

## **Iron and Manganese in the Newport Water Supply**

The City of Newport has experienced random occurrences of brown colored water during the past several summers. Staff has researched to determine why the manganese started becoming a problem, why it is seasonal, and how to correct the problem. This information contains the findings to date.

### **What is Manganese?**

Iron and manganese are common metallic elements found in the earth's crust. Iron and manganese are dissolved in the water as it percolates through soil and rock. After they are dissolved, these minerals are said to be in solution. Iron and manganese are chemically similar and cause similar problems.

Iron and manganese that are in this state, are normally colorless and you cannot tell by the taste or appearance of the water if they are present. However, once they become exposed to air or certain chemicals, they oxidize and yield the brown or rusty colored sediment which stains fixtures and laundry.

Manganese can accumulate on the walls of pipelines and other plumbing fixtures. This sludge is easily disturbed as water flow increases which can cause it to discolor the water and transfer with the flow. If the water remains calm, the manganese will settle again.

### **What are the health effects of iron and manganese in the water?**

Iron and manganese can affect the flavor and color of food and water. They may react with tannins in coffee, tea, and some alcoholic beverages to produce a black sludge, which affects both taste and appearance. Manganese does not present a danger to human health, nor to the environment, but it is unpleasant in excessive concentrations or in certain forms. Nevertheless, both iron and manganese are essential in human development.

### **How can iron and manganese be removed from the water?**

Manganese can either be removed from the water, or it can be sequestered. Sequestering involves adding sodium hexametaphosphate. Metaphosphate does not prevent oxidation of iron and manganese, but stops agglomeration of the individual tiny particles of iron and manganese oxides. This allows the sequestered oxides to pass through the distribution system without creating discoloration or taste and odor problems. The manganese is still there, but it is not seen or noticed.

Iron and manganese can actually be removed from water by oxidation. The oxidized particles can then be collected during filtration and removed during backwash. Oxidation can be done by the addition of chemicals such as chlorine, ozone, sodium permanganate, or potassium permanganate. It can also be done by aeration, although it is not as effective.

### **Why has this been a recent problem?**

About the same time the discoloration problem began, the city changed its chlorination system from gaseous chlorine to a liquid chlorine solution (sodium hypochlorite). Newport staff suspected a connection, however after discussion with experts from engineering firms and professional association support staff, it was determined that the change in chlorine would not affect the manganese. It was suggested that the problem was due to a buildup of manganese on the walls of the pipelines. Each expert said that the first step would be to develop and implement a line flushing program – as explained later in this report.

It has since been determined that the problems with manganese are not solely being caused by not having a line flushing program – instead, the levels of manganese in the water leaving the water treatment plant are high during certain times of the year. To understand the cause, an understanding of the steps in the treatment process is helpful.

1. Pre-treatment. As water is pumped from the reservoir, the first step is to add lime to adjust the pH of the water and add aluminum sulfate to promote the formation of floc (floc is the agglomeration of very small suspended particles into larger heavier particles which can settle out).
2. Mixing/Flocculation – A paddle slowly mixes the water so that suspended particles come in contact with each other and form floc.
3. Sedimentation – The water moves slowly through the settling area so that the floc and other heavy particles settle to the bottom where they are removed.
4. Filtration – the water passes through layers of carbon and sand where particles that did not settle in Step 3, are collected on the surface. Filters are backwashed periodically to remove the captured material.
5. Post-treatment – Addition of disinfectant (chlorine) and fluoride.
6. Clear Well – The water is detained in a clear well to allow the disinfectant sufficient time to destroy any microorganisms.

When the Newport Water Treatment Plant was constructed in 1954, it had one flocculator/settling tank and two filter bays. Old records show that high levels of manganese and iron were a problem at some time in the late '60s or early '70s. At that time, a potassium permanganate feed system was installed. In that system, granular potassium permanganate was fed into the water stream just as it exited the sedimentation process (step 3), where it would cause the iron and manganese to precipitate into an insoluble form and be captured on the filters.

