The Waldo Wetlands Project

Teresa Frame and Edward M. Toby

Photographs by Steve Yeats, Gainesville

Teresa Frame is with the Florida Department of Environmental Protection, Tallahassee. Edward M. Toby III, CET, is with the University of Florida TREEO Center, Gainesville.

Man-made wetlands have been successfully used throughout Florida for such projects as wastewater treatment, wetland mitigation, and habitat enhancement. The success of treatment wetland sites, such as the Orlando Eastern Service Area and Orlando Wetlands Park for tertiary wastewater treatment, has been well documented on several levels. Natural biological and chemical processes within the wetlands provide effective tertiary treatment to domestic wastewater, and the systems regularly comply with state discharge requirements. The sites are also beautiful wetland systems that provide substantial habitat and recreational value.

What is different about the Waldo Wetlands Project is that it addresses small community needs, and it represents a unique collaboration of the city of Waldo, federal and state agencies, and institutions.

The lead partner is the University of Florida Center for Training, Research and Education for Environmental Occupations (UF/TREEO), which initiated the project to creatively resolve Waldo's wastewater disposal problems. The partners on the project include the Suwannee River Water Management District (SRWMD), EPA, DEP, and the University of Florida Center for Wetlands (UF/CW). Each partner brought assets and specific skills to the project.

The primary purposes of this project were to design, construct, and then manage a man-made wetland for tertiary wastewater treatment for the city of Waldo. The project provides important additional benefits of watershed protection, wildlife habitat creation, as well as community recreation and education opportunities.

Background and History

The city of Waldo is a 1,037-person community on the eastern edge of Alachua County. Wastewater permitting and processing has a long and interesting history in Waldo. According to early permit records, in 1934 the city of Waldo constructed a 40,000-gallon, 5-cell settling tank providing only primary treatment. The effluent was discharged to a drainage ditch, which flowed into a cypress swamp leading to Lake Alto and then to Lake Santa Fe through the Santa Fe canal. This chain of lakes forms the headwaters to the Santa Fe River. The original wastewater treatment system served about 100 connections.

In 1983 the city entered into an agreement with DEP to construct a new 0.085 MGD activated sludge sewage treatment facility capable of meeting the minimum secondary treatment standards required by the state. The plant began operations in October 1985. Discharge continued to be into the drainage ditch flowing to the Santa Fe Swamp. With the new permit, DEP included additional monitoring requirements within the receiving wetland.

With the designation of the Santa Fe River System (which includes Santa Fe Swamp) as an Outstanding Florida Water in 1984, and the adoption of FAC Chapter 62-611 Wetlands Application rule, Waldo was required to find an alternate means of effluent disposal. In September 1986, DEP issued a temporary five-year operation permit to Waldo to allow the city time to develop an alternative effluent disposal site, such as percolation ponds or spray irrigation.

The city purchased property immediately adjacent to its wastewater treatment facility, and in March 1989 the city applied for a permit to construct a percolation pond system. In January 1990 DEP issued the permit and construction of the percolation pond system was completed in August 1991.

Because of limited funds, the pond system was designed so that existing land and vegetation would not be disturbed except for the construction of an access road, installation of effluent distribution piping, and construction of berms.

Unfortunately, the percolation ponds did not function as permitted. Effluent frequently overflowed into adjacent natural wetlands. After repeated attempts to correct the problems, the

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Using ASR to Manage Water Resources in Seasonal Communities

Jim McGee, Joseph R. Elarde, Anthony Inniss, and Mark B. McNeal

Jim McGee is with Bonita Springs Utilities, Inc. Joseph R. Elarde; Anthony Inniss, P.E.; and Mark B. McNeal, P.G.; are with CH2M Hill.

The Bonita Springs Utilities, Inc. (BSU) service area has a consistent and high growth rate for years. Located within a water resource caution area, as defined by SFWMD, the area's limited freshwater is used to meet the increasing demand for both potable and non-potable water.

The freshwater resources of this growing coastal area show signs of deteriorating water quality, especially in the western portion toward the Gulf of Mexico. Increased water storage and high service pumping facilities are needed to meet increasing maximum day and peak hour potable water needs.

