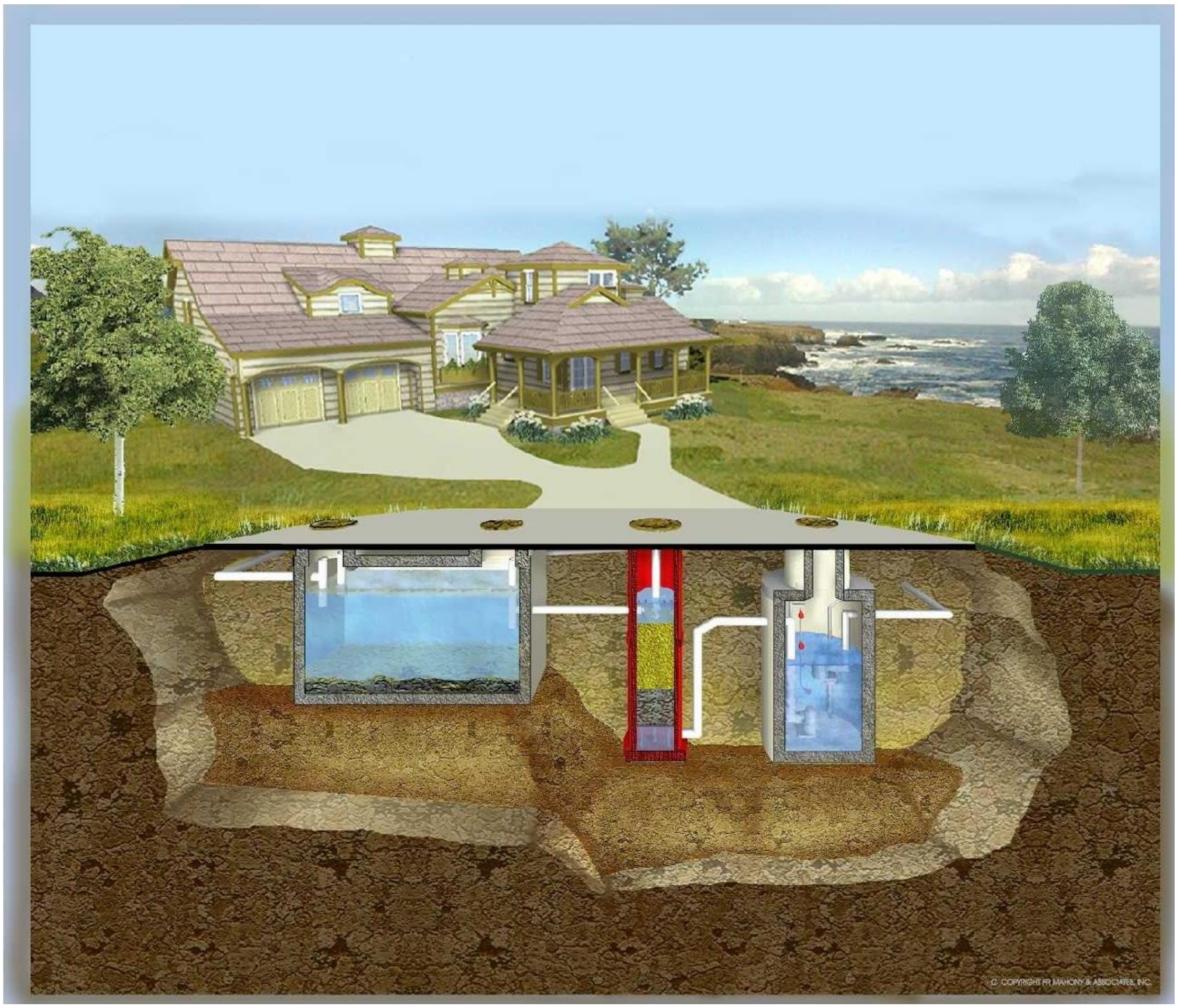
Amphidrome®

Design Guidance Document

The highest level of Nitrogen removal available...



...and at a reasonable cost.

f.r. mahony & associates, inc.

Revision 6/15/2020

A. Introduction

This manual has been prepared to help meet the objectives of long equipment life, minimal equipment maintenance, and cost-effective performance. This manual must be read and understood by those responsible for the operation and maintenance of an Amphidrome® Wastewater Treatment System. Non-recommended, or unauthorized operating or maintenance procedures may result in damage to the equipment, down time, substandard treatment, and voidance of any warranties. Included in this manual is a brief summary of biological nutrient removal, a description of the Amphidrome® process, and a detailed description of the control programming. Operation and maintenance procedures for all of the equipment used in an Amphidrome® system are also included. The specific manufacturer's literature should always be referenced when performing any maintenance or troubleshooting. This manual should be used in conjunction with the design or the "As-built" plans, when provided. All standard safety procedures must be observed.

If any special information, regarding the care and operation of the Amphidrome® Wastewater Treatment System, is desired, F.R. Mahony will furnish it upon request.

Requests for information should be directed to:

F.R. Mahony & Associates, Inc.
273 Weymouth Street
Rockland, MA 02370
Email: info@frmahony.com
Telephone: 781-982-9300
800-791-6132
Fax: 781-982-1056

B. Table of Contents

C. Applicant Information

F.R. Mahony & Associates, Inc.
273 Weymouth Street
Rockland, MA 02370
Email: info@frmahony.com
Telephone: 781-982-9300
800-791-6132
Fax: 781-982-1056

D. Technology Information - The Amphidrome® Process

The Amphidrome® system is a BNR process utilizing a submerged attached growth bioreactor operating in a batch mode. The deep bed sand filter is designed for the simultaneous removal of soluble organic matter, nitrogen and suspended solids within a single reactor.

To achieve simultaneous oxidation of soluble material, nitrification and denitrification in a single reactor, the process must provide aerobic and anoxic environments for the two different populations of microorganisms. The Amphidrome® system utilizes two tanks and one submerged attached growth bioreactor, subsequently called Amphidrome® reactor. The first tank, the anoxic/equalization tank, is where the raw wastewater enters the system. The tank has an equalization section, a settling zone, and a sludge storage section. It serves as a primary clarifier before the Amphidrome® reactor.

This Amphidrome® reactor consists of the following three items: underdrain, support gravel, and filter media. The underdrain, constructed of stainless steel, is located at the bottom of the reactor. It provides support for the media and even distribution of air and water into the reactor. The underdrain has a manifold and laterals to distribute the air evenly over the entire filter bottom. The design allows for both the air and water to be delivered simultaneously, or separately, via individual pathways to the bottom of the reactor. As the air flows up through the media, the bubbles are sheared by the sand producing finer bubbles as they rise through the filter. On top of the underdrain is 18" (five layers), of four different sizes of gravel. Above the gravel is a deep bed of coarse, round, silica sand media. The media functions as a filter; significantly reducing suspended solids, and provides the surface area for which an attached growth biomass can be maintained.

To achieve the two different environments required for the simultaneous removal of soluble organics and nitrogen, aeration of the reactor is intermittent rather than continuous. Depending on the strength and the volume of the wastewater, a typical aeration scheme may be three to five minutes of air and ten to fifteen minutes without air. Concurrently, return cycles are scheduled every hour, regardless of the aeration sequence. During a return, water from the clear well is pumped back up through the filter and overflows into the return flow/backwash pipe. A check valve in the influent line prevents the flow from returning to the anoxic/equalization tank, via that route. The return flow/backwash is set at a fixed height above both the media and the influent line; and the flow is by gravity back to the front of the anoxic/equalization tank.

The cyclical forward and reverse flow of the waste stream, and the intermittent aeration of the filter, achieve the required hydraulic retention time and create the necessary aerobic and anoxic conditions to maintain the required level of treatment.

E. Summary/Description

The Amphidrome®Process

The Amphidrome® system is a biological nutrient removal (BNR) process utilizing a submerged attached growth bioreactor operating in a batch mode. The deep, bed sand filter is designed for the simultaneous removal of soluble organic matter, nitrogen and suspended solids, within a single reactor.

To achieve simultaneous: oxidation of soluble material, nitrification, and denitrification in a single reactor, the process must provide aerobic and anoxic environments for the two different populations of microorganisms. The Amphidrome® system utilizes two tanks and one submerged attached growth bioreactor, subsequently called Amphidrome® reactor. The first tank, the anoxic/equalization tank, is where the raw wastewater enters the system. The tank has an equalization section, a settling zone, and a sludge storage section. It serves as a primary clarifier before the Amphidrome® reactor.

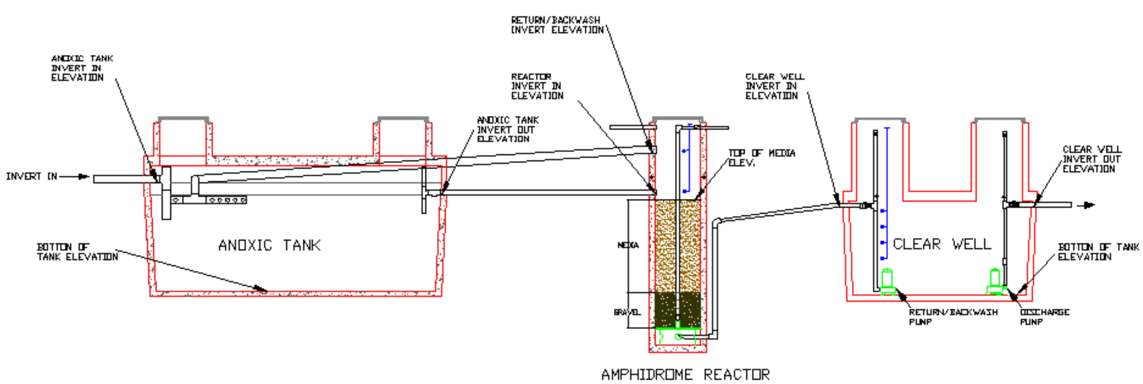


Figure 1. Amphidrome® Layout (TN < 20 mg/L)

This Amphidrome® reactor consists of the following three items: underdrain, support gravel, and filter media. The underdrain, constructed of stainless steel, is located at the bottom of the reactor. It provides support for the media and even distribution of air and water into the reactor. The underdrain has a manifold and laterals to distribute the air evenly over the entire filter bottom. The design allows for both the air and water to be delivered simultaneously, or separately, via individual pathways, to the bottom of the reactor. As the air flows up through the media the bubbles are sheared by the sand; producing finer bubbles as they rise through the filter. On top of the underdrain is 18”, (five layers), of four different sizes of gravel. Above the gravel is a deep bed of coarse, round, silica sand media. The media functions as a filter; significantly reducing suspended solids, and provides the surface area for which an attached growth biomass can be maintained.

To achieve the two different environments required for the simultaneous removal of soluble organics and nitrogen, aeration of the reactor is intermittent, rather than continuous. Depending on the strength and the volume of the wastewater, a typical aeration scheme may be three to five minutes of air and ten to fifteen minutes without air. Concurrently, return cycles are scheduled every hour, regardless of the aeration sequence. During a return, water from the clear well is pumped back up through the filter and overflows into the return flow/backwash pipe. A check valve in the influent line prevents the flow from returning to the anoxic/equalization tank, via that route. The return flow/backwash is set at a fixed height above both the media and the influent line; and the flow is by gravity back to the front of the anoxic/equalization tank.

The cyclical forward and reverse flow of the waste stream, and the intermittent aeration of the filter, achieve the required hydraulic retention time and create the necessary aerobic and anoxic conditions to maintain the required level of treatment.

In order to achieve lower nitrogen discharge levels, a second denitrification (Amphidrome® Plus) filter is added to the system (see Figure 2). This filter takes nitrified wastewater stored in the clear well and pumps it into the Amphidrome® Plus filter with an additional carbon source.

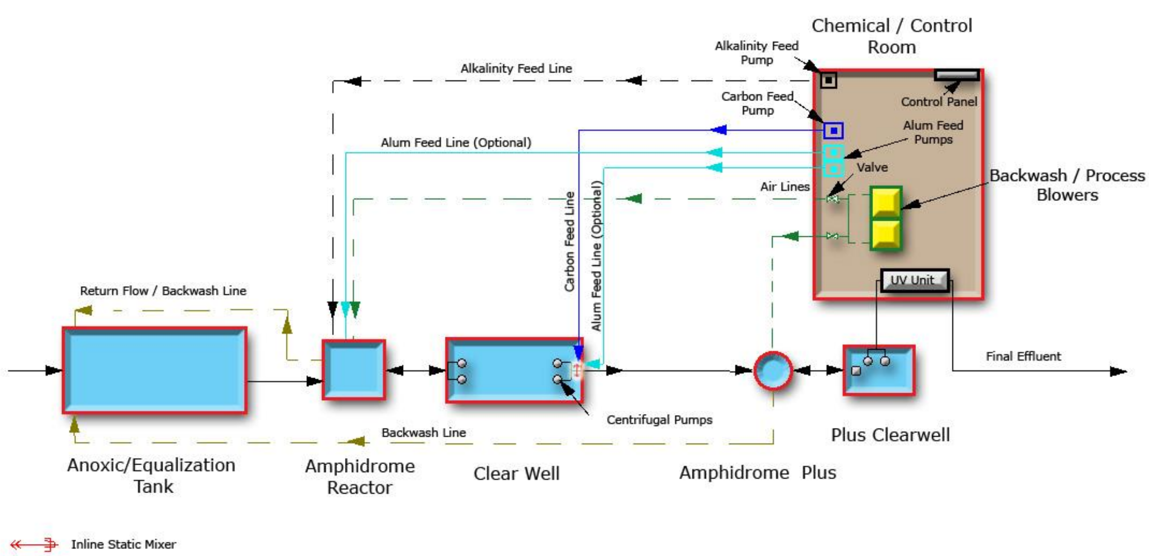


Figure 2. Amphidrome® Plus Process Flow Diagram (TN < 10 mg/L)

Background

The removal of soluble organic matter (SOM) from wastewater was traditionally the primary objective of biological wastewater treatment. The removal of SOM occurs as microorganisms use it as a food source, converting a portion of the carbon in the waste stream, to new biomass and the remainder to carbon dioxide (CO_2) and water (H_2O). The CO_2 is released to the atmosphere as a gas and the biomass is removed by sedimentation, yielding a waste stream free of the organic matter.

Cultures of aerobic microorganisms are especially effective for waste streams, which have a biodegradable chemical oxygen demand (bCOD) ranging between 50-4,000 mg/l. To accomplish this task, treatment units were designed and operated to maintain a culture of heterotrophic bacteria, under suitable environmental conditions so that the bacteria utilized the organic carbon from the incoming waste stream. The biochemical unit operations were coupled with additional solid-liquid separations processes to remove the suspended and colloidal solids in the waste stream. The result was an effective method for the removal of both soluble and particulate organic matter from the waste stream.

However, since the discovery of the effects of eutrophication, the removal of inorganic nutrients from wastewater has become an important consideration, and has imposed additional challenges on the design of wastewater treatment plants. The two primary causes of eutrophication are nitrogen and phosphorus and a number of biological nutrient removal (BNR) processes have been developed to remove them. In sea water and in tidal estuaries, nitrogen is typically the limiting nutrient. Therefore, nitrogen discharge limits, in coastal areas, have been made especially stringent in recent years.

In domestic waste water, nitrogen is present as ammonia (NH_3) and as organic nitrogen (NH_2^-) in the form of amino groups. The organic nitrogen is released as ammonia, in the process of ammonification, as the organic matter containing it, undergoes biodegradation. Two groups of bacteria are responsible for converting ammonia to the innocuous form, nitrogen gas (N_2). The completion of this process occurs in two steps, by completely different bacteria, and in very different environments. In the first step, bacteria oxidize ammonia to nitrate (NO_3^-) in a process called nitrification. The bacteria responsible for nitrification are chemolithotrophic, autotrophs that are also obligate aerobes; therefore, requiring an aerobic environment. Chemolithotrophic bacteria obtain energy from the oxidation of inorganic compounds, which in the nitrogen cycle, are ammonia (NH_3) and nitrate (NO_3^-). Autotrophic bacteria obtain their carbon source from inorganic carbon, such as carbon dioxide. In the second step, denitrification, facultative, heterotrophic bacteria convert nitrate to nitrogen gas, which is released to the atmosphere. This is accomplished only in an anoxic environment in which the bacteria use NO_3^- as the final electron acceptor. The ultimate electron acceptor being nitrogen, as it undergoes a stepwise conversion from an oxidation state of +5 in NO_3^- to 0 in N_2. This process may be carried on by some of the same facultative, heterotrophic bacteria that oxidize the soluble organic matter under aerobic conditions. However, the presence of any dissolved oxygen inhibits denitrification, since the preferential path, for electron transfer, is to oxygen not to nitrate.

Since biological removal of nitrogen is both possible and economically viable, many of today's waste water treatment plants require the removal of both soluble organic matter and nitrogen. To achieve this requires: a heterotrophic population of bacteria, operating in an aerobic environment to remove the SOM; a chemolithotrophic autotrophic population of bacteria, also operating in an aerobic environment, to convert the ammonia to nitrate; and finally a facultative heterotrophic population of bacteria, to convert nitrate to nitrogen gas, but in an anoxic environment. Therefore, typical treatment plant designs approach the removal of organics and nutrients, in one of three ways. The first, method is to combine the aerobic steps, (i.e. SOM removal and nitrification), into one operation and design the anoxic denitrification process as a separate unit operation. The second method is to design three separate unit operations for each step. The third method to is to design a sequencing batch reactor (SBR), which has both aerobic zones and anoxic zones. The type of technology utilized greatly influences the number of unit operations to reach the desired effluent treatment level.

Biochemical operations have been classified according to the bioreactor type because the completeness of the biochemical transformation is influenced by the physical configuration of the reactor. Bioreactors fall into two categories, depending on how the biological culture is maintained within, suspended growth, or attached growth, (also called fixed film). In a suspended growth reactor the biomass is suspended in the liquid being treated. Examples of suspended growth reactors include activated sludge and lagoon. In a fixed film reactor the biomass attaches itself to a fixed media in the reactor and the wastewater flows over it. Examples of attached growth reactors include rotating biological contactor, (RBC), trickling filter, and submerged attached growth bioreactor, (SAGB).

During the last twenty years different configurations of SAGBs have been conceived and advances in the understanding of the systems have been made. The advantages of SAGBs are that they may operate without a solids separation unit process after biological treatment, and with high concentrations of viable biomass. Removal of sludge is usually achieved by backwashing the filter. In such bioreactors the hydraulic retention time (HRT) is less than the minimum solids retention time (SRT) required for microbial growth on the substrates provided. This means that the growth of suspended microorganisms is minimized and the growth of attached microorganisms is maximized. The low hydraulic retention time results in a significantly smaller required volume, to treat a given waste stream, than would be achieved with either a different fixed film reactor, or a suspended growth reactor, for the same waste stream.

Biochemical Reactions

The removal of SOM is achieved by the oxidation of carbonaceous matter, which is accomplished by the aerobic growth of heterotrophic bacteria. The biochemical transformation is described by the following normalized mass based stoichiometric equation in which the carbonaceous matter is a carbohydrate (CH_2O) and the nitrogen source for the bacteria is ammonium (NH^+_4).

$$CH_2O + 0.309\ O_2 + 0.085\ NH^+_4 + 0.289\ HCO_3^- \rightarrow 0.535\ C_5H_7O_2N + 0.633\ CO_2 + 0.515\ H_2O$$

The oxidation of ammonia to nitrate is accomplished by the aerobic growth of chemolithotrophic, autotrophic bacteria and is described by the following normalized mass based stoichiometric equation. The overall equation describes the two-step process in which ammonia is converted to nitrite by *Nitrosifyers*, and nitrite is converted to nitrate by *Nitrifyers*.

$NH^{+}_{4} + 3.30\ O_2 + 6.708\ HCO_3^{-} \rightarrow 0.129\ C_5H_7O_2N + 3.373\ NO^{-}_{3}{}^{-} + 1.041\ H_2O + 6.463\ H_2CO_3$

The final step in the removal of nitrogen from the waste stream occurs when carbonaceous matter is oxidized by the growth of heterotrophic bacteria utilizing nitrate as the terminal electron accepter. The equation describing the biochemical transformation depends on the organic carbon source utilized. The following is the normalized mass based stoichiometric equation with the influent waste stream as the organic carbon source.

