Town of Berthoud

Water and Wastewater Master Plan

Tetra Tech Project #200-314530-22001

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PREPARED FOR

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Acronyms/Abbreviations

Acronyms/Abbreviations	Definition
AACE	American Association of Cost Engineers (AKA Association for the Advancement of Cost Engineering)
ABAC	Ammonia-based Aeration Control
AE	Administrative Extension
AF	Acre-Feet
ADD	Average Daily Demand (annual average)
ADF	Average Daily Flow (annual average)
AFF	Available Fire Flow
AL	Action Level
ANA	Anaerobic and Anoxic
AWWA	American Water Works Association
Bio-P	Biological Phosphorus Uptake
BNR	Biological Nutrient Removal
BOD	Biochemical Oxygen Demand
BOD_5	5-Day Biochemical Oxygen Demand
BPS	Booster Pump Station
C-BT	Colorado-Big Thompson
CCPP	Calcium Carbonate Precipitation Potential
CCR	Consumer Confidence Report
Chemical-P	Chemical Phosphorus Precipitation
CIP	Cast Iron Pipe
CIP	Capital Improvement Plan
CDO	Colorado Demography Office
CDPHE	Colorado Department of Public Health and Environment
CDPS	Colorado Discharge Permit System
CoF	Consequence of Failure
CT	Disinfectant Residual Concentration (C) times Effective Contact Time (T)
DBPs	Disinfection Byproducts
d/D	Ratio of depth of flow to pipe diameter
DON	Dissolved Organic Nitrogen
EPA	Environmental Protection Agency
EQ	Equalization
FFD	Fire Flow Demand
FOG	Fats, Oils and Grease
FRP	Fiber-reinforced Polymer
gpcd	Gallons per Capita per Day
GPD	Gallons per Day
gpm	Gallons per Minute
GT	Mixing Energy x Detention Time
GWUDI	Groundwater under the Direct Influence of Surface Water

Acronyms/Abbreviations	Definition
HAA5	Haloacetic Acids
HDPE	High-Density Polyethylene
HDXLPE	High-density Cross-linked Polyethylene
hp	Horsepower
HSP	High Service Pump
HSPS	High Service Pump Station
I/I	Infiltration and Inflow
I-25	Interstate 25
ICEAS	Intermittent Cycle Extended Aeration Activated Sludge
ICS	Industrial Control Systems
IFAS	Integrated Fixed Film Activated Sludge
IPP	Industrial Pretreatment Program
ISDS	Individual Sewage Disposal System
LCRR	Lead and Copper Rule Revisions
LLWL	Low Low Water Level
LoF	Likelihood of Failure
LOT	Limit of Technology
LT1ESWTR	Long Term 1 Enhanced Surface Water Treatment Rule
LT2ESWTR	Long Term 2 Enhanced Surface Water Treatment Rule
LTR	Little Thompson River
LTWD	Little Thompson Water District
MBBR	Moving bed bioreactor
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MDD	Maximum Daily Demand
MG	Million Gallons
MGD	Million Gallons per Day
MHD	Minimum Hour Demand
MMF	Maximum Month Flow
MLE	Modified Ludzack-Ettinger (activated sludge process)
MLR	Mixed Liquor Recycle
NFRWQPA	North Front Range Water Quality Planning Association
Northern Water	Northern Colorado Water Conservancy District
NPDES	National Pollutant Discharge Elimination System
O&M	Operation and Maintenance
OCCT	Optimal Corrosion Control Treatment
OPCC	Opinion of Probable Construction Cost
PAC	Powder Activated Carbon
PAO	Phosphorous Accumulating Organism
PD	Potentially Dissolved
PDF	Peak Daily Flow

Acronyms/Abbreviations	Definition
PF	Peaking Factor
PHD	Peak Hour Demand
PHF	Peak Hour Flow
PLC	Programmable Logic Controller
ppd	Pounds per Day
PRV	Pressure Regulating Valve
Q	Influent Flow
RAS	Return Activated Sludge
RGRC	Ryan Gulch Reservoir Company
RO	Reverse Osmosis
RTU	Remote Terminal Unit
SBR	Sequencing Batch Reactor
SCADA	Supervisory Control and Data Acquisition
SCD	Schedule Compliance Delay
SFE	Single-Family Equivalent
SMCL	Secondary Maximum Contaminant Level
SOC	Synthetic Organic Compound
SRT	Solids Retention Time
SU	Standard Units
SVI	Sludge Volume Index
SWTR	Surface Water Treatment Rule
TDH	Total Dynamic Head
TIN	Total Inorganic Nitrogen
TN	Total Nitrogen
T&O	Taste and Odor
Town; Berthoud	Town of Berthoud
TP	Total Phosphorus
TR	Total Recoverable
TRC	Total Residual Chlorine
TSS	Total Suspended Solids
TTHM	Total Trihalomethanes
UV	Ultraviolet
VFAs	Volatile Fatty Acids
VFD	Variable Frequency Drive
VIP	CDPHE Voluntary Nutrient Incentive Program
VOC	Volatile Organic Compound
WAS	Waste Activated Sludge
WD	Water Distribution
WQA	Water Quality Assessment
WQBEL	Water Quality Based Effluent Limit
WQCC	Water Quality Control Commission
WQCD	Water Quality Control Division

Acronyms/Abbreviations	Definition
WRF	Water Reclamation Facility
WTP	Water Treatment Plant
WWTF	Wastewater Treatment Facility

1. EXECUTIVE SUMMARY

The Water and Wastewater Master Plan proposes Capital Improvement Plan (CIP) projects between 2023 and 2043 for both water and wastewater infrastructure through the lenses of project specific scope, budget and implementation. This executive summary defines evaluations performed for the Town of Berthoud Water and Wastewater Master Plan and how the results inform the 20-year CIP development.

1.1 Population Projections

Population projections over the 20-year timeline of this master plan provided a basis for identifying and quantifying CIP projects. The Town of Berthoud service area population for 2021 is reported as 11,062 residents per the latest 2021 Colorado Demography Office (CDO) census data.

Two different population projections were developed: one for the collection and distribution infrastructure, and another for the treatment plant infrastructure. This decoupling allowed for below-grade collection/distribution infrastructure sizing that better accommodates projected build-out conditions and does not require near or mid-term pipeline upsizing or parallel line installations. When evaluating treatment plant improvements, however, a population projection was developed to support a phased, economical approach to treatment capacity expansion preventing unused, excess capacity at the treatment plants prior to reaching build out conditions. The population projections are shown in Figure 1-1. The projections specify the following 2043 population estimates for the 20-year master planning horizon:

- Collection/Distribution Systems: 66,516 residents
- Treatment Plants: 26,216 residents

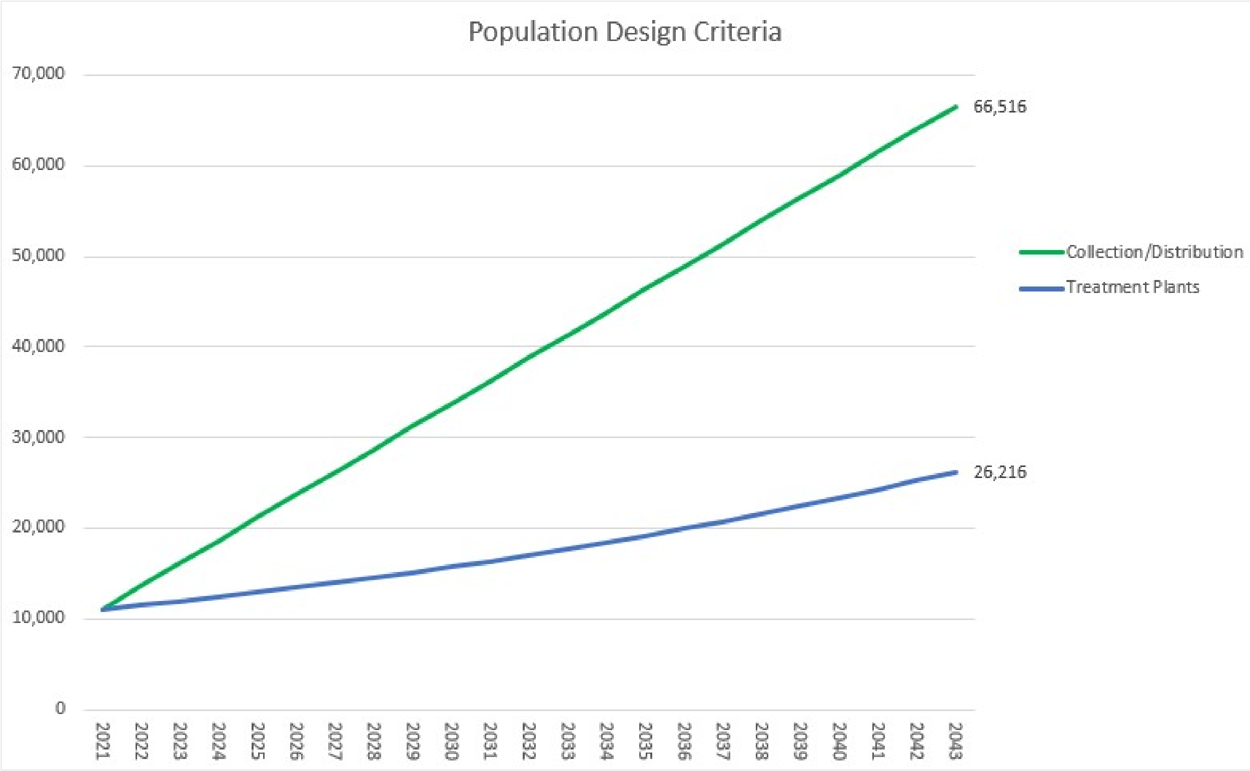

Figure 1-1: Population Projection

1.2 Flow Projections

Service area population projections were used in anticipating future wastewater flows and potable water demand. These flow forecasts are summarized below.

1.2.1 Water Demand Projections

Based on existing flow data and projected future high-density housing, a conservative estimate of 140 gallons per capita per day (gpcd) is assumed for the Average Day Demand (ADD) flows. Population projections differ when evaluating the distribution system and treatment plant systems, which results in different projected flow rates for the purpose of capital planning. The projected flow demands are summarized in Table 1-1. The Maximum Day Demand (MDD) and Peak Hour Demand (PHD) projections utilized the same peaking factors as the existing 2021 data represented.

Table 1-1: Existing Water Demand Summary

		ORIGINAL		REDUCED	
	Existing	Distribution	Plant	Distribution	Plant
Category	2021	2043	2043	2043	2043
Population	11,062	66,516	26,216	66,516	26,216
ADD (MGD)	1.63	9.41	3.67	7.68	3.00
MDD (MGD)	3.59	20.70	8.07	16.90	6.59
PHD (MGD)	6.71	38.68	15.08	31.58	12.31
MDD/ADD Ratio	2.20	2.20	2.20	2.20	2.20
PHD/ADD Ratio	4.11	4.11	4.11	4.11	4.11

1.2.2 Wastewater Flow Projections

Flow meters were placed in the collection system to measure wastewater flows throughout the Town's collection system. This data was used in conjunction with the WRF influent flow rate measurements to establish a baseline existing condition. Based on this data and the peaking factors under the existing condition, future flows were projected for new developments throughout the Town. Each flow meter sewershed was individually calculated where there were new developments scheduled in the 20-year horizon. Each new single-family equivalent (SFE) home in the 20-year planning horizon was assumed to house 2.6 persons per year at 95 gpcd. Based on location and size of the new developments, the sewer flows were added to the system in the hydraulic model in that geographic location. Table 1-2 summarizes the proposed flows and peaking factors through 2043 for the Berthoud Water Reclamation Facility (WRF) and Regional Wastewater Treatment Facility (WWTF).

Table 1-2: Proposed Wastewater Treatment Flows Summary

Category	Berthoud WRF		Regional WWTF	
	2033	2043	2033	2043
Population	17,543	24,347	168	1,869
ADF (MGD)	1.42	2.0	0.016	0.178
MMF (MGD)	2.17	3.06	0.033	0.362
MDF (MGD)	2.67	3.77	0.040	0.446
PHF (MGD)	4.25	6.0	0.064	0.7103
MMF : ADF	1.53		2.04	
MDF : ADF	1.89		2.51	
PHF : ADF	3.00		4.00	

1.3 Water CIP Plan

The Water CIP was developed by evaluating several factors including individual process performance evaluations, existing and future regulatory posture assessments, site inspections, condition assessments, hydraulic modeling assessments, and coordination with the Town, maintenance staff, and other hired consultants. This CIP Plan includes upgrades to the existing WTP, a new WTP and upgrades to the distribution system, consisting of water mains, a storage tank, and a booster pump station.

1.3.1 Project Drivers

The project drivers and findings are summarized in the following sections.

1.3.1.1 Water Source Evaluation

Meetings were held with the Town, water rights lawyers, and consultants to identify potential future water sources to meet the demand quantities. The water sources chosen will dictate location and processes of treatment infrastructure required in the future. The most likely future water sources were identified as groundwater originating from the South Platte River and Little Thompson River which would be accessed on the east end of Town near I-25. This water source would likely require reverse osmosis (RO) filtration (or equivalent) due to the anticipated brackish quality. The Town is investigating the potential to source additional water from Handy Ditch and Carter Lake. The existing WTP is able accommodate a capacity upgrade of 1 MGD. The Town's existing water sources are summarized in Table 1-2.

Table 1-3: Existing Raw Water Source Yields

Raw Water Source	Number of Units	Dry Year Yield (AF/Year)
Big Thompson River Priority No. 1	-	1,822.6
C-BT	1,088	652.8
Handy Ditch Company	40.33	261.0
Windy Gap	8	0.0
	Total:	**2,585.5**

The anticipated future raw water source yields are summarized in Table 1-4.

Table 1-4: Future Raw Water Source Yields

Raw Water Source	Water Treatment Plant	AADD Flow (MGD)	MDD Flow (MGD)
Big Thompson River Priority No. 1	Berthoud WTP (Existing)	1.91	4.0
C-BT			
Handy Ditch Company			
Windy Gap			
South Platte	New WTP	1.82	4.0
Little Thompson			
	Total:	**3.73**	**8.0**

1.3.1.2 Process Capacity Evaluation

The Berthoud WTP equipment was analyzed and summarized in inventory tables. The existing equipment was evaluated against existing flows, loadings and standard design criteria to verify proper sizing. The infrastructure was also evaluated for future flow demands and loadings to identify if upgrades would be required within the 20-year horizon.

Based on the rated capacity of the WTP and potential future water sources, installation of additional high-service pumps is the priority project to achieve the 4.0 MGD firm capacity.

1.3.1.3 Regulatory Assessment

The WTP is not presently in violation of any compliance provisions based on the Town of Berthoud 2022 Drinking Water Quality Report. The treatment capabilities of the WTP were evaluated for conformance with both existing and anticipated future regulatory requirements. Two upcoming regulations that may pose a challenge for the WTP are regarding PFAS and phosphate-based corrosion control. PFAS regulations have not yet been announced, but it is likely that six new MCLs will come into effect, which could require additional treatment. It is unknown if or when regulations for phosphate-based corrosion control will be implemented by the EPA, but this would likewise require additional efforts form the Town to maintain compliance.

1.3.1.4 Condition Assessment

A condition and risk assessment was performed for the water treatment and distribution system equipment under Town ownership. This assessment identified failure scenarios and their likelihood of occurrence (LoF); the consequence of failure of a unit process (CoF); and the resulting risk score (LoF x CoF). The derived risk scores have been used as a driver for prioritization of capital improvement projects. The consequences, likelihoods and risks for unit processes at the Berthoud WTP and throughout the distribution system are presented in Table 1-5.

Table 1-5: Berthoud WTP and Distribution System Asset Risk Assessment Summary

Unit Process	Consequence of Failure	Likelihood of Failure	Risk Score
Carter Lake Water Supply	15	Unlikely	30
Other Raw Water Supply	26	Unlikely	52
Blending Facility/Corrosion Control	12	Possible	36
Rapid Mixing	13	Possible	39
Flocculation	18	Possible	54
Sedimentation	20	Possible	60
Filtration	20	Possible	60
Disinfection	20	Possible	60
High-service Pumps	21	Possible	63
Caustic Soda Storage/Feed Systems	13	Possible	39
PAC Storage/Feed Systems	13	Possible	39
Polymer Storage/Feed Systems	18	Possible	54
Sodium Hypo Storage/Feed Systems	19	Possible	57
SCADA Systems	14	Possible	42
Cybersecurity	29	Possible	87
Elevated Storage Tank	12	Unlikely	24
3.0 MG Storage Tank	26	Unlikely	52
Booster Pump Station	19	Unlikely	38

1.3.1.5 Hydraulic Evaluations

Hydraulic evaluations were performed for the entire water system, including the Berthoud WTP and distribution system. A proprietary hydraulic profile calculation spreadsheet was used to calculate the hydraulic profile through the WTP, with the intent of identifying any hydraulic bottlenecks or restrictions within the system. The calculated hydraulic profile of the WTP is shown in Figure 1-2, which depicts hydraulically critical elements in the system under existing ADD (2.2 MGD), existing PHD (3.8 MGD), future PHD (4.2 MGD), and the proposed WTP expansion to 5.2 MGD. It should be noted that the plant needs to accommodate 4.2 MGD (existing capacity) and 5.2 MGD (future capacity) for a full throughput capacity due to treatment losses, primarily backwash waste. It was found that a majority of headloss through the plant occurs in the 14-inch pipe between the sedimentation basin and the filters as well as through the filters themselves. This can be mitigated by upsizing the 14-inch pipe and changes to the operating procedures of the filters.

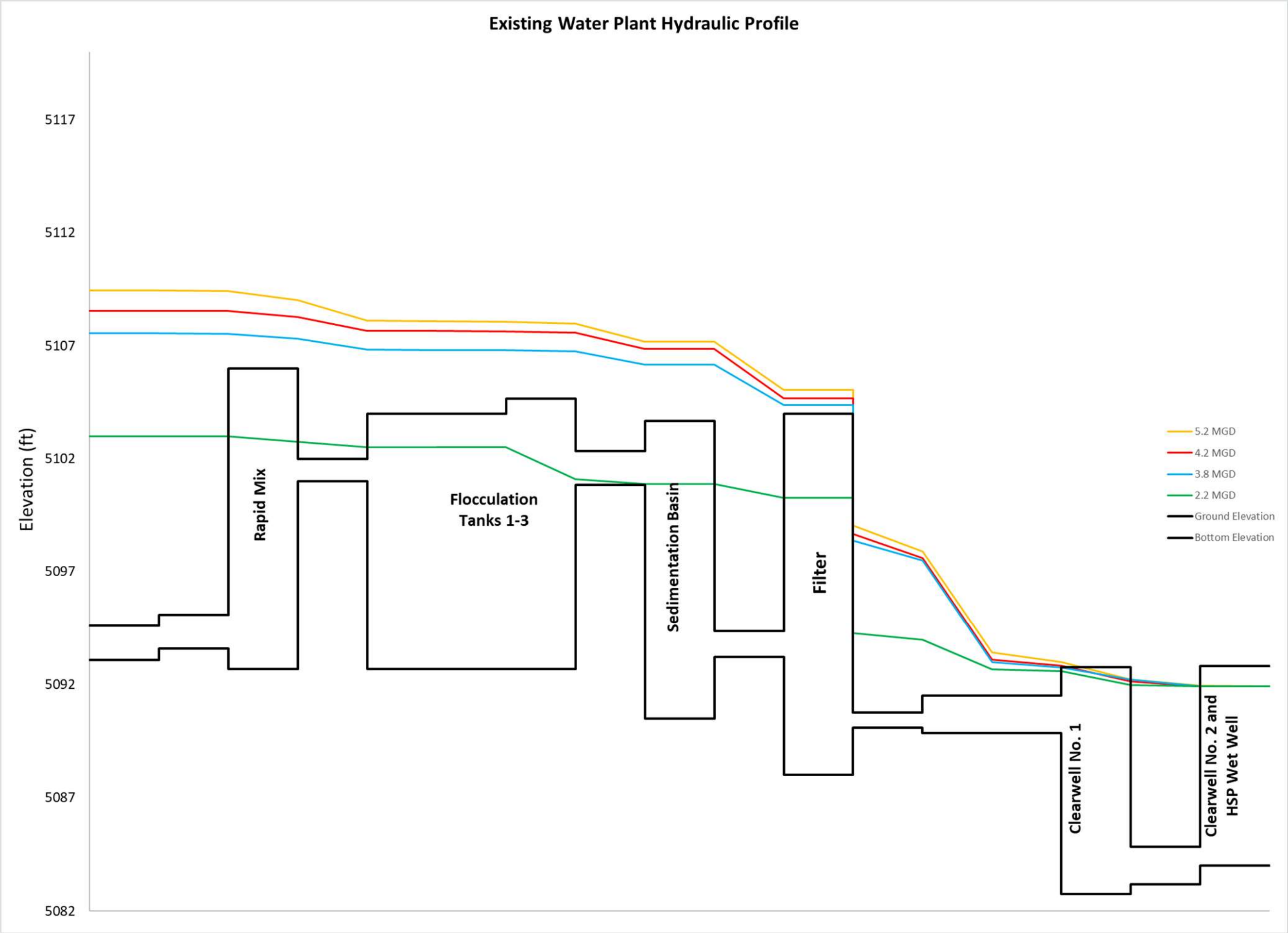

Figure 1-2: WTP Hydraulic Profile

InfoWater was utilized to run a thorough analysis on system-wide distribution system demands in the existing and future scenarios. For the water system, the most critical factors in identifying overall distribution system health are headloss and pressure. The existing distribution system was analyzed for existing demands, 5-year demands, and 20-year demands. The future 20-year demand system pressure and headloss are shown in Figure 1-3 and Figure 1-4, respectively. These figures are the primary driver for identifying new distribution system projects.

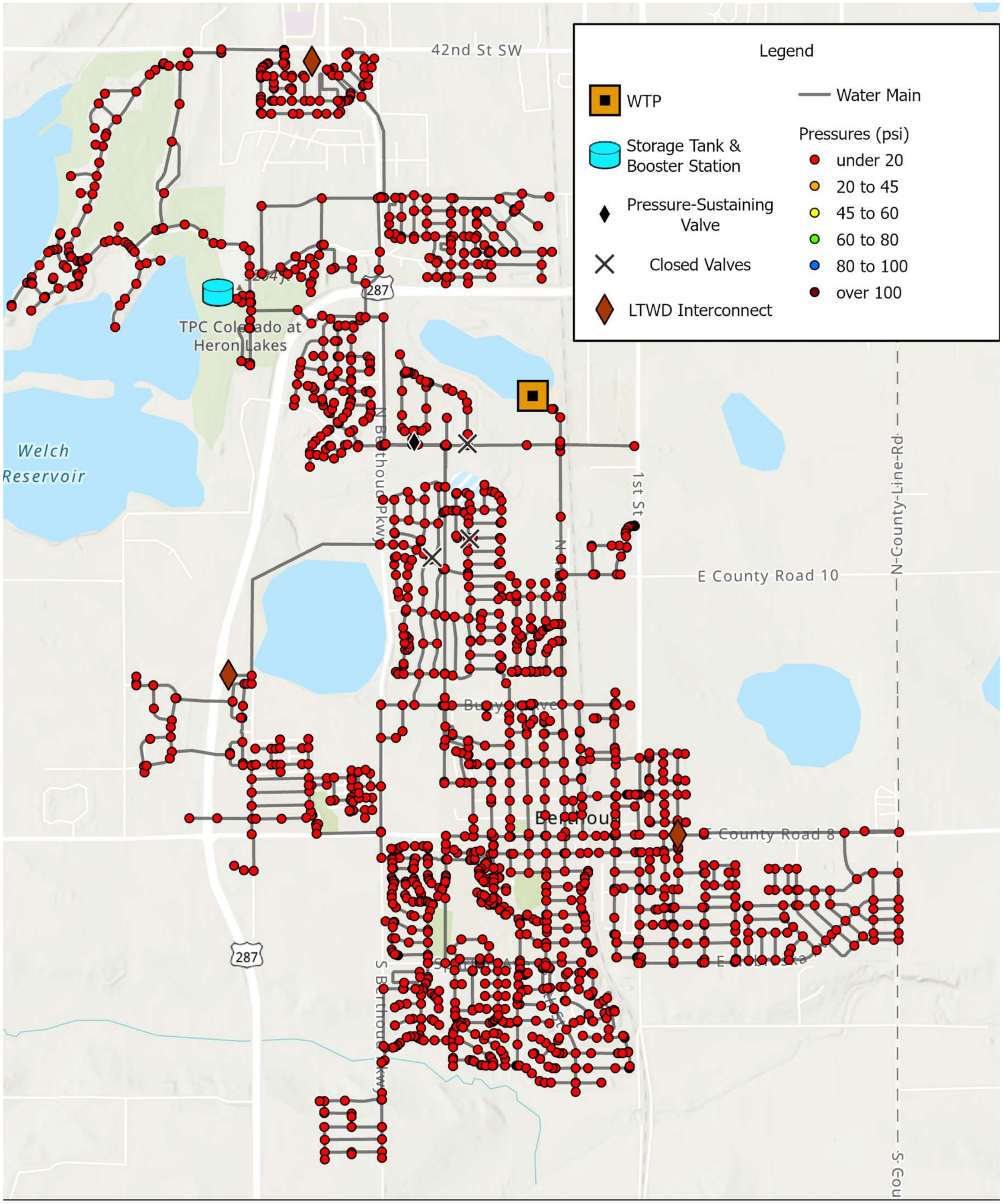

Figure 1-3: Scenario 5 | 20-Year Projection, Peak Hour Demand, Minimum Pressures

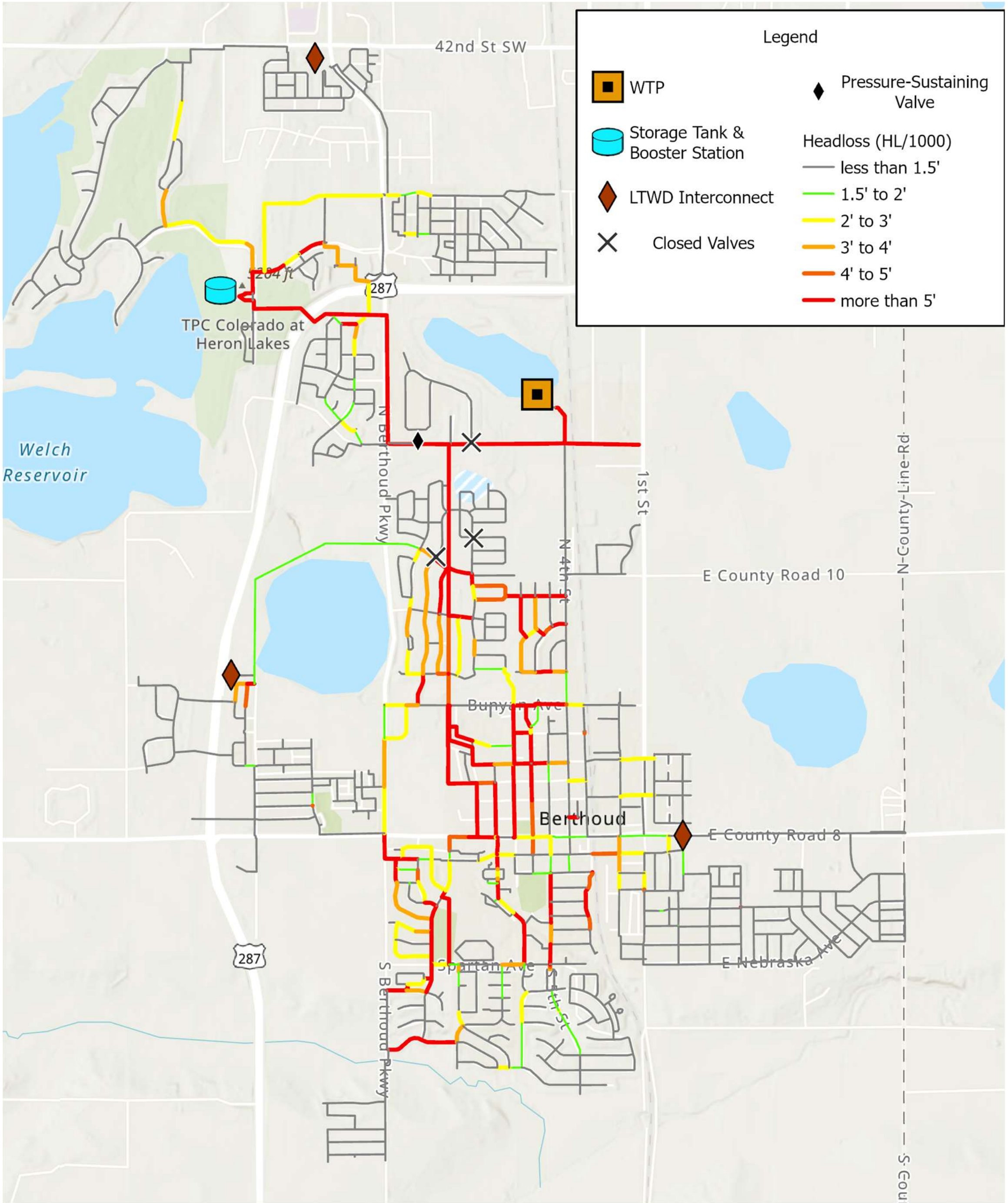

Figure 1-4: Scenario 5 | 20-Year Projection, Peak Hour Demand, Headlosses

Overall, the existing water distribution system is in good condition. Improvements to the system will be required to meet the pressure and headloss requirements for future demands.

1.3.2 Distribution System CIP Projects

The distribution system CIP projects were primarily identified by hydraulic assessments of the system. Condition assessments were also completed for the booster pump station, and storage tank which drove the addition of CIP. The distribution projects and project IDs are summarized in Table 1-6 and Figure 1-5. Water distribution CIP projects have a prefix of "WD" to denote "Water Distribution".

Table 1-6: Water Distribution System CIP Projects

CIP Project #	Name	Length (ft)	Proposed Diameter
WD-1	Bacon Lake Transmission Main, Phase 1	9,390	12" – 30"
WD-2	Bacon Lake Transmission Main, Phase 2	6,290	12" – 16"
WD-3	West BPS Transmission Main	870	16" - 20"
WD-4	West BPS Upgrade, Phase 1	-	-
WD-5	West Tank Low Pressure Zone Transmission Main	7,770	16"
WD-6	Berthoud Parkway Transmission Main	11,450	16" - 20"
WD-7	BPS Upgrade, Phase 2	-	-
WD-8	East Zone Storage Tank and Pump Station	-	-
WD-9	CR 44 Transmission Main, Phase 1	7,800	24"
WD-10	Serenity Ridge Connection	6,180	12"
WD-11	CR 44 Transmission Main, Phase 2	18,350	24"
WD-12	PLC & Telemetry Upgrades	-	-

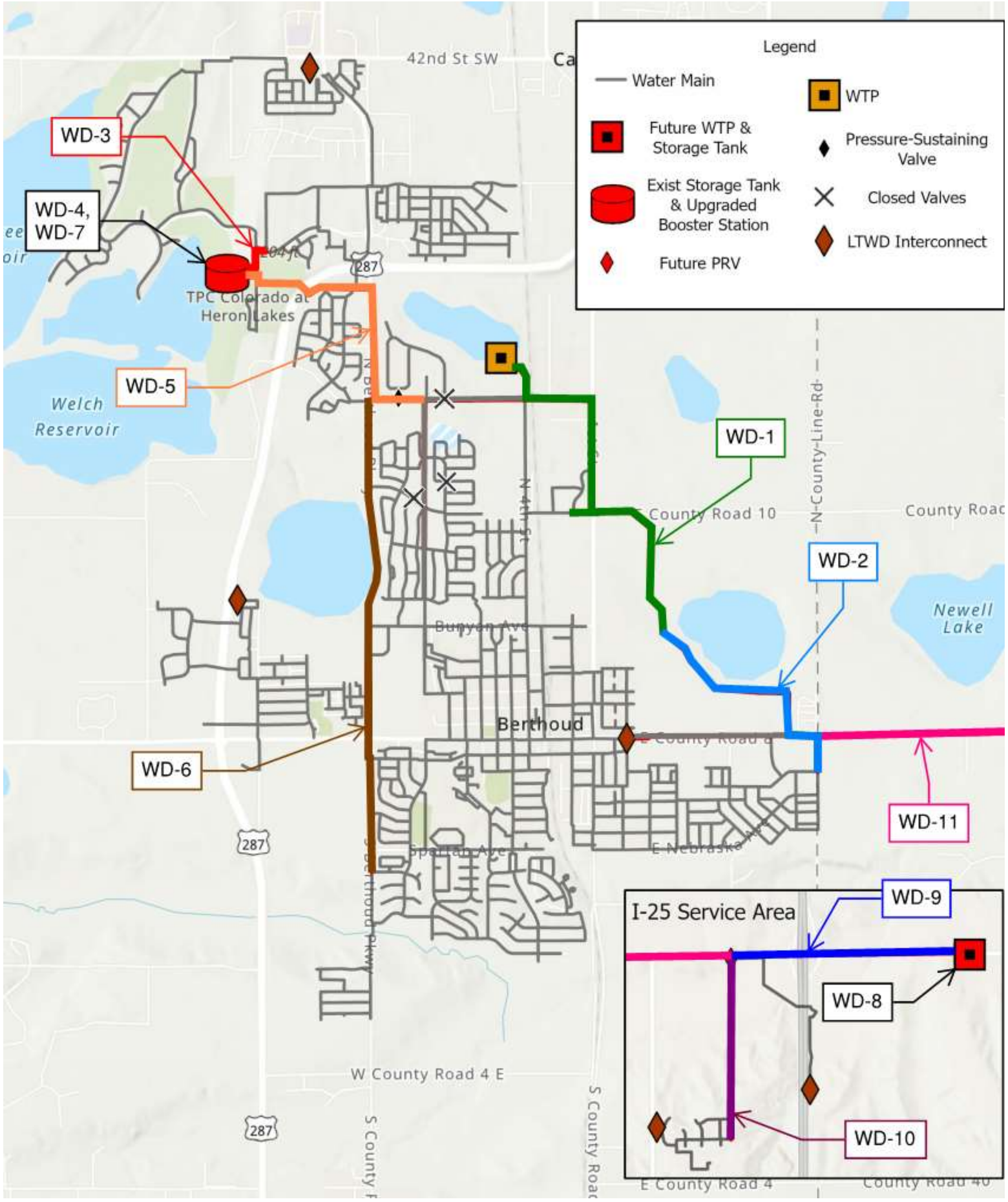

Figure 1-5: Distribution System CIP Projects

1.3.3 Water Treatment CIP Projects

The Town of Berthoud service area population growth and demand projections were considered in development of the Water Plan and recommended 20-year CIP. The Town of Berthoud service area primarily consists of residential demands, with few commercial and industrial users by comparison. Availability of raw water supplies to meet the demands of the service area and anticipated future growth is the key driver for CIP. Through coordination with the Town and water rights consultants it was determined that the best location to access water rights is near I-25 through the South Platte and Little Thompson systems. The location of future development was accounted for when evaluating if a capacity upgrade is required at the existing plant or if a secondary water plant should be constructed closer to the South Platte and Little Thompson water supplies. Based on projected population growth and location of future developments, maximum treatment capacity of the existing plant will be

5.0 MGD, and a new water treatment facility will be constructed with 1.6 MGD capacity, each in the 20-year planning horizon.

Development of the CIP for the Town's water treatment system was based on unit process performance and capacity, existing and regulatory assessments, and regulatory and industry standards. Existing instrumentation and controls and cybersecurity were also considered. Predicted regulatory and subsequent compliance timing was considered and discussed with respect to the existing plant's compliance status.

Water treatment CIP projects have a prefix of "WTP" to denote "Water Treatment Plant".

1.3.4 Project Timeline and Cost Breakdown

The proposed 20-Year Prioritized Plan is driven primarily by plant capacity requirements, which are dependent on development in the Berthoud service area. If the rate of actual development does not align with that predicted in this Master Plan, Berthoud should reevaluate project sequencing. Each project description contains an explanation of drivers so the Town can readjust timing based on these thresholds for demand.

Figure 1-6 illustrates the annual CIP expenditures for the wastewater system. Class V cost opinions for each project described above can be found in **Appendix C**.

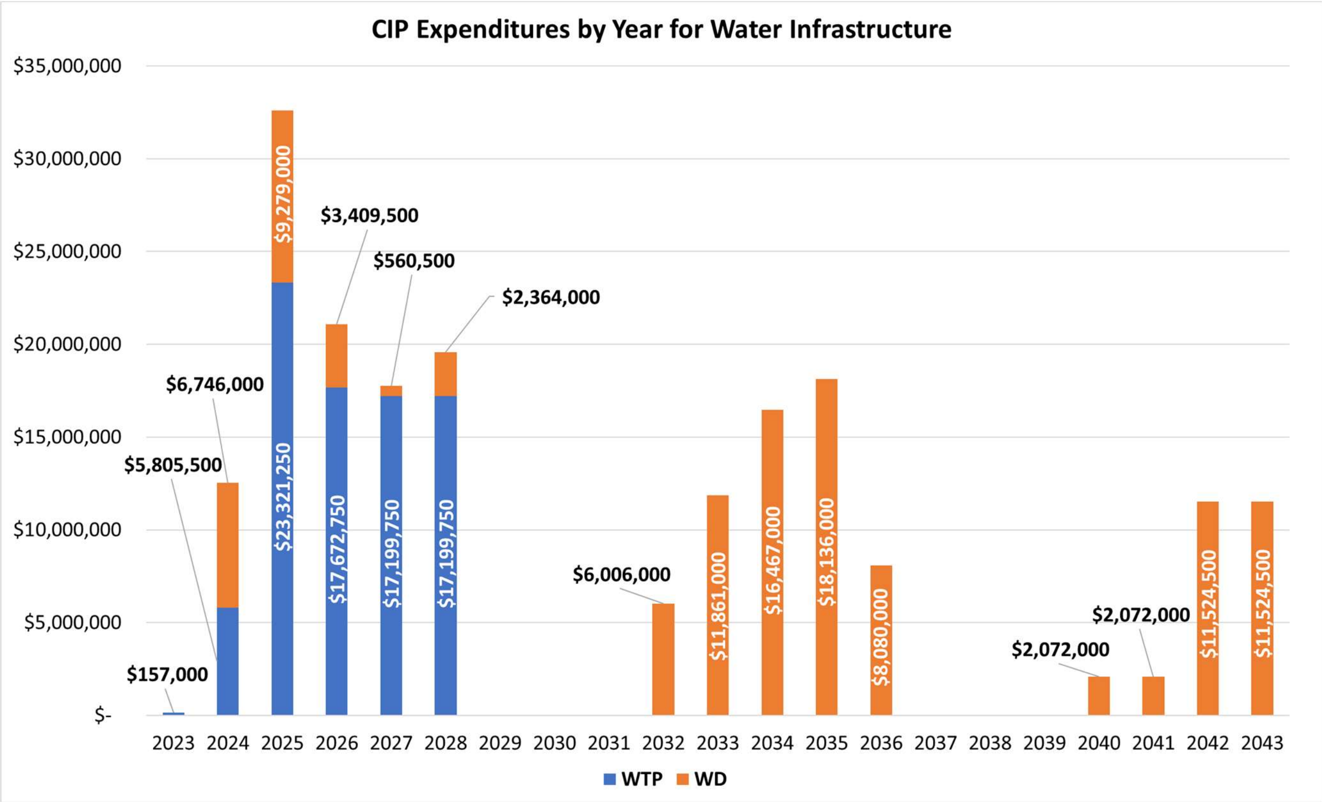

Figure 1-6: 20-Year Prioritized Plan Expenditures by Year for Water Infrastructure

Figure 1-7 shows the sequenced implementation schedule timeline for water infrastructure in the 20-year prioritized plan.

Proposed Capital Improvement Projects	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Water Treatment Plants																					
WTP-1: High Service Pump Capacity Increase																					
Planning, Financing and Design	■																				
Construction, Startup and Optimization	■	■																			
WTP-2: Filtration System Improvements																					
Planning, Financing and Design		■																			
Construction, Startup and Optimization		■	■																		
WTP-3: Berthoud WTP Expansion to 5.0 MGD																					
Planning, Financing and Design		■																			
Construction, Startup and Optimization		■	■																		
WTP-4: Chemical Storage and Feed System Improvements																					
Planning, Financing and Design			■																		
Construction, Startup and Optimization				■																	
WTP-5: Pretreatment Improvements																					
Planning, Financing and Design			■																		
Construction, Startup and Optimization				■																	
WTP-6: I-25 RO WTP and HSPS																					
Planning, Financing and Design			■	■																	
Construction, Startup and Optimization					■	■															
WTP-7: Network and Cybersecurity Updates																					
Planning, Financing and Design	■																				
Construction, Startup and Optimization	■	■																			
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WD-1: Bacon Lake Transmission Main, Phase 1																					
Planning, Financing and Design		■																			
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Planning, Financing and Design			■																		
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Planning, Financing and Design																				■	
Construction and Startup																					■
WD-12: PLC & Telemetry Upgrades																					
Planning, Financing and Design		■																			
Construction and Startup		■																			

Figure 1-7: Water 20-Year Prioritized Plan Implementation Schedule Timeline

1.4 Wastewater CIP Plan

The Wastewater CIP was developed by considering several factors including individual process performance, existing and future regulatory compliance, site visit inspections, condition assessments, hydraulic modeling assessments, capacity assessments and coordination with the Town and maintenance staff. This CIP Plan includes upgrades to the Berthoud Water Reclamation Facility (WRF), the Regional Wastewater Treatment Facility (WWTF), and the wastewater collection system infrastructure.

1.4.1 Project Drivers

The project drivers and findings are summarized in the following sections.

1.4.1.1 Process Capacity Evaluation

Capacity staging for the Berthoud WRF was an important aspect of the Wastewater Plan that driving CIP project development and prioritization for the plant. Capacity staging considered projected flows and loads for the Berthoud WRF based on predicted population growth and development in the service area. The Colorado Department of Public Health and Environment (CDPHE) requires the Town to begin planning for capacity expansions when flows reach 80% of rated capacity, and construction should be completed when flows reached 95% of rated capacity.

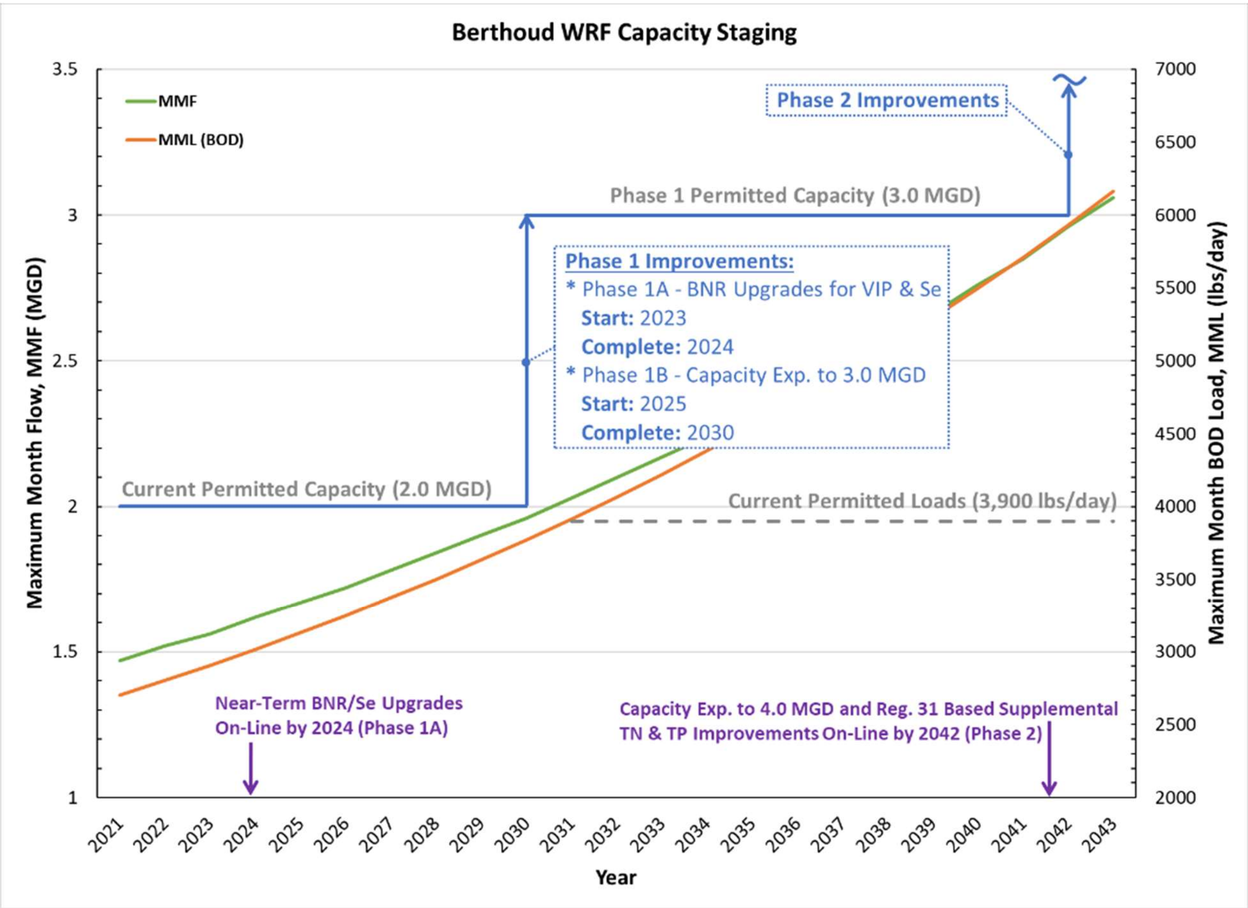


Figure 1-8: Berthoud WRF Capacity Staging Graph

Figure 1-9Error! Reference source not found. presents a suggested phasing plan for adding capacity and additional Biological Nutrient Removal (BNR) improvements at the Berthoud WRF. The principal goal of Phase 1A (WRF-1) is to improve BNR treatment to maximize the length of Regulation 31-based compliance schedule extension credits before the Voluntary Nutrient Incentive Program (VIP) ends (2027). Enhanced selenium removal is a companion goal the Phase 1A project. The Phase 1B (WRF-2) expansion to 3.0 MGD will also include the same BNR upgrades selected for the existing two, 1.0-MGD maximum month flow trains. The Phase 2 Improvements (WRF-3) will (1) expand maximum month flow and associated BOD load capacity to 4.0 MGD and (2) add supplemental Total Nitrogen (TN) and Total Phosphorous (TP) removal facilities to meet Regulation 31-based, in-stream numeric nutrient standards for the Little Thompson River.

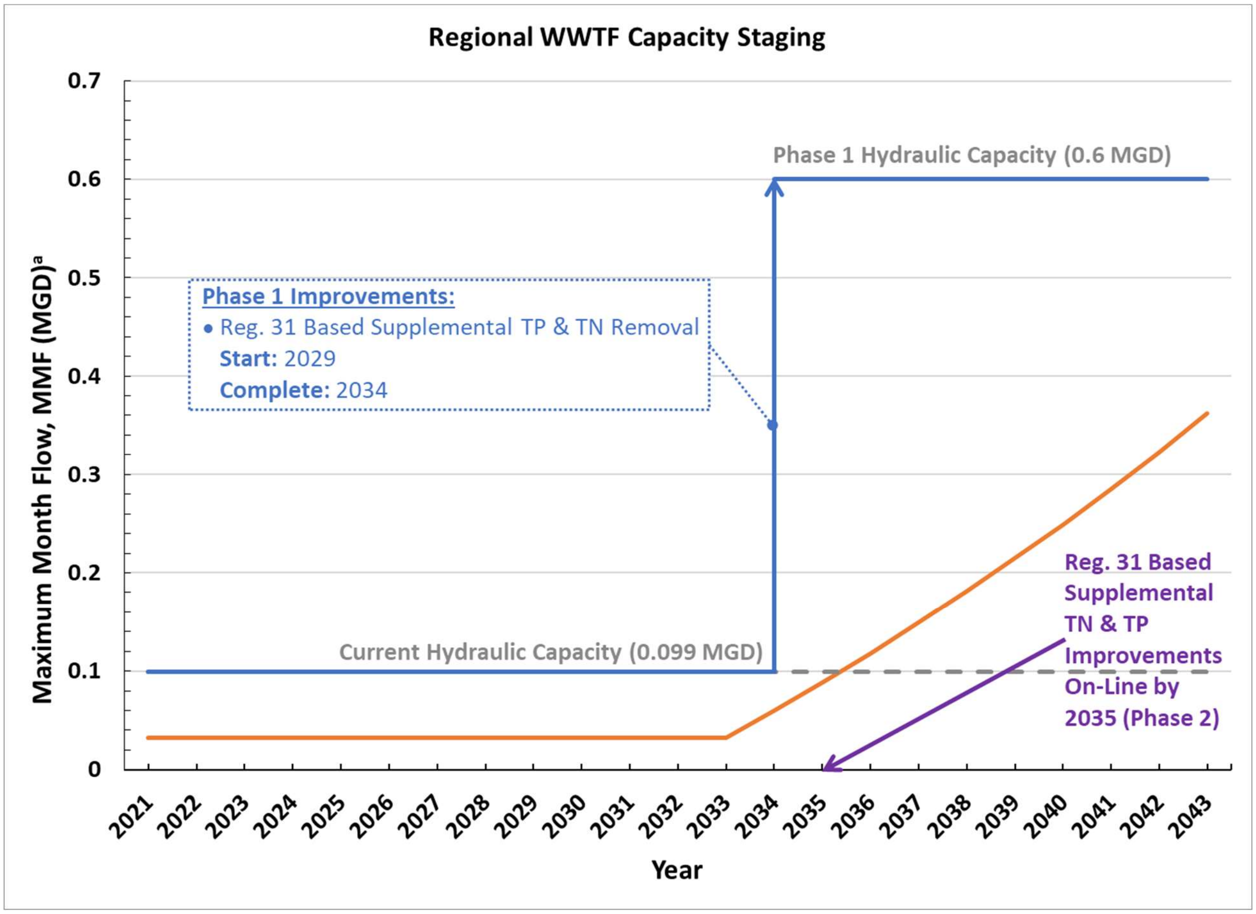


Figure 1-9: Regional WWTF Capacity Staging Graph

The Regional WWTF will also require capacity upgrades as growth occurs near I-25. Error! Reference source not found. presents a potential phasing plan for adding capacity and additional BNR improvements at Regional WWTF. The graph was prepared assuming that 20% of the total growth in the Town would occur around the Highway 56 and I-25 interchange. It further assumes that construction of additional residential and commercial properties will create an appreciable increase in flow to the WWTF beginning in 2033. The goal of Phase 1 (WWTF-1) is to increase the MMF and associated BOD load capacity to 0.6 MGD using the same BNR and Chemical-P removal technology currently employed at the Regional WWTF. An incremental increase to 0.6 MGD will provide sufficient capacity through the planning period, assuming development does not start discharging until 2033. The timing of Phase 1 is dependent on Turion and thus changes to development plans will alter the above project sequencing. The Phase 2 (WWTF-2) project objective is to bring Regulation 31-based TN and TP improvements online by 2035, so

Regional WWTF may be fully operational when Regulation 31 TP and TN limits are expected to be effective in 2036.

1.4.1.2 Regulatory Assessment

The Berthoud WRF is currently rated for 2.0 MGD and 3,900 ppd of BOD.

Review of the regulatory environment was a critical aspect of the Water and Wastewater Master Plan. Figure 1-10 illustrates the anticipated regulatory timeline for Berthoud WRF. Based on predicted timelines for permit renewal, it is possible that the Berthoud WRF will first see Regulation 31 TN and TP limits appear in their permit during the 2031 renewal. Considering schedule compliance delays as well as the Voluntary Incentive Program (VIP), stringent TN and TP limits will be effective at Berthoud WRF in 2042. Delay of the limit effective date until 2042 is dependent on implementation of Phase 1A BNR upgrades at the Berthoud WRF (WRF-1).

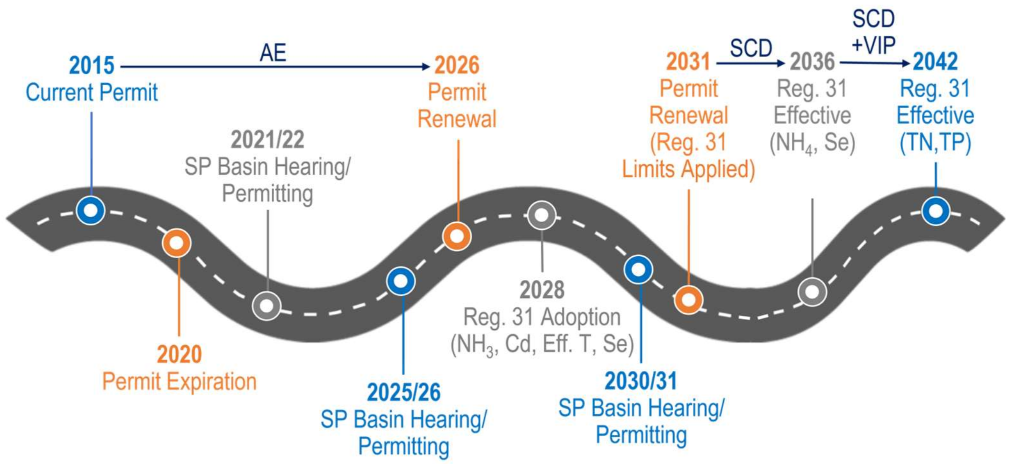


Figure 1-10: Berthoud WRF Anticipated Regulatory Timeline

Total ammonia, Selenium, Sulfate, Total Inorganic Nitrogen (TIN), TP and TN were parameters identified as possibly exceeding future limits at the Berthoud WRF and will likely require regulatory advocacy, capital improvements, and/or process modifications to reliably meet permit limits. Selenium has been and will continue to be a challenge at the Berthoud WRF due to the underlying seleniferous geology and infiltration and inflow (I/I) in the collection system. The Town is identifying and actively trying to mitigate selenium issues through source control. Berthoud is also evaluating optimal BNR upgrades to address selenium removal. However, if source control and BNR upgrades do not sufficiently address selenium compliance, costly upgrades will be required, such as reverse osmosis (RO) filtration. Ammonia and TIN compliance can be addressed through any of the suggested Phase 1A BNR upgrades, which will improve nitrogen removal. TN and TP compliance can be addressed through the Phase 2 Improvements (WRF-3). This project entails the addition of an anoxic moving bed bioreactor (MBBR) basin in combination with supplemental carbon addition for TN removal and chemical phosphorus removal using coagulation, flocculation, sedimentation, and effluent filtration for TP removal.

Figure 1-11 shows the anticipated regulatory timeline for the Regional WWTF. Based on predicted timelines for permit renewal, it is possible that the Berthoud WRF will first see Regulation 31 TN and TP limits appear in their permit during the 2031 renewal. Considering schedule compliance delays, this means stringent TN and TP limits will be effective at the Regional WWTF in 2036 since the facility is not able to earn VIP credits.

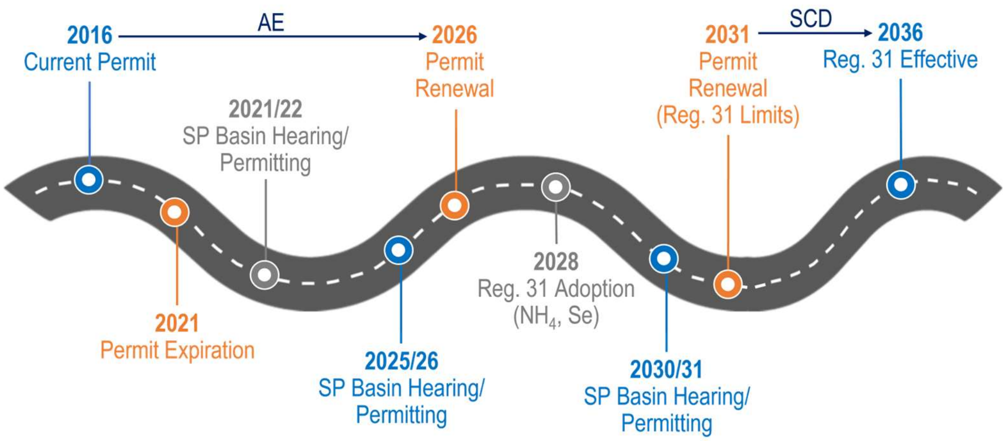


Figure 1-11: Regional WWTF Anticipated Regulatory Timeline

Total ammonia, TP and TN were parameters identified as possibly exceeding future limits at the Regional WWTF and will likely require regulatory advocacy, capital improvements, and/or process modifications to reliably meet permit limits. TN and TP compliance can be addressed through the Phase 2 Improvements (WWTF-2). The treatment upgrades in this package are identical to WRF-3. Berthoud should also advocate with the State for dissolved organic nitrogen (DON) exclusion from TN regulation; otherwise, both the Berthoud WRF and Regional WWTF will likely need to add a third stage of nitrogen removal treatment, such as RO, as the receiving stream receives minimal dilution.

1.4.1.3 Condition Assessment

A condition and risk assessment was performed on wastewater treatment and collection system equipment under Town ownership. This assessment captured the probable failure scenarios and their likelihood of occurrence (LoF); the consequence of failure of a unit process (CoF); and the resulting risk score (LoF x CoF). The derived risk scores have been used as a driver for prioritization of capital improvement projects. The consequences, likelihoods and risks for unit processes at the Berthoud WRF, Regional WWTF, and the collection system lift stations and throughout the distribution system are presented in Table 1-7 through Table 1-9, respectively.

Table 1-7: Berthoud WRF Asset Risk Assessment Summary

Unit Process	Consequence of Failure	Likelihood of Failure	Risk Score
Headworks	16	Possible	48
Influent Pump Station	17	Possible	51
Aeration (Blowers, Diffusers)	20	Possible	60
Activated Sludge (Basins, MLR Pumps)	19	Unlikely	38
Clarifiers	15	Possible	45
RAS/WAS Pumping	14	Possible	42
Disinfection	16	Possible	48
Digestion	15	Possible	45
Dewatering	15	Possible	45
Polymer Storage/Feed Systems	12	Likely	48
Non-Potable Water System	11	Likely	44
SCADA Systems	14	Possible	42
Cybersecurity	28	Possible	84

Table 1-8: Regional WWTF Asset Risk Assessment Summary

Unit Process	Consequence of Failure	Likelihood of Failure	Risk Score
Influent Pump Station	13	Possible	39
Headworks	12	Likely	48
Aeration/Blowers	18	Possible	54
Activated Sludge Basin	19	Unlikely	38
Disinfection	14	Unlikely	28
Chemical Storage/Feed Systems	14	Possible	42
Emergency Generator	14	Unlikely	28
SCADA Systems	15	Possible	45
Cybersecurity	28	Possible	84
Influent Pump Station	13	Possible	39
Headworks	12	Likely	48
Aeration/Blowers	18	Possible	54
Activated Sludge Basin	19	Unlikely	38
Disinfection	14	Unlikely	28
Chemical Storage/Feed Systems	14	Possible	42
Emergency Generator	14	Unlikely	28
SCADA Systems	15	Possible	45
Cybersecurity	28	Possible	84

Table 1-9: Collection System Asset Risk Assessment Summary

Unit Process	Consequence of Failure	Likelihood of Failure	Risk Score
Campion Lift Station	19	Likely	76
Bomar Lift Station	18	Likely	72
River Glen Lift Station	18	Possible	54
Heron Lakes Lift Station	19	Possible	57

1.4.1.4 Hydraulic Evaluations

Hydraulic evaluations were performed for the entire wastewater system, including the Berthoud WRF, Regional WWTF, and the collection system. A proprietary hydraulic profile calculation spreadsheet was used to calculate the hydraulic profile through the Berthoud WRF, with the intent of identifying any hydraulic bottlenecks or restrictions within the system. The calculated hydraulic profile of the Berthoud WRF is illustrated in Figure 1-12. As depicted, hydraulically critical elements in the system exist under varying and future flow conditions. The Regional WWTF has minimal gravity hydraulics and therefore a profile was not created for this facility. The Berthoud WRF was found to have capacity limitations near the secondary clarifiers under future flow demand conditions.

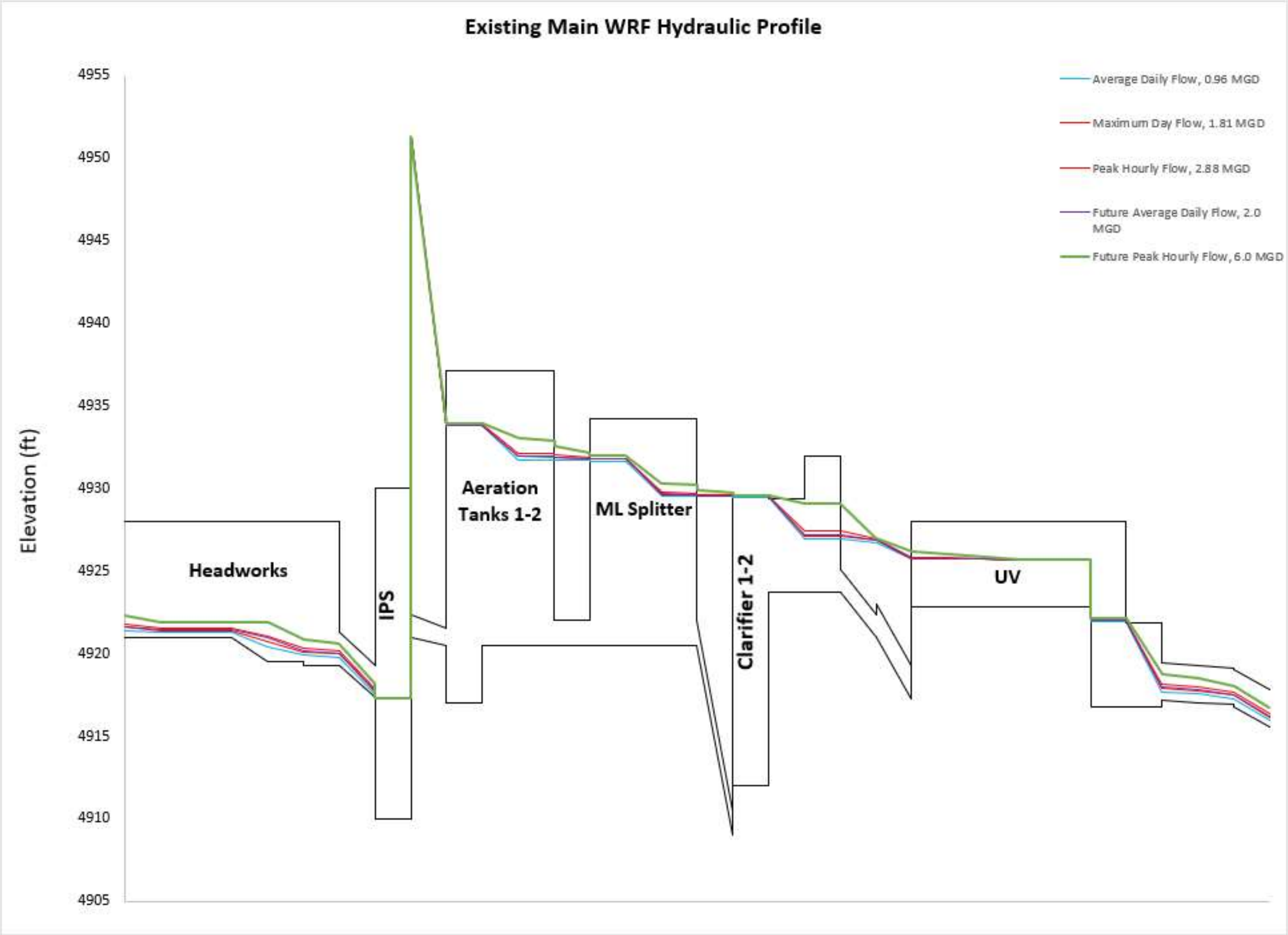


Figure 1-12: WRF Hydraulic Profile

Existing and future sewer collection system scenarios were analyzed using PCSWMM software for system-wide flows. For the wastewater system, the most critical factor in identifying overall collection system health is the ratio of depth of flow to pipe diameter (d/D). The existing collection system was analyzed for existing flows, 5-year flows, and 20-year flows. The future 20-year flows d/D ratios are shown in Figure 1-13. This figure is the primary driver for identifying new collection system projects.

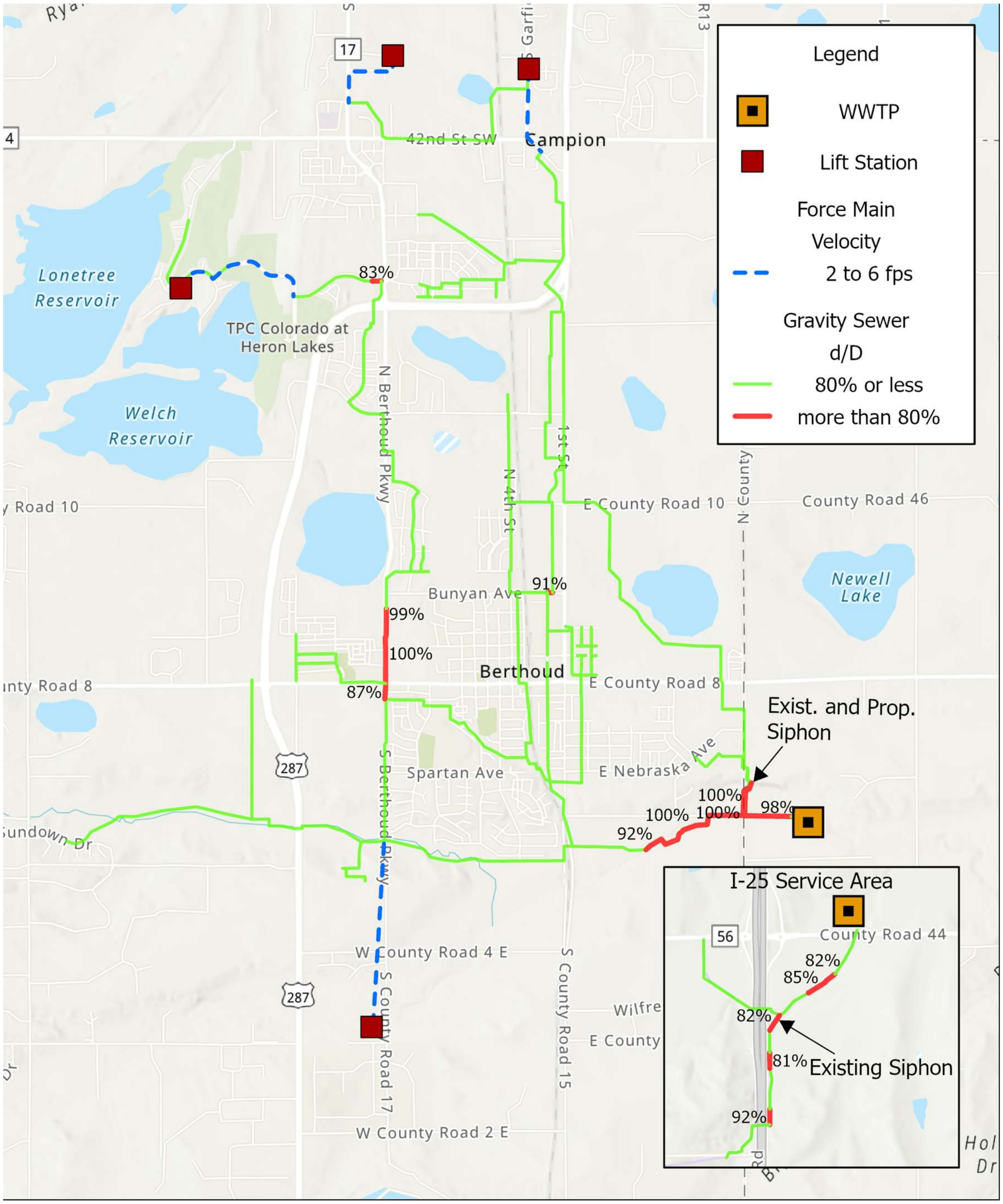


Figure 1-13: 20-Year Projection Conditions, Peak Flow, d/D Ratio

1.4.2 Collection System CIP Projects

The CIP projects were developed based on the 5-year and 20-year projection hydraulic models. Based on the anticipated future growth and geographic location of the developments, the CIP projects were developed and prioritized. The collection system projects and project IDs are summarized in Figure 1-14 and Table 1-10, respectively. All wastewater collection CIP projects have a prefix of “WWC” to denote “Wastewater Collection”.

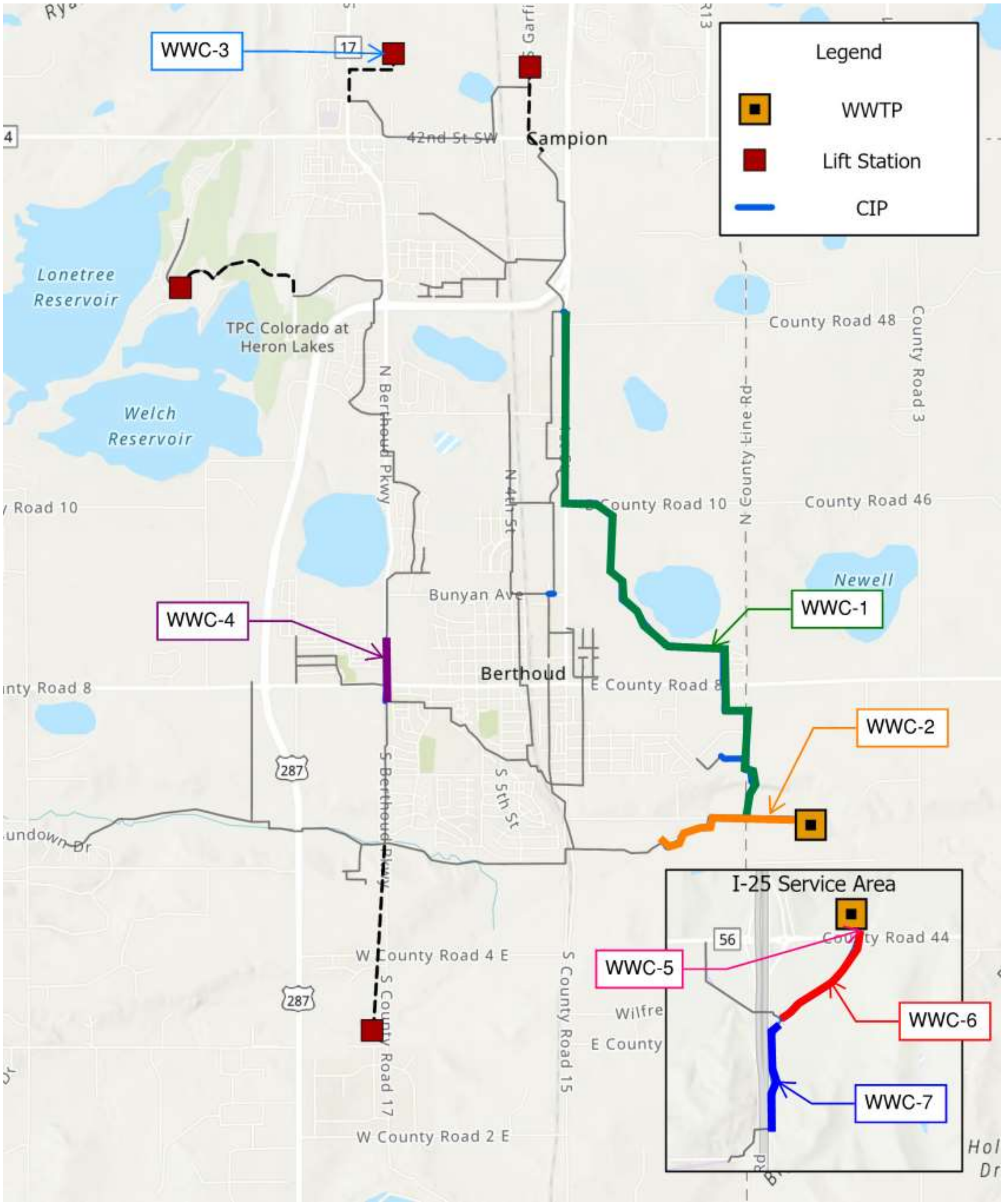


Figure 1-14: Wastewater Collection CIP Projects

Table 1-10: Sanitary Sewer CIP Projects

CIP Project #	Name	Length (ft)	Diameter (in)	
			Existing	Proposed
WWC-1	Bacon Lake Interceptor Improvements	19,270	-	15"-30"
WWC-2	Little Thompson Trunk Sewer	4,980	24"-30"	30"-42"
WWC-3	Bomar Lift Station Upgrade	-	-	-
WWC-4	Berthoud Parkway Trunk Sewer	1,840	12"	18"
WWC-5	Regional WWTF Influent Lift Station Upgrades, Phase 1	-	-	-
WWC-6	Turion Trunk Sewer, Phase 1	2,930	15"	18"
WWC-7	Turion Trunk Sewer, Phase 2	2,550	12"	15"

1.4.3 Wastewater Treatment CIP Projects

Both Berthoud WRF and Regional WWTF were evaluated individually for the wastewater treatment portion of the scope. The Wastewater Plan considered the service area population growth and associated discharges in CIP development for both plants. The Town of Berthoud service area consists of primarily residential discharges with minor commercial contributions and even fewer industrial. Considering population growth and makeup, the Plan projected where growth with respect to each plant would occur based on construction underway and future development opportunities. With this information, flows and loads were projected through 2043 for each plant. This Master Plan evaluated the current process infrastructure at each plant based on each unit process capacity and regulatory and industry standards for each process. The Plan also considered the current instrumentation and control, security and infiltration and inflow conditions for Berthoud WRF and Regional WWTF. Predicted regulatory requirements and subsequent compliance timing was included in the Wastewater Plan and discussed with respect to the compliance status of both plants. Each of these evaluations informed the development of CIP projects for Regional WWTF and Berthoud WRF.

1.4.4 Project Timeline and Cost Breakdown

The proposed 20-Year Prioritized Plan is driven primarily by capacity and regulatory requirements. The capacity drivers are heavily dependent on development in the Berthoud service area. If the rate of development does not align with that predicted in this Master Plan, Berthoud should reevaluate project sequencing to correspond with these changes in flows and loads. Projects provide explanation of drivers so the Town can readjust timing based on these thresholds for flow and load.

Figure 1-15 shows the annual CIP expenditures for the wastewater system. Class V cost opinions for each project described above can be found in **Appendix C**.

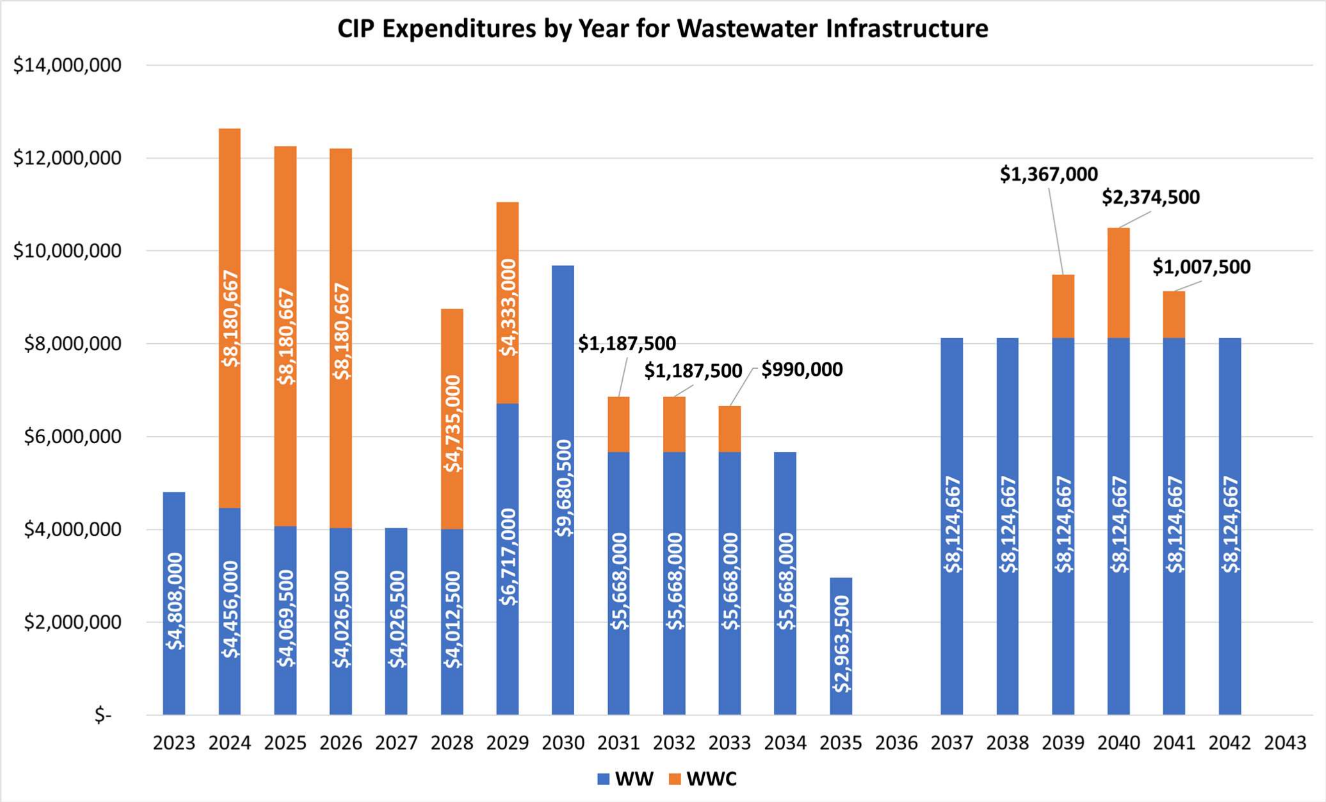


Figure 1-15: 20-Year Prioritized Plan Expenditures by Year for Wastewater Infrastructure

Figure 1-15 briefly describes the sequenced implementation schedule for the wastewater infrastructure projects prioritized in the 20-year CIP.

Proposed Capital Improvement Projects	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Wastewater Treatment Plants																					
WRF-1: Phase 1A – BNR Upgrades for VIP Credits and Selenium Reduction																					
Planning, Financing and Design	■																				
Construction, Startup and Optimization		■																			
WRF-2: Phase 1B – Capacity Expansion to 3.0 MGD																					
Planning, Financing and Design			■	■	■																
Construction, Startup and Optimization						■	■	■													
WRF-3: Phase 2 – Capacity Increase to 4.0 MGD and Regulation 31 Improvements																					
Planning, Financing and Design															■	■	■				
Construction, Startup and Optimization																		■	■	■	
WRF-4: Network and Cybersecurity Upgrades																					
Planning, Financing and Design		■																			
Construction, Startup and Optimization		■	■																		
WRF-5: PLC and Automation Upgrades																					
Planning, Financing and Design		■																			
Construction, Startup and Optimization		■																			
WWTF-1: Phase 1 – Capacity Expansion to 0.6 MGD																					
Planning, Financing and Design							■	■	■												
Construction, Startup and Optimization										■	■	■									
WWTF-2: Phase 2 – Regulation 31 Improvements																					
Planning, Financing and Design									■	■	■										
Construction, Startup and Optimization												■	■	■							
WWTF-3: Security and Automation																					
Planning, Financing and Design				■																	
Construction, Startup and Optimization				■	■																
Wastewater Collection Systems																					
WWC-1: Bacon Lake Interceptor Improvements																					
Planning, Financing and Design		■																			
Construction and Startup			■																		
WWC-2: Little Thompson Trunk Sewer																					
Planning, Financing and Design						■															
Construction and Startup							■														
WWC-3: Bomar Lift Station Upgrades																					
Planning, Financing and Design						■															
Construction and Startup						■															
WWC-4: Berthoud Parkway Trunk Sewer																					
Planning, Financing and Design									■												
Construction and Startup										■											
WWC-5: Regional WWTF Influent Pump Station Upgrades																					
Planning, Financing and Design											■										
Construction and Startup											■										
WWC-6: Turion Trunk Sewer, Phase 1																					
Planning, Financing and Design																	■				
Construction and Startup																		■			
WWC-7: Turion Trunk Sewer, Phase 2																					
Planning, Financing and Design																		■			
Construction and Startup																			■		

Figure 1-16: Wastewater 20-Year Prioritized Plan Implementation Schedule Timeline

2. INTRODUCTION

This Master Plan is intended to provide the Town of Berthoud (Town or Berthoud) with an overarching assessment of its water, wastewater, collection and distribution infrastructure. It contains a compilation of historical background, infrastructure data, and operational reporting for the Town. It also provides a regulatory compliance outlook, review of asset conditions, and financial positioning summary. Subsequently a suggested prioritized capital improvements plan (CIP) is presented. The goal of the CIP is to proactively plan for and address aging and/or undersized infrastructure to maintain desired service levels for Town customers while complying with regulatory requirements in the face of continued rapid growth in the Town.

2.1 Scope

The scope of work for this Master Plan is outlined below:

Master Plan Component	Description	Master Plan Section
Population and Growth Projection	Evaluate impending growth in the Town's population and identify which areas will see significant increases in population density over the planning horizon.	Section 3
Raw Water Assessment	Capture the Town's existing raw water positioning and glidepath on acquisition and development of new raw water sources.	Section 4.2
Treated Water Demand	Estimate increases in treated water demand across the Town for the planning horizon (20-year, 2043) and ability of existing infrastructure to meet these demands.	Section 4.4
Wastewater Flow and Load Projection	Estimate increases in wastewater generation for the planning horizon and ability of existing infrastructure to meet these flows and loads.	Section 1.2
Regulatory Outlook	Review the Town's current regulatory compliance posture and review/triage forthcoming regulations against the Town's treatment capabilities.	Sections 4.5 (Water) and 5.3 (Wastewater)
Unit Process Performance Analysis	Document sizing criteria and condition of Town-owned assets.	Section 4.6 (Water0 and 5.4 (Wastewater)
Hydraulic Evaluation	Model the hydraulics through the Town's treatment facilities and piping networks to identify restrictive components.	Section 4.7 (Water) and 5.5 (Wastewater)
SCADA and Security Evaluation	Assess the suitability of the Town's existing controls assets for effective operation of the water and wastewater systems, and defense against potential cyberattacks.	Section 5.6
20-year Capital Improvement Plan	Compile and prioritize capital improvement projects that should occur over the planning horizon, including projected costs to complete.	Section 5.7.3
Cash Flow Projection	Project the Town's revenues, expenses, and debt service over the planning horizon.	Section 5.7

2.2 Planning Period

The planning horizon considered for this Master Plan is through 2043. The short-term planning period is considered as the forthcoming five years, 2023 through 2028.

2.3 Background

Tetra Tech was retained in 2022 to holistically assess the Town's wastewater collection system, potable water distribution system, and treatment assets, and compile the findings in this combined Water and Wastewater Master Plan.

2.3.1 Town of Berthoud

Berthoud is located west of Interstate 25 (I-25), accessible via State Highway 56. In recent years, development of the I-25 corridor has accelerated, leading to rapid population growth in Berthoud and other towns in the vicinity. Much of the Town's water and wastewater infrastructure does not have the capacity to handle the increased service demands that are expected in the coming years. The Berthoud Public Works Department manages the Town's water, wastewater, and stormwater utilities, each of which are detailed below.

2.3.2 Water System

Drinking water for the Town is produced at the Berthoud Water Treatment Plant (WTP). This facility can treat at an instantaneous rate of 4.2 million gallons per day (MGD), but has a net maximum day throughput capacity, exclusive of clarifier underflow and backwash water volumes, of 4.0 MGD. Raw water is presently sourced from a combination of the adjacent Berthoud Reservoir and Carter Lake to the west. There are two pressure zones throughout the existing system. The distribution system consists of over 418,000 linear feet of water mains ranging in size between 4- and 20-inches in diameter.

The WTP uses a high service pump station (HSPS) to deliver flow directly to distribution and to the 3-million-gallon (MG) storage tank to the west of the plant. The storage tank delivers flow directly to distribution or flow is routed through an adjacent booster pump station to meet peak hour demands in the higher pressure zone.

2.3.3 Wastewater System

The collection system consists of an estimated 480,889 linear feet of sanitary sewer ranging in size between 4- to 24-inches in diameter. There are four (4) lift stations throughout the Town, not including influent pumping at the treatment plants. The lift stations are rated for capacities ranging from 86 gallons per minute (gpm) to 490 gpm. The collection system routes flow to the Berthoud Wastewater Reclamation Facility (WRF), near the main part of Town, and the Regional Wastewater Treatment Facility (WWTF), near I-25.

Wastewater is treated at two treatment plants to achieve suspended solids, biochemical oxygen demand (BOD), ammonia, and partial nutrient removal, along with ultraviolet (UV) disinfection prior to discharge into the Little Thompson River (LTR). The 2.0 MGD Berthoud WRF, located west of I-25, receives the majority of wastewater generated in the Town, while the 0.099 MGD Regional WWTF, located east of I-25, receives wastewater in the eastern portion of Berthoud surrounding the intersection of I-25 and State Highway 56.

2.4 Reference Reports

The following reports are referred to herein:

- Raw Water Master Plan, LRE Water, 2020
- Town of Berthoud 5-Year Water Plan, LRE Water, November 2021
- Water Master Plan Update, JVA Inc., November 2017
- Wastewater Master Plan Update, JVA Inc., November 2017
- 208 Areawide Water Quality Management Plan, North Front Range Water Quality Planning Association, 2020
- 2022 Drinking Water Quality Report for Calendar Year 2021, Town of Berthoud, 2022

3. POPULATION AND GROWTH PROJECTIONS

3.1 Historical and Current Population

According to the Colorado Demography Office (CDO), the population of the Town is summarized in Table 3-1. The most recent census data indicated there were approximately 2.6 persons per household. The 2021 state census as reported by the CDO listed a population of 11,062 people. The Town of Berthoud's 2021 Comprehensive Plans project exponential growth to 2040.

Table 3-1: Historical Population

Year	Population	Annual Growth Rate (%)
Town of Berthoud		
1980	2,362	-
1990	2,990	2.66
2000	5,005	6.74
2010	5,103	0.20
2020	10,509	10.59

3.2 Population Projection Methods

Population-change projections are, by nature, very approximate and can range significantly based on the method used. A common approach, therefore, is to use several methods of projection, compare the results and recommend what appears to be the most reasonable result. In this effort, the following documents and data were referenced to develop assumptions and complete this evaluation.

1) Colorado Demography Office for historical population data from 1980 to 2021. (CDO)
2) 2017 Berthoud Master Plan – JVA Consulting Engineers (2017 MP)
3) Town Website: 2021 Comprehensive Plan, Town of Berthoud, Colorado https://www.berthoud.org/home/showpublisheddocument/17203/637625411199600000
4) Town Website: Current Development Review Projects: https://www.berthoud.org/departments/community-development/planning-department/current-development-review-projects

Four different methods were used to project population change:

1) **CDO Historical Data Review.** This method used a simple non-compound annual-growth rate applied to current population based on the CDO's population database.
   a) Historical population data was downloaded from 1980 to 2021.
   b) The data was reviewed to develop average annual growth rates for the past 5 years, 10 years, 20 years, and 40 years. Results were as follows in Table 3-2.

Table 3-2: Historical Growth Analysis

Growth Statistics	
5 Year Average Annual Growth (%)	12.52%
10 Year Average Annual Growth (%)	11.07%
20 Year Average Annual Growth (%)	5.71%
40 Year Average Annual Growth (%)	3.90%

2) **2017 Master Plan Estimate.** The 2017 Master Plan estimated that between 45 and 50 new homes would be built every year. This assumed growth rate was used to predict household growth and corresponding population.

3) **The 2021 Comprehensive Plan Method.** The Town also provided estimated growth in their 2021 Comprehensive Plan. This data is summarized on Figure 3-1 from that report, reproduced below. The overall growth from 2030 to 2040 is (27,285-18,433)/10 or 885 persons per year. Adding two years of growth to the 2040 value, the estimated Year 2042 value would be 29,055 in Year 2042.

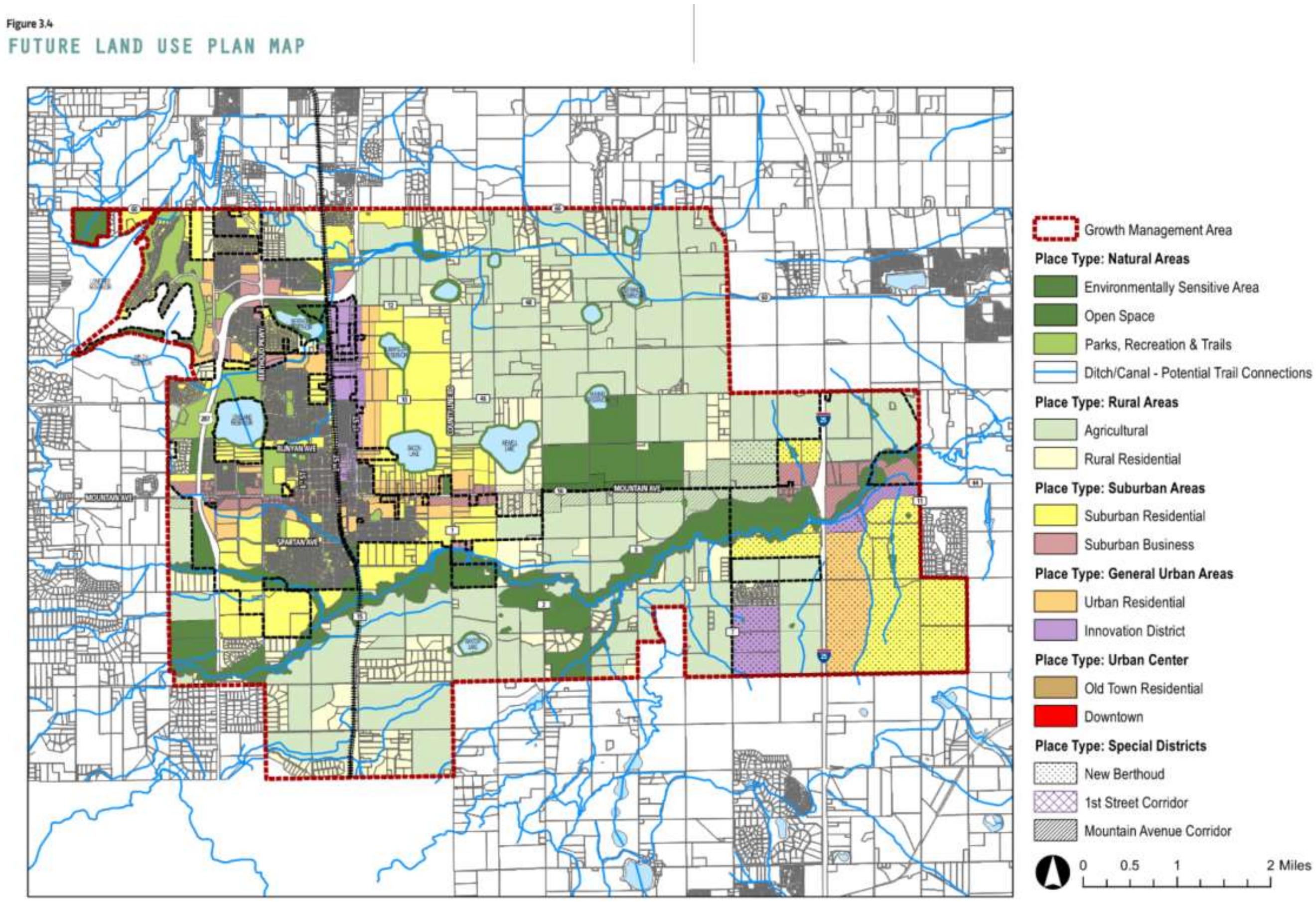


Figure 3-1: 2021 Comprehensive Plan Estimated Growth

4) **Future Developments Method.** The final method was an independent review of the Town's growth maps. This data was supplemented by adding the Future Development Review Projects and coordinating directly with Town staff. Table 3-3 is a summary of new developments and the added households and population.

   a) The first step was the collection of proposed developments. Known development size was taken from the Town's Future Development Review Projects.

Table 3-3: Known Future Developments

Developments	PROPOSED	
	Housing Units	Population
Fickle Farm	168	437
Heron Lakes 17th	162	421
Heron Lakes 19th	200	520
Farmstead	1497	3,892
Vantage	550	1,430
Ludlow Farm	1800	4,680
Westside Crossing	56	146
The Meadows	60	156
Trails at Creekview	481	1,251
Hammond 7th	46	120
Village at Rose Farm	50	130
Harvest Ridge	174	452
1st St and Mountain Ave	10800	28,080
US-287 and 42nd St	269	699
Turion	4000	10,400
Total:	**20,313**	**52,814**

   b) The development at 1st St and Mountain Ave has an unknown number of proposed housing units. The Town indicated this development may be high density housing containing apartments and multi-family homes. To account for this high density and at direction from the Town, the number of housing units was estimated to be a relatively high value of 10 housing units per acre.

   c) The total proposed additional population was estimated at 52,814, representing a growth rate of 2,641 persons per year if such growth were to take place in 20 years. Such a growth rate is extremely high and most likely not sustainable for developers or the Town. It's expected this amount of growth will take 40 years, for a rate of 1,320 persons per year.

   d) The 2021 census data lists Berthoud as having a population of 11,062. Assuming a similar growth rate in the year 2022 (2,641 people) and with the additional population of 52,814, that results in an estimated 40-year timeline (Year 2063) population of 66,516.

Figure 3-2 displays curves from all four methods, graphed over 20 years. The CDO data (grey) is shown in separate curves for 5-, 10-, 20-, and 40-year average growth. The 2017 MP (orange), Comprehensive Plan (dashed orange) and the Future Development method (green) are shown as single curves.

The four methods show a wide range of projected population change. For example, the 2017 MP Year-2042 estimate is less than a third of the 5-year CDO projection. The Future Development line, however, is between the 5-Year Average Growth and 10-Year Average Growth lines. This exercise was completed as a check that the future development growth rate is within reason of historical growth patterns.

The Future Development predicted Year 2043 population (40,110) is 34% higher than that for the Comprehensive Plan extrapolation (29,940). This may be due to the following:

- More specific data regarding actual development plans.
- Very high densities in newer developments.

