32 Years of Indirect Potable Reuse in El Paso, Texas

by
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Abstract

The City of El Paso's Fred Hervey Water Reclamation Plant (WRP) was one of the pioneers for indirect potable reuse in the nation. At the time it was brought on line in 1985, it was the nation's first full-scale wastewater reclamation plant to use tertiary treatment to restore wastewater to national and state potable water standards, and inject back into the groundwater aquifer. After 30 years of operation, the Fred Hervey plant holds its own in cost effectiveness, performing these objectives using the same technology. Because of this plant, the life of the city's groundwater resources has been extended significantly and it remains a key component of the city's overall water resource management portfolio. This report will review the plant's design and treatment cost from its early years of operation, its current cost of treatment, compare these treatment costs to that of the Orange County Ground Water Replenishing Facility, formerly the Water Factory 21 Facility, and show how cutting-edge research being done on the plant's biologically activated carbon filters continues to keep this plant in the forefront of innovation.

Introduction

The Fred Hervey Water Reclamation Plant (WRP) constructed in 1985 for $33M, is a 12 MGD wastewater treatment facility that takes raw wastewater, treats it to drinking water quality, and then injects it into the groundwater aquifer. This plant was the nation's first full-scale wastewater reclamation plant to use tertiary treatment to restore wastewater to national and state potable water standards.[17] It was the first plant in Texas to treat wastewater to drinking water quality and inject it into the groundwater aquifer. It was the first plant in the nation to use the PACT® system as part of the treatment train to achieve drinking water quality effluent. And since it's been in operation, it has received the following recognition and awards:

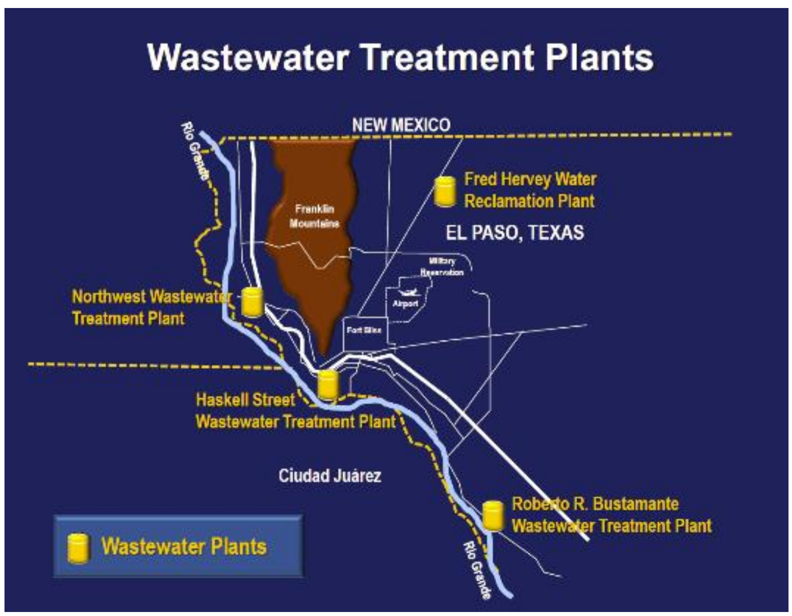

Figure 1 – Plant Location (courtesy of EP Water)

- National Association of Clean Water Agencies (NACWA) Public Information and Education Award, 1994
- EPA Operations and Maintenance Excellence Award, 2nd in Nation, 1994
- AWWA Conservation and Reuse Award, 1999
- AWWA Recognition as Pioneer in Water Reclamation, 2015

The plant is in northeast El Paso. Figure 1 shows a map of El Paso and the location of the Fred Hervey WRP. It is one of four wastewater treatment plants in El Paso and is the second oldest plant in the city. It has a service area of 22 square miles and service population of 95,000 people.
This report will cover the following topics:

- Project Drivers
- Overview of Plant Process
- What has Changed from 1985
- Cost of Treatment
- Benefits of Plant