$NO^{-}_{3} + 0.324\ C_{10}H_{19}O_3N \rightarrow 0.226\ N_2 + 0.710\ CO_2 + 0.087\ H_2O + 0.027\ NH_3 + 0.274\ OH^{-}$

Biological removal of nitrogen has been the focus of much attention and many of today's wastewater treatment plants incorporate it. However, the difficultly in promoting these biochemical transformations in one reactor is the different environmental conditions required for each transformation.

This Amphidrome® process is designed to achieve the above reactions simultaneously within one reactor. The aerobic environment within the filter promotes the first two reactions. The return flow, to the anoxic/equalization tank, mixes the nitrates with organic carbon in the raw influent, and with organic carbon that has been released from the stored sludge. The anoxic environment within the filter promotes denitrification, the third reaction.

F. Terms and Definitions

ADVANCED WASTE TREATMENT Any process of water renovation that upgrades treated wastewater to meet specific reuse requirements. May include general cleanup of water or removal of specific parts of wastes insufficiently removed by conventional processes. Typical processes include chemical treatment and pressure filtration. Also called **TERTIARY TREATMENT**.

AERATION The process of adding air to water. With mixture of wastewater and activated sludge, adding air provides mixing and oxygen for the microorganisms treating the wastewater.

AEROBES Bacteria that must have molecular (dissolved) oxygen (DO) to survive. Aerobes are aerobic bacteria.

AEROBIC A condition in which atmospheric or dissolved molecular oxygen is present in the aquatic (water) environment.

AEROBIC BACTERIA Bacteria which reproduce in an environment containing oxygen which is available for their respiration (breathing), namely atmospheric oxygen or oxygen dissolved in water. Oxygen combined chemically, such as in water molecules (H_2O), or nitrate (NO_3^-), cannot be used for respiration by aerobic bacteria.

AEROBIC DECOMPOSITION The decay or breaking down or organic material in the presence of "free" or dissolved oxygen.

AEROBIC PROCESS A waste treatment process conducted under aerobic (in the presence of "free" or dissolved oxygen) conditions.

ALKALINITY The capacity of water or wastewater to neutralize acids. The capacity is caused by the water's content of carbonate, bicarbonate, hydroxide, and occasionally borate, silicate, and phosphate. Alkalinity is expressed in milligrams per liter of equivalent calcium carbonate. Alkalinity is not the same as pH because water does not have to be strongly basic (high pH) to have a high alkalinity. Alkalinity is a measure of how much acid must be added to a liquid to lower the pH to 4.5.

ANOXIC A condition in which the aquatic (water) environment does not contain enough dissolved molecular oxygen, which is called an oxygen deficient condition. Generally refers to an environment in which chemically bound oxygen, such as in nitrate, is present.

ANOXIC DENITRIFICATION A biological nitrogen removal process in which nitrate nitrogen is converted by microorganisms to nitrogen gas in the absence of dissolved oxygen.

ATTACHED GROWTH PROCESS Wastewater treatment processes in which the microorganisms and bacteria treating the wastes are attached to the media in the reactor. The wastes being treated flow over the media. Trickling filters and rotating biological contactors are attached growth reactors. These reactors can be used for BOD removal, nitrification and denitrification.

AUTOTROPHIC Describes organisms, plants, and some bacteria that use inorganic materials for energy and growth.

BOD Biochemical Oxygen Demand. The rate at which organisms use the oxygen, in water or wastewater, for oxidation of organic matter. In decomposition, organic matter serves as food for the bacteria and energy results from its oxidation. BOD measurements are used as a measure of the organic strength of wastes in water.

BACTERIA Bacteria are living organisms, microscopic in size, which usually consist of a single cell. Most bacteria use organic matter for their food and produce waste products as a result of their life processes.

BATCH PROCESS A treatment process in which a tank or reactor is filled, the wastewater (or other solution) is treated or a chemical solution is prepared, and the tank is emptied. The tank may then be filled and the process repeated. Batch processes are also used to cleanse, stabilize or condition chemical solutions foe use in industrial manufacturing and treatment processes.

BIOCHEMICAL OXYGEN DEMAND (see BOD)

COD Chemical Oxygen Demand. A measure of the oxygen-consuming capacity of organic matter present in wastewater. COD is expressed as the amount of oxygen consumed from a chemical oxidant in mg/l during a specific test. Results are not necessarily related to the biochemical oxygen demand (BOD) because the chemical oxidant may react with substances that bacteria do not stabilize.

CARBONACEOUS STAGE A stage of decomposition that occurs in biological treatment processes when aerobic bacteria, using dissolved oxygen, change carbon compounds to carbon dioxide. Sometimes referred to as "first-stage BOD" because the microorganisms attack organic or carbon compounds first and nitrogen compounds later.

CHEMICAL OXYGEN DEMAND (see COD)

DO Abbreviation of Dissolved Oxygen. DO is the molecular (atmospheric) oxygen dissolved in water and wastewater.

DENITRIFICATION (1) The anoxic biological reduction of nitrate nitrogen to nitrogen gas. (2) Te removal of some nitrogen from a system. (3) An anoxic process that occurs when nitrite or nitrate ions are reduced to nitrogen gas and nitrogen bubbles are formed as a result of this process. The bubbles attach to the biological floc in the activated sludge process and float the floc to the surface of the secondary clarifiers. This condition is often the cause of rising sludge observed in secondary clarifiers or gravity thickeners.

DISSOLVED OXYGEN (see DO)

EFFLUENT Wastewater or other liquid – raw (untreated), partially or completely treated – flowing FROM a reservoir, basin, treatment process, or treatment plant.

F/M RATIO Food to microorganism ratio. A measure of food provided to bacteria in an aeration tank or reactor in relation to the microorganism population expressed as follows:

$$\frac{\text{Food}}{\text{Microorganisms}} = \frac{\text{BOD, lbs/day}}{\text{MLVSS, lbs}}$$

FIXED FILM Process in which the bacteria attach to a media from a film. The film is fixed to the media being used.

HEADER A large pipe to which the ends of a series of smaller pipes are connected. Also called manifold.

HETEROTROPHIC Describes organisms that use organic matter for energy and growth. Animals, fungi and most bacteria are heterotrophs.

INFLUENT Wastewater or other liquid – raw (untreated) or partially treated, flowing into a treatment plant.

LOADING Quantity of material applied to a device at one time. Hydraulic loading is a measure of liquid flow into a vessel.

MLSS Mixed Liquor Suspended Solids expressed as mg/l of solids usually measured in an aeration tank.

MANIFOLD A large pipe to which the ends of a series of smaller pipes are connected (see HEADER).

MEDIA The material in a trickling filter or biologically aerated filter on which organisms grow and become attached.

MICROORGANISMS Very small organisms that can be seen only through a microscope. Some microorganisms use the waste in wastewater for food and thus remove or alter much of the undesirable matter.

MILLIGRAMS PER LITER mg/l Measure of the concentration of a substance per unit volume. For practical purposes, one mg/l of a substance in water is equal to one part per million parts (ppm)

MIXED LIQUOR SUSPENDED SOLIDS When the activated sludge in an aeration tank is mixed with primary effluent or the raw wastewater and return sludge, this mixture is then referred to as mixed liquor which is measured as solids in mg/l or ppm.

MIXED LIQUOR VOLATILE SOLIDS The organic or volatile suspended solids in the mixed liquor of an aeration tank. This volatile portion is used as a measure or indication of the microorganisms present.

MOLECULAR OXYGEN The oxygen molecule, O_2, that is not combined with another element to form a compound.

NITRIFICATION An aerobic process in which bacteria change the ammonia and organic nitrogen in wastewater into oxidized nitrogen (usually nitrate). The second-stage BOD is sometimes referred to as the "nitrogenous BOD" (first-stage BOD is called the "carbonaceous BOD")

NITRIFICATION STAGE A stage of decomposition that occurs in biological treatment processes when aerobic bacteria, using dissolved oxygen, change nitrogen compounds (ammonia and organic nitrogen) into oxidized nitrogen (usually nitrate). The second-stage BOD is sometimes referred to as the "nitrification stage" (first-stage BOD is called the "carbonaceous stage").

NITRIFYING BACTERIA Bacteria that change the ammonia and organic nitrogen in wastewater into oxidized nitrogen (usually nitrate).

NITROGENOUS A term used to describe chemical compounds (usually organic) containing nitrogen in combined forms. Proteins and nitrate are nitrogenous compounds.

NUTRIENT CYCLE The transformation or change of a nutrient from one form to another until the nutrient has returned to the organic form, thus completing the cycle. The cycle may take place under either aerobic or anaerobic conditions.

NUTRIENTS Substances, which are required to support living plants and organisms. Major nutrients are carbon, hydrogen, oxygen, sulfur, nitrogen and phosphorous. Nitrogen and phosphorous are difficult to remove from wastewater by conventional treatment processes because they are water-soluble and tend to recycle.

O & M MANUAL Operation and Maintenance Manual. A manual that describes detailed procedures for operators to follow to operate and maintain a specific wastewater treatment or pretreatment plant and the equipment of that plant.

ORGANIC WASTE Waste material comes mainly from animal or plant sources. Bacteria and other small organisms generally can consume organic wastes. Inorganic wastes are chemical substances of mineral origin.

ORGANISM Any form of animal or plant life.

PROGRAMMABLE LOGIC CONTROLLER (PLC) A small computer that controls process equipment (variables) and can control the sequence of valve operations.

RESPIRATION The process in which an organism uses oxygen for its life processes and gives off carbon dioxide.

RETENTION TIME The time water, or solids are retained or held in a process tank

SCFM Cubic Feet of air per Minute at Standard conditions of temperature, pressure, and humidity (0 degrees C, 14.7 psia, and 50% relative humidity).

SECONDARY TREATMENT A wastewater treatment process used to convert dissolved or suspended materials into a form more readily separated from the water being treated. Usually the process follows primary treatment by sedimentation. The process commonly is a type of biological treatment process followed by secondary clarifiers that allow the solids to settle out from the water being treated.

SENSOR A device that measures (senses) a physical condition or variable of interest. Floats and thermocouples are examples of sensors.

SEPTIC A condition produced by anaerobic bacteria. If severe, the wastewater produces hydrogen sulfide, turns black, gives off foul odors, contains little or no dissolved oxygen, and the wastewater has a high oxygen demand.

SERIES OPERATION Wastewater being treated flows through one treatment unit and then flows through another similar treatment unit.

SET POINT The position at which the control or controller is set. This is the same as the desired value of the process variable.

SEWAGE The used household water and water-carried solids that flow in sewers to a wastewater treatment plant. The preferred term is Wastewater.

SHOCK LOAD The arrival at a plant of a waste which is toxic to organisms in sufficient strength to cause operating problems. Possible problems include odors, loss of treatment efficiency with excess solids and BOD discharge.

SLUDGE The settleable solids separated from liquids during processing.

SOLUBLE BOD Soluble BOD is the BOD of water that has been filtered in the standard suspended solids test.

SUSPENDED GROWTH Wastewater treatment processes in which the microorganisms and bacteria treating the wastes are suspended in the wastewater being treated. The wastes flow around and through the suspended growths. The various modes of the activated sludge process make use of the suspended growth reactors. These reactors can be used for BOD removal, nitrification, and denitrification.

SUSPENDED SOLIDS Solids that are suspended in water, wastewater, or other liquids, and which are largely removable by laboratory filtering.

TOC Total organic carbon. Measures the amount of organic carbon in water.

TERTIARY Any process of water renovation that upgrades treated wastewater to meet specific reuse requirements. May include general cleanup of water or removal of specific parts of wastes insufficiently removed by conventional treatment processes. Typical processes include chemical treatment and pressure filtration. Also called **ADVANCED WASTE TREATMENT**.

TOTALIZER A device or meter that continuously measures and calculates (adds) as process rate variable in cumulative fashion, such as a flow meter.

TURBIDITY Turbidity units measure of the cloudiness of water. If measured by a nephelometric (deflected light) instrumental procedure, turbidity units are expressed in nephelometric units (NTU) or simply TU.

G. Design Criteria

AMPHIDROME™ DESIGN CALCULATIONS
10/28/08

SEVERN TRENT SERVICES
Water Purification Solutions, Inc.

Project Name:	Single Family
STS #:	not yet assigned
Sales Rep.:	none
Client's Engr.:	n/a
Plant Location:	MA
STS Engineer:	n/a
Comments:	(30,30,19)
Date:	5/1/2009

I. DESIGN BASIS

A. Pollutant Removal Rate in Amphidrome™ @ 20 deg C prior to temp. correction

NH_4-N removal rate	=	40	lbs N/1000 cu.ft./day
CBOD removal rate	=	150	lbs CBOD/1000 cu.ft./day

B. General Design Parameters

Number of batches per day	=	2.0	batches/day
Number of aerobic cycles/batch	=	3.0	cycles (forw.+ rev.)/batch
Number of anoxic cycles/batch	=	2.0	cycles (forw.+ rev.)/batch
Backwash water rate	=	6.0	gpm/sq.ft.
Minimum BW duration acceptable	=	10.0	minutes/BW
Reverse flow duration, calculated	=	23.4	minutes/reverse flow
Estimated duration of forward flow	=	90.0	minutes/forward cycle
Backwash air rate	=	5.0	icfm/sq.ft.
Desired BW frequency for design	=	1.0	day/reactor
Amphidrome reactor surface area	=	3.1	sq.ft. 4 ft. x 4 ft.
Media depth	=	4.0	ft.
Media specific surface area	=	250.0	sq.ft./cu.ft.
Max. specific solids loading	=	0.7	lbs/sq.ft.
Biomass yield for CBOD heter.	=	0.4	lb. biomass/lb. CBOD ox.
Biomass yield for NO_3-N heter.	=	1.0	lb. biomass/lb. NO3-N red.
Biomass yield for NH_4-N auto.	=	0.1	lb. biomass/lb. NH4-N ox.
Solids yield from TSS	=	0.4	lb. solids/lb. TSS removed
Oxygen demand for total CBOD	=	1.8	lb. O_2/lb. CBOD removed
Oxygen demand for NH_4-N	=	4.6	lb. O_2/lb. N oxidized
Oxygen Transfer Efficiency (OTE)	=	12.0	%
N assimilation in biomass	=	5.0	%
P assimilation in biomass	=	1.0	%
Arrhenius theta for temp. corr.	=	1.04	
Estimated power cost	=	$0.15	/KWH
Press. rating for BW blower/pump	=	9.0	psig

C. Design Flow

		MGD	gpm
Average	=	0.000	0.31
Peak	=	0.000	0.31

Amphidrome™ design based on Avg. flow assuming adequate EQ in anoxic tank

D. Influent Characteristics of Raw Wastewater Applied to Anoxic Tank

Parameter		Summer	Winter	
CBOD total, mg/L	=	350.0	350.0	Assumed
TKN, mg/L	=	50.0	50.0	Assumed
Ammonium as N, mg/L	=	40.0	40.0	Assumed
TSS, mg/L	=	200.0	200.0	Assumed
pH, SU	=	6.8	6.8	Assumed
Alkalinity, mg/L $CaCO_3$	=	150.0	150.0	Assumed
Phosphate as P, mg/L	=	8.0	8.0	Assumed
Min. temperature, deg.C	=	20.0	11.0	Assumed

E. Influent Characteristics of Wastewater Applied to Amphidrome™ Tank

Assume TSS removed to < 50 mg/L in upstream anoxic tank

Assume organic N component of TKN oxidizes to NH_4-N in Amphidrome™ reactor

Assume insoluble CBOD in raw ww is converted to soluble CBOD in anoxic tank

Assume ratio of raw CBOD to carbon	=	2.5	CBOD/C
Carbon consump. using CBOD as C source	=	2.5	C/NO_3-N

		Summer	Winter
Carbon content of raw CBOD, mg/L	=	140.0	140.0
, lb/day	=	0.5	0.5
Max. NO_3-N removal in anoxic tank, using 100% of the raw CBOD as carbon source:			
, mg/L	=	56.0	56.0
, lb/day	=	0.2	0.2
Desired design value for % removal of CBOD in anoxic tank due to denitrification:			
	=	35.0	% CBOD removal
NO_3-N removal in anoxic tank based on desired design % CBOD removal:			
, mg/L	=	19.6	19.6
, lb/day	=	0.1	0.1
Biomass yield due to denitrification in anoxic tank:			
, lb/day	=	0.1	0.1
NH_4-N removal in anoxic tank due to assimilation in denitrification culture:			
, mg/L	=	1.0	1.0
, lb/day	=	0.0	0.0
P removal in anoxic tank due to assimilation in denitrification culture:			
, mg/L	=	0.2	0.2
, lb/day	=	0.0	0.0
Alkalinity generated in anoxic tank due to denitrification:			
, mg/L CaCO3	=	58.8	58.8
, lb/day CaCO3	=	0.2	0.2

F. Amphidrome™ influent characteristics for first forward cycle, not incl. recycle

Parameter		Summer	Winter
CBOD total, mg/L	=	227.5	227.5

TKN, mg/L	=	49.0	49.0
Ammonium as N, mg/L	=	39.0	39.0
TSS, mg/L	=	50.0	50.0
pH, SU	=	6.8	6.8
Alkalinity, mg/L $CaCO_3$	=	208.8	208.8
Phosphate as P, mg/L	=	7.8	7.8
Min. temperature, deg.C	=	20.0	11.0

G. Desired Effluent Characteristics (Discharge Limits)

Parameter		Summer	Winter	(rem. in Amph.)
CBOD total, mg/L	=	30.0	30.0	87%
Ammonium as N, mg/L	=	2.0	2.0	96%
TSS, mg/L	=	5.0	5.0	
pH, SU	=	6-9	6-9	

II. SUMMARY OF AMPHIDROME™ DESIGN FOR SUMMER CONDITIONS

A. Kinetics	Influent CBOD:TKN ratio	=	4.64			
	CBOD removal required	=	0.7	lbs/day		
	Heterotrophic yield	=	0.3	lbs/day		
	NH_4-N removal required	=	0.2	lbs/day		
	N assimilation in heterotrophs	=	0.0	lbs/day		
	P assimilation in heterotrophs	=	0.0	lbs/day		
	Est. phosphate in effluent	=	7.0	mg/L as P		
	N Bio-oxidation required	=	0.2	lbs/day		
	NO_3-N rem. req'd in anoxic mode	=	23.5	mg/L		
	Autotrophic yield	=	0.0	lbs/day		
	TSS removal required	=	0.2	lbs/day		
	Solids yield from TSS	=	0.1	lbs/day		
	Total Bio-solids yield	=	0.3	lbs/day		
	Temp. correction factor	=	1.0	Arrhenius correction		
	Design BOD ldng. w/temp corr.	=	150.0	lbs/day/1000 cu.ft.		
	Design N ldng. w/temp corr.	=	40.0	lbs/day/1000 cu.ft.		
B. Reactor	Media required for CBOD	=	4.8	cu.ft.	55%	
	Media required for nitrification	=	4.0	cu.ft.	45%	
	Total media volume required	=	8.8	cu.ft.		
	Media volume/reactor	=	12.6	cu.ft.		of total
	Raw # of reactors required	=	0.7	reactors		of total
	Fractional portion of reactor	=	0.7	reactors		
	Number of reactors required	=	1.0	reactor(s)		
	Total reactor surface area	=	3	sq.ft.		
	Actual media volume	=	13	cu.ft. =	94	gal
	Media surface area	=	3,140	sq.ft.		
	Specific media loading, NH_4-N	=	0.11	lbs/Ksf/d		
	Actual volummetric load, N ox.	=	27.97	lbs/Kcf/d	0.45	Kg/m3/d
	Full-bed vol. load, N ox.	=	12.58	lbs/Kcf/d	0.20	Kg/m3/d
	Specific media loading, CBOD	=	0.42	lbs/Ksf/d		
	Actual volummetric load, CBOD	=	104.89	lbs/Kcf/d	1.68	Kg/m3/d
	Full-bed vol. load, CBOD	=	57.70	lbs/Kcf/d	0.93	Kg/m3/d
C. Hydraulics	Avg. hyd. load for forward flow	=	0.78	gpm/sq.ft.		
	Avg. hyd. load for reverse flow	=	6.00	gpm/sq.ft.		
	Duration of forward cycles/batch	=	450	minutes/batch		
	Duration of reverse cycles/batch	=	93	minutes/batch		
	Batch processing time	=	9.06	hours,	**Batch time ok**	
	EBDT for aerobic cycles, total	=	128	minutes		
	EBDT for anoxic cycles, total	=	81	minutes		
D. Process Air	Min. theoretical process air	=	0.75	icfm		
	Min. process air, DF= 2.7	=	2.02	icfm		

