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NEW YORK WATER SERVICE (AQUA)
NASSAU COUNTY, NEW YORK

ENGINEERING REPORT

WELLHEAD TREATMENT FOR
TRICHLOROETHENE CONTAMINATION
AT
SEAMANS NECK ROAD PLANT

DRAFT

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H2MGROUP

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1.0 SCOPE, PURPOSE AND INTRODUCTION

1.1 SCOPE AND PURPOSE

This engineering report was initiated at the request of New York Water Service to determine the most viable method for removing trichloroethene (TCE) contamination found in the raw water supply of Wells Nos. 3 (SN 3) and 4 (SN 4) at the Seamans Neck Road plant. This report was authorized due to presence of TCE contamination in the raw water of the above mentioned wells, and the inability of the Water Service to eliminate this facility from their production capacity.

1.2 INTRODUCTION

The United States Navy published a Record of Decision (ROD) in January 2003, in consultation with the New York State Department of Environmental Conservation and the New York State Department of Health, in regards to the Naval Weapons Industrial Reserve Plant located in Bethpage, New York. The ROD discussed the United States Navy's findings of a large VOC contaminated groundwater plume, the area affected by the plume, and the plume's potential to affect an even greater area in the near future. Based on the data provided in the ROD, an extensive VOC contamination plume has been found in the Glacial and Magothy formations positioned beneath the Northrop Grumman Corporation property and downgradient (geographically southward).

Based on the findings made in previous studies and upgradient monitoring wells indicating VOCs above the New York State MCL of 5 ug/l, New York Water Service (NYWS) faces the possible risk of “restricted use” or closing the well(s) located at the Seamans Neck Road Plant. To satisfy existing and future average day, peak day and fire flow demands, this supply facility must be available for operation. The loss of any of this site’s wells would adversely impact NYWS’s ability to meet peak and emergency pumping requirements. This engineering study was prepared to establish the feasibility of treatment for TCE removal at this location. Our technical analysis, conclusions and recommendations are discussed herein.

2.0 GENERAL BACKGROUND AND EXISTING FACILITIES

2.1 GENERAL

New York Water Service presently supplies potable water to an estimated population of 173,000 through approximately 44,380 metered service connections. Geographically, the water supply service area covers approximately 26 square miles within the southeastern portion of Nassau County in the Towns of Hempstead and Oyster Bay.

Adjacent water purveyors to NYWS include the Town of Hempstead, and East Meadow Water District to the north, the Long Island Water Corporation, and Freeport Village to the west, South Farmingdale and Massapequa Water District to the east and the Suffolk County Water Authority to the far east. The location of the NYWS service area is shown on Figure 2-1.

2.2 SYSTEM AND SOURCE OF WATER SUPPLY

NYWS currently obtains its entire potable water supply from the Magothy formation and Upper Glacial Aquifer through eighteen (18) wells at eight (8) individual plant sites throughout its service area. All eighteen (18) supply facilities provide a combined available capacity of 52.13 million gallons per day (MGD). A summary of each supply well location, authorized capacity and other pertinent information is presented on Table 2-1.

Raw water treatment methods employed by NYWS include pH adjustment and disinfection for all active wells. Sodium Hydroxide is currently being used for pH adjustment. Sodium hypochlorite is used for disinfection. A long chained polyphosphate product (Calciquest) is currently being used at all well sites for iron sequestering purposes and/or to maintain corrosion control in the un-lined portion of their distribution system. Iron removal systems are in place to remove naturally occurring iron from the raw water at the Seamans Neck Road, Jerusalem Avenue and Newbridge Road Plants.

2.3 DISTRIBUTION SYSTEM

Potable water is presently transmitted through approximately 430 miles of mains within NYWS's service area. Transmission and distribution piping range in size from 4 to 18 inches in diameter. Approximately 80 percent of the water mains maintained by the NYWS are cast iron piping. In addition to the 430 miles of piping, NYWS also maintains approximately 3,207 hydrants within the distribution system.

2.4 STORAGE FACILITIES

NYWS currently maintains five (5) storage tanks with a total volume of 5.75 million gallons (MG) at the five (5) plants. Four of the five tanks are ground storage tanks. They are used to satisfy peak and fire flow demand conditions but must be pumped to system. The elevated storage tank at Jefferson Street has an overflow elevation of 180 feet above mean sea level. The elevated storage tank is used primarily to maintain static pressures throughout the service area and optimize supply well pumping rates. The elevated tank is also used to satisfy peak and fire flow demand conditions. A summary of all existing storage facilities is provided on Table 2-2.

2.5 INTERCONNECTIONS

NYWS maintains ten (10) emergency interconnections with adjacent water purveyors. All of the interconnections are for emergency use. The interconnection locations, sizes and maximum flow rates through the interconnections are listed on Table 2-3.

3.0 PROJECT LOCATION AND EXISTING FACILITIES

3.1 BACKGROUND

Well Nos. SN 2, SN 3 and SN 4 are located just west of Seamans Neck Road, north of Hunt Road. These wells are located in the eastern portion of the NYWS service area near its eastern boundary. Well No. SN 2 is a shallow well with a history of nitrates, so this well has been held in reserve and not routinely operated by NYWS. As such, the well will not be included as a production source for this site.

Supply Well No. SN 3 (N-8480) was constructed in 1969 and SN 4 was constructed in 1978, and both are screened in the Magothy formation. Well No. SN 3 was drilled to a terminal depth of 655 feet below grade, while Well No. SN 4 was terminated at a depth of 649 feet. Each supply well has an authorized capacity of 2100 gpm (3.024 MGD), yielding a total facility design capacity of 6.05 MGD for these 2 wells.

Water treatment at the plant includes iron removal, pH adjustment, disinfection and corrosion inhibitor. Sodium Hydroxide is used for pH adjustment, sodium hypochlorite is used for disinfection, while a long chained linear phosphate compound (Calciquest) is used for corrosion inhibitor purposes. All treatment chemicals are injected in liquid form prior to the potable water entering the distribution system.

3.2 WELL PUMPAGE

Two of the eighteen active wells within the NYWS service area are located at the Seamans Neck Plant. As shown on Table 3-1, Well Nos. SN 3 and SN 4 have pumped a combined average of 3.06 million gallons per day (MGD) between 2001 and 2006. These wells have a total capacity of 6.05 MGD, so they have been operating at 50 percent of capacity during

this period. These two wells have averaged a combined production of 1,118 million gallons per year for the five year period from 2001 through 2006.

Due to the high concentration of iron in these wells and the limited success of the linear long chain phosphate compound to sequester the iron concentrations at levels above 1.0 mg/L, an iron removal treatment system was constructed and put into service in 2002.

4.0 GROUNDWATER QUALITY

4.1 OVERVIEW

Historically, the general water quality found on Long Island has been exceptionally good. Through the 1970s and to the present, water quality has significantly deteriorated in a number of areas throughout Nassau and Suffolk Counties. This is primarily due to large increases in industrial chemical usage, lack of sewers in densely populated areas, the continued application of fertilizer, and the continued application of increasing amounts of pesticides and herbicides.

Within the past 20 years, there has been a dramatic increase in the ability to test for even more minute concentrations of pollutants. During the 1940s through the 1970s, water quality issues on Long Island were related to parameters such as pH, hardness, iron, dissolved solids, chlorides, nitrate nitrogen, and bacteria. With the advent of new and improved technology, the detection of organic compounds has been incorporated into today's drinking water standards.

The June 1987 implementation of the 1986 Safe Drinking Water Act Amendments has brought water quality standards concerning organic compounds to a new level for water management planning. The NYSDOH has established maximum contaminant levels (MCLs) for organic compounds as follows:

CONTAMINANT	MCL
Principal Organic Compounds	< 5 µg/ℓ
Unspecified Organic Compounds	50 µg/ℓ

As summarized on Table 4-1, the United States Environmental Protection Agency (USEPA) regulations under the 1986 Amendments resulted in the lowering of MCLs for eight volatile organic compounds. The NYSDOH has established more rigorous requirements with MCLs of 5 µg/ℓ for 45 other compounds also depicted on Table 4-1. The MCLs became

enforceable by the NYSDOH as of January 9, 1989. If a supply well is used which does not meet these standards, the water supplier must notify the public of this fact. The NYSDOH requires that quarterly monitoring must be maintained when prior sampling has shown the presence of volatile organics or the source is considered potentially at risk.

