CalgonCarbon

Roche Harbor

Surface water treatment using GAC reduced TOC levels to meet DBP regulations

Project Profile

The Roche Harbor Water Treatment Plant is located on the northwest side of San Juan Island in San Juan County, Washington state. Although a significant part of the land in the county is privately owned, the watersheds there provide a public benefit for both residents and visitors. San Juan Island's economy is tourist-driven; the island was voted #2 on the New York Times list of "41 Places to Go in 2011." Its marina has been a top boating destination for over fifty years. Incorporated in 1886, the community has seen slow but steady population growth in recent decades. Roche Harbor Water System Inc. has been in operation since 1968 when PVC piping replaced the island's existing wooden pipes.

Roche Harbor serves approximately 500 homes and one resort. The facility's capacity is rated at 0.5 millions of gallons per day (MGD), but is normally operated at 0.3 MGD. The Washington Department of Health regulates the area's drinking water. The plant draws its water from Briggs Lake, a small surface impoundment. High color and total organic carbon (TOC) were water filtration challenges associated with the lake water source. Suspended matter – comprised of a wide variety of organic particles, such as zooplankton, algal cells, threadlike organisms, and bacterial cells combined – leads to high TOC. Roche Harbor's filtered water had high levels of tastes and odors that generated numerous customer complaints.

Raw Water Quality and Filter Plant Performance

Roche Harbor source water is low in turbidity, high in total organic carbon (TOC), and high in color as shown in Table 1. Current filter plant performance removes approximately 56% of the TOC.

Table 1
Raw Water Quality and Filter TOC Performance

Parameter	Value
Color	~30 Units
Raw Water TOC Range	8 - 15 mg/L
Average Raw Water TOC	11.5 mg/L
Average Filtered Water TOC	5.0 mg/L
Average TOC Removal by Filtration	56%
Alkalinity	60 - 120 mg/L as $CaCO_3$
Turbidity	<1.0 NTU

Meeting Regulatory Requirements

In 1998, the U.S. Environmental Protection Agency (EPA) established two drinking water regulations with which the Roche Harbor Water System needed to comply: the Stage 1 Disinfectant and Disinfection Byproducts Rule (DBPR), designed to protect water consumers from disinfectant byproducts (DBPs), and the Interim Enhanced Surface Water Treatment Rule (IESWTR), which targets the reduction of microbial contamination. The EPA introduced the Stage 2 DBPR in 2006 to build upon earlier rules that addressed DBPs to improve drinking water quality and provide additional public health protection from DBPs.

Roche Harbor turned to Gray and Osborne consultant Russell Porter to help them identify a technology that would treat the high TOC levels in its water and bring them into compliance with DBPR. Roche Harbor's plant manager David Gibbs found that the plant's water exceeded the DBPR compliance levels for both trihalomethane (THM) and haleoacetic acid (HAA).

Historical DBP Monitoring

Roche Harbor uniformly failed to meet the 80 µg/L THM standard and often failed to meet the 60 µg/L HAA5 standard.

Table 2 Historical DBP Data, 2004-2009

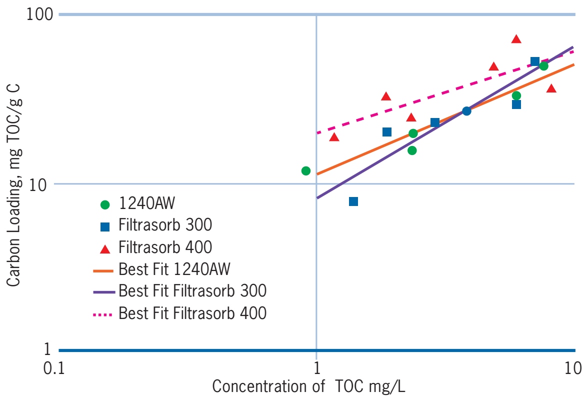
Parameter	THMs, µg/L	HAA5s,µg/L
Range of Quarterly Averages	68.5 – 156.7	35.7 – 109.0
Range of Running Annual Average	83.5 – 128.9	50.5 –80.9
Average Running Annual Average	103.6	64.1

Mr. Porter suggested the use of granular activated carbon (GAC) to remove the organic precursors from the water that, when combined with the chlorine used to disinfect the water, formed the regulated DBPs. Mr. Porter performed a bench scale GAC test in September 2007 and then installed a GAC column pilot test in December 2007 that was operated for slightly more than one year.

