DEVELOPMENT OF A DECISION SUPPORT TOOL (DST) FOR OPERATION OF A SURFACE WATER/ASR WATER SUPPLY FACILITY

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Abstract

The Peace River/Manasota Regional Water Supply Authority (Authority) was formed to provide regional water supply to a four county area of southwest Florida. The Authority is expanding the Peace River Regional Water Supply Facility (Facility) to meet water supply contracts to deliver 18 million gallons per day (mgd) to three of the four member counties. The facility relies on surface water from the Peace River, a highly variable water source with flows ranging from billions of gallons per day to periods of almost no flow. To protect the Charlotte Harbor estuary, diversion from the Peace River is strictly regulated, and no diversion is allowed during times when river flows are low. As a result of limits imposed by the Authority's water use permit, there are times when the facility is unable to divert any water from the river, and must rely on storage to meet contract obligations. The main component of storage is an aquifer storage and recovery (ASR) system. This system relies on wells to store finished water at times when raw water can be diverted and treated at rates in excess of the daily demand. Water is recovered from these same wells to meet demand during periods of low river flow when diversion is prohibited.

The expanded facility will include the following main components:

- A river pumping station, consisting of 4 pumps having a combined pumping capacity of 36 mgd;
- A raw water reservoir having a usable storage capacity of 525 million gallons (mg), designed to store flows diverted from the river in excess of the capacity of the water treatment plant;
- A surface water treatment plant, having a treatment capacity of 24 mgd; and
- Twenty-one ASR wells, each having a nominal injection/recovery capacity of 1 mgd and a target storage volume of 300 mg per well.

Operation of these facilities is complex, requiring frequent operator decisions balancing demand for water, daily flow and quality of water in the Peace River, volume and quality of water in storage in the raw water reservoir, and volume and quality of water in storage in the ASR system. The operator's decisions are complicated because the quality of water recovered from the ASR system degrades during recovery due to mixing with native groundwater. In periods of low river flow, when the facility must rely heavily on water recovered from ASR, it becomes necessary to blend water from multiple sources (river, raw water reservoir, each of 21 ASR wells) to extend the recovery cycle while meeting water quality goals.

Working with the Authority operations staff to identify their decision processes, Boyle Engineering Corporation developed a computer-based Decision Support Tool (DST) to support the day-to-day operation of the facility. The DST will poll instrument sites at each of the main components of the facility to collect data on flow, storage volumes, and water quality. Using this information, the DST

provides the operator with: analysis of operating status; analysis of trends in water quality and flow conditions; analysis of ASR well performance, including the need for well rehabilitation; analysis of ASR recovery efficiency and water quality; and guidance for blending of water from various sources. The DST will also continuously update a forecast of the facility's reserves and its capability to sustain demand during periods of low or no river flow. This last feature of the DST is critical during droughts, when the Authority must rely on water stored in ASR and the raw water reservoir as the sole source of water.

The DST will be implemented in conjunction with the new supervisory control and data acquisition (SCADA) system included in the Facility expansion, scheduled for completion in 2001. The DST relies largely on data provided through the instrumentation and control features common to most water treatment facilities.

Background

The Peace River/Manasota Regional Water Supply Authority was formed to meet regional water supply needs of Charlotte, DeSoto, Manatee, and Sarasota Counties in southwestern Florida. The existing water supply facilities include: a river diversion structure and high-service pumps rated at 24 mgd; a surface reservoir having a nominal capacity of 625 mg and an estimated recoverable capacity of 525 mg; a conventional water treatment plant rated at 12 mgd; nine ASR wells each rated to inject and recover about 1 mgd; and related infrastructure. The location of these facilities is shown in Figure 1. The overall layout of facilities is shown in Figure 2. As presently configured, these facilities are able to supply about 10 mgd on a reliable, long-term basis. The Authority is expanding these facilities such that the combined system is capable of supplying 18 mgd on a reliable, long-term basis.

The Facility relies on surface water from the Peace River as its sole source of raw water supply. Diversions from the Peace River are limited by permit to times when flows in the river are greater than 130 cubic feet per second (cfs). In addition, diversions cannot exceed 10 percent of the river's flow, and cannot cause the flow to fall below 130 cfs. Given the magnitude and frequency of daily flows, the Authority is unable to divert water an average of 12 percent of the time historically, and must rely on storage to meet demands for water.