In addition to the compounds listed in Table 4-1, regulations related to synthetic organic chemicals (SOCs) were published by the USEPA in January of 1991. These regulations include maximum contaminant levels (MCLs) for a total of 40 SOCs. A listing of the SOCs required by the New York State Department of Health to be analyzed for all groundwater sources and the corresponding MCLs is shown on Table 4-2.

In addition to the water quality standards previously described, NYWS must test for and comply with primary and secondary standards for inorganic chemicals as established during March 1992 in Part 5 of the New York State Sanitary Code. These standards are summarized on Table 4-3. The standards for secondary contaminants were established to address aesthetic water quality concerns such as taste, odor, and discolored and rusty water. The secondary contaminants listed on Table 4-3 do not pose as a health risk to humans. The primary contaminants are based on public health concerns.

The more stringent VOC MCLs have significantly impacted the typical water suppliers' planning procedures. In the past, a supplier usually had sufficient time to implement the construction of a treatment system between the time a contaminant was first detected until it exceeded the acceptable maximum level. In the past MCLs for volatile organic contaminants were set at 50 µg/L for any one VOC and 100 µg/L for the sum of all VOCs present. Under the current MCLs, a supplier will have little or no time to provide treatment after a contaminant is detected. Therefore, with the current MCLs, all suppliers must plan for treatment once trace levels of a compound are detected to protect against the possibility that a well or wells may have to be taken out of service due to VOC contamination.

Deteriorating water quality as a result of VOC contamination is a trend that has impacted many Long Island water suppliers. The potential for the future loss of supply wells due to increasing organic compounds is a realistic threat. At which time or location contamination will occur is uncertain without performing extensive hydrogeologic investigations. These investigations are rather costly and would involve the drilling of several monitoring wells at strategic locations. This type of investigation can be used to precisely map the extent of VOC contamination and identify the source of contamination. Generally, sources of VOC contamination will occur hydraulically downgradient from industrial and/or commercially developed areas. Fortunately for NYWS, extensive monitoring wells and hydrogeologic data is available to assist in mapping and identifying the extent and source of VOC contamination. Analysis and further discussion of this data and update of critical statistics are provided in subsections 4.2 and 4.3 of this report.

4.2 SERVICE AREA WATER QUALITY

Dissolved iron is a naturally occurring element found in the aquifers of the South Shore of Long Island. Consequently, the water pumped from the underlying aquifers in many locations, including the NYWS service area, contain iron. The New York State drinking water standard for iron (0.3 mg/L) is a secondary standard based on the aesthetic quality or appearance of the water. Since iron concentrations above 0.3 mg/L may generate rusty water, but are not a health concern, the Nassau County Health Department does allow the addition of sequestering agents. For NYWS, elevated levels of iron in supply wells has been the primary water quality issue of concern. NYWS has been diligent in actively addressing elevated iron levels by installing iron filtration systems at sites with the highest concentrations.

Beyond the iron levels, the untreated water from supply wells located within NYWS can be generally characterized as:

- Very corrosive with a low pH generally in the range of 4.4 to 5.9. The water can be expected to be aggressive and will generally cause undesirable amounts of

corrosion to ferrous iron and copper piping, resulting in red and green water complaints if not properly treated.

- Low in carbonate and non-carbonate hardness, ranging from 17 to 51 mg/ℓ. This characterizes the water as moderately soft, making it excellent for laundering and most similar purposes, but also more corrosive or active toward piping and plumbing.
- Low to moderate in total dissolved solids, generally between 4 and 110 mg/ℓ.
- Low levels of chloride, ranging between 2 and 15 mg/ℓ. These levels are typical for the Magothy aquifer.
- Contains very low level concentrations of dissolved manganese below 0.05 mg/ℓ. The aesthetic secondary standard for this parameter is established at 0.3 mg/ℓ. The oxidation of high levels of manganese can result in “black” water consumer complaints.

4.3 SITE SPECIFIC WATER QUALITY

As previously indicated, Well Nos. SN-3 and SN-4 have yielded detectable concentrations of TCE that were first detected in 2006. This compound has been utilized in many industrial and commercial applications. TCE is used in metal degreasing, dry cleaning operations, refrigerants and fumigants and was once an ingredient in household cleaning products.

The Seamans Neck site is situated approximately 2.4 miles south of the Northrop Grumman property. Since groundwater flow in this area of Nassau County is to the south and southeast, the Seamans Neck Road site is downgradient from the Northrop Grumman property. The water quality recorded in upgradient Vertical Profile Borings (VPB), monitoring wells, and



supply wells indicates that a plume emanating from the Northrop Grumman property is moving in a southerly direction toward the Seamans Neck Plant.

Over the past ten to fifteen years, H2M has prepared several wellhead treatment reports for neighboring Water Districts to address the contamination from the Northrop Grumman site. These reports were written specifically to document the existence of extensive VOC contamination of the groundwater in areas surrounding the Northrop Grumman property. Along with these previous reports, many reports have been generated by Arcadis, Geraghty & Miller (Arcadis), a consultant working for Northrop Grumman and the United States Navy, to address the off-site VOC contamination in the groundwater. H2M has been actively reviewing the reports prepared by Arcadis on behalf of the affected public water suppliers impacted by the groundwater plume, and as such, has become intimately familiar with the characteristics of the off-site contamination based on available data.

Extensive VOC contamination is present both in the Glacial and the shallow and deep regions of the Magothy formations upgradient of the Seamans Neck Plant. The most prevalent compounds found in the monitoring wells, supply wells, and VPBs located upgradient of the Seamans Neck Plant included TCE, Tetrachloroethene (PCE), 1,1,1-Trichloroethane (1,1,1-TCA), 1,1-Dichloroethene (1,1-DCE), 1,1-Dichloroethane (1,1-DCA), cis-1,2-Dichloroethene (CIS-1,2-DCE) and Chloroform. TCE was the most prevalent compound found in the wells and VPBs located upgradient of the Seamans Neck Plant. The historical sampling data indicates a large VOC plume traveling downgradient from the Northrop Grumman property toward the Seamans Neck Plant. The Arcadis report dated April 28, 2003 and titled "*Comprehensive Model Report for the U.S. Naval Weapons Industrial Reserve Plant, Northrop Grumman*", had projected that the South Farmingdale Water District's Plant No. 3 will be impacted by this VOC plume in less than four years, or by 2007. This VOC plume is also expected to impact South Farmingdale's Plant No. 1 in the near future. Based on the US Navy's report, this VOC plume was not expected to impact the water supply wells further west. The Seamans Neck Road Plant is located approximately 1.7 miles to the southwest of South Farmingdale's Plant No. 1 and approximately ½ mile to the southwest of South Farmingdale's Plant No. 3.

The US Navy installed VPBs to gather groundwater quality and lithologic data in areas hydraulically downgradient from the Northrop Grumman property. The data was to be used in the groundwater computer model prepared by Arcadis to aid in the placement of outpost monitoring wells. The VPBs were constructed in accordance with the Public Water Supply Protection Program, which was set forth by the New York State Department of Environmental Conservation (NYSDEC) in their Groundwater Record of Decision (ROD) for the Naval Weapons Industrial Reserve Plant (NWIRP). The NWIRP site is located on the Northrop Grumman property.

