7. Source Water Quality

Data on the quality of the Catskill Aqueduct water was obtained from the New York City Department of Environmental Protection's Bureau of Water Supply, Quality and Protection and from the Montrose Improvement District, which also maintains a connection to the Catskill Aqueduct. This information is included in Appendix A.

A review of this data was undertaken as part of the regulatory review. Implication of the data with respect to needed water treatment facilities and compliance with Federal and State regulations is discussed in Chapter 6 – Regulatory Compliance Review.

8. Treatment Facilities

This section discusses the proposed methods to provide treatment of the Catskill Aqueduct source water to meet Federal and State requirements. For water obtained from outside districts, those districts are responsible for supplying potable water that meets Federal and State requirements.

8.1. Water Treatment Plant Capacity

Because of the limited demand data from the existing Lake Peekskill water system, the firm capacity for a proposed water treatment plant was estimated based on the *Distribution Network Analysis for Water Utilities*, American Water Works Association (AWWA) Manual M32, First Edition, which states "Peaking factors are most-limiting demand conditions". A peak factor is generally developed for the ratio of maximum-day demand to average-day demand. This ratio has been observed to vary from 1.2 to 2.5. Most plants in the northeast have a peaking factor of at least 2.0. The more conservative 2.5 peaking factor was used, giving a firm plant capacity of:

projected average day demand x 2.5 = projected maximum day demand

- or -

0.6 mgd x 2.5 = 1.5 mgd

The water system will be designed for the future average daily design flow of 0.60 mgd and a maximum day flow of 1.5 mgd plus fire flow.

8.2. Filtration Process

Based on the reviews of the Federal and State requirements for drinking water and quality of the Catskill Aqueduct water, it was decided to select membrane technology as the treatment method to be utilized for the Lake Peekskill Water Treatment Plant. Regulations are headed towards tighter control on giardia and cryptosporidium removals. Membrane technology (microfiltration or ultrafiltration), offers removal levels that would exceed current and future removal requirements for these organisms. Other technologies such as sand filtration and dissolved air floatation have limitations with respect to higher levels of removal of giardia and cryptosporidium. Also, these technologies would require chemical coagulants and produce more treatment residuals.

Membrane filtration is a pressure gradient driven, "filtering" process. In the drinking water field, the microfiltration membranes are capable of removing particulates having a size larger than about 0.08 to 0.50 microns in size. Ultrafiltration membranes can remove particles down to a size of about 0.001 to 0.02 microns in size. *Giardia* cysts are about 7 to 15 microns in size and cryptosporidium oocysts are about 2 to 7 microns in size, and therefore would be removed by microfiltration or ultrafiltration membranes. Most bacteria are larger than 0.1 microns and most viruses are larger than about 0.08 microns. However, disinfection, generally with chlorine, is still a required treatment technique for bacteria and virus destruction following filtration.

Membranes for drinking water applications are generally made from ceramics or polymers. The membranes typically come in tubular or hollow fiber configuration. There are many manufacturers of membrane systems for drinking water applications.

The selection of a membrane system usually requires pilot testing of several different manufacturer's systems on the source water. The goal of pilot testing is to obtain quality and performance data that can be utilized by the engineer and manufacturers to determine the most applicable system in consideration of treatment quality, system performance and site specific issues and costs.

Membrane systems are modular, generally skid mounted systems, and almost always housed in a building. The membrane modules periodically need to be replaced, and typically have a 5 to 10 year operating life. The membranes also require backwashing or "back pulsing" to control fouling of the membrane surface, so as to maintain water flow or "flux rate". This is done automatically and is computer controlled. Some systems backwash with air and some backpulse with permeate alone. Other systems backwash with permeate mixed with bleach, or mixed with bleach and caustic. The membranes also need to be cleaned, generally monthly, to remove contaminants, such as organic matter and crystallized salts, that foul the membrane surface. Typically citric acid, caustics and bleach are chemicals used to clean the membranes of organic and inorganic foulants. The exact cleaning regime varies somewhat between manufacturer's systems and source waters characteristics. Backwashing/back pulsing, as well as chemical cleaning requirements, are usually determined during pilot testing. For this facility plan, the systems from three manufacturers (Koch, Memcor, and Zenon) were considered. Manufacturer's drawings are included in Appendix B.

8.2.1. Koch

The membrane process manufactured by Koch is an "Inside-Out" type of system. That is, raw water flows from the inside surface of the hollow membrane fibers (ultrafilters) to the outside of the membrane fibers, where it is ejected out as permeate. Before the raw water enters the membrane modules, it must first pass through self cleaning prefilters. These prefilters removed particles which are greater than 200 microns in size, and thus reduce clogging to the membranes fibers.

The Koch membrane modules are housed within pressurized vessels, which would make it possible to pump through the membranes, to the clearwell, utilizing the feed pumps that will draw the raw water from the Catskill Aqueduct. Typically, the feed water needs to be provided at a pressure of 40 psi. Normal operating transmembrane pressure is approximately 7-25 psi, depending on the timing of the last chemical cleaning.

Backwashing of the membranes is normally done once every hour. This involves forcing permeate through the membranes fibers from the "Outside-In" using the backflush pumps. The permeate is pumped from a backwash storage tank that is filled during normal plant operation. The backwash flow serves to dislodge any solids that have been deposited on the inside surface of the fibers and to remove the solids from the membrane modules. A 100-200 mg/l sodium hypochlorite solution and a 20-50 % caustic solution is added to the permeate used for backwashing. The backwash volume is about 4-5 % of the influent raw water flow and is drained to waste. An additional 3 % of the influent needs to be bled and wasted from the system at several different points in the process; this helps control solids build-up within the membrane modules.