	Dedicated blower per reactor		2.02	icfm	
	~ P blower motor, full load	=	0.10	HP @	9.0 psig
	Process air loading	=	0.64	icfm/sq.ft.	
	MESSAGE: Process air loading is too low for adequate distribution, increase DF				
	CBOD+N oxidizing load @ 20 C	=	162	lbs O_2/1000 cu.ft.	
	MESSAGE: Oxidizing load is within acceptable range				
E. Backwash	Backwash air requirement	=	15.70	icfm	
option #1	BW air minus 1 process blower	=	13.68	icfm	
	~ BW blower motor, full load	=	0.70	HP @	9.0 psig
option #2	BW air demand-all process-all BW blov	=	13.68	icfm	
	~ BW blower motor, full load	=	0.70	HP @	9.0 psig
	Backwash water flow	=	18.84	gpm with 2 pumps operating	
	~ BW pump motor, full load	=	0.09	HP @	9.0 psig
	BW water volume/BW	=	220	gallons	
	Min. Mudwell/Clearwell size	=	440	gallons	(see PFD sheet)
	Backwash frequency theo. req'd	=	5.56	days/reactor	
	Desired design BW frequency	=	1.00	days/reactor	
	Backwash flow duration	=	11.7	minutes/BW	
	MESSAGE: Batch volume (w/o heel in clearwell) is adequate for min. BW duration				
F. Nutrients, P	Theoretical P req'd as nutrient	=	0.00	lbs/day	
	Est. actual P req'd (1.2 factor)	=	0.00	lbs/day	
	P available in raw wastewater	=	0.03	lbs/day	
	Supplemental P required	=	none req'd	lbs/day	
	Supplemental P as 75% H_3PO_4	=	N/A	gpd =	0.0 ml/min
	55-gal of 75% H_3PO_4 will last	=	N/A	days	
, N	Theoretical N req'd as nutrient	=	0.02	lbs/day	
	Est. actual N req'd (1.2 factor)	=	0.02	lbs/day	
	N available in applied flow	=	0.18	lbs/day	
	Supplemental N required	=	none req'd	lbs/day	
	Supplemental N as $(NH_4)_2SO_4$	=	0.00	lbs/day	
	@ 25% $(NH_4)_2SO_4$ solution	=	0.00	gpd =	0.0 ml/min
G. Alkalinity	Alk. needed for acid neut.	=	308	mg/L as $CaCO_3$	
	Supplemental Alk. req'd	=	99	mg/L as $CaCO_3$	
		=	0	lb/day as $Mg(OH)_2$	
		=	0	lb/day as Na_2CO_3	
		=	0	gpd of 25% Na_2CO_3	
	Size of day tank for alkali sol'n	=	0	gallons	
	Agitator size @ 1 HP/1000 gal.	=	0.00	HP	
	Alk. needed as carbon source	=	31	mg/L as $CaCO_3$	

IV. ESTIMATED OPERATING COSTS

Power @ $0.15 /KWH

Backwash pump power	=	$1	per year
Reverse pump power	=	$5	per year
Discharge pump power	=	$1	per year
Backwash blower power	=	$5	per year

Process blower power	=	$42	per year	
Subtotal:		$54	per year	22%
Chemicals				
75% Phosphoric acid @ $0.85/lb	=	$0	per year	
95% Amm. Sulfate @ $0.07/lb	=	$0	per year	
97% Hyd. Lime @ $60/ton	=	$3	per year	
Subtotal:		$3	per year	1%
Labor				
1 laborer @ $60k/yr, PT		$0	per year	0%
Maintenance				
% of index	=	$0	per year	0%
Sludge Disposal				
1,282 gal/yr @ 1.5%,$0.15/gal	=	$192	per year	77%
Total Est. Operating Cost	=	**$249**	**per year**	

II. SUMMARY OF AMPHIDROME^{TM} DESIGN FOR WINTER CONDITIONS

A. Kinetics	Influent CBOD:TKN ratio	=	4.64			
	CBOD removal required	=	0.7	lbs/day		
	Heterotrophic yield	=	0.3	lbs/day		
	NH_4-N removal required	=	0.2	lbs/day		
	N assimilation in heterotrophs	=	0.0	lbs/day		
	P assimilation in heterotrophs	=	0.0	lbs/day		
	Est. phosphate in effluent	=	7.0	mg/L as P		
	N Bio-oxidation required	=	0.2	lbs/day		
	NO_3-N rem. req'd in anoxic mode	=	23.5	mg/L		
	Autotrophic yield	=	0.0	lbs/day		
	TSS removal required	=	0.2	lbs/day		
	Solids yield from TSS	=	0.1	lbs/day		
	Total Bio-solids yield from Amph.	=	0.3	lbs/day		
	Temp. correction factor	=	0.7	Arrhenius correction		
	Design BOD ldng. w/temp corr.	=	105.4	lbs/day/1000 cu.ft.		
	Design N ldng. w/temp corr.	=	28.1	lbs/day/1000 cu.ft.		
B. Reactor	Media required for CBOD	=	6.9	cu.ft.	55% of total	
	Media required for nitrification	=	5.6	cu.ft.	45% of total	
	Total media volume required	=	12.5	cu.ft.		
	Media volume/reactor	=	12.6	cu.ft.		
	Raw # of reactors required	=	1.0	reactors		
	Fractional portion of reactor	=	1.0	reactors		
	Number of reactors required	=	1.0	reactor(s)		0.0
	Total reactor surface area	=	3.1	sq.ft.		
	Actual media volume for system	=	12.6	cu.ft. =	94 gal	
	Media surface area	=	3,140	sq.ft.		
	Specific media loading, NH_4-N	=	0.11	lbs/Ksf/d		
	Actual volummetric load, N ox.	=	27.97	lbs/Kcf/d	0.45 Kg/m3/d	
	Full-bed vol. load, N ox.	=	12.58	lbs/Kcf/d	0.20 Kg/m3/d	
	Specific media loading, CBOD	=	0.42	lbs/Ksf/d		
	Actual volummetric load, CBOD	=	104.89	lbs/Kcf/d	1.68 Kg/m3/d	
	Full-bed vol. load, CBOD	=	57.70	lbs/Kcf/d	0.93 Kg/m3/d	
C. Hydraulics	Avg. hyd. loading for forward flow	=	0.78	gpm/sq.ft.		
	Avg. hyd. loading for reverse flow	=	3.00	gpm/sq.ft.		
	Duration of forward cycles/batch	=	450	minutes/batch		
	Duration of reverse cycles/batch	=	93	minutes/batch		
	Batch processing time	=	9.06	hours,	**Batch time ok**	
	EBDT for aerobic cycles	=	145	minutes/batch		
	EBDT for anoxic cycles	=	87	minutes/batch		
				assume last cycle is anoxic		
D. Process Air	Min. theoretical process air, total	=	0.75	icfm		
	Min. process air, DF= 2.7	=	2.02	icfm		

	Dedicated blower per reactor		2.02	icfm	
	~ P blower motor, full load	=	0.10	HP @ 9.0 psig	
	Process air loading	=	0.64	icfm/sq.ft.	
	MESSAGE:	Process air loading is too low for adequate distribution, increase DF			
	CBOD+N oxidizing load @ 20 C	=	230	lbs O_2/1000 cu.ft.	
	MESSAGE:	Oxidizing load is within acceptable range			
E. Backwash	Backwash air requirement	=	15.70	icfm	
option #1	BW air demand - 1 process blower	=	13.68	icfm	
	~ BW blower motor, full load	=	0.70	HP @ 9.0 psig	
option #2	BW air demand-all process-all Denite B	=	(5.16)	icfm	
	~ BW blower motor, full load	=	(0.26)	HP @ 9.0 psig	
	Backwash water flow	=	18.84	gpm w/2 pumps operating	
	~ BW pump motor, full load	=	0.09	HP @ 9.0 psig	
	BW water volume/BW	=	220	gallons	
	Min. Mudwell/Clearwell size	=	440	gallons (see PFD sheet)	
	Backwash frequency theo. req'd	=	5.56	days/reactor	5.56
	Desired design BW frequency	=	1.00	days/reactor	
	Backwash flow duration	=	11.7	minutes/BW	
	MESSAGE:	Batch volume (w/o heel in clearwell) is adequate for min. BW duration			
F. Nutrients, P	Theoretical P req'd as nutrient	=	0.00	lbs/day	
	Est. actual P req'd (1.2 factor)	=	0.00	lbs/day	
	P avail. in applied wastewater	=	0.03	lbs/day	
	Supplemental P required	=	none req'd	lbs/day	
	Supplemental P as 75% H_3PO_4	=	N/A	gpd = 0.0 ml/min	
	55-gal of 75% H_3PO_4 will last	=	N/A	days	
, N	Theoretical N req'd as nutrient	=	0.02	lbs/day	0.00
	Est. actual N req'd (1.2 factor)	=	0.02	lbs/day	
	N available in applied flow	=	0.18	lbs/day	
	Supplemental N required	=	none req'd	lbs/day	
	Supplemental N as $(NH_4)_2SO_4$	=	0.00	lbs/day @ 100%	
	@ 25% $(NH_4)_2SO_4$ solution	=	0.00	gpd = 0.0 ml/min	
G. Alkalinity	Alk. needed for acid neut.	=	308	mg/L as $CaCO_3$	
	Supplemental Alk. req'd	=	99	mg/L as $CaCO_3$	0.00
		=	0	lb/day as $Mg(OH)_2$	
		=	0	lb/day as Na_2CO_3	
		=	0	gpd of 25% Na_2CO_3	
	Size day tank for Na_2CO_3 sol'n	=	0	gallons	
	Agitator size @ 1 HP/1000 gal.	=	0.00	HP	
	Alk. needed as carbon source	=	31	mg/L as $CaCO_3$	

IV. ESTIMATED OPERATING COSTS

Power @ $0.15 /KWH

Backwash pump power	=	$1	per year
Reverse pump power	=	$5	per year
Discharge pump power	=	$1	per year
Backwash blower power	=	$5	per year

Process blower power	=	$42	per year	
Subtotal:		$54	per year	76%
Chemicals				
75% Phosphoric acid @ $0.85/lb	=	$0	per year	
95% Amm. Sulfate @ $0.07/lb	=	$0	per year	
97% Soda Ash @ $150/ton	=	$11	per year	
Subtotal:		$11	per year	15%
Labor				
1 laborer @ $60k/yr, PT	=	$0	per year	0%
Maintenance				
% of index	=	$0	per year	0%
Sludge Disposal				
0 yd/yr @ 25%, $25/yd	=	$6	per year	9%
Total Est. Operating Cost	=	**$71**	**per year**	

Power for BW blower, option #2		-0.26	HP
Power for Process blower	=	0.10	HP

III. EQUIPMENT LIST FOR ROM-TYPE ESTIMATE (based on winter conditions)

	Qty	Description						
	1	Amphidrome reactor @	3.1	sq.ft. 4 ft. x 4 ft.				
	1 lot	6 x 9 media @	0.6	tons,	4.0	ft. depth		
	1 lot	support gravel @	0.2	tons,	1.5	ft. depth		
	1	Anoxic tank @	330	gallons, operating + sludge storage vol.				
	1	Clearwell @	440	gallons operating capacity				
	2 *	BW/reverse water pump @	9	gpm @	9	psig,	0.1	HP
op#1	1 +	BW blower dedicated @	14	icfm @	9	psig,	0.7	HP
op#2	1 +	BW blower dedicated @	(5)	icfm @	9	psig,	(0.3)	HP
	1	Process blower dedicated@	2	icfm @	9	psig,	0.1	HP
	0	P Nutrient pump @	0.00	ml/min =	0.0	gph		
	0	N Nutrient pump @	0.00	ml/min =	0.0	gph		
	2	Alkali feed pump	0.45	ml/min (assuming soda ash)				
	1	Alkali day tank	0	gallons				
	1	Alkali tank agitator	0.00	hp				
	0	Instrument air comp.	10	scfm @ 100 psig				
	0	Instrument air dryer	20	scfm @ 100 psig				
	0	Control System						

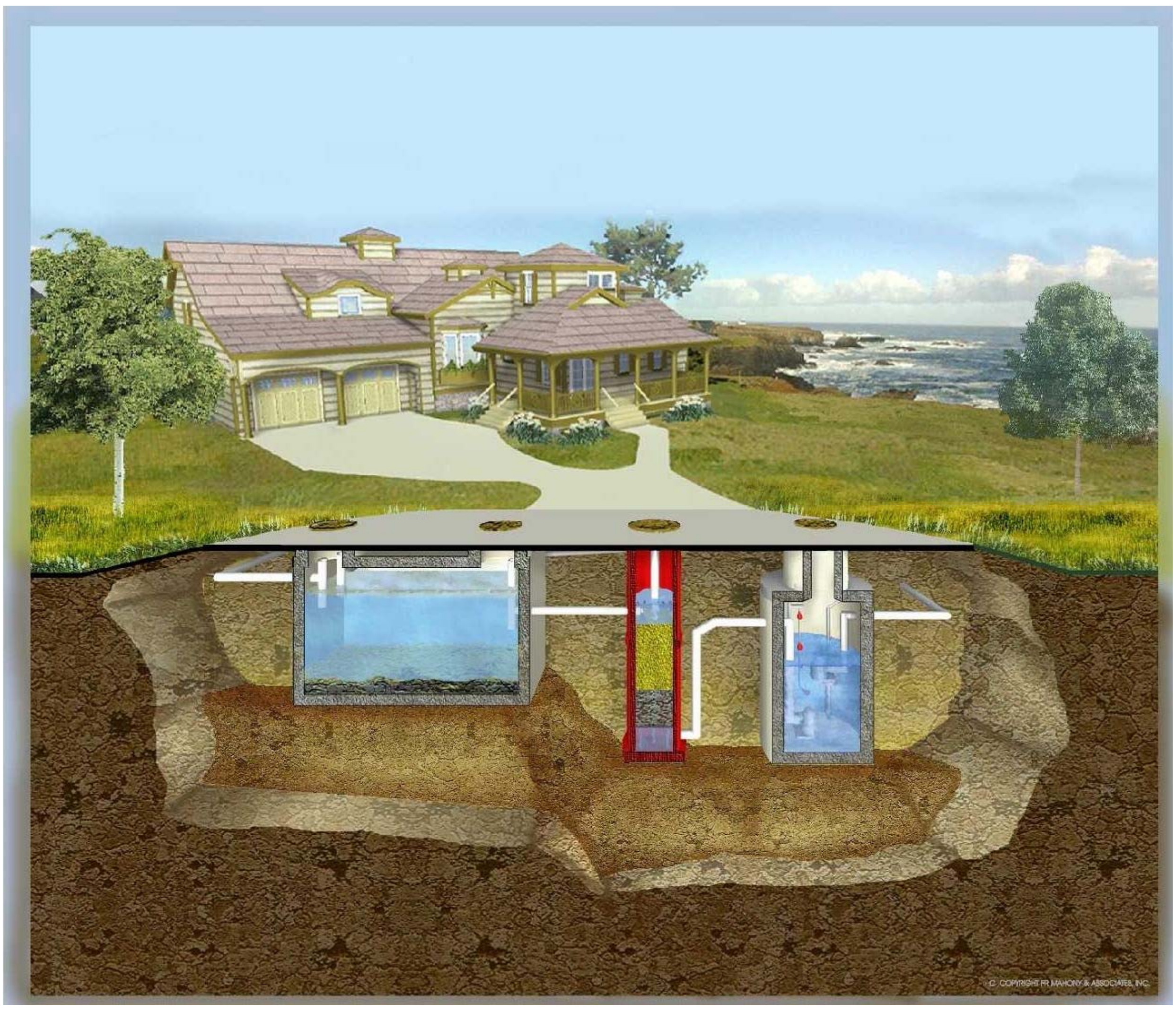
* 2 pumps operating for BW, 1 operating for reverse flow
\+ op#1 assumes 1 BW blower + 1 process blower operating
\+ op#2 assumes all BW blowers + all process blowers operating + Denite BW blowers

H. Installation Criteria

Amphidrome®

Installation Instructions

The highest level of Nitrogen removal available...



...and at a reasonable cost.

f.r. mahony & associates, inc.
frma

TABLE OF CONTENTS

The Amphidrome® Process

The Amphidrome® system is a submerged attached growth bioreactor process, designed around a deep-bed sand filter. It is specifically designed for the simultaneous removal of soluble organic matter, nitrogen and suspended solids within a single reactor. Since it removes nitrogen, it may also be considered a biological nutrient removal (BNR) process.

To achieve simultaneous oxidation of soluble material, nitrification, and denitrification in a single reactor, the process must provide aerobic and anoxic environments for the two different populations of microorganisms. The Amphidrome® system utilizes two tanks and one submerged attached growth bioreactor, called the Amphidrome® reactor. The first tank, the anoxic/equalization tank, is where the raw wastewater enters the system. The tank has an equalization section, a settling zone, and a sludge storage section. It serves as a primary clarifier before the Amphidrome® reactor.

This Amphidrome® reactor consists of the following three items: underdrain, support gravel, filter media. The underdrain, constructed of stainless steel, is located at the bottom of the reactor. It provides support for the media and even distribution of air and water into the reactor. The underdrain has a manifold and laterals to distribute the air evenly over the entire filter bottom. The design allows for both the air and water to be delivered simultaneously--or separately--via individual pathways to the bottom of the reactor. As the air flows up through the media, the bubbles are sheared by the sand, producing finer bubbles as they rise through the filter. On top of the underdrain is 18" (five layers) of four different sizes of gravel. Above the gravel is a deep bed of coarse, round silica sand media. The media functions as filter, significantly reducing suspended solids and provides the surface area for which an attached growth biomass can be maintained.

To achieve the two different environments required for the simultaneous removal of soluble organics and nitrogen, aeration of the reactor is intermittent rather than continuous. Depending on the strength and the volume of the wastewater, a typical aeration scheme may be three to five minutes of air and ten to fifteen minutes without air. Concurrently, return cycles are scheduled every hour, regardless of the aeration sequence. During a return, water from the clear well is pumped back through the filter and overflows into the energy-dissipating TEE. A check valve in the influent line prevents the flow from returning to the anoxic/equalization tank via that route. The energy-dissipating TEE is set at a fixed height above both the media and the influent line, and the flow is by gravity back to the front of the anoxic/equalization tank.

The cyclical forward and reverse flow of the waste stream and the intermittent aeration of the filter achieve the required hydraulic retention time and create the necessary aerobic and anoxic conditions to achieve the required level of treatment.

General

Installers of Amphidrome® systems should be versed in installation of Onsite Wastewater Treatment Systems (OWTS) and trained in the installation of Amphidrome®. Installers must comply with RIDEM OWTS Rules, the Amphidrome® certification, System permit, Installation Manual requirements and other applicable safety requirements such as licenses for equipment operators and truck drivers.

Construction of Amphidrome® systems require that the approved plans and instructions be followed. Engineered plans showing elevations of tanks and pipelines and the layout should be on site and referenced by the Installer and their agents. The manufacturer shall be consulted with regard to any conflicts or questions regarding clarification of plans, details, and any omissions or errors that may be encountered.

The Amphidrome® system is designed to use standard construction materials that may be found in any region. Tanks are typically concrete with rubber grommets, boots or gaskets for all pipe penetrations. Piping is standard PVC or cast iron or stainless steel material.

