WELL REDEVELOPMENT WORK PLAN
FYN PAINT & LACQUER CO., INC.
230 KENT AVENUE
BOROUGH OF BROOKLYN
CITY OF NEW YORK
VCP SITE #V00380-2, VCP INDEX #W2-0873-00-10

Prepared For
Fyn Paint & Lacquer Co., Inc.

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1.0 INTRODUCTION

The Fyn Paint & Lacquer Co., Inc. (Fyn Paint) is the subject of a Voluntary Cleanup Program (VCP), Index Number W2-0873-00-10 pursuant to the New York State Department of Environmental Conservation (NYSDEC) VCP. Leggette, Brashears & Graham, Inc. (LBG) was retained to implement the onsite activities as outlined in the Remedial Action Work Plan (RAWP), submitted to the NYSDEC in August 2009 and approved by the NYSDEC in October 2009.

As observed during the pilot tests: activities, the extraction wells at the Site appear to have reduced yields with respect to groundwater and soil vapor. As has been recorded during historical operation and maintenance of the pump and treat interim remedial measure, iron and related iron bacteria are present in the groundwater at the Site. This condition (common in the New York City area) minimizes the yield of groundwater wells due to bacterial growth and iron precipitation within the well screen. To ensure the site groundwater/soil vapor extraction wells are providing maximum recovery rates, LBG proposes that the onsite wells EW-1 and EW-2 be redeveloped/rehabilitated.

2.0 BACKGROUND

Well screen problems generally fall into three categories: physical blockage, biological blockage and chemical blockage. All of these have been observed at the Site through the lifecycle of the extraction wells and/or the groundwater treatment system. No matter how screen blockage happens, it decreases the well yield. A summary of the blockages are presented below:
1. **Physical Screen Blockage**

   An accumulation of sand, silt and other materials inside the well screen can reduce water flow into a well. As they accumulate in the bottom of the screen, the inlet area is reduced. These materials can find their way into the well through a variety of ways. The most common are holes in the casing from corrosion, migration of fines from overpumping, poor placement or sizing of the gravel pack, screen openings that are too wide and poor well development following construction.

   "Bailing" these materials from a well is relatively easy, but the pump has to be removed. This is the procedure which was performed during the post well installation development activities.

2. **Biological Screen Blockage**

   Naturally occurring, common soil bacteria are found in almost all aquifers and are the cause of biological screen blockage. The groundwater beneath the Site contains elevated levels of dissolved iron. Generally, if the iron amount in the water is greater than 0.3 parts per million (ppm), iron bacteria problems will arise. Even small quantities of iron provide a source of energy for the growth and development of iron bacteria. These bacteria form a slimy organic substance on the well screen, pump intake and pump column, and in the water-bearing aquifer materials surrounding the screen. As the bacteria build up, they reduce the open area of the screen and the open spaces in the aquifer materials surrounding the screen, thus reducing well yield. If exposed to air, this buildup hardens and becomes much more difficult to remove.

3. **Chemical Screen Blockage**

   Chemical blockage results from the deposition of minerals in the form of scales or incrustation on the well screen. It also cements parts of the gravel pack and aquifer materials on the outside of the screen. Most mineral deposits on well screens either are calcium and magnesium carbonates or calcium and magnesium hydroxides.
magnesium sulfates. They precipitate out of the water where the water velocity is highest and the pressure is lowest -- at or near the entrance to the well screen. These are the same materials that build up around the ends of faucets in many houses. These minerals bond the aquifer materials into a solid mass that over time will plug the well screen openings and cement the materials outside the screen. The rate of incrustation accelerates with time because as some of the screen openings become plugged, the water enters the remaining slots at a higher velocity, which causes more incrustation.

Iron-reducing bacteria and mineral incrustation are different in origin and require different treatments for removal. However, having both of these problems in the same well is common.

3.0 WELL REDEVELOPMENT STEPS AND ALTERNATIVE METHODS

Rehabilitating a well requires specialized knowledge, equipment and powerful chemicals. To be done properly, the pump will be removed from the active extraction well. This will provide an opportunity to have the pump and motor examined for wear and other problems. Rehabilitating the onsite recovery/extraction wells and the surrounding aquifer formation will be a four-step process using a combination of mechanical tools and chemical treatment. In practice, chemical treatment and redevelopment often are done at the same time.

3.1 Mechanical Tools

Mineral incrustation and bacteria buildup in easy-to-reach areas, such as within the casing and screen, often can be dislodged and removed using mechanical tools, such as wire brushes, disk swabs or surge blocks, combined with airlift pumping. All debris from this operation should be removed from the well. Removing much of the mineral and biological buildup mechanically will increase the effectiveness of the subsequent chemical treatment greatly.
3.2 Chemical Treatment

Chemically treating a well usually refers to using some form of strong acid to dissolve the mineral incrustation on the screen, casing, and in the gravel pack or aquifer surrounding the screen. Often this is called "acidizing" a well. However, sometimes because of water chemistry, using a strong base might be better than acid. Many types of acid can be used for this purpose, but the acid selection is site specific and depends on the materials used to make the casing and screen, as well as water quality and aquifer materials. Screens made from plastic, fiberglass and stainless steel are resistant to most strong acids and bases used for chemical treatment.

