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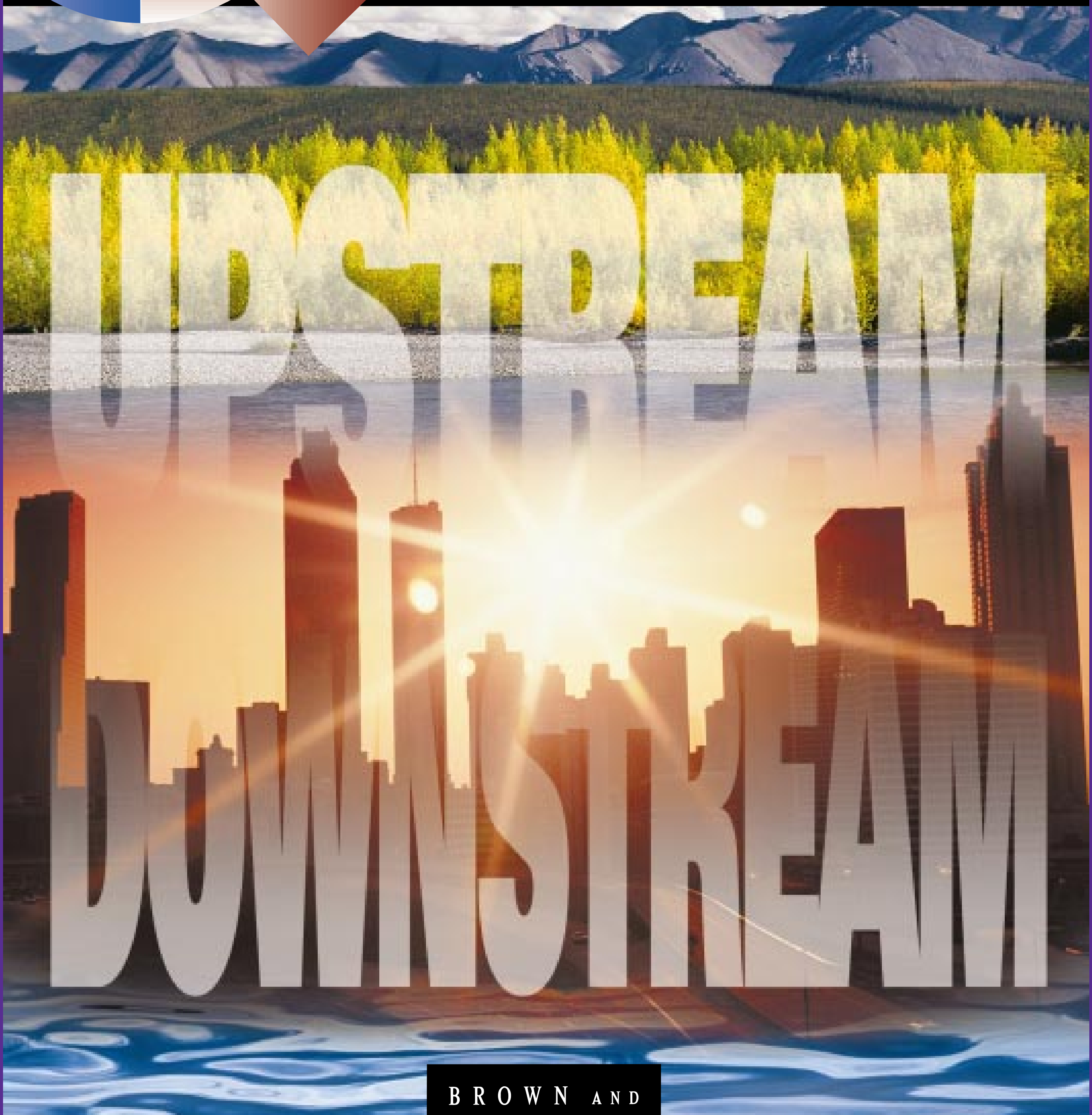
QUARTERLY



BROWN AND CALDWELL

QUARTERLY

Marketing Communications Manager Terry Peckham

Editor Lisa Bernstein

Editorial Advisor Cindy Paulson

Writers Lisa Bernstein, Terry Cole, Sam Wilson

Assistant Andrea Atkins

Design and Illustration Marc Rappaport

Printing Bacchus Press

To speak with a Brown and Caldwell representative, call us at (800) 727-2224 or visit our web site at www.brownandcaldwell.com.

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We Need a MORE Comprehensive Approach to Managing Water Quality

In the early '70s, two pillars of water-quality regulation were constructed: the Clean Water Act and the Safe Drinking Water Act. Almost 30 years later, we need a specific linkage between the two.

In the past, the availability of pristine water allowed us to separate the issue of safe drinking water from the issue of water pollution. We had the luxury of drawing on unspoiled water to drink without having to clean up low-quality supplies to potable levels.

But now, supplies of high-quality water are limited—as are ratepayer resources. To optimize our finite resources, we have no choice but to integrate upstream controls and downstream water treatment.

It's currently difficult, however, to find the best balance between the two approaches. One reason is the lack of a clear linkage between the Clean Water Act (CWA) and the Safe Drinking Water Act (SDWA). The technical approaches of the two acts aren't directly connected: They quantify acceptable water quality in different ways and at different points in the water-supply system.

The objective of the CWA is to provide fishable and swimmable waters; it requires the application of water-quality criteria to rivers and lakes to protect various designated uses, including raw drinking-water supply. In contrast, the SDWA has focused on treatment to provide safe water at the tap; it applies maximum contaminant levels to treated drinking water. The SDWA's 1996 amendments provide for source water assessment and protection, but they provide no numeric objectives or criteria for raw water supplies.

The other major reason we don't yet know how to optimally balance upstream controls with downstream water treatment is that each has different costs and focuses, and each typically is managed by different entities. Upstream controls are achieved through treatment of municipal wastewater, storm water runoff, and nonpoint sources, while water treatment is provided before distribution to customers. As a result, the two groups—the people responsible for upstream controls and those responsible for downstream water treatment—tend to hold different views about how to spend money to achieve high-quality drinking water.

The two groups must integrate their different approaches and work together—because, in the end, their functions are supported by ratepayers, and ratepayer resources are limited. Yet right now, there's no legislative or regulatory bridge between the different agendas. The CWA and the SDWA don't resolve the historically different focuses of the upstream versus downstream approaches.

Our policy-makers and industry leaders must re-examine the two acts and establish a specific linkage between them, whether regulatory or legislative, reflecting decisions about the following: 1) what water-quality criteria under the CWA will best protect drinking-water supplies and 2) when we should apply water treatment and when watershed controls, such as wastewater and storm water treatment. This linkage would help all of us navigate tough choices.

On the first question: To meet the objective of the CWA, the USEPA, which is responsible for implementing the two acts, has largely focused its water-quality criteria guidance on the protection of aquatic life. If we wish to apply the CWA to make the nation's waters drinkable as well as fishable and swimmable, we need more guidance from the EPA. Even more important, we need to decide if providing drinkable waters, with only conventional water treatment, is a realistic goal, particularly for lower-quality waters.

Without further guidance from the USEPA, cities and states will be left on their own, and they could go in many different directions to develop criteria. For example, the city of Thornton, Colo., recently proposed stringent criteria to be applied to streams across the state to protect drinking-water uses: total organic carbon of 2 milligrams per liter (mg/L), fecal coliform of 2.2/100 milliters, phosphorus of 0.3 mg/L, and nitrate of 5 mg/L. Many are questioning whether these can be attained, and at what cost. This situation could have been averted if the EPA had taken steps to refine CWA water-quality criteria to keep pace with new SDWA requirements and/or clarified that existing criteria are protective, even with new SDWA requirements.