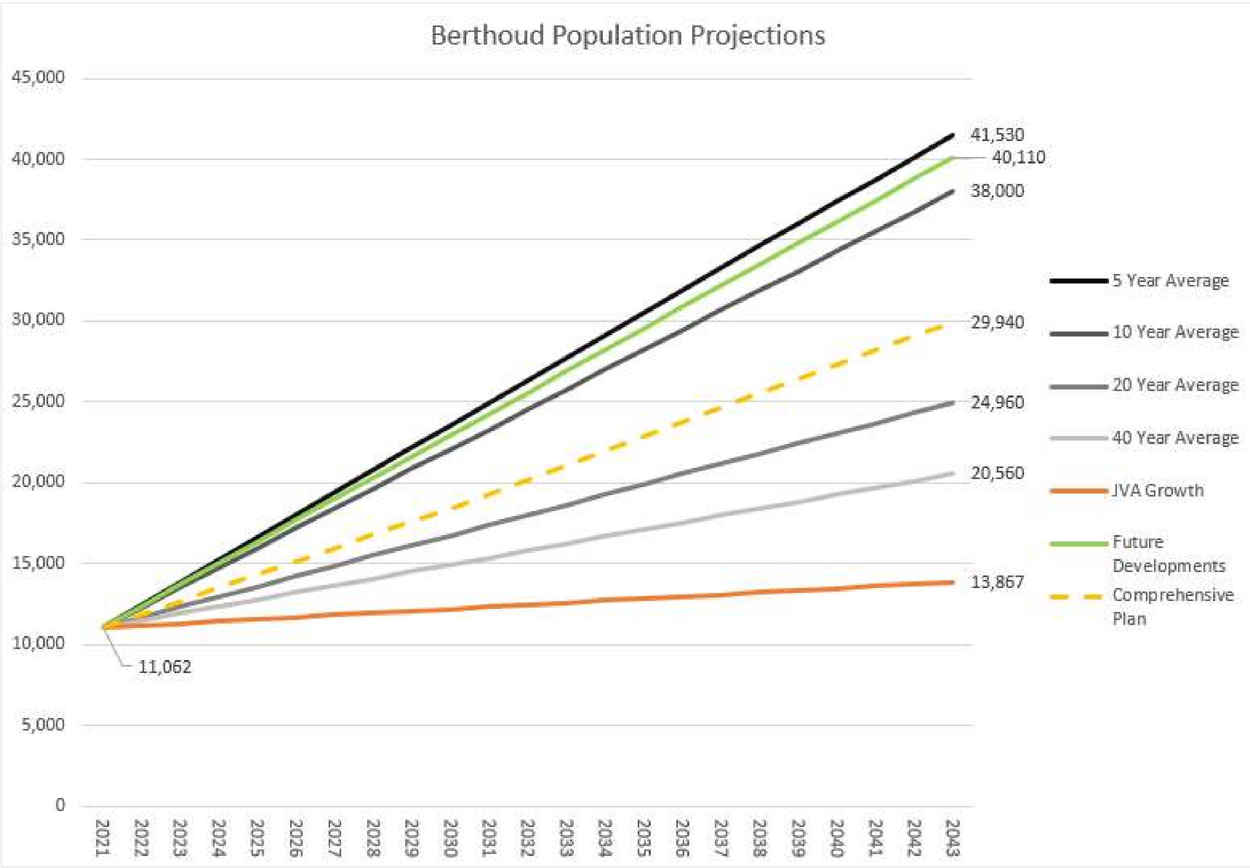


Figure 3-2: 20-Year Population Projection Methods

3.3 Population Projection Recommendation

Two different population projections were developed: one for the collection and distribution infrastructure, and another for the treatment plant infrastructure. This decoupling allowed for below-grade collection/distribution infrastructure sizing that better accommodates build-out conditions and does not require near or mid-term pipeline upsizing or parallel line installations. For evaluating treatment plant improvements, however, a dampened population projection was developed to support a more phased approach to treatment capacity expansion to prevent having an uneconomical amount of unused, excess capacity at the treatment plants prior to build out conditions.

3.3.1 Collection/Distribution Analysis

Full build-out is expected to take 40 years and the collection/distribution infrastructure needs to be installed to prepare for that growth. Because of this, full build-out of wastewater collection and water distribution infrastructure is scheduled to occur within the 20-year Master Plan timeline. The infrastructure will be sized for full build-out population of 66,516. While this infrastructure will be oversized in the short term, the Town will ultimately save money by planning for that growth now and mitigating the need to install replacement or parallel infrastructure in the future. However, the initially oversized infrastructure will require judicious selection of appropriate materials of construction and increased maintenance to mitigate near-term effects of lower flow velocities, such as solids settling and hydrogen sulfide-related odors and corrosion in the collection system.

3.3.2 Treatment Plant Analysis

Treatment plants have optimized performance and costs when the flow is within design parameters and not oversized. Accordingly, the Town opted to have incremental, or phased, expansions based on an estimated compound annual population growth rate of 4% for the 20-year Master Plan timeline. As the Town tracks local and regional growth trends over time, it must navigate a course between not overbuilding and making sure it has adequate treatment capacity on a rolling 5-year horizon since it typically takes that long to plan, finance, permit, construct, and bring on stream major plant improvements. The population design criteria for the 20-Year Master Plans for collection/distribution systems and treatment plants are shown on Figure 3-3.

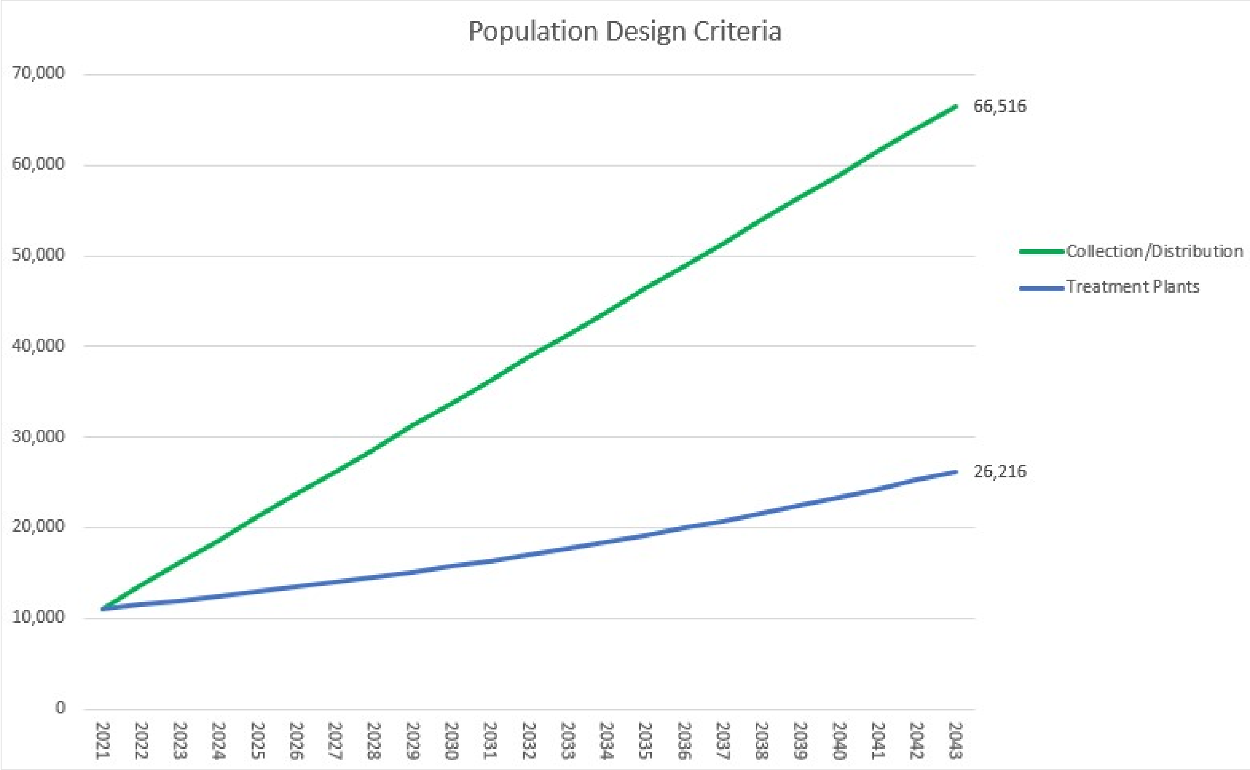


Figure 3-3: Population Projection

After comparing all the methods, the population design criteria as specified on Figure 3-3 is recommended. These criteria specify the following population estimates for the 20-year master planning horizon:

- Collection/Distribution Systems: 66,516
- Treatment Plants: 26,216

4. WATER PLAN

This section contains an assessment of existing assets, vulnerable elements, and proposed capital improvements for the Town's WTP and potable water distribution system.

4.1 Overview of System

Raw water is supplied to the Berthoud WTP from Berthoud Reservoir and Carter Lake. Finished water has also been purchased from the Little Thompson Water District (LTWD), the source for which is the Carter Lake Filter Plant, which LTWD jointly owns with another district. The Town has one WTP that treats raw water using conventional pretreatment, gravity granular media filtration, and disinfection with sodium hypochlorite before pumping to distribution. The distribution system is made up of over 418,000 linear feet of water mains, one 3 MG storage tank, and one booster pump station.

4.2 Raw Water Plan

4.2.1 Existing Water Sources

According to the Town's water rights engineer (LRE Water), several raw water rights sources are being delivered to the Berthoud WTP, as summarized in Table 4-1 from LRE's 5-Year Water Plan memorandum dated November 18, 2021. This includes two sources from Northern Colorado Water Conservancy District (Northern Water), Colorado-Big Thompson (C-BT) and Windy Gap, Berthoud's Big Thompson River Priority No. 1 water rights, and the Handy Ditch Company. As of the 2021 memo, the Town was in process of converting 34 Ryan Gulch Reservoir Company (RGRC) shares and an additional 25.83 Handy Ditch Company shares (inclusive of the 33.33 units specified in Table 4-1) in Division 1 Water Court. The memo indicates 250 acre-feet (AF) of these shares are allocated for non-potable irrigation use at the Heron Lakes Golf Course. This irrigation allocation utilizes all of the RGRC shares, and approximately 6.4 AF/year of the Handy Ditch Company yield. The yield specified in Table 4-1 deducts the non-potable allocation. It should also be noted that the Windy Gap shares are not a reliable water source until additional infrastructure is provided to deliver the water. It's possible that the shares can deliver up to 1,235 AF/year should the Town acquire an additional 5 units (for a total of 13 units), but due to the unreliability of the shares, it has been considered as 0 AF/year. These water supplies deliver flow to Carter Lake, which feeds the WTP.

Table 4-1: Existing Raw Water Source Yields

Raw Water Source	Number of Units	Dry Year Yield (AF/Year)
Big Thompson River Priority No. 1	-	1,822.6
C-BT	1,088	652.8
Handy Ditch Company	40.33	261.0
Windy Gap	8	0.0
	Total:	3,278.1

4.2.2 Future Water Sources

The Town's current average potable water demand is estimated at 2,133 AF/year, approximately 1.65 MGD after considering a 14% loss per the 5-Year Water Plan. The remaining available water rights is 452.5 AF/year, which results in a total annual average supply to customers (taking into account a 14% deduct for water losses) of 1.99 MGD. Since Carter Lake and Berthoud Reservoir supplies are 'stored water', peak deliveries can be made to meet maximum day demands for water. Utilizing existing demand factors (2.15 MDD/ADD), the current portfolio of surface water rights can support a maximum day demand of 4.37 MGD, just above the rated, 4.0 MGD net throughput capacity of the WTP. In conclusion, the amount of raw water that can be delivered to the Berthoud WTP is well balanced with the amount it can treat and deliver to the Town's customers.

Potential future water sources have been identified as alluvial supplies from (1) the Little Thompson River immediately downstream of the WRF and (2) the South Platte River, the latter via well(s) and pipeline owned by United Water. It is assumed that these water supplies will be classified as Ground Water Under Direct Influence (GWUDI) of surface water and will contain enough mineral content to require Reverse Osmosis (RO) treatment. Dependent upon timing of development and the Town's need for more potable water, there could be either two separate or one combined RO facility in the vicinity of I-25 and Highway 56. These sources would be used to supply developments in the eastern region of the Town.

In review of the population projection, the 20-year projected Town population for the potable water supply and treatment is 26,216 people. For a unit factor of 140 gallons per capita per day (gpcd) (based on existing flow data) and a MDD factor of 2.2, the future ADD is 3.67 MGD and the future MDD is 8.07 MGD. It is assumed that the future flow demand will be achieved by routing flows as summarized in Table 4-2.

Table 4-2: Future Raw Water Source Yields

Raw Water Source	Water Treatment Plant	AADD Flow (MGD)	MDD Flow (MGD)
Big Thompson River Priority No. 1	Existing WTP	1.91	4.0
C-BT			
Handy Ditch Company			
Windy Gap			
South Platte	I-25 RO WTP	1.82	4.0
Little Thompson			
	Total:	**3.73**	**8.0**

As mentioned previously, Windy Gap surface water is listed but assumed to provide no reliable dry year yield at this time. Berthoud is not a participant in the Chimney Hollow Reservoir Project (construction of which began in 2021) and does not currently have an alternative means to store this water and convey it to the Berthoud WTP. The City of Longmont and Town of Superior have been identified as having excess shares, which profile as potential acquisitions for the Town should conveyance and storage allow. LRE Water is simultaneously investigating the viability of potential sources from Handy Ditch and Carter Lake.

Acquisition of additional raw water sources is also contingent on the Berthoud WTP having sufficient capacity to treat the flows. To accommodate these raw water sources, a capacity upgrade of 1 MGD to the WTP (for a total capacity of 5.0 MGD) is recommended. As most of the existing equipment at the WTP has capacity to treat 5 MGD, this upgrade would primarily entail an expansion to filtration capacity and chemical feed systems, with incremental upgrades to select equipment throughout the facility. The scope of this upgrade is further discussed in Section 4.9.2.2 under project WTP-3: Berthoud WTP Expansion to 5.0 MGD.

Non-potable water and development of infrastructure to distribute this water throughout the Town can offset the demand for potable water. Non-potable water utilization is further discussed in Section 4.4.2.

4.3 Water Quality

The Town is required to monitor for certain chemical contaminants, turbidity, and disinfection byproducts (DBPs) at the entry point to the distribution system. Entry point monitoring is performed in the High Service Pump Station (HSPS) building downstream of the high service pumps (HSPs) prior to distribution. Turbidity is monitored in the Filter Building downstream of the filters. The monitoring requirements are covered in greater detail in the Regulatory Outlook section of this report. Table 4-3 shows the treated water quality at the entry point monitoring location for 2022, average pH was reported to be +/- 8.7.

Table 4-3: Treated Water Quality Monitored at Entry Point

	Temperature (°C)	Disinfection Residual (mg/L)
Minimum	4.50	0.60
Maximum	18.60	2.87
Average	11.18	2.00

4.3.1 Raw Water Quality

A majority of the Town's treated water currently comes from Carter Lake, which is the preferred source of raw water over Berthoud Reservoir. This is largely due to Berthoud Reservoir being a terminal reservoir which limits the amount of mixing or movement in the water leading to reduced water quality. Berthoud Reservoir water has double the hardness of Carter Lake, and is more prone to algal growth, which can reduce filter throughput and create taste and odor control challenges.

4.4 Demand: Existing and Projected

This section details the present raw water demands, and those expected over the 20-year planning horizon.

4.4.1 Existing Demands

Data was provided by the Town for the flow pumped to the distribution system between 2018 and 2022. This data includes flows from the HSPs at the WTP as well as the Booster Pump Station (BPS) at the 3 MG storage tank and was used to calculate the total distribution demand. Most of 2018 had zero flow readings so the data was not used. In addition, the 2022 data set only included data through October 5, 2022. While this data captured the most recent high demand period through the summer of 2022, the demand ratios may be slightly elevated due to not having data through the lower demand period (late fall/winter months of 2022). The flow data is summarized in Table 4-4:

Table 4-4: Existing Water Demand Summary

Year	ADD (MGD)	MDD (MGD)	PHD (MGD)	ADD/ MDD RATIO	ADD/ PHD RATIO
2019	1.21	2.76	5.01	2.27	4.13
2020	1.50	3.25	5.88	2.17	3.93
2021	1.63	3.59	6.71	2.20	4.11
2022	1.62	3.80	7.07	2.35	4.36

The daily flow demand over the last full year of data, 2021, is shown on Figure 4-1.

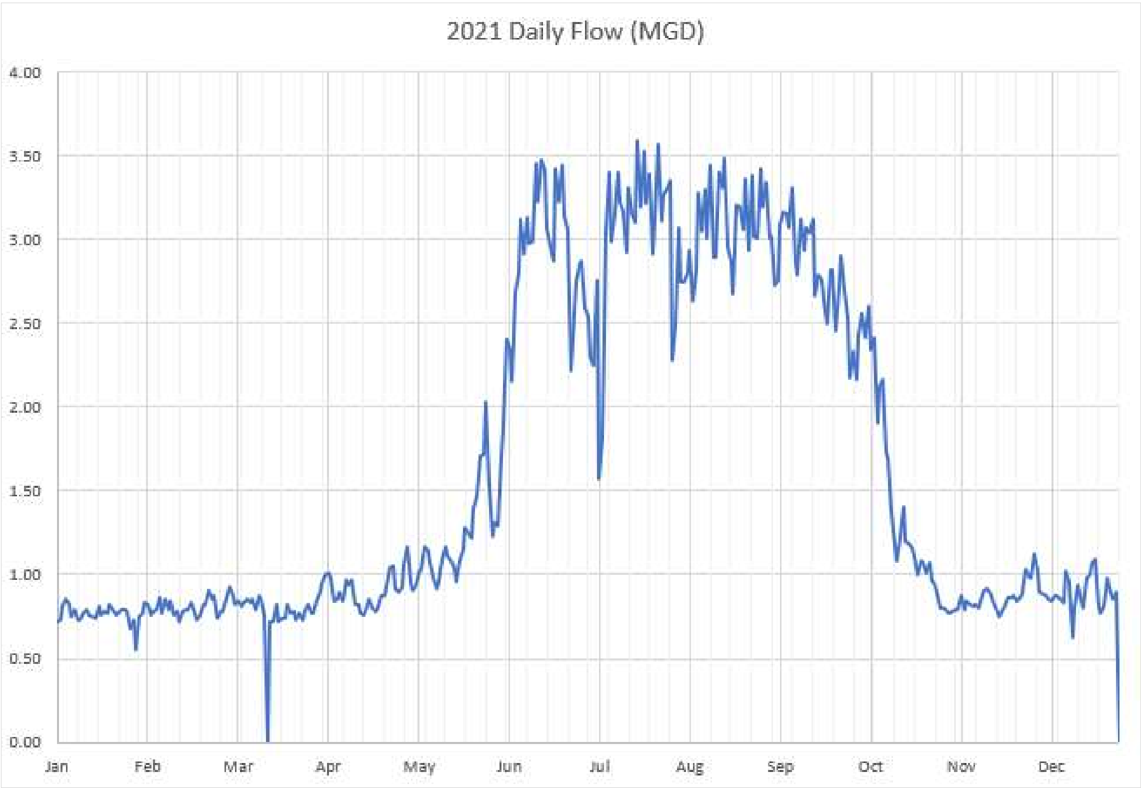


Figure 4-1: 2021 Distribution Daily Flow Demands

4.4.2 Proposed Demands

Based on existing flow data and projected future high-density housing, it was decided that 140 gpcd is a conservative estimate for projecting future ADD flows. As discussed in Section 3.3.2, the population projections differ between evaluating the distribution system and plant systems, which resulted in different projected flow rates for the purpose of capital planning. The projected flow demands are summarized in Table 4-5. The MDD and PHD projections utilized the same peaking factors as the existing 2021 data represented. It should be noted, however, that for the storage tank assessment it was more conservative to evaluate storage off of the most recent peak flow months, the summer of 2022, and therefore the peaking factors for MDD and PHD were based off of the 2022 data. More information on the storage analysis is provided in Section 4.8.2.2

The Town of Berthoud is incentivizing new developments to install dedicated non-potable water systems. Depending on the service provided by these non-potable systems, the estimated potable flow reductions to each new development will be as follows:

- Dedicated non-potable systems to each lot: 50% reduction
- Dedicated non-potable systems to parks and open space for irrigation: 15% reduction

Since it is currently unknown what infrastructure each developer will elect to construct, it was assumed that a 15% reduction will be used for each new future development. The reduced demands are included in Table 4-5.

Table 4-5: Existing Water Demand Summary

Category	Existing 2021	ORIGINAL Distribution 2043	ORIGINAL Plant 2043	REDUCED Distribution 2043	REDUCED Plant 2043
Population	11,062	66,516	26,216	66,516	26,216
ADD (MGD)	1.63	9.41	3.67	7.68	3.00
MDD (MGD)	3.59	20.70	8.07	16.90	6.59
PHD (MGD)	6.71	38.68	15.08	31.58	12.31
MDD/ADD Ratio	2.20	2.20	2.20	2.20	2.20
PHD/ADD Ratio	4.11	4.11	4.11	4.11	4.11

4.5 Regulatory Outlook

A current focus area for the Colorado Department of Public Health and Environment (CDPHE) is disinfection credit allowance. CDPHE is in the process of re-evaluating WTPs for their ability to meet disinfectant residual concentration (C) times effective contact time (T) requirements (i.e., CT requirements). CDPHE is arranging site visits through their initiative “Disinfection Outreach and Verification Effort” intended to verify log inactivation credits awarded to WTPs. The Town of Berthoud should anticipate that CDPHE will be scheduling a visit for these purposes.

Table 4-6 summarizes CDPHE and Environmental Protection Agency (EPA) regulations pertinent to the Berthoud WTP. The WTP is not presently in violation of any compliance provisions based on the Town of Berthoud 2022 Drinking Water Quality Report.

Table 4-6: Water Quality Regulatory Summary

Regulation	Key Provisions	Potential Treatment Implications	Compliance Status
Chemical Contaminants			
Arsenic Rules	• Establish a Maximum Contaminant Level (MCL) and a Maximum Contaminant Level Goal (MCLG) for arsenic	• Treatment to remove arsenic in excess of MCL	Compliant
Lead and Copper Rule	• Established action levels (AL) for lead and copper in at-risk customer tap samples. The Lead and Copper Rule Revisions (LCRR) establish a new trigger level for lead, with the goal of implementing corrective actions before the lead AL is exceeded.	• Optimization of corrosion control treatment for lead and copper if ALs are exceeded. May require implementation of a lead service line replacement program.	Compliant
Radionuclide Rule	• Established MCLs and MCLGs for combined radium-226/-228, adjusted gross alpha, beta particle and photon radioactivity, and uranium	• Treatment for combined radium 226/228, adjusted gross alpha, and beta particle and photon radioactivity above MCLs	Compliant
Variance and Exemption Rules	• Allow eligible systems to provide drinking water that does not comply with a national primary drinking water regulation on the condition that the system installs a certain technology, and the quality of the drinking water is still protective of public health	• The state may grant a small system a variance when treated water cannot meet the MCL and there are no PWS restructuring options, no other sources of water, and no affordable technology. • An exemption may only be granted if the system agrees to undergo capital improvements that may take an extended amount of time to be completed so that the treated water will meet the MCL.	Not Applicable at Berthoud
Microbial Contaminants			
Groundwater Rule	• Periodic sanitary surveys to evaluate system components and identify significant deficiencies • Triggered source water monitoring if no virus inactivation provided • Corrective action for significant deficiencies and raw water fecal coliform detection • Compliance monitoring to ensure 4-log viral inactivation treatment provisions established for vulnerable systems	• Disinfection with CT requirements for viral inactivation for vulnerable systems	Not Applicable at Berthoud

Regulation	Key Provisions	Potential Treatment Implications	Compliance Status
Stage 1 and Stage 2 DBPs Rule	• Stage 1 reduces drinking water exposure to DBPs • Stage 2 requires systems to monitor for two classes of disinfection by products; TTHMs and HAA_5 at representative sites in the distribution system likely to have the highest water age and DBP levels • Establishes locational running annual average MCLs for TTHMs and HAA_5	• Reduction of disinfection by product levels	Compliant
SWTR	• Requires most water systems to filter and disinfect water from surface water sources or groundwater under the direct influence of surface water (GWUDI) • Establish MCLGs for viruses, bacteria, and *Giardia* • Includes treatment technique requirements for filtered and unfiltered systems to protect against adverse health effects of exposure to pathogens	• Disinfection and/or filtration for Giardia and viruses • In Colorado, all surface water and GWUDI sources must filter and provide disinfection to achieve 3-log *Giardia* and 4-log virus removal/inactivation	Compliant
LT1ESWTR	• Surface water and groundwater under the influence of surface water must provide treatment for *Cryptosporidium*	• Filtration and/or disinfection for *Cryptosporidium*	Compliant
LT2ESWTR	• Surface water and groundwater under the influence of surface water must provide treatment for Cryptosporidium	• Filtration and/or disinfection for *Cryptosporidium* based on bin classification of raw water supply	Compliant
Total Coliform Rule and Revised Total Coliform Rule	• Establishes MCLs and MCLGs for total coliforms, *E. coli*, monitoring requirements, including seasonal systems, and treatment technique triggers for conducting sanitary defect assessments and corrective actions	• Filtration, disinfection, and use of sanitary defect management practices for total coliform and *E. coli* compliance	Compliant
Applicable to all Contaminant Types			
National Primary Drinking Water Standards	• Established MCLs and some TT for several SOCs, VOCs, inorganic chemicals, physical parameters, and microbial contaminants	• Treatment for a variety of compounds if MCLs or ALs are exceeded • See following sections for individual compounds, and levels requiring treatment	Compliant
National Secondary Drinking Water Standards	• Established SMCLs for several inorganic and physical properties of water	• Requirements vary by state, but are generally viewed as guidelines and not mandatory standards for drinking water quality	Compliant

Regulation	Key Provisions	Potential Treatment Implications	Compliance Status
Filter Backwash Rules	• Surface waters and GWUDI using filtration with recycling of backwash water must conduct recycling in a manner that meets regulatory guidelines	• Potential process changes for recycling of backwash water • The Berthoud WTP does not recycle/retreat its clarifier solids underflow or backwash water, so this rule does not currently apply at this facility	Compliant
Right-To-Know Rules			
Consumer Confidence Report (CCR) Rules	Requires community water systems to prepare and provide to their customers annual consumer confidence reports on the quality of the water delivered by the systems	CCRs are 'report only' and do not, by themselves, trigger treatment plant changes...those are based on violation of the above-noted rules	CCRs are posted online
Public Notification Rule	Ensures that consumers will know if there is a problem with their drinking water; these notices alert consumers if there is risk to public health	Public notification rules provide information and advice, such as boil orders, to the town's water customers. They do not, by themselves, trigger treatment plant changes...those are based on violation of the above-noted rules.	Not evaluated as part of this report

4.5.1 Finished Water Pathogen Criteria

The Berthoud WTP is a surface water treatment facility that consists of pretreatment (coagulation, flocculation, and sedimentation) and granular media filtration. Table 4-7 summarizes the regulatory requirements for inactivation/removal for viruses, *Giardia* and *Cryptosporidium*. By meeting the finished water turbidity goals established by EPA in the Surface Water Treatment Rule, as adopted and made more stringent by CDPHE (e.g., no filtration waivers in Colorado), the WTP receives a 2-log virus, 2.5-log *Giardia*, and 2-log *Cryptosporidium* particle removal credit. The remaining virus and *Giardia* inactivation are accomplished using free chlorine. The total log removal for *Cryptosporidium* is based on occurrence data gathered through sampling regulated under the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR). The Berthoud WTP source is classified as Bin 1 meaning no additional removal/inactivation beyond the 2-log removal credit is required.

Table 4-7: Disinfection Regulatory Requirements

Criteria	Virus	*Giardia*	*Cryptosporidium*
Total required removal/inactivation	4-log	3-log	2-log
Removal Credit for Conventional Treatment	2-log	2.5-log	2-log
Inactivation Needed at Berthoud WTP	2-log	0.5-log	0-log

The Berthoud WTP does not currently present compliance concerns related to drinking water regulatory requirements. However, there are two impending regulations that may challenge the Berthoud WTP.

4.5.1.1 PFAS

Per- and polyfluoroalkyl substances (PFAS) are a large and complex class of anthropogenic compounds. PFAS compounds have recently created a strong public and regulatory response due to their ubiquitous presence in the environment, their persistence, and potential toxicity to human and ecological receptors. PFAS have been designated as emerging contaminants of concern since the early 2000s. PFAS are a family of human-made chemicals with over 5,000 compounds that have been used for decades in products like food packaging, carpets, non-stick products, other household items, medical supplies, and firefighting foam due to their ability to resist heat, oil, stains, grease, and water. The PFAS molecule contains covalent $C-F$ bonds, the shortest and strongest bond in nature. This is responsible for their thermal and chemical stability. This property, in conjunction with its ability to lower surface tension, has made PFAS ideal for a wide range of industrial and commercial applications. These same properties also render PFAS as bioaccumulative, toxic, and ubiquitous in the environment. Although the long-chain PFAS molecules are no longer manufactured in the USA, many shorter-chain PFAS are still in use.

Drinking water is one of several pathways by which individuals may be exposed to PFAS. It is known that with long-term exposure PFAS can cause numerous detrimental health effects:

- Leads to negative health effects in pregnant individuals and developing infants
- Weaken a body’s ability to fight disease
- Increased risk for certain cancers and liver damage
- Elevated cholesterol levels, which can increase risk of heart attack or stroke

In March 2023, EPA proposed a National Primary Drinking Water Regulation (NPDWR) to establish legally enforceable levels, called Maximum Contaminant Levels (MCLs), for six PFAS in drinking water. PFOA and PFOS as individual contaminants, and PFHxS, PFNA, PFBS, and HFPO-DA (commonly referred to as GenX Chemicals) as a PFAS mixture. EPA is also proposing health-based, non-enforceable Maximum Contaminant Level Goals (MCLGs) for these six PFAS.

Table 4-8: Proposed EPA MCLG and MCL for PFAS Compounds

Compound	Proposed MCLG (ppt*)	Proposed MCL (enforceable levels, ppt*)
PFOA	0.0	4.0
PFOS	0.0	4.0
PFNA	1.0 (unitless) Hazard Index**	1.0 (unitless) Hazard Index**
PFHxS		
PFBS		
HFPO-DA (aka GenX)		

* ppt = parts per trillion (also expressed as ng/L)
** The Hazard Index is a tool used to evaluate potential health risks from exposure

The proposed rule would also require public water systems to:

- Monitor for these PFAS
- Notify the public of the levels of these PFAS
- Reduce the levels of these PFAS in drinking water if they exceed the proposed standards.

4.5.1.2 Phosphate-Based Corrosion Control

Although no formal regulations have been imposed on the States, EPA is a strong advocate of using phosphates. i.e., orthophosphate and polyphosphates, for optimal corrosion control treatment (OCCT). It is believed that calcium carbonate, the current OCCT used at Berthoud WTP, is effective at preventing lead corrosion, but less effective at copper corrosion reduction, especially in waters high in carbonate. EPA believes phosphates are a more ubiquitous and reliable OCCT for both copper and lead. However, CDPHE has pushed back on this trend and avoided requiring phosphate-based corrosion control as the water quality matrices in much of Colorado do not see challenges with copper corrosion and are not high in carbonate. Additionally, adding phosphates to the water requires downstream wastewater treatment utilities to remove phosphate prior to discharge to the environment. It is possible that EPA may use the new 10 µg/L trigger level for Lead as means to impose phosphate-based corrosion control on utilities, or at minimum require utilities to review and consider new OCCT, if Lead concentrations meet this level.

4.5.2 Compliance Review and Recommendations

As mentioned before, there are no current compliance concerns for Berthoud WTP. This section discusses the compliance implications and subsequent recommendations for two potential regulations related to PFAS and phosphate-based corrosion control.

4.5.2.1 PFAS

Although PFAS regulations have yet to be promulgated, it is likely the new proposed six PFAS MCLs will come into effect. However, there are a number of steps Berthoud WTP should take prior to adding a PFAS removal process to the plant.

- Begin regular monitoring and sampling of pfas in source water
- Work with wastewater utility and local industry to determine PFAS sources
- Implement a source control program to mitigate PFAS contamination based on source identification
- Position and plan for treatment funding opportunities, such as with the Drinking Water State Revolving Fund

If source control does yield results in line with the proposed MCLs, there are numerous treatment options for PFAS removal in drinking water. Both granular activated carbon (GAC) and ion exchange (IX) can be used to treat PFAS in source water and have been applied successfully on large scales. Determination of the optimal PFAS removal strategy is site-specific, dependent on the source water quality matrix, and should be evaluated in-depth prior to implementation.

Berthoud should also plan to see high costs and planning efforts if and when PFAS monitoring requirements for drinking water plants are regulated. Labs that test for PFAS are overwhelmed with samples and turnaround times can be lengthy. Additional, testing is expensive and may be required monthly or quarterly. Budget in the drinking water O&M should be allocated for potential PFAS testing in coming years.

4.5.2.2 Phosphate-Based Corrosion Control

It is unknown whether the EPA will implement requirements for phosphate-based corrosion control. A pH of 7.6 is the optimal pH for phosphate-based corrosion control, if a regulation is promulgated, Berthoud WTP will need to adjust its sodium hydroxide addition for pH control. The switch to phosphate-based corrosion control will likely not be a costly implementation for Berthoud WTP, possibly only requiring minor chemical feed system replacements and improvements.

4.6 Unit Process Performance Analysis

The Berthoud WTP individual process evaluation and capacity evaluations are presented in the following sections.

4.6.1 Berthoud Water Treatment Plant

The WTP treats raw water via conventional pretreatment, gravity granular media filtration, and free chlorine disinfection before high-service pumping and distribution. Pretreatment includes coagulation, flocculation, and Lamella plate sedimentation. Powdered activated carbon (PAC) is added to the pretreatment train when needed for taste and odor (T&O) control. Disinfection to meet the 2-log virus and 0.5-log *Giardia* inactivation requirement is achieved via sodium hypochlorite addition and two baffled, below-grade clearwells. Dilute solids collected in the sedimentation basin, plus backwash water from the filters is sent to the sanitary sewer system. The WTP has a net maximum day throughput, subtracting out sedimentation basin underflow and backwash water volumes, of 4.0 MGD. Individual unit processes appear to be sized for an instantaneous flow of 4.2 MGD, which is necessary to achieve a net maximum day throughput capacity of 4.0 MGD considering the loss of water in the plate settling basin underflow and via filter backwashing.

Figure 4-2 is an aerial view of the WTP and major process facilities. Construction of the Blending Building was completed in 2022 and this facility has been overlayed in its approximate location. The Berthoud WTP consists of the following major unit processes:

- Pretreatment: A rapid mix coagulation basin, slow mix flocculation tanks, and sedimentation basins equipped with plate settlers. Nalco 8157 (an aluminized polymer) is fed for coagulation and PAC is added as needed for T&O control.
- Filtration: Four gravity filters.
- Disinfection: Two well-baffled clearwells.

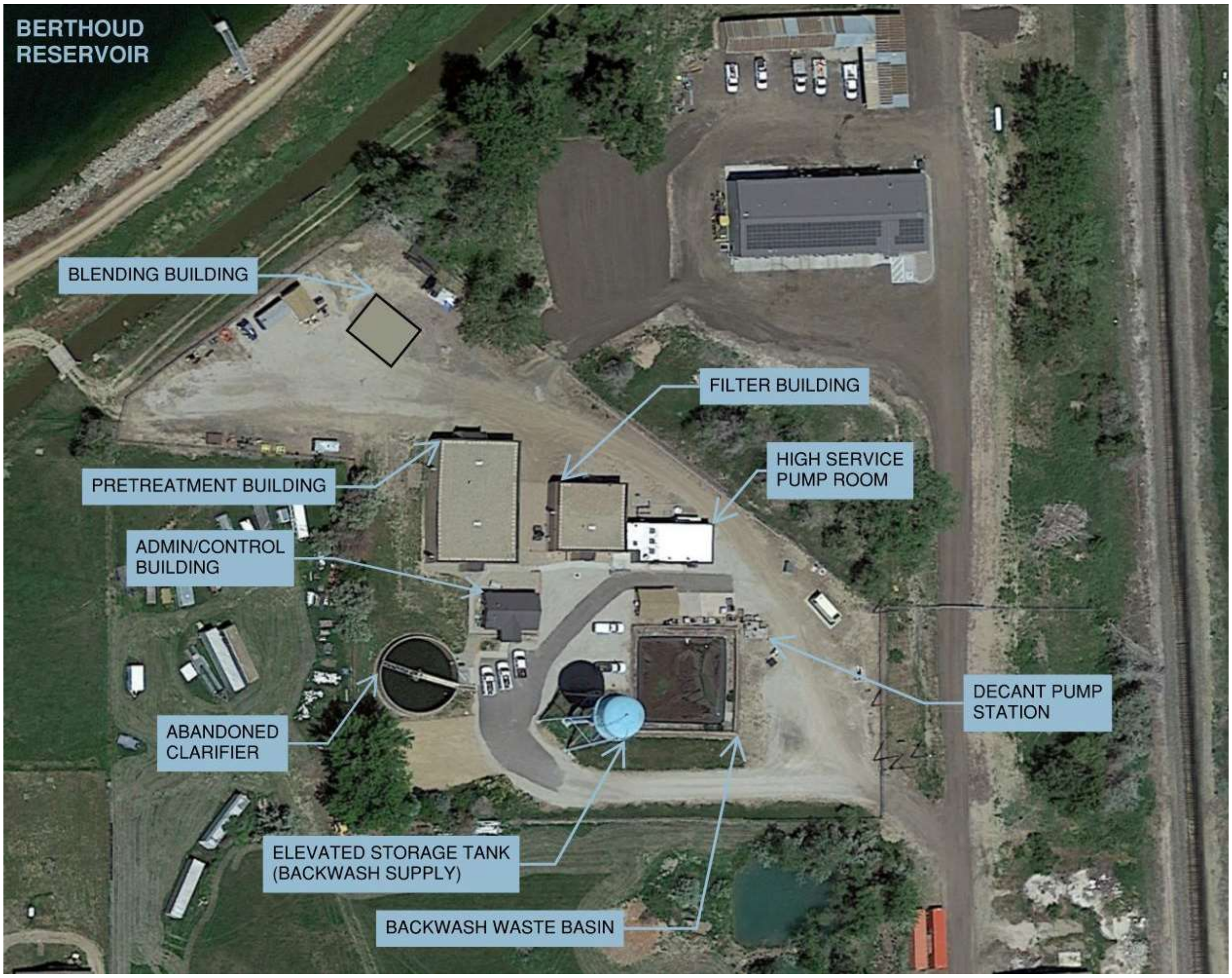


Figure 4-2: Berthoud WTP Site Arrangement

4.6.1.1 Taste and Odor Control

Raw water from Carter Lake and Berthoud Reservoir enters the WTP in the Blending Building, which allows controlled mixing of the two source waters prior to treatment. Each intake pipeline is equipped with a flow meter and PAC dose point. PAC is currently stored in 1,100-pound sacks that are hoisted into the hopper located outside of the Blending Building. The hopper sits on top of the PAC Tank, which is located below grade. The PAC is mixed with potable water within this tank using a vertical mixer and pumped into the raw water lines in the Blending Building when the operators determine it is necessary to do so for T&O control. In addition to PAC dosing in the Blending Building, the East cell of Berthoud reservoir is equipped with an LG Sonic Bouy and Solar Bee mixers to aid with water quality and T&O control.

Capacity Analysis

Table 4-9: Taste and Odor Control Design Criteria

Criteria	Units	Value
POWDER-ACTIVATED CARBON FEED PUMPS		
Quantity	-	2 (lead/lag)
Type	-	Peristaltic
Capacity	gph	3 – 102
Chemical Service	-	Powder activated carbon slurry
Maximum Attainable Dosage Rate with One Feed Pump	mg/L	10.0

Condition Assessment

PAC feed equipment was installed 2022 and became operational in December of the same year. The equipment is in new/excellent condition.

Recommendations

If T&O issues persist, increasing the dose (if possible) or increasing contact time (potentially through installing a pipe loop between the Blending Building and Pretreatment Building) would offer additional T&O control using solely PAC. Consider other long-term options include feeding potassium permanganate, chlorine dioxide, or ozone to oxidize organic T&O compounds.

4.6.1.2 Coagulation

After being treated with PAC, the raw water enters the rapid mix chamber in the Pretreatment Building. The coagulant, currently Nalco 8157 aluminized polymer, is dosed in the rapid mix chamber. The rapid mix chamber is equipped with a paddle wheel mixer. The coagulant is stored in two fiber reinforced polymer (FRP) tanks and dosed using peristaltic pumps.

Capacity Analysis

Table 4-10: Coagulation Design Criteria

Criteria	Units	Value	CDPHE Standard	× / ✓
MECHANICAL RAPID MIX				
Instantaneous Flow Capacity	MGD	4.2	NA	-
Basin Quantity	-	1	NA	-
Basin Size (L x W x D)	ft	4.0 x 4.0 x 12.5	NA	-
SWD	ft	10	NA	-
Type	-	Paddle Wheel Mixer	NA	-
HDT @ 4.2 MGD	s	31	NA	-
Velocity Gradient	s^{-1}	725	Minimum velocity gradient of 500 s^{-1}	✓
Motor Size	hp	5.0	NA	-
COAGULANT FEED PUMPS				
Quantity	-	2 (lead/lag)	NA	-
Type	-	Peristaltic	NA	-
Capacity	gph	0-5	NA	-
Coagulant Currently in Use	-	Nalco 8157 Aluminized Polymer	NA	-
Maximum Attainable Dosage Rate with One Feed Pump	mg/L wet wt	36(1)	NA	-
COAGULANT STORAGE				
Quantity	-	2	NA	-
Material	-	FRP	NA	-
Capacity	gal	3,000 each	NA	-

Note:
(1) Operators believe this is sufficient for this type of primary coagulant.

Condition Assessment

Equipment was in good condition per the site walk conducted December 12, 2022. Areas of noted deficiency are listed below:

- Piping was leaking.
- No controls or alarms on the polymer feed system.
- The mixer is not equipped with a variable frequency drive (VFD).
- The rapid mix tank is not equipped with anti-vortex baffles.

Recommendations

Consider adding a VFD on the mixer to turn down the velocity gradient to a lower level more suitable for aluminized polymer. Add controls and alarms through SCADA to the polymer feed system. Investigate and repair leaks in the floc piping. Consider installing antivortex baffles in the rapid mix tank to improve mixing while reducing energy input.

4.6.1.3 Flocculation

Following the rapid mix chamber are two flocculation trains each with a series of three tanks. Each flocculation tank is equipped with a horizontal paddle wheel mixer and the velocity gradient decreases from one tank to the next. The trains have the same design as one another.

Capacity Analysis

Table 4-11: Flocculation Design Criteria

Criteria	Units	Value	CDPHE Standard	× / ✓
Basin Quantity	-	2 (in parallel)	NA	-
Flocculator Type	-	Vertical paddle wheel	NA	-
HDT @ 4.2 MGD	min	30(1)	Minimum detention time at least 30 min	✓
FIRST STAGE				
Basin Size (L x W x D)	ft	14.0 x 14.0 x 11.3	NA	-
SWD	ft	9.8	NA	-
Motor Size	hp	1.0	NA	-
Velocity Gradient(2)	s^{-1}	117	Agitators must provide decreasing mixing energy; Target 75-100	✓
SECOND STAGE				
Basin Size (L x W x D)	ft	14.0 x 14.0 x 11.3	NA	-
SWD	ft	9.8	NA	-
Motor Size	hp	0.8	NA	-
Velocity Gradient(2)	s^{-1}	105	Agitators must provide decreasing mixing energy; Target 50-75	✓
THIRD STAGE				
Basin Size (L x W x D)	ft	14.0 x 14.0 x 12.0	NA	-
SWD	ft	9.8	NA	-
Motor Size	hp	0.5	NA	-
Velocity Gradient(2)	s^{-1}	83	Agitators must provide decreasing mixing energy; Target 25-50	✓

Note:

(1) Set weir sufficient to provide minimum HDT with sufficient freeboard at 4.2 MGD.

(2) Each agitator is meeting the state requirement of providing decreasing mixing energy; however, the agitators in the first and second stages are not able to be turned down to meet the target velocity gradient.

Condition Assessment

Flocculation tanks and mixers were in good condition per the site walk conducted on December 12, 2022. Areas of noted deficiency are listed below:

- The agitators in the first and second stages are not equipped with VFDs.

Recommendations

General best practice is to maintain a minimum value for mixing energy times detention time (GT) for flocculation of at least 100,000. Currently the Town provides a GT of 183,000 during summer months (high flow) and 329,000 during winter months (low flow) which is more than sufficient to achieve the desired conditioning of the solids prior to Lamella plate sedimentation. The addition of VFDs to the agitators in the first and second stages would allow the Town to scale back the velocity gradient to just what is required and save energy.

4.6.1.4 Sedimentation

Once through the flocculation tanks, the water and solids enter the sedimentation basin where the flocculated solids settle on the Lamella plate settlers and eventually to the bottom of the basin. Sludge from the bottom of the basin is pumped out and sent to the sanitary sewer system.

Capacity Analysis

Table 4-12: Plate Sedimentation Design Criteria

Criteria	Units	Value	CDPHE Standard	× / ✓
Number of Basins	-	2 (in parallel)	NA	-
Instantaneous Flow Capacity	MGD	4.2	NA	-
Basin Size (L x W x D)	ft	35.0 x 24.5 x 13.2	NA	-
SWD	ft	11.7	NA	-
Basin Area per Train	ft^2	857.5	NA	-
Total Volume per Basin	gal	77,000	NA	-
Number of Rows per Basin	-	3	NA	-
Number of Plates per Row	-	99	NA	-
Number of Plates per Basin	-	297	NA	-
Plate Inclination	degrees	55	NA	-
Projected Effective Area of Each Plate	ft^2/plate	19.6	NA	-
Surface Overflow Rate (SOR) at Maximum Flow	gpm/ft^2 (based on projected effective area)	0.25	Must not exceed 0.4	✓
Effective Projected Area (per basin)	ft^2	5,823	NA	-
Settling Time at Maximum Flow (4.2 MGD)	hr	0.9	NA	-
Flowrate Through Outlet Weirs	gpd/ft	17,500	Must not exceed 20,000 gpd/ft	✓

Condition Assessment

Sedimentation equipment was in good condition per the site walk conducted on December 12, 2022.

Recommendations

No action needed at this time.

4.6.1.5 Filtration

Following the pretreatment process is the filter building which houses four gravity filters in parallel. Two of the filters are original to the plant and two were installed as part of the 2017 plant expansion. The underdrains on the older filters are not the same as the newer filter underdrains. Filters are currently backwashed by water only and backwash waste is sent to the sanitary sewer system.

Capacity Analysis

Table 4-13: Filtration Design Criteria

Criteria	Units	Filter 1 & 2	Filter 3 & 4	CDPHE Standard	× / ✓
Filter Type	-	Dual-Media, Gravity		NA	-
Quantity (n)	-	4 (in parallel)		NA	-
Filter Width	ft	14		NA	-
Filter Length	ft	14		NA	-
Surface Area per Filter	ft^2	196		NA	-
Total Surface Area	ft^2	784		NA	-
Total Surface Area (n-1)	ft^2	588		NA	-
Instantaneous Flow Capacity	MGD	4.2		NA	-
Filter Loading Rate	gpm/ft^2	4.96		Must not exceed 5 gpm/ft^2	✓
Underdrain Type	-	See note 1 below.		NA	-
Minimum Backwash Rate	gpm/ft^2	15		15 gpm/ft^2	✓
Surface Wash Rate	gpm/ft^2	0.5		Minimum 50 psi	✓
Media	-	Anthracite/Sand		NA	-
TOP MEDIA: ANTHRACITE					
Depth	in	18		NA	-
Effective Size (D_{10})	mm	0.95 - 1.05		NA	-
Uniformity Coefficient	-	1.4		NA	-
Specific Gravity	-	1.40 - 1.75		Greater than 1.4	✓
L/d Ratio	-	585		NA	-
BOTTOM MEDIA: SAND					
Depth	in	12		NA	-
Effective Size (D_{10})	mm	0.45 - 0.55		NA	-
Uniformity Coefficient	-	1.4		Less than 1.5	✓
Specific Gravity	-	2.6		Greater than 2.5	✓
L/d Ratio	-	571		NA	-
COMBINED MEDIA					
Total Depth	in	16	30	Minimum of 30 inches; Media must conform to AWWA B100	× | ✓
Total L/d Ratio	-	1,156		Must be at least 1,000	✓

Note:
(1) Filter underdrain in Filters 1 & 2 are made of filter tile and were retrofitted with caps in 2012. Filter underdrain in Filters 3 & 4 are made of HDPE block with I.M.S. cap.
(2) L/d = depth of media (L)/effective size of media (d)

Condition Assessment

Filtration equipment and media condition was unable to be assessed at the site walk conducted on December 12, 2022. Plant operators have reported decreasing media depth over time and challenges with backwashing the media. Other noted areas of deficiency include:

- Only one surface wash pump is presently installed.

- No level monitoring on the filters.
- Only water backwash is presently installed.

Recommendations

It is recommended that the Town investigate the current condition of the filters, underdrains, and media. Media loss may be caused by underdrains being in poor condition or using backwash flow rates that are too high. A media change out is recommended along with adding a retrofit air wash system to provide sequential air/water wash. If surface wash is preferred by the Town/REC, a redundant surface wash pump should be installed. Add level sensors in each filter for enhanced process control.

4.6.1.6 Disinfection

After filtration, the water being treated enters the clearwells. The Berthoud WTP has two clearwells in series which are both baffled. Clearwell 1 is located below grade in the yard north of the HSPs and east of the Filter Building. Clearwell 2 is located under the high service pump room. Sodium hypochlorite is used for disinfection and is dosed in the filter building before entering Clearwell 1.

Capacity Analysis

Table 4-14: Chemical Flash Mixing Design Criteria

Criteria	Units	Value	CDPHE Standard	× / ✓
Quantity	-	1	NA	-
Type	-	Inline Static Mixer	NA	-
Diameter	in	20	NA	-
SODIUM HYPOCHLORITE FEED PUMPS				
Quantity	-	2 (lead/lag)	NA	-
Type	-	Diaphragm	NA	-
Capacity	gph	0-4	NA	-
Chemical Service	-	10% Sodium Hypochlorite	NA	-
Maximum Attainable Dosage Rate with One Feed Pump	mg/L as Cl_2	2.9	NA	-
SODIUM HYPOCHLORITE STORAGE: TANK T1001				
Quantity	-	1	NA	-
Material	-	HDXLPE	NA	-
Capacity	gal	1,350	NA	-
Containment	-	2-ft high coated containment wall approx. 4,780 gal	Must hold volume of the largest tank	✓
SODIUM HYPOCHLORITE STORAGE: TANK T1002				
Quantity	-	1	NA	-
Material	-	HDPE	NA	-
Capacity	gal	1,170	NA	-
Containment	-	2-ft high coated containment wall approx. 4,780 gal	Must hold volume of the largest tank	✓

Table 4-15: Disinfection Design Criteria

Criteria	Units	Value	CDPHE Standard	× / ✓
CLEARWELL NO. 1				
Capacity	gal	50,000	NA	-
SWD	ft	9.5	NA	-
L:W Ratio(1)	-	34:1	NA	-
CLEARWELL NO. 2				
Capacity	gal	67,000	NA	-
SWD	ft	8	NA	-
L:W Ratio(1)	-	40:1	NA	-
DISINFECTION				
Baffle Factor (2)	-	0.7	NA	-
Design Cl_2 Residual Concentration	mg/L	1.4	NA	-
CT_{10}	mg/L-mins	41	38(3)	✓

Note:
(1) Does not include end arounds.
(2) Baffle factor presented is from previous work approved by CDPHE. In general, CDPHE assigns baffle factors of 0.6 or less, unless higher ratios can be justified via tracer studies or using pipe reactors.
(3) Based on achieving 0.5-log of *Giardia* inactivation using the highest pH and lowest temperature at which the peak instantaneous design flow of 4.2 MGD could occur.

Condition Assessment

Disinfection equipment was in good condition per the site walk conducted on December 12, 2022. While the clearwells are 30–40 years old, the concrete that comprises them is in good condition, likely because they are covered basins that are continuously submerged, not subject to freeze/thaw and have a ‘light duty’ application. Other noted deficiencies are listed below:

- It is recommended that the maximum attainable chlorine dose (as Cl_2) be in the range of 4 to 5 mg/L. The sodium hypochlorite feed pumps do not have sufficient capacity to achieve this range.
- Sodium hypochlorite feed is monitored indirectly via finished water chlorine residual and is not automated.
- Based on current conditions, the Town has 19 days of sodium hypochlorite storage at peak demand.

Recommendations

It is recommended that automatic flow monitoring be added to the sodium hypochlorite feed pumps to provide direct feed monitoring and alarms. The current firm capacity of the hypochlorite feed pumps is not sufficient to cover the full range of dosing needed for the maximum capacity of the plant. It is recommended to leave the current pumps in place and add two, 8 gph (each) pumps of the same type. This will cover a wider range of dosage requirements. It is also recommended that the sodium hypochlorite storage be increased.

4.6.1.7 Corrosion Control

Corrosion control is provided via pH adjustment using sodium hydroxide, which is blended into the filtered and disinfected water via static mixer in the high service pump room downstream of the HSPs.

Capacity Analysis

Table 4-16: Corrosion Control Design Criteria

Criteria	Units	Value
SODIUM HYDROXIDE FEED PUMPS		
Quantity	-	2 (lead/lag)
Type	-	Peristaltic
Capacity	gph	0.2 – 5.0
Chemical Service (Diluted)	-	8% Sodium Hydroxide
SODIUM HYDROXIDE STORAGE		
Quantity	-	1
Material	-	IBC Tote
Capacity	gal	300
Chemical Service	-	50% Sodium Hydroxide
Containment	-	Ultra Tech P1 Bladder System

Condition Assessment

Sodium hydroxide storage and feed equipment was in good condition per the site walk conducted on December 12, 2022. The system appears to be of adequate capacity as the Operations Staff has not reported an inability to meet a pH placing calcium carbonate precipitation potential (CCPP) within the desired 4-10 mg/L as $CaCO_3$ range. Areas of deficiency are noted below:

- The corrosion control system is indirectly monitored by pH.

Recommendations

It is recommended that flow pacing controls, possibly with pH trim, be added to the sodium hydroxide feed pumps. Feed pump and pH alarms should be added since OCCT is to be provided continuously.

4.6.1.8 Fluoridation

The original powder feed fluoride system is no longer in place. At this time, the Town does not have plans to install a new system. The fluoridation room is vacant and can accommodate new equipment should fluoridation be pursued in the future.

4.6.1.9 High Service Pumps

The Town currently has two HSPs pumps, each of which draw treated water from the end of Clearwell 2 and pump it to the elevated storage tank onsite and the ground storage tank near the Heron Lakes subdivision. There is an equipment pad for a third pump in the HSPS. The Town is in the process of adding a third HSP in 2023 or 2024.

Capacity Analysis

Table 4-17: High Service Pumps Design Criteria

Criteria	Units	Value	CDPHE Standard	× / ✓
Quantity	-	2 (parallel)	NA	-
Type	-	Vertical Turbine	NA	-
Capacity (each)	MGD	2.0	NA	-
Existing Capacity (firm)	MGD	2.0	4.0	×
Future capacity with 3 identical pumps (firm)	MGD	4.0	4.0	✓
TDH	ft	187	NA	-
Power	-	480 Volt, 3 Phase	NA	-
Horsepower (each)	hp	100	NA	-

Condition Assessment

The equipment was in good condition per a site walk conducted December 12, 2022. Areas of noted deficiency are listed below:

- The plant does not have firm capacity to meet peak summer MDD of 4.0 MGD. Potable water supplied by LTWD is available as a supplemental supply if one HSP is out of service.

Recommendations

Install the third high service pump as quickly as possible to ensure the WTP has the firm capacity to supply its full, 4.0 MGD (2,800 gpm) net throughput capacity to the distribution system.

4.6.1.10 Backwash/Solids Handling

The filter backwash waste is currently sent to the backwash waste basin onsite and gravity fed to the sanitary sewer system. Solids from the sedimentation basin are pumped/metered into the sanitary sewer system.

Recommendations

No action needed at this time.

4.6.2 Distribution System

The distribution system consists of over 418,000 linear feet of water main ranging between 4-inch diameter to 20-inch diameter. The existing system has two pressure zones. The higher pressure zone is in the northwest corner of the Town, the Heron Lakes subdivision and a few adjacent neighborhoods, which contains the existing 3 MG storage tank and BPS. The storage tank and WTP directly feed the lower pressure zone which is the remaining part of the Town.

4.6.2.1 Booster Pump Station

Assets

The BPS is connected to the storage tank and feeds the high pressure zone near the Heron Lakes developments. The booster pump station was constructed in 2014 and consists of a 33-foot by 15-foot aboveground building. The building houses four pumps, piping, valves, electrical panels, and variable frequency drives (VFDs). The pump characteristics are summarized in Table 4-18. The large 60 horsepower (hp) pump was not included in the original construction of the station and was added at a later date.

Table 4-18: Booster Pump Station Characteristics

BERTHOUD BOOSTER STATION		
Location	**TPC Parkway and Grand Market Avenue**	
Main Size (in)	12	
Main Material	DIP	
Pump Types	Horizontal centrifugal	
Number of Pumps	4	Rotating duty
Duty Pumps (#1/#2)		
Drive	VFD	
Flow Rate (gpm)	250	each
TDH (ft)	170	
Power (hp)	25	each
Jockey Pump		
Drive	VFD	
Flow Rate (gpm)	80	each
TDH (ft)	170	
Power (hp)	10	each
Large Pump		
Drive		
Flow Rate (gpm)	850	each
TDH (ft)	170	
Power (hp)	60	each

Condition Assessment

There are no known operational issues with the booster pump station. The existing capacity meets all required design criteria under existing modeled conditions, however, there are known instances where the Little Thompson Water District (LTWD) interconnections need to be activated to provide supplemental flow to meet the demand.

Recommendations

Based on future development that is served by this BPS the pumps will need to be replaced and upsized to accommodate future growth. This can be accomplished through incremental expansions to the BPS. The two expansion projects at the BPS include first upgrading the pumping capacity to 2,808 gpm to accommodate 5-year peak hour demands and then upgrading the pumping capacity to 3,254 gpm to accommodate 20-year peak hour demands. These upgrades are expected to be completed within the existing building footprint.

4.6.2.2 Storage Tank

Assets

The distribution system has one existing storage tank. The tank is constructed of precast concrete panels and was erected in 1981. It is located near the Heron Lakes subdivision, the naturally higher area of the Town. The tank has a diameter of 129-feet and a height of 32-feet which results in a capacity of 3 MG. The distribution system's only booster pump station is located directly adjacent and northeast of the storage tank. The WTP has a HSPS that directs flow to the water storage tank through a 14-inch and 20-inch transmission main. The booster pump station sends flow to the higher-pressure zone in the Heron Lakes subdivision on the northwest side of the Town. The storage transmission main does have service connections directly connected by means of a pressure sustaining valve. The storage tank gravity feeds the rest of the town to create the lower pressure zone. The water storage tank, booster station, and transmission main feeding the storage tank are shown in Figure 4-3.

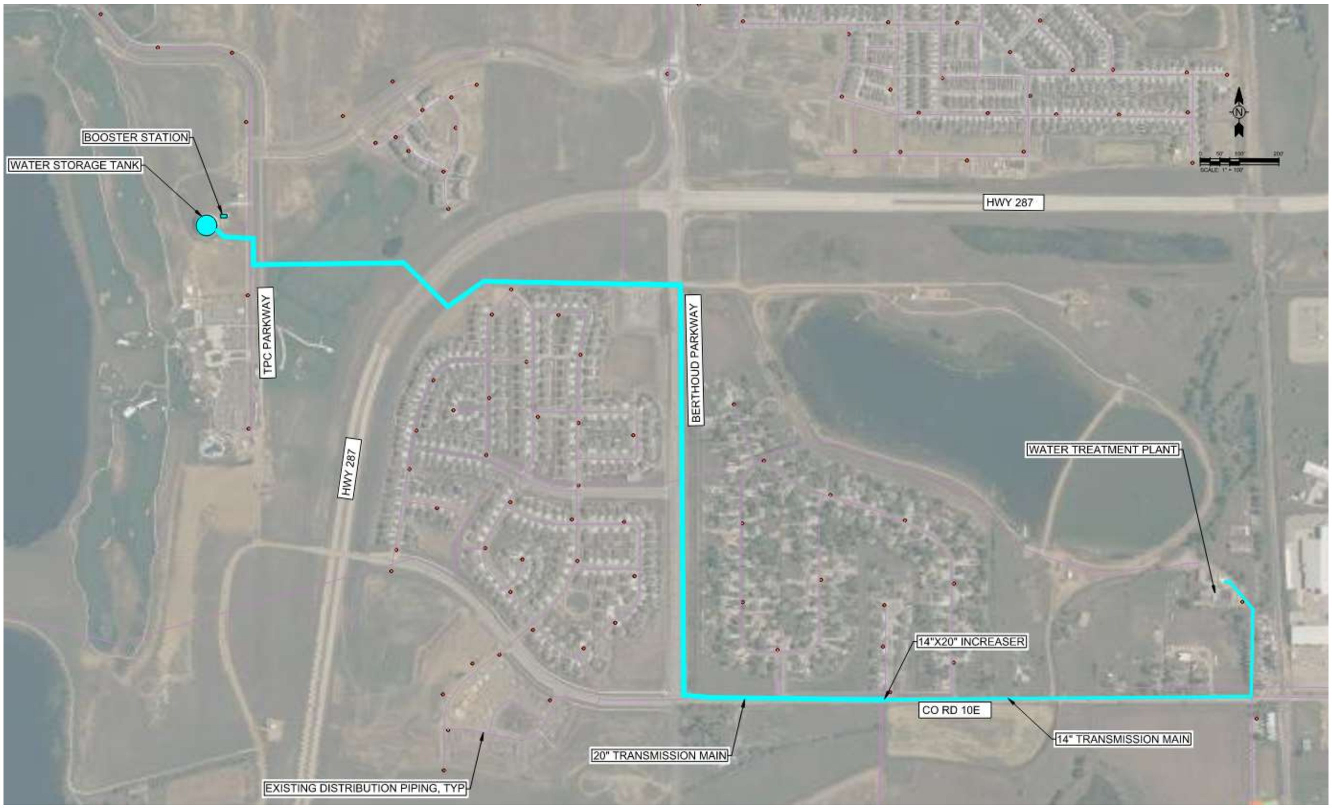


Figure 4-3: Booster Station and Storage Tank Location Map

The tank finish floor elevation is 5,189.00 feet, with a dome base elevation of 5,221.00 feet. The flow from the storage tank is primarily routed through the booster pump station, however, during peak flow demands there is a gravity feed to the lower pressure zone through a separate water main. When the tank reaches the Low-Low Water Level (LLWL) the northern LTWD interconnection is automatically opened to supply the necessary flow demand.

Tank elevation data received between 2018 through 2022 was utilized to assist in calculating the full flow to distribution.

Existing Capacity Assessment

The 3 MG storage tank was evaluated for capacity based on flow data provided by the Town. The data was provided in 15-minute increments over 5 years, 2018 through 2022, for the WTP HSPs and the BPS. This data was used to calculate overall distribution demand for the system. As previously discussed in Section 4.6, the storage tank analysis utilized the most recent data set for summer months which was year 2022. The distribution demand is summarized in Table 4-19. Based on the population of Berthoud in 2022 the AADD per person was calculated as 140 gpcd.

Table 4-19: Storage Assessment Flow Demand

Category	Existing Flows 2022	Future Flows 2043	Ratio Future to Existing
Population	11,717	66,516	5.74
AADD (MGD)	1.62	9.31	
MDD (MGD)	3.80	21.85	
PHD (MGD)	7.07	40.63	
MDD/AADD	2.35	2.35	Same
PHD/AADD	4.36	4.36	

The summer months result in the highest water demand primarily due to irrigation demands. Due to high water demands in July, water demand data was pulled for several days to complete this analysis. The WTP will deliver the MDD and the tank will provide flows during the PHD. Figure 4-4 plots a graph over a 24-hour cycle on July 18th depicting the flow demands against the MDD that will be provided by the WTP. The tank provides supplemental flows for the periods when the demand rises above the MDD. The area between the curves – the source of the equilibrium flow – shows that the required equilibrium capacity is about 0.61 MGD, or approximately 16% of the MDD. Fire Flows will require an additional 1,500 gpm for 4 hours, or 0.36 MGD. Adding these two requirements, 0.61 MG equilibrium storage and 0.36 MG fire-flow requirement, results in a total required storage of 0.97 MG.

As a double check, a 4-day analysis was completed to analyze consistent high-flow demand days against the provided storage. This exercise evaluated the storage available during a 4-day window over 15-minute increments to verify the levels are maintained and sufficient fire flows are provided during the highest demand period for the Town. This analysis is included in Figure 4-5, which depicts the flow demand data, MDD, Storage Available (with a corresponding trend line), and the required fire flow volume. Figure 4-5 indicates that, even during the highest flow-demand periods, there was a minimum of 2 MG stored in the tank, well above the required fire flow storage of 0.36 MG.

In short, the existing storage tank provides more-than-sufficient storage for existing conditions.

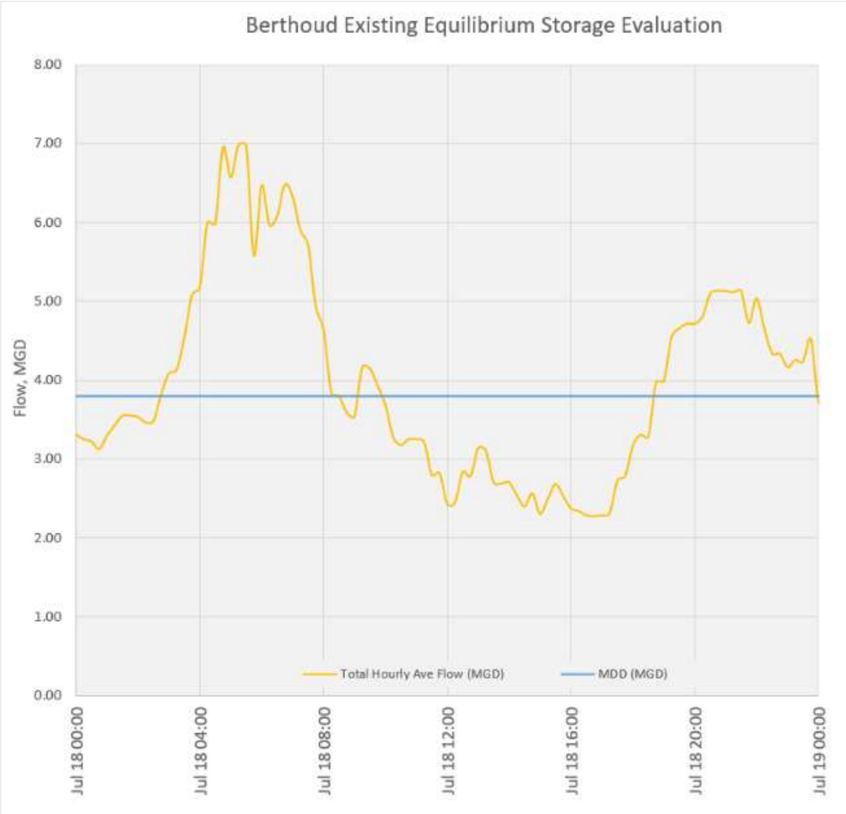


Figure 4-4: Existing Equilibrium Storage

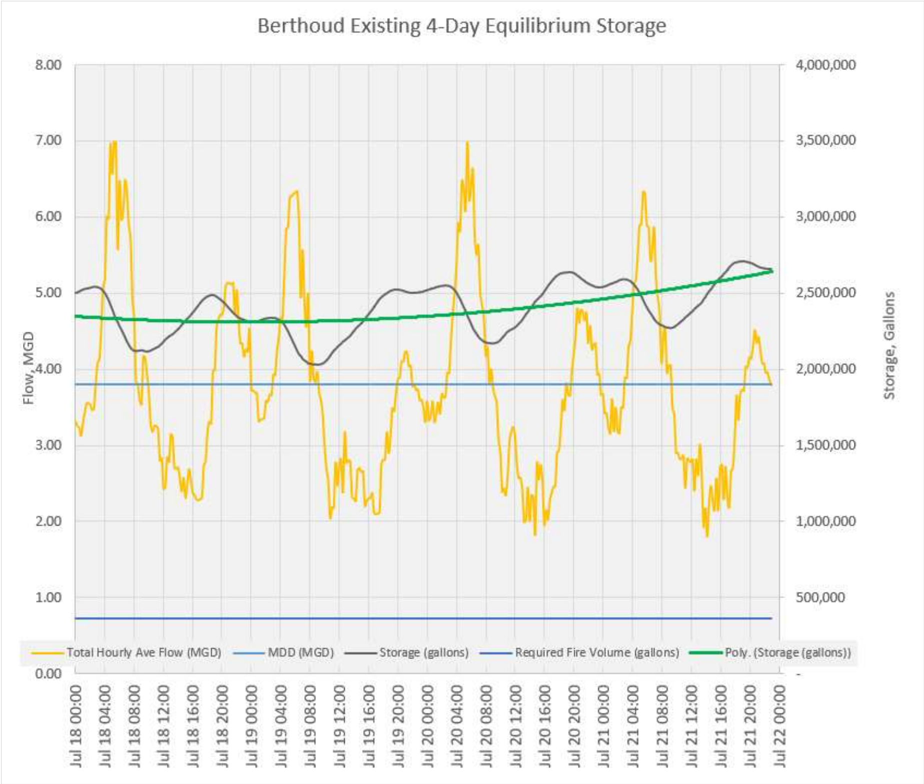


Figure 4-5: Existing Storage 4-Day Analysis

Future Capacity Assessment

The 40-year buildout for the Town is projected to increase population from 11,717 people (2022) to 66,516 people (2043). To accommodate this increase in population, a storage evaluation was completed for the same 20-year period to assess the distribution system under full buildout conditions.

Similar to the existing storage system, storage was assessed under projected future flows. Projected flows are summarized in Table 4-19. Projected flows were based on the flow data received from the Town, using a simple extrapolation based on population. For example, the 2022 AADD (1.61 MGD) was multiplied by a factor of 5.74 to project the Year 2043 AADD of 9.31 MGD.

The 15-minute incremental flow data was multiplied by this factor to generate a new daily flow demand curve. Figure 4-6 plots a graph over a 24-hour cycle to show the flow demands against the MDD that will be provided by the WTP. The tank is responsible for providing flows for the periods when the demand rises above the MDD, projected to be 21.85 MGD. This area between the curves is calculated and results in a required equilibrium capacity of 3.43 MG, or approximately 16% of the MDD. Fire Flows were estimated as providing 1,500 gpm for 4 hours, a total of 0.36 MGD. This results in a total required storage of 3.79 MGD. The existing storage tank has 3 MG storage, so the remaining required storage is 0.79 MG. In order to provide some additional flexibility and storage to the east zone, a 1.5 MG storage tank would be recommended.

As a double check, a 4-day analysis was completed for each zone, the main part of Town to the West and the new development area to the east by I-25. The 4-day analysis looked at consistent high-flow demand days against the provided storage. This exercise evaluated the storage available during a 4-day window over 15-minute increments to verify the levels are maintained and sufficient fire flows are provided during the highest demand period for the Town.

The flow demands split between the east and west zones are summarized in Table 4-20. It was assumed that the two water treatment plants would be sized equally to meet the full MDD of 21.85 MGD. The sizing of the water treatment plant will be dependent on water rights, water sources, areas of development, and plant expansion possibilities, among other factors. This analysis is shown in Figure 4-7 and Figure 4-8 for the east zone and west zone, respectively. These graphs show the flow demand data, MDD, Storage Available (with a corresponding trend line), and the required fire flow volume. The figures indicate that the minimum required fire flow volume is provided in each tank even during the highest flow demand periods.

Table 4-20: Proposed Storage Assessment Demand

Category	Total	East Zone	West Zone
Population	66,516	11,000	55,516
AADD (MGD)	9.31	1.54	7.77
MDD (MGD)	21.85	3.61	18.24
PHD (MGD)	40.63	6.72	33.92
MDD/AADD	2.35	2.35	2.35
PHD/AADD	4.36	4.36	4.36

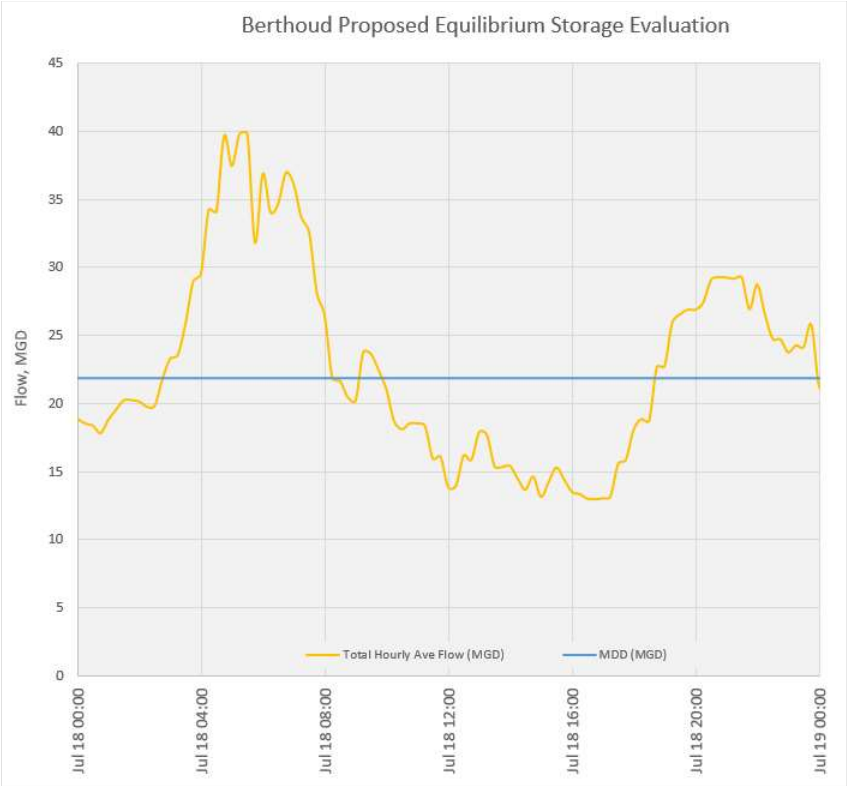


Figure 4-6: Proposed Equilibrium Storage

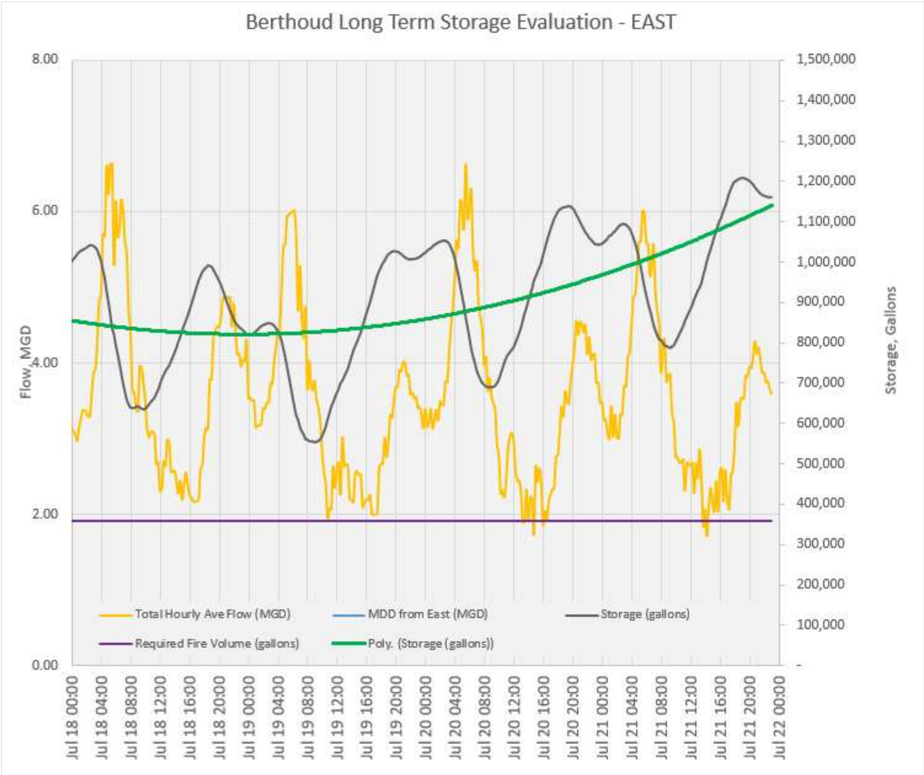


Figure 4-7: Proposed Storage 4-Day Analysis, East Zone

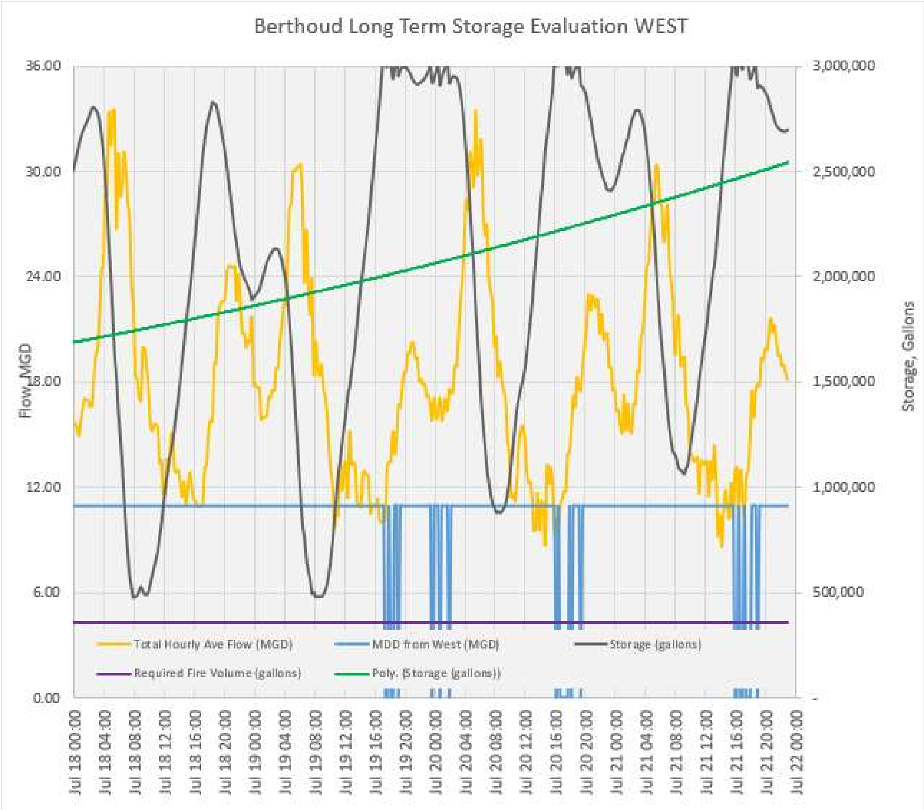


Figure 4-8: Proposed Storage 4-Day Analysis, West Zone

In summary, there will need to be approximately 1.5 MG of additional storage to prepare for full 40-year buildout. Since there is significant development on the far-east side near I-25 (approximately 11,000 people) and the existing storage tank is on the far-west side, the new storage tank is recommended to be located by I-25 on the east side of Town. This will help to balance pressures within the system, especially during high-demand periods. The distribution systems between the western portion of Town and the eastern portion of Town near the new tank will need to be connected by a large transmission main to provide this balance of flows and pressures.

It is recommended that the tank is located near the proposed treatment plant site and utilize the high service pumps (HSPs). These pumps will need to be sized to accommodate the east zone's WTP full treatment capacity of 10.92 MGD as well as the east zone's PHD. The WTP MDD covers all of the demand for the east zone (3.61 MGD) and partially for the west zone. The east zone PHD is 6.72 MGD, and since the MDD pumping capacity of 3.61 MGD is already accounted for, the pumps need to accommodate the 3.11 MGD difference. This results in a WTP HSPS pumping capacity of approximately 14 MGD. If the HSPS is sized for the full 14 MGD, a booster station is not required. The total of 4.5 MG of storage will have the ability to be conveyed to the west zone of the distribution system. Since each plant is estimated to treat and deliver 10.92 MGD, the east zone will be responsible for sending flow back to the west zone at a peak rate of 9.2 MGD to help accommodate the MDD and PHD. This transmission main will be sized for a full 10 MGD to allow for additional peak hour or fire flow pumping if necessary. Additional flow can be delivered to the west zone; however, it will not meet the required design criteria of 2 ft/1000 ft for large transmission mains.

Condition Assessment

A tank inspection was completed on December 1, 2018. An exterior inspection and interior inspection (using a dive team) was completed. The dive team removed sediment from the bottom of the tank ranging from 1/8-inch to 2-inches in depth. Sediment composition was primarily iron, manganese, concrete popouts, and insects. Minor corrosion, concrete spalling, and cracking was noted.

Recommendations

The existing tank is in good condition but should be cleaned every 3-5 years per AWWA standards. A tank cleaning is currently due based on the last record of inspection and cleaning. No other improvements for the existing tank are necessary at this time.

A new 1.5 MG storage tank should be provided by I-25 as part of the 20-year CIP to accommodate the future expected buildout.

4.6.2.3 Linear Assets

Assets

The Town's distribution system has a primary network which is fed by the WTP, Storage Tank, and Booster Pump Station. The Town of Berthoud's distribution system consists of 418,435 linear feet of water main ranging in size from 4-inch diameter to 20-inch diameter. The full breakdown of linear assets by diameter is summarized in Table 4-21.

Table 4-21: Water Main Inventory By Size

Water Main Diameter (in)	Length (ft)
4	5,902
6	53,194
7	250
8	257,006
10	651
12	81,479
14	4,112
16	8,565
20	7,276
Total:	**418,435**

There are two other smaller and independent distribution systems with Berthoud that are fed by separate LTWD interconnections:

- The Serenity Ridge subdivision by I-25.
- Love’s truck stop, just north of Serenity Ridge.

Critical to operation are two normally closed valves near Water Avenue and Berthoud Parkway. These valves separate the high-pressure zone from the low-pressure zone. These closed valves are shown on Figure 4-12. In the primary distribution system, there are three LTWD interconnections. These interconnections are automatically activated when there is a higher-than-normal flow demand.

The lower pressure zone is fed directly from the WTP HSPs and gravity flow from the storage tank during high flow demand periods. The higher pressure zone is fed from the storage tank and booster station.

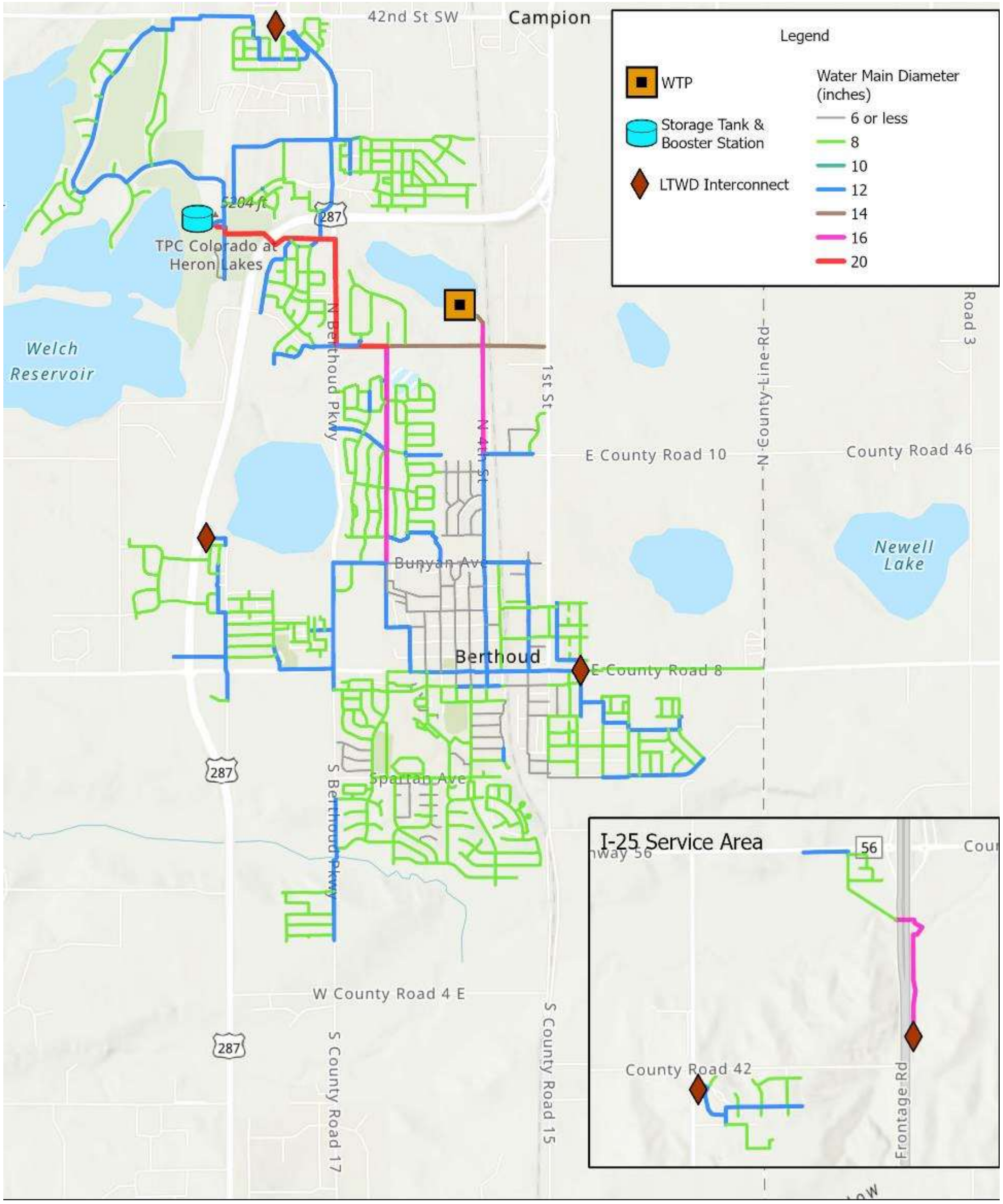


Figure 4-9: Water Main Distribution Network

Recommendations

It is encouraged that water mains undergo a routine flushing program and records kept for local pressures, water main breaks or maintenance activities. Any problem areas should be considered for a replacement-in-kind capital improvement project.

4.6.3 Asset Risk Assessment

As part of the infrastructure condition evaluation, a risk assessment was performed on the process units under Town ownership. This assessment captured the most prominent failure scenarios and their likelihood of occurrence (LoF); the consequence of failure of a unit process (CoF); and the resulting risk score (LoF x CoF). The derived risk scores have been used as a driver for prioritization of capital improvement projects in Section 4.9.

The consequences, likelihoods and risks for unit processes at the Berthoud WTP and throughout the distribution system are presented in Table 4-22. These results categorize the unit processes from most to least vulnerable based on their current condition, with a high score indicating heightened risk. The full risk matrix with scoring is presented in **Appendix A**. Safeguards, defined as precautions taken to mitigate the likelihood and/or severity of a failure, are presented in the risk matrix.

Table 4-22: Berthoud WTP and Distribution System Asset Risk Assessment Summary

Unit Process	Consequence of Failure	Likelihood of Failure	Risk Score
Carter Lake Water Supply	15	Unlikely	30
Other Raw Water Supply	26	Unlikely	52
Blending Facility/Corrosion Control	12	Possible	36
Rapid Mixing	13	Possible	39
Flocculation	18	Possible	54
Sedimentation	20	Possible	60
Filtration	20	Possible	60
Disinfection	20	Possible	60
High-service Pumps	21	Possible	63
Caustic Soda Storage/Feed Systems	13	Possible	39
PAC Storage/Feed Systems	13	Possible	39
Polymer Storage/Feed Systems	18	Possible	54
Sodium Hypo Storage/Feed Systems	19	Possible	57
SCADA Systems	14	Possible	42
Cybersecurity	29	Possible	87
Elevated Storage Tank	12	Unlikely	24
3.0 MG Storage Tank	26	Unlikely	52
Booster Pump Station	19	Unlikely	38

4.7 Hydraulic Evaluation

Hydraulic evaluations were performed for the Town's water system, including the existing WTP and distribution system. A proprietary hydraulic profile calculation spreadsheet was used to calculate the hydraulic profile through the existing WTP. The intent of this analysis was to identify any hydraulic bottlenecks or restrictions. InfoWater was used to analyze system-wide demands for existing and future water supply scenarios.

4.7.1 Water Treatment Plant

A hydraulic evaluation was performed on the existing WTP under existing and future flow conditions. The following flow scenarios were conducted:

1) 2.2 MGD for ADD
2) 3.8 MGD for PHD
3) 4.2 MGD for future PHD and rated capacity of the WTP
4) 5.2 MGD for future plant expansion

The hydraulic evaluation strictly analyzed the gravity system through the plant and does not evaluate the capacity of pumped systems.

4.7.1.1 Existing System

A model was developed for the existing WTP and evaluated using the varying flow rates to identify any existing or future capacity restrictions. Figure 4-10 summarizes the hydraulic profiles of each. It was discovered that performing backwash operations at the manufacturer recommended 6-feet of headloss through the filters creates hydraulically unfavorable conditions in the process at high flow rates. These headlosses cause the water level to rise above the top of the sedimentation basins and flocculation tanks. There is a 14-inch diameter pipe between the sedimentation basins and the filters where 100% of the flow is conveyed, this could also be contributing to a bottleneck in the system causing an excess of headloss, especially during higher flow rates. Reducing the headloss through the filters which triggers a backwash during high flows would provide favorable hydraulic conditions upstream of the filters, specifically in the sedimentation basin. Based on available information, the control elevation within the filter basins is 5,102.00 feet. If this control elevation can be adjusted while not sacrificing performance of the filters, the hydraulic profiles may be lowered, offering another solution.

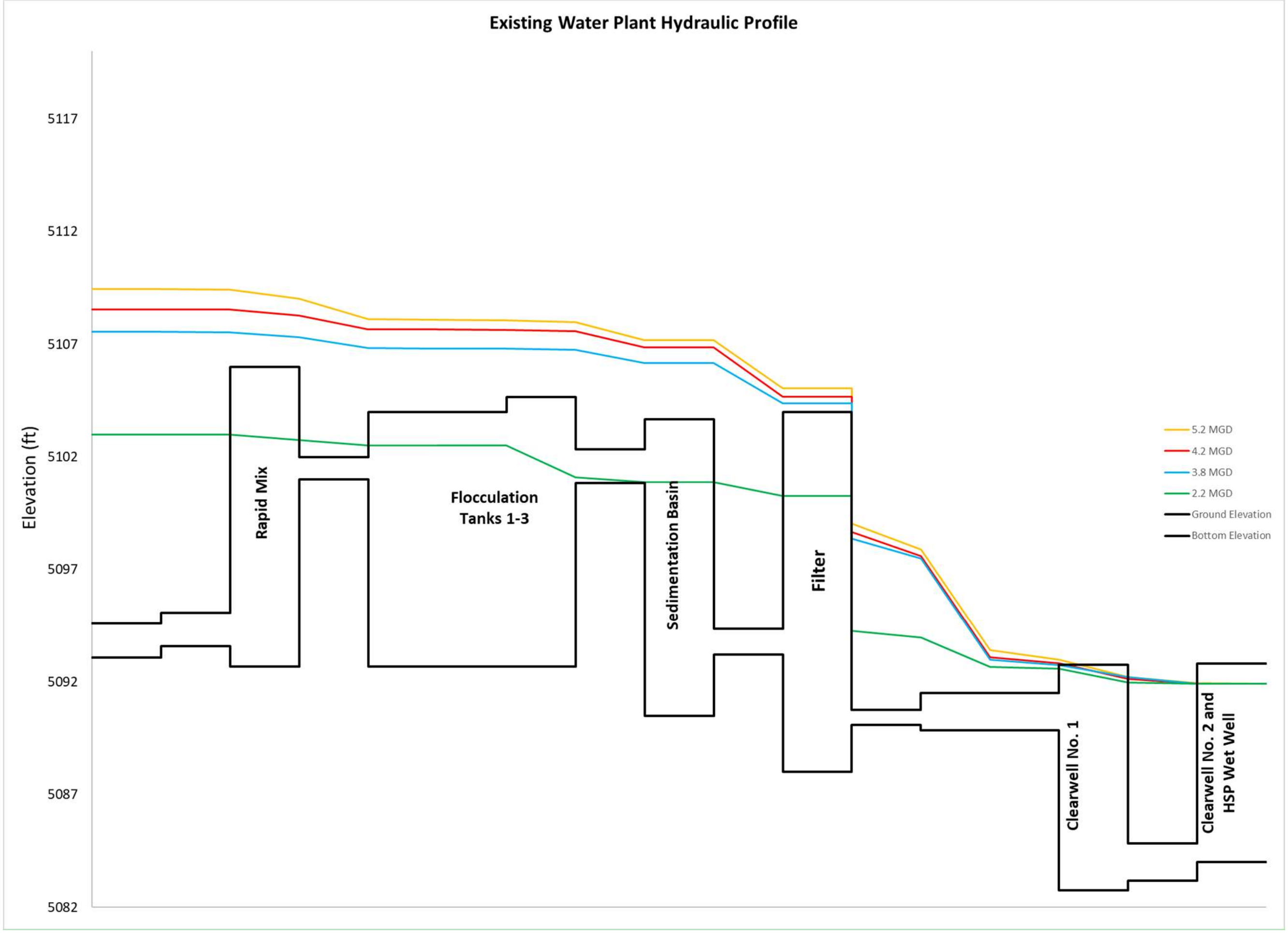


Figure 4-10: Existing WTP Hydraulic Profile

4.7.1.2 Proposed System

In addition to the recommendations above, another solution to reducing headloss between the filter basins and sedimentation basins is to upsize the 14-inch underground pipe between the sedimentation basins and the filters. It is estimated that a 20-inch parallel pipe would give the system sufficient conveyance capabilities to convey future flows. The future hydraulic profile with the proposed upgrade and adjusted headloss through the filters is shown in Figure 4-11.

