Tres Rios – Water for the Desert

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Water in the desert is a scarce commodity, coveted by humans and animals alike, admired for the sights and sounds it can create, and even fought over. When quality of life in the arid Southwest is the topic of conversation, water, or the lack thereof, is often included. Desert water resources come in many forms: ground water, surface water, precipitation (that rare gem of the desert, rain), and recycled or reclaimed water. Proper terminology aside, as the population of the Southwest continues to grow, the strain of demand on this precious resource requires thoughtful conservation.

Larger cities in the Southwest use infrastructure and regulation to mitigate waste and prevent system loss. The City of Phoenix, among others, takes further steps to maximize the potential of their water resources. Wastewater is produced, then collected and treated. The treated effluent can be recycled for other uses such as for the Tres Rios Constructed Wetlands Project.

The Tres Rios Wetlands began in 1994 as a proposal for alternative water quality treatment. It was developed as a cost-effective method for advanced nitrogen removal and from there the project grew to incorporate numerous additional characteristics. A very large wastewater treatment plant is located at the Salt River confluence with the Gila and Agua Fria rivers. The influent into the facility is a co-mingling of discharges from the City of Phoenix and several of the surrounding cities. The plant sits at the low point of the geography and is capable of handing very large flows from the populace.

The original demonstration project was built in partnership with the Bureau of Reclamation, and encompassed approximately 25 acres of land, including 15 acres of wetland cells. The areas were designated as the Cobble Site, the Hayfield Site, and the Research Site. Each site had its own characteristics, but collectively they would help develop an understanding of the natural dynamics of constructed wetlands in an arid environment.

The Cobble Site was situated in the bed of the Salt River with two parallel basins. The basins were identical with the exception of lining material. One was lined with native material and the other with soil from a local farm field. The site provided important information regarding infiltration rates and expected water quality based on liner construction. Additionally, the site served as a recreational area and provided insight into public interaction with an environmental project of this nature.

The Hayfield Site was actually a working hayfield before the project began. Located on the upper bank of the Salt River, above the ephemeral flow path, Hayfield has two parallel cells that discharge into a riparian area below. The site has become a true desert oasis. A heron rookery, beaver, and bobcats are examples of the varied wildlife it has attracted. It is not surprising that the Hayfield site has become a favorite of bird watchers and photographers. As important and unique as the fantastic collection of wildlife, the site has provided an opportunity to learn about surface water quality requirements for constructed wetlands, helped develop mosquito control programs (vector management), and has shaped budget and labor expectations for the future.

The Research Site consisted of 12 half-acre fast-flowing cells. Though problematic from the outset, the data collected were very helpful in determining minimum design standards of future wetland projects. It became apparent that size matters and constructed wetlands are not just basins containing water; wetlands encompass everything from the soil below to the treetops overhead.

Through successes and failures, the demonstration project (Figure 1) provided valuable information on the intricate nature of constructed wetlands. The original concept changed from purely one of water quality improvement to expanded goals:

1. Flood control elements for general area.
2. Ground water recharge.
3. Habitat restoration and development.
4. Public outreach and education.
5. Area-wide vector management.
6. Water reuse and availability.
7. Carbon footprint offset.

With the operational and water quality knowledge gained through the demonstration project, larger, more ambitious projects, the Tres Rios Flow Regulating Wetlands (FRW) and Tres Rios Overbank Wetlands (OBW) were constructed in partnership with the Army Corps of Engineers (Figure 2). These two larger systems are immediately west of the 91st Avenue Wastewater Treatment Plant, on the north bank of the Salt River. Using knowledge gained from the demonstration project, the new Tres Rios Wetland systems were designed and constructed to provide greatly improved performance, with considerations for water quality, localized flood management, and mosquito control taking precedence to make the project safe and useful.

Figure 1. Demonstration wetlands.

grassland features. All portions of the project utilize vegetation native to the Sonoran Southwest, including Freemont cottonwood, Goodings willow, cattail, bulrush, giant and alkali sacaton grasses, mesquites, desert screwbean, and saltbush.