BSU is currently implementing potable water Aquifer Storage and Recovery (ASR) as a cost-effective potable-water storage alternative that will provide long-term benefits to meet the freshwater needs of the Bonita Springs area. ASR will provide subsurface seasonal storage of treated groundwater for potable use, and storage of chlorinated surface water for regional irrigation use. ASR will store these water supplies during wet-weather periods for recovery during periods of increased demands (seasonal population influx and dry season periods). Further, the use of ASR technology will level freshwater withdrawal rates from the shallow aquifer system, thus limiting peak pumping events during the dry season when groundwater resources are most sensitive to adverse impacts from overpumping.

Overview of ASR

ASR is (1) the subsurface storage of water, when excess water is available, through a well in a suitable aquifer in a zone of moderate to high permeability, and (2) the subsequent recovery of the water when needed. Figure 1 illustrates the recharge and recovery phases of ASR operations. Usable storage zones include confined and unconfined aquifers containing freshwater, brackish water, or seawater.

ASR has gained international acceptance as a viable, cost-effective method of providing sufficient storage to meet seasonal peak water demands. Currently there are 30 successful operational potable water ASR systems in the United States and others abroad. Several ASR systems have been in operation in Florida since 1983.

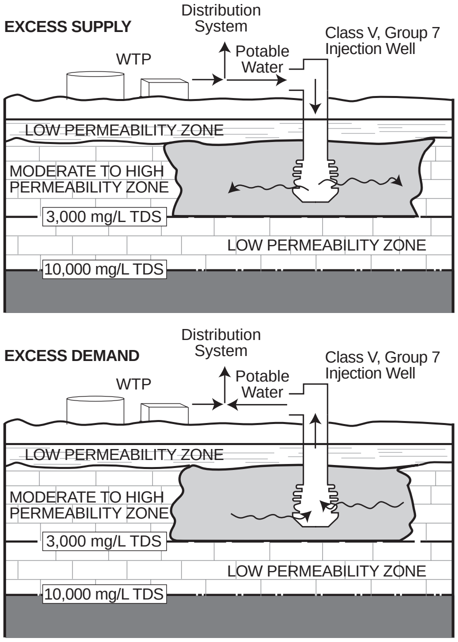

Figure 1. ASR Recharge and Recovery

ASR offers the following significant advantages over conventional water storage methods: (1) because water is stored in large underground geological formations, typical ASR storage quantities are orders of magnitude greater than conventional above-ground storage methods, (2) capital expenditures are typically a fraction of the cost of conventional above-ground storage systems with high construction costs and land requirements, and (3) evaporative losses, which are significant in above-ground reservoir systems, are non-existent in ASR systems.

In addition to the inherent cost-saving benefits of an ASR system, water management districts often offer funding assistance to help defray the costs of new ASR systems. For example, BSU received funding from SFWMD's alternative water supply funding support program.

ASR in brackish portions of coastal aquifers is an important water management tool for preventing saltwater intrusion, conserving water, and meeting local peak emergency water demands. The utilization of a deeper, more brackish aquifer as the storage zone can level pumpage from shallow, fresher, and more heavily utilized aquifers during the dry season when groundwater resources are most sensitive to overpumping.

ASR Feasibility Criteria

Water Availability and Demand. Storage and recovery volumes must be of reasonable scale for the ASR system to be cost-effective. Generally, flows must support a minimum ASR well capacity of 1 MGD. BSU is currently constructing improvements at the Bonita Springs WTP to provide a firm treatment capacity of 6 MGD. From demand projections, maximum daily demand will approach firm treatment capacity this year. Figure 2 shows projected demands in comparison to firm treatment capacity with a 3-MGD ASR system. Seasonal storage and recovery capabilities of a 3-MGD ASR system will allow BSU to defer further treatment capacity through 2014.