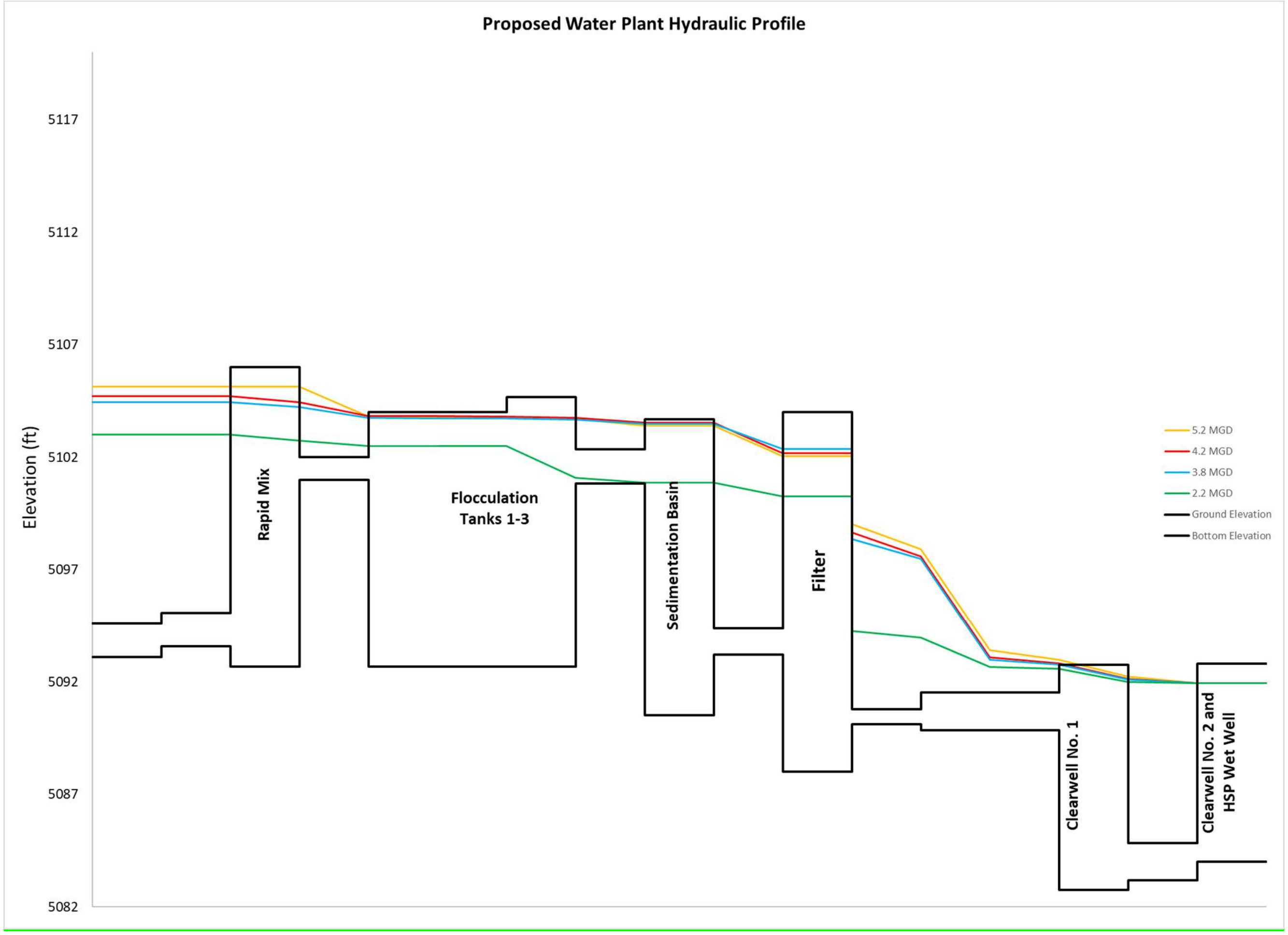


Figure 4-11: Proposed WTP Hydraulic Profile

4.7.2 Distribution System

4.7.2.1 Hydraulic Modeling

The Town's distribution system was hydraulically modeled utilizing InfoWater. The Town provided Tetra Tech with an existing WaterCAD model which covered approximately 60% of the existing system. The model includes transmission mains, storage, and pumping systems, as well as some 8-inch and 10-inch mains for distribution redundancy. Hydraulic modeling flow scenarios include:

5) Current Conditions, ADD Flow Rates

6) Current Conditions, Peak Day Demand (PDD) Flow Rates

7) Current Conditions, Fire Flow Demand (FFD) Flow Rates

8) 5-Year Projection Conditions, PDD Flow Rates

9) 20-Year Projection Conditions, PDD Flow Rates

The Town of Berthoud Design Standards and Construction Specifications do not dictate the methodology for estimating water demand on a large-scale basis. Tetra Tech developed an estimate based on average water demands and associated peaking factors, outlined below.

Industry standard range for average daily water demand is 120 to 140 gpcd. Typical peaking factors range from 1.1 to 1.4 for maximum month, 1.6 to 2.2 for maximum day, and 2.25 to 3.2 for maximum hour. Tetra Tech received Town record historical flow data in 15-minute increments from 2018 through October 5,2022. The historical data included WTP HSP flows, water storage tank elevations, and booster pump station flows. This flow was analyzed to calculate an ADD, MDD, and PHD. Due to the number of errors and zero values found in the 2018 data, it was not included in the flow analysis.

The annual flow data provided by the Town is summarized in Table 4-23. Compared to other communities, the MDD/ADD Ratio and the PHD/ADD Ratio are both relatively high. The number of greenspaces or parks that require irrigation during the summer months can cause the PHD to be higher than expected. The ADD and PHD flow rates were cross-checked with the hydrant test data (Section 4.9.2.2). These ADD and PHD values were used, unchanged, to calibrate the hydraulic model.

Table 4-23: Historical Flow Data

Year	ADD (MGD)	MDD (MGD)	PHD	MDD/ADD Ratio	PHD/ADD Ratio
2018	-	-	-	-	-
2019	1.21	2.76	5.01	2.27	4.13
2020	1.50	3.25	5.88	2.17	3.93
2021	1.63	3.59	6.71	2.20	4.11
2022	1.62	3.80	7.07	2.35	4.36

The operating design criteria, as specified in the Town of Berthoud Design Standards and Construction Specifications, are:

- Pressure in the distribution system shall be between 45 psi and 100 psi, during normal operating conditions.
- Pressure fluctuation at any location between PHD and Minimum Hour Demand (MHD) shall not exceed 30 psi.
- Headlosses shall be below the limits specified in Table 4-24 under max hour flow conditions.

Table 4-24: Headloss Design Criteria

Main Type	Size	Headloss per 1,000 ft
Distribution	6" through 12"	2 ft
Transmission	16"	2 ft
Transmission	20"	1.5 ft

- FFD shall provide minimum 20 psi residual pressure in all areas.
- Generally, 1,500 gpm Available Fire Flow (AFF) is acceptable.
  - After evaluating the distribution system and working directly with the Town, it was determined that the headloss criteria could be modified and increased provided it maintained minimum pressures throughout the system under PHD scenarios. This would allow for more reasonable sizes of new infrastructure and would save the Town a significant amount of money in the CIP. Multiple iterations of the hydraulic model were evaluated to optimize the distribution system infrastructure sizing.

Deviations of the design criteria are fully summarized in this master plan. Recommendations to resolve any failed design criteria or mitigate negative effects of failed design criteria are presented. Conformance of the specified design criteria will be identified utilizing the hydraulic modeling scenarios and flow scenarios presented in Table 4-25.

Table 4-25: InfoWater Hydraulic Modeling Scenarios

Flow Condition	Scenario	Flow Type	Purpose
Current Condition	1	ADD, MHD	Identify Maximum Pressures
	2	MDD, PHD	Identify Minimum Pressures, Headlosses
	3	FFD, MDD	Identify Operating Pressures
5-Yr Condition	4	MDD, PHD	Identify Minimum Pressures, Headlosses
20-Yr Condition	5	MDD, PHD	Identify Minimum Pressures, Headlosses

4.7.2.2 Hydrant Flow Tests

Fire hydrant flow tests were conducted to calibrate the hydraulic model. The locations of the hydrants were strategically selected to collect the static and residual pressure while using an adjacent hydrant. The flow tests conducted by the Town were an average of two minutes long and major operational effects to the storage tank and booster station were generally not observed. The hydrant locations, where pressure was measured are summarized in Figure 4-12. The flow test results are summarized in Table 4-26.

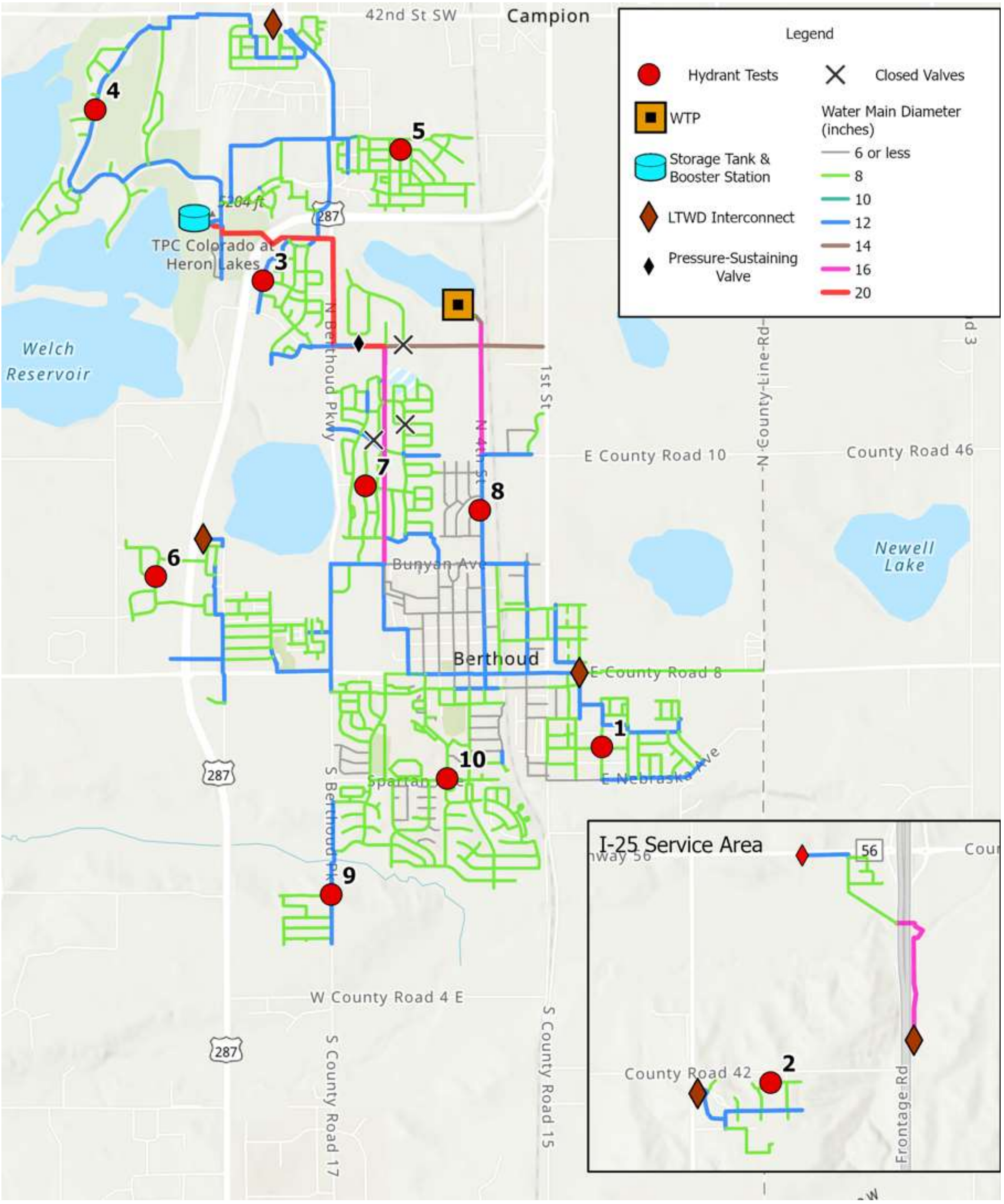


Figure 4-12: Hydrant Flow Test Locations

Table 4-26: Hydrant Flow Test Results

Flow Test Number	Static Pressure at Hydrant	Residual Pressure at Hydrant	Flow Rate (gpm)
1	88	67	1250
2	65	25	650
3	82	33	840
4	76	41	1100
5	87	36	920
6	50	27	700
7	53	49	1000
8	61	-	-
9	80	58	1215
10	78	69	1250

4.7.2.3 Current Condition Results

The results of the existing system's hydraulic model are illustrated on Figure 4-13 through Figure 4-16.

Overall, the existing water distribution system is in good condition. Figure 4-13 illustrates the lower elevation areas of the two pressure zones exceed the 100-psi maximum pressure design criteria. Figure 4-14 illustrates that the majority of the Town is above minimum pressure design criteria, except for the development just west of US-287 which is exhibiting pressures of 40 psi. There are also low-pressure notifications for the 20-inch transmission main feeding the storage tank. The low pressures in this segment are by design and to not pose concern as no direct service laterals are currently connected to it.

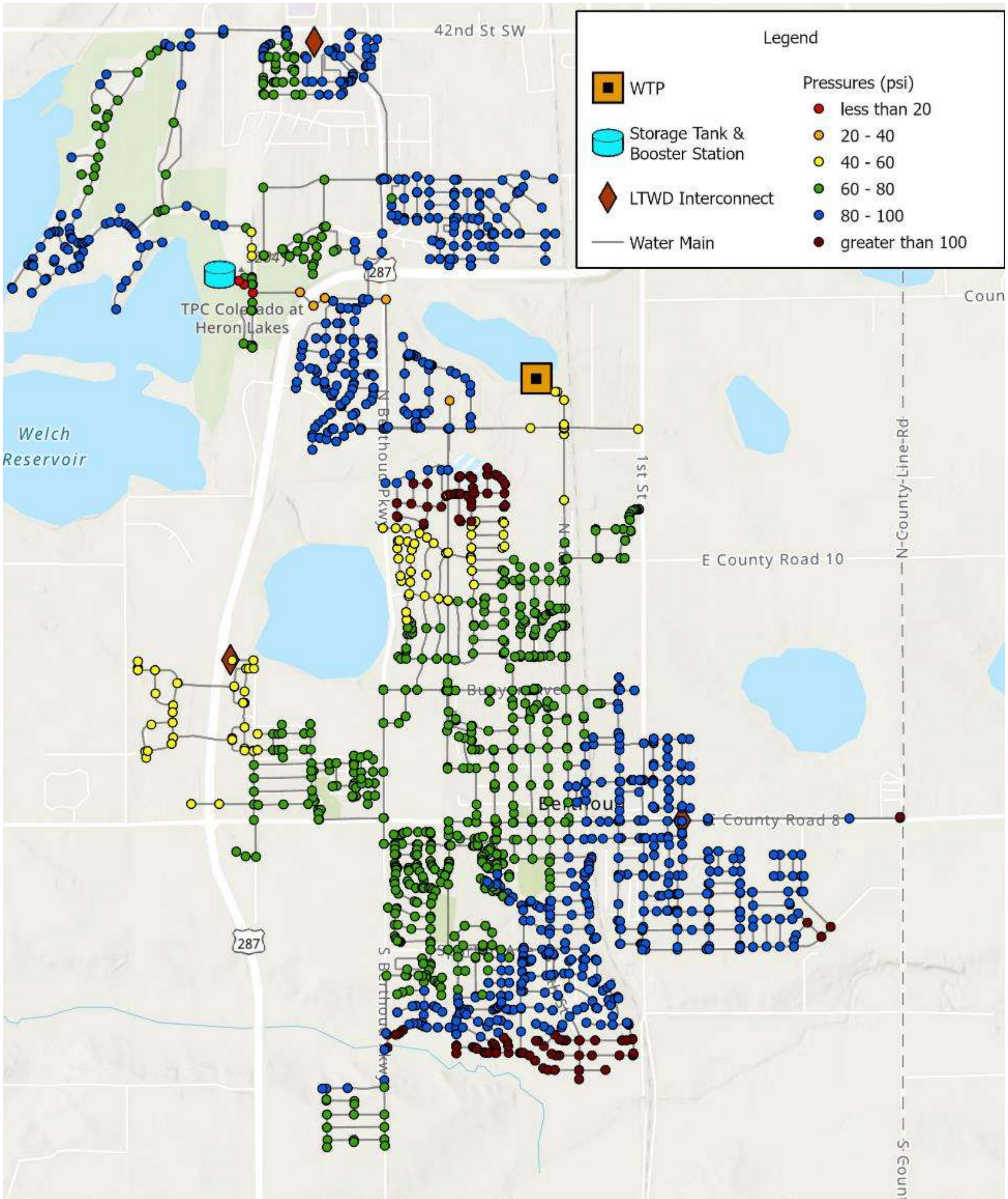


Figure 4-13: Scenario 1 | Current Conditions, Average Day Demand, Minimum Hour Flow, Maximum Pressures

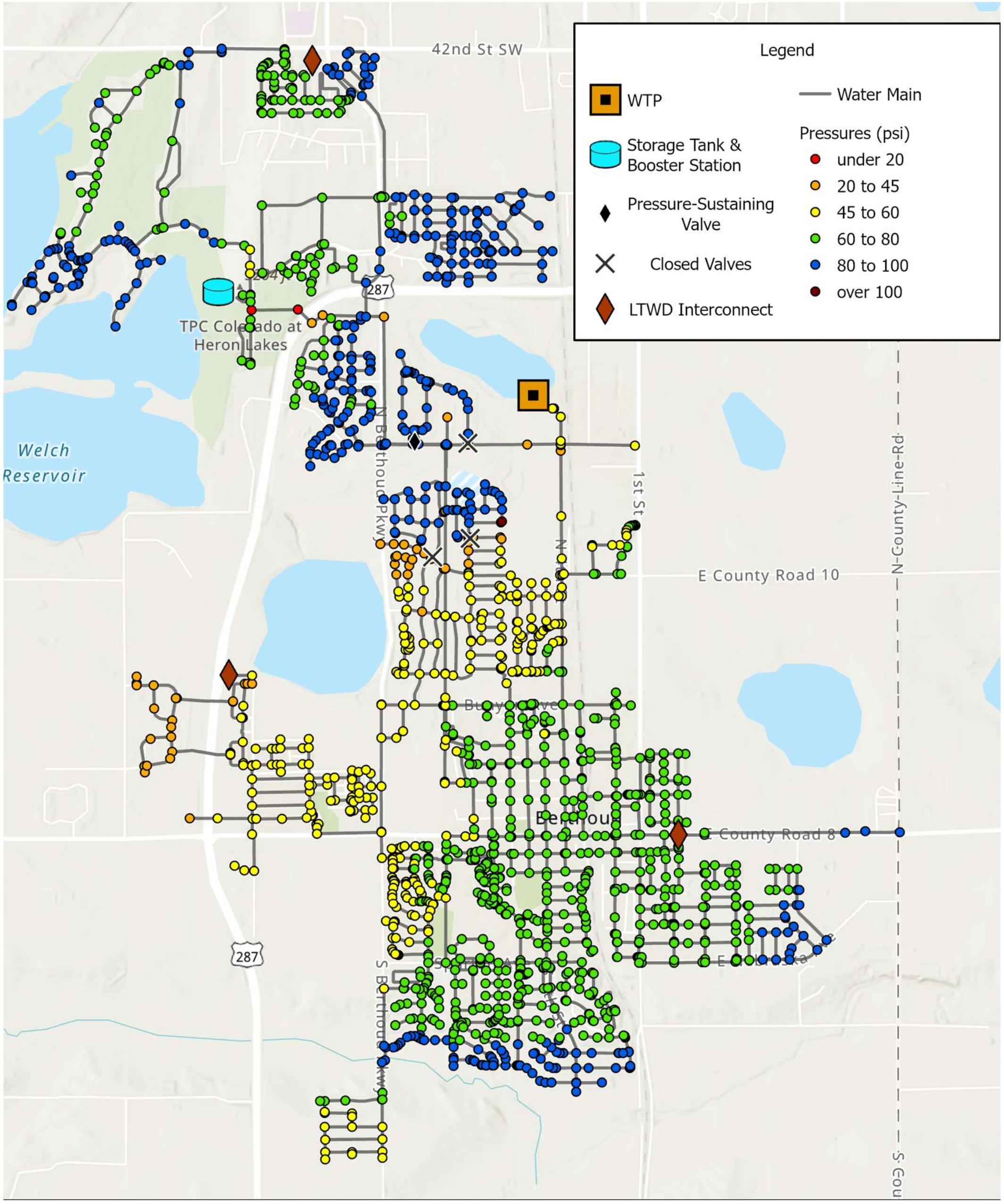


Figure 4-14: Scenario 2 | Current Conditions, Peak Hour Demand, Minimum Pressures

To verify design criteria, headloss per 1,00 linear feet of pipe were evaluated against the design criteria as displayed in Figure 4-15. In general, the allowable headloss is 1.5 feet per 1,000 linear feet, however up to 2 feet per 1,000 linear feet for transmission mains of 20-inch diameter is allowable. The only 20-inch diameter pipe in the system is from the HSPS to the 3 MG Storage Tank. This transmission main is designed for a specific headloss to convey flows to the storage tank and does not pose a concern by not meeting the headloss design criteria.

The 16-inch transmission main on Berthoud Parkway and the 16-inch main on 14th Street exceed the 2 feet per 1,000 linear feet design criteria in several locations. These mains are undersized for the existing flow conditions, and are anticipated to be considerably undersized under future growth scenarios.

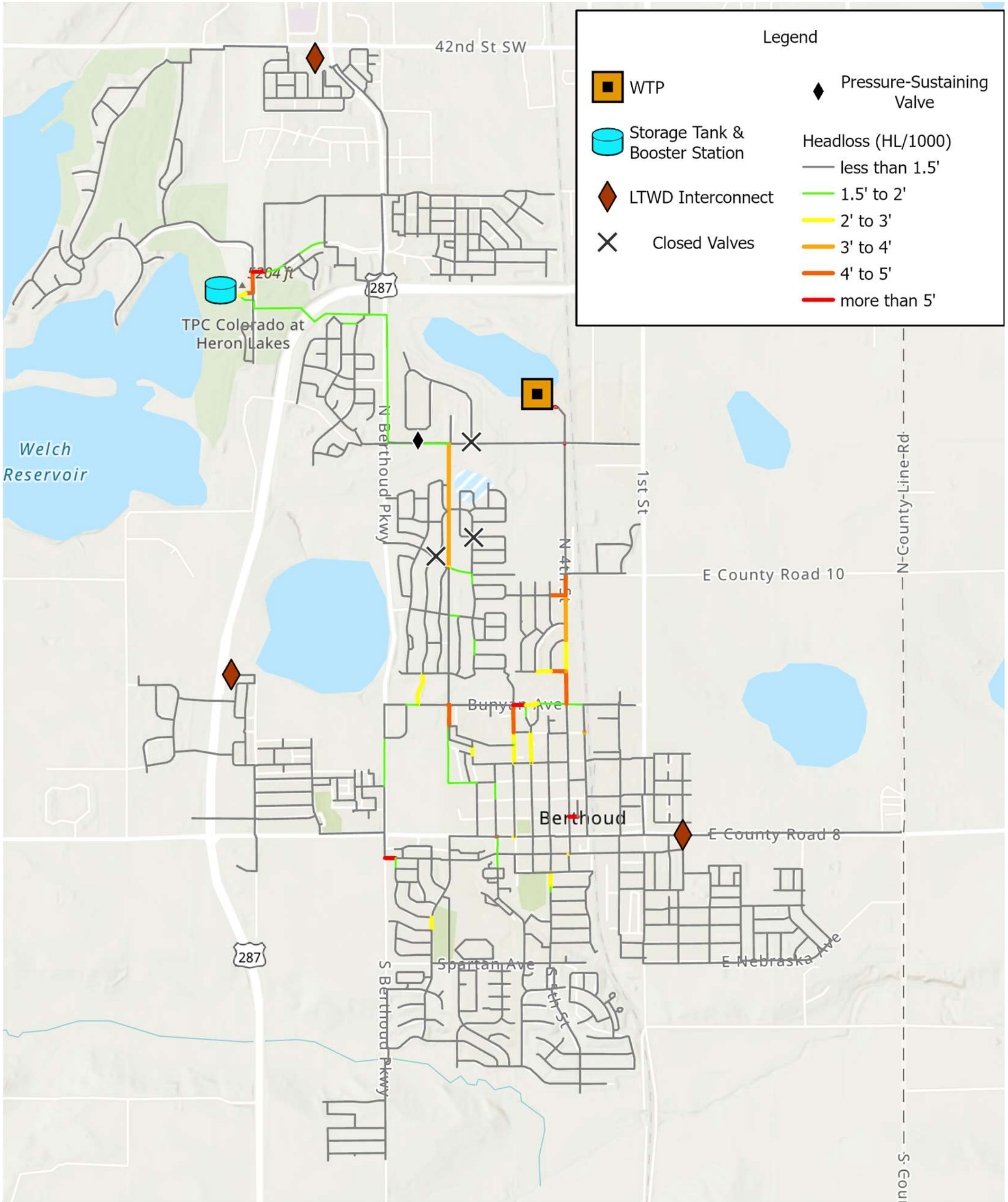


Figure 4-15: Scenario 2 | Current Conditions, Peak Hour Demand, Headlosses

Figure 4-16 displays available fire flow throughout the distribution system. Based on modeling results, fire flow of 1,000 gpm is available throughout the system. The Town's service area is predominantly residential, and this available fire flow is believed to be sufficient. This information should be shared with the local fire protection agency for review and input.

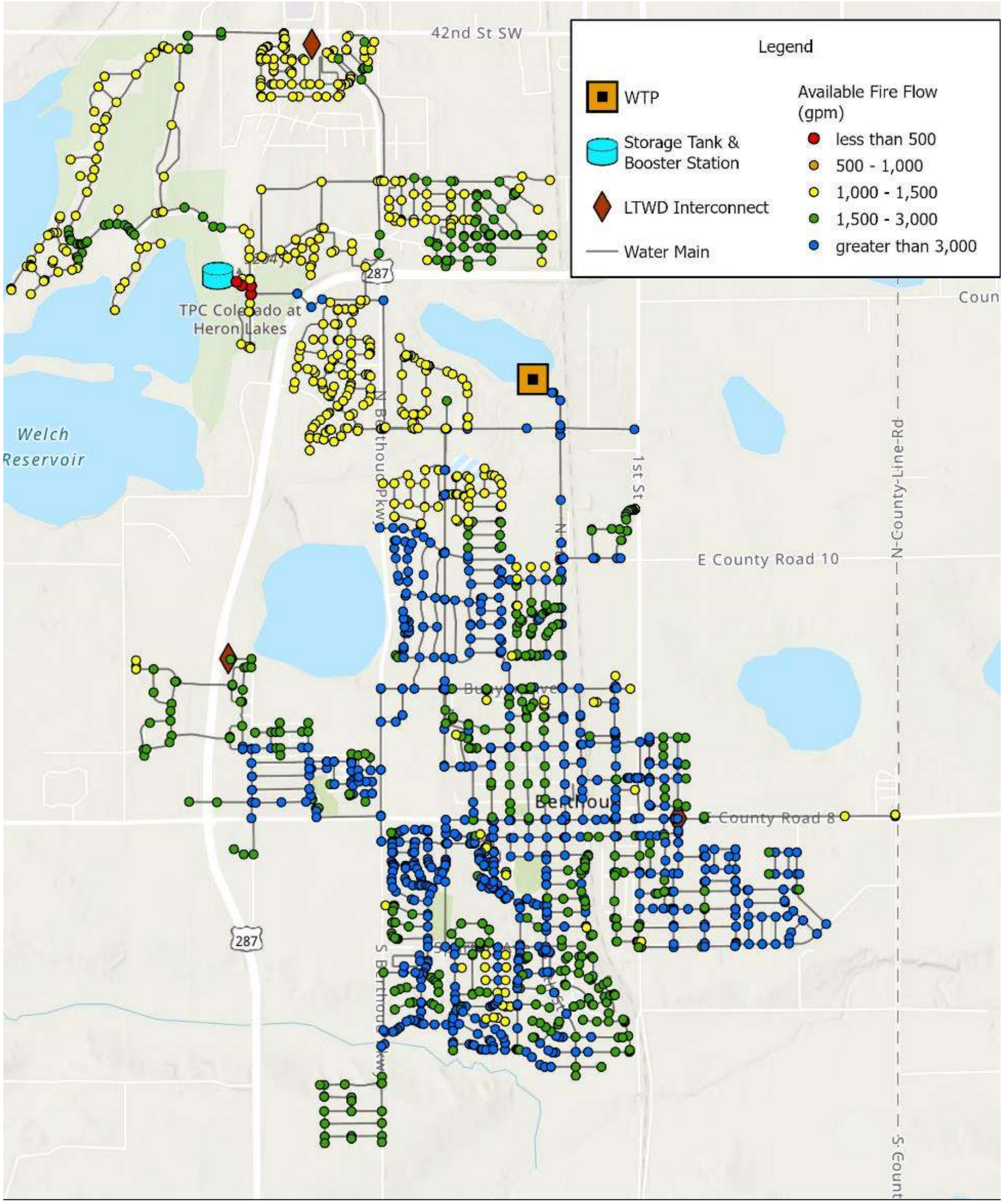


Figure 4-16: Scenario 3 | Current Conditions, Maximum Day Demand, Available Fire Flows

4.7.2.4 Future Scenario, Existing Condition Results

The 5-year and 20-year development projections were developed by the Town with assistance from Tetra Tech. Population projections were evaluated jointly with the Town based on development locations and quantity of SFEs for the 5-year and 20-year horizons. These projections are provided in Figures in **Appendix G**. A skeletonized model was produced based on anticipated projections. This model included treatment plant(s), storage tanks, and pump stations. The 5-year and 20-year future models were hydraulically modeled using the existing infrastructure distribution system to identify impacts, problem areas, and CIP projects.

The results of these future models are displayed in Figure 4-17 through Figure 4-20. Design criteria compliance issues were observed for pressure and headloss within the distribution system for the 5-year and 20-year projections.

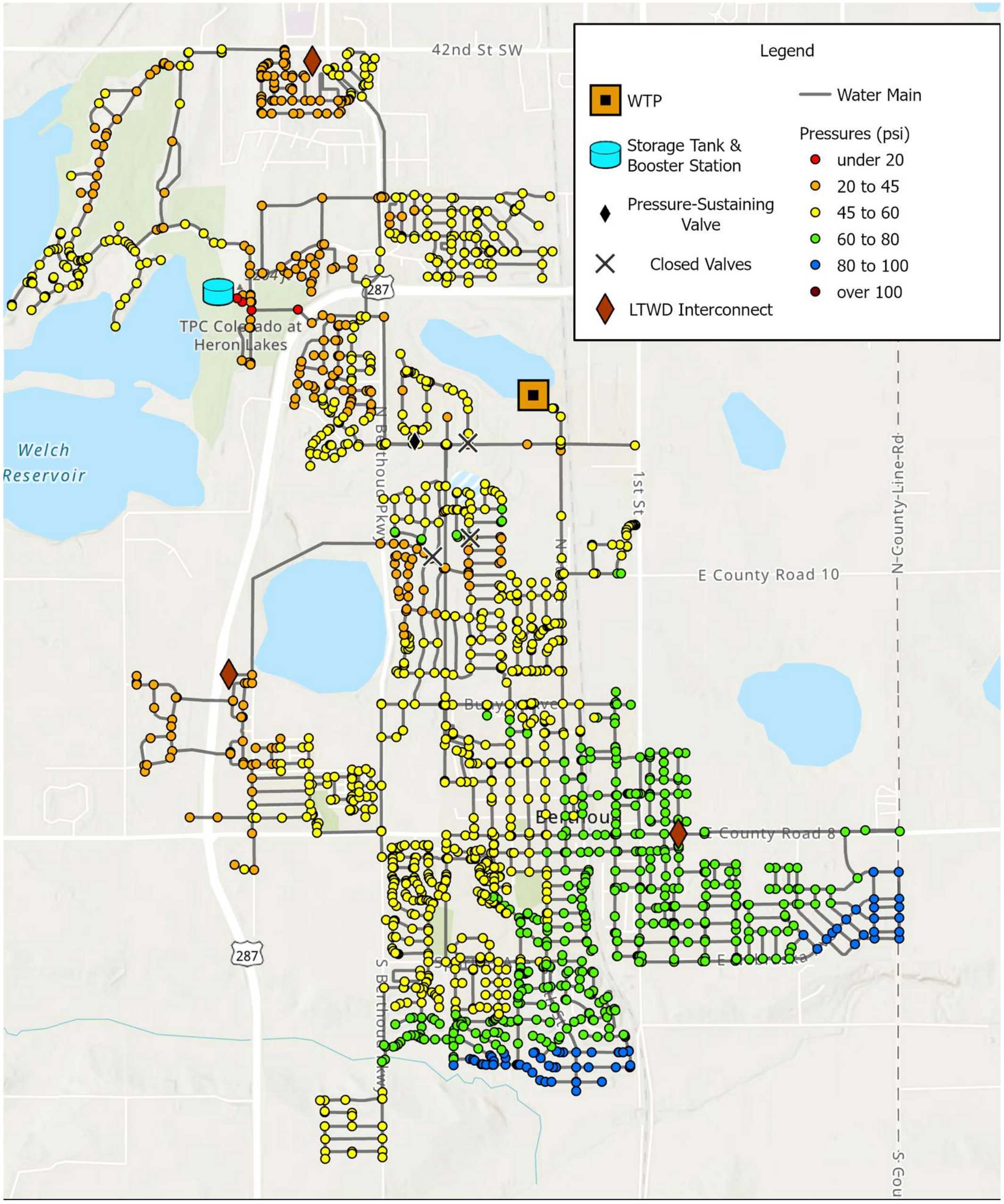


Figure 4-17: Scenario 4 | 5-Year Projection, Peak Hour Demand, Minimum Pressures

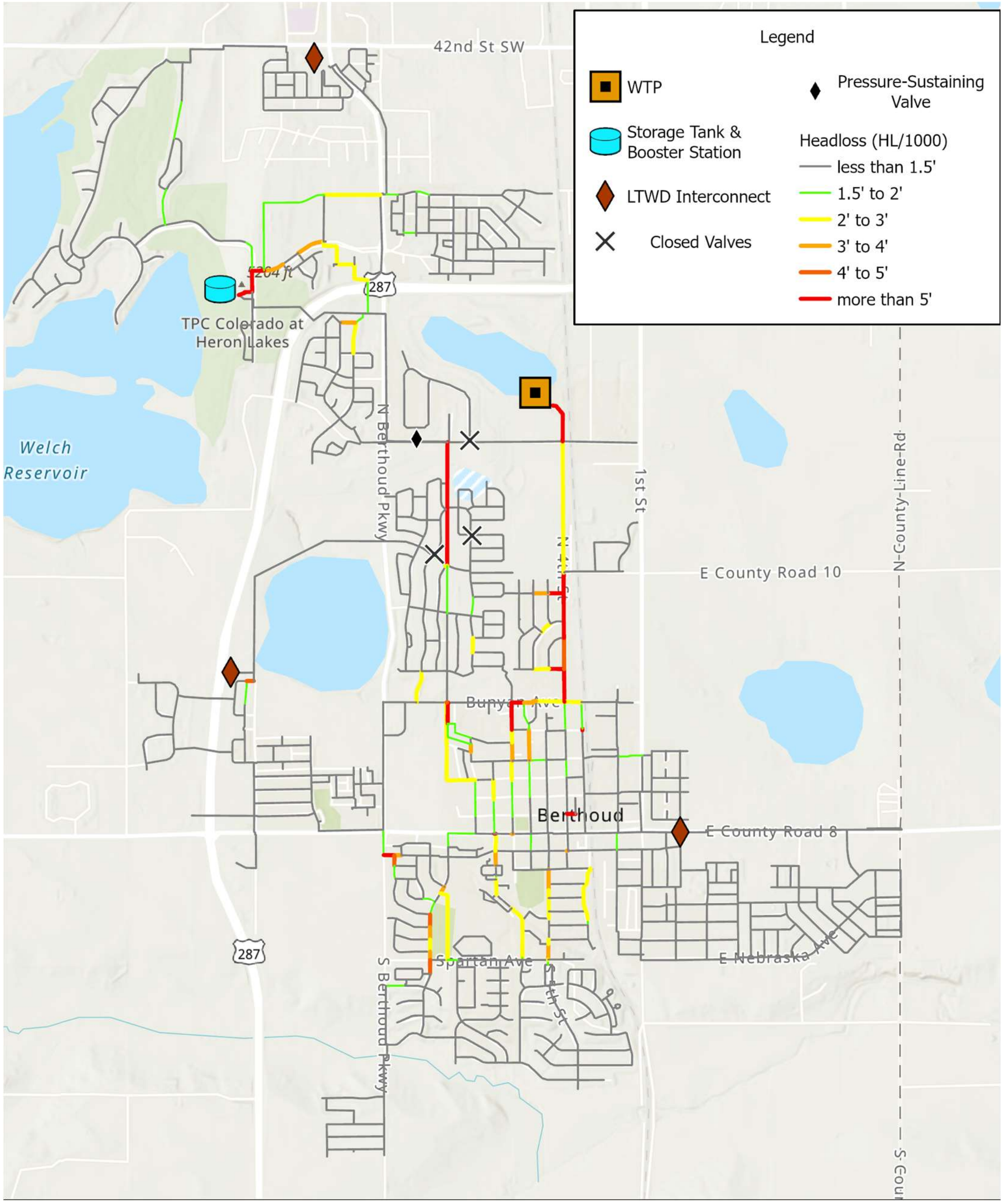


Figure 4-18: Scenario 4 | 5-Year Projection, Peak Hour Demand, Headlosses

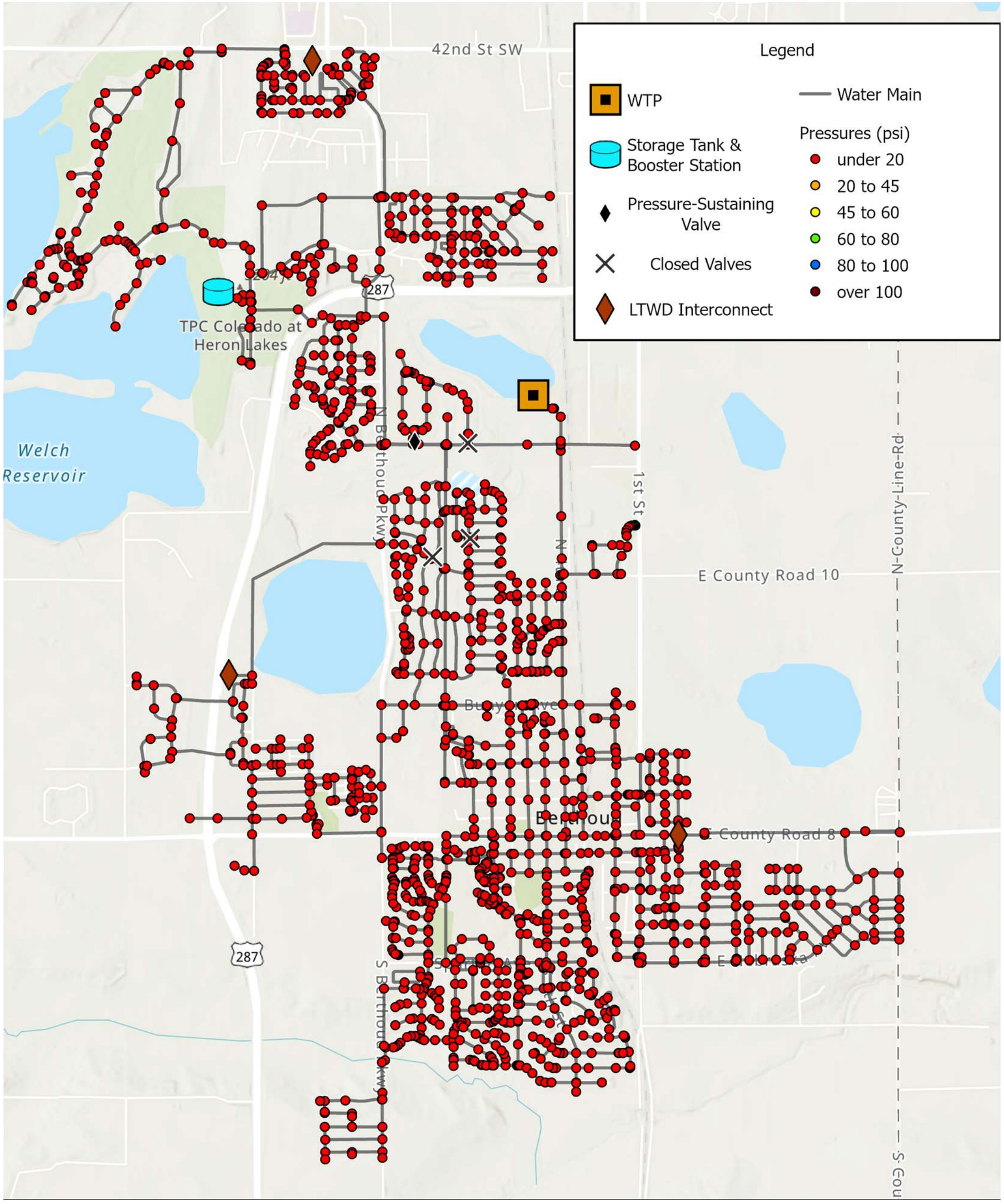


Figure 4-19: Scenario 5 | 20-Year Projection, Peak Hour Demand, Minimum Pressures

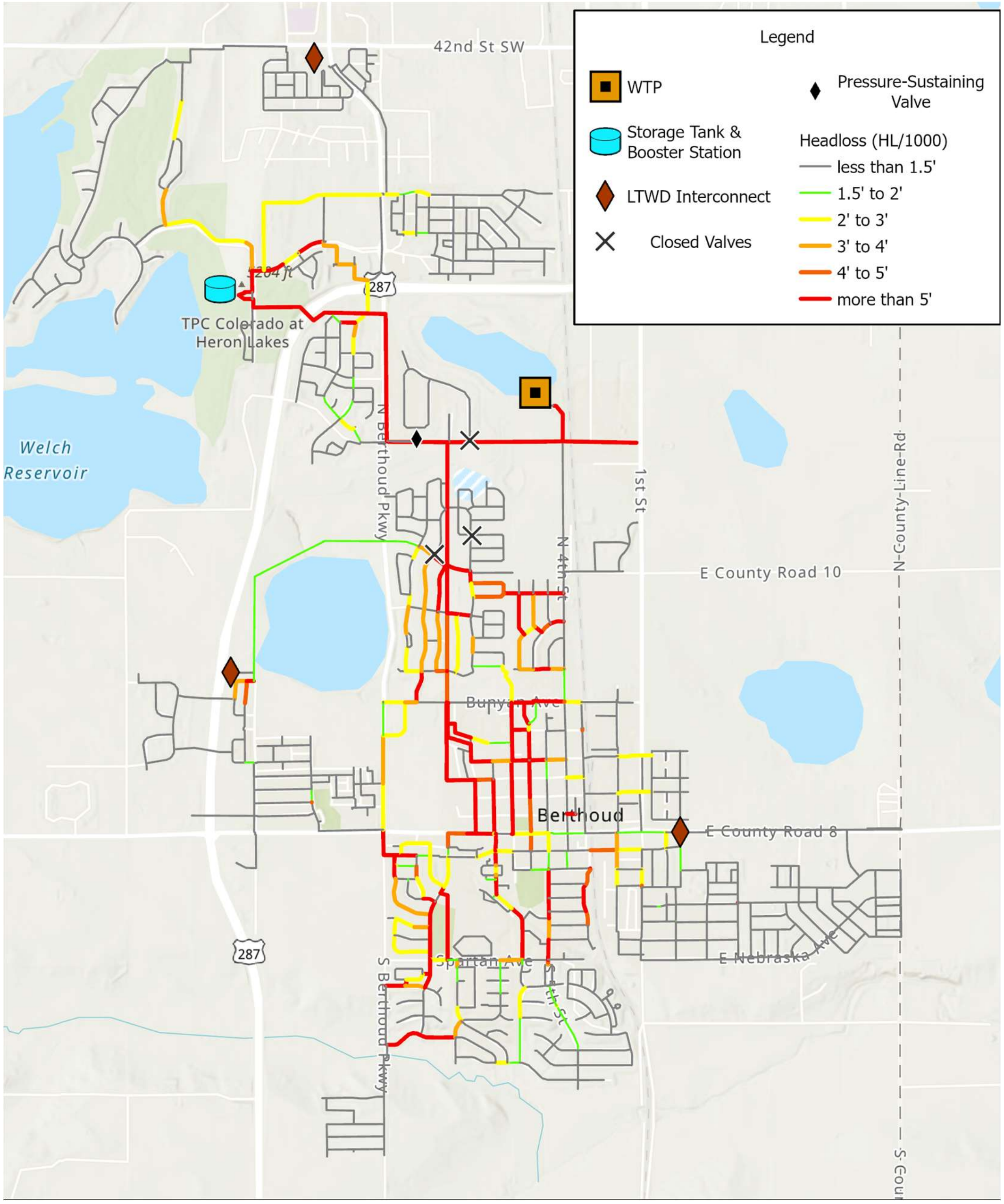


Figure 4-20: Scenario 5 | 20-Year Projection, Peak Hour Demand, Headlosses

4.7.2.5 Recommendations

The CIP Projects were developed and prioritized based on the hydraulic modeling results for the 5-year and 20-year anticipated future growth projections. The distribution projects and project IDs are summarized in Figure 4-21 and Figure 4-22 for 5-year and 20-year horizons, respectively. The water distribution CIP projects have a prefix of "WD" to denote "Water Distribution". The water treatment plant projects have prefix of "WTP" and are summarized in the related section.

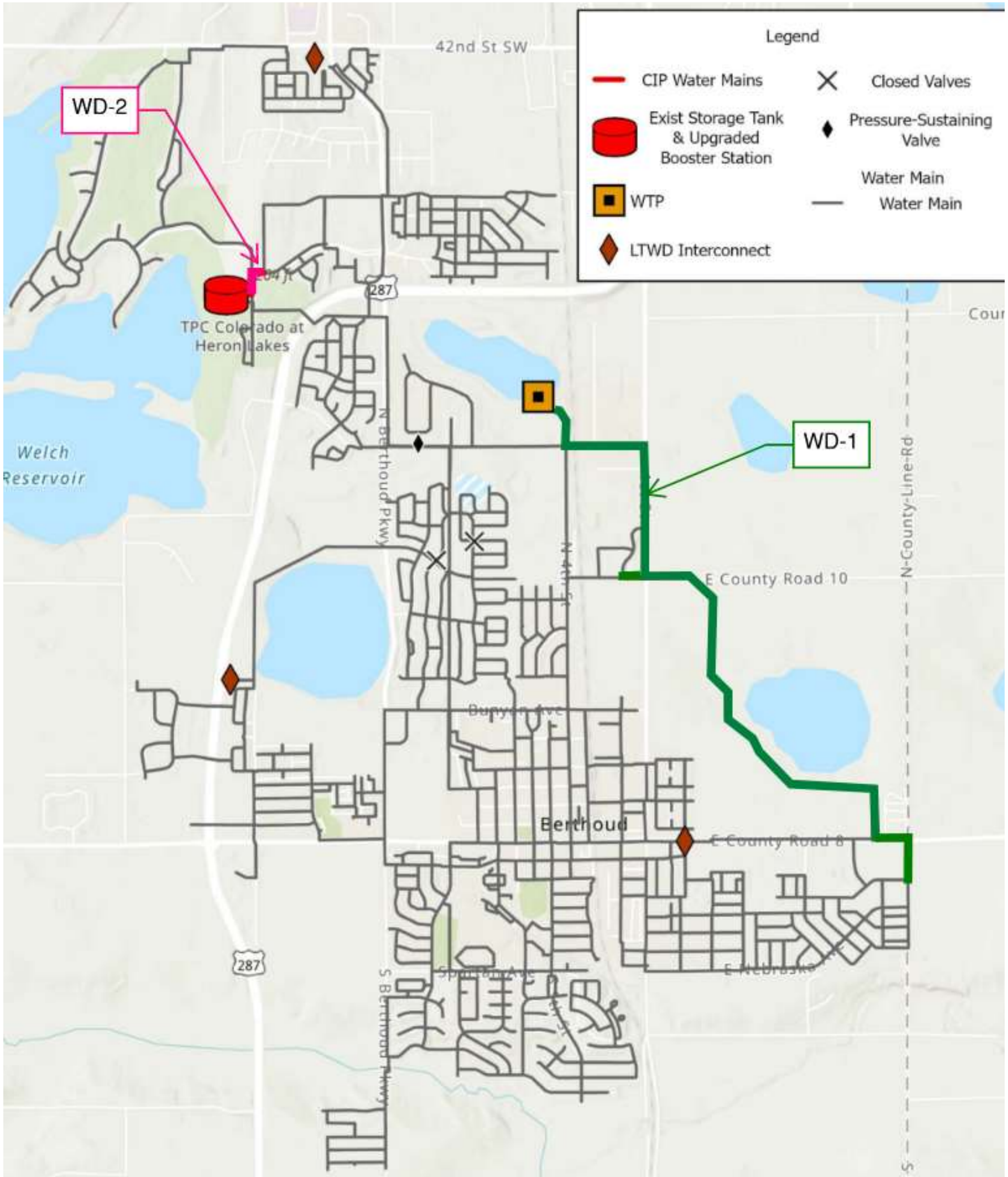


Figure 4-21: 5-Yr Distribution System CIP Projects

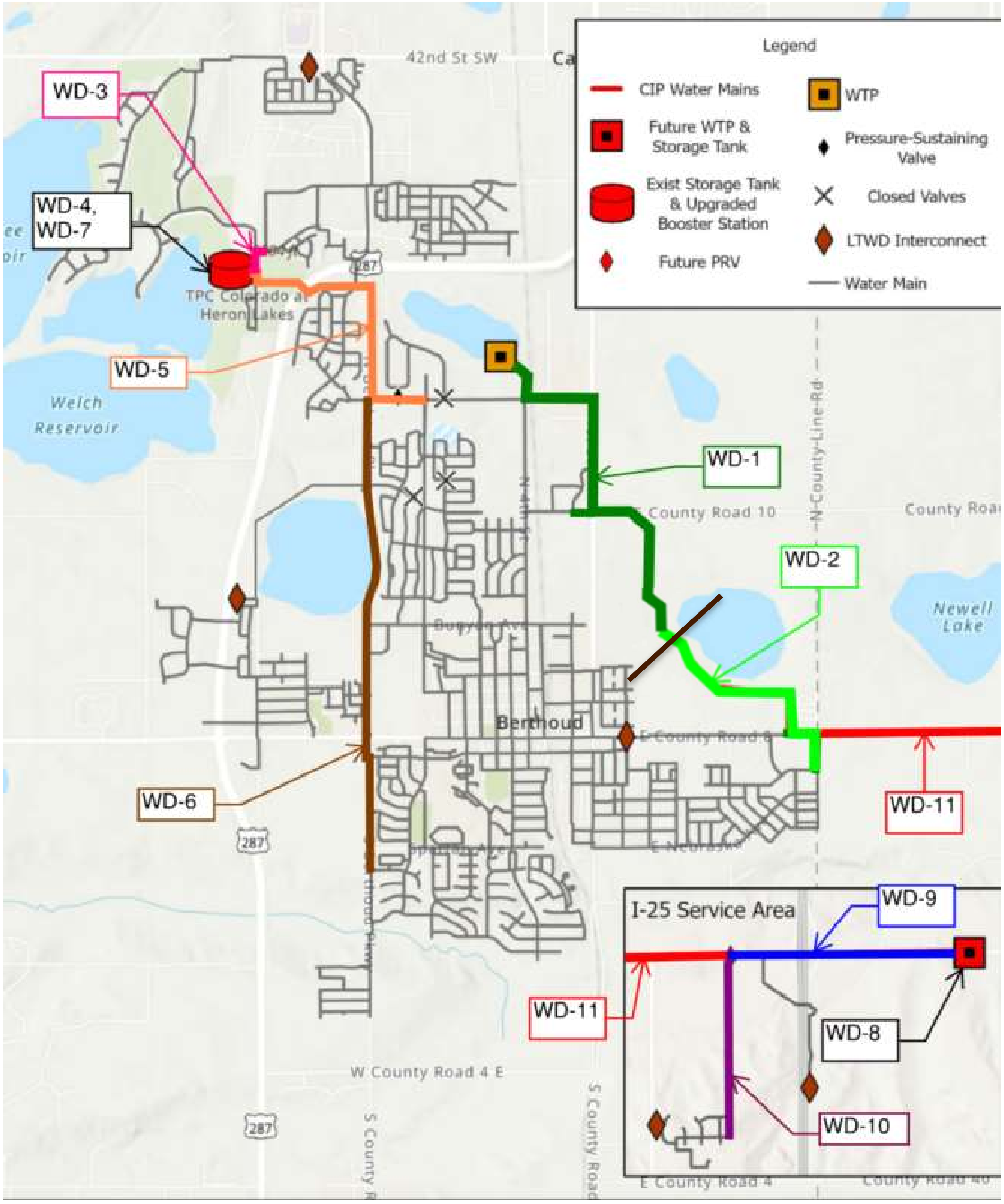


Figure 4-22: 20-Yr Distribution System CIP Projects

Table 4-27: Water Distribution System CIP Projects

CIP Project #	Name	Length (ft)	Proposed Diameter (in)
WD-1	Bacon Lake Transmission Main, Phase 1	9,394	12 - 30
WD-2	Bacon Lake Transmission Main, Phase 2	6,290	12 - 16
WD-3	West BPS Transmission Main	865	16 - 20
WD-4	West BPS Upgrade, Phase 1	-	-
WD-5	West Tank Low Pressure Zone Transmission Main	7,774	16
WD-6	Berthoud Parkway Transmission Main	11,447	16 - 20
WD-7	West BPS Upgrade, Phase 2	-	-
WD-8	East Zone Storage Tank and BPS	-	-
WD-9	CR 44 Transmission Main, Phase 1	7,802	24
WD-10	Serenity Ridge Connection	6,179	12
WD-11	CR 44 Transmission Main, Phase 2	18,349	24

The proposed infrastructure for the 20-year projections was hydraulically modeled to verify resolution of the distribution system issues. The updated 20-year distribution system model displayed conformance to headloss and pressure design criteria, as illustrated in Figure 4-23 and Figure 4-24, respectively. It should be noted that while several mains exceed the maximum headloss criteria, the velocities remain under 5 ft/s while also maintaining minimum pressures. For these reasons, the Town agreed that an upgrade of these pipes is not required.

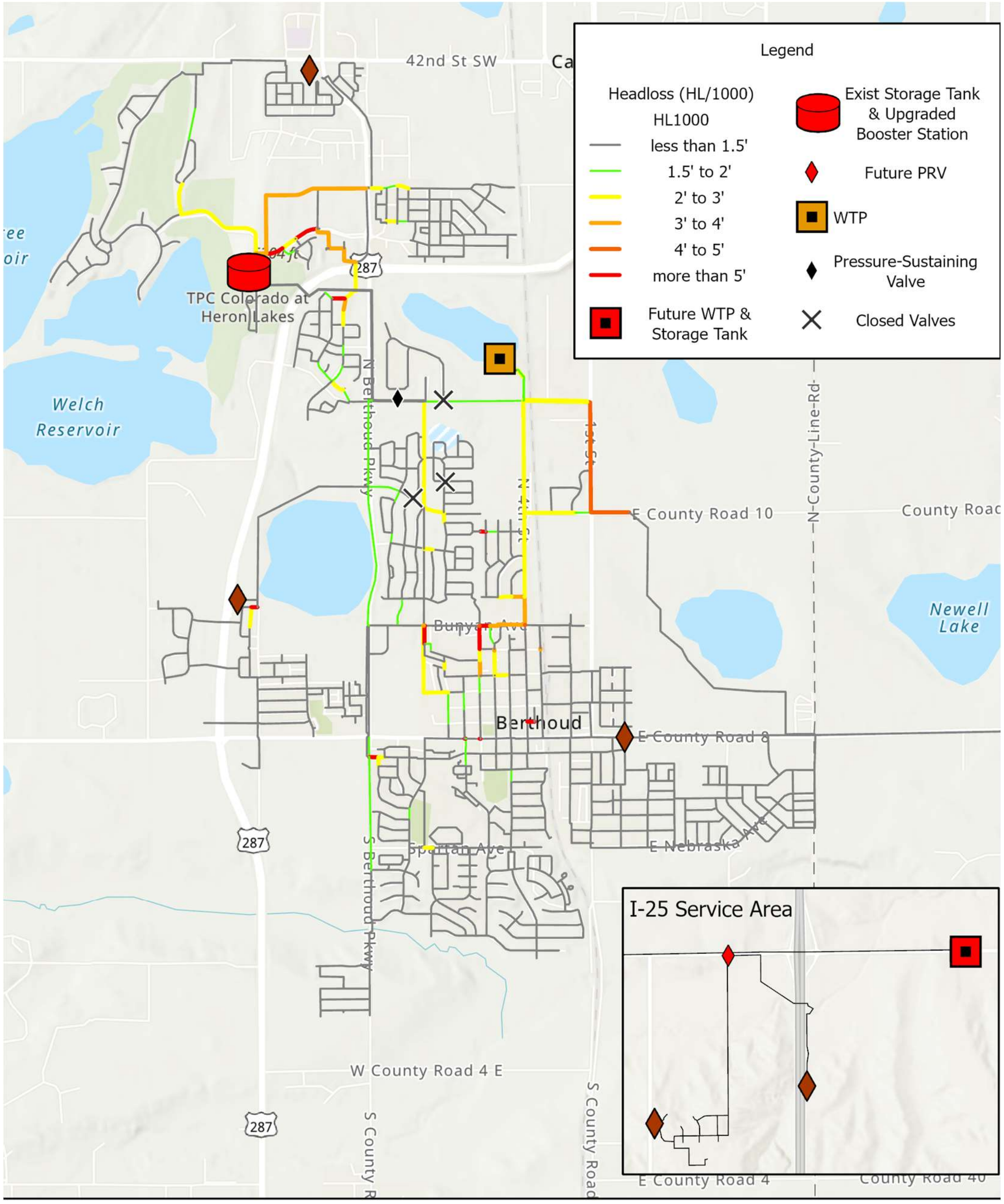


Figure 4-23: 20-Yr Improved Distribution System, Headloss

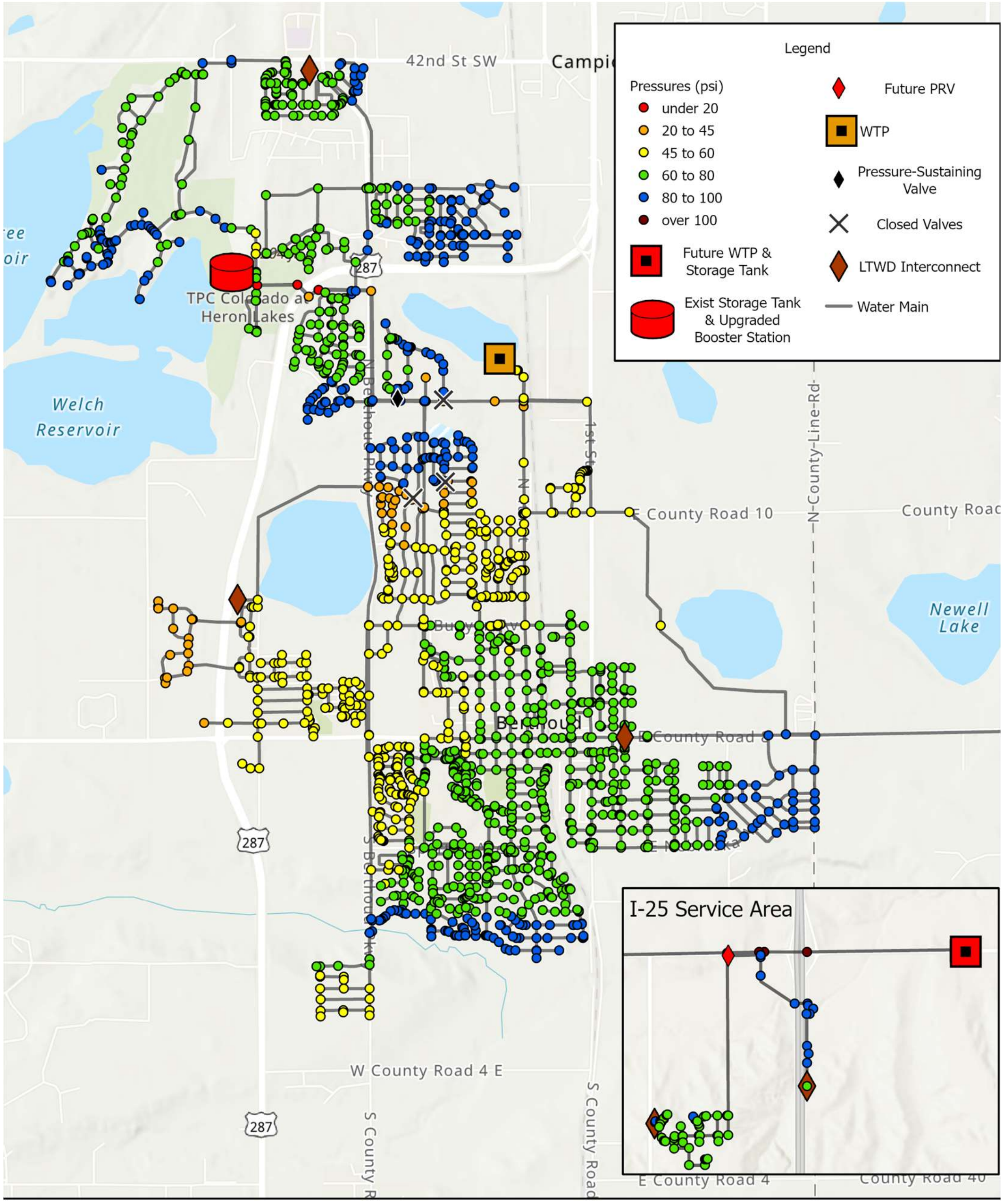


Figure 4-24: 20-Yr Improved Distribution System, Pressures

The 5-year and 20-year improved system AFF are illustrated in Figure 4-25 and Figure 4-26, respectively. The future, 5-year and 20-year future systems provide the minimum flow rate of 1,000 gpm, with the majority of the system exhibiting flows above 1,500 gpm. In Tetra Tech's experience this is more than sufficient for the Town, however it should be shared with the Fire Marshal to verify the system is providing sufficient fire flows for the Fire Department's needs.

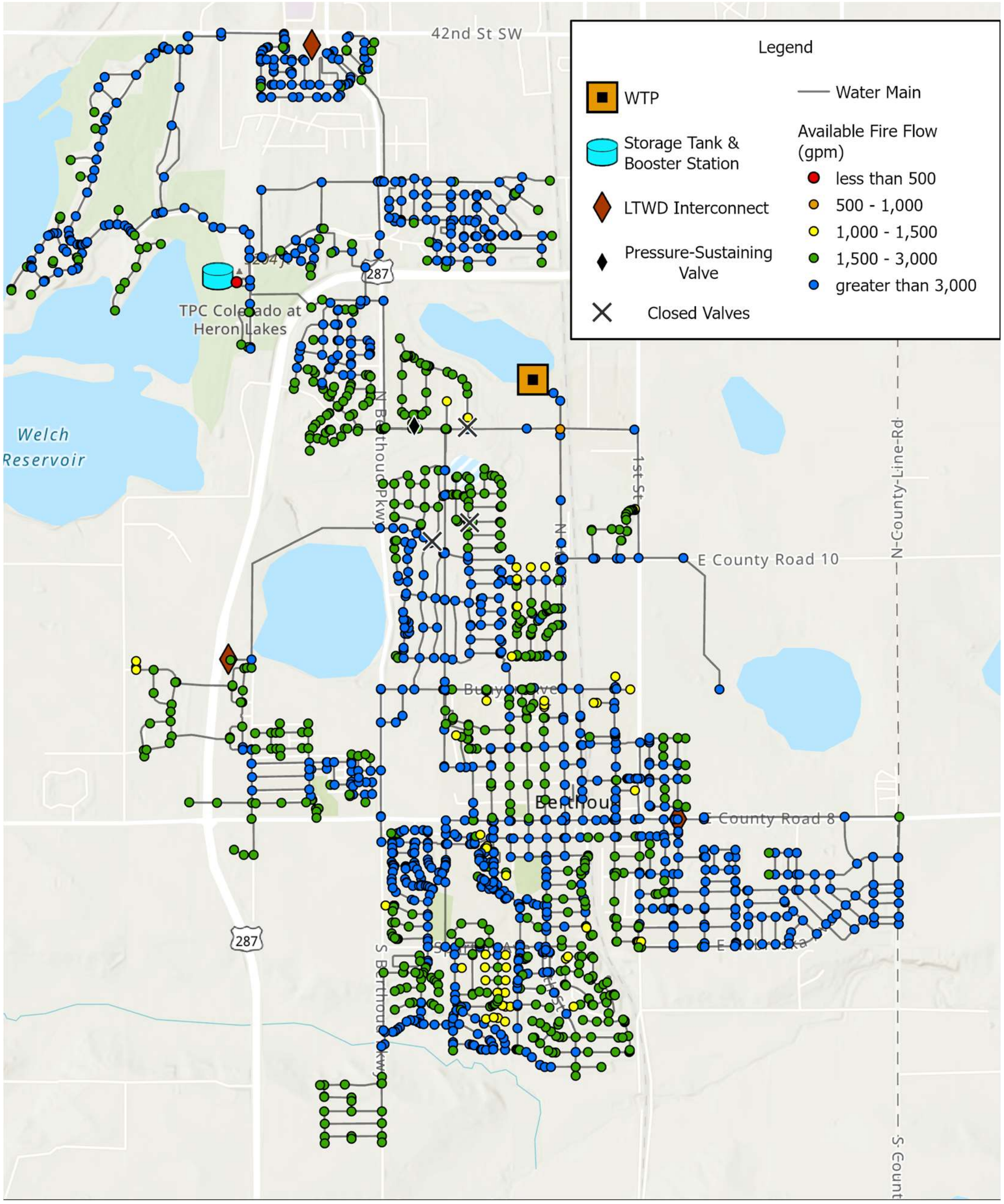


Figure 4-25: 5-Yr Improved Distribution System, Available Fire Flow

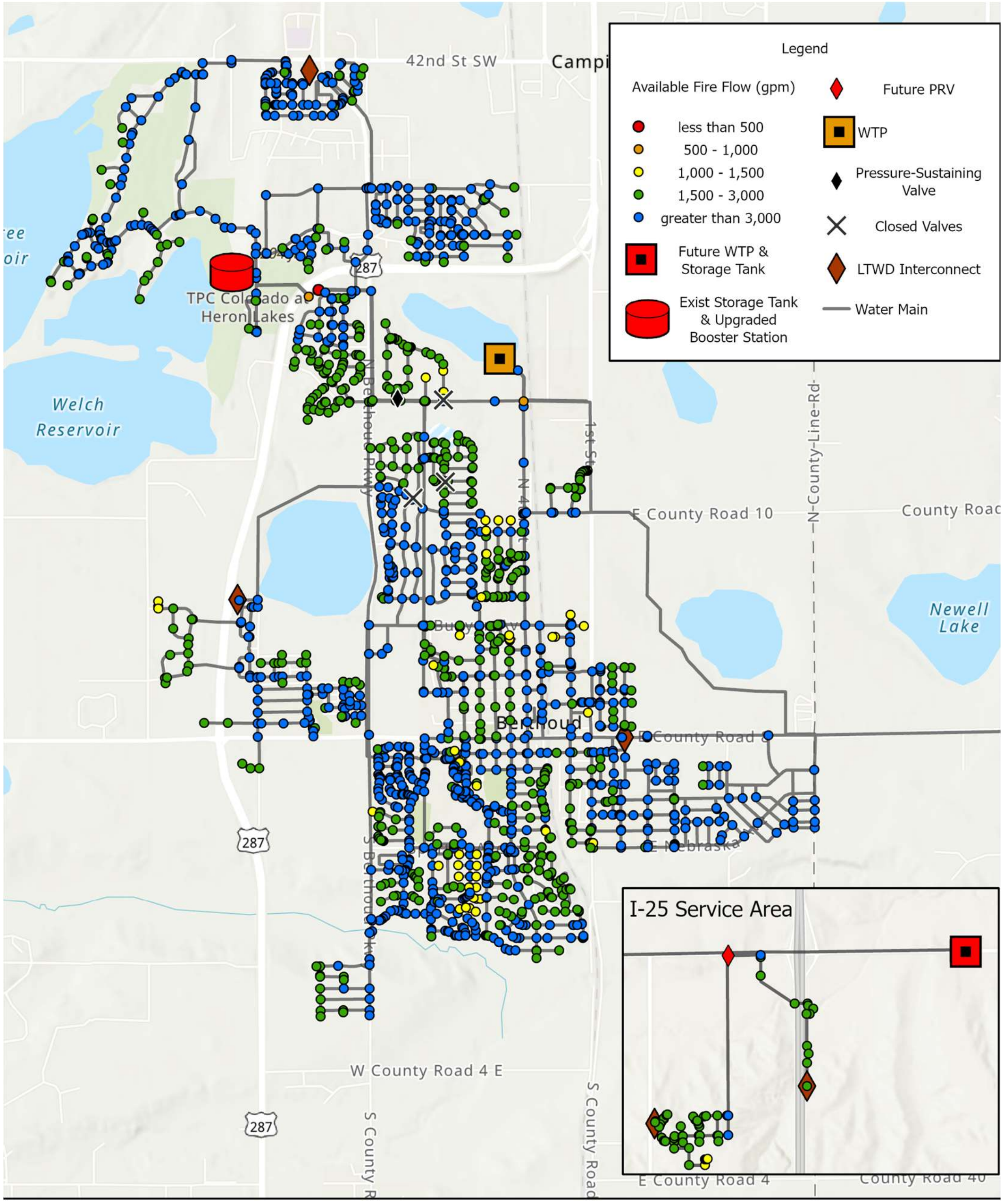


Figure 4-26: 20-Yr Improved Distribution System, Available Fire Flow

4.8 SCADA and Security Evaluation

The Town's water Supervisory Control and Data Acquisition (SCADA) system covers the water treatment plant and receives data from remote sites. Additionally, data is exchanged with the neighboring Little Thompson Water District. The treatment plant has full manual controls with some automation. Remote sites provide read-only data to SCADA, located at the treatment plant.

4.8.1 SCADA

SCADA software currently in use is GE iFIX version 6.0 which is still supported by the manufacturer. Programmable Logic Controllers (PLCs) in the plant are Allen Bradley, most of which are no longer supported (SLCs, older MicroLogix) though some have been upgraded with current models. Automation at the treatment plant is limited and there is a strong desire to develop control strategies and automation for some of the critical processes – filtration and chemical dosing – in particular. Reliability of the SCADA server has been problematic with instances of data loss.

Remote sites (storage tank, wells, etc.) have proprietary Remote Terminal Units (RTUs) with limited internal and third-party support. Performance of the telemetry system appears to be adequate though power outages typically require visits to the remote sites to reset the equipment.

4.8.2 Cybersecurity

The water SCADA system will need cybersecurity improvements to meet EPA rules and industry best practices. In March of 2023, the EPA released a memorandum with and updated interpretation of the scope of sanitary surveys to include assessing water system Industrial Control Systems (ICS) for cybersecurity.

4.8.3 Recommendations

Immediate improvements to cybersecurity need to be made to the water SCADA system to reduce vulnerabilities and comply with regulations. Automation within existing PLCs should be developed to reduce operator load and improve treatment performance. Outdated ICS hardware needs to be replaced and the remote site telemetry system should be upgraded to a less proprietary platform to allow broader availability of third-party support.

4.9 Proposed 20-Year Capital Improvement Plan

The proposed 20-year capital improvement plan for the Town's water treatment and distribution infrastructure was developed and prioritized with consideration of drivers as described in the previous sections. Below sections describe the proposed 20-year CIP and each CIP project's main objectives and drivers as well as suggested timing and estimated cost.

4.9.1 Basis of Cost Estimating

This report developed Class V AACE Opinion of Probable Construction Costs (OPCC) for each project identified in the proceeding sections. A Class V OPCC, as defined by AACE International, is developed when engineering is very conceptual and based on limited information. Examples of estimating methods used include cost/capacity curves and factors, scale-up factors, and parametric and modeling techniques. The typical expected accuracy for a Class V OPCC ranges from -50 percent to +100 percent. The following major assumptions for the OPCC development presented include:

- This estimate does not include escalation beyond April 2023.
- Taxes were not included.

Direct cost multipliers were included for projects and adjusted according to the project scope (i.e., no demolition cost was included if the project is not retrofit or replacement of current infrastructure) and previous consultant experience. The direct cost multipliers included are as follows:

- Equipment Installation
- Electrical, Instrumentation and Controls
- Sitework
- Demolition

- Piping, Valves and Appurtenances

Indirect cost multipliers were included on the sum of the equipment and direct cost markup subtotal. The indirect cost multipliers were kept consistent across all projects, except for special circumstances (i.e., the cost used includes contractor markups). The direct cost multipliers include contractor markups, contingency and engineering services and are summarized below:

- 3% Contracts/Bonds/Insurance
- 2% Mobilization/Demobilization
- 8% Contractor Superintendence
- 18% Overhead and Profit
- 30% Contingency
- 20% Engineering Design & Services During Construction

See **Appendix C** for cost opinions for each project described below.

4.9.2 Prioritized Plan Development

The evaluation of Town assets, such as the WTP and distribution system, have resulted in multiple projects to be completed under a CIP. This plan was developed based on reviewing assets, condition assessments, hydraulic assessments, and regulatory review.

4.9.2.1 Distribution System Proposed Projects

The distribution system CIP projects were developed utilizing the Town design criteria to determine hydraulic deficiencies of existing infrastructure and to preliminarily size new infrastructure. It should be noted that not all violations of the criteria were selected for CIP improvement projects and there were selected on a strategic and case by case basis.

The Town design standards indicate to utilize ductile iron pipe (DIP) for transmission main piping (16-inch diameter and larger), but smaller water mains can be AWWA C900 PVC DR 18. For quantity and cost estimations, it was assumed that all piping would be DIP as most of the CIP projects involve 16-inch diameter and larger piping. Based on recent quotes from vendors, there is not a significant cost difference between the two products and the projected CIP costs should not change if PVC pipe is selected for the recommended 12-inch piping. The standards also indicate to have isolation butterfly valves every 1,200 feet for transmission piping and every 600 feet in smaller piping. Fire hydrants generally are not recommended, with the exception for one project, for these transmission mains as they are routed through agricultural fields or are parallel mains where hydrants already exist. Fire hydrant spacing was assumed to be 500 feet.

WD-1: Bacon Lake Transmission Main, Phase 1

This project consists of approximately 9,390 linear feet of water transmission main ranging in size from 12-inch to 30-inch diameter. This project will feed future developments on the east side of Town such as Farmstead and the large high-density development along First Street between Mountain Avenue and E County Road 12, an estimated size of 1,200 acres. There are also multiple connections from this transmission main to the existing system to assist with providing looping, meeting pressure requirements, and available fire flow.

This project follows the same general alignment of WWC-1 (Bacon Lake Interceptor Improvements) which is through undeveloped agricultural land, along Bacon Lake, and down N County Road 13. It is recommended that easement acquisitions that occur can accommodate full installation of both of the water transmission main and sanitary sewer as well as any related appurtenances and required maintenance activities. All water infrastructure needs to maintain a minimum 10 feet horizontal separation from all sewer infrastructure.

An estimated plan and profile of this alignment is provided in Figure 4-27. The project cost is estimated at $12.86 M.

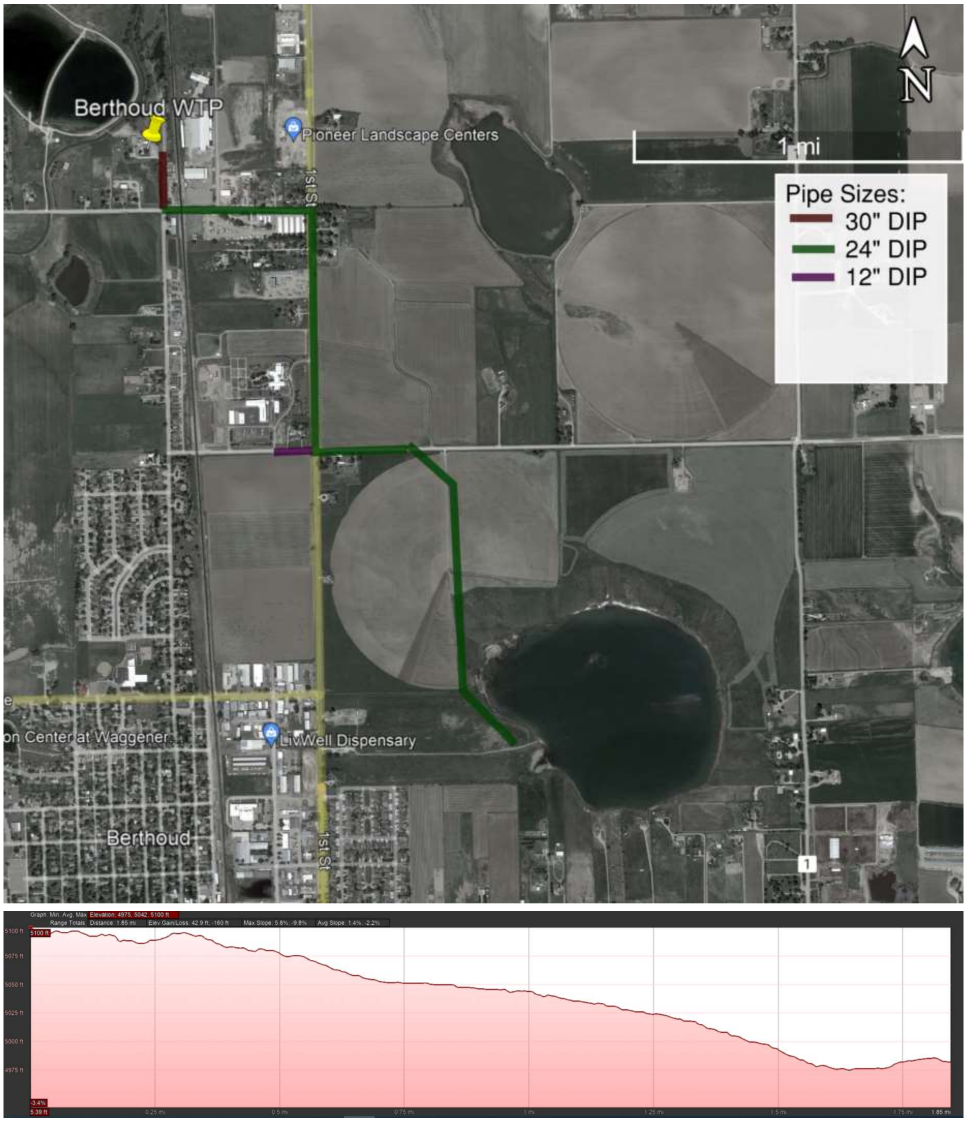


Figure 4-27: WD-1 | Bacon Lake Transmission Main, Phase 1

WD-2: Bacon Lake Transmission Main, Phase 2

This project consists of approximately 6,290 linear feet of water transmission main ranging in size from 12-inch to 16-inch diameter. This project extends Phase 1 to provide better looping and help with pressures on the outskirts of the system. The main also will feed future developments on the east side of Town such as Farmstead and the large high-density development along First Street between Mountain Avenue and E County Road 12, an estimated size of 1,200 acres. There are also multiple connections from this transmission main to the existing system to assist with providing looping, meeting pressure requirements, and available fire flow.

This project follows the same general alignment of WWC-1 (Bacon Lake Interceptor Improvements) which is through undeveloped agricultural land, along Bacon Lake, and down N County Road 13. It is recommended that easement acquisitions that occur can accommodate full installation of both water transmission main and sanitary sewer as well as any related appurtenances and required maintenance activities. All water infrastructure needs to maintain a minimum 10 feet horizontal separation from all sewer infrastructure.

An estimated profile of this alignment is provided in Figure 4-28. The project cost is estimated at $5.70 M.

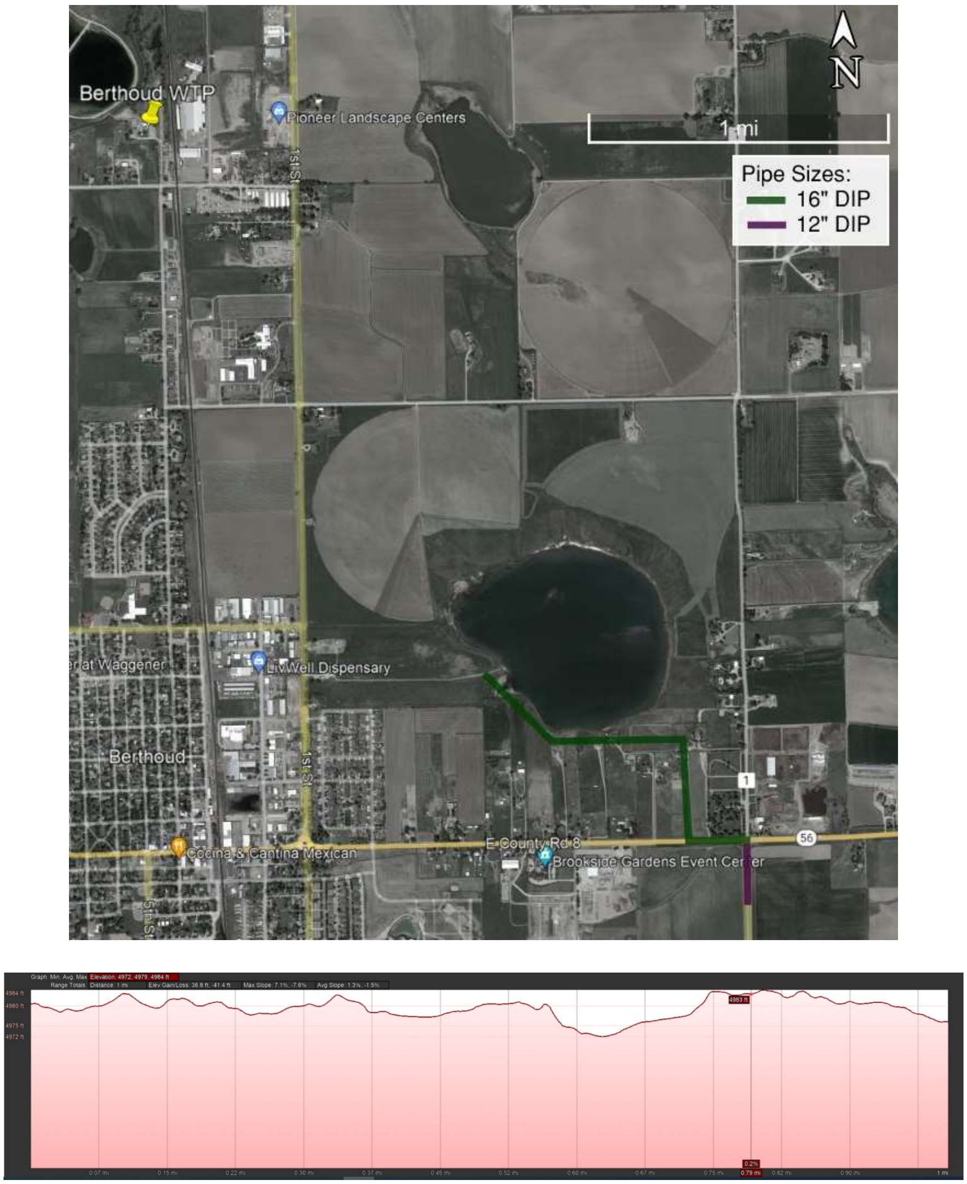


Figure 4-28: WD-2 | Bacon Lake Transmission Main, Phase 2

WD-3: West BPS Transmission Main

This project consists of approximately 870 linear feet of 16-inch and 20-inch diameter DIP water transmission main. This project is intended to prepare for the BPS Upgrade project (WD-4), which will be needed to accommodate future growth. The BPS upgrades will increase the pumping capacity first to 2,808 gpm to accommodate the growth in the 5-year horizon and then to 3,254 gpm to accommodate growth in the 20-year horizon. The alignment will go from the West BPS, north along TPC Parkway and east along Grand Market Ave within the Heron Lakes subdivision.

An estimated plan and profile of this alignment is provided in Figure 4-29. The project cost is estimated at $1.12M.

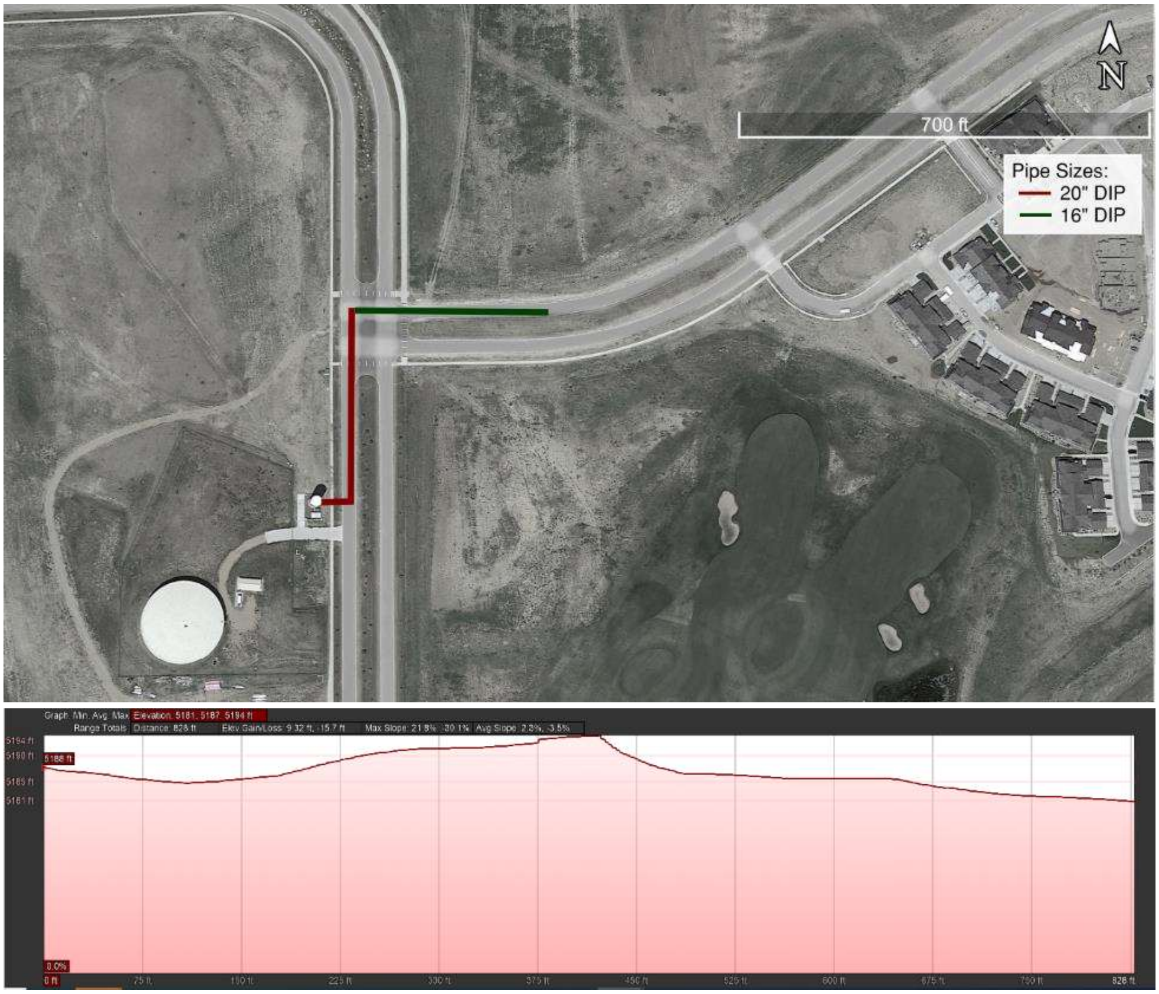


Figure 4-29: WD-3 | West BPS Transmission Main

WD-4: West BPS Upgrade, Phase 1

This project consists of increasing the pumping capacity of the West BPS to 2,808 gpm to accommodate growth within a 5-year timeline. The existing BPS has space for four total pumps. There is one 60 hp pump that is rated for 850 gpm at 170 feet of head, two 25 hp pumps rated at 250 gpm, and one 10 hp pump rated at 80 gpm. It is proposed that the 10 hp pump and one of the 25 hp pumps be replaced as part of this capacity upgrade project to two, 1,000 gpm pumps to meet a total PHD of 2,850 gpm (with the three highest rated pumps running). It is estimated that the two 1,000 gpm pumps will have 70 hp motors with VFD starters. It is assumed that there will need to be internal piping and appurtenance upgrades to accommodate the future flows. The piping upgrades should be sized for the full buildout flows of 3,254 gpm.

A BPS plan is provided in Figure 4-30. The fourth pump, rated for 60 hp, was added in the last couple of years. The project cost is estimated at $2.36M.

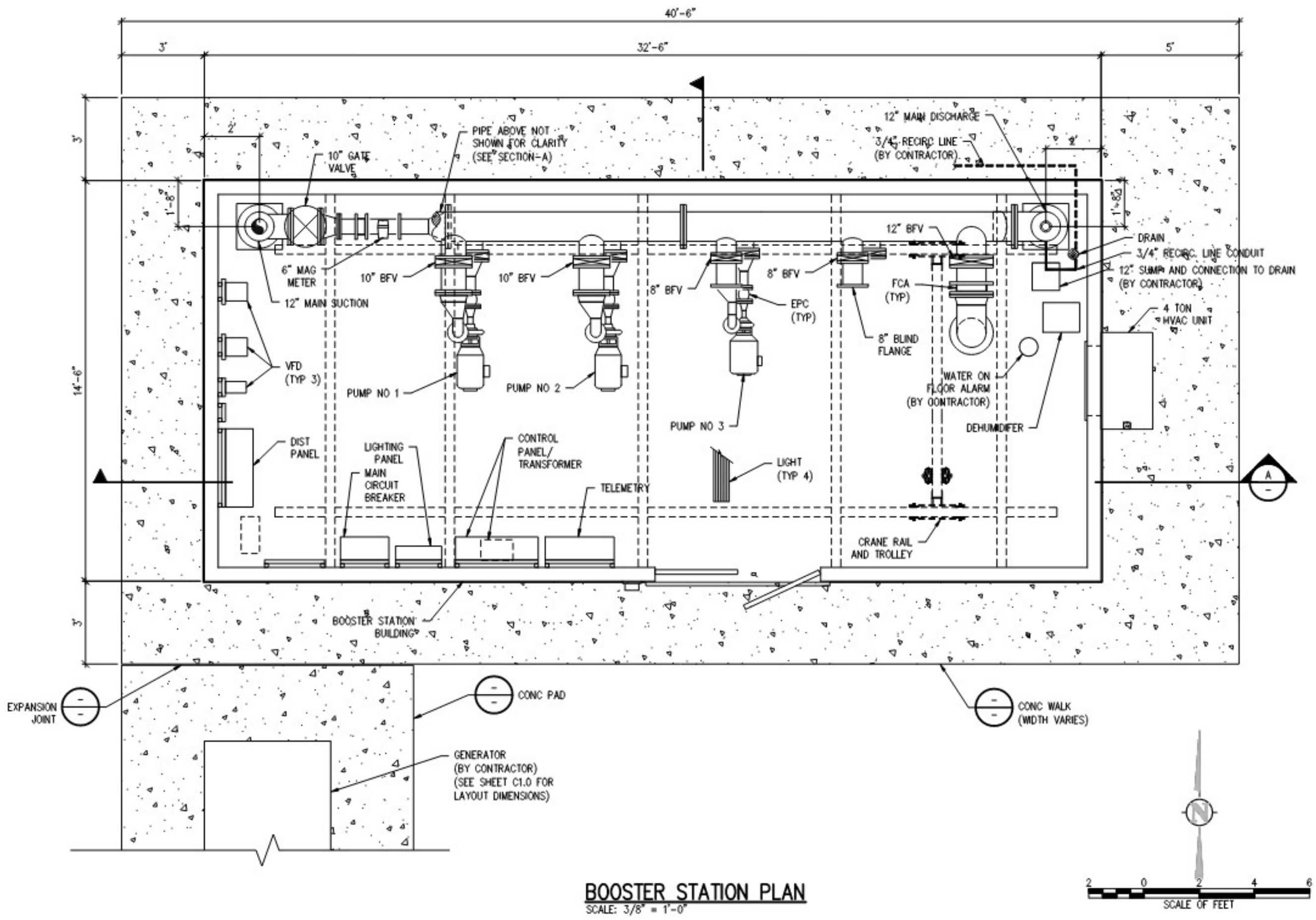


Figure 4-30: WD-4 | West BPS Upgrade, Phase 1

WD-5: West Tank Low Pressure Zone Transmission Main

This project consists of approximately 7,770 linear feet of 16-inch diameter DIP water transmission main. This project provides the future MDD and PHD to the lower west pressure zone. The alignment starts at the 3 MG storage tank and heads east to cross US-287. The highway crossing will need to be trenchless installation. Due to unknown geotechnical conditions, it is assumed that microtunneling will be required to install a 36-inch steel casing. The alignment continues east and turns south along Berthoud Parkway, then east along County Road 10E, then to Vantage Road where it will connect to the existing mains at Vantage.

An estimated plan and profile of this alignment is provided in Figure 4-31. The project cost is estimated at $12.01 M.

Figure 4-31: WD-7 | Vantage Transmission Main

WD-6: Berthoud Parkway Transmission Main

This project consists of approximately 11,450 linear feet of 16-inch to 20-inch diameter DIP water transmission main. The alignment starts at the intersection of Berthoud Parkway and County Road 10E and continues south along the full length of Berthoud Parkway until it reaches Blue Bell Road, just south of Spartan Avenue. This project provides future flows to the new developments on the west end of the Town and helps sustain pressures throughout the Town. There are multiple connections to existing water mains along the alignment. Since there is no existing water main along Berthoud Parkway, it is recommended that fire hydrants be installed at an estimated spacing of 500 feet.

An estimated plan and profile of this alignment is provided in Figure 4-32. The project cost is estimated at $11.71M.

