Authors

John R. Hollenbeck, P.E.[1], is the Nacimiento Project Manager within the Public Works Department of San Luis Obispo County, California. He is the full-time manager of the project through the design, bidding and construction phases. Mr. Hollenbeck has been engaged in the evaluation, design, and construction management for hydraulic structures since graduating from Kansas State University with a B.S. and a M.S. degree in Civil Engineering in 1984 and 1986, respectively.

Thomas C. Trott, P.E.[2], is the Nacimiento Project Engineer within the Public Works Department of San Luis Obispo County, California. He works full-time to assist the management of the Nacimiento Water Project through its design, bidding and construction phases. Mr. Trott received his B.S. degree in Civil Engineering in 2003 from California Polytechnic State University, San Luis Obispo. He has experience in design and construction of a variety of facilities including roadways, sewer systems, storm water systems and water supply systems.

Paul R. Kneitz, P.E.[3], is an Associate Vice President and Senior Project Manager with Black & Veatch Corporation in Walnut Creek, California. He specializes in managing large water resources projects principally involving raw water and treated water conveyance and water treatment. For the Nacimiento Water Project, he is serving as Deputy Project Manager and Chief Engineer during the design, bidding and construction phases. Mr. Kneitz graduated from the University of California, Berkeley with a B.S. degree in Civil Engineering and an M.S. degree in Structural Engineering in 1976 and 1977, respectively.

Carolyn K. Berg, E.I.T., is the Nacimiento Project Engineer within the Public Works Department of San Luis Obispo County, California. She works full time assisting with the overall management of the Nacimiento Water Project through its design, bidding and construction phases. Ms. Berg graduated from California Polytechnic State University, San Luis Obispo with her B.S. degree in Civil Engineering in 2008. Her experience lies in design, construction, and management of water filtration and water supply systems, specifically in developing communities, and her course work emphasized geotechnical studies.

[1] in Kansas and California
[2] in California
[3] in California

ACHIEVING SUSTAINABILITY BY DESIGNING FOR EFFICIENCY A CASE HISTORY OF THE NACIMIENTO WATER PROJECT

John R. Hollenbeck, P.E. [1], M. ASCE, Thomas C. Trott, P.E. [2], M. ASCE
Paul R. Kneitz, P.E. [3], Carolyn K. Berg, E.I.T. [4], AM. ASCE

ABSTRACT

The Board of Supervisors of the San Luis Obispo County Flood Control and Water Conservation District (District) adopted the Final Environmental Impact Report for the Nacimiento Water Project (Project) in January 2004, thus directing staff to design the raw water conveyance that will supply up to 15,750 acre-feet per year from Lake Nacimiento located in San Luis Obispo County, California.

The Project consists of a sloping multi-port intake and pump station facility, two intermediate pump stations, three storage tanks, control center, and approximately 45 miles of transmission pipelines ranging in diameter from 36-inches to 12-inches. The Project's Participants (customers) currently include Paso Robles, Templeton, Atascadero, and San Luis Obispo (Initial Participants) and later were joined by San Luis Obispo County Service Area 10- Zone A.

The District began the design in 2005, set specific design objectives for a sustainable and reliable water supply and for the efficiency of the water conveyance system to minimize electrical operating costs. This paper describes the sustainability aspects of the Project's design that include water supply sustainability, reduced energy use through energy efficiency initiatives, and balancing of resources.

[1], [2], [4],San Luis Obispo County Flood Control and Water Conservation District, County Government Center-Room 207, San Luis Obispo, CA 93408,
[1] jhollenbeck@co.slo.ca.us, [2] ttrot@co.slo.ca.us, [4] cberg@co.slo.ca.us
[3] Black & Veatch Corporation, 2999 Oak Road, Suite 490, Walnut Creek, CA 94597, KneitzPR@bv.com

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PROJECT PURPOSE

The primary objective of the Project is to provide a reliable supplemental water source for a variety of uses within San Luis Obispo County (County) by supplementing the local groundwater and surface water supplies with a new water source. Other Project objectives are to increase reliability of existing water supplies, to improve water quality, to lessen the extent of future groundwater pumping, and to provide sufficient supplies to support planning objectives in various communities of the County. Overall, this will ensure better management of available water resources throughout the County.

