TETRA TECH

August 6, 2021
Ms. Karen A. Cahill
Assistant Engineer
NYSDEC Region 7
615 Erie Boulevard W.
Syracuse, NY 13204-2400

RE: Proposed Treatment System Modification for 1,4-Dioxane - Revised
Abandoned Solvent Center Site – Pompey, NY
(NYSDEC #734035)

Dear Ms. Cahill:

On July 13, 2021, Tetra Tech submitted on behalf of the Participating Parties for the Abandoned Solvent Center Site (Site) in Pompey, New York, an evaluation of two options using granular activated carbon (GAC) for (1,4-D) treatment for the groundwater collection and treatment system (GCTS) at the Site. The application of GAC for the GCTS was based on the success we have achieved using GAC in residential point of entry treatment (POET) systems adjacent to the Site. In correspondence dated July 23, 2021 the New York State Department of Environmental Conservation (NYSDEC) and the New York State Department of Health (NYSDOH) requested the following modifications to the July 13 proposal:

1. Provide calculations used for estimating lead carbon vessel breakthrough time of 364 days for 1,4-D at 80 µg/L at an average flowrate of 800 gpd (i.e., calculations used for sizing the carbon vessels).

2. Provide a conceptual system drawing for the preferred treatment system option.

3. Fully demonstrated ex-situ groundwater treatment technologies for 1,4-D, including advanced oxidation and sorptive resin processes, must also be evaluated as a treatment option.[1]

Calculations for estimating lead carbon vessel breakthrough are attached (comment 1) as is a conceptual system drawing for the preferred treatment system option (comment 2). Options for sorptive resin and advanced oxidation treatment technologies (comment 3) have been added to the revised evaluation provided below.

[1] It was also noted in the July 23 comment letter that depending upon the results of the 1,4-D source area study, in-situ chemical oxidation may also need to be considered. The investigation and assessment of the nature and extent of 1,4-D is ongoing and considerations such as noted are more appropriately addressed as part of that process and not applicable to the evaluation being provided herein.

Current Air Stripper Treatment System

Groundwater is pumped from the groundwater collection trench wet well at a flow rate of 15 gallons per minute (gpm) to a 200-gallon influent flow equalization tank. A sulfuric acid feed system lowers the pH in the influent water from approximately 7 down to 3 to reduce scale build up in the air stripper. A float-controlled centrifugal feed pump conveys flow from the equalization tank to the top of a low-profile air stripper at a flow rate of 15 gpm. The amount of collected and treated water averages approximately 800 gallons per day (gpd). Treated water is discharged by gravity downstream of the air stripper via a 3-inch diameter PVC effluent pipe to the roadside drainage ditch south of Route 20. The influent water quality contains approximately 200 ug/L of total VOCs and 80 ug/L of 1,4-D. The current air-stripping treatment technology removes all of the VOCs but provides little reduction in the 1,4-D concentration which has a groundwater quality standard of 1.0 ug/L (Title 10, Subpart 5-1.52 Table 3).

The following options were evaluated for the treatment of 1,4-D:

Option 1: Retain Air Stripper and Add Carbon Treatment System

This option retains the current air stripper (AS) and acid adjustment system but adds carbon at the end of the treatment train. The effluent of the existing system would be pumped to an equalization tank to normalize flow. The water from the equalization tank would then be pumped at 10 gpm through three 1,000-pound granular activated carbon (GAC) vessels in series. The 10 gpm flow rate is the minimum necessary to prevent channeling in the carbon bed to ensure all the carbon bed is used. The beds are sized to ensure enough contact time for adsorption of 1,4-D at 80 ug/L because the air stripper will not remove a significant amount of this compound due to low vapor pressure. The limiting compound in this configuration is 1,4-D, requiring a change of the lead carbon vessel every 364 days based on the historical average flow of 800 gpd (see attached calculations). This system will be in lead/lag/lag2 configuration and changeout will be determined based on concentrations of samples collected in the mid sample port between vessels. Once a carbon vessel is changed the lag vessel will become the new lead vessel, the lag2 vessel will become the new lag vessel and the changed vessel with become the lag2 vessel. This option could cause fouling of the carbon bed (due to oxygen addition by AS) that may lead to premature changeout since up-flow beds cannot be backwashed. The treated water will then discharge via gravity to the exiting outfall.