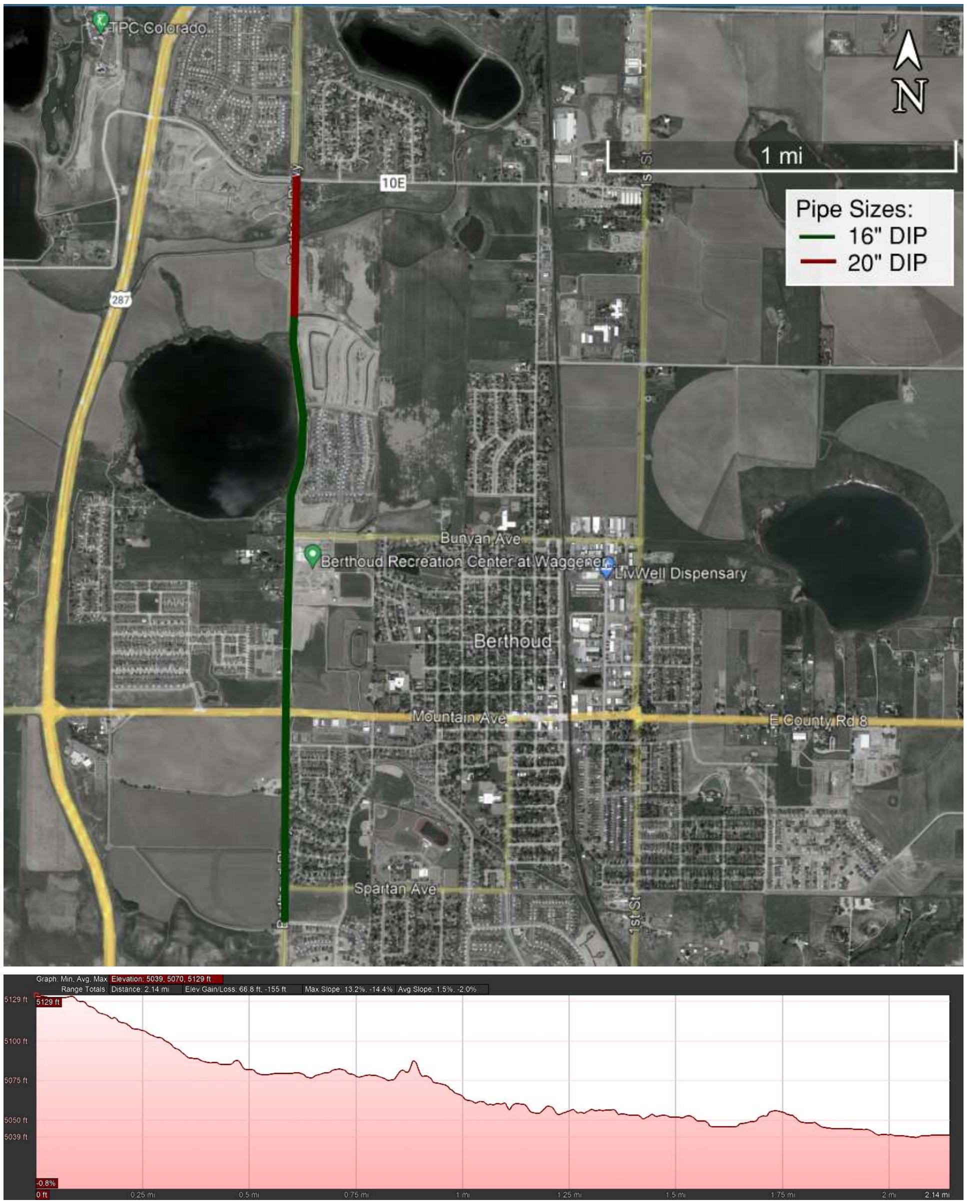


Figure 4-32: WD-6 | Berthoud Parkway Transmission Main

WD-7: BPS Upgrade, Phase 2

This project involves replacing the last remaining 25 hp pump in the BPS with an estimated 40 hp pump having a 600 gpm capacity. This pump will give the BPS the capability of pumping 3,254 gpm to accommodate the PHD in the north higher-pressure zone in the 20-year horizon. A VFD starter is anticipated for the new 40 hp pump.

A BPS plan is provided in Figure 4-33. The fourth pump (not shown), rated for 60 hp, was added in the last couple of years. The project cost is estimated at $556k.

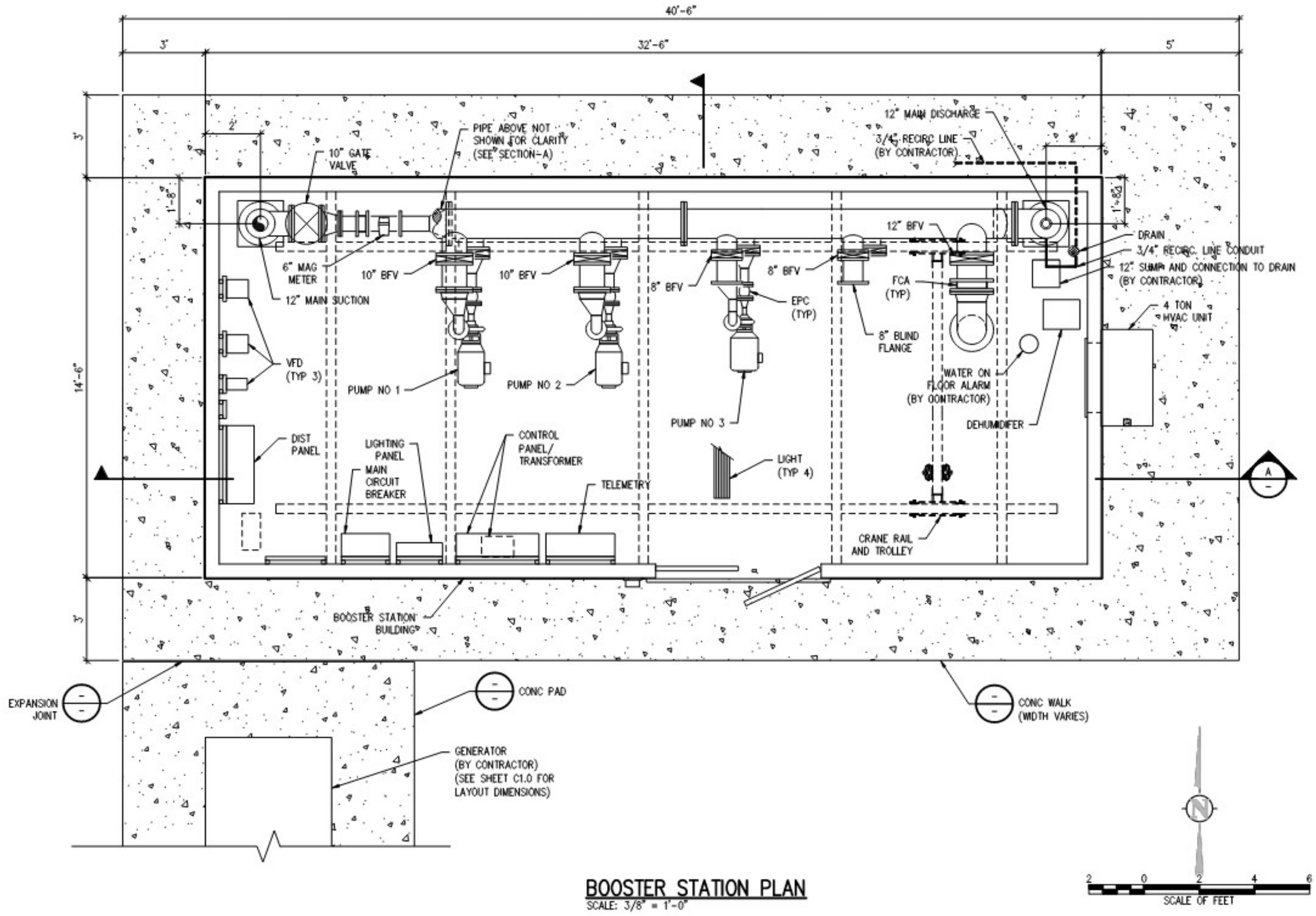


Figure 4-33: WD-7 | West BPS Upgrade, Phase 2

WD-8: East Zone Storage Tank and Pump Station

This project consists of a 1.5 MG storage tank and 3.5 MGD Pump Station that will primarily be used to offset the 3.11 MGD PHD and required fire flow storage in this zone. The Pump Station will primarily be used in the east zone but can be pumped over to the west zone. It includes two 2,500 gpm pumps to achieve the overall pumping capacity. When the new WTP (CIP project WTP-6) is operational, it is expected that the high service pumps will work in conjunction with the storage tank pumping system to achieve the MDD and PHD of 14 MGD.

The project cost is estimated at $20.11M.

WD-9: CR 44 Transmission Main, Phase 1

This project consists of approximately 7,800 linear feet of 24-inch diameter DIP water transmission main. This project will connect the new WTP, storage tank, booster pump station to the Turion development and a location near the Serenity Ridge neighborhood to be extended in the future as WD-10. This area is estimated to have a future 20-year planning horizon population of 11,000 people. The transmission main will primarily flow east to serve the new developments. There will also be a trenchless installation required under I-25, with the exact alignment to be determined. With unknown geotechnical conditions, the estimate reflects a microtunnel installation of a 36-inch steel casing under I-25.

An estimated plan and profile of this alignment is provided in Figure 4-34. The project cost is estimated at $16.16M.

Figure 4-34: WD-9 | CR 44 Transmission Main, Phase 1

WD-10: Serenity Ridge Connection

This project consists of approximately 6,180 linear feet of 12-inch diameter DIP water main. The alignment starts at County Road 44 just west of I-25 and goes south to the Serenity Ridge subdivision. There are two connections to the serenity ridge existing system, which is currently served by LTWD. An 8-inch water main is sufficient for providing MDD and PHD flows to this subdivision, however, 12-inch diameter sizing is required to keep AFF above 1,000 gpm in the neighborhood.

An estimated plan and profile of this alignment is provided in Figure 4-35. The project cost is estimated at $4.14M.

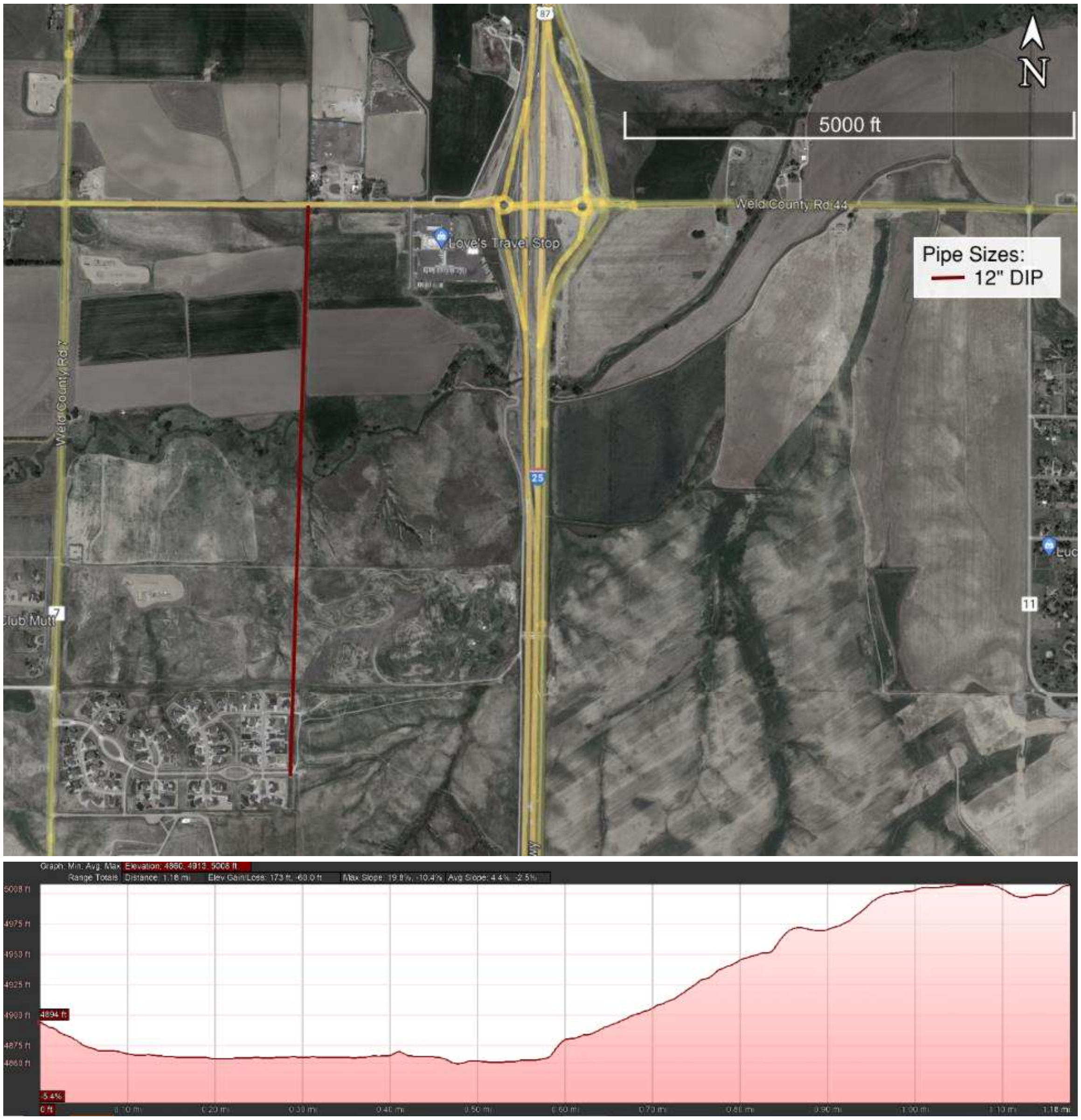


Figure 4-35: WD-10 | Serenity Ridge Connector

WD-11: CR 44 Transmission Main, Phase 2

This project consists of approximately 18,350 linear feet of 24-inch diameter DIP water transmission main. This project will connect Phase 1 (WD-9) to the western part of the Town for emergency fire flow purposes, and to help with pressures as necessary.

An estimated plan and profile of this alignment is provided in Figure 4-36. The project cost is estimated at $23.05M.

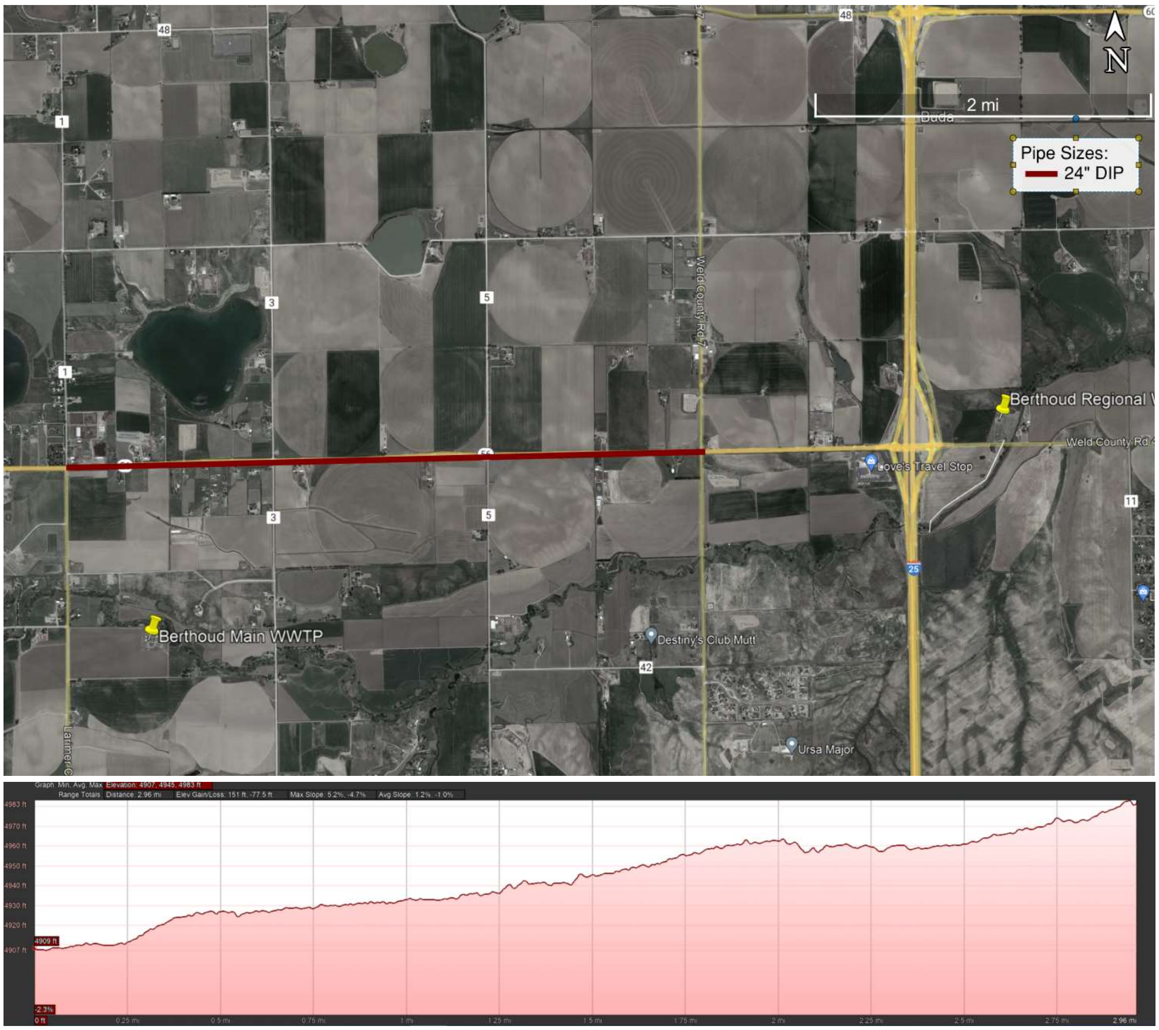


Figure 4-36: WD-11 | CR 44 Transmission Main, Phase 2

WD-12: PLC & Telemetry Upgrades

All remote sites observed communicate via Motorola ACE 3600 radios. The current 3 MG tank radio has solar power with no backup power which results in frequent outages. This radio should be removed, and the tank level sensor should be wired to the Booster Station PLC. Support for the radio telemetry system is by a single local vendor. It is preferred to have an openly supported system with a broader support network. Radios and associated RTUs need to be replaced at seven sites total, including the WTP.

The Booster Pump Station contains a MicroLogix 1400 PLC which is considered “Active Mature”, meaning the PLC is fully supported but a newer product family exists. It is recommended to upgrade this PLC.

4.9.2.2 Berthoud WTP Proposed Projects

This section contains the proposed capital improvement plan projects for the Berthoud WTP. They are listed in prioritized order of recommended completion.

WTP-1: High Service Pump Capacity Increase

The Berthoud WTP does not have firm HSP capacity to meet the rated net throughput capacity of the plant. The total installed pumping capacity (two pumps) is 4.0 MGD, with a firm capacity of 2.0 MGD. The Town is currently in the process of procuring a third high-service pump that will allow the plant to achieve a firm capacity of 4.0 MGD. It is recommended this upgrade be made as soon as possible. Should one of the two existing pumps fail, the Town would be temporarily unable to deliver more than 50% of the WTP output. Until the third pump is installed, Berthoud may need to rely on rapid response from LTWD to help meet maximum day usage over 2.0 MGD.

WTP-2: Filtration System Improvements

Filtration is crucial for protecting the drinking water supply from viruses, *Giardia*, and *Cryptosporidium*. It is therefore of great importance to ensure all filters are in good condition. This project would include media replacement in all four filters, rebuilding of filters one and two, addition of blowers and piping to provide sequential air/water backwashing capabilities, installation of level sensors on all four filters, increasing hydraulic capacity in the pipe between the plate settlers and the filters with a 20-inch parallel pipe, and implementing automation for backwash including developing control narratives, graphical displays, and integrating controls. The pressure instrument on the elevated backwash tank was noted to need replacement.

WTP-3: Berthoud WTP Expansion to 5.0 MGD

The Town of Berthoud is evaluating sources for additional surface water rights. If the Town is able to secure the water rights the additional flow will be routed through the existing WTP. The equipment at the WTP has been evaluated for its ability to treat additional flow and it was found that the existing equipment is capable of treating 1.0 MGD of additional flow with minor changes and upgrades. The most significant upgrades required to treat additional flow will be adding filtration capacity and pumping capacity. It is recommended to add 1.0 MGD of ultra filtration with the ability to expand to 2.0 MGD of ultra filtration in the future. WTP-2: Filtration Improvements will be required to be completed in addition to the plant expansion. High service pumping capacity will need to be increased to meet firm capacity with one pump out of service as described above in WTP-1. It is possible that increased pumping capacity may be achieved through replacement of impellers rather than needing to replace the entire pump.

Other necessary changes include increasing chemical dosing ability. The PAC pumps should be upgraded to dose 10 mg/L either by additional pumps or replacing pumping mechanisms and the disinfection pumps should be able to provide a maximum dose of 5 mg/L.

The Town would also like to construct a new 1,000 ft^2 administration building at the WTP. This is planned to be completed during the plant expansion and has been included in the OPCC.

WTP-4: Chemical Storage and Feed System Improvements

The Berthoud WTP chemical feed systems are manually controlled and not monitored by the plant SCADA system. Operations must physically look at the pump or read entry point monitoring data to detect a failure. This project would entail addition of flow monitoring and alarm systems to all chemical feed equipment, as well as flow pacing and pH trim to the sodium hypochlorite feed and caustic feed, respectively. These improvements will provide operations with better control of the chemical storage and feed systems and alert them to any malfunctions in a timely manner. This project will also involve implementing automation for backwash including developing control narratives, graphical displays, and integrating controls.

Sodium hypochlorite storage should be increased to provide 30 days of storage during peak demand months. This equates to two to three months of storage during lower demand periods, which is a reasonable amount of time to store sodium hypochlorite without experiencing excessive degradation.

WTP-5: Pretreatment Improvements

The mixers in the rapid mix basin and first/second stage flocculation basins are not VFD controlled. Addition of VFDs to these mixers would allow for optimization of mixing speed and potential energy cost savings. Installation of anti-vortex baffles to the rapid mix basin would reduce vortexing in the basin, increase interparticle collisions/initial flocculation, and improve chemical dispersion efficacy. Additionally, a SLC and MicroLogix 1100 PLC were observed in the Pretreatment building at the time of this report. Both PLCs should be upgraded during this project.

WTP-6: I-25 RO WTP and HSPS

As previously discussed in Section 4.2, the existing WTP has a net throughput capacity of 4.0 MGD and has sufficient water rights for that amount. As discussed in Section 4.7.1, the plant can be upgraded to 5 MGD with upgrades described in WTP-3. This leaves the new RO treatment plant(s) by I-25 to provide the remainder of the Year 2043 MDD, which was rounded to 1.6 MGD. These water rights, including accounting for losses, need to be obtained in the future 20-year projection.

This project will entail construction of a new WTP near the I-25/State Highway 56 interchange. These plant(s) will treat alluvial water that is (1) extracted from below the Little Thompson River downstream of the Berthoud WRF and/or (2) pumped from shallow wells in the South Platte Basin. Treated water from the new WTP(s) would serve a new pressure zone in this area. Excess water from the Main Town Zone/Berthoud WRP can feed from west to east to the I-25/Highway 56 Zone via pressure regulating valves (PRVs). Excess water from the new WTP(s) can be wheeled from east to west into the Main Town Zone via booster pumping.

Due to what is expected to be the saline/brackish quality of these water supplies, financial planning should be based on the use of RO technology with blending of demineralized RO permeate and membrane filtered water (without RO) to achieve the desired corrosion control characteristics. This project will construct a new RO WTP and HSPS with a net throughput of 1.6 MGD.

WTP-7: Network and Cybersecurity Updates

The Berthoud WTP's ICS network has connections to third parties such as LTWD, integrators, and the Internet as shown in Figure 4-37. This project will entail isolating the WTP ICS from outside connections, establishing secure inter-agency connection with LTWD, establishing secure means for alarm notification from SCADA, and implementing secure remote access for Operations and third-party support.

Additionally, the EPA issued a new rule and guidance directing state officials responsible for implementing the Safe Drinking Water Act to assess cybersecurity resilience using the sanitary survey program. This action applies to all Public Water Systems (PWS) of all sizes, effective March 3, 2023. This project ensures compliance with these EPA rules. See the EPA Compliance Matrix in **Appendix F** for a complete list of rules and guidance.

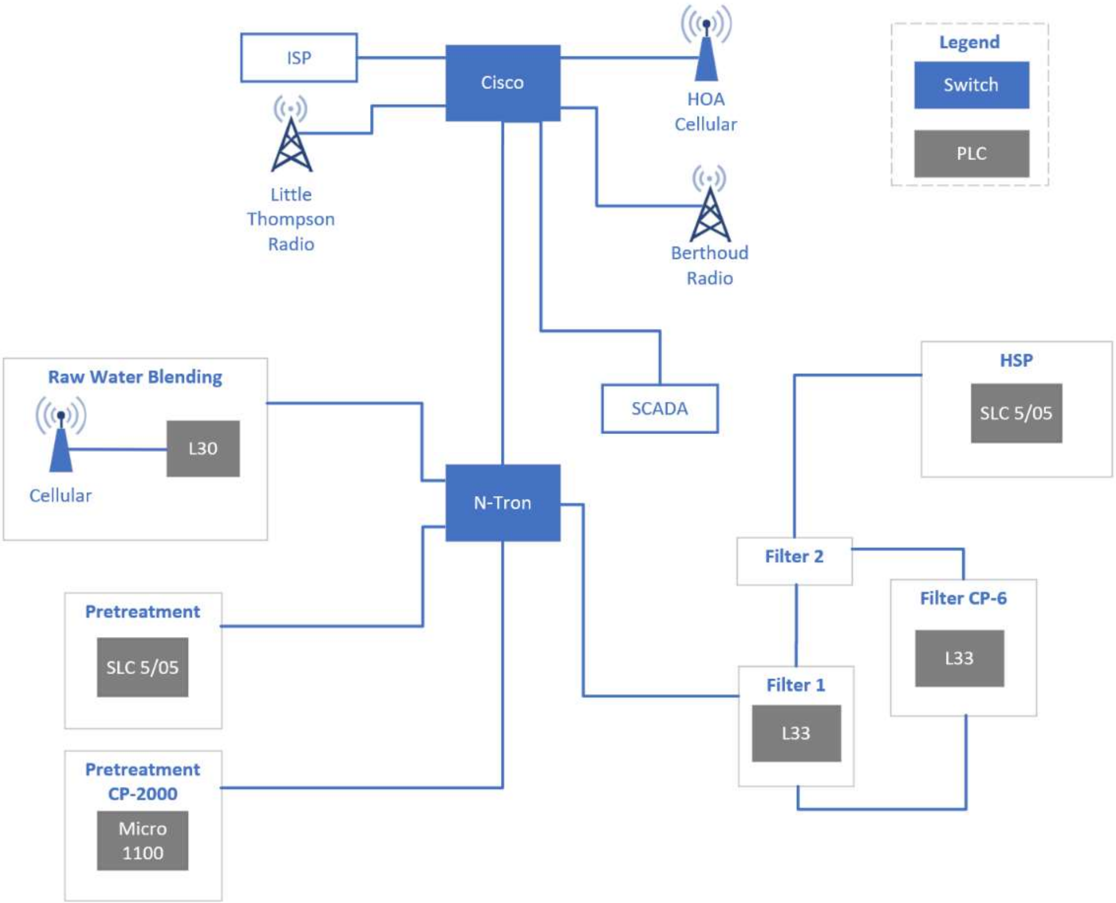


Figure 4-37: WTP-7 | Existing Network Architecture

Phase 1: ICS Policies and Procedures/Documentation

The Berthoud ICS OT Cybersecurity Program should have the following elements:

- OT Risk Management Plan
- OT Incident Response, Disaster Recovery, and Business Continuity Plans
- OT Cybersecurity Policies and Procedures
- OT Asset Management Program (asset inventory and tracking, critical component identification, asset lifecycle plan, software licensing tracking, firmware and software revision tracking)
- Change Management Program (configuration, programs, component, architecture, and topology changes)
- Identity and Access Management
- OT Patch Management Program
- OT Cybersecurity Awareness Training
- SCADA Standardization Program

Specifically, implement strict policies for use of iPads on the SCADA network. iPads necessary for SCADA operations should only be used for the Berthoud WTP.

Phase 2: Secure Internet Connection and Remote Access

Install a firewall to segment Internet Service Provider and other external communications from SCADA. All cellular connections should be removed. A Front-End Processor (FEP) should be installed to poll the SCADA system for data without creating a direct connection. A jump box should also be installed to create segregated security zones to allow for secure remote access.

Some PLCs were noted as out of support; the replacements for these PLCs are captured in other projects. A SLC 5/05 was observed at HSP at the time of this report. It is understood that an upgrade is underway, no action is recommended at this time.

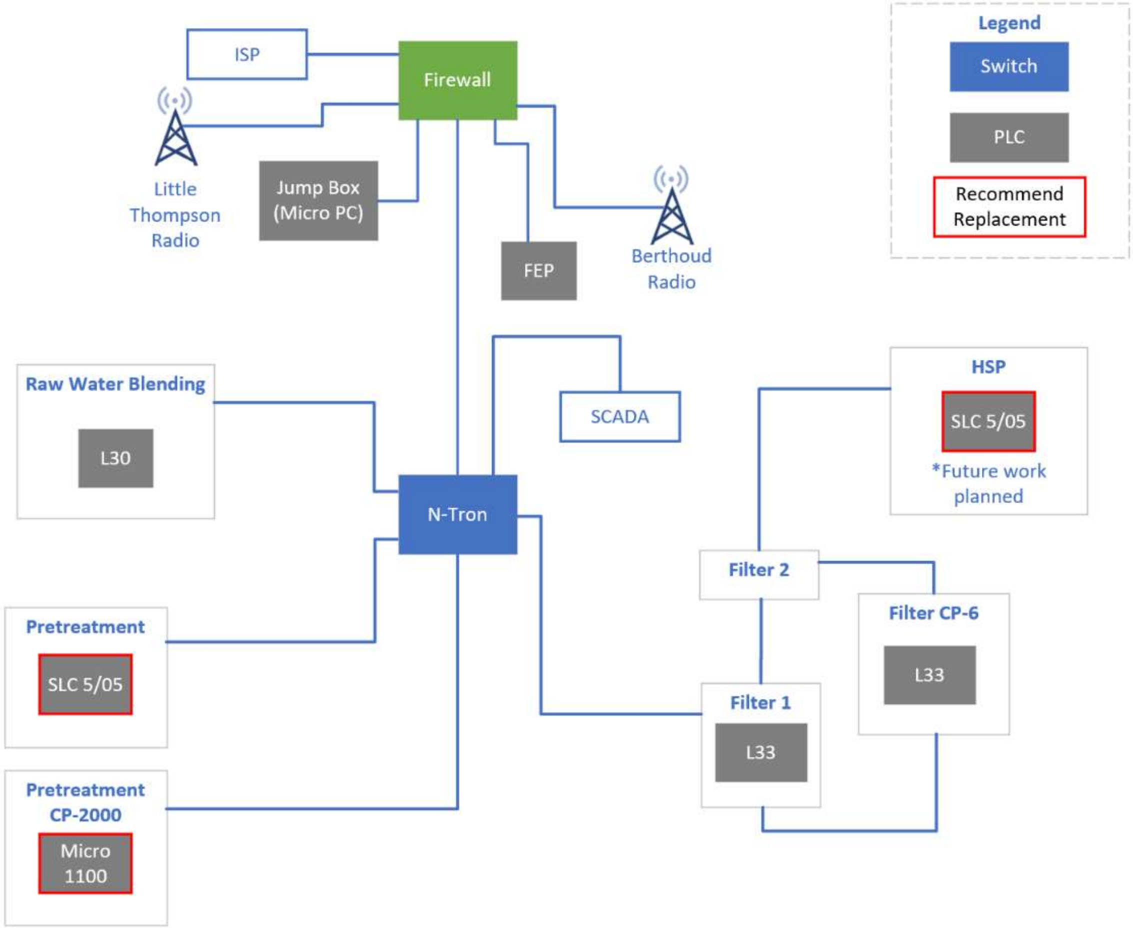


Figure 4-38: WTP-7 | Recommended Network Architecture

Phase 3: EPA ICS Security Compliance

After Phases 1 and 2 are complete, the remaining EPA rules can be complied with. The remaining rules include but are not limited to active directory policies for password control, complete asset inventory, event logging, and ICS-specific training. The SCADA Historian was noted as unreliable or instable. It is recommended to evaluate the issues with the SCADA historian and perform replacements as necessary during this Phase.

4.9.3 Proposed 20-Year Prioritized Plan

The proposed 20-Year Prioritized Plan is driven primarily by capacity and regulatory drivers. The capacity drivers are dependent on level and rate of development in the Berthoud service area. If the rate of actual development does not align with that predicted in this Master Plan, Berthoud should reevaluate project sequencing to line up with these changes in water demands. Projects provide explanation of drivers so the Town can readjust timing based on the thresholds for flow. Overall, the Berthoud WTP and associated distribution systems should justify project scope and sequencing based on the current needs of the plant.

Figure 4-39 shows the annual CIP expenditures for the water system. Class V cost estimate details for each project described above can be found in **Appendix C**.

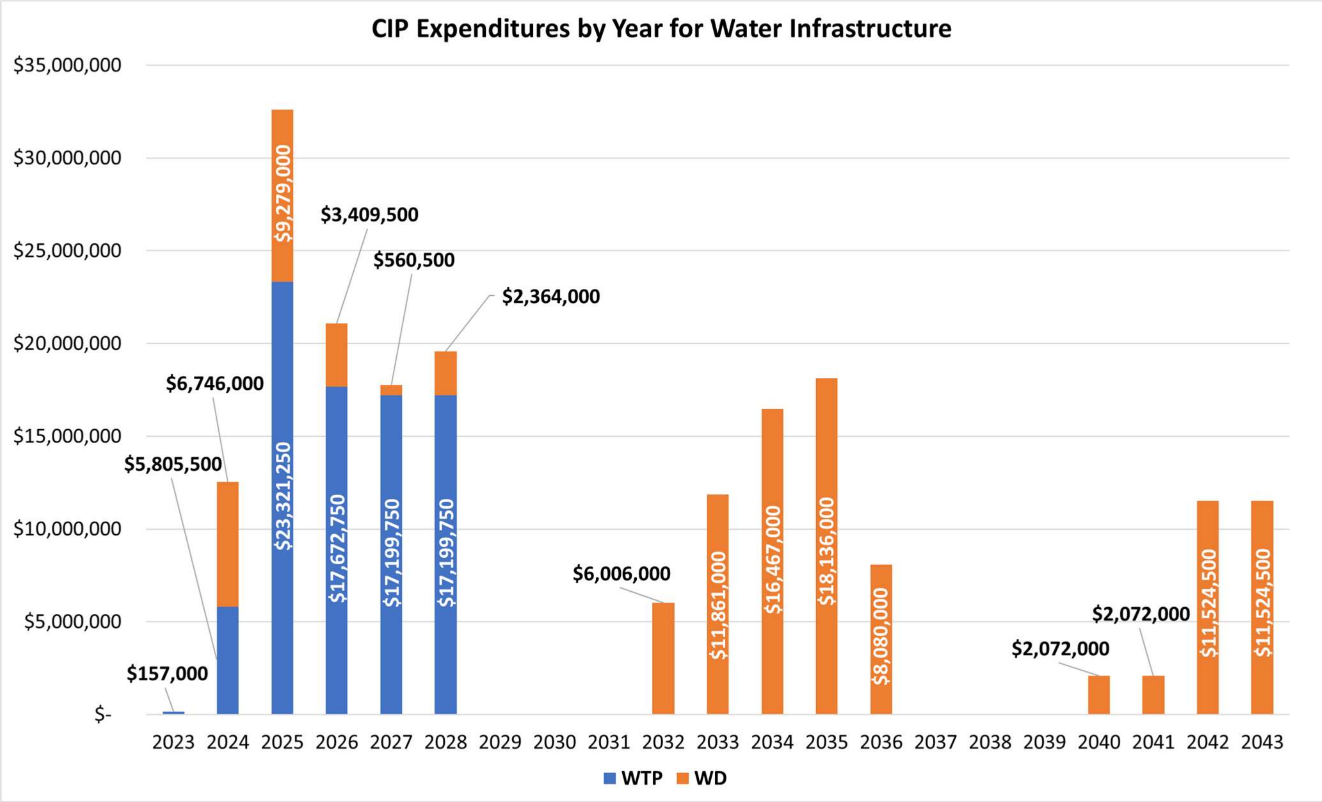


Figure 4-39: 20-Year Prioritized Plan Expenditures by Year for Water Infrastructure

4.9.3.1 *Implementation Schedule Timeline*

Figure 4-40 briefly describes the sequenced implementation schedule timeline for all the water infrastructure in the 20-year prioritized plan.

Proposed Capital Improvement Projects	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Water Treatment Plants																					
WTP-1: High Service Pump Capacity Increase																					
Planning, Financing and Design	■																				
Construction, Startup and Optimization	■	■																			
WTP-2: Filtration System Improvements																					
Planning, Financing and Design		■																			
Construction, Startup and Optimization		■	■																		
WTP-3: Berthoud WTP Expansion to 5.0 MGD																					
Planning, Financing and Design		■																			
Construction, Startup and Optimization		■	■																		
WTP-4: Chemical Storage and Feed System Improvements																					
Planning, Financing and Design			■																		
Construction, Startup and Optimization				■																	
WTP-5: Pretreatment Improvements																					
Planning, Financing and Design			■																		
Construction, Startup and Optimization				■																	
WTP-6: I-25 RO WTP and HSPS																					
Planning, Financing and Design			■	■																	
Construction, Startup and Optimization					■	■															
WTP-7: Network and Cybersecurity Updates																					
Planning, Financing and Design	■																				
Construction, Startup and Optimization	■	■																			
Water Distribution Systems																					
WD-1: Bacon Lake Transmission Main, Phase 1																					
Planning, Financing and Design		■																			
Construction and Startup			■																		
WD-2: Bacon Lake Transmission Main, Phase 2																					
Planning, Financing and Design			■																		
Construction and Startup				■																	
WD-3: West BPS Transmission Main																					
Planning, Financing and Design				■																	
Construction and Startup					■																
WD-4: West BPS Upgrade, Phase 1																					
Planning, Financing and Design						■															
Construction and Startup						■															
WD-5: West Tank Low Pressure Zone Transmission Main																					
Planning, Financing and Design										■											
Construction and Startup											■										
WD-6: Berthoud Parkway Transmission Main																					
Planning, Financing and Design											■										
Construction and Startup												■									
WD-7: BPS Upgrade, Phase 2																					
Planning, Financing and Design												■									
Construction and Startup												■									
WD-8: East Zone Storage Tank and Pump Station																					
Planning, Financing and Design												■									
Construction and Startup													■								
WD-9: CR 44 Transmission Main, Phase 1																					
Planning, Financing and Design													■								
Construction and Startup														■							
WD-10: Serenity Ridge Connection																					
Planning, Financing and Design																		■			
Construction and Startup																			■		
WD-11: CR 44 Transmission Main, Phase 1																					
Planning, Financing and Design																				■	
Construction and Startup																					■
WD-12: PLC & Telemetry Upgrades																					
Planning, Financing and Design		■																			
Construction and Startup		■																			

Figure 4-40: Water 20-Year Prioritized Plan Implementation Schedule Timeline

4.9.4 Funding Opportunities

Potential funding opportunities for the proposed 20-year CIP projects for water infrastructure are described in **Appendix E**.

5. WASTEWATER PLAN

This section contains an assessment of existing assets and recommended capital improvements for the Town's wastewater treatment and collection systems. In this document, the acronym 'WRF' stands for the main Town of Berthoud Water Reclamation Facility just east of County Road 1, and the acronym 'WWTF' will be used to denote all other community wastewater treatment facilities, including the Town's regional plant. The Wastewater Division manages the Town's gravity wastewater collection system, WRF, Regional WWTF, and four lift stations that serve the Town and adjacent service areas in unincorporated Larimer County, all of which are operated by REC. Residents beyond these service areas primarily rely on individual sewage disposal systems (ISDSs), principally septic tanks and leach fields, for wastewater management.

5.1 Overview of System

The following sections provide a brief background on the Town of Berthoud's treatment and collection system facilities referenced above.

5.1.1 Collection System

The collection system consists of an estimated 480,889 linear feet of sanitary sewer pipe ranging in size between 4-inch and 24-inch diameter. There are four lift stations throughout the Town, not including the plant influent lift stations. The lift stations are rated for capacities ranging between 86 gpm and 490 gpm. The collection system routes flow to the Regional WWTF or the Berthoud WRF for treatment.

5.1.2 Wastewater Treatment

The Town operates two treatment facilities for wastewater management. The Regional WWTF is the smaller of the two, serving a commercial area near the intersection of I-25 and State Highway 56. It is also intended to accommodate future growth in the vicinity of the WWTF.

The Berthoud WRF was completed in 2004 and upgraded in 2013 due to flooding of the Little Thompson River. The Berthoud WRF is located in southeast Berthoud and receives flows from the majority of the Town, including the four existing lift stations.

5.1.2.1 Service and Planning Area

The Berthoud 208 planning area boundary, as currently established and approved through the North Front Range Water Quality Planning Association (NFRWQPA), is shown on Figure 5-1. The figure indicates the extent of the Town's service area. The WWTFs are listed below along with their rated 30-day average hydraulic and organic loading capacities as biochemical oxygen demand (BOD):

- **Berthoud WRF** – 2.0 MGD and 3,900 ppd BOD
- **Regional WWTF** – 0.099 MGD and 248 ppd BOD

Temporary minor WWTFs in Berthoud's ultimate planning area include:

- Western/Mini Ranches/Vaquero Estates WWTF

The River Glen HOA WWTF no longer exists and is now the River Glen Lift Station, which received flow from the River Glen HOA and Riverside Farms HOA. The Serenity Ridge WWTF has been decommissioned, and its flow is now routed to Regional WWTF for treatment.

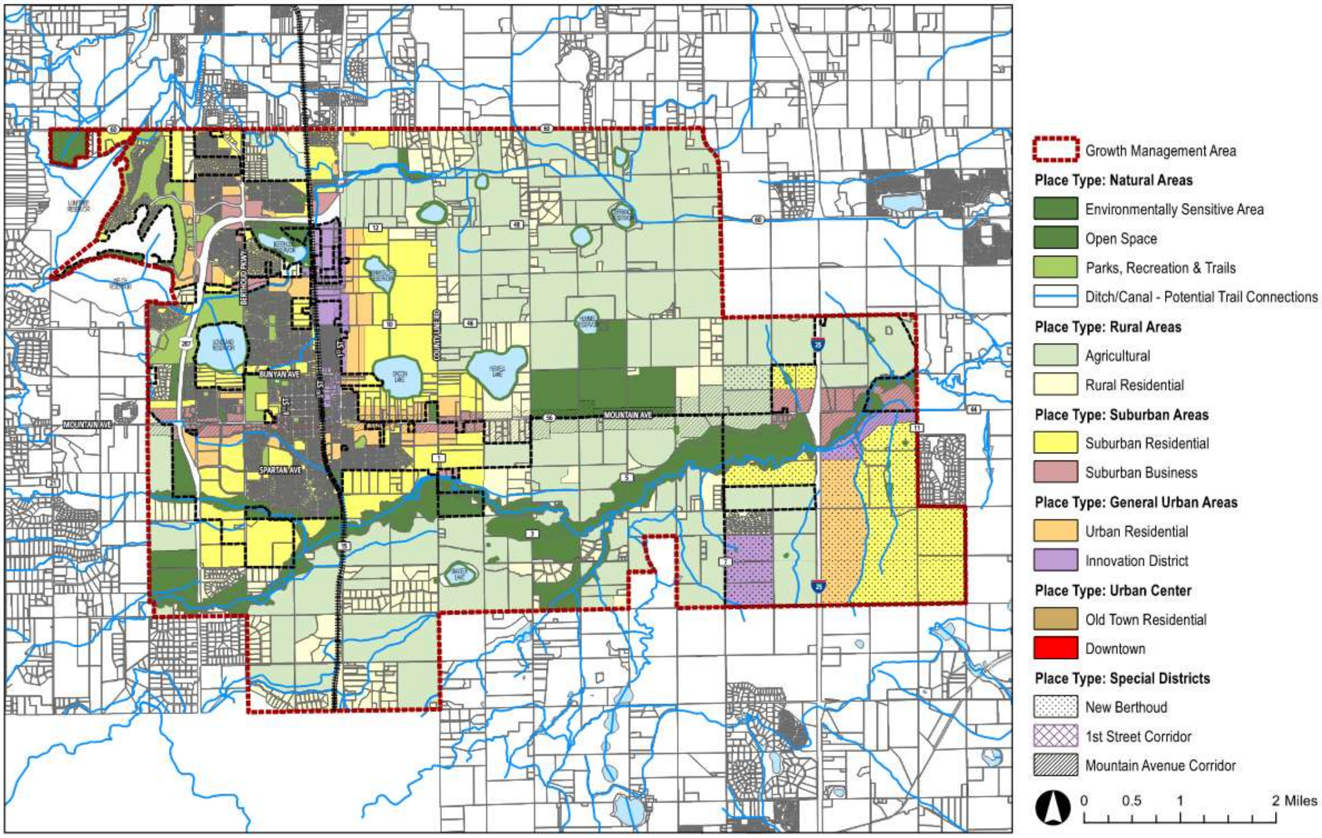


Figure 5-1: Future Land Use and Growth Management Area

5.1.2.2 Wastewater Composition

Wastewater flows within the Town's service area, and routed to the Berthoud WRF, are primarily residential, with few commercial and industrial dischargers. Industrial discharges are primarily received from Berthoud Industrial Park, which is located along N 2nd Street between Mountain Avenue and Bunyan Avenue.

Influent flow to the Regional WWTF consists primarily of discharges received from the nearby Love's gas station and contains a high density of debris. A residential development is currently being constructed in this area.

5.1.2.3 Wastewater Reuse

While wastewater effluent can be a reliable source of supply in the arid West, water rights are complicated and site-specific within Colorado. For the Town of Berthoud, LRE Water believes indirect potable reuse, rather than potable water demand management via substitution of final effluent for non-potable uses, will maximize the use/reuse of its imported West Slope water supplies that are delivered via Carter Lake. Consequently, the Town is contemplating recovery of the reusable portion of its effluent via horizontal wells placed under the Little Thompson River below the point of discharge from the Berthoud WRF. It is not anticipated that the Town will directly utilize much, if any, of the final effluent from the WRF or Regional WWTF for non-potable uses.

5.1.2.4 Industrial Pretreatment Program (IPP) and Best Management Practices

Since the industries discharging in Berthoud's service area fall under the general umbrella of 'light', the Town does not currently differentiate between commercial and industrial flows. As such, an IPP program has not been deemed necessary for protection of the WRF and WWTF from passthrough, toxicity, or biosolids management. This may need to be reviewed in the future as the Berthoud service area develops. EPA requires that plants with a rated capacity above 5 MGD have an IPP. However, based on flow projections and necessary capacity increases as described in Section 5.2, neither the Berthoud WRF nor Regional WWTF will be mandated to include an IPP based on future rated capacity. However, National Pollutant Discharge Elimination System (NPDES) permits have general prohibitions regarding industrial/non-domestic wastes. As Colorado has been delegated primary with respect to issuing discharge permits, the WRF and WWTF permits are Colorado Discharge Permit System (CDPS) permits, but these general prohibitions still apply. These are described in the Terms and Condition section, under "Pretreatment Program – Industrial Waste Management," for both Berthoud WRF and Regional WWTF permits. These Permits are discussed further in Section 5.3.

5.2 Flow and Load: Existing and Projected

The Town's wastewater infrastructure has seen a steady increase in flows and loads. It is important to understand the rate of this increase to identify assets that are approaching their rated capacities. Wastewater flows are categorized as ADF, MMF, MDF, and PHF.

Table 5-1 summarizes these flows and associated peaking factors based on data from July 2017 through June 2022. Hourly data was not made available for review, a peak hour to average daily (PHF:ADF) peaking factor of 3.0 was assumed for the Berthoud WRF. This is conservative compared to the City of Denver peaking factor formula, and is agreed for use until there is sufficient hourly data to allow for a site-specific value.

When compared to MMF, the Berthoud WRF peaking factors are as follows:

- ADF:MMF: 0.65
- MDF:MMF: 1.23
- PHF:MMF: 2.00.

These MMF-based peaking factors are used when making capacity determinations and equating them to equivalent MMF as the 'common barometer'.

Due to the size and rated capacity of the Regional WWTF, flow-based peaking factor formulas typically indicate inordinately high peaks. Accordingly, both the MDF:ADF and PHF:ADF ratio were capped at 4.0 for the Regional WWTF. As data becomes available, this value should be verified.

Table 5-1: Wastewater Influent Data (July 2017 – June 2022)

	Berthoud WRF	Berthoud Regional WWTF
Influent Flows (MGD)		
ADF	0.96	0.016
MMF	1.47	0.023
MDF	1.81	0.040
PHF	2.88	0.064
Peaking Factors (Dimensionless)		
ADF : ADF	1.00	1.00
MMF : ADF	1.53	2.04
MDF : ADF	1.89	2.51
PHF : ADF	3.00	4.00
ADF : MMF	0.65	0.49
MMF : MMF	1.00	1.00
MDF : MMF	1.23	1.74
PHF : MMF	2.00	2.78

5.2.1 Infiltration and Inflow

Infiltration and Inflow (I/I) is a known issue in the collection system that the Town is actively addressing. The flow monitoring period for this master plan did not capture any wet weather events. The Berthoud Design and Construction Standards indicate to assume an additional 10% of PHF as I/I. The regulatory compliance impacts likely caused by I/I challenges are discussed in Section 5.3.

5.2.2 Berthoud WRF

This section describes the methodology used to predict wastewater treatment capacity expansions due to predicted flows and loads at the Berthoud WRF.

5.2.2.1 Capacity Staging

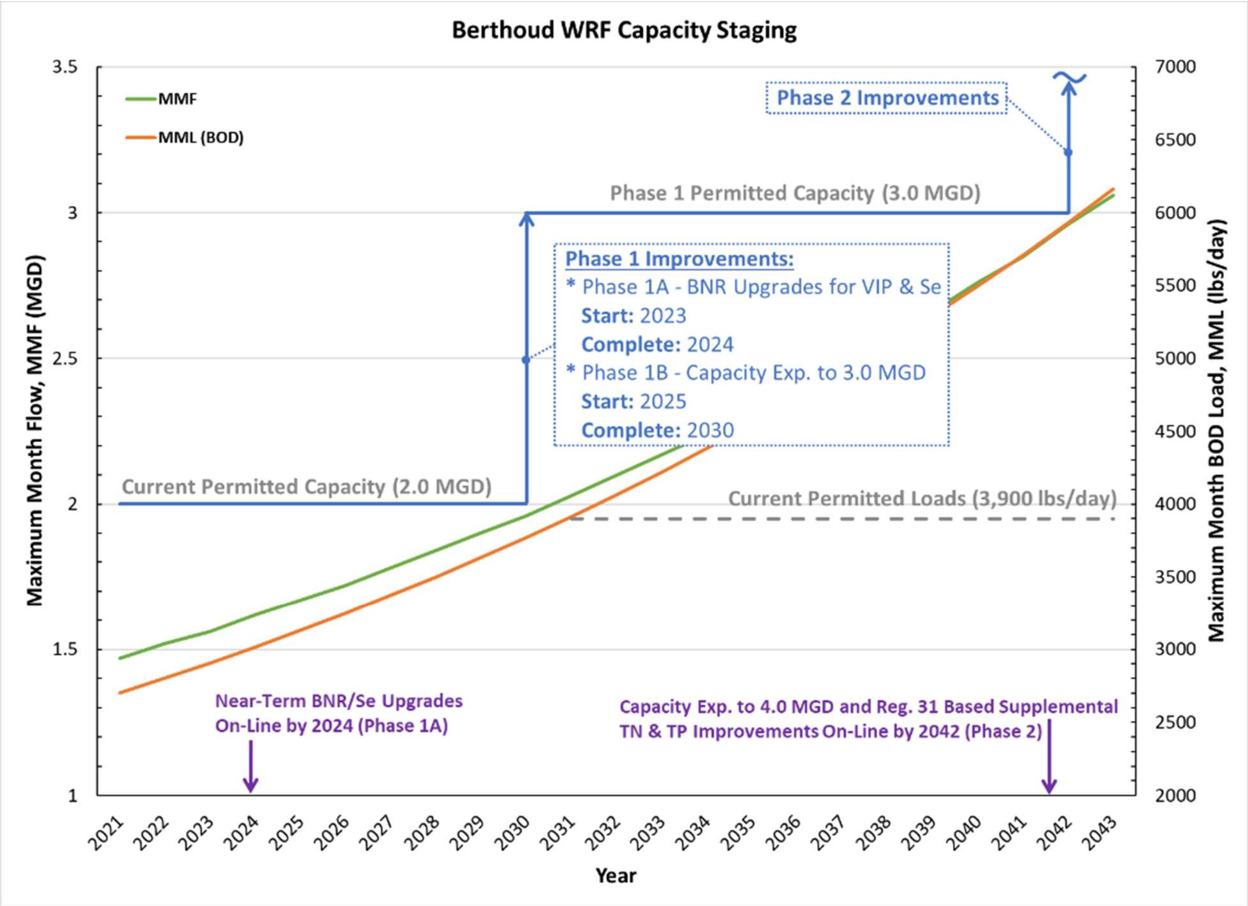


Figure 5-2: Berthoud WRF Capacity Staging

Figure 5-2 graphically illustrates a suggested phasing plan for adding capacity and additional BNR improvements at the Berthoud WRF. As agreed with the Town, the projected increase in MMF and load is based on a 4% compound annual growth rate. The principal goal of Phase 1A is to improve biological nitrate and phosphorous reduction so the Town can maximize the length of Regulation 31-based compliance schedule extension credits before the VIP program ends (2027). Enhanced selenium removal is a companion goal the Phase 1A project. The A_2O/BNR retrofit will enable the Berthoud WRF to comply with Regulation 85 effluent TIN and TP requirements, should they be applied by CDPHE once the rated capacity of the WRF is increased beyond 2.0 MGD and/or delayed implementation 'clocks out' in 2027.

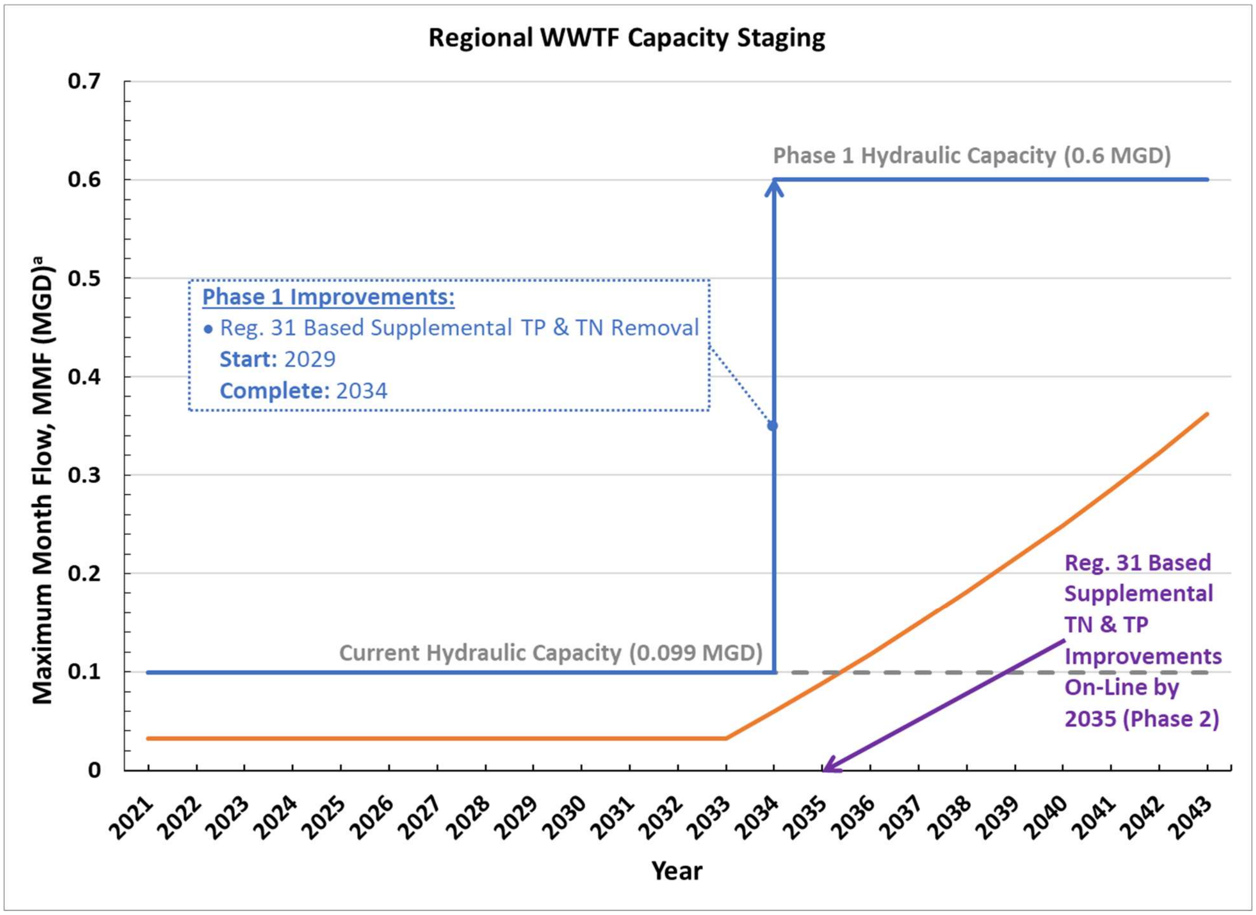
The Phase 1B expansion to 3.0 MGD will also include the same BNR upgrades selected for the existing two, 1.0-MGD MMF treatment trains. Several alternatives have been identified for creating a more effective A_2O process at the WRF. These include (1) adding separate ANA tanks upstream of the existing 3-pass aeration basins and (2) retrofitting defined, separate, and mechanically mixed anaerobic and anoxic zones in series within the first pass of the existing aeration basins. If Pass 1 is converted to ANA treatment, it may require that oxic Passes 2 and 3 be converted to IFAS, or hydrocyclones added on the return activated sludge lines (RAS) lines to create a granular activated sludge that can support higher mixed liquor concentrations that will settle well in the existing secondary clarifiers. Preliminary design and alternative selection for the BNR improvements will also take into consideration which BNR configuration is likely to have the best selenium removal of the options being considered.

The Phase 2 Improvements will (1) expand MMF and associated BOD load capacity to 4.0 MGD and (2) add supplemental TN and TP removal facilities to meet Regulation 31-based, in-stream numeric nutrient standards for the Little Thompson River. The timeline takes advantage of the VIP compliance schedule extension credits anticipated that the WRF can earn between 2023 and 2027. The Town's need for a capacity expansion and compliance with Regulation 31 appear in year 2042.

5.2.3 Regional WWTF

This section describes the methodology used to predict capacity expansions due to predicted flows and loads at Regional WWTF.

5.2.3.1 Capacity Staging



Projected maximum month flows and loads are in balance for Regional WWTF. For simplicity, only flows are depicted on the above figure.

Figure 5-3: Regional WWTF Capacity Staging

The Regional WWTF has a rated treatment capacity of 0.099 MGD, and was financed and constructed by a developer solely to serve new growth near I-25 and Colorado Highway 56. Figure 5-3 presents a potential phasing plan for adding capacity and BNR improvements at the Regional WWTF. The graph was prepared assuming that 20% of the future growth in the Town would occur in and around the Highway 56 and I-25 interchange. It further assumes that construction of additional residential and commercial properties will create an appreciable increase in flow to the WWTF beginning in 2033. The goal of Phase 1 is straightforward: increase the MMF and associated BOD load capacity to 0.6 MGD using the same BNR and Chemical-P removal technology currently employed at the Regional WWTF. An incremental increase to 0.6 MGD will provide sufficient capacity through the planning period, assuming development does not start discharging until 2033.

According to the Town, the principal developer of the area, Turion, will pay for the expansion of the Regional WWTP when needed to support its development plans and schedules. It is anticipated the facility expansion will take three to four years. The current Regional WWTP can accommodate additional flows for approximately 400 single family homes.

Turion development start date depends on economic conditions. At the completion of this Master Plan, the timing of Turion development was unknown. When Turion expands the Regional WWTP, the Master Plan presumes this facility will be enlarged (Phase 1 Project) from 0.099 to 0.60 MGD and can then handle the equivalent of approximately 2,400 single family homes. The timing of Phase 1 (WWTF-1) is dependent on Turion and thus changes to development plans will alter the above scenario.

The Phase 2 expansion must include supplemental, Regulation 31-based TN and TP improvements. Since the Regional WWTF cannot earn VIP credits, it is anticipated a typical compliance schedule of five years will be provided by CDPHE when the discharge permit is renewed after 2027 and prior to 2035, which was anticipated to be 2031 for the development of this Master Plan.

The Phase 1 and 2 projects were kept as separate projects since the capacity upgrade will likely be 100% funded by developers, where the Regulation 31 improvements may be the responsibility of the Town if regulatory upgrades are needed ahead of capacity expansion. If the Phase 1 Project is required at approximately the same time as the Phase 2 Project, improvements may be consolidated into a common Phase 1/2 Project and developer financed, resulting in no net impact on the Town's cash flow posture in the Wastewater Fund. If the timing does not match up, Phase 2 will be a separate project for which the Town would need to be prepared to finance and construct. For the purpose of the Town's cash flow projection for the Wastewater Fund, it is assumed that Town-financing of the Phase 2 Project, if required, would occur in the 2029 to 2034 timeframe. Although 4 years is likely sufficient to increase capacity to 0.6 MGD and make regulatory improvements at Regional WTF, the CIP conservatively estimated 6 years for both phases to plan for feasibility studies and alternatives evaluations that will likely be necessary to determine the most economical approach to meeting these drivers.

5.2.4 Proposed Flows and Peaking Factors

Table 1-2 summarizes the proposed flows and peaking factors through 2043 for Berthoud WRF and Regional WWTF. While peaking factors will likely decrease as flows and loads increase at each plant, using the historical peaking factors provides the Town with a conservative approach to capital improvement planning for the next 20 years.

Table 5-2: Proposed Wastewater Treatment Flows Summary

Category	Berthoud WRF		Regional WWTF	
	2033	2043	2033	2043
Population	17,543	24,347	168	1,869
ADF	1.42	2.0	0.016	0.178
MMF	2.17	3.06	0.033	0.362
MDF	2.67	3.77	0.040	0.446
PHF	4.25	6.0	0.064	0.7103
MMF:ADF	1.53		2.04	
MDF:ADF	1.89		2.51	
PHF:ADF	3.00		4.00	

5.3 Regulatory Outlook

The Berthoud WRF and Regional WWTF discharge either directly or via tributary to the Little Thompson River, which is part of the South Platte River Basin. The CDPHE Water Quality Control Commission (WQCC) holds basin hearings on a five-year cycle. The next rule-making hearing for the South Platte River Basin will be held in 2025, and the Water Quality Control Division (WQCD) will endeavor to issue permit renewals for the South Platte Basin the following year. The WQCD does not have the resources to renew all permits on time and on a statewide basis, is three to four years in arrears in this regard. As noted below, the permits for the Berthoud WRF and the Regional WWTF expired in 2020 and 2021, respectively, and have been administratively extended by the WQCD. For the purposes of facility planning, it is assumed both permits will be renewed in 2026 immediately after the next rule-making hearing for the South Platte Basin. It is recommended that the Town's long-term capital improvement program schedule be developed assuming that permits will be renewed on-time, according to the five-year basin schedule, even though the permit renewal backlog may continue into the future. By anticipating upcoming regulatory changes, the Town can plan to use its budget and resources in the most effective way for its ratepayers. Table 5-3 summarizes the effective date and status of the discharge permits for the Berthoud WRF and Regional WWTF.

Table 5-3: Summary of Town of Berthoud CDPS Permits

Facility	Permit No.	Issued Date	Effective Date	Status
Berthoud WRF	CO0046663	July 1, 2015	Aug. 1, 2015	Expired in 2020 (Administrative Extended)
Regional WWTF	CO0048998	March 23, 2016	May 1, 2016	Expired in 2021 (Administrative Extended)

The WQCD issued a 10-year water quality roadmap in 2017 that forecasted upcoming major regulatory actions. Table 5-4 summarizes the forecasted changes and their approximate timeline. In general, the WQCD is proceeding along that pathway, making mid-course adjustments and revising schedules as it moves forward, with input from a wide range of stakeholders and technical advisors. The relevance of these upcoming regulatory actions at each of Berthoud's treatment plants will be discussed in Section 5.3.3.2 and 5.3.4.2.

Table 5-4. Timeline of Potential Regulatory Changes based on CDPHE's 10-Year Water Quality Roadmap

Year	Update
2023	Adopt chlorophyll *a* standards statewide.
2024	Release draft ammonia and arsenic criteria. Release draft selenium criteria.
2026	Release draft TN and TP criteria for streams. Adopt arsenic standards statewide.
2027	Adopt ammonia, selenium, TN, and TP standards statewide.

5.3.1 CDPHE Voluntary Nutrient Incentive Program (WQCC Policy 17-1)

Regulation 85 Section 85.5(1.5) established a Voluntary Incentive Program for Early Nutrient Reductions, which encourages WWTFs to work towards nutrient reductions prior to 2028 in exchange for extension of compliance schedules necessary to meet Regulation 31-based, in-steam numeric nutrient standards, which are currently slated to go into effect on a statewide basis at the end of 2027. CDPHE intends to use the proposed in-stream numeric nutrient standards to help derive effluent limits for the first permit renewal that occurs after the standards are adopted, and this could be as soon as 2028 depending upon when a permittee's discharge permit is up for renewal and actually renewed.

Typically, CDPHE provides up to a five-year compliance schedule to plan, finance, design, permit, construct, commission, and optimize the performance of improvements needed to meet new effluent quality limits. As noted below, the length of the compliance schedule extension beyond five years (i.e., credits) is proportional to how well a plant enrolled in the VIP (such as the Berthoud WRF) performs with respect to the median annual effluent quality target values set by CDPHE, which are 7 mg-N/L for total inorganic nitrogen (TIN) and 0.7 mg-P/L for total phosphorus (TP).

A frequently asked question is why VIP compliance schedule credits for nitrogen are based on TIN even though Regulation 31 numeric nutrient limits will be based on TN. Based on stakeholder input in 2012, CDPHE elected to use TIN for Regulation 85 effluent quality compliance because (1) it is less difficult for dischargers meet a TIN effluent standard of 15 mg-N/L compared to a TN limit of the same magnitude and (2) a significant amount of nitrogen removal will still be achieved. CDPHE then structured its VIP policy to be consistent with Regulation 85 effluent limits. Note that TIN reductions in the VIP count one-for-one for Regulation 31-based TN compliance schedule extension purposes, which is a cash flow management benefit to permittees. Complete guidelines for this program are outlined in WQCC Policy 17-1.

Based on median annual effluent quality, VIP participants earn Regulation 31 compliance schedule credits as follows:

- TIN Credits (to extend Regulation 31 compliance schedule deadline for TN limits):
  - **TIN ≥ 15 mg/L** – No TN compliance schedule credits earned
  - **TIN < 15 mg/L and > 7 mg/L** – Partial credits (i.e., months) earned
  - **TIN ≤ 7 mg/L** – Full 12 months of TN compliance schedule credits earned
  - Maximum of 7.5 years of Regulation 31 compliance schedule extension credits for TN
- TP Credits (to extend Regulation 31 compliance deadline for TP limits):
  - **TP ≥ 1 mg/L** – No TP compliance schedule credits earned
  - **TP < 1 mg/L and > 0.7 mg/L** – Partial credits (i.e., months) earned
  - **TP ≤ 0.7 mg/L** – Full 12 months of TP compliance schedule credits earned
  - Maximum of 7.5 years of Regulation 31 compliance schedule extension credits for TP
- TIN + TP Credits (to extend Regulation 31 compliance schedule deadline for both TN and TP limits):

A combination of full and partial credits for both TIN and TP is required to get Regulation 31 compliance schedule extension for both TN and TP limits

Combined maximum of 10 years of Regulation 31 compliance schedule extension credits can be earned for both TN and TP limits

Berthoud WRF opted into the VIP, while the Regional WWTF cannot be part of this program because (1) CDPHE site approval for this facility was subsequent to 2012 and (2) it is already required to meet the VIP targets as enforceable effluent quality limits. CDPHE developed a VIP Credit Calculator that can be used to determine credits based on actual or anticipated effluent TIN and TP concentrations. A summary of submitted results to-date are presented in Table 5-5. Berthoud WRF will earn seven months of incentive credits for the TIN values submitted in 2021. Other submitted TIN and TP concentrations exceed limits and therefore will not earn credits.

Table 5-5: Median Annual Effluent TIN and TP Concentrations

Limit	Year	Berthoud WRF	Regional WWTF
TIN (mg-N/L)	2018	--	N/A
	2019	--	N/A
	2020	16.2	N/A
	2021	10.2	N/A
	2022	16.2	N/A
TP (mg-P/L)	2018	--	N/A
	2019	--	N/A
	2020	2.5	N/A
	2021	2.0	N/A
	2022	1.9	N/A

To forecast the compliance schedule extension credits that Berthoud WRF can expect, two scenarios were analyzed:

- Status Quo (i.e., no near-term improvements made to enhance BNR performance)
- Proactive Case (i.e., improvements are made to enhance BNR performance in the near-term)

Figure 5-4 and Figure 5-5 summarize these theoretical scenarios. Compliance history and exceedances will be discussed in Section 5.3.3 and 5.3.4, respectively for Berthoud WRF and Regional WWTF.

ENTER DATA HERE

CREDITS EARNED

	Annual median concentrations		Incentive credits earned		
	TIN	TP	TIN	TP	TIN+TP
	mg/L	mg/L	Month	Month	Month
2018	--	--	0	0	
2019	--	--	0	0	
2020	16.2	2.5	0	0	
2021	10.2	2	7.2	0	
2022	16.2	1.9	0	0	
2023	15	2	0	0	
2024	15	2	0	0	
2025	15	2	0	0	
2026	15	2	0	0	
2027	15	2	0	0	
Total months			7.2	0	0
Eligible Months			7	0	0
Eligible Years			0.58	0	0

Figure 5-4: VIP Credit Calculator with Possible Values for 2023-2027 for Status Quo Scenario

The status quo case assumes the Berthoud WRF will not make near-term Phase 1A improvements to install upstream ANA (anaerobic and anoxic) basins or baffled and mixed anaerobic and anoxic zones within Pass 1. Therefore, the status quo option assumes the Town will not be able to improve Bio-P removal and nitrate reduction performance compared to what was achieved in 2020-2022. Accordingly, this scenario results in only 7 months of VIP credit delays based on what was achieved in 2021.

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CREDITS EARNED

	Annual median concentrations		Incentive credits earned		
	TIN	TP	TIN	TP	TIN+TP
	mg/L	mg/L	Month	Month	Month
2018	--	--	0	0	
2019	--	--	0	0	
2020	16.2	2.5	0	0	
2021	10.2	2	7.2	0	
2022	16.2	1.9	0	0	
2023	15	2	0	0	
2024	15	2	0	0	
2025	7	0.7	12	12	
2026	7	0.7	12	12	
2027	7	0.7	12	12	

Total months	43.2	36	79.2
Eligible Months	43	36	79
Eligible Years	3.58	3	6.58

Figure 5-5: VIP Credit Calculator with Possible Values for 2023-2027 for Proactive Case Scenario

The proactive case assumes Berthoud will initiate a project in 2023 to install upstream ANA basins or mixed anaerobic and anoxic zones in Pass 1 to create the environmental conditions needed to reliably lower effluent TIN and TP residuals and obtain Regulation 31 compliance schedule credits for each full year from 2025-2027. Mixing can be achieved by very large bubble diffusers or either submersible or floating mixers. The proactive case is expected to result in a total of 6.5 years of additional compliance schedule credits.

5.3.2 Receiving Water Quality

Both Berthoud WRF and Regional WWTF discharge into the Little Thompson River stream segment COSPBT09, corresponding to the South Platte River Basin, Big Thompson Sub-Basin, Stream Segment 09. This segment is described as "mainstem of the Little Thompson River from the Culver Ditch diversion to the confluence with the Big Thompson River." The stream is classified as Aquatic Life Warm 2, Recreation Class E, Water Supply, Agriculture. 'Aquatic Life Warm 2' signifies that the Little Thompson River Segment 09 is not capable of sustaining a wide variety of warm water species due to currently uncorrectable conditions. 'Recreation Class E' signifies that primary contact recreation is currently or potentially attainable within Segment 09. Additionally, Segment 09 is classified as reviewable for anti-degradation purposes.

The following Table 5-6 summarizes the water quality standards for segment COSPBT09 of the South Platte Basin. Although the 2015 and 2016 Water Quality Assessments (WQAs) completed for Berthoud WRF and Regional WWTF (respectively) evaluated the same stream segment of Little Thompson River, these standards are slightly different. Differences in the standards reported for these WQAs are explained in the table footnotes.

Table 5-6: Pertinent Water Quality Standards for Segment COSPBT09

Parameter	Acute	Chronic
Physical and Biological		
Temperature – March-November (°C)	28.6 (DM)	27.5 (MWAT)
Temperature – December-February (°C)	14.3 (DM)	13.8 (MWAT)
DO (mg/L)		5
pH (s.u.)	6.5 - 9	
E. coli (#/100 mLs)		126
Chlorophyll *a* (mg/m^2)		150
Inorganic		
Ammonia (mg/L)	TVS Varies	TVS Varies
Boron (mg/L)		0.75
Chloride (mg/L)		250 WS
Chlorine (mg/L)	0.019	0.011
Cyanide (mg/L)	0.005	
Nitrate (mg/L)	10[1]	
Nitrite (mg/L)	0.5	
Sulfate (mg/L)		250 WS
Sulfide (mg/L)		0.002
Total Phosphorus (µg-P/L, Reg. 31 Placeholder)		170
Metals (All dissolved unless noted)		
Arsenic (µg/L)	340	
Total Recoverable Arsenic (µg/L)		0.02-10 WS
Cadmium (µg/L)	TVS (9.1)	TVS (1.2)
Total Recoverable Cadmium (µg/L)	5.0	
Trivalent Chromium (µg/L)	TVS	TVS
Total Recoverable Trivalent Chromium (µg/L)	50	
Hexavalent Chromium (µg/L)	TVS (16)	TVS (11)
Copper (µg/L)	TVS (50)	TVS (29)
Iron (µg/L)		300 WS
Total Recoverable Iron (µg/L)		1,000
Lead (µg/L)	TVS (281)	TVS (11)
Total Recoverable Lead (µg/L)	50	
Manganese (µg/L)		50 WS
Total Mercury (µg/L)		0.01
Total Recoverable Molybdenum (µg/L)		150
Nickel (µg/L)	TVS (1513)	TVS (168)
Total Recoverable Nickel (µg/L)		100

Parameter	Acute	Chronic
Selenium (µg/L)	TVS (18.4)	TVS (4.6)
Silver (µg/L)	TVS (22)	TVS (3.5)
Zinc (µg/L)	TVS (564)	TVS (428)
Additional Standards Being Evaluated Based on Regulation 31		
Nonylphenol (µg/L)	28	6.6

NOTES:
DM = daily maximum
MWAT = maximum weekly average temperature
TVS = Table Value Standard. Refers to Regulation 31, Table III Metals Parameters or Table A-4, TVS-Based Metals Water Quality Standards for CO0046663, of the 2015 Water Quality Assessment. Values that came from Table A-4 are noted in parentheses.
WS = Water Supply. All surface waters with a potable water supply use. The less restrictive of the following two options shall apply as numerical standards, as specified in the Basic Standards and Methodologies at 31.16 Table II and III: (i) existing quality as of January 1, 2000; or (ii) Iron = 300 µg/l (dissolved), Manganese = 50 µg/l (dissolved), Sulfate = 250 mg/l. For all surface waters with a "water supply" classification that are not in actual use as a water supply, no water supply standards are applied for iron, manganese, or sulfate, unless the Water Quality Control Commission determines as the result of a site-specific rulemaking hearing that such standards are appropriate.
In the 2015, a Water Quality Assessment was developed to support the effluent limits in the permit. The WQCD caps in-stream hardness value of 400 mg/L to calculate the water quality standards for hardness-based metals and those values are listed in Table 5-6.
1) The 2016 WQA for Regional WWTF shows a nitrate limit of 100 mg-N/L, which is 10 times higher than for the Berthoud WRF. This is likely a mistake since the entire segment of the Little Thompson River is designated as a potential water supply source.

Standards are converted to effluent limits using the following equation, which is based on the allowable loading from a discharge under a low flow scenario. The mass balance equation used is as follows:

$$M_2 = \frac{M_3 Q_3 - M_1 Q_1}{Q_2}$$

where

Q_1 = Upstream low flow (1E3 or 30E3)
Q_2 = Average daily effluent flow (design capacity)
Q_3 = Downstream flow (Q1 + Q2)
M_1 = In-stream background pollutant concentrations at the existing quality
M_2 = Calculated Water Quality Based Effluent Limit (WQBEL)
M_3 = Water Quality Standard, or other maximum allowable pollutant concentration

Although stream segment COSPBT09 is on the 303(d) list of impaired streams for selenium, *E. coli* (May-October) and manganese, no wasteload allocations have been distributed by CDPHE yet.

Regulatory low flows in the Little Thompson River immediately upstream of the discharges for both the Berthoud WRF and Regional WWTF are listed in Table 5-7. The low flows were derived by CDPHE and included in the 2015 and 2016 WQAs for the Berthoud WRF and Regional WWTF, respectively.

Table 5-7: Little Thompson Low Flows for Berthoud WRF and Regional WWTF (cfs)

Low Flow (cfs)	Permit	Ann.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1E3 Acute	Berthoud WRF	0	0	0	0	0	0	0	0	0	0	0	0	0
	Regional WWTF	2	2	2	2	2	2	2	2	2	2	2	2	2
7E3 Chronic	Berthoud WRF	0	0	0	0	0	0	0	0	0	0	0	0	0
	Regional WWTF	2	2	2	2	2	2	2	2	2	2	2	2	2
30E3 Chronic	Berthoud WRF	0	0	0	0	0	0	0	0	0	0	0	0	0
	Regional WWTF	2	2	2	2	2	2	2	2	2	2	2	2	2

cfs = cubic feet per second
1E3 = one day low flow with a recurrence of every 3 years, used to develop limits based on acute standards
7E3= seven-day average low flow recurring every 3 years, used for maximum weekly average temperature
30E3 = thirty-day average low flow recurring every 3 years, used to develop limits based on chronic standards

With respect the Berthoud WRF, regulatory low flows were zero in the last permit renewal and all receiving stream standards must be met at end-of-pipe, without benefit of dilution. When Regulation 31-based numeric nutrient standards are applied to the Little Thompson River, the applicable regulatory low flows for nutrients will be the 20^{th} percentile of the median annual flow, which may be more than zero in this situation. Any dilution can be helpful in setting Regulation 31-based effluent limits for TN that can be met with one or two-stage biological nitrogen removal technology. Current technology, either chemical phosphorous (Chemical-P) precipitation or biological phosphorous (Bio-P) uptake plus Chemical-P, is capable of meeting the in-stream TP criteria currently listed as the placeholder value in Regulation 31 (0.17 mg-P/L for warm water streams). Since there is no dilution for the 7E3 conditions at the Berthoud WRF, it is WQCD policy (as per Regulation 31) not to include temperature when deriving effluent limits.

For Regional WWTF, the background in-stream low flow scenario is set to 2 cfs, and ratio of the regulatory low flow of Little Thompson River to the Regional WWTF maximum month design flow is 13:1 (2 cfs/(0.10 MGD x 1.55)). When the ratio of regulatory low flow to maximum month design flow is greater than 10:1 for the 7E3 condition, it is also WQCD policy not to include temperature as an effluent limit (see WQCD-WQP-23).

5.3.3 Berthoud WRF

This section discusses the current effluent limits, current and future parameters of concern, and recommendations to better position for regulatory compliance at the Berthoud WRF.

5.3.3.1 Effluent Limits

Table 5-8 lists current effluent limits for Berthoud WRF (Permitted Feature/Limit Set 001A).

Table 5-8: Current Effluent Limits for the Berthoud WRF

Effluent Parameter	Effluent Limitations Maximum Concentrations				Monitoring Requirements	
	30-Day Average	7-Day Average	Daily Maximum	2-Year Average	Frequency	Sample Type
Flow, MGD	2.0		Report		Continuous	Recorder
pH, standard units (SU)			6.5-9		Daily	Grab
E. coli, number per 100 mLs	126	252			Weekly	Grab
Total Residual Chlorine (TRC), mg/L	0.011		0.5		Weekly	Grab
Total Inorganic Nitrogen, mg/L as N			Report		Weekly	Composite
Total Ammonia, mg/L as N						
January	5.5		37		Monthly	Composite
February	6		37		Monthly	Composite
March	5.3		32		Monthly	Composite
April	4.9		36		Monthly	Composite
May	4.5		35		Monthly	Composite
June	3.7		31		Monthly	Composite
July	2.8		32		Monthly	Composite
August	3.2		33		Monthly	Composite
September	3.4		33		Monthly	Composite
October	3.7		36		Monthly	Composite
November	4.8		36		Monthly	Composite
December	5.6		35		Monthly	Composite
BOD_5, mg/L	30	45			Monthly	Composite
BOD_5, percent removal	85 (min)				Monthly	Calculated
TSS, mg/L	30	45			Monthly	Composite
TSS, percent removal	85 (min)				Monthly	Calculated
Oil and Grease, mg/L, visual			Report		2 Days/ Week	Visual
Oil and Grease, mg/L			10		Contingent	Grab
As, TR, µg/L	2				Quarterly	Composite
Cr+3, TR, µg/L			Report		Monthly	Grab
Cr+6, TR, µg/L	Report		Report		Quarterly	Grab
Cu, PD, µg/L	29		50		Monthly	Composite
CN, WAD, µg/L			5		Quarterly	Grab
Fe, Dis, µg/L	Report				Monthly	Composite
Mn, Dis, µg/L	50		Report		Quarterly	Composite
Mo, TR, µg/L	Report			Report	Monthly	Composite
Hg, Tot, µg/L	0.01				Quarterly	Composite
Se, PD, µg/L	4.6				Quarterly	Composite
Zn, PD, µg/L	Report		Report	Report	Quarterly	Composite
Chloride, mg/L	Report				Monthly	Composite
Sulfate, mg/L	Report				Monthly	Composite
Nonylphenol, mg/L	Report		Report		Monthly	Grab
WET, chronic						
Static Renewal 7 Day Chronic *Pimephales promelas*			NOEC or IC25 ≥ IWC		Semi-annually	3 Composites/Test
Static Renewal 7 Day Chronic *Ceriodaphnia dubia*			NOEC or IC25 ≥ IWC		Semi-annually	3 Composites/Test

5.3.3.2 Current and Future Issues

Table 5-9 summarizes Berthoud WRF's compliance posture with respect to current effluent limits. Each parameter in the table points to an associated figure in **Appendix B** that graphically depicts the 30-day average and maximum 7-day average values reported in DMRs from EPA's ECHO data base between April 2018 and March 2023. The Berthoud WRF is entirely compliant over the period for flow, *E. coli*, ammonia, BOD_5, TSS, oil and grease. The most notable, recurring violations (14) are for the 30-day average limit for selenium, beginning in 2019. Berthoud WRF also experienced isolated, and typically non-recurring exceedances for pH, copper, and manganese.

Table 5-9: Analysis of Current Permit Violations at Berthoud WRF from April 2018-January 2023

Parameter	Summary of Limit Exceedances
Effluent Flow	No exceedances
pH	One minimum (i.e., low pH) exceedance in November 2022
E. coli	No exceedances
TRC	No exceedances
Total Ammonia	No exceedances
BOD_5	No exceedances
TSS	No exceedances
Oil and Grease	No exceedances
Copper	One daily maximum and one 30-day average violation in November 2021
Manganese	Two daily maximum limit exceedances and one 30-day average limit exceedance: September and December 2021
Selenium	Fourteen 30-day average limit exceedances: March 2020, 2021 and 2022; June 2020, 2021 and 2022; September 2018, 2019, 2020, 2021 and 2022; and December 2019, 2020, 2021 and 2022
TIN	No exceedances…there are no specific limits in the permit and Berthoud is required to report only

The last rulemaking hearing for Regulation 31 (Statewide Basic Standards) was in 2021, and the next is slated for 2026. Similarly, the last rulemaking hearing for Regulation 38 (South Platte River Basin Standards) was in 2020, and the next is anticipated for 2025. From a financial planning standpoint, it appears the Town would benefit if its discharge permits were renewed prior to 2025 because the limits would reflect the rules 'on the books' for year 2020 for Regulation 38. However, CDPHE is 3 to 4 years in arrears, on average, in renewing discharge permits. Accordingly, it is difficult to predict when the Town's discharge permits will be renewed in the future. The best case with respect to cash flow management is for discharge permits to be renewed before the next rulemaking hearing for Regulation 38, say 2024. While having them renewed just after the next rule-making hearing, say 2026, could accelerate the timing of the Town's CIP at the WRF and WWTF.

On the other hand, a 2026 renewal may be good timing with respect to complying with Regulation 31 in-stream nutrient quality standards, which is expected to the most expensive wastewater treatment proposition the Town will face in the next 20 years. Note that when in-stream nutrient quality standards are promulgated, which is expected at the end of 2027, they will immediately become effective statewide and included in the Town's next permit renewals following 2027, regardless of when the next rulemaking hearing is for Regulation 38. Figure 5-6 shows the anticipated regulatory compliance timeline for the Berthoud WRF assuming the next permit is issued in 2026, and then every five years thereafter. This assumption means nutrient-related effluent limits will likely be included in the projected 2031 permit renewal. Including CDPHE's 'standard' five-year compliance schedule, plus up to 6.5 years of additional VIP compliance schedule extension credits for the proactive case, the Berthoud WRF will have to meet Regulation 31-based nutrient limits in 2042. Note that 'Eff. T' and 'AE' are abbreviated terms for effluent temperature and administrative extension, respectively.

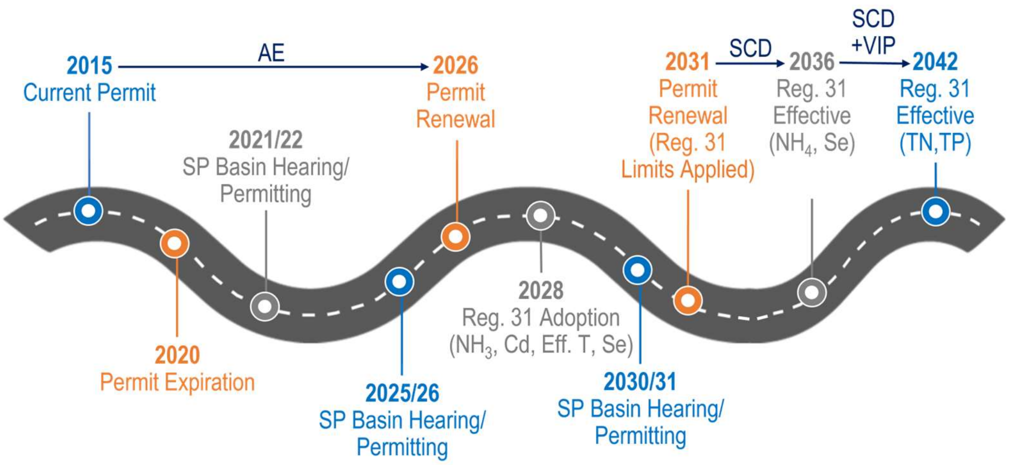


Figure 5-6: Berthoud WRF Anticipated Regulatory Timeline

Table 5-10 summarizes the possible future limits for current effluent parameters, based on anticipated regulatory changes or the results of reasonable potential analyses from historical compliance and regulatory trends. The past five years of reporting at Berthoud WRF demonstrate that certain parameters are present in low concentrations and do not have reasonable potential for an exceedance. Therefore, it is unlikely that limits will be added to the permit for cadmium, chloride, hexavalent chromium, trivalent chromium, copper, cyanide, iron, manganese, mercury, molybdenum, zinc, and nonylphenol. Additionally, no regulatory changes are expected for BOD_5, TSS, pH, TRC, oil and grease, and whole effluent toxicity (and thus not included in Table 5-10). Changes in regulations are expected for ammonia, arsenic, selenium, sulfate, TP, TIN and TN. These potential revisions are based on either anticipated regulatory changes (i.e., Regulation 31) or comparison of historical DMR data with in-stream water quality standards.

Table 5-10: Comparison of Current Permit Effluent Limits to Possible Future Limits for Berthoud WRF

Effluent Parameter	Current Effluent Limit 30-Day Avg / 7-Day Avg / Daily Max	2026-2031 Permit 30-Day Avg / 7-Day Avg / Daily Max	2031 Permit or Beyond 30-Day Avg / 7-Day Avg / Daily Max
Temp, March-November (°C)[d]	NA / NA / NA	NA / NA / NA	NA / NA / NA
Temp, December-February (°C)	NA / NA / NA	NA / NA / NA	NA / NA / NA
***E. coli* (#/100 mLs)**	126 / 252 / NA	126 / 252 / NA	126 / 252 / NA
Total Ammonia, (mg-N/L)	2.8-6.0 / NA / 31-37	2.8-6.0 / NA / 31-37	TBD[a]
Arsenic, TR (µg/L)	2 / NA / NA	2 / NA / NA	0.02-10 / NA / NA
Cadmium, TR (µg/L)	NA / NA / NA	NA / NA / NA	NA / NA / NA
Chloride (mg/L)	Report / NA / NA	NA / NA / NA	NA / NA / NA
Chromium, Hexavalent, Dis (µg/L)	Report / NA / Report	NA / NA / NA	NA / NA/ NA
Chromium, Trivalent, TR (µg/L)	NA / NA / Report	NA / NA / NA	NA / NA / NA
Copper, PD (µg/L)	29 / NA / 50	29 / NA / 50	29 / NA / 50
Cyanide, Total (µg/L)	NA / NA / 5	NA / NA / 5	NA / NA / 5
Iron, Dis	Report / NA / NA	NA / NA / NA	NA / NA / NA
Manganese, Dis (µg/L)	50 / NA / Report	50 / NA / NA	50 / NA / NA
Mercury, TR (µg/L)	0.01 / NA / NA	0.01 / NA / NA	0.01 / NA / NA
Molybdenum, TR (µg/L)	Report / NA / NA	NA / NA / NA	NA / NA / NA

Effluent Parameter	Current Effluent Limit 30-Day Avg / 7-Day Avg / Daily Max	2026-2031 Permit 30-Day Avg / 7-Day Avg / Daily Max	2031 Permit or Beyond 30-Day Avg / 7-Day Avg / Daily Max
Selenium, PD (µg/L)	4.6 / NA / NA	4.6 / NA / NA	3.3 / NA / NA
Sulfate (mg/L)	Report / NA / NA	250 / NA / NA	250 / NA / NA
Zinc, PD (µg/L)	Report / NA / Report	NA / NA / NA	NA / NA / NA
Nonylphenol (µg/L)	Report / NA / Report	NA / NA / NA	NA / NA / NA
Total Phosphorus (mg-P/L)	NA / NA	NA / NA	0.17[b,c]
Total Inorganic Nitrogen (mg-N/L)	NA / NA / Report	NA / NA / NA	NA / NA / 10[e]
Total Nitrogen (mg-N/L)	NA / NA	NA / NA	2.01[b,c]

a) The WQCD is in the process of evaluating how to modify its ammonia standard to take into consideration EPA's 2013 Ammonia Criteria. If fresh water snail/mussel habitat is found in the Little Thompson River downstream of the WRF, effluent limits could be approximately 50% of current values. If such habitat is not found, then effluent ammonia limits should remain the same or be slightly higher than at present.
b) When the Voluntary Incentive Program (VIP) was initially rolled out by CDPHE in 2017, dischargers had the potential to earn up to 10 years of extension credits for compliance with Regulation 31-based in-stream numeric nutrient standards. Given that the VIP program is slated to end at the end of 2027, it is anticipated that the Berthoud WRF can earn a maximum of 6.5 years of compliance schedule extension credits. Therefore, more stringent Regulation 31-based TP and TN effluent limits may not become effective until 2042 assuming the permit is renewed in 2031 and the total compliance schedule spans approximately 11 years assuming a standard 5-year compliance schedule is granted by CDPHE plus, about six years for the extension credits.
c) In-stream standards are median annual values, which are not to be exceeded more than one year out of five. Effluent limits assume the worst case condition that there is no high quality upstream dilution flow in the Little Thompson River and in-stream standards must be met at end-of-pipe.
d) CDPHE policy is not to assign effluent temperature limits for treatment plants with zero 7E3 dilution flow or where the ratio of the 7E3 stream low flow to the treatment plant rated capacity is greater than 10:1.
e) It is possible that an in-stream daily maximum TIN of 10 mg-N/L will be added by CDPHE in the future because of the Town's potential plans for to use shallow horizontal wells under the Little Thompson River just downstream of the WRF. Since the receiving stream of the WRF has no dilution, it is likely the daily maximum effluent limit for TIN will also be 10 mg-N/L.

Based on the above analysis and historical data (depicted in Table 5-10 and **Appendix B**), it is anticipated the following parameters will be reliably met at the Berthoud WRF without operational/process modifications:

- Effluent Temperature
- *E. coli*
- Arsenic, TR:

The low end of the potential arsenic limit is below the current detection limit. It is possible that CDPHE will ultimately adopt a limit of technology (LOT) standard of 2 to 3 ug/L, which is well above the quarterly 30-day average Berthoud WRF is currently reporting.

- Cadmium, TR
- Chloride
- Chromium, Hexavalent, Dis
- Chromium, Trivalent, TR
- Copper, PD
- Cyanide, Total
- Iron, Dis
- Manganese, Dis
- Mercury, TR
- Molybdenum, TR
- Zinc, PD
- Nonylphenol

Conversely, several parameters could have multiple exceedances for either current or potential limits and will likely require regulatory advocacy, capital improvements, and/or process modifications to reliably meet permit limits:

- Total Ammonia
  - Even though future effluent ammonia limits might be reduced by 50% if snail/mussel habitat is found in the Little Thompson River below the point of discharge, such values are still attainable with activated sludge treatment. However, some relatively minor cost upgrades might be required such as: (1) conversion to ammonia-based or ammonia versus nitrate aeration control, (2) conversion of the oxic passes to integrated fixed film activated sludge (IFAS) or (3) installation of sludge granularization technology so higher mixed liquor concentrations can be maintained with lower sludge volume index (SVI) levels.
- Selenium, PD
  - Berthoud is presently conducting a study to optimize selenium removal through BNR improvements. These BNR improvements coupled with I/I source identification and control in areas known to have selenium-laden infiltration from groundwater will assist the WRF in coming into compliance with selenium limits. However, if source control and BNR upgrades do not entirely address selenium compliance, much more costly upgrades will be required, such as reverse osmosis (RO).
- Sulfate
  - This conclusion assumes that a 30-day average sulfate limit of 250 mg/L will be included in the 2026 or 2031 permit. The source of selenium-laden groundwater, marine shales, is also a source of sulfates. There are no practical ways to remove sulfate from municipal wastewater, so Berthoud should continue with infiltration source control efforts to address sulfate.
- Total Inorganic Nitrogen
  - It is likely that Regulation 85 will be applied to plants after the delayed implementation ends in 2027 when Regulation 31 limits become effective in 2028. However, it is unknown if Regulation 85 will be added to new plants following Regulation 31 implementation. It is also possible that an in-stream daily maximum TIN of 10 mg-N/L will be added by CDPHE in the future because the Town may install shallow horizontal wells under the Little Thompson River just downstream of the WRF as a potable water supply. With no dilution from the receiving stream, it is possible Berthoud WRF will need to comply with a daily maximum TIN of 10 mg-N/L at end-of-pipe.
- Total Phosphorus
  - Based on effluent TP residuals since 2019, the 0.17 mg/L as P limit is especially low and will not be met without process changes. However, the WRF will be able to meet this at end-of-pipe, considering the stream segment offers no dilution, through a combination of Bio-P and Chemical-P strategies.
- Total Nitrogen
  - Two stage nitrogen removal will not be sufficient to meet the median annual value of 2.01 mg/L-N unless CDPHE deletes dissolved organic nitrogen (DON) from its calculation of TN and/or adopts a limit of technology (LOT) cap in low dilution conditions such as at the WRF.

