# Down-Hole Perforating: A Technique to Increase Water Production from Existing Wells

## Introduction

Today's well-refined methods of well design, drilling, construction and development commonly result in water supply wells that are efficient, reliable, and productive. However, on occasion a well may fall short of these ideal results despite the best applied design and construction efforts. This memorandum describes an approach that has the potential to improve water production by using a down-hole perforator to increase the linear footage of open area and expand the production zones of the well. Assuming that the site-specific hydrogeology and ground-water levels are favorable for this approach, marked improvement in the well's performance can be realized at a relatively low cost.

## Approach

In the case of a completed well which yields appreciably less than its pre-design forecast, it may be advisable to revisit the well-specific data, including the following:

- well driller's log
- geologist's lithologic log (if prepared)
- down-hole geophysical log
- as-built well design
- pumping test results
- water quality results

Well Logs. During the drilling of the borehole, the driller and geologist (if assigned to the project) visually analyze the cuttings that were returned from the hole and independently prepare well logs. The logs consist of concise physical descriptions of the cuttings and estimated depths for the top and bottom of each zone that encountered. A typical geologist's log provides important notations on the size, angularity, and sorting of each geologic unit. These are key parameters when one re-evaluates a potential water-yielding zone that was not screened and is not as yet a source of water for an existing well.

Geophysical Log. The down-hole geophysical log typically includes resistivity logs and a spontaneous potential log. These two logs are interpreted to determine the top and bottom of each water-bearing unit and nonwater-bearing unit. The geologist's log (and/or driller's log) is used in conjunction with the resistivity and spontaneous potential logs to interpret the results.

As-Built Well Design. This design drawing shows key below-ground details of the well including (but not limited to) the current depth intervals of blank casing, well screen, gravel pack, annular fill, seal(s), and sounding tubes. It also shows the gradation of the gravel pack, slot size of the louvers or wire-wrapped well screen, and casing thickness.

Pumping Test Results. These data indicate the depth of the static water level, pumping water level, well yield, and specific capacity.

Water Quality. Depending upon the suite of analyses performed on water samples from the well, the test results may show the physical and chemical parameters that characterize the water quality conditions. In some instances, if isolated aquifer testing was performed, the results that might be used to characterize various water-bearing units that were tested prior to the installation of the well casing and well screen. This type of information would be used to identify and characterize zones, i.e., depth intervals that might yield more water to the well.

At this point, the objective would be to re-consider the depth, thickness, lithology (sand, silty sand, clay, etc.) and the gradation of the sediments in each blanked-off zone. One must carefully evaluate the gradation of the sediments because perforating blank casing has the potential to cause the well to begin producing sand through the new perforations. The final selection of the zones to be perforated should also consider the hydraulic and water quality conditions. It would be undesirable, for instance, to open perforations in a shallow zone and then induce water to cascade into the well, thereby entrain air, and cause performance problems when the well is operated. Likewise, one would not want to pump water from a zone that has undesirable water quality. Both issues should be carefully assessed beforehand.

**Construction Phase**

The down-hole hydraulic perforator (Figure 1) used by Roscoe Moss Company is an effective tool that produces horizontal openings with a downward facing aperture that are about 3 inches long and can be made from 3/32-inch to 3/16-inch wide (Figure 2). It was designed for use on high strength steel casing and it is able to produce openings in steel well casing with a maximum wall thickness of 3/8 inch. This perforator has also been used with other types of spiral seam, submerged arc welded casing. However, the down-hole perforator is not recommended for casing manufactured using the electric resistance weld process. A typical perforation pattern is determined by the diameter of the casing; the number of perforations (i.e., rows) per round is equal to ½ casing diameter (in inches) less 2.

***Case Study No. 1: Municipal Well – West Covina, California***

This water purveyor drilled a new 800-foot deep well in an area where other existing wells were only about 600 feet deep. During the design phase of the project it was clear that the well yield from the lower zone alone might not meet the owner's expectations. However, the owner wanted to only pump from the lower zone (if possible) to minimize interference with nearby wells. The final design for the well was based on the results of down-hole geophysical logs and the geologist's log.

The well was constructed with 18-inch diameter high-strength, low alloy blank casing with louvered perforations, and gravel packed. However, due to the possibility that the deep zone might not produce sufficient yield, the well was designed with a backup plan in mind. The well was constructed so that, if necessary, the blank casing installed within the upper zone could be retrofitted by making new perforations with a hydraulic perforator. To accommodate this option, the annular space within the upper zone was filled with a filter pack that would be 100% retained by the perforations made by the perforator.

When the well was initially pump tested, the lower zone produced about 100 gpm, which was considerably less than the yield needed by the purveyor. As a result, it was decided to make new perforations in the upper zone. After this was done, the well was pump tested at 850 gpm and was so equipped.

### *Case Study No. 2: Municipal Well – Glendora, California*

In an effort to improve its existing water supply system, the city drilled a new, high-capacity well to a depth of 450 feet deep in an area near other city wells that were prolific producers. When the new well was completed and pump tested, it produced 1,260 gpm, which was considerably less than its pre-construction design rate of 2,250 gpm. When local water demand increased, the city decided to make an attempt to improve the well's performance by adding new perforations within an "untapped" shallow zone that was above the existing perforations. According to the well driller's log there were about 100 feet of coarse, granular sediments within the shallow zone at a depth of 100 and 200 feet. When the well was constructed, blank casing was installed within this shallow zone.

After consulting with a hydrogeologist, the city contacted a local well contactor who was experienced in the use of a down-hole hydraulic perforator. Prior to working on the well, the contractor evaluated the as-built well design, casing materials, and gravel pack. Then, the down-hole perforator was used to make 3/32-inch openings in the blank casing from a depth of 140 to 200 feet. This newly perforated zone was then developed and afterwards, a pumping test was conducted. The post-retrofit results showed that the well's production was increased by 72.6% to 2,175 gpm. The well's efficiency was increased from 60.9 % to 67.6%. The well is now the highest producing well in the system and the city has a rejuvenated well that should be in service for many years to come.

Figure 1 - Hydraulic Perforator

Figure 2 - Perforations

### Summary

Adding new perforations to existing wells with a down-hole perforator is an alternative that has the potential for dramatic improvement to well performance. However, before undertaking this approach, one should carefully assess the site-specific hydrogeology and water quality, and as-built well design. Then, one needs a well contractor, who is experienced in the use of the down-hole perforator. As shown by the two case studies described above, it is possible to successfully retrofit an existing well with new perforations, thereby increasing the linear footage of source aquifer sediments. The relative cost and potential for improved well performance make this a interesting option to consider.

**References**

*Handbook of Ground Water Development*, 1990, Roscoe Moss Company, John Wiley and Sons, New York, NY