Chemical Clean In Place (CIP) of the membranes, which consists of pumping a chemical solution from a CIP storage tank into the membrane vessels, is performed whenever the transmembrane pressure exceeds about 25 psi. The membranes are allowed to soak in the cleaning solution for up to four hours. Depending on the characteristics of the raw water, the cleaning solution may be sodium hypochlorite, caustic, or citric acid. Chemical cleaning of the membranes is performed about once per month. After a cleaning, the membrane fibers are rinsed with permeate water, which is wasted along with any spent chemicals. Certain chemical cleaning solutions can be reused and may be returned to the CIP tanks.

For the proposed Lake Peekskill WTP with a firm capacity of 1.5 mgd, the Koch membrane system would consist of three stages in parallel. Each skid will have a capacity of 0.75 mgd, allowing the maximum day flow of 1.5 mgd to be met with one of the units off-line. The output, however, can be pushed to a peak production of about 2.0 mgd with one unit off-line. The system will utilize three HF-40 V8048 stages, each of which contains 33 (each stage has room for 40) V8048-35 membrane modules. The system may incorporate raw water recirculation pumps. These pumps raise the velocity of the feed across the membrane surface to insure a sufficient flux rate is maintained. The Koch membrane is system is automated and a control panel, control software program, an operator interface are provided.

The system has an integrity check to ensure the membranes are intact. This test is automatically performed after each cleaning and can be initiated at any time by the plant operator. The integrity check determines if there are any damaged membrane fibers using an air pressure decay test. Damaged modules can be removed from a HF-40 V8048 unit without taking it out of service.

8.2.2. Memcor

The membrane process manufactured by the Memcor division of U.S. Filter is an "Outside-In" type of system. That is, raw water flows from the outside surface of the hollow membrane fibers (microfilters) to the inside of the membrane fibers, where it is ejected out as permeate. Before the raw water enters the membrane modules, it must first pass through self cleaning strainers. These strainers remove particles which are greater than 500 microns in size, and thus reduce clogging to the membranes fibers.

The Memcor membrane modules are housed within pressurized vessels, which would make it possible to pump through the membranes, to the clearwell, utilizing the feed pumps that will draw the raw water from the Catskill Aqueduct. Typically, the feed water needs to be provided at a pressure of 30-35 psi. Normal operating transmembrane pressure is approximately 7-22 psi, depending on the timing of the last chemical cleaning.

Backwashing of the membranes is normally done every 15 minutes and last about 2-3 minutes. This involves forcing compressed air through the membranes fibers from the "Inside-Out". The air serves to dislodge any solids which have been deposited on the outside surface of the fibers. Raw water is simultaneously used to rinse the membranes and removed the solids from the membrane modules. The backwash flow is directed to a backwash energy dissipation tank from where it is wasted. The backwash volume is about 7-10 % of the influent raw water flow.

Chemical Clean In Place (CIP) of the membranes, which consists of pumping a chemical solution from a CIP storage tank into the membrane vessels, is performed whenever the transmembrane pressure exceeds 18-22 psi. The membranes are allowed to soak in the cleaning solution for several hours. Although an operator must be present to start and monitor a chemical cleaning, the process is automatic after initiation. A citric acid cleaning is routinely done about every 3-4 weeks, and a caustic cleaning is usually necessary every 12 weeks. The chemical cleaning solutions can be reused and may be returned to the CIP tanks or to another skid. After soaking in the

chemical solution, the membrane fibers are rinsed with permeate water, which is wasted along with any spent chemicals.
For the proposed Lake Peekskill WTP with a firm capacity of 1.5 mgd, the Memcor membrane system would consist of three skid mounted units in parallel. Each skid will have a capacity of 0.75 mgd, allowing the maximum day flow of 1.5 mgd to be met with one of the units off-line. The system will utilize three 90M10C units, each of which contains 90 M10C membrane modules. The Memcor membrane is system is automated and is provided with a Programmable Logic Controller (PLC) based system with an operator interface.

The system has an integrity check to ensure the membranes are intact. This test is automatically performed every 24 hours and can be initiated at any time by the plant operator. The integrity check cycle determines if there are any damaged membrane fibers using an air pressure decay test. Damaged modules can be removed from a 90M10C unit without taking the unit out of service.

8.2.3. Zenon

The Z-Weed membrane process manufactured by Zenon is an "Outside-In" type of system. That is, raw water is drawn from the outside surface of the hollow membrane fibers to the inside of the membrane fibers (ultrafilters), where it flows out as permeate. For the Zenon membrane system, prefiltering of the raw water is not necessary.

The Zenon membrane modules are installed within 304 stainless steel tanks, there is no pressure housing required. The tanks would be filled by the feed pumps that will draw raw water from the Catskill Aqueduct. Permeate will be drawn through the membranes, to the clearwell, under a slight vacuum created by the permeate pumps. For this type of system, air flow is added to the bottom of the membranes to help scour solids from the outside surface of the membranes. The air would also oxidize iron and organic compounds.

Backwashing of the membranes is done approximately every 22 minutes. This involves reversing the permeate pumps, and thus reversing the flow through the membrane fibers. During backwashing, the permeate is pumped at low pressure from a backwash storage tank that is filled during normal operation. The backwash flow serves to dislodge any solids which have been deposited on the outside surface of the fibers. The backwashing permeate contains approximately 5 mg/l of sodium hypochlorite. Retentate is continuously wasted from the process tanks, and flows to the disposal point by gravity. The total wasted volume is about 3-10 % of the influent raw water flow.

Chemical Clean In Place (CIP) of the membranes, which consists of pumping a chemical solution from a storage CIP tank into the stainless steel tanks, is performed about once every 2-3 months. During the process, the membranes are allowed to soak in the cleaning solution for 6-8 hours. Depending on the characteristics of the raw water, the chemical cleaning chemicals used may be sodium hypochlorite or citric acid. The membrane fibers are rinsed with permeate water, which is then wasted from the stainless steel tanks by gravity, along with any spent chemicals. Certain chemical cleaning solutions can be reused and may be returned to the CIP tanks or to another skid.

