City of Thornton

Owner's Advisor Services
PFAS Treatment

Project No. 23-127

Conceptual Design Report

FINAL / July 2024

carollo

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Abbreviations

AFY	acre-feet per year
ANSI	American National Standards Institute
°C	degrees Celsius
$CaCO_3$	calcium carbonate
cal/cm^2	calories per square centimeter
CCPP	calcium carbonate precipitation potential
CDPHE	Colorado Department of Public Health and Environment
City	City of Thornton
CPDWR	Colorado Primary Drinking Water Regulations
CT/mL	count per milliliter
CT/100 mL	count per 100 milliliters
D/DBPR	Disinfectants and Disinfection Byproducts Rule
DO	dissolved oxygen
EGL	East Gravel Lakes
EPA	Environmental Protection Agency
GAC	granular activated carbon
Galv Stl	galvanized steel
GenX	hexafluoropropylene oxide dimer acid
gpm	gallons per minute
GRC	galvanized rigid steel conduit
HART	highway addressable remote transducer
HFPO-DA	hexafluoropropylene oxide dimer acid
HI	Hazard Index
hp	horsepower
HVAC	heating, ventilation, and air conditioning
IEEE	Institute of Electrical and Electronic Engineers
IX	ion exchange
LED	light emitting diode
µg/L	micrograms per liter
mA	milliamperes
MCC	motor control center
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
mgd	million gallons per day
mg/L	milligrams per liter
MIB	2-methylisoborneol
mm	millimeter
ND	Non-Detect

NEC	National Electric Code
NEMA	National Electric Manufacturers Association
NFPA	National Fire Protection Association
ng/L	nanograms per liter
No.	number
NPDWR	National Primary Drinking Water Regulation
NTU	nephelometric turbidity unit
ortho-P	orthophosphate
P&ID	process and instrumentation diagram
PCC	point of common coupling
PCS	Polyvinyl chloride coated rigid steel conduit systems
PFAS	per- and polyfluoroalkyl substances
PFBS	perfluorobutane sulfonic acid
PFHxS	perfluorohexane sulfonic acid
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonic acid
PLC	programmable logic controller
Project	Thornton PFAS Treatment Project
RFP	Request for Proposals
SCADA	Supervisory Control and Data Acquisition
SMCL	secondary maximum contaminant level
sq ft	square feet
SST	stainless steel
TDS	total dissolved solids
TOC	total organic carbon
TTP	(old) Thornton Treatment Plant
TWTP	Thornton Water Treatment Plant
UL	Underwriters' Laboratories, Inc.
UPS	uninterruptable power supply
Utility	Xcel Energy
VFD	variable frequency drive
WBWTP	Wes Brown Water Treatment Plant
WSSC	Water Supply and Storage Company
Xcel	Xcel Energy

SECTION 1 INTRODUCTION AND PROJECT OVERVIEW

1.1 Introduction

The Conceptual Design Report documents the technical intent, goals, criteria, and objectives of the City of Thornton (City) Per- and Polyfluoroalkyl Substances (PFAS) Treatment Project (Project), which consists of implementing PFAS treatment at the Thornton Water Treatment Plant (TWTP). The Conceptual Design includes the technical information to be utilized by prospective design teams in preparing and submitting proposals in response to the Designer Request for Proposals (RFP) and prospective contractor teams in preparing and submitting proposals in response to the Contractor RFP. It also establishes the minimum technical and performance requirements of the Project to be used as the basis for the design.

The primary purpose of the Conceptual Design is to:

- Define the technical and performance requirements that are critical to the City, which the Designer and Contractor must satisfy.
- Provide an indicative design concept that demonstrates technical feasibility of the design that is estimated to be within the project budget and for the Designer to consider in developing the design.
- Identify specific technical evaluations that the Designer shall perform in its design scope of services.
- Allow for more targeted technical proposals by prospective design engineer and contractor teams.
- Provide the Designer and Contractor with existing conditions information and documentation.
- Allow for the Designer to expedite their design development efforts (reducing project schedule).

The Conceptual Design Report includes an Indicative Design for the PFAS treatment facility, which is defined as the treatment process and associated design criteria that informs the design development and delivery of the Project. It is anticipated that the Designer may propose changes to the Indicative Design as enhancements and/or modifications to the Indicative Design are determined as beneficial in achieving the goals established for the Project. The Designer bears the responsibility of demonstrating clearly and factually that the proposed changes to the Indicative Design will result in a PFAS treatment facility that performs as well or better than the Indicative Design.

1.2 Project Overview

In April of 2024, the Environmental Protection Agency (EPA) announced the National Primary Drinking Water Regulation (NPDWR) for six PFAS compounds in drinking water. PFAS is present in the City's source waters, and the TWTP does not have a treatment process that removes PFAS at present. Currently, the City can reduce PFAS levels by controlling the blend of source water supplies to TWTP, which is only available depending on demand.

The City and its Owner's Advisor, Carollo Engineers, recently completed a treatment process alternative evaluation for the new PFAS treatment facility. As a result of the evaluation, the preferred PFAS treatment process at the TWTP consists of gravity granular activated carbon (GAC) contactors. This treatment process can meet the Project's established budget and provides the greatest value to the City in achieving the Project's treatment, operations, and maintenance goals. The City desires the new facility be rated for

32 million gallons per day (mgd) firm capacity. After consideration of backwash supply flow requirements to the backwash supply tank, this results in a firm finished water capacity for use in the City's potable water distribution system of not less than 30 mgd, the expected build-out capacity of TWTP.

1.3 Project Budget

The City's projected budget for the Project is presented in Table 1. This budget includes the costs for all project elements, including Owner's Advisor and construction management services, permitting, design, construction, and commissioning.

Table 1 Projected Budget

Description	Cost	Notes
Total Construction Costs	$63,100,000	
Owner's Contingency	$12,600,000	20% of Total Construction Costs
Design Engineer – Design Services	$6,100,000	8% of Total Construction Costs with Contingency
Design Engineer – Servies During Construction	$4,500,000	6% of Total Construction Costs with Contingency
Owner's Advisor Services	$2,300,000	3% of Total Construction Costs with Contingency
TOTAL PROJECT COSTS	**$88,600,000**	
Federal Funding Requirements	$11,400,000	15% of Total Project Costs
TOTAL PROJECT COSTS WITH FEDERAL FUNDING REQUIREMENTS	**$100,000,000**	

The City is pursuing the following funding opportunities for the Project:

- Colorado Department of Public Health and Environment (CDPHE) Drinking Water Revolving Fund Emerging Contaminants Loan and Principal Forgiveness.
- Unites States Bureau of Reclamation WaterSMART Drought Response Program Grant.

Both funding opportunities have federal compliance requirements including, but not limited to, American Iron and Steel, Davis Bacon wage determinations, anti-lobbying, Disadvantaged Business Enterprise, Build America Buy America, Bipartisan Infrastructure Law Signage, prohibition of certain telecommunications and video surveillance series or equipment, Williams-Steiger Occupational Safety and Health Act, and environmental, archeological, procurement, and reporting requirements. The Designer and Contractor are responsible for ensuring that the design and construction, respectively, complies with federal compliance requirements in the event that one or both of these funding opportunities are awarded to the City.

1.4 Project Schedule

The City's goal is to provide finished water from the new PFAS treatment facility to the distribution system by the end of 2027.

1.5 Existing Facilities

The existing TWTP facilities are critical to the supply of water to its customers. It is imperative that the existing TWTP facilities remain operational during construction of the PFAS treatment facility. Towards this goal, the Project will be required to adhere to the following general requirements, which shall be further refined by the Designer:

- Shutdowns: Shutdowns must be scheduled a minimum of 30 days in advance of when they occur and approved by City staff. Shutdowns should be avoided June through August and November through April. The expected tie-ins between the PFAS treatment facility and the existing facilities include:
  - Combined filter effluent connection to the new PFAS treatment facility.
  - GAC effluent connection to the chlorine contact chamber.
  - Backwash waste connection.
  - Backwash supply connection.
  - Electrical tie-ins.
- Existing plant access: Traffic to existing facilities, including staff, deliveries, visitors, and other designated vehicles shall be maintained at all times.
- The existing facilities shall be protected from construction activities for the PFAS treatment facility.
- Security requirements for the TWTP shall be adhered to.

SECTION 2 PROJECT SITE AND EXISTING CONDITIONS

2.1 Overview

This section of the report provides a summary of the site and information that is relevant to the design and construction of the Project.

2.2 Property Description

The new PFAS treatment facility will be constructed at the TWTP, located at 920 Thornton Parkway in Thornton, Colorado. The TWTP treatment process consists of coagulation, flocculation, sedimentation, intermediate ozone, biological filtration, and free chlorine disinfection. Filter backwash waste and sedimentation basin solids are conveyed via a gravity pipeline to three solids handling lagoons located at the City's Wes Brown Water Treatment Plant (WBWTP). The TWTP site consists of approximately 13 acres. Figure 1 provides an aerial coverage of the site and nearby features.

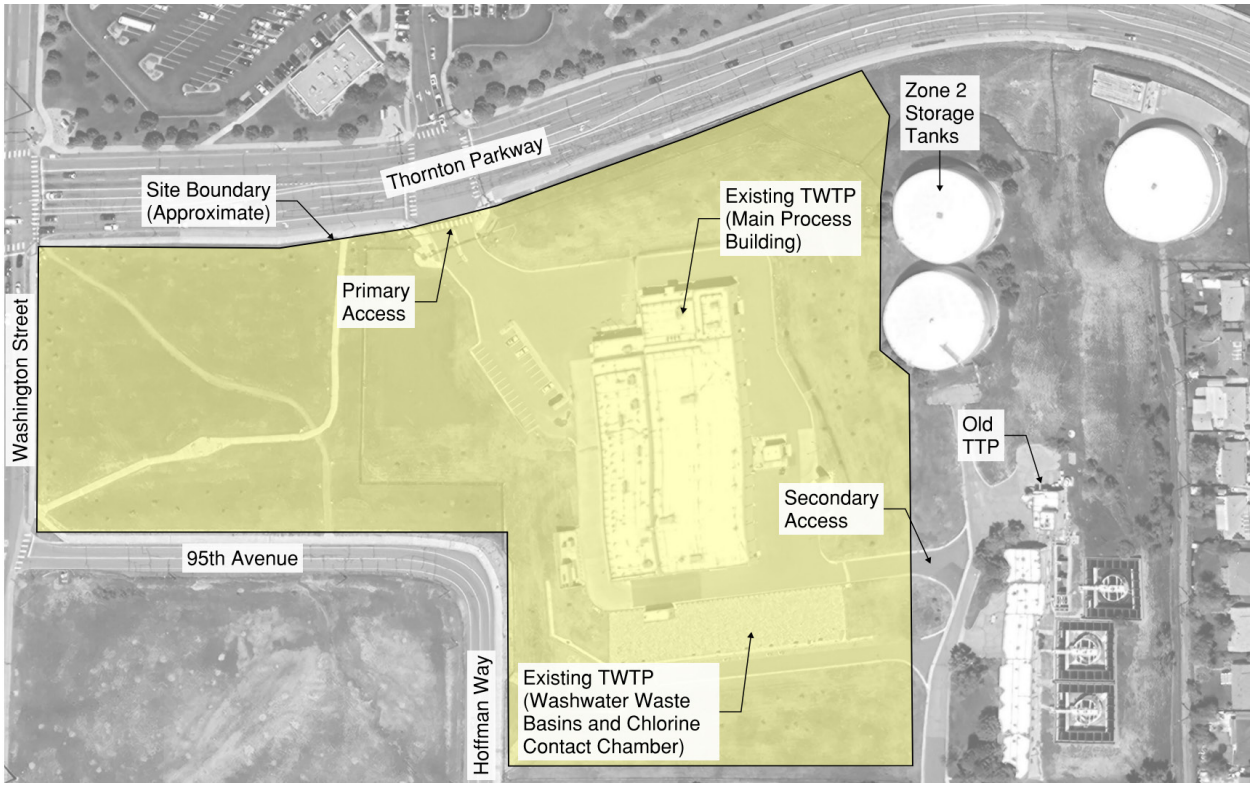


Figure 1 Site Aerial

The Designer and Contractor should note the following key pieces of information about the area and site:

- Primary access into and out of the site is located off Thornton Parkway at the traffic light intersection for Lambertson Lakes Shopping Center. A dedicated right turning lane into the site and traffic signal are provided.
- Secondary access for fire trucks and other emergency vehicles is provided via connection with the old Thornton Treatment Plant (TTP) access road. The old TTP is located east of TWTP at 9520 Ellen Court in Thornton, Colorado.
- The site is surrounded by commercial areas to the north and west. A residential apartment complex and school are located adjacent to the southern boundary of the property.
- Potential locations for the new PFAS treatment facility on the TWTP site include the undeveloped portion of the site on the western half of the property, the undeveloped portion of the site south of the chlorine contact chamber, and the area immediately east of the filters.
- The old TTP site is also available for potential facility siting. However, the old plant would require demolition, and this area may have asbestos contaminated soils that would require remediation.

2.3 Raw Water Sources

The TWTP is supplied by Standley Lake and East Gravel Lakes (EGL) source waters. In the future, water supplies to TWTP will be augmented by northern supply source waters originating from the Cache la Poudre River. Table 2 presents the raw water supply capacities for TWTP. Historical water quality data for each source are presented in Section 3.

Table 2 TWTP Raw Water Supply Capacities

Description	Capacity	Units
Standley Lake Pipeline (Gravity), Maximum Flow	20	mgd
EGL Pump Station, Maximum Flow	15	mgd

2.3.1 Standley Lake

Standley Lake is a manmade reservoir fed primarily by Upper Clear Creek. Standley Lake is also the supply source for the City of Westminster, the City of Northglenn, and Farmers Reservoir and Irrigation Company. The water stored in Standley Lake flows via a 48-inch pipeline shared by the City of Northglenn and City of Thornton to Northglenn's Water Treatment Plant, and then via a 36-inch pipeline to the TWTP. The firm yield from Standley Lake is considered 6,000 acre-feet per year (AFY) (i.e., rights to water during the 3-year drought conditions used for water supply planning purposes). On average, approximately 9,000 AFY is delivered to the TWTP, and as much as 12,000 AFY has been delivered historically. The flow capacity of the 36-inch pipeline, in combination with the water surface elevation of Standley Lake and the amount of water utilized concurrently by other utilities, can limit the flow that can enter the TWTP. Historically, 15 to 17 mgd of Standley Lake water can typically be fed to the TWTP with a historical maximum flow of approximately 20 mgd.

2.3.2 East Gravel Lakes

EGL is the terminus downstream of the South Tani Reservoir and a series of reclaimed gravel pit reservoirs that are fed by the South Platte River via the Burlington Canal. The EGL supply is a more challenging source water to treat due to influence from upstream treated wastewater discharge into the South Platte River. A series of alluvial wells located along the South Platte River can augment EGL supplies. However, these wells are rarely used due to high PFAS levels. From EGL, water is pumped to the TWTP (15 mgd pumping capacity).

2.3.3 Northern Supply

The City is implementing the Thornton Water Supply Project to deliver Cache La Poudre River (i.e., northern supply) water to the City for treatment at the WBWTP (42-inch direct pipeline feed) and the TWTP (indirectly fed through EGL). The Thornton Water Supply Project is projected to deliver up to an average of 14,000 AFY to the City. Future northern supply water will be available for 3 to 4 months per year during the summer at flows up to 40 mgd. It is anticipated that northern supply water will be withdrawn from Water Supply and Storage Company Reservoir 3, located in Larimer County. Northern supply water quality is similar to that of Standley Lake, with the exception of lower alkalinity and higher total organic carbon (TOC) levels.

2.4 Existing Facilities, Utilities, and Easements

A list of applicable record drawings that identify the TWTP site, old TWTP site, raw water supplies, and appurtenant facilities, along with property boundaries, easements, and utilities is included as reference documentation in Appendix A. These record drawings will be made available to the Designer at the

initiation of the Project. The Designer is responsible for verifying all information regarding existing utilities and easements within the site. Key information about the site includes:

- The old TWTP is located directly east of the Project site. This area includes significant underground and above ground utilities. Except for any potential tie-ins between the existing utilities and the new PFAS treatment facility, this area will be designated as off limits to construction activities.
- The TWTP, raw water conveyance piping (including Standley Lake and EGL supplies), finished water conveyance piping, Denver Water interconnect piping, and all supporting facilities shall remain in service throughout the entire duration of the Project, including start-up and commissioning of the new PFAS treatment facility, other than for maintenance shutdowns and any other shutdowns agreed upon by and coordinated with the City for tie-in with the new PFAS treatment facility.
- The following utilities are present to the east and south of the chlorine contact chamber and extend through the area available for construction of the new PFAS treatment facility.
  - A 24-inch potable water line that serves Thornton Zone 3. This line needs to remain in service throughout the duration of the Project. It is to remain in its current location.
  - A 24-inch potable water line that serves as the Denver Water interconnect. This line will need to remain in service throughout the duration of the Project. It is to remain in its current location.
  - A 16-inch potable water line that serves Thornton Zone 1. This line needs to remain in service throughout the duration of the Project. It is to remain in its current location.
- The following electrical feed utilities are present on site and extend through the area available for construction of the new PFAS treatment facility.
  - Primary electrical feed for the TWTP, which runs from the utility connection cabinet on Thornton Parkway to the utility transformer immediately north of the emergency generator. This feed needs to remain in service throughout the duration of the Project. It is to remain in its current location.
  - Secondary electrical feed for the TWTP, which runs from the old TTP site to the east, south and west of the chlorine contact chamber, to the utility transformer immediately north of the emergency generator. This feed needs to remain in service throughout the duration of the Project. It is to remain in its current location.
- Additional utilities are present on site, including gas, electrical duct banks, process piping, telephone, fiber optic infrastructure, and other services not identified below, which are to be verified by the Designer.
- Several utility easements are present along the north and west sides of the Project site. Additionally, a utility easement extends from 95th Avenue to the old TTP. Record drawings that identify all known easements will be provided to the Designer at the initiation of the Project.

2.5 Geotechnical Information

The Designer is responsible for performing a geotechnical investigation of the site and determining the appropriate design for the PFAS treatment facility. Based upon previous investigations, the existing soils at the site consist of uncontrolled fill material, Colorado clay expansive material, and fractured shale bedrock. The existing TWTP facilities include deep foundations and void forms.

SECTION 3 WATER QUALITY AND PERFORMANCE REQUIREMENTS

3.1 Overview

The new PFAS treatment facility must produce finished water that meets regulatory standards and the City's water quality goals over the full range of anticipated water quality conditions and design flow rates. The Designer is responsible for the design of the new PFAS treatment facility to meet these standards and goals, as well as other performance requirements defined herein or as further defined and agreed upon by the Designer and the City during the design phase.

3.2 Historical Raw Water Quality

Historical water quality for each of the City's source water supplies is presented below.

3.2.1 Standley Lake

Table 3 contains a summary of the characteristics of Standley Lake source water.

