PFAS Treatment Alternatives Analysis for Doylestown Borough

CKS ENGINEERS

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TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 Project Overview

At the request of Doylestown Borough, CKS Engineers has prepared a PFAS Treatment Alternatives Analysis for the Borough's drinking water system. Doylestown Borough has performed water quality testing of its five drinking water supply wells and detected Per and Polyfluoroalkyl substances at low levels in each well. This study will evaluate the alternatives for possible treatment and summarize the advantages and disadvantages of each treatment technology. The study will consider capital costs, operational costs, permitting considerations, waste disposal, and site constraints at each of the wells.

1.2 PFAS Background and Regulatory Status

Per and Polyfluoroalkyl substances, referred to as PFAS throughout this report, are a large group of manufactured chemical substances which have been in use since the 1940s and used in a variety of consumer products including carpeting, furniture fabrics, clothing, non-stick cookware, paper packaging for food products, and other materials. These chemical compounds were used for their resistance to water penetration, stains, and grease. PFAS compounds have also been widely used in firefighting foams at airports and military installations.

Two of the many PFAS compounds have been the primary focus of study and regulation to this point in time. These are Perflourooctane Sulfonate (PFOS) and Perflourooctanoic Acid (PFOA). In 2016, the United State Environmental Protection Agency (USEPA) issued a Lifetime Health Advisory Limit of 70 nanograms per liter (ng/L), which is also referred to as 70 parts per trillion (ppt), for the allowable amount of combined PFOS and PFOA in drinking water. The USEPA is proceeding with steps to regulate PFAS under the Safe Drinking Water Act, the maximum contaminate levels have not been announced, but are expected to be as close to zero as the current laboratory testing procedures will allow.

Additionally, in 2021, USEPA announced a fifth round of the Unregulated Contaminant Monitoring Rule (UCMR 5) which will require water utilities to test for 29 PFAS compounds between 2023 and 2025. The PFAS data collected may lead to further determinations to regulate additional PFAS compounds.

On January 14, 2023, the Pennsylvania Department of Environmental Protection (PADEP) announced a final rule setting maximum contaminate levels (MCL) for PFOS and PFOA, levels of 18 ppt for PFOS and 14 ppt for PFOA. Quarterly monitoring for these PFAS compounds will be required to start in 2024. Initial monitoring will be required quarterly at each entry point. Exceedances of the new MCL will require tier 2 public notices be distributed. Tier 2 notification must be distributed within 30 days of the detection of the violation.

Additionally, on March 14, 2023 the United States Environmental Protection Agency (EPA) announced the proposed National Primary Drinking Water Regulation (NPDWR) for six PFAS including perfluorooctanoic acid (PFOA), perfluorooctane sulfonic acid (PFOS), perfluorononanoic acid (PFNA), hexafluoropropylene oxide dimer acid (HFPO-DA, commonly known as GenX Chemicals), perfluorohexane sulfonic acid (PFHxS), and perfluorobutane sulfonic acid (PFBS). The proposed PFAS NPDWR does not require any actions until it is finalized. EPA anticipates finalizing the regulation by the end of 2023. EPA is proposing a National Primary Drinking Water Regulation (NPDWR) to establish legally enforceable levels, called Maximum Contaminant Levels (MCLs), for six PFAS in drinking water. PFOA and PFOS as individual contaminants, and PFHxS, PFNA, PFBS, and HFPO-DA (commonly referred to as GenX Chemicals) as a PFAS mixture. EPA is also proposing health-based, non-enforceable Maximum Contaminant Level Goals (MCLGs) for these six PFAS.

Compound	**Proposed MCLG**	**Proposed MCL (enforceable levels)**
PFOA	Zero	4.0 parts per trillion (also expressed as ng/L)
PFOS	Zero	4.0 ppt
PFNA	1.0 (unitless) Hazard Index	1.0 (unitless) Hazard Index
PFHxS		
PFBS		
HFPO-DA (commonly referred to as GenX Chemicals)		

Further, PFAS compounds are now being regulated under environmental clean-up standards under CERCLA Superfund rules, and consideration of regulations on PFAS in sewage biosolids and possible regulation under the NPDES permit process for wastewater treatment plants are likely to be enacted in the near future.

2.0 EXISTING FACILITIES

The Doylestown Borough drinking water system consists of five groundwater wells with limited treatment facilities, two water storage tanks totaling 1,400,000 gallons, and a distribution system of 4-to-10-inch diameter water mains. The distribution system also includes nine (9) interconnections between the Doylestown Borough water systems and the Doylestown Township Municipal Authority.

The existing Wells are as follows:

Table 2.1 – Existing Wells

Well #	Location	Flow Rate (gpm)	Average Flow (gpd) 2021
7	East Street	350	279,068
8	West Street	250	58,526
9	Maplewood Park	350	254,658
10	Sandy Ridge Dr.	350	240,496
12	Chapman Park	200	117,027
Total Well Production			**949,775**
Water Purchased from DTMA			**17,230**
Average Daily Water Usage			**967,005**

The flow rates shown in the above table are based on the maximum allowable flow rate as shown in the Delaware River Basin Groundwater Withdrawal Docket. Average flow shown is based on 2021 Water Usage Report (Chapter 110 Report) calculated for the full year.

Water quality testing of the wells has shown levels of PFAS were well below the previous Health Advisory Limits of 70 ppt, but are very close and, in one case, equal to the new PADEP MCL. The following table presents the highest results found at each of the Borough's wells in past sampling and laboratory testing.

Table 2.2 – Past Sample Results and PADEP Regulatory Limits

Sample Results			Regulatory Limits		
Well #	PFOS (ppt)	PFOA (ppt)	EPA Health Advisory PFOS + PFOA (ppt)	PADEP MCL PFOS (ppt)	PADEP MCL PFOA (ppt)
7	10	11	70	18	14
8	9	10	70	18	14
9	13	13	70	18	14
10	10	14	70	18	14
12	7	11	70	18	14

3.0 PFAS TREATMENT ALTERNATIVES

The USEPA provides scientific evaluation of treatment technologies to remove contaminates from drinking water supplies; this evaluation provides a listing of Best Available Technology for the specific contaminates. USEPA lists three Best Available Technology choices for removal of PFOS and PFOA from drinking water. These technologies are:

- Granular Activated Carbon (GAC)
- Ion Exchange (IX)
- Membrane Filtration/Reverse Osmosis (RO)

The following sections will present a summary of the treatment system, operational considerations, and cost estimates.

3.1 GAC Treatment

GAC treatment of drinking water has a well-known and proven record for removal of total organic compounds, disinfection by-products and by-product precursors, volatile organic compounds (VOCs), and synthetic organic compounds (SOCs) in addition to removal of PFAS compounds. GAC has been used successfully in the local area for removal of PFAS in Warrington, Horsham, and Warminster Townships.

GAC for drinking water is typically made from bituminous coal, which is thermally activated to create micropores within the carbon which adsorb and bonds the PFAS to the carbon. This is a very strong bond and the PFAS is not separated from the carbon by backwashing of the filters. GAC is also made from coconut shells and is capable of treating drinking water to the same degree as bituminous GAC, but coconut shell GAC generally has a shorter useful life in the treatment system. One aspect of quality control needed in purchasing of GAC is the need for requiring testing of the arsenic content tested prior to accepting delivery of the GAC. Warminster did experience a problem with receiving GAC that contained arsenic and caused contamination of the drinking water effluent.

GAC treatment occurs in large, pressurized tanks; a typical installation has two tanks per treatment train operating in a series or lead/lag configuration. Each tank is sized to provide full PFAS treatment; the two tank systems provide a significant margin of safety and extends the time period available to arrange change out of spent carbon media. Pressure to the treatment tanks is provided from the well pump and flow would first flow through the top of the first (lead) vessel through the carbon bed; the carbon bed is supported by an underdrain system which allows treated water to flow out the bottom of the tank and the carbon to be retained. The flow then goes to the top of the second (lag) tank and through the second carbon bed and then treated water is disinfected and flows to the distribution system. Regular sampling for laboratory testing of the PFAS levels of the water being treated would be taken on the inlet of the treatment system; between the first and second treatment vessel; and on the outlet of the second vessel. When PFAS is found in the water from the outlet of the first vessel, the flow can be redirected to go through the second (lag) vessel first, while replacement of the spent carbon in the former lead vessel is scheduled. Process flow schematics, equipment drawings, and media information for GAC treatment systems for the wells is included in the GAC exhibits section of this report.

GAC treatment system constructed in Warrington Township for the North Wales Water Authority.

Headloss through the GAC treatment system is low, usually only 1 to 2 pounds per square inch of pressure loss. In the systems we have designed in Warminster and Warrington, well pump upgrades have not been necessary. The existing well pumps would be evaluated as part of the treatment design and if the well pump output is low based on age and mechanical wear of the pumps, pump upgrades should be included in the project.

GAC filters require backwash of the filters following replacement of the carbon beds. This backwash is needed to remove fine carbon particles from the filter. After initial bedding of the filter, backwash is seldom needed; however, a sanitary sewer connection is required for each filter building.

We have performed sizing calculations for GAC treatment systems needed at each of the Borough's five wells. These calculations have been based on the flow rates in each well and utilizing information provided by TIGG LLC, which has supplied vessels, piping systems, and GAC media to projects that CKS Engineers have constructed in the area. Two distinct size tanks and carbon bed volumes were determined to be appropriate for use throughout the Borough's wells. The sizing considerations are summarized below.

Table 3.1 – GAC Treatment Design Parameters

Design Factors	Wells 7, 9, & 10	Wells 8 & 12
Design Flow Rate (gpm)	350	250
No. of Trains	1	1
No. of Vessels per Train	2	2
Vessel Diameter (ft)	10	8
Vessel Height (ft)	17.5	15
Vessel Operating Configuration	Series (Lead/Lag)	Series (Lead/Lag)
GAC per Vessel (lbs.)	20,000	10,000
Bed Volume per Vessel (gallons)	5,000	2,500
Empty Bed Contact Time per Train (minutes) ***Minimum 20 minutes required by PADEP regulations***	28.6	20
Maximum Head Loss through Train (psi)	11	11
Hydraulic Loading Rate (gpm/ft2)	4.5	5.0
Recommended Backwash Rate (gpm)	700	500

The GAC contained within the lead vessel of each treatment system is projected to remove PFAs to non-detect levels for a period of approximately 12 to 24 months before breakthrough is detected. When breakthrough is detected, the carbon bed would be replaced. GAC can be reactivated at the carbon manufacturer's facility by thermal process which will incinerate the PFAS. However, most drinking water facilities specify the use of virgin carbon as an additional factor of safety.

The GAC treatment systems are recommended to be located in a 40 ft long x 28 ft wide x 20 ft high at the eaves building near the existing pump house buildings. The disinfectant and any other chemical feeds would be applied following the GAC treatment. The building would also house necessary flow meters, electrical equipment, and associated piping, valves, and miscellaneous equipment.

GAC treatment building constructed in Warrington Township for the North Wales Water Authority.

Operational costs of the GAC treatment systems would include regular testing of PFAS levels on the influent water, between the two GAC vessels, and on the effluent water on a monthly basis. The cost of this testing is estimated at $1,000 per month per well.

Carbon replacement for the lead GAC vessels is estimated to be required every two years. Carbon purchase and disposal costs are currently $4.00 per pound. This would be an annualized cost of $160,000 per year, based on treatment of all five wells.

Detailed capital cost estimates for the purchase of GAC treatment vessels, GAC media, building construction, electrical equipment, along with engineering, permitting, construction oversight, and contingencies are included in the Cost Estimates section of this report. The Capital Costs are summarized in the Table below.

Table 3.2 – Capital Costs of GAC Treatment Systems

Well No.	Estimated Capital Cost
7	$1,704,587
8	$1,913,450
9	$1,913,450
10	$1,913,450
12	$1,704,587
Total	**$9,149,524**

3.2 Ion Exchange Treatment

Ion Exchange (IX) treatment is listed as a Best Available Technology of drinking water by the USEPA and has been in active uses in drinking water and industrial water treatment systems for many years. IX technology is currently being used for PFAS treatment of drinking water in Warminster Township, which has experienced much higher levels of PFAS contamination which may be attributed to the Willow Grove and Johnsville military airbases.

Ion exchange resin removes PFAS by two mechanisms, ion exchange and adsorption. PFAS selective resin can remove PFOS and PFOA to non-detect levels. The included data is based on Purolite buffered resins PFA694EBF and A595EBF. These two resins are buffered to control reduction of pH of treated water and are designed not to reduce the chloride to sulfate mass ratio of the water. These two matters are of concern relative to the corrosivity of the drinking water following treatment and maintaining compliance with the lead and copper standards at the customers taps.

IX treatment occurs in large, pressurized tanks very similar to the vessels used for GAC treatment. In fact, the Warminster system previously referenced was originally filled with GAC and, following a lengthy permitting process with PADEP, the GAC was removed and an equivalent amount of ion exchange resign was installed. A typical IX installation has two tanks per treatment train operating in a series or lead/lag configuration. Pressure to the treatment tanks is provided from the well pump and flow would first flow through the top of the first (lead) vessel through the resin bed; the resin bed is supported by an underdrain system which allows treated water to flow out the bottom of the tank and the IX resin to be retained. The flow then goes to the top of the second (lag) tank and through the second resin bed and then treated water is disinfected and flows to the distribution system. Regular sampling for laboratory testing of the PFAS levels of the water being treated would be taken on the inlet of the treatment system; between the first and second treatment vessel; and on the outlet of the second vessel. When PFAS is found in the flow of the outlet of the first vessel, the water can be redirected to go the second (lag) vessel first, while replacement of the spent resin in the former lead vessel is scheduled. Process flow schematics for the IX treatment for the wells is included with this report.

Headloss through the IX treatment systems is low, only 1 to 2 pounds per square inch of pressure loss. In the systems we have designed in Warminster, well pump upgrades have not been necessary. The existing well pumps would be evaluated as part of the treatment design and, if the well pump output is low based on age and mechanical wear of the pumps, pump upgrades should be included in the project.

IX resin has greater chemical reactivity as compared to GAC; this allows smaller volumes of IX resin and therefore, slightly smaller treatment vessels to be used in IX systems. This allows the treatment time in the vessels, referred to as Empty Bed Contact Time, to be reduced to 3 minutes per vessel as compared to 10 minutes per vessel for GAC. We have performed sizing calculations for the IX treatment systems needed at each of the Borough’s five wells. These calculations have performed based on the flow rate in each well and utilizing resin manufactured by Purolite. Three distinct size tanks and resin bed volumes were determined to be appropriate. The sizing considerations are summarized below.

Table 3.3 - IX Treatment Design Parameters

Design Factors	Wells 7, 9, & 12	Well 8	Well 12
Design Flow Rate (gpm)	350	250	200
No. of Trains	1	1	1
No. of Vessels per Train	2	2	2
Vessel Diameter (ft)	7	6	5
Vessel Height (ft)	12.6	12.2	10
Vessel Operating Configuration	Series (Lead/Lag)	Series (Lead/Lag)	Series (Lead/Lag)
IX Resin per Vessel (gallons)	1050	750	600
Bed Volume per Vessel (ft3)	140	100	80
Empty Bed Contact Time per Train (minutes)	3	3	3
Maximum Head Loss through Train (psi)	11	11	11
Hydraulic Loading Rate (gpm/ft2)	9.1	8.8	10.2

IX treatment vessels do not require backwash of the filters following replacement of the resin beds. This eliminates the need for a large capacity supply of backwash water and sanitary sewer connection.

IX resin has a greater capacity for removal of contaminants per volume than GAC. The IX resin contained within the lead vessel of each treatment system is projected to remove PFAs to non-detect levels for a period of approximately 3 years. When breakthrough is detected, the resin bed would be replaced. IX resin is a single use filter media and spent media would be disposed of by high temperature incineration.

The IX treatment system is recommended to be located in a 36 ft long x 24 ft wide x 16 ft high eaves building near the existing pump house buildings. The disinfectant and any other chemical feeds would be applied following the IX treatment. The building would also house necessary flow meters, electrical equipment, and associated piping, valves, and miscellaneous equipment.

Operational costs of the IX treatment systems would also include regular testing of PFAS levels on the influent water, between the two GAC vessels, and on the effluent water on a monthly basis. The cost of this testing is estimated at $1,000 per month per well.

IX resin replacement for the lead GAC vessels is estimated to be required every three years. Resin purchase and disposal costs are currently $450 per cubic foot of resin. This would be an annualized cost of $81,000 per year, based on treatment of all five (5) wells.

Detailed capital cost estimates for the purchase of IX treatment vessels, IX media, building construction, electrical equipment, along with engineering, permitting, construction oversight and contingencies are included in the Cost Estimates section of this report. The Capital Costs are summarized in the Table below.

Table 3.3 – Capital Costs of IX Treatment Systems

Well No.	Estimated Capital Cost
7	$1,760,000
8	$1,553,750
9	$1,760,000
10	$1,760,000
12	$1,416,250
Total	**$8,250,000**

3.3 Reverse Osmosis (RO) Treatment

Reverse Osmosis (RO) is a type of membrane filtration treatment which is a pressure driven process that retains all ions on one side of an osmotic membrane and purified water passes through the membrane. Reverse osmosis is a very fine level of filtration which can remove particles as small as 0.001-micron size. RO treatment has been shown to be highly effective in removing PFAS compounds from water. Third party testing of the equipment we have considered in this study showed removal of both long and short chain PFAS compounds to non-detect levels, even from waters with high influent concentrations. Reverse Osmosis is the final type of treatment listed by USEPA as Best Available Technology for removal of PFAS.

RO treatment varies from GAC and IX treatment in that it is a physical separation type treatment rather than a chemical adsorption-based treatment. RO treatment systems use feed pumps to pressurize the water to be treated and forced through the osmotic membrane. The RO equipment we have reviewed for this study uses three feed pumps from 40 to 100 horsepower each, as well as a circulation pump of 15 to 20 horsepower. The existing electrical service to the well systems will need to be evaluated to determine if existing service is adequate for the additional loads. The capability of the existing emergency generators will also need to be reviewed. The RO systems include all electrical controls for the pumps and monitoring of the RO process. Electrical use costs for the RO treatment are considerable, and power consumption is estimated to add $3,000 per month to each well site. This would be an estimated total cost of $180,000 per year for all five of the Borough’s well utilizing IX treatment.

The RO equipment manufacturers also recommend the addition of antiscalant chemical to maintain the function of the RO membranes. The costs of antiscalant chemical are estimated to be $150 per month per site. Additionally, the RO units require periodic cleaning and a clean in place tank system is also needed at each site.

Another item to be considered is the waste stream from the RO system. The RO process will create a concentrated brine containing the rejected minerals and PFAS compounds. The waste rate of the RO system is estimated at approximately 10% of the water input. This brine water will include concentrated PFAS compounds up to approximately 250 parts per trillion. PADEP and the local sewer utility will likely require the PFAS compounds be removed before the waste stream can be discharged to the sewer. To remove the PFAS compounds, we would recommend the use of a small granulated activated carbon (GAC) system. The carbon contactor would contain 2,000 pounds of GAC; PFAS would be removed to non-detectable levels. The carbon is anticipated to be effective for over 6 months before a carbon changeout is required. Annualized cost of carbon replacement is estimated to be $90,000.

The RO membranes are contained in long cylindrical pressure vessels and the number of membranes needed is varied based on the flow requirements. The manufacturer has recommended three different treatment unit sizes, with 10, 12, and 15 pressure vessels and 50, 60, and 75 membranes, respectively. The RO units are contained on equipment skids including the feed pumps and piping. These skids are approximately 27.5' long and 6.3 feet wide; the RO skids are 8' tall, this would allow the building rooflines to be lower than those for the GAC or IX treatment units.

RO Treatment Design Parameters

Design Factors	Wells 7, 9, & 12	Well 8	Well 12
Design Flow Rate (gpm)	350	250	200
No. of Skids	1	1	1
No. of Pressure Vessels per Skid	15	12	10
No. of RO Membranes per Skid	75	60	50
Feed Pumps (Horsepower)	60/75/100	50/60/75	40/50/60
Circulation Pump (Horsepower)	20	15	15

RO treatment system does not require backwash of the membranes, but a sanitary sewer connection would be needed for the effluent of the carbon absorber vessels on the waste stream.

RO membranes are projected to remove PFAS to non-detect levels for a period of approximately 5 years, before replacement would be required. Replacement cost of the membranes is $600 each. An outside service technician would be needed for these replacements. Total cost for replacement of membranes at all five of the Borough's wells after five years of services is estimated $220,000.

The RO treatment system is recommended to be located in a 36 ft long x 24 ft wide x 12 ft high at the eaves building near the existing pump house buildings. The disinfectant and any other chemical feeds would be applied following the IX treatment. The building would also house necessary flow meters, electrical equipment, and associated piping, valves, and miscellaneous equipment.

Operational costs of the RO treatment systems would also include regular testing of PFAS levels on the influent and effluent water on a monthly basis. The cost of this testing is estimated at $1,000 per month per well.

Detailed capital cost estimates for the purchase of RO treatment equipment, building construction, electrical equipment, along with engineering, permitting, construction oversight and contingencies are included in the Cost Estimates section of this report. The Capital Costs are summarized in the Table below.

Table 3.3 – Capital Costs of RO Treatment Systems

Well No.	Estimated Capital Cost
7	$1,897,500
8	$1,863,125
9	$1,897,500
10	$1,897,500
12	$1,780,625
Total	**$9,336,250**

4.0 PERMITTING REQUIREMENTS

A summary of the anticipated permits is provided below by permit type:

4.1 PADEP Public Water Supply (PWS) Permit

The addition of any treatment processes or modification to existing public water supply systems require a PADEP PWS Permit. PADEP has varying requirements for the issuance of permits depending upon the type of treatment proposed.

PWS permits for granular activated carbon (GAC) treatment systems can be obtained through the regular permitting process. PADEP has a high level of confidence in GAC treatment and GAC has been shown not to have any impact on water chemistry related to corrosion control and the Lead and Copper regulations. Issuance of PWS permits for GAC is relatively simple and permits can be expected within a few months of submission of a completed application.

PWS permits for Ion Exchange (IX) systems for PFAS treatment systems are more difficult to obtain than permits for GAC treatment. The PADEP currently considers IX treatment for PFAS removal as “innovative technology” and has required significant pilot testing of the treatment equipment on the specific water source. The initial guidelines provided for pilot testing required the test extends through three calendar seasons (9 months) to study the effect of seasonal temperature variations. Based on that length of the required testing and the expense of multiple laboratory tests for PFAS compounds, permitting of IX systems would add significant costs and delay the implementation of IX treatment. PADEP has begun to soften its policy and we have received from PADEP Southeast Region the following statement: “Piloting requirements for ion exchange treatment for PFAS removal are determined on a case by case basis. Piloting is often required at this stage, but if water systems can show that pilot testing already exists for water quality similar to that at the proposed sources, it is possible that a pilot may not be required. With or without the pilot, the permit may still be issued as an innovative technology permit."

Based on the quote from PADEP, we would recommend laboratory testing of the raw water at each well to determine water quality to make comparisons to water quality in the Warminster wells being treated with IX. If they are similar, piloting requirements could be greatly reduced. At the very least, we would hope to show that the water quality of all five of the Borough's wells is similar to each other in order to only conduct one pilot test rather than up to five separate pilot tests.

As mentioned previously, GAC vessel systems can be converted to use IX resin if the permitting requirements were to be eased in the future as PADEP gains experience with these systems. If new maximum contaminant levels for PFAS are enacted, the PADEP will likely be forced to simplify its permitting procedures for IX treatment units.

Permits would also be required for the installation of reverse osmosis treatment units; the PADEP will also require pilot testing for RO treatment systems. The RO treatment process removes minerals and other ions in the water in addition to the PFAS compounds; this can impact the corrosive characteristics of the drinking water and therefore, is a concern. Additionally, the treatment and handling of the waste stream would be a significant issue that would have to be thoroughly documented for permitting.

4.2 Bucks County Water and Sewer Sanitary Sewer Connections

Sanitary sewer connections would be required for GAC and RO systems installations. This will require sewage facilities planning for any sites currently without a sewer connection. Details of the quantity and chemical characteristic of the flow would need to be documented for the connections.

4.3 Doylestown Borough Permits

Coordination with the staff of the Borough's Building and Zoning Department will be required to determine local requirements and approvals applicable. Permits for building, electrical, plumbing, stormwater and grading will be necessary. Specific site considerations are included in the following section of this report, however, based on the existing lot sizes and the area needed for construction of treatment buildings, variances for setbacks and related ordinances will be required.

5.0 SITE CONSIDERATIONS

A summary of the site considerations for each of the five existing well sites is provided below:

5.1 Well No. 7

Well No. 7 is located within a small building that is a portion of the Central Bucks EMS facility on East Street near Easton Road (S.R. 0611). The existing building and parking area take up the majority of the 0.91-acre lot area. A small area of lawn exists adjacent to the parking lot, on which the treatment building could be constructed. This location would require variances of building setbacks and would have visual impact on neighboring residential properties. Careful coordination would be required during construction to avoid impact on the Emergency Squad operations.

5.2 Well No. 8

Well No. 8 is located within a small building in the parking area for the William E. Neis Community Park on West Street near Doyle Elementary School. A potential location for a treatment building exists between one of the ballfields and the tennis courts. The building is a reasonable distance from the nearby condominiums.

5.3 Well No. 9

Well No. 9 is located within Veterans Memorial Park in the Maplewood subdivision near the existing water storage tank. Adequate area does exist in the park for a treatment building. Development of a site near the wellhouse would require clearing of trees for the building and truck access.

5.4 Well No. 10

Well No. 10 is located on a 0.288-acre parcel off Sandy Ridge Drive near the Route 611 By-pass. Area does exist within the existing parcel for the construction of a treatment building. Variances may be necessary for setbacks on this parcel.

5.5 Well No. 12

Well No. 12 is located within Chapman Park near the Borough Dam. Area does exist for construction of a treatment system near the existing wellhouse. This may have some adverse effect to recreation in the park, particularly during construction.

6.0 OTHER WATER SUPPLY SOURCES

In addition to the Borough's five water supply wells, the Borough has nine (9) interconnections to the Doylestown Township Municipal Authority (DTMA) water system creating the ability to transfer water between the two systems. DTMA supplies their system with ten groundwater supply wells and is currently also evaluating the impact of PFAS contamination on those wells and their options for treatment. DTMA also has an interconnection with North Penn Water Authority (NPWA) and receives water from the Forest Park surface water treatment plant in Chalfont. The Forest Park treatment plant includes membrane filtration and activated carbon treatment. Water could be transferred from NPWA through DTMA water mains to Doylestown Borough to replace the capacity of wells not equipped with treatment. Flow testing and perhaps a hydraulic model of the piping systems may be needed to determine the maximum flows that could be transferred. Additionally, the existing interconnection agreements with DTMA would require modification and an additional agreement with NPWA may be needed.

