"SMART" WELLFIELD™ DESIGN TO OPTIMIZE GROUNDWATER SUPPLY

ABSTRACT

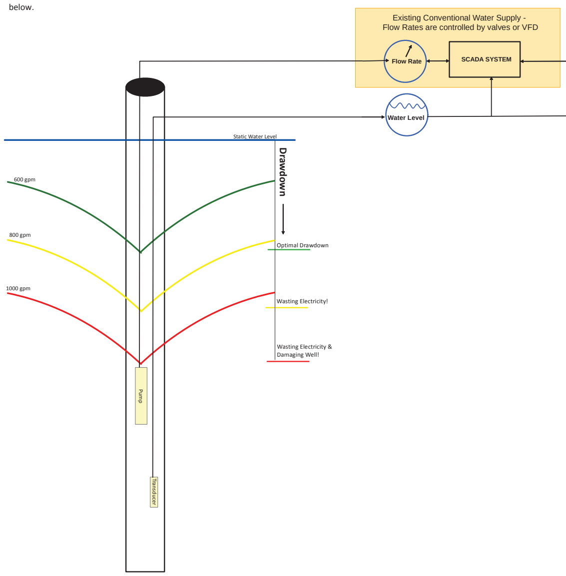
Municipal wellfield operators face many factors that drive up the cost to produce water. Energy to extract groundwater, treatment to remove natural and manmade constituents, infrastructure for distribution systems, and operation and maintenance costs to keep a wellfield producing an adequate quantity and quality of water all require management by wellfield operators. Moreover, these factors exist in a context of existing wellfields that originated decades ago and have been expanded piece by piece in response to population growth. As such there is a tendency to seek out and favor incremental improvements rather than large-scale changes.

For years operators relied on their own experience and the advice of industry representatives such as consultants, equipment suppliers, and well drillers to respond to problems or to plan production increases. SCADA systems are used to compile pertinent data and assist operators with the control key water quantity needs of the community. More recently, groundwater modeling has been used to try to better understand groundwater issues and predict future conditions. These tools and approaches may or may not result in an efficient groundwater production system.

Components of an optimal wellfield design include:

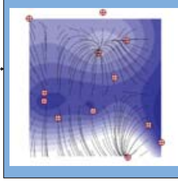
- Wells that yield the most available water given the aquifer characteristics
- Wells that pump water from the shallowest depth possible
- Wells that produce clean water that is protected from existing and future contamination sources
- Wells that provide continuous feedback to managers with which to assess their operational status and efficiency.

The smart wellfield concept begins with equipping wells with continuous water level measurement sensors for compilation in the SCADA system along with flow rates and other information. Innovative computer technologies are then used for sophisticated trend analysis essential to understanding the dynamic operation of the system. Kriging algorithms and other visualization tools enhance this understanding in real time or for any segment within the period of record. Thus a smart wellfield can minimize energy costs for pumping – for example by analyzing well interference, highlight the need for basic well maintenance, and focus well head protection areas for existing and proposed wells. Examples of these uses are shown below.



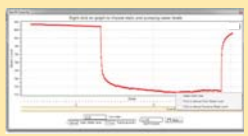
SMART WELLFIELD CHARACTERISTICS

Visualize Current Conditions



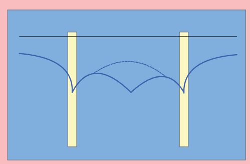
- Access SCADA water level and flow rate data
- Use sophisticated kriging algorithms
- Create potentiometric surface and flow tracks
- Visualize real-time "current" conditions and historical trends

Determine Well Hydraulics



- Smart Wellfields regularly schedule step-drawdown tests
- Calculate specific capacity in pumping wells
- Identify specific-capacity trends and changes in trends
- Monitor well efficiency
- Evaluate Entrance Velocity

Evaluate Well Interference



- Wells compete for the same water
- Overlapping cones of depression
- Increased drawdown
- Identify and quantify well interference
- "Learn" optimal flow rates
- Minimize drawdown

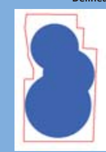
Perform Hydrogeologic Evaluation

$$d = \frac{Q}{4\pi T}\int_u^\infty \frac{e^{-u}}{u}\,du = \frac{Q}{4\pi T}W(u)$$

- A "smart" wellfield performs continuous aquifer tests
- Aquifer parameters are calculated on-the-fly
- Transmissivity, storativity, specific yield, and hydraulic conductivity can be calculated using conventional graphic or mathematical solutions
- Results can be used to increase the accuracy of groundwater models
- Predictive modeling is facilitated

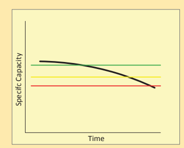
SMART WELLFIELD ECONOMIC IMPACT

Delineate Accurate Well Head Protection Areas



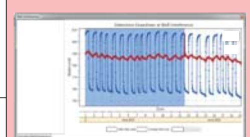
- Estimate capture zones under varying time of travel
- Use site specific SCADA data
- Observe aquifer response to actual pumping changes
- Provides an efficient, accurate, and defensible delineation of well head protection areas
- Limit WHPA to actual size to minimize compliance costs

Maximize Well Efficiency and Schedule Maintenance



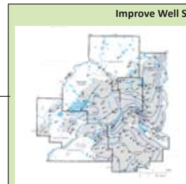
- Trends in specific capacity are an indicator of the health of a well
- Schedule well redevelopment/rehabilitation based on actual well conditions
- Maintain efficient wells to reduce electricity costs
- Avoid well damage by early identification of excessive pumping
- Take preventative action based on indicators of the health of a well

Minimize Well Interference



- Pumping modifications are made within the limitations of existing infrastructure
- Pumping schedules reduce interference and increase pumping efficiency
- Reduced energy costs as a result of pumping against less hydraulic head

Improve Well Siting and Water Appropriation

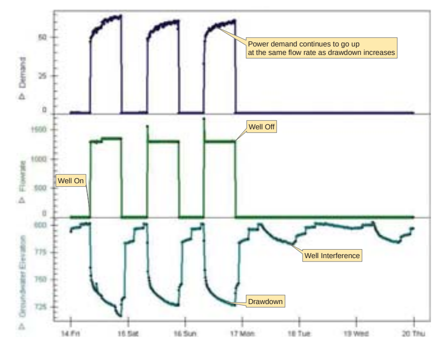


Source: USGS Scientific Investigations Report 2009-5226, p. 12.

When utilized on a regional basis, smart wellfields can be a valuable tool for:

- Contingency planning
- Groundwater modeling
- Regional planning
- Watering restrictions
- Early warning systems for aquifer depletion

Graphs of Wellfield Data Tell an Interesting Story



Conclusions:

"Smart" Wellfields (US Patent 8,244,499):

- **Decrease energy consumption, reporting, and compliance costs**
- **Decrease well rehabilitation and water treatment costs**
- **Decrease well interference costs and drawdown issues**
- **Implement aquifer resource management tools that are based on real data**

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