Sustainable rural partnerships evolve with need, good research, collaboration, creativity, adaptability..…and active listening

"Lessons from the Small Fry"

Robert R. Casavant

Maricopa Association of Governments
Greening Water & Wastewater Infrastructure Workshop
Phoenix, AZ
Jan. 12, 2010

Arizona State Parks™

Preliminary Analysis:

A Water / Energy Best Practices Guide for AZ's Rural Water & Wastewater Systems

http://www.waterenergy.nau.edu/

An AZ Water Institute funded project (07-08)

Research Team:

S. Mead, C. Schlinger, W. Auberle, M. Roberts

NORTHERN ARIZONA UNIVERSITY

B. Billy, M. Budhu, R. Casavant

THE UNIVERSITY OF ARIZONA

Project Purpose

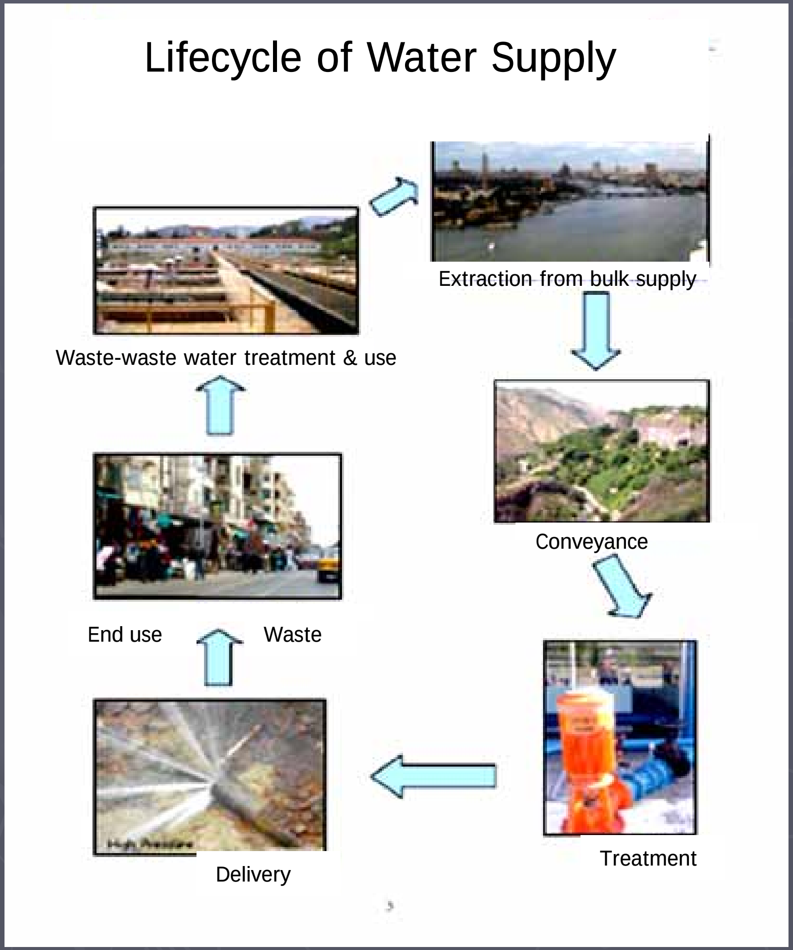
- Conduct preliminary research into "best water practices" of innovative small and/or rural communities in the United States, Europe, and elsewhere....
- to identify, evaluate and prioritize technologies and strategies that can be used by the rural Arizona providers to conserve water, reduce energy usage and related expenditures, and minimize greenhouse gas (GHG) emissions.

(Letter of Intent RFP to AWI)

Gen. Conclusions, Observations

- Rural WWS's, large & small, old & current -- can be optimized to enhance operational efficiency, reduce O&M costs, increase ROI leverage purchase power, & attract investment
  - On-site visits
    - Promote open discussion, collaborative data collection, review & analysis
    - "pilot checklist" developed and recommended - can lead to new insights, questions, and strategy for researchers and on-site managers
    - Continuation of detailed state-wide rural systems inventory is recommended
  - Interdisciplinary - "neighborhood watch" approach
    - Cost-effective sharing and opportunity to enhance material management, process, reduce infrastructure & O&M costs, & develop energy-efficiency
    - Invest in "low-hanging fruit" -- opens/maintains communication, builds advocacy, partnerships, experience to complete future and long-term investment for savings
    - Comparative "systems" analysis leads to continuous improvement
  - Rural partnerships
    - Provide for a "neighborhood watch"--faster transitions, less loss
    - Able to leverage & develop much needed political, financial and technical"capital" (intra- & interstate)-- the "school" effect ("we" vs. "me")
    - Smart growth, sustainability

Site Assessment



- Extraction Bulk Source
- Conveyance
- Treatment
- Delivery
- End Use
- Wastewater Treatment
- Compile, Analyze, Contrast Available Data

http://www.watergy.org/resources/publications/watergy.pdf

NAU-UA WWS study --Project Methodology

- Identify Study Sites
  - Rural Arizona towns (<50,000 pop.)
  - Relative proximity to universities
  - End-user, technical and geographic diversity
- Site Assessment
  - Visit each site to meet with personnel
  - Data accessibility for water/wastewater facilities
- Site Selection
  - Inventory of major processes – NAU questionnaire
  - Operational table matrix
- Analysis
  - Energy Usage (kwh)/1000 gals processed
  - Comparative Analysis

A Water/Energy Best Practices Guide for Rural Arizona's Water and Wastewater Systems

http://www.waterenergy.nau.edu/

Table of Contents

NAU-UA WWS study

NAU-UA WWS study

Appendix 3 – Case Study Summaries

The following case studies were completed at Northern Arizona University and the University of Arizona as part of this project. Each consists of an evaluation of existing water and energy use at a rural Arizona water or wastewater facility, together with recommendations for best practices, presented herein, that may be of value at the respective facilities.

- Benson, AZ: Energy, Water, and Wastewater
- Grand Canyon National Park, AZ: Energy and Wastewater
- ● Kartchner Caverns State Park, AZ: Energy, Water and Wastewater
- ● Patagonia, AZ: Energy, Water and Wastewater
- ● Patagonia Lake, AZ: Energy, Water and Wastewater
- Payson, AZ: Energy and Wastewater
- ● Slide Rock State Park, AZ: Energy and Water

● ASP technical contribution

City of Benson, AZ

- Water Distribution Network
  - Brad Hamilton, City Engineer & Public Works Director
  - Al Carruthers, Water Supervisor
- Wastewater Treatment Plant
  - Larry Napier, Public Works Wastewater Supervisor
- Sulphur Springs Valley Electric Cooperative, Inc.
  - Dave Bane, Key Account Manager Sulphur Springs Valley Electric Cooperative, Inc.