We have made preliminary inquiries with DTMA about supplying drinking water to the Borough on a wholesale basis, and they have responded positively. There are three possible locations for transfer of bulk quantities of water to the Borough. The existing Taversall interconnection operates at a higher pressure gradient on the DTMA side and could transfer water to the Borough's distribution system. Currently, DTMA supplies approximately 15,000 gallons per day to the Borough, and this interconnection has been used to supply approximately 100,000 gallons per day several times in the past, when Borough wells were off-line for maintenance. A second possibility is the existing Broad Street interconnection at the intersection of Shady Retreat Road and Broad Street. The DTMA pressure gradient at this location is significantly higher than the Borough's water pressure and with minor modifications, the interconnection could transfer significant quantities of drinking water. Testing of water main pressures at each of these interconnections should be checked and, if allowable, hydrant flow testing could be conducted to verify the quantity of drinking water that could be transferred.

Finally, North Penn Water Authority and the North Wales Water Authority are beginning construction of a large diameter transmission main in Ferry Road which will be capable of transferring additional drinking water into the DTMA system, which in turn could be transferred to Doylestown Borough.

The Borough's drinking water production/usage in 2021 as shown on Page 2 of this report was 967,000 gallons per day. For estimating purposes, DTMA has provided an initial wholesale rate of $3.80 per 1,000 gallons. DTMA has further stated that the rate could possibly be negotiated to a better price based on possibly creating tiered price structure depending on the quantity of drinking water contracted. Based on the $3.80 per thousand gallon rate, a conservative estimate of purchased drinking water can be calculated. For a supply of 970 one thousand gallon units per day, the Borough would incur a cost of $3,686 per day or $1,345,390 per year if all of the Borough's wells were taken out of service.

7.0 COST SUMMARY

A summary of the capital costs for each treatment option is provided below.

Table 7.0 – Estimated Capital Costs

Treatment Type	Well 7	Well 8	Well 9	Well 10	Well 12	Total Cost
GAC	$1,913,450	$1,704,587	$1,913,450	$1,913,450	$1,704,587	$9,149,524
IX	$1,704,587	$1,553,750	$1,704,587	$1,704,587	$1,416,250	$8,250,000
RO	$1,897,500	$1,863,125	$1,897,500	$1,897,500	$1,780,625	$9,336,250

Table 7.1 – Annualized Estimated Operational & Maintenance Costs

Cost Category	GAC Treatment	IX Treatment	RO Treatment	Purchased Water
Media Changeout Costs	$160,000	$81,000	$44,000	N/A
Laboratory Testing	$60,000	$60,000	$60,000	$10,000
Additional Electrical Energy	N/A	N/A	$180,000	N/A
Additional Hazardous Waste Removal (RO brine treatment)	N/A	N/A	$90,000	N/A
Bulk Purchase of Water	N/A	N/A	N/A	$1,345,390
TOTAL ANNUALIZED COST	$220,000	$141,000	$374,000	$1,355,390

The purchase of bulk water has a high annual cost, but it would not require the capital cost expenditure.

8.0 SUMMARY, CONCLUSION, AND RECOMMENDATIONS

Three treatment technology options have been considered for the five water supply wells operated by Doylestown Borough. Each of the technologies can meet the Borough's treatment goals. Although the total project costs for the three treatment options are relatively close together, the operational and maintenance costs for each of the options must also be considered. In addition, due to the Borough's current interconnections with DTMA, the bulk purchase of water and decommissioning of the Borough's wells is a potential alternative to be considered. However, due to the annual cost of this option and the Borough having to become dependent on another public water system for the supply of water, this may not be the best solution for the Borough.

RO treatment has the highest capital cost and highest operational and maintenance cost considering the electrical power usage and the need for disposal of carbon treating the RO system waste brine. Based on those operational cost considerations, we do not consider RO treatment to be the best option for the Borough.

Capital costs of IX treatment is very close to that of GAC treatment. In addition, IX will offer lower operational costs as the media is longer lasting and a smaller volume of media is needed. However, as stated previously, the PADEP considers IX treatment for PFAS removal "innovative treatment" and requires pilot testing of the technology on the source water. Conducting pilot testing would add to the timeline for installing treatment on the Borough's wells. As a result, we recommend monitoring the PADEP's actions in issuing permits for IX treatment and possibly considering IX resin treatment as the alternative selected initially or possibly in the future through the change-out of media.

GAC treatment for the Borough's five wells has the lowest capital cost and moderate operational cost. The treatment is proven and relatively easy to operate. GAC is readily permitted by PADEP and would be the most expedient path to providing drinking water treated for PFAS removal. In addition, moving forward on preliminary designs and permitting for the well stations may put the Borough in the best position for securing any State or Federal funding of PFAS treatment. An implementation schedule is provided below based on GAC treatment as the alternative selected.

GAC Well Treatment Implementation Schedule

PHASE	Duration (Months)																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Design	■	■	■	■	■	■																		
Permitting					■	■	■	■																
Bidding								■	■															
Construction										■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

Due to the capital cost of treatment, we would recommend the Borough continue in identifying funding sources, particularly grants for the construction of treatment systems for the Borough's wells. In addition to consideration of moving forward on GAC treatment of the wells, we would also recommend moving ahead with discussions with DTMA on operational and contractual consideration involved in obtaining drinking and moving water from North Penn Water Authority and the Forest Park treatment plant through Doylestown Township and into the Borough. By developing a secure source of purchased drinking water supply from DTMA, it would allow the Borough time to secure funds and perform the necessary design, permit, and construct GAC treatment systems.

8.1 Comparative Summary Matrix

The following is a "Comparative Summary" matrix identifying the various items to consider with each treatment option along with the bulk purchase of water.

DOYLESTOWN BOROUGH PUBLIC DRINKING WATER SYSTEM PFAS TREATMENT ALTERNATIVES ANALYSIS COMPARATIVE SUMMARY				
	PFAS TREATMENT – GRANUALAR ACTIVATED CARBON (GAC) AT WELL STATIONS	**PFAS TREATMENT – ION EXCHANGE RESIN (IX) AT WELL STATIONS**	**PFAS TREATMENT – REVERSE OSMOSIS (RO) AT WELL STATIONS**	**PURCHASE OF BULK WATER SUPPLY FROM DTMA AND NPWA**
1. Scope	Installation of GAC treatment systems at each of the Borough's five (5) groundwater wells, Construction of additional treatment building at each site included.	Installation of IX treatment systems at each of the Borough's five (5) groundwater wells, Construction of additional treatment building at each site included.	Installation of RO treatment systems at each of the Borough's five (5) groundwater wells, Construction of additional treatment building at each site included.	Purchase additional bulk water supply of drinking water treated at the NPWA Forest Park Water Treatment Plant, transferring water through DTMA mains to the Doylestown Borough distribution system.
2. Capital Cost (Total Project)	$9,149,524(1)	$8,250,000(1)	$9,336.250(1)	$0(1)
3. Operation Cost (Yearly)	$160,000 (GAC replacements)(2) $60,000 (laboratory testing)(4)	$81,000 (resin exchange)(2) $60,000 (laboratory testing)(4)	$44,000 (membrane replacements)(2) $60,000 (laboratory testing)(4) $180,000 (electrical energy costs) $90,000 (annual costs of GAC replacement and disposal from concentrated PFAS waste stream.)	$1,345,390 (water purchase)(3) $10,000 (laboratory testing)(4)
4. Design Considerations	Additional building at each well site, some sites have limited area available for construction. GAC is proven treatment for PFAS and does not require pilot testing. Sanitary sewer connection needed at each site.	Additional building at each well site, some sites have limited area available for construction. IX is proven treatment for PFAS but will require pilot testing. Sanitary sewer connection needed at each site.	Additional building at each well site, some sites have limited area available for construction. RO is capable for removing PFAS but will require pilot testing. Additional GAC treatment needed for concentrated PFAS waste stream. Sanitary sewer connection needed at each site.	No building construction needed. Minor field testing to verify capacity and pressures available. New/revised legal agreements with DTMA and NPWA. Minor PADEP permitting approvals needed.

DOYLESTOWN BOROUGH PUBLIC DRINKING WATER SYSTEM
PFAS TREATMENT ALTERNATIVES ANALYSIS
COMPARATIVE SUMMARY
(CONTINUED)

	PFAS TREATMENT – GRANUALAR ACTIVATED CARBON (GAC) AT WELL STATIONS	PFAS TREATMENT – ION EXCHANGE RESIN (IX) AT WELL STATIONS	PFAS TREATMENT – REVERSE OSMOSIS (RO) AT WELL STATIONS	PURCHASE OF BULK WATER SUPPLY FROM DTMA AND NPWA
5. Remarks:				
Pros:	Proven technology, ease of operation. Moderate operating costs. Operation independent of other water sources and/or public water systems.	Proven technology, ease of operation. Lowest operating costs. Operation independent of other water sources and/or public water systems.	Operation independent of other water sources and/or public water systems.	Lowest implementation cost. Could be in service before other alternatives. Some additional price negotiation/discount is possible.
Cons:	Site constraints to construct treatment systems. Building addition/expansion in open space may not be easily accepted by neighbors.	Site constraints to construct treatment systems. Building addition/expansion in open space may not be easily accepted by neighbors. Pilot testing required which will delay implementation.	Highest capital cost. Highest annual operations and maintenance cost. Complex operation. Additional disposal of concentrated waste stream. Pilot testing required. Site constraints to construct treatment systems.	Dependence on other water supplies/water systems to meet Borough's needs. Subject to future rate hikes.

NOTES:

(1) Based on PFAS Treatment Alternatives Analysis for Doylestown Borough - prepared by CKS Engineers, Inc. dated February 2023.

(2) Annualized cost based on media replacement costs shown in study.

(3) Annual cost based on a rate of \$3.80/1,000 gallons and an average use of 970,000 gpd (970 x \$3.80/1,000 gal x 365 days = \$1,345,390).

(4) Annual operational cost.

COST ESTIMATES

GAC TREATMENT

TABLE 1
DOYLESTOWN BOROUGH – WELLS 8 & 12
PFAS TREATMENT WITH GRANULAR ACTIVATED CARBON

PROJECT COST ESTIMATE PER WELL

Item No.	Description	Lump Sum Cost
Construction Cost		
1.	Brick and Block Treatment Building – 28'x 40'	$425,000
2.	GAC Treatment System, Installed 2 - 8' diameter Vessels - 10,000 lbs. GAC each	$395,000
3.	Yard Piping (8" DIP, Fittings and Valves)	$160,000
4.	Controls and Instrumentation	$ 80,000
5.	Electrical, Lighting, Heating and Ventilation	$175,000
6.	Site Work/Restoration	$ 30,000
	SUBTOTAL – ITEMS 1-6	$1,265,000
	CONTINGENCIES (10%)	$126,500
	TOTAL CONSTRUCTION COST	**$1,391,500**
	ENGINEERING DESIGN AND BIDDING (10%)	$139,150
	PERMITTING (2.5%)	$34,787
	CONSTRUCTION OVERSIGHT & INSPECTION (10%)	$139,150
	TOTAL PROJECT COST PER WELL	**$1,704,587**

TABLE 2 DOYLESTOWN BOROUGH – WELLS 7, 9, & 10 PFAS TREATMENT WITH GRANULAR ACTIVATED CARBON PROJECT COST ESTIMATE PER WELL	
Description	**Lump Sum Cost**
Construction Cost	
1. Brick and Block Treatment Building – 28'x 40'	$425,000
2. GAC Treatment System, Installed 2 – 10' diameter Vessels - 20,000 lbs. GAC each	$550,000
3. Yard Piping (8" DIP, Fittings and Valves)	$160,000
4. Controls and Instrumentation	$ 80,000
5. Electrical, Lighting, Heating and Ventilation	$175,000
6. Site Work/Restoration	$ 30,000
SUBTOTAL – ITEMS 1-6	$1,420,000
CONTINGENCIES (10%)	$142,000
TOTAL CONSTRUCTION COST	**$1,562,000**
ENGINEERING DESIGN AND BIDDING (10%)	$156,200
PERMITTING (2.5%)	$39,050
CONSTRUCTION OVERSIGHT & INSPECTION (10%)	$156,200
TOTAL PROJECT COST PER WELL	**$1,913,450**

COST ESTIMATES

IX TREATMENT

TABLE 3 DOYLESTOWN BOROUGH – WELL 12 PFAS TREATMENT WITH IX RESIN PROJECT COST ESTIMATE PER WELL		
Item No.	**Description**	**Lump Sum Cost**
Construction Cost		
1.	Brick and Block Treatment Building – 24'x 36'	$360,000
2.	IX Treatment System, Installed 2 - 5' diameter Vessels – 80 FT3 of IX resin each	$250,000
3.	Yard Piping (8" DIP, Fittings and Valves)	$160,000
4.	Controls and Instrumentation	$ 80,000
5.	Electrical, Lighting, Heating and Ventilation	$150,000
6.	Site Work/Restoration	$ 30,000
	SUBTOTAL – ITEMS 1-6	$1,030,000
	CONTINGENCIES (10%)	$103,000
	TOTAL CONSTRUCTION COST	**$1,133,000**
	ENGINEERING DESIGN AND BIDDING (10%)	$113,300
	PERMITTING (5%)	$56,650
	CONSTRUCTION OVERSIGHT & INSPECTION (10%)	$113,300
	TOTAL PROJECT COST PER WELL	**$1,416,250**

TABLE 4
DOYLESTOWN BOROUGH – WELL 8
PFAS TREATMENT WITH IX RESIN

PROJECT COST ESTIMATE PER WELL

Item No.	Description	Lump Sum Cost
Construction Cost		
1.	Brick and Block Treatment Building – 24'x 36'	$360,000
2.	IX Treatment System, Installed 2 - 6' diameter Vessels – 100 FT3 of IX resin each	$350,000
3.	Yard Piping (8" DIP, Fittings and Valves)	$160,000
4.	Controls and Instrumentation	$ 80,000
5.	Electrical, Lighting, Heating and Ventilation	$150,000
6.	Site Work/Restoration	$ 30,000
	SUBTOTAL – ITEMS 1-6	$1,130,000
	CONTINGENCIES (10%)	$113,000
	TOTAL CONSTRUCTION COST	**$1,243,000**
	ENGINEERING DESIGN AND BIDDING (10%)	$124,300
	PERMITTING (5%)	$62,150
	CONSTRUCTION OVERSIGHT & INSPECTION (10%)	$124,300
	TOTAL PROJECT COST PER WELL	**$1,553,750**

TABLE 5 DOYLESTOWN BOROUGH – WELLS 7, 9, & 10 PFAS TREATMENT WITH IX RESIN PROJECT COST ESTIMATE PER WELL	
Description	**Lump Sum Cost**
Construction Cost	
1. Brick and Block Treatment Building – 24'x 36'	$360,000
2. GAC Treatment System, Installed 2 – 10' diameter Vessels - 20,000 lbs. GAC each	$475,000
3. Yard Piping (8" DIP, Fittings and Valves)	$160,000
4. Controls and Instrumentation	$ 80,000
5. Electrical, Lighting, Heating and Ventilation	$175,000
6. Site Work/Restoration	$ 30,000
SUBTOTAL – ITEMS 1-6	$1,280,000
CONTINGENCIES (10%)	$128,000
TOTAL CONSTRUCTION COST	**$1,408,000**
ENGINEERING DESIGN AND BIDDING (10%)	$140,800
PERMITTING (5%)	$70,400
CONSTRUCTION OVERSIGHT & INSPECTION (10%)	$140,800
TOTAL PROJECT COST PER WELL	**$1,760,000**

COST ESTIMATES

RO TREATMENT

TABLE 6
DOYLESTOWN BOROUGH – WELL 12
PFAS TREATMENT WITH RO MEMBRANES

PROJECT COST ESTIMATE PER WELL

Item No.	Description	Lump Sum Cost
Construction Cost		
1.	Brick and Block Treatment Building – 24'x 36'	$360,000
2.	RO Treatment System, Installed- 10 membranes	$390,000
3.	GAC treatment for Reject Brine	$125,000
4.	Yard Piping (8" DIP, Fittings and Valves)	$160,000
5.	Controls and Instrumentation	$ 80,000
6.	Electrical, Lighting, Heating and Ventilation	$150,000
7.	Site Work/Restoration	$ 30,000
	SUBTOTAL – ITEMS 1-7	$1,295,000
	CONTINGENCIES (10%)	$129,500
	TOTAL CONSTRUCTION COST	**$1,424,500**
	ENGINEERING DESIGN AND BIDDING (10%)	$142,450
	PERMITTING (5%)	$71,225
	CONSTRUCTION OVERSIGHT & INSPECTION (10%)	$142,450
	TOTAL PROJECT COST PER WELL	**$1,780,625**

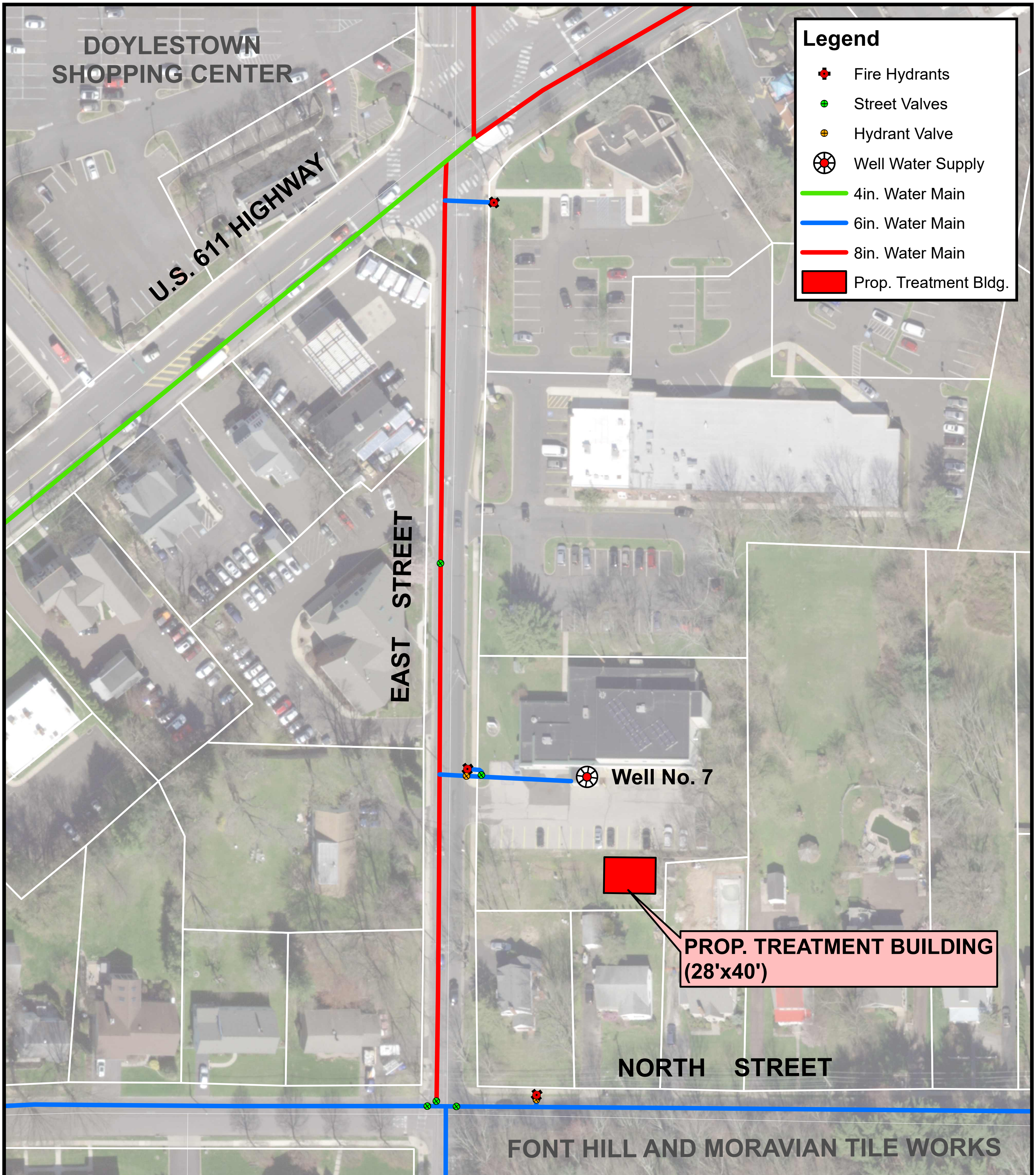
TABLE 7 DOYLESTOWN BOROUGH – WELL 8 PFAS TREATMENT WITH RO MEMBRANES PROJECT COST ESTIMATE PER WELL		
Item No.	**Description**	**Lump Sum Cost**
Construction Cost		
1.	Brick and Block Treatment Building – 24'x 36'	$360,000
2.	RO Treatment System, Installed- 12 membranes	$450,000
3.	GAC treatment for Reject Brine	$125,000
4.	Yard Piping (8" DIP, Fittings and Valves)	$160,000
5.	Controls and Instrumentation	$ 80,000
6.	Electrical, Lighting, Heating and Ventilation	$150,000
7.	Site Work/Restoration	$ 30,000
	SUBTOTAL – ITEMS 1-7	$1,355,000
	CONTINGENCIES (10%)	$135,500
	TOTAL CONSTRUCTION COST	**$1,490,500**
	ENGINEERING DESIGN AND BIDDING (10%)	$149,050
	PERMITTING (5%)	$74,525
	CONSTRUCTION OVERSIGHT & INSPECTION (10%)	$149,050
	TOTAL PROJECT COST PER WELL	**$1,863,125**

TABLE 8
DOYLESTOWN BOROUGH – WELLS 7, 9, & 10
PFAS TREATMENT WITH RO MEMBRANES

PROJECT COST ESTIMATE PER WELL

Item No.	Description	Lump Sum Cost
Construction Cost		
1. Brick and Block Treatment Building – 24'x 36'		$360,000
2. RO Treatment System, Installed- 15 membranes		$475,000
3. GAC treatment for Reject Brine		$125,000
4. Yard Piping (8" DIP, Fittings and Valves)		$160,000
5. Controls and Instrumentation		$ 80,000
6. Electrical, Lighting, Heating and Ventilation		$150,000
7. Site Work/Restoration		$ 30,000
SUBTOTAL – ITEMS 1-7		$1,380,000
	CONTINGENCIES (10%)	$138,000
	TOTAL CONSTRUCTION COST	**$1,518,000**
	ENGINEERING DESIGN AND BIDDING (10%)	$151,800
	PERMITTING (5%)	$75,900
	CONSTRUCTION OVERSIGHT & INSPECTION (10%)	$151,800
	TOTAL PROJECT COST PER WELL	**$1,897,500**

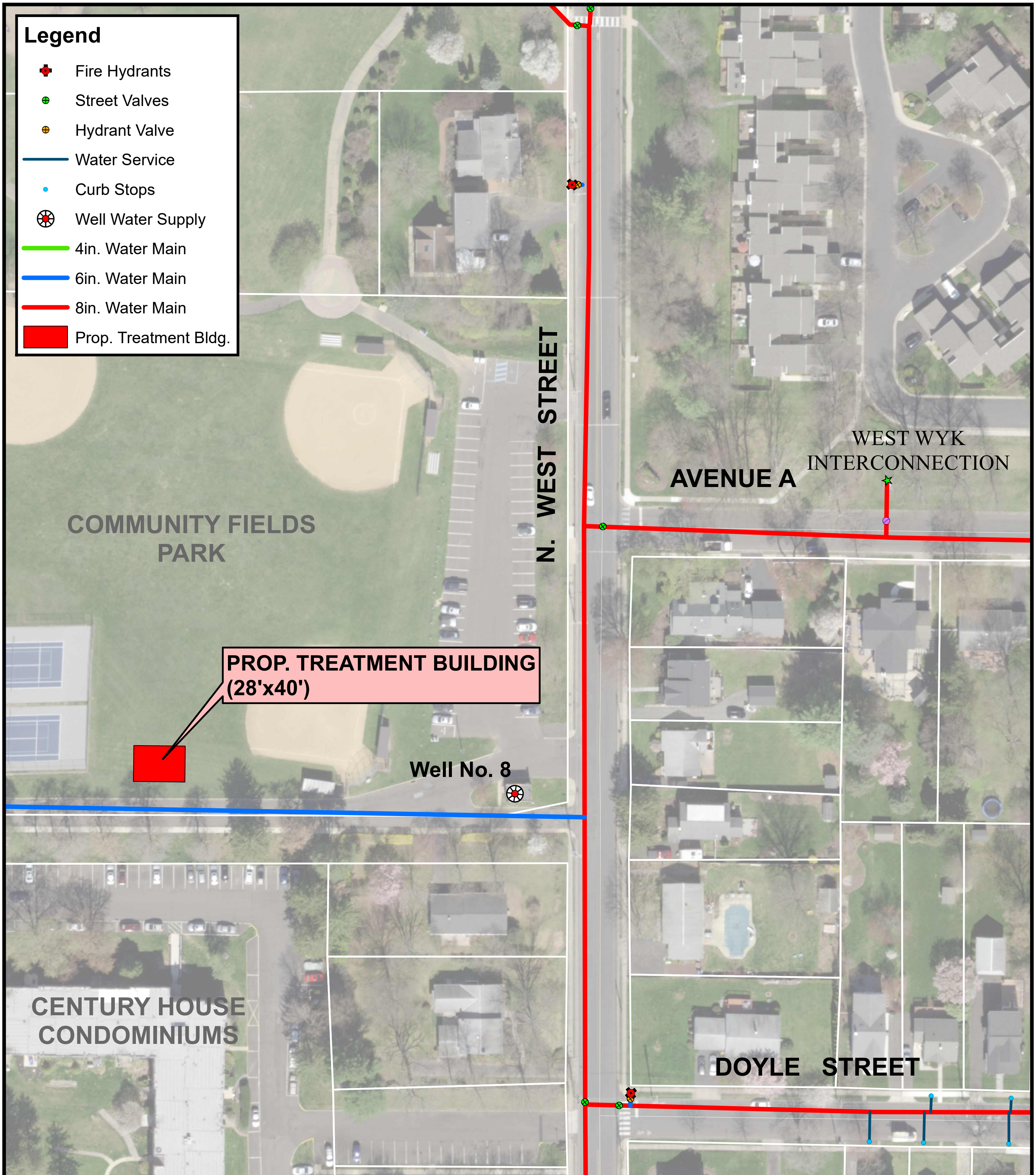
LOCATION/SITE SCHEMATICS



WELL No. 7
PFAS TREATMENT ALTERNATIVES ANALYSIS
DOYLESTOWN BOROUGH, BUCKS COUNTY, PA

100 50 0 100 200 Feet
1 inch = 100 feet

REF# 1100-91



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DOYLESTOWN BOROUGH, BUCKS COUNTY, PA