For the proposed Lake Peekskill WTP with a firm capacity of 1.5 mgd, the Zenon Z-Weed membrane system would consist of three skid mounted units in parallel. Each skid will have a capacity of 0.75 mgd, allowing the maximum day flow of 1.5 mgd to be met with one of the units off-line. The system will utilize three stainless steel tanks, each of which contains 12 membrane cassettes. Each cassette, in turn, is comprised of 96 membrane modules. The Zenon membrane system is an automated and PLC based system with an operator interface provided.

The Zenon system has an integrity check to ensure the membranes are intact. This test can be automatically be performed every 24 hours or less and can be initiated at any time by the plant operator. The integrity check determines if there are any damaged membrane fibers using an air pressure decay test. In addition, the Zenon system has the ability to detect a membrane break through continuous particle count monitoring. Damaged cassettes can be removed from a process tank without taking the tank out of service.

8.3. Disinfection

8.3.1. Clearwell Size

The clearwell was sized to meet Stage I ESWTR regulations regarding CT (residual disinfectant concentration times the T_{10} contact time) to achieve the desired level of organism removal and/or inactivation. Specifically, 99.9 % (3-log) and 99.99% (4-log) inactivation/removal is required for Giardia lamblia cysts and enteric viruses, respectively. Under Stage I, disinfection capable of inactivating *Giardia lamblia* cysts is considered to be equally, or more capable of inactivating other organisms of concern. Therefore, 3-log removal of *Giardia lamblia* cysts will adequately provide 4-log removal of enteric viruses.

A 2-log removal "credit" is given under the *NYS Sanitary Code* for filtration facilities, thus lowering the required inactivation value through disinfection to 1-log. As the Lake Peekskill WTP will incorporate a filtration system, only 1-log inactivation from disinfection is required. New York is not allowing additional log removal credits for plants using more efficient filters such as membranes.

The following assumptions were made to estimate the minimum clearwell volume necessary for proper disinfection:

Target Cl_2 residual:	2 $^{mg}/_{L}$
Min water temp:	0.5° C
Max pH:	7.5

This gives a CT value of 96 $^{mg}/_{L}$ min and an effective detention time of 48 minutes. A baffling factor of 0.6 was chosen, which is considered superior by the NYS Department of Health. Based on a maximum flow of 1.5 mgd, the resulting minimum disinfection volume is 83,333 gallons. It should be noted that, while these inactivation/disinfection requirements are currently in effect, the proposed Stage II ESWTR is anticipated to have more stringent requirements for *Cryptosporidium* oocysts. If the Stage II ESWTR includes more stringent requirements, they are better addressed either by processes with higher removal credits or alternate disinfection strategies. The clearwell size would not need to be changed. Any of the proposed membrane systems would easily meet proposed changes in *Cryptosporidium* oocyst removal requirements.

For Lake Peekskill , the new water distribution network will be divided into a gravity system (lower pressure) and a pumped (upper pressure) system. Each will incorporate a storage tank to be utilized during peak hourly and fire demand periods. Each system will designed to handle one half of the total demand, and water for both systems will be drawn from the clearwell.

The clearwell working storage volume will provide some slack between the WTP output and the system demand. This arrangement would allow operators the option of filling the clearwell and storage tanks during the day and leaving the WTP idle during nighttime hours. The WTP would be unstaffed at night when system demand is at its lowest, but would have the capability of automatically starting-up when demand increases and the storage tanks and clearwell volumes drop below preset levels.

8.3.2. Clearwell Design

It is anticipated that the clearwell will be a cast-in-place concrete structure. The clearwell disinfecting volume is to be divided into two equal sized basins. This would allow servicing of one basin without taking the entire plant offline. During periods when one of the "chlorine contact" basins is out of service, the minimum required CT value of 96 mg/l · min will need to be met by either increasing the chlorine dose or reducing the WTP output.

As noted above, each chlorine contact compartment will have a baffling factor of 0.6. This can be achieved with baffles arranged in such a way to give an effective length to width ratio of 15:1. This is common practice in clearwell design. Both chlorine contact tanks will empty into the clearwell working storage volume.

8.3.3. Chlorination Equipment

The chlorine required for proper disinfection was estimated based on a 2.5 $^{mg}/_{L}$ average feed rate, a 4 $^{mg}/_{L}$ maximum feed rate and maximum flow into the clearwell (1.5mgd). It should be noted that the average and maximum feed rates are somewhat arbitrary at this point, and have been estimated based on previous experience with plants of this size. It is assumed that more accurate feed rates will be found using historical chlorine use data (feed rates, purchase data. etc.). Based on the assumed feed rates, the 30-day chlorine supply required was assessed at 420 lb. (420 gal). Given this, the most economical chlorination choice is a liquid sodium hypochlorite system.

The chlorination system should include a storage area, 500-gallon day tank, two metering pumps and associated piping and feed equipment. The storage area, day tank and pumps should be surrounded by a concrete curb designed to contain the maximum storage volume. A coating system chemically compatible with sodium hypochlorite should cover the floor and curb within the storage area. The sodium hypochlorite can be purchased in either 300 gallon totes or 55 gallon drums.

8.4. Residuals

Residuals for membrane WTPs consists of the backwash and chemical cleaning wastes streams. The waste from the in place chemical cleaning would be similar for the three manufacturer's previously discussed, but there would be significant differences in the make-up of the backwash waste flow. For a summary of membrane cleaning and residuals for each manufacturer see Table 8-1, Membrane Filtration Plants Residuals.

The first option for the disposing of the backwash and chemical cleaning waste streams would be to sewer the flow to a local sewage treatment plant (STP). In the event that a STP is not available to receive this waste, the alternatives described below would need to be implemented.

It is planned that the backwash waste flow would be discharged to a stream near the proposed location for the new WTP. The SPDES requirement for discharging a membrane WTP backwash into a New York State stream, as per the Department of Environmental Conservation (DEC), is shown below.