Bench - Scale Pilot Study

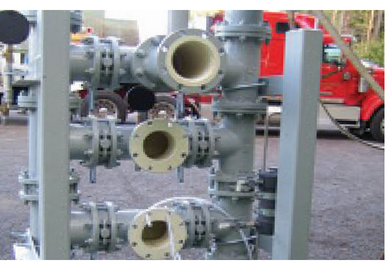
- 3 Carbons Tested
- GAC Pulverized in Coffee Mill
- Used only the Fraction Passing #200 Sieve
- Measured Weights Added to Filtered Plant Water (TOC = 9.2 mg/L) for Set Period
- Filtered With 0.45 Micron Filter
- Measured for UV254 and TOC
- Filtrasorb® 400 and 1240AW Selected for Further Study Based on Isotherm Data (Figure 1)

Figure 1: Bench-Scale Pilot Study Isotherm Results



GAC Column Pilot Study

- 2 Carbons Tested
  - Filtrasorb 400
  - 1240AW
- Designed to Approximate Full Scale Application
- Installed at Package Plant Filter Outlet
- Measured for UV254 and TOC
- Simulated Distribution System (SDS) Testing
  - THM
  - HAA5



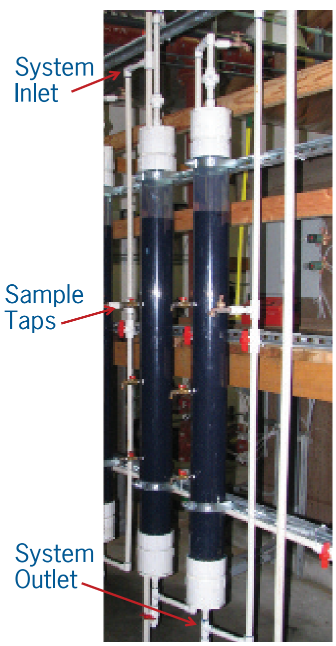


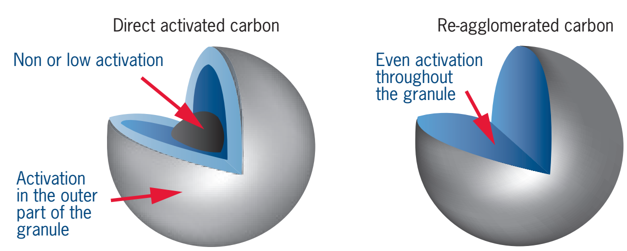
Table 3
Comparison of Pilot and Full-Scale Parameters

Parameter	Pilot Unit	Full Scale Unit (Calgon)
Columns per Carbon Type	2	2
Operation	Lead/Lag	Lead/Lag
Column Diameter	4 inches	8 feet
Column Height	5 feet	8 feet
Depth of Media	4 feet	6 feet
Column Material	Clear PVC	Steel
Flow Rate	0.5 gpm (30 gph)	200 gpm (normal operation) 350 gpm (plant max. flow)
Hydraulic Loading	5.7 gpm/f^2	4.0 gpm/f^2 (normal operation) 7.0 gpm/f^2 (plant max. flow)
Empty Bed Contact Time (2 Vessels)	10.4 minutes	12.8 minutes (normal operation) 22.6 minutes (plant max. flow)

After both of these test programs confirmed the effectiveness of activated carbon for this application, Mr. Porter made the recommendation to install a full-scale GAC system.

In order to aid in specifying the optimal carbon for this project, Mr. Porter designed the GAC column pilot test to compare activated carbon products from Calgon Carbon and another supplier. Mr. Porter made the decision to sole-source the Calgon Carbon GAC based on the results of this testing. The specifications for Calgon Carbon's Filtrasorb 400 and the competing product – an imported, direct activated coal-based GAC – were technically the same (i.e. both had the same mesh size, iodine number, abrasion number, etc.), Calgon Carbon's product was made from low ash, metallurgical-grade bituminous coal furnished from North American mines, and manufactured via a reagglomeration method that increases both the adsorptive capacity (as confirmed by the pilot study) and durability of the product as compared to the direct-activated imported GAC (an important consideration for custom reactivation.)

