coarsely parsed into professional and resident stakeholders. Professional stakeholders are defined here as specific groups whose professions impact or are potentially related to water management in Tucson. The professionals were further divided into two sub-groups: (1) experts and advocates (including hydrologists, city and state administrators, and water harvesting businesses and advocates); and (2) landscape professionals (including civil engineers, builders, landscape architects, and landscapers). Resident stakeholders are defined here as members of the general public who impact or are potentially related to water management as residents of the community.

As a scoping study, the intent of the research was to obtain a breadth of views regarding rainwater harvesting in Tucson so as to guide future research and advocacy. Systematic random sampling was not possible or even favorable within the constraints and intentions of the project. Participants from the stakeholder groups were chosen based on contacts made and interest expressed, and data gathered is not necessarily representative of each stakeholder group.

Although the team encountered various challenges, a reflexive, evolving research strategy was employed, allowing for the research methods to adapt to new information and insights gleaned from active fieldwork. Primarily, the research tools and approach varied with each stakeholder group; however, consistent themes endured such as; perceptions of water problems; awareness of rainwater harvesting techniques and resources; incentives to increase rainwater harvesting; impediments to increase rainwater harvesting; and responsibility for water conservation and promotion of rainwater harvesting. During the initial planning stages, five phases of research were outlined, and a schedule was kept for completing the work.

2.1 Phase 1: Background Research

Phase 1 involved background literature review of the following topics: (1) Tucson and Pima County water; (2) rainwater harvesting in Tucson and at the University of Arizona; (3) Austin, Texas, as a case study for the implementation of rainwater harvesting incentives; and, (4) the Community of Civano.

In order to supplement the literature review, the research team participated in meetings, lectures, and discussions on water conservation issues and rainwater harvesting. Additionally, as issues came up during research, further background research was conducted. In particular, environmental values as they relate to urban growth became an important issue that required review.

2.2 Phase 2: Civano Community as a Case Study

The second phase consisted of conducting research in the community of Civano as a case study that may yield insights into water harvesting awareness and practice among the general public. Although clearly not representative of the general community of Tucson, Civano would serve as a “best-case-scenario” community, in which impediments were minimized, awareness and channels of information were maximized, and the necessary resources were easily available.

Since Civano was created as a case study in sustainable development and community building (see below), it seemed to be an ideal place to examine rainwater harvesting as a conservation strategy being employed by residents. One assumption was that most of Civano residents choose to live there because, on some level, they share and participate in a sustainable living and conservation ethic, and therefore, are more likely to be aware of water conservation issue, including rainwater harvesting.

Furthermore, the neighborhood association at Civano (Civano Neighbors) is well established, and the existence of a website and online discussion forum were seen as indicative of the high level of communication among Civano residents, making it attractive to our research needs. This is complemented by educational and technical resources for rainwater harvesting that easily available at Civano through Civano Nursery. Lastly, visible examples of rainwater harvesting can be seen in common spaces in the community, such as the Community School and the Welcome Center.

In 2001, a group of researchers from the Bureau of Applied Research in Anthropology (BARA) at the University of Arizona conducted an environmental values perception survey of the Civano community (Austin, McGuire et.al.: 2001). After several years and with the implementation of rainwater harvesting in many households thereat, the research team decided that this as an opportune time to supplement BARA's study by conducting a participatory evaluation of the success, feasibility, issues, and problems associated with rainwater harvesting in the community.

Community leaders and organizations were contacted through the neighborhood association representative in order to conduct an electronic survey of Civano residents on conservation practices at Civano, including rainwater harvesting. The questions were posted on the website for residents to access. This was followed by a focus group discussion (FGD) conducted with Civano residents regarding the abovementioned success, feasibility, issues, and problems associated with rainwater harvesting in the community. Lastly, in depth interviews with a few key members of the community were conducted on the same issues. A total of 13 Civano residents participated in our research at one or more of these levels.

Particular interest was paid to how members of this community rank water conservation among environmental concerns; whether or not they are aware of water harvesting as a means of water conservation; and whether or not and to what extent they practice water harvesting. The team also explored the motivations behind community members' decisions to harvest or not, as well as what issues impact water harvesting at Civano. Questions and discussions about rainwater harvesting were framed within a larger discussion of sustainable living practices at Civano in order to contextualize the topic.

This research was participatory in the sense that discussions with community members aided the team in formulating future discussion points and questions raised. Community members facilitated the conduct of the electronic survey and FGD, and comments of community members regarding problem identification on rainwater harvesting issues led to the development of suggested strategies for increasing rainwater harvesting in other communities in Tucson.

2.3 Phase 3: Focus Group Discussions with Experts and Advocates

The third phase of research was actually conducted prior to the second phase due to scheduling concerns. It consisted of a focus group discussion (FGDs) with members of the experts and advocates, a subgroup of the professional stakeholder groups identified above. In order to identify and invite potential participants for this FGD, three members of the research team attended the October meeting of the CATCH Water consortium meeting, a multi-sectoral volunteer organization promoting rainwater harvesting in Tucson.

The FGD was held soon thereafter on the UA campus. The discussion agenda included: (1) Water supply, demand, and conservation issues; (2) Level of awareness and commitment to rainwater harvesting in Pima County and City of Tucson; (3) Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis of rainwater harvesting.

Though the original plan had been to have these experts comment on Civano as a case study for water harvesting among the general public, time constraints did not allow for this component of the research.

2.4 Phase 4: Interviews with Landscape Professionals and Key Informants

The final phase of data gathering consisted of conducting interviews with key informants from the identified stakeholder groups in order to further probe specific water harvesting issues based upon the responses received during the FGDs. Of particular interest to the research team were the inputs of the members of the landscape professionals, including engineers, because of their integral roles in landscaping and flood control infrastructure in property development. The methods employed included a combination of short phone interviews, emailed questions, and longer in-person interviews. A

total of 13 experts, advocates, and landscape professionals participated in phases 3 and 4 of our research.

2.5 Phase 5: Report Preparation and Presentations

The final stage of the project consisted of analysis, report writing, and presentation of the findings of the study to interested groups. A final presentation was given for the class, and the CATCH Water Consortium and Civano Neighbors have expressed interest in having the team present its findings at their January meetings. Additionally, a summary version of the final report will be posted on the Civano Neighbors discussion forum for participants and other interested residents to access.

3.0 Background

This chapter provides a background on the water supply and demand situation in the City of Tucson and Pima Country, as well as in introduction to rainwater harvesting principles.

3.1 Tucson/Pima County Water Resources

This section provides a brief summary of the water resources of Tucson and Pima County based primarily on *Water Resources in Pima Country: A Report for the Sonoran Desert Conservation Plan and for Update of the Pima County Comprehensive Plan* by Barbara Tellman, Water Resources Research Center, The University of Arizona (2001).