Suspended Solids: 20-40 mg/l
Settleable Solids: 0.1 ml/l
Chlorine Residual: 0.1 mg/l
pH range: 6-9
Temperature: 70° C for Trout Streams

It may necessary to store the chemical cleaning waste volume in an underground storage tank and haul it for treatment at a nearby sewage treatment plant. Chemical neutralization would be necessary for the chemical waste and depending on the membrane system, for the backwash waste as well.

Wasting the chemical cleaning volume to a New York State stream would more than likely not be feasible due to the suspended solids SPDES effluent requirement. If it is demonstrated that the neutralized chemical cleaning waste meets all the SPDES requirements, however, then discharging the waste to the previously mentioned stream may be a viable option. A summary of the expected residuals for each of the three membrane plants discussed in this facility report is shown in Table 8-1, Membrane Treatment Plant Residuals.

8.4.1. Koch

The total backwash and bleed waste flow for the Koch membrane system would be about 7 - 8 % of the total influent raw water flow, or 42,000 - 48,000 gallons per day based on the average demand. Backwashing for Koch membrane systems involve the use of caustic and a 100-200 mg/l solution of sodium hypochlorite. As a result, dechlorination and/or pH adjustment could be required before discharge to a New York State stream. Neutralization would not be necessary for the bleed flow. Backwash requirements would be determined during pilot testing.

The chemical cleaning waste volume generated for a Koch HF-40 V8048 stage is about 4,600 gallons. Typically, the cleaning process involves the use of a 200 mg/l sodium hypochlorite solution, a 0.5% caustic solution, or a 0.5% citric acid solution. The waste volume includes the wasting of spent chemicals and the water used to rinse the membranes. The chemical cleaning waste would require dechlorination or pH adjustment before being hauled from the underground storage tank to a STP. Cleaning requirements would be determined during pilot testing.

8.4.2. Memcor

The total backwash waste flow for the Memcor membrane system would be about 7 - 10 % of the total influent raw water flow, or 42,000 - 60,000 gallons per day based on the average demand. Backwashing for Memcor membrane systems does not involve the use of any chemicals. As a result, dechlorination would not be necessary before discharge to a New York State stream. Adjustment for pH may be necessary for the periods the Catskill Aqueduct waters fall below pH 6. Backwash requirements would be determined during pilot testing.

The chemical cleaning waste volume generated for a Memcor 90M10C skid is about 9,000 gallons. Typically, the cleaning process involves caustic or a 2% citric acid solution. The waste volume includes the wasting of spent chemicals and the water used to rinse the membranes. The chemical cleaning waste could require pH adjustment before being hauled from the underground storage tank to a STP. Cleaning requirements would be determined during pilot testing.

8.4.3. Zenon

The total backwash waste flow for the Zenon Z-Weed membrane system would be about 3 - 10 % of the total influent raw water flow, or 18,000 - 60,000 gallons per day based on the average demand. Backwashing for Zenon membrane systems involves the use of a 5 mg/l sodium hypochlorite solution. As a result, dechlorination may be necessary before discharge to a New York State stream. Adjustment for pH may be necessary for the periods the Catskill Aqueduct waters fall below pH 6.

The chemical cleaning waste volume generated for a Z-Weed tank is about 22,900 gallons. Typically, the cleaning process involves the use of a 250 mg/l sodium hypochlorite solution or a 1-2 % citric acid solution. The waste volume includes the wasting of spent chemicals and the water used to rinse the membranes. The chemical cleaning waste could require dechlorination or pH adjustment before being hauled from the underground storage tank to a STP.

8.5. Other Plant Facilities

8.5.1. Laboratory

New York State Department of Health Subpart 5-1, Public Water Systems, requires the following minimum monitoring for systems relying on a surface water supply and serving greater than 3,300 but less than 10,000 persons:

Table 8-1. ***Minimum Monitoring Requirements, Public Water Systems using Surface Water Supply***

Parameter	Frequency	Limit / Notes
Microbiological – Total and Fecal Coliforms	10 / month Total Coliform	>8,500 and <13,000 served No positive samples
	Fecal coliform all positive	No positive samples
Turbidity	Every 4 hours or continuous for *filtered* supplies on raw and treated	0.5 NTU conventional treatment 1.0 NTU DE / Slow Sand Filtration
	Daily for *unfiltered* supplies at entry point	1 NTU monthly average
	5 samples/week distribution system all	5 NTU, no two samples on same day or same location within week
Inorganics (As, Ba, Be, Cd,	Annually each entry point	MCL

Table 8-1. ***Minimum Monitoring Requirements, Public Water Systems using Surface Water Supply***

Parameter	Frequency	Limit / Notes
Cr, CN^-, F^-, Hg, Ni, Sb, Se, Th)		
Nitrate-Nitrogen	Quarterly each entry point	10 mg/L as N
Others (Ag,Cl^- ,Fe,Mn,Na^+,SO_4^{2-}, Zn, Color, Odor)	State discretion (if potential violation of limits)	MCL, SMCL
Lead and Copper	Twice/year initial monitoring until compliance demonstrated in 2 consecutive periods	0.015 mg/L Lead 1.3 mg/L Copper 40 sampling sites
Total Trihalomethanes (TTHM) Total Organic Carbon (TOC) UV-absorbance at 254nm (UV254)	TTHM - State discretion TTHM, TOC, UV254 - recommended quarterly, in plant and distribution system	80 µg/L TTHM MCL for distribution system samples TOC, UV254 on raw and treated in plant for treatment optimization
Principal and Specific Organic Contaminants (POC, SOC)	Quarterly sample for one year initial monitoring	MCL
Organic Chemicals, Pesticides, Dioxins, PCBs	Quarterly sample for one year initial monitoring, every 18 months thereafter	MCL
Radium-226, Radium-228, Gross alpha and Gross beta radioactivity	Annual composite of quarterly samples every four years	MCL
Disinfectant Monitoring	Continuous at entry point	≥0.2 mg/L
Concentration x Contact Time (CT) (pH, temperature and disinfectant residual)	Continuous at entry point	3-log *Giardia Lamblia* inactivation unfiltered supplies 1-log *Giardia Lamblia* inactivation filtered supplies 4-log inactivation of viruses achieved with *Giardia* CT

As a new system, the Lake Peekskill WTP will be required to conduct all monitoring in Table 1, including that to establish initial compliance.