Table 3 Characteristics of Standley Lake Source Water

Parameter	Units	No. of Samples	Minimum	5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile	Maximum
PFOA	ng/L	14	ND	ND	ND	0.6	0.7	0.8	0.8
PFOS	ng/L	14	ND	ND	ND	0.6	0.6	0.9	1.3
PFBS	ng/L	14	ND	ND	ND	0.7	0.8	0.9	0.9
GenX	ng/L	14	ND	ND	ND	ND	ND	ND	ND
PFNA	ng/L	14	ND	ND	ND	ND	ND	ND	ND
PFHxS	ng/L	14	ND	ND	ND	ND	ND	ND	ND
PFAS HI	--	14	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Turbidity	NTU	128	0.06	0.32	0.90	1.9	3.9	10.6	17.4
pH	--	128	6.5	6.7	7.0	7.5	7.8	8.1	8.9
Alkalinity	mg/L as $CaCO_3$	126	49.0	50.0	53.0	54.7	56.0	57.0	67.0
TOC	mg/L	128	1.8	1.9	2.0	2.0	2.2	2.4	6.0
Total Hardness	mg/L as $CaCO_3$	128	100	112	124	136	148	199	220
Calcium Hardness	mg/L as $CaCO_3$	88	64.0	77.4	84.0	92.0	100	108	124
TDS	mg/L	9	174	180	200	209	218	240	241
Iron	mg/L	128	ND	ND	0.03	0.06	0.09	0.22	0.61
Manganese	mg/L	128	ND	0.02	0.03	0.05	0.12	0.21	0.78
Bromide	mg/L	128	ND	ND	ND	ND	ND	ND	0.12

Parameter	Units	No. of Samples	Minimum	5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile	Maximum
Temperature	°C	128	5.4	5.9	7.5	12.0	15.9	18.7	19.5
DO	mg/L	128	1.4	2.4	4.3	8.1	10.0	10.8	10.9
Ortho-P	mg/L	128	ND	ND	ND	ND	ND	0.15	0.19
Nitrite	mg/L	127	ND	ND	ND	ND	ND	ND	ND
Nitrate	mg/L	128	ND	ND	ND	0.13	0.19	0.42	0.61
E. coli	CT/ 100 mL	128	ND	ND	ND	3.0	15.0	34.3	118
Algae	CT/mL	128	ND	4	15	32	85	555	2080
Chlorophyll-a	µg/L	128	ND	0.90	1.5	2.0	3.2	9.0	27.3
Geosmin	ng/L	11	ND	ND	ND	ND	ND	ND	ND
MIB	ng/L	11	ND	ND	ND	ND	ND	ND	ND
Chloride	mg/L	128	38.0	39.8	43.2	45.2	50.0	55.0	60.0
Fluoride	mg/L	128	0.49	0.51	0.54	0.56	0.60	0.78	0.95
Sulfate	mg/L	127	47.1	51.0	54.0	58.0	60.6	64.0	69.0
Ammonia	mg/L	128	ND	ND	ND	ND	ND	ND	0.07
Antimony	mg/L	1	ND	ND	ND	ND	ND	ND	ND
Arsenic	mg/L	1	ND	ND	ND	ND	ND	ND	ND
Barium	mg/L	1	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Beryllium	mg/L	1	ND	ND	ND	ND	ND	ND	ND
Cadmium	mg/L	1	ND	ND	ND	ND	ND	ND	ND
Chromium	mg/L	1	ND	ND	ND	ND	ND	ND	ND
Copper	mg/L	1	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Mercury	mg/L	1	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Nickel	mg/L	1	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Selenium	mg/L	1	ND	ND	ND	ND	ND	ND	ND
Silver	mg/L	1	ND	ND	ND	ND	ND	ND	ND
Sodium	mg/L	1	19	19	19	19	19	19	19
Thallium	mg/L	1	ND	ND	ND	ND	ND	ND	ND
Zinc	mg/L	1	0.02	0.02	0.02	0.02	0.02	0.02	0.02

Notes:
°C - degrees Celsius; $CaCO_3$ - calcium carbonate; CT/mL - count per milliliter; CT/100 mL - count per 100 milliliters;
DO - dissolved oxygen; GenX - hexafluoropropylene oxide dimer acid; HI - Hazard Index; µg/L - micrograms per liter;
mg/L - milligrams per liter; MIB - 2-methylisoborneol; ND - Non-Detect; ng/L - nanograms per liter;
NTU - nephelometric turbidity unit; ortho-P - orthophosphate; PFBS - perfluorobutane sulfonic acid;
PFHxS - perfluorohexane sulfonic acid; PFNA - perfluorononanoic acid; PFOA - perfluorooctanoic acid;
PFOS - perfluorooctane sulfonic acid; TDS - total dissolved solids
(1) Historical data collected from 2020 to 2023 from Standley Lake.

3.2.2 East Gravel Lakes

Table 4 contains a summary of the characteristics of EGL source water.

Table 4 Characteristics of East Gravel Lakes Source Water

Parameter	Units	No. of Samples	Minimum	5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile	Maximum
PFOA	ng/L	23	7.4	7.8	8.1	9.1	11.0	13.7	14.0
PFOS	ng/L	23	7.0	7.6	9.0	9.6	9.9	12.0	19.0
PFBS	ng/L	23	6.3	6.4	8.1	9.2	10.4	11.9	12.0
GenX	ng/L	23	ND	ND	ND	ND	ND	ND	ND
PFNA	ng/L	23	ND	ND	ND	1.5	1.7	2.0	2.1
PFHxS	ng/L	23	5.1	5.4	5.9	6.5	7.8	9.9	10.0
PFAS HI	--	23	0.6	0.6	0.7	0.8	0.8	1.2	1.2
Turbidity	NTU	439	ND	0.20	0.52	0.90	1.3	2.8	10.7
pH	--	439	7.7	8.0	8.3	8.5	8.7	9.1	9.3
Alkalinity	mg/L as $CaCO_3$	277	115	128	147	155	162	176	233
TOC	mg/L	277	4.2	4.9	5.4	5.9	6.3	6.8	8.1
Total Hardness	mg/L as $CaCO_3$	277	212	248	268	292	312	340	360
Calcium Hardness	mg/L as $CaCO_3$	107	104	161	192	212	226	251	288
TDS	mg/L	20	493	503	559	628	681	709	733
Iron	mg/L	277	ND	ND	ND	ND	0.03	0.07	0.25
Manganese	mg/L	277	0.03	0.05	0.11	0.17	0.24	0.34	0.46
Bromide	mg/L	274	ND	ND	0.16	0.23	0.29	0.33	0.67
Temperature	°C	439	2.4	3.6	9.2	16.5	22.2	24.3	30.0
DO	mg/L	439	2.5	5.5	6.8	8.1	10.4	12.1	15.5
Ortho-P	mg/L	274	0.29	0.47	0.70	0.84	1.09	1.34	1.58
Nitrite	mg/L	273	ND	ND	ND	ND	ND	0.06	0.20
Nitrate	mg/L	274	ND	ND	0.30	0.57	0.81	1.29	1.59
E. coli	CT/ 100 mL	273	ND	ND	ND	ND	2.0	8.8	238
Algae	CT/mL	277	ND	5	19	53	131	689	6266
Chlorophyll-a	µg/L	277	ND	1.2	2.6	4.4	8.4	19.2	76.6
Geosmin	ng/L	305	ND	ND	2.5	6.9	14.2	80.4	310
MIB	ng/L	305	ND	ND	1.6	8.5	17.8	52.0	137
Chloride	mg/L	274	109	114	125	162	180	196	237
Fluoride	mg/L	274	0.47	0.68	0.78	0.84	0.89	0.96	1.4
Sulfate	mg/L	274	101	114	133	146	160	170	197

Parameter	Units	No. of Samples	Minimum	5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile	Maximum
Ammonia	mg/L	194	ND	ND	ND	0.12	0.19	0.28	0.38
Antimony	mg/L	3	ND	ND	ND	ND	ND	ND	ND
Arsenic	mg/L	3	0.001	0.001	0.001	0.002	0.002	0.002	0.002
Barium	mg/L	3	0.05	0.05	0.05	0.06	0.06	0.06	0.06
Beryllium	mg/L	3	ND	ND	ND	ND	ND	ND	ND
Cadmium	mg/L	3	ND	ND	ND	ND	ND	ND	ND
Chromium	mg/L	3	ND	ND	ND	ND	ND	0.001	0.002
Copper	mg/L	3	0.004	0.005	0.007	0.010	0.016	0.021	0.022
Mercury	mg/L	3	ND	ND	ND	ND	ND	ND	ND
Nickel	mg/L	3	ND	ND	ND	ND	0.001	0.003	0.003
Selenium	mg/L	3	ND	ND	ND	ND	ND	ND	ND
Silver	mg/L	3	ND	ND	ND	ND	ND	ND	ND
Sodium	mg/L	3	77	81	99	120	120	120	120
Thallium	mg/L	3	ND	ND	ND	ND	ND	ND	ND
Zinc	mg/L	3	ND	ND	ND	ND	ND	ND	ND

Notes:
(1) Historical data collected from 2018 to 2023 from EGL4@PS TOP.

3.2.3 Northern Supply

Cache la Poudre River water quality is monitored by the City at the Larimer County Canal and the Water Supply and Storage Company (WSSC) reservoirs. It is anticipated that northern supply water will be withdrawn from WSSC Reservoir 3. Water quality characteristics of Larimer County Canal at WSSC Reservoir 3 are summarized in Table 5.

Table 5 Characteristics of Northern Supply Source Water

Parameter	Units	No. of Samples	Minimum	5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile	Maximum
PFOA	ng/L	5	ND	ND	ND	ND	ND	ND	ND
PFOS	ng/L	5	ND	ND	ND	ND	ND	1.0	1.3
PFBS	ng/L	5	ND	ND	ND	ND	ND	ND	ND
GenX	ng/L	5	ND	ND	ND	ND	ND	ND	ND
PFNA	ng/L	5	ND	ND	ND	ND	ND	ND	ND
PFHxS	ng/L	5	ND	ND	ND	ND	ND	ND	ND
PFAS HI	--	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Turbidity	NTU	29	1.2	1.4	4.1	8.0	12.3	18.3	25.5
pH	--	29	7.1	7.8	7.9	8.3	8.6	8.8	8.8
Alkalinity	mg/L as $CaCO_3$	26	21.0	23.4	29.8	37.0	49.8	121	223
TOC	mg/L	24	3.3	3.4	3.6	4.1	5.4	7.0	7.9

Parameter	Units	No. of Samples	Minimum	5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile	Maximum
Total Hardness	mg/L as $CaCO_3$	26	28.0	37.0	61.0	78.0	152	604	1684
Calcium Hardness	mg/L as $CaCO_3$	16	24.0	24.0	34.0	44.0	51.5	69.0	72.0
TDS	mg/L	12	40.0	57.1	90.8	119	181	205	213
Iron	mg/L	12	0.05	0.07	0.10	0.13	0.26	0.52	0.73
Manganese	mg/L	12	0.02	0.03	0.04	0.05	0.07	0.12	0.17
Bromide	mg/L	27	ND	ND	ND	ND	ND	0.18	0.25
Temperature	°C	29	6.0	7.7	13.0	14.8	16.6	18.1	19.0
DO	mg/L	29	7.8	7.9	8.2	8.6	9.1	10.0	10.6
Ortho-P	mg/L	27	ND	ND	ND	ND	ND	ND	ND
Nitrite	mg/L	27	ND	ND	ND	ND	ND	ND	ND
Nitrate	mg/L	27	ND	ND	ND	ND	0.16	0.68	0.89
E. coli	CT/ 100 mL	28	ND	21.1	28.8	37.5	53.3	216	387
Chloride	mg/L	27	ND	ND	ND	ND	ND	12.4	31.0
Fluoride	mg/L	27	ND	ND	ND	0.22	0.27	0.48	0.57
Sulfate	mg/L	26	ND	ND	16.0	36.0	85.2	125	136
Ammonia	mg/L	10	ND	ND	ND	ND	ND	ND	ND
Antimony	mg/L	7	ND	ND	ND	ND	ND	ND	ND
Arsenic	mg/L	4	ND	ND	ND	ND	0.19	0.64	0.75
Barium	mg/L	4	0.02	0.02	0.02	0.03	6.4	21.8	25.7
Beryllium	mg/L	7	ND	ND	ND	ND	ND	ND	ND
Cadmium	mg/L	7	ND	ND	ND	ND	ND	ND	ND
Chromium	mg/L	7	ND	ND	ND	ND	ND	ND	ND
Copper	mg/L	4	ND	ND	ND	ND	ND	ND	ND
Mercury	mg/L	7	ND	ND	ND	ND	ND	ND	ND
Nickel	mg/L	7	ND	ND	ND	ND	ND	ND	ND
Selenium	mg/L	7	ND	ND	ND	ND	ND	ND	ND
Silver	mg/L	7	ND	ND	ND	ND	ND	ND	ND
Sodium	mg/L	4	6.9	7.1	8.1	89.3	835	2431	2830
Thallium	mg/L	7	ND	ND	ND	ND	ND	ND	ND
Zinc	mg/L	4	ND	ND	ND	ND	ND	ND	ND

Notes:
(1) Historical data collected from 2018 to 2023 from LRCC@RES3.

3.3 Historical Finished Water Quality

Finished water quality is representative of the typical water quality anticipated for post-filter PFAS treatment. Table 6 contains a summary of the characteristics of TWTP finished water.

Table 6 Characteristics of TWTP Finished Water

Parameter	Units	No. of Samples	Minimum	5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile	Maximum
PFOA	ng/L	25	1.2	1.6	3.0	3.9	5.1	7.1	8.6
PFOS	ng/L	25	ND	1.0	2.2	2.6	3.3	4.9	5.6
PFBS	ng/L	25	1.2	1.7	3.4	4.1	6.0	8.1	9.0
GenX	ng/L	25	ND	ND	ND	ND	ND	ND	ND
PFNA	ng/L	25	ND	ND	ND	ND	0.5	0.6	0.7
PFHxS	ng/L	25	ND	0.1	1.8	2.4	3.4	5.7	5.9
PFAS HI	--	25	0.0	0.0	0.2	0.3	0.4	0.6	0.6
pH	--	166	7.6	7.6	7.9	8.1	8.3	8.6	8.8
Alkalinity	mg/L as $CaCO_3$	166	50	56	83	99	112	144	155
TOC	mg/L	166	ND	1.0	1.6	2.1	2.4	3.2	3.7
Total Hardness	mg/L as $CaCO_3$	166	104	125	180	208	251	312	368
Calcium Hardness	mg/L as $CaCO_3$	166	78	91	124	148	176	235	280
TDS	mg/L	165	177	214	349	430	527	709	744
Iron	mg/L	166	ND	ND	ND	ND	ND	0.05	0.50
Manganese	mg/L	166	ND	ND	ND	0.02	0.02	0.04	0.06
Bromide	mg/L	146	ND	ND	0.14	0.27	0.40	0.64	0.95
Temperature	°C	166	4.6	8.7	11.2	15.0	18.5	21.0	23.7
DO	mg/L	161	4.9	7.3	8.6	11.1	12.4	13.3	13.9
Ortho-P	mg/L	166	ND	ND	ND	ND	ND	ND	0.23
Nitrite	mg/L	165	ND	ND	ND	ND	ND	ND	0.06
Nitrate	mg/L	166	ND	0.10	0.20	0.33	0.55	1.0	1.5
Geosmin	ng/L	148	ND	ND	ND	ND	ND	ND	3.9
MIB	ng/L	148	ND	ND	ND	ND	ND	ND	3.6
Chloride	mg/L	166	43	49	92	108	137	188	207
Fluoride	mg/L	165	0.44	0.54	0.60	0.67	0.72	0.86	1.18
Sulfate	mg/L	166	57	70	99	112	140	188	202
Ammonia	mg/L	166	ND	ND	0.06	0.08	0.11	0.16	0.21
Antimony	mg/L	10	ND	ND	ND	ND	ND	ND	ND
Arsenic	mg/L	10	ND	ND	ND	ND	ND	0.001	0.001
Barium	mg/L	10	0.04	0.04	0.04	0.04	0.05	0.05	0.05
Beryllium	mg/L	10	ND	ND	ND	ND	ND	ND	ND
Cadmium	mg/L	10	ND	ND	ND	ND	ND	ND	ND

Parameter	Units	No. of Samples	Minimum	5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile	Maximum
Chromium	mg/L	10	ND	ND	ND	ND	ND	0.001	0.002
Copper	mg/L	10	ND	ND	0.001	0.002	0.003	0.004	0.004
Mercury	mg/L	10	ND	ND	ND	ND	ND	ND	ND
Nickel	mg/L	10	ND	ND	0.002	0.003	0.003	0.005	0.005
Selenium	mg/L	10	ND	ND	ND	ND	ND	ND	ND
Silver	mg/L	10	ND	ND	ND	ND	ND	ND	ND
Sodium	mg/L	10	26.0	28.9	64.3	105	120	133	135
Thallium	mg/L	10	ND	ND	ND	ND	ND	ND	ND
Zinc	mg/L	10	ND	ND	ND	ND	ND	0.01	0.02

Notes:
(1) Historical data collected from 2020 to 2023.

3.4 Basis of Design Criteria

Table 6 presents the influent water quality conditions to the PFAS treatment facility that the Designer shall use as the basis of its design, in addition to the previously presented historical data. The water quality values shown in Table 7 provide a larger range of conditions than the available historical data to account for the limitations of the available sampling data set and future changes to water quality. The new PFAS treatment facility must be able to achieve the City's treatment goals over the full range of raw water quality presented.

Table 7 Basis of Design – Influent Water Quality

Parameter	Unit	Minimum	Maximum
PFOA	ng/L	0	20
PFOS	ng/L	0	30
PFHxS	ng/L	0	20
PFNA	ng/L	0	4
GenX	ng/L	0	5
PFBS	ng/L	0	50
PFAS HI	--	0	1.5
Turbidity	NTU	0.01	0.10
pH	--	7.5	9.0
Temperature	°C	0.5	27
Alkalinity	mg/L as $CaCO_3$	30	250
TOC	mg/L	0.5	4.0
Total Hardness	mg/L as $CaCO_3$	60	400
TDS	mg/L	50	800
Geosmin	ng/L	0	5
MIB	ng/L	0	5
Nitrate	mg/L	0	2

3.5 Finished Water Quality Requirements

The EPA has promulgated rules and regulations governing the treatment of drinking water. In Colorado, these rules have been adopted and are codified along with state-specific requirements in the Colorado Primary Drinking Water Regulations (CPDWR). These regulations are administered and enforced by CDPHE, and the City is required to meet the applicable requirements of these regulations.

The Designer is responsible for verifying the regulatory requirements information herein.

3.5.1 PFAS

In April 2024, the EPA announced the NPDWR for six PFAS compounds in drinking water as listed in Table 8.

Table 8 NPDWR for PFAS

Compound	MCL (enforceable levels)	MCLG (health based, non-enforceable)
PFOA	4 ng/L(1)	Zero
PFOS	4 ng/L(1)	Zero
PFHxS	10 ng/L(1)	10 ng/L
PFNA	10 ng/L(1)	10 ng/L
GenX	10 ng/L(1)	10 ng/L
Mixtures containing two or more of PFHxS, PFNA, GenX, and PFBS	1.0 (unitless) HI(1)	1.0 (unitless) HI

Notes:
MCL - maximum contaminant level; MCLG - maximum contaminant level goal
(1) Running annual average from quarterly sampling.

The HI is calculated as a sum of fractions of the measured concentration of each of the four PFAS divided by its corresponding health reference value, as shown in the following equation.

$$HI = \frac{GenX}{10\ ng/L} + \frac{PFBS}{2{,}000\ ng/L} + \frac{PFNA}{10\ ng/L} + \frac{PFHxS}{10\ ng/L}$$

The Designer is responsible for designing a new PFAS treatment facility that allows the TWTP to continuously meet the PFAS NPDWR over the full range of water quality conditions.

3.5.2 Other Regulations

In addition to the NPDWR for PFAS, the Designer is required to review the impact of all applicable rules and regulations on the new PFAS treatment facility including, but not limited to, the following:

- Safe Drinking Water Act (National Primary Drinking Water Regulations).
- National Secondary Drinking Water Regulations.
- Lead and Copper Rule.
- Arsenic Rule.
- Radionuclides Rule.
- Total Coliform Rule.

- Revised Total Coliform Rule.
- Surface Water Treatment Rule.
- Interim Enhanced Surface Water Treatment Rule.
- Long-Term 1 Enhanced Surface Water Treatment Rule.
- Long-Term 2 Enhanced Surface Water Treatment Rule.
- Stage 1 Disinfectants and Disinfection Byproducts Rule (D/DBPR).
- Stage 2 D/DBPR.
- Filter Backwash Recycling Rule.
- Anticipated Future Regulations.

The Designer is responsible for designing a new PFAS treatment facility that continues or improves the City's capacity to meet all applicable and promulgated drinking water regulations over the full range of water quality conditions.

3.5.3 City Treatment Goals

The City produces finished water that meets or exceeds all federal and state drinking water regulations. To continue providing high quality water to its customers, the City has established the following specific treatment and monitoring goals for its facilities that are more stringent than federal and state requirements. The City's finished water treatment goals are presented in Table 9.

