DEP Permit Application

BRP WS 21D
Approval to Conduct Pilot Study ≥ 1 MGD

Nagog Pond Pilot Treatability Study
Acton, Massachusetts

Concord Public Water System

May 2013

Environmental Partners GROUP
A partnership for engineering solutions.

www.envpartners.com

Headquarters:
1900 Crown Colony Drive, Suite 402
Quincy, Massachusetts 02169
Phone: 617.657.0200
Fax: 617.657.0201

Woburn:
18 Commerce Way, Suite 2000
Woburn, Massachusetts 01801
Phone: 781.281.2542
Fax: 781.281.2543

Hyannis:
396 North Street
Hyannis, Massachusetts 02601
Phone: 508.568.5103
Fax: 508.568.5125

Town of Concord
Nagog Pilot Test Proposal
May 2013

Section 1: Background, Purpose, Scope

The Town of Concord, Massachusetts is bordered by the communities of Carlisle to the north; Acton and Maynard to the west; Sudbury and Wayland to the south; and Bedford and Lincoln to the east. The current annual average daily water demand for the Town of Concord is approximately 2.0 million gallons per day (MGD). Nagog Pond is a surface water supply for the Town of Concord that is located along the Littleton-Acton border.

Water from Nagog pond is currently treated in two locations: the Ozone Facility located adjacent to the pond and at the Rt 2A Pump Station, located approximately 1 mile to the southeast along Rt. 2A in Acton. A schematic plan of the existing Ozone Facility is presented in Figure 1. Raw water from Nagog Pond flows by gravity via the 16-inch intake pipe, gate/screen house, and wetwell, where it is then pumped through the Ozone Facility for oxidation/disinfection by ozone gas. The Ozone Facility has a permitted hydraulic design capacity of 1.5 MGD. Ozonated water then flows by gravity to the Rt. 2A Pump Station, where it is treated by ultraviolet (UV) light for disinfection, potassium hydroxide for pH adjustment, sodium fluoride for fluoridation, polyphosphate for sequestration, and sodium hypochlorite for secondary disinfection (chlorine residual). The treated water is then pumped to the Concord distribution system.

Nagog Pond is currently used as a public water supply under a Surface Water Treatment Rule filtration waiver. The raw water from Nagog Pond is typically below 1 NTU. In order to optimize this supply, the Town has embarked on an evaluation of filtration treatment alternatives. This will allow Nagog Pond to be used as a more reliable water supply regardless of variations in raw water quality.

The purpose and intent of this report is to present detailed information on Concord's pilot study proposal which meets the requirements of DEP's Policy #90-04 "Pilot Study Requirements for Proposed Treatment". The scope of the pilot study is to evaluate three alternative filtration processes for the production of high quality potable water and meet the latest drinking water regulations. The objectives of the pilot test are to:

1. Assess the effects of oxidation (oxidant type, dose, pH, contact time, and application point) for the precipitation and subsequent removal of source water iron and manganese and the enhancement of natural organic matter (NOM) removal from subsequent solids separation processes.

2. Assess the role of coagulation/flocculation (coagulant dose, pH, and mixing time) on the removal of NOM and solids separation performance.

3. Assess the effectiveness of dissolved air flotation for clarification and solids separation performance.

4. Assess the effectiveness of media filtration (with and without clarification) on solids separation performance.

5. Identify process operating parameters for the design of a full scale water treatment facility and development of detailed cost estimates, including: chemical dosages, mixing, and contact times; plant and process hydraulics; process sizing and loading rates; filtration media depths and materials; process cleaning cycles; and, residuals management.

Section 2: Source Water Quality Characterization

Nagog Pond has been used by the Town of Concord as a drinking water supply for over 100 years. As a result, there is an abundance of useful available water quality information to characterize the source water. Water quality sampling is routinely conducted on a daily, weekly, monthly, and annual basis as part of Concord's treatment and operations program and to meet DEP sampling requirements. A summary of recent existing available source water quality information for the period January 2000 through December 2012 is presented in the following table:

Table 1
Nagog Pond Water Quality Summary, 2000-2012

Parameter	Average	90th %tile	Minimum	Maximum
Temperature (°C)	14.5	N/A	3.9 (Jan)	27.8 (Aug)
pH (s.u.)	6.57	7.20	5.1	8.1
Alkalinity (mg/L $CaCO_3$)	8.5	13.0	1.0	26.0
Turbidity (NTU)	0.74	1.2	0.20	6.99
Apparent Color (cu)	17	26	ND	85
UV-254 (1/cm)	0.045	0.059	0.019	0.066
TOC (mg/L)	3.4	4.6	1.2	19.0
DOC (mg/L)	2.9	3.9	12.0	0.1
SUVA (m^{-1}/mg/L)	1.6	2.2	0.7	3.9
Algae (cells/mL)	1,355	2,320	40,000	ND
Iron (mg/L)	0.13	0.27	0.01	0.64
Manganese (mg/L)	0.063	0.09	0.001	2.1

To adequately evaluate and characterize the Nagog Pond source water, including the identification of treatment requirements, potentially suitable treatment technologies, and target piloting seasons, recent existing available water quality information is presented in the following figures:

Figure 2 – Nagog Pond Raw Water Temperature, January 2000 – December 2012
Figure 3 – Nagog Pond Raw Water pH and Alkalinity, January 2000 – December 2012
Figure 4 – Nagog Pond Raw Water Turbidity, January 2000 – December 2012
Figure 5 – Nagog Pond Raw Water Color, January 2000 – December 2012
Figure 6 – Nagog Pond Raw Water TOC, January 2000 – December 2012
Figure 7 – Nagog Pond Raw Water Iron, January 2000 – December 2012
Figure 8 – Nagog Pond Raw Water Manganese, January 2000 – December 2012
Figure 9– Nagog Pond Raw Water SUVA and UV-254, January 2000 – December 2012
Figure 10 – Nagog Pond Raw Water Algae, January 2000 – December 2012

Based on a review and evaluation of the information provided in Table 1 and Figures 2through 10, Nagog Pond is a high quality surface water supply with some seasonal variability: low turbidity (<1 NTU), moderate pH (6.0 to 7.0), low alkalinity (5 to 10 mg/L as $CaCO_3$), low levels of natural

organic matter (TOC: 2.5 to 3.9 mg/L), low levels of iron and manganese (Fe < ~0.3, Mn < ~0.1), with consistent background levels of algae and susceptible to algal blooms. The following discussion highlights the most important water quality characteristics for the proposed pilot study.

Temperature

Pond water temperature varies between a low of approximately 5°C in the winter and a high of approximately 25°C in the summer, which is typical for surface water supplies in this region. The proposed pilot study is timed to occur during the warmest summer days and coldest winter days. These two extreme periods represent the most challenging water treatment conditions for this surface water supply source.

pH and Alkalinity

Nagog Pond has a relatively consistent pH near neutral (6.0 to 7.0) despite typical alkalinity levels below 10 mg/L as $CaCO_3$. A pond with moderate pH and low alkalinity is usually very susceptible to pH fluctuations due to its limited buffering capacity. Nagog Pond's consistent pH could be attributed to effective source water protection measures that have been implemented by the community. The low raw water alkalinity suggests that chemical dosing should be consistently maintained to allow for stable treatment pH levels for optimal treatment chemistry.

Turbidity

With typical raw water turbidity readings below 1.0 NTU at Nagog Pond, the Town currently operates this supply under a filtration waiver. A review of historic raw water turbidity information indicates that turbidity levels occasionally can spike above 1.0 NTU. However, these low turbidity levels have been demonstrated to be readily treatable by both dissolved air flotation and direct filtration.

Organics

The color, TOC/DOC, UV-254, and SUVA levels found in the source water are indicative of low levels of natural organic matter (NOM). The organics appear to be from autotrophic sources rather than from the degradation of organic materials. Optimizing the removal of NOM is essential for controlling the formation of disinfection by-products (DBPs), especially for water systems using free chlorine for disinfection.

Iron and Manganese

The Secondary Standards for iron and manganese are 0.3 mg/L and 0.05 mg/L, respectively. The presence of iron or manganese in finished water can consume free available chlorine and contribute to aesthetically displeasing colored water. During the past 13 years at Nagog Pond, the majority of iron and manganese samples indicate levels at or below the Secondary Standards. However, seasonal episodes above Secondary Standards typically occur during the summer.

Algae

Since 2000, typical algae counts measured within Nagog Pond are typically in the range of 1,000 to 1,500 cells/mL, with a variety of different algae species detected. However, several episodes have occurred infrequently (every 2 to 3 years) resulting in levels in the order of 5,000 and 10,000 cells/mL. (One spike of 40,000 cells/mL reported in 2010 has been attributed to laboratory or sampling error.) Nagog Pond is known to have occasional algal blooms, resulting in taste and odor complaints if untreated (ozonated). The proposed pilot treatment processes were selected based on their demonstrated ability to remove algae and address the negative water quality impacts of algae (objectionable tastes and odors).

Section 3: Alternative Treatment Technologies

This section will examine the application of alternative treatment technologies for the treatment of Nagog Pond source water. In reviewing applicable candidate treatment technologies, the Town also considered the principles of Envision™ for targeting efficient and effective applicable water treatment technologies. The information provided in Section 2 indicates that the following water quality issues need to be addressed for the consistent production of high quality drinking water using Nagog Pond as a water supply source:

- Solids separation should be effective for the removal of low density particulates (algae, and floc formed from the coagulation of low turbidity waters containing NOM) and be suitable for treating turbidity spikes upwards in the range of 2 to 7 NTU.

- Treatment technologies suitable for the removal of algae cells while maintaining acceptable solids separation performance and net water production are recommended.

- The removal of NOM. This will help minimize the production of distribution system disinfection by-products (DBPs) and maintain distribution system chlorine residuals.

- The treatment and removal of source water iron and manganese to levels consistently below Secondary Standards.

- Processes suitable for the control of tastes and odors.

- Treatment technologies need to be effective in both cold water (less than 5°C) and warm water (greater than 25°C) conditions.

Technologies applicable for the treatment of Nagog Pond source water and the production of high quality drinking water are presented and discussed below:

Dissolved Air Flotation

Dissolved air flotation (DAF) is well-suited for the treatment of low turbidity waters, naturally colored waters, and algal laden waters. There are more than 200 full-scale DAF drinking water treatment plants currently operating in the United States, Scandinavia, Finland, the Netherlands, the United Kingdom, and South Africa. Water treatment plants utilizing DAF for clarification in Massachusetts are in operation in Cambridge, Lenox, Pittsfield, Rockport, Swansea, and Weymouth. These treatment plants report typical clarified water turbidities less than 0.5 NTU and excellent removal of algae.

Flotation as a clarification process involves the introduction of air at the head of the flotation tank and the attachment of particulates to the rising air bubbles. In drinking water applications, the most suitable flotation process is accurately described as pressurized recycle flow dissolved air flotation (hereupon referred to as DAF). In DAF a percentage of the treated flow is saturated with air under pressure and recycled back to the head of the flotation basin. The recycle stream is injected through either specially designed nozzles or needle valves resulting in the formation of bubbles with diameters between 10 µm and 120 µm (40 µm average). Successful particle-bubble attachments resulting in efficient flotation performance relies on properly destabilized particles controlled by coagulant dose, pH, and raw water quality conditions. Therefore, coagulation and flocculation are essential pretreatment processes for the successful application of DAF. Optimal coagulation/flocculation conditions for DAF can be predicted by standard jar tests.

A general treatment schematic of a water treatment plant incorporating DAF is presented in Figure 11. The pretreatment processes typically employed ahead of DAF include chemical addition for coagulation and pH adjustment followed by flocculation. Clarification by DAF is then usually followed by the separate unit process of filtration (media filtration or membrane filtration). However, there are applications that employ a common flotation/filtration cell referred to as stacked flotation. There are several stacked DAF/filtration facilities in operation in Connecticut. In addition, the largest DAF facility in the Unites States (290 MGD, New York City, NY) utilizes stacked DAF/filtration

Typical design and operating parameters for full scale DAF WTPs are presented in Table 3. Usually between 5 and 15 minutes of flocculation time at a G value of 70 S^{-1} is adequate for effective flotation. In the flocculation stage the formation of floc particles between 10 µm and 30 µm is favored for effective clarification performance. The recycle stream consists of either clarified or filtered water pressurized at 70 psi to 85 psi in an air saturation device (packed column or ejector). In practice typical recycle flows between 6% and 12% are used; however, research studies have demonstrated that between 6% and 8% (or 2,900 - 4,600 ppm of air) is sufficient for effective flotation. Clarified water is drawn from the bottom of the flotation basin while the floated sludge is removed from the water surface. Float sludge can either be continuously or intermittently removed by mechanical scrapers or by flooding. Overflow rates in a DAF basin can range between 4 and 18 gpm/sf resulting in nominal detention times between 5 and 15 minutes. However, DAF loading rates for stacked DAF/filtration are limited to practical filtration rates which are typically between 2 and 6 gpm/sf for high rate filtration.

Table 3
DAF Design and Operating Parameters

PARAMETER	RESEARCH STUDIES	UNITED STATES	NETHER-LANDS	FINLAND	UNITED KINGDOM
FLOCCULATION					
Time (min)	2-15	1-20	8-16	30-45	20-29
FLOTATION					
Time (min)	5-15	5-20	--	10-160	5-20
SOR (gpm/sf)	2-18	2.5-16	4-8	3-18	1-8
% Recycle	4-15	8-40	6.5-15	6-42	6-10
Sat. Pressure (psi)	50-85	70-90	60-115	43-100	45-120
RESIDUALS HANDLING					
Method of Choice	Mechanical Scrapers	Mechanical Scrapers	---	---	Mechanical Scrapers
Frequency, 1/h	Continuous	2 to 12 times /hour	---	0-24	0-2
Sludge % Solids	1-3	0.5 - 2	0.1-8	3	0.3-3

Filtration

Media filtration is one of the most common solids separation processes. In most cases, media filtration is preceded by clarification (DAF or sedimentation) to remove solids before the filter. Modern high rate media filters can achieve filter loading rates up to 8 gpm/sf. For low turbidity waters which are not susceptible to turbidity spikes or high particle loading rates, direct filtration can be suitable. Direct filtration is typically preceded by chemical treatment: coagulation/flocculation with polymer or with an aluminum based coagulant (sometimes both), and the filters are responsible for removing all of the solids. Direct filtration media filters can achieve filter loading rates up to 8 gpm/sf. One of the largest direct filtration water treatment facilities is located in Worcester. The Worcester facility has a hydraulic capacity of 50 MGD and uses pre-ozone for disinfection, coagulation/flocculation using alum and polymer, and dual media filters (sand and anthracite). The Worcester filters are designed for a filter loading rate of 8 gpm/sf and consist of 60 inches of anthracite and 12 inches or sand.