State Certification may be sought for reporting monitoring parameters to the State. However, increased requirements would be necessary which would be both time consuming and costly. The main difference for certification is the need for a certified Lab Director, with a minimum 4-yr college education. Differences in salary requirements alone will be significant, in addition to efforts to fulfill annual proficiency testing and stricter laboratory QA/QC controls. In our experience, this additional effort and cost is not warranted for a small WTP.

Laboratory spacing requirements are suggested in Figure 8-2, New Water Treatment Plant – Building Layout. This laboratory size was estimated from past water treatment projects and assuming the plant operator's work station would be located within the laboratory space. Overall dimensions for laboratory area would be 15 ft by 22 ft. encompassing a U-shaped countertop with 10 ft length sections. The laboratory will contain a sink and an exhaust hood.

8.5.2. Corrosion Control

The alkalinity of Catskill Aqueduct water, as a consequence of acid rain, is very low. On average, the alkalinity level of the proposed raw water supply is 10.32 mg/l as calcium carbonate. The average pH is 6.92, with recorded minimums as low as 5.8. Alkalinity may help form protective coatings, and helps in preventing pH changes. Low to neutral pH tends to increase corrosion, as a result of higher hydrogen ion (electron acceptors) concentrations. Data on pH and alkalinity was obtained from the 1995 NYCDEP Report *Technical Memorandum, Task 2.1.1 Water Quality Regulations and New York City Water Quality Data* and is included as Appendix A.

As a result of the low alkalinity and low to neutral pH, water from the Catskill Aqueduct is very aggressive and may corrode distribution piping and fittings, and household fixtures. Corrosion is of concern because of the health, aesthetic, and O&M problems it may cause. Two toxic metals, lead and cadmium, that may occur in potable water are usually present as a result of leaching caused by corrosion. Other metals that are present in water as a result of corrosion induced leaching may lead to metallic taste and/or staining. For example, copper (blue stains and metallic taste), iron (red-brown stains and metallic taste), and zinc (metallic taste). In addition, corroded surfaces in the distribution system can provide locations for microorganisms to attach. These microbe habitats may also shield microorganisms from the chlorine residual. Microorganism growth can lead to bad tastes, odors, slimes, and additional corrosion. Some of the O&M problems associated with corrosion are listed below.

1. damage to pipes, fittings, and fixtures
2. loss of water and water pressure due to leaks
3. increased pumping costs

For the proposed Lake Peekskill distribution system, corrosion will be controlled by raising the pH with sodium hydroxide and adding a coating agent. To raise the pH from the average value of 6.92 to 7.5, a sodium hydroxide supply of approximately 2 mg/l, or 300 lbs/month is necessary. Using a 50 % solution of sodium hydroxide (12.8 lbs/gal), the monthly requirement can be met with 24 gallons.

In combination with the raising the pH, most water supply systems that tap into the Catskill Aqueduct are also using some form of phosphate for corrosion control. Orthophosphates form protective films that do not allow the water to come into direct contact with pipes, fittings, and fixtures. For corrosion control, a phosphate feed rate of 1-4 mg/l is necessary. This translates to an average dose of approximately 375 lbs/month as PO_4^{-3}. It is possible to use a phosphate blend corrosion inhibitor which is commercially available in a 34 % solution (11.3 lbs/gal). Approximately 35 gallons of this solution would be required per month.

8.5.3. Iron Control

Iron has a Secondary Maximum Contaminant level (SMCL) of 0.3 mg/l. From the *Technical Memorandum Task 2.1.1 Water Quality Regulations and New York City Water Quality Data*, the 1987 to 1994 measured concentrations of iron are well below the SMCL. The average concentration of iron for the Catskill Aqueduct is 0.09 mg/l, although there are rare measured levels up to 1.2 mg/l. Provisions could be made for iron removal just in case iron becomes a issue in the future.

Iron is typically removed by oxidizing the more soluble iron (II) to the less soluble iron (III), and removing the precipitate by filtration. Iron can be oxidized with molecular oxygen. The Zenon membrane system provides aeration in the process tanks to scour the membranes and dislodge solids. This air supply could also serve to oxidize iron (II) in the feed water. The Zenon system can therefore be used to remove iron, as the membrane barrier will not allow the passage of the insoluble iron (III) compounds.

The oxidation of iron (II) produces hydrogen ions and destroys alkalinity. This reaction is catalyzed by hydroxide ions and would be accelerated by the addition of sodium hydroxide. A sodium hydroxide feed point to the raw water could be provided in the event that iron removal becomes necessary.

Another method to control iron is to provide a sequestering agent. By selecting an appropriate phosphate, both iron control and corrosion control can be accomplished.

The selection of phosphate will be made during preliminary design. Alternate pH control locations would be considered for sodium hydroxide addition.

8.5.4. Feed Water Pump Station

The water from the Catskill Aqueduct is provided via a pump station that was most likely constructed in the 1930's and is located in the vicinity of the Catskill Aqueduct at Traverse Road. This existing pump station consists of pumps and appurtenances that are old and not sized to provide water to the entire Lake Peekskill community year round. In addition, the distribution piping for this system is not adequately protected from freezing, and is therefore not useable during winter months. For this facility to be used as the feed pump station for the new water treatment plant, it will be necessary to gut the existing building and replace all the pumps, equipment, piping, and wiring. It will also be necessary to refurnish the building itself by repairing the floor and roof, replacing windows and doors, installing a new HVAC system, and painting the walls. The intake piping to the Catskill Aqueduct was replaced in the 1980's and it is not anticipated that it will need to be replaced. The velocity in the intake piping would be within an acceptable range, even at the maximum day flow of 1.5 mgd.