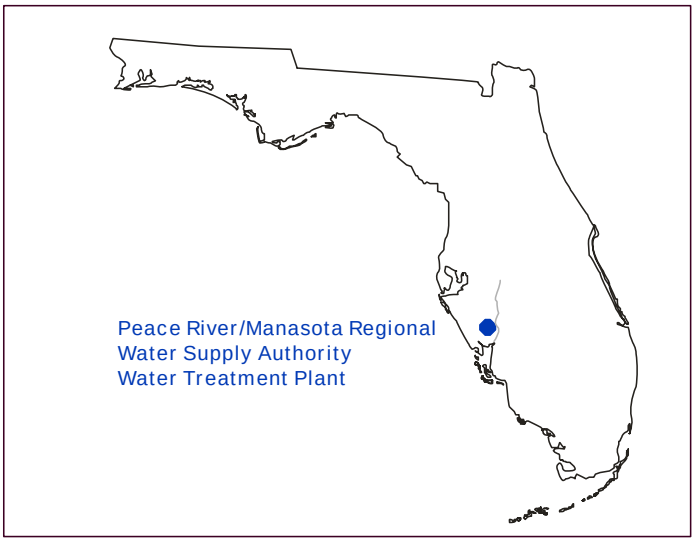

Figure 1. Site Location

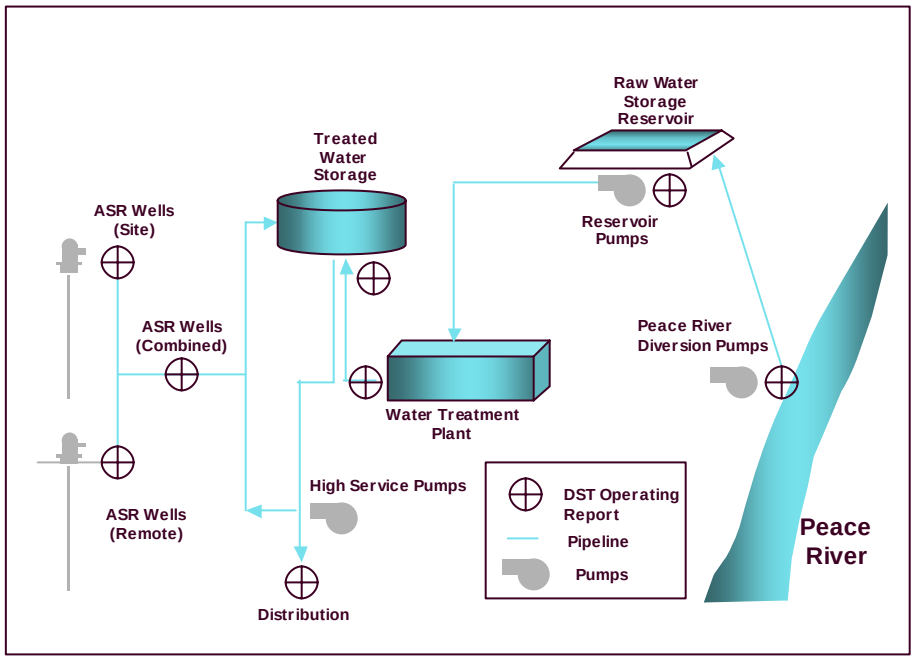

Figure 2. Peace River / Manasota Regional Water Supply Facility Layout and DST Operating Reports

The main component of storage is an aquifer storage and recovery (ASR) system. This system relies on wells to store water at times when raw water can be diverted and treated at rates in excess of the daily demand. Water is recovered from these same wells when the plant is unable to divert water from the river.

The DST is being implemented in connection with the expansion of the water treatment plant and associated facilities. A part of the expansion involves the construction and equipping of an additional 12 ASR wells, bringing the total number of wells serving the facility to 21. It became apparent early in the planning process that managing, operating and maintaining this many wells would involve extraordinary efforts. This task would become particularly challenging for plant operations personnel during recovery periods, when the wells would be called upon to supply part or all of the daily demand. The quality of water produced by the ASR wells varies between wells, and also varies over time for individual wells. The number of possible combinations of wells that would need to be considered to achieve a specific water quality goal, combined with constraints on the ways in which individual wells and groups of wells need to be operated, is formidable. This task was considered to be one better handled by a decision support tool, as described in the following sections.

Overall Attributes of the Decision Support Tool

The DST is built around “Operating Reports” as shown in Figure 2. Operating reports, accessible on the facility’s main computer, can be accessed for information on performance of the main components of the facility (river pumps, reservoir, plant, ASR wells) and for assistance in decisions concerning the facility’s operation.

Figure 3 presents an outline of the logic for operating the plant on a daily basis. The facility is essentially operated in one of two modes, storage or recovery, depending on the flow of the Peace River.