The two FRW deep-water basins have an approximate volume of 45 million gallons. Taking advantage of the diurnal flow patterns of the influent, water is stored in the cells and slowly discharged to the flow regulating cells using a computer control system. The discharge from these cells is monitored by pulse-Doppler flow meters as it makes it way through a set of discharge gates that provide feedback to the control system.

The three FRW flow regulating cells have a capacity of about 170 million gallons. The three cells are designed to have very tight level control functions of plus or minus one inch to help generate consistent water quality and achieve vector management requirements. Radar level sensors, pulse-Doppler flow meters, and effluent weir gate assemblies at the end of each of the three cells send information to the computer control system to maintain the tight water level tolerances.

Each of the three FRW cells has four separate islands that provide wildlife

Water Source

Influent for the project is supplied by discharge from one of the largest wastewater treatment facilities in the Southwest, the 91st Avenue Wastewater Treatment Plant (Figure 3). The plant has a treatment capacity up to 230 million gallons a day, with an average daily flow of 140 million gallons. The treatment plant is the starting point of the City's reclamation effort. It provides highly treated effluent that historically had been discharged directly into the Salt River corridor, creating a perennial flow for the Salt River to its confluence with the Gila and Agua Fria rivers. Now, a portion of the daily flow provides cooling water to a power generating plant; the remainder supports the wetlands and riparian area. Water leaving the wetlands makes its way into a canal system, providing irrigation for non-food crop production. The wetlands construction was completed and steady wastewater flow was introduced in the spring of 2010.

Basin Design

The FRW incorporates two deep-water basins used for diurnal flow attenuation and three flow-regulating cells for enhanced water treatment and habitat features. The OBW system has two long parallel cells, one an emergent marsh and riparian corridor setting, and the other, a desert tree forest with

Figure 2. Tres Rios wetlands and vicinity.

Figure 3. City of Phoenix 91st Avenue Wastewater Treatment Plant.

habitat and that can only be accessed by boat. These islands will be populated with large riparian trees to foster a soil-to-treetop complete ecosystem. Bald eagles, bobcats, and beavers have already visited the wetland and greater species diversity is anticipated.

At the end of this system, a collection channel can discharge effluent to U.S. navigable waters by direct route to the Salt River or through OBW. A function of this wetland system is to provide public interaction and wildlife habitat development. Public amenities, such as park benches and trails will be included to provide a more intimate nature experience. The cells are very long and narrow, allowing good public interaction and ease of facility management.

Vector Management

It became very apparent early on in the demonstration project that mosquitoes were going to be a difficult adversary. Mosquitoes are resilient and highly adaptable. Eradicating them is difficult, usually unsuccessful, and environmentally disruptive to the food chain, particularly natural predators. Accordingly, an integrated vector management plan was developed that incorporated monitoring, the assimilatory capacity of the wetland (predator-prey relations), and use of environmentally friendly vector control agents to moderate mosquito numbers. The FRW and OBW systems are designed to produce a well-regulated number of mosquito larvae to promote food chain development, while limiting the potential of adult mosquito production.

Multiple carbon dioxide traps are used to monitor adult mosquito densities and dipping is performed to identify areas of larvae presence. Numeric triggers are being established to signal when food chain dynamics require adjustment by addition of larvicide. The biological larvicides, *Bacillus thuringiensis israelensis* and *Bacillus sphaericus* are applied in a rotational schedule to reduce the development of genetic resistance. The mosquitofish, *Gambusia affinis* is used as a primary predator and has been introduced to work in concert with the larvicides.

Initial Water Quality

When evaluating the benefits of constructed wetland systems in terms of ecosystem stability and water quality improvement, the rate and degree of change need to be measured against that which a regional natural source could produce. Natural systems take considerable time to establish, ecologically balance, and thrive before producing measurable water quality improvement. Constructed wetlands are no different.

One of the water quality improvements desired is nitrogen removal. Wetland systems are robust nitrogen consumers that can yield beneficial results. Although Tres Rios FRW system is in its infancy, initial nitrogen results are encouraging (Figure 4). As the system matures, more biomass will be accumulated and make more carbon available for synthesis, both of which are crucial for nitrogen sequestration.