On the second question, consider an example. When a drinking-water supplier in a rapidly developing area has limited potential water sources and selects a less-than-pristine supply, should the supplier force the entities upstream—the municipal dischargers and the cities and counties with urban runoff—to treat that supply? Or should the supplier take responsibility to provide more advanced levels of water treatment?

Probably, the answer is "some of both." But we don't know how to determine what this means concretely. A specific linkage between the two acts would give us some guidance—and provide a reasonable response to today's limits on high-quality water supplies and the money to gain and maintain them.

–CINDY PAULSON, PH.D., P.E.

Caltrans DRIVES FORWARD with Storm Water Management

Ahead of the nation's curve, the California Department of Transportation embarks on storm water quality-control for all runoff from its extensive urban properties.

In 1994, a lawsuit on storm water standards targeted the California Department of Transportation (Caltrans), District 7, and several other government entities in the Los Angeles area. Its outcome was unprecedented: For all storm water runoff leaving its property throughout the district, Caltrans was charged with meeting Clean Water Act standards for receiving waters—in California, equivalent to drinking-water quality or better.

Further, the ruling on the suit—filed by the National Resources Defense Council and the Santa Monica Bay Keepers—required not just runoff treatment for new highways and facilities, but potential retrofitting of the district's entire metropolitan system.

"Caltrans is ahead of the curve in the nation—the only state agency faced with such far-reaching requirements, and such a committed response," says Bob Finn, P.E. For the past five years, Finn has managed the Brown and Caldwell project to help Caltrans accomplish its mandated mission. "We're not talking about swales and wetlands in rural areas, but about treatment of large volumes of runoff from existing highways, maintenance yards, fuel stations, and other facilities in congested areas."

Caltrans extended its storm water treatment efforts to include all of California when it applied for, and received, a statewide permit to consolidate the requirements of the nine state Regional Water Quality Control Boards (RWQCBs), which issue National Pollution discharge Elimination System (NPDES) storm water management permits.

Spearheading local and statewide programs

"We've come quite some distance," reflects Steve Borroum, Caltrans' manager for the program. "Brown and Caldwell took on the challenges put before us by the federal decision, and they enhanced our understanding of issues now faced by all municipal dischargers in dealing with urban runoff."

Previously, storm water quality was unregulated, and quantity was managed only to prevent flooding. In the early 1990s, the EPA began developing regulations for storm water quality. Now, to retrofit storm water treatment in District 7, Caltrans must address a drainage system that dates back to a time when pollution control wasn't even a consideration. And it must contend with precious little space for new treatment facilities.

Brown and Caldwell was hired to spearhead the agency's response in 1995, developing a storm water management program for District 7 and seeing it through acceptance by the RWQCB. The management plan included field investigations and evaluations of current practices at various Caltrans facilities.

Brown and Caldwell also interviewed Caltrans staff, who were largely unfamiliar with storm water issues, about their needs and concerns, and developed an education program for them. The company's training specialists offered an overall storm water management class, along with specialized classes for maintenance, construction, project development, and design staff and contractors. Caltrans trainers are now giving the classes.

The next phase involved a landmark study—to be completed, by court decree, in only 12 months—of the District 7 metropolitan area, to determine costs and issues for retrofitting storm water treatment into an urban transportation system. The first-of-its-kind study addressed such thorny issues as condemning existing

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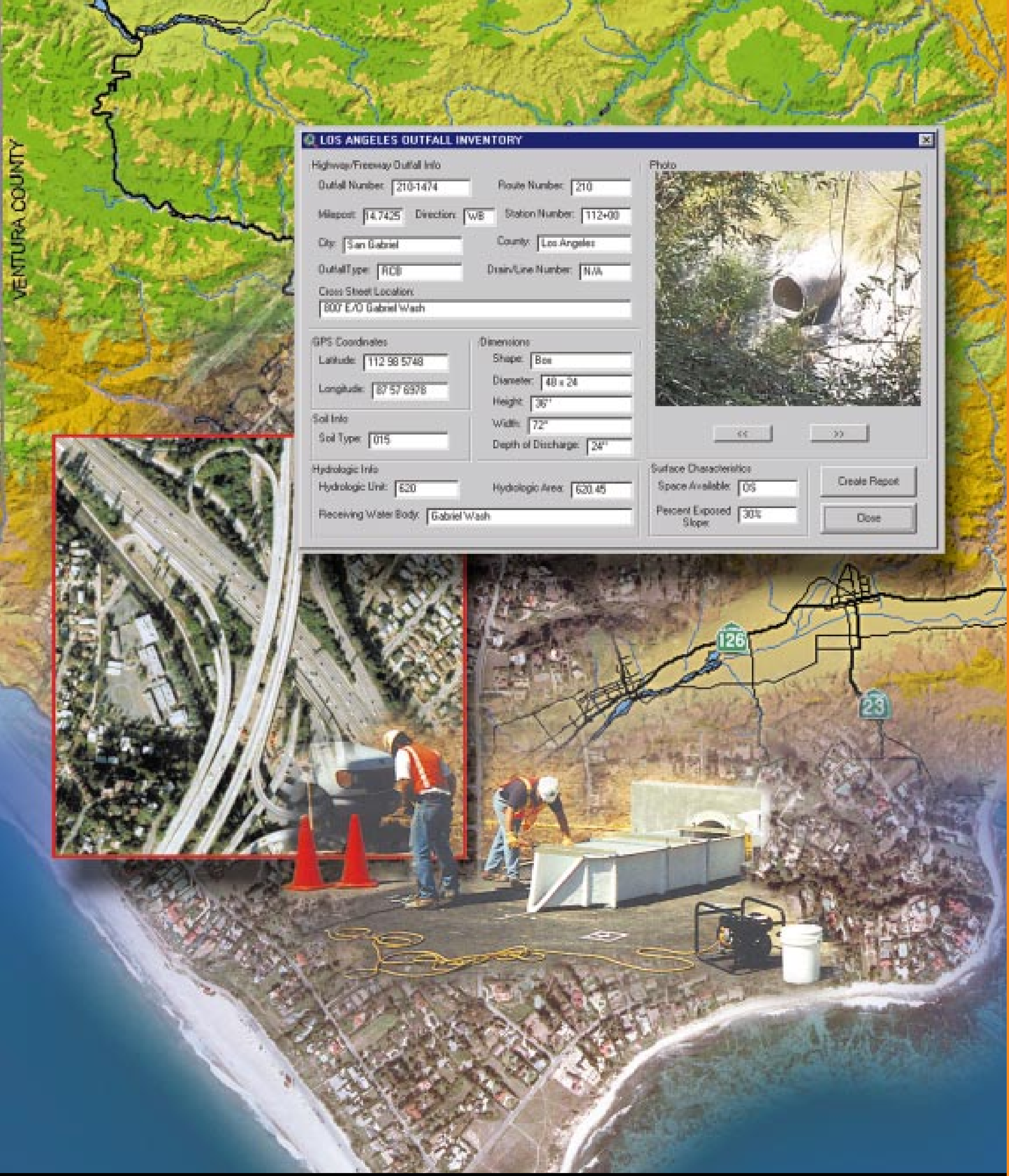

Brown and Caldwell project engineers are shown installing a flume to monitor one of the storm water treatment basins the company designed and operates for Caltrans. In associated work, Brown and Caldwell is using a global positioning system (GPS) to navigate in real time to Caltrans outfalls in the Los Angeles area and map the drainage basins that lead to them. The resulting geographical information system (GIS) database will include the outfalls' precise geographical coordinates and extensive information on the drainage basins (illustrated in the screen above). Caltrans workers will use the database and hand-held GPS units to identify problem sites and efficiently locate them in the field for maintenance or redesign.

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facilities and land to make room for treatment facilities.