Comparison of Direct Activated and Reagglomerated GAC



Two 10,000 lb carbon adsorber vessels and Calgon Carbon Filtrasorb 400 GAC were then specified based on the pilot data. The vessels, known as “post-filter contactors”, were added to the existing treatment plant after the coagulation, clarification, and filtration steps, and just prior to the final chlorination step. Roche Harbor purchased 20,000 pounds of Filtrasorb 400 and a Model 8 dual vessel system from Calgon Carbon and installed them at their filter plant in June 2009.

Full Scale Implementation

The pilot program had shown that Calgon Carbon’s GAC lasted twice as long as the competition’s carbon, and the full-scale actual system performance even exceeded that predicted by the pilot work. The activated carbon system allowed the water plant to come into compliance with the DBP Stage 2 regulation.

The 13-month pilot data indicated that GAC would provide effective THM treatment for approximately one year. A life-cycle cost analysis indicated that a one-year GAC life was cost effective (<$1/1,000 gallons for GAC replacement). Full scale installation occurred in June 2009.

Figure 2 compares the normalized UV absorbance data with THM and HAA5 data for the first 14 months of full-scale GAC treatment. As the data indicate, UV absorbance provided a good qualitative indicator of THM and HAA5 levels with the exception of the final THM value in August 2010. THM values were higher than predicted by pilot SDS testing.

Figure 3 compares the normalized UV absorbance data for both the pilot and full-scale installations as a function of treated water per volume of carbon. The data indicate that the pilot study was a good predictor of full-scale performance for removal of UV absorbing material.

Figure 2: Comparison of Full-Scale UV Absorbance Data and Compliance DBP Averages

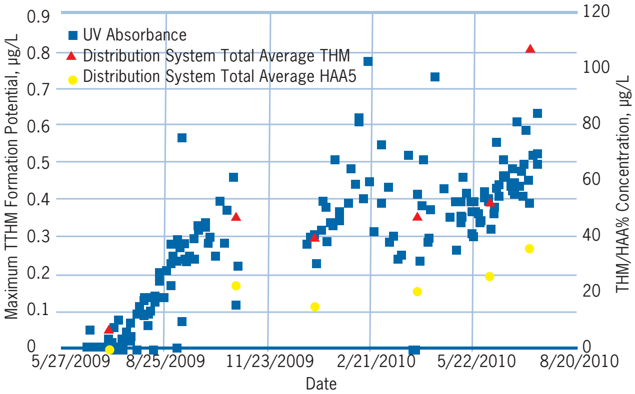
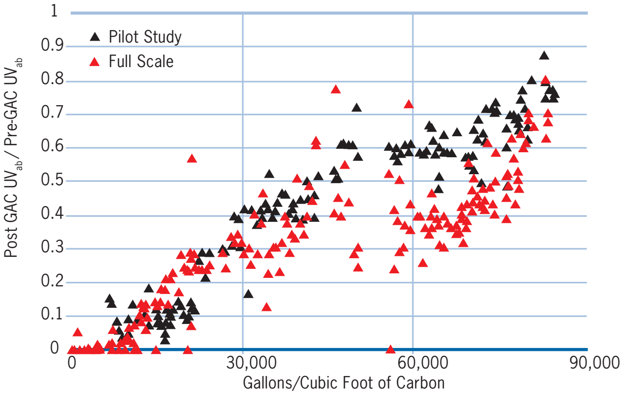


Figure 3: Comparison of UV Absorbance Data For Pilot and Full-Scale Installations



Model 8

The Calgon Carbon Model 8 is an adsorption system designed for the removal of dissolved organic compounds from water or other liquids using granular activated carbon. The modular design concept allows for selection of options or alternate materials to best meet the requirements of the site and treatment application.

The Model 8 system is delivered as two adsorbers: a separate compact center piping network and interconnecting piping requiring minimal space and field assembly. The pre-engineered Model 8 design ensures that adsorption system functions can be performed with the system as provided. The design has the benefit of Calgon Carbon’s extensive expertise and has been proven in numerous applications. The engineering package can be provided quickly and the system expedited through Calgon Carbon’s production capabilities.

The process piping network for the Model 8 offers operation of the two adsorbers in parallel or two-stage series flow, with either adsorber in the lead position. The piping can also isolate either adsorber for carbon exchange or backwash operations, while maintaining flow through the other adsorber. In addition, the Calgon Carbon underdrain design provides for efficient use of the carbon through uniform collection of water at the bottom of the bed, and even distribution of backwash water to minimize carbon bed disturbance.