GAC media filters are used successfully at a number of water treatment plants in Massachusetts including, but not limited to: Andover, Billerica, Cambridge, Hingham, Ipswich, Lawrence, Methuen, Randolph, Tewksbury, Weymouth, and Wilmington. GAC media depths at these facilities range from 36 inches to 60 inches.

Discussions with the operators of several Massachusetts facilities indicate average GAC media filter run times between 24 and 72 hours, depending on water quality and filter loading rates. Applied filter loading rates at these facilities have been reported to be between 2 gpm/sf and 6 gpm/sf. Filter backwashing techniques in use include surface wash or air scour followed by a water only backwash to achieve a target bed expansion between 20% and 50%. GAC bed life at these faculties varies between 1 and 5 years. Most of the facilities evaluate the iodine number of the GAC media obtained from core sampling the filter bed to determine the condition of the carbon, and the need for replacement. Media replacement is usually conducted as a service contract by various GAC vendors.

However, when ozone is used ahead of GAC media filtration, the objective is to implement biological filtration whereby the adsorbed and captured NOM is assimilated by biological activity for enhanced removal. Another secondary benefit of GAC media filters is the control of tastes and odors, as discussed in the following section.

Control of Tastes and Odors

The majority of objectionable tastes and odors in surface waters are due to the presence of biological organisms (algae, bacteria, and fungi) or decaying vegetation. Biological related tastes and odors can be caused by the production of "extracellular metabolic by-products" or from the decomposition of dead cells. The most documented naturally occurring odor causing compounds associated with biological organisms are geosim and 2-methylisoborneol (MIB). The two most prevalent producers of geosim and MIB in surface water impoundments are "blue-green" algae and actinomycetes (a filamentous bacteria). Geosim has been classified as having an "earthy" odor while MIB has been classified as having a "musty" odor. Geosim and MIB can cause objectionable odors at levels as low as 9 ng/L (nanograms per liter).

The most successful treatments for tastes and odors in drinking water are oxidation and adsorption using activated carbon (either powdered activated carbon or granular activated carbon). Oxidation can be accomplished by ozone, chlorine dioxide, chlorine, and potassium permanganate. Chlorine dioxide and ozone have been shown to have the greatest success, while potassium permanganate has been reported to have worked in several applications. Although chlorine has been shown to be successful, it is usually not practiced ahead of NOM removal due to the production of disinfection by-products. Additional secondary impacts of oxidation for taste and odor control include:

- The potential benefits of pre-oxidation as an aid to coagulation, increased NOM removal, and the simultaneous oxidation of iron and manganese.
- The potential production of assimilable organic carbon (AOC) by ozone, which if not removed can increase the likelihood of biological regrowth in the distribution system and serve as a substrate for distribution system biofilms.
- The potential production of brominated disinfection by-products and bromate while using ozone.
- Ozone can react with NOM to produce aldehydes, which impart a "fruity" odor.
- The use of chlorine dioxide can result in unacceptable levels of inorganic by-products such as chlorite and chlorate.

Activated carbon, both GAC and PAC has been successfully used to treat tastes and odors at many drinking water treatment facilities in Massachusetts. It is documented that the communities of Braintree, Essex, North Brookfield, and Salem-Beverly use PAC. Typical PAC dosages in the order of 2 to 25 mg/L have been reported to be successful.

Other communities which use GAC media filters have also reported excellent control of tastes and odors. The successful control of tastes and odors have been reported for carbon empty bed contact times (EBCTs) between 5 and 15 minutes.

Some of the benefits of GAC media filtration for the control of tastes and odors include:

- GAC acts as a filter media capable of filtered water turbidities less than 0.1 NTU.

- GAC also adsorbs various other natural and man-made organics, including disinfection by-product pre-cursers, and AOC.
- GAC has been shown to adsorb taste and odor compounds even after the adsorptive capacity for other compounds has been reached.

Section 4: Water Quality Regulatory Approach

This section describes the requirements of several drinking water quality regulations as they relate to the scope and objectives of the proposed pilot study.

Surface Water Treatment Rule

The Surface Water Treatment Rule (SWTR) was promulgated by the United States Environmental Protection Agency (USEPA) in 1989 to protect public drinking water from waterborne microbiological pollutants such as *Giardia* and viruses. Under the provisions of the SWTR, all public water systems using surface water supplies or groundwater supplies under the direct influence of surface water must provide disinfection. In addition, unless the water meets strict water quality criteria, filtration is required to physically remove waterborne microorganisms that are resistant to conventional disinfection practices (chlorination) and may be present in the water. For water systems in the Commonwealth of Massachusetts, detailed requirements of the SWTR are defined in 310 CMR 22.20A.

Approved filtration technologies include conventional filtration, direct filtration, diatomaceous earth filtration, slow sand filtration, and membrane filtration. Combined filtration and disinfection must achieve 99.9% (3-log) removal/inactivation of *Giardia* and 99.99% (4-log) removal/inactivation of viruses. Removal credits are achieved for several water treatment processes such as sedimentation (2.5-log), dissolved air flotation (2.5-log), and direct filtration (2-log). Under the rule, 95% of monthly filtered water turbidity samples must be less than 0.5 NTU, and the maximum allowable filtered water turbidity is 5 NTU. Inactivation credits are achieved based on the type, concentration, and dose of disinfectant, water temperature and pH, and the contact time between the disinfectant and the water. The SWTR has been updated with additional requirements as described in the sections that follow.

The Town of Concord has a filtration waiver under the SWTR. To maintain a filtration waiver:

1. *Source water total coliform samples must be $\leq$ 100/100 mL (or fecal coliform samples must be $\leq$ 20/100 mL) in 90% of the samples.*
2. *Source water turbidity must be $\leq$ 1 NTU, except that a turbidity $\leq$ 5 NTU may be allowed if the higher turbidity does not:*
   - *Interfere with disinfection.*
   - *Prevent maintenance of an effective disinfectant agent throughout the distribution system.*
   - *Interfere with microbiological determinations.*
3. *Source water turbidity cannot exceed 5 NTU (at any time) unless:*
   - *DEP determines that any such event was caused by circumstances that were unusual and unpredictable; and,*

- *As a result of any such event, there have not been more than two events in the past 12 months the system served water to the public, or more than five events in the past 120 months the system served water to the public, in which the turbidity level exceeded 5 NTU. An "event" is a series of consecutive days during which at least*

The Town currently has ozone, UV-light, and chlorine facilities to meet the log inactivation requirements for Giardia and viruses.

Enhanced Surface Water Treatment Rule

Under the 1996 amendments to the Safe Drinking Water Act (SDWA), improvements to the SWTR were proposed by the USEPA in the form of an Enhanced Surface Water Treatment Rule (ESWTR). These changes addressed increased removal/inactivation requirements for poorer quality source waters and proposed treatment requirements for the removal/inactivation of *Cryptosporidium*, which was found to be highly resistant to standard disinfection practices. The ESWTR applied to water systems already regulated by the SWTR.

Implementation of the ESWTR proceeded based on USEPA's promulgation and enactment of four major provisions:

1. The Interim Enhanced Surface Water Treatment Rule (IESWTR),
2. The Long Term 1 – Enhanced Surface Water Treatment Rule (LT1ESWTR),
3. The Long Term 2 – Enhanced Surface Water Treatment Rule (LT2ESWTR), and
4. The Filter Backwash Recycling Rule (FBRR).

Interim Enhanced Surface Water Treatment Rule

The IESWTR was promulgated in December 1998 and applies to water systems serving a population greater than 10,000. The main purpose of the IESWTR is to provide increased protection against *Cryptosporidium* and to guard against increases in microbial risk that might otherwise occur as systems also implement the Stage 1 Disinfectants/Disinfection By-Products Rule (D/DBPR). The IESWTR requires all large systems (i.e. those serving more than 10,000 people) that are required to filter under the SWTR to provide 2-log (99%) removal of *Cryptosporidium*. Physical removal of *Cryptosporidium* is required under the IESWTR because *Cryptosporidium* is highly resistant to standard disinfectant practices. For water systems in the Commonwealth of Massachusetts, detailed requirements of the IESWTR are provided in 310 CMR 22.20D.

Compared with the SWTR, the IESWTR provides more stringent turbidity standards and requires individual filter monitoring, the establishment of a disinfection benchmark, and a requirement for covering new water storage reservoirs. Under the IESWTR, the required 2-log *Cryptosporidium* removal is accomplished as long as the new turbidity standards are met. The rule also requires additional watershed control measures for systems with a filtration avoidance waiver. Large systems, such as the Concord Water System, were required to be in compliance with the

requirements of the IESWTR by December 2001. A summary of turbidity and filter monitoring requirements for conventional filtration is provided below:

- The average Combined Filter Effluent (CFE) Turbidity must be $\leq$ 0.3 NTU in 95% of monthly samples.
- The maximum CFE turbidity must be < 1.0 NTU.
- Individual turbidity monitors required for each filter.
- If the turbidity of an individual filter exceeds 0.5 NTU after 4 hours of operation following a backwash or being off-line in two consecutive measurements taken 15 minutes apart, then a filter turbidity profile must be completed within 7 days.
- If the turbidity of an individual filter exceeds 1.0 NTU in two consecutive measurements taken 15 minutes apart in three consecutive months, then a self assessment of the filter must be completed within 14 days.
- If the turbidity of an individual filter exceeds 2.0 NTU in two consecutive measurements taken 15 minutes apart in two consecutive months, then a Comprehensive Performance Evaluation must be completed.

Because the Town of Concord has operated Nagog Pond with a filtration waiver from the DEP, the Town has not been required to meet these filter effluent turbidity requirements. However, one focus of the proposed pilot study will be to demonstrate compliance with the aforementioned filter turbidity requirements of the IESWTR.

Filter Backwash Recycling Rule

The Filter Backwash Recycling Rule (FBRR) was promulgated by USEPA in June 2001 (Federal Register, June 8, 2001). This rule applies to water systems that (1) use a surface water source or ground water source under the direct influence of surface water, (2) employ conventional filtration, direct filtration, softening, or contact clarification treatment, and (3) recycle spent filter backwash water, thickener supernatant, or liquids from dewatering processes. Water systems are required to notify DEP and submit a process treatment schematic, typical recycle flows, maximum recycle flows, and the hydraulic capacity of the treatment facility. Recycle flows must be introduced into the treatment stream prior to coagulation. For water systems in the Commonwealth of Massachusetts, detailed requirements of the FBRR are defined in 310 CMR 22.20E.

This requirement may come into play during the design phase depending on the approach for handing residuals on-site.

The Long Term 1 – Enhanced Surface Water Treatment Rule

The Long Term 1 ESWTR (LT1ESWTR) was promulgated by USEPA in April 2000 (Federal Register, April 10, 2000) to extend the provisions of the IESWTR to systems serving populations less than 10,000. The rule was finalized in January 2002 (Federal Register, January 14, 2002). Under the LT1ESWTR, all of the provisions of the IESWTR were extended to small systems required to filter under the SWTR. Systems had to come into compliance with the final rule by

January 2005. For water systems in the Commonwealth of Massachusetts, detailed requirements of the LT1ESWTR are defined in 310 CMR 22.20F.

The Long Term 2 – Enhanced Surface Water Treatment Rule

The Long Term 2 ESWTR (LT2ESWTR) was proposed by USEPA in August 2003 (Federal Register, August 11, 2003) to reduce disease incidence associated with *Cryptosporidium* and other pathogenic microorganisms in drinking water and to supplement existing regulations by targeting additional *Cryptosporidium* treatment requirements to higher risk systems. The rule was finalized in January 2006 (Federal Register, January 5, 2006). The final regulation also contains provisions to mitigate risks from uncovered finished water storage facilities and to ensure that systems maintain microbial protection as they take steps to reduce the formation of disinfection byproducts. The LT2ESWTR applies to all systems that use surface water or ground water under the direct influence of surface water. The LT2ESWTR was implemented concurrently with the Stage 2 D/DBP Rule so that systems do not jeopardize DBP levels as a result of meeting the requirements of LT2ESWTR. For water systems in the Commonwealth of Massachusetts, detailed requirements of the LT2ESWTR are defined in 310 CMR 22.20G.

Under the LT2ESWTR, systems regulated under the SWTR must perform two rounds of sampling 6 years apart (unless "grandfathered" data is available) to determine their additional *Cryptosporidium* inactivation requirements. In general, each round must consist of monthly source water sampling for *Cryptosporidium*, *E. Coli*, and turbidity for a period of two years, or semi-monthly sampling for a period of 1 year. Small systems are allowed to use *E. coli* as a surrogate for *Cryptosporidium* monitoring as long as *E. coli* concentrations are below an established level. Plants that operate for only part of a year also have reduced sampling requirements. These sampling results dictate inactivation requirements, and these requirements differ for filtered and unfiltered systems.

