City of Thornton

WES BROWN WTP AND THORNTON WTP PFAS STUDY

FINAL | July 2023

carollo

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Abbreviations

AACE	Advancement of Cost Engineering
cm^{-1}	reciprocal centimeter
DOC	dissolved organic carbon
EBCT	empty bed contact time
EGL	East Gravel Lake
EPA	Environmental Protection Agency
GAC	granular activated carbon
gpm/sq ft	gallons per minute per square foot
HCl	hydrogen chloride
HFPO-DA	hexafluoropropylene oxide dimer acid (GenX chemicals)
IX	ion exchange
M	million
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MG	million gallons
mgd	million gallons per day
mg/L	milligrams per liter
mm	millimeters
$NaClO_2$	sodium chlorite
NaOCl	sodium hypochlorite
NF	nanofiltration
ng/L	nanograms per liter
No.	number
NPDWR	National Primary Drinking Water Regulation
NPV	net present value
NSF	National Science Foundation
OCWD	Orange County Water District
O&M	operation and maintenance
PAC	powdered activated carbon
PFAS	per- and polyfluoroalkyl substances
PFBS	perfluorobutanesulfonic acid
PFHxS	perfluorohexanesulfonic acid
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonic acid
ppd	pounds per day

psi	pounds per square inch
RO	reverse osmosis
sq ft	square feet
SU	Standard Unit
TDS	total dissolved solids
Thornton	City of Thornton
TOC	total organic carbon
TWTP	Thornton Water Treatment Plant
WBWTP	Wes Brown Water Treatment Plant
WGL	West Gravel Lake
WPF	water purification facility
WTF	water treatment facility

Section 1

INTRODUCTION

1.1 Background

Per- and polyfluoroalkyl substances (PFAS) constitute a large family of manufactured chemicals that have been extensively used in a wide range of industrial and domestic applications since the 1940s. Because of their unique physical and chemical properties, PFAS have been used in a variety of products, including nonstick cookware, waterproof clothing, and firefighting foams. PFAS are chemically, biologically, and thermally stable, and can accumulate in people, animals, and the environment over time. Today, PFAS are ubiquitously present in every stage of the water cycle, soil, air, and food as well as in everyday consumer products at trace concentration levels (i.e., parts per trillion or nanograms per liter [ng/L]).

1.2 Regulations

In March of 2023, the Environmental Protection Agency (EPA) announced the proposed National Primary Drinking Water Regulation (NPDWR) for six PFAS compounds in drinking water as listed in Table 1.

Table 1 Proposed NPDWR for PFAS

Compound	Proposed MCL (enforceable levels)	Proposed MCLG (health based, non-enforceable)
Perfluorooctanoic Acid (PFOA)	4 ng/L	Zero
Perfluorooctane Sulfonic Acid (PFOS)	4 ng/L	Zero
Perfluorononanoic Acid (PFNA)	1.0 (unitless) Hazard Index	1.0 (unitless) Hazard Index
Perfluorohexane Sulfonic Acid (PFHxS)		
Perfluorobutane Sulfonic Acid (PFBS)		
Hexafluoropropylene Oxide Dimer Acid (HFPO-DA) (commonly referred to as GenX chemicals)		

Notes:
MCL maximum contaminant level MCLG maximum contaminant level goal

The Hazard Index is calculated from a sum of fractions which compares the level of each PFAS measured in the water to the highest level determined not to have risk of health effects.

$$\text{Hazard Index} = \frac{\text{GenX}}{10\ \text{ng/L}} + \frac{\text{PFBS}}{2{,}000\ \text{ng/L}} + \frac{\text{PFNA}}{10\ \text{ng/L}} + \frac{\text{PFHxS}}{9\ \text{ng/L}}$$

The EPA anticipates finalizing the regulation by the end of 2023. The proposed rule would require compliance 3 years after promulgation, such that if the EPA issues a final NPDWR for PFAS by the end of 2023, actions required to comply with the rule, including installation of treatment technologies, will need to occur by 2026. A state or EPA may grant an extension of up

to an additional 2 years to comply with an NPDWR's MCL if the state or EPA determines an individual system needs additional time for capital improvements.

1.3 Source and Finished Water PFAS Levels

Recent PFAS sampling in the City of Thornton's (Thornton) water supplies shows PFAS concentration ranging from below the reporting limit of 2 ng/L in the Standley Lake supply to a median concentration of 10 ng/L of PFOA in the East Gravel Lakes (EGL) supply. Between EGL and West Gravel Lakes (WGL), PFAS occur at relatively higher concentrations in EGL. A comparison between measured levels in Thornton's water supplies and the proposed MCL (or Hazard Index health-based value) are presented in Figure 1. HFPO-DA (GenX chemicals) was consistently not detected in both source water and finished water and is not shown.

Average PFAS levels in Thornton's finished water are presented in Table 2. Average PFAS levels at the Wes Brown Water Treatment Plant (WBWTP) are below the proposed MCLs, while the Thornton Water Treatment Plant (TWTP) would exceed the MCL for PFOA.

Table 2 Average Finished Water PFAS Levels

Location	No. of Samples	PFOA (ng/L)	PFOS (ng/L)	Hazard Index
WBWTP	8	3.0	2.0	0.2
TWTP	11	4.7	2.9	0.4

In addition to PFAS concentrations in the source water, the presence of other constituents, including total organic carbon (TOC) and inorganic anions (e.g., nitrate, sulfate, alkalinity, etc.) also impact treatment technology selection and PFAS treatment performance. Table 3 summarizes the general source water quality of Standley Lake and EGL (*Owner's Advisory Services for the Water Treatment Plant Replacement Project Final Report* [Carollo Engineers, 2016]). In general, source water quality of EGL and WGL is of lower quality compared to that of the Standley Lake, with higher concentrations of TOC and salinity, which may render some advanced treatment processes (e.g., ion exchange) less viable for PFAS treatment.

Table 3 General Source Water Quality of Standley Lake and East Gravel Lake

Parameter	Units	Standley Lake			East Gravel Lake		
		Minimum	50th Percentile	Maximum	Minimum	50th Percentile	Maximum
pH	SU	6.6	8.1	9.2	7.4	8.7	9.8
Alkalinity	mg/L as $CaCO_3$	44	54	65	107	140	228
TOC	mg/L	1.1	1.7	2.8	3.8	4.9	7.6
DOC	mg/L	1.2	1.7	2.4	3.1	4.8	7.1
UV254	cm^{-1}	0.016	0.031	0.069	0.069	0.084	0.123
TDS	mg/L	139	158	200	341	443	701
Nitrate	mg/L as N	ND	0.2	0.9	ND	0.6	2.0
Chloride	mg/L	17	25	77	58	87	190
Sulfate	mg/L	10	52	98	78	121	212

Notes:
cm^{-1} reciprocal centimeter
DOC dissolved organic carbon
mg/L milligrams per liter
SU Standard Unit
TDS total dissolved solids

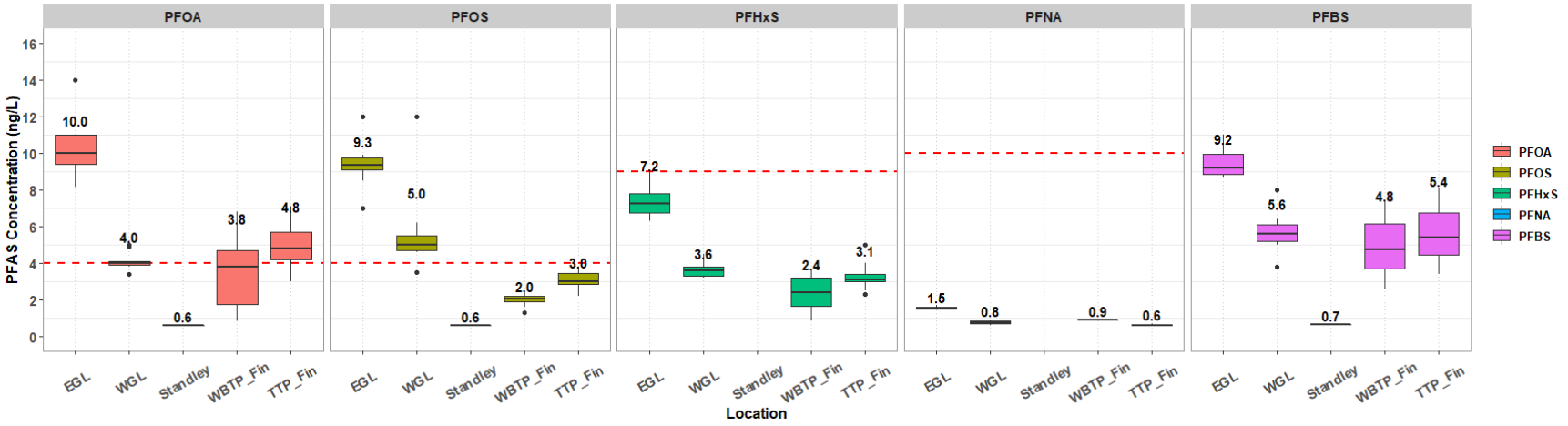

Figure 1 PFAS Occurrence in Thornton's Water Supplies

1.4 Treatment Alternatives

PFAS treatment technologies are rapidly evolving, but only a few options are currently mature and applicable for full-scale drinking water treatment. Advanced treatment processes that can effectively remove PFAS from drinking water include:

- Granular activated carbon (GAC).
- Ion exchange (IX).
- Nanofiltration (NF).
- Reverse osmosis (RO).

Each of these technologies has its own advantages and challenges. Table 4 lists the key considerations for each advanced treatment process. PFAS removal efficiency using these advanced treatment processes is site-specific and depends on the following impacting factors:

- PFAS compounds targeted for removal (e.g., PFOA, PFOS, or others).
- PFAS concentrations in the source water.
- Treatment targets.
- Influent water quality, including TOC, pH, nitrate, sulfate, chloride, TDS, etc.
- Treatment process design (e.g., empty bed contact time [EBCT] for GAC and IX, contactor configuration, etc.)

It is important to note that powdered activated carbon (PAC) has also been shown to be moderately effective at removing long-chain PFAS; however, it is not as effective for short-chain PFAS removal. Furthermore, PAC performance is significantly impacted by dose, contact time, and other water quality parameters, such as TOC. Based on limited process data that are available, PAC has reduced PFAS concentrations at WBWTP to below MCL levels on average. PAC dose and corresponding PFAS removal is presented in Figure 2. Additional paired sampling could provide further insight into PFAS treatment efficacy for different source water levels and PAC dose to determine if PAC may be a potential treatment alternative in the intermediate term.

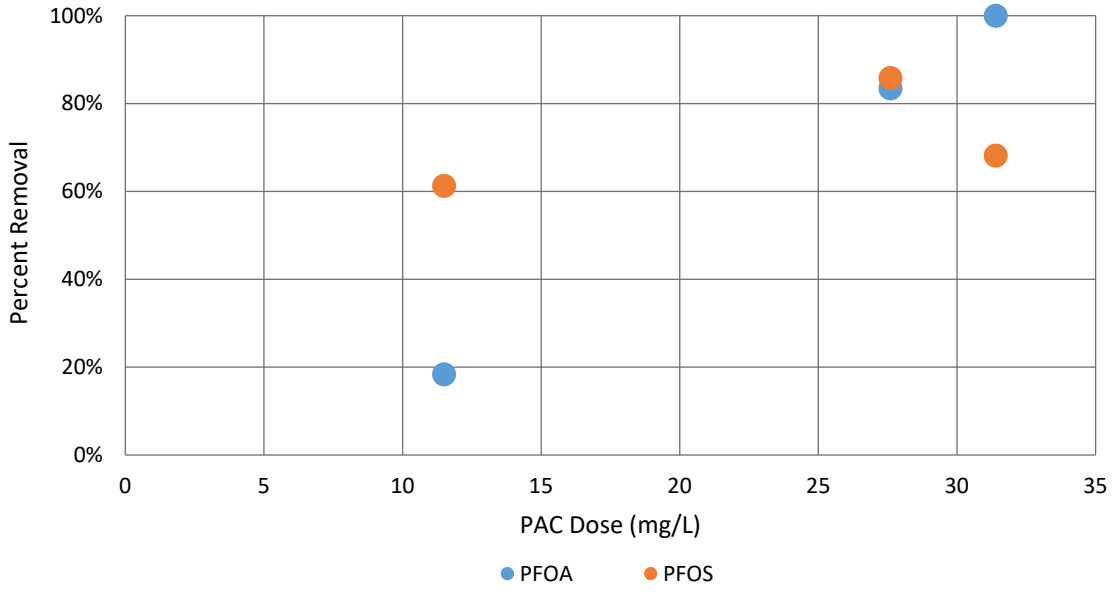

Figure 2 WBWTP PFAS Removal Utilizing PAC

In addition to activated carbon and ion exchange resin, alternative adsorbents, such as CETCO FLUORO-SORB® 200 and Cyclopure DEXSORB+® are under development for drinking water treatment. FLUORO-SORB® 200 is a National Science Foundation (NSF 61)-certified, proprietary, surface-modified bentonite clay material. Although FLUORO-SORB® 200 was recently shown to have promise in removing both long- and short-chain PFAS from pristine groundwater source in a pilot-scale treatment study conducted by the Orange County Water District (OCWD) in California, its performance in treating PFAS in surface water with relatively higher concentrations of TOC and other constituents is largely unknown. Perhaps most importantly, there is no precedent full-scale implementation of FLUORO-SORB® 200 for drinking water treatment. As a result, there is limited understanding of design and operation requirements for FLUORO-SORB® 200 and its long-term, life-cycle cost for PFAS treatment. Cyclopure DEXSORB+®, which is a renewable cyclodextrin-based material derived from corn, is in the process of pursuing NSF 61 certification and is not yet applicable for full-scale drinking water treatment.

It is important to note that these advanced treatment processes are effective in PFAS removal but not PFAS destruction. As a result, they produce PFAS-containing residuals (e.g., spent media or NF/RO concentrate) that must be properly managed. Residual management can be an important consideration when selecting a treatment technology. Common options for spent media management are off-site disposal by thermal destruction (e.g., commercial incineration or cement kilns), reactivation/regeneration for reuse, and landfilling. The currently viable practices for disposing of solids or liquid waste streams generated from PFAS treatment are discussed in Table 4 for each technology.

Destructive treatment technologies, including electrochemical oxidation, advanced reduction process, photochemical oxidation or reduction, plasma, sonolysis, etc., are still under development. Many of these emerging destructive technologies are currently being tested at either bench- or pilot-scale and are limited in treatment capacity due to the requirements for intensive energy supply or extended long reaction times to break the carbon-fluorine bond for PFAS destruction.

Table 4 Comparison of Available Drinking Water Treatment Technologies for PFAS

Technology	Advantages	Disadvantages	Residuals Management
GAC	• Effective in removing PFOA and PFOS and other long-chain PFAS. • Lower media cost on a unit mass basis compared to IX resins. • Provide a treatment barrier for other contaminants (e.g., TOC, disinfection byproduct precursors, taste and odor compounds, etc.). • Lower head loss. • Can use gravity filter design for large-scale systems. • Spent GAC can be regenerated, reactivated, and reused.	• Longer EBCT or larger system footprint. • High operation and maintenance (O&M) costs if GAC is replaced or regenerated/ reactivated frequently. • Less effective in treating shorter-chain PFAS. • GAC fouling by competing contaminants (e.g., TOC). • Non-steady state treatment process.	• Spent GAC can be returned to the vendor for regeneration and reactivation. • GAC vendors have indicated that thermal regeneration destroys greater than 99% of adsorbed PFAS. If the EPA accepts or validates this destruction, GAC would be a sustainable long-term PFAS solution. • Spent GAC can also be landfilled or incinerated.
IX	• Faster adsorption kinetics, shorter EBCT, and smaller system footprint. • Longer media life than GAC resulting in less frequent media changeout. • Higher hydraulic loading rate. • More effective in treating short-chain PFAS.	• IX resins are 3 to 5 times more expensive than GAC on a unit mass basis. • Potential resin fouling by TOC and inorganic anions (e.g., sulfate, nitrate, bicarbonate, etc.). • Increase chloride to sulfate mass ratio or corrosion potential of treated effluent. • Greater head loss. • Require pretreatment (e.g., cartridge filtration) for turbidity removal. • Resin bed cannot be backwashed. • Non-steady state treatment process. • Does not remove taste and odor compounds.	• The IX resins that work best for PFAS are non-regenerable. • Disposal through high-temperature incineration is recommended.

Technology	Advantages	Disadvantages	Residuals Management
NF/RO	• Broadly removes all measurable PFAS, including both long- and short-chain PFAS. • Removes other constituents, including TOC, salts, and pathogens. • Produces excellent treated water quality. • Steady-state treatment process.	• Produces large volume of concentrate that results in cost-prohibitive disposal. • Concentrate disposal is hard to permit given current regulatory uncertainty. • High capital cost. • High O&M cost. • Energy intensive. • Require post-membrane treatment to ensure stable finished water quality. • Pretreatment is imperative to prevent membrane fouling or scaling and reduced finished water recovery.	• Produces concentrate with about five times higher PFAS concentrations than the feedwater. • Many NF/RO systems in the nation discharge concentrate to the ocean (not suitable for Thornton). • Deep well injection is challenging to permit in Colorado. The concentrate may also require a special permitted hazardous deep injection well if PFOA and PFOS are designated as hazardous. • Concentrate could be further treated for PFAS with IX or GAC, but results in greater costs.
FLUORO-SORB®	• Media cost in between GAC and IX resin on a unit mass basis. • Short EBCT comparable to IX systems. • Comparable effectiveness in removing short-chain PFAS in groundwater as shown by the OCWD pilot-scale study.	• No precedent full-scale implementation for PFAS treatment in drinking water. • Performance in surface water treatment has not been investigated and demonstrated. • Media selectivity towards PFAS and the impact of competing co-contaminants (e.g., TOC, nitrate, sulfate, etc.) remain unknown. • Limited understanding of design criteria, operation requirements, and life cycle cost.	• Unknown due to the lack of full-scale implementations.

1.5 Technology Selection

A number of factors need to be balanced when selecting the most suitable treatment technology with site-specific considerations. For the WBWTP and TWTP, the recommended treatment approach is post filter GAC adsorbers. Rationales for this recommendation are listed in Table 5. Given the source water quality at the WBWTP and TWTP and other finished water quality goals (e.g., taste and odor compounds removal) to be achieved, both IX and NF/RO are less viable treatment options compared to GAC adsorption for both water treatment plants.