Option 2: Replace Air Stripper with Carbon Treatment System

The existing air stripper system would be removed and replaced with an equalization tank and a feed pump to provide 10 gpm flow through three 1,000-pound GAC vessels in series. The 10 gpm flow rate is the minimum necessary to prevent channeling in the carbon bed to ensure all the carbon bed is used. The beds are sized to ensure enough contact time for adsorption of 1,4-D at 80 ug/L. The limiting compound in this configuration is 1,4-D requiring a change of the lead carbon vessel every 364 days based on the historical average flow of 800 gpd (see attached calculations). This system will be in lead/lag/lag2 configuration and changeout will be determined based on concentrations of samples collected in the mid sample port between vessels. Once a carbon vessel is changed the lag vessel will become the new lead vessel, the lag2 vessel will become the new lag vessel and the changed vessel with become the lag2 vessel. No acid adjustment is anticipated to be needed for this option. The treated water will then discharge via gravity to the exiting outfall.

Option 3: Resin (Ambersorb) Treatment System
This option replaces the AS system with an equalization tank and pump to regulate flow to 10 gpm. This option assumes a self-contained system fabricated off site in a Conex and delivered to the site as a turnkey system. The flow will be directed to two of three synthetic media vessels loaded with Ambersorb 560. This media will sorb all contaminants of concern (COCs) in the water stream in a lead/lag configuration. Once spent, the lead vessel will be thermally regenerated with steam to release sorbed chemicals, forming a contaminant concentrate that will be collected in a storage tank and subsequently sorbed to carbon for solidification and off Site disposal. The regenerated vessel will be available to take the lag position once samples show break through between the active lead and lag vessels. The treated water will discharge via gravity to the existing outfall. Resin regeneration and associated waste volume reduction (spent GAC vs. spent resin) greatly reduces annual O&M costs for this technology.

Option 4: Advanced Oxidation Process (AOP) System
This option replaces the AS system with an equalization tank and pump to regulate flow to 10 gpm like the other options. It is assumed the unit would be fabricated off site in a Conex and delivered as a turnkey system. The flow will be directed through an in-line mixer that will feed a fixed proportion of hydrogen peroxide into the inlet stream. The hydrogen peroxide will be activated utilizing ozone injection and mixing. The ozone will be generated onsite utilizing a rotary screw air compressor with receiver, air dryer, pressure swing oxygen concentrator and coronal discharge ozone generator(s). The ozone will be injected through several plug flow reactors as determined by a pilot study to mineralize all COCs by advanced oxidation. The advanced oxidation process (AOP) treated water will then discharge via gravity to the exiting outfall.

This option comes with potential health and safety hazards that the other options don't present. This option requires delivery and handling of hydrogen peroxide on a regular basis. The handling and storage of hydrogen peroxide requires site-specific safety training in addition to on site safety showers and eye wash stations. The potential for ozone leaks would also require real time monitoring and alarms to allow for automatic system shut down in the event of a leak.

Preferred Option
All of the options evaluated are capable of providing the treatment needed to reduce 1,4-D to below the groundwater standard of 1.0 ug/L. Capital and annual operation, maintenance and monitoring (OM&M) costs for each option are provided in the attached tables and summarized below.

Option	Description	Capital	Annual O&M
1	Retain Air Stripper and Add Carbon Treatment System	$208,200	$106,970
2	Replace Air Stripper with Carbon Treatment System	$203,700	$102,570
3	Resin (Ambersorb) Treatment System	$820,600	$144,990
4	Advanced Oxidation Process (AOP) System	$871,475	$368,970

The lowest cost options by a significant margin for both capital and annual O&M are Options 1 and 2 which include activated carbon to remove 1,4-D. Because 1,4-D is the limiting compound for carbon life for both Options 1 and 2, retaining the air stripper to remove VOCs provides no added benefit and could actually shorten carbon life due to enhanced fouling by oxygenating the water prior to carbon treatment.

A carbon treatment pilot test is recommended to demonstrate performance and confirm design criteria for the final system. The pilot system consists of a small scale group of three GAC columns. Site groundwater will be passed through the columns at a continuous, low flow rate to simulate performance of the full scale system. Time series influent, mid-column and effluent samples will be collected and analyzed for VOCs and 1,4-D to evaluate system breakthrough curve dynamics for full scale implementation. The pilot test duration is estimated to take 45 to 90 days to complete. A conceptual system drawing for the preferred treatment system option (Option 2) is attached as Figure 1. Revised treatment system design plans will be submitted for NYSDEC approval after pilot testing has been completed.

Please feel free to contact me, if you have any questions.

Tetra Tech, Inc.