Filtered systems are assigned into one of four bins. Each bin has its own log inactivation requirements depending on the selected treatment technologies. The "tool box" of available treatment technologies includes watershed controls, alternative sources, pretreatment, improved treatment performance, supplemental filtration, disinfection, and peer review performance testing. The additional LT2ESWTR *Cryptosporidium* removal/inactivation requirements for filtered systems are summarized in Table 4:

Table 4
***Cryptosporidium* Inactivation Requirements for Filtered Systems**

Source Water *Cryptosporidium* Level (Bin)	Log Inactivation Requirement	Additional Requirements
Cryptosporidium ≤ 0.075/L	No Action Required	None
0.075/L ≤ *Cryptosporidium* ≤ 1.0/L	≥ 1-log	Any technology from tool box
1.0/L ≤ *Cryptosporidium* ≤ 3.0/L	≥ 2-log	At least 1-log removal from ozone, ClO_2, UV, membranes, bag/cartridge filters
Cryptosporidium ≥ 3.0/L	≥ 2.5-log	At least 1-log removal from ozone, ClO_2, UV, membranes, bag/cartridge filters

Unfiltered systems must provide at least 2-log inactivation of *Cryptosporidium* (or at least 3-log inactivation if the average *Cryptosporidium* level exceeds 0.10 oocysts/L). These systems need to use chlorine dioxide, UV, or ozone to achieve the mandated *Cryptosporidium* inactivation. Unfiltered systems are also required to use at least two disinfectants so that they can meet the requirements of the LT2ESWTR and the SWTR separately.

The Town of Concord regularly samples Nagog Pond for* Cryptosporidium *once a month. Historic results are presented graphically in Figure 12. To comply with the initial sampling requirements of the LT2ESWTR, the Town of Concord submitted 24 months of grandfathered data from August 2005 to July 2007. Because Nagog Pond has very low* Cryptosporidium *oocyst concentrations, the current facility is in bin 1 for unfiltered systems and only has a 2-log inactivation requirement, which it achieves using the existing ozone and UV facilities. Under a Concord filtration facility, the Town would not need to include additional inactivation technology because the facility would be placed into Bin 1 (average* Cryptosporidium *≤ 0.075 oocysts/L). Consequently, the proposed pilot study does not need to evaluate additional* Cryptosporidium *inactivation to comply with the LT2ESWTR.

Disinfection/Disinfection By-Product Rule

Chemical reactions between natural organic matter (NOM) and the disinfectant chlorine can produce regulated organo-chlorine compounds called disinfection-by-products (DBPs). A group of four DBPs (chloroform, bromoform, bromodichloromethane and dibromochloromethane) referred to as total trihalomethanes (TTHMs), are regulated under the SDWA. The MCL for TTHMs under the SDWA of 1986 is 100 µg/L, based on a running annual average (RAA) of quarterly distribution system THM sampling results. This MCL for TTHMs applies only to community water systems which serve a population of 10,000 or more and which use a disinfectant in any part of their drinking water treatment process. Detailed requirements of the TTHM Rule are provided in 310 CMR 22.07.

The Disinfectants/Disinfection-by-Product Rule (D/DBPR) was promulgated by the USEPA in December 1998 (Federal Register December 16, 1998), and applies to all water systems that utilize a disinfectant. Under the Stage 1 D/DBPR, the TTHM MCL was lowered to 80 µg/L, and MCLs were established for a group of five haloacetic acids (HAA5: mono-chloroacetic acid, di-chloroacetic acid, tri-chloroacetic acid, mono-acetic acid, and di-acetic acid) at 60 µg/L, bromate at 100 µg/L, and chlorite at 1 mg/L. Compliance is determined based on a RAA of samples taken quarterly or annually, where the number of samples taken depends on system size and whether the source is under influence of surface water. Chlorite monitoring is required for systems that use chlorine dioxide, and bromate monitoring is required for systems that use ozone. Systems may qualify for a reduced long-term monitoring schedule if byproduct concentrations remain low.

Maximum residual disinfectant levels (MRDLs) for chlorine, chloramines, and chlorine dioxide are also established at 4 mg/L as free chlorine, 4 mg/L as total chlorine, and 0.8 mg/L as ClO2, respectively. Monitoring requirements also exist for disinfection byproduct precursors, such as TOC and bromide. TOC removal may be required if concentrations exceed 2.0 mg/L as shown in Table 5. For water systems in the Commonwealth of Massachusetts, detailed requirements of the Stage 1 D/DBP Rule are defined in 310 CMR 22.07E.

Table 5
TOC Removal Requirements

Source Water TOC (mg/L)	Source Water Alkalinity (mg/L as $CaCO_3$)		
	0-60	>60 - 120	> 120
>2.0 – 4.0	35%	25%	15%
>4.0 – 8.0	45%	35%	25%
>8.0	50%	40%	30%

The Stage 2 Disinfectants/Disinfection-by-Product Rule was proposed by USEPA in August 2003 (Federal Register, August 18, 2003). The rule was finalized in January 2006 (Federal Register, January 4, 2006). For water systems in the Commonwealth of Massachusetts, detailed requirements of the Stage 1 D/DBP Rule are defined in 310 CMR 22.07F.

The Stage 2 D/DBPR applies to all water systems using a disinfectant other than UV and establishes more stringent TTHM and HAA5 standards. The updated TTHM and HAA5 standards were implemented in two phases:

- Under Phase I, all systems were required to meet running annual averages (RAAs) of 80 µg/L for TTHMs and 60 µg/L for HAA5s and locational running annual averages (LRAA) of 120 µg/L for TTHMs and 100 µg/L for HAA5s. Systems had to comply with the Phase I levels within three years after the rule was promulgated in January 2006, except that an additional two-year extension was available for systems requiring capital improvements; and

- Under Phase II, all systems were required to conduct an initial distribution system evaluation (IDSE) based on system size and source water type to determine new DBP monitoring sites that represent maximum DBP formation sites, unless historic monitoring results indicated TTHM levels less than 40 µg/L and HAA5 levels less than 30 µg/L (40/30 certification). In addition the LRAA levels for TTHMs and HAA5s were lowered to 80 µg/L and 60 µg/L, respectively. Compliance scheduling depends on system size: large sized systems (>100,000) must be in compliance by April 1, 2012 (within 6 years of the final rule); medium sized systems (>50,000) must be in compliance by October 1, 2012 (within 6.5 years); small systems required must be in compliance by October 1, 2013 (within 7.5 years of the final rule); except that an additional two year extension is available for systems requiring capital improvements.

Compliance with the D/DBPR is a delicate balance between achieving compliance with the surface water treatment rules, the Revised Total Coliform Rule, and the Lead and Copper Rule, since all of these rules can relate to the use and application of disinfectants and distribution system pH levels. Although disinfection is required to ensure the protection against waterborne pathogens, the misuse of disinfectants can result in unallowable levels of disinfection by-products.

Concord is currently qualified for a 40/30 certification. The pilot study will examine the potential formation of DBPs and bromate.

Total Coliform Rule

While the SWTR/ESWTR addresses source water microbiological pollutants, the 1989 Total Coliform Rule (TCR) and the 2013 Revised Total Coliform Rule (RTCR) address the protection against waterborne bacteria in drinking water distribution systems. Compliance with the TCR was based on distribution system sampling results and the detection of total coliforms. Coliforms are a collective group of microorganisms that typically originate from the intestines of warm-blooded animals, but which may also occur naturally in the environment. Therefore, a subset of the total coliform group (E. coli or fecal coliforms) is used to identify fecal contamination. The EPA recognized that total coliform detection does not itself necessarily signify a health threat, so in 2013, the EPA issued the RTCR to focus on E. coli. The MCL and MCL Goal (MCLG) for total coliforms were eliminated and replaced with an MCL and MCLG for E. coli.

Water systems must collect a minimum number of distribution system samples per month based on the population served. Compliance with the RTCR is based on the presence or absence of E. coli. For water systems collecting less than 40 distribution system samples per month, no more than one sample per month can be positive for E. coli. For water systems collecting more than 40 distribution system samples per month, compliance with the RTCR is achieved if no more than 5% of the samples are positive. Any positive coliform sample must be re-sampled within 24 hours and two additional samples taken (upstream and downstream of the site). A system is out of compliance if the results of repeat sampling are positive for fecal coliforms or E. coli, in which case the water system must contact the DEP within 24-hours and perform public notification.

Best available treatment techniques for compliance with the RTCR include source water protection, filtration, primary disinfection, and secondary disinfection. Detailed requirements of the TCR for Massachusetts public water systems are provided in 310 CMR 22.05. The Massachusetts DEP RTCR regulations are anticipated to be finalized in 2016.

The proposed pilot study for the Town of Concord will not specifically address or evaluate compliance with the TCR or RTCR. The Town of Concord is currently in compliance with the TCR.

Lead and Copper Rule

The Lead and Copper Rule (LCR) was promulgated by USEPA on June 6, 1991 based on the requirements of the 1986 Amendments to the SDWA. The objective of the LCR is to reduce consumer exposure to lead and copper resulting from corrosion of drinking water piping and plumbing systems. Unlike other drinking water regulations that establish maximum contaminant levels (MCLs), the LCR requires various treatment techniques, such as optimal corrosion control treatment, source water treatment, public education, and lead service line replacement, which are triggered by lead and copper action levels (AL's) measured at the consumer's tap. USEPA has set AL's at a 90th percentile concentration of 0.015 mg/L for lead and 1.3 mg/L for copper, respectively.

Water systems must sample tap water distribution system sites for lead and copper and for corrosion control water quality parameters based on service population. Sampling sites are selected based on an inventory of distribution system materials (lead services) and residential house age (homes built just prior to the USEPA lead ban, between 1982 and 1986). Systems that comply with the 90th percentile Action Levels are eligible for reduced monitoring. Systems exceeding the lead Action Level must install optimal corrosion control, perform source water monitoring, replace lead service lines, and complete a lead public education program annually.

Under the 1996 amendments to the SDWA, USEPA provided several revisions to the LCR (Federal Register, January 12, 2000) including changes or additions in requirements for the demonstration of optimal corrosion control, lead service line replacement, public education, monitoring, analytical methods, reporting and record keeping, and special primacy considerations. Subsequently, USEPA published minor corrections and revisions to the LCR in 2004 and 2007. Detailed requirements of the LCR are provided in 310 CMR 22.06B.

This proposed pilot study will not be evaluating alternative methods for compliance with the LCR. The Town of Concord's most recent round of tap water sampling indicated 90th percentile lead and copper levels less than the Action Levels. The Town currently uses pH adjustment and a phosphate inhibitor for the control of tap water lead and copper levels.

Section 5: Pilot Test Description

The proposed pilot study will examine different methods for using dissolved air flotation for clarification and dual media for filtration (alone and following DAF). In addition, the pilot study will compare the use of potassium permanganate and ozone for pre-oxidation and the use of ozone after clarification. A schematic diagram of the proposed pilot treatment processes is presented in Figure 13.

During a screening analysis, other processes were considered for piloting, but not selected, including the following clarification alternatives: gravity plate settling, contact clarification, ballasted flocculation, and magnetic ion exchange. Although these technologies all have small footprints, dissolved air flotation was selected for its superior ability to handle low density particles, in particular algae. Membrane filtration technology was also evaluated as an alternative to dissolved air flotation and media filtration; however, its complexity, high costs (capital and O&M), substantial operation and maintenance requirements, and potential sensitivity to algal blooms eliminated it from further consideration.

The proposed pilot test will be completed on the site of the existing Nagog Pond ozone treatment facility. A site layout of the full scale facilities and the location of pilot treatment units and piping are presented in Figure 14. Raw water will be obtained from intake screening and gate house and pumped to a common tank for the pilot vendors to draw from. Any excess raw water not used will be directed to Nagog Brook. Treated water (clarification and filter effluent) will also be directed to Nagog Brook. Filer backwash waste and clarification residuals will be directed into an engineered infiltration and collection system (refer to Figure 14). The infiltration system will consist of an excavated pit filled with crushed stone overlying a geotextile filter fabric. The perimeter of the pit will be surrounded by a berm or staked hay bales and silt fencing with an overflow directed to Nagog Brook. The infiltration system will be located adjacent to the ozone facility and pilot trailers. Solids will settle within the collection system and be retained by the geotextile filter fabric, while the liquid (water) will infiltrate into the ground. Any excess liquid that does not infiltrate into the ground will be directed to Nagog Brook. At the conclusion of the pilot test, the accumulated solids from the infiltration system will be removed and legally disposed. All discharges to Nagog Brook will be clean water (of higher quality than raw water from Nagog Pond) and include appropriate energy dissipation to prevent scouring.

After a detailed review and assessment of source water quality information, it is recommended that the pilot study be conducted for two seasons: cold water and warm water. These two seasons represent the most challenging periods for treating Nagog Pond source water, and therefore piloting additional seasons is unnecessary for the identification of appropriate design and operating parameters and to demonstrate effective treatment performance.

We are proposing to conduct warm water testing in July 2013 and August 2013 when source water temperatures are typically greater than 20°C. The cold water pilot testing shall occur in January 2014 and February 2014, or whenever source water temperatures are less than 7° C. A minimum of 5 filter runs will be performed during each season. At least three (3) filter runs will be performed at design loading rates and two (2) filter runs will be performed at peak loading rates. The proposed pilot test schedule and filter run loading rates are presented in Table 6.

Table 6
Proposed Pilot Test Schedule
and Filter Run Schedule

	Dissolved Air Flotation	Stacked DAF/Filtration	Direct Filtration
Schedule (warm)	3 weeks 7/29/13 – 8/16/13	3 weeks 7/29/13 – 8/16/13	3 weeks 7/29/13 – 8/16/13
Schedule (cold)	3 weeks 1/27/14 – 2/14/14	3 weeks 1/27/14 – 2/14/14	3 weeks 1/27/14 – 2/14/14
Clarifier Runs Design	2 @ 8 gpm/sf		N/A
Clarifier Runs Design	2 @ 10 gpm/sf	3 @ 6 gpm/sf	N/A
Clarifier Runs Peak	2 @ 14 gpm/sf	2 @ 8 gpm/sf	N/A
Filter Runs Design			2 @ 4 gpm/sf
Filter Runs Design	3 @ 6 gpm/sf	3 @ 6 gpm/sf	2 @ 6 gpm/sf
Filter Runs Peak	2 @ 8 gpm/sf	2 @ 8 gpm/sf	2 @ 8 gpm/sf

Filter runs will be terminated based on head loss (4 to 6 feet) or turbidity breakthrough (0.3 NTU). It is expected that the filter runs will last between 24 hours and 72 hours. The filter columns will run on a continuous basis while turbidity and headloss are monitored and recorded using on-line instrumentation and data logging. At least one filter run will be operated to terminal head loss.