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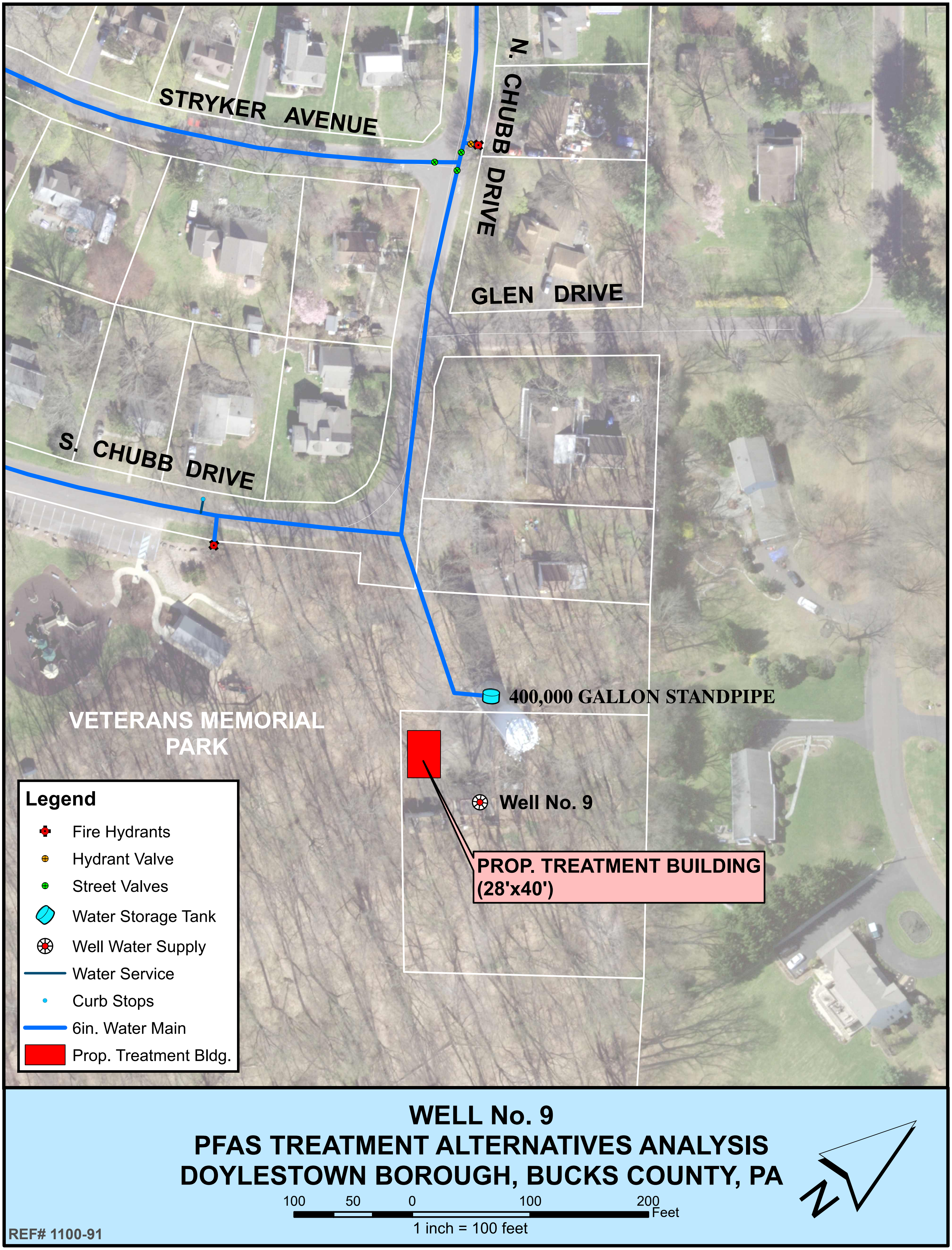

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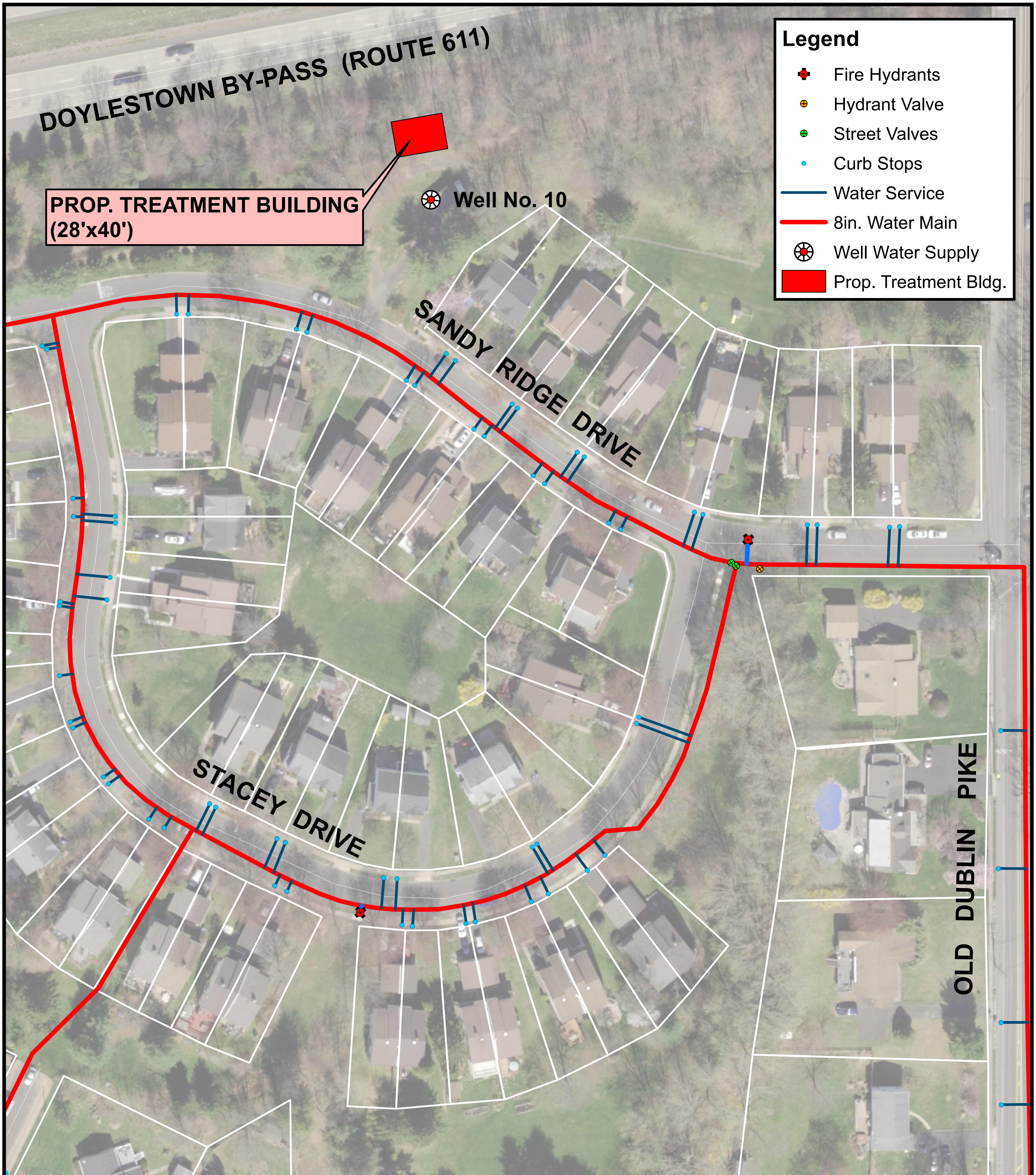

WELL No. 10
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DOYLESTOWN BOROUGH, BUCKS COUNTY, PA

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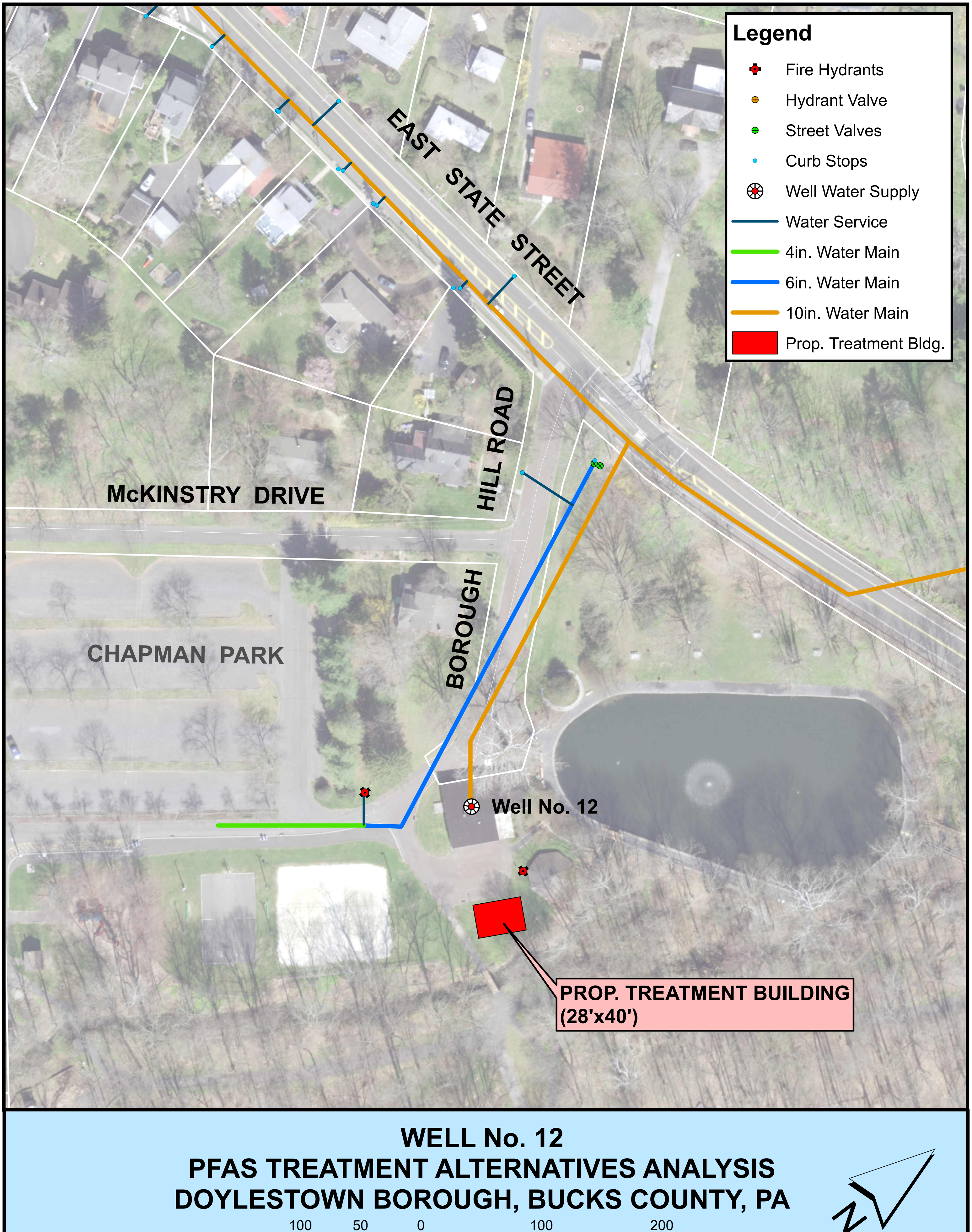
1 inch = 100 feet

REF# 1100-91

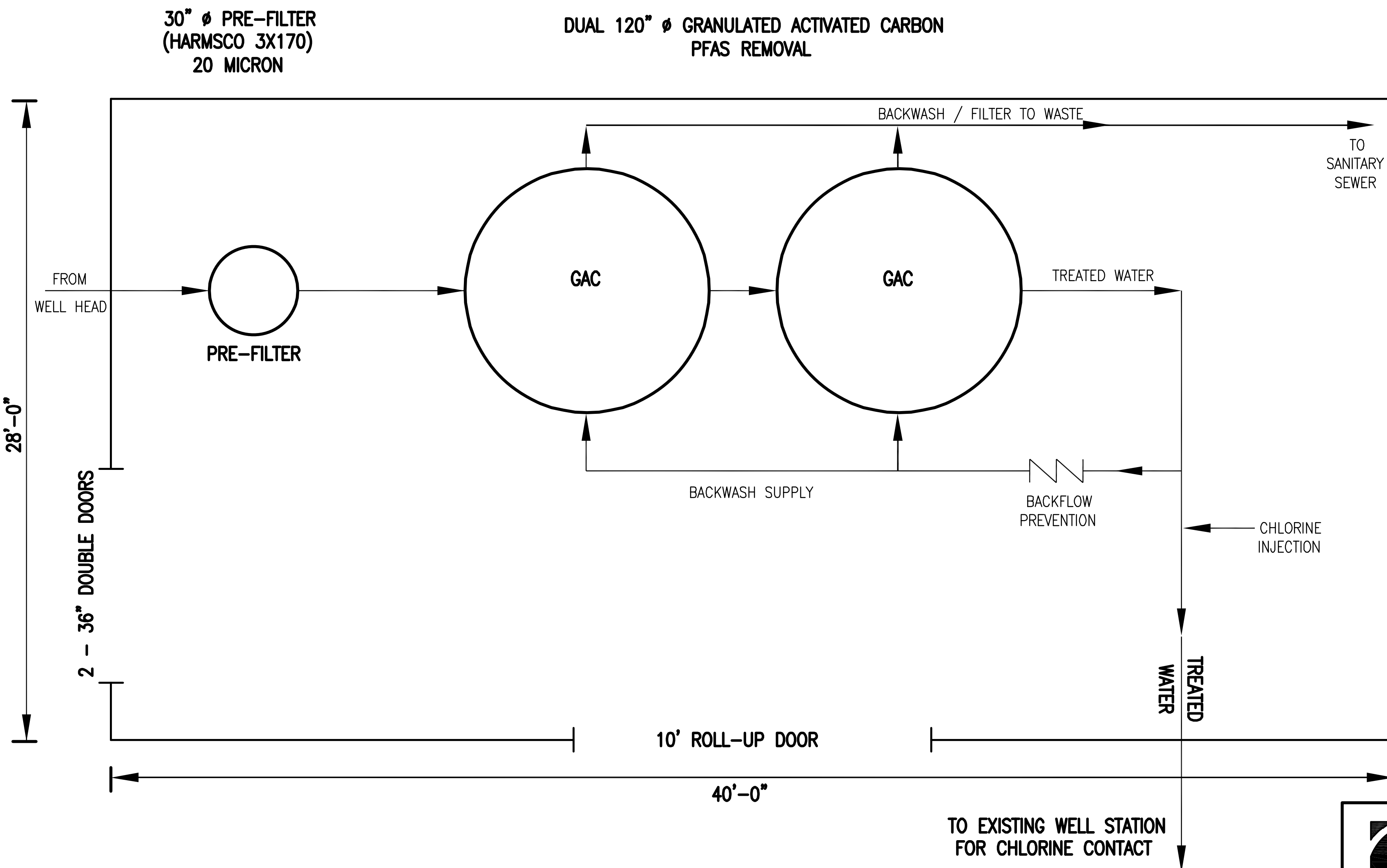


WELL No. 12
PFAS TREATMENT ALTERNATIVES ANALYSIS
DOYLESTOWN BOROUGH, BUCKS COUNTY, PA

REF# 1100-91

TREATMENT PROCESS SCHEMATICS

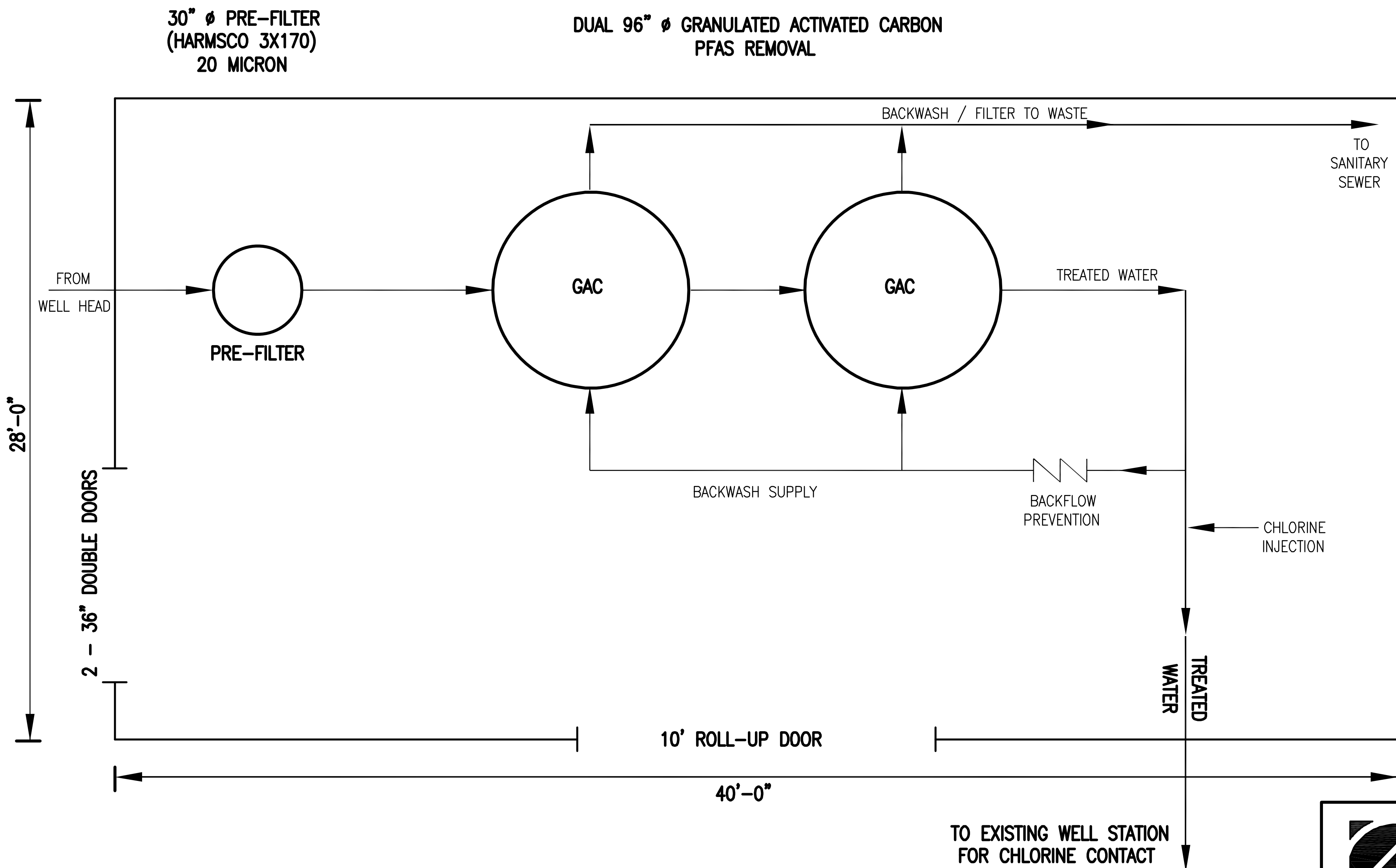
GAC TREATMENT



DOYLESTOWN BOROUGH, BUCKS COUNTY, PA
WELL NOS. 7, 9 & 10
PROCESS FLOW SCHEMATIC

12/7/2022
REF. NO. 1100-91

CKS
ENGINEERS
AN ARRO CONSULTING COMPANY
4259 W. Swamp Road
Suite 410
Doylestown, PA 18902
www.cksengineers.com
215.340.0600



DOYLESTOWN BOROUGH, BUCKS COUNTY, PA
WELL NOS. 8 & 12
PROCESS FLOW SCHEMATIC

12/7/2022
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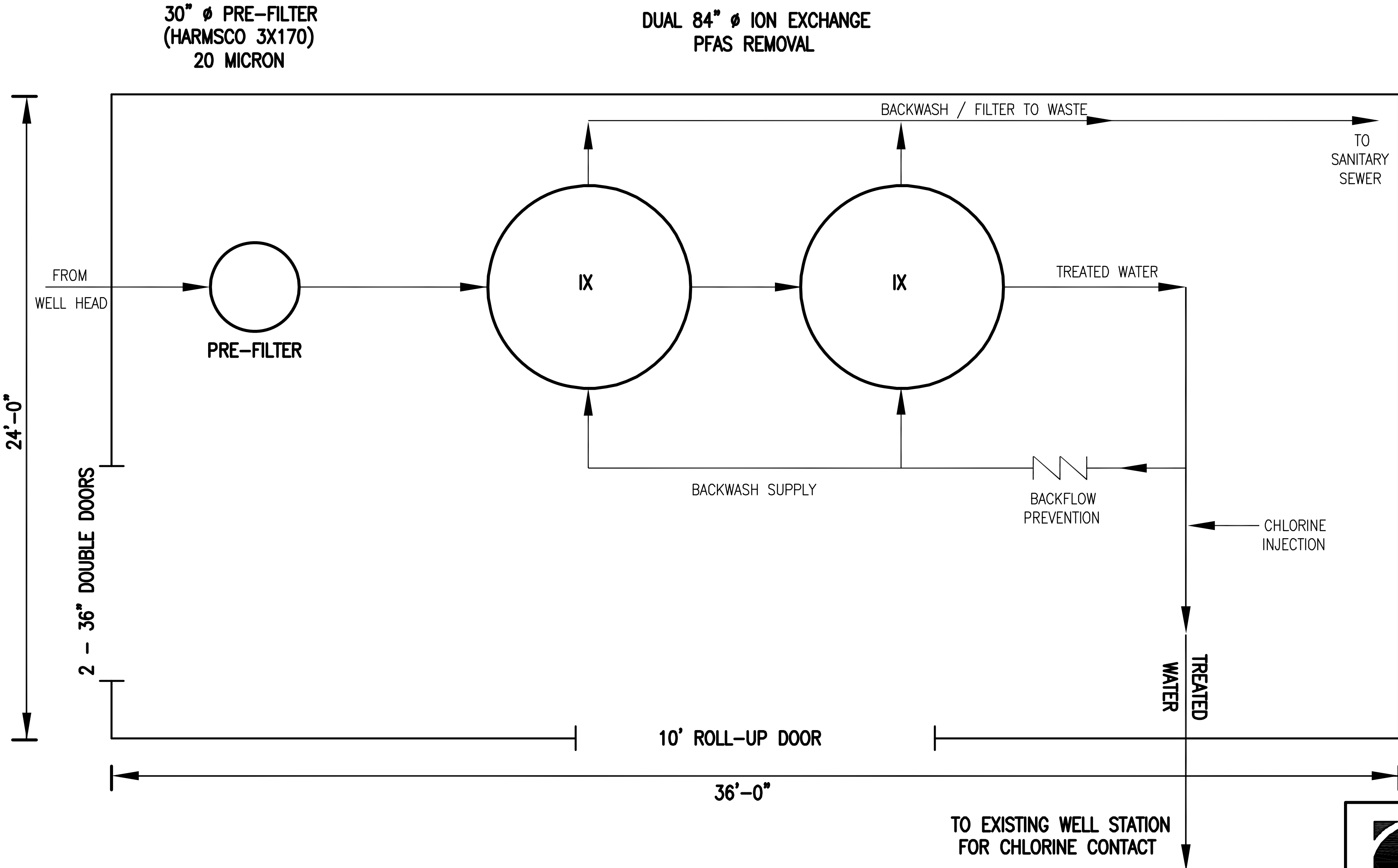
TREATMENT PROCESS SCHEMATICS

IX TREATMENT



DOYLESTOWN BOROUGH, BUCKS COUNTY, PA
WELL NOS. 7, 9 & 10
PROCESS FLOW SCHEMATIC

12/7/2022
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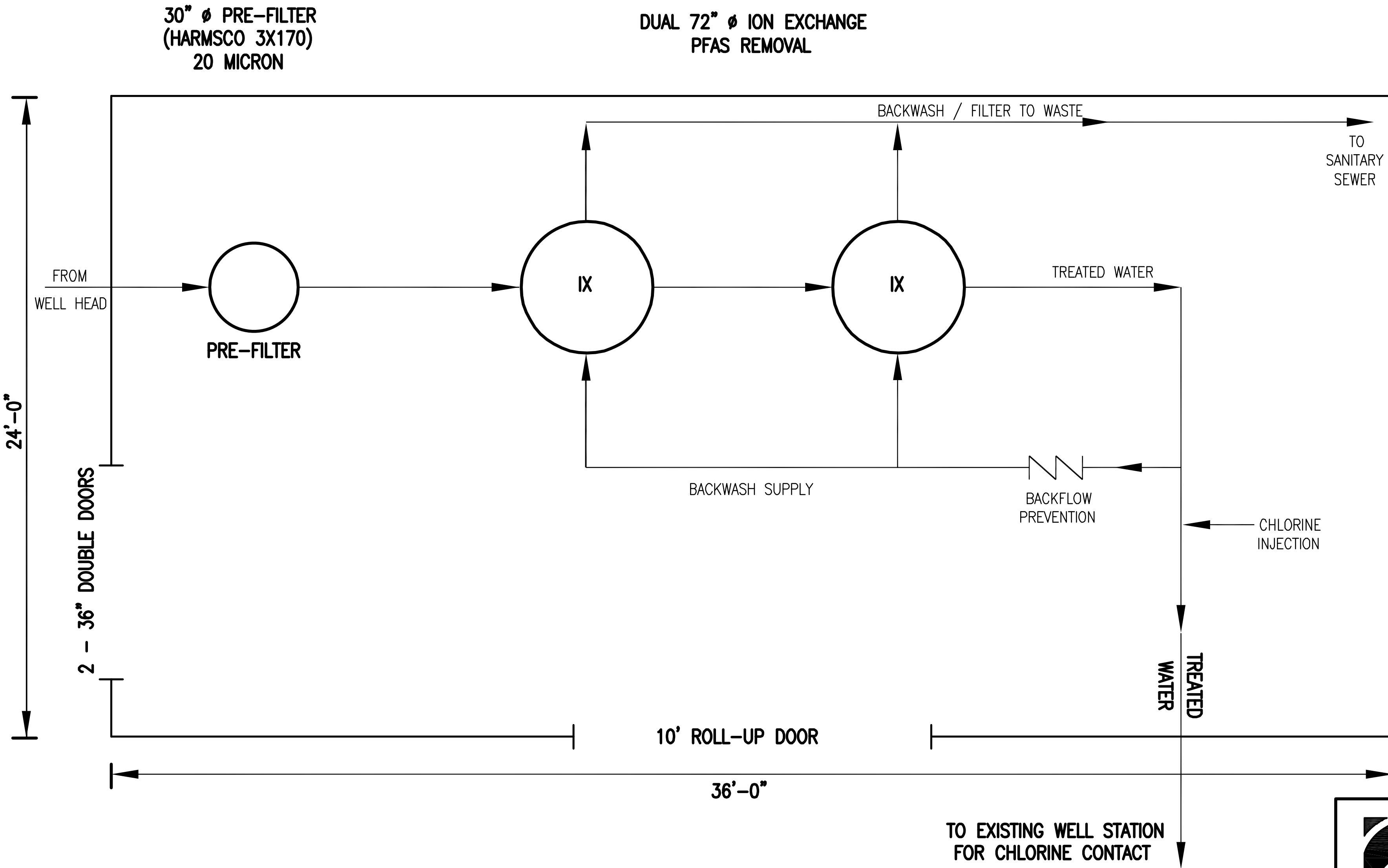