Project Drivers

In the early ‘70s, northeast El Paso was one of the fastest growing areas of the city. The city needed a new wastewater treatment plant to serve the growing population. At that time the City heavily relied on groundwater. About 90% of the city’s water supply was from groundwater from two different aquifers – the Mesilla Bolson (25%) on the west side of the Franklin Mountains and Heuco Bolson (65%) on the east side of the Franklins. The other 10% of the city’s water supply came from the Rio Grande River via a conventional surface water treatment plant in downtown El Paso – the Robertson/ Umbenhauer Water Treatment Plant. The water level in the Heuco Bolson at that time was dropping by 3 feet per year. Studies done by USGS in the ‘40s showed that geology in northeast El Paso was favorable for groundwater recharge. In the mid-‘70s EPA was funding a lot of wastewater treatment projects and they had a grant program for “innovative” technology. The plant’s development was based somewhat on the Water Factory 21 facility in California. This facility took wastewater, treated it to near drinking water quality, and injected it into the groundwater aquifer to prevent saltwater intrusion into freshwater supplies. Although there are portions of the Hueco Bolson that are very brackish, the intent of the Fred Hervey Plant was to replenish the groundwater aquifer and reduce the rate at which the water table was dropping. Innovative elements of the Fred Hervey Plant design qualified it for EPA grant funding. Some of these elements were the use of the proprietary PACT® treatment process, combination of wastewater and water treatment facilities into a single facility, ozone disinfection, GAC filters, and aquifer injection. This allowed the plant to qualify for $20M in EPA grant funding.

Overview of the Plant Process

The plant is basically two plants in one, an activated sludge treatment plant with anoxic basins and a conventional water treatment plant utilizing lime. Figure 2 is aerial photo showing the Fred Hervey WRP. The “yellow” depicts the wastewater treatment part of the facility and the “blue” depicts the water treatment part of the facility.

Figure 2 – Fred Hervey WRP 12 MGD

Figure 3 illustrates the treatment train for the plant. The wastewater treatment plant consists of screening ①, equalization storage②, primary clarification③, aeration basins④ utilizing a 2-stage PACT® process, anoxic basins⑤ using methanol as a carbon source, and secondary clarification⑥. Primary solids are anaerobically digested⑦, sent to sludge drying beds, then landfilled. Secondary sludge is centrifuged⑧ and sent to a landfill. From the secondary clarifiers, effluent is sent to the water treatment part of the plant where lime is added to raise pH, kill viruses, remove hardness, phosphorus and heavy metals⑨. The treated water is then sent to a sand filter⑩, followed by the addition of ozone, GAC filters⑪, and then chlorination. After chlorination, the water is stored in a 10 million gallon on-site basin⑫ where it undergoes a battery of testing that includes 23 daily analyses for contaminants.[17] Once the testing is successfully passed, the water is pumped to a ground storage tank⑬ from where it can be directed to either injection wells or infiltration basins which replenish the Hueco Bolson.