5.3.3.3 Recommendations

Based on the analysis of historical DMR data and potential regulatory changes discussed in Section 5.3.3.2, the following recommendations are suggested for Berthoud WRF:

- Because the Berthoud WRF is rated for a maximum month capacity of $\leq$2.0 MGD, it falls under the regulatory umbrella of delayed implementation for Regulation 85 at least until the end of 2027. It is not yet known if Regulation 85 will be applied to the WRF after it is expanded to 3.0 MGD since this will not occur until after Regulation 31 numeric nutrient standards are adopted statewide at the end of 2027. Even if CDPHE opted to make Regulation 85 applicable at the Berthoud WRF after 2027, the VIP-related BNR improvements will enable the Town to comply with Regulation 85 effluent limits without need to construct additional improvements. It is Regulation 31 in-stream numeric nutrient standards that could cause another stage of nitrogen and phosphorous removal to be added to the WRF in the 2030-2040 timeframe.
- Since there will not be much, if any, dilution at the point of discharge, Berthoud should request that dissolved organic nitrogen (DON) be excluded from the measurement of effluent TN and/or push CDPHE to establish a LOT for all dischargers with minimal to no dilution. Otherwise, dischargers will be forced to add a third stage of nitrogen removal treatment, such as RO, which is both inordinately expensive and counterproductive with respect to greenhouse gas emissions, brine disposal, loss of water, and energy usage. RO may also be required if current source control efforts and future BNR upgrades do not effectively decrease levels of selenium in plant effluent.
- To gain the maximum amount of VIP compliance schedule extension credits in the time remaining for this program (through 2027), Berthoud should immediately implement a project to improve TIN and TP removals. Several alternatives have been identified for creating a more effective A_2O process at the WRF. These include (1) adding separate ANA tanks upstream of the existing 3-pass aeration basins and (2) retrofitting defined, separate, and mechanically mixed anaerobic and anoxic zones in series within the first pass of the existing aeration basins, plus reduce backmixing of aerated mixed liquor from Pass 2 into Pass 1. If Pass 1 is converted to ANA treatment, it may require that oxic Passes 2 and 3 be converted to IFAS, or hydrocyclones added on the RAS lines to create a granular activated sludge that can support higher mixed liquor concentrations that will settle well in the existing secondary clarifiers. Preliminary design and alternative selection for the BNR improvements will also take into consideration which BNR configuration is likely to have the best selenium removal of the options being considered.
- Berthoud should monitor ongoing regulatory discussions regarding how CDPHE may revise its arsenic standard in the future, and if arsenic removal will be needed at the Berthoud WRF. It is likely that with regulatory advocacy by the many stakeholders potentially affected by the current arsenic standard, the 'low-range' limit of 0.02 µg/L will not be retained as it cannot be met except through RO treatment and this value is below the current detection limit for arsenic. It is possible that regulatory advocacy will result in CDPHE adopting a LOT of 2 to 3 ug/L.

5.3.4 Regional WWTF

This section discusses the current effluent limits, current and future parameters of concern, and recommendations to better position for regulatory compliance at the Regional WWTF.

5.3.4.1 *Effluent Limits*

Table 5-11 lists current effluent limits for Regional WWTF (Permitted Feature/Limit Set 001A). Table 5-12 lists current nutrient effluent limits (TIN and TP).

Table 5-11: Effluent Limits for the Regional WWTF

Effluent Parameter	Effluent Limitations Maximum Concentrations				Monitoring Requirements	
	30-Day Average	7-Day Average	Daily Maximum	2-Year Average	Frequency	Sample Type
Flow, MGD	0.099		Report		Continuous	Recorder
pH, standard units (SU)			6.5-9		Weekly	Grab
E.coli, number per 100 mLs	126	252			Monthly	Grab
Total Residual Chlorine, mg/L	0.16		0.27	0.024	Weekly	Grab
Total Ammonia, mg-N/L						
January	10		19	2.4	Monthly	Composite
February	8.6		13	2.4	Monthly	Composite
March	10		14	2.1	Monthly	Composite
April	9.3		15	1.4	Monthly	Composite
May	9.5		33	1.5	Monthly	Composite
June	9.7		35	1.5	Monthly	Composite
July	8.9		35	1.4	Monthly	Composite
August	10		45	1.6	Monthly	Composite
September	9.8		40	1.5	Monthly	Composite
October	10		35	1.6	Monthly	Composite
November	12		24	1.9	Monthly	Composite
December	14		35	2.2	Monthly	Composite
BOD_5, mg/L	30	45			Monthly	Composite
BOD_5, percent removal	85 (min)				Monthly	Calculated
TSS, mg/L	30	45			Monthly	Composite
TSS, percent removal	85 (min)				Monthly	Calculated
Oil and Grease, visual			Report		Weekly	Visual
Oil and Grease, mg/L			10		Contingent	Grab
Se, PD, µg/L	4.6		18.4		Monthly	Composite

Table 5-12: Current Nutrient Limits for the Regional WWTF

Effluent Parameter	Effluent Limitations Maximum Concentrations		Monitoring Requirements	
	Running Annual Median	95th Percentile	Frequency	Sample Type
Total Inorganic Nitrogen, mg-N/L	7	14	Monthly	Composite
Total Phosphorus, mg-P/L	0.7	1.75	Monthly	Composite

*Reported as a running annual median, which is a median of all samples taken in the most recent 12 calendar months.
** Reported as the 95th percentile of all samples taken in the most recent 12 calendar months.

5.3.4.2 *Current and Future Issues*

Table 5-13 summarizes Regional WWTF's current compliance posture towards established effluent limits. Each parameter in the table points to an associated figure in **Appendix B** that graphically depicts the 30-day average and maximum 7-day average values reported in DMRs from EPA ECHO between April 2018 and March 2023. Regional WWTF is compliant with all parameters listed in Table 5-13 except for ammonia and TIN in August of 2022, which were for three rolling average limit exceedances for ammonia and one daily maximum limit exceedance for TIN.

Table 5-13: Analysis of Limit Exceedances for Current Permit Limits at Regional WWTF, Apr-2018–Jan-2023

Parameter	Summary of Limit Exceedances
Effluent Flow	No exceedances
pH	No exceedances
E. coli	No exceedances
TRC	No exceedances
Ammonia	Three, two-year rolling average limit exceedances: October 2018, January 2020, and February 2020
BOD_5	No exceedances
TSS	No exceedances
Oil and Grease	No exceedances
Selenium	No exceedances
TIN	No Exceedances
TP	No exceedances

Figure 5-7 shows the anticipated regulatory compliance timeline for Regional WWTF including predicted ~5-year schedule compliance delay (SCD) and administrative extension (AE). Regional WWTF did not opt into the VIP program, thus no VIP extensions were included. Effluent temperature is abbreviated as Eff. T.

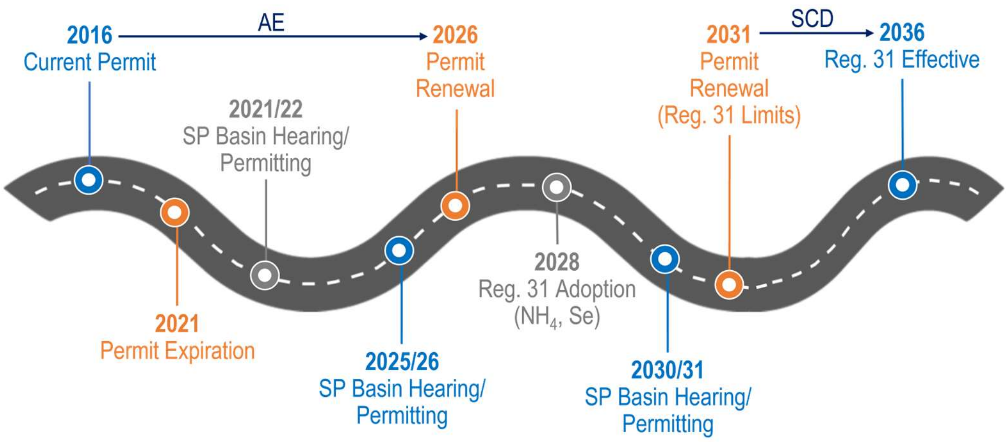


Figure 5-7: Regional WWTF Anticipated Regulatory Timeline

Table 5-14 summarizes the possible future limits for current effluent parameters, based on anticipated regulatory changes or the results of reasonable potential analyses from historical compliance and regulatory trends. The past five years of reporting at Regional WRF demonstrate that selenium is present in low concentrations and does not have reasonable potential for an exceedance. Therefore, it is unlikely that limits will be added to the permit for selenium. Additionally, no regulatory changes are expected for BOD_5, TSS, pH, TRC, and oil and grease (and thus are not included in Table 5-14). Changes in regulations are expected for ammonia, arsenic, TP and TN. These potential revisions are based on either predicted or certain regulatory changes (i.e., Regulation 31) or historical DMR data in comparison with in-stream standards.

Table 5-14: Comparison of Current Permit Effluent Limits to Possible Future Limits for Regional WWTF

Effluent Parameter	Current Effluent Limit 30-Day Avg / 7-Day Avg / Daily Max	2026-2030 Permit 30-Day Avg / 7-Day Avg / Daily Max	2031 Permit or Beyond 30-Day Avg / 7-Day Avg / Daily Max
Temp, March-November (°C)[d]	NA / NA / NA	NA / NA / NA	27.5 / NA / 28.6
Temp, December-February (°C)[d]	NA / NA / NA	NA / NA / NA	13.8 / NA / 14.3
E. coli (#/100 mLs)	126 / 252 / NA	126 / 252 / NA	126 / 252 / NA
Total Ammonia, (mg-N/L)	8.6-14 / NA / 13-45	8.6-14 / NA / 13-45	TBD[a,b]
Arsenic, TR (µg/L)	NA / NA / NA	NA / NA / NA	0.02-10 / NA / NA
Cadmium, TR (µg/L)	NA / NA / NA	NA / NA / NA	NA / NA / NA
Selenium, PD (µg/L)	4.6 / NA / 18.4	4.6 / NA / 18.4	3.3 / NA / 18.4
Total Phosphorus (mg-P/L)	0.7 / 1.75[c]	0.7 / 1.75[c]	0.17 / 1.75[c]
Total Inorganic Nitrogen (mg-N/L)	7 / 14[c]	7 / 14[c]	7 / 14[c] / 12-15[e]
Total Nitrogen (mg-N/L)	NA / NA[c]	NA / NA[c]	2.01 / NA[c]

a) The WQCD is in the process of evaluating how to modify its ammonia standard to take into consideration EPA's 2013 Ammonia Criteria. If fresh water snail/mussel habitat is found in the Little Thompson River downstream of the WRF, effluent limits could be approximately 50% of current values. If such habitat is not found, then effluent ammonia limits should remain the same or be slightly higher than at present.

b) When the Voluntary Incentive Program (VIP) was initially rolled out by CDPHE in 2017, dischargers had the potential to earn up to 10 years of extension credits for compliance with Regulation 31-based in-stream numeric nutrient standards. Given that the VIP program is slated to end at the end of 2027, it is anticipated that the Berthoud WRF can earn a maximum of 6.5 years of compliance schedule extension credits. Therefore, more stringent Regulation 31-based TP and TN effluent limits may not become effective until 2042 assuming the permit is renewed in 2031 and the total compliance schedule spans approximately 11 years assuming a standard 5-year compliance schedule is granted by CDPHE plus, about six years for the extension credits.

c) In-stream standards are median annual values, which are not to be exceeded more than one year out of five. Effluent limits assume the worst case condition that there is no high quality upstream dilution flow in the Little Thompson River and in-stream standards must be met at end-of-pipe. It is likely that Regional will still need to comply with TIN limits in Regulation 85.

d) CDPHE policy is not to assign effluent temperature limits for treatment plants with zero 7E3 dilution flow or where the ratio of the 7E3 stream low flow to the treatment plant rated capacity is greater than 10:1. Presently, the Regional WWTF has a 7E3 to plant capacity ratio of 13:1, but as predicted WWTF flows increase, Regional may face a daily maximum of 27.5 ºC (March-November) or 13.5ºC (December-February) and a maximum weekly average temperature of 28.6 ºC (March-November) or 14.3ºC (December-February).

e) It is possible that an in-stream daily maximum TIN of 10 mg-N/L will be added by CDPHE in the future because of the Town's potential plans for to use shallow horizontal wells under the Little Thompson River just downstream of the WRF. With Regional's dilution, it is likely the WWTF will see a daily maximum effluent limit between 12 and 15 mg-N/L.

Based on the above analysis and historical data (depicted in Table 5-14 and **Appendix B**), the following parameters will likely be reliably met without operational/process modifications:

- *E. coli*
- Arsenic, TR:
  - The low end of the potential arsenic limit is below the current detection limit. It is possible that CDPHE will adopt a LOT standard of 2 to 3 ug/L, which is well above the quarterly 30-day average the Berthoud WRF is currently reporting.
- Cadmium, TR
- Selenium
- Total Inorganic Nitrogen
  - It is unknown likely that Regulation 85 will be applied to plants after the delayed implementation ends in 2027 when Regulation 31 limits become effective in 2028. It is possible that an in-stream daily maximum TIN of 10 mg-N/L will be added by CDPHE in the future because of the Town's consideration of utilizing for shallow horizontal wells under the Little Thompson River just downstream of the WRF as a water supply. However, considering Regionals high dilution and low report TIN (less than 10 mg/L-N for both rolling median and 95th percentile values), it is unlikely the WWTF will have challenges meeting this limit.

Conversely, several parameters could have multiple exceedances for either current or potential limits and will likely require regulatory advocacy, capital improvements, and/or process modifications to reliably meet permit limits:

- Total Ammonia:
  - Even though future monthly average and daily maximum effluent ammonia limits might be reduced by 50% if snail/mussel habitat is found in the Little Thompson River below the point of discharge, such values are still meetable with activated sludge treatment such as via an SBR. However, some relatively minor cost upgrades might be required such as: (1) conversion to ammonia-based or ammonia versus nitrate aeration control or (2) installation of sludge granularization technology so higher mixed liquor concentrations can be maintained with lower sludge volume index (SVI) levels.
- Total Phosphorus
  - Based on effluent TP residuals since 2019, the 0.17 mg/L as P limit is especially low and will not be met without process changes. However, the WWTF will be able to meet this at end-of-pipe, considering the stream segment offers minimal dilution, through a combination of Bio-P and Chemical-P strategies.
- Total Nitrogen
  - Two stage nitrogen removal will not be sufficient to meet the in-stream median annual value of 2.01 mg/L-N unless CDPHE deletes dissolved organic nitrogen (DON) from its calculation of TN and/or adopts a LOT cap.

5.3.4.3 Recommendations

Based on the analysis of historical DMR data and potential regulatory changes discussed in Section 5.3.4.2, the following recommendations are suggested for Regional WWTF:

- The Regional WWTF is considered a 'new' facility with respect to Regulation 85 and is already in compliance with enforceable effluent standards for TIN and TP. However, Regulation 31 in-stream numeric nutrient standards could cause another stage of nitrogen and phosphorous removal to be added to the Regional WWTF in the 2030-2040 timeframe. As long as the Regional WWTF remains relatively small compared to the WRF, it will benefit from dilution in its reach of the Little Thompson River and it may not have to upgrade the degree of treatment to comply with Regulation 31-based numeric nutrient limits. As growth occurs over time, the Town will be able to monitor the relationship between size of the Regional WWTF and the required degree of nutrient removal treatment.

- Although currently less critical for the Regional WWTF due to its small size compared to the WRF, the Town should nonetheless request that DON be excluded from the measurement of effluent TN and/or push CDPHE to establish a LOT for all dischargers with minimal to no dilution. Otherwise, dischargers will be forced to add a third stage of nitrogen removal treatment, such as RO, which is both inordinately expensive and counterproductive with respect to greenhouse gas emissions, brine disposal, loss of water, and energy usage.
- Berthoud should monitor ongoing regulatory discussions regarding how CDPHE may revise its arsenic standard in the future, and if arsenic removal will be needed at the Berthoud WRF. It is likely that with regulatory advocacy by the many stakeholders potentially affected by the current arsenic standard, the 'low-range' limit of 0.02 µg/L will not be retained as it cannot be met except through RO treatment and this value is below the current detection limit for arsenic. It is likely that regulatory advocacy will result in CDPHE adopting a LOT of 2 to 3 ug/L.

5.4 Unit Process Performance Analysis

The Berthoud WRF, Regional WWTF and collection system facilities individual process evaluation and capacity evaluations are presented in the following sections.

5.4.1 Berthoud WRF

The rated hydraulic and organic loading capacities of the plant are 2.0 MGD and 3,900 ppd of BOD, respectively. As originally designed, the treatment process consists of two, nitrifying activated sludge treatment trains using three-pass aeration basins, with aerobic digestion for sludge stabilization. In 2019, the Town added one mixed liquor recycle (MLR) pump for each train so some nitrate reduction could also be achieved at the WRF. Centrifuge dewatered biosolids from the WRF are land-applied for beneficial use.

Figure 5-8 is an aerial view of the WRF and major process facilities.

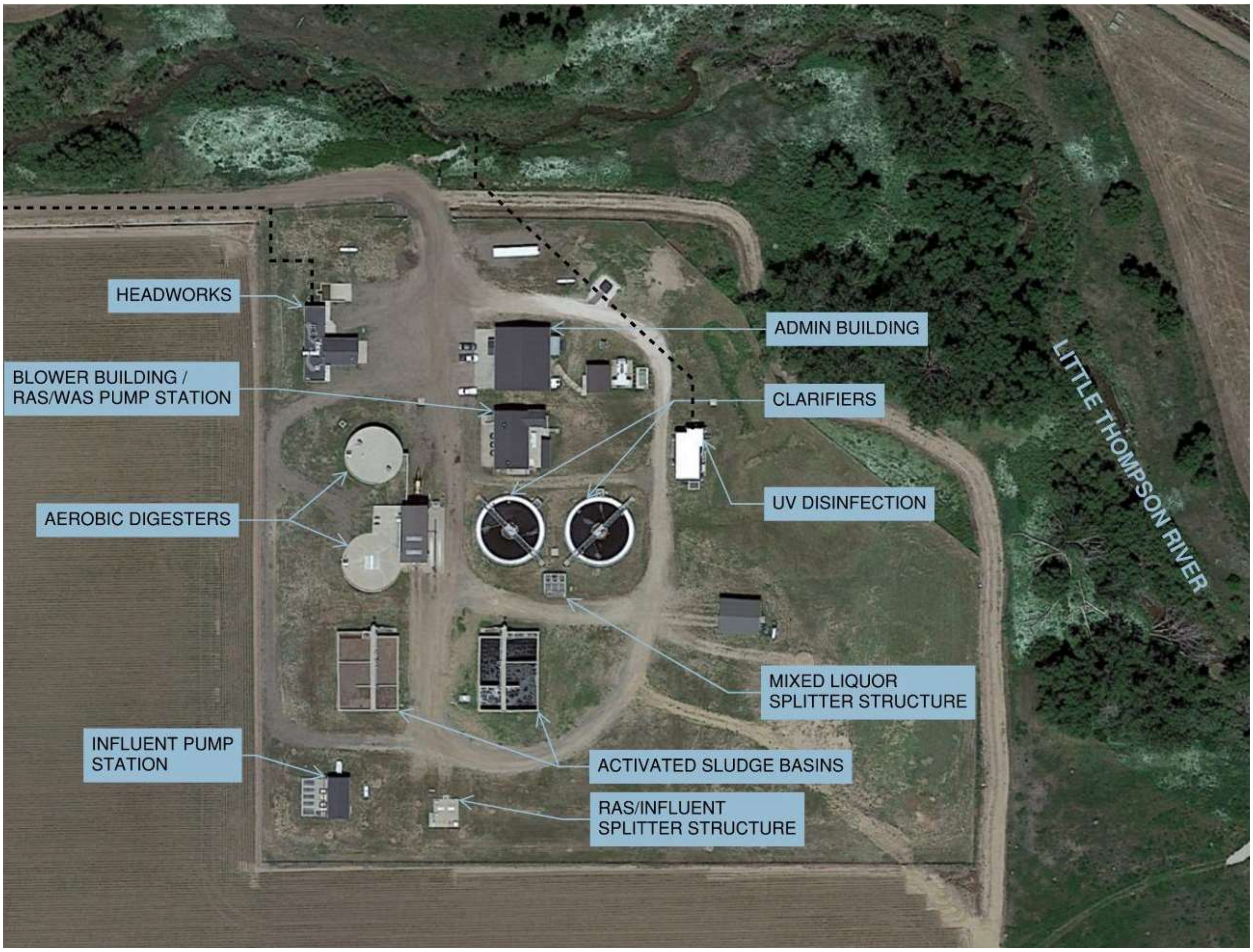


Figure 5-8: Berthoud WRF Site Arrangement

The Berthoud WRF consists of an influent pump station, headworks with screening and grit removal, nitrifying activated sludge treatment without primary clarifiers, secondary clarification, and open channel UV disinfection prior to discharge to the Little Thompson River. Waste activated sludge (WAS) produced in the secondary processes are aerobically digested and dewatered using a centrifuge. The WRF was originally designed for treating a maximum 30-day average flow of 2.0 MGD (i.e., MMF), a maximum 30-day average BOD_5 load of 3,900 ppd.

The Berthoud WRF consists of the following major unit processes:

- Headworks: Includes a perforated plate screen with integral washing, compacting, and lifting of the screenings (via auger) to a dumpster, bypass channel with 2-inch opening manually cleaned bar screen, and a separate vortex grit removal basin and grit handling system for washing, dewatering, lifting (via auger) of the grit to a dumpster.
- Influent Pump Station: Includes screw centrifugal impeller pumps for headworks effluent wastewater
- Nitrifying Activated Sludge Process: Includes two parallel, three-pass basins to handle a total MMF of 2.0 MGD and 3,900 ppd of BOD_5. The original 2002 design anticipated the possibility of addition of a third activated sludge train in the future. In 2019, the Town added one MLR pump for each train so some nitrate reduction could also be achieved at the WRF.

- Secondary Clarification: Includes two, 60-foot diameter, 14.5-foot side water depth clarifiers.
- Sludge Pumping: Includes pumps for RAS and WAS/scum.
- UV System: Includes open-channel UV system, with horizontal lamp arrays, for disinfection, plus an ultrasonic flow element for effluent flow measurement.
- Aerobic Digestion: Includes two (2) aerobic digesters whose total volume is 602,000 gallons.

The original design MMF for the Berthoud WRF was 2.0 MGD. In the following tables, the actual historical relationship between PHF and MMF at the Berthoud WRF, the ratio for which is 2.0, was utilized to estimate the 'Design PHF' for those units where PHF is an important design parameter. Where needed, each capacity estimate was converted to an equivalent MMF so there is a 'common barometer' when comparing one unit process versus another. Future efforts to accommodate service area and population growth expansion should focus on expanding the capacity of these limiting unit processes. These capacity summaries of each unit process are presented below in maximum month flow.

5.4.1.1 Preliminary Treatment

Upon entering the WRF, influent passes through a single rotary-type perforated plate screen. Solids removed by the screen are washed, compacted, and deposited into a dumpster. When required, influent may be routed through a bypass channel with a 2-inch opening manual bar screen. Screened influent then passes through a single grit chamber where high specific gravity solids, such as sand, are removed and routed to a hydrocyclone separator, classifier (small clarifier), washing/dewatering and screw auger to a dumpster for landfill disposal.

Capacity Analysis

Table 5-15: Berthoud WRF Preliminary Treatment Design Criteria

Criteria	Units	Value	CDPHE Standard	✗ / ✓
MECHANICAL SCREEN				
Quantity	-	1	NA	-
Type	-	Rotary Perforated Plate	NA	-
Horsepower	hp	5	NA	-
Capacity(1)	MGD	9.0	Design PHF(2) (4.0/6.0/8.0)	✓
BYPASS SCREEN				
Quantity	-	1	NA	-
Screenings Removal Mechanism	-	Hand Raking	NA	-
Bar Spacing	in	2	>0.25 in <1.75 in	✗
Capacity(1)	MGD	9.0	Design PHF(2) (4.0/6.0/8.0)	✓
GRIT REMOVAL TANK				
Quantity	-	1	NA	-
Type	-	Vortex Grit Chamber	NA	-
Upper Chamber Diameter	ft	8.0	NA	-
Lower Chamber Diameter	ft	3.0	NA	-
Total Height	ft	13.5	NA	-
Capacity(1)	MGD	9.0	Design PHF(2) (4.0/6.0/8.0)	✓
GRIT PUMPS				
Quantity	-	1	NA	-
Type	-	Recessed Impeller	NA	-
Capacity(1)	gpm	250	NA	-
TDH(1)	ft	24.0	NA	-
Motor Size	hp	10	NA	-

NOTE:
(1) Estimate based on past master plans and operations staff input.
(2) PHFs shown are based on a 2:1 PHF : MMF peaking factor for the following maximum month design flows: existing (2.0 MGD)/Phase 1B expansion (3.0 MGD)/Phase 2 expansion (4.0 MGD) for the Berthoud WRF. Refer to Section 5.2.2 Berthoud WRF and 5.2.3 for Regional WWTF for further description of these expansions.

Condition Assessment

Equipment was in good condition per the site walk conducted on 10 October 2022. Areas of deficiency noted by REC are listed below:

- HVAC in this building is showing accelerated signs of aging that require repair/upgrade.
- Burden on operations to monitor rotary fine screen and switch to manually-cleaned bypass bar screen when needed.

- Grit pump suction is prone to clogging.

Recommendations

Consider replacement of the manual bar screen with a second mechanical screen and provide passive overflow (i.e., no operator intervention required) upon blockage in the duty channel. Add valving to grit pump suction to facilitate cleanout. Review the need and viable options for odor control to reduce potential for off-site odor complaints.

5.4.1.2 Influent Pump Station

Following grit removal, screened and de-gritted wastewater flows to a wetwell, from which the drywell influent pumps take suction. Influent flows are pumped to Pass 1 of one or both of the two activated sludge basins depending on flows and loads and how the facility is being operated. Three influent pumps are presently installed, with a total of four equipment pads (one available for future pump).

Capacity Analysis

Table 5-16: Berthoud WRF Influent Pump Station Design Criteria

Criteria	Units	Value	CDPHE Standard	× / ✓
Configuration	-	Wet Well / Dry Well	NA	-
Wet Well Size (L x W x D)	ft	31.0 x 10.0 x 20.5	NA	-
Wet Well Operating Depth(1)	ft	7.3	NA	-
Wet Well Working Volume	gal	15,000	NA	-
INFLUENT PUMPS				
Quantity	-	3 (2 duty, 1 standby)	≥2	✓
Type	-	Submersible Dry Pit Screw Centrifugal	NA	-
Horsepower (each)	hp	10 (1) 30 (2)	NA	-
Capacity (each)	gpm	10-hp: 1,050 30-hp: 2,100	NA	-
Capacity (firm, n-1)	MGD	4.54	Design PHF(2) (4.0/6.0/8.0)	✓
TDH(3)	ft	10-hp: 22.0 30-hp: 34.0	NA	-

Note:
(1) Design operating depth.
(2) PHFs shown are based on a 2:1 PHF:MMF peaking factor for the following maximum month design flows: existing (2.0 MGD)/Phase 1B expansion (3.0 MGD)/Phase 2 expansion (4.0 MGD). Refer to Section 5.2.2 Berthoud WRF and 5.2.3 for Regional WWTF for further description of these expansions.
(3) Estimate based on past master plans and operations staff input.

Condition Assessment

Equipment was in fair condition per the site walk conducted on 10 October 2022. Areas of deficiency noted by REC are listed below:

- The newest pump was noted as having intense vibration during operation.
- The smaller pump is aging and requires rehabilitation.
- Fats, oils and grease (FOG) accumulation in the wet well is a recurring problem.

Recommendations

Monitor condition of influent pumps and replace before end of useful life. Consider standardization of all influent pumps. Consider adjustment of pump programming to facilitate periodic evacuation of FOG from the wetwell.

5.4.1.3 Activated Sludge and Secondary Clarification

Discharge from the influent pumps goes to the RAS/influent splitter structure. The term ‘splitter’ is a misnomer in this case as the structure is really a valve vault since secondary influent and RAS are separately metered and piped to the head of Pass 1 for both trains. The influent and RAS are mixed within the two cast-in-place concrete activated sludge basins, which were originally designed for nitrification treatment, yet set up in a way so an anoxic denitrification zone could be added either upstream of the aeration tanks or within Pass 1 itself. A submersible MLR pump was added to each activated sludge train in 2019 so MLE treatment could be implemented in at least an interim way. A separate MLR discharge line was routed to the front of Pass 1 in each train. Air to Pass 1 is turned down/off to create anoxic conditions for nitrate reduction, with limited mixing provided by the MLR discharge flow. Back-mixing of aerated mixed liquor from Pass 2 into the second half of Pass 1 means just the first half of Pass 1 has a combination of anoxic and anaerobic conditions over which the operators presently have little control.

The design point for the MLR pump is about 744 gpm at 29.4 feet of TDH, much of which comes from friction and ‘minor’ losses due to the high flow velocity (about 20 feet per second) through various sections of 4-inch diameter piping. The MLR flow rate is not metered. However, assuming each MLR pump is operating at its design point of 744 gpm, plus an allowance for RAS flows, total MLR + RAS recycle flows (R) are respectively 1.8 to 2.9 times the current average day influent flows (Q) of approximately 1.0 MGD based on either one or two activated sludge trains in service. This is an acceptable range for MLE treatment, although higher MLR pumping rates are needed for design MMF conditions and higher R:Q ratios will typically yield lower final effluent nitrate and TIN levels.

Although some nitrate reduction does occur in Pass 1, it is highly variable and secondary effluent TIN levels have routinely been above 15 mg-N/L since the MLE modifications were implemented. Biological phosphorous (Bio-P) removal is sometimes achieved, demonstrating that anaerobic conditions and a sufficient amount of volatile fatty acids (VFAs) can be present in Pass 1 to foster growth of phosphorous accumulating organisms (PAOs). Like nitrate reduction, Bio-P removal has been inconsistent and could benefit from creating well-baffled, sufficiently mixed, multi-stage anaerobic and anoxic zones in series, either in a separate upstream basin or within Zone 1 itself depending upon whether Pass 2 plus Pass 3 combined has sufficient volume and solids retention time (SRT) to assure continuous nitrification at the original, maximum month design flow and loading of 2.0 MGD and 3,900 ppd of BOD, respectively.

As of the writing of this Master Plan, TIN and TP reductions have not been sufficient to gain many months of compliance schedule credit planning, financing, design and construction of improvements to meet in-stream numeric nutrient limits associated with Regulation 31. Physical improvements to Pass 1 appear to be necessary to attain a consistently high level of TIN and TP reductions and more quickly build up compliance schedule delay credits. Mixed liquor from the third pass of the activated sludge basins flows to the clarifiers for separation of biomass from secondary effluent. The activated sludge basins and secondary clarifiers work in tandem, in that changes to one affect the operation and performance of the other and are therefore presented together here.

Capacity Analysis

Table 5-17: Berthoud WRF Activated Sludge and Secondary Clarification Design Criteria

Criteria	Units	Value	CDPHE Standard	× / ✓
ACTIVATED SLUDGE BASINS				
Number of Trains	-	2	NA	-
Basin Configuration	-	Concrete, 3-pass Serpentine Nitrification only or Interim MLE	NA	-
Total Train Dimensions (L x W x D)	ft	63.0 x 50.0 x 21.2	NA	-
Design Sidewater Depth	ft	17.0	>10 <25	✓
Liquid Volume of Each Train	gal	400,000	NA	-
Freeboard	in	50.5	>18	✓
Design Operating MLSS	mg/L	4,000(1)	2,000 – 3,500	×
Total SRT @ 2.0 MGD & 3,900 ppd of BOD	d	10.0	8-20	✓
Oxic SRT with 100% of Pass 1 Used for Anaerobic/Anoxic Zones	d	7.0	NA	-
Total HRT (all passes combined)	h	9.6	NA	-
PASS 1				
Size (L x W)	ft	21.0 x 50.0	NA	-
Volume	gal	133,400	NA	-
Aerated?	-	No or Partially for MLE	NA	-
PASS 2				
Size (L x W)	ft	21.0 x 50.0	NA	-
Volume	gal	133,400	NA	-
Aerated?	-	Yes	NA	-
PASS 3				
Size (L x W)	ft	21.0 x 50.0	NA	-
Volume	gal	133,400	NA	-
Aerated?	-	Yes	NA	-
BLOWERS				
Quantity	-	3 (1 duty, 2 standby)	NA	-
Type	-	Multi-Stage Centrifugal	NA	-
Motor Size	hp	125	NA	-
Capacity (ea)	SCFM	1,430 (@ 9.20 psig)	NA	-
Capacity (n-1)	SCFM	2,860	2000(2)	✓
DIFFUSED AERATION SYSTEM (ALL PASSES)				
Type	-	Fine Bubble Membrane Discs	NA	-
Diffuser Quantity	-	1004 (502 per train)	NA	-
Membrane Disc Size	in	9	NA	-

Criteria	Units	Value	CDPHE Standard	× / ✓
Depth of Submergence	ft	16	9	✓
SECONDARY CLARIFIERS				
Quantity	-	2	NA	-
Type	-	Center Feed/ Peripheral Overflow	NA	-
Diameter	ft	60.0	NA	-
SWD	ft	14.9	≥11	✓
Return and Scum Removal		Bottom Scraper and Surface Skimmer	Collection and Removal Mechanism	✓
SOR	gpd/ft^2	1060	<1,200 at PHF	✓
SLR at PHF of 4.0 MGD	ppd/ft^2	35	40 at Peak Hourly Flow	✓
RAS PUMPS				
Quantity	-	3 (2 duty, 1 standby)	NA	-
Type	-	Screw Centrifugal (2) Submersible (1)	NA	-
Motor Size	hp	7.5	NA	-
Capacity (total) (3)	gpm	1,300 (2) 800 (1)	NA	-
Capacity (firm, n-1) (3)	gpm	2,100	≥ 100 – 150% of MMF	✓
TDH(3)	ft	19 (2) 18 (1)	NA	-
WAS PUMPS				
Quantity	-	2 (1 duty, 1 standby)	NA	-
Type	-	Rotary Lobe Positive Displacement (1) Submersible (1)	NA	-
Motor Size	hp	5 (1) 4 (1)	NA	-
Capacity(3)	gpm	100	NA	-
TDH(3)	ft	27	NA	-
SCUM PUMPS				
Quantity	-	2 (1 duty, 1 standby)	NA	-
Type	-	Rotary Lobe Positive Displacement	NA	-
Motor Size	hp	5	NA	-
Capacity(3)	gpm	100	NA	-
TDH(3)	ft	27	NA	-
MIXED LIQUOR RECYCLE PUMPS				
Quantity	-	2 (1 per train)	NA	-
Capacity(3)	gpm	744	NA	-
TDH(3)	ft	29.4	NA	-

Note:
(1) Clarifiers were intentionally oversized to maintain compliance with SLR requirements at this target MLSS.
(2) Operations estimate of required air flow to achieve peak carbonaceous BOD and ammonia oxidation.
(3) Estimate based on past master plan and operations staff input.

Condition Assessment

Basins and clarifiers were in good condition per the site walk conducted on October 10, 2022. Blowers were in fair condition—all three are 20 years old and energy inefficient multi-stage centrifugal units with limited turndown capability. Areas of noted deficiency are listed below:

- Aeration basin instrumentation is limited to pH.
- The RAS pumps appear to work against each other when both trains are in use.
- Backmixing of aerated mixed liquor from Pass 2 into Pass 1 is an impediment to nitrate reduction.

Recommendations

Continue to periodically inspect the basins for any signs of structural integrity degradation. Consider reconfiguration of basins and decoupling of the two trains to further improve nutrient removal efficacy. Install new, more energy-efficient blowers with the following type of instrumentation and control possibilities: DO gradient across the three passes; ammonia-based aeration control (ABAC); ammonia and nitrate-based aeration control, and on/off aeration using a ORP and DO measurements. Evaluate upgrades to the RAS system, such as flow control valves, to equalize flow.

Convert the MLE process to an A_2O process, one option for which is to construct upstream ANA basins. If Passes 2 and 3 provide enough oxic solids retention time (SRT) to assure complete nitrification at the MMF of 1.0 MGD per train, the first pass of the three-pass basin can be converted to provide both an anaerobic zone and an anoxic zone. Approximately 30% of the total biological process volume should be provided in these two zones combined, with about 10% in the anaerobic zone and 20% in the anoxic zone. Using baffle walls, two mixed (but not aerated) reactors in series should be provided in series in the anaerobic volume and two or three in series for the anoxic volume. Backmixing of aerated mixed liquor from Pass 2 to Pass 1 would have to be eliminated to assure the right environmental conditions are present in Pass 1 for nitrate reduction and Bio-P release.

5.4.1.4 UV Disinfection

Secondary effluent passes through UV disinfection prior to discharge into the Little Thompson River. Open-channel UV banks deactivate harmful microorganisms. When required, secondary effluent can be diverted through a bypass channel.

Capacity Analysis

Table 5-18: Berthoud WRF UV Disinfection Design Criteria

Criteria	Units	Value	CDPHE Standard	× / ✓
Type	-	In-Channel Lamps	NA	-
Quantity of Channels	-	1	NA	-
Quantity of Banks per Channel	-	2 (1 duty, 1 standby)	2 in series	✓
Quantity of Modules per Bank	-	8	NA	-
Quantity of Lamps per Module	-	8	NA	-
Water Level Control	-	Adjustable Weir	NA	-
PHF Capacity	MGD	6.0	NA	-
Design UV Transmittance	%	65 @ 254 nm	65	✓
Design Delivered Dose	Millijoules/cm^2	30	30	✓

Condition Assessment

Equipment was in excellent condition per the site walk conducted on 10 October 2022. No areas of deficiency were identified.

Recommendations

No action needed at this time.

5.4.1.5 Sludge Processing and Handling

The WAS handling process consists of aerobic digestion followed by centrifuge dewatering. Polymer is added as a dewatering aid. Dewatering is operated as a batch process, typically three times per week.

Capacity Analysis

Table 5-19: Berthoud WRF Sludge Processing and Handling Design Criteria

Criteria	Units	Value	CDPHE Standard	× / ✓
AEROBIC DIGESTERS				
Quantity	-	2	NA	-
Type	-	Aerobic	NA	-
Side Water Depth	ft	20.5	≥10	✓
Freeboard	ft	1.5	≥1.5	✓
Diameter	ft	52.0	-	-
Sidewall Depth	ft	22.3	-	-
Sidewall Depth : Diameter Ratio	-	0.43	≥0.3 ≤0.7	✓
Volume (per cell at max SWD)	gal	301,082	NA	-
Max Volume (at max SWD)	gal	602,164	NA	-
SRT	days	46	40 - 60	✓
Aeration System	-	Diffused Aeration	-	-
BLOWERS				
Quantity	-	3 (2 duty, 1 standby)	NA	-
Type	-	Positive Displacement	NA	-
Motor Size	hp	125	NA	-
Capacity (at max SWD)	CFM	1,768	NA	-
DIGESTER RECIRCULATION AND TRANSFER PUMPS				
Quantity	-	2 (1 duty, 1 standby)	NA	-
Type	-	Progressive Cavity	NA	-
Motor Size	hp	20	NA	-
Capacity	gpm	370	NA	-
TDH	ft	45	NA	-
GRINDER				
Capacity	gpm	100	NA	-
CENTRIFUGE FEED PUMPS				
Quantity	-	2 (1 duty, 1 standby)	NA	-
Type	-	Progressive Cavity	NA	-
Motor Size	hp	10	NA	-
Capacity	gpm	125	NA	-
TDH	ft	125	NA	-
CENTRIFUGE				
Quantity	-	1	NA	-
Hydraulic Loading Rate	gpm	125	NA	-

Condition Assessment

Equipment was in good condition per the site walk conducted on 10 October 2022. Areas of deficiency are listed below:

- Dewatering aid polymer is difficult to control, as it is based on dilution water flow.
- The centrifuge was last repaired in 2018, and will require a rebuild in the near future.
- The slide gate on the centrifuge discharge is not automated. If the centrifuge stops mid-cycle, this gate needs to be automated to fail shut.
- The single discharge chute results in buildup of dewatered cake at a single point in the collection dumpster if the dumpster is not shifted.
- The biosolids building is not on emergency power.

Recommendations

Provide cross-conveyor and multiple discharge chutes (with knife gates) to provide for even distribution of dewatered cake in the collection dumpster. Identify a suitable location for polymer storage on the ground floor to avoid hoisting totes to the upper floor. Install emergency generator dedicated to biosolids building.

5.4.2 Regional WWTF

The Regional WWTF was constructed in 2016. The rated hydraulic capacity through a single train is 99,000 gpd. As of this writing, typical flows through the Regional WWTF are around 20,000 gpd. The biological treatment process is an intermittent cycle extended aeration activated sludge (ICEAS) process. While ICEAS systems are frequently called a sequencing batch reactor (SBR) because they look like one and the treatment cycles mimic one, it is actually a continuous flow system. It is just the decanting operation that is intermittent.

Figure 5-9 is an aerial view of the WWTF and major process facilities.

Figure 5-9: Regional WWTF and Influent Lift Station

The Regional WWTF consists of the following major unit processes:

- Influent Pump Station: submersible pumps.
- Headworks: manual bar screens.
- Secondary Treatment: Includes a pre-react zone, ICEAS basin, and post-flow equalization (EQ) basin. Two trains are constructed with one presently in use. Air is supplied from positive displacement blowers. Micro-C, aluminum sulfate, and lime are added to aid in treatment.
- UV System: Includes parallel open-channel UV systems, with horizontal lamp arrays, for disinfection
- Sludge processing and handling: One aerated solids holding tank that is periodically drained down by a vacuum truck.

5.4.2.1 Influent Pump Station

Located approximately 500 feet southeast of the Regional WWTF, the influent pump station receives local wastewater flows and lifts them to the WWTF.

Capacity Analysis

Table 5-20: Regional WWTF Influent Pump Station Design Criteria

Criteria	Units	Value	CDPHE Standard	× / ✓
WET WELL				
Type	-	Precast Concrete Tank W/ Lid	NA	-
Diameter	ft	8.0	NA	-
Working Depth	ft	4.0	NA	-
Working Volume	gal	1,500	NA	-
INFLUENT PUMPS				
Quantity	-	2 (1 duty, 1 standby)	≥2	✓
Type	-	Submersible	NA	-
Capacity (each)	gpm	275	NA	-
Capacity (firm, n-1)	gpm	275	Peak Hourly Flow (160)	✓
TDH	ft	70	NA	-
Motor Size	hp	15	NA	-

Condition Assessment

Wetwell and equipment were in good condition per the site walk conducted on October 10, 2022. No areas of deficiency noted at this time. The influent pumps are pulled from the wetwell for inspection twice per year and do not experience clogging issues.

Recommendations

No action needed at this time.

5.4.2.2 Preliminary Treatment

Raw influent is screened prior to entering the SBR treatment process. The bar screen is monitored by operations staff and periodically cleaned to remove accumulated debris. The screen has been situated at an angle that facilitates overflow directly into the SBR pre-react zone when clogged.

Capacity Analysis

Table 5-21: Regional WWTF Preliminary Treatment Design Criteria

Criteria	Units	Value	CDPHE Standard	× / ✓
INFLUENT BAR SCREEN				
Quantity	-	1	NA	-
Bypass	-	Yes	NA	-
Screenings Removal Mechanism	-	Manual	NA	-
Bar Spacing	in	1.75	>1 ≤1.75	✓
Capacity	MGD	0.40	NA	-

Condition Assessment

Screen was in excellent condition per the site walk conducted on 10 October 2022. No areas of deficiency noted at this time.

Recommendations

Install automated screening equipment to combat high density of paper solids and other debris, primarily from the nearby gas station, which enter with the raw influent.

5.4.2.3 Secondary Treatment – ICEAS

Screened influent proceeds through the ICEAS system, comprised of two parallel trains of three basins. At present, one train is large enough to handle all flow to the WWTF. The pre-react zone and ICEAS basin of the second train are used as emergency storage. The post-EQ basin of the second train is used as a WAS holding basin. Micro-C and alum are metered into the SBR basin during the reaction period. Hydrated lime is manually added.

Capacity Analysis

Table 5-22: Regional WWTF Secondary Treatment – ICEAS Design Criteria

Criteria	Units	Value	CDPHE Standard	× / ✓
PRE-REACT ZONES				
Quantity	-	2	NA	-
Type	-	Rectangular, Concrete Tank	NA	-
Size of Each Basin (L x W x D)	ft	23.0 x 10.0 x 23.5	NA	-
Low Water Level	ft	16.9	NA	-
High Water Level	ft	22.0	NA	-
Minimum Operating Volume (ea)	gal	29,075	>PHF for settle/decant duration	✓
Maximum Operating Volume (ea)	gal	37,850	NA	-
PRE-REACT AERATION SYSTEM				
Type	-	Fine Bubble	NA	-
Diffuser Quantity	-	183	NA	-
Membrane Disc Size	in	9	NA	-
ICEAS BASINS				
Quantity	-	2 (1 duty, 1 emergency storage)	NA	-

Criteria	Units	Value	CDPHE Standard	× / ✓
Type	-	Rectangular, Concrete Tank	NA	-
Basin Size (L x W x D) (ea)	ft	23.0 x 68.0 x 23.5	NA	-
Low Water Level	ft	16.9	10	✓
High Water Level	ft	22.0	NA	-
Freeboard	in	18	18	✓
Minimum Operating Volume	gal	197,710	NA	-
Maximum Operating Volume	gal	257,370	NA	-
Hydraulic Retention Time @ (Q Max Month)	day	2.6	NA	-
SRT @ (Q Max Month) (w/ pre-react zone)	day	37	NA	-
ICEAS DECANTER				
Quantity	-	1	NA	-
Type	-	Mechanical w/ Scum Exclusion Float	Scum excluding	✓
Weir Length	ft	7.5	NA	-
Capacity (Design/Maximum)	gpm	921 / 1,320	NA	-
BLOWERS				
Quantity	-	2 (1 duty, 1 standby)	NA	-
Type	-	Positive Displacement	NA	-
Capacity (each)	CFM	399	NA	-
Discharge Pressure	psia	27.4	NA	-
Horsepower (each)	hp	30	NA	-
AERATION SYSTEM				
Type	-	Fine Bubble	NA	-
Diffuser Quantity	-	184	NA	-
Membrane Disc Size	in	9.0	NA	-
Depth of Submergence	ft	15.8	9	✓
WASTE SLUDGE PUMP				
Quantity	-	1	NA	-
Type	-	Submersible Sewage Pump	NA	-
Capacity	gpm	117	NA	-
TDH	ft	25	NA	-
Horsepower	hp	2.3	NA	-
POST-EQ BASIN				
Quantity	-	1	NA	-
Type	-	Rectangular, Concrete Tank	NA	-
Basin Size (L x W x D)	ft	23.0 x 20.5 x 23.5	NA	-
High Water Level	ft	15.4	NA	-
Max Operating Volume	gal	47,259	NA	-
Minimum Volume	gal	7,054	NA	-
POST-EQ PUMP				

Criteria	Units	Value	CDPHE Standard	× / ✓
Quantity	-	2 (1 duty, 1 standby)	NA	-
Type	-	Submersible	NA	-
Motor Size	hp	4.5	NA	-
Capacity (each)	gpm	350	NA	-
TDH	ft	27	NA	-

Condition Assessment

All basins, internals and blowers were in good condition per the site walk conducted on October 10, 2022. No areas of deficiency noted at this time.

Recommendations

Improve chemical dosing systems to minimize operations involvement.

5.4.2.4 UV Disinfection

Decanted effluent is stored in the post-EQ basin and then pumped to UV disinfection prior to discharge into the Little Thompson River. Open-channel UV banks arranged in parallel deactivate harmful microorganisms. Only one channel is operated at a time.

Capacity Analysis

Table 5-23: Regional WWTF UV Disinfection Design Criteria

Criteria	Units	Value	CDPHE Standard	× / ✓
Type	-	In-channel Lamps	NA	-
Quantity of Channels	-	2	NA	-
Quantity of Banks	-	2 in parallel	2 in series	-
Capacity	gpm	350	NA	-
Minimum Transmittance	%	65	65	✓
Minimum Dose @ Q Max Month	Millijoules/cm^2	30	30	✓

Condition Assessment

Equipment was in excellent condition per the site walk conducted on 10 October 2022. No areas of deficiency identified at this time.

Recommendations

No action needed at this time.

5.4.2.5 Sludge Processing and Handling

Capacity Analysis

Table 5-24: Berthoud Regional WWTF Sludge Processing and Handling Equipment

Criteria	Units	Value	CDPHE Standard	× / ✓
SOLIDS HOLDING BASIN				
Quantity	-	1	NA	-
Type	-	Rectangular, Concrete Tank	NA	-
Basin Size (L x W x D)	ft	23 x 20.5 x 23.5	NA	-
High Water Level	ft	22		
Maximum Storage Volume	gal	77,595		
Total Volume Wasted from SBR	gpd	2,424		
Decant Volume Returned to IPS	gpd	700		
Storage Time	days	45		
SOLIDS AERATION SYSTEM				
Type	-	Coarse Bubble	NA	-
Diffuser Quantity	-	40	NA	-
SOLIDS DECANT PUMP				
Quantity	-	1	NA	-
Type	-	Submersible Sewage Pump	NA	-
Motor Size	hp	1	NA	-
Capacity	gpm	70	NA	-
SOLIDS TRANSFER PUMP (NOT IN USE)(1)				
Quantity	-	1	NA	-
Type	-	Submersible Sewage Pump	NA	-
Motor Size	hp	2.3	NA	-
Capacity	gpm	117	NA	-
TDH	ft	25	NA	-

Notes:
(1) Vac truck pump is used to draw sludge from this tank.

Condition Assessment

Basin was in good condition per the site walk conducted on 10 October 2022. No areas of noted deficiency at this time.

Recommendations

No action needed at this time.

5.4.3 Collection System Facilities

5.4.3.1 Lift Stations

Assets

There are four lift stations located in the collection system, not including the two influent pump stations at each of the two wastewater treatment plants. The collection-system lift station locations are shown in Figure 5-10. Each of the collection-system lift stations are duplex configurations with identically sized pumps.

Figure 5-10: Lift Station Location Map

The lift station characteristics and flow rates are summarized in Table 5-25. The average influent rate and peak influent rate are listed for existing conditions only.

Table 5-25: Town's Lift Station Inventory

Lift Station Name	Location	Station Configuration	Pumping Capacity (gpm)	Force Main
Bomar Lift Station	Bomar Ave & 35th St SW	5' Diameter Wet Well, Submersible Pumps	86	4" PVC
Campion Lift Station	Leanne Ct and S County Road 15	4' x 8' Wet Well, Dry Pit Pumps	404	6" CIP
Heron Lakes Lift Station	Heron Lakes Parkway	12' Diameter Wet Well, Submersible Pumps	490	6" DIP
Riverglen Lift Station	County Road 17	6' Diameter Wet Well, Submersible Pumps	100	4" HDPE

Existing Lift Station Site Visits

A site visit was completed on October 18, 2022 for all the lift station sites. Below are the features and observations of each lift station:

- Campion Lift Station
  - Previous dry pit application converted to a wet well submersible application.
  - Dry pit is abandoned in place.
  - Isolation valves buried outside the wetwell.
  - Above ground emergency bypass connection.
  - Emergency storage occurs within wet well.
  - Emergency generator on site.
- Bomar Lift Station
  - A lot of FOG issues.
  - Pumps installed in 2017.
  - Propane fueled generator.
  - Development going in near lift station – will have increased flows.
- Riverglen Lift Station
  - Separate vault for valves.
  - Above ground building with pump starters and electrical equipment.
  - Exterior diesel-fueled emergency generator.
  - Emergency bypass connection.
  - Emergency storage system is in a detention pond area to the northeast of the lift station.
  - Pumps (Flygt Concerter) were installed approximately 6 months ago.
- Heron Lakes Lift Station
  - Large building and large site.
  - Building contains pumps, above ground valves, odor control and generator.
  - Odor control system refilled every 10 years.

- Emergency overflow storage in wet well.
- Natural gas-fueled emergency generator.

Condition Assessment

From the site visit, there were high-level condition assessments completed as well. Below are the conditions and operational challenges for each lift station.

- Campion Lift Station
  - Pump 2 was down at the time of the site visit. A bypass pumping system was connected to the emergency connection. The pump has since been repaired.
  - Valves within wet well.
  - Concern over if there is sufficient storage within the wet well and inline gravity system.
- Bomar Lift Station
  - FOG issues.
  - Aging wet well and hatch.
  - Aging electrical equipment.
  - Propane fueled generator isn't cost efficient and appears to be aging.
- Riverglen Lift Station
  - There is an upstream lift station from another subdivision (owned by the HOA) which feeds into this lift station which supposedly has a larger capacity than Riverglen.
  - The previous pumps that were in this lift station had trouble keeping up with the flow demand and would consistently burn out due to fast on/off cycles. Heron Lakes Lift Station
  - New lift station with no known operational challenges.

Recommendations

Based on observations from the site visits and high-level condition assessments, the following recommendations were formulated.

- Campion Lift Station
  - Repair Pump 2.
  - Assess upstream sufficient storage.
- Bomar Lift Station
  - Address FOG with more frequent cleaning or removal equipment.
  - Repair or replace structural elements and electrical equipment.
  - Replace or upgrade generator.
- Riverglen Lift Station
  - Determine true impacts of upstream HOA lift station and resize pump station pumping requirements.
  - Replace pumps after determining reasons for short cycles.
- Heron Lakes Lift Station
  - New lift station with no known operational challenges.

5.4.3.2 Pipelines

Assets

The Berthoud sanitary sewer collection system has a total of 480,889 linear feet of sewer ranging from 4-inch diameter to 24-inch diameter. Like the water distribution system, the sewer collection system has the large primary collection system which feeds the Berthoud WRF and a smaller collection system by I-25 which feeds the Regional WWTF. The smaller collection system serves the Serenity Ridge subdivision and Love's Truck Stop. The full inventory list of linear sewer assets is summarized in Table 5-26.

Table 5-26: Sewer Inventory by Size

Sewer Diameter (in)	Length (ft)
4	52
6	29,663
8	305,708
10	31,681
12	50,276
15	32,076
16	141
18	12,931
21	4,675
24	13,339
Not Specified	348
Total:	**480,889**

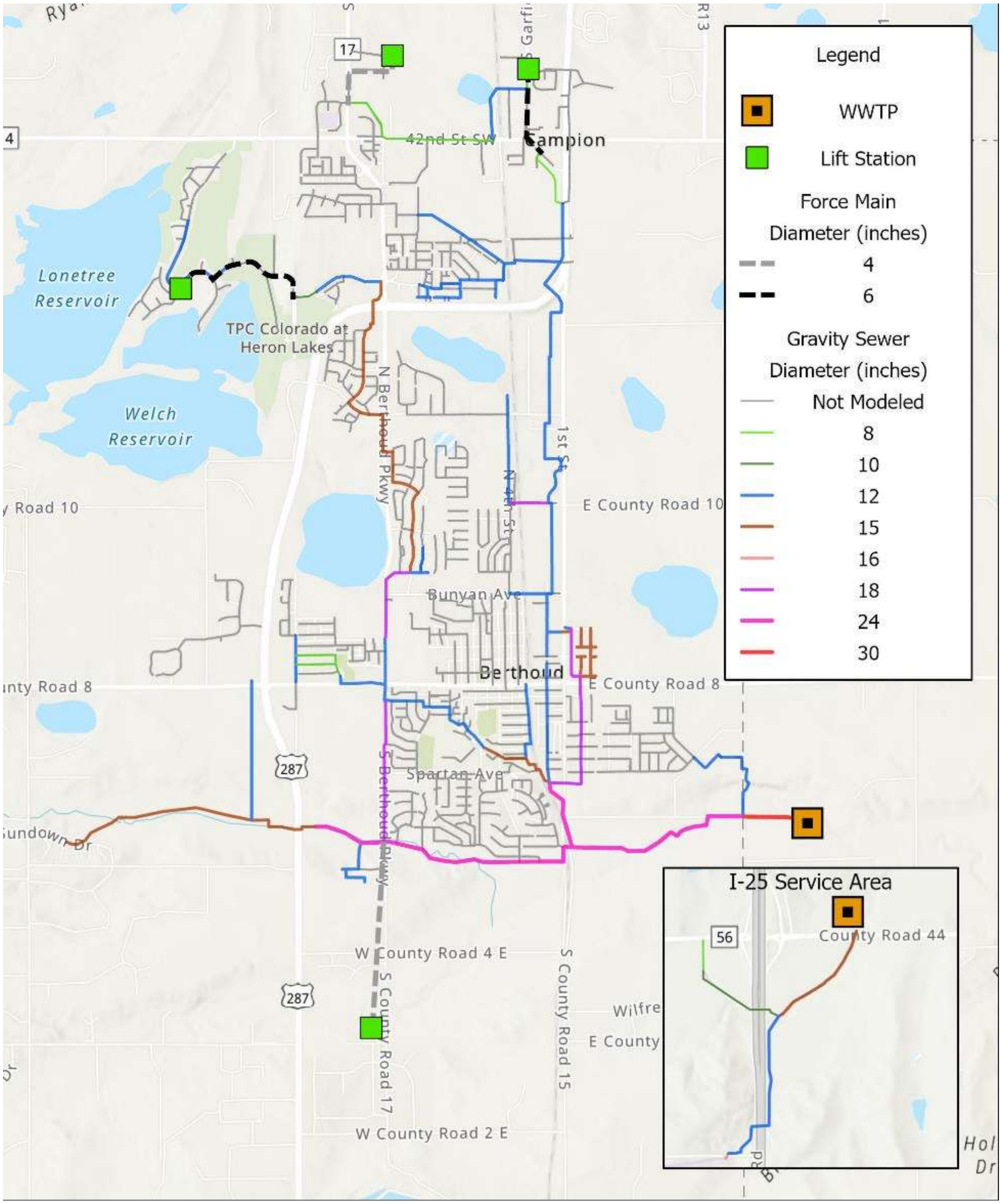


Figure 5-11: Sanitary Sewer Network

Condition Assessment

There is no record of any condition assessments such as Closed-Circuit Television (CCTV) inspections being conducted. The Town should consider conducting CCTV inspections recurring on a 10-year cycle to verify the system is in good condition.

Recommendations

5.4.4 Asset Risk Assessment

As part of the infrastructure condition evaluation, a risk assessment was performed on the process units under Town ownership. This assessment captured the most prominent failure scenarios and their likelihood of occurrence (LoF); the consequence of failure of a unit process (CoF); and the resulting risk score (LoF x CoF). The derived risk scores have been used as a driver for prioritization of capital improvement projects in Section 5.8.

The consequences, likelihoods and risks for unit processes at the Berthoud WRF, Regional WWTF and throughout the collection system are presented in Table 5-27, Table 5-28, and Table 5-29, respectively. These results categorize the unit processes from most to least vulnerable based on their current condition, with a high score indicating heightened risk. The full risk matrix with scoring is presented in **Appendix A**. Safeguards, defined as precautions taken to mitigate the likelihood and/or severity of a failure, are presented in the risk matrix.

Table 5-27: Berthoud WRF Asset Risk Assessment Summary

Unit Process	Consequence of Failure	Likelihood of Failure	Risk Score
Headworks	16	Possible	48
Influent Pump Station	17	Possible	51
Aeration (Blowers, Diffusers)	20	Possible	60
Activated Sludge (Basins, MLR Pumps)	19	Unlikely	38
Clarifiers	15	Possible	45
RAS/WAS Pumping	14	Possible	42
Disinfection	16	Possible	48
Digestion	15	Possible	45
Dewatering	15	Possible	45
Polymer Storage/Feed Systems	12	Likely	48
Non-Potable Water System	11	Likely	44
SCADA Systems	14	Possible	42
Cybersecurity	28	Possible	84

Table 5-28: Regional WWTF Asset Risk Assessment Summary

Unit Process	Consequence of Failure	Likelihood of Failure	Risk Score
Influent Pump Station	13	Possible	39
Headworks	12	Likely	48
Aeration/Blowers	18	Possible	54
Activated Sludge Basin	19	Unlikely	38
Disinfection	14	Unlikely	28
Chemical Storage/Feed Systems	14	Possible	42
Emergency Generator	14	Unlikely	28
SCADA Systems	15	Possible	45
Cybersecurity	28	Possible	84
Influent Pump Station	13	Possible	39
Headworks	12	Likely	48
Aeration/Blowers	18	Possible	54
Activated Sludge Basin	19	Unlikely	38
Disinfection	14	Unlikely	28
Chemical Storage/Feed Systems	14	Possible	42
Emergency Generator	14	Unlikely	28
SCADA Systems	15	Possible	45
Cybersecurity	28	Possible	84

Table 5-29: Collection System Asset Risk Assessment Summary

Unit Process	Consequence of Failure	Likelihood of Failure	Risk Score
Campion Lift Station	19	Likely	76
Bomar Lift Station	18	Likely	72
River Glen Lift Station	18	Possible	54
Heron Lakes Lift Station	19	Possible	57

5.5 Hydraulic Evaluation

Hydraulic evaluations were performed for the entire wastewater system, including the existing WRF, Regional WWTF, and the collection system. The existing WRF and Regional WWTF utilized a proprietary hydraulic profile calculation spreadsheet to calculate the hydraulic profile through the plant. The intent is to identify any hydraulic bottlenecks or restrictions through the system. The collection system utilized PCSWMM to run a thorough analysis on system-wide flows in the existing and future scenarios.

5.5.1 Treatment Plants

A hydraulic evaluation was performed on the existing WRF and Regional WWTF under existing and future flow conditions. The Regional WWTF is an SBR plant so there are minimal true gravity hydraulics. The plant runs in batches and level is controlled by instrumentation. While the capacities of this plant were hydraulically evaluated, the results of the hydraulic profile calculations didn't result in any significant findings. The flow scenarios that were modeled are summarized in Table 5-31. The hydraulic evaluation strictly analyzes the gravity system through the plant and does not evaluate the pumped systems for capacity.

Table 5-30: Hydraulic Profile Flow Scenarios

Year	Flow Condition	Berthoud WRF	Berthoud Regional WWTF
Existing	ADF	0.96	0.016
	MDF	1.81	0.040
	PHF	2.88	0.064
20-Yr	ADF	2	0.178
	PHF	6.0	0.710

5.5.1.1 WRF Existing System

The existing WRF system was modeled for the varying flow rates to identify any existing or future capacity restrictions. Figure 5-12 summarizes the hydraulic profiles. During future flow demands, the clarifiers and associated piping seem to be hydraulically overloaded. The rest of the gravity system appears to have hydraulic capacity for the 20-year future flows.

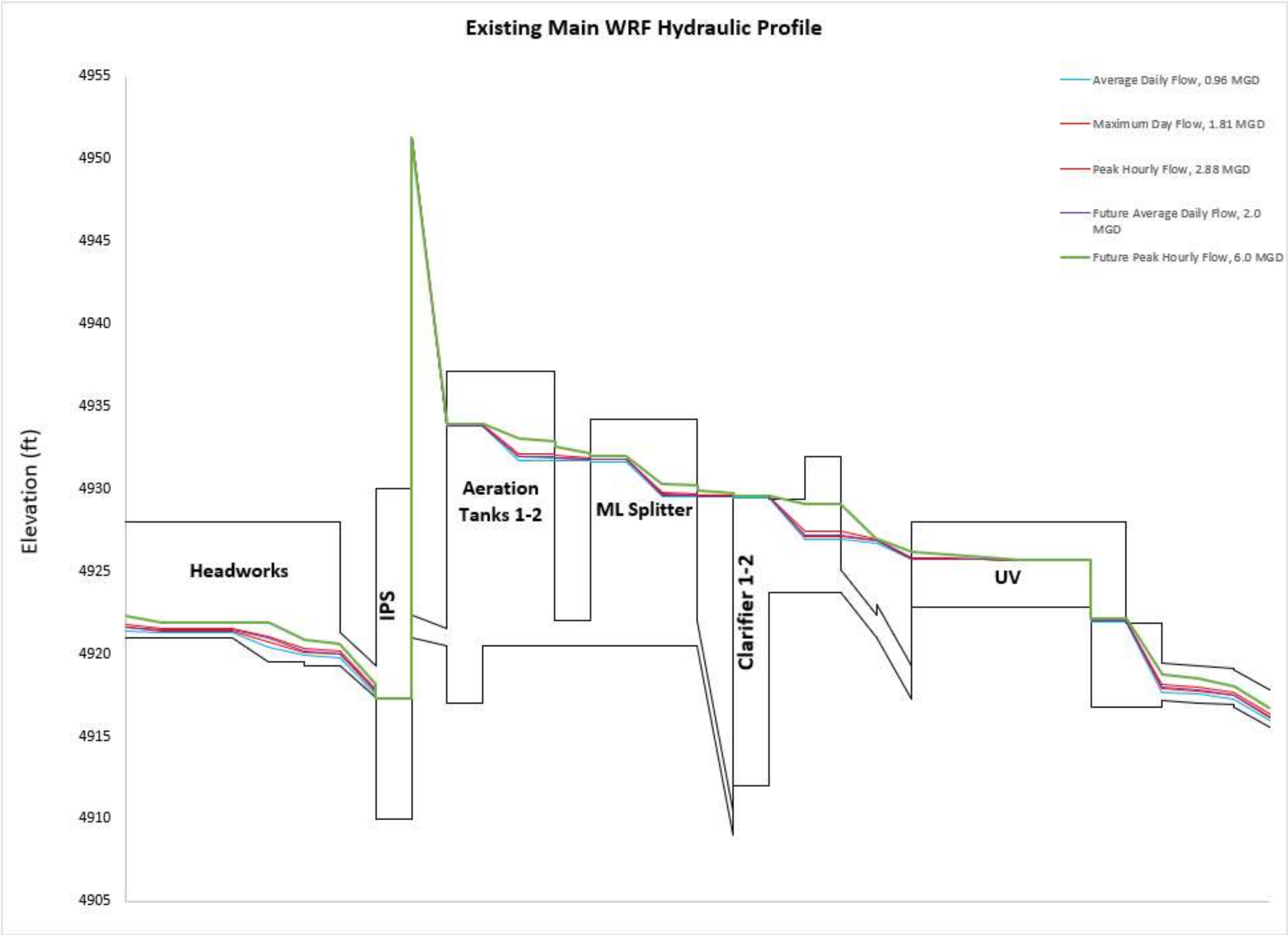


Figure 5-12: Existing WRF Hydraulic Profile

5.5.1.2 Proposed System

The hydraulics results indicate that the two clarifiers and associated piping is not sized for the future peak hour flow of 6.0 MGD. There needs to be a third clarifier and piping added to reduce headlosses and the hydraulic profile. Additional upgrades are also required due to process treatment limitations with the increased flows. The proposed system hydraulic profile with the three clarifiers is shown in Figure 5-13.

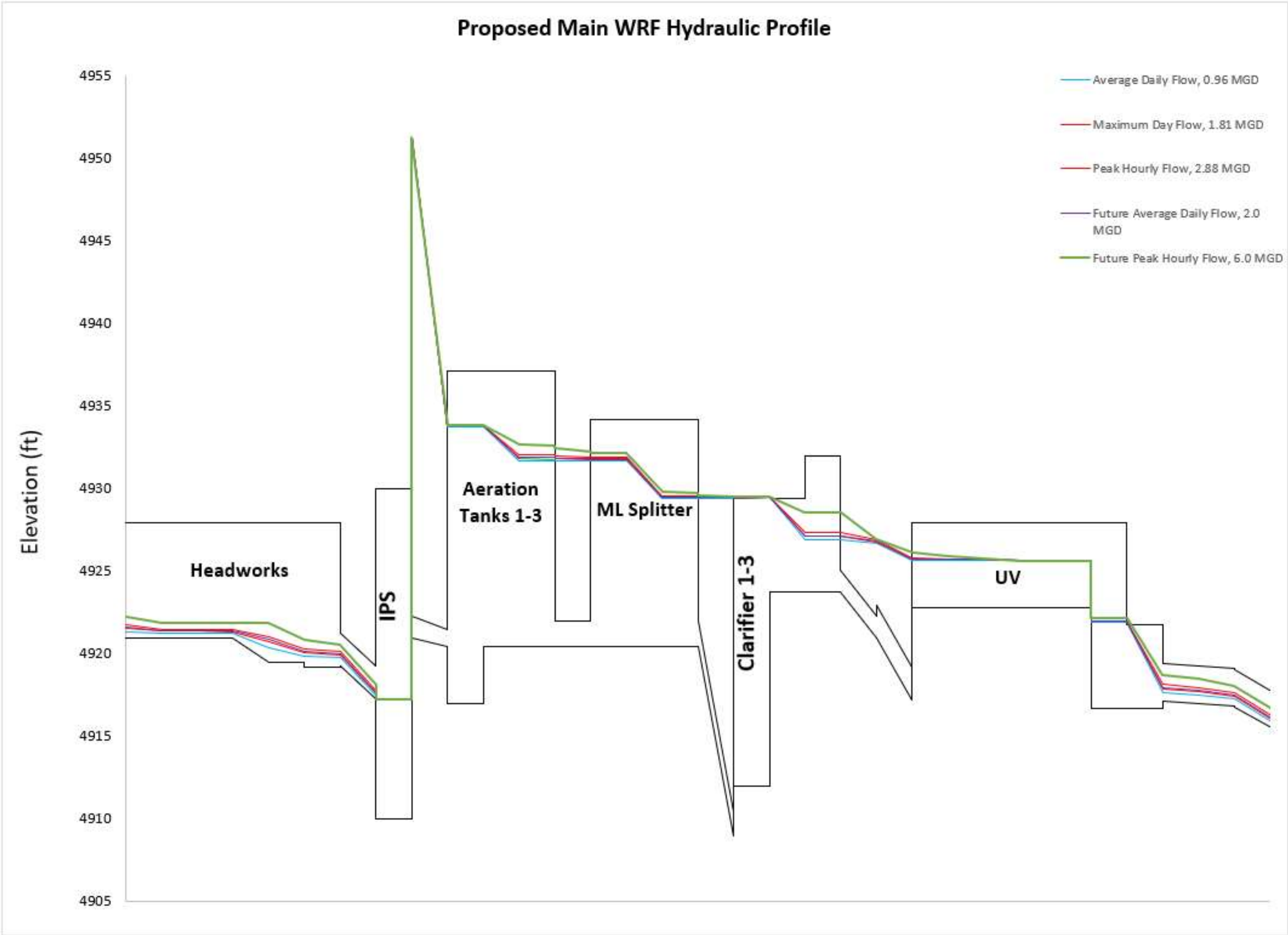


Figure 5-13: Proposed WRF Hydraulic Profile

5.5.2 Collection System

5.5.2.1 Hydraulic Assessment

The Town's collection system was hydraulically modeled as a steady-state model using PCSWMM software. The steady-state model included all sewers, 10 inches and above, as well as 8-inch sewers that serve a substantial area.

Hydraulic modeling involved utilizing average flows, then applying a peaking factor to develop peak flows. Flow scenarios include:

1) Current Conditions, Peak Design Flow (PDF)
2) 5-Year Projection Conditions, PDF
3) 20-Year Projection Conditions, PDF

Following the Town of Berthoud Design Standards and Construction Specifications, ADF was calculated assuming 95 gpd/capita and 2.55 persons per dwelling unit. This is in line with recent census data has indicated that the number of persons per dwelling unit is about to 2.6. Per direction from the Town, 2.6 persons per dwelling unit was used for all analyses.

To account for wet-weather impacts, average daily flow was increased by 10% to account for infiltration and inflow (I/I). There is no peaking factor (PF) for the ratio of average flow to peak day flow specified in the Berthoud

Standards. Therefore, the model used the peaking-factor equation from the City and County of Denver Sanitary Sewer Design Technical Criteria Manual. This is summarized in Figure 5-14.

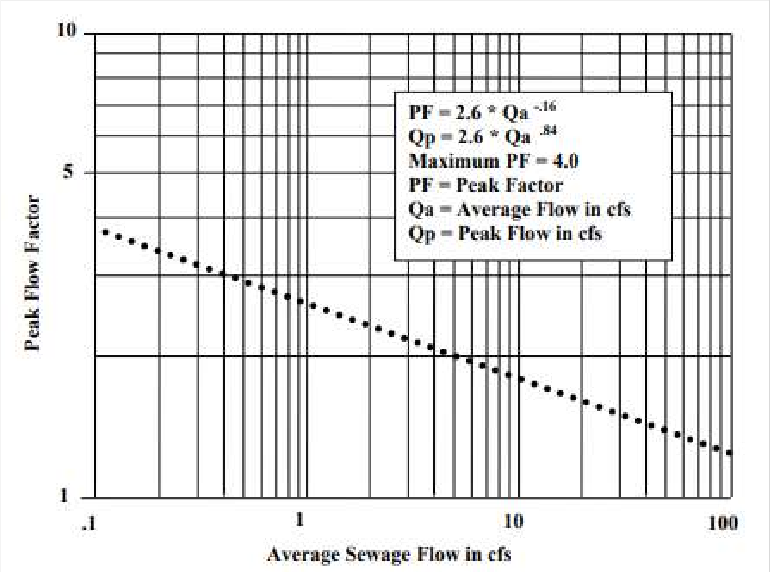


Figure 5-14: Peaking Factor Calculation

The ADF and PHF flow rates were then cross-checked with the flow monitoring data (Section 5.5.2.2). The flow monitoring data, however, was not used to fully calibrate the model. Flow meter data is included in **Appendix D**.

The design criteria as specified in the Town of Berthoud Design Standards and Construction Specifications are:

- Peak Hour Flow (PHF) shall not exceed 0.8 q/Q. After evaluation of this specific criteria with Town Staff, the team decided to utilize 0.8 d/D as the governing criteria.
- PHF flow velocity shall not exceed 10 ft/s.
- ADF, Minimum Hour Flow (MHF) flow velocity shall maintain 2 ft/s.

The model was used to determine where pipelines violated the design criteria. These violations were summarized in this master plan as well as recommendations to either resolve the failed design criteria or mitigate negative effects of failed design criteria. Conformance of the specified design criteria will be identified utilizing the hydraulic modeling scenarios and flow types specified in Table 5-32.

Table 5-31: Hydraulic Modeling Scenarios

Flow Condition	Scenario	Flow Type	Purpose
Current Conditions	1	PHF	d/D Ratio
5-Year Projection	2	PHF	d/D Ratio
20-Year Projection	3	PHF	d/D Ratio

Due to the number of assumptions utilized in developing inverts in the hydraulic model, it was decided that velocity would not be closely analyzed as part of the hydraulic analysis. Velocities are included in the shapefile deliverables for informational purposes, however.

5.5.2.2 Flow Monitoring

Flow monitoring was completed at strategic locations throughout the Town to use as a cross-check tool to verify the hydraulic model was making sense. Flow monitoring generally occurred between October and December of 2022. There were no wet weather events captured during the monitoring period to make an assessment on I/I. Flow meter locations are displayed in Figure 5-15 along with their respective sewersheds.

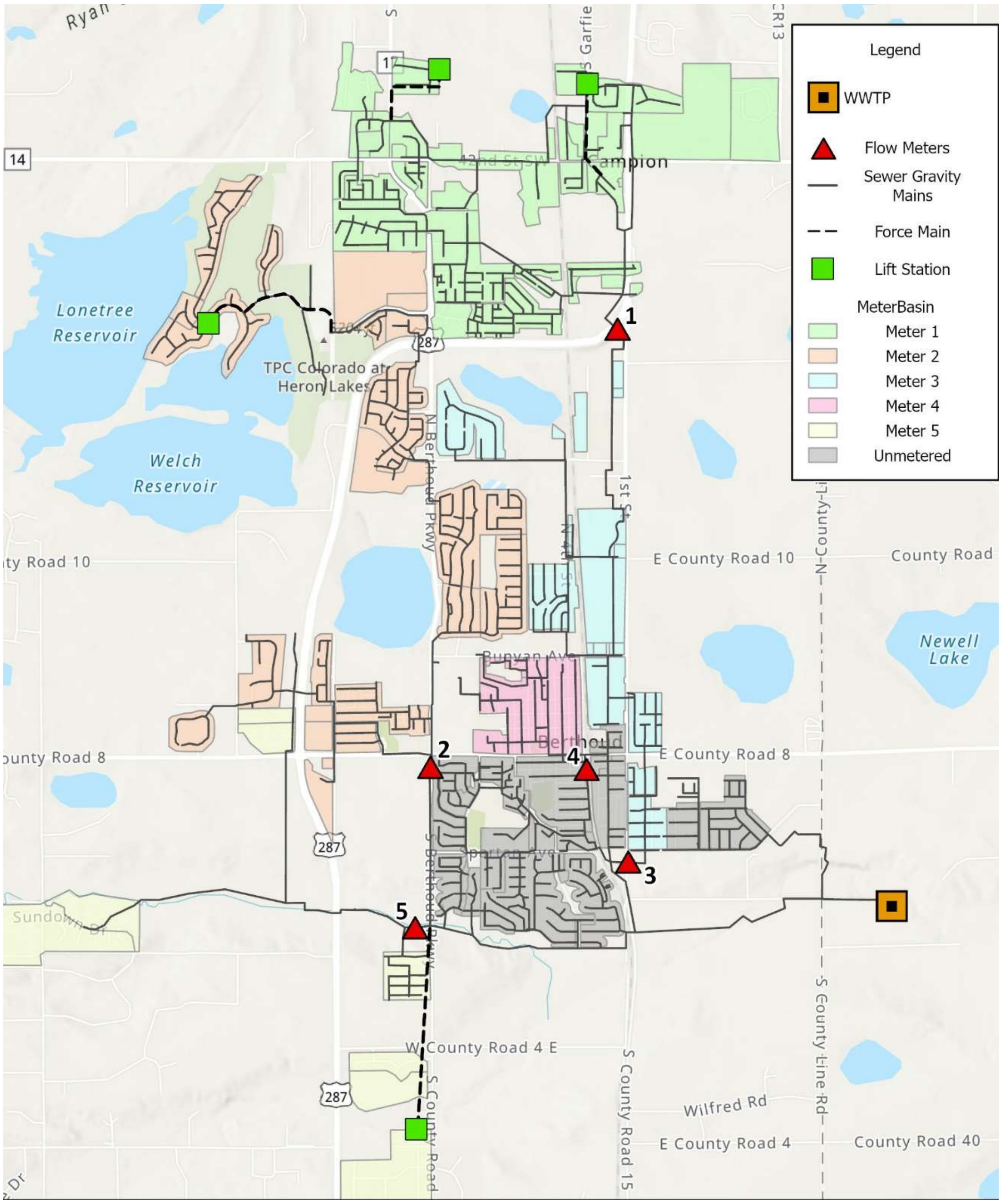


Figure 5-15: Collection System Flow Monitoring Locations

The flow meter data was analyzed and the ADF for the hydraulic model and the metered flow was compared. The sewershed's number of housing units was counted to identify the unit flow for each meter. This unit flow helped in applying flows and peaking factors to unmetered areas. The unit flow analysis and comparison to modeled flows are provided in Table 5-33. Individual flow meter results are provided in **Appendix D**. Flow Meters 3 and 5 have high unit flows of 434 gpd/SFE and 331 gpd/SFE, respectively. It's advised that the Town investigate these specific sewershed to identify the reason for the high discharge. There could be a high industrial discharger, sump pump connections, a high residential discharger, or I/I issues. A unit flow of 175 gpd/SFE was applied to the unmonitored sewershed based on measured plant influent flow and calculating against the flow meters.

Table 5-32: Flow Monitoring Results Summary

Flow Meter	SFE	Measured ADF, MGD	Unit Flow (gpd/SFE)	Model ADD, MGD	Percent Difference
1	1,788	0.194	108	0.194	0%
2	1,336	0.254	190	0.251	-1%
3	921	0.399	223	0.397	-1%
4	511	0.067	131	0.067	0%
5	185	0.061	331	0.061	0%
Unmonitored	2,082		175		

5.5.2.3 Current Condition Results

Overall, the existing sewer collection system is in good hydraulic condition while comparing against the design criteria. Figure 5-16 displays the d/D ratios and is showing only one area along the First Street sewer which has a capacity concern. The First Street sewer was previously known to have capacity concerns and the situation will only get worse as development increases. There are two siphons in the system which will show as surcharged.

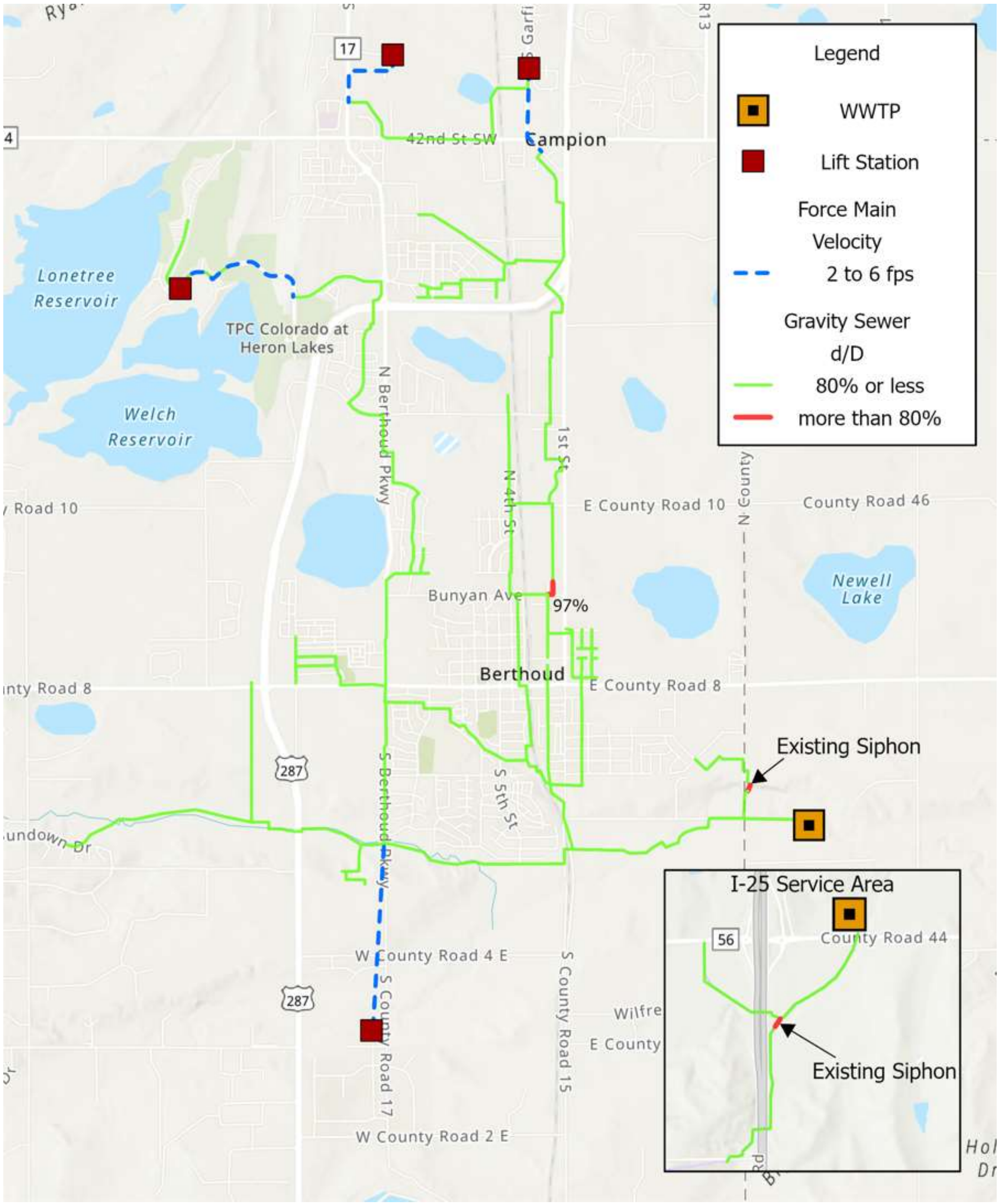


Figure 5-16: Scenario 1 | Current Conditions, Peak Flow, d/D Ratio

5.5.2.4 Future Scenario, Existing Condition Results

The 5-yr and 20-yr development projections were developed by the Town with assistance by Tetra Tech. These development projections assisted with the population projections, but further than that the geographic locations of the developments helped to skeletonize the future collection system and all associated components such as treatment plants, lift station, and siphons if necessary. The location and quantity of SFEs estimated for the future developments were provided by the Town for each 5-year and 20-year projection. The 5-year and 20-year future models were modeled using the existing infrastructure collection system to identify impacts, problem areas, and CIP projects. The results of these future models are displayed in Figure 5-17.

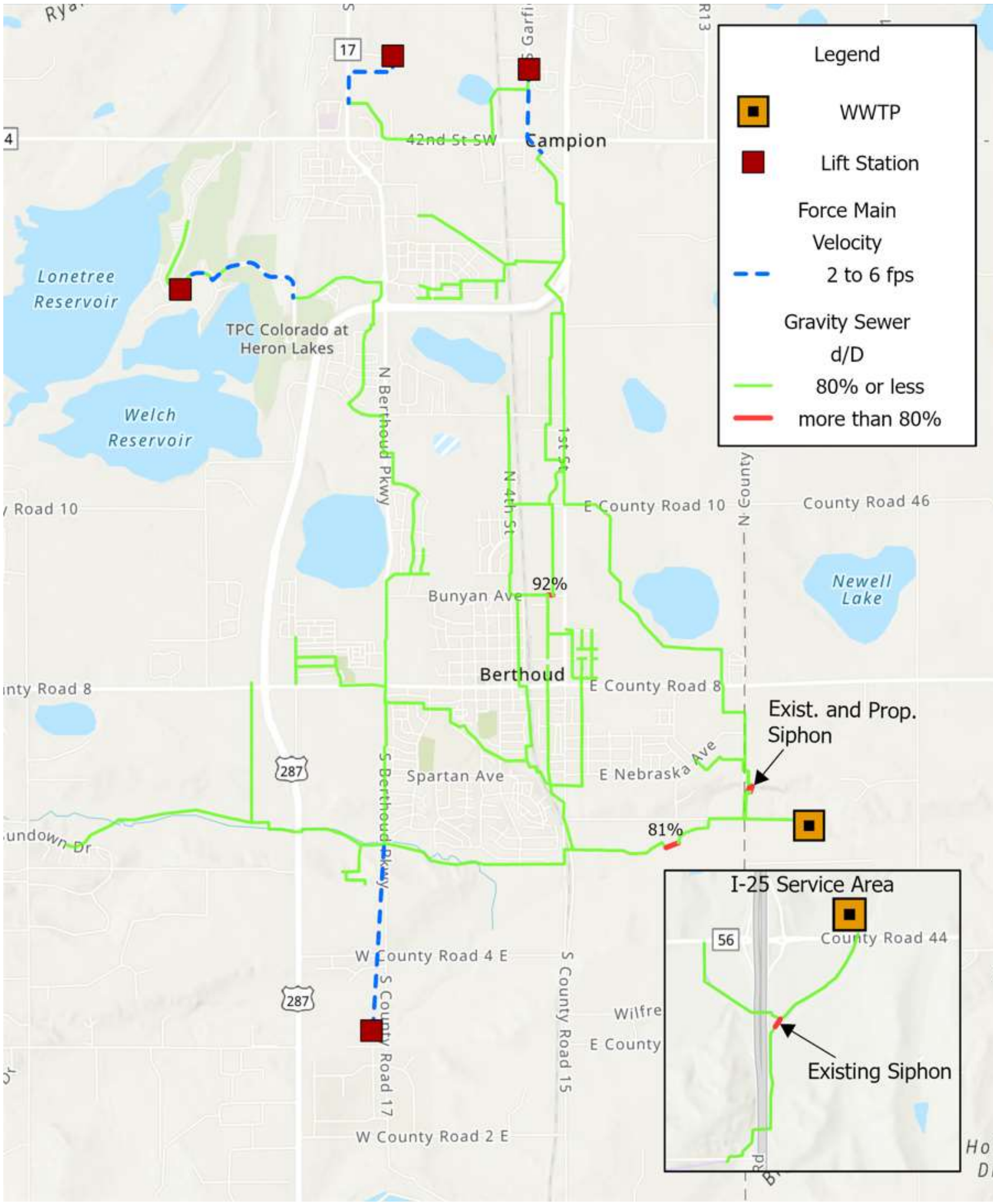


Figure 5-17: Scenario 2 | 5-Year Projection Conditions, Peak Flow, d/D Ratio

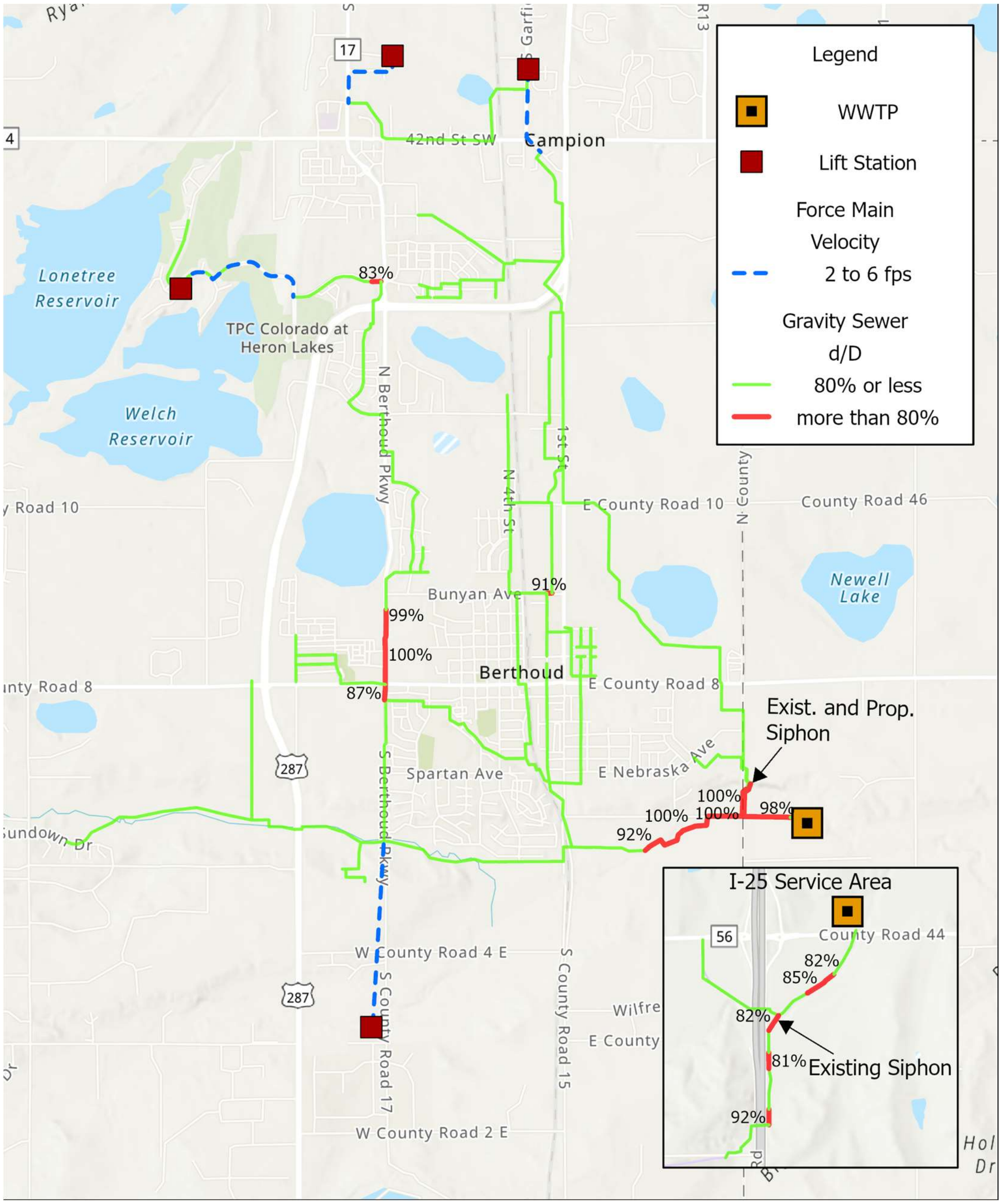


Figure 5-18: Scenario 3 | 20-Year Projection Conditions, Peak Flow, d/D Ratio

5.5.2.5 *Recommendations*

The CIP Projects were developed based on the 5-year and 20-year projection hydraulic models. Based on the anticipated future growth and geographic location of the developments, the CIP projects were developed and prioritized. The distribution projects and project IDs are summarized in Figure 5-19 and Table 5-33. All wastewater collection CIP projects have a prefix of “WWC” to denote “Wastewater Collection”.

Figure 5-19: Wastewater Collection CIP Projects

Table 5-33: Sanitary Sewer CIP Projects

CIP Project #	Name	Length (ft)	Diameter (in)	
			Existing	Proposed
WWC-1	Bacon Lake Interceptor Improvements	19,270	-	15 - 30
WWC-2	Little Thompson Trunk Sewer	4,978	24-3	30-42
WWC-3	Regional WWTF Influent Lift Station Upgrades, Phase 1	-	-	-
WWC-4	Berthoud Parkway Trunk Sewer	1,843	12	18
WWC-5	Bomar Lift Station Upgrade	-	-	-
WWC-6	Regional WWTF Influent Lift Station Upgrades, Phase 2	-	-	-
WWC-7	Turion Trunk Sewer, Phase 1	2,932	15	18
WWC-8	Turion Trunk Sewer, Phase 2	2,550	12	15

The upgraded infrastructure for future 20-year projections was also hydraulically modeled to ensure the issues with the collection system were solved. The improved 20-year collection system is displayed for conformance with d/D ratio criteria in Figure 5-20. There are a few siphons in the system which show being over 0.8 d/D by design. These siphons will require increased cleaning and maintenance as compared to the rest of the gravity collection system. In addition, there is a sewer near Heron Lakes which is showing as being equal to 0.8 d/D, so it's borderline deficient. This area is considered to be fully built out in the 20-year condition and therefore an upgrade is not recommended. It is recommended that the Town monitor this area to determine if an upgrade project is warranted in the future.