Michael R. Noel, P.G.
Vice President, Principal Hydrogeologist

Enclosure

cc: Dan Tucholski, Bureau of Environmental Exposure Investigation - NYSDOH
Bob Gibson, General Electric Company
Richard Mator, Bristol-Myers Squibb Company

CALCULATIONS FOR CARBON VESSEL BREAKTHROUGH

Carbon Breakthrough Calculations

A point of entry treatment (POET) system has been operating on a residential supply well located downgradient of the property. The system contains three carbon vessels in series, each with a volume of 5.61 gallons empty. Each vessel is filled with approximately 54 pounds of Calgon Centaur Catalytic Carbon to remove volatile organic compounds (VOCs) and metals from the extracted groundwater to make the treated water potable. In April 2020, the POET system was sampled for 1,4-dioxane (1,4-D) in addition to routine parameters. During the initial sampling event, three samples were collected from the system: system influent, after the initial vessel (Mid A) and system effluent. The effluent of the second vessel (Mid B) was added in subsequent events. This data is summarized on Table 1 and includes the dates of carbon change-outs and observed flow. Note that all three of the carbon vessels are replaced with virgin carbon during each change-out. The system has effectively removed 1,4-D to below the laboratory method detection limit of 0.07 micrograms per liter (ug/L) during all sample events with an average flow of 242 gallons per day (GPD) based on system flow totalizer readings recorded and shown on Table 1.

Because of the POET system's observed success in removing 1,4-D, a carbon usage rate calculation was requested for the system, including a comparison of the system's observed loading rates against the carbon manufacturer's recommendations for Centaur Catalytic Carbon based on the carbon's characteristics. The initial model results for all compounds of concern (COCs) detected in the influent stream consisted of the following in order of elution:

- 1,4-Dioxane – 72 ug/L
- Vinyl Chloride – 24 ug/L
- trans-1,2-Dichloroethene – 0.67 ug/L
- 1,1,1-Trichloroethane - 2.7 ug/L
- cis-1,2-Dichloroethene – 160 ug/L
- 1,1-Dichloroethane – 23 ug/L
- Trichloroethylene – 4.1 ug/L

Based on the modeling, 1,4-D is the first to breakthrough and, thus, is designated the design compound for sorption.

As summarized in Table 1, using the carbon consumption rate of 2.356 pounds/1000 gallons treated demonstrates a reasonable prediction in initial carbon breakthrough with significant values found after the lead vessel when 46.75 to 59.87 pounds are used. It also shows that a lead, mid, lag configuration of three carbon vessels results in no detectible 1,4-D in the final effluent.

Based on the POET system's observed success at removing 1,4-D from groundwater extracted from the residential supply well, carbon treatment was evaluated as a treatment alternative to remove 1,4-D from groundwater extracted by the Abandon Solvent Saver Site's groundwater collection and treatment system (GCTS). The GCTS has an average operational flow rate of 800 GPD and the treatment train, which employs air stripping for removal of VOCs, was not designed for removal of 1,4-D. Note that a significantly higher flow rate would make carbon treatment for 1,4-D impractical and, under normal circumstances, would not be considered. Since successful use of three carbon vessels in series has been demonstrated in the POET system, an equalization tank will be used to collect water and allow for a low pumping rate of 10 gallons per minute (GPM) through the GCTS. This will result in an empty bed contact time of greater than 20 minutes per vessel. The carbon manufacturer recommended virgin coconut shell carbon (OLC 12x40) due to its better sorption characteristics over the Centaur Catalytic Carbon product. OLC 12x40 has a 1,4-D carbon consumption rate of 1.713 pounds/1000 gallons treated, resulting in a longer life. If a significant total organic carbon (TOC) load exists in the GCTS influent, the bed life could be further reduced. To account for this, the carbon consumption rate was calculated for groundwater that contains TOC at a concentration of 10 ug/L [OLC 12X40 (High TOC)] to show the worst case. However, this is not anticipated based on likely conditions at the site. The breakthrough time frames calculated are shown on Table 2 and summarized below:

- OLC 12X40 - greater than 1 year for initial vessel breakthrough.
- Centaur – 310 days for initial vessel breakthrough.
- OLC 12X40 (High TOC) - 85 days for initial vessel breakthrough.

Based on these results, it is proposed to adopt an annual change-out of one carbon vessel with the mid vessel becoming the new lead, the lag vessel becoming the new mid, and the changed vessel becoming the new lag vessel. The effluent of the lag vessel would discharge to a storage tank to provide clean water for replaced carbon saturation and flushing activities during carbon change-outs. Excess treated water from the storage tank will gravity flow to the outfall. Figure 1 shows the anticipated system process flow diagram.

