

# The Optimatics Letter

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*Advances in Optimization for Water Distribution System Design & Operations*

## Top 10 Reasons Not To Optimize

*(Editor's note—Here's a tongue-in-cheek look at some of the interesting reasons we've heard for not optimizing a water system.)*

The first time we applied genetic algorithm (GA) optimization to a significant real-world distribution system was in 1994-95 when we reviewed a Master Plan solution that a local consultant had developed for Fort Collins-Loveland Water District in Colorado. The consultant's recommended solution had 46 new pipes totaling 29.4 miles in length. The GA identified an alternate solution that satisfied all of the same demand conditions and design criteria. The GA-optimized solution had just 21 new pipes totaling 18.8 miles at an estimated cost 49% lower than the original solution (a projected cost savings of \$2.97 million).

Our first major GA review study was thus a resounding success. The client was very happy to have a lower cost, hydraulically superior baseline solution to work from. We were excited to have demonstrated the great potential of GA optimization to identify low-cost alternative solutions. And the original consultant could take solace in the fact that they had developed quite a good solution—they just didn't have the "horsepower" to formulate and evaluate hundreds of thousands of trial solutions like the GA did in its relentless search for the best alternatives.

### Why Not Optimize?

In 1995-96, the staff of Optimatics/Frey had high expectations that water utilities and consultants would quickly embrace the powerful new GA technology and use it to identify significantly better and cheaper solutions to their distribution system planning and operations problems. Indeed, why would a water utility not be interested in reducing the cost of its annual capital improvement program by 20% or more, while at the same time improving the hydraulic performance of its transmission and distribution system?

We've since heard all sorts of reasons why a water utility may not want to optimize. These top 10 reasons are real—we (and you) need to address them if optimization is to achieve its potential of saving water utilities millions of dollars in capital and operating costs.

#### **No. 1—Cost is not a consideration!**

This one happens to be my personal favorite. An engineer at a major municipal utility came right out and said she didn't think they needed to use optimization because "cost is not a consideration!" Granted some of the needed system improvements would be paid for by developers, but certainly the water utility's management should be concerned that the extra cost of a modeler's over-priced solution is not passed on to its unsuspecting customers. An extra 20% cost is significant.

#### **No. 2—We don't want to embarrass our engineer.**

Another classic, from a municipal utility's project manager—the person responsible for hiring a consultant to prepare a multi-million dollar transmission and distribution plan. After admitting that optimization could very likely save the utility money, he decided not to consider adding optimization to the study

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*Why would a water utility not be interested in optimizing its distribution system? Our top 10 list of reasons ranges from logical to comical.*

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### **San Diego & Toronto/York Studies Underway**

This quarter, Optimatics/Frey Water Engineering begins work on two exciting GA optimization studies. The first study is with the City of San Diego Water Department to optimize a main replacement for the Otay Second Pipeline. Some 4.5 miles of the 70-year old pipeline are to be replaced, while the GA identifies other infrastructure upgrades to improve system hydraulic performance.

In the second study, Optimatics/Frey serves as Optimization Consultant under Earth Tech Canada for the City of Toronto/Region of York Water Supply Joint Optimization Study. A customized Optimatics GA linked to Earth Tech's joint hydraulic model will be used to develop near-optimal infrastructure and operations alternatives for a series of demand scenarios. The different scenarios will help determine an infrastructure cost sharing basis between Toronto and York.

scope for fear the consultant would be shown up. Isn't this a misplaced concern? Why wouldn't the utility instead encourage its consultant to utilize a proven technique to develop better and cheaper distribution solutions? Both the utility and the consultant would come out looking brilliant.

**No. 3—GA optimization locates pipes under buildings.**

The misunderstanding here is that the GA search permits pipes to be located between any two nodes—this is not the case. The GA specialist and the utility staff (and consultant modelers) decide together where new or parallel pipes (and tanks, pumps, valves, etc.) can be added by the GA. These “allowable choices” represent the full extent of the optimization solution space.

**No. 4—GA analysis cannot guarantee we will find the optimal solution.**

Absolutely correct—there is no guarantee that the optimal solution will be found. So why bother looking? Water distribution problems are usually so complex that solutions found by traditional simulation analysis alone are nearly always far from optimum. The GA search will identify several feasible near-optimal solutions resulting in cost savings of 20-30%. This most often makes adding GA worth the effort.