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WELL NO. 8

PROCESS FLOW SCHEMATIC

12/7/2022

REF. NO. 1100-91

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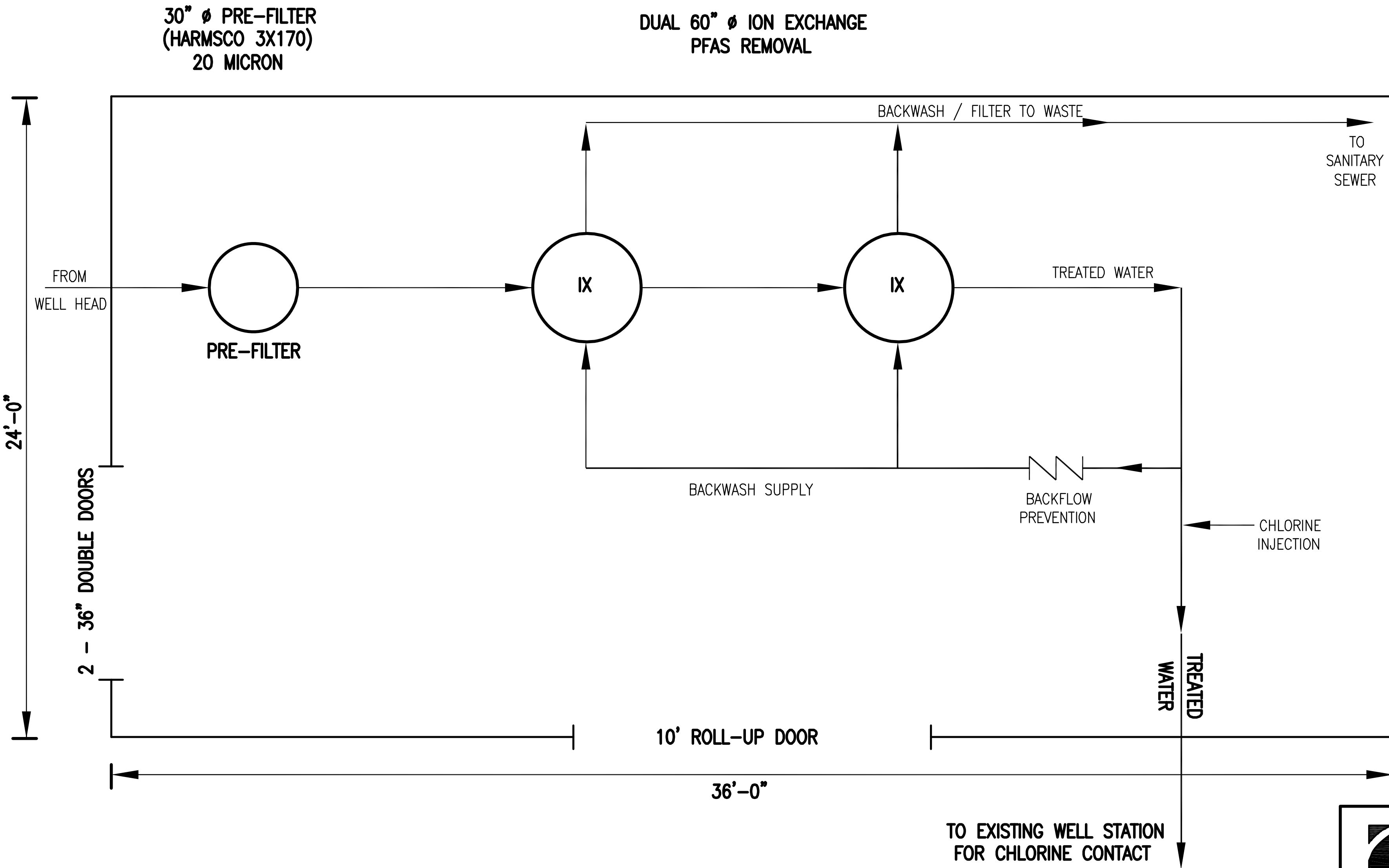

DOYLESTOWN BOROUGH, BUCKS COUNTY, PA
WELL NO. 12
PROCESS FLOW SCHEMATIC

12/7/2022
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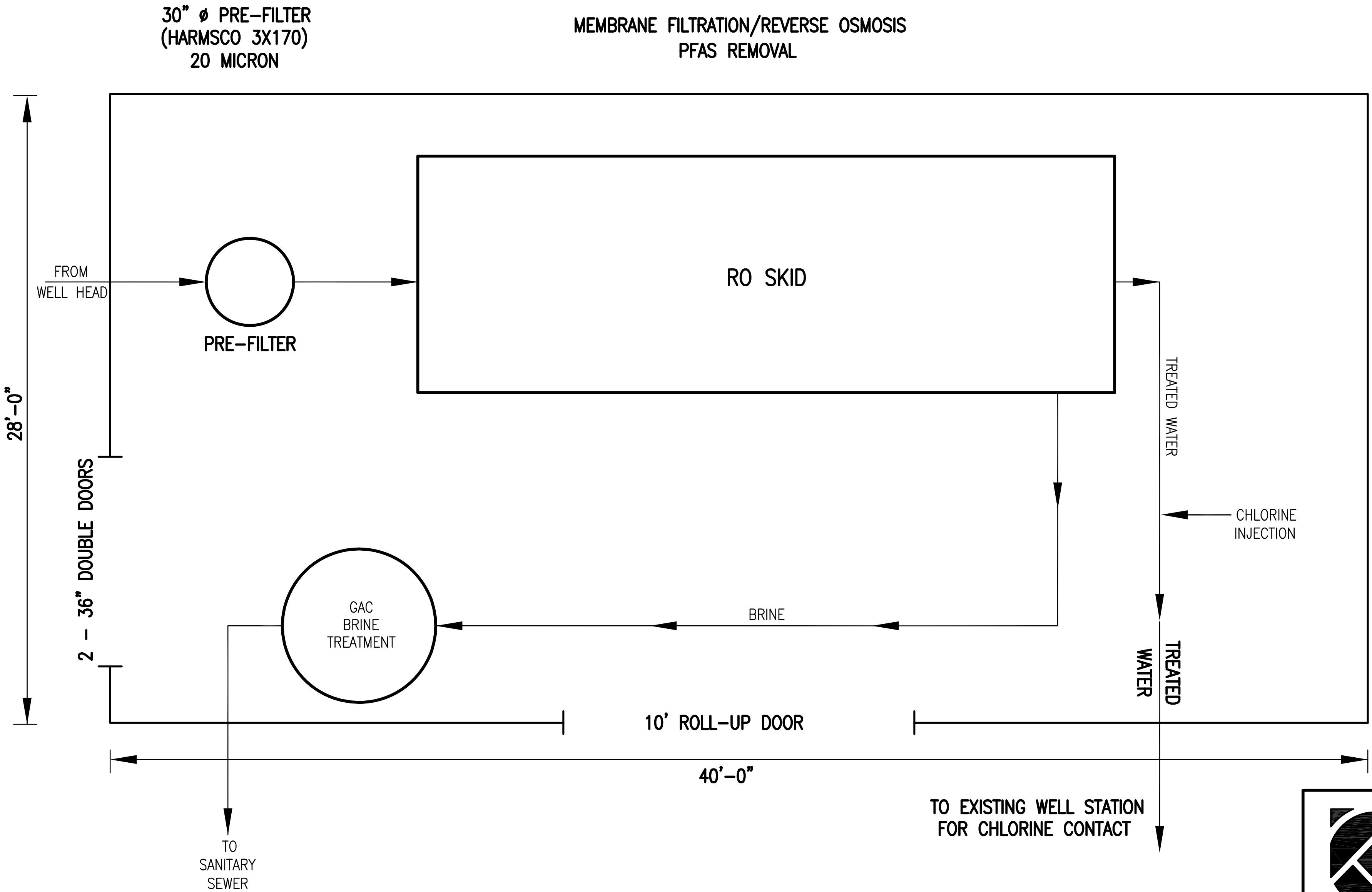
TREATMENT PROCESS SCHEMATICS

RO TREATMENT



DOYLESTOWN BOROUGH, BUCKS COUNTY, PA
WELL NOS. 7, 8, 9, 10 & 12
PROCESS FLOW SCHEMATIC

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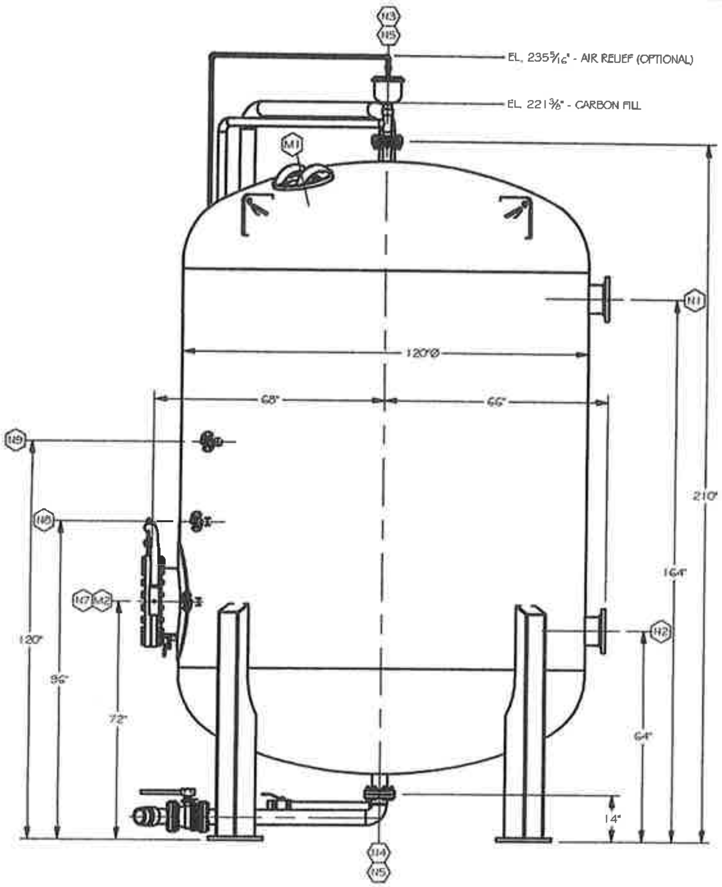
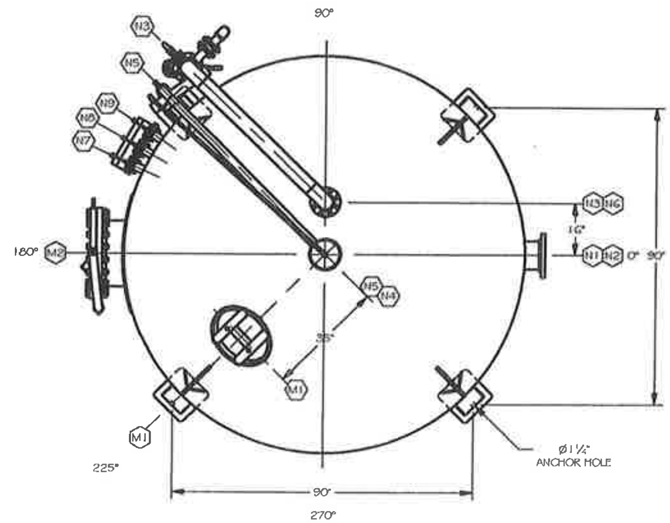
MANUFACTURER'S INFORMATION

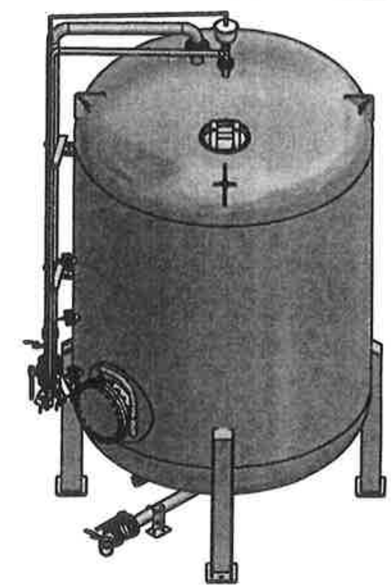
GAC TREATMENT



ELEVATION



PLAN



N9	SAMLE	2" 150# FLANGE	SIDE SHELL
N8	SAMLE	2" 150# FLANGE	SIDE SHELL
N7	SAMLE	2" 150# FLANGE	SIDE SHELL
N6	DRAIN	2" 150# FLANGE	BOTTOM HEAD
N5	VENT	2" 150# FLANGE	TOP HEAD
N4	CARBON OUT	4" 150# FLANGE	BOTTOM HEAD
N3	CARBON IN	4" 150# FLANGE	TOP HEAD
N2	OUTLET	8" 150# FLANGE	SIDE SHELL
N1	INLET	8" 150# FLANGE	SIDE SHELL
M2	MANWAY	20" 150# FLANGE W/ BLIND	SIDE SHELL
M1	MANWAY	14"x18" ELL. MANWAY	TOP HEAD
MARK	SERVICE	DESCRIPTION	LOCATION

NOZZLE SCHEDULE

REVISION HISTORY

REV	DESCRIPTION	BY	DATE
5	UPDATE VESSEL TO CODE EDITION 2017	JB	11/19/2016
4	UPDATE VESSEL STANDARDS	JAK	2/10/2016

VESSEL STANDARDS:

VESSEL MATERIAL: SA-516-70

- HEAD THICKNESS: 1/2" HEAD TYPE: 2:1 ELLIPTICAL
- SHELL THICKNESS: 1/2"

COATINGS:

- INTERIOR LINING: PLASITE 4110 – DFT 35-45(MAX)
- EXTERIOR COAT: EPOXY BASE W/ URETHANE TOP

INTERNALS:

- 304 STAINLESS STEEL

VESSEL PROPERTIES:

- MAWP: 125 PSIG / -15 PSIG AT 150 f
- EMPTY SHIP WEIGHT: 13,110 LBS
- TOTAL VESSEL VOLUME: 1055 FT³
- MAXIMUM MEDIA FILL: N/A FT³

PROJECT

CP-20K-10

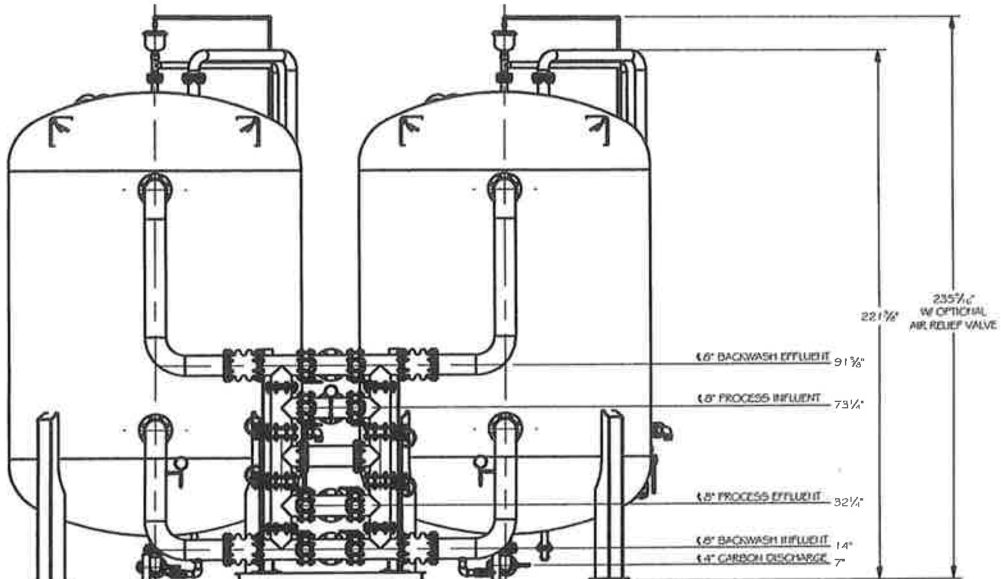
TIGG LLC.

PROJ. NO.	SALES
P.O. NO.	

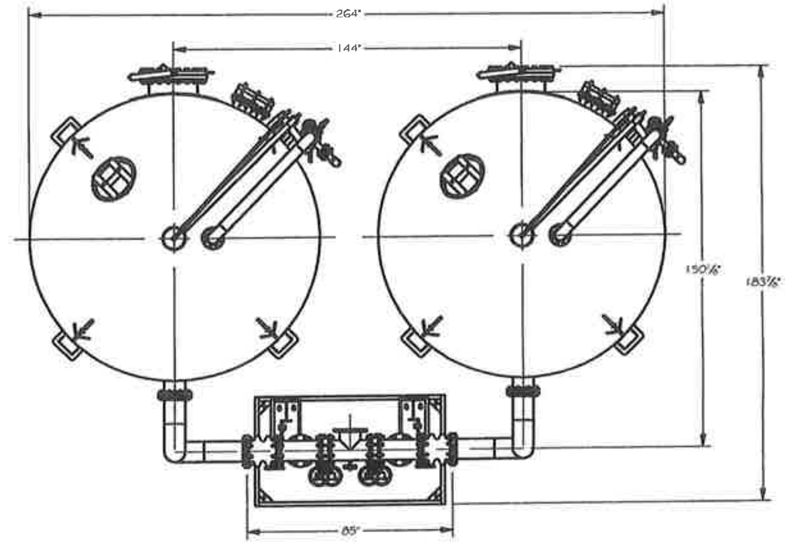
DRAWN BY	JB
DESIGN BY	JB
CHECKED BY	BB
DATE	2/28/2011
SCALE	NTS

PLAN & ELEVATION

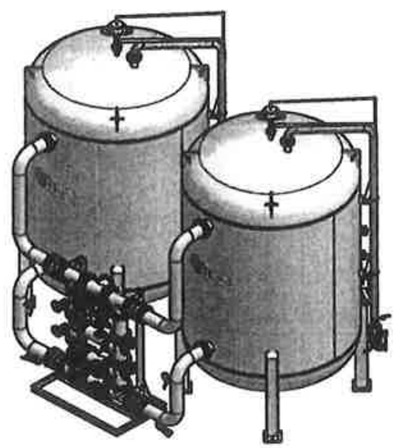
CP-20K-10-GA-001 | 5



ELEVATION



PLAN



SHEET 1 OF 2

REVISION HISTORY			
REV	DESCRIPTION	BY	DATE
4	UPDATE VESSEL TO CODE EDITION 2017	JB	11/21/2018
3	ADD 2" MANUAL VENT & EFFLUENT DRAIN	JB	3/21/14
2	ADD EXPANSION JOINTS	JB	1/10/13

SYSTEM SPECIFICATIONS:

- MAXIMUM SERIES FLOW: 1000 GPM
- MAXIMUM PRESSURE: 125 PSIG
- MAXIMUM TEMPERATURE: 150°F
- EMPTY VESSEL WEIGHT: 14,000 LBS
- VESSEL OPERATING WEIGHT: 79,000 LBS
- PIPE RACK OPERATING WEIGHT: 12,000 LBS
- SYSTEM OPERATING WEIGHT: 170,000 LBS

FOR VESSEL INFORMATION SEE DRAWING # CP-20K-10-GA-001
FOR P&ID SEE DRAWING # CP-20K-10-PL-001

RELEASED FOR FABRICATION

PROJECT
CP-20K-10
(SYSTEM)

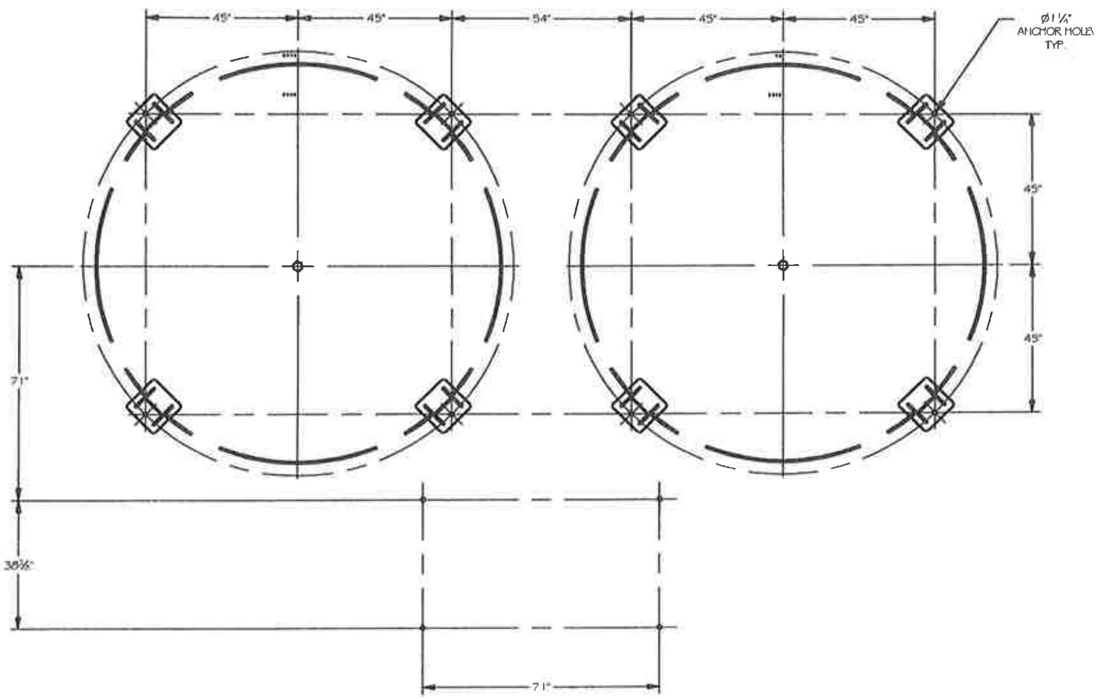
TIGG LLC.

PROJ. NO.	SALES
P.O. NO.	

DRAWN BY	JB
DESIGN BY	JB
CHECKED BY	BB
DATE	2/8/2010
SCALE	NTS

SYSTEM GENERAL ARRANGEMENT

CP-20K-10-GA-002 | 4



SHEET 2 OF 2

REVISION HISTORY			
REV	DESCRIPTION	BY	DATE
4	UPDATE VESSEL TO CODE EDITION 2017	JB	11/21/2018
3	ADD 2" MANUAL VENT & EFFLUENT DRAIN	JB	3/21/14
2	ADD EXPANSION JOINTS	JB	1/10/13

PROJECT

CP-20K-10
(SYSTEM)

PROJ. NO. SALES
P.O. NO.

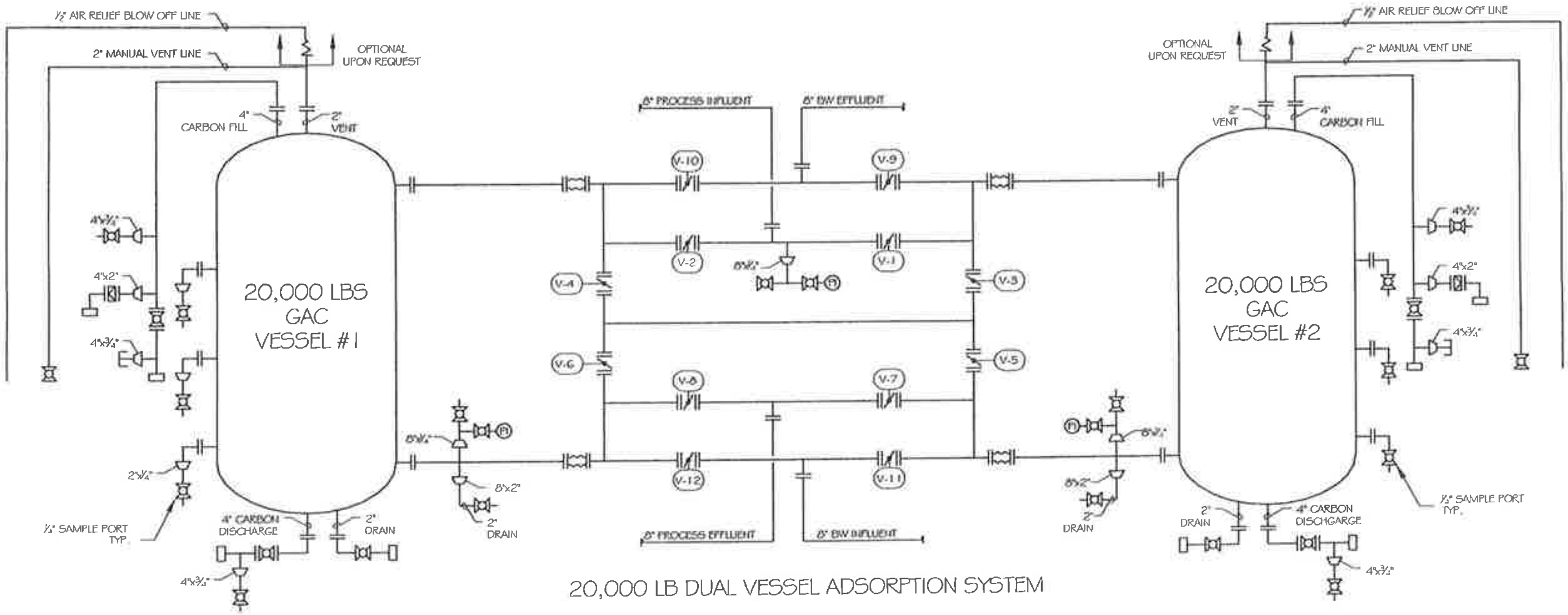
DRAWN BY	JB
DESIGN BY	JB
CHECKED BY	BB
DATE	2/9/2010
SCALE	NTS

TIGG LLC.