Wastewater Treatment Questions

1. Name and location (address) of plant: ____________________
2. Operators (Please include contact information) ____________________
3. When was the plant built? ____________________
4. Have there been any modifications to the plant since its original design? (Yes/No) ____________________
   a. If so, what? ____________________
   b. Which components have been replaced / repaired? ____________________
   c. When? ____________________
5. Are operation & maintenance manuals available for reference? (Yes/No) ____________________
6. Are mechanical / electrical / civil plans & specifications available for reference? (Yes/No) ____________________

Plant Characteristics

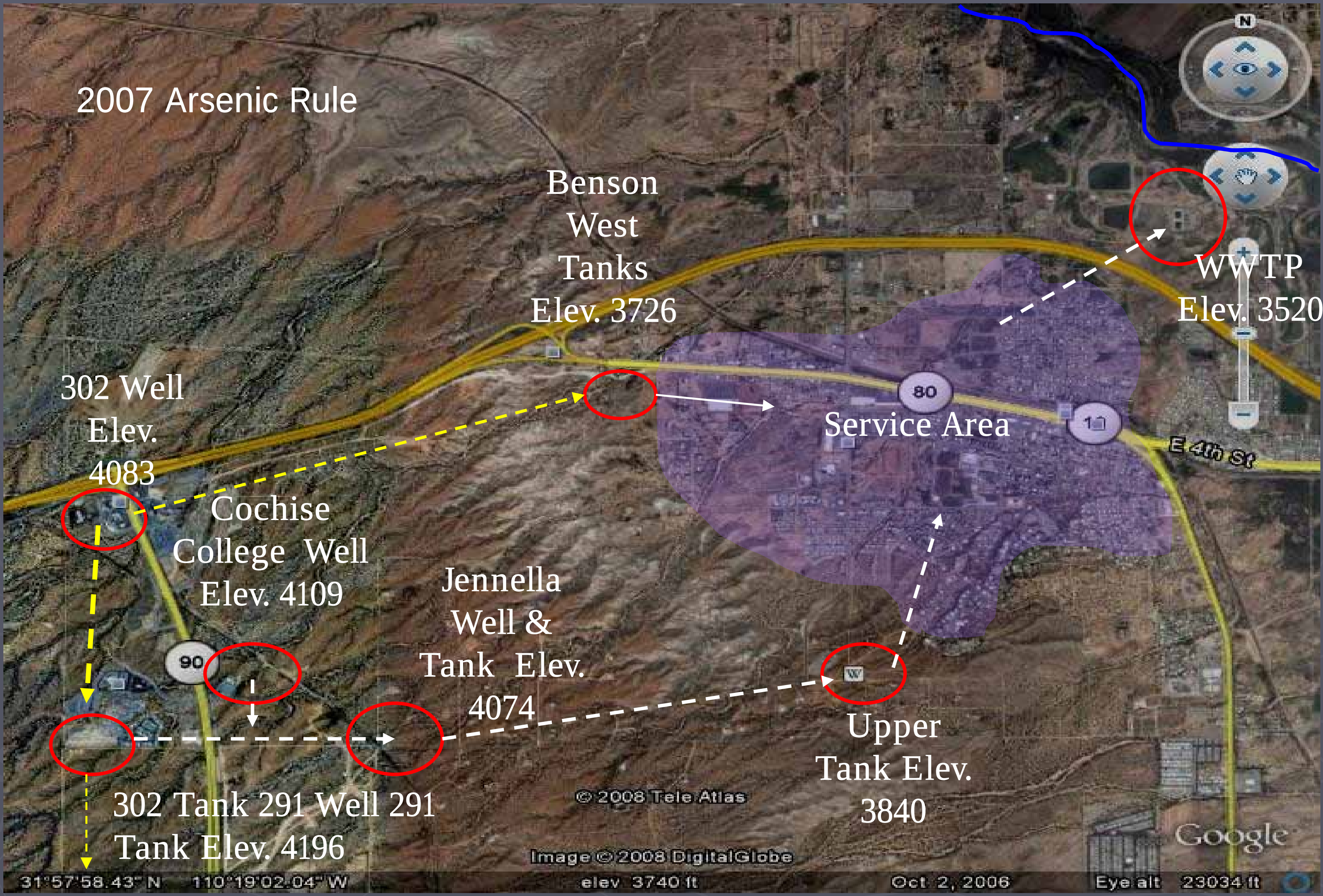
1. What is the design flow rate? (million gallons per day - MGD) ____________________
2. What is the average flow rate? (MGD) ____________________
3. What percentage of influent is residential? ____________ Institutional? ____________ Commercial? ____________ Industrial? ____________
4. What is the retention time? ____________ What is the retention capacity? ____________

Treatment Processes

1. Please describe the sequence of treatment used at this facility: ____________________
2. What are the horizontal and vertical distances that water is moved within the treatment facility? (horizontal) ____________________ (vertical distance, up/down)

Example page from site survey questionnaire

Benson Water Distribution Network



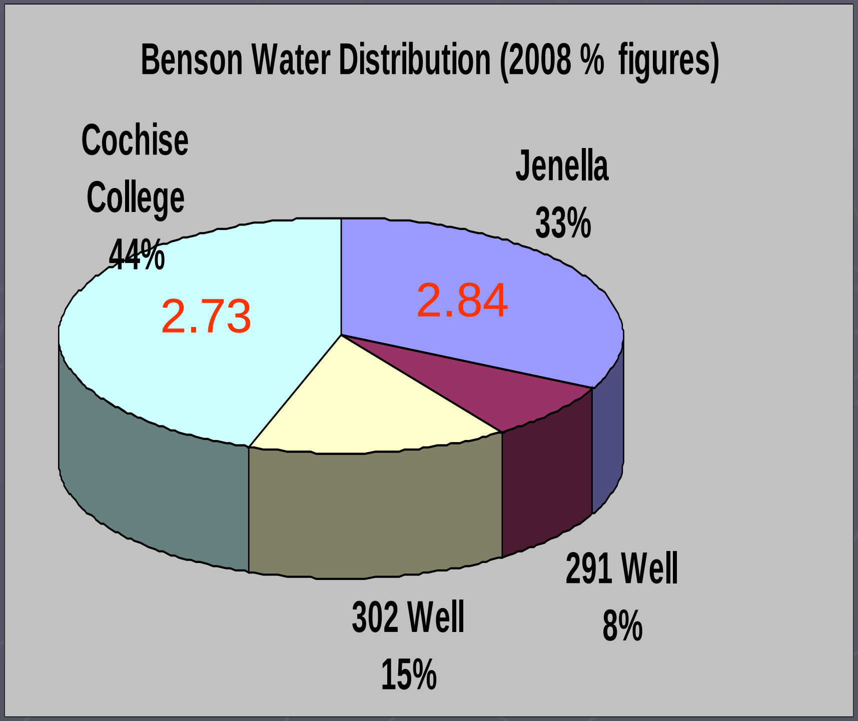
Benson Wastewater Plant

Facility Size ~ 250,000 sq ft

- Major Energy Consumption Processes
  - Oxidation Ditches – 3 rotors
  - Blowers/Agitators
- Plant Efficiencies
  - Gravity-Fed System
  - Completely Automated
  - Recently built in 2003
  - Expandable
- Plant Inefficiencies
  - Concrete piping

