Report - Water Conservation Conference for Far West Texas Water Plan Region E

Interlocal Agreement between Rio Grande Council of Governments and El Paso Water Utilities Public Service Board.

Executive Summary

This report summarizes the work done under Study #4: Municipal Water Conservation Education Program found on the interlocal agreement between the Rio Grande Council of Governments (RGCG) and El Paso Water Utilities Public Service Board (EPWU). It includes the purpose of study, background information, methodology, results and recommendations, of the conference held October 17, 2008 at both El Paso TecH20 Center and Ft. Stockton Extension Center.

Purpose of Study

The main goal for the conference was technology and information transfer based on EWPU success. EPWU wanted to share its experiences related to the implementation of conservation programs and incentives. The information presented at the conference was not specifically designed as part of the long range Far West Texas Regional Water Plan of 2011 but as an ongoing intraregional cooperative effort to share information so that regional water purveyors can implement programs that fit their needs in their planning strategies.

Background Information

For more than seventeen years, EPWU has dedicated its efforts and resources to developing and implementing successful water conservation programs. In 1991, our objective was to reduce consumption from an initial 200 gallons per capita per day (gpcd) to 160 gpcd by the end of 2000. As such, consumption dropped to 159 gpcd. Our new goal of reaching 140 gpcd by 2010 was surpassed at the end of 2004 when we reached 139 gpcd. Last year (2008), water consumption reached 133 gpcd. Maintaining a 140 gpcd through 2010 is our new goal. This incredible achievement is attributed to the implementation of best management practices; such as education programs, system audits, rebates and incentives, rate structures, mandatory ordinances and supply side conservation for the complete management of water resources.

Staff from EPWU participated in the Water Conservation Implementation Task Force created by the 78th Texas Legislature under Senate Bill 1094 to review, evaluate and recommend optimum levels of water use efficiency and conservation for the state. As a result, the Water Conservation Best Management Practices Guide was created. The conservation program described in this document incorporates some of the BMP's found on the guide relevant to municipal water users.

In December 2007, EPWU staff requested Far West Texas Water Planning Group Members submit ideas for topics in order to develop relevant conservation training for the water utilities in the Far West Texas Region. The following topics were suggested.

- *Training on the options open to small suppliers for using/selling their WWTP effluent. How do they market it? What are legal use options? How did the purple pipe program get started, funded, and what is involved?*
- *Water conservation programs and best management practices recommended by the Texas Water Development Board and the Water Conservation Implementation Task Force. Including education programs, supply side water conservation, system water audits, landscape water efficiency and xeriscape principles.*

A one day conference was proposed; the conference included two concurrent tracks. The Utility Staff Track was designed for the technical staff of water purveyors. This track incorporated sessions regarding BMP's found on the state guide and on the contract requirements between EPWU and the RGCG.

The Community Outreach Track was planned for those who help utility staff disseminate educational presentations into the community such as extension agents, teachers and master volunteers. This track introduced many of the available school curriculum programs on water conservation. The track included hands-on activities that can be used at school settings and community events. Attending teachers received professional credit hours for their participation in the conference.

Methodology

The conference took place Friday October 17, 2008. Recognizing that the driving distance between the counties in Region E might become a problem; we proposed to offer different venues for this conference.

1. The El Paso site (Tec$H_2$0 Center) hosted the one-day conference with two tracks, the Utility Staff Track and the Community Outreach Track.
2. An EPWU facilitator and an Extension Agent were sent to Ft. Stockton site (Extension Center) to host the Community Outreach Track. Both sites were linked via long-distance conferencing and video.
3. In addition, the Utility Staff Track pre-recorded presentations were made available through a link to the El Paso Water Utilities Webpage. This option was offered for those attendees that were interested in such track but couldn't drive to El Paso.

There was no registration cost for the conference. The most important benefits, by offering the conference in the previously described format, were cost savings and work schedule flexibility by minimizing lost work time and expenses due to travel. Additionally, teachers that attended the Community Outreach Track received, at no cost to them, 6

hrs of professional CEU's. Copies of presentations and the conference program are included on attachment "A" at the end of this report.

As per expenses, a description of such along with in-kind donation received, are included on attachment "B" at the end of this report.

An electronic invitation to "save the date" was emailed to a list of members provided by RGCG and TWDB staff. The same printed invitation was mailed to those members with no electronic mail. Such invitations were distributed at the extension service during their fall district meeting. Following the invitation, a conference program was mailed. Registrations were handled via emailed and regular mail. A total of 55 registrations were received; 32 for the Community Outreach Track for both sites, Ft. Stockton (12) and El Paso (20) and 23 for the Utility Track in El Paso. Subsequently, EPWU Webmaster reported 140 web link requests from the link that contained the conference presentations. Such requests were measured during the time the link was available, October 14, 2009 to December 30, 2009. Copies of sing-in sheets included on attachment "C" at the end of this report.

Results

We experienced minor video and audio glitches during the simultaneous broadcasting of the Community Outreach track between El Paso and Ft. Stockton site however; we did received positive comments from attendees.

We only collected evaluation forms from attendees of the Community Track. We did not collect any evaluation forms from the Utility Track attendees. A total of 45 evaluation forms were received from both sites, El Paso and Ft. Stockton, the majority from 3-5 grade teachers. These teachers were mainly rural (10), suburban (2) and urban (7). The majority work at public schools. The following table indicates how attendees rated the Community Outreach track.

How strongly do you agree or disagree with the following statements?	Strongly agree (1)	2	3	4	5	6	Strongly disagree (7)
I acquired new skills at the workshop	14	1	3	4			
The workshop increase my knowledge of how to use water resources as the context for interdisciplinary teaching and learning	13	5	1	3			
Students/participants will learn from Project WET activities	16	3	1	1		1	
The facilitator showed ways to integrate activities into my program	15	3	1	2	1		
The facilitator was well prepared	17	2	1	1	1		
The facilitator demonstrated ways to modify activities	16	2	1	1	1	1	
The facilitator was knowledgeable	17	4	1			1	
It was worth my time to come today	15	4	1	1		1	
I'm excited to use Project WET	16	3		1		1	1

The resources and materials provided at the workshop are useful	16	2	1		1	1	
I will recommend this workshop to colleagues and friends	16	2	3		1		
Overall the workshop was excellent	17	2	1	1		1	

The following are comments from conference attendees:

- I will use some of the ideas to plan future professional development units
- Provided me new ways to use content
- Will incorporate activities
- I will be more interactive
- I became more excited to schedule more programs
- I need a Willie Bingo
- Learned hands-on experiments
- Gave great resources
- Need more information on wastewater treatment, hydrogen fuel cell, methane gas and energy production
- I learned about water conservation
- This workshop meet my expectations
- I learned about water waste through leaks
- I learned about local area issues
- Is there a "friends" organization for the Rio Grande?
- Teleconfercing glitches were only slightly unproductive
- I learned to spend more time in lesson preparation
- I learned a lot! I did not knew
- Tour of the desalination plant would be nice
- Include a vocabulary list
- The information was helpful, relevant for children
- Conference was helpful
- Include more information about pathogens, airborne diseases
- Conference was fun, I'm anxious to use the program in my class
- Add more background information to every presentation
- I usually don't worry about water issues but I'm starting to see all the work it takes to harvest it and to keep it clean
- Give me more ideas to use in my class
- I got a lot more than I planned, thank you very much
- Add more hands-on activities
- Excited to present this in afterschool programs
- Thank you for the conference. This was exactly what we needed and I want to be able to duplicate some of the things ya'll have accomplished. Once again the meeting was very informative.

Recommendations

As stated previously, the conference was designed as a way to transfer information and experiences from a successful conservation program in El Paso, not specifically designed as part of the long range Far West Texas Regional Water Plan of 2011. The information and examples of programs presented at the conference could be used as a model by other water purveyors in the region when designing their own future conservation programs. Based on comments received, the conference was a success.

ATTACHMENT "A" Copies of Presentations on separate CDROM

ATTACHMENT A-1 Conservation Conference Program

7:30 am – 8:30 am	Registration	
	Utility Staff Track	**Community Outreach Track**
8:30 am – 9:00 am	**Welcome and Introductions** **Bill Hutchison (EPWU)**	**Welcome and Introductions: Icebreaker: Raining Cats & Dogs** **State Coordinator/Facilitator**
9:00 am – 9:45 am	**Conservation Program - El Paso's Experience** **Anai Padilla (EPWU)**	**Introduction to Project WET** **Workshop Objectives** **Bringing Teachers to the table** **State Facilitator**
9:45 am – 10:00 am	Morning Break	
10:00 am – 10:30 am	**System Water Audit-Identify the losses (water and revenue)** **John Balliew (EPWU)**	**Project WET Activities:** **The Incredible Journey** **Get the Groundwater Picture** **Discover a Watershed-Rio Grande/Rio Bravo** **It All Adds Up**
10:30 am -11:30am	**Pricing and Rate Structures** **Michael Cortez (EPWU)**	
11:30 am – 12:30 pm	Lunch Break - Lunch on your own Visit the Exhibit Hall	
12:30 pm – 1:30 pm	**Reclaimed water – benefits, marketing strategies. El Paso's Experience** **Irazema Solis (EPWU)**	**Introduction to: Investigating Water Curriculum** **Opposites Attract** **Sink or Swim** **List of additional programs and links** **Extension Service Staff**
1:30 pm – 2:45pm	**Landscape Irrigation, golf courses and athletic fields.** **Ray Bader (Extension)**	**Easy and inexpensive activities to increase public participation:** **Well in a Cup - Demonstration** **Indoor Water Audits (residential)**
2:45 pm – 3:30 pm	**Outdoor conservation-Xeriscape Principles and Irrigation Audits** **John White, Curator Botanical Garden UTEP**	

ATTACHMENT "B" Expenses

Loaded Salaries and Wages

40	Lorraine Sanchez	$14.08	$ 563.20
40	Shawn Smith	$14.08	$ 563.20
45	Virginia Galarza	$13.02	$ 585.90
45	Diane Perez	$21.52	$ 968.40
60	Anai Padilla	$34.89	$ 2,093.40
		Total	**$ 4,774.10**

Travel to Ft. Stockton

La Quinta (Hotel)	$ 134.47
John Chihuahua's (Meals)	$ 21.23
Town & Country (Gasoline 2 tanks)	$ 112.52
Total	**$ 268.22**

Other Expenses

	Wal-Mart (Plastic bowls)	$ 17.58
	Family Dollar (Color pencils)	$ 5.00
	Family Dollar (Color markers)	$ 15.00
	Glue, tape, paper and scissors	$ 17.92
	Steve Spangler Science (Magnets)	$ 33.41
	Wal-Mart (Scissors and glue)	$ 17.92
	Hobby Lobby (Stickers)	$ 11.94
	Sam's (Snacks)	$ 104.56
	Wal-Mart (food for presenters)	$ 39.78
50	Investigating Water (books) AgriLife Extension Bookstore	$ 1,945.43
3,650	Copies	$

		365.00
		$
	Total	**3,573.54**

Overhead

TecH20 Center		$ 750.00
IT staff and webcasting connection		$ 500.00
Security		$ 162.24
	Total	**$ 1,412.24**
	Grand Total	**$ 10,028.10**

In-kind Donations

Qty	Category		Total Amount
50	Project WET (staff, books)		$ 1,400.00
57	Discover a Watershed Books		$ 1,450.00
150	Brochures (Planting guide, plant wheel, sunscape etc)		$ 3,000.00
	AgriLife conference room		$ 300.00
		Total	**$ 6,150.00**

ATTACHMENT "C" Copies of Sign-in Sheets

Corrections Note

Corrections and recommendations listed on email dated April 29, 2009 from Connie Townsend related to Study #4 have been made and or included on this report. All review comments included file attached to the same email have been addressed on this report. They include:

1. Contract Scope of Work (SOW) Task 2-3 Deliverables section states that the report will include the following sections: Executive Summary, Purpose of Study, Methodology, Results and Recommendations.

    - Report has been formatted to comply with this comment.

2. Please clarify what "members" are referred to throughout this report.

    - Members are described on page 1 paragraph 5 as "Far West Texas Water Planning Group Members".

3. Page 1: Please document and discuss how this study supports regional water planning in the Purpose section of the report, as per the contract SOW Task 2.

    - Purpose section has been reviewed to address this comment.

4. Please document and discuss under the Methodology section of the final report outlining the conservation training program developed and provide all of the conference materials developed as per contract SOW, Task 1. (Attachment A's list of conference topics does not appear to be adequate to meet this task deliverable).