SYSTEM GENERAL ARRANGEMENT

CP-20K-10-GA-002 | 4

RELEASED FOR FABRICATION



20,000 LB DUAL VESSEL ADSORPTION SYSTEM

LEGEND

- EXPANSION JOINT
- REDUCER
- RUPTURE DISK
- BALL VALVE
- AIR RELIEF VALVE
- QUICK CONNECT CAM LOCK FITTING
- MANUALLY OPERATED BUTTERFLY VALVE
- PRESSURE GUAGE

REVISION HISTORY			
REV	DESCRIPTION	BY	DATE
8	INVENTOR INTEGRATION	JAK	10/26/18
7	ADD OPTIONAL AIR RELIEF	JD	03/07/2017
6	UPDATE AIR RELIEF DETAIL	ZM	9/30/14

PROJECT
CP-20K-10 (SYSTEM)

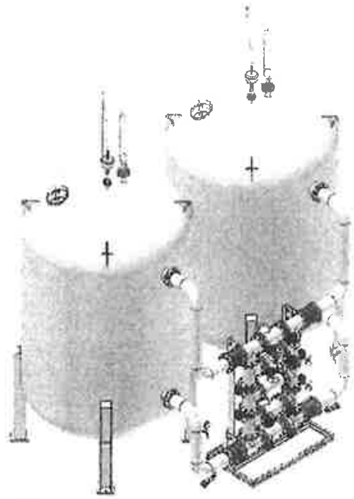
PROJ. NO.	SALES
PO. NO.	

DRAWN BY	JB
DESIGN BY	JB
CHECKED BY	JI
DATE	1/12/2012
SCALE	NTS

TIGG LLC.

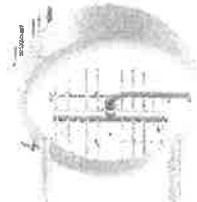
SYSTEM P&ID

CP-20K-10-PL-001 | 8



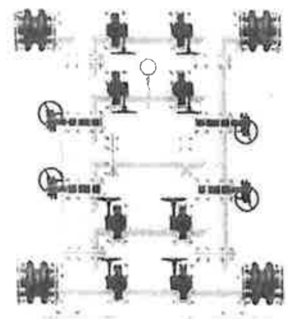
System Layout

Inlet Distributor



Header Lateral

Internals



Pipe Rack

CP20K-10 System Scope Of Supply

Vessel (x2)

Rating:
- ASME code stamped 125PSI

Top Head
- 14x18 elliptical manway
- 4" carbon in
- 2" vent
- 4 lifting lugs

Middle shell:
- 8" inlet/outlet located on the upper and lower side-shell respectively
- 2" sample ports (4 total)
- 4" carbon discharge
- 20" round manway with davit arm

Bottom Head:
- 4" carbon discharge
- 2" drain

Internals:
- 8" SCH10 SA312 304L stainless steel inlet distributor consisting of 2 upturned nozzles
- Header lateral underdrain consisting of 316 stainless steel wedge-wire laterals (20 total)

Paint/Lining:
- Internal lining Plasite 4110 (DFT 35-45 MILS) or Reactamine 760 (DFT 40-60 MILS)
- External paint Carboguard 891 (DFT 4-10 MILS) Carbothane 134HG (DFT 2-3 MILS)

Process/External

Process Pipe:
- 8" A53 SCH40 unlined carbon steel

Air Relief:
- ½" Air relief line A53 SCH40 with 2" Crispin Air relief valve

Vent Line:
- 2" A53 SCH40
- 2" Ball Valve 316SS

Carbon Fill Line:
- 4" SCH10 SA312 304L stainless steel
- 3" Rupture Disk Graphite 125PSI

Sample Ports:
- ¼" Ball Valves 316 stainless steel

Pipe Rack

Expansion Joints:
- 8" Molded expansion joint twin sphere neoprene rubber

Pressure gauge:
- 4" Face 100 PSI with ¼" liquid filled thermoplastic case

Cast Iron Tee's:
- 8" Unlined Cast Iron Tee 125#

Butterfly Valves:
- 8" Bray series 30 Cast Iron body, Nylon Coated Ductile Iron Disc, 416 Stainless Steel Stem, EPDM Seat

TIGG.
a newterra company

TIGG 5D 1240 NSF

Virgin Liquid Phase Coal Based Activated Carbon

DESCRIPTION

TIGG 5D 1240 is a granular activated carbon made from selected grades of bituminous coal. The range of pore sizes can accommodate organic molecules of varied size. The higher adsorption energy pores of this activated carbon permit the attainment of 100% removal of most organics from water and other liquids. This material meets AWWA B-600-96 and is NSF approved.

TYPICAL PROPERTIES	TIGG 5D 1240 NSF
U.S Sieve, 90 wt% min	12 x 40*
Iodine Number, mg/g, min	1000
Apparent Density, (dense packing)	
g/cc	0.43 - 0.48
lbs/ft^3	27 - 30
Moisture - wt% max (as packed)	3
Hardness No. - min	95
Abrasion No. min	80

** Size 0830 is also available*

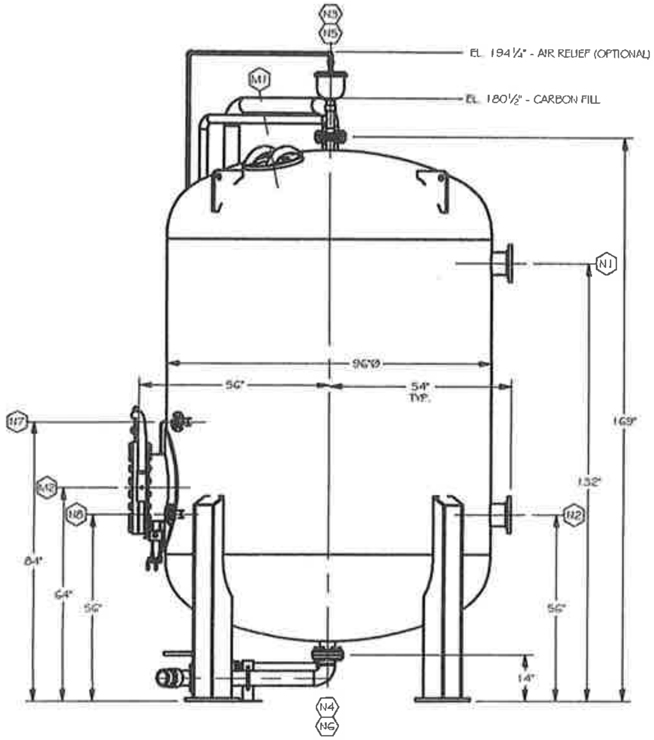
TYPICAL APPLICATIONS

This activated carbon can be used to remove :

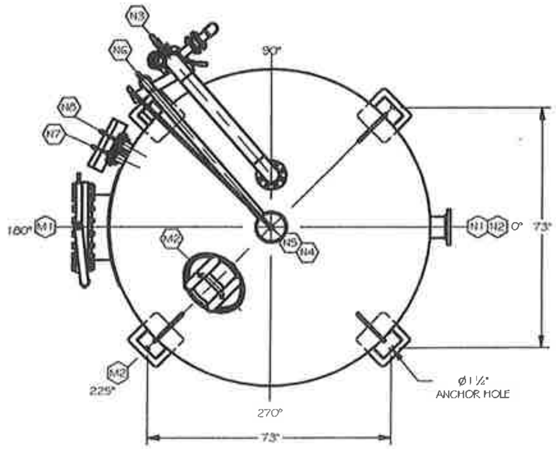
- BTEX and other organic compounds from ground water
- Organic compounds from wastewater
- Organic compounds from potable water
- Trace organics from process streams such as alcohols, glycerine, MEA, acids, etc.

Standard packaging of the activated carbon is in 55 pound bags or 1100 pound supersaks.

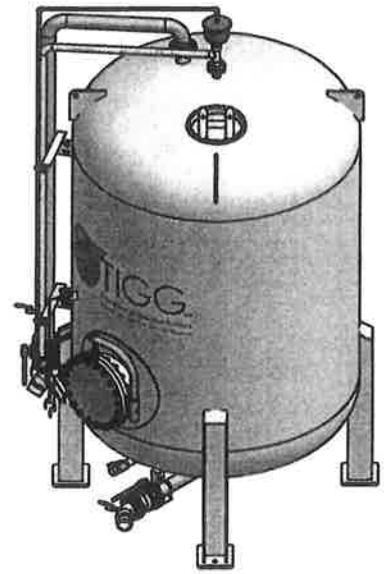
Wet drained activated carbon adsorbs oxygen from the air. Therefore, when workers need to enter a vessel containing wet activated carbon, they should follow confined space/low oxygen level procedures. Activated carbon dust does not present an explosion hazard.



ELEVATION



PLAN



N8	SAMPLE - LO	2" 150# FLANGE	SIDE SHELL
N7	SAMPLE - HI	2" 150# FLANGE	SIDE SHELL
N6	DRAIN	2" 150# FLANGE	BOTTOM HEAD
N5	VENT	2" 150# FLANGE	TOP HEAD
N4	CARBON OUT	4" 150# FLANGE	BOTTOM HEAD
N3	CARBON IN	4" 150# FLANGE	TOP HEAD
N2	OUTLET	6" 150# FLANGE	SIDE SHELL
N1	INLET	6" 150# FLANGE	SIDE SHELL
M2	MANWAY	20" 150# FLANGE W/ BLIND	SIDE SHELL
M1	MANWAY	14"x18" ELL. MANWAY	TOP HEAD
MARK	SERVICE	DESCRIPTION	LOCATION

NOZZLE SCHEDULE

REVISION HISTORY

REV	DESCRIPTION	BY	DATE
1	UPDATE VESSEL TO CODE EDITION 2017	JB	11/5/2018

VESSEL STANDARDS:

VESSEL MATERIAL: SA-516-70
- HEAD THICKNESS: 3/8" HEAD TYPE: 2:1 ELLIPTICAL
- SHELL THICKNESS: 3/8"

COATINGS:
- INTERIOR LINING: PLASITE 4110 – DFT 35-45(MAX)
- EXTERIOR COAT: EPOXY BASE W/ URETHANE TOP

INTERNALS:
- 304 STAINLESS STEEL

VESSEL PROPERTIES:
- MAWP: 125 PSIG / -15 PSIG AT 150 F
- EMPTY SHIP WEIGHT: 8000 LBS
- TOTAL VESSEL VOLUME: 537 FT³
- MAXIMUM MEDIA FILL: N/A FT³

PROJECT

CP-10K-8

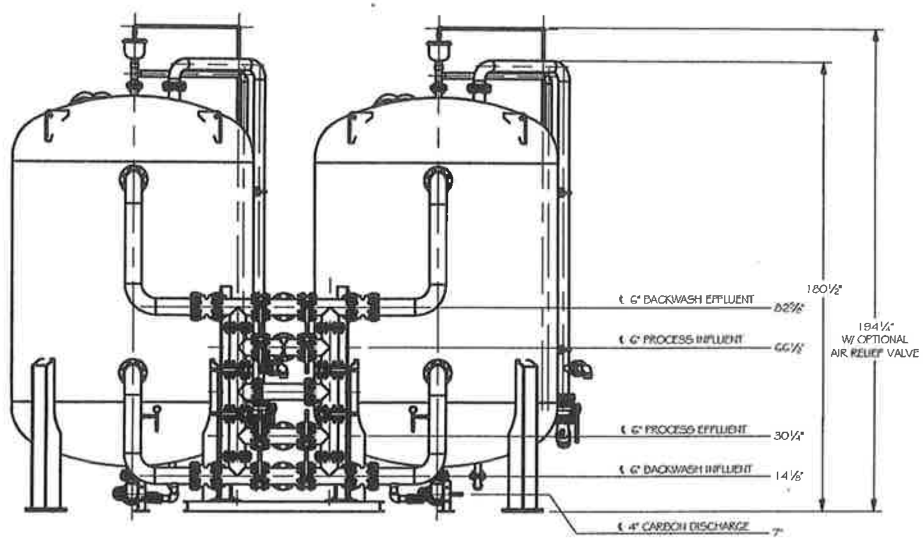
PROJ. NO.	STANDARD
PO. NO.	

DRAWN BY	JB
DESIGN BY	JB
CHECKED BY	JB
DATE	12/2/2016
SCALE	NTS

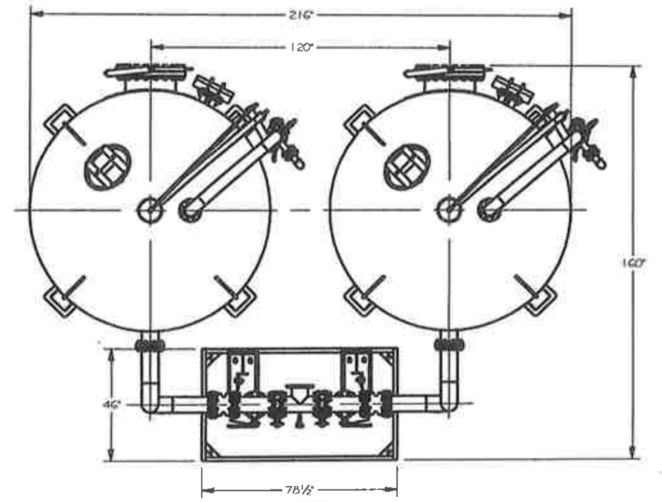
TIGG LLC.

GENERAL ARRANGEMENT

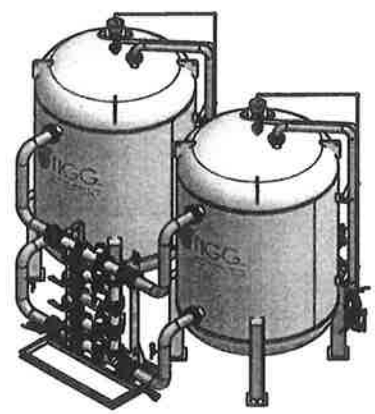
CP-10K-8-GA-001 | 1



ELEVATION



PLAN



SYSTEM SPECIFICATIONS:

- MAXIMUM SERIES FLOW: 500 GPM
- MAXIMUM PRESSURE: 125 PSIG
- MAXIMUM TEMPERATURE: 150°F
- EMPTY VESSEL WEIGHT: 8,000 LBS
- VESSEL OPERATING WEIGHT: 50,000 LBS
- PIPE RACK OPERATING WEIGHT: 6,000 LBS
- SYSTEM OPERATING WEIGHT: 112,000 LBS

FOR VESSEL INFORMATION SEE DRAWING # CP-10K-8-GA-001
FOR P&ID SEE DRAWING # CP-10K-8-PL-001

SHEET 1 OF 2

REVISION HISTORY

REV	DESCRIPTION	BY	DATE
2	UPDATE VESSEL TO CODE EDITION 2017	JB	11/5/2018
1	REVISE VESSEL CENTERLINE SPACING	JB	03/07/2017

PROJECT
CP-10K-8
(SYSTEM)

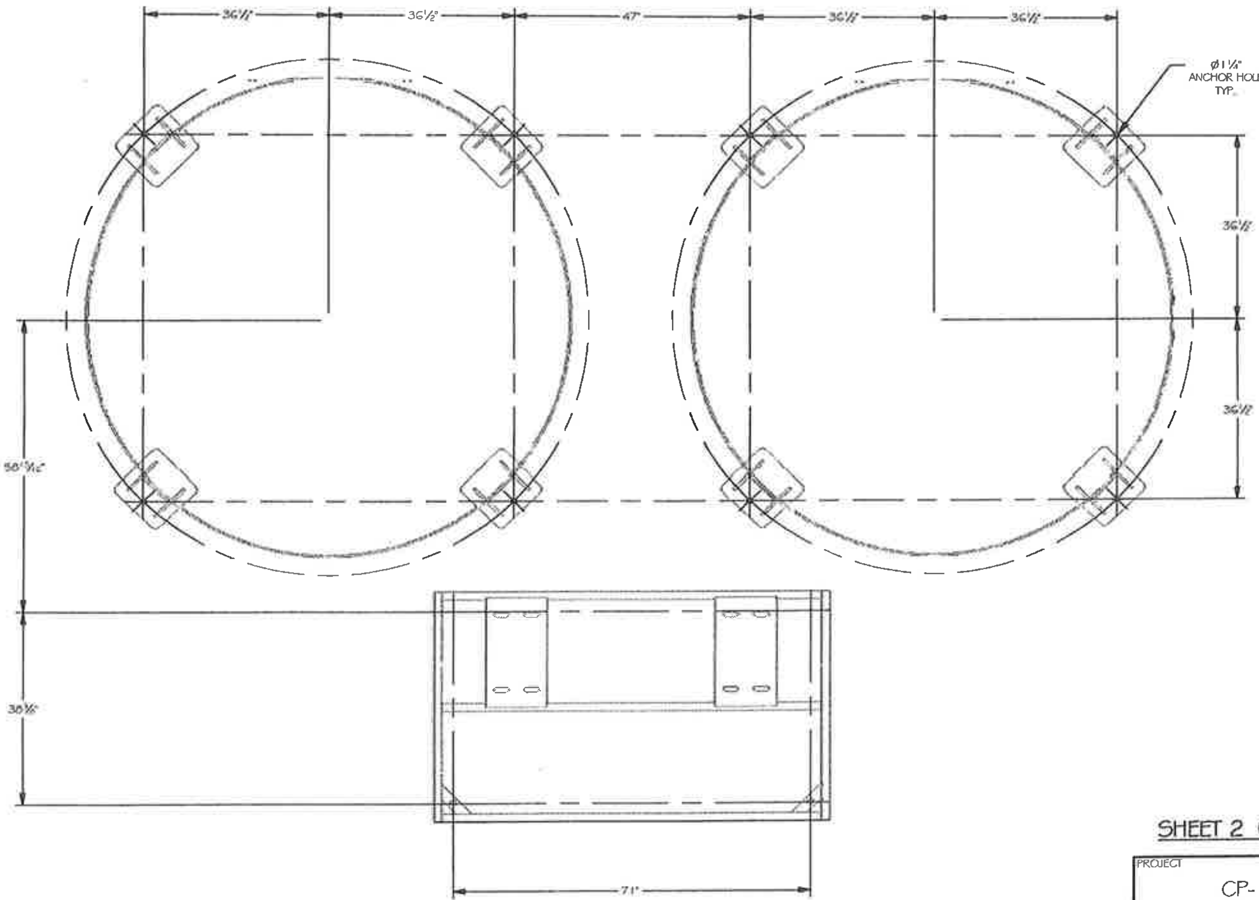
PROJ. NO.	SALES
P.O. NO.	

DRAWN BY	JAK
DESIGN BY	JB
CHECKED BY	JB
DATE	1/22/2014
SCALE	NTS

TIGG LLC.

SYSTEM GENERAL ARRANGEMENT

CP-10K-8-GA-002 | 2



SHEET 2 OF 2

REVISION HISTORY			
REV	DESCRIPTION	BY	DATE
2	UPDATE VESSEL TO CODE EDITION 2017	JB	11/5/2018
1	REVISE VESSEL CENTERLINE SPACING	JB	03/07/2017

PROJECT

CP-10K-8
(SYSTEM)

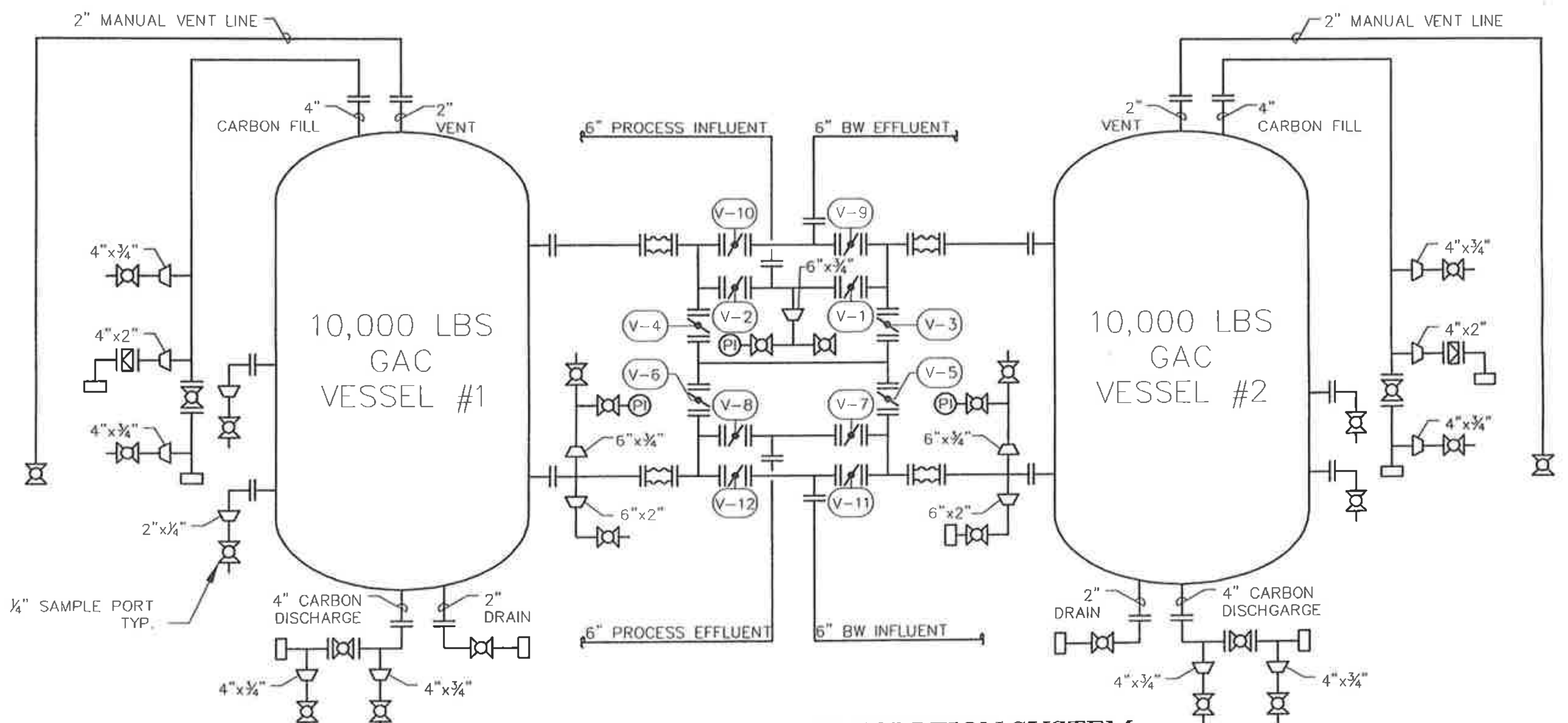
TIGG LLC.

SYSTEM GENERAL ARRANGEMENT

PROJ. NO.	SALES
PO. NO.	

DRAWN BY	JAK
DESIGN BY	JB
CHECKED BY	JB
DATE	1/22/2014
SCALE	NTS

CP-10K-8-GA-002 | 2



10,000 LB DUAL VESSEL ADSORPTION SYSTEM

LEGEND

- EXPANSION JOINT
- REDUCER
- RUPTURE DISK
- BALL VALVE
- QUICK CONNECT CAM LOCK FITTING
- MANUALLY OPERATED BUTTERFLY VALVE
- (PI) — PRESSURE GUAGE

NO.	REVISION	BY	DATE
4			
3			
2			
1			

PROJECT: CP-10K-8

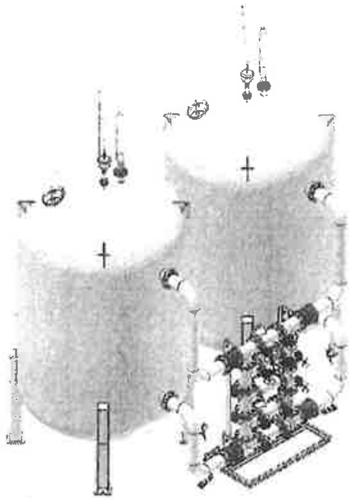
TIGG LLC.

PROJ. NO.	SALES
P.O. NO.	

DRAWN BY	JAK
DESIGN BY	JB
CHKD. BY	JB
DATE	11/15/13
SCALE	NTS

P&ID

CP-10K-8-1002 REV. 0

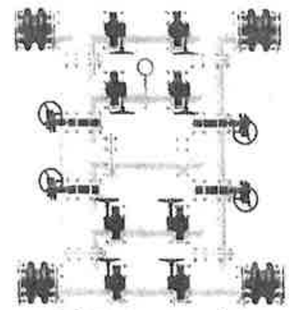


System Layout

Inlet Distributor

Header Lateral

Internals



Pipe Rack

CP10K-8 System Scope Of Supply

Vessel (x2)

Rating:
- ASME code stamped 125PSI

Top Head
- 14x18 elliptical manway
- 4" carbon in
- 2" vent
- 4 lifting lugs

Middle shell:
- 6" inlet/outlet located on the upper and lower side-shell respectively
- 2" sample ports (4 total)
- 4" carbon discharge
- 20" round manway with davit arm

Bottom Head:
- 4" carbon discharge
- 2" drain

Internals:
- 6" SCH10 SA312 304L stainless steel inlet distributor consisting of 2 upturned nozzles
- Header lateral underdrain consisting of 316 stainless steel wedge-wire laterals

Paint/Lining:
- Internal lining Plasite 4110 (DFT 35-45 MILS) or Reactamine 760 (DFT 40-60 MILS)
- External paint Carboguard 891 (DFT 4-10 MILS) Carbothane 134HG (DFT 2-3 MILS)

Process/External

Process Pipe:
- 6" A53 SCH40 unlined carbon steel

Air Relief:
- ½" Air relief line A53 SCH40 with 2" Crispin Air relief valve

Vent Line:
- 2" A53 SCH40
- 2" Ball Valve 316SS

Carbon Fill Line:
- 4" SCH10 SA312 304L stainless steel
- 3" Rupture Disk Graphite 125PSI

Sample Ports:
- ¼" Ball Valves 316 stainless steel

Pipe Rack

Expansion Joints:
- 6" Molded expansion joint twin sphere neoprene rubber

Pressure gauge:
- 4" Face 100 PSI with ¼" liquid filled thermoplastic case

Cast Iron Tee's:
- 6" Unlined Cast Iron Tee 125#

Butterfly Valves:
- 6" Bray series 30 Cast Iron body, Nylon Coated Ductile Iron Disc, 416 Stainless Steel Stem, EPDM Seat

TIGG®
a newterra company

TIGG 5D 1240 NSF

Virgin Liquid Phase Coal Based Activated Carbon

DESCRIPTION

TIGG 5D 1240 is a granular activated carbon made from selected grades of bituminous coal. The range of pore sizes can accommodate organic molecules of varied size. The higher adsorption energy pores of this activated carbon permit the attainment of 100% removal of most organics from water and other liquids. This material meets AWWA B-600-96 and is NSF approved.

TYPICAL PROPERTIES	TIGG 5D 1240 NSF
U.S Sieve, 90 wt% min	12 x 40*
Iodine Number, mg/g, min	1000
Apparent Density, (dense packing)	
g/cc	0.43 - 0.48
lbs/ft^3	27 - 30
Moisture - wt% max (as packed)	3
Hardness No. - min	95
Abrasion No. min	80

** Size 0830 is also available*

TYPICAL APPLICATIONS

This activated carbon can be used to remove :

- BTEX and other organic compounds from ground water
- Organic compounds from wastewater
- Organic compounds from potable water
- Trace organics from process streams such as alcohols, glycerine, MEA, acids, etc.