A pilot study column is recommended by the carbon manufacturer to determine actual carbon consumption rates by the redesigned GCTS. Based on experience with modeling, the modeled values are typically conservative, providing for longer operations between change-outs. For the purposes of the operational cost estimates, annual change-outs were anticipated.

Tables

Residential Sampling Results with Modeled Consumption

	1,4-Dioxane Samples													
Carbon Replacement Date	Sample Date	Influent	Mid A	Lead Vessel Breakthrough	Mid B	Second Vessel Breakthrough	Effluent	Days	Daily Flow	Volume Treated	Loading Mass	Model Carbon Usage At 72 ppb	Carbon Used	Beds Consumed
		ug/L	ug/L	%	ug/L	%	ug/L	-	GPD	Gallon	Grams	Lb/1000 Gallons	Lbs	54 Lbs/bed
1/14/2020	4/28/2020	46	**41**	89%	NS	NA	0.07 U	105	242	25410	**4.423551**	2.356	59.87	**1.11**
6/19/2020	8/4/2020	42	**11**	26%	0.07 U	0%	0.07 U	46	242	11132	1.76942	2.356	26.23	0.49
9/11/2020	10/27/2020	55	**0.77**	1%	0.07 U	0%	0.07 U	46	242	11132	2.317098	2.356	26.23	0.49
12/17/2020	1/6/2021	67	**1.2**	2%	0.07 U	0%	0.07 U	20	242	4840	1.227238	2.356	11.40	**0.21**
12/17/2020	3/9/2021	76	**26**	34%	**0.73**	3%	0.07 U	82	242	19844	**5.707571**	2.356	46.75	**0.87**
3/17/2021	4/6/2021	42	0.021	0%	0.07 U	0%	0.07 U	20	242	4840	0.769313	2.356	11.40	**0.21**
6/21/2021	7/8/2021	42	**1.9**	5%	0.07 U	0%	0.07 U	17	242	4114	0.653916	2.356	9.69	**0.18**

NS- Not Sampled

NA- Not Availble

Totalizer Data			
	Gallons	Days	GPD
1/15/2020	2347350	3747	228.6
4/28/2020	2371000	3851	227.4
7/21/2020	2393890	3935	272.5
1/6/2021	2430990	4104	219.5
3/9/2021	NM	4166	216.4
4/6/2021	2450190	4194	213.3
7/8/2021	2479580	4287	316.0
		Average Flow	**242.0**

Vessel	Bed Volume	5.61	Gallon/Vessel
Centaur Density	g/cc	0.56	
	Gram/Gallon	4359.824	
	Pound/Gallon	9.61341192	
	Pound/Bed	53.93124087	

Estimated Exhaustion Mass Singel Vessel		
4.66	Grams	100%

Table 2. Carbon Consumption Rate at 72 ug/L 1,4-Dioxane

	Carbon Type	OLC 12x40		Centaur		OLC 12x40 (High TOC)	
Day	Volume Treated (1000 gal)	Carbon Used (lbs/1000 gal)	Vessels Used (1000 Lb)	Carbon Used (lbs/1000 gal)	Vessels Used (1000 Lb)	Carbon Used (lbs/1000 gal)	Vessels Used (1000 Lb)
Quarter 1							
0	0	0	0	0	0	0	0
5	4	6.9	0	16.3	0	61.9	0
10	8	13.7	0	32.3	0	122.7	0
15	12	20.6	0	48.5	0	184.3	0
20	16	27.4	0	64.6	0	245.5	0
25	20	34.3	0	80.8	0	307	0
30	24	41.1	0	96.8	0	367.8	0
35	28	48	0	113.1	0	429.8	0
40	32	54.8	0	129.1	0	490.6	0
45	36	61.7	0	145.4	0	552.5	0
50	40	68.5	0	161.4	0	613.3	0
55	44	75.4	0	177.6	0	674.9	0
60	48	82.2	0	193.7	0	736.1	0
65	52	89.1	0	209.9	0	797.6	0
70	56	95.9	0	225.9	0	858.4	0
75	60	102.8	0	242.2	0	920.4	0
80	64	109.6	0	258.2	0	981.2	0
85	68	116.5	0	274.5	0	1043.1	**1**
90	72	123.3	0	290.5	0	1103.9	**1**
Quarter 2							
95	76	130.2	0	306.8	0	1165.8	**1**
100	80	137	0	322.8	0	1226.6	**1**
105	84	143.9	0	339	0	1288.2	**1**
110	88	150.7	0	355	0	1349	**1**
115	92	157.6	0	371.3	0	1410.9	**1**
120	96	164.4	0	387.3	0	1471.7	**1**
125	100	171.3	0	403.6	0	1533.7	**1**
130	104	178.2	0	419.8	0	1595.2	**1**
135	108	185	0	435.9	0	1656.4	**1**
140	112	191.9	0	452.1	0	1718	**1**
145	116	198.7	0	468.1	0	1778.8	**1**
150	120	205.6	0	484.4	0	1840.7	**1**
155	124	212.4	0	500.4	0	1901.5	**1**
160	128	219.3	0	516.7	0	1963.5	**1**
165	132	226.1	0	532.7	0	2024.3	**2**
170	136	233	0	548.9	0	2085.8	**2**
175	140	239.8	0	565	0	2147	**2**
180	144	246.7	0	581.2	0	2208.6	**2**