The majority of Pima County's land area is within the Sonoran Desert where water is a limited and valuable resource. Rainwater and water from melting snow are insufficient to supply the needs of human settlements, since they compete with wildlife and vegetation for water. Tucsonans have long resorted to groundwater supplies, which are fast being depleted. Thus, Arizona's 1980 Groundwater Management Act (GMA) was established to prolong groundwater supplies by employing renewable supplies. Although the GMA was clearly a sign of progress towards sustainable water management, its passage has had serious impacts on surface water supplies. Pima County has two natural water resources whose capacities are increasingly being strained. On the other hand, the Central Arizona project (CAP) provides urban areas of Pima County with the option of using water sourced from the Colorado River.

History of Water Use in Pima County.

The oldest known irrigation canal in North America is in Pima County, where people have lived for at least 12,000 years and practiced irrigated agriculture along the Santa Cruz River and its environs since at least 1200 B.C. Rainwater harvesting was also used to irrigate crops, i.e. O'odham's Ak Chin farming, where summer rains are harvested for small plots. The arrival of the Spaniards and the formation of the San Xavier del Bac community modified land use and water extraction in the area. The Spaniards introduced new and winter crops thereby expanding agriculture. Cattle were also introduced in such large numbers that the natives complained that their springs were drying up.

The arrival of Anglos in the mid 19th century further increased water usage by expanding the extensive canal system established by the Spaniards near the Presidio, expanding the farms established by the Spaniards, establishing new ones, and also by building dams to create lakes for various uses. Most were washed out in the floods of the 1890s and were never rebuilt.

Since then, groundwater supply has become problematic. Springs developed and expanded by modern technology led to over extraction to such an extent that by the 1930s, the water table dropped to a point that it was no longer hydrologically connected to the rivers, except in some remote areas. By the 1950s, the problem was so serious that Arizona had to enact new laws on water extraction and sought to import water from the Colorado River. By the 1980s, the federal government made the passage of the GMA a condition for the CAP to become operational. The GMA led to the overhaul of policies on water supply and usage.

Supply and Demand.

No relationship between groundwater and surface water is recognized by Arizona statutes. Thus, there are no safeguards for protecting flowing streams affected by groundwater extraction. Over extraction has led to water table depletion of as much as 200 ft, with 50 ft being the minimum decline in the study area. This is unfortunate, since groundwater and surface water in the Santa Cruz watershed was a hydrologically connected system, i.e. streams replenished groundwater supplies, while a high water table maintained surface water flows.

Table 1:Water Use and Supply in the Tucson Active Management Area (AMA) as of 1998:

	Est. Volume in acre feet/ year		Est. Volume in acre feet/ year
Total Demand	349,000	Total Supply	349,000
Mining and Industrial	50,000	Mined Groundwater	150,000
Golf	24,000	Naturally renewed groundwater	50,000
Municipal	140,000	Effluent	110,000
Agricultural	160,000	CAP	25,000

(Tellman, 2001)

Note: i) Based on bar graph, figures are estimates.

ii) An acre foot (af) is enough water to cover an acre of land to a depth of one foot or 325,851 gallons of water. It is also enough to meet the needs of two averaged sized families for a year. Four to five AF would be able to irrigate an acre of cotton for a season or one golf course HOLE for a year.

iii) Central Tucson, which contains the highest population, consequently has the largest municipal water usage.

Central Arizona Project (CAP).

The CAP is a system of canals, pumping stations, and storage facilities that transport water 320 miles from the Colorado River at Lake Havasu to the Phoenix area before heading to Tucson. Fourteen pumping plants lift water 2,400 ft to reach Tucson. In 1920, seven states along Colorado River agreed on the judicial use of the river water. Arizona disagreed with the terms for 12 years. Hoover Dam and other dams were consequently built in the 1930s and with southern California about to enjoy water from the river, Arizona realized the significant benefits that water supply from the Colorado River may bring. The state began to lobby for a share in the 1940s. Arizona is covered by the "Law of the River" and the Colorado River Compact of 1922, which divided the river into two basins, Upper and Lower Basins. Arizona's share is 2.8 million acre feet/year from the Upper Basin and 50,000 acre feet/year from the Lower Basin. About 1.5 million acre feet/ year "survives" the transport to the CAP canal.

By 1968, Congress approved of the CAP with federal funding to be paid by Arizona with a low interest rate. Then Pres. Jimmy Carter required Arizona to change its water laws before federal funding could be provided, thus the Arizona Groundwater Management Act of 1980 was passed. The GMA has four active management areas in Phoenix, Prescott, Pinal and Tucson. The project was completed in 1990. Current project implementation difficulties/ issues include the following:

1. **Few big users such as farms and mines have signed up to the CAP, citing high costs, unreliable supply, and fluctuating water quality (for the mines). The only big user is the City of Tucson. Total allocation is only 215,333 acre feet/year;**

2. **Groundwater is still being resorted to by big water users at a relatively low cost, while CAP customers are paying higher and more realistic costs;**

3. **Long-term, reliable supply is an issue considering long-term drought conditions and increasing water demand leading to increased competition for water. This is especially true for California, which has a priority claim to fill its 4.4 million acre feet/ year allocation before Arizona. This was Arizona's concession to gain California's congressional support for the CAP. Arizona protects its rights, among other ways, through the Arizona Water Banking Authority (AWBA).**

Future reliable supply options for CAP water include constructing a 15,000 acre-foot above-ground reservoir and a 15,000 acre-foot underground storage and recovery facility costing $6 Million.

Water Recharge Strategies.

Pima County, including Tucson, has adopted several other water recharge strategies including the following discussed below.

1. Natural Recharge: **Mountain-front recharge to the Tucson AMA is estimated at an annual average of 39,000 acre-feet. Stream channel recharge, on the hand, contributes 38,000 acre feet annually. Groundwater flowing to the north and northwest of Tucson from the south also add approximately 9,000 acre feet a year on the average.**

2. Incidental Recharge: **This is water used in human activities such as in agriculture, mining, and effluent discharge, estimated at 81,000 acre feet/year.**

3. Artificial Recharge: **Tucson has constructed the Central Avra Valley Storage and Recovery Project (CAVSARP), PIMA Mine Road Recharge Project, Avra Valley Recharge Project, and the Sweet-water Underground Storage and Recovery Project. New recharge projects are being developed. About 11,000 acre feet were recharged in 1997. Other artificial recharge methods include in-channel and off channel artificial recharge, as well as injection wells, considered the most certain and effective method of recharge.**

Wastewater.

Wastewater or graywater is considered a water resource in both Pima County and Tucson and is used as a non-potable water supply, for irrigation of golf courses, non-edible plants and flowers etcetera. Pima County treats the wastewater, while the City of Tucson maintains ownership of about 90% of all effluent produced. This has caused some conflict and tension, which is being discussed by both parties.

Subsidence.