Filter backwash conditions to be evaluated during the pilot test include the use of air scour versus wash water alone. Backwash rates for 20% expansion and 50% expansion will be determined. Manufacturer information and full scale experience with similar GAC filters suggests a filter bed expansion of at least 20% for a period of 8 to 15 minutes for effective backwashing. Air scouring will be examined at a rate of 3 to 5 cubic feet per minute (CFM).

Chemical addition for the pilot study will consist of two alternative oxidants for taste and odor control and iron and manganese oxidation. The proposed oxidants will be potassium permanganate and ozone. Oxidant dosages will be based on stoichiometric requirements of the raw water or clarified water as determined by water quality sampling during the pilot testing period. For coagulation, we are proposing to use a high basicity polyaluminum chloride due to the low alkalinity of the source water.

The treatment units will be staffed 8 to 16 hours per filter run. The following on-line instrumentation will be used to operate, monitor, and record treatment performance during automated operations: flow, rate controllers, chemical feed pacing, pressure transmitters, pH meters, and turbidimeters. Raw water, clarified water, filtered water, and process residuals will be collected and tested for the water quality parameters shown in Table 7. Routine water quality analyses (temperature, pH, alkalinity, turbidity, color, UV-254, iron, and manganese) will be completed by the pilot operations staff using on-site bench-top instruments. Bench top laboratory instruments will be used to complete the analyses include: a HACH ratio turbidimeter, HACH spectrophotometers (HACH DR 4000), a Fischer Scientific pH analyzer, and a HACH digital titrator. All bench top laboratory equipment will

be calibrated on a daily basis. Supplemental water quality samples will be sent to an independent laboratory certified in Massachusetts.

Table 7
Water Quality Sampling Schedule
(for each filter technology train)

Parameter	Sample Location	Number of Filter Runs	Testing Frequency
Temperature	Raw & Filtered	5/season	Grab every 4 hours when staffed
Turbidity	Raw, Clarified, Filtered	5/season	Continuous plus grab sample every 4 hours when staffed
Particle Counts 2–5 µm & 5-15 µm	Raw & Filtered	5/season	Continuous
Color	Raw, Clarified, Filtered	5/season	Grab every 4 hours when staffed
UV-254	Raw, Clarified, Filtered	5/season	Grab every 4 hours when staffed
TOC	Raw, Clarified, Filtered	5/season	Once during each filter run
Alkalinity	Raw & Filtered	5/season	Grab every 4 hours when staffed
pH	Raw & Filtered	5/season	Continuous plus grab sample every 4 hours when staffed
Odor	Raw & Filtered	5/season	Once during each filter run
Aluminum	Raw, Clarified, Filtered	5/season	Once during each filter run
Iron	Raw, Clarified, Filtered	5/season	Once during each filter run
Manganese	Raw, Clarified, Filtered	5/season	Once during each filter run
Total Coliform	Raw & Filtered	5/season	Once during each filter run
Fecal Coliform	Raw & Filtered	5/season	Once during each filter run
SDS TTHMs	Finished	2/season	Two filter runs for each train per season
SDS HAA5s	Finished	2/season	Two filter runs for each train per season
VOCs	Raw & Filtered	1/season	Once each season
Sanitary Group (Na, Ca, Mg, K, SO_4, NO_3, NO_2, NH_4, Hardness)	Raw & Filtered	1/season	Once each season
IOCs (As, Ba, Cd, Cr, Pb, Hg, Se, Cu, F, Se)	Raw, Filtered, Clarifier Sludge, Filter Backwash Residuals	1/season	Once each season
TSS	Clarifier Sludge & Filter Backwash Residuals	5/season	Once during each filter run
Bromide	Raw Water	1/season	Once each season
Bromate	Filter Effluent	1/season	Once each season for each train
Algae	Raw, Clarified, Filtered	3/season	Three filter runs for each train per season
Aluminum & TSS	Backwash Supernatant	2/season	1 filter run for a DAF train, 1 filter run for a direct filtration train

Residuals testing will consist of measuring for TSS and IOCs and completing a settleability test on the filter backwash waste. The supernatant will then be tested for TSS and aluminum. SDS DBP testing will be completed by adjusting the pH of the filter effluent using potassium hydroxide to a target pH of 7.1. In addition sodium hypochlorite, zinc polyphosphate, and fluoride will be used to dose the SDS DBP samples and match the Town's existing target dosages for chlorine, phosphate, and fluoride. SDS DBP samples will be stored in the dark in containers with no head space at temperatures that are approximately 5° C above the raw water temperature encountered during testing. Water quality performance goals for the pilot test are presented in Table 8.

Table 8
Water Quality Goals

Location	Parameter	Goal
Clarified Water	Turbidity	< 0.5 NTU
Clarified Water	UV-254	< 0.035 1/cm
Filtered Water	Turbidity	< 0.1 NTU
Filtered Water	TOC Removal	> 45% when raw water TOC > 4 to 8 mg/L > 35% when raw water TOC > 2 to 4 mg/L SUVA ≤ 2 L/mg-m
Filtered Water	Iron	< 0.1 mg/L
Filtered Water	Manganese	< 0.025 mg/L

Pilot Equipment

Various specifications and information describing the pilot filter media are presented in Table 9.

Table 9
Pilot Filter Media

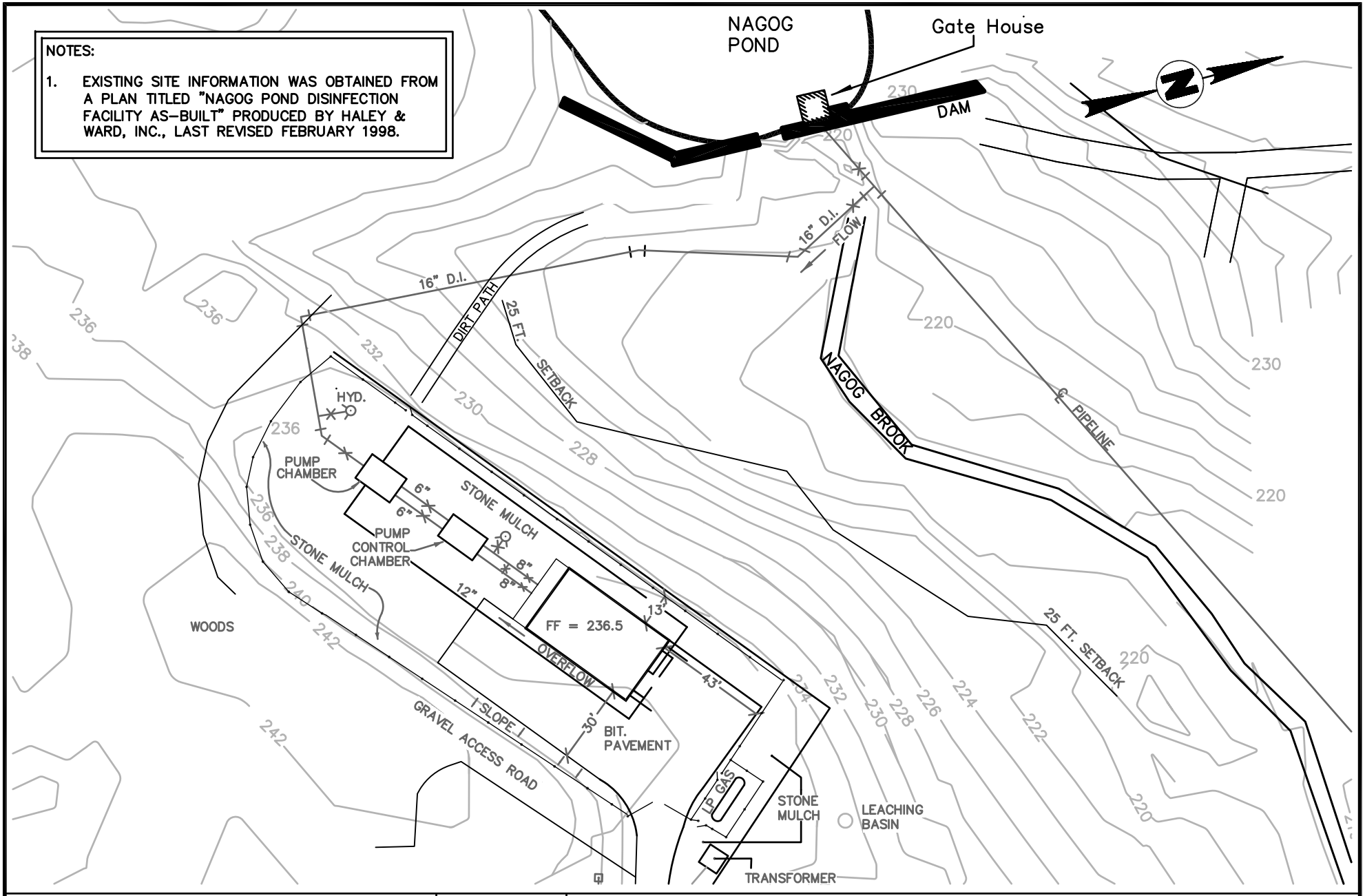
	Filter #1 DAF Train GAC	**Filter #2 Stacked DAF Train GAC**	**Filter #3 Direct Filtration Train Dual Media**
	Top Layer	*Top Layer*	Top Layer
Media Type	Calgon Filtrasorb 820	Calgon Filtrasorb 820	Calgon Filtrasorb 820
Media Depth	48"	48"	48"
Effective Size	1.0 – 1.2 mm	1.0 – 1.2 mm	1.0 – 1.2 mm
Uniformity Coef	< 1.5	< 1.5	< 1.5
	Bottom Layer	*Bottom Layer*	*Bottom Layer*
Media Type	Filter Sand	Filter Sand	Filter Sand
Media Depth	6"	6"	6"
Effective Size	0.45 – 0.55 mm	0.45 – 0.55 mm	0.45 – 0.55 mm
Uniformity Coef	< 1.4	< 1.4	< 1.4

A description of each pilot treatment unit is attached to this proposal. The direct filtration filter will take a side stream from the Leopold pilot unit ahead of flotation. Environmental Partners will control the water treatment chemistry, treatment loading rates, and water quality sampling.

Figures

NOTES:

1. EXISTING SITE INFORMATION WAS OBTAINED FROM A PLAN TITLED "NAGOG POND DISINFECTION FACILITY AS-BUILT" PRODUCED BY HALEY & WARD, INC., LAST REVISED FEBRUARY 1998.

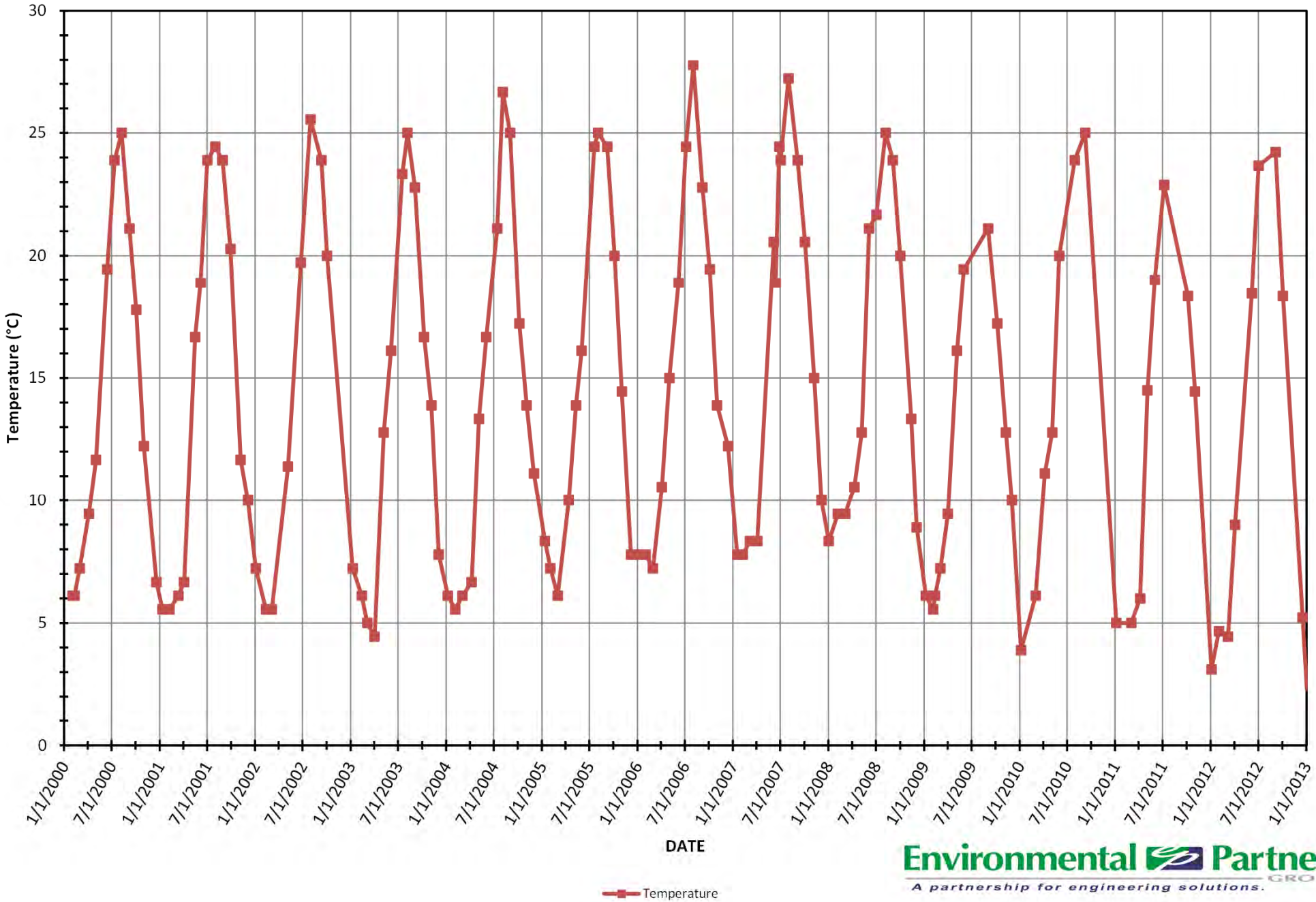


Environmental Partners GROUP
A partnership for engineering solutions.