Standard packaging of the activated carbon is in 55 pound bags or 1100 pound supersaks.

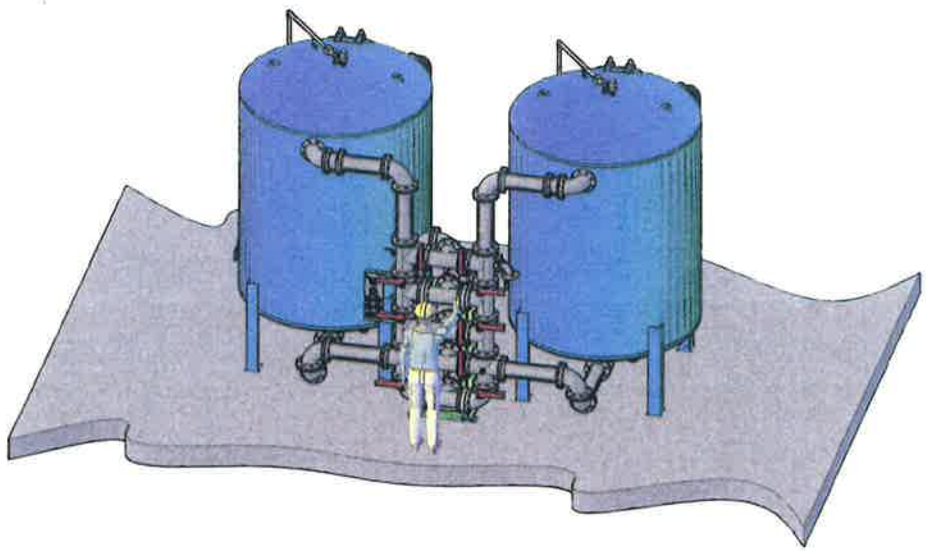
Wet drained activated carbon adsorbs oxygen from the air. Therefore, when workers need to enter a vessel containing wet activated carbon, they should follow confined space/low oxygen level procedures. Activated carbon dust does not present an explosion hazard.

MANUFACTURER'S INFORMATION

IX TREATMENT

MODGAC-PFX-8496CS-2-MVT-LL

ADEDGE TREATMENT SYSTEM



AdEdge
2055 Boggs Road
Duluth, GA 30096
P 678-835-0052 F 678-835-0057
www.adedgetechnologies.com

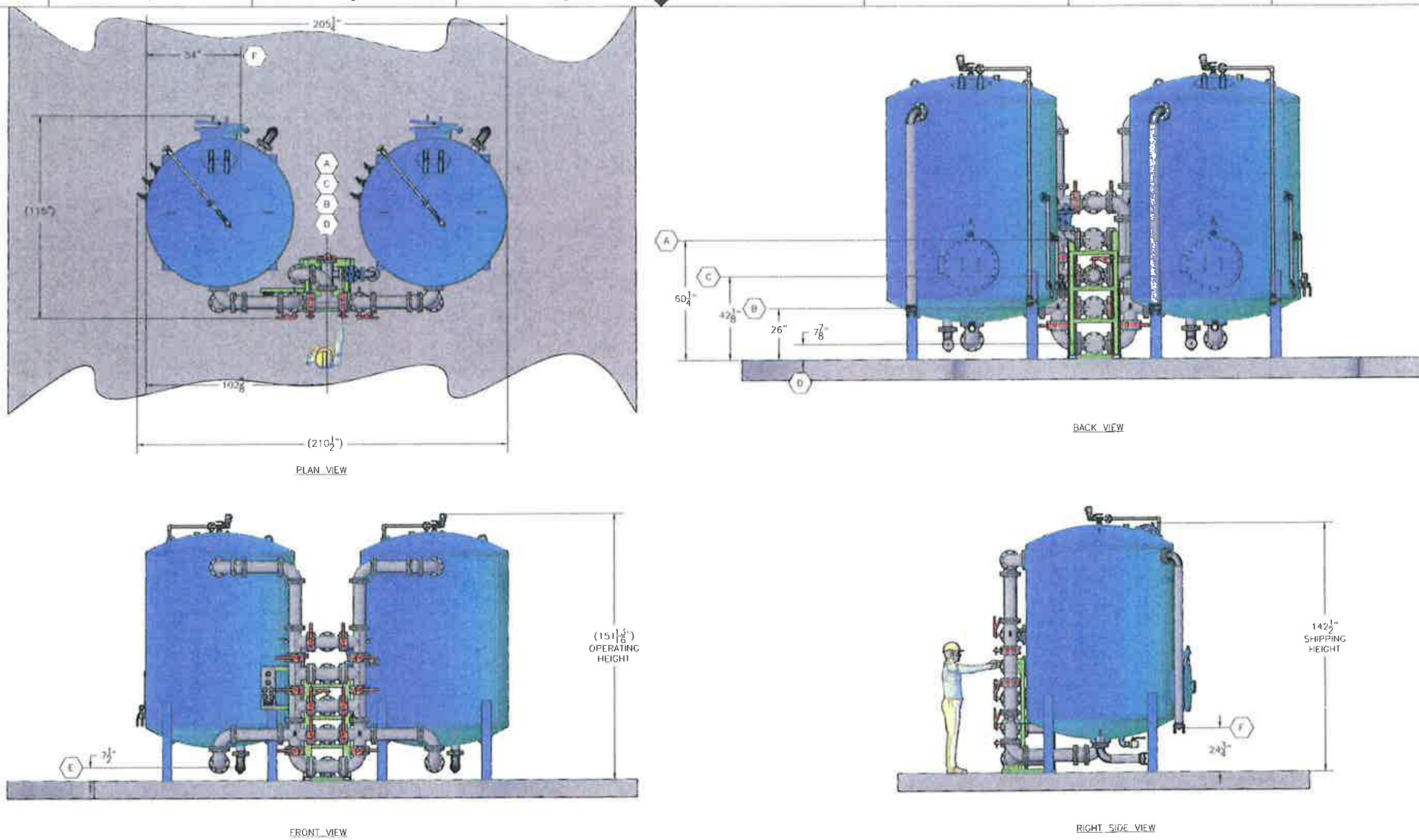
DRAWN BY	CHECKED BY	APPROVED BY	PROJECT #	DATE	SCALE
MC	CN	GC	TBD-0000	12/15/21	NTS

MODEL: ADEDGE MODULAR PFAS TREATMENT SYSTEM MODGAC-PFX-8496CS-2-MVT-LL

CUSTOMER: TBD

TITLE: COVER

SALES DRAWING



SALES DRAWING

AdEdge
2055 Boggs Road
Duluth, GA 30096
P. 678-835-0052 F. 678-835-0057
www.adedgetechnologies.com

#	SERVICE CONNECTIONS	TYPE/MATERIAL
A	SYSTEM RAW WATER INLET	6" 150# DI FLANGE
B	SYSTEM TREATED OUTLET	6" 150# DI FLANGE
C	SYSTEM BACKWASH OUTLET	6" BUTTERFLY VALVE
D	AUX. BACKWASH INLET	6" 150# DI FLANGE
E	SLUICING NOZZLE (DISCHARGE)	4" 316SS PLUG
F	SLUICING NOZZLE (FILL)	4" 316SS PLUG

REV. #	DATE	BY	APPROVED BY	REVISION DESCRIPTION
–	–	–	–	–

DRAWN BY	CHECKED BY	APPROVED BY	PROJECT #	DATE	SCALE
MC	CN	GG	TBD-0000	12/15/21	NTS

MODEL: ADEDGE MODULAR PFAS TREATMENT SYSTEM MODGAC-PFx-B496CS-2-MVT-LL

CUSTOMER: TBD

TITLE: SALES GENERAL ARRANGEMENT

DRAWING NUMBER: M-001

SHEET: 3 OF 4

DIMENSIONAL NOTES

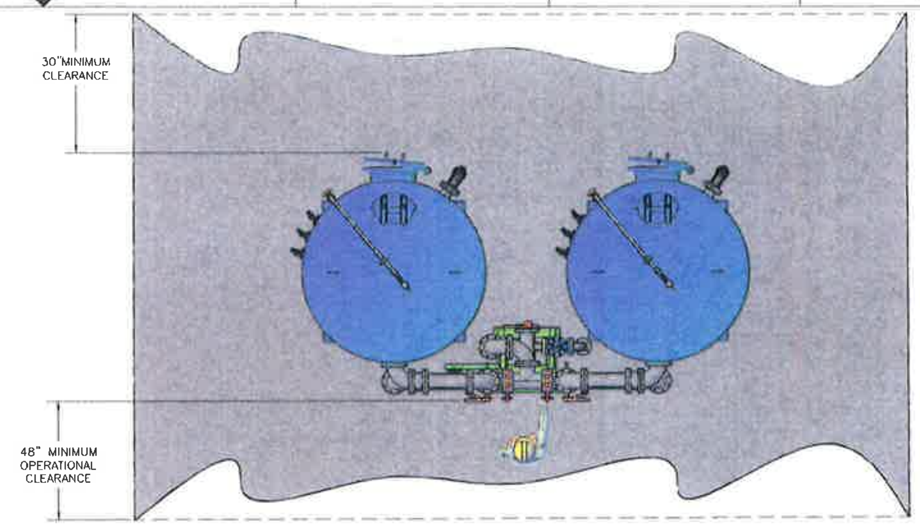
1. ALL DIMENSIONS ARE +/- 2"
2. DO NOT SCALE DRAWING. REFER TO ADEDGE ENGINEERING DEPT FOR ALL DIMENSIONS
3. (##) REFERENCE DIMENSION

GENERAL SYSTEM SPECIFICATIONS:

1. DUCTILE IRON INLET/OUTLET WITH FLANGED TIE POINTS
2. DUCTILE IRON VALVE TREE PIPING
3. LUG-STYLE BUTTERFLY VALVES WITH MANUEL OPERATOR ON VALVE TREE
4. LUG-STYLE BUTTERFLY VALVE WITH MANUAL OPERATOR FOR BACKWASH OUTLET
5. 304SS HYDRAULIC PANEL WITH DP GAUGE FOR EACH VESSEL
6. PRESSURE GAUGES AND SAMPLE VALVES ON EACH VESSEL'S INLET AND OUTLET

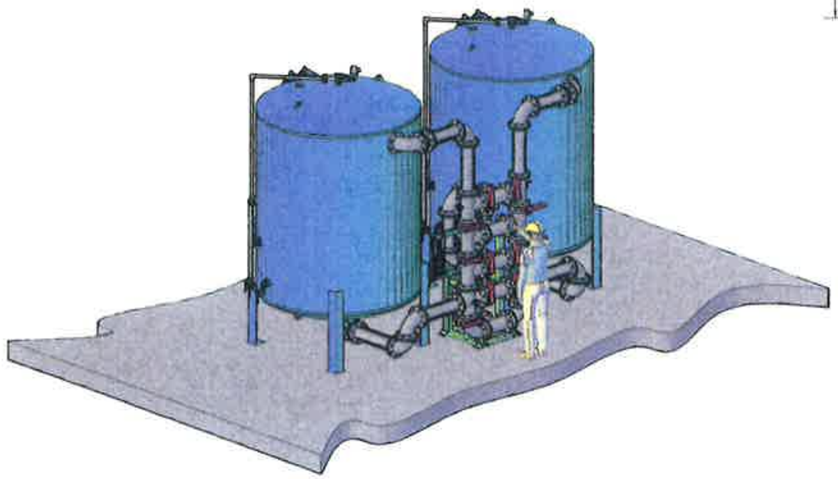
SYSTEM WEIGHT:

1. APPROXIMATE SHIPPING WEIGHT:



(OPERATOR LOCATION)

PLAN VIEW
FRONT AND BACK CLEARANCE



SALES DRAWING

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2055 Boggs Road
Duluth, GA 30096
P 678-835-0052 F 678-835-0057
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DRAWN BY	CHECKED BY	APPROVED BY	PROJECT #	DATE	SCALE
MC	CN	GG	TBD-0000	12/15/21	NTS

MODEL: ADEDGE MODULAR PFAS TREATMENT SYSTEM MODCAC-PFx-8496CS-2-MVT-LL

CUSTOMER: TBD

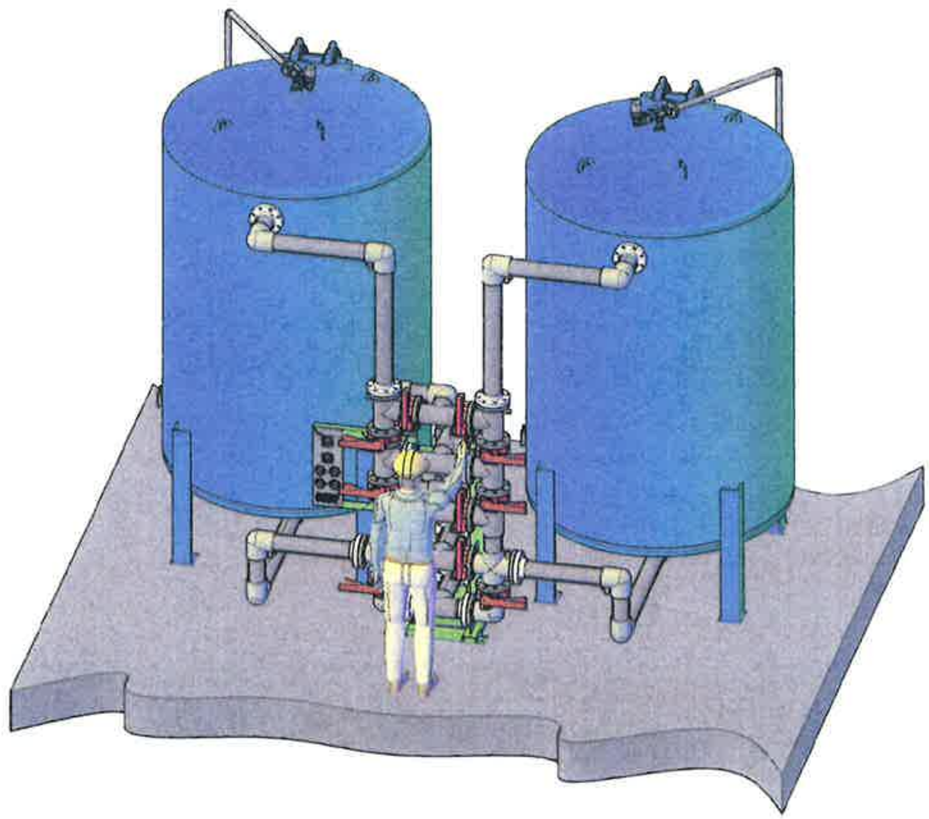
TITLE: SALES GENERAL ARRANGEMENT

DRAWING NUMBER: M-002

SHEET: 4 OF 4

MODGAC-PFx-7296CS-2-MVT-LL

ADEDGE TREATMENT SYSTEM



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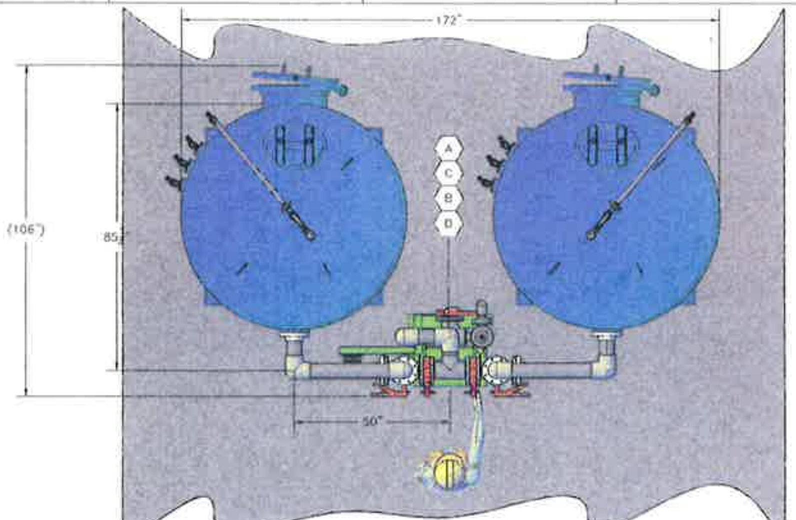
DRAWN BY	CHECKED BY	APPROVED BY	PROJECT #	DATE	SCALE
MC	CN	GG	TBD-0000	12/15/21	NTS

MODEL: ADEDGE MODULAR PFAS TREATMENT SYSTEM MODGAC-PFx-7296CS-2-MVT-LL

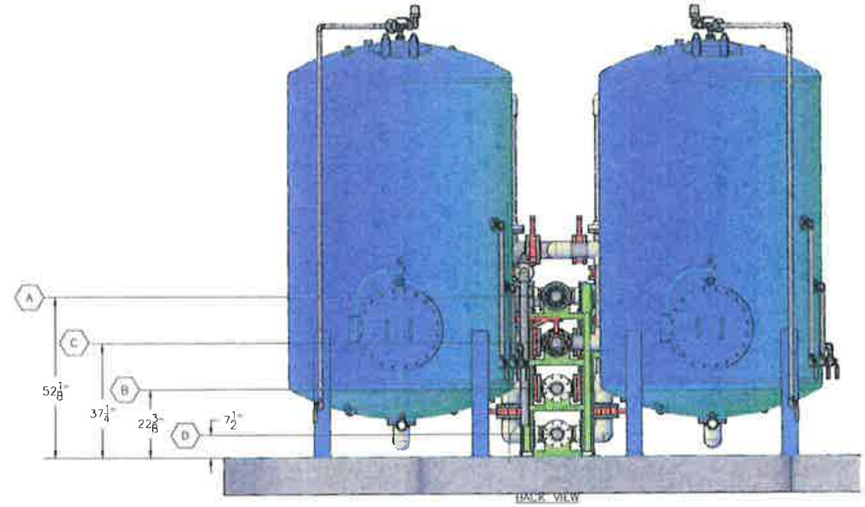
CUSTOMER: TBD

TITLE: COVER

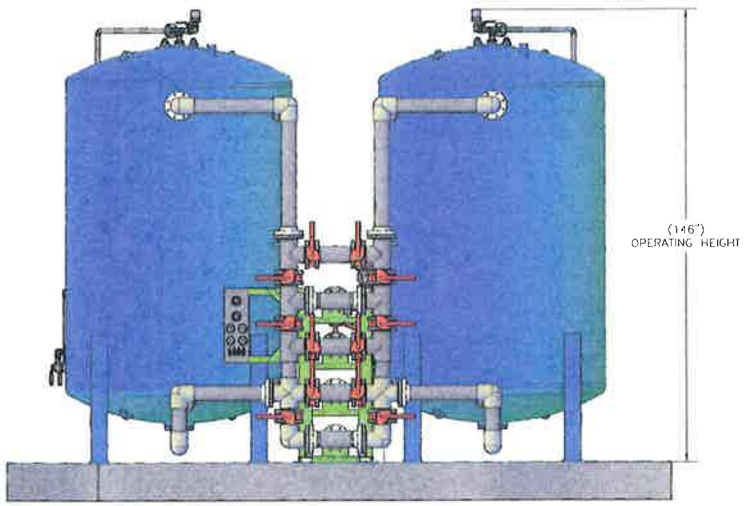
SALES DRAWING



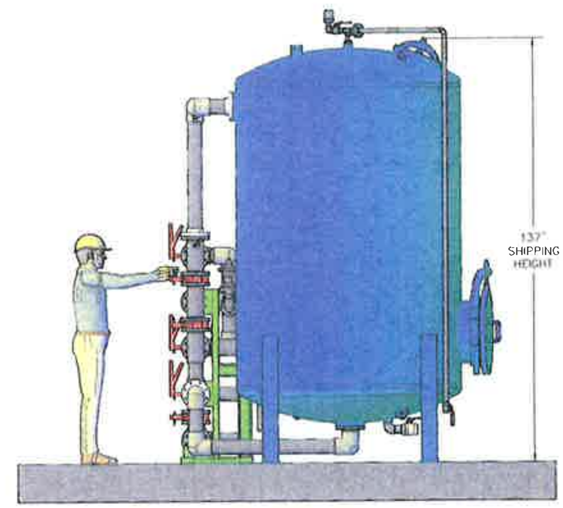
PLAN VIEW



BACK VIEW



FRONT VIEW



RIGHT SIDE VIEW

SALES DRAWING

AdEdge
2055 Boggs Road
Duluth, GA 30096
P. 678-835-0052 F. 678-835-0057
www.adedgetechnologies.com

ID	SERVICE CONNECTIONS	PIPE/MATERIAL
A	SYSTEM RAW WATER INLET	4" 150# SCH80 PVC FLANGE
B	SYSTEM TREATED OUTLET	4" 150# SCH80 PVC FLANGE
C	SYSTEM BACKWASH OUTLET	4" BUTTERFLY VALVE FLANGE
D	AUX. BACKWASH INLET	4" 150# SCH80 PVC FLANGE

REV. #	DATE	BY	APPROVED BY	REVISION DESCRIPTION
-	-	-	-	-

DRAWN BY	CHECKED BY	APPROVED BY	PROJECT #	DATE	SCALE
MC	CN	GG	TBD-0000	12/15/21	NTS

MODEL	CUSTOMER
ADEDGE MODULAR PFAS TREATMENT SYSTEM MODGAC-PFx-7296CS-2-MVT-LL	TBD

TITLE	DRAWING NUMBER	SHEET
SALES GENERAL ARRANGEMENT	M-001	3 OF 4

DIMENSIONAL NOTES:

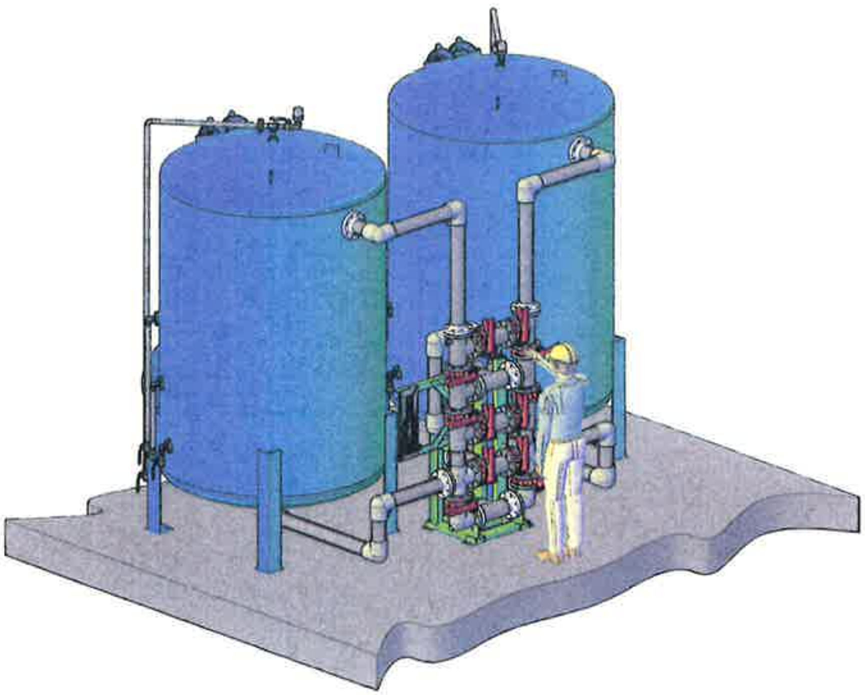
1. ALL DIMENSIONS ARE +/- 2"
2. DO NOT SCALE DRAWING. REFER TO ADEDGE ENGINEERING DEPT FOR ALL DIMENSIONS
3. (##): REFERENCE DIMENSION

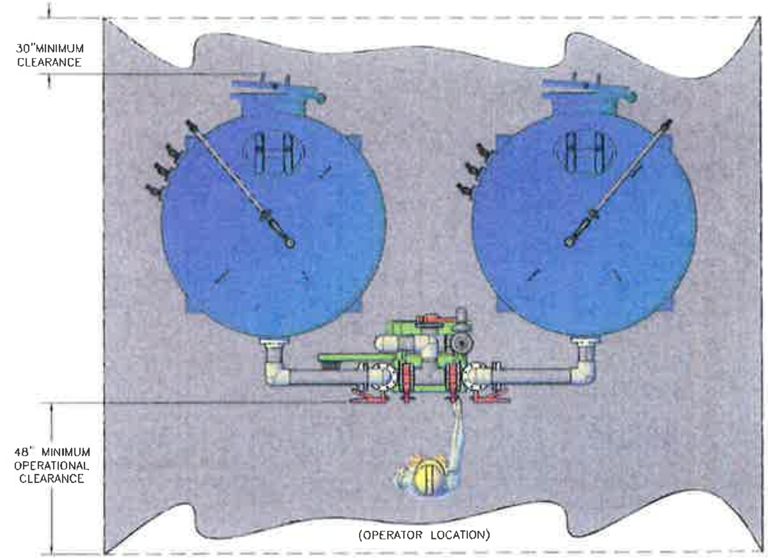
GENERAL SYSTEM SPECIFICATIONS:

1. SCH80 PVC INLET/OUTLET WITH FLANGED TIE POINTS
2. SCH80 PVC VALVE TREE PIPING
3. LUG-STYLE BUTTERFLY VALVES WITH MANUEL OPERATOR ON VALVE TREE
4. LUG-STYLE BUTTERFLY VALVE WITH MANUAL OPERATOR FOR BACKWASH OUTLET
5. 304SS HYDRAULIC PANEL WITH DP GAUGE FOR EACH VESSEL
6. PRESSURE GAUGES AND SAMPLE VALVES ON EACH VESSEL'S INLET AND OUTLET

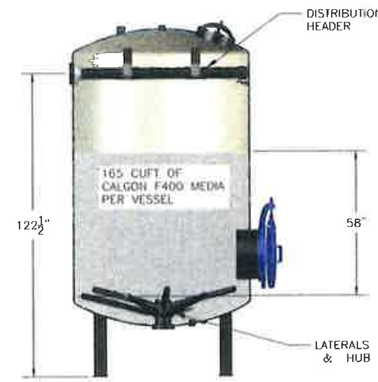
SYSTEM WEIGHT:

1. APPROXIMATE SHIPPING WEIGHT: 13,500 LBS





PLAN VIEW
FRONT AND BACK CLEARANCE



VESSEL INTERNAL VIEW

SALES DRAWING

AdEdge

2055 Boggs Road
Duluth, GA 30096
P. 678-835-0052 F. 678-835-0057
www.adedgetechnologies.com

DRAWN BY	CHECKED BY	APPROVED BY	PROJECT #	DATE	SCALE
MC	CN	GG	TBD-0000	12/15/21	NTS

MODEL: ADEDGE MODULAR PFAS TREATMENT SYSTEM MODGAC-PFx-7296CS-2-MVT-LL

CUSTOMER: TBD

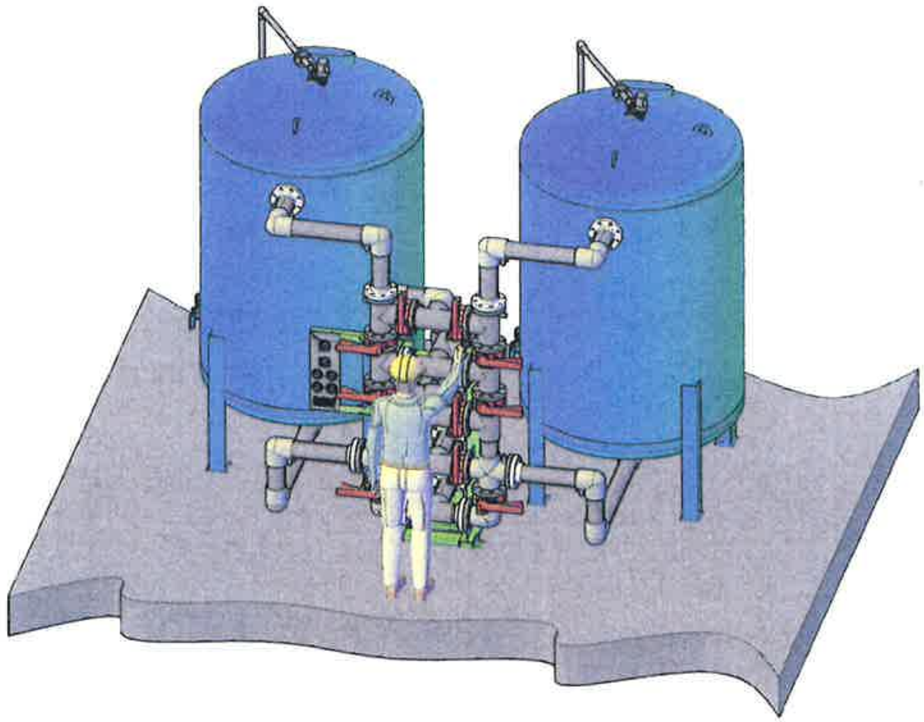
TITLE: SALES GENERAL ARRANGEMENT

DRAWING NUMBER: M-002

SHEET: 4 OF 4

MODGAC-PFx-6072CS-2-MVT-LL

ADEDGE TREATMENT SYSTEM



AdEdge

2055 Boggs Road
Duluth, GA 30096
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www. adedgetechnologies.com

CONTRACTOR

SHEET INDEX		
DRAWING NO.	TITLE	SHEET NO.