In 2001, sampling conducted during the development of VPB-44 yielded maximum VOC levels exceeding the 5 µg/L MCL, including 30 µg/L of TCE, 9 µg/L of 1,1-DCA, 7 µg/L of 1,1-DCE, and 6 µg/L of 1,1,1-TCA. This boring is approximately 0.7 miles northeast of the Seamans Neck Road Plant, and 1.5 miles south of the Northrop Grumman property. The samples taken at VPB-44 also yielded trace amounts of Chloroform and PCE.

A second boring, VPB-76, is also located upgradient of Seamans Neck Road in the path of the VOC plume. VPB-76 is approximately 1.0 miles north of Seamans Neck Road and 1.0 miles south of the Northrop Grumman property. Sampling conducted in 2000 during this boring yielded a maximum TCE level of 200 µg/L. Results for both 1,1-DCE and PCE exceeded their MCL, with levels of 9 µg/L and 5 µg/L respectively. Furthermore, trace amounts of 1,1,1-TCA, 1,1-DCA, and Chloroform were discovered during the boring.

A third boring, VPB-50, is located approximately ¼ mile north of the Seamans Neck Road plant. In 2001, this VPB detected TCE at 1 µg/l. DCA, DCE and TCA were also detected. The detections were made in one of the shallower regions of the VPB.

The western and southern boundaries of the plume are not well defined. With inadequate plume delineation to the west, the potential maximum TCE impacts at the Seamans Neck Road Plant is very difficult to assess. Therefore, we have approached the assessment of available

groundwater data from a conservative perspective such that actual contaminants to impact the supply wells will be less than the design influent contamination concentrations for the life of the treatment system.

Bethpage Water District's Plant No. 6, which is approximately 1.6 miles north of the Seamans Neck Road Plant site, has been adversely impacted by VOC contaminated groundwater emanating from the Northrop Grumman property for the past 20 years. The wells at this site each have a terminal depth of approximately 384 feet for Well No. 6-1 and 670 feet for Well No. 6-2. Samples collected from Well No. 6-1 between 2000 and 2007 had a range of TCE levels from 170 µg/L to 250 µg/L. Over the same period, TCE at Well No. 6-2 has ranged from non detect to 432 µg/L. Most alarmingly, Well No. 6-2 is at the deepest portion of the Magothy aquifer and the TCE concentration has drastically increased from a maximum of 42 µg/L in 2005 to 432 µg/L in 2007. This means that a very significant portion of the plume continues to persist into the deeper portions of the aquifer. With such little known information about the plume in this area due to the lack of monitoring wells, a conservative approach must be taken in assessing the potential impacts to the NYWS wells. Bethpage's Plant No. 6 is the only public supply well facility to be considered upgradient of the NYWS Seamans Neck Road site.

Northrop Grumman monitoring well GM-35D2 is located 1.9 miles north of the Seamans Neck Road Plant. TCE levels sampled from this monitoring well have been on an upward trend since 2000, ranging from 190 µg/L in 2000 to 419 µg/L in early 2003. In September 2006 the TCE level was observed at 310 µg/L. GM-35D2 has had several other VOC levels in excess of the MCL on several occurrences. In 2000, the maximum sampled level of 1,1-DCE was 6.7 µg/L. This same VOC during the September 2006 sampling, had a recorded level of 3.0 µg/L. PCE levels were first exceeded MCL during the 3rd Quarter 2002 sampling, with a recorded level of 6.8 µg/L, and the level was 9.0 µg/L during the sampling in September 2006. Freon-113 has also exceeded the MCL in September 2006 with a level of 7.0 µg/L. Additionally, GM-35D2 has had trace amounts of 1,1,1-TCE, 1,1-DCA, CIS-1,2-DCE and Chloroform in various samples taken since 2000.

Northrop Grumman monitoring wells GM-34D2 and GM-34D are located 1.5 miles north-northwest of the Seamans Neck Road Plant and 0.5 miles southwest of the Northrop Grumman property. This is the only representative monitoring well which is considered upgradient of the Seamans Neck Road supply wells. GM-34D2 and GM-34D have had VOC levels in excess of the MCL on several occurrences. In September 2006, the maximum sampled level of 1,1-DCE was 11.0 µg/L in GM-34D and 8.0 µg/L in GM-34D2. Also in November 2006, TCE levels were recorded at an all time high of 1,100 µg/L in GM-34D.

The TCE contamination at this location has increased significantly in the past two years. Over the last quarter, the TCE concentration has increased from 880 µg/L to 1,100 µg/L. Based on the increasing levels at this location and the lack of sufficient monitoring well data in the area, we do not know how high the TCE concentration is going to become and how extensive this mass of contamination exists. As such, any determination of an expected maximum influent level at NYWS Seamans Neck Road site must be as conservative as possible.

As such, we recommend that the design influent TCE concentration for the treatment system be similar to the current design influent for the Bethpage Water District's Plant No. 6 at 600 µg/L.

5.0 WELL HEAD TREATMENT

5.1 TREATMENT ALTERNATIVES

The suitability of a groundwater treatment system for a particular site is based on two (2) distinct criteria: (1) the type and concentrations of contaminants in the raw water; and (2) the type and concentrations of contaminants that can safely be allowed in the treated water (drinking water standards or no detection of contaminants). Selection among the technically feasible treatment systems will be based upon the results of an analysis of each system. Two (2) different treatment processes will be evaluated for the project site. The two (2) types of treatment which are most commonly employed for removal of organic contaminants from groundwater are air stripping and granular activated carbon (GAC) filtration. Resin adsorption systems will not be economically competitive for the contaminants under consideration and will not be considered.

5.2 VOC TREATMENT CAPACITY

In order to accurately size any treatment system, the range of expected influent flows and contaminant concentrations must be known. In this case, the water to be treated will originate from two (2) wells with a total capacity of 4,200 GPM.

One can anticipate the concentrations of the influents at Well SN3 and SN4 to approach the recorded VOC levels sampled from GM-34D, which was most recently 1,100 µg/L. With such limited information available, we recommend that the design influent for this site be similar to the design of the Bethpage Plant No. 6 treatment system of 600 µg/L.

The clay layers identified in the logs of Well Nos. SN3 and SN4 could minimize the migration of highly concentrated plumes to the deeper sections of the Magothy aquifer. However, these clay layers are likely not continuous between the plant site and the upgradient source areas. It is anticipated that contaminants will migrate to the screened area of the well, but can undergo dilution in the process. With such limited information, however, any effects of

dilution can not be considered. Therefore, the design influent must be conservative and is justified based on several considerations:

1. The incremental operating and capital costs for an air stripping facility between the 600 $\mu\text{g/L}$ TCE level and any defensible lower level will be extremely small. In comparison, the operating costs of a GAC filtration system increase tremendously with increasing influent levels, particularly for those contaminants that do not adsorb very easily.
2. The higher capacity treatment system will result in non-detectable effluent concentrations for most volatile organic compounds in the foreseeable future.
3. The higher influent design limit will avoid the necessity of extensive additional monitoring should observed contaminant levels increase. If levels begin to approach the design limits, then adequate time should remain to upgrade the air stripping system in an orderly manner. Preventing breakthrough of a GAC filter under such circumstances cannot be reliably accomplished.

The selection of the design effluent level should be based on meeting drinking water standards of 5 $\mu\text{g/L}$ as set by the State of New York. As a practical matter, the treatment system should be sized for a design effluent of 1 $\mu\text{g/L}$ or less in accordance with the recommendations of the Nassau County Department of Health and the policy of NYWS relative to “no detectable” VOC contamination in the treated water supply.

5.3 AIR STRIPPING TOWER

“Air stripping” as a water treatment process is implemented by pumping untreated water to the top of a tower which contains a particular height of inert “packing” material along with water distribution and collection systems. The tower has ambient air blowing up from the

bottom of the tower as the water flows downward, hence the more proper name of “counter current packed tower”.

