City/County
Water and Wastewater Study

Date: September 4, 2009

To: City/County Water and Wastewater Study Oversight Committee

From: Mike Letcher
City Manager

Chuck Huckelberry
County Administrator

Re: **Water Quality Technical Paper**

Background

As part of the Joint City of Tucson/Pima County Water and Wastewater Infrastructure Supply and Planning Study, the Tucson Water Department (TW) and the Pima County Regional Wastewater Reclamation Department (RWRD) were asked to describe how they ensure the strict compliance with water quality requirements in the region and how they are preparing for future regulatory requirements for emerging contaminants. The attached paper includes the following:

- Description of Water Quality Standards
- Tucson Water System & Water Quality Regulation
- Drinking Water Sampling & Compliance Activities
- Pima County Regional Wastewater Reclamation System and Treatment Processes
- Wastewater Sampling & Compliance Activities
- Review of Emerging Contaminants and their Regulatory Status
- Research Considerations and Summary
- Recommendations

The fundamental underpinnings of water quality control lie in Water Quality Standards and the framework of water quality regulatory programs that apply those standards. This paper contains an overview of the City and County's water and wastewater systems which are complex, sophisticated, highly regulated and are maintained and managed at a level to achieve excellent compliance with these standards.

Emerging Contaminants

Since the mid-1990's, the Environmental Protection Agency's (EPA) Office of Water used the term "emerging contaminant" to loosely describe substances that have no regulatory standard, that have been recently "discovered" in the environment because of improved analytical detection, and that may cause public health or ecosystem risk, although the epidemiologic impact is relatively unknown. EPA now uses the term "contaminant of emerging concern," (CEC) for these compounds. CECs describe a wide range of substances that fall into a number of subgroups which lend themselves to additional acronyms, including Endocrine Disrupting Compounds (EDC), Pharmaceutical and Personal Care Products (PPCP), and minute quantities of organic compounds (trace organics). Other pollutants that may be regarded as "emerging" include a number of trace metals, perchlorate, various parasites, and some commonly occurring compounds such as salinity and sulfate.

CECs can enter the environment through a complex variety of sources. Some CECs are similar to conventional toxic pollutants because they are associated with industrial releases. Many others are used by the general public every day in homes, on farms, by commercial businesses or even by hospitals. Many of the compounds, such as hormones and trace metals, can also be naturally occurring in the environment. CECs are also released through septic system or municipal wastewater discharge, landfill impact, agricultural wastes, or industrial discharge. CECs can enter the waste stream through human excretion, flushing of unused medications, and industrial disposal. Any CECs that are not removed during the wastewater treatment process remain in discharged effluent. Discharges that may impact the aquifer raise concern about the need to monitor and protect drinking water supply wells and the public drinking water system from CECs.

Studies Discovering "Emerging" Compounds in the Environment – United States Geological Survey (USGS)

Detection of pharmaceutical contaminants (including endocrine disrupting compounds) and personal care product residues in the environment received national attention in 2002 with the publication of a United States Geological Survey (USGS) report regarding samples collected from 139 streams across 30 states. The sampling sites focused on streams considered susceptible to contamination and representing a wide variety of hydrologic, climatic, and land-use settings. Results indicated a broad range of chemicals detected in surface water impacted by residential, industrial, and agricultural wastewaters in mixtures at low concentrations in most streams. The chemicals included human and veterinary drugs, natural and synthetic hormones, detergent metabolites, plasticizers, insecticides, and fire retardants. One or more of these chemicals were found in 80 percent of the streams sampled. Half of the streams contained seven or more of these chemicals, and about one-third contained 10 or more

of these chemicals. This study was the first national-scale examination of emerging contaminants in surface water.
Since 2002, additional research has added to our understanding of CECs. A report by the Water Environment Research Foundation indicates that advanced wastewater treatment technology is a tremendous benefit to lowering PPCP levels. A sampling study of 10 different wastewater treatment facilities in Arizona (Ina Road, Roger Road and Avra Valley Wastewater Reclamation Facilities (WRF) included) concluded that no single technology can remove all PPCPs from effluent produced by wastewater treatment facilities. However, conventional secondary wastewater treatment along with denitrification can remove over 90 percent of EDCs. A 2004 study demonstrated biodegradation of select PPCPs can be achieved with adequate solids retention time and/or hydraulic retention times. Based on these and other studies, it is projected that when the Roger and Ina Road WRF are fully transformed to denitrifying facilities under Regional Optimization Master Plan (ROMP), there will be considerable additional benefit from organic chemical biodegradation.

Tucson Water has experience researching and managing CECs through its operation of TARP to address TCE and recent work on 1,4-Dioxane. Since the 2001 USGS study, Tucson Water has remained engaged in supporting and even conducted further research into the persistence of microconstituents in the local environment, including the groundwater supply and drinking water sources. Tucson Water maintains a "sentry" monitoring program to sample wells that may be mostly likely to introduce CEC's into the potable water distribution system. Since many of these products that contain microconstituents are used by humans in therapeutic doses to enhance their lives, research is ongoing to see if any of these compounds found at levels well below any therapeutic dose have any toxicological effects.

Research Considerations and Summary

The situation with respect to trace organics in wastewater can be summarized in the following way:

- The great number of synthetic chemicals in widespread use and the advances in analytical chemistry that allow us to measure these compounds at exceptionally low concentrations make the presence and detection of many trace organics in wastewater unavoidable.

- Most trace organics that are now commonly found in municipal wastewater are present at concentrations that are unlikely to produce physiological response in exposed organisms. However, hormones are designed to affect organism development at very low concentrations, and more evaluation is needed regarding the effects of many trace organics in stream systems receiving wastewater.

- Most estrogenic activity arises from the population's natural hormones excreted as human waste into the wastewater collection system. Conventional wastewater treatment is efficient, although imperfect, at removing the chemicals responsible for estrogenic activity, as well as many other organic CECs. Well-operated plants that are designed for nutrient removal can bring about nearly a hundred-fold reduction in estrogenic activity.

- The fates of trace organics in wastewater effluent discharged to surface waters or infiltrated for groundwater replenishment have not been well studied, are incompletely understood and offer opportunity for further research.

- There is no compelling evidence in favor of a direct link between residual trace organic compounds in wastewater effluent and human health effects. There is, however, great potential complexity in the mechanisms by which chronic exposure to trace contaminants could affect public health.

Regulatory Status of Emerging Contaminants

The EPA has a process for periodic evaluation of research data to determine whether or not to add new pollutants to established standards. Due to the fragmentary nature of current research information, most CECs will likely not have standards for years to come. In the absence of specific water quality standards, regulatory programs cannot set specific controls on pollutants. General preventive measures can often be effective in such situations. Wastewater systems can emphasize pre-treatment and industrial source control to minimize system inputs. Drinking water operators can assure system integrity with sound backflow prevention measures. Public outreach can also be an effective preventive tool with regard to the public's choice to dispose of problematic compounds wisely.

Recommendations

- ***Wastewater Facility Improvements – Regional Optimization Master Plan (ROMP)***

  - Implement the ROMP Improvements - Implementing the ROMP improvements to wastewater treatment facilities in Pima County is the single most effective step that can be taken to minimize impact of emerging contaminants on public health and the environment. The County is proposing to fund these improvements through a sewer revenue bond election to be held in November 2010.

- ***Continue Source Control Programs & System Monitoring***

  - Multiple Barrier - In accordance with EPA and ADEQ drinking water regulation, Tucson Water should continue to operate all facets of its "multiple barrier" approach to potable water protection.

  - Industrial Wastewater Control - RWRD should continue its aggressive and effective pre-treatment program.
  - Household Hazardous Waste - The City of Tucson and Pima County should continue to support the success of this program to reduce chemicals that might be discharged into our sewers and landfills.

  - Pharmaceutical Take-Back Program - Tucson Water and RWRD should continue working together with the established stakeholder group to develop a plan to implement pharmaceutical take-back activities.

- ***Tucson Water And RWRD Professionals Need To Collaborate In National, Regional And State Research And Regulatory Activities***

  - WESTCAS and Effluent Dependent Streams Advocacy - Make sure that federal guidelines and ADEQ standard setting reflects our arid western environment and appropriate exposure risks.

  - Standards Development - Tucson Water and RWRD staff should actively participate in the anticipated ADEQ stakeholder process to revise Reuse Standards.

  - USGS and University Research - Continue to support and participate in USGS and University research related to emerging contaminants.

  - Workshops and Conferences - Participate in local, regional and national workshops and conferences related to emerging contaminants to keep staff abreast of latest treatment technology, monitoring strategies and research results.

- ***Conduct Public Outreach & Education***

  - Public Outreach and Education - Continue and increase public outreach and education through existing programs such as Environmental Monitoring for Public Access and Community Tracking Program; Stormwater Public Outreach Program; Fats, Oils and Grease Program; Pharmaceutical Take-back Events; and Household Hazardous Waste Program.

- ***Seek Additional Federal Funding***

  - Federal Funding - Actively pursue federal funding for local/regional research, local/regional take-back programs, and increased Industrial Wastewater Control/pre-treatment outreach programs.

It is respectfully recommended that the Committee consider this report and provide input to the City and County on its recommendations.

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City/County Water and Wastewater Study
Phase 2

City of Tucson and Pima County

Water Quality Technical Paper

September, 2009

This paper was prepared by a joint team of City of Tucson and Pima County staff from the following departments: City of Tucson - TW, Water Quality Management Division, and City Manager's Office; Pima County – Regional Wastewater Reclamation Department, and County Administrator's Office. Lead authors on the paper were Stephen Dean, Ed Curley, Remy Sawyer, James DuBois, John Kmiec and Jeff Prevatt.

City of Tucson and Pima County Water Quality Technical Paper

Water and Wastewater Infrastructure, Supply and Planning Study, Phase 2

September 2009

It would be difficult to overstate the impact that disease has had throughout history or the important role that wastewater treatment and water treatment methods have played in protecting against waterborne illnesses. Diseases such as cholera, yellow fever and typhoid were once common and prior to WW II, cholera and dysentery combined as the most common causes of death in the United States. As a result, water and wastewater treatment facilities were developed with the common goal of disease prevention. Modern water and wastewater treatment systems have virtually eliminated these diseases wherever they are in place.

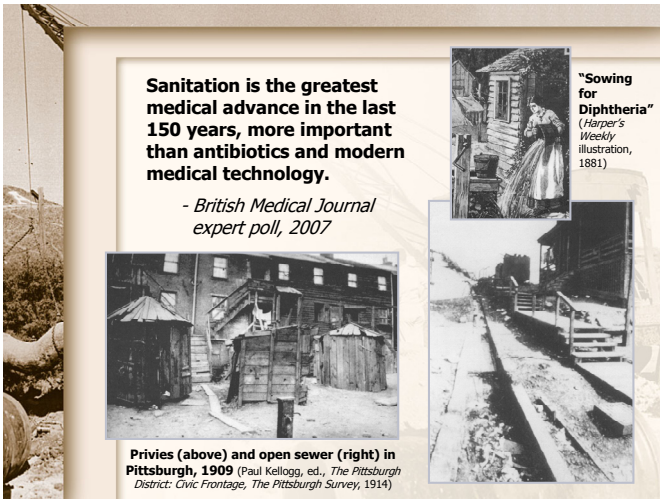

Figure 1

As part of the scope for the Joint City of Tucson/Pima County Water and Wastewater Infrastructure Supply and Planning Study, the Tucson Water Department (TW) and the Pima County Regional Wastewater Reclamation Department (RWRD) were asked to describe how we ensure the strict compliance with water quality requirements in the region and how we are preparing for future regulatory requirements for emerging contaminants. This paper includes the following:

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Background

Surface water protection requirements and activities are currently one of the primary regulatory drivers dictating treatment requirements at RWRD facilities. Enacted in 1972, the Clean Water Act (CWA) regulates the physical, chemical, and biological integrity of the nation's waters. The 1972 Clean Water Act (substantially amended in 1987), and previous amendments of the Water Pollution Control Act of 1948, provides the current framework for surface water quality regulation in the United States and Arizona. The objective of the CWA is "to restore and maintain the chemical, physical, and biological integrity of the Nation's water" (Section 101(a)). Initially the CWA was based on using technology requirements to attain secondary treatment universally across the nation. The CWA amendments of 1987 established water quality-based standards, and compliance with these new standards necessitated advanced treatment, including in many instances, nitrification/denitrification and enhanced disinfection.

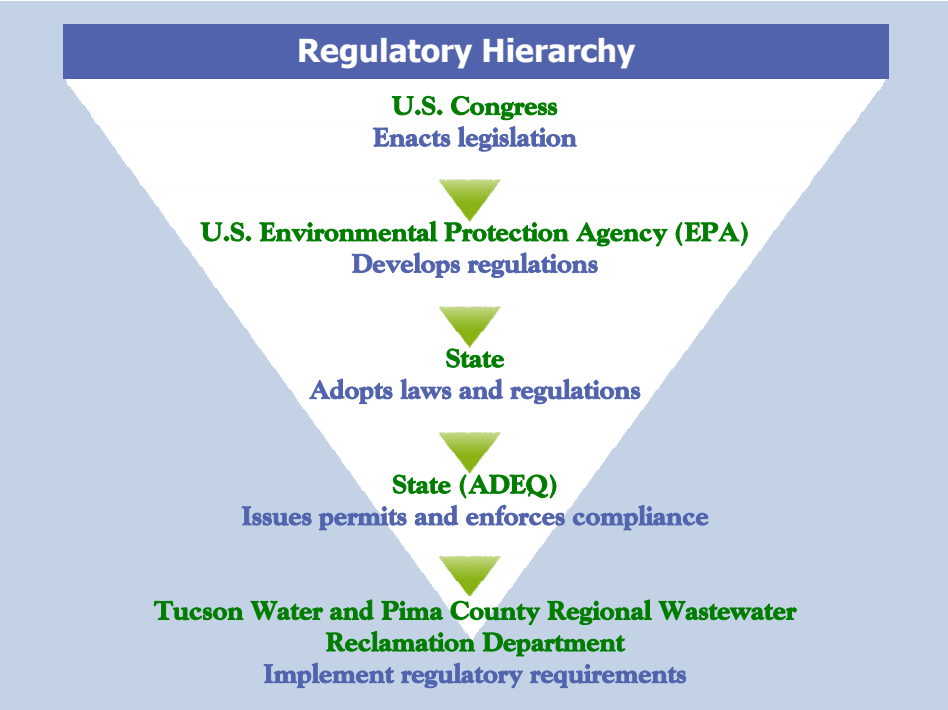


Figure 2

Drinking water standards are set by EPA to protect public health from exposure based upon ingestion. The Safe Drinking Water Act (SDWA) passed in 1974 and amended in 1986 and 1996, gives the Environmental Protection Agency (EPA) authority to set drinking water standards. Drinking water standards set minimum allowable levels of contaminants that can otherwise adversely affect public health and are known or anticipated to occur in the nation's drinking water. These controls are called the National Primary Drinking Water Regulations (NPDWRs). The established list of primary drinking water standards (see Appendix A) contains numeric maximum contaminant limits (MCLs) for one type of micro-organism, four disinfection byproducts, fourteen inorganic compounds, fifty-one organic compounds, and four radionuclides. In addition to the primary standards, EPA has a list of compounds for which the agency has set secondary standards based solely upon aesthetic considerations for drinking water. The later list (see Appendix A) is generally not incorporated as standards for regulatory programs designed to protect human health.

Synopsis of Water Quality Standards and Regulatory Programs

The fundamental underpinnings of water quality control lie in the Water Quality Standards and the framework of water quality regulatory programs that apply those standards. Appendix A contains a discussion of each set of standards that apply to drinking water, aquifer water quality, stream uses, and reclaimed water. It includes an overview of how our regulators, EPA and ADEQ, apply standards to implement the drinking water program, aquifer protection permit program, various surface water pollution control programs, and the reclaimed water program. Key aspects of the material presented in Appendix B include the following major themes:

- **EPA establishes standards for pollutants that are scientifically well-documented as having toxic, carcinogenic, or pathogenic effects on humans at specific concentrations in water.** Surface water standards incorporate impacts on aquatic wildlife.

- **Standards provide clarity to the regulated community about safe levels to target in design and operation of activities related to water quality so that public health and environmental quality are adequately protected.** The standards are applied through state and federal rules and state and federal permit requirements.

- **Some water quality pollutant controls are achieved through required treatment technology rather than substance-specific standards.** Such strategies typically address a group of similar pollutants.

- **EPA has a process for periodic evaluation of epidemiologic research data to determine whether or not additional pollutants need to be added to the established standards**. For drinking water and related standards they have a formal contaminant candidate list (CCL) (see Appendix C) to draw upon for new standards. Most "emerging contaminants" are not yet on the CCL, and likely will not be elevated for five years or more due to lack of toxicological data.

- **Research developments in analytical detection at the part per trillion level, epidemiology, risk analysis, and field studies are identifying new contaminants and contaminant effects that were previously unknown or unquantifiable.** New data will contribute to evolution of new water quality standards or technology-based regulatory controls. It is important for local agencies responsible for water quality to stay abreast of new developments with regard to emerging contaminants.

City of Tucson Water

Overview

We begin by describing the Tucson Water operational distribution system and regulatory compliance issues with: an overview of the Tucson Water potable system; the Potable Water Compliance Program; Reclaimed Water Quality and Public Outreach, Protection, Research and Development, including Tucson Airport Remediation Program; Backflow Prevention and Cross Connection Control Program; other Special Projects; and current challenges including salinity, uranium, radon, 1,4-dioxane and perchlorate.

According to EPA, there are 10 times more groundwater systems than surface water systems in the United States. Over 75% of groundwater systems serve less than 3,300 people, and over ½ serve less than 500 people. **TW's main system is one of the largest and complex groundwater systems in the nation.** In its 330-plus-square-mile service area, it operates 10 public water systems that serve 775,000 customers. The systems include 4,800 miles of pipelines that deliver drinking water to sites located throughout the region in the City of Tucson, and surrounding areas including Silverbell, Diamond Bell, Catalina, Corona de Tucson, and Thunderhead. TW wholesales its water to 24 entities, including the Town of Marana, Oro Valley, and Metropolitan Water Domestic Water Improvement District (MDWID), as needed.

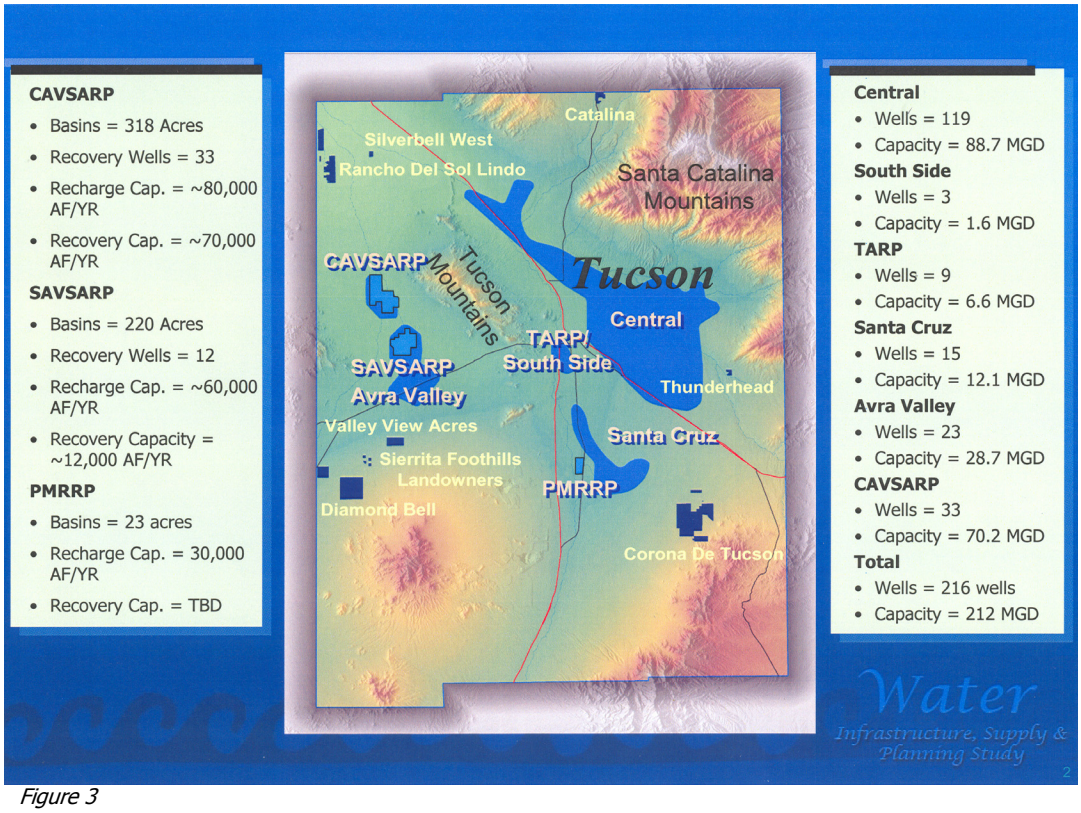


Figure 3

TW delivers an average 100 million gallons a day, from a typical winter low of 75 million gallons a day to a high of about 155 million gallons per day. It operates over 200 drinking water wells that serve 65 reservoirs totaling 200 million gallons in storage capacity.

TW has three facilities utilizing treatment techniques or processes to enhance water quality. One is the Hayden Udall facility in Avra Valley, where water is chlorinated and has the pH adjusted. The second is at the Tucson Airport Remediation Project Superfund site, where trichloroethylene (TCE) is removed by an air stripping process. Another treatment technique is applied at the Thunderhead system, aerating water at Well G-006A to adjust its pH and to make it less corrosive.

Regulations require that chemistry testing be conducted at a point after the water has been chlorinated but before it enters the distribution system (entry-point to the distribution system or EPDS). TW samples from approximately 144 EPDSs. One-hundred-fifty-three or 71% of TW's 215 drinking water wells are chlorinated and deliver water to the distribution system directly. The remaining unchlorinated wells are in the Santa Cruz, Avra Valley, TARP/ Southside, and CAVSARP well fields. The sources from each well field are combined and chlorinated before introduction into the distribution system.

Regulations require that total coliform, *Escherichia coli (E.coli),* and disinfection-by-products (DBPs) be tested in the distribution system. Samples are collected from 266 designated sampling stations located throughout the region.

Figure 4

Coliforms in the water are not a health threat in themselves; numbers or the presence of coliforms are used to indicate whether other potentially harmful bacteria may be present. Coliforms are naturally present in the environment and in feces. Fecal coliforms and *E.coli* only come from human and animal fecal waste. DBPs are byproducts of drinking water disinfection, such as trihalomethanes.

TW customers collect lead and copper samples from their household kitchen taps. The regulations currently require 140 household taps to be tested.

Because of the physical size of the main system, applying some of the NPDWRs becomes challenging. For example, the Ground Water Rule (effective December 1, 2009) will require TW to collect, within 24 hours of being notified that a sample collected under the Total Coliform Rule (TCR) is total coliform-positive, at least one groundwater source sample from each groundwater source in use at the time the total coliform-positive sample was collected for the TCR. It is impossible for TW to meet these requirements at some locations because it would require sampling at 170 drinking water wells in 24 hours. For this reason, Tucson Water has worked with regulators to find an alternative approach.

According to US EPA's *Ground Water Rule (GWR) Triggered and Representative Source Water Monitoring Guidance Manual* (EPA 815-D-08-004, 4/2009), there are two general reasons a system will propose conducting representative monitoring: 1) to sample wells that represent certain TCR sampling sites in the distribution system (and not sample other wells that do not provide water to the particular TCR sampling site; or 2) to sample one or more wells that represent multiple wells. The EPA and ADEQ believe that this alternative can be as protective of public health as monitoring all wellheads, provided that the chosen wells are truly representative of all wellheads. Therefore, ADEQ will allow TW to use both types of representative monitoring to comply with the GWR. For the past year, ADEQ managers have worked collaboratively with TW staff and EPA Region 9 to assist TW with their Groundwater Rule representative monitoring.

Potable Water Compliance Program

"A fundamental promise we must make to our people is that the food they eat and the water they drink are safe." - Safe Drinking Water Act Reauthorization, August 6, 1996

Regulatory Requirements

Delivering safe drinking water is heavily regulated - from where to test, what to test for, and how to report. An overview of the National Primary Drinking Water Regulations (NPDWRs) is presented first to provide the basis for determining "safe" drinking water. Compliance or non-compliance with the NPDWRs will ultimately determine if the water can be safely served to the public without affecting their health.

There are 90 National Primary Drinking Water Contaminants. Drinking water standards are regulations that EPA sets to control the level of contaminants that can adversely affect public health and are known or anticipated to occur in the nation's drinking water. These are called the National Primary Drinking Water Regulations (NPDWRs). Each NPDWR does not apply universally to all Public Water Systems. Each NPDWR specifies which type of water system must follow it. Exceeding a standard from a single sample does not necessarily constitute a violation of the NPDWRs because most violations are calculated from averages. Standards are not always evaluated against the Maximum Contaminant Level (MCL). **The MCL is the maximum level allowed in public drinking water supplies and is set at very stringent levels.** Finally, the health effects are based on risk assessments conducted by EPA and their examination of data for cancer and/or non-cancer causing health effects. **To potentially realize the associated health effects of ingesting water at the MCL, a person would have to drink 2 liters (1 liter for VOCs) a day for 70 years to have a chance of developing the potential health effects (USEPA, "Drinking Water Standard Setting Question-and-Answer Primer," November 1994).**

There are 15 National Secondary Drinking Water Contaminants. The National Secondary Drinking Water Regulations (NSDWRs) are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. EPA recommends secondary standards to water systems but does not require systems to comply. In Arizona, these are not enforceable standards.

There are 25 Unregulated Contaminants (List 2). USEPA is required to develop regulations for monitoring unregulated contaminants. The monitoring data from the Unregulated Contaminant List provides the basis for identifying contaminants that may be placed on future Contaminant Candidate Lists (CCLs) and support the USEPA Administrator's decision to regulate a contaminant in the future.

These standards are part of the Safe Drinking Water Act's "multiple barrier" approach to drinking water protection, which includes assessing and protecting drinking water sources; protecting wells; making sure water is treated by qualified operators; ensuring the integrity of distribution systems; and making information available to the public on the quality of their drinking water. With the involvement of EPA, states, tribes, drinking water utilities, communities and citizens, these multiple barriers ensure that tap water in the United States and territories is safe to drink. In most cases, EPA delegates responsibility for implementing drinking water standards to states and tribes.