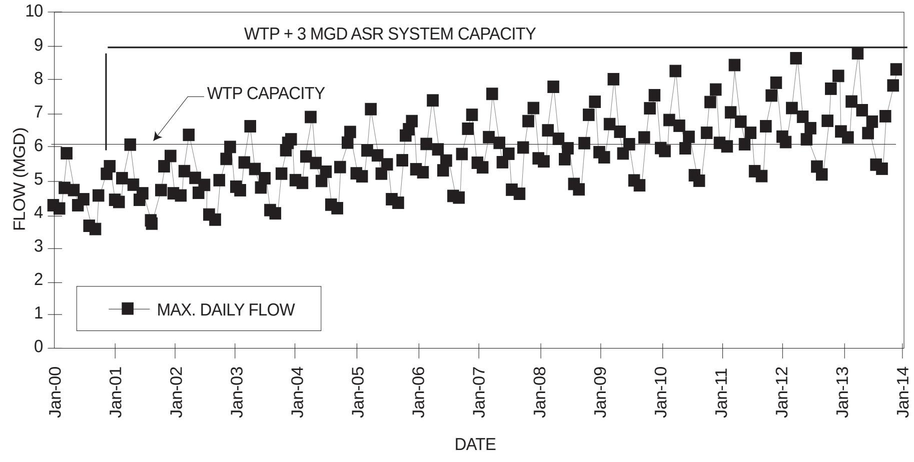

Figure 2. projected demands in comparison to firm treatment capacity

The upper portion of Figure 3 shows the water demand and rainfall for the BSU service area during 1996. Water demand in

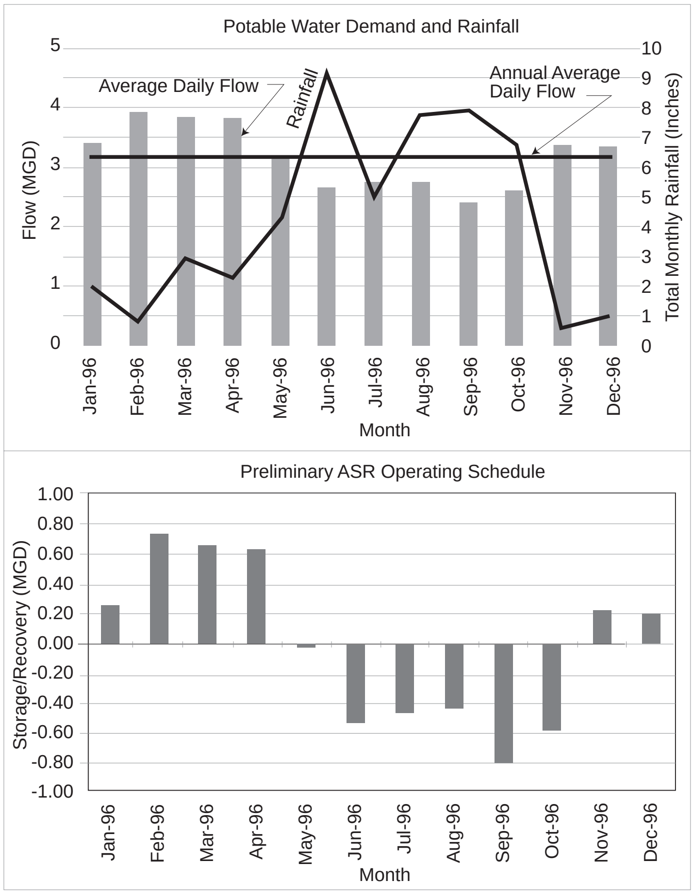

Figure 3. Water Demand and Rainfall, and Operating Schedule

the BSU service area is shown to fluctuate seasonally, with periods of higher demand corresponding to the dry season when rainfall is minimal. Groundwater withdrawals from the BSU wellfields may be leveled in the dry season through augmentation from recovered ASR water, thus preserving the water quality of this vulnerable water supply. The lower portion of Figure 3 shows a conceptual seasonal ASR operating schedule — ASR recovery would take place during the drier months of November through May, while ASR recharge would take place in the wetter, lower-demand months of June through October. Seasonal populations are also highest during the drier months, further exasperating the water supply and delivery requirements during early calendar months each year.

Water Quality. For a potable ASR system to be permitable, the recharge water quality must meet the drinking water standards required by federal and state regulatory agencies. Finished water quality data from the BSU water treatment plant indicate a high quality water that reliably meets all primary and secondary drinking water standards.