It is expected that three centrifugal pumps with Variable Frequency Drives (VFDs) would be installed within the existing building once the building is repaired. Each pump will have a capacity of 0.75 mgd. The pumps will be able to provide the maximum day flow of 1.5 mgd with two units, allowing one unit to serve as a backup.

8.5.5. Distribution System Pumping

The distribution system pumps will provide water to the upper pressure system and to fill the upper pressure zone storage tank. The maximum day flow to the high-pressure system is approximately 0.75 mgd. Two pumps, each rated at 0.75 mgd, will be provided for the upper pressure zone. These units will be turbine type pumps, drawing water from the clearwell, and installed within the new water treatment plant building as shown in Figure 8-2, New Water Treatment Plant – Building Layout.

8.6. Treatment Plant Building

The architectural features of a building to house the membrane treatment plant is subject to review by the Town of Putnam Valley. To control cost, it is envisioned that a metal pre-fabricated building will be utilized. At this time it is assumed the existing soils will allow the use of floating slab construction, and piles are not required. This assumption will be checked during preliminary design by undertaking a soils boring and sampling program. The following is a tentative list of treatment plant building size criteria:

Treatment Plant Building	Tentative Size (ft^2)
Membrane Process Skids	1,977
Chemical Room	500
Laboratory and Operator's Workstation	330
Bathroom and closet	100
	2,907 ft^2

Approximate overall floor space 54'x 54'

9. Site Considerations

The proposed site of the water treatment plant (see Figure 8-1, Site Plan) will require consideration of several issues possibly impacting facilities design and the nearby residents.

9.1. Location

The location chosen for the proposed water treatment plant is in the vicinity of the existing pump station/Catskill Aqueduct connection at the end of Mimosa Street (Mill Road) in the southwestern corner of the study area. Factors in choosing this location are:

- close vicinity to existing water system facilities
- close vicinity to the Catskill Aqueduct
- presence and availability of municipally owned properties
- remotely located (not highly visible from the majority of the LPID)
- existing watercourse (necessary for water treatment plant discharge)

The *Recommended Standards For Water Works, 1997 Edition, (a.k.a. Ten States Standards)* recommends the following with respect to flood protection:

- main switch gear electrical controls shall be located above grade in areas not subject to flooding.
- no pump station should be subject to flooding.
- pump stations shall be elevated to a minimum of three feet above the 100 year flood or the highest recorded flood, whichever is highest.

According to the FEMA *Flood Insurance Rate Maps*, the proposed site is in Flood Zone C, areas of minimal flooding. Therefore no special flood proofing is required.

According to the *New York State Wetlands Inventory*, no portion of the treatment plant site contains mapped wetlands. The Town of Putnam Valley has adopted a wetland ordinance within the Town and accordingly the absense of local wetlands would have to be field verified by the Town Wetland Inspector.

The Town's ordinance requires a permit for activities in a wetland or adjacent area.

9.2. Neighborhood

The proposed water treatment plant site requires about one acre of land. There are homes nearby and special considerations in the proposed facilities have been included, such as building placement and landscaping. The Town may want to consider obtaining other underdeveloped lands surrounding the proposed facilities to provide increased visual buffer.

10. Cost of Treatment Facilities

Equipment and construction costs were based on manufacturers' quotes, RSMeans cost data, and past water treatment plant projects. Capital costs in this facility plan are shown in 1999 dollars and include an appropriate contingency. Percentages for legal, administration, engineering, permits, and bonds have also been incorporated into the total capital cost.

Capital and operating costs for the plant water quality laboratory were estimated based on the monitoring requirements outlined in Section 8.4, as well as for process control and optimization. For this evaluation, it was assumed that continuous process control monitoring would include in-line measurement of pH, temperature, turbidity, chlorine and orthophosphate (for corrosion control treatment). Major laboratory equipment supplies included a computer with internet access for data processing and reporting, below-counter refrigerator, acid-storage and standard cabinetry, a small point of use water polishing system (deionized and organic free water), bench-top and portable basic analytical equipment, and an optional exhaust hood. Costs for optional but recommended equipment such as continuous phosphate monitoring and installation of a laboratory exhaust hood are also included in the total capital costs. Outside laboratory fees were estimated for performing both initial compliance monitoring and subsequent periodic certified analyses and included in the total operating costs.

10.1. Capital Costs

10.1.1 Capital Costs – Connection to the Cortlandt Consolidated Water District

No treatment plant capital expenditures are anticipated for treatment facilities.

10.1.2 Capital Costs - New Water Treatment Plant

The estimated capital costs for the construction of a new 0.6 mgd membrane filtration water treatment plant includes the costs for the site work, plant building, membrane equipment, clearwell, feed and distribution pump stations, laboratory equipment, inside and outside plant piping, underground storage tank, emergency generator, and chemical feed systems.

The total capital cost for this plant is estimated at $5,790,000. Components of this total cost are shown in Table 10-1, Capital Costs – Membrane

Filtration Plant. This cost includes an allowance of $200,000 for pilot testing of the treatment systems.

Pilot testing is performed during the preliminary design phase. For treatment systems, especially water treatment systems such as membranes, pilot testing is required to establish site-specific design and operational criteria for each manufacturer's system performance. These criteria are utilized to establish a baseline of expected performance and become the basis for the design of the water treatment plant and selection of the treatment system equipment.

10.2. Operation & Maintenance (O&M) Costs

10.2.1. O&M Costs – Connection to the Cortlandt Consolidated Water District

No treatment O&M costs are associated with this option.

10.2.2. O&M Costs – New Water Treatment Plant

O&M costs were developed for the new treatment facility from manufacturers' quotes and past water treatment projects. The O&M costs are shown in 1999 dollars.