Figure 5

The 1996 Amendments to the SDWA require that every five years EPA establish a list of contaminants that are known to occur or are anticipated to occur in the future in water systems and may require future regulations. This Contaminant Candidate List (CCL) is developed with significant input from the scientific community and other interested parties. When developing a National Primary Drinking Water Regulations (NPDWR), EPA's office of Water derives a MCL or treatment technique (TT) for each drinking water contaminant EPA has identified to be a potential threat. As noted above, the MCL is the maximum level allowed in public drinking water supplies and is set at very stringent levels. TTs are usually established instead of MCLs when a contaminant cannot be measured accurately at levels of public concerns.

EPA established a TT for the Lead and Copper Rule (LCR) because the majority of lead and copper contaminants come from household plumbing fixtures and public water systems have no control of the composition of the household plumbing. Therefore EPA established a TT, which among other things, requires Public Water Systems to control the corrosivity of the water instead. Corrosivity is the dissolving of metal caused by a chemical reaction between the water and the lead and copper in the pipes. A corrosion control treatment (CCT) will inhibit the leaching of lead and copper from household plumbing and lead distribution lines caused by corrosive water. As part of each NPDWR, EPA also develops requirements for monitoring, treatment technologies and analytical methods for each contaminant.

Currently, EPA has developed NPDWRs for synthetic organic chemicals (SOCs), volatile organic chemicals (VOCs), inorganic chemicals (IOCs), radionuclides, and microbiologicals. SOCs are manmade chemicals such as pesticides and industrial chemicals. VOCs are manmade volatile chemicals that can move easily from water to air. Most VOCs are industrial chemicals. IOCs are metals and minerals that can occur naturally or be introduced by humans. Radionuclides are radioactive contaminants that can occur naturally or be introduced by humans.

EPA has granted the Arizona Department of Environmental Quality (ADEQ) the right and responsibility to oversee the NPDWR program (primacy agency). Public Water Systems in Arizona, such as TW, must comply with the NPDWRs that ADEQ adopts in order to serve drinking water. Water systems must test and treat their water, maintain the distribution systems that deliver water to consumers, and report on their water quality to ADEQ and the public.

Tucson Water staff are responsible for interpreting the NPDWR, identifying the requirements, and assisting in implementing the regulation on the effective date of the regulation.

TW's Water Quality Management Practices – More Stringent Than Required

Managing groundwater system compliance is becoming increasingly complicated. As the numbers of contaminants and regulations increases (according to EPA it has increased exponentially within the last 20 years), groundwater systems are increasingly required to juggle competing regulatory requirements.

TW has adopted the following monitoring and operational policies to assist in complying with the NPDWRs while balancing the operational needs to deliver water to our customers. The following policies are intended to improve compliance and reliability because the results generated from the policies are used to evaluate and optimize the system by the establishment of trigger points to dictate increased discretionary monitoring:

- Volatile Organic Chemical Monitoring and Operations
- Operating Drinking Water Wells with Potential for Exceeding the MCLs
- Sampling Inactive Wells and Notification to ADEQ When Activating Wells
- Operating New Source Wells that Exceed NPDWR's MCLs or Alert Levels

Without careful planning and implementation, actions intended to improve water quality in distribution systems can produce serious, unintended, water quality consequences – especially in the areas of microbial regrowth, corrosion, stability of existing pipe scales, and aesthetics. TW has adopted the following monitoring and operational strategies to assist in improving water quality.

- Chlorine Target Levels
- Blending Strategies
- pH Adjustment and Corrosion
- Extended Parameters
- EMPACT Public Information and Outreach

Drinking Water Compliance Results

In 2007 the WQMD sampled, analyzed, and reported approximately 16,000 regulated drinking water chemical and 3,228 coliform results. TW met all EPA NPDWRs and ADEQ drinking water quality standards with no violation of MCLs identified in the required samples.

TW's drinking water compliance monitoring results are from 2007. Public Water Systems must monitor within the regulatory compliance monitoring time-frames assigned by ADEQ. In general, Public Water Systems collect NPDWR contaminants every three years, as long as contaminants are not detected. If contaminants are detected at a regulatory-defined level, the NPDWR requires increased monitoring at that source. If contaminants are not detected for a specified period of time, ADEQ will allow the monitoring frequency to be decreased to reduce monitoring burdens on the Public Water System.

The 2007 data does not include radiochemical results for the majority of TW's sources because TW is not required to monitor for radiochemicals under the Final Radiochemical Rule of 2000 until 2010.

Regulated Chemicals Tested	Samples for Calendar Year 2007
Coliforms	3228
Disinfection By-Products	48
Inorganic Chemicals	2028
Lead and Copper	186
Maximum Residual Detection Levels	44
Synthetic Organic Chemicals	10165
Volatile Organic Chemicals	3278
Total	19,061

Figure 6

- *Facts and Figures for the 19,000 Drinking Water Compliance Results for Calendar Year 2007*

Total coliforms were not detected in 99.6% of the samples monitored and reported to ADEQ. NPDWR chemical contaminants were not detected in approximately 95% of the results submitted.

Tucson Water - Results of 2007 Drinking Water Compliance Tests

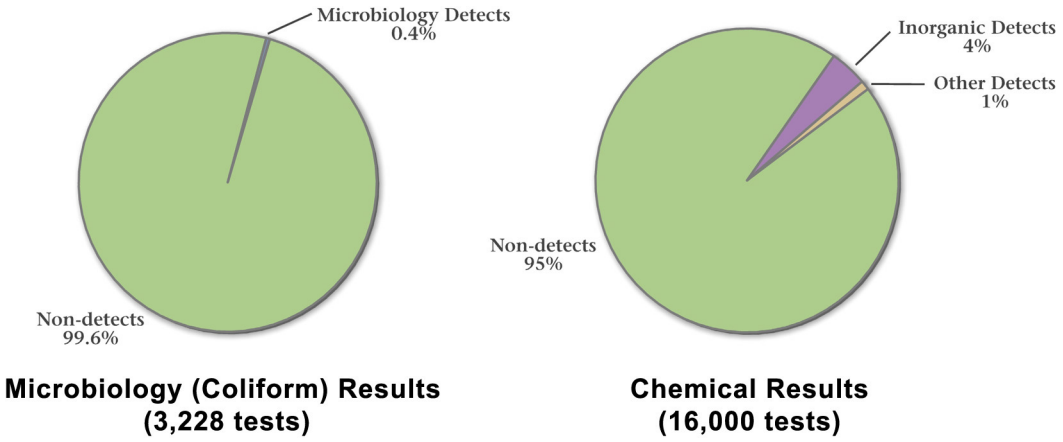


Figure 7

Although the majority (64%) of the reported results were SOCs, it was the IOCs arsenic, barium, fluoride, nitrate, and sodium that were detected most frequently. This is consistent with historical monitoring results. Nitrate was detected at all of the sites tested because there is a natural ambient level of nitrate in groundwater. The main sources of elevated nitrate in Tucson are from fertilizers and septic tanks. Compliance with the MCL was achieved for all of the sources tested.

Monitoring Cycle

When a Public Water System introduces a source into their system, ADEQ assigns the monitoring year a PWS must begin initial monitoring at that source. Once ADEQ assigns the initial monitoring year for that source, it is the Public Water Systems responsibility to monitor that source within the regulatory compliance time-frames. Failing to monitor in an assigned monitoring year will result in a monitoring violation.

The assigned initial and subsequent monitoring years are based on a regulatory compliance schedule. One cycle consists of nine calendar years. Each compliance cycle has 3 three-year compliance periods. ADEQ assigns the monitoring year within each 3-year compliance period.

Monitoring Cycle	Calendar Year	Compliance Period
1	1993-2001	**1993, 1994, 1995**
		1996, 1997, 1998
		1999, 2000, 2001
2	2002-2010	**2002, 2003, 2004**
		2005, 2006, 2007
		2008, 2009, 2010
3	2011-2019	**2011, 2012, 2013**
		2014, 2015, 2016
		2017, 2018, 2019

Figure 8

Reporting Requirements

- *Routine Reporting*

Regulations require that any Public Water System submit results of drinking water compliance testing to ADEQ (EPA for the UCMR2). Public Water Systems must report the data on ADEQ's Drinking Water Analyses Forms within regulatory reporting deadlines. If the agency identifies a significant deficiency, ADEQ notifies the Public Water System to follow-up or confirm the deficiency. Violations and follow-up actions are reported to EPA's Safe Drinking Water Information System (SDWIS) quarterly. In most cases, corrected violations are not deleted from SDWIS but are shown as being corrected.

The Consumer Confidence Rule (CCR) requires each Public Water System to report annually to its customers information about the quality of the water**. Eleven consumer confidence reports are published annually (one for each of TW's Public Water Systems).** Public Water Systems must follow the form, manner, frequency, and content of the report specified in the CCR and other requirements from ADEQ. The CCR helps people make informed choices about the water they drink by letting people know what contaminants, if any, are in their drinking water, and how these contaminants may affect their health. CCRs also give TW the opportunity to inform our customers about the effort it takes and our effectiveness in delivering safe drinking water.

- *Non-Routine Reporting*

The regulations require a Public Water System to initiate correspondence with ADEQ as soon as possible when there is a failure to comply with the requirements of the NPDWR. **Furthermore, the Public Notice Rule (PNR) requires Public Water Systems to provide public notification of violations to persons served when there is a failure to comply with the requirements of the NPDWR. Failing to monitor, monitoring at an incorrect frequency, failing to submit results within regulatory deadlines, and exceeding MCLs are all examples of non-compliance situations.** Public Water Systems must follow the form, manner, frequency, and content of the public notice specified in the PNR and additional requirements from ADEQ.

Associated Costs for Complying with the National Primary Drinking Water Regulations (NPDWRs)

SDWA-driven regulations impact utilities financially. TW's cost to comply with the NPDWRs in 2007 was $1,118,399. During an "off" monitoring year (2008), the cost is approximately half.

Costs include Environmental Scientists to interpret, identify, and audit results of NPDWRs requirements and associated tasks, Water Quality Analysts to sample the sources, and Chemists to analyze the samples.

TW aims to ensure that the water is safe to drink and to be fiscally responsible. Monitoring year 2007 was TW's most recent assigned monitoring year, and it was the most costly so far. During 2007, TW was ineligible for Synthetic

Organic Compound (SOC) monitoring waivers, and SOC testing makes up the bulk of the expenses, costing $379,845 to perform the analyses. Because SOC waivers were used in 2004 and the SOC Rule will only allow monitoring waivers once every compliance cycle, TW was ineligible for waivers in 2007. Yet, our results consistently show that SOCs are not detected in the water.

ADEQ's SOC waiver program is an excellent means of focusing monitoring efforts where they are most needed by eliminating unnecessary monitoring costs. ADEQ may grant a waiver if there has been no previous use (including transport, storage, or disposal) of a contaminant within half-mile radius of a source (well) and provided that the contaminant is not detected at that source within the last three years. If previous use of that contaminant is determined, then other factors are evaluated, such as proximity to point sources of contamination and how well the water source is protected against contamination due to such factors as depth of the well, type of soil and integrity of the well casing. TW is currently working with ADEQ on their SOC monitoring waiver application for monitoring year 2010, when Tucson Water is scheduled to begin SOC monitoring. If approved, TW can potentially save up to $200,000 in SOC analyses costs.

Tucson Water Quality Laboratory

Figure 9

Chemists and Water Quality Analysts in the Tucson Water Quality Laboratory are responsible for collecting and testing water samples daily that have been identified in monitoring plans, schedules, and permits. To accomplish this mission, the laboratory employs a unique team of skilled professionals with backgrounds in chemistry, microbiology, engineering, computers, and management.

Thousands of water samples are collected annually from hundreds of sites including groundwater wells, reservoirs and pumping stations, and from locations throughout the water distribution system specially selected to represent the entire water delivery system. Samples are tested for numerous constituents, including bacteria, minerals, metals, or man-made chemicals.

The Tucson Water Quality Laboratory maintains their environmental laboratory licensure which is issued by the Office of Laboratory Services of the Arizona Department of Health Services (ADHS), in order to analyze samples that will be used to meet regulatory requirements. According to ADHS's website, the purpose of maintaining licensure is to "help protect the Public Health and Environment by surveying all licensed laboratories for compliance with all applicable regulations and reviewing their compliance testing data for scientific validity and defensibility." This protection is assured through annual on-site audits of every laboratory, participation in proficiency evaluation samples, and providing training and technical resources.

Reclaimed Water Quality

Regulatory Requirements

The TW Reclaimed Water System is monitored continuously to ensure that the reclaimed water provided to the TW reclaimed customer meets or exceeds the reclaimed water quality requirements established by ADEQ.

Monitoring Policies

Tucson Water, in an effort to enhance its knowledge of the water quality of the reclaimed system, conducts additional water quality sampling at several distribution locations throughout the system.

Reclaimed Water Sources

There are three main sources of water available for the reclaimed water system: class B output directly from Roger Rd WRF, recovered effluent stored in the aquifer, and class A output from Randolph Park Wastewater Reclamation Facility (WRF). To further treat the reclaimed water produced by Roger Road WRF, TW is authorized to operate a tertiary treatment wastewater treatment plant (WWTP) consisting of an effluent booster station, a 10 million gallon per day (MGD) capacity tertiary filtration plant (TFP), chlorine contact chamber, reservoir and a reclaimed booster station. Tucson Water sends some of the output from Roger Road WRF that is not processed at the filter plant, to the Sweetwater Recharge Facilities for aquifer storage and eventual recovery. The water recovered from the Sweetwater extraction wells and water processed at the TFP is then chlorinated and distributed to the reclaimed system as Class A reclaimed water via the reclaimed booster station located at the TW Reclamation facility. Reclaimed water is monitored for water quality constituents as it leaves the reclaimed booster station and enters the reclaimed water distribution system. The reclaimed booster station pumps reclaimed water to multiple reuse sites permitted under the authority of a Type 3 Reclaimed Water Agent permit. Reclaimed water quality monitoring for inorganic and organic constituents is designed to assess compliance with "Class A" reclaimed water standards.

Figure 10

The third source of water supplied to the Reclaimed Water System comes from the Randolph Park WRF. This water meets or exceeds the Class A reclaimed water standards and is added with no additional treatment directly into the Tucson Water Reclaimed Water Distribution system. The Randolph Park WRF is owned and operated by the Pima County Regional Wastewater Reclamation Department.

Environmental Protection, Backflow Prevention, Public Outreach, Special Projects, and Research and Development

Environmental Protection

Tucson Airport Remediation Project (TARP)

TARP is an example of TW's involvement in, and response to, discovery of two emerging contaminants in groundwater, TCE and 1,4-Dioxane. Initially, the TCE was unregulated and now it has a drinking water standard. 1,4-Dioxane is currently on the CCL. From the 1950s-1970s industrial and defense-related activities resulted in the release of hazardous wastes into the groundwater leading to extensive contamination of the regional aquifer. The source of contamination for the TARP plume was Air Force Plant 44 (AFP-44) and the Airport Property Project Areas of Tucson International Airport Authority (TIAA).

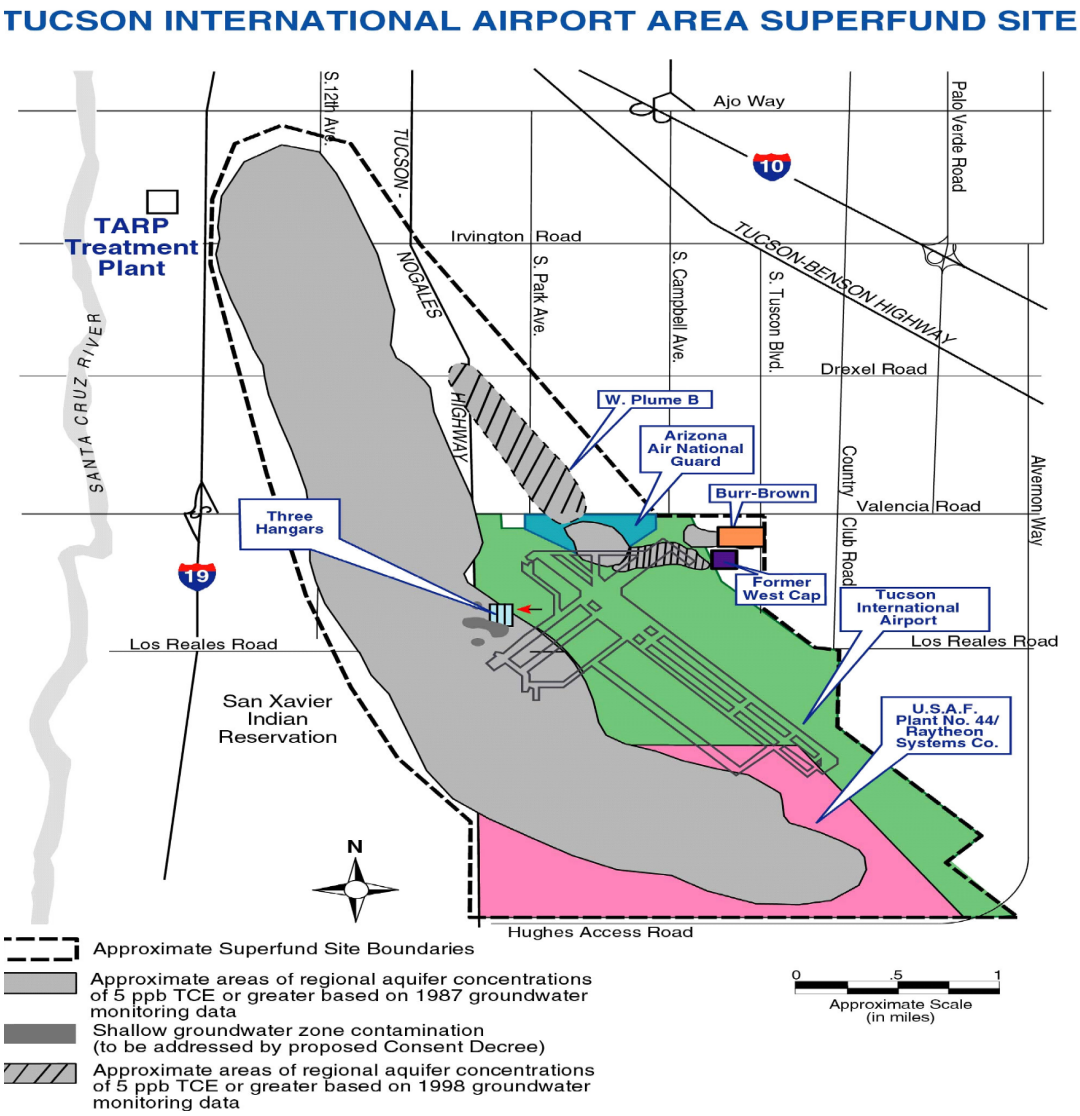


Figure 11

Beginning in 1981, with the discovery of VOC contamination of groundwater, the City began closing all TW wells that exceeded the State Action Level, and the EPA MCL of 5 µg/L for trichloroethylene (TCE). Since 1981, extensive testing for VOCs has provided a high level of assurance that TCE and other VOCs are well below the MCLs in all active production potable wells that serve TW customers.

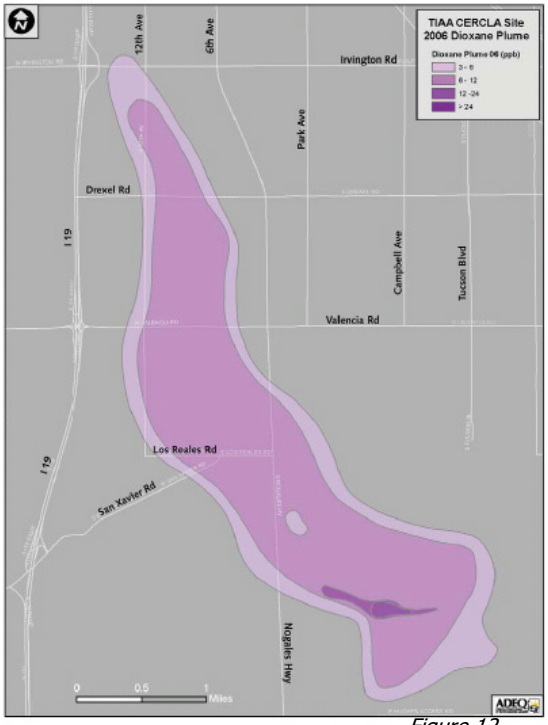
The Tucson Airport Remediation Project (TARP) extends north from Los Reales Road more than three and one-half miles to just beyond Irvington Road. The VOC Plume Area "A" is approximately three quarters of a mile wide. Most of the contamination at TARP is in the upper aquifer of the regional divided aquifer. However, as the main contaminant plume has migrated to the northwest, its leading edge has also spread into the regional undivided aquifer.

Chronology:

- TCE contamination discovered in groundwater and production wells shutdown
- 1983 USEPA begins Remedial Investigation/Feasibility Study (RI/FS) for groundwater contamination
- 1988 USEPA issues Record of Decision: Tucson Airport Area regional aquifer
- 1989 USEPA sets drinking water MCL for TCE
- 1990 Consent Decree for TARP effective
- 1994 TARP Treatment Plant begins operation in accordance with Consent Decree
- 2003 Optimization TARP Monitoring Plan in accordance with Consent Decree

1,4-Dioxane

1,4-dioxane was used as a stabilizer in 1,1,1-trichloroethane (TCA), which was used as an industrial solvent after the use of TCE ceased at AFP-44 in 1974. In 2002, 1,4-dioxane was detected in groundwater samples in the vicinity of TARP. This sampling occurred after the analytical technique for detecting 1,4-dioxane in water samples was modified, reducing the reporting limit from 100 micrograms per liter (ug/L) to 1 µg/L. Subsequent further monitoring indicated 1,4-dioxane was widely distributed in groundwater at the TARP Superfund site. The air stripping process used to remediate groundwater at TARP and at AFP-44 does not remove 1,4-dioxane due to its high solubility in water. Remediated groundwater re-injected into the aquifer at AFP-44 remained impacted by 1,4-dioxane, which migrated north into the TARP area following the natural groundwater gradient.



Map 3: 2006 Dioxane Plume

Figure 12

As mentioned, the TARP WTP does not have the capability to remove 1,4-dioxane from groundwater extracted from the TARP remediation well fields. Over the past six years, the concentration of 1,4-dioxane in extracted groundwater at the inlet point to the TARP WTP has ranged from 1 µg/L to 3 µg/L. **The current United States Environmental Protection Agency (EPA) drinking water Health Advisory Level and the one in one million (10-6) excess cancer risk level in the EPA Integrated Risk Information System (IRIS) database is 3 µg/L for 1,4-dioxane, although this contaminant is not currently regulated by the EPA.** It may be regulated in the future due to the high cancer risk at low concentrations. **Tucson Water currently manages 1,4-dioxane concentrations to no more than 3 µg/L at the point-of-entry to the potable system at the Santa Cruz Lane Reservoir.** 1,4-dioxane concentrations are managed by blending treated water from the TARP WTP with uncontaminated water from the Southside (SS) Production Well Field and from the pressurized distribution system (B-Zone). The current blending strategy for managing 1,4-dioxane in potable water at the Santa Cruz Lane Reservoir is based on the following priority listing of blending water sources:

1) B-Zone
2) Well SS-021A
3) Well SS-001A
4) Well SS-023B

Technical Solutions for 1,4-Dioxane Include the following:

1. **Blending.** Continue to utilize the existing blending strategies by way of existing available water sources to manage and mitigate 1,4-dioxane levels at or below 3 µg/L going into the drinking water system.

2. **Treatment.** Engineering evaluation, pilot-testing, design, construct, and operation and maintenance of Advanced Oxidation Plant, for removal of 1,4-dioxane levels down to 1.00 µg/L (or future Laboratory Method Minimum Detection Levels) going into the drinking water system.

3. **Enhanced Blending.** (i.e., additional water sources, pipelines, appurtenances, controls, etc.); based on potential 1,4-dioxane levels rising in TARP North Wellfield &/or the Heath Advisory being reduced (officially).

Backflow Prevention and Cross Connection Control – To Protect System Integrity

The Arizona Department of Environmental Quality requires public water systems to protect against contamination caused by backflow through unprotected cross-connections by requiring the installation and periodic testing of backflow-prevention assemblies (A.A.C. R18-4-115). The City of Tucson (Ordinance #9976, amended Ordinance #10563) details the requirement for the Tucson Water Department to develop, administer, and enforce a Backflow

Prevention Cross-Connection Control Program. The intent of this program is to minimize the risk posed to the public water system from real or potential backflow conditions or cross-connections with non-potable substances.

- *Background*

In order to maintain the sanitary condition of potable water within a water distribution system, public water systems in Arizona are required to develop and maintain a cross-connection control program in accordance with A.A.C. R18-4-115.

- *Regulatory Requirements*

The City of Tucson adopted its Backflow Prevention and Cross-Connection Control ordinance in May 1990, and revised in July 2008. **This ordinance requires a customer to install a backflow prevention assembly if the water customer has the potential of contaminating the TW potable distribution system through either a cross connection with a non-potable source or through the conditions of back-siphonage or back pressure of non-potable water, into the potable supply**. A customer with a backflow prevention assembly must have that assembly tested at least annually, per ADEQ regulations A.A.C. R18-4-115. The test must prove the assembly is in good working order. The majority of customers who require backflow prevention assemblies are commercial services, industrial-use services, multi-family units, and sites with reclaimed water connections.

The City of Tucson's Cross Connection Control Ordinance can be found at:
http://www.cityoftucson.org/water/backflow.htm

- *Program Overview*

TW's Backflow Prevention Section administers compliance on over 19,000 registered backflow prevention assemblies in the TW service area. Office staff maintains a database of records of the customers in the Backflow Prevention Program, notifies each customer 45 days in advance of the date when annual compliance testing is required, monitors compliance activities, and responds to questions from customers and registered backflow assembly testers. The office staff also assists the private tester community in electronic data entry of backflow tests into the TW iBak (Backflow) Management system.