Table 9 Finished Water Treatment Goals

Parameter	Goal
PFAS	
PFOA	Zero(1) (MCLG)
PFOS	Zero(1) (MCLG)
PFHxS	< 10 ng/L (MCLG)
PFNA	< 10 ng/L (MCLG)
HFPO-DA	< 10 ng/L (MCLG)
PFAS HI	< 1.0 (MCLG)
Particulate/Microbial	
Combined Filter Effluent Turbidity	< 0.10 NTU 95% of the time(2)
Disinfection By-Products	
Total Trihalomethanes	< 40 µg/L (50% of MCL)
Haloacetic Acids	< 30 µg/L (50% of MCL)
Bromate	< 5 µg/L (50% of MCL)
Chlorite	< 0.5 mg/L (50% of MCL)

Parameter	Goal
General Physical	
pH Tolerance	± 0.1 of Setpoint to meet CCPP
Iron	< 0.1 mg/L
Manganese	< 0.03 mg/L (60% of SMCL)
Arsenic	< 0.002 mg/L
TDS	< 500 mg/L
Taste and Odor	< 3 ng/L for Geosmin and MIB
Langelier Index	> 0
CCPP	3 to 8 mg/L
Free Ammonia (as Nitrogen)	0.01 to 0.05 mg/L
Alkalinity	> 44 mg/L as $CaCO_3$
TOC	Compliance with Stage 1 D/DBPR
Disinfection	
Disinfection Inactivation Ratio	1.5 at 0.5°C

Notes:
CCPP - calcium carbonate precipitation potential; HFPO-DA - hexafluoropropylene oxide dimer acid; SMCL - secondary maximum contaminant level
(1) Assumes a method reporting limit of 1.7 ng/L or greater.
(2) Partnership for Safe Water Phase IV Performance Goals include settled water turbidity less than 1.0 NTU 95% of the time.

The City participates in the Partnership for Safe Water, a national volunteer initiative developed by the EPA and other water organizations, whose members strive to provide their customers with drinking water quality that surpasses federal standards. The Designer is responsible for designing a new PFAS treatment facility that continues or improves the City's capacity to meet these finished water treatment goals over the full range of water quality conditions, including Partnership for Safe Water Phase IV.

SECTION 4 CODES AND STANDARDS

4.1 Overview

This section of the Conceptual Design Report identifies key codes, standards, and design guidelines that are anticipated to be applicable to the Project. Given the limited Project development that has occurred to date, it is anticipated that the design phase of the Project will be used to develop, confirm, and as needed, refine and supplement, the full suite of codes, standards, and guidelines that will apply to the design and implementation of the Project, including those listed herein.

4.2 References, Codes, Standards, and Guidelines

The following lists summarize key reference codes, standards, and guidelines anticipated for the Project. It provides a general summary only, with the expectation that it will be further refined by the Designer through the design phase of the Project.

4.2.1 State and Local

State and local references, codes, standards, and guidelines include:

- City of Thornton Infrastructure Department: City of Thornton Standards and Specifications for Design and Construction of Public and Private Improvements.
- City of Thornton Development Services: Comply with City of Thornton Development Standard Requirements.
- City of Thornton Building Inspection Division: The most recently adopted version of the building codes and associated amendments. Below are the current versions of the code that have been adopted by the City:
  - 2021 International Building Code.
  - 2021 International Plumbing Code.
  - 2021 International Mechanical Code.
  - 2021 International Fuel Gas Code.
  - 2021 International Existing Building Code.
  - 2021 International Energy Conservation Code.
  - 2021 International Fire Code.
  - 2020 National Electric Code (NEC).
- City of Thornton Noise Ordinance: City Code Section 38-441.
- CDPHE:
  - CPDWR (5 CCR 1002-11).
  - State of Colorado Design Criteria for Potable Water Systems.
- State of Colorado:
  - Department of Regulatory Agencies – Laws, Rules, and Policies of the State Board of Licensure for Architects, Professional Engineers, and Professional Land Surveyors.

4.2.2 Other Applicable Agencies and Organizations

Other references, codes, standards, and guidelines from applicable agencies and organizations include:

- Air-Conditioning, Heating, and Refrigeration Institute.
- Air Movement and Control Association International.
- American Architectural Manufacturers Association.
- American Association of State Highway and Transportation Officials.
- American Bearing Manufacturers Association.
- American Concrete Institute.
- Americans with Disabilities Act.
- American Gear Manufacturer's Association.
- American Institute of Steel Construction.
- American Iron and Steel Institute.
- American National Standards Institute.

- American Petroleum Institute.
- American Society of Heating, Refrigerating, and Air-Conditioning Engineers.
- American Society of Mechanical Engineers.
- American Society for Testing and Materials International.
- American Welding Society.
- American Water Works Association.
- Association of Edison Illuminating Companies.
- Brick Industry of America.
- Chlorine Institute.
- Crane Manufacturers' Association of America, Inc.
- Consumer Product Safety Commission.
- Concrete Reinforcing Steel Institute.
- Ductile Iron Pipe Research Association.
- Federal Highway Administration.
- Hydraulic Institute.
- Institute of Electrical and Electronic Engineers (IEEE) including but not limited to IEEE 519 Standard for Harmonic Control in Electrical Power Systems.
- International Institute of Welding.
- Institute of Power Cable Engineers Association.
- International Code Council Evaluation Service, Inc.
- International Concrete Repair Institute.
- International Conference of Building Officials.
- International Organization for Standardization.
- International Society of Automation.
- Lightning Protection Institute.
- Manufacturers Standardization Society.
- National Association of Corrosion Engineers International.
- National Association of Architectural Metal Manufacturers.
- National Association of Pipe Fabricators.
- National Electric Code.
- National Electrical Safety Code.
- National Electrical Manufacturers Association.
- National Fire Protection Association (NFPA), including but not limited to NFPA 820 Fire Protection in Wastewater Treatment and Collection Facilities, NFPA 70E Electrical Safety in the Workplace, and NFPA 780 Standard for the Installation of Lightning Protection Systems.
- National Fuel Gas Code.

- National Institute for Occupational Safety and Health.
- National Science Foundation International.
- Occupational Safety and Health Administration.
- Plastics Pipe Institute.
- Precast Concrete Institute.
- Research Council of Structural Connections.
- Sheet Metal and Air Conditioning Contractors' National Association.
- Society for Protective Coatings.
- Steel Pipe Fabricators Association.
- Telecommunications Industry Association/Electronics Industry Association.
- Testing Adjusting and Balancing Bureau.
- Underwriters' Laboratories, Inc.
- U.S. Army Corps of Engineers.
- U.S. Code of Federal Regulations.
- U.S. General Services Administration.
- U.S. Green Building Council.
- Window and Door Manufacturers Association.

SECTION 5 TREATMENT PROCESS DESIGN CRITERIA

5.1 Overview

The City and its Owner's Advisor have developed the initial design definition of the PFAS treatment process as documented in this section of the report. The Designer will further progress the design after receiving the Notice to Proceed. As such, the indicative design and treatment process design criteria included herein are intended to provide guidance and direction to the selected Designer and to set the stage for the overall project definition.

The Indicative Design is defined as the treatment process and associated design criteria that informs the design development of the Project by the Designer. The City recognizes that enhancements and/or modifications to the Indicative Design may be beneficial in achieving the goals established for the Project. It is anticipated that the Designer may propose changes to the Indicative Design. The Designer bears the responsibility of demonstrating clearly and factually that proposed changes will result in a new PFAS treatment facility that performs as well or better than the Indicative Design. It is expected that the Designer will use data analysis and calculations, alternative evaluations, published science or engineering reports and literature, and testing or actual operational experience backed by verifiable references to demonstrate the equivalence or superiority of proposed changes. General anecdotal information, promotional or sales information, or unsupported opinion may not be considered compelling evidence.

5.2 Capacity

The required PFAS treatment facility capacity is 32 mgd measured at the point of entry into the existing chlorine contact chamber when both the chlorine contact chamber and the backwash supply tank are held at constant level (i.e., no change in storage volume); this is defined as the PFAS treatment facility capacity measurement. After consideration of backwash supply flow requirements to the backwash supply tank, this results in a firm finished water capacity for use in the City's potable water distribution system of not less than 30 mgd.

5.3 Redundancy

The Designer shall not provide less redundancy than summarized herein. In general, the requirement is for a minimum of N+1 redundancy for the GAC contactors and all process equipment. For example, the GAC influent pumps shall be capable of meeting the design flow rate with one pump out of service. If the Designer proposes pump capacities that are not uniform, the required redundancy shall be provided assuming failure of the highest capacity pump.

5.4 Indicative Facility Layout

Indicative Design Drawings are provided in Appendix B. As illustrated in the process flow diagram, the Indicative Design for the PFAS treatment facility includes GAC influent pumping and gravity GAC contactors. Waste flows are transferred to the existing washwater basins before being pumped to the WBWTP for solids handling utilizing the existing detention basin and sludge line.

5.4.1 Site Layout

Three site layouts are presented for consideration by the Designer in the Indicative Design Drawings:

- **Alternative 1:** GAC influent pumping is located adjacent to the GAC contactors on the west side of the TWTP site.
  - This alternative simplifies construction of the new facilities, but results in challenging deep yard piping in the roadway between the existing chemical building and standby generator and a deep GAC influent pumping wet well.
- **Alternative 2:** GAC influent pumping is located south of the existing standby generator, and the GAC contactors are located on the west side of the TWTP site.
  - This alternative reduces the amount of deep yard piping in the roadway adjacent to the chemical building, but requires relocation of storm drain, foundation drain, sanitary sewer, and backwash waste piping currently located where GAC influent pumping is proposed.
- **Alternative 3:** GAC influent pumping is located in the re-purposed north washwater basin, and the GAC contactors are located on the west side of the TWTP site. A new washwater basin is constructed to the south of the existing basins.
  - This alternative eliminates all deep yard piping associated with the combined filter effluent piping tie-in but requires rework of the existing stormwater detention pond system located to the southwest of the washwater basins.

It is anticipated that the design phase of the Project will be used to develop, evaluate, and refine site alternatives, in addition to those presented herein.

5.4.2 Process Layout

A conceptual process layout of the GAC influent pump station and GAC contactors is presented for consideration by the Designer in the Indicative Design Drawings. The conceptual process layout includes the following key features:

- Monolithic slab with media retaining nozzles to provide flexibility for different media sizes and types in the future, such as CETCO FLUORO-SORB and ion exchange (IX) resin.
- Sample ports at 25 percent, 50 percent, and 75 percent depth of GAC media for monitoring breakthrough.
- Contactor box length-to-width ratio selected to reduce gallery costs by minimizing large diameter piping and reducing the length of the filter troughs to increase their structural strength.
- Common backwash supply header/GAC-to-Waste is utilized to save costs given the infrequent backwashing and GAC-to-Waste activities.
- Overflow forward design in the influent channel passively directs overflows to the GAC effluent pipe.
- Filter effluent boxes provide laminar flow into the filter effluent flow meter and allows for the installation of a "submarine" hatch for quick and easy access to the underdrains.

It is anticipated that the design phase of the Project will be used to develop, evaluate, and refine the conceptual process layout presented.

5.5 Design Criteria

The criteria listed in Table 10 are identified as "fixed" criteria or an "indicative" design assumption. The fixed criteria represent specific parameters that are not anticipated to be revised as design progresses, based on the evaluation and vetting efforts completed to date, without additional justification or as a result of currently unforeseen changes. As such, the Designer is expected to assume these criteria to be fixed throughout the remainder of the design phase efforts. However, it should be noted that some of the fixed criteria may be revisited if financial reasons dictate changes to the overall design (i.e., should the subsequent cost model updates exceed the overall project budget).

Other criteria are identified only as indicative design assumptions, which represent the preliminary parameters used by the City and Owner's Advisor as part of the initial design definition efforts, but that are not specifically fixed at this point in the design process. The indicative design assumptions establish an indication of the City's preferences and are to be used as a basis for comparing alternatives and making decisions during design development. The indicative design assumptions are expected to be evaluated and considered by the Designer, the City, and the Owner's Advisor as design progresses. It is anticipated that innovation, value engineering, and general preference by the Designer may result in proposed variations to the indicated design assumptions presented herein.

The process design criteria for the new PFAS treatment facility are presented in Table 10.

Table 10 Process Design Criteria Summary

Design Parameter	Units	Criteria	Criteria Intention	
			"Indicative" Design Assumption	"Fixed" Criteria
Building Configuration				
All Facilities Enclosed within Building, protected from weather	-	-		X
GAC Influent Pump Station located within a separate room or wet well, isolating noise from the remainder of the building	-	-		X
GAC Influent Flow Rate(1)				
Influent Flow Rate, Maximum	mgd	32		X
Standley Lake Raw Water Flow Rate, Maximum	mgd	20		X
EGL Raw Water Flow Rate, Maximum	mgd	15		X
Treated Water Flow Rate				
PFAS Treatment Facility Production Rate, Maximum	mgd	32		X
PFAS Treatment Facility Production Rate, Minimum	mgd	2.5		X
Plant Hydraulic Grade Line				
Existing Chlorine Contact Chamber Water Surface Elevation, Maximum Operating Level	feet	5,378.15		X
GAC Influent Pumping				
Type: Submersible	-	-	X	
Flow Rate Control: Variable Frequency Drive	-	-		X
Number of Pumps	No.	4 + 1(2)	X	
Capacity, Each	mgd	8	X	
Total Dynamic Head	feet	20	X	
Motor Size, Each	hp	40	X	
GAC Contactors				
Contactor Type: Gravity	-	-		X
Contactor Control: Rate-of-Flow	-	-		X
Underdrain Type: Monolithic Slab with Nozzles	-	-	X	
Number of Contactors	No.	5 + 1(2)	X	
Contactor Width	feet	18	X	
Contactor Length	feet	62	X	
Depth of Water Above Media	feet	7	X	
Available Headloss for Solids Accumulation	feet	3 - 4		X
Contactor Area				
Each Contactor	sq ft	1,110	X	
Total	sq ft	6,700	X	

Design Parameter	Units	Criteria	Criteria Intention	
			"Indicative" Design Assumption	"Fixed" Criteria
Surface Loading Rate (at 32 mgd)				
One Contactor Out of Service	gpm/sq ft	4.0	X	
Empty Bed Contact Time of GAC (at 32 mgd)				
One Contactor Out of Service	minutes	15		X
Contactor Media				
GAC	-	-		X
Depth	inches	96	X	
Sieve Size	mesh	12 x 40		X
Effective Size	mm	0.55 - 0.75	X	
Number of Sample Taps Along Depth of Media	No.	3	X	
Alternate Medias				
Compatibility with FLUORO-SORB	-	-		X
Compatibility with IX Resin	-	-	X	
Effluent Flow Meter Accuracy				
Percent of Flow Rate Over Operating Range	%	0.25	X	
Number of GAC Drain Pumps	No.	1	X	
Pumped Sample Line to Lab for Combined GAC Effluent	-	-		X
Contactor Backwash				
Type: Pumped Backwash	-	-	X	
Backwash Pumps: Existing	-	-	X	
Media Expansion During Backwash, Maximum	%	20 - 30		X
Backwash Loading Rate, Maximum	gpm/sq ft	12.5	X	
Backwash Flow Rate, Maximum	gpm	13,750	X	
Backwash Loading Rate, Minimum	gpm/sq ft	3.0	X	
Backwash Flow Rate, Minimum	gpm	3,350	X	
GAC-to-Waste Capability	-	-		X

Notes:
gpm - gallons per minute; hp - horsepower; mm - millimeter; No. - number; sq ft - square feet
(1) Raw water flow rate may consist entirely of Standley Lake or EGL source waters, or a blend of both source waters.
(2) Duty plus standby.

SECTION 6 ELECTRICAL, INSTRUMENTATION, AND CONTROLS DESIGN CRITERIA

6.1 Introduction

This section defines the Indicative Design associated with the power distribution system configuration and instrumentation and control system for the new PFAS treatment facility. The design and implementation of these systems shall meet the following objectives:

- Provide electrical power and standby power generation for the PFAS treatment facility.
- Provide instrumentation and controls for a fully automated PFAS treatment facility that is integrated into the existing plant control system.
- Provide a safe, functional, maintainable, and economical electrical, instrumentation, and control system design.

6.2 Electrical Indicative Design

6.2.1 Design Philosophy

The existing TWTP electrical system is provided with main electrical service from Xcel Energy (Xcel or Utility). TWTP is equipped with an automatic transfer switchgear and standby generation. In the event of Utility power failure, the automatic transfer system will detect a power outage and automatically transfer to standby generation. Transfer back to Xcel service is performed utilizing a closed transition to prevent a second power outage on the back transfer.'

Power from the Xcel metering enclosure is routed to the main 480-volt switchgear (SWGR-MAIN) located inside the main electrical building. SWGR-MAIN feeds various process motor control centers (MCC) and distribution panels required throughout the facility. The general distribution approach follows a traditional radial feed philosophy without redundancy. An overall one-line diagram showing the indicative power distribution system layout for the new PFAS treatment facility is presented in the Indicative Design Drawings in Appendix B.

The electrical design will comply with the latest edition of the NEC, National Electric Safety Code, Life Safety Code (NFPA 101), National Electric Manufacturers Association (NEMA), IEEE, American National Standards Institute (ANSI), and Underwriters' Laboratories, Inc. (UL).

6.2.2 Design Criteria

6.2.2.1 Electrical System Studies

A complete electrical system study including full short circuit analysis, coordination study, arc flash assessment, and arc flash labels for all equipment shall be completed as part of the Project for all electrical distribution equipment per NFPA 70E standards. A Professional Engineer licensed in the state of Colorado shall certify and stamp the study. The report will show one-line diagrams of the entire electrical distribution system, corresponding short-circuit data, and identify incident energy levels. The fault current

contribution from Xcel shall be obtained prior to conducting the study. The report will show a tabulation of protective devices, time-current characteristic curves of each device and their respective settings, approach boundaries and incident energy in calories per square centimeter (cal/cm^2) for each piece of equipment.

Incident energy levels downstream of the service disconnect circuit breaker shall be maintained at a level not to exceed 12 cal/cm^2 wherever possible. Electrical system modeling will be required during the design phase to appropriately incorporate the required system protection devices and coordination to limit the incident energy levels throughout the electrical distribution system.

6.2.2.2 Harmonic Mitigation

Harmonic mitigation shall be performed on all added equipment to meet the guidelines set forth in IEEE 519. Variable frequency drives (VFD) on 50-hp motors or less shall use harmonic mitigating technology to bring harmonic content within the facility within the guidelines set forth by the IEEE 519 standard. Harmonic metering shall be performed by the Contractor to show compliance with IEEE 519. For VFDs greater than 50 hp, the manufacturer shall provide factory and field harmonic testing to show compliance with IEEE 519 on voltage and current distortion at the point of common coupling (PCC). The PCC shall be defined as the terminals on the line side of the individual VFD feeding the motor load.

Overall distribution system harmonics shall be tested while running on both Utility power as well as standby generator power and closed transition system. The main 480-volt service switchgear SWGR-MAIN shall be designated as the point of common coupling. Additional active harmonic filtering shall be incorporated into the design to establish compliance with the IEEE 519 standard.

6.2.2.3 Standby Power System

In the event of a utility power outage, the automatic transfer controller internal to the main switchgear will transfer the power source from the Utility to standby generation. Existing standby power generation consists of one 1,125-kilovolt-ampere, 480-volt standby diesel engine generator. Identifying which additional loads need to be supported by the standby generator and the amount of required generation capacity will be determined during design. Preliminary evaluation of potential electrical loads indicates that the existing standby power generation capacity may be adequate to support the new PFAS treatment facility (the air scour blowers and backwash supply pumps are not backed up by standby power generation). The Designer is responsible for confirming the existing standby power generator has adequate capacity for full back-up of all critical loads associated with the PFAS treatment facility and/or designing additional standby power generation as required.

'If additional generator capacity is required, the generator unit may be located either inside the PFAS treatment facility process building or outdoors in a weatherproof acoustical housing. A base-mounted diesel storage fuel tank shall be sized to support continuous 100 percent generator loading for 72 hours.

6.2.2.4 Reliability and Safety

The primary power distribution switchgear is located in the main electrical room at the treatment complex. Electrical, control, and network distribution between the main process building and the PFAS treatment facility shall be via an underground concrete reinforced duct bank system. To easily identify

electrical duct banks from other buried ducts, concrete used in the electrical duct bank system shall be dyed red. Manholes will be located as required throughout the facility.