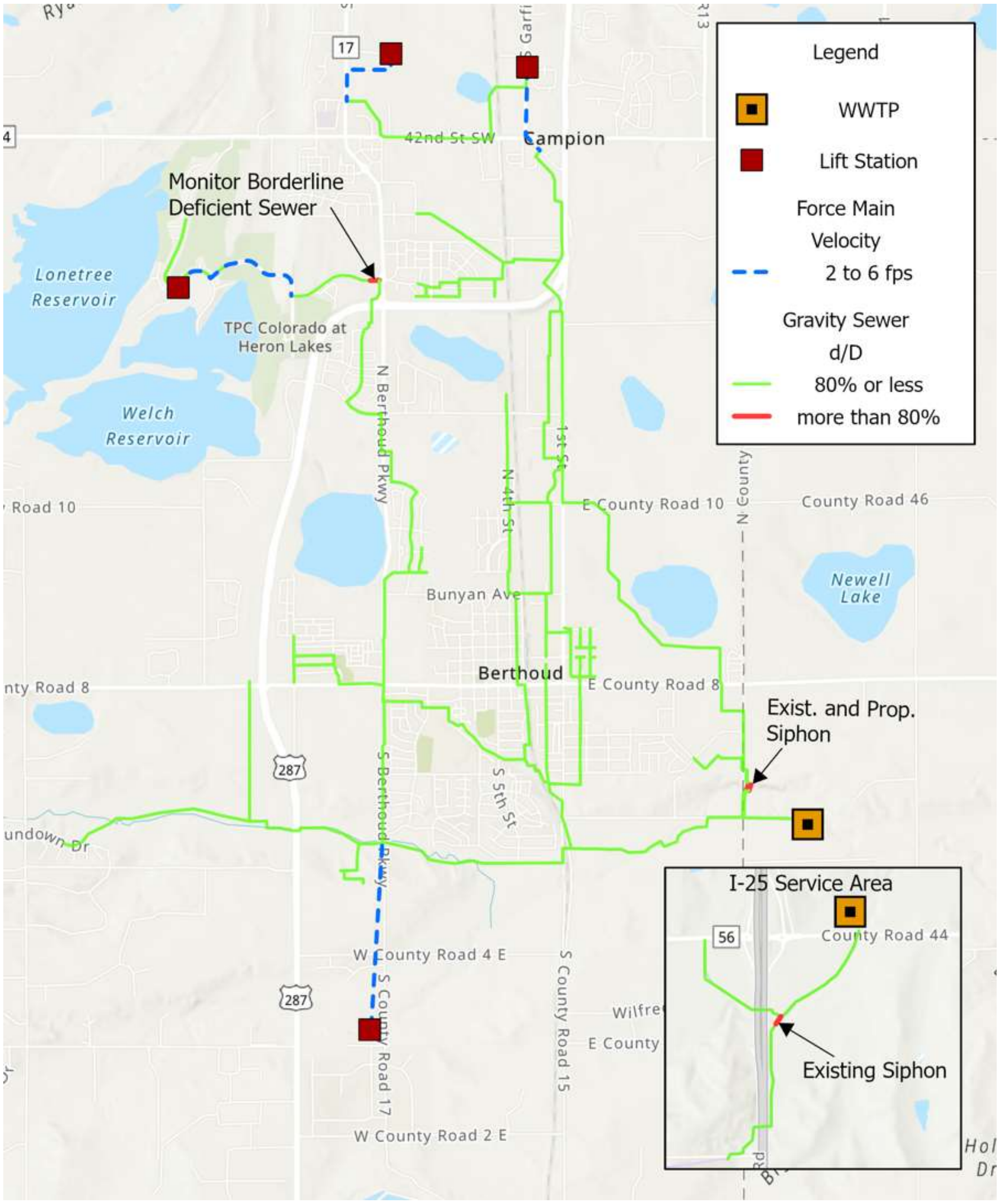


Figure 5-20: Improved Collection System, d/D Ratio

5.6 SCADA and Security Evaluation

5.6.1 Berthoud WRF

SCADA software currently in use is GE iFIX version 5.9 which will reach end of support in October of 2023. PLCs in the plant are Allen Bradley, most of which are no longer supported (SLCs) though some have been upgraded with current models. Automation at the treatment plant is adequate with opportunities for enhancements.

5.6.2 Regional WWTF

The Regional WWTF is a packaged plant with a single PLC located in a master control panel. PLC hardware is currently supported. Key data is transmitted to the Berthoud WRF for logging and remote viewing. Currently, there is no remote control.

5.6.3 Cybersecurity

The wastewater SCADA system will need cybersecurity improvements to meet EPA rules and industry best practices. In March of 2023, the EPA released a memorandum with and updated interpretation of the scope of sanitary surveys to include assessing wastewater system ICS's for cybersecurity.

5.6.4 Recommendations

Immediate improvements to cybersecurity need to be made to the wastewater SCADA system to reduce vulnerabilities and comply with regulations. Outdated ICS hardware needs to be replaced to support system reliability and security. Data from the Regional WWTF currently is transmitted cellularly without sufficient cybersecurity protections. Communication between the WWTF's should be enhanced to meet EPA regulations and industry best practices for site-to-site communication.

5.7 Proposed 20-Year Capital Improvement Plan

The proposed 20-year CIP for wastewater infrastructure was developed and prioritized with consideration of drivers as described in the previous sections. Below sections describe the proposed 20-year CIP and the main objectives and drivers for each project, as well as suggested timing and estimated cost.

5.7.1 Depreciation Account

The 20-Year CIP focuses on large capital projects with project drivers such as insufficient capacity with increasing development, and/or regulatory compliance. Accordingly, it is recommended the Town have a different tool, i.e., a depreciation fund, to finance routine asset renewal and operation and maintenance (O&M) improvements. It is good practice for Berthoud to establish and maintain a dedicated depreciation account, separate from the Capital Fund, to address the decreasing effectiveness and reliability of assets over time.

When the plant reaches a 'steady state' age with say an overall average useful life of the various assets of 40 years, the Town will need to reinvest 2.5% of the facility replacement cost each year just to maintain the 'fit and fitness' status quo. Frequently, deteriorating or obsolete assets are wrapped into whatever is the next capital construction project, but timing does not always work for this to occur. However, it may occur often enough to reduce the re-investment rate to 1-2% per year. Even this low re-investment rate is a sizeable annual sum and the tendency might be to reduce or defer making deposits into the account during economic downturns. Unfortunately, the assets keep aging in good times or bad. Projects identified by the Town or REC that were not captured in the Master Plan should be coordinated with the plan, depending upon the need (or not) for a general contractor and if an expansion or regulatory upgrade is pending.

5.7.2 Basis of Cost Estimating

This report developed Class V American Association of Cost Engineers (AACE) Opinion of Probable Construction Costs (OPCC) for each project identified in the proceeding sections. A Class V OPCC, as defined by AACE is developed when engineering is very conceptual and based on limited information. Examples of Class V estimating methods used include cost/capacity curves and factors, scale-up factors, and parametric and modeling techniques. The typical expected accuracy for a Class 5 OPCC ranges from -50 percent to + 100 percent.

The following major assumptions for the OPCC development presented include:

- This estimate does not include escalation beyond April 2023.
- Taxes were not included.

Direct cost multipliers were included for projects and adjusted according to the project scope (i.e., no demolition cost was included if the project is not retrofit or replacement of current infrastructure) and previous consultant experience. The direct cost multipliers included are as follows:

- Equipment Installation
- Electrical, Instrumentation and Controls
- Sitework
- Demolition
- Piping, Valves and Appurtenances

Indirect cost multipliers were included on the sum of the equipment and direct cost markup subtotal. The indirect cost multipliers were kept consistent across all projects, except for special circumstances (i.e., the cost used includes contractor markups). The direct cost multipliers include contractor markups, contingency and engineering services and are summarized below:

- 3% Contracts/Bonds/Insurance
- 2% Mobilization/Demobilization
- 8% Contractor Superintendence
- 18% Overhead and Profit
- 30% Contingency
- 20% Engineering Design & Services During Construction

See **Appendix C** for cost opinions for each project described below.

5.7.3 Prioritized Plan Development

The evaluation of Town assets, such as the Berthoud WRF, Regional WWTF, and collection system have resulted in multiple projects to be completed under a CIP. This plan was developed based on reviewing assets, condition assessments, capacity staging requirements, and regulatory review.

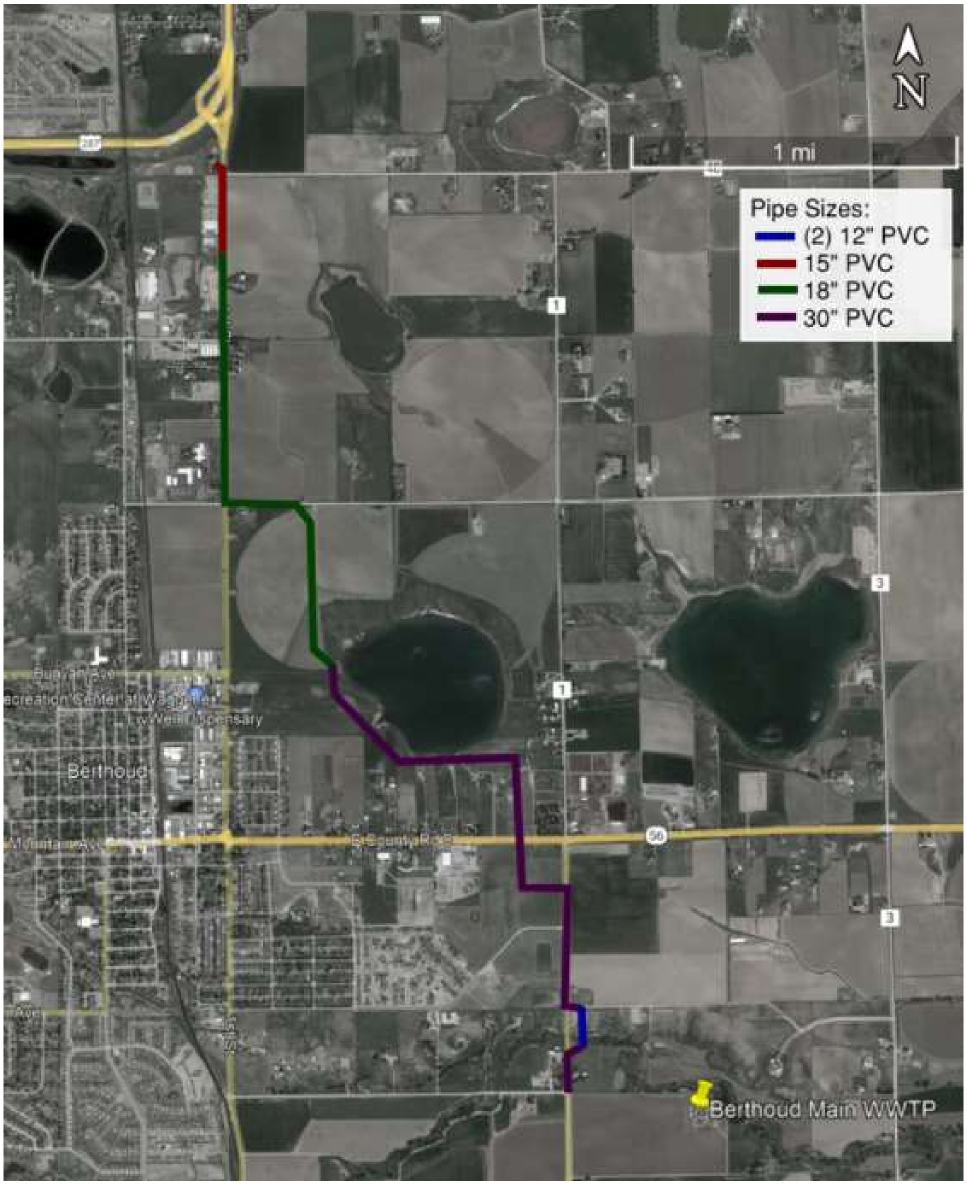
5.7.3.1 Collection Systems Projects

The collection system CIP projects were developed utilizing the Town design criteria to determine hydraulic deficiencies of existing infrastructure and to preliminarily size new infrastructure. It should be noted that not all violations of the criteria were selected for CIP improvement projects, which were selected on a strategic and case-by-case basis. The Town design standards indicate to utilize ASTM D3034, SDR 35 PVC for all sanitary sewers. The standards also indicate 48-inch diameter manholes shall be utilized for sewers under 30-inch diameter, and 60-inch diameter manholes shall be used for sewers 30-inch diameter and larger. For quantity and cost estimations, it was assumed that manhole maximum spacing is 400 linear feet for both 48-inch and 60-inch diameter manholes.

WWC-1: Bacon Lake Interceptor Improvements

This project consists of approximately 19,270 linear feet of sanitary sewer ranging in size from 15-inch to 30-inch diameter. There is one section of two parallel 12-inch sewers that needs to be a siphon under the Little Thompson River. This project is intended to redirect flow away from the existing First Street sewer, which has some hydraulic capacity issues. This project will allow future development within the first street sewer shed, including the large high density development along First Street from Mountain Ave to E County Road 12, an estimated size of

1,200 acres. This project follows the same general alignment of WD-1 (Bacon Lake Transmission Main) which is through undeveloped agricultural land, along Bacon Lake, and down N County Road 13 (County Line Road). It is recommended for easement acquisitions that occur to accommodate full installation of both the water transmission main and sanitary sewer, as well as any related appurtenances and required maintenance activities. All water infrastructure needs to maintain a minimum 10 ft horizontal separation from all sewer infrastructure. An estimated plan and profile of this alignment is provided in Figure 5-21. The project cost is estimated at $24.54 M.



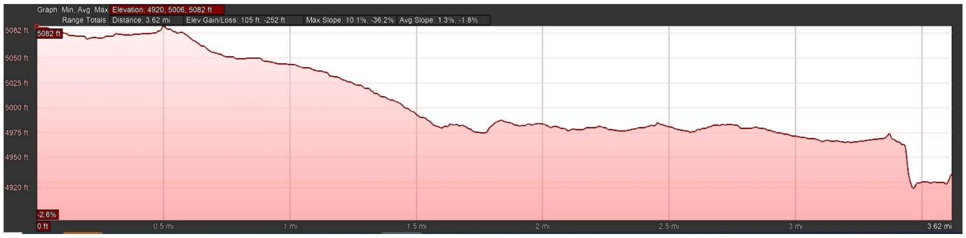


Figure 5-21: WWC-1 | Bacon Lake Interceptor Improvements

WWC-2: Little Thompson Trunk Sewer

This project consists of approximately 4,980 linear feet of sanitary sewer, ranging in size from 30-inch to 42-inch diameter, replacing the existing 24-inch and 30-inch diameter piping feeding the Berthoud WRF. This sewer is the trunk sewer for the entire main part of Town (excluding the I-25 area) and is the only feed into the WRF. Any new development in this area will be fed into this trunk sewer. WWC-1 helps alleviate flows in the existing 24-inch sewer, which will provide a few more years of service before an upgrade is required as the Town increases in population. It is estimated that the trunk sewer will need to be upsized prior to the 10-year horizon to accommodate the future developments currently planned. The alignment generally follows the Little Thompson River, and also involves a crossing at the upstream end of the upgrades. After following the Little Thompson, it follows Weld County Road 42 1/4 where it connects with the First Street Trunk Sewer (WWC-1).

An estimated plan and profile of this alignment is provided in **Figure 5-22**. The project cost is estimated at $8.67M.

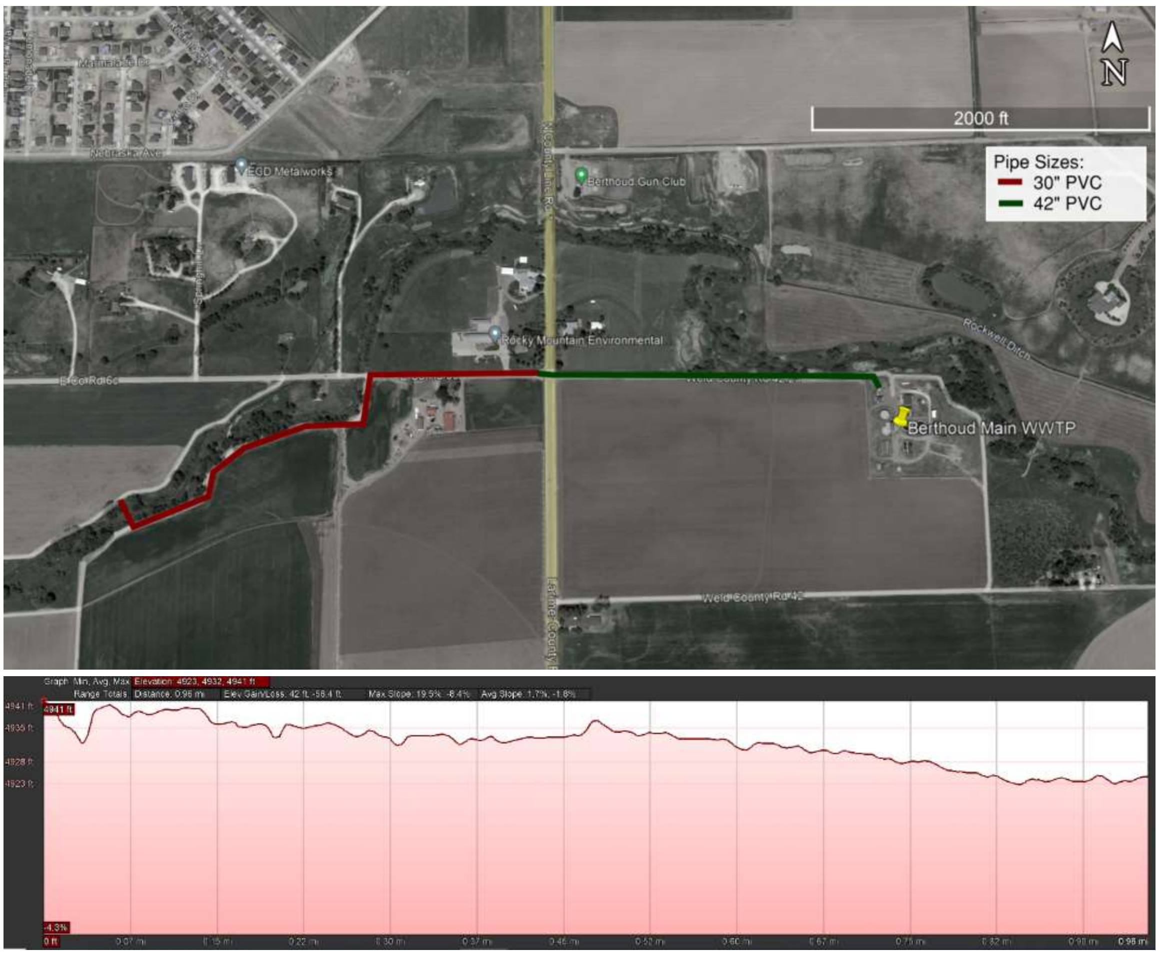


Figure 5-22: WWC-2 | Little Thompson Trunk Sewer

WWC-3: Bomar Lift Station Upgrades

This project consists of upgrading the aging Bomar Lift Station. The lift station has an estimated capacity of 85 gpm. While there are some new developments in the area, they are small enough to not justify increasing the pump rated capacity. Prior to the project initiation, it is recommended to perform a flow study to verify the required flow rate. This lift station has an aging and deteriorating wet well, access hatch, and electrical equipment. In addition, there is a propane generator on site which does not provide a cost-effective or practical solution for emergency power generation.

A new wet well with new pumps will be installed complete with guide rails, chains, and motor starters. It is recommended that the electrical panel and I&C control system is completely replaced due to their existing condition. A new diesel-fueled emergency generator system will be provided as well. After the new station is operational, the existing pumps will be pulled and salvaged (if possible) and the existing wet well partially demolished near grade and filled with sand/backfill. Each pump will be sized for the full rated capacity of the station, 85 gpm.

Existing conditions of the lift station are provided in Figure 5-23, and as-builts are provided in Figure 5-24. The project cost is estimated at $402,000.

Figure 5-23: WWC-3 | Bomar Lift Station Upgrades – Existing Conditions

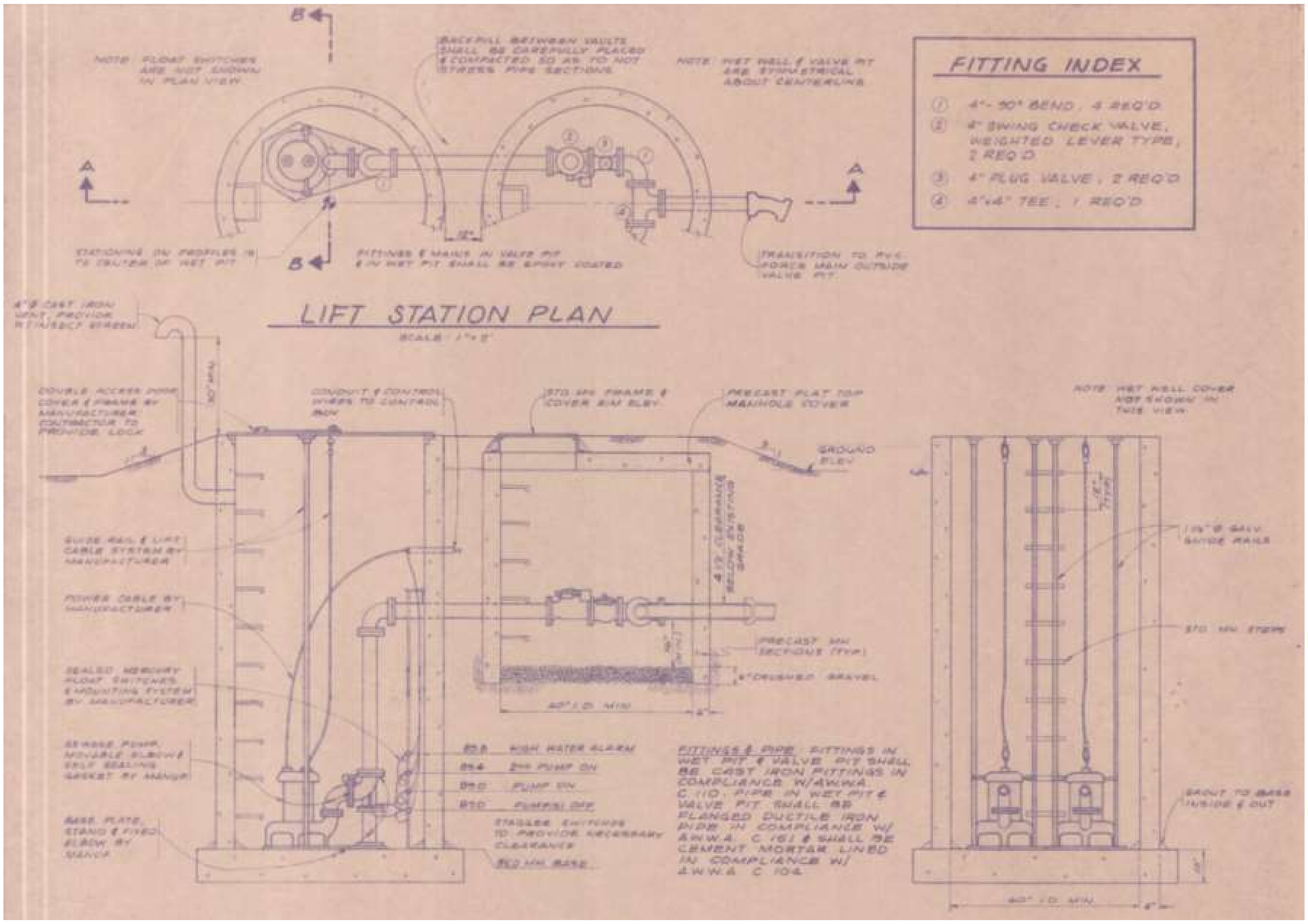


Figure 5-24: WWC-5 | Bomar Lift Station Upgrades – As-Builts

WWC-4: Berthoud Parkway Trunk Sewer

This project consists of approximately 1,840 linear feet of 18-inch sanitary sewer replacing the existing 12-inch sanitary sewer along Berthoud Parkway. The upstream segment of this 12-inch sewer was previously replaced and upsized to 18-inch diameter, creating a bottleneck. Due to the slope of the existing sewer, there are no existing hydraulic capacity issues; however, with new developments planned in the future, this sewer does have capacity restrictions and will need to be upsized. The full alignment is within the Berthoud Parkway roadway.

An estimated plan and profile of this alignment is provided in Figure 5-25. The project cost is estimated at $2.38M.

Figure 5-25: WWC-4 | Berthoud Parkway Trunk Sewer

WWC-5: Regional WWTF Influent Pump Station Upgrades, Phase 1

This project is an upgrade for the existing influent lift station at the Regional WWTF. The lift station has an estimated capacity of 0.4 MGD and needs to be upsized to 0.6 MGD to accommodate future estimated growth in the Turion development to the south. The existing pumps will be removed and salvaged and new pumps installed complete with guide rails, chains, new VFD starters, and associated electrical and I&C upgrades. The existing wet well can be utilized for the new pumps. There is a singular 48"x36" access hatch that is sufficiently sized for the new, larger pumps. Each pump will be sized for the full rated capacity of the station, 420 gpm (0.6 MGD). The project should be sequenced with the Regional WWTF Upgrade project (WWTF-1) so they are complete and operational around the same time. It's estimated that the design/construction of this project should happen in 2033.

A plan and section view of the existing lift station is provided in Figure 5-26. The project cost is estimated at $990K.

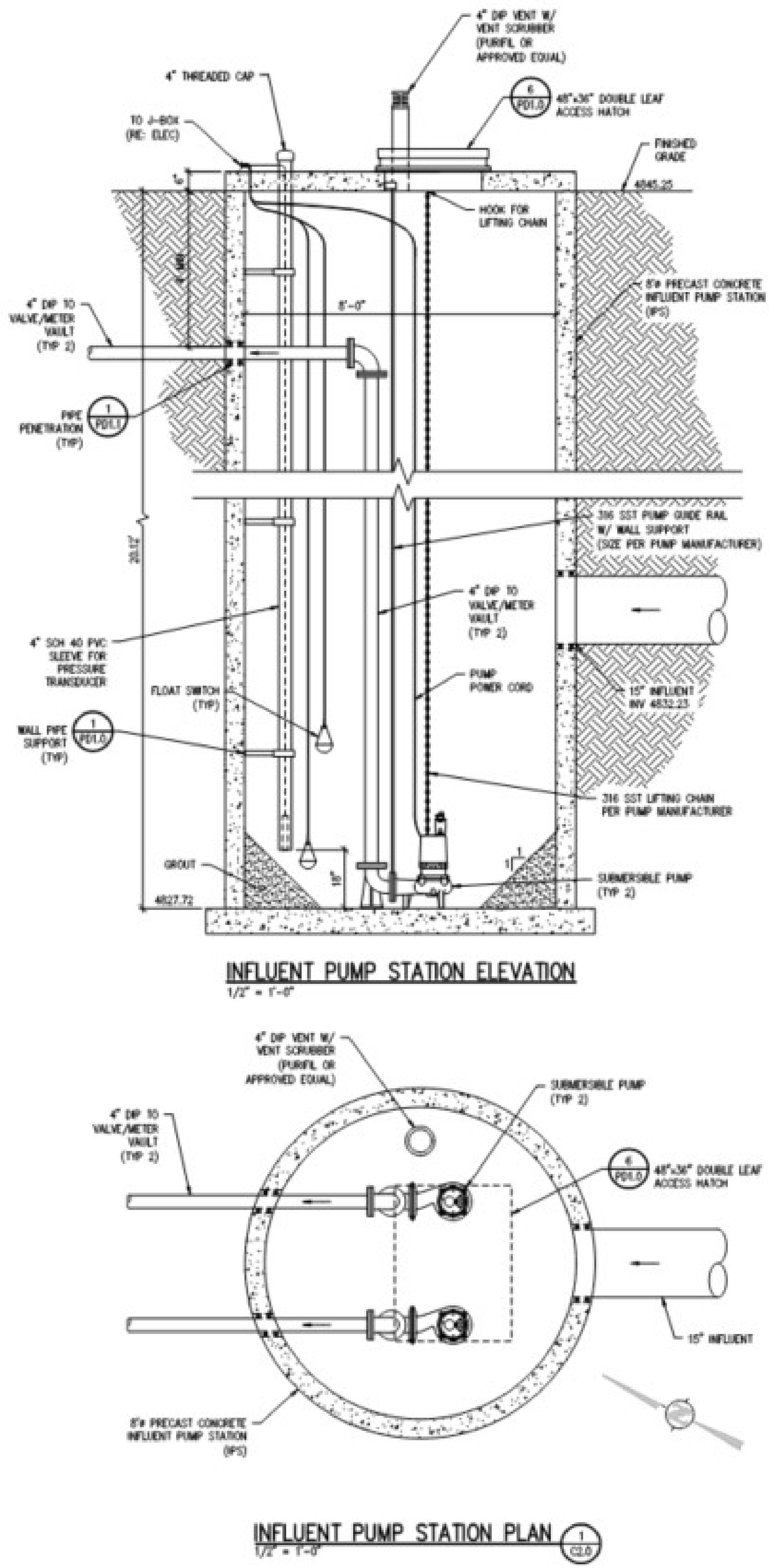


Figure 5-26: WWC-5 | Regional WWTF Influent Pump Station Upgrades, Phase 1

WWC-6: Turion Trunk Sewer, Phase 1

This project consists of approximately 2,930 linear feet of 18-inch sanitary sewer replacing the existing 15-inch sanitary sewer along the Little Thompson River. This trunk sewer upgrade provides additional capacity to accommodate the future development expected within the Turion subdivision. Upstream of this project is a double barrel 12" diameter siphon which has sufficient capacity to convey the full buildout flow of the Turion subdivision. Further upstream of the siphon is project WWC-9. This project's alignment follows the existing sewer's alignment down the Little Thompson River and crosses Weld County Road 44 to the Regional WWTF Influent Lift Station.

An estimated plan and profile of this alignment is provided in Figure 5-27. The project cost is estimated at $2.73M.

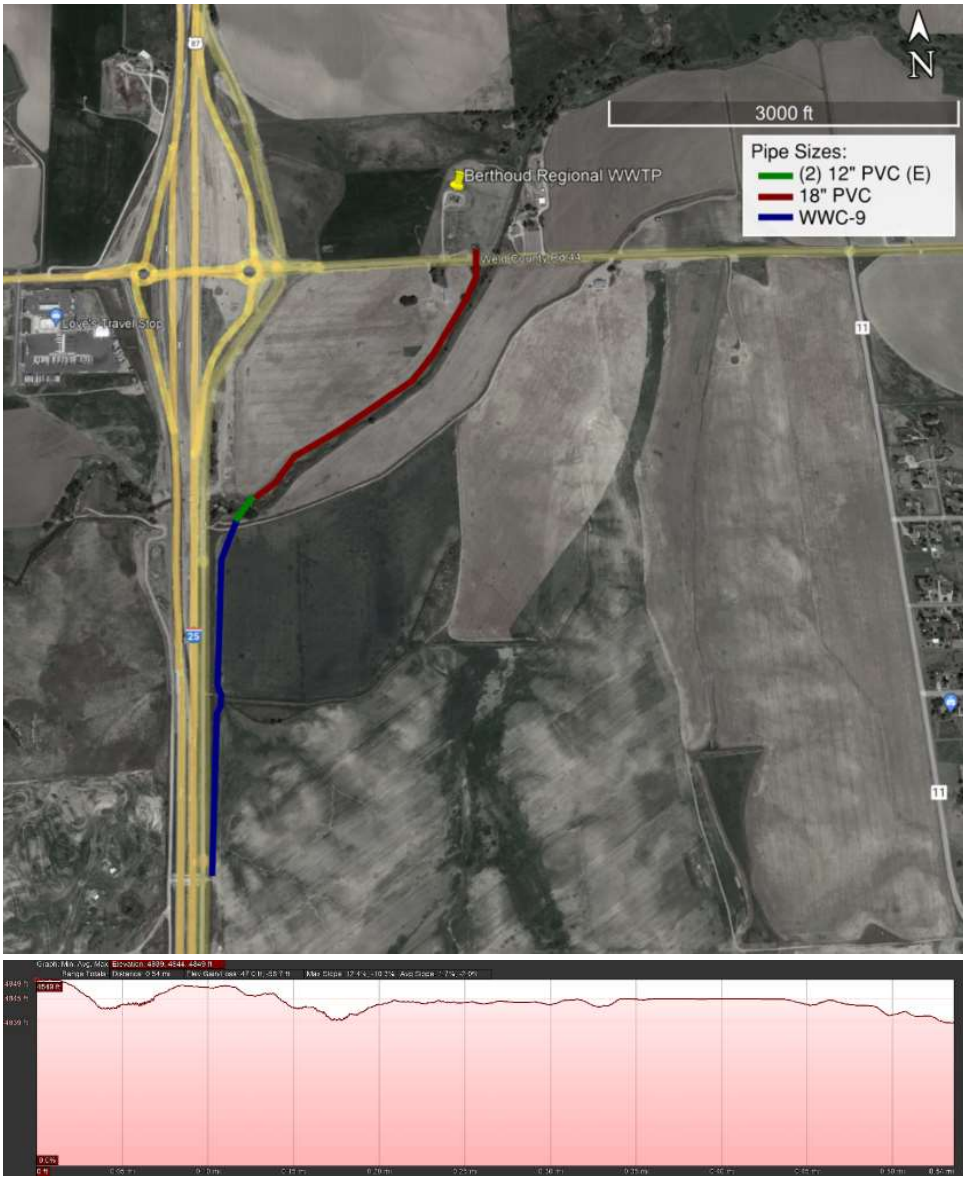


Figure 5-27: WWC-7 | Turion Trunk Sewer, Phase 1

WWC-7: Turion Trunk Sewer, Phase 2

This project consists of approximately 2,550 linear feet of 15-inch sanitary sewer replacing the existing 12-inch sanitary sewer on the east side of I-25. This trunk sewer upgrade provides additional capacity to accommodate the future development expected within the Turion subdivision. Downstream of this project is a double barrel 12" diameter siphon which has sufficient capacity to convey the full buildout flow of the Turion subdivision. Further downstream of the siphon is project WWC-8. This project's alignment follows the existing sewer's alignment along I-25 and connects to the existing siphon.

An estimated plan and profile of this alignment is provided in Figure 5-28. The project cost is estimated at $2.02M.

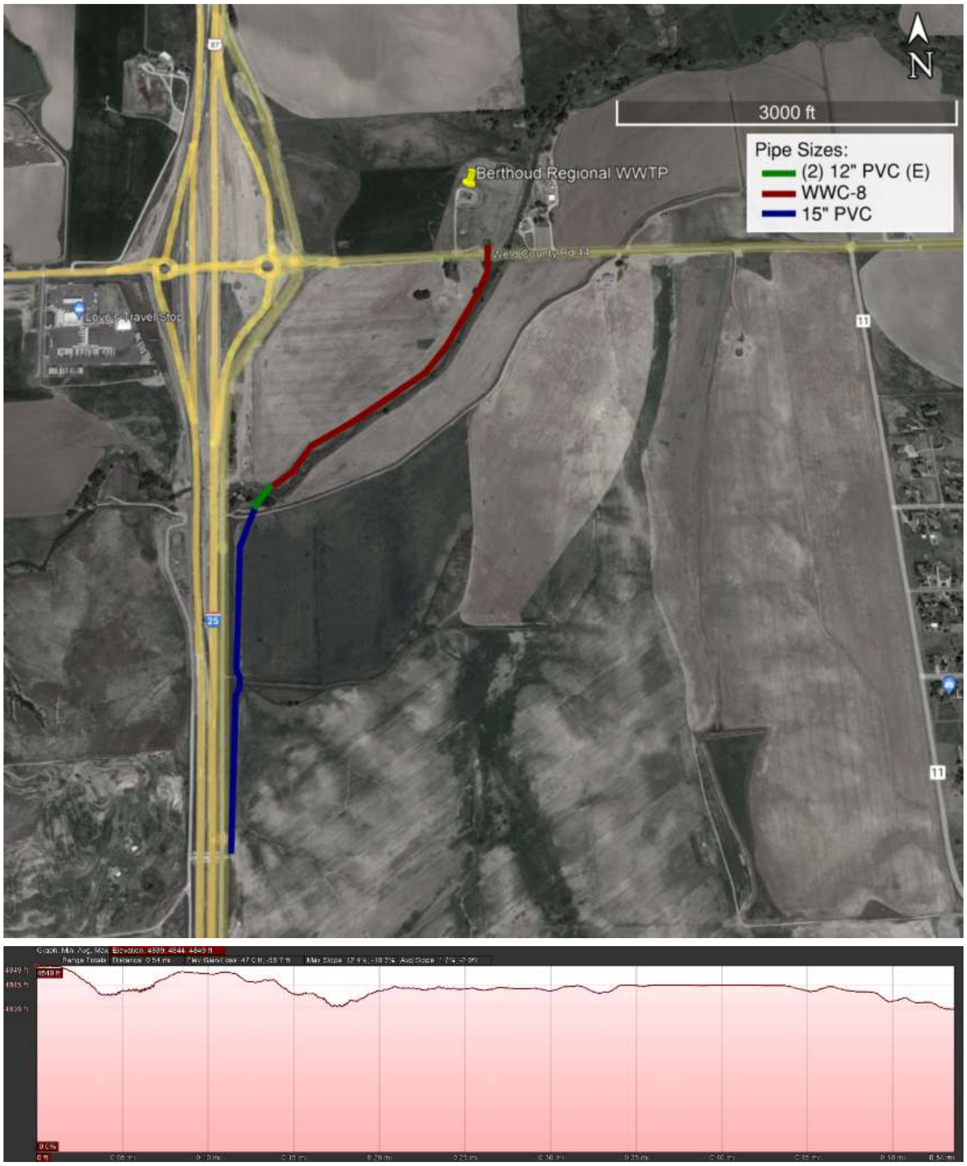


Figure 5-28: WWC-8 | Turion Trunk Sewer, Phase 2

5.7.3.2 Berthoud WRF Proposed Projects

The proposed Master Plan projects for the Berthoud WRF are broken down in a phased approach based on predicted regulatory timing, as described in Section 5.3.3, and capacity staging as depicted in Figure 5-2. The project objectives and main project drivers are described below. Note that capacity expansion projects for Berthoud WRF do not consider space constraints related to land rights and floodplains. The original design plan allotted space for expansion to 3.0 MGD (Phase 1) and for future advanced water treatment buildings. Conceptual design of the projects described below will be necessary to determine if any additional land, outside of the 100-year floodplain, must be acquired for expansion to 4.0 MGD (Phase 2).

WRF-1: Phase 1A – BNR Upgrades for VIP Credits and Selenium Reduction

- Alternative 1: Convert to A_2O by Retrofitting Pass 1 to Anaerobic and Anoxic (ANA) Capacity
- Alternative 2: Retrofit Pass 1 to provide ANA Zones and Convert Passes 2 and 3 to IFAS
- Alternative 3: Build Upstream ANA Capacity as per the 2002 WRF Site Plan Layout

The Phase 1 Improvements is broken down into two stages with two distinct drivers. The principal focus of Phase 1A is to make immediate BNR upgrades so that beginning in 2025, Berthoud WRF can attain VIP schedule delay credits towards compliance with TP and TN limits for Regulation 31. The collateral benefit of this project is expected to be enhanced selenium reduction within the BNR process so the Town can avoid future selenium exceedances. At present, Berthoud is conducting a study to determine which of the above three alternatives will provide the best selenium removal at the lowest cost. All three alternatives are capable of meeting the low end of the VIP target concentrations with optimal O&M. Because it is anticipated to have the highest capital cost, Alternative 3 was included in the 20-year prioritized plan budget. The total project cost with contingency is approximately $8.8 million.

WRF-2: Phase 1B – Capacity Expansion to 3.0 MGD

- Construct Third, 1.0-MGD MMF Train and Expand Overall Capacity to 3.0 MGD (including ANA Basins/Zones)
- Automation Upgrades
- Building drainage improvements
- Headworks, Biosolids, and Blower Upgrades Identified by the Town and REC

The principal focus of Phase 1B is to increase the Berthoud WRF capacity to 3.0 MGD. The original design plan allotted space to expand the Berthoud WRF to 3.0 MGD and assumed a PHF:MMF peaking factor of 3.0. Historical flow data shows that a PHF:MMF peaking factor of 2.0 is more accurate to what the plant currently sees. As such, much of the equipment is well sized to meet a MMF of 3.0 MGD and PHF of 6.0 MGD. This project includes the necessary equipment to expand to 3.0 MGD (e.g. adding and equipping a third clarifier and additional RAS pumps) as well as other identified projects by the Town and REC. Based on Capacity Staging Graphs as shown on Figure 5-2, this project will need to begin in 2025 for project completion in 2030, so the system can be operational when the MMF is projected to surpass 2.0 MGD in 2031. The estimated total project cost with contingency is approximately $24 million.

WRF-3: Phase 2 – Capacity Increase to 4.0 MGD and Regulation 31 Improvements

- 4-Stage BNR Capacity Expansion to 4.0 MGD
- Moving Bed Biofilm Reactor (MBBR) with Soluble Carbon Feed for Supplemental TN Removal for Regulation 31
- Tertiary Treatment for Supplemental Chemical-P Removal for Regulation 31

The objective of Phase 2 is to increase Berthoud WRF capacity to 4.0 MGD and to add necessary treatment improvements to meet Regulation 31 nutrient limits. Further studies will be needed prior to the project start date (2037) to determine if projected flows will surpass 4.0 MGD, or if a smaller capacity increase will be sufficient. This project assumes the addition of a fourth treatment train for 1.0 MGD of MMF. However, during conceptual design, Berthoud should consider other BNR upgrades that may allow the WRF to increase biological treatment capacity by intensifying current infrastructure, such as IFAS or sludge granulation via hydrocyclones.

To meet the stringent TP limits in Regulation 31, it is suggested that the WRF add tertiary treatment for supplemental Chemical-P removal at the plant. This includes full-scale coagulation, flocculation, sedimentation and dual media filtration. For the low TN limits in Regulation 31, it is suggested that Berthoud WRF install a post-anoxic MBBR system with soluble carbon feed for supplemental TN removal. Regulation 31 improvements and capacity upgrades to 4.0 MGD are aptly timed as MMFs are predicted to surpass 3.0 MGD between 2042 and 2043, and the WRF's forecasted timeline for Regulation 31 compliance begins in 2042. The Town should allot at least 5 years for planning, financing, design and construction, so the project should begin in 2037 with construction occurring by 2040 at the latest. Discussion on regulatory timing for Berthoud WRF can be found in Section 5.3.3.2. The estimated total project cost with contingency is approximately $48.8 million.

WRF-4: Network and Cybersecurity Upgrades

The Berthoud WRF's ICS network has connections to third parties such as integrators and the Internet as shown in Figure 5-29. This project will entail isolating the WRF's ICS from outside connections and implementing secure remote access for Operations and third party support.

Additionally, this project ensures compliance with the EPA rules. See the EPA Compliance Matrix in **Appendix F** for a complete list of rules and guidance.

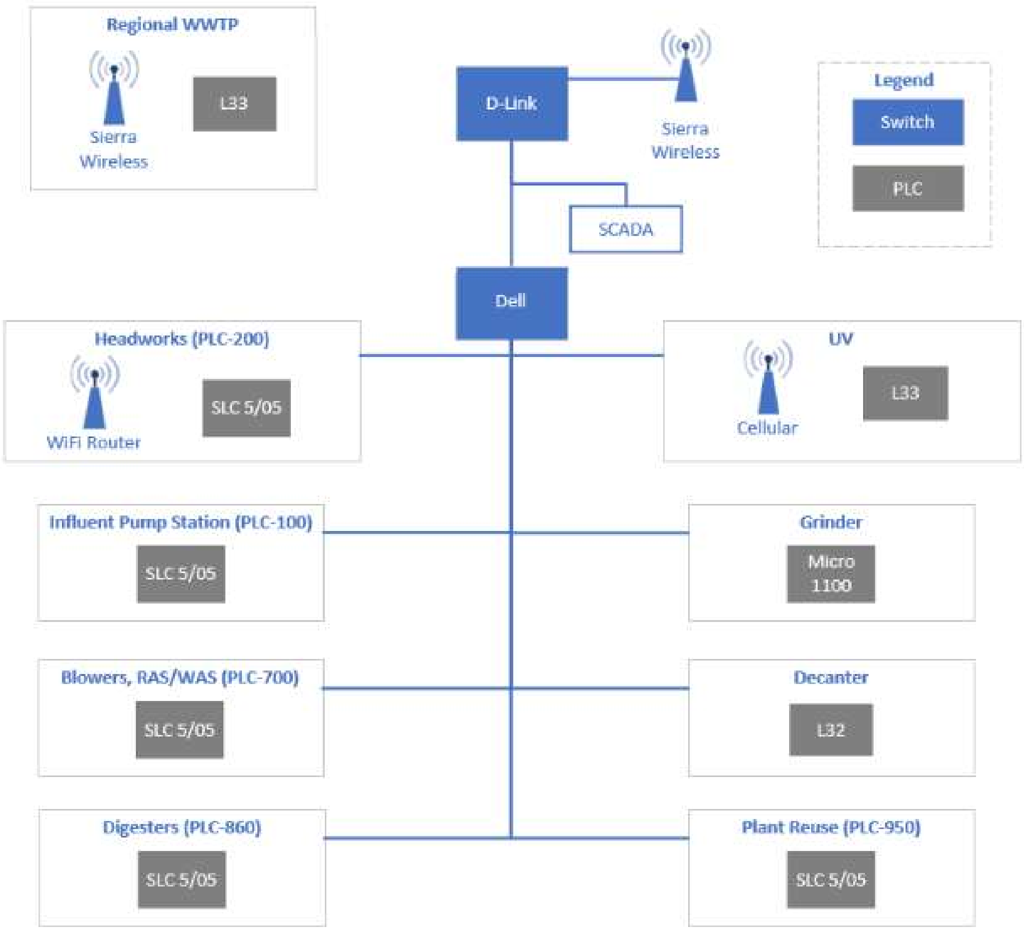


Figure 5-29: WRF-4 | Existing Network Architecture

Phase 1: ICS Policies and Procedures/Documentation

The Berthoud ICS OT Cybersecurity Program should have the following elements:

- OT Risk Management Plan
- OT Incident Response, Disaster Recovery, and Business Continuity Plans
- OT Cybersecurity Policies and Procedures
- OT Asset Management Program (asset inventory and tracking, critical component identification, asset lifecycle plan, software licensing tracking, firmware and software revision tracking
- Change Management Program (configuration, programs, component, architecture, and topology changes)
- Identity and Access Management
- OT Patch Management Program
- OT Cybersecurity Awareness Training
- SCADA Standardization Program

These policies, procedures, and documentation can be replicated from the WTP but must be specific to the WRF plant.

Phase 2: Secure Internet Connection and Remote Access

Install a firewall to segment Internet Service Provider and other external communications from SCADA. A jump box should also be installed to create segregated security zones to allow for secure remote access.

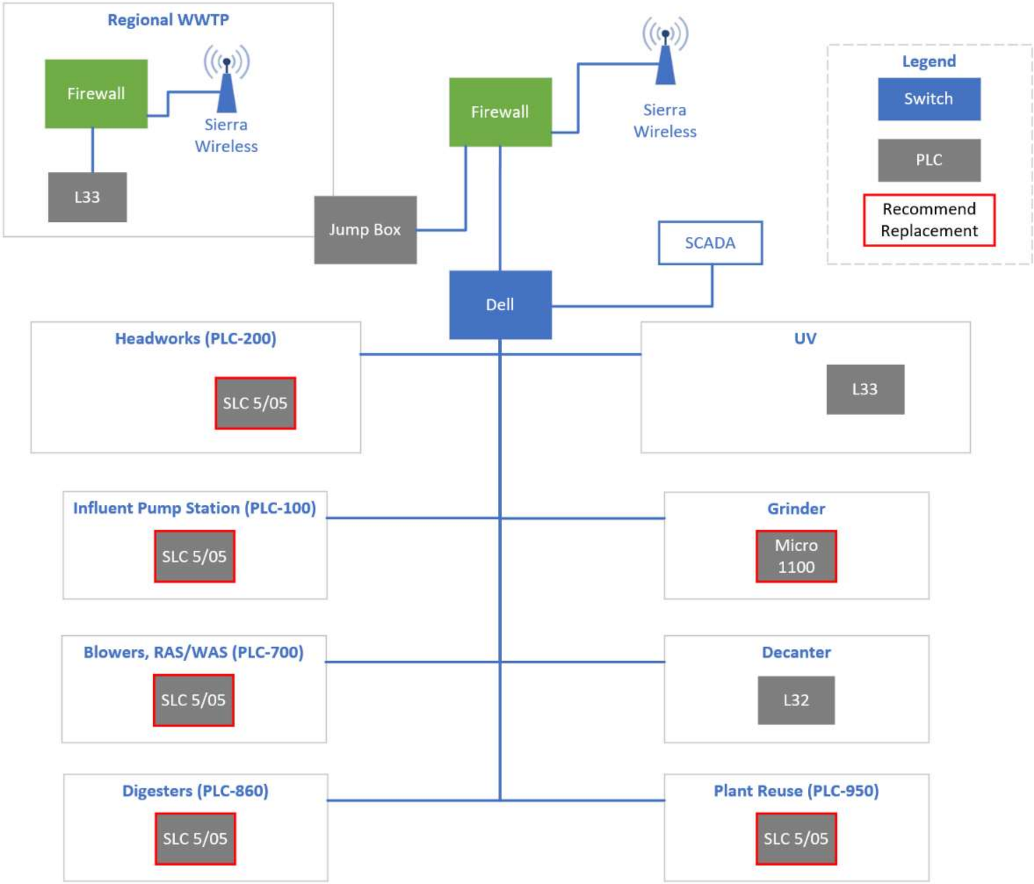


Figure 5-30: WTP-7 | Recommended Network Architecture

Phase 3: EPA ICS Security Compliance

After Phases 1 and 2 are complete, the remaining EPA rules can be complied with. The remaining rules include but are not limited to active directory policies for password control, complete asset inventory, event logging, and ICS-specific training.

WRF-5: PLC and Automation Upgrades

Various automation improvements were noted by operators at Berthoud WRF. It is recommended to pursue the following replacements and upgrades to WRF control systems. PLCs listed below are past the end of support by their manufacturer and replacement and repairs will become increasingly more expensive and harder to find. Equipment that is no longer maintained by the manufacturer also presents a security vulnerability.

Phase 1: PLC Upgrades

Replace the following PLCs that are beyond support:

- SLC 5/05 at Headworks
- SLC 5/05 at Influent Pump Station
- SLC 5/05 at Blowers, RAS/WAS
- SLC 5/05 at Digesters
- MicroLogix 1100 at Grinders
- SLC 5/05 at Plant Reuse

Phase 2: Automation Upgrades

Operations noted there is minimal control over Aeration Basin programming at the Blowers PLC; automation upgrades should provide operators with more control. The Influent Pump Station PLC is programmed based on the pump curves of the influent pumps which has proven to be unintuitive. Operations would prefer programming updates to simplify and improve control. The slide gates in the Headworks PLC are not currently automated; operations would prefer for the slide gates to automatically switch between channels when a screen goes down.

5.7.3.3 Regional WWTF Proposed Projects

The proposed Master Plan projects for the Regional WWTF are broken down in a phased approach based on predicted regulatory timing as described in Section 5.3.4.2 and capacity staging as depicted on Figure 5-3. The project objectives and main project drivers are described below. Note that capacity expansion projects for Regional WWTF do not consider space constraints related to land rights and floodplains; however, the original design plan shows ample additional area within the Regional WWTF property boundary. Conceptual design of the projects described below will be necessary to determine if any additional land, outside of the 100-year floodplain, must be acquired for capacity expansion.

WWTF-1: Phase 1 – Capacity Expansion to 0.6 MGD

- Overall SBR Capacity Expansion to 0.6 MGD
- Headworks, Blower, Controls and Security Upgrades Identified by the Town and REC

The principal focus of Phase 1 is to increase the Regional WWTF capacity to 0.6 MGD. This project includes the necessary equipment to expand to Regional WWTF to a 0.6 MGD SBR plant as well as other identified projects by the Town and REC. Based on Capacity Staging Graphs as shown on Figure 5-3, this project will need to begin in 2029 for project completion in 2034, so the system can be operational when predicted flows surpass the current MMF capacity of 0.099 MGD in 2035. Capacity expansion projects are highly dependent on when development causes an appreciable increase in flow and/or load, which is assumed to be 2034 based on the status of development. Project timeline should be reevaluated if development in the area is accelerated or delayed. The estimated total project cost with contingency is approximately $16.2 million.

WWTF-2: Phase 2 – Regulation 31 Improvements

- Anoxic MBBR with Soluble Carbon Feed for Supplemental TN Removal for Regulation 31
- Tertiary Treatment for Supplemental Chemical-P Removal for Regulation 31

The objective of Phase 2 is to add necessary treatment improvements to meet Regulation 31 nutrient limits. To meet the stringent TP limits in Regulation 31, it is suggested that the WWTF add tertiary treatment for supplemental Chemical-P removal at the plant. This includes full-scale coagulation, flocculation, sedimentation and dual media filtration. For the low TN limits in Regulation 31, it is suggested that Regional WWTF install a post-anoxic MBBR system with soluble carbon feed for supplemental TN removal. Regulation 31 improvements are timed to meet the WWTF's predicted regulatory timeline for required Regulation 31 compliance, which is set to begin in 2036. The Town should allot at least 5 years for planning, financing, design and construction, so the project should begin in 2030 with construction occurring by 2033 for project completion in 2035 at the latest. Discussion on regulatory timing for Regional WWTF can be found in Section 5.3.4.2. The estimated total project cost with contingency is approximately $40 million. This project was bundled separately from the capacity upgrades in WWTF-1 because capacity upgrades are likely to be 100% funded by developers, whereas regulatory improvements may be the Town's responsibility if improvements are needed ahead of capacity expansion.

WWTF-3: Security and Automation

It is recommended to install a dedicated firewall and VPN to secure the connection between the Regional WWTF and WRF. The current cellular modem firmware should also be updated for security patches. Currently, only certain data points are available for viewing remotely. To improve visibility and gain control of the remote plant, the local WWTF HMI should be recreated in the WRF SCADA system. It was also noted that Operations preferred to implement local control for the influent lift station pumps where there currently is none.

5.7.4 Proposed 20-Year Prioritized Plan

Aforementioned, the proposed 20-Year Prioritized Plan is driven primarily by capacity and regulatory drivers. The capacity drivers are heavily dependent on development in the Berthoud service area. If the rate of actual development does not align with that predicted in this Master Plan, Berthoud should reevaluate project sequencing to line up with these changes in flows and loads. Projects provide explanation of drivers so the Town can readjust timing based on these thresholds for flow and load.

Figure 5-31 shows the annual CIP expenditures for the wastewater system. Class V cost opinions for each project described above can be found in **Appendix C**.

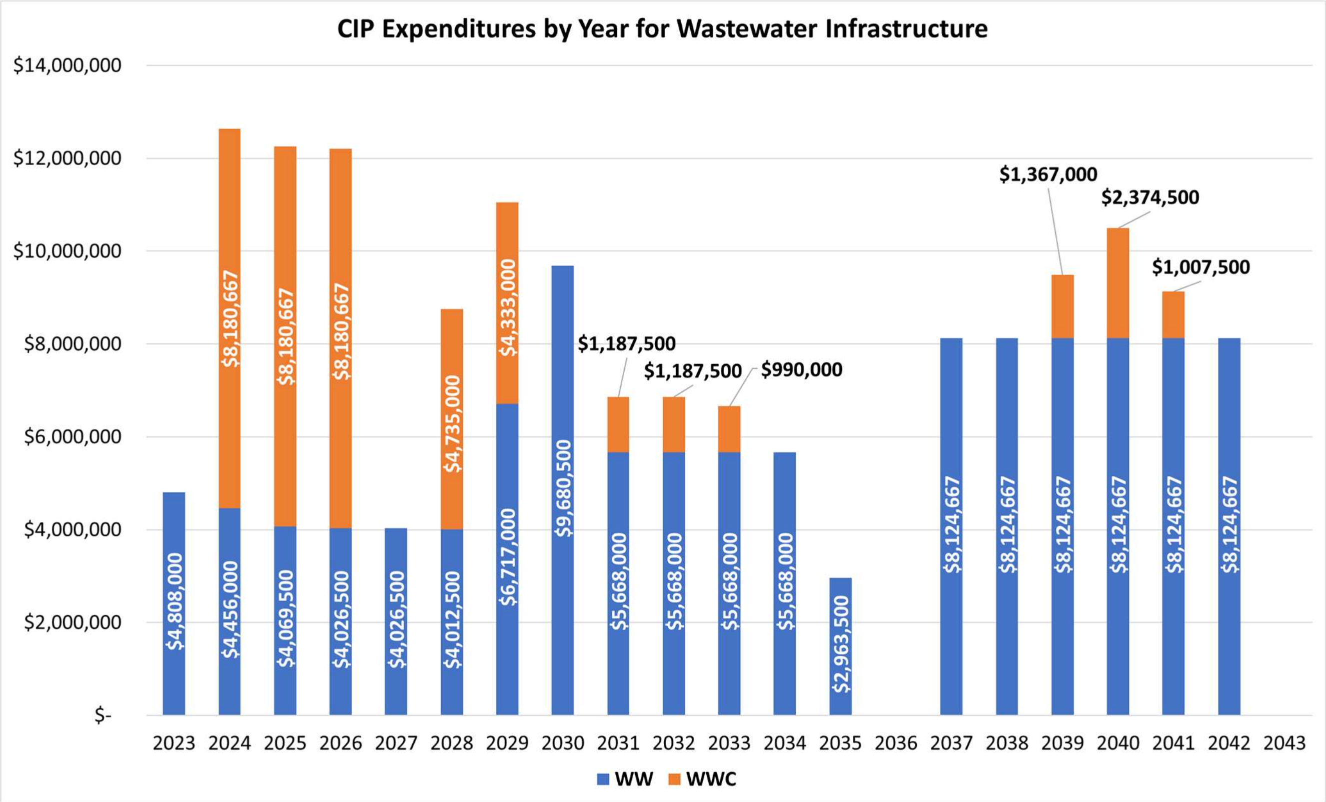


Figure 5-31: 20-Year Prioritized Plan Expenditures by Year for Wastewater Infrastructure

5.7.4.1 *Implementation Schedule Timeline*

Figure 5-32 briefly describes the sequenced implementation schedule timeline for all the wastewater infrastructure in the 20-year prioritized plan.

Proposed Capital Improvement Projects	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Wastewater Treatment Plants																					
WRF-1: Phase 1A – BNR Upgrades for VIP Credits and Selenium Reduction																					
Planning, Financing and Design	■																				
Construction, Startup and Optimization		■																			
WRF-2: Phase 1B – Capacity Expansion to 3.0 MGD																					
Planning, Financing and Design			■	■	■																
Construction, Startup and Optimization						■	■	■													
WRF-3: Phase 2 – Capacity Increase to 4.0 MGD and Regulation 31 Improvements																					
Planning, Financing and Design															■	■	■				
Construction, Startup and Optimization																		■	■	■	
WRF-4: Network and Cybersecurity Upgrades																					
Planning, Financing and Design		■																			
Construction, Startup and Optimization		■	■																		
WRF-5: PLC and Automation Upgrades																					
Planning, Financing and Design		■																			
Construction, Startup and Optimization		■																			
WWTF-1: Phase 1 – Capacity Expansion to 0.6 MGD																					
Planning, Financing and Design							■	■	■												
Construction, Startup and Optimization										■	■	■									
WWTF-2: Phase 2 – Regulation 31 Improvements																					
Planning, Financing and Design									■	■	■										
Construction, Startup and Optimization												■	■	■							
WWTF-3: Security and Automation																					
Planning, Financing and Design				■																	
Construction, Startup and Optimization				■	■																
Wastewater Collection Systems																					
WWC-1: Bacon Lake Interceptor Improvements																					
Planning, Financing and Design		■																			
Construction and Startup			■																		
WWC-2: Little Thompson Trunk Sewer																					
Planning, Financing and Design						■															
Construction and Startup							■														
WWC-3: Bomar Lift Station Upgrades																					
Planning, Financing and Design						■															
Construction and Startup						■															
WWC-4: Berthoud Parkway Trunk Sewer																					
Planning, Financing and Design									■												
Construction and Startup										■											
WWC-5: Regional WWTF Influent Pump Station Upgrades																					
Planning, Financing and Design											■										
Construction and Startup											■										
WWC-6: Turion Trunk Sewer, Phase 1																					
Planning, Financing and Design																	■				
Construction and Startup																		■			
WWC-7: Turion Trunk Sewer, Phase 2																					
Planning, Financing and Design																		■			
Construction and Startup																			■		

Figure 5-32: Wastewater 20-Year Prioritized Plan Implementation Schedule Timeline

5.7.5 Funding Opportunities

Potential funding opportunities for the proposed 20-year CIP projects are described in **Appendix E**.

APPENDIX A:
Likelihood of Failure/Consequence of Failure Scoring Matrix

BERTHOUD WTP

				Consequence Category										
Unit Process	Considerations	Safeguards	Notes	Capital Cost	O&M Cost	Technical Integrity	Staff H&S	Public H&S	Environmental	Regulatory	Public Perception	Total Consequence Score	Likelihood of Failure	Risk Score
Carter Lake Water Supply	**Severe drought leading to water supply shortage, dependence on LTWD** Break in conveyance line leading to water supply shortage	Alternate water supplies (LTWD also pulls from Carter Lake, so would be limited)	Assumes both reservoirs depleted (i.e. no switchover to Berthoud Reservoir), but LTWD still has water and can supply Severe water restrictions, indoor use only	Moderate	Minor	Moderate	Insignificant	Insignificant	Insignificant	Insignificant	Moderate	15	Unlikely	30
Other Raw Water Supply	Severe drought leading to water supply shortage, dependence on LTWD **Accident resulting in major chemical spill on HWY 257 leading to contamination of Berthoud Reservoir**	Alternate water supplies (Carter Lake)	Assumes both reservoirs depleted (i.e. no switchover to Carter Lake), but LTWD still has water and can supply Need to consider no LTWD scenario??	Major	Major	Major	Insignificant	Moderate	Moderate	Moderate	Major	26	Unlikely	52
Blending Facility/Corrosion Control	**Loss of blending capabilities leading to dependence on single water source at a time**	Acceptable to use single water source	Valve malfunction, REC has to repair (assumed < 1 week)	Minor	Minor	Moderate	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	12	Possible	36
Rapid Mixing	**Motor failure leading to loss of rapid mixing (only one motor, one chamber)**	Shift to solely Carter Lake raw water supply Acquire rental drop-in mixer Dose chemicals into flocculation basins	Repaired within 1 week maximum Reduced removal efficiency of solids, T&O compounds	Minor	Minor	Minor	Insignificant	Insignificant	Insignificant	Minor	Minor	13	Possible	39
Flocculation	**Motor/gear/VFD failure on single paddle mixer leading to reduced mixing energy** Break in paddle	Two stages almost as effective as three stages	Reduced removal efficiency of solids, T&O compounds	Minor	Minor	Moderate	Insignificant	Moderate	Insignificant	Moderate	Moderate	18	Possible	54
Sedimentation	**Vac-track sludge collector breakage leading to sludge buildup at bottom of basin**	Run plant in direct filtration mode (not viable in peak demand season) Can run one basin in 25% overload	Single train has to come offline and be drained to repair One train cannot handle the full flow Ineffective solids removal will impact the filters	Moderate	Moderate	Major	Insignificant	Insignificant	Insignificant	Moderate	Major	20	Possible	60
Filtration	Media washout leading to limited filtration, replacement of media **Underdrain failure leading to media washout and inadequate backwash, channeling of flow through cracks and crevices in media** Ineffective backwash/rapid fouling leading to shortened filter run times Valve failure (influent or effluent) Surface wash spray issue leading to ineffective backwash PLC failure	None - two trains needed to meet summer flow demand	Filter isolated and repaired, WTP depends on remaining three filters, impacting capacity and requiring LTWD supply Assumed to occur during summer when all filters are needed Potential for a boil order Required supplementation with LTWD supply	Moderate	Moderate	Major	Insignificant	Insignificant	Insignificant	Moderate	Major	20	Possible	60
Disinfection	**Overfeed of disinfectant leading to excessive chlorine residual** Underfeed of disinfectant leading to insufficient disinfection/residual	SOPs Online monitoring of finished water chlorine residual Storage tank as a buffer	Setpoint not noticed for 4 hours (potential delay due to feedback loop)	Minor	Minor	Major	Insignificant	Moderate	Insignificant	Moderate	Major	20	Possible	60
High-service Pumps	**Motor failure on single pump leading to inability to distribute water during peak demand season** Loss of VFD control leading to limited flexibility in treated water distribution	Duplex pump arrangement (only effective during non-peak demand); third pump being installed in 2023	Result is paying for LTWD water supply and replacement of pump motor	Moderate	Moderate	Severe	Insignificant	Insignificant	Insignificant	Moderate	Major	21	Possible	63
Caustic Soda Storage/Feed Systems	Loss of pumping capabilities leading to lessened or no caustic soda feed Breach in tanks leading to chemical spill Manual setpoint error by Operations leading to underfeed or overfeed of chemical **Delivery failure leading to no chemical feed**	Duplex pump arrangement Periodic inspection SOPs Proactive deliveries	No significant corrosion induced in the distribution system during outage	Minor	Minor	Minor	Insignificant	Insignificant	Insignificant	Minor	Minor	13	Possible	39
PAC Storage/Feed Systems	Loss of pumping or makedown capabilities leading to lessened or no PAC feed Manual setpoint error by Operations leading to underfeed or overfeed of chemical **Delivery failure leading to no chemical feed**	Duplex pump arrangement Periodic inspection SOPs Proactive deliveries	Assumed Berthoud Reservoir water Leads to T&O issues in treated water Chemical delivery secured within one week	Minor	Minor	Minor	Insignificant	Insignificant	Insignificant	Insignificant	Moderate	13	Possible	39
Polymer Storage/Feed Systems	Loss of pumping capabilities leading to lessened or no polymer feed Breach in tanks leading to chemical spill Manual setpoint error by Operations leading to underfeed or overfeed of chemical **Delivery failure leading to no chemical feed**	Duplex pump arrangement Periodic inspection SOPs Proactive deliveries	Ineffective coag/floc/sed Chemical delivery secured within one week	Minor	Minor	Moderate	Insignificant	Insignificant	Insignificant	Major	Major	18	Possible	54
Sodium Hypo Storage/Feed Systems	Loss of pumping capabilities leading to lessened or no sodium hypo feed Breach in tanks leading to chemical spill **Delivery failure leading to no chemical feed**	Duplex pump arrangement Proactive deliveries Storage tank as a buffer	Chemical delivery secured within one week	Minor	Minor	Major	Insignificant	Insignificant	Insignificant	Major	Major	19	Possible	57
SCADA Systems	**PLC and/or SCADA computer failure leading to manual operation**	Manual operation	-	Moderate	Moderate	Moderate	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	14	Possible	42
Cybersecurity	**Systems hacked leading to overfeed of chemicals or short-circuited treatment** Loss of remote control leading to manual control	None	Temporary shut down of plant, multi-week process to identify source and update systems prior to bringing WTP back online. Malicious actions could put operators and public at risk	Minor	Moderate	Severe	Severe	Severe	Insignificant	Moderate	Severe	29	Possible	87
Elevated Storage Tank	**Breach in tank leading to loss in storage capacity, temporary flooding of surrounding area**	Periodic structural inspections, maintenance as needed Can backwash with high service pumps	Multi-week repair, tank has to be drained Refurbished in 2022, estimated 40 years old Backwash can be performed using water in the distribution system, requiring additional operator oversight to maintain supply to end users	Moderate	Moderate	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	12	Unlikely	24
3.0 MG Storage Tank	**Breach in tank leading to loss in storage capacity, temporary flooding of surrounding area**	Periodic inspections, maintenance as needed	Multi-week repair, tank has to be drained No issues identified during inspections conducted over the past four years Bypass around the tank available; would require supplying Booster Station and adjacent zone directly from HSPs	Major	Major	Major	Insignificant	Moderate	Moderate	Moderate	Major	26	Unlikely	52
Booster Pump Station	**Failure of all pumps leading to inability to distribute water to highest pressure zone** Loss of VFD control leading to limited flexibility in treated water distribution	Full system redundancy (four pumps, generator)	Insufficient storage volume available to serve the highest pressure zone Result is paying for LTWD water supply to meet pressure requirements Low likelihood of losing all pumps and/or power	Moderate	Moderate	Major	Insignificant	Insignificant	Insignificant	Minor	Major	19	Unlikely	38

BERTHOUD WRF

				Consequence Category										
Unit Process	**Considerations**	**Safeguards**	**Notes**	**Capital Cost**	**O&M Cost**	**Technical Integrity**	**Staff H&S**	**Public H&S**	**Environmental**	**Regulatory**	**Public Perception**	**Total Consequence Score**	**Likelihood of Failure**	**Risk Score**
Headworks	**Screen plugged leading to use of bypass channel with wide screen, backup in septage pit** Grit chamber mixer breakage leading to bypass of grit removal Clogging of grit pump leading to accumulation of grit in vortex chamber	None	Some larger items get through, either clogging the influent pumps or entering BNR and being caught on diffuser heads Operators have to observe and manually rake Backup in septage pit reportable to CDPHE	Major	Moderate	Moderate	Insignificant	Insignificant	Insignificant	Minor	Insignificant	16	Possible	48
Influent Pump Station	Individual pump goes down leading to switchover to backup pump (old pumps) **Burst suction or discharge line leading to flooding of dry well**	Periodic inspections/maintenance	Dry well cannot drain quickly enough Pumps continue operation (submersible, electrical equipment 10+ ft off floor) Significant clean up required in dry well	Moderate	Moderate	Moderate	Insignificant	Insignificant	Minor	Minor	Minor	17	Possible	51
Aeration (Blowers, Diffusers)	**Individual blower goes down leading to switchover to swing blower, limited capacity** Burst aeration lateral leading to uneven air distribution, fountaining in basin	None	Blowers are around 20 years old, could realistically fail No aeration for one day. Microbial community survives	Major	Major	Major	Insignificant	Insignificant	Minor	Moderate	Insignificant	20	Possible	60
Activated Sludge (Basins, MLR Pumps)	MLR pump goes down leading to loss of recycle capability **Slug into plant leading to killoff of microbial population**	None	Both basins in use, entire biological population lost, re-seeding required, one month to get back to equilibrium	Moderate	Moderate	Moderate	Moderate	Insignificant	Minor	Minor	Minor	19	Unlikely	38
Clarifiers	**Rake mechanism failure leading to sludge buildup on clarifier bottom**	Periodic maintenance	Clarifier drawn down and repaired. No impact to WWTP capacity. Long repair time if damage to rake mechanism	Minor	Moderate	Moderate	Insignificant	Insignificant	Minor	Minor	Insignificant	15	Possible	45
RAS/WAS Pumping	**Pump failure leading to insufficient activated sludge transfer**	Standby pumps	Six pumps total; two of these are around 7 years old, remainder are new	Moderate	Minor	Moderate	Insignificant	Insignificant	Insignificant	Minor	Insignificant	14	Possible	42
Disinfection	**Loss of UV banks leading to no disinfection**	None	-	Moderate	Moderate	Moderate	Insignificant	Insignificant	Minor	Minor	Insignificant	16	Possible	48
Digestion	Loss of power to blowers **Break in air line leading to lack of oxygen/mixing in digesters**	Periodic inspections	Air line repair within 2 days Digesters and associated equipment are not connected to backup generators	Moderate	Moderate	Moderate	Insignificant	Insignificant	Minor	Insignificant	Insignificant	15	Possible	45
Dewatering	**Loss of centrifuge functionality leading to equipment replacement, no dewatering capabilities**	Periodic inspections/maintenance	Multi-month repair at off-site location Either use of a portable dewatering unit, purchase of a new dewatering unit, or hauling of non-dewatered sludge	Major	Moderate	Moderate	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	15	Possible	45
Polymer Storage/Feed Systems	**Loss of pumping capabilities leading to lessened or no polymer feed** Breach in tote leading to chemical spill Overfeed/underfeed due to control based on dilution water flow	Duplex pump arrangement	Both pumps fail, repaired within 2 days Limited dewatering efficiency, lower cake percent solids, higher hauling costs, need to landfill	Minor	Minor	Moderate	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	12	Likely	48
Non-Potable Water System	**Pump failure leading to limited or no non-potable water availability**	Periodic inspections/maintenance	Repair within 1 week No makedown water for washdown, polymer makedown	Minor	Minor	Minor	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	11	Likely	44
SCADA Systems	**PLC and/or SCADA computer failure leading to manual operation**	Manual operation	PLCs are universally aging and increasingly obsolete Full manual operation is difficult	Moderate	Moderate	Moderate	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	14	Possible	42
Cybersecurity	**Systems hacked leading to short-circuited treatment, release of raw WW to environment** Loss of remote control leading to manual control	Most systems report feedback that would indicate an unintended change has occurred	Temporary shut down of plant, multi-week process to identify source and update systems prior to bringing WWTP back online. Malicious actions could put operators and environment at risk	Minor	Moderate	Severe	Severe	Insignificant	Major	Moderate	Severe	28	Possible	84

REGIONAL WWTF

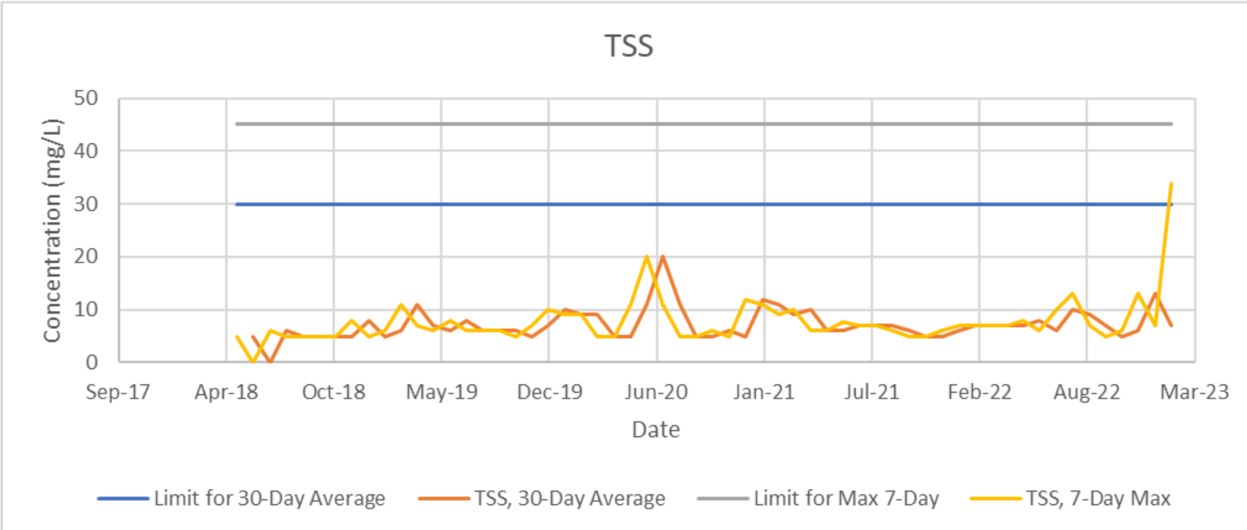
				Consequence Category										
Unit Process	**Considerations**	**Safeguards**	**Notes**	**Capital Cost**	**O&M Cost**	**Technical Integrity**	**Staff H&S**	**Public H&S**	**Environmental**	**Regulatory**	**Public Perception**	**Total Consequence Score**	**Likelihood of Failure**	**Risk Score**
Influent Pump Station	Pump clogging/blockage leading to switchover to standby pump Level instrumentation fault leading to undesired pump on/off run schedule **Total failure of lift station infrastructure leading to overflow and equipment replacement**	Duplex pump arrangement Alarm at Berthoud WWTP	-	Minor	Minor	Moderate	Insignificant	Insignificant	Minor	Insignificant	Insignificant	13	Possible	39
Headworks	**Clogging of manual bar screens leading to blockage and backing up of sewage**	Periodic visual inspection Periodic unclogging of screen using rake, grabber, cut-resistant gloves (biweekly) Screen angle diverts overflow directly into the basin	Operators have to notice blackage and manually unclog Pumps can handle debris that enters the basins during overflow events No overflow to the environment	Minor	Minor	Insignificant	Insignificant	Insignificant	Minor	Minor	Insignificant	12	Likely	48
Aeration/Blowers	**Individual blower goes down leading to switchover (manual) to swing blower - cannot aerate SBR and solids holding tank concurrently, leading to less effective treatment** Burst aeration lateral leading to uneven air distribution, fountaining in basin Air piping freezes leading to potentially catastrophic pressure buildup in blower	Spare basin used to store wastewater until repaired	For true backup need actuated valves and PLC programming	Moderate	Moderate	Major	Insignificant	Insignificant	Moderate	Minor	Insignificant	18	Possible	54
Activated Sludge Basin	**Crack in basin leading to WW leak to environment**	Preventative inspections and maintenance	-	Moderate	Moderate	Major	Moderate	Insignificant	Minor	Minor	Insignificant	19	Unlikely	38
Disinfection	Failure in one UV bank leading to switchover to standby bank **Issue with control center leading to failure of both UV banks**	Standby bank Spare basin used to store wastewater until repaired	Scenario considered is power outage plus no emergency generator availability	Minor	Minor	Major	Insignificant	Insignificant	Insignificant	Minor	Insignificant	14	Unlikely	28
Chemical Storage/Feed Systems	Loss of pumping capabilities leading to lessened or no chemical feed (alum, micro C) Breach in tanks leading to chemical spill **Chemicals unavailable for purchase leading to less effective treatment**	Duplex pumping arrangements Shelf-spare pumps Manual chemical addition Extra basin used to store WW until repaired Reserve supply of chemicals	Ineffective treatment (phosphorus) Micro-C pumps: run 24/7 Alum pumps: run once per hour Pumps are off-the-shelf (readily available) Alum has double containment storage, but Micro-C is kept in 50-gal drums on containment pallet	Insignificant	Minor	Moderate	Insignificant	Insignificant	Moderate	Minor	Insignificant	14	Possible	42
Emergency Generator	**Generator failure leading to repair/replacement**	None	-	Minor	Moderate	Moderate	Insignificant	Insignificant	Insignificant	Minor	Insignificant	14	Unlikely	28
SCADA Systems	**Outdated systems, limited control from Berthoud WWTP leading to plant malfunction with delayed response time**	None	Regional is tied into main plant SCADA (visible but no remote control of facility) SCADA system needs upgrades and additional work to the PLC	Moderate	Moderate	Moderate	Insignificant	Insignificant	Insignificant	Minor	Insignificant	15	Possible	45
Cybersecurity	**Systems hacked leading to shortcircuited treatment, release of raw WW to environment** Loss of remote control leading to manual control Rodents	None	Temporary shut down of plant, multi-week process to identify source and update systems prior to bringing WWTP back online. Malicious actions could put operators and environment at risk	Minor	Moderate	Severe	Severe	Insignificant	Major	Moderate	Severe	28	Possible	84

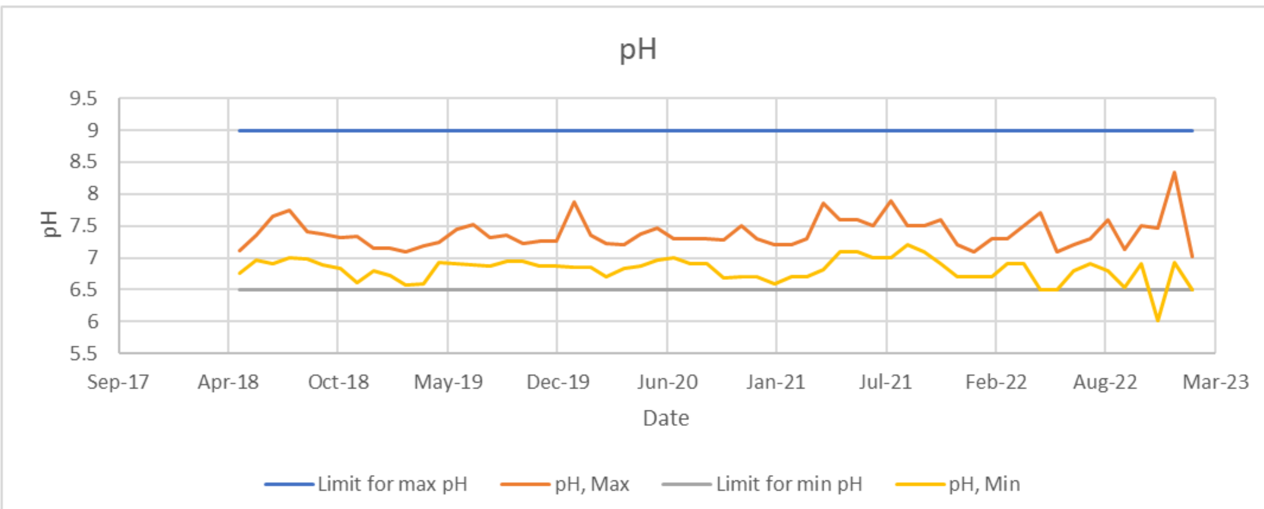
COLLECTION SYSTEM

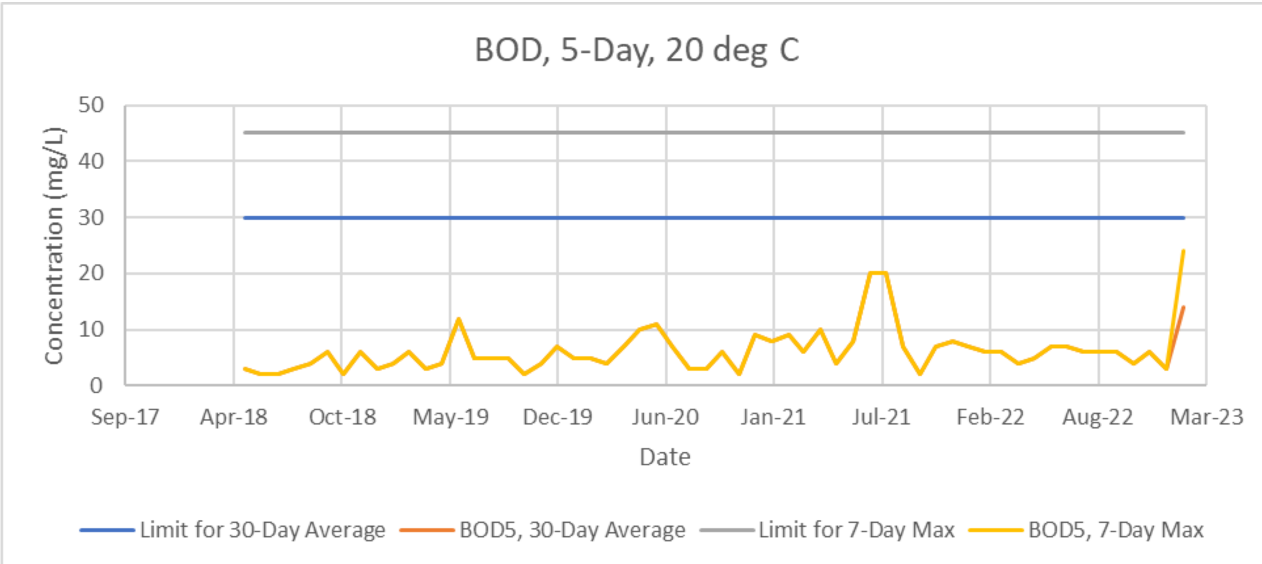
Unit Process	Considerations	Safeguards	Notes	Consequence Category: Capital Cost	O&M Cost	Technical Integrity	Staff H&S	Public H&S	Environmental	Regulatory	Public Perception	Total Consequence Score	Likelihood of Failure	Risk Score
Campion Lift Station	Pump clogging/blockage leading to switchover to standby pump Level instrumentation fault leading to undesired pump on/off run schedule **Total failure of lift station infrastructure leading to overflow and equipment replacement**	Duplex pump arrangement None	Equipment is aging, outdated Lift station in vicinity of spread-out homes Bomar LS pumps to Campion LS, so loss of Campion LS will impact both service areas	Moderate	Minor	Major	Insignificant	Insignificant	Moderate	Minor	Moderate	19	Likely	76
Bomar Lift Station	Pump clogging/blockage leading to switchover to standby pump Level instrumentation fault leading to undesired pump on/off run schedule **Total failure of lift station infrastructure leading to overflow and equipment replacement**	Duplex pump arrangement None	Equipment is aging, outdated Lift station in vicinity of spread-out homes A pump truck can sustain this lift station	Minor	Minor	Major	Insignificant	Insignificant	Moderate	Minor	Moderate	18	Likely	72
River Glen Lift Station	Pump clogging/blockage leading to switchover to standby pump Level instrumentation fault leading to undesired pump on/off run schedule **Total failure of lift station infrastructure leading to overflow and equipment replacement**	Duplex pump arrangement None	Lift station in vicinity of spread-out homes Containment pond fills	Minor	Minor	Major	Insignificant	Insignificant	Moderate	Minor	Moderate	18	Possible	54
Heron Lakes Lift Station	Pump clogging/blockage leading to switchover to standby pump Level instrumentation fault leading to undesired pump on/off run schedule **Total failure of lift station infrastructure leading to overflow and equipment replacement**	Duplex pump arrangement None	Lift station in close proximity to new, tightly-spaced homes	Moderate	Minor	Major	Insignificant	Insignificant	Moderate	Minor	Moderate	19	Possible	57

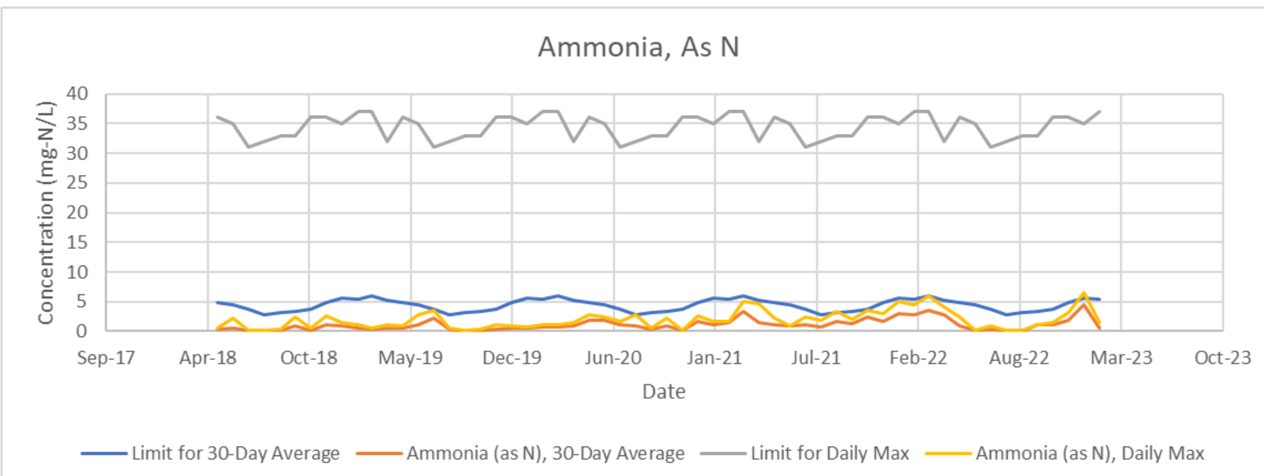
APPENDIX B:
Regulatory Compliance Charts

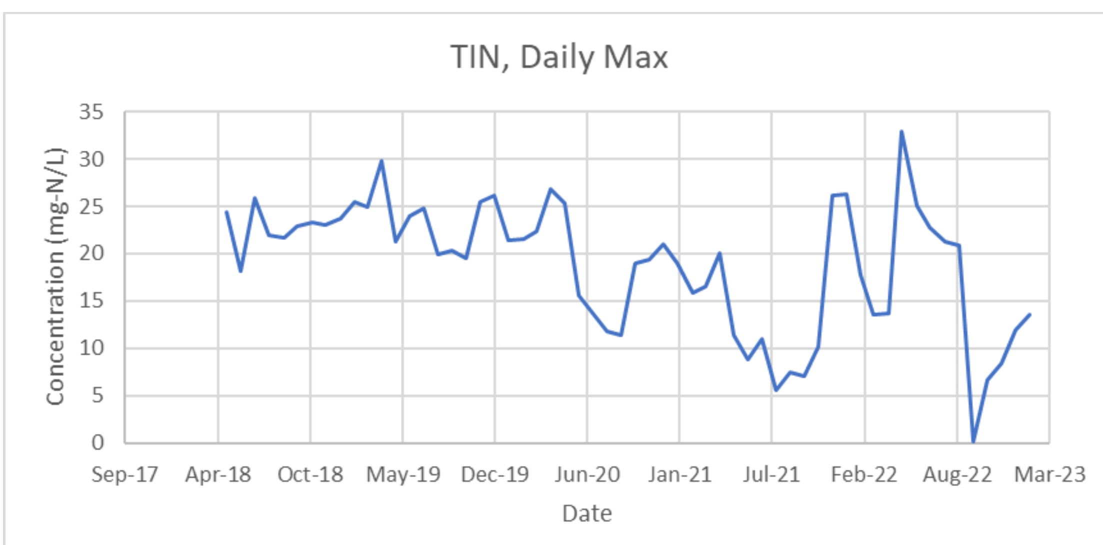
Berthoud WRF Regulatory Compliance Charts

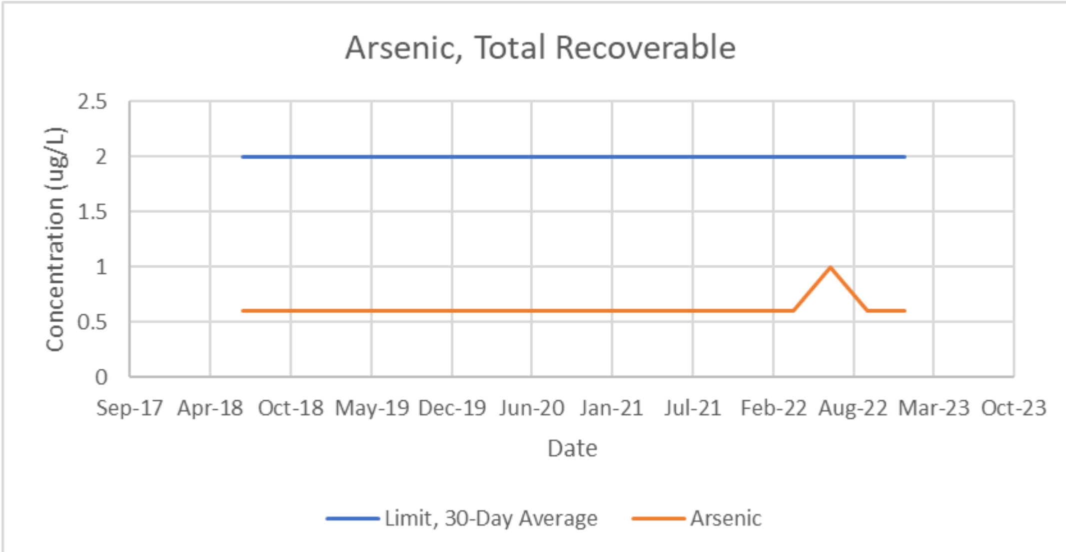


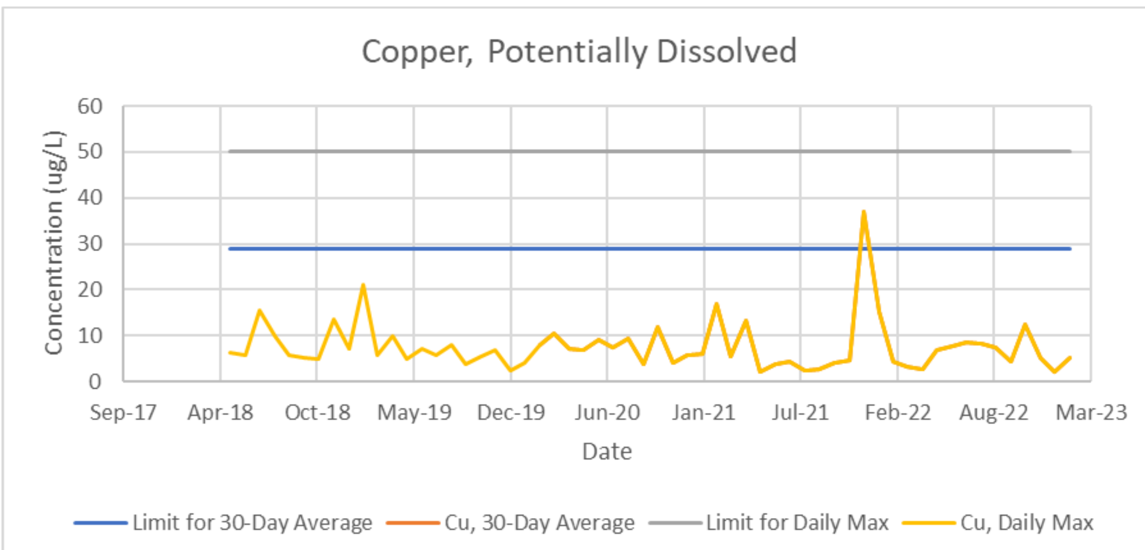


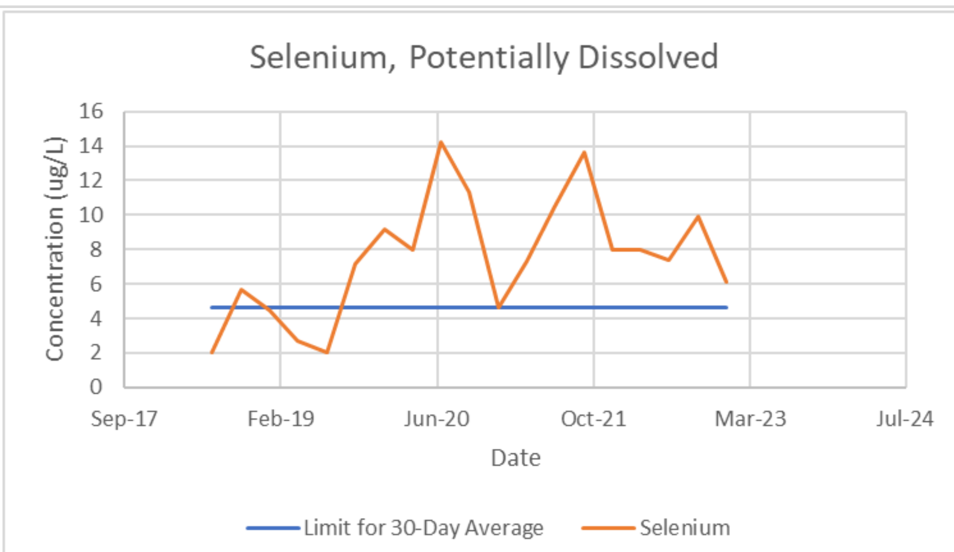

BOD, 5-Day, 20 deg C
Concentration (mg/L)
50
40
30
20
10
0
Sep-17
Apr-18
Oct-18
May-19
Dec-19
Jun-20
Jan-21
Jul-21
Feb-22
Aug-22
Mar-23
Date
Limit for 30-Day Average
BOD5, 30-Day Average
Limit for 7-Day Max
BOD5, 7-Day Max

