Development of an Aquifer Recharge Enhancement Plan for Orange County

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Orange County is facing increasing potable-water demands due to a rapidly increasing population base that is expected to increase by approximately 50 percent over the next 20 years. Increasing aquifer recharge is one approach that has been identified as an incremental water-supply strategy to increase the available amount of potable groundwater and prolong the sustainable yield of the Floridan Aquifer.

Aquifer recharge allows for a reduction or elimination of the impacts of increased groundwater pumping. These impacts include wetland dehydration, surficial aquifer and lake drawdowns, and lateral and vertical saltwater interface movement. Because of this recognition that aquifer recharge can prolong the sustainable yield of the Floridan Aquifer, Orange County Utilities (OCU) and the St. Johns River Water Management District (SJRWMD) are cooperating to implement the Central Florida Aquifer Recharge Enhancement Phase 2 (CFARE2) Project.

The purpose of the CFARE2 Project is to develop an aquifer recharge enhancement plan for Orange County. The plan, if implemented, will maximize recharge in the Orange County area and will minimize the impacts of groundwater withdrawals in order to increase the sustainable fresh groundwater supply and reduce or delay the need to develop more expensive alternative supplies.

The plan will also provide long-term flexibility and consistency with other plans being developed by neighboring cities and counties to the benefit of the overall East Central Florida region. Its objective is to designate how current and future available sources of reclaimed water, stormwater, and surface water can be used to enhance aquifer recharge in a way that allows for continued development of current and projected groundwater supplies in the region.

As of August 2003, the project is nearing completion. Candidate projects were identified and under evaluation. The final report is due to be completed in early 2004 and will be available from the SJRWMD. This article describes the methodology for development of the plan and presents the results to date.

Methodology

The development of the aquifer recharge enhancement plan involves the systematic identifying and ranking of projects that match areas where excess reclaimed water and stormwater are available with areas that can accept and benefit from the recharge.

Figure 1 is a flow chart summarizing the process for identifying and ranking candidate projects. Generally, these projects were identified by matching available sources of water to areas where different recharge technologies are potentially feasible.

Suggestions from utility and public-works providers were significant in helping define candidate projects. The conceptual cost and total benefit of each project will then be calculated. Projects with the lowest cost-to-benefit ratio (higher benefit per unit cost) will be selected to be part of the aquifer recharge enhancement plan.

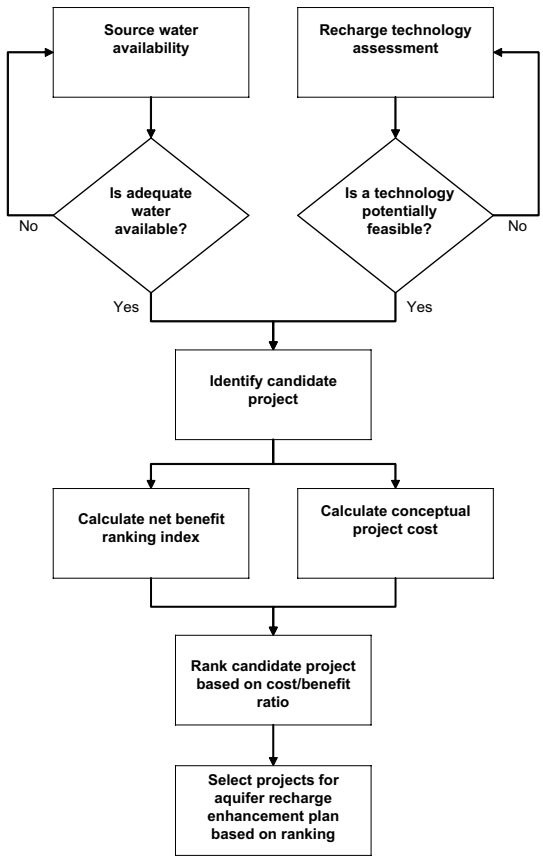

Figure 1. Summary of Aquifer Recharge Enhancement

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Source Water Availability

The first part of the project-identification phase involved an analysis of source-water availability. As part of this analysis, the availability of both surface water and reclaimed water was assessed. The result is geographic information system (GIS) mapping that shows areas where these sources are available to be captured for use in aquifer-recharge projects.

Surface-water availability was determined based on the type of basin (open, closed, or intermittently open) and a calculation of stormwater generation using annual storm-runoff coefficients. The calculation of the volume available accounts for downstream environmental needs by assuming that maintaining predevelopment flows to these areas is sufficient to meet these needs.

The availability of reclaimed water was assessed from utility estimates and available mapping of water-reclamation facilities (WRFs) and reclaimed-water transmission lines. Several discussions with local utilities have been held to assist in developing this information.