All chemicals used to clean the onsite groundwater wells will be approved for use in water wells. The amount of chemical added to a well will be based on the quantity of water in the well. Often adding too much acid to a well may not help and actually can hinder the rehabilitation process. With severe mineral incrustation, doing the acidizing in two steps often is better. Use the first batch of cleaning chemicals to dissolve some of the minerals, then pump them out and add the second batch to dissolve the remaining parts. For all chemical treatment activities and when handling well-cleaning acids, proper safety equipment will be worn as recommended by the chemical manufacturer. Equipment will include goggles, masks, rubber gloves and full clothing coverage. In addition, a supply of clean water for eyewash and rinsing spills will be available. Several of the common well cleaning acids include:

*Muriatic Acid*

Muriatic acid, a common product used for acidizing a well, is an industrial name for a hydrochloric acid solution with about 30 percent concentration. This is a very strong acid. It provides a fast chemical reaction to dissolve carbonate scales and incrustation. It is particularly effective against iron and manganese oxides but doesn't remove biological buildup very effectively. Although good for cleaning wells, hydrochloric acid can be dangerous to handle. Excessive amounts in the well can produce large amounts of toxic fumes. Inhaling these fumes can cause death. Use only the recommended amount of acid for the volume of water in the well. Only professionals with training and access to proper safety equipment should handle this acid.
Sulfamic Acid

This is a type of sulfuric acid and comes in a dry form. It is safer to use than muriatic acid, but has a moderate chemical reaction, so it takes longer to dissolve carbonate scales and incrustations. It is not very effective against sulfate mineral deposits. Sulfamic acid doesn’t produce harmful fumes and is not very corrosive. It isn’t very effective at removing biological buildup.

Phosphoric Acid

Phosphoric acid is a mild acid that contains phosphorus, which if discharged into wetlands or water bodies can increase algae buildup. It is less corrosive to metal than muriatic acid. It is somewhat effective in dissolving iron and manganese oxides but is not very effective against biological buildup in the well.

Glycolic Acid

Glycolic acid, also known as hydroxyacetic acid, is effective against biological accumulations. It will disperse and help remove biofilms that build up on the screen, pump and casing. The chemical reaction is slow and creates no harmful fumes.

Acid Combinations

To remove both biological products and mineral incrustations effectively at the same time, well drillers often use a combination of acids when rehabilitating a well. One combination is to mix muriatic and glycolic acid together, with each added to a volume of water at about the same percentage by weight or volume. More often, well drillers will use commercial products that are premixed acid combinations designed to address specific incrustation problems.

3.3 Redevelopment

When a well is drilled, development is the last step of the drilling process. Development entails agitating the water in the vicinity of the screen to remove fine sand and drilling
mud in the borehole left over from the drilling process. This was performed on the onsite wells following well installation.

Redevelopment of a well involves the same procedure, but now the goal is to remove encrusted material in the gravel pack or aquifer material outside of the screen. Quite often the redevelopment process is combined with chemical treatment to dislodge, dissolve and remove minerals and iron deposits in the well. It's common to introduce chemicals (acids) about 24 hours prior to starting the redevelopment operation. Several methods are available for redeveloping a well. They are, in order of increasing effectiveness, as well as cost: airlift pumping and agitation, mechanical surging and jetting.

**Airlift Pumping and Agitation**

Airlift pumping forces compressed air through an air line to the bottom of the well. As air bubbles rise, they create a surging effect that carries water and dislodged materials out of the well. Airlift pumping is alternated with short periods of no pumping, which forces water and chemicals out into the formation to help break up minerals and bacteria lodged in the aquifer formation surrounding the screen. This method of well development is effective only if the water is deep enough in the well to get the surging action. Airlifting does not work if the lift to the surface is too great.

**Mechanical Surging**

Surging alternately forces water into and out of the formation through the well screen openings. A piston-like tool moves up and down in the well to create the surging action. The water surging through the well screen loosens the minerals and fines in the borehole and draws them into the well to be removed by pumping or bailing.

**Jetting**

The best well development method is high-pressure water jetting with simultaneous pumping. High-velocity water jets through the screen and gravel pack into the formation to loosen and break down the fine materials. The jetting tool rotates slowly as it moves up and down inside the well screen. Pumping removes the loosened sand and
mud as they enter the well screen. The jet stream can be directed at any part of the formation around the well for selective development. Cage-wound screen is best for jetting because its design allows the jet to impinge directly on the gravel pack or borehole.