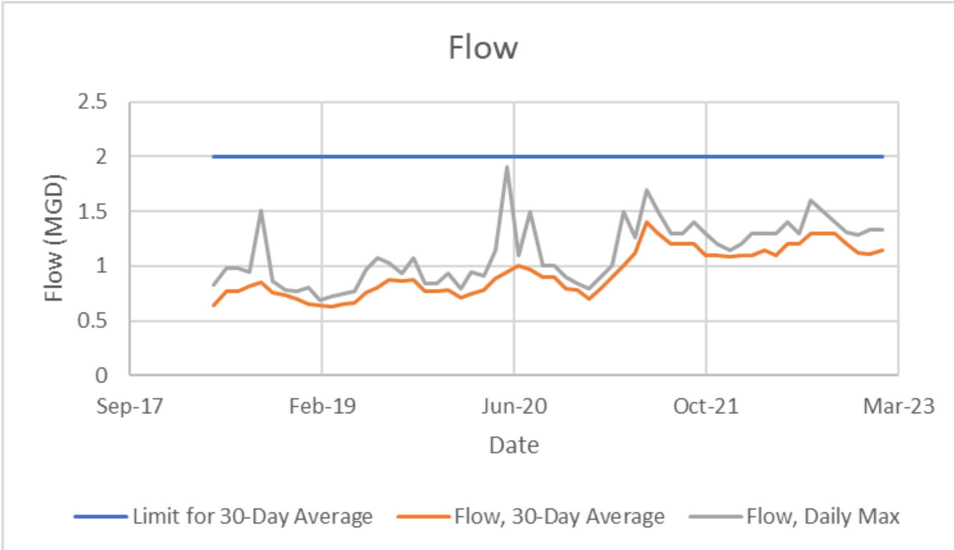

Ammonia, As N
Concentration (mg-N/L)
40
35
30
25
20
15
10
5
0
Sep-17
Apr-18
Oct-18
May-19
Dec-19
Jun-20
Jan-21
Jul-21
Feb-22
Aug-22
Mar-23
Oct-23
Date
Limit for 30-Day Average
Ammonia (as N), 30-Day Average
Limit for Daily Max
Ammonia (as N), Daily Max


TIN, Daily Max
Concentration (mg-N/L)
35
30
25
20
15
10
5
0
Sep-17
Apr-18
Oct-18
May-19
Dec-19
Jun-20
Jan-21
Jul-21
Feb-22
Aug-22
Mar-23
Date


Arsenic, Total Recoverable
Concentration (ug/L)
2.5
2
1.5
1
0.5
0
Sep-17 Apr-18 Oct-18 May-19 Dec-19 Jun-20 Jan-21 Jul-21 Feb-22 Aug-22 Mar-23 Oct-23
Date
Limit, 30-Day Average
Arsenic

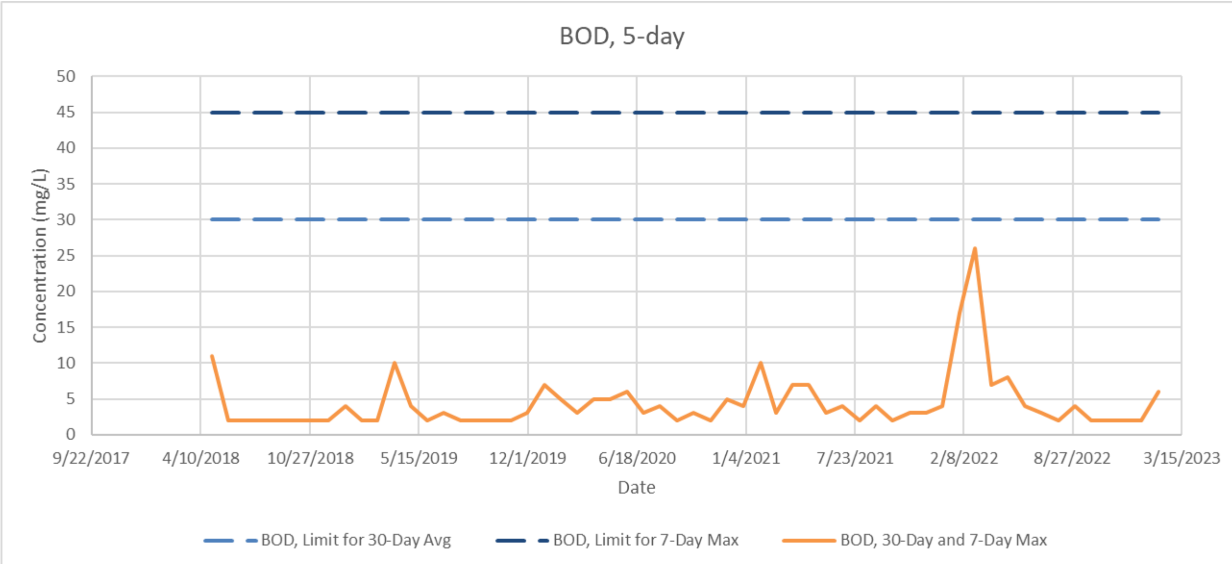

Copper, Potentially Dissolved
Concentration (ug/L)
60
50
40
30
20
10
0
Sep-17 Apr-18 Oct-18 May-19 Dec-19 Jun-20 Jan-21 Jul-21 Feb-22 Aug-22 Mar-23
Date
Limit for 30-Day Average
Cu, 30-Day Average
Limit for Daily Max
Cu, Daily Max

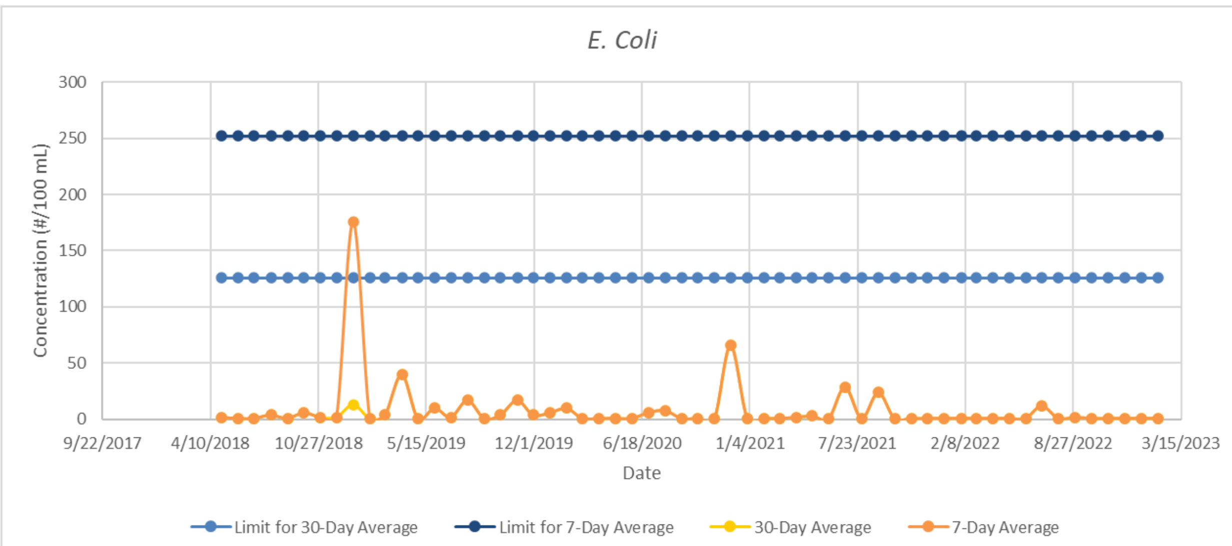

Selenium, Potentially Dissolved
Concentration (ug/L)
16
14
12
10
8
6
4
2
0
Sep-17 Feb-19 Jun-20 Oct-21 Mar-23 Jul-24
Date
Limit for 30-Day Average
Selenium

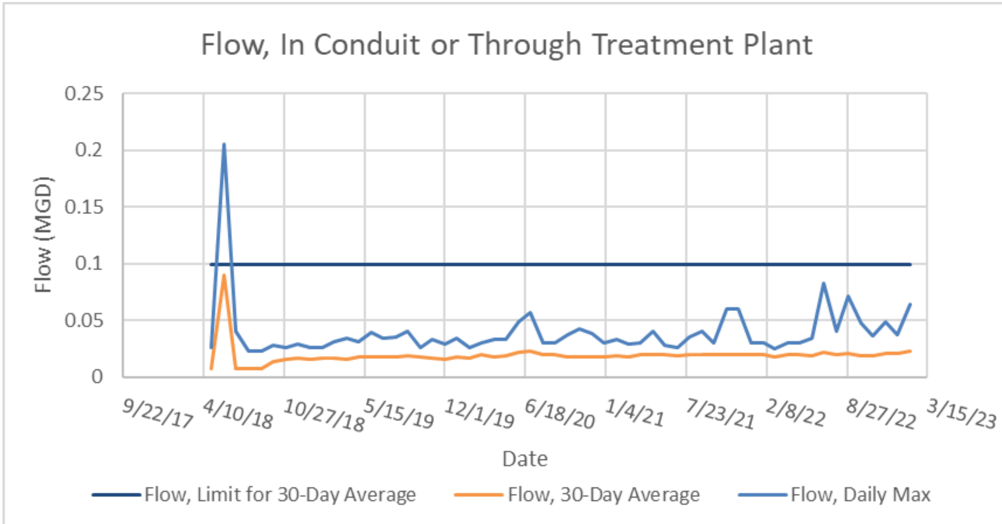


Flow
2.5
2
1.5
1
0.5
0
Flow (MGD)
Sep-17
Feb-19
Jun-20
Oct-21
Mar-23
Date
Limit for 30-Day Average
Flow, 30-Day Average
Flow, Daily Max

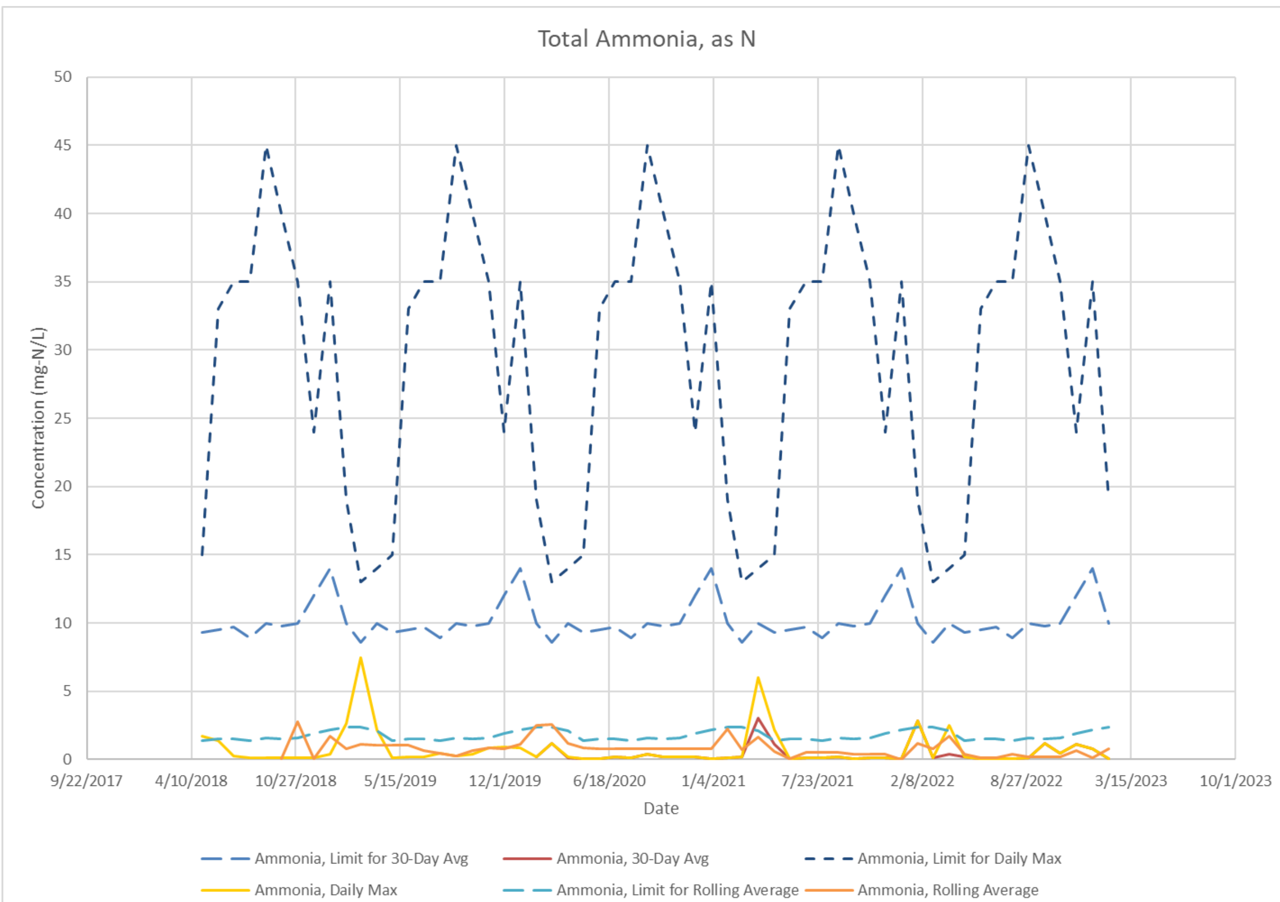
Regional WWTF Regulatory Compliance Charts



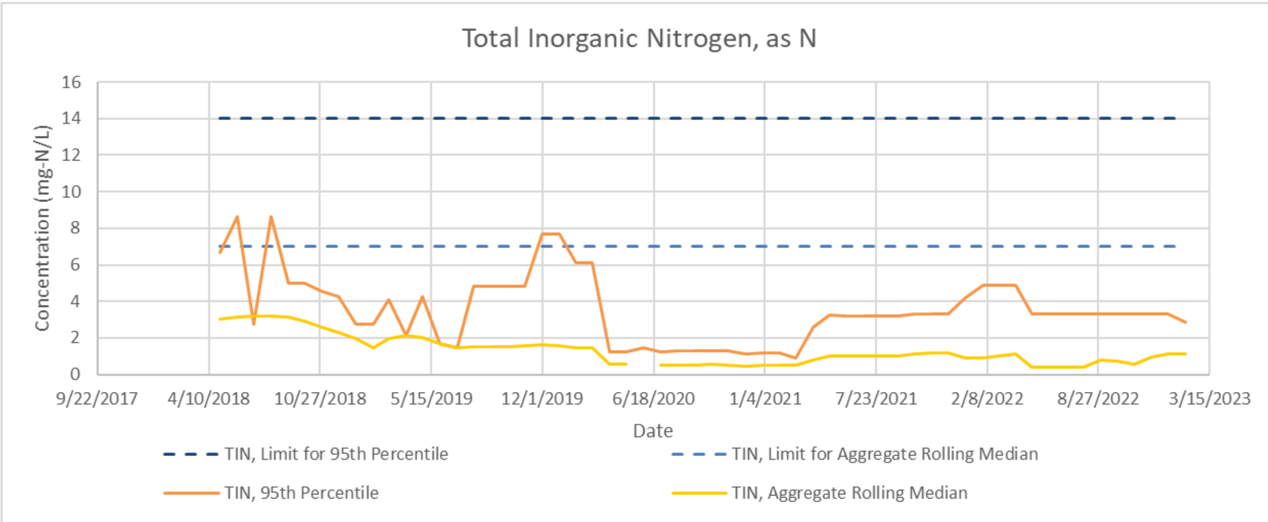




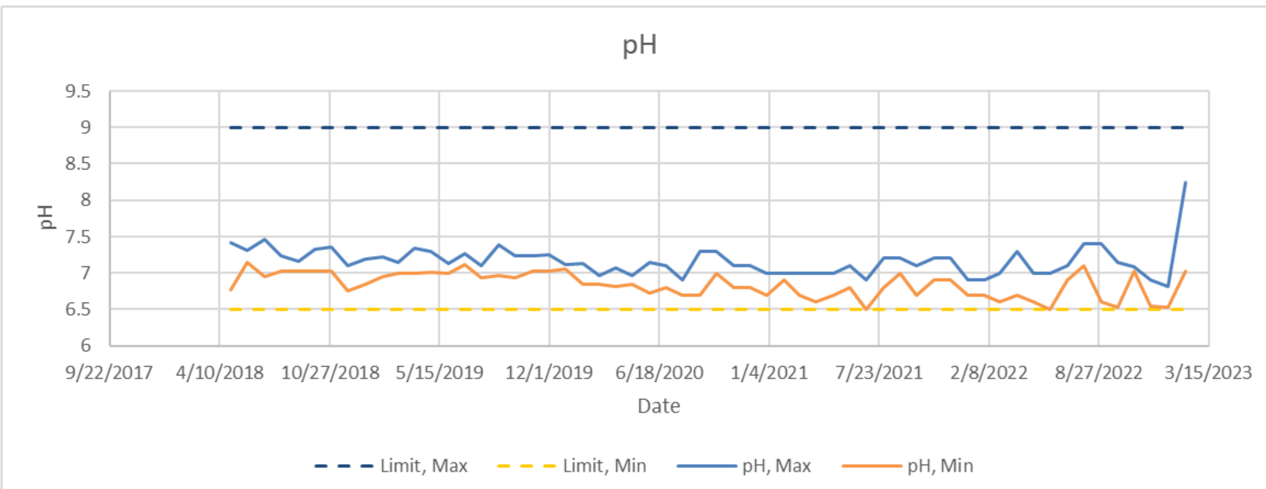
Flow, In Conduit or Through Treatment Plant
0.25
0.2
0.15
0.1
0.05
0
Flow (MGD)
9/22/17
4/10/18
10/27/18
5/15/19
12/1/19
6/18/20
1/4/21
7/23/21
2/8/22
8/27/22
3/15/23
Date
Flow, Limit for 30-Day Average
Flow, 30-Day Average
Flow, Daily Max



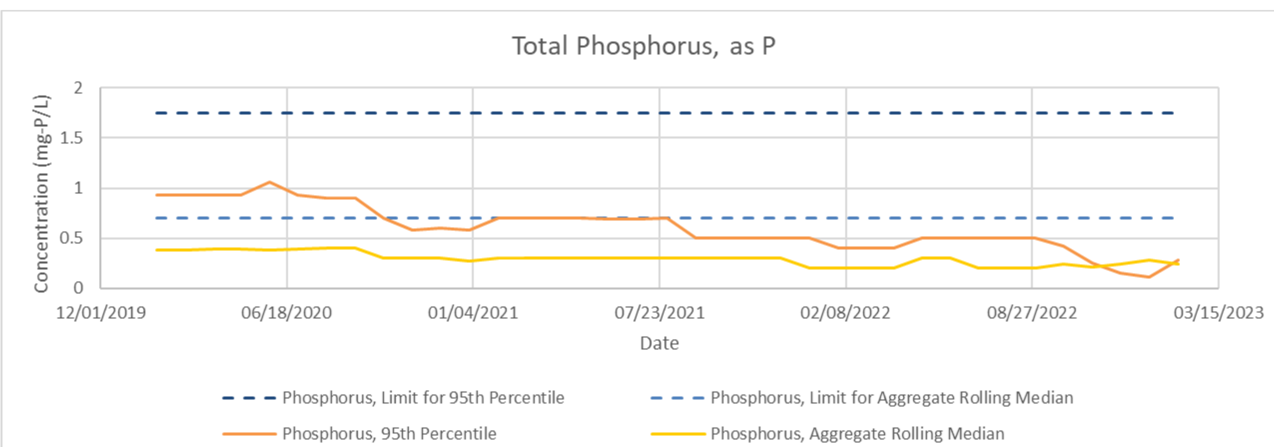
Total Ammonia, as N
50
45
40
35
30
25
20
15
10
5
0
Concentration (mg-N/L)
9/22/2017
4/10/2018
10/27/2018
5/15/2019
12/1/2019
6/18/2020
1/4/2021
7/23/2021
2/8/2022
8/27/2022
3/15/2023
10/1/2023
Date
Ammonia, Limit for 30-Day Avg
Ammonia, 30-Day Avg
Ammonia, Limit for Daily Max
Ammonia, Daily Max
Ammonia, Limit for Rolling Average
Ammonia, Rolling Average



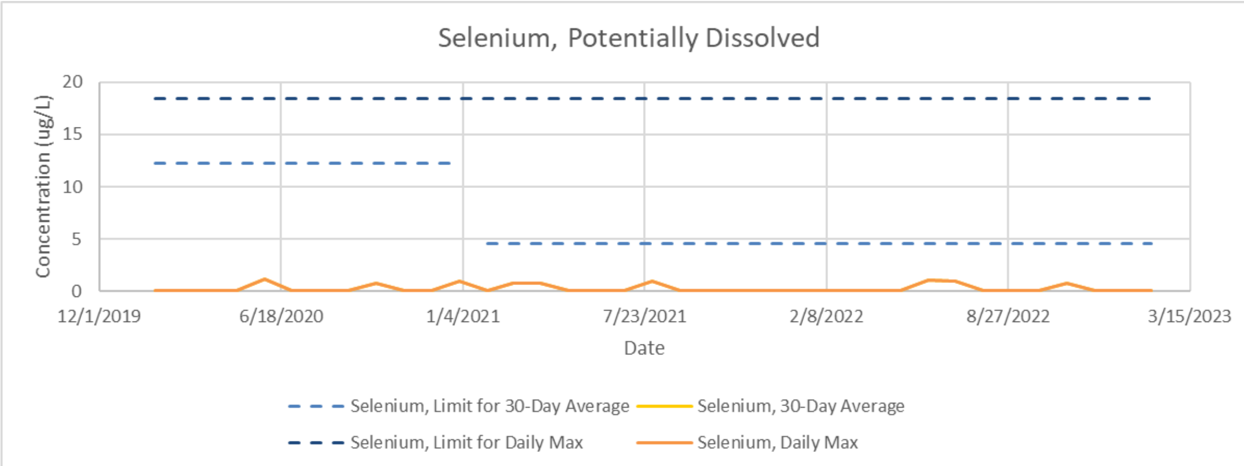
Total Inorganic Nitrogen, as N
Concentration (mg-N/L)
16
14
12
10
8
6
4
2
0
9/22/2017
4/10/2018
10/27/2018
5/15/2019
12/1/2019
6/18/2020
1/4/2021
7/23/2021
2/8/2022
8/27/2022
3/15/2023
Date
TIN, Limit for 95th Percentile
TIN, Limit for Aggregate Rolling Median
TIN, 95th Percentile
TIN, Aggregate Rolling Median

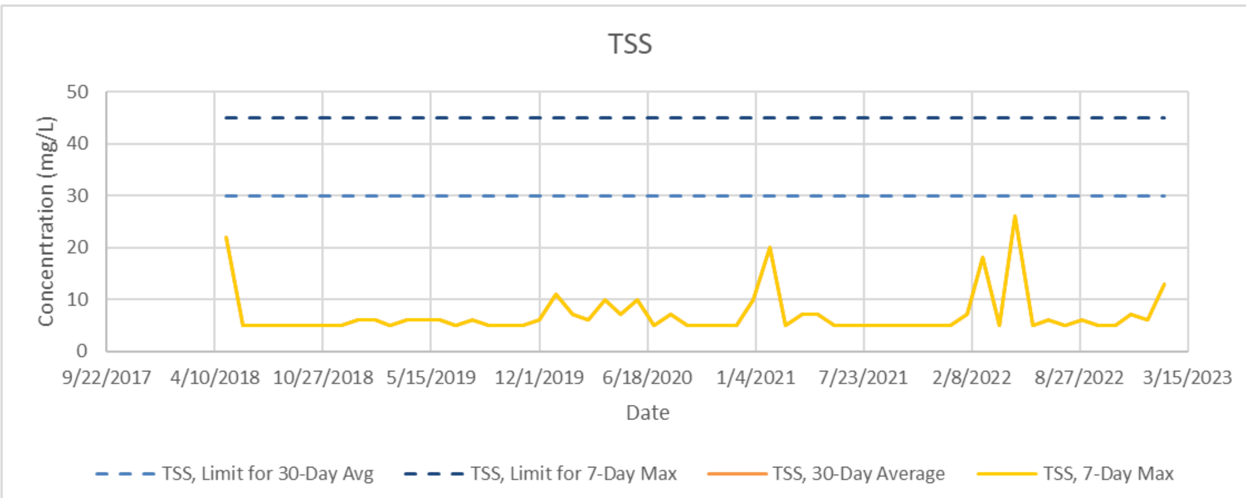


pH
pH
9.5
9
8.5
8
7.5
7
6.5
6
9/22/2017
4/10/2018
10/27/2018
5/15/2019
12/1/2019
6/18/2020
1/4/2021
7/23/2021
2/8/2022
8/27/2022
3/15/2023
Date
Limit, Max
Limit, Min
pH, Max
pH, Min



Total Phosphorus, as P
Concentration (mg-P/L)
2
1.5
1
0.5
0
12/01/2019
06/18/2020
01/04/2021
07/23/2021
02/08/2022
08/27/2022
03/15/2023
Date
Phosphorus, Limit for 95th Percentile
Phosphorus, Limit for Aggregate Rolling Median
Phosphorus, 95th Percentile
Phosphorus, Aggregate Rolling Median


Selenium, Potentially Dissolved
Concentration (ug/L)
20
15
10
5
0
12/1/2019
6/18/2020
1/4/2021
7/23/2021
2/8/2022
8/27/2022
3/15/2023
Date
Selenium, Limit for 30-Day Average
Selenium, 30-Day Average
Selenium, Limit for Daily Max
Selenium, Daily Max


TSS
Concenrtration (mg/L)
50
40
30
20
10
0
9/22/2017
4/10/2018
10/27/2018
5/15/2019
12/1/2019
6/18/2020
1/4/2021
7/23/2021
2/8/2022
8/27/2022
3/15/2023
Date
TSS, Limit for 30-Day Avg
TSS, Limit for 7-Day Max
TSS, 30-Day Average
TSS, 7-Day Max

APPENDIX C:
20-Year CIP Class V Cost Opinions

TETRA TECH

Project: WD-1: Bacon Lake Transmission Main, Phase 1
PN: WD-1
Date: 9/8/23
Desc: 12" to 30" Transmisson Main feeding the Farmstead Development
Class: 5 (-50% to +100%)
Timeframe: 2024-2025

Item	Unit	Quantity	Unit Cost	Item Cost
30" DI Class 250 Pipe	LF	843	$600	$505,800
24" DI Class 250 Pipe	LF	8,182	$480	$3,927,360
12" DI Class 350 Pipe	LF	369	$240	$88,560
30" Isolation Butterfly Valves	EA	1	$83,200	$83,200
24" Isolation Butterfly Valves	EA	7	$25,376	$177,632
12" Isolation Butterfly Valves	EA	1	$11,700	$11,700
30" Bend Fittings	EA	2	$9,360	$18,720
24" Bend Fittings	EA	8	$5,835	$46,680
12" Bend Fittings	EA	2	$998	$1,995
30" Tee Fittings	EA	1	$13,536	$13,536
24" Tee Fittings	EA	2	$8,610	$17,220
12" Tee Fittings	EA	1	$1,386	$1,386
Blowoff Assemblies	EA	4	$65,000	$260,000
Combination Air Release Valve Assemblies	EA	3	$54,000	$162,000
Testing and Commissioning	LS	1	$35,583	$35,583
Asphalt Replacement	SY	1,481	$80	$118,519
Equipment/ Materials Subtotal				***$5,470,000***
Electrical, Sitework, and Demolition				
Electrical I&C (30%)	LS	0	$1,640,967	$0
Sitework (15%)	LS	1	$820,484	$821,000
Demolition (20%)	LS	0	$1,093,978	$0
Subtotal Equipment and Labor				**$6,291,000**
Contractor Markups				
Contracts/Bonds/Insurance (3%)	LS	1	$188,730	$189,000
Mobilization/Demobilization (2%)	LS	1	$125,820	$126,000
Contractor Superintendence (8%)	LS	1	$503,280	$504,000
Overhead and Profit (18%)	LS	1	$1,132,380	$1,133,000
Subtotal Pre-Contingency Construction Cost				**$8,243,000**
Contingency (30%)	LS	1	$2,472,900	$2,473,000
Subtotal Construction Cost				**$10,716,000**
Engineering Design & Services During Construction (20%)	LS	1	$2,143,200	$2,144,000
Project Total	**$12,860,000**			
Class V Cost Range	**$6,430,000**		**$25,720,000**	

Note:

1. Project total rounded to the nearest $1,000

TETRA TECH

Project: WD-2: Bacon Lake Transmission Main, Phase 2
PN: WD-2
Date: 9/8/23
Desc: 12" to 16" Transmisson Main feeding the Farmstead Development
Class: 5 (-50% to +100%)
Timeframe: 2025-2026

Item	Unit	Quantity	Unit Cost	Item Cost
16" DI Class 250 Pipe	LF	5,456	$320	$1,745,920
12" DI Class 350 Pipe	LF	834	$240	$200,160
16" Isolation Butterfly Valves	EA	5	$13,663	$68,315
12" Isolation Butterfly Valves	EA	1	$11,700	$11,700
16" Bend Fittings	EA	8	$1,200	$9,600
12" Bend Fittings	EA	2	$998	$1,995
16" Tee Fittings	EA	2	$1,600	$3,200
12" Tee Fittings	EA	1	$1,386	$1,386
Blowoff Assemblies	EA	2	$65,000	$130,000
Combination Air Release Valve Assemblies	EA	2	$54,000	$108,000
Testing and Commissioning	LS	1	$23,826	$23,826
Asphalt Replacement	SY	1,481	$80	$118,519
Equipment/ Materials Subtotal				***$2,423,000***
Electrical, Sitework, and Demolition				
Electrical I&C (30%)	LS	0	$726,786	$0
Sitework (15%)	LS	1	$363,393	$364,000
Demolition (20%)	LS	0	$484,524	$0
Subtotal Equipment and Labor				**$2,787,000**
Contractor Markups				
Contracts/Bonds/Insurance (3%)	LS	1	$83,610	$84,000
Mobilization/Demobilization (2%)	LS	1	$55,740	$56,000
Contractor Superintendence (8%)	LS	1	$222,960	$223,000
Overhead and Profit (18%)	LS	1	$501,660	$502,000
Subtotal Pre-Contingency Construction Cost				**$3,652,000**
Contingency (30%)	LS	1	$1,095,600	$1,096,000
Subtotal Construction Cost				**$4,748,000**
Engineering Design & Services During Construction (20%)	LS	1	$949,600	$950,000
Project Total	**$5,698,000**			
Class V Cost Range	**$2,849,000**		**$11,396,000**	

Note:

1. Project total rounded to the nearest $1,000

TETRA TECH

Project: WD-3: West BPS Transmission Main
PN: WD-3
Date: 9/8/23
Desc: 16" to 20" Transmisson Main from the west BPS to Grand Market Ave in Heron Lakes Subdivision.
Class: 5 (-50% to +100%)
Timeframe: 2026-2027

Item	Unit	Quantity	Unit Cost	Item Cost
20" DI Class 250 Pipe	LF	610	$400	$244,000
16" DI Class 350 Pipe	LF	255	$320	$81,600
20" Isolation Butterfly Valves	EA	2	$18,300	$36,600
16" Isolation Butterfly Valves	EA	2	$13,663	$27,326
20" Bend Fittings	EA	3	$3,909	$11,727
16" Bend Fittings	EA	2	$998	$1,995
20" Tee Fittings	EA	1	$4,353	$4,353
16" Tee Fittings	EA	1	$1,386	$1,386
Combination Air Release Valve Assemblies	EA	1	$54,000	$54,000
Testing and Commissioning	LS	1	$3,277	$3,277
Asphalt Replacement	SY	98	$80	$7,852
Equipment/ Materials Subtotal				***$475,000***
Electrical, Sitework, and Demolition				
Electrical I&C (30%)	LS	0	$142,235	$0
Sitework (15%)	LS	1	$71,117	$72,000
Demolition (20%)	LS	0	$94,823	$0
Subtotal Equipment and Labor				**$547,000**
Contractor Markups				
Contracts/Bonds/Insurance (3%)	LS	1	$16,410	$17,000
Mobilization/Demobilization (2%)	LS	1	$10,940	$11,000
Contractor Superintendence (8%)	LS	1	$43,760	$44,000
Overhead and Profit (18%)	LS	1	$98,460	$99,000
Subtotal Pre-Contingency Construction Cost				**$718,000**
Contingency (30%)	LS	1	$215,400	$216,000
Subtotal Construction Cost				**$934,000**
Engineering Design & Services During Construction (20%)	LS	1	$186,800	$187,000
Project Total	**$1,121,000**			
Class V Cost Range	**$560,500**		**$2,242,000**	

Note:

1. Project total rounded to the nearest $1,000

TETRA TECH

Project: WD-4: West BPS Upgrade, Phase 1
PN: WD-4
Date: 9/8/23
Desc: Replace existing pumps with larger capacity pumps within existing building. Pumps need to deliver 2,800 gpm under PHD conditions, Existing 60 HP Pump
Class: 5 (-50% to +100%)
Timeframe: 2028

Item	Unit	Quantity	Unit Cost	Item Cost
End Suction Cenrtifugal Pump, 1000 gpm	EA	2	$250,000	$500,000
Upgrade BPS Piping and Appurtenances	LS	1	$150,000	$150,000
Testing and Commissioning	LS	1	$50,000	$50,000
Equipment/ Materials Subtotal				***$700,000***
Electrical, Sitework, and Demolition				
Electrical I&C (30%)	LS	1	$210,000	$210,000
Sitework (15%)	LS	1	$105,000	$105,000
Demolition (20%)	LS	1	$140,000	$140,000
Subtotal Equipment and Labor				**$1,155,000**
Contractor Markups				
Contracts/Bonds/Insurance (3%)	LS	1	$34,650	$35,000
Mobilization/Demobilization (2%)	LS	1	$23,100	$24,000
Contractor Superintendence (8%)	LS	1	$92,400	$93,000
Overhead and Profit (18%)	LS	1	$207,900	$208,000
Subtotal Pre-Contingency Construction Cost				**$1,515,000**
Contingency (30%)	LS	1	$454,500	$455,000
Subtotal Construction Cost				**$1,970,000**
Engineering Design & Services During Construction (20%)	LS	1	$394,000	$394,000
Project Total	**$2,364,000**			
Class V Cost Range	**$1,182,000**		**$4,728,000**	

Note:

1. Project total rounded to the nearest $1,000

TETRA TECH

Project: WD-5: West Tank Low Pressure Zone Transmission Main
PN: WD-5
Date: 9/8/23
Desc: 16" Transmission Main from the West Storage Tank to the Low Pressure Zone on Vantage Rd.
Class: 5 (-50% to +100%)
Timeframe: 2032-2033

Item	Unit	Quantity	Unit Cost	Item Cost
16" DI Class 250 Pipe	LF	7,774	$320	$2,487,680
16" Isolation Butterfly Valves	EA	7	$13,663	$95,641
16" Bend Fittings	EA	6	$998	$5,988
16" Tee Fittings	EA	2	$1,386	$2,772
30" Steel Casing, Trenchless Installation, Microtunneling	LF	400	$5,000	$2,000,000
Blowoff Assemblies	EA	3	$65,000	$195,000
Combination Air Release Valve Assemblies	EA	2	$54,000	$108,000
Testing and Commissioning	LS	1	$29,447	$29,447
Asphalt Replacement	SY	2,303	$80	$184,273
Equipment/ Materials Subtotal				***$5,109,000***
Electrical, Sitework, and Demolition				
Electrical I&C (30%)	LS	0	$1,532,640	$0
Sitework (15%)	LS	1	$766,320	$767,000
Demolition (20%)	LS	0	$1,021,760	$0
Subtotal Equipment and Labor				**$5,876,000**
Contractor Markups				
Contracts/Bonds/Insurance (3%)	LS	1	$176,280	$177,000
Mobilization/Demobilization (2%)	LS	1	$117,520	$118,000
Contractor Superintendence (8%)	LS	1	$470,080	$471,000
Overhead and Profit (18%)	LS	1	$1,057,680	$1,058,000
Subtotal Pre-Contingency Construction Cost				**$7,700,000**
Contingency (30%)	LS	1	$2,310,000	$2,310,000
Subtotal Construction Cost				**$10,010,000**
Engineering Design & Services During Construction (20%)	LS	1	$2,002,000	$2,002,000
Project Total	**$12,012,000**			
Class V Cost Range	**$6,006,000**		**$24,024,000**	

Note:

1. Project total rounded to the nearest $1,000

TETRA TECH

Project: WD-6: Berthoud Parkway Transmission Main
PN: WD-6
Date: 9/8/23
Desc: 16"-20" Transmisson Main along Berthoud Parkway
Class: 5 (-50% to +100%)
Timeframe: 2033-2034

Item	Unit	Quantity	Unit Cost	Item Cost
20" DI Class 250 Pipe	LF	2,138	$400	$855,200
16" DI Class 250 Pipe	LF	9,309	$320	$2,978,880
20" Isolation Butterfly Valves	EA	2	$18,300	$36,600
16" Isolation Butterfly Valves	EA	8	$13,663	$109,304
20" Bend Fittings	EA	2	$3,909	$7,818
16" Bend Fittings	EA	4	$998	$3,990
20" Tee Fittings	EA	2	$4,353	$8,706
16" Tee Fittings	EA	4	$1,386	$5,544
Fire Hydrant Assembly	EA	23	$8,000	$184,000
Blowoff Assemblies	EA	5	$65,000	$325,000
Combination Air Release Valve Assemblies	EA	5	$54,000	$270,000
Testing and Commissioning	LS	1	$35,261	$35,261
Asphalt Replacement	SY	3,392	$80	$271,336
Equipment/ Materials Subtotal				***$5,092,000***
Electrical, Sitework, and Demolition				
Electrical I&C (30%)	LS	0	$1,270,932	$0
Sitework (15%)	LS	1	$635,466	$636,000
Demolition (20%)	LS	0	$847,288	$0
Subtotal Equipment and Labor				**$5,728,000**
Contractor Markups				
Contracts/Bonds/Insurance (3%)	LS	1	$171,840	$172,000
Mobilization/Demobilization (2%)	LS	1	$114,560	$115,000
Contractor Superintendence (8%)	LS	1	$458,240	$459,000
Overhead and Profit (18%)	LS	1	$1,031,040	$1,032,000
Subtotal Pre-Contingency Construction Cost				**$7,506,000**
Contingency (30%)	LS	1	$2,251,800	$2,252,000
Subtotal Construction Cost				**$9,758,000**
Engineering Design & Services During Construction (20%)	LS	1	$1,951,600	$1,952,000
Project Total	**$11,710,000**			
Class V Cost Range	**$5,855,000**		**$23,420,000**	

Note:

1. Project total rounded to the nearest $1,000

Project: WD-7: West BPS Upgrade, Phase 2
PN: WD-7
Date: 9/8/23
Desc: Add a single pump to west BPS to achieve a total flow of 3,300 gpm
Class: 5 (-50% to +100%)
Timeframe: 2034

Item	Unit	Quantity	Unit Cost	Item Cost
End Suction Cenrtifugal Pump, 600 gpm	EA	1	$150,000	$150,000
Testing and Commissioning	LS	1	$25,000	$25,000
Equipment/ Materials Subtotal				***$175,000***
Electrical, Sitework, and Demolition				
Electrical I&C (30%)	LS	1	$52,500	$60,000
Sitework (15%)	LS	0	$26,250	$0
Demolition (20%)	LS	1	$35,000	$35,000
Subtotal Equipment and Labor				**$270,000**
Contractor Markups				
Contracts/Bonds/Insurance (3%)	LS	1	$8,100	$9,000
Mobilization/Demobilization (2%)	LS	1	$5,400	$6,000
Contractor Superintendence (8%)	LS	1	$21,600	$22,000
Overhead and Profit (18%)	LS	1	$48,600	$49,000
Subtotal Pre-Contingency Construction Cost				**$356,000**
Contingency (30%)	LS	1	$106,800	$107,000
Subtotal Construction Cost				**$463,000**
Engineering Design & Services During Construction (20%)	LS	1	$92,600	$93,000
Project Total	**$556,000**			
Class V Cost Range	**$278,000**		**$1,112,000**	

Note:

1. Project total rounded to the nearest $1,000

TETRA TECH

Project: WD-8: East Zone Storage Tank and BPS
PN: WD-8
Date: 9/8/23
Desc: 1.5 MG Storage Tank and BPS
Class: 5 (-50% to +100%)
Timeframe: 2034-2035

Item	Unit	Quantity	Unit Cost	Item Cost
1.5 MG Prestressed Concrete Resorvoir	LS	1	$5,250,000	$5,250,000
24" Concrete Slab Foundation	CY	300	$1,200	$360,000
Foundation Support System	LS	1	$100,000	$100,000
Tank Accessories	LS	1	$100,000	$100,000
Centrifugal Split Case Booster Pumps, 2500 gpm	EA	2	$200,000	$400,000
BPS Building	SFT	800	$250	$200,000
BPS Piping and Appurtenances	LS	1	$120,000	$120,000
30" DI Class 250 Pipe	LF	100	$600	$60,000
30" Isolation Butterfly Valves	EA	2	$83,200	$166,400
30" Bend Fittings	EA	2	$9,360	$18,720
Testing and Commissioning	LS	1	$5,000	$5,000
Equipment/ Materials Subtotal				***$6,781,000***
Electrical, Sitework, and Demolition				
Electrical I&C (30%)	LS	1	$2,034,036	$2,040,000
Sitework (15%)	LS	1	$1,017,018	$1,018,000
Demolition (20%)	LS	0	$1,356,024	$0
Subtotal Equipment and Labor				**$9,839,000**
Contractor Markups				
Contracts/Bonds/Insurance (3%)	LS	1	$295,170	$296,000
Mobilization/Demobilization (2%)	LS	1	$196,780	$197,000
Contractor Superintendence (8%)	LS	1	$787,120	$788,000
Overhead and Profit (18%)	LS	1	$1,771,020	$1,772,000
Subtotal Pre-Contingency Construction Cost				**$12,892,000**
Contingency (30%)	LS	1	$3,867,600	$3,868,000
Subtotal Construction Cost				**$16,760,000**
Engineering Design & Services During Construction (20%)	LS	1	$3,352,000	$3,352,000
Project Total	**$20,112,000**			
Class V Cost Range	**$10,056,000**		**$40,224,000**	

Note:

1. Project total rounded to the nearest $1,000

TETRA TECH

Project: WD-9: CR 44 Transmission Main, Phase 1
PN: WD-9
Date: 9/8/23
Desc: 24" Transmisson Main down CR 44 to east zone.
Class: 5 (-50% to +100%)
Timeframe: 2035-2036

Item	Unit	Quantity	Unit Cost	Item Cost
24" DI Class 250 Pipe	LF	7,802	$480	$3,744,960
24" Isolation Butterfly Valves	EA	7	$25,376	$177,632
24" Bend Fittings	EA	4	$5,835	$23,340
24" Tee Fittings	EA	3	$8,610	$25,830
36" Steel Casing, Trenchless Installation, Microtunneling	LF	400	$6,000	$2,400,000
Blowoff Assemblies	EA	4	$65,000	$260,000
Combination Air Release Valve Assemblies	EA	3	$54,000	$162,000
Pressure Reducing Valve Assembly	EA	1	$50,000	$50,000
Testing and Commissioning	LS	1	$29,553	$29,553
Equipment/ Materials Subtotal				***$6,874,000***
Electrical, Sitework, and Demolition				
Electrical I&C (30%)	LS	0	$2,061,995	$0
Sitework (15%)	LS	1	$1,030,997	$1,031,000
Demolition (20%)	LS	0	$1,374,663	$0
Subtotal Equipment and Labor				**$7,905,000**
Contractor Markups				
Contracts/Bonds/Insurance (3%)	LS	1	$237,150	$238,000
Mobilization/Demobilization (2%)	LS	1	$158,100	$159,000
Contractor Superintendence (8%)	LS	1	$632,400	$633,000
Overhead and Profit (18%)	LS	1	$1,422,900	$1,423,000
Subtotal Pre-Contingency Construction Cost				**$10,358,000**
Contingency (30%)	LS	1	$3,107,400	$3,108,000
Subtotal Construction Cost				**$13,466,000**
Engineering Design & Services During Construction (20%)	LS	1	$2,693,200	$2,694,000
Project Total	**$16,160,000**			
Class V Cost Range	**$8,080,000**		**$32,320,000**	

Note:

1. Project total rounded to the nearest $1,000

Project: WD-10: Serenity Ridge Connection
PN: WD-10
Date: 9/8/23
Desc: 12" Main connecting Serenity Ridge to Berthoud water supply
Class: 5 (-50% to +100%)
Timeframe: 2040-2041

Item	Unit	Quantity	Unit Cost	Item Cost
12" DI Class 350 Pipe	LF	6,179	$240	$1,482,960
12" Isolation Butterfly Valves	EA	11	$11,700	$128,700
12" Bend Fittings	EA	2	$998	$1,995
12" Tee Fittings	EA	3	$1,386	$4,158
Blowoff Assemblies	EA	1	$65,000	$65,000
Combination Air Release Valve Assemblies	EA	1	$54,000	$54,000
Testing and Commissioning	LS	1	$23,405	$23,405
Equipment/ Materials Subtotal				***$1,761,000***
Electrical, Sitework, and Demolition				
Electrical I&C (30%)	LS	0	$528,065	$0
Sitework (15%)	LS	1	$264,033	$265,000
Demolition (20%)	LS	0	$352,044	$0
Subtotal Equipment and Labor				**$2,026,000**
Contractor Markups				
Contracts/Bonds/Insurance (3%)	LS	1	$60,780	$61,000
Mobilization/Demobilization (2%)	LS	1	$40,520	$41,000
Contractor Superintendence (8%)	LS	1	$162,080	$163,000
Overhead and Profit (18%)	LS	1	$364,680	$365,000
Subtotal Pre-Contingency Construction Cost				**$2,656,000**
Contingency (30%)	LS	1	$796,800	$797,000
Subtotal Construction Cost				**$3,453,000**
Engineering Design & Services During Construction (20%)	LS	1	$690,600	$691,000
Project Total	**$4,144,000**			
Class V Cost Range	**$2,072,000**		**$8,288,000**	

Note:

1. Project total rounded to the nearest $1,000

TETRA TECH

Project: WD-11: CR 44 Transmission Main, Phase 2
PN: WD-11
Date: 9/8/23
Desc: 24" Transmisson Main down CR 44 to east zone.
Class: 5 (-50% to +100%)
Timeframe: 2042-2043

Item	Unit	Quantity	Unit Cost	Item Cost
24" DI Class 250 Pipe	LF	18,349	$480	$8,807,520
24" Isolation Butterfly Valves	EA	16	$25,376	$406,016
24" Bend Fittings	EA	4	$5,835	$23,340
24" Tee Fittings	EA	3	$8,610	$25,830
Blowoff Assemblies	EA	4	$65,000	$260,000
Combination Air Release Valve Assemblies	EA	3	$54,000	$162,000
Pressure Reducing Valve Assembly	EA	1	$50,000	$50,000
Testing and Commissioning	LS	1	$69,504	$69,504
Equipment/ Materials Subtotal				***$9,805,000***
Electrical, Sitework, and Demolition				
Electrical I&C (30%)	LS	0	$2,941,263	$0
Sitework (15%)	LS	1	$1,470,631	$1,471,000
Demolition (20%)	LS	0	$1,960,842	$0
Subtotal Equipment and Labor				**$11,276,000**
Contractor Markups				
Contracts/Bonds/Insurance (3%)	LS	1	$338,280	$339,000
Mobilization/Demobilization (2%)	LS	1	$225,520	$226,000
Contractor Superintendence (8%)	LS	1	$902,080	$903,000
Overhead and Profit (18%)	LS	1	$2,029,680	$2,030,000
Subtotal Pre-Contingency Construction Cost				**$14,774,000**
Contingency (30%)	LS	1	$4,432,200	$4,433,000
Subtotal Construction Cost				**$19,207,000**
Engineering Design & Services During Construction (20%)	LS	1	$3,841,400	$3,842,000
Project Total	**$23,049,000**			
Class V Cost Range	**$11,524,500**		**$46,098,000**	

Note:

1. Project total rounded to the nearest $1,000

TETRA TECH

Project: WD-12: Telemetry and PLC Upgrade
PN: WD-12
Date: 04/20/2023
Desc: Securing existing ICS and SCADA equipment
Class: 5 (-50% to +100%)
Timeframe: 2024

Item	Unit	Quantity	Unit Cost	Installation %	Installation $	Item Cost
Radio telemetry system equipment	LS	7	$15,000	40%	$6,000	$147,000
Booster pump station PLC replacement	LS	1	$50,000	10%	$5,000	$55,000
Equipment/ Materials Subtotal						***$202,000***
Electrical, Sitework, and Demolition						
Electrical I&C (20%)	LS	0	$40,400	N/A		$0
Sitework (15%)	LS	0	$30,300	N/A		$0
Demolition (20%)	LS	0	$40,400	N/A		$0
Piping, Valves and Appurtenances (20%)	LS	0	$40,400	N/A		$0
Subtotal Equipment and Labor						**$202,000**
Contractor Markups						
Contracts/Bonds/Insurance (3%)	LS	0	$6,060	N/A		$0
Mobilization/Demobilization (2%)	LS	0	$4,040	N/A		$0
Contractor Superintendence (8%)	LS	0	$16,160	N/A		$0
Overhead and Profit (18%)	LS	0	$36,360	N/A		$0
Subtotal Pre-Contingency Construction Cost						**$202,000**
Contingency (30%)	LS	1	$60,600	N/A		$61,000
Subtotal Construction Cost						**$263,000**
Engineering Design & Services During Construction (20%)	LS	1	$52,600	N/A		$53,000
Project Total	**$316,000**					
Class V Cost Range	**$158,000**		**$632,000**			

Note:

1. Project total rounded to the nearest $1,000

TETRA TECH

Project: High Service Pump Capacity Project
PN: WTP-1
Date: 05/11/2023
Desc: Media replacement and improvements to filter appurtenances and backwash equipment
Class: 5 (-50% to +100%)
Timeframe: 2023 - 2024

Item	Unit	Quantity	Unit Cost	Installation %	Installation $	Item Cost
High Service Pump, 1,400 gpm	EA	1	$44,000	30%	$13,200	$58,000
Equipment/ Materials Subtotal						***$58,000***
Electrical, Sitework, and Demolition						
Electrical I&C (40%)	LS	1	$23,200	N/A		$30,000
Piping, Valves and Appurtenances (30%)	LS	1	$17,400	N/A		$18,000
Subtotal Equipment and Labor						**$106,000**
Contractor Markups						
Contracts/Bonds/Insurance (3%)	LS	1	$3,180	N/A		$4,000
Contractor Superintendence (8%)	LS	1	$8,480	N/A		$9,000
Overhead and Profit (18%)	LS	1	$19,080	N/A		$20,000
Subtotal Pre-Contingency Construction Cost						**$139,000**
Contingency (30%)	LS	1	$41,700	N/A		$42,000
Subtotal Construction Cost						**$181,000**
Engineering Design & Services During Construction (10%)	LS	1	$18,100	N/A		$19,000
Project Total	**$200,000**					
Class V Cost Range	**$100,000**		**$400,000**			

Note:
1. Project total rounded to the nearest $1,000

TETRA TECH

Project: Filtration Improvement Project
PN: WTP-2
Date: 05/11/2023
Desc: Media replacement and improvements to filter appurtenances and backwash equipment
Class: 5 (-50% to +100%)
Timeframe: 2024 - 2025

Item	Unit	Quantity	Unit Cost	Installation %	Installation $	Item Cost
Rebuild filters 1 & 2 from underdrain to top of media (exclude	EA	2	$200,000	40%	$80,000	$560,000
Blowers (duty and shelf spare)	EA	2	$75,000	40%	$30,000	$210,000
Media replacement	LS	1	$35,000	30%	$10,500	$46,000
Anthracite Top-off (Filters 3 & 4)	LS	1	$15,000	30%	$4,500	$20,000
Level sensors	EA	5	$2,400	20%	$480	$15,000
Parallel or replace 14" pipe , 30 LF	LS	1	$70,000	50%	$35,000	$105,000
Equipment/ Materials Subtotal						***$956,000***
Electrical, Sitework, and Demolition						
Electrical I&C (30%)	LS	1	$286,800	N/A		$290,000
Demolition (20%)	LS	1	$191,200	N/A		$192,000
Piping, Valves and Appurtenances (20%)	LS	1	$191,200	N/A		$192,000
Subtotal Equipment and Labor						**$1,630,000**
Contractor Markups						
Contracts/Bonds/Insurance (3%)	LS	1	$48,900	N/A		$49,000
Mobilization/Demobilization (2%)	LS	1	$32,600	N/A		$33,000
Contractor Superintendence (8%)	LS	1	$130,400	N/A		$131,000
Overhead and Profit (18%)	LS	1	$293,400	N/A		$294,000
Subtotal Pre-Contingency Construction Cost						**$2,137,000**
Contingency (30%)	LS	1	$641,100	N/A		$642,000
Subtotal Construction Cost						**$2,779,000**
Engineering Design & Services During Construction (10%)	LS	1	$277,900	N/A		$278,000
Project Total	**$3,057,000**					
Class V Cost Range	**$1,528,500**		**$6,114,000**			

Note:

1. Project total rounded to the nearest $1,000

TETRA TECH

Project: WTP Expansion
PN: WTP-3
Date: 09/19/2023
Desc: Expand existing WTP to 5.0 MGD
Class: 5 (-50% to +100%)
Timeframe: 2024 - 2025

Item	Unit	Quantity	Unit Cost	Installation %	Installation $	Item Cost
Taste & Odor Control						
PAC Feed Pumps	EA	2	$15,000	40%	$6,000	$42,000
Filtration - Add 1 MGD Membrane Filtration						
Process/Operations Building (~1,800 SF)	SF	1,800	$275	20%	$55	$594,000
Process Water Ultra Filters	EA	1	$830,000	40%	$332,000	$1,162,000
High Service Pumps						
Upgrade high service pump impeller for firm capacity at 5.0 MGD	EA	3	$44,000	30%	$13,200	$172,000
Office Building						
New Admin Builidng (~1,000 SF)	SF	1,000	$275	20%	$55	$330,000
Equipment/ Materials Subtotal						***$2,300,000***
Electrical, Sitework, and Demolition						
Electrical I&C (45%)	LS	1	$1,035,000	N/A		$1,040,000
Sitework (15%)	LS	1	$345,000	N/A		$345,000
Piping, Valves and Appurtenances (15%)	LS	1	$345,000	N/A		$345,000
Subtotal Equipment and Labor						**$4,030,000**
Contractor Markups						
Contracts/Bonds/Insurance (3%)	LS	1	$120,900	N/A		$121,000
Mobilization/Demobilization (2%)	LS	1	$80,600	N/A		$81,000
Contractor Superintendence (8%)	LS	1	$322,400	N/A		$323,000
Overhead and Profit (18%)	LS	1	$725,400	N/A		$726,000
Subtotal Pre-Contingency Construction Cost						**$5,281,000**
Contingency (30%)	LS	1	$1,584,300	N/A		$1,585,000
Subtotal Construction Cost						**$6,866,000**
Engineering Design & Services During Construction (20%)	LS	1	$1,373,200	N/A		$1,374,000
Project Total	**$8,240,000**					
Class V Cost Range	**$4,120,000**		**$16,480,000**			

Note:

1. Project total rounded to the nearest $1,000

TETRA TECH

Project: Chemical Feed Improvement Project
PN: WTP-4
Date: 05/11/2023
Desc: Improvements to controls, monitoring, storage and dosing chemicals
Class: 5 (-50% to +100%)
Timeframe: 2025 - 2026

Item	Unit	Quantity	Unit Cost	Installation %	Installation $	Item Cost
Chemical flow meters and alarms (polymer, disinfection, corrosion control)	EA	8	$5,000	20%	$1,000	$48,000
Peristaltic pumps (NaOCl dosing)	EA	2	$15,000	40%	$6,000	$42,000
FRP tank, 2,000 gal (NaOCl storage)	EA	2	$33,000	20%	$6,600	$80,000
PAC feed hopper	EA	1	$20,000	30%	$6,000	$26,000
Automation	LS	1	$50,000		$0	$50,000
Equipment/ Materials Subtotal						***$246,000***
Electrical, Sitework, and Demolition						
Electrical I&C (30%)	LS	1	$73,800	N/A		$80,000
Demolition (10%)	LS	1	$24,600	N/A		$25,000
Piping, Valves and Appurtenances (5%)	LS	1	$12,300	N/A		$13,000
Subtotal Equipment and Labor						**$364,000**
Contractor Markups						
Contracts/Bonds/Insurance (3%)	LS	1	$10,920	N/A		$11,000
Contractor Superintendence (8%)	LS	1	$29,120	N/A		$30,000
Overhead and Profit (18%)	LS	1	$65,520	N/A		$66,000
Subtotal Pre-Contingency Construction Cost						**$471,000**
Contingency (30%)	LS	1	$141,300	N/A		$142,000
Subtotal Construction Cost						**$613,000**
Engineering Design & Services During Construction (10%)	LS	1	$61,300	N/A		$62,000
Project Total	**$675,000**					
Class V Cost Range	**$337,500**		**$1,350,000**			

Note:

1. Project total rounded to the nearest $1,000

TETRA TECH

Project: Pretreatment Improvement Project
PN: WTP-5
Date: 05/11/2023
Desc: Improvements to mixing in the rapid mix and flocculation basins.
Class: 5 (-50% to +100%)
Timeframe: 2025 - 2026

Item	Unit	Quantity	Unit Cost	Installation %	Installation $	Item Cost
VFD control (Floccuation: Stage 1 and 2)	EA	4	$3,000	20%	$600	$15,000
VFD control (Rapid Mix Basin)	EA	1	$5,000	20%	$1,000	$6,000
Antivortex baffles (Rapid Mix Basin)	Unit	1	$5,000	30%	$1,500	$7,000
PLC Replacement	Unit	1	$70,000	10%	$7,000	$77,000
Equipment/ Materials Subtotal						***$105,000***
Electrical, Sitework, and Demolition						
Electrical I&C (30%)	LS	1	$31,500	N/A		$40,000
Subtotal Equipment and Labor						**$145,000**
Contractor Markups						
Contracts/Bonds/Insurance (3%)	LS	1	$4,350	N/A		$5,000
Contractor Superintendence (8%)	LS	1	$11,600	N/A		$12,000
Overhead and Profit (18%)	LS	1	$26,100	N/A		$27,000
Subtotal Pre-Contingency Construction Cost						**$189,000**
Contingency (30%)	LS	1	$56,700	N/A		$57,000
Subtotal Construction Cost						**$246,000**
Engineering Design & Services During Construction (10%)	LS	1	$24,600	N/A		$25,000
Project Total	**$271,000**					
Class V Cost Range	**$135,500**		**$542,000**			

Note:
1. Project total rounded to the nearest $1,000

TETRA TECH

Project: New WTP
PN: WTP-6
Date: 09/19/2023
Desc: New 2.0 MGD water treatment plant
Class: 5 (-50% to +100%)
Timeframe: 2025 - 2028

Item	Unit	Quantity	Unit Cost	Installation %	Installation $	Item Cost
Treatment Process						
Process/Operations Building (~16,000 SF)	SF	16,000	$275	20%	$55	$5,280,000
Process Water Micron Filters	EA	2	$188,000	20%	$37,600	$452,000
High Pressure Pumps and Cans	EA	3	$611,000	20%	$122,200	$2,200,000
High Pressure Pump Cans (Future Pumps)	EA	2	$67,000	20%	$13,400	$161,000
Membrane Treatment Skids	EA	2	$1,728,000	20%	$345,600	$4,148,000
Process Piping (Skids & Building SS)	LS	1	$507,000	20%	$101,400	$609,000
Blending Basin/Wetwell	LS	1	$220,000	20%	$44,000	$264,000
Transfer Pumps	EA	3	$172,000	20%	$34,400	$620,000
Degasifiers and Blowers	EA	2	$660,000	20%	$132,000	$1,584,000
Exhaust Blowers and Stack	LS	1	$205,000	20%	$41,000	$246,000
Emergency Generator with ATS & Enclosure	LS	1	$446,000	20%	$89,200	$536,000
Fuel Storage	LS	1	$50,000	20%	$10,000	$60,000
Fuel Piping and Appurtenances	LS	1	$14,000	20%	$2,800	$17,000
Cleaning System	LS	1	$155,000	20%	$31,000	$186,000
Laboratory Casework	LS	1	$20,000	20%	$4,000	$24,000
Miscellaneous Metals	LS	1	$193,000	20%	$38,600	$232,000
Pump Room Bridge Crane	LS	1	$55,000	20%	$11,000	$66,000
Septic Tank	LS	1	$78,000	20%	$15,600	$94,000
Neutralization Station	LS	1	$89,000	20%	$17,800	$107,000
Sodium Hydroxide Feed System	LS	1	$110,000	20%	$22,000	$132,000
Sulfuric Acid Feed System	LS	1	$110,000	20%	$22,000	$132,000
Antiscalant Feed System	LS	1	$45,000	20%	$9,000	$54,000
Chlorine Building (~1200 SF)	LS	1	$220,000	20%	$44,000	$264,000
Chlorine Room Bridge Crane	LS	1	$83,000	20%	$16,600	$100,000
Chlorine Feed System	LS	1	$110,000	20%	$22,000	$132,000
Ammonia Feed System	LS	1	$45,000	20%	$9,000	$54,000
Phosphate Feed System	LS	1	$40,000	20%	$8,000	$48,000
Yard Piping						
Finished Water Piping	LS	1	$177,000	20%	$35,400	$213,000
Neutralization Piping	LS	1	$28,000	20%	$5,600	$34,000
Minor Piping	LS	1	$110,000	20%	$22,000	$132,000
Chemical Feed Piping	LS	1	$45,000	20%	$9,000	$54,000
Concentrate Piping	LS	1	$78,000	20%	$15,600	$94,000
Permeate Blending Facilities						
2 MG Storage Tank	LS	1	$1,760,000	20%	$352,000	$2,112,000
RO Permeate Transfer Pumps	EA	2	$155,000	20%	$31,000	$372,000
Permeate Basin	LS	1	$50,000	20%	$10,000	$60,000
Permeate Piping	LS	1	$260,000	20%	$52,000	$312,000
Concentrate Disposal						
Deep Injection Well	LS	1	$4,730,000	20%	$946,000	$5,676,000
Dual Zone Monitoring Well	LS	1	$1,210,000	20%	$242,000	$1,452,000
Equipment/ Materials Subtotal						***$28,313,000***
Electrical, Sitework, and Demolition						
Electrical I&C (45%)	LS	1	$3,207,600	N/A		$3,210,000
Sitework (15%)	LS	1	$1,069,200	N/A		$1,070,000
Piping, Valves and Appurtenances (15%)	LS	1	$1,069,200	N/A		$1,070,000
Subtotal Equipment and Labor						**$33,663,000**
Contractor Markups						
Contracts/Bonds/Insurance (3%)	LS	1	$1,009,890	N/A		$1,010,000
Mobilization/Demobilization (2%)	LS	1	$673,260	N/A		$674,000
Contractor Superintendence (8%)	LS	1	$2,693,040	N/A		$2,694,000
Overhead and Profit (18%)	LS	1	$6,059,340	N/A		$6,060,000
Subtotal Pre-Contingency Construction Cost						**$44,101,000**
Contingency (30%)	LS	1	$13,230,300	N/A		$13,231,000
Subtotal Construction Cost						**$57,332,000**
Engineering Design & Services During Construction (20%)	LS	1	$11,466,400	N/A		$11,467,000
Project Total				**$68,799,000**		
Class V Cost Range		**$34,399,500**			**$137,598,000**	

Note:
1. Project total rounded to the nearest $1,000

TETRA TECH

Project: Network & Cybersecurity Upgrades
PN: WTP-7
Date: 05/11/2023
Desc: Securing existing ICS and SCADA equipment
Class: 5 (-50% to +100%)
Timeframe: 2023 - 2024

Item	Unit	Quantity	Unit Cost	Installation %	Installation $	Item Cost
Firewall w/ MFA	LS	1	$4,550	20%	$910	$6,000
Front End Processor (FEP)	LS	1	$10,000	20%	$2,000	$12,000
Remote Access Jump Box	LS	1	$2,500	20%	$500	$3,000
Integration	LS	1	$4,800	0%	$0	$5,000
Network Enclosure	ea	1	$1,000	20%	$200	$2,000
Security Logging	LS	1	$3,000	0%	$0	$3,000
SCADA Server Config Evaluation	LS	1	$2,400	0%	$0	$3,000
Equipment/ Materials Subtotal						***$34,000***
Electrical, Sitework, and Demolition						
Electrical I&C (30%)	LS	1	$10,200	N/A		$20,000
Subtotal Equipment and Labor						**$54,000**
Contractor Markups						
Contracts/Bonds/Insurance (3%)	LS	1	$1,620	N/A		$2,000
Mobilization/Demobilization (2%)	LS	1	$1,080	N/A		$2,000
Contractor Superintendence (8%)	LS	1	$4,320	N/A		$5,000
Overhead and Profit (18%)	LS	1	$9,720	N/A		$10,000
Subtotal Pre-Contingency Construction Cost						**$73,000**
Contingency (30%)	LS	1	$21,900	N/A		$22,000
Subtotal Construction Cost						**$95,000**
Engineering Design & Services During Construction (20%)	LS	1	$19,000	N/A		$19,000
Project Total	**$114,000**					
Class V Cost Range	**$57,000**		**$228,000**			

Note:

1. Project total rounded to the nearest $1,000

TETRA TECH

Project: WWC-1: First Street Parallel Sewer
PN: WWC-1
Date: 05/10/23
Desc: 15" to 30" Trunk Sewer to relieve flow off of the First Street sewer and collect future developments on the east side of town.
Class: 5 (-50% to +100%)
Timeframe: 2024-2025

Item	Unit	Quantity	Unit Cost	Item Cost
30" PVC SDR-35	LF	9,989	$600	$5,993,400
18" PVC SDR-35	LF	7,624	$360	$2,744,640
15" PVC SDR-35	LF	1,657	$300	$497,100
60" Manholes	EA	25	$12,000	$299,670
48" Manholes	EA	23	$9,000	$208,823
Testing and Commissioning	LS	1	$240,875	$240,875
Asphalt Replacement	SY	5,689	$80	$455,111
Equipment/ Materials Subtotal				***$10,440,000***
Electrical, Sitework, and Demolition				
Electrical I&C (30%)	LS	0	$3,131,886	$0
Sitework (15%)	LS	1	$1,565,943	$1,566,000
Demolition (20%)	LS	0	$2,087,924	$0
Piping, Valves and Appurtenances (20%)	LS	0	$2,087,924	$0
Subtotal Equipment and Labor				**$12,006,000**
Contractor Markups				
Contracts/Bonds/Insurance (3%)	LS	1	$360,180	$361,000
Mobilization/Demobilization (2%)	LS	1	$240,120	$241,000
Contractor Superintendence (8%)	LS	1	$960,480	$961,000
Overhead and Profit (18%)	LS	1	$2,161,080	$2,162,000
Subtotal Pre-Contingency Construction Cost				**$15,731,000**
Contingency (30%)	LS	1	$4,719,300	$4,720,000
Subtotal Construction Cost				**$20,451,000**
Engineering Design & Services During Construction (20%)	LS	1	$4,090,200	$4,091,000
Project Total	**$24,542,000**			
Class V Cost Range	**$12,271,000**		**$49,084,000**	

Note:

1. Project total rounded to the nearest $1,000

TETRA TECH

Project: WWC-2: Little Thompson Trunk Sewer
PN: WWC-2
Date: 05/10/23
Desc: 30"-42" Trunk Sewer along the Little Thompson River feeding the Berthoud Main WWTP
Class: 5 (-50% to +100%)
Timeframe: 2028-2029

Item	Unit	Quantity	Unit Cost	Item Cost
42" PVC SDR-35	LF	1,914	$840	$1,607,760
30" PVC SDR-35	LF	3,064	$600	$1,838,400
60" Manholes	EA	12	$12,000	$149,340
Testing and Commissioning	LS	1	$62,225	$62,225
Gravel Road Replacement	SY	2,222	$12	$26,667
Equipment/ Materials Subtotal				***$3,685,000***
Electrical, Sitework, and Demolition				
Electrical I&C (30%)	LS	0	$1,105,318	$0
Sitework (15%)	LS	1	$552,659	$553,000
Demolition (20%)	LS	0	$736,878	$0
Piping, Valves and Appurtenances (20%)	LS	0	$736,878	$0
Subtotal Equipment and Labor				**$4,238,000**
Contractor Markups				
Contracts/Bonds/Insurance (3%)	LS	1	$127,140	$128,000
Mobilization/Demobilization (2%)	LS	1	$84,760	$85,000
Contractor Superintendence (8%)	LS	1	$339,040	$340,000
Overhead and Profit (18%)	LS	1	$762,840	$763,000
Subtotal Pre-Contingency Construction Cost				**$5,554,000**
Contingency (30%)	LS	1	$1,666,200	$1,667,000
Subtotal Construction Cost				**$7,221,000**
Engineering Design & Services During Construction (20%)	LS	1	$1,444,200	$1,445,000
Project Total	**$8,666,000**			
Class V Cost Range	**$4,333,000**		**$17,332,000**	

Note:

1. Project total rounded to the nearest $1,000

TETRA TECH

Project: WWC-3: Bomar Lift Station Upgrade
PN: WWC-3
Date: 05/10/23
Desc: Upgrades to the aging Bomar Lift Station, includes electrical panel upgrade
Class: 5 (-50% to +100%)
Timeframe: 2028

Item	Unit	Quantity	Unit Cost	Item Cost
Submersible Pump, 85 gpm	EA	2	$20,000	$40,000
VFD Starters	EA	2	$8,000	$16,000
72" Precast Manhole	EA	1	$16,000	$16,000
Pump Access Hatch	EA	1	$2,000	$2,000
New Generator	EA	1	$20,000	$20,000
Testing and Commissioning	LS	1	$20,000	$20,000
Equipment/ Materials Subtotal				***$114,000***
Electrical, Sitework, and Demolition				
Electrical I&C (30%)	LS	1	$34,200	$40,000
Sitework (15%)	LS	1	$17,100	$18,000
Demolition (20%)	LS	1	$22,800	$23,000
Piping, Valves and Appurtenances (20%)	LS	0	$22,800	$0
Subtotal Equipment and Labor				**$195,000**
Contractor Markups				
Contracts/Bonds/Insurance (3%)	LS	1	$5,850	$6,000
Mobilization/Demobilization (2%)	LS	1	$3,900	$4,000
Contractor Superintendence (8%)	LS	1	$15,600	$16,000
Overhead and Profit (18%)	LS	1	$35,100	$36,000
Subtotal Pre-Contingency Construction Cost				**$257,000**
Contingency (30%)	LS	1	$77,100	$78,000
Subtotal Construction Cost				**$335,000**
Engineering Design & Services During Construction (20%)	LS	1	$67,000	$67,000
Project Total	**$402,000**			
Class V Cost Range	**$201,000**		**$804,000**	

Note:

1. Project total rounded to the nearest $1,000

TETRA TECH

Project: WWC-4: Berthoud Parkway Trunk Sewer Upgrade
PN: WWC-4
Date: 05/10/23
Desc: An existing 12" sewer along Berthoud Parkway will be upsized to 18"
Class: 5 (-50% to +100%)
Timeframe: 2031-2032

Item	Unit	Quantity	Unit Cost	Item Cost
18" PVC SDR-35	LF	1,843	$360	$663,480
48" Manholes	EA	5	$9,000	$41,468
Testing and Commissioning	LS	1	$23,038	$23,038
Asphalt Replacement	SY	1,638	$80	$131,058
Equipment/ Materials Subtotal				***$860,000***
Electrical, Sitework, and Demolition				
Electrical I&C (30%)	LS	0	$257,713	$0
Sitework (15%)	LS	1	$128,856	$129,000
Demolition (20%)	LS	1	$171,809	$172,000
Piping, Valves and Appurtenances (20%)	LS	0	$171,809	$0
Subtotal Equipment and Labor				**$1,161,000**
Contractor Markups				
Contracts/Bonds/Insurance (3%)	LS	1	$34,830	$35,000
Mobilization/Demobilization (2%)	LS	1	$23,220	$24,000
Contractor Superintendence (8%)	LS	1	$92,880	$93,000
Overhead and Profit (18%)	LS	1	$208,980	$209,000
Subtotal Pre-Contingency Construction Cost				**$1,522,000**
Contingency (30%)	LS	1	$456,600	$457,000
Subtotal Construction Cost				**$1,979,000**
Engineering Design & Services During Construction (20%)	LS	1	$395,800	$396,000
Project Total	**$2,375,000**			
Class V Cost Range	**$1,187,500**		**$4,750,000**	

Note:

1. Project total rounded to the nearest $1,000

TETRA TECH

Project: WWC5: Regional WWTF Influent Pump Station Upgrades, Phase 1
PN: WWC-5
Date: 05/10/23
Desc: New submersible pumps to handle increased flows from Turion. Upgrade to 0.6 MGD
Class: 5 (-50% to +100%)
Timeframe: 2033

Item	Unit	Quantity	Unit Cost	Item Cost
Submersible Pump, 420 gpm	EA	2	$100,000	$200,000
VFD Starters	EA	2	$20,000	$40,000
Testing and Commissioning	LS	1	$20,000	$20,000
Equipment/ Materials Subtotal				***$260,000***
Electrical, Sitework, and Demolition				
Electrical I&C (30%)	LS	1	$78,000	$80,000
Sitework (15%)	LS	1	$39,000	$39,000
Demolition (20%)	LS	1	$52,000	$52,000
Piping, Valves and Appurtenances (20%)	LS	1	$52,000	$52,000
Subtotal Equipment and Labor				**$483,000**
Contractor Markups				
Contracts/Bonds/Insurance (3%)	LS	1	$14,490	$15,000
Mobilization/Demobilization (2%)	LS	1	$9,660	$10,000
Contractor Superintendence (8%)	LS	1	$38,640	$39,000
Overhead and Profit (18%)	LS	1	$86,940	$87,000
Subtotal Pre-Contingency Construction Cost				**$634,000**
Contingency (30%)	LS	1	$190,200	$191,000
Subtotal Construction Cost				**$825,000**
Engineering Design & Services During Construction (20%)	LS	1	$165,000	$165,000
Project Total	**$990,000**			
Class V Cost Range	**$495,000**		**$1,980,000**	

Note:

1. Project total rounded to the nearest $1,000

TETRA TECH

Project: WWC-6: Turion Trunk Sewer, Phase 1
PN: WWC-6
Date: 05/10/23
Desc: `
Class: 5 (-50% to +100%)
Timeframe: 2039-2040

Item	Unit	Quantity	Unit Cost	Item Cost
18" PVC SDR-35	LF	2,932	$360	$1,055,520
48" Manholes	EA	7	$9,000	$65,970
Testing and Commissioning	LS	1	$36,650	$36,650
Asphalt Replacement	SY	27	$80	$2,133
Equipment/ Materials Subtotal				***$1,161,000***
Electrical, Sitework, and Demolition				
Electrical I&C (30%)	LS	0	$348,082	$0
Sitework (15%)	LS	1	$174,041	$175,000
Demolition (20%)	LS	0	$232,055	$0
Piping, Valves and Appurtenances (20%)	LS	0	$232,055	$0
Subtotal Equipment and Labor				**$1,336,000**
Contractor Markups				
Contracts/Bonds/Insurance (3%)	LS	1	$40,080	$41,000
Mobilization/Demobilization (2%)	LS	1	$26,720	$27,000
Contractor Superintendence (8%)	LS	1	$106,880	$107,000
Overhead and Profit (18%)	LS	1	$240,480	$241,000
Subtotal Pre-Contingency Construction Cost				**$1,752,000**
Contingency (30%)	LS	1	$525,600	$526,000
Subtotal Construction Cost				**$2,278,000**
Engineering Design & Services During Construction (20%)	LS	1	$455,600	$456,000
Project Total	**$2,734,000**			
Class V Cost Range	**$1,367,000**		**$5,468,000**	

Note:

1. Project total rounded to the nearest $1,000

TETRA TECH

Project: WWC-7: Turion Trunk Sewer, Phase 2
PN: WWC-7
Date: 05/10/23
Desc: 15" Trunk Sewer upstream of Little Thompson siphon and discharging to the Regional WWTP Influent Lift Station
Class: 5 (-50% to +100%)
Timeframe: 2040-2041

Item	Unit	Quantity	Unit Cost	Item Cost
15" PVC SDR-35	LF	2,550	$300	$765,000
48" Manholes	EA	6	$9,000	$57,375
Testing and Commissioning	LS	1	$31,875	$31,875
Equipment/ Materials Subtotal				***$855,000***
Electrical, Sitework, and Demolition				
Electrical I&C (30%)	LS	0	$256,275	$0
Sitework (15%)	LS	1	$128,138	$129,000
Demolition (20%)	LS	0	$170,850	$0
Piping, Valves and Appurtenances (20%)	LS	0	$170,850	$0
Subtotal Equipment and Labor				**$984,000**
Contractor Markups				
Contracts/Bonds/Insurance (3%)	LS	1	$29,520	$30,000
Mobilization/Demobilization (2%)	LS	1	$19,680	$20,000
Contractor Superintendence (8%)	LS	1	$78,720	$79,000
Overhead and Profit (18%)	LS	1	$177,120	$178,000
Subtotal Pre-Contingency Construction Cost				**$1,291,000**
Contingency (30%)	LS	1	$387,300	$388,000
Subtotal Construction Cost				**$1,679,000**
Engineering Design & Services During Construction (20%)	LS	1	$335,800	$336,000
Project Total	**$2,015,000**			
Class V Cost Range	**$1,007,500**		**$4,030,000**	

Note:

1. Project total rounded to the nearest $1,000

TETRA TECH

Project: WRF-1: Phase 1A Improvements
PN: WRF-1
Date: 05/10/2023
Desc: BNR Upgrades for VIP Credits and Selenium Reduction
Class: 5 (-50% to +100%)
Timeframe: 2023-2028 (Start: 2023)

Item	Unit	Quantity	Unit Cost	Installation %	Installation $	Item Cost
ANA Basin	SF	3,000	$670	0%	$0	$2,010,000
Large Bubble Mixing + Enclosure	LS	1	$250,375	40%	$100,150	$351,000
Nitrate Probe	ea	2	$3,190	20%	$638	$8,000
Ammonia Probes	ea	2	$5,000	20%	$1,000	$12,000
ORP Analyzers	ea	2	$3,190	20%	$638	$8,000
1400 gpm Recessed Impeller RAS Pump	ea	2	$30,000	20%	$6,000	$72,000
1000 gpm MLR Pumps	ea	3	$20,000	20%	$4,000	$72,000
MLR Flow Meters	ea	3	$15,000	20%	$3,000	$54,000
Additional RAS/Influent Splitter for New Aeration Basins	SF	600	$670	0%	$0	$402,000
RAS Flow Meters	ea	2	$15,000	20%	$3,000	$36,000
Equipment/ Materials Subtotal						***$3,025,000***
Electrical, Sitework, and Demolition						
Electrical I&C (20%)	LS	1	$605,000	N/A		$610,000
Sitework (10%)	LS	1	$302,500	N/A		$303,000
Demolition (2%)	LS	1	$60,500	N/A		$61,000
Piping, Valves and Appurtenances (10%)	LS	1	$302,500	N/A		$303,000
Subtotal Equipment and Labor						**$4,302,000**
Contractor Markups						
Contracts/Bonds/Insurance (3%)	LS	1	$129,060	N/A		$130,000
Mobilization/Demobilization (2%)	LS	1	$86,040	N/A		$87,000
Contractor Superintendence (8%)	LS	1	$344,160	N/A		$345,000
Overhead and Profit (18%)	LS	1	$774,360	N/A		$775,000
Subtotal Pre-Contingency Construction Cost						**$5,639,000**
Contingency (30%)	LS	1	$1,691,700	N/A		$1,692,000
Subtotal Construction Cost						**$7,331,000**
Engineering Design & Services During Construction (20%)	LS	1	$1,466,200	N/A		$1,467,000
Project Total	**$8,798,000**					
Class V Cost Range	**$4,399,000**		**$17,596,000**			

Note:

1. Project total rounded to the nearest $1,000

TETRA TECH

Project: WRF-2: Phase 1B Improvements
PN: WRF-2
Date: 05/10/2023
Desc: Capacity expansion to 3.0 MGD
Class: 5 (-50% to +100%)
Timeframe: 2023-2028 (Start: 2025)

Item	Unit	Quantity	Unit Cost	Installation %	Installation $	Item Cost
3-Pass Aeration Basin	SF	3,150	$670	0%	$0	$2,111,000
ANA Basin	SF	1,500	$670	0%	$0	$1,005,000
Large Bubble Mixing + Enclosure	LS	1	$165,186	40%	$66,074	$232,000
Nitrate Probe	ea	1	$3,190	20%	$638	$4,000
Ammonia Probes	ea	1	$5,000	20%	$1,000	$6,000
ORP Analyzers	ea	1	$3,190	20%	$638	$4,000
750 gpm MLR Pumps	ea	1	$16,500	20%	$3,300	$20,000
Perforated Plate Mechanical Screen, 6 mm spacing	LS	1	$205,000	20%	$41,000	$246,000
60' Diameter Clarifier	SF	2,827	$670	0%	$0	$1,895,000
Clarifier Mechanism	ea	1	$461,855	20%	$92,371	$555,000
Replace Polymer Feed System (Skid and Pump)	ea	1	$25,818	20%	$5,164	$31,000
100 HP, 1430 SCFM High Speed Turbo Blower and Blower Control Upgrades	ea	3	$200,000	20%	$40,000	$720,000
1400 GPM Submersible Dry Pit Pumps	ea	2	$30,000	0%	$0	$60,000
Multidirectional Biosolids Shoot Allowance	LS	1	$50,000	0%	$0	$50,000
RAS Weir Gate Replacement Allowance	LS	1	$60,000	0%	$0	$60,000
Building Drainage Improvements Allowance	LS	1	$50,000	0%	$0	$50,000
Equipment/ Materials Subtotal						***$7,049,000***
Electrical, Sitework, and Demolition						
Electrical I&C (30%)	LS	1	$2,114,700	N/A		$2,120,000
Sitework (20%)	LS	1	$1,409,800	N/A		$1,410,000
Demolition (2%)	LS	1	$140,980	N/A		$141,000
Piping, Valves and Appurtenances (15%)	LS	1	$1,057,350	N/A		$1,058,000
Subtotal Equipment and Labor						**$11,778,000**
Contractor Markups						
Contracts/Bonds/Insurance (3%)	LS	1	$353,340	N/A		$354,000
Mobilization/Demobilization (2%)	LS	1	$235,560	N/A		$236,000
Contractor Superintendence (8%)	LS	1	$942,240	N/A		$943,000
Overhead and Profit (18%)	LS	1	$2,120,040	N/A		$2,121,000
Subtotal Pre-Contingency Construction Cost						**$15,432,000**
Contingency (30%)	LS	1	$4,629,600	N/A		$4,630,000
Subtotal Construction Cost						**$20,062,000**
Engineering Design & Services During Construction (20%)	LS	1	$4,012,400	N/A		$4,013,000
Project Total	**$24,075,000**					
Class V Cost Range	**$12,037,500**		**$48,150,000**			

Note:

1. Project total rounded to the nearest $1,000

TETRA TECH

Project: WRF-3: Phase 2 Improvements
PN: WRF-3
Date: 05/10/2023
Desc: Regulation 31 Improvements and Capacity Expansion to 4.0 MGD
Class: 5 (-50% to +100%)
Timeframe: 2033-2038 (Start 2037)

Item	Unit	Quantity	Unit Cost	Installation %	Installation $	Item Cost
Anoxic MBBR Equipment	LS	1	$2,000,000	20%	$400,000	$2,400,000
Anoxic MBBR Basin	SF	4,000	$670	0%	$0	$2,680,000
Carbon Storage Tanks	ea	2	$29,201	20%	$5,840	$71,000
Chemical Feed Pumps and Skids	ea	4	$23,891	20%	$4,778	$115,000
Tertiary Treatment for Chem-P (Coag/Flocc/Sed/Filtration)	LS	1	$3,425,389	30%	$1,027,617	$4,454,000
UV Equipment for Bypass Channel	LS	1	$162,193	25%	$40,548	$203,000
60' Diameter Clarifier	SF	2,827	$670	0%	$0	$1,895,000
Clarifier Mechanism	ea	1	$461,855	20%	$92,371	$555,000
100 HP, 1430 SCFM High Speed Turbo Blower	ea	1	$200,000	20%	$40,000	$240,000
5 HP, 100 gpm Scum Pump	ea	2	$3,000	20%	$600	$8,000
3-Pass Aeration Basin	SF	3,150	$670	0%	$0	$2,111,000
ANA Basin	SF	1,500	$670	0%	$0	$1,005,000
Floating Mixers	ea	1	$25,000	20%	$5,000	$30,000
Nitrate Probe	ea	1	$3,190	20%	$638	$4,000
Ammonia Probes	ea	1	$5,000	20%	$1,000	$6,000
ORP Analyzers	ea	1	$3,190	20%	$638	$4,000
1400 gpm Recessed Impeller RAS Pump	ea	1	$30,000	20%	$6,000	$36,000
700 gpm Recessed Impeller RAS Pump	ea	2	$16,000	20%	$3,200	$39,000
750 gpm MLR Pumps	ea	1	$16,500	0%	$0	$17,000
MLR Flow Meters	ea	3	$15,000	20%	$3,000	$54,000
Solids Handling Expansion Allowance - Conversion to Aerated Sludge Holding	LS	1	$200,000	0%	$0	$200,000
Large Bubble Mixing + Enclosure	LS	1	$165,186	40%	$66,074	$232,000
Equipment/ Materials Subtotal						***$16,359,000***
Electrical, Sitework, and Demolition						
Electrical I&C (20%)	LS	1	$3,185,400	N/A		$3,190,000
Sitework (15%)	LS	1	$2,389,050	N/A		$2,390,000
Demolition (2%)	LS	1	$318,540	N/A		$319,000
Piping, Valves and Appurtenances (10%)	LS	1	$1,592,700	N/A		$1,593,000
Subtotal Equipment and Labor						**$23,851,000**
Contractor Markups						
Contracts/Bonds/Insurance (3%)	LS	1	$715,530	N/A		$716,000
Mobilization/Demobilization (2%)	LS	1	$477,020	N/A		$478,000
Contractor Superintendence (8%)	LS	1	$1,908,080	N/A		$1,909,000
Overhead and Profit (18%)	LS	1	$4,293,180	N/A		$4,294,000
Subtotal Pre-Contingency Construction Cost						**$31,248,000**
Contingency (30%)	LS	1	$9,374,400	N/A		$9,375,000
Subtotal Construction Cost						**$40,623,000**
Engineering Design & Services During Construction (20%)	LS	1	$8,124,600	N/A		$8,125,000
Project Total	**$48,748,000**					
Class V Cost Range	**$24,374,000**		**$97,496,000**			

Note:

1. Project total rounded to the nearest $1,000

TETRA TECH

Project: WRF-4: Network & Cyber Security Updates
PN: WRF-4
Date: 05/10/2023
Desc: Securing existing ICS and SCADA equipment
Class: 5 (-50% to +100%)
Timeframe: Immediate

Item	Unit	Quantity	Unit Cost	Installation %	Installation $	Item Cost
Firewall w/ MFA	LS	1	$4,550	20%	$910	$6,000
Front End Processor (FEP)	LS	1	$10,000	20%	$2,000	$12,000
Remote Access Jump Box (TS and licensing)	LS	1	$2,500	20%	$500	$3,000
Integration - configuration of Firewall and Jump Box	LS	1	$4,800	0%	$0	$5,000
Network Enclosure	ea	1	$1,000	20%	$200	$2,000
Security Logging	LS	1	$3,000	0%	$0	$3,000
SCADA Server Config Evaluation	LS	1	$2,400	0%	$0	$3,000
Equipment/ Materials Subtotal						***$34,000***
Electrical, Sitework, and Demolition						
Electrical I&C (30%)	LS	1	$10,200	N/A		$20,000
Subtotal Equipment and Labor						**$54,000**
Contractor Markups						
Contracts/Bonds/Insurance (3%)	LS	1	$1,620	N/A		$2,000
Mobilization/Demobilization (2%)	LS	1	$1,080	N/A		$2,000
Contractor Superintendence (8%)	LS	1	$4,320	N/A		$5,000
Overhead and Profit (18%)	LS	1	$9,720	N/A		$10,000
Subtotal Pre-Contingency Construction Cost						**$73,000**
Contingency (30%)	LS	1	$21,900	N/A		$22,000
Subtotal Construction Cost						**$95,000**
Engineering Design & Services During Construction (20%)	LS	1	$19,000	N/A		$19,000
Project Total			**$114,000**			
Class V Cost Range	**$57,000**		**$228,000**			

Note:

1. Project total rounded to the nearest $1,000

TETRA TECH

Project: WRF-5: Plant Wide PLC Replacements
PN: WRF-5
Date: 05/10/2023
Desc: Replacing all PLCs at Berthoud WRF
Class: 5 (-50% to +100%)
Timeframe: Immediate

Item	Unit	Quantity	Unit Cost	Installation %	Installation $	Item Cost
Headworks	LS	1	$40,000	10%	$4,000	$44,000
IPS	LS	1	$50,000	10%	$5,000	$55,000
Grinder	LS	1	$20,000	10%	$2,000	$22,000
Blowers	LS	1	$100,000	10%	$10,000	$110,000
Digesters	LS	1	$75,000	10%	$7,500	$83,000
Plant Reuse	LS	1	$40,000	10%	$4,000	$44,000
Equipment/ Materials Subtotal						***$314,000***
Electrical, Sitework, and Demolition						
Electrical I&C (15%)	LS	0	$53,700	N/A		$0
Sitework (0%)	LS	0	$0	N/A		$0
Demolition (15%)	LS	0	$53,700	N/A		$0
Piping, Valves and Appurtenances (0%)	LS	0	$0	N/A		$0
Subtotal Equipment and Labor						**$314,000**
Contractor Markups						
Contracts/Bonds/Insurance (3%)	LS	0	$9,420	N/A		$0
Mobilization/Demobilization (2%)	LS	0	$6,280	N/A		$0
Contractor Superintendence (8%)	LS	0	$25,120	N/A		$0
Overhead and Profit (18%)	LS	0	$56,520	N/A		$0
Subtotal Pre-Contingency Construction Cost						**$314,000**
Contingency (30%)	LS	1	$94,200	N/A		$95,000
Subtotal Construction Cost						**$409,000**
Engineering Design & Services During Construction (10%)	LS	0	$40,900	N/A		$0
Project Total	**$409,000**					
Class V Cost Range	**$204,500**		**$818,000**			

Note:

1. Project total rounded to the nearest $1,000

TETRA TECH

Project: WWTF-1: Phase 1 Improvements
PN: WWTF-1
Date: 05/10/2023
Desc: Capacity Expansion to 0.6 MGD
Class: 5 (-50% to +100%)
Timeframe: 2029-2034

Item	Unit	Quantity	Unit Cost	Installation %	Installation $	Item Cost
ICEAS Packaged Plant System	LS	1	$10,200,076	0%	$0	$10,201,000
Solids Handling Implementation Allowance - Aerated Sludge Holding	LS	1	$200,000	0%	$0	$200,000
Equipment/ Materials Subtotal						***$10,401,000***
Electrical, Sitework, and Demolition						
Electrical I&C (0%)	LS	1	$0	N/A		$0
Sitework (0%)	LS	1	$0	N/A		$0
Demolition (0%)	LS	1	$0	N/A		$0
Piping, Valves and Appurtenances (0%)	LS	1	$0	N/A		$0
Subtotal Equipment and Labor						**$10,401,000**
Contractor Markups						
Contracts/Bonds/Insurance (0%)	LS	1	$0	N/A		$0
Mobilization/Demobilization (0%)	LS	1	$0	N/A		$0
Contractor Superintendence (0%)	LS	1	$0	N/A		$0
Overhead and Profit (0%)	LS	1	$0	N/A		$0
Subtotal Pre-Contingency Construction Cost						**$10,401,000**
Contingency (30%)	LS	1	$3,120,300	N/A		$3,121,000
Subtotal Construction Cost						**$13,522,000**
Engineering Design & Services During Construction (20%)	LS	1	$2,704,400	N/A		$2,705,000
Project Total	**$16,227,000**					
Class V Cost Range	**$8,113,500**		**$32,454,000**			

Note:

1. Project total rounded to the nearest $1,000

TETRA TECH

Project: WWTF-2: Phase 2 Improvements
PN: WWTF-2
Date: 05/10/2023
Desc: Regulation 31 Improvements
Class: 5 (-50% to +100%)
Timeframe: 2026-2027

Item	Unit	Quantity	Unit Cost	Installation %	Installation $	Item Cost
Anoxic MBBR Equipment	LS	1	$500,000	20%	$100,000	$600,000
Tertiary Treatment for Chem-P (Coag/Flocc/Sed/Filtration)	LS	1	$1,663,346	30%	$499,004	$2,163,000
Chemical Storage and Feed Facility	SF	5,000	$270	0%	$0	$1,350,000
Anoxic MBBR Basin	SF	2,000	$670	$0	$0	$1,340,000
Carbon Storage Tanks	ea	2	$12,710	20%	$2,542	$31,000
Chemical Feed Pumps and Skids	ea	4	$10,399	20%	$2,080	$50,000
Equipment/ Materials Subtotal						***$5,534,000***
Electrical, Sitework, and Demolition						
Electrical I&C (30%)	LS	1	$1,660,200	N/A		$1,670,000
Sitework (15%)	LS	1	$830,100	N/A		$831,000
Demolition (2%)	LS	1	$110,680	N/A		$111,000
Piping, Valves and Appurtenances (10%)	LS	1	$553,400	N/A		$554,000
Subtotal Equipment and Labor						**$8,700,000**
Contractor Markups						
Contracts/Bonds/Insurance (3%)	LS	1	$261,000	N/A		$261,000
Mobilization/Demobilization (2%)	LS	1	$174,000	N/A		$174,000
Contractor Superintendence (8%)	LS	1	$696,000	N/A		$696,000
Overhead and Profit (18%)	LS	1	$1,566,000	N/A		$1,566,000
Subtotal Pre-Contingency Construction Cost						**$11,397,000**
Contingency (30%)	LS	1	$3,419,100	N/A		$3,420,000
Subtotal Construction Cost						**$14,817,000**
Engineering Design & Services During Construction (20%)	LS	1	$2,963,400	N/A		$2,964,000
Project Total	**$17,781,000**					
Class V Cost Range	**$8,890,500**		**$35,562,000**			

Note:

1. Project total rounded to the nearest $1,000

TETRA TECH

Project: WWTF-3: Security & Automation Upgrades
Date: 05/10/2023
PN: WWTF-3
Desc: Securing existing ICS and SCADA equipment
Class: 5 (-50% to +100%)
Timeframe: Immediate