Arizona ranks third after California and Texas in land affected by subsidence with more than 3,000 square miles of land experiencing subsidence. Since the 1950s, hundreds of fissures (gullies or trenches of up to 50 feet deep and 10 feet wide) have occurred along with more than 500 sinkholes in San Xavier District. The CAP canal has some fissure damage along the route to Pima County. The U.S. Geological Survey (USGS) reports that groundwater levels have dropped 220 feet since 1940. Central Tucson water levels have been dropping one foot per year since 1950. Satellite images show sections of Central Tucson sinking at a rate of 2 cm or 0.8 inches per year. Of particular concern is the intersection of East Speedway and Country Club Rd.

Assured Water Supply (AWS).

Land developers must demonstrate the following before being allowed to develop new subdivisions:

1. **Sufficient supply to meet demands for 100 years;**
2. **Must meet water quality standards;**
3. **Consistent with conservation demands;**
4. **Consistent with water management goals; and,**
5. **Demonstrate that the developer is financially capable.**

The common and generally accepted ways of resolving water problems include the following strategies:

1. **Find more water;**
2. **Use less water; and,**
3. **Settle disputes for limited supplies through legal means.**

3.2 Rainwater Harvesting: Principles and Techniques

The City of Tucson defines water harvesting as "the process of intercepting stormwater runoff from a surface such as a roof, parking area, or land surface, and putting it to beneficial use" (Phillips 2003). The Water Harvesting Guidance Manual, published by the City of Tucson in 2003, outlines the basic principles, design process, and techniques for rainwater harvesting; while the City of Tucson Land Use Code includes requirements for water harvesting at various scales of development. The city advocates rainwater harvesting as a

method of water conservation to reduce reliance on groundwater extraction, to reduce flooding and erosion, as well as to increase alternative sources of water for landscaping, and to help its citizens reduce their water bills.

Rainwater harvesting involves the capturing, diverting, and/or storing of rainwater for beneficial use such as landscape irrigation. As outlined in the Guidance Manual, rainwater harvesting principles include the following:

1. **Start managing water at the top of the watershed;**
2. **Create multiple watersheds;**
3. **Spread and infiltrate the water;**
4. **Prepare for overflow;**
5. **Mulch to reduce evaporation;**
6. **Put rainwater to beneficial use; and,**
7. **Start small and adjust your systems as needed.**

Rainwater is a good alternative water source because it is virtually salt free, chemical free, saves money on water bills, and is environmentally friendly. Tucson's precipitation is bimodal, with 47% of its 11-12 in/year falling in winter and 53% in summer. However, most landscaping requires approximately 32% of its moisture in the winter and 68% in the summer. Thus it makes sense to find ways to capture rainwater for water for immediate or later use.

Although both encompass a great deal of variety, there are two primary systems for rainwater harvesting – *active* and *passive*. The goal of passive systems is to slow and spread storm water. Fast moving water during storms cause flooding, erosion, and infrastructure damage. Passive water harvesting systems help prevent these by keeping that water on site for eventual beneficial use. This is primarily achieved through land contouring – creating berms, swales, basins, and other techniques that will slow down fast water and make it available to landscaping and other uses.

On the other hand, the goal of active systems is to capture and store rainwater through a combination of gutters and tanks or cisterns. A common storage technique is the use of an upright culvert with a faucet from which people may water their landscape by hand or install a pump and connect a drip irrigation system. The table below outlines some common elements, issues and concerns of both active and passive rainwater harvesting systems:

Table 2:Comparison of Passive and Active Rainwater Harvesting Systems

Passive Systems	Active Systems
• Land contouring • Water use is immediate • Basins • French drains • Swales (crescent shaped burms) • Gabions • No tanks or pumps • Objective: slow and spread water • Enemy = fast water • Gravity dependent • Labor is most of the cost • Easy to construct • Low maintenance • Determine highs and lows of the property → where does the water go? • Example: new library/police station at Golf Links (many new municipal projects are incorporating passive elements)	• Water is stored • Delayed water use • Gutters • Tanks • Cisterns • Pumps • Greater water savings • Longer payback period • May require professional assistance • Requires maintenance (cleaning, etc.) • Storage: 1000 sq ft collection surface yields 7000 gallons of water, 75% of which can be captured • Above/below ground storage options • Concerns: must cover storage unit, filtration needed if drip system will be used to distribute the water • Example: many residences around Tucson and at Civano

3.3 Rainwater Harvesting at the University of Arizona

This section discusses rainwater harvesting initiatives in the University of Arizona as part of a class and at the U of A Science and Technology Park.

3.3.1 Proposed RWH Projects at the UA

Many in the University of Arizona community feel that rainwater harvesting should be more extensively incorporated on campus. One such advocate for RWH at the university is Dr. Jim Riley who teaches a course on water resources in the Tucson Basin. For the Fall 2003 term, he required his students to prepare a pilot study on how to use rainwater to supplement the water needs of select University of Arizona buildings and facilities. Members of the research team attended presentations of these studies, and our notes on four pilot studies are summarized below:

1) Potential Rainwater Harvesting for the Old Main Building and surrounding buildings.

   The Old Main Building currently houses the university's executive offices and is the preeminent building in the campus. The study proposed collecting rainwater from the roofs of Old Main, Social Sciences, César C. Chávez, Engineering, and Forbes buildings. The Old Main has roof

area of 22,042 square feet and can collect approximately 19,893 cubic feet of rainwater a year. The Social Sciences is even bigger with a roof area of 26,385 square feet and can collect 23,812 cubic feet. The César C. Chávez Building has 14,872 square feet of roof area and can collect 13,472 cubic feet of rainwater yearly. Lastly, the Forbes Building has a roof area of 23,752 square feet and call collect 21,472 cubic feet a year.

Storage size, area, and system are problematic considering space limitations, piping, and funding. However, the students proposed using a high-impact polypropylene (HIPP) or high density polyethylene (HDPE) plastic underground storage tank to collect just enough rainwater to meet the irrigation needs of the nearby turf and vegetation. To irrigate 2,000 square feet of turf west of the Old Main Building, storage requirements ranging from 1,368-2,112 square feet would be required of all the buildings assessed, except Old Main.

2) Potential Rainwater Harvesting for Bear Down Gym, Science Library, and Main Library.

The students proposed harvesting rainwater from the three buildings estimated at 107,800 cubic feet from a total roof area of 120,499 square feet. The nearby campus swimming pool was identified as the storage tank. The current 75 x 60 x 5.4 (feet) dimensions of the pool was proposed to be expanded to 75 x 60 x 10 (feet) to accommodate the rainwater to be harvested. The collected and stored rainwater be used irrigate a total of 30,000 square feet of turf areas in front of these buildings. The present dimensions of the swimming pool can hold 17,597 cubic feet or rainwater, which can easily irrigate the turf area in front of the Main Library.

3) Potential Rainwater Harvesting for Integrated Learning Center.