WATER SUPPLY SUSTAINABILITY

Lake Nacimiento holds 377,900 acre-feet when at normal maximum storage, and has 10,700 acre-feet below the dead pool elevation. Monterey County Water Resources Agency (MCWRA), the reservoir owner, and the District hold their water entitlements between these limits. The reservoir yield is about 210,000 acre-feet per year (MCWRA 2000), and MCWRA's water rights permit with the State of California sets a maximum annual withdrawal of 180,000 acre-feet (California 1985). The District's total entitlement of 17,500 acre-feet annually from the lake (15,750 acre-feet for the Project, and 1,750 acre-feet for lakeside users) makes up a small portion of the overall yield of the reservoir, and past engineering reliability assessments, based on historic records from 1950 through 1990 (Boyle 1992) have indicated that the watershed would supply nearly 100-percent of the District's entitlement. Adding the Project to the local community's primary water supply portfolio will improve water supply reliability, even with the Project serving as a "supplemental" supply.

The growing City of Paso Robles (City), in the northern region of the County, population of approximately 30,000, overlies the Paso Robles Groundwater Basin (see Figure 1) and has always relied upon groundwater as its sole water supply. The City constantly faces challenges to meet water quality mandates specified by the local regulatory agency for the waste discharge requirements regarding TDS levels. The Total Dissolved Solids (TDS) measured from the City's wells range between 370 and 740 parts per million (ppm) (Paso Robles 2009) and the effluent from the City's wastewater treatment plant has even greater TDS levels. The treated wastewater is discharged into the