Recharge Technology Assessment

The first part of the project-identification phase also involved an assessment of where various recharge technologies are potentially feasible. As part of this assessment, the use of land application (via rapid infiltration basins [RIBs] or retention ponds modified to accept recharge), lake augmentation, or direct application to the Floridan Aquifer (via recharge wells or injection wells) of available surface or

reclaimed water to increase aquifer recharge were all evaluated. The result of this evaluation is GIS mapping of the areas where each of the different technologies may be feasible and a method for quantifying the potential recharge rate for a given candidate project.

Potentially feasible areas for RIBs and modified retention ponds were determined based on soil type and depth to the water table. The mapping indicated that suitable conditions for efficient land application of recharge existed primarily in western and northwestern Orange County. Potential RIB recharge rates were calculated based on PB Water's operational experience, which indicates that 1 million gallons per day (MGD) requires approximately 100 acres in the western part of the county near Water Conserv II and approximately 200 acres in the northwestern part of the county near Apopka. Regulatory limits on the reclaimed-water recharge rate may also be a limiting factor. Developing a modified retention pond will require keeping the recharged water from ponding to maintain the stormwater capacity of the pond. The calculation of the potential recharge rate was based on similar parameters as the calculation of potential RIB recharge rate.

Potentially feasible lakes for augmentation with reclaimed or surface water were evaluated based on lake leakiness. Using observed lake and Floridan Aquifer levels, maps were developed showing the variability in lake leakiness throughout the county. Leakier lakes may be more feasible for lake augmentation because this augmentation will be less likely to cause flooding and will be able to accept a higher flow rate. The potential recharge rate through lake augmentation is derived by evaluating the lake area and the modeled leakance of the confining unit underlying the lake.

Locations potentially feasible for direct recharge into the Floridan Aquifer via wells were selected based on water quality. Well recharge benefits water supply if a well is located in the potable section of the aquifer and the water source is potable. The potable section of the Floridan Aquifer underlies most of the developed portions of Orange County.

Central Florida currently achieves a large volume of aquifer recharge through drain wells (recharge wells) used for flood control. Studies are currently underway to demonstrate that these wells are a net benefit to water resources. Several types of recharge wells were considered, including maintenance activities to restore capacity and the construction of new wells. The current status of a recharge well determines if a recharge-well maintenance project is feasible. A location where a recharge well has been abandoned may not be as feasible for use in a recharge project as a location where a well is operable.

Candidate Project Identification

Candidate projects were determined for different areas by assessing whether adequate water is available and whether a technology is potentially feasible. The GIS mapping produced for the source-water availability assessment and the recharge-technology assessment facilitated these analyses by simplifying the spatial display of these components. Projects will be preferentially identified in areas where the most benefit can be obtained while minimizing cost.

In addition to project identification with the assistance of GIS mapping, input was solicited from utilities and public works providers within and adjacent to Orange County. CFARE2 Project ideas and concepts were also incorporated into the list of candidate projects. As a part of the CFARE2 Project, discussions with the following agencies have occurred to assist in the development of candidate projects:

- Altamonte Springs
- Orlando
- Apopka
- Orlando Utilities Commission
- Cocoa
- Reedy Creek
- Kissimmee
- Sanford
- Maitland
- Seminole County
- Ocoee
- Winter Garden
- Orange County Public Works
- Winter Park

Benefit Ranking Index Calculation

A county-wide, consistent assessment of the benefit of each identified project is critical for ranking of the projects. Without such an assessment, the rankings could end up artificially skewed to one type of recharge technology, source-water type, or location. To allow for all these factors, a new assessment tool called the benefit ranking index (BRI) was developed and agreed upon for this county-wide consistent assessment. For each candidate project, a measure of total project benefit, the BRI, is calculated.

The BRI is a dimensionless number that represents the cumulative regional environmental benefit of recharging a specified amount of water into the Floridan Aquifer at a specified location. The cumulative environmental benefit is derived from the sum of the weighted water-level increases that occur at the environmental constraint points in the East Central Florida groundwater model as a result of the recharge at the specified location. The weighting factors applied to the water-level increases are designed to account for the variation in projected impacts at the constraint points that result from projected future groundwater withdrawals.

The BRI is derived from influence functions developed for use in the SJRWMD's

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optimization model and its control points (constraints) developed as part of the *Water 2020* process. As part of the optimization model, influence functions were derived to simulate the effects on the control points of each East Central Florida regional groundwater model cell with a public-supply pumping withdrawal. The control points represent locations where various types of impacts are assessed and compared to a constraining water level change. These impacts include minimum flows and levels (lakes and springs), native vegetation, and groundwater quality.

The purpose of the BRI is to calculate the cumulative weighted benefit that a project will have on the identified constraints at the control points. This BRI calculation provides a method of comparing potential recharge locations and choosing those that will maximize the overall benefit of available recharge. **Figure 2** presents the BRI due to recharging 1 MGD at a specified location.