Rainwater from ILC is currently stored in a holding tank with a storage capacity of 26,000 gallons (3,300 cubic feet). An overflow system pumps out the water into 4th Street during intense rain periods, which is considered a wasted resource. The students proposed a hose system to direct the rainwater to a proposed flower garden 791 square feet in area by the Bear Down Gym.

4) Potential Rainwater Harvesting for buildings under construction.

The Institute for Biomedical Sciences and Biotechnology Building (ISBS), the Highland Common Area, and the Euclid graduate housing areas are under construction and were assessed as to the rainwater harvesting potential. The ISBS building had an estimated roof area of 33,706 square feet that can collect 30,333 cubic feet of rainwater, enough to water 8,426.5 square feet of turf for a year. The Highlands Common Area, divided into tree separate structures, has a total rooftop area of 45,552 square feet. A total of 40,997 cubic feet of rainwater can be collected annually to irrigate 11,388 square feet a year. The surrounding vegetation of 15 palm trees, 119 courtyard trees, and nine raised planters occupies 13,250 square feet. The Euclid Avenue Graduate housing apartments had a total roof area of 56,500 square feet that can collect 50,850 cubic feet of rainwater a year, enough to irrigate 14,125 square feet of turf. The proposed vegetation plan for the area includes 189 trees, 1,032 shrubs, 1,485 accents, and 2,179 ground cover plants, and 69 vines. The storage system proposed is a HDPE plastic underground storage tank with a solar powered submersible pump to distribute the stored rainwater.

A discussion during the open forum with a campus facilities representative revealed a rainwater harvesting policy is not in place at the university. Further space and budget constraints have made RWH systems a low priority in the university, although the opportunity is there.

3.3.2 University of Arizona Science and Technology Park

According to our informants (reliable, though unpublished), the present University of Arizona Science and Technology Park was formerly the IBM plant site west of Tucson, within Pima County. It was built in 1978 and operated until 1986, when economic and operational issues led IBM to practically shut down the plan except for a very small division that is still holding office at the site.

Many of the approximately 5,000 IBM personnel were from Boulder, Colorado, and possessed a high level of awareness of environmental issues. IBM also had a commitment to minimize environmental impacts in its site location and construction, as well as to blend in with the local environment and to use native plant and tree species.

IBM personnel lived in the Catalina Foothills, Rita Ranch. They wanted homes that were environment friendly, used native species, colorful designs, etc. Eventually, there were complaints from IBM workers on the lack of park, recreation, and other family activities in Tucson. Many were dissatisfied with the location, so when it came to downsize and to shut down some plants nationwide, the Tucson plant was one of the first to go. The UA took over the site and tried to convert it into an international campus. This effort was not successful, and it currently operates it as a science and technology park with several locations, including a secondary school.

First large scale RWH in Tucson. **The IBM site was the first large scale landscape project that incorporated RWH features and the use of desert plant species. IBM wanted to make a statement in the design of the plant site. After its completion, the design was submitted to the American Society for Landscape Architects (ASLA) for possible award/ recognition, but the design was not chosen, perhaps since the design made use of desert species, a radical idea to the judges in the late 1970s when the trend at the time was the "California look." Our informant presupposes that at the time, the ASLA board was not used to the idea of using native plants.**

Working together. **The project, started in 1979, took about 1-½ years to complete. Albert C. Martin was the lead architect. IBM officers, architects, and landscape architects worked closely together on this project. IBM officers monitored closely the progress of the project and consulted with the architects and landscape architects frequently. The IBM people were perceived to be good people to work with, and it was a good experience on the part the design team.**

Environmental design principle. **The resulting product was a combination of both IBM and the landscape architects' ideas to make this project environmentally sensitive. IBM's design philosophy was that the buildings were to have a modern, efficient look and design, but was supposed to blend in with the local environment. Site clearing was to be minimal and native plant and trees species were to be used. Water was to be conserved, recycled, and reused. The landscape design element is dramatic in IBM. The site is nicely done and very aesthetically pleasing.**

Vegetation was planted en masse on designated areas. The natural drainage system at IBM and natural areas at perimeter were preserved as a natural buffer zone to the highway.

Multi-sectoral cooperation. **The IBM site landscape involved the salvaging and replanting of saguaros from a copper mine in Green Valley. Larry Doolittle, a horticulturist and the acknowledged guru on saguaro balling and transplanting, was contracted to ball 300-400 saguaros, yucca, ocotillo etc., set up a nursery for the saguaros, and transplant them in the IBM site, among other sites. Losses were insignificant, at approximately one percent.**

The IBM buildings have flat roofs with gutters and piping and provide a good view when on top. The top of watershed in the IBM site is the entrance, which was graded to cafeteria area. A hard pipe bubbler system (polyurethane) was used instead of plastic tubes, which deteriorate over time. The overall drainage system was designed to use rainwater for irrigation. The water harvesting techniques are passive. The system was based on gravity flow, that led to underground culverts. IBM also had a tertiary wastewater/ water treatment plant for its operations, while the City of Tucson only uses a secondary treatment system. Because everyone involved in the project was aware of the environmental concepts, the landscapers themselves were very knowledgeable about what they were doing.

The IBM personnel extensively used the outdoors for its functions. The trees planted were placed in strategic areas to provide shade (as they do now). Some of the trees on site that required supplemental irrigation were ideally going to be weaned over the years.

So far, the landscape looks good, although less lush than the original, according to our informant. The walkway is new. The new owners of the plant site (UA) seem to have difficulties with maintenance. The thick vegetation before has been gradually thinned out, i.e. shrubs have been pulled out. The two oaks were planted as seedlings by the front of the welcome center. These are semi-deciduous trees, not too big, yet provide shade to the building.

The original design called for heavy vegetation to cover water pipes, utility boxes etc., and to provide shade. The lush vegetation now looks trimmed and lessened, maybe because the present operators of the property, the University of Arizona, cannot afford to maintain the vegetation to the extent that IBM did when they operated the site.

There is no indication that the UA is highlighting the Science and Technology Park as a classic example of environmental design and a large scale working example of RWH.

3.4 Comparative Example: Austin, Texas

Austin, Texas is often cited as a leader in the implementation of green builder and water conservation programs and policies. As such, it serves as a good comparison for this study and may provide insights into what policy incentives for rainwater harvesting might be feasible for Tucson.

Based on current population projections, if a drought were to occur in 2050, almost half (43%) of the Austin municipal demand would not be satisfied by current water sources. The 2002 Texas State Water Plan is a long-term plan to meet state water demands even during drought conditions by demand reduction through conservation and reuse and by water supply acquisition. Since conventional freshwater supplies in Texas are already 75-80% developed, water conservation is a very critical element to meeting the State's long-term water needs. (TWDB 2002).