Contaminants of storm water in an urban setting include a complex brew of hydrocarbons, microorganisms, and soluble and suspended metal compounds. Bob Finn and his team, which included more than 175 Brown and Caldwell employees and numerous subconsultants, considered a number of treatment facilities, such as retention/detention ponds, infiltration facilities, biofiltration, below-ground vaults, and replacement of self-cleaning drain inlets with trapping catch basins.

One of the detention basins designed and operated by Brown and Caldwell to treat storm water for Caltrans.The company designed ten full-scale storm water treatment units for the agency and has been operating eight of them, six of which Brown and Caldwell also built. They include an oil/water separator and units with various types of filters.

Because of the size of the District transportation network and the time limit, the team studied a representative part of the freeway system and extrapolated from the results. Brown and Caldwell also used the study to evaluate retrofit designs for the Ballona Creek drainage basin, a key tributary to Santa Monica Bay. This evaluation was the basis for a maximum-extent-practicable (MEP) analysis of potential costs and benefits.

Ultimately, the treatment facilities to be retrofitted into Caltrans facilities will depend on complex factors including cost, feasibility, and pollutant-removal efficiency. Decisions will rest with state and local officials allocating resources. Meanwhile, Caltrans is pushing forward with its pilot studies to better define the concerns.

Forging new treatment technologies

Brown and Caldwell initiated Caltrans' pilot storm water treatment project, which includes designing, building, and operating 10 unique facilities. "They're called pilot units, but they're full-scale for the individual drainage areas," explains Finn. "Two are still being designed, and eight are operating: two detention basins, one oil/water separator, and five units with various types of filters. One of the filter designs is what's known as a multi-chambered treatment train, which includes filter media similar to sand but containing peat to grab more of the metals."

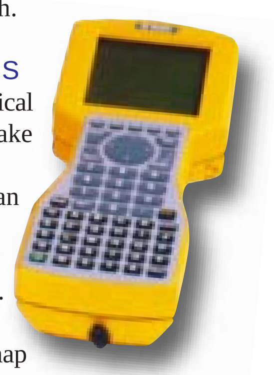
The two detention basins are located at freeway intersections along Interstate 605 in eastern Los Angeles County. The other six units are located at either park-and-ride areas or maintenance yards, which are among the most likely targets for retrofits.

The earthen detention basins were designed to fit into typical freeway interchange areas. They hold water for as long as three days, allowing solids to settle while slowly emptying them through small orifices. "These normally dry basins are the most appropriate type of detention for Southern California," says Finn, "because of concerns about safety, mosquitoes, wetlands regulations, and lack of dry-season flows."

The filter type of storm water treatment units have a settling tank in addition to filters, and a smaller footprint than the detention ponds. Because of their second-stage filtering process, these units are more efficient at removing fine solids and smaller floating materials. They are well-suited for areas of concentrated activities and limited space, such as maintenance yards.

Brown and Caldwell is now operating the eight pilot facilities and is quantifying their efficacy at removing pollutants and maintenance requirements. For example, the team is analyzing how well the detention basins remove copper-containing residues from brake pads, one of the most significant contaminants that Caltrans has to contend with.

Complex mapping calls for GIS



The powerful capabilities of geographical information system (GIS) mapping make it an ideal tool for organizing the vast amount of data involved in metropolitan storm water management. Brown and Caldwell has applied the technology to two aspects of the Caltrans program.

In one project, the team is using a global positioning system (GPS) to map District 7 outfalls and drainage basins, fulfilling part of the permit requirement to map such basins throughout California. The database will allow maintenance workers to quickly identify problem sites with hand-held GPS units. The sites can then be targeted for preventative maintenance or redesign.

Venu Kolli, Brown and Caldwell's manager for the mapping project, explains, "We're determining how big the watersheds are and where drainage leaves Caltrans property. Eventually, the database will include information on the slopes and shapes of thousands of drainage basins, how much area is paved, and soil characteristics."

In another GIS application, Brown and Caldwell organized statewide water-quality standards into a single database, which provides an instantaneous readout of regulatory information on any potential receiving water. The database, now being maintained by the University of California at Davis, will help Caltrans contend with the varying standards of the state's RWQCBs.

To access the statewide water-quality database, contact Steve Line at (925) 937-9010 or sline@brwncald.com. For more information on the Caltrans project or storm water management related to transportation, contact Bob Finn at (949) 660-1070.

Rivers Don't Follow Political BOUNDARIES

Leaders of 15 jurisdictions collaborate to form community-specific watershed management solutions– concentrating on implementation first.

Along the Alcovy River in Georgia, pastureland is quickly becoming subdivisions, and cows graze ever closer to earth-movers and real estate signs.

Wrangling the watershed's politicians into agreement over water-quality protection could have been more arduous than wrangling cattle. Yet the region's many leaders are working together to tailor a watershed management plan that will include varying, community-specific solutions.

The Brown and Caldwell-led project is turning conventional watershed planning on its head: Instead of considering implementation as the last step in a long process, at every phase the team focuses on the specifics. This emphasis involves defining customized options for each community—based on experience rather than just planning maps.

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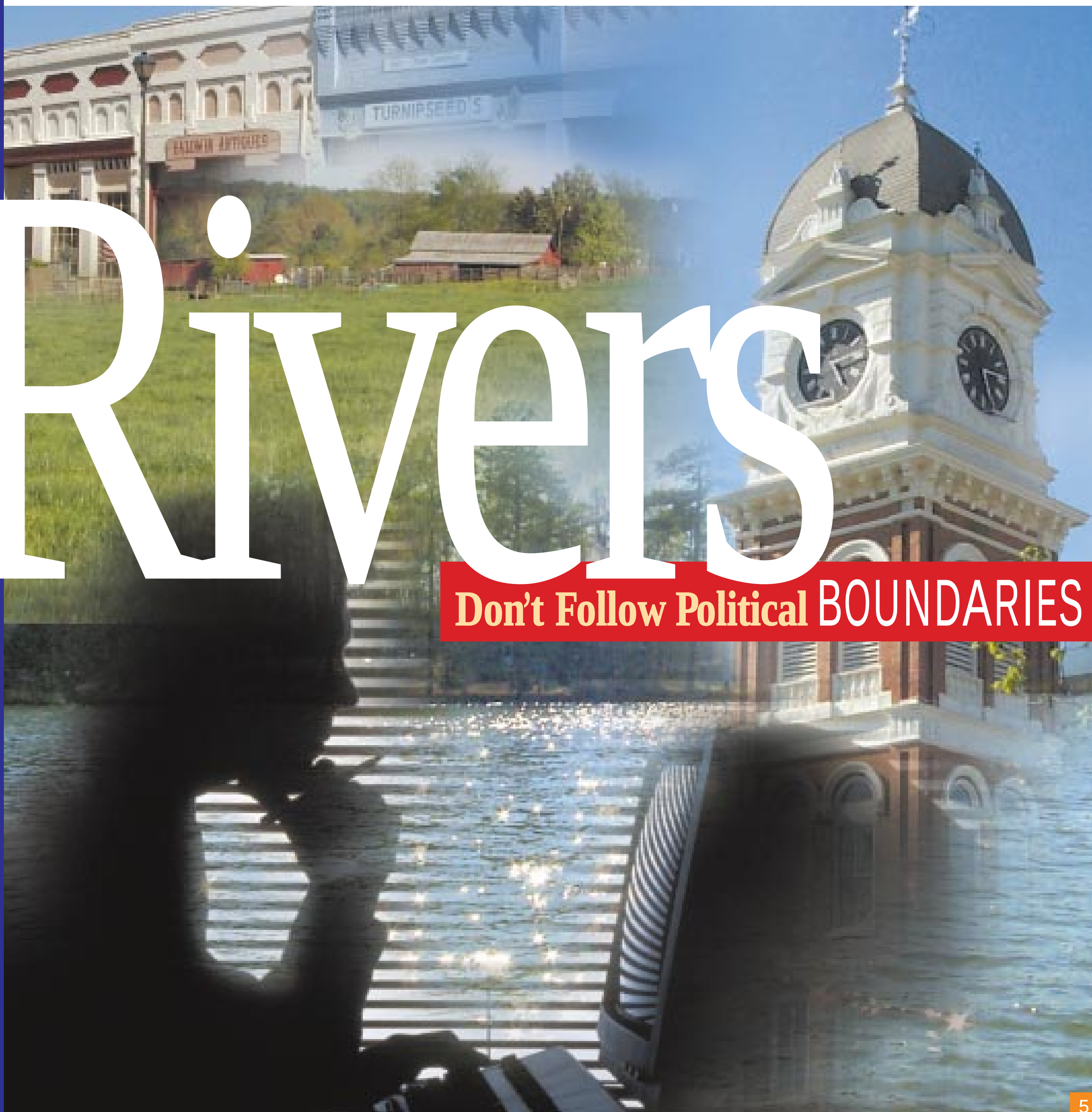