Table 5 Key Considerations for PFAS Treatment Technology Selection at WBWTP and TWTP

GAC	IX	NF/RO
• High PFOA and PFOS removal efficiency. • Relatively low capital cost compared to NF/RO. • Remove TOC and taste and odor compounds in addition to PFAS, improves overall finished water quality. • Reduce the need for PAC addition at WBWTP. • Spent GAC can be regenerated, reactivated, and reused to lower O&M cost and is a more sustainable PFAS treatment approach. • A mature advanced treatment process that has high levels of operator familiarity in drinking water treatment.	• Higher concentrations of TOC and inorganic anions in surface water are expected to cause rapid resin fouling and thus shortening media lifetime. • Few secondary water quality benefits as compared to GAC or NF/RO. • Fewer implementations in surface water treatment as compared to GAC. • Much greater head loss compared to GAC. • Potential increase in finished water corrosivity, which may require post-treatment to stabilize treated effluent. • Limited options for spent resin disposal (e.g., incineration or landfill). • Spent resin disposal feasibility and cost are subject to uncertain future regulatory requirements.	• Concentrate disposal (via sewer discharge, surface water discharge, or deep well injection) is challenging to permit in Colorado and is cost prohibitive. • Much higher capital and O&M costs compared to GAC and IX. • Low finished water recovery. • Requires post-membrane treatment to stabilize finished water quality.

GAC can be used in gravity contactors or pressure vessels. Gravity contactors are better suited to larger systems and when large pressure drops are undesirable because of their effect on existing plant hydraulics and operation costs. Pressure vessels enclose the GAC and can be operated over a wide range of flow rates because of the wide variations in pressure drop that can be used. Pressure vessels are more suited to systems with capacities of less than 10 million gallons per day (mgd). Table 6 presents a comparison between gravity filter adsorbers and pressure vessels for GAC adsorption.

Table 6 Comparison of GAC Gravity Contactors and Pressure Vessels

	Gravity Contactor	Pressure Vessel
Cost	• More cost effective than pressure vessels for facilities greater than 10 mgd of treatment capacity. • Potentially can be converted from conventional granular media filters.	• Most cost effective for facilities that require less than 10 mgd of treatment capacity. • As capacity increases, more vessels are needed, and equipment costs become less economical.
Space Requirement	• Depends on flow rate and EBCT. • For systems greater than 10 mgd, gravity filters are more compact.	• Depends on flow rate and EBCT. • For systems greater than 10 mgd, larger space requirements are needed for additional vessels and appurtenances.
Sizing	• Optimized basin sizing.	• Restricted by manufacturer vessel sizing.
O&M Requirements	• Low O&M requirements.	• Greater operational requirements for a pressurized system.
Pumping Requirements	• Hydraulic gradient established by contactor level. • May require pumping to provide sufficient EBCT and maintain plant production capacity.	• Typically require pumping of influent to feed at the top of the vessel.
Media Changeout Requirements	• Changeouts often require multiple days due to the larger size of filter boxes.	• Changeout is often simpler due to multiple loading options, such as manhole access and direct pumping of media into vessels from trucks. • GAC vendors have indicated a half-day for media changeout.
Lead-Lag Conversion Capabilities	• Conversion to lead-lag or staggered operations is more difficult	• Lead-lag or staggered configuration is readily achievable.

Figure 3 presents an example of GAC gravity filters at the Binney Water Purification Facility (WPF) with a total capacity of 50 mgd.

Figure 3 GAC Gravity Filters at Binney WPF, Aurora, CO

GAC pressure vessels at the Wyckoff WTP with a total capacity of 72 mgd and at the Klein Water Treatment Facility (WTF) with a total capacity of 14 mgd are presented in Figure 4.

Figure 4 GAC Pressure Vessels at Wyckoff WTP, Marietta, GA (72 mgd) and Klein WTF, South Adams County, CO (14 mgd)

Section 2

WBWTP TREATMENT ALTERNATIVES

Preliminary designs for potential PFAS treatment alternatives were developed for the WBWTP. The following sections include proposed design criteria, site layout, capital cost estimate, and anticipated O&M costs.

2.1 Gravity GAC Contactors – Lead/Lag

The alternative for lead/lag GAC contactors (gravity adsorbers) at WBWTP incorporates the following treatment and operations project goals:

- Provide treatment for a finished water PFAS goal of non-detect to meet the EPA's lifetime drinking water health advisories.
- A design media life of 10,000 bed volumes was utilized. This value was estimated from EGL and WGL influent water quality parameters and testing performed by Aurora Water at the Binney WPF with similar water quality.
- Provide lead/lag treatment units to better utilize the adsorptive capacity of the GAC in each treatment unit, provide redundancy for achieving the finished water PFAS goals, and reduce sampling requirements.
- Provide adequate GAC empty bed contact time so that GAC adsorbers only require media replacement once per year under current demand conditions (13.2 mgd average yearly flow rate) and twice per year under build-out demand conditions (28.2 mgd average yearly flow rate).
- Provide backwashing facilities for the new GAC adsorber units. Backwash waste will be sent to the existing WBWTP lagoons.
- Provide intermediate pump station to allow for addition of the GAC adsorption process within the existing hydraulic profile of the plant (downstream of membrane filtration and upstream of the chlorine contact chamber).
- Locate new treatment facility at the Midgordon site to the west of the existing WBWTP.

2.1.1 Design Criteria

Table 7 outlines the proposed design criteria for a lead/lag gravity GAC contactor facility at the WBWTP.

Table 7 Gravity GAC Contactors Design Criteria – Lead/Lag

Parameter	Value	Unit
Plant Flow Rates		
Process Design Capacity	50	mgd
Design Plant Flow Rate (Current Yearly Average)	13.2	mgd
Design Plant Flow Rate (Build-Out)	28.2	mgd
GAC Contactors		
Contactor Type: Gravity – Lead/Lag Operation		
Number of Contactors, Total	20	
Number of Lead Contactors	10	
Number of Lag Contactors	10	
Contactor Dimensions, Width x Length	18 x 55	feet x feet
Available Head Loss for Solids Accumulation	3	feet
Contactor Area		
Each Contactor	990	sq ft
Total	19,800	sq ft
Surface Loading Rate (at 50 mgd)		
All Contactors in Service	3.5	gpm/sq ft
One Contactor Out of Service	3.9	gpm/sq ft
Empty Bed Contact Time, Each Contactor (at 50 mgd)		
All Contactors in Service	17.1	minute
One Contactor Out of Service	15.4	minute
GAC Contactor Media		
Depth	96	inch
Effective Size	1.0	mm
Media Life		
Design Bed Volumes	10,000	
Media Life Until Exhaustion of Lead Contactors (Current)	1.2	years
Media Life Until Exhaustion of Lead Contactors (Build-Out)	0.6	years
Intermediate Pump Station		
Type: Vertical Turbine Pumps		
Number of Pumps	5 (4+1)	
Capacity, Each	12.5	mgd
Backwash Pump Station		
Type: Vertical Turbine Pumps		
Number of Pumps	2 (1+1)	
Capacity, Each	28.5	mgd

Notes:
gpm/sq ft gallons per minute per square foot sq ft square feet
mm millimeter

2.1.2 Site Layout

A preliminary site layout is presented in Figure 5. The new facility is proposed at the Midgordon site to the west of WBWTP. Future softening facilities are included in the site layout for master planning purposes.

Figure 5 WBWTP Gravity GAC Contactor Site Layout – Lead/Lag

2.1.3 Operational Considerations

The advantages and disadvantages of this alternative are presented in Table 8.

Table 8 Operational Considerations for Gravity GAC Contactors – Lead/Lag

Advantages	Disadvantages
• GAC provide robust taste and odor compound removal in addition to PFAS removal. • GAC contactors require less valves and instrumentation than pressure vessels due to the lower number of contactors required. • GAC contactors provide fewer sample locations that would be required for monitoring GAC media life due to the lower number of contactors required. • The footprint for GAC contactors is slightly smaller than the footprint for GAC pressure vessels. • Lead/lag treatment maximizes available GAC adsorption capacity. • Lead/lag treatment provides more reliable treatment when compared to single pass.	• The time required for GAC replacement is longer and is a more complicated process for gravity contactors as opposed to a pressure vessel. An additional redundant contactor has been provided to account for this challenge. • GAC contactors provide less modularity and redundancy than pressure vessels. • GAC contactors require more complicated construction (water-bearing concrete structures) compared to pressure vessels. • GAC contactor backwash flows are greater than those required for pressure vessels and require larger pumps and wet well sizing. • Lead/lag treatment requires twice as many valves, actuators, and instruments for maintenance.

2.1.4 Cost Estimate

An Association for the Advancement of Cost Engineering (AACE) International Class 4 construction cost estimate (-30 percent to +50 percent) was developed for this alternative utilizing costs from other projects of similar scope and complexity and escalated for time. Construction cost is estimated at $80 million.

2.1.5 Net Present Value

A net present value (NPV) analysis was performed to evaluate alternatives on a life-cycle cost basis. The NPV of a given alternative is a summation of present and future costs converted to present day dollars. The NPV of this alternative is estimated at $145 million. Detailed NPV analysis forms are provided in Appendix A.

2.2 Gravity GAC Contactors – Single Pass

The alternative for single pass GAC contactors (gravity adsorbers) at WBWTP incorporates the following treatment and operations project goals:

- Provide treatment to meet the EPA's proposed MCLs for six PFAS compounds in drinking water.
  - Treatment goals of both 2 ng/L and 4 ng/L were evaluated.
- A design media life of 10,000 bed volumes was utilized. This value was estimated from EGL and WGL influent water quality parameters and testing performed by Aurora Water at the Binney WPF with similar water quality.
  - Bypassing of flow was considered when historical finished water PFAS levels were below treatment goals (PAC would continue to be fed in these scenarios).
    - For PFAS levels below the treatment goal, all flow was bypassed.

  - For PFAS levels less than 150 percent of the treatment goal, 50 percent of flow was treated.
  - For PFAS levels greater than 150 percent of the treatment goal, all flow was treated.
- Provide single pass treatment units with optional recycle flow to extend GAC life.
- Provide adequate GAC empty bed contact time so that GAC adsorbers only require media replacement once per year under current demand conditions (13.2 mgd average yearly flow rate) and twice per year under build-out demand conditions (28.2 mgd average yearly flow rate) if bypassing is not utilized.
- Provide backwashing facilities for the new GAC adsorber units. Backwash waste will be sent to the existing WBWTP lagoons.
- Provide intermediate pump station to allow for addition of the GAC adsorption process within the existing hydraulic profile of the plant (downstream of membrane filtration and upstream of the chlorine contact chamber).
- Locate new treatment facility at the Midgordon site to the west of the existing WBWTP.

2.2.1 Design Criteria

Table 9 outlines the proposed design criteria for a new gravity GAC contactor facility at the WBWTP.

Table 9 Gravity GAC Contactors Design Criteria – Single Pass

Parameter	Value	Unit
Plant Flow Rates		
Process Design Capacity	50	mgd
Design Plant Flow Rate (Current Yearly Average)	13.2	mgd
Design Plant Flow Rate (Build-Out)	28.2	mgd
GAC Contactors		
Contactor Type: Gravity – Single Pass Operation		
Number of Contactors, Total	10	
Contactor Dimensions, Width x Length	18 x 55	feet x feet
Available Head Loss for Solids Accumulation	3	feet
Contactor Area		
Each Contactor	990	sq ft
Total	9,900	sq ft
Surface Loading Rate (at 50 mgd)		
All Contactors in Service	3.5	gpm/sq ft
One Contactor Out of Service	3.9	gpm/sq ft
Empty Bed Contact Time, Each Contactor (at 50 mgd)		
All Contactors in Service	17.1	minute
One Contactor Out of Service	15.4	minute
GAC Contactor Media		
Depth	96	inch
Effective Size	1.0	mm

Parameter	Value	Unit
Design Bed Volumes	10,000	
Media Life (No Bypass)		
Media Life Until Exhaustion (Current)	1.2	years
Media Life Until Exhaustion (Build-Out)	0.6	years
Media Life (2 ng/L Treatment Goal)		
Historical Finished Water Exceedance of Treatment Goal	63	%
Historical Finished Water Exceedance of 150% of Treatment Goal	50	%
GAC Bypass Flow	44	%
Media Life Until Exhaustion (Current)	2.2	years
Media Life Until Exhaustion (Build-Out)	1.0	years
Media Life (4 ng/L Treatment Goal)		
Historical Finished Water Exceedance of Treatment Goal	25	%
Historical Finished Water Exceedance of 150% of Treatment Goal	13	%
GAC Bypass Flow	81	%
Media Life Until Exhaustion (Current)	6.6	years
Media Life Until Exhaustion (Build-Out)	3.1	years
Intermediate Pump Station		
Type: Vertical Turbine Pumps		
Number of Pumps	5 (4+1)	
Capacity, Each	12.5	mgd
Backwash Pump Station		
Type: Vertical Turbine Pumps		
Number of Pumps	2 (1+1)	
Capacity, Each	28.5	mgd

2.2.2 Site Layout

A preliminary site layout is presented in Figure 6. The new facility is proposed at the Midgordon site to the west of WBWTP. Future softening facilities are included in the site layout for master planning purposes.

Figure 6 WBWTP Gravity GAC Contactor Site Layout – Single Pass

2.2.3 Operational Considerations

The advantages and disadvantages of this alternative are presented in Table 10.

Table 10 Operational Considerations for Gravity GAC Contactors - Single Pass

Advantages	Disadvantages
• GAC provide robust taste and odor compound removal in addition to PFAS removal. • GAC contactors require less valves and instrumentation than pressure vessels due to the lower number of contactors required. • GAC contactors provide fewer sample locations that would be required for monitoring GAC media life due to the lower number of contactors required. • The footprint for GAC contactors is slightly smaller than the footprint for GAC pressure vessels. • Single pass treatment requires fewer valves, actuators, and instruments for maintenance.	• The time required for GAC replacement is longer and is a more complicated process for gravity contactors as opposed to a pressure vessel. An additional redundant contactor has been provided to account for this challenge. • GAC contactors provide less modularity and redundancy than pressure vessels. • GAC contactors require more complicated construction (water-bearing concrete structures) compared to pressure vessels. • GAC contactor backwash flows are greater than those required for pressure vessels and require larger pumps and wet well sizing. • Single pass treatment requires more sampling/operator attention to meet treatment goals compared to lead/lag operation.

2.2.4 Cost Estimate

An AACE International Class 4 construction cost estimate (-30 percent to +50 percent) was developed for this alternative utilizing costs from other projects of similar scope and complexity and escalated for time. Construction cost is estimated at $50 million.

2.2.5 Net Present Value

A NPV analysis was performed to evaluate alternatives on a life-cycle cost basis. The NPV of a given alternative is a summation of present and future costs converted to present day dollars. The NPV of this alternative is estimated at:

- $95 million for a treatment goal of 2 ng/L.
- $65 million for a treatment goal of 4 ng/L.

Detailed NPV analysis forms are provided in Appendix A.

2.3 GAC Pressure Vessels – Lead/Lag

The alternative for lead/lag GAC pressure vessels at WBWTP incorporates the following treatment and operations project goals:

- Provide treatment for a finished water PFAS goal of non-detect to meet the EPA's lifetime drinking water health advisories.
- A design media life of 10,000 bed volumes was utilized. This value was estimated from EGL and WGL influent water quality parameters and testing performed by Aurora Water at the Binney WPF with similar water quality.
- Provide lead/lag treatment units to better utilize the adsorptive capacity of the GAC in each treatment unit, provide redundancy for achieving the finished water PFAS goals, and reduce sampling requirements.

- Alternative is based around Calgon Model 14 modular carbon adsorption pressure vessels with 5 pounds per square inch (psi) pressure drop across the vessel when operating at design flow rate.
- Provide adequate GAC empty bed contact time so that GAC pressure vessels only require media replacement once per year under current demand conditions (13.2 mgd average yearly flow rate) and twice per year under build-out demand conditions (28.2 mgd average yearly flow rate).
- Provide backwashing facilities for the new GAC adsorber units. Backwash waste will be sent to the existing WBWTP lagoons.
- Provide intermediate pump station to allow for addition of the GAC adsorption process within the existing hydraulic profile of the plant (downstream of membrane filtration and upstream of the chlorine contact chamber).
- Locate new treatment facility at the Midgordon site to the west of the existing WBWTP.

2.3.1 Design Criteria

Table 11 outlines the proposed design criteria for lead/lag GAC pressure vessel facility at the WBWTP.

Table 11 GAC Pressure Vessels Design Criteria – Lead/Lag

Parameter	Value	Unit
Plant Flow Rates		
Process Design Capacity	50	mgd
Design Plant Flow Rate (Current Yearly Average)	13.2	mgd
Design Plant Flow Rate (Build-Out)	28.2	mgd
GAC Contactors		
Contactor Type: Pressure Vessels – Lead/Lag Operation		
Number of Vessels, Total	66	
Number of Lead Vessels	33	
Number of Lag Vessels	33	
Vessel Dimensions		
Diameter	14	feet
Height	27	feet
Carbon per Vessel	60,000	pounds
Empty Bed Contact Time, Each Vessel (at 50 mgd)	15	minutes
Vessel Flow Rate, Maximum	1,050	gpm
Media Life		
Design Bed Volumes	10,000	
Media Life Until Exhaustion of Lead Contactors (Current)	1.2	years
Media Life Until Exhaustion of Lead Contactors (Build-Out)	0.6	years
Intermediate Pump Station		
Type: Vertical Turbine Pumps		
Number of Pumps	5 (4+1)	
Capacity, Each	12.5	mgd

Parameter	Value	Unit
Backwash Pump Station		
Type: Vertical Turbine Pumps		
Number of Pumps	2 (1+1)	
Capacity, Each	3.7	mgd

2.3.2 Site Layout

A preliminary site layout is presented in Figure 7. The new facility is proposed at the Midgordon site to the west of WBWTP. Future softening facilities are included in the site layout for master planning purposes.

Figure 7 WBWTP GAC Pressure Vessels Site Layout – Lead/Lag

2.3.3 Operating Considerations

The advantages and disadvantages of this alternative are presented in Table 12.

Table 12 Operational Considerations for GAC Pressure Vessels – Lead/Lag

Advantages	Disadvantages
• GAC provides robust taste and odor compound removal in addition to PFAS removal. • GAC replacement is a shorter and more simple process (about 4 hours) for pressure vessels as opposed to gravity contactors. Given the large number of vessels, when GAC is being replaced in a vessel, the remaining vessels can be operated at a slightly higher flow rate. • Pressure vessels provide more modularity and redundancy than gravity GAC contactors. • A pressure vessel facility is simpler to construct than GAC contactors (slab on grade with building as compared to water-bearing concrete structures). • Pressure vessels are smaller than GAC contactors and require smaller backwash pumps and wet well sizing. • Lead/lag treatment maximizes available GAC adsorption capacity. • Lead/lag treatment provides more reliable treatment when compared to single pass.	• Pressure vessels require more valves and instrumentation than gravity GAC contactors due to the greater number of contactors vessels. • Utilizing pressure vessels results in a greater number of sample locations that would be required for monitoring GAC media life due to the greater number of vessels required. • The footprint for GAC pressure vessels is slightly greater than the footprint for gravity GAC contactors. • Lead/lag treatment requires twice as many valves, actuators, and instruments for maintenance.