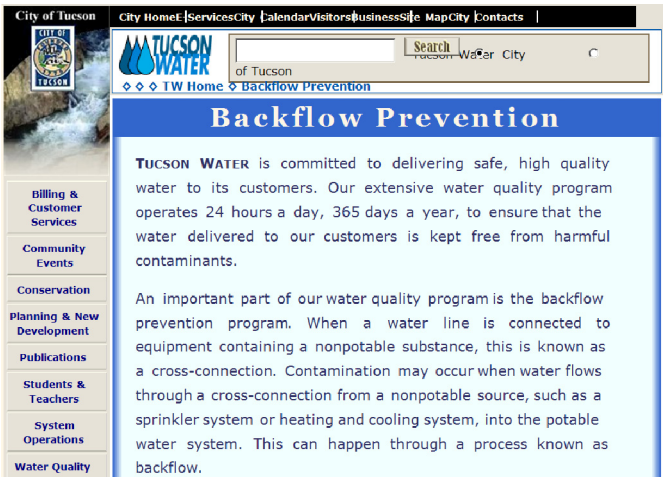


Figure 13

Public Outreach

- *Environmental Monitoring for Public Access and Community Tracking (EMPACT) Program*

In the late 1990s, TW began developing an outreach plan to provide timely water quality data and information to our customers with the inception of the "At the Tap Program" which was followed by the "Ambassadors Neighborhood Demonstration Program". Based on the success of both of these programs, the USEPA supported Environmental Monitoring for Public Access and Community Tracking (EMPACT) Program. It was created to provide near real-time water quality data on CAP water as it was being re-introduced to the community. Surveys of our customer base indicated that certain impurities and contaminants were of interest due to health and lifestyle of our base. These were bacteria, chlorine, pH, total dissolved solids, hardness, nitrate, sodium, fluoride, total trihalomethanes (TTHM) and temperature. TW transformed this successful targeted, pilot project into a standing outreach program that is now a major component of TW's multiple outreach programs. The program is currently in its ninth year and will continue to provide timely water quality data and information to the community on CAP water, groundwater, emerging contaminants and regulatory issues through a quarterly newsletter, focused brochure development, attendance at community events, and related website.

Special Projects

As a result of successfully implementing the EMPACT program, opportunities for participation in other water quality-oriented projects and water security projects have been forthcoming from both locally focused projects and projects at the national level. These groups include the University of Arizona, National Science Foundation, USEPA, Water Research Foundation, Sandia National Laboratories and the University of Cincinnati to name a few.

This program provides TW the flexibility to participate in a collaborative manner on focused water quality topics such as the presence of *Naegleria fowleri* in groundwater, microbial cloning of groundwater to characterize the microbial population that may be present in untreated groundwater, detecting the presence of enteric viruses in groundwater, and validating if customer concerns can be used reliably as an indictor of the occurrence of an contamination event in the potable distribution system to name a few.

Other projects include evaluating continuous online monitoring instrumentation to measure levels of specific contaminants in real-time as applied to address improved management of specific water quality issues within the potable system and creating robust security monitoring platforms to detect deliberate and accidental contamination events throughout the potable system.

This approach has provided invaluable information to TW concerning dynamic water quality changes that are the used to modify distribution system operation to ensure delivery of the highest water quality possible.

Research and Development

TW has a long history of research and development (R&D) in collaboration with academia, government and the private sector to address issues in water resources and potable and reclaimed water quality. R&D efforts are concentrated on local water quality issues and specific contaminants that can affect the quality of the delivered product. Active research and development partners include the National Science Foundation Water Quality Center, the CAMRA center and the Water Village located at the University of Arizona's Environmental Research Laboratory.

There are not any regulatory requirements associated with R&D studies, although the data and information resulting from these projects can be applied as supporting information to better understand future regulations such as the Groundwater Rule, and the Stage ll DBP Rule and emerging contaminants that may be added to the Contaminant Candidate List (CCL) such as *Naegleria fowleri* and 1,4 dioxane.

R&D efforts address current and future water quality issues in Central Arizona Project water, groundwater, recharged groundwater, and reclaimed water. TW also conducts R&D studies of the potable distribution and in the reclaimed water systems to address any finished water quality issues that may affect the timely delivery of high quality water to customers and the community. Ongoing research efforts in potable water concentrate on the effects of rising total dissolved solids concentration delivered in water due to increased use of CAP water. In addition, TW is studying if the use of CAP water over the last nine years has increased the TTHM, TOC and HAA levels in the blended groundwater and the potable water. TW has applied for a grant to study the health risks of pharmaceuticals, endocrine disruptors, personnel care products and 1,4-Dioxane in our community. TW also participates in a study that will be testing alternative home treatment methods to soften hard water.

For reclaimed water, TW is conducting two studies in parallel with the UA and PCRWRD as part of the Joint City and County study addressing the future water needs of the community. The studies focus on two topics: 1) improving the quality of finished reclaimed water in the distribution system, and 2) decentralizing some aspects of the reclaimed and wastewater systems to increase efficiency, improve water quality and reduce transmission costs. As water quality issues and emerging contaminants are identified, TW will be at the forefront learning how to keep improving the quality of potable and reclaimed water.

Current Challenges

Uranium

Uranium is a metal that may cause renal toxicity and is regulated in the 2000 Radiochemical Rule. Before uranium was regulated, TW monitored for uranium once every three years. The main sources of uranium in Tucson are naturally occurring uranium minerals in rocks and sediments that comprise the aquifer. Uranium occurrence is sporadic and it is typically found only at low concentrations. The data in the table below show that the average concentrations in the system before the introduction of the CAP recharged water and from EPDS 159 (EP1) that represents the CAP recharged water are close to the regulatory detection level of 1 ug/L.

Source	Collection Date	Sampling Point	Count	Average ug/L	Range ug/L
System-wide	2001,2002, 2007[1,2]	EPDS	220[3]	3.95	< 1 – 28.3
EP1	2004-2009	EPDS	17	3.96	1.6 – 6

Figure 14

[1]85% of the data were collected in 2001
[2]Uranium testing not required between2004-2009.
[3]Count exceeds number of EPDSs because some EPDSs were tested multiple times.

ADEQ has assigned TW to monitor for uranium and the 3 other radionuclides in 2010 at all EPDSs. At that time, the data will be evaluated to ensure compliance with the uranium regulatory maximum allowable level of 30 ug/L and with the other radionuclide MCLs (5 picocouries/liter or pCi/L for combined radium-226 and radium-228, and 15 pCi/L for adjusted gross alpha exposure). The data will also be used to determine subsequent monitoring frequencies.

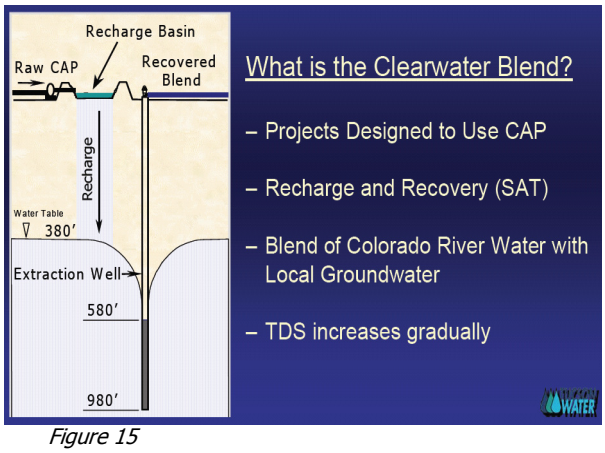


Figure 15

Salinity

- ***Decision H2O***

One of the largest outreach campaigns ever conducted by Tucson Water centered on issues associated with Decision #1 of *Water Plan: 2000-2050*. This campaign was titled *Decision H2O* and was focused on determining the long-term mineral content of the Utility's Colorado River water supply delivered through the Clearwater Program.

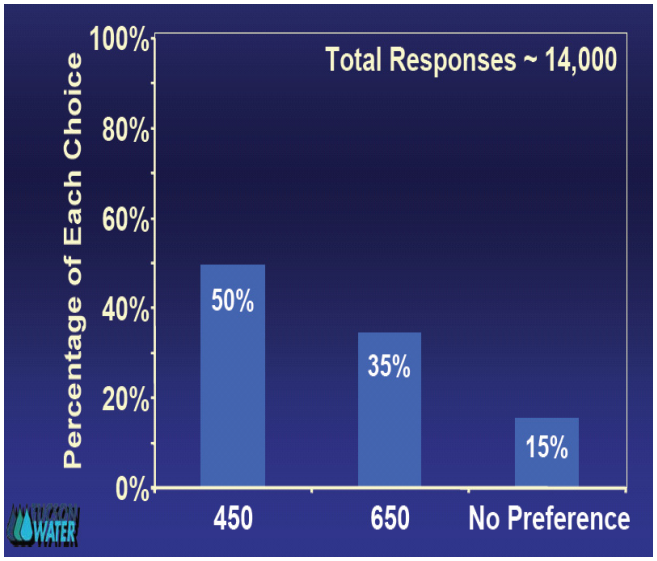


Figure 16

As additional Colorado River water has been added to the Clearwater Project, the mineral content of the blended supply has increased over time and will eventually reach approximately 650 parts per million (ppm), which is the average mineral content of the Colorado River water.

During the Utility's initial public involvement campaign which was conducted to determine acceptable mineral content of the Clearwater blend, Tucson Water customers selected 450 ppm as the preferred blend.

The data collection process that was conducted was to determine whether customers would accept the slow rise in mineral content, or would prefer to pay for a new treatment facility to maintain the minerals at 450 ppm. To support a mineral content decision,

comprehensive technical and cost information was developed and shared with Tucson Water's customers through the Decision H2O outreach program.

The outreach effort was centered on determining consumer preferences between two potential future mineral levels of the Clearwater blend and customer's willingness to pay in order to meet discretionary water quality targets. Three investigations were undertaken including a Flavor Profile Analysis (taste tests conducted by a trained panel), structured consumer panels, and an extensive kiosk outreach program.

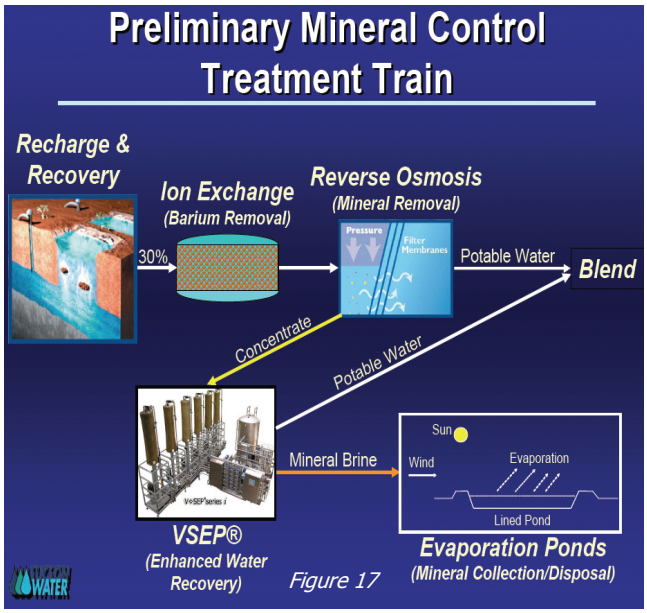


Figure 17

The most visible part of the outreach program involved direct interaction with Tucson Water customers at information kiosks from October 2006 through January 2007. Tucson Water operated demonstration kiosks at two retail malls and two traveling kiosks that visited locations and events throughout the community. Participants had the opportunity to taste each mineral blend (blind test) and express their taste preference. The participants were then provided additional information about water resources, environmental impacts, health considerations, treatment costs, and potential household impacts of changing mineral levels.

After the customers received the additional information and staff responded to their questions, they were asked to provide their overall preference. Over a period of four months, more than 13,000 Tucson Water customers participated in kiosk activities. Throughout the course of the program, weekly results were posted on a *Decision H2O* a website established specifically for the program.

Throughout 2007 and into early 2008, the Utility continued to conduct a number of studies to develop recommendations to bring forward to Tucson's Mayor and Council. These efforts include decision-matrix analyses on the customer surveys and further investigations of the potential treatment technologies and costs to ensure that the information provided to Mayor and Council is as current and accurate as possible.

Tucson Water is also in process of conducting a comprehensive sustainability analysis to determine the environmental, financial and social impacts of the two alternative water qualities and provide a broader context within which to make the mineral decision. Factors such as carbon generation, salt loading, land usage, water efficiency, affordability and social equity are currently being assessed to compare the various options.

Radon

Radon is a naturally occurring radioactive gas that may cause cancer and may be present in indoor air and tap water. While ingesting radon in tap water does involve risk, inhaling radon is a primary health concern, particularly for smokers or ex-smokers. Radon seeping up into homes and buildings from the soil is the main source of radon in indoor air. Only about 1-2 percent of radon in indoor air comes from tap water.

Although there is no federal regulation for radon in indoor air, the United States Environmental Protection Agency (US EPA) recommends testing homes for indoor radon levels and taking action to reduce levels at or above 4 picoCuries per Liter (pCi/L). Because most radon risk is from indoor air, EPA has proposed a drinking water regulation, expected to be final in 2011, that provides for combined programs to limit radon in tap water while focusing on the major problem - reducing radon levels in the air inside buildings. More information from EPA about radon testing and control is available from the US EPA Radon Hotline (800 767-7236) or online at http://www.epa.gov/radon/rnwater.html.

In anticipation of eventual regulation of radon in drinking water, when US EPA proposed the regulatory program in 1999 that is discussed above, Tucson Water monitored for radon at over 500 locations. Testing indicated that Tucson has fairly typical concentrations for radon in the water supply, compared with other communities across the country.

Perchlorate

Perchlorate refers to a group of salts based on the anion ClO_4^-. Common forms include both potassium perchlorate ($KClO_4$) and ammonium perchlorate (NH_4ClO_4). Perchlorate has been used as a medicine for more than 50 years to treat thyroid gland disorders and has been widely used as an oxidizer in rocket fuel, explosives, automotive airbags, and fireworks. Low levels of perchlorate have been detected in both drinking water and groundwater in 35 states in the US according to the Environmental Protection Agency. In some places, perchlorate is detected because of contamination from industrial sites that use or manufacture it. In other places, there is no clear source of perchlorate – it may be naturally occurring, or could be present because of the use of Chilean fertilizers, which were imported to the U.S. for agricultural use in the early 19th century. Perchlorate can adversely affect human health by interfering with iodide uptake into the thyroid gland. In adults, the thyroid gland helps regulate the metabolism by releasing hormones, while in children, the thyroid helps in proper development.

On October 10, 2008, the EPA issued a preliminary determination for perchlorate in the *Federal Register* for public review and comment. The notice described EPA's preliminary decision that there is not a "meaningful opportunity for health risk reduction" through a national drinking water regulation. Based on the comments that it received, EPA believes that it would benefit once again from National Research Council (NRC) of the National Academies input regarding perchlorate, this time in the context of a physiologically based pharmacokinetic (PBPK) modeling effort and assumptions regarding sensitive populations, to development of the interim Health Advisory (HA) level. Thus in 2009, EPA will engage the NRC to provide additional advice. In addition, perchlorate is on the draft CCL3 list, due to be finalized in October of 2009.

The EPA has not set a maximum contaminant level for perchlorate in drinking water. In December 2008, EPA established an interim health advisory level of 15 ug/L for subchronic exposure. A subchronic HA covers a period of more than 30 days, but less than a year, and considers the following exposure assumption: a 70 kg adult consuming 2 Liters of water per day. Contributions from other sources (air, food, soil, etc) are also taken into account to calculate the subchronic HA. HAs establish non-regulatory concentrations of drinking water contaminants at which adverse health effects are not anticipated to occur over specific exposure durations (one day, ten days, a subchronic period, several years, and a lifetime). HAs serve as informal technical guidance to assist Federal, State and local officials, and managers of public or community water systems in protecting public health when emergency spills or contamination situations occur. They are not legally enforceable Federal standards and are subject to change as new information becomes available.

The SDWA allows States to establish drinking water standards that are more stringent than EPA's national standards. ADEQ has established a protective health-based guidance level for drinking water of 14 ppb. Based on data currently available to ADHS, drinking water at or below this concentration is believed to be safe for consumption.

- *National Occurrence of Perchlorate*

Perchlorate was sampled in drinking water supplies as part of the Unregulated Contaminant Monitoring Regulation (UCMR) 1, List 1 Assessment Monitoring program. According to EPA, occurrence data for perchlorate were collected from 3,865 public water supplies between 2001 and 2005. Approximately 160 (4.1%) of these systems had at least 1 analytical detection of perchlorate (in at least 1 entry/sampling point) at levels greater than or equal to 4 µg/L. These 160 systems are located in 26 states and 2 territories. Approximately 1.9% (or 637) of the 34,331 samples collected by all 3,865 public water supplies had positive detections of perchlorate at levels greater than or equal to 4 µg/L. The average concentration of perchlorate for those positive samples was 9.85 µg/L, and the median concentration was 6.40 µg/L.

- *Perchlorate in the Southwest*

ADEQ's website (http://www.azdeq.gov/function/about/perchfaq.html), describes the perchlorate problem arising from two facilities near Henderson, Nevada - Pacific Engineering & Production Company of Nevada and Kerr-McGee Chemical Corporation. Since World War II, considerable amounts of perchlorate were discharged in the liquid wastes from the facilities into unlined evaporation ponds. The groundwater contaminated with soluble ammonium perchlorate has been seeping into Las Vegas Wash, which drains into Lake Mead and ultimately into the Colorado River. Remediation actions undertaken at the Nevada site have significantly reduced the levels of perchlorate in Colorado River water. Latest results from just downstream of Hoover Dam are now in the 4-6 ppb range. Both Arizona and California withdraw Colorado River water from Lake Havasu and deliver it via the CAP canal for use in

agriculture, municipal and industrial uses, as well as for storage for future use in underground storage facilities permitted by the Arizona Department of Water Resources.

- *Local Perchlorate Monitoring Results*

TW found extremely low levels of perchlorate in the Colorado River water that is recharged at the Clearwater facility. Concentrations ranged from about 4 to 7 parts per billion (one part per billion is equivalent to one grain of salt in an Olympic-size swimming pool). The levels found are just above the limits of technology to accurately measure this compound. TW continues to test the Colorado River water for perchlorate semi-annually. Perchlorate has not been detected since 2004.

Because TW is recharging Colorado River water and delivering the resulting blend of recharged water and groundwater to customers, TW is carefully monitoring perchlorate levels in the recovered blend, as well. **Extensive quarterly testing by TW has not found any perchlorate in the blended water recovered at the Clearwater Facility in Avra Valley or in any of the water served to customers (2001 data).**

Pima County Regional Wastewater Reclamation Department

Overview

Pima County Regional Wastewater Reclamation Department owns and operates the regional wastewater conveyance and treatment systems within a 700± square mile sanitary sewerage system service area in eastern Pima County. RWRD's conveyance system includes 3,400 miles of public sanitary sewers, 73,000 manholes and cleanouts, 15 siphons, 4 flow management structures and 31 lift stations. These sewers are located in the cities of Tucson and South Tucson; the towns of Marana, Oro Valley, and Sahuarita; and unincorporated communities such as Summerhaven (Mt. Lemmon), Arivaca Junction, Avra Valley, Green Valley, Corona de Tucson and Catalina. Approximately 400 miles are considered truck or interceptor sewers of 18 inches internal pipe diameter and larger.

- *Geography and Topography of Eastern Pima County*

Located primarily in Eastern Pima County, the service area for RWRD is surrounded by mountains on most sides including the Santa Catalina, Rincon, Santa Rita and Tortolita ranges. The generally gentle slope of the basin floor tends to increase rapidly as it nears the various mountain ranges, Surface runoff generally flows northward and westward through the basin. Elevations in this basin range from 3,720 feet in the southeast to 2,030 feet in the northwest. The Santa Cruz River is the major surface drainage channel and flows northward through Pima County to Pinal County. The two major wastewater treatment plants, Roger Road WRF and Ina Road WRF, are located adjacent to the Santa Cruz River in low-lying areas on the western edge of the basin to take advantage of the gravity flow provided by the shape and slope of the basin.

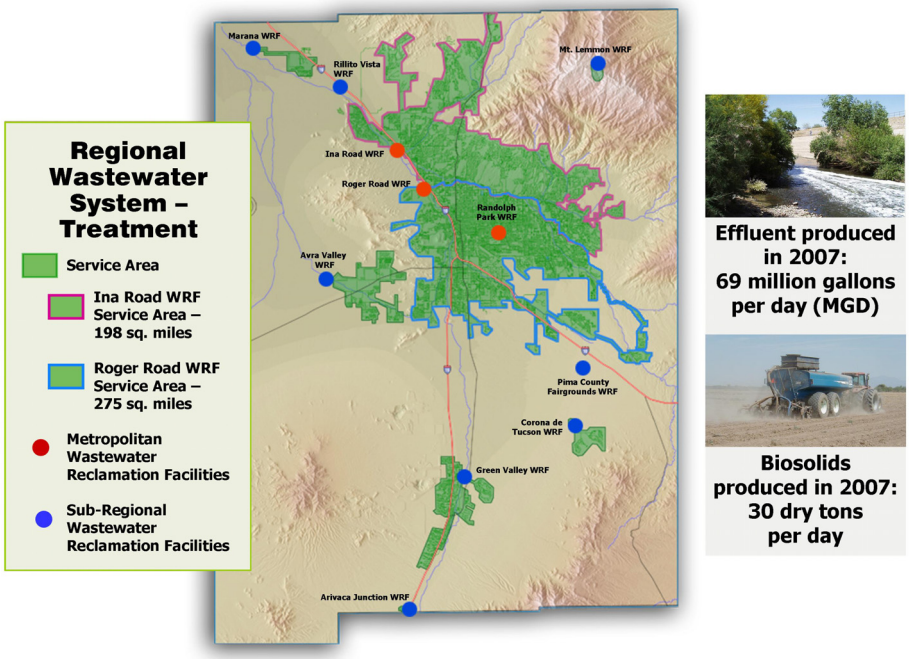


Figure 18

- *Reclamation Facilities and Processes*

252 employees operate and maintain the treatment facilities of the regional wastewater system. The treatment system comprises metropolitan and sub-regional wastewater reclamation facilities. The metropolitan systems account for most of the area, with the Ina Road WRF service area encompassing approximately 198 square miles and the Roger Road WRF service area covering approximately 275 square miles.

In 2007, RWRD treated over 69 million gallons each day (MGD) at the metropolitan facilities (Ina Road, Roger Road and Randolph Park WRFs) and the sub-regional facilities (Avra Valley, Arivaca, Corona de Tucson, Fairgrounds, Green Valley, Marana, Mt. Lemmon, and Rillito Vista WRFs).

Historical and Regulatory Perspective

The Roger Road WRF was the first modern wastewater treatment facility in Pima County and began operation in 1955. Primary and biological treatment coupled with disinfection became the norm and the results were instantly obvious.

Additional regulatory oversight has further standardized and raised the level of treatment beginning with the introduction of the Clean Water Act in 1972. The 1970's focused on creating the infrastructure necessary to support the National Pollutant Discharge Elimination System (NPDES) permit program and development of technology-based effluent limitations for parameters such as BOD, TSS, fecal coliform bacteria and pH. Pima County responded to new regulations with the construction of the Ina Road WRF in 1978. This facility was constructed with an emphasis on secondary treatment and disinfection to meet technology-based standards. One year later, in 1979, Pima County assumed responsibility for the operation of all the region's public wastewater collection and treatment facilities.

Figure 19

Throughout the 1980's, public health concerns shifted from waterborne illnesses and disease causing microorganisms to anthropogenic water pollution contaminants such as pesticide residues, industrial sludge and organic chemicals. Pima County responded to these concerns by creating a pre-treatment program through the Industrial Wastewater Control (IWC) section and through adopting the first pre-treatment ordinance for controlling these compounds in 1981.

Figure 20

The IWC mandate was to protect the Publicly Owned Treatment Works (POTWs) from interferences to POTW operations, pass-through of pollutants, municipal sludge contamination and exposure of workers and the public to chemical hazards. This program has been highly effective at managing water quality by monitoring releases from both industrial and commercial sources in the collection system. IWC also monitors grease discharges from numerous food service facilities because grease blockages in the sewers cause sewer overflows and represent the primary risk for human exposure to untreated sewage. As a result, IWC has developed an extensive inspection and public outreach program for controlling fats, oils and grease discharges from food service industries to ensure the safe and effective conveyance of sewage and protection of public health.

During the 1980's, EPA also emphasized improved biosolids treatment and disposal for wastewater facilities. Pima County responded by creating a Regional Biosolids Management Facility (RBMF) in 1987. The RBMF was

constructed to standardize biosolids quality for use as a source of agricultural fertilizer. Biosolids serve as a beneficial soil amendment and can improve soil quality by providing essential plant nutrients such as nitrogen, phosphorus, sulfur and potassium. Unlike fertilizers which are susceptible to leaching of nutrients, the inherent organic composition of biosolids releases nutrients more slowly making these constituents available for plant growth for a longer period of time. In our arid environment, biosolids can increase soil organic matter and greatly enhance the water holding capacity of soils thereby reducing soil erosion and providing enhanced dust control.

The 1990's began a new era in which State Regulations developed by the Arizona Department of Environmental Quality (ADEQ) added requirements for removal of nutrients, mainly ammonia and nitrates, from wastewater discharges. Aquifer protection permits (APP) and reuse permits incorporated these concerns. APPs were written to protect groundwater sources by regulating discharges at the source and are required at each of the County's eleven reclamation facilities, unlike surface water permits which are only required for discharges to listed navigable waters. Another regulatory requirement of the APP program required all new treatment facilities to meet Best Available Demonstrated Control Technologies (BADCT) for which nutrient removal in the form of nitrification and denitrification are required. An additional BADCT parameter was disinfection for which more stringent water quality standards were implemented. Throughout the 1990's, RWRD expanded the capacity of the Avra Valley WRF, Mt. Lemmon WRF and the Marana WRF with each constructed to meet BADCT regulatory criteria for nutrient removal and disinfection.

Figure 21

The new millennium continued with improvements in treatment performance through the introduction of new treatment technologies. RWRD responded with the construction of nutrient removal facilities at the Green Valley WRF, Avra Valley WRF and an expansion at the Ina Road WRF. In addition, the Randolph Park WRF was constructed utilizing state-of-the-art membrane filtration. In 2004 ADEQ assumed primacy and oversight of the NPDES program and began issuing AZPDES permits for discharges to surface waters. The newly issued AZPDES permits required whole effluent toxicity testing on three species including vertebrate, invertebrate and algal organisms; dechlorination to non-detectable levels; and stricter water quality standards with increased monitoring to support the introduction of "reasonable potential" surveillance monitoring. Public health concerns again expanded to address the minimization of carcinogens including disinfection by-products such as trihalomethanes (THMs). RWRD responded by actively participating in multiple disinfection by-product research studies. RWRD also adopted state-of-the-art UV disinfection systems at Randolph Park WRF, Marana WRF and the Avra Valley WRF.