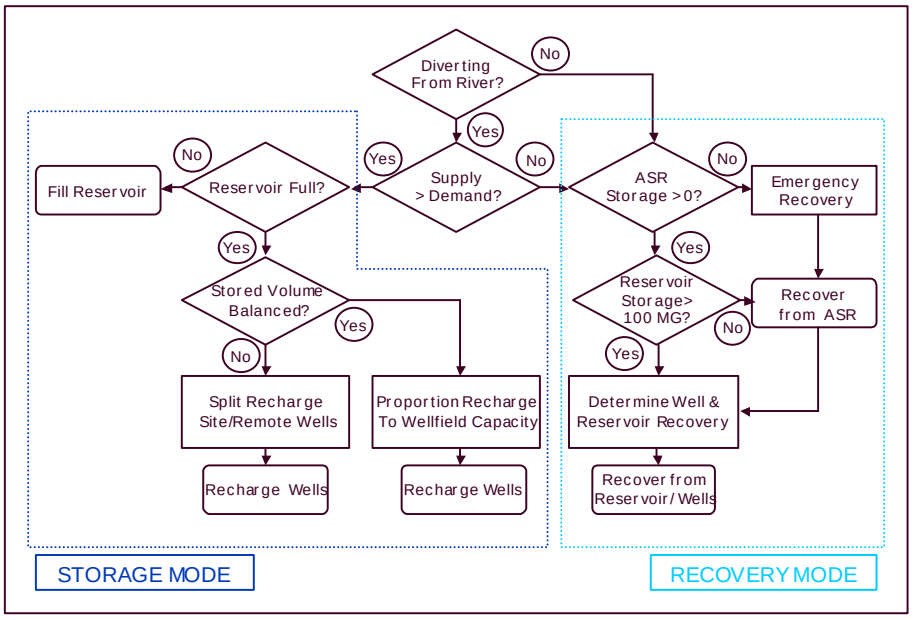

Figure 3. Logic for Decision Support Tool

The DST will reside on the plant's main computer, forming a part of the supervisory control and data acquisition (SCADA) system. The DST is designed to complement the control capabilities of the SCADA operations software, although there are no plans to incorporate control capabilities in the DST itself. Rather, the DST will provide information and support to decision processes. Plant control functions will reside exclusively in the SCADA system.

The DST will access both real-time and historical hydrologic and facility performance data to support plant operations staff in day-to-day decisions. In this role, the DST will have the capability to perform elementary engineering analyses. The results of these analyses may be used by operations personnel in making assessments of system performance, need for system repairs and rehabilitation, and in making limited forecasts of near-term (up to several months) future system performance.

The DST will provide current and historical (24-hour, 7-day, and 30-day) information on operating conditions such as flow rates, storage levels, water levels, and total dissolved solids (TDS) concentrations (estimated from conductivity measurements) at various locations within the facility. The information will be displayed in tabular and graphical formats and will show recent trends in measured parameters, such as ASR storage over the prior 30-day period. The reports will also provide a current forecast of the number of days of remaining supply for both the raw water reservoir and ASR storage. These forecasts are continually updated to incorporate current conditions, such as recovery rates observed in the ASR system.

Principal Elements of the Decision Support Tool

General

Following are some of the interactive reports available to plant operations staff (see Figure 2). These reports are accessed for information on performance of the main components of the facility (river pumps, reservoir, plant, ASR wells) and for assistance in decisions concerning the facility's operation. The operator develops set points for daily operations on a trial and error basis using these reports. Once a configuration is developed that satisfies the supply and demand and water quality requirements for the facility for the day, these selections would be used in controlling wells, pumps, valves, etc. for the facility.

Overall Facility Report

This report provides current and historical (24-hour, 7-day, and 30-day) information on overall facility status (water in storage, river flow, sources of supply). This report provides two estimates of the number of days of supply remaining, both based on demand. The first estimate is based on a condition of full recovery, in which all water stored is recovered without regard to water quality. The second estimate is based on the current calculated ASR recovery. Both estimates are continuously updated to current conditions.

System Demand Report

The separate demand locations served by the Authority are summed to determine the overall requirements for potable supply from the Peace River Facility.