MAY 2013	FIGURE 1
200-1301	EXISTING FACILITIES
1"=50'	

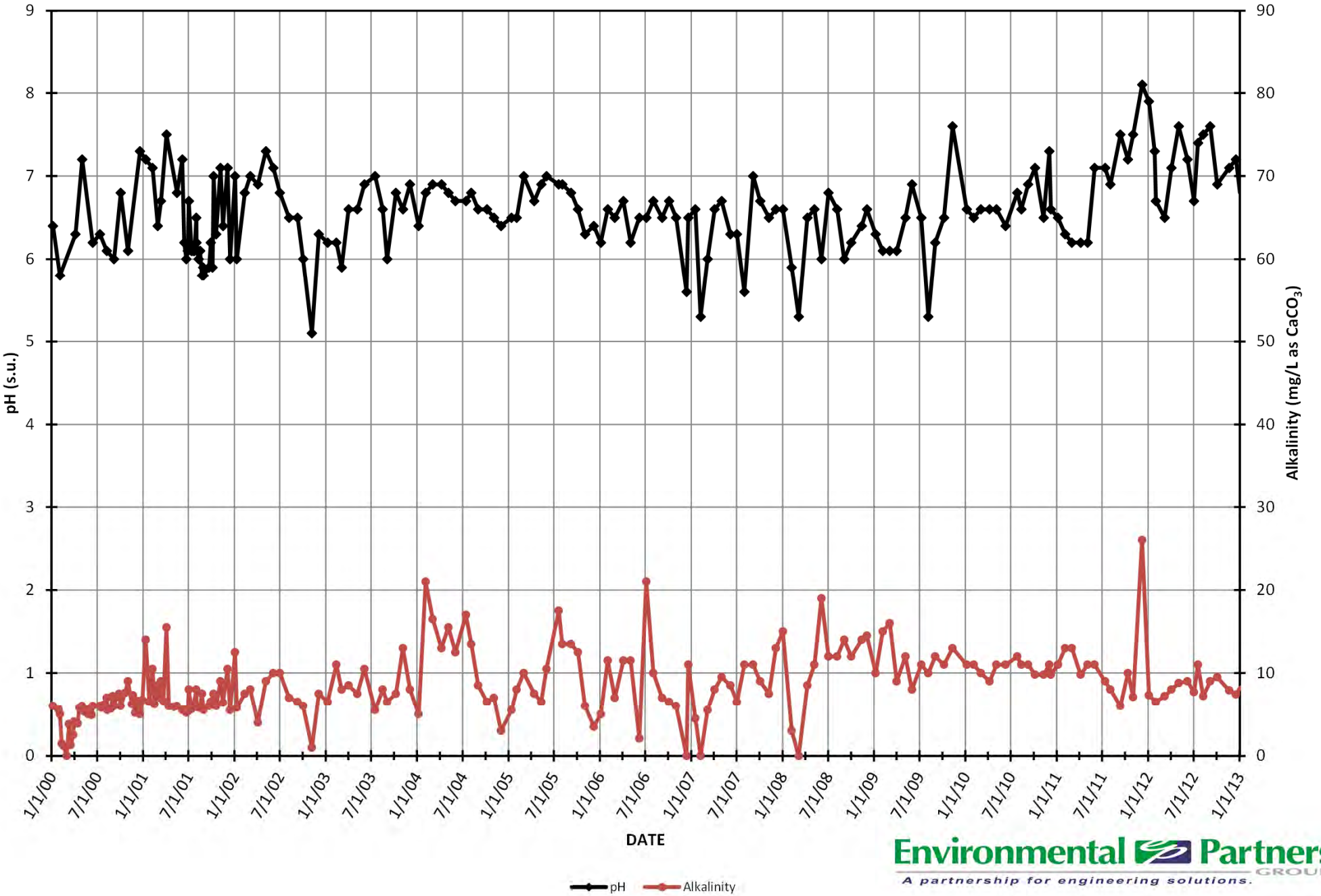
I:\CONCORD\200\200-1301 NAGOG POND WATER SUPPLY MASTER PLAN\01 PILOT STUDY\PILOT TEST PROPOSAL\FIGURES\007-048R (FOR SITE PLANS).DWG

Figure 2
Nagog Pond Raw Water Temperature
January 2000 - December 2012



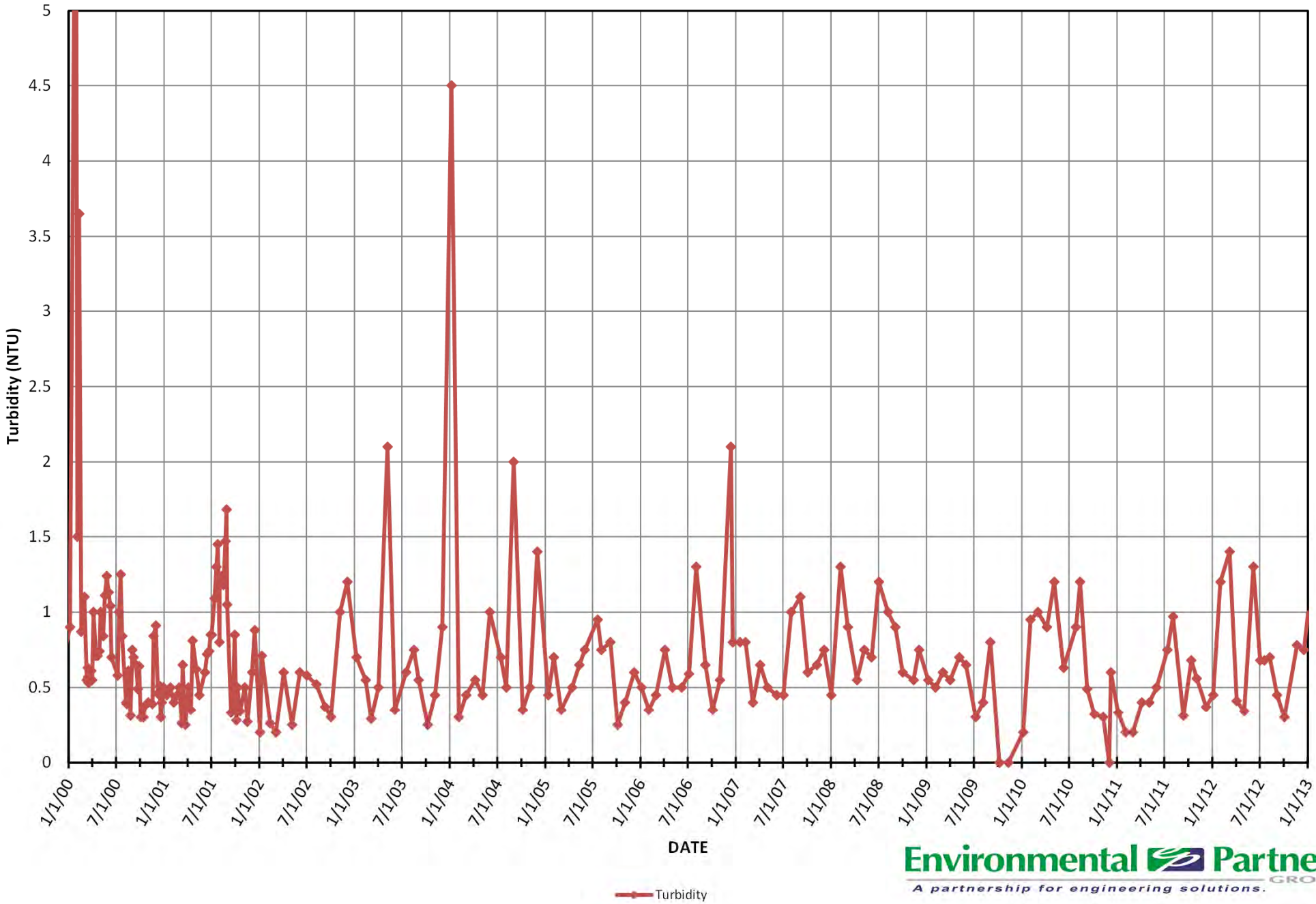
Environmental Partners GROUP
A partnership for engineering solutions.

Figure 3
Nagog Pond Raw Water pH and Alkalinity
January 2000 - December 2012



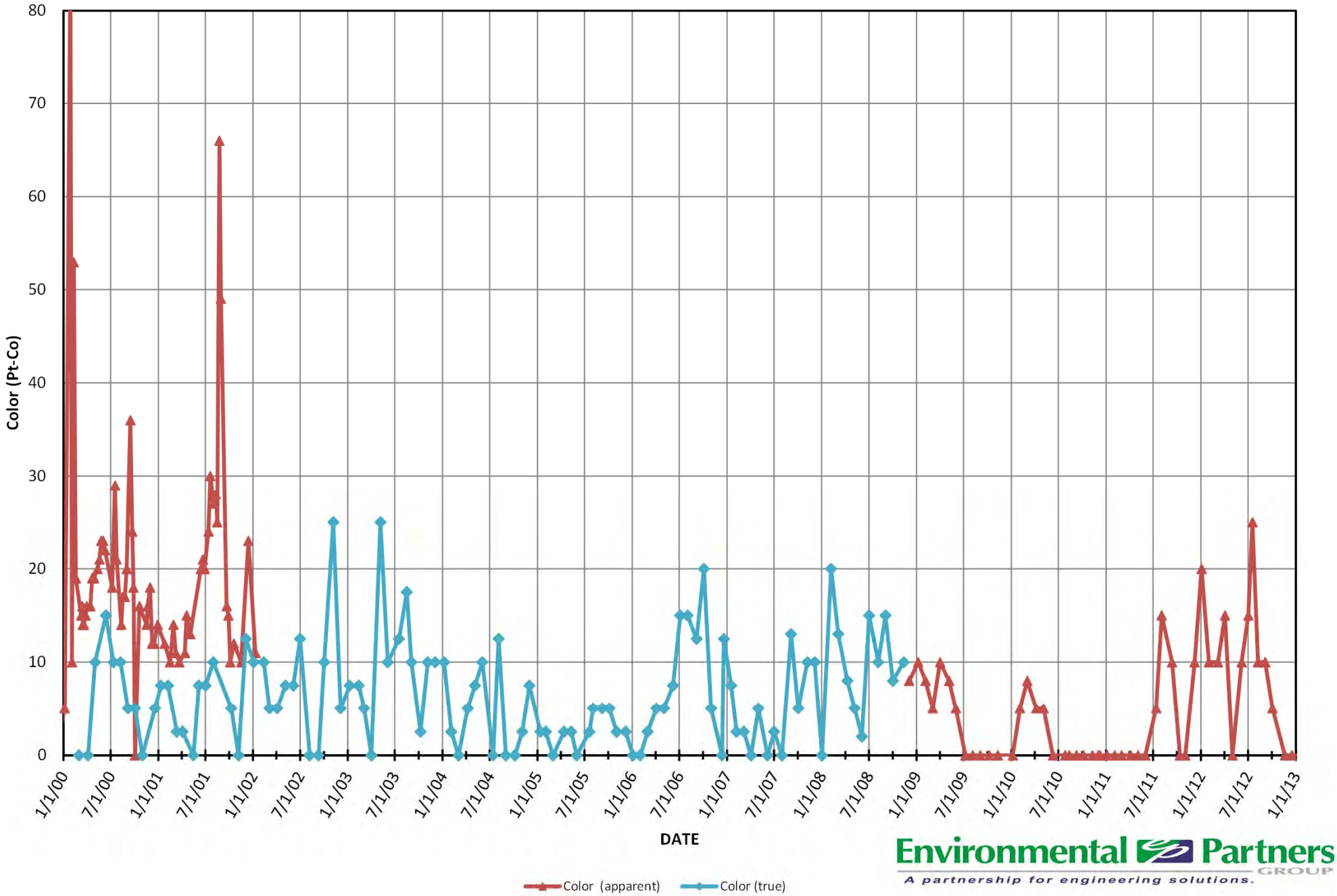
Environmental Partners GROUP
A partnership for engineering solutions.

Figure 4
Nagog Pond Raw Water Turbidity
January 2000 - December 2012



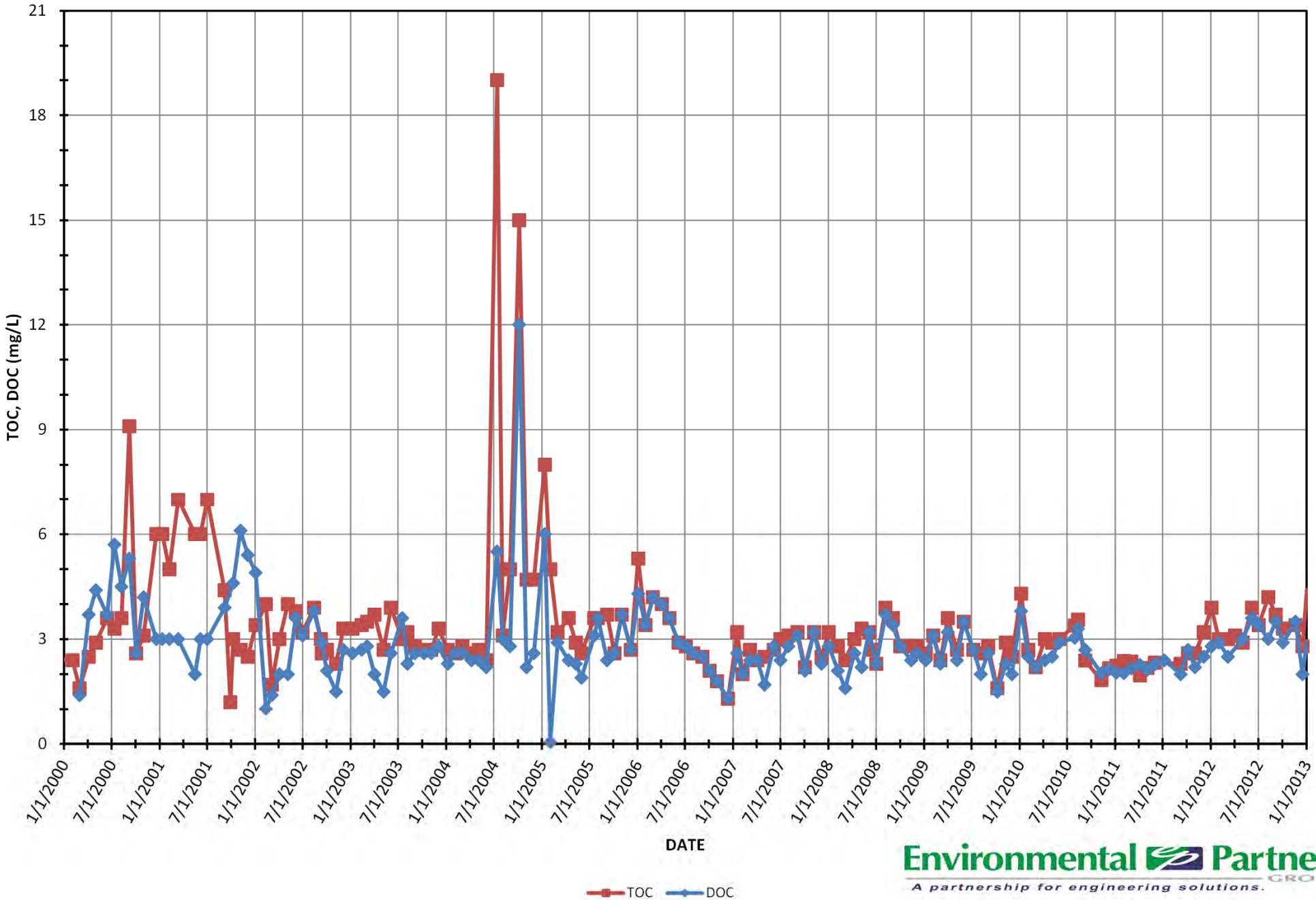
Environmental Partners GROUP
A partnership for engineering solutions.