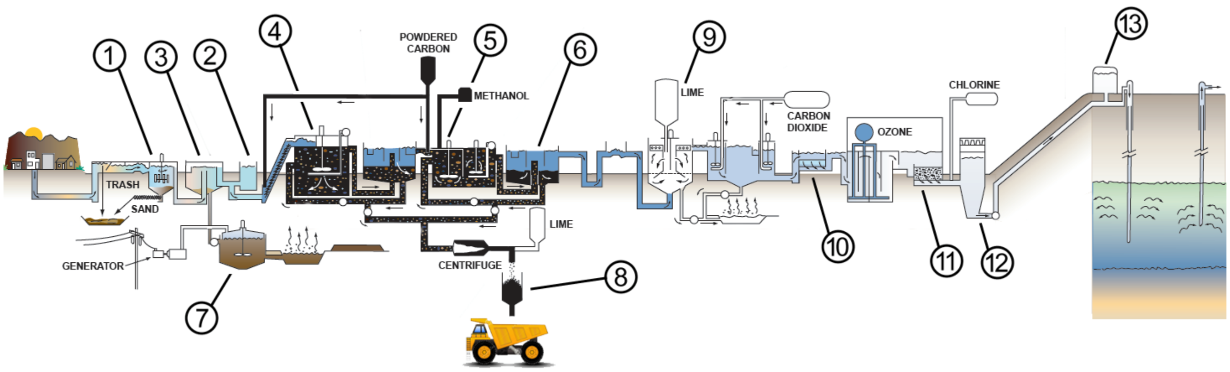

Figure 3 – Fred Hervey WRP Treatment Train

The PACT® process

The PACT® process was a proprietary process developed in the 1970s under a collaborative effort between DuPont and Zimpro.[10] Powdered activated carbon (PAC) is added to aerated wastewater where it becomes part of the mixed liquor suspended solids (MLSS). Figure 4 is the aeration basin at Fred Hervey where the PAC is added. Once the aeration is completed, the treated wastewater and carbon-biomass slurry is allowed to settle. Figure 5 shows the clarifiers following the 1st stage aeration, followed by the 2nd stage denitrification tanks and the 2nd stage clarifiers. This process was primarily used by the petroleum industry in the 1970s and at the time Fred Hervey was being planned, just one domestic wastewater treatment plant in the U.S used the PACT® process for treatment. This was a single stage plant in New England that used the process to remove dye from wastewater coming from a textile plant.

Figure 4 – 1sT Stage Aeration Basin

Figure 5 – 2nd Stage Anoxic Tanks & Clarifiers

Powdered activated carbon has been used for years in water treatment to improve taste and color but not extensively used in treating municipal wastewater. The carbon in the biological treatment process acts as a "buffer" against the effects of toxic organics in the wastewater. The main removal mechanism using powder activated carbon is "adsorption" where molecules adhere to the surface of the organics, but it also provides surface area for microorganisms to grow. The combination of these two mechanisms operating simultaneously offers a means of producing tertiary quality water in a single process. The addition of powdered activated carbon results in several benefits, such as stabilizing biological systems against upsets and shock loading, removing ammonia, controlling color and odor, removing soluble organics, and adsorbing heavy metals. The most unique aspect of the powder activated process and the part of the process that appears to be "proprietary" was the regeneration of carbon. The name of this process was the "wet air regeneration" process and was part of the treatment train at the Fred Hervey plant. This process involves incinerating the thickened carbon sludge to burn off the organics, allowing the carbon to be re-used.

Ozone

The ozone disinfection system originally installed at the plant generated ozone from air using electricity. At the time the plant was being constructed, ozone disinfection was still considered a relatively new technology, but today it is considered an accepted and proven means of disinfection. The original ozone system was changed to a LOX system in 2016. Figure 6 shows the new Ozone equipment at Fred Hervey plant.

Figure 6 – Ozone Equipment

GAC Filters

The granular activated carbon (GAC) filters were also considered a relatively new technology when the plant was being constructed. An interesting thing about the GAC filters is that these types of filters are now called "Biologically" activated carbon filters or BAC filters. That was not the original intent, but over time it has been determined that organisms are supported by the carbon filters and are a beneficial part of the treatment process. The carbon has only been replaced twice in 32 years of operation.[15] Figure 7 shows the BAC filters at the Fred Hervey plant.