Since 1993, all expansion and modifications to RWRD facilities have been constructed to meet BADCT standards. The Ina Road WRF and Roger Road WRF facilities are now 30 and 54 years of age, respectively, and were designed at a time when secondary treatment and disinfection were standard technologies. As a result, the existing Ina Road WRF and Roger WRF AZPDES permits contain variances for ammonia toxicity to *Pimephales promelas* (flathead minnow) and *Ceriodaphnia dubia* (water flea) and for copper in the current permit terms since the effluent does not consistently meet the toxicity and the copper standards. These AZPDES permits contain compliance schedules with deadlines for upgrade of these facilities to meet current BADCT standards.

RWRD is responding to this need for improved treatment through the creation of the Regional Optimization Master Plan (ROMP). Two of the major components of ROMP will be the rehabilitation of the Ina Road WRF and the decommissioning of the Roger Road WRF with construction of a state-of-the-art replacement facility at the Roger Road location. RWRD is currently on schedule to address compliance with ammonia toxicity at the Ina Road WRF by January 2014 and at the Roger Road WRF by January 2015 as well as compliance with copper standards at the Ina Road WRF by December 2010.

Treatment Processes.

A typical treatment process includes a number of steps, such as screening, primary clarification, bacterial processing, biological processing, secondary clarification and disinfection. These phases or components of treatment system processes can be physical, biological or chemical.

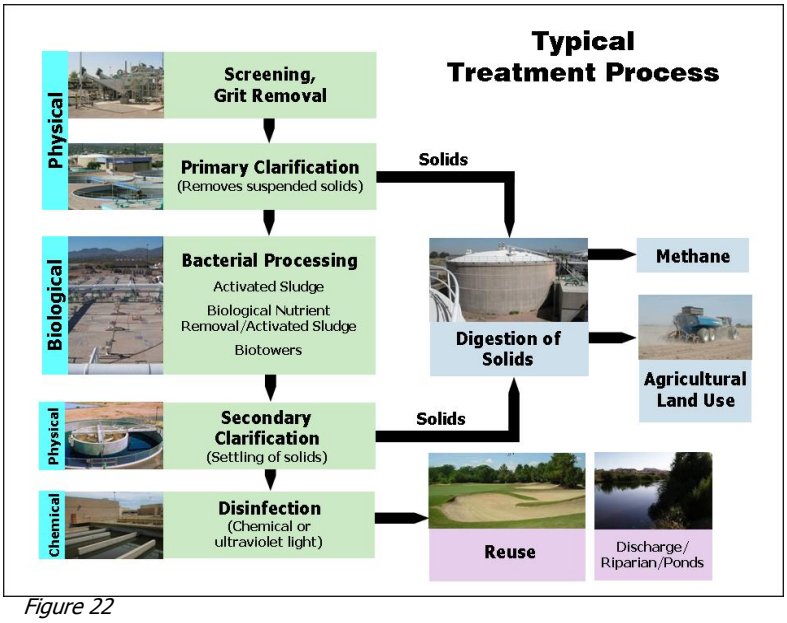


Figure 22

These processes are employed at various different components of a WRF or reclamation facility, such as the headworks with screening and grit removal, clarifiers, membrane bio-reactor, and chlorine contact chambers, among others.

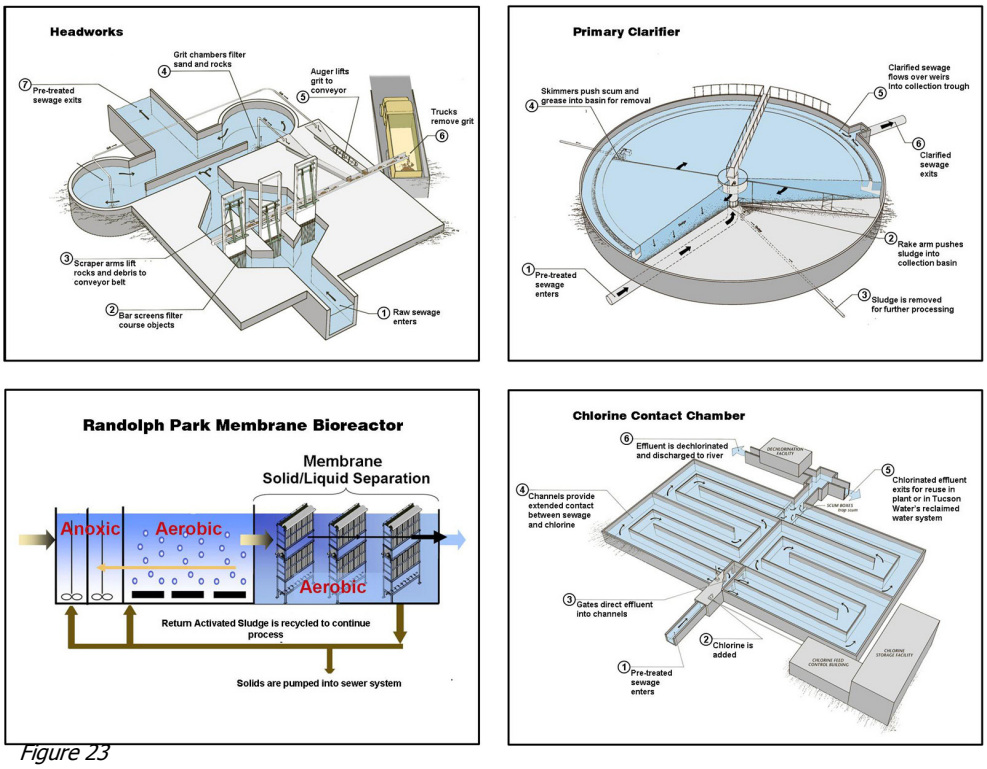


Figure 23

Effluent Distribution –Every attempt is made to utilize effluent in a beneficial and environmentally sustainable manner where available. RWRD currently meets these goals by distributing effluent for use in the Tucson Water Reclaimed Water System, aquifer recharge, construction related dust control and onsite turf irrigation reuse. Remaining effluent is discharged into the Santa Cruz River allowing for the capture of recharge credits through he Lower Santa Cruz Managed Recharge Project.

Biosolids Processing – Historically, biosolids have been land applied or landfilled. These practices have been dramatically altered with the advent of technology and the adoption of heightened regulations, requiring increased capital investments to upgrade facilities.

Technology has improved the processing of biosolids through higher levels of de-watering. The de-watering process has been evolving over a number of years. It reduces the amount of material to be hauled and improves treatment options. This approach has allowed re-use to replace disposal to a large extent. The recent innovation of high-solids centrifuges has enhanced technology to achieve much higher extents of de-watering.

Regulations such as the United States Environmental Policy Act (USEPA 503) have required changes in the way biosolids are processed and disposed/re-used. Other factors include the potential cost and environmental advantages of beneficial re-use and the increasingly stringent landfill restrictions.

Pima County facilities generated 10,300 tons of biosolids in 2007, which can be equated to 5,850 truck-loads. The biosolids are applied to non-food crops such as cotton.

Overview of Wastewater Compliance Program

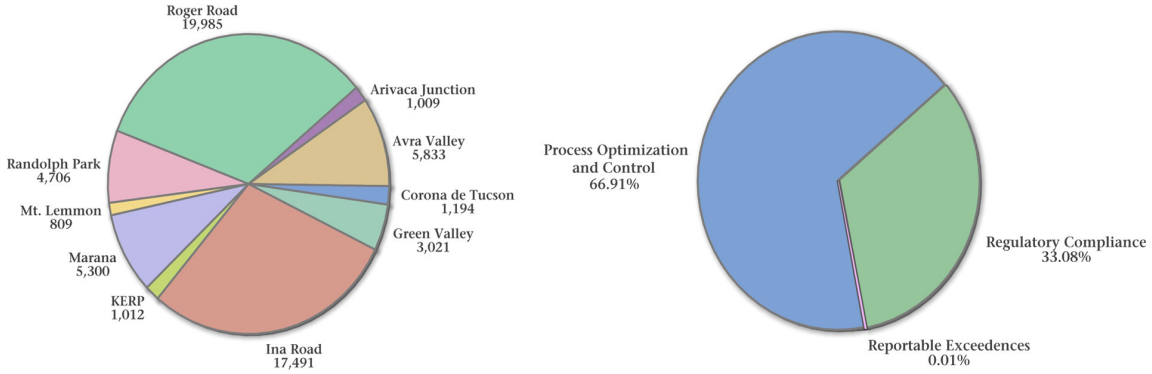
RWRD's Compliance and Regulatory Affairs Office (CRAO) oversees the water quality and regulatory issues associated with RWRD operations and supports meeting RWRD's primary mission to protect public health and the environment. An extensive water quality program is administered through the various CRAO sections that include the IWC pretreatment surveillance group, a state and federally certified environmental laboratory and permitting and water quality compliance sections. These groups work in concert to perform surveillance sampling of treatment facilities, analytical testing and documentation and reporting of water quality.

- *Monitoring, Sampling and Analysis*

Each of RWRD's treatment facilities operate under a variety of water quality permits including AZPDES, APP and reuse permits. Each of these permits contains specific lists of contaminants that must be monitored and their prescribed monitoring frequencies. As a result, it is common for many of the facilities to be subject to over 3,000 individual analyses per year to document and ensure water quality objectives are met.

The following charts show the distribution by analysis by facility in 2008 and the results of 2008 water quality testing. RWRD performed more than 67,000 tests in 2008. It can be seen that the majority of the tests were performed at the Ina Road and Roger Road WRFs.

RWRD - 2008 Water Quality Tests



Analyses Performed per Facility (67,000 total)

Water Quality Results

Figure 24

Approximately one-third of those analyses were directly related to meeting specific permit requirements. Approximately two-thirds of the tests followed a regimen that was more stringent than required and enabled optimal process control of WRFs. **In 2008 less than 0.01% of the tests identified an exceedence that triggered reporting and follow-up action.**

Reporting Requirements

- *Routine Reporting*

In 2008, Pima County Regional Wastewater Reclamation Department collected nearly 5000 samples for analysis of compliance with permit requirements. There were over 22,000 individual analyses conducted for regulatory reporting purposes and over 67,000 analyses performed in total. This figure indicates that approximately 33% of all analyses performed are required for regulatory purposes, but an additional 45,000 analyses, or 67%, were performed for quality assurance purposes and process control and optimization of treatment performance.

RWRD is required to submit discharge monitoring reports of wastewater and groundwater compliance testing to ADEQ on both a monthly and quarterly basis. Each regulatory permit mandates strict monitoring frequencies and specifies reporting deadlines that must be adhered to. In addition, each report must be signed by the department's authorized representative and bears the following statement:

> **"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations. Penalties under these statutes may include fines up to $27,500 and imprisonment from six months up to 5 years."**

The regulations require permittees to verbally notify ADEQ by 9:00 a.m. the following day when there is a failure to comply with the requirements of a permit. Failing to monitor or monitoring at an incorrect frequency, failing to submit results within regulatory deadlines, and contaminant exceedences are all examples of non-compliance situations. PCRWRD failure rate in these incidences is extremely low, despite the large number of facilities and permit-associated requirements.

If a permit exceedence or violation should occur, RWRD follows an established Regulatory Compliance Response which includes notification to the appropriate permitting authority, notification of treatment personnel, increased sampling frequency and a comprehensive investigation and audit. After sufficient corrections are made to bring the facility back into compliance, a final report is submitted to the permitting agency and post-incident staff training is conducted.

Associated Costs of Compliance.

Regulatory driven permit requirements are necessary for ensuring water quality and the protection of public health. The regulatory impacts can have a substantial financial impact on wastewater reclamation utilities. **RWRD associated costs for regulatory compliance for fiscal year 2008/2009 was $5,255,000.** This figure includes $1,470,000 costs for permitting, auditing, regulatory reporting and permit associated fees; $1,570,000 for administering the pretreatment program; and $2,215,000 for the laboratory analyses of over 67,000 contaminants.

Awards and Recognition.

Each year, the National Association of Clean Water Agencies recognizes the nation's top wastewater treatment facilities. Gold Awards are issued to honor treatment works that have achieved 100 percent compliance, with their NPDES/AZPDES permit for an entire calendar year while Silver Awards recognize facilities that have received no more than five NPDES/AZPDES permit exceedences per calendar year. Compliance is defined as any exceedence of a water quality numerical limitation as established in the permit. RWRD's performance history is demonstrated below.

Platinum	Gold	Silver
Facilities that have received Gold Awards for five or more consecutive years ➢ **Avra Valley WRF** (2008) ➢ **Green Valley WRF** (2008)	**Facilities that consistently meet all National Pollutant Discharge Elimination System (NPDES) permit limits during a calendar year** ➢ **Randolph Park WRF** (2006, 2007, 2008) ➢ **Roger Road WRF** (1989, 2005, 2007) ➢ **Avra Valley WRF** (2004, 2005, 2006, 2007) ➢ **Green Valley WRF** (2004, 2005, 2006, 2007) ➢ **Marana WRF** (2004, 2006, 2008) ➢ **Mt. Lemmon WRF** (2008)	**Facilities that have had five or fewer National Pollutant Discharge Elimination System (NPDES) permit violations during a calendar year** ➢ **Roger Road WRF** (1987, 1990, 1991, 1992, 1995, 1998, 2000, 2001, 2004, 2006, 2008) ➢ **Ina Road WRF** (1990, 1991, 1994, 1999, 2001, 2003, 2004, 2005, 2007, 2008) ➢ **Marana WRF** (2005, 2007)

Figure 25

To demonstrate the significance of these achievements, each of RWRD's facilities performs over 3,000 water quality analyses per year with fewer than five exceedences. In 2008, the Avra Valley WRF and Green Valley WRF received platinum awards for the first time. A platinum award is used to honor treatment facilities that have achieved five consecutive years of 100% compliance for all water quality monitoring parameters. In addition, the Roger Road WRF received Arizona Water Pollution Control Association Peak Performance Awards in 2002 and 2007 for wastewater facilities serving large populations. During that same period, the Ina Road WRF has received five Silver Awards.

Special Projects

Pollutant Elimination and Prevention

Wastewater treatment is critical to protecting both the public health and quality of the environment. Modern wastewater facilities do an excellent job of treatment and are capable of producing very high quality effluent suitable for a variety of uses. However, no single treatment technology is capable of removing every contaminant; continued analytical advancements and continued introduction of newer manufactured compounds are sure to increase the number of emerging contaminants. As a result, RWRD has a comprehensive source control program structured towards preventing contaminants from entering the sewerage system, thereby controlling treatment costs and improving overall water quality.

- ***Industrial Waste Control***

The Industrial Waste Control (IWC) Program is a federally mandated pretreatment program designed to protect Publicly Owned Treatment Works (POTWs) from interferences to POTW operations, pass-through of pollutants and municipal sludge contamination. It also minimizes exposure of workers and the public to chemical hazards. IWC has developed an extensive program for ensuring the safe and effective conveyance of wastewater and protection of public health.

Figure 26

The IWC program has been highly effective at managing water quality by monitoring both industrial and commercial discharges to the sewerage system and by controlling fats, oils and grease discharged from food service industries. Grease discharge from food service facilities is a major cause of sewer blockages and sewer overflows and thus pose

a significant risk for human exposure to untreated sewage. The fats, oils and grease (FOG) program has created educational videos for distribution to food service industries describing appropriate best management practices (BMPs) for maintaining grease traps and grease interceptors and promoting healthy sewers.

In total, IWC managed over 600 industrial wastewater permits and conducts over 112 surveillance audits on both categorical and significant industrial users and 434 general inspections in 2008. A total of 25 notices of violation were issued as a result. Businesses receiving violations and all newly permitted businesses are required to attend a one-day Pollution Prevention School which educates users on sewer regulations, the use of proper Best Management Practices and proper use of the sewer system. Since its inception in 1993, pollution prevention school has been given to over 1060 attendees.

Because biosolids are often considered to be an end product of treatment, there are often overlooked from the pretreatment perspective. Heavy metals, which are not removed through the treatment processes, can often partition and become concentrated in solid fraction known as biosolids. IWC conducts routine metals surveillance and biosolids performance monitoring to ensure that all RWRD generated biosolids meet Clean Water Act Section 503 regulations for Class B or Class A biosolids.

- ***Regional Biosolids Management Facility***

The RBMF was constructed to standardize biosolids quality for use as a source of agricultural fertilizer. Biosolids serve as a beneficial soil amendment and can improve soil quality by providing essential plant nutrients such as nitrogen, phosphorus, sulfur and potassium. Unlike fertilizers which are susceptible to leaching of nutrients, the inherent organic composition of biosolids releases nutrients more slowly making these constituents available for plant growth for a longer period of time and reduce leaching of nitrogen to the aquifer. In our arid environment, biosolids can greatly enhance the water holding capacity of soils thereby reducing soil erosion and providing enhanced dust control.

- ***Household Hazardous Waste Program***

The Household Hazardous Waste (HHW) program is a joint project between the City of Tucson and Pima County designed to collect household hazardous wastes from residents and small businesses which would otherwise be destined for landfill or sewer disposal. RWRD currently funds the County's 50 percent share of this program at a cost of $282,000 for FY 2008. Since the Program's inception, over 14 million pounds of household hazardous waste have been collected and diverted from wastewater treatment plants and landfills in Tucson and Pima County. Recent changes to the Multi-Sector General Stormwater permit stress the importance of this program as an effective mechanism for diversion of unwanted materials form entering our Nation's sewers, roadways and waterways.

The Program also conducts education and outreach activities. The Program recognizes that education must focus not only on raising the public's awareness of the collection program, but also on pollution prevention methods to reduce the generation of household hazardous waste.

- ***Pharmaceutical Disposal Program***

Pharmaceuticals are an emerging environmental contaminant and have been detected in surface waters around the United States and in the drinking water of 24 major metropolitan areas. While a substantial portion of pharmaceuticals and their metabolites may enter the environment by passing through human bodies, disposing of waste medicines by flushing into wastewater or disposal in the solid waste stream also contributes to contamination. Unwanted medicines disposed to sanitary sewer systems are not completely treated by the wastewater treatment facilities, which may allow pharmaceuticals to be released into the environment through effluent and biosolids. Unwanted medicines disposed to solid waste systems may also end up in landfill leachate, eventually allowing pharmaceuticals to be released into the environment.

While advanced wastewater treatment technologies to enhance removal of organic wastewater contaminants may be utilized in the future, they are not yet refined for complete removal of these compounds and are often too expensive for most municipalities to consider. Eliminating the disposal of waste medicines into the sewerage system or the solid waste stream is a simple and critical source reduction approach to mitigating the impact of pharmaceuticals in the environment.

A potentially greater community risk is the presence and storage of unwanted pharmaceuticals in home residences. Storage of unwanted medicines in the home can result in accidental poisonings and increase opportunities for drug abuse, theft, burglary and unsafe diversion of prescription drugs. The abuse of prescription pain killers ranks second, only behind marijuana, as the Nation's most prevalent illegal drug problem.

In response to these public concerns, RWRD has initiated steps toward a preventive program. In the last year, the agency prepared two white papers addressing the public safety impacts of leftover medicines in resident's homes, sponsored a survey by PAG of disposal practices and receptivity to take-back approaches at local long-term-care facilities, and has formed a local stakeholder group comprised of representative businesses, jurisdictional governments and utilities from within our community. Meeting since May 2009, this stakeholder group is focused on preventing sewer disposal of unwanted medications and reducing the quantities of unwanted pharmaceuticals within homes. At present, the activities are being initiated through the use of take-back and medicine return options in a manner which provides for the safe disposal of unwanted medicines without relying on local and state governments to pay these expenses. The group meets monthly and is growing in membership. Recently, participants conducted a pilot take-back event at the Walmart in Oro Valley. With minimal advertising, this event attracted 50 people and succeeded in collecting two 60-lb boxes of pills and two boxes of liquids. Oro Valley Police Department provided chain-of-custody transport of the wastes to DEA for incineration. The stakeholder group will use this first, pilot event to design similar public events around the region.

Pharmaceutical Working Group Participants

- Pima County Regional Wastewater Reclamation (Lead)
- Tucson Water
- City of Tucson Environmental Services
- City of Tucson Household Hazardous Waste
- Oro Valley Police Dept
- Marana Utility Services
- Town of Marana Police Department
- Green Valley Community Coordinating Council
- Community Water Company Green Valley
- Northwest Fire District
- Golder Ranch Fire District
- University of Arizona College of Pharmacy
- Arizona Pharmacy Alliance
- US DEA
- Raytheon
- Sharps Compliance
- Meth Free Alliance

- ***Stormwater Pollution Prevention***

Stormwater runoff from construction and industrial sites can cause significant harm to our rivers, lakes, and coastal waters. RWRD maintains an effective Stormwater Pollution Program to help prevent stormwater pollution and thereby comply with the requirements of the Clean Water Act. This plan requires that a Stormwater Pollution Prevention Plan (SWPPP) be developed for each new construction activity that disturbs more than one acre and for each wastewater reclamation facility. Regular facility audits are conducted and Best Management Practices (BMPs) are continually maintained to ensure stormwater pollution is minimized.

- ***Regional Optimization Master Plan***

The ROMP includes the Ina Road Wastewater Reclamation Facility (WRF) upgrade and expansion project which will increase the capacity of this facility to 50 million gallons per day (MGD) and also convert the existing processes at Ina to the new Bardenpho® [wastewater treatment] process to bring nitrogen and ammonia levels down. RWRD will centralize all biosolids processing and handling at the Ina Road WRF, as well as bio-gas utilization. The new Water Reclamation Campus in the vicinity of the existing Roger Road WRF site includes a new 32 MGD Bardenpho® treatment process and will house the central laboratory facility and may be a showcase for cultural and biological resources. Some environmental enhancements could include adjacent parks, natural areas and economic development as well as the County's solar energy project. The Plant Interconnect will connect the Roger Road WRF to the Ina Road WRF. The intent of the Plant Interconnect is to convey wastewater from the Roger Road service area

to the Ina Road WRF where more treatment capacity is available. **ROMP improvements will significantly increase overall of removal of organic pollutants because improved solids retention and denitrification are among the key ROMP Program upgrades.**

- ***Arid West Water Quality Standards***

As already noted, surface water quality regulations are constantly evolving. However, the foundation for many of these regulations is based on national guidelines with limited applicability to arid West waters, especially effluent-dependent and ephemeral waters. Effluent-dependent waters (aquatic environments created as a result of the discharge of treated effluent to an otherwise dry or intermittent streambed) represent unique aquatic ecosystems. EPA, through the Arid West Water Quality Research Project (AWWQRP), has funded interdisciplinary research in this area. Pima County was selected to manage the AWWQRP based on its experience with these extreme arid West conditions.

Research conducted to date has noted how arid West waters contrast markedly with the relatively stable aquatic habitats characteristic of Midwestern and Eastern regions. In the arid West, aquatic communities are largely controlled by the physical conditions that tend to be harsh and extremely variable. Effluent-dependent waters, such as the Santa Cruz River, represent unique stream ecosystems consisting of a highly variable ephemeral system into which effluent flow introduces significant changes in ecosystem characteristics. For example, as was demonstrated in the AWWQRP-funded Habitat Characterization Study, the physical and chemical template established by the discharge of effluent exerts important controls on the potential composition of the aquatic community. Accordingly, gaining an understanding of what is attainable in effluent-dependent waters such as the Santa Cruz River ultimately may have a significant influence on establishing appropriate surface water quality regulations in the future.

The AWWQRP has helped ADEQ come to some realization of the need for flexibility in applying SWQSs to effluent dependent waters. ADEQ's most recent Notice of Final Rulemaking for the SWQSs states that "The Department recognizes that there may be infrequent, sporadic, or emergency point source discharges of wastewater to ephemeral waters where it is reasonable to conclude that chronic A&W EDW (aquatic and wildlife/effluent dependent waters) standards are unnecessary. There may be point source discharges to ephemeral waters where the amount of flow, the frequency, or the duration of the discharge is such that it is unlikely that water may be present in the receiving ephemeral water for a sufficient period of time for organisms in the receiving water to be chronically exposed to pollutants."

Emerging Contaminants

Overview

Since the mid-1990's, EPA's Office of Water used the term "emerging contaminant" to loosely describe chemicals and other substances that have no regulatory standard, that have been recently "discovered" in the environment because of improved analytical detection levels, and that may cause public health or ecosystem risk, although the epidemiologic impact is relatively unknown. EPA now uses the term "contaminant of emerging concern," (CEC) for these compounds**. CECs describe a wide range of substances that fall into a number of subgroups which lend themselves to additional acronyms including Endocrine Disrupting Compounds (EDC), Pharmaceutical and Personal Care Products (PPCP), and trace organics known as Persistent Organic Pollutants (POP).** Other pollutants that may be regarded as "emerging" include a number of trace metals, perchlorate (a compound similar to nitrate that has been used as an oxidizer in rocket fuel), various parasites, and some commonly occurring compounds such as salinity and sulfate.

CECs can enter the environment through a complex variety of sources. Some CECs are similar to conventional toxic pollutants because they are associated with industrial releases. Many others are used by the general public every day in homes, on farms, by commercial businesses or even by hospitals. Many of the compounds, such as hormones and trace metals, can also be naturally occurring in the environment. Some typical modes of human-caused release of CECs are through septic system or municipal wastewater discharge, landfill impact, agricultural wastes, or industrial discharge. PPCPs can enter the environment through human excretion, flushing of unused medications, throwing unused medications into the trash, farm runoff, stormwater runoff and industrial discharges. In Arizona alone, 54 million prescriptions are dispensed by pharmacies, and the pharmaceutical industry estimates that three percent of these prescriptions go unused – either disposed of into the trash or down the drain. Any PPCPs that are not removed during the wastewater treatment process remain in discharged effluent. PPCPs that are removed from liquid waste undergo an anaerobic digestion process that is commonly used to treat solids. PPCP residuals from this process can be present in biosolids, which often are used as fertilizer on farmlands that grow non-food crops. In homes that are served by septic systems, no treatment/removal of PPCPs occurs and the pollutants percolate directly into the soil and underlying aquifer.