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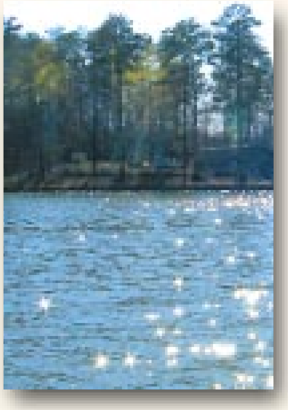
Considering implementation from day one

Extremely valuable to the region, the Alcovy River is a unique ecosystem providing high-quality drinking water and recreational opportunities to thousands of residents and businesses.

In 1998, farsighted elected officials in the watershed's counties and cities recognized the need to work together to protect the river now, as development gears up. Typically, watershed planning proceeds once an area is intensely developed, when implementation options are fewer and more expensive.

The Northeast Georgia Regional Development Center (NEGRDC), a state-funded resource center for local governments, is coordinating the 15 affected jurisdictions for the project. They span highly developed Gwinnett County, site of the Alcovy's headwaters, south through rapidly growing Walton and Newton counties, to rural Jasper County. Supporting this unique approach to watershed planning, the State of Georgia Environmental Protection Division helped fund the project.

NEGRDC hired Brown and Caldwell to study existing water quality, help define a suite of possible watershed-protection measures tailored to each community, and model future outcomes. Once the project is completed in late 2000, communities will be able to choose from multiple options to meet water quality goals.



"One size does not fit all for regional watershed management," explains Terry Cole, project communications manager. "For the plan to succeed, it has to reflect the needs of every stakeholder. That means our process has to be flexible and responsive, and has to offer different watershed-protection measures. And it means we need to start considering participants' visions from the start."

To define multiple visions, the Brown and Caldwell team is going beyond the traditional engineering approach, asking developers, farmers, Chamber of Commerce officials, planners, environmentalists, and residents for input on where land use is headed. At the same time, the team is educating stakeholders about watershed protection issues, which is enabling them to make informed decisions and staving off potential discord when the draft plan hits the streets later this year. The team has met with local Cattlemen's Associations, Rotary Clubs, Kiwanis Clubs, Homebuilders Associations, and others.

Early in the project, the team also started meeting one-on-one with planners and policy experts in all 15 communities to identify rationales, approaches, and trends for each area's watershed protection. These discussions opened the door to crafting a suite of options acceptable to local leaders.

Meanwhile, a group of elected officials from the affected four counties, 11 cities, and four water/wastewater utilities gives regular guidance on policy—an unusual complement to the more typically given technical guidance from staff representing the same entities.

Predictive modeling of the watershed

Complementing its focus on community values is the project's scientific assessment program. A dozen scientists and engineers from Brown and Caldwell's Atlanta office are now characterizing the watershed by collecting historical data; monitoring water quality, depth, and velocity; and assessing the biological condition of the 63-mile-long river.

Already, computer modeling of water quality is integrating historical and current data with information on future land use and potential watershed-protection measures. The results will illuminate the mechanisms now affecting water quality—and will predict how different development scenarios will affect it in the future.

"The model will be an accurate predictive tool," says Joe Tichy, special projects coordinator with the NEGRDC. "With the model, we can allow communities to 'try on' different development patterns and see the effects on water quality. That way, they will be able to fashion a future that protects water quality even while, in some cases, growth continues by leaps and bounds."

One size does not fit all

Using the model, communities in each of the 15 jurisdictions will choose from a suite of watershed-protection options, incorporating both policy approaches and structural approaches.

Policy approaches will include innovative land use and zoning code changes, such as conservation easements (areas set aside as permanent green space) and conservation subdivisions (property subdivided according to ecological needs), as well as more common programs, such as strict enforcement of erosion and sedimentation regulations, buffer-zone ordinances, limits on impervious surfaces, and water efficiency programs.

Structural approaches to watershed protection, or best management practices, typically seek to slow storm water entry into the river and remove storm-water-borne contaminants that cause pollution, erosion, and sedimentation. Structural approaches being considered include vegetated swales, wet ponds, dry ponds, storm water wetlands, and retrofits of existing development.

The project team will use water-quality assessment data, regulations, cost information, and community input to establish goals for concentrations of contaminants, nutrients, and other parameters in the Alcovy River and its tributaries and reservoirs. Then, modeling will help determine what combinations of land use and water-quality improvements will be needed to meet those goals. Community interest, aesthetics, cost, health and safety, and politics are influencing which options are being modeled for different locations.

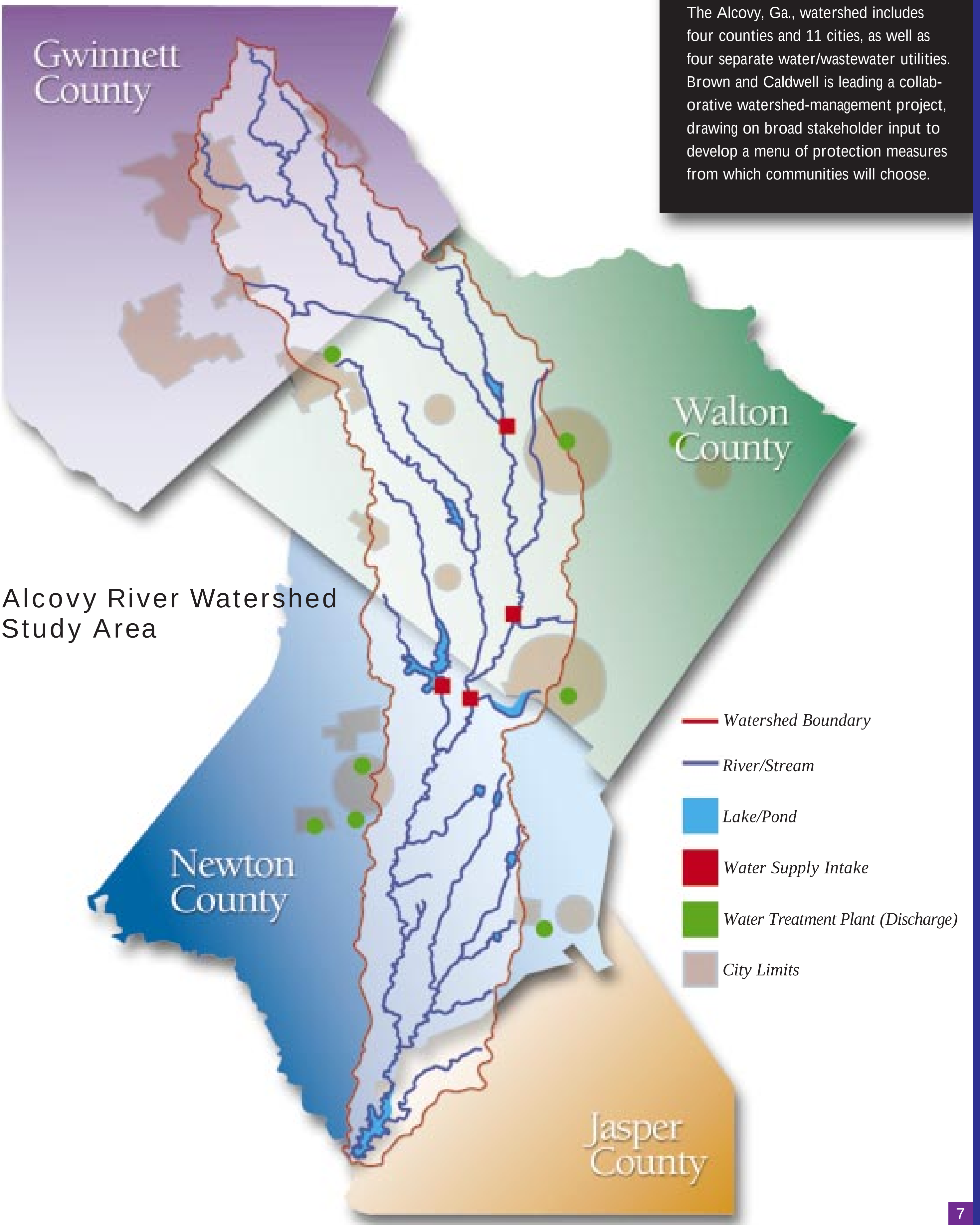
After that, communities will have still more flexibility in the way they act to protect the watershed. Each city or county will be able to select from the chosen protection measures—both policy and structural—and adjust ordinances and standards to implement them.