The Presence of a Suitable Subsurface Storage Zone. A subsurface storage zone must be able to provide acceptable storage capacity and recovery efficiency, and must have adequate confinement and permeability. Hydrogeology plays a key role in identifying and determining a potential ASR zone and its ultimate storage capacity and recovery efficiency. The primary elements of hydrogeology that affect storage capacity and recovery efficiency include vertical confinement, transmissivity, and regional flow gradients.

The selection of the targeted ASR zone is based on the following factors: (1) adequate confinement from above and below, (2) moderate production capacity (an overly transmissive aquifer may allow too much mixing), and (3) fresh to moderately brackish ambient groundwater quality (high-quality groundwater usually lends itself to competing use, whereas ASR can achieve complete recovery in moderately brackish zones if mixing is moderate through successive operational cycles.)

Figure 4 summarizes the hydrogeology and ambient groundwater quality in the vicinity of the BSU site. The hydrogeology includes layers of varying permeability, with the more permeable layers constituting production zones and the less permeable layers serving as confinement. The hydrogeologic feasibility of using aquifers down to the lower Hawthorn aquifer was determined. The water quality of deeper aquifers becomes increasingly brackish and, therefore, infeasible.

The Tamiami aquifers yield moderate amounts of water, but are highly utilized. The Sandstone aquifer also yields large amounts of water, but it is discontinuous and absent in many locations. The Mid-Hawthorn aquifer has limited production capacity and is not locally used as extensively as overlying zones. The Lower Hawthorn aquifer is capable of high yields and is separated from the more utilized upper zones by the Lower Hawthorn confining zone and from lower zones by a relatively thin semi-confining interval. In the vicinity of the Bonita Springs ASR wells, potentiometric surface contours in the Lower Hawthorn aquifer indicate a relatively flat gradient of approximately 0.0002 feet/feet, which indicates little potential for horizontal migration of stored water from ASR.

Based on the above criteria, the Lower Hawthorn aquifer system is the targeted ASR zone for the BSU service area. It has confinement above and below, a moderate to high production capacity, and a moderately brackish water quality (which results in minimal competing use).

Ambient Groundwater Quality. Ambient groundwater quality can influence the feasibility of potable ASR by affecting the recovery efficiency and, in some cases, the permitability of ASR systems. Extremely poor quality may result in lower recovery efficiencies, particularly in more transmissive aquifers with substantial mixing. Conversely, if the proposed ASR zone contains higher quality water than the recharge water for standards that are not met, ASR permitting becomes more involved. Permitting has been straightforward at this site since the recharge water is treated drinking water.

With the proximity of Bonita Springs' ASR wells to the coastline and the potential for saltwater intrusion, salinity was identified as the primary ambient groundwater characteristic for assessing groundwater quality. Data in the vicinity of the ASR well site indicate that as the deeper aquifers are encountered, water quality becomes more brackish, with anticipated chloride concentrations ranging from 1,000 to 2,000 mg/L in the Mid-Hawthorn and Lower Hawthorn aquifers. It is important to note that more brackish zones may be utilized successfully for ASR if mixing in the aquifer is not excessive and adequate recharge quantities are available to build the required buffer zone capacity.

Limited Nearby Competing Groundwater Users in the Proposed ASR Zone: Existing (or competing) groundwater use affects the feasibility of potable water ASR, primarily by decreasing the *storage bubble* (level of hydraulic control of the water stored underground). If the competing use is less than a mile away and the groundwater withdrawal rate of that use is high, a hydraulic gradient of sufficient magnitude may cause lateral movement of the storage bubble. Conversely, from a permitability standpoint, the water management districts generally consider ASR recovery operations as a groundwater withdrawal, and may consider ASR operations as an impact to existing, legal competing users if the competing use is within the area of influence of the ASR well.