    - Copies of all the presentations and promotional materials developed for the conference are included on a separate CDROM electronic attachment "A". Conference program is included on this report as attachment "A-1"

5. Please document the number of web link requests received and all of the entities that participated in the conference, as per SOW Task 2-3 deliverables.

    - Number of web link request received included on report, top of page 3.

    - List of participating entities included on attachment "C"

6. Provide the table of Utility Track attendee evaluations and provide summary discussion on results of program based on all of the feedback received for both training tracks. Statistics on the evaluation item scores is an example of how to present this type of summary data in the final report.

    - EPWU did not receive any evaluation forms from the Utility Track. Comments received are included on this report on page 3.

Attachment A-1

Power Point Presentations

Water Conservation Conference

Bill Hutchison, Ph.D., P.E., P.G.
Water Resources Manager
El Paso Water Utilities
October 17, 2008

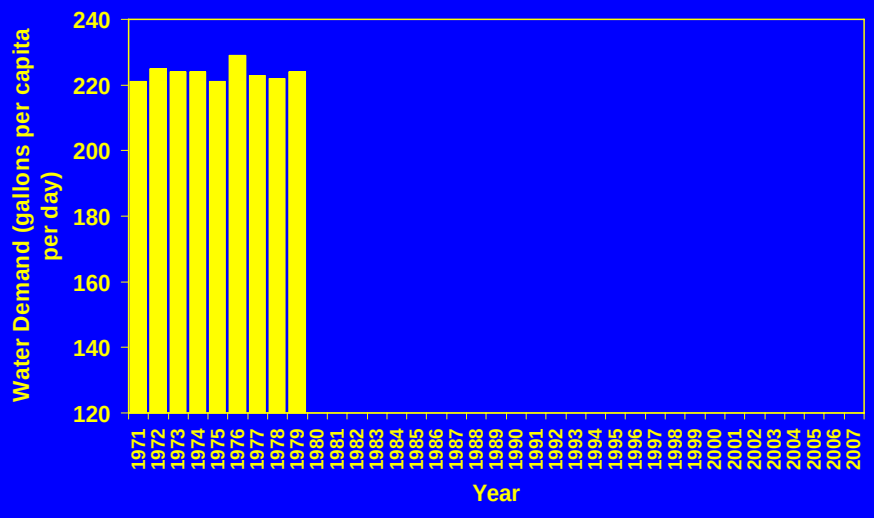
Topics (Morning)

- El Paso Water Conservation
  - Anai Padilla (EPWU)
- System Water Audits
  - John Balliew (EPWU)
- Pricing and Rate Structures
  - Michael Cortez (EPWU)

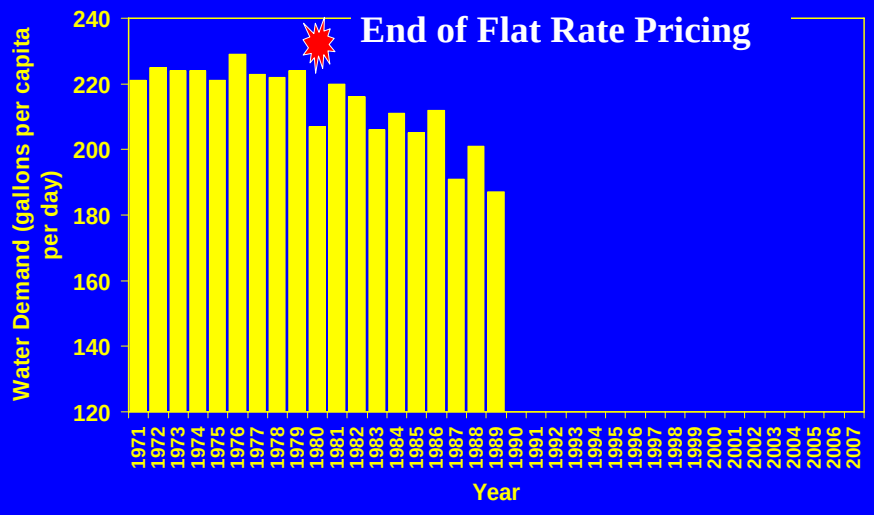
Topics (Afternoon)

- Reclaimed Water
  - Irazema Rojas (EPWU)
- Landscape Irrigation
  - Ray Bader (TAMU)
- Xeriscape
  - John White (UTEP)

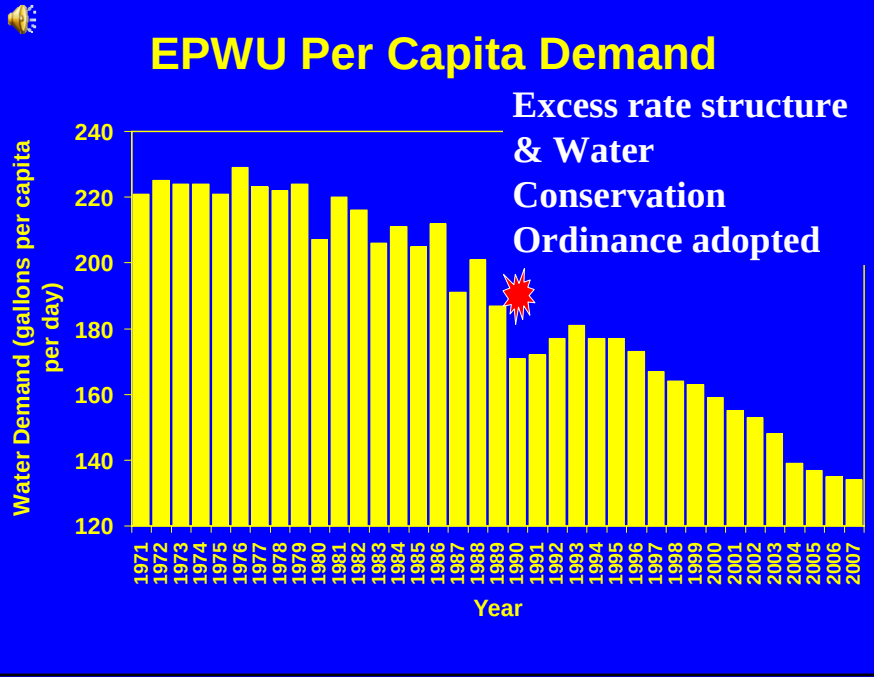
EPWU Per Capita Demand

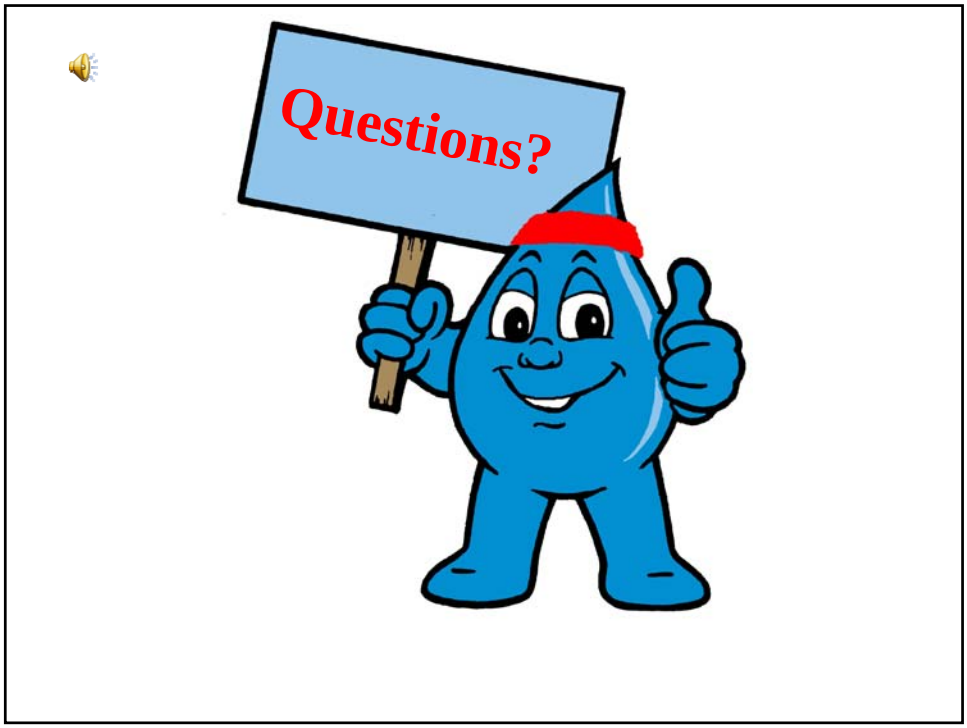


EPWU Per Capita Demand

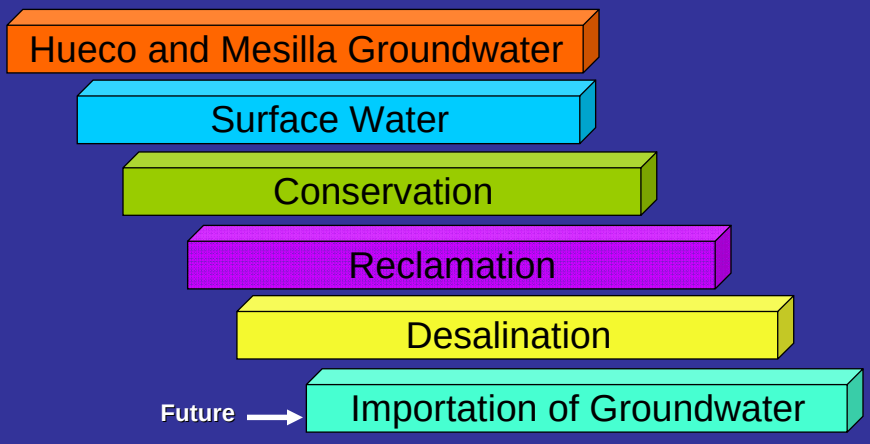


EPWU Per Capita Demand



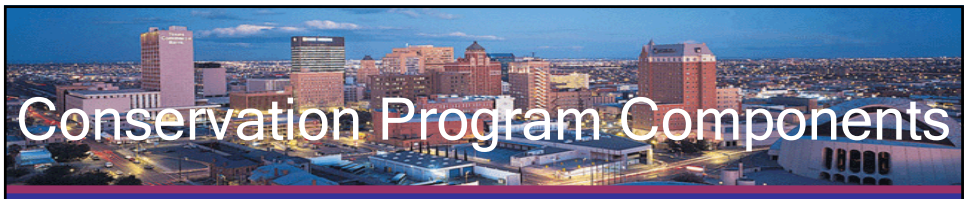

Questions?

El Paso's Water Sources



Identified Conservation Goals and Objectives

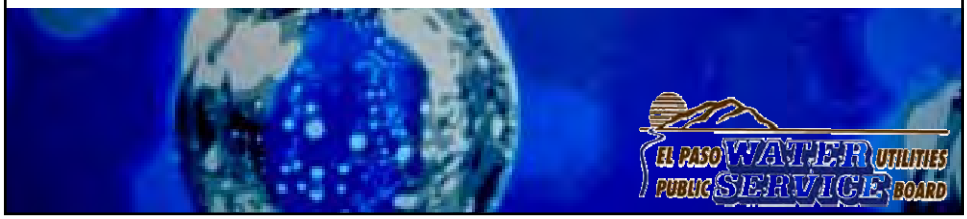
- Reduce peak demand
- Meeting long term goals
- Reduce per capita consumption
- Wasteful water use practices
  - Landscape irrigation
  - Plumbing fixtures
  - Evaporative air units
  - Car washing



Conservation Program Components

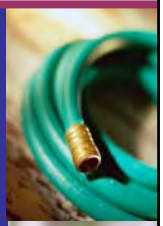
- Mandatory
  - Ordinances
- Voluntary participation
  - Rebates and incentives
  - Education programs
- Utility Best Management Practices
  - Rate structure
  - Reclaimed water
  - Supply side conservation
  - Regional collaboration