In some cases, developers will go through a similar process. Local ordinances would specify goals and requirements for the developer to meet. The developer then would select watershed-protection measures from among approved options. For example, one developer might choose buffers and storm water ponds, while another developer might choose vegetated swales and storm water wetlands.

"Rather than a series of prescribed steps," says Project Manager Linda MacGregor, P.E., "the final watershed-management plan will be a road map with many paths."

For more information, contact Linda MacGregor in Brown and Caldwell's Atlanta office, at (770) 394-2997 or lmacgregor@brwncald.com.

The Alcovy, Ga., watershed includes four counties and 11 cities, as well as four separate water/wastewater utilities. Brown and Caldwell is leading a collaborative watershed-management project, drawing on broad stakeholder input to develop a menu of protection measures from which communities will choose.



QUARTERNOTES

Boulder *Takes the Lead* in Source Water Assessment

Over the next three years, every state in the nation must develop and implement source water assessment programs (SWAPs), according to the 1996 amendments to the federal Safe Drinking Water Act (SDWA). The effort will include 180,000 public water systems.

Boulder, Colo., has taken the initiative. With the help of Brown and Caldwell, the city recently assessed its drinking-water sources as part of a comprehensive watershed study—one of the first assessments in Colorado to follow the state's SWAP methodology.

The work built on Boulder's earlier efforts. Beginning in 1991, Brown and Caldwell helped the city develop an initial assessment that united information on watershed boundaries, point and nonpoint contaminant sources, and customer delivery, revealing how susceptible the water supply could be to constituents including suspended solids, precursors of disinfection by-products, nutrients, pathogens, and other toxic materials. The initial assessment produced a matrix identifying potential contaminant sources and recommendations.

The city's efforts have evolved with technology. The recent assessment drew on geographical information system (GIS) capabilities, arming the city with a powerful tool to evaluate land-use changes in the watershed and prioritize source protection efforts.

What is a SWAP?

The SDWA amendments embrace a watershed approach to safeguarding drinking-water supplies: They view source-water protection as the first of multiple barriers that ultimately protect water quality and human health.

Each state's SWAP outlines how it will perform the following four elements to assess every public water supply within its boundaries:

- Delineate the watershed or recharge area that could impact a drinking-water supply
- Identify existing and potential contaminant sources within the delineated area
- Assess the susceptibility of the water supply
- Involve the public in the process

So far, every state has drafted a SWAP for USEPA approval. After approval, states will adopt various approaches to meet SWAP requirements (such as hiring staff or contractors, or working with water suppliers and watershed groups). Implementation can be funded by the state's Drinking Water Revolving Loan Fund, but can use only as much as 10 percent of the fund's resources.

Given these funding limits, states will need help from public and private water utilities. And many of these are finding that they'll benefit from getting involved in the assessments—or embarking on them now. Completion of the SWAPs also requires cooperation among federal regulators, watershed groups, local management agencies, and individuals. Brown and Caldwell is working with a variety of stakeholders to lead source-water assessments throughout the western U.S.

Water utilities get involved in assessments

Driven by impending growth and rising costs for treatment and supply development, many public and private utilities have begun their own source-water assessments. While their water-quality may be acceptable now, utilities are seeking to identify system susceptibilities before they become problems.

Also, water-supplier participation in the assessments means greater accuracy and clearer reporting to customers. If states have to perform the SWAPs on their own, they will be relying on existing, accessible databases that could contain many errors and lack local detail. And, meeting USEPA requirements, the states will disseminate the results to all water customers. Meanwhile, utilities are required to inform customers, through Consumer Confidence Reports, where their water comes from and how its quality measures up to regulations. Some utilities foresee that working together with states to implement SWAPs will increase efficiency, reduce errors, customize assessments to meet utility needs, and lift consumer confidence.

For instance, although Colorado is embarking on SWAPs statewide, Boulder's proactive efforts have led to a detailed, customized water-supply assessment that's already being put to use in the city.

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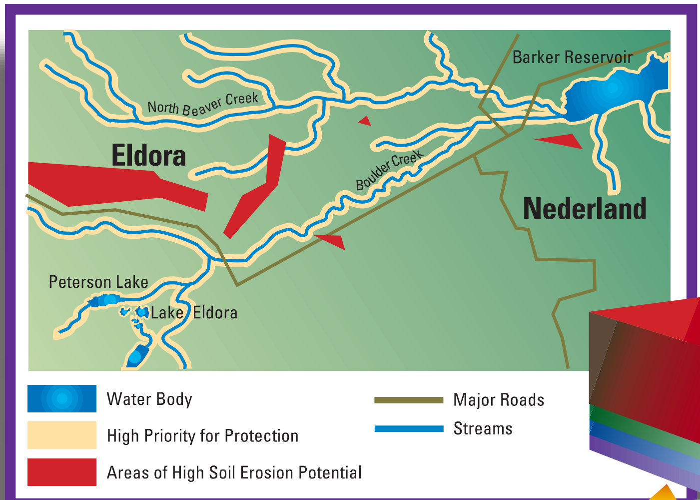
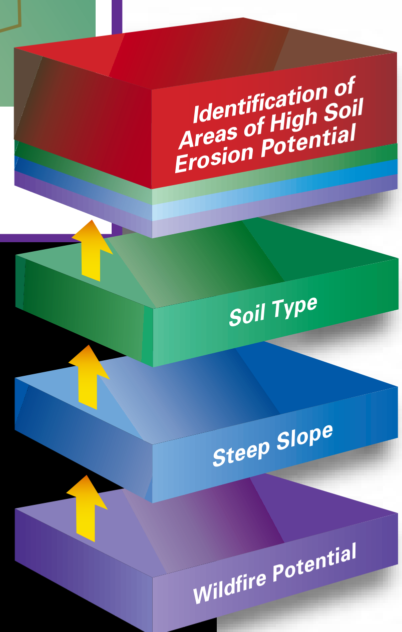
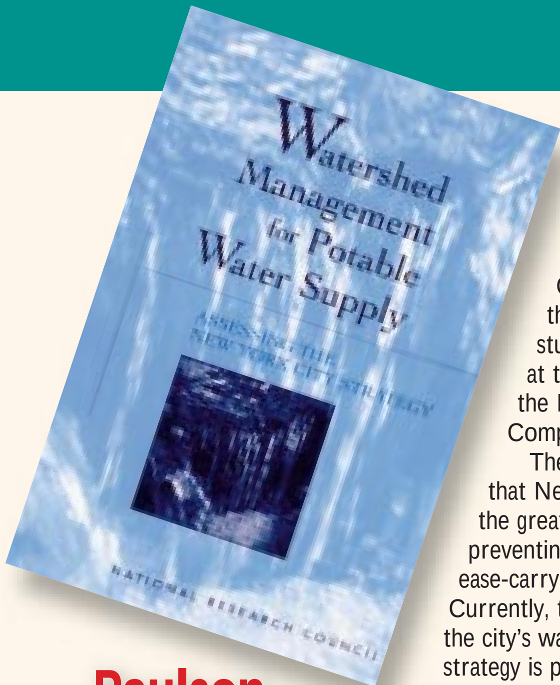