Figure 5
Nagog Pond Raw Water Color
January 2000 - December 2012



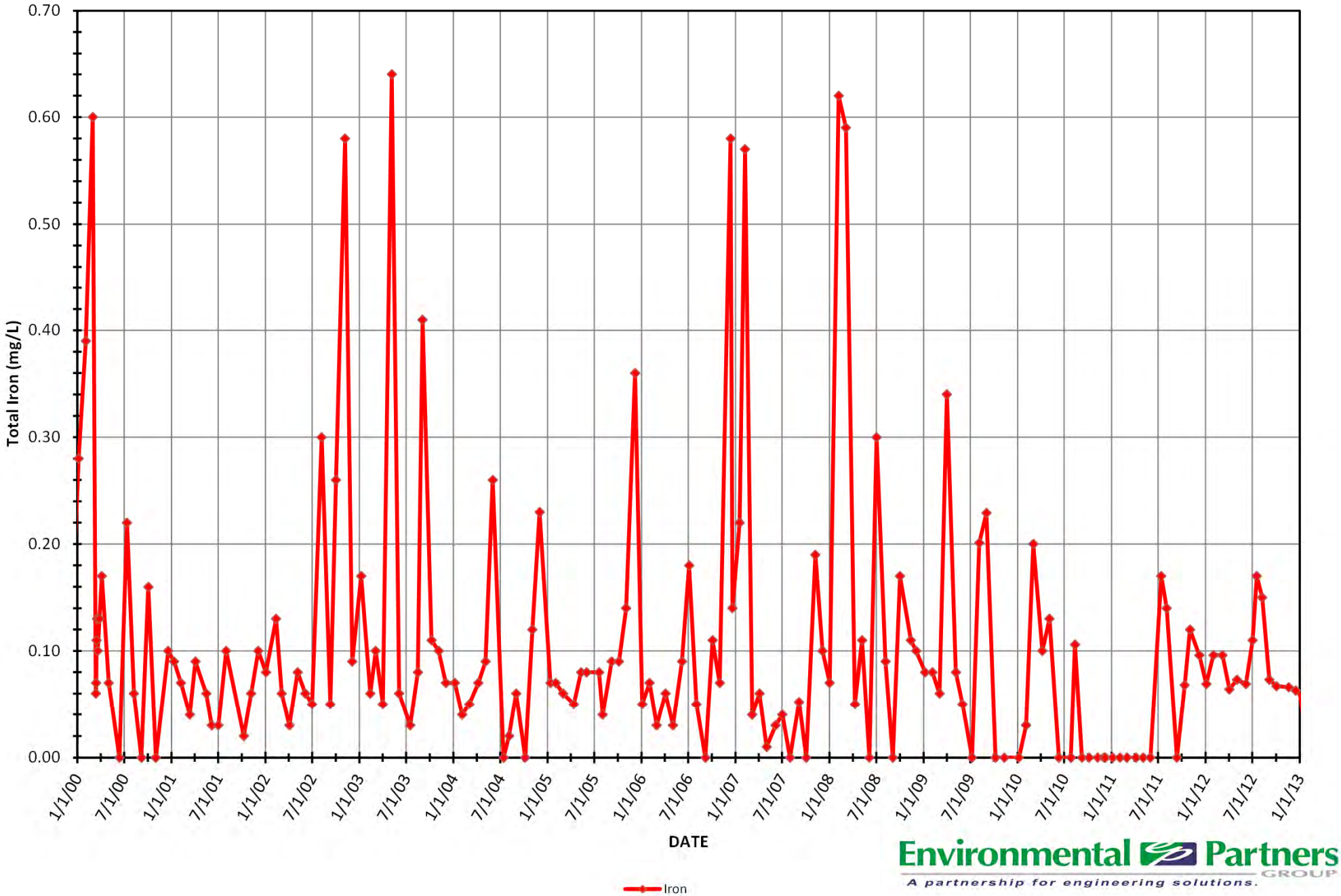
Environmental Partners GROUP
A partnership for engineering solutions.

Figure 6
Nagog Pond Raw Water TOC
January 2000 - December 2012



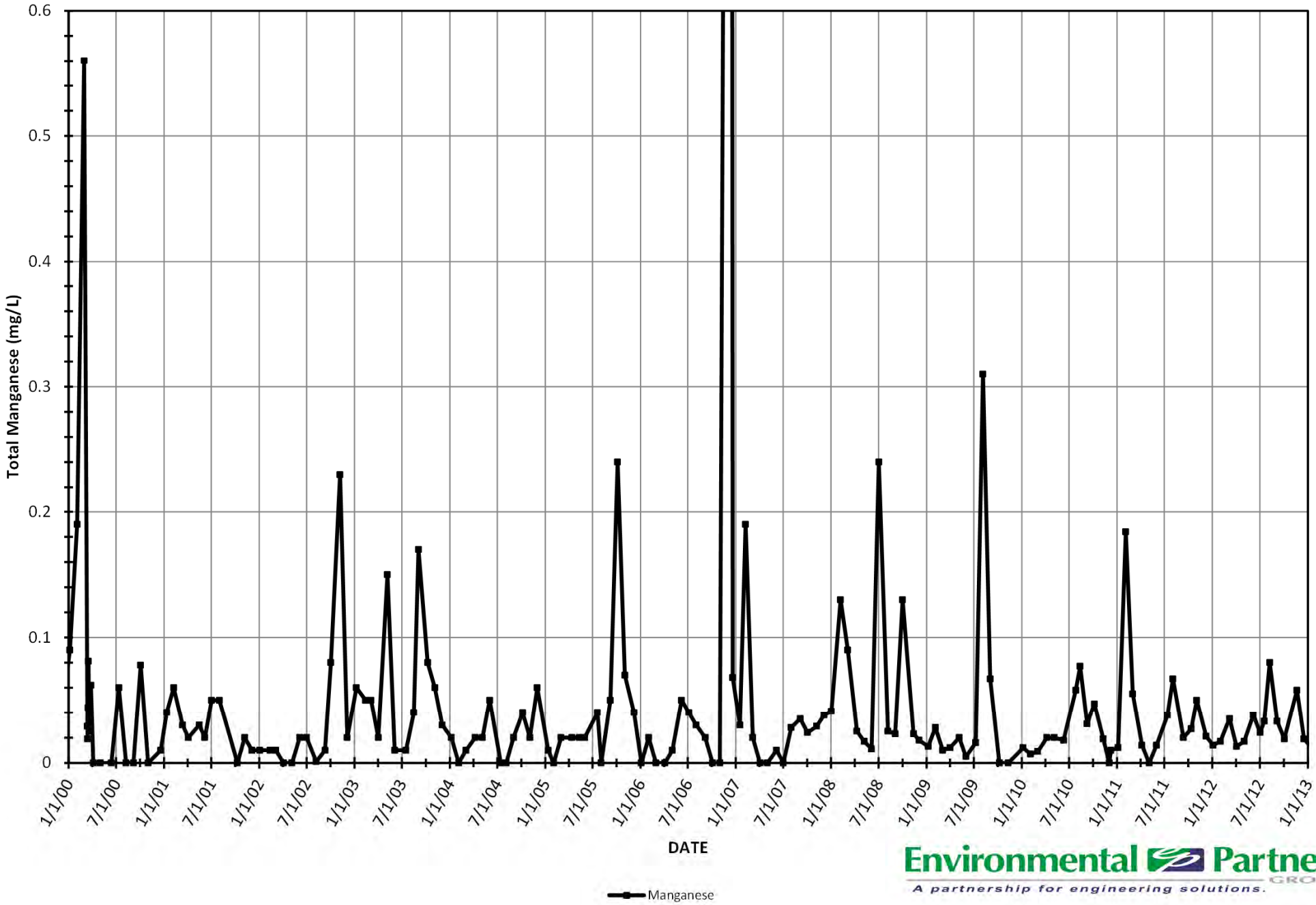
Environmental Partners GROUP
A partnership for engineering solutions.

Figure 7
Nagog Pond Raw Water Iron
January 2000 - December 2012



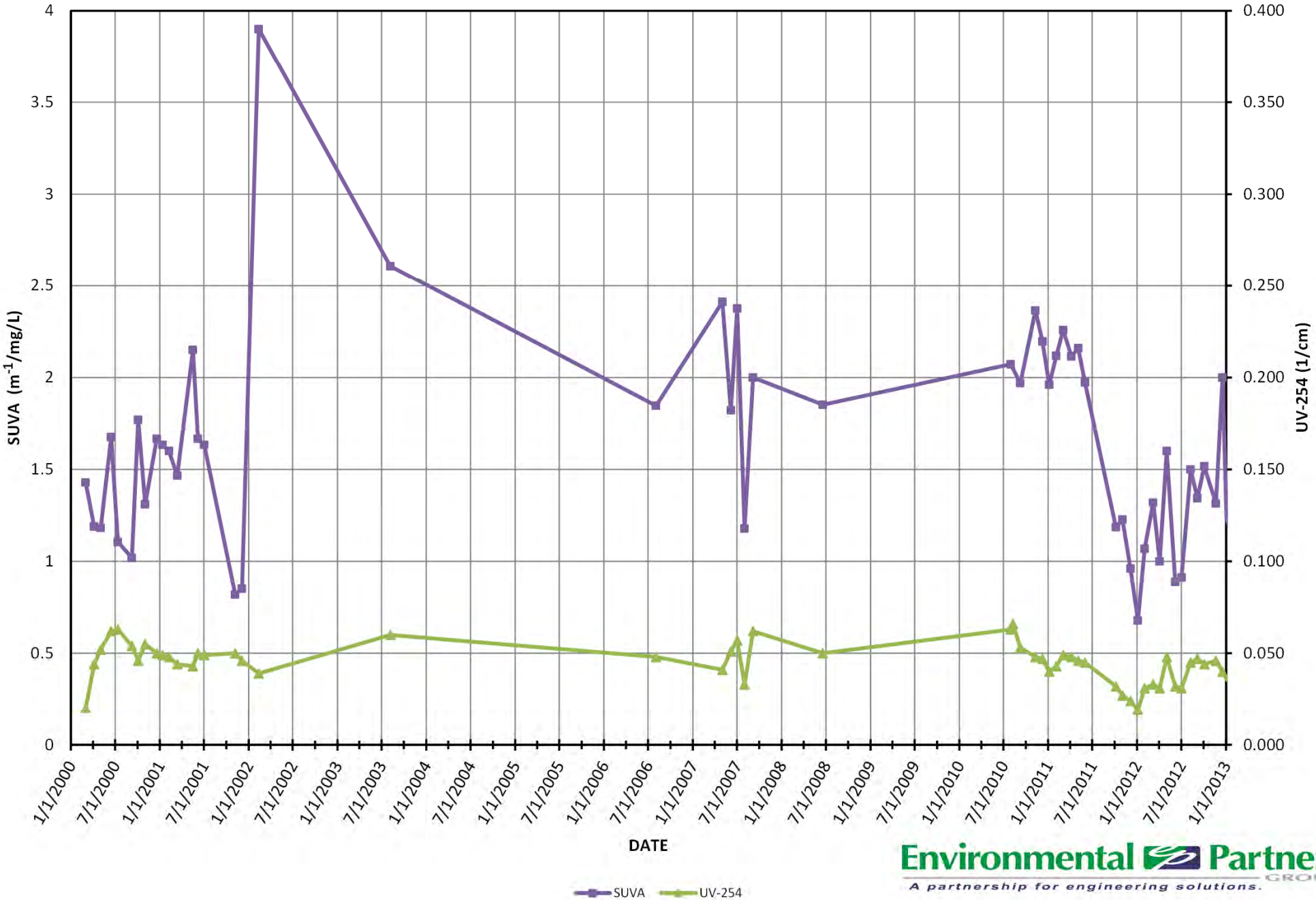
Environmental Partners GROUP
A partnership for engineering solutions.