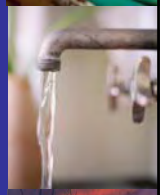
Mandatory Program Components

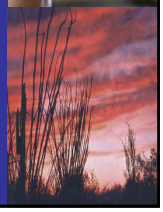


Mandatory

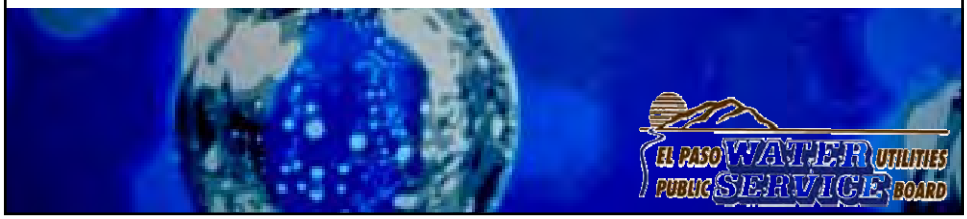
- Conservation Ordinance
  - Landscape watering days (odd/even)
    - Wednesday, Friday and Sunday
    - Tuesday, Thursday and Saturday
  - Watering times restrictions (April - September)
    - Before 10 a.m. or after 6 p.m.
  - Illegal to waste water/allow runoff
- Plumbing Code
  - Installation of efficient plumbing fixtures







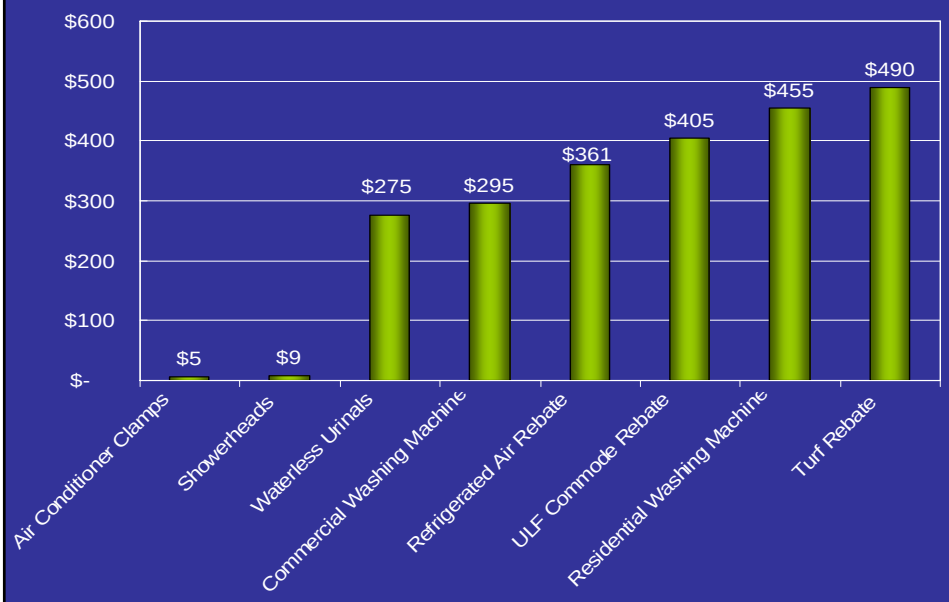
Voluntary Program Components



Rebates and Incentive Programs

- Cash for your Commode
- Turf Rebate Program
- Clothes Washing Machines
- Refrigeration Systems
- Free showerheads
- Free air conditioner clamps
- Waterless Urinals Pilot Program
- Leak Assistance Program

Cost per Acre-Foot



Education Efforts

- School presentations
- Workshops and seminars offered to community
- Free indoor and outdoor irrigation audits
- Poster contest
- TV, radio, billboards, bill stuffers and printed materials

TecH$_2$0 Center

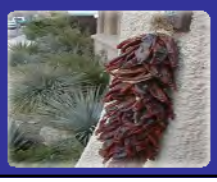
A new training facility for water conservation professionals. This state-of-the-art site demonstrates total water management in the Chihuahuan Desert.

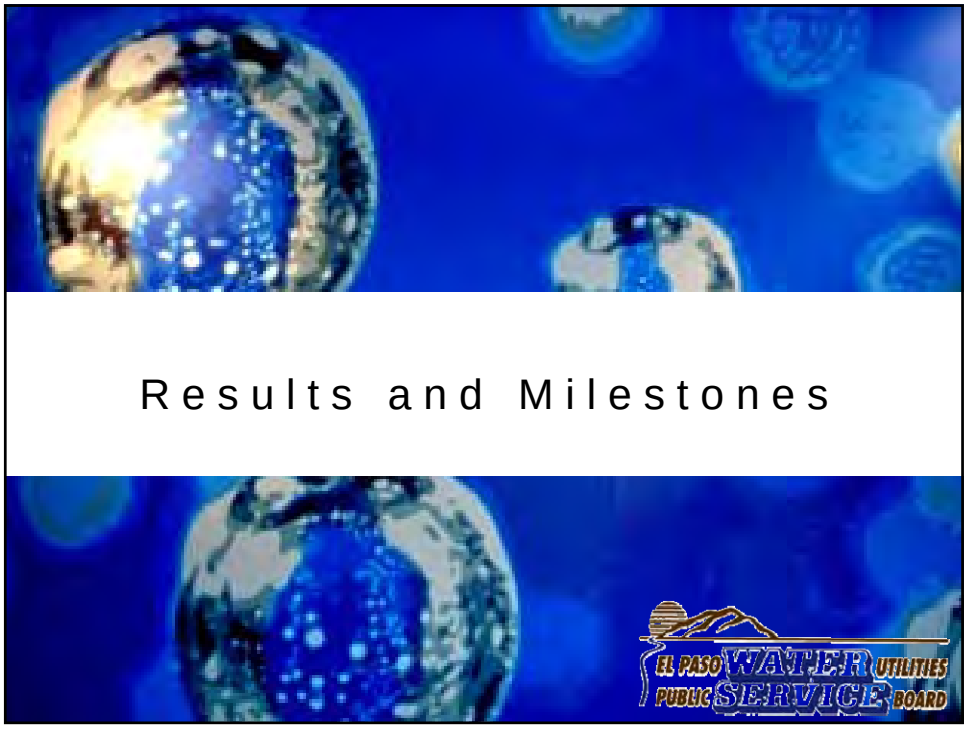
- Auditorium and classroom facilities
- Exhibit hall with 16 themed interactive exhibits
- Perfect for school field trips

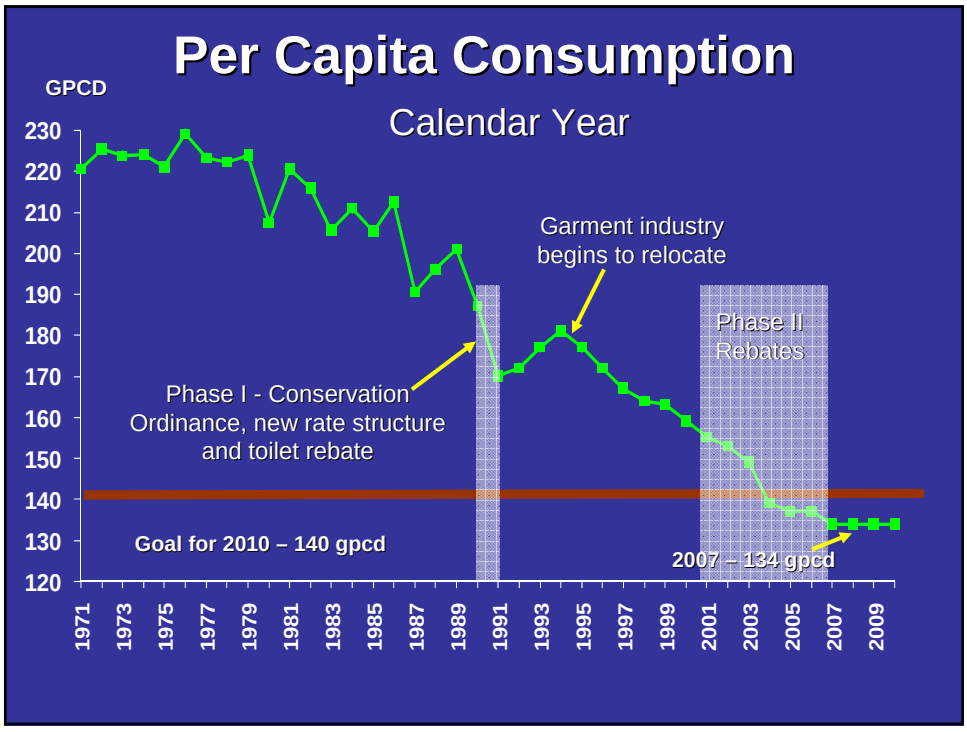
Utility Best Management Practices

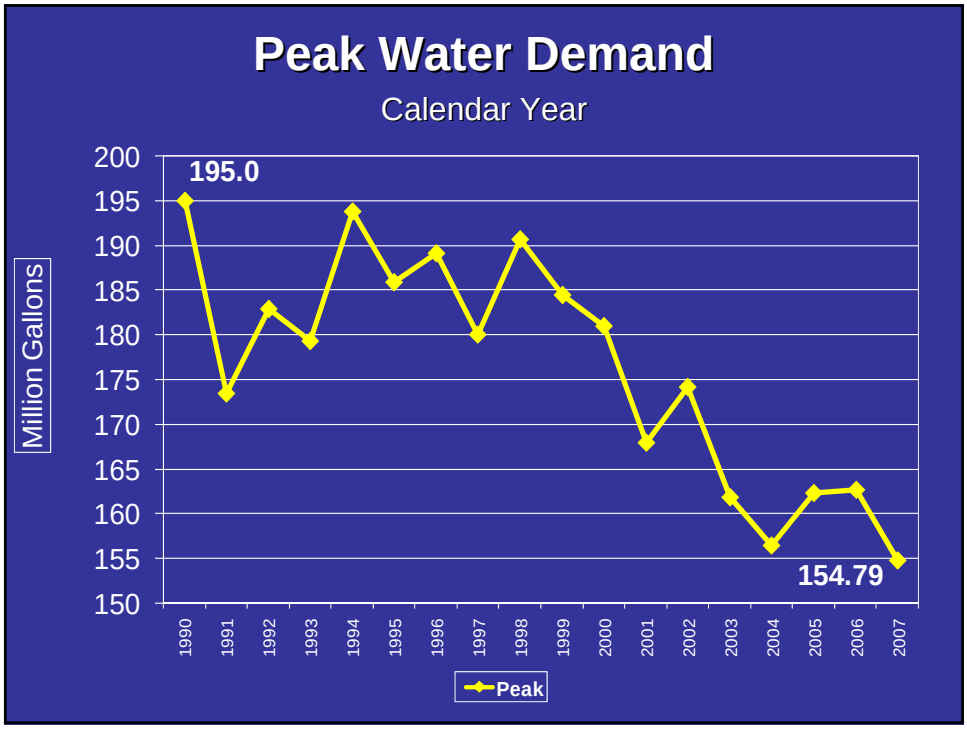
EL PASO WATER UTILITIES PUBLIC SERVICE BOARD

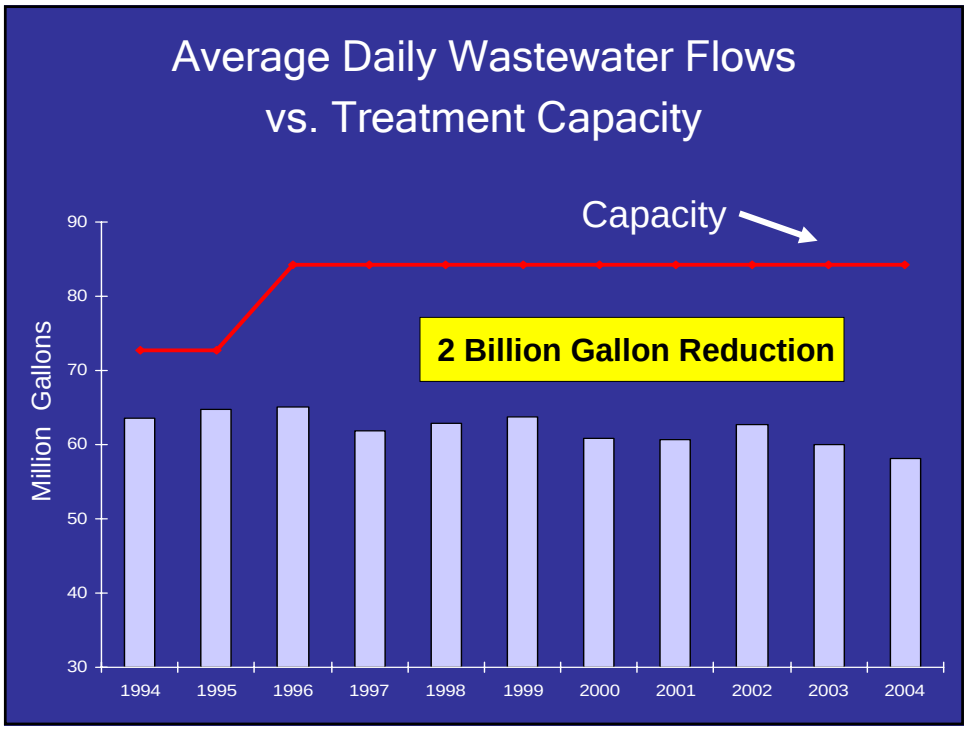
- Rate structure
- Reclaimed water
- Supply side conservation
- Regional collaboration
  - Southern New Mexico, West Texas, North Mexico and Ft. Bliss


Results and Milestones
EL PASO WATER UTILITIES
PUBLIC SERVICE BOARD


Per Capita Consumption
GPCD
Calendar Year
230
220
210
200
190
180
170
160
150
140
130
120
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
Garment industry begins to relocate
Phase II Rebates
Phase I - Conservation Ordinance, new rate structure and toilet rebate
Goal for 2010 – 140 gpcd
2007 – 134 gpcd


Peak Water Demand
Calendar Year
Million Gallons
200
195
190
185
180
175
170
165
160
155
150
195.0
154.79
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
Peak


Average Daily Wastewater Flows
vs. Treatment Capacity
Capacity
2 Billion Gallon Reduction
Million Gallons
90
80
70
60
50
40
30
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004

Summary

- Conservation is a key component of El Paso's 50 year water resource water management plan
- Conservation has saved El Paso over $500 million in deferred capital and operating costs
- Conservation is an inexpensive alternative as compared to the development of more expensive water resource projects
- The Conservation programs have made El Paso water supply sustainable and allows for economic development

Q U E S T I O N S ?