~~Contractors~~ Installers will be required to follow the plans and prepare the site in the same manner as would be used with a conventional ~~SSDS~~ OWTS. The Amphidrome® system is an advanced wastewater treatment process that performs in much the same way as a conventional ~~SSDS~~ OWTS with certain modifications.

The process flow stream will enter an anoxic tank rather than a Septic Tank. The anoxic tank will provide the first function of primary settling and flow equalization. The flow will then proceed to the Amphidrome® Reactor for aerobic treatment and filtration in the forward flow direction. Treated waste will leave the bottom of the reactor and flow through the return pump line and the return pump into the clear well. The clear well will store a batch of treated effluent until a float switch is activated causing the return pump to pump effluent in the return mode back through the reactor and then back to the anoxic tank. Once the return pump stops, the flow will then flow by gravity in the forward direction through the reactor and into the clear well. During this cycle the aeration blowers will be off causing an anoxic condition to occur. The process results in denitrification of the wastewater in the clear well. The discharge pump will pump to the leach field or absorption field when the process is completed. For a more detailed process description, refer to the Operation and Maintenance Manual.

Installers will be required to provide and set tanks and provide and install piping as called for on the design plans~~. The installer~~ field wiring of pumps and panels supplied by the manufacturer shall be performed by a properly credentialed electrician. All site work and site restoration shall be supplied by the Installer.

Start up services and inspection services of the manufacturer or authorized agents shall include:

1) Inspection of air pattern in the reactor or "Air Pattern Test" prior to installation of media. See media installation instructions below.
2) Process startup including verification of wiring connections, operation of pumps, blowers and process controller.
3) Annual collection of wastewater samples and measurement of the level of sludge in the anoxic/equalization tank.

Installer shall perform installation in conformance with the RIDEM-approved plan. The manufacturer's inspections shall in no way imply approval to backfill components that must be inspected by other authorities without their inspection.

Installation Procedures

Each installation will vary based on individual site conditions and restrictions. The general procedures should be followed for placement of components. These instructions are not intended to instruct installers on every aspect of an individual installation. It is expected that good construction practices will be followed with regards to excavation, setting of pipes and tanks and placement of bedding and backfill materials with proper grade, slopes, and compaction techniques. Field wiring shall be in accordance with Local and National Wiring Codes and the Manufacturer's wiring diagrams.

Construction will most likely begin with setting of the deepest components first. The anoxic tank, reactor and clear well must be set on level, firm foundation of excavated material or properly compacted and stable fill material. Proper grade or elevations of pipes and tanks is essential to the functioning of this system. Improper grade of pipelines or tanks shall void process warranties.

It is recommended that the contractor verify measurements of each tank and verify the location of pipe penetrations and the size and elevation of these penetrations before placing each tank. It is important to install proper gaskets and seals as provided by the concrete supplier prior to backfilling and water testing the tank.

Refer to Appendix 1, Drawing 1, Amphidrome® Process, Single Family Unit

Amphidrome® System Piping

Amphidrome® Reactor Outside Piping

The Amphidrome® Reactor discharge line (2-inch PVC) and associated elbows and fittings should be placed and supported as the backfill material is brought up to the grade of the next lowest horizontal pipe. This fill material must be properly compacted to support all pipes that will be placed in fill material.

Anoxic Tank Outside Piping

Pipelines for inlet and discharge to the anoxic tank and the return and backwash line should be installed to the slope and elevations marked on the plans. The inlet line from the home to the anoxic tank is 4-inch schedule 40 PVC unless otherwise indicated on the plans. The backwash and return line is 4-inch Schedule 40 PVC. The discharge line from the anoxic tank is 2-inch Schedule 40 PVC.

Pipes should penetrate the inside of the tank wall with sufficient length to connect inlet TEE, Discharge TEE and check valve assembly and return & backwash return TEE and energy dissipating drop pipe and diffuser assembly provided by the manufacturer. Pipes shall be properly cleaned and glued with PVC solvent. Pipelines shall be watertight and airtight and tested prior to operation of the system.

Amphidrome® Reactor Interconnecting Piping

The backwash and return line and inlet line may be connected to the Amphidrome® reactor after completion of the installation of air header, support gravel and media as described below. Depending on the reactor depth, the Installer may find it is easier to complete this work before adding the top reactor section that will receive the interconnecting pipes. The discharge line from the reactor (2-inch Schedule 40 PVC) may be continued to the clear well providing sufficient pipe inside the clear well to connect the return pump discharge hose and coupler.

Clear Well Outside Piping

The piping consists of the inlet line referenced above and a discharge line (2-inch Schedule 40 PVC) that will flow to the distribution box or dosing chamber if required. Sufficient pipe must be left inside the clear well to connect the discharge pump discharge hose and coupler.

Air Piping Outside

Air piping from the blower location to the clear well must be properly assembled to provide an airtight assembly from the Amphidrome® Reactor to the blower. The air piping shall be 1-1/2 inch Schedule 80 PVC.

Amphidrome® Reactor Internals

This Amphidrome® reactor consists of the following three (3) items: underdrain, support gravel, and filter media that are assembled in a concrete vessel. The underdrain, constructed of stainless steel, is located at the bottom of the vessel. It provides support for the media and even distribution of air and water into the reactor. The underdrain has a manifold and laterals to distribute the air evenly over the bottom of the reactor. The design allows for both the air and water to be delivered simultaneously, or separately, via individual pathways, to the bottom of the reactor. As the air flows up through the media, the bubbles are sheared by the sand; producing finer bubbles as they continue to rise. On top of the underdrain is 18”, (five layers), of four different sizes of gravel. Above the gravel is a deep bed of coarse, round, silica sand media. The media functions as a filter; significantly reducing suspended solids, and provides the surface area for which an attached growth biomass can be maintained.

Refer to Appendix 1, Drawing 2, 2' Diameter Amphidrome® Reactor, Construction Dimensions

Amphidrome® Reactor Floats (2)

All conduits from tanks shall be sealed with appropriate material to prevent liquid and gas to travel from tank penetrations.

PICTURE 1.
REACTOR FLOATS

Amphidrome® Reactor High Float

- The float controls the duration of each return after the float is elevated. If the float remains elevated for twenty minutes (20) after either a backwash or a return, a high level alarm is sent.

Amphidrome® Reactor Low Float

- The float initiates a return if liquid level drops to the level of the float. **This function is provided as an option**, which is activated by inputting both a start and stop time into the appropriate V register. Inputting a value of 9999 eliminates the use of the option. The ability to set a start and stop time for this option is provided.

Amphidrome® Reactor Installation Sequence

Pre-Installation Check

- The underdrain assembly is a single piece 23.5" in diameter. Measure the inside of the concrete vessel to be sure the underdrain assembly will fit.
- Check to see that the pipe penetrations are located properly.

Underdrain Installation

- The influent, dirty backwash, effluent, and backwash air piping are not to be installed until the underdrain assembly is installed.
- Place the underdrain in the vessel so that it is centered in the vessel and completely level.

Air Pattern Test

- With the underdrain assembly in place, fill the basin with water to 2" above the top of the underdrain.
- Use either the backwash blower or an air compressor to provide a minimum of 7 CFM of air.
- If the air distribution is visually even across the bottom, proceed to the next step. If not, remove the underdrain and check for plugged holes. Repeat the test after clearing the plugged holes.

Piping

- Install the influent, dirty backwash, effluent, and backwash air piping as shown.
- Install the influent check valve at the anoxic tank.

Gravel and Media Installation

Gravel and Sand

- Gravel and sand are to be installed in the reactor using buckets to drop the material into place. **Do not drop gravel and media from the top of the reactor.**
- The bucket should have two (2) ropes attached. One for lowering the bucket into place and a second to tip the bucket to dispense the gravel or media.

- Beginning with the proper size gravel for Layer # 1, carefully lower the bucket into the reactor to within 6" of the underdrain, tip the bucket and move the bucket as it is tipped in order to evenly distribute the material.
- Use a rod with a small plate on the end to move mounded material and to gently tamp the material level. Be careful not to tamp too much or too hard as this will cause the gravel to intermix. The top of each layer is to be level across the reactor.
- Repeat this process until the total amount of gravel for each layer has been dispensed.

Media

- Use the same method as the gravel for installation. Be careful not to get sand into the influent pipe nozzle. Use a survey rod to determine the level of the media layer as each layer is added. **NOTE: A SILICA SAND WARNING FOR POTENTIAL LUNG HAZARD IS PRINTED ON THE BACK OF EACH BAG OF MEDIA. PRECAUTION SHOULD BE USED WHEN DISTRIBUTING THIS MATERIAL.**

Layer No. 1 goes into the basin first, then Layer No. 2, and so on through Layer No. 5. A total of 18" of support gravel is placed in the basin. Layer No. 6, Filter Media, is 4'-0" in depth and is put in place last.

LAYER NO.	GRAIN SIZE	DEPTH	VOLUME Cubic Feet	# Bags
1	1 1/2" x 3/4" Gravel	0'-4"	1.0	2
2	3/4" x 1/2" Gravel	0'-2"	0.5	1
3	1/2" x 1/4" Gravel	0'-4"	1.0	2
4	1/4" x 1/8" Gravel	0'-4"	1.0	2
5	1/2" x 1/4" Gravel	0'-4"	1.0	2
6	Filter Media	4'-0"	12.5	25

Reactor Media Flushing

- After installation of gravel and media, the reactor is to be flushed with clean water and air to remove dust and fines. The backwash air blower and pump is used for this purpose. Flushing shall continue for a minimum of 15 minutes or until the backwash water is clear of fines. The reactor is to be filled with water before flushing begins.
- After completion of flushing, drain the reactor as much as possible and cover the media with plastic, or close over the top of the reactor, until the reactor is placed into service. This is to keep foreign contaminants out of the media.

Completion of the top access way cover and interconnecting external piping connections must be completed before backfilling around the top portion of the Reactor. Conduits for float and air piping and Reactor vent piping must be properly bedded and backfilled prior to final grading around the Reactor.

Anoxic Tank Internals

The Anoxic Tank Internals consists of the inlet TEE and vent and discharge line. The inlet line is 4-inch Schedule 40 PVC. The drop pipe or vertical discharge pipe shall be extended to 12-inches below the minimum water level or invert of the tank discharge line. The vent riser pipe shall extend above the maximum water level of the tank.

All TEE's and inside piping must be properly installed with PVC cleaner and solvent and supported with suitable supports as shown or otherwise required to hold the pipe assemblies in place.

The discharge 2-inch Schedule 40 PVC TEE and check valve assembly shall be properly cleaned and PVC solvent shall be used to seal to the 2-inch Schedule 40 PVC discharge line. The vertical inlet pipe shall extend to 10-inches below the minimum water level or invert of the discharge line. The vent riser pipe shall extend above the maximum water level of the tank.

Return & Backwash line shall be 4-inch Schedule 40 PVC. The inlet TEE and energy dissipation header shall be installed with PVC pipe cleaner and solvent. The top of the energy-dissipating header shall be just below the minimum water level of the tank so the header is fully submerged. The vertical drop pipe must be field measured and field cut to the proper length. Proper pipe hangers and supports shall be used to support this assembly.

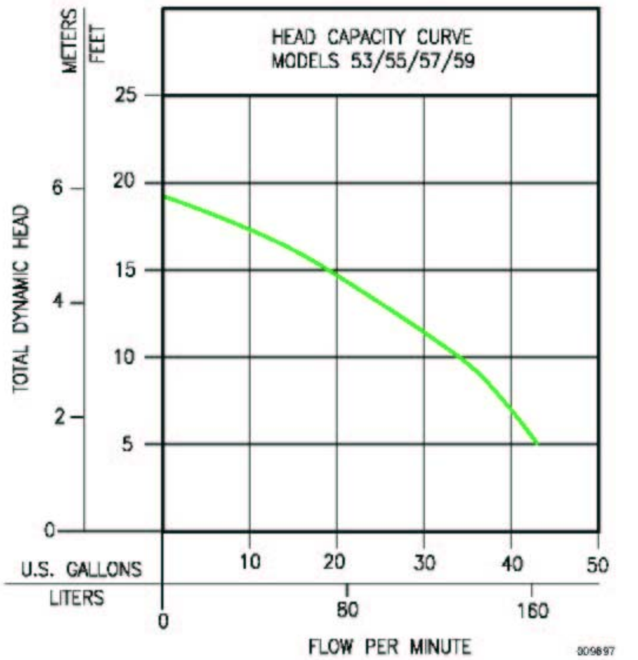
Refer to Appendix 1, Drawing 3, 2,000 Gallon Anoxic Tank

Clear Well Internals

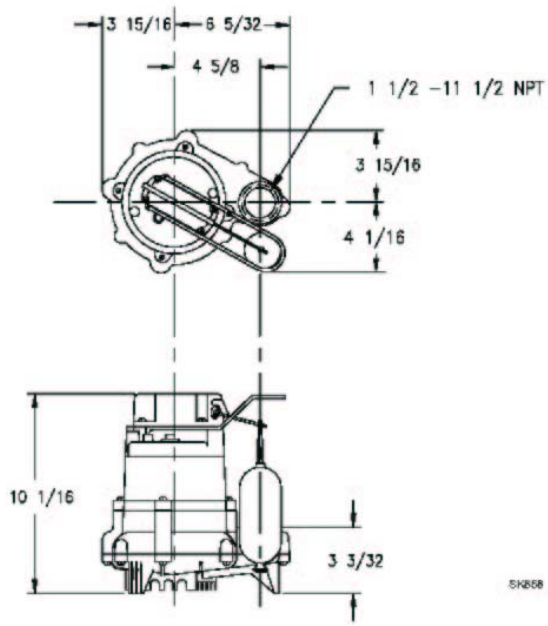
The clear well internals shall consist of the three process control floats, Return and Backwash pump with discharge hose and connector, and discharge pump enclosed in a sump with discharge hose and connector. Conduit penetrations for floats and two pump power supply cables. Each pump shall have polypropylene lifting rope with hanger.

Refer to Appendix 1, Drawing 4, 1,000 Gallon Clear Well Tank

For specifications and pump curve for the return flow/backwash and effluent pumps, refer to **Cut Sheet 1, Return Flow/Backwash and Effluent Pumps.**



MODEL		53/55/57/59	
Feet	Meters	Gal.	Liters
5	1.5	43	163
10	3.1	34	129
15	4.6	19	72
Shut-off Head:		19 ft.(5.8m)	



CONSULT FACTORY FOR SPECIAL APPLICATIONS

- Variable level float switches available.
- Variable level long cycle systems available.
- Available with special cord lengths of 15', 25', 35' and 50'.
- Alarm systems available.
- Duplex systems available.

Single Seal	Control Selection						Listings	
Model	Volts	Phase	Mode	Amps	Simplex	Duplex	CSA	UL
M53/55 & M57/59	115	1	Auto	9.7	1	----	Y	Y
N53/55 & N57/59	115	1	Non	9.7	2	3 or 4 & 5	Y	Y
* BN53	115	1	Auto	9.7	*	----	Y	Y
* BN57	115	1	Auto	9.7	*	----	N	Y
* BE53/57	230	1	Auto	4.8	*	----	Y	Y
D53/55 & D57/59	230	1	Auto	4.8	1	----	Y	Y
E53/55 & E57/59	230	1	Non	4.8	2	3 or 4 & 5	Y	Y

* Single piggyback switch included.

SELECTION GUIDE

1. Integral float operated mechanical switch, no external control required.
2. Single piggyback variable level float switch or double piggyback variable level float switch. Refer to FM0477.
3. Mechanical alternator "M-Pak" 10-0072 or 10-0075.
4. See FM0712 for correct model of Electrical Alternator.
5. Variable level control switch 10-0225 used as a control activator, with Electrical Alternator (3) or (4) float system.

CUT SHEET 1.RETURN FLOW/BACKWASH AND EFFLUENT PUMPS MODEL E57

Amphidrome® Clear Well Floats (3)

Amphidrome®Clear Well High Float

- The float serves as a high alarm float when it is elevated. The high float shall be set level with the top of the return line.

Amphidrome®Clear Well Middle Float

- The float serves as control to start the return pump when it is elevated. This shall be set near the mid-point of the tank and field adjusted by the manufacturer during start-up.

Amphidrome®Clear Well Low Float

- The float stops the return pump cycle when liquid level drops to the level of the float. The low float shall be set one foot above the bottom of the tank floor.

The floats are mini-floats with counterweights. The floats are to be hung in the clear well with sufficient cable slack to permit for level adjustments. Loose cable is to be neatly coiled and fastened with nylon wire tie or suitable non-corrosive strap.

All conduits from tanks shall be sealed with appropriate material to prevent liquid and gas to travel from tank penetrations.

Clear Well Air Bleed

The air bleeds for the return pipe and the discharge pipe in the clear well are required to prevent siphoning after the pumps shut down. This is accomplished by drilling a 3/16 inch hole near the top of the discharge and return piping.

Refer to Appendix 1, Drawings 10, Return Pump and Drawing 11, Effluent Pump and Sampler Detail

Drill the 3/16 inch hole in both locations shown on the drawings. The hole should be drilled at an angle to direct the vented flow in a downward direction.

Tools Required: Drill and 3/16-inch bit.

Access Covers Manholes

There shall be a minimum of 4 cast iron bolted and gasketed access covers for the entire system. These are shown on the **Amphidrome® Drawings1, 2, 3, and 4**. One will be located over the discharge of the Anoxic Tank to permit the removal of waste sludge and to permit the inspection of the discharge TEE.

A single access cover shall be installed over the Amphidrome® Reactor to permit access to the reactor for service and inspection.

Two covers shall be placed at each end of the clear well to access each pump for service and to access the discharge end for sample collection.

All access ways and covers shall be securely fastened to each tank and grouted in place to provide watertight seals. Cast Iron manhole covers with a 24-inch clear opening are required.

Access covers may be flush with finished grade to blend into the landscaping. **Covers should not be buried.**

Blowers And Controls

Blowers will include a process air blower and backwash blower. A single blower will operate to provide process air in the aerobic phase of treatment. During the backwash cycle, the second blower will run to provide additional backwash air. The blowers must be installed in a well-ventilated enclosure that provides shelter from rain and snow. The enclosure may be a separate shed or house constructed to blend into the landscaping and architecture of the property. The blowers will generate some noise during operation. Placement of the blowers should be such that the noise can be reduced.

The blowers must be accessible for service and should not be placed in manholes or otherwise below grade where they may be subject to groundwater or surface water accumulations.

In order to reduce the length of power cables and conduits, the blowers should be located within reasonable distance of the Amphidrome® system and the Amphidrome® control panel. Each installation will be different, as homeowners will have different ideas on a suitable location for these components.

Blower Piping

Blower piping shall be assembled with a common header. The header piping and blower placement are designed to reduce the space required. Piping consists of standard iron pipe thread fittings. Assembly should be made with Teflon paste or Teflon tape on all pipe joints. Air piping can be tested for leaks with soapy water. A dilution of dish soap and water in a small squirt bottle works well for this purpose.

Refer to Appendix 1, Drawing 12, Blower Detail A, Process Air Piping Assembly, Drawing 13, Blower Detail B, Backwash Blower and Piping Arrangement, and Blower Parts List Attachment

The blowers must be anchored to the floor of the enclosure to restrict vibration and stress on the blower piping. Anchors should be used that will permit the easy removal of a blower for service. Be sure to use the rubber isolation washers provided with the blowers.

Pipe unions will permit removal of a blower with minimal disturbance to the air header.

Refer to Appendix 1, Drawing 12, Blower Detail A, Parts 43 and 47

Amphidrome® Control Panel

The Amphidrome® control panel is the central control of all processes in the system. The panel must be mounted in a secure dry place. The panel can be placed in a closet, basement, storage building, garage or any place that can be kept reasonably warm and dry and is in reasonable distance from other system components.

The Amphidrome® control panel is a complete assembly supplied by the manufacturer with field terminal connections and wiring connections to be made by a qualified, licensed electrician. No modification to this panel may be made by anyone other than the manufacturer. Main power supply to the panel must be 30 amp, 120/240 volt.
The panel contains breakers, disconnects, fuses, alarm lights and indicators for system operations, system program interface connection, programmable logic controller PLC, and process time clock. A main power supply from the household main service panel must be brought to this panel. All wiring from outside conduits must be made gas tight before the system is to be accepted by the owner and warranty begins.