In 1976, the water treatment plant was expanded and an additional flocculator/settling basin and two filter bays were added. This doubled the treatment plant capacity for steps 1-5. However, it was not feasible to add on to the clear well. In order to achieve the necessary chlorine contact time, operators had to add chlorine as part of the pretreatment (step 1) and take advantage of the contact time during sedimentation and filtration. This added chlorination had an unexpected positive effect, in that chlorine oxidizes iron and manganese. These minerals were then captured in their insoluble form in the

sedimentation and filtration process. Apparently the potassium permanganate was no longer necessary and was discontinued.

When chlorine is used to disinfect water with organic contaminants, a number of secondary compounds are created which are called “disinfection byproducts.” These include various trihalomethanes and haloacetic acids. In the 1990s, a correlation was found between disinfection byproducts and certain types of cancer. In response, the Environmental Protection Agency modified the drinking water standards to limit these compounds. Because the raw water in the Big Creek Reservoir has high levels of organic material, pretreatment chlorine levels had to be reduced to limit the production of disinfection byproducts. It appears that the lowered levels of chlorine were not sufficient to oxidize all of the iron and manganese. Therefore these elements got past the filters. The post chlorination then promoted the oxidation of iron and manganese in the clearwell and distribution pipelines. This settled manganese and iron in the pipelines, breaks loose during higher flows and causes the discolored water.

### **Why are manganese problems limited to summer?**

There are two reasons for manganese problems being concentrated during the summer.

First, water usage is higher in the summer. Hourly demands fluctuate widely. During low flows, the manganese and iron settle in the pipelines. During high flows rates, it is scoured loose and sometimes appears in homes and businesses.

Second, shallow surface water impoundments, such as Newport’s raw water reservoirs, may have problems with manganese. A stagnant bottom water layer in a raw-water reservoir, dissolves precipitated iron and manganese from bottom muds. In the summer, the sun warms the bottom of the reservoir and causes the water to overturn. At that time the minerals are dispersed throughout the entire depth.

### **What is being done to clean up the water?**

The State of Oregon provides a circuit rider program to give technical assistance to water systems. A circuit rider was authorized to work with the city on the manganese problems. Much of the information in this report is a result of those efforts. Samples of raw water have been analyzed to determine the levels of manganese and iron. The circuit rider evaluated potential methods of removing or sequestering the manganese, and concluded that addition of either potassium permanganate or sodium permanganate in the pretreatment process was the most practical change at this point.

The city has installed permanganate injection equipment and has conducted tests to determine the dosage that is appropriate to add to the raw water. It should be noted that too much permanganate would turn the water purple.

### **Will the water then be clean again?**

Injection of permanganate began in August 2008. Initial tests show that the level of manganese leaving the plant has been reduced to near zero. There will still be remnants in the distribution system. A general line flushing program has been implemented in winter

months to try to remove most of the manganese in the lines. A more thorough “unidirectional” line flushing program will need to be implemented to remove the remaining deposits. This involves flowing the water through the pipes at a high rate of flow so that the pipe walls are scoured. On a 12-inch line this would require up to 1,760 gallons per minute for a period of 15 minutes to an hour. This method requires planning a detailed sequence of lines to be cleaned so that the water in the pipes is not disturbed until they are ready to be flushed. All of the valves and hydrants need to be in working order. To achieve the flow rates in the larger lines, at least two hydrants would need to be opened at the same time. One of the challenges in preparing a flushing plan is to find enough hydrants at the right locations. Another challenge is disposing of large quantities of water without causing local flooding. In areas that contribute to fish-bearing streams, the water must be dechlorinated. A computer model of the water distribution system will be used to determine where additional valves and hydrants are needed and to develop the unidirectional flushing program.

A flushing program requires a crew of at least three people to open and close various hydrants and valves and to monitor flows. To flush all of the lines in the city, it is estimated that it would take a crew of three, working full-time, six months to a year to complete. With existing staff, the whole process may take three or four years. Incidents of colored water will decrease during that time.

**What is being done until the flushing program is completed?**

As the department receives complaints, crews monitor the area and may attempt to drain enough water from the system to replace the affected water. However, sometimes it is best not to flush at an isolated location because it scours the lines, increasing the problem.

The Public Works Department carries a supply of a product called Red-B-Gone. If a customer has staining of laundry, they can pick up a bottle of this product to remove the stains.