Anai Padilla
aipadilla@epwu.org
(915) 621-2007

System Water Audit-Identify the Losses (Water & Revenue)

John Balliew
El Paso Water Utilities
October 17, 2008
10:00 - 10:30 am

Overview and Regulatory Framework

- House Bill 3338 was enacted by the 78th Texas Legislature in 2003.
  - Help conserve state's water resources, by reducing losses
- Texas Water Development Board (TWDB) has required all Texas retail public utilities to file a standardized water audit once every five years.
- The audit will later be used to compare with past usage, as well as other utilities around the state.
- Among helping with other things, this will help increase efficiencies and financial status, within the utility.

TWDB Methodology

- This methodology not only helps the utility to identify losses, and their volumes, but it also helps to associate a cost with the loss.
- The basic procedure TWDB takes during the audit:
  - The utilities business practices and procedures are observed.
  - The system inputs all the information needed (such as input volume, consumption, and loss).
    - The term “unaccounted-for” water is discouraged since all water is considered accounted for at this point.
  - The validity of the data is then ranked by the utility, and scores are assigned.

Implementation of Water Audits

- Ways a utility can operate more efficiently:
  - Active leakage control-good maintenance program.
  - Metering the production, and consumption from customers.
  - Correct billing deficiencies; keeping accurate track of customer use can significantly recover lost revenue.
  - Use of new technology such as automatic meter readers.

Implementation Continued

- The Water Audit Worksheet has created a set of standard terms, so measurement will remain the same from utility to utility across the state.
  - Allows and individual utility to notice losses.
  - Makes it easier to identify losses of an area in the statewide system.
- Implementing a water auditing program on an annual routine basis will help minimize losses.

Water Audit Method Analyzed

- Assumes that all water is accounted for, and quantified as either:
  - Beneficial consumption
  - Wasteful loss by metering
  - Estimating water quantities
- The Water Balance table is an easy way to categorize water to make sure there is a balance.
  - All quantities fit into a column, and the sum of every column is equal to the next.

Pitfalls in the Process?

- Although the tools are for self-assessment, comparison to other utilities will happen.
- The assessment must be done honestly and without reservation.
- Starting the assessment before you do anything and then following with another assessment in future years may yield the best results.
- Utilities that historically worked to reduce unbilled water may be at a disadvantage.

Types of Losses and Their Cost

- Apparent losses have more of a dramatic effect on the financial end of the utilities.
  - Occurs when water reaches the customer but is not properly accounted for.
  - Valued at retail cost.
- Real losses occur when a portion of the treated, pressurized water is lost before reaching the customer.
  - Is essentially an excess of treated water.
  - Valued at the variable production cost.

Performance Indicators

- These are designed to:
  - Track the water utility's progress on a year-to-year basis.
  - Set performance targets.
  - Benchmark performance with other water utilities.
- Categorized as operational or financial.

Practicalities

- All utilities should have a leak control program in effect.
  - The moment a leak is reported, respond quickly and make the repair.
  - Rehabilitate old or deteriorating pipes, to help reduce costs elsewhere.
- Pressure management
  - Pressure management should be considered as more water is lost under high-pressure situations than low.

Practicalities

- All utilities should have accurate metering
  - Accurate metering means meter replacement programs
  - Do not expect to have correlation between different types of meters
- Leakage can occur outside of the pipe
  - Reservoirs
  - Concrete versus steel
  - Lining systems

Conclusion

- As water availability decreases, and treatment costs increase, it is more important than ever to track where the water we use goes.
- The water audit method helps track consumption and loss.
- Implementing a water management program, utilities can extend existing resources.
- It may take several years to begin to see the effects, but the goals are achievable and worth it!

Water Conservation Based Rate Structure

Presented by Michael Cortez,
Water & Wastewater Economic Analyst
El Paso Water Utilities

October 17, 2008

Water Conservation Based Rate Structure

- Definitions
  - **Water Conservation** – the beneficial reduction in water use, water waste and water loss
  - **Conservation Based Rate Structure** – A rate structure designed to…
    - reflect the cost of providing water
    - send a price signal about the TOTAL marginal cost of additional water
    - encourage efficient use of water by customers

Water Conservation Based Rate Structure

Objectives of a Conservation Rate Structure

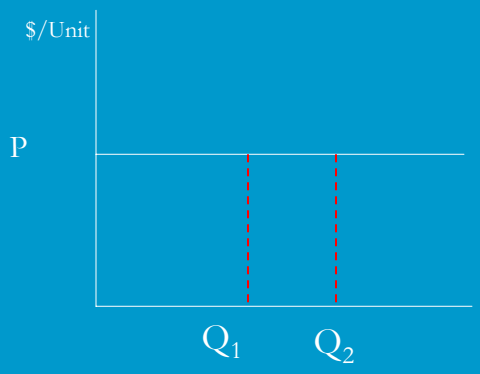
- Reduce peak water demand
- Influence Consumption Patterns
- Reduce seasonal usage
- Reduce total system demand
- Maintain Revenue Requirements

Types of Rate Structures

Conservation & Non-Conservation Oriented Rates

Types of Rate Structures

Flat Rate



Two types of uniform rates

a) Different uniform rate for each customer class

b) Same uniform rate for all customer classes

Flat Rate Structure is Conservation Poor!

Types of Rate Structures

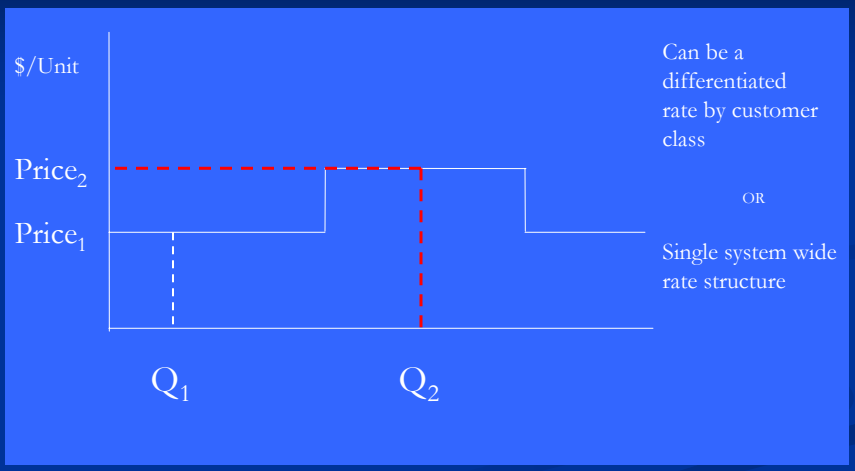
Flat Rate

Limitations on a Uniform Rate Structure

- Restrict the ability to create price signals
  - methods of influencing consumption are limited
- Create Cross-subsidization between non-peak and peak water users.
  - Non-peak demand customers are overcharged
  - Peak demand customers are undercharged

Types of Rate Structures

Seasonal Rates



Types of Rate Structures

Conservation & Non-Conservation Oriented Rates

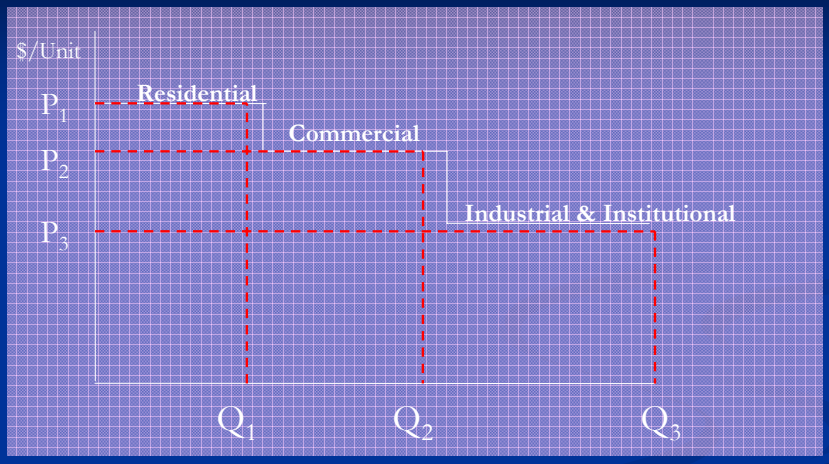
- Seasonal Rates are rates that vary during different periods of the year, most typically during peak outdoor water usage
- Encourages a more efficient use of water resources by shifting demand from peak to off-peak periods

Limitations of Seasonal Rate Structures

- Customers with fairly consistent usage who do not contribute to summer peaking usage are still required to pay a higher price
- For Example: Multi-family, commercial, institutional (hospitals)

Types of Rate Structures

Declining Block Rate



The cost per unit of water decreases as the water use increases beyond the basic block. This rate structure provides no incentive to conserve because the cost of water per unit decreases with increased use

Types of Rate Structures

Declining Block Rate

Used to develop a single rate schedule that takes into account the different costs usage characteristics of all customers- yet equitable to all customers

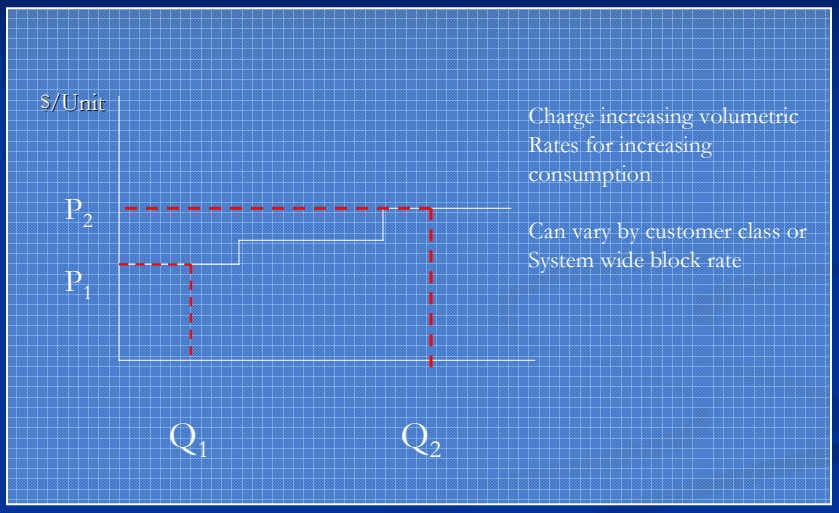
Residential Customers	=	Higher peaking costs
Commercial	=	Somewhat high peaking costs
Institutional / Industrial	=	Flat or little peaking costs

Limitations of Declining Block Rates

- Assumptions about customer class average consumption need to be verified
- Appears to be in conflict with conservation goals and efficient water use. May not be appropriate during drought management

Types of Rate Structures

Increasing Block Rate



Types of Rate Structures

Increasing Block Rate

- Increasing Block Rates should be designed by customer class.
- When not differentiated by customer class – can be inequitable to industrial / high volume users
- Require metering and defining consumption blocks over which rates increase