Wiring must be completed in accordance with the manufacturer's wiring diagrams. Cable splices should be avoided when possible. When cable splices are required, proper junction boxes located above ground and average snow cover levels must be used*. Splices that are subject to wet conditions shall be sealed with Scotchcast® or equal power cable splice kit. Splices should be made with enough cable slack to permit the disconnection of a pump or float for service repair and replacement with adequate cable length to re-connect and seal the connection.

***Junction Disconnect Boxes that are installed below grade will void warranty for pumps, and control panel**.
***Splices made to cords without use of FRMA approved splice kits will void warranty to pumps, and control panel.**

Refer to Appendix 1, Drawing14, Amphidrome® Control System, Electrical Schematic and Drawings 15 and 16, Amphidrome® Control System, Control Panel Layout

Note: At any time, the manufacturer reserves the right to modify and to improve the Amphidrome® Control System wiring. Modified drawings would supersede drawings included in the Installation Instructions.

Automatic Voice/Pager Alarm Dialer System

The voice/pager alarm dialer system is used to transmit high clear well or filter high level alarms to one or more remote locations. The dialer features busy line and no answer detection to ensure prompt transmission of a prerecorded message, delivered sequentially to as many as four standard telephones, cellular telephones, voice and/or numeric pagers.

The dialer is fully programmable, offering personalized customization for each individual project. Programming options include but are not limited to:

- Store up to four telephone/pager numbers.
- Choose 1 to 9 calling efforts for the numbers dialed.
- Select 1 to 3 message repeats.
- Voice record an outgoing message in any language.
- Program voice messages to telephones and numeric code to pagers.
- The dialer will report weekly to FRMA's Rockland, MA office to insure that it is in operation.

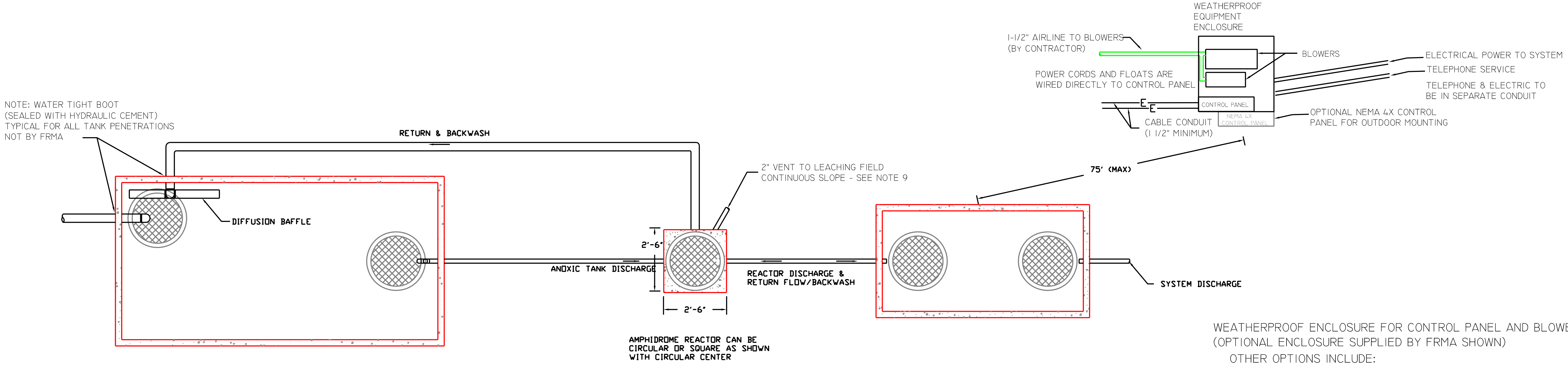
The voice pager/alarm dialer is a stand alone unit operating 24 hours per day. Monitoring fees are not required.

Contact Information

If additional information regarding the installation of the Amphidrome® Wastewater Treatment System is desired, F.R. Mahony will furnish it upon request.

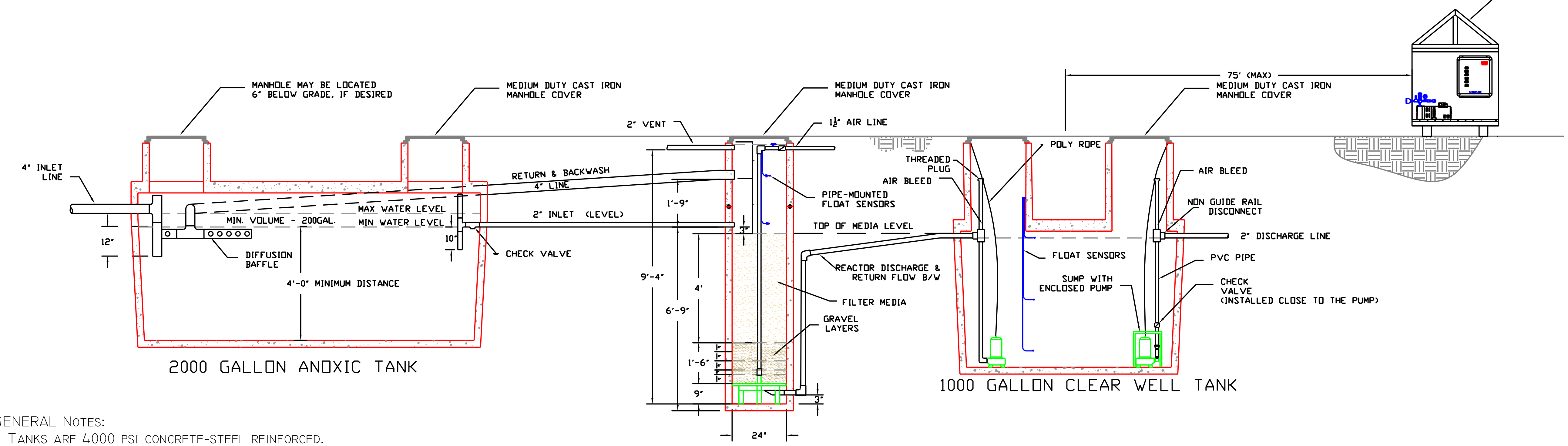
Requests for information should be directed to:

F.R. Mahony & Associates, Inc.
273 Weymouth Street
Rockland, MA 02370
Email: info@frmahony.com
Telephone: 781-982-9300
800-791-6132
Fax: 781-982-1056



PIPING AND CONDUIT NOTES:
1. ALL INTERNAL PIPING SUPPLIED BY FRMA AND INSTALLED BY OTHERS
2. ALL EXTERNAL PIPING AND CONDUIT SUPPLIED AND INSTALLED BY OTHERS, UNLESS OTHERWISE NOTED ON PLAN.
3. ELECTRICAL PENETRATIONS INTO TANKS MUST BE SEALED TO PREVENT CORROSIVE GASES FROM ENTERING CONTROL PANEL

WEATHERPROOF ENCLOSURE FOR CONTROL PANEL AND BLOWERS (OPTIONAL ENCLOSURE SUPPLIED BY FRMA SHOWN)
OTHER OPTIONS INCLUDE:
1. WEATHERPROOF CONTROL PANEL
2. CONTROL PANEL LOCATED INSIDE GARARGE OR HOUSE WITH REMOTE ACCESS PORT
3. ROCK ENCLOSURE FOR BLOWERS
FINAL ENCLOSURE TYPE AND LOCATION (WITHIN 75' OF CLEARWELL) MUST BE APPROVED BY FRMA



AMPHIDROME® REACTOR

GENERAL NOTES:
1. TANKS ARE 4000 PSI CONCRETE-STEEL REINFORCED.
2. CONCRETE CONFORMS TO ACI 318-16-4.5.1 AND ACI 318-16-4.5.2.
3. TANKS ARE TO BE APPROVED FOR USE IN F.R. MAHONY AMPHIDROME SYSTEMS APPROVED TANK SUPPLIERS LISTED ON THIS DRAWING.
4. TANKS ARE NOT PROVIDED BY F.R. MAHONY (FRMA)
5. TOP OF REACTOR IS LOCATED AT FINISHED GRADE. ANOXIC TANK DEPTH SHOULD BE COORDINATED WITH REACTOR INLET
6. BLOWERS AND CONTROL PANEL MUST BE LOCATED IN A WEATHER-PROOF ENCLOSURE. (SEE NOTE THIS SHEET)
7. BLOWERS MUST BE LOCATED AT AN ELEVATION HIGHER THAN THE TOP OF THE REACTOR
8. ALL ELECTRICAL JUNCTION BOXES MUST BE LOCATED AT LEAST 18" ABOVE GRADE - BELOW-GRADE JUNCTION BOXES ARE NOT PERMITTED.
9. VENT PIPING MUST HAVE CONTINUOUS SLOPE TO LEACHING FACILITY

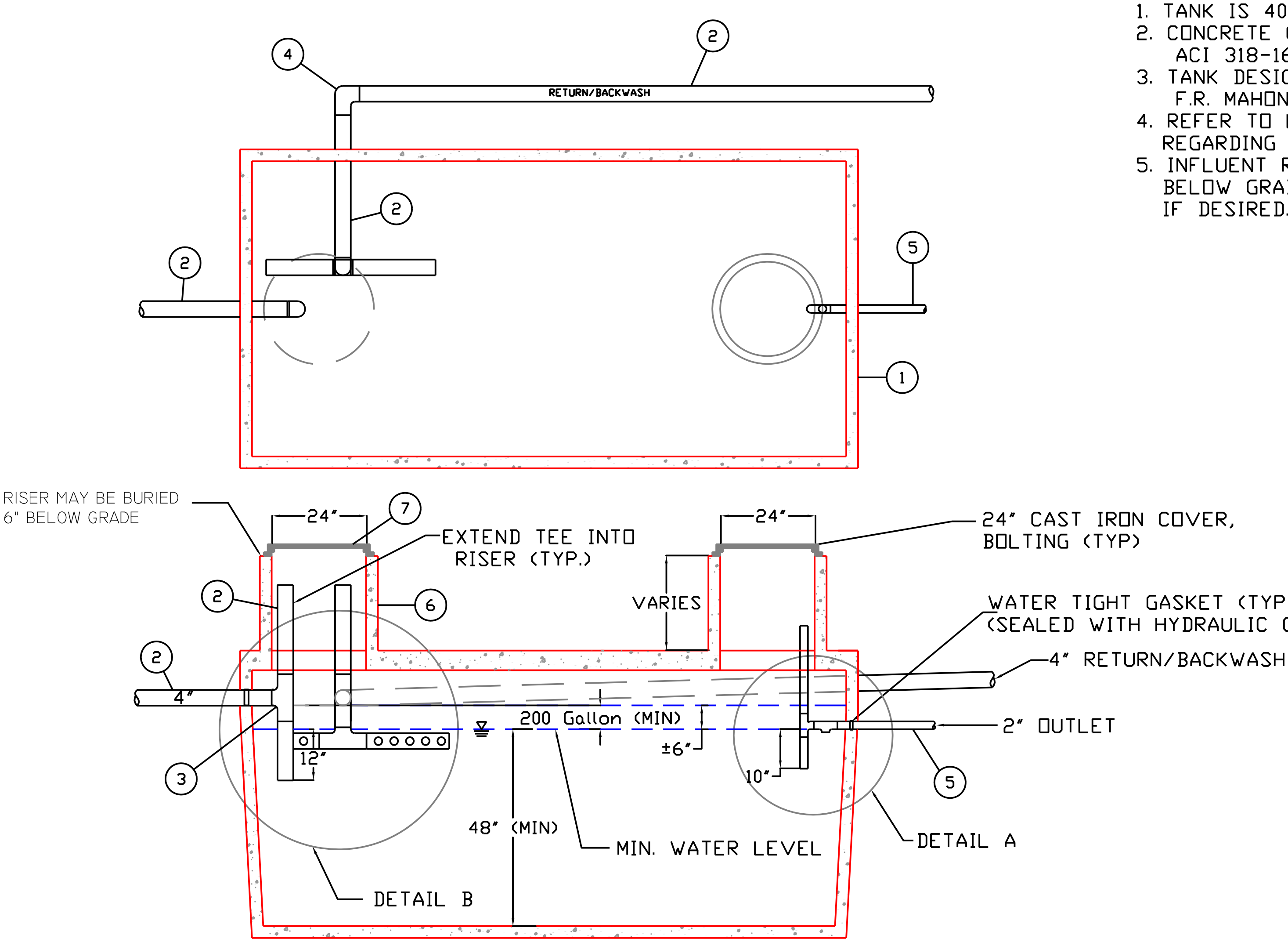
FRMA APPROVED TANK SUPPLIERS:
1. MERSHON CONCRETE, BORDENTOWN, NJ
2. SCITUATE RAY PRECAST, MARSHFIELD, MA

Rev.	Date:	By:	Description:
6	02/28/11	ARM.	Renumber parts and revise

Dwg: Drawing 1	AMPHIDROME® SINGLE FAMILY LAYOUT
Rev: 6 (02-28-2011)	
Drawn by: ADW / ARM	App'd by:
Scale: NTS	Date: 01/23/08

FRM AHONY & associates, inc.
Water Supply & Pollution Control Equipment
273 Weymouth Street, Rockland, Massachusetts 02370

pg.



NOTES:

1. TANK IS 4000 PSI STEEL-REINFORCED CONCRETE
2. CONCRETE CONFORMS TO ACI 318-16-4.5.1 AND ACI 318-16-4.5.2
3. TANK DESIGNED AND APPROVED FOR USE IN F.R. MAHONY AMPHIDROME SYSTEMS
4. REFER TO LAYOUT FOR ADDITIONAL NOTES REGARDING INSTALLATION AND TANKS
5. INFLUENT RISER MAY BE PLACED 6" BELOW GRADE WITH CONCRETE COVER, IF DESIRED.

Rev.	Date:	By:	Description:
6	02/28/11	ARM.	Renumber parts and revise

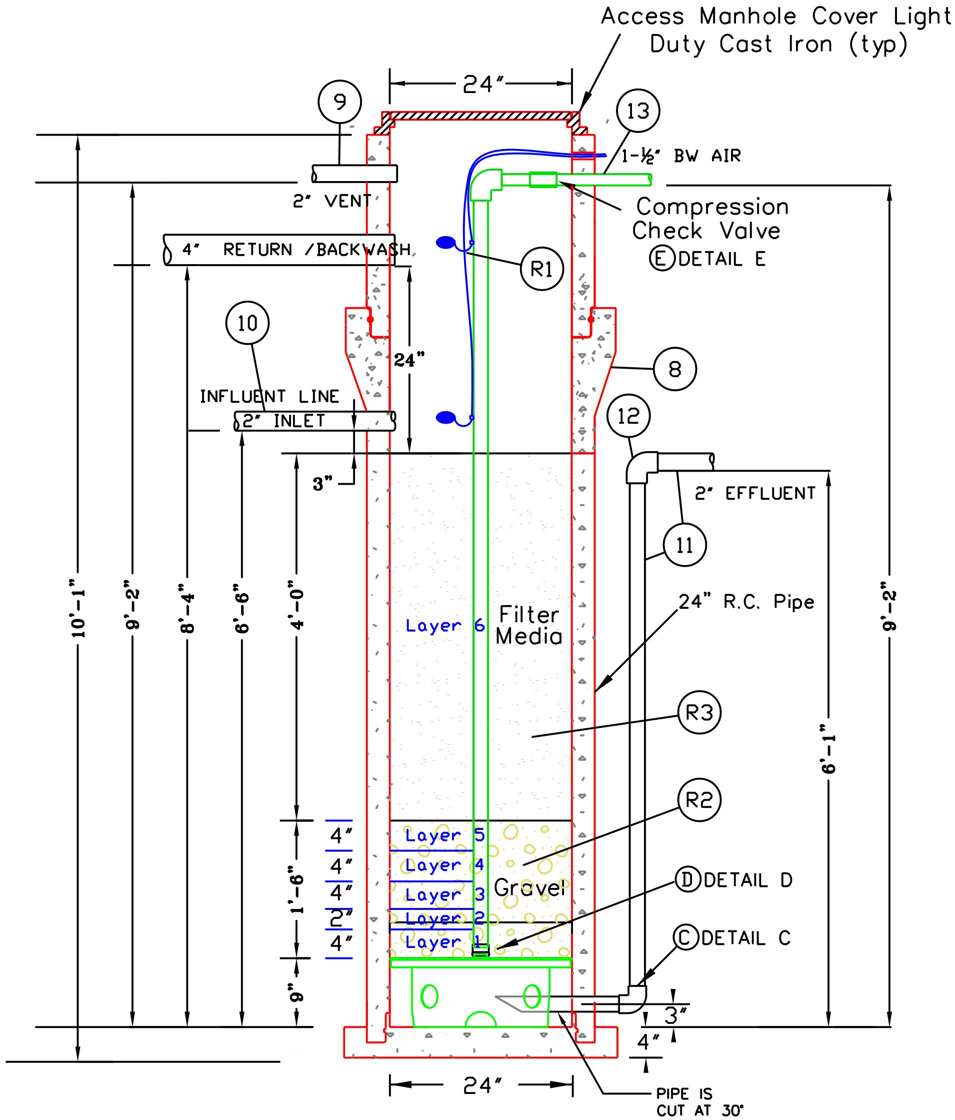
Dwg: Drawing 2	2000 Gallon Anoxic Tank
Rev: 2008SCI	
Drawn by: ADW	App'd by:
Scale: NTS	Date: 1/22/08

F R MAHONY & associates, inc.
Water Supply & Pollution Control Equipment
273 Weymouth Street, Rockland, Massachusetts 02370

pg.

v.7

PROFILE VIEW



AMPHIDROME® REACTOR

GRAVEL AND MEDIA LAYERS

LAYER 1	1½" × ¾"	GRAVEL	0'-4" DEPTH
LAYER 2	¾" X ½"	GRAVEL	0'-2" DEPTH
LAYER 3	½" × ¼"	GRAVEL	0'-4" DEPTH
LAYER 4	¼" × ⅛"	GRAVEL	0'-4" DEPTH
LAYER 5	½" × ¼"	GRAVEL	0'-4" DEPTH
LAYER 6	FILTER MEDIA		4'-0" DEPTH

DIMENSIONS FROM INSIDE BOTTOM OF TANK TO PIPE INVERTS

INFLUENT LINE	6'-6"
EFFLUENT LINE	0'-2"
RETURN/BACKWASH LINE	8'-4"
VENT LINE	9'-2"
BACKWASH AIR LINE	9-2"

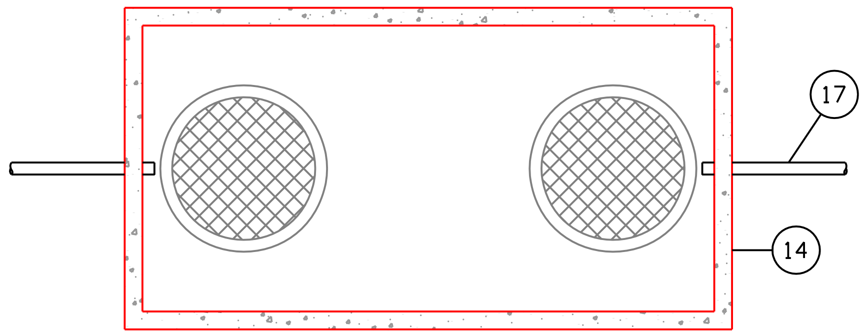
Rev.	Date:	By:	Description:
6	02/28/11	ARM.	Renumber ports and revise

2' Dia. Amphidrome® Reactor
Construction Dimensions

Scale: NTS	Drawn By: ARM	REV.: 6
Date: 11/16/10	App'd By:	Plan No: Drawing 3

F R MAHONY & associates, inc.
Water Supply & Pollution Control Equipment
273 Weymouth Street, Rockland, Massachusetts 02370

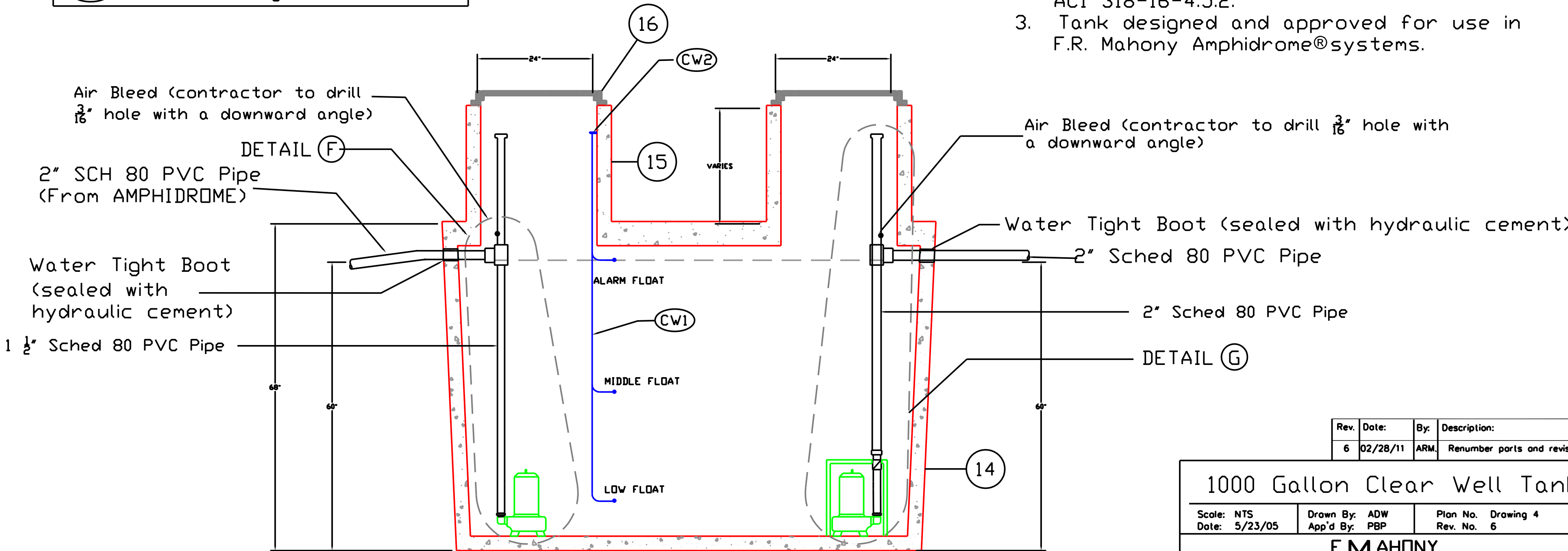
v.7



PARTS LIST

- (CW1) Mini Floats (3ea) with 50' Cable
- (CW2) Float Mounting Bracket Kit

Notes:
1. Tank is 4000 psi concrete-steel reinforced.
2. Concrete conforms to ACI 318-16-4.5.1 and ACI 318-16-4.5.2.
3. Tank designed and approved for use in F.R. Mahony Amphidrome® systems.