2.3.4 Cost Estimate

An AACE International Class 4 construction cost estimate (-30 percent to +50 percent) was developed for this alternative utilizing costs from other projects of similar scope and complexity and escalated for time. Construction cost is estimated at $100 million.

2.3.5 Net Present Value

A NPV analysis was performed to evaluate alternatives on a life-cycle cost basis. The NPV of a given alternative is a summation of present and future costs converted to present day dollars. The NPV of this alternative is estimated at $170 million. Detailed NPV analysis forms are provided in Appendix A.

2.4 GAC Pressure Vessels – Single Pass

The alternative for single pass GAC pressure vessels at WBWTP incorporates the following treatment and operations project goals:

- Provide treatment to meet the EPA's proposed MCLs for six PFAS compounds in drinking water.
  - Treatment goals of both 2 ng/L and 4 ng/L were evaluated.

- A design media life of 10,000 bed volumes was utilized. This value was estimated from EGL and WGL influent water quality parameters and testing performed by Aurora Water at the Binney WPF with similar water quality.
  - Bypassing of flow was considered when historical finished water PFAS levels were below treatment goals (PAC would continue to be fed in these scenarios).
    - For PFAS levels below the treatment goal, all flow was bypassed.
    - For PFAS levels less than 150 percent of treatment goal, 50 percent of flow was treated.
    - For PFAS levels greater than 150 percent of the treatment goal, all flow was treated.
- Provide single pass treatment units with optional recycle flow to extend GAC life.
- Alternative is based around Calgon Model 14 modular carbon adsorption pressure vessels with 5 psi pressure drop across the vessel when operating at design flow rate.
- Provide adequate GAC empty bed contact time so that GAC pressure vessels only require media replacement once per year under current demand conditions (13.2 mgd average yearly flow rate) and twice per year under build-out demand conditions (28.2 mgd average yearly flow rate) if bypassing is not utilized.
- Provide backwashing facilities for the new GAC adsorber units. Backwash waste will be sent to the existing WBWTP lagoons.
- Provide intermediate pump station to allow for addition of the GAC adsorption process within the existing hydraulic profile of the plant (downstream of membrane filtration and upstream of the chlorine contact chamber).
- Locate new treatment facility at the Midgordon site to the west of the existing WBWTP.

2.4.1 Design Criteria

Table 13 outlines the proposed design criteria for lead/lag GAC pressure vessel facility at the WBWTP.

Table 13 GAC Pressure Vessels Design Criteria – Single Pass

Parameter	Value	Unit
Plant Flow Rates		
Process Design Capacity	50	mgd
Design Plant Flow Rate (Current Yearly Average)	13.2	mgd
Design Plant Flow Rate (Build-Out)	28.2	mgd
GAC Contactors		
Contactor Type: Pressure Vessels – Single Pass Operation		
Number of Vessels, Total	33	
Vessel Dimensions		
Diameter	14	feet
Height	27	feet
Carbon per Vessel	60,000	pounds
Empty Bed Contact Time, Each Vessel (at 50 mgd)	15	minutes
Vessel Flow Rate, Maximum	1,050	gpm
Design Bed Volumes	10,000	

Parameter	Value	Unit
Media Life (No Bypass)		
Media Life Until Exhaustion (Current)	1.2	years
Media Life Until Exhaustion (Build-Out)	0.6	years
Media Life (2 ng/L Treatment Goal)		
Historical Finished Water Exceedance of Treatment Goal	63	%
Historical Finished Water Exceedance of 150% of Treatment Goal	50	%
GAC Bypass Flow	44	%
Media Life Until Exhaustion (Current)	2.2	years
Media Life Until Exhaustion (Build-Out)	1.0	years
Media Life (4 ng/L Treatment Goal)		
Historical Finished Water Exceedance of Treatment Goal	25	%
Historical Finished Water Exceedance of 150% of Treatment Goal	13	%
GAC Bypass Flow	81	%
Media Life Until Exhaustion (Current)	6.6	years
Media Life Until Exhaustion (Build-Out)	3.1	years
Intermediate Pump Station		
Type: Vertical Turbine Pumps		
Number of Pumps	5 (4+1)	
Capacity, Each	12.5	mgd
Backwash Pump Station		
Type: Vertical Turbine Pumps		
Number of Pumps	2 (1+1)	
Capacity, Each	3.7	mgd

2.4.2 Site Layout

A preliminary site layout is presented in Figure 8. The new facility is proposed at the Midgordon site to the west of WBWTP. Future softening facilities are included in the site layout for master planning purposes.

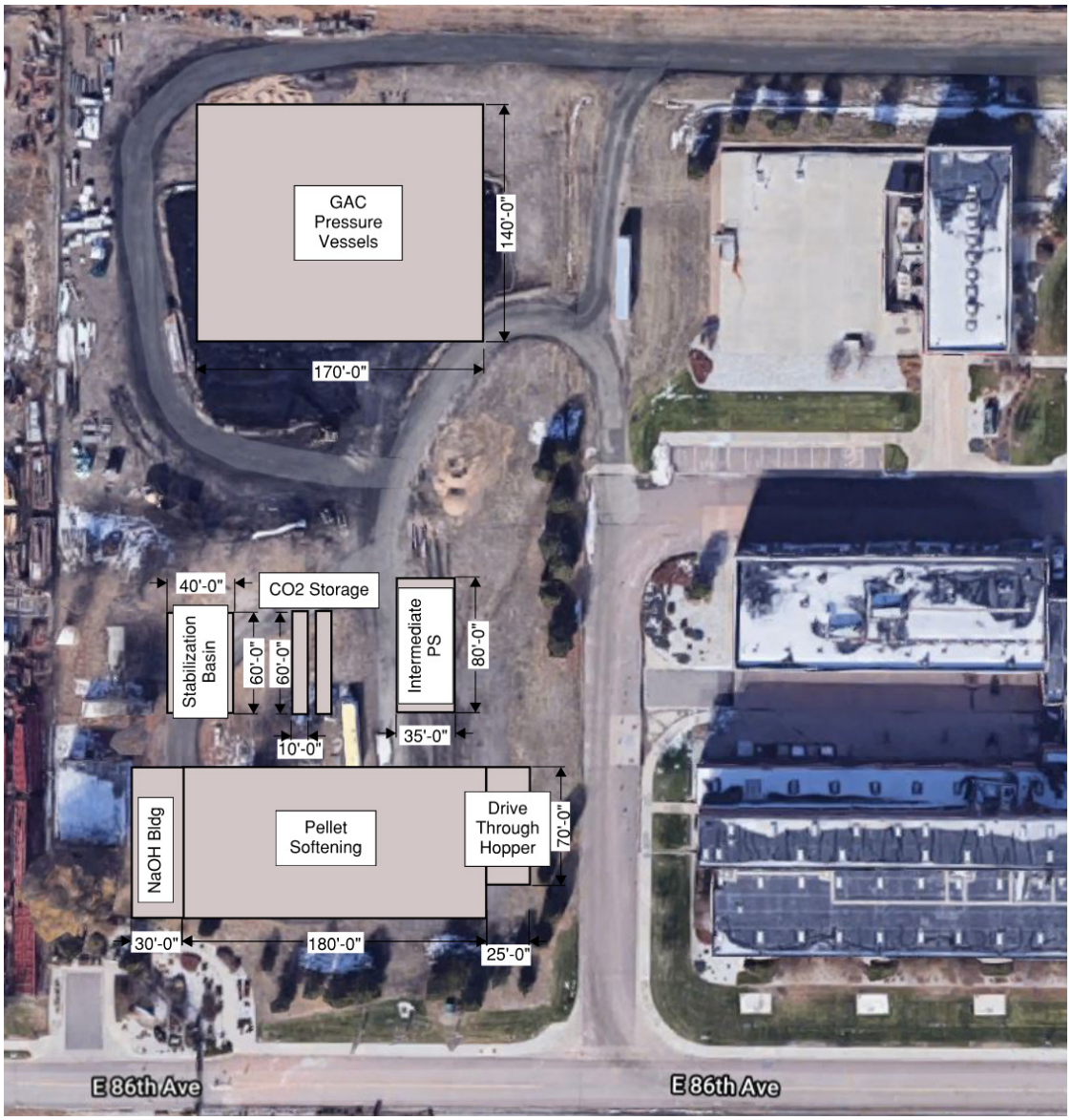

Figure 8 WBWTP GAC Pressure Vessels Site Layout – Single Pass

2.4.3 Operating Considerations

The advantages and disadvantages of this alternative are presented in Table 14.

Table 14 Operational Considerations for GAC Pressure Vessels – Single Pass

Advantages	Disadvantages
• GAC provides robust taste and odor compound removal in addition to PFAS removal. • GAC replacement is a shorter and more simple process (about 4 hours) for pressure vessels as opposed to gravity contactors. Given the large number of vessels, when GAC is being replaced in a vessel, the remaining vessels can be operated at a slightly higher flow rate. • Pressure vessels provide more modularity and redundancy than gravity GAC contactors. • A pressure vessel facility is simpler to construct than GAC contactors (slab on grade with building as compared to water-bearing concrete structures). • Pressure vessels are smaller than GAC contactors and require smaller backwash pumps and wet well sizing. • Single pass treatment requires fewer valves, actuators, and instruments for maintenance.	• Pressure vessels require more valves and instrumentation than gravity GAC contactors due to the greater number of contactors vessels. • Utilizing pressure vessels results in a greater number of sample locations that would be required for monitoring GAC media life due to the greater number of vessels required. • The footprint for GAC pressure vessels is slightly greater than the footprint for gravity GAC contactors. • Single pass treatment requires more sampling/operator attention to meet treatment goals compared to lead/lag operation.

2.4.4 Cost Estimate

An AACE International Class 4 construction cost estimate (-30 percent to +50 percent) was developed for this alternative utilizing costs from other projects of similar scope and complexity and escalated for time. Construction cost is estimated at $65 million.

2.4.5 Net Present Value

A NPV analysis was performed to evaluate alternatives on a life-cycle cost basis. The NPV of a given alternative is a summation of present and future costs converted to present day dollars. The NPV of this alternative is estimated at:

- $110 million for a treatment goal of 2 ng/L.
- $85 million for a treatment goal of 4 ng/L.

Detailed NPV analysis forms are provided in Appendix A.

Section 3

TWTP TREATMENT ALTERNATIVES

Preliminary designs for potential PFAS treatment alternatives were developed for the TWTP. The following sections include proposed design criteria, site layout, capital cost estimate, and anticipated O&M costs.

3.1 Convert Biofilters to Gravity GAC Contactors

The alternative for conversion of the existing biofilters to gravity GAC contactors at the TWTP incorporates the following treatment and operations project goals:

- Re-purposing of the existing biofilters to gravity GAC contactors with a 5.7-minute EBCT at the maximum plant process design capacity of 30 mgd. GAC would be replaced at a more frequent interval to provide continuous adsorptive capacity.
- Provide treatment to meet the EPA's proposed MCLs for six PFAS compounds in drinking water.
- A design media life of 8,000 bed volumes was utilized. The design media life for this alternative is lower than other alternatives due to the shorter empty bed contact time and inability to recycle flow to maximize GAC adsorptive capacity.
- The existing backwash supply pumps could be utilized for backwashing.
- Since biological removal of manganese across the biofilters will no longer be reliable, a chlorine dioxide system is proposed for oxidation of manganese prior to removal through the pretreatment system. This system is proposed as the existing permanganate system has not been able to reliably meet Thornton's finished water goal for manganese (<0.030 mg/L) without biological manganese removal through the filters.

3.1.1 Design Criteria

Table 15 outlines the proposed design criteria for a new GAC contactor facility at the TWTP.

Table 15 Conversion of Biofilters to Gravity GAC Contactors Design Criteria

Parameter	Value	Unit
Plant Flow Rates		
Process Design Capacity	30	mgd
Design Plant Flow Rate (Current Yearly Average)	9.6	mgd
Design Plant Flow Rate (Build-Out)	17.0	mgd
GAC Contactors		
Contactor Type: Gravity		
Number of Contactors, Total	6	
Contactor Dimensions (Width x Length)	23.5 x 27	feet x feet
Available Head Loss for Solids Accumulation	10	feet
Contactor Area		

Parameter	Value	Unit
Each Contactor	635	sq ft
Total	3,810	sq ft
Surface Loading Rate (at 30 mgd)		
All Contactors in Service	5.5	gpm/sq ft
One Contactor Out of Service	6.6	gpm/sq ft
Empty Bed Contact Time, each contactor (at 30 mgd)		
All Contactors in Service	6.8	minute
One Contactor Out of Service	5.7	minute
GAC Contactor Media		
Depth	60	inch
Effective Size	1.4	mm
Media Life		
Design Bed Volumes	8,000	
Design Treatment Volume, Total	1,139	MG
Media Life Until Exhaustion (Current)	0.3	years
Media Change Outs per Year (Current)	18.5	
Media Life Until Exhaustion (Build-Out)	0.2	years
Media Change Outs per Year (Build-Out)	32.7	
Plant Capacity Reduction		
Filters Out of Service for Media Change Out, Avg. (Current)	0.7	No.
Available Plant Capacity Due to Media Change Out (Current)	26.5	mgd
Filters Out of Service for Media Change Out, Average (Build-Out)	1.3	No.
Available Plant Capacity Due to Media Change Out (Build-Out)	23.7	mgd
Chlorine Dioxide		
Type: Three Chemical Generation (NaOCl, $NaClO_2$, HCl)		
Number of Generators	2 (1+1)	
Generator Capacity, Each	300	ppd

Notes:

HCl	hydrogen chloride	NaOCl	sodium hypochlorite
MG	million gallons	No.	number
$NaClO_2$	sodium chlorite	ppd	pounds per day

3.1.2 Site Layout

A preliminary site layout is presented in Figure 9. The new chlorine dioxide facility is proposed to the west of the TWTP.

Figure 9 TWTP GAC Contactor Conversion Site Layout

3.1.3 Operating Considerations

The advantages and disadvantages of this alternative are presented in Table 16.

Table 16 Operational Considerations for Conversion of Biofilters to Gravity GAC Contactors

Advantages	Disadvantages
• This alternative requires minimal construction costs. • No additional pumping is required for this alternative. • The remainder of the site can be preserved for future treatment and/or expansion needs. • Conversion of the existing filters to GAC contactors can be accomplished with a short construction schedule.	• Media changeout will be more challenging since the existing TWTP uses dual media filters and the sand layer will need to be preserved during changeout. • Based on required PFAS adsorption kinetics, the shorter EBCT of this alternative (5 to 7 minutes) is less optimal for PFAS adsorption. An EBCT less than 10 minutes will increase carbon use rate. • The limited EBCT results in frequent media changeout. Each filter will need to change out media three times per year initially and six times per year at build-out. The required out of service time for media changeout reduces plant capacity to 27 mgd initially and 24 mgd at build-out. • Chlorine dioxide generation and feed is more maintenance intensive than the existing permanganate system.

3.1.4 Cost Estimate

An AACE International Class 4 construction cost estimate (-30 percent to +50 percent) was developed for this alternative utilizing costs from other projects of similar scope and complexity and escalated for time. Construction cost is estimated at $6 million.

3.1.5 Net Present Value

A NPV analysis was performed to evaluate alternatives on a life-cycle cost basis. The NPV of a given alternative is a summation of present and future costs converted to present day dollars. The NPV of this alternative is estimated at $80 million. Detailed NPV analysis forms are provided in Appendix A.

3.2 GAC Gravity Contactors – Lead/Lag

The alternative for lead/lag GAC contactors (gravity adsorbers) at the TWTP incorporates the following treatment and operations project goals:

- Provide treatment for a finished water PFAS goal of non-detect to meet the EPA's lifetime drinking water health advisories.
- A design media life of 10,000 bed volumes was utilized. This value was estimated from EGL and Standley Lake influent water quality parameters and testing performed by Aurora Water at the Binney WPF with similar water quality.
- Provide lead/lag treatment units to better utilize the adsorptive capacity of the GAC in each treatment unit, provide redundancy for achieving the finished water PFAS goals, and reduce sampling requirements.
- Provide adequate GAC empty bed contact time so that GAC adsorbers only require media replacement once per year under current demand conditions (9.6 mgd average yearly flow rate) and twice per year under build-out demand conditions (17.0 mgd average yearly flow rate).
- Provide intermediate pump station to allow for addition of the GAC adsorption process within the existing hydraulic profile of the plant (downstream of biological filtration and upstream of the chlorine contact chamber).
- The GAC contactors (gravity adsorbers) have been sized so that the existing backwash supply pumps could be utilized for backwashing.
- Locate new treatment facility at the available site west of the existing TWTP.

3.2.1 Design Criteria

Table 17 outlines the proposed design criteria for a lead/lag GAC contactor (gravity adsorbers) facility at the TWTP.

Table 17 Gravity GAC Contactors Design Criteria – Lead/Lag

Parameter	Value	Unit
Plant Flow Rates		
Process Design Capacity	30	mgd
Design Plant Flow Rate (Current Yearly Average)	9.6	mgd
Design Plant Flow Rate (Build-Out)	17.0	mgd
GAC Contactors		
Contactor Type: Gravity – Lead/Lag Operation		
Number of Contactors, Total	12	
Number of Lead Contactors	6	
Number of Lag Contactors	6	
Contactor Dimensions (Width x Length)	18 x 55	feet x feet
Available Head Loss for Solids Accumulation	3	feet
Contactor Area		
Each Contactor	990	sq ft
Total	11,880	sq ft
Surface Loading Rate (at 30 mgd)		
All Contactors in Service	3.5	gpm/sq ft
One Contactor Out of Service	4.2	gpm/sq ft
Empty Bed Contact Time, Each Contactor (at 30 mgd)		
All Contactors in Service	17.1	minute
One Contactor Out of Service	14.2	minute
Empty Bed Contact Time, Total (at 30 mgd)		
All Contactors in Service	34.2	minute
One Contactor Out of Service	28.5	minute
GAC Contactor Media		
Depth	96	inch
Effective Size	1.0	mm
Media Life		
Design Bed Volumes	10,000	
Media Life Until Exhaustion of Lead Contactors (Current)	1.0	years
Media Life Until Exhaustion of Lead Contactors (Build-Out)	0.6	years
Intermediate Pump Station		
Type: Vertical Turbine Pumps		
Number of Pumps	5 (4+1)	
Capacity, Each	7.5	mgd

3.2.2 Site Layout

A preliminary site layout is presented in Figure 10. The new facility is proposed to the west of the TWTP.