Limitations of Inverted Block Rates

•Residential customers are subsidized by the higher rates paid by large volume non-residential customers that do not have significant peaking factors

•Not considered the most effective rate design for conservation purposes

•Can be more effective if seasonally adjusted

Types of Rate Structures
Hybrid Rate Structure

- EPWU implements a seasonal / inverted rate structure
  - Customers are charged a premium rate only for summer usage in excess of their average winter consumption (AWC)
  - Specifically targets customers who use substantially more water during the peak season than during the nonpeak season

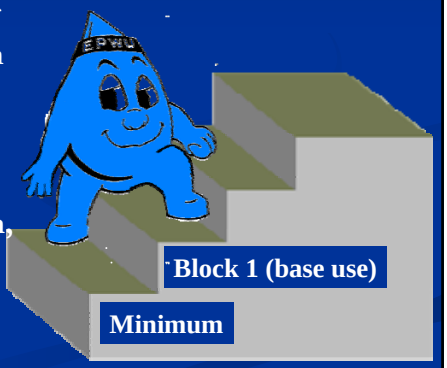
Types of Rate Structures
Hybrid Rate Structure

- EPWU implements a seasonal / inverted rate structure

  - Most effective of the conservation –related rate formats in terms of…
    - Reducing usage without increasing revenue instability
    - Rate design to reflect the consumption pattern of each individual customer (rather than consumption pattern of customer class
    - Strongest Pricing signal – individual customers have more control over changing their own usage patterns

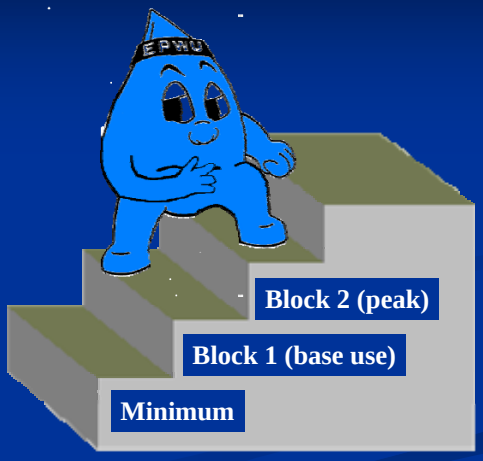
Conservation Rate Design

- **Block 1: >4 CCF to 150% of AWC ($1.45/CCF)**
  - Recover base costs and portion of "peaking"
  - Accounts for 55% to 60% of revenue
  - Include domestic consumption, swamp coolers, and minimal lawn watering



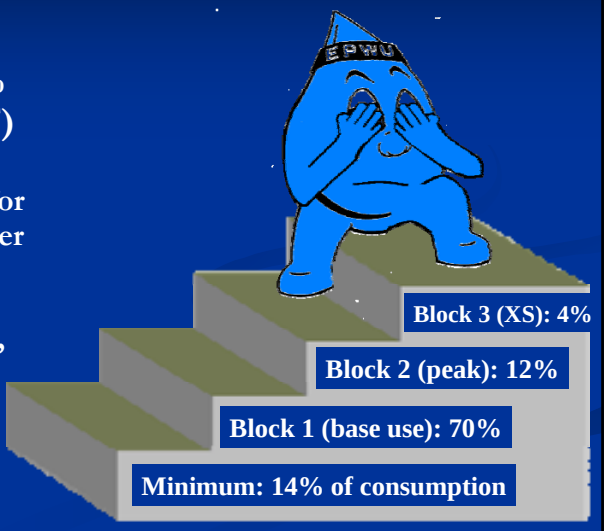
Conservation Rate Design

- **Block 2: 151% to 250% of AWC ($3.40/CCF)**
  - Recovers all remaining volume-related costs
  - 15% to 20% of revenue
  - Designed to include some irrigation use



Conservation Rate Design

- **Block 3 – Over 251% of AWC ($4.87/CCF)**
  - Priced at 125% of Block 2 rate; Proxy for marginal cost of water
  - Accounts for about 10% of revenue
  - Considered "excess" use under normal conditions



Customer Response to Changes in the Price of Water

- Concept of price elasticity
- An overview of price elasticity of water demand
- How to use price elasticity concepts

Customer Response to Changes in the Price of Water

Price Elasticity – the measure that enables utility managers to project the likely changes in demand and associated changes in revenues resulting from changes in water rates or rate structures

$$\text{Price Elasticity} = \frac{\%\ \text{Change in Quantity Demanded}}{\%\ \text{Change in Price}}$$

- Price Elasticity is a measures of "Sensitivity" or "Responsiveness" to changes in price

Customer Response to Changes in the Price of Water

$$\frac{\%\ \text{Change } Q_d}{\%\ \text{Change P}} > -1.0$$ = Elastic Good: common substitutes, discretionary goods

$$\frac{\%\ \text{Change } Q_d}{\%\ \text{Change P}} < -1.0$$ = Inelastic Good: few or no substitutes, in-discretionary good

Water Service is essential with no close substitutes, therefore, water is *Inelastic*

Customer Response to Changes in the Price of Water

- Price Inelastic: a 10% increase in price will yield a less than 10% reduction in demand.
  - Important for generating revenue projections and proposing rate increases
- Water Elasticity varies with customer classes.
  - Depending on usage characteristics, peak vs. nonpeak, weather, seasonal, type of demand, etc.

Customer Response to Changes in the Price of Water

- How to use price elasticity concepts.
  - Any projections of revenue increases expected from a rate increase have to factor in likely reductions in demand for the higher rates
- Model: Ln(Consumption) = Ln(real rate) + Ln (Real Income) + Ln (Temp)+ Ln (Rain)

Conclusion

- Conservation based rate structures vary in format, level of difficulty in implementation and revenue stability
- All conservation based rates should be coupled with non-price conservation efforts to include
  - Outreach and education
  - Customer incentives, rebates
  - Proper evaluation and analytical ability to measure performance goals

Reclaimed Water Benefits, Marketing Strategies: El Paso's Experience

By

Irazema Solis-Rojas, P.E.
Water Reclamation & Biosolids

September 2008

El Paso Water & Wastewater Plants

Water Plant Wastewater Plant Reclamation Plant Desalination Plant

History

- 1963 – EPWU supplies reclaimed water to golf course for irrigation from Haskell Street Wastewater Treatment Plant
- 1985 – Fred Hervey Water Reclamation Plant was built for aquifer recharge
  - treats wastewater to potable water
  - customers requested service for irrigation and cooling tower water

quality

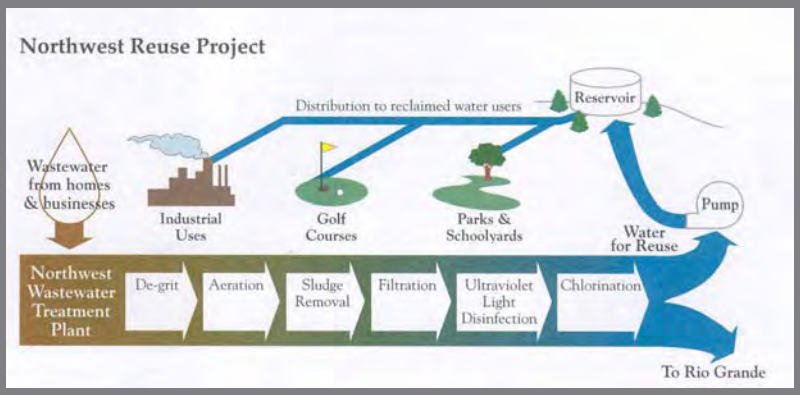
intake up

History

- 1987 – Northwest Wastewater Treatment Plant is built with reclaimed water supply in mind
  - all effluent meets TCEQ requirements for Reclaimed Water Type I
- 1991 – Bustamante Wastewater Treatment Plant is built. A reclaimed water supply system is added in 1998
- To date, all reclaimed water produced in El Paso meets at least Type I Standards

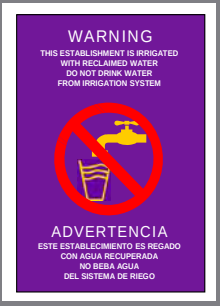
What is Reclaimed Water

It is HIGHLY treated wastewater suitable for non-potable uses



Quality

- El Paso's reclaimed water consistently meets TCEQ Chapter 210 standards for Type I uses
  - Contact with humans
    - Requires sampling twice weekly at peak load, report monthly
  - Fecal Coliform
    - < 75 CFU/100mL, single grab sample
    - < 20 CFU/100mL, 30-day geometric mean
  - Biological Oxygen Demand (BOD_5)
    - < 5 mg/L, 30-day average
  - Turbidity
    - < 3 NTU, 30-day average



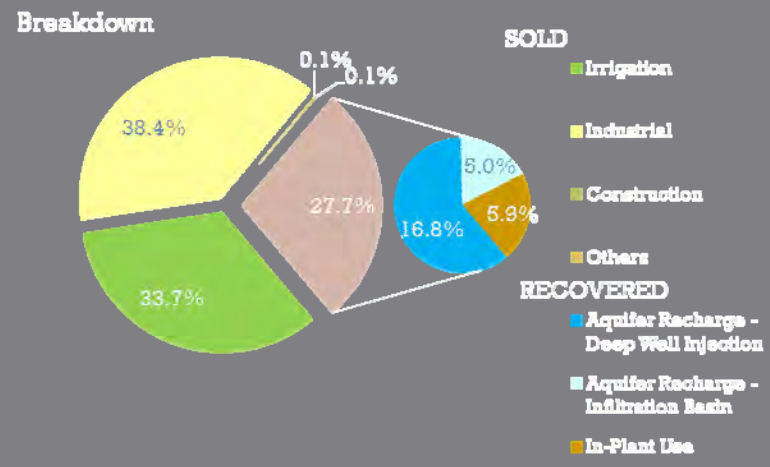
Customer Base

- IRRIGATION
  - Public Areas
    - City Parks (17)
    - Street Medians (7)
    - Tree Farm (1)
  - Schools (9)
  - Golf Courses
    - Private (1)
    - City/County (2)
  - Commercial
    - Apartments & Townhomes (5)
    - Retail/Office (7)
    - Cemeteries (7)
  - Residential (5)

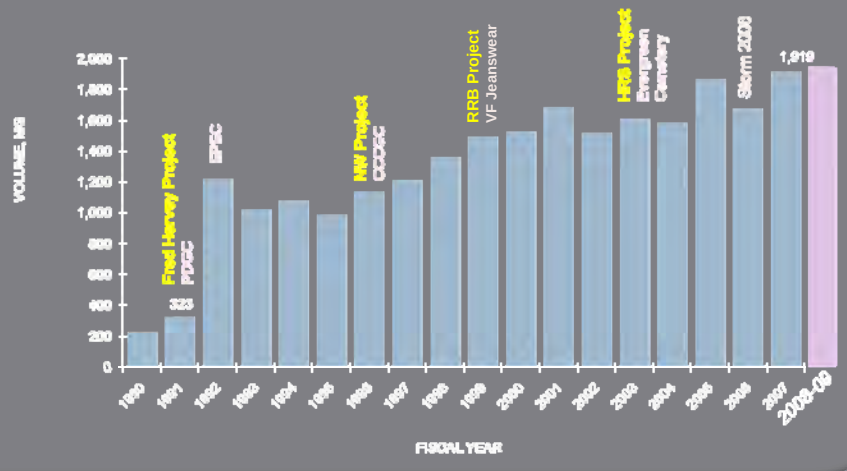
Customer Base

- INDUSTRIAL (1)
- CONSTRUCTION (14)
  - Dispensing Stations
  - Standpipes at WWTPs
  - Post Hydrants
- OTHER (1)