Overall Facility Storage and Recovery Options

There are a number of relatively complex decisions that are required during recovery from the ASR system to assure that treated water supplies are available to meet demands, and to manage the quality of these supplies. Operator decisions required during this period include target TDS concentration of delivered water and target withdrawal rates from the raw water reservoir and each of the 21 ASR wells. Information on current river flow, reservoir and ASR storage values, and water quality from each of these sources is provided to assist in these decisions. The operator is given the opportunity to pick "set points" for these alternate sources, and optionally, set points for each of the ASR wells. The DST in turn estimates both the quantity and quality of water that can be delivered using these set points. This process is interactive.

Peace River Diversion

Peace River flow is currently determined by telephone contact with a river gage located about 15 miles upriver from the plant, at Arcadia. Plant personnel determine gage height approximately six times per day. The gage height is then converted to a discharge value using a rating table prepared by the U.S. Geological Survey (USGS). These values of river discharge are averaged to determine the average daily flow, from which the facility's diversion entitlement can be determined.

This process will be automated as part of the DST development. The Arcadia gage is one of many throughout the state that is maintained by the USGS. Automated gage height readings are made hourly at this site, and transmitted via satellite every four hours to a station in Miami where the gage height readings are converted to river discharge using the most current rating curve available. This data will be made available to the Authority on an accessible, anonymous FTP (file transfer protocol) site. The FTP site provides a means for transferring of data files from a host computer (the USGS) to a remote computer (the plant's main computer). The plant's main computer will be programmed to automatically dial the FTP site, at which time the previous day's hourly discharge readings would be downloaded to the plant's computer. The DST will access this data to determine average discharge for the preceding day and diversion entitlement for the current day.

The Peace River Diversion report provides both current and historical information on hydrologic conditions of the Peace River. It also compares year-to-date diversions with permitted diversions. A 30-day report showing divertible flow is based on applying the diversion rules to average daily flows recorded over the prior 30 days.

Raw Water Reservoir

The raw water reservoir has a storage capacity of 625 mg of which 100 mg is estimated to be unrecoverable because of reduced water quality at low reservoir levels. Usable storage is equivalent to about 30 days of supply at a withdrawal rate of 18 mgd.

One function of the off-river reservoir is to provide some pretreatment and buffering of water quality changes in the river. The reservoir also provides an important source of water for use in blending with water from the ASR system, at times when the water recovered from ASR exceeds the target concentration of 500 milligrams per liter of total dissolved solids (TDS). The need for blending may occur during the latter stages of an ASR recovery cycle. Use of the raw water reservoir provides a means to extend recovery. Accordingly, drawdown of the raw water reservoir is typically reserved for times of severe shortage and when needed as a source of blending with water recovered from the ASR facilities.

The raw water reservoir report provides both current and historical information on flows to and from the reservoir. It provides an estimate of the number of days of supply remaining in the reservoir based on current demand. The report also provides an analysis of reservoir gains and losses based on a comparison of measured inflows and outflows with reservoir stage.

ASR Reports

These reports provide key information on the ASR system, including current and historical storage and recovery rates, current and historical storage, and TDS of water that is being stored or recovered. In addition, these reports provide estimates of the number of days of supply remaining for each of the wellfields. These reports include graphs of the wells' hydraulic performance (specific capacity) over the previous 30 day period, a calculation of current performance, and a comparison of current performance to performance at the time of installation. The operator will be notified of conditions that indicate the need for remedial measures (such as acidification, well workover) if there is evidence of a significant decline in well performance.

Summary

Operation of the Peace River water supply facilities is complex, requiring frequent operator decisions balancing demand for water, daily flow and quality of water in the Peace River, volume and quality of water in storage in the raw water reservoir, and volume and quality of water in storage in the ASR system. The operator's decisions are complicated because the quality of water recovered from the ASR system degrades during recovery due to mixing with native groundwater. There are times when it is necessary to blend water from multiple sources (river, raw water reservoir, each of 21 ASR wells) to extend the recovery cycle while meeting water quality goals.

A computer-based Decision Support Tool (DST) was developed to assist plant operations staff in operation of these facilities. The DST will be implemented in conjunction with the new Supervisory Control and Data Acquisition (SCADA) system, and relies largely on data provided through the instrumentation and control features common to most water treatment facilities.

The DST provides the operations staff with information on key conditions relating to the plant's operation. It also provides the operator with analysis of trends in water quality and flow conditions, analysis of ASR well performance, analysis of ASR recovery efficiency and water quality; and guidance for blending of water from various sources to achieve water quality objectives. Most importantly, the DST will provide continuously updated forecasts of the facility's water supply reserves and the facility's capacity to sustain demand during periods of low or no river flow. This last feature of the DST is critical during droughts, when the Authority must rely on water stored in the ASR and raw water reservoir as the sole source of water.

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