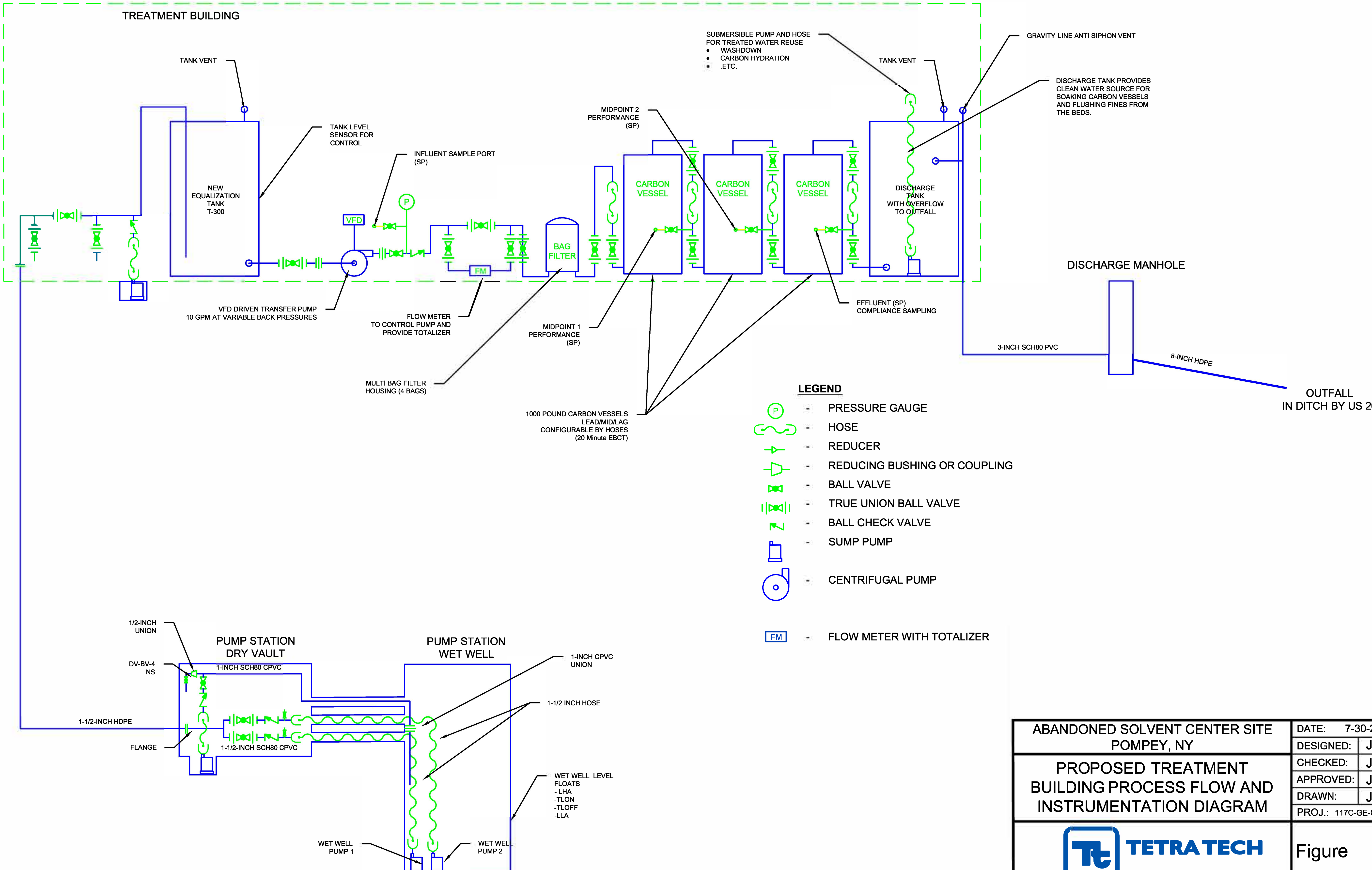
1000 Lb Carbon Vessels - 3 in Series
OLC 12X40: 1.713 Lbs/1000 Gal
Centaur: 2.356 Lbs/1000 Gal
OLC 12X40 (High TOC): 3.8 Lbs/1000 Gal

