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SPECIFIC CAPACITY — A MEASURE OF WELL PERFORMANCE, WELL PROBLEMS, AND AQUIFER TRANSMISSIVITY: PART 2 OF 2

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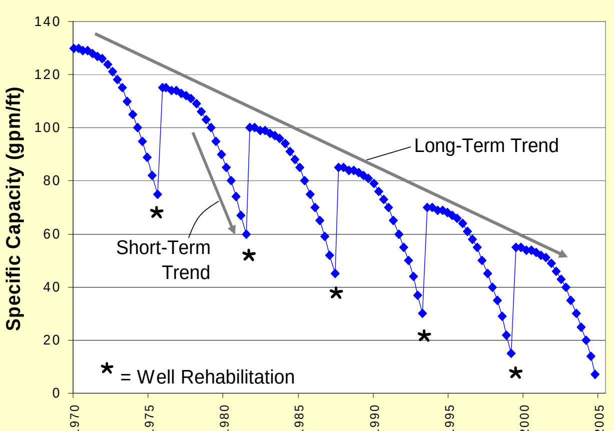
The WRD is pleased to present this latest edition of our Technical Bulletin series to provide information on wells and groundwater resources in the Central and West Coast Basins (CWCB) of coastal Los Angeles County, California. We welcome any questions or comments to this bulletin or suggestions for future topics.

Declining Specific Capacity

Part 1 defined Specific Capacity (SC), explained how it can be used to estimate aquifer transmissivity, and provided a map of SC distribution in the CWCB. It also described how the initial SC value serves as a baseline to compare against subsequent values to determine when well rehabilitation is needed. A new well will start to lose SC as soon as it is put into service. Although the rate of this deterioration will vary from well to well, good record-keeping will allow declining performance to be recognized so that proper evaluation can be made and maintenance or rehabilitation performed.

Decline in SC occurs when the well's screen, filter pack, or near-well aquifer becomes plugged from physical (sand, silt, clay, rust particles), chemical (mineral incrustation), or biological sources ("biofouling" or "bioslimes"). Rehabilitation is performed to remove these blockages and restore the well's SC and improve the well's efficiency. There are both short-term and long-term declines in SC over the normal life of a well. Short-term declines are caused by the plugging and may be partially reversed with rehabilitation efforts. However, the causes of the plugging can generally not be removed completely resulting in a chronic, long-term decline in SC over the life of the well until a new well is needed (**Figure 1**).

Figure 1 - Declining Specific Capacity Trends



Record-Keeping and Maintenance

A well should be on a program of regular preventative maintenance like any other piece of equipment to keep it in good working condition. Accurate and consistent record-keeping is one of the easiest and most important programs to implement. Record-keeping at a minimum should consist of measuring non-pumping (static) and pumping water levels, pumping rates, calculating SC, measuring sand content, collecting water quality data, and recording pump performance at frequent intervals. The records should be tabulated, graphed, and reviewed regularly to identify well, pump, or aquifer problems.

If SC is declining and plugging is suspected, an easy and inexpensive method to try is to simply turn the pump on and off several times to cause the water to rise and fall, thereby creating a surge effect that may wash material from the screen and filter pack. This is a good practice to follow even if SC is not declining to give the well a break as continuous pumping may cause compaction of silts and sands on the filter pack and restrict water from entering the well. Caution must be exercised before doing this, however, since it will not work in wells with check valves or foot valves, or if there is a submersible pump, or if there are any other issues with the well, pump, or motor that could cause damage by the on/off cycles.

Rehabilitation to Restore Specific Capacity

A preventative maintenance program is good but will usually have to be supplemented with more aggressive (and expensive) well rehabilitation efforts when the SC falls by 25% or more from the original value. If the SC is allowed to drop too far, it may not be able to be reversed and the useful life of the well may come to an end. There are many reference materials available with detailed discussions of SC losses, well plugging causes, and well redevelopment techniques such as Driscoll (1986), Mansuy (1999), and Roscoe Moss Company (1990), and many technical seminars such as the recent AWWA Water Well Rehabilitation Workshop in Lakewood, CA (May 17, 2005). These references and others, as well as discussions with professionals in the field, should be consulted to design the proper maintenance and rehabilitation program for a well.

Rehabilitation techniques generally fall into two broad categories: mechanical techniques and chemical techniques. Mechanical techniques use some type of down hole tool to physically scrape, dislodge, and remove buildup on the perforations and to unplug the filter pack and near-well aquifer. Chemical techniques use chemicals such as acids, dispersants, chlorine, or carbon dioxide to dissolve mineral or biological plugging or to remove drilling mud, clay, or silts from the well or filter pack. Typical techniques for rehabilitation are shown on **Table 1**.