Of a total of 375 wells within a one-mile radius of the Bonita Springs ASR well site, 92% are completed into the shallow aquifer system with a depth of 100 feet or less. Based on well

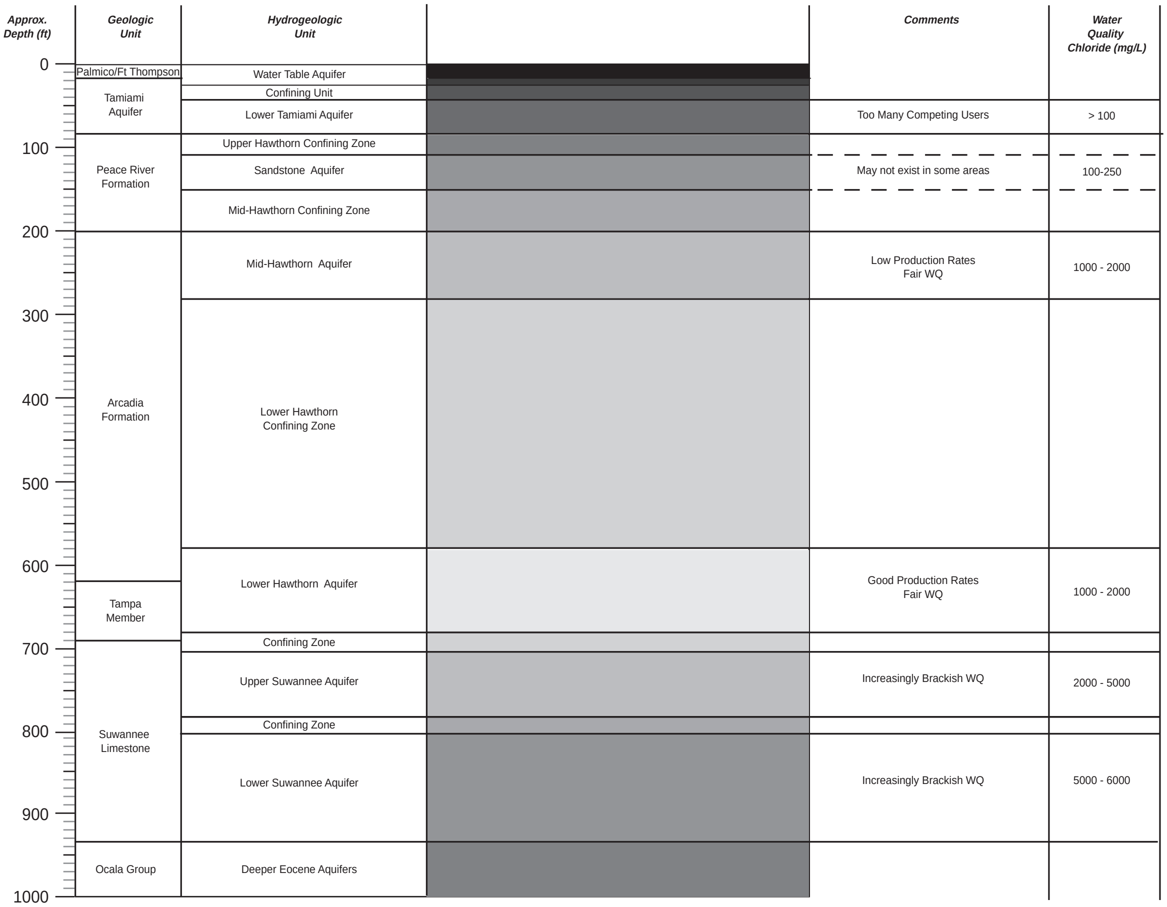

Figure 4. Hydrogeology and Ambient Groundwater Quality Near Bonita Springs

inventory data, no wells of interest were identified at the BSU potable water ASR site. Well depths are primarily shallow, with the deepest well identified from the public record search as completed to a depth of 275 feet. No known wells are located in the proposed storage zone within a one-mile radius.

Geochemical Compatibility of Recharge Water with Ambient Groundwater: The ASR recharge water must be chemically compatible with the ambient groundwater of the storage zone to prevent plugging or fouling of the storage zone and a decreased ASR capacity. In addition, the recovered water should have similar quality as the recharge water, with minimal mixing of more mineralized ambient groundwater of the storage zone.

Site Constraints. Site constraints can affect the feasibility of future testing and implementation phases of ASR. Factors to be considered include availability of supply and distribution facilities, adequate land area for above-ground storage and pump station, construction and testing considerations, including surrounding land use, and the level of surrounding demand.

The Bonita Springs ASR site is located in a rural residential area; therefore, disruption to the surrounding area from noise of well construction activities was a consideration. The land area is sufficient for the location of an ASR well, an aboveground storage tank, and pump station facilities. This site is located near an existing potable water main with sufficient carrying capacity to deliver and return the desired ASR flows at this location.