Maintenance mode switches shall be utilized as required per NEC 240.87 to reduce the incident energy level at switchgear and MCCs below 12 cal/cm^2. Maintenance mode switches shall be located remotely from the electrical rooms in a dedicated enclosure.

Dedicated local disconnects shall be provided at all motors throughout the facility. Local disconnects shall be of the non-fused type assuming the rating of the disconnect is adequate for the available fault current as determined by the electrical system study.

6.2.2.5 Equipment Selection

Electrical distribution equipment including MCCs, motor starters, and power distribution panels shall be specified within the scope of the detailed design phase of this project. The "fixed" criteria listed in Table 11 shall be applied.

Table 11 Equipment Selection Criteria ("Fixed" Criteria for Design Team)

Equipment	Criteria
VFDs	All VFDs shall be equipped with line and load reactors as required. Surge suppression shall be included. Harmonic mitigation shall be provided to meet the guidelines set forth in IEEE 519.
MCCs	480-volt, tin plated copper bus, NEMA 1 enclosures with surge protection devices, smart overloads, and networked power monitoring. Solid state protective breakers for all mains and feeder breakers rated over 400 amperes.
Power Distribution Panels	480-volt and 208/120-volt circuit breaker type, copper bus, and main lugs or breakers in enclosures to suit the environment.

Enclosures for electrical, instrumentation, and control equipment shall meet NEMA 250 and UL requirements for the environment for which they are installed. All valve actuators shall be UL listed and labeled. Table 12 lists the "indicative" criteria for the NEMA enclosure type, conduit type, environment, and support materials associated with the various plant areas.

Table 12 Enclosures, Conduit, Environment, and Support Materials ("Indicative" Design Assumption)

Plant Area	NEMA Enclosure Type	Exposed Conduit Type	Environment W = Wet D = Damp C = Clean/Dry X = Corrosive	Support Materials
Electrical Rooms	1	GRC	C	Galv Stl
Piping Galleries	4X SST	PCS	D	SST
Process Areas	4X SST	PCS	D	SST
Chemical Area	4X Nonmetallic	PCS	X	Nonmetallic
Outdoor Locations	4X SST	PCS	W	SST

Notes:
GRC - galvanized rigid steel conduit; Galv Stl - galvanized steel; PCS - polyvinyl chloride coated rigid steel conduit systems; SST - stainless steel

6.2.2.6 Electrical Equipment Sizing and Ratings

Electrical equipment shall be sized to continuously carry all electrical loads without overloading and overheating. Equipment and materials shall be rated to withstand the available fault currents as determined in the electrical system study.

6.2.2.7 Lightning Protection

A lightning protection system shall be installed according to NFPA 780 guidelines for the PFAS treatment facility. All lightning protection components shall be protected from roof venting of corrosive chemicals.

6.2.2.8 Lighting System Requirements

The PFAS treatment facility lighting system shall comply with the Energy Policy Act and the Energy Independence and Security Act. These requirements shall be met and exceeded by using a combination of energy efficient ballasts, high output lamps, and light emitting diode (LED) fixtures. LED type fixtures will be utilized wherever possible. Other fixture types, such as fluorescent and metal halides, will be utilized in applications where LED technology does not offer comparative advantages.

Overall criteria for site lighting are as follows:

- Specific lighting levels indoors and outdoors shall be per the latest published version of the Illuminating Engineering Society of North America Handbook.
- Switch-controlled local task lighting shall be provided in critical operations areas, and where nighttime maintenance or repairs may be necessary.
- Pole-mounted, full-cutoff lighting fixtures will provide street lighting and area lighting for plant equipment.
- Area lighting shall be photocell controlled.
- Lighting for building entrances shall be by wall-mounted lighting fixtures, controlled by photocells. Hand-Off-Auto (HOA) switches shall be located inside the doors to allow for testing and operating the lights in the "Hand" mode. Lighting levels at building entrances shall be sufficient to allow safe entrance and egress from the buildings yet shall minimize visual site lighting impacts. Specific luminance requirements shall be established once the final building locations and layouts are established.
- Walk-through lighting shall be provided in all production areas that may require periodic maintenance checks at night. All interior areas shall be provided with emergency lighting for safe building egress in the event of a power outage.
- Emergency lighting will be using emergency battery packs and ballasts in-ceiling or wall-mounted lighting fixtures.
- New lighting shall match the color and temperature of existing light fixtures.

6.2.2.9 Voltage Drop

To meet the NEC 210.19(A)(1) requirements, the voltage drop to motor terminals shall not exceed 3 percent of the rated voltage. Feeder and branch circuit conductors shall be sized such that the combined voltage drop does not exceed 5 percent, with a maximum of 3 percent in either the feeder or branch circuit.

6.2.2.10 Grounding

Equipment, structures, and raceway systems shall be grounded as required by the NEC 250. Bonding jumpers and wire, grounding bushings, clamps and appurtenances shall be used to establish a complete grounding system to bond equipment and raceways to equipment grounding conductors. The overall ground system resistance of the completed installation shall be tested for conformance with specified resistance values. A separate, green insulated grounding conductor shall be provided in each raceway independent of raceway material.

6.2.2.11 Electrical Manholes

At minimum, all electrical manholes and associated accessories, such as grade rings and covers, shall comply with ANSI C2. All conductors within the manholes shall be routed and tied to prevent damage during personnel ingress. Manhole covers shall be installed at least 4 inches above adjacent finished grade (unless located in roadways), as established using surveyor markings, and grade sloped smoothly away to allow for drainage. No electrical manholes shall be installed in storm water retention ponds or low-lying areas. The manholes and covers shall be sealed to avoid water leakage. The size of each manhole shall be dictated by duct bank, conduit, and cable installation requirements. Dedicated manholes shall be provided for 120- through 480-volt circuits and analog control and networking.

6.3 Instrumentation and Control System Design Criteria

6.3.1 Process Control Network

The process control network consists of the programmable logic controller (PLC) Network as well as the supervisory control and data acquisition (SCADA) network described in the following sections.

6.3.1.1 PLC Network

The existing PLC network consists of distributed PLCs throughout the facilities. To match the existing facility, the PLC technology that shall be utilized at the PFAS treatment facility shall be Schneider Electric's Modicon M580 series hardware platform with the latest version of EcoStruxure™ programming software. The PLC has a secure digital card available that stores PLC programming. A spare processor will be provided in the event of a processor failure. During a failure, the existing program can quickly be loaded into the spare processor and swapped with the failed processor. The PLC code and programming will be backed up by network-attached storage. New PLCs will connect to the PLC network through managed industrial process floor Ethernet switches.

All PLC cabinets shall be backed up with double conversion uninterruptable power supplies (UPS) with a minimum of 30-minute battery backup. UPS units shall be located in the network panels throughout the facility. Instrument power shall be provided from the battery backed up PLC cabinets. Valves critical to

operation of the GAC treatment facility shall be provided with battery back-up actuators to provide fail-safe operation by utilizing power from the battery source during a power supply outage.

Input and output PLC hardware shall be as follows:

- Digital input and output models shall be 120 volts alternating current.
- Analog input and output modules shall be 4-20 milliamperes (mA), highway addressable remote transducer (HART) enabled.

Process equipment starters and VFDs shall be network connected. Valve controls shall be hardwired.

6.3.2 Networking and Communications

The existing PLC and SCADA networks will utilize a fiber optic backbone for Modbus Transmission Control Protocol/Internet Protocol (TCP/IP) communications throughout the facility. The fiber backbone cables loop the facility and land at dedicated fiber optic patch panels located at each major facility. From the facility fiber patch panels, fiber is routed to the process control network managed Ethernet switches. A self-healing loop topology is utilized for distribution of the fiber optic backbone. If a cable is damaged somewhere in the loop, managed switches will utilize the IEEE Rapid Spanning Tree Protocol (RSTP) or switch manufacture derivative to re-route the network around the break with minimal to no process interruption. The new PFAS treatment facility shall be integrated into the existing networks, maintaining full functionality of the network.

6.3.3 Design Criteria

6.3.3.1 Control Descriptions Outline

Control descriptions shall be provided for each new process. The control description will identify control at the local level, PLC level, and SCADA level. Format of the control descriptions shall be as follows:

1. Loop Number and Title.
2. Loop Abstract and General Description.
3. Programming Function Blocks:
    a. Process Blocks.
    b. Alarm Blocks.
    c. Equipment Blocks.
4. Control:
    a. Hardwired Control.
    b. Hardwired Interlocks.
    c. Software Interlocks.
    d. PLC/SCADA Control.
5. Alarms:
    a. General Alarm Description.
    b. Alarm Loop Number and Description.

Detailed control descriptions for each new process shall be developed by the Designer during the detailed design phase.

6.3.3.2 Instrumentation

Instruments shall be provided as required to provide automation and protection for facility processes. Instruments shall be powered from PLC cabinets with a minimum of 30-minute battery backup. Instrument power shall be individually fused in the PLC cabinet.

Digital networks for instrumentation shall not be utilized. Traditional instrumentation using 4-20 mA signals with HART capability and discrete wiring as required is preferred.

6.3.3.3 Process and Instrumentation Diagrams

Process and instrumentation diagrams (P&ID) shall be based on International Society of Automation standards and will be developed to show all new signals originating from the field to the SCADA system. This will be shown through distinct bands in the P&IDs; namely field, power source, operator interface, PLC input/output, and SCADA.

SECTION 7 OTHER PROJECT REQUIREMENTS

7.1 Architectural and Landscaping

The objective of these guidelines is to establish the architectural and landscaping preferences for the new PFAS treatment facility as determined by the City. These guidelines are intended to be used as a starting point in determining the appearance of the new PFAS treatment facility. Many decisions will need to be evaluated during the design phase in order to achieve an economical and functional design.

7.1.1 Architectural Requirements

The location and sizing of the new PFAS treatment facility on site is primarily predicated on process requirements, such as hydraulic requirements, pipeline alignments, and treatment capacities. Exterior materials and colors shall match the existing TWTP.

Based on preliminary discussions, it is anticipated that fire sprinklers will not be required in the PFAS treatment facility. However, a code analysis will need to be completed during detailed design.

It is currently not anticipated that restrooms will be included with the new PFAS treatment facility.

7.1.2 Landscaping Requirements

7.1.2.1 Planting Requirements

Refer to Appendix C for the allowable plantings list. Evergreen trees are also an acceptable planting, although not included on this list. City preference is to include evergreens in landscaping, similar to existing plants on and near the site. Austrian Pine is the second most abundant tree in Thornton. To enhance diversity, the City prefers to limit that particular species. Trees should not be planted within 20 feet of the building or fence.

Low water usage plants with a focus on xeric landscaping should be considered. Irrigation should not extend more than 20 feet away from the PFAS treatment facility building. The remainder of the disturbed

site is to be native grasses, not irrigated, and able to be mowed – both with regard to the type of grass and grading of site. Most landscaped areas should make use of mulch to match the existing TWTP.

Sidewalks should be detached from the building to the extent possible, allowing for landscaping directly adjacent to the building walls.

7.1.2.2 Fencing Requirements

The TWTP is surrounded by an ornamental iron fence and pedestrian pathways consisting of wooden trail stairs, crusher fines trail, and concrete trail, are provided on the western side of the site for the community. It is anticipated that the new PFAS facility will be partially located over the existing pedestrian pathways and perimeter fencing, both of which will need to be relocated/replaced along with the associated landscaping. Sections of the fence that are disturbed during construction and new perimeter fencing shall match the existing fence.

7.2 Site Development Requirements

7.2.1 General

Development of the PFAS treatment facility site shall adhere to the City of Thornton Standard Specifications for Design and Construction of Public Improvements, the City of Thornton Development Standard Requirements, the City's stormwater management policies, and good engineering practice. In addition, or complementary to these requirements, are the design criteria specific to the new PFAS treatment facility described below. Any conflict between the City's standard requirements and the criteria described below shall be identified by the Designer and brought to the City's attention.

7.2.2 Roadway, Grading, and Parking Improvements

Roadway improvements and grading design criteria for the PFAS treatment facility are presented in Table 13. The criteria listed in Table 13 are identified as an "indicative" design assumption or as "fixed" criteria. These two criteria intentions are defined in Section 5.

Table 13 Roadway Improvements and Grading Design Criteria

Design Parameter	Units	Criteria	Criteria Intention	
			"Indicative" Design Assumption	"Fixed" Criteria
Roadway Improvements				
Maximum Roadway Slope	%	5		X
Minimum Roadway Slope, Asphalt	%	2		X
Minimum Roadway Slope, Concrete	%	1		X
Typical Cross Slope	%	2	X	
Typical Road Width (Two Lane Road)	feet	22	X	
Minimum Inside Turn Radius	feet	45		X
Grading				
Maximum Grading Slope, Earthwork	-	4:1		X

Parking will be required at the new PFAS treatment facility. The number of parking spaces shall be a function of the final location of the facility and required maintenance activities and shall be in accordance with applicable codes and standards and the City's and Designer's judgment. On-street parking along the access road is not desired.

7.2.3 Drainage and Utility Improvements

Drainage and utility improvements design criteria specific to the new PFAS treatment facility include the following:

- The stormwater collection/detention system (if required) shall be connected to the City's stormwater conveyance system located offsite.
- All sewers should be designed for gravity flow; no sewage lift stations allowed.
- All underground utilities in pipes or conduit shall incorporate methods to accommodate possible movement due to soil expansion or settlement.
- All utility trenches shall have water cutoff seals to prevent conveyance of ground water toward the building foundation.
- To ensure positive drainage away from the building, grading at perimeter of structures shall be at minimum 10 to 1 slope except at sidewalks approaching doorways.
- All roof area drainage, including overflow drains, shall be piped to storm drain. No downspouts discharging within 10 feet of the building envelope or discharging across pedestrian walkways will be allowed.
- All drainage and utility improvements shall be designed to prevent erosion of soil and standing water.

7.3 Security Requirements

The Designer and City shall collaborate to define the appropriate security equipment and materials to be implemented for the Project. In general, the City desires robust security provisions that protect the PFAS treatment facility from theft, vandalism, and acts of terror. At a minimum, the following security measures shall be incorporated into the design of the Project:

- Access Control System:
  - Honeywell Tridium Niagara, preferred vendor is CSI.
  - Identiv/Hirsch Velocity, preferred vendor is Surveillance One or Palladium.
- Doors and Hardware:
  - Door Locks: Best.
- Video Camera and Recording Devices:
  - Server storage required.
- Communication Protocols:
  - Communication through City's network.
  - SCADA notifications, including all intrusion type alarms.

7.4 Process and Mechanical Equipment Requirements

The following summarizes the City's requirements for specific process equipment manufacturers.

- Water Quality Instruments:
  - Turbidity Analyzers: Hach or approved equal.
  - pH Probes: Hach or approved equal.
- Chemical Metering Pumps:
  - Peristaltic Pumps: Watson-Marlow or approved equal.
  - Diaphragm Pumps: Wallace and Tiernan Encore 700 or approved equal.
- Valves:
  - Plastic Body Valves: Spears or approved equal.
- Indoor Piping and Valves:
  - Preference for exposed piping and valves rather than buried.
  - Provide access and adequate safety devices for all valves greater than 6 feet above the finished floor.

7.5 Building Maintenance Department Standards

The City's Building Maintenance Department is standardized on certain equipment, systems, and products. The Designer shall incorporate these standards into its design of the project facilities. The standardized equipment, systems, and products shall include, but is not necessarily limited to, the following:

- Heating, Ventilation, and Air Conditioning (HVAC) Requirements:
  - Equipment, Materials, and Installation:
    - Split-Systems Air Conditioners: Mitsubishi or equal.
    - Make Up Air Units: Greenheck or equal.
    - Hail guards required on all rooftop units.
    - Louvers: Anodized metal material; include bird screen and mosquito screen.
    - Access:
      - Adequate spacing around equipment to allow for proper airflow and maintenance access per manufacturer's recommendations.
      - If equipment is located on roof, provide spacing between unit and parapet walls per manufacturer's recommendations.
      - Pathways on roof required for access.
      - Access ladder/stairs to roof shall be located inside the building.
    - Location:
      - Preference: Roof.
      - Alternate: Pad on grade.
      - Unit shall not be visible from the street. Provide mechanical screens as required.

  - Performance Requirements:
    - Energy Efficiency: As defined by City's Building Department's most recently adopted versions of building codes.
- Electrical Requirements:
  - Equipment, Materials, and Installation:
    - Emergency Backup Diesel Generators: Cummins.
    - LED Lighting (Interior and Exterior): Match existing TWTP.
- Building Finishes Requirements:
  - General: Finishes to match existing TWTP.
  - Roofs: Fully adhered ethylene propylene diene monomer (EPDM) membrane with warranty, white, walking spaces.
  - Other (Trims, Moldings):
    - Corner Guards: Stainless steel.

7.6 Information Technology Department Requirements

The City's Information Technology Department is standardized on certain equipment, systems, and products. The Designer shall incorporate these standards into its design of project facilities. The standardized equipment, systems, and products shall include, but is not necessarily limited to, the following:

- General Requirements:
  - The TWTP is one of the City's quadrant network hubs.
  - The Community Pool, Recreation Center, Senior Center, and Community Center are connected via the network hub, and the fiber for these facilities is routed through the TWTP.
  - Network connection needs to be maintained during construction.
- Network Requirements:
  - Wireless, security cameras, and HVAC go through the network.
  - Wi-Fi access throughout the PFAS treatment facility.
    - American Data Path is the preferred installer.

APPENDIX A

REFERENCE DOCUMENTATION

The following Owner-provided information will be made available to the Designer and Contractor as reference documentation. In accordance with the Designer and Contractor Agreements, Designer and Contractor shall carefully study and compare all Owner-provided information with field conditions, as well as for the internal consistency of such information, and shall promptly report in writing to Owner any conflict, ambiguity, or discrepancy which the Designer and Contractor may discover and shall obtain a written interpretation or clarification from Owner before proceeding with any Work affected thereby:

1. *Thornton Water Treatment Plant, City of Thornton, Colorado*. Thornton Project No. 15-468. Burns & MacDonnell, 2021.
2. *Denver-Broomfield Treated Water Transmission Line Conduit No. 81*. Nelson Haley Patterson and Quick Engineering Consultants, 1972.
3. *24-inch Valve Actuator Installations at the Intersection of Thornton Parkway and Dorothy Blvd, City of Thornton, Colorado*. Thornton Project No. 05-472, 05-473. HDR, 2006.
4. *Treated Water System Improvements, City of Thornton, Colorado*. Thornton Project No. 97-14. HDR, 1997.
5. *2002 Treated Water System Improvements, City of Thornton, Colorado*. Thornton Project No. 02-37. HDR, 2003.
6. *Columbine WTP to Thornton WTP Treated Water Pipeline (E. 96th Avenue), City of Thornton*. Thornton Project No. 93-11. URS, 1993.
7. *Connection to New 3 M.G. Water Storage Tank*. City of Thornton Utilities Engineering Department, 1972.
8. *Feeder Main from Distribution System to Clear Well, City of Thornton, Colorado*. Phillips-Carter-Osborn, Inc., 1963.
9. *North Washington Water Transmission Pipeline, Adams County, Colorado*. Phillips-Carter-Osborn, Inc., 1960.
10. *Thornton WTP Valve Vault Modifications, City of Thornton, Colorado*. Thornton Project No. 00-111. HDR, 2001.
11. *Water Transmission Pipeline, Adams County, Colorado*. Phillips-Carter-Osborn, Inc., 1959.
12. *Waterworks Improvements, City of Thornton, Colorado*. City of Thornton Utilities Engineering Department, 1973.
13. *Thornton Water Treatment Plant Clearwell & Pumping Improvements, City of Thornton, Colorado*. HDR Project No. 148-42-50. HDR, 1986.
14. *Part 1: Zone 4 Booster Pump Station; Part 2: 24" Distribution Main, City of Thornton, Colorado*. HDR Project No. 148-29-10. HDR, 1984.
15. *Pretreatment Facilities East and West Gravel Lakes Pumps Stations, City of Thornton, Colorado*. Thornton Project No. 99-116. Jacobson Helgoth, 2001.
16. *West Raw Water Pump Station, City of Thornton, Colorado*. Thornton Project No. 88-16. HDR, 1990.
17. *Zone 2-3 Pump Station, City of Thornton, Colorado*. Thornton Project No. 07-690. HDR, 2010.
18. *Zone 3/4 Backup Booster Pump Station, City of Thornton, Colorado*. Thornton Project No. 09-778. Olsson Associates, 2012.