In assessing Boulder's drinking-water sources, Brown and Caldwell used GIS capabilities to identify, and then model, areas with the greatest potential for soil erosion. In subsequent modeling, this information was combined with data on other nonpoint sources of contamination.



Paulson Co-Authors Study of New York City Water Supply

"Watershed Management for Potable Water Supply: Assessing the New York City Strategy" was recently published by the National Academy Press. Brown and Caldwell's **Cindy Paulson, Ph.D., P.E.,** was a member of the National Research Council committee that produced the study, undertaken at the request of the New York City Comptroller's Office.

The study recommends that New York City place the greatest importance on preventing and controlling disease-carrying pathogens. Currently, the main target of the city's watershed management strategy is phosphorus, which can play a large role in degrading water quality but which by itself is not toxic. Overall, the committee hailed the city's watershed management plan as a prototype for water suppliers nationwide.

The study report can serve as a detailed guide for others on how to take steps to protect a water supply.

For copies, contact the National Academy Press at 2101 Constitution Avenue, NW, Lockbox 285, Washington, D.C., 20005, (800) 624-6242, or www.nap.edu.

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Information technology yields richer data

For the Boulder assessment, Brown and Caldwell began with the city's identification of issues and site-specific information. Public feedback was gained through an organized watershed group.

"Then we used a GIS with integrated databases to pull together information on point and nonpoint contaminant sources, their locations, and their effects," says Brown and Caldwell environmental engineer **Michelle Wind, P.E.** "These tools provided more-integrated data and greater accuracy."

The GIS included a digital elevation model that analyzes different elevations and automatically delineates the watershed. It also was used to prioritize contaminants of concern and provide a context in which to assess more complex nonpoint contaminant sources. For example, it accounted for the distance of the contaminant sources from the water treatment intake.

"We didn't just plot data points," explains professional wetlands scientist **Elisabeth Benjamin,** who managed the project. "For example, to assess erosion potential, a nonpoint source of contamination, we used the GIS to combine information on soil type, slope, elevation, amount of vegetation, and other factors. Then we modeled the results—along with the results for other contaminant sources."

For more information on source water assessments, contact Michelle Wind at (303) 743-5400 or mwind@brwncald.com.

TMDLs No Fleeting Problem for Mining Companies and Other Dischargers

Brown and Caldwell is now negotiating with the USEPA, on behalf of a Southwestern mining company, on a cutting-edge technical issue: the development of a total maximum daily load (TMDL) for an ephemeral stream. The effort is particularly challenging, because an ephemeral stream does not flow year-round.

For ephemeral streams as for perennial water bodies, dischargers are beginning to realize that TMDLs are no fleeting concern. Although development of TMDLs has been required by federal regulations since the early '90s, many dischargers are still not aware of the requirement, or of how they may benefit from early involvement in the regulatory process.

The state regulatory agency has assigned all receiving waters a designated use, such as drinking-water source, fishery, recreational, or industrial. If the water quality doesn't match the use, based on instream water-quality criteria, the agency deems the water body impaired. The agency prioritizes receiving waters for TMDL development according to the extent of impairment. TMDLs are now being developed by state and federal regulators for pollutants discharged by mining companies, industrial facilities, and municipalities into

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TMDLs

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impaired receiving waters.

But the process can be complicated by the fact that a water body's designated use and quality criteria—and the associated waste loads it can handle—may have been inaccurately defined by the state regulatory agency because of limited information.

"If dischargers get involved in the regulatory process early, they may be able to influence TMDL and permit limits, by ensuring that the load allocation process is accurate. In truth, background and nonpoint source loads could have a larger instream impact, which the agency would attribute to point source discharges without the proper data," explains **Debbie Schatzlein**, Brown and Caldwell project manager and expert in industrial regulatory compliance. "Dischargers can collect and provide site-specific data to get a more accurate picture of the sources of toxicity and thus determine appropriate load allocations."

In the case of the mining company releasing into the ephemeral stream, the technical challenges are substantial. "How do you protect fish in a water body that's flowing only during an occasional storm water event?" asks Schatzlein. She and her team are identifying more accurate criteria to determine waste loads that protect the stream's health. Specifically, they have studied runoff patterns, soil and sediment conditions, instream flow, and water quality, and they have assessed load contributions from the watershed, including direct discharges from mining processes as well as indirect contributions from storage areas and waste piles.

Thousands of facilities will be affected by TMDLs at their next renewal of discharge permits. For information on how to respond, call Schatzlein at (303) 743-5443 or email her at dschatzlein@brwncald.com.

New Method Adds Stream Habitat to the Water-Quality Equation

A Water Environment Research Foundation (WERF) study is yielding a new method to account for the physical characteristics—not just the chemistry—of a receiving stream.

The implications? Water-quality managers at wastewater treatment plants, as well as regulators, can now consider stream habitat when setting effective limits on discharges.

And, as they try to meet demands for high-quality water and protected aquatic life, managers can gain better information on how to allocate resources: removing contaminants or improving habitat.

Targeting physical as well as chemical stressors to streams

Brown and Caldwell has teamed up with Chadwick Ecological Consultants in Denver and Risk Sciences in Nashville, Tenn., in the two-year-long study, to be completed this fall. The study will yield the integrated impact analysis (IIA), which will determine the relative impact of a measured stressor, whether chemical or physical, on the biology of a particular stream.

Using site-specific equations, IIA gives a comprehensive, three-dimensional picture of a water body's health, including information about how it is affected by effluent.