In the November, 2002 edition of the City of Austin Green Building Newsletter, The Texas Controller of Public Accounts, Al Van Allen, refers to the 2002 Sales Tax Update. This is a publication that is available by request through their office and lists different items that can be exempt from sales tax if the purchaser completes the Texas Sales Tax and Use Tax Exemption Certificate. The Sales Tax Update article states: "To encourage Texans to conserve water, the 2001 Texas Legislature created a new sales tax exemption which applies to equipment, supplies and services used solely for certain types of water conservation."

The following items are covered by the exemption: rain barrels, gutters used solely to route the water into rain barrels or rainwater collection systems; tanks and cisterns; roof washers used in a harvesting system; screens and filters for the gutters, barrels, tanks, cisterns and roof washers; and a collection surface are that is not used as a roof of a structure or storage area. It should be noted however, that local suppliers are not obligated to accept the Exemption Certificate. Evidently, the state cannot force retailers to comply, and no information was found on the level of compliance among retailers.

City of Austin Water customers can take advantage of a couple of different rainwater harvesting incentive programs. One program offers single-family households rebates anywhere from a minimum of

$45 up to a maximum of $500 on the cost of installing a rainwater harvesting system. Applications must be approved prior to purchasing the equipment and there are other stipulations including making the site available for public display for a couple of days upon completion. According to William DeHerrera, a City Planner for Austin, TX, since this policy's inception in 1998, 37 households have taken advantage of it. The second rainwater harvesting rebate program specifically focuses on rain barrels. Customers can receive up to $30 rebate for a maximum of four barrels per account/household. Customers must agree to an inspection. Again, according to Mr. DeHerrera, this program began in 2001 and over 5000 households have participated.

Comparable Programs in Tucson. **Local water conservation efforts include Tucson's Metropolitan Domestic Water Improvement District (Metro Water) rebate program, which was implemented in September of 2002. Metro Water is a privately owned utility company which services communities northwest of Tucson, outside of the city limits. According to the 2002 report of General Manager Mark. R. Stratton, it has more than 16,500 connections and serves the water needs of some 45,000 people as well as hundreds of businesses.**

Metro Water District's rebate program is somewhat similar to Austin's Rainbarrel Program except that it can be applied to a wider array of equipment. The customer must provide an original sales receipt for the purchase of container(s), piping, gutters, or other parts as components necessary for water harvesting. The customer must provide a description as well as a photo of that equipment and Metro Water District reserves the right to an inspection. Provided the applicant meets required criteria, a rebate check for $50 will be mailed to the customer in six weeks or less.

According to Metro Water's Assistant General Manager, Warren Tenney, eight Metro Water customers have utilized this program so far and have received $50 rebates each for water harvesting projects. Due to the infancy of this program, no follow up has been yet been conducted. Only Metro water customers, who are primarily on northwest side of the Metro Tucson area, are eligible for these programs. The City of Tucson (Tucson Water) itself does not currently offer any or rebate programs or incentives for its customers to utilize rainwater harvesting techniques.

3.5 Community of Civano: History and Principles of Development

Civano is a planned community in the southeastern part of Tucson, Arizona. It is the largest housing project ever developed under the concept of "sustainable housing" in the United States, attracting national and even international attention. Fifteen years of planning and pre-development activities took place before the first residents began living in the community in 1999. At its completion, Civano is expected to become a small town located on 820 acres, with 2,500 homes, and about 5,000 residents spread over three separate neighborhoods. Presently, there is only one neighborhood completed with over 300 occupied homes.

The development includes mixed-use, light industry, commercial, and institutional facilities. Sustainable principles influence the development of the Civano community through the use of environment-friendly and if possible, recycled, building materials and systems. Active and passive solar energy, water harvesting, cooling towers, thermal construction, high efficiency windows and household appliances, xeriscaping, recycling and composting, are used as much as possible by the homeowners.

New urbanism sustainability principles are also incorporated. This concept uses architecture and design to create a sense of community through narrow winding streets, garages behind homes, extensive walking and biking paths, mixed-use zoning, mass transit, and localized home design. The result is increased resident interaction and community sense of place.

The Civano community is a private-public partnership in which the City of Tucson and the State of Arizona have provided more than $4 million in financing as well as land transaction facilitation and energy standards legislation since the project inception in 1980.

As a response to the energy crisis in the 1970s, the idea for the community that became Civano was focused on energy conservation. In the beginning, solar energy was the most important feature, but over time, the plan has evolved and now Civano is referred to as a "sustainable community." The IMPACT standards (Integrated Methods of Performance and Cost Tracking System for Sustainable Development) are used for all development (Civano Guiding Documents 1998). The IMPACT goals are to:

1. reduce potable water consumption by 65%

2. reduce home energy consumption by 50% over the 1995 model energy code
3. reduce internal vehicle miles by 40%
4. create one job onsite for every two residences; and,
5. reduce landfill-destined solid waste.

The water reduction standards present the biggest challenge. In an effort to meet the water use requirements, reclaimed water is supplied by Pima County Wastewater Management to Civano Neighborhood I and is used for irrigation at residences and in common areas, with separate meters for reclaimed and potable water. Reclaimed water studs were mandatory in Neighborhood I, and approximately 90% of households use these to reduce potable water consumption.

A recent study by Al Nichols Engineering, Inc. (2003) concluded that the total water use at Civano in 2003 was 61% of the average Tucson home and that the use of reclaimed water at Civano resulted in a 62% reduction in potable water use over Tucson homes. Lower use at Civano was attributed to strict landscaping standards, small lot size and the reclaimed water system.

No data were available for the effect of rainwater harvesting, though it was noted that Civano homes not using reclaimed water only used about 2% more potable water than homes using reclaimed water. Problems with the reclaimed water system, such as maintenance issues and high cost, led to the decision not to require use of reclaimed water for residences in future neighborhoods. Public spaces will still use reclaimed water for landscape irrigation. Since the IMPACT standards will still apply to the new developments, other efforts will have to be made to reduce potable water consumption, creating an increased opportunity to implement rainwater harvesting systems.

4.0 Results

This chapter discusses the results of the case study on Civano and the FGDs conducted with RWH experts and advocates.

4.1 Case Study: Community of Civano

In conducting research at Civano, it became clear to the team early on that while the Civano community is a good case study for sustainable

development and conservation practices, there are a few notable differences between Civano and the average Tucson community that must be taken into account when evaluating the results of the research.

First, it has already been mentioned that reclaimed water studs were mandatory in Neighborhood I and that about 90% of households utilize this resource to meet IMPACT standards for water conservation. While this has been a successful strategy for reducing potable water consumption at Civano, the presence and use of reclaimed water may be seen as an impediment to practicing rainwater harvesting and set Civano apart from the rest of Tucson, where reclaimed water is not widely available. This issue was addressed in discussions with Civano residents and will be dealt with further below.