Table 2. Carbon Consumption Rate at 72 ug/L 1,4-Dioxane

	Carbon Type	OLC 12x40		Centaur		OLC 12x40 (High TOC)	
Day	Volume Treated (1000 gal)	Carbon Used (lbs/1000 gal)	Vessels Used (1000 Lb)	Carbon Used (lbs/1000 gal)	Vessels Used (1000 Lb)	Carbon Used (lbs/1000 gal)	Vessels Used (1000 Lb)
Quarter 3							
185	148	253.5	0	597.2	0	2269.4	**2**
190	152	260.4	0	613.5	0	2331.3	**2**
195	156	267.2	0	629.5	0	2392.1	**2**
200	160	274.1	0	645.8	0	2454	**2**
205	164	280.9	0	661.8	0	2514.8	**2**
210	168	287.8	0	678.1	0	2576.8	**2**
215	172	294.6	0	694.1	0	2637.6	**2**
220	176	301.5	0	710.3	0	2699.1	**2**
225	180	308.3	0	726.4	0	2760.3	**2**
230	184	315.2	0	742.6	0	2821.9	**2**
235	188	322	0	758.6	0	2882.7	**2**
240	192	328.9	0	774.9	0	2944.6	**2**
245	196	335.7	0	790.9	0	3005.4	**3**
250	200	342.6	0	807.2	0	3067.4	**3**
255	204	349.5	0	823.4	0	3128.9	**3**
260	208	356.3	0	839.4	0	3189.7	**3**
265	212	363.2	0	855.7	0	3251.7	**3**
270	216	370	0	871.7	0	3312.5	**3**
Quarter 4							
275	220	376.9	0	888	0	3374.4	**3**
280	224	383.7	0	904	0	3435.2	**3**
285	228	390.6	0	920.3	0	3497.1	**3**
290	232	397.4	0	936.3	0	3557.9	**3**
295	236	404.3	0	952.5	0	3619.5	**3**
300	240	411.1	0	968.6	0	3680.7	**3**
305	244	418	0	984.8	0	3742.2	**3**
310	248	424.8	0	1000.8	**1**	3803	**3**
315	252	431.7	0	1017.1	**1**	3865	**3**
320	256	438.5	0	1033.1	**1**	3925.8	**3**
325	260	445.4	0	1049.4	**1**	3987.7	**3**
330	264	452.2	0	1065.4	**1**	4048.5	**4**
335	268	459.1	0	1081.6	**1**	4110.1	**4**
340	272	465.9	0	1097.7	**1**	4171.3	**4**
345	276	472.8	0	1113.9	**1**	4232.8	**4**
350	280	479.6	0	1129.9	**1**	4293.6	**4**
355	284	486.5	0	1146.2	**1**	4355.6	**4**
360	288	493.3	0	1162.2	**1**	4416.4	**4**
365	292	500.2	0	1178.5	**1**	4478.3	**4**

1000 Lb Carbon Vessels - 3 in Series
OLC 12X40: 1.713 Lbs/1000 Gal
Centaur: 2.356 Lbs/1000 Gal
OLC 12X40 (High TOC): 3.8 Lbs/1000 Gal

CONCEPTUAL SYSTEM DRAWING



ABANDONED SOLVENT CENTER SITE POMPEY, NY	DATE: 7-30-21
	DESIGNED: JRD
PROPOSED TREATMENT BUILDING PROCESS FLOW AND INSTRUMENTATION DIAGRAM	CHECKED: JRD
	APPROVED: JRD
	DRAWN: JRD
	PROJ.: 117C-GE-00070
TETRA TECH	Figure 1