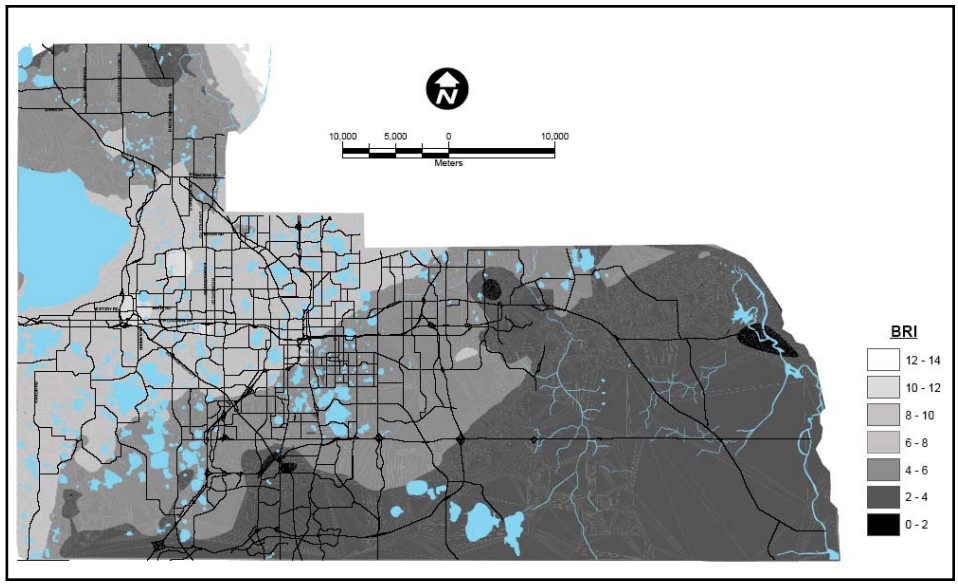

Figure 2. Benefit Ranking Index Due to a 1-MGD Recharge Project

Conceptual Project Cost Calculation

Conceptual project cost is an important component necessary to rank candidate projects since the proposed method for ranking is cost-to-benefit ratio. The candidate project flowrate, hydraulic head requirements, treatment requirements, distance from the source water to the project, and conveyance method are inputs to the cost functions developed as part of Orange County Utilities' water and wastewater planning.

The cost functions provide consistent conceptual capital construction costs for water treatment, RIB sites, wells, pumping facilities, and conveyance costs. The engineering, permitting, and construction-management costs will be determined as a percentage of these capital construction costs. For projects where land is required, the land requirements and cost per acre of land will be derived directly from the cost functions proposed for use in the CFARE2 Project. The sum of the capital-construction, engineering, and land-acquisition costs is the total implementation cost.

For ranking purposes, these costs will be assessed on a project-lifetime basis. The value of land will assume to increase at the same rate as inflation; therefore, the future value of land will be assumed to be equal to the present value of the land.

Project Ranking and Plan Formulation

Since the candidate projects are ranked based on the cost-to-benefit ratio, projects with a lower cost-per-unit benefit will be ranked highest. Table 1 provides a hypothetical example of a project ranking analysis that incorporates the other elements of project identification discussed previously. In this hypothetical example, Sample Project 1 is ranked highest.

Once projects are ranked using the cost-to-benefit ratio, higher-ranked projects will be selected to be included in the aquifer recharge enhancement plan for Orange County, based on their ability to provide complementary benefits throughout the county. It also is recognized that the projects selected may be a function of the implementation sequence of the projects; however, it may not be possible to determine the sequence by the conclusion of the CFARE2 Project.

Summary

The SJRWMD *District Water Supply Plan* identifies increased aquifer recharge as one method to "significantly increase available fresh groundwater supplies and thereby reduce or delay the need for development of alternative water supplies." The purpose of the CFARE2 Project is to identify and evaluate potential projects that would allow for increased recharge to occur in the Orange County area. To assist with the identification of these projects, GIS-based analyses were performed and several meetings with interested agencies were held. In order to better evaluate the benefit of each project, a new assessment tool called the BRI was developed based on previous SJRWMD work. Upon completion of the project identification and evaluation, the SJRWMD has programmed funds to assist with the development of these projects.

Project Name	Location	Type	Recharge Rate (MGD)	Source Water	Time to Implement (years)	Total Cost ($)	Cost ($/gpd)	Project Screening	BRI	Cost/BRI ($x1000)
Sample Project 1	Within 1-mile radius of Trout Lake	RIB	1.5	NWWRF	4	4,500,000	3.00	Acceptable	3.00	1,500
Sample Project 2	Stormwater retention pond near Lake Sherwood	Retention pond	0.1	Stormwater, Lake Sherwood Basin	5	500,000	2.50	Acceptable	0.30	1,667
Sample Project 3	Crooked Lake	Lake augmentation	0.5	Stormwater, Little Wekiva Basin	3	2,000,000	4.00	Acceptable	0.75	2,667

Table 1. Example Project Ranking Analysis