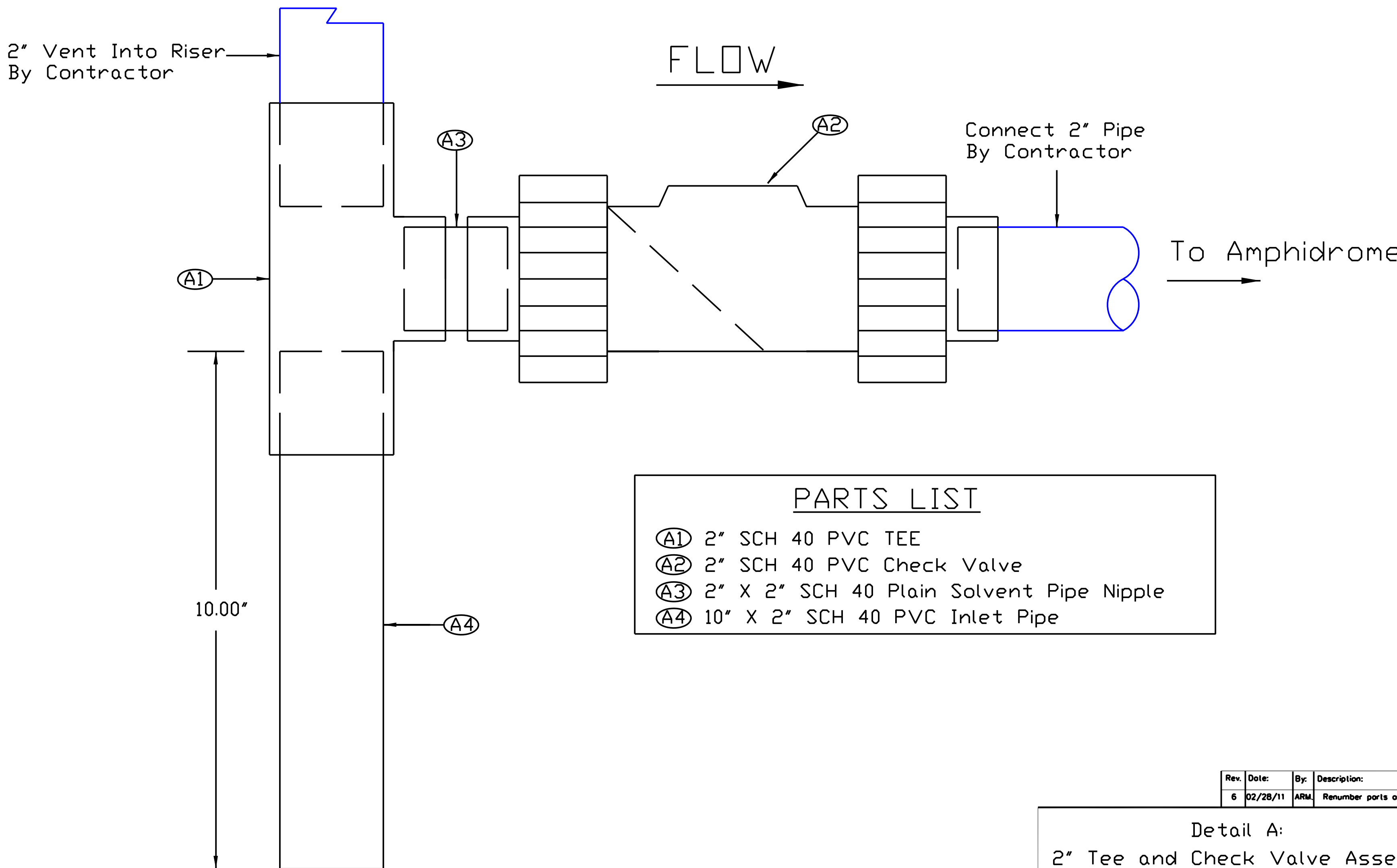
Rev.	Date:	By:	Description:
6	02/28/11	ARM	Renumber parts and revise

1000 Gallon Clear Well Tank

Scale: NTS Date: 5/23/05	Drawn By: ADW App'd By: PBP	Plan No. Drawing 4 Rev. No. 6

F R MAHONY & associates, inc.
Water Supply & Pollution Control Equipment
273 Weymouth Street, Rockland, Massachusetts 02370

v.7



PARTS LIST

A1	2" SCH 40 PVC TEE
A2	2" SCH 40 PVC Check Valve
A3	2" X 2" SCH 40 Plain Solvent Pipe Nipple
A4	10" X 2" SCH 40 PVC Inlet Pipe

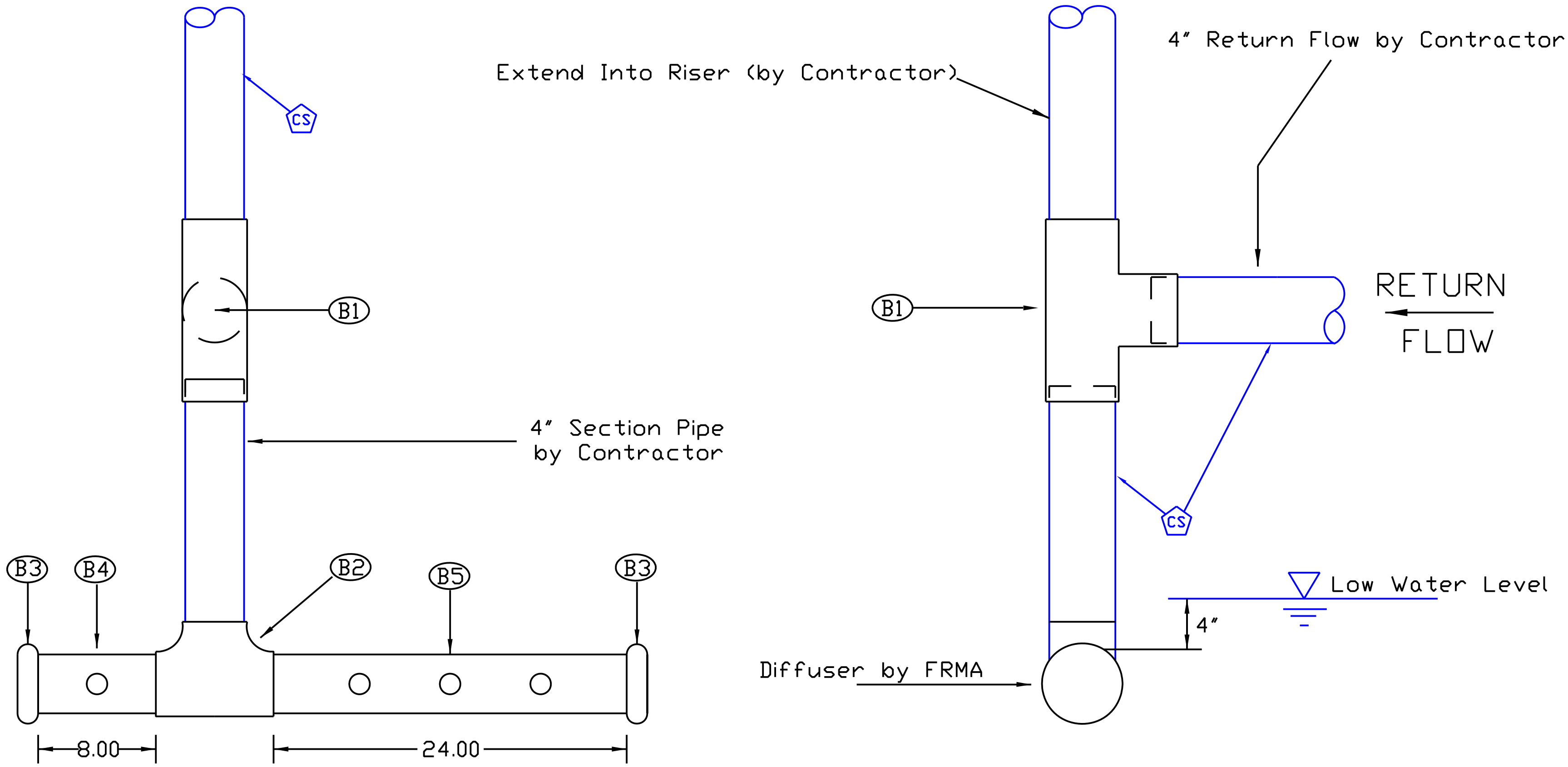
Rev.	Date:	By:	Description:
6	02/28/11	ARM.	Renumber parts and revise

Detail A:
2" Tee and Check Valve Assembly

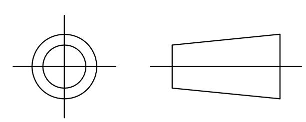
Scale: NTS Date: 5/19/05	Drawn By: JTB App'd By: PBP	Plan No. Drawing 5 Rev. No. 6

F R MAHONY & associates, inc.
Water Supply & Pollution Control Equipment
273 Weymouth Street, Rockland, Massachusetts 02370

v.7



PARTS LIST		
B1	4" X 4" SCH 40 TEE (Loose)	
B2	4" X 4" SCH 40 TEE	
B3	2ea.	4" SCH 40 PVC End Caps
B4	8" X 4" Perforated PVC Pipe	
B5	24" X 4" Perforated PVC Pipe	



Rev.	Date:	By:	Description:
6	02/28/11	ARM.	Renumber parts and revise

Detail B:
4" Energy Diffuser

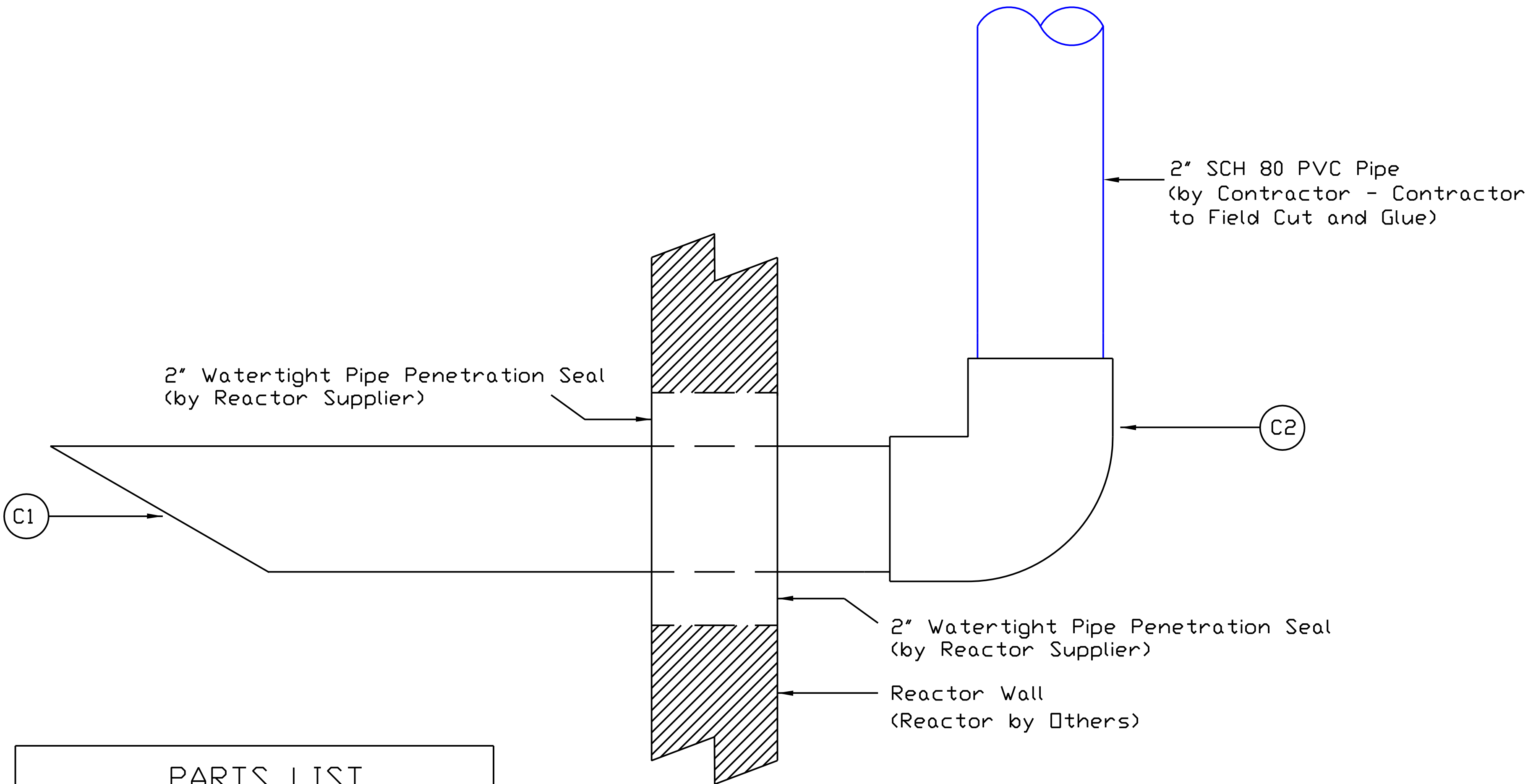
Scale: NTS
Date: 5/19/05

Drawn By: JTB
App'd By: PBP

Plan No. Drawing 6
Rev. No. 6

F R MAHONY & associates, Inc.
Water Supply & Pollution Control Equipment
273 Weymouth Street, Rockland, Massachusetts 02370

v.7



PARTS LIST

- C1 14" X 2" Schedule 80 PVC Pipe
- C2 2" Schedule 80 Elbow

Rev.	Date:	By:	Description:
6	02/28/11	ARM.	Renumber ports and revise

Detail C:
Underdrain Discharge Assembly

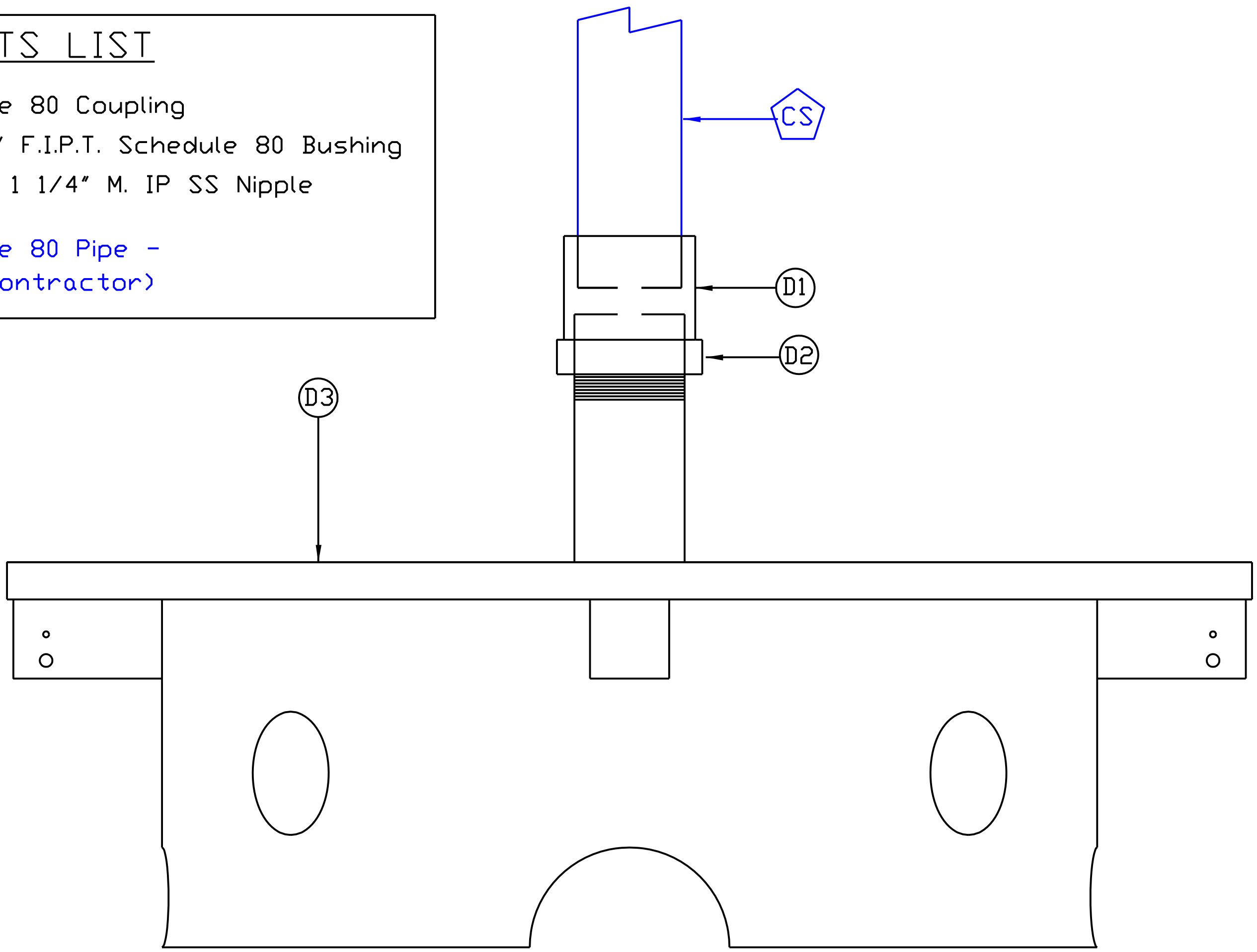
Scale: NTS Date: 5/19/05	Drawn By: JTB App'd By: PBP	Plan No. Drawing 7 Rev. No. 6