Item	Unit	Quantity	Unit Cost	Installation %	Installation $	Item Cost
Firewall w/ MFA	LS	1	$4,550	20%	$910	$6,000
Integration into WRF SCADA (HMI Programming)	LS	1	$15,000	0%	$0	$15,000
Equipment/ Materials Subtotal						***$21,000***
Electrical, Sitework, and Demolition						
Electrical I&C (30%)	LS	0	$6,300	N/A		$0
Sitework (15%)	LS	0	$3,150	N/A		$0
Demolition (20%)	LS	0	$4,200	N/A		$0
Piping, Valves and Appurtenances (20%)	LS	0	$4,200	N/A		$0
Subtotal Equipment and Labor						**$21,000**
Contractor Markups						
Contracts/Bonds/Insurance (3%)	LS	0	$630	N/A		$0
Mobilization/Demobilization (2%)	LS	0	$420	N/A		$0
Contractor Superintendence (8%)	LS	0	$1,680	N/A		$0
Overhead and Profit (18%)	LS	0	$3,780	N/A		$0
Subtotal Pre-Contingency Construction Cost						**$21,000**
Contingency (30%)	LS	1	$6,300	N/A		$7,000
Subtotal Construction Cost						**$28,000**
Engineering Design & Services During Construction (20%)	LS	0	$5,600	N/A		$0
Project Total	**$28,000**					
Class V Cost Range	**$14,000**		**$56,000**			

Note:

1. Project total rounded to the nearest $1,000

APPENDIX D:
Individual Sewer Flow Meter Results

Event Start	Event End
11/2/2022	11/11/2022

Meter	MG
Brthd_300I-cfs	0.1377
Meter #3	0.0640
Meter #1	0.0294
Meter #2	0.0179
Meter #4	0.0113
Meter #6	0.0056
Brthd_Regional_300I-cfs	0.0024

Mass Balance:	
Sum Meters 2,3,4,6	*0.0988*
Brthd_300I-cfs	*0.1377*

IDs:	Brthd_300I-cfs	Brthd_Regional_300I-cfs
Date/Time	Flow	Flow
M/d/yyyy	cfs	cfs
11/3/2022	1.39	0.02
11/4/2022	1.39	0.02
11/5/2022	1.35	0.03
11/6/2022	1.39	0.03
11/7/2022	1.40	0.02
11/8/2022	1.36	0.02
11/9/2022	1.36	0.02
11/10/2022	1.36	0.02
11/11/2022	1.33	0.03

IDs:	Meter #1	Meter #2	Meter #3	Meter #4	Meter #6
Date/Time	Flow	Flow	Flow	Flow	Flow
M/d/yyyy	cfs	cfs	cfs	cfs	cfs
11/3/2022	0.31	0.16	0.69	0.07	0.07
11/3/2022	0.23	0.15	0.61	0.07	0.07
11/3/2022	0.23	0.11	0.61	0.07	0.06
11/3/2022	0.20	0.09	0.61	0.07	0.07
11/3/2022	0.22	0.08	0.54	0.07	0.07
11/3/2022	0.21	0.09	0.57	0.07	0.06
11/3/2022	0.16	0.11	0.56	0.06	0.06
11/3/2022	0.12	0.13	0.47	0.06	0.06
11/3/2022	0.21	0.11	0.49	0.06	0.01
11/3/2022	0.11	0.09	0.39	0.06	0.01
11/3/2022	0.17	0.08	0.46	0.06	0.01
11/3/2022	0.10	0.06	0.44	0.06	0.01
11/3/2022	0.14	0.06	0.40	0.06	0.01
11/3/2022	0.16	0.06	0.37	0.06	0.01
11/3/2022	0.09	0.05	0.41	0.06	0.01
11/3/2022	0.16	0.05	0.35	0.06	0.01
11/3/2022	0.12	0.05	0.33	0.06	0.01
11/3/2022	0.08	0.05	0.31	0.06	0.01
11/3/2022	0.15	0.05	0.26	0.05	0.01
11/3/2022	0.12	0.05	0.47	0.05	0.01
11/3/2022	0.10	0.06	0.41	0.05	0.01
11/3/2022	0.16	0.05	0.34	0.06	0.01
11/3/2022	0.11	0.06	0.35	0.06	0.01
11/3/2022	0.09	0.10	0.36	0.09	0.01
11/3/2022	0.19	0.14	0.30	0.07	0.01
11/3/2022	0.14	0.12	0.36	0.08	0.01
11/3/2022	0.20	0.14	0.41	0.09	0.01
11/3/2022	0.24	0.17	0.44	0.09	0.01
11/3/2022	0.21	0.19	0.42	0.12	0.01
11/3/2022	0.37	0.16	0.45	0.11	0.01
11/3/2022	0.30	0.18	0.50	0.12	0.01
11/3/2022	0.39	0.21	0.52	0.13	0.01
11/3/2022	0.47	0.20	0.62	0.13	0.01
11/3/2022	0.44	0.22	0.66	0.13	0.06
11/3/2022	0.38	0.22	0.73	0.12	0.06
11/3/2022	0.40	0.33	0.87	0.13	0.06
11/3/2022	0.41	0.32	0.78	0.12	0.05
11/3/2022	0.36	0.26	0.81	0.12	0.07
11/3/2022	0.39	0.21	0.98	0.12	0.04
11/3/2022	0.41	0.20	0.93	0.12	0.04
11/3/2022	0.35	0.21	0.72	0.11	0.07
11/3/2022	0.34	0.29	0.71	0.12	0.07
11/3/2022	0.36	0.25	0.67	0.12	0.06
11/3/2022	0.32	0.20	0.72	0.12	0.06
11/3/2022	0.30	0.19	0.80	0.12	0.06
11/3/2022	0.39	0.21	0.84	0.12	0.06
11/3/2022	0.34	0.27	0.73	0.11	0.06
11/3/2022	0.33	0.21	0.70	0.12	0.06
11/3/2022	0.35	0.21	0.62	0.12	0.06
11/3/2022	0.34	0.18	0.68	0.12	0.01
11/3/2022	0.31	0.15	0.67	0.12	0.01
11/3/2022	0.29	0.14	0.63	0.11	0.01
11/3/2022	0.29	0.15	0.66	0.13	0.01
11/3/2022	0.27	0.25	0.71	0.12	0.01
11/3/2022	0.33	0.20	0.68	0.13	0.01
11/3/2022	0.32	0.19	0.66	0.14	0.01
11/3/2022	0.31	0.17	0.61	0.13	0.01
11/3/2022	0.35	0.17	0.60	0.12	0.01
11/3/2022	0.24	0.14	0.57	0.11	0.01
11/3/2022	0.31	0.12	0.69	0.11	0.01
11/3/2022	0.33	0.13	0.64	0.12	0.01
11/3/2022	0.23	0.22	0.67	0.12	0.06
11/3/2022	0.36	0.19	0.60	0.13	0.06
11/3/2022	0.32	0.16	0.64	0.12	0.06
11/3/2022	0.26	0.14	0.61	0.11	0.01
11/3/2022	0.32	0.14	0.65	0.12	0.01
11/3/2022	0.31	0.15	0.73	0.11	0.01
11/3/2022	0.23	0.17	0.70	0.11	0.01
11/3/2022	0.35	0.17	0.66	0.11	0.01
11/3/2022	0.36	0.25	0.67	0.10	0.01
11/3/2022	0.35	0.23	0.80	0.11	0.01
11/3/2022	0.36	0.19	0.75	0.12	0.01
11/3/2022	0.40	0.19	0.70	0.12	0.04
11/3/2022	0.41	0.20	0.62	0.12	0.05
11/3/2022	0.42	0.22	0.68	0.12	0.06
11/3/2022	0.38	0.32	0.74	0.12	0.06
11/3/2022	0.44	0.28	0.69	0.12	0.06
11/3/2022	0.43	0.26	0.73	0.13	0.06
11/3/2022	0.38	0.26	0.72	0.13	0.06
11/3/2022	0.45	0.25	0.86	0.13	0.01
11/3/2022	0.49	0.23	0.78	0.13	0.01
11/3/2022	0.41	0.42	0.86	0.13	0.01
11/3/2022	0.48	0.32	0.74	0.13	0.01

11/3/2022	0.40	0.28	0.87	0.13	0.01
11/3/2022	0.45	0.28	0.84	0.12	0.01
11/3/2022	0.45	0.24	0.91	0.10	0.01
11/3/2022	0.39	0.27	0.85	0.11	0.01
11/3/2022	0.44	0.34	0.84	0.11	0.01
11/3/2022	0.42	0.27	0.84	0.10	0.01
11/3/2022	0.37	0.23	0.78	0.10	0.01
11/3/2022	0.32	0.19	0.92	0.10	0.01
11/3/2022	0.35	0.20	0.77	0.10	0.01
11/3/2022	0.32	0.18	0.70	0.10	0.01
11/3/2022	0.29	0.26	0.75	0.09	0.01
11/3/2022	0.32	0.18	0.80	0.10	0.01
11/3/2022	0.27	0.15	0.68	0.09	0.01
11/4/2022	0.26	0.14	0.64	0.08	0.01
11/4/2022	0.27	0.13	0.58	0.08	0.01
11/4/2022	0.17	0.11	0.63	0.07	0.01
11/4/2022	0.26	0.09	0.62	0.07	0.01
11/4/2022	0.20	0.16	0.56	0.08	0.01
11/4/2022	0.20	0.12	0.51	0.08	0.01
11/4/2022	0.17	0.11	0.48	0.07	0.01
11/4/2022	0.18	0.09	0.49	0.06	0.01
11/4/2022	0.11	0.08	0.48	0.06	0.01
11/4/2022	0.17	0.08	0.47	0.06	0.01
11/4/2022	0.11	0.06	0.46	0.07	0.01
11/4/2022	0.12	0.06	0.46	0.06	0.01
11/4/2022	0.16	0.06	0.44	0.06	0.01
11/4/2022	0.10	0.06	0.45	0.06	0.01
11/4/2022	0.13	0.06	0.36	0.06	0.01
11/4/2022	0.12	0.06	0.37	0.06	0.01
11/4/2022	0.08	0.05	0.40	0.06	0.01
11/4/2022	0.12	0.10	0.44	0.06	0.01
11/4/2022	0.14	0.10	0.35	0.06	0.01
11/4/2022	0.09	0.09	0.34	0.06	0.01
11/4/2022	0.15	0.08	0.33	0.06	0.01
11/4/2022	0.10	0.07	0.35	0.06	0.01
11/4/2022	0.09	0.07	0.39	0.06	0.01
11/4/2022	0.18	0.07	0.29	0.08	0.01
11/4/2022	0.15	0.08	0.33	0.08	0.01
11/4/2022	0.17	0.08	0.38	0.07	0.01
11/4/2022	0.20	0.10	0.34	0.09	0.01
11/4/2022	0.18	0.11	0.41	0.10	0.01
11/4/2022	0.29	0.15	0.46	0.11	0.01
11/4/2022	0.29	0.16	0.45	0.12	0.01
11/4/2022	0.32	0.16	0.61	0.12	0.01
11/4/2022	0.36	0.24	0.54	0.13	0.01
11/4/2022	0.40	0.23	0.59	0.13	0.05
11/4/2022	0.38	0.34	0.56	0.14	0.05
11/4/2022	0.42	0.28	0.81	0.13	0.06
11/4/2022	0.37	0.27	0.80	0.11	0.06
11/4/2022	0.38	0.22	0.70	0.13	0.06
11/4/2022	0.42	0.21	0.81	0.13	0.05
11/4/2022	0.37	0.20	0.94	0.13	0.06
11/4/2022	0.31	0.18	0.77	0.13	0.09
11/4/2022	0.39	0.28	0.80	0.12	0.07
11/4/2022	0.36	0.26	0.74	0.12	0.07
11/4/2022	0.29	0.25	0.83	0.13	0.07
11/4/2022	0.43	0.19	0.73	0.13	0.07
11/4/2022	0.57	0.19	0.75	0.13	0.07
11/4/2022	0.36	0.30	0.72	0.14	0.06
11/4/2022	0.23	0.27	1.26	0.12	0.07
11/4/2022	0.28	0.23	1.64	0.13	0.07
11/4/2022	0.46	0.20	1.31	0.13	0.07
11/4/2022	0.42	0.18	1.34	0.13	0.07
11/4/2022	0.26	0.25	1.52	0.12	0.07
11/4/2022	0.21	0.25	1.72	0.13	0.07
11/4/2022	0.24	0.19	1.38	0.13	0.07
11/4/2022	0.19	0.19	1.23	0.14	0.07
11/4/2022	0.33	0.19	1.01	0.13	0.07
11/4/2022	0.48	0.16	0.83	0.13	0.07
11/4/2022	0.27	0.15	0.76	0.13	0.07
11/4/2022	0.21	0.25	0.58	0.12	0.06
11/4/2022	0.31	0.20	0.61	0.13	0.06
11/4/2022	0.33	0.19	0.61	0.13	0.07
11/4/2022	0.26	0.17	0.74	0.14	0.07
11/4/2022	0.32	0.17	0.67	0.14	0.07
11/4/2022	0.33	0.15	0.73	0.13	0.06
11/4/2022	0.38	0.16	0.67	0.13	0.07
11/4/2022	0.30	0.24	0.73	0.12	0.07
11/4/2022	0.33	0.21	0.68	0.12	0.07
11/4/2022	0.36	0.20	0.77	0.13	0.07
11/4/2022	0.34	0.16	0.77	0.13	0.07
11/4/2022	0.30	0.15	0.77	0.13	0.07
11/4/2022	0.30	0.16	0.73	0.13	0.07
11/4/2022	0.36	0.28	0.71	0.12	0.06
11/4/2022	0.34	0.22	0.71	0.11	0.06
11/4/2022	0.37	0.22	0.73	0.12	0.06
11/4/2022	0.43	0.21	0.60	0.11	0.06

11/4/2022	0.33	0.19	0.63	0.12	0.06
11/4/2022	0.37	0.16	0.57	0.12	0.06
11/4/2022	0.37	0.23	0.63	0.12	0.06
11/4/2022	0.40	0.28	0.70	0.12	0.06
11/4/2022	0.38	0.27	0.72	0.12	0.07
11/4/2022	0.37	0.21	0.59	0.13	0.06
11/4/2022	0.41	0.23	0.64	0.12	0.06
11/4/2022	0.39	0.22	0.77	0.12	0.07
11/4/2022	0.43	0.20	0.75	0.13	0.07
11/4/2022	0.41	0.32	0.72	0.12	0.07
11/4/2022	0.37	0.26	0.79	0.12	0.07
11/4/2022	0.37	0.21	0.78	0.12	0.07
11/4/2022	0.32	0.20	0.74	0.11	0.07
11/4/2022	0.33	0.19	0.75	0.11	0.06
11/4/2022	0.36	0.17	0.74	0.10	0.08
11/4/2022	0.32	0.27	0.71	0.13	0.08
11/4/2022	0.31	0.23	0.74	0.11	0.07
11/4/2022	0.33	0.19	0.69	0.10	0.07
11/4/2022	0.32	0.18	0.65	0.09	0.07
11/4/2022	0.31	0.16	0.68	0.10	0.07
11/4/2022	0.28	0.15	0.82	0.09	0.07
11/4/2022	0.30	0.17	0.71	0.08	0.07
11/5/2022	0.26	0.22	0.64	0.08	0.07
11/5/2022	0.23	0.16	0.58	0.08	0.07
11/5/2022	0.26	0.12	0.60	0.09	0.07
11/5/2022	0.26	0.12	0.58	0.09	0.07
11/5/2022	0.19	0.10	0.55	0.08	0.01
11/5/2022	0.22	0.10	0.54	0.07	0.01
11/5/2022	0.17	0.08	0.50	0.07	0.01
11/5/2022	0.22	0.13	0.60	0.06	0.01
11/5/2022	0.14	0.14	0.49	0.07	0.01
11/5/2022	0.17	0.11	0.45	0.06	0.01
11/5/2022	0.15	0.11	0.48	0.07	0.01
11/5/2022	0.18	0.10	0.47	0.06	0.01
11/5/2022	0.13	0.08	0.52	0.06	0.01
11/5/2022	0.12	0.07	0.44	0.06	0.01
11/5/2022	0.14	0.07	0.38	0.06	0.01
11/5/2022	0.10	0.06	0.36	0.06	0.01
11/5/2022	0.15	0.06	0.46	0.06	0.01
11/5/2022	0.13	0.07	0.35	0.06	0.01
11/5/2022	0.09	0.06	0.38	0.06	0.01
11/5/2022	0.16	0.11	0.33	0.06	0.01
11/5/2022	0.12	0.12	0.34	0.07	0.01
11/5/2022	0.17	0.10	0.33	0.06	0.01
11/5/2022	0.14	0.09	0.33	0.06	0.01
11/5/2022	0.10	0.09	0.40	0.06	0.01
11/5/2022	0.15	0.07	0.37	0.07	0.01
11/5/2022	0.12	0.08	0.40	0.08	0.01
11/5/2022	0.13	0.07	0.41	0.08	0.01
11/5/2022	0.16	0.08	0.39	0.08	0.01
11/5/2022	0.12	0.09	0.45	0.09	0.01
11/5/2022	0.23	0.11	0.38	0.12	0.01
11/5/2022	0.16	0.10	0.47	0.10	0.01
11/5/2022	0.23	0.08	0.46	0.11	0.01
11/5/2022	0.18	0.12	0.41	0.13	0.01
11/5/2022	0.25	0.16	0.41	0.13	0.01
11/5/2022	0.25	0.16	0.46	0.15	0.01
11/5/2022	0.35	0.27	0.64	0.15	0.01
11/5/2022	0.34	0.30	0.55	0.15	0.01
11/5/2022	0.35	0.27	0.60	0.16	0.01
11/5/2022	0.38	0.29	0.76	0.16	0.06
11/5/2022	0.48	0.25	0.81	0.15	0.06
11/5/2022	0.50	0.27	0.74	0.16	0.05
11/5/2022	0.54	0.28	0.70	0.15	0.05
11/5/2022	0.55	0.30	0.71	0.16	0.06
11/5/2022	0.50	0.41	0.87	0.17	0.06
11/5/2022	0.56	0.32	0.91	0.17	0.06
11/5/2022	0.53	0.26	0.95	0.17	0.06
11/5/2022	0.53	0.24	0.99	0.18	0.07
11/5/2022	0.52	0.32	0.96	0.18	0.07
11/5/2022	0.57	0.38	0.92	0.18	0.08
11/5/2022	0.52	0.33	0.85	0.17	0.08
11/5/2022	0.47	0.26	0.95	0.17	0.08
11/5/2022	0.48	0.24	0.92	0.16	0.07
11/5/2022	0.49	0.23	0.81	0.17	0.07
11/5/2022	0.53	0.39	0.91	0.17	0.07
11/5/2022	0.50	0.31	0.83	0.16	0.07
11/5/2022	0.46	0.26	0.85	0.15	0.07
11/5/2022	0.48	0.22	0.75	0.17	0.07
11/5/2022	0.45	0.23	0.72	0.16	0.07
11/5/2022	0.42	0.33	0.87	0.15	0.08
11/5/2022	0.45	0.27	0.78	0.15	0.08
11/5/2022	0.41	0.23	0.79	0.17	0.09
11/5/2022	0.41	0.20	0.72	0.16	0.08
11/5/2022	0.45	0.20	0.79	0.16	0.08
11/5/2022	0.44	0.18	0.92	0.16	0.07
11/5/2022	0.46	0.17	0.84	0.16	0.08

11/5/2022	0.40	0.29	0.77	0.16	0.07
11/5/2022	0.38	0.26	0.84	0.16	0.07
11/5/2022	0.41	0.19	0.78	0.16	0.07
11/5/2022	0.38	0.23	0.82	0.15	0.07
11/5/2022	0.41	0.20	0.85	0.15	0.07
11/5/2022	0.41	0.18	0.88	0.15	0.08
11/5/2022	0.42	0.29	0.81	0.15	0.08
11/5/2022	0.44	0.26	0.68	0.15	0.08
11/5/2022	0.45	0.22	0.67	0.16	0.07
11/5/2022	0.44	0.21	0.63	0.15	0.07
11/5/2022	0.36	0.21	0.76	0.16	0.07
11/5/2022	0.45	0.21	0.84	0.15	0.07
11/5/2022	0.40	0.18	0.77	0.16	0.07
11/5/2022	0.43	0.28	0.77	0.16	0.08
11/5/2022	0.43	0.25	0.74	0.16	0.08
11/5/2022	0.42	0.21	0.72	0.15	0.07
11/5/2022	0.39	0.20	0.76	0.18	0.07
11/5/2022	0.33	0.20	0.67	0.16	0.08
11/5/2022	0.37	0.19	0.74	0.15	0.07
11/5/2022	0.39	0.20	0.67	0.15	0.07
11/5/2022	0.34	0.29	0.68	0.14	0.08
11/5/2022	0.33	0.23	0.71	0.15	0.08
11/5/2022	0.32	0.20	0.68	0.13	0.08
11/5/2022	0.33	0.20	0.67	0.14	0.08
11/5/2022	0.34	0.19	0.79	0.14	0.07
11/5/2022	0.31	0.18	0.93	0.13	0.08
11/5/2022	0.33	0.26	0.69	0.12	0.07
11/5/2022	0.34	0.24	0.70	0.13	0.07
11/5/2022	0.26	0.18	0.62	0.13	0.07
11/5/2022	0.25	0.16	0.67	0.13	0.07
11/5/2022	0.28	0.16	0.67	0.11	0.06
11/6/2022	0.26	0.14	0.63	0.11	0.07
11/6/2022	0.23	0.12	0.62	0.11	0.07
11/6/2022	0.26	0.12	0.65	0.10	0.07
11/6/2022	0.22	0.17	0.53	0.11	0.07
11/6/2022	0.19	0.15	0.55	0.10	0.07
11/6/2022	0.24	0.12	0.55	0.10	0.06
11/6/2022	0.16	0.12	0.55	0.09	0.06
11/6/2022	0.21	0.10	0.53	0.08	0.06
11/6/2022	0.15	0.08	0.50	0.08	0.06
11/6/2022	0.19	0.08	0.49	0.08	0.06
11/6/2022	0.13	0.06	0.45	0.08	0.06
11/6/2022	0.16	0.05	0.44	0.08	0.06
11/6/2022	0.14	0.05	0.44	0.08	0.06
11/6/2022	0.16	0.12	0.42	0.07	0.06
11/6/2022	0.11	0.11	0.39	0.08	0.06
11/6/2022	0.05	0.09	0.42	0.08	0.06
11/6/2022	0.15	0.07	0.36	0.08	0.06
11/6/2022	0.09	0.06	0.33	0.07	0.06
11/6/2022	0.11	0.06	0.35	0.07	0.06
11/6/2022	0.14	0.06	0.44	0.07	0.06
11/6/2022	0.06	0.06	0.46	0.07	0.06
11/6/2022	0.13	0.05	0.36	0.07	0.06
11/6/2022	0.09	0.05	0.29	0.07	0.06
11/6/2022	0.07	0.05	0.34	0.07	0.06
11/6/2022	0.13	0.05	0.32	0.07	0.06
11/6/2022	0.12	0.05	0.33	0.07	0.06
11/6/2022	0.08	0.05	0.00	0.07	0.06
11/6/2022	0.15	0.05	0.25	0.09	0.06
11/6/2022	0.12	0.05	0.32	0.08	0.04
11/6/2022	0.14	0.07	0.35	0.09	0.04
11/6/2022	0.17	0.08	0.31	0.09	0.04
11/6/2022	0.13	0.08	0.35	0.10	0.04
11/6/2022	0.20	0.15	0.42	0.11	0.04
11/6/2022	0.17	0.16	0.38	0.11	0.04
11/6/2022	0.18	0.15	0.39	0.11	0.04
11/6/2022	0.28	0.17	0.49	0.13	0.04
11/6/2022	0.23	0.20	0.52	0.14	0.04
11/6/2022	0.29	0.18	0.48	0.15	0.04
11/6/2022	0.36	0.19	0.47	0.16	0.06
11/6/2022	0.37	0.26	0.62	0.17	0.06
11/6/2022	0.40	0.29	0.60	0.16	0.06
11/6/2022	0.49	0.28	0.70	0.16	0.08
11/6/2022	0.48	0.26	0.67	0.17	0.08
11/6/2022	0.46	0.40	0.67	0.18	0.08
11/6/2022	0.46	0.33	0.80	0.20	0.08
11/6/2022	0.51	0.32	0.86	0.18	0.06
11/6/2022	0.51	0.30	0.96	0.18	0.07
11/6/2022	0.52	0.31	0.98	0.17	0.06
11/6/2022	0.53	0.30	0.90	0.16	0.07
11/6/2022	0.57	0.42	0.91	0.17	0.07
11/6/2022	0.55	0.35	0.90	0.17	0.07
11/6/2022	0.53	0.30	0.86	0.17	0.07
11/6/2022	0.51	0.30	0.87	0.17	0.07
11/6/2022	0.52	0.26	1.03	0.16	0.07
11/6/2022	0.49	0.41	1.01	0.15	0.07
11/6/2022	0.48	0.37	0.91	0.15	0.01

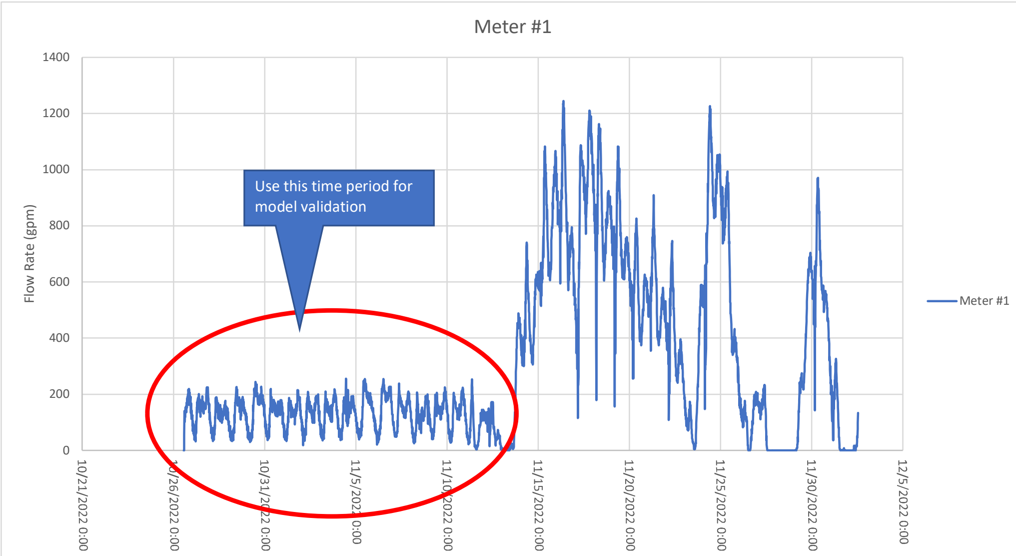
11/6/2022	0.47	0.31	0.80	0.15	0.01
11/6/2022	0.47	0.27	0.92	0.15	0.01
11/6/2022	0.46	0.23	1.02	0.16	0.01
11/6/2022	0.44	0.34	0.83	0.15	0.01
11/6/2022	0.47	0.32	0.87	0.15	0.01
11/6/2022	0.39	0.28	0.86	0.15	0.01
11/6/2022	0.44	0.26	0.83	0.17	0.01
11/6/2022	0.38	0.22	0.79	0.17	0.01
11/6/2022	0.41	0.22	0.82	0.16	0.01
11/6/2022	0.43	0.21	0.83	0.15	0.01
11/6/2022	0.44	0.29	0.69	0.16	0.01
11/6/2022	0.45	0.23	0.76	0.17	0.01
11/6/2022	0.40	0.22	0.72	0.17	0.01
11/6/2022	0.41	0.17	0.75	0.15	0.01
11/6/2022	0.43	0.20	0.99	0.16	0.01
11/6/2022	0.40	0.20	0.82	0.16	0.01
11/6/2022	0.40	0.33	0.85	0.15	0.01
11/6/2022	0.44	0.28	0.80	0.18	0.01
11/6/2022	0.46	0.23	0.89	0.18	0.01
11/6/2022	0.41	0.22	0.94	0.19	0.01
11/6/2022	0.43	0.21	0.81	0.17	0.01
11/6/2022	0.45	0.23	0.66	0.16	0.01
11/6/2022	0.45	0.31	0.80	0.17	0.01
11/6/2022	0.50	0.30	0.77	0.15	0.01
11/6/2022	0.50	0.29	0.77	0.17	0.01
11/6/2022	0.51	0.28	0.76	0.15	0.01
11/6/2022	0.45	0.23	0.84	0.16	0.01
11/6/2022	0.44	0.27	0.83	0.17	0.01
11/6/2022	0.43	0.37	0.87	0.16	0.01
11/6/2022	0.47	0.33	0.87	0.17	0.01
11/6/2022	0.48	0.28	0.85	0.18	0.01
11/6/2022	0.45	0.29	0.81	0.17	0.06
11/6/2022	0.51	0.24	0.74	0.16	0.06
11/6/2022	0.43	0.28	0.76	0.15	0.06
11/6/2022	0.38	0.34	0.81	0.14	0.01
11/6/2022	0.38	0.27	0.80	0.13	0.01
11/6/2022	0.39	0.26	0.79	0.13	0.01
11/6/2022	0.39	0.21	0.83	0.12	0.06
11/6/2022	0.34	0.19	0.75	0.12	0.06
11/6/2022	0.31	0.16	0.80	0.13	0.07
11/7/2022	0.29	0.28	0.75	0.12	0.08
11/7/2022	0.29	0.22	0.74	0.12	0.08
11/7/2022	0.24	0.17	0.81	0.11	0.06
11/7/2022	0.22	0.14	0.66	0.11	0.08
11/7/2022	0.22	0.12	0.61	0.10	0.08
11/7/2022	0.20	0.09	0.58	0.09	0.08
11/7/2022	0.21	0.09	0.57	0.09	0.09
11/7/2022	0.23	0.07	0.51	0.09	0.01
11/7/2022	0.16	0.14	0.44	0.08	0.01
11/7/2022	0.18	0.14	0.49	0.08	0.06
11/7/2022	0.15	0.11	0.49	0.09	0.08
11/7/2022	0.14	0.09	0.42	0.08	0.07
11/7/2022	0.15	0.07	0.44	0.08	0.07
11/7/2022	0.13	0.07	0.42	0.08	0.07
11/7/2022	0.11	0.06	0.46	0.08	0.07
11/7/2022	0.12	0.06	0.50	0.08	0.07
11/7/2022	0.14	0.06	0.45	0.08	0.07
11/7/2022	0.12	0.05	0.39	0.08	0.07
11/7/2022	0.11	0.06	0.34	0.08	0.07
11/7/2022	0.11	0.04	0.39	0.08	0.07
11/7/2022	0.11	0.05	0.32	0.08	0.07
11/7/2022	0.12	0.05	0.28	0.08	0.07
11/7/2022	0.11	0.05	0.31	0.08	0.07
11/7/2022	0.13	0.06	0.35	0.08	0.07
11/7/2022	0.14	0.05	0.38	0.08	0.07
11/7/2022	0.13	0.11	0.39	0.09	0.07
11/7/2022	0.16	0.10	0.37	0.10	0.01
11/7/2022	0.14	0.09	0.39	0.10	0.01
11/7/2022	0.24	0.11	0.34	0.11	0.01
11/7/2022	0.19	0.11	0.45	0.12	0.01
11/7/2022	0.26	0.12	0.45	0.14	0.01
11/7/2022	0.32	0.16	0.50	0.15	0.01
11/7/2022	0.36	0.19	0.50	0.16	0.08
11/7/2022	0.40	0.22	0.50	0.15	0.08
11/7/2022	0.44	0.24	0.63	0.15	0.08
11/7/2022	0.53	0.27	0.61	0.17	0.08
11/7/2022	0.48	0.30	0.67	0.16	0.08
11/7/2022	0.48	0.33	0.74	0.17	0.10
11/7/2022	0.47	0.40	0.88	0.17	0.09
11/7/2022	0.40	0.31	0.98	0.18	0.09
11/7/2022	0.43	0.27	0.92	0.17	0.09
11/7/2022	0.38	0.27	1.04	0.18	0.09
11/7/2022	0.42	0.24	1.07	0.18	0.07
11/7/2022	0.41	0.32	0.97	0.17	0.08
11/7/2022	0.39	0.26	0.95	0.17	0.08
11/7/2022	0.42	0.23	0.84	0.18	0.09
11/7/2022	0.38	0.24	0.85	0.17	0.09

11/7/2022	0.36	0.32	0.94	0.17	0.10
11/7/2022	0.34	0.29	0.84	0.17	0.08
11/7/2022	0.39	0.20	0.81	0.17	0.08
11/7/2022	0.37	0.19	0.82	0.17	0.10
11/7/2022	0.37	0.16	0.72	0.16	0.09
11/7/2022	0.37	0.14	0.70	0.15	0.08
11/7/2022	0.31	0.22	0.70	0.14	0.08
11/7/2022	0.34	0.19	0.89	0.15	0.08
11/7/2022	0.30	0.18	0.79	0.16	0.09
11/7/2022	0.33	0.15	0.81	0.16	0.09
11/7/2022	0.32	0.12	0.77	0.17	0.08
11/7/2022	0.35	0.13	0.67	0.16	0.08
11/7/2022	0.34	0.22	0.70	0.15	0.09
11/7/2022	0.33	0.21	0.73	0.16	0.09
11/7/2022	0.30	0.17	0.70	0.16	0.09
11/7/2022	0.26	0.15	0.66	0.14	0.09
11/7/2022	0.29	0.11	0.72	0.15	0.09
11/7/2022	0.32	0.14	0.61	0.15	0.09
11/7/2022	0.26	0.11	1.34	0.15	0.09
11/7/2022	0.26	0.17	1.35	0.14	0.08
11/7/2022	0.32	0.21	1.05	0.14	0.08
11/7/2022	0.28	0.16	0.87	0.15	0.08
11/7/2022	0.28	0.15	0.83	0.15	0.01
11/7/2022	0.26	0.14	0.74	0.15	0.10
11/7/2022	0.29	0.14	0.73	0.14	0.09
11/7/2022	0.35	0.12	0.68	0.15	0.09
11/7/2022	0.33	0.13	0.64	0.14	0.09
11/7/2022	0.31	0.27	0.57	0.15	0.09
11/7/2022	0.32	0.24	0.78	0.14	0.09
11/7/2022	0.39	0.17	0.65	0.15	0.08
11/7/2022	0.36	0.20	0.62	0.14	0.09
11/7/2022	0.36	0.20	0.66	0.14	0.09
11/7/2022	0.40	0.18	0.68	0.15	0.09
11/7/2022	0.40	0.26	0.72	0.15	0.08
11/7/2022	0.43	0.30	0.76	0.14	0.09
11/7/2022	0.44	0.29	0.78	0.15	0.09
11/7/2022	0.46	0.29	0.77	0.15	0.09
11/7/2022	0.47	0.24	0.81	0.16	0.09
11/7/2022	0.47	0.27	0.75	0.16	0.10
11/7/2022	0.41	0.28	0.83	0.15	0.09
11/7/2022	0.38	0.26	0.81	0.15	0.10
11/7/2022	0.46	0.33	0.81	0.16	0.10
11/7/2022	0.40	0.28	0.89	0.15	0.09
11/7/2022	0.39	0.27	0.80	0.15	0.09
11/7/2022	0.36	0.23	0.79	0.15	0.09
11/7/2022	0.39	0.23	0.70	0.13	0.10
11/7/2022	0.39	0.20	0.74	0.14	0.10
11/7/2022	0.36	0.28	0.71	0.11	0.09
11/7/2022	0.33	0.24	0.74	0.12	0.08
11/8/2022	0.30	0.21	0.73	0.11	0.08
11/8/2022	0.31	0.16	0.68	0.10	0.09
11/8/2022	0.31	0.15	0.68	0.10	0.09
11/8/2022	0.26	0.13	0.64	0.10	0.09
11/8/2022	0.23	0.12	0.55	0.09	0.08
11/8/2022	0.25	0.19	0.57	0.09	0.09
11/8/2022	0.18	0.14	0.59	0.08	0.08
11/8/2022	0.18	0.13	0.51	0.08	0.04
11/8/2022	0.19	0.11	0.52	0.09	0.04
11/8/2022	0.13	0.09	0.58	0.08	0.04
11/8/2022	0.18	0.08	0.52	0.08	0.04
11/8/2022	0.13	0.06	0.45	0.07	0.04
11/8/2022	0.14	0.06	0.44	0.08	0.01
11/8/2022	0.10	0.05	0.47	0.08	0.01
11/8/2022	0.10	0.06	0.44	0.07	0.01
11/8/2022	0.12	0.13	0.41	0.07	0.01
11/8/2022	0.07	0.12	0.41	0.07	0.01
11/8/2022	0.13	0.09	0.40	0.07	0.01
11/8/2022	0.09	0.07	0.32	0.07	0.01
11/8/2022	0.06	0.07	0.33	0.07	0.01
11/8/2022	0.12	0.06	0.29	0.07	0.01
11/8/2022	0.07	0.06	0.32	0.07	0.01
11/8/2022	0.09	0.05	0.29	0.08	0.01
11/8/2022	0.11	0.05	0.25	0.08	0.01
11/8/2022	0.07	0.05	0.37	0.09	0.01
11/8/2022	0.13	0.05	0.41	0.09	0.01
11/8/2022	0.13	0.06	0.38	0.10	0.01
11/8/2022	0.12	0.06	0.37	0.10	0.01
11/8/2022	0.16	0.08	0.31	0.11	0.01
11/8/2022	0.15	0.07	0.31	0.12	0.09
11/8/2022	0.25	0.12	0.40	0.13	0.08
11/8/2022	0.21	0.16	0.41	0.15	0.09
11/8/2022	0.33	0.17	0.49	0.16	0.08
11/8/2022	0.31	0.18	0.48	0.16	0.08
11/8/2022	0.41	0.30	0.46	0.16	0.08
11/8/2022	0.46	0.28	0.54	0.17	0.09
11/8/2022	0.45	0.26	0.62	0.17	0.08
11/8/2022	0.39	0.26	0.72	0.17	0.09

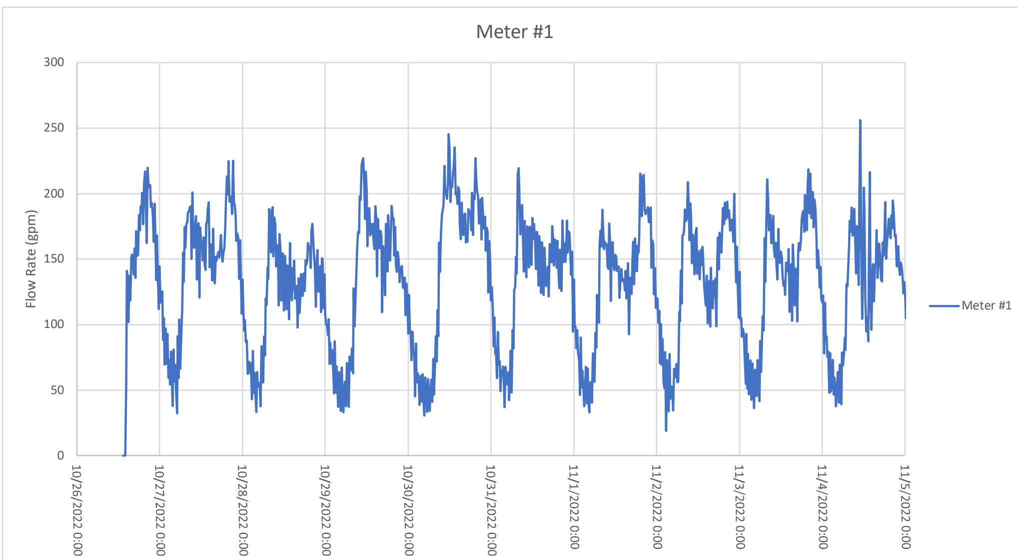
11/8/2022	0.36	0.26	0.99	0.15	0.11
11/8/2022	0.37	0.27	0.98	0.15	0.11
11/8/2022	0.31	0.25	0.91	0.16	0.11
11/8/2022	0.26	0.30	0.78	0.16	0.11
11/8/2022	0.26	0.27	0.97	0.17	0.09
11/8/2022	0.24	0.24	0.81	0.17	0.13
11/8/2022	0.23	0.22	0.82	0.17	0.10
11/8/2022	0.21	0.20	0.76	0.17	0.11
11/8/2022	0.24	0.28	0.70	0.17	0.08
11/8/2022	0.17	0.23	0.75	0.17	0.08
11/8/2022	0.24	0.19	0.69	0.16	0.08
11/8/2022	0.28	0.18	0.65	0.15	0.07
11/8/2022	0.23	0.18	0.64	0.15	0.10
11/8/2022	0.28	0.17	0.65	0.15	0.10
11/8/2022	0.29	0.27	0.77	0.15	0.08
11/8/2022	0.23	0.21	1.69	0.14	0.07
11/8/2022	0.25	0.17	1.47	0.15	0.09
11/8/2022	0.17	0.16	1.13	0.14	0.09
11/8/2022	0.14	0.14	1.14	0.14	0.09
11/8/2022	0.28	0.15	0.69	0.15	0.09
11/8/2022	0.32	0.25	0.69	0.15	0.09
11/8/2022	0.31	0.19	0.73	0.15	0.09
11/8/2022	0.33	0.18	0.75	0.14	0.09
11/8/2022	0.34	0.15	0.68	0.14	0.09
11/8/2022	0.26	0.14	0.67	0.15	0.01
11/8/2022	0.29	0.14	0.65	0.15	0.01
11/8/2022	0.31	0.15	0.62	0.15	0.01
11/8/2022	0.25	0.13	0.61	0.16	0.01
11/8/2022	0.27	0.15	0.77	0.16	0.01
11/8/2022	0.30	0.19	0.79	0.14	0.01
11/8/2022	0.25	0.17	0.69	0.15	0.01
11/8/2022	0.24	0.16	0.58	0.14	0.09
11/8/2022	0.29	0.14	0.59	0.15	0.10
11/8/2022	0.31	0.14	0.62	0.14	0.10
11/8/2022	0.29	0.14	0.66	0.14	0.10
11/8/2022	0.29	0.16	0.61	0.15	0.10
11/8/2022	0.27	0.28	0.62	0.14	0.11
11/8/2022	0.32	0.24	0.63	0.14	0.10
11/8/2022	0.34	0.23	0.55	0.15	0.09
11/8/2022	0.39	0.18	0.63	0.15	0.10
11/8/2022	0.37	0.20	0.66	0.16	0.10
11/8/2022	0.37	0.21	0.70	0.16	0.09
11/8/2022	0.43	0.19	0.69	0.16	0.09
11/8/2022	0.38	0.25	0.69	0.16	0.11
11/8/2022	0.37	0.31	0.71	0.16	0.10
11/8/2022	0.43	0.29	0.71	0.17	0.11
11/8/2022	0.41	0.27	0.67	0.17	0.11
11/8/2022	0.43	0.27	0.76	0.18	0.10
11/8/2022	0.41	0.22	0.77	0.17	0.10
11/8/2022	0.38	0.25	0.76	0.16	0.10
11/8/2022	0.39	0.23	0.74	0.15	0.11
11/8/2022	0.45	0.37	0.78	0.15	0.10
11/8/2022	0.41	0.27	0.78	0.15	0.10
11/8/2022	0.21	0.26	0.80	0.14	0.10
11/8/2022	0.39	0.23	0.74	0.14	0.11
11/8/2022	0.37	0.20	0.76	0.13	0.10
11/8/2022	0.40	0.26	0.71	0.14	0.08
11/8/2022	0.33	0.25	0.67	0.14	0.09
11/9/2022	0.34	0.21	0.66	0.12	0.09
11/9/2022	0.32	0.18	0.65	0.11	0.09
11/9/2022	0.29	0.15	0.66	0.13	0.10
11/9/2022	0.28	0.12	0.61	0.11	0.10
11/9/2022	0.29	0.11	0.60	0.10	0.09
11/9/2022	0.20	0.16	0.65	0.09	0.09
11/9/2022	0.22	0.17	0.57	0.09	0.10
11/9/2022	0.25	0.14	0.64	0.09	0.09
11/9/2022	0.21	0.13	0.58	0.08	0.08
11/9/2022	0.19	0.10	0.55	0.08	0.08
11/9/2022	0.17	0.09	0.52	0.08	0.08
11/9/2022	0.16	0.08	0.46	0.08	0.08
11/9/2022	0.17	0.08	0.44	0.08	0.08
11/9/2022	0.15	0.06	0.46	0.08	0.08
11/9/2022	0.17	0.07	0.47	0.08	0.08
11/9/2022	0.14	0.06	0.44	0.08	0.08
11/9/2022	0.14	0.12	0.40	0.08	0.08
11/9/2022	0.15	0.10	0.40	0.08	0.08
11/9/2022	0.09	0.10	0.36	0.08	0.08
11/9/2022	0.16	0.09	0.38	0.08	0.08
11/9/2022	0.10	0.07	0.36	0.08	0.08
11/9/2022	0.10	0.07	0.49	0.07	0.01
11/9/2022	0.12	0.07	0.39	0.06	0.01
11/9/2022	0.09	0.06	0.36	0.06	0.01
11/9/2022	0.16	0.06	0.30	0.06	0.01
11/9/2022	0.11	0.05	0.29	0.07	0.01
11/9/2022	0.17	0.06	0.38	0.07	0.01
11/9/2022	0.14	0.06	0.30	0.08	0.01
11/9/2022	0.18	0.07	0.38	0.07	0.01

11/9/2022	0.19	0.11	0.39	0.08	0.01
11/9/2022	0.22	0.11	0.40	0.10	0.01
11/9/2022	0.27	0.15	0.49	0.10	0.01
11/9/2022	0.34	0.27	0.47	0.12	0.01
11/9/2022	0.30	0.25	0.58	0.11	0.01
11/9/2022	0.38	0.23	0.58	0.11	0.01
11/9/2022	0.44	0.23	0.57	0.12	0.01
11/9/2022	0.44	0.27	0.53	0.13	0.09
11/9/2022	0.38	0.26	0.66	0.13	0.09
11/9/2022	0.35	0.27	0.89	0.13	0.11
11/9/2022	0.33	0.25	0.81	0.13	0.10
11/9/2022	0.29	0.35	0.88	0.12	0.11
11/9/2022	0.27	0.29	0.90	0.13	0.12
11/9/2022	0.30	0.22	0.88	0.12	0.09
11/9/2022	0.46	0.25	0.85	0.12	0.10
11/9/2022	0.39	0.27	0.77	0.13	0.11
11/9/2022	0.37	0.33	0.91	0.12	0.11
11/9/2022	0.34	0.27	0.79	0.12	0.11
11/9/2022	0.31	0.24	0.84	0.13	0.11
11/9/2022	0.33	0.20	0.78	0.13	0.10
11/9/2022	0.33	0.19	0.73	0.13	0.10
11/9/2022	0.36	0.28	0.67	0.13	0.09
11/9/2022	0.33	0.26	0.69	0.12	0.09
11/9/2022	0.34	0.19	0.68	0.13	0.09
11/9/2022	0.34	0.16	0.64	0.13	0.09
11/9/2022	0.29	0.15	0.66	0.12	0.09
11/9/2022	0.31	0.25	0.62	0.12	0.10
11/9/2022	0.33	0.21	0.67	0.12	0.10
11/9/2022	0.32	0.19	0.72	0.12	0.10
11/9/2022	0.32	0.17	0.67	0.12	0.10
11/9/2022	0.32	0.16	0.67	0.12	0.09
11/9/2022	0.35	0.17	0.65	0.12	0.09
11/9/2022	0.29	0.24	0.63	0.12	0.08
11/9/2022	0.25	0.19	0.57	0.12	0.09
11/9/2022	0.31	0.17	0.55	0.11	0.09
11/9/2022	0.33	0.16	0.66	0.11	0.09
11/9/2022	0.25	0.16	0.53	0.11	0.09
11/9/2022	0.32	0.15	0.58	0.13	0.09
11/9/2022	0.30	0.14	0.68	0.12	0.09
11/9/2022	0.30	0.12	0.58	0.12	0.09
11/9/2022	0.29	0.22	0.64	0.12	0.09
11/9/2022	0.34	0.19	0.68	0.11	0.11
11/9/2022	0.29	0.19	0.59	0.12	0.09
11/9/2022	0.30	0.19	0.61	0.12	0.09
11/9/2022	0.38	0.17	0.56	0.12	0.09
11/9/2022	0.35	0.17	0.63	0.13	0.09
11/9/2022	0.34	0.21	0.61	0.13	0.09
11/9/2022	0.33	0.17	0.67	0.13	0.09
11/9/2022	0.39	0.27	0.67	0.12	0.09
11/9/2022	0.38	0.23	0.63	0.11	0.09
11/9/2022	0.40	0.21	0.65	0.12	0.09
11/9/2022	0.45	0.23	0.63	0.12	0.09
11/9/2022	0.42	0.20	0.72	0.13	0.09
11/9/2022	0.46	0.21	0.74	0.13	0.09
11/9/2022	0.41	0.24	0.79	0.13	0.09
11/9/2022	0.47	0.36	0.71	0.13	0.10
11/9/2022	0.50	0.32	0.81	0.12	0.09
11/9/2022	0.47	0.26	0.80	0.12	0.09
11/9/2022	0.46	0.23	0.78	0.12	0.10
11/9/2022	0.43	0.24	0.76	0.11	0.10
11/9/2022	0.43	0.21	0.66	0.11	0.08
11/9/2022	0.47	0.30	0.77	0.12	0.08
11/9/2022	0.39	0.28	0.86	0.11	0.08
11/9/2022	0.40	0.23	0.82	0.11	0.08
11/9/2022	0.33	0.20	0.76	0.11	0.08
11/9/2022	0.34	0.21	0.76	0.10	0.08
11/9/2022	0.37	0.18	0.92	0.10	0.08
11/10/2022	0.30	0.27	0.69	0.10	0.08
11/10/2022	0.35	0.19	0.74	0.09	-0.01
11/10/2022	0.29	0.17	0.64	0.08	-0.01
11/10/2022	0.29	0.14	0.66	0.09	-0.01
11/10/2022	0.23	0.12	0.63	0.08	-0.01
11/10/2022	0.24	0.11	0.59	0.08	-0.01
11/10/2022	0.28	0.09	0.60	0.08	-0.01
11/10/2022	0.20	0.16	0.57	0.08	-0.01
11/10/2022	0.19	0.12	0.52	0.07	-0.01
11/10/2022	0.13	0.11	0.55	0.07	-0.01
11/10/2022	0.17	0.08	0.51	0.06	-0.01
11/10/2022	0.13	0.07	0.50	0.06	-0.01
11/10/2022	0.16	0.06	0.54	0.06	0.07
11/10/2022	0.09	0.05	0.46	0.06	0.07
11/10/2022	0.13	0.06	0.43	0.06	-0.01
11/10/2022	0.12	0.05	0.40	0.05	-0.01
11/10/2022	0.07	0.05	0.40	0.05	-0.01
11/10/2022	0.15	0.05	0.33	0.06	0.07
11/10/2022	0.08	0.05	0.35	0.06	0.07
11/10/2022	0.06	0.05	0.41	0.06	0.06

11/10/2022	0.13	0.11	0.33	0.05	0.07
11/10/2022	0.08	0.08	0.35	0.06	0.06
11/10/2022	0.06	0.08	0.31	0.05	0.06
11/10/2022	0.14	0.07	0.32	0.05	0.06
11/10/2022	0.08	0.06	0.31	0.05	0.06
11/10/2022	0.07	0.05	0.34	0.06	0.07
11/10/2022	0.16	0.07	0.40	0.06	0.06
11/10/2022	0.11	0.06	0.37	0.08	0.06
11/10/2022	0.18	0.09	0.35	0.08	0.06
11/10/2022	0.15	0.10	0.38	0.09	0.06
11/10/2022	0.18	0.11	0.35	0.09	0.07
11/10/2022	0.28	0.13	0.40	0.13	0.06
11/10/2022	0.31	0.17	0.49	0.12	0.06
11/10/2022	0.34	0.18	0.49	0.12	0.06
11/10/2022	0.41	0.20	0.52	0.12	0.06
11/10/2022	0.46	0.34	0.57	0.13	0.06
11/10/2022	0.45	0.30	0.63	0.13	0.07
11/10/2022	0.40	0.27	0.72	0.14	0.11
11/10/2022	0.41	0.29	0.94	0.13	0.10
11/10/2022	0.43	0.27	0.82	0.12	0.10
11/10/2022	0.43	0.24	0.84	0.13	0.09
11/10/2022	0.38	0.35	0.89	0.13	0.10
11/10/2022	0.40	0.30	0.93	0.13	0.10
11/10/2022	0.37	0.24	0.78	0.13	0.09
11/10/2022	0.38	0.21	0.74	0.12	0.09
11/10/2022	0.38	0.20	0.73	0.12	0.10
11/10/2022	0.34	0.26	0.77	0.11	0.11
11/10/2022	0.33	0.28	0.65	0.11	0.10
11/10/2022	0.34	0.24	0.74	0.12	0.09
11/10/2022	0.33	0.21	0.88	0.10	0.09
11/10/2022	0.34	0.19	0.90	0.10	0.09
11/10/2022	0.32	0.16	0.77	0.11	0.09
11/10/2022	0.31	0.17	0.72	0.08	0.09
11/10/2022	0.33	0.24	0.70	0.07	0.11
11/10/2022	0.29	0.21	0.63	0.07	0.10
11/10/2022	0.25	0.16	0.61	0.06	0.10
11/10/2022	0.30	0.17	0.67	0.05	0.08
11/10/2022	0.30	0.15	0.57	0.07	0.08
11/10/2022	0.33	0.16	0.61	0.08	0.08
11/10/2022	0.31	0.16	0.62	0.07	0.08
11/10/2022	0.30	0.22	0.60	0.07	0.08
11/10/2022	0.27	0.20	0.54	0.05	0.08
11/10/2022	0.32	0.17	0.65	0.07	0.08
11/10/2022	0.28	0.16	0.82	0.05	0.08
11/10/2022	0.24	0.15	0.81	0.04	0.08
11/10/2022	0.34	0.16	1.12	0.04	0.07
11/10/2022	0.37	0.11	1.42	0.04	0.09
11/10/2022	0.31	0.23	1.14	0.04	0.08
11/10/2022	0.28	0.21	0.97	0.04	0.08
11/10/2022	0.34	0.17	0.86	0.04	0.08
11/10/2022	0.29	0.14	0.74	0.04	0.08
11/10/2022	0.27	0.15	0.55	0.07	0.08
11/10/2022	0.34	0.13	0.64	0.06	0.08
11/10/2022	0.32	0.14	0.67	0.10	0.08
11/10/2022	0.36	0.16	0.62	0.11	0.07
11/10/2022	0.42	0.30	0.63	0.10	0.08
11/10/2022	0.44	0.25	0.60	0.10	0.07
11/10/2022	0.48	0.21	0.65	0.09	0.07
11/10/2022	0.41	0.19	0.63	0.11	0.07
11/10/2022	0.42	0.18	0.69	0.08	0.07
11/10/2022	0.45	0.23	0.65	0.11	0.07
11/10/2022	0.49	0.21	0.71	0.11	0.08
11/10/2022	0.46	0.20	0.76	0.13	0.07
11/10/2022	0.50	0.31	0.72	0.15	0.07
11/10/2022	0.48	0.27	0.68	0.14	0.08
11/10/2022	0.43	0.22	0.71	0.13	0.09
11/10/2022	0.40	0.24	0.79	0.12	0.08
11/10/2022	0.45	0.22	0.75	0.12	0.08
11/10/2022	0.38	0.25	0.79	0.11	0.09
11/10/2022	0.36	0.26	0.80	0.11	0.10
11/10/2022	0.37	0.25	0.75	0.11	0.10
11/10/2022	0.39	0.24	0.75	0.12	0.09
11/10/2022	0.41	0.22	0.79	0.11	0.10
11/10/2022	0.38	0.18	0.69	0.11	0.10
11/10/2022	0.35	0.27	0.74	0.11	0.09
11/10/2022	0.28	0.24	0.78	0.10	0.08
11/11/2022	0.30	0.19	0.95	0.10	0.08



Meter #1
Use this time period for model validation
Flow Rate (gpm)
1400
1200
1000
800
600
400
200
0
10/21/2022 0:00
10/26/2022 0:00
10/31/2022 0:00
11/5/2022 0:00
11/10/2022 0:00
11/15/2022 0:00
11/20/2022 0:00
11/25/2022 0:00
11/30/2022 0:00
12/5/2022 0:00
Meter #1



Meter #1
Flow Rate (gpm)
300
250
200
150
100
50
0
10/26/2022 0:00
10/27/2022 0:00
10/28/2022 0:00
10/29/2022 0:00
10/30/2022 0:00
10/31/2022 0:00
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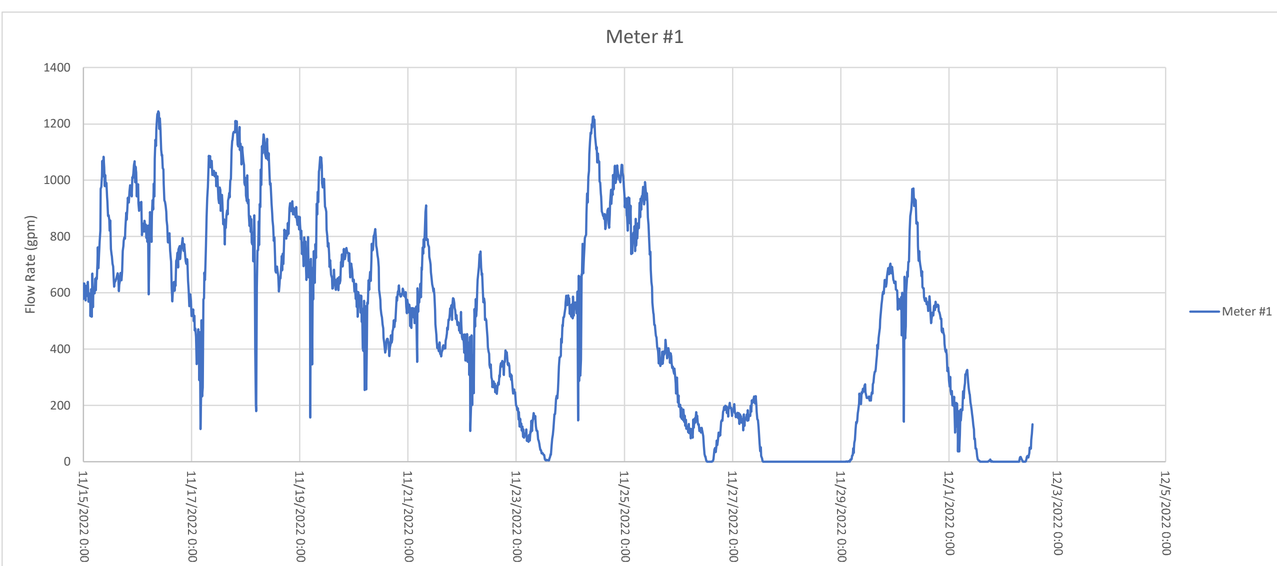
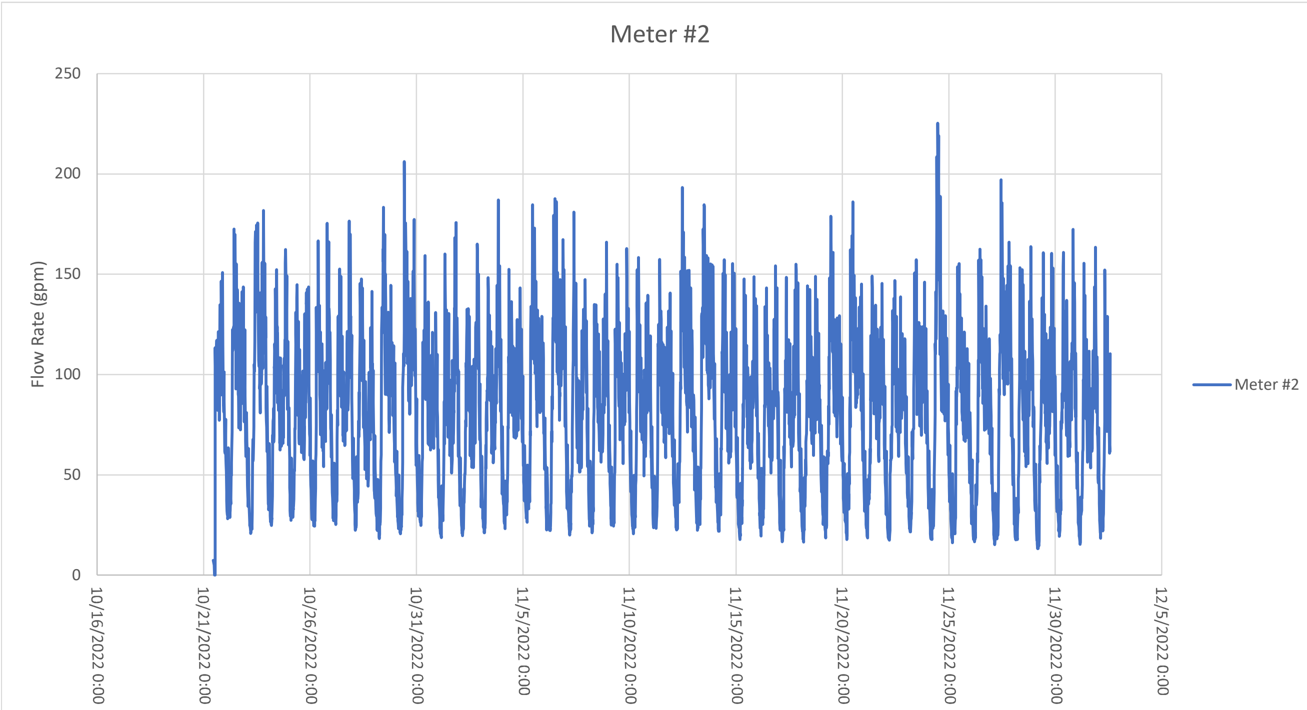
11/5/2022 0:00
Meter #1



Meter #1
Flow Rate (gpm)
1400
1200
1000
800
600
400
200
0
11/15/2022 0:00
11/17/2022 0:00
11/19/2022 0:00
11/21/2022 0:00
11/23/2022 0:00
11/25/2022 0:00
11/27/2022 0:00
11/29/2022 0:00
12/1/2022 0:00
12/3/2022 0:00
12/5/2022 0:00
Meter #1


Meter #2
Flow Rate (gpm)
250
200
150
100
50
0
10/16/2022 0:00
10/21/2022 0:00
10/26/2022 0:00
10/31/2022 0:00
11/5/2022 0:00
11/10/2022 0:00
11/15/2022 0:00
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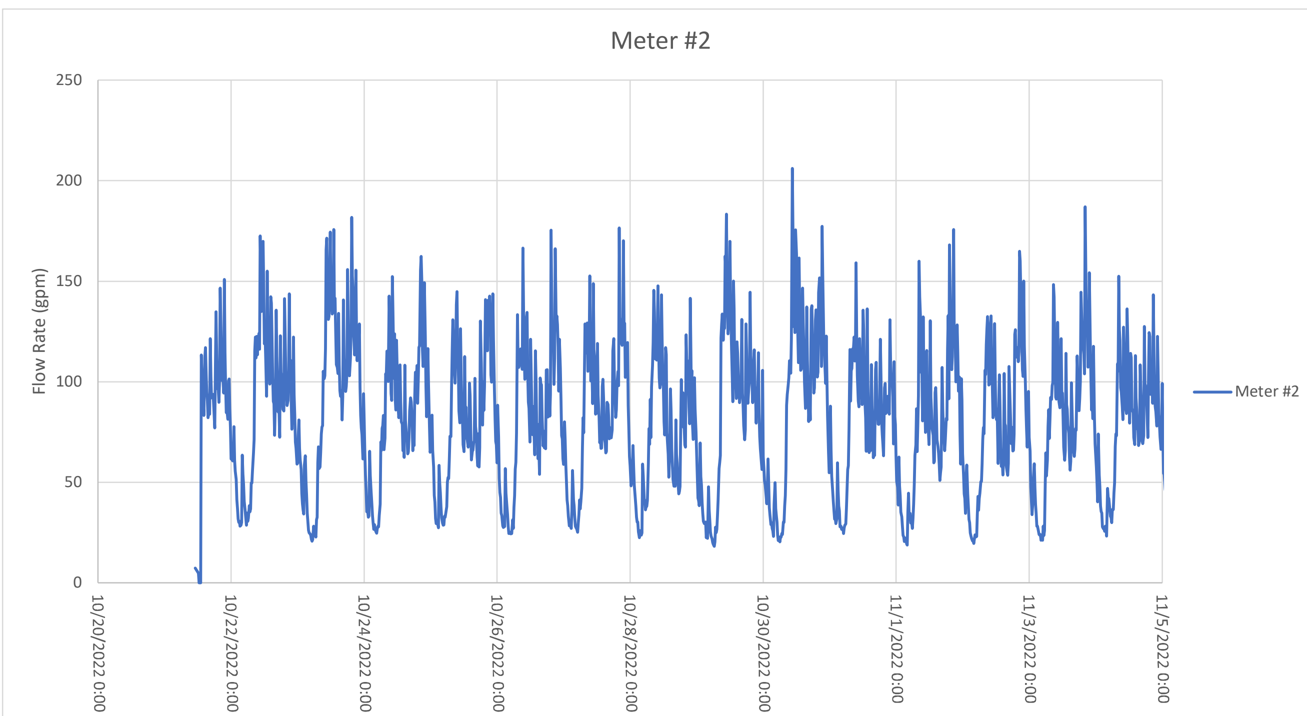
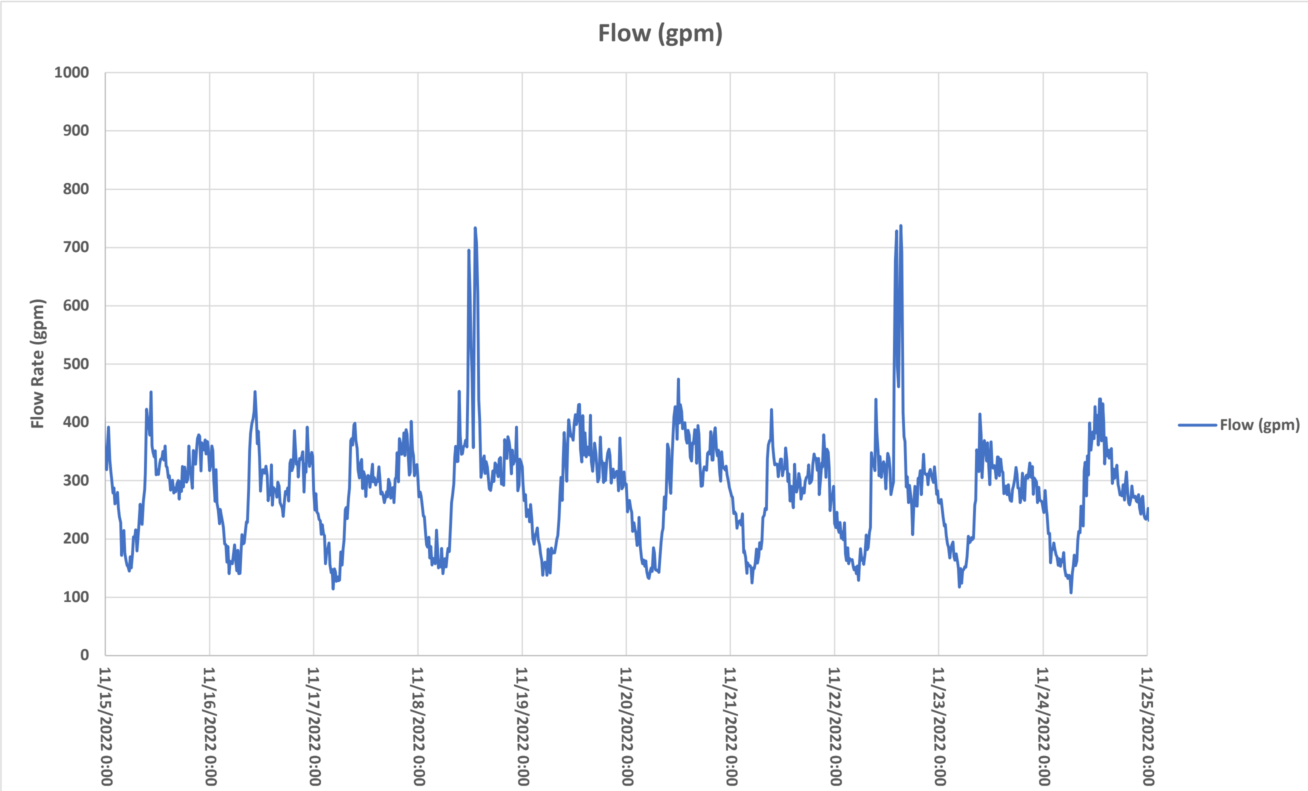
11/25/2022 0:00
11/30/2022 0:00
12/5/2022 0:00
Meter #2


Meter #2
Flow Rate (gpm)
250
200
150
100
50
0
10/20/2022 0:00
10/22/2022 0:00
10/24/2022 0:00
10/26/2022 0:00
10/28/2022 0:00
10/30/2022 0:00
11/1/2022 0:00
11/3/2022 0:00
11/5/2022 0:00
Meter #2


Flow (gpm)
Flow Rate (gpm)
1000
900
800
700
600
500
400
300
200
100
0
11/15/2022 0:00
11/16/2022 0:00
11/17/2022 0:00
11/18/2022 0:00
11/19/2022 0:00
11/20/2022 0:00
11/21/2022 0:00
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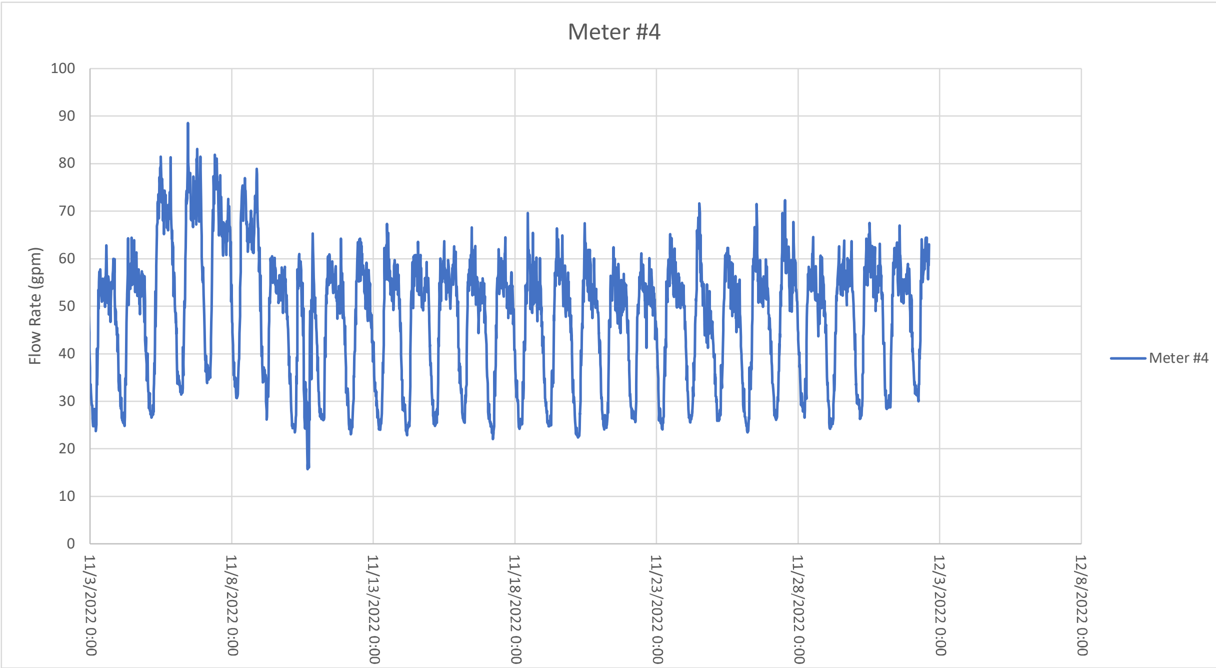
11/23/2022 0:00
11/24/2022 0:00
11/25/2022 0:00
Flow (gpm)



Meter #4
Flow Rate (gpm)
100
90
80
70
60
50
40
30
20
10
0
11/3/2022 0:00
11/8/2022 0:00
11/13/2022 0:00
11/18/2022 0:00
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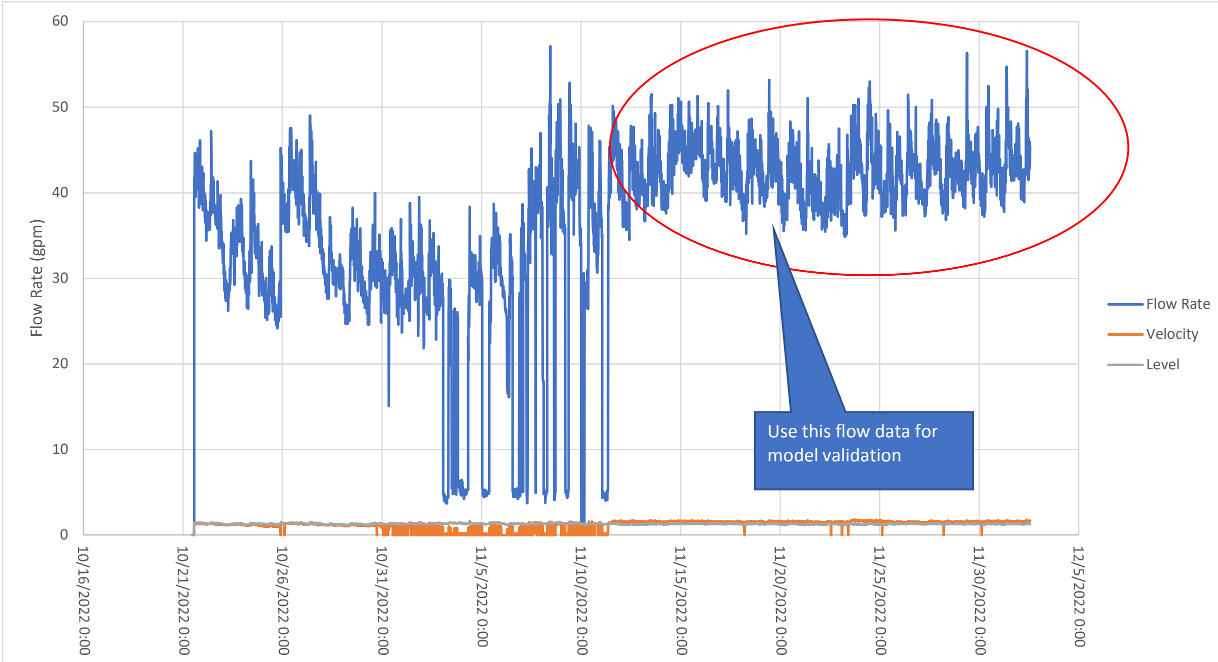
11/28/2022 0:00
12/3/2022 0:00
12/8/2022 0:00
Meter #4



60
50
40
30
20
10
0
Flow Rate (gpm)
10/16/2022 0:00
10/21/2022 0:00
10/26/2022 0:00
10/31/2022 0:00
11/5/2022 0:00
11/10/2022 0:00
11/15/2022 0:00
11/20/2022 0:00
11/25/2022 0:00
11/30/2022 0:00
12/5/2022 0:00
Use this flow data for model validation
Flow Rate
Velocity
Level

APPENDIX E:
Potential Funding Opportunities Matrix

Potential Funding Opportunities for Water and Wastewater CIP

Water and Wastewater Funding sources						
Funding source	**Agency**	**Type**	**Interest %**	**Benefits**	**Challenges**	**Additional considerations**
SRF (State Revolving Fund)	CDPHE/Water and Power Authority	Loan	1.5-2.5%	Low Interest Finances construction of public drinking water and wastewater infrastructure projects Dont need an O&M reserve fund Does not require insurance	State health department approves loans based on needs assessment Project applications must have a very broad scope placed in intended use plan Must be on the intended use plan, but can only get on the intended use plan once a year. Must re-verify every year that you are on the intended use plan. There are requirements: disadvantaged business enterprise goals, Davis-Bacon prevailing wage rates, by-American provisions	Get Town on the intended use plan Does not fund development driven projects For Drinking Water and Cleanwater (wastewater) projects
SRF (State Revolving Fund)	CDPHE/Water and Power Authority	Grant	NA	Nonfederal match funding for nonpoint source projects	No Project Needs Assessment means no loan Application Deadline April 20, 2023 Generally small (<25k) for planning and design. Typically doesn't even cover the cost of the Project Needs Assesment	Must apply for a loan and complete a Project Needs Assesment to qualify
SRF Green Project Reserve	CDPHE/Water and Power Authority	Loan	0.5%-1%	Lower interest than SRF loans	State health department must approve loans based on needs assessment Has a cap on size of loan Projects applications benefit from a very broad scope placed in intended use plan Must be on the intended use plan, but can only get on intended use plan once a year. Must re-verify every year that you are on the intended use plan. Requirements: disadvantaged business enterprise goals, Davis-Bacon prevailing wage rates, by-American provisions	To Qualify: 1 Be categorically green (i.e., solar panels, hydropower) 2 Business Case evaluation (20% energy reduction)
DOLA (Department of Local Affairs)	State of CO	Grant	NA	For areas impacted by mineral or energy extraction Can be generally paired with SRF loans Primarily a matching grant	Requires detailed tracking of where money is spent (paperwork)	Funded by mineral tax. If applying for SRF loan, good idea to apply for this as well.
WIFIA (Water Infrastructure Finance and Innovation Act)	EPA	Loan	Equal to US Treasury rate of a smiliar maturity	Fixed interest rate established at closing Interest rate not impacted by credit or loan structure Long and customizable repayment period Payments deferred up to 5 years WIFIA may take a subordinate position in payment priority Can be combined with various funding sources	Application is made directly to EPA, which tends to use this source of funding for larger and more complicated projects.	Must complete a WIFIA Leter of interest form including a Financial Pro Forma May apply if EPA invites the the borrow to submit an application
Drinking Water State Revolving Fund (DWSRF)	EPA	Loan/Grant	States must offer loans at or below market interest rate than can be repaid over a term of up to 20 years.	Federal government provides capitalization grant to states and the states provide a 20% match for those grants	Must be on intended use plan Project must be for: treatment, transmission and distribution, source, storage, consolidation, or creation of a new system.	For community water systems that serve at least 15 service connections year-round or system that regularly serves at least 25 year-round residents For New community water systems that represent cost-effective solutions to existing public health problems with serious risks.
Water Pollution Control Revolving Fund	Colorado Water Resources and Power Development Authority	Loan	3-3.25% (non-disadvantaged direct loan) 20-30 year	Long-term funding for wastewater and water quality infrastructure Up to 30 year terms Can cover up to 100% of the project. No match required. Loan repayment does not begin until project completion	Project must be on WPCRF Eligibility list. To get on the the list, the eligibility survey should be completed if it is active/open)	Direct Loan Deadlines on June 15 (for August Board Meeting), August 15 (October Board Meeting), October 15 (December Board Meeting), November 15 (January Board Meeting)

APPENDIX F:
EPA Cybersecurity Regulations

Cybersecurity Performance Goals Security Control	EPA Recommendation	Compliance Recommendation
1. Account Security.		
1.1. Detect and block repeated unsuccessful login attempts?	*Where technically feasible, System Administrators should be notified after a specific number of consecutive, unsuccessful login attempts in a short amount of time. At that point, future login attempts by the suspicious account should be blocked for a specified time or until re-enabled by an Administrator.*	Create an active directory policy to notify a designated OT group mailbox on unsuccessful login attempts. Do not block access to the account as EPA recommends. This can create safety issues. Print out the policy for compliance documentation.
1.2. Change default passwords?	*When feasible, change all default manufacturer or vendor passwords before equipment or software is put into service.*	Create a policy requiring that all default passwords are changed. Ensure vendors and 3rd parties have this direction. Provide written policy for compliance documentation. Change all default passwords on all devices and systems. Utilize TACACS or Radius Server for managing logins to devices that are not part of the domain.
1.3. Require multi-factor authentication (MFA) wherever possible, but at a minimum to remotely access PWS Operational Technology (OT) networks?	*Deploy MFA as widely as possible for both information technology (IT) and operational technology (OT) networks. At a minimum, MFA should be deployed for remote access to the OT network.*	Deploy MFA for remote access. Provide MFA login SOP for compliance documentation. Explore using MFA on all systems.
1.4. Require a minimum length for passwords?	*Where feasible, implement a minimum length requirement for passwords. Implementation can be through a policy or administrative controls set in the system.*	Create an Active Directory password policy with minimum length requirements. Print out the policy for compliance documentation.
1.5. Separate user and privileged (e.g., System Administrator) accounts?	*Restrict System Administrator privileges to separate user accounts for administrative actions only and evaluate administrative privileges on a recurring basis to be sure they are still needed by the individuals who have these privileges.*	Create separate administrative user accounts. Install Privileged Access Management Solution to better control administrative access. Provide statement of compliance as compliance documentation.
1.6. Require unique and separate credentials for users to access OT and IT networks?	*Require a single user to have two different usernames and passwords; one set is to be used to access the IT network, and the other set is to be used to access the OT network. This reduces the risk of an attacker being able to move between both networks using a single login.*	Use a separate Active Directory for OT with different username nomenclature. Provide statement of compliance as compliance documentation.
1.7. Immediately disable access to an account or network when access is no longer required due to retirement, change of role, termination, or other factors?	*Take all steps necessary to terminate access to accounts or networks upon a change in an individual's status making access unnecessary.*	Create an HR policy to notify the OT group of any change in job position or status for any users of the OT environment. Remove any unused or abandoned accounts from all OT devices and Systems. Provide policy as evidence of compliance.
2. Device Security.		
2.1. Require approval before new software is installed or deployed?	*Only allow Administrators to install new software on a PWS-issued asset.*	Create a change management policy and procedure. Ensure change management approval is documented. Create Active Directory policy only allowing

		administrators to install software. Provide both policies as evidence of compliance.
2.2. Disable Microsoft Office macros, or similar embedded code, by default on all assets?	*Disable embedded macros and similar executable code by default on all assets.*	Create an Active Directory Policy and ensure embedded macros and embedded executable code cannot run in the OT environment. Provide AD policy as evidence of compliance.
2.3. Maintain an updated inventory of all OT and IT network assets?	*Regularly review (no less than monthly) and maintain a list of all OT and IT assets with an IP address. This includes third-party and legacy (i.e., older) equipment.*	Consider deploying an electronic asset inventory software to ensure compliance. Provide statement of compliance as compliance documentation.
2.4. Prohibit the connection of unauthorized hardware (e.g., USB devices, removable media, laptops brought in by others) to OT and IT assets?	*When feasible, remove, disable, or otherwise secure physical ports (e.g., USB ports on a laptop) to prevent unauthorized assets from connecting.*	Create an Active Directory Policy to prevent removable device connectivity. Provide the policy as evidence of compliance.
2.5. Maintain current documentation detailing the set-up and settings (i.e., configuration) of critical OT and IT assets?	*Maintain accurate documentation of the original and current configuration of OT and IT assets, including software and firmware version.*	Backup configurations of all OT assets (switches, routers, firewalls, PLCs, gateways). Backup servers and workstations. Catalog all software and firmware revisions. Provide statement of compliance as compliance documentation.
3. Data Security.		
3.1. Collect security logs (e.g., system and network access, malware detection) to use in both incident detection and investigation?	*Collect and store logs and/or network traffic data to aid in detecting cyberattacks and investigating suspicious activity.*	Implement log server and OT network monitoring. Provide logs as evidence of compliance.
3.2. Protect security logs from unauthorized access and tampering?	*Store security logs in a central system or database that can only be accessed by authorized and authenticated users.*	Implement log server and OT network monitoring and limit access to cybersecurity personnel. Provide statement of compliance as compliance documentation.
3.3. Use effective encryption to maintain the confidentiality of data in transit?	*When sending information and data, use Transport Layer Security (TLS) or Secure Socket Layer (SSL) encryption standards.*	Ensure all OT components can support in transit data encryption. Ensure encryption across any WAN transports (VPN tunnels or other encryption techniques). Segment and segregate all unencrypted traffic behind firewalls. Provide statement of compliance as compliance documentation.
3.4. Use encryption to maintain the confidentiality of stored sensitive data?	*Do not store sensitive data, including credentials (i.e., usernames and passwords) in plain text.*	Create a policy regarding storing passwords in clear text and provide password managers for administrative staff. Utilize a privileged access management solution for administrative access. Provide policy as evidence of compliance.
4. Governance and Training.		
4.1. Have a named role/position/title that is responsible and accountable for planning, resourcing, and	*Identify one role/position/title responsible for cybersecurity within the PWS. Whoever fills this role/position/title is then in charge of all PWS cybersecurity activities.*	Create a position/title for ICS Cybersecurity and appoint a person with the appropriate skillsets to manage the ICS cybersecurity program. Position can

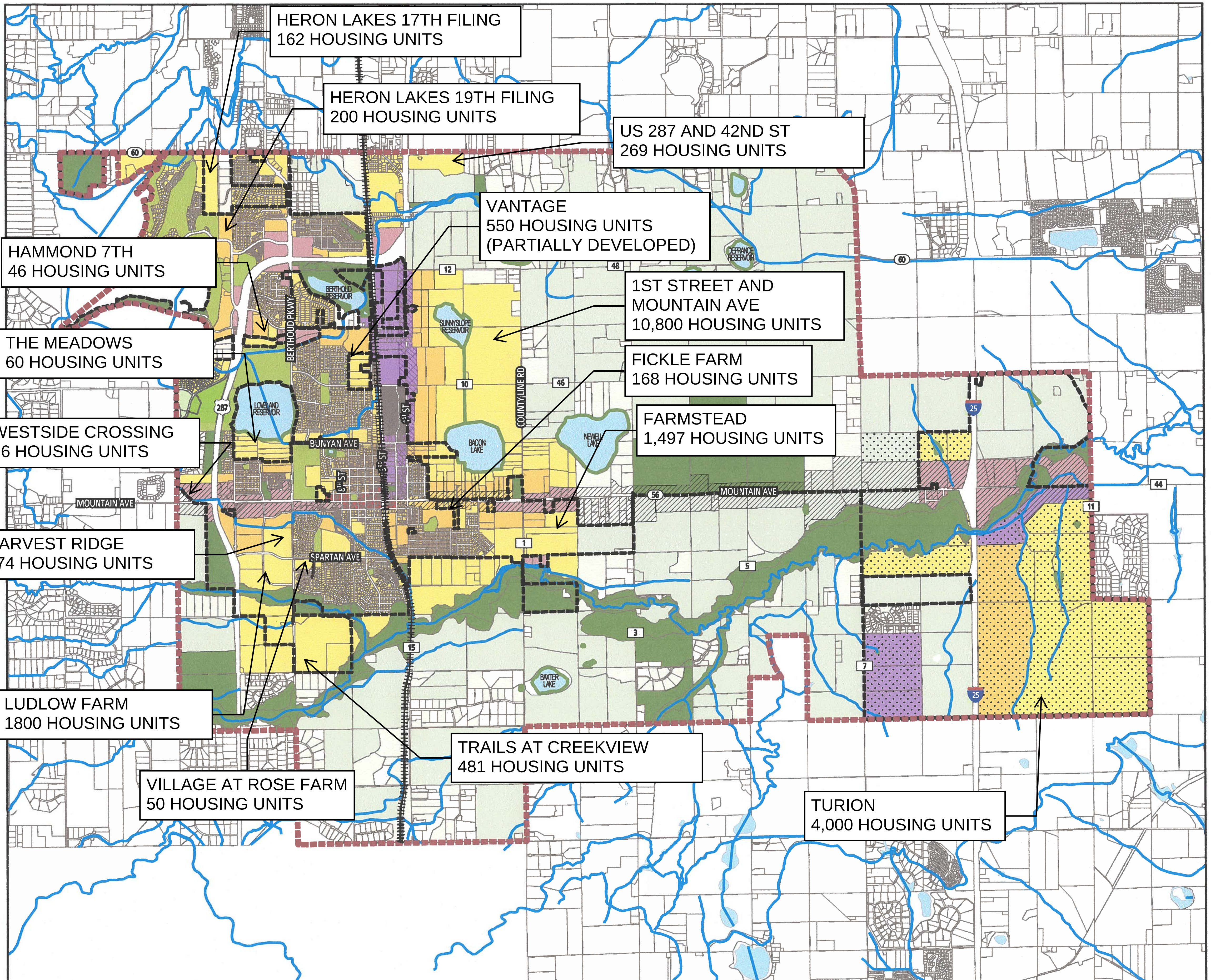
execution of cybersecurity activities within the PWS?		be filled by vCISO. Provide name of person and title as evidence of compliance.
4.2. Have a named role/position/title that is responsible and accountable for planning, resourcing, and execution of OT-specific cybersecurity activities?	*Identify one PWS role/position/title responsible for ensuring planning, resourcing, and execution of OT-specific cybersecurity activities.*	Create a position/title for ICS Cybersecurity and appoint a person with the appropriate skillsets to manage the execution of ICS cybersecurity activities. Provide name of person and title as evidence of compliance.
4.3. Provide at least annual training for all PWS personnel that covers basic cybersecurity concepts?	*Conduct annual basic cybersecurity training for all PWS personnel.*	Provide annual basic cybersecurity awareness training and a training log as evidence of compliance.
4.4. Offer OT-specific cybersecurity training on at least an annual basis to personnel who use OT as part of their regular duties?	*Provide specialized OT-focused cybersecurity training to all personnel who use OT assets.*	Create an ICS specific cybersecurity awareness training program and ensure staff are trained annually. Provide training log as evidence of compliance.
4.5. Offer regular opportunities to strengthen communication and coordination between OT and IT personnel, including vendors?	*Facilitate meetings between OT and IT personnel to provide opportunities for all parties to better understand organizational security needs and to strengthen working relationships.*	Staff coordinate efforts and meet regularly. Provide meeting schedule as evidence of compliance.
5. Vulnerability Management.		
5.1 Patch or otherwise mitigate known vulnerabilities within the recommended time frame?	*Identify and patch vulnerabilities in a risk-informed manner (e.g., critical assets first) as quickly as possible.*	Create an ICS patch management program and policy. Provide policy as evidence of compliance.
5.2. This control number is included here to be consistent with the CISA CPGs but is not applicable to most PWSs.		
5.3. This control number is included here to be consistent with the CISA CPGs but is not applicable to most PWSs.		
5.4. Ensure that assets connected to the public Internet expose no unnecessary exploitable services (e.g., remote desktop protocol)?	*Eliminate unnecessary exposed ports and services on public-facing assets and regularly review.*	Create a scheduled task for review of public facing services and equipment. Provide statement of compliance as compliance documentation.
5.5 Eliminate connections between its OT assets and the Internet?	*Eliminate OT asset connections to the public Internet unless explicitly required for operations.*	Explore alternatives to Geo-Web setup to provide better isolation of ICS. Implement and utilize a DMZ and a proxy for Geo-web to prevent direct access to/from ICS. Prepare statement of use case and security protections for evidence of compliance.
5.6 This control number is included here to be consistent with the CISA		

CPG but is not applicable to most PWSs.		
6. Supply Chain/Third Party.		
6.1. Include cybersecurity as an evaluation criterion for the procurement of OT assets and services?	*Include cybersecurity as an evaluation criterion when procuring assets and services.*	Create a policy to include cybersecurity criteria in procurement of OT assets. Develop criteria. Provide policy and criteria as evidence of compliance.
6.2/6.3 Require that all OT vendors and service providers notify the PWS of any security incidents or vulnerabilities in a risk-informed timeframe?	*Require vendors and service providers to notify the PWS of potential security incidents and vulnerabilities within a stipulated timeframe described in procurement documents and contracts.*	Create a vendor policy and include with vendor agreements. Provide policy as evidence of compliance.
7. Response and Recovery.		
7.1. Have a written procedure for reporting cybersecurity incidents, including how (e.g., phone call, Internet submission) and to whom (e.g., FBI or other law enforcement, CISA, state regulators, WaterISAC, cyber insurance provider)?	*Document the procedure for reporting cybersecurity incidents promptly to better aid law enforcement, receive assistance with response and recovery, and to promote water sector awareness of cybersecurity threats.*	Create a policy for reporting along with a Business Continuity Plan, Incident Response Plan, and Disaster Recovery Plan. Provide statement of compliance as compliance documentation.
7.2. Have written cybersecurity incident response (IR) plan for critical threat scenarios (e.g., disabled or manipulated process control systems, the loss or theft of operational or financial data, exposure of sensitive information), which is regularly practiced and updated?	*Develop, practice, and update an IR plan for cybersecurity incidents that could impact PWS operations. Participate in tabletop exercises to improve responses to any potential cyber incidents.*	Create an Incident Response Plan. Perform tabletop exercises once annually. Provide statement of compliance as compliance documentation.
7.3. Backup systems necessary for operations (e.g., network configurations, PLC logic, engineering drawings, personnel records) on a regular schedule, store backups separately from the source systems, and test backups on a regular basis?	*Maintain, store securely and separately, and test backups of critical PWS OT and IT systems.*	Create a backup policy and procedure including testing of backups. Provide statement of compliance as compliance documentation.
7.4. Maintain updated documentation describing network topology (i.e., connections between all network components) across PWS OT and IT networks?	*Maintain complete and accurate documentation of all PWS OT and IT network topologies to facilitate incident response and recovery.*	Create an accurate set of network documentation along with a policy to keep it updated when changes occur. Provide statement of compliance as compliance documentation.
8. Other.		

8.1. Segment OT and IT networks and deny connections to the OT network by default unless explicitly allowed (e.g., by IP address and port)?	*Require connections between the OT and IT networks to pass through an intermediary, such as a firewall, bastion host, jump box, or demilitarized zone, which is monitored and logged.*	Create a DMZ. Provide statement of compliance as compliance documentation.
8.2. Keep a list of threats and adversary tactics, techniques, and procedures (TTPs) for cyberattacks relevant to the PWS and have the capability to detect instances of key threats?	*Receive CISA alerts and maintain documentation of TTPs relevant to the PWS.*	Create a mechanism to receive and review alerts and TTPs. Provide statement of compliance as compliance documentation.
8.3. Use email security controls to reduce common email-based threats, such as spoofing, phishing, and interception?	*Ensure that email security controls are enabled on all corporate email infrastructure.*	Good practice, but does not apply to a fully segregated ICS. EPA does not have the jurisdiction to enforce this.

APPENDIX G:
Future Development Figures

20-YEAR HORIZON ANTICIPATED FUTURE DEVELOPMENTS



FUTURE LAND USE PLAN MAP
BERTHOUD COMPREHENSIVE PLAN

Last Revised: September 9, 2021

Growth Management Area

Place Type: Natural Areas
- Environmentally Sensitive Area
- Open Space
- Parks, Recreation & Trails
- Ditch/Canal - Potential Trail Connections

Place Type: Rural Areas
- Agricultural
- Rural Residential

Place Type: Suburban Areas
- Suburban Residential
- Suburban Business

Place Type: General Urban Areas
- Urban Residential
- Innovation District

Place Type: Urban Center
- Old Town Residential
- Downtown

Place Type: Special Districts
- New Berthoud
- 1st Street Corridor
- Mountain Avenue Corridor

0 0.5 1 2 Miles