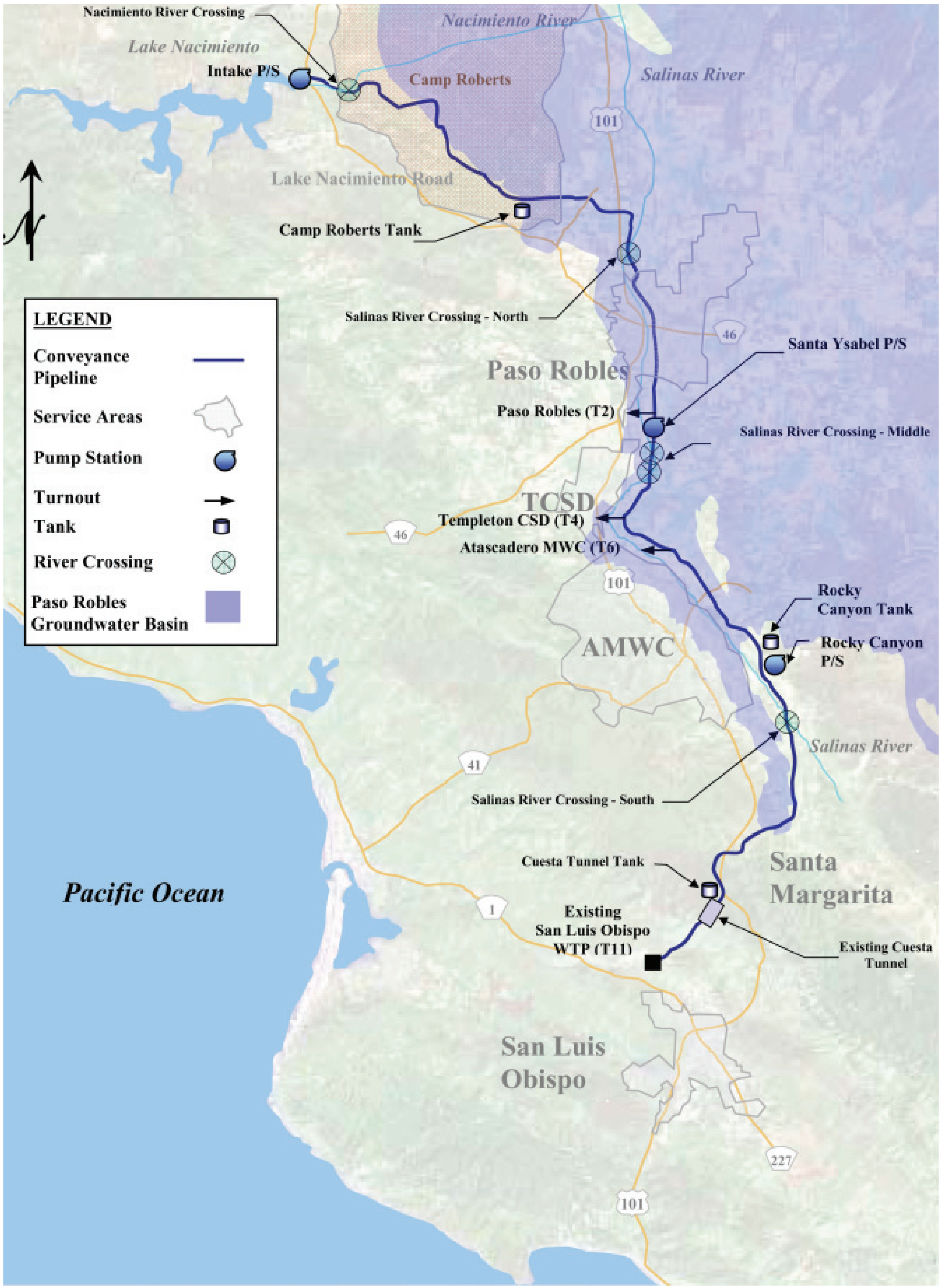

Figure 1. Nacimiento Water Project with Paso Robles Groundwater Basin Overlay

Salinas River and eventually recharges the groundwater basin. Furthermore, water softeners have been installed within homes and businesses, and these have further contributed to higher TDS levels in the waste stream. The City plans to construct a water treatment plant to treat the raw water delivered by the Project, which the City will then blend with their well water. This will result in reduced TDS levels in the potable water supply system. The City benefits from the Project in several ways: (1) receiving a reliable supplemental water supply, (2) lower TDS levels in the waste stream by receiving a lower TDS water supply, (3) reducing the need for an expensive wastewater treatment plant upgrade which would be needed to lower the effluent's TDS level, and (4) reducing the groundwater pumping, thus contributing to a more sustainable groundwater supply.

By contrast, the City of San Luis Obispo (SLO), in the south-central portion of the County, population of approximately 45,000, relies predominantly on surface water sources. The City of SLO utilizes such existing small surface water supplies as Salinas Reservoir and Whale Rock Reservoir, and has little access to large-scale groundwater resources. The City of SLO does not face growth concerns, but rather, they need a reliable secondary water supply as a reserve to manage drought cycles.

The communities of Templeton and Atascadero, located between the Cities of Paso Robles and SLO, are both supplied with groundwater from the Paso Robles Basin. Both are constructing groundwater recharge ponds (percolation ponds) and will use their deliveries to replenish the groundwater locally near their well fields.

REDUCED ENERGY USE - ENERGY EFFICIENCY

During the Project's preliminary and final design phases, the design team performed an on-going series of life-cycle cost evaluations to continually evaluate and optimize the Project facilities' size and capacity with the eventual goal of reducing overall Project energy usage in a cost-effective manner. As an example, the District participated in the Savings By Design program which is a California statewide nonresidential new construction and renovation/remodel energy efficiency program. Pacific Gas and Electric (PG&E) manages the program in the San Luis Obispo Project area. The program enables customers to improve the energy efficiency of their projects using design assistance and financial incentives available through the program.

The design of the Project's pump stations showed potential for feasibility of inclusion in Savings By Design program. By participating in this program, use of premium-efficiency pump motors and energy efficient electrical systems and lighting would pay for themselves within a reasonable payback period. The design team also reviewed the potential of upsizing several miles of Project pipeline to reduce hydraulic losses which would yield reduced pump station power capacity and thus lower pumping costs. The team developed a plan to receive alternative bids for upsizing entire pipeline reaches, provided that the cost for upsizing the pipe based on the alternative bids was less than the breakeven point dictated by energy savings and incentives payments. Based on bid results, the northern-most reach (about nine miles) of the Project pipeline was upsized from 30 to 36 inches with a resulting reduction of the Intake Pump Station power capacity and expected lower pumping costs. As a result, the pump units were downsized from 700- to 500- horsepower (hp). The design team estimates the investment's payback period to be between 10 and 15 years.

BALANCING RESOURCES

The District sought to achieve a sustainable design by creating solutions that balanced the use of resources, including monetary (cost), electrical energy (temporary and permanent), raw materials, and manufactured equipment. Several applicable design evaluations were performed, including pipeline optimizations, renewable energy studies, the intake pump station wetwell optimization, and time-of-use pumping evaluations.

Pipeline Optimizations

The design team performed a series of ongoing life-cycle studies to confirm the optimal combination of pipeline diameter and pump station capacity by comparing upfront construction costs to long-term operating costs.