Bonita Springs ASR System

Components needed to complete an ASR system include ASR wells to both inject and recover potable water, a storage tank to provide operational flexibility, a disinfection system to meet drinking water regulations, an unlined retention pond for reject water, and high service pumping to send water to the distribution system. The Bonita Springs ASR system will include these components.

Excess potable water will be diverted from the distribution system to the potable water ASR well for storage. During peak demand periods, ASR well pumps will deliver recovered water to a storage tank after disinfection. The water will then be pumped to distribution.

Chlorine will be added to disinfect the recovered potable water per drinking water regulations. Ammonia will then be added to create a chloramine residual before storage and distribution. An aboveground storage tank will serve as a break between the well pumps and high service pumps, and will increase the operational flexibility of the water system by allowing short-term increases of capacity. High service pumps will convey water from the one-million-gallon storage tank to the distribution system. This provides the added benefit of additional fire flow protection and boosting system pressures in this area during peak demand periods.

When starting an ASR well that has not been in use, it is normal to find a small amount of the stored water near the well casing exhibiting elevated turbidity and conductivity. This water, referred to as *development water*, will be sent to the retention pond for a short time during each startup period of the BSU potable water ASR well. The pond is provided to collect the water and slowly release it to adjacent wetlands via a pipeline.

Conclusions

Design and construction of an ASR system at BSU identified the following points to consider when determining the feasibility of ASR:

- Larger ASR systems (greater than 1 MGD) have significant benefits when compared to above-ground storage.
- ASR can increase firm plant capacity by storing excess water in low demand periods for use during high demand periods. Plant expansion can therefore be delayed by several years.
- An evaluation of site-specific conditions must be performed to determine ASR feasibility.
- Implementation of ASR includes low capital cost improvements similar to existing finished water treatment and pumping.

References

1. CH2M HILL. 1998. Bonita Springs ASR Feasibility Report. Tampa, FL.
2. Pyne, R.D.G. 1995. Groundwater Recharge and Wells. Boca Raton, FL. CRC Press, Inc. ■

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city decided to re-design the percolation pond system into a man-made wetland system. In the new system, effluent from the secondary level wastewater treatment facility would flow through the man-made wetland and discharge into a receiving wetland in accordance with the criteria set forth in FAC Chapter 62-611 Wetlands Application. In November 1996 Waldo applied to DEP for a permit to operate the wastewater treatment facility and construct a man-made wetland system. The permit was issued on October 21, 1997.

How the Project Got Started

In 1997, at the request of DEP, UF/TREEO conducted a diagnostic evaluation of the Waldo Wastewater Treatment Facility. The evaluation was requested because the facility was violating the terms of its operating permit on an ongoing basis and because of the effluent disposal problems. The evaluation was performed at no cost to the city under the “Operator Outreach Training Program,” which is funded by the Clean Water Act and administrated in Florida by EPA Region IV in Atlanta. The evaluation set up the groundwork for the Waldo Wetlands Project.

Over the next few years, UF/TREEO staff worked with the city staff to correct the design and operational problems that were leading to non-compliance. The last and most difficult-to-solve performance-limiting factor identified in the report was how the city was going to dispose of its wastewater effluent. DEP and UF/TREEO concurred that discharge into a man-made wetland and then to the natural wetland was the best current disposal option. UF/TREEO then brokered a partnership between Waldo and its primary partners, SRWMD and the UF/CW. SRWMD agreed to match funds with the city for the budgeted cost of the project, and the UF/CW provided the project design and initial management of the project. DEP provided skilled manpower for the initial planting season under a separate grant, and UF/TREEO continued on-site training of the city’s wastewater treatment staff in the operations of a wetlands treatment system.

Man-made Wetlands System Design

The UF/CW provided the expertise for the man-made wetland design. The goal of the design was to convert the three existing percolation ponds to effective wetland treatment cells with minimal alteration to the existing structure. The UF/CW provided the personnel, time, and equipment necessary to develop a design that was financially realistic to construct, operate, and manage.