Counter current packed towers have been utilized in the water treatment industry for decades as a standard unit operation to affect mass transfer, both in adsorption and desorption (stripping). For that reason, the physical chemistry and mass kinetics are well understood and documented. Essentially, the packed tower is a chemical engineering process unit which promotes intimate contact between a gas phase and a liquid phase so as to enhance the establishment of equilibrium between the phases. In adsorption, mass transfer occurs from the gas phase to the liquid phase, while in desorption (stripping), mass transfer is a function of the divergence from equilibrium. Once equilibrium is reached, mass transfer will no longer occur.

In the case of air stripping to remove volatiles, the solutes are the individual organics contained in water (liquid phase), which are desired to transfer to air (gas phase). The organic constituents in water must be at concentrations which exceed the equilibrium concentration in order to be removed.

Henry’s law has been seen to work well at low concentrations and provides for a linear relationship between partial pressure and concentration. For any given compound in water, a higher Henry’s Constant will mean that the compound would be more easily removed from water by stripping.

From the foregoing discussion, the organic constituents in water that should be removed must be at concentrations that exceed the equilibrium concentration. In order to understand the vapor-liquid equilibrium, some basic principles of physical chemistry must be outlined. The relationships can most clearly be presented starting with a principle of physical chemistry that is always valid, whether or not the gas behaves as an ideal gas. This relationship can be defined by the following equation:

- $$\bar{\rho}_A = \gamma_A \rho$$

Where, \bar{p}_A is the partial pressure of component A in the gas phase
 $\bar{\gamma}_A$ is the mole fraction of component A in the gas phase
 p is the total pressure

In order to determine the partial pressure of a constituent in a solution, Raoult's law can be utilized, as follows:

$$2. \quad \bar{p}_A = \bar{\gamma}_A P_a$$

Where, $\bar{\gamma}_A$ is the mole fraction of component A in the liquid phase
 P_a is the vapor pressure of component A at the appropriate temperature.

Raoult's law, however, only applies when both the liquid and gas behave as ideal solutions and gases, respectively. Experiment and experience has revealed that Raoult's law has shown applicability only when working with high concentrations. Fortunately, a more general form of Raoult's law is available and is known as Henry's law:

$$3. \quad \bar{p}_A = \bar{\chi}_A H_A$$

Where, H_A is a constant (Henry's Constant) and is found experimentally for each particular contaminant. Henry's Constant can vary significantly with temperature.

Henry's law has been seen to work well at low concentrations and provides for a linear relationship between partial pressure and concentration. By combining equations (1) and (3), an equilibrium relationship is developed for a component A in the vapor and liquid phases:

$$4. \quad \tilde{\gamma}_A = \bar{x}_A H_A / \rho$$

From the above equation, it can be seen that the greater the magnitude of the Henry's Constant, the higher $\tilde{\gamma}_A$ becomes and, therefore, the equilibrium mole fraction of a component A increases in the gas phase. For any given compound in water, a higher Henry's Constant will mean that the compound would be more easily removed from water by stripping.

In the case of the specific problem at hand, namely moderate to high concentrations of volatile halogenated organics in water which are to be removed, the situation is certainly one in which Henry's law has been proven to be applicable. For design purposes, a water temperature of 10 degrees C is assumed. There is little or no effect of air temperature on the performance of air stripping towers. Values of Henry's Constant (atm-m³-water/m³-air) are available for selected compounds in the literature.

Compound	Henry's Constant (10°C)
Trichloroethene (TCE)	0.2315
1,1,1-TCA	0.1500
1,1-DCA	0.1584
<i>cis</i> -1,2-DCE	0.093

The liquid phase resistance is the limiting factor in the transfer of the volatile organics from the liquid (water) to the gas (air). In general, the higher the value of the Henry's Constant for a particular contaminant, the easier it will be to remove by air stripping.

The removal efficiency of a particular size air stripping tower for a given contaminant is dependent upon the overall transfer coefficient, usually denoted as $K_L * a$, where K_L is the overall liquid film coefficient, and a is the specific surface of the packing media, expressed as

wetted surface area per tower volume. The overall transfer coefficient can be determined empirically through the results of a pilot study.

Performance of a pilot study in this case is not necessary as the behavior of the proposed hollow spherical shaped packing material for these contaminants has been well proven during pilot studies performed by H2M and the manufacturer of the packing. For purposes of design, use of published values of Henry's Constant together with a conservative overall transfer coefficient value have proven successful. Transfer coefficients utilized in the design are based on an air to water ratio of 60:1 are as follows:

Compound	$K_L * a \text{ (hour)}^{-1}$
Trichloroethene (TCE)	46.9
1,1,1-TCA	45
1,1-DCA	45
<i>cis</i> -1,2-DCE	34.9

The use of a packing media such as Tripacks, suitable for use with low air to water ratios is recommended in an installation such as the one being discussed. For purposes of design, air to water ratios of 30:1 to 60:1 are typical with Tripacks, while high throughput media will usually operate at air to water ratios of 75:1 and higher. The maximum air to water ratio as allowed under the Recommended Standards for Water Works is 80:1.

The design of an appropriate air stripping tower is based upon selection of reasonable overall transfer coefficients, liquid loading rates and packing height matched to the design conditions. Conventional practice in sizing the packing height for a tower of known cross section is based upon determining the height of a transfer unit (HTU) and then the number of transfer units (NTU) required to achieve the desired removal.

The derivation of the mass balance equation can be found in the literature. The formulation results in the following equation for determining the packing height of the tower:

$$Z = \frac{Q}{(1-A)(K_L a)} \times \ln\left(A + \left[(1-A) \frac{C_i}{C_e}\right]\right) = (\text{HTU}) \times (\text{NTU})$$

Where,

- Q = Tower loading rate (ft/hr)
- A = Absorption factor (dimensionless) = $[(H)(R)]^{-1}$
- H = Henry's Constant (dimensionless)
- R = Air to Water Ratio (dimensionless)
- $K_L a$ = Overall transfer coefficient (hour)⁻¹
- $NTU = \frac{1}{1-A} \times \ln\left(A + \left[(1-A) \frac{C_i}{C_e}\right]\right)$
- $HTU = Q/K_L a$ (ft)
- Z = packing height of the tower
- C_i = Influent concentration of the contaminant compound
- C_e = Effluent concentration of the contaminant compound

The tower loading rate (Q) is based upon the well flow (L) in GPM, the diameter of the tower in feet, the area of the tower (D) in square feet and is calculated as follows:

$$Q = \frac{L}{D}$$

The absorption factor (A) is based upon the air to water ratio (R) which is dimensionless and Henry's Constant (H), also dimensionless, for the contaminant compound to be absorbed.

Based on the chemical characteristics of the contaminants of concern, treatment scenarios have been investigated for each maximum contaminant level in order to determine the most efficient combination of tower diameter and height for the contaminant that emerges as the dictating contaminant. This report will investigate TCE at concentrations of 600 µg/L.

TCE loading will govern the tower design. The air-to-water ratios will be kept within recommended limits, but no more than 60:1, and 2" Jaeger Tripack media will be used based on its extensive and proven performance history. If the diameter of the tower is revised based on fabrication considerations, the depth of packing will also need to be adjusted. The optimum tower diameter that approximates the design size is 10.2 feet. This will result in a typical liquid loading rate of 25.7 gpm/sf, based on maximum flow of 2,100 gpm. However, due to the site considerations surrounding the plant site, a lower profile tower would be desirable. Therefore, the tower design will include a 12' shell to minimize overall tower height. This will result in a liquid loading rate of 18.6 gpm/sf.

