Chapter 7

Special Applications of the BART Testers

7.1 Specialty Tester uses, water well diagnostics

From 1990 when the Bart testers were first sold the principal market was seen to be in the diagnosis of water well problems caused by nuisance bacteria with various forms of costly biofouling effects. These effects could be so significant that the well could end up failing to meet production or injection goals due to combinations of plugging, clogging and corrosion. Plugging mainly involves the generation of a biomass which prevents water movement into or out of the well. Clogging involves a biomass generating scaling with a high bioaccumulation of inorganic chemicals (e.g. ferric oxides, calcium carbonates). Corrosion involves the biomass attacking and corroding parts of the structures used in the installation of the well (e.g. steel casings, screens, concrete grouting, and pump impellers). Service lives for water wells are often controlled by the amount and focus of these biomass influenced activities.

Biofouling thus clearly can take on a number of forms in, and around, water wells. Principal concerns relate to corrosion (losses of equipment), plugging (losses in production), and deterioration in the quality of the product water all resulting indirectly from the infesting biomass. Biofouling events are therefore side effects of the growth of biomass in, and around, the water well. Not all of these events are bad since the biomass also acts as a biological filter taking out and storing some chemicals (like iron, arsenic and manganese) while degrading others (such as organics). The net effect of these interactions is therefore that as the biomass initially grows then the product water quality can actually improve (e.g. less iron, less organics) but when the biomass gets too big (reaching 60+% of the void or fracture volume) then it destabilizes. This then causes the releases of iron, other chemistries including organics to the water. These biomass-related influences are cyclic which means that a given sampling may only show the state of the bacteria within that sample at that time and maybe not be relevant to the production and quality status of that water. This means that the value of microbiological investigations of wells involves variability in the data generated. It is only by repeated and sequenced sampling that a truer picture can be gained of the status of the well. Selecting the right tester is the subject of 7.2 and diagnosis of biofouling in Chapter 13.

7.2 Selecting the testers for water well diagnostics

Field testers come in a format that makes them easy to use in conditions away from a laboratory. The major difference from the laboratory version is that there is a second tester (vial / bottle) provides additional stability and protection to the tester when it is being transported and used in the field. There are occasions when there is a need to take a water sample that would then be used to fill the inner testers while out in the field. With the field testers there is the potential to use the outer tester (vial / bottle) as the means of taking the water sample for subsequent use in the testing. The inside contents of the field tester are effectively sterile and so therefore, when removed, the outer tester can be used to collect the water sample. To do this, use the following procedure:

(1) Unscrew and remove the outer cap, remove the inner tester and place on a clean dry surface, and lay the outer cap down on a clean surface without turning it over;

(2) Screw the outer cap back onto the outer vial and it is now ready to be used for collecting the water sample;

(3) When collecting the water sample in the outer tester then remove the outer cap again and place on a clean surface;

(4) Add the water sample to the outer tester but do not fill beyond the line beneath the threads, this line denotes that 65ml of water has been added;

(5) Put the outer cap back on to the outer vial and screw down. A 65ml water sample has now been taken which would be enough to charge four inner testers.

It should be remembered that the water sample only remains valid if it has not been contaminated during collection. Therefore do not charge the outer vial in an environment that is dust laden and always handle the outer vial from the outside to avoid contaminating the inside. If sterile latex gloves are available then it is advantageous to handle the outer vial wearing the gloves to further reduce the risk of contamination. There are no chemicals added to the outer vial and so any chemicals present in the water (for example, chlorine) would not be neutralised while in the outer container.