3.4 Chlorination

The last step in rehabilitating the onsite recovery wells would be to chlorinate using either liquid or solid forms of chlorine. Chlorination will help kill the remaining iron bacteria and other bacteria introduced during the rehabilitation process. The object of well chlorination is to raise the chlorine level in the well to around 500 ppm using a quick-acting form of chlorine and hold it there for at least 24 hours to allow the chlorine to attack and kill the bacteria. Getting the chlorine out into the aquifer material surrounding the well screen is also very important. Chlorine comes in either dry or liquid formulations and is described below:

**Calcium Hypochlorite**

Calcium hypochlorite (sometimes referred to as HTH) is a dry, white to yellowish material. It comes in pellets, powder or granular forms. It contains about 65 percent available chlorine by weight. Calcium hypochlorite requires careful storage to avoid contact with organic materials, especially petroleum-based products. If calcium hypochlorite is mixed with petroleum products, it will become hot enough to start a fire. When mixed with water, calcium hypochlorite will create heat. If preparing a mixture to pour into the well, never add water to the container holding the calcium hypochlorite because of the excessive heat and noxious gases that will be produced. Rather, add a measured amount of calcium hypochlorite to a sufficient quantity of water (at least 30 gallons) to control the heat.

**Sodium Hypochlorite**

Sodium hypochlorite is a clear, yellow liquid familiar to most people as laundry bleach. Common laundry bleach sold in stores contains about 6 percent chlorine, but commercially available formulations can be up to 12 percent chlorine.
Because acid treatment combined with chlorination can produce dangerous gases, the chlorination procedure would be performed to maintain the well after the well redevelopment. The chlorination events would be performed to target the remaining iron bacteria present within the well (specifically pumping wells) and prevent additional bacterial growth.

Use the following procedure to chlorinate your well(s):

1. Determine the depth of the water standing in the well. This is the total well depth minus the depth to static water.
2. Determine the amount of chlorine needed. This will be determined as per the manufacturers recommendation.
3. Introduce the chlorine into the well. Use protective gloves and goggles since chlorine solutions this strong can cause skin burns. If you are using the dry form of chlorine, always read the label to make sure you are using the correct amount.
   a. When using liquid bleach, mix with at least 50 gallons of water and pour into the well. Add another 100 gallons of water or more to distribute the chlorine mixture throughout the well.
   b. When using chlorine granules or powder, dissolve slowly by mixing with 50 gallons of water or more. Pour slowly into the well. Add another 100 gallons of water or more to distribute the chlorine mixture throughout the well.
   c. When using chlorine pellets, drop them through the well access port very slowly (about 20 to 30 pellets every minute). When that is completed, pour 10 to 20 gallons of water down the access hole to wash off any pellets that might be stuck in the access pipe or hung up on pipe flanges.
4. Wait at least four hours for the chlorine to disperse throughout the water column.
5. Surge the well for one hour (surging is starting and stopping the pump intermittently, but not allowing water to discharge from the well). This action also is
called "rawhiding" a well. With deep-well turbine pumps, allow five minutes between starts with no more than six starts in an hour.

6. **Let the chlorine stand in the well for 24 hours.** Chlorine needs time to kill iron bacteria. Concentrated chlorine will attack the metal in the pump, casing and screen and weaken these components.

7. Surge the well at least two more times, then pump the water to the treatment system. The water should be quite dirty and it should smell...an indication that the chlorine did its job. Pump until the odor of chlorine is gone.

Of note, the generation of chlorinated organics is not an issue considering the treatment application is a short-term application intended to treat the well, well pack and immediately adjacent formation. Following the 24-hour stand time, the chlorinated treatment water will be pumped from the well to the onsite groundwater treatment system for treatment prior to discharge to the sanitary sewer.

### 4.0 SELECTED WELL REDEVELOPMENT METHODS

Based on the evaluation of the above well redevelopment methods, it is proposed that all of the previously installed onsite groundwater extraction wells (EW-1 and EW-2) be redeveloped using the following technologies:

1. Mineral incrustation and bacteria buildup in easy-to-reach areas, such as within the casing and screen, often can be dislodged and removed using mechanical tools, such as wire brushes, disk swabs or surge blocks, combined with airlift pumping. All debris from this operation should be removed from the well. Removing much of the mineral and biological buildup mechanically will increase the effectiveness of the subsequent chemical treatment greatly.

2. To remove both biological products and mineral incrustations effectively at the same time, a combination mix of muriatic and glycolic acid (or similar premixed acid) will be used. It should be noted that prior to carbon treatment and subsequent discharge to the sanitary sewer system, the post air stripper water (in the air stripper sump) will be treated to make it pH neutral (ph 5-11).
3. Approximately 24 hours after the application of the acid mix, the well will be redeveloped by mechanical surging and subsequent pumping. Additionally, it is recommended that this be augmented by high pressure water jetting.

4. The last technology will be periodic chlorination rounds to target the remaining iron bacteria present within the well and prevent additional bacterial growth.

These well redevelopment activities should improve the effectiveness of the onsite wells for incorporation into the future Site remediation system.

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August 9, 2010

LEGGETTE, BRASHEARS & GRAHAM, INC.