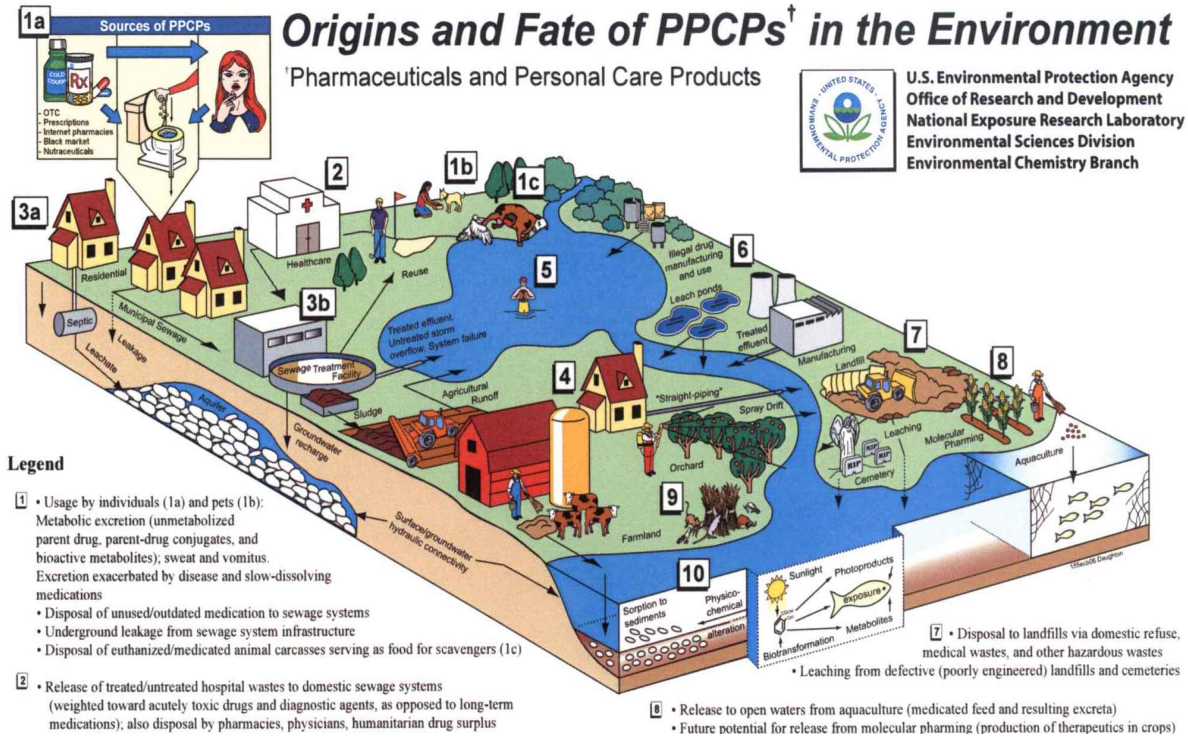


Figure 27

Emerging contaminants can be grouped into several classes of substances:

- ***Endocrine Disrupting Compounds*** (EDCs) are ones that act on the hormonal level in organisms. The World Health Organization defines an EDC as "an exogenous substance or mixture that alters function(s) of the endocrine system and consequently causes adverse health effects in an intact organism, or its progeny…." Some insecticides are EDCs. Also included are pthalates, steroids, natural estrogens, and birth control drugs, as well as polychlorinated byphenols (PCBs) and polyaromatic hydrocarbons (PAHs). Bis-phenyl A (BPA) and polybrominated diphenyl ether (PBDE) are EDCs.

- ***Pharmaceuticals*** encompass a wide range of compounds available over-the-counter, by prescription, administered in hospital situations, and as veterinary/agricultural use. Illicit drugs and illicit labs may also be sources. Some example compounds found in national surface water sampling studies include Carbamazepine (anti-convulsant), Cimetidine (histamine blocker for stomach acid), Gemfibrozil (cholesterol reduction), Ibuprofen, and Sulfamethoxazole (antibiotic).

- ***Personal Care Products*** (PCPs) are typically fragrances, shampoos, cosmetics, and sun-screen products. These can contain compounds such as 1,4 dioxane and nonylphenols at low levels where they are used as surfactants and emulsifiers.

- ***Trace metals*** are emerging contaminants in the sense that standards for more metals are being established, and existing standards are being reset to lower levels with new data. Arsenic is the most familiar compound here, but the list includes tungsten, cobalt, germanium, molybdenum, selenium, strontium, uranium, and vanadium.

- ***Perchlorate*** is a unique compound that has no current standard. It is a component of rocket fuel and can be found as an environmental contaminant at a number of government installations and fuel manufacturing sites around the West.

- ***Salinity and sulfate*** can be regarded as emerging contaminants in that they have no numeric standard and yet they are compounds which limit the use of water when present in concentrated quantities.

- ***Naegleria fowleri*** is an amoeba that can be deadly and is listed on EPA's contaminant candidate list. It enters the body through mucous membrane tissue and finds its way to the brain. This parasite has turned up in discrete incidents in well water in Peoria, AZ and in surface water of Lake Havasu.

Studies Discovering "Emerging" Compounds in the Environment – United States Geological Survey (USGS)

Detection of pharmaceutical contaminants (including endocrine disrupting compounds) and personal care product residues in the environment received national attention with the publication of a United States Geological Survey (USGS) report titled *Pharmaceuticals, Hormones, and Other Organic Wastewater Contaminants in U.S. Streams, 1999-2000: A National Reconnaissance*. USGS hydrologists collected water samples from 139 streams across 30 states during 1999 and 2000. The sampling sites focused toward streams considered to be susceptible to contamination and represented a wide variety of hydrologic, climatic, and land-use settings across the United States. Results indicated a broad range of chemicals detected in surface water impacted by residential, industrial, and agricultural wastewaters in mixtures at low concentrations in most streams. The chemicals included human and veterinary drugs, natural and synthetic hormones, detergent metabolites, plasticizers, insecticides, and fire retardants. One or more of these chemicals were found in 80% of the streams sampled. Half of the streams contained 7 or more of these chemicals, and about one-third contained 10 or more of these chemicals. This study was the first national-scale examination of emerging contaminants in streams of the United States. The study used four sample locations in Arizona, and one of those locations was the Santa Cruz River near Cortaro Road in Pima County. **Analytical results performed by the USGS for a variety of compounds appeared unusually high for both Pima and Maricopa Counties, due largely to the fact that the water in our desert streams consists almost entirely of treated effluent, with no surface water dilution.**

The first USGS report raised many questions about chemical risks to populations, potential contamination of groundwater, analytical validity, and even compound identification and classification. At the time, most of the detected compounds were grouped under a class called endocrine disrupting compounds, or EDCs. These compounds

were aptly named because many have the potential to affect the endocrine system and therefore induce a disruption for regulating biological processes. EDCs come from both natural and manmade sources and can mimic or interfere with natural hormone activity.

Recent advances in laboratory analytical methods have given scientists the tools to detect a wide range of contaminants in the environment at extremely low concentrations. As detection technologies improve, scientists are likely to find more and a larger variety of these chemicals in ground water, streams, rivers, and drinking-water sources in the future. **It is important to note that detection at a low concentration does not necessarily signal a health concern, and that some of the chemicals detected in these reconnaissance studies can occur naturally**. Data from additional research will help scientists, regulators, water-resource managers, and health professionals to determine if the concentrations and mixtures of chemicals measured in these waters pose a threat to human or environmental health, and will help with the development of mitigating strategies, where needed.

To determine what the groundwater impact has been from the surface water discharges sampled in their study, the USGS collected groundwater samples from a network of 47 wells with common environmental conditions and which typically were not used for drinking water (Barnes and others (2004, 2005, and 2008)). The wells, in 18 states, were analyzed for 65 chemicals. The most frequently detected chemicals include *N,N*-diethyltoluamide **(insect repellant**), bisphenol A (**plastic- and epoxy-manufacturing ingredient**), tri(2-chloroethyl) phosphate **(fire retardant**), sulfamethoxazole **(veterinary and human antibiotic**), and 4-octylphenol monoethoxylate **(detergent metabolite).** The concentrations of chemicals detected were low. Eighty-seven percent of the 137 measured detections were less than 1 microgram per liter (µg/L). Mixtures of chemicals were common. Although the chemicals detected were similar to those found in the previous national stream reconnaissance, the chemicals were detected less frequently in this study's ground-water sites (35 percent of the sites) than they were in the stream reconnaissance (86 percent of the sites).

Figure 28

In another related USGS study, Focazio and others (2004) and (2008) took water samples from untreated sources of drinking water at 25 groundwater and 49 surface water sites in 25 states and Puerto Rico. The most frequently detected chemicals in surface water were cotinine (**nicotine metabolite)**, and 1,7-dimethylxanthine **(caffeine metabolite)**; and in ground water were carbamazepine **(pharmaceutical**), bisphenol-A **(plastic- and epoxy-manufacturing ingredient**), 1,7-dimethylxanthine (**caffeine metabolite**), and tri(2-chloroethyl) phosphate **(fire retardant**). Overall, detections were more common in water collected from surface-water sites than from ground-water sites. Sixty percent of the 36 pharmaceuticals (including prescription drugs and antibiotics) analyzed were not detected in any water sample. The maximum concentrations of the measured chemicals were only slightly above detection levels. Mixtures of chemicals were common. Pharmaceuticals, including antibiotics and prescription and non-prescription drugs, generally were detected less frequently in sources of drinking water than they were in the national stream reconnaissance.

In 2003 and 2004, the RWRD's Pretreatment Group performed a comprehensive survey of community sources of PPCPs in order to develop a strategy for curtailing the introduction of these substances into the sewer system. The results of that study demonstrated that most hospitals, nursing homes and pharmacies have an organized system for keeping these compounds out of the sewers. Many of these substances are collected and disposed of in designated trash receptacles or are shipped out of town to regional collection points. Therefore, it has been concluded that the primary sources of PPCPs are likely the result of human excretion of medication residuals to the sewer. Other sources are the disposal of unused medications in the household trash or the disposal of medications through flushing or pouring down toilets and drains. In addition, there are many natural sources of PPCPs which include plants and plant byproducts and even natural human and animal hormones. Plants, for example, create phytoestrogen.

Since 2002, RWRD has partnered with the USGS and the Environmental Protection Agency (EPA) on many research sampling studies. These recent studies reported on by the Water Environment Research Foundation (WERF), indicate that advanced wastewater treatment technology is a tremendous benefit to lowering PPCP levels. In 2002, RWRD participated in a sampling study of 10 different wastewater treatment facilities. The Ina Road, Roger Road and Avra Valley facilities were included in this study – with sampling locations also occurring along the Santa Cruz River. In 2003, additional studies were conducted to characterize the removal of PPCPs through the different treatment processes including Randolph Park WRF, Roger Road WRF and Green Valley WRF. **The study concluded that no single technology can remove all PPCPs from effluent produced by wastewater treatment facilities. However, conventional secondary wastewater treatment along with nitrogen removal significantly lowers total organic carbon (TOC) and can remove over 90 percent of EDC compounds.**

A 2004 Black & Veatch study demonstrated biodegradation of select PPCPs can be achieved with adequate solids retention time and/or hydraulic retention times where further removal can be achieved. In 2004, the Roger Road WRF converted from a trickling filter scenario to a trickling filter/activated sludge process based on previous studies. Since this 2004 transition, effluent quality has improved significantly.

Furthermore, it is projected that when the Roger and Ina Road facilities are fully transformed to de-nitrification facilities under ROMP, there will be considerable additional benefit from organic chemical biodegradation.

Tucson Water has always been interested in emerging issues related to drinking water quality. Since the 2001 USGS river study, which highlighted the presence of these compounds in the environment, TW has remained engaged in supporting and even conducted further research into the persistence of microconstituents in the local environment, including our groundwater supply and drinking water sources. Nationally, microconstituents are generally found in the environment in incredibly small quantities. Most of the research in this field monitor for these constituents in the parts per trillion range.

With the advancement of reliable and cost efficient laboratory methods for microconstituent monitoring, TW initiated a microconstituent sampling program in 2008. The purpose of this program is to identify the possibility of microconstituents being present in portions of our potable water supply. The initial sampling program chose locations that had the possibility of demonstrating a potential water quality signature associated with discharge from a water reclamation facility. In the initial sampling event, a well located in Marana, not far from the effluent dependant Santa Cruz River, showed the presence of four microconstituents.

The most recent sampling (summer 2009) detected several constituents at a variety of wells and locations. Four sampling points were chosen within close proximity to the Santa Cruz River, two were from our Clearwater Supply in Avra Valley. Other than the water from the Southern Avra Valley Storage and Recovery Project, detections of PPCPs and/or other microconstituents were present at the sentry locations. Since many of these products that contain microconstituents are used by humans in therapeutic doses to enhance their life, research is ongoing to see if any of these compounds found at levels well below any therapeutic dose have any toxicological effects on humans.

Potential effects of human exposure to trace organics

In Spring 2008, the Associated Press ran a series of news stories highlighting the widespread detection of pharmaceuticals and other trace organics in drinking waters from metropolitan areas around the United States, raising public awareness and causing widespread concern regarding trace organics in water supplies.

Much has been said about the potential effects of human exposure to trace organics. It is possible, for example to compare the likely exposure of pharmaceuticals in drinking water, even at the highest concentrations reported in the USGS study, to the masses of these compounds that are ingested in a single therapeutic dose (Table 1). Daily ingestion of two liters of water containing ibuprofen, a common anti-inflammatory, at 1 µg/L (the highest concentration measured in the USGS reconnaissance of United States surface water) for >270 years would provide the same total mass of ibuprofen present in a single Motrin tablet. Comparisons of this nature almost invariably suggest that human health effects from exposure to pharmaceuticals in drinking water are negligible. Nonetheless, attention remains focused to some extent on endocrine disrupting compounds (EDCs), due primarily to the sensitivity of endocrine system response to hormone stimulation and to the widespread observation of physiological response among fish and other organisms that are exposed to low-concentrations of endocrine disruptors in mixtures of natural water and treated wastewater (Drewes et al., 2005).

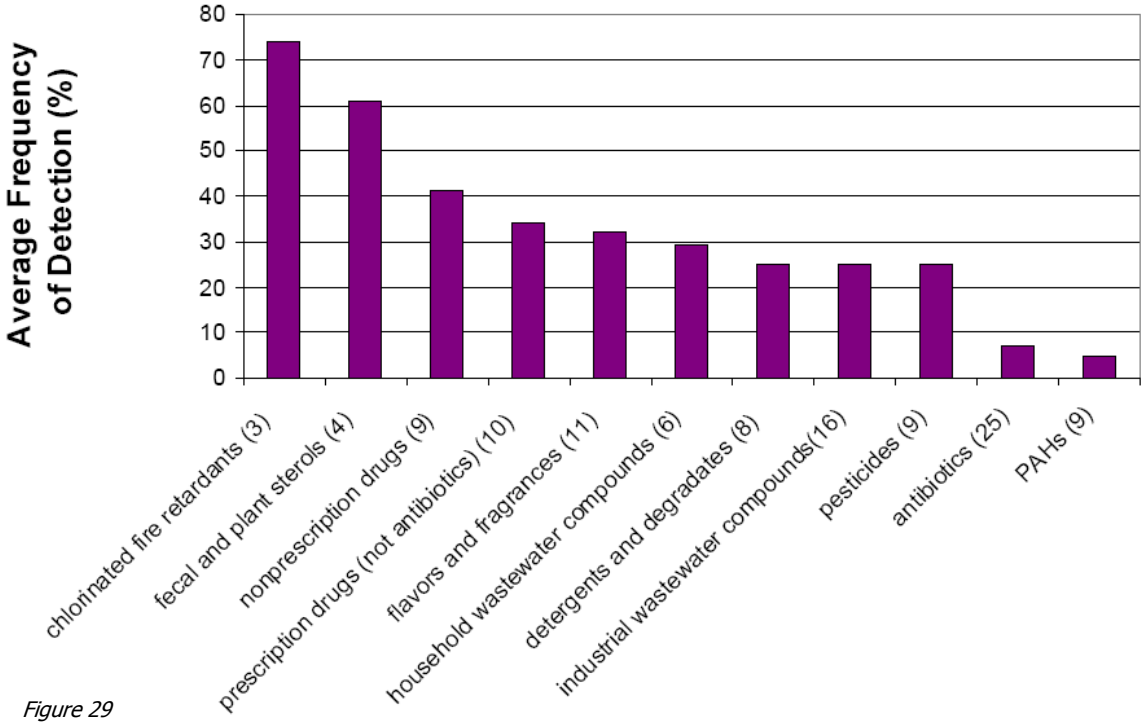


Figure 29

Wastewater Treatment and Removal of Emerging Contaminants

During the last ten years or so, there have been several attempts to evaluate the effectiveness of wastewater treatment for the destruction of estrogenic compounds and/or total estrogenic activity. Consequently, there is a body of literature on which to base certain general expectations regarding the fates of estrogens during conventional wastewater treatment processes. Several years ago the Arizona Water Institute commissioned a University of Arizona/Northern Arizona University effort to measure the removal of whole sample estrogenic activity at select wastewater treatment facilities in Tucson and Flagstaff, AZ. Results (Table 4) indicate that influent-to-effluent reductions in total estrogenic activity are highly variable and probably treatment plant- or process-dependent. Ninety-nine percent removals were observed for the Avra Valley oxidation ditch, the Randolph Park membrane bioreactor and the Rio de Flag nitrifying/denitrifying wastewater treatment plants. On the other hand, the Roger Road Wastewater Treatment Plant, which provides secondary treatment in a biotower, removed only one-third of the measured influent estrogenic activity. Clearly, the type and efficiency of biochemical treatment provided are major determinants of estrogen transformation efficiency.

Total Estrogenic Activity (M as EE_2)	
Facility	**Percent Removal**[1]
Avra Valley	99.8%
Roger Road	33%
Ina Road	88%
Randolph Park	> 99%
Wildcat	96%
Rio de Flag	> 99.6%

Figure 30

Table 4. Total estrogenic activities at major wastewater treatment facilities in Flagstaff and Tucson, Arizona. Influent and effluent values were obtained using the YES bioassay.

[1] RWRD's Roger Road and Ina Road WWTPs did not have nitrification-denitrification at the time of this study. All others were tertiary plants with nitrification-denitrification.

The results of several broad surveys have produced a weak consensus on the ability of conventional wastewater treatment processes to remove estrogenic activity and/or specific chemicals that contribute to total estrogenic activity in wastewater and wastewater effluent (Table 5; Teske and Arnold, 2008). Most acknowledge that there is a direct relationship between the removal of the natural estrogens and both sludge age and hydraulic retention time in activated sludge aeration basins. Nitrifying plants are generally very successful at removing estrogenic activity, and there is mild debate over whether or not nitrifying bacteria are directly responsible for the biochemical transformations of interest. Success in removing trace organics with longer sludge age could also be due to greater metabolic diversity in activated sludge under those conditions, for example. Several studies have shown that removals of 17β-estradiol and estriol are generally greater than the removal of estrone during conventional wastewater treatment. Estrone removal varies greatly from plant to plant and may account for a significant fraction of overall estrogenic activity in effluents from facilities that do not perform well in this regard.

Average Removal Efficiency

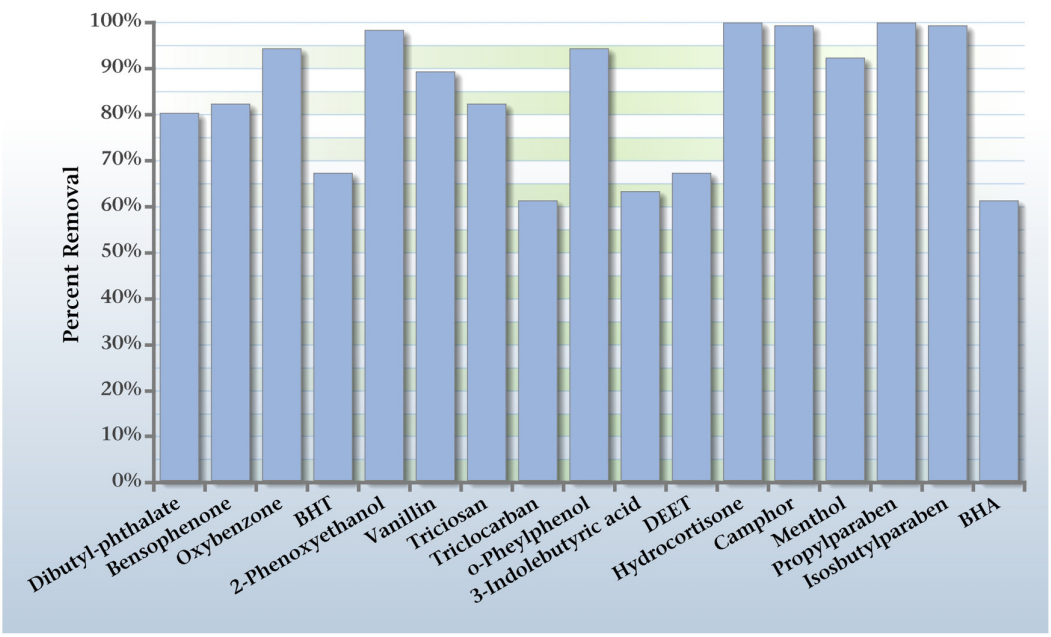


Figure 31 Removal Efficiencies by Type of Substance

More elaborate tertiary treatment such as advanced oxidation processes and reverse osmosis can produce effluents that are free of estrogenic activity. The costs of such processes cannot be justified for removal of trace organics alone in most situations (Jones et al., 2007). The net benefits of advanced treatment, however, are potentially much greater when reclaimed wastewater is reused for potable purposes without the benefit of multiple barriers (e.g., infiltration and extended underground storage) between reclamation and reuse.

The fates of trace organics in effluents that reenter the environment are governed by physical properties of the compounds, by their biodegradability and by their vulnerability to photolysis reactions. The Santa Cruz River provides an excellent opportunity to study attenuation processes in surface waters, where biodegradation, photolysis and sorption to sediments and vegetation are candidate mechanisms. For most of the year, there is little or no opportunity for dilution within the effluent-dependent river. Ten miles below the outfalls of the Roger Road Wastewater Treatment Plant and Ina Road Water Reclamation Facility the total estrogenic activity in Santa Cruz River water is perhaps 80% lower that levels measured in plant effluents. This generalization, however, is based on only a few data points. It is more certain that infiltration and biodegradation processes that contribute to soil-aquifer treatment have a beneficial effect on water quality. The loss of residual estrogenic activity during infiltration through ~100 feet of unconsolidated sediment at the Sweetwater Recharge Facility (SRF) is on the order of 90%.

It is important to distinguish between observable environmental effects arising from exposure to estrogenic compounds in treated municipal wastewater and health effects among humans from exposure to trace organics in wastewater. No direct link has been established between exposure to

trace organics in wastewater and any kind of human health response. The tools with which to find such links are admittedly crude, and the human toxicology related to chronic exposure to mixtures of trace organics in water is, at present, poorly understood.

Research Considerations and Summary

The situation with respect to trace organics in wastewater can be summarized in the following way:

- **Advances in analytical chemistry over the last 10-20 years allow us to measure aqueous-phase organics at low nanograms/liter concentrations.** The great number of synthetic chemicals in widespread use and the ability to measure these compounds at vanishingly low concentrations make the presence and detection of many trace organics in wastewater unavoidable.

- **Most trace organics that are now commonly measured in municipal wastewater are present at concentrations that are unlikely to produce physiological response in exposed organisms. However, hormones are designed to affect homeostasis and organism development at very low concentrations, and it is firmly established that exposure to estrogenic activity in treated wastewater during critical life stages can disrupt organismal development and function.** The endocrine system effects of many trace organics in wastewater have not yet been tested. Nevertheless, it is widely held that natural estrogens and their immediate metabolic derivatives are primarily responsible for observed estrogenic activity in treated wastewater. The potential for effects on organism development from exposure to androgenic, thyroid, or retinoic acid activity in wastewater is unclear. Likewise, the effect of simultaneous exposure to multiple trace organic contaminants (potential synergy) is not known.

- **It is unlikely that source control measures or even chemical product prohibitions will greatly reduce whole-sample estrogenic activity in municipal wastewater**. Most estrogenic activity arises from the population's natural hormones excreted as human waste into the wastewater collection system.

- **Conventional wastewater treatment is efficient, although imperfect, at removing the chemicals responsible for estrogenic activity from municipal wastewater.** Well-operated plants that are designed for nutrient removal can bring about two-log reductions in estrogenic activity (influent to effluent). Responsible mechanisms have not been completely identified, although sorption on sludges produced during wastewater treatment and biodegradation are important contributors. The roles of specific groups of organisms in breaking down important classes of trace organics have not yet been fully developed. There are, however, potentially important trace organics that are poorly attenuated by conventional wastewater treatment processes.

- **The fates of trace organics in wastewater effluent discharged to surface waters or infiltrated for groundwater replenishment have not been well studied and are incompletely understood.** More effort is warranted here if natural processes such as photolysis, sorption and biodegradation are relied upon to assist in the recovery of water quality following water use, wastewater recovery and treatment.

- **There is no compelling evidence in favor of a direct link between residual trace organic compounds in wastewater effluent and human health effects.** There is, however, great potential complexity in the mechanisms by which chronic exposure to trace contaminants could affect public health, and the tools now employed to deduce cause-effect relationships between exposure and physiological change are probably inadequate for the task.

Regulatory Status of Emerging Contaminants

Regulators, scientists, and environmental activists have sharpened their focus on these "emerging contaminants," however standards regulating these compounds are not likely to appear soon. EPA's drinking water contaminant candidate list (CCL) contains mostly industrial chemicals and pesticides; many of the emerging contaminants that have captured the public's attention are not even on the list for potential consideration. Four PPCPs are on the list (1,4 dioxane, 2-methoxyethanol, 2-propen-1-ol). Eleven microorganisms are on the list, including *Naegleria fowleri.* Several trace metals are also listed – Cobalt, Germanium, Molybdenum, Strontium, Tellurium, Vanadium. Perchlorate is included, too. However, establishment of MCLs for these listed compounds is at least several years in the future,

and may take longer depending on data availability. For emerging contaminants not yet on the CCL, standards are unlikely in the near-term.

With regard to surface water standards, EPA is in the process of developing guidelines that would accommodate specifying Aquatic Life Criteria (ALC) for contaminants of emerging concern (CECs). The primary interest is in limiting EDC impact to aquatic organisms, and they propose to redefine the ALC methodology so that it will evaluate reproductive and other hormonal effects rather than standard toxicity. EPA is in an early stage of this process, and the development of surface water standards taking this approach to regulate CECs in point source discharges will require substantial research.