One of the major challenges for the determination of biofouling risk and effective management is that a prime factor is that different bacteria are growing at various sites around the bore hole. Of these bacterial communities it is often the iron related bacteria (IRB) that are the closest to the bore hole. They have the oxidative ability to accumulate ferric forms of iron inside the biomass, around the slime tubes that they make, or push it out of the cells as ribbons. They like a lot of oxygen and are largely responsible for the development of rust-like growths. Using IRB- testers it is possible to detect these IRB by the types of reaction they develop. Brown ring (BR) means a reaction specific to the (aerobic) slime forming IRB. If there is a brown clouding (BC) then that means a whole collection of different IRB are active. Normally the first reaction observed is either clouding (CL) which means an oxidative condition, or foam (FO) which indicates that the sample was from a more reductive environment.

Just outside of the IRB biozones is the second concentric ring that contains the general heterotrophically active bacteria (HAB). These are the “filter feeders” or “organic busters”. That means that they feed within the natural biomass filters that build around wells and they have two very important competitive edges: (1) efficiently break down many organics particularly in the presence of oxygen; and (2) adapt relatively easily to both oxygen rich and oxygen deficient conditions. They are the main “workers” or “harvesters” in the natural filters formed by the biomass. HAB- testers will detect these bacteria by one of two types of reaction. These are the UP and DO reactions. UP remains aerobic, oxidative; and DO means anaerobic, reductive. In oxidative conditions the UP reaction dominates while in reductive conditions the DO reaction dominates. Thus sequential sampling of a well can locate the oxidative-reductive interface (Redox front) where most of the biomass is active which is where the UP reactions become DO..

Further away in the more reductive conditions around the bore hole (third concentric biozones) the biomass becomes dominated by the sulfate reducing bacteria (SRB). These bacteria generate hydrogen sulfide from sulfates or proteins and cause odours, blackened waters and corrosion.

They are driven by the amount of organic acids being generated in the biomass. There are two reactions (black bottom, BB and black top, BT). BB signifies communities that are more covert and prefer more reductive conditions which are often more difficult to treat. BT occurs when the SRB- are growing inside aerobic communities and are both more active and easier to control.

Beyond the SRB in the very reductive regions surrounding the bore hole (concentric zone four) there are the CH4- (methane producing) communities which generate methane (natural) gas as a major product. When there is a major activity in this community then the methane gas can escape into the bore hole and represent a problem to the well user (well might flare occasionally and the head space over the well's water column might even become combustible). Normally the IRB-, HAB- and SRB- BART testers can also be included to determine the activity of the biomass and the possible location of the Redox front. To do this the zone of interrogation projection (ZIP, see also Chapter 4.12 for more information).

7.3 Diagnosing water wells

When water wells suffer from significant production losses it becomes necessary to treat the wells to get the flow back (preferably sooner rather than later since preventative maintenance is cheaper than the cure!). Very often specific capacity readings are taken before treatment and then again afterwards. The success of a treatment is based on the percentage increase in the specific capacity. For example a well that had an initial specific capacity of 5gpm/ft and had a post treatment capacity of 15gpm/ft could be considered to have undergone a 200% improvement in specific capacity. While that may sound impressive the only valid comparison should be with the original specific capacity taken when the well was first developed. If the original specific capacity was 50gpm/ft then taking this as 100% would mean that the treatment only recovered the well from 10% to 30% (5pgm/ft to 15gpm/ft for a well originally developed at 50gpm/ft) which would then be an improvement of only 20% towards the original specific capacity! Always use the original developed specific capacity as the benchmark and not the specific capacity of the fouled well before treatment

In calling for a preventative maintenance or radical regenerative treatment on a well it important to judge success on the basis of the original specific capacity of the newly developed well and theoretically no improvement can exceed 100% unless there has been some major changes in the aquifer or geology encompassing that well. Many well treatment companies tend to favour the use of the pre-treatment specific capacity to determine effective gains. This is because much greater percentile claims can be made that is not restricted to the 0 to 100% range. Caution should be observed when any claim exceeds 100% and care must be taken to ensure that the original specific capacity of the newly developed well is being used in the development of any such claims.