C:\USERS\JAMIE.DICKSON\DOCUMENTS\GE POMPEY\CAD\TREATMENT BUILDING PF&ID CARBON.DWG

COST ESTIMATES FOR TREATMENT OPTIONS

Option 1. Retain Air Stripper and Add Carbon Treatment System						
Capital Costs	**Unit Cost**		**Unit**	**Quantity**	**Total**	
Pilot Column Study (on-site)	$	20,000	LS	1	$	20,000
Carbon Vessels	$	17,000	EA	3	$	51,000
Activated Carbon	$	2	Lb	3000	$	6,000
Additional Pump Back End	$	2,000	EA	1	$	2,000
Misc Piping and Installation	$	6,000	LS	1	$	6,000
EQ Tank (Dual Wall 1000 gallon)	$	3,000	EA	1	$	3,000
Controls (PLC with integrated 5 gpm VFD)	$	25,000	LS	1	$	25,000
Pump (VFD 5 gpm Feed Pump)	$	2,000	EA	1	$	2,000
Flow Meter	$	3,000	EA	1	$	3,000
Bag Filters (4 bag unit)	$	3,000	EA	1	$	3,000
Sensephone Upgrade	$	2,500	EA	1	$	2,500
Roof Repairs/Access Hatch	$	5,000	LS	1	$	5,000
Installation (Mechanical/Electrical)	$	10,000	LS	1	$	10,000
Floats	$	300	EA	1	$	300.00
Subtotal					$	138,800
Engineering & Contingency						
Permitting & Design (20%)					$	27,760
Construction Oversight (15%)					$	20,820
Contingency (15%)					$	20,820
SubTotal					$	69,400
Total Capital				**Total**	**$**	**208,200**
Annual OM&M Costs	**Unit Cost**		**Unit**	**Quantity**	**Total**	
Carbon Characterization Sample/Profile	$	1,800	EA	1	$	1,800
GAC Change Service	$	5,000	EA	1	$	5,000
Activated Carbon	$	2	Lb	1000	$	2,000
Electricity (w/ A/S)	$	2,400	Annual	1	$	2,400
Cellular Data Plan	$	100	Month	12	$	1,200
O&M System (twice monthly, 4 alarm responses)	$	815	Visit	28	$	22,820
Acid	$	800	Annual	1	$	800
AS Cleaning	$	2,000	Annual	1	$	2,000
Mowing	$	2,000	Annual	1	$	2,000
Plowing	$	350	Annual	1	$	350
Scalisi GAC	$	6,000	Annual	1	$	6,000
Bumpus GAC	$	2,300	Annual	1	$	2,300
Monitoring & Reporting	$	58,300	Annual	1	$	58,300
Total Annual OM&M				**Total**	**$**	**106,970**
Simple NPV (30 years)					**$**	**3,417,300**

Option 2. Replace Air Stripper with Carbon Treatment System				
Capital Costs	**Unit Cost**	**Unit**	**Quantity**	**Total**
Pilot Column Study (on-site)	$ 20,000	LS	1	$ 20,000
Carbon Vessels	$ 17,000	EA	3	$ 51,000
Activated Carbon	$ 2.00	Lb	3000	$ 6,000
Misc Piping and Installation	$ 5,000	LS	1	$ 5,000
EQ Tank (Dual Wall 1000 gallon)	$ 3,000	EA	1	$ 3,000
Controls (PLC with integrated 5 gpm VFD)	$ 25,000	LS	1	$ 25,000
Pump (VFD 5 gpm Feed Pump)	$ 2,000	EA	1	$ 2,000
Flow Meter	$ 3,000	EA	1	$ 3,000
Bag Filters (4 bag unit)	$ 3,000	EA	1	$ 3,000
Sensephone Upgrade	$ 2,500	EA	1	$ 2,500
Roof Repairs/Access Hatch	$ 5,000	LS	1	$ 5,000
Installation (Mechanical/Electrical)	$ 10,000	LS	1	$ 10,000
Floats	$ 300	EA	1	$ 300
Subtotal				**$ 135,800**
Engineering & Contingency				
Permitting & Design (20%)				$ 27,160
Construction Oversight (15%)				$ 20,370
Contingency (15%)				$ 20,370
Subtotal				**$ 67,900**
Total Capital			**Total**	**$ 203,700**
Annual OM&M Costs	**Unit Cost**	**Unit**	**Quantity**	**Total**
Carbon Characterization Sample/Profile	$ 1,800	EA	1	$ 1,800
GAC Change Service	$ 5,000	EA	1	$ 5,000
Activated Carbon	$ 2	Lb	1000	$ 2,000
Electricity (no A/S)	$ 800	Annual	1	$ 800
Cellular Data Plan	$ 100	Month	12	$ 1,200
O&M System (monthly, 2 alarm responses)	$ 815	Visit	28	$ 22,820
Mowing	$ 2,000	Annual	1	$ 2,000
Plowing	$ 350	Annual	1	$ 350
Scalisi GAC	$ 6,000	Annual	1	$ 6,000
Bumpus GAC	$ 2,300	Annual	1	$ 2,300
Monitoring & Reporting	$ 58,300	Annual	1	$ 58,300
Total Annual OM&M			**Total**	**$ 102,570**
Simple NPV (30 years)				**$ 3,280,800**