**No. 5—GA optimization costs too much.**

No doubt there are many hours of set-up and analysis, as well as sophisticated software required to apply GA to a water system. The steps in the process, however, are simple—to prepare a calibrated hydraulic model and then to apply GA optimization to identify near-optimal solution alternatives. The hours normally spent on evaluating alternatives in a simulation trial-and-error analysis can thus be reallocated to the GA step.

The payoff for the additional hours and dollars spent on a GA is the capital and operating cost savings that will be achieved. A payoff of 20-100 times the cost of the GA effort should be expected.

**No. 6—We have very few choices, so we we don't need optimization.**

This may really be the case—if you need to lay new pipe from point A to point B and

there is only one possible route, then you don't need optimization. Most distribution problems, however, are more complex. In fact, the planner or modeler usually first tries to simplify a problem—for example, by fixing a tank at site X and then evaluating related pipe locations. Using GA optimization, this early assumption may not be necessary. The GA can instead automatically generate and evaluate a range of alternative solutions for tank sites X, Y and Z. The utility can then choose the best overall solution, based on factors other than cost alone.

*GA optimization will save us 20-100 times the cost of a GA study—we need to check it out ASAP.*



**No. 7—Our modeler is great; she can find a better solution than the GA can find.**

How about giving your great modeler access to a very powerful analysis tool, namely GA optimization? Your modeler could then raise her level of analysis to investigate numerous scenarios, demand conditions and sensitivity analyses. She could direct the GA to search through hundreds of thousands of trial solutions to minimize both capital and operating costs. With assistance from a GA specialist, she could develop a range of alternatives giving decision-makers a choice of feasible near-optimal solutions. The solutions would be hydraulically superior and significantly less costly than your modeler could find using simulation analysis alone.

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**No. 8—What good is optimization if our demand projections are uncertain?**

We've heard this concern expressed often by water utilities. Many progressive utilities periodically update their master plans and/or CIPs using updated hydraulic models and demand projections. To address the demand uncertainty issue, they might develop distinct infrastructure plans for low, medium and high demand projections. But what if these plans are far from optimum for each case?

Using GA optimization, the utility can quickly identify feasible low-cost plans for each demand case, making any comparison much more valid. Alternatively, the GA search could investigate multiple demand cases in a single run, ensuring that minimum levels of system performance are achieved. Finally, the GA step could be applied each time the model is updated—this would allow the utility to re-adjust its optimized plans in order to stay on target as future demand projections evolve over time.

**No. 9—GA optimization is great for CIPs, but we want to optimize operations.**

For water utilities that are nearly built out, anticipated capital works might comprise only in-filling of the distribution system and main rehabilitation and replacement. If the utility has an up-to-date hydraulic model that simulates system operations, then the GA can be effectively focused on revising operations to correct existing deficiencies and reduce system operating costs. Constraints in the GA search are particularly powerful, such as a minimum drawdown for tanks during a maximum day extended period simulation to ensure that water quality is maintained by adequate storage turnover. Pumping hours and set points can be optimized for a series of typical days to see if revised operations at different times of the year could lead to cost savings and improved system performance.

**No. 10—We have no time/staff to optimize now; we can do it next year.**

Like many organizations, water utilities feel they don't have time to plan, due to the urgency of getting things done. Adding an optimization step would only "waste" more

time. Undoubtedly there is also a general resistance to change from simulation analysis to adding optimization. As Lorelle Young, president of the U.S. Metric Association (founded in 1916), recently said: "People resist change. They don't want to be bothered with it."

Whatever the excuse to delay, it makes sense to optimize a water system's infrastructure plans and operations sooner rather than later. Waiting risks that advantageous options will be foreclosed by non-optimal decisions taken today. Waiting ensures that improvements and operations will cost the utility (and its customers) more than should be spent. Don't despair that the utility's master plan or CIP has recently been updated without benefit of optimization. Don't wait five years until the next plan update to optimize. Instead apply GA optimization now as the ultimate "value engineering" tool and get started on a cost-effective, near-optimal path today.



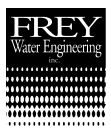
*Out with the old,  
and in with the new.*

**The Optimatics Letter**

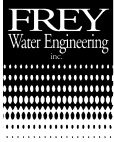
*Advances in optimization for water utilities and consultants*

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## The Optimatics Letter

*Advances in Optimization for Water Distribution System Design & Operations*



*We don't want to embarrass our engineer, so we'd better not optimize.*

*No stupid pet tricks in this issue, but we do present our very own top 10 list — top 10 reasons not to optimize a distribution system.*