19. *Croke Lake to Thornton Water Treatment Plant Raw Water Line, City of Thornton, Colorado*. City of Thornton Utilities Department, 1968.
20. *East Gravel Lakes Pump Station to Thornton Treatment Plant Raw Water Pipeline (Phase I), City of Thornton, Colorado*. Thornton Project No. 02-336. Burns & McDonnell, 2004.
21. *East Gravel Lakes Pump Station to Thornton Treatment Plant Raw Water Pipeline (Phase II), City of Thornton, Colorado*. Thornton Project No. 02-336. Burns & McDonnell, 2005.
22. *Raw Water Piping Tie-In Configurations at East Gravel Lake #4*. City of Thornton Survey Department.
23. *95th Avenue & Hoffman Way Sanitary Sewer*. City of Thornton, 1964.
24. *Thornton Water Treatment Plant Sewer, City of Thornton*. Thornton Project No. 10-469. Dewberry, 2011.
25. *Washington Heights Sewer Plan & Profile*. Miller-Ernstsen and Moore, 1974.
26. *Water Transmission Line 88th Ave. to Russell Way to Clearwell, City of Thornton Colorado*. Nelson-Haley-Patterson and Quirk, 1965.
27. *Water Treatment Plant 12" Sludge Line Replacement, City of Thornton, Colorado*. Thornton Project No. 94-22. Centennial Engineering Inc., 1994.
28. *Sludge Line from Thornton Treatment Plant to Columbine Treatment Plant, City of Thornton, Colorado*. Thornton Project No. 81-5. City of Thornton Utilities, 1981.
29. *Standley Lake 36-Inch Raw Waterline, City of Thornton Utilities Board, Colorado*. Thornton Project No. 79-7. URS, 1981.
30. *Hoffman Way Drainage and Street Improvements, City of Thornton, Colorado*. Muller Engineering Company, Inc., 1983.
31. *Hoffman Way Storm Sewer*. Thornton, Colorado, Office of the City Engineer, 1972.
32. *Lambertson Lakes Storm Sewer*. J.R. Engineering, 2003.
33. *Thornton Water Treatment Plant Automation Project, City of Thornton, Colorado*. Thornton Project No. 95-20. HDR, 1998.
34. *Columbine Treatment Plant Additions, City of Thornton, Colorado*. Thornton Project No. 76-49. Black & Veatch, 1977.
35. *Chlorine Hoist and Building Modifications at the Columbine and Thornton Water Treatment Plants, City of Thornton, Colorado*. Thornton Project No. 91-A1. HDR, 1991.
36. *City Hall Properties, City of Thornton,* Colorado. Office of the City Engineer, 1972.
37. *Zone 4 Booster Pump Station Landscaping*. City of Thornton Utilities Engineering Department, 1985.
38. *Water Treatment Plant Additions, City of Thornton, Colorado*. Black & Veatch Project No. 3956. Black & Veatch, 1967.
39. *Thornton Water Treatment Plant Slope Stabilization Project, City of Thornton, Colorado*. Thornton Project No. 05-468. Huitt-Zollars, 2008.
40. *Thornton Water Treatment Plant and Columbine Water Treatment Plant Cathodic Protection, City of Thornton, Colorado*. Corro-Tek Engineering Inc., 1995.
41. *Thornton Water Treatment Plant Clearwell and Pumping Improvements, City of Thornton, Colorado*. HDR Project No. 148-42-50. HDR, 1988.

42. *Thornton Water Treatment Plant Expansion Project, City of Thornton, Colorado*. Thornton Project No. 85-16. Richard P. Arber Associates, 1986.
43. *Thornton Water Treatment Plant, City of Thornton, Colorado*. Henningson, Durham & Richardson, Inc., 1973.
44. *Ultraviolet Disinfection Project for Columbine Water Treatment Plant and Thornton Water Treatment Plant, City of Thornton, Colorado*. Thornton Project No. 01-248. Burns & McDonnell, 2004.
45. *Thornton Water Treatment Plant Slope Stabilization Project, City of Thornton, Colorado*. Thornton Project No. 01-267. Huitt-Zollars, 2004.
46. *Thornton Treatment Plant Landscape Development Plans, City of Thornton, Colorado*. Thornton Project No. 87-34. The Norris Company, 1988.
47. *North Washington Water Transmission Pipeline, Adams County, Colorado*. Phillips-Carter-Osborn, Inc., 1960.
48. *Northglenn Supply 20" Transmission Line, City of Thornton, Colorado*. Nelson-Haley-Patterson and Quirk, 1964.
49. *95th and Washington Water Line, City of Thornton, Colorado*. Thornton Project No. 98-151. HDR, 1999.
50. *Denver/Thornton Interconnect, City of Thornton, Colorado*. Thornton Project No. 02-339. Black & Veatch, 2002.
51. *95th and Washington Water Line, Phase II, City of Thornton, Colorado*. HDR Project No. 06589-055-050. HDR, 2002.

APPENDIX B

INDICATIVE DESIGN DRAWINGS

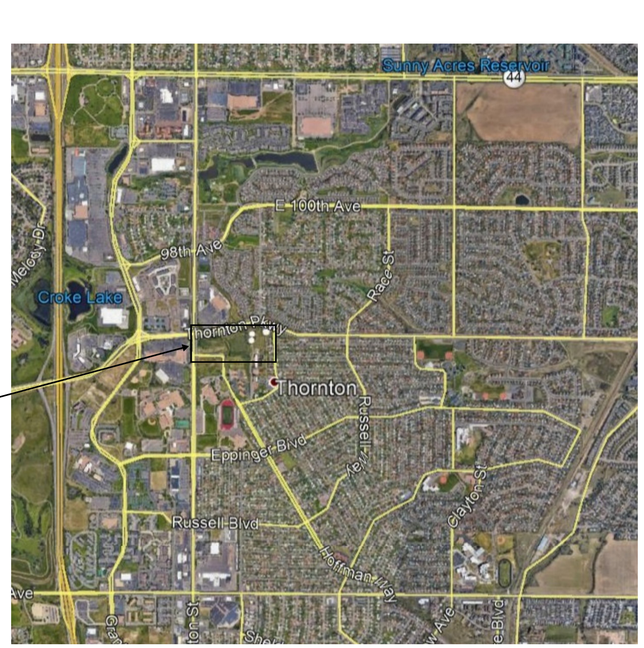
THORNTON WATER TREATMENT PLANT
PFAS TREATMENT PROJECT

920 THORNTON PARKWAY
THORNTON, CO 80229

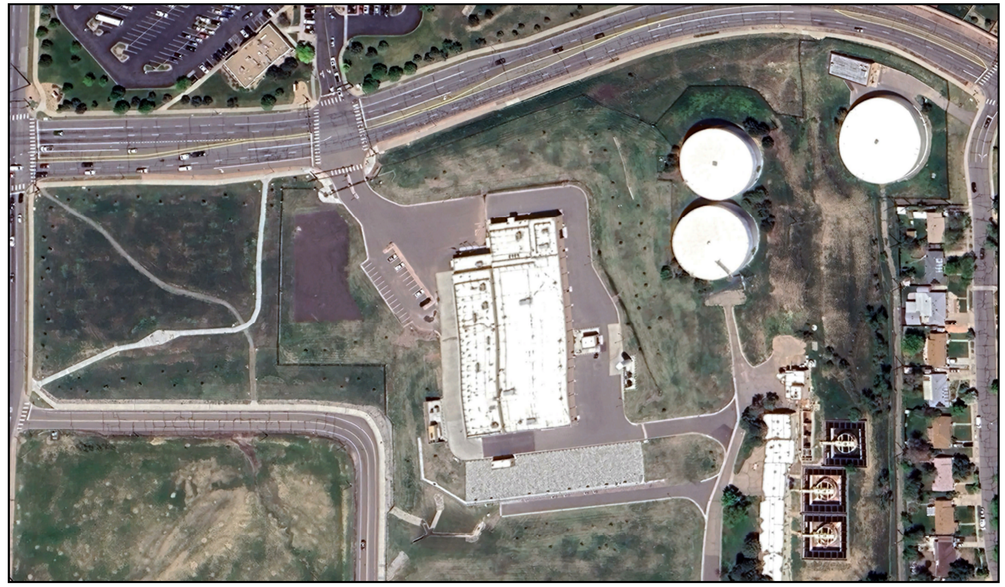
INDICATIVE DESIGN

PROJECT NO. 23-127

JUNE 2024



LOCATION MAP
SCALE: NONE



SITE MAP - THORNTON WTP
SCALE: NONE

JOB NO. 202719
DRAWING NO. G01
SHEET NO. 1 OF 13

SHEET LIST

SHEET NO.	DRAWING NO.	SHEET TITLE
1	G01	COVER SHEET
2	G02	SHEET LIST, DESIGN CRITERIA, AND FLOW STREAM ABBREVIATIONS
3	G03	PROCESS FLOW DIAGRAM
4	G04	HYDRAULIC PROFILE
5	G05	SITE PLAN AND FACILITIES INDEX ALTERNATIVE 1
6	G06	SITE PLAN AND FACILITIES INDEX ALTERNATIVE 2
7	G07	SITE PLAN AND FACILITIES INDEX ALTERNATIVE 3
8	M01	GAC CONTACTORS PERSPECTIVE 1
9	M02	GAC CONTACTORS PERSPECTIVE 2
10	M03	GAC CONTACTORS PERSPECTIVE 3
11	M04	GAC CONTACTORS PERSPECTIVE 4
12	E01	OVERALL ONE-LINE DIAGRAM
13	E02	MCC-GAC ONE-LINE DIAGRAM

FLOW STREAM ABBREVIATIONS

PROCESS PIPING AND UTILITIES

CODE	DESCRIPTION
BWS	BACKWASH SUPPLY
BWW	BACKWASH WASTE
CFE	COMBINED FILTER EFFLUENT
FDW	FIRE/DOMESTIC WATER
FW	FINISHED WATER
GE	GAC EFFLUENT
GI	GAC INFLUENT
GTW	GAC TO WASTE
NPW	NON POTABLE WATER
OVF	OVERFLOW
PD	PROCESS DRAIN
PW	POTABLE WATER
RW	RAW WATER
SS	SANITARY SEWER
ST	STORM DRAIN
UW	UTILITY WATER

CHEMCIALS

CODE	DESCRIPTION
AMS	AMMONIUM SULFATE
CAP	COAGULANT AID POLYMER
CAS	CAUSTIC SODA
FAP	FLOCCULANT AID POLYMER
FES	FERRIC SULFATE
H2O2	HYDROGEN PEROXIDE
LOX	LIQUID OXYGEN
O3	OZONE SOLUTION
PHA	PHOSPHORIC ACID
SBI	SODIUM BISULFITE
SH	SODIUM HYPOCHLORITE
SP	SODIUM PERMANGANATE

DESIGN CRITERIA

DESCRIPTION	UNITS	CRITERIA
GAC CONTACTORS		
CONTACTOR TYPE: GRAVITY, CONCRETE BOX		
CONTACTOR CONTROL: RATE-OF-FLOW		
UNDERDRAIN TYPE: MONOLITHIC SLAB WITH NOZZLES		
TREATED WATER FLOW RATE		
PFAS TREATMENT FACILITY PRODUCTION RATE, MAX.	mgd	32
PFAS TREATMENT FACILITY PRODUCTION RATE, MIN.	mgd	3
NUMBER OF CONTACTORS	No.	6 (5 + 1)
CONTACTOR DIMENSIONS (W x L)	ft x ft	18 x 62
DEPTH OF WATER ABOVE MEDIA	ft	7
MINIMUM AVAILABLE HEADLOSS FOR SOLIDS ACCUMULATION	ft	3-4
CONTACTOR AREA		
EACH CONTACTOR	sq ft	1,110
TOTAL	sq ft	6,700
SURFACE LOADING RATE (@32 MGD)		
ONE CONTACTOR OUT OF SERVICE	gpm/sq ft	4.0
EMPTY BED CONTACT TIME OF GAC (@32 MGD)		
ONCE CONTACTOR OUT OF SERVICE	min	15
CONTACTOR MEDIA		
GRANULAR ACTIVATED CARBON (GAC)		
DEPTH	in	96
SIEVE SIZE	mesh	12 x 40
EFFECTIVE SIZE	mm	0.55-0.75
CONTACTOR BACKWASH		
TYPE: PUMPED BACKWASH		
BACKWASH PUMPS: EXISTING		
MEDIA EXPANSION DURING BACKWASH, MAXIMUM	%	20-30
BACKWASH LOADING RATE, MAXIMUM	gpm/sq ft	12.5
BACKWASH FLOW RATE, MAXIMUM	gpm	13,750
BACKWASH LOADING RATE, MINIMUM	gpm/sq ft	3.0
BACKWASH FLOW RATE, MINIMUM	gpm	3,350
GAC INFLUENT PUMP STATION		
TYPE: SUBMERSIBLE PUMPS		
FLOW RATE CONTROL: VARIABLE FREQUENCY DRIVE		
NUMBER OF PUMPS	No.	5 (4 + 1)
CAPACITY, EACH	mgd	8
TOTAL DYNAMIC HEAD	ft	20
MOTOR SIZE, EACH	hp	40

REV	DATE	BY	DESCRIPTION

DESIGNED BRE
DRAWN BRE
CHECKED WVS
DATE JUNE 2024

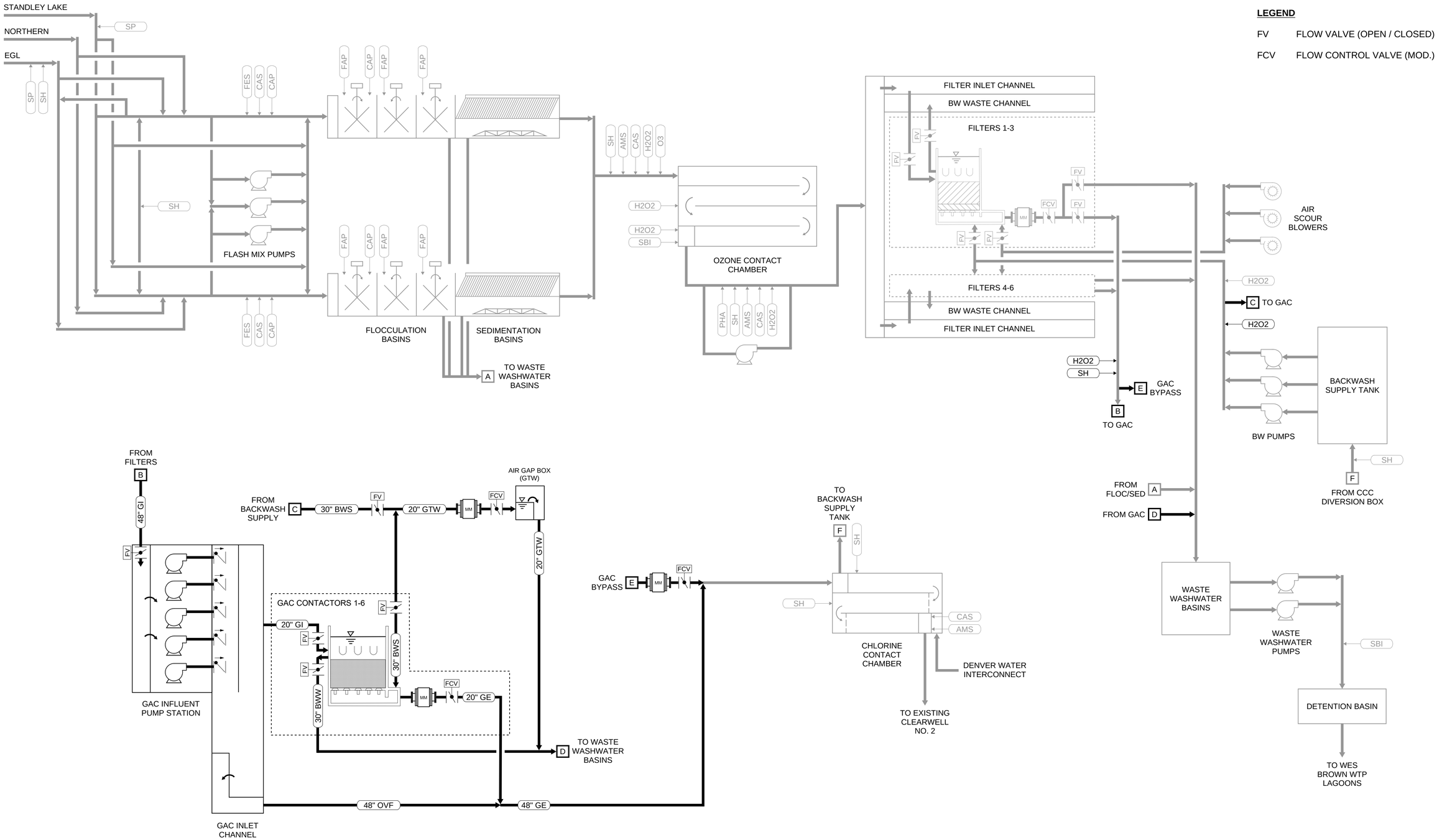
carollo®

CITY OF THORNTON

CITY OF THORNTON
PFAS TREATMENT PROJECT
GENERAL
SHEET LIST, DESIGN CRITERIA, AND FLOW STREAM ABBREVIATIONS

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202719
DRAWING NO. G02
SHEET NO. 2 OF 13



LEGEND

FV FLOW VALVE (OPEN / CLOSED)

FCV FLOW CONTROL VALVE (MOD.)