Option 3. Resin (Ambersorb) Treatment System				
Capital Costs	**Unit Cost**	**Unit**	**Quantity**	**Total**
Containerized System	$538,000	LS	1	$ 538,000
Misc Piping and Installation	$ 5,000	LS	1	$ 5,000
EQ Tank (Dual Wall 1000 gallon)	$ 3,000	EA	1	$ 3,000
Controls (PLC with integrated 5 gpm VFD)	$ 25,000	LS	1	$ 25,000
Pump (VFD 5 gpm Feed Pump)	$ 2,000	EA	1	$ 2,000
Flow Meter	$ 3,000	EA	1	$ 3,000
Bag Filters (4 bag unit)	$ 3,000	EA	1	$ 3,000
Sensephone Upgrade	$ 2,500	EA	1	$ 2,500
Roof Repairs/Access Hatch	$ 5,000	LS	1	$ 5,000
Installation (Mechanical/Electrical)	$ 10,000	LS	1	$ 10,000
Floats	$ 300	EA	1	$ 300
Subtotal				**$ 596,800**
Engineering & Contingency				
Permitting & Design (15%)				$ 89,520
Construction Oversight (7.5%)				$ 44,760
Contingency (15%)				$ 89,520
Subtotal				**$ 223,800**
Total Capital			**Total**	**$ 820,600**
Annual OM&M Costs	**Unit Cost**	**Unit**	**Quantity**	**Total**
Monthly Regeneration (electricity included)	$ 5,000	Month	12	$ 60,000
Disposal (concentrate)	$ 1,000	Annual	1	$ 1,000
Electricity	$ 800	Annual	1	$ 800
Cellular Data Plan	$ 100	Month	12	$ 1,200
O&M System (monthly, 4 alarm responses)	$ 815	Visit	16	$ 13,040
Mowing	$ 2,000	Annual	1	$ 2,000
Plowing	$ 350	Annual	1	$ 350
Scalisi GAC	$ 6,000	Annual	1	$ 6,000
Bumpus GAC	$ 2,300	Annual	1	$ 2,300
Monitoring & Reporting	$ 58,300	Annual	1	$ 58,300
Total Annual OM&M			**Total**	**$ 144,990**
Simple NPV (30 years)				**$ 5,170,300**

Option 4. Advanced Oxidation Process (AOP) System						
Capital Costs	**Unit Cost**		**Unit**	**Quantity**	**Total**	
Containerized AOP Unit	$	500,000	LS	1	$	500,000
Ancillary Equipment	$	75,000	LS	1	$	75,000
Misc Piping and Installation	$	5,000	LS	1	$	5,000
EQ Tank (Dual Wall 1000 gallon)	$	3,000	EA	1	$	3,000
Controls (PLC with integrated 5 gpm VFD)	$	25,000	LS	1	$	25,000
Pump (VFD 5 gpm Feed Pump)	$	2,000	EA	1	$	2,000
Flow Meter	$	3,000	EA	1	$	3,000
Bag Filters (4 bag unit)	$	3,000	EA	1	$	3,000
Sensephone Upgrade	$	2,500	EA	1	$	2,500
Roof Repairs/Access Hatch	$	5,000	LS	1	$	5,000
Installation (Mechanical/Electrical)	$	10,000	LS	1	$	10,000
Floats	$	300	EA	1	$	300
Subtotal					**$**	**633,800**
Engineering & Contingency						
Permitting & Design (15%)					$	95,070
Construction Oversight (7.5%)					$	47,535
Contingency (15%)					$	95,070
Subtotal					**$**	**237,675**
Total Capital				**Total**	**$**	**871,475**
Annual OM&M Costs	**Unit Cost**		**Unit**	**Quantity**	**Total**	
Monthly AOP Operating Cost	$	20,000	Month	12	$	240,000
Consumables	$	3,000	Month	12	$	36,000
Cellular Data Plan	$	100	Month	12	$	1,200
O&M System (twice monthly, 4 alarm responses)	$	815	Visit	28	$	22,820
Mowing	$	2,000	Annual	1	$	2,000
Plowing	$	350	Annual	1	$	350
Scalisi GAC	$	6,000	Annual	1	$	6,000
Bumpus GAC	$	2,300	Annual	1	$	2,300
Monitoring & Reporting	$	58,300	Annual	1	$	58,300
Total Annual OM&M				**Total**	**$**	**368,970**
Simple NPV (30 years)					**$**	**11,940,575**