F R MAHONY & associates, inc.
Water Supply & Pollution Control Equipment
273 Weymouth Street, Rockland, Massachusetts 02370

v.7

PARTS LIST

- D1 — 1 1/2" Schedule 80 Coupling
- D2 — 1 1/2" X 1 1/4" F.I.P.T. Schedule 80 Bushing
- D3 — Underdrain w/ 1 1/4" M. IP SS Nipple
- CS — 1 1/2" Schedule 80 Pipe - (Supplied by Contractor)



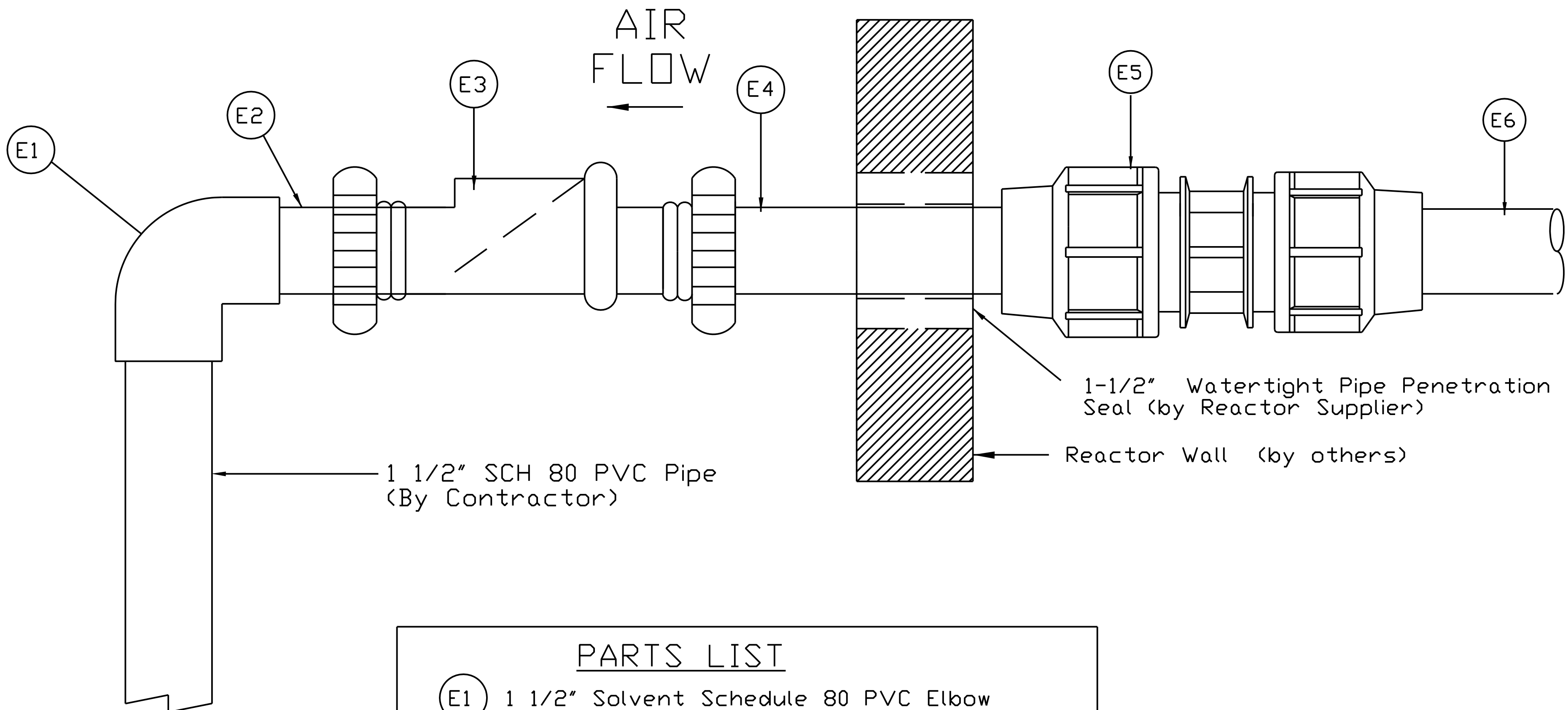
Rev.	Date:	By:	Description:
6	02/28/11	ARM.	Renumber parts and revise

Detail D: Underdrain Adapter Assembly

Scale: NTS Date: 8/19/05	Drawn By: JTB App'd By: PBP	Plan No. Drawing 8 Rev. No. 6

FR MAHONY & associates, inc.
Water Supply & Pollution Control Equipment
273 Weymouth Street, Rockland, Massachusetts 02370

v. 7



Rev.	D
7	0
6	0

PARTS LIST

E1	1 1/2" Solvent Schedule 80 PVC Elbow
E2	1 1/2" x 3" Schedule 80 PVC Pipe
E3	1 1/2" PVC CHECK VALVE
E4	1 1/2" x 9" Schedule 80 PVC Pipe
E5	1 1/2" x 1 1/4" Comp. Fitting
E6	1 1/4" SDR 11 Air Line

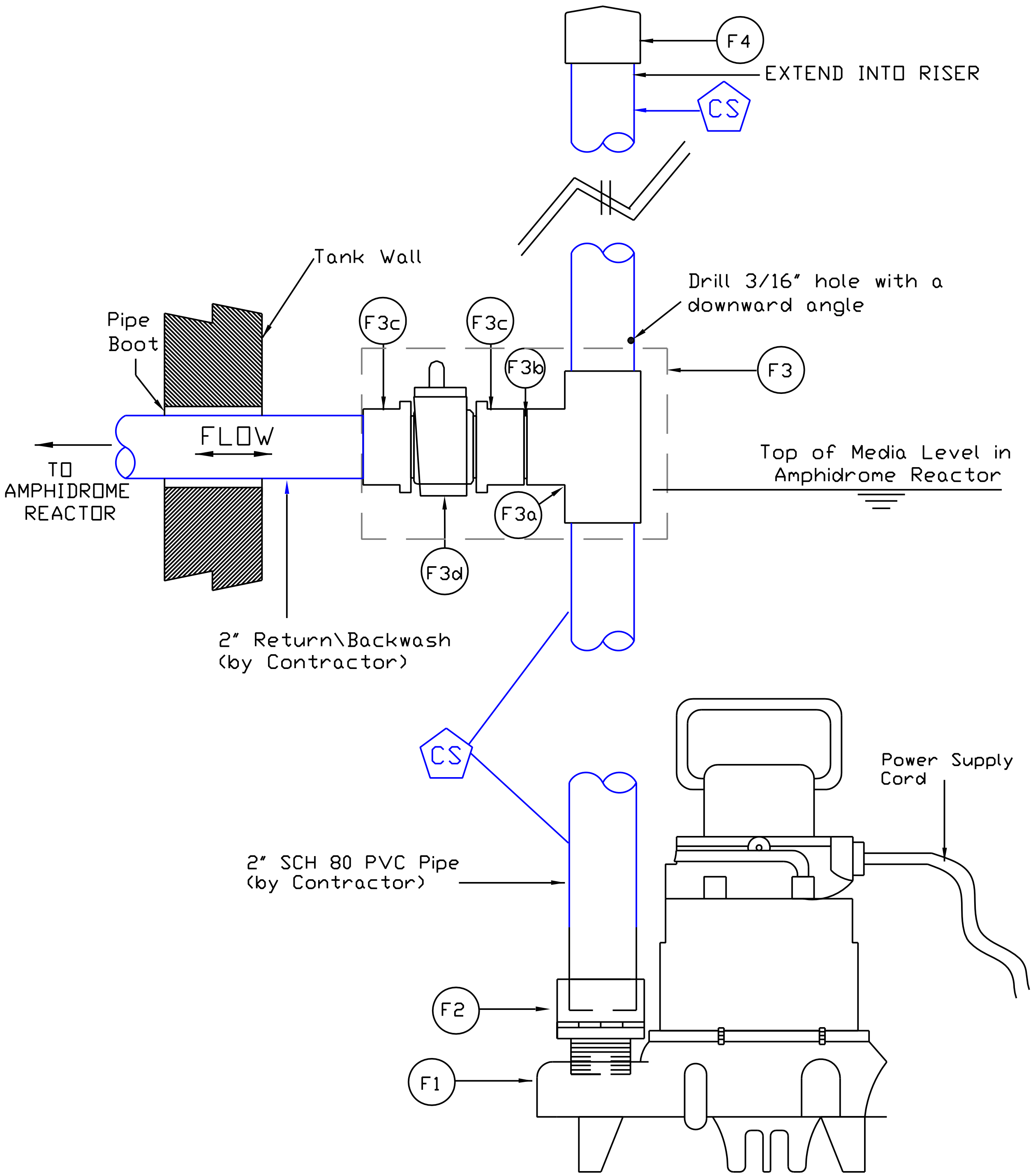
Description:

Detail E:
Inlet Air Check Valve Detail

Scale: NTS Rev: 04/06/11 ARM	Drawn By: JTB App'd By: PBP	Plan No. Drawing 9 Rev. No. 7

FR MAHONY & associates, inc.
Water Supply & Pollution Control Equipment
273 Weymouth Street, Rockland, Massachusetts 02370

v.7



PARTS LIST

F1 Return Pump

F2 1-1/2" x 2" Coupling

F3 Pump Non Guide Rail Disconnect Assy.
- F3a 2" Schedule 80 TEE
- F3b 2" Schedule 80 pipe (cut 3")
- F3c 2" Schedule 80 Threaded Coupling (2ea)
- F3d 2" EZ-Pull Quick-Disconnect

F4 2" Schedule 80 PVC End Cap

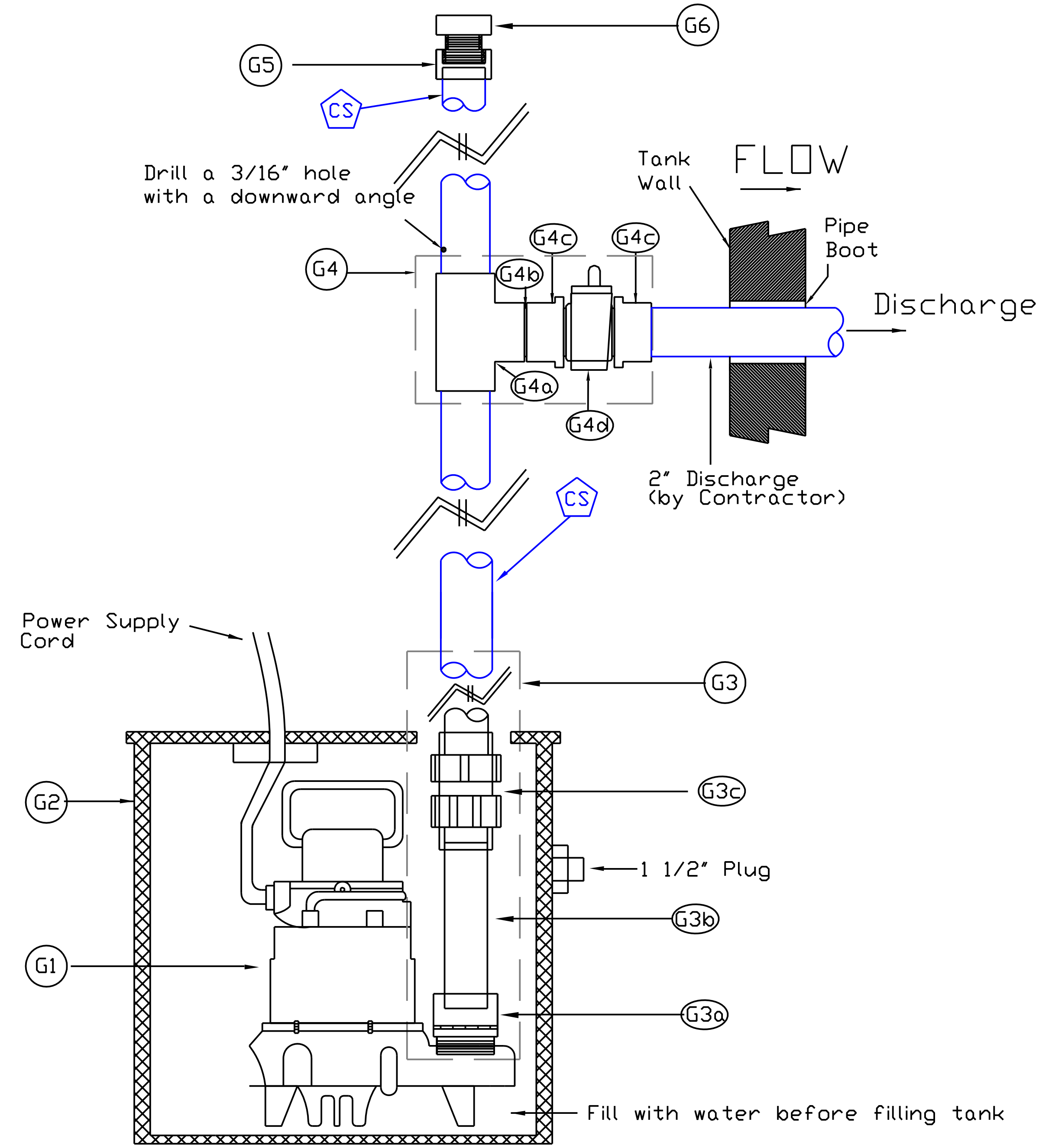
Rev.	Date:	By:	Description:
6	03/18/11	ARM.	Renumber parts and revise

Detail F:
Return Pump Detail

Scale: NTS Date: 02/28/11	Drawn By: ARM App'd By:	Plan No. Drawing 10 Rev. No. 6

FRMAHONY & associates, inc.
Water Supply & Pollution Control Equipment
273 Weymouth Street, Rockland, Massachusetts 02370

v.7



Note: Sump lid will be notched for removal of Part No. G3, Check Valve Assembly.

PARTS LIST

G1 Effluent Pump

G2 Sump Container with Lid

G3 Check Valve Assembly
- G3a 2" Check Valve
- G3b 1-1/2" Threaded - 2" Schedule 80 Coupling
- G3c 2" Schedule 80 pipe (cut to approx 8" in warehouse)

G4 Pump Non Guide Rail Disconnect Assy.
- G4a 2" Schedule 80 TEE
- G4b 2" Schedule 80 pipe (cut 3 ")
- G4c (2ea) 2" Schedule 80 Threaded Coupling
- G4d 2" EZ-Pull Quick-Disconnect

G5 2" Threaded Adapter

G6 2" Threaded Plug

CS 2" SCH 80 pipe (By Contractor)

Rev.	Date:	By:	Description:
6	03/18/11	ARM.	Renumber parts and revise

Detail G:
Effluent Pump and Sampler Detail

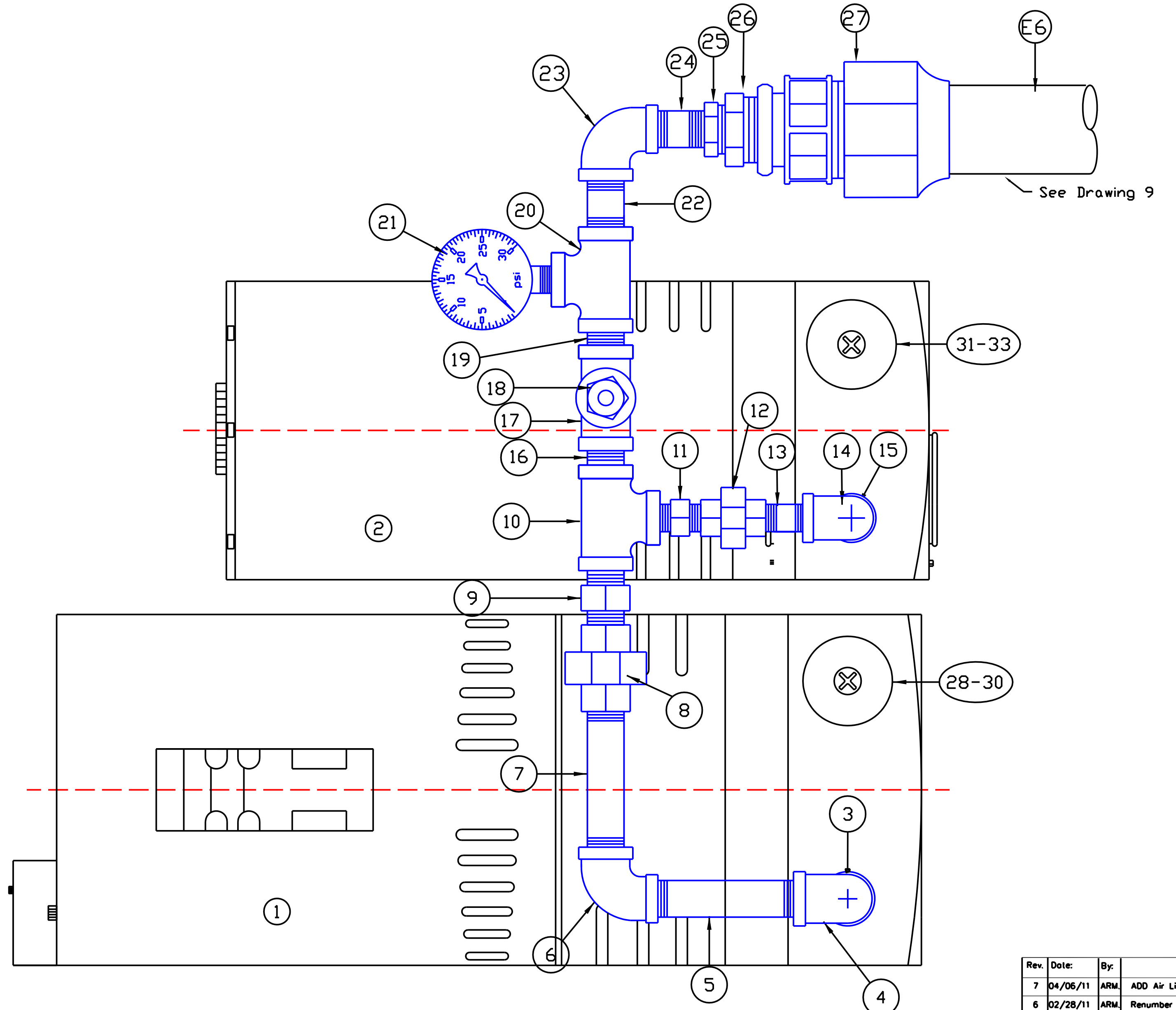
Scale: NTS Rev: 02/27/11 ARM	Drawn By: AKH App'd By: PBP	Plan No. Drawing 11 Rev. No. 6

F&M MAHONY & associates, inc.
Water Supply & Pollution Control Equipment
273 Weymouth Street, Rockland, Massachusetts 02370

v.7

PARTS LIST

1. Backwash Blower
2. Process Blower
3. 3/8" x 1 1/2" Nipple
4. 3/8" 90° Elbow
5. 3/8" x 4" Nipple
6. 3/8" 90° Elbow
7. 3/8" x 4" Nipple
8. 3/8" Union
9. 3/8" Check Valve
10. 3/8" x 3/8" x 1/4" TEE
11. 1/4" Check Valve
12. 1/4" Union
13. 1/4" x 1" Nipple
14. 1/4" Elbow
15. 1/4" x 2" Nipple
16. 3/8" CL Nipple
17. 3/8" TEE
18. 3/8" Relief Valve
19. 3/8" CL Nipple
20. 3/8" x 3/8" x 1/4" TEE
21. 1/4" Pressure Gauge
22. 3/8" x 3/4" Nipple
23. 3/8" Elbow
24. 3/8" CL Nipple
25. 3/8" x 1/2" Bushing
26. 1/2" X 1 1/4" Bushing
27. 1 1/4" X 1 1/4" Compression
28. 3/8" CL Nipple
29. 3/8" x 3/4" Adapter
30. Filter
31. 1/4" CL Nipple
32. 1/4" x 3/4" Adapter
33. Filter