REV	DATE	BY	DESCRIPTION

DESIGNED BRE
DRAWN BRE
CHECKED WVS
DATE JUNE 2024

CITY OF THORNTON

PFAS TREATMENT PROJECT

GENERAL

PROCESS FLOW DIAGRAM

VERIFY SCALES
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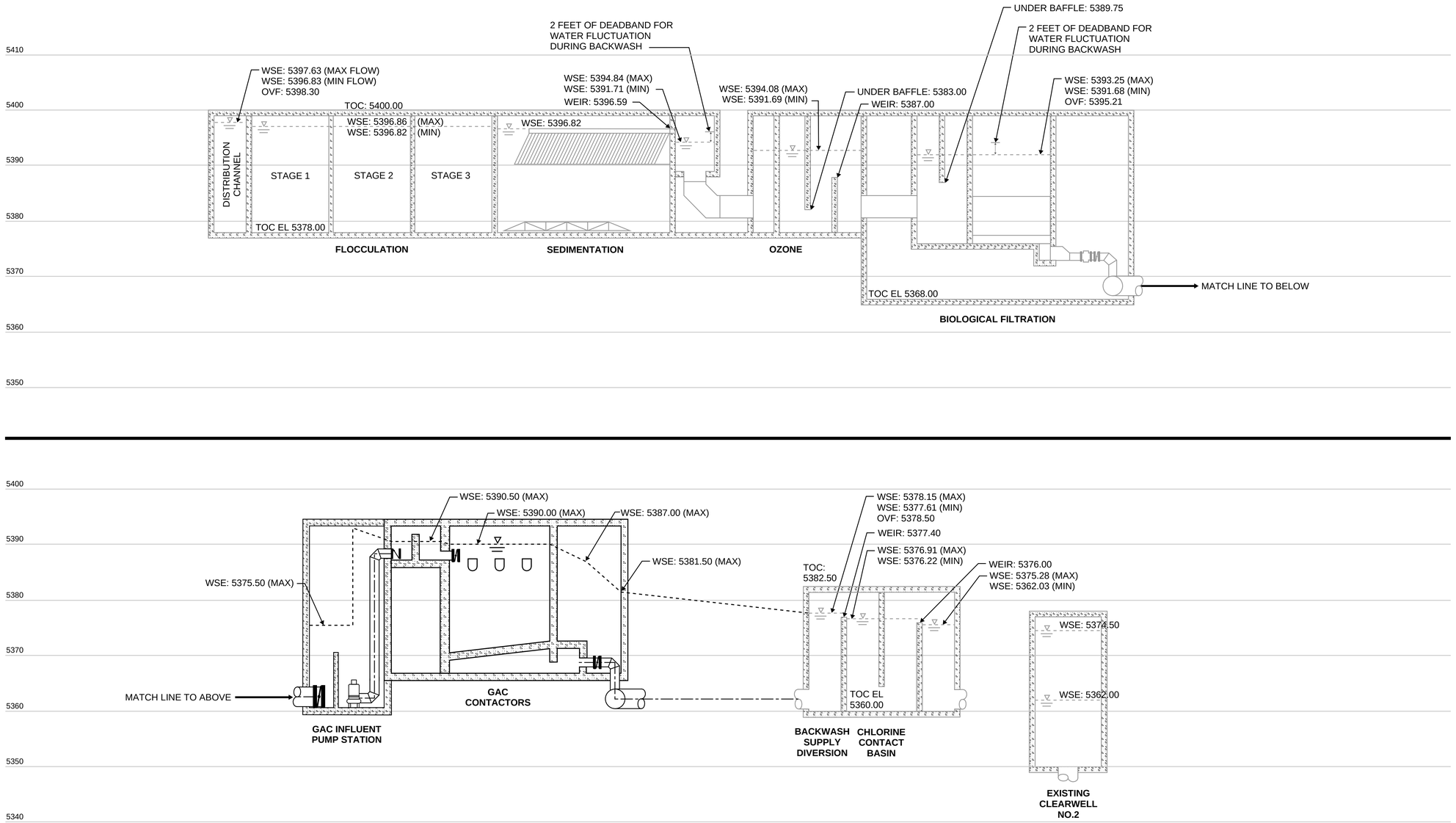
JOB NO. 202719
DRAWING NO. G03
SHEET NO. 3 OF 13



HYDRAULIC SCENARIO

	3 MGD (MIN)		30 MGD (MAX)	
	FLOW	# ONLINE	FLOW	# ONLINE
PRETREATMENT	3.2 MGD	1 TRAIN	32 MGD	2 TRAINS
OZONE	3.2 MGD	N/A	32 MGD	N/A
FILTRATION	3.2 MGD	1 FILTER	32 MGD	5 FILTERS
GAC CONTACTORS	3.2 MGD	1 CONTACTOR	32 MGD	5 CONTACTORS
CHLORINE CONTACT BASIN	3 MGD	N/A	30 MGD	N/A

REV	DATE	BY	DESCRIPTION

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CITY OF THORNTON

CITY OF THORNTON
PFAS TREATMENT PROJECT
GENERAL
HYDRAULIC PROFILE

VERIFY SCALES
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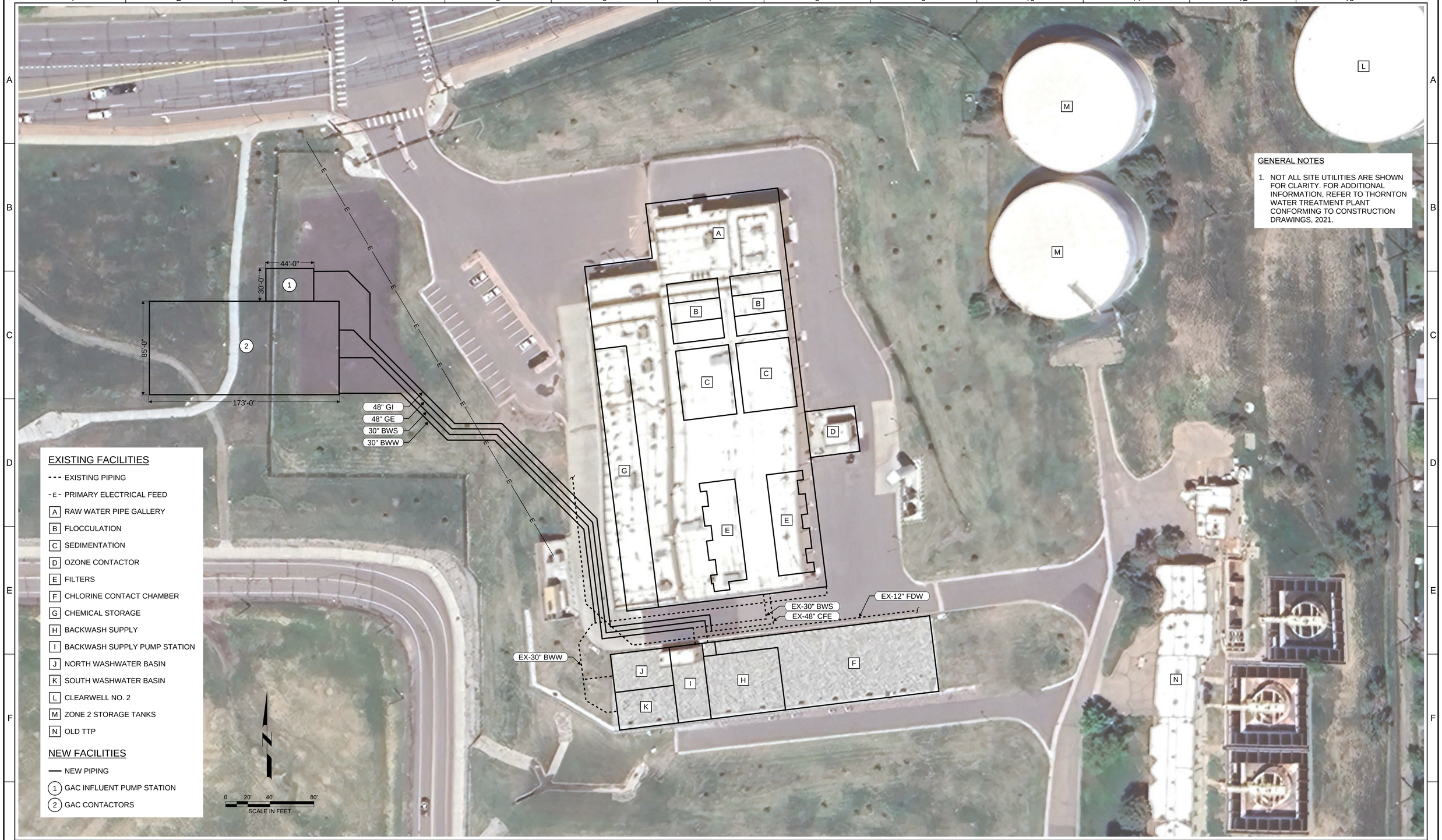
JOB NO. 202719
DRAWING NO. G04
SHEET NO. 4 OF 13



REV	DATE	BY	DESCRIPTION

DESIGNED BRE
DRAWN BRE
CHECKED WVS
DATE JUNE 2024

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CITY OF THORNTON

PFAS TREATMENT PROJECT

GENERAL

SITE PLAN AND FACILITIES INDEX ALTERNATIVE 1

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
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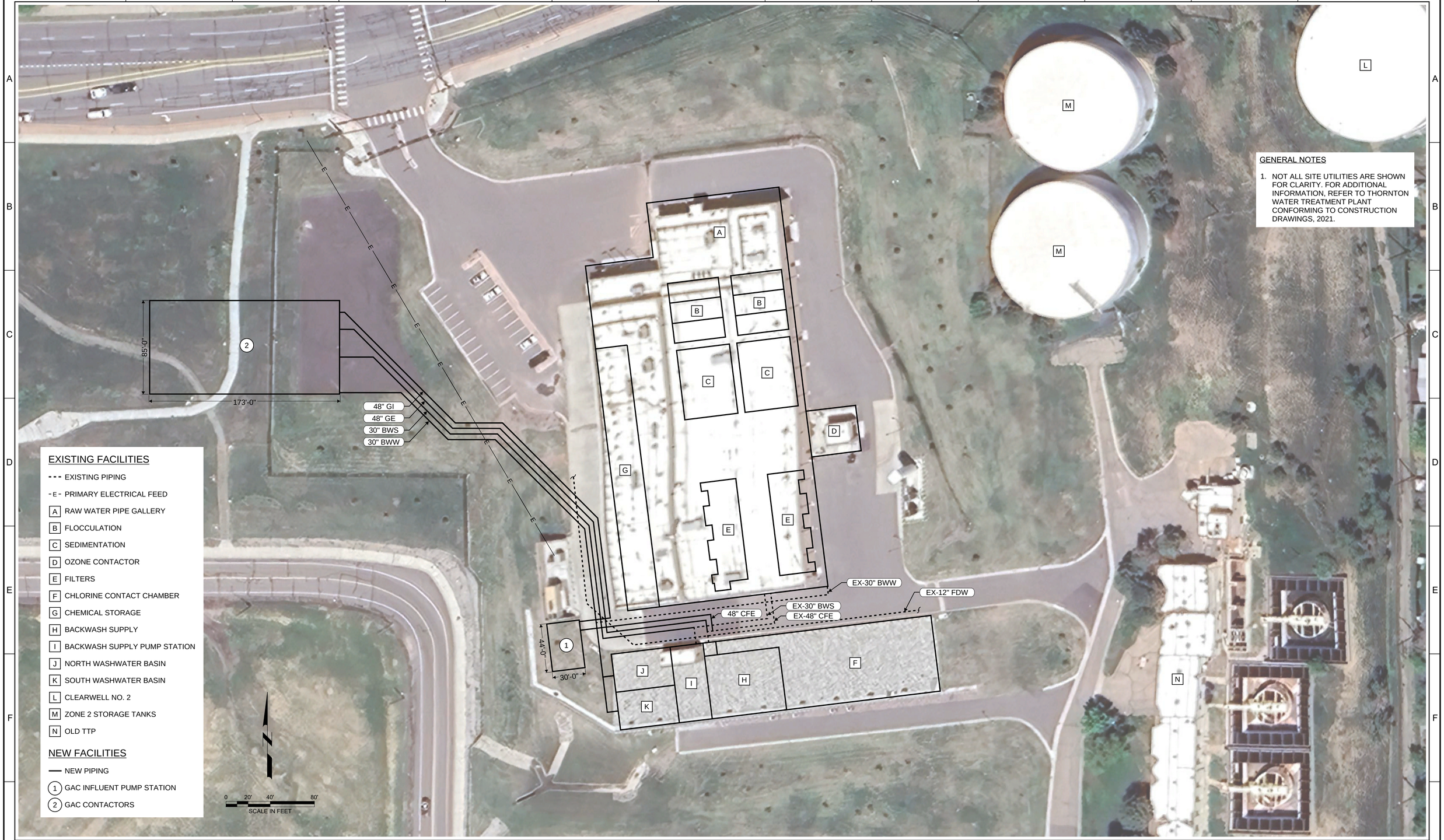
JOB NO. 202719
DRAWING NO. G05
SHEET NO. 5 OF 13



GENERAL NOTES

1. NOT ALL SITE UTILITIES ARE SHOWN FOR CLARITY. FOR ADDITIONAL INFORMATION, REFER TO THORNTON WATER TREATMENT PLANT CONFORMING TO CONSTRUCTION DRAWINGS, 2021.

EXISTING FACILITIES

- EXISTING PIPING
- E PRIMARY ELECTRICAL FEED
- A RAW WATER PIPE GALLERY
- B FLOCCULATION
- C SEDIMENTATION
- D OZONE CONTACTOR
- E FILTERS
- F CHLORINE CONTACT CHAMBER
- G CHEMICAL STORAGE
- H BACKWASH SUPPLY
- I BACKWASH SUPPLY PUMP STATION
- J NORTH WASHWATER BASIN
- K SOUTH WASHWATER BASIN
- L CLEARWELL NO. 2
- M ZONE 2 STORAGE TANKS
- N OLD TTP

NEW FACILITIES

- NEW PIPING
- 1 GAC INFLUENT PUMP STATION
- 2 GAC CONTACTORS

REV	DATE	BY	DESCRIPTION

DESIGNED BRE
DRAWN BRE
CHECKED WVS
DATE JUNE 2024

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CITY OF THORNTON

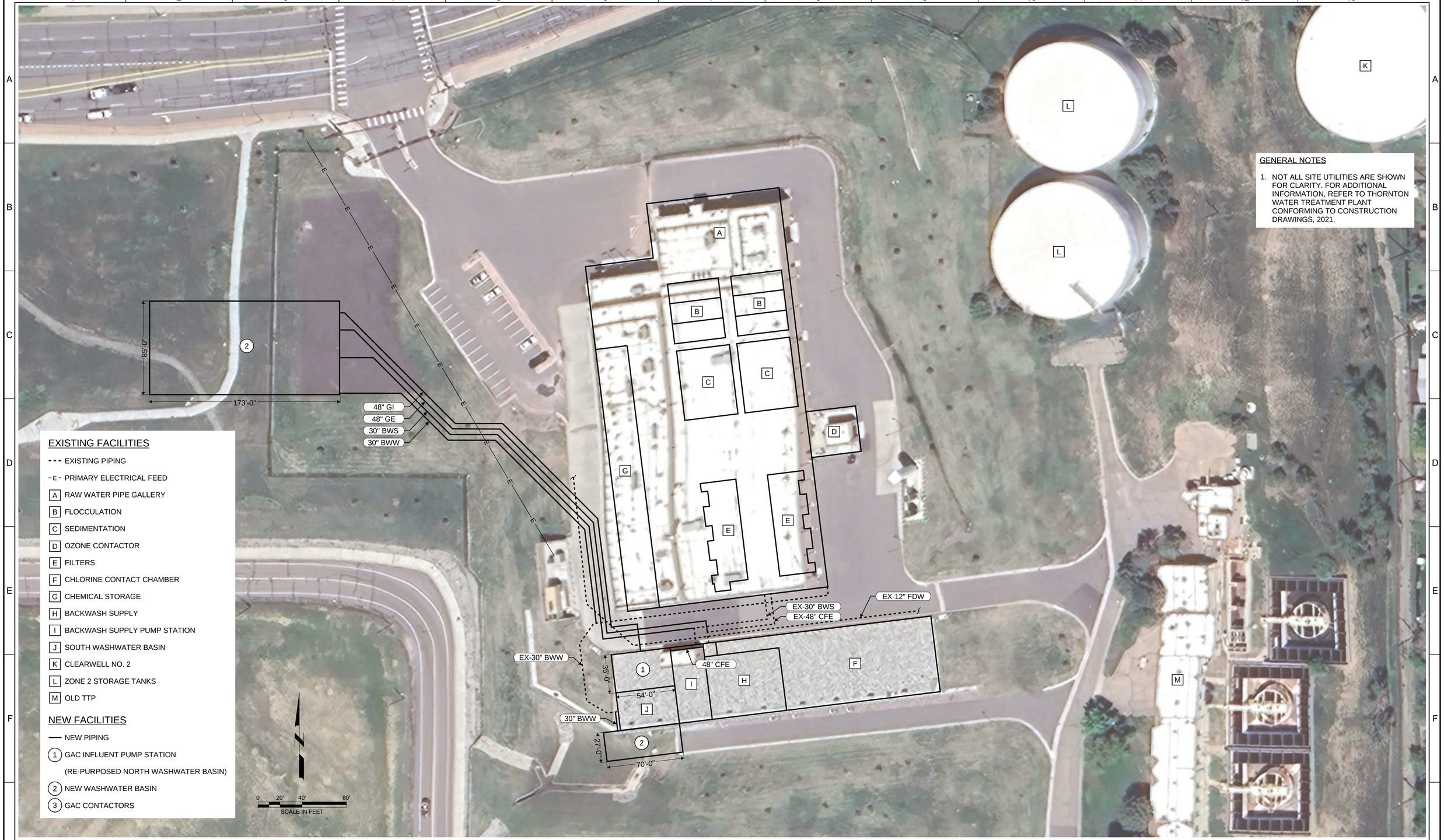
PFAS TREATMENT PROJECT

GENERAL

SITE PLAN AND FACILITIES INDEX ALTERNATIVE 2

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202719
DRAWING NO. G06
SHEET NO. 6 OF 13



EXISTING FACILITIES

- EXISTING PIPING
- PRIMARY ELECTRICAL FEED
- A RAW WATER PIPE GALLERY
- B FLOCCULATION
- C SEDIMENTATION
- D OZONE CONTACTOR
- E FILTERS
- F CHLORINE CONTACT CHAMBER
- G CHEMICAL STORAGE
- H BACKWASH SUPPLY
- I BACKWASH SUPPLY PUMP STATION
- J SOUTH WASHWATER BASIN
- K CLEARWELL NO. 2
- L ZONE 2 STORAGE TANKS
- M OLD TTP

NEW FACILITIES

- NEW PIPING
- (1) GAC INFLUENT PUMP STATION (RE-PURPOSED NORTH WASHWATER BASIN)
- (2) NEW WASHWATER BASIN
- (3) GAC CONTACTORS

GENERAL NOTES

1. NOT ALL SITE UTILITIES ARE SHOWN FOR CLARITY. FOR ADDITIONAL INFORMATION, REFER TO THORNTON WATER TREATMENT PLANT CONFORMING TO CONSTRUCTION DRAWINGS, 2021.

REV	DATE	BY	DESCRIPTION

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CHECKED WVS
DATE JUNE 2024

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CITY OF THORNTON

CITY OF THORNTON

PFAS TREATMENT PROJECT

GENERAL

SITE PLAN AND FACILITIES INDEX ALTERNATIVE 3

VERIFY SCALES
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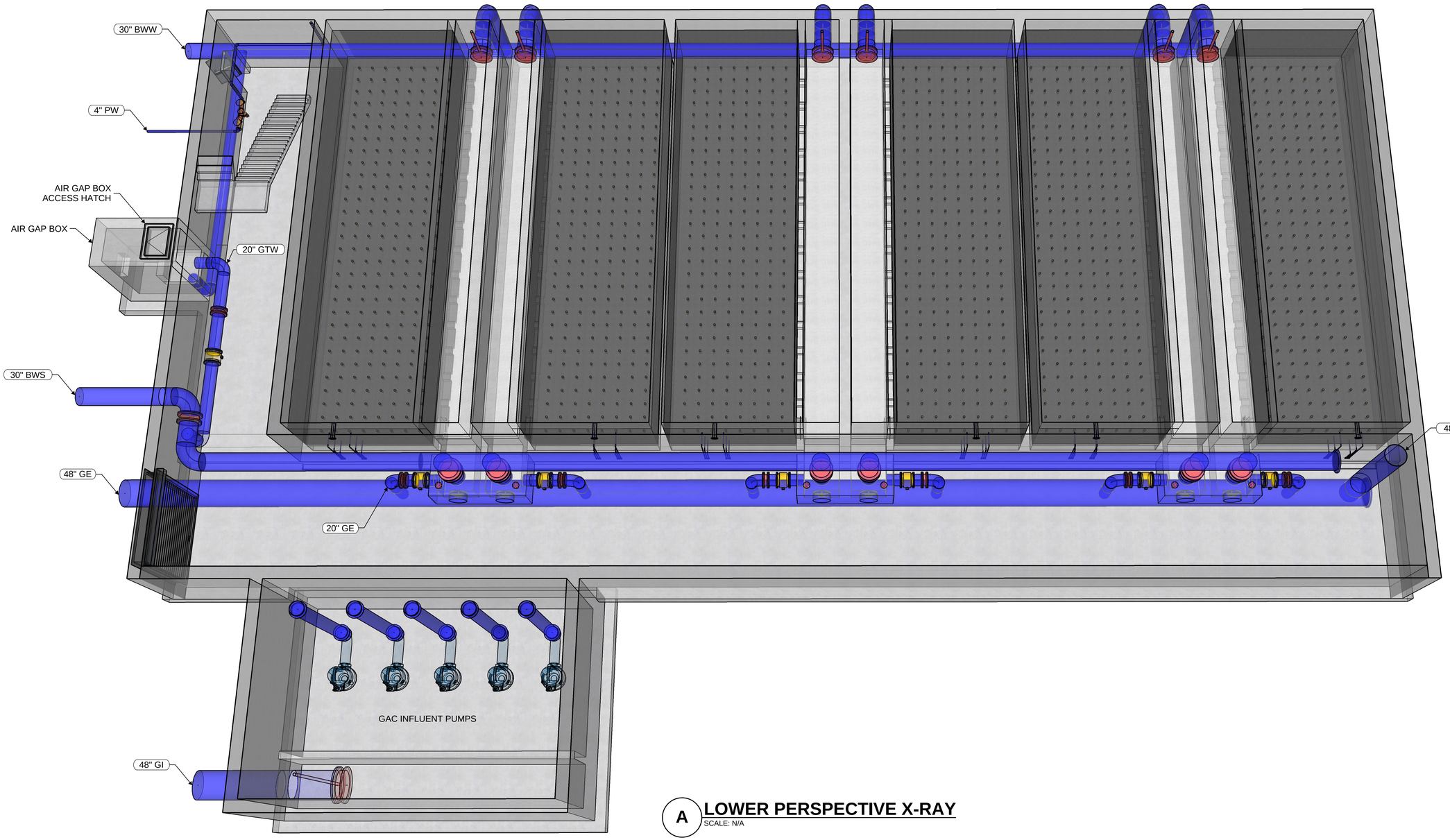
JOB NO. 202719
DRAWING NO. G07
SHEET NO. 7 OF 13