Figure 8
Nagog Pond Raw Water Manganese
January 2000 - December 2012



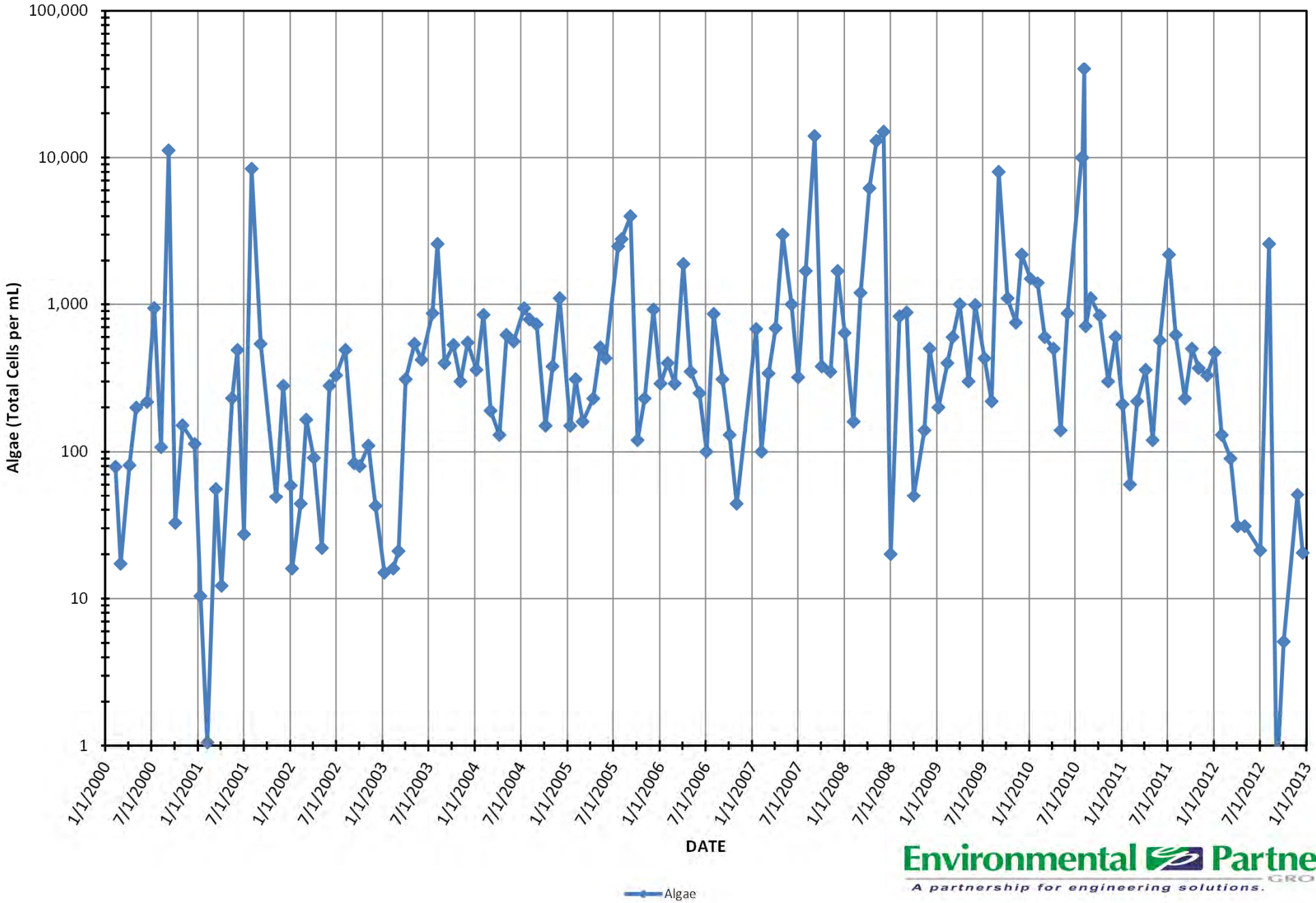
Environmental Partners GROUP
A partnership for engineering solutions.

Figure 9
Nagog Pond Raw Water SUVA and UV-254
January 2000 - December 2012

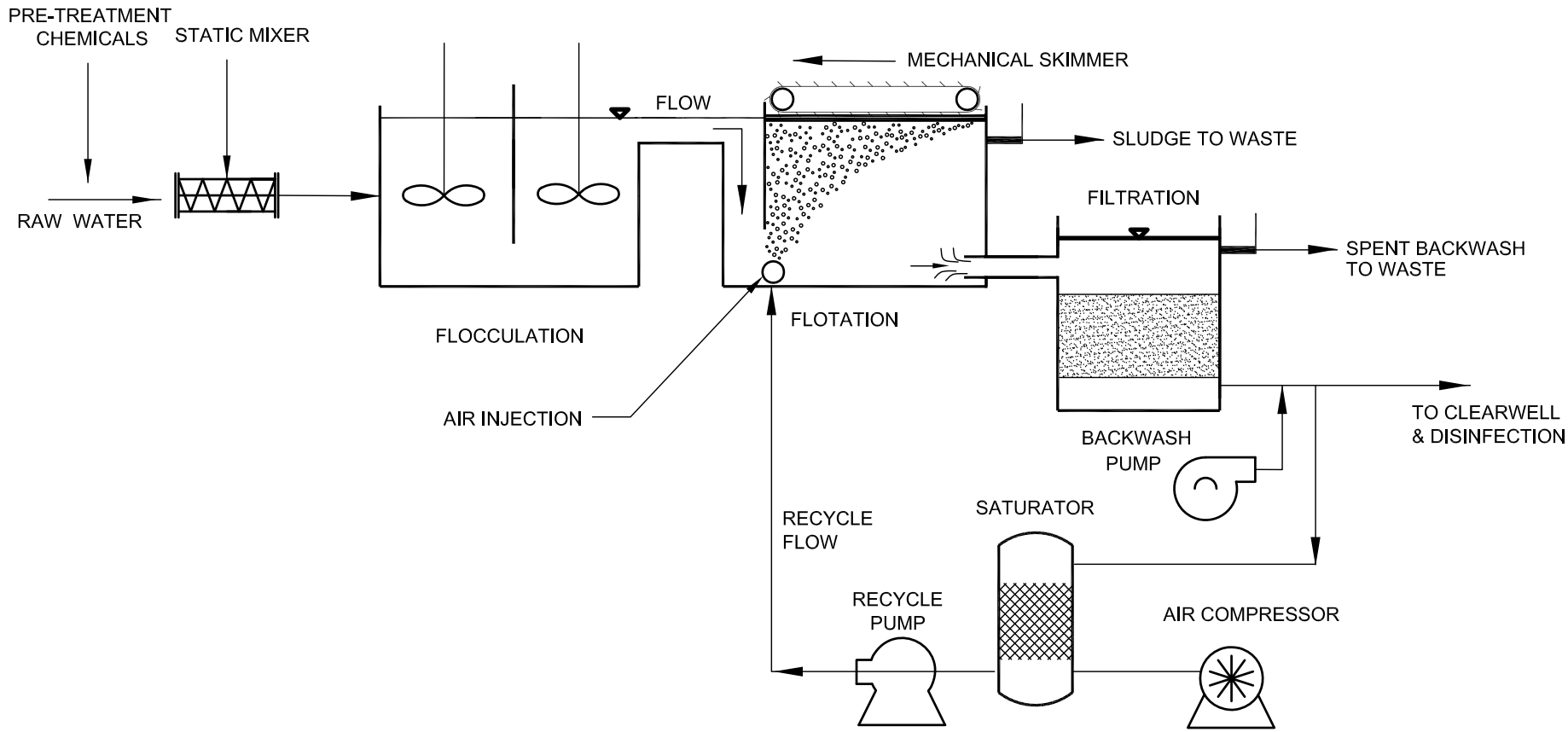


Environmental Partners GROUP
A partnership for engineering solutions.

Figure 10
Nagog Pond Raw Water Algae
January 2000 - December 2012



Environmental Partners GROUP
A partnership for engineering solutions.



Environmental Partners GROUP
A partnership for engineering solutions.

MAY 2013

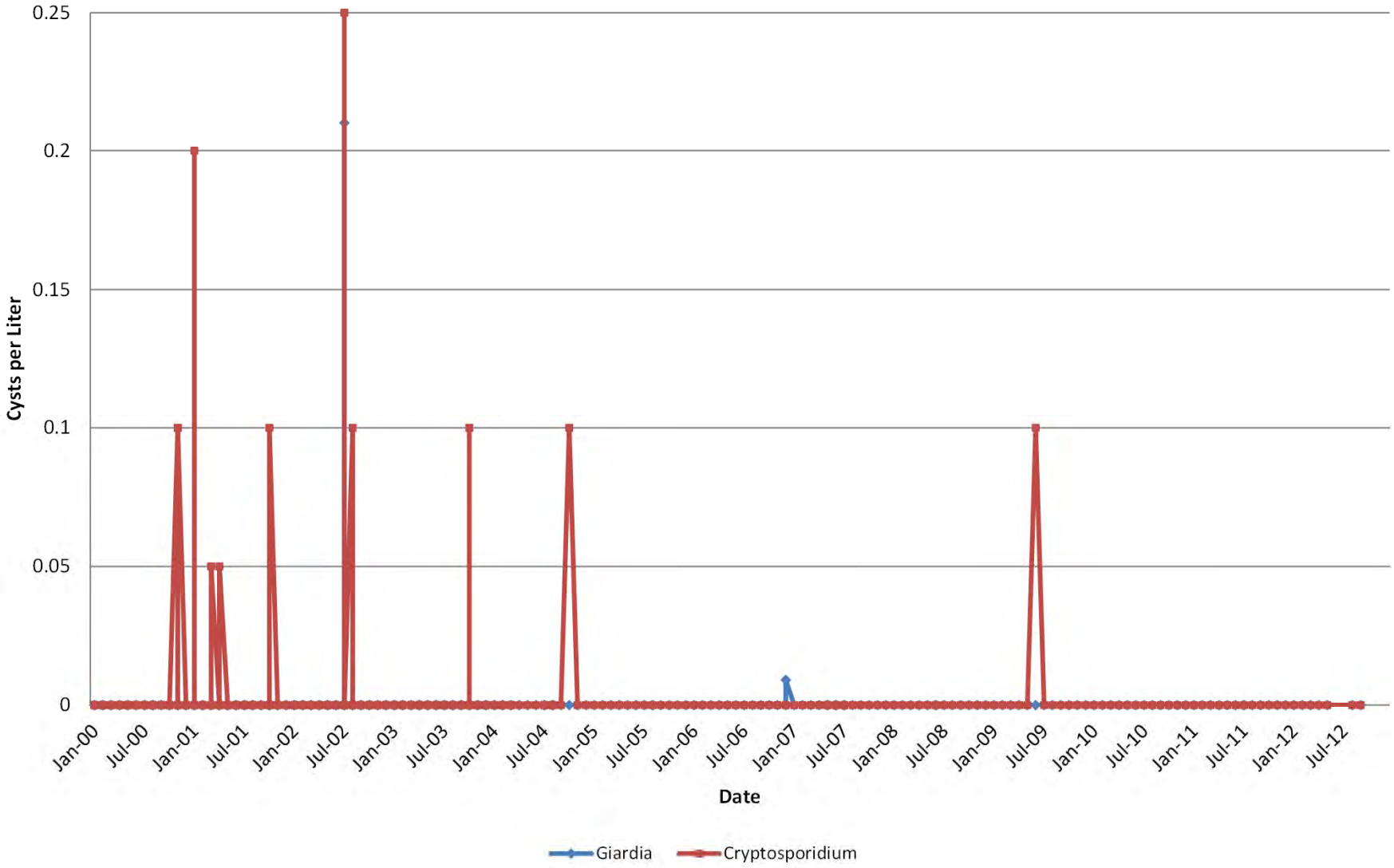
200-1301

SCALE: NTS

FIGURE 11

DISSOLVED AIR FLOTATION
PROCESS FLOW SCHEMATIC

Figure 12
Nagog Pond Cryptosporidium and Giardia
January 2000 - December 2012



Environmental Partners GROUP
A partnership for engineering solutions.