EPA has a process for periodic evaluation of research data to determine whether or not to add new pollutants to established standards. Due to the fragmentary nature of current research data, most CECs will not have standards for years to come. In the absence of specific water quality standards, regulatory programs cannot set specific controls on pollutants **General preventive measures can often be effective in such situations. Wastewater systems can emphasize pre-treatment and industrial source control to minimize system inputs. Drinking water operators can assure system integrity with sound backflow prevention measures. Public outreach can also be an effective preventive tool with regard to the public's choice to dispose of problematic compounds wisely.**

RECOMMENDATIONS

- **Wastewater Facility Improvements – Regional Optimization Master Plan (ROMP)**

  - **Implement the ROMP Improvements.** **Implementing the ROMP improvements to wastewater treatment facilities in Pima County is the single most effective step that can be taken to minimize impact of emerging contaminants on public health and the environment.** The County is proposing to fund these improvements through a sewer revenue bond election to be held in November 2010. Once completed, RWRD and TW should conduct thorough sampling of the treatment system to determine removal efficiencies and of the surface discharge and reclaimed system to assess the quality of various discharge modes. Staff should develop a scope of work for this monitoring study that identifies appropriate emerging contaminants to assess.

- **Continue Source Control Programs & System Monitoring**

  - **Multiple Barrier**. In accordance with EPA and ADEQ drinking water regulation, Tucson Water should continue to operate all facets of its "multiple barrier" approach to potable water protection. These activities include sampling for 15 secondary and 25 unregulated drinking water contaminants on a regular basis, maintaining chlorine target levels in the system, and maintaining policies and procedures that can react to any newly developing contaminant situation in a preventive manner.

  - **Industrial Wastewater Control**. RWRD should continue its aggressive and effective pre-treatment program. RWRD should strike a balance between inspection/compliance/enforcement activities and a proactive outreach to the commercial and industrial community regarding emerging contaminants issues.

  - **Household Hazardous Waste**. This program has been effective for general reduction of chemicals that might be discharged into our sewers and landfills. The City of Tucson and Pima County should continue to support the success of this program.

  - **Pharmaceutical Take-Back Program**. TW and RWRD should continue working together with the established stakeholder group to develop a plan to implement pharmaceutical take-back activities. Also participate at the state and national level as efforts to facilitate such programs become available.

- **Tucson Water and RWRD Professionals Need to Collaborate in National, Regional and State Research and Regulatory Activities**

  - **WESTCAS and Effluent Dependent Streams Advocacy.** Make sure that federal guidelines and ADEQ standard setting reflects our arid western environment and appropriate exposure risks.

  - **Standards Development**. ADEQ is likely to begin a stakeholder process to revise Reuse Standards soon. TW and RWRD staff should actively participate in this process.

  - **USGS and University Research**. Continue to support and participate in USGS and University research related to emerging contaminants.

  - **Workshops and Conferences**. Participation in local, regional and national workshops and conferences related to emerging contaminants to keep staff abreast of latest treatment technology, monitoring strategies and preparations necessary for the developments in regulation of these compounds.

- **Conduct Public Outreach & Education**

  - **Public Outreach and Education**. Continue and increase public outreach and education through existing programs such as Environmental Monitoring for Public Access and Community Tracking Program (EMPACT); Stormwater; Fat, Oil and Grease (FOG); Pharmaceutical Take-back Events; and Household Hazardous Waste (HHW) Program.

- **Seek Additional Federal Funding**

  - **Federal funding**. Actively pursue federal funding for local/regional research, local/regional take-back programs, and increased Industrial Wastewater Control/pre-treatment outreach programs.

List of Appendices

Appendix A……EPA Drinking Water Standards

Appendix B……Background – Water Quality Standards & Regulations

Appendix C……Contaminant Candidate List

Appendix D……List of Abbreviations

Appendix E……Global Science Research Coalition Science Brief

Appendix A

EPA Primary Drinking Water Standards

Microorganisms

Contaminant	MCLG[1] (mg/L)[2]	MCL or TT[1] (mg/L)[2]	Potential Health Effects from Ingestion of Water	Sources of Contaminant in Drinking Water
Cryptosporidium (pdf file)	zero	TT [3]	Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste
Giardia lamblia	zero	TT[3]	Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste
Heterotrophic plate count	n/a	TT[3]	HPC has no health effects; it is an analytic method used to measure the variety of bacteria that are common in water. The lower the concentration of bacteria in drinking water, the better maintained the water system is.	HPC measures a range of bacteria that are naturally present in the environment
Legionella	zero	TT[3]	Legionnaire's Disease, a type of pneumonia	Found naturally in water; multiplies in heating systems
Total Coliforms (including fecal coliform and *E. Coli*)	zero	5.0%[4]	Not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present[5]	Coliforms are naturally present in the environment; as well as feces; fecal coliforms and *E. coli* only come from human and animal fecal waste.
Turbidity	n/a	TT[3]	Turbidity is a measure of the cloudiness of water. It is used to indicate water quality and filtration effectiveness (e.g., whether disease-causing organisms are present). Higher turbidity levels are often associated with higher levels of disease-causing microorganisms such as viruses, parasites and some bacteria. These organisms can cause symptoms such as nausea, cramps, diarrhea, and associated headaches.	Soil runoff
Viruses (enteric)	zero	TT[3]	Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste

Disinfection Byproducts

Contaminant	MCLG[1] (mg/L)[2]	MCL or TT[1] (mg/L)[2]	Potential Health Effects from Ingestion of Water	Sources of Contaminant in Drinking Water
Bromate	zero	0.010	Increased risk of cancer	Byproduct of drinking water disinfection
Chlorite	0.8	1.0	Anemia; infants & young children: nervous system effects	Byproduct of drinking water disinfection

Haloacetic acids (HAA5)	n/a[6]	0.060[7]	Increased risk of cancer	Byproduct of drinking water disinfection
Total Trihalomethanes (TTHMs)	--> n/a[6]	--> 0.080[7]	Liver, kidney or central nervous system problems; increased risk of cancer	Byproduct of drinking water disinfection

Disinfectants

Contaminant	MRDLG[1] (mg/L)[2]	MRDL[1] (mg/L)[2]	Potential Health Effects from Ingestion of Water	Sources of Contaminant in Drinking Water
Chloramines (as Cl_2)	MRDLG=4[1]	MRDL=4.0[1]	Eye/nose irritation; stomach discomfort, anemia	Water additive used to control microbes
Chlorine (as Cl_2)	MRDLG=4[1]	MRDL=4.0[1]	Eye/nose irritation; stomach discomfort	Water additive used to control microbes
Chlorine dioxide (as ClO_2)	MRDLG=0.8[1]	MRDL=0.8[1]	Anemia; infants & young children: nervous system effects	Water additive used to control microbes

Inorganic Chemicals

Contaminant	MCLG[1] (mg/L)[2]	MCL or TT[1] (mg/L)[2]	Potential Health Effects from Ingestion of Water	Sources of Contaminant in Drinking Water
Antimony	0.006	0.006	Increase in blood cholesterol; decrease in blood sugar	Discharge from petroleum refineries; fire retardants; ceramics; electronics; solder
Arsenic	0[7]	0.010 as of 01/23/06	Skin damage or problems with circulatory systems, and may have increased risk of getting cancer	Erosion of natural deposits; runoff from orchards, runoff from glass & electronicsproduction wastes
Asbestos (fiber >10 micrometers)	7 million fibers per liter	7 MFL	Increased risk of developing benign intestinal polyps	Decay of asbestos cement in water mains; erosion of natural deposits
Barium	2	2	Increase in blood pressure	Discharge of drilling wastes; discharge from metal refineries; erosion of natural deposits
Beryllium	0.004	0.004	Intestinal lesions	Discharge from metal refineries and coal-burning factories; discharge from electrical, aerospace, and defense industries
Cadmium	0.005	0.005	Kidney damage	Corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; runoff from waste batteries and paints
Chromium (total)	0.1	0.1	Allergic dermatitis	Discharge from steel and pulp mills; erosion of natural deposits
Copper	1.3	TT[8]; Action	Short term exposure: Gastrointestinal	Corrosion of household plumbing systems;

		Level=1.3	distress Long term exposure: Liver or kidney damage People with Wilson's Disease should consult their personal doctor if the amount of copper in their water exceeds the action level	erosion of natural deposits
Cyanide (as free cyanide)	0.2	0.2	Nerve damage or thyroid problems	Discharge from steel/metal factories; discharge from plastic and fertilizer factories
Fluoride	4.0	4.0	Bone disease (pain and tenderness of the bones); Children may get mottled teeth	Water additive which promotes strong teeth; erosion of natural deposits; discharge from fertilizer and aluminum factories
Lead	zero	TT[8]; Action Level=0.015	Infants and children: Delays in physical or mental development; children could show slight deficits in attention span and learning abilities Adults: Kidney problems; high blood pressure	Corrosion of household plumbing systems; erosion of natural deposits
Mercury (inorganic)	0.002	0.002	Kidney damage	Erosion of natural deposits; discharge from refineries and factories; runoff from landfills and croplands
Nitrate (measured as Nitrogen)	10	10	Infants below the age of six months who drink water containing nitrate in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits
Nitrite (measured as Nitrogen)	1	1	Infants below the age of six months who drink water containing nitrite in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits
Selenium	0.05	0.05	Hair or fingernail loss; numbness in fingers or toes; circulatory problems	Discharge from petroleum refineries; erosion of natural deposits; discharge from mines
Thallium	0.0005	0.002	Hair loss; changes in blood; kidney, intestine, or liver problems	Leaching from ore-processing sites; discharge from electronics, glass, and drug factories

Organic Chemicals

Contaminant	MCLG[1] (mg/L)[2]	MCL or TT[1] (mg/L)[2]	Potential Health Effects from Ingestion of Water	Sources of Contaminant in Drinking Water

Acrylamide	zero	TT[9]	Nervous system or blood problems; increased risk of cancer	Added to water during sewage/wastewater treatment
Alachlor	zero	0.002	Eye, liver, kidney or spleen problems; anemia; increased risk of cancer	Runoff from herbicide used on row crops
Atrazine	0.003	0.003	Cardiovascular system or reproductive problems	Runoff from herbicide used on row crops
Benzene	zero	0.005	Anemia; decrease in blood platelets; increased risk of cancer	Discharge from factories; leaching from gas storage tanks and landfills
Benzo(a)pyrene (PAHs)	zero	0.0002	Reproductive difficulties; increased risk of cancer	Leaching from linings of water storage tanks and distribution lines
Carbofuran	0.04	0.04	Problems with blood, nervous system, or reproductive system	Leaching of soil fumigant used on rice and alfalfa
Carbon tetrachloride	zero	0.005	Liver problems; increased risk of cancer	Discharge from chemical plants and other industrial activities
Chlordane	zero	0.002	Liver or nervous system problems; increased risk of cancer	Residue of banned termiticide
Chlorobenzene	0.1	0.1	Liver or kidney problems	Discharge from chemical and agricultural chemical factories
2,4-D	0.07	0.07	Kidney, liver, or adrenal gland problems	Runoff from herbicide used on row crops
Dalapon	0.2	0.2	Minor kidney changes	Runoff from herbicide used on rights of way
1,2-Dibromo-3-chloropropane (DBCP)	zero	0.0002	Reproductive difficulties; increased risk of cancer	Runoff/leaching from soil fumigant used on soybeans, cotton, pineapples, and orchards
o-Dichlorobenzene	0.6	0.6	Liver, kidney, or circulatory system problems	Discharge from industrial chemical factories
p-Dichlorobenzene	0.075	0.075	Anemia; liver, kidney or spleen damage; changes in blood	Discharge from industrial chemical factories
1,2-Dichloroethane	zero	0.005	Increased risk of cancer	Discharge from industrial chemical factories
1,1-Dichloroethylene	0.007	0.007	Liver problems	Discharge from industrial chemical factories

cis-1,2-Dichloroethylene	0.07	0.07	Liver problems	Discharge from industrial chemical factories
trans-1,2-Dichloroethylene	0.1	0.1	Liver problems	Discharge from industrial chemical factories
Dichloromethane	zero	0.005	Liver problems; increased risk of cancer	Discharge from drug and chemical factories
1,2-Dichloropropane	zero	0.005	Increased risk of cancer	Discharge from industrial chemical factories
Di(2-ethylhexyl) adipate	0.4	0.4	Weight loss, liver problems, or possible reproductive difficulties.	Discharge from chemical factories
Di(2-ethylhexyl) phthalate	zero	0.006	Reproductive difficulties; liver problems; increased risk of cancer	Discharge from rubber and chemical factories
Dinoseb	0.007	0.007	Reproductive difficulties	Runoff from herbicide used on soybeans and vegetables
Dioxin (2,3,7,8-TCDD)	zero	0.00000003	Reproductive difficulties; increased risk of cancer	Emissions from waste incineration and other combustion; discharge from chemical factories
Diquat	0.02	0.02	Cataracts	Runoff from herbicide use
Endothall	0.1	0.1	Stomach and intestinal problems	Runoff from herbicide use
Endrin	0.002	0.002	Liver problems	Residue of banned insecticide
Epichlorohydrin	zero	TT[9]	Increased cancer risk, and over a long period of time, stomach problems	Discharge from industrial chemical factories; an impurity of some water treatment chemicals
Ethylbenzene	0.7	0.7	Liver or kidneys problems	Discharge from petroleum refineries
Ethylene dibromide	zero	0.00005	Problems with liver, stomach, reproductive system, or kidneys; increased risk of cancer	Discharge from petroleum refineries
Glyphosate	0.7	0.7	Kidney problems; reproductive difficulties	Runoff from herbicide use
Heptachlor	zero	0.0004	Liver damage; increased risk of cancer	Residue of banned termiticide
Heptachlor epoxide	zero	0.0002	Liver damage; increased risk of cancer	Breakdown of heptachlor
Hexachlorobenzene	zero	0.001	Liver or kidney problems; reproductive	Discharge from metal refineries

			difficulties; increased risk of cancer	and agricultural chemical factories
Hexachlorocyclopentadiene	0.05	0.05	Kidney or stomach problems	Discharge from chemical factories
Lindane	0.0002	0.0002	Liver or kidney problems	Runoff/leaching from insecticide used on cattle, lumber, gardens
Methoxychlor	0.04	0.04	Reproductive difficulties	Runoff/leaching from insecticide used on fruits, vegetables, alfalfa, livestock
Oxamyl (Vydate)	0.2	0.2	Slight nervous system effects	Runoff/leaching from insecticide used on apples, potatoes, and tomatoes
Polychlorinated biphenyls (PCBs)	zero	0.0005	Skin changes; thymus gland problems; immune deficiencies; reproductive or nervous system difficulties; increased risk of cancer	Runoff from landfills; discharge of waste chemicals
Pentachlorophenol	zero	0.001	Liver or kidney problems; increased cancer risk	Discharge from wood preserving factories
Picloram	0.5	0.5	Liver problems	Herbicide runoff
Simazine	0.004	0.004	Problems with blood	Herbicide runoff
Styrene	0.1	0.1	Liver, kidney, or circulatory system problems	Discharge from rubber and plastic factories; leaching from landfills
Tetrachloroethylene	zero	0.005	Liver problems; increased risk of cancer	Discharge from factories and dry cleaners
Toluene	1	1	Nervous system, kidney, or liver problems	Discharge from petroleum factories
Toxaphene	zero	0.003	Kidney, liver, or thyroid problems; increased risk of cancer	Runoff/leaching from insecticide used on cotton and cattle
2,4,5-TP (Silvex)	0.05	0.05	Liver problems	Residue of banned herbicide
1,2,4-Trichlorobenzene	0.07	0.07	Changes in adrenal glands	Discharge from textile finishing factories
1,1,1-Trichloroethane	0.20	0.2	Liver, nervous system, or circulatory problems	Discharge from metal degreasing sites and other factories
1,1,2-Trichloroethane	0.003	0.005	Liver, kidney, or immune system problems	Discharge from industrial chemical factories

Trichloroethylene	zero	0.005	Liver problems; increased risk of cancer	Discharge from metal degreasing sites and other factories
Vinyl chloride	zero	0.002	Increased risk of cancer	Leaching from PVC pipes; discharge from plastic factories
Xylenes (total)	10	10	Nervous system damage	Discharge from petroleum factories; discharge from chemical factories

Radionuclides

Contaminant	MCLG[1] (mg/L)[2]	MCL or TT[1] (mg/L)[2]	Potential Health Effects from Ingestion of Water	Sources of Contaminant in Drinking Water
Alpha particles	none[7] ---------- zero	15 picocuries per Liter (pCi/L)	Increased risk of cancer	Erosion of natural deposits of certain minerals that are radioactive and may emit a form of radiation known as alpha radiation
Beta particles and photon emitters	none[7] ---------- zero	4 millirems per year	Increased risk of cancer	Decay of natural and man-made deposits of certain minerals that are radioactive and may emit forms of radiation known as photons and beta radiation
Radium 226 and Radium 228 (combined)	none[7] ---------- zero	5 pCi/L	Increased risk of cancer	Erosion of natural deposits
Uranium	zero	30 ug/L as of 12/08/03	Increased risk of cancer, kidney toxicity	Erosion of natural deposits

Notes

[1] Definitions:
Maximum Contaminant Level (MCL) - The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to MCLGs as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards.
Maximum Contaminant Level Goal (MCLG) - The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals.
Maximum Residual Disinfectant Level (MRDL) - The highest level of a disinfectant allowed in drinking water. There is convincing evidence that addition of a disinfectant is necessary for control of microbial contaminants.
Maximum Residual Disinfectant Level Goal (MRDLG) - The level of a drinking water disinfectant below which there is no known or expected risk to health. MRDLGs do not reflect the benefits of the use of disinfectants to control microbial contaminants.
Treatment Technique - A required process intended to reduce the level of a contaminant in drinking water.

[2] Units are in milligrams per liter (mg/L) unless otherwise noted. Milligrams per liter are equivalent to parts per million.

[3] EPA's surface water treatment rules require systems using surface water or ground water under the direct influence of surface water to (1) disinfect their water, and (2) filter their water or meet criteria for avoiding filtration so that the following contaminants are controlled at the following levels:

- Cryptosporidium: (as of1/1/02 for systems serving >10,000 and 1/14/05 for systems serving <10,000) 99% removal.
- Giardia lamblia: 99.9% removal/inactivation
- Viruses: 99.99% removal/inactivation
- Legionella: No limit, but EPA believes that if *Giardia* and viruses are removed/inactivated, *Legionella* will also be controlled.

- Turbidity: At no time can turbidity (cloudiness of water) go above 5 nephelolometric turbidity units (NTU); systems that filter must ensure that the turbidity go no higher than 1 NTU (0.5 NTU for conventional or direct filtration) in at least 95% of the daily samples in any month. As of January 1, 2002, turbidity may never exceed 1 NTU, and must not exceed 0.3 NTU in 95% of daily samples in any month.

- HPC: No more than 500 bacterial colonies per milliliter.

- Long Term 1 Enhanced Surface Water Treatment (Effective Date: January 14, 2005); Surface water systems or (GWUDI) systems serving fewer than 10,000 people must comply with the applicable Long Term 1 Enhanced Surface Water Treatment Rule provisions (e.g. turbidity standards, individual filter monitoring, Cryptosporidium removal requirements, updated watershed control requirements for unfiltered systems).

- Long Term 2 Enhanced Surface Water Treatment Rule (Effective Date: January 4, 2006) - Surface water systems or GWUDI systems must comply with the additional treatment for Cryptosporidium specified in this rule based on their Cryptosporidium bin classification calculated after the completion of source water monitoring.

- Filter Backwash Recycling; The Filter Backwash Recycling Rule requires systems that recycle to return specific recycle flows through all processes of the system's existing conventional or direct filtration system or at an alternate location approved by the state.

[4] more than 5.0% samples total coliform-positive in a month. (For water systems that collect fewer than 40 routine samples per month, no more than one sample can be total coliform-positive per month.) Every sample that has total coliform must be analyzed for either fecal coliforms or E. coli if two consecutive TC-positive samples, and one is also positive for E.coli fecal coliforms, system has an acute MCL violation.

[5] Fecal coliform and E. coli are bacteria whose presence indicates that the water may be contaminated with human or animal wastes. Disease-causing microbes (pathogens) in these wastes can cause diarrhea, cramps, nausea, headaches, or other symptoms. These pathogens may pose a special health risk for infants, young children, and people with severely compromised immune systems.

[6] Although there is no collective MCLG for this contaminant group, there are individual MCLGs for some of the individual contaminants:

- Trihalomethanes: bromodichloromethane (zero); bromoform (zero); dibromochloromethane (0.06 mg/L): chloroform (0.07mg/L).

- Haloacetic acids: dichloroacetic acid (zero); trichloroacetic acid (0.02 mg/L); monochloroacetic acid (0.07 mg/L). Bromoacetic acid and dibromoacetic acid are regulated with this group but have no MCLGs.

[7] The MCL values are the same in the Stage 2 DBPR as they were in the Stage 1 DBPR, but compliance with the MCL is based on different calculations. Under Stage 1, compliance is based on a running annual average (RAA). Under Stage 2, compliance is based on a locational running annual average (LRAA), where the annual average at each sampling location in the distribution system is used to determine compliance with the MCLs. The LRAA requirement will become effective April 1, 2012 for systems on schedule 1, October 1, 2012 for systems on schedule 2, and October 1, 2013 for all remaining systems.

[8] Lead and copper are regulated by a Treatment Technique that requires systems to control the corrosiveness of their water. If more than 10% of tap water samples exceed the action level, water systems must take additional steps. For copper, the action level is 1.3 mg/L, and for lead is 0.015 mg/L.

[9] Each water system must certify, in writing, to the state (using third-party or manufacturer's certification) that when acrylamide and epichlorohydrin are used in drinking water systems, the combination (or product) of dose and monomer level does not exceed the levels specified, as follows:

- Acrylamide = 0.05% dosed at 1 mg/L (or equivalent)

- Epichlorohydrin = 0.01% dosed at 20 mg/L (or equivalent)

List of National Secondary Drinking Water Regulations

(Set based on aesthetic considerations and not enforced for protection of public health)

Contaminant	Secondary Standard
Aluminum	0.05 to 0.2 mg/L
Chloride	250 mg/L
Color	15 (color units)
Copper	1.0 mg/L
Corrosivity	noncorrosive
Fluoride	2.0 mg/L
Foaming Agents	0.5 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Odor	3 threshold odor number
pH	6.5-8.5
Silver	0.10 mg/L
Sulfate	250 mg/L
Total Dissolved Solids	500 mg/L
Zinc	5 mg/L

Appendix B

BACKGROUND – WATER QUALITY STANDARDS & REGULATIONS

- ***Types Of Standards***

Drinking Water Quality Standards & Aquifer Water Quality Drinking water standards are set by EPA to protect public health from exposure based upon ingestion. The established list of primary drinking water standards (see Appendix A) contains numeric maximum contaminant limits (MCLs) for one type of micro-organism, four disinfection byproducts, fourteen inorganic compounds, fifty-one organic compounds, and four radionuclides. In addition to the primary standards, EPA has a list of compounds for which the agency has set secondary standards based solely upon aesthetic considerations for drinking water. The later list (see Appendix A) is generally not incorporated as standards for regulatory programs designed to protect human health.

EPA adds new primary drinking water standards in accordance with the 1996 Amendments to Safe Drinking Water Act. The process requires several steps to determine whether setting a standard is appropriate for a contaminant, and if so, what the protective level should be. Peer-reviewed scientific data must support an intensive technological evaluation considering many factors: occurrence in the environment; human exposure and risks of adverse health effects; analytical methods of detection; technical feasibility to implement the standard; and impacts of regulation on water systems, the economy and public health.

EPA must decide which contaminants to regulate based on health risks and the likelihood that the contaminant occurs in public water systems at levels of concern. Every five years the agency publishes a National Drinking Water Contaminant Candidate List (CCL) and includes on it substances that: (1) are not already regulated under SDWA; (2) may have adverse health effects; (3) are known or anticipated to occur in public water systems; and (4) may require regulations under SDWA. Appendix B contains the current CCL.

Every five years, EPA will select five or more contaminants from the regulatory priorities on the CCL and formally determine whether or not to regulate them. To support these decisions, EPA must determine that regulating the contaminants would present a meaningful opportunity to reduce health risk. The agency also selects unregulated contaminants from the CCL for monitoring by public water systems serving at least 100,000 people. Currently, most of the unregulated contaminants with potential of occurring in drinking water are pesticides and microbes. Every five years, EPA will repeat the cycle of revising the CCL, making regulatory determinations for five contaminants and identifying up to 30 contaminants for unregulated monitoring. In addition, every six years, EPA re-evaluates existing regulations to determine if modifications are necessary.

After reviewing health effects studies, where possible EPA sets a Maximum Contaminant Level Goal (MCLG), the maximum level of a contaminant in drinking water at which no known or anticipated adverse effect on the health of persons would occur, and which allows an adequate margin of safety. MCLGs are non-enforceable public health goals. Since MCLGs consider only public health and not the limits of detection and treatment technology, they may be set at a level which water systems cannot reasonably achieve. When determining an MCLG, EPA considers the risk to sensitive subpopulations (infants, children, the elderly, and those with compromised immune systems) of experiencing a variety of adverse health effects using an established rationale:

Non-Carcinogens (not including microbial contaminants): For chemicals that can cause adverse non-cancer health effects, the MCLG is based on the reference dose. A reference dose (RFD) is an estimate of the amount of a chemical that a person can be exposed to on a daily basis that is not anticipated to cause adverse health effects over a person's lifetime. In RFD calculations, sensitive subgroups are included, and uncertainty may span an order of magnitude. The RFD is multiplied by typical adult body weight (70 kg) and divided by daily water consumption (2 liters) to provide a Drinking Water Equivalent Level (DWEL). The DWEL is multiplied by a percentage of the total daily exposure contributed by drinking water (often 20 percent) to determine the MCLG. So, to potentially suffer the associated health effects of drinking water above the MCLG, a person would have to drink 2 liters (1 liter for VOCs) a day for 70 years to have a chance of developing the potential health effects (USEPA, "Drinking Water Standard Setting Question-and-Answer Primer", November 1994).

Chemical Contaminants -- Carcinogens: If there is evidence that a chemical may cause cancer, and there is no dose below which the chemical is considered safe, the MCLG is set at zero. If a chemical is carcinogenic and a safe dose can be determined, the MCLG is set at a level above zero that is safe.

Microbial Contaminants: For microbial contaminants that may present public health risk, the MCLG is set at zero because ingesting one protozoa, virus, or bacterium may cause adverse health effects. EPA is conducting studies to determine whether there is a safe level above zero for some microbial contaminants. So far, however, this has not been established.