Based on the equations noted above, the following design conditions for the air stripping system would be required to reduce 600 µg/L of TCE down to 1.0 µg/L.

$$Q = \frac{L}{D} = \left(\frac{2100 \text{ gpm}}{113.1 \text{ sf}} \right) \times \left(\frac{1}{7.481 \text{ gal / ft}^3} \right) \times \left(\frac{60 \text{ min}}{1 \text{ hr}} \right) = 149.2 \text{ ft / hr}$$

$$A = [(H)(R)]^{-1} = [(0.2315)(60)]^{-1} = 0.072$$

$$NTU = \frac{1}{1-A} \times \ln \left[A + (1-A) \left(\frac{C_i}{C_e} \right) \right] = \frac{1}{1-0.072} \times \ln \left[0.072 + (1-0.072) \left(\frac{600 \text{ ppb}}{1 \text{ ppb}} \right) \right] = 6.81$$

$$HTU = \frac{Q}{K_{La}} = \frac{149.2 \text{ ft / hr}}{46.9 \text{ hr}^{-1}} = 3.18 \text{ ft}$$

$$Z = NTU \times HTU = 6.81 \times 3.18 \text{ ft} = 21.7 \text{ ft}$$

$$Z = 22 \text{ ft}$$

The exhausted air emissions, which are negligible, from the tower are exempt from NYSDEC emissions standards.

5.4 GAC FILTRATION

GAC filtration units have distinctly different operational and cost features as compared to air stripping units. As a generalization, GAC units have lower capital costs and are quicker to construct. However, the operating costs of GAC rise rapidly with increasing contaminant levels, while those for an air stripping tower remain relatively constant independent of the contaminant loading.

The operational reliability of GAC units can be much lower than for air stripping units. This arises from the great difficulty of operating GAC units during freezing weather unless they are enclosed. More importantly, unpredictable variations in influent VOC concentrations can require impractical sampling frequencies in order to prevent breakthrough of the GAC filter bed.

The adsorption capacity of activated carbon for organic contaminants can be estimated from an adsorption isotherm, which relates the concentration of a contaminant in water to that which is adsorbed by the GAC. This is derived by fitting the results of multiple batch equilibrium isotherm tests to the Freundlich equation to obtain values of empirical coefficients which characterize the properties of the carbon used and the contaminant adsorbed.

Carbon adsorption isotherms are available for many common groundwater contaminants. The isotherm for TCE is shown in Figure 5-1. This isotherm was developed from laboratory measurements which utilized "Filtrisorb 300" carbon by Calgon Carbon Company.

The Freundlich equation can be expressed as:

$$\frac{C_o - C_f}{M} = K (C_f)^{1/n}$$

Where, C_o is the contaminant concentration of the influent (mg/ℓ)
 C_f is the contaminant concentration of the effluent (mg/ℓ)
 M is the total weight of carbon
 K and $1/n$ are empirical constants unique to the contaminant and carbon

The ultimate capacity of the carbon can be estimated by defining carbon as reaching saturation when the contaminant influent concentration equals the effluent concentration. Choosing the point on the isotherm where $C_f = C_o$ will yield a value of carbon adsorption capacity $(C_o - C_f) / M$ at the contaminant concentrations.

Based on our review of the relative isotherms, treatment of 600 µg/ℓ of TCE results in an adsorptive capacity of 5.0 grams solvent adsorbed per 100 grams of carbon. This information can be converted to more meaningful units as follows:

$$\frac{600 \times 10^{-6} \text{ g}}{\text{L}} \times \frac{100 \text{ g C}}{5.0 \text{ g}} \times \frac{3.785 \text{ L}}{1 \text{ gal}} \times \frac{1 \text{ lb}}{454 \text{ g}} \times \frac{1,000,000 \text{ gal}}{1 \text{ MG}} = 100 \text{ lbs / MG}$$

The carbon consumption predicted by the Freundlich isotherm must be used carefully when evaluating a GAC treatment system. Field experience has shown that only 50 to 70 percent of the predicted batch adsorptivity will be obtained in typical installations. With a Freundlich efficiency of 70%, the carbon required to treat TCE at the given influent design concentration is 143 lbs / MG.

In order to size the vessels, the expected treatment capacity between change outs versus the amount of water that can be pumped through the filter vessels must be analyzed.

The following design criteria are used to size the vessels:

Flow Well No. SN-2:	2,100 GPM	or	550 MG/yr
Flow Well No. SN-3:	2,100 GPM	or	550 MG/yr
Combined Flow Both Wells:	4,200 GPM	or	1,100 MG/yr
Head Loss:	15 psi		
Freundlich Efficiency:	70%		
Empty Bed Contact Time:	7.5 minutes		
Effluent Contaminant Level:	1 µg/l	or less	

The expected treatment capacity between carbon change outs is controlled by TCE with a carbon consumption of 143 lbs / MG of treated water. Assuming carbon will not be exchanged more than once annually then,

$$\begin{aligned} \text{The carbon required (lbs)} &= \text{Annual pumpage (MG)} \times \text{carbon consumption (lbs)/MG} \\ &= 1,100 \text{ MG} \times 143 \text{ lbs/MG} \\ &= \underline{157,300 \text{ lbs / year}} \end{aligned}$$

If each filter vessel contains 20,000 lbs of carbon, then the required number of vessels to treat both wells at the current five (5) year average annual pumping rate, changing carbon once per year, is as follows:

$$\text{Design Maximum Contaminant Loading: } \frac{157,300 \text{ lbs}}{20,000 \text{ lbs / vessel}} = 7.8 \text{ or } 8 \text{ vessels}$$

In designing for the maximum contaminant loading, the report will consider utilizing three (3) sets of two (2) filters in parallel. Additionally, each filter vessel is limited to a design flow of 700 gpm, further limiting the minimum required vessels to six. This means that at the average annual production rate at this site, the carbon would have to be replaced every 9 months.

5.5 GENERAL DESIGN REQUIREMENTS

The requirements to be fulfilled by the well head treatment installation are to treat a total flow of 4,200 GPM from both Well Nos. SN-3 and SN-4. The nature and concentration of contaminants were tabulated in previous sections.

Factors that must be considered in the design and economic analysis of the GAC filter or air stripper installation include the treatment equipment and all buildings, piping, pumps and tanks associated with each treatment alternative. Regulatory requirements such as chlorination contact time and GAC filter contact time must also be addressed in the design.

Recommendations to improve the facility under either the air stripping or GAC filtration alternative include the following:

1. Miscellaneous mechanical and electrical upgrades in the existing well houses.
2. Incorporation of existing well building upgrades into new treatment.
3. Install new standby power generator sufficiently sized to operate the plant at full capacity.

5.5.1 GAC FILTRATION

Some of the advantages of Granular Activated Carbon (GAC) filtration as compared to air stripping are: a GAC installation can normally be constructed more quickly than an air stripping facility; there is little noise associated with the GAC operation; the filter building tends to be of lower profile than an air stripper.

Hydraulic considerations of installing GAC filter vessels include minimizing friction losses due to piping and especially through the carbon bed and filter underdrain. The well pump will experience an increase backpressure and corresponding decrease in flow. A

pipng configuration will be established that will allow the wells to filter to waste, backwash to waste and to isolate individual filter vessels for carbon loading and unloading operations.

Any proposed filter vessel should be an ASME Code pressure vessel with underdrain and overdrain system and piping for carbon filling and removal, filtering and backwashing. Taps for influent and effluent sampling with pressure gauges and flow metering capability shall be provided. The filter configuration, as proposed, would be a vertical cylinder having dished ends and supporting legs. The filters will have a 12 foot straight shell height and be 10 foot in diameter.

The existing blow-off system will be utilized to accept the water used to backwash the filter vessels and to rinse and settle the carbon bed prior to pumping to the system. Additional blow-off pits would be required to be installed.

In order to utilize the GAC system year round, the filters would need to be enclosed and heated. To reduce the building height, the building can be constructed with a portion of the filters below grade.

5.5.2 AIR STRIPPING

An air stripping installation would consist of several distinct components. The discharge from the existing iron removal plant would be piped to the top of two air stripping towers. Each tower would contain an inlet water distribution system, demisters, packing media, support gratings, flow redirectors, effluent water collection system and influent air connection. Effluent from the air strippers would flow by gravity to a new divided clearwell, and then pumped via transfer pumps to another set of air stripping towers. Effluent from the air strippers would flow by gravity to a new common clearwell, and then pumped the distribution system. Restaging of the well pumps may be required due to the reduction in the discharge pressure from the well.