REV #	DATE	BY	APPROVED BY	REVISION DESCRIPTION

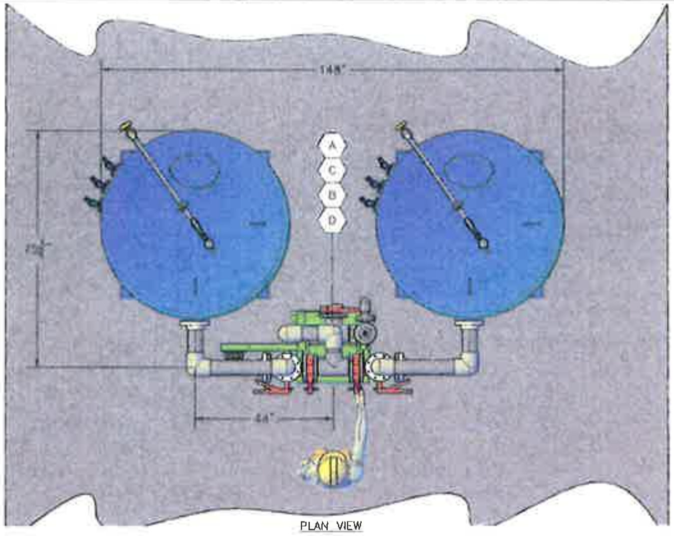
DRAWN BY	CHECKED BY	APPROVED BY	PROJECT #	DATE	SCALE
MC	CN	GC	TBD-0000	12/15/21	NTS

MODEL: ADEDGE MODULAR PFAS TREATMENT SYSTEM MODGAC-PFx-6072CS-2-MVT-LL

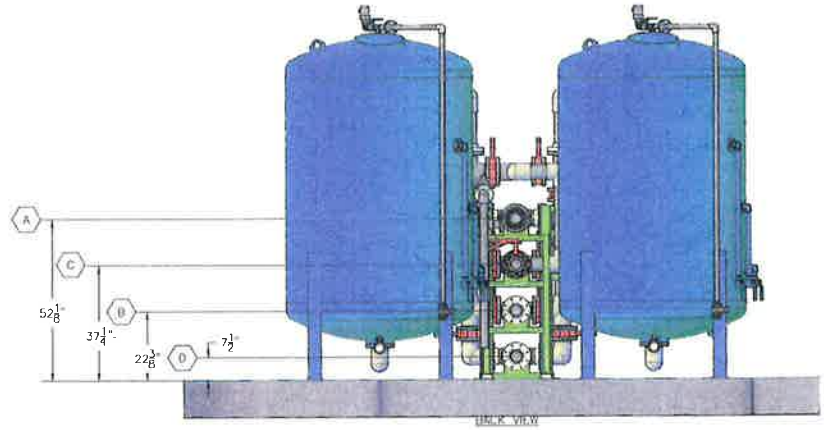
CUSTOMER: TBD

TITLE: COVER

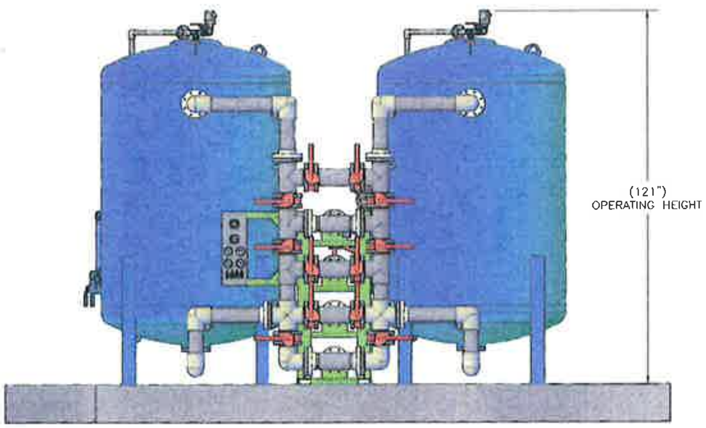
SALES DRAWING



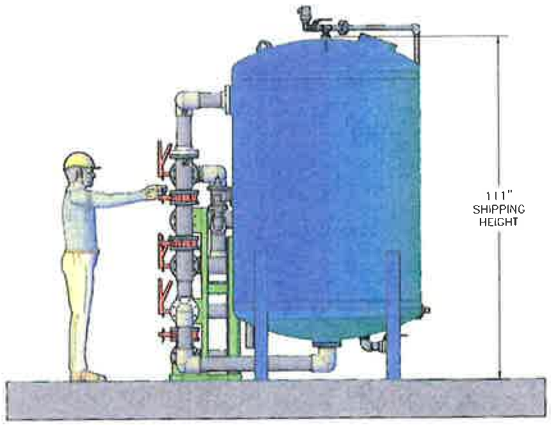
PLAN VIEW



BACK VIEW



FRONT VIEW



RIGHT SIDE VIEW

SALES DRAWING

AdEdge

2055 Boggs Road
Duluth, GA 30096
P. 678-835-0052 F. 678-835-0057
www. adedgetechnologies.com

	Service Connections	Type/Material
A	SYSTEM RAW WATER INLET	4" 150# SCH80 PVC FLANGE
B	SYSTEM TREATED OUTLET	4" 150# SCH80 PVC FLANGE
C	SYSTEM BACKWASH OUTLET	4" BUTTERFLY VALVE FLANGE
D	AUX. BACKWASH INLET	4" 150# SCH80 PVC FLANGE

Rev #	Date	By	Approved By	Revision Description
–	–	–	–	–

Drawn By	Checked By	Approved By	Project #	Date	Scale
MC	CN	GG	TBD-0000	12/15/21	NTS

Model: ADEDGE MODULAR PFAS TREATMENT SYSTEM MODGAC-PFx-6072CS-2-MVT-LL

Customer: TBD

Title: SALES GENERAL ARRANGEMENT

Drawing Number: M-001

Sheet: 3 OF 4

DIMENSIONAL NOTES:

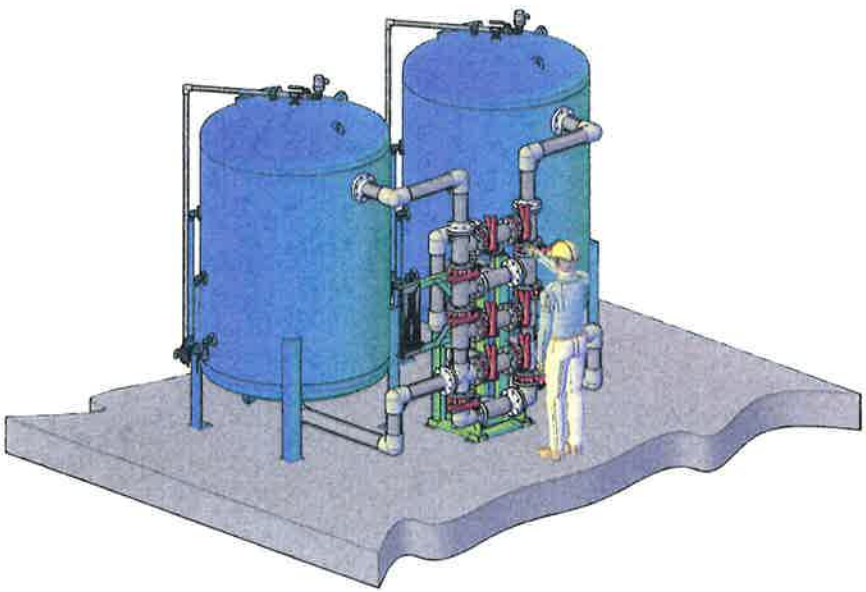
1. ALL DIMENSIONS ARE +/- 2"
2. DO NOT SCALE DRAWING REFER TO ADEDGE ENGINEERING DEPT FOR ALL DIMENSIONS
3. (##): REFERENCE DIMENSION

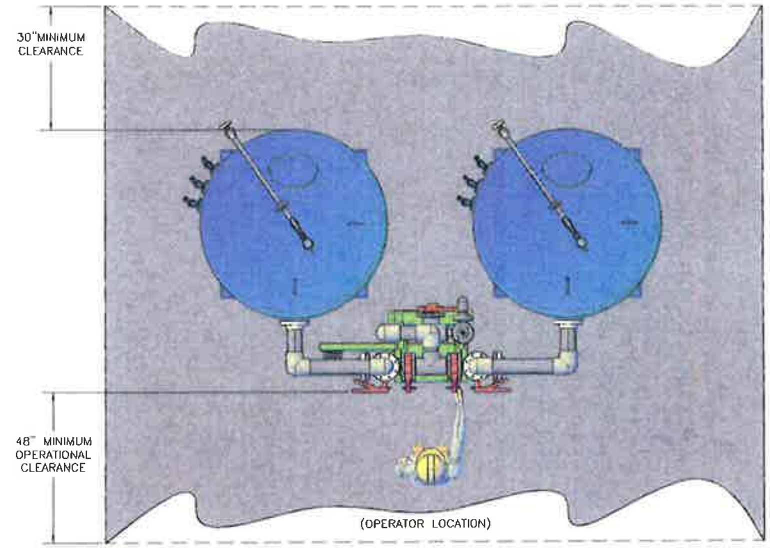
GENERAL SYSTEM SPECIFICATIONS:

1. SCH80 PVC INLET/OUTLET WITH FLANGED TIE POINTS
2. SCH80 PVC VALVE TREE PIPING
3. LUG-STYLE BUTTERFLY VALVES WITH MANUEL OPERATOR ON VALVE TREE
4. LUG-STYLE BUTTERFLY VALVE WITH MANUAL OPERATOR FOR BACKWASH OUTLET
5. 304SS HYDRAULIC PANEL WITH DP GAUGE FOR EACH VESSEL
6. PRESSURE GAUGES AND SAMPLE VALVES ON EACH VESSEL'S INLET AND OUTLET

SYSTEM WEIGHT.

1. APPROXIMATE SHIPPING WEIGHT:





PLAN VIEW
FRONT AND BACK CLEARANCE

SALES DRAWING

AdEdge
2055 Boggs Road
Duluth, GA 30096
P 678-835-0052 F 678-835-0057
www. adedgetechnologies com

DRAWN BY	CHECKED BY	APPROVED BY	PROJECT #	DATE	SCALE
MC	CN	GG	TBD-0000	12/15/21	NTS

MODEL: ADEDGE MODULAR PFAS TREATMENT SYSTEM MODGAC-PFx-6072CS-2-MVT-LL

CUSTOMER: TBD

TITLE: SALES GENERAL ARRANGEMENT

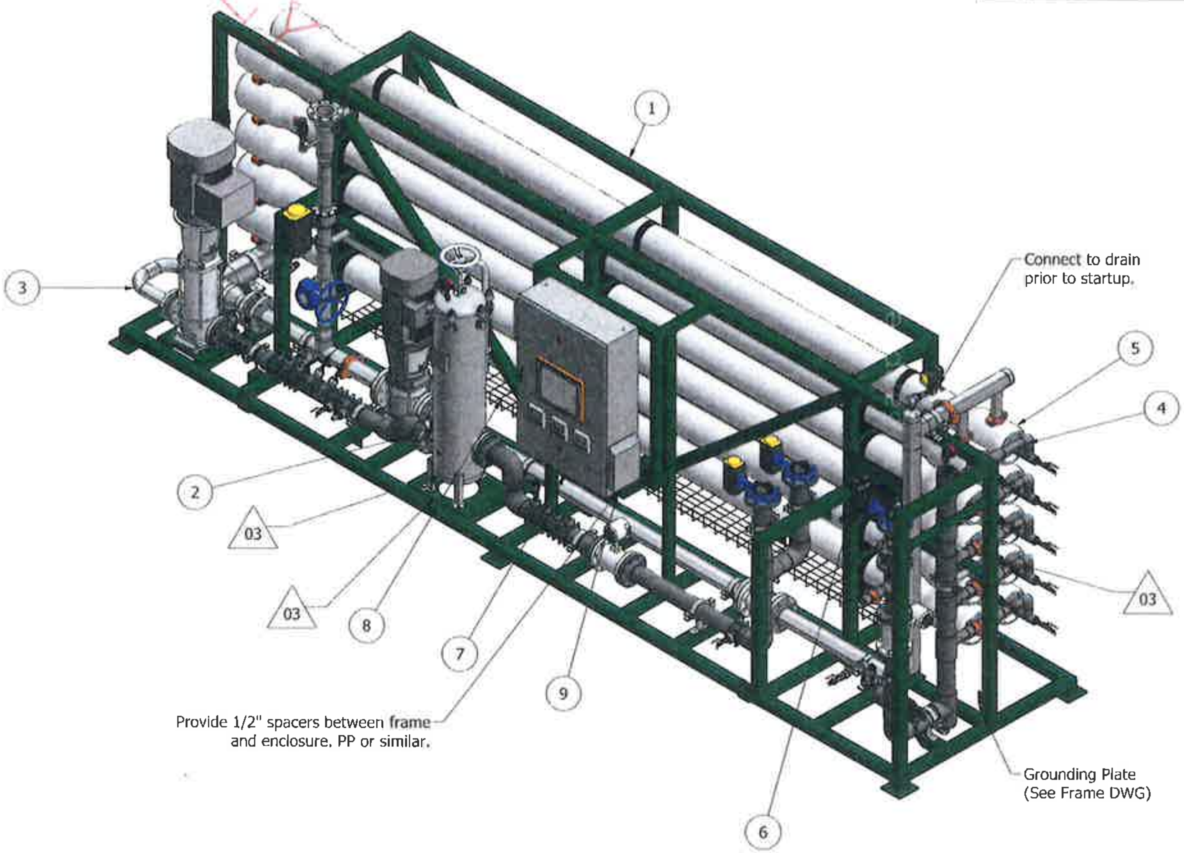
DRAWING NUMBER: M-002

SHEET: 4 OF 4

MANUFACTURER’S INFORMATION

RO TREATMENT

PARTS LIST			
ITEM	PART NUMBER	DESCRIPTION	QTY/ Length
1	RO Frame	DWG No. STR-GPGF-R10-01	1
2	Feed Line	DWG No. PI-FD-GPGF-R10-01	1
3	HP Line	DWG No. PI-HP-GPGF-R10-01	1
4	Permeate Line	DWG No. PI-PR-GPGF-R10-01	1
5	PV Assembly	DWG No. PI-PV-GPGF-R10-01	1
6	Air Set		1
7	Control Board	Compact Enclosure 800mm. X 1200mm. X 300mm.	1
8	Electrical Tray		1
9	Electrical Cabinet Spacer	7.0 in x 3.0 in x 1/2"	2
10	Pipe Support Parallel Welded Clamp 3"	DWG No. GD-STR-51 "Type 1"	1
11	Pipe Support Parallel Welded Clamp 4"	DWG No. GD-STR-51 "Type 1"	7
12	Pipe Support Parallel Welded Clamp 6"	DWG No. GD-STR-51 "Type 1"	2
13	SS Pipe Support Welded Threaded Clamp 3"	EPDM insulated custom heavy duty clamp. DWG No. GD-STR-61 "Type 1"	1
14	SS Pipe Support Welded Threaded Clamp 4"	EPDM insulated custom heavy duty clamp. DWG No. GD-STR-61 "Type 1"	8



NOTES:
1) Adjust all dimensions during installation.
2) Prepare and support all equipment to the shipment in order to prevent damage during transportation.
3) Estimated weight:
- Dry weight ~9000 lb
- Operational (Wet) weight ~12800 lb
4) Drain the system completely before lifting or transporting.

Designed by:	Checked by:	Approved by:	Project:
Slava Snitser 17.Oct.2017	Ian S. 02.Nov.2017		SAMPLE ONLY

DESALITECH
One Gateway Center,
Suite 809 Newton,
MA 02458
Phone: (617) 564 1647

Confidential Information

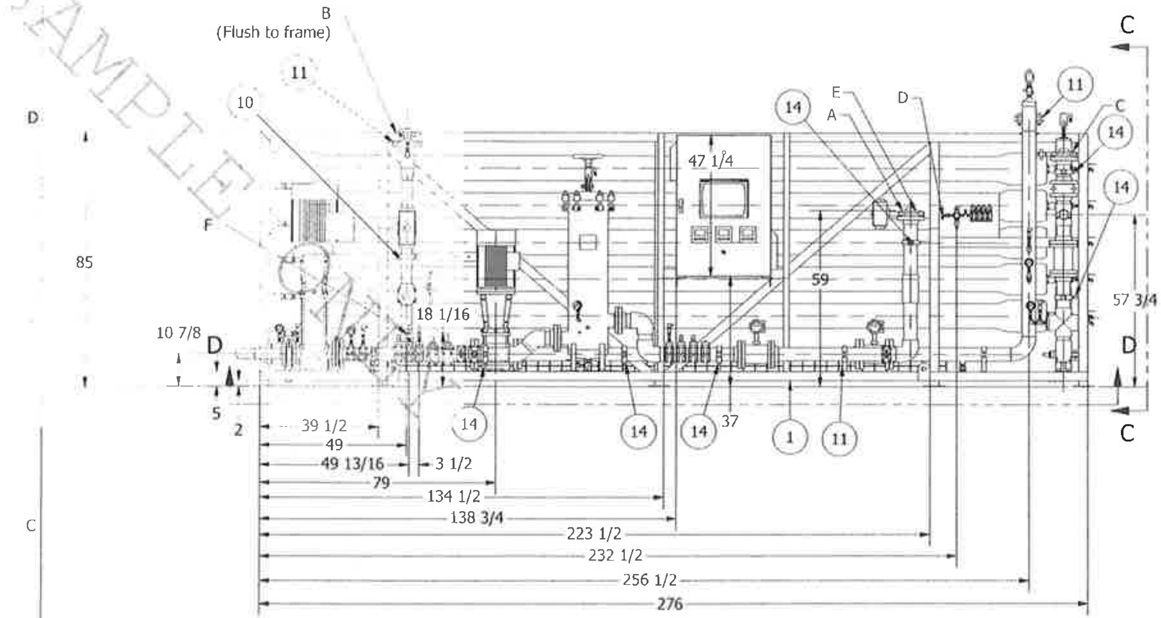
Unless Other Specified:
All Dimentions are in inches.
Tolerances:
Linear ±1/16"; Angular ±0.5°

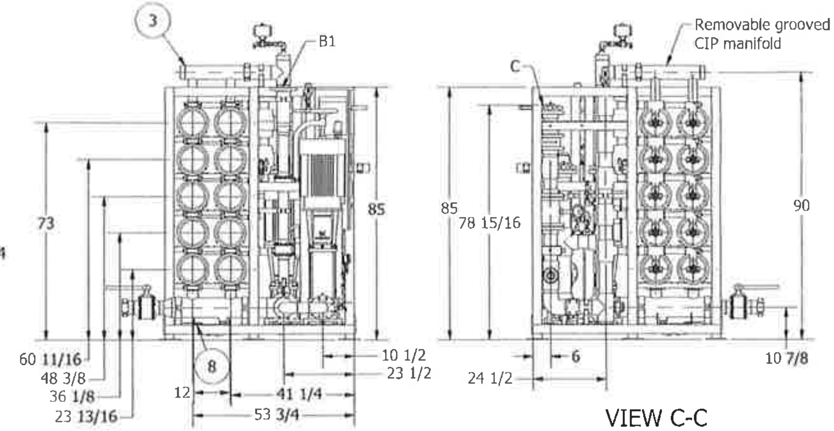
First Angle Projection

Part Number: CCRO Model No. S10

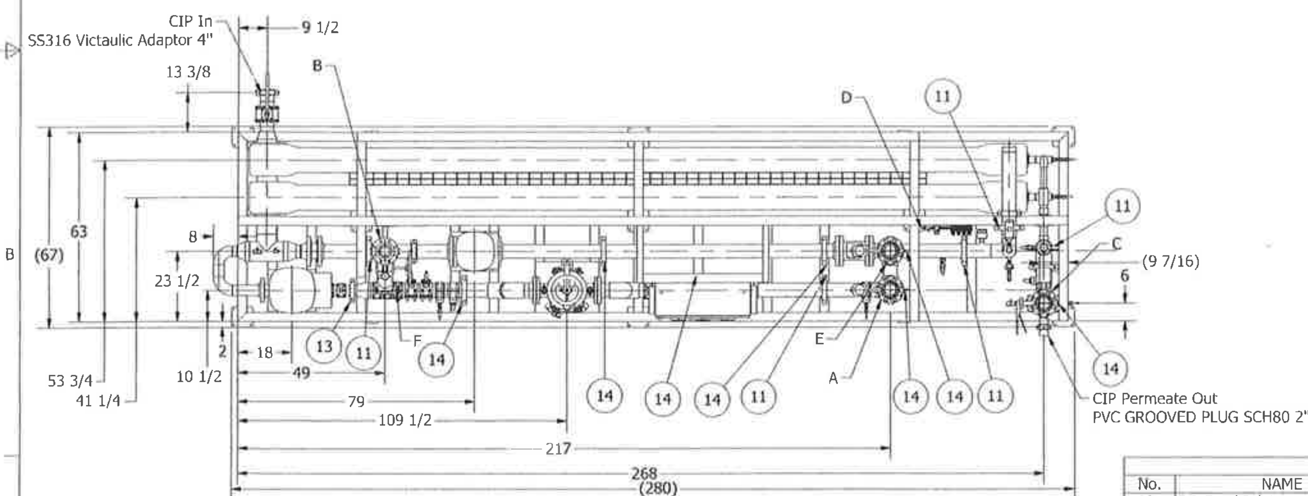
Drawing Number: GA-GPGF-R10-02

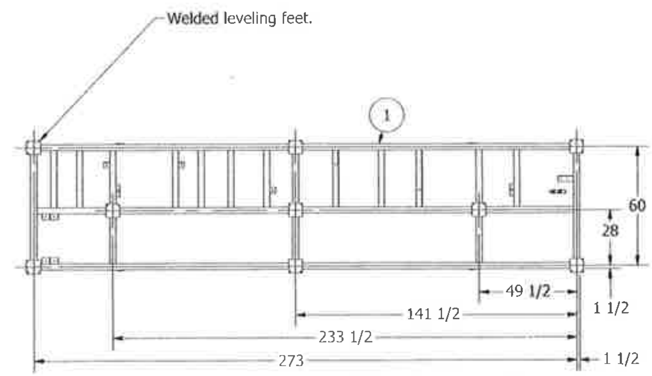
Size:	Scale:	Revision:	Sheet:
C	NTS	03	1 of 3





VIEW C-C
SCALE 3/8"=1'0"





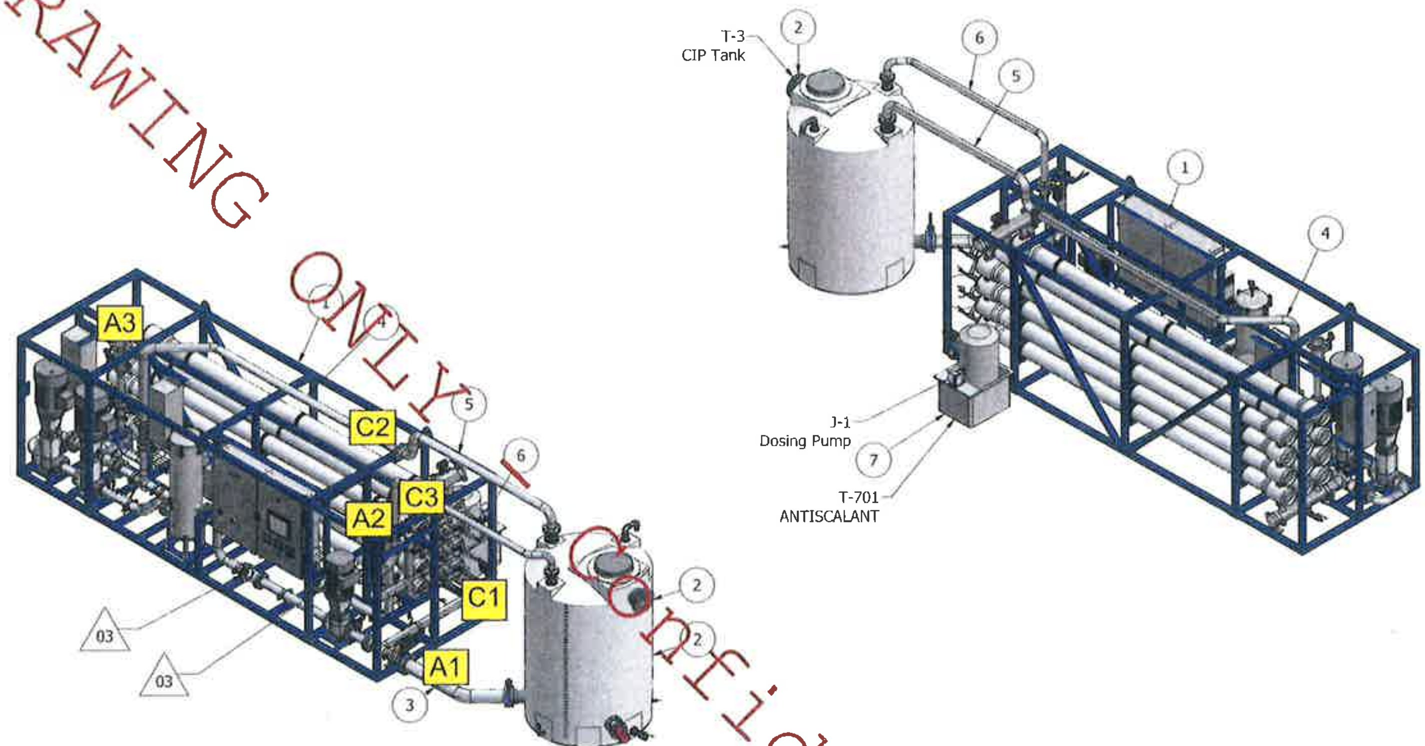
Skid Supports X9
SECTION D-D
SCALE 1/4"=1'0"

EXTERNAL PIPING CONNECTIONS		
No.	NAME OF CONNECTION	TYPE OF CONNECTION
A	RO Feed Inlet	4" ANSI #150 Lugged Butterfly Valve
B	RO Brine to Drain Outlet	4" ANSI #150 Flange
C	RO Permeate Outlet	4" ANSI #150 Lugged Butterfly Valve
D	Air Connection	3/8" Air Tubing Connector
E	Permeate Flush Inlet	4" ANSI #150 Lugged Butterfly Valve
F	SDI/Silica Analyzers	1/2" FNPT

NOTES:
1) Adjust all dimensions during installation.
2) Prepare and support all equipment to the shipment in order to prevent damage during transportation.
3) Estimated weight:
- Dry weight ~9000 lb
- Operational (Wet) weight ~12800 lb
4) Drain the system completely before lifting or transporting.