Figure 10 TWTP Gravity GAC Contactor Site Layout – Lead/Lag

3.2.3 Operating Considerations

The advantages and disadvantages of this alternative are presented in Table 18.

Table 18 Operational Considerations for Gravity GAC Contactors – Lead/Lag

Advantages	Disadvantages
• GAC contactors require less valves and instrumentation than pressure vessels due to the lower number of contactors required. • GAC contactors provide fewer sample locations that would be required for monitoring GAC media life due to the lower number of contactors required. • The footprint for GAC contactors is slightly smaller than the footprint for GAC pressure vessels. • GAC contactor backwash can utilize the existing TWTP backwash supply system for the biofilters. • Lead/lag treatment maximizes available GAC adsorption capacity. • Lead/lag treatment provides more reliable treatment when compared to single pass.	• The time required for GAC replacement is longer and is a more complicated process for gravity contactors as opposed to a pressure vessel. An additional redundant contactor has been provided to account for this challenge. • GAC contactors provide less modularity and redundancy than pressure vessels. • GAC contactors require more complicated construction (water-bearing concrete structures) compared to pressure vessels. • Lead/lag treatment requires twice as many valves, actuators, and instruments for maintenance.

3.2.4 Cost Estimate

An AACE International Class 4 construction cost estimate (-30 percent to +50 percent) was developed for this alternative utilizing costs from other projects of similar scope and complexity and escalated for time. Construction cost is estimated at $50 million.

3.2.5 Net Present Value

A NPV analysis was performed to evaluate alternatives on a life-cycle cost basis. The NPV of a given alternative is a summation of present and future costs converted to present day dollars. The NPV of this alternative is estimated at $105 million. Detailed NPV analysis forms are provided in Appendix A.

3.3 GAC Gravity Contactors – Single Pass

The alternative for single pass GAC contactors (gravity adsorbers) at the TWTP incorporates the following treatment and operations project goals:

- Provide treatment to meet the EPA's proposed MCLs for six PFAS compounds in drinking water.
  - Treatment goals of both 2 ng/L and 4 ng/L were evaluated.
- A design media life of 10,000 bed volumes was utilized. This value was estimated from EGL and Standley Lake influent water quality parameters and testing performed by Aurora Water at the Binney WPF with similar water quality.
  - Bypassing of flow was considered when historical finished water PFAS levels were below treatment goals (PAC would continue to be fed in these scenarios).
    - For PFAS levels below the treatment goal, all flow was bypassed.
    - For PFAS levels less than 150 percent of the treatment goal, 50 percent of flow was treated.
    - For PFAS levels greater than 150 percent of the treatment goal, all flow was treated.
- Provide single pass treatment units with optional recycle flow to extend GAC life.
- Provide adequate GAC empty bed contact time so that GAC adsorbers only require media replacement once per year under current demand conditions (9.6 mgd average yearly flow rate) and twice per year under build-out demand conditions (17.0 mgd average yearly flow rate) if bypassing is not utilized.
- Provide intermediate pump station to allow for addition of the GAC adsorption process within the existing hydraulic profile of the plant (downstream of biological filtration and upstream of the chlorine contact chamber).
- The GAC contactors (gravity adsorbers) have been sized so that the existing backwash supply pumps could be utilized for backwashing.
- Locate new treatment facility at the available site west of the existing TWTP.

3.3.1 Design Criteria

Table 19 outlines the proposed design criteria for a single pass GAC contactor (gravity adsorbers) facility at the TWTP.

Table 19 Gravity GAC Contactors Design Criteria – Single Pass

Parameter	Value	Unit
Plant Flow Rates		
Process Design Capacity	30	mgd
Design Plant Flow Rate (Current Yearly Average)	9.6	mgd
Design Plant Flow Rate (Build-Out)	17.0	mgd
GAC Contactors		
Contactor Type: Gravity – Lead/Lag Operation		
Number of Contactors, Total	12	
Number of Lead Contactors	6	
Number of Lag Contactors	6	
Contactor Dimensions (Width x Length)	18 x 55	feet x feet
Available Head Loss for Solids Accumulation	3	feet
Contactor Area		
Each Contactor	990	sq ft
Total	11,880	sq ft
Surface Loading Rate (at 30 mgd)		
All Contactors in Service	3.5	gpm/sq ft
One Contactor Out of Service	4.2	gpm/sq ft
Empty Bed Contact Time, Each Contactor (at 30 mgd)		
All Contactors in Service	17.1	minute
One Contactor Out of Service	14.2	minute
Empty Bed Contact Time, Total (at 30 mgd)		
All Contactors in Service	34.2	minute
One Contactor Out of Service	28.5	minute
GAC Contactor Media		
Depth	96	inch
Effective Size	1.0	mm
Design Bed Volumes	10,000	
Media Life (No Bypass)		
Media Life Until Exhaustion (Current)	1.0	years
Media Life Until Exhaustion (Build-Out)	0.6	years
Media Life (2 ng/L Treatment Goal)		
Historical Finished Water Exceedance of Treatment Goal	100	%
Historical Finished Water Exceedance of 150% of Treatment Goal	91	%
GAC Bypass Flow	5	%
Media Life Until Exhaustion (Current)	1.1	years
Media Life Until Exhaustion (Build-Out)	0.6	years

Parameter	Value	Unit
Media Life (4 ng/L Treatment Goal)		
Historical Finished Water Exceedance of Treatment Goal	73	%
Historical Finished Water Exceedance of 150% of Treatment Goal	27	%
GAC Bypass Flow	50	%
Media Life Until Exhaustion (Current)	2.0	years
Media Life Until Exhaustion (Build-Out)	1.1	years
Intermediate Pump Station		
Type: Vertical Turbine Pumps		
Number of Pumps	5 (4+1)	
Capacity, Each	7.5	mgd

3.3.2 Site Layout

A preliminary site layout is presented in Figure 11. The new facility is proposed to the west of the TWTP.

Figure 11 TWTP Gravity GAC Contactor Site Layout – Single Pass

3.3.3 Operating Considerations

The advantages and disadvantages of this alternative are presented in Table 20.

Table 20 Operational Considerations for Gravity GAC Contactors – Single Pass

Advantages	Disadvantages
• GAC contactors require less valves and instrumentation than pressure vessels due to the lower number of contactors required. • GAC contactors provide fewer sample locations that would be required for monitoring GAC media life due to the lower number of contactors required. • The footprint for GAC contactors is slightly smaller than the footprint for GAC pressure vessels. • GAC contactor backwash can utilize the existing TWTP backwash supply system for the biofilters. • Single pass treatment requires fewer valves, actuators, and instruments for maintenance.	• The time required for GAC replacement is longer and is a more complicated process for gravity contactors as opposed to a pressure vessel. An additional redundant contactor has been provided to account for this challenge. • GAC contactors provide less modularity and redundancy than pressure vessels. • GAC contactors require more complicated construction (water-bearing concrete structures) compared to pressure vessels. • Single pass treatment requires more sampling/operator attention to meet treatment goals compared to lead/lag operation.

3.3.4 Cost Estimate

An AACE International Class 4 construction cost estimate (-30 percent to +50 percent) was developed for this alternative utilizing costs from other projects of similar scope and complexity and escalated for time. Construction cost is estimated at $30 million.

3.3.5 Net Present Value

A NPV analysis was performed to evaluate alternatives on a life-cycle cost basis. The NPV of a given alternative is a summation of present and future costs converted to present day dollars. The NPV of this alternative is estimated at:

- $80 million for a treatment goal of 2 ng/L.
- $60 million for a treatment goal of 4 ng/L.

Detailed NPV analysis forms are provided in Appendix A.

3.4 GAC Pressure Vessels – Lead/Lag

The alternative for lead/lag GAC pressure vessels at the TWTP incorporates the following treatment and operations project goals:

- Provide treatment for a finished water PFAS goal of non-detect to meet the EPA's lifetime drinking water health advisories.
- A design media life of 10,000 bed volumes was utilized. This value was estimated from EGL and Standley Lake influent water quality parameters and testing performed by Aurora Water at the Binney WPF with similar water quality.
- Provide lead/lag treatment units to better utilize the adsorptive capacity of the GAC in each treatment unit, provide redundancy for achieving the finished water PFAS goals, and reduce sampling requirements.

- Alternative is based around Calgon Model 14 modular carbon adsorption pressure vessels with 5 psi pressure drop across the vessel when operating at design flow rate.
- Provide adequate GAC empty bed contact time so that GAC adsorbers only require media replacement once per year under current demand conditions (9.6 mgd average yearly flow rate) and twice per year under build-out demand conditions (17.0 mgd average yearly flow rate).
- Provide intermediate pump station to allow for addition of the GAC adsorption process within the existing hydraulic profile of the plant (downstream of biological filtration and upstream of the chlorine contact chamber).
- Provide backwashing facilities for the new GAC pressure vessels. Backwash waste will be sent to the existing WBWTP lagoons.
- Locate new treatment facility at the available site west of the existing TWTP.

3.4.1 Design Criteria

Table 21 outlines the proposed design criteria for a new GAC pressure vessel facility at the TWTP.

Table 21 TWTP GAC Pressure Vessels Design Criteria – Lead/Lag

Parameter	Value	Unit
Plant Flow Rates		
Process Design Capacity	30	mgd
Design Plant Flow Rate (Current Yearly Average)	9.6	mgd
Design Plant Flow Rate (Build-Out)	17.0	mgd
GAC Contactors		
Contactor Type: Pressure Vessels – Lead/Lag Operation		
Number of Vessels, Total	40	
Number of Lead Vessels	20	
Number of Lag Vessels	20	
Vessel Dimensions		
Diameter	14	feet
Height	27	feet
Carbon per Vessel	60,000	pounds
Empty Bed Contact Time, Each Vessel (at 30 mgd)	15	minutes
Vessel Flow Rate, Maximum	1,050	gpm
Media Life		
Design Bed Volumes	10,000	
Media Life Until Exhaustion of Lead Contactors (Current)	1.0	years
Media Life Until Exhaustion of Lead Contactors (Build-Out)	0.6	years
Intermediate Pump Station		
Type: Vertical Turbine Pumps		
Number of Pumps	5 (4+1)	
Capacity, Each	7.5	mgd

3.4.2 Site Layout

A preliminary site layout is presented in Figure 12. The new facility is proposed to the west of the TWTP.

Figure 12 TWTP GAC Pressure Vessels Site Layout – Lead/Lag

3.4.3 Operating Considerations

The advantages and disadvantages of this alternative are presented in Table 22.

Table 22 Operational Considerations for GAC Pressure Vessels – Lead/Lag

Advantages	Disadvantages
• GAC replacement is a shorter and more simple process (about 4 hours) for pressure vessels as opposed to gravity contactors. Given the large number of vessels, when GAC is being replaced in a vessel, the remaining vessels can be operated at a slightly higher flow rate. • Pressure vessels provide more modularity and redundancy than gravity GAC contactors. • A pressure vessel facility is simpler to construct than GAC contactors (slab on grade with building as compared to water-bearing concrete structures). • GAC pressure vessel backwash can utilize the existing TWTP backwash supply system for the biofilters (one pump operating). • Lead/lag treatment maximizes available GAC adsorption capacity. • Lead/lag treatment provides more reliable treatment when compared to single pass.	• Pressure vessels require more valves and instrumentation than gravity GAC contactors due to the greater number of contactors vessels. • Utilizing pressure vessels results in a greater number of sample locations that would be required for monitoring GAC media life due to the greater number of vessels required. • The footprint for GAC pressure vessels is slightly greater than the footprint for gravity GAC contactors. • Lead/lag treatment requires twice as many valves, actuators, and instruments for maintenance.

3.4.4 Cost Estimate

An AACE International Class 4 construction cost estimate (-30 percent to +50 percent) was developed for this alternative utilizing costs from other projects of similar scope and complexity and escalated for time. Construction cost is estimated at $65 million.

3.4.5 Net Present Value

A NPV analysis was performed to evaluate alternatives on a life-cycle cost basis. The NPV of a given alternative is a summation of present and future costs converted to present day dollars. The NPV of this alternative is estimated at $120 million. Detailed NPV analysis forms are provided in Appendix A.

3.5 GAC Pressure Vessels – Single Pass

The alternative for single pass GAC pressure vessels at the TWTP incorporates the following treatment and operations project goals:

- Provide treatment to meet the EPA's proposed MCLs for six PFAS compounds in drinking water.
  - Treatment goals of both 2 ng/L and 4 ng/L were evaluated.
- A design media life of 10,000 bed volumes was utilized. This value was estimated from EGL and Standley Lake influent water quality parameters and testing performed by Aurora Water at the Binney WPF with similar water quality.
  - Bypassing of flow was considered when historical finished water PFAS levels were below treatment goals (PAC would continue to be fed in these scenarios).
    - For PFAS levels below the treatment goal, all flow was bypassed.
    - For PFAS levels less than 150 percent of the treatment goal, 50 percent of flow was treated.
    - For PFAS levels greater than 150 percent of the treatment goal, all flow was treated.
- Provide single pass treatment units with optional recycle flow to extend GAC life.
- Alternative is based around Calgon Model 14 modular carbon adsorption pressure vessels with 5 psi pressure drop across the vessel when operating at design flow rate.
- Provide adequate GAC empty bed contact time so that GAC adsorbers only require media replacement once per year under current demand conditions (9.6 mgd average yearly flow rate) and twice per year under build-out demand conditions (17.0 mgd average yearly flow rate) if bypassing is not utilized.
- Provide intermediate pump station to allow for addition of the GAC adsorption process within the existing hydraulic profile of the plant (downstream of biological filtration and upstream of the chlorine contact chamber).
- Provide backwashing facilities for the new GAC pressure vessels. Backwash waste will be sent to the existing WBWTP lagoons.
- Locate new treatment facility at the available site west of the existing TWTP.

3.5.1 Design Criteria

Table 23 outlines the proposed design criteria for a new GAC pressure vessel facility at the TWTP.

Table 23 TWTP GAC Pressure Vessels Design Criteria – Single Pass

Parameter	Value	Unit
Plant Flow Rates		
Process Design Capacity	30	mgd
Design Plant Flow Rate (Current Yearly Average)	9.6	mgd
Design Plant Flow Rate (Build-Out)	17.0	mgd
GAC Contactors		
Contactor Type: Pressure Vessels – Lead/Lag Operation		
Number of Vessels, Total	20	
Vessel Dimensions		
Diameter	14	feet
Height	27	feet
Carbon per Vessel	60,000	pounds
Empty Bed Contact Time, Each Vessel (at 30 mgd)	15	minutes
Vessel Flow Rate, maximum	1,050	gpm
Design Bed Volumes	10,000	
Media Life (No Bypass)		
Media Life Until Exhaustion (Current)	1.0	years
Media Life Until Exhaustion (Build-Out)	0.6	years
Media Life (2 ng/L Treatment Goal)		
Historical Finished Water Exceedance of Treatment Goal	100	%
Historical Finished Water Exceedance of 150% of Treatment Goal	91	%
GAC Bypass Flow	5	%
Media Life Until Exhaustion (Current)	1.1	years
Media Life Until Exhaustion (Build-Out)	0.6	years
Media Life (4 ng/L Treatment Goal)		
Historical Finished Water Exceedance of Treatment Goal	73	%
Historical Finished Water Exceedance of 150% of Treatment Goal	27	%
GAC Bypass Flow	50	%
Media Life Until Exhaustion (Current)	2.0	years
Media Life Until Exhaustion (Build-Out)	1.1	years
Intermediate Pump Station		
Type: Vertical Turbine Pumps		
Number of Pumps	5 (4+1)	
Capacity, Each	7.5	mgd

3.5.2 Site Layout

A preliminary site layout is presented in Figure 13. The new facility is proposed to the west of the TWTP.

Figure 13 TWTP GAC Pressure Vessels Site Layout – Single Pass

3.5.3 Operating Considerations

The advantages and disadvantages of this alternative are presented in Table 24.

Table 24 Operational Considerations for GAC Pressure Vessels – Single Pass

Advantages	Disadvantages
• GAC replacement is a shorter and more simple process (about 4 hours) for pressure vessels as opposed to gravity contactors. Given the large number of vessels, when GAC is being replaced in a vessel, the remaining vessels can be operated at a slightly higher flow rate. • Pressure vessels provide more modularity and redundancy than gravity GAC contactors. • A pressure vessel facility is simpler to construct than GAC contactors (slab on grade with building as compared to water-bearing concrete structures). • GAC pressure vessel backwash can utilize the existing TWTP backwash supply system for the biofilters (one pump operating). • Single pass treatment requires fewer valves, actuators, and instruments for maintenance.	• Pressure vessels require more valves and instrumentation than gravity GAC contactors due to the greater number of contactors vessels. • Utilizing pressure vessels results in a greater number of sample locations that would be required for monitoring GAC media life due to the greater number of vessels required. • The footprint for GAC pressure vessels is slightly greater than the footprint for gravity GAC contactors. • Single pass treatment requires more sampling/operator attention to meet treatment goals compared to lead/lag operation.

3.5.4 Cost Estimate

An AACE International Class 4 construction cost estimate (-30 percent to +50 percent) was developed for this alternative utilizing costs from other projects of similar scope and complexity and escalated for time. Construction cost is estimated at $45 million.

3.5.5 Net Present Value

A NPV analysis was performed to evaluate alternatives on a life-cycle cost basis. The NPV of a given alternative is a summation of present and future costs converted to present day dollars. The NPV of this alternative is estimated at:

- $100 million for a treatment goal of 2 ng/L.
- $75 million for a treatment goal of 4 ng/L.

Detailed NPV analysis forms are provided in Appendix A.

Section 4

SUMMARY AND RECOMMENDATIONS

4.1 Summary

Table 25 provides a comparison of each PFAS treatment alternative and estimated construction and NPV costs.