After air stripping, the water will be collected in a belowgrade concrete clearwell. The clearwell would be sized at a minimum to provide a 30 minute contact time for chlorination if required. The clearwell volume would then be equal to the volume of flow times the contact time which is: $4,200 \text{ GPM} \times 30 \text{ min.} \div 7.481 \text{ gals./CF}$ or 16,842 CF, which is equal to 126,000 gallons. The clearwell would be sized slightly larger to permit it to be used to store water to backwash the iron removal plant.

Including an unusable freeboard space of 18", the finish water clearwell shall have dimensions equal to 43' wide x 43' long x 13' deep. A reinforced concrete clearwell will be constructed below grade to minimize the overall building height. The two towers would be located on top of the clearwell.

A building will be constructed over the clearwell and air stripping towers to house the towers, pumps, power, controls and blowers. The building will be designed to enclose the air stripping towers as the site is in the middle of a residential community.

In a potable water application, supply air to the blower must be prefiltered before use. As a minimum, a two-step particulate filter, which can furnish air at the equivalent of FDA or acceptable criteria in food applications, would be appropriate. Pressure drops through these filters, under normal operating conditions, should be approximately 1/2-inch of water. The air flow and pressure drop through the filters will be monitored to ensure that the filters are changed when necessary.

All chemical feed injection points will require modification. The existing chemical feeders will be replaced or modified to accommodate water quality changes associated with air stripping treatment. Caustic soda, for pH adjustment, and /or sodium hypochlorite, for disinfection, may be injected into the effluent clearwell piping, as required. A recirculation line will be provided to allow a closed loop flow to chlorinate the tower. Provisions for direct blow-off from the stripping tower will also be made.

6.0 ECONOMIC ANALYSIS

A generalized comparison between GAC filtration and air stripping reveals that the most appropriate installation depends not only upon the concentration and type of contaminant, but also is sensitive to the total hours of operation and correspondingly the total pumpage from the wells to be treated. The anticipated costs for any treatment facility can be categorized as either capital costs, which do not vary with the degree of utilization of the facility, and operating costs, which do vary with the degree of utilization.

6.1 CAPITAL COSTS

Total capital costs must also include the expected cost of the facilities outlined under “General Design Requirements” in Section 5.5.

Capital improvements required for GAC include:

- GAC filter vessels
- Foundation, slab and treatment building construction
- Initial carbon loading
- Piping modifications
- Well pump replacements
- Site improvements
- Electrical power modifications
- Emergency standby power provisions

The air stripping alternative involves the following capital improvements:

- Air stripping towers
- Treatment building construction

- Concrete clearwell
- Piping modifications
- Booster pump installations
- Well pump replacements
- Site improvements
- Electrical and control modifications
- Emergency standby power provisions

The cost opinions for the capital improvements for the treatment alternatives are given in Tables 6-1 and 6-2. The total capital cost for the GAC alternative is \$3,334,000. The total capital cost for the air stripping alternative is \$5,168,000.

6.2 OPERATING COSTS

Operating costs for the GAC filtration alternative, which vary with the amount of water being treated, consist primarily of the following annual costs:

- Increased electrical costs for power and heat
- GAC replacement costs
- Increased laboratory monitoring costs
- Increased plant monitoring costs

The variable costs associated with the GAC filtration alternative are sensitive to changes in contaminant type and concentration, while those for the air stripper will change very little for moderate changes in contaminant concentration.

Increases in the contaminant concentration and high pumpage rates will require carbon change outs of more than once per year. As stated in Section 5.4, the evaluation of the GAC alternative will utilize six (6) GAC 20,000 lb vessels. The adsorptive capacity of activated carbon varies with the influent concentration of a contaminant. While the efficiency of carbon

adsorption increases with increasing concentration, the rate at which the carbon reaches its adsorptive capacity increases even more quickly.

Operating costs for the air stripping alternative consist primarily of the following annual costs:

- Annual filter replacement costs
- Increased electrical costs for power and heat
- Increased laboratory monitoring costs
- Increased plant monitoring costs

The pumpage rates are anticipated to be consistent for the foreseeable future. The electrical demand charges associated with the air stripping option are the only variables that would depend on the total annual pumpage, where electrical charges and GAC consumption costs are variables in the GAC filtration alternative.

The cost opinions for the annual operational and maintenance costs for both treatment alternatives are shown in Tables 6-3 and 6-4. The annual operating costs associated with the GAC treatment alternative is \$198,290. At an inflation rate of 5.0% and an investment rate of 1.5%, the present worth value requirement for a 30 year treatment system operation is 10,150,000. For the air stripping alternative, the annual costs are \$139,840, and the present worth requirement for a 30 year system operation with the same financial conditions is \$7,160,000.

6.3 TOTAL COSTS

The selection among the various alternatives should be based in-part upon an evaluation of the capital costs and the present value of annual operating costs taken in combination. For the GAC alternative, the capital cost of \$3,334,000 combined with the present value cost requirement of \$10,150,000 for a 30 year operation, results in a total

cost requirement of \$13,439,000. For the air stripping alternative, the capital cost of \$5,168,000, when combined with the 30 year operating cost of \$7,160,000, results in a total present value cost requirement of \$12,328,000. Based on this analysis, the air stripping alternative is the most cost effective treatment option.

7.0 CONCLUSIONS

The more stringent volatile organic compound MCLs have significantly impacted the typical water supplier's planning procedures. In the past, a supplier usually had sufficient time to implement the construction of a treatment system between the time a contaminant was first detected and when it first exceeded the acceptable maximum level. Prior to 1989, the MCL for principal VOCs was set at 50 µg/L for any one VOC and 100 µg/L for total VOCs present in the product of a supply well. Under the present MCLs of 5 µg/L, a supplier has little or no time to plan for treatment after a contaminant is detected. Therefore, with the current MCLs, suppliers should plan additional reserve capacity to protect against the possibility that a well may have to be taken out of service due to organic contamination.

1. Upstream well data indicate that low level VOCs are prevalent in the Upper Glacial, and shallow and deep Magothy formation upgradient of the Seamans Neck Road Plant
2. Based on available data, TCE, is currently impacting this site. TCE is the primary contaminant in the contamination plume emanating from the Northrop Grumman property..
3. The Seamans Neck Road Plant is critical to the average and peak day pumpage operations of the NYWS. The abandonment or closure of these wells would translate into a lost well capacity of 6.04 MGD (4,200 GPM). This is not an option for NYWS.
4. Based on the economic analysis performed, production from the Seamans Neck Road Plant supply wells, and the nature and concentration of the VOCs projected to impact the facility, it has been determined that air stripping is the most technically viable and cost effective treatment method for this site. The recommended treatment system will allow the plant facility to meet current MCLs while allowing the supply wells to function adequately with increasing raw water concentrations up to 600 µg/L for TCE.

5. It is expected that two air stripping towers will be sufficient for the removal of the contamination expected to impact this plant. The proposed treatment system will provide water from the supply wells at or below 1 $\mu\text{g/L}$, with the intention of providing drinking water with “non-detectable” VOC contamination.

6. The present day capital cost for constructing an air stripping treatment system at the Seamans Neck Road Plant is estimated to be \$5,168,000. This estimate includes the air stripping treatment towers; tower foundations; transfer clearwells and pumps; treatment, electrical and mechanical modifications; filters and blowers; air stripper buildings; standby generators and enclosures; site work; well pump modifications; engineering; construction administration; legal; and contingencies.

7. The present day operation and maintenance costs for operating an air stripping treatment system depend on the extent of operation following installation of the system. Based on average historic operation at the Seamans Neck Road Plant, the annual operating costs are estimated to be \$139,840. Over an operating period of 30 years, the present day value of this annual cost is \$7,160,000.