A **LOWER PERSPECTIVE X-RAY**
SCALE: N/A

REV	DATE	BY	DESCRIPTION

DESIGNED BRE
DRAWN BRE
CHECKED WVS
DATE JUNE 2024

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CITY OF THORNTON

CITY OF THORNTON
PFAS TREATMENT PROJECT
MECHANICAL
GAC CONTACTORS PERSPECTIVE 1

VERIFY SCALES
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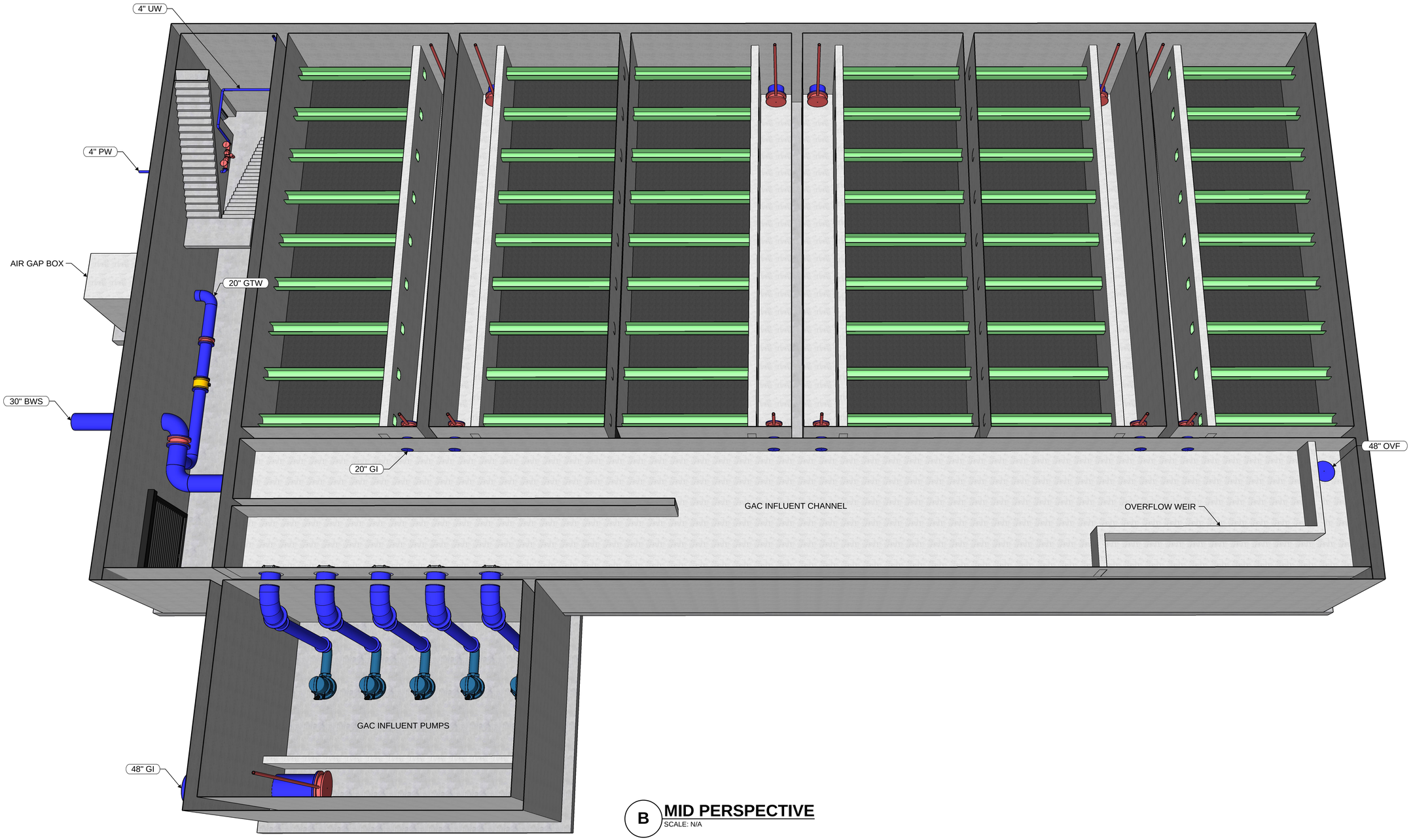
JOB NO. 202719
DRAWING NO. M01
SHEET NO. 8 OF 13



B **MID PERSPECTIVE**
SCALE: N/A

REV	DATE	BY	DESCRIPTION

DESIGNED BRE
DRAWN BRE
CHECKED WVS
DATE JUNE 2024

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CITY OF THORNTON

CITY OF THORNTON
PFAS TREATMENT PROJECT
MECHANICAL
GAC CONTACTORS PERSPECTIVE 2

VERIFY SCALES
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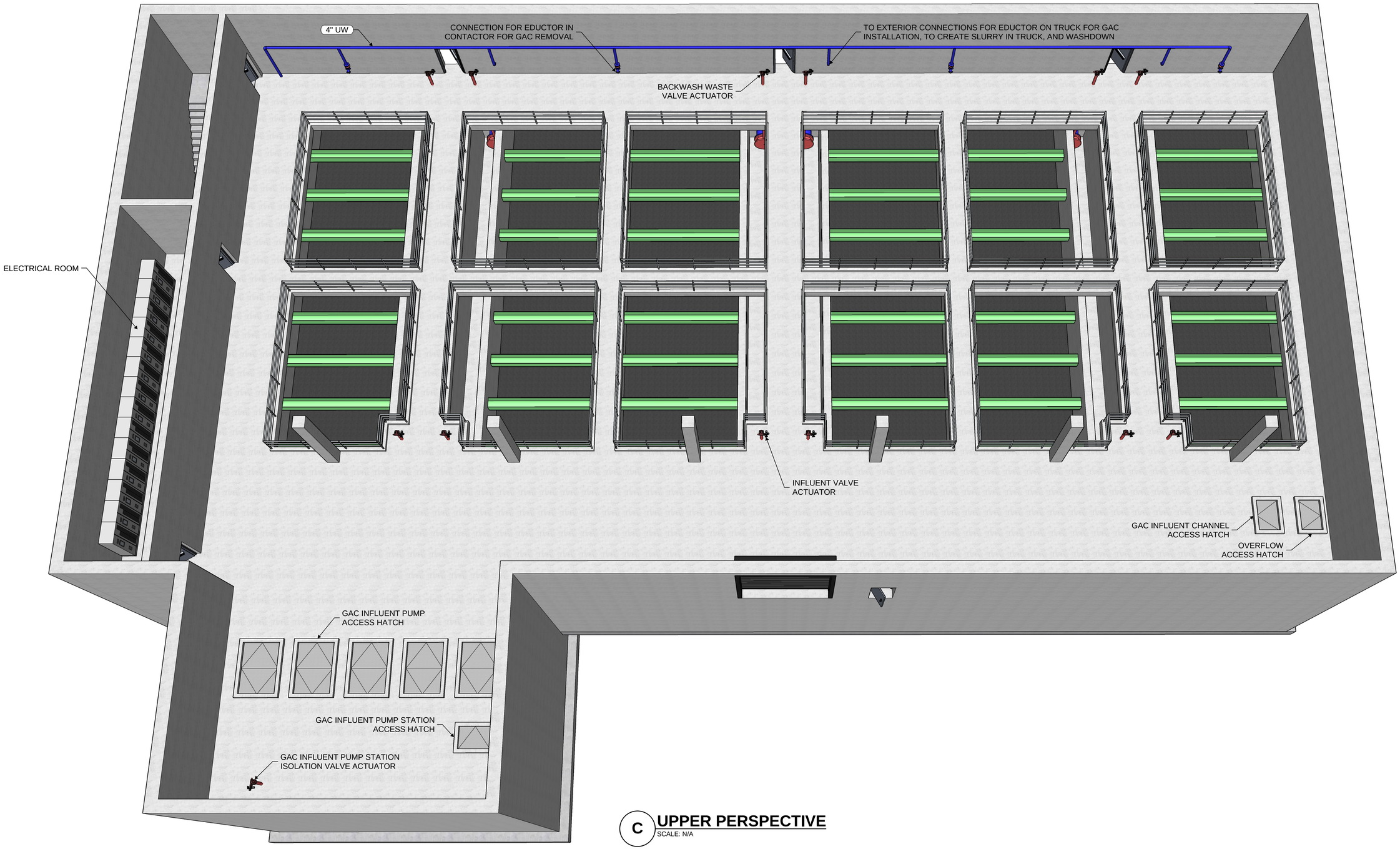
JOB NO. 202719
DRAWING NO. M02
SHEET NO. 9 OF 13



C UPPER PERSPECTIVE

SCALE: N/A

REV	DATE	BY	DESCRIPTION

DESIGNED BRE
DRAWN BRE
CHECKED WVS
DATE JUNE 2024

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CITY OF THORNTON

CITY OF THORNTON
PFAS TREATMENT PROJECT
MECHANICAL
GAC CONTACTORS PERSPECTIVE 3

VERIFY SCALES
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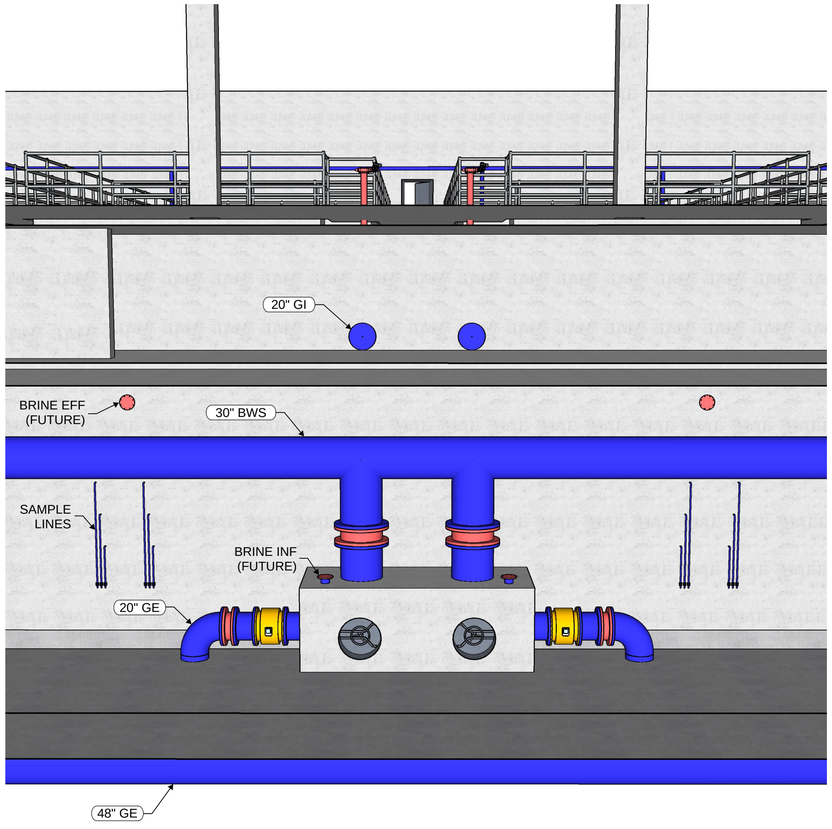
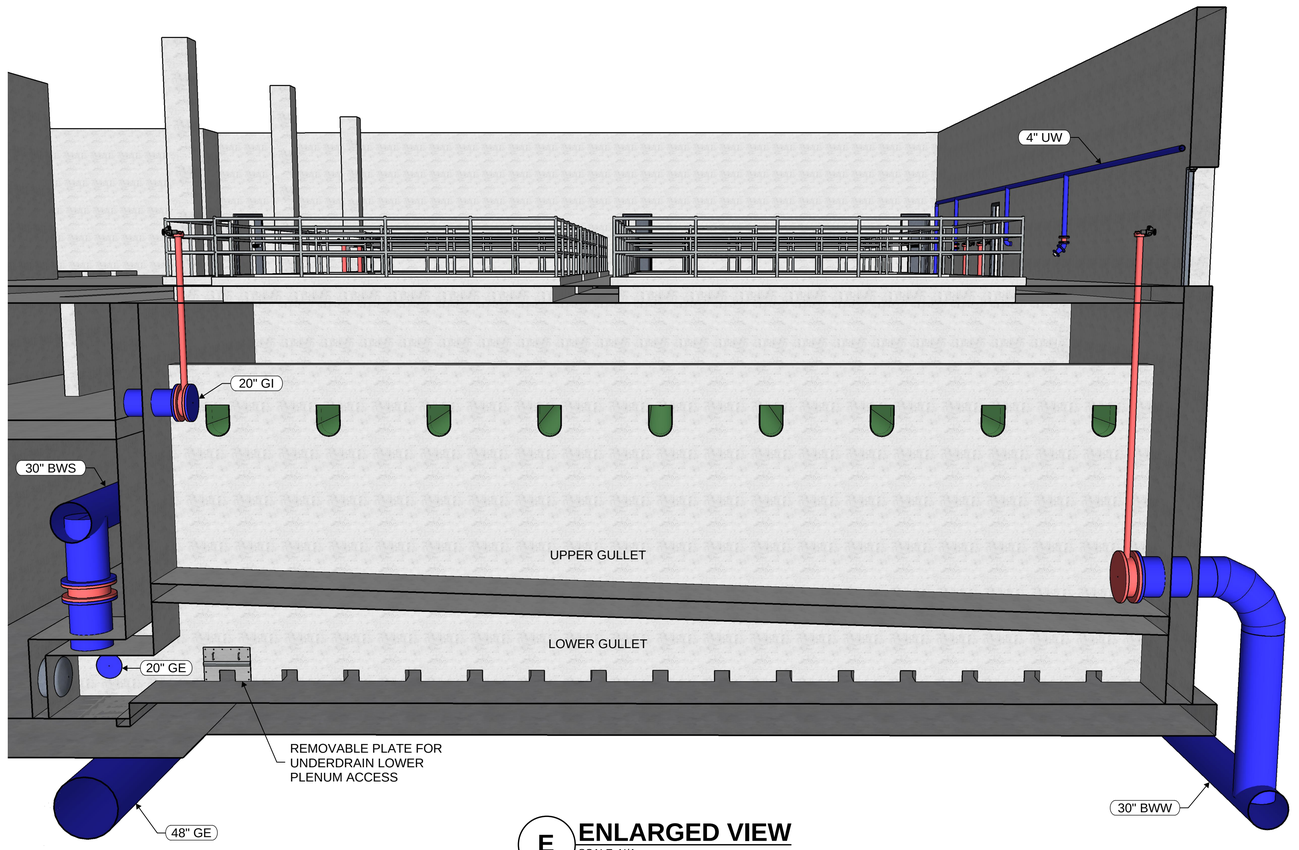
JOB NO. 202719
DRAWING NO. M03
SHEET NO. 10 OF 13



D ENLARGED VIEW
SCALE: N/A



E ENLARGED VIEW
SCALE: N/A

REV	DATE	BY	DESCRIPTION

DESIGNED BRE
DRAWN BRE
CHECKED WVS
DATE JUNE 2024

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CITY OF THORNTON

CITY OF THORNTON
PFAS TREATMENT PROJECT
MECHANICAL
GAC CONTACTORS PERSPECTIVE 4

VERIFY SCALES
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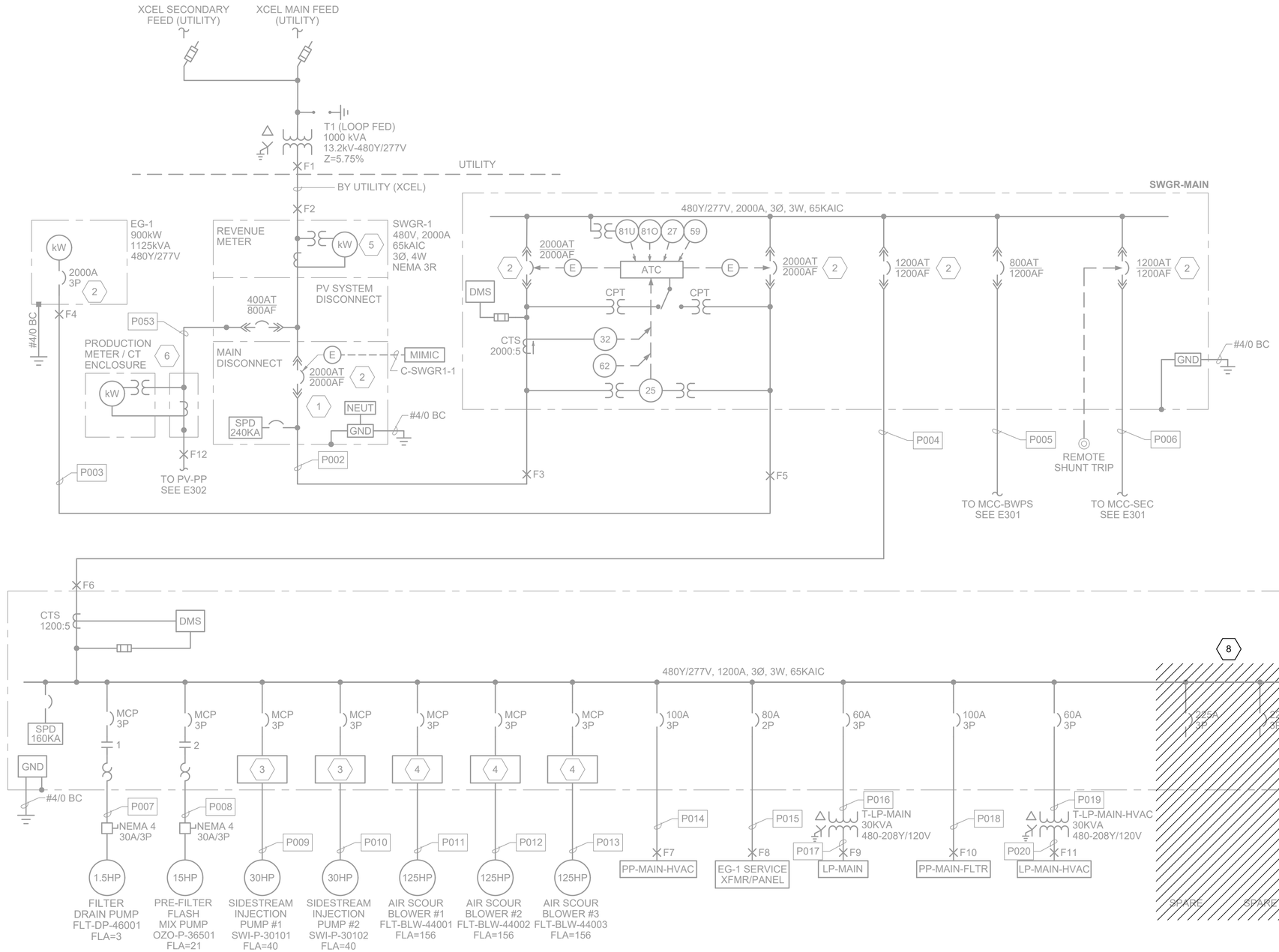
JOB NO. 202719
DRAWING NO. M04
SHEET NO. 11 OF 13