Table 25 Summary of PFAS Alternatives

Treatment Alternatives	Construction Cost[1]	20-Year NPV[1]	GAC Replacement Cost per Year[1]	Plant Capacity (mgd)	Number of Contactors / Vessels	Time Between GAC Replacement (years)
WBWTP Treatment Alternatives						
GAC Gravity Contactors (Lead/Lag, Non-Detect Treatment Goal)	$80 M	$145 M	$4.5 M	50	20	0.5-1
GAC Gravity Contactors (Single Pass, 2 ng/L Treatment Goal)	$50 M	$95 M	$2.5 M	50	10	1-2
GAC Gravity Contactors (Single Pass, 4 ng/L Treatment Goal)	$50 M	$65 M	$0.9 M	50	10	3-7
GAC Pressure Vessels (Lead/Lag, Non-Detect Treatment Goal)	$100 M	$170 M	$4.5 M	50	66	0.5-1
GAC Pressure Vessels (Single Pass, 2 ng/L Treatment Goal)	$65 M	$110 M	$2.5 M	50	33	1-2
GAC Pressure Vessels (Single Pass, 4 ng/L Treatment Goal)	$65 M	$85 M	$0.9 M	50	33	3-7
TWTP Treatment Alternatives						
Conversion of Biofilters to GAC Contactors (Single Pass, 4 ng/L Treatment Goal)	$6 M	$80 M	$4.1 M	24 - 27	6	<0.5
GAC Gravity Contactors (Lead/Lag, Non-Detect Treatment Goal)	$50 M	$105 M	$3.3 M	30	12	0.5-1
GAC Gravity Contactors (Single Pass, 2 ng/L Treatment Goal)	$30 M	$80 M	$3.1 M	30	6	0.5-1
GAC Gravity Contactors (Single Pass, 4 ng/L Treatment Goal)	$30 M	$60 M	$1.6 M	30	6	1-2

Treatment Alternatives	Construction Cost[1]	20-Year NPV[1]	GAC Replacement Cost per Year[1]	Plant Capacity (mgd)	Number of Contactors / Vessels	Time Between GAC Replacement (years)
GAC Pressure Vessels (Lead/Lag, Non-Detect Treatment Goal)	$65 M	$120 M	$3.3 M	30	40	0.5-1
GAC Pressure Vessels (Single Pass, 2 ng/L Treatment Goal)	$45 M	$100 M	$3.1 M	30	20	0.5-1
GAC Pressure Vessels (Single Pass, 4 ng/L Treatment Goal)	$45 M	$75 M	$1.6 M	30	20	1-2

Notes:
(1) All costs are in 2023 dollars, the base year used for this evaluation.
M million

The plant capacities listed in Table 25 include the current peaking capacity for both WBWTP and TWTP. Thornton is currently performing a WTP capacity evaluation to determine opportunities to improve plant continuous capacities and/or expansion of both facilities. Modifications to the plant capacities listed above as a result of the WTP capacity evaluation would necessitate revisions to the costs presented.

4.2 Recommendations

Recommendations for the next steps in development of PFAS treatment alternatives for both the WBWTP and TWTP facilities are presented below:

- **Continue to perform regular PFAS sampling in raw water sources, WBWTP, and TWTP.** Additional paired sampling will provide a better understanding of current source water levels, PFAS treatment capabilities through existing plant processes (such as PAC at WBWTP), and finished water quality.
- **Monitor PFAS regulations and amend treatment goals as needed.** The EPA anticipates finalizing the draft PFAS regulation by the end of 2023. The final regulation may influence Thornton's treatment goals and is the best alternative for meeting the treatment goal.
- **While pilot testing would help inform PFAS treatment design and operations, proceeding directly into design may be required to comply with the forthcoming NPDWR for PFAS by the end of 2026.** Thornton is procuring an instrument to measure PFAS in their own laboratory, which will allow Thornton to obtain many of the benefits of piloting through more frequent sampling at the full-scale with shorter turnaround times. Benefits include monitoring PFAS breakthrough dynamics in real time, balancing GAC replacement frequency between contactors, and active monitoring of influent concentrations to understand bypass opportunities.

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Appendix A

NET PRESENT VALUE ANALYSIS

Wes Brown WTP - GAC Contactors
(Lead/Lag, Non-Detect Treatment Goal)

Item Description	Costs	Escalation / Interest (%)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital Costs	**$80,000,000**	-										
Initial Construction - Bond Repayment (5%)	**$128,400,000**	5.0%	$6,420,000	$6,420,000	$6,420,000	$6,420,000	$6,420,000	$6,420,000	$6,420,000	$6,420,000	$6,420,000	$6,420,000
WBWTP O&M Costs												
Electrical Usage ($/yr)												
GAC Contactor (Backwash)	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Intermediate Pumping	$70,000		$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000
Electrical Cost ($/year)			**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**
Chemical Usage ($/yr)												
Hydrogen Peroxide	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Powdered Activated Carbon	($500,000)		-$500,000	-$500,000	-$500,000	-$500,000	-$500,000	-$500,000	-$500,000	-$500,000	-$500,000	-$500,000
Chemical Cost ($/year)			**-$490,000**	**-$490,000**	**-$490,000**	**-$490,000**	**-$490,000**	**-$490,000**	**-$490,000**	**-$490,000**	**-$490,000**	**-$490,000**
Operations and Maintenance												
GAC Replacement and Disposal	$4,500,000		$4,500,000	$4,500,000	$4,500,000	$4,500,000	$4,500,000	$4,500,000	$4,500,000	$4,500,000	$4,500,000	$4,500,000
Solids Removal	($80,000)		-$80,000	-$80,000	-$80,000	-$80,000	-$80,000	-$80,000	-$80,000	-$80,000	-$80,000	-$80,000
Sampling, Labor, and Preventative Maintenance	$30,000		$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000
Maintenance Operations Cost ($/year)			**$4,450,000**	**$4,450,000**	**$4,450,000**	**$4,450,000**	**$4,450,000**	**$4,450,000**	**$4,450,000**	**$4,450,000**	**$4,450,000**	**$4,450,000**
Cost Summary												
Capital Cost Bond Repayment for Year	-	-	$6,420,000	$6,420,000	$6,420,000	$6,420,000	$6,420,000	$6,420,000	$6,420,000	$6,420,000	$6,420,000	$6,420,000
O&M Cost for Year	-	-	$4,040,000	$4,040,000	$4,040,000	$4,040,000	$4,040,000	$4,040,000	$4,040,000	$4,040,000	$4,040,000	$4,040,000
Total for Year	-	-	$10,460,000	$10,460,000	$10,460,000	$10,460,000	$10,460,000	$10,460,000	$10,460,000	$10,460,000	$10,460,000	$10,460,000
Net Present Value												
Discount Rate =	**5.0%**											
Escalation Rate =	**3.0%**											
Net Present Value Capital Cost =	**$79,990,000**		**$6,110,000**	**$5,820,000**	**$5,550,000**	**$5,280,000**	**$5,030,000**	**$4,790,000**	**$4,560,000**	**$4,350,000**	**$4,140,000**	**$3,940,000**
Net Present Value for O&M =	**$66,430,000**		**$3,960,000**	**$3,890,000**	**$3,810,000**	**$3,740,000**	**$3,670,000**	**$3,600,000**	**$3,530,000**	**$3,460,000**	**$3,400,000**	**$3,330,000**
Total Net Present Value for Alternative =	**$146,420,000**		**$10,070,000**	**$9,710,000**	**$9,360,000**	**$9,020,000**	**$8,700,000**	**$8,390,000**	**$8,090,000**	**$7,810,000**	**$7,540,000**	**$7,270,000**

For Twenty (20) Year NPV = $146,420,000

Wes Brown WTP - GAC Contactors
(Lead/Lag, Non-Detect Treatment Goal)

Item Description	Costs	Escalation / Interest (%)	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Capital Costs	**$80,000,000**	-										
Initial Construction - Bond Repayment (5%)	**$128,400,000**	5.0%	$6,420,000	$6,420,000	$6,420,000	$6,420,000	$6,420,000	$6,420,000	$6,420,000	$6,420,000	$6,420,000	$6,420,000
WBWTP O&M Costs												
Electrical Usage ($/yr)												
GAC Contactor (Backwash)	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Intermediate Pumping	$70,000		$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000
Electrical Cost ($/year)			**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**
Chemical Usage ($/yr)												
Hydrogen Peroxide	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Powdered Activated Carbon	($500,000)		-$500,000	-$500,000	-$500,000	-$500,000	-$500,000	-$500,000	-$500,000	-$500,000	-$500,000	-$500,000
Chemical Cost ($/year)			**-$490,000**	**-$490,000**	**-$490,000**	**-$490,000**	**-$490,000**	**-$490,000**	**-$490,000**	**-$490,000**	**-$490,000**	**-$490,000**
Operations and Maintenance												
GAC Replacement and Disposal	$4,500,000		$4,500,000	$4,500,000	$4,500,000	$4,500,000	$4,500,000	$4,500,000	$4,500,000	$4,500,000	$4,500,000	$4,500,000
Solids Removal	($80,000)		-$80,000	-$80,000	-$80,000	-$80,000	-$80,000	-$80,000	-$80,000	-$80,000	-$80,000	-$80,000
Sampling, Labor, and Preventative Maintenance	$30,000		$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000
Maintenance Operations Cost ($/year)			**$4,450,000**	**$4,450,000**	**$4,450,000**	**$4,450,000**	**$4,450,000**	**$4,450,000**	**$4,450,000**	**$4,450,000**	**$4,450,000**	**$4,450,000**
Cost Summary												
Capital Cost Bond Repayment for Year	-	-	$6,420,000	$6,420,000	$6,420,000	$6,420,000	$6,420,000	$6,420,000	$6,420,000	$6,420,000	$6,420,000	$6,420,000
O&M Cost for Year	-	-	$4,040,000	$4,040,000	$4,040,000	$4,040,000	$4,040,000	$4,040,000	$4,040,000	$4,040,000	$4,040,000	$4,040,000
Total for Year	-	-	$10,460,000	$10,460,000	$10,460,000	$10,460,000	$10,460,000	$10,460,000	$10,460,000	$10,460,000	$10,460,000	$10,460,000
Net Present Value												
Discount Rate =	**5.0%**											
Escalation Rate =	**3.0%**											
Net Present Value Capital Cost =	**$79,990,000**		**$3,750,000**	**$3,570,000**	**$3,400,000**	**$3,240,000**	**$3,090,000**	**$2,940,000**	**$2,800,000**	**$2,670,000**	**$2,540,000**	**$2,420,000**
Net Present Value for O&M =	**$66,430,000**		**$3,270,000**	**$3,210,000**	**$3,150,000**	**$3,090,000**	**$3,030,000**	**$2,970,000**	**$2,910,000**	**$2,860,000**	**$2,800,000**	**$2,750,000**
Total Net Present Value for Alternative =	**$146,420,000**		**$7,020,000**	**$6,780,000**	**$6,550,000**	**$6,330,000**	**$6,120,000**	**$5,910,000**	**$5,710,000**	**$5,530,000**	**$5,340,000**	**$5,170,000**

For Twenty (20) Year NPV = $146,420,000

Wes Brown WTP - GAC Contactors
(Single Pass, 2 ng/L Treatment Goal)

Item Description	Costs	Escalation / Interest (%)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital Costs	**$50,000,000**	-										
Initial Construction - Bond Repayment (5%)	**$80,200,000**	5.0%	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000
WBWTP O&M Costs												
Electrical Usage ($/yr)												
GAC Contactor (Backwash)	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Intermediate Pumping	$70,000		$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000
Electrical Cost ($/year)			**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**
Chemical Usage ($/yr)												
Hydrogen Peroxide	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Powdered Activated Carbon	$0		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Chemical Cost ($/year)			**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**
Operations and Maintenance												
GAC Replacement and Disposal	$2,500,000		$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000
Solids Removal	$0		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Sampling, Labor, and Preventative Maintenance	$15,000		$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000
Maintenance Operations Cost ($/year)			**$2,515,000**	**$2,515,000**	**$2,515,000**	**$2,515,000**	**$2,515,000**	**$2,515,000**	**$2,515,000**	**$2,515,000**	**$2,515,000**	**$2,515,000**
Cost Summary												
Capital Cost Bond Repayment for Year	-	-	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000
O&M Cost for Year	-	-	$2,605,000	$2,605,000	$2,605,000	$2,605,000	$2,605,000	$2,605,000	$2,605,000	$2,605,000	$2,605,000	$2,605,000
Total for Year	-	-	$6,615,000	$6,615,000	$6,615,000	$6,615,000	$6,615,000	$6,615,000	$6,615,000	$6,615,000	$6,615,000	$6,615,000
Net Present Value												
Discount Rate =	**5.0%**											
Escalation Rate =	**3.0%**											
Net Present Value Capital Cost =	**$49,970,000**		**$3,820,000**	**$3,640,000**	**$3,460,000**	**$3,300,000**	**$3,140,000**	**$2,990,000**	**$2,850,000**	**$2,710,000**	**$2,580,000**	**$2,460,000**
Net Present Value for O&M =	**$42,850,000**		**$2,560,000**	**$2,510,000**	**$2,460,000**	**$2,410,000**	**$2,370,000**	**$2,320,000**	**$2,280,000**	**$2,230,000**	**$2,190,000**	**$2,150,000**
Total Net Present Value for Alternative =	**$92,820,000**		**$6,380,000**	**$6,150,000**	**$5,920,000**	**$5,710,000**	**$5,510,000**	**$5,310,000**	**$5,130,000**	**$4,940,000**	**$4,770,000**	**$4,610,000**

For Twenty (20) Year NPV = $92,820,000

Wes Brown WTP - GAC Contactors
(Single Pass, 2 ng/L Treatment Goal)

Item Description	Costs	Escalation / Interest (%)	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Capital Costs	**$50,000,000**	-										
Initial Construction - Bond Repayment (5%)	**$80,200,000**	5.0%	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000
WBWTP O&M Costs												
Electrical Usage ($/yr)												
GAC Contactor (Backwash)	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Intermediate Pumping	$70,000		$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000
Electrical Cost ($/year)			**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**
Chemical Usage ($/yr)												
Hydrogen Peroxide	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Powdered Activated Carbon	$0		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Chemical Cost ($/year)			**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**
Operations and Maintenance												
GAC Replacement and Disposal	$2,500,000		$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000
Solids Removal	$0		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Sampling, Labor, and Preventative Maintenance	$15,000		$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000
Maintenance Operations Cost ($/year)			**$2,515,000**	**$2,515,000**	**$2,515,000**	**$2,515,000**	**$2,515,000**	**$2,515,000**	**$2,515,000**	**$2,515,000**	**$2,515,000**	**$2,515,000**
Cost Summary												
Capital Cost Bond Repayment for Year	-	-	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000
O&M Cost for Year	-	-	$2,605,000	$2,605,000	$2,605,000	$2,605,000	$2,605,000	$2,605,000	$2,605,000	$2,605,000	$2,605,000	$2,605,000
Total for Year	-	-	$6,615,000	$6,615,000	$6,615,000	$6,615,000	$6,615,000	$6,615,000	$6,615,000	$6,615,000	$6,615,000	$6,615,000
Net Present Value												
Discount Rate =	**5.0%**											
Escalation Rate =	**3.0%**											
Net Present Value Capital Cost =	**$49,970,000**		**$2,340,000**	**$2,230,000**	**$2,130,000**	**$2,030,000**	**$1,930,000**	**$1,840,000**	**$1,750,000**	**$1,670,000**	**$1,590,000**	**$1,510,000**
Net Present Value for O&M =	**$42,850,000**		**$2,110,000**	**$2,070,000**	**$2,030,000**	**$1,990,000**	**$1,950,000**	**$1,920,000**	**$1,880,000**	**$1,840,000**	**$1,810,000**	**$1,770,000**
Total Net Present Value for Alternative =	**$92,820,000**		**$4,450,000**	**$4,300,000**	**$4,160,000**	**$4,020,000**	**$3,880,000**	**$3,760,000**	**$3,630,000**	**$3,510,000**	**$3,400,000**	**$3,280,000**

For Twenty (20) Year NPV = $92,820,000

Wes Brown WTP - GAC Contactors
(Single Pass, 4 ng/L Treatment Goal)

Item Description	Costs	Escalation / Interest (%)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital Costs	**$50,000,000**	-										
Initial Construction - Bond Repayment (5%)	**$80,200,000**	5.0%	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000
WBWTP O&M Costs												
Electrical Usage ($/yr)												
GAC Contactor (Backwash)	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Intermediate Pumping	$70,000		$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000
Electrical Cost ($/year)			**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**
Chemical Usage ($/yr)												
Hydrogen Peroxide	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Powdered Activated Carbon	$0		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Chemical Cost ($/year)			**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**
Operations and Maintenance												
GAC Replacement and Disposal	$900,000		$900,000	$900,000	$900,000	$900,000	$900,000	$900,000	$900,000	$900,000	$900,000	$900,000
Solids Removal	$0		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Sampling, Labor, and Preventative Maintenance	$15,000		$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000
Maintenance Operations Cost ($/year)			**$915,000**	**$915,000**	**$915,000**	**$915,000**	**$915,000**	**$915,000**	**$915,000**	**$915,000**	**$915,000**	**$915,000**
Cost Summary												
Capital Cost Bond Repayment for Year	-	-	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000
O&M Cost for Year	-	-	$1,005,000	$1,005,000	$1,005,000	$1,005,000	$1,005,000	$1,005,000	$1,005,000	$1,005,000	$1,005,000	$1,005,000
Total for Year	-	-	$5,015,000	$5,015,000	$5,015,000	$5,015,000	$5,015,000	$5,015,000	$5,015,000	$5,015,000	$5,015,000	$5,015,000
Net Present Value												
Discount Rate =	**5.0%**											
Escalation Rate =	**3.0%**											
Net Present Value Capital Cost =	**$49,970,000**		**$3,820,000**	**$3,640,000**	**$3,460,000**	**$3,300,000**	**$3,140,000**	**$2,990,000**	**$2,850,000**	**$2,710,000**	**$2,580,000**	**$2,460,000**
Net Present Value for O&M =	**$16,530,000**		**$990,000**	**$970,000**	**$950,000**	**$930,000**	**$910,000**	**$900,000**	**$880,000**	**$860,000**	**$850,000**	**$830,000**
Total Net Present Value for Alternative =	**$66,500,000**		**$4,810,000**	**$4,610,000**	**$4,410,000**	**$4,230,000**	**$4,050,000**	**$3,890,000**	**$3,730,000**	**$3,570,000**	**$3,430,000**	**$3,290,000**

For Twenty (20) Year NPV = $66,500,000

Wes Brown WTP - GAC Contactors
(Single Pass, 4 ng/L Treatment Goal)