The O&M costs associated with this option would include staff, electrical, chemical, water testing and equipment replacement costs for the proposed membrane water treatment plant. The total annual O&M cost for this plant, as shown in Table 10-2 (O&M Costs – Membrane Filtration Plant), would be about $332,800 per year. This total includes salary and benefits for the expected staff of two operators. These two operators would also perform any necessary monitoring and sampling, and on-site laboratory work.

Plant Staffing Requirements

Factors that affect plant staffing requirements are level of plant automation, number of processes, and plant layout. The proposed membrane water treatment plant would incorporate a Programmable Logic Controller (PLC) system to monitor and control most plant functions. The plant would consist of one process stage and be housed completely within one building. Based on the above, a staff of two operators would be adequate for the proposed Lake Peekskill Water Treatment Plant. Each plant employee would have a workday from 8:00 AM to 4:00 PM, five days per week. Night and weekend staffing would not be necessary, however, the plant operators would be on call via a telephone connected to an autodialer system at the plant. Salaries and benefits for the two plant operators would be approximately $134,000 per year.

10.3. Cost of Water

10.3.1. Cost of Water – Connection to the Cortlandt Consolidated Water District

In lieu of building a new water treatment plant, the Lake Peekskill community may opt to purchase treated water. One likely source is the Cortlandt Consolidated Water District (CCWD). At the projected demand, the cost of purchasing treated water would be about $1,280,911 per year, based on out of district rates from the CCWD.

10.3.2. Cost of Water – New Water Treatment Plant

If Lake Peekskill decides to construct a new water treatment plant, then the New York City owned Catskill Aqueduct would continue to be used as the raw water source. Based on information from Lake Peekskill, the current cost for Catskill Aqueduct water is approximately $343.58 per million gallons. Assuming a projected demand of 469,000 gpd for the Lake Peekskill Improvement District, the total future cost of water would be $58,816 per year.

11. Distribution System

11.1. Distribution

Water distribution will be provided through a network of pipes and storage tanks relying primarily on gravity to provide adequate pressure to all users.

The proposed water distribution system consists of piping, valving, fire hydrants, pressure reducing valves (PRVs), storage tanks , master metering, service metering and service connections. The *Recommended Standards for Water Works, 1997 Edition (a.k.a. Ten States Standards)* was referenced for the design of the distribution system components, as it is the industry standard for this region.

The piping for the distribution system consists of 6 inch, 8 inch and 12 inch PVC—Class 200. DR 14 water main, with 4 to 4.5 feet of cover to protect the pipe from freezing. The distribution system was conceptually sized based on a pipe network analysis. The minimum and maximum permissible pressures in the system under average and maximum day and peak hour demands were assumed to be 35 psi and 120 psi, respectively. A minimum residual pressure of 20 psi was maintained in all parts of the distribution system under fire flows of 750 gpm and a simultaneous maximum day demand. The design average day demand is 600,000 gallons with maximum day and peak hour factors of 2.5 and 4.0 respectively.

A water distribution system model was developed using the Cybernet 3.1, by Haested Methods, Inc. computer program. A base model was developed using a combination of 6-inch, 8-inch, and 12-inch piping to connect the junctions located at each street intersection in order to meet the design parameters previously stated. Junction elevations were estimated utilizing USGS topographic mapping. System demand was assumed to be for residential use and was spread uniformly throughout the study area. A major consideration in conceptually designing the distribution system was the large range in elevation (600'+/-) within the service area. Refer to Figure 11-1, Topographic Map, for study area detail and Figures 11-2 and 11-3 for graphical output from the Cybernet 3.1 Pipe Network analysis computer program. The high point of the distribution system, is at approximately 720' while the lowest users are at approximately 100'. This elevation difference alone results in a 260 psi pressure differential. Therefore, the system was divided into 3 to 4 separate pressure zones, using pressure reducing valves (PRVs), and divide valves in order to keep pressures in the desired operating range. The divide valves are gate valves, which are normally kept closed, while the PRVs regulate the flow from higher elevations to lower elevations, and are called emergency cut-in valves. For ease of operation, a minimum number of pumps and emergency cut-in PRVs have been proposed for the system.

The conceptual distribution system design for both the connection to the Cortlandt Consolidated Water District distribution system and the new water treatment plant supply options are very similar. Two 345,000 gallon storage tanks, one located at the high point (El.740ft.+/- existing tank location) on Ridgecrest Road between Union Place and Alta Road, and the other located near the end of Mimosa Street near the Catskill Aqueduct (380 ft +/-).

Under the new water treatment plant supply option, three pressure zones were defined. The higher elevations of the system will be one pressure zone (upper presssure zone) supplied with water from the treatment plant's clearwell which will be pumped into the distribution system and the upper pressure zone storage tank. Water to the lower elevations of the system (two separate pressure zones) will be supplied water from the clearwell and a second storage tank by gravity into the lower pressure distribution system zones. During times when demand exceeds 1.5 mgd or the plant is idle or inoperative, the distribution system will be fed from the storage tanks.

For added flexibility, several automatically operated emergency cut-in pressure reducing valves will be provided at several locations in the distribution system. These valves will allow upper pressure zone water to be delivered to lower pressure zones when needed. The pressure reducing valves will be located in precast concrete vaults for access and maintenance.

The distribution system for the connection to the Cortlandt Consolidated Water District water distribution system supply alternative is very similar to the new water treatment plant supply alternative. The basic difference is there would be 4 separate pressure zones. The two lower zones would be supplied, under normal flow conditions, directly from Cortlandt; while the two higher elevation zones would require a booster pump station. This system would also utilize two storage tanks, one upper pressure zone tank and one lower pressure zone tank. The connection with Cortlandt was modeled with a connection in the Walnut Road area and with a booster pump station located at the existing pump house site between Mimosa Road and Traverse Road. For added flexibility, water could flow from the upper pressure zones to the lower pressure zones, as needed, through emergency cut-in valves.