Habitat Development

Creation and expansion of habitat is one of the most important benefits of a wetland, especially in an arid environment. The design specifications for the FRW and OBW have taken into account both successes and failures experienced in the demonstration project. Vegetation species, plant spacing, flow and depth regimes, open water zones, isolated islands, and routes for human access and maintenance were elements of the final design.

Several primary producers (macrophytic plants) and secondary consumers (fish) were introduced into the wetlands to create an accelerated communal system, based on the findings of the demonstration project. The remaining components of the food web were expected to find and colonize the site unassisted. Early evaluations indicated

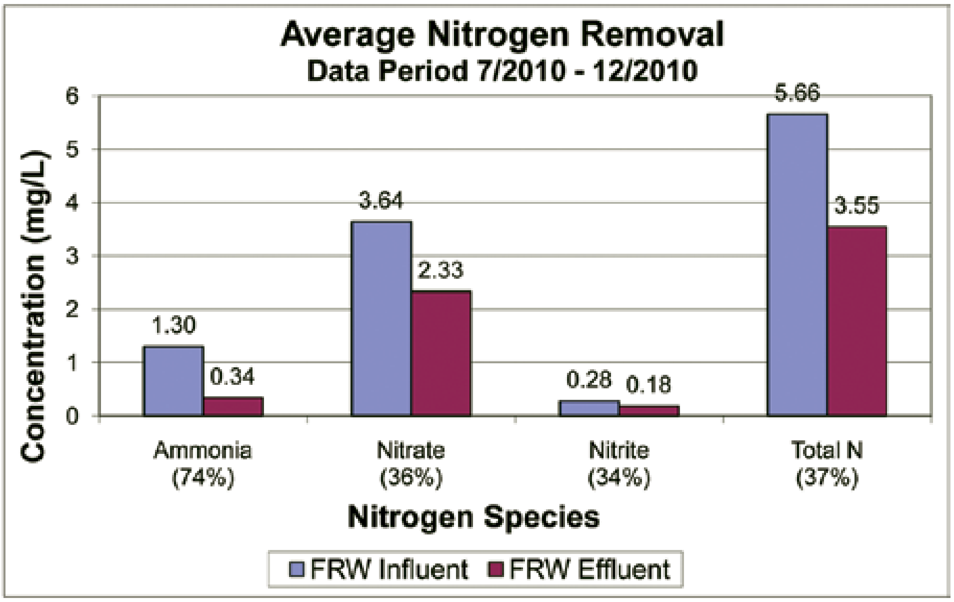

Figure 4. Preliminary nitrogen species removal efficiencies.

that each system was functionally different, with a different level of species diversity (Figure 5).

There is a good indication of a viable and evolving micro/macro invertebrate community and food web based on less than one year of operation. Periphyton consists of 16 species and eight genera of diatoms (*Gomphonema, Navicula, Cymbella, Achnanthes, Diatoma, Cyclotella, Synedra,* and *Nitzschia)* at a total density of up to 159,000 per sq cm. Phytoplankton has included the following number of genera from each algal division: Cyanophyta (4), Chlorophyta (9), Bacillariophyta (2), Euglenophyta (10), Pyrrhophyta (1) and Cryptophyta (1). Densities were as high as 7.3 x 10^5 cells per ml. Zooplankton forms have included rotifers (50.1 percent), cladocerans (7.1 percent), copepods (29.3 percent), and ostracods (13.5 percent) at a maximum density of 5.1 x 10^4 per ml.

Opportunities and Challenges

The project provides a rare opportunity for documenting the development of a wetland system in the desert from its inception. Habitat development is crucial to the viability of the ecosystem, as is initial water quality data upon which relevant operational decisions are made. Internal processes need to be monitored and the personnel and equipment to do so must be made available. The current economic climate dictates that this will be a challenge for some time. With the assistance of its caretakers, the wetlands can yield impressive water quality results, perform flood mitigation, and be an ecological benefit to the area.

Figure. 5. Flow regulating wetlands.

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