Item Description	Costs	Escalation / Interest (%)	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Capital Costs	**$50,000,000**	-										
Initial Construction - Bond Repayment (5%)	**$80,200,000**	5.0%	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000
WBWTP O&M Costs												
Electrical Usage ($/yr)												
GAC Contactor (Backwash)	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Intermediate Pumping	$70,000		$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000
Electrical Cost ($/year)			**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**	**$80,000**
Chemical Usage ($/yr)												
Hydrogen Peroxide	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Powdered Activated Carbon	$0		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Chemical Cost ($/year)			**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**
Operations and Maintenance												
GAC Replacement and Disposal	$900,000		$900,000	$900,000	$900,000	$900,000	$900,000	$900,000	$900,000	$900,000	$900,000	$900,000
Solids Removal	$0		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Sampling, Labor, and Preventative Maintenance	$15,000		$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000
Maintenance Operations Cost ($/year)			**$915,000**	**$915,000**	**$915,000**	**$915,000**	**$915,000**	**$915,000**	**$915,000**	**$915,000**	**$915,000**	**$915,000**
Cost Summary												
Capital Cost Bond Repayment for Year	-	-	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000
O&M Cost for Year	-	-	$1,005,000	$1,005,000	$1,005,000	$1,005,000	$1,005,000	$1,005,000	$1,005,000	$1,005,000	$1,005,000	$1,005,000
Total for Year	-	-	$5,015,000	$5,015,000	$5,015,000	$5,015,000	$5,015,000	$5,015,000	$5,015,000	$5,015,000	$5,015,000	$5,015,000
Net Present Value												
Discount Rate =	**5.0%**											
Escalation Rate =	**3.0%**											
Net Present Value Capital Cost =	**$49,970,000**		**$2,340,000**	**$2,230,000**	**$2,130,000**	**$2,030,000**	**$1,930,000**	**$1,840,000**	**$1,750,000**	**$1,670,000**	**$1,590,000**	**$1,510,000**
Net Present Value for O&M =	**$16,530,000**		**$810,000**	**$800,000**	**$780,000**	**$770,000**	**$750,000**	**$740,000**	**$720,000**	**$710,000**	**$700,000**	**$680,000**
Total Net Present Value for Alternative =	**$66,500,000**		**$3,150,000**	**$3,030,000**	**$2,910,000**	**$2,800,000**	**$2,680,000**	**$2,580,000**	**$2,470,000**	**$2,380,000**	**$2,290,000**	**$2,190,000**

For Twenty (20) Year NPV = $66,500,000

Wes Brown WTP - GAC Pressure Vessels
(Lead/Lag, Non-Detect Treatment Goal)

Item Description	Costs	Escalation / Interest (%)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital Costs	**$100,000,000**	-										
Initial Construction - Bond Repayment (5%)	**$160,400,000**	5.0%	$8,020,000	$8,020,000	$8,020,000	$8,020,000	$8,020,000	$8,020,000	$8,020,000	$8,020,000	$8,020,000	$8,020,000
WBWTP O&M Costs												
Electrical Usage ($/yr)												
GAC Contactor (Backwash)	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Intermediate Pumping	$140,000		$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000
Electrical Cost ($/year)			**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**
Chemical Usage ($/yr)												
Hydrogen Peroxide	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Powdered Activated Carbon	($500,000)		-$500,000	-$500,000	-$500,000	-$500,000	-$500,000	-$500,000	-$500,000	-$500,000	-$500,000	-$500,000
Chemical Cost ($/year)			**-$490,000**	**-$490,000**	**-$490,000**	**-$490,000**	**-$490,000**	**-$490,000**	**-$490,000**	**-$490,000**	**-$490,000**	**-$490,000**
Operations and Maintenance												
GAC Replacement and Disposal	$4,500,000		$4,500,000	$4,500,000	$4,500,000	$4,500,000	$4,500,000	$4,500,000	$4,500,000	$4,500,000	$4,500,000	$4,500,000
Solids Removal	($80,000)		-$80,000	-$80,000	-$80,000	-$80,000	-$80,000	-$80,000	-$80,000	-$80,000	-$80,000	-$80,000
Sampling, Labor, and Preventative Maintenance	$60,000		$60,000	$60,000	$60,000	$60,000	$60,000	$60,000	$60,000	$60,000	$60,000	$60,000
Maintenance Operations Cost ($/year)			**$4,480,000**	**$4,480,000**	**$4,480,000**	**$4,480,000**	**$4,480,000**	**$4,480,000**	**$4,480,000**	**$4,480,000**	**$4,480,000**	**$4,480,000**
Cost Summary												
Capital Cost Bond Repayment for Year	-	-	$8,020,000	$8,020,000	$8,020,000	$8,020,000	$8,020,000	$8,020,000	$8,020,000	$8,020,000	$8,020,000	$8,020,000
O&M Cost for Year	-	-	$4,140,000	$4,140,000	$4,140,000	$4,140,000	$4,140,000	$4,140,000	$4,140,000	$4,140,000	$4,140,000	$4,140,000
Total for Year	-	-	$12,160,000	$12,160,000	$12,160,000	$12,160,000	$12,160,000	$12,160,000	$12,160,000	$12,160,000	$12,160,000	$12,160,000
Net Present Value												
Discount Rate =	**5.0%**											
Escalation Rate =	**3.0%**											
Net Present Value Capital Cost =	**$99,930,000**		**$7,640,000**	**$7,270,000**	**$6,930,000**	**$6,600,000**	**$6,280,000**	**$5,980,000**	**$5,700,000**	**$5,430,000**	**$5,170,000**	**$4,920,000**
Net Present Value for O&M =	**$68,070,000**		**$4,060,000**	**$3,980,000**	**$3,910,000**	**$3,830,000**	**$3,760,000**	**$3,690,000**	**$3,620,000**	**$3,550,000**	**$3,480,000**	**$3,420,000**
Total Net Present Value for Alternative =	**$168,000,000**		**$11,700,000**	**$11,250,000**	**$10,840,000**	**$10,430,000**	**$10,040,000**	**$9,670,000**	**$9,320,000**	**$8,980,000**	**$8,650,000**	**$8,340,000**

For Twenty (20) Year NPV = $168,000,000

Wes Brown WTP - GAC Pressure Vessels
(Lead/Lag, Non-Detect Treatment Goal)

Item Description	Costs	Escalation / Interest (%)	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Capital Costs	**$100,000,000**	-										
Initial Construction - Bond Repayment (5%)	**$160,400,000**	5.0%	$8,020,000	$8,020,000	$8,020,000	$8,020,000	$8,020,000	$8,020,000	$8,020,000	$8,020,000	$8,020,000	$8,020,000
WBWTP O&M Costs												
Electrical Usage ($/yr)												
GAC Contactor (Backwash)	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Intermediate Pumping	$140,000		$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000
Electrical Cost ($/year)			**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**
Chemical Usage ($/yr)												
Hydrogen Peroxide	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Powdered Activated Carbon	($500,000)		-$500,000	-$500,000	-$500,000	-$500,000	-$500,000	-$500,000	-$500,000	-$500,000	-$500,000	-$500,000
Chemical Cost ($/year)			**-$490,000**	**-$490,000**	**-$490,000**	**-$490,000**	**-$490,000**	**-$490,000**	**-$490,000**	**-$490,000**	**-$490,000**	**-$490,000**
Operations and Maintenance												
GAC Replacement and Disposal	$4,500,000		$4,500,000	$4,500,000	$4,500,000	$4,500,000	$4,500,000	$4,500,000	$4,500,000	$4,500,000	$4,500,000	$4,500,000
Solids Removal	($80,000)		-$80,000	-$80,000	-$80,000	-$80,000	-$80,000	-$80,000	-$80,000	-$80,000	-$80,000	-$80,000
Sampling, Labor, and Preventative Maintenance	$60,000		$60,000	$60,000	$60,000	$60,000	$60,000	$60,000	$60,000	$60,000	$60,000	$60,000
Maintenance Operations Cost ($/year)			**$4,480,000**	**$4,480,000**	**$4,480,000**	**$4,480,000**	**$4,480,000**	**$4,480,000**	**$4,480,000**	**$4,480,000**	**$4,480,000**	**$4,480,000**
Cost Summary												
Capital Cost Bond Repayment for Year	-	-	$8,020,000	$8,020,000	$8,020,000	$8,020,000	$8,020,000	$8,020,000	$8,020,000	$8,020,000	$8,020,000	$8,020,000
O&M Cost for Year	-	-	$4,140,000	$4,140,000	$4,140,000	$4,140,000	$4,140,000	$4,140,000	$4,140,000	$4,140,000	$4,140,000	$4,140,000
Total for Year	-	-	$12,160,000	$12,160,000	$12,160,000	$12,160,000	$12,160,000	$12,160,000	$12,160,000	$12,160,000	$12,160,000	$12,160,000
Net Present Value												
Discount Rate =	**5.0%**											
Escalation Rate =	**3.0%**											
Net Present Value Capital Cost =	**$99,930,000**		**$4,690,000**	**$4,470,000**	**$4,250,000**	**$4,050,000**	**$3,860,000**	**$3,670,000**	**$3,500,000**	**$3,330,000**	**$3,170,000**	**$3,020,000**
Net Present Value for O&M =	**$68,070,000**		**$3,350,000**	**$3,290,000**	**$3,220,000**	**$3,160,000**	**$3,100,000**	**$3,040,000**	**$2,990,000**	**$2,930,000**	**$2,870,000**	**$2,820,000**
Total Net Present Value for Alternative =	**$168,000,000**		**$8,040,000**	**$7,760,000**	**$7,470,000**	**$7,210,000**	**$6,960,000**	**$6,710,000**	**$6,490,000**	**$6,260,000**	**$6,040,000**	**$5,840,000**

For Twenty (20) Year NPV = $168,000,000

Wes Brown WTP - GAC Pressure Vessels
(Single Pass, 2 ng/L Treatment Goal)

Item Description	Costs	Escalation / Interest (%)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital Costs	**$65,000,000**	-										
Initial Construction - Bond Repayment (5%)	**$104,400,000**	5.0%	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000
WBWTP O&M Costs												
Electrical Usage ($/yr)												
GAC Contactor (Backwash)	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Intermediate Pumping	$140,000		$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000
Electrical Cost ($/year)			**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**
Chemical Usage ($/yr)												
Hydrogen Peroxide	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Powdered Activated Carbon	$0		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Chemical Cost ($/year)			**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**
Operations and Maintenance												
GAC Replacement and Disposal	$2,500,000		$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000
Solids Removal	$0		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Sampling, Labor, and Preventative Maintenance	$30,000		$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000
Maintenance Operations Cost ($/year)			**$2,530,000**	**$2,530,000**	**$2,530,000**	**$2,530,000**	**$2,530,000**	**$2,530,000**	**$2,530,000**	**$2,530,000**	**$2,530,000**	**$2,530,000**
Cost Summary												
Capital Cost Bond Repayment for Year	-	-	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000
O&M Cost for Year	-	-	$2,690,000	$2,690,000	$2,690,000	$2,690,000	$2,690,000	$2,690,000	$2,690,000	$2,690,000	$2,690,000	$2,690,000
Total for Year	-	-	$7,910,000	$7,910,000	$7,910,000	$7,910,000	$7,910,000	$7,910,000	$7,910,000	$7,910,000	$7,910,000	$7,910,000
Net Present Value												
Discount Rate =	**5.0%**											
Escalation Rate =	**3.0%**											
Net Present Value Capital Cost =	**$65,050,000**		**$4,970,000**	**$4,730,000**	**$4,510,000**	**$4,290,000**	**$4,090,000**	**$3,900,000**	**$3,710,000**	**$3,530,000**	**$3,360,000**	**$3,200,000**
Net Present Value for O&M =	**$44,250,000**		**$2,640,000**	**$2,590,000**	**$2,540,000**	**$2,490,000**	**$2,440,000**	**$2,400,000**	**$2,350,000**	**$2,310,000**	**$2,260,000**	**$2,220,000**
Total Net Present Value for Alternative =	**$109,300,000**		**$7,610,000**	**$7,320,000**	**$7,050,000**	**$6,780,000**	**$6,530,000**	**$6,300,000**	**$6,060,000**	**$5,840,000**	**$5,620,000**	**$5,420,000**

For Twenty (20) Year NPV = $109,300,000

Wes Brown WTP - GAC Pressure Vessels
(Single Pass, 2 ng/L Treatment Goal)

Item Description	Costs	Escalation / Interest (%)	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Capital Costs	**$65,000,000**	-										
Initial Construction - Bond Repayment (5%)	**$104,400,000**	5.0%	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000
WBWTP O&M Costs												
Electrical Usage ($/yr)												
GAC Contactor (Backwash)	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Intermediate Pumping	$140,000		$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000
Electrical Cost ($/year)			**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**
Chemical Usage ($/yr)												
Hydrogen Peroxide	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Powdered Activated Carbon	$0		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Chemical Cost ($/year)			**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**
Operations and Maintenance												
GAC Replacement and Disposal	$2,500,000		$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000
Solids Removal	$0		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Sampling, Labor, and Preventative Maintenance	$30,000		$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000
Maintenance Operations Cost ($/year)			**$2,530,000**	**$2,530,000**	**$2,530,000**	**$2,530,000**	**$2,530,000**	**$2,530,000**	**$2,530,000**	**$2,530,000**	**$2,530,000**	**$2,530,000**
Cost Summary												
Capital Cost Bond Repayment for Year	-	-	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000
O&M Cost for Year	-	-	$2,690,000	$2,690,000	$2,690,000	$2,690,000	$2,690,000	$2,690,000	$2,690,000	$2,690,000	$2,690,000	$2,690,000
Total for Year	-	-	$7,910,000	$7,910,000	$7,910,000	$7,910,000	$7,910,000	$7,910,000	$7,910,000	$7,910,000	$7,910,000	$7,910,000
Net Present Value												
Discount Rate =	**5.0%**											
Escalation Rate =	**3.0%**											
Net Present Value Capital Cost =	**$65,050,000**		**$3,050,000**	**$2,910,000**	**$2,770,000**	**$2,640,000**	**$2,510,000**	**$2,390,000**	**$2,280,000**	**$2,170,000**	**$2,070,000**	**$1,970,000**
Net Present Value for O&M =	**$44,250,000**		**$2,180,000**	**$2,140,000**	**$2,090,000**	**$2,060,000**	**$2,020,000**	**$1,980,000**	**$1,940,000**	**$1,900,000**	**$1,870,000**	**$1,830,000**
Total Net Present Value for Alternative =	**$109,300,000**		**$5,230,000**	**$5,050,000**	**$4,860,000**	**$4,700,000**	**$4,530,000**	**$4,370,000**	**$4,220,000**	**$4,070,000**	**$3,940,000**	**$3,800,000**

For Twenty (20) Year NPV = $109,300,000

Wes Brown WTP - GAC Pressure Vessels
(Single Pass, 4 ng/L Treatment Goal)

Item Description	Costs	Escalation / Interest (%)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital Costs	**$65,000,000**	-										
Initial Construction - Bond Repayment (5%)	**$104,400,000**	5.0%	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000
WBWTP O&M Costs												
Electrical Usage ($/yr)												
GAC Contactor (Backwash)	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Intermediate Pumping	$140,000		$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000
Electrical Cost ($/year)			**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**
Chemical Usage ($/yr)												
Hydrogen Peroxide	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Powdered Activated Carbon	$0		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Chemical Cost ($/year)			**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**
Operations and Maintenance												
GAC Replacement and Disposal	$900,000		$900,000	$900,000	$900,000	$900,000	$900,000	$900,000	$900,000	$900,000	$900,000	$900,000
Solids Removal	$0		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Sampling, Labor, and Preventative Maintenance	$30,000		$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000
Maintenance Operations Cost ($/year)			**$930,000**	**$930,000**	**$930,000**	**$930,000**	**$930,000**	**$930,000**	**$930,000**	**$930,000**	**$930,000**	**$930,000**
Cost Summary												
Capital Cost Bond Repayment for Year	-	-	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000
O&M Cost for Year	-	-	$1,090,000	$1,090,000	$1,090,000	$1,090,000	$1,090,000	$1,090,000	$1,090,000	$1,090,000	$1,090,000	$1,090,000
Total for Year	-	-	$6,310,000	$6,310,000	$6,310,000	$6,310,000	$6,310,000	$6,310,000	$6,310,000	$6,310,000	$6,310,000	$6,310,000
Net Present Value												
Discount Rate =	**5.0%**											
Escalation Rate =	**3.0%**											
Net Present Value Capital Cost =	**$65,050,000**		**$4,970,000**	**$4,730,000**	**$4,510,000**	**$4,290,000**	**$4,090,000**	**$3,900,000**	**$3,710,000**	**$3,530,000**	**$3,360,000**	**$3,200,000**
Net Present Value for O&M =	**$17,930,000**		**$1,070,000**	**$1,050,000**	**$1,030,000**	**$1,010,000**	**$990,000**	**$970,000**	**$950,000**	**$930,000**	**$920,000**	**$900,000**
Total Net Present Value for Alternative =	**$82,980,000**		**$6,040,000**	**$5,780,000**	**$5,540,000**	**$5,300,000**	**$5,080,000**	**$4,870,000**	**$4,660,000**	**$4,460,000**	**$4,280,000**	**$4,100,000**

For Twenty (20) Year NPV = $82,980,000

Wes Brown WTP - GAC Pressure Vessels
(Single Pass, 4 ng/L Treatment Goal)

Item Description	Costs	Escalation / Interest (%)	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Capital Costs	**$65,000,000**	-										
Initial Construction - Bond Repayment (5%)	**$104,400,000**	5.0%	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000
WBWTP O&M Costs												
Electrical Usage ($/yr)												
GAC Contactor (Backwash)	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Intermediate Pumping	$140,000		$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000
Electrical Cost ($/year)			**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**	**$150,000**
Chemical Usage ($/yr)												
Hydrogen Peroxide	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Powdered Activated Carbon	$0		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Chemical Cost ($/year)			**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**
Operations and Maintenance												
GAC Replacement and Disposal	$900,000		$900,000	$900,000	$900,000	$900,000	$900,000	$900,000	$900,000	$900,000	$900,000	$900,000
Solids Removal	$0		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Sampling, Labor, and Preventative Maintenance	$30,000		$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000
Maintenance Operations Cost ($/year)			**$930,000**	**$930,000**	**$930,000**	**$930,000**	**$930,000**	**$930,000**	**$930,000**	**$930,000**	**$930,000**	**$930,000**
Cost Summary												
Capital Cost Bond Repayment for Year	-	-	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000
O&M Cost for Year	-	-	$1,090,000	$1,090,000	$1,090,000	$1,090,000	$1,090,000	$1,090,000	$1,090,000	$1,090,000	$1,090,000	$1,090,000
Total for Year	-	-	$6,310,000	$6,310,000	$6,310,000	$6,310,000	$6,310,000	$6,310,000	$6,310,000	$6,310,000	$6,310,000	$6,310,000
Net Present Value												
Discount Rate =	**5.0%**											
Escalation Rate =	**3.0%**											
Net Present Value Capital Cost =	**$65,050,000**		**$3,050,000**	**$2,910,000**	**$2,770,000**	**$2,640,000**	**$2,510,000**	**$2,390,000**	**$2,280,000**	**$2,170,000**	**$2,070,000**	**$1,970,000**
Net Present Value for O&M =	**$17,930,000**		**$880,000**	**$870,000**	**$850,000**	**$830,000**	**$820,000**	**$800,000**	**$790,000**	**$770,000**	**$760,000**	**$740,000**
Total Net Present Value for Alternative =	**$82,980,000**		**$3,930,000**	**$3,780,000**	**$3,620,000**	**$3,470,000**	**$3,330,000**	**$3,190,000**	**$3,070,000**	**$2,940,000**	**$2,830,000**	**$2,710,000**