Figure 7 – BAC Filters

Changes from 1985

Due to maintenance issues with the incineration equipment, carbon is no longer re-generated. The plant now uses virgin carbon and it is disposed with the waste activated sludge (WAS). However, the plant has significantly reduced the amount of carbon being used by extending the solids retention time (SRT) in the second stage of treatment (denitrification) from the original design of 7 days to 36 days while still meeting the treatment requirements. This has resulted in a 90% reduction in PAC usage and 70% reduction in methanol. Other changes include the operation of the GAC filters as "biologically" activated carbon filters and conversion of the original ozone equipment to a LOX system. The last full change out of the GAC filters was in 1997. The original design had planned for change-out every three years. In the last 32 years, the carbon has only been replaced twice. The BAC filters only require replenishing of the carbon that is lost through the filtering/bachwash process, which is a very small amount and done on an annual basis. This has reduced the cost of operating the BAC filters. The new LOX system is much more efficient method of producing ozone and has also reduced the energy requirements for disinfection. But, by far the biggest reduction in operating cost has been due to the reduction of PAC. With an SRT going over 30 days, the standard process calculations are not well understood, and there is research demonstrating that once in this realm, simultaneous nitrification/denitrification is possible.[1,4,9] And when you look at the microscopic makeup of the carbon (Figure 8), it is not difficult to envision both nitrifiers and denitrifiers living on the same particle. See Figure 9. The denitrifiers, shown in yellow, live on the inside of the carbon particle in an anaerobic (no oxygen) area and the nitrifiers, shown in blue, live on the outside of the carbon particle where there is oxygen available to them. This is clearly evidenced by the reduction in PAC and methanol in the treatment process. The PAC and methanol changes have been accomplished by the plant operators, reducing the amount of PAC usage over a course of several years in small increments.

Figure 8 – Microscopic Image of PAC

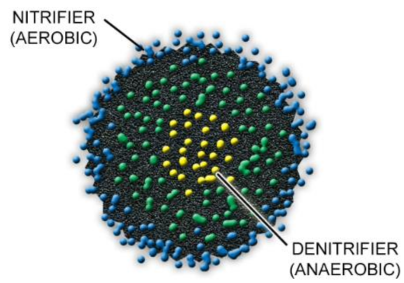

Figure 9 – Cross Section of Carbon Particle

Cost of Treatment

Because of the way the plant operations staff have been able to reduce the use of PAC in the treatment process and taking advantage simultaneous nitrification/denitrification, the plant's treatment cost is nearly the same today as it was when it first started operating. In 1987, it cost $1.55 per thousand gallons to treat wastewater to drinking water quality at the Fred Hervey Plant. Adjusting for an annual inflation rate at 1.5% puts this treatment cost at $2.46 per thousand gallons in 2017. The actual treatment cost in 2015 was $1.54 per thousand gallons. Adjusting this cost for inflation gives a 2017 treatment cost of $1.59 per thousand gallons. This is a 35% reduction in treatment cost over what it was costing in 1986 when adjusted for inflation and equates to about $2 M in annual treatment cost savings.

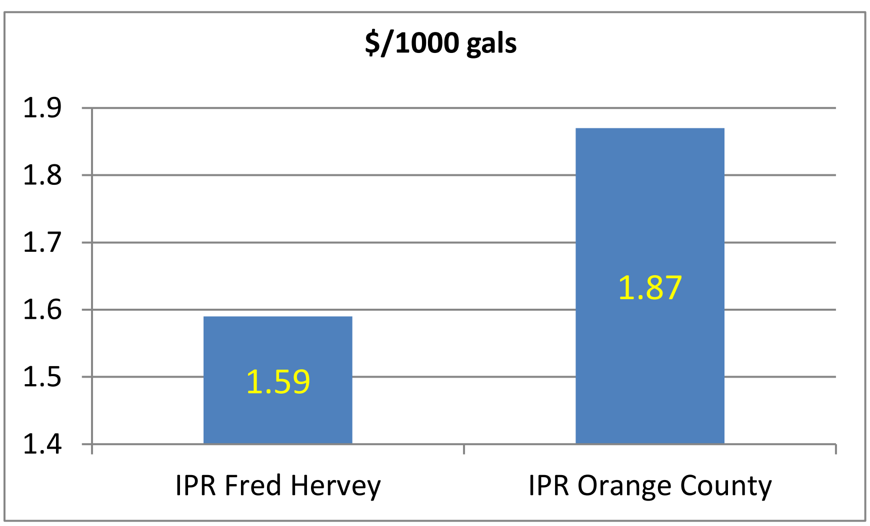

Figure 9 – O&M Treatment Cost Comparison

Figure 9 compares the operation and maintenance (O&M) treatment costs for the Fred Hervey Plant to the Orange County Ground Water Replenishing Facility. Both plants are considered indirect potable reuse (IPR) plants because the treated water is used for aquifer replenishment, not direct public consumption.