As part of Project sizing, a pipeline optimization analysis (Black & Veatch 2006) compared alternative pipeline diameters by Project Unit (the identifier for the pipeline reaches) in conjunction with variable pumping energy costs. This optimization defined the recommended Project pipeline diameters. The approach found the best combination and size of conveyance components that produced the least present-worth total of capital, operating, and maintenance costs.

The operation of the three pump stations will generate the largest operating electrical energy (power) cost component associated with the Project water delivery. The power required for pump operation is inversely proportional to changes in the pipeline diameter. As the pipe diameter increases, power costs decrease due

Pipeline Construction Cost, $/foot dia-inch	12
Manning's n	0.011
Power Cost, $/kWh (First Year)	0.15
Life Cycle, years	30
Present Worth Discount Rate, %	7.00
Power Escalation Rate, %	3.00

Table 1. Assumptions Used for Pipeline Optimization Analysis

Table 2. Nacimiento Pipeline Optimization

Unit	Length (feet)	Flow (cfs)	Pipeline Diameters (inches)	
			Optimized	Constructed
A	7,524	32.79	30	36
A1	42,450	32.79	30	36
C	24,690	32.79	36 and 30	36 and 30
C1	38,935	32.79	30	30
D	20,851	19.89	24	24
E	9,294	18.62	24	24
F	27,678	8.40	18	18
G	36,679	8.40	18	18
G1	15,783	8.40	18	18
H1	13,704	8.40	12	12

to the decrease in friction loss in the pipeline, and vice-versa. Table 1 shows the assumptions used in the analysis:

To determine the optimal pipe diameter for a given system operating condition. the estimated pipeline construction cost was added to the estimated present worth cost of operating power for a series of increasing pipeline diameters. This combination resulted in a cost optimization curve. The lowest combined cost over the range of pipeline diameters indicated the optimized pipeline diameter. The pipeline optimization analysis utilized the Ultimate Project operating scenario, which is the full delivery of 15,750 acre-feet per year, including the peaking factors for each of the participating agencies. In general, the analysis found that pipe diameters could be reduced by six-inches. An example of the pipeline optimization analysis is shown in Figure 2. Table 2 presents results of the pipeline optimization.

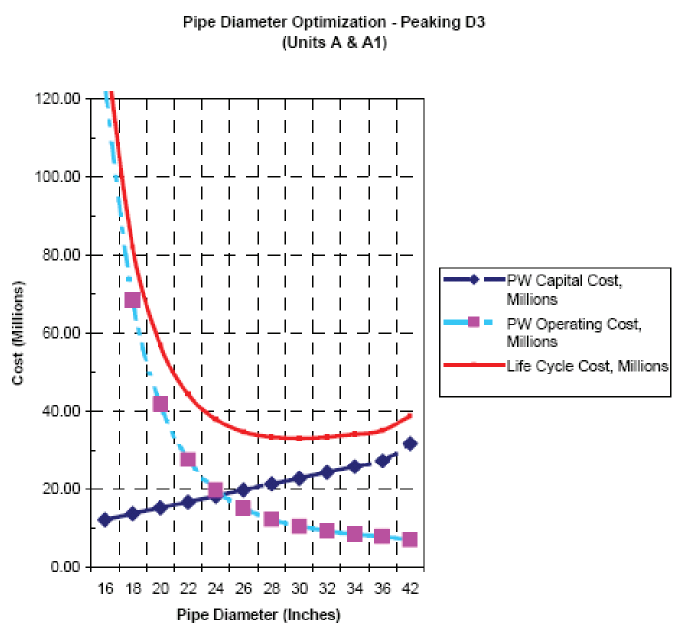

Figure 2.
Pipeline Diameter Optimization Results

Renewable Energy Studies

The design team reviewed options

for the District to reduce its overall energy operating costs through either self-generation of electrical power, by constructing and operating solar or hydroelectric facilities, or by selling wholesale power to PG&E. These evaluations resulted in neither option being economically feasible at this time; however, the District will continue to evaluate these options as an additional capital project once the Project becomes operational.