Reclaimed Water Production



Reclaimed Water Sold



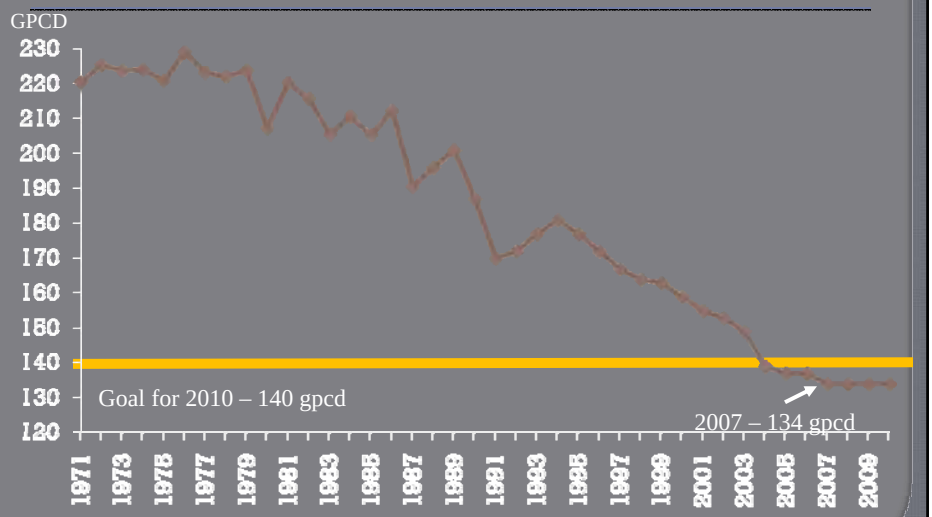
Planning

- Target potential customers based on
  - Water Consumption – High
  - Landscape Area – Large
  - Site Suitability
  - Proximity to existing systems
- The Utilities' Strategic Plan calls for reclaimed water use to reach 15% of total wastewater over the next ten years

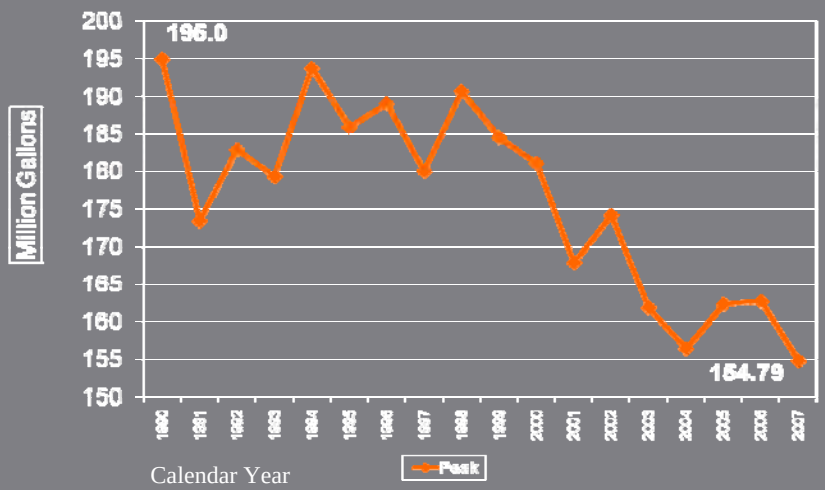
Benefits for Using Reclaimed Water

- Saves Potable Water
- No restrictions on its use during drought
- It is less expensive than Potable Water
- Provides Nutrient Value to irrigated soils at no added cost
- Reduces Peak Demands on Potable Water System
- Prevents waste of Potable Water on non-essential uses
- Slows down depletion of aquifer storage
- Helps lower potable water rates

Per Capita Consumption



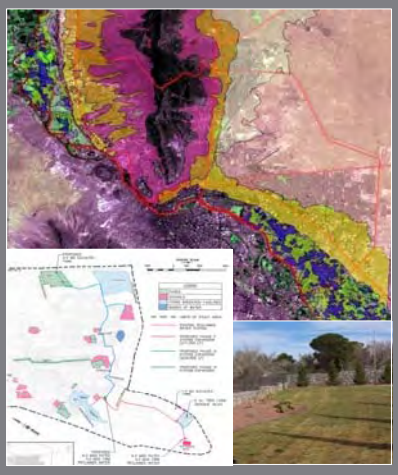
Peak Water Demand



Marketing Strategy

- New Strategies implemented with new projects
  - Sites identified based on landscape area
  - A preliminary *site suitability assessment* is performed
  - Identify sites with favorable site conditions
- Contact potential customers
- Provide cost savings analysis based on last 2 years of consumption
- Provide cost estimate of upfront expenses
- Request letter of commitment from Customer

Site Suitability Assesment



- Discriminative assessment based on
  - soil condition
  - plant material
  - use of site
  - maintenance efforts
- Performed during project planning phase

Site Suitability Assessment

- Advantages for the Producer/Provider
  - Helps us identify customers interested in make the best use of reclaimed water – not only to save money
  - Prevents connection of customers with soils that promote salinization
  - Prevents connection of customers with no maintenance programs
  - Ensures customer compliance with TCEQ Regulations (ponding or runoff)

Regulations

- 30TAC210.24 Irrigation Using Reclaimed Water
  - "User shall provide reasonable control of the application rates… efficiently use reclaimed water and avoid surface runoff or excessive percolation below the root zone"
  - "The reclaimed water provider or user, shall determine and document typical irrigation demands for the proposed use based on type of vegetation and land area to be irrigated.."
  - Prevent incidental ponding or standing water
  - Minimize wet-grass conditions
  - Avoid overspraying, etc.

Customer Assistance

- Customer Assistance Programs that help customers meet regulations
  - Soil Salinization Prevention Education
  - Landscape Management Program
  - Biannual Monitoring
  - Outreach

Soil Salinization Prevention Education

- Obstacles
  - Reclaimed water contains ~2X more salts than potable water
  - Short irrigation periods promote salt accumulation on surface
  - Soil characteristics impair drainage
- Proactive Measures
  - Texas A&M University TAES Cooperative Agreement
    - Research and Laboratory Services
  - Instruct Customer
    - soil condition
    - management practices
    - recommend mitigation approaches

Landscape Management Program

- State (30TAC210) and City require prevention of runoff and ponding
  - continuous “patrolling” by EPWU & Community
  - literature on soil amendments & proper management
- Irrigation system (sprinklers) spray onto foliage causing plant stress
  - produced literature on prevention of foliar damage induced by sprinkler irrigation

Biannual Monitoring

- Inspection performed by staff
  - Inspect functionality of irrigation system
  - Cross-Connection Preventive Inspection
  - Monitor soil salinity content (soil sampling)
  - Assess plant condition
- Produce report to customer
  - Identifies deficiencies
  - Provides improvement suggestions

Biannual Monitoring

- Recommended by a Public Working Committee
  - assist customers in using reclaimed water effectively and beneficially
- No cost to customer

Outreach

- Instructional videos on landscape management
- Vast array of literature
- Demonstration plots on landscape establishment
- Workshops on research activities
- On demand assistance
- Support provided by TAMU-TAES
- Paid in part through grants from USBR
- Annual Newsletter

El Paso Water Utilities

PURPLE PIPE NEWS
reclaimed water issues

September 2006 — Vol.1 Issue 2

Reclaimed Water Awareness Program

El Paso Water Utilities and the Junta Municipal de Agua y Saneamiento de Ciudad Juárez have received a $200,000 grant from the Paso del Norte Health Foundation to fund a regional reclaimed water awareness project. The grant is administered by the FEMAP Foundation and coordinated by the Paso del Norte Water Task Force. The two utilities are matching a part of the funds through in-kind participation.

The goal of the project is to reduce the amount of potable water used for irrigation and industrial activities by increasing awareness of the availability and effective use of reclaimed water. Workshops and public service announcements will simultaneously take place on both sides of the El Paso/Juárez border.

This grant comes at the right time. The demand for reclaimed water continues to increase in El Paso. The number of customers surpassed the 2005 goal by 46 percent, and demand will increase with the extension of the Northwest, Mission Valley and North Central systems.

In Juárez, the Chemical and Parque Central, smaller parks and medians are served from small treatment and distribution systems, and JMAS will soon start up its largest reclaimed water system. The North Wastewater Treatment Plant will provide reclaimed water to industrial parks, public parks and residential customers.

Biannual Inspections Are Underway

El Paso Water Utilities is performing programmed biannual inspections for cross-connection control and beneficial use at all reclaimed water sites. El Paso Independent School District schools were inspected in 2005. Commercial customers, public parks and residential customers are being inspected this year.

Inspectors ensure that there has not been a change to the irrigation system that can jeopardize the quality of potable water through a cross-connection. They also serve as reminders that purple appurtenances must be maintained at all times for facilities conveying reclaimed water, and proper signage must be used throughout the premises.

Signage located at a residence indicating the use of reclaimed water.

Customers are urged to notify EPWU before changing an irrigation system or reclaimed water plumbing. In the event of a cross-connection, backflow prevention devices in potable water service lines prevent contamination of the public distribution system. However, the plumbing system within the property might not be protected. By inspecting the system, El Paso Water Utilities can prevent a cross-connection between the potable and reclaimed water systems.

Evergreen Cemetery.

Customers sign a User Agreement as a condition of service. By signing, the customer agrees to ensure that reclaimed water is used only for approved activities and to prevent runoff, ponding, irrigating bare spots, etc. Also, the State requires that reclaimed water be used in a "beneficial" manner and not wasted, impounded or used for non-authorized purposes, and EPWU enforces this requirement.

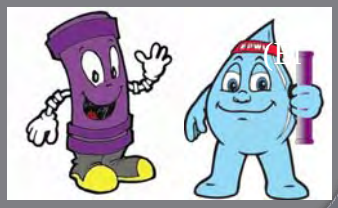
We will continue to perform inspections every two years. As the need arises and more personnel are available, inspections may take place more often.

Reclaimed Water Section:
Ingeniero E. Rojas, P.E., Water Reclamation Manager, 915.594.5772, lerojas@epwu.org
David G. Tirrs, S.I., Engineer Associate, 915.534.5445, dtirrs@epwu.org
FAX: 915.533.7081
www.epwu.org

EL PASO WATER UTILITIES PUBLIC SERVICE BOARD

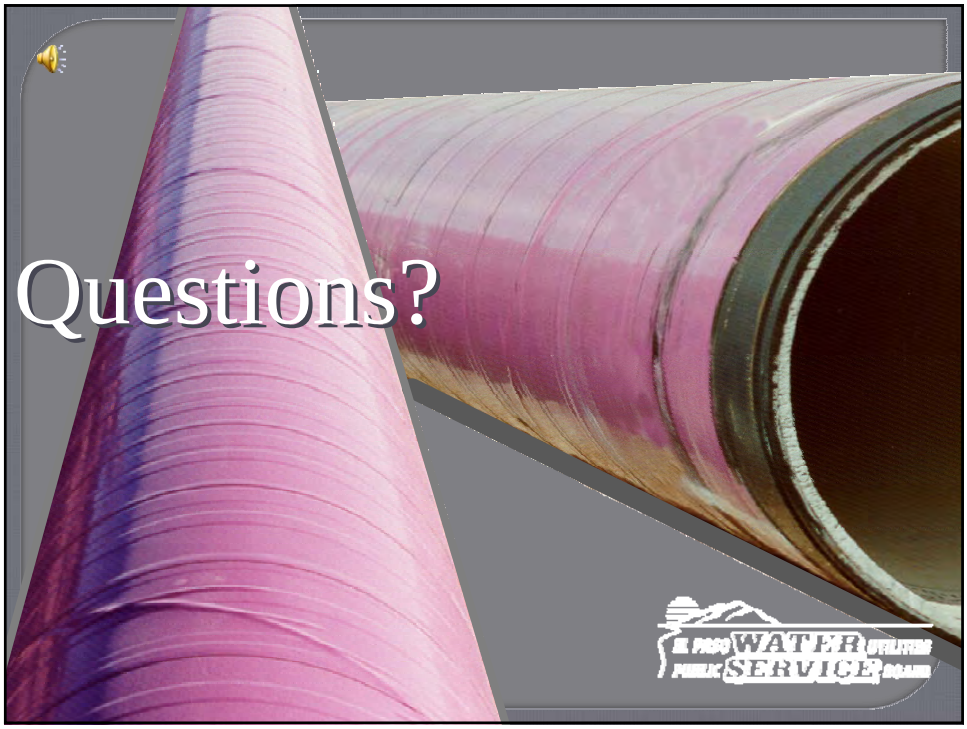
Outreach

- TV Spots/Commercials
  - Advertise conservation and resource management initiatives
  - Promote proper use of reclaimed water
  - Awareness campaign funded by Paso del Norte Health Foundation
    - Protect Health Region-wide Paso-Juárez)
    - Targeted to children



Program Recognition

- El Paso's Reclaimed Water Program has been recognized nationally
  - "2006 Award of Merit – Haskell Reclaimed Water Project" by the WateReuse Association
  - "2007 Public Education Program of the Year – Awareness Campaign" by the WateReuse Association


Questions?
EL PASO WATER UTILITIES
PUBLIC SERVICE BOARD

AgriLIFE EXTENSION
Texas A&M System

S.A.F.E. Program

(**S**ports **A**thletic **F**ield **E**ducation)

•**Raymond Bader, CED, El Paso**

•**James McAfee, Extension Turfgrass Specialist**

What is SAFE?