TABLES

Table 2-1
New York Water Service Corporation
Summary of Existing Supply Well Facilities

NYWS Well No.	NYSDEC No.	Year Placed in Service	Depth (feet)	Approved Capacity (MGD)
Jefferson St. # 11	N-7404	1963	649	3.024
Jefferson St. # 12	N-8253	1967	602	3.024
Charles St. #2	N-9976	1983	570	3.024
Newbridge Rd. #1	N-3895	1952	350	3.024
Newbridge Rd. #3	N-8976	1979	700	3.024
Newbridge Rd. #4	N-9878	1982	664	3.024
Old Mill Rd #1	N-8031	1967	513	3.024
Jerusalem #4	N-9514	1980	660	3.024
Jerusalem #5	N-10195	1985	583	3.024
DeMott #4	N-5767	1956	387	3.024
DeMott #5	N-8837	1972	680	3.024
DeMott #6	N-9910	1983	774	3.024
Seaman Neck Rd. #2	N-3893	1952	151	2.016
Seaman Neck Rd. #3	N-8480	1969	655	3.024
Seaman Neck Rd. #4	N-9339	1979	649	3.024
Sunrise Mall #6	N-7414	1963	533	3.024
Sunrise Mall #7	N-8603	1971	892	3.024
Sunrise Mall #8	N-10630	1983	684	3.024

Table 2-2
New York Water Service Corporation
Storage Tank Capacity

NYWS Plant Location	Description	Capacity (MG)	Overflow Elevation feet (AMSL)
Jefferson Street	Elevated Steel	.75	174.88
Bernard	Ground Steel	1.0	31.55
DeMott Avenue	Ground Steel	1.0	52
Newbridge	Ground Pre-Stressed Concrete	1.0	55
Morton	Ground Steel	2.0	49.75
NYWS Total		5.75MG	

Table 2-3
New York Water Service Corporation
Interconnections with Neighboring Suppliers

Water Supplier	Location	Interconnection Size (Inches)
South Farmingdale Water District	4057 Wicks Avenue	6" X 6"
South Farmingdale Water District	Ford Drive and Emily Street	6" X 8"
South Farmingdale Water District	Stuart Place and Alken Avenue	6" X 6"
East Meadow Water District	Jerusalem Avenue and Southern State Parkway	8" X 8"
East Meadow Water District	Foxglove Road and Jerusalem Avenue	6" X 6"
Suffolk County Water Authority	Merrick Road and County Line Road	12" X 12"
Massapequa Water District	Jerusalem Avenue and Washington Avenue	8" X 8"
Massapequa Water District	Clark Street and Lakeview Avenue.	6" X 12"
Massapequa Water District	Front Street and Park Avenue	10" X 12"
Massapequa Water District	Park Place and Illinois Avenue	6" X 6"

Table 3-1
New York Water Service Corporation
Annual Pumpage of Selected Wells (Million Gallons)

Year	Seamans Neck 3	Seamans Neck 4	Newbridge 4
1996	630.5	673.4	38.8
1997	360.5	673.4	38.8
1998	301.0	767.2	58.9
1999	680.6	288.7	58.7
2000	581.9	423.3	13.1
Average	426.25	471.67	35.38

Table 4-1
New York Water Service Corporation
Current MCLs As Determined Under The Safe Drinking Water Act (1986)

Parameter	MCL (ug/l)
Benzene	5
Vinyl Chloride	2
Carbon tetrachloride	5
1,2-Dichloroethene	5
Trichloroethene	5
1,1-Dichloroethene	7
1,1,1-Trichloroethane	200
p-Dichlorobenzene	75
Chloroform	100

Additional Compounds with MCLs lowered to 5 ug/l by NYSDOH [Date of Enforcement: January 1989]	
Bromobenzene	2,2-Dichloropropane
Bromochloromethane	1,1-Dichloropropene
Bromomethane	cis-1,3-Dichloropropene
n-Butylbenzene	trans-1,3-Dichloropropene
sec-Butylbenzene	Ethylbenzene
tert-Butylbenzene	Fluorotrichloromethane
Chlorobenzene	Hexachlorobutadiene
Chloroethane	Isopropyl Benzene
Chloromethane	n-Propylbenzene
o-Chlorotoluene	Styrene
p-Chlorobenzene	1,1,1,2-Tetrachloroethane
p-Cymene	1,1,2,2-tetrachloroethane
Dibromomethane	Toluene
m-Dichlorobenzene	1,2,3-Trichlorobenzene
o-Dichlorobenzene	1,2,4-Trichlorobenzene
Dichlorodifluoromethane	1,1,2-Trichlorobenzene
1,1-Dichloroethane	1,2,3-Trichloropropane
cis-1,2-Dichloroethene	1,2,4-Trimethylbenzene
trans-1,2-Dichloroethene	1,3,5-Trimethylbenzene
Dichloromethane	m-Xylene
1,2-Dichloropropane	o-Xylene
1,3-Dichloropropane	p-Xylene
Bromodichloromethane	1,1,2-Trichloroethane
Bromoform	Monochlorobenzene
Chlorodibromomethane	Napthalene
p-Chlorotoluene	1,1,1,2-Tetrachloroethylene
1,2-Dichloroethane	

Table 4-2
New York Water Service Corporation
Synthetic Organic Chemicals (SOCs)

SYNTHETIC ORGANIC CHEMICALS	MCL (ug/l)	NYSDOH CATERGORY
Alachlor	2	1.1.1.1.1.1.1.1 GROUP I
Adlicarb	3	
Aldicarb Sulfoxide	4	
Aldicarb Sulfone	2	
Atrazine	3	
Carbofurane	40	
Chlordane, Total	2	
1,2-Dibromo-3-Chloropropane (DBCP)	0.2	
2,4-D	50	
Endrin	0.2	
1,2-Dibromoethane (EDB)	0.05	
Heptachlor	0.4	
Heptachlor Epoxide	0.2	
Lindane	0.2	
Methoxychlor	40	
Polychlorinated Biphenyls (PCB)	0.5	
Pentachlorophenol	1	
Toxaphene	3	
2,4,5-TP (Silvex)	10	
Aldrin	5	1.1.1.1.1.1.1.2 GROUP II
Benzo (a) Pyrene	0.2	
butachlor	50	
Carbaryl	50	
Dalapon	200	
Di (2-Ethylhexyl) Adipate	400	
Di (2-Ethylhexyl) Phthalates	6	
Dicamba	50	
Dieldrin	5	
Dinoseb	7	
Glyphosate	700	
Hexachlorobenzene	1	
Hexachlorocyclopentadiene	50	
3-Hydroxycarbofuran	50	
Methomyl	50	
Metolachlor	50	
Metribuzin	50	
Oxamyl (Vydate)	200	
Pichloram	500	
Propachlor	50	
Simzaine	4	

Table 4-3
New York Water Service Corporation
New York State Primary And Secondary Standards For Inorganic Chemicals

Primary Contaminants

CONTAMINANT	MCLs (mg/l)
Arsenic	0.05
Barium	2.0
Cadmium	0.005
Chromium	0.01
Fluoride	2.2
Lead	0.015*
Mercury	0.002
Selenium	0.01
Silver	0.05

Secondary Contaminants

CONTAMINANT	MCLs (mg/l)
Chloride	250
Copper	1.3*
Corrosivity	Non-Corrosive
Iron	0.3
Manganese	0.3
Sodium	No Designated Limit
Sulfate	250
Zinc	5.0
Color	15 units
Odor	3 units

1. "If iron and manganese are present, the total...of both should not exceed 0.5 mg/l. Higher levels may be allowed by the State when justified by the supplier of water."
2. "Water containing more than 20 mg/l of sodium should not be used...on severely restricted diets." "Water containing more than 270 mg/l of sodium should not be used...on moderately restricted diets."