Preventative maintenance should only be applied to water wells that have not lost more than 15% of the original specific capacity. Under these circumstances it would be reasonable to consider as being very acceptable the 10 to 15% improvements possible by preventative maintenance. Radical regenerative treatments should be applied to wells that have lost between 10 to 40% of original specific capacity and there should be a near total recovery of production. Effective radical regenerative treatments should cause improvements commonly in the 20 to 40% range returning the well ideally to within 10% of its original specific capacity. Generally water wells that have lost more than 40% of their original specific capacity cannot be effectively regenerated to original but improvements of 30 to 40% towards the original may be viewed as successful treatments.

Again caution should be taken with any claims that exceed 100% because this would mean the claimant is likely to have exaggerated the effectiveness of the well treatment. Use only the original specific capacity set as 100% for when the well was developed then any treatment may be judged by the percentage improvements in the well and this should never normally exceed 100%.

7.4. Water well treatment claims and reality

The golden rule is **“no one size fits all”** means that all treatments need to be customised to the water well scheduled for attention and possible treatment. Beware of sales persons who claim that their treatment method will either:

(1) Causes production to exceed 100% after treatment;

(2) Be applicable to all wells equally and regenerative treatments will return all wells to full production; or

(3) This treatment will be the only one that the well will ever need to be given.

All of these claims are warning signs that should trigger the “red flag” and these treatment claims/proposals should be discounted as not realistic. Reality is that every well should be treated as a separate challenge and there should be some attempt to customise each well to address differences between them that are observed.

Treatment of a well can commonly be chemical and / or physical and vary to include a combination of the various treatments when blended. There has never been the successful development of biological treatments that has been shown to be effective in the long term. That is partly because the wells already have a natural microbial population in, and around, the well and would react to the introduction of third party microbes to the system. Traditional chemical treatments can include a single compound or a blend of various chemicals. Single chemical treatments for water wells has now tended to be replaced with blends of chemicals usually used together or in sequence and commonly including some form of biocide, pH modifier and a detergent/dispersant. This combination of chemicals can kill the biomass, destroying the associated plugs and clogs, and cleaning off the surfaces respectively. In general the new blended approach involves phased treatments summarised as occurring with the three sequences of **shock, disrupt and disperse**. At the end of the treatment it is common for the well environment to contain a lot of dispersed biomass that has to be removed. It needs to be remembered that this biomass has grown acting as a biofilter degrading some organics but accumulating many other chemicals. These bioaccumulated chemicals will now be released by dispersion and enter the water. This would mean that a successful treatment of a well could potentially include treating the dispersing biomass as hazardous waste depending upon the bioaccumulates found to be present.

Some treatments involve modifications to the applied temperature for the treatment by the addition of heat (to raise the temperature) and coolants (to lower the temperature). Generally raising the temperature during treatment causes faster chemical reactions and greater impacts on the biomass. The blended chemical heat treatment (BCHT™) uses this approach. More recently in an effort to be "greener" treatments have been used that are purely physical in nature. Here physical forces are pulsed through the wells environment in a manner that becomes disruptive to the biomass causing it to collapse and then disperse.

Many traditional treatment methods employ chemicals in which phosphorus is employed as phosphate, phosphoric acid or polyphosphates. These could cause stimulation of post-treatment biomass growth (it is not practical to generate "sterile" conditions in natural environments). It is therefore recommended that it should be demonstrated that at least all of the treatment phosphorus has been effectively removed with the dispersed biomass from the treated well. Failure to do this means that the residual phosphorus left down hole will stimulate the growth of the biomass that will inevitably form after treatment. Even if it could be generated that all of the applied phosphorus was removed by the end of the treatment this would still mean a zero impact on the removal of phosphorus from the biofouling biomass that would be down hole. Any residual phosphorus left after treatment could would trigger a heavier biomass generation (on the additional phosphorus entrapped during treatment) to cause very active post-treatment biofouling (bloom) in the treated well. Because of these risks it would be important to restrict any well treatment chemicals to those that do not contain phosphorus as an active ingredient.