- **A program designed to develop a turfgrass management protocol for each specific field based on a comprehensive evaluation and monitoring of the field's resources and use.**
- **Focus:**
  - Audit of Athletic Fields
  - Irrigation Audit

Benefits from well managed fields

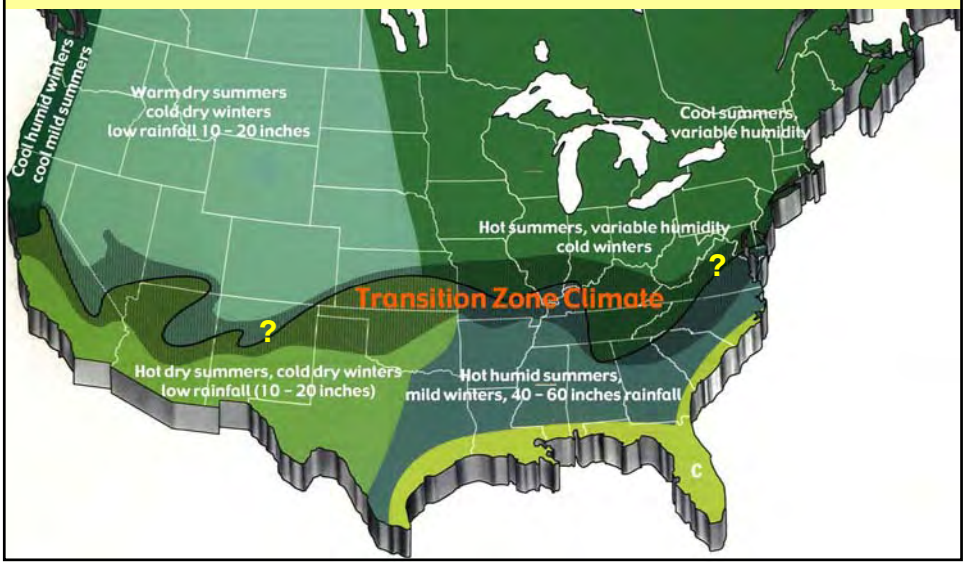
- Provide safer playing conditions
- Improves player performance
- Efficient use of resources
  - water, fertilizers, pesticides, manpower

Management based on:

- Turfgrass quality
  - Type, root depth, frequency of use
- Soil properties of the area
  - Physical - soil type, texture, depth, compaction
  - Chemical - pH, salinity, fertility
- Irrigation
  - comprehensive irrigation audit of hardware and delivery
- Management practices & field use

Turfgrass Adaptation

Adapted From: Time-Life Gardener's Guide - Lawns and Groundcovers



Primary Warm Season Turfgrasses

- **Bermudagrass (*Cynodon* L.C. Rich)**
- **St Augustinegrass (*Stenotaphrum secundatum* [Walt.] Kuntze.)**
- **Zoysiagrass (*Zoysia* Willd.)**
- **Centipedegrass (*Eremochloa ophiuroides* [Munro]**

Secondary Warm Season Turfgrasses

- **Buffalograss** (*Buchloë dactyloides* [Nutt.] Engelm.)
- **Bahiagrass** (*Paspalum notatum* Flugge)
- **Carpetgrass** (*Axonopus affinis* Chase)
- **Seashore paspalum** (*Paspalum vaginatum* Swartz.)

Cool Season Turfgrasses Used in Texas

- **Tall Fescue** (*Festuca arundinacea* Schreb.)
- **Perennial ryegrass** (*Lolium perenne* L.)
- **Annual ryegrass** (*Lolium multiflorum* Lam.)
- **Kentucky bluegrass (***Poa pratensis* **L.)**
- **Creeping bentgrass** (*Agrostis palustris* Huds. or *A. stoloniufera* L.)


BRYAN
20
30
40
50
K

Cultural Practices for Sports Fields

- Fertilization
- Mowing
- Irrigation
- Aerification
- Topdressing

Fertilization Program

- Soil testing
- Single vs. multiple use facility
- Fertilizer sources
- Turf use

Mowing Sports Fields

- Key cultural practice

Irrigation Principles for Sports Fields

- Turfgrass
- Soil type
- Use
- Fertilization program
- PET values

Turfgrass Water Use Requirements

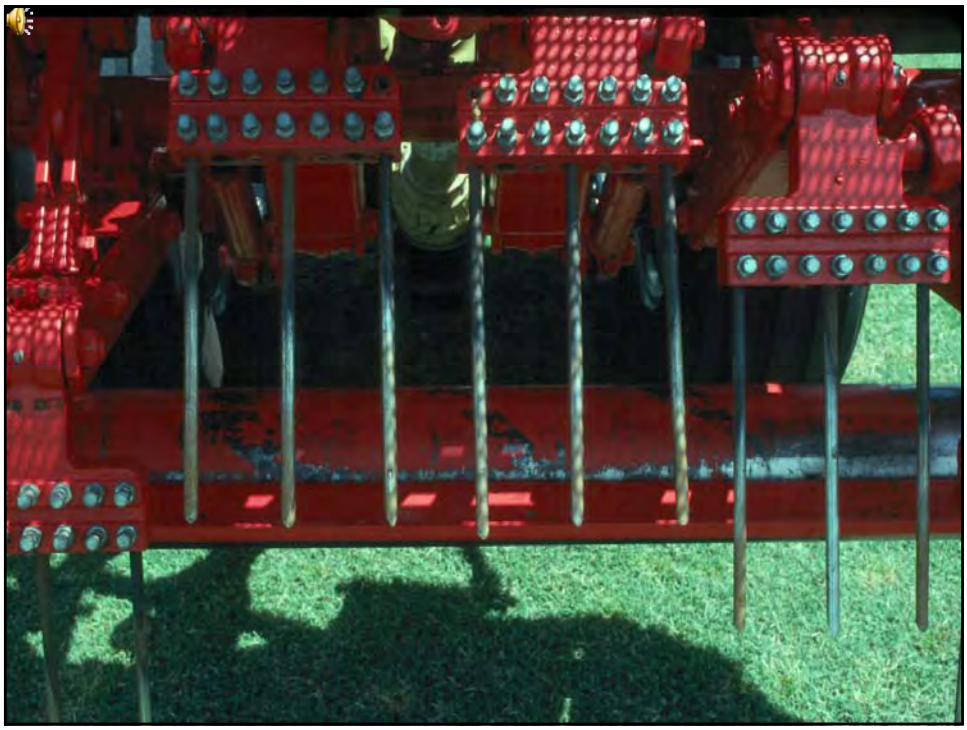
Turfgrass Species	Mean Summer ET mm/day	Relative Ranking
Buffalograss	5-7	Very low
Bermuda Hybrid	6-7	Low
Centipedegrass	6-9	Medium
Bermuda Common	6-9	Medium
Zoysiagrass	5-8	Medium
St. Augustinegrass	6-9	Medium
Seashore Paspalum	6-8.5	Medium
Tall Fescue	7.2-12.6	High
Creeping Bentgrass	5-10	High
Kentucky Bluegrass	>10	Very High

Aerification of Sports Fields

- Soil compaction major problem for sports fields

Problems Associated with Compaction

- Reduced oxygen availability
- Build up of toxic gases
- Reduced water movement
- Reduced nutrient uptake
- Increased root rot problems
- Increase in player injury



Irrigation Audits

Why Audit?

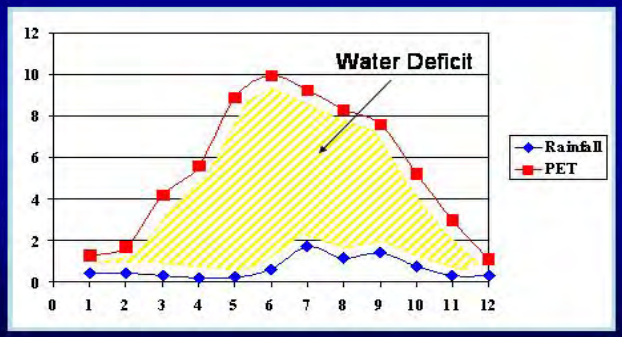
- Water conservation
- Healthy plant material
- Cost savings


JUST CAN'T HIDE
MUSTANG PRIDE
KILL


JUST CAN'T HIDE
KILL

Water Deficit Comparison:

Annual Rainfall vs. PET for **El Paso, Texas**



Conducting an Irrigation Audit

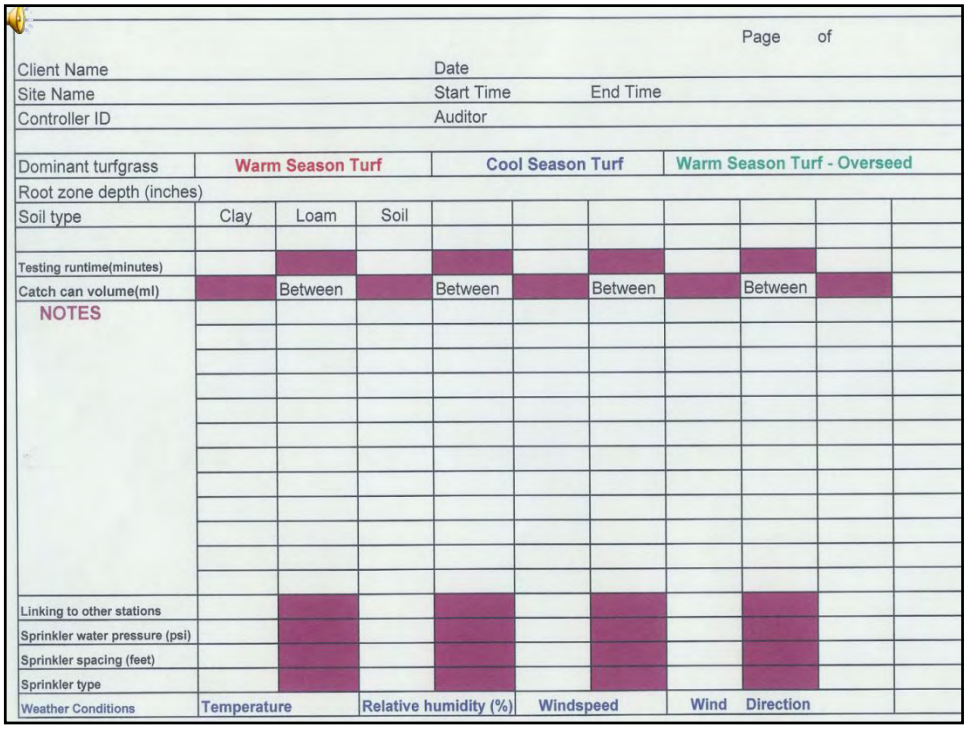
- Site Inspection
  - identify problems
  - correct problems before audit
- Performance testing
  - determine precipitation rate (in./hr.)
  - determine distribution uniformity
- Irrigation scheduling
  - irrigation frequency
  - run times per zone

Audits – Required Equipment

- Flags
- Tape measure/measuring wheel
- Pressure gage (pitot)
- Catch cans
- Soil probe
- Watch
- People – two or more

Auditing Procedure

- flag irrigation heads (by zone)
- set up catch cans
- run each zone
- record pressure
- record problems
- collect and measure water
- collect and analyze data
- develop irrigation schedule



Page of

Client Name Date

Site Name Start Time End Time

Controller ID Auditor

Dominant turfgrass	Warm Season Turf		Cool Season Turf		Warm Season Turf - Overseed			
Root zone depth (inches)								
Soil type	Clay	Loam	Soil					
Testing runtime(minutes)								
Catch can volume(ml)		Between		Between		Between		Between
NOTES								
Linking to other stations								
Sprinkler water pressure (psi)								
Sprinkler spacing (feet)								
Sprinkler type								
Weather Conditions	Temperature		Relative humidity (%)		Windspeed		Wind Direction	

Efficiency vs. Uniformity

Efficiency – ratio between how much water the plant beneficially uses compared to how much water the irrigation system applies.

Uniformity – relates to how evenly the water is applied over a given area. Equipment selection affects uniformity.

Precipitation Rate

- How fast water is applied.
- Generally measured in inches per hour (in./hr.).

Infiltration Rate

- The rate at which water moves into the soil.
- Generally measured in inches per hour (in./hr.).

Factors Affecting Infiltration Rate

- Soil structure and texture
- Soil compaction
- Thatch layer
- Slope variation
- Plant material

Evapotranspiration Rate (ET, ETo)

The rate at which water is transpired by the plant and evaporated from the soil.