The Orange County Plant is a state-of-the-art plant and is the updated version of the Water Factory 21 plant from 1977. It takes treated effluent from a conventional activated sludge wastewater treatment plant and performs advanced treatment utilizing microfiltration, reverse osmosis, ultraviolet (UV) disinfection, hydrogen peroxide, and lime stabilization. This plant received $142M in upgrades in 2015 (100 MGD capacity). After disinfection, the water is pumped to injection wells with the dual purpose of controlling saltwater intrusion and augmenting groundwater supply.

Treatment costs for the Orange County Facility were taken from actual 2009 O&M costs[12] and adjusted for inflation at a 1.5% annual increase. This cost did not include treatment cost from the conventional activated sludge plant supplying effluent to the Orange County Facility, so wastewater treatment cost ($.60 per 1000 gallons[11]) from AWWA's 2013 Benchmarking Water and Wastewater Cost Survey were added, resulting in an estimated 2017 treatment cost of $1.87 per thousand gallons.

Benefits of the Plant

The Fred Hervey WRP has provided significant benefits to the City of El Paso. The Heuco Bolson depletion has been reduced from 3 feet per year to less than 1 foot per year. By the end of 2013, the plant had injected a total of 70,843 acre-feet of reclaimed water into the Heuco Bolson.[18] The plant has been a proving ground for technology with the use of PAC for wastewater treatment, GAC/BAC filters, and ozone disinfection. The plant has promoted the need for conservation. As part of the original planning and design for the plant, EP Water undertook a public education and outreach program to reduce water usage. The Fred Hervey Plant was the first step of this important and successful program. During the planning of the plant, per capita water usage was 225 gal/cap/day. Today, the water usage is 134 gal/cap/day. Even today, the plant is on the cutting edge, realizing the benefit of simultaneous nitrification/denitrification by using the unique physical characteristics of the carbon itself and talented plant operations staff who are willing to experiment with process changes. The granular activated carbon filters originally intended for polishing and odor control have evolved to "biologically" activated carbon filters and were part of a study that was just published in 2016.[15] This study involved testing for 40 different trace organic compounds (TOrC) going in and out of the BAC filters at the Fred Hervey Plant. Many of these TOrCs are considered contaminants of emerging concern and are related to disinfection by-products (DBP), pharmaceuticals, and personal care products. Of the 40 different compounds tested, the filters at Fred Hervey were able to show a reduction in 21 of them. Table 1 below shows the top ten highest removed compounds. The compounds shown in **BOLD** are the those compounds that are directly removed "biologically." The other compounds are primarily removed by absorption/adsorption.

Table 1 – TOrC Removal Percentage by BAC after Ozonation[15]

No.	Compound	Use	% Removal BAC
1	Atenolol	High Blood Pressure	74.70%
2	Diphenhydramine	Allergy Medicine	68.90%
3	**Ibuprofen**	**Fever/Pain**	**41.60%**
4	Ihohexol	X-Ray Imaging	38.10%
5	**Trimethoprim**	**Antibiotic**	**34.30%**
6	Primidone	Epilepsy	29.30%
7	DEET	Insect Repellent	27.40%
8	Simazine	Weed Killer	21.60%
9	Caffeine	Coffee	11.60%
10	TCEP	Chemotherapy	11.10%

With the plant providing 32 years of successful service, it is still comparable in treatment cost to more modern treatment plants, and based on recently published studies, is doing some very interesting, beneficial and innovative treatment.

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