Once the MCLG is determined, EPA considers other factors beyond the health effects to arrive at an enforceable standard. In most cases, the standard is a Maximum Contaminant Level (MCL), the maximum permissible level of a contaminant in water which is delivered to any user of a public water system. The MCL is set as close to the MCLG as feasible, and reflects the level that may be achieved with the use of the best available technology, treatment techniques, and other means which are available, taking cost

into consideration. When there is no reliable method that is economically and technically feasible to measure a contaminant at particularly low concentrations, a Treatment Technique (TT) is set rather than an MCL. Examples of Treatment Technique rules are the Surface Water Treatment Rule (disinfection and filtration) and the Lead and Copper Rule (optimized corrosion control).

Primary standards go into effect three years after they are finalized. If capital improvements are required, EPA's Administrator or a state may allow this period to be extended up to two additional years. Once EPA develops a new standard, the rule is sent to the states. States adopt and build upon drinking water standards based on their own laws and rules. In Arizona, ADEQ has primacy for drinking water rules and programs. This means EPA has granted ADEQ the right and responsibility to oversee this program. Under the ADEQ Primacy agreement, federal drinking water rules are incorporated into the Arizona Administrative Code so that they then become enforceable by the state.

Aquifer water quality standards (AWQSs) are set by the state of Arizona to protect all of its aquifers for drinking water use. These standards are adopted by rule and derived from EPA's primary drinking water MCLs. State statute requires addition of a compound to the AWQSs by ADEQ whenever EPA sets an MCL for a new compound as a primary drinking water standard. Arizona's Aquifer Water Quality Standards include a narrative standard (A.A.C. R18-11-405(A)) that can be applied to a substance that is not covered by any established numeric standard when it is present in an aquifer in a "concentration which endangers human health." Aquifer water quality standards serve as the benchmark for whether or not a discharge will impair the downgradient drinking water use of an aquifer. Furthermore, they serve as the goal for remediation in instances where an aquifer is contaminated and requires cleanup.

- ***Surface Water Quality Standards & Stream Uses***

Surface water protection requirements and activities are currently one of the primary regulatory drivers dictating treatment requirements at PCRWRD facilities. The 1972 Clean Water Act (substantially amended in 1987), and previous amendments of the Water Pollution Control Act of 1948, provides the current framework for surface water quality regulation in the United States and Arizona. The objective of the CWA is "to restore and maintain the chemical, physical, and biological integrity of the Nation's water" (Section 101(a)).

Section 303(c) of the Clean Water Act requires all states to, where appropriate, adopt and revise water quality standards at least once every three years. States must preserve and protect the quality of navigable waters and adopt surface water quality standards by considering the following factors:

- The protection of the public health and the environment;
- The uses that have been made, are being made, or with reasonable probability may be made of the waters;
- The provisions and requirements of the Clean Water Act, the Safe Drinking Water Act, and their implementing regulations;
- The degree to which standards for one category of water could cause violations of standards for other hydrologically-connected water categories (for example, ADEQ must consider the degree to which surface water quality standards could cause violations of aquifer water quality standards);
- Guidelines, action levels, or numeric criteria adopted or recommended by the U.S. Environmental Protection Agency (EPA) or any other federal agency; and
- Any unique, physical, biological, or chemical properties of the waters.

A.R.S. § 49-222 authorizes ADEQ to adopt surface water quality standards that assure water quality, if attainable, that provides for protecting the public health and welfare; to develop standards to enhance the quality of water in Arizona; and to take into consideration the use and value of water for public water supplies, the propagation of fish and wildlife, and recreational, agricultural, industrial, and other purposes. ADEQ is charged with adopting numeric surface water standards that establish numeric limits on the concentrations of each of the 126 toxic pollutants listed by EPA under § 307 of the Clean Water Act. In adopting numeric water quality standards, ADEQ may consider:

- The effect of local water quality characteristics on the toxicity of pollutants;
- The varying sensitivities of local affected aquatic populations to these pollutants; and
- The extent to which the natural flow of the stream is perennial, intermittent, effluent-dependent, or ephemeral.

While ADEQ may consider these site-specific factors in establishing water quality standards for ephemeral waters and effluent-dependent waters, any water quality standard adopted must be consistent with the requirements of the Clean Water Act. Section 303(c) of the Clean Water Act provides the basis in federal law for Arizona's surface water quality standards program. The key elements are:

- A water quality standard is defined as consisting of the designated beneficial uses of a water body and water quality criteria necessary to support the designated uses;
- The following minimum beneficial uses must be considered when establishing surface water quality standards under the Clean Water Act:
    - public water supply;
    - the propagation of fish, shellfish, and wildlife;

    - recreation;
    - agricultural uses;
    - industrial uses; and
    - navigation.
- Arizona's water quality standards must protect public health and welfare, enhance the quality of water, and serve the purposes of the Clean Water Act;
- The surface water quality standards rules must be reviewed at least once every three years using a process that includes public participation; and
- A process exists for EPA review of the surface water quality standards adopted by ADEQ.

EPA requires that ADEQ specify appropriate uses to be achieved and protected in Arizona's surface waters. These designated uses include domestic water source (DWS), fish consumption (FC), full body contact recreation (FBC), partial body contact recreation (PBC), aquatic and wildlife (cold water) (A&Wc), aquatic and wildlife (warm water) (A&Ww), aquatic and wildlife (effluent-dependent water) (A&Wedw), aquatic and wildlife (ephemeral water) (A&We), agricultural irrigation (AgI), and agricultural livestock watering (AgL). Individual surface waters in Arizona and their respective designated uses are specifically listed in ADEQ's SWQS rules.

PCRWRD facilities that are permitted to discharge to jurisdictional waters and the uses which must be protected include:

- Avra Valley WWTF - Black Wash; Aquatic & Wildlife (ephemeral), Partial Body Contact.
- Green Valley WWTF - Santa Cruz River (Tubac Bridge to Roger Road WWTP Outfall); Aquatic & Wildlife (ephemeral), Partial Body Contact, Agricultural Livestock.
- Ina Road WPCF - Santa Cruz River (Roger Road WWTP Outfall to Baumgartner Road); Aquatic & Wildlife (effluent-dependent water), Partial Body Contact.
- Kino ERP – Santa Cruz River (Tubac Bridge to Roger Road WWTP Outfall); Aquatic & Wildlife (ephemeral), Partial Body Contact, Agricultural Livestock.
- Marana WWTF – Santa Cruz River (Roger Road WWTP Outfall to Baumgartner Road); Aquatic & Wildlife (effluent-dependent water), Partial Body Contact.
- Mount Lemmon WWTF – Unnamed Wash; Aquatic & Wildlife (ephemeral), Partial Body Contact.
- Roger Road WWTP - Santa Cruz River (Roger Road WWTP Outfall to Baumgartner Road); Aquatic & Wildlife (effluent-dependent water), Partial Body Contact.

Water quality criteria are established to protect the designated uses and include both narrative and numeric criteria. The narrative criteria generally require all waters, regardless of the designated uses, be "free from pollutants in amounts or combinations" that could have various adverse effects, such as being "toxic to humans, animals, plants, or other organisms." The numeric criteria provide protection for each of the designated uses; the numeric thresholds vary depending on the type of receptor (e.g., humans, fish or wildlife). Where the identified use is drinking water, the drinking water MCLs become the SWQS. Where the identified use is full body or partial body contact, ADEQ uses the drinking water standards to calculate the standard based on ingestion that would be likely during those types of activities.

With regard to inclusion of emerging contaminants in SWQSs, ADEQ states in their most recent rule package explanatory statement, "Research has just begun and little data currently exists about the consequences of PPCPs on human health or aquatic life. Currently, there is no basis for developing scientifically defensible water quality standards for PPCPs. ADEQ will follow the development of the regulation and science concerning these pollutants. Although ADEQ does not have detailed plans for where and when testing for these pollutants will occur, ADEQ has conceptual plans to conduct environmental testing over the coming years and will continue to support university research on this matter as resources allow." This statement responds to a commenter asking specifically about PPCPs, but most other emerging contaminants have a similar status.

- ***EPA Review of Arizona's Surface Water Quality Standards***

ADEQ is required to submit new and revised water quality standards to the Region 9 Administrator of the EPA for review. EPA Region 9 reviews the rules to determine whether they are consistent with the requirements of the Clean Water Act and EPA's Water Quality Standards Regulation at 40 CFR 131. Under § 303(c)(4) of the Clean Water Act, EPA may federally promulgate water quality standards if the Regional Administrator disapproves a water quality standard and ADEQ does not adopt the necessary revisions as specified by EPA.

- ***Reclaimed Water Quality Standards***

Reuse Standards

In accordance with A.R.S. §49-221(E), ADEQ has adopted by rule standards for direct reuse of reclaimed water. The Reclaimed Water Quality Standards rule (A.A.C. Title 18, Chapter 11, Article 3) establishes five classes of reclaimed water expressed as a combination of minimum treatment requirements and a limited set of numeric reclaimed water quality criteria.

Class A reclaimed water is required for reuse applications where there is a relatively high risk of human exposure to potential pathogens in the reclaimed water. Class A must be produced through secondary treatment, filtration and disinfection to achieve low levels of pathogens. It is generally described as "an essentially coliform-free product."

For uses where the potential for human exposure is not as likely, Class B reclaimed water may be appropriate. Class B reclaimed water is achieved by secondary treatment combined with disinfection to a level that is consistent with partial body contact considerations.

Class C reclaimed water is produced with an older treatment technology, stabilization lagoons, combined with minimal disinfection. Class C reuse is only acceptable in agricultural applications and other uses likely to occur in rural or remote settings.

The Reclaimed Water Quality Standards allow for two "+" categories of reclaimed water, Class A+ and Class B+. Both categories require treatment to remove nitrogen to a concentration of less than 10 mg/l. These categories of reclaimed water minimize concerns over nitrate contamination of groundwater beneath sites where reclaimed water is applied. As a result, the general permits for the direct reuse of Class A+ and Class B+ reclaimed water do not include nitrogen management as a condition of the reuse. The reclaimed standards do not require wastewater providers to achieve the "+" designation. Instead, the incentive to treat to the "+" classification lies in more lenient permit conditions regarding reporting, application rates, and lining for impoundments.

Drinking Water Regulatory Requirements

ADEQ Primacy. Currently, EPA has developed National Primary Drinking Water Regulations (NPDWRs) for synthetic organic chemicals (SOCs), volatile organic chemicals (VOCs), inorganic chemicals (IOCs), radionuclides, and microbiologicals. SOCs are manmade chemicals such as pesticides and industrial chemicals. VOCs are manmade volatile chemicals that can move easily from water to air. Most VOCs are industrial chemicals. IOCs are metals and minerals that can occur naturally or be introduced by humans. Radionuclides are radioactive contaminants that can occur naturally or be introduced by humans. Currently, there are 90 primary contaminants, 15 secondary contaminants, and 25 unregulated contaminants.

These standards are part of the Safe Drinking Water Act's "multiple barrier" approach to drinking water protection, which includes assessing and protecting drinking water sources; protecting wells; making sure water is treated by qualified operators; ensuring the integrity of distribution systems; and making information available to the public on the quality of their drinking water. With the involvement of EPA, states, tribes, drinking water utilities, communities and citizens, these multiple barriers ensure that tap water in the United States and territories is safe to drink. In most cases, EPA delegates responsibility for implementing drinking water standards to states and tribes. EPA has granted the Arizona Department of Environmental Quality (ADEQ) the right and responsibility to oversee the NPDWR program. As a primacy agency, ADEQ adopts and builds upon the NPDWRs based on their own laws and rules. After the NPDWRs are incorporated by reference into ADEQ's Arizona Administrative Code (A.A.C.), they then become enforceable. ADEQ can take legal action against systems that fail to provide water that meets these standards. Penalties of up to $25,000 per day may be assessed for every day a PWS fails to comply.

PWSs in Arizona, such as TW, must comply with the NPDWRs that ADEQ adopts in order to serve drinking water. Water systems must test and treat their water, maintain the distribution systems that deliver water to consumers, and report on their water quality to ADEQ and the public. Staff in the Water Quality Management Division (WQMD) of TW is responsible for interpreting the NPDWR, identifying the requirements, and assisting in implementing regulations on their effective date (usually 18 months are the effective date of the NPDWR).
Drinking Water Contaminant Lists
The drinking water contaminants PWSs are required to monitor for are found on three major listings:

- National Primary Drinking Water Contaminants
- National Secondary Drinking Water Contaminants
- Unregulated Contaminant List

The lists also contain MCL and TT levels and potential health effects and sources of contaminants. Note that each NPDWR does not apply universally to all PWSs. Each NPDWR specifies which type of water system must follow it.

TW's Optimized Monitoring and Operational Policies and Strategies. Managing groundwater system compliance is becoming increasingly complicated. The WQMD has adopted the following monitoring and operational policies to assist in complying with the Drinking Water Compliance Program while balancing the operational needs to deliver water to our customers. The following policies are intended to improve compliance and reliability because the results generated from the policies are used to evaluate and optimize the system:

- Volatile Organic Chemical Monitoring and Operations
- Operating Drinking Water Wells with Potential for Exceeding the MCLs
- Sampling Inactive Wells and Notification to ADEQ When Activating Wells
- Operating New Source Wells that Exceed NPDWR's MCLs or Alert Levels

Without careful planning and implementation, actions intended to improve water quality in distribution systems can produce serious unintended water quality consequences – especially in the areas of microbial regrowth, corrosion, stability of existing pipe scales, and aesthetics. The WQMD have adopted the following monitoring and operational strategies to assist in improving water quality:

- Chlorine Target Levels
- Blending Strategies
- pH Adjustment and Corrosion
- 1,4-Dioxane
- Extended Parameters

Surface Water Regulatory Requirements. Surface water quality standards are essential elements of several important water quality management programs including: Arizona Pollutant Discharge Elimination System (AZPDES) permitting; the § 305(b) water quality assessment and § 303(d) impaired water listing; and total maximum daily load (TMDL) programs.

AZPDES Permit Program. Surface water quality standards are used to regulate point source discharges of pollutants under the AZPDES permit program authorized under § 402 of the Clean Water Act. These permits require compliance with effluent limits that are either technology-based or based upon meeting the SWQSs.

Technology-based limits for a wastewater reclamation facility are set for certain constituents (e.g., biochemical oxygen demand and total suspended solids) based upon secondary treatment criteria. Water quality-based limits (WQBELs) are required in the AZPDES permit where it is determined that, despite technology-based limits, the effluent discharge has a reasonable potential to cause an exceedence of a receiving water quality standard. Because effluent-dependent waters are created by effluent discharge with no dilution from other flow, applicable water quality-based effluent limits are typically equivalent to the water quality criteria. WQBELs are more stringent than technology-based limits and ultimately affect the level of treatment that a discharger must provide to control pollutants added to surface waters in Arizona.

AZPDES permits also require Whole Effluent Toxicity (WET) testing to implement the narrative toxics criterion. Through the use of indicator test species, WET tests are intended to assess the cumulative or synergistic toxic effects associated with the effluent discharge. The most commonly used WET test species include: a fish (Pimephales promelas, fathead minnow); water flea (Ceriodaphnia dubia or Daphnia magna); and a green algae species (Selenastrum capricornutum). WET testing may assess both short-term, acute effects (mortality endpoint) and long-term, chronic effects (growth and reproduction endpoints). WET testing functions as a "proxy" for directly monitoring specific compounds that might be toxic alone or in combination with other pollutants present in the discharge.

Section 305(b) Water Quality Assessment and § 303(d) Impaired Water Listing. Section 305(b) of the Clean Water Act requires ADEQ to monitor surface waters within its boundaries and to prepare a biennial report describing the status of water quality in Arizona rivers, streams, lakes, and reservoirs. The § 305(b) water quality assessment process is the primary means by which ADEQ evaluates whether water bodies in Arizona are meeting surface water quality standards, that progress has been made in maintaining and restoring surface water quality, and the extent of remaining water quality problems. The surface water quality standards are the benchmarks to assess water quality status and identify which waters in Arizona are water quality-limited or impaired.

Total Maximum Daily Load (TMDL) Program. Under § 303(d) of the Clean Water Act, ADEQ is required to develop TMDL analyses for impaired water bodies that do not meet one or more surface water quality standards. A TMDL is a calculation of the maximum "loading" of a pollutant that a water body can receive and still meet its designated surface water quality standards. The TMDL allocates that amount among the point and non-point sources in the watershed that discharge the pollutant of concern. This pollutant "budget" is implemented through ADEQ water quality management programs such as the AZPDES permit program and the § 319 Non-Point Source Program. The ultimate goal of a TMDL is restoration of water quality so that an impaired water attains surface water quality standards for all of its uses.

Other ADEQ Programs Using Surface Water Quality Standards. Section 319 of the Clean Water Act requires ADEQ to identify surface waters in Arizona that, without additional controls to control non-point sources of pollution cannot be reasonably expected to attain or maintain applicable water quality standards or the goals and requirements of the Clean Water Act. Management measures and best management practices (BMPs) are the primary mechanisms in § 319 of the Act to enable achievement of surface water quality standards. ADEQ administers the Water Quality Improvement Grant program that provides financial assistance to projects that control the discharge of pollutants to surface waters from non-point sources with a goal of achieving applicable water quality standards. Under § 401 of the Clean Water Act, ADEQ may grant, condition, or deny water quality certification for a federally permitted or licensed activity that may result in a discharge to a surface water in Arizona.

- *Groundwater Regulatory Requirements*

Aquifer Protection Permits

The Aquifer Protection Permit (APP) Program was established in 1986 to regulate discharge to groundwater and to protect all of Arizona's aquifers for drinking water use. Any facility discharging to an aquifer must seek a permit from ADEQ. Municipal wastewater facilities that are generally considered to be discharging include wastewater treatment plants, impoundments, point source outfalls to surface water bodies, injection wells, and constructed wetlands. There are two major controls used by this program to regulate water quality. One control is a technology-based requirement for the treatment process called Best Available Demonstrated Control Technology (BADCT). The second control relies on the Aquifer Water Quality Standards.

The BADCT portion of APP regulations requires the application of current technology to reduce or eliminate the discharge of pollutants to the greatest extent practicable. BADCT for wastewater treatment is defined in rule (A.A.C. R18-9-B204 for new facilities or facilities undergoing major modification and A.A.C. R18-9-B205 for existing facilities). The optimal treatment outlined in BADCT is to achieve secondary treatment enhanced by nitrogen removal and disinfection. For metals, VOCs, pesticides, and radionuclides that have numeric AWQSs, BADCT requires meeting those levels. Organic carcinogens and organic toxic pollutants are addressed under BADCT by instituting a pretreatment program. Also under BADCT the production of THMs as a byproduct of disinfection is to be minimized. The specific treatment technology and design may be negotiated on a case-specific basis for most discharges, and soil aquifer treatment may be demonstrated for either nitrogen removal, pathogen removal, or removal of other compounds susceptible to adsorption and biodegradation in the vadose zone.

Ultimately the APP Program disallows any discharge that has the potential to cause or contribute to a violation of an aquifer water quality standard at a downgradient point of compliance. The point of compliance is set to protect all current and reasonably foreseeable uses of the aquifer. Monitoring at the point of compliance is incorporated into the permit along with alert levels that may serve as early warning indicators of a potential violation of AWQS.

Reclaimed Water Regulatory Requirements

ADEQ's reclaimed water regulations apply to wastewater treatment facilities supplying reclaimed water and to the sites where reclaimed water is applied or used. Reclaimed water permits stipulate controls at the site of reclaimed water application, but a Reclaimed Water Individual Permit or Reclaimed Water General Permit is required if you are:

- An end user
- An owner or operator of a reclaimed water blending facility
- A reclaimed water agent
- A person who uses gray water

All wastewater treatment facilities providing reclaimed water for reuse must have an individual Aquifer Protection Permit (APP) certifying the particular class (A+, A, B+, B or C) of reclaimed water produced at that facility. Seven of Pima County's WRFs and Tucson Water's Reclaimed Filtration Plant hold APP's that certify the facilities for a reuse class. If certified for reuse, a treatment facility's APP requires certain treatment technology, monitoring and reporting of reclaimed water quality to ensure that effluent limitations for the specified reclaimed water quality class is met. It is the responsibility of the end user to assure that the class of reclaimed water they are supplied is appropriate to their use. ADEQ recognizes that reclaimed water may change hands more than once between the place of treatment and the final end user. Therefore, permitting options are provided for reclaimed water blending facilities and reclaimed water agents.

A reclaimed water blending facility receives reclaimed water of a certain class and improves the quality by blending the reclaimed water with water from one or more additional sources. The improved quality of the resultant reclaimed water allows more or different reuse applications than the original quality would have allowed.

ADEQ regulations provide an option for a person or entity to act as a reclaimed water agent representing multiple end users. The reclaimed water agent operates under a general or individual reclaimed water permit and allows end users to receive reclaimed water for appropriate reuse applications. The agent obtains permit coverage and handles reporting to the department for all end users on the system. Tucson Water is a reclaimed water agent for the City's reclaimed system. Most of Pima County's reclaimed water that it applies is wheeled through the City's system, and the county is covered by Tucson Water's permit as a Reclaimed Water Agent.

Appendix C

EPA's Most Recent Contaminant Candidate List

CCL 3 Candidates

Microbial Contaminant Candidates

Microbial Contaminant Name	Information
Caliciviruses	Virus (includes Norovirus) causing mild self-limiting gastrointestinal illness
Campylobacter jejuni	Bacterium causing mild self-limiting gastroentestinal illness
Entamoeba histolytica	Protozoan parasite which can cause short as well as long-lasting gastrointestinal illness
Escherichia coli (0157)	Toxin-producing bacterium causing gastrointestinal illness and kidney failure
Helicobacter pylori	Bacterium sometimes found in the environment capable of colonizing human gut that can cause ulcers and cancer
Hepatitis A virus	Virus that causes a liver disease and jaundice
Legionella pneumophila	Bacterium found in the environment including hot water systems causing lung diseases when inhaled
Naegleria fowleri	Protozoan parasite found in shallow, warm surface and ground water causing primary amebic meningoencephalitis
Salmonella enterica	Bacterium causing mild self-limiting gastrointestinal illness
Shigella sonnei	Bacterium causing mild self-limiting gastrointestinal illness and bloody diarrhea
Vibrio cholerae	Bacterium found in the environment causing gastrointestinal illness

Chemical Contaminant Candidates

Contaminant	CASRN[1]	Information about the contaminant
alpha-Hexachlorocyclohexane	319-84-6	It is a component of benzene hexachloride (BHC) and was formerly used as an insecticide.
1,1,1,2-Tetrachloroethane	630-20-6	It is an industrial chemical used in the production of other substances.
1,1-Dichloroethane	75-34-3	It is an industrial chemical used as a solvent.
1,2,3-Trichloropropane	96-18-4	It is an industrial chemical used in paint manufacture.
1,3-Butadiene	106-99-0	It is an industrial chemical used in rubber production.
1,3-Dinitrobenzene	99-65-0	It is an industrial chemical and is used in the production of other substances.
1,4-Dioxane	123-91-1	It is used as a solvent or solvent stabilizer in the manufacture and processing of paper, cotton, textile products, automotive coolant, cosmetics and shampoos.
1-Butanol	71-36-3	It is used in the production of other substances, and as a paint solvent and food additive.
2-Methoxyethanol	109-86-4	It is used in consumer products, such as synthetic cosmetics, perfumes, fragrances, hair preparations, and skin lotions.
2-Propen-1-ol	107-18-6	It is used in the production of other substances, and in the manufacture of flavorings and perfumes.
3-Hydroxycarbofuran	16655-82-6	It is a carbamate, and is a pesticide degradate. The parent, carbofuran, is used as an insecticide.
4,4'-Methylenedianiline	101-77-9	It is used in the production of other substances, and as a corrosion inhibitor and curing agent for polyurethanes.
Acephate	30560-19-1	It is used as an insecticide.
Acetaldehyde	75-07-0	It is used in the production of other substances, and as a pesticide and food additive.
Acetamide	60-35-5	It is used as a solvent, solubilizer, plasticizer, and stabilizer.
Acetochlor	34256-82-1	It is used as an herbicide for weed control on agricultural crops.
Acetochlor ethanesulfonic acid (ESA)	187022-11-3	Acetochlor ESA is an acetanilide pesticide degradate. The parent, acetochlor, is used as an herbicide for weed control on agricultural crops.
Acetochlor oxanilic acid (OA)	184992-44-4	Acetochlor OA is an acetanilide pesticide degradate. The parent, acetochlor, is used as an herbicide for weed control on agricultural crops.
Acrolein	107-02-8	It is used as an aquatic herbicide, rodenticide, and industrial chemical.
Alachlor ethanesulfonic acid (ESA)	142363-53-9	Alachlor ESA is an acetanilide pesticide degradate. The parent, alachlor, is used as an herbicide for weed control on agricultural crops.
Alachlor oxanilic acid (OA)	171262-17-2	Alachlor OA is an acetanilide pesticide degradate. The parent, alachlor, is used as an herbicide for weed control on agricultural crops.
Aniline	62-53-3	It is used as an industrial chemical, as a solvent, in the synthesis of

Contaminant	CASRN[1]	Information about the contaminant
		explosives, rubber products, and in isocyanates.
Bensulide	741-58-2	It is used as an herbicide.
Benzyl chloride	100-44-7	It is used in the production of other substances, such as plastics, dyes, lubricants, gasoline and pharmaceuticals.
Butylated hydroxyanisole	25013-16-5	It is used as a food additive (antioxidant).
Captan	133-06-2	It is used as a fungicide.
Chloromethane (Methyl chloride)	74-87-3	It is used as a foaming agent and in the production of other substances.
Clethodim	110429-62-4	It is used as an herbicide.
Cobalt	7440-48-4	It is a naturally-occurring element and was formerly used as cobaltus chloride in medicines and as a germicide.
Cumene hydroperoxide	80-15-9	It is used as an industrial chemical and is used in the production of other substances.
Cyanotoxins (3)*		Toxins naturally produced and released by cyanobacteria ("blue-green algae"). Various studies suggest three cyanotoxins for consideration: Anatoxin-a, Microcystin-LR, and Cylindrospermopsin.
Dicrotophos	141-66-2	It is used as an insecticide.
Dimethipin	55290-64-7	It is used as an herbicide and plant growth regulator.
Dimethoate	60-51-5	It is used as an insecticide on field crops, (such as cotton), orchard crops, vegetable crops, in forestry and for residential purposes.
Disulfoton	298-04-4	It is used as an insecticide.
Diuron	330-54-1	It is used as an herbicide.
Ethion	563-12-2	It is used as an insecticide.
Ethoprop	13194-48-4	It is used as an insecticide.
Ethylene glycol	107-21-1	It is used as an antifreeze, in textile manufacture and is a cancelled pesticide.
Ethylene oxide	75-21-8	It is used as a fungicidal and insecticidal fumigant.
Ethylene thiourea	96-45-7	It is used in the production of other substances, such as for vulcanizing polychloroprene (neoprene) and polyacrylate rubbers, and as a pesticide.
Fenamiphos	22224-92-6	It is used as an insecticide.
Formaldehyde	50-00-0	It has been used as a fungicide, may be a disinfection byproduct, and can occur naturally.
Germanium	7440-56-4	It is a naturally-occurring element and is commonly used as germanium dioxide in phosphors, transistors and diodes, and in electroplating.
HCFC-22	75-45-6	It is used as a refrigerant, as a low-temperature solvent, and in fluorocarbon resins, especially in tetrafluoroethylene polymers.
Hexane	110-54-3	It is used as a solvent and is a naturally-occurring alkane.
Hydrazine	302-01-2	It is used in the production of other substances, such as rocket propellants, and as an oxygen and chlorine scavenging compound.
Methamidophos	10265-92-6	It is used as an insecticide.
Methanol	67-56-1	It is used as an industrial solvent, a gasoline additive and also as anti-freeze.
Methyl bromide (Bromomethane)	74-83-9	It has been used as a fumigant as a fungicide.
Methyl tert-butyl ether	1634-04-4	It is used as an octane booster in gasoline, in the manufacture of isobutene and as an extraction solvent.
Metolachlor	51218-45-2	It is used as an herbicide for weed control on agricultural crops.
Metolachlor ethanesulfonic acid (ESA)	171118-09-5	Metolachlor ESA is an acetanilide pesticide degradate. The parent, metolachlor, is used as an herbicide for weed control on agricultural crops.
Metolachlor oxanilic acid (OA)	152019-73-3	Metolachlor OA is an acetanilide pesticide degradate. The parent, metolachlor, is used as an herbicide for weed control on agricultural crops.
Molinate	2212-67-1	It is used as an herbicide.
Molybdenum	7439-98-7	It is a naturally-occurring element and is commonly used as molybdenum trioxide as a chemical reagent.
Nitrobenzene	98-95-3	It is used in the production of aniline, and also as a solvent in the manufacture of paints, shoe polishes, floor polishes, metal polishes, explosives, dyes, pesticides and drugs (such as acetaminophen), and in its re-distilled form (oil of mirbane) as an inexpensive perfume for soaps.
Nitrofen	1836-75-5	It is used as an herbicide.