Factors Affecting ET Rates

- Wind
- Humidity
- Temperature
- Solar radiation

Potential ET Rates (PET)

Cool humid	0.1 to 0.15
Cool dry	0.15 to 0.2
Warm humid	0.15 to 0.2
Warm dry	0.2 to 0.25
Hot humid	0.2 to 0.3
Hot dry	0.3 to 0.5

Crop Coefficient (Kc)

Factor used to compensate for differences in plant usage. Reported as percentage of ET.

Crop Coefficient Values

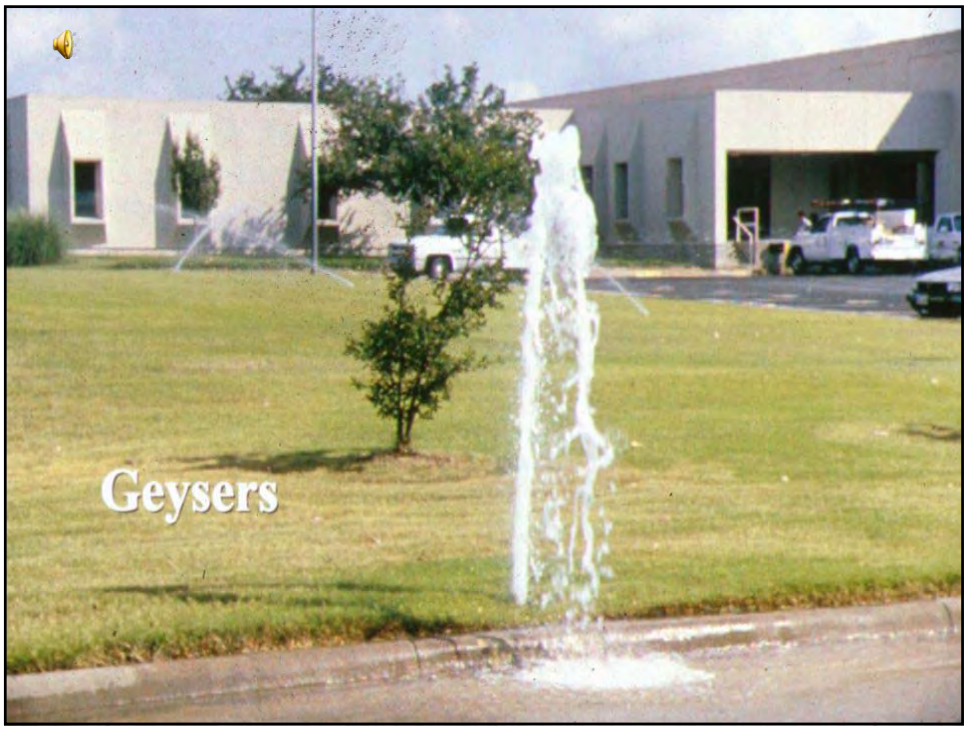
- Mature trees 0.8
- Vines & shrubs (> 4') 0.7
- Small shrubs (< 4') 1.0
- Turf
  - warm season 0.6
  - cool season 0.8

Site Inspection

- broken sprinkler heads
- sunken sprinkler heads
- broken pipelines
- mis-aligned sprinkler heads
- too high operating pressure
- too low operating pressure

SAFE Audit Program
1998

Problem	Occurrences
Sunken heads	4 sites
Mis-aligned heads	14 sites
Broken piping	5 sites
Too high pressure	2 sites
Too low pressure	3 sites
Mixed spray arcs	5 sites




Low Pressure

Performance Testing

- precipitation rate
  (inches/hour)
- distribution uniformity
  (in percent)


JUST CAN'T HIDE
MUSTANG PRIDE
KILL

Measuring Distribution Uniformity

- Coefficient of Uniformity
- Distribution Uniformity
- Denso-Gram
- Schedule Coefficient

Distribution Uniformity

- DU = LQ avg. divided by Total avg.
- Doesn't tell where low areas are in the field

Reasons for Poor Distribution

- Improper operating pressure
- Too low volume
- Heads spaced too far apart
- Mis-aligned heads
- Broken heads
- High wind

Football Field Audit

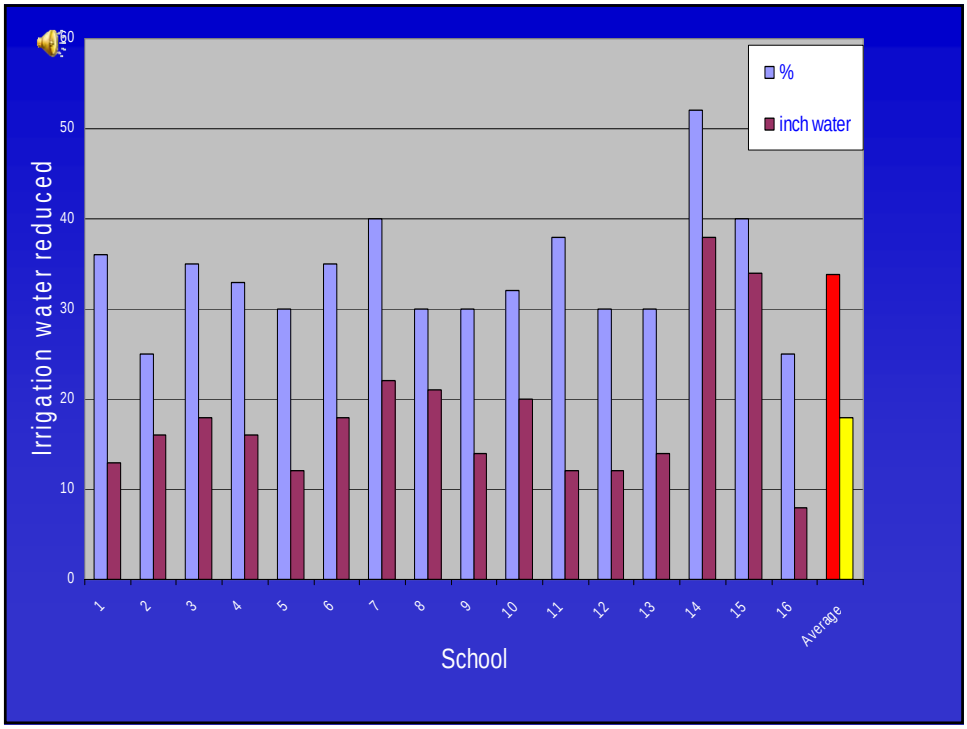
Zone	Precipitation Rate	Distribution Uniformity
1	0.72	67
2	0.29	44
3	0.36	71
4	0.39	56
5	0.45	32
6	0.51	59

SAFE Program
(23 fields)

Distribution Uniformity	Occurrence
31 – 40 %	1
41 – 50%	13
51 – 60%	7
61 – 70%	2
71 and Higher	0

Three College Fields

Field	in./hr.	DU
University Houston	3.11	34%
Kyle Field	0.54	52%
Soccer Field	0.54	43%



El Paso - Summary

- Saved average of 18 inches per year.
- Savings ranged from 8 to 38 inches.
- Average percent savings equals 34%.

El Paso – Water Savings

- 18 inches equals 977,544 gals./field/yr.
- At $ 2.39/1,000 gallons, savings equals $ 2,336 per field.

Irrigation Scheduling

- Recommended minutes per application
- Recommended irrigations per week
- Schedule will change with season
- Based on PET values

Factors Used to Calculate Schedule

- Grass species
- Effective root depth
- Soil water holding capacity
- Allowable soil moisture depletion between irrigations
- Precipitation rate
- Distribution unifromity
- Turf water use (ET)

Soil Factors

- Field capacity
- Available moisture
- Permanent wilting point

Approximate Water-Holding Capacity for Soils

Soil Texture	Moisture held at field capacity	Moisture held at permanent wilting point	Available Moisture	Available Moisture at MAD=50%
Sands	1.0 – 1.4	0.2 – 0.4	0.8 – 1.0	0.45
Sandy Loams	1.9 – 2.3	0.6 – 0.8	1.3 – 1.5	0.70
Loams	2.5 – 2.9	0.9 – 1.1	1.6 – 1.8	0.85
Silt Loams	2.7 – 3.1	1.0 – 1.2	1.7 – 1.9	0.90
Clay Loams	3.0 – 3.4	1.1 – 1.3	1.9 – 2.1	1.00
Clays	3.5 – 3.9	1.5 – 1.7	2.0 – 2.2	1.05

Factors Determining PET Values

- Plant species
- Time of year
- Climatic conditions

Base Irrigation Schedule

Run Times (minutes) per Irrigation

Sta.#	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.
1	111	94	129	110	105	106	110	127
2	140	119	163	140	133	134	140	161

Number of Irrigations per Week

Sta.#	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.
1-2	1	3	3	4	4	4	3	2

Conducting an Irrigation Audit (Summary)

- can identify problems with irrigation system
- provides potential water savings
- improved water distribution
- increased quality of turf
- excellent public relations
- most accurate way to determine run times

PET Stations in Texas

http://texaset.tamu.edu

AgriLIFE EXTENSION
Texas A&M System

Rbader@ag.tamu.edu
(915) 851-2515

Xeriscape Principles

John M. White
UTEP Chihuahuan Desert Gardens
Assistant Botanical Curator

Xeriscape:

Water Conservation Through
Creative Landscaping

Principles of Xeriscaping

- Design & Planning
- Improving the Soil
- Efficient Irrigation
- Use of Mulches
- Practical Turf Areas
- Water-Wise Plants
- Proper Maintenance

#1 Design & Planning

- Drawn to scale
- Use bubble diagram
- Include hardscapes and existing plants
- Include utilities
- Include scenic views
- Topography
- Future use?
- Draw plants at mature size

#2 Improving the Soil

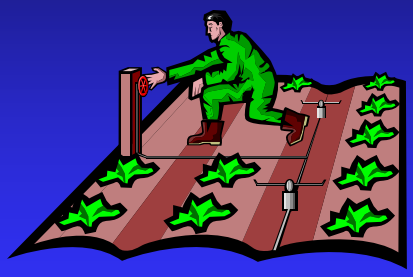
- Important basic
- Know your soil
- Know the depth
- Add organic matter
- Use 1 lb. OM/ sq.ft.
- Till or spade 10” deep
- Helps in sand & clay
- Holds moisture

#3 Efficient Irrigation

- Learn drought symptoms
- Develop hydro-zones
- Select irrigation system
  - Low volume drip
  - Spray heads
  - Bubblers
- Adjust emitters/heads
- Adjust seasonal schedule
- Check soil moisture

#4 Use of Mulches

- Protective layer
- Reduces water loss
- Reduces weed growth
- Alter soil temperature
- Use local materials
- Organic mulches
- Inorganic mulches
- Apply 2-4 inches deep



#5 Practical Turf Areas

- Functional size/use
- Appropriate turf
- Maintenance level
- Replace with ground cover or hardscape
- Expand shrub & ground cover areas
- Time and use schedules

#6 Water-Wise Plants

- Hydro-zone plants
- Know mature sizes
- Allow to grow natural
- Plant properly
- Group for effect/color
- Native vs. adapted
- Learn cultural needs
- Know plant problems

#7 Proper Maintenance

- Low maintenance
- Reduced resources
  - less fertilizer
  - less pesticides
  - less labor
- Avoid over-pruning
- Keep irrigation system maintained & adjusted

Landscape Irrigation Audits

- Know your soil types and depth
- Know type of irrigation system
- Know types of plants/crops
- Know weather conditions
- Know functional use of area
- Identify potential problems

“Can Test” for Lawns

- Placement of uniform sized cans at random
- Operate irrigation system for a set time
- Measure & record amount of water in cans
- Calculate run time to match soil/crop needs
- Back-up results with soil sampling
- Correct defective parts of irrigation system

“Rod Test” for Water Depth

- Insert a sharp pointed rod into the soil
- Push on the rod until it shows resistance
- Measure the depth on the rod
- Repeat this method in several areas
- The depth of moisture should match the plant’s rooting depth

Other Landscape Problems

- Soil compaction near plants
- Impervious layers in soil
- Pest management issues
- Irrigation system maintenance/repair
- Evapo-transpiration rates
- Misuse of equipment and procedures
- Misuse of pesticides and fertilizers

The End

- More questions ???

John M. White
UTEP Centennial Museum
500 W. University Ave.
El Paso, Texas 79968
(915) 747-5335
jmwhite@utep.edu