Individual dischargers, regulators, and stakeholder groups will be able to use IIA to:

- Identify the most limiting stressors, whether chemical (such as contaminants) or physical (such as flow, channelization, and vegetative cover), on a stream system
- Predict how changes in effluent will affect a stream
- Assess the value of physical habitat improvements
- Develop total maximum daily loads (TMDLs)
- Find out how much, and what type of, data must be collected to lead to meaningful conclusions

A more holistic approach to water-quality management

The Clean Water Act focuses on three parts of a stream system: chemistry, physical habitat, and biology. Chemistry and physical habitat are the independent variables, or stressors,

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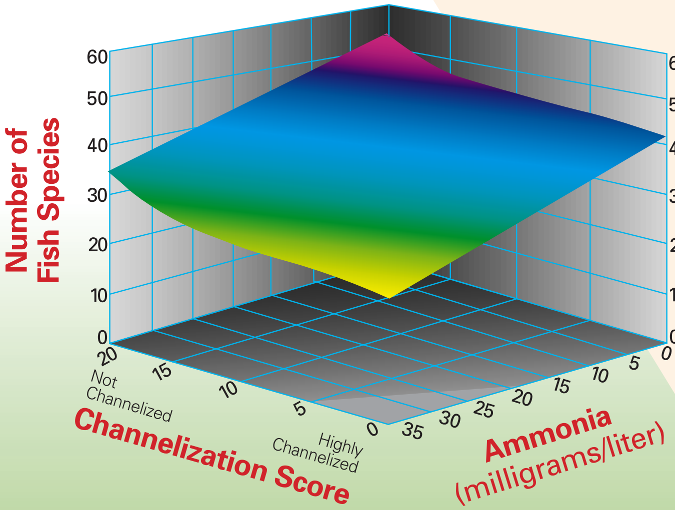

A new Brown and Caldwell/WERF method will allow wastewater treatment plant managers and regulators to consider stream habitat when setting discharge limits. The method yields site-specific equations and corresponding three-dimensional pictures to illustrate the effects of effluents. This example output shows the combined effect of two variables, which the method identified as key stressors, on a particular stream's health: a chemical parameter, ammonia, a physical parameter, channelization, and a dependent variable, number of fish species.

New Method

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while the stream biology is the dependent variable. Physical habitat can be measured using factors such as flow, channel shape, gradient, vegetative stream cover, and stream-bottom composition.

So far, the process of setting discharge limits for receiving streams has focused on stream chemistry. But WERF, along with others, realized that a key determinant of whether or not a stream's ecology is sound is often not just chemistry, but physical limitations.

"Figuring out how to assess physical limitations on streams has drawn little attention and few research dollars," explains WERF Project Manager **Jami Montgomery**. "We wanted to correct that imbalance." The work is funded in part by the USEPA through Cooperative Agreement CR 825237-01.

Statistical analysis and the fruits of experience

IIA takes the form of a "script," or flow chart of steps, for analyzing water quality, physical habitat, and biological data on a site-specific basis.

Unlike previous methods to determine TMDLs and permit limits, IIA incorporates the early use of high-powered statistical analyses to identify important variables. It also applies a new combination of statistical analysis types.

"IIA uses high-powered statistics early in the analysis to trim down the list of variables, removing those that seem to have the same effect as other, stronger variables and those that produce no response," explains **Sarah Reeves**, Brown and Caldwell project manager for the study. The approach employs three statistical methods to weed out variables: principal component analysis, the all-possible-regressions method, and a form of cluster analysis.

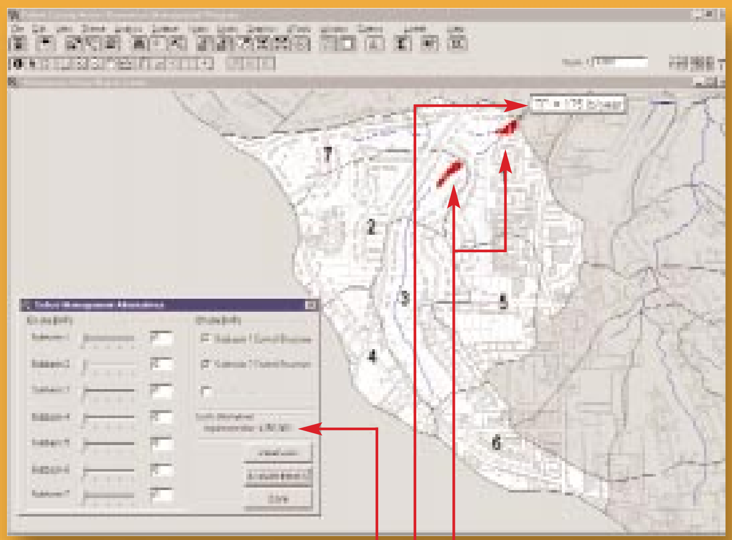
"But statistical analysis is no substitute for experience and knowledge about a particular stream," adds **Cindy Paulson, Ph.D., P.E.,** the study's principal investigator. "So an IIA user will follow steps in the accompanying guidance document we're creating to combine analysis results with his or her knowledge of the stream system, narrowing the list of key variables to a few chemical and physical habitat stressors and several responding biological variables."

The user then will input these variables into a curve-fitting program—most such commonly used programs will work—to gain a site-specific equation, and a corresponding three-dimensional graphic. The results show how a pair of physical and chemical parameters affects a biological variable, including various combinations of parameters.

To create the new method, the team analyzed data sets from water bodies across the country, including the Santa Ana River in California; Fountain Creek and the South Platte River in Colorado; and Ohio's Cuyahoga River.

For more information, or to get the IIA guidance document, contact Sarah Reeves or Cindy Paulson in Brown and Caldwell's Denver office, at (303) 743-5400, or via email: sreeves@brwncald.com or cpaulson@brwncald.com.

Software Illustrates Storm Water Solutions for Concerned Homeowners



The challenge: Generate agreement among residents about potentially unpopular storm water management solutions, such as detention ponds in existing neighborhoods.

The solution: a one-of-a-kind, interactive, software program called Lorelei that allows residents to compare costs, effectiveness, and specific locations of best management practices—all without moving the first backhoe of dirt.

Developed by Brown and Caldwell and its subcontractor Limno-Tech, Inc., the program is based on the ArcView geographical information system and tailored to address storm water control options for the northern suburbs of Atlanta, in Fulton County, Ga.

Because of problematic storm water runoff in the region, along with growth pressures and the need to obtain permits to expand wastewater treatment plants, the state Department of Natural Resources, Environmental Protection Division, had warned officials that action had to be taken. In January 2000, Brown and Caldwell was hired by the county to help produce a watershed management plan for one of five study areas, by monitoring storm water, surveying and identifying storm drainage infrastructure (20,700 structures), modeling the flood plain (1,300 surveyed cross sections), modeling water quality, and proposing best management practices (BMPs) to reduce flooding and improve water quality.

Public acceptance of the proposed solutions in the densely developed area is critical to the success of the watershed management plan. "If Brown and Caldwell were to propose a detention pond or a check dam for an area and it could not be built because of resident protest, valuable time and resources would be wasted," says

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In-line booster pump stations with bidirectional flow capacities, designed in three months by Brown and Caldwell as part of the City of Phoenix's new Cave Creek Road Facilities to convey potable and reclaimed water. The company also served as program manager of the project's $34 million worth of construction, including 21 miles of large-diameter pipeline.

BC Boosts Phoenix's Water Distribution

Brown and Caldwell is now commissioning Phoenix's $34 million project to convey potable and reclaimed water to customers in the city's North Valley Water System.

The new Cave Creek Road Facilities include five booster pump stations and 21 miles of large-diameter pipelines. These facilities have unique operational restraints: initially low demands, multiple pump stations operating in series without the benefit of storage, variable-frequency drives, the ability to reverse flow direction, and the need to integrate operation of multiple existing groundwater wells.

Brown and Caldwell designed the five pump stations in a fast-tracked three months, along with providing construction management and inspection services for them. The company also served as the City's program manager during construction of the entire project. Project Manager **Ron Ablin, P.E.,** and his team coordinated the general contractor for the five pump stations, seven pipeline design firms, five pipeline general contractors, material testing, surveying, and staff from the City's Water Services, Development Services, and Street Transportation departments.

"The biggest challenge was coordination of the various parties involved during the project, especially without knowing the final operating strategy for the system until very late in the construction phase," says **Andrew Brown, P.E.,** project manager with the City of Phoenix. "Somehow Brown and Caldwell was able to pull it off."

Potable water to northeastern Phoenix was historically supplied by groundwater wells, but rapid growth has required more potable water sources. To meet that demand, water from the existing Union Hills Water Treatment Plant is currently being pumped north by four new booster pump stations. Each booster pump station also is equipped with pressure-reducing valves to allow water to be conveyed by gravity southward from future storage reservoirs and the Lake Pleasant Water Treatment Plant, which will be located at Phoenix's northern limits.