NOTE: 1. PART NOS. 28 and 29, NOT SHOWN, CONNECT PART NO. 30 TO BACKWASH BLOWER.
2. PART NOS. 31 and 32, NOT SHOWN, CONNECTS PART NO. 33 TO PROCESS BLOWER

Rev.	Date:	By:	
7	04/06/11	ARM.	ADD Air Line and Fittings
6	02/28/11	ARM.	Renumber parts and revise

Blower Detail A:
Process Air Piping Assembly
Top View

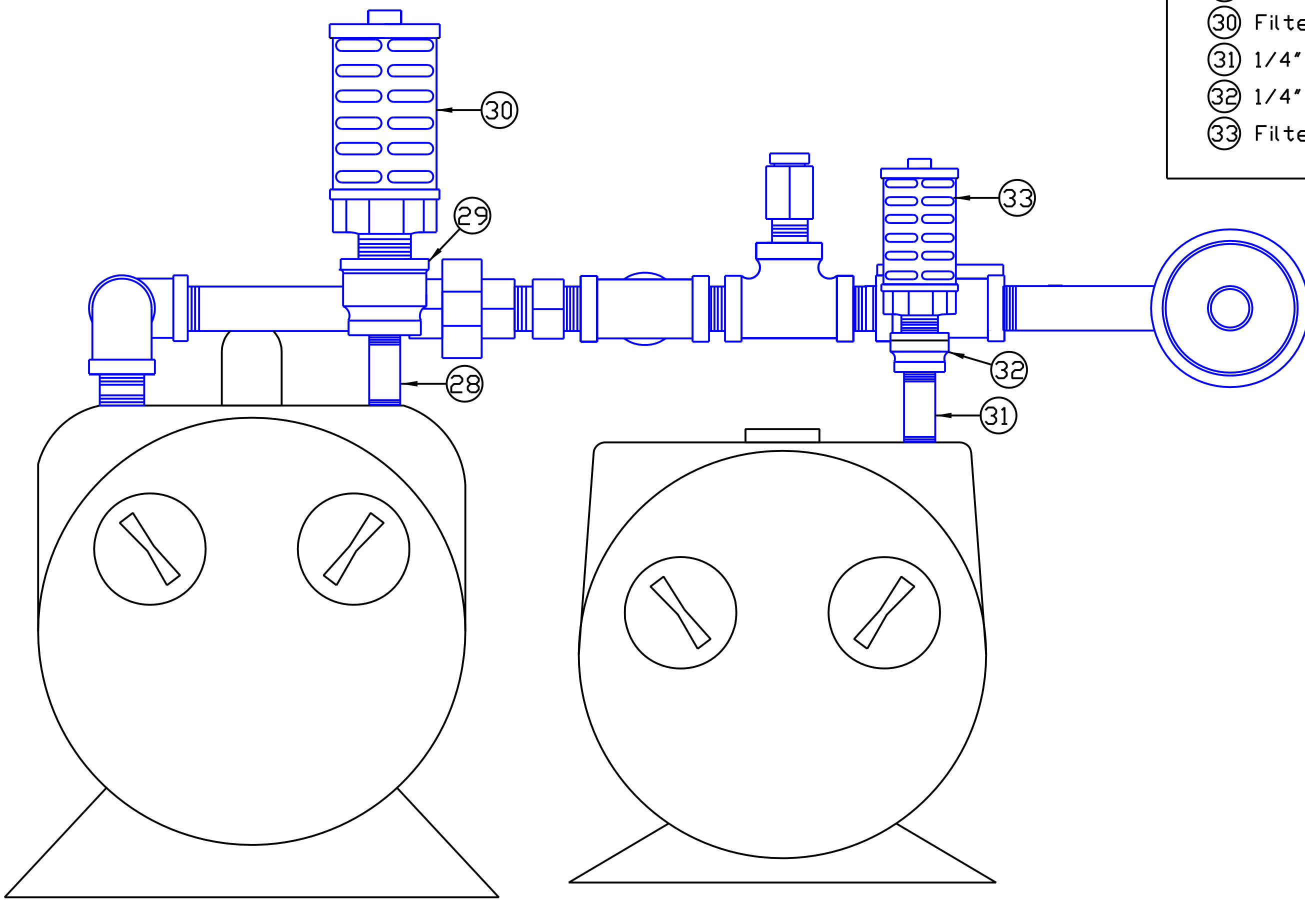
Scale: none Rev: 04/06/11 ARM	Drawn By: JTB Date: 5/19/05	Plan No. Drawing 12 Rev. No. 7

MAHONY & associates, inc.
Water Supply & Pollution Control Equipment
273 Weymouth Street, Rockland, Massachusetts 02370

v. 7

PARTS LIST

28 3/8" CL Nipple
29 3/8" x 3/4" Adapter
30 Filter
31 1/4" CL Nipple
32 1/4" x 3/4" Adapter
33 Filter



Rev.	Date:	By:	
7	04/06/11	ARM.	ADD Air Line and Fittings
6	02/28/11	ARM.	Renumber parts and revise

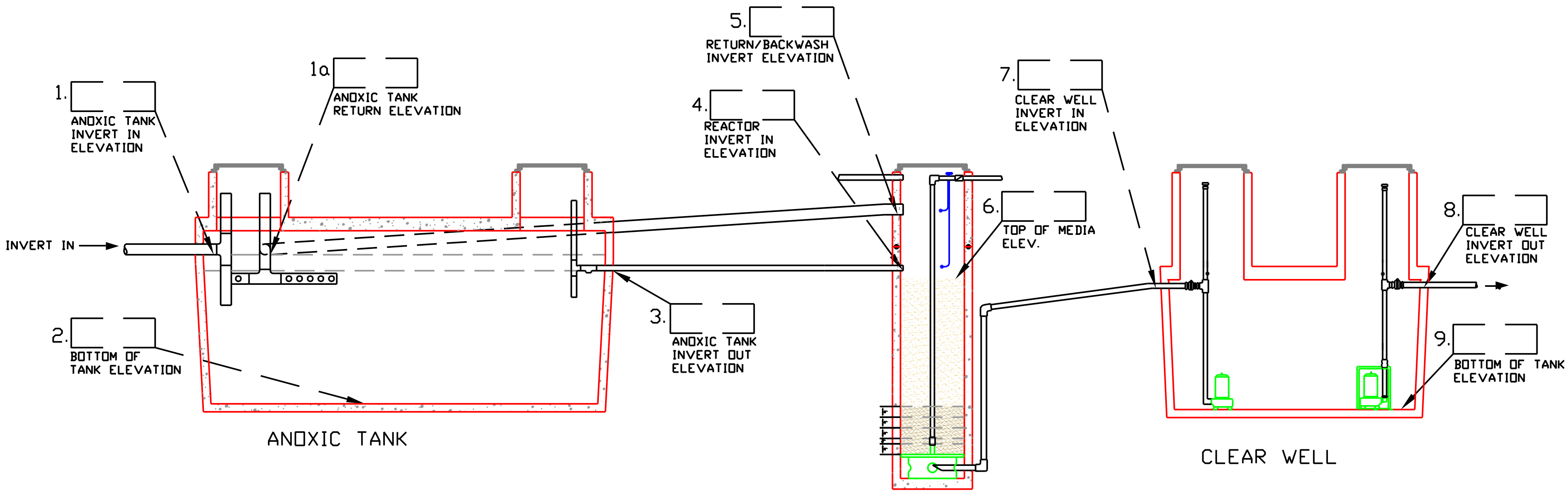
Blower Detail B:
Backwash Blower with Piping Arrangement

Scale: none Rev: 04/06/11 ARM	Drawn By: JTB Date: 5/19/05	Plan No. Drawing 13 Rev. No. 7

F R MAHONY & associates, inc.
Water Supply & Pollution Control Equipment
273 Weymouth Street, Rockland, Massachusetts 02370

v.7

AMPHIDROME® AS-BUILT ELEVATIONS



THE FOLLOWING MINIMUM INFORMATION IS REQUIRED ON STAMPED AS-BUILT DRAWING.

1. ANOXIC TANK INVERT IN.
1a. ANOXIC TANK RETURN INVERT
2. BOTTOM OF ANOXIC TANK.
3. ANOXIC TANK INVERT OUT.
4. AMPHIDROME REACTOR INVERT IN.
5. AMPHIDROME RETURN/BACKWASH INVERT.
6. TOP OF MEDIA
7. CLEAR WELL INVERT IN.
8. CLEAR WELL INVERT OUT.
9. BOTTOM OF CLEAR WELL ELEVATION.

NOTES

1. ALL MEASUREMENTS SHOULD BE TAKEN USING A ROD THAT MEASURES IN FEET AND TENTHS OF FEET.
2. USE THE TOP OF THE REACTOR AS A BM IF THE TOP OF FLOAT BRACKET IS NOT AVAILABLE ,

.

SITE LOCATION INFORMATION

SITE ADDRESS __ ___ ___ ___ ___ __Block/Lot ___ ___

TOWN___ ___ ___ ___ ___ __TOWNSHIP___ ___ ___ ___

INSTALLER NAME ___ ___ ___ ___ ___ PH: __ ___ ___ __

INSTALLER'S COMPANY ___ ___ ___ ___ ___ ___ ___ ___

FRMA REPRESENTATIVE___ ___ ___ ___ ___ ___ ___ ___

DATE ___ ___ ___ ___

Dwg: FMRA/Drawings/Amphidrome	AS-BUILT GUIDE
Rev: 7-15-08	
Drawn by: ARM	App'd by:
Scale: NTS	Date: 6/14/2006

FRMAHONY & associates, inc.
Water Supply & Pollution Control Equipment
273 Weymouth Street, Rockland, Massachusetts 02370

pg.

v.7

SINGLE FAMILY AMPHIDROME® WASTEWATER TREATMENT SYSTEM
BILL OF MATERIALS

REV. 4-11-2011 arm

ANOXIC TANK					
CONTRACTOR BILL OF MATERIALS			**F.R. MAHONY BILL OF MATERIALS**		
#	**QUANT**	DESCRIPTION	**#**	**QUANT**	DESCRIPTION
		ITEMS 1 - 7 REFER TO DRAWING 2			**ITEMS A1 - A4 REFER TO DETAIL A**
1	1	2000 GALLON ANOXIC TANK WITH WATER	A1 - A4	1	2" TEE AND CHECK VALVE ASSEMBLY
		TIGHT PENETRATION SEALS			**ITEMSB1 - B5 REFER TO DETAIL B**
2	varies	4" SCH 40 PVC INFLUENT PIPE	B1 - B5	1	4" ENERGY DIFFUSER
3	1	4" SCH 40 PVC INFLUENT TEE			
4	varies	4" SCH 40 PVC RETURN PIPE			
5	1	2" SCH 40 PVC EFFLUENT PIPE			
6	2	TANK RISERS			
7	2	TANK COVERS			

AMPHIDROME® REACTOR					
CONTRACTOR BILL OF MATERIALS			**F.R. MAHONY BILL OF MATERIALS**		
#	**QUANT**	**DESCRIPTION**	**#**	**QUANT**	**DESCRIPTION**
		ITEMS 8 - 13 REFER TO DRAWING 3			**ITEMS C1 - C2 REFER TO DETAIL C**
8	1	REACTOR BASIN WITH COVER AND	C1-C2	1	UNDERDRAIN DISCHARGE ASSEMBLY
		WATER TIGHT PENETRATION SEALS			**ITEMS D1 - D3 REFER TO DETAIL D**
9	varies	2" SCH 80 PVC PIPE FOR VENT	D1-D2	1	UNDERDRAIN ADAPTER ASSEMBLY
10	varies	2" SCH 80 PVC RETURN PIPE	D3	1	2' UNDERDRAIN
		(FIELD CUT AND GLUED)			**ITEMS E1 - E6 REFER TO DETAIL E**
11	varies	2" SCH 80 PVC DISCHARGE PIPE	E1-E6		INLET AIR ASSEMBLY
12	1	2" SCH 80 PVC ELBOW			**ITEMS R1 - R3 REFER TO 2' DIA. AMPHIDROME®**
13	none	n/a			**REACTOR**
			R1	2	PIPE MOUNTED MINI FLOATS W/50' CABLE
			R2	18"	5-LAYERS OF GRAVEL- SORTED SIZES
			R3	4'	FILTER MEDIA

CLEAR WELL					
CONTRACTOR BILL OF MATERIALS			**F.R. MAHONY BILL OF MATERIALS**		
#	**QUANT**	**DESCRIPTION**	**#**	**QUANT**	**DESCRIPTION**
		ITEMS 14 - 17 REFER TO DRAWING 4			**ITEMS F1 - F5 REFER TO DETAIL F**
14	1	1000 GALLON CLEAR WELL TANK WITH	F1	1	RETURN PUMP
		WATER TIGHT PENETRATION SEALS	F2	1	1 1/2" x 2" COUPLING
15	2	TANK RISERS	F3	1	RETURN NON GUIDE RAIL DISCONNECT
16	2	TANK COVERS			ASSEMBLY
17	2	2" SCH 80 PVC PIPE	F4	1	2" SCH 80 CAP
					ITEMS G1 - G5 REFER TO DETAIL G
			G1	1	EFFLUENT PUMP
			G2	1	SUMP CONTAINER WITH LID
			G3	1	1 1/2" SCH 80 CHECK VALVE ASSEMBLY
			G4	1	EFFLUENT NON GUIDE RAIL DISCONNECT
					ASSEMBLY
			G5	1	1 1/2" x 2" INCREASER
					ITEMS 31 - 33 REFER TO CLEAR WELL TANK
			CW1	3	MINI FLOATS W/50' CABLE
			CW2	1	FLOAT MOUNTING BRACKET KIT

BLOWERS AND CONTROL SYSTEM					
CONTRACTOR BILL OF MATERIALS			**F.R. MAHONY BILL OF MATERIALS**		
#	**QUANT**	**DESCRIPTION**	**#**	**QUANT**	**DESCRIPTION**
18		CONDUIT FOR CONTROL PANEL			**ITEMS 1 - 33 REFER TO BLOWER DETAIL A & B**
			1	1	BACKWASH BLOWER
			2	1	PROCESS BLOWER
			3 - 10	1	BACKWASH BLOWER PIPING ARRANGEMENT
			11 - 15	1	PROCESS AIR PIPING ASSEMBLY
			16 - 27	1	DISACHARGE MANIFOLD ASSEMBLY
					CONTROL SYSTEM
				1	CONTROL PANEL
				1	AUTOMATIC DIALER (MAY BE OPTIONAL, CHECK LOCAL REGULATIONS)
				1	ABOVE GRADE JUNCTION BOX (OPTIONAL)
				1	IRRIGATION/SPRINKLER BOX AND SCOTCH KIT (OPTIONAL)

INTEGRAL SINGLE FAMILY AMPHIDROME® WASTEWATER TREATMENT SYSTEM
BILL OF MATERIALS

REV. 4-11-2011 arm

ANOXIC TANK					
CONTRACTOR BILL OF MATERIALS			**F.R. MAHONY BILL OF MATERIALS**		
#	QUANT	DESCRIPTION	#	QUANT	DESCRIPTION
		ITEMS 1 - 7 REFER TO DRAWING 2			**ITEMS A1 - A4 REFER TO DETAIL A**
1	1	2000 GALLON ANOXIC TANK WITH WATER TIGHT PENETRATION SEALS	A1 - A4	1	2" TEE AND CHECK VALVE ASSEMBLY
					ITEMSB1 - B5 REFER TO DETAIL B
2	varies	4" SCH 40 PVC INFLUENT PIPE	B1 - B5	1	4" ENERGY DIFFUSER
3	1	4" SCH 40 PVC INFLUENT TEE			
4	varies	4" SCH 40 PVC RETURN PIPE			
5	1	2" SCH 40 PVC EFFLUENT PIPE			
6	2	TANK RISERS			
7	2	TANK COVERS			

INTEGRAL AMPHIDROME® REACTOR and CLEARWELL					
CONTRACTOR BILL OF MATERIALS			**F.R. MAHONY BILL OF MATERIALS**		
#	QUANT	DESCRIPTION	#	QUANT	DESCRIPTION
		ITEMS 8 - 13 REFER TO DRAWING 3			**ITEMS C1 - C2 REFER TO DETAIL C**
8	1	INTEGRAL 1000 GALLON CLEAR WELL TANK\	C1-C2	1	UNDERDRAIN DISCHARGE ASSEMBLY
		REACTOR BASIN WITH COVER AND			**ITEMS D1 - D3 REFER TO DETAIL D**
		WATER TIGHT PENETRATION SEALS	D1-D2	1	UNDERDRAIN ADAPTER ASSEMBLY
9	varies	2" SCH 80 PVC PIPE FOR VENT	D3	1	2' UNDERDRAIN
10	varies	2" SCH 80 PVC RETURN PIPE			**ITEMS E1 - E6 REFER TO DETAIL E**
		(FIELD CUT AND GLUED)	E1-E6		INLET AIR ASSEMBLY
11	varies	2" SCH 80 PVC DISCHARGE PIPE			**ITEMS R1 - R3 REFER TO 2' DIA. AMPHIDROME® REACTOR**
12	1	2" SCH 80 PVC ELBOW			
13	none	n/a	R1	2	PIPE MOUNTED MINI FLOATS W/50' CABLE
15	2	TANK RISERS	R2	18"	5-LAYERS OF GRAVEL- SORTED SIZES
16	2	TANK COVERS	R3	4'	FILTER MEDIA
17	varies	2" SCH 80 PVC PIPE EXTENSION INTO RISER			

INTEGRAL AMPHIDROME® REACTOR and CLEARWELL (CONT'D)					
CONTRACTOR BILL OF MATERIALS			**F.R. MAHONY BILL OF MATERIALS**		
#	**QUANT**	**DESCRIPTION**	**#**	**QUANT**	**DESCRIPTION**
					ITEMS F1 - F8 REFER TO DETAIL F
			F1	1	RETURN PUMP
			F2	1	1 1/2" x 2" COUPLING
			F3	1	PUMP NON GUIDE RAIL DISCONNECT ASSEMBLY
			F4	2	2" SCH 80 END CAP
			F5	1	2" SCH 80 PVC PIPE (approx 75")
			F6	1	2" SCH 80 PVC PIPE (cut 3")
			F7	1	2" SCH 80 PVC TEE
			F8	1	2" SCH 80 PVC PIPE (67.5" Long)
					ITEMS G1 - G5 REFER TO DETAIL G
			G1	1	EFFLUENT PUMP
			G2	1	SUMP CONTAINER WITH LID
			G3	1	1 1/2" SCH 80 CHECK VALVE ASSEMBLY
			G4	1	EFFLUENT NON GUIDE RAIL DISCONNECT ASSEMBLY
			G5	1	1 1/2" x 2" INCREASER
					ITEMS 31 - 33 REFER TO CLEAR WELL TANK
			CW1	3	MINI FLOATS W/50' CABLE
			CW2	1	FLOAT MOUNTING BRACKET KIT

BLOWERS AND CONTROL SYSTEM					
CONTRACTOR BILL OF MATERIALS			**F.R. MAHONY BILL OF MATERIALS**		
#	**QUANT**	**DESCRIPTION**	**#**	**QUANT**	**DESCRIPTION**
18		CONDUIT FOR CONTROL PANEL			**ITEMS 1 - 32 REFER TO BLOWER DETAIL A & B**
			1	1	BACKWASH BLOWER
			2	1	PROCESS BLOWER
			3 - 10	1	BACKWASH BLOWER PIPING ARRANGEMENT
			11 - 15	1	PROCESS AIR PIPING ASSEMBLY
			16 - 26	1	DISACHARGE MANIFOLD ASSEMBLY
					CONTROL SYSTEM
				1	CONTROL PANEL
				1	AUTOMATIC DIALER (MAY BE OPTIONAL, CHECK LOCAL REGULATIONS)
				1	ABOVE GRADE JUNCTION BOX (OPTIONAL)
				1	IRRIGATION/SPRINKLER BOX AND SCOTCH KIT (OPTIONAL)