For Twenty (20) Year NPV = $82,980,000

Thornton WTP - Conversion of Biofilters to GAC Contactors
(Single Pass, 4 ng/L Treatment Goal)

Item Description	Costs	Escalation / Interest (%)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital Costs	**$6,000,000**	-										
Initial Construction - Bond Repayment (5%)	**$9,600,000**	5.0%	$480,000	$480,000	$480,000	$480,000	$480,000	$480,000	$480,000	$480,000	$480,000	$480,000
TWTP O&M Costs												
Electrical Usage ($/yr)												
Chlorine Dioxide Generation	$20,000		$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000
Electrical Cost ($/year)			**$20,000**	**$20,000**	**$20,000**	**$20,000**	**$20,000**	**$20,000**	**$20,000**	**$20,000**	**$20,000**	**$20,000**
Chemical Usage ($/yr)												
Chlorine Dioxide	$400,000		$400,000	$400,000	$400,000	$400,000	$400,000	$400,000	$400,000	$400,000	$400,000	$400,000
Chemical Cost ($/year)			**$400,000**	**$400,000**	**$400,000**	**$400,000**	**$400,000**	**$400,000**	**$400,000**	**$400,000**	**$400,000**	**$400,000**
Operations and Maintenance												
GAC Replacement and Disposal	$4,100,000		$4,100,000	$4,100,000	$4,100,000	$4,100,000	$4,100,000	$4,100,000	$4,100,000	$4,100,000	$4,100,000	$4,100,000
Sampling, Labor, and Preventative Maintenance	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Maintenance Operations Cost ($/year)			**$4,110,000**	**$4,110,000**	**$4,110,000**	**$4,110,000**	**$4,110,000**	**$4,110,000**	**$4,110,000**	**$4,110,000**	**$4,110,000**	**$4,110,000**
Cost Summary												
Capital Cost Bond Repayment for Year	-	-	$480,000	$480,000	$480,000	$480,000	$480,000	$480,000	$480,000	$480,000	$480,000	$480,000
O&M Cost for Year	-	-	$4,530,000	$4,530,000	$4,530,000	$4,530,000	$4,530,000	$4,530,000	$4,530,000	$4,530,000	$4,530,000	$4,530,000
Total for Year	-	-	$5,010,000	$5,010,000	$5,010,000	$5,010,000	$5,010,000	$5,010,000	$5,010,000	$5,010,000	$5,010,000	$5,010,000
Net Present Value												
Discount Rate =	**5.0%**											
Escalation Rate =	**3.0%**											
Net Present Value Capital Cost =	**$5,970,000**		**$460,000**	**$440,000**	**$410,000**	**$390,000**	**$380,000**	**$360,000**	**$340,000**	**$320,000**	**$310,000**	**$290,000**
Net Present Value for O&M =	**$74,480,000**		**$4,440,000**	**$4,360,000**	**$4,280,000**	**$4,190,000**	**$4,110,000**	**$4,040,000**	**$3,960,000**	**$3,880,000**	**$3,810,000**	**$3,740,000**
Total Net Present Value for Alternative =	**$80,450,000**		**$4,900,000**	**$4,800,000**	**$4,690,000**	**$4,580,000**	**$4,490,000**	**$4,400,000**	**$4,300,000**	**$4,200,000**	**$4,120,000**	**$4,030,000**

For Twenty (20) Year NPV = $80,450,000

Thornton WTP - Conversion of Biofilters to GAC Contactors
(Single Pass, 4 ng/L Treatment Goal)

Item Description	Costs	Escalation / Interest (%)	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Capital Costs	**$6,000,000**	-										
Initial Construction - Bond Repayment (5%)	**$9,600,000**	5.0%	$480,000	$480,000	$480,000	$480,000	$480,000	$480,000	$480,000	$480,000	$480,000	$480,000
TWTP O&M Costs												
Electrical Usage ($/yr)												
Chlorine Dioxide Generation	$20,000		$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000
Electrical Cost ($/year)			**$20,000**	**$20,000**	**$20,000**	**$20,000**	**$20,000**	**$20,000**	**$20,000**	**$20,000**	**$20,000**	**$20,000**
Chemical Usage ($/yr)												
Chlorine Dioxide	$400,000		$400,000	$400,000	$400,000	$400,000	$400,000	$400,000	$400,000	$400,000	$400,000	$400,000
Chemical Cost ($/year)			**$400,000**	**$400,000**	**$400,000**	**$400,000**	**$400,000**	**$400,000**	**$400,000**	**$400,000**	**$400,000**	**$400,000**
Operations and Maintenance												
GAC Replacement and Disposal	$4,100,000		$4,100,000	$4,100,000	$4,100,000	$4,100,000	$4,100,000	$4,100,000	$4,100,000	$4,100,000	$4,100,000	$4,100,000
Sampling, Labor, and Preventative Maintenance	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Maintenance Operations Cost ($/year)			**$4,110,000**	**$4,110,000**	**$4,110,000**	**$4,110,000**	**$4,110,000**	**$4,110,000**	**$4,110,000**	**$4,110,000**	**$4,110,000**	**$4,110,000**
Cost Summary												
Capital Cost Bond Repayment for Year	-	-	$480,000	$480,000	$480,000	$480,000	$480,000	$480,000	$480,000	$480,000	$480,000	$480,000
O&M Cost for Year	-	-	$4,530,000	$4,530,000	$4,530,000	$4,530,000	$4,530,000	$4,530,000	$4,530,000	$4,530,000	$4,530,000	$4,530,000
Total for Year	-	-	$5,010,000	$5,010,000	$5,010,000	$5,010,000	$5,010,000	$5,010,000	$5,010,000	$5,010,000	$5,010,000	$5,010,000
Net Present Value												
Discount Rate =	**5.0%**											
Escalation Rate =	**3.0%**											
Net Present Value Capital Cost =	**$5,970,000**		**$280,000**	**$270,000**	**$250,000**	**$240,000**	**$230,000**	**$220,000**	**$210,000**	**$200,000**	**$190,000**	**$180,000**
Net Present Value for O&M =	**$74,480,000**		**$3,670,000**	**$3,600,000**	**$3,530,000**	**$3,460,000**	**$3,390,000**	**$3,330,000**	**$3,270,000**	**$3,200,000**	**$3,140,000**	**$3,080,000**
Total Net Present Value for Alternative =	**$80,450,000**		**$3,950,000**	**$3,870,000**	**$3,780,000**	**$3,700,000**	**$3,620,000**	**$3,550,000**	**$3,480,000**	**$3,400,000**	**$3,330,000**	**$3,260,000**

For Twenty (20) Year NPV = $80,450,000

Thornton WTP - GAC Contactors
(Lead/Lag, Non-Detect Treatment Goal)

Item Description	Costs	Escalation / Interest (%)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital Costs	**$50,000,000**	-										
Initial Construction - Bond Repayment (5%)	**$80,200,000**	5.0%	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000
TWTP O&M Costs												
Electrical Usage ($/yr)												
GAC Contactor (Backwash)	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Intermediate Pumping	$50,000		$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000
Electrical Cost ($/year)			**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**
Chemical Usage ($/yr)												
Hydrogen Peroxide	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Chemical Cost ($/year)			**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**
Operations and Maintenance												
GAC Replacement and Disposal	$3,300,000		$3,300,000	$3,300,000	$3,300,000	$3,300,000	$3,300,000	$3,300,000	$3,300,000	$3,300,000	$3,300,000	$3,300,000
Sampling, Labor, and Preventative Maintenance	$20,000		$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000
Maintenance Operations Cost ($/year)			**$3,320,000**	**$3,320,000**	**$3,320,000**	**$3,320,000**	**$3,320,000**	**$3,320,000**	**$3,320,000**	**$3,320,000**	**$3,320,000**	**$3,320,000**
Cost Summary												
Capital Cost Bond Repayment for Year	-	-	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000
O&M Cost for Year	-	-	$3,390,000	$3,390,000	$3,390,000	$3,390,000	$3,390,000	$3,390,000	$3,390,000	$3,390,000	$3,390,000	$3,390,000
Total for Year	-	-	$7,400,000	$7,400,000	$7,400,000	$7,400,000	$7,400,000	$7,400,000	$7,400,000	$7,400,000	$7,400,000	$7,400,000
Net Present Value												
Discount Rate =	**5.0%**											
Escalation Rate =	**3.0%**											
Net Present Value Capital Cost =	**$49,970,000**		**$3,820,000**	**$3,640,000**	**$3,460,000**	**$3,300,000**	**$3,140,000**	**$2,990,000**	**$2,850,000**	**$2,710,000**	**$2,580,000**	**$2,460,000**
Net Present Value for O&M =	**$55,740,000**		**$3,330,000**	**$3,260,000**	**$3,200,000**	**$3,140,000**	**$3,080,000**	**$3,020,000**	**$2,960,000**	**$2,910,000**	**$2,850,000**	**$2,800,000**
Total Net Present Value for Alternative =	**$105,710,000**		**$7,150,000**	**$6,900,000**	**$6,660,000**	**$6,440,000**	**$6,220,000**	**$6,010,000**	**$5,810,000**	**$5,620,000**	**$5,430,000**	**$5,260,000**

For Twenty (20) Year NPV = $105,710,000

Thornton WTP - GAC Contactors
(Lead/Lag, Non-Detect Treatment Goal)

Item Description	Costs	Escalation / Interest (%)	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Capital Costs	**$50,000,000**	-										
Initial Construction - Bond Repayment (5%)	**$80,200,000**	5.0%	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000
TWTP O&M Costs												
Electrical Usage ($/yr)												
GAC Contactor (Backwash)	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Intermediate Pumping	$50,000		$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000
Electrical Cost ($/year)			**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**
Chemical Usage ($/yr)												
Hydrogen Peroxide	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Chemical Cost ($/year)			**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**
Operations and Maintenance												
GAC Replacement and Disposal	$3,300,000		$3,300,000	$3,300,000	$3,300,000	$3,300,000	$3,300,000	$3,300,000	$3,300,000	$3,300,000	$3,300,000	$3,300,000
Sampling, Labor, and Preventative Maintenance	$20,000		$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000
Maintenance Operations Cost ($/year)			**$3,320,000**	**$3,320,000**	**$3,320,000**	**$3,320,000**	**$3,320,000**	**$3,320,000**	**$3,320,000**	**$3,320,000**	**$3,320,000**	**$3,320,000**
Cost Summary												
Capital Cost Bond Repayment for Year	-	-	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000	$4,010,000
O&M Cost for Year	-	-	$3,390,000	$3,390,000	$3,390,000	$3,390,000	$3,390,000	$3,390,000	$3,390,000	$3,390,000	$3,390,000	$3,390,000
Total for Year	-	-	$7,400,000	$7,400,000	$7,400,000	$7,400,000	$7,400,000	$7,400,000	$7,400,000	$7,400,000	$7,400,000	$7,400,000
Net Present Value												
Discount Rate =	**5.0%**											
Escalation Rate =	**3.0%**											
Net Present Value Capital Cost =	**$49,970,000**		**$2,340,000**	**$2,230,000**	**$2,130,000**	**$2,030,000**	**$1,930,000**	**$1,840,000**	**$1,750,000**	**$1,670,000**	**$1,590,000**	**$1,510,000**
Net Present Value for O&M =	**$55,740,000**		**$2,740,000**	**$2,690,000**	**$2,640,000**	**$2,590,000**	**$2,540,000**	**$2,490,000**	**$2,440,000**	**$2,400,000**	**$2,350,000**	**$2,310,000**
Total Net Present Value for Alternative =	**$105,710,000**		**$5,080,000**	**$4,920,000**	**$4,770,000**	**$4,620,000**	**$4,470,000**	**$4,330,000**	**$4,190,000**	**$4,070,000**	**$3,940,000**	**$3,820,000**

For Twenty (20) Year NPV = $105,710,000

Thornton WTP - GAC Contactors
(Single Pass, 2 ng/L Treatment Goal)

Item Description	Costs	Escalation / Interest (%)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital Costs	**$30,000,000**	-										
Initial Construction - Bond Repayment (5%)	**$48,200,000**	5.0%	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000
TWTP O&M Costs												
Electrical Usage ($/yr)												
GAC Contactor (Backwash)	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Intermediate Pumping	$50,000		$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000
Electrical Cost ($/year)			**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**
Chemical Usage ($/yr)												
Hydrogen Peroxide	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Chemical Cost ($/year)			**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**
Operations and Maintenance												
GAC Replacement and Disposal	$3,100,000		$3,100,000	$3,100,000	$3,100,000	$3,100,000	$3,100,000	$3,100,000	$3,100,000	$3,100,000	$3,100,000	$3,100,000
Sampling, Labor, and Preventative Maintenance	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Maintenance Operations Cost ($/year)			**$3,110,000**	**$3,110,000**	**$3,110,000**	**$3,110,000**	**$3,110,000**	**$3,110,000**	**$3,110,000**	**$3,110,000**	**$3,110,000**	**$3,110,000**
Cost Summary												
Capital Cost Bond Repayment for Year	-	-	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000
O&M Cost for Year	-	-	$3,180,000	$3,180,000	$3,180,000	$3,180,000	$3,180,000	$3,180,000	$3,180,000	$3,180,000	$3,180,000	$3,180,000
Total for Year	-	-	$5,590,000	$5,590,000	$5,590,000	$5,590,000	$5,590,000	$5,590,000	$5,590,000	$5,590,000	$5,590,000	$5,590,000
Net Present Value												
Discount Rate =	**5.0%**											
Escalation Rate =	**3.0%**											
Net Present Value Capital Cost =	**$30,030,000**		**$2,300,000**	**$2,190,000**	**$2,080,000**	**$1,980,000**	**$1,890,000**	**$1,800,000**	**$1,710,000**	**$1,630,000**	**$1,550,000**	**$1,480,000**
Net Present Value for O&M =	**$52,270,000**		**$3,120,000**	**$3,060,000**	**$3,000,000**	**$2,940,000**	**$2,890,000**	**$2,830,000**	**$2,780,000**	**$2,730,000**	**$2,670,000**	**$2,620,000**
Total Net Present Value for Alternative =	**$82,300,000**		**$5,420,000**	**$5,250,000**	**$5,080,000**	**$4,920,000**	**$4,780,000**	**$4,630,000**	**$4,490,000**	**$4,360,000**	**$4,220,000**	**$4,100,000**

For Twenty (20) Year NPV = $82,300,000

Thornton WTP - GAC Contactors
(Single Pass, 2 ng/L Treatment Goal)

Item Description	Costs	Escalation / Interest (%)	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Capital Costs	**$30,000,000**	-										
Initial Construction - Bond Repayment (5%)	**$48,200,000**	5.0%	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000
TWTP O&M Costs												
Electrical Usage ($/yr)												
GAC Contactor (Backwash)	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Intermediate Pumping	$50,000		$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000
Electrical Cost ($/year)			**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**
Chemical Usage ($/yr)												
Hydrogen Peroxide	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Chemical Cost ($/year)			**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**
Operations and Maintenance												
GAC Replacement and Disposal	$3,100,000		$3,100,000	$3,100,000	$3,100,000	$3,100,000	$3,100,000	$3,100,000	$3,100,000	$3,100,000	$3,100,000	$3,100,000
Sampling, Labor, and Preventative Maintenance	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Maintenance Operations Cost ($/year)			**$3,110,000**	**$3,110,000**	**$3,110,000**	**$3,110,000**	**$3,110,000**	**$3,110,000**	**$3,110,000**	**$3,110,000**	**$3,110,000**	**$3,110,000**
Cost Summary												
Capital Cost Bond Repayment for Year	-	-	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000
O&M Cost for Year	-	-	$3,180,000	$3,180,000	$3,180,000	$3,180,000	$3,180,000	$3,180,000	$3,180,000	$3,180,000	$3,180,000	$3,180,000
Total for Year	-	-	$5,590,000	$5,590,000	$5,590,000	$5,590,000	$5,590,000	$5,590,000	$5,590,000	$5,590,000	$5,590,000	$5,590,000
Net Present Value												
Discount Rate =	**5.0%**											
Escalation Rate =	**3.0%**											
Net Present Value Capital Cost =	**$30,030,000**		**$1,410,000**	**$1,340,000**	**$1,280,000**	**$1,220,000**	**$1,160,000**	**$1,100,000**	**$1,050,000**	**$1,000,000**	**$950,000**	**$910,000**
Net Present Value for O&M =	**$52,270,000**		**$2,570,000**	**$2,520,000**	**$2,480,000**	**$2,430,000**	**$2,380,000**	**$2,340,000**	**$2,290,000**	**$2,250,000**	**$2,210,000**	**$2,160,000**
Total Net Present Value for Alternative =	**$82,300,000**		**$3,980,000**	**$3,860,000**	**$3,760,000**	**$3,650,000**	**$3,540,000**	**$3,440,000**	**$3,340,000**	**$3,250,000**	**$3,160,000**	**$3,070,000**

For Twenty (20) Year NPV = $82,300,000

Thornton WTP - GAC Contactors
(Single Pass, 4 ng/L Treatment Goal)

Item Description	Costs	Escalation / Interest (%)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital Costs	**$30,000,000**	-										
Initial Construction - Bond Repayment (5%)	**$48,200,000**	5.0%	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000
TWTP O&M Costs												
Electrical Usage ($/yr)												
GAC Contactor (Backwash)	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Intermediate Pumping	$50,000		$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000
Electrical Cost ($/year)			**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**
Chemical Usage ($/yr)												
Hydrogen Peroxide	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Chemical Cost ($/year)			**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**
Operations and Maintenance												
GAC Replacement and Disposal	$1,600,000		$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000
Sampling, Labor, and Preventative Maintenance	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Maintenance Operations Cost ($/year)			**$1,610,000**	**$1,610,000**	**$1,610,000**	**$1,610,000**	**$1,610,000**	**$1,610,000**	**$1,610,000**	**$1,610,000**	**$1,610,000**	**$1,610,000**
Cost Summary												
Capital Cost Bond Repayment for Year	-	-	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000
O&M Cost for Year	-	-	$1,680,000	$1,680,000	$1,680,000	$1,680,000	$1,680,000	$1,680,000	$1,680,000	$1,680,000	$1,680,000	$1,680,000
Total for Year	-	-	$4,090,000	$4,090,000	$4,090,000	$4,090,000	$4,090,000	$4,090,000	$4,090,000	$4,090,000	$4,090,000	$4,090,000
Net Present Value												
Discount Rate =	**5.0%**											
Escalation Rate =	**3.0%**											
Net Present Value Capital Cost =	**$30,030,000**		**$2,300,000**	**$2,190,000**	**$2,080,000**	**$1,980,000**	**$1,890,000**	**$1,800,000**	**$1,710,000**	**$1,630,000**	**$1,550,000**	**$1,480,000**
Net Present Value for O&M =	**$27,650,000**		**$1,650,000**	**$1,620,000**	**$1,590,000**	**$1,560,000**	**$1,530,000**	**$1,500,000**	**$1,470,000**	**$1,440,000**	**$1,410,000**	**$1,390,000**
Total Net Present Value for Alternative =	**$57,680,000**		**$3,950,000**	**$3,810,000**	**$3,670,000**	**$3,540,000**	**$3,420,000**	**$3,300,000**	**$3,180,000**	**$3,070,000**	**$2,960,000**	**$2,870,000**