"The potable water facilities are a very complex system, since these bidirectional pump stations currently operate in line without the benefit of storage tanks," says Ablin. "Each station has to maintain a variable flow with a constant discharge pressure to ensure a satisfactory supply of water to the next pump station. If one pump station fails, the entire system goes down."

The pump station capacities range from 16 to 60 million gallons per day (mgd). Each station is equipped with variable-speed vertical turbine pumps ranging in capacity from 8 to 11.25 mgd each. Each site is automatically controlled locally, based on intake and discharge pressure, and monitored remotely through supervisory control and data acquisition (SCADA). The system includes 7 miles of 30- to 54-inch-diameter pipeline.

The fifth pump station and associated pipelines convey water from the new Cave Creek Water Reclamation Plant to irrigate golf courses, parks, schools, cemeteries, and other non-potable water users. The reclaimed-water delivery system includes a 23.3 mgd booster pump station, two remote chlorination stations, multiple customer-service connections, and 14 miles of 30- to 36-inch-diameter pipeline. This pump station is designed to handle highly variable flows, from maintaining line pressure during no-flow periods to concurrent watering of multiple golf courses. The pump speed is controlled based on information transmitted through fiber optics to maintain a minimum pressure of 20 pounds per square inch at the system high point.

Storm Water Solutions

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Project Manager **Roger Copp, P.E.** "We created Lorelei to avoid that. It lets us present real data tailored to each neighborhood at community meetings."

The click of a mouse selects one or more storm water control measures and highlights a map with the exact location(s) of the measure(s). Another button yields the implementation costs; a third button produces water-quality benefits. In the example on the previous page, the user has selected two off-site BMPs, detention ponds. The ponds would capture 175 pounds per year of phosphorus from the storm water, preventing the phosphorus from reaching downstream receiving waters, at a cost of $350,000. On-site BMPs, such as cisterns to store rooftop runoff or on-lot infiltration galleys, also can be selected for evaluation of alternative scenarios.

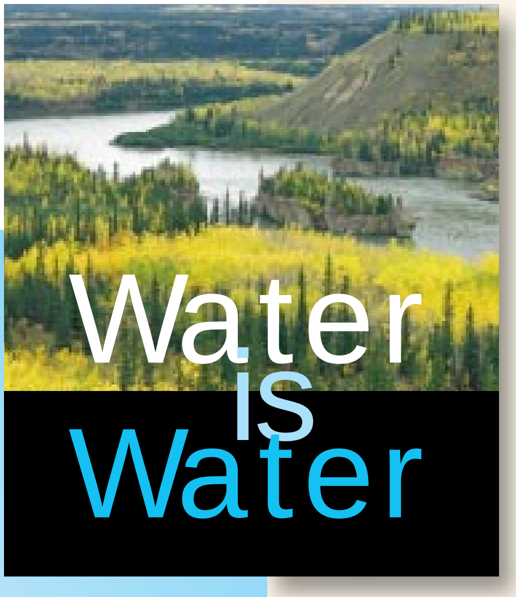
Showing citizens costs and water-quality benefits, along with a detailed map, has been highly effective in conveying the implications of proposed strategies. Also, Lorelei helps homeowners visualize the exact locations of proposed measures in their neighborhoods.

For example, some residents who at first opposed detention ponds for aesthetic reasons have come to favor them over more costly and less effective strategies once the comparison is illustrated. "Spending twice as much to implement a strategy that only reduced pollutant loads by half as much didn't seem reasonable to homeowners, who realize that, as taxpayers, they would be picking up the tab," explains Copp.

Brown and Caldwell can provide similar, customized software to other communities seeking to control storm water runoff, point and nonpoint contamination sources, and other watershed issues. Contact Roger Copp at (813) 889-9515 or rcopp@brwncald.com for more information.

The simple declaration *water is water* describes a vision for the water and wastewater industry in the year 2018. If it becomes reality, the vision will be driven by the rate- and tax-paying customer, who will embrace the full value of water and agree that "all water must be managed collectively to be managed effectively."

This vision, and the future end state it could create, was one of five formulated by a diverse group of industry experts brought together by the Water Environment Research Foundation (WERF) in a workshop conducted in January 1999. The expert group explored what the industry may look like 18 to 20 years out. A key objective was to identify critical activities for WERF as part of a project called "Mapping the Future of Water Quality Research." Brown and Caldwell's Dr. Denny Parker, a founding director of WERF, participated in this stimulating strategy session. (For more details, go to www.werf.org and search for this project by its title.)



Here is a brief synopsis of the *water is water* end state:

- All water is both governed and managed on a watershed basis.
- A single water-focused entity in each municipality operates both the water and wastewater systems.
- Wastewater and water plants work together in a complementary fashion as key water-quality control points.
- The watershed itself is a part of the water infrastructure, providing treatment, storage, and buffer (wetlands, percolation, attenuation, etc.).
- Decision-making on land use and water quality is driven by common watershed objectives.
- Water quality is optimized, yielding the best result for the best economics, across the entire watershed.

At the core of this striking vision is the concept of the watershed. Further, according to the workshop participants, the *water is water* vision is one that would benefit all stakeholders; may be too idealized and unattainable; despite this, is the vision that, compared to other approaches, provides the best framework for site-specific science and sensible regulation; and is the vision that will emerge as the common backdrop against which any alternate end states would unfold.

As with any bold vision, getting there depends on the successful execution of multiple, interrelated steps, or tactics, rather than a quantum leap. Beyond this, the ability to arrive at *water is water* will hinge upon stakeholder perception and acceptance of the true value of water.

Why? Because over the same 20-year period, tremendous capital investment will be needed to replace aging infrastructure and meet regulatory requirements. Stakeholder approval of the costs of this investment will exert the strongest single influence on the future of the water and wastewater industry.

A recent report, "Clean Safe Water for the 21st Century," issued by the Water Infrastructure Network (WIN), puts the cost of critical water and wastewater infrastructure investment for the next two decades at nearly a trillion dollars. This equates to an estimated funding gap of $23 billion a year over the next 20 years between current and necessary spending for water infrastructure investments. (For the report, go to www.amsa-cleanwater.org/advocacy/winreport.htm.)

So, will the *water is water* vision be realized, or will a different end state be shaped by economic factors and stakeholder acceptance? Is the core of the vision—the watershed model—compatible with the huge need for capital funding?

While it's early for hard and fast conclusions, the fact that key members of the industry are rallying together supports a prediction of commonality. WIN is a broad-based coalition of drinking-water, wastewater, municipal and state government, engineering, and environmental groups tackling investment and funding issues.

And this issue of *Quarterly* is evidence that various sectors of the water and wastewater industry are engaged in tactics aimed at the *water is water* end state. In Brown and Caldwell's work, we're applying better science to important water-quality decision making. We're seeing growing public acceptance of watershed concepts. We're deploying information technology to improve data gathering, analysis, response to regulations, infrastructure maintenance, and communication with stakeholders. And we're helping to lead more projects requiring the cooperative efforts of states, public and private utilities, regulators, and watershed groups. It's exciting to be part of the forefront that's formulating the tactics—and the vision—of our water's future.

–CRAIG GOEHRING, P.E., CEO

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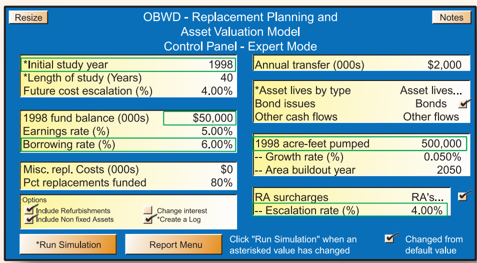

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