The pipe network was routed within Town road right-of-ways as much as possible, in order to minimize the necessity for the district to obtain property or easements. In the few areas where the piping was not able to be within Town road right-of-ways, municipally owned properties were chosen as the first priority for the pipe routes. This will also reduce the need for easements on private property. The four different municipal bodies that own property in the study area are the Lake Peekskill Improvement District, the Town of Putnam Valley, the County of Putnam, and the City of New York. (Refer to Figure 11-2, Municipal Ownership Map.)

Fire hydrants are proposed for fire protection. Standard fire hydrants have 1-4½-inch pumper nozzle facing the road and 2-2½ inch outlets. *Ten State Standards* recommends a spacing range of 350 feet to 600 feet between hydrants. A 500 feet spacing was chosen for this study. Approximately 130 hydrants will be required for the LPID water system. Hydrants shall connect to the water main through a 6 inch diameter connection along with a 6 inch isolation valve.

Isolation valves along the water mains are provided so inconvenience and sanitary hazards are minimized during repairs. The *Ten State Standards* recommends a spacing of not more than 800 feet in non-commercial districts. An 800 feet spacing was chosen for this study. Approximately (110) 6-inch, (60) 8-inch and (12) 12-inch valves will be required for the LPID system. Each valve will have a valve box and cover for access and protection and will also serve as a visible marker for location and operation.

Restraints will be provided at all tees, bends, plugs, and fire hydrants in order to prevent movement of the piping due to thrust. Thrust is due to sudden changes in water flow rates and flow direction. Restraint is typically achieved utilizing poured, in-place concrete blocks, rodding and/or restraining glands and/or special pipe jointing.

11.2. Storage

According to design standards, distribution system storage should be provided for the average day demand plus fire flow volume. For this system, the design average daily demand is 600,000 gallons per day and the design fire flow volume is based on 750 gallons per minute for 2 hours (90,000 gallons), resulting in a total storage volume of 690,000 gallons. In addition, pressures in the water mains should not drop below 35 psi during normal periods and not lower than 20 psi at any time.

These conditions can be met with several alternatives for storage tanks, with respect to the planned upper and lower pressure zone systems. For the purposes of this facility plan it is envisioned that a 345,000 gallon storage tank would be provided in each zone. One would be located at the water treatment plant (lower pressure zone) and the other at the hill near Ridgecrest Road (upper pressure zone).

For the connection to the Cortlandt Consolidated Water District option, it is assumed that Cortlandt will supply up to the maximum day demand.

Therefore storage requirements would be the same as for the new treatment plant option, (two 345,000 gallon storage tanks) and at the same locations.

11.3. Pumping Stations

11.3.1. Pump Stations - Connection to the Cortlandt Consolidated Water District

During summer months, when water usage is high, the Lake Peekskill Community relies on water from the Catskill Aqueduct to supplement the normal well water supply. The water from the Catskill Aqueduct is provided via a pump station that was most likely constructed in the 1930's and is located in the vicinity of the Catskill Aqueduct at Traverse Road. This existing pump station consists of pumps and appurtenances that are old and not properly sized to provide water to the entire Lake Peekskill community year round. In addition, the distribution piping for this system is not adequately protected from freezing, and is therefore not useable during winter months. For this facility to be used as the feed pump station for the new distribution system, it will be necessary to gut the existing building and replace all the pumps, equipment, piping, and wiring. It will also be necessary to refurnish the building itself by repairing the floor and roof, replacing windows and doors, installing a new HVAC system, and painting the walls.

It is expected that three centrifugal pumps with Variable Frequency Drives (VFDs) would be installed within the existing building once the building is rehabilitated. Each pump will have a capacity of 0.75 mgd. The pumps will be able to provide the maximum day flow of 1.5 mgd with two units, allowing one unit to serve as a backup.

11.3.2. Pump Stations – New Water Treatment Plant

For the treatment plant option, see Section 8.5.5. for a description of pumping stations.

11.4. Service Connections

Each occupied parcel will be provided with a ¾ inch diameter (or larger if necessary) type "K" copper service line. The service line will have a corporation stop (shut-off valve and saddle) on the water main and a curb stop (shut-off valve) on the service line. The curb stop will be located at the property line/right of way line.

11.5. Service Metering

A meter will be installed on all service lines. The meter location will be within the building at the point the service line enters the building. The majority of the residential meters will be 5/8" meters. Various remote metering systems are available. The most common is a remote register, located on the outside of the building serviced, which shows the same reading as the actual water meter. These remove registers must be either physically read and the data manually recorded by water department personnel, or electronically read and recorded with a "meter reading wand" by water department personnel. An alternative to the need for water department personnel to physically go to each service is to install an automatic meter reading system that obtains meter readings automatically via the phone lines.

Each user will be equipped with a pressure reducing valve (PRV) inside the home. These valves prevent excessive pressures inside buildings.

11.6. Metering-Outside Source

An outside supply source, such as the connection to the Cortlandt Consolidated Water District, whether primary or secondary, will require metering to properly account for water use and subsequent billing to the LPID.

It is anticipated a 6 inch turbine meter would be installed to provide metering of an outside source. This type of meter typically can handle flows in the range of 20 gpm – 2,500 gpm. The meter installation would housed in an underground vault for protection and access, for maintenance and meter reading, and include a 12 inch by-pass to facilitate meter replacement and service without an interruption in water flow.

11.7. Staffing Requirements

Staffing requirements for the distribution system will differ for the two options studied. As mentioned in Chapter 10, if a new water treatment plant is constructed, 2 full time operators would be needed to operate the plant. It is assumed under this scenario that the 2 plant operators would also maintain the distribution system, performing routine operations and maintenance duties. It is assumed that the existing LPID facilities and manpower would be available to supplement the 2 plant operators for emergency situations.

For the connection to the Cortlandt Consolidated Water District, there is no treatment plant, therefore no plant operators. For this scenario, 1 full time employee is required for routine operation & maintenance of the water distribution system. It is assumed that the existing LPID facilities and manpower would be available to supplement the 1 employee for emergency situations.