The Model 8 system is designed for use with Calgon Carbon’s closed loop carbon exchange service. Using specially designed carbon transport trailers, the spent carbon can be removed from the adsorber via a pressurized carbon-water slurry, and fresh carbon refilled in the same manner. This closed loop transfer is accomplished without exposure of personnel to either spent or fresh carbon. The spent carbon is then returned to a Calgon Carbon facility for custom reactivation. The reactivated carbon is returned to the customer using the same carbon transport trailers.

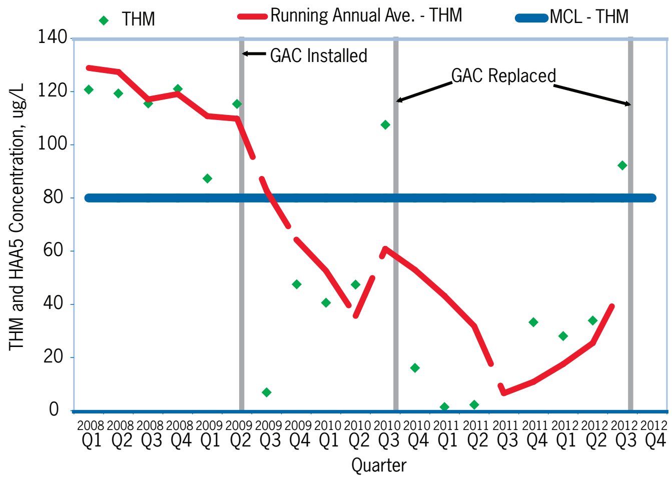
In addition to achieving compliance with the USEPA DBP rule, the number of taste and odor complaints that Roche Harbor received decreased substantially after installation. Another benefit resulting from the installation of the GAC system was the reduction in chlorine demand for disinfection. When free chlorine reacts with natural organic matter (NOM), it forms THMs, HAAs and other DBPs. Chlorine that has reacted with NOM in this way is no longer present to disinfect. By reducing the amount of NOM present in the untreated water before it was chlorinated – through the introduction of both enhanced coagulation and GAC filtration – there was less NOM present to react with the chlorine. That outcome enabled the plant to use less chlorine for disinfection while maintaining an effective dose for its distribution residual.

Optimizing GAC Operations

During the first year of usage, Mr. Gibbs discovered ways to optimize the operation of the GAC and the plant's coagulation dosing system in order to extend the carbon life. The GAC originally installed with the Model 8 units lasted approximately 15 months (from June 2009 to September 2010) before the carbon was spent and required replacement. Because of the lessons learned during the first year of operation, Roche Harbor was able to make the second installment of carbon last two years before it required replacement in September 2012. This improvement was due to increased operator attention to post-filter, pre-GAC conditions like minimizing organic carryover as measured by UV254 absorbance. The first batch of carbon filtered 46,952,562 gallons and the second batch filtered 60,493,248 gallons. Roche Harbor's increased run-time was also attributed to more effective coagulation monitoring and dosing, as indicated by the UV 254 (see Figure 4).

Mr. Gibbs commented, "Carbon has worked extremely well for Roche Harbor water systems. The taste of our water has greatly improved. People like to drink their coffee now." He noted that changeover can be completed in one day and that Calgon Carbon's extremely knowledgeable field service employees put the client's needs first. Nearby Friday Harbor followed suit after Roche Harbor, installing Calgon Carbon's system. Mr. Gibbs added that municipalities would be "crazy not to use Calgon Carbon".

Figure 4: Quarterly Results



The Future

The next step for Roche Harbor is to have their GAC custom reactivated once it becomes spent. Custom reactivated GAC offers many of the same advantages for water treatment applications as new GAC, including the ability to perform multiple processes simultaneously, such as the enhancement of taste, the elimination of odor and the removal of disinfection byproducts. Custom reactivated GAC achieves these aims at a significant cost savings, while producing only a fraction of the greenhouse gas emissions associated with the manufacture of new GAC. Custom reactivation transforms GAC into a sustainable technology, conserving both energy and raw materials.

For more about the advantages of reactivated carbon, or to learn more about Calgon Carbon's complete collection of air and water filtration technologies, visit www.calgoncarbon.com or call 1-800-422-7266.

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