* - USEPA Action Level

Table 4-4
New York Water Service Corporation
Historical Iron Concentration of Selected Wells

Year	Iron Concentrations (mg/l)		
	Seamans Neck Well No. 3	Seamans Neck Well No. 4	Newbridge Well No. 4
1990	0.70	0.60	0.57
1991	0.60	0.80	0.73
1992	0.55	0.72	0.80
1993	0.61	0.76	0.78
1994	0.70	0.78	0.85
1995	0.75	0.84	1.11
1996	0.84	0.94	1.20
1997	0.86	0.95	1.38
1998	0.81	0.92	1.47
1999	0.90	1.11	2.10
2000	0.94	1.17	2.10

Table 6-1
New York Water Service Corporation
Seamans Neck Road Plant
Opinion of Cost
GAC Treatment

1. Site work, drainage and utilities, landscaping	\$100,000
2. GAC Filter & Well house building, general construction	\$800,000
3. GAC Filters (6 vessels) with initial carbon	\$600,000
4. Electrical controls and power distribution upgrades	\$200,000
5 Mechanical work and piping	\$200,000
6 Replacing Well No.SN-3 pump and motor	\$75,000
7 Replacing Well No.SN-4 pump and motor	\$75,000
8 Emergency power generator and enclosure	\$400,000
CONSTRUCTION SUBTOTAL	\$2,450,000
Engineering, Permits and Design (15%)	\$368,000
Construction Administration (3%)	\$74,000
Inspection (5%)	\$123,000
Legal (3%)	\$74,000
Contingencies (10%)	\$245,000
TOTAL	\$3,334,000

Table 6-2
New York Water Service Corporation
Seamans Neck Road Plant
Opinion of Cost
Air Stripping Treatment

1. Site work, drainage and utilities, landscaping	\$200,000
2. Two Stainless steel air stripping towers with packing, blowers and blower motors, inlet weirs, redistribution, inlet air filtering and liquid collection	\$750,000
3. Air Stripper / Well House Buildings and clearwells, general construction	\$1,250,000
4. Electrical controls and power distribution upgrades	\$700,000
5. Installation of standby power generator in sound attenuated enclosure	\$500,000
6. Booster pumps, mechanical work and piping modifications	\$300,000
7. Replacing Well No. SN-3 pump and motor	\$50,000
8. Replacing Well No. SN-4 pump and motor	\$50,000
CONSTRUCTION SUBTOTAL	\$3,800,000
Engineering, Permits and Design	\$570,000
Construction Administration	\$114,000
Inspection	\$190,000
Legal	\$114,000
Contingencies	\$380,000
TOTAL	\$5,168,000

Table 6-3

**New York Water Service Corporation
Seamans Neck Road Plant**

**Summary of Additional Annual Operating Costs
After Installation of New Treatment System
Granular Activated Carbon**

INCREASE IN ANNUAL ELECTRICAL OPERATING COSTS

1. Electric Utility Provider: LIPA
2. Electrical Rate Code: 285
3. Increase in Plant Electrical Demand: 57 KW
4. Cost of Electric: \$.17 / KWH

5. Consumption Charges:

<u>Increased Demand</u>	<u>Operating Hours*</u>	<u>Annual Demand</u>	<u>Electrical Rate Charge</u>	<u>Annual Costs</u>
57 KW	3000 Hrs	171,000 KW Hrs	\$0.17 / KW Hr	\$29,070

Increase in Annual Electrical Operating Costs **\$29,070**

* - Based on average Annual Pumpage over the last five years.

GAC REPLACEMENT COSTS

1. Quantity of vessels: 6
2. Carbon per vessel: 20,000 lbs.
3. Frequency of carbon replacement: Annually

Annual GAC Replacement Costs = (\$1.00 per lb.) (120,000 lbs.) = **\$120,000**

INCREASE IN ANNUAL LAB MONITORING OPERATING COSTS

1. Monthly VOC Water Samples Required for Raw and Treated Water
2. VOC Sample Rate Charge = \$265 / Sample
3. Annual Number of Samples Required = 4 Samples / Month x 12 Months = 48 Samples

Increase in Annual Lab Monitoring Operating Costs = \$265 x 48 Samples = **\$ 12,720**

INCREASE IN ANNUAL PLANT MONITORING LABOR COSTS

1. Required Additional Plant Monitoring = 2 Hrs / Day
2. Required Additional Man-hours = 2 Hrs / Day x 365 Days / year = 730 Hrs

Increase in Annual Plant Monitoring Labor Costs = \$50 / Hr* x 730 Hrs = **\$ 36,500**

* - Estimated hourly rate for plant operator – includes associated benefit costs.

SUM OF INCREASE IN ANNUAL DISTRICT OPERATING COSTS

1. Increase in Annual Electrical Operating Costs:	\$ 29,070
2. Annual GAC Replacement Costs:	\$ 120,000
3. Increase in Annual Lab Monitoring Operating Costs:	\$ 12,720
4. Increase in Plant Monitoring Operating Costs:	<u>\$ 36,500</u>

SUM OF INCREASE IN ANNUAL DISTRICT OPERATING COSTS: \$ 198,290

PRESENT WORTH VALUE

Additional Annual Operating Costs:	\$198,290
Treatment System Life:	30 Years
Operating Cost Inflation Rate	5.0%
Investment Interest Rate:	1.5%

PRESENT WORTH VALUE: \$10,150,000

TABLE 6-4

**New York Water Service Corporation
Seamans Neck Road Plant**

**Summary of Additional Annual Operating Costs
After Installation of New Treatment System
Air Stripping**

INCREASE IN ANNUAL ELECTRICAL POWER AND HEATING COSTS

1. Electric Utility Provider: LIPA
2. Electrical Rate Code: 285
3. Increase in Plant Electrical Demand: 162 KW
4. Cost of Electric: \$.17 / KWH

5. Consumption Charges:

<u>Increased Demand</u>	<u>Operating Hours*</u>	<u>Annual Demand</u>	<u>Electrical Rate Charge</u>	<u>Annual Costs</u>
162 KW	3000 Hrs	486,000 KW Hrs	\$0.17 / KW Hr	\$82,620

Increase in Annual Electrical Operating Costs **\$82,620**

* - Based on average Annual Pumpage over the last five years.

ANNUAL FILTER REPLACEMENT OPERATING COSTS

1. Pre-Filters Must Be Replaced Every Month of Operation
2. Filters Must Be Replaced Twice per Year
3. Cost of Replacing Pre-Filters = \$500
4. Cost of Replacing Filters = \$1000

Annual Filter Replacement Operating Costs = (\$500 x 12) + (\$1000 x 2) = \$ **8,000**

INCREASE IN ANNUAL LAB MONITORING OPERATING COSTS

1. Monthly VOC Water Samples Required for Raw and Treated Water
2. VOC Sample Rate Charge = \$265 / Sample
3. Annual Number of Samples Required = 4 Samples / Month x 12 Months = 48 Samples

Increase in Annual Lab Monitoring Operating Costs = \$265 x 48 Samples = \$ **12,720**

INCREASE IN ANNUAL PLANT MONITORING LABOR COSTS

1. Required Additional Plant Monitoring = 2 Hrs / Day
2. Required Additional Man-hours = 2 Hrs / Day x 365 Days / year = 730 Hrs

Increase in Annual Plant Monitoring Labor Costs = \$50 / Hr* x 730 Hrs = **\$ 36,500**

* - Estimated hourly rate for plant operator – includes associated benefit costs.

SUM OF INCREASE IN ANNUAL DISTRICT OPERATING COSTS

1. Increase in Annual Electrical Operating Costs:	\$ 82,620
2. Annual Filter Replacement Costs:	\$ 8,000
3. Increase in Annual Lab Monitoring Operating Costs:	\$ 12,720
4. Increase in Plant Monitoring Operating Costs:	<u>\$ 36,500</u>

SUM OF INCREASE IN ANNUAL DISTRICT OPERATING COSTS: \$ 139,840

PRESENT WORTH VALUE

Additional Annual Operating Costs:	\$139,840
Treatment System Life:	30 Years
Operating Cost Inflation Rate	5.0%
Investment Interest Rate	1.5%

PRESENT WORTH VALUE: \$7,160,000