Other aspects of Civano that are dissimilar to Tucson in general are the probable tendency for greater awareness of water conservation issues and of rainwater harvesting as a conservation practice; the high degree of resident interaction due to New Urbanism principles and the well established and digitally connected neighborhood association; and rainwater harvesting resources such as Civano Nursery and community examples. While all these elements were mentioned above in discussing why Civano was desirable as a case study for this research, these are also serve to set Civano apart from the average Tucson community and must be considered in order to contextualize the results of the study.

Perceptions – Prevalence, Awareness, and Responsibility at Civano.
Based on data gathered, approximately 40 (~13%) of the 300 current residences at Civano have active rainwater harvesting systems, with passive elements present in residential and common landscaping. In accordance with expectations, our data gathering exercises at Civano indicate that awareness of water conservation issues there is qualitatively high. However, many residents expressed the sentiment that while they are aware of rainwater harvesting as a conservation practice, they did not know enough about the principles and techniques to implement them.

Information about rainwater harvesting is spread among residents largely through local examples, word-of-mouth among neighbors, and workshops at Civano Nursery. In fact, most residents knew of "culvert-raisings" that had been held in the neighborhood, in which

neighbors cooperated to install active rainwater harvesting systems at each others' homes.

Finally, all residents that we spoke with agree that the responsibility for water conservation education and advocacy should exist at all levels – at individual, local, and community levels as well as governmental levels.

Impediments to Rainwater Harvesting at Civano. **As discussed, the biggest impediment to rainwater harvesting at Civano is the prevalence of reclaimed water systems due to the requirements set for the construction of Neighborhood I. Because most residents currently use reclaimed water to irrigate their landscaping, many may not see the need to do more to conserve potable water.**

Next, the small lot sizes at Civano deter some people from wanting to put large cisterns in their yards. On the other hand, in spite of small lot sizes, many people believe that rainwater harvesting would have to be supplemented by another irrigation source, because not enough water could be collected to meet annual needs. In this situation, some residents doubt whether incorporating rainwater harvesting would actually result in monetary savings.

Somewhat contrary to expectations, Civano does not differ from the rest of Tucson in that lack of information is an impediment to increased rainwater harvesting. Although aware of conservation issues, many do not know enough about rainwater harvesting to consider it a viable option. People need to learn what techniques are appropriate for their property and how to maintain the system once it is in place. Additionally, many people are unwilling to invest a lot of time in learning about and maintaining systems. They want something that is convenient and problem-free.

In addition to lack of information, misinformation is a problem. Our data shows that many people think of rainwater harvesting only as active systems which include storage of water in containers. This narrow concept is an impediment because people are not aware that landscape designs can incorporate passive harvesting techniques.

Finally, while residents of Civano are typically familiar with and open to sustainable practices, there does exist a perception that rainwater harvesting is something for the more radical environmentalists. While this may seem contradictory, it can be explained in part by the fact that many residents moved to Civano for reasons other than the

sustainable living practices. For instance, some were attracted to the New Urbanism design and others to the idea of a new community with a diversity of residents. In these cases, there appears to be a social stigma associated with the practice of rainwater harvesting despite its practicality in a desert environment and its adherence to a conservation aesthetic.

Potential Incentives to increasing Rainwater Harvesting in Civano. **If the biggest impediment to rainwater harvesting at Civano is the widespread use of reclaimed water, then the greatest opportunity to increase rainwater harvesting could be that reclaimed water will not be required for homes in the new neighborhoods. The costs of setting up a reclaimed water system, estimated at $5,000 per household, is seen as a disincentive to investing in a Civano lot. Achieving water use reduction IMPACT standards will have to be flexible in terms of strategies, some of the informants stated.**

In the new neighborhoods, water reduction standards will remain in place, meaning that residents will have to find alternative methods for conservation if they choose not to use reclaimed water. Currently, there has been no official decision to require rainwater harvesting systems for all homes, despite rumors to this effect, but perhaps if enough interest was generated, a mass production deal could be arranged with builders and landscapers.

Our research indicates that economic incentives would reach a large number of Civano residents. Some examples are: free or discounted equipment, free workshops to teach people about techniques and maintenance, free assistance with installation and tax credits or rebates for installing systems. Other possibilities include trade-offs or discounts. For instance, if a home uses reclaimed water and practices rainwater harvesting, a discounted rate could be offered on the reclaimed water or on the potable water.

One way to encourage rainwater harvesting is to discourage potable water use. This is done in principle by the IMPACT standards at Civano, but it could also be done economically, by raising water rates for Tucson in general. Our data shows mixed reactions to this suggestion; however, some feel that most residents would only resort to harvesting rainwater if water became very expensive or scarce. Others disagreed that changing rates would alter consumption behavior and expressed concern about issues of equality if a necessity like water were to become prohibitively expensive.

Finally, laws and regulations are potential incentives for increasing rainwater harvesting. Similar to the IMPACT standards, regulations could be developed for greater Tucson, which would limit the amount of potable water that could be used by each home or by each person. These regulations could be phased in so that new developments would be subject to the new requirements while older houses would not have to bear the financial burden of retrofitting.

In the long term, the most positively viewed incentives for increasing rainwater harvesting are economic credits of some type and subsidized information from reliable and qualified sources.

4.2 Experts, Advocates, and Landscape Professionals

The Experts and Advocates who participated in this study consisted of individuals whose professional, and sometimes personal, background gave them a vested interest in the promotion of rainwater harvesting (RWH) in the Tucson area. They included hydrologists, employees of Tucson Water, the City of Tucson, the Department of Water Resources, Water Harvesting Entrepreneurs, Landscape Architects, Landscaping Company Owners, and Civil Engineers. The points of view expressed by these individuals are not intended to represent the viewpoints of their respective professions at large. Nevertheless, the compilation of opinions from a diverse group of experts, including those from the City and the State, in one setting may help contribute to formulating a more realistic and sustainable RWH promotion strategy.

Perceptions. **According to the experts, there appear to be two prevalent public perceptions concerning the water supply in Tucson: (1) Water is too expensive and is bountiful, or (2) Water is too cheap and is a threatened resource. One problem contributing to the public's alleged confusion is that Tucson's water supply is hidden. It is not possible to see the water supply being drained and therefore, it is not clear how much groundwater is available. A common sentiment expressed by informants suggested that as long as water comes out of the tap, Tucsonans do not seem to be concerned with how much water is left, much less ways to conserve it.**

The experts and advocates focus group discussion showed that a multi-sectoral and holistic approach, at various levels, is needed in water conservation and in promoting and using RWH systems. No one group or sector can handle this. Promoting it on a sustained basis, if not full-time basis, is also required.