Table 1 - Rehabilitation Methods

Mechanical Techniques	Chemical Techniques
Pump On/Off	Acids (for mineral deposits)
Bailing	- Hydrochloric (muriatic),
Surging / Surge Block	- Phosphoric, Sulfamic
Overpumping / Rawhiding	Acids (for organic biofilms)
Airlift Pumping	- Hydroxyacetic (Glycolic),
Brushing (steel or nylon)	- Glacial acetic, Oxalic
Swabbing (single or dual swabs)	Carbon Dioxide (AquaFreed)
Acoustic Shock/Fluid Displacement	Caustics (for organic biofilms)
Vibratory Explosive Shock	- Sodium/Potassium Hydroxide
Air Displacement Surging (juttering)	Chlorine Dioxide
Single Shot Explosives (primer cord)	Dispersants, Sufactants
Jetting (high-pressure air or water)	Sodium or Calcium Hypochlorite

Before the proper rehabilitation method can be chosen, the cause for the declining well performance should be determined. A video log is a valuable tool to observe the condition of the well screen to help diagnose the problem. **Figure 2** shows a picture from a video log for a well in the West Coast Basin that was experiencing a SC loss. The picture clearly shows a clean well with no internal plugging of the perforations. Therefore, the plugging was suspected to be outside of the well, in the filter pack or aquifer. Dual-swab with airlifting and acoustic shocks were used to remove silts and increase the SC by over 20%. **Figure 3** shows a picture inside a well in Central Basin that could not pump more than 850 gpm without pulling in excessive sand. The picture shows completely plugged perforations in the lower part of the well. The sand was coming in from the upper perforations (not shown). Wire brushing and an acoustic shock tool were used to open up the lower perforations, and the well can produce over 1,300 gpm of sand-free water.

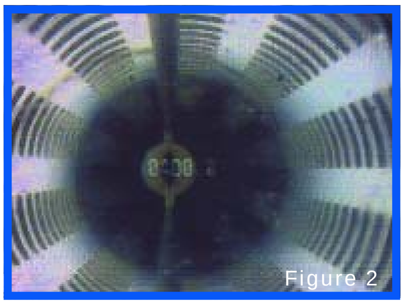


Figure 2

Figure 3

Environmental Considerations

Waste disposal (pumped groundwater with sediment, chemicals, and/or contamination) are environmental considerations that may be dealt with through an NPDES or Waste Discharge permit from the Regional Water Quality Control Board for storm drain or land disposal, respectively, or a permit from the Sanitation Districts for sewer discharge. Or, the wastes can be containerized and hauled offsite to an appropriate waste disposal facility. Permits can take 30-45 days or more to obtain, so early planning is important for a rehabilitation project.

Rehabilitation Costs

A traditional well rehabilitation might include the following steps (in order): Pulling and inspecting the pump; video log; spinner log; zone sample; mechanical rehabilitation; chemical rehabilitation; pump to waste; another video log; re-install the original pump; disinfection; and waste disposal. Costs can be highly variable, from several thousand dollars to over $100,000, depending on the amount of rehabilitation and whether or not the original pump is pulled. **Table 2** provides potential cost ranges for various rehabilitation techniques. A big part of the cost is to remove and replace the original pump and the use of a temporary test pump. Therefore, new well designs should incorporate separate access ports for chemicals, video logging, spinner logging and zone sampling so the pump does not have to be pulled to perform some types of evaluation and rehabilitation.

Table 2 - Costs for Some Rehabilitation Techniques*

Pull/Push Pump**	$6,000 - $15,000
Test Pump	$10,000 - $25,000
Video Log	$1,000 - $2,000
Spinner Log	$1,000 - $3,000
Zone Samples	$1,000 - $5,000
Brushing/Bail	$2,000 - $10,000
Airlift Pumping	$3,000 - $25,000
Acoustic Shock	$5,000 - $20,000
Swabbing	$2,000 - $15,000
Chlorine Dioxide	$5,000 - $20,000
Acid	$10,000 - $50,000
Carbon Dioxide	$15,000 - $50,000
Disinfection	$1,000 - $15,000
Wastes/Permits	$2,000 - $50,000

* Not all Techniques will be needed at a well. Costs based on WRD experience and will vary based on well and pump construction and degree of problem.

** additional costs may be incurred for pump repair.

Considering that the cost of a new well can be $500,000 or more (not including land, building, piping, and treatment), the costs for a regular maintenance program with rehabilitation as needed to extend the useful life of the existing well are easy to justify. Closely monitoring the SC and other data from a well will lead to early problem recognition, cost savings, a long lasting well, and provide experience and knowledge of the well's performance that can be applied to any new wells constructed at the same site.

Sources of Information for this Technical Bulletin:

Driscoll, F.G., 1986, Groundwater and Wells: Second Edition: Johnson Filtration Systems Inc.

Mansuy, N., 1999, Water Well Rehabilitation, A Practical Guide to Understanding Well Problems and Solutions: Lewis Publishers

Roscoe Moss Company, 1990, Handbook of Ground Water Development: John Wiley & Sons, Inc.

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