Contaminant	CASRN[1]	Information about the contaminant
Nitroglycerin	55-63-0	It is used in pharmaceuticals, in the production of explosives, and in rocket propellants.
N-Methyl-2-pyrrolidone	872-50-4	It is a solvent in the chemical industry, and is used for pesticide application and in food packaging materials.
N-nitrosodiethylamine (NDEA)	55-18-5	It is a nitrosamine used as an additive in gasoline and in lubricants, as an antioxidant, as a stabilizer in plastics, and also may be a disinfection byproduct.
N-nitrosodimethylamine (NDMA)	62-75-9	It is a nitrosamine and has been formerly used in the production of rocket fuels, is used as an industrial solvent and an anti-oxidant, and also may be a disinfection byproduct.
N-nitroso-di-n-propylamine (NDPA)	621-64-7	It is a nitrosamine and may be a disinfection byproduct.
N-Nitrosodiphenylamine	86-30-6	It is a nitrosamine chemical reagent that is used as a rubber and polymer additive and may be a disinfection byproduct.
N-nitrosopyrrolidine (NPYR)	930-55-2	It is a nitrosamine used as a research chemical and may be a disinfection byproduct.
n-Propylbenzene	103-65-1	It is used in the manufacture of methylstyrene, in textile dyeing, and as a printing solvent, and is a constituent of asphalt and naptha.
o-Toluidine	95-53-4	It is used in the production of other substances, such as dyes, rubber, pharmaceuticals and pesticides.
Oxirane, methyl-	75-56-9	It is an industrial chemical used in the production of other substances.
Oxydemeton-methyl	301-12-2	It is used as an insecticide.
Oxyfluorfen	42874-03-3	It is used as an herbicide.
Perchlorate	14797-73-0	It is both a naturally occurring and man-made chemical. Most of the perchlorate manufactured in the United States is used as the primary ingredient of solid rocket propellant.
Permethrin	52645-53-1	It is used as an insecticide.
PFOA (perfluorooctanoic acid)	335-67-1	It is used for its emulsifier and surfactant properties in or as fluoropolymers (such as Teflon), fire-fighting foams, cleaners, cosmetics, greases and lubricants, paints, polishes and adhesives and photographic films.
Profenofos	41198-08-7	It is used as an insecticide and an acaricide.
Quinoline	91-22-5	It is used in the production of other substances, and as a pharmaceutical (anti-malarial) and as a flavoring agent.
RDX (Hexahydro-1,3,5-trinitro-1,3,5-triazine)	121-82-4	It is used as an explosive.
sec-Butylbenzene	135-98-8	It is used as a solvent for coating compositions, in organic synthesis, as a plasticizer and in surfactants.
Strontium	7440-24-6	It is naturally-occurring element and is used as strontium carbonate in pyrotechnics, in steel production, as a catalyst and as a lead scavenger.
Tebuconazole	107534-96-3	It is used as a fungicide.
Tebufenozide	112410-23-8	It is used as an insecticide.
Tellurium	13494-80-9	It is a naturally-occurring element and is commonly used as sodium tellurite in bacteriology and medicine.
Terbufos	13071-79-9	It is used as an insecticide.
Terbufos sulfone	56070-16-7	Terbufos sulfone is a phosphorodithioate pesticide degradate. The parent, terbufos, is used as an insecticide.
Thiodicarb	59669-26-0	It is used as an insecticide.
Thiophanate-methyl	23564-05-8	It is used as a fungicide.
Toluene diisocyanate	26471-62-5	It is used in the manufacture of plastics.
Tribufos	78-48-8	It is used as an insecticide and as a cotton defoliant.
Triethylamine	121-44-8	It is used in the production of other substances, and as a stabilizer in herbicides and pesticides, in consumer products, in food additives, in photographic chemicals and in carpet cleaners.
Triphenyltin hydroxide (TPTH)	76-87-9	It is used as a pesticide.
Urethane	51-79-6	It is used as a paint ingredient.
Vanadium	7440-62-2	It is a naturally-occurring element and is commonly used as vanadium pentoxide in the production of other substances and as a catalyst.
Vinclozolin	50471-44-8	It is used as a fungicide.
Ziram	137-30-4	It is used as a fungicide.

[1] Chemical abstract service registry numbers are used in reference works, databases, and regulatory compliance documents by many organizations around the world to identify substances with a standardized name.

APPENDIX D

LIST OF ABBREVIATIONS

A.A.C.	Arizona Administrative Code
AOP	Advanced Oxidation Process
CAP	Central Arizona Project
CAVSARP	Central Avra Valley Storage and Recovery Project
CCL	Contaminant Candidate List
CCR	Consumer Confidence Report
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COT	City of Tucson
DBPs	Disinfection-By-Products
EMPACT	Environmental Monitoring for Public Access and Community Tracking
EPA	U.S. Environmental Protection Agency
EPDS	Entry Point to the Distribution System
ERCS	Environmental and Regulatory Compliance Section
ES	Environmental Scientist
E.coli	Escherichia coli
FOP	Field Operations Plan
GWR	Ground Water Rule
GIS	Geographic Information System
HA	Health Advisory
IOC	Inorganic Chemicals
kg	kilogram
L	liter
MCL	maximum contaminant level
MDL	method detection limit
mg	milligram
mg/L	milligrams per liter (equivalent to parts per million [ppm])
µg	microgram (one-millionth of a gram)
MGD	million gallons per day
NPDWRs	National Primary Drinking Water Regulations
NRC	National Research Council
NWF	North Well Field
OSHA	Occupational Safety and Health Administration
OW	Office of Water
PBPK	Physiologically-Based Pharmacokinetic
PIO	Public Information Office
PNR	Public Notice Rule
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
pCi/L	pico-couries per liter
PPCP	pharmaceutical and personal care products
ppm	parts per million
PRV	pressure regulating valve
PWS	public water system
R&D	Research and Development
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SOCs	Synthetic Organic Chemicals
SWF	South Well Field
TARP	Tucson Airport Remediation Project
TAA	Tucson Airport Authority
TDS	total dissolved solids
TIAA	Tucson International Airport Authority
TCE	trichloroethylene or trichloroethene
TCR	Total Coliform Rule
TFP	tertiary filtration plant
TT	treatment technique
TTHM	Total trihalomethanes
TW	Tucson Water
TWQL	TW Quality Laboratory

UCMR	Unregulated Contaminant Monitoring Regulation
VOCs	Volatile Organic Chemicals
WQA	Water Quality Analyst
WQMD	Water Quality Management Division
WSA	Water Service Area
WTP	Water Treatment Plant
WTPO	Water Treatment Plant Operators

Appendix E

Global Water Research Coalition

SCIENCE BRIEF

OCCURRENCE AND POTENTIAL FOR HUMAN HEALTH IMPACTS OF PHARMACEUTICALS IN THE WATER SYSTEM

Detections of pharmaceuticals in water systems raise understandable concerns about the potential implications for public health. Research organizations around the world including members of the Global Water Research Coalition (GWRC), are exploring these implications and assessing the risks through a number of extensive peer-reviewed research projects. This paper is a synthesis of nine recently published reports that address the occurrence and potential for human health impacts of pharmaceuticals in the water system. Synopses of these reports are attached. They are principally review documents that summarize previously published research.

Although the nine reports were commissioned for various purposes, they present consistent findings across the topics of occurrence and health impacts. It can be concluded from these reports that, to date, no definitive link has been reported or established between human exposure to pharmaceutical exposure in drinking water and human health risk. Put another way, there is no known impact on human health.

Even though the trace levels of detected pharmaceuticals present a very low health risk (there is no "zero risk" in today's environment), the water sector continues to investigate the issues and to invest in treatment technologies to safeguard the quality of drinking water today and for the future.

Detections of pharmaceuticals in water systems are not new

As long as humans use prescription medicines and over-the-counter drugs, we will find trace amounts in wastewater, surface water, groundwater and drinking water. Scientists first found pharmaceuticals in wastewater during the 1970s when they detected lipid regulators and aspirin but, of course, pharmaceuticals have been in the water environment since they were put on the market.

Today's methods can detect concentrations as low as one part per trillion of many compounds, and even lower concentrations in some cases. We hear more reports about the presence of pharmaceuticals in water mainly because of improvements of the analytical methods of detection. What was not detectable in the past has become detectable today, even at very low concentrations.

It is only just recently that advances in analytical technology have made it possible to detect and quantify nearly any compound known to humankind at diminishingly low concentrations in water.

Methods of detection are not available for all pharmaceuticals, and new pharmaceuticals are developed every year, which may require new methodologies to enable their detection in water.

There is no known impact on public health

Since human medicines are intended for human consumption, the pharmaceutical manufacturers have developed much data on human health effects, for both cancer and non-cancer (including developmental) endpoints.

With that information, researchers and regulatorscancomparethehighest concentrations reported to date in drinking water to the provisional safe levels that are derived from the toxicological data.

The comparisons lead to the conclusion that adverse human health effects through exposure to pharmaceuticals in drinking water are highly unlikely. In fact, according to the literature summarized in the nine reports, to date no definitive link between pharmaceutical exposure in drinking water and human health risk has been reported nor established.

Multiple reports have explained that if a person – over their lifetime – consumed drinking water with the reported levels of pharmaceuticals, that person would consume only 5 percent (or less) of one daily therapeutic dose of an individual pharmaceutical during their whole life.

The issue of mixtures, that is the simultaneous presence of multiple pharmaceuticals, is an ever present question for trace residual compounds of all types in drinking water supplies. The guidelines for "provisionally safe" or "acceptable intake" levels are calculated separately for individual compounds. However, the "worst case scenario" approach used in screening risk assessment includes large uncertainty factors and safety factors and is considered by regulatory and health authorities (e.g., the World Health Organization in their Drinking Water Quality Guidelines) to be sufficient to account for possible interactions among compounds a person might be exposed to simultaneously.

The water sector invests in processes to detect and remove pharmaceuticals

Around the world, the water industry is developingandimplementingadvanced treatment processes that may lower the concentrations of pharmaceuticals to non-detectable levels. Even the most advanced and expensive wastewater and drinking water treatment processes, however, will not be able to remove all pharmaceutical residues to zero. In addition, as scientific advancements improve our analytical methods, in the future it is entirely likely that we will detect compounds that are currently non-detectable.

The aging population and more pharmaceutical development are two driving factors behind an expectation that increased pharmaceutical use will result in higher levels of trace residues in water. On the other hand, reducing the use of pharmaceuticals, or otherwise reducing their release into the water system, would reduce the level of trace residues. Efforts are underway that may reduce their release (e.g., targeted dosing, advanced treatment, take back programs, etc.).

These reductions, in turn, may lead to reduced residues that pass through municipal wastewater treatment into surface and ground water and eventually end up as trace amounts in drinking water.

Although the concentrations in drinking water are very low, and current information indicates health effects in humans are highly unlikely, both from an absolute standpoint as well as relative to health risks from other activities, continued vigilance is still appropriate. In addition, by providing water quality data the water sector proactively supports the pharmaceutical industry to evaluate and improve their wastewater treatment systems and reduce their emissions to the aquatic environment.

The water sector takes seriously its responsibility to safeguard water quality, and will continue to invest in the further improvement of analytical methods and in water treatment technology and processes.

GLOBAL WATER RESEARCH COALITION –The Global Water Research Coalition (GWRC) was established in 2002 as a non-profit international partnership among leading water research organisations. The 14 member organisations are:
Anjou Recherche – Water Operations Research Center of Veolia Water (France); EAWAG – Swiss Federal Institute for Aquatic Science and Technology; KWR – Watercycle Research Institute (Netherlands); PUB – National Water Agency of Singapore; SUEZ Environmental – CIRSEE – International Research Center on Water and Environment (France); Stowa – Foundation for Applied Water Management Research (Netherlands); TZW - Water Technology Center of the German Waterworks Association; UKWIR - UK Water Industry Research; Water Environment Research Foundation (USA); WQRA - Water Quality Research Australia; WRC - Water Research Commission (South Africa); Water Research Foundation (USA); WateReuse Foundation (USA); WSAA - Water Services Association of Australia(For information: www.globalwaterresearchcoalition.net)

OCCURRENCE AND POTENTIAL FOR HUMAN HEALTH IMPACTS OF PHARMACEUTICALS IN THE WATER SYSTEM

Synopses of the Scope, Findings and Conclusions from the Nine Reports

Geneesmiddelen in bronnen voor drinkwater (Pharmaceuticals in source waters for water supply)
This 2008 paper prepared by the National Institute for Public Health and the Environment (RIVM) in the Netherlands uses data on the consumption rates of prescribed pharmaceuticals, provided by pharmacies through the Foundation for Pharmaceutical Statistics, to predict surface water concentrations. The consumption of pharmaceuticals in the Netherlands is increasing due to an expanding population and the proportional increase in the ageing population. In the absence of emission reduction measures, the residues of pharmaceuticals may pass through sewage water into surface water. Therefore, measures at the source including the separate treatment of various types of wastewater are currently being tested in pilot projects by several hospitals in the Netherlands. The effectiveness of urine source separation in office buildings is also being tested. Such measures will most likely be most effective at the local level. In addition, advanced sewage treatment technologies show a particularly great potential for reducing the emission of pharmaceuticals.

Desk Based Review of Current Knowledge on Pharmaceuticals in Drinking Water and Estimation of Potential Levels
This 2007 report was commissioned by the UK Drinking Water Inspectorate to identify all relevant, robust studies that investigate pharmaceutical concentrations in raw or treated water, or factors affecting those concentrations. The observed concentrations of pharmaceuticals in raw wastewater indicate that the major source of pharmaceuticals to the water environment is via sewage treatment works effluent. Reported removal rates vary considerably by treatment process, seasonality and weather. Concentrations of some compounds have been found to increase during treatment, probably because of the transformation of human excreted conjugates back to the dosed pharmaceutical compound. Neither wastewater nor drinking water treatment processes are specifically designed to remove pharmaceuticals, so it is not surprising to find residues in wastewater effluent and in finished drinking water. That said,
- a few pharmaceuticals are oxidized to smaller molecules by chlorine or chlorine dioxide
- amino or phenolic moieties are completely oxidized
- activate carbon removes most non-polar organic compounds
- neutrally charged pharmaceuticals are removed by ozone or ultraviolet radiation
- many pharmaceuticals are removed by reverse osmosis
- combined ozonation and activated carbon can remove >90% of pharmaceuticals

Where pharmaceutical compounds have been reported to occur in surface waters, their concentrations are generally very low, in the ng/L (part per trillion) to low µg/L (part per billion) range. Modeling for the major used pharmaceuticals in the UK under "worst-case" scenarios predicts safety margins (i.e., comparison of minimum therapeutic dose to the estimated intake from drinking water) to be significantly greater than 1000. Only the combination of all NSAIDS (non-steroidal anti-inflammatory compounds; e.g., ibuprofen, statins) resulted in a safety margin of less than 100. It was concluded "even in the worst case situation there is no significant health risk from pharmaceuticals discharged to drinking water sources".

Approaches to Screening for Risk from Pharmaceuticals in Drinking Water and Prioritization for Further Evaluation
This late 2008 report was prepared under contract to the U.S. EPA Office of Water as an overview of the agency's current activities and research strategy to respond to the issue of pharmaceuticals in the water system. The presence of pharmaceuticals in water was known as far back as the 1970s when lipid regulators and aspirin were detected in wastewater. As analytical techniques have grown more sensitive over the years, many more pharmaceuticals have been detected in surface water, wastewater and drinking water. The paper goes on to summarize and evaluate a number of risk assessment approaches

including EPA's current approach. Comparison of either the minimum therapeutic dose or the lowest daily therapeutic dose to drinking water intake (with a predicted or measured concentration of the pharmaceutical of interest) is the basis for screening and prioritizing the potential human health risk from low levels of pharmaceuticals in drinking water.

Regulatorische, gesundheitliche und ästhetische Bewertung sogenannter Spurenstoffe im Trinkwasser unter besonderer Berücksichtigung von Arzneimitteln (Assessment of so called organic trace compounds in drinking water from the regulatory, health and aesthetic-quality points of view, with special consideration given to pharmaceuticals)
This 2007 publication of a representative of the German Federal Environment Agency (UBA) speaks to precautionary approaches to health related risk assessment for the more than 2500 chemically defined substances approved as drugs in Germany. In the absence of complete toxicological data for the compounds as well as for their metabolites and mixtures, the "similar joint action" addition rule should be applied. The general precautionary value is 0.10 µg/L (100 parts per trillion, or one-tenth of a part per billion) in drinking water for weakly to not genotoxic compounds, and represents a workable compromise between preventative health protection, water management considerations and aesthetic quality claims. More work is needed on the byproducts of these chemicals and environmentally sound substitute products should be developed.

Technical Brief: Trace Organic Compounds and Implications for Wastewater Treatment
This 2008 report was prepared under contract to the Water Environment Research Foundation to summarize available scientific data and information on the subject of trace organic compounds, including pharmaceuticals, in wastewater. Six human health risk assessments, published in the U.S. from 1998 to 2008, were identified that, in total, evaluated 66 over-the-counter and prescription medications in potable water whose source is assumed to be municipal treated wastewater effluent. The potential health risks from exposure to pharmaceuticals in the environment are relatively easy to assess because of the wealth of human toxicity data produced during United States Food and Drug Administration (FDA) approval of pharmaceutical compounds. In these six assessments, upper-bound estimates of exposure to both adults and children using both measured and estimated concentrations of pharmaceuticals in drinking water and consumed fish were evaluated. Metrics of toxicity included carcinogenicity, mutagenicity, reproductive effects, developmental effects, immunotoxicity, and neurotoxicity. The results of these six risk assessments indicated no adverse affect to human health (including sensitive subpopulations such as children, the elderly and infirmed) from ingestion of drinking water or eating fish that may contain residues of pharmaceuticals.

State of Knowledge of Endocrine Disruptors and Pharmaceuticals in Drinking Water
This 2008 report was prepared under contract to the Water Research Foundation. Peer reviewed published manuscripts, reports, and books were reviewed for pertinent information about specific indicator chemicals, including their treatment, occurrence in drinking water and possible human health effects. The most important sources for release of pharmaceuticals into surface and groundwater are discharges from wastewater treatment plants, industrial manufacturing processes, leaky sewers, combined sewer overflows and onsite wastewater systems (e.g., septic tanks). Over 1000 references reporting occurrence in studies across the globe were considered. No single treatment process alone can provide an absolute barrier to pharmaceuticals in drinking water. Effective treatment processes include disinfectants chlorine and chlorine dioxide, ozone and advanced oxidation, activated carbon, high pressure (but not low pressure) membranes or reverse osmosis, river bank filtration and soil-aquifer treatment. The maximum reported concentrations of two dozen pharmaceuticals in source water (surface and groundwater) range from 30 to 10,000 ng/L (equals 10,000 parts per trillion or 10 parts per billion). The highest reported concentration was for acetaminophen. Reported maximum concentrations in finished drinking water range from <5 to almost 1000 ng/L (so just under 1 part per billion). Comparing the minimum therapeutic dose (MTDs) and/or acceptable daily intakes (ADIs) for these same pharmaceuticals to the estimated drinking water exposures yields margins of safety ranging from <50 to

about 90,000. Such screening-level risk assessments conducted to date have not indicated that the residual pharmaceuticals in drinking water pose a risk to humans.

Toxicological Relevance of EDCs and Pharmaceuticals in Drinking Water
This 2008 report was prepared under contract to the Water Research Foundation. The study objectives included: chose a representative group of chemicals based on toxicity, treatability, occurrence, structure and analytical capability; develop robust analytical protocols; monitor for indicator chemicals in a diverse set of U.S. drinking waters; conduct risk analysis; and develop communication tools. Twenty pharmaceuticals and active metabolites were selected as representative. More than 300 water samples were collected and analyzed from 20 geographically diverse U.S. drinking water sources – either finished or distributed drinking water. Toxicological data on cancer and non-cancer endpoints were gathered from information submitted to the U.S. FDA or from drug labels and monographs. Acceptable daily intakes (ADIs) were calculated for risk screening purposes and drinking water equivalent levels (DWELs) were calculated for each pharmaceutical using regulatory-accepted water intake estimates and maximum detected chemical concentrations. Nine of the 20 pharmaceuticals were detected in finished drinking water – two additional pharmaceuticals were also detected in distributed drinking water. Nine were not detected in either source. The maximum finished water concentrations ranged from 43 ng/L (43 parts per trillion) to non-detect at 0.25 ng/L (less than a part per trillion). None of the pharmaceuticals was detected at levels above their calculated health risk thresholds (e.g., ADIs). In addition, the minimum margins of safety (MOS), the DWEL divided by maximum detected concentration, ranged from 170 to 40 million. According to U.S. EPA policy, a margin of error (MOE) [equivalent to the MOS] greater than 100, even for developmental effects, would generally indicate a low level of concern. The evaluation of toxicological relevance indicated some pharmaceuticals are in drinking water but there is no evidence of human health risk from consumption of these waters. In fact, drinking water exposure is small compared to a person's intake of prescription and non-prescription medication. Further, the daily water consumption rate required to exceed the ADI-DWEL for the 20 pharmaceuticals evaluated ranges from 1,400 to over 300 million glasses of water per day.

Pharmaceuticals and Personal Care Products in the Water Cycle: An International Review
This 2004 report was commissioned by the Global Water Research Coalition under the direction of Kiwa and Stowa in the Netherlands. The issue of pharmaceuticals and their residues was part of the research agenda of most of the members of GWRC in 2004. This report was intended to review and summarize the literature on occurrence and risks to set the stage for a workshop of GWRC members to develop a coordinated research strategy. At the time, data on the occurrence of pharmaceuticals in drinking water had only been published for Germany, Italy and the Netherlands. Reported maximum concentrations of 15 widely used pharmaceuticals in drinking water ranged from 1.7 to 170 ng/L (parts per trillion). The five published health risk assessments at that time all concluded that no appreciable risk for humans exists at the low levels measured in drinking water. It was calculated that lifetime consumption of drinking water with these concentrations of pharmaceuticals would result in a maximum consumption of 5% of one (1) daily therapeutic dose. While exposure could theoretically also take place during recreation in surface waters, the low frequency of this exposure in combination with the low amount of water ingested (<100 ml) makes this route of exposure of negligible importance.

Development of an International Priority List of Pharmaceuticals Relevant for the Water Cycle
This 2008 report was commissioned by the Global Water Research Coalition under the direction of Kiwa (Netherlands), CIRSEE (France) and TZW (Germany). Numerous published studies have shown that a wide variety of pharmaceuticals are present in wastewater influents and effluents, surface water, ground waters, and finished drinking water. The objective of this study was to develop a consensus list of representative, priority pharmaceuticals that would become the focus of further studies on analytical methods, occurrence, treatability, and potential risks associated with exposure in the water supply. Pharmaceutical prioritization efforts were identified in 25 reports from researchers, research institutions or regulatory bodies in Australia, Europe, East Asia and the USA. Across the reports, 17 different prioritization criteria were identified and 153 compounds were evaluated. From these reports, seven

criteria (equally weighted) were regarded as being of special relevance and selected for drawing up a "GWRC" priority list of pharmaceuticals. The seven criteria are regulation, consumption / sales, physicochemical properties, toxicity, occurrence, degradability / persistence, and resistance to treatment. Forty four (44) pharmaceuticals were classified as "high", "medium" or "low" priority. The 10 compounds on the high priority list represent the minimum that should be considered in any study on pharmaceuticals in water management (e.g., occurrence, treatability, potential risks, etc.). These pharmaceuticals are carbamazepine, sulfamethoxazole, diclofenac, ibuprofen, naproxen, bezafibrate, atenolol, ciprofloxacin, erythromycin, and gemfibrozil. This agreed upon prioritized list will enable harmonization of the selection of compounds to be studied and thereby contribute to comparability of results worldwide. The list should be updated as "new" compounds and/or new data on the current list of compounds become available.

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