Benson Water Distribution Audit

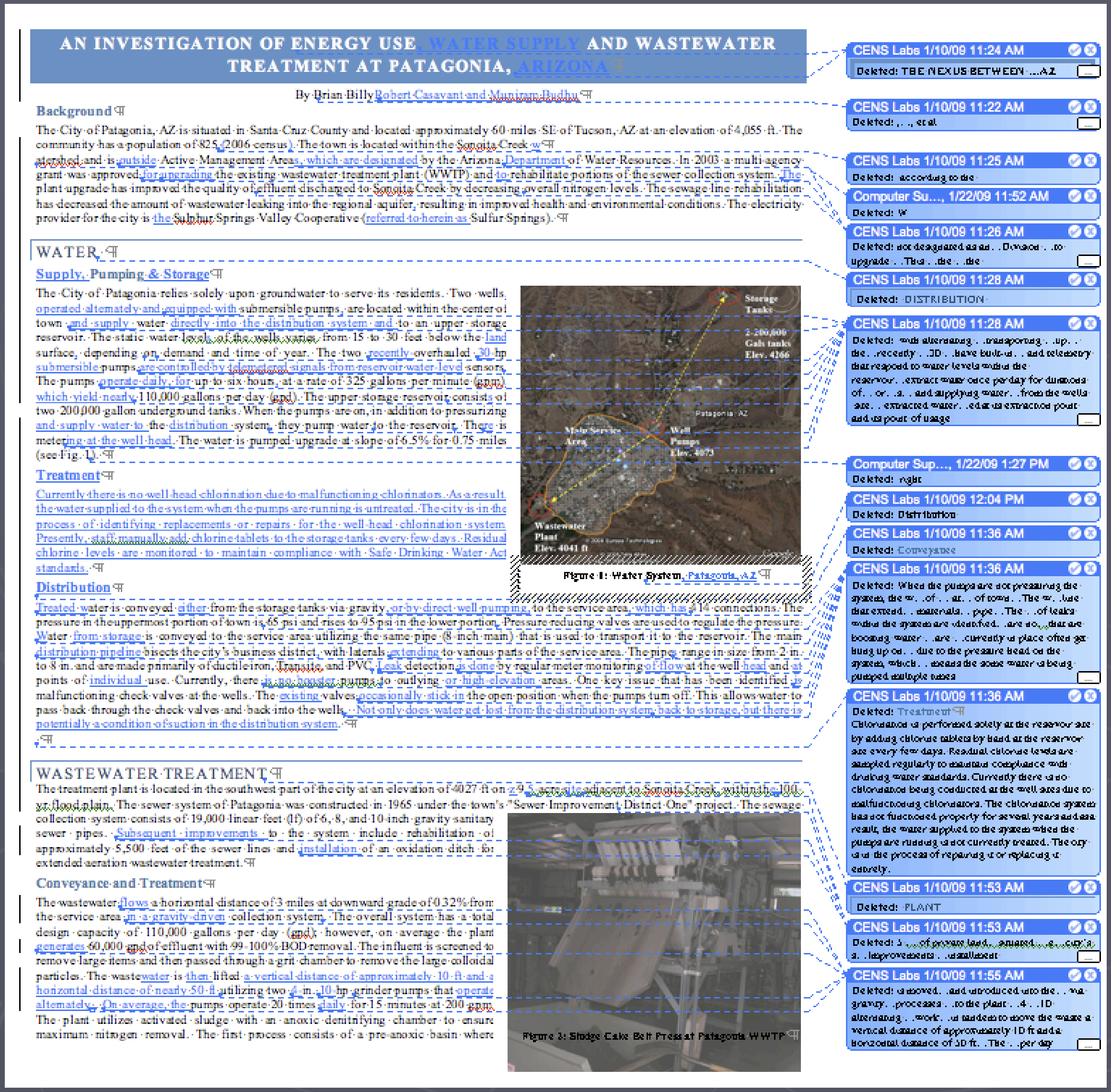
- Total gallons pumped (2007) – 274.6 MG
- Energy consumed – 856,659 kwh
- Kwh/1000 gallons pumped – 3.12
- Jennella & Cochise Pumping Efficiencies in 2008
- Possible Water Loss – 2.7 MG (10%)
- Non-Chlorination



Benson Wastewater Audit

- 135.4 MG processed (2007)
- Energy consumed – 984,516 kwh
- Kwh/1000 gals – 7.27
- Annual Billing Cost – $124,200
- Cost($)/1000 gals processed – $0.92

NAU-UA
"case study" briefs



AN INVESTIGATION OF ENERGY USE WATER SUPPLY AND WASTEWATER TREATMENT AT PATAGONIA, ARIZONA

By Brian Billy Robert Casavant and Mansour Budhu

Background

The City of Patagonia, AZ is situated in Santa Cruz County and located approximately 60 miles SE of Tucson, AZ at an elevation of 4,055 ft. The community has a population of 825 (2006 census). The town is located within the Sonoita Creek watershed and is outside Active Management Areas, which are designated by the Arizona Department of Water Resources. In 2003 a multi-agency grant was approved for upgrading the existing wastewater treatment plant (WWTP) and to rehabilitate portions of the sewer collection system. The plant upgrade has improved the quality of effluent discharged to Sonoita Creek by decreasing overall nitrogen levels. The sewage line rehabilitation has decreased the amount of wastewater leaking into the regional aquifer, resulting in improved health and environmental conditions. The electricity provider for the city is the Sulphur Springs Valley Cooperative (referred to herein as Sulfur Springs).

WATER

Supply, Pumping & Storage

The City of Patagonia relies solely upon groundwater to serve its residents. Two wells operated alternately and equipped with submersible pumps, are located within the center of town and supply water directly into the distribution system and to an upper storage reservoir. The static water level of the wells varies from 15 to 30 feet below the land surface, depending on demand and time of year. The two recently overhauled 30 hp submersible pumps are controlled by telemetered signals from reservoir water level sensors. The pumps operate daily for up to six hours at a rate of 325 gallons per minute (gpm), which yield nearly 110,000 gallons per day (gpd). The upper storage reservoir consists of two 200,000 gallon underground tanks. When the pumps are on, in addition to pressurizing and supply water to the distribution system, they pump water to the reservoir. There is metering at the well head. The water is pumped upgrade at slope of 6.5% for 0.75 miles (see Fig. 1).

Treatment

Currently there is no well head chlorination due to malfunctioning chlorinators. As a result the water supplied to the system when the pumps are running is untreated. The city is in the process of identifying replacements or repairs for the well head chlorination system. Presently, staff manually add chlorine tablets to the storage tanks every few days. Residual chlorine levels are monitored to maintain compliance with Safe Drinking Water Act standards.