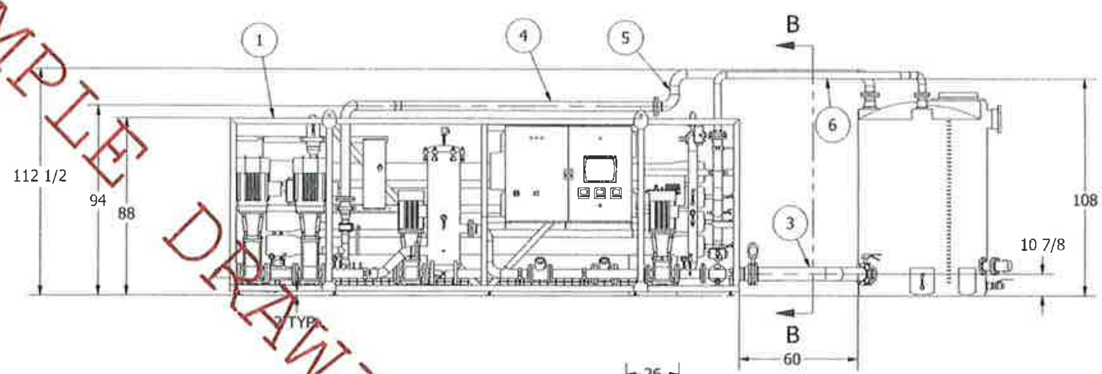
Designed by: Slava Snitser 17.Oct.2017	Checked by: Ian S. 02.Nov.2017	Approved by:	Project: SAMPLE ONLY
Desalitech	DESALITECH One Gateway Center, Suite 809 Newton, MA 02458 Phone: (617) 564 1647	Unless Other Specified: All Dimentions are in inches. Tolerances: Linear ±1/16"; Angular ±0.5°	Part Number: CCRO Model No. S10
Confidential Information		First Angle Projection	Drawing Number: GA-GPGF-R10-02
			Size: C; Scale: 1/4"=1'0"; Revision: 03; Sheet: 2 of 3

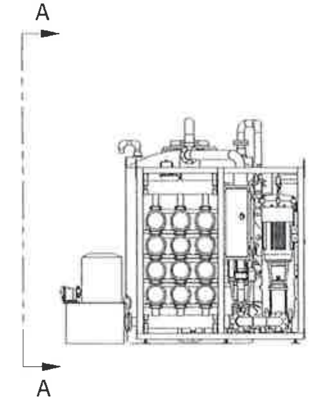
PARTS LIST			
ITEM	PART NUMBER	DESCRIPTION	QTY/ Length
1	RO R12	DWG No. GA-DSS-R12-02	1
2	CIP Tank 1200 GAL	DWG No. WT-CIP-DSS-R12-01	1
3	CIP Tank to Feed Line	Customer Scope	1
4	Brine to CIP Tank Line1	Customer Scope	1
5	Brine to CIP Tank Line2	Customer Scope	1
6	Permeate to CIP Tank Line	Customer Scope	1
7	Chemical Storage Tank 40 gal		1

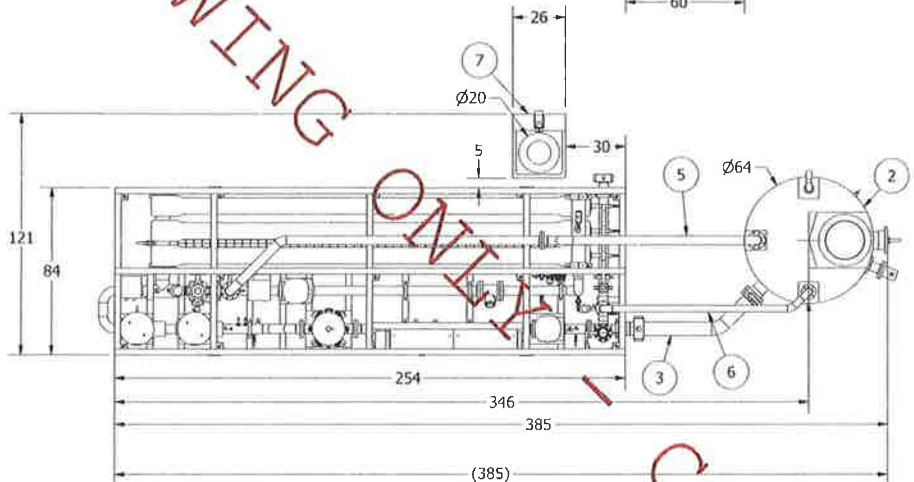


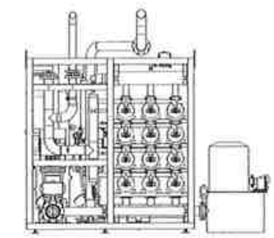
NOTES:
1) Adjust all dimensions during installation.
2) Prepare and support all equipment to the shipment in order to prevent damage during transportation.
3) Drain the system completely before lifting or transporting.

Designed by: Slava Snitser 09.Oct.2017	Checked by: Shimi G. 23.Oct.2017	Approved by:	Project:
DESALITECH One Gateway Center, Suite 809 Newton, MA 02458 Phone: (617) 564 1647		Unless Other Specified: All Dimentions are in inches. Tolerances: Linear ±1/16"; Angular ±0.5°	Part Number: GA R12
Confidential Information		First Angle Projection	Drawing Number: GA-DSS-R12-01
			Size: C / Scale: NTS / Revision: 03 / Sheet: 1 of 2

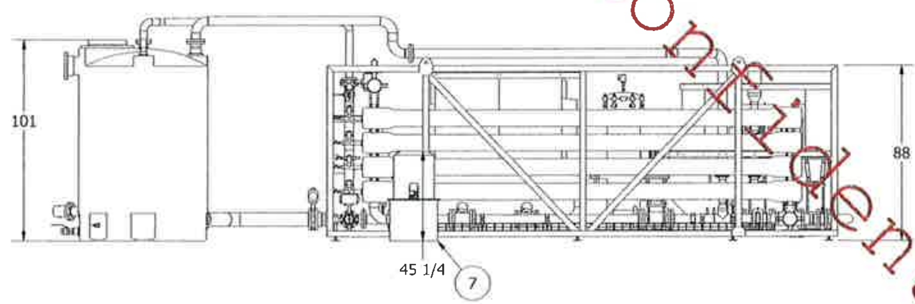








SECTION B-B
SCALE 1/4"=1'0"



VIEW A-A
SCALE 1/4"=1'0"

NOTES:
1) Adjust all dimensions during installation.
2) Prepare and support all equipment to the shipment in order to prevent damage during transportation.
3) Drain the system completely before lifting or transporting.

Designed by:		Checked by:		Approved by:	Project:
Slava Snitser	09.Oct.2017	Shimi G.	23.Oct.2017		

Desalitech
Advanced Desalination Technologies

DESALITECH
One Gateway Center,
Suite 809 Newton,
MA 02458
Phone: (617) 564 1647

Unless Other Specified:
All Dimentions are in inches.
Tolerances:
Linear ±1/16"; Angular ±0.5°

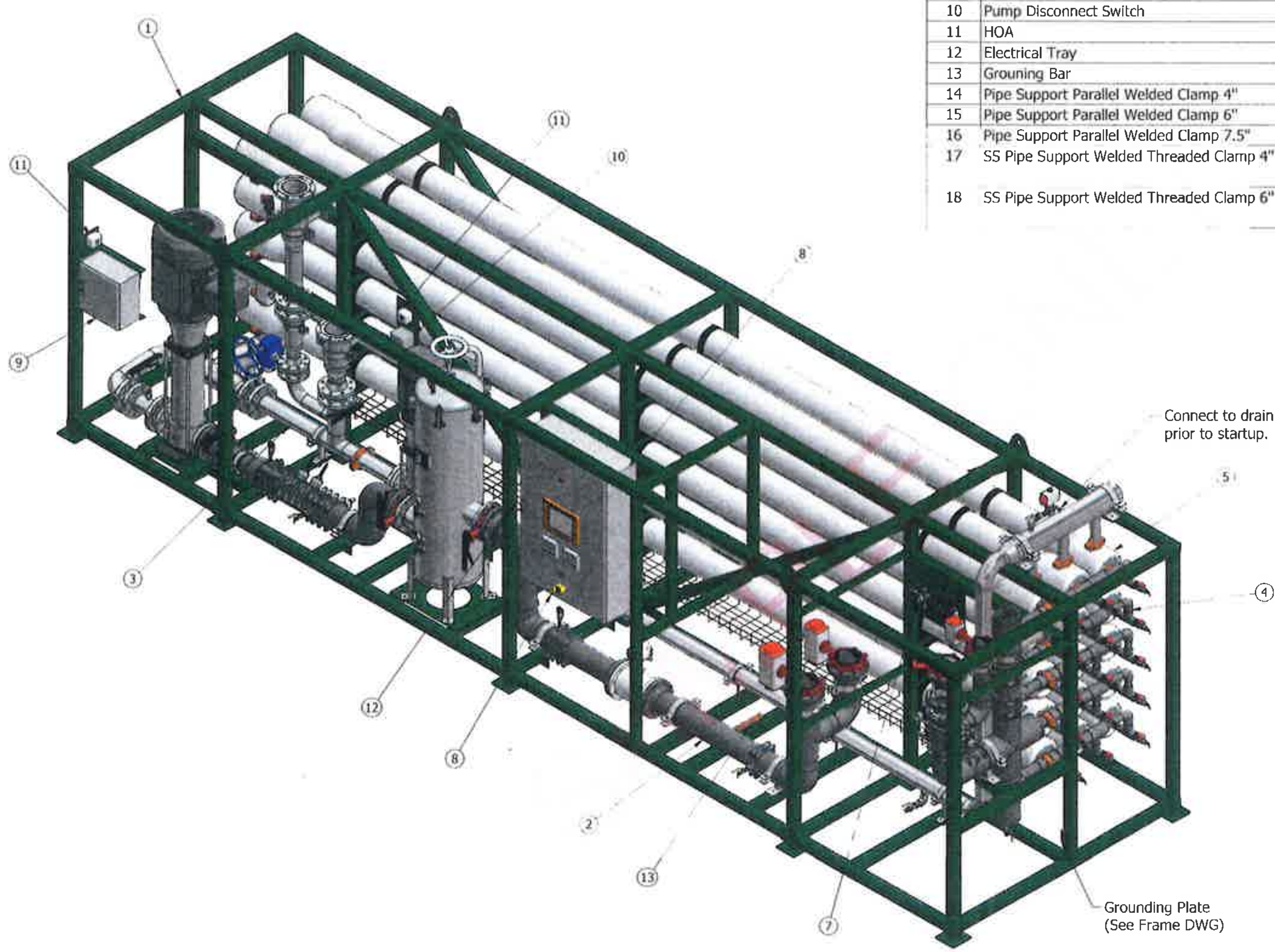
Part Number: GA R12

Drawing Number: GA-DSS-R12-01

First Angle Projection

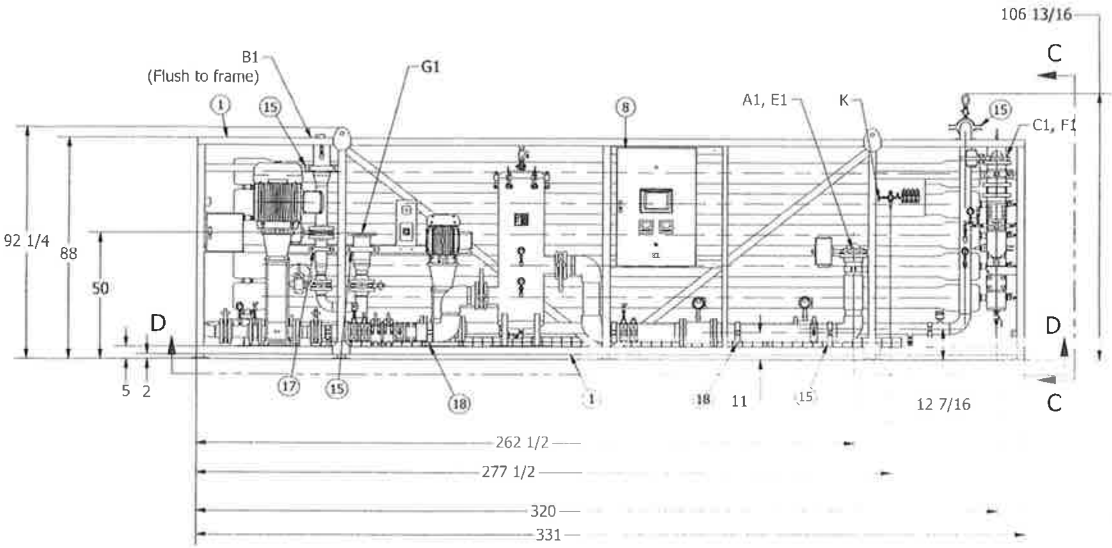
Size:	Scale:	Revision:	Sheet:
C	1/4"=1'0"	03	2 of 2

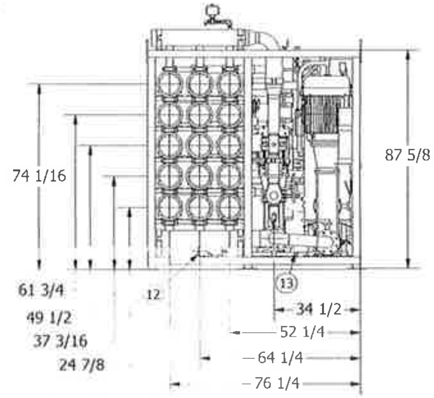
PARTS LIST			
ITEM	PART NUMBER	DESCRIPTION	QTY/ Length
1	RO Frame	DWG No. STR-RO-1133C-R15-01	1
2	Feed Line	DWG No. PI-FD-1133C-R15-01	1
3	HP Line	DWG No. PI-HP-1133C-R15-01	1
4	Permeate Line	DWG No. PI-PR-1133C-R15-01	1
5	PV Assembly	DWG No. PI-PV-1133C-R15-01	1
6	Support Assembly	DWG No. STR-RO-1133C-R15-04	4
7	Air Set		1
8	Control Panel	Enclosure Size WxHxD: 800mm x 1200mm x 300mm	1
9	Disconnect Box for HP Pump	Enclosure Size WxHxD: 380mm x 380mm x 210mm	1
10	Pump Disconnect Switch	194E-Y63-1753-6A	1
11	HOA	HOA 800F-1PP	2
12	Electrical Tray		1
13	Grouning Bar	Erico EGBA14215JJ 15"x2"x0.25" or similar	1
14	Pipe Support Parallel Welded Clamp 4"	DWG No. GD-STR-51 "Type 1"	2
15	Pipe Support Parallel Welded Clamp 6"	DWG No. GD-STR-51 "Type 1"	10
16	Pipe Support Parallel Welded Clamp 7.5"	DWG No. GD-STR-51 "Type 1" Enlarged for 6" PVC fitting	1
17	SS Pipe Support Welded Threaded Clamp 4"	EPDM insulated custom heavy duty clamp. DWG No. GD-STR-61 "Type 1"	7
18	SS Pipe Support Welded Threaded Clamp 6"	EPDM insulated custom heavy duty clamp. DWG No. GD-STR-61 "Type 1"	4

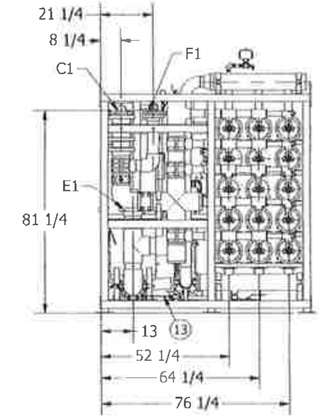


NOTES:
1) Adjust all dimensions during installation.
2) Prepare and support all equipment to the shipment in order to prevent damage during transportation.
3) Estimated weight:
- Dry weight ~22500 lb
- Operational (Wet) weight ~27000 lb
4) Drain the system completely before lifting or transporting.

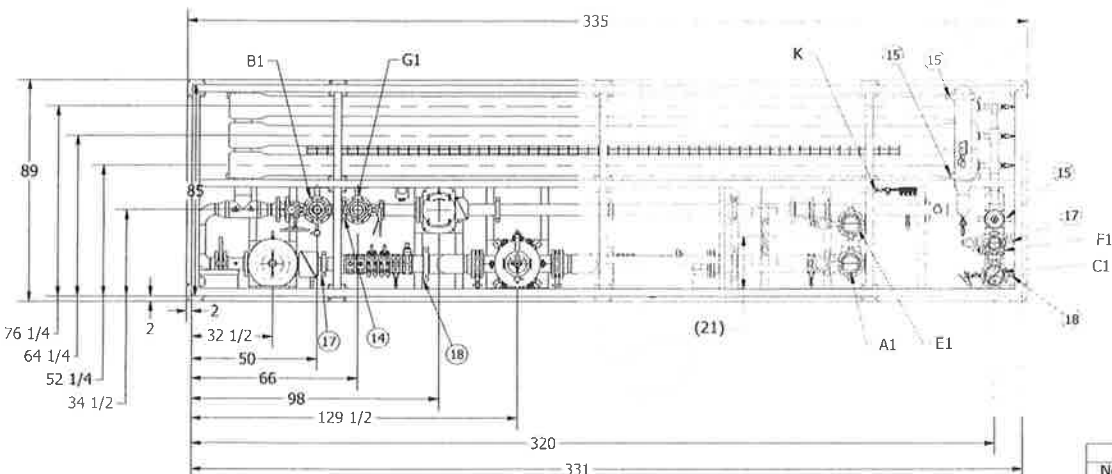
Designed by:	Checked by:	Approved by:	Project:
Dima Velikovich 13.Mar.2019	Ran N. 07.Apr.2019		SAMPLE ONLY
Desalitech — DESALITECH One Gateway Center, Suite 809 Newton, MA 02458 Phone: (617) 564 1647		Unless Other Specified: All Dimentions are in inches. Tolerances: Linear ±1/16"; Angular ±0.5'	Part Number: CCRO Model No. S15
Confidential Information		First Angle Projection	Drawing Number: GA-1133C-R15-02-2
			Size: C / Scale: NTS / Revision: 01 / Sheet: 1 of 4



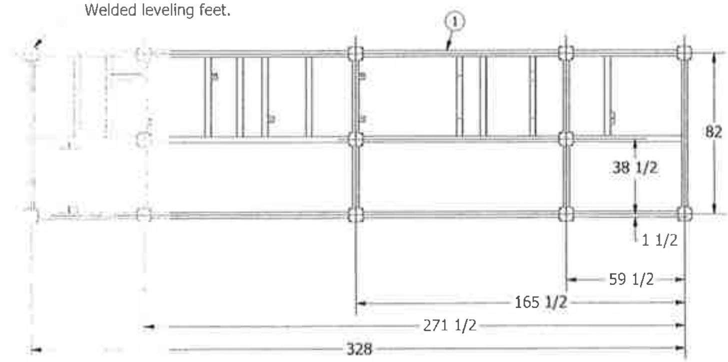




VIEW C-C
SCALE 5/16"=1'0"



Welded leveling feet.



Skid Supports
SECTION D-D
SCALE 1/4"=1'0"

EXTERNAL PIPING CONNECTIONS		
No.	NAME OF CONNECTION	TYPE OF CONNECTION
A1	RO Feed Inlet	6" ANSI #150 Lugged Butterfly Valve
B1	RO Brine to Drain Outlet	6" ANSI #150 Flange
C1	RO Permeate Outlet	6" ANSI #150 Lugged Butterfly Valve
E1	RO CIP Inlet	6" ANSI #150 Lugged Butterfly Valve
F1	RO Permeate CIP Outlet	4" ANSI #150 Lugged Butterfly Valve
G1	RO Brine CIP Outlet	6" ANSI #150 Flange
K	Air Connection	3/8" Air Tubing Connector

NOTES:
1) Adjust all dimensions during installation.
2) Prepare and support all equipment to the shipment in order to prevent damage during transportation.
3) Estimated weight:
- Dry weight ~22500 lb
- Operational (Wet) weight ~27000 lb
4) Drain the system completely before lifting or transporting.

Designed by:	Checked by:	Approved by:	Project:
Dima Velikovich 13.Mar.2019	Ran N. 07.Apr.2019		Sample ONLY

Desalitech
DESALITECH
One Gateway Center,
Suite 809 Newton,
MA 02458
Phone: (617) 564 1647

Unless Other Specified:
All Dimentions are in inches.
Tolerances:
Linear ±1/16"; Angular ±0.5°

First Angle Projection

Part Number:
CCRO Model No. S15

Drawing Number:
GA-1133C-R15-02-2

Size:	Scale:	Revision:	Sheet:
C	5/16"=1'0"	01	2 of 4

DOYLESTOWN BOROUGH PUBLIC DRINKING WATER SYSTEM
PFAS TREATMENT ALTERNATIVES ANALYSIS
COMPARATIVE SUMMARY

	PFAS TREATMENT – GRANUALAR ACTIVATED CARBON (GAC) AT WELL STATIONS	PFAS TREATMENT – ION EXCHANGE RESIN (IX) AT WELL STATIONS	PFAS TREATMENT – REVERSE OSMOSIS (RO) AT WELL STATIONS	PURCHASE OF BULK WATER SUPPLY FROM DTMA AND NPWA
1. Scope	Installation of GAC treatment systems at each of the Borough's five (5) groundwater wells, Construction of additional treatment building at each site included.	Installation of IX treatment systems at each of the Borough's five (5) groundwater wells, Construction of additional treatment building at each site included.	Installation of RO treatment systems at each of the Borough's five (5) groundwater wells, Construction of additional treatment building at each site included.	Purchase additional bulk water supply of drinking water treated at the NPWA Forest Park Water Treatment Plant, transferring water through DTMA mains to the Doylestown Borough distribution system.
2. Capital Cost (Total Project)	$9,149,524(1)	$8,250,000(1)	$9,336.250(1)	$0(1)
3. Operation Cost (Yearly)	$ 160,000 (GAC replacements)(2) $ 60,000 (laboratory testing)(4)	$ 81,000 (resin exchange)(2) $ 60,000 (laboratory testing)(4)	$ 44,000 (membrane replacements)(2) $ 60,000 (laboratory testing)(4) $ 180,000 (electrical energy costs) $ 90,000 (annual costs of GAC replacement and disposal from concentrated PFAS waste stream.)	$1,345,390 (water purchase)(3) $ 10,000 (laboratory testing)(4)
4. Design Considerations	Additional building at each well site, some sites have limited area available for construction. GAC is proven treatment for PFAS and does not require pilot testing. Sanitary sewer connection needed at each site.	Additional building at each well site, some sites have limited area available for construction. IX is proven treatment for PFAS but will require pilot testing. Sanitary sewer connection needed at each site.	Additional building at each well site, some sites have limited area available for construction. RO is capable for removing PFAS but will require pilot testing. Additional GAC treatment needed for concentrated PFAS waste stream. Sanitary sewer connection needed at each site.	No building construction needed. Minor field testing to verify capacity and pressures available. New/revised legal agreements with DTMA and NPWA. Minor PADEP permitting approvals needed.
5. Remarks: Pros:	Proven technology, ease of operation. Moderate operating costs. Operation independent of other water sources and/or public water systems.	Proven technology, ease of operation. Lowest operating costs. Operation independent of other water sources and/or public water systems.	Operation independent of other water sources and/or public water systems.	Lowest implementation cost. Could be in service before other alternatives. Some additional price negotiation/discount is possible.
Cons:	Site constraints to construct treatment systems. Building addition/expansion in open space may not be easily accepted by neighbors.	Site constraints to construct treatment systems. Building addition/expansion in open space may not be easily accepted by neighbors. Pilot testing required which will delay implementation.	Highest capital cost. Highest annual operations and maintenance cost. Complex operation. Additional disposal of concentrated waste stream. Pilot testing required. Site constraints to construct treatment systems.	Dependence on other water supplies/water systems to meet Borough's needs. Subject to future rate hikes.

NOTES:

(1) Based on PFAS Treatment Alternatives Analysis for Doylestown Borough - prepared by CKS Engineers, Inc. dated February 2023.

(2) Annualized cost based on media replacement costs shown in study.

(3) Annual cost based on a rate of $3.80/1,000 gallons and an average use of 970,000 gpd (970 x $3.80/1,000 gal x 365 days = $1,345,390).

(4) Annual operational cost.