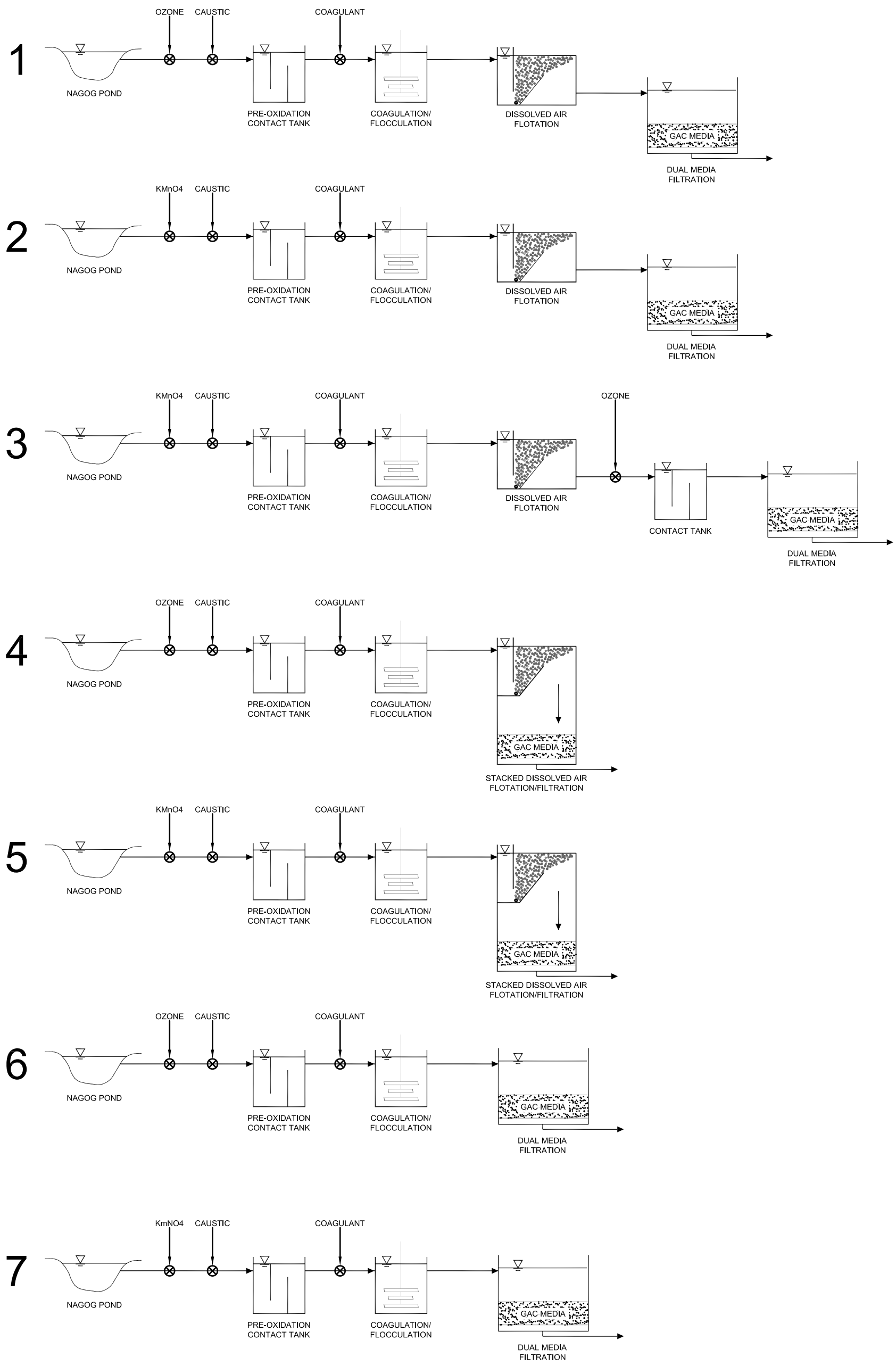


FIGURE 13

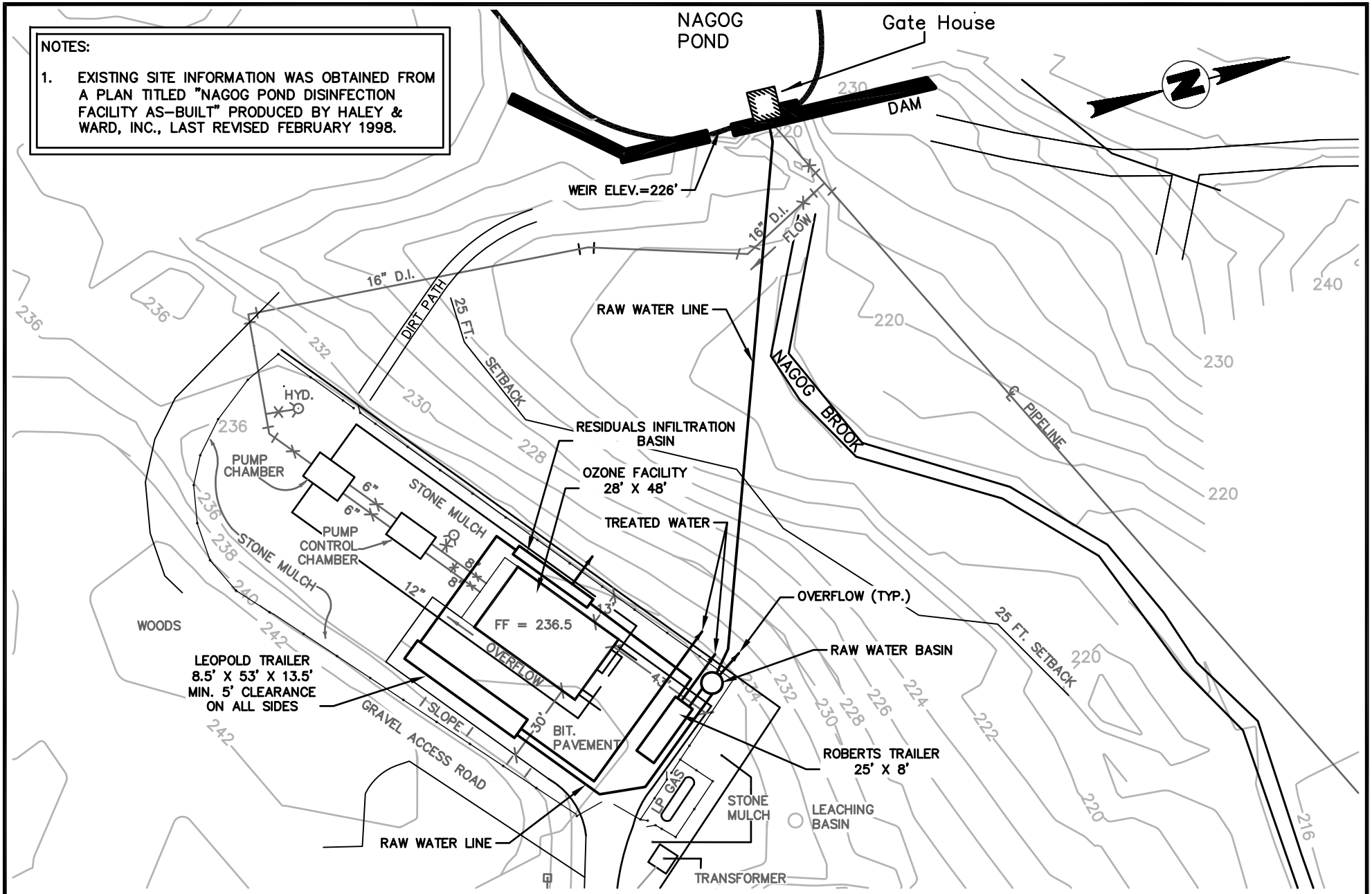
NAGOG POND PILOT PROCESS TRAINS

SCALE:	NTS
DATE:	MAY 2013
JOB NO.:	200-1301

Environmental Partners GROUP
A partnership for engineering solutions.

NOTES:

1. EXISTING SITE INFORMATION WAS OBTAINED FROM A PLAN TITLED "NAGOG POND DISINFECTION FACILITY AS-BUILT" PRODUCED BY HALEY & WARD, INC., LAST REVISED FEBRUARY 1998.



Environmental Partners GROUP
A partnership for engineering solutions.

MAY 2013	FIGURE 14
200-1301	PROPOSED TRAILER LOCATIONS
1"=50'	

I:\CONCORD\200\200-1301 NAGOG POND WATER SUPPLY MASTER PLAN\01 PILOT STUDY\PILOT TEST PROPOSAL\FIGURES\007-048R (FOR SITE PLANS).DWG

Pilot Plant Schematics and Data Sheets

Xylem, Inc

Leopold
227 S. Division St
Zelienople, PA 16063
(724) 452-6300
www.xyleminc.com

Clari-DAF® Dissolved Air Flotation System Pilot Unit #2

Leopold's Clari-DAF® System Pilot Unit #2 is a full treatment pilot plant designed to test our Dissolved Air Flotation process to remove algae, TOC, turbidity, iron and other constituents. The new pilot plant is housed in a 53-foot semi-trailer and includes all the necessary process equipment, pumps, valves, instruments, laboratory and ancillary equipment, etc. to function as a stand-alone unit to test source, pretreated, waste or other waters.

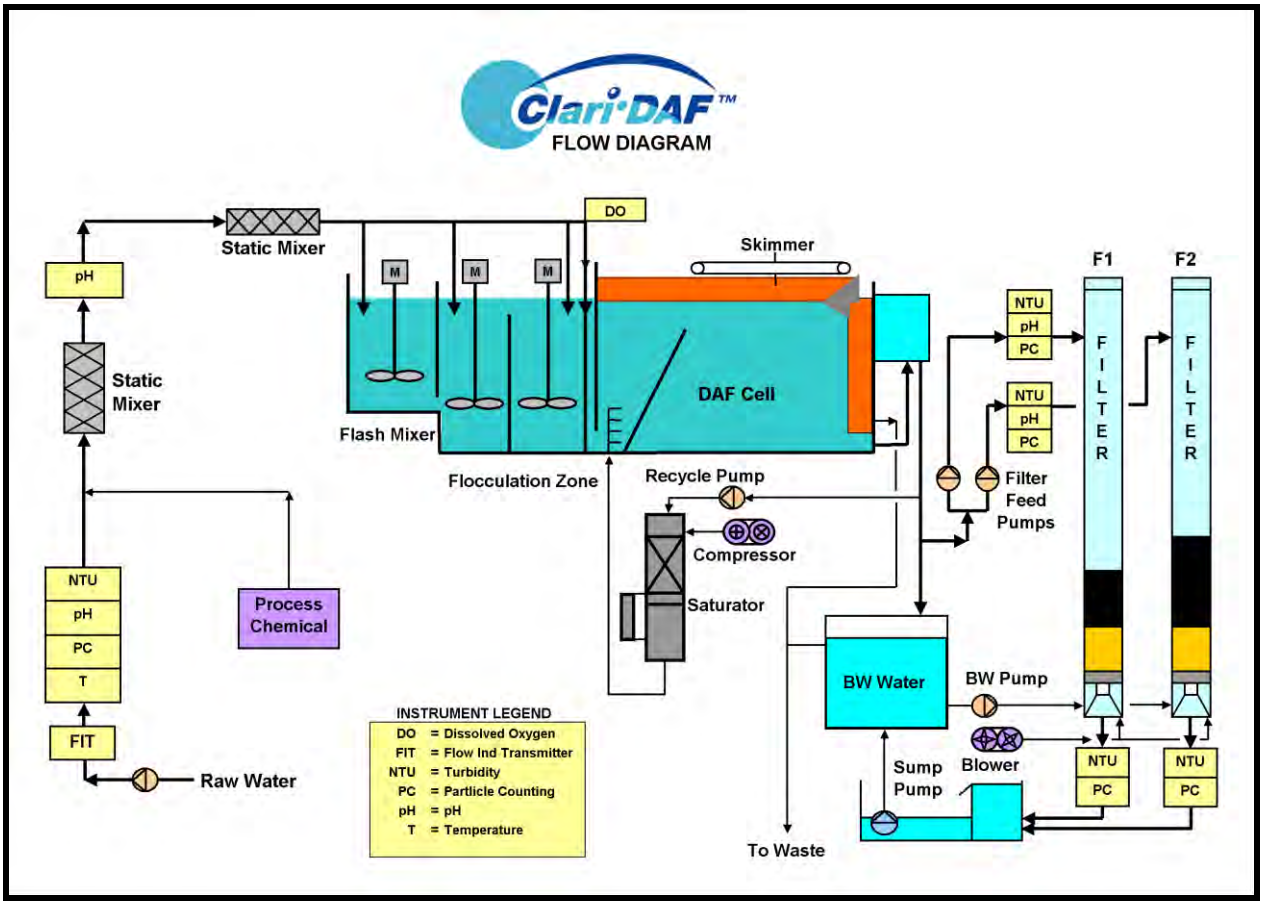
A typical Clari-DAF pilot runs 3-4 weeks, which includes 2 days for setup and 2 days for tear down.

A field process engineer is supplied for the duration of the study. This engineer is responsible for optimizing the process, gathering the process data and, along with Leopold's technical management, provide recommendations to the client or client's engineer.

After the study is completed, a full pilot report will be submitted. The report includes recommendations for design (i.e. loading rate, recycle rate, flocculation times) to achieve the established water quality effluent goals along with a full compliment of graphs displaying process performance collected under various operational conditions.

Process Design

Process Flow - Min/ Max	40 to 200 gpm (9 – 45 M^3/hr)
Loading Rate – Min/ Max	4 to 20-gpm/ft^2 (10 to 50 M/hr)
Flocculation Times - Min/ Max	3 to 30 minutes
Flocculation Stages	1 to 3
Filtration	Two (2)-1ft^2 (0.09 M^2) ea, independent media filters
Sludge Production	0.1% to 0.25% of flow with 1 - 5% solids



Pilot Plant Connections:

All Feed, Waste and DAF Effluent trailer Connections are 3” Cam Lock Type. Leopold supplies 200 feet of 3” Cam Lock terminated hoses in 25-foot sections for routing to customer connections.

Electrical connections

Leopold provides 100 feet of 4-wire outdoor grade electric cable with a receptacle on one end to connect to the trailer-mounted plug. An approved electrician must terminate the other end at the site’s power source.

Power requirements:	100 amp - 480V, Three-Phase, 60 HZ

Physical Layout

The pilot plant is furnished with heating, air-conditioning, interior lighting, power drops, laboratory, desk space, storage, test equipment, spare parts as may be necessary to operate and maintain the plant.

Trailer footprint Ft – In/ M:	8’-6”’ (2.6) wide x 53’ (16.2) long x 13’ 6” (4.1) high
Minimum Clearance all sides	5 foot (1.5 M)
Estimated Trailer Weight # / Kg:	40,000 (18,200) empty 70,000 (31,800) operational
Equipment pad:	Level concrete or asphalt

Quality Assurance & Control

The Clari-DAF system pilot unit is equipped with instruments that meet all compliance standards and are inspected and calibrated before the study begins. Quality assurance methods include Standard Methods, EPA-approved methods, methods recommended by instrument manufacturers, and published methods by researchers. The table below lists the elements and methods for analysis during the studies.

Summary of Methods		
Elements	**Method Description**	**Compliance Standard**
Turbidity	Light Scattering (Nephelometric)	Std. Method 2130B, USEPA 180.1, HACH Method 8195
pH	Electrometric	Standard Method 4500-H
Particle Counts	Volumetric	Standard Method 2560
Iron	HACH DR 5000	HACH Method 8008
Manganese	HACH DR 5000	HACH Method 8149
Color	HACH DR 5000	HACH Method 8025
Aluminum	HACH DR 5000	HACH Method 8012
UV254	HACH DR 5000	HACH Method 10054

During pilot plant setup, all turbidimeters are calibrated with HACH Formazin solutions of 20 ntu. The solutions are made manually by mixing distilled water with HACH Formazin 4000 ntu solution. Also, pH sensors are calibrated using solutions made up with HACH 4 and 10 powder pillows and distilled water. The sensors are checked with a solution made from HACH pH of 7 powder pillows and distilled water to confirm accuracy. Pilot plant operators then verify flow through turbidimeters and particle counters to insure measurement accuracy. Also, during the pilot study operators will routinely measure flows through instruments to confirm correct flows.