Impediments to Rainwater Harvesting in Tucson. **According to our informants, impediments to water harvesting exist in several dimensions. Impediments occur socially, educationally, and economically. For example, despite an increasing appreciation for aspects of environmentalist ethics, a social stigma continues to surround an interest in rainwater harvesting. There is a persistent concern among informants in all community groups that the general public may perceive rainwater harvesting techniques as part of an "alternative lifestyle". Even among the rainwater harvesting experts themselves there seems to be a feeling that they are viewed as "grassroots" and are not likely to be taken seriously. These feelings have previously prevented them from approaching other professional stakeholders to discuss rainwater harvesting issues.**

Lack of awareness is another problem. If people don't know how to harvest water, or that it is even an option, they are not likely to do it. Even those who are aware seem to believe that rainwater harvesting will be inconvenient as well as expensive. Most people with limited water harvesting exposure envision large tanks, cisterns, culverts, and intricate drip systems that indeed do require some initial work and investment. They also have to meet certain requirements and ongoing maintenance will be in order. Additionally, these stakeholders feel that the many people view upright culverts and other cistern systems as aesthetically unpleasing. Unfortunately, people are also unaware of the many alternative passive rainwater harvesting techniques they can employ at a much lower cost (if any) and relatively minimal effort.

Responsibility. **Our informants largely feel that the community itself, along with the University of Arizona and government bodies, is also not without its duty to be aware and actively promote water conservation practices such as rainwater harvesting. Experts and advocates agree that more publicized working examples of rainwater harvesting are needed, both at the University and at other public structures. The more prominently displayed the system is, the more interest it will generate and hopefully, the more quickly it will catch on. Outside of public examples, the topic of appropriate venues for public outreach and education remained a persistent and unresolved issue in our discussions with informants. Future research may elucidate solutions to this issue.**

The responsibility of initiating these types of public promotion strategies was agreed to be primarily the government at the state,

county, and city levels. However, it is also widely accepted that if water harvesting is to become a successful means of water conservation the entire community must be receptive and cooperative. Current existing social stigmas along with other obstacles will need to subside before significant progress can be made.

City of Tucson. **Our research indicates that there is a great deal of opportunity for rainwater harvesting promotion at the level of the city government. There are virtually no existing governmental rebate policies that focus on rainwater harvesting systems or equipment, and virtually no highly publicized government building to serve as examples or working systems. As mentioned in a previous section, Austin, Texas, serves as an example of a city whose government has incorporated rainwater harvesting rebate programs as well as eliminated sales tax on all rainwater harvesting equipment. Austin also demonstrates the potential water, as well as energy conservation power of building "green."**

Newcomers. **New residents to the area are seen as being among the least water-conscious members of the community. The highly transient and steadily increasing local population is a real concern for many water harvesting experts and advocates. People come from all over the world and bring with them different types of plants that are not well equipped to deal with a desert climate. These plants therefore require significant irrigation and are a further drain on the water supply. Educating the public at large, especially newcomers, about desert appropriate plants, rainwater harvesting techniques, and the water supply itself continues to be a top priority among experts.**

Landscape Professionals. **It was not uncommon for informants to suggest that other professionals were critical targets for outreach and advocacy. For example, landscape architects and civil engineers are regularly targeted for educational programs concerning water harvesting. Implicit in these activities, is the sentiment that there may be a deficit in awareness amongst landscape professionals concerning rainwater harvesting techniques and methods. This sentiment prompted additional research targeting landscape professionals.**

Among the landscape professionals interviewed, it became clear that the degree of awareness concerning water harvesting techniques appears to be much higher than was expected based on our interaction with advocates. Although the degree of education and exposure to these techniques was somewhat variable, nearly all

landscape professionals contacted by the research team were aware of such techniques and how to implement them. When asked, many would reply that they did not actively encourage or design rainwater harvesting systems into their landscapes. However, as each interview progressed it became clear that each informant implemented passive elements and associated "rainwater harvesting" exclusively with active systems.

Engineers are concerned with health and safety issues such as: a) immediate drainage of standing water, b) buildings not settling, c) the most efficient way of construction with less priority with aesthetics, d) no mosquitoes in standing water, e) compliance with regulations- the CODE, and f) meeting deadlines and the timeframe. RWH should work within this constraint.

Landscape professionals also exhibited highly variable views concerning their ability to effectively promote rainwater harvesting through their clients. Although some professionals always advised their clients on the benefits of manipulating rainwater and runoff on their landscape, others felt that "rainwater harvesting" (read: active harvesting) was economically prohibitive and would immediately disincline their client to approve the design. In other cases, the informant felt that the ultimate responsibility for implementing designs lay in the hands of the builders. These interviewees felt that the difficult to manage humped profiles of Tucson house-lots and plant profiles are the consequences of builders ignoring landscape designs provided by informed landscape designers.

In terms of education and outreach, many landscape professionals were open to additional training, but only if such training could be provided "in house" within the company. Others expressed a concern that existing outreach activities geared towards landscape professionals were "preaching to the choir." Effective outreach would be best suited by tailoring to the unique needs of the professionals. For example, outreach in which creative uses of water harvesting systems within landscapes or in which the potentially negative aesthetic effects of active systems are mitigated would be found useful among many landscape professionals.

Unfortunately, no matter how well thought out the original design, unless everyone involved with the execution of that design is aware of the underlying concept, the possibility of not getting the desired result is extremely high. One Landscape Architect that had been interviewed for this study lamented that unless the Architect is

physically on site virtually from a project's beginning to end, the subtle grading and rock placement patterns that are sometimes involved in effective Rainwater Harvesting will not be properly executed. Then, of course, whoever maintains the property will also have to be familiar with the purpose of the design so that they do not unintentionally render it useless.

Further, clients do not want to pay for supervision of the implementation of the landscape design. The "buried horse" design (a mound on which a tree or plant is planted channels away, rather than collects rainwater) is more often than not a deviation from the landscape architect's design. Even the plants and trees to be placed get changed in an ad hoc manner. Unfortunately, these design changes are attributed, unfairly, to the landscape architect contracted. One estimated that about 50% of landscape plans and designs are not implemented to specification.

Incentives and Recommendations. **Many of the experts and advocates agreed that there is a need to make the general public aware of the issues confronting water supply and conservation. First of all, the groundwater supplies are not an infinite resource. Because of the rapid growth of metro Tucson, especially its population, a time will come when water resources will be seriously strained. Planning for the future begins today. An expert even noted that should supplies be significantly strained, reclaimed effluent may have to considered as a source of potable water.**

Second, over extraction of groundwater leads to serious issues of ground subsidence and the subsequent destruction of structures such as buildings and homes. This must be addressed soonest. Discussion of water issues must take into account over extraction of groundwater and how it induces ground subsidence.

Initiation of an information, education, and communication (IEC) campaign on water conservation and RWH is definitely needed. Current IEC programs are inadequate to meet the requirements of a growing Tucson. The target audience is not only changing, but is also rapidly expanding. Hence, the IEC campaign should be sustainable and should tailor fit the various demographics that comprise metro Tucson. Innovative IEC programs are needed and should incorporate 'training the trainers' and hands on programs. It should be multi-sectoral in approach, in funding, in implementation.