Figure 1: Water System, Patagonia, AZ

Distribution

Treated water is conveyed either from the storage tanks via gravity or by direct well pumping to the service area, which has 414 connections. The pressure in the uppermost portion of town is 65 psi and rises to 95 psi in the lower portion. Pressure reducing valves are used to regulate the pressure. Water from storage is conveyed to the service area utilizing the same pipe (8 inch main) that is used to fill the reservoir. The main distribution pipeline bisects the city's business district, with laterals extending to various parts of the service area. The pipes range in size from 2 in. to 8 in. and are made primarily of ductile iron, Transite, and PVC. Leak detection is done by regular meter monitoring of flow at the well head and at points of individual use. Currently, there is no booster pumps to outlying or high elevation areas. One key issue that has been identified is malfunctioning check valves at the wells. The existing valves occasionally stick in the open position when the pumps turn off. This allows water to pass back through the check valves and back into the wells. Not only does water get lost from the distribution system back to storage, but there is potentially a condition of suction in the distribution system.

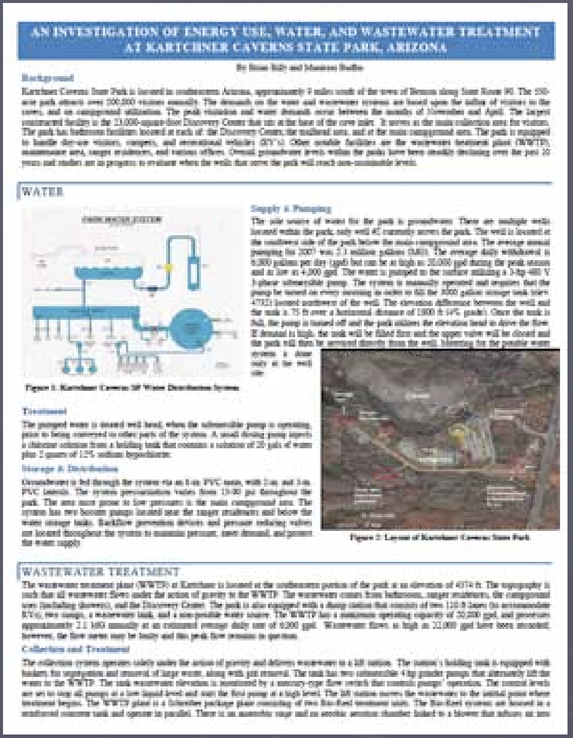
WASTEWATER TREATMENT

The treatment plant is located in the southwest part of the city at an elevation of 4027 ft on a 9.5 acre lot adjacent to Sonoita Creek within the 100 yr flood plain. The sewer system of Patagonia was constructed in 1965 under the town's "Sewer Improvement District One" project. The sewage collection system consists of 19,000 linear feet (lf) of 6, 8, and 10 inch gravity sanitary sewer pipes. Subsequent improvements to the system include rehabilitation of approximately 5,500 feet of the sewer lines and installation of an oxidation ditch for extended aeration wastewater treatment.

Conveyance and Treatment

The wastewater flows a horizontal distance of 3 miles at downward grade of 0.32% from the service area in a gravity driven collection system. The overall system has a total design capacity of 110,000 gallons per day (gpd); however, on average the plant generates 60,000 gpd of effluent with 99-100% BOD removal. The influent is screened to remove large items and then passed through a grit chamber to remove the large colloidal particles. The wastewater is then lifted a vertical distance of approximately 10 ft and a horizontal distance of nearly 50 ft utilizing two 4 in. 10 hp grinder pumps that operate alternately. On average, the pumps operate 20 times daily for 15 minutes at 200 gpm. The plant utilizes activated sludge with an anoxic denitrifying chamber to ensure maximum nitrogen removal. The first process consists of a pre-anoxic basin where

Figure 3: Sludge Cake Belt Press at Patagonia WWTP



AN INVESTIGATION OF ENERGY USE, WATER, AND WASTEWATER TREATMENT AT KARTCHNER CAVERNS STATE PARK, ARIZONA

Background

WATER

Supply & Pumping

Figure 1: Kartchner Caverns SP Water Distribution System

Treatment

Storage & Distribution

Figure 2: Layout of Kartchner Caverns State Park

WASTEWATER TREATMENT

Collection and Treatment

- 2-pg summaries
- consistent metrics
- quick-look capability for comparison and analysis
- applied training for future resource managers, planners
- basis for new research (algorithm) = measuring effective system performance despite sig. diversity in infrastructure, age, demographics, population size

AN INVESTIGATION OF ENERGY USE, POTABLE WATER AND WASTEWATER TREATMENT AT BENSON, ARIZONA

By Brian Billy and Muniram Budhu

Background

The City of Benson is located in southeastern Arizona, approximately 45 miles south of Tucson, AZ, along Interstate 10 (I-10). It is located within Cochise County and has a population of 4,934 (2006 census). The area is experiencing a growth rate of 4.7% based on figures from 2000 to 2005. The city is located within the Upper San Pedro Watershed at an elevation of 3,580 ft above sea level. The city utilizes groundwater as its sole water source. In early 2007, wells that produced water containing elevated levels of arsenic were taken off line, and the water system was modified so that all water was supplied by low-arsenic wells located in the upper southwest region of the city. Compliance with the EPA's present arsenic rule is an issue of concern for Benson. The water uses in the area are: municipal, agricultural, livestock, industrial, and riparian. This study deals only with the municipal use. The electricity provider for the City of Benson is the Sulphur Springs Valley Electric Cooperative (referred to as Sulfur Springs).

WATER

Supply & Pumping

The City of Benson pumped approximately 842 acre-ft (af) of water in 2007. The average per capita water usage is 150 gallons/person, with 1794 connections. The four wells that currently supply the city are Jennella, Cochise College, 302, and 291. Static water depths have been measured at 463 ft, 450 ft, 580 ft, and 571 ft respectively; the water table has not demonstrated a significant amount of drawdown with the current pumping regime. Figure 1 shows the relative location of the wells and tanks. The Cochise College and Jennella Wells work in tandem and currently provide 80% of the total water supply to the City of Benson. The 302 and 291 wells supply the Benson west tanks and the growing population along State Route 90.

Figure 2: Jannella Well

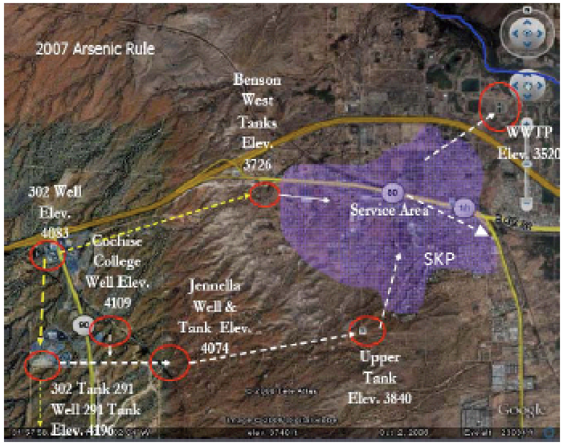


Figure 1: Wells and Tank locations in Benson, AZ

Treatment

Raw water is not treated. In the event of bacterial exceedance, the system is spot chlorinated and flushed. The water quality is monitored daily and monthly compilations of lab results are submitted to the Arizona Department of Environmental Quality.

Transmission, Storage & Distribution

Groundwater is pumped to the surface and conveyed to multiple storage tanks within the city. Two booster pumps are needed to supply the SKP development area and convey water from the 302 well to the 302 tank. The total system production is approximately 274 million gallons annually and total storage capacity is 2.45 million gallons. The topography allows for the distribution system to convey the water via gravity through 4-in., 6-in., and 8-in. pipes. Distribution occurs over an area with elevation difference of 616 ft. Pressure reducing valves are utilized to maintain a pressure of 40-80 psi within the service regions. The ability to utilize gravity for conveyance from storage is one of the major efficiencies within the Benson system.

WASTEWATER TREATMENT

The wastewater treatment plant (WWTP) is located in the northern part of town (see Fig. 1) along I-10,, north of the main business district,at elevation 3,515 feet. The service area includes the main business district and residential areas west of the San Pedro River. The original treatment plant (pond system) was moved to its current location in 1960 and was completely rebuilt in 2002 to its current operation. The flows are metered at both the influent and effluent pump stations. The effluent is used to irrigate the city golf course at no cost.

Collection / Conveyance

The city's wastewater is conveyed to the plant via gravity and received at an average rate of approximately 420,000 gallons per day (gpd). During the peak season the flow rate increases to nearly 520,000 gpd. The system works efficiently and there have been no significant maintenance issues. The installed collection piping is a combination of concrete, vitreous clay, and PVC types.

Treatment

Town of Benson (pg. 1)

solid waste facility for disposal.

SYSTEM METRICS

Monthly water pumping data were provided by the City of Benson. The wastewater processing energy expenditures were provided by Sulphur Springs. The wastewater processing figures were provided on a monthly time step by plant personnel and are estimates derived from 2008 billing records. The records for gas usage were not considered since they were not readily available and are only used for back up generators that are periodically tested. Since the water distribution operations were modified in 2007 to accommodate new arsenic standards, the tables to the right reflect the operations of a system within its transition period.

Benson Potable Water System (2007)	
Number of Gallons Pumped	274,563,200
Service Population	5,000
Gallons Pumped per Day	752,228
Gallons Used per Person per Day	150
Annual kWh Usage	856,659
kWh/kgal	3.12

Benson Wastewater Treatment Plant	
Gallons of Wastewater Processed	135,360,000
Service Population	5,000
Average Gallons Processed per Day	370,850
Gallons Processed per Person per Day	74
Annual kWh Usage	984,516
kWh/kgal	7.27

Table 1: Water Distribution and Wastewater Treatment Plant Metrics

RECOMMENDATIONS/SUGGESTIONS

Presented below are best practice recommendations and suggestions developed as part of our qualitative evaluation.

NO OR MINIMAL COST

- Balance revenue and expenses.
- Understand how energy and water are utilized in the system.
- Review system plans, specifications, and records before considering upgrades/improvements.
- Evaluate costs for different available water sources.
- Secure operations and maintenance guides and training for city staff when new systems/components are installed.
- Further investigate blending of high- and low-arsenic ground water supplies.

LOW TO MODERATE COST

- Evaluate pumps, blowers, and motors for upgrade to either high-efficiency or VFD, as appropriate.
- Investigate available technologies for arsenic and other heavy metal reduction for future consideration.
- Consider high-efficiency ballasts and bulbs in the UV disinfection process, and elsewhere within the facility.
- Adequately ventilate or sunshield all electrical and mechanical equipment in warm weather.
- Utilize off-peak power usage strategies.
- Develop water audits and implement leak detection programs.
- Implement water budgets and rate structures.
- Create financial (or other) incentives for water customers to conserve.
- Adopt water-efficient codes and ordinances.
- Create water conservation education programs.

MODERATE TO HIGH COST

- Identify and eliminate areas where there are inefficiencies in potable water booster pumping and pressure management.
- Replace old meters and install automated units.
- Optimize treatment processes to reduce water and energy consumption.
- Reduce friction/energy losses in pumps, fans, pipes, valves, and production wells.
- Utilize renewable energy, as appropriate.

CONTACT INFORMATION

- Benson water system, contact Brad Hamilton, City Engineer: (520) 586-2245.
- Benson WWTP, contact Larry Napier: (520) 586-2245.
- Sulphur Springs Valley Electric Cooperative, contact Dave Bane,: (520) 515-3472.
- Project Sponsor: Arizona Water Institute.
- Partnering Universities: Northern Arizona University, University of Arizona.
- Lead case study author, Brian Billy: bbilly@email.arizona.edu.

Town of Benson (pg. 2)

City of Payson example - NAU

AN INVESTIGATION ENERGY USE AND WASTEWATER TREATMENT AT PAYSON, ARIZONA

By Matthew Roberts, Charlie Schlinger and Steve Mead

Background

All too often, little thought is put toward estimating how much energy is consumed after water goes down the drain, but wastewater treatment systems may use considerably more energy than potable water systems. With increasing concern about global climate change due to the use of fossil fuels and their rising costs, the Arizona Water Institute (AWI) sponsored this case study to identify potential applications for increasing the efficiency and decreasing the overall energy use of water and wastewater systems in rural Arizona. The purpose of the case study analyses of rural water systems is to determine the unique challenges that these smaller systems face and provide some guidance in overcoming this complexity. The Northern Gila County Sanitary District operates The American Gulch Water Reclamation Facility in Payson, Arizona, serving over 15,000 people. This facility was designed for 2 million gallons per day (MGD) and can expect an average flow of 1.3 MGD when the weather is dry. During periods of wet weather, short duration inflows at a rate of up to 5 MGD can be expected due to storm water infiltration.

WASTEWATER TREATMENT

The first step in the system is a continuously actuated conveyor-belt-type bar screen that removes large debris. The next step in the treatment process is uncommon in most wastewater treatment plants (WWTP): phosphorous removal. The influent flow has about 4 ppm phosphorous and the effluent has around 0.2 ppm, amounting to 99.5% removal efficiency. This is done by the five-stage Bardenpho process that uses volatile fatty acids (VFA) to encourage the uptake of phosphorous (P) by the microorganisms (bugs) in the nitrification basin.

Diversion of wastewater to the VFA basins was a supplement to the original design, utilizing a screw pump to lift the wastewater to where the VFA are mixed with return activated sludge at the entry to a fermentation basin. In the fermentation basin, P is released by the microorganisms, only to be taken up in greater amounts in the nitrification basin. Following fermentation, mixed liquor is returned from the nitrification basin and the water flows into the first anoxic basin where nitrates are converted to nitrogen gas. In the nitrification basin, two 100-hp blowers aerate the water through fine-bubble diffusers, digesting nutrients and converting ammonia to nitrates. Two reclaimed water sprayers from a hydro-pneumatic system are used to knock down foam atop the nitrification basin where most of the P is removed from the wastewater. A secondary anoxic basin allows further conversion of nitrates to nitrogen gas and, after re-aeration by a single 40-hp blower through fine-bubble diffusers to prevent the secondary release of P, the water flows to secondary clarifiers where excess biosolids are removed.

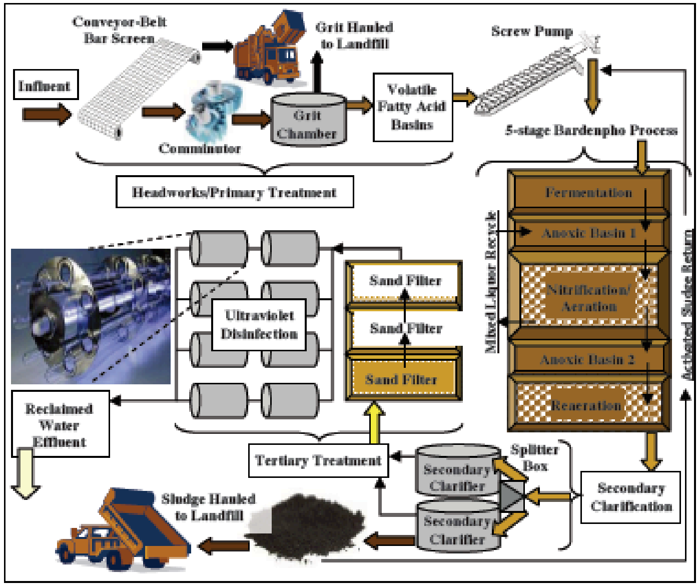


Figure 1: Schematic of the Wastewater Treatment Facility in Payson, AZ

Wastewater from the secondary clarifiers passes through a series of dual-media sand filters. The backwash water from cleaning these filters is returned to the headworks. The final step in the process is disinfection via low intensity UV lamps that sit directly in the flow of water. There are 30 bulbs in each of the 8 banks of lights; the bulbs are replaced every 2 years. The residence time in this system was estimated at 2.5 days.

The sludge removed from the secondary clarifiers is used in the manufacturing of fertilizer and some is recirculated to keep the bugs alive. The bio-solids enrichment and recycling (BER) process consisted of a dual belt-press to dewater the sludge before it is baked in a propane rotating dryer. By adding phosphoric acid and anhydrous ammonia to the sludge makes about 1500 lbs of pelletized fertilizer each day. This fertilizer was sold to local farmers, schools and golf courses at a loss of $900 per ton. This BER system was not large enough to support the amount of biosolids so hauling to the landfill has resumed, at a cost of $47/ton for solids taken to the landfill.

ere provided by
se data provide
ity. Occasional
l an estimate of
trics in Table 1

Electricity Use	Natural Gas Use	Annual Electricity Use	Annual Natural Gas Use
4.48-5.84 kWh/kgal	2.64-5.33 kWh/kgal	2.55 million kWh $215,300	72,800 Therms 2.13 million kWh $172,200

Table 1: Wastewater Metrics in Payson, AZ

NS

ons and suggestions as a result of additional qualitative analyses.

NO OR MINIMAL COST

nly enough to expose more bar screen, letting excess water drip off before deposition in a
ndfill.
n freezing is not a threat. This could reduce the need for grinders as the bar screen is more
en. The grinders then could be used only during times when the bar screen is in motion and

vement planning.

system.
fore considering upgrades/improvements.
scoping, design and specification of future projects.
upgrading over the expected life of the system.
chilled water or air.
ng for staff when new systems/components are installed.

LOW TO MODERATE COST

either high-efficiency or VFD.
eaks, and operate the facility at night.
activities warmer and possibly more reactive, to dry bio-solids in the fertilizer manufacturing

e facility, especially in the UV disinfection process.

nechanical equipment in warm weather.

mers to conserve instead of expanding plant capacity.

conserve water and reduce wastewater production, instead of increasing plant capacity.

MODERATE TO HIGH COST

the amount of flow. This facility currently operates 3 of 4 light banks continuously.
tment facility.
y utilizing: photovoltaic cells; drying beds, or a greenhouse with proper ventilation.
ergy consumption.
valves, and production wells.
out the wastewater system.

bout the study, supporting data, and background information: Matt Roberts (msr43@nau.edu), Charlie Schlinger (charles.schlinger@nau.edu) or Steve Mead (stephen.mead@nau.edu) at Northern Arizona University.
For further information on the American Gulch Water Reclamation Facility, please contact Dave Millien by email: ops@npgcable.com, or telephone: (928) 474-5257.
Project Sponsor: Arizona Water Institute (http://www.azwaterinstitute.org/).

System/process illustration

Kartchner State Park - example

- Water Distribution Network
  - Don Fletcher, Kartchner SP Building Maintenance
- Wastewater Plant
  - Rob Van Zandt, ASP
- Sulphur Springs Valley Electric Cooperative, Inc.
  - Dave Bane, Account Manager, Sulphur Springs Valley Electric Cooperative, Inc.

Kartchner Water Distribution e.g. site info collection

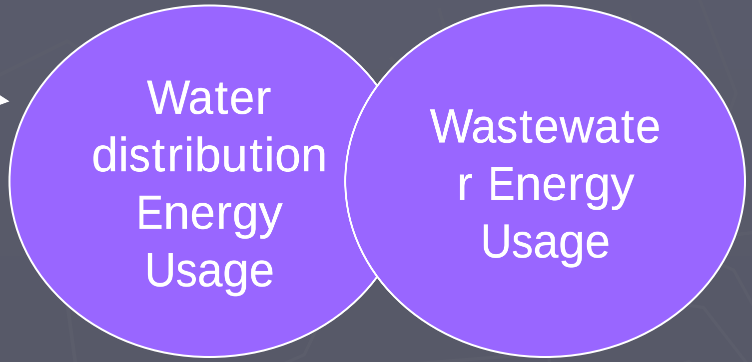
- Manual operated System (tank level dependent) – sensors turned off – too costly
- Well #2 Pump manually operated
- Gravity fed
- Metered at well only
- Chlorine injection at well

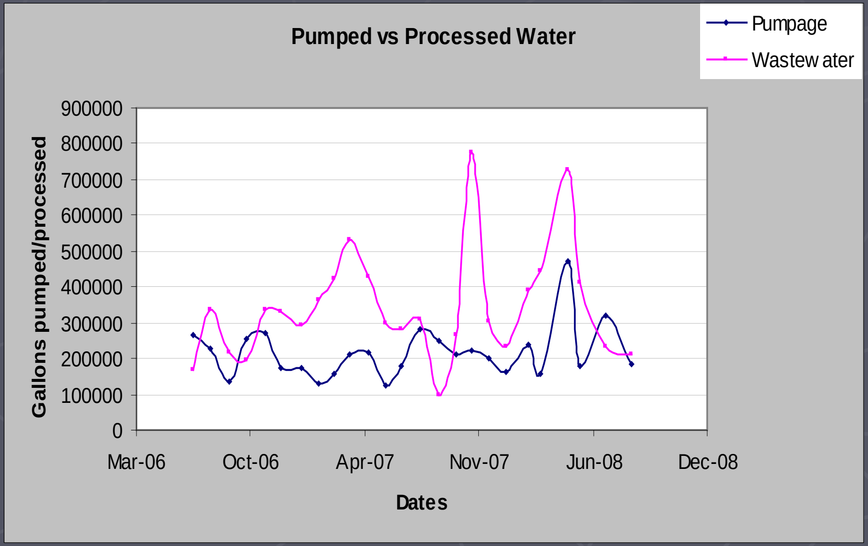
Kartchner Wastewater Plant

- Major Energy Consumers
  - 2 Blowers/train 24/7 altern
  - Grinder Pumps
  - Effluent Pumps
- Gravity Fed 3 ft/sec – topography
- Seasonal demand
- Metering – water & energy
- Single Utility Bill (estimate 65% - inventory being performed)
- Minimal sludge disposal

Kartchner Billing Records

	Kwh
4-Jan-07	91,200
2-Feb-07	102,000
5-Mar-07	109,680
4-Apr-07	91,920
2-May-07	75,120
5-Jun-07	78,240
5-Jul-07	76,080
3-Aug-07	68,160
6-Sep-07	81,360
3-Oct-07	60,720
5-Nov-07	86,160
5-Dec-07	87,600





Kartchner Water & Wastewater Systems Comp.

- Water distribution
  - 2.3 MG pumped (2007)
- Energy Consumed (0.65% of total)
  - 6633 kwh
- Kwh/1000 gals – 2.83
- Cost($)/1000 gals - $0.44

- Wastewater
  - 4.3 MG processed (2007)
- Energy Consumed (65% of total)
  - 663,000 kwh
- Kwh/1000 gals – 154
- Cost($)/1000 gals - $16

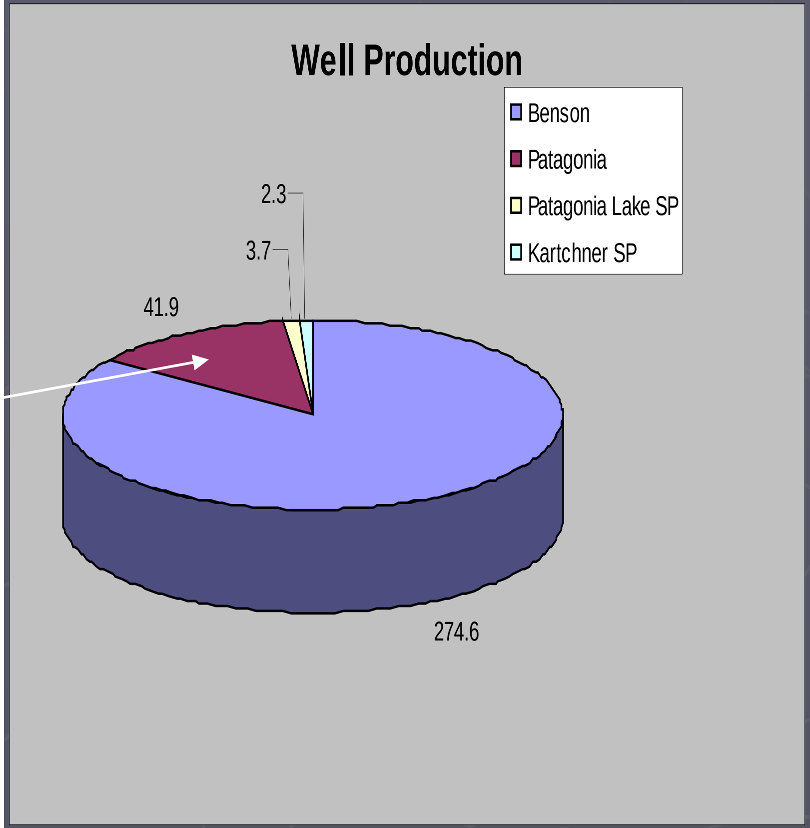
Example of preliminary findings

- Kwh/1000 gals processed = an equalizing metric
- Cities more efficient than parks
  - More funding & tax revenues?
  - On-site engineer/certified operators
  - Modernized systems, profit driven, less waste
- Little or no intra-system metering at State Parks
- Energy & water record keeping, monitoring, and knowledge transfer variable among many rural sites
- Macro billing data available, but little/no data for micro processes, on-park intra-system analysis and optimization
- Quantification of system losses is often minimal or inaccurate
- Best practice guides and flow metrics (audit templates) desired

Independent audits and data = raise candid questions, uncover data errors, separate people from the process, promote consistency & objectiveness, present WWS in terms of mass balance and energy consumption, incite best practices for energy cost savings and investment = profitability, efficiency

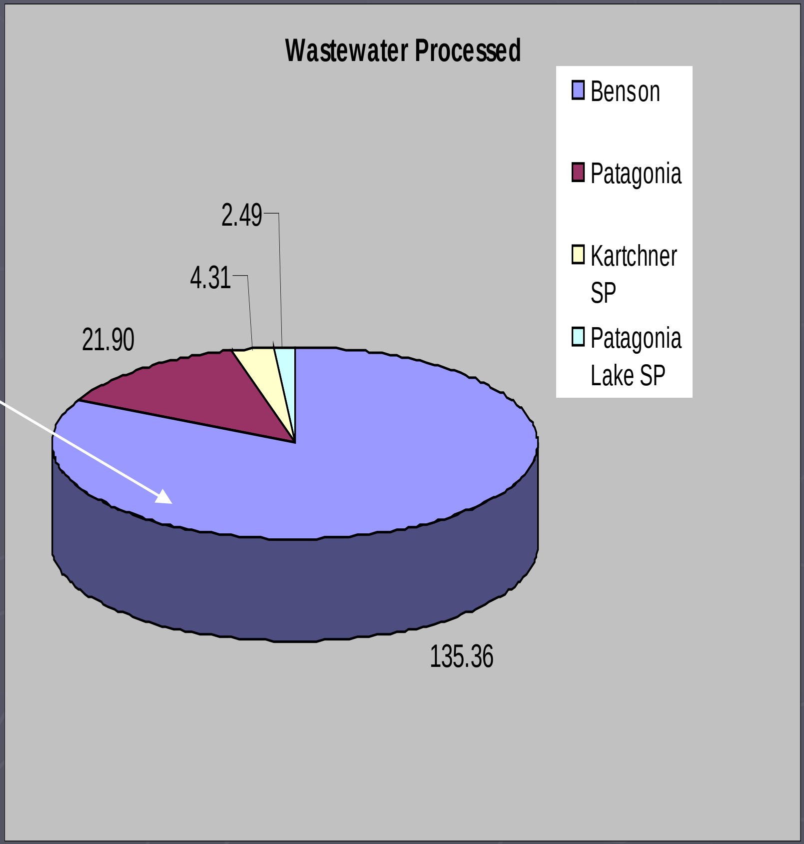
Water Distribution Analysis

	City Population Number of Park Visitors	Number of Gallons Pumped (MG)	Energy Consumption (kwh)	Kw h per 1000 gals pumped	Cost ($)/1000 gals processed
City of Benson	5000	275	857,000	3.1	Being calculated
City of Patagonia	822	41	56,000	1.4	$0.20
Kartchner State Park	225,000	2.3	6633	2.8	$0.44
Patagonia State Park	230,000	3.7	8125	2.2	$0.47



Wastewater Analysis

	Number of Gals processed (MG)	Energy Consumed (kwh) for processing	Kwh/1000 gals processed
Benson WWTP	136	985,000	7.3
Patagonia WWTP	22	296,000	13.5
Kartchner WWTP	4.3	663,000	154
Patagonia SP WWTP	2.5	29,000	11.7



Additionally, overall education and training for operators is essential so that they can understand utility policies, management and operations, be aware of energy supplies and uses and costs and understand the basis for successful application of best practices for water and energy conservation (Cantwell, 2008).

Renewable Energy

Because water and wastewater systems have regular and continuous power demands, there are excellent opportunities for using renewable energy sources. Renewable energy sources such as photovoltaic panels and wind turbines can be used to help meet day-to-day energy needs. Given the significant recent and ongoing investment in renewable

energy, technologies are becoming more efficient and cost effective. In Arizona, where there are ample sun and significant wind resources, renewable systems can be effective at reducing expensive peak power demand placed on conventional providers.

Other renewable sources include sludge digesters that produce methane. The methane is captured and used to power a gas engine generator or a micro-turbine system. These systems utilize the methane gas produced in anaerobic treatment processes, reducing the GHG emissions of the wastewater treatment plant. To date, these kinds of systems have been limited to plants that exceed a threshold of 5-10 million gallons per day (Mgd).

31. Wind Energy

Wind has long been used to help pump, distribute and treat water. In the early 20th century, the development of the steel windmill and reciprocating pump provided water to farms, ranches, and railroads in the rapidly developing American west. This technology is still used to pump water worldwide. According to a report from the National Renewable Energy Laboratory (NREL), there are over one million windmills in the United States, Argentina, and Australia alone (Argaw, 2001). However, wind-powered mechanical pumps have limitations. Because of their reciprocating pump design, these pumps need to be installed directly over a well head. This poses problems because groundwater is often tapped in low-lying valleys, and these locations are not usually optimal for available wind energy.

Given the above location constraints on windmill / reciprocating pump installations, an electric wind turbine offers greater versatility. These turbines are designed to generate electricity (AC or DC) that can be used to operate a variety of electrical devices. Wind power can be used effectively to power pump motors, fans, lights, controls, and

"Local & consistent energy needs of WWS are well-suited to renewable energy augmentation"

- wind
- solar
- biofuels
- small-scale hydroelectric

Appendix 2 – Funding Sources, Renewable Energy Specialists, and Other Resources

Funding Sources

WIFA – Water Infrastructure and Financing Authority (Arizona)

http://www.azwifa.gov/

Clean Water State and Safe Drinking Acts (State Revolving Fund Program)

http://www.epa.gov/safewater/

DOLA, CDPHE, CWRPDA
National Water Program Strategy (Response to Climate Change)
Direct and Leveraged Loans
Disadvantaged Community Loans

Colorado Water Resources and Power Development Authority

http://www.cwrpda.com/Programs.htm

Small Hydro Loan Program (Colorado only)
Water Resources and Power Development Authority
Engineering up to $150K per year, $15,000 per local government
Up to $2 million per borrower, 2% for 20 years
SRF – Planning and Design Grants have been a success

Energy Efficiency and Conservation Block Grant Program (EECBG)

http://www.usmayors.org/climateprotection/documents/eecbghandout.pdf

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Future Research

- System Constraints / Optimization
  - Historical context – town & park politics - system inheritance
  - Data reliability and repeatability
  - Quick-look assessment software capabilities
  - Topographic considerations
  - State/Federal regulations
  - Monetary funding mechanisms
  - Consistency in system audits
  - Develop Mass Balance Model
  - Land locked areas - Expansion
- Carbon Emissions Impact
- Application of green technologies
- Parallel Systems approach

Big & small fry --- think & act as a "cooperative"

Collaborative inventorying and management of diverse rural systems will help you learn what you have / what you need…so that you collectively plan, optimize, and sustain natural / human ecosystems for "smart growth"

"Neighborhood watch"

-- a tree trimming story

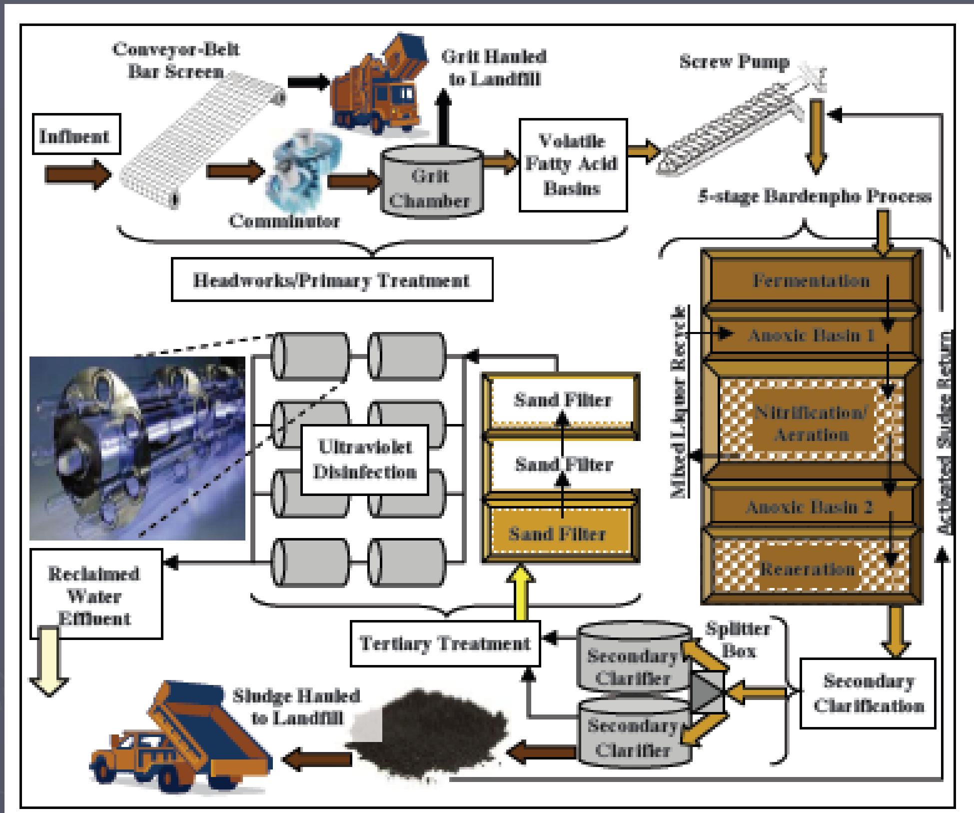

Figure 1: Schematic of the Wastewater Treatment Facility in Payson, AZ

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City of Patagonia
City of Payson
MAG
AZ DEQ

“What gets measured, gets managed”.

(Peter Drucker)