For Twenty (20) Year NPV = $57,680,000

Thornton WTP - GAC Contactors
(Single Pass, 4 ng/L Treatment Goal)

Item Description	Costs	Escalation / Interest (%)	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Capital Costs	**$30,000,000**	-										
Initial Construction - Bond Repayment (5%)	**$48,200,000**	5.0%	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000
TWTP O&M Costs												
Electrical Usage ($/yr)												
GAC Contactor (Backwash)	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Intermediate Pumping	$50,000		$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000
Electrical Cost ($/year)			**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**	**$60,000**
Chemical Usage ($/yr)												
Hydrogen Peroxide	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Chemical Cost ($/year)			**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**
Operations and Maintenance												
GAC Replacement and Disposal	$1,600,000		$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000
Sampling, Labor, and Preventative Maintenance	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Maintenance Operations Cost ($/year)			**$1,610,000**	**$1,610,000**	**$1,610,000**	**$1,610,000**	**$1,610,000**	**$1,610,000**	**$1,610,000**	**$1,610,000**	**$1,610,000**	**$1,610,000**
Cost Summary												
Capital Cost Bond Repayment for Year	-	-	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000	$2,410,000
O&M Cost for Year	-	-	$1,680,000	$1,680,000	$1,680,000	$1,680,000	$1,680,000	$1,680,000	$1,680,000	$1,680,000	$1,680,000	$1,680,000
Total for Year	-	-	$4,090,000	$4,090,000	$4,090,000	$4,090,000	$4,090,000	$4,090,000	$4,090,000	$4,090,000	$4,090,000	$4,090,000
Net Present Value												
Discount Rate =	**5.0%**											
Escalation Rate =	**3.0%**											
Net Present Value Capital Cost =	**$30,030,000**		**$1,410,000**	**$1,340,000**	**$1,280,000**	**$1,220,000**	**$1,160,000**	**$1,100,000**	**$1,050,000**	**$1,000,000**	**$950,000**	**$910,000**
Net Present Value for O&M =	**$27,650,000**		**$1,360,000**	**$1,330,000**	**$1,310,000**	**$1,280,000**	**$1,260,000**	**$1,240,000**	**$1,210,000**	**$1,190,000**	**$1,170,000**	**$1,140,000**
Total Net Present Value for Alternative =	**$57,680,000**		**$2,770,000**	**$2,670,000**	**$2,590,000**	**$2,500,000**	**$2,420,000**	**$2,340,000**	**$2,260,000**	**$2,190,000**	**$2,120,000**	**$2,050,000**

For Twenty (20) Year NPV = $57,680,000

Thornton WTP - GAC Pressure Vessels
(Lead/Lag, Non-Detect Treatment Goal)

Item Description	Costs	Escalation / Interest (%)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital Costs	**$65,000,000**	-										
Initial Construction - Bond Repayment (5%)	**$104,400,000**	5.0%	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000
TWTP O&M Costs												
Electrical Usage ($/yr)												
GAC Contactor (Backwash)	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Intermediate Pumping	$100,000		$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000
Electrical Cost ($/year)			**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**
Chemical Usage ($/yr)												
Hydrogen Peroxide	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Chemical Cost ($/year)			**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**
Operations and Maintenance												
GAC Replacement and Disposal	$3,300,000		$3,300,000	$3,300,000	$3,300,000	$3,300,000	$3,300,000	$3,300,000	$3,300,000	$3,300,000	$3,300,000	$3,300,000
Sampling, Labor, and Preventative Maintenance	$40,000		$40,000	$40,000	$40,000	$40,000	$40,000	$40,000	$40,000	$40,000	$40,000	$40,000
Maintenance Operations Cost ($/year)			**$3,340,000**	**$3,340,000**	**$3,340,000**	**$3,340,000**	**$3,340,000**	**$3,340,000**	**$3,340,000**	**$3,340,000**	**$3,340,000**	**$3,340,000**
Cost Summary												
Capital Cost Bond Repayment for Year	-	-	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000
O&M Cost for Year	-	-	$3,460,000	$3,460,000	$3,460,000	$3,460,000	$3,460,000	$3,460,000	$3,460,000	$3,460,000	$3,460,000	$3,460,000
Total for Year	-	-	$8,680,000	$8,680,000	$8,680,000	$8,680,000	$8,680,000	$8,680,000	$8,680,000	$8,680,000	$8,680,000	$8,680,000
Net Present Value												
Discount Rate =	**5.0%**											
Escalation Rate =	**3.0%**											
Net Present Value Capital Cost =	**$65,050,000**		**$4,970,000**	**$4,730,000**	**$4,510,000**	**$4,290,000**	**$4,090,000**	**$3,900,000**	**$3,710,000**	**$3,530,000**	**$3,360,000**	**$3,200,000**
Net Present Value for O&M =	**$56,880,000**		**$3,390,000**	**$3,330,000**	**$3,270,000**	**$3,200,000**	**$3,140,000**	**$3,080,000**	**$3,020,000**	**$2,970,000**	**$2,910,000**	**$2,850,000**
Total Net Present Value for Alternative =	**$121,930,000**		**$8,360,000**	**$8,060,000**	**$7,780,000**	**$7,490,000**	**$7,230,000**	**$6,980,000**	**$6,730,000**	**$6,500,000**	**$6,270,000**	**$6,050,000**

For Twenty (20) Year NPV = $121,930,000

Thornton WTP - GAC Pressure Vessels
(Lead/Lag, Non-Detect Treatment Goal)

Item Description	Costs	Escalation / Interest (%)	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Capital Costs	**$65,000,000**	-										
Initial Construction - Bond Repayment (5%)	**$104,400,000**	5.0%	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000
TWTP O&M Costs												
Electrical Usage ($/yr)												
GAC Contactor (Backwash)	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Intermediate Pumping	$100,000		$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000
Electrical Cost ($/year)			**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**
Chemical Usage ($/yr)												
Hydrogen Peroxide	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Chemical Cost ($/year)			**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**
Operations and Maintenance												
GAC Replacement and Disposal	$3,300,000		$3,300,000	$3,300,000	$3,300,000	$3,300,000	$3,300,000	$3,300,000	$3,300,000	$3,300,000	$3,300,000	$3,300,000
Sampling, Labor, and Preventative Maintenance	$40,000		$40,000	$40,000	$40,000	$40,000	$40,000	$40,000	$40,000	$40,000	$40,000	$40,000
Maintenance Operations Cost ($/year)			**$3,340,000**	**$3,340,000**	**$3,340,000**	**$3,340,000**	**$3,340,000**	**$3,340,000**	**$3,340,000**	**$3,340,000**	**$3,340,000**	**$3,340,000**
Cost Summary												
Capital Cost Bond Repayment for Year	-	-	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000	$5,220,000
O&M Cost for Year	-	-	$3,460,000	$3,460,000	$3,460,000	$3,460,000	$3,460,000	$3,460,000	$3,460,000	$3,460,000	$3,460,000	$3,460,000
Total for Year	-	-	$8,680,000	$8,680,000	$8,680,000	$8,680,000	$8,680,000	$8,680,000	$8,680,000	$8,680,000	$8,680,000	$8,680,000
Net Present Value												
Discount Rate =	**5.0%**											
Escalation Rate =	**3.0%**											
Net Present Value Capital Cost =	**$65,050,000**		**$3,050,000**	**$2,910,000**	**$2,770,000**	**$2,640,000**	**$2,510,000**	**$2,390,000**	**$2,280,000**	**$2,170,000**	**$2,070,000**	**$1,970,000**
Net Present Value for O&M =	**$56,880,000**		**$2,800,000**	**$2,750,000**	**$2,690,000**	**$2,640,000**	**$2,590,000**	**$2,540,000**	**$2,500,000**	**$2,450,000**	**$2,400,000**	**$2,360,000**
Total Net Present Value for Alternative =	**$121,930,000**		**$5,850,000**	**$5,660,000**	**$5,460,000**	**$5,280,000**	**$5,100,000**	**$4,930,000**	**$4,780,000**	**$4,620,000**	**$4,470,000**	**$4,330,000**

For Twenty (20) Year NPV = $121,930,000

Thornton WTP - GAC Pressure Vessels
(Single Pass, 2 ng/L Treatment Goal)

Item Description	Costs	Escalation / Interest (%)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital Costs	**$45,000,000**	-										
Initial Construction - Bond Repayment (5%)	**$72,200,000**	5.0%	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000
TWTP O&M Costs												
Electrical Usage ($/yr)												
GAC Contactor (Backwash)	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Intermediate Pumping	$100,000		$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000
Electrical Cost ($/year)			**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**
Chemical Usage ($/yr)												
Hydrogen Peroxide	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Chemical Cost ($/year)			**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**
Operations and Maintenance												
GAC Replacement and Disposal	$3,100,000		$3,100,000	$3,100,000	$3,100,000	$3,100,000	$3,100,000	$3,100,000	$3,100,000	$3,100,000	$3,100,000	$3,100,000
Sampling, Labor, and Preventative Maintenance	$20,000		$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000
Maintenance Operations Cost ($/year)			**$3,120,000**	**$3,120,000**	**$3,120,000**	**$3,120,000**	**$3,120,000**	**$3,120,000**	**$3,120,000**	**$3,120,000**	**$3,120,000**	**$3,120,000**
Cost Summary												
Capital Cost Bond Repayment for Year	-	-	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000
O&M Cost for Year	-	-	$3,240,000	$3,240,000	$3,240,000	$3,240,000	$3,240,000	$3,240,000	$3,240,000	$3,240,000	$3,240,000	$3,240,000
Total for Year	-	-	$6,850,000	$6,850,000	$6,850,000	$6,850,000	$6,850,000	$6,850,000	$6,850,000	$6,850,000	$6,850,000	$6,850,000
Net Present Value												
Discount Rate =	**5.0%**											
Escalation Rate =	**3.0%**											
Net Present Value Capital Cost =	**$44,990,000**		**$3,440,000**	**$3,270,000**	**$3,120,000**	**$2,970,000**	**$2,830,000**	**$2,690,000**	**$2,570,000**	**$2,440,000**	**$2,330,000**	**$2,220,000**
Net Present Value for O&M =	**$53,290,000**		**$3,180,000**	**$3,120,000**	**$3,060,000**	**$3,000,000**	**$2,940,000**	**$2,890,000**	**$2,830,000**	**$2,780,000**	**$2,730,000**	**$2,670,000**
Total Net Present Value for Alternative =	**$98,280,000**		**$6,620,000**	**$6,390,000**	**$6,180,000**	**$5,970,000**	**$5,770,000**	**$5,580,000**	**$5,400,000**	**$5,220,000**	**$5,060,000**	**$4,890,000**

For Twenty (20) Year NPV = $98,280,000

Thornton WTP - GAC Pressure Vessels
(Single Pass, 2 ng/L Treatment Goal)

Item Description	Costs	Escalation / Interest (%)	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Capital Costs	**$45,000,000**	-										
Initial Construction - Bond Repayment (5%)	**$72,200,000**	5.0%	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000
TWTP O&M Costs												
Electrical Usage ($/yr)												
GAC Contactor (Backwash)	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Intermediate Pumping	$100,000		$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000
Electrical Cost ($/year)			**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**
Chemical Usage ($/yr)												
Hydrogen Peroxide	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Chemical Cost ($/year)			**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**
Operations and Maintenance												
GAC Replacement and Disposal	$3,100,000		$3,100,000	$3,100,000	$3,100,000	$3,100,000	$3,100,000	$3,100,000	$3,100,000	$3,100,000	$3,100,000	$3,100,000
Sampling, Labor, and Preventative Maintenance	$20,000		$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000
Maintenance Operations Cost ($/year)			**$3,120,000**	**$3,120,000**	**$3,120,000**	**$3,120,000**	**$3,120,000**	**$3,120,000**	**$3,120,000**	**$3,120,000**	**$3,120,000**	**$3,120,000**
Cost Summary												
Capital Cost Bond Repayment for Year	-	-	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000
O&M Cost for Year	-	-	$3,240,000	$3,240,000	$3,240,000	$3,240,000	$3,240,000	$3,240,000	$3,240,000	$3,240,000	$3,240,000	$3,240,000
Total for Year	-	-	$6,850,000	$6,850,000	$6,850,000	$6,850,000	$6,850,000	$6,850,000	$6,850,000	$6,850,000	$6,850,000	$6,850,000
Net Present Value												
Discount Rate =	**5.0%**											
Escalation Rate =	**3.0%**											
Net Present Value Capital Cost =	**$44,990,000**		**$2,110,000**	**$2,010,000**	**$1,910,000**	**$1,820,000**	**$1,740,000**	**$1,650,000**	**$1,580,000**	**$1,500,000**	**$1,430,000**	**$1,360,000**
Net Present Value for O&M =	**$53,290,000**		**$2,620,000**	**$2,570,000**	**$2,520,000**	**$2,480,000**	**$2,430,000**	**$2,380,000**	**$2,340,000**	**$2,290,000**	**$2,250,000**	**$2,210,000**
Total Net Present Value for Alternative =	**$98,280,000**		**$4,730,000**	**$4,580,000**	**$4,430,000**	**$4,300,000**	**$4,170,000**	**$4,030,000**	**$3,920,000**	**$3,790,000**	**$3,680,000**	**$3,570,000**

For Twenty (20) Year NPV = $98,280,000

Thornton WTP - GAC Pressure Vessels
(Single Pass, 4 ng/L Treatment Goal)

Item Description	Costs	Escalation / Interest (%)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital Costs	**$45,000,000**	-										
Initial Construction - Bond Repayment (5%)	**$72,200,000**	5.0%	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000
TWTP O&M Costs												
Electrical Usage ($/yr)												
GAC Contactor (Backwash)	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Intermediate Pumping	$100,000		$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000
Electrical Cost ($/year)			**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**
Chemical Usage ($/yr)												
Hydrogen Peroxide	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Chemical Cost ($/year)			**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**
Operations and Maintenance												
GAC Replacement and Disposal	$1,600,000		$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000
Sampling, Labor, and Preventative Maintenance	$20,000		$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000
Maintenance Operations Cost ($/year)			**$1,620,000**	**$1,620,000**	**$1,620,000**	**$1,620,000**	**$1,620,000**	**$1,620,000**	**$1,620,000**	**$1,620,000**	**$1,620,000**	**$1,620,000**
Cost Summary												
Capital Cost Bond Repayment for Year	-	-	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000
O&M Cost for Year	-	-	$1,740,000	$1,740,000	$1,740,000	$1,740,000	$1,740,000	$1,740,000	$1,740,000	$1,740,000	$1,740,000	$1,740,000
Total for Year	-	-	$5,350,000	$5,350,000	$5,350,000	$5,350,000	$5,350,000	$5,350,000	$5,350,000	$5,350,000	$5,350,000	$5,350,000
Net Present Value												
Discount Rate =	**5.0%**											
Escalation Rate =	**3.0%**											
Net Present Value Capital Cost =	**$44,990,000**		**$3,440,000**	**$3,270,000**	**$3,120,000**	**$2,970,000**	**$2,830,000**	**$2,690,000**	**$2,570,000**	**$2,440,000**	**$2,330,000**	**$2,220,000**
Net Present Value for O&M =	**$28,600,000**		**$1,710,000**	**$1,670,000**	**$1,640,000**	**$1,610,000**	**$1,580,000**	**$1,550,000**	**$1,520,000**	**$1,490,000**	**$1,460,000**	**$1,440,000**
Total Net Present Value for Alternative =	**$73,590,000**		**$5,150,000**	**$4,940,000**	**$4,760,000**	**$4,580,000**	**$4,410,000**	**$4,240,000**	**$4,090,000**	**$3,930,000**	**$3,790,000**	**$3,660,000**

For Twenty (20) Year NPV = $73,590,000

Thornton WTP - GAC Pressure Vessels
(Single Pass, 4 ng/L Treatment Goal)

Item Description	Costs	Escalation / Interest (%)	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Capital Costs	**$45,000,000**	-										
Initial Construction - Bond Repayment (5%)	**$72,200,000**	5.0%	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000
TWTP O&M Costs												
Electrical Usage ($/yr)												
GAC Contactor (Backwash)	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Intermediate Pumping	$100,000		$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000
Electrical Cost ($/year)			**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**	**$110,000**
Chemical Usage ($/yr)												
Hydrogen Peroxide	$10,000		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Chemical Cost ($/year)			**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**
Operations and Maintenance												
GAC Replacement and Disposal	$1,600,000		$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000
Sampling, Labor, and Preventative Maintenance	$20,000		$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000
Maintenance Operations Cost ($/year)			**$1,620,000**	**$1,620,000**	**$1,620,000**	**$1,620,000**	**$1,620,000**	**$1,620,000**	**$1,620,000**	**$1,620,000**	**$1,620,000**	**$1,620,000**
Cost Summary												
Capital Cost Bond Repayment for Year	-	-	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000	$3,610,000
O&M Cost for Year	-	-	$1,740,000	$1,740,000	$1,740,000	$1,740,000	$1,740,000	$1,740,000	$1,740,000	$1,740,000	$1,740,000	$1,740,000
Total for Year	-	-	$5,350,000	$5,350,000	$5,350,000	$5,350,000	$5,350,000	$5,350,000	$5,350,000	$5,350,000	$5,350,000	$5,350,000
Net Present Value												
Discount Rate =	**5.0%**											
Escalation Rate =	**3.0%**											
Net Present Value Capital Cost =	**$44,990,000**		**$2,110,000**	**$2,010,000**	**$1,910,000**	**$1,820,000**	**$1,740,000**	**$1,650,000**	**$1,580,000**	**$1,500,000**	**$1,430,000**	**$1,360,000**
Net Present Value for O&M =	**$28,600,000**		**$1,410,000**	**$1,380,000**	**$1,360,000**	**$1,330,000**	**$1,300,000**	**$1,280,000**	**$1,250,000**	**$1,230,000**	**$1,210,000**	**$1,180,000**
Total Net Present Value for Alternative =	**$73,590,000**		**$3,520,000**	**$3,390,000**	**$3,270,000**	**$3,150,000**	**$3,040,000**	**$2,930,000**	**$2,830,000**	**$2,730,000**	**$2,640,000**	**$2,540,000**

For Twenty (20) Year NPV = $73,590,000