Intake Pump Station Wetwell Evaluation

The water delivery process begins at the Intake, which consists of an Intake Pipe with varying inlet valves to provide optimal water quality, an intake tunnel that moves water from the pipe into the wetwell, and the Intake wetwell. The wetwell is a 180-foot deep, 20-foot diameter, concrete-lined shaft that the pump columns sit in. The design team commissioned a physical hydraulic model study of the Intake Pump Station's wetwell to avoid the occurrence of pump operating problems. The model study investigated the possible presence of hydraulic conditions in the pump station wetwell that would adversely impact operation and maintenance of the vertical turbine pumps. Such hydraulic conditions could include flow pre-swirl entering pumps, vortex formation, and flow velocity imbalance approaching the impeller(s), all of which could lead to pump vibration, cavitation damage, accelerated bearing wear, reduction of pump capacity, and/or deviation from the best efficiency point.

The hydraulic model looked to optimize the intake shaft and inlet port diameters for hydraulic purposes. In addition, if adverse hydraulic conditions were present, the model could investigate appropriate mitigation measures to incorporate into the Project design.

The hydraulic modeling work was performed by a hydraulic laboratory in Edmonton, Canada (see Figures 3 and 4), under subconsulting contract with the design firm. Initially, the team reviewed the

Figure 3.
Wetwell at Hydraulic Modeling Laboratory.

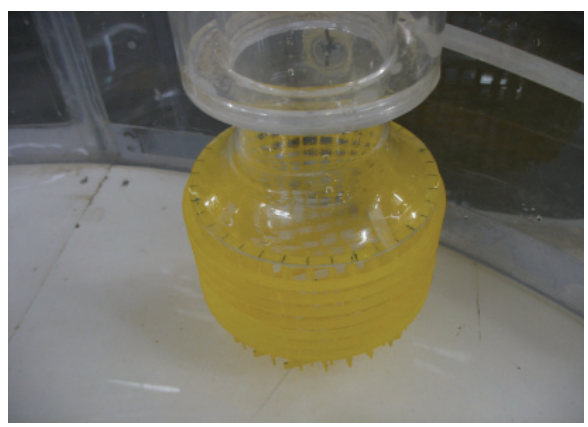

Figure 4. Pump Suction Bell and Assembly of Anti-Vortex Baffle.

intake concept, focusing on determining the minimum wetwell diameter, minimum intake tunnel diameter, floor elevation of the pump station (submergence), and pump spacing and layout. An analysis using computational fluid dynamics (CFD) followed to verify expected hydraulic conditions. The CFD results aided in determining the recommended geometry for the physical hydraulic model.

The hydraulic model study (Northwest Hydraulic Consultants 2006) determined that the initial wet well configuration did not meet established performance criteria. Several modifications to the initial design were developed and tested in the physical model, including the following.

- Raising all five pumps to provide a one-foot clearance between the wetwell floor and the pump inlet.

- Suspending a 36-vane basket (see Figure 4) with bottom grating and seven equally-spaced horizontal vane rings from all five pumps.

Time-of-Use Pumping Evaluation

Following the determination of optimal pipeline diameters for conveying Project flows, the feasibility of Time-of-Use (TOU) operation was evaluated. TOU operation means that the pump stations would be shutdown to avoid operating during the electrical peak demand period defined as 12:00 Noon to 6:00 pm weekdays, from May 1 to October 31. By avoiding peak period operation, the District could save on energy costs, depending on the alternative evaluated. To accommodate system operation in the summer peak period under a TOU scenario, the analysis showed that the Project facilities had to be sized accordingly to permit continued delivery of flows to the Participants while the system is shutdown from Noon to 6:00 pm. In this example, the increased costs for system storage (water tank volume) to accommodate TOU operation was found to be more than the present worth of energy savings expected. As a result, the Project was not designed to allow for TOU operation, but it may still be possible for the District to try it as an operating scenario if actual water deliveries in the early years of Project operation are well below system capacity.

CONCLUSION

The District conducted several analyses to create a new hydraulic structure that would satisfy, as best it can, design criteria that benefit the Participants (economic resources) and the environment (natural resources). The balance of both has yielded a successful project in the authors' judgment.

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Unit Conversion

1 mile = 1.6093 kilometers
1 foot = 12 inches = 0.3048 meters
1 acre = 0.4047 hectare
1 cubic foot = 0.02832 cubic meters
1 cubic yard = 0.765 cubic meters
1 pound per square inch = 6894.76 pascals
1 ton = 2,000 pounds = 907.18 kilograms
1 acre-foot = 1,233.5 cubic meters
1 horespower = 0.746 kilowatts

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