Man-made Wetlands System Construction

Construction efforts consisted of three principal goals: (1) removing the dead tree and debris materials from percolation ponds; (2) constructing berms within the existing treatment cells with structural stability to withstand standing water loads; and (3) grading elevations within the treatment cells to optimize conditions for desirable wetland plant communities. Since the city did not have adequate staff or equipment to conduct these activities, it rented earthmoving equipment and sub-contracted operators.

The most substantial task was in earthmoving to establish level grades. Earthmoving and conversion of the percolation ponds to man-made wetlands began in February 1999. Approximately 6,000 cubic yards of earth were moved to bring the existing 3-foot slopes closer to the desired 1-foot slope.

Removal of debris was also a substantial undertaking. The percolation ponds had been constructed without removal of existing vegetation. The existing pine and oak species on the site were not adapted to flooded conditions and had died long before. In some cases, dozens of tree stumps, most of them around eighteen inches in diameter, had to be cleared before grading activities could be completed.

Man-made Wetlands Planting and Management

Establishing a diverse and robust plant community desirable for effective tertiary wastewater treatment was the primary focus of the UF/CW. It worked with other state agencies, including DEP, the Division of Forestry, the Department of Corrections, and various volunteer groups, to coordinate proper planting and botanical layout. Planting, transplanting, and removal of undesirable species will continue throughout the first two to three years. Additionally, minor structural modifications may be necessary to insure optimal hydrologic conditions. Wastewater operating permit compliance issues could also necessitate design and botanical adjustments.

The middle wetland cell has been completed and the Waldo Wetlands discharge went online in May 1999. The wetland plants have become well established and appear to be flourishing. The second of the three wetland cells has been partially planted. Planting in the third cell is scheduled for the spring of 2000. If the wetland plants in the first cell continue with the current growth rate, they could be divided to finish the second cell and start the planting on the third cell.

The UF/CW is also responsible for monitoring the treatment efficiency of the man-made wetlands. This includes biological and biogeochemical parameters encompassing vegetation (population and cover), sedimentation, soil redox conditions, phosphorus accumulation estimates for plant biomass, phosphorus accumulation in sediments, and nitrogen and phosphorus levels in surface area monitoring sites in each cell. In addition, routine monitoring of the berm structures will be conducted to verify any suspected seepage.

Facility Compliance

The new treatment facility operating permit calls for the discharge from the man-made wetland to meet annual limits of 5.0 mg/L CBOD, 5.0 mg/L TSS, 3.0 mg/L total nitrogen and 1.0 mg/L total phosphorus. For the first six months of operation the facility has met those limits.

Additional Project Benefits

It is envisioned that the Waldo Wetlands Project will provide additional benefits beyond tertiary wastewater treatment and the final resolution of a 15-year wastewater disposal compliance problem. By elimination of unwanted discharges, it will provide protection of the headwaters of the Santa Fe River, a designated Outstanding Florida Water. It will provide a natural habitat for a diversity of valued wildlife, as well as a nursery for aquatic plants to be used by other wastewater or stormwater facilities. It can serve as a wetlands display and training area for local schools, colleges and universities, and as a training area for operators of advanced natural wastewater treatment facilities. It can also provide a nature walk and birdwatching area to be used by the citizens of Florida.

City of Waldo Wastewater Treatment Facility: Compliance Data (mg/L)

Month	*CBOD,*	*TSS*	*Total – N*	*Total – P*
May-99	2.3	5.0	1.8	0.40
Jun-99	3.0	6.0	1.53	0.65
Jul-99	15.0	4.0	1.0	0.68
Aug-99	2.0	6.0	1.5	0.35
Sep-99	2.0	4.0	1.5	0.82
Oct-99	2.5	4.0	1.0	1.16
Annual Avg.	4.5	4.8	1.4	0.68
Permitted Annual Avg.	5.0	5.0	3.0	1.0

Partnership

Many small communities are faced with aging and antiquated sewer systems and changing regulatory requirements. With limited funds and lack of expertise, such communities may depend on grants and loans to upgrade their systems. The Waldo Wetlands Project was a creative alternative and a unique collaboration between a small community, federal and state agencies, and institutions. Through this joint effort the partnership was able to identify and address small community wastewater needs and restore facility compliance in an economically feasible manner. ■