MCC-MAIN ONE-LINE DIAGRAM

REV	DATE	BY	DESCRIPTION

DESIGNED JW
DRAWN JW
CHECKED KA
DATE JUNE 2024

CITY OF THORNTON
PFAS TREATMENT PROJECT
ELECTRICAL
OVERALL ONE-LINE DIAGRAM

VERIFY SCALES
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0 1"
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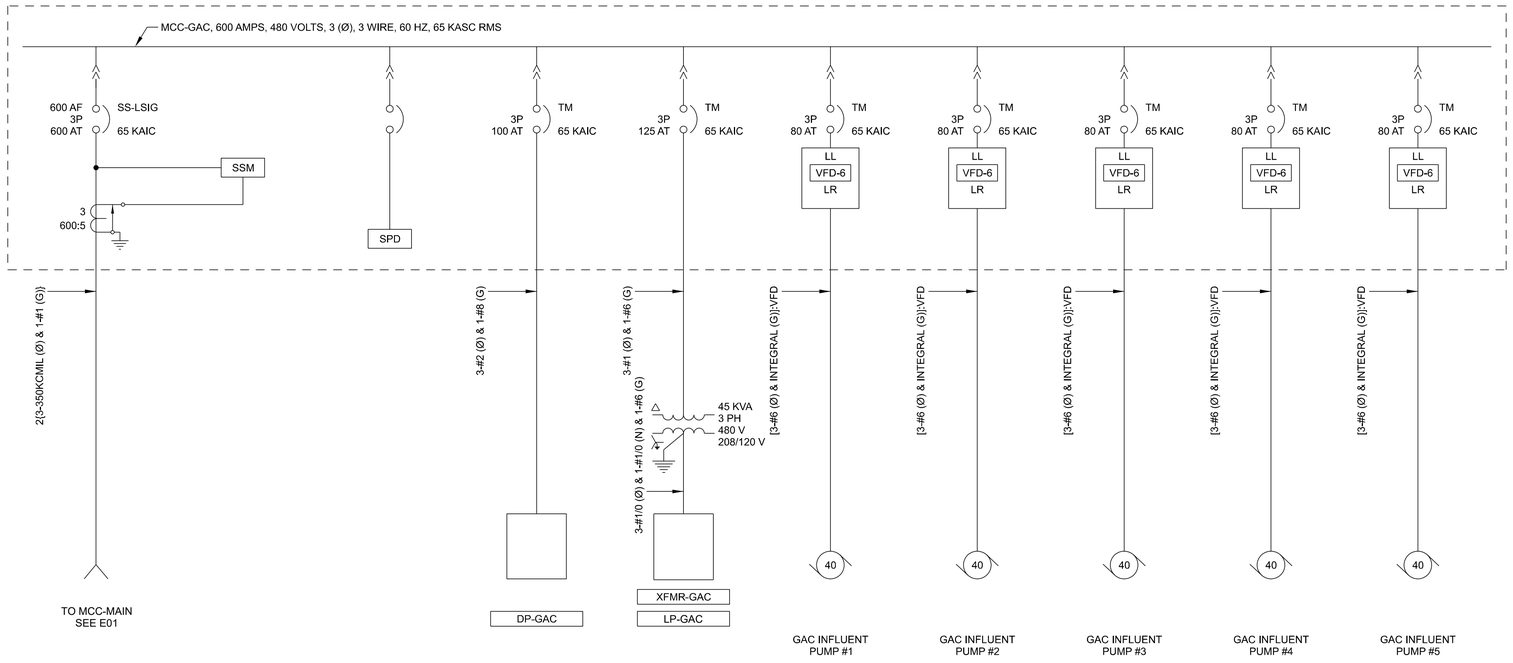
JOB NO. 202719
DRAWING NO. E01
SHEET NO. 12 OF 13



REV	DATE	BY	DESCRIPTION

DESIGNED JW
DRAWN JW
CHECKED KA
DATE JUNE 2024

CITY OF THORNTON

PFAS TREATMENT PROJECT

ELECTRICAL

MCC-GAC ONE-LINE DIAGRAM

VERIFY SCALES
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0 1"
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JOB NO. 202719
DRAWING NO. E02
SHEET NO. 13 OF 13

APPENDIX C

ALLOWABLE PLANTINGS LIST

CITY OF THORNTON

HYDROZONE WATER-DEMAND PLANT MATERIAL

VERY LOW WATER-DEMAND SUGGESTIONS

City of Thornton

2020

Latin Name	Common Name	Design Height x Width
SHADE TREES		
Gymnocladus dioicus	Kentucky Coffeetree	50’ x 40’
SMALL TREES		
Crataegus ambigua	Russian Hawthorn	15’ x 20’; clump, thorns
Quercus spp	Gambel, Wavyleaf	varies w/water; use B&B
Acer grandidentatum	Wasatch Maple, if grown on own roots/not grafted	20-30’ x 20-30’
EVERGREENS	**Common Name**	**Design Height x Width**
Juniperus chinensis, scopulorum, virginiana	Upright Juniper; Woodward=narrow	varies
Pinus aristata	Bristlecone Pine	20’ x 15’
Pinus edulis	Pinon Pine	10’ x 15’
Pinus ponderosa	Ponderosa Pine	40’ x 20’
SHRUBS OVER SIX FEET TALL	**Common Name** *no fabric*	**Design Height x Width**
Artemesia tridentatum	Tall Western Sagebrush	varies w/water
Caragana arborescens	Siberian Peashrub	8’ x 6’
Caragana microphylla Tidy	Tidy Peashrub (WY)	6’ x 6’
Cercocarpus ledifolius	Curlleaf Mountain Mahogany	10’ x 8’
Cercocarpus montanus	Common Mountain Mahogany	9’ x 8’
Chrysothamun (Ericameria) spp	Tall Rabbitbrush	varies w/water
Cotoneaster racemiflorus soongoricus	Sungari Cotoneaster (Wy)	7’ x’7’
Forestiera neomexicana	New Mexico Privet	8’ x 6’
Philadelphus lewisii	Cheyenne Mockorange (WY)	6’-9’ x 5’-8’
Prunus americana	American Wild Plum	9’ x 6’; plant as thicket
Rhus spp	Sumac: Staghorn, Cutleaf, Three-Leaf	varies w/water; suckers

VERY LOW WATER-DEMAND PLANT MATERIAL

Sorbaria sorbifolia	Ural False Spirea,	6’ x 5’, large arching, suckers
SHRUBS UNDER SIX FEET	**Common Name** *no fabric*	**Design Height x Width**
Amorpha nana	Dwarf Leadplant (hard to find in trade)	2’ x 2’
Atriplex canescens	Four Wing Saltbush	3’ x 3’
Ceratoides or Krascheninnikovia lanata	Winterfat	2’ x 2’
Chamaebatiaria millefolium	Fernbush (bee magnet)	5.5’ x 5.5’
Chrysothamnus (Ericameria) spp	Dwarf Rabbitbrush	2’ x 2’, seeds
Fallugia paradoxa	Apache Plume	4’ x 4’
Jamesia americana	Waxflower	3’ x 3’
Peraphyllum ramosissimum	Squaw apple	4-6’
Perovskia atriplicifolia	Russian Sage (maintenance concerns)	3’ x 3’, suckers; only w/city approval
Rhus spp	Dwarf Sumac: Gro-low, Rocky Mountain	varies w/water
Ribes aureum Gwen’s Buffalo	Gwen’s Buffalo Currant (WY)	5’ x 4’
Ribes odoratum Crandall	Crandall Clove Currant (WY)	5’ x 4’
Rubus deliciosus	Boulder Raspberry	5’ x 4’, delicate arching
PERENNIALS & GROUNDCOVERS	**Common Name** *no fabric*	**Design Height x Width**
Achillea millefolium	Western Yarrow	
Artemesia ludoviciana	Valerie Finnis Sage	2-3’
Aster	Common Blue Aster	choose native, 8-24”
Baptisia australis	False Indigo	3-4’
Berlandiera lyrata	Chocolate Flower	1’ x 1’
Callirhoe involucrata	Poppy Mallow/Wine Cups	Creeps along ground but climbs up through low shrubs
Chamerion angustifolium	Fireweed	3’ x’2’; suckers
Coreopsis tinctoria	Plains Coreopsis	1.5-2.5’

VERY LOW WATER-DEMAND PLANT MATERIAL

Echinacea purpurea	Purple Coneflower	2-3’
Gaillardia aristate	Common Gaillardia	1-2’
Helianthus helianthoides	Ox-eye Sunflower	3-5’
Helianthus maximiliani	Maximilian Sunflower	6’ x 3’, varies w/water
Ipomopsis aggregata	Scarlet Gilia	12” x 12”
Liatris punctata	Native Gayfeather	12” x 6”
Linum lewisii	Blue Flax	1’x1’
Mahonia repens	Creeping Mahonia	12-24”, evergreen ground cover w/woody stems, do not plant past June 15th
Monarda fistulosa	Native Bee-Balm	2’ x 18”
Mirabilis multiflora	Desert Four O’clock	18” x 4’ clump
Oenothera caespitosa	White Evening Primrose	6-12”
Penstemon angustifolius, P. virgatus etc.	Penstemon	choose native, 1-3’
Ratibida columnifera	Upright Prairie Coneflower	1.5-2’
Sphaeralcea munroana, S.coccinea	Globemallow	1-2’
Zinnia grandiflora	Paper Flower	6” x 6”
GRASSES *plus others*	**Common Name** *no fabric*	**Design Height x Width**
Achnatherum, Andropogon, Schizachyrium, Sorghastrum, Sporobolus, Panicum, Bouteloua spp,	Indian Rice, Big Bluestem, Little Bluestem, Indian, Giant Sacaton, Switchgrass, Blue Grama etc.	varies

CITY OF THORNTON

HYDROZONE WATER-DEMAND PLANT MATERIAL LIST

LOW WATER-DEMAND SUGGESTIONS

2020

Latin Name	Common Name	Design Height x Width
SHADE TREES		
Acer negundo 'Sensation'	Sensation Box Elder	30' x 25'
Catalpa speciosa	Western Catalpa	40' x 30'
Celtis occidentalis	Hackberry	40' x 40'
Gleditsia triancanthos inermis	Thornless Honeylocust varieties	35' x 40'
Quercus spp	Oaks: Swamp White, Bur, English, Chinkapin, Turbinella, Northern Red, Shumard, Texas Red, Crimson Spire	varies
SMALL TREES	**Common Name**	**Design Height x Width**
Acer grandidentatum	Wasatch Maple	20' x 25' clump
Acer tartaricum, A.ginnala	Tartarian, Ginnala Maple	20' x 20' clump
Crataegus spp	Hawthorn: Thornless Cockspur, Washington, Winter King	varies; thorns
Koelreuteria paniculata	Goldenrain Tree	20' x 25'
EVERGREENS	**Common Name**	**Design Height x Width**
Cupressus arizonica glabra	Arizona Cypress	30' x 20'; w/city approval
Juniperus horizontalis, sabina, cheninsis, x media	Hughes, Buffalo etc	varies, min 3-5'oc; use sparingly w/city approval
Mahonia aquifolium & M.a.'Compacta'	Oregon Grape Holly & Compact Oregon Grape Holly	2' x 2' & 4' x 3', varies w/water, spreading
Pinus flexilis	Limber Pine	25' x 20'
Pinus heldreichii (leucodermis)	Bosnian Pine	20' x 15'
Pinus mugo	Mops, Pumilo, Tannenbaum (not Big Tuna)	varies
Pinus nigra	Austrian Pine	30' x 20'
Pinus sylvestris (questionable)	Scotch Pine	30'-40' x 20'
SHRUBS OVER SIX FEET TALL	**Common Name** *no fabric*	**Design Height x Width**
Amelanchier alnifolia	Serviceberry, B&B	10' x 8'

Chaenomeles speciosa	Quince, tall	7'x7' fruiting thorns
Cornus serica Baileyi	Bailey Redtwig Dogwood	varies w/water
Cotoneaster lucidus	Peking or Hedge Cotoneaster	6' x 6'
Forsythia x intermedia	Forsythia, cold hardy varieties	8' x 8'
Hibiscus syriacus	Rose of Sharon	8' x 8'; tender; protect
Kolkwitzia amabilis	Beauty Bush	9' x 9'
Lonicera korolkowii Cheyenne Pink Velvet	Cheyenne Pink Velvet Honeysuckle (WY)	8'-10' x 8'-12'
Ligustrum vulgare 'Cheyenne'	Cheyenne Privet (WY)	8'-16' x 4'-8' hedge
Philadelphus spp	Mockorange	varies
Physocarpus opulifolius	Common Ninebark	7' x 7', check availability
Prunus tomentosa	Nanking Cherry	8' x 8'
Rhamnus frangula 'Columnaris'	Tall Hedge Buckthorn	8' x 4'
Spirea x vanhouttei	Vanhoutte Spirea	6' x 5'
Syringa hyacinthiflora	Early Lilac: Pocahontas	9' x 8'
Syringa vulgaris	Lilac varieties	9' x 8'
SHRUBS UNDER SIX FEET TALL	**Common Name** *no fabric*	**Design Height x Width**
Amelanchier alnifolia 'Regent'	Regent Serviceberry	5.5' x 5.5'
Aronia melanocarpa elata	Black Chokeberry	4' x 3'
Caryopteris x clandonensis	Blue Mist Spirea, named variety	3' x 3', maintenance
Chaenomeles japonica	Quince, Dwarf Flowering	3' x 4'
Cotoneaster divaricatus	Cotoneaster, Spreading	4' x 5'
Ligustrum vulgare 'Lodense'	Lodense Privet	3' x 2' hedge
Mahonia aquifolium & M.a.'Compacta'	Oregon Grape Holly & Compact Oregon Grape Holly	2' x 2' & 4' x 3', varies w/water, spreading
Potentilla fruticosa davurica	Prairie Snow Potentilla (WY)	2' x 5'
Potentilla fruticosa Jackman	Jackman Potentilla	3' x'3'
Philadelphus spp	Dwarf Mockorange	varies
Prunus besseyi, P.besseyi 'Pawnee Buttes'	Western Sandcherry, Pawnee Buttes Sandcherry	4' x 4'; use sparingly 2' x 3', use sparingly
Ribes alpinum	Alpine Currant	3' x 3'
Spirea spp	Spirea: Anthony Waterer,	durable, varies

	Frobel, Snowmound (v. tosaensis (WY), Threeleaf, Magic Carpet	
Symphoricarpos spp	Coralberry varieties Hancock	3' x 3' spreads 2' x 3'
Syringa meyeri or S.patula	Dwarf Lilac	4' x 4'
GRASSES *plus others*	**Common Name** *no fabric*	**Design Height x Width**
Calmagrostis acutiflora spp	Feather Reed Grass varieties	4' x 2'
Chasmanthium latifolium	Northern Sea Oats	2' x 2', seeds
Erianthus or Saccharum ravennae	Plume Grass	8' x 3'; seeds, use sparingly
Miscanthus spp	Maiden Grass varieties	varies; use sparingly w/city approval; dies out in middle
SPRING FLOWERING BULBS	**Common Name** *no fabric*	**Design Height x Width**
Allium spp	Ornamental Onion	varies, seeds, use sparingly w/city approval
Crocus, Species & Giant spp	Crocus	
Iris reticulata	Botanical Iris	especially purple/dk blue
Muscari spp	Grape Hyacinth	hardy, seeds
Tulipa spp	Species Tulip batalinii, humilis, vvedenskyi, linifolia	varies
VINES	**Common Name** *no fabric*	**Design Height x Width**
Campsis radicans	Trumpet Vine	
Clematis terniflora	Sweet Autumn Clematis	
Lonicera spp	Honeysuckle varieties	
Parthenocissus quinquefolia	Virginia Creeper	fruit is messy, seeds
Polygonum aubertii	Silverlace Vine	chain link fence cover
PERENNIALS AND GROUNDCOVERS	**Common Name** *no fabric*	
Achillea 'Moonshine'	Moonshine Yarrow	use sparingly

LOW WATER-DEMAND PLANT MATERIAL

Agastache spp	Hyssop varieties	varies
Alcea rosea	Hollyhock	5-6’ bi-annual
Asclepias tuberosa	Butterfly Weed	1.5-2.5’
Aster novi-belgii varieties	Dwarf Fall Asters	use sparingly; seeds
Centranthus ruber	Red Valerian	
Ceratostigma plumbaginoides	Plumbago	deciduous ground cover
Erigeron speciosus	Showy Fleabane	1.5-2’
Eschscholzia callifornica	California Poppy	1-2’
Euonymous fortunei ‘Coloratus’	Purpleleaf Wintercreeper	evergreen ground cover
Geranium spp	Perennial Geranium (G.Rozanne, G.sanguineuum, G.Bevan)	Rozanne=long bloomer
Hemerocallis spp	Daylily: Happy Returns yellow short; Rocket City orange tall	
Iris	Bearded Iris	varies
Knautia macedonica	Knautia	2-2.5’, seeds
Kniphofia spp	Red Hot Poker	varies; dwarf doesn’t flop
Liatris	Liatris, garden variety	18”x18”
Monarda	Bee-Balm, garden variety	2’x18”
Nepeta spp	Catmint	varies, seeds; use sparingly
Penstemon spp	Penstemon	Varies
Pulsatilla vulgaris	Pasqueflower	6-12”
Saponaria ocymoides	Rock Soapwort	6-12”, seeds
Scabiosa spp	Pincushion flower	varies, seeds
Solidago spp	Goldenrod	varies
Thermopsis divaricarpa	Golden Banner	8-12”, spreads underground
Vinca minor	Periwinkle	evergreen ground cover
Zauschneria (Epilobium) spp	Hummingbird Plant	

CITY OF THORNTON

HYDROZONE WATER-DEMAND PLANT MATERIAL LIST

MODERATE WATER-DEMAND SUGGESTIONS

2020

Latin Name	Common Name	Design Height x Width
SHADE TREES		
Acer spp	A.saccharum John Pair Caddo, Fall Fiesta, Green Mountain	30'-40' x 40', not within 15' BOC
Quercus spp	Oaks: Heritage	50' x 30'
Tilia spp	Linden: Littleleaf, American	30'-40' x 25'-35'
Ulmus spp	Accolade, or other city/CSU approved cultivars	45' x 40'
SMALL TREES	**Common Name**	**Design Height x Width**
Acer ginnala	Ginnala Maple	15' x 15' clump
Amelanchier grandiflora	Serviceberry	15'-15', choose clump
Betula fontinalis	Native River Birch	15' x 10' clump
Malus spp (use CSU disease resistant)	Crabapple	varies
Pyrus spp	Ornamental varieties	20' x 15'
Sophora (Styphnolobium) jabonica	Japanese Pagoda Tree	40' x 40'
Syringa x chinensis or reticulata	Chinese or Japanese Tree Lilac	20' x 15'
EVERGREENS	**Common Name**	**Design Height x Width**
Abies concolor	Concolor Fir	40' x 20'
Dwarf Evergreens	Many varieties	varies
Picea pungens	Colorado Spruce	40' x 20'
SHRUBS OVER SIX FEET TALL	**Common Name** *no fabric*	**Design Height x Width**
Aronia x prunifolia	Purple Chokeberry	9' x 7'
Cornus spp	Dogwoods	varies w/water
Euonymous alatus	Burning Bush	9' x 9'
Rosa spp	Roses grown on their own roots	varies
Viburnum spp	Viburnum: Alleghany, BlackHaw, Arrowwood; Burkwood etc	varies

MODERATE WATER-DEMAND PLANT MATERIAL

City of Thornton
2020

SHRUBS UNDER SIX FEET TALL	**Common Name** *no fabric*	**Design Height x Width**
Cornus stolonifera Farrow	Arctic Fire Red Twig Dogwood	4' x4'
Euonymous spp fortunei	E.fortunei shrub form, E.alatus compacta	varies
Rosa spp	Roses grown on their own roots	varies
Viburnum spp	Viburnum: Dwarf European; Koreanspice etc.	varies
BULBS	**Common Name** *no fabric*	
Chionodoxa, Colchicum, Daffodils, Large Flowered Tulips		
PERENNIALS AND GROUNDCOVERS	**Common Name** *no fabric*	
Anemone vitifolia 'Robustissima'	Fall Grape-leaf Anemone	
Campanula	Harebell C.carpatica Bellflower C.persicifolia, C. glomerta	
Galium odorata	Sweet Woodruff	deciduous ground cover; aggressive spreader with water
Rudbeckia fulgida 'Goldstrum'	Black-eyed Susan	