Cost is an issue both in the use of water and in using RWH systems. Ground and surface waters, are valuable resources, which should be valued adequately. It was suggested that adjusting water rates may help encourage water conservation and even RWH practice; however, this is a sensitive and political issue that must be studied carefully.

For promoting water harvesting at the scale of new housing developments, our informants consistently suggested that Tucson implement a Green Builder program. In some cases, our informants suggested using the guidelines from Austin, Texas as a template for local regulations. Implementing a Green Builder Program in Tucson that resembles that of Austin would encourage builders, architects, owners, and others to build and remodel homes using "green" guidelines. "Green" guidelines serve to assist with the environmentally as well as community sensitive construction and remodeling of homes. These houses are not only water efficient, but efficient in terms of energy and materials used as well. The residential Green Building Program rates new homes and remodels using "green" guidelines on a scale of one to five stars. The greener features in the home, the higher the star rating. Austin's program is ideal to serve as an example of how a Green Builder Program can be beneficial as it has earned national recognition by the American Council for an Energy-Efficient Economy for having an "Exemplary" program in 2002 (City of Austin 2002).

Among landscape professionals, the few suggested incentives were variably supported. For some informants, tax incentives for landscape professionals who design and implement water conserving designs appeared effective. Other informants suggested that a certification system for professionals with certain training in implementing water harvesting designs might effectively promote the reputation of water-responsible landscapers.

From an institutional perspective, it was suggested that the initiation of a storm water fee with a variable rate may be an effective incentive. The rate structure for the fee system would be dependent upon the amount of runoff that could be contained on-site without contributing to citywide storm water runoff. This suggestion was not repeated through informant discussions, but may be a creative alternative in which local officials can promote passive water harvesting.

Another creative suggestion surrounded the sponsorship of loan or mortgage benefits for those who install rainwater-harvesting systems. For example, if applicants install active water harvesting systems, they would be eligible for interest rate breaks or higher capital availability on their loan. Such a system may serve to offset some of the initial costs of installing a water harvesting system as well as provide an economic driver for aspiring homeowners and/or newcomers to the area.

Providing rebates on cisterns or culverts for use as cisterns was a frequently echoed suggestion for providing economic incentives. In this rebate system, Tucson could follow the example established by Austin, Texas and discussed above. Particularly with respect to the rain-barrel program, such rebates appear to be effective incentives.

Finally, some informants suggested that the only effective incentive for promoting rainwater harvesting would be to legislate or regulate it. Although the stormwater fee mentioned above might fall in this category, alternative suggestions included mandating low-water front yards and mandated decreases in potable water per unit area usage.

5.0 Discussion: Avenues for Future Research and Advocacy

Based on the variety of data gathered during the course of this project, the research team has generated a number of recommendations. As a scoping study, this project began an initial phase of exploration into what issues are related to the current level of rainwater harvesting (RWH) in Tucson and what further avenues of research and advocacy might be taken to increase RWH practice.

5.1 Advocacy

As stated above, a primary impediment to increasing rainwater harvesting in Tucson is lack of awareness among residents, and while many landscape professionals know of rainwater harvesting and implement some passive techniques, there seems to be a lack of incentive for them to explicitly incorporate RWH into their work. Thus, various forms of advocacy are needed to educate the general public about rainwater harvesting and to demonstrate to residents and to landscape professionals how the incorporation of RWH techniques can be beneficial. Furthermore, it should be emphasized that RWH

need not be considered a radical conservation practice but can serve as an easy and effective way to reduce water consumption.

However, it is important to recognize that different audiences require different forms of information and different methods of delivery and that rainwater harvesting education must be tailored to the knowledge, needs, and abilities of different audiences. For instance, residents may have little or no knowledge of rainwater harvesting, or even of Tucson's water situation and the need for water conservation, not to mention how to best care for their landscaping. Thus advocacy to the general public may need to start broad and basic and move on to more advanced issues once this base of knowledge is established. On the other hand, landscape designers may already know of rainwater harvesting and need some creative ideas as to how best to incorporate RWH elements into their designs.

Next, since household-based RWH practice is an area with high potential for growth, reaching people at the micro-community level can be an effective means of getting out the word about rainwater harvesting principles and techniques. Information about household conservation practices seems to be primarily spread among neighbors and friends and by local examples. It is thus important to target community groups like neighborhood associations, or gardening clubs, in order to spread the word.

Finally, we saw at Civano how local examples can very effectively inform and educate people about rainwater harvesting. It is the opinion of this research team that as a focal point for the macro-community of Tucson, the University of Arizona could be an ideal place for promoting RWH through local examples. As a land-grant institute, the UA has made outreach part of its mission, attempting to "serve many needs through programs that: (a) identify and attempt to satisfy some of the most pressing needs of the state and its citizenry; (b) provide formal and informal educational programs, and (c) conduct fundamental and applied research" (The University of Arizona, n.d.).

According to our background research, many efforts to implement and promote rainwater harvesting at the UA have already begun (see above), and two sites in particular have great potential for becoming RWH sites – the Science and Technology Center and Old Main. The UA campus is visited not only by students, faculty and staff, but by many members of the community on a regular basis, and RWH

initiatives could potentially reach a large portion of the Tucson community and beyond.

5.2 Research

While this study generated a great deal of information about rainwater harvesting in Tucson, more research is needed to systematically explore the issues highlighted here. A few areas of interest have been cited. First, since Tucson is growing at a rapid pace, newcomers to the Tucson area may be considered an additional stakeholder group among whom rainwater harvesting and the need for water conservation may not be well known. An evaluation of newcomer interest and awareness of these issues may be beneficial in determining the potential for increasing RWH practice in Tucson.

Next, though this study has generated some suggestions for good venues for disseminating RWH information, a more specific and thorough exploration of such venues is needed. Third, a quantitative evaluation of the economic feasibility of RWH for residents and businesses would be beneficial for educational purposes and may provide insight into what policy incentives may be most appropriate for increasing RWH practice in Tucson. Finally, a systematic evaluation of such policy incentives for residents and landscape professionals is required before policy reform and implementation can proceed.

5.3 Concluding Thoughts

In conclusion, there is a great deal of potential for increasing rainwater harvesting in Tucson, but more work is needed. What is clear though is that rainwater harvesting is intimately related to issues of resource use and its control, as well as to the growth and development of Tucson and the paradigms that influence its expansion. Thus, a well-planned, multi-sectoral approach is needed to increase RWH practice.

It is the hope of the research team that the data and suggestions presented here will be of practical use in guiding future research, advocacy, and policy. As stressed in a recent article entitled *Strategy Myopia*, a successful strategy is "…seeing what everybody else has seen and thinking what nobody else has thought…" (Bentulan 2002).

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