final report

recycled water tour 05

mexico • singapore • usa

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Arris Pty Ltd would like to thank everyone who attended this Study Tour for their enthusiastic participation and value contribution into what will provide them and Australia with a valuable insight into recycled water projects in a range of countries around the world. We also recognize the invaluable contribution of a range of individuals from water industries in Singapore, Mexico, Florida and California, who gave our study tour participants the time to discuss and show us some of the most fascinating and innovative recycled water projects in the world.

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Contents

Abbreviations

af	acre feet
DEP	Department of Environmental Protection
mgd	mega gallons per day.
RCID	Reedy Creek Improvement District
RIB	Rapid Infiltration Basin
STP	Sewage Treatment Plant (used more in Mexico)
WRF	Water Reclamation Facility (Used more in the USA)
WWRF	Waste Water Reclamation Facility (Sometime used in the USA and Mexico)
WTP	Water Treatment Plant

Conversions

1 Program: 28th May, Singapore

Singapore is the largest port in South East Asia and one of the busiest in the world. It owes its growth and prosperity to its focal position at the southern extremity of the Malay Peninsula, where it dominates the Strait of Malacca, which connects the Indian Ocean to the South China Sea. Once a British colony and now a member of the Commonwealth, Singapore first joined the Federation of Malaysia on its formation in 1963, but seceded to become an independent State on August. 9, 1965.

Singapore is located 137 km north of the equator, with a total land area of 680 km^2. The country is generally flat. It has 14 impounding reservoirs, with an average annual rainfall of 2370 mm and a population of approximately 4.2 million people.

1.1 NEWater – Singapore

http://www.pub.gov.sg/NEWater

1.1.1 Background (from tour booklet)

http://www.pub.gov.sg/NEWater_files/overview/index.html

The Singapore Water Reclamation Study (NEWater Study) was initiated in 1998 as a joint initiative between the Public Utilities Board (PUB) and the Ministry of the Environment and Water Resources (MEWR). The primary objective of the joint initiative was to determine the suitability of using NEWater as a source of raw water to supplement Singapore's water supply. NEWater is treated used water that has undergone stringent purification and treatment process using advanced dual-membrane (microfiltration and reverse osmosis) and ultraviolet technologies. NEWater could be mixed and blended with reservoir water and then undergo conventional water treatment to produce drinking water (a procedure known as Planned Indirect Potable Use or Planned IPU).

Planned IPU as a source of water supply is not new. It has been practised in several parts of the United States for more than 20 years. At Water Factory 21, Orange County Water District, Southern California, high quality water reclaimed from treated used water has been injected into ground water since 1976. Similarly, at Upper Occoquan Sewage Authority (UOSA), North Virginia, high quality reclaimed water is discharged into Occuquan Reservoir since 1978. Occoquan Reservoir is a source of water for more than a million people living in the vicinity of Washington DC.

Water reclamation is a growing trend in the U.S. and around the world. In the U.S., there are several other water reclamation projects that are now being planned or under construction. Two of them are at Gwinnett near Atlanta, Georgia and at Scottsdale near Phoenix, Arizona.

In 2001, PUB embarked on a new initiative to increase water supply from unconventional sources for non-potable use. The use of NEWater for wafer fabrication processes, non-potable applications in manufacturing processes as well as air-con cooling towers in commercial buildings would free large amount of potable water for other potable purposes.

The NEWater Factories at Bedok and Kranji Water Reclamation Plants was commissioned at the end of 2002. Following that since Feb 2003, NEWater has been supplied to wafer fabrication plants at Woodlands and Tampines/Pasir Ris and other industries for non-potable use. In Jan 2004, another milestone in the NEWater initiative was accomplished with the commissioning of the third NEWater Factory at Seletar Water Reclamation Plant which began supplying NEWater to the wafer fabrication plants at Ang Mo Kio. The total capacity of the three NEWater factories is 92,000 m^3/day or 20 mgd.

PUB has also completed its evaluation of the Expert Panel's report and accepted the proposal to use NEWater for indirect potable use in Sep 2002. This means mixing and blending NEWater with raw water in the reservoirs before undergoing conventional treatment at the waterworks for supply to the public for potable use. PUB has introduced 3 mgd of NEWater (about 1% of total daily water consumption) into our raw water reservoirs. The amount will be increased progressively to about 2.5% of total daily water consumption by 2011.

1.1.1.1 Overseas Experiences

The reuse of treated used water is not new. In countries with long riverine systems, upstream communities use the water and discharge the used water after treatment back into the river.

Successive downstream communities then reuse the water several times, before the river finally flows into the sea. Until recently, the constraint to greater recycling was cost. This is falling rapidly. New technology is producing superior filters and membranes, and this is significantly reducing the cost of microfiltration and reverse osmosis. It has become economically attractive to recycle used water on a large scale.

1.1.1.2 Unplanned Indirect Potable Use

Unplanned Indirect Potable Use occurs when a water supply is abstracted for potable purposes from a natural source (surface or groundwater) that is fed, in part, by the discharge/disposal of treated or non-treated wastewater. The subsequent potable use of the wastewater was not an intentional part of the effluent disposal plan. This type of potable use occurs whenever an upstream water user (City A) discharges wastewater into a water source (river, lake or aquifer) that serves as a water supply for a downstream user (City B). Many large communities have been unintentionally practising unplanned Indirect Potable Use. Some examples are cities along the Rhine and Thames rivers in Europe, the Mississippi River in the U.S., the Yangtze River in China, and the Mekong River in Indo-China.

1.1.1.3 Planned Indirect Potable Use

Planned Indirect Potable Use is the abstraction, treatment and distribution of water for drinking from a natural source (river, lake or aquifer) that is intentionally and partially fed by the discharge of treated wastewater effluent. This type of potable use is becoming more common as other viable water sources become more scarce because of population growth and watershed urbanisation. Some U.S. examples are Water Factory 21, Orange County Water District, Southern California and Upper Occoquan Sewage Authority (UOSA), North Virginia.

1.1.1.4 Plans for NEWater

It is safe to use NEWater to supplement our water supply
NEWater is high grade water, produced when treated used water has been further purified using a 3-step process. This process involves advanced membrane technologies like Microfiltration, Reverse Osmosis and the final disinfection of the water using ultraviolet light.

The multiple-barrier membrane treatment process has enabled the Public Utilities Board (PUB) to produce consistently good quality NEWater at the Bedok NEWater Factory.

With its consistently good quality and reliability in production, NEWater could be put to greater use in terms of being a source of non-potable water and for indirect potable use, by blending it with reservoir water.

1.1.1.5 Non-Potable Uses of NEWater

PUB's NEWater initiatives, which began in 2001 to increase water supply from unconventional sources has produced good outcomes. Substitution of PUB water with NEWater for non-potable use would free a large amount of potable water for other potable purposes. Besides wafer fabrication processes, NEWater can also be used for non-potable applications in manufacturing processes and other industries, as well as air-con cooling towers in commercial buildings.

The NEWater Factories at Bedok and Kranji Water Reclamation Plants were commissioned at the end of 2002. Since February 2003 NEWater has been supplied to wafer fabrication plants at Woodlands and Tampines/Pasir Ris and other industries for non-potable use. In January 2004 another milestone in the NEWater initiative was accomplished, with the commissioning of the third NEWater Factory at Seletar Water Reclamation Plant, which began supplying NEWater to the wafer fabrication plants at Ang Mo Kio. The total capacity of the three NEWater factories is 92,000 m^3/day or 20 mgd.

The development of NEWater Factories is well on track for meeting the goal of increasing the non-potable use of NEWater to at least 15% of Singapore's water demand by 2010. More NEWater Factories are in the pipeline.

1.1.1.6 Indirect Potable Usage

NEWater could also be used for indirect potable use by blending with reservoir water. This is nothing new. For more than 20 years, several cities in the United States have mixed reclaimed water with reservoir water to supply households. Some of these places include Orange County (outside Los Angeles), Phoenix, Arizona and Fairfax County (North Virginia). In fact, many cities along major rivers in the world like the River Rhine, the Mississippi River, the Yangtze River and the Mekong River have also been practicing unplanned indirect potable use of reclaimed water, with upstream water users discharging treated used water into a water source that serves as a water supply for a downstream user. NEWater is also of drinking water standard.

The Public Utilities Board (PUB) received a report from the Panel of Experts studying the suitability of NEWater as a source of water to supplement our water supply. The Panel of Experts concluded that NEWater is consistently of high quality and well within the requirements of the United States Environmental Protection Agency's (USEPA) National Primary and Secondary Drinking Water Standards, and the World Health Organisation's (WHO) Drinking Water Guidelines. The Panel has endorsed NEWater as a safe and sustainable source of water and has supported its indirect potable use in Singapore through storing and mixing with the water in our reservoirs.

PUB has completed its evaluation of the Expert Panel's report and accepted the proposal to use NEWater for indirect potable use. This means mixing and blending NEWater with raw water in the reservoirs before undergoing conventional treatment at the waterworks for supply to the public for potable use. PUB has introduced 3 mgd of NEWater (about 1% of total daily water consumption) into our raw water reservoirs. The amount will be increased progressively to about 2.5% of total daily water consumption by 2011.

1.1.1.7 NEWater Technology

NEWater is Reverse Osmosis Water
NEWater is the product of a multiple barrier water reclamation process. The first barrier is the conventional wastewater treatment process, where used water is treated to globally recognised standards in the Water Reclamation Plants.

The second barrier is the first stage of the NEWater production process, known as Microfiltration (MF). In this process, the treated used water is passed through membranes to filter out and retained on the membrane surface suspended solids, colloidal particles, disease-causing bacteria, some viruses and protozoan cysts. The filtered water that goes through the membrane contains only dissolved salts and organic molecules.

The third barrier or second stage of the NEWater production process is known as Reverse Osmosis (RO). In RO a semi-permeable membrane is used. The semi-permeable membrane has very small pores which only allow very small molecules, like water molecules to pass through. Consequently, undesirable contaminants such as bacteria, viruses, heavy metals, nitrate, chloride, sulphate, disinfection by-products, aromatic hydrocarbons, pesticides etc, cannot pass through the membrane. Hence, NEWater is RO water and is free from viruses and bacteria and contains very low levels of salts and organic matters.

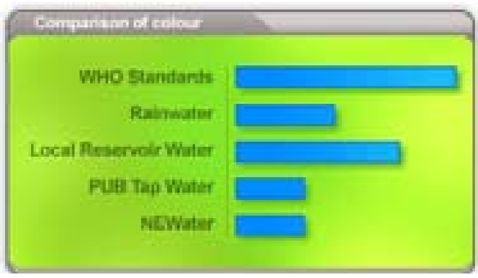
At this stage, the water is already a high grade water quality. The fourth barrier or third stage of the NEWater production process really acts as a further safety back-up to the RO. In this stage ultraviolet, or UV, disinfection is used to ensure that all organisms are inactivated and the purity of the water is guaranteed.

With the addition of some alkaline chemicals to restore the acid-alkali or pH balance, the NEWater is now ready to be piped off to its wide range of applications.

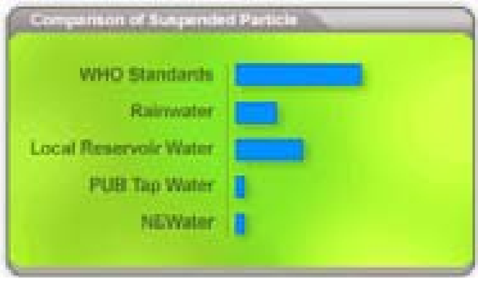
In fact, RO is a widely recognised and established technology, which has been used extensively in many other areas. This includes the production of bottled drinking water and ultra-clean water for the wafer fabrication and electronics industry. RO is also becoming increasingly popular as one of the technologies used in desalination of seawater for human consumption. It is also used to recycle used water to drinking water on space shuttles and on International Space Stations.

1.1.1.8 NEWater Quality

NEWater is cleaner than PUB Water (Colour)
NUS Laboratory has been conducting very comprehensive analyses of NEWater to ensure that the water quality is indeed good. These analyses are supervised by a panel of local and international experts. So far 20,000 analyses over the last two years have been conducted and these have established that NEWater is cleaner than PUB water.



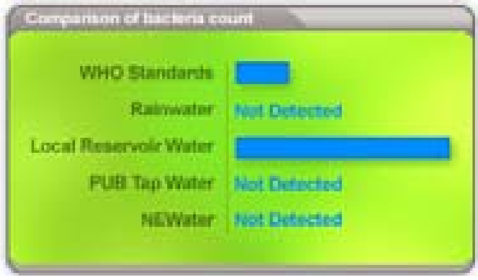
Physically, NEWater is very clear and sparkling. The river sources and reservoir water has more colour as they contain more minerals and organic substances.



The river sources and reservoir water also contain more suspended particles. These particles are washed into rivers and reservoirs by rainfall running off the ground. NEWater on the other hand is clearer, even clearer than PUB water.

NEWater is cleaner than PUB Water (Organic Substances).
The organic substance of NEWater is less than one-tenth of PUB water. Precisely because of that, industry users find NEWater to be attractive. For example, currently a fabrication plants take PUB water and process it to reduce the organic substance to a level that is acceptable for their operations. Starting from next year, the wafer fabrication plants in Singapore will be using NEWater instead of PUB water, because NEWater is cleaner than PUB water and is more suitable for their operations.

NEWater is cleaner than PUB Water (Bacteria Count).
The bacteriological quality of water is a very important factor for potable use. Pathogenic bacteria are harmful to health and are found in animal waste and soil. Rain that falls onto the ground will carry the bacteria into the rivers and the reservoirs. Bacteriological quality of NEWater is as good as PUB water, due to the fact that the presence of bacteria and virus is not detectable, thereby meeting the World Health Organization's Standards.



1.1.2 Visit to Bedok NEWater Visitors Centre and Water factory.

1.1.2.1 Key Contacts

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1.1.2.2 Welcome

Mr Chan Yoon Kum

Welcome from the Ministry of the Environment and Water Resources (MEWR) and the Public Utility Board (PUB). The goal of the MEWR and PUB is "To deliver and sustain a clean and healthy environment and water resource for all in Singapore".

Introduction

PUB was registered in 1963, and was a quasi government organisation, looking after piped gas, electricity and water. They supply water to the whole nation of Singapore. PUB water and wastewater was linked with stormwater management in April 2001 to become a full comprehensive water agency. The PUB board has 11 members, appointed by the Minister on a 2 - 3 year term and meeting every two months. The board has no jurisdiction on Tariffs however, PUB has its own budget and is self financing. They receive no grants from the government and actually pay taxes. However, wastewater and stormwater are supported by the government. All money collected goes to PUB or the government, not to any shareholders, similar to Australia. Singapore uses 1.36 MKL/per day.

Pricing

Pricing is covered under the public utilities act, approved by the government and cabinet. PUB has to make sure they are financially sound. When they need to modify the cost of water, a case to the Ministry of Trade Industry must be made and the Minsters and Cabinet decide.

1.1.2.3 Visit to the NEWater Visitor Centre and Water factory

Speaker - Lim Chiow Giap
Presentation: Water for all Conserve, Value, Enjoy. Visit to the NEWater Visitor Centre
Location: CD\ppt\1.1.3 Chiow Giap – NEWater Singapore.ppt

The Ministry of Environment covers health and the environment. They have formed the Department of Environment which is now the National Environment Agency. The National Environment Agency and PUB are two agencies involved in Singapore's clean air, clean land and public health.

Singapore's GDP has increased by 24 times, water demand is up 4.5 times and the population is up 2.5 times on what it was 40 years ago.

PUB treats the complete water cycle. They insist you call it a water reclamation plant not a sewage treatment plant. Some of the water is used as NEWater, but the primary use at present is to supply it directly to industry (around 15% of industry water comes from NEWater). The secondary use at present is the small amount that goes into reservoir water for indirect potable reuse. PUB also desalinates water for potable and industry uses.

PUB's thrust is to:

1. Ensure a diversified and sustainable supply of water for Singapore
2. Adopt a 3P (private participation process) approach to engage partners to conserve water

Their 3 major strategies are:

Strategy 1. 4 National Taps (Diversify water sources)

Singapore has developed four sources of water:

- Rainfall and catchment in reservoirs;
- Johor pipeline from Malaysia (Contract expiring in 2011 and 2061) where water is imported to Singapore;
- NEWater; and
- Desalination.

The 4 National taps have helped Singapore to close the water cycle loop. Technology development is also considered crucial in diversifying and providing water.

The local catchment water will be increased from 1/3 to 2/3 of Singapore's area by 2011 (total area of Singapore's main island is 46.62 km^2, counting all the islands the total area is 640 km^2). Evolution of catchments is from pristine catchment to highly developed catchments. The Marina Basin is being made into a Barrage/Reservoir. Marina Barrage is a 3 in 1 project:

- Flood control
- Water supply (a reservoir in the middle of city)
- Lifestyle (including Casino)

Strategy 2. Closing the water loop

100% of Singapore's sewerage is collected. A deep tunnel sewerage system will be used to do this as Singapore develops. Stormwater management maximises yield by diverting drain water into reservoirs instead of out to sea.

Area of land without Flood control in 1970 was 3178 ha, today it is 147 ha and by 2007 it will be less than 100 ha.

Strategy 3: Technology Development.

Leverage on R&D to increase water resources, manage water quality and lower production costs. Singapore Utilities International develops technologies internationally, e.g. Membrane bioreactors ultrasonic disintegrations of used water sludge.

- About 150 PUB staff work with experts from the CAWT, PUB's scholars as well as NUS/NTU on R&D projects
- PUB's in-house research arm with 50 staff, mostly PhDs, doing R&D testing for PUB and industries

PUB promote sustainable water management through a "Conserve, value, enjoy water" promotion.

<u>3P program</u>

1. Conserve water. Water Efficient Homes/Buildings. Target to reduce per capita domestic consumption to 160 litres per day
2. Value our water. Getting private and people sectors to help keep our catchments and waterbodies clean
3. Enjoy Our Waters. Opening up reservoirs for lifestyle activities e.g. sports and recreation

Get private and people sector to help keep our catchments clean.

There will be four NEWater supply zones

- Kranji – 9 mgd, commissioned January 2003.
- Seletar – 5 mgd, commissioned 2004
- Ulu Pandan – 25 mgd, to be commission in 2006
- Bedo – 6 mgd, commissioned in January 2003.

NEWater production process is Treated Used Water – Microfiltrations/unltrafiltrations – reverse osmosis – Ultra-violet – NEWater.

Figure 1: Study tour participants in front of NEWater visitor centre and water factory.

NEWater Visitor Centre is the focal point of continuing education on:

- The importance of water
- Role of NEWater as one of the 4 National taps
- The technology behind NEWater
- The visitor centre targets mainly the younger generation (e.g. students). It is visitor friendly with multi-media computer interactive activities (games) and videos. It also provides first hand experience of the NEWater plant operations.

This is the place for school children to come at least once in secondary education and once in primary education. 240,000 visitors have attended NEWater so far, many of them from overseas.

Questions

Average use is 170L/d/person and their target is to decrease this to 160 L/d/person. The population has gone from 3.5 to 4 million people in the last 3 years. The population growth of Singapore is approximately 2-3%.

Why locate the Changi plant where it is? It is located on reclaimed land and land use is a significant factor - it is in the middle of an industrial area. Two big plants allow them to take advantages of scale. This is also the lowest part of the land for the Western part of Singapore. The water treatment plant was conceptualised on gravity. They currently have over 130 pumping stations and hope to not need most of these. They are keeping the older plants once the Changi plant is operational, and they will need to consider in the future how to optimise the operation and volumes going to the other older plants. There are some opportunities for sewer mining. However, PUB believed larger scale collections of used water is much more cost effective, especially as their population is very dense. Even with grey water reuse, small scale is not considered economically feasible compared with large scale.

Since the centre of education has been established in 2003 have public perceptions changed?
No, the Singaporean realised that they must recycle water and adopt it relatively easily.

How do you make the trade off between energy costs and water extraction?
The cost to produce NEWater is $0.30/KL. Cost is based on used water already completing a standard of treatment to discharge to the environment.

Arris would like to thank Syed Omar Fadzil (Corporate Communications Department) for supplying his photos for the tour participants' use.

1.1.2.4 Stormwater management in Singapore

Speaker: Ms Sophie Lim
Presentation: Water for All. Conserve, Value, Enjoy. Stormwater Collection Facilities
Located: CD/ppt/1.1.4 Lim – Stormwater Singapore.ppt

Barrage gates use water sensitive devices. PUB used a planning approach with other government agencies (i.e. Land Use Planning). Many of the ponds are under expressways, or football oval above the ponds, where big fences are required to prevent balls from entering.

Questions

There is no nutrient problem in stormwater capture as there is no agriculture in Singapore. PAH isn't seen to be a big problem as a good rain day can bring 25 mm rain. 25 to 50 mm per day is common so the catchment is cleaned regularly in the wet season. Soil erosion is a bigger problem. Connection to sewerage is mandatory for all industry and residents. Industry must treat waste to PUB standards before releasing it into the sewer. Water quality is 50 mg/L TDS. So salinity is not a problem and effluent water is still not very saline, making treatment cheaper. Singapore is relatively flat and small (Singapore East to West is 30 km) so pumping costs are low. Approximately 30% of the runoff goes back to sea as it is not cost effective to treat. Private Participation Process = PPP.

Singapore is not an agricultural country and is relatively small, so if water is captured and used for potable purposes and then goes to the sea there is a fairly insignificant reduction in environmental flows.

Table 1 NEWater - Questions and answer summary table

Questions	Answers
Drivers	
What were the key drivers for the scheme?	Importing water and needed additional water for the future.
What incentives etc were given to customers?	NEWater customers do not pay the 30 – 45% Water conservation tax. See Costs below.
Risks	
What was considered the major risk during development?	Maintaining the trust of the public.
After establishment, what new or unexpected risks appeared?	None, so far.
How are commercial risks allocated?	PUB is a self funding Government enterprise and needs to run at a profit, and does.
Health, Environment and Resources	
Was there any environmental impacts?	None were discussed, but there are some questions on environmental flow and removal of stormwater from the hydrological cycle. The brine produced from the process is disposed at sea and no impacts of this were discussed.
Was there any human health impacts?	No
What are the key benefits?	Water supply independence. 4 Taps (sources) of water give them security.
Are there alternative water sources available?	4 Taps. See text above
How much recycled water is substituted for drinking water?	1 - 3% is used for potable / indirect potable. NEWater supplies about 15% of industry water. There are currently 3 Plants running. 5ML/day, 9ML/day, 6 ML/day and in 2006 a 25 ML/day plant will be commissioned.
Who does the auditing and monitoring?	PUB does the monitoring and they are audited by the National Environment Agency of Singapore. They used to audit themselves, but this has changed over the last decade with restructuring of the government departments and the formation of PUB.
How have you managed salinity levels in the recycled water and ground/soil?	Salinity is not an issue as the TDS of the reservoir water is 30 - 50 mg/L TDS and with the increase in the sewer it is approximately 100 TDS. So the effluent is still relatively good water from a salinity perspective.
Are there any other environmental management issues?	None were discussed
Have you assessed the impact of pharmaceuticals, personal care products and industrial chemicals on groundwater dependent ecosystems when using ASR for indirect potable reuse?	No ASR used, but membrane technology removes all of the issues.
Are there any emerging pathogens	PAHs

or chemicals of concern?	
Lessons	
What would you do differently next time? (Technology, acceptance operational, efficiency, customer interface, price).	Nothing
What issues and problems arise in mature water recycling schemes that could have been planned for at implementation?	The demand for the demonstration bottled water outstripped supply in the first 3 months of starting the community education program. We should have had more available earlier.
What is the most critical consideration for this particular reuse scheme?	Getting the technology right, get the experts in your country working on it (eg University, Government Research Organisations) Getting political support Gaining the trust of the public.
Were there any unexpected benefits?	NEWater has also become a tourist destination of the World. Leading the way in indirect potable reuse.
Issues	
What issues have arisen for end users during operation of the scheme?	None
Salinity/sodicity issues?	None
What happens to your biosolids?	Most goes to landfill. It is processed using digesters at present. However, they are trialling ultrasonic digestion of sewage sludge and are achieving 30% reduction in volume (solids?) and 30% increase in gas production. They have not yet assessed the economics of doing this.
Costs	
Who funds it initially?	PUB is a self funded government agency.
Who funds it long-term?	PUB will continue to fund NEWater as part of its self funded business.
How much is charged for the water? Pricing structure?	Domestic drinking water has two prices: 1) If consumption is <40KL/month $1.17 + 30% water conservation tax + $0.30 water treatment cost. So a total cost of $1.82/KL. 2) If consumption is >40 KL/month $1.40/KL + 45% water conservation tax + $0.30 water treatment cost. So a total cost of $2.33/KL. A household in Singapore uses about 20 KL per month or 162L/day/person. There is also a wastewater charge. $0.30/KL domestic and $0.60/KL for non-domestic. All $ in this cell are Singapore dollars.
What is the willingness to pay for recycled water?	Great support.

What is the cost to produce the recycled water? Including capital repayments allowance for grant monies etc?	NEWater costs $0.30/KL to produce.
What is the cost of potable water?	As per above with Water conservation tax.
Is it full cost recovery?	Yes.
Is there any ongoing & shortfall from revenue Vs apex costs?	Not known.
Are the any outstanding cost issues?	None reported.
Operational and end user requirements	
How are end users administered – costs, good management practices, agreements?	No special requirements are required for NEWater as it is fit for drinking and has a salinity concentration of approximately 30 mg/L TDS.
What changes have growers/users had to make in their management practices? How have they been assisted?	None.
Does the project address seasonal variations in demand (winter storage)?	Industrial and potable uses are constant requirements throughout the year.
What is the period of time for the scheme to have full take-up?	The scheme started in 2001/2 when there were great concerns of the security of imported water from Malaysia. It is now (June 2005) fully operational and well accepted in the Singaporean community.
What are the inline QA systems? Eg Backflow devices.	Sample points are online for the R/O plants. Pressure monitoring for integrity of membranes?
Water quality	
See Table 2 below or http://www.pub.gov.sg/NEWater_files/newater_quality/index.html	
Communication/engagement/partnership programs	
What where the community's perceptions of reuse?	Considered as the norm.
What strategy has been used to obtain community acceptance of product (fit for purpose)?	Reclaimed water classes are fit for irrigation and Guidelineyyy
How were community expectations/concerns dealt with?	
What was the public engagement strategy? Eg Extent of customer and community consultation undertaken – what worked well and what didn't?	2 issues, engineering challenges, must make the public aware of this. Learnt from the USA experience. If public does not accept this then you cannot use NEWater for potable use. Right from the beginning, once engineering treatment confirmed, an extensive education program is necessary. 1: confirm you have good water, 2: get political view on side and trust of public figures 3: extensive public education. In a period of two months the public education program was completed with full ministerial support. Now they have undertaken the long term education program for

	the public. Direct and indirect potable reuse is something that helped this guideline. PUB learnt significantly from the USA and adopted a cautious approach. The reality is that water has been recycled indirectly for ever as part of the water cycle. The plan is to have NEWater supply 15% of Singapore's total supply of indirect potable water by 2012.
Was consumer market research undertaken?	No, this wasn't done as we just had to make it work.
	Industry has no perception issues. Drinking water has an environmental tax, NEWater does not have this so it is cheaper.
Regulation	
What is the regulatory structure/framework for recycled water?	Recycled water is use driven solely. Population 4.2 Million, 680 sq km. Singapore 1.4 GL/day 300 mgd, 1.62 L/person/day.
What are the water quality standards for each purpose?	Infrastructure for dual reticulation was too expensive, so indirect potable reuse was chosen as the way forward.
For dual reticulation legislation, what is the compulsion for customers to connect?	Industry has two water lines, ReWater pipe and Potable water pipe. Domestic customers have only the potable water which has the indirect potable water
Current and future innovations/technology	
What are the future challenges and directions facing water recycling schemes? (Governments, water industry, business).	See DVD. In the future PUB's challenge will be to make another tap (5th Tap) which is industry wastewater that currently goes to sea. The government has asked PUB to assess the feasibility of doing this as membrane technology develops.

1.2 Stormwater pond – Singapore

The pond has a 30 GL, 15 GL/day pump capacity with a grill drain where water enters the pond when flow exceeds low flow. The first flush pump pumps the first flush to sea and the rest is pumped to the reservoir. There is a 150mm (approx) grill on the drop grill from the stormwater drain to the pond and some manual removal of rubbish in the pond is required. However, the high rainfall and clean city keeps the removal of rubbish to a minimum.

Table 2 **NEWater water quality from: www.pub.gov.sg/NEWater_files/newater_quality/index.html**

Water Quality Parameters	NEWater	USEPA /WHO Standards
A) Physical		
Turbidity (NTU)	<5	5 / 5
Colour (Hazen units)	<5	15 / 15
Conductivity (µS/cm)	<200	Not Specified(- / -)
pH Value	7.0 - 8.5	6.5-8.5 / -
Total Dissolved Solids (mg/L)	<100	500 / 1000
Total Organic Carbon (mg/L)	<0.5	- / -
Total Alkalinity (CaCO3) (mg/L)	<20	- / -
Total Hardness (CaCO3) (mg/L)	<20	Not available
B) Chemical (mg/l)		
Ammoniacal nitrogen (as N)	<1.0	- / 1.5
Chloride (Cl)	<20	250 / 250
Fluoride (F)	<0.5	4 / 1.5
Nitrate (NO3)	<15	- / -
Silica (SiO2)	<3	- / -
Sulphate (SO4)	<5	250 / 250
Residual Chlorine (Cl, Total)	<2	- / 5
Total Trihalomethanes (as mg/l)	<0.08	0.08 / -
C) Metals (mg/l)		
Aluminium	<0.1	0.05-0.2 / 0.2
Barium (Ba)	<0.1	2 / 0.7
Boron (B)	<0.5	- / 0.9
Calcium (Ca)	<20	- / -
Copper (Cu)	<0.05	1.3 / 2
Iron (Fe)	<0.04	0.3 / 0.3
Manganese (Mn)	<0.05	0.05 / 0.5
Sodium (Na)	<20	- / 200
Strontium (Sr)	<0.1	- / -
Zinc (Zn)	<0.1	5 / 3
D) Bacteriological		
Total Coliform Bacteria (Counts/100 ml)	Not detectable	Not detectable
Enterovirus	Not detectable	Not detectable

1.3 Waterworks Membrane Plant – Chestnut Avenue, Singapore and Marina Barrage Reservoir

Presentation: Water for All. Conserve, Value, Enjoy. Chestnut Avenue Waterworks
Located: CD\ppt\1.3 Chestnut Ave Waterworks - Singapore.ppt

Stage 1. Capacity 60 mgd, completed in 1975 at a cost of $19 million. Equipment controlled by SCADA 680.

Stage2. Capacity 60 mgd, completed in 2003 at a cost of $168 million. Equipment controlled by SCADA 2130. The treatment train is outlined in Figure 2.

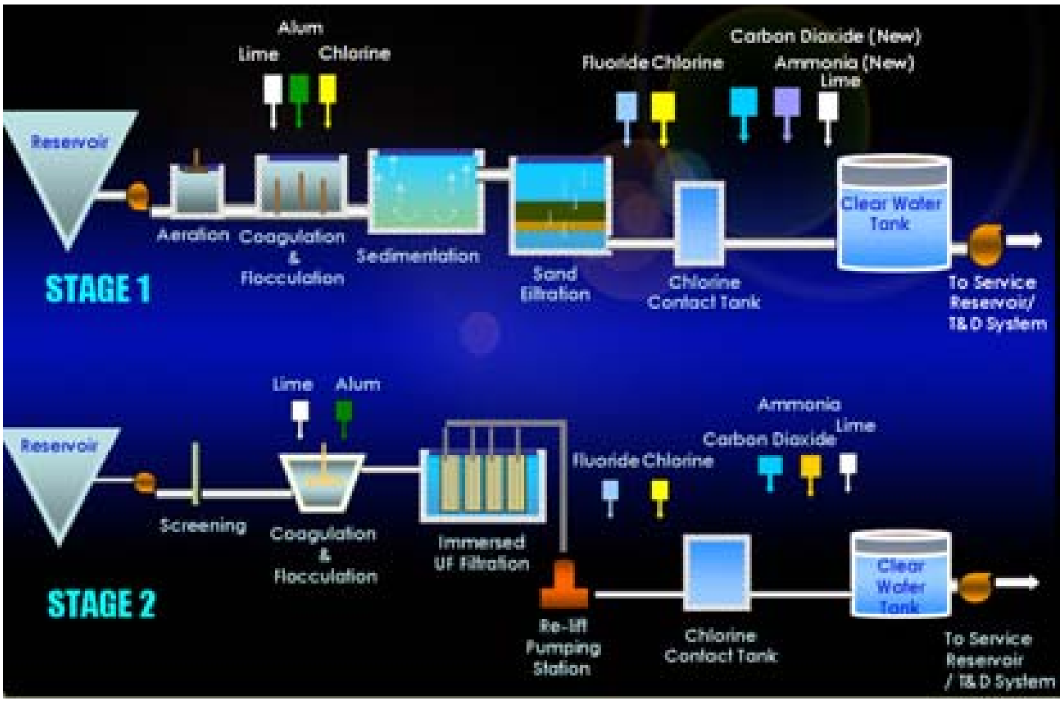

Figure 2 Chestnut avenues waterworks (potable water) treatment facility, Singapore.

Zee Weed 500d Operation

- Airline
- Permeate
- Header 500d Cassettes
- Concentrate

The new plant will be 273 ML/day or 60 mgd with 16 membrane tanks.

Membrane Plant Operations

Clean in place Operations – Maintenance clean carried out weekly with sodium hypochlorite solution. Recovery Cleaning is a two stage process:

Parameter	Stage 1	Stage 2
NTU	0.2-0.3	0.2-0.2
pH	6.0-6.4	6.0–6.2
Color (Hazen color)	<0.5	<0.5
Residual Aluminium	0.02 mg/L	0.02 mg/L

Singapore does not have a problem with Cryptosporidium and Giardia as there is no agriculture. But water from Malaysia is closely monitored.

The WTP is monitored 24/7.

Rural water quality is decreasing in quality, leading to changes in the membrane required. This plant is designed for the future; water may be taken from the Barrage area, which is a reservoir in the city where pollution may be higher as the water comes from a pristine catchment. To protect the water catchment, catchments are not allowed to have any hard hoofed animals.

Neutralisation is with citric acid, to dispose of the hypochlorite waste from cleaning filters. New filters will be nano technology. Filtration and sand filters work well together. Currently they use a lot of alum, but with membranes the flocks can be lower and still work well. Phosphoric and citric acid are also used for cleaning membranes.

What chemicals/pollutants are the biggest risk or most difficult to remove or prevent entering the water supply? Membrane integrity is monitored using pressure and after a certain number of membrane leakages they must shut that cell down completed. Trace organics are the biggest concern. Streams coming into Marina Bay and solvents are the biggest concern. Even formaldehyde has been detected in some sewage water.

They are upgrading this plant ahead of time, but are still keeping their options open as ultrafiltration is a good pre-treatment if they need to go to nano-filtration in the future due to the PAH, trace organics and solvents.

Three armed guards patrol the boundary of the treatment plant (not the reservoir) as they are obsessed with security at the WTP.

1.3.1 Quote of the Day

“Don’t wait for it to happen, make it happen! “

“Water sustains all” – Thales of Miletus, 600 BC

“You don’t miss your water until your well runs dry” – an old English country proverb

“Water is the driver of nature” – Leonardo da Vinci

1.3.2 Participants wrap up

Perceptions and acceptance of NEWater is fantastic. The education facility is fantastic* and leadership from the top is brilliant. The overall vision is fantastic as is the faith in their people to make it work. The importance of keeping abreast of technology and commitment to R&D is admirable and the investments made have been fantastic*.

*Fantastic is “the word” they use consistently in the visitors centre for the message they would like visitors to take away with them.

It is much better economics to put water into the pipes you have already. Town planning and rubbish management with stormwater is managed really well to keep wastes out of the storm water systems (eg wash down areas in high rise building bin areas go to the sewer).

Stormwater is very clean due to volume and flushing. Erosion (slope x volume) means silt is the bigger issue with respect to stormwater quality. Any air pollution is blown off the island. Storm water control measures have people fences everywhere.

It was well worth the visit. The visitor centre was great and much bigger than was thought from seeing pictures. All the information on water quality, safety and treatment had been brought down to Ministerial level (eg a 5 year old kid). They had engaged a communication company to do the promotion with a “fantastic” message. The whole feel of the place was that it was really well looked after and managed. Every single employee was drinking NEWwater and everyone on the tour drank the NEWater without a problem.

The performance of the plants was even better than the specification. Scale was an issue if pH wasn’t controlled tightly. There is a 15 minute backwash required for membranes. The cost of membranes is still coming down.

2 Program: 31st May, Florida

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Tour organisers thank David York, Florida Department of Environmental Protection, for his assistance, knowledge and contacts when planning the Florida leg of this tour. David's assistance was instrumental in us gaining Florida connections at the appropriate level to meet the needs of tour delegates.

2.1 Water Conserv II Reclamation Facility - City of Orlando

2.1.1 Key contacts

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2.1.2 Water Conserv II Reclamation Facility (WRF) - City of Orlando.

2.1.2.1 Background (from tour book)

http://www.cityoforlando.net/public_works/wastewater/reclaim.htm#wc2

The McLeod Road Water Pollution Control Facility was constructed in 1964 to provide sewer service to the western half of the City. The facility was rated 4 mgd and utilised primary clarifiers, trickling filters, and secondary clarifiers, followed by chlorination for treatment. The facility was expanded in 1970 to 12 mgd of capacity and the biological process was changed to an activated sludge system. Effluent was discharged to Shingle Creek, which ultimately reached Lake Tohopekaliga.

At the same time that the City faced a March 1988 zero-discharge mandate for its McLeod Road plant. Orange County, whose Sand Lake Road Treatment Plant also discharged to Shingle Creek, was faced with a similar order. (The City of Orlando is located within Orange County.) To maximise federal grant funding and because of the close proximity of the two treatment plants, the City and County decided to embark upon a joint project: the Water Conserv II Water Reclamation Project. They commissioned the Southwest Orange County 201 Facilities plan to evaluate the available effluent disposal options which could provide the estimated 50 mgd of capacity required by both entities. Citrus irrigation and rapid infiltration basins (RIBs) appeared to be the most viable option for a readily implementable program.

Studies showed that 10 to 15 miles west of McLeod Road and Sand Lake Road facilities, the geological features of the land were conducive to the surface application of reclaimed water. While citrus irrigation was both viable and cost effective, it could not provide an all-weather effluent disposal solution. The use of RIBs appeared to be equally viable, but required the acquisition of 4,260 acres for RIB construction, making it more costly than practical. Combining both citrus irrigation and RIBs offered the desired level of economy and flexibility. The system not only reduced demand on the

Floridian aquifer by eliminating the need for well water for irrigation, it also helped replenish the aquifer and stabilise area lake levels.

A list of water quality criteria was developed to protect the citrus trees from damage as a result of irrigation. A 20-year commitment from participating growers needed for federal funding compliance required the development of an agreement to formalise the terms and conditions of reclaimed water use and delivery. After hundreds of hours of intensive study and negotiation over a year's time by the City and growers, the plan was developed.

The resulting agreement represents a significant departure from conventional lease arrangements used previously for normal effluent disposal. For example, if a grower desired to stop utilising a parcel of land as described in the agreement for the purpose of irrigation, modification or termination of the agreement prior to the end of its term could be achieved in one of the following three ways:

- Quantity or quality of water specified could be modified if the water proved detrimental to citrus production.
- The grower could construct facilities required to transfer his commitment from one parcel of land to another at his own cost or by compensating participants for the associated costs.
- The grower's obligation to accept his/her allocation of reclaimed water on the land specified could be terminated by the grower paying participants $3,600 per acre for the cost associated with the distribution system minus five percent that amount for each year water had been accepted up to the time of termination.

The treatment process train designed for the Water Conserv II effluent disposal program met state requirements for slow rate land application (i.e., secondary treatment followed by high level disinfection with TSS level not exceeding 5 mg/l and no detectable faecal coliform or virus). Because the criteria dictated that the water be safe for human contact, one of the most critical phases of treatment related to suspended solids removal and disinfection for bacteriological and viral deactivation. Pilot testing was performed to evaluate different filtration systems and varying levels of chemical addition. Results indicated that secondary treatment, followed by flocculation with alum, filtration with dual media filters, and chlorination was effective in deactivating the virus.

Numerous improvements were made to the Conserv II Water Reclamation Facility in order to meet the required water quality for citrus irrigation. The most important and difficult limit to meet is the 5 mg/l of total suspend solids (TSS) needed to prevent clogging of irrigation nozzles and to ensure complete pathogen removal.

A dual medial rapid gravity filtration system was employed to coagulate and remove TSS. The filter material consists of 12 inches of graded silica sand with 12 inches of anthracite coal on top. Success of the filtration and subsequent chlorination system can be measured by the virus testing that has consistently produced less than zero plaque forming infectious units (PFUs).

Following treatment, the reclaimed water is pumped by a 4,000 HP transmission pump station located at the treatment facilities through approximately 15 miles of 42- and 54-inch diameter prestressed concrete cylinder pipe to a distribution centre located in west Orange County. The distribution centre is equipped with four 5 mg storage tanks, pumping facilities, and operation and maintenance buildings. During normal operation, the reclaimed water is pumped from the distribution centre into a 24-mile pipeline network which transports the water to participating citrus growers at a minimum residual pressure of 40 psi. When the growers do not wish to irrigate or the quantity of effluent exceeds the available irrigation capacity, the reclaimed water can be discharged into RIBs. Because disposal into the RIBs is short-term in nature, the area requirements are minimised, making efficient use of available lands.

Currently, reclaimed water is being supplied to 24 growers through a series of 50 turnouts along the distribution system. Since the system began operation in December, 1986, over 35 billion gallons has been pumped to the distribution centre for redistribution to the citrus groves and RIBs. In 1989, the project won the annual American Consulting Engineers Council's Grand Conceptor Award for its attention to environmental and social concerns.

As a result of ceasing discharge into Shingle Creek, 1990 water quality data reflects a 96% reduction in total phosphorus and 93% reduction in total nitrogen that was found in 1980.

The City of Orlando's total construction cost for Water Conserv II was $100 million.

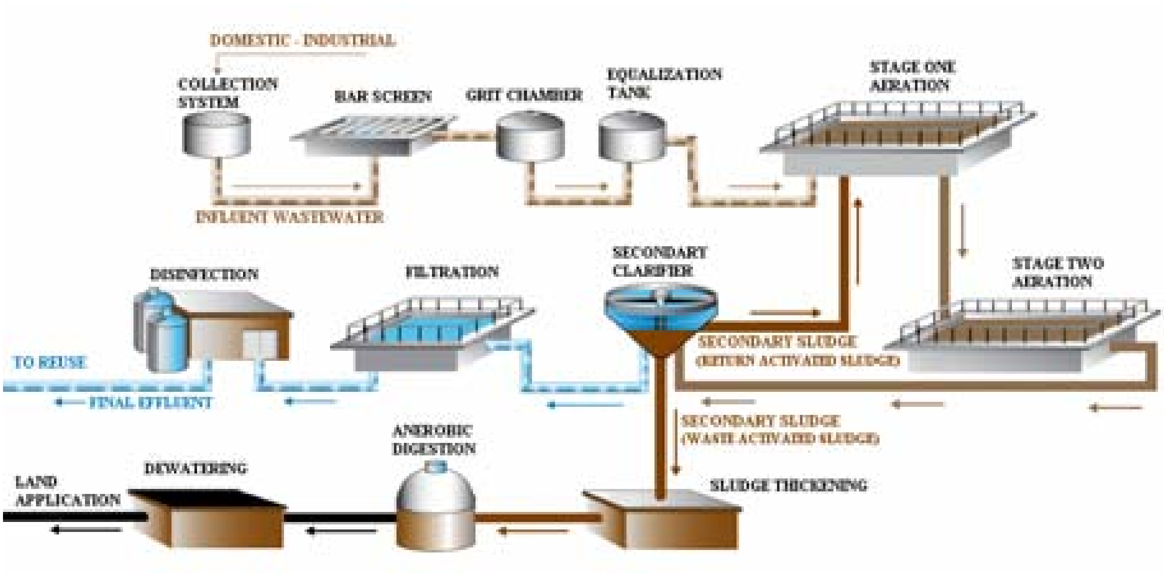

Figure 3 Design of Water Conservation II reclamation facility, Orlando.

2.1.2.2 Biosolids

The sludge press facility is a 4-belt press. The best they get from this is a 14% dry solid. Biosolids are applied to orange trees, pasture and hayfields. The water company pays for haulage and application. It is probably equivalent to class B in Australia. They will be using heat stabilisation to get it to class A. Co-generation is not run anymore. Diesel generators are for back-up power. The cost of maintaining Co-generation generators was too high and the whole process wasn't cost effective. They produce about 80t of biosolids per day. This is lime stabilised (10% lime) secondary treated sludge. Approximately 50% of the biosolids go to one farmer and he loves it.

2.1.2.3 Clarifiers, chlorination

Aqua clarification is accomplished using 2 million gallon tanks after clarification, before filtration. About 80% of the water goes to their distribution centre (Wayne) and 20% goes locally to golf courses and universal studios. The city has a mandate that any new development must take recycled water. If they don't have the facilities they must put them in.

The chlorine facility keeps 24 - 36 tonnes on site and uses about 0.5 mg/L total for disinfection. For reuse 1.0 mg/L is required and they operate at adding 2.0 mg/L. Total chlorine and ammonia use is usually low enough to get free chlorine. Chloramines cause problems in pipes.

They have no N or P problems, but nitrate of 12.5 mg/L can impact on sensitive plants.

Feacal coliform was <1 with a max of 25/100 ml of water.

< 2.0 NTU picks up breakthroughs, valves control feedback to shut system down.

Their biggest problem is they get lots of mosquitoes, which lead to spiders, birds feed on spiders and then poo in the water, increasing faecal coliform.

2.1.2.4 Reclaimed water

Fire fighters using hydrants at the WRF and don't have a problem. Recycled water is not used offsite for fire fighting as they could not guarantee pressure. Locally they use 7mgd and can distribute up to 145 mgd. The average is 25 mgd. The class of water is "reuse", they only have "reuse" and "discharge" quality that these operators referred to. Discharge quality exceeds the quality of drinking water, except for faecal coliform. With surface water discharge they use a fatality test (Add shrimp like organisms in water to see if they survive) to determine if it is at an acceptable standard. At present the WRF averages 25 mgd and they are looking to upgrade supply to 40 mgd. It has a load of 200,000 EP.

The Environmental Control Department, which is part of the water treatment authority, licenses discharges to the sewage system.

Florida is moving away from discharge to surface water bodies. They have a water supply problem as they get a lot of rain, but a lot ends up in the ocean. There is no stormwater reuse. Most stormwater goes to rivers or retention ponds. Any new construction must contain 1.5 days on–site storage. All public drinking water must be extracted from 300 ft beneath a lime aquifer (water is very hard), this give protection to water quality.

Cost is US $60/month for sewage and water. Universal Studios is the major user and they don't pay for the recycled water. Pantone purple 522c is the recycled water color from the federal color code (Chapter 62-610 reuse of reclaimed water and land application www.dep.state.fl.us/legal/rules/wastewater/62-610.pdf).

WRF terrorists control is fences and locked gates, security cameras are minimal.

They have not had an odor complaint in 6 years.

Table 3 Permitted capacities and effluent limitations for the Water Conserv II Reclamation Facility - City of Orlando.

Parameter	Designed/permitted limit
Permitted flow capacity	25 mgd
CBOD5	60m/L single sample 45 mg/L weekly average, 30 mg/L monthly average, 20 mg/L annual average
TSS (before disinfection)	5 mg/L
Faecal coliform	<1/100ml
pH	6.0 to 8.5
NO3	12 mg/L monthly average, 10 mg/L annual average
Total Chlorine Residual	Never less than 1.1 mg/L
Protocol	
Pre-filtration total chlorine residual	Never greater than 0.5 mg/L
Pre-chlorination turbidity	< 2.0 NTU

They estimate it would cost $15/1000 gallons of potable water for operation of desalination near the sea.

2.1.3 Water Conserv II Distribution Centre

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.
Chuck Nichols (helped arrange the tour).
Project Manager
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Phil Frost

2.1.3.1 Background (from tour book)

www.cityoforlando.net/public_works/wastewater/distribution.htm

Faced with the need to expand wastewater treatment services and a state requirement to eliminate discharge of treated effluent to surface waters, Orange County and the City of Orlando jointly developed an innovative water reclamation program.

The Water Conserv II/Southwest Orange County Water Reclamation Project involves the use of highly treated wastewater, called reclaimed water, for citrus irrigation and groundwater recharge through rapid infiltration basins (RIBS). It is one of the largest water reuse projects in the country, and the first reuse program permitted in Florida that involves irrigation of crops intended for human consumption. The project provides approximately 28 million gallons per day (mgd) of reclaimed water and will ultimately deliver 50 mgd.

Advanced Treatment

The project includes two treatment facilities: Orlando's Water Conserv II Water Reclamation Facility and Orange County's Sand Lake Road Wastewater Treatment Facility, which have been upgraded and expanded to 25 mgd and 31 mgd, respectively. Both treatment facilities are designed to produce virus-free reclaimed water suitable for citrus irrigation and safe for human contact.

Advanced secondary treatment to reduce turbidity and remove viruses is achieved through dual-media (carbon and sand) filtration and chlorination. Because of the strict treatment requirements, extensive pilot testing of the filtration and disinfection processes was performed. Both facilities were designed to meet EPA Class I Reliability Requirements to ensure a clear, odourless, and virus-free product.

Transmission

After treatment, transmission facilities transport the reclaimed water from the metropolitan area to the centre of the agricultural community located about 15 miles to the west. Large effluent pump stations at each treatment plant pump the reclaimed water to a common transmission force main. The transmission main, which varies from 42 to 54 inches in diameter, extends 21 miles to deliver the combined flows to the distribution centre.

Distribution

The distribution centre includes for 5 million gallon ground storage tanks, a 100 mgd pumping station, a maintenance building, and an operations building with computer facilities for monitoring and operating the system.

From the distribution centre, reclaimed water is pumped through the distribution system to citrus groves for irrigation and/or rapid infiltration basins for recharge of the aquifer. The distribution system includes over 30 miles of pipeline, 23 supplemental wells, and over 20 computer controlled, metered connections. Under 20-year contracts, the water is delivered to the participating grower's property lines for use in their irrigation systems.

The Innovative Reuse System

The citrus irrigation and rapid infiltration basin reuse methods complement each other. Citrus irrigation provides beneficial reuse without costly land acquisition. Rapid infiltration basins provide reuse capacity when irrigation demand is low. Both systems provide the added benefit of recharging the Florida aquifer.

The citrus irrigation system currently provides reclaimed water to about 8,000 acres and will ultimately serve between 12,000 and 15,000 acres. A key environmental benefit of the system is the conservation of our freshwater supply. Without reclaimed water, these thousands of acres would continue to be irrigated with groundwater from wells on each grower's property.

The project also aids the agricultural community, which has recently suffered from diminished rainfall, damaging freezes, and more stringent groundwater use restrictions. Benefits to the growers include a dependable water supply for irrigation and freeze protection, potential reduced fertilisation due to nutrients in the reclaimed water, and reduced energy costs because the water is delivered under pressure.

The rapid infiltration basin system consists of 60 individual basins, each about 300 to 400 feet long and 150 feet wide. The reclaimed water percolates rapidly through the underlying sands, which range in depth from 30 to 200 feet. This sand layer provides additional filtration before the reclaimed water reaches the aquifer to replenish the freshwater supply.

The rapid infiltration basins are distributed over four different sites covering about 1,600 acres of freeze-damaged citrus groves and open land in an area of groundwater recharge.

Instead of the traditional rectangular shape, the basins are curved to maintain the existing landform and natural character of the gently rolling landscape.

2.1.3.2 Site visit

An extensive reforestation program was designed to return the area to its pre-citrus, forest-like state. Between 500,000 and 600,000 seedlings and shrubs have been planted, including long-leaf pines, turkey oaks, pawpaws, gopher apples, and other native species. The reforested land attracts wildlife once common to the area.

The City of Orlando/Orange County water reuse project has become a benchmark for other communities faced with a water reclamation challenge. The program demonstrates how cooperative efforts between the urban and agricultural communities can result in water reuse projects that effectively satisfy the water-related needs of all.

There are currently 14 million people in Florida and they estimate there will be 20 million in 2020. Most of these people live in the coastal counties.

Reclaimed water is used for wetlands, cooling towers in power stations, washing and cleaning buses at Disney resort, watering golf courses, and hay, wheat, soy bean and citrus production. Secondary treatment and high-level disinfection makes it comply with Florida regulations. It passes through a series of baffle that allows long enough contact time to ensure a chlorine residual.

Turbidity, SS, pH, Chlorine residual and faecal coliforms are all monitored, with data reviewed by the Florida Department of Environment Protection. Regulations are there to make sure it is safe for human activities around where it is used. There has never been a public health issue from the use of reclaimed water. Recycling of wastewater can be done safely.

The power station generates power for 200,000 people using 7 mgd of recycled water in two 450 ft cooling towers. The reclaimed water is condensed and reused back in the cooling cycle (recycled).

Disney complex uses reclaimed water as well; some of this is for the animals in the Disney park animal kingdom, where they have created an African savannah. 300 buses are used to carry people around the Disney complex; they are washed every day. Fresh water is used for the last rinse. Part of the reclaimed water from the Reedy Creek WRF is used for recharge of groundwater.

Over 300 golf courses are using reclaimed water across Florida. Millions of gallons are used saving potable water from the aquifer. Annual rainfall is 50 inches. Sometimes they go 60 days with out rainfall, so irrigation is also required.

Approximately 11,000 acres of citrus groves are irrigated with reclaimed water. Reclaimed water is available to citrus grows 24/7. There are also some nutrients in it which offsets some of their fertiliser crops. Reclaimed water has given them security to maintain and develop citrus groves. Sandy soils require constant irrigation to maximise yield. There are about 2000 acres of soybean, corn, coastal Bermuda grass and other crops also grown.

Residential irrigation demand is also growing. People love it; home owners want to use it because it is cheaper and helps conserve potable water sources. They like it and they don’t think about it much as it has become normal.

Reclaimed water is used primarily to free up potable ground water for drinking, making aquifers sustainable. About 2 billion gallons of reclaimed water is used and saves the equivalent in aquifer water. “Use it again Florida” is their catch line.

Questions

Is it considered indirect potable reuse through the aquifers? In Orlando they have been through public consultation and this is accepted, but there has been no general acknowledgement as indirect potable reuse, but as natural replenishment of aquifers. Movement from infiltration bay to where it may be extracted from the aquifer could take a year and this is considered the natural component.

Demand is much higher than they are able to supply. Pricing could be used to decrease the demand. The goal is to ensure that every gallon of reclaimed water replaces a gallon of potable water. There is plenty of water out their but it is a matter of if you can afford it. A citrus grower cannot afford to pay the same as urban people.

Ground water is not costed per volume, just bore and pumping costs. For the reclaimed water system, farmer receives water at 40 PSI then the farmer is responsible to irrigate tree and the systems used.

Dr Koo and John (Robert. C J. Koo. was a local researcher) promoted the scheme and won the community's trust of the reuse schemes developed. The EPA funded $180 M to build the infrastructure and start the scheme. The scheme is now approaching $300 M total capital spent as it has expanded.

Some references to the work Dr Koo contributed to are:

- Koo, R.C.J., and M. Zekri. "Citrus Irrigation with Reclaimed. Municipal Wastewater." *Proceedings Florida State Horticultural Society*. 102:51. 1989.
- http://www.lal.ufl.edu/CRECHOME/parsonsprofile.htm
- http://www.ag.arizona.edu/AZWATER/research/2004/Schuch2.pdf

Citrus prices have fluctuated over the years with harsh environmental conditions. Imports have also impacted on prices. For a 90 lb box they get $4 per box. For grape fruit they get $15 per box. Before the storms it was $5 per box, highlighting the volatility of the agricultural markets. The produce retail market is pretty well set by Wal-Mart (supermarket chain).

Reclaimed water people don't apply boron fertiliser anymore as they get this from the reclaimed water. The pH of reclaimed water is better than bore water, but nitrate is not high enough to meet orange tree demands. The water treatment authority is responsible for ensuring the water is being used properly, the farmers don't even know what the water authority is doing to ensure this.

Excess water decreases the amount of sugar per box of citrus and they get paid per sugar content, so over watering isn't cost effective. Groundwater monitoring is ongoing. Carrot philosophy is that if you follow strict BMP, i.e. 200 pounds of nitrogen/acre/year and no more than 60 lbs per application, you will not get sued for contamination of groundwater. Citrus growers are also trying to maximise fertiliser efficiencies so excess fertilisation is rare.

Contracts with farmers are very flexible. When there is a freeze, this is the biggest demand for water to protect the tree from freezing and being killed. Freeze protection is 2100 gallons/acre/hour applied near the trunk of the tree to save the tree from freezing. If the freeze isn't severe, then you can save more of the tree. If every grower turns on their supply the system can supply water to everyone. The citrus area is currently decreasing so this will maintain good supply. The scheme design is based on 30 gallons/min/acre (1800 gallon/acre/minute) and Water Conserv II would never sign up more than they can provide. Farmers use 20-30 inches per year to grow citrus.

Was there over extraction of the aquifer? Yes, but with the Rapid infiltration basin this has been stabilised and levels are now rising.

Reclaimed water has become an asset. Pressures from urban development may lead to changes in land use and reclaimed water use. By 2018 the first grower contracts will expire, so charging will not occur until these expire. Only the land owned by the city council will be kept for agricultural irrigation. There are approximately 4000 acres under citrus and irrigated with reclaimed water now. Current land prices are currently $3-5K/acre, they will get $75K/acre for urban developments so grower will cash in on this. If they swap from citrus for urban/residential/landscape use, the demand for reclaimed water should be similar.

The rate structure ranges from 28 - 84 cents per 1000 gallons (7 – 22 cents/KL; divide by 3.78 to get cent/KL). General residential users pay the highest. Some other agricultural projects are in the 2 - 13 cent per 1000 gallons. There are two grades; public access and reuse. There is no direct contact of edible crops unless they are to be cooked or peeled etc.

Lake levels are governed by rainfall and the water cycle in general. If you are in a municipal area houses must be sewered. Rural areas have septics.

When it was a liability to the water authority they were happy for people to take it, now that it is an asset they will charge you for it. 60% of reclaimed water goes to irrigation and 40% goes to rapid infiltration basins (RIB).

There are 25 supplementary wells to cover maximum demand for reclaimed water and if there is not enough reclaimed water. There are 43 miles of pipeline, supplying 11,000 acres of land. Agricultural use is the lowest grade option for disposal compared to surface water discharge.

2.1.4 Rapid Infiltration Basin (RIB)

RIBs are used to dispose of reclaimed water when agricultural demand is low. It is not a storage and recovery project, but to recharges aquifer. They have deep sand infiltration rates that are about 20 inches/hour.

The N in the reclaimed water is about 10 mg/L, N as NO_3. P is bound up by the aquifer and N levels must be below 10 to prevent contamination of the aquifer. Guideline is 50 ppm nitrate.

Biosolid use is limited by copper concentrations when growing citrus.

Figure 4 Rapid Infiltration Bay (RIB) where recycled water is stored and can move into the soil and eventually the aquifer at a rate of up to 30 inches per day.

2.2 Power Station - Orange County

2.2.1 Contacts

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Power Resources
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2.2.2 Background on Wastewater

http://www.orangecountyfl.net

The Water Reclamation Division provides service to unincorporated Orange County through the operation and maintenance of wastewater collection and transmission systems, pump stations, water reclamation facilities and reclaimed water systems. This division operates three regional water reclamation facilities.

There are approximately 1,600 miles of sewer mains, 250 miles of reclaimed water lines, 600 Orange County Utilities maintained pump stations and eight reclaimed water pump stations in the Orange County service area. Approximately 250 employees keep the division up and running 24 hours a day.

Water Reclamation Division
9150 Curry Ford Road, Orlando, FL 32825
Hours: 8:00 a.m. to 5:00 p.m., Monday - Friday
Phone: 407-254-9680 email: Water.Reclamation@ocfl.net

2.2.2.1 Power plant

This site can produce 2000 mega watt (MW). There are 3200 acres of land. 1000 acres fenced and the rest surrounding the 1000 acres is a nature reserve (specified by Land Planning). This also serves as a buffer from local residents. In the last 20 years there has been a significant increase in the density of populations.

There are three power generating units:

- Unit 1, 468 MW – pulverised coal unit
- Unit 2, 682 MW – pulverised coal unit.
- Unit 3, 633 MW – combine cycled unit

Figure 5 Recycled water used in a cooling tower at the Orange County Power Station, Florida.

The coal used here comes from West Virginia and Kentucky. Orlando State built the power plant so they could control the cost of power to the region. Condensers run a continuous blow down (addition of reclaimed water to flush the salty water out) and monitor water quality for conductivity, which is run in the electrical conductivity range of 50 – 100 uS/cm. The boilers run on a completely different system using groundwater, which is demineralised through sorption plates, acid/anion, weak/strong, cation and anion beds and polishers. They may possibly use reclaimed water for the boiler water line in the future.

Currently the only customer for the WRF (Wastewater Reclamation Facility) for reclaimed water is the power station. The location was ideal to use reclaimed water as the power plant is nearby to the WRF. Stage 1 of development was complete in 1986 using 4 - 5 mgd. When Unit 2 came online 10 MW were produced. All three units use reclaimed water for cooling. Total water use in the peak period is 13 mgd, lost through evaporation.

At present they can't use reclaimed water in the boiler and there is limited groundwater available in the area. Chemically, the salt concentration of reclaimed water is a bit higher than potable water, but there is not really much difference. If reclaimed water wasn't there they would have tried to obtain groundwater for condenser use. However, the water "wars" were just starting in Florida at the time. The wars were about taking the pressure off groundwater use. So it is great to have a secure, guaranteed supply not threatened by this process.

When constructed there was nothing special in the design of the power station because it was using reclaimed water. However, the frequency of chlorination and filtration would probably be less if reclaimed water wasn't used. Approximately 160 million gallons (640 ML) of water is stored in the ponds.

Stanton Energy Centre is required to make a profit but is owned by the state, not run by the state.

2.2.2.2 Reclaimed water

The reclaimed water used at the power station is treated to a level which is safe for any use. Originally the reclaimed water was used for cooling towers only, now it is used for service water (washing) and fire water. Groundwater was used for service water, but reclaimed water is now used to help take the pressure of over-allocated groundwater resources.

Originally they did not pay for the water. Now there is a commercial rate that is paid (Speaker was unsure of the rate). Reclaimed water is filtered again after sitting in the ponds to remove SS and algae before being used. Filters use chlorine and sand filters; they did use alum and found it just added more load to the filter with no real benefits.

Potable water is around $1.20 per 1000 gallon (32c/kL), reclaimed water would be about half that cost but ranges between 30 and 60 cents per 1000 gallons (7.9-15.8 c/kL).

Reclaimed water goes through a BNR type plant. Nitrify, denitrify. Total nitrogen is 4-5 mg/L and total phosphorus is 1.0 mg/L (0.3 -2 mg/L) through biological removal. BOD is less than one normally. They did use alum removal of P, but found it very costly. When the WRF is operated at 60% capacity they can consistently get 0.3 mg/L P. Sand filtration is used for solids removal. They chlorinate water for public access where they need 1.0 mg/L total residual, but this is restricted public access, in total 0.5 mg/L residual chloride is obtained. There is an 8 times concentration of salts in the cooling water, this is then evaporated to salt using brine concentrators and the salt is disposed to landfill.

The big concerns when using recycled water in a power station are:

- Nutrients in storage ponds causing algae growth
- Flushing lines on a monthly basis to prevent algae growth in line

Scaling hasn't been a problem, but they do use a scale inhibitor.

2.2.3 Quote for the day

'Is that what I think it is?' – Thomas, the bus driver experiences his first sewage treatment plant.

2.3 Participants wrap up of site visits for the day

They had a problem they needed to solve (i.e. they were not allowed to put effluent into the creek anymore). Confidence in the market came from an independent University Researcher (Dr Koo). We were surprised by the lack of understanding of perceptions regarding putting water onto crops; they seem to have been recycling water for so long that it is considered what you should do. Why is it so hard in Australia when it seems to be the norm in Florida; accepted by everyone. Money to make it work didn't seem to be a problem. Everyone had very defined jobs and knew little about the rest of the process. Discharge to aquifer through RIB does not seem to be considered to be discharge to the environment. Price and contractual arrangement seem very lose and done on a hand shake.

They are mandated to put a 3rd pipe in, but may never actually use it. In some areas they recognise that not all new residential developments will need the 3rd pipe. In the Florida there seems to be a common goal between government departments to make reclaimed water work and lots of money is put towards making this happen.

OHS and Hazard control at WRF are far from the standard found in Australia. There was no induction for us, or washing hands when leaving the WRF. Planning power of the water authority seems fairly powerful.

2.4 Anthony Andrade – Dinner Speaker

2.4.1 Southwest Florida Water Management District reuse program (Was unable to attend).

2.4.1.1 Reuse requirements inside water resource caution areas

The District has declared four water resource caution areas. The rules in Chapter 40D-2, F.A.C., provide the foundation for the District's regulatory reuse policies. Domestic wastewater treatment facilities located in, serving a population within, or discharging to water resource caution areas must investigate the feasibility of water reuse. If it is determined feasible, then reclaimed water must be used. If reclaimed water becomes available, water use permittees must accept it (provided that the quantity and quality are acceptable for intended use. Water users who receive reclaimed water must submit an annual reuse report that gives an account of their use of reclaimed water.

Water use permittees who generate reclaimed water must submit an annual report to the District summarising the quantity of wastewater generated, the quantity of reclaimed water reused, a list of reclaimed water customers, and a map depicting the reuse service area. Water users who receive reclaimed water must also submit an annual report that gives an account of their use of reclaimed water.

2.4.1.2 Reuse requirements outside water resource caution areas

In areas outside of water resource caution areas, Chapter 40D-2, F.A.C. requires applicants to use the lowest quality water available, including reclaimed water, for the proposed use if technically and economically feasible.

2.4.1.3 Other efforts

The Southwest Florida Water Management District conducts numerous activities to promote and encourage reuse. The District Water Management Plan, completed in September 1994, provides a road map for managing and protecting water and related natural resources. The water supply policies pertaining to reuse in the plan include assuring the availability of an adequate water supply; regularly evaluating existing available water supplies and future needs; requiring that alternative sources be developed to the greatest extent practicable, considering feasibility of alternatives; and requiring that lowest quality water available to be used for suitable purposes.

2.4.1.4 Funding assistance

SWFWMD's Cooperative Funding Program provides financial assistance to local governments and utilities for water resource related projects, including reclaimed water projects. Usually 50 percent of the cost of design and construction, pumping, storage, transmission fees and development of reuse master plans is funded.

Through Fiscal Year (FY) 1997, the basin boards budgeted approximately $95.5 million for 116 reuse projects. When fully constructed the 116 budgeted Cooperative Funding Program reuse projects will increase reclaimed water use in the Southwest Florida Water Management District by approximately 115 mgd.

The District Governing Board also established a "New Water Sources Initiative" (NWSI) program to provide assistance for alternative water supply projects with regional benefits including reuse. Since FY 1994 the Board has allocated $10 million per year to fund eligible NWSI projects.

SWFWMD Reuse Contact:
Anthony Andrade
2379 Broad Street
Brooksville, FL 34609
Phone: 800.423.1476 email: anthony.andrade@swfwmd.state.fl.us

3 Program: 1st June, Florida

3.1 *Apopka Regional Reuse of Water (ARROW) – Apopka*

3.1.1 Contacts

The City of Apopka, 748 East Cleveland Street, Apopka, Fl 32703
Staff: Jack Douglas, Director of Public Services,
John Jreij, P.E., Assistant Director of Public Services
Almon Fisher. Lead Op. B. Public Service Department, Waste Water Plant Division
Phone: 407 703 1782 email: afisher@apopka.net

For more information on the WRF treatment process and performance see information supplied by Hamish Reid: CD\report\hamish Case study - Rock Springs Ridge.doc

3.1.2 Background (from tour book)

Project ARROW (Apopka Regional Reuse of Water) is currently supplying 100% of the effluent treated by the wastewater treatment facility to customers for irrigation.

Since its conception Project ARROW has grown considerably. The list of Reclaimed Water recipients includes the commercial foliage industry, 2 (27 hole) golf courses, 22 residential developments, 29 commercial sites and 2-city recreational athletic complexes. In the mixed usage you will find greenhouses, orange groves, watering for medians, irrigation for playgrounds, football, soccer, soft and baseball fields and of course residential irrigation. It is anticipated that growth will continue with the anticipation of approximately 32 new projects for Homes, Town Homes, Golf Villas and additional Phases to already existing developments resulting in roughly 5900 lots/units.

The success of this project can be attributed to several key factors, the increase of public awareness to conserve water, state and national recognition and excellent wastewater treatment. We also have 3 storage ponds (20 million gallons) at the Rock Springs Ridge community, which allow us to store reuse when the demands are lower in the winter.

Public awareness of conservation has increased tremendously as a result of the decreased rainfall over the past few years combined with the accelerated population growth. The city has installed a Water Resource person to provide constant and increased education and enforcement to preserve one of the most precious resources we have.

State recognition began with a paper presented, on Project ARROW, at the 63RD Annual Florida Water Resources Conference in November 1989. National recognition began with the presentation at the National Water Supply Improvement Association in August 1990 and the National Water Pollution Control Federation held in October 1990 and "Environmental Achievement Award" presented by the National Environmental Awards Council in 1991 to our current Plant Operations Excellence Award for 2004.

This entire project could not be made possible without the hard work put forth by the personnel who insure that the treatment process is maintained in such a manner as to supply a product worthy of distribution throughout our community.

3.1.3 Site visit

The cost for residential use of reclaimed water is 65 cents per 1000 gallons (17.1c/kL), for nurseries it is 33 cents per 1000 gallons (11c/kL). New subdivisions must use recycled water. The city could not have imagined the expansion in reclaimed water use with over 6000 different lots/units now using reclaimed water.

Treatment process finishes with sand filtration, chlorination and storage in 2, 1 megagallon (8ML) storage tanks. They also have 2 large open lined ponds which hold 9 million gallons each. Once the water level gets down low there is a certain amount of algae and sedimentation that they try to avoid sucking in to their pumps.

They have an onsite laboratory at their facility, run by the state, where they do their own compliance testing (SS, BOD, chlorine residual, etc). Once a year they test influent and effluent for a larger number of chemicals, focusing on heavy metals, etc. Not a lot of industry contributes to the influent. They are trialling poly aluminium chloride to improve removal of these pathogens. Some of the WTFs are a bit overloaded, which may be contributing to the high load of cryptosporidium and giarda they are finding in the WRF. In 25 – 30 years they will have a serious issue with their water supply if they don't start being smarter with their water use (eg reclaimed water). Reclaimed water use is 2.6 mgd (10ML/d) and this is augmented with well water to 5 mgd (19 ML/d). There have been no issues with salt water intrusion into their potable water aquifer.

3.1.4 Hermann Engelmann Greenhouses – Apopka

3.1.4.1 Contacts

2121 Clarcona Road, Apopka, Fl 32703
Presentation: Nat Roberts

3.1.4.2 Background (from tour book)

Our founder and CEO Hermann Engelmann came to Apopka, Florida (just north of Orlando) in 1971. Where others saw swamps, alligators and hot, humid weather, he saw opportunity for a large scale greenhouse operation that would produce high quality exotic foliage. Apopka, itself, has become known as the "Foliage Capital of the World."

Today, almost 30 years later, Hermann Engelmann Greenhouses consists of eight locations totaling 2.2 million square feet of glass greenhouses.

3.1.4.3 Site visit

A lot of the reclaimed water is used for growing indoor plants. The water use is much lower than expected as they use micro sprays. The reclaimed water has been adequate for their needs. The water authority provides them with water quality data quarterly. Although there have been some concerns about salinity at times. EC is 0.4 - 0.5 dS/m.

There is only a verbal agreement regarding the quality of water supplied. They plant 1.1 plants per sq ft. They do not rely on or considers nutrients in recycled water. It takes approximately 10 weeks, with one trim before plants are ready to be sold. Spider mites are a big pest problem and they need to spray every week. Many plants go interstate so they must not contain any pests.

The company is based on providing a quality of product. All packing and cleaning is done by hand. The 9 inch potted plant wholesales for $4 and retails for $9.

Reclaimed water is supplied to farms at 160 psi where they reduce it to 80 psi. OHS for recycled water is signage and all employees a made aware that they cannot drink or wash with it, it is for irrigation only. Salts in reclaimed water are corrosive if concentrated. There are no restrictions on contact with recycled water, even when mist watering plants. Water distribution pattern when irrigating is very important. The nursery is so happy with reclaimed water that they are also looking into recycling their wastewater.

Protected cropping areas are often damaged by hurricanes in Florida, so the design of their protected cropping area is being modified to help prevent this.

Figure 6 Nursery and pot with dripper water system (insert), Hermann Engelmann Greenhouses – Apopka, Florida.

3.1.5 Bronson Nursery - Apopka

1400 Ocoee-Apopka Road, Apopka, Fl 32703

Presentation: City Staff

Bronson Nursery is located just off of the Ocoee-Apopka Road, it has approximately 257.94+/- of land that primarily produces Oranges. The grove is irrigated with reclaimed water from a trunk line on Boyscout Road. From there it feeds 4 separate turnouts, which in turn feed a micro-irrigation system. The jets are located at the bottoms of the trees for more effective watering.

In the beginning, owner, Mr. Troy Bronson agreed to accept 36.5 million gallons of reclaimed water per year. During the 03 - 04 period Bronson's used approximately 10,715,000 gallons.

3.1.6 NW Recreation Facility (Field of Dreams) - Apopka

3200 Recreation Way, Apopka, Fl 32712
Presentation: Candy McCrary

"The Field of Dreams", as it is known locally, was developed by the City of Apopka in 2000 and offers Soccer, Baseball, Softball, Rock climbing and Pavilions (Figure 7). The entire 70 acres is irrigated with reclaimed water that is pumped from the WRF to what is know as Pond 2a, it is then pumped to the irrigation system less that half a mile away. The reclaimed water is piped to customers at 52 to 55 PSI, but they only guarantee a pressure of 40 psi at the point of delivery. Holding ponds are amongst the residential community and water is pumped from these into the reclaimed water reticulation system, which also feeds the golf courses in the area.

Properties' deeds are restricted, with controls on painting, fencing, etc.

Figure 7 Sport areas at the Field of Dreams irrigated with reclaimed water.

3.2 Rock Springs Ridge and Rock Springs Golf Club - Apopka

3.2.1 Residential development with golf course

3.2.1.1 Contacts

625 Rock Ridge Blvd. Apopka, Fl 32712
Presentation: Mr. Kenny Ezell, P.E. of Clifton, Ezell, Clifton, Designers of the Course
118 West Plymouth Ave
Deland, Florida 32720
Phone: 386 734 2321 email: kezell@cecgolfdesign.com

3.2.1.2 Background

This development was established in 1997 with the first phase of residential development and 9 holes of golf. The development is a planned premier community that contains city water, reuse (reclaimed water), and sewer, and is considered a duel pipe scheme.

Since then the community has recently opened Phase V and is moving to open phases 6 and 7. It has increased the size Golf Club to 27 holes of well used public golf courses. It is ranked in the Top 5 in central Florida. Located just 25 minutes northwest of Orlando in Apopka, golf enthusiasts and tourists alike endorse the unspoiled nature of this outstanding venue. The "Rock" tees measure 7,135 yards with four other multiple tee complexes. Extreme topography changes highlighted by tree-lined fairways, strategic bunkering and humongous greens provide unique drama to every shot. Eighteen unforgettable holes of golf, plus the unique "Short Game" practice area,

In April of this year the community's total usage was 23.099 million gallons of reclaimed water for residential irrigation. The Golf Club is permitted facility used 12.253 million gallons.

3.2.1.3 Site visit

Kenny Ezell
Pro golfer – details in brochure and information supplied onsite.

The cost of the reclaimed water is $0.60 per 1000 gallons (later discussions with Almon put this cost at $0.90/1000 gallons). One lesson they learnt was that you must specify your delivery pressure at day one. They guaranteed a pressure of 40 PSI, however some irrigation systems were set up on what was measured in the pipeline early on rather than what was specified/guaranteed, so these irrigation systems need to be redesigned/modified to work effectively at 40 PSI. There are dual meters at all houses in the development to meter reclaimed water and potable water. The average price of a house in the development is $350,000 – $400,000.

Public space for the development also has a retention point to capture stormwater and let it percolate to the aquifer.

Signage requirements at Apopka are on the entrance of the development where reclaimed water is used. No signage is required at the house, just a purple subsurface meter box and a meter at the boundary of the property. All reclaimed water use is only through the automated garden irrigation system. All above ground taps outside the house are potable water only. There are no external taps in the garden or house where a garden hose can be attached to reclaimed water. This is a safety measure so people walking by don’t accidentally drink recycled water from a tap.

However, in places like Tampa if you connect a hose up to recycled water then it must be purple and inspectors will enforce this.

There are not many issues with algae growth in storage ponds within the residential area (Figure 8). Ponds are lined with thick PVC so there is no percolation. All ponds are signed at 4 locations around the pond which say not to drink from or swim in the recycled water (Figure 8).

Figure 8 Reclaimed water storage pond within the residential development at Rock Spring Ridge Residential and Golf Development, showing some of the signage. We weren’t too sure about the risk from golf balls to children playing in the playground?

There are a lot of mosquitos in the area (as you get when you have a warm wet climate) so people have insect cages at the back of their house which can extend over the pool (Figure 9).

Figure 9 Insect cage over a backyard swimming pool in the Rock Spring Ridge Residential area.

There are restrictions on water irrigation times, usually in the evening, but you can hand water with potable water during the day. The problem with this is that only potable water can be used for hand watering.

Golf course

When developing the golf course it was evident that there were pressures on water and developing a golf course would be difficult if only groundwater was to be used. They now have 360 holes and plan to have 621 holes of golf courses in the future. All planning is done around two water sources; groundwater for house use and effluent for yards and golf course use. Groundwater also provides a backup for the golf courses.

Groundwater is taken from deep aquifers at approximately 1000 ft. In some cases they also use stormwater.

Apopka City has developed over the years and they now have a 2 million gallon capacity with their storage ponds (calculated to a 2 ft depth, to ensure the residential ponds always have sufficient water in them, for aesthetic purposes). They are now trying to get DEP to allow treated stormwater storage and reuse. The golf/residential area have a large storage capacity, but they are not allowed to line any more ponds.

For this reuse scheme, effluent water can be irrigated at anytime, but if you only have potable water you may be put on restrictions during the dry periods. There is a 2020 plan to look at different solutions for making potable water from sea, lakes and rivers, rather than just groundwater.

Re-treatment of any stored reclaimed water is necessary because the US is a litigation based society, and to protect themselves from litigation they retreat reclaimed water that is stored, so if someone gets sick they can prove it wasn't the water. However, stormwater can be sent out to the yards without treatment!

Capital and operating costs were based on the developer putting the recycled water system in at their cost. Potable water pipes were down-sized because of the significant water supplied through the recycled water systems. Florida has construction standards for recycled water by the city, which are monitored by the state. Environmental Resource Permit (ERP) and Environmental Protection Permits are controlled by the DEP.

Reclaimed water use for toilet flushing hasn't been considered here. Some other schemes have considered it, but it is not a popular idea in this city. Dual flush toilets are not even known of here. Cross connection is not common as the recycled water is not taken within the house. They actively monitor for cross connections yearly.

Primary high breed Bermuda Grass is used a lot on their golf courses. Paspalum is more tolerant to salinity and is being introduced to golf courses. However, salt is not a big problem with respect to salt intolerance in most cases. They cannot use pesticides or non-natural fertilisers within 25 m of a water body for a specific type of accredited golf course.

There is a pricing structure to encourage home owners to irrigate on a particular day. There is a slight issue with golf course irrigation, which is not restricted during dry time, and residential irrigation which might be put under restriction during these periods. That is, it is hard to keep the golf course green, while restricting the use of water by residents adjoining the golf course.

You can get fined as much as $500 for irrigation events that break water restrictions.

They are starting to focus education younger people in schools etc.

Table 4 Apopka resident/golf course recycled water use - Questions and answers summary table

Drivers	
What were the key drivers for the scheme?	Lack of water, economic growth and stress on the Florida aquifer. Quality of the water from part of the aquifer (deeper part) also required treatment for drinking. Potable water comes off the shallower aquifer
What incentives etc were given to customers?	Lower cost for recycled water, drought proofing. Nursery initially received water for no cost. Residents received water for 10 cents/1000 gallons. It is now 90 cents/1000 gallons, as education and water shortages showed the benefits of using recycled water.
Risks	
What was considered the major risk during development?	Cross connection was not a big risk due to irrigation use of recycled water only. Drinking of the water and signage to be used were major considerations. Long-term effect on grasses; they are now looking at more salt tolerant varieties. Community acceptance, after what had happened in California, acceptance of recycled water use. The developer produced an information brochure.
After establishment, what new or unexpected risks appeared?	Pressure tested and irrigation systems developed on pressure at pipe, but only 40 PSI guaranteed. People think it is an endless source of water.
How are commercial risks allocated?	The commercial risk is transferred to the purchasers of house and land packages. Wear the commercial risk themselves on the golf courses, of any potential rejection of course use associated with use of RCW.
Health, Environment and Resources	
Was there any environment impacts?	None identified. The nursery at the propagation area
Was there any human health impacts?	None have been recorded.
What are the key benefits form recycled water?	Water supply and saving the aquifer. Identify and bring online a new water resource. Drought proofing.
Are there alternative water sources available?	Aquifer water.
How much recycled water is substituted for drinking water?	No potable use.
Who does the auditing and	The DEP was yearly.

monitoring?	
How is ongoing-monitoring reported?	Yearly.
How have you managed salinity levels in the recycled water and ground/soil?	It is not a problem.
Are there any other environmental management issues?	Cannot mix storm water with reclaimed water.
Have you assessed the impact of pharmaceuticals, personal care products and industrial chemicals on groundwater dependent ecosystems?	There seems to be no concern.
Lessons	
What issues and problems arise in mature water recycling schemes that could have been planned for at implementation?	Pressure information needs to be set up-front.
Issues	
What issues have arisen for end users during operation of the scheme?	Irrigation systems which were set up for a measured pressure higher than the guaranteed (52 psi) only have 40 PSI guaranteed when fully operation. So some irrigation systems don't operate as efficiently as they should.
Salinity/sodicity issues?	None.
What happens to your biosolids?	Information not obtained.
Costs	
Who funds it initially?	CAPEX is funded by the developer. The pipeline to the estate is funded by the city, but they get grants up to 85% from the Federal Government, which is related to overall person income tax. So the local water authority makes up the other 15%. When customers buy their land they become a customer.
Who funds it long-term?	Self funding.
How much is charged for the water? Pricing structure? Cost of potable water?	They pay \$0.90 per 1000 gallons for reclaimed water, \$1.25 per 1000 gallons for potable water and \$2 per 1000 gallons for sewerage treatment, up to a cap of 12,000 gallons. They have two meters that they pay on. A direct reading form the recycled water meter and for the potable water meter, sewage changed at 1:1 on potable water. Commercial /industrial customers pay the same, but there is no cap on the sewage charge. They don't have much trade waste entering the system so not costs for this where discussed. Prices started at \$0.10 per 1000 gallons to get people to adopt it on 5 - 8 year contracts. When the contracts expired prices increased if they wanted to keep getting it. They now have many people waiting to get recycled water, but there is none available (100% committed, plus mix in ground water to help winter use by supplementing with aquifer water in the summer peaks).
What is the willingness to pay for recycled water?	Given the cost saving, quality and acceptance of the water payment is not a problem.

What is the cost to produce the recycled water? Includes capital repayments allowance for grant monies etc?	Not known.
Is it full cost recovery?	Yes.
Is there any ongoing and shortfall from revenue vs. CAPEX costs?	Funded through Federal Government grants, so not applicable. Interest rates are low at 2.99% for housing so to service CAPEX would be low, if applicable.
Are the any outstanding cost issues?	As recycled water is now being identified as a valuable resource, the pricing structure is being reconsidered.
Operational and end user requirements	
How are end users administered? Costs, good management practices, agreements?	Regulation on time for using water when restrictions are in place.
What changes have growers/users had to make in their management practices? How have they been assisted?	For the nursery some species are sensitive to the higher salt/chloride concentration, so mist watering of some plants is not done or well monitored. Growers generally work this out themselves. Residential developments are new, so changes are not made as this is what is entered into as the norm when you purchase real estate in the development. Nutrients from recycled water are small and not considered in the fertiliser application. Lime is applied to overcome the acidification effect of sulphur in the water.
Does the project address seasonal variations in demand (winter storage)?	Winter storage and boost summer peak with aquifer water.
What governs the application rate? N, P?	The value of N and P is not considered significant and neither governs application rates. The soils are considered quite sandy and leach nutrients away from the root zone, meaning extra nutrients need to be applied to maintain sufficient nutrients to plants. There didn't seem to be an issue with these nutrients moving down the soil profile into groundwater.
What are the inline QA systems? E.g. Backflow devices.	In all residential areas backflow prevention valves are required. They required testing every year and must get approved.
Communication/engagement/partnership programs	
What where the community's perceptions of reuse?	There seems to be very little consultation with residents, it was case of develop the golf course and houses with recycled water then sell it to the resident, who gets very little info on recycled water.
What strategy has been used to obtain community acceptance of the product (fit for purpose)?	Jessica is putting together some education and training information. Everyone is given upfront some water schedules, but not much other information on recycled water.
How was community expectations/concerns dealt with?	There weren't any.
What was the public engagement strategy? E.g. Extent of customer and community consultation undertaken – what worked well and what didn't?	As they are new developments the public choose to purchase blocks where reclaimed water is used and are made aware of that before purchasing properties. As reclaimed water use is the norm in Florida, there seems to be little information on public engagement strategies.

Regulation	
What is the regulatory structure/framework for recycled water?	Federal Regulation, County (state), water district (?), local municipal requirement. They are also mandating recycled water into new developments.
For dual reticulation legislation, what is the compulsion for customers to connect?	Price of water.
Current and future innovations/technology	
Are any innovative technical processes used in this project now or in the future?	Automatic reading of meter by driving by.

3.3 *The City of Sanford – Sanford, Florida*

3.3.1 Contact details

Charles W. Turner III
Utility Plants Manager
Phone: (407) 302 1011 email: turnercw@ci.sanford.fl.us

City of Sanford
Utility Department
Project Administrator
Phone: 07-330-5649.

Presentation title: Optimizing Water Reuse In Sanford Area. North Seminole Regional Reclaimed Water and Surface Water Augmentation System Expansion and Optimization Study. By Bill Marcos, City of Sanford.

See cd\ppt\3.3.2 Marcos – Sanford reuse.ppt

3.3.2 Background (from tour book)

What is reclaimed water?

- Reclaimed Water is a service from the City of Sanford's Utility Department.
- Reclaimed Water is the result of highly treated and disinfected wastewater.
- Reclaimed Water is primarily used for irrigation.
- It is NOT for drinking and bathing or filling swimming pools.
- Other possible uses for reclaimed water include commercial car washing, industrial process cooling, concrete mixing and decorative fountains.

Is reclaimed water safe?

- Reclaimed Water is safe for irrigation.
- Nature reclaims water, too!
- The Water Reclamation Facility imitates nature and has established safeguards.
- It is essentially free of bacteria and viruses.
- Irrigation of edible crops that will be peeled, skinned or thermally processed before consumption is allowed. All others must be irrigated indirectly.
- NATURE USES: Rivers, flowing streams or lakes, rocks and the sun in its process to reclaim water.
- ADVANCED TREATMENT CONSISTS OF: gravity sedimentation, aeration, filtration and chlorination.
- Continuous on-line monitoring of the reclaimed water occurs 24 hours a day.

How does reclaimed water help you save?

The City of Sanford's Reclaimed Water helps you save three ways!

FIRST Reclaimed water helps you save groundwater.

SECOND Reclaimed water helps you save money. The consumption charge per 1,000 gallons is $0.50 versus $1.81 for drinking water (13.3c and 47.6c per kL respectively).

THIRD Reclaimed water's nutrients helps you save the environment.

What does reclaimed water service mean to you?

- Reclaimed Water is used for irrigation throughout the City of Sanford and surrounding areas.
- Reclaimed water is distributed through an extensive transmission line and is used for irrigation (not drinking) at sites including: golf courses; City parks; schools; the City agricultural site; residential; commercial; industrial; and agricultural areas.
- Reclaimed water service areas are limited.

- Those now irrigating with well water can benefit by switching to the Reclaimed Water Program.
- Former well irrigators will save on pump costs for operation, maintenance and repair.
- Generally, reclaimed water is not subject to water restrictions.
- It will not stain concrete.
- No buffer zone from shallow irrigation wells is required.
- The Reclaimed Water Program was not funded by City taxes.
- Funding for construction of the distribution system is a combination of Utility bond funds and Florida Department of Environmental Protection grant monies.
- Proceeds from Utility charges are used to repay the bond debt.
- Billing for reclaimed water service will remain the same.
- Charges for reclaimed water will appear on a separate bill similar to your current utility bill.

Why reclaimed water?

- Reclaimed Water is needed as a water resource.
- Through its new reclaimed water program, Sanford joins a number of cities in Florida and around the nation that are protecting the environment and conserving groundwater for our children.

Is reclaimed water service reliable?

The City of Sanford has two strategies to ensure reclaimed water service reliability and maximize alternative water supplies for irrigation. First, it encourages the efficient use of reclaimed water. Second, beginning in 2001, Sanford will augment its reclaimed water supply with treated water from Lake Monroe. Yet it is important to note, that the effectiveness of any program relies on people and equipment.

How do you get reclaimed water service?

- There are five (5) easy steps to obtain Reclaimed Water Service for irrigation (once service lines are installed in your area).
- To participate in the Reclaimed Water Program:
- Contact the Reclaimed Water Program office. You will receive and information package including a reclaimed water application and subscriber responsibilities;
- Fill out an application and return it to the Reclaimed Water Program office;
- Complete a Reclaimed Water Program introduction;
- Pay connection fee; then--
- Upon obtaining Reclaimed Water Service [within thirty (30) days of fee payment], complete a free cross-connection control/irrigation inspection to correct deficiencies.

The keys to expanding reclaimed water service.

Reclaimed water service expansion to your property is based on demand, reclaimed water availability, cost effectiveness and budget restraints.

3.3.3 Site Visit

Reclaimed water contained 10 mg/L total N and 2 mg/L total P. The salinity was not known. They reuse around 90% of the effluent.

The driver to adopt reclaimed water was that no discharge to the lake was allowed. To get the scheme started they leveraged off the schemes already going. They had a few big customers who got the recycled water for free to get the scheme running. Potable water costs $1.50 per 1000 gallons and reclaimed water costs about $0.53 per 1000 gallons.

Most of their demand is irrigation so they need lots of storage. The reclaimed water has become so popular that they are supplementing it with lake water. They don't have licences to add water to aquifers and soils are a bit different so RIB might be a bit more difficult. WRF used sand filtration and chlorination.

A powerpoint presentation was also provided electronically summarising recycled water developments in the Sanford Area, see:

Cd\ppt\3.3.2 Marcos – Stanford reuse.ppt

3.3.4 Golf Courses

There is a WRF next to the golf course that pools water out of the aquifer. Reclaimed water is used at the golf course and eventually some would leach through to the aquifer, possibly causing indirect potable reuse. The golf course uses about 450,000 gallons per day.

Figure 10 Recycled water storage dam backing on to residential housing and signage used (insert), City of Sanford, Sanford, Florida.

3.3.5 Citrus trees

Biosolids and recycled water are used at the citrus orchard and they balance the nutrients applied. Copper (500 – 700 mg/kg on a dry weight basis) limits biosolid application.

They have problems with blockages from plastics (there is an industry that discharges really fine ground plastics into the influent that cannot be removed).

The citrus property is leased on a percent of profit basis. There was also some hay and turf production.

Figure 11 Citrus trees grown with reclaimed water and biosolids, Sanford, Florida.

Table 5 The City of Sanford – Sanford, Florida. Summary

Drivers	
What were the key drivers for the scheme?	Regulatory driver to cease discharge to the lake. And an additional driver now is to conserve water for potable uses.
What incentives etc were given to customers?	Water was free for starters; the infrastructure was free, and included pump station and storage facilities on the course. For the farm the water was free and plantation and irrigation infrastructure was paid for the by the water authority
Risks	
What was considered the major risk during development?	Acceptance by users and consumers. Could use other schemes running to show it was OK.
After establishment, what new or unexpected risks appeared?	Water supply and demand balance. Top up with water from the lake when demand outstrips supply. There does seem to be very good control on demand. Only three days balance in storage, so they still discharge 20 % of recycled water to the environment.
How are commercial risks allocated?	Commercial risks where originally taken out of their hands by

	generous government grants. Facing increased risk as they are financing new infrastructure through banks. They overcome some of the threat by charging $0.30 per 1000 gallons. Supply contacts are being tightened up too.
Health, Environment and Resources	
Were there any environmental impacts?	Creeks are still receiving water, there were impact from withdrawing water from lakes.
Were there any human health impacts?	None report to date.
What are the key benefits?	Potable replacement, protection of aquifers. Well accepted as normal practice and demand outstrips supply.
Are there alternative water sources available?	Well and lake. They were also looking at some stream flows.
How much recycled water is substituted for drinking water?	
Who does the auditing and monitoring?	A monthly report was produced by the regulators. When they discharge to stream there is daily contact with regulator.
How is ongoing monitoring reported?	Yearly report DEP.
How have you managed salinity levels in the recycled water and ground/soil?	Not a problem.
Are there any other environmental management issues?	Nitrogen was being monitored in groundwater, but not much information is available.
Lessons	
What would you do differently next time? Technology, acceptance, operational, customer interface, price?	As contracts expire they are progressively locking in new prices, up to $0.50 per 1000 gallons, starting to recoup some of the costs associated with running the scheme.
What is the most critical consideration for the particular reuse scheme?	Customer acceptance, then after prices.
Issues	
What issues have arisen for end users during operation of the scheme?	Treatment plant issues. Problems with removal of plastic material from industry.
What happens to your biosolids?	Land applied on citrus plantations.
Costs	
Who funds it initially?	Federal Government first and then later through loans or developers installing infrastructure.
How much is charged for the water? Pricing structure?	$1.50 potable and $0.53 for reclaimed per 1000 gallons.
What is the cost to produce the recycled water? Includes capital repayments allowance for grant monies etc?	Not available.

Is it full cost recovery?	No, but moving toward it.
Communication/engagement/partnership programs	
What where the community's perceptions of reuse?	Did a lot of meeting and information and video early on, but now acceptance is there they haven't been doing this. There is a minority that don't support it.
How were community expectations/concerns dealt with?	Just went and did it.
Was consumer market research undertaken?	Just went and did it.

3.3.6 Quote for the day

"Poo stinks."

"Not another question from Danny!"

3.3.7 Participants wrap up

Just do it. Regulations in Australia are too prohibitive and precautionary to get schemes running. It seems here that recycled water is considered normal. In Australia we are to over-protective to encourage use, but then it is too hard to slacken the standards to a more appropriate level.

Asset management is important and upgrading WRF before it is too late. Demand exceeded supply of recycled water. Initial idea was disposal to land. WRF was very close to residents, driven by political pressures, not form the Department of Environmental Protection (DEP). WRF operators didn't believe DEP had any control over odour, however this is probably not the case.

Once they supply the water there does not seem to be much care on how it is used. Water is used very inefficiently. They still discharge 10% of the reclaimed water to the river as they can't use RIB with the geological conditions they have.

City of Sanford does the monitoring of water storage, soil monitoring and groundwater. There is no onus on the end user. Philosophy seems to be reuse, but a bit more care in the actual use should be taken.

3.3.8 Dinner speaker

Chris (Christianne) C. Ferraro, P.E.
Program Administrator
Water Facilities and
Watershed Management
FDEP Central District
Chris.Ferraro@dep.state.fl.us
Chair, Water Reuse Committee
Florida Water Environment Association

Presentation - Water Reuse in Florida. See Cd\ppt\3.3.7 Ferrero – Florida reuse.ppt
Information from the DEP is available at:
www.dep.state.fl.us/water/reuse
www.dep.state.fl.us
www.dep.state.fl.us/water
www.dep.state.fl.us/water/wastewater/dom
www.dep.state.fl.us/water/wastewater/forms.htm

Other websites of interest are:

Florida Water Environment Association	www.fwea.org
WateReuse Association	www.watereuse.org
Water Environment Federation	www.wef.org
National Water Research Institute	www.nwri-usa.org

Water environment Research Foundation	www.werf.org
American water Work	www.awwa.org

Rapid Infiltration Basins (RIBs) must not be within 500 yards of a groundwater extraction well.

Documentation supplied:

- Power point presentation
- Statement of support for water reuse
- Summary of DEP rules
- Code of good practices for water reuse in Florida

Code of Good Practices for Water Reuse in Florida

http://www.fwrj.com/articles3/0008.pdf

David W. York and Christianne Ferraro

Christianne Ferraro, P.E., water facilities administrator, DEP, Orlando, chairs the FWEA Water Reuse Committee.

The Code of Good Practices for Water Reuse in Florida was developed by DEP and FWEA's Water Reuse Committee to aid reuse utilities as they implement quality water reuse programs. The focus is on reuse systems that provide reclaimed water for irrigation of public access areas (golf courses, parks and other landscaped areas), residential lawns and edible food crops. These types of reuse activities are regulated under Part III of Chapter 62-610, FAC. The full text of the code follows:

Protection of Public Health and Environmental Quality

- Public Health Significance – To recognize that distribution of reclaimed water for non-potable purposes offers potential for public contact and that such contact has significance related to the public health.
- Compliance – To comply with all applicable state, federal, and local requirements for water reclamation, storage, transmission, distribution, and reuse of reclaimed water.
- Product – To provide reclaimed water that meets state treatment and disinfection requirements and that is safe and acceptable for the intended uses when delivered to the end users.
- Quality Monitoring and Process Control – To continuously monitor the reclaimed water being produced and rigorously enforce the approved operating protocol such that only high-quality reclaimed water is delivered to the end users.
- Effective Filtration – To optimize performance of the filtration process in order to maximize the effectiveness of the disinfection process in the inactivation of viruses and to effectively remove protozoan pathogens.
- Cross-Connection Control – To ensure that effective cross-connection control programs are rigorously enforced in areas served with reclaimed water.
- Inspections – To provide thorough, routine inspections of reclaimed water facilities, including facilities located on the property of end users, to ensure that reclaimed water is used in accordance with state and local requirements and that cross-connections do not occur.

Reuse System Management

- Water Supply Philosophy – To adopt a "water supply" philosophy oriented towards reliable delivery of a high-quality reclaimed water product to the end users.
- Conservation – To recognize that reclaimed water is a valuable water resource, which should be used efficiently and effectively to promote conservation of the resource.
- Partnerships – To enter into partnerships with the Department of Environmental Protection, the end users, the public, the drinking water utility, other local and regional

agencies, the water management district, and the county health department to follow and promote these practices.

- Communications – To provide effective and open communication with the public, end users, the drinking water utility, other local and regional agencies, the Department of Environmental Protection, the water management district, and the county health department.
- Contingency Plans – To develop response plans for unanticipated events, such as inclement weather, hurricanes, tornadoes, floods, drought, supply shortfalls, equipment failure, and power disruptions.
- Preventative Maintenance – To prepare and implement a plan for preventative maintenance for equipment and facilities to treat wastewater and to store, convey, and distribute reclaimed water.
- Continual Improvement – To continually improve all aspects of water reclamation and reuse.

Public Awareness

- Public Notification – To provide effective signage advising the public about the use of reclaimed water and to provide effective written notification to end users of reclaimed water about the origin of, the nature of, and proper use of reclaimed water.
- Education – To educate the public, children, and other agencies about the need for water conservation and reuse, reuse activities in the state and local area, and environmentally sound wastewater management and water reuse practices.

See also:

Irrigating Edible Crops with Reclaimed Water. David York, Lawrence Parsons, and Lauren Walker-Coleman. Page 33 on of http://www.fwrj.com/articles3/0008.pdf

Hamish Reid also supplied a summary he has been working on for California and Florida see:

CD\report\hamish\Californian urban regul requirements.doc

CD\report\hamish\Florida urban regul requirements.doc

4 Program: 2nd June, Florida

4.1 Reedy Creek Utilities – Reedy Creek

4.1.1 Contact

Ted McKim. P.E.
Chief Sanitary Engineer
Planning and Engineering
Reedy Creek Energy Services
Phone: 407 824 4529 email ted.mckim@disney.com

The tour organisers would like to thank Ted McKim and his board of management for granting the tour group access to the site, our group has been the first major tour to be granted access since ceasing tour following September 11.

4.1.2 Background - How one utility met the water use restriction goals (From tour book)

4.1.2.1 Background

Reedy Creek Improvement District (RCID) is the municipal entity that provides utility and other governmental services to the Walt Disney World Resort Complex in Central Florida.

RCID began potable water service in October 1987, when it acquired and leased water system assets from a private company. The water system is very simple because the source (the Floridian Aquifer) is of high quality and yield, requiring no treatment other than chlorination. The system consists of 12 main production wells, four pumping stations and the distribution system piping. The pumping stations contain ground storage reservoirs, the chlorination system (liquid sodium hypochlorite) and booster pumps. System capacity is 60 MGD, and demand ranges between 10 and 30 MGD.

RCID began wastewater reuse efforts in 1971, by irrigation of an 110+/- acre tree farm with secondary effluent. Efforts to improve and expand reuse of treated wastewater have been underway almost continuously since that time. Major improvements and expansion efforts completed in 1993 were the backbone of the current public access reuse system. These included upgrading of the treatment facility to achieve biological nutrient removal, adding deep bed filtration and high level disinfection; and installation of a reuse distribution system, complete with storage tanks and pumping station. Additionally, in 1990, RCID employed the use of rapid rate infiltration basins (RIBs) for wet weather groundwater recharge.

Deficit rainfall over the 1998 to 2001 period resulted in the South Florida and St. Johns River Water Management Districts declaring water use restrictions in January of 2001. These restrictions remain in force today for RCID. To illustrate the duration and severity of the current drought, Figure 1 shows the cumulative rainfall deficit experienced at RCID from 1998 to 2002. Average rainfall was determined to be about 53"/year, based on the average of eight (8) rainfall gauge stations located throughout RCID, with 30 years or more of historic record. As the figure illustrates, the rainfall deficit exceeded 80" in May of 2002 – over a year of average rainfall. But some recovery has been observed in the latter months of 2002 as a result of above average rainfall.

The water use restrictions were aimed at reducing the demands on the Floridian Aquifer, the primary drinking water source for most of Central Florida. Restrictions on the use of reclaimed water were not imposed, which led to a renewed interest in reclaimed water at RCID. The goal of the restrictions was to cut consumption by at least 15% compared to the prior year (calendar year 2000 was considered the base year against which comparisons were made). The restrictions that were of highest concern to RCID included the ban on street and sidewalk cleaning with hoses, banning the use of non-recirculating decorative fountains, restricting irrigation to twice per week and to less than 0.75 inch per week, and reducing distribution system pressure to 45 psi or less. With the exception of the latter restriction, reclaimed water played a significant role in helping RCID meet these restrictions and exceed the 15% reduction goal.

4.1.2.2 Complying with the restrictions - The role of reclaimed water

The major priority for RCID customers was to find a way to wash the streets and sidewalks of their theme parks without using potable water, which has been a nightly practice for the past 30+ years. While the restrictions allowed the use of high-pressure washers, these damaged baseboards and other "soft" surfaces and could remove paint and finishes, making their use undesirable. The obvious solution was to use reclaimed water, but the challenge was to find a suitable means of delivery, since three of the four theme parks were not equipped with their respective reclaimed water distribution systems. The solution was to build "filling stations" for a fleet of delivery vehicles, called "water buffaloes". The filling stations constructed were similar to the way a stream train takes on water and consisted of a 4" diameter line supported above grade, equipped with valves and flexible hoses. The water buffaloes consist of a trailer or truck bed mounted storage tank, gasoline powered pump and hose. Storage tank volumes ranged from 500 gallons to 3000 gallons.

All street and sidewalk cleaning is done at night, after the theme parks close. The water buffaloes fill their tanks from the filling station and make five to six return trips per night. The use of the water buffaloes and filling stations reduced the potable water demand by an estimated 0.3 million gallons per day (MGD) on average at the three theme parks.

A second priority for RCID customers was to convert irrigation uses from a potable water source to reclaimed water. Landscaping plays an important role in the "show" and a huge investment exists in turf grass, trees, shrubs and annuals, requiring a reliable source of irrigation to protect that investment. Plans and construction for the conversions of three major and three minor customers were accelerated and completed in the spring of 2001. These conversions ranged from the installation of a few feet of pipe and meters to the extension of about 1000 ft. of 8" line for one customer. An estimated savings of 0.46 MGD of average day demand was accomplished with these conversions.

A third area of conversion included cooling tower makeup. RCID owns and operates some of the largest centralised chiller facilities in Florida to provide chilled water for air conditioning needs. Additionally, numerous smaller cooling towers exist at many resorts within the RCID boundaries. These were evaluated and analysed from a cost-effective viewpoint, and the lowest hanging fruit was chosen for conversion to reclaimed water. The main Central Energy Plant (18,000 tons of air conditioning capacity) was converted and three smaller cooling towers at selected resorts. These conversions resulted in an average potable water demand reduction of 0.35 MGD.

Conversion of the Central Energy Plant cooling towers required the installation of an on-line phosphorus analyser in the reclaimed water feed-line, to aid the operators in adjusting chemical feed rates for control of fouling in condenser tubes and cooling towers. A slight but insignificant increase in chemical expenditure for anti-foulants resulted from the conversion.

Lastly, about 10 acres of land irrigated for fire suppression purposes were converted to reclaimed water. This land was formerly wetted with potable water to preclude fire hazards. An estimated 0.1 MGD of potable water demand reduction was accomplished with this conversion.

4.1.2.3 Conservation efforts

Conservation practices played a major role in reducing both reclaimed and potable water demands during the drought (and most of these practices will be continued into the future, regardless of the water use restriction status). Most of the conservation efforts were for potable water, but some were practiced to conserve reclaimed water. Upon imposition of the Water Use Restrictions, a decision was made to reduce reclaimed water used for irrigation by 10%, even though reclaimed water was not subject to restrictions. Almost all irrigation systems within RCID are operated under the Rainbird Maxicon™ control system, which analyses a number of soil, weather and other variables to determine the optimum amount of irrigation required. These control devices were reprogrammed to reduce reclaimed water consumption by 10% at all reclaimed water locations. Areas irrigated with potable water were likewise re-programmed to restrict irrigation to the maximum application rate of 0.75”/week and no more than twice weekly. RCID sought and was granted an exemption from the restrictions on the days of the week that irrigation could be allowed, but this did not result in a net change in consumption or conservation.

Potable water conservation measures were generally in compliance with the water use restriction guidelines. These included distribution system pressure reduction in most buildings to 45psi or less at the most remote plumbing fixtures. Fortunately for RCID, most buildings and customers have separate fire and domestic service lines and the latter are equipped with a pressure reducing valves (PRVs). Therefore, it was a relatively simple task to re-set the pressure reducing valves at the buildings to achieve the 45 psi pressure at the top floor, in the most remote fixture. The few buildings that were not equipped with PRVs, were retrofitted. The separation of the fire and domestic service lines allowed the distribution system to maintain its normal pressure level for fire demand purposes and allowed full compliance with the pressure reduction requirements. Maintenance of fire system pressure was an important consideration in the success of the conservation efforts. If the fire system pressure were lowered significantly, some systems would suffer from inadequate coverage of the sprinklers, and others would require alarm settings to be re-programmed.
Therefore, maintenance of the fire system pressure at normal levels was a prime consideration in maintaining the safety and protection of the building occupants.

Many of the decorative fountains within RCID employ re-circulation of their contents, and therefore were not subject to the restrictions. But a few do not and operate as once through systems. To meet the restrictions, these fountains were discontinued. A few have since been converted to re-circulate their contents, and one was converted to reclaimed water. Fountains that were guest-interactive and non-recirculating were also shut–down. These fountains played a small role in the overall conservation effort, but made a major visual impact and served as a constant reminder to employees and guests about the severity and duration of the drought and the need to conserve.

Additional aesthetic uses of water were also halted. These typically involved the use of water to create a mist or fog-like look for a special effect. While these uses were small and relatively insignificant from a consumption saving point of view, their message played an important role in reminding employees and guests of the presence of the restrictions.

4.1.2.4 Supplemental sources

In calendar years 2000 through 2002, RCID utilised approximately 60% of its total wastewater effluent volume for reuse purposes. The balance was used for groundwater recharge via rapid infiltration basins. Approximately 6.1 MGD, on average, was used by the reuse system in calendar years 2000 through 2002. This represents about 30% of the total water resource needs within RCID.

To achieve high effluent utilisation rates in the reuse system, supplemental sources of water are typically needed to meet extended duration peak demands. RCID was no exception to this requirement. When reuse system demands started to exceed 50% of the available effluent volume on an annual average basis, mining of the existing storage reservoirs was observed during peak demand periods. Some irrigation customers with surface water backup systems were advised to temporarily return to these sources to help meet the supply shortage. To avoid this condition and plan for the future, RCID looked at possible alternatives that could serve the entire reuse system rather than rely on selected customers to bear the load. This was accomplished with the conversion of two idle, formerly potable water wells (Wells #13 and #14), to serve as supplemental sources of water to the reclaimed water system. The wells were equipped with new pumps and motors and piped to the reuse system.

In 2001 and 2002, operation of Well #14 successfully enabled RCID to meet the extended duration peak demands. Approximately 15 million gallons were pumped from Well #14 in 2001 and 38.8 million gallons in 2002 to supplement the reclaimed water supply. Well #13 has not been required, to date. While the consumption of water from these wells slightly increases RCID's consumptive use withdrawal, their use allows more reclaimed water customers to be reliably served and thereby reduces the total consumption of water from the Floridian Aquifer.

At RCID, where the major use of reclaimed water is for irrigation, the peak demands must also be met within an 8 hour window, typically between 11pm and 7am. RCID's customers demand that their irrigation systems operate when most people are sleeping. This factor requires significant storage and booster pumping station capacity to meet the daily peak. To meet this need, a third ground storage reservoir of 5 million gallons capacity was added to the existing 10 million gallons of capacity. The reservoir was completed in May 2002. A fourth reservoir is planned for the future.

4.1.2.5 Assessing the impacts to the water resources

For calendar year 2000, the average daily potable water demand at RCID was 19.95 MGD. For 2001, the demand dropped to 14.57 MGD; for 2002 the demand averaged 14.32 MGD and has remained in this range for 2003. These correspond to 26% and 27% reductions in demand for CY 2001 and 2002 respectively, when compared to CY 2000 demands. The total annual difference in demand between 2000 and 2001 was 1.969 billion gallons; and 2.055 billion gallons for 2002, with the total reduction just over 4 billion gallons. (CY 2000 is considered the base year or year in which comparisons on demand reductions are to be judged, per direction from the SFWMD).

Four major factors are believed to contribute to the demand reduction. They are: conservation practices of potable water, increased use of reclaimed water, differences in weather/rainfall and non-controllable factors, such as the general economy and its relationship to the number of guests and employees using the facilities within RCID. Quantifying these differences proved to be relatively simple for the weather and reclaimed water uses, but were more challenging to measure for conservation and the non-controllable factors.

To quantify reclaimed water use differences between CY 2000 and 2001 & 2002, the meter readings of the customers converted to reclaimed water were examined and tabulated. Some of the data was adjusted and annualised, if the conversion took place after January 1, 2001. This value totalled over 670 million gallons for the two-year period, or 0.92 MGD, on average.

To quantify weather related differences, two values were evaluated: differences in annual average rainfall and the area irrigated with potable water. The former value amounted to 17.1 inches of rainfall for 2001 and 23.0 inches for 2002. There were 17.1 fewer inches of rainfall in CY 2000 than in CY 2001, and 23.0 fewer inches of rainfall in 2000 than in 2002. These differences are based on the average of eight rainfall gages throughout RCID. The latter value (the number of acres of property irrigated with potable water) was determined from aerial photo interpretation using GIS to calculate the areas. This totalled approximately 541.5 acres. The assumption was then made that the irrigation control systems would account for the rainfall differences and would deliver equivalent volumes of water to any given acre of land (i.e. the rainfall deficit would be made up by the irrigation control system). The difference in rainfall times the irrigated area therefore accounted for about 590 million gallons of water over the two-year period.

Because of multiple factors influencing potable water consumption, the consumptive differences between 2000 and 2001 & 2002 relating to the changes in business activity (non-controllables) could not be readily calculated. Therefore a different approach was taken. Wastewater records were examined for the two periods and the difference in wastewater volume was assumed to be proportionate to the change in business activity. A 75% return factor of wastewater generated from potable water consumed was assumed, based on historic data. From the differences in wastewater volumes and using the assumed return factor, a value was calculated. Non-controllable factors were estimated to account for a potable water demand reduction of about 1,100 million gallons over the two-year period.

The value attributed to demand reduction from actual conservation practices was assumed to be the difference between the total conservation effort (4,024 MG) and the sum of the above three components (670 + 590 + 1100 MG). Actual conservation practices therefore amounted to an estimated 1,664 million gallons over the two-year period. Customer conversions to reclaimed water accounted for about 17% of the total, and conservation efforts accounted for about 41% of the total. Weather accounted for about 15% and non-controllable factors accounted for the balance.

4.1.2.6 Consumptive use ramifications

Like most utilities in central and south Florida, RCID has a Water Use Permit or Consumptive Use Permit (CUP) that limits the amounts of water used for reasonable, beneficial purposes. The past and current source for the majority of this water for RCID has been the Floridian Aquifer. And like most utilities, obtaining significant additional volumes of groundwater from the Floridian Aquifer is an unlikely prospect for the future. This once abundant source has reached (some claim exceeded) its sustainable yield and alternative sources must be sought. Alternative water sources for RCID are few. There are no high-quality, perennial surface waters within a reasonable distance of RCID, the shallow groundwater is of poor quality and yield, and desalination seems unlikely for a utility that is 50+ miles from coastal sources. Therefore, maximising the use of reclaimed water and water conservation are the obvious choices for RCID to meet its future consumptive needs, and remain within its CUP limits.

The important and growing role of conservation and reclaimed water in meeting the water resource needs of RCID is illustrated in Figure 3. This figure is a bar graph showing historic potable water consumption since 1990. Stacked on top of the potable consumption is the volume of reclaimed water. The sum is representative of the total water resource demands within RCID. The graph clearly illustrates the growing role reclaimed water has played in RCID’s water resources, and shows the dramatic decrease in potable water consumption for CY2001 and 2002, after implementation of water conservation measures. Without reclaimed water, RCID could have exceeded its CUP limitation (about 23.4 MGD AADF) in 1998, 1999 and 2000. Continued expansion of the reclaimed water distribution system and continuation of water conservation efforts are expected to enable RCID to remain within its CUP limit well into the future.

4.1.2.7 Summary

The drought condition from 1998 to 2002 has had a bright side at RCID, and resulted in a renewed awareness and appreciation for water, both reclaimed and from the Floridian Aquifer. The expanded and increasing role of reclaimed water in meeting the water resource needs of RCID has changed preconceptions about its value and utility. Without conservation and reclaimed water, RCID could be facing a serious water crisis in the near term future. With reclaimed water and continuing conservation, RCID is looking to effectively and reliably meet its customer’s needs for many years into the future.

4.1.3 Site visit – Reedy Creek

The State owns the water, as water is a public resource in Florida. The WRF was first built in 1971, where they also used some wetland treatment in the 80’s for part of the treatment process. The RIBs were built in the early 90s. Approximately 55% of treated wastewater is used in the irrigation system and the rest goes to the RIB. During the drought last year they would have lost their 5 golf courses if they were not using reclaimed water. Reclaimed water is also used for cooling towers, fire suppression, washing vehicles, street washing and garden irrigation. The rainmaker equipment is used for irrigation scheduling.

The Disney complex pays rates, some of which some go to the Reedy Creek operation body. The Reedy creek facility looks after gas, electricity and water, so they do generate power for themselves. Their biosolids facility is slowly being surrounded by development which has lead to odour complaints; they are now looking at some thermal drying facilities.

Enough recycled water is not available during dry periods, so it is topped up with some water wells to augment the reclaimed water systems. There were also some surface irrigation pumps used. Peak demand will often stress the reclaimed water system so augmentation is required.

It costs approximately $5.50 per 1000 gallons to treat the sewage.

With so much public exposure, the DEP has still been very supportive of the process. They are very aware of public perceptions and do everything to make sure there isn't any bad/negative press.

Visitors on a peak day are approximately 250,000 per day. Pollutant load when you wash the road is higher than it is in the reclaimed water. Road washing goes into the storm water system. Roads are vacuumed before washing to minimise the SS in washwater entering the stormwater.

Reclaimed water contains a P concentration of 0.5 mg/L and total N concentration of 3 – 4 mg/L. The 2000 acres of irrigated turf includes 5 x 18 hole golf courses and 1 x 9 hole golf course. They have no problems with micro jets used for irrigation blocking. Some construction workers thought reclaimed water was causing a rash, but this was found to be the concrete material they were working with. Reclaimed water actually fits drinking water standards. Retrofitting areas with a recycled water service has a risk of cross connection, and they prefer to do it when building residential areas.

Meters for reclaimed water use cost from $20 - $2000 per meter depending on the volume of water required. Potable water costs about $1.00 per 1000 gallons and reclaimed water costs $0.80 per 1000 gallons. They like to charge a reasonable amount for the reclaimed water so people don't waste it, like what has happened in some other schemes.

Residential use returns 80 - 90% of water used to wastewater, however the Disney theme parks return 50 - 60% of water to wastewater. Some pay sewage costs linked to potable water used. Other theme parks pay according to the volume of sewage.

It costs them $10,000,000 annually for maintenance of sewer and WRF, and RCID make $150,000,000 from their facilities. No government funding has been taken, as Walt didn't want to burden the tax payer for the Disney facility.

Their rate of recovery on capital is not considered on maintenance. However, they can improve this by asking developers to contribute. The cost recovery only system is based on a high level of service and reliability. There are 35 staff members involved with the WRF and 350 people work the Utility Company (RCID).

The WRF (Figure 12) is equivalent to 200,000 - 250,000 EP. Currently have 33,000 rooms with 98% occupancy entering the sewer system. Stormwater has retention bays, post 1985 when laws started to require this and these retention bays/areas percolate into the groundwater. Some stormwater areas (food areas, rubbish areas, kitchen (where they wash) areas, animal kingdom theme park where covered) are fed to the sewers, rather than stormwater due to the point source contamination.

Fodder for animal at Disney is grown on site with reclaimed water, but this reclaimed water is from another reclamation scheme.

Tanks can not go underground at the WRF as they would float. The water table varies seasonally from 1ft (?) to 60 ft, depending on season (wet season summer) and soil type.

There are 55,000 people employed at Disney World.

4.1.4 Wastewater Treatment

The water treatment process includes:

- Archimedes Screw lift pumps
- Clarifiers
- BNR
- Sludge storage

- Lagoon settling
- Caustic and chlorine used to neutral the odour
- Some areas are covered for odour control.

As designed, the WRF is currently using 25% of the plant most of the time. About 75% of the reclaimed water ends up in RIB and the Florida aquifer used for dinking. They have noticed an increase in Cl only in the aquifer.

Biosolids are composted and cured at the backstage area of the property. Once composted, they are used for landscaping of roads. They don't put it into public areas due to odour complaints. It cost them $250 per dry tonne for the treatment of their biosolids.

The Cl concentration in potable water is 10 mg/L and increases to 100 mg/L in sewage. The total dissolved solids (TDS) in potable water is 100 - 150 mg/L and increases to 350 - 400 mg/L in reclaimed water. The turbidity is 0.1 NTU in reclaimed water.

Figure 12 Wastewater Reclamation Facility at Reedy Creek/Disney World, Florida.

4.1.5 Composting operation and biosolids

Solid waste used to be incinerated and this building is now the dewater operation. Activated sludge is sent to a belt filter press. The composting process keeps compost at 50^{o}C for 28 days. Then there is an 8 - 12 week residence time. Woodchips are mixed with the biosolids (food waste is composted separately) in a 1:1, sometimes 2:1 ratio woodchips: biosolids to:

- Help aeration
- Control moisture
- Provide carbon to obtain the ideal C:N ratio.

Plastic in the food waste is an issue with composting as you end up with quite a lot of rubbish (plastic) in it, which is difficult to remove.   This is a problem somewhat specific to Reedy Creek Utilities due to the large percentage of food waste in their compost.

There is also a fire risk involved with composting. They have had a few fires caused by the compost drying out too much or the piles being too big. It costs $250 per dry tonne to treat. The amount of compost produced is approximately 6000 tonne per year.

Figure 13   Biosolid and food waste composting facility at Reedy Creek/Disney World, Florida.

4.1.6   Raped Infiltration Basins (RIB)

There is a 60 to 80 ft vadose zone (surface to water table) beneath the RIB. The inside walls of RIB are lined to stop erosion on the side walls when pumping water into the central inlet. They have about 8 - 10 RIBs and operate them 6 - 8 weeks off and 1 week on. The surface of the RIB can grow algae or plants after a while, so the circular rings around the central inlet valve (

Figure 14) are for two purposes; to prevent weed growth and to help drainage. Approximately 2.5 billion gallons per year go to RIB and 3.0 billion gallons are recycled on Disney Worlds.

Figure 14 Rapid Infiltration Basin (RIB) – Reedy Creek Energy Services. Disney World, Florida.

Table 6 Reedy Creek, Florida. Summary table of participant questions.

Drivers	
What were the key drivers for the scheme?	Limited water supply and zero discharge.
What incentives etc were given to customers?	None in this case, although it was a philosophy of Walt Disney that the theme park was not to be a financial burden on the local community.
Costs	
How much is charged for the water? Pricing structure? What is the cost of potable water?	Potable water costs about $1.00 per 1000 gallons and reclaimed water costs $0.80 per 1000 gallons. They like to charge a reasonable amount for the reclaimed water so people don't waste it, like what has happened in some other schemes.
What is the willingness to pay for recycled water?	Good.
What is the cost to produce the recycled water? Includes capital repayments allowance for grant monies etc?	Covers operation and maintenance costs.

4.2 Participants wrap up

The lasting impression was that a lot of money was spent on creating big capacity, with the assumption of growth down the track. This was a big operation. Out of all schemes so far they got the best out of reclaimed water. Indirect potable is a reality, but it is not talked about in this context and there seems to be no health and environmental issues.

Much better approach to managing consumption, they linked price managing to their scheme. They seem to see reclaimed water more as an asset and it is sold accordingly. Money wasn't an issue. Like the comment that he didn't want to burden the government and tax payer.

They have reached the capacity of recycled water use unless they begin storing it somewhere for reuse. Unlike Australia there seems to be limited projection into the future with respect to water supplies and uses.

The WRF is cost neutral.

4.3 City of Lakeland Water Utilities-Lakeland

4.3.1 Contacts

http://www.lakelandgov.net/water/wwplantoperations.html

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4.3.2 Background (from tour book)

4.3.2.1 Glendale WWRF

The Glendale Wastewater Reclamation Facility (WWRF) is located at 1825 Glendale Street in Southeast Lakeland. The facility began operation in 1926 as a 2.5 MGD primary setting and sludge digestion facility. Treated effluent was discharged through Stahl Canal to Banana Lake, and ultimately the Peace River. In 1987 the City of Lakeland changed its discharge point by constructing a 1400 acre Artificial Wetlands Treatment System (AWTS) in Mulberry. Effluent from the WWRF is pumped to the AWTS and ultimately flows to the Alafia River.

Glenside treats about 8 mgd (160,000 EP).

4.3.2.2 Northside WWRF

The Northside Wastewater Reclamation Facility (WWRF) was designed in 1986 to treat wastewater flow from the North Lakeland Service Area. The Northside pumping station, which had discharged to the Glendale WWRF, acts as the major source of wastewater for the facility. Other major wastewater pumping stations that contribute flow to the Northside operations include Northeast, Socrum Loop, Wedgewood, Interstate, American Cyanamid and Eastside Village pumping stations. Thus, the Northside plant provides for future growth in the Northern sections of the City. In 1988, the Northside plant started operation. It is located just north of the McIntosh power plant. The facility was initially permitted for a 4.0 mgd annual average daily flow (AADF). In 1996 the Northside operation was expanded and now has a liquid treatment capacity of 8.0 mgd and a solids treatment capacity of 6.25 mgd. The facility uses a secondary treatment process to treat the raw wastewater. The process utilised is an Activated Sludge System that is called the "Carrousel Process".

Treated effluent from the WWRF is pumped to a 1.5 MG storage tank located at the entrance to the plant site. Treated effluent is stored in the tank and is reused as cooling water by the McIntosh power plant. Cooling water requirements that exceed the flow from the Northside WWRF are supplied by the 'W. Carl Dicks WWRF'. Excess effluent, exceeding the requirements of the power plant, is bypassed for disposal at the Lakeland Artificial Wetlands Treatment System. Waste sludge from the WWTF is treated using a process to further reduce pathogens (PFRP). The process used is the Autothermal Thermophilic Aerobic Digestion (ATAD) method. The ATAD process produces a Class A stabilised residual product. The Class A residuals are land applied in accordance with FDEP and EPA requirements.

The Northside WRF processes about 3.1 mgd (40,000 EP). They only use 2 of 4 treatment chains at present. They have a scrubber for odour control, which has reached the end of its useful life and will be replaced shortly. Flows from splitter boxes go to anoxic stage, with low lift propeller pumps. Then go into the toxic basin where sludge is settled and separated. They try and keep a DOC of 2 mg/L as part of the nitrification/denitrification stage to remove nitrogen, this is a major focus of the WWTF.

Table 7 Influent and effluent flow quality from the Northside WWRF

Water source	Flow rate	CBOD5	TSS	Ntot	F/Coli	pH	Ptot	NH3	NO3	EC
	MGD	mg/L	mg/L	mg/L	Ct/100mL		mg/L	mg/L	mg/L	uS/cm
Influent	3.42	253	185	35.9		6.5	7.2	20.4		830
Effluent		1	3	2.1	1	6.4	1.3	0.3	0.9	722
Reduction		99.3	97.5	93.6			80.7	98.7		

4.3.2.3 Biosolids

Class AA biosolids are produced using Anaerobic Temperature Aided Digestion (check). ATAD is a three stage process where the temperature is self generated, and there is a 7 - 10 day retention time. This is an aerobic thermophilic process that produces a double A class sludge. The ranchers just love it as it is like a liquid manure (3% solids). The WRF gives it away and transports it at their cost to farmers. The final product can also be used in public spaces (eg median strips).

4.3.3 WRF and Effluent Storage

Handout from WRF.

4.3.4 Wetlands Treatment System

Speaker Doug Gleckler

http://www.epa.gov/owow/wetlands/pdf/Lakeland.pdf

4.3.4.1 Introduction (from tour book)

The City of Lakeland (City) operates a 1,400 acre wetland treatment system located just |east of the town of Mulberry, Florida. The wetland system serves as the final treatment process for the City of Lakeland's 10.8 mgd Glendale Wastewater Treatment Plant and their 4.0 mgd Northside Wastewater Treatment Plant. These treatment plants serve a combined population of approximately 79,000 people within the city limits, as well as portions of the unincorporated areas of Polk County. Many of the natural upland and wetland communities within Polk County and the surrounding counties have been replaced by agricultural and industrial development. Citrus and phosphate mining industries have altered the landscape around Lakeland to a greater extent than any other development activity. The phosphate mines have provided the most dramatic changes to the lands in Polk County by not only eliminating the natural ecosystems, but also by significantly altering the topographic nature of these areas.

Restoration efforts within most of the abandoned mine sites have been limited in scope at best, since no real efforts generally are made to restore the original topography and vegetative communities. Instead, upland areas are normally replanted as monoculture pine forests, while most aquatic areas are comprised of lakes formed in unfilled mine pits. Most emergent wetland communities are restricted to the littoral zones of the lakes or are usually dominated by monoculture stands of cattails (Typha spp.) and/or Carolina willow (Salix caroliniana).

4.3.4.2 Project background

The City originally began treating wastewater on the Glendale site in 1926, using a 2.5 mgd primary treatment plant. This plant began discharging effluent to Banana Lake via Stahl Canal, a practice that continued for more than 65 years. In 1939 the City upgraded the treatment plant with trickling filters to achieve secondary treatment. In the late 1950's and 1960's, the City rebuilt the trickling filters and expanded the facility to 10 mgd. The City began diverting up to 5.5 mgd of effluent from the Glendale treatment plant to the newly constructed C.D. McIntosh Jr. Power Plant for use as cooling water. In 1981 effluent pumped to the power plant was further treated on the power plant site and discharged (rapid infiltration) to the surficial aquifer adjacent to Lake Parker, thereby reducing the flows and loadings to Banana Lake. In 1988, the City expanded the wastewater treatment system to include its newly constructed 4.0 mgd Northside plant. When the Northside plant went on-line, it became the primary source of cooling water for the power plant.

The sustained effluent discharge to Banana Lake, along with agricultural development in the Banana Lake watershed, severely degraded the water quality of the lake and down stream waterways. Early in 1983, the Florida Department of Environmental Protection (FDEP) indicated that the City's discharge permit to Banana Lake would not be renewed due to water quality problems in the lake. For this reason, both FDEP and the U.S. Environmental Protection Agency (USEPA) negotiated compliance schedules with the City to cease discharging effluent to Stahl Canal and Banana Lake.

One of the lakes located at the downstream end of the wetlands.

Faced with compliance schedules to cease discharging to Banana Lake, the City retained Post, Buckley, Schuh & Jernigan, Inc. (PBS&J) to develop and evaluate viable effluent disposal alternatives. Analysis of these alternatives indicated that disposal via an artificial wetland system would be the most cost effective method of effluent disposal for the existing Glendale plant. The Glendale facility has since been re-rated to 10.8 mgd. The wetland site selected includes 1,600 acres that were formally used by W.R. Grace Inc. as a phosphate settling area.

The site is characterised by a series of seven cells surrounded by levees (See Figure 1.). Process waters from the previous mining operation were recycled through the cells to settle solids out of the water column. Overflow from the recycle system is discharged to the Alafia River. This process created a soil gradient across the cells where course-grained sands settled on the influent side of cells 1, 2 and 3, while fine clayey sediments settled on the effluent side of the cells. The settling process also created a significant topographic gradient in the first three cells that slope downward from the influent to effluent sides of the cell. The sediments in cells 4 through 7 are predominately nearly level fine clayey soils. A shallow lake still exists on the downstream side of cell 5, while cells 6 and 7 remain as deep lakes.

4.3.4.3 Wetland design

Since 1987, approximately 1,400 acres of the project site have been used as part of the wetland treatment system. This area provides a permitted treatment capacity of 14 mgd of secondary effluent, although the current flows average approximately 8.0 mgd. Effluent is pumped from the Glendale plant polishing ponds through 6.4 miles of force main to the wetland system. In 1989, the influent to the wetland system was augmented by the inclusion of blow down waters from the Unit No. 3 cooling tower at the McIntosh Power Plant, along with periodic discharges from the ash ponds. Blow down waters from the power plant are mixed with effluent from the wastewater treatment plants at the Glendale plant and are then pumped to the wetland.

The introduction of the cooling waters and the ash pond effluent has significantly increased the total dissolved solids concentrations to the wetland. As an example, the average annual influent conductivity levels have increased.

The influent enters the wetland through a cascade inlet structure. The inlet structure is designed to aerate the influent waters through turbulent fall down the structure's 13 steps. The flow is split at the inlet structure between two Fabriform lined ditches that lie along the eastern boundary (influent side) of cell 1. Water is discharged from the distribution ditches through weirs located every 100 feet along the ditch. Flow rates through individual weirs can be controlled by the addition or removal of flashboards.

Once the water passes through the cell it is collected and discharged to cell 2. This general pass-through and collection system is repeated in cells 2 and 3. These three cells have the greatest change in topography. This system helps better distribute flow in these cells. Cells 4 through 7 do not have distribution ditches. An H-flume outlet structure located at the South end of cell 7 is used to monitor and control flows leaving the wetland site. A meteorological station provides data to assist in the preparation of annual water budgets for the wetland.

4.3.4.4 Site conditions

When the City assumed control of the wetland site, much of the interior of cells 1 through 4 were covered by cattails and Carolina willow. Upland islands within the cells generally were vegetated by undesirable grass/herbaceous species, and in some areas by pine (Pinus spp.) and live oak (Quercus virginiana) tree species. Vegetation in the upstream areas of cell 5 was a mixture of cattails and Carolina willow, while the downstream half of the cell was a shallow lake system that was ringed by a dense population of water hyacinths (Eichhornia crassipes). Densities of algal populations in this lake often created a lime green color in the open water areas.

Although minimal disruption of the existing wetland vegetation within the treatment cells resulted from the construction activities, restoration grant monies received by the City from the Florida Department of Natural Resources were used to plant trees including; black gum, red maple, sweet bay, swamp laurel oak, bald cypress, dahoon holly and pop ash, within certain areas of cells 1 through 5. Secondly, the water hyacinths were removed from cell 7 in response to concerns, voiced by the Polk County Environmental Services Division, that operation of the wetland system would increase mosquito production in areas covered by water hyacinths.

In operation since 1987, the Lakeland Wetland Treatment System offers wildlife a natural habitat.

The areas along the Eastern sides of cells 1 and 2 were originally barren sands or sparsely covered by upland grass species. These were the only areas planted with herbaceous wetland vegetation during construction. In both cells the pre-construction vegetation was cleared to allow the site to be graded.

Initially, the highly permeable sandy soils made it difficult to establish wetland vegetation in these areas. However, after five years of operation both areas now support dense communities of wetland vegetation.

4.3.4.5 Operational Results

The original design objectives for the wetland treatment system were to improve the City's effluent quality beyond the secondary level (shown in Table 8 as Original Goals). Since startup of the wetland system, State legislation was enacted that required the wetland to meet even more advanced wastewater treatment levels (also shown in Table1 as Existing Permit Conditions). Table 1 provides a summary of: the influent BOD, TSS, TN and TP concentrations; water quality after passing through the first two cells (represented by station G3) that are primarily emergent wetlands; and the final effluent discharge structure. The average annual concentrations for the first four years of operation are presented, as well as the FDEP and USEPA permit limits. As shown, the wetland effluent quality has consistently met the permit limits, with the exception of TSS for 1990 and 1991. This can be at least partially attributed to increased algal populations in the last four cells within the wetland. Cell 7 previously was covered by water hyacinths, which served to limit the concentration of algae near the effluent structure. The removal of the water hyacinths in response to county concerns has allowed the algal concentrations to increase, which appears to interfere with the wetlands ability to maintain TSS concentrations below permit limits.

Table 8 Water quality data of the wetland treatment system for the first four years of operation.

	BOD (mg/L)	TSS (mg/L)	Total N (mg/L)	Total P (mg/L)
Influent	3.88	5.0	10.36	9.05
G3	1.14	1.74	23.79	6.54
Effluent	3.12	4.7	1.99	4.22
Original goals	5.0	10	3.0	Exempt
Existing permit conditions	5.0	5	3.0	mpt

Effluent phosphorus limits are exempted due to the high background phosphorus levels in the receiving stream

The City is currently working with FDEP, USEPA and PBS&J to lower water levels in cells 3 through 6, and to increase the density and distribution of macrophytic vegetation in cells 4 through 7. Increased densities of macrophytic vegetation in the latter four cells should help limit the density of algae in these cells and, consequently, reduce their contribution to TSS in the effluent. The wetland has also provided habitat for a variety of wildlife species. Most notable are the large rookeries formed by wood storks (*Mycteria americana*), white pelicans (*Pelecanus erythrorhynchos*), cormorants (*Phalacrocorax auritus*) anhingas (*Anhinga anhinga*), white ibis (*Eudocimus albus*) and several egret and heron species on the upland islands within cells 5, 6, and 7. In addition, there are several bobcat (*Felix rufus*) and otter (*Lutra canadensis*) families now living within the boundaries of the wetland.

4.3.4.6 Summary details

Project cost

Wetland	$3 100 000
Pipeline	$2 800 000
Pump station	$ 780 000
Total	$6 680 000

Acknowledgements

Numerous individuals have contributed to the success of the Lakeland Wetland Treatment System. Listed below are some of the key groups and individuals.

City of Lakeland

John K. Allison, former Public Works Director
Virgil Caballero, Wastewater Superintendent
David Hill, Project Biologist

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4.3.4.7 Site visit

The wetland was an old phosphate mine and now it includes 1400 acres of wetland with three treatment areas and 7 cells. One of the biggest management challenges is salinity. The effluent from the power plant that enters the sewage system increases salinity 6 times. The water from the power plant is 5000 uS/cm EC and when diluted with WRF water it is 1500 - 3000 uS/cm EC. The limit for the wetland release of water is 1275 uS/cm EC. Approximately 5 - 6 mgd of treated reclaimed water is supplied. They are P exempt with respect to water quality release as they were an old phosphate mine. Phosphorus is a problem with respect to algae blooms. They have tried to shade out the cells naturally to minimise algae blooms and are trialing some plastic balls at present (Figure 15). The wetlands are a funny shape so it is difficult to put traditional covers on. The cost of 15 million balls is approximately $2.7 million. Others have used them for 15 yeas with no losses or problems and they prevent concentration though evaporation.

Figure 15 Black plastic balls being trialled to determine their effectiveness on minimising the exposure of algae to direct sun light, Lakeland, Florida.

Doug Gleckler looks after the wetlands. The largest cell (pond) within the system is 410 acres and there are 7 cells. The problem with the system is that the large lakes are at the end of the system. They sometimes by-pass these large lakes at the end as you get a lot of algae growth and/or evaporation. The wetland systems works as anaerobic and aerobic systems, but when water is released to the environment they must have at least 5 mg/L DOC. Salinity needs to be managed through dilution. Dilution comes from rain. Sometimes they store water for up to 4 months. However, they get a concentrating effect. The wetland has no public access and regulators like them to use desirable plants.

The cost of the wetland has been $6,000,000; the cost for a WRF which would treat similar volumes would be in the vicinity of $20,000,000 so relatively it has been fairly cheap. Approximately 8 mgd of effluent enters the wetlands. The wetlands are an unknown tributary to a local river system.

The water quality entering and leaving the wetlands is summarised below (Table 9).

Table 9 Influent and effluent water qualities of wetland water (as of Apr 2005), Lakeland, Florida.

	CBOD	TSS	TN	TP	DO	pH	EC	F.Col	Flow in	Flow retained
	mg/L	mg/L	mg/L	mg/L	mg/L		µS/cm	Col/100ml	mgd	mgd
Influent	3.37	6.42	6.94	4.0	5.22	6.77	1463	1	8.48	1.6
									Rain (inch)	Flow out
Effluent	1.59	2.74	0.91	2.8	7.98	7.21	923	30	5.94/mth	9.5

4.4 Quote for the day

At Disney Land, Regulators are in fantasy land

Great for a brown water rafting facility!

5 Program: 3rd June Florida

5.1 St Petersburg - Tampa Bay

5.1.1 Contacts

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Charlie
Field Operator for Recycled Water and cross connections.

David
Manager of Reclaimed Water

Wayne
Sewer Maintenance

John works with the 291 miles of reclaimed water piping.

Presenter: Joseph V. Towry
Presentation: St Petersburg Water Reclamation Scheme
Located: CD\ppt\5.1.1 Towry – WWRF St Petersburg.ppt

For more information on the WRF treatment process and performance see information supplied by Hamish Reid: CD\report\hamish\Case study - St Petersburg water recycling.doc

Websites of interest

EPA US 2004
http://www.epa.gov/ORD/NRMRL/pubs/625r04108/625r04108.pdf

5.1.2 Background (from tour book)

From Innovative Applications in Water Reuse, Ten Case Studies, May 2004 (pages 30 to 33)

The City of St. Petersburg, Florida is a largely residential peninsular community located on Florida's west-central coast. It is bounded on the east and south by Tampa Bay and on the west by Boca Ciega Bay and the Gulf of Mexico. St. Petersburg has a population of approximately 255,000.

In the early 1900s, municipal wells located in St. Petersburg were being pumped for increasingly longer intervals to satisfy a growing population. The resulting seawater intrusion into the groundwater aquifer eventually required the city to seek other sources of potable water supply. In the 1940s, St. Petersburg purchased well fields in western Hillsborough County and Pasco County. By the 1940s the City was treating its groundwater supplies at a water treatment plant located 26 miles north of St. Petersburg. In the early to mid- 1970s, St. Petersburg needed additional water but was uncertain if permission could be obtained to develop a new supply. Also, because of rapid population growth, the City's four wastewater treatment facilities needed to be enlarged. Concurrently, the Florida Legislature enacted a bill in 1972 requiring all communities in the Tampa Bay area to either cease discharging to Tampa Bay or treat their wastewater with advanced wastewater treatment (AWT) processes for nutrient removal. The City evaluated the alternatives and based on the cost of constructing and operating AWT facilities, and in consideration of its water supply problems, opted to upgrade its treatment plants to tertiary treatment (i.e., secondary treatment, coagulation, filtration, and disinfection) and implement a water reuse and deep well injection program that would result in no discharge to surface waters.

Reclaimed water system

The initial portion of the retrofit system went into operation in 1977. At this time the reclaimed water distribution system was limited to serving irrigation water from the City's four water reclamation plants to golf courses, parks, school grounds and large commercial areas. In 1981 the City applied for grant funding from the U.S. Environmental Protection Agency to expand the reclaimed water distribution system into residential areas. From 1977 through 1987, St. Petersburg spent more than $100 million upgrading and expanding its four water reclamation facilities (WRFs) and constructing more than 200 miles of reclaimed water pipelines. The WRFs range in capacity from 12.8 to 20 mgd.

In 2002, the total average flow from the four WRFs was about 42 mgd, half of which was reclaimed for beneficial uses. The four WRFs supplied 21 mgd of the 54 mgd of water provided by the City's Utility Department. The quantity of reclaimed water used has been relatively consistent for the last 10 years.

Figure 16 Recycled water pumps at the St Petersburg WRF, Florida.

The dual water system currently serves more than 10,500 customers throughout the City, including 10,000 residential customers for landscape irrigation. Residential landscape irrigation with reclaimed water is voluntary in St. Petersburg. Reclaimed water lines are brought into an area when at least 50 percent of the residents in that area petition for service and agree to connect to the reclaimed water system. Reclaimed water is also used for irrigation at 95 parks, 64 schools, six golf courses and 335 commercial sites. The water is also used for fire protection via more than 300 reclaimed water hydrants throughout the system and for cooling water at 10 sites. In recent years, the system has been expanding at a rate of 300 to 500 new customers per year.

Injection wells

Deep injection wells are used to dispose of excess reclaimed water and inadequately treated wastewater. The city operates a total of 10 injection wells at the four WRFs. The wells penetrate to a saltwater aquifer, approximately 1,000 feet below the land surface. The groundwater contains approximately 22,000 mg/L of chlorides (Salt), precluding its use as a water supply. It was hoped that the injected water would form a bubble in the aquifer such that it could be extracted as needed in the future. However, hydrogeologic conditions in the subsurface have thus far thwarted attempts to extract high quality water for reuse through aquifer storage and recovery.

Distribution system

Prior to distribution, reclaimed water is pumped to covered storage tanks at all four reclamation plants. Reclaimed water is delivered through more than 100 miles of trunk and transmission mains ranging from 10 to 48 inches in diameter. Local service is provided through more than 190 miles of small diameter distribution pipe ranging from two to eight inches in diameter. The transmission mains from all four WRFs are interconnected, so that reclaimed water flow and pressure can be maintained on the entire distribution network when any one plant is taken out of service. System pressure is monitored at key locations. The reclaimed water system incorporates five City owned and operated booster pump stations and four privately owned and operated booster pump stations to provide reclaimed water for all of the applications throughout the City.

All potable water services located in areas where reclaimed water service is provided are protected with cross-connection control backflow assembly devices. Top loading double check valve assemblies are used at residences. Cross-connection control provisions for commercial uses are based on the degree of hazard the facility presents.

Residential irrigation with reclaimed water

A typical residence in St. Petersburg uses about 30,000 gallons of reclaimed water per month during peak demand periods. The average irrigation rate is 1.5 inches per week. The average home discharges approximately 6,000 gallons of wastewater per month into the sanitary sewer system. Thus, it requires about five sanitary sewer customers to provide an adequate supply to one reclaimed water customer during peak demand periods.

Water quality

The Florida Department of Environmental Protection's (DEP's) water reuse criteria for residential and public access irrigation requires that wastewater receives secondary treatment, filtration and disinfection such that the faecal coliform level is below detectable limits in 75 percent of the samples analysed over a 30-day period, and does not exceed 25 faecal coliforms/l00 mL at any time. A minimum total chlorine residual of 1.0 mg/L is required after at least 15 minutes contact at peak hour flow. The regulations also specify a maximum BOD limit of 20 mg/L, a TSS limit of five mg/L prior to disinfection and continuous monitoring of turbidity and chlorine residual. St. Petersburg's Water Reclamation Facilities consistently meet all Florida DEP criteria.

System problems and solutions

Pressure: During the first few years of operation, it was discovered that the installation of backflow assemblies on residential services presented thermal expansion problems in plumbing systems when pressure built up by the hot water heater created a discharge at the hot water heater's temperature and pressure relief valve. To rectify this condition, the City provided pressure relief regulating devices to property owners for installation on an external spigot, so that the discharge would occur outside the structure rather than inside. Other recommended solutions involved installing expansion tanks or flushometers in toilets.

Chlorides: In about 1985, St. Petersburg began receiving complaints from some residential homeowners, claiming damage to ornamental plants and trees caused by irrigation with reclaimed water. Chloride levels in the reclaimed water were, at times, as high as 700 mg/L due to infiltration of seawater into sewers near the coast. Research conducted by the City found that chloride levels above 400 mg/L in irrigation water for an extended time period damages salt-sensitive species of plants. The problem was solved by reducing seawater intrusion through an infiltration/inflow correction program; by mixing high chloride reclaimed water with reclaimed water containing low concentrations of chloride, and by diverting some reclaimed water containing very high chloride levels to the deep wells for disposal. Reclaimed water chloride levels are now kept below 400 mg/L and complaints have ceased.

Inadequate Supply: Although approximately 50 percent of the effluent is injected into deep wells for disposal on a yearly basis, there are times when the demand for reclaimed water exceeds the supply. Demand increases substantially during the hot, dry spring months when wastewater flows are at a minimum and occasionally stresses the supply. The City addressed this problem by providing additional storage, which proved to be marginally successful, and by imposing a moratorium on distribution expansion until a solution has been developed to maintain current service levels. Other measures being considered include: metering the reclaimed water to control overuse; restricting irrigation during critical periods; developing an aquifer storage and recovery system to seasonally store reclaimed water and recover it for use during high demand periods; and developing informational programs to further educate the public about proper use techniques and lawn management.

Educational outreach

Adult educational programs include: public forums that address water issues; water conservation booklets and videos; weekly taped television broadcasts; online water conservation information via a website; annual public recognition awards; and community events promoting water reuse and conservation. A youth education program has been created to provide water conservation education through schools and youth agencies.

Funding, costs and subsidy

Residents who connect to the system pay the cost of extending distribution lines to serve them, which typically ranges from $500 to $1,200 per customer, through a Voluntary Assessment Program. The total connection charge is $295 - a $180 tapping *fee* and $115 for a backflow prevention device on the potable water line. Reclaimed water costs $11.36 for the first acre and $6.51 for each additional acre or portion thereof. The flat *fee* rate structure does not encourage water conservation, and most residents use more reclaimed water than necessary for proper irrigation. The reclaimed water rate for commercial customers who are metered is $0.33 per 1,000 gallons; however not all commercial customers have reclaimed water meters. The total capital cost of the program to date is about $135 million. Of this total, U.S. EPA provided $100 million to upgrade the four treatment plants and construct the distribution system, and the City contributed $20 million. The remaining $15 million is recoverable through the Voluntary Assessment Program, $11 million of which has been recovered to date. The current annual operating cost is $5.2 million. System revenue is $1.6 million; the remaining $3.6 million is subsidised by the City's water and wastewater utilities, each of which pays half of that cost.

Benefits

While the initial impetus for developing the dual system was to avoid costs associated with upgrading treatment to reduce nutrient levels in effluent discharged to receiving waters, reclaimed water use is now an important component of St. Petersburg's overall water resources management. Because of the lowered demand for potable water, the need to develop additional potable water supply sources has been postponed and may not be needed at all, if current water usage trends continue. For further information, contact: Joseph V. Towry, Assistant Director, Water Resources Department, 1635 Third Avenue North, St. Petersburg, FL33713.

5.1.3 Water Reclamation Facility (WRF), St Petersburg

There is a self imposed limit of 600 mg/L TDS for reclaimed water leaving the WRF. The turbidity is 2.5 NTU and coliform <25 count/100ml. State governs (DEP) give us our operating permit and there are also some local codes.

They have a lot of problems with salinity at present. They use the water for irrigation of a variety of plant species, so they need to be very conscious of the salinity of the water. There was some ingress into the sewage systems in the 80s where the TDS was 1600 mg/L, which had devastating effects on some plants. So sewer leakage identification and sealing has been a priority to fixed salinity, and this is an ongoing priority to keep the water salinity at acceptable levels.

Figure 17 Aerators and clarifiers at St Petersburg WRF, showing St Petersburg in the background.

Table 10 Summary of reclaimed and well water quality from the WRF at St Petersburg, and groundwater in the region.

Analyte	Reclaimed water[A]	Well water (potable)
pH	7.06-7.31	Na
F	0.54-0.69	0.59
Cl	159-372	na
SO4	93-125	na
TDS	594 – 1000[B]	na
Electrical conductivity (uS/cm)	1300-2400[B]	na
Na	102-206	12
TSS	<0.5 – 2.9	na
Zn	0.01 – 0.028	na
Cu	<0.002 – 0.004	0.32
NH3-N	4.9 – 29.5	an
NO3-N	<0.050 – 3.74	0.07-0.53
NO2-N	0.02 – 3.49	0.02
TKN	9.95 – 30.1	na
Ptot	0.49 – 6.62	Na
B	0.230 – 0.350	na
K	1.6 – 3.0	na

[A]Results are single point analysis randomly taken from a detailed sampling program, between 2003 and 2005.

[B]Note: at the time of sampling salinity was relatively high. Generally this is <600 TDS mg/L.

5.1.4 Sports ground and cooling tours – Tropicana Field, Tampa Bay

5.1.4.1 Contact

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5.1.4.2 Background (from the tour book)

http://tampabay.devilrays.mlb.com/NASApp/mlb/tb/ballpark/index.jsp

Tropicana Field was completed in October 1989. The reclaimed water service installation and start-up was initiated in 1990. The reclaimed water system supports a 51 ton cooling system for the complex and meets the irrigation needs for the 5 acres of green space surrounding the complex. Additionally, there are several out-croppings that are irrigated as well with reclaimed water.

The original Florida Suncoast Dome was opened to the public on March 3, 1990, at a cost of $138 million. It became the Thunder Dome in 1993 with the arrival of the area's National Hockey League expansion franchise, the Tampa Bay Lightning. It was renamed Tropicana Field on Oct. 4, 1996, in accordance with a naming rights agreement between the Devil Rays and Tropicana Dole Beverages North America, located in Bradenton.

Though originally built for baseball, there have been 16 other sports and competitions presented in the facility. These include hockey, basketball, football, sprint car racing, gymnastics, soccer, tennis, weightlifting, ping-pong, karate, motorcycle racing, equestrian events, track and figure skating. Depending on the event the capacity of the stadium ranges from 43000 to 54000 people

5.1.4.3 Site visit

At the St Petersburg Sports Dome, home of the Devil Rays (Baseball team) reclaimed water was used for cooling towers (chiller system) for the fully enclosed stadium. Anthony said that he would not use reclaimed water again for this purpose because of sealing and filtering problems associated with it. However, this was predominantly because it was a poor design, with some undersized piping installed. If designed and built properly, reclaimed water may have been OK. The cooling system for the fully enclosed stadium was chillers (Figure 18) rather than evaporative cooling, so the recycled water chiller system was completely isolated from the air moving in and out of the stadium. Chillers where linked to the cooling towers outside the stadium (Figure 19). Air ducts where at the base of every seating level in the stadium.

Reclaimed water was not used on playing field, as synthetic turf was used to give a consistent field surface and overcome the minimal light that entered the stadium through the roof structure. They do use potable water on the dirt areas and mounds however, reclaimed water was not use as it stinks too much.

Figure 18 Chiller units and piping linked to cooling towers at the St Petersburg Sports Dome.

Figure 19 St Petersburg Sports Dome cooling towers.

Figure 20 The Study Tour team in the dugout at St Petersburg, Florida.

5.2 *Manatee County*

5.2.1 Contacts

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Manatee County

5.2.2 Background

Manatee County operate three wastewater treatment plants that serve the southwest, south east and the Northern portions of the county. Their system serves virtually the entire urban area of unincorporated Manatee County and the cities of Bradenton Beach, Homes Beach, Anna Maria, and the town of Longboat Key. The treatment systems were built in the 1970-80s at a cost of approximately $102 million with Federal construction grants that paid more than half the cost. At the time, construction of the systems was one of the largest capital improvement projects of it kind in Florida.

The southwest treatment plant can treat up to 22 million gallons of wastewater a day, while the other two plants can treat between 7 and 11 million gallons of wastewater a day. This is enough to handle their population growth well into the future.

One of the main driver for the construction of the WRF was to eliminate thousands of septic tanks and small, inefficient package plants that previously discharge wastewater into the Sarasota Bay. The treatment plant has also greatly improved the quality of water in the Bay. Manatee County's treatment plants do no normally discharge into any surface waters (i.e. zero discharge).

The treatment process has three main steps:

1. Preliminary treatment, where large objects and rags are removed from the waste stream
2. Treatment with micro-organisms, where oxygen is mixed with the sewage (activated sludge) to optimise organic matter consumption by the micro-organisms, then the water passes through the clarifiers. There is limited oxygen in this stage and the bugs stop consuming organic matter, settle to the bottom are either are returned to the head of the aeration tank or send to the solids facility to generate biosolids. The water on top of the clarifiers is sent to the final stage.
3. Polish prior to entering the reclaimed water scheme, where the water passes through sand and anthracite filters and is chlorinated with sodium hypochlorite. Manatee County switched from gaseous chlorine in 2001 to sodium hypochlorite because of the dangers associated with the gaseous form. Total chlorine is kept at 2 mg/L.

One of the main problems they have as a coastal community is the salt which is in the influent. In 2003-05 they spent $2.5 M in sealing sewers to prevent saline ingress into the system. They are currently building a line to link the three plants together, because most of the agricultural users are near the Northern Plant. Chloride concentration ranges from 150 -250 mg/L Cl.

Reclaimed water is supplied to citrus, tomato, gladioli and tree (30,000 trees) farm, and a scattering of residential properties. They are trying to target the large users such as agriculturalist as this is scene as lower cost and higher volumes of water use. This approach is also important as the farmers also have wells that they pump potable water from. If the WRF supply 2 million gallons to a farmer with a potable well, then 1 million gallons of well water can be used by the Water Authority for potable uses (i.e. potable substitution).

At present the WRFs pump 10 million gpd down into the aquifer to approximately 900-1000 ft. North plant is zero discharge so if farmers don't want the water they have a problem with storage.

The cost for agricultural use is:

- $0.05 per 1000 gallons (with potable water substitution)
- $0.10-0.20 per 1000 gallons (without potable water substitution)

Residential use $0.50 per 1000 gallons

Contracts with growers and Manatee County are 10 to 20 years, and can be cancelled at anytime with 30 day notice.

The cost of ground water is only cost of pumping, not the volume of water. Using recycled water also saves money on pumping costs. There is no guaranteed of supply or pressure as this is difficult to achieve with respect to times when the water quality doesn't meet guideline specification.

The reclaimed water suppler does not seem to guarantee supply of reclaimed water to farmers. In Australia guarantee of supply is usually and integral part of the contract to ensure a crop will not be ruin because it can not be watered.

County money was helping the connection of farmers to reclaimed water, but this is not available now as the county has decided if they want it now they should pay for it (i.e. they are starting to recognize the true value of this resource). Water table in the area is only 2-3 feet. There is no requirement to line reclaimed water pond storages.

Potable water is not produced by desalination yet, but they are looking at it.

Biosolids

Sludge from the wastewater treatment process is sent to belt presses, and trucks cart the biosolids to agricultural sites throughout Southwest Florida. Manatee County produces Class B biosolids, which is suitable for agricultural land spreading (with some restriction on the type of crops it can be applied to). They are now in the process of upgrading the treatment process so they can produce Class A biosolids, making it suitable for use on any crop.

Biosolids cost the WRF $13 per tonne to cart and spread onto the farmers land. The State is leaning towards everyone going to Class A plus biosolids, as eventually they think this will be required by all WRF in 5 - 10 years. They are looking at a thermal drying process to produce Class A biosoilds. Currently, 200 wet tonnes per day are produced, with a capital cost of $1,000,000. They are adjacent to a city landfill where they extract methane, which will be used to assist the process. This Landfill is still active. Multiple applications of biosolids are allowed to agricultural land, with nitrogen governing loading rates. Heavy metals (probably copper) are the overall loading limitation. There is talk of putting a regional drying plant in, which might help making Class A biosolids more economical for all WRFs.

5.2.3 Southwest and Southeast WRF – Treatment plant

The Southwest WRF, located at 5101 – 65th St. W., is a 22 mgd conventional activated sludge treatment plant. The flow scheme is: influent bar-screens and grit/sand removal; 4 primary clarifiers; 4 aeration basins using diffused air; 4 secondary clarifiers; 7 shallow-bed travelling bridge filters; disinfection with sodium hypochlorite; and open lake storage of reclaimed water. The current flow averages 14 mgd.

The Southeast WRF, located at 3331 Lena Rd., is an 11 mgd extended air (Carrousel) activated sludge treatment plant. The flow scheme is: influent bar-screens and grit/sand removal; splitter box; 3 extended air aeration basins with surface mechanical aerators; 3 secondary clarifiers; travelling bridge filters; disinfection with sodium hypochlorite; open lake storage of reclaimed water. There are no primary clarifiers. The long (~24 hour) aerator detention time results in a reduction of nitrogen. This plant provides leachate treatment for the adjoining landfill. The current flow averages 3.6 mgd.

Golf courses in the area are irrigated with reclaimed water.

5.2.4 Worlds largest Gladioli Farm

The gladioli farm is situated across the street from the treatment plant. It encompasses approximately 1600 acres. The property is divided into multiple growing areas. The areas are planted at different times, depending upon when a final crop is desired. Some plants may mature in 5 to 7 weeks, while others may mature in 6 to 8 or 7 to 9 weeks. The areas may also be divided according to desired colour production. In addition, some areas may be planted in early spring, while others may be planted in early summer. There are generally 2 to 3 crops per year to supply flowers for events such as Thanks Giving and Mothers Day. The gladioli supply the American and some international markets.

The entire farm is irrigated with reclaimed water. A perimeter ditch surrounds the farm in order to capture draining reclaimed water, which may be returned to the growing area by tail-water pumps. They average 5 mgd in the peak of the irrigation/growing season. There is a county ordinance that you cannot use potable water for irrigation.

Nutrients in the water are fairly low, but there is some reduction in the requirement of N and P fertilisation. Nitrogen is mostly in the NH_3 form at 12-20 mg/L and P concentrations range from 5-6 mg/L.

The price of property in the area is now so high that the gladioli farm and some citrus farms are under big pressure to be used for urban development. Land is being sold for approximately $100,000 per acre. It is anticipated that parts of the farm will be converted to residential areas within the next 2 to 4 years.

5.2.5 North WRF

The North WRF, located at 8500 – 68th St. E. in Parrish, is similar to the Southeast WRF, being a 5.4 mgd extended air (Carrousel) activated sludge treatment plant. Presently, the plant has submitted a request to expand the capacity to 7.5 mgd after the construction of new cloth disk filters and an additional chlorine contact chamber. The flow scheme is: influent bar-screens and grit/sand removal; 2 extended air aeration basins with surface mechanical aerators; 2 secondary clarifiers; 2 travelling bridge filters and 2 (new) cloth disk filters; disinfection with sodium hypochlorite; and open lake storage of reclaimed water. There are no primary clarifiers. The long (~24 hour) aerator detention time results in a reduction of nitrogen. The current flow averages 3.1 mgd.

They have a real problem here as they don't have any well injections at this plant, so they dread rain and no demand for reclaimed water. Under the DEP licence they can discharge to surface water if there is more than 8 inches of rain in a day.

David suggested that Chris Ferraro (DEP) may be consultative, but her officers make it hard work at times. Obviously, there are ongoing discussions with wastewater treatment facility operators and the DEP.

Figure 21 Cloth disk filters at the North WRF, Manatee County.

Table 11 Manatee County , Florida. Summary table of participant questions.

Drivers	
What were the key drivers for the scheme?	Zero surface discharge allowed by the DEP. A driver to keep recycling is and the need to secure more potable water for the county.
What incentives etc were given to customers?	Lower cost of water and assistance by the Federal Government to build the scheme and the County to connect the farmers.

Risks	
What was considered the major risk during development	Risks during development were not discussed.
After establishment, what new or unexpected risks appeared?	One major risk now is that zero surface discharge is allowed and some of the bigger users of recycled water are selling land for urban development. The urban development is costly to set up with recycled water supply and there will be a lag between farming and full urban development, meaning the demand for reclaimed water may decrease. Thus, the amount of water injected into the aquifer may have to be increased.
How are commercial risks allocated?	There seems to be little allocation of risk other than the WRF operators are very keen not to guarantee water supply, putting the commercial risk on the farmers if they do not have an alternative water supply.
Health, Environment and Resources	
Were there any environmental impacts?	Environmental impacts were from the effluent entering waterways or the ocean.
Were there any human health impacts?	None have been reported.
What are the key benefits?	Potable replacement, prevention of nutrient rich effluent entering sensitive water bodies/ways.
Are there alternative water sources available?	Well water.
Who does the auditing and monitoring?	DEP.
How is ongoing monitoring reported?	Monthly reporting. Reporting to a database that is checked monthly for key parameters and yearly for a full audit.
How have you managed salinity levels in the recycled water and ground/soil?	Salinity levels have been high in the reclaimed water due to saline ingress from salty groundwater. Most of their sewage systems are covered by the watertable. An extensive sewer sealing program has decreased the salinity to acceptable levels for irrigation.
Issues	
What happens to your biosolids?	Biosolids are treated to Class B level and applied to agricultural land (see text above).
Costs	
Who funds it initially?	Federal government funded 75% initially.
Who funds it long-term?	The Manatee County, with some offset by the sales of water.
How much is charged for the water? Pricing structure?	The cost for agricultural use is $0.05 per 1000 gallons (with potable water substitution) $0.10 - 0.20 per 1000 gallons (without potable water substitution). Residential use $0.50 per 1000 gallons.
Is it full cost recovery?	No.
Is there any ongoing and shortfall from revenue vs. apex costs?	Yes.

5.2.6 Quote

American flags, beige painted tanks, green grass and pick up trucks.

Build it and they will come!

The locals call the use of recycled water on their lawns, ‘Arse to Grass’.

5.3 Wrap up from tour participants

There is a real feeling that in Florida that recycled water use is considered normal practice. Treatment levels are perhaps between Class A and B compared with Australian Standards, and irrigation of public spaces has no controls for exposure of the general public to sprinkler irrigation. People have been using it so long now (20 years). The idea of recharging aquifers for indirectly supplementing potable water sources ensures that you don’t create two classes of water. One is a lesser quality to the other. Why use 3rd pipes and create another costly reticulation systems when you can indirectly add it to potable water sources and just use the reticulation system you have?

6 Program: 4th June, Cape Canaveral

Five tour participants visited the Cape Canaveral Space Centre. Amongst a fascinating history of the space race with Russia, they also found some water reclamation and reuse being practiced. In the early stage of the space race the Polo Space Craft jettisoned their urine and faeces. However, the later space shuttles recycled their urine for potable uses. Reclaimed water was also used in cooling and noise suppression during launch.

Figure 22 Kennedy Space Centre, Cape Canavaral

7 Program: 5th June.

Travel to Monterrey, Mexico

8 Program: 6th June, Mexico

8.1 Contacts

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Presenter: Alejandro F. Garza
Presentation: Earth Tech Mexico. WWTP Operations
Location: CD\ppt\8.2 Alejandra - Monterrey.ppt

8.2 General background - There are 100 million people in Mexico. It is one of the most advanced countries in Latin South America.

According to their constitution, the owner of the water is the Federal Government. You need permission even for a rainwater tank. After capturing the water you get permission to use it. Everybody must put the water back to where it came from without any detrimental effects; return it in the same condition you found it.

Mexico has a Federal Government, 32 states and 1400 municipalities. Federal and State terms are for 6 years, and municipalities are 3 years. You are not allowed to be re-elected to sit a consecutive term. This creates a big problem with the water industry in this country. A 3-year term does not give you time to plan the management of water for the next 25 years. In addition, some municipalities do not have enough money to do this. So there is a lack of term and resources to develop and maintain wastewater treatment plants and facilities. It used to be that 50% of the city water went directly to dams and rivers without any treatment, however this is currently about 30%. Many big cities are 2000m above sea level, so it is very difficult to move water to these locations from lower areas where there is lots of potable water.

Mexico City is an exception, where there are 20 million people there is limited wastewater treatment, most effluent goes directly to the field to be used for farming. To overcome this problem Earthtech has been working with the government to develop wastewater treatment facilities. The rainfall in Monterrey is very low, annual rainfall averaging 23 inches, 16 of which fall between June and October which corresponds to the Atlantic hurricane season. (http://www.vaultbbs.com/csteiner/aboutmonterrey.php)

Farmers in Mexico are very poor, so they cannot afford to pay for it. It is very difficult to charge farmers for treated water, so treated water is used more in industries. Major uses are oil refinement and power production (see below). They have hydroelectric, natural gas and nuclear power generation.

There are some cases where the government is negotiating with farmers using well water to swap this with reclaimed water. Around Monterrey there are no farming activities, so industrial reuse is the only option. The Federal Water Commission monitors all water use in Mexico. Some water wells have been shut down or have had their use restricted to conserve water resources. 90% of the population have access to potable water and 75% of population have access to sewage. The city of Monterrey has seven municipalities within it. Monterrey is the most important industrial city in Mexico, with big industries in steel, electronics, glass and automotive.

Up to 30 to 40% of sewage water in Monterrey is reused in industry. There are 20 STPs in Monterrey, ranging in size from 430 to 5000 L/s. The municipality operates 3 of these plants and the rest are privately owned. Earthtech operates 3 of the private plants. One of these is one of the most advanced STPs in the country (see below).

Potable water supply for Monterrey comes from 3 dams and 5 - 6 wells. The furthest water source is 100 km away. The population of Monterrey is 4 million people.

Water quality for reuse depends on the use of the water. For agricultural use the BOD must be <20 - 30 and disinfection with chloride. The standard is fixed by the company supplying the water, the government says you can use it, but it must be fit for purpose.

For instance, in the Cadereyta refinery they used to get 6000 ML from the river at a cost of US $1.60 per KL and they now use reuse water. Treatment of recycled water costs more than this ($3 per KL). But now they use much less as they can use it for 5 cycles in the cooling tower rather than 2 cycles in the cooling, as it is much softer (better quality).

Companies like Earthtech are in Mexico because they have a guarantee of payment (Figure 23). In Indonesia companies are pulling out as there are no such guarantees. The Federal National Water Commission (FNWC) put all the competitors around the table to kick off the bidding process for treating wastewater. The time for these negotiations is 1.5 to 2 years, and then 1 to 2 years for construction. The FNWC approves requests for the reuse of water. How they determine who will be bidding for these projects is very strongly regulated. The government must release an announcement internationally and you must meet appropriate qualifications before proceeding to the final stage of the tender process. The first stage of the bid is in two separate stages; technical and economical. Technical proposals are checked first, then if you pass these your economical proposal will be considered. If you are selected, then you have to sign the contract to complete the work or there will be a penalty.

There used to be a lack of resources, so all the money was going to potable water treatment; wastewater treatment was being neglected in Mexico. However, the Federal Government now puts a 40% subsidy to encourage development of wastewater treatment plants. They amortise the cost of the development over the 10 year period and then the asset is donated back to the municipality. Assets are co-owned during the 10 year period.

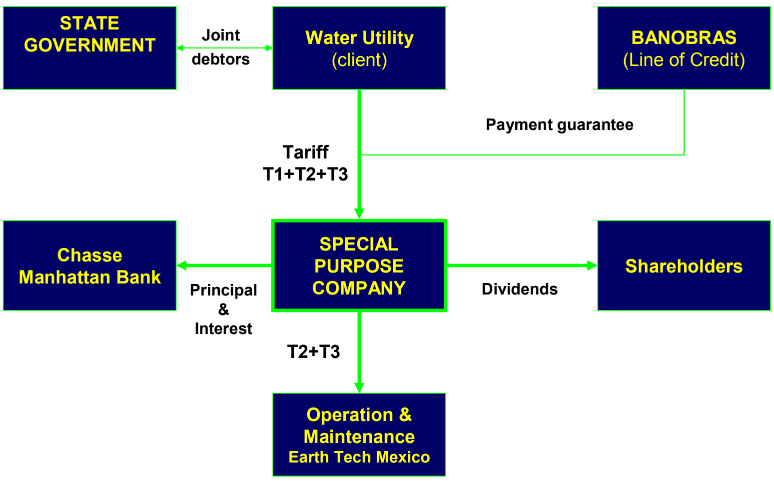

Figure 23 Financial scheme payment diagram from Earthtech (8.2 Monterrey – Alejandro.ppt)

8.3 Cadereyta

8.3.1 Contacts

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Figure 24 Alejandro Graza talking to study tour participants

8.3.2 Background

The capacity of the plant is 597 l/s. It started its operation in October 1998 and consisted of three separate treatment lines that yielded water for cooling towers, ionic exchange units and the reuse of the effluent of the refinery (Hector R. Lara. Sosa); where contaminants and discharges are reduced. The refinery, where the water is used, receives 207 million barrels of oil a day, which come from the Gulf of Mexico, via 200 - 300 km of pipeline. There are three treatment streams which include San Rafael Line, effluents line and demineralised line. These are summarised below.

8.3.2.1 San Rafael Line

The water resulting form the sewage facility owned by PEMEX in Guadalupes, N.L. Mexico, is received by Earthtech. In order to reduce the hardness and phosphates they add lime, sodium carbonate, aluminium sulphate and polymers. Then it is sent to the carbonation tank where carbon dioxide is added to achieve a pH close to neutral.

8.3.2.2 Effluents line

The treated effluent of the refinery is received in a secondary, extended-aeration type process (biological), which is used to remove organic contaminants such as oil, grease, nitrogen and phosphate. In addition, chlorine is added and acts as a biocide, achieving the elimination of coliform bacteria.

8.3.2.3 Demineralised line

The saline effluent from the cooling towers and the neutralised effluents from the regeneration and rinsing of the ionic-enhanced resins are heated to 38^oC in a heat exchanger in order to pass them to a lukewarm softening system, which precipitates most of its hardness. When cool, they are sent to the multimedia and organic-adsorption filters prior to entering the reverse osmosis systems. This system removes most of the salt from the effluent. The reject is treated through the evaporation and crystallisation processes. The high content of salts is dehydrated by a centrifuge.

8.3.3 WWTP Cadereyta Refinery- Cadereyta, Nuevo León

The objective of this waste treatment plant is the treatment of wastewater from the PEMEX refinery, to be used in the refining process. The capacity is 600 L/s and the capital investment is US $26 million. The treatment process is: Biological, lime softening, filtration, activated carbon, reverse osmosis, evaporation, crystallisation and sludge drying.

The concept is to provide water for to refinery cooling towers for steam and cooling. With the reduction of hardness the cooling towers use the water for 5 cycles not 2, so they are much more efficient. Rejected from the cooling system is evaporated, producing a water softening sludge, making it a closed discharged system. In Monterrey, they have two options for solids disposal. According to law, if they produce a hazardous waste, like the solid from the cooling tower, by definition it must be disposed of in a hazardous waste dump. If they can show that the solid is not hazardous, an exemption can be obtained and it can be taken to a normal land dump. The cost of dumping hazardous waste is 10 times higher than in the normal dump.

The operational cost of producing water is $1.60 per KL with capital cost of about $3.00 per KL. The TDS is 650 to 700 mg/L initially and after 5 cycles 3000 mg/L. After the R/O process the water is approximately 100 mg/L TDS.

This site had some demonstration plants early on which helped Earthtech secure an extra 3 more water treatment projects in Monterrey.

The R/O plant works on a 9 to 5, to 2 to 1 reduction in units (i.e. 4 stages) and achieves 80% recovery of water. Evaporators then take the brine from the R/O down to 5% solids, where it is then centrifuged to increase the solids to 80%. This part is 25% of the treatment cost. This solid is then combined with the water softening sludge.

Figure 25 Participants at the administration office of the Cadereyta Refinery, Muevo León, Mexico. Anoxic and aeration tanks and RO system.

8.4 Iberdrola – reclaimed water for power generation

8.4.1 Contacts

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8.4.2 Background

The objective of this plant is to provide advanced treatment of municipal wastewater, previously subjected to biological treatment by the STP, to be used for the generation of electrical power. This included softening of the water for cooling towers and r/o treated water for steam generation water.

The capacity of the plant is 450 lts/sec and it has been a $6.5US million investment. The treatment process is:

- Lime softening
- Filtration
- Reverse Osmosis
- Sludge treatment
- Sludge dewatering with band filter

In Mexico only the government can produce and sell electricity. However, you may be able to produce power (special permit required) if it is for self consumption or to put into grid. At this plant 80% of the electricity goes to industry, 20% to the grid. Reuse (or sometimes called reclaimed) water is used for cooling towers (400L/s). R/O water goes to steam generation, but the volumes used are low, as this is a closed system which only required topping up with R/O water; R/O is the sole source of water for steam. Less than 10% of the 5000 L/s STP plant (8 km away, see below) is used at this power station. Reuse water is sold to the power plant for $0.40 per KL. The only other source of water allowed to be used is potable, which costs $1.60 per KL. R/O has 70% recovery of water and the reject (4 L/s) goes back to the municipal treatment plant (5000 L/s) at no cost. Regulation does not regulate TDS, so the salinity of the water entering the STP is not a problem, especially after it is diluted with the 5000 L/s STP.

The power plant is a steam generator. The major use of water is cooling. It seems to be much more economical to get good quality water and cycle it many times, rather than poor quality water which can only be cycled a few times. The reject from blow down in the cooling towers goes back to the STP where it came from at no cost.

The R/O system gets cleaned every 2 months in summer and 3 months in winter. It has a design life of 3 years, but has run for 5 years so far.

Interestingly, there seems to be no color coding (purple/lilac) for piping using reuse water within the facilities we have been too.

Figure 26 Power generation plant at Iberdrola, N.L. Mexico.

8.5 Monterrey IV

8.5.1 Contacts

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8.5.2 Background

WWTP Dulces Nombres, Monterrey, Nuevo León.

The objective of this facility is the treatment of the municipal wastewater from the metropolitan area of Monterrey. This WWTP is operated by AYDM, a local water utility.

The capacity of the plant is 5000 L/s with a capital cost of US $110 million. The treatment processes are:

- Primary clarifiers
- Biological process by extended aeration
- Secondary clarifiers
- Chlorine disinfection
- Sludge thickener
- Sludge digestion
- Sludge drying

This STP is very smelly, but had good buffer distances. They have up to 80% bypass when there is a big rainfall event. Treated water is discharged to the river and farmers down stream use the water for irrigation. There is no potable water that comes out of this river. There are a number of examples in Mexico where treated wastewater is put into non-potable rivers.

The industrial areas in Mexico seem to be in the areas which have a lack of water. So it is cost effective to recycle.

Table 12 Monterrey - Summary of participant questions.

Drivers	
What were the key drivers for the scheme?	Price and lack of water.
What incentives etc were given to customers?	None.
Risks	
What was considered the major risk during development?	The ability to pay, which was contracted to be underwritten by the Mexican Government (see “CD/ppt/8.2 Monterrey - Alejandra.ppt”), minimising this risk.
After establishment, what new or unexpected risks appeared?	None.
How are commercial risks allocated?	Risks to Earthtech are; not achieving quality and quantity requirements for customers or not maintaining the reliability of supply.
Health, Environment and Resources	
Were there any environmental impacts?	TDS is not an issue, P and N are removed in the treatment and water softening process and any discharge to rivers seems to have a large dilution factor.
Were there any human health impacts?	None mentioned as the water is in a closed system for steam generation and gone through RO. Cooling towers are chlorinated water.
What are the key benefits?	Benefits are released potable water substitution.
Are there alternative water sources available?	The only two water sources are reuse water or potable water from 5 - 6 wells or 3 dams in the area.
How much recycled water is substituted for drinking water?	There was no official direct or indirect potable reuse. However, there may have been some indirect potable reuse through treated effluent discharge to rivers, where drinking water was extracted down stream. In many cases where STP effluent is discharged to rivers, the downstream water is only used for agriculture. It is difficult to believe that there is not some unplanned use of this water for drinking given that Monterrey is >200km from the sea.
Who does the auditing and monitoring?	The Federal EPA has a Water National Commission Branch, who is in charge of the fines given for breaches of licenses.
How is ongoing monitoring reported?	There is very little environmental impact associated with these schemes as they have zero discharge from one treatment plant and return waste to the STP at the Power Generation Facility. The large STP discharged to a big river where dilution and flow prevent algal problems.
How have you managed salinity levels in the recycled water and ground/soil?	Salinity is not considered an issue, especially as there is no agricultural reuse.
Are there any other environmental management issues?	Disposal of the water softener and R/O sludges were to land fill and no work had been undertaken to assess beneficial uses.
Have you assessed the impact of pharmaceuticals, personal care	Given the recycled water users visited (industrial) these types of risk were not a consideration.

products and industrial chemicals on groundwater dependent ecosystems when using ASR for indirect potable reuse?	
Are there any emerging pathogens or chemicals of concern?	Not considered due to specific uses low risk.
Lessons	
What is the most critical consideration for the particular reuse scheme?	Guarantee of supply for industrial uses is important and Earthtech has 2 - 3 personnel at all water treatment plants to always ensure good procedure and backup if required.
Issues	
What issues have arisen for end users during operation of the scheme?	None.
Salinity/sodicity issues?	None.
What happens to your biosolids?	Solids from processes are disposed in landfill?
Costs	
Who funds it initially?	45% Earthtech, 45% Investors, 10% Bank. See “CD/ppt/8.2 Monterrey - Alejandra.ppt”
Who funds it long-term?	In ten years many schemes revert back to ownership by the municipality. So they may eventually be self-funding or supported by the municipality.
How much is charged for the water? Pricing structure?	Cadereyta $1.60 per KL for potable water and $3.00 per KL for reuse water, but high quality means reuse water can be used 2.5 times in the cooling tower, making it more cost effective. Iberdrola $0.40 per KL for reuse water and $1.60 per KL for potable water.
What is the willingness to pay for recycled water?	
What is the cost to produce the recycled water? Includes capital repayments allowance for grant monies etc?	Cadereyta $1.60 per KL for reuse water, but high quality means reuse water can be used 2.5 times in the cooling tower, making it more cost effective. Iberdrola Not known.
What is the cost of potable water?	Sold at $1.60 per KL.
Is it full cost recovery?	The Earthtech water treatment plants are.
Flexibility of private sector?	
Is there any ongoing and shortfall from revenue vs. apex costs?	It would appear not.
Are the any outstanding cost issues?	None discussed.
Operational and end user requirements	

What changes have growers/users had to make in their management practices? How have they been assisted?	No growers supplied with reuse water.
Does the project address seasonal variations in demand (winter storage)?	Industrial uses have a fairly constant demand for recycled water across seasons.
What governs the application rate? N, P?	N and P not considered an issue.
What are the inline QA systems? eg Backflow devices	All Earthtech WWTPs have: ISO 9000 and ISO 14000; Safety Management System; Maintenance Management System – Proteus; Executive Report; and Operation Report.
Water quality	
What is the:	
• Salinity	TDS from R/O systems around 100 mg/L.
Communication/engagement/partnership programs	
What were the community's perceptions of reuse?	Not discussed as industrial use of reuse water is low risk and human contact is low, so it doesn't have the social implication of agricultural or urban reuse.
Regulation	
What is the regulatory structure/framework for recycled water?	The Federal Water Commission is responsible for allocation and licensing of water use. The EPA has a Water National Commission Branch, who are in charge of the fines given for breaches of licenses.
What are the water quality standards for each purpose?	TDS for cooling towers and steam generation.
For dual reticulation legislation, what is the compulsion for customers to connect?	None used.
Current and future innovations/technology	
What are the future challenges and directions facing water recycling schemes? (Governments, water industry, business).	As water treatment plants are donated back to the municipality the cost of ongoing maintenance and future development/upgrades will be a challenge.
Are any innovative technical processes used in this project now or in the future?	All the technologies were standard processes used in water and wastewater treatment.
Is the trend towards membranes – or other alternatives? Eg fabric media filtration	In Monterrey, R/O is popular and cost effective for cooling and steam production in industry.
Are there any innovative management process?	The safety and quality control practiced by Earthtech was well planned and of a very high standard.

8.6 Participants wrap up

Water reuse is driven by industry, as this is where the money is. Once they have the capital investment if there is no money for big replacements or upgrades in municipally managed STPs the upfront capital costs are transferred into payments over time.

People are used to costly automation. Labour is cheap. Security is high with electrified razor wire on top of fences. No environmental controls on discharges, and TDS is not a problem. If STP got to 180% the whole flow would be diverted. They paint everything as the labour is cheaper than materials.

Monterrey is a fairly dry place with unpredictable rainfall, when it does rain. The environment is secondary to industrial development.

8.7 Quote for the day

That's absolutely rotten!

Have another crack!

9 Program: 7th June, Mexico to San Diego

Travel to San Diego

10 Program: 8th June, California

10.1 Sweetwater Authority – San Diego

10.1.1 Contacts

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The Water Conservation Garden at Cuyamaca College has information on plants to grow in gardens that have low water requirements. See www.thegarden.org

Presenter: Dennis Bostad
Presentation: Sweetwater Authority
Location: by Dennis Bostad See CD\ppt\10.1 2 Bostad - Sweetwater San Deigo.ppt

10.1.2 Background (presentation on tour and from tour book)

Sweetwater Authority is a publicly owned water agency with policies and procedures established by a seven-member Board of Directors.
Sweetwater Authority provides safe, reliable water service (for more than 25 years) to approximately 177,000 people in National City, Bonita and the Western and Central portions of Chula Vista, California.
Sweetwater Authority owns and operates Loveland Reservoir, Sweetwater Reservoir, a brackish groundwater desalination facility and deep freshwater wells. Water obtained in each of these areas is influenced by the 200-square-mile Sweetwater River Watershed, a land stretching from the Cleveland National Forest to the San Diego Bay.

Water supply

Water delivered to Sweetwater Authority consumers is obtained from a variety of sources. Our customers can expect to receive 70% of their water from local water supplies, including the

Sweetwater River, the Sweetwater Alluvium and the San Diego Groundwater Formation. The remainder, about 30 %, is obtained from imported water sources.
Sweetwater Authority owns and operates Loveland Reservoir, Sweetwater Reservoir, deep freshwater wells and brackish water wells. The water is treated at the Robert A. Perdue Water Treatment Plant in Spring Valley, and the Richard A. Reynolds Groundwater Desalination Facility in Chula Vista.
Sweetwater Authority is deeply involved in programs to protect its water sources, and continually investigates ways to increase its local supplies of water. Programs include: tracking development; watershed outreach and education; urban runoff diversion and treatment; and studies of aquifer storage.

Facilities

Sweetwater Authority owns and operates Sweetwater Reservoir in Spring Valley, Loveland Reservoir near Alpine, and wells in National City and Chula Vista.
While water drawn at the National City wells site requires only disinfection, the brackish water drawn from the alluvial and groundwater formation sites near the Richard A. Reynolds Facility requires reverse-osmosis treatment, to remove dissolved salts and particles from the water before it is disinfected.

Perdue water treatment plant

Sweetwater Authority treats its surface water supplies at the Robert A. Perdue Treatment Plant, Sweetwater Reservoir in Spring Valley, CA. There, particles are removed from the water through a four-step cleaning process, and the water is disinfected with chlorine and ammonia, chemically bound together to form chloramine. The water is also treated to improve its taste, colour and odour. The Perdue Treatment Plant can process 30 million gallons of water each day. After the water is tested, treated and ready to drink, it is delivered to customers through more than 400 miles of pipelines.

Groundwater desalination

Sweetwater Authority customers are among the first in the region to benefit from a desalination process designed to treat "brackish," or saline, groundwater to make it safe for human use.
The Richard A. Reynolds Groundwater Desalination Facility, formerly known as a Demineralisation Facility, uses reverse-osmosis treatment (R/O) to remove dissolved salts and microscopic particles, such as bacteria and other contaminants that could be found in alluvial groundwater. The R/O process water is treated to prevent corrosion, and chlorine and ammonia are added to further assure disinfection.
The facility, completed in 1999, can produce four million gallons of drinking water per day. It was honoured with a 1999 San Diego Orchid in the competition's environmental solutions category.

Sweetwater Authority Boundaries

Gross land area (sq. miles) - 41
Loveland reservoir - 5.1
Service area - 32
San Diego Bay - 3.7
City of San Diego - 0.2

Service Area

Total Service Area (sq. miles) - 32
National City - 7.5
South Bay ID - 24.5

2003 Population estimates (SANDAG)

Service area - 176,210
South Bay ID - 121,690
National City – 54,520

Service Connections

(as of December 2003)
Total 33,855
Residential - 29,809
Commercial - 3,447
Government/Other – 544
Industrial – 47
Agricultural - 9

Pipelines

Total length - 390 miles
6 inch diameter and smaller - 161
8 to 10 inch - 139
12 inch - 52
14 to 16 inch - 13
Larger than 16 inch - 25
Average pipe age - 35.23 years

Public Fire Hydrants

Total - 2,447
Bonita - 436
Chula Vista - 1,252
National City - 759

Production

2003 total system production - 24,801 af
Local reservoirs - 528 af
NC wells - 1,588 af
Imported water - 20,433 af
Demineralisation- 2,272 af
Historical use imported (20 yrs) - 51.2%
Maximum daily consumption-98 - 32.1 mgd
Average daily consumption - 22.1 mgd

Raw Water Storage

Total capacity - 53,466 af

Treated Water

Total storage reservoirs - 25
Total capacity (gallons) - 42,835,200
Concrete reservoirs - 3
Concrete reservoir capacity (gallons) - 32,000,000
Steel tanks - 16
Hydro-pneumatic steel tanks - 6
Tank capacity (gallons) - 10,835,200
Total pump stations - 17
Approximate total pumping capacity (gallons/minute) - 36,000

Sweetwater River Watershed

Total watershed (sq. miles) - 182
Lower watershed - 38
Middle watershed - 42
Upper watershed - 102

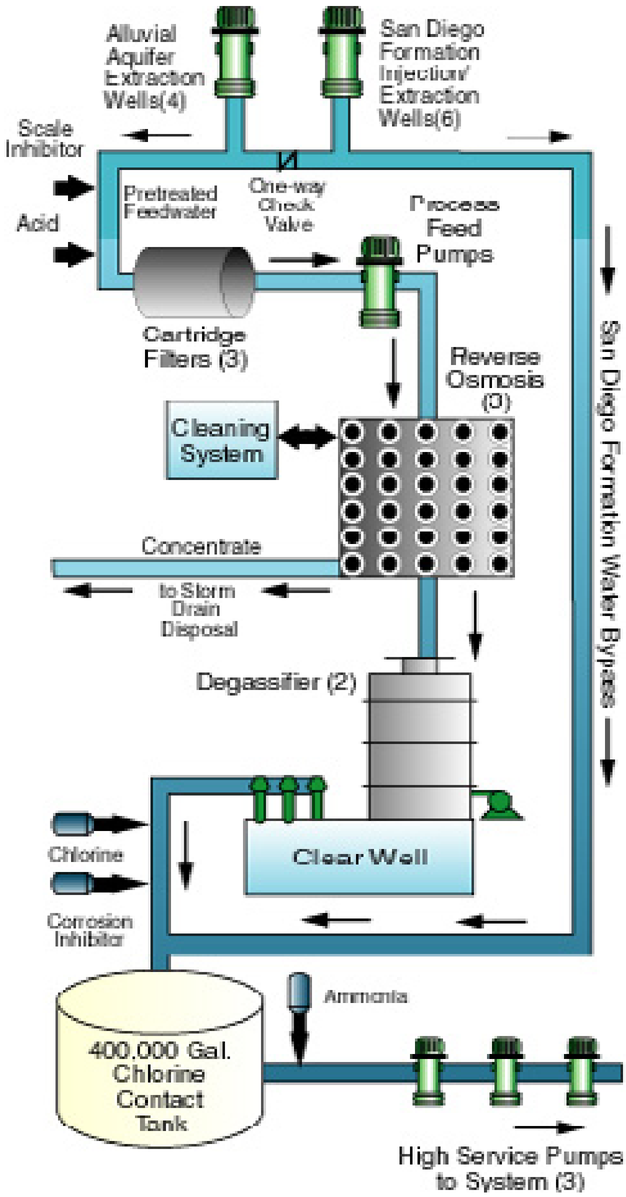

Figure 27 Diagram of desalination process

Wholesale Imported Water Cost

per acre foot, from San Diego County Water Authority - Jan 2003

Raw water (Tier I & II) - $381 / $462
Treated water (Tier I & II) - $463 / $544

Budget

2003-2004 Operating and capital - $43,703,800

Water Equivalents

1 cubic foot - 7.48 gal.
1 acre-foot - 325,850 gal.
1 million gallons - 3.07 af
1 million gallons/day - 1,120 af/year

10.1.3 Brackish groundwater desalination facility

Scott Donald showed part of the tour group through the water treatment facility.

The R/O unit treats 4 mgd and the whole facility had capital cost of $25 million. Water extracted from the groundwater is tritium dated and is thought to be more than 50 years old. There are lots of fault lines influencing water quality in this area. They have a roaming operator for this treatment plant and full control is at the nearby WRF. Where the water is sourced influences how water is recycled or what water source is used. At this site, if they extract water from the surface affected aquifer (down to 100 m) then there is a chance of contamination by surface flow and pollution, therefore treatment standards must be higher than just R/O. However, if the water is extracted from the lower aquifer (300 m) there is no chance of contamination from surface water, so R/O treatment is sufficient. Cryptosporidium rating is not given for R/O plants in California, as o-rings are considered a risk (i.e. if they fail, the integrity of the plant is compromised).

There is no saltwater intrusion into their aquifers at this stage, but the extract well has been constructed to allow both extraction and injection, so they can inject in the future if required.

Brackish groundwater feed is a TDS of 2500 mg/L. They are currently operating the R/O plant at 150 PSI as it is a fairly old system, but a new system will be installed in a few years that will operate at 100 PSI, having a much lowing power cost. The R/O water produced is usually a TDS of 100 - 120 mg/L. Their target is to produce water with a TDS <150 mg/L. Other potable water is a TDS of 500 - 550 mg/L, so the water is blended back with the feed water to a TDS of 500 mg/L.

They strongly recommend that if you have an R/O system you must have a cleaning facility onsite, as this saves a lot of money and time. Part of the cleaning facility should be a good water heating facility in the cleaning tank.

The R/O concentrate (waste) is discharged to a nearby stormwater drain which discharges into the tidal zone of a river. Anything above 50% recovery is good for an R/O plant and they get 80% recovery at this facility. For seawater, which is much saltier than this groundwater, it is much harder to get recovery above 50%. At this facility approximately of 30 to 50% of cost is the R/O process.

Figure 28 Discharge from water treatment facility's R/O plant entering a stormwater drain, Sweetwater, San Diego.

They give no disinfection credits for R/O. The risk is considered to be the o-ring part of the system. However, salinity monitoring may not be a good indication of membrane integrity. In Australia you might get a 4-log reduction credit for R/O systems.

Exposure builds up resistance, so are we making our environment too sterile, so that when we do become exposed we will be more susceptible to disease and our natural defence systems less able to defend us? Is it possible that in Australia we are making the guidelines too high, magnifying them through addition of precautionary principles? Perhaps this will overcome perceptions, but it may lead to much greater costs and maybe a more sensitive society?

The garden surrounding the treatment facility was grown from water sensitive plants.

Figure 29 Desalination plant, Sweetwater, San Diego, California.

10.1.4 Sweetwater Reservoir and urban runoff diversion system

The Urban Runoff Diversion System (Figure 30), located immediately adjacent to the North side of Sweetwater Reservoir, captures first flush storm flows and low flow runoff before the water enters Sweetwater Reservoir. When water contains high salt loads (TDS) it is diverted downstream into the river, where it joins the underground alluvium and becomes a source of supply for the Richard A. Reynolds Groundwater Desalination Facility. Water with acceptable TDS levels is routed into the reservoir and treated at the Robert A. Perdue Water Treatment Plant.

The Urban Runoff Diversion System allows Sweetwater Authority to avoid the problem of ever-higher salt levels in Sweetwater Reservoir, thereby providing continued storage capacity and avoiding the need to add more costly treatment at its 30 million gallon per day conventional treatment plant. Net water losses are addressed with the Authority's groundwater desalination facility downstream, which utilises reverse-osmosis treatment to produce 4 million gallons of drinking water from alluvial and groundwater sources. The average annual salts removed is 535 tonnes, and average annual recharge to the lower river basin is 300 af (97.7 million gallons).

Capacity of the reservoir is 28,000 acre ft. When the river flows and TDS is <1000mg/L the flow is switched to the reservoir 2 or 3 miles up stream. First flushes, which are more saline, are diverted to a number of lined ponds/wetlands where the flow is slowed, unwanted material settles or adsorbs to plants in the wetland and the water is put back into the river after the reservoir, where it percolates down to the aquifer (>20 year retention time before it reaches the extraction point of the brackish water desalination plant (Section 10.1.3)). They also have a natural spring that discharges to the river, and in low flows this can contribute significant bromide, which is continually monitored. Where the first flush water is diverted and taken out of the river for 2 miles before it enters the reservoir, potable water is dechlorinated in the two tanks on-site and put back into the river to ensure that the natural flow, which enters the next two miles of river, is not altered. This protects the native willow tree and some protected species that live in this riparian strip. This may sounds a bit ridiculous, but the EPA says that they must replace water taken out of any natural system.

Figure 30 Urban Runoff Diversion System lake and first flush diversion gates.

10.2 Padre Dam Municipal Water District – Santee Lakes

10.2.1 Contacts

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Allen Carlisle
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Paul Gagliardo
San Diego
Earthtech
Phone: (858) 536 5610 email: Paul.gagliardo@earthtech.com
The tour managers thank Paul for his efforts in organizing the tour at Padre Dam Municipal Water District and Santee Lakes Recreation Park. Our thanks also extend to Paul's Family who opened their home to the tour group.

For more information on the WRF treatment and performance see a report supplied by Hamish Reid at CD\report\hamish Case study - Padre Dam.doc

10.2.2 Background (from tour book)

Mission statement

The mission of Padre Dam Municipal Water District is to provide quality water, recycled water, park and recreational facilities, and wastewater management services for our customers. We accomplish this mission in the most cost-effective manner possible, earning customer and community respect.

Vision statement

We set the standard for delivering exceptional value and service in providing important life necessities for our customers and community.

Historical data

In 1976, the voters of the District's service area approved the merger of the Santee County Water District, formed in 1956, into the Rio San Diego Municipal Water District, formed in 1955. The surviving agency was named the Padre Dam Municipal Water District and uses 1955 as its origination date. The Alpine Highlands Water District and the Crest Public Utility District later merged into Padre Dam. The District is named for the Old Mission Dam, located just west of Santee. The dam, built circa 1807, supplied water to the Mission San Diego de Alcala. The mission was founded in 1769 and was the first of California's 21 Spanish missions. The dam has been named a historic water landmark and is believed to be the first major non-indigenous irrigation project on the California coast.

Service area

The District is a multi-purpose public utility providing wholesale and retail water, wastewater collection, disposal, treatment, water recycling and recreation at the Santee Lakes Recreation Preserve. The District sells wholesale water to the Lakeside and Riverview Water Districts.

There are approximately 85 square miles divided into the Eastern and Western Service Areas. Wastewater service is provided to the city of Santee, parts of El Cajon and parts of the county of San Diego. Water service is provided to the city of Santee; parts of El Cajon; and the unincorporated areas of Lakeside, Flinn Springs, Harbison Canyon, Blossom Valley, Alpine, Dehesa and Crest.

Population served

Wholesale service area population estimated at 126,254 (based on SANDAG data published 08/27/02)

Number of customers

23,816 total services - 12,975 accounts receive water and sewer service; 9,183 receive water-only service; 1,492 receive sewer-only service; 166 receive recycled water service (water and sewer services as of 12/31/03, recycled services as of 2 /11/0 4, water services a re active and inactive installed meters)

Governing body

The District is a public agency governed by a five-member Board of Directors, each representing a geographic area within the District. Directors are elected by the voters for staggered four-year term s. Board meetings are open to the public and are held at 3:30 p.m. the second and fourth Tuesday of each month at the District's administrative office.

Number of employees

139 permanent, full time.

Annual budget

$55,016,087 (2002/03) $59,513,490 (2003/04).

10.2.3 Recreational park

There are 7 ponds containing recycled water that form part of the recreational park (Figure 31).

In August 2005 the 128 new campsites will bring the total number of campsites to 300, making Santee Lakes the second largest campground in San Diego County. Each new campsite features cable TV and wi-fi internet access, and is built to accommodate the new generation of retirees and their large RVs. The campground expansion project will be completely paid for by Santee Lakes revenues, and will have no impact on water or sewer rates. Occupancy in the park is around 80%.

Figure 31 Recreational park with pond containing recycled water and campervans in the background.

10.2.4 Wastewater Management

See brochure.

Santee has a population of 65,000 people. They produce 5 mgd, 2 mgd is treated by this WRF and the rest (3 mgd) is sent to San Diego for treatment. They set the treatment plant up to be independent of San Diego and they were for while, but as the town grew it became more economical to pipe the excess to San Diego. Solids from this plant are also put in the sewage and sent to San Diego. There are 5 people who work at the WRF and two people in the laboratory that analyse drinking water supplies.

Phosphorus in the reclaimed water is almost non-detectable. They do have chemical dosing with aluminium sulfate, but P removal is mostly through BNR. The WRF has a constant flow (peak flow excesses are diverted to San Diego) and a fairly constant temperature (20-25^{o}C), so it works very efficiently.

At the time this plant was built and the concept developed, people may have been more easily convince than today. A small, some what isolated, population may be easier to handle too. Although, some tour participants have experienced that this is not the case in current day Australia.

They are thinking about doubling the size of the WRF, as there is an increasing demand for water in the area. One mgd is needed in the lake system to keep it healthy and another mgd is used for irrigation of all parks and schools throughout the city of Santee and the 187 residential connections. The water is sold at 85% of potable costs, but he wasn't sure of the potable water cost. The Padre Dam Municipal Water District also provides potable water to the City of Santee. Grant funding (which was more an interest free loan) helped set up the reclaimed water system. The WRF can treat the water for about half the cost of what the City of San Diego charges them for the excess flow they send to San Diego WRF for treatment. So, if you can treat it and then sell it, it becomes very cost effective. Extra demand will come from new residential developments being proposed in the area. They will probably have dual systems put into the new developments. However, this is currently being decided.

Reclaimed water at the WRF is used for fire control, with purple hydrants everywhere (

Figure 32). To get the entire reuse 3rd pipe systems in Santee, they were able to use 20% abandoned piped (smaller ones were abandon where larger ones had been put in to meet demand). Cross connections have been minable, except for one classic example of a public drinking water fountain, where they didn't realise until the recycled water was turned off for maintenance a few years after commissioning and the drinking fountain wouldn't work. Even though many people had drunk from the water fountain there were no obvious effects.

Figure 32 Reclaimed water fire hydrant at the Padre Dam Municipal Water District Wastewater Treatment Plant.

Residences connected to reclaimed water have a series of rules, they must have and maintain backflow devices and irrigate at night to minimise contact with humans. However, paddle boats are used in the recycled water lakes, which are different to kids running around in it and lots of spray mist from it.

Signage along the lake is limited. There is signage as you enter the lake, but excessive signage wasn't wanted by the manager of the park.

The general manager of the WRF at the time it was built was incredibly clever. To get public approval he added the third lake (first two were part of the treatment process), then he added grass, ducks, trees and made it look great so people wanted to have access (as there wasn't much water around). However, he fenced it off from public access. Then people were told we are confirming that the water is safe before you can have access.

They do not use reclaimed water in the Spray Park (play ground with structures where water comes out of the structures and kids play in the water), potable water is used (Figure 33).

Figure 33 Spray Park in Santee Lakes recreational area, Santee, California.

The reclaimed water main comes directly out of the WRF, not the lake. Limits for the release of the water to San Diego River are 1 mg N/L and 0.1 mg P/L. The water is highly disinfected with 10 mg/L chlorine for 90 minutes contact time.

People are allowed to fish in the lakes. Residential use is just starting; they currently have 187 metered reclaimed water connections. The public is more than willing to buy into residential use, but only if it is cost effective (e.g. new developments). After prospective costumers tour the plant they always want the water, as it is cheaper.

There are 7 lakes where fishing and boating are allowed. All drinking water is brought in from many miles away. It is only with recycling that they are able to have these lakes. People throw water away because they don't understand that it can be recycled. They are at the end of the pipeline for San Diego. People in the area already have very little water, and it costs a lot of money to pump it up the hill to Santee.

Reclaimed water helps protect the community from drought. Water is America's most valuable natural resource.

The Lakes where old pits from a gravel mine. This is a town that launders its water, 2 mgd is now treated producing this much reclaimed water. We can't live without water. The WRF is a river in a box, the process is just like what happens in nature, but sped up.

The primary sedimentation basin (5hrs) settles solids out and water moves into secondary treatment tanks, where bugs flocculate and settle out then the tertiary treatment is flocculated chemically, using alum sulphate. The water is then put into a sand filter where microbes denitrify the water. Once it goes through the chlorination it is read for recycling.

They monitor pH, COD, BOD, total N, nitrate, total P and pH. Every stage of the process is monitored to determine if the WRF is functioning well. The final step is disinfected with chlorine. The Reclaimed water looks like drinking water, but we only use it for irrigation. There is a separate reclaimed water irrigation system throughout the town, giving our young people a future.

They used to use reclaimed water in their swimming pool, they don't anymore. There was a lot of Fe in the water early on and chlorination made it very brown, so they went back to potable water in the swimming pool. Reclaimed water's physical appearance wasn't any good and it would have given reclaimed water a bad image.

There is no real possibility of overusing the recycled water in Santee, as there is a general acknowledgement in the community that they should use their water efficiently and wisely. It is about utilising the resources that you have. California has enough water, but 70% of the water is in the North and 70% of the people are in the South.

They have given about 53 tours to 1200 people.

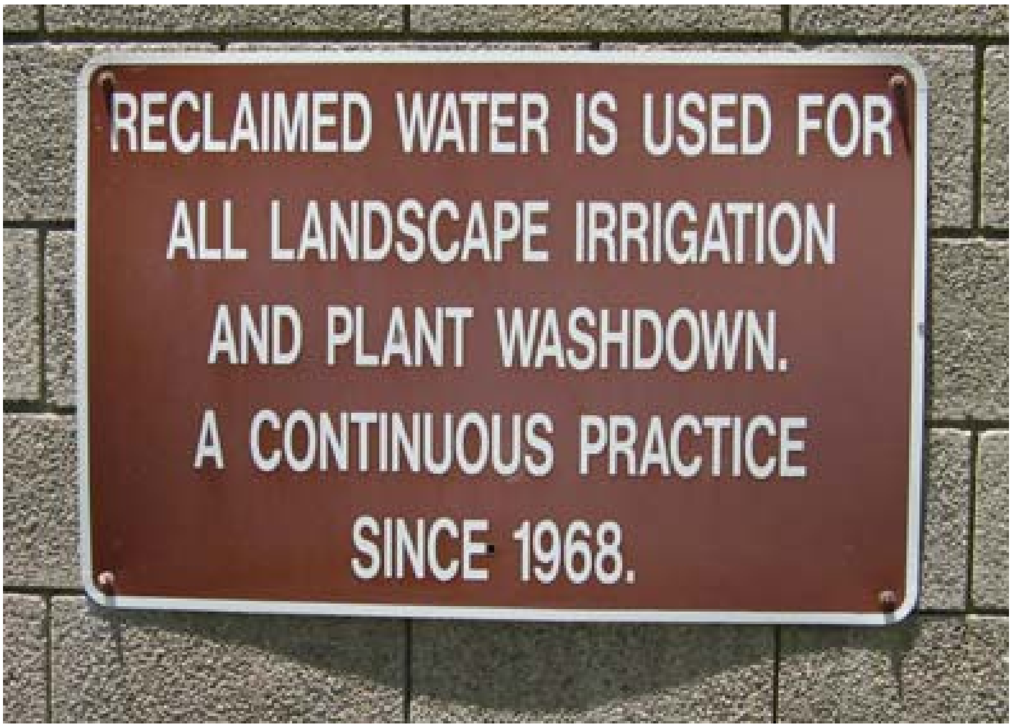

Figure 34 Signage displayed in the Padre Dam Municipal Water District Wastewater Treatment Plant.

10.2.5 Tour participants wrap up

Orange County was impressive as they told people what they were doing, how they were doing it and that is was safe. They just brought them along with the process, rather than doing an enormous amount of consulting with the public first.

10.3 Dinner Speaker - Jeff Stone, DHS California

10.3.1 Contacts

Jeffrey L. Stone
Recycled Water Program Coordinator
Department of Health Services
Drinking Water Field Operations Branch
Phone: (805) 566 9767 email: jstone1@dhs.ca.gov

Presenter: Jeff Stone
Presentation: Regulatory Framework of Water Reclamation in California
Location: Cd\ppt\10.3 Stone – Regs California.ppt

10.3.2 Background

Jeffrey spoke on the regulatory framework for the development of recycled water use in California, and objectives in the guideline rewrite.

- Public health protection
- Implementable
- Public confidence/defensible

Guidelines, policies etc are posted on: http://www.dhs.ca.gov/ps/ddwem/index.htm

Reference Jeffery quote with respect to safety and risk assessment:

Tanaka, Asano *et al.* 1998

Other references Jeffery supplied that he thought may be of interest to the group were:

Asano, Richard *et al.* 1992; Stone 2003a; Stone 2003b; Tanaka, Asano *et al.* 1998

10.4 Quote of the day

It is all about relationships

Absolutely!

It's the Australian Way.

I think I have answered my own question

Our groundwater even contains dinosaur piss

We are trying to find the truth!

11 Program: 9th June, California

11.1 Groundwater Replenishment System - Orange County

11.1.1 Contacts

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www.ocwd.com

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Orange County's Groundwater Authority
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11.1.2 Background (from tour book)

A new, visionary water purification project called the Groundwater Replenishment System is being built in Orange County. The Groundwater Replenishment System will help increase Orange County's water independence by creating a new locally controlled, drought-proof supply of safe, high-quality water—enough water to meet the annual needs of 144,000 families by 2007.

The Groundwater Replenishment System will take highly treated sewer water from the Orange County Sanitation District that is currently released into the ocean, and purify it through one of the world's most advanced water purification systems, consisting of microfiltration, reverse osmosis and ultraviolet light and hydrogen peroxide. The purified water then will be injected into a seawater intrusion barrier, with the remaining water being pumped to spreading basins in Anaheim, where it will naturally filter through the ground and blend with Orange County's other sources of groundwater. This water will follow the same natural filtering process rainwater has taken since time began. Most of the drinking water for north and central Orange County is drawn from the groundwater basin.

Groundwater Replenishment System water will exceed all state and federal drinking water standards and have water quality similar to bottled water.

Project benefits: A safe, reliable, locally controlled supply of water to replenish the groundwater basin; to protect the groundwater basin from seawater intrusion; to help meet predicted future water shortages; and decrease our reliance on imported water; and help make Orange County more tolerant of future droughts.

Construction required: A new purification plant on existing water agency land in Fountain Valley, new injection wells for an expanded seawater intrusion barrier and a 13-mile pipeline alongside the Santa Ana River between Fountain Valley and Anaheim.

Location of construction: Anaheim, Fountain Valley, Garden Grove, Huntington Beach, Orange and Santa Ana.

Agency reviews and approvals: More than a dozen federal, state and local agencies responsible for health, environmental safety and water quality will review and/or approve the Groundwater Replenishment System before it is built.

Estimated Phase I cost: Approximately $483 million.

Funding sources: A mix of federal, state and local funding. Grants of $92.5 million are secured, which includes $37 million from the State Water Bond (Proposition 13) approved by California voters in 2000, $30 million from the California Department of Water Resources and $5 million from the State Water Resources Control Board awarded in 2002. Additional grants were provided by the California Energy Commission, Environmental Protection Agency, Bureau of Reclamation and Metropolitan Water District of Southern California. Additional grants are being pursued.

Project Timeline:

1994:	Project research began.
1999:	Environmental review completed.
2000:	Project development in preparation of project design completed.
2001:	Water agencies' boards of directors voted to proceed with project design.
2002:	Project design began.
June 2003:	Interim Water Purification Facility construction began.
December 2003:	Project design completed.
January 2004:	Pipeline construction began; Water Factory 21 decommissioned; and Southeast Barrier Pipeline completed
Summer 2004:	Advanced Water Purification Facility construction begins.
2007:	Project scheduled to be operational, producing about 70,000 acre-feet per year.

Awards:

"1998 Planned Project of the Year," presented by the WateReuse Association of California

"2002 Environmental Achievement Award" presented by the U.S. Environmental Protection Agency (EPA) [This sentence doesn't read very clearly when compared to the other two awards—delete?]The Groundwater Replenishment System's education and information program also was selected by the U.S. Department of Energy as a national example of "best practices" in communicating scientific information.

Project Area Facts

Acre-foot: Sufficient water for two families for an entire year, about 326,000 gallons, or amount of water to cover football field to a depth of one foot.

Project area: 350 square miles in north and central Orange County, overlying Orange County's large groundwater basin.

Project area population: 2.3 million residents; 300,000 to 700,000 additional Orange County residents projected by 2020.

Current water demand: 505,000 acre-feet per year.

Projected water demand in 2020: 605,000 acre-feet per year.

Current sources of water in North Orange County: Currently, approximately 50 percent groundwater, 50 percent imported (purchased) water from the Colorado River and State Water Project.

Orange County Water District: Agency responsible for providing groundwater to 23 cities and water agencies in north-central Orange County; protecting Orange County's flow of the Santa Ana River; and for managing and protecting the Orange County groundwater basin.

Orange County Sanitation District: Agency responsible for collecting, treating and disposing of wastewater generated in 23 cities in north and central Orange County.

11.1.3 The groundwater replenishment system

11.1.3.1 Outreach program

Presenter: Ron Wildermuth
Presentation: The Groundwater Replenishment System (GRS)
Located: CD\ppt\11.1.3 Ron Wildermuth – Orange County.ppt
CD\ppt\11.1.3 Ron Wildermuth Kids -Orange county.ppt
CD\ppt\11.1.3 DHS Public Hearing - Orange county.ppt

Ron also supplied some social research studies on acceptance of the GRS that included:

- 2005 GWR System Survey.ppt
- Comparison of 2002_2003_2005 Data.pdf
- focusgroupanalysisRM.doc
- Latino In-Language Focus Group Report.doc
- Research Summary 2005.doc
- Vietnamese Focus Group Report.doc

(See CD\photos\050609 Thu - Orange County\11.1.3 Groundwater Repl. System - Orange County\reports*.*)

One of the major drivers has been the need to expand the seawater intrusion barrier. They are expanding from 15 mgd to 40 mgd injection of reclaimed water into the aquifer. The expansion of the OCWD Factory 21 water reclamation facility will be the world's largest water treatment facility of its type. It has probably one of the most successful outreach programs in the world. Perhaps second only to NEWater in Singapore. The major focus of the outreach program is to sell the benefits of reclaimed water and that it is safe.

They have 3 - 4 people in a PR agency that augment their staff to assist the outreach program. At present, they can't get a visitors centre funded due to budget constraints, but would like to have one like Singapore.

11.1.3.2 Treatment and water quality

Discussions with Mark P. Wehner. Director of Water Quality and Technology

NDMA and some other organic chemicals make it through the filtration system, so they need to have an advanced oxidation process. Peroxide and UV light is an enhanced oxidation process they use. 1,4-dioxane (solvent stabiliser), this problem was fixed through source control and newer more effective membranes. Titanium dioxide photocatalysis are being trialed in Australia as a collaborative project to determine if it is capable of degrading the 1,4-dioxane (Coleman, Leslie *et al.* 2005).

They are changing to 75% recycled water in their injection barrier because they want to go above the 50% level, the DHS wanted to see additional barriers. The advanced oxidation is not for specific compounds, but provides a barrier for all unknown organics (emerging contaminants). Pharmaceuticals may be present, but measurement at low levels is difficult. Estrogens are a concern of toxicologists at ppt levels, but more from an environmental perspective. For a lot of emerging contaminants we are unsure what is safe and don't have methods to measure them at the very low levels required, e.g. parts per quadrillion.

In the outreach program, emerging contaminants are addressed by the DHS (Department of Health Services); they require them to have an advisory panel, appointed by the National Research Institute. The public then see there is some independent oversight. The problem with the emerging contaminants is they will turn out to be a problem at very low levels. What has been useful is answering the questions before they are asked. They actually discuss issues publicly to increase public confidence and trust, and to show the public they are working on it with the best of the best.

NDMA and 1,4-dioxane have been picked up in some wells. The driving force for estrodiols is the sexual changes of fish. A lot of the concerns discussed above come from extrapolations at present.

Other natural water sources are probably not as good a quality. The water will be 25 mg/L TDS and they will buffer it up to 75 mg/L TDS, so it may be aggressive on the soil/aquifer and leach contaminates from the soil. Low salts are a consequence of the treatment based on toxicological standards, which is an added benefit. Natural water supplies range from 450 to 700 mg/L TDS.

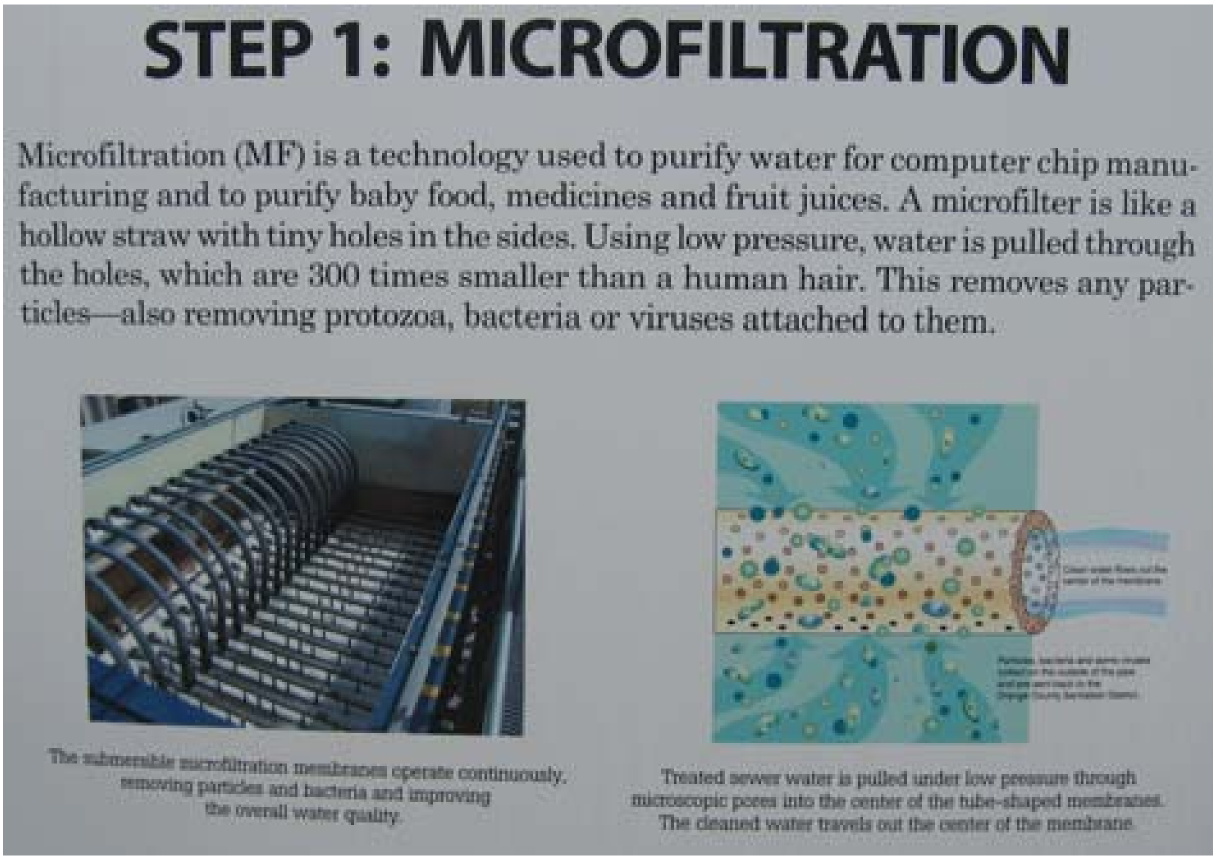
Cost recovery is through charge for extracting groundwater. They are recovering half of their capital and operating costs. Their aim is cover operating and upgrade costs. The cost is about $400 – 500 per acre foot, $205 per acre foot is what people pay to extract water, but the Orange County also get a lot of free water they on sell.

This project has some direct links to NEWater with respect to emerging contaminants. Water from this factory will not need to be retreated (except for chlorination) when extracted from the deep aquifers, as these aquifers are not subject to surface contaminants.

Source control is now being operated differently and there is a real mentality of preventing unwanted contaminants from entering the sewage system. Chemicals stores in buildings are kept by the Fire Department, so this list can also be used to assess what chemicals are possibly entering the sewerage system.

Bottled water is considered better than tap water however, one supermarket had been found putting tap water into bottles and selling it as bottled water. Tap water is considered, “Too thick to drink and too thin to plough”. The level of treatment and testing is driven by regulators who want to be comfortable with it, so they can tell the public is safe.

Planned indirect potable reuse limits are much stricter than those for unplanned indirect potable reuse of wastewater.



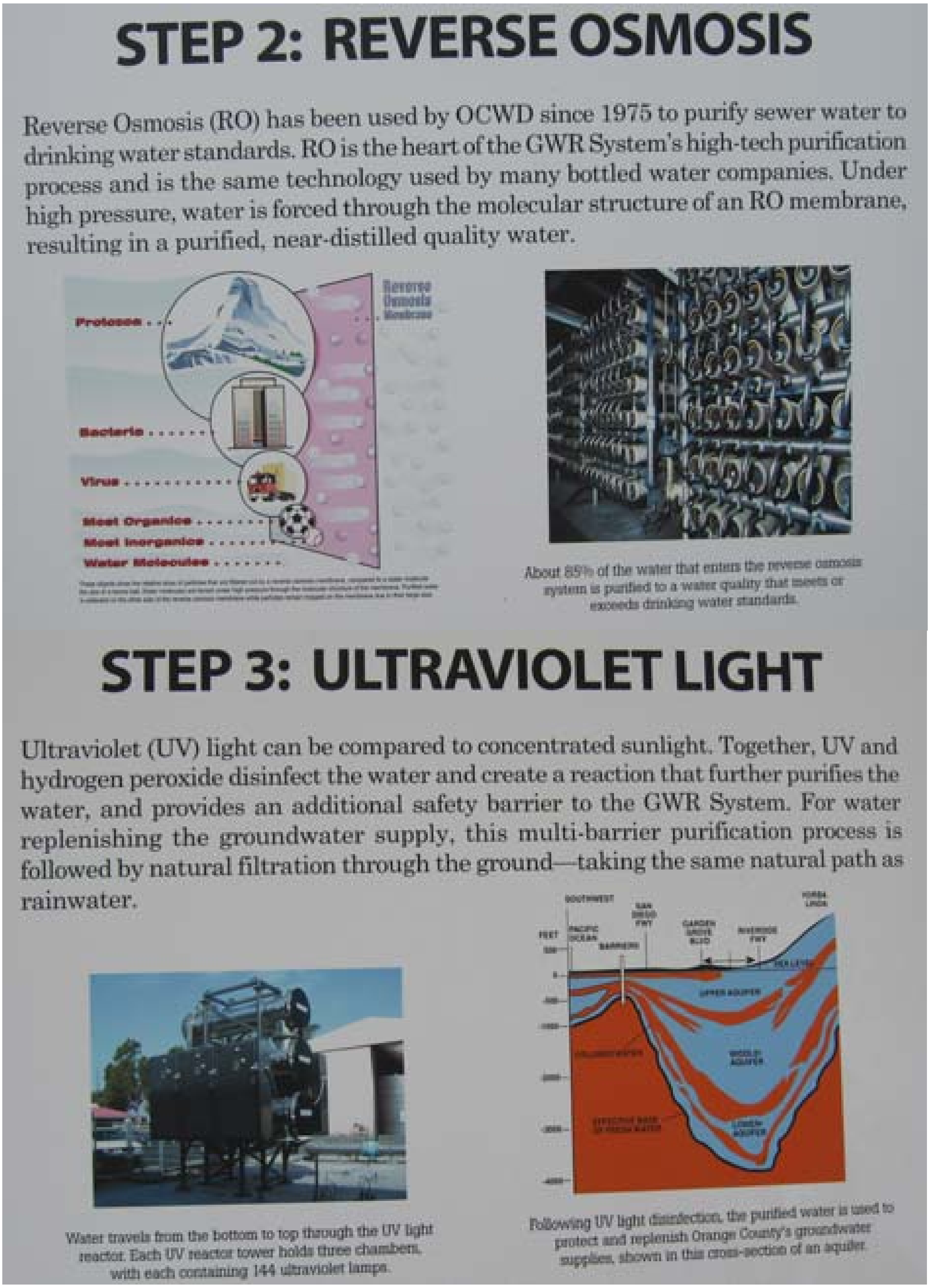


Figure 35 **Steps in treatment process at the Groundwater Replenishment System - Orange County**

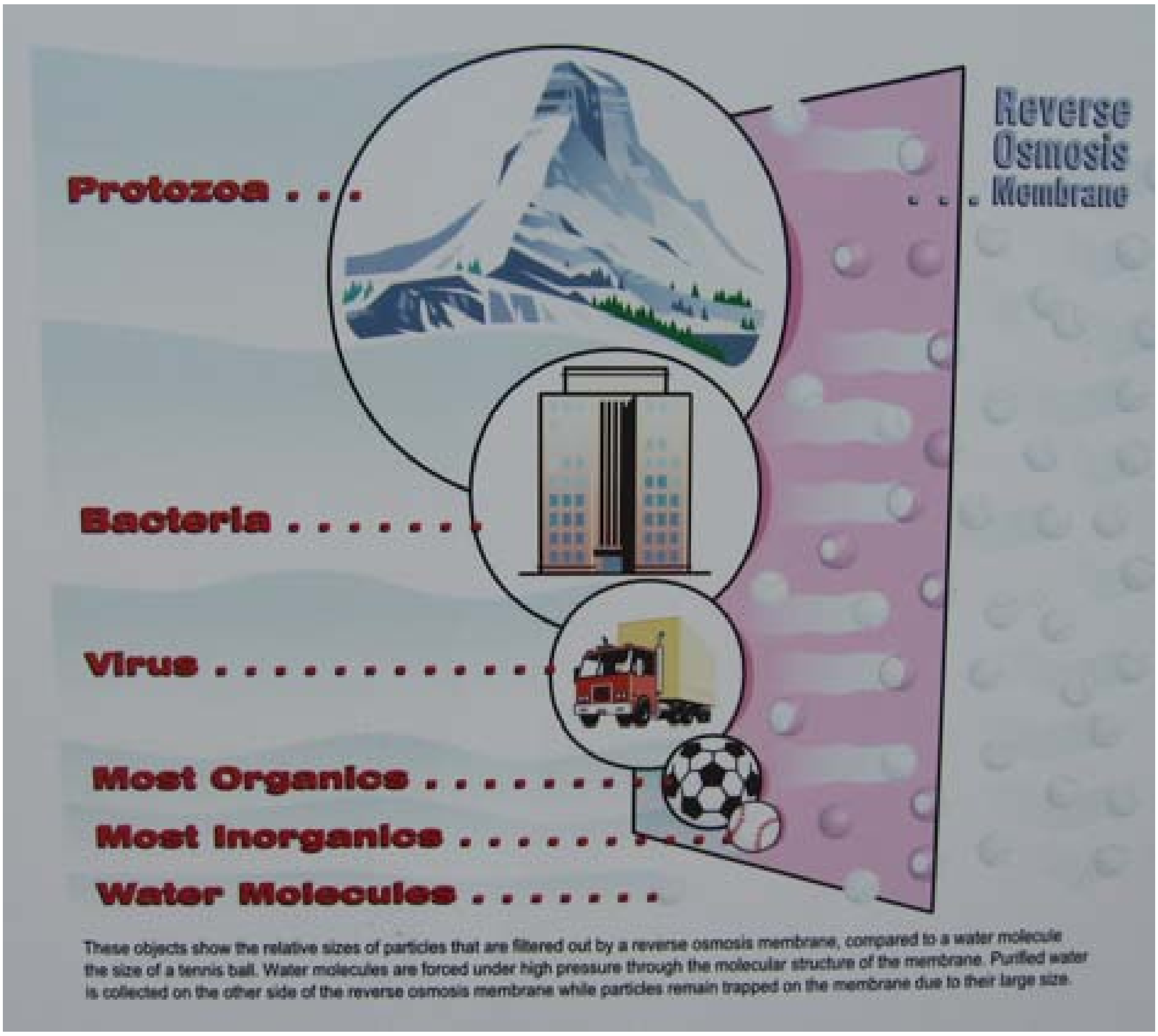


Figure 36 Diagram to show how membranes work, from Groundwater Replenishment System - Orange County

11.1.4 Wrap up by tour members

Seven years of pilot testing has proven the concept. They have had 25 years of factory 21 for the sea barrier, with expert panels overseeing it and extensive interchange of information. They recognised they need to be open and transparent, as the days of slipping underneath the radar are well gone! They developed a strong relationship with the regulator, working and standing together to inform the public it is safe. All of this has given the community great trust in the process and the final water product.

11.2 Irvine Ranch Water District (IRWD) – Irvine

11.2.1 Contacts

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IRWD (2004). "Rules and regulations for water, sewer, recycled water, and natural treatment system service," Rep. No. F:/grm/wrd/rulesreg/rulesreg_rev122004.doc. Irvine Ranch Water District, Orange County, California.

CD\photos\050609 Thu - Orange County\11.2 Irvine Ranch Water District\reports\RulesReg_rev122004.pdf

Presenter: Marylin Smith
Presentation: Irvine Ranch Water District
Cd\ppt\11.2.3 Marylin Smith - Irvine RWD.ppt

For more information on the WRF treatment process and performance see information supplied by Hamish Reid: CD\report\hamish\Case study - Irvine Ranch.doc

Figure 37 Marylin Smith (IRWD) talk to study tour participants before the field trip.

There is no such thing as new water on the planet. They are using recycled water in the cooling towers of some buildings, in these cases there is some extra chemical dosing required, but this should still be cost effective. They have done some retrofitting, but they try to build into areas as they are developed, as this is much more cost effective.

11.2.2 Background

Irvine Ranch Water District (IRWD) was founded in 1961. They have been recycling water since 1967. The current rate structure was applied in 1991. Recycled water is very well accepted by people. They run bus tours 5 times a year to show customers what it is all about; they get to see the laboratory right through to use of the final product. They also have an education program from primary to final school age. Recycled water is introduced to the school children at the Grade 5 level, giving them an understanding and awareness of water use.

The reclaimed water is delivered through a completely separate distribution system that includes more than 245 miles of pipeline, eight storage reservoirs and 12 pump stations. The system provides reclaimed water to approximately 1,000 acres of fields and orchards planted with a variety of fruits, vegetables and nursery products. Reclaimed water is also used to irrigate landscapes including parks, schools, golf courses, streetscapes and open spaces managed by many community associations.

There are 300 staff servicing approximately 300,000 people. Average house prices in district are $700,000, with many above $1 million. See Marilyn's powerpoint presentation (11.2.3 Marilyn Smith - Irvine RWD.ppt).

In 1991 IRWD was granted an unrestricted use permit (first in California). They now have 15 high rise buildings dual plumbed. Initially they set dual plumbing to be for buildings higher then 5 storeys, however the trend shortly after this was to build low slung buildings of one or two storeys. So regulations for putting in dual systems are now based on building area and toilet fixtures.

Potable reuse is not practiced because of the 'Yuk' factor, but they will be using some of the Groundwater Replenishment System's water (See Section 11.1.3).

11.2.3 Operation of the reclaimed water system and IRWD

The operation and maintenance (O&M) for flushing of mains is well controlled as they operate under zero discharge to the environment, therefore all recycled water mains are flushed to the sewer. The maintenance program is low point flushing annually and there are limited dead ends in the system.

The do have some problems with sediment being dragged through at the start of the irrigation season and have limited this problem by putting basket strainers on for big customers after the meter. They have ten staff in their O&M Department who are responsible for the transfer and distribution mains. They also have four repair crews who work on the small mains for fixing burst leaks. These crews also have the tools to work on potable and recycled water mains. Maintenance of the irrigation systems within the estates is managed by the local Home Owners Association (HOA).

There is a Cross Connection group of five staff who are responsible for inspecting all systems as they are installed. They receive all plans to be checked by their standards, design apartments and undertake regular checks. The biggest concern for regulators is cross connection, and monitoring from the WWTF through the use of reclaimed water is required. They have been very successful in not ever having a cross connection on a residential property. However, they have had two outside residential properties where the potable water line was connected into a recycled water main.

Currently, before any house goes live with reclaimed water a 48 hour cross connection test is undertaken. This involves a 24 hour shutdown on the reclaimed systems, with potable water, and a 24 hours shutdown on the potable system (with potable water) before they can connect the reclaimed water to the property. This process must be finalised with an engineering report. They are currently looking at some dye tracers to overcome the 48 hour testing.

The pricing structure is based on the individual user pays (see 11.2.3 Marilyn Smith - Irvine RWD.ppt). For example, if you live in an elevated area then you pay more for your water as it costs more to pump it to you. IRWD are not dependent on the penalty money from over use of water for their day to day operations, but use it to develop more water conservation and reuse.

They are only allowed to use reclaimed water for automatic sprinkler application. No hoses are connected to recycled water, so the irrigation system is completely separate to the plumbing of the house.

All water from the watershed goes into the storm drains, which are separate to sewers. There has been a suggestion that the pollution load from urban runoff going to sea could be captured in the sewer system. This is too costly, but a system based on a reconstructed wetland has been put into place where the water has a 7 - 10 retention time, which removes most of the nitrogen. They get about 30 - 70% of nitrogen removed. They have a Natural Treatment System being developed which is about 25, 1 to 2 acres wetland/marshes that will help with incremental cleaning of stormwater.

In some areas the types of vegetation grown are changing to more water efficient plants. They have also been testing out synthetic turf. The example they have at their office is getting lots of interest. They also have Californian friendly plant species identified to help residents chose plants for their gardens.

Figure 38 Urban use of recycled water in the IRWD

A chlorine residual of 5 mg/L is required in their reclaimed water reticulation. The 5 mg/L residual doesn't have any toxic effects on the domestic plants. There is a 30 minute response time goal for reclaimed water pipe breakages. From the treatment plant they have to chlorinate to 5 - 10 mg/L residual before pumping it to storage.

Some of the early houses were only fitted with recycled water in the front garden, but now it is front and back. This was because the HOA (Home Owners Association) looks after the front yards and common areas (including nature strip), which are much bigger than the back yards.

They recently undertook a study that looked at using recycled water for strawberry production and found there was a very small decrease in yield, but the lower price of the water still made it more economical to use recycled water.

11.2.4 Reservoir used for storage of reclaimed water

The reclaimed water is considered gulpable water. This was a drinking water reservoir built in the early 70s. Over the years drinking water protection agencies frowned upon the storage of treated drinking water in open storage. So it sat empty for a while and complaints from residents and demand for reclaimed water storage facilities lead to the reservoir being used for storage of reclaimed water (Figure 39). It was filled in December and opened in February 2005. There are 3.6 GL stored in the reservoir, which has an asphalt liner.

Figure 39 Old potable water reservoir used for storing recycled water, IRWD, California.

11.2.5 Shady Canyon

Shady Canyon is a residential development where the landscaping is as close as possible to the natural state, but they also use the term Californian friendly vegetation as some of it isn't native. Houses have front and back yard use of reclaimed water and use around 3.6 acre feet with native vegetation, compared with 3.9 acre feet per month for more traditional gardens. The golf course within the development is $250,000 to join. The DHS were very strict about reclaimed water systems, making it very difficult to develop, but very safe.

11.2.6 Shade Tree Nursery – Irvine

http://www.shadetreepartnership.org/nursery.htm

Irvine Ranch Water District is a co-sponsor of The Shadetree Partnership Nursery Project. This innovative nursery employs the latest technology and trends in water management. The goal of the nursery is to grow trees, common to all nurseries, in an environment that promotes water conservation and lowers operating costs. Currently the nursery is growing approximately 10,000 trees. Nearly two dozen varieties of seedlings are planted directly into 15 gallon containers. The model nursery was developed from a mere notion into its final form at the local University of California, Irvine when it was officially dedicated in September of 1996. The nursery goal is to have 20,000 seedlings growing at the nursery. The five-acre nursery will serve as an example for the ideal Southern California nursery.

A dual pipe watering system incorporates the use of reclaimed (recycled) water along with potable water. The use of recycled water in a nursery environment serves many goals. Using reclaimed water helps to conserve the region's limited supply of potable water. Conservation of the potable water in Southern California enables us to be less dependent on imported potable water.

Reclaimed water piped from the IRWD treatment plant has been trusted as an irrigation alternative to domestic water for many years by the agricultural community. Additionally, the use of recycled water lessens the demand for nitrogen additives used by the farming and planting industries throughout the state.

The variety of trees grown in the nursery includes California oaks, Sycamores and Monterey pines. The proof of the project will be concluded through an experiment using the Monterey pines. One group of seedlings will be grown to full size trees with the irrigation of recycled water. An equal amount of Monterey pines used as a control group will be irrigated with domestic water. This research project conducted by the University of California will document and analyse the growth rate, needle colour and overall tree quality of both groups of trees. Monterey pines are a popular variety used by the cut Christmas tree industry. The cut Christmas tree industry is monitoring and helping sponsor the project and is interested in the possibility of using reclaimed water instead of potable water. The project will prove that the average nursery, along with specialty industries, can benefit from the methods developed. This is a five- year demonstration and will be an on-going project. So far, the project has shown that there is no discernible difference in using reclaimed versus potable water.

A further innovation of the project is that the seedlings are planted in the containers by volunteers from the community. Shadetree members work with volunteer groups and the recipients of the trees to facilitate the plantings. The Shadetree is a non-profit organisation sponsored by grants and IRWD support. There is broad-based community support from six surrounding cities consisting of community groups such as the National Charity League, Cub and Boy Scouts, Girl Scouts, Key Clubs, Associated Square Dancers, Lions Club, Soroptimist International, students, other civic organisations and many IRWD employees. The benefits of enlisting the help of willing volunteers are far-reaching. The volunteer planting of the seedlings makes the setup and maintenance of the nursery very cost efficient. Volunteers have the opportunity to become familiar with the use of recycled water for irrigation purposes. The reclaimed water industry standards are so high that there is no reason the community should fear its use. When the time is right the seedlings will be transplanted in the community with the help of volunteers. Volunteers learn about and develop appreciation for these nursery grown trees which will help beautify and protect the local environment.

IRWD's initial investment was minimal. The Irvine Ranch Water District entered into a five-year ground lease with the University of California at Irvine for the nursery demonstration project. As a means of payment, the University receives 300 trees per year and the volunteers to plant them. This amounts to a total savings of $22,500 per year, the cost of having trees installed by a contractor.

Although the nursery is an ongoing project, the success is evident by the 10,000 seedlings currently growing strong in the community. This water conservation project has provided trees that are essential to the community. The trees will provide years of aesthetic value and help to promote a healthy environment.

11.2.7 Wrap up by participants

Very affluent society it would seem, who can afford to pay and they have been doing it for nearly 40 years now so they have a system they know works and seem to have become a little bit set in their paradigm, keeping indirect potable use off the agenda. The scheme is well managed, well run and very low risk. Their quality control focuses on cross connections, and levels of disinfection of the water are probably the most stringent in the world.

11.3 Dinner speakers - Monterey

11.3.1.1 Mr Bob Jaques (Director EPT), Dinner EPT

Bob outlined that regulatory arrangement signage has to have specific wording and must be in English and Spanish. Regulators can do unscheduled checks and some continuous monitoring is required. Any violation of limits must be reported within 24 hours.

11.3.1.2 Ms Cheryl Sandoval (Monterey County Environmental Health – MCEH)

Cheryl became involved with the project 8 months ago. MCEH’s goal as a regulator is to enforce regulation to ensure public health standards are maintained. They check all design plans and make sure water meets quality standards and is safe. Part of this is developing a water quality program that needs to be operated continually and well documented. There is continuous turbidity monitoring which dumps it automatically to waste if limits are exceeded. Sewage discharge ordinances are for groundwater quantity protection and protecting them from nitrate contamination.

One of the biggest hurdles is to overcome the public acceptance and perceptions. Cheryl’s office has a great relationship with the MRWPCA. They have regular groups that meet with growers and remain involved with the process.

The MCEH has a crisis plan in place, but it hasn’t needed to be evoked yet. The crisis plan is supported by the grower as they want quality water. If the water didn’t meet standards they would stop it being used immediately. There are a number of agencies that could prevent the water being used; MRWPCA, Regional board, MCEH.

The growers are very receptive of the project, in fact growers have more confidence in the recycled water than the river water.

The EPA and DHS are more observers than participants in the process of developing and maintaining the reuse scheme. The health department wants the water authority to prove that the scheme will work. MCEH & EPA are no rubber stamp. The MRWPCA must prove to them that the water is at a certain level and that they can guarantee quality.

11.4 Quote for the day

It is all good spin!

There is no such thing as new water on the planet.

Too thick to drink and too thin to plough.

12 Program: 10th June, California

12.1 Pebble Beach and Spyglass Hill golf course and residential areas

12.1.1 Contacts

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Bob Yeo
yeob@peoplebeach.com .
Golf Course Superintendent.

12.1.2 Background - Pebble Beach Community Services District Wastewater Reclamation Project

The Carmel Area Wastewater District, on the Monterey Peninsular, owns a wastewater treatment plant and distribution system that is producing high quality water that meets California Title 22 regulations for unrestricted irrigation use. The water is used for irrigating the seven golf courses in the region, including the famous Pebble Beach course (Figure 40).

There have been some problems with turbidity levels in the reclaimed water and the district is considering putting in a DAFF (Dissolved Air Flotation and Filtration) plant. The water currently has a turbidity of 7 and a salinity of 800 mg/L TDS. In winter, the reclaimed water is not required for irrigation and is currently discharged to the ocean. In summer, the treatment plant cannot supply the full requirements of the golf courses, so the District is looking into taking over an abandoned 400 acre foot reservoir (485 ML) to provide storage of winter produced reclaimed water for summer use.

The District charges approximately US $1300 per acre foot ($1580 per ML) for reclaimed water, which is the same as potable water. The high price is feasible because of the high charges for use of the golf courses, up to US $700 per round.

Mark Thomas, the irrigation manager at the Pebble Beach golf course, says the decision to switch to reclaimed water six years ago was based on freeing up more potable water for drinking by reducing the irrigation requirements for potable water at the golf course. A strategic watering regime has been adopted to maintain the quality of the greens and soils, which involves a monthly flushing with fresh (potable water) in order to move excessive salts out of the root zone. Mark believes that the greens are as good as they were under potable water irrigation.

Figure 40 Tour participants discussing the Pebble Beach greens and fairways irrigated with reclaimed water with greens keepers and water authority, Pebble Beach, California.

12.1.3 Site visit

It costs US $400 for a round of golf at Pebble Beach and US $275 at Spyglass Hill. The golf courses are very good at paying for the water. They are in the top 10 golf courses in the world. Each property situated on the golf course pays an annual fee for the up-keep of roads.

They have just about no rainfall over winter so salts have built up in the greens and fairways. The grass they use is sensitive to Na; they use wetting agents to cope with the salinity effect and apply gypsum at the treatment plant to lower reclaimed water SAR. They also schedule a good leaching irrigation monthly to flush the salts down the soil profile.

The score card has “SPECIAL NOTE: THE PEBBLE BEACH RESORT COURSES ARE IRRIGATED WITH RECLAIMED WATER” written across the bottom of it to let golfers know that recycled water is used on the golf course. No other signage was evident on the golf course.

The greens have the grass species Poa annua growing on it and the fairways have Poa annua and ryegrass growing. The Poa annua is fairly salt sensitive, so management is a delicate balance. They wouldn’t consider changing grass species to overcome the odd problem with the salinity of the reclaimed water, as this would be an enormous job and they are very happy with the golfing surface produced by the grasses they are using.

The irrigation system is elaborate. It consists of a fully radio controlled system which is single head control (i.e. every sprinkler head can be turned off and on individually. These types of irrigation systems can cost up to $4 - 5 million for per golf course.

They need to leach with potable water and use solid tynes for aeration. When it rains the course looks great. The course pays for the water they use and this is approximately 8 – 10% of the maintenance budget. When irrigating they apply 6 mm per irrigation and when flushing 40 - 50 mm per irrigation. They do not consider the N and P significant in reclaimed water to adjust their fertiliser program (Table 13).

The WWTF produces 6 ML per day and the golf course uses 8 ML per day irrigation at night time. Secondary effluent, which cannot be reclaimed, goes out to an outfall pipe into the Pacific Ocean. In November/September the WWTF tertiary treatment shuts down as rainfall is sufficient until February/March. There is pressure on stopping the ocean outfall completely. They hope to eventually reclaim all their water, by storage or microfilter/reverse osmosis, and develop some RIBs to recharge the aquifer near the sea. Potable reuse is not being considered.

Table 13 Reclaimed water quality use and Pebble Beach and Spyglass Hill golf course, Monterey.

Parameter	Results	Desired Range
Alkalinity	240	<250
Ammonia N	31	
Bicarbonate	293	<305
Boron	0.32	<0.3
Calcium	45	75-123
Chloride	198	<90
Magnesium	14	<20
Nitrate - N	Nd	<20
Nitrite – N	Nd	
o-Phosphate –P	0.83	<10
pH (none)	7.3	6.3-7.5
Potassium	23	<30
SAR	5.4	<2.8
SAR adjusted	6.3	<4.0
Sodium	161	<75
Electrical Conductivity (uS/cm)	1368	<700
Sulfate	139	<90
Total dissolved solids (TDS)	695	<500

Note: Units are mg/L unless stated otherwise

12.2 Monterey Regional Water Pollution Control Agency (MRWPCA) - Monterey

12.2.1 Contacts and references

Keith Israel
General Manager
MRWPCA
Monterey, California, USA
Phone: 831 372 2267 email: keith@mrwpca.com www.mrwpca.org

Tom Curtis (Picked us up from the airport)
Associate Engineer
MRWPCA
Monterey, California, USA
Phone 831 883 6179 email: tomcurtis@mrwpca.com

Robert (Bob) B. Holden
MRWPCA
Monterey, California, USA
Water Recycling Projects Coordinator Engineering Services
Phone: (831) 883 6137 email: bobh@mrwpca.com

References

Supplied with information pack from MRWPCA

WRA 2004

CPRC 1996

WQOC 1998

12.2.2 Background - Monterey Regional Water Pollution Control Agency Water Recycling Plant

The treatment process consists of secondary facilities (headworks; primary clarifiers with anaerobic digestion of biosolids; trickling filters; bio-flocculation; secondary clarifiers; Figure 41), followed by tertiary treatment (coagulation, flocculation, multi-media filtration and disinfection). After treatment, the reclaimed water is directed to an 80 acre feet pond (95 ML), which stores around one day of grower requirements. When reclaimed water is not required for irrigation during winter, the secondary treated water is discharged to the ocean two miles off-shore. The tertiary treatment is sufficient to meet the California Title 22 regulations for unrestricted irrigation use, requiring a seven-day median coliform limit of less than 2.2 MPN per 100mL, a turbidity of less than 2.0 NTU and 5 mg/L of available chlorine as the reclaimed water enters the storage pond.

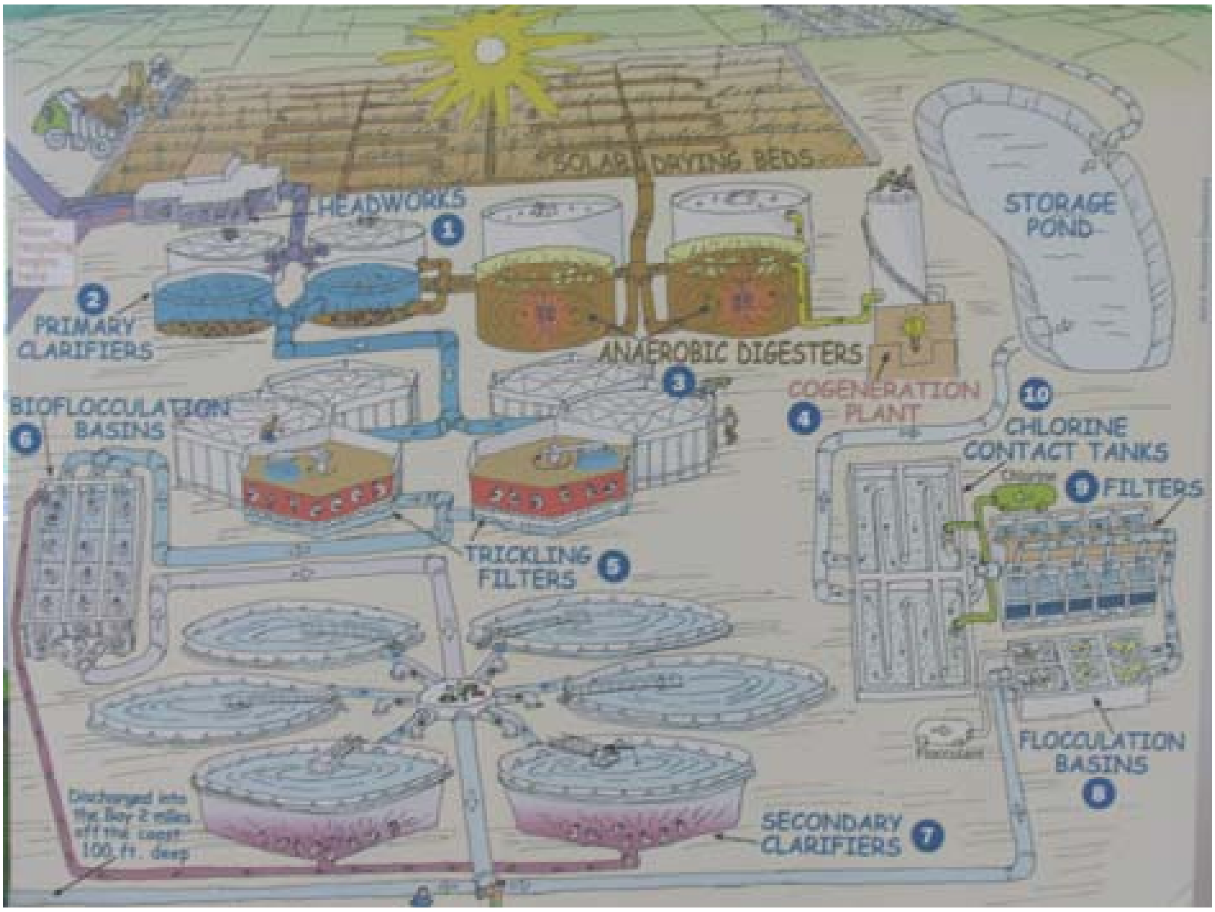

Figure 41 Schematic of MRWPCA Water Recycled Plant, Monterey, California

Chemicals and processes used in well water treatment are the same as those used in potable water treatment.

- polymer and alum flocculation and filtration
- 4 ft of anthracite coal with one foot of gravel
- functions similar to swimming pool filter (sand)
- add chlorine to disinfect
- 3 hours contact
- released to storage dam

A chlorine residual of 10 mg/L at the exit of the chlorine contact tanks is maintained, as this was found to be effective in keeping the coliform count within compliance guidelines, and helps to keep down algae growth in the storage pond. This translates to a chlorine residual of around 4-6 mg/L in the water leaving the storage pond. Testing on cauliflower seedlings has shown chlorine residuals of up to 15 mg/L did not cause adverse effects such as leaf burn. Covers on the chlorine contact tanks also help to keep the coliform count down by preventing settlement of coliform-containing dust from agricultural areas. Pathogen monitoring has shown that the plant has always stayed within its compliance conditions. The County Health Department has approved the use of *Clostridium* testing as a quicker and cheaper surrogate for full pathogen testing. A five log pathogen reduction has typically been found across the whole treatment plant, over two years of bi-weekly Clostridium testing.

Treatment and water costs: The scheme is run as a non-profit operation, with a “user pays” philosophy. In 2001, the cost of the water to scheme participants was US $237 per acre foot (US $198 per ML: US $209 water cost, covering tertiary treatment costs; and US $28 delivery and infrastructure maintenance) and the cost was indexed with CPI. This was about twice the current price of extracting well water, although the cost of well water is likely to increase as pumping costs rise and aquifers get lower. Other water users in the region are also charged a levy because the scheme reduces saline intrusion into the groundwater, which brings benefit to everyone. The costs of collection and secondary treatment are borne by the producers of wastewater (the local residents and businesses) through sewerage charges of around US $10 per month.

Costs in 2005 were quoted as US $112 per ML (land assessment and supply costs) and well water costs were around US $89 per ML. Residents that have their home over the aquifer being protected by injection of reclaimed water pay for some the tertiary treatment costs and farmers that use the reclaimed water pay for the water also, which helps pay for the tertiary treatment.

In Salinas every home owner pays US $9 per year for the protection of the aquifer under their home.

Farm land, where the recycled water is used, costs approximately $250,000 per hectare as it is some of the most productive land in the USA. They grow crops all year round with an approximate 8 week growth period.

The annual operating budget is around US $6 million, with around US $3.5 million for direct operating costs and the remainder for debt repayment. Initial funding for the US $75 million project came from low interest loans from the Bureau of Reclamation and the State of California, as well as short-term bonds. The use of the reclaimed water helps produces more than $3 billion in produce yearly from the area.

12.2.2.1 Salt minimisation program

Recycled water is typically saltier than the drinking water from which it originates. The salt content of the recycled water is generally in the range that may affect salt sensitive crops like lettuce and strawberries. In spite of this, irrigation with recycled water has been so successful and well received by the farmers that it has resulted in more salt-sensitive crops being grown in the service area. Artichokes are very salt tolerant and are still the predominant crop in the project service area. However, artichokes have been gradually removed to plant lettuce and other row crops. Those crops have, in turn, been replaced with strawberries. The progression from artichokes to strawberries generally results in increased revenue for the farmers, but also a greater necessity to address salt issues. Compounding this problem is that the salt level in the drinking water within the service area has recently increased, causing the recycled water salt content to also increase.

A five-year soil salinity study has shown that the soil salt concentrations are in the range that may affect crop yields of the most salt-sensitive crops. This study includes sampling the two types of soils found in the project area, three times each year:

(1) After the winter rains and before the first crop is planted,

(2) Between crops, and

(3) Following harvest of the last crop before winter.

Four samples are taken at each site, from three different depths. Control sites receive only groundwater irrigation. Test sites receive recycled water. The control and test sites are paired for similar soil type, crop and farming practices. The soil testing began in 2000 and is intended to continue for at least another five years.

- Soil sodium adsorption ratio (SAR) is a measure of the relative importance of sodium in the soil, compared with calcium and magnesium. Low (<4) SAR values allow clay soils to percolate readily (given our water conductivity of 1.6 µS/cm). High (>10) SAR values can result in impermeable clay soils and reduced crop yields. In the soil test study, SARs appear to be in equilibrium, with test sites (recycled water irrigated) averaging 2.8 and control sites (ground water irrigated) averaging 2.0.

- Sodium levels in the soil at the test sites decreased more in 2004 than at control sites. This may be because the higher salt content of the recycled water allows for more rapid draining of salts through the soil.
- A privately owned well at one control site began to be seawater intruded. The owner installed a tile drainage system during 2000, abandoned his well that he had been using for irrigation and began to use recycled water (it thus became Test Site 7). The changes have resulted in a significant decrease in soil SAR since then. This reduction shows that recycled water can successfully flush salt out of the soil.

12.2.2.2 Salt Reduction at Source

For the past six years, several voluntary methods have been used to reduce salt (particularly sodium) that enters the wastewater. A study of the sources of salt into the recycled water revealed that water softeners were a major source. MRWPCA went to each of the major salt users and asked them to voluntarily replace their timed regeneration water softeners with the more modern, demand-induced water softeners. They were also asked to switch from using sodium chloride to potassium chloride for regenerating their water softeners. Some success was achieved (Table 4) but, unfortunately the reductions were not as large as the increases in the drinking water salt content. In addition, the program was started when there were no strawberries in the project area. Strawberries are very chloride sensitive. Using potassium chloride in a water softener actually increases the concentration of chloride in the wastewater. Therefore, MRWPCA stopped the shift to potassium chloride. MRWPCA has an ocean outfall which it still uses to discharge secondary treated wastewater during the winter months, when there is no demand for recycled water. Recently, that outfall was connected to a brine disposal system and a water softener company began to haul brine (that otherwise would have entered the sewer) for disposal directly to the ocean. This brine disposal shift caused a noticeable decrease in the recycled water sodium concentration. However, more sodium reduction is necessary. MRWPCA has initiated a partnering program to help the major salt users to install brine storage tanks and to subsidise the hauling of that brine to the treatment plant for disposal. The problem now is that the regulators require the brine to be diluted 100:1, and there is no water available for that dilution. It is hoped that the regulators will reduce or eliminate that requirement after another year.

Table 14 Recent voluntary reductions in sodium introduced into the MRWPCA sewer system.

Business Type	Monthly Discharge of Sodium in kg	Monthly Reduction of Sodium in kg
Water Softener Service	17,700	5,400
Large Hotels and County Jail	9,300	3,900
Large Laundries	10,100	1,500
Hospitals and Dialysis Centres	3,300	1,700
Other Commercial/Industrial	2,800	400
Total	**43,200 kg/month**	**12,900 kg/month**

12.2.2.3 Biosolids

California is one of 3 states in the USA which are not allowed to land apply biosolids. This is because the previous county health inspector did not believe in it. However, MRWPCA are currently conducting a composting study, blending thermal-treated biosolids (solid waste) from the regional treatment plant with green waste from the landfill. This study has confirmed the product is safe for landscape application. The next step will be to attain authorisation for its use, and develop a marketing program for its distribution.

12.2.3 Agricultural Reuse

12.2.3.1 Background (updated from tour book)

The Monterey recycled water scheme treats and distributes high quality reclaimed water for unrestricted irrigation use to 12,000 acres (4,800 ha) growing crops such as herbs, strawberries, lettuce, artichoke and celery. The scheme began operation in 1998 and has grown to an annual distribution of around 13,000 ML (2001) of reclaimed water and is promoted as a benchmark for world's best practice. It was initiated in 1978, beginning with an extensive period of consultation, research into health and agricultural impacts, education and construction. This research cost $7 million. Some references that outline some of the research completed to verify the agricultural use of reclaimed water are: MRWPCA 1987; Sheikh, Cort *et al.* 1999; Sheikh, Cooper *et al.* 1999; Sheikh, Cort *et al.* 1990; WQOC 1998.

The motivation for the scheme was to provide a new source of water for agriculture as the groundwater used for irrigation in the region was threatened by seawater intrusion (Figure 43). Agriculture is seen as a very important part of the Californian landscape and economy, and if an alternative water source could not be found then agriculture was likely to become unfeasible in the region and the land taken over by urban development. The reclaimed water is sourced largely from urban effluent from the Northern Monterey County.

The plant has an output of around 120 ML per day. Grower demand during the peak growth season of May to September is around 23,000 ML, based on an irrigation rate of 4.9 ML per ha. The reclaimed water is not sufficient to supply this demand so supplemental well water is added to make up the difference of up to 40% of requirements.

The reclaimed water has a higher salinity and sodicity than the well water (Table 15). The reclaimed water – supplemental well water mixture delivered to irrigators has an average SAR of around 3.9, which is higher than the level of 3.0 preferred by many growers. However, it is not known how high the SAR can be in the long-term without significant impacts on yield and soil properties. The original project research did not indicate any salt build up problems over five years of pure reclaimed water application, so long-term research and monitoring of this issue is continuing. Attempts are being made to lower the sodium levels in the reclaimed water by reducing the input to wastewater, particularly from water softeners. For example, big salt users and the general public are educated on the benefits of a shift to more efficient softeners and from sodium to potassium based softeners.

Table 15 Comparison of recycled and well water properties at Monterey, California.

Parameter	Reclaimed water	Good quality well water
Salinity (mg/L TDS)	862	375
Chloride (mg/L)	283	60
Sodium (mg/L)	186	50
Sodium Absorption Ratio (SAR)	5.3	1.8
Total nitrogen (mg/L)	37	na

The reclaimed water contains quite high nutrient levels, as the ocean dumping permit does not require their removal. Total nitrogen averages around 30 mg/L (mostly present as ammonia), while phosphorus averages around 2 mg/L.

The reclaimed water has very low levels of metals and trace organics because of the low level of heavy industry in the area. Commercial wastewater disposal customers are also regularly monitored and the general public is educated to ensure that inappropriate wastes are not disposed of into the system.

Distribution: The distribution system consists of a rectangular grid with 72 km of piping, 112 irrigation turnouts, three pump booster stations and 21 supplemental wells located away from seawater intrusion in the Salinas Valley (Figure 42). Backflow protection is used on the groundwater wells to protect the aquifer. Each turnout is signposted with "Reclaimed water – do not drink" in English and Spanish, and similar signs are placed at 500 m intervals along the distribution network. The treatment plant draws electricity from one power grid, while the wells are on a second power grid, so that at least one system is always on-line. This arrangement is necessary because of the current power restrictions in California.

There is a pressure minimum of 10 psi of head at the highest point in the system, with 30 - 40 psi in other parts of the system. Turnouts can supply 4 - 500 acre-feet per day. Growers have booster pumps with pressure regulating valves so they cannot capture more water than has been allocated. This system also protects the growers' infrastructure from pressure surges. Many growers on the system irrigate directly from the pipeline.

Experiences with reclaimed water: At the beginning of the project, the main areas of concern were public health and safety, and public perception. Extensive research was carried out over 11 years by the US $8 million Monterey Wastewater Reclamation Study for Agriculture (MWRSA) in order to address these issues. The research included five years of field trials, using reclaimed water for irrigation to evaluate crop yield and quality, and the presence of pathogens on produce and in reclaimed water. It was found that there were no viruses present on any of the produce irrigated with reclaimed water and the level of naturally occurring bacteria on crops irrigated with reclaimed water was equivalent to that on crops irrigated with well water. Produce yields and quality were found to be as good as, or better than, crops irrigated with well water. Later research also looked at other emerging pathogens such as *E. coli, Cryptosporidium, Cyclospora, Giardia* and *Legionella* and confirmed that the reclaimed water was free of viable pathogens and of a high quality.

This research, together with a stringent monitoring program and a strong commitment to achieve 100% compliance with permit regulations, has provided the basis for the scheme to win public and commercial confidence and support. A proactive communication strategy was adopted, which acquainted the produce industry and the local media and public with the project. A communications company was hired before the start of operation to develop a plan for education and to deal with potential crises with a three hour response time. Material was produced to educate local produce sellers, growers and workers for their own benefit and safety, as well as to help answer any consumer questions about the safety of reclaimed water and produce grown with it. Marketability surveys were carried out in 1983 and 1997 and showed that industry buyers and sellers felt that there was no need to label or separate produce grown with reclaimed water, and that consumers would purchase the produce as long as the safety of the product was assured. A measure of the effectiveness of the strategies to address the public health and perception issues revealed that after three years of operation, the major issue of concern is now salinity (Figure 43).

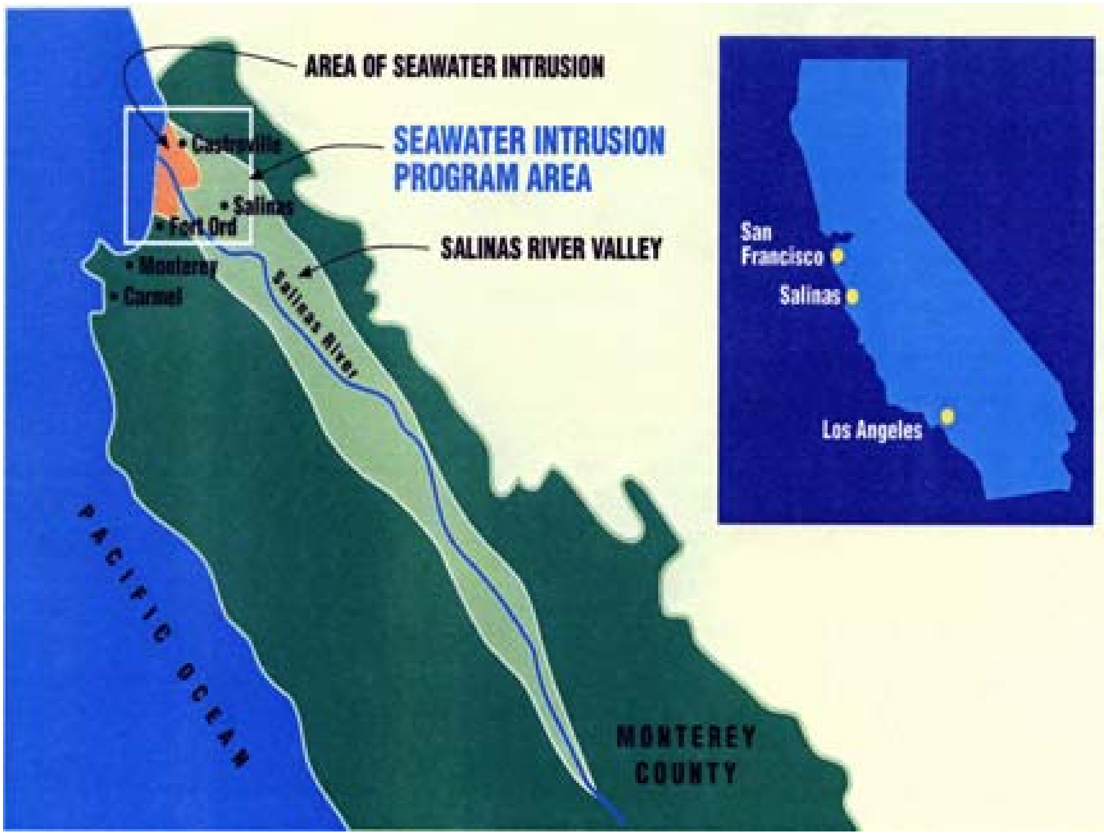

Figure 42 Salinas Valley, where reclaimed water from the MCRPCA WWTF is used for agricultural irrigation, from Robert Holden's talk.

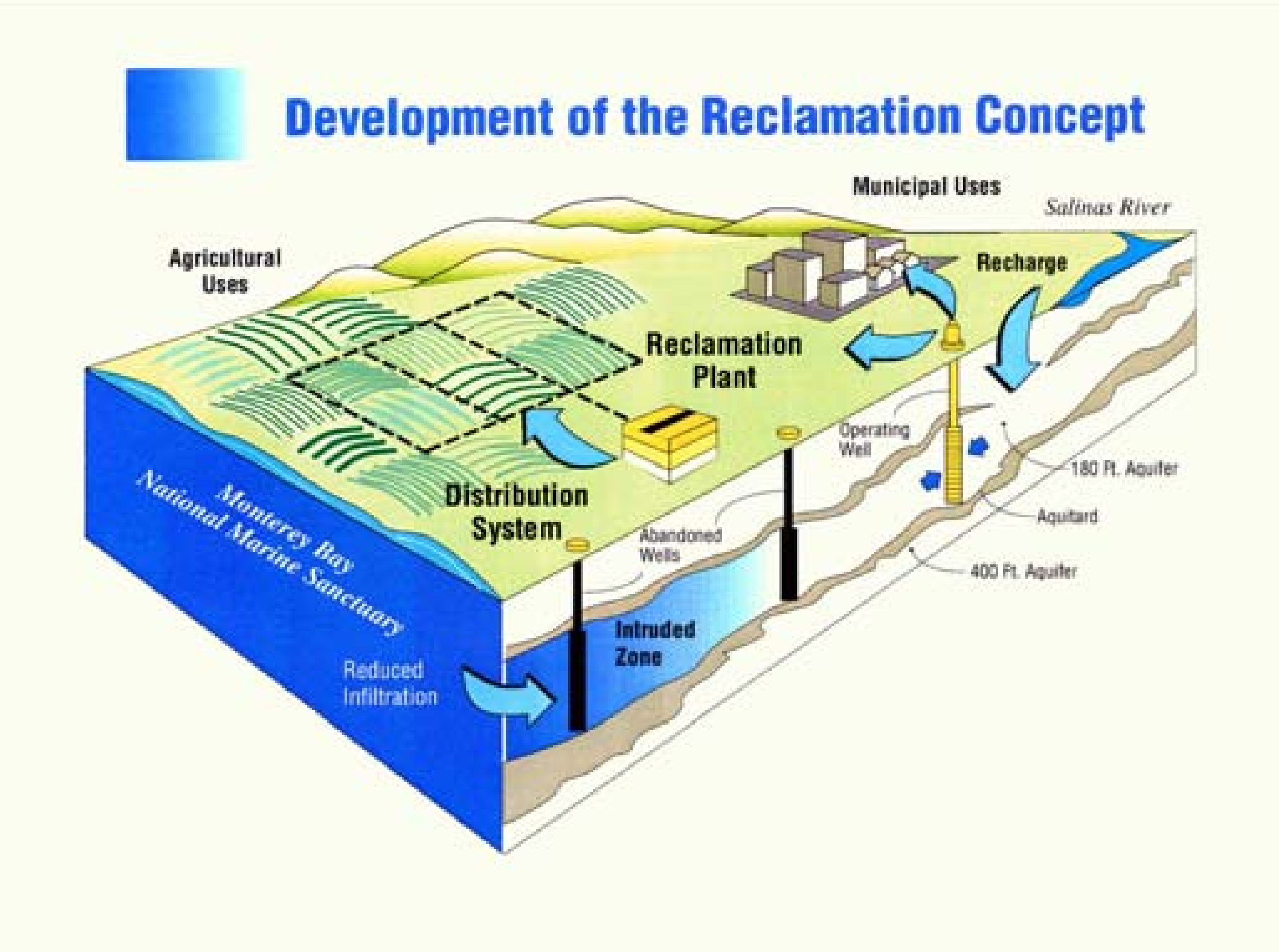

Figure 43 Diagrammatic representation of sea water intrusion in the groundwater aquifer at Monterey, from Robert Holden's talk.

12.2.3.2 Farming with recycled water - Adrian Derhas

Adrian farms about 2500 ha in the Salinas Valley (Figure 42), using reclaimed water extensively. Crops grown are: celery, broccoli, spinach and lettuce. Approximately 95% of crops grown in the area are grown with recycled water. The recycled water is considered great for drip or sprinkler irrigation.

The major issue they have at present is the systems for ordering water. At present water is ordered by fax, which can take a day or two and sometimes you need it quicker than this. If growers take too much water at once it can affect supply to others.

Irrigation is scheduled by watching the local news. If it is going to be really hot, head irrigators need to fax for water as soon as possible. For perennial artichoke, they use moisture monitors to schedule irrigations. For annual row crops they do have some moisture sensors, but daily checking of the soils is used more frequently. Perennial artichoke is irrigated approximately every three weeks (21 days). They irrigate for 10 - 12 hours per set, at a rate of 6 mm per h. If irrigating with sprinklers they irrigate every 10 - 15 days, or if irrigating with dripper they irrigate every 5 - 10 days. Sprinkler and drip is used on row artichokes. If it is used on annuals they may bury it 1 or 2 inches or leave on top. Irrigation dripper tape use is for 7 to 10 crops, but they will need to do some splicing of tapes to make it last this long. For perennial artichoke they bury the tape at 10 inches and they have been in the ground now for more than 8 years without any problems.

The water is supplied to the grower under pressure (40 lbs), which is perfect as drip irrigation requires approximately 15 to 20 lbs. It still needs to be filtered as the well water used to augment the recycled water during peak demands puts sand into the systems, and some slime may come through from the mains. If sprinklers are used for leach or application of water, 80 lbs pressure is required and growers use a pump onsite to increase the pressure. To minimise any pumping costs they irrigate during off peak, saving on the price of power.

Figure 44 Artichoke grown with recycled water from the MRWPCA Water Recycling Plant, Salinas Valley, California.

The reclaimed water is used on certified organic crops. Organic certified artichokes and strawberries are currently being grown with recycled water. There may be other crops and Bob Holden will ask the growers at their next meeting. The National Organic Program (NOP), referred to below, can be found at http://www.ams.usda.gov/nop/indexIE.htm.

Figure 45 Large areas in Salinas Valley cropped with recycled water.

Email to support organic use of recycled water in the USA

From: Brian McElroy [mailto:Brian@ccof.org]
Sent: Tuesday, March 05, 2002 5:35 PM
To: 'CBrennan@ci.santa-cruz.ca.us'
Cc: John McKeon; Brian Sharpe
Subject: RE: Rules for Certified Organic Growers
Hello.

I am the CCOF Certification Services Manager. John asked me to respond to your email.

Due to the implementation of the USDA National Organic program CCOF standards have been modified. In this particular area CCOF standards have changed substantially.

Reclaimed water may be used for organic production according to the applicable state and federal health and safety codes. There is no section in the NOP regulations that specifically states that treated water is allowed. However, "water" and we include treated water are considered allowed under Section 205.105 as it is not synthetic and not specifically prohibited.

As you likely know, "sludge" is prohibited. Clearly if the NOP sought to prohibit the use of reclaimed or treated water they would have specifically named the material as prohibited.

I hope this helps you. If you would like to see the NOP regulations you may access the NOP website through the CCOF website www.ccof.org.

You may also want to contact the NOP staff and ask if there is an EPA liaison person to provide you with further assurance.

Please call me if you need more information.

End of email………………………………………….

Crops are harvested using contracting companies and they sometimes have trouble getting enough staff.

Nutrients are starting to be considered in the recycled water as part to the nutrient program and they are using soil tests to balance their fertilisers' needs. However, it is hard to change habits of how much fertiliser you have applied in the past annual, and then modify this for recycled water by applying less. They are starting to think they might need to add nitrogen, as there isn't a sufficient amount in the recycled water.

They use gypsum and more water to overcome salinity and soil crusting problems when getting lettuce seeds to grow. SAR is a problem and gypsum is used to overcome this. Two to three tonne of gypsum is applied per acre before planting.

New employees have an induction and other staff a yearly reminder that recycled water is not safe to drink, but very safe to work with.

Their wholesalers know they use reclaimed water and there haven't been any problems with selling their product. The price of artichokes at retail can range between $5 - 25 per a box, dependent on the state of the market (demand).

Lettuce and salinity is a problem, and the Roman species seems to be more sensitive than head lettuce. To manage this everyone leaches every now and again with sprinklers. Drippers on wide beds seem to have a problem with salt build up, but not so much on the narrow beds.

Farmers don't need to monitor nutrient build up in soil. The only thing the grower provides to the Water Authority is the order for water. There is no contract between them. The farmers pay $0.11 per KL for their recycled water on a pay as you go basis.

This County uses some reclaimed water for toilet flushing, but this is rare in California.

12.2.3.3 Recycled Water – The Proven Source of "New" Water for the 21st Century by Keith Israel

Presentation can be found at cd/ppt/12.2.5.4 Keith Israel MRWPCA.ppt
The cost of whole project will be paid back and it will be run at full cost recovery, at $1100 per acre foot. Money spent on outreach program will be a lot, may be around $1,000,000 for the first few years.

12.2.3.4 MRWPCA Recycled Water Scheme by Robert Holden

The presentation can be found at cd/ppt/12.2.5.5 Bob Holden MRWPCA.ppt
Salinity and sodicity of soils in the district were also covered in Bob's presentation (see slides 21 – 26). Soils that are paired sites with the difference of recycled water or well water being applied are currently being tested to determine the effects of recycled water on soil salinity and sodicity. Differences determined so far are summarised in Figure 46.

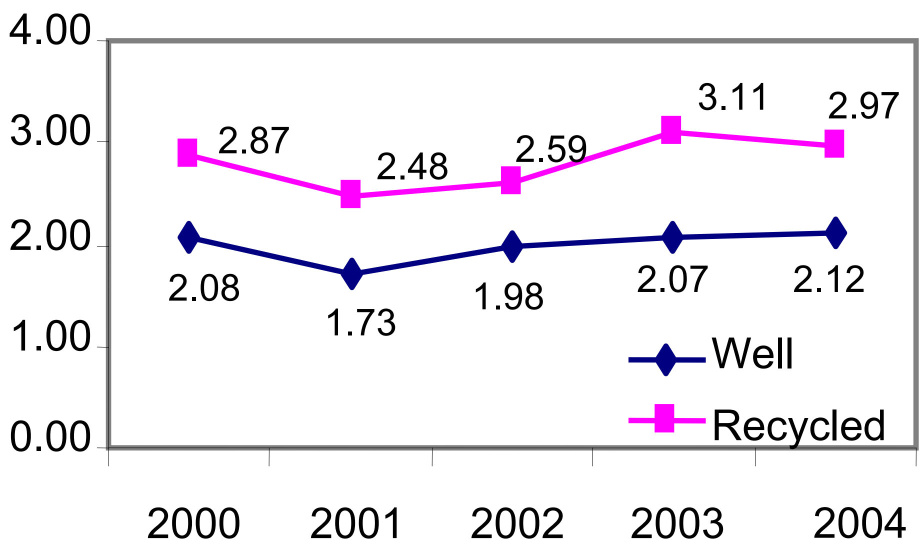

Figure 46 Changes in SAR of soil irrigated with well or recycled water, from Robert Holden's presentation.

12.2.3.5 Filter Loading Evaluation for Water Reuse by Tom Kouretas

The presentation can be found at [CD/ppt/12.2.5.6 Tom Kouretas - MRWPCA.ppt]

Table 16 Summary of reclaimed water use in Monterey – Golf course and agricultural.

Drivers	
What were the key drivers for the scheme?	Degradation of aquifers through seawater intrusion. An issue for the protection of their potable water source and agricultural water. Insufficient water for sustainable agricultural use.
What incentives etc were given to customers?	Guaranteed water supply. There is increasing pressure on securing potable water resources. Development in the region is limited by the availability of potable water, so farmers could see the need to secure a water source for themselves.
Risks	
What was considered the major risk during development?	There was a big risk that the regulators would not accept application of recycled water to produce crops eaten raw. Public and grower acceptance and perceptions.
After establishment, what new or unexpected risks appeared?	Salt and sodium concentrations are requiring management now. The system for allocation of water is not very effective as some growers cannot get water quick enough or the volumes they require at the time are sometimes not met adequately.
How are commercial risks allocated?	There are no official contracts with growers, but ordinances that recycled water should be used by preference.
Health, Environment and Resources	
Were there any environmental impacts?	Water was a bit salty for lettuce, sodium in water is high enough that soil becomes less friable so gypsum is used to manage soil sodicity.
Were there any human health impacts?	No.

What are the key benefits?	Minimising saline ingress into the potable water aquifer, supply of water for agricultural use of reclaimed water.
Are there alternative water sources available?	The reclaimed water scheme is augmented with well water. During peak demand about 30% of the water used is well water.
How much recycled water is substituted for drinking water?	None.
Who does the auditing and monitoring?	There is no requirement for the farmer to do any monitoring. All monitoring (soils, water) is undertaken by the MRWPCA. The EPA had no requirement for soils monitoring, but they where doing this for their own benefit.
How is on going monitoring reported?	
How have you managed salinity levels in the recycled water and ground/soil?	Pebble Beach Leaching is required monthly during the irrigation season. Agricultural use Some properties on heavier soils have tile drainage. Salinity source control program as decreased recycled salinity from 1100 to 750 TDS so far. The addition of gypsum and efficient irrigation systems (drip and subsurface) are used to manage salinity and sodicity, and for water efficiencies.
Are there any other environment management issues?	
Have you assessed the impact of pharmaceuticals, personal care products and industrial chemicals on groundwater dependent ecosystems when using ASR for indirect potable reuse?	Not considered as an issue because recycled water is used on golf courses and agriculture.
Are there any emerging pathogens or chemicals of concern?	None.
Lessons	
What would you do differently next time? Technology, acceptance, operational, customer interface, price?	The scheme wasn't very well designed to deliver recycled water on demand, at full capacity. So they would have put more thought into this side of the business on reflection. They also now require storage capacity for November to February because they will be required to have zero discharge in the future. At present the mixing of well and recycled water in the systems is such that some growers will get all well water and others could get all recycled water. They hope to change this in the future so a consistent mix is delivered to all customers.
What is the most critical consideration for the particular reuse scheme?	Once they had the research data to help the acceptance of recycled water from a pathogen perspective, managing the soil salinity within sustainable limits.
Were there any unexpected benefits?	No.
Issues	
What issues have arisen for end users during operation of the scheme?	Salinity and sodicity management using gypsum, leaching and tile drains. Reduction in salt sources entering the sewerage system.
Salinity/sodicity issues?	Yes see above.

What happens to the biosolids?	Biosolids are currently not allowed to be disposed to agricultural land and they are reused at the neighbouring landfill as cover material. Composting trials are being undertaken to provide the science for the regulators to assess if biosolids would be allowed to be applied to land after this type of processing.
Costs	
Who funds it initially?	Initial funding of US $75 million for the Salinas Valley Reclamation Plant (Tertiary part of the Regional Treatment Plant) and Castroville Seawater Intrusion Project (Distribution System for Recycled Water). It cost $130 million for the interceptor systems and Regional Treatment Plant. Project money came from low interest loans from the Bureau of Reclamation and the State of California as well as short-term bonds.
Who funds it long-term?	It has been developed on a user pay basis, growers and the residents that benefit from protection of their groundwater from saline intrusion.
How much is charged for the water? Pricing structure?	$0.11 per KL is the approximate cost of recycled water. Well water cost is $0.09 per KL.
What is the willingness to pay for recycled water?	Growers are very happy to pay for the water.
Is it full cost recovery?	Yes see above.
Are the any outstanding cost issues?	No.
Operational and end user requirements	
What changes have growers/users had to make in their management practices? How have they been assisted?	MRWCPA has undertaken soil monitoring programs for the growers. Some growers have changed to higher value crops such as strawberries.
Does the project address seasonal variations in demand (winter storage)?	No, ASR or groundwater replenishment is currently being investigated by the WWTF.
What governs the application rate? N, P?	There are no environmental restrictions with respect to nutrient loadings.
What is the period of time for the scheme to have full take up?	Approximately 3 years.
What are the inline QA systems? E.g. Backflow devices.	All turnouts have backflow devices.
Water quality	
What is the:	See **12.1.6.3 Bob Holden MRWPCA.ppt,** slide numbers 8 and 20
• Salinity	862 mg/L
• SAR/ESP	5.3
• N total	37
• P	2
• Ecoli	<2.2 MPN/100ml
• Salmonella	<2.2 MPN/100ml
• Viruses	<0.1 culturable/100L

<table>
<tr><th colspan="2">Communication/engagement/partnership programs</th></tr>
<tr><td>What where the community's perceptions of reuse?</td><td>The thorough research, together with a stringent monitoring program and a strong commitment to achieve 100% compliance with permit regulations, has provided the basis for the scheme to win public and commercial confidence and support.</td></tr>
<tr><td>How were community expectations/concerns dealt with?</td><td rowspan="3">A proactive communication strategy was adopted which acquainted the produce industry, the local media and the public with the project. A communications company was hired before the start of operation to develop a plan for education and to deal with potential crises within a three hour response time. Material was produced to educate local produce sellers, growers and workers for their own benefit and safety as well as to help answer any consumer questions about the safety of reclaimed water and produce grown with it. Marketability surveys were carried out in 1983 and 1997 and showed that industry buyers and sellers felt there was no need to label or separate produce grown with reclaimed water, and that consumers would purchase the produce as long as the safety of the product was assured. A measure of the effectiveness of the strategies to address the public health and perception issues revealed that after three years of operation, the major issue of concern is now salinity.</td></tr>
<tr><td>What was the public engagement strategy? Eg Extent of customer and community consultation undertaken – what worked well and what didn't?</td></tr>
<tr><td>Was consumer market research undertaken?</td></tr>
<tr><th colspan="2">Regulation</th></tr>
<tr><td>What are the water quality standards for each purpose?</td><td>Title 22</td></tr>
<tr><th colspan="2">Current and future innovations/technology</th></tr>
<tr><td>What are the future challenges and directions facing water recycling schemes? (Governments, water industry, business).</td><td>Managing salinity and sodicity of the water and the types of crops grown in the area changing to meet market needs.</td></tr>
</table>

12.2.4 Wrap up by participants

This is the best site we visited. The size of the operation was amazing. They seem to have lots of money available to do things properly from the WRF, to farmland monitoring.

12.3 Bahman Sheikh's dinner and speakers.

Bahman Sheikh, Ph.D., P.E.
Water Reuse Consultant
3524 22nd Street
San Francisco, California 94114-3406
Phone: (415) 695 1178 email: bsheikh@bahmansheikh.com
Cellphone: 415/990-9980 Website: www.bahmansheikh.com

Presentation: CD/ppt/12.3 Sheikh CA FL – San Fransico.ppt
Compared and contrasted the differences between reclaimed water development in Florida and California. His presentation highlighted the many difference in reclaimed water development between the states, including their different regulatory frameworks. Of interest was his exclamation that there is an inverse relationship between the number of agencies that a water authority has to deal with and the number of successfully developed schemes.

Richard W. Harris P.E.
Manager of Water Conservation
East Bay Municipal Utility District
Phone: (510) 287 1675 email: rharris@edmud.com

Figure 47 Bahman Shiek presenting a summary of recycled water use in America at a Dinner he hosted at his house in San Fransico, California.

12.4 Quote of the day

Whiskey is for drinking, water is for fighting over, Mark Twain.

We all hold a piece of the puzzle and together we start to get a better picture of recycled water.

Water is water.

13 Program: 11th June, California

13.1 Marin Municipal Water District – Marin

13.1.1 Contacts

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Dan Carlson and Ken Feil

13.1.2 Background

The story of water recycling at MMWD is one of overcoming obstacles and creating success, despite the absence of natural advantages (such as aquifers, new development, or large irrigators) that can greatly enhance the feasibility of a recycling project. In addition, MMWD's program has included many pioneering innovations, usually practiced only by much larger agencies.

MMWD serves the 147-square mile populous Eastern corridor of Marin County, just north of the Golden Gate Bridge. The community of 185,000 is mostly residential with some light industrial, retail and office buildings. Due to a relatively wet microclimate, water supply has traditionally come from a system of local reservoirs. The local geology is a poor aquifer and local surface water supplies can be drastically affected by variations in rainfall. To supplement the limited supply of local water, the District is expanding water conservation efforts, water recycling and water imports from neighbouring Sonoma County.

Recycling started during the drought of 1976 - 77 when a pilot plant, built in 1975, was used for drought relief. This experience vividly demonstrated that recycled water was available when other sources disappear. Increased concern about limited potable supplies led to a joint effort, with the Las Gallinas Valley Sanitary District, to build a permanent facility. In 1981, a 1 mgd direct filtration plant was completed and served a nearby park and CALTRANS landscaping, with plans for further expansion. In an example of "beating swords into ploughshares", three former Nike missile vaults near the plant were recycled and used for water storage and chlorine contact chambers.

Water recycling enhances the environment

To protect the environmentally sensitive San Francisco Bay, shallow wastewater discharges are prohibited in the dry season and effluent is stored in ponds. In addition to 40 acres of wastewater storage, there is a 20 acre freshwater marsh, a 10 acre saltwater marsh and public access trails to view the numerous wildlife and waterfowl. This project, performed by our reclamation partner, the Las Gallinas Valley Sanitary District, received an award for Engineering Excellence from the Consulting Engineers Association of California, and a nomination from the American Consulting Engineers Council. Although this storage provides water for the summer irrigation season, growth of algae, colloidal silica, and frequent water quality changes present water treatment challenges.

Regulatory changes initiate plant improvements

A major setback occurred when the state water reclamation regulations were made more stringent. The water quality the plant was capable of producing was no longer adequate for irrigation of parks, playgrounds and greenbelts. However, the commitment to water recycling remained strong and a decision was made to improve and enlarge the project to 2 mgd.

This led to further process development, which was complicated by an extremely small site and highly variable raw water quality reaching turbidity of up to 300 NTU. The key to the process improvement was application of a high-rate DensaDeg clarifier, the first in the USA to be used for recycled water.

The DensaDeg requires only 1/10 of the space and 1/3 of the cost of conventional clarifiers. The finished water turbidity averages 0.6 NTU, far better than the 2 NTU required by state regulations. Other process parameters are equally impressive, meeting all but three of the chemical criteria for drinking water. The outstanding water quality makes it easier to gain acceptance from regulators and customers for non-traditional uses such as toilet flushing, commercial laundries, cooling towers and car washes.

Expansion of the distribution system

The next challenge was distribution of the high-quality recycled water. To overcome a potable water supply deficit, and because planned development in Marin is mainly complete, recycled water had to serve existing consumers. Unfortunately, existing irrigation was relatively small, with average annual consumption of only 3 acre feet. Due to the wide variety of consumers, these retrofit conversions presented unique challenges. In addition to digging up the streets to install 25 miles of pipeline, each consumer's private irrigation system had to be separated from the potable system. In most cases, drawings of the existing systems were not available and performing cross-connection control was a tedious effort. Schools, parks, apartments, condominiums, shopping centres and office buildings, each one with unique and unusual plumbing, had to be verified by the retrofit conversion team, who resembled urban archaeologists. More than 310 services have been retrofitted to date.

Pioneering new uses for recycled water

Although irrigation remains the main market for recycled water, MMWD has been involved in pioneering such non-traditional uses as toilet flushing, commercial laundries, cooling towers and car washes.

Figure 48 Carwash using recycled water in Marin Municipal Water District, Marin, California.

In July 1993, the first car wash in the State was converted from potable to recycled water. The first hurdle in this effort was gaining regulatory approval. Concern about bacterial regrowth and Legionella was resolved by establishing a shock disinfection program in the basin that collected and recycled used washwater. The next challenge was eliminating a "spotting" problem due to the higher dissolved solids of recycled water (1000 ppm) versus potable (100 ppm). This was solved by installing a reverse osmosis unit with 2-stage prefiltration and ion exchange. This reduced the dissolved solids of the recycled water to the same level as potable. It sounds so easy now. However, a lot of head scratching and trial-and-error was required to develop the system. The washed cars are now spot free and the car wash has realised a cost savings by using recycled water versus potable. There are now 3 car washes in Marin that use recycled water.

The new 320-bed Marin County Jail is the first penal institution to use recycled water for toilet flushing. This is also the first facility to be designed and operated in conformance with the new Uniform Plumbing Code Appendix J - Reclaimed Water Systems for Non-Residential Buildings. The

Management Plan for operating the system has a very significant regulatory first: an exemption from annual cross connection testing. In 2001, there were eight buildings in Marin (and four more under construction) that were dual-plumbed to flush toilets with recycled water, more than any other County in the State.

In 1995, we finally succeeded in gaining regulatory approvals to convert HVAC cooling towers from potable to recycled water. In 1991, the District received initial health department approval to convert a cooling tower, only to have it stalled at the final inspection. The cause of this was fear of *Legionella* and reorganisation within the health department, which moved the jurisdiction from the regional office to the Environmental Management Branch in Sacramento. Since then, the District has worked patiently with the health department, helped with risk assessment models and educated them about typical (and effective) practices that cooling tower maintenance firms use to maintain bacterial quality. The cooling tower has now been using recycled water for about 6 years and another one has been installed at the Marin Technology Centre.

Legislative accomplishments

The MMWD has been involved in several legislative activities that have promoted water recycling. Through the late Assemblyman Filante, in 1990 the District initiated AB 24, which created the revolving fund for low-interest loans to fund water recycling projects. In 1991, we initiated AB 1698 which empowered public agencies State-wide to require dual plumbing in non-residential buildings to flush toilets with recycled water.

In 1993, the District served on the California Ad Hoc Dual Plumbing Committee to create plumbing code language that addresses dual plumbing design and installation. The MMWD was a strong advocate for safe but practical safeguards to prevent cross-connections. Work on this committee was instrumental in securing regulatory acceptance of a Management Plan for the Marin County Jail that does not blindly require unnecessary system shutdowns to verify cross connection control.

In 1997, the District initiated new legislation to further expand the types of structures where recycled water dual plumbing systems may be installed. Assemblywoman Helen Thomson (D-Davis) sponsored AB 1522, which specifically authorised dual plumbing systems for commercial, retail and office buildings, theatres, auditoriums, schools, hotels, apartments, barracks, dormitories, jails and prisons. Despite reservations about trying to pass water legislation in a non-drought year, the legislature proved its commitment to water recycling by unanimous votes of approval in both the Senate and Assembly.

In 2001, Bob Castle was appointed as Co-Chair to the WateReuse Association Legislative/Regulatory Committee along with Bill Jacoby of San Diego County Water Agency. One of the first legislative priorities (AB 331) will be the creation of a task force, administrated by the California Department of Water Resources and reporting to the Legislature on ways to reduce water recycling regulatory obstacles. One of the areas of focus will be improving the California Plumbing Code to facilitate dual plumbing in commercial and industrial settings.

Managing salt in recycled water

Saltwater intrusion into sewer systems is a problem in this area and has increased subsequent to the Loma Prieta earthquake of 1989. The sanitation district has been cooperative in identifying and repairing intrusion points, but a fact of life in this area is that recycled water will always have elevated salt levels.

Some landscapes have apparently suffered as a result of the increased salt in the recycled water. Customers and landscape maintenance firms were quick to blame the recycled water for any and all problems. However, we observed that the same plant species that suffers in one area absolutely thrives elsewhere. Obviously there is more to maintaining a healthy landscape than salt concentration and plant species selection.

While there is much data on the effect of salt on agricultural crops, we found little useful information regarding ornamental plants, particularly the species popular in this area. With the cooperation of horticultural experts from UC Davis, a program was developed to study the long-term effects of recycled water on ornamental plants and soil. The project was expected to continue for about 5 years.

Part of this study involved construction of a 25,000 sq ft demonstration garden to study the following variables:

- Water Quality - Irrigation with potable and recycled water for side-by-side comparison.

- Irrigation Method - Overhead spray, bubbler, drip and subsurface irrigation methods are being tested.
- Plant Species - Different trees, shrubs, grasses and ground covers popular in this region are being tested.

Another positive aspect of the study was involving the local landscape maintenance firms in both the construction and operation of the demonstration garden. This saved the District over $75,000 by donations of labour and materials, but more importantly it took the harshest critics of recycled water quality and involved them in seeking solutions. The garden has been in place since 1994, and we have observed some dramatic examples of plants irrigated with recycled water performing far better than those irrigated with potable water. Another plus is that the garden is located adjacent to a high school and a local community garden, providing a positive public exposure and teaching tool.

Local chapter of Watereuse

The MMWD has long been active in the San Francisco Bay Recycling Task Force initiated by the City of San Francisco. This water recycling forum involves most of the Bay Area water agencies and has provided an opportunity to share experiences and ideas with active and potential water recyclers. The District has taken an active role in transforming the Task Force to the Northern California Chapter of the WateReuse Association with Bob Castle serving as first Chapter Secretary from 1994 – 1998.

Recycling program receives awards

In 1993 the MMWD and Kennedy/Jenks Consultants received an award for Engineering Excellence from the Consulting Engineers and Land Surveyors of California.

In 1994 MMWD's Water Recycling Program won a Special Award of Merit from the WateReuse Association of California in recognition of the innovative and pioneering aspects of the program.

In 1997, the Association of California Water Agencies named MMWD as a finalist in the Innovations Category of ACWA's Clair A. Hill Water Agency Award for Excellence. This award recognised the recycled water demonstration garden, recycled water training manual and seminars for landscape professionals.

Also in 1997, the AWWA CA/NV Section published the "Guidelines for the On-Site Retrofit of Facilities Using Disinfected Tertiary Recycled Water" culminating a five-year effort by an ad-hoc group, chaired by MMWD's Ken Feil. The primary sections were authored by MMWD staff, with Ken Feil writing the regulatory and general sections, and Roger Waters writing the landscape and agricultural sections. This allowed the guidelines to take on a Northern California flavour, resulting in a much less restrictive guideline than could have been expected from the more conservative Southern Californians. One of the significant features of the document was the endorsements by both the California Department of Health Services and the Nevada Division of Environmental Protection.

Ken was also successful in securing a grant from the U.S. Bureau of Reclamation, which covered printing costs and allowed the guideline to incorporate colour photographs. The guidelines have already been well received by the water recycling community in California and around the globe. We are proud that we have been able to share our experience with others and use our local success as the new paradigm for retrofits of recycled water.

In recognition of Ken Feil’s leadership in creating the Retrofit Guidelines, in 1998 Ken received the George A. Elliot Memorial Award from the CA-NV Section of the American Water Works Association.

At the WateReuse Symposium XV in Napa, September 13 - 15, 2000, Bob Castle received the WateReuse Association's "Outstanding Service Award" for 2000. Accomplishments cited were legislative and regulatory activities which have expanded the types of uses for which recycled water may be used, several first in California recycled water applications and leadership in the formation and development of the Northern California Chapter of WateReuse.

Summary

With a customer base of only 185,000, the Marin Municipal Water District cannot match the volume and staff available to larger water recyclers in Southern California. However, we feel that our water recycling program is the best in Northern California and, considering our size, have demonstrated leadership and made significant State-wide contributions to the water recycling industry. We also serve as an example that, despite the absence of many natural advantages, water recycling can be successfully achieved if the conviction is there'.

13.1.3 Marin Municipal Water District, Recycled Water Program status as of December 2004

Total Number of Uses: 340

Total Irrigation Uses:	316
Total Non-Irrigation Uses:	24
Total Recycled Water Entitlement:	934.39 AF
Total Irrigation Entitlement:	889.01 AF (95.14% of total use)

Total Non-Irrigation Entitlement: 45.389 AF (4.86% of total use)

Buildings that use recycled water for toilet flushing: 16

Las Gallinas Recycling Plant	0.017 AF	1991 retrofit (first in N. California)
Marin County Jail	4.24 AF	1994 new construction
Civic Center North	5.96 AF	1994 new construction
65 Mitchell Blvd.	0.051 AF	1995 new construction
Unocal Carwash	0.034 AF	1996 new construction
Regency Plaza II	0.96 AF	1997 new construction
Civic Place	2.77 AF	1998 new construction
Civic Mart	0.068 AF	2000 new construction
Freitas Park, City of San Rafael	0.034 AF	2000 remodel
Marin Center (Vets Auditorium)	0.34 AF	2001 new construction
Lagoon Park (COM)	0.034 AF	2002 new construction
Saint Mark's (Gymnasium)	1.03 AF	2001 new construction
Ranchitos Park Restrooms	0.051 AF	2004 new construction
McInnis Park Skate Park - Restrooms	0.034 AF	2004 new construction
5000 Civic Center Dr	0.051 AF	2004 new construction
Valley Baptist Church (Gym)	0.102 AF	2004 new construction
	15.776 AF	

Car Wash facilities that use recycled water: 3

Betts Car Wash	6.00 AF	1995 retrofit (first in California*)
Unocal Car Wash	4.303 AF	1996 new construction
Shell Car Wash	1.07 AF	2001 new construction
	11.373 AF	

HVAC Cooling Towers that use recycled water: 2

Marin County Civic Center	3.00 AF	1995 retrofit (first in California*)
Marin Technology Center	8.00 AF	1997 remodel
	11.00 AF	

Commercial Laundries that use recycled water: 1

Nazareth House	5.00 AF	1998 retrofit (first in California*)

Single Family Residences that use recycled water: 28 single-family homes

Northview Project	0.08 AF each	2000 – 2002 new construction
	2.24 AF	

Future Projects

Mendoza Investments, 1050 Northgate Dr	1.36 AF	retrofit irrigation
Valero Station, 980 Del Ganado Bl	0.28 AF	retrofit irrigation
Redwood Village (In construction)	2.09 AF	new irrigation
McInnis Park Apartments	2.00 AF	new irrigation
Merrydale Court	0.08 AF	new irrigation
Smith Ranch Homes	1.07 AF	new irrigation
260 Channing Way	undetermined	new irrigation

* These projects were the first of their kind in California and necessitated pioneering the regulatory approval process, an effort which sometimes required up to five years for MMWD to accomplish.

AF = acre-feet = 325,851 gallons

HVAC = Heating Ventilating and Air Conditioning

13.1.4 Marin Municipal Water District. Recycled Water System - January 2005

Type of Use	*Number of Sites*	*Number of Services*
Commercial Landscape Irrigation (Retail, Office, etc)	115	124
Multi-Family Residential (Apartments, Condominiums, Townhomes, HOA's)	51	107
Single Family Residential	28	28
Municipal Parks & Playgrounds	16	16
Schools (K - 12)	11	12
Irrigation (Median strips, etc)	26	28
Toilet / Urinal Flushing	16	16
Car Washes	3	3
HVAC Cooling Towers	2	2
Commercial Laundry	1	1
Totals	269	337

13.1.5 Point of interest while visiting sites

Sites visited included: Redwood Village, Marin County Civic Centre Complex, Civic Centre North, Union 76 Carwash and Nazareth House. A bus breakdown prevented the tour from seeing the Smith Ranch Homes and the all sites outlined under Section 13.2, as planned.

The points of interest discussed below are a summary from the sites visited.

This is one district in Marin Municipal Water District where they recycled water from the sewer is less salty when the tide is out as leakage to the sewers is less, but they become too salty when the tide is in.

The stringent standards used for many of the reuse option above add a comfort level.

Artificial turf is being substituted for natural grass surfaces of playing fields. However, this is threatening the viability of reuse schemes as some large customers are taking on using artificial turf and don't require water anymore, making it difficult to make specific recuse schemes viable.

Marin Municipality District Water have had one cross connection with garden watering only. So they are currently trying to think outside of the box to develop new ways where they will try and get the developers to look after the cross connection.

The development of a new jail in the area was being limited by the amount of water available for toilet and urinal flushing in the proposed facility. So they proposed to flush the toilets with recycled water. However, a lawyer took the stance that he did want the prisoners being guinea pigs for using recycled water for flushing toilets. It was fortunate that Irvine Ranch Water District has already developed some high-rise hotels to use dual pipes and flush toilets with reclaimed water, as this lead to the case being dismissed. The 330 bed jail facility was constructed in 1994 using recycled water for toilet and urinal flushing.

The Marin County Civic Centre is the first (1995) high-rise to use recycled water in their cooling tower. The water is saltier so they use more, but the pay 50% less for the water. They also need to pay more for chemicals. However, it seems that there is still an overall economic gain by using the recycled water.

The have a regulation that doesn't allow reclaimed water to be used in toilet flushing in a mental asylum. Some public buildings and office buildings in the area use recycled water for toilet flushing. One office building owner thought it might be difficult to rent his building with recycled water flushing toilets, the water authority helped them talk to perspective leasers and they found the leasers actually thought it was great and they insisted on it remaining in the building, as this helped with their image of being a very environmentally friendly company.

Where recycled water is used in car washes, they had a few problems with spots left on the car so they needed to dry them after washing to over come this. The TDS of the recycled water is approximately 800 mg/L.

When recycled water was initially used in landscapes, if any problems arose with the landscape it was blamed on recycled water, in some cases this was correct. For example, they found that if Na was <200 mg/L and Cl <250 mg/L there was limited effect from salts and recycled water would generally not to be at fault for causing problems in plant growth/look.

13.2 Santa Rosa

Due to the bus breakdown this site was not visited, but the information from the website is provided below for your information.

13.2.1 Geysers Operation Centre

http://ci.santa-rosa.ca.us/default.aspx?PageId=265

For those of you new to this project, there is a history to this effort. The City of Santa Rosa needs to construct a project that will make the Subregional Wastewater System weather independent.

The following is a chronology of significant events that have led to the current status of the Subregional System, and its need for the Geyser Recharge Project. Prior to 1985: in the early 1970's, the City built one of the first water reclamation and reuse systems in the world. Reclaimed water was produced through secondary treatment, and the system started with 1,500 acres of agricultural irrigation. During the 1970's and 1980's Santa Rosa and its Subregional member partners experienced rapid growth. This growth, combined with increasingly stringent regulations on wastewater and unusual weather conditions, made the system vulnerable to failure.

February of 1985: A storm caused a sudden inflow into the collection system, resulting in spilling of about one million gallons of untreated sewage from a man-hole near Llano Road, prior to reaching the Laguna Plant.

March 1985 and January 1986: Dry weather caused low-flow conditions in the Russian River, preventing release of reclaimed water and causing the holding ponds to fill to capacity. Two planned and coordinated, through illegal releases of reclaimed water, were conducted to reduce strain on the system. The releases exceeded the 1% of river flow allowed in the City's permit. The 1985 release discharged reclaimed water up to 10% of the river flow; the 1986 release, up to 5% of river flow.

Spring 1985: Responding to the 1985 spill and planned discharge, the North Coast Regional Water Quality Control Board fined the City $50,000 and issued a cease-and-desist order. The Board required the City to develop a long-term project that would prevent such releases in the future.

Spring 1986: The Board adopted exception criteria which allowed discharges of up to 5% of river flow during dry winters, but required continued expansion of the irrigation system to compensate for growth.

Fall 1986: The City was challenged in court on the adequacy of the first EIR prepared on an ocean discharge project. Although the lawsuit was settled, the City ultimately decided not to use the EIR or the project it analysed as a basis for implementing a solution.

December 1988: The Laguna Plant expanded its capacity to 18 million gallons per day and was upgraded to an advanced treatment (tertiary) level. 1990: The Board of Public Utilities (BPU) directed the City staff to proceed with an EIR on a West County Reclamation Alternative, which would expand the existing reuse system into western Sonoma County.

1991: An EIR/EIS was certified and the West County Reclamation project was selected. The City was sued on the adequacy of the document, and it was eventually held to be inadequate.

1992: The California Department of Health Services rescinded its guidelines for the discharge of tertiary-treated reclaimed water into drinking water sources, thus increasing the number of potential solutions to the reclaimed water disposal problem.

1993: Rather than correct the inadequacies the court found in its previous EIR/EIS, the City initiated a completely new planning and environmental evaluation process. That decision led to the current EIR/EIS and the subsequent decision to analyse a range of options and give equal consideration to each. The BPU selected and contracted with Harland Bartholomew & Associates to prepare the EIR/EIS. The work was conducted in two steps:

Step I - Scoping Phase to identify and weigh all the solutions considered during previous processes plus any and all solutions suggested through an extensive public involvement program. All these potential solutions or parts of solutions were evaluated and screened resulting in a final set of alternatives to be evaluated in the environmental process. No preferred alternative was selected; all alternatives were evaluated equally. This extensive Scoping Phase took place over a two-year period.

Step II - Environmental Study Phase, during which the environmental analysis of the alternatives was carried out:

Alternative 1: No Action (No Project).

Alternative 2: South County Reclamation: agricultural irrigation and associated reclaimed water storage in areas south of Santa Rosa.

Alternative 3: West County Reclamation: agricultural irrigation and associated reclaimed water storage in areas west of Santa Rosa.

Alternative 4: Geysers Recharge: injection of reclaimed water for recharge of the Geysers steamfield located in north eastern Sonoma County.

Alternative 5: Discharge: release of reclaimed water to the Russian River or Laguna de Santa Rosa at a design discharge rate of up to 20 percent of river flow.

Summer 1996: In July of 1996 the Draft EIR/EIS was released for review. In October the City held a Public Hearing to receive comment on the EIR/EA. On October 7, 1996 , the end of the comment period, the City began preparing the Final EIR.

Spring 1997: The Final EIR was published in May and Certified on June 19, 1997.

Summer and Fall 1997: A series of selection meetings was held by the City Council and Board of Public Utilities to select a preferred alternative from the five Alternatives evaluated in the Certified EIR.

Fall 1997: The City of Santa Rosa prepared and adopted the Addendum to the Certified EIR that evaluated the Modified Geysers Recharge Alternative (Alternative 4 Mod).

Winter 1998: The BPU selected the Modified Geysers Recharge Alternative as the preferred project and began preparation of the Final EIS. Engineering design of the project began.

Summer 1998: The Corps published the Final EIS and circulated the document for review. Fall 1998: The Burns Creek Draft Supplemental EIR was published. The Burns Creek Supplemental EIR evaluated an alternative alignment in the Northern Section of the Geysers Recharge Project.

Winter 1999: Scoping Meetings were held on potential modifications and refinements to the Mid-, Northern and Southern Sections of the Geysers Recharge Project. The Mid- and Southern Section Scoping Reports and Draft Supplemental EIRs were published. The Burns Creek Alignment was included in the Northern Section Supplemental EIR, precluding the need to complete the Burns Creek Final Supplemental EIR.

14 End of tour itinerary

Approximately 10 Study Tour 05 participants remained in San Francisco to attend the AWWA Annual Conference and Exposition (June 12–16, 2005) Moscone Centre — South Building, San Francisco, California. This was promoted as the world's water event and included topics such as: Wastewater Issues; Water